HIGHLAND CITY

DRINKING WATER MASTER PLAN UPDATE

(HAL Project No.: 314.12.100)

JULY 2012

HANSEN ALLEN & LUCE INC
ENGINEERS

HIGHLAND CITY

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ENGINEERS

July 2012

HIGHLAND CITY
DRINKING WATER SYSTEM MASTER PLAN

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EXECUTIVE SUMMARY

Introduction

In November of 2011 Highland City retained Hansen Allen & Luce Engineering to update the Drinking Water Master Plan. This Executive Summary provides a brief overview of the efforts and recommendations provided within the Master Plan document.

Statement of Purpose

The purpose of this Drinking Water System Master Plan is to evaluate the existing drinking water system and to provide recommendations for facilities and operations for the existing and future needs of the city. This plan covers the Highland City boundary including future conditions which were estimated to be near buildout by the year 2030. The Master Plan will be a guide for development of the water distribution facilities in serving both current and future needs.

The specific objectives of the plan include:

- Quantify existing and future demands on the water system
- Update the hydraulic model of the water system with facilities that have been constructed since the previous master plan
- Prepare an extended period simulation model
- Evaluate the existing system against current needs
- Identify major distribution system improvements
- Prepare a Capital Facilities Plan for future improvements

Water System Modeling

An existing model of Highland's drinking water distribution system was updated to include all existing facilities. The hydraulic model for the water distribution system was updated with EPANet, modeling software developed by the EPA. A future water model was also prepared to include future demands introduced into the water system by new development. Demands for these models utilized those required by the Division of Drinking Water. A third existing system model was prepared as an extended period simulation (EPS) model. The EPS model can be used to identify operation issues or water quality over a number of days.

Existing System Evaluation

Highland's existing drinking water distribution system is comprised of a pipe network, water storage facilities, pump stations and well sources. Figure ES-1 illustrates the existing water distribution system. The existing water distribution system was evaluated based on operating wells, distribution piping, pumping, storage, and fire flow capacity with the current demands on the system.

The existing water lines, both distribution and transmission, were evaluated by modeling for two conditions. The first was Peak Instantaneous Demands. The second was Peak Day Demands plus fire flow conditions. It is important to analyze the system under these two demand conditions because they represent the worst-case scenarios for the distribution system.

The existing water system was also evaluated using a Four-Point Analysis which is included as Appendix A of this report. This analysis reviewed the existing and future conditions of the system in four different categories. These categories are water rights, water source, water storage, and zone pumping. The existing system capacities were compared against the State of Utah Division of Drinking Water (DDW) requirements to determine whether a surplus or deficit exists. Based upon this analysis, the existing water system **meets or exceeds** the minimum criteria in each of the four areas.

The water system was also analyzed during a fire flow event. All transmission lines met the velocity requirement of 10 fps. It was observed that a number of 4-inch and 6-inch distribution lines in subdivisions exceeded 10 fps when conveying a fire flow demand of 1,500 gpm. A few areas, typically at the end of 4-inch and 6-inch lines, were found to not satisfy the 20 psi residual pressure DDW requirement. Improvements were identified through looping or upsizing lines to meet the pressure requirement (see project number 9, Table ES-1).

New Pressure Zone

The majority of the system is within the pressure limits of 50 psi to 120 psi during dynamic conditions. However, the southwest portion of the City, south of the Murdock Canal, does experience pressures up to 170 psi. Each connection in this area is equipped with a pressure reducing valve within the residence. A new pressure zone has been identified at the Canal to reduce pressures by approximately 80 psi. The new pressure zone would be created with PRV's. In the future with adequate funding, the City plans to build a new storage tank to meet average day demands for this lower zone. Well #3 would be retrofitted to pump into the tank with chlorine. From the tank a booster pump would provide adequate pressure and peak day demands to the system. Fire flow demands and demands above the peak day would be provided through the PRV's.

Well House Improvements

The Cities drinking water source is provided exclusively from wells. The City has identified three well houses that are in need of improvements. These wells were the earliest constructed from 1958 to 1977. Though the well houses have been working acceptably to date, they are quickly reaching their design life.

Chlorination Equipment

The drinking water currently does not have chlorine introduced into the system. However, during recent water quality samplings the City has found coliforms within the sampled water. Should more of these samples come back positive the State will require chlorination to safeguard the public's health. The City is progressing to a population that chlorination may be inevitable with more strict EPA requirements. There are currently two options for the Chlorination System. Option one includes directly injecting chlorine into the system at the well sources, before being mandated by the State. An acceptable chlorine residual would be present throughout the system to deter a positive coliform test. This option is pre-emptive and is less costly as it is not State mandated and does not require contact time. If the City decides however to wait until the State mandates chlorine, costly improvements to provide contact time will be required. This option would require large vessels or volume of pipe to achieve adequate contact time. Both options are provided within the costs.

Recommendations and Capital Facilities Plan

A Capital Facilities Plan was developed to assist Highland in budgeting for the recommended improvements. Figure ES-2 shows the culinary water system with the recommended future improvements. Table ES-1 further identifies the improvements along with a cost estimate for the completion of the project and if the project is for future development or an existing deficiency. The numbering coincides with the future figure ES-2. Costs are in 2012 dollars and would need to be indexed accordingly.

Table ES-1: Capital Improvements

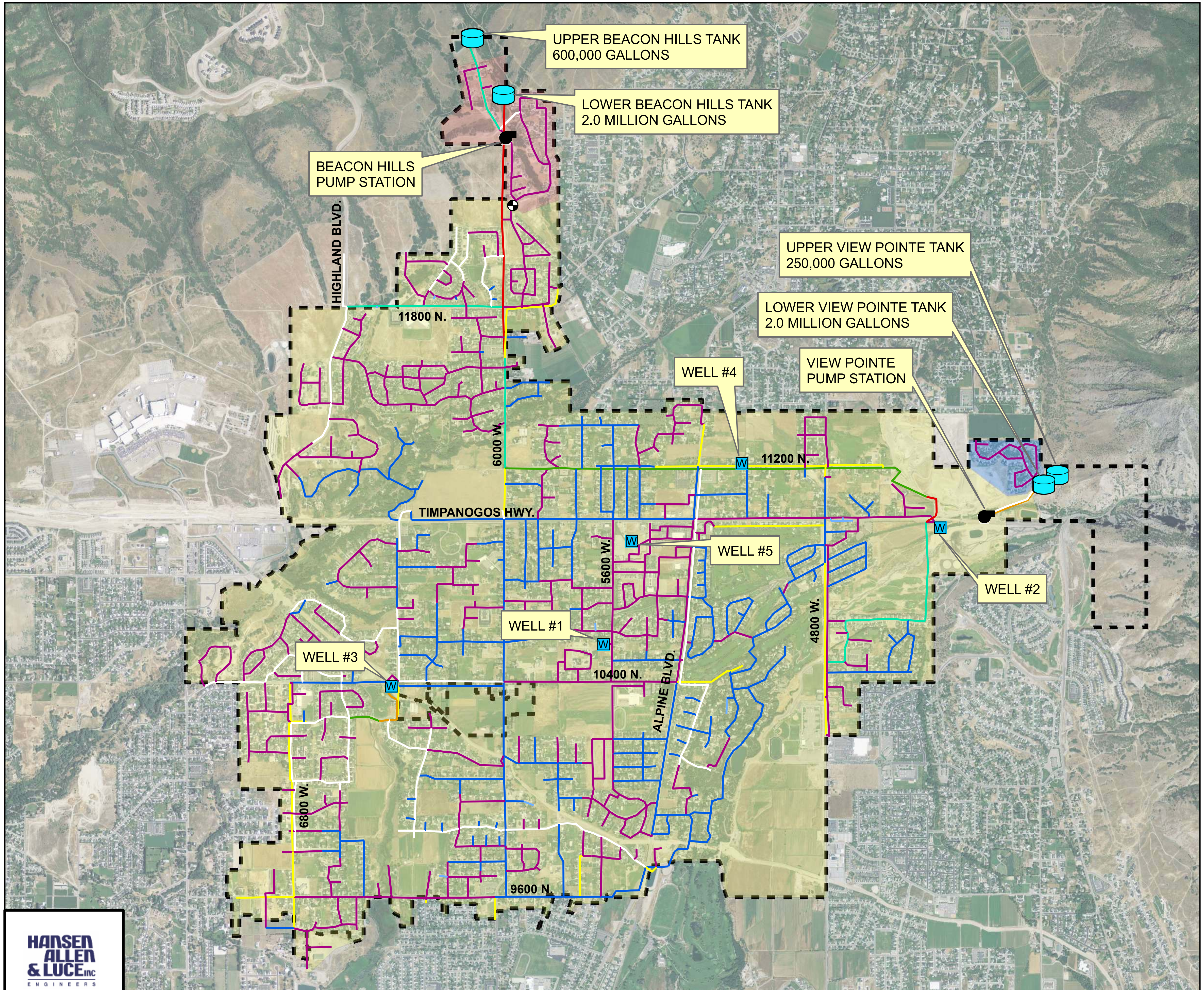
Project Number	Description	Year Constructed	Estimated Total Cost
1	Install PRVs to Create Lower Murdock Zone – Existing Deficiency	Short Term	$ 202,000
2	11000 N. 16" Transmission Line – Future Development	Future Growth	$ 257,000
3	Northwest Upper Zone Transmission Lines – Future Development	Future Growth	$ 784,000
4	Southeast Area and Lone Peak High School – Future Development	Future Growth	$ 1,737,000
5	6000 West & 11000 N. – Future Development	Future Growth	$ 182,000
6	6800 West 8" Transmission Line – Existing Deficiency	Short Term	$ 123,000
7	Chlorination Upgrades at Wells – Existing Deficiency	Short Term	$ 350,000
8	Well House Upgrades (Well #1, #2 & #5) – Existing Deficiency	Short Term	$ 1,890,000
9	Fire Flow Line Improvements – Existing Deficiency	Short Term & Future	$ 496,000
10	Abandon Existing 4-Inch Lines – Existing Deficiency	Short Term	$ 364,000
11	Chlorine Contact Time Improvements at Wells 1,2,4 & 5– Existing Deficiency	Short Term	$ 1,184,000
12	Construct New 500k Tank, Well #3 Modifications, Booster Pump & Chlorination Equipment for New Lower Zone	Short Term	$ 1,624,000
		TOTAL	**$ 9,123,000**

The cost estimates in Table ES-1 are budget level and reflect current pricing. They include a 20 percent allotment for contingencies and 20 percent for engineering, construction management services, and administration costs. Costs associated with the acquisition of property or right-of-way are not included.

Future Growth improvements are those required for build-out demands, which is expected to take place by the year 2030. Otherwise short term projects are those identified as existing needs and can be prioritized and budgeted for over the next 10 years.

It is recommended as the need and opportunity arise, that smaller waterlines be upgraded to a minimum of 8-inch diameter. For cost efficiency, these improvements should be coordinated with other facility improvements such as road, sewer, or storm drainage. Pipe replacement should be prioritized based on the age of the pipe. Continually maintaining and upgrading the drinking water system, as has been done in the past, should be the key long-term improvement that will provide Highland City with reliable drinking water for the future.

Table ES-1 only identifies specific projects and costs for infrastructure needed before buildout. A detailed financial analysis will need to be developed by the City that ascertains how funding for the projects will occur. The cost identified for existing deficiencies is approximately $6,040,000 and those for future growth as $3,083,000. The majority of the future growth items could be installed through the new developments. The future water lines shown in Figure ES-2 through non-developed properties are schematic only and are included for planning purposes.



N
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0 0.25 0.5 1 Miles

Legend

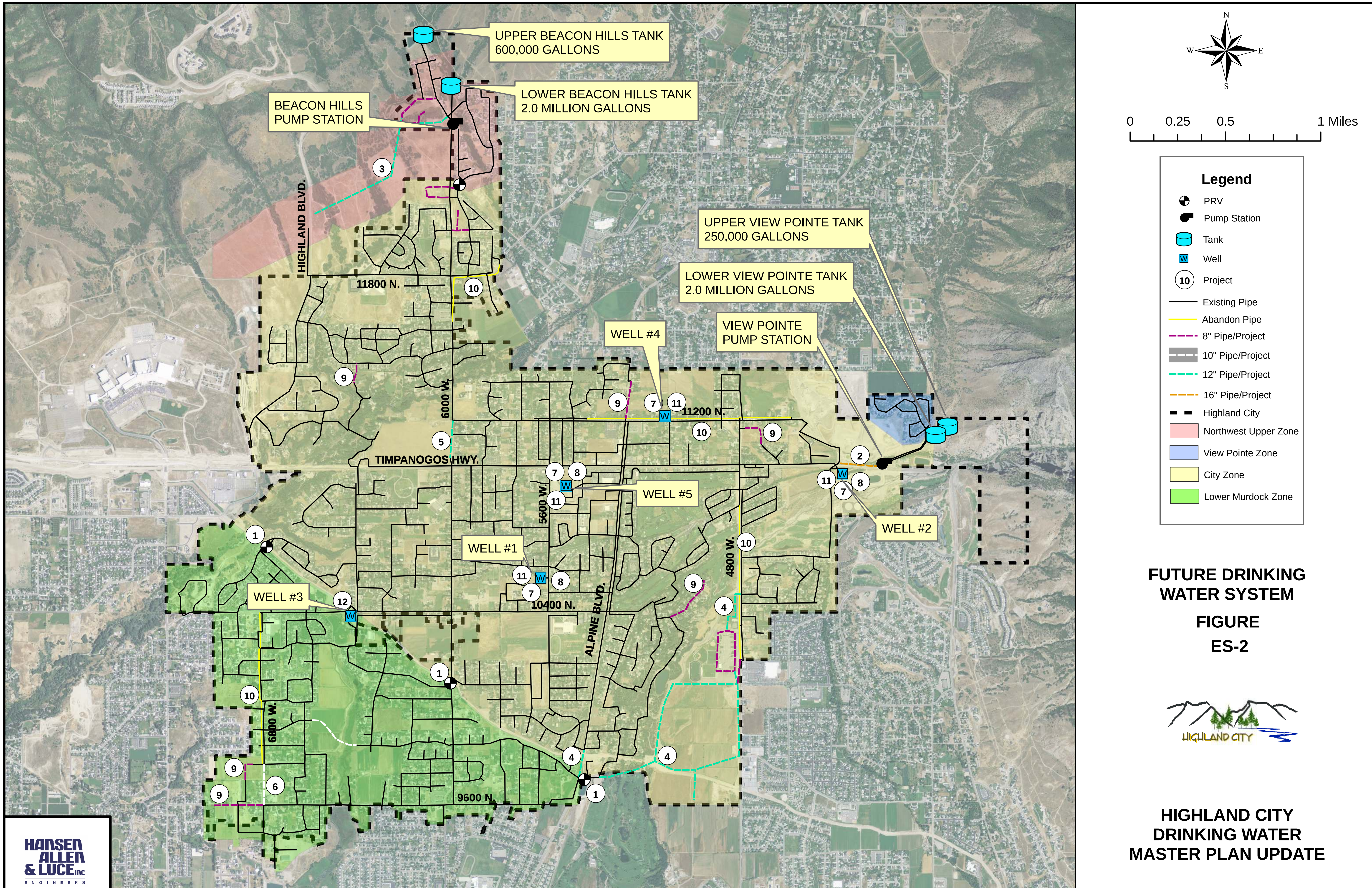
- PRV
- Pump Station
- Tank
- Well
- 2" Pipe
- 4" Pipe
- 6" Pipe
- 8" Pipe
- 10" Pipe
- 12" Pipe
- 14" Pipe
- 16" Pipe
- 18" Pipe
- Highland City
- Northwest Upper Zone
- View Pointe Zone
- City Zone

EXISTING DRINKING WATER SYSTEM

FIGURE ES-1

HIGHLAND CITY

HIGHLAND CITY DRINKING WATER MASTER PLAN UPDATE


UPPER BEACON HILLS TANK
600,000 GALLONS
LOWER BEACON HILLS TANK
2.0 MILLION GALLONS
BEACON HILLS
PUMP STATION
HIGHLAND BLVD.
11800 N.
UPPER VIEW POINTE TANK
250,000 GALLONS
LOWER VIEW POINTE TANK
2.0 MILLION GALLONS
VIEW POINTE
PUMP STATION
WELL #4
11200 N.
6000 W.
TIMPANOGOS HWY.
WELL #5
5600 W.
WELL #2
WELL #1
4800 W.
WELL #3
10400 N.
ALPINE BLVD.
6800 W.
9600 N.
N
W
E
S
0
0.25
0.5
1 Miles
Legend
PRV
Pump Station
Tank
Well
Project
Existing Pipe
Abandon Pipe
8" Pipe/Project
10" Pipe/Project
12" Pipe/Project
16" Pipe/Project
Highland City
Northwest Upper Zone
View Pointe Zone
City Zone
Lower Murdock Zone
FUTURE DRINKING
WATER SYSTEM
FIGURE
ES-2
HIGHLAND CITY
HIGHLAND CITY
DRINKING WATER
MASTER PLAN UPDATE
HANSEN
ALLEN
& LUCE INC
ENGINEERS

CHAPTER 1
PROJECT OVERVIEW

1.1 Project Background

Highland City is located on a bench near American Fork, Lehi, and Alpine in northern Utah County. According to the 2010 Census, during the past decade, the population has almost doubled to a population of approximately 15,523 since 2000. People are attracted to the rural atmosphere, large lot sizes, and close proximity to Salt Lake City and Provo.

Highland began as a 15 family settlement in the 1850's and was incorporated on July 13, 1977. Several landowners formed the Highland Water Company in 1958 to provide drinking water via a central system versus utilizing individual wells. Soon after, the first well was drilled and a storage tank was constructed in 1958. Other tanks, wells, pump stations, and large water lines have since been installed to form the present drinking water system.

During the fall of 2004 the membership of the Water Company voted to dissolve the Company and transfer all assets and obligations to the City of Highland. Since 2005 the City of Highland has operated and maintained the drinking water system.

1.2 Statement of Purpose

The purpose of this Drinking Water Master Plan is to provide recommendations to Highland City, based on demand data and standards established by the Utah Division of Drinking Water (DDW). This plan covers the Highland City boundary, possible annexation lands including future conditions to the year 2030, which is projected to be near buildout conditions. Once the plan is adopted, it will be the guide for development of the water system facilities in serving both current and future needs. The Capital Facilities Plan, in Chapter 7, sets forth recommended short-term and long-term improvements.

The specific objectives of the plan include:

- Quantify existing demands on the drinking water system
- Update the hydraulic model of the water system with facilities that have been constructed since the previous master plan
- Prepare an extended period simulation model
- Evaluate the existing system against current demands
- Determine future growth demands
- Identify major system improvements
- Prepare a Capital Facilities Plan for future improvements

1.3 Water System Master Planning Approach

The Highland City drinking water system 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 system's components must be designed and operated properly. Furthermore, careful planning is required in order to ensure that the drinking water system is capable of meeting the City's drinking water needs in the future.

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 record data. Future water needs were estimated by identifying locations where development is expected and adding the incremental increase in water demand associated with the development to the current demand. Highland City's build-out water demand was estimated by applying this process throughout the Annexation Boundary for the City.

In order to facilitate the analysis of Highland City's drinking 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 added to the drinking water system and the analysis was repeated. Recommendations for system improvement were prepared based on the results of this analysis. 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".

CHAPTER 2
CITY ENVIRONMENT

2.1 Existing Water Systems

2.1.1 *Drinking Water System*

Highland City owns, operates, and maintains the drinking water system, which is the subject of this Master Plan. The drinking water system provides indoor water use only, with certain exceptions. These exceptions are for a small amount of residents still utilizing for outdoor irrigation and industrial use at the gravel pits during the winter months. The city's secondary system, described below, provides for outdoor water use. The details of the drinking water system such as the number of connections, water source, water rights, distribution piping and storage are described in Chapter 3.

2.1.2 *Secondary Water System*

In 1997-1998, Highland City constructed and now operates and maintains a secondary water system that provides residents with outdoor water for irrigation of landscaped areas and gardens. The system is comprised of transmission lines, pump stations, and large reservoirs at the mouth of American Fork Canyon, Canterbury North and above Beacon Hills. The majority of the water source for the system is supplied by American Fork River water and conveyed by canals that receive water from the river.

Before the secondary system was constructed, the Water Company provided outdoor irrigation water from their well sources and conveyed that water through the Company's system to the residents of Highland. The outdoor demands required all of the well sources to be active during the summer. The construction of the secondary system has allowed for the use of the high quality groundwater to be used mostly for drinking water purposes. The secondary system has also allowed for the construction of smaller storage tanks and water lines than would be required if the drinking water system provided for outdoor irrigation. All water users, with the exception of approximately 200 connections, utilize the existing secondary water system for outdoor irrigation. The View Pointe subdivision alone has 103 connections that utilize drinking water for outdoor irrigation due to its elevation above the existing secondary service area. However, the subdivision does have separate secondary pipelines that are supplied by a single connection to the drinking water system. Highland City requires all new developments to provide secondary water lines and connect into the existing secondary system.

2.2 Population Projections and Future Growth Areas

A key factor in the evaluation of the drinking water system is the consideration of future growth. As Highland City continues to grow, both in terms of population and in amount of developed area, the delivery of drinking water is of paramount importance. The following section discusses current population projections, zoning, and future growth areas as they affect the City's drinking water system.

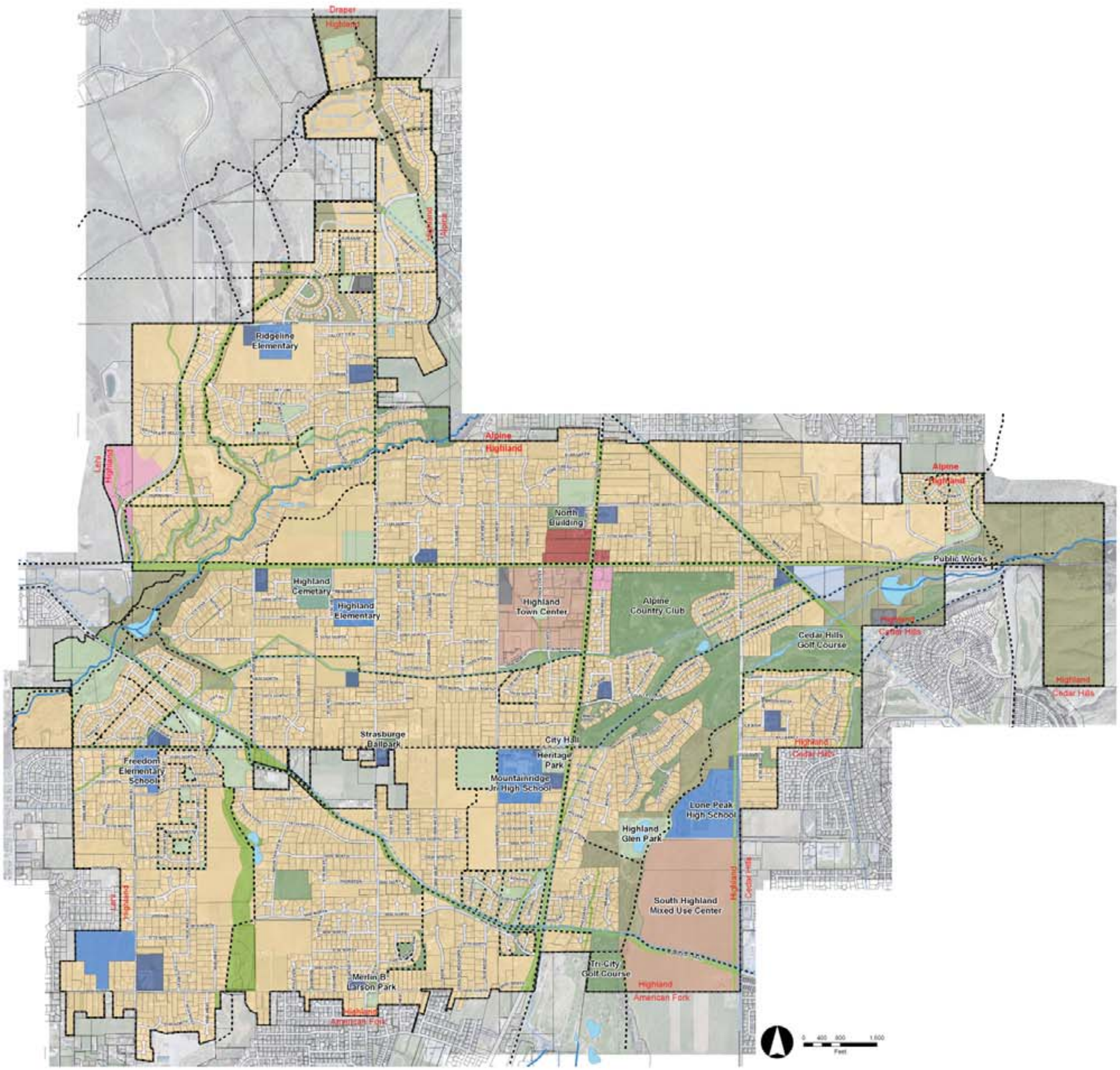
2.2.1 Population Projections

The latest population projections from the State of Utah (2008) estimates that the population will increase from the current population of approximately 15,523 to 22,775 in the year 2030.

2.2.2 Future Land Use Map

The City provided a Future Land Use Map adopted February, 2008 (see Figure 2-1) which was utilized to determine the future build-out zoning conditions. The future land use map is a dynamic document utilized for planning purposes. The map does not always reflect current zoning but instead the City's intentions for use at City build-out.

Based on the land use map and City development regulations, by the year 2030 the City will be considered to be in a full build-out condition with no vacant land remaining for future development. The City's current undeveloped areas are zoned for residential development, business development, and open space.



MAP 2-3
FUTURE LAND USE

Land Use

- Low-Density Residential
- Mixed Use Development
- Commercial
- Office
- Institutional
- School
- Religious
- Open Space
- Highland City Public Park
- Trail Corridor & Greenway
- Private Recreation & Mini Park
- Cemetery
- Utility
- Waterbody
- Parcels
- Stream or River
- Canal or Ditch
- Pipeline or Aquaduct
- Trails
- City Boundary

Highland City
General Plan Update

LANDMARK DESIGN

Adopted February 19, 2008

CHAPTER 3
EXISTING DRINKING WATER SYSTEM

3.1 General

Highland's existing drinking water system is comprised of a pipe network, water storage facilities, and water supply sources. Figure 3-1 illustrates the existing water distribution system. As shown, the system services all of Highland City. This chapter summarizes the existing system facilities and water sources.

3.2 Water Rights

Table 3-1 lists the drinking water rights which are owned by Highland City and that are tied to their existing drinking water wells. A total of 3,853.99 acre-feet (AF) per year of water is available through the below referenced water rights. Some of these water rights were transferred to the City by the Water Company.

In addition to the water rights tied to the existing drinking water wells, the City has another 1,226.36 AF per year of water rights tied to other ground water sources with approved beneficial use listed as "municipal". These include water rights a28710, 55-1636, 55-2081, 55-9453, 55-9656, 55-9708, and 55-11898. Thus, the City has a total approved municipal water right volume of 5080.354 AF per year. These rights can be used either in the City's drinking water system or they can be used in the City's separate secondary water system.

Table 3-1: Existing Drinking Water Rights Tied to City's Drinking Water Wells

Water Right No.	Source	Amount
55-6054	Underground well	2.0 cfs/192 AF
55-9341	Underground well	121 AF
55-751	Underground well	10.0 cfs/2,000 AF
55-908	Underground well	4.2 cfs/1,200 AF
55-9707	Underground well	288.99 AF
55-12283	Underground well	52 AF

3.3 Water Supply

Highland City's current drinking water supply is strictly from groundwater sources. All five wells, located throughout the City, are actively used throughout the year on a rotating basis. Table 3-2 summarizes the information of each well. Additionally, all water sources have a current source protection plan filed with the State of Utah. The active wells are equipped with submersible pumps. It should be noted that in 2004 Highland City drilled a new well, designated as, No. 6 located at 6000 West and 11800 North. This new well will provide secondary irrigation to the community but was constructed in accordance with the Division of Drinking Water's drinking water standards so that if necessary it could be utilized to supply drinking water. However a connection from the well to the drinking water system would be required before the well could be used as a drinking water source.

Table 3-2: Existing Well Water Sources

Name	Year Drilled	Capacity (gpm)	Status	Notes:
Well No. 1	1968	600	Active	
Well No. 2	1958	800	Active	
Well No. 3	1977	1300	Active	
Well No. 4	1986	900	Active	
Well No. 5	1987	1000	Active	
Well No. 6	2004	1500	Secondary	Currently utilized in secondary system.

As shown in Table 3-2 wells one through five (along with the adjoining pump stations) are all at least twenty five years old, with Well No. 2 being over 50 years old. Though the wells work as needed and have been well maintained, they are in need of extensive improvements so that they can continue to provide drinking water to the residents of Highland. A list of well house recommended improvements, along with costs, are provided in the Capital Facility Plan.

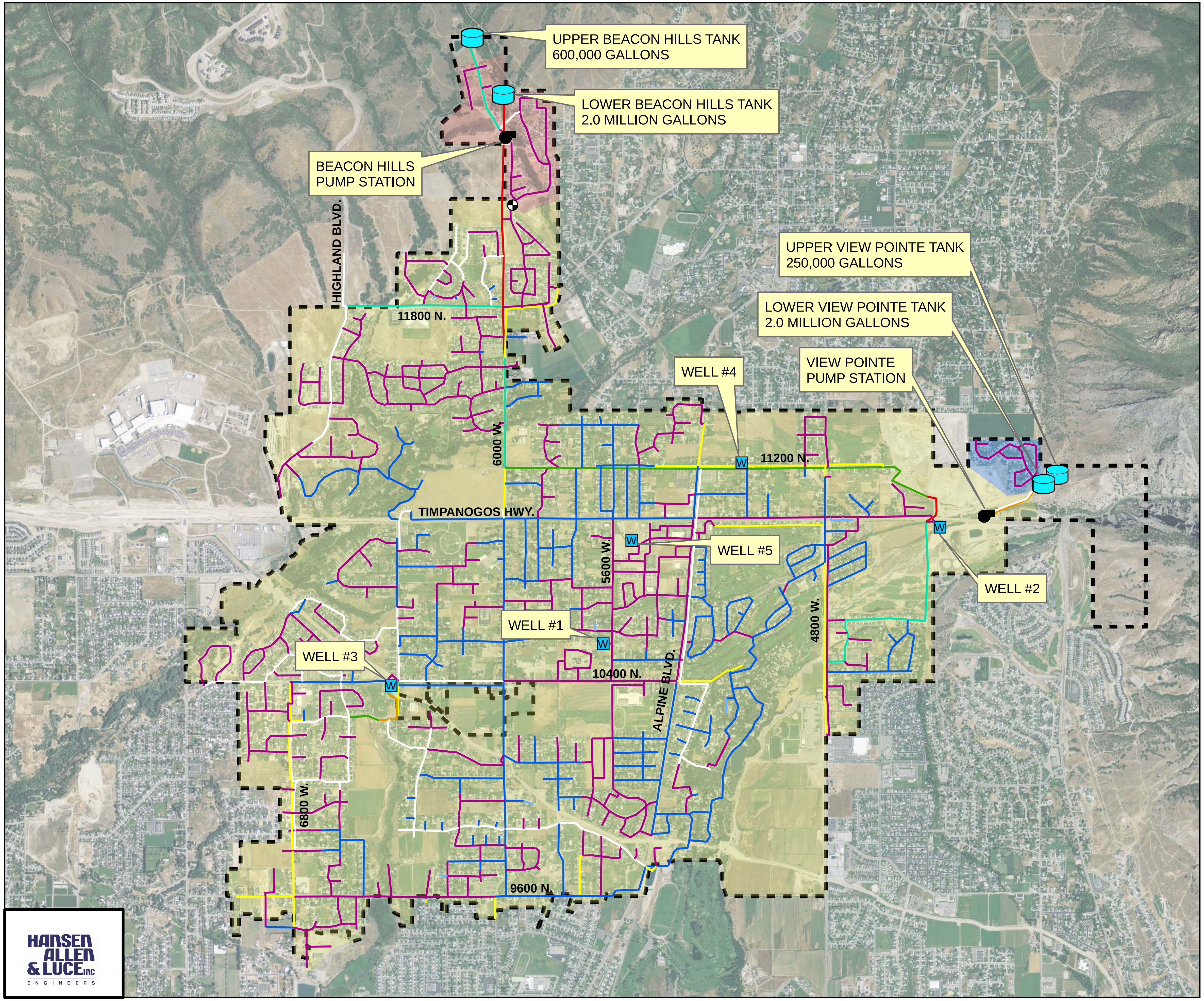
Currently the drinking water is not treated. Recently, the City through its scheduled testing, have found coliform (non-fecal) traces. After further flushing and testing the coliform traces were not present in subsequent testing. As the size of the system increases, the need for chlorination residual becomes more necessary. Though the DDW has not required chlorination in the past, with more coliform traces they are likely to mandate a chlorination residual in the system. Recommendations and costs are provided in the proceeding chapters so that the City may budget and plan for chlorination.

3.4 Pipe Network

Pipe diameters range from 2-inches to 18-inches, with the majority being 6 or 8 inches within the individual subdivision developments. Highland's current standard is the exclusive use of ductile iron pipe. When the Water Company first started in 1958, 13 miles of steel pipe were installed throughout the city. Through the 60's, 70's and 80's cast iron pipe was installed. Since 1994, ductile iron pipe with a poly wrap has been installed exclusively.

3.5 Pressure Zones

Currently, the drinking water distribution system serving Highland City has three pressure zones. These zones are the Main City Zone, the recently constructed Northwest Upper Zone, and View Pointe Zone. The static pressures in the Main City Zone range from 50 to 173 psi. The Northwest Upper Zone provides water to new developments in the upper northwest annexation area of the City and has a static pressure range from 55 psi to 121 psi. The View Pointe Zone provides drinking and secondary water to the View Pointe Subdivision and has a static pressure range from 56 psi to 64 psi.



N
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0 0.25 0.5 1 Miles

Legend

- PRV
- Pump Station
- Tank
- Well
- 2" Pipe
- 4" Pipe
- 6" Pipe
- 8" Pipe
- 10" Pipe
- 12" Pipe
- 14" Pipe
- 16" Pipe
- 18" Pipe
- Highland City
- Northwest Upper Zone
- View Pointe Zone
- City Zone

EXISTING DRINKING WATER SYSTEM

FIGURE 3-I

HIGHLAND CITY

HIGHLAND CITY DRINKING WATER MASTER PLAN UPDATE

3.6 Storage Facilities

Highland City currently operates four concrete water storage tanks serving the City. Two of the tanks are located near the mouth of American Fork Canyon in the View Pointe Development and two are located in the Beacon Hills Development at the northern most section of Highland. The total storage capacity is 4.85 million gallons. The 2.0 million gallon Lower View Pointe Tank and the 2.0 million gallon Lower Beacon Hills Tank service the Main City Zone. The 250 thousand gallon Upper View Pointe Tank services the View Pointe Zone. The 600 thousand gallon Upper Beacon Hills Tank services the new Northwest Upper Zone. All four tanks were constructed between 2004 and 2005. Table 3-3 summarizes the storage facility information.

Table 3-3: Existing Storage Tank Summary

Name	Year Built	Capacity (gal)	Diameter (ft)	Depth (ft)	Overflow Elevation (ft)
Lower Beacon Hills Tank	2004	2.0 million	138	20	5140
Upper Beacon Hills Tank	2005	600,000	75	20	5305
Upper View Pointe Tank	2005	250,000	48	20	5276
Lower View Pointe Tank	2005	2.0 million	138	20	5140

3.7 Pump Stations

The City operates two new pump stations required to boost water from the Main City Zone to the elevated zones. These pump stations are the Beacon Hills Pump Station and the View Pointe Pump Station. The Beacon Hills Pump Station delivers water to the 600,000 gallon tank described previously, which services development in the Upper Northwest Annexation Area of the City. The View Pointe Pump Station delivers water to the new 250,000 gallon tank, which services View Pointe exclusively.

The Beacon Hills pump station receives suction from the Lower Beacon Hills Tank and can provide 500 gpm of flow for expected drinking water peak day demands. The View Pointe pump station was designed to provide both drinking water and outdoor peak instantaneous demands of 826 gpm. Both pump stations are equipped with a variable frequency drive (VFD) to allow for the pump stations to maintain minimal flows should the tanks be out of service.

CHAPTER 4
HYDRAULIC MODEL DEVELOPMENT

4.1 General

As part of the analysis an existing model of Highland's drinking water distribution system was updated to include all existing facilities. This chapter discusses the details associated with the development of the model and as a reference for future model use.

4.2 Hydraulic Analysis

The hydraulic model for the water distribution system was originally created in Haestad's WaterCAD 6.0. For this report the model was converted into an EPANet model. The model allows the user to analyze the system's flows and pressures as the system tries to meet existing and projected demand scenarios. The model also allows the user to conduct alternative comparisons by placing and sizing future pipes, tanks, and pumps until the projected demands are met.

An extended period simulation (EPS) model was prepared to analyze the existing system and provide a tool for analysis of operations and water quality. The EPS model and how it was utilized is discussed further in Section 4.6.

4.3 Determination of Equivalent Residential Units

The Drinking Water Master Plan utilized Equivalent Residential Units (ERU's) to equate an average residence water demand to a non-residential connection. The use of ERU's is a common engineering practice to describe the entire system's usage based upon a single average residence.

In order to determine the number of ERU's assigned to a model node, demand areas were created around each node and the number of residential lots within the demand area was calculated. It was assumed that each lot had one connection and was therefore considered one ERU. This process was performed for the entire city.

Based on this criteria, it was determined that at the time of this plan's preparation there are 3,910 ERU's within the City of Highland that have drinking water connections. There are also 413 platted lots within approved developments that have City Agreements in place to provide drinking water, for a total existing ERU of 4,323.

4.3.1 *Existing Non-Residential Connections*

For each non-residential connection, an equal number of ERU's was determined by each connections usage, as recorded from their past meter readings. For example, a non-residential connection with an average day usage 20 times more than the average day residential demand was assigned an ERU of 20.

4.3.2 Future ERU Determination

Future ERU's for the analysis of the buildout system were determined by the land use and zoning maps. An undeveloped area will have a future ERU count attributed per the zoning designation and acreage. For example, a 20-acre parcel in an R-40 (1 acre lot) zone will receive an ERU designation of 20 future ERU's due to the assumption that 20 residences can be placed in the undeveloped area per current zoning. If the existing zoning changes significantly, the Master Plan should be updated to reflect those changes.

4.3.3 *Future ERU Determination in the Northwest Annexation*

Future ERU's for the analysis of the buildout system in the Northwest Annexation area of the City utilized a 1.5 ERU's per acre designation. This conservative designation was utilized in the sizing of the Upper Beacon Hills Tank and Pump Station (in 2005) to ensure that future improvements would not be necessary if the City annexes more property than is currently anticipated or zoning changes up to the 1.5 ERU/acre density. This assumption was approved by City Staff.

4.4 Development of Water Demands

4.4.1 Existing Indoor Demands

Indoor demands for the entire system were determined using the City's usage information from meter readings obtained monthly from 2008 through 2011. These billing records were used to develop existing average annual water demands.

Peaking factors were applied to the Equivalent Residential Unit's number at each node to result in an Average Day Demand, a Peak Day Demand, and a Peak Instantaneous Demand as shown in Table 4-1.

Table 4-1: Model Water Demands

Demand Type	Demand (gallons per day per ERU)
Average Day Demand	274
Peak Day Demand	800*
Peak Instantaneous Demand	1600

* Suggested value from State of Utah Drinking Water Rules

Average Day Demands – Average day residential indoor demands were determined by dividing the number of residential connections by the yearly residential usage as reported by the City. Average water demands for institutional, commercial, and other non-residential connections were determined using the water meter information for each connection from July 2011. Based upon the City's records, it was determined that an average of 274 gallons per day (gpd) (0.19 gpm) per ERU is used within the city.

Peak Day Demands – Peak day residential indoor demands were represented by the Division of Drinking Water (DDW) recommended demand of 800 gallons per day (0.56 gpm) per ERU. Peak day non-residential demands were identified through the DDW regulations. When Peak Day suggestions were not available from the DDW, a conservative factor was multiplied to the Average Day Demand to approximate peak day use. Therefore, a peaking factor of 2.92 was multiplied by the Average Day Demand to get the Peak Day Demand for the model (800gpd/274 gpd).

Peak Instantaneous Demands – Peak instantaneous demands for the entire system was determined by the Diurnal Curve and compared against the DDW's recommended formula for determining system demands. The Peak Instantaneous Demand was calculated as 1,600 gpd (1.11 gpm) per ERU. Therefore, based on the Peak Day

Demand of 800 gpd per ERU, a peaking factor of 2.0 was applied to attain the Peak Instantaneous Demand for each ERU throughout the system.

4.4.2 Outdoor Demands

It was assumed that there are currently 100 residences that continue to utilize drinking water for outdoor irrigation. It was assumed that each residence irrigates one-half acre, which would total 50 irrigable acres for existing outdoor irrigation. It was also assumed that the future system will supply less outdoor water demands to residents. The City anticipates that over the upcoming years half of those residents using the drinking water system will eventually connect to the secondary system. This decrease is anticipated to account for 50 less residences and provide a total future outdoor irrigation demand of 25 irrigable acres for the main city zone.

The above mentioned outdoor irrigation demands exclude the View Pointe Subdivision. The 103 residences and open space within the View Pointe Development will be supplied with outdoor irrigation water from the drinking water system as the City does not have a pressurized irrigation zone that could provide the water. An analysis of the development provided 21 acres of irrigated acreage (71 existing acres and 46 future acres total for the City). It must be noted that the drinking water system is impacted only slightly by outdoor demands as irrigation water is supplied by the city's secondary system to nearly all of the residents of Highland.

Outdoor demands were determined by the 2009 Highland City Pressurized Irrigation Master Plan. The Peak Day demand was reported as 5.29 gpm per irrigated acre and 2,528 gallons per irrigated acre was required for storage capacity. A peak instantaneous demand of 12.74 gpm per irrigated acre was also presented in the Master Plan. DDW requires an average yearly demand of 2.63 acre-feet per irrigated acre for water rights. This average yearly demand includes a 90% conveyance loss and a 70% irrigation loss.

4.4.3 Fire Flow Demands

Fire flow demands were determined using the Uniform Fire Code. The Code allows for a deduction of fire flow demands if structures have internal fire suppression sprinkling systems. The Lone Peak Fire Marshall was contacted and directed, where possible, that the water system plan for half of the fire code requirement when sprinklers are provided. He also designated, for undeveloped areas that are zoned for commercial, a 4,000 gpm fire demand be used for planning purposes. Table 4-2 lists institutions and commercial properties in Highland City with their fire flow requirement per Code without any deductions, fire flow with the sprinkler deduction of 50% and the fire flow available in the existing hydraulic model. A minimum demand of 2,000 gpm was utilized for all commercial properties.

Table 4-2: Institutions and Commercial Property

Building	Approx Area (sq. ft.)	Fire Code Req. w/out Sprinklers (gpm)	Fire Flow w/Sprinkler Deduction (gpm)	Avail. Fire Flow (gpm)
Church at 10400 N. 6000 W.	16,000	2000 @ 2 hrs	2000	2000 +
Church at 9600 N. 6800 W.	31,000	2500 @ 2 hrs	2000	2500+
2-Story Office Building at 11000 N. 5500 W.	23,000	2250 @ 2 hrs	2000	2250 +
Strip Mall at 11000 N. 5350 W.	39,000	2750 @ 2 hrs	2000	2750 +
Grocery Store at 10000 N. 5350 W.	75,000	4000 @ 4 hrs	2000	4000 +
Jr. High School at 10400 N. 5500 W.	160,000	5750 @ 4 hrs	2875	4000
Elementary School at 10400 N. 6800 W.	100,000	4500 @ 4 hrs	2250	3350
Elementary School at10900 N. 6000 W.	92,000	4250 @ 4 hrs	2775	2000

*A residential fire demand of 1,500 gpm for two hours is assumed to satisfy residential areas.
*A 4,000 gpm for 4 hour fire demand was utilized for planning in future commercial areas and for use in storage calculations.

4.4.4 Future Demands

Future demands are dependent on the City's growth. Highland City adopted a General Plan Update on February 19, 2008, as was shown in Figure 2-1. Based on the Future Land Use Plan, and previous annexation agreements, all lands that could potentially be in Highland City were included in determining the future demands. Therefore, without substantial land use changes, the future demands were reasonably estimated.

Future demands were incorporated into the model using the same methodology as the existing demands. Possible future developable areas were given an Equivalent Residential Unit value depending on the Master Land Use Plan. Non-developable areas include Preservation Districts and designated Parks and Open Space and were assumed to not provide any drinking water demands to the system.

The Average Day future indoor demand was assumed to be the same as the existing indoor demand of 274 gpd per ERU which was based on billing records. Peak Day future indoor demands were also assumed to be the same as the existing demands of 800 gpd per ERU which was based on DDW recommended values.

4.5 Other System Capacity Criteria

4.5.1 Source and Pump Station Capacity

The source and pump station capacity of the drinking water system were analyzed per the DDW requirements. The capacity of the water source and pump stations must meet system Peak Day Demands. The source must also have sufficient water rights to satisfy the Average Yearly Demand of 146,000 gallons (0.45 AF) per ERU for indoor use.

4.5.2 Storage Capacity

The storage capacity of the drinking water system was analyzed per the DDW requirements. Drinking water systems are required to have adequate equalization storage. In order to be conservative 400 gallons per day per ERU for indoor use and 2,528 gallons per irrigated acre for outdoor use were utilized.

4.5.3 Water Line Velocity

To facilitate the analysis of the velocities in the water lines, the model was reviewed during different peaking scenarios. High velocities in water lines over a length of time will lead to unnecessary replacements and damage to the water line. Standard engineering practice was followed in analyzing the velocities during two peaking scenarios. The following guidelines were used to determine the adequacy of water lines:

Normal Operation during Peak Instantaneous – Velocities should be less than 5 feet per second.

Fire Flow plus Peak Day Demands – Velocities should be less than 10 feet per second.

4.5.4 Pressure Constraints

Areas within the drinking water system with excessive and/or insufficient pressures were identified. Highland City has designated a normal or preferred system operational pressure range from 50 to 120 psi. Pressures outside of these boundaries may damage water lines and residential plumbing or provide inadequate pressure during high usage. The following guidelines were used to determine adequate pressure ranges in the system:

- A minimum of 50 psi at the curb for connections during Peak Day Demands
- A minimum of 45 psi at the curb for connections during Peak Instantaneous Demands
- A minimum of 20 psi in the system during fire flow events
- A maximum of 120 psi during Peak Day Demands

4.6 Modeling Assumptions

For the purposes of this Master Plan, some assumptions were made during the development of the model to best reflect the attributes of the water system. These assumptions are provided below:

<u>Water Storage Tanks:</u> In order to conservatively analyze the system it was assumed that tank levels are five feet below the overflow elevation. Also it was assumed that the tanks will supply water for the system without the assistance of the wells. This assumption was also utilized during the fire flow modeling as wells are manually placed into service.

<u>Water Line Roughness Values</u>: Water line roughness values are used in the model to identify major head loss through pipes. This analysis used a conservative roughness value for the pipes to account for minor head loss through valves and fittings. The roughness value also accounts for age of the pipe due to older pipe having more head loss than newer pipe. The following describes the Hazen-Williams roughness values, used in the hydraulic model:

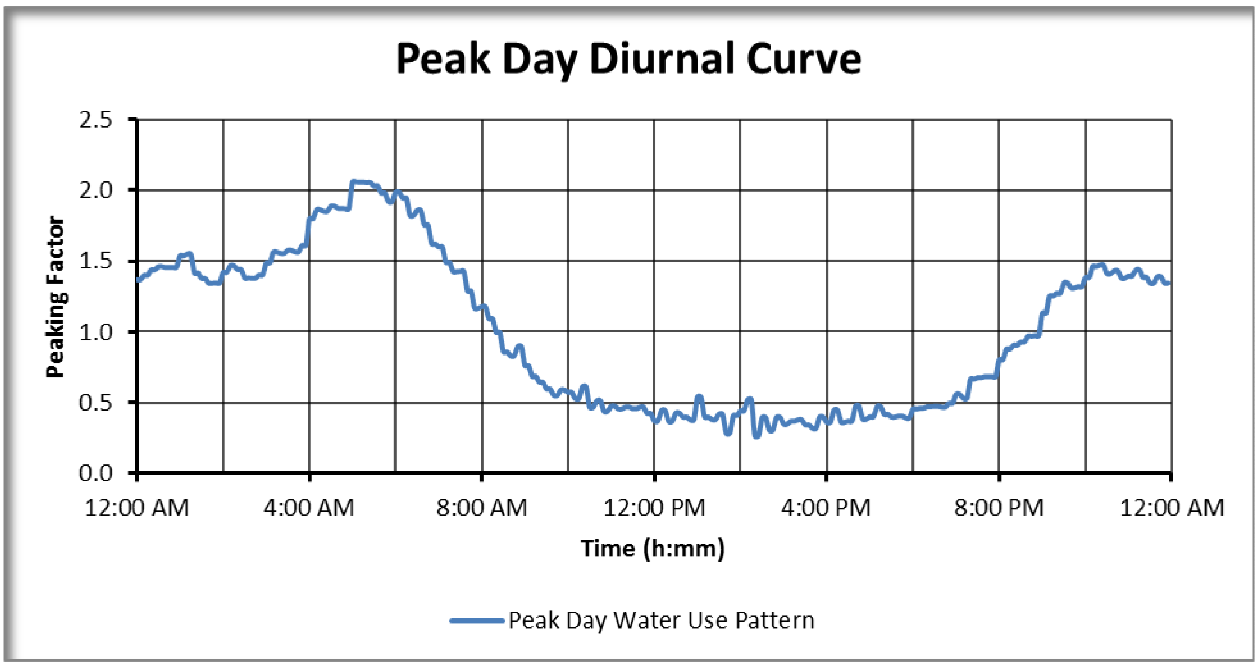
- Water lines that were installed before 2003 – 115
- Ductile iron pipe that was installed after 2003 and future pipe – 120

<u>Steady State Analysis</u>: The model analyzed the water system for a single moment in time or using “Steady State” conditions for the fire flow analysis. Peak Day demands were analyzed with the Steady State Analysis plus a Fire Flow Demand.

Extended Period Simulation: To enable a better analysis of the system, the existing static model was converted into an Extended Period Simulation (EPS) model. Evaluation of the system through the use of an EPS model has several advantages. The model allows for the evaluation of the system over days versus a brief moment in time. The EPS model also evaluates operation of the system's pump stations and tank filling cycles. Two EPS models were produced, one with the State DDW 800 gpd peak day demand requirement and another with a peak summer day as reported by meter readings. The peak summer day model was utilized to calibrate and to understand how the system typically operates during the summer months. The demands for the typical operation model were determined by the actual meter reading for a resident. This model is important in understanding operations and water quality.

Diurnal Curve: A typical residential diurnal curve for a drinking water system that does not provide large amounts of outdoor watering was used, figure 4.1. The curve was compared to SCADA information received from the City. The peak for the system occurs roughly near 6:00 am and then tappers into the afternoon with another minor peak near dinner time. The diurnal curve includes the peak instantaneous demand. The scope of this project did not include preparing a unique Highland City curve.

Figure 4-1: Diurnal Curve



Calibration: The original 2006 model was verified by three fire hydrant tests performed and monitored by Highland. The tests were performed near 6000 West and 11800 South, the future elementary school on 11800 South, and at the intersection of 6800 West and 9600 South. These fire flow tests verify that the model's results are very accurate to those observed in the actual system. The differences between the dynamic and fire flow pressures in the model versus the observed results were only an average of 3 psi. The EPS Model was calibrated and verified against existing SCADA data trends.

CHAPTER 5
IDENTIFY EXISTING SYSTEM DEFICIENCIES

5.1 General

The existing water distribution system was evaluated based on operating wells, distribution piping, pumping, storage, and fire flow capacity with the current demands on the system. The demand criteria, was that established by DDW Rules.

The existing piping system was evaluated by modeling for two conditions. The first was the Peak Demands with the EPS Model. The second was Peak Day Demands plus fire flow conditions through a Static Model. It is important to analyze the system under these two demand conditions because they represent the worst-case scenarios for the distribution system.

The existing drinking water system was also evaluated using a Four-Point Analysis which is included as Appendix A of this report. This analysis reviewed the existing and future conditions of the system in four different categories. These categories are Water Rights, Water Source, Water Storage, and Zone Pumping. The existing system capacities were compared with the requirements to determine whether a surplus or deficit exists. Based upon this analysis, the existing water system meets or exceeds the State of Utah's minimum criteria in each of the four areas.

5.2 Water Rights

The water system must have enough water rights to satisfy the indoor and outdoor needs of the system. Based upon the State of Utah Drinking Water Rules, the indoor requirement is 146,000 gallons per year per ERU. Based on information from the State of Utah Division of Water Rights the outdoor duty requirement is 4 acre-feet (ac-ft) per year per irrigable acre. Therefore, with 4,323 ERUs and 71 irrigable acres, the water system must have 2,211 ac-ft of water rights. Currently the water system has 5,080 ac-ft of water rights. These water rights are more than ample for the existing system.

5.3 Water Source

The existing well houses for pumping and supplying water are more than adequate with a current capacity of 4,600 gpm. The State of Utah Drinking Water Rules requires that the total source capacity of a system provide for Peak Day Demands. A Peak Day Demand of 800 gallons per day per ERU for indoor demands and 5.29 gpm per irrigable acre for outdoor demands was utilized. Highland's current source requirement or Peak Day Demand was calculated as 2,778 gpm. The additional source allows for redundancy should a problem arise with one of the City's wells.

5.4 Water Storage

Based upon the State of Utah Drinking Water Rules, the water system must supply a minimum of 400 gallons of storage per ERU. For storage associated with outdoor irrigation the system will must supply a minimum of 2,528 gallons per irrigated acre. Required fire storage was established by the Fire Marshall as 4,000 gpm for 4 hours. With 4,323 equivalent residential units, the system must have at least 1.73 million gallons for indoor equalization storage.

Another 0.96 million gallons is required for fire storage (4,000 gpm for 4 hours) and 0.18 million gallons is required for outdoor irrigation. The combined storage capacity of 4.85 million gallons from the View Pointe Tanks and Beacon Hills Tanks is adequate to serve the existing needs of the City. Zone storage was also analyzed in the same manner and is adequate for the zones as illustrated in Appendix A.

5.5 Zone Pumping

Zone pumping requirements were evaluated to model the Peak Day Demands in the different zones. Peak Day Demands were utilized as all of the zones are supplied with tanks to supply peak instantaneous flows. Under these scenarios the existing water system performed exceptionally well, meeting the State's pressure and velocity requirements.

5.6 Distribution Piping

5.6.1 *Velocity*

The velocities under the Peak Instantaneous and fire flow demand scenarios were analyzed. A velocity of 5 fps was considered to be the maximum allowable velocity during the peak instantaneous demand. The model detected no pipelines that exceeded the allowable velocity of 5 fps during peak instantaneous conditions.

During a fire flow event a maximum velocity of 10 fps was considered allowable. All transmission lines met this velocity requirement. It was observed that a number of 6-inch distribution lines in subdivisions exceeded 10 fps when conveying a fire flow demand of 1,500 gpm. Other than these 6-inch distribution pipelines, the system meets the velocity requirements.

5.6.2 *Pressure*

The majority of the system is within the allowable limits of 50 psi to 120 psi during peak day scenarios. Peak Instantaneous is also above 45 psi throughout the system. A few homes near the Upper Beacon Hills Zone Boundary are near the 50 psi pressure. These pressures have been accepted by the City as they are near tanks, provide indoor water only, and pressures do not fluctuate. The southwest part of town, south of the Murdock Canal, does experience pressures above the limits set for this plan and are near 170 psi. Each connection in this area is equipped with a pressure reducer to lower the pressure within individual residences.

5.6.3 Fire Flow

A general fire flow analysis was performed on the existing system to identify possible problem areas. The analysis identified general areas where the pressure dropped below 20 psi when a fire was simulated nearby. A typical residential fire flow of 1500 gpm was utilized. Larger fire events were also modeled at commercial and institutions with results shown previously in Table 4-2.

Six areas were identified where the pressure dropped below 20 psi in a fire event. These areas are listed in Table 5-1. The main problem source is the 6-inch and smaller water lines servicing the areas as their velocities exceed current standards during fire events. Although the velocities in a few local smaller pipes around the simulated fire exceeded 10 fps, there were no mainline pipes that exceeded 10 fps.

Table 5-1: Residential Fire Flow Problem Areas

Approx. Address	Reason
9600 N. 7000 W.	4" Dead End Line
Old Oak Ln.	6" Dead End Line
Manor Drive	6" Dead End Line
Alpine Hwy & 11400 N.	4" Line
Tamarack Road	6" Dead End Line

5.7 Transmission Piping

The transmission piping of the existing system is adequate for the City's needs. None of the transmission lines are over 3-fps during the peak instantaneous modeling. Some of the water lines were installed over 40 years ago and could experience some deterioration. If problems arise, existing pipelines may need to be replaced in the future. The City has identified 4-inch lines that parallel existing larger and newer lines. As funds are available the 4-inch lines will be abandoned to provide a more simple system. Modeling was provided to determine the need for the 4-inch lines and the analysis did not find them necessary.

5.8 Fire Hydrant Spacing

In discussions with the Lone Peak Fire Marshall, he provided feedback that in portions of the City fire hydrant spacing is not adequate to provide for firefighting activities. It was his recommendation that in the older areas of the City that fire hydrant spacing be reviewed and if possible new hydrants be provided at appropriate locations. A detailed analysis was not part of the Master Planning efforts. During the replacement of water lines new fire hydrants should be installed at appropriate locations to satisfy current fire code requirements.

CHAPTER 6
FUTURE DRINKING WATER SYSTEM IMPROVEMENTS

6.1 General

Future water demands based on the ERU projections through 2030 or buildout were provided by the City and added to the hydraulic model. These future demands were then applied to the existing waterlines to analyze how the drinking water system will respond to future growth. The model was then used to identify problem areas and to identify needed improvements to the system including transmission and distribution pipelines, additional pressure zones, source pumping and storage facilities.

The future water demands were determined by evaluating all undeveloped lands that could potentially be in Highland City. These undeveloped lands were assigned an ERU value depending on the 2008 General Land Use Plan along with discussions from City Planning Staff. An additional 1,365 acres with 3,003 ERU's were identified for future development. Total ERU's at buildout would therefore be 7,326 ERU's. The future drinking water system is comprised of the existing system with needed future improvements.

The future system was evaluated in the same manner as the existing system, by modeling (1) Peak Instantaneous Demands and (2) Peak Day Demands plus fire flow conditions.

6.2 Future Water Rights

The future water system must have enough water rights to satisfy the indoor and outdoor future needs of the system. Based upon the State of Utah Drinking Water Rules, the indoor requirement is 146,000 gallons per year per ERU. Based on information from the State of Utah Division of Water Rights, the outdoor duty requirement is 4 ac-ft per year per irrigable acre. Therefore, with a total of 7,326 ERU's and 46 irrigable acres, serviced by the drinking water system at build-out, a total of 3,467 ac-ft per year of water rights are required. With approximately 5,080 ac-ft per year of current water rights, no additional water rights will be needed for the drinking water system. The excess water rights not required for the City's drinking water system (i.e. the difference between available water rights at 5,080 acre-feet/year versus the build-out demand of 3,467 ac-ft per year) will be required for the City's separate secondary water system which is used to meet the majority of the City's outdoor water demands.

Note that although additional water rights will not be required to meet the City's indoor demands, which are serviced by the drinking water system; additional water rights will be required as development occurs to meet the City's outdoor watering demands which are serviced by the City's separate secondary water system. These additional water rights will help the City provide an overall reliable water supply to meet both indoor and outdoor water demands city-wide. More specific information regarding water rights requirements by the City is contained in the "Highland City 40-Year Water Rights Plan…". September 3, 2010, prepared by Hansen, Allen & Luce, Inc.

6.3 Future Water Source

The future system will continue to rely upon groundwater sources for drinking water. The five existing wells should provide sufficient groundwater to meet indoor needs for future build-out of the city. Currently only two wells are used to supply the city with their drinking water needs at any one time.

The State of Utah Drinking Water Rules requires a system's water source be capable of meeting a peak day demand for the system. A peak day demand of 800 gallons per day per ERU for indoor demands and 5.29 gpm per irrigable acre for outdoor demands (from Highland City Pressurized Irrigation Master Plan) was utilized. Highland's buildout Peak Day Demand was calculated as 4,313 gpm. The existing wells have a total capacity of 4,600 gpm. Therefore, no additional water sources need to be developed for future growth.

6.4 Future Water Storage

Based upon the State of Utah Drinking Water Rules, the water system must supply a minimum of 400 gallons per ERU. With 7,326 future ERUs, the system must have at least 2.93 million gallons for indoor equalization storage. Another 0.96 million gallons is required for fire storage (4,000 gpm for 4 hours) and 0.12 million gallons for outdoor irrigation (2,528 gallons per irrigated acre) for a combined required storage of 4.01 million gallons. The combined existing storage capacity of 4.85 million gallons is adequate to serve the future needs of the City. Appendix A also provides the analysis for zone storage which is shown to be adequate for each specific zone.

6.5 Future Zone Pumping

Future zone pumping requirements were evaluated to model the peak day future demands. All zones are directly connected to tanks that supply flows above the peak day demand. As discussed below, it is recommended to create a Lower Murdock pressure zone to alleviate the high pressures in the southwest section of the city. With the creation of the Lower Murdock Zone, it is recommended to alter the pumping facilities at Well #3 which is located at approximately 10400 North 6400 West. Currently the pump for Well #3 is designed to lift the water from the well up to the water storage tanks. A smaller pump would allow the well to be able to more efficiently service the Lower Murdock Zone without having to lift it up to the storage tanks. All zone pumping meets the 800 gpm requirement from the DDW Rules. Specific results are illustrated in Appendix A.

6.6 Distribution Piping

6.6.1 Velocity

The velocities under the peak instantaneous and fire flow demand scenarios were analyzed. A velocity of 5 fps was considered to be the maximum allowable velocity during the peak instantaneous demand. The model detected no pipelines that exceeded the allowable velocity of 5 fps during peak instantaneous conditions. During fire events transmission lines did not exceed 10 fps, but smaller dead end 6-inch distribution lines, discussed in Chapter 5, did reach velocities over 10 fps.

6.6.2 Pressure

Similar to the existing analysis the majority of future pressures did not fall below 50 psi during peak day demands and even during peak instantaneous were not below 45 psi. Again those near 50 psi were in proximity to the Beacon Hills Zone Boundary. This has been acceptable to the City as the pressures do not fluctuate and indoor watering only is observed.

Because existing pressures south of the Murdock Canal exceed the recommended limit of 120 psi, it is recommended that a new pressure zone be created to alleviate the high pressures in that area. This could be accomplished by installing pressure reducing valves (PRVs) on the pipelines that currently cross the canal. The PRVs should be set to allow a minimum pressure of 50 psi in the zone.

Another alternative to minimizing pressures below the Murdock Canal that has been discussed with the City staff would be to construct another water storage tank adjacent to the well. This water tank would exclusively service the Lower Murdock Zone with peaking demands. Fire flow would be serviced through the PRV's. A booster pump station would need to be constructed near the tank to provide sufficient pressures. Chlorination equipment and modifying the well to pump against less head would also be required.

Figure 6-1 shows the proposed future pressure zones. In addition to the existing Main City, Northwest Upper, and View Pointe Zones, a Lower Murdock Zone would be created by installing the PRVs shown on the figure. The pressures for the entire system now fall within the recommended limits. Figure 6-2 illustrates the future hydraulic schematic of the system with the lower zone.

6.6.3 Fire Flow

The same procedure used for the existing model was used to evaluate the fire flow conditions in the future model. The future model detected the same problem areas as listed in Chapter 5. These problems would need to be fixed on an individual basis by either replacing the smaller lines with larger ones, or providing additional looping to those areas. New lines were identified in the southeast to provide a 4,000 gpm fire flow to the undeveloped State of Utah property.

6.7 Future Transmission Piping

Figure 6-1 shows the drinking water system with the recommended future transmission waterlines. The transmission lines would need to be constructed to allow for future growth in the undeveloped areas. These transmission lines were added to keep the waterline velocities and pressures within the criteria limits for future demands.

6.7.1 Northwest Upper Zone

The Northwest Upper Zone will need to have a 12" transmission line constructed from the Beacon Hills area to allow the Upper Beacon Hills Tank to service the southern part of the zone. The construction of the water line can take place when new development is introduced into the area. These water lines may even be constructed as part of the development's distribution system.

6.7.2 Southeast Area and Lone Peak High School

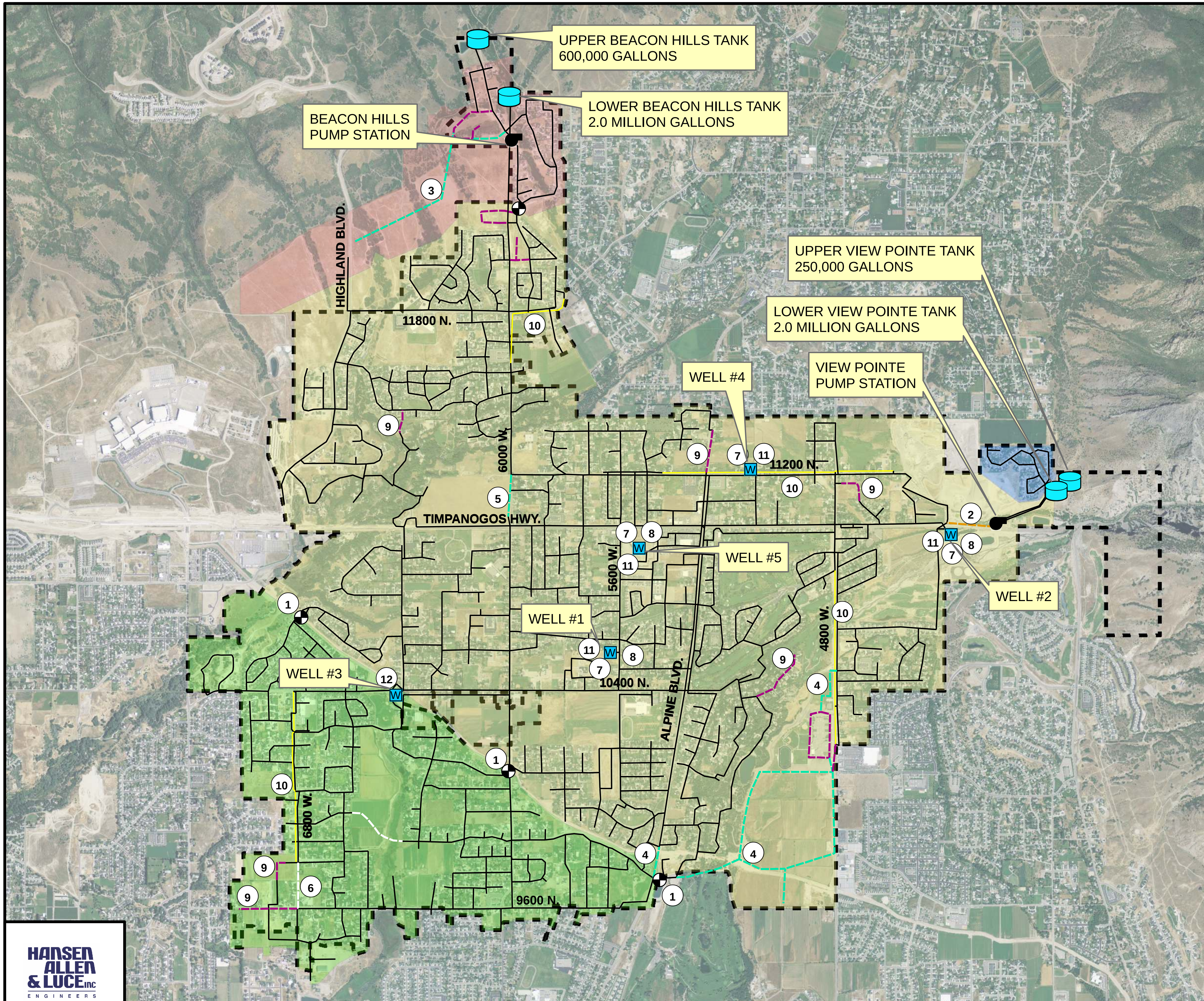
The Southeast Area of the City will need to have additional transmission lines constructed to allow for the growth expected in that area and also to allow Lone Peak High School to be serviced by Highland. Lone Peak is currently serviced by American Fork City's drinking water system. however with the recommended improvements the high school would be able to utilize Highland for their drinking water needs. This could be accomplished by connecting the existing 12” line along 4720 West and then extending it south to Lone Peak High School. The undeveloped areas south of the high school could be serviced by constructing 10” transmission lines from the high school and looping them with the waterline west of Highland Glen Park.

6.7.3 Lower View Pointe Transmission Line
A 16” transmission line runs from the 2.0 million gallon Lower View Pointe Tank to 11000 North. Currently a 12” waterline connects the 16” line to the rest of the Main City Zone. During Peak Instantaneous Demands, this 12” waterline experiences velocities around 8 fps. It is recommended that an additional 10” waterline be constructed parallel to the existing 12” line to bring the velocities back within the acceptable limits. This new line may be located on the north side of the highway and could provide water to new developments. Should the line become necessary before development occurs, the 12” line may be replaced with a 16” line or paralleled with the above mentioned 10” line.

6.7.4 6800 West Transmission Line
The Southwest corner of the city currently has sufficient pressure and flow to satisfy existing demands. However, as growth occurs in this area, additional transmission lines would be needed to supplement the existing smaller waterlines currently servicing the area. It is recommended that an 8” transmission line be constructed along 6800 West from 9770 North to 9600 North to alleviate future growth.

6.8 Future Operation and Maintenance

The continued operation and maintenance of the drinking water system should follow the same pattern currently used with no drastic changes needing to take place. The overall condition of the drinking water system is extremely reliable and should continue to provide the citizens of Highland City with their drinking water needs. As new well houses are reconstructed SCADA should be incorporated that allows for pumps to automatically turn on versus the current manual operation.



N
W E
S

0 0.25 0.5 1 Miles

Legend

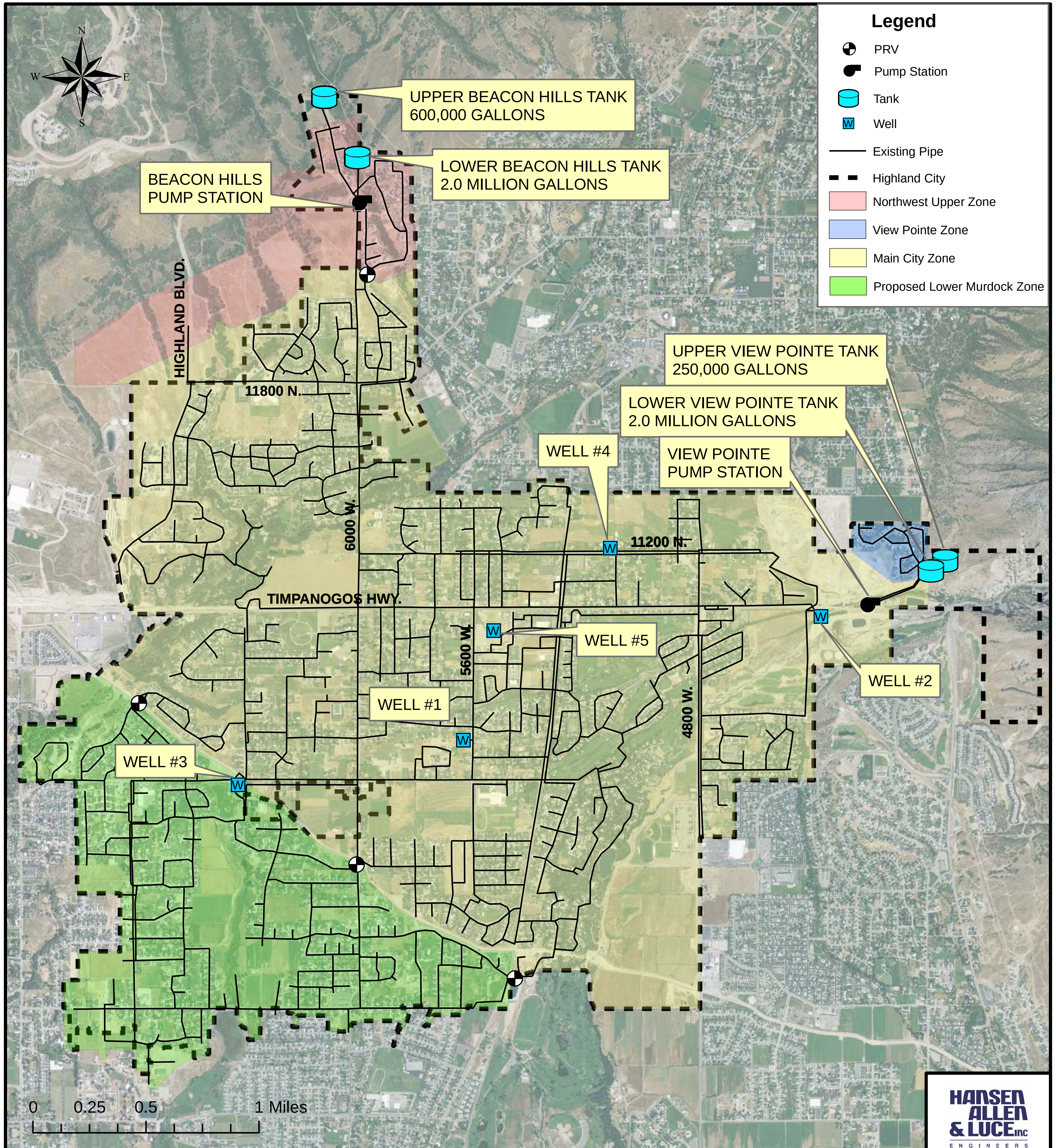
- PRV
- Pump Station
- Tank
- Well
- Project
- Existing Pipe
- Abandon Pipe
- 8" Pipe/Project
- 10" Pipe/Project
- 12" Pipe/Project
- 16" Pipe/Project
- Highland City
- Northwest Upper Zone
- View Pointe Zone
- City Zone
- Lower Murdock Zone

FUTURE DRINKING WATER SYSTEM

FIGURE 6-1

HIGHLAND CITY

HIGHLAND CITY DRINKING WATER MASTER PLAN UPDATE



HYDRAULIC SCHEMATIC WATER SYSTEM

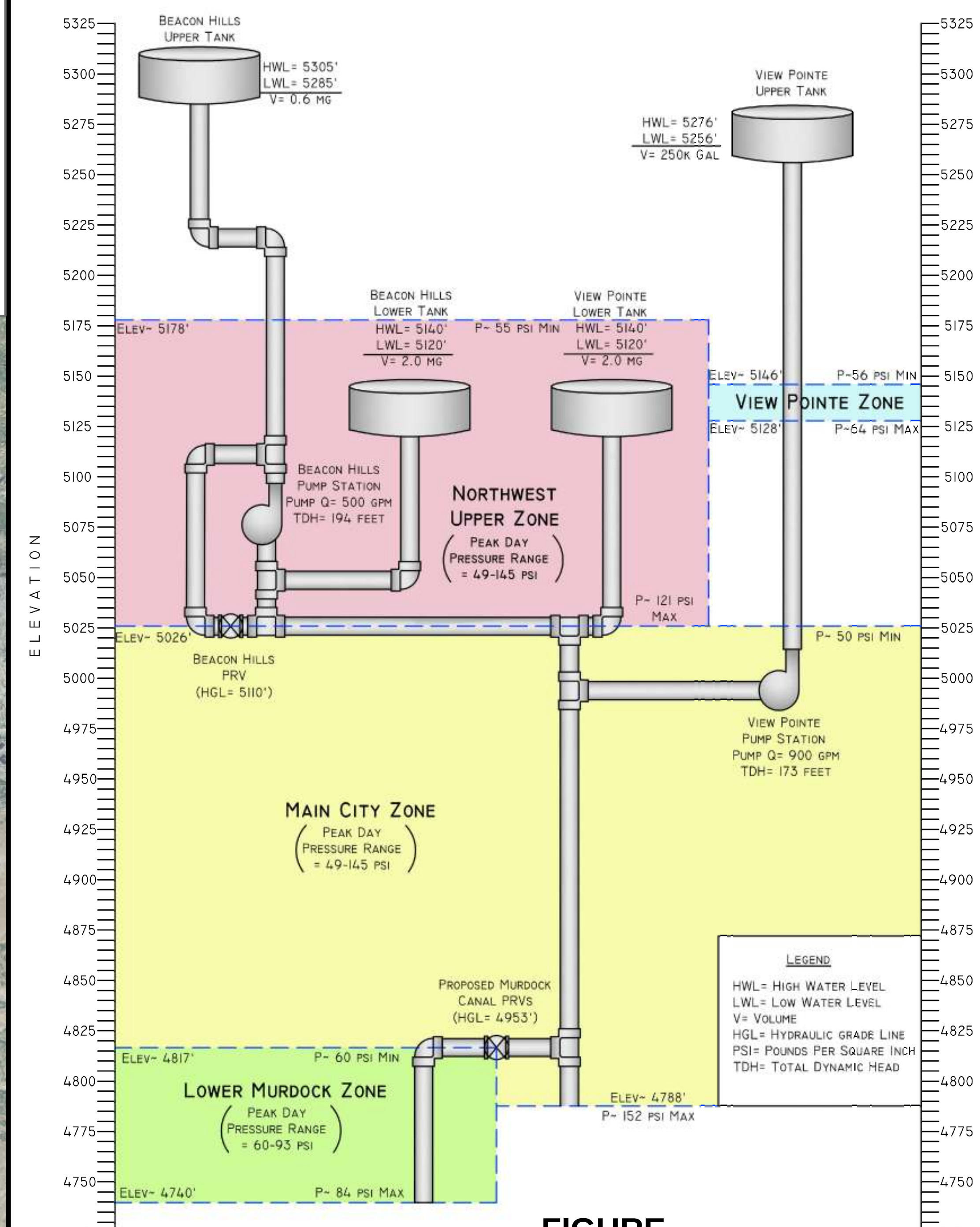


FIGURE 6-2

HIGHLAND CITY

HIGHLAND CITY DRINKING WATER MASTER PLAN UPDATE

CHAPTER 7
RECOMMENDATIONS AND CAPITAL FACILITIES PLAN

7.1 General

This section presents recommended water system improvements as a result of the study provided in the previous chapters. The Master Plan consists of a Capital Facilities Plan (CFP) presented below. The Capital Facilities Plan identifies and separates future improvements into two phases including the existing deficiency projects and future growth projects. Finally, cost estimates are included for these plans. Projects identified as existing deficiencies address needs of the existing system. Projects included as Growth will need to be constructed as new growth occurs in undeveloped areas.

7.2 Project Improvement Recommendations

The existing water distribution system is in relatively good condition in terms of the facilities needed to supply water to the City. Three existing issues are the fire flow projects, high pressures in the southwest and system chlorination. As future development is planned, water line improvements will be required to meet the extra demands.

7.3 Capital Facilities Plan

7.3.1 Existing Deficiency Improvements

This CFP was developed to assist Highland City in budgeting for the construction of projects. These existing deficiency improvements were discussed in Chapter 6. A portion of the costs associated with these improvements may be used within Impact Fees to pay for added capacity. Figure 7-1 can be referred to for the location of these improvements. Table 7-1 further identifies these existing deficiency projects along with a cost estimate for the completion of the project. Costs are in 2011 dollars and would need to be indexed accordingly.

The cost estimates in Table 7-1 are budget level and reflect current pricing. They include a 20 percent allotment for contingencies and 20 percent for engineering, construction management services, and administration costs. Costs associated with the acquisition of property or right-of-way are not included. Detailed cost estimates for each project are included in Appendix D.

7.3.2 Growth Improvements

Growth improvements are those required for build-out demands, which are expected to take place by the year 2030. The majority of these projects are necessary for new development and would be Impact Fee related if constructed by the City. Table 7-2 provides a summary of costs associated with existing deficiency projects vs growth projects.

7.3.3 Chlorination Improvements

Providing chlorination to the system is shown in projects 7, 11 and 12 as existing deficiency. Item 11 would only be necessary if the City was required to have contact time for chlorination of its sources. It has been discussed previously that a less expensive option may be to voluntarily introduce chlorine and maintain a residual so that coliforms are not detected in the system.

TABLE 7-1
CAPITAL IMPROVEMENT PROJECTS

TYPE & IMPLEMENTATION DATE	MAP ID	RECOMMENDED PROJECT	COST
Create New Zone – Existing Deficiency	1	Install three PRV's to Create a Lower Murdock Zone. Minor piping reconfiguration will be required at Well #3 to ensure the well water stays in the City Zone. If the zone is created at the same time as the new tank (project 12) only 2 PRV's will be required.	$202,000
Transmission – Growth Project	2	Install 1,200 feet of 16-inch transmission line in 11000 North from Well #2 to the City Operations Building. The existing line is not sufficient for future growth in the Southeast Area.	$257,000
Transmission – Growth Project	3	Install 7,000 feet of 12-inch transmission line in the Northwest Upper Zone. This project will be required with new growth in the Upper Zone to provide fire flow. The water line location will be determined during development.	$784,000
Transmission – Growth Project	4	Install 14,000 feet of 12-inch transmission line for new development in the Southeast Area. This project will be required with new growth. Project are planned to loop water from the Alpine Highway along the planned East/West connector. The improvements also include a line in 4800 West and connecting to the Lone Peak Facility. The Fire Marshall requested 4,000 gpm fire flow to the area for planning purposes. The water line locations are shown schematically on the figures and will need to be properly modeled and located during development.	$1,737,000
Transmission – Growth Project	5	Replace the existing 4-inch line with a 12-inch line in 6000 West. This project is required to supply fire flows for a planned development on the corner of 6000 West and 11000 North. The Fire Marshall requested 4,000 gpm fire flow to the area for planning purposes. Once development plans are submitted, modeling of the water system is recommended.	$182,000
Transmission – Growth Project	6	Replace the existing 4-inch line with an 8-inch line to assist with fire flow in the area. This project is necessary should the School District build a school on its property.	$123,000
Chlorination – Existing Deficiency	7	Install chlorination equipment/upgrades at wells to provide a residual within the system. Cost also includes minor piping and a simple enclosure outside the well houses for the equipment. This project does not include required contact time should DDW require chlorination.	$70,000 each

TYPE & IMPLEMENTATION DATE	MAP ID	RECOMMENDED PROJECT	COST
Well House Upgrades – Existing Deficiency	8	Remove and replace well houses #1, #2 and #5. Provide more room and upgrade to meet current State Standards. These projects could be phased over numerous years as budgets allow. Well house #2, built in 1958, is the priority.	$630,000 each
Fire Flow Projects – Existing Deficiency	9	Install 1,400 feet of 8-inch line in 9600 North.	$157,000
		Install 700 feet of 8-inch line through new development to loop Manor Drive with 4800 West. Paid by Developer.	No Cost
		Replace 4-inch line with 8-inch line in Alpine Hwy.	$123,000
		Install 700 feet of 8-inch line from end of Tamarack to Bull River Road.	$59,000
		Install 700 feet of 8-inch line through future property to loop existing lines at 6800 W and 9650 N, through Alpine District Property, only necessary if School is Built. Paid by Developer.	No Cost
		Replace 6-inch line with 8-inch line in Oak Lane.	$157,000
4-inch Line Abandonment – Existing Deficiency	10	Abandon 4-inch lines in place and connect services and hydrants to existing larger distribution lines.	$364,000
Chlorine Contact Time – Existing Deficiency	11	Install 24-inch lines near each wells 1,2,4 & 5 to achieve contact time. This is required if chlorination is mandated by DDW.	$1,184,000
New Lower Zone Tank, Booster, Chlorine & Well Improvements	12	Construct a new 500,000 gallon tank, 720 gpm Booster Station and Modify Well #3 to pump directly into the adjoining new tank for lower zone. Place chlorine equipment at Well #3 for contact time in the new tank. Tank would be placed on City property adjoining the well and City park.	$1,624,00

TABLE 7-2
CAPITAL IMPROVEMENT PROJECT SUMMARY

TYPE	DESCRIPTION	TOTAL COST
Existing Deficiency Projects	Projects required for the system that are necessary to eliminate existing deficiencies.	$6,040,000
Growth Projects	Projects to resolve system deficiencies placed on the system by new growth. These projects may be impact fee projects or projects directly funded by the developer.	$3,083,000
	TOTAL	**$9,123,000**

Appendix A

Highland Culinary Water System Four-Point Analysis

Introduction

The culinary water system was evaluated using this Four-Point Analysis. This analysis reviewed the existing and future conditions of the system in four different categories. These categories are Water Rights, Water Source, Water Storage, and Zone Pumping. The first 3 categories were evaluated using recommended guidelines given by the Division of Drinking Water. Zone Pumping capacities were determined from the hydraulic model. The existing and future system capacities were compared with the requirements to determine whether a surplus or deficit exists. Based upon this analysis, the drinking water system has a surplus in each of the four areas.

HIGHLAND DRINKING WATER SYSTEM FOUR POINT ANALYSIS

System User Analysis					
Zone	Entire City	NW Upper	Main City	Future Lwr Murdock	View Pointe
Existing ERUs	4,323	199	4,021		103
Existing Irrigation Acreage	71	0	50		21
Projected ERUs	7,326	644	5,292	1,287	103
Projected Irrigation Acreage	46	0	25	0	21
Existing System Capacities					
Water Right (ac-ft)	5,080				
Water Source (gpm)	4,600				
Water Storage (gallons)	4,850,000	600,000	4,000,000	0	250,000

Water Rights	Number of ERUs	Acres Irrigated	DDW Factor	Unit	Total Need (ac-ft)	Existing Capacity	Surplus (Deficit)
Existing Indoor Need	4323		146,000	gal/year/conn	1936.96		
Existing Outdoor Need		71	4	ac-ft/irr ac	284.00		
Existing Total WR Need					2220.96	5080.00	2859.04
Projected Indoor Need	7326		146,000	gal/year/conn	3282.47		
Projected Outdoor Need		46	4	ac-ft/season	184.00		
Projected Total WR Need					3466.47	5080.00	1613.53

Water Source	Number of ERUs	Acres Irrigated	DDW Factor	Unit	Total Need (gpm)	Existing Capacity	Surplus (Deficit)
Existing Indoor Need	4323		800	gal/day/conn	2402.00		
Existing Outdoor Need		71	5.29	gpm/irr-acre	376.00		
Existing Total WS Need					2778.00	4600.00	1822.00
Projected Indoor Need	7326		800	gal/day/conn	4070.00		
Projected Outdoor Need		46	5.29	gpm/irr-acre	243.00		
Projected Total WS Need					4313.00	4600.00	287.00

Northwest Upper Zone

Water Storage	Number of ERUs	Acres Irrigated	DDW Factor	Unit	Total Need (gal)	Existing Capacity	Surplus (Deficit)
Existing Indoor Need	199		400	gal/conn	79,600		
Existing Outdoor Need		0	2528	gal/irr-acre	-		
Fire Protection			2500	gpm*2hours	300,000		
Existing Total Storage Need					379,600	600,000	220,400
Projected Indoor Need	644		400	gal/conn	257,600		
Projected Outdoor Need		0	2528	gal/irr-acre	-		
Fire Protection			2500	gpm*2hours	300,000		
Projected Total Storage Need					557,600	600,000	42,400

Zone Pumping Requirements	Number of ERUs	Acres Irrigated	DDW Factor	Unit	Total Need (gpm)	Existing Capacity	Surplus (Deficit)
Existing Indoor Need	199		800	gal/day/conn	111.00		
Existing Outdoor Need		0	5.29	gpm/irr-acre	0.00		
Existing Total WS Need					111.00	500.00	389.00
Projected Indoor Need	644		800	gal/day/conn	358.00		
Projected Outdoor Need		0	5.29	gpm/irr-acre	0.00		
Projected Total WS Need					358.00	500.00	142.00

HIGHLAND DRINKING WATER SYSTEM FOUR POINT ANALYSIS

City Zone

Water Storage	Number of ERUs	Acres Irrigated	DDW Factor	Unit	Total Need (gal)	Existing Capacity	Surplus (Deficit)
Existing Indoor Need	4021		400	gal/conn	1,608,400		
Existing Outdoor Need		71	2528	gal/irr-acre	179,488		
Fire Protection			4000	gpm*4hours	960,000		
Existing Total Storage Need					2,747,888	4,000,000	1,252,112
Projected Indoor Need	5292		400	gal/conn	2,116,800		
Projected Outdoor Need		46	2528	gal/irr-acre	116,288		
Fire Protection			4000	gpm*4hours	960,000		
Projected Total Storage Need					3,193,088	4,000,000	806,912

View Pointe Zone

Water Storage	Number of ERUs	Acres Irrigated	DDW Factor	Unit	Total Need (gal)	Existing Capacity	Surplus (Deficit)
Existing Indoor Need	103		400	gal/conn	41,200		
Existing Outdoor Need				gal/irr-acre	-		
Fire Protection			1500	gpm*2hours	180,000		
Existing Total Storage Need					221,200	250,000	28,800
Projected Indoor Need	103		400	gal/conn	41,200		
Projected Outdoor Need				gal/irr-acre	-		
Fire Protection			1500	gpm*2hours	180,000		
Projected Total Storage Need					221,200	250,000	28,800

Zone Pumping Requirements	Number of ERUs	Acres Irrigated	DDW Factor	Unit	Total Need (gpm)	Existing Capacity	Surplus (Deficit)
Existing Indoor Need	103		800	gal/day/conn	57		
Existing Outdoor Need		21	12.74	gpm/irr-acre	268		
Existing Total Dist Need					325	750	425
Projected Indoor Need	103		800	gal/day/conn	57		
Projected Outdoor Need		21	12.74	gpm/irr-acre	268		
Projected Total Dist Need					325	750	425

Future Lower Murdock

Water Storage	Number of ERUs	Acres Irrigated	DDW Factor	Unit	Total Need (gal)	Existing Capacity	Surplus (Deficit)
Existing Indoor Need	1015		400	gal/conn	406,000		
Existing Outdoor Need				gal/irr-acre	-		
Fire Protection			0	gpm*2hours	-		
Existing Total Storage Need					406,000	-	(406,000)
Projected Indoor Need	1,287		400	gal/conn	514,800		
Projected Outdoor Need				gal/irr-acre	-		
Fire Protection			0	gpm*2hours	-		
Projected Total Storage Need					514,800	-	(514,800)

Zone Pumping Requirements	Number of ERUs	Acres Irrigated	DDW Factor	Unit	Total Need (gpm)	Existing Capacity	Surplus (Deficit)
Existing Indoor Need	1015		800	gal/day/conn	564		
Existing Outdoor Need		0	12.74	gpm/irr-acre	-		
Existing Total Dist Need					564	-	(564)
Projected Indoor Need	1287		800	gal/day/conn	715		
Projected Outdoor Need		0	12.74	gpm/irr-acre	-		
Projected Total Dist Need					715	-	(715)

Appendix B

Recommended Improvement Cost Estimates

Introduction

Budget level cost estimates for the proposed Improvements are presented in this Appendix. These estimates are in 2011 dollars and should be indexed accordingly. Only major items for each project are included. The estimates include a 20 percent allotment for contingencies and 20 percent for engineering, construction management services and administration costs. Costs associated with the acquisition of property or right-of-way are not included.

Highland City Drinking Water Master Plan
Recommended Improvements
Cost Estimates

Item	Unit	Unit Price	Quantity	Total Price
1. Install PRVs to Create Lower Murdock Zone				
Concrete Valve Vault	Lump Sum	$ 10,000	3	$ 30,000
Furnish & Install PRV and Piping	Lump Sum	$ 25,000	3	$ 75,000
Furnish & Install Piping at Well #3	Lump Sum	$ 50,000	1	$ 50,000
		Engineering & Admin. (20%)		$ 23,250
		Contingency (20%)		$ 23,250
		Total to Install PRVs to Create Lower Murdock Zone		**$ 202,000**
2. 11000 N. 16" Transmission Line				
Replace 12" Line with 16" DIP Line	LF	$ 165	1200	$ 198,000
		Engineering & Admin. (15%)		$ 29,700
		Contingency (15%)		$ 29,700
		Total for 11000 N. 16" Transmission Line		**$ 257,000**
3. Northwest Upper Zone Transmission Line				
Furnish & Install 12" DIP - During Development	LF	$ 80	7000	$ 560,000
		Engineering & Admin. (20%)		$ 112,000
		Contingency (20%)		$ 112,000
		Total for Northwest Upper Zone Transmission Line		**$ 784,000**
4. Southeast Area and Lone Peak High School				
Furnish & Install 12" DIP in New E/W Road	LF	$ 80	6500	$ 520,000
Furnish & Install 12" DIP in New Development	LF	$ 80	6000	$ 480,000
Furnish & Install 12" DIP to Connect LPHS	LF	$ 80	1500	$ 120,000
Furnish & Install 8" DIP in 4800 W	LF	$ 80	700	$ 56,000
Cross Murdock Canal	Lump Sum	$ 50,000	1	$ 50,000
Connect to Existiing Lone Peak Facilities	Lump Sum	$ 15,000	1	$ 15,000
		Engineering & Admin. (20%)		$ 248,200
		Contingency (20%)		$ 248,200
		Total for Southeast Area and Lone Peak High School		**$ 1,737,000**
5. 6000 West & 11000 N Development				
Replace 4" Line with 12" DIP Line	LF	$ 100	1300	$ 130,000
		Engineering & Admin. (20%)		$ 26,000
		Contingency (20%)		$ 26,000
		Total for 6000 West & 11000 N Development		**$ 182,000**
6. 6800 West 8" Transmission Line				
Furnish & Install 8" DIP	LF	$ 80	1100	$ 88,000
		Engineering & Admin. (20%)		$ 17,600
		Contingency (20%)		$ 17,600
		Total for 6800 West 8" Transmission Line		**$ 123,000**

Highland City Drinking Water Master Plan
Recommended Improvements
Cost Estimates

Item	Unit	Unit Price	Quantity	Total Price
7. Chlorination Upgrades at Wells 1,2,4,5				
Furnish & Install Chlorination Equipment	EA	$ 20,000	4	$ 80,000
Furnish & Install Structure - Simple Enclosure	EA	$ 20,000	4	$ 80,000
Piping Improvements	EA	$ 10,000	4	$ 40,000
		Engineering & Admin. (20%)		$ 40,000
		Contingency (20%)		$ 40,000
		Total for Chlorination Upgrades at Wells 1,2,4,5		**$ 280,000**
8. Well House Upgrades				
Remove and Replace Well House #2	LS	$ 450,000	1	$ 450,000
Remove and Replace Well House #1	LS	$ 450,000	1	$ 450,000
Remove and Replace Well House #5	LS	$ 450,000	1	$ 450,000
		Engineering & Admin. (20%)		$ 270,000
		Contingency (20%)		$ 270,000
		Total for Well House Upgrades		**$ 1,890,000**
9. Fire Flow Line Improvements				
F&I 8" DIP in 9600N, 6800-7000 W	LF	$ 80	1400	$ 112,000
F&I 8" DIP Manor Dr to 4800 W	LF	$ 60	700	$ -
F&I 8" DIP in Alpine Hwy, 11200-11400 N	LF	$ 80	1100	$ 88,000
F&I 8" DIP Loop to Tamarack	LF	$ 60	700	$ 42,000
F&I 8" DIP Loop through Future School Prop	LF	$ 60	700	$ -
F&I 8" DIP at Oak Lane	LF	$ 80	1400	$ 112,000
		Engineering & Admin. (20%)		$ 70,800
		Contingency (20%)		$ 70,800
		Total for Fire Flow Line Improvements		**$ 496,000**
10. Abandon 4" Lines				
Abandon 4" in 11200 N, 4600-5400 W	LF	$ 20	6000	$ 120,000
Abandon 4" in Westfield & 6000 W	LF	$ 20	3000	$ 60,000
Abandon 4" in 6800 W, 9800-10400 N	LF	$ 20	4000	$ 80,000
		Engineering & Admin. (20%)		$ 52,000
		Contingency (20%)		$ 52,000
		Total for Abandon 4" Lines		**$ 364,000**
11. Chlorine Contact Time at Wells				
F&I 24" DIP at Well #1	LF	$ 200	800	$ 160,000
F&I 24" DIP at Well #2	LF	$ 200	1000	$ 200,000
F&I 24" DIP at Well #4	LF	$ 200	1150	$ 230,000
F&I 24" DIP at Well #5	LF	$ 200	1280	$ 256,000
		Engineering & Admin. (20%)		$ 169,200
		Contingency (20%)		$ 169,200
		Total for Chlorine Contact Time at Wells		**$ 1,184,000**
12. New Lower Zone Tank, Well Modification & Booster Pump Station				
New 500,000 Gallon Concrete Tank	Gal	$ 1	500000	$ 500,000
Modify Well Pump for New Hydraulics	LS	$ 200,000	1	$ 200,000
Addition of Chlorination Equipment	LS	$ 60,000	1	$ 60,000
Booster Pump Station & Piping for New Zone	LS	$ 400,000	1	$ 400,000
		Engineering & Admin. (20%)		$ 232,000
		Contingency (20%)		$ 232,000
		Total for New Lower Zone Tank, Well Modification & Booster Pump Station		**$ 1,624,000**
		Subtotal for Improvements		**$ 9,123,000**

Appendix C

Hydraulic Model Design Elements & System Capacity Expansion Report Certification

HYDRAULIC MODEL DESIGN ELEMENTS & SYSTEM CAPACITY EXPANSION REPORT

REPORT CERTIFICATION

It is hereby certified that the Hydraulic Model Design Elements & System Capacity Expansion Report for:

Highland City Drinking Water Master Plan
(Project Name)

25014
(Water System Number)

Highland City Water System
(Water System Name)

(DDW File Number, If Available)

June 15, 2012
(Date)

Meets all requirements as set forth in *R309-511 Hydraulic Modeling Rule* and *R309-110-4 Definitions* and complies with the provisions thereof, as well as the sizing requirements of *R309-510*, and the minimum water pressures of *R309-105-9*. Where applicable the proposed additions to the distribution system will not cause the pressures at any new or existing connections to be less than those specified in R309-105-9. The calibration methodology is described in the report and the model is sufficiently calibrated and accurate to represent the conditions within this water system. The hydraulic modeling method is (*use of computer software or hand calculations*), and the computer software used was *(name and version)*.

Tavis B. Timothy, P.E.

State of Utah No. 324092

CHECKLIST FOR HYDRAULIC MODEL DESIGN ELEMENTS REPORT

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

Highland City Drinking Water Master Plan
(Project Name)

25014
(Water System Number)

Highland City Municipal Water System
(Water System Name)

June 15, 2011
(Date)

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

1. The Report contains:

(a) A listing of sources including: the source name, the source type (i.e., well, spring, reservoir, stream etc.) for both existing sources and additional sources identified as needed for system expansion, the minimum reliable flow of the source in gallons per minute, the status of the water right and the flow capacity of the water right.
[R309-110-4 "Master Plan" definition] ☑ TI

(b) A listing of storage facilities including: the storage tank name, the type of material (i.e., steel, concrete etc.), the diameter, the total volume in gallons, and the elevation of the overflow, the lowest level (elevation) of the equalization volume, the fire suppression volume, and the emergency volume or the outlet.
[R309-110-4 "Master Plan" definition] ☑ TI

(b) A listing of pump stations including: the pump station name and the pumping capacity in gallons per minute. Under this requirement one does not need to list well pump stations as they are provided in requirement (a) above.
[R309-110-4 "Master Plan" definition] ☑ TI

(d) A listing by customer type (i.e., single family residence, 40 unit condominium complex, elementary school, junior high school, high school, hospital, post office, industry, commercial etc.) along with an assessment of their associated number of ERC'S. *[R309-110-4 "Master Plan" definition]* ☑ TI

(e) The number of connections along with their associated ERC value that the public drinking water system is committed to serve, but has not yet physically connected to the infrastructure. *[R309-110-4 "Master Plan" definition]* ☑ TT

(f) A description of the nature and extent of the area currently served by the water system and a plan of action to control addition of new service connections or expansion of the public drinking water system to serve new development(s). The plan shall include current number of service connections and water usage as well as land use projections and forecasts of future water usage.

[R309-110-4 "Master Plan" definition] ☑ TT

(h) A hydraulic analysis of the existing distribution system along with any proposed distribution system expansion identified in (g) above.

[R309-110-4 "Master Plan" definition] ☑ TT

(i) A description of potential alternatives to manage system growth, including interconnections with other existing public drinking water systems, developer responsibilities and requirements, water rights issues, source and storage capacity issues and distribution issues.

[R309-110-4 "Master Plan" definition] ☑ TT

2. At least 80 percent of the total pipe lengths in the distribution system affected by the proposed project are included in the model.

   [R309-511-5(1)] ☑ TT

3. 100 percent 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 percent of the flow delivered by the distribution system affected by the proposed project.

   [R309-511-5(2)] ☑ TT

4. 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)] ☑ TT

5. 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)] ☑ TT

6. 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)] ☑ TT

7. 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)] ☑ TT

8. 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)] ☑ TT

9. 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 Executive Secretary per *R309-510-5, Reduction of 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)] ☑ TT

10. The hydraulic model incorporates the appropriate demand requirements as specified in *R309-510, Minimum Sizing Requirements*, and *R309-511, Hydraulic Modeling Rule*, 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)] ☑ TT

11. 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)] ☑ TT

12. The Hydraulic Model Design Elements Report includes a statement regarding whether fire hydrants exists 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), Fireflows*, or alternatively established by the local fire suppression agency, pursuant to *R309-510-9(4), Fireflows.* 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)] ☑ TI

13. 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), Estimated Outdoor 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), Estimated Outdoor 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)] ☑ TI

14. 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)] ☑ TI

15. 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 Executive Secretary. *[R309-511-7(3)]* ☑ TI

16. 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 Pressure Requirements.*
[R309-511-7(6)] ☑ TI

17. 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)] ☑ TI

18. 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)] ☑ TT

19. 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 Pressure Requirements.*
[R309-511-6(1)(c)] ☑ TT

20. 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 Pressure Requirements* are not met.
[R309-511-6(1)(d)] ☑ TT