Water Facility Plan

Baker City, Oregon

February 2016

MSA
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Engineers/Planners

WATER FACILITY PLAN

FOR

CITY OF BAKER CITY

FEBRUARY 2016

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ACRONYMS & ABBREVIATIONS

A

ADD	average daily demand
ASR	aquifer storage and recovery
AWWA	American Water Works Association

B

bgs	below ground surface
BLM	Bureau of Land Management

C

CAD	computer aided drafting
ccf	100 cubic feet
cf	cubic foot/feet
cfs	cubic feet per second
CIP	capital improvement plan

D

D/DBP	disinfectants and disinfection byproducts
DWP	Drinking Water Services

E

EPA	U.S. Environmental Protection Agency
ERU	equivalent residential unit

F

fps	feet per second
ft	foot, feet
ft bgs	feet below ground surface
FY	fiscal year

G

gal	gallons
GIS	geographic information system
gpcpd	gallons per capita per day
gpd	gallons per day
gph	gallons per hour
gpm	gallons per minute
GR	Groundwater Rule
GSI	GSI Water Solutions, Inc.

H

HAA5	haloacetic acids
HGL	hydraulic grade line
hp	horsepower

I

IWA	International Water Association

K

kW	kilowatt
kWH	kilowatt hour

L

L	liter
LCR	Lead and Copper Rule
LCRMR	Lead and Copper Rule Minor Revisions

M

MCL	maximum contaminant level
MCLG	maximum concentration level goal
MDD	maximum day demand
mg	milligram
MG	million gallons
mgd	million gallons per day
MSA	Murray, Smith & Associates, Inc.

O

OHA	Oregon Health Authority
OWRD	Oregon Water Resources Department

P

PF	peaking factor
pH	measure of acidity of alkalinity
PHD	peak hour demand
PSPRC	Portland State Population Research Center
psi	pounds per square inch
PRV	Powder River Volcanics

S

SCADA	supervisory control and data acquisition
SDWA	Safe Drinking Water Act
SWTR	Surface Water Treatment Rule

T

TAZ	traffic analysis zone
TC	total coliform
TCR	Total Coliform Rule
TSP	Transportation System Plan
TTHM	total trihalomethanes

U

UCMR 3	Unregulated Contaminant Monitoring Rule 3
UGB	urban growth boundary
UV	ultraviolet
UVTF	Ultraviolet Treatment Facility

W

WFP	Water Facility Plan

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Section 1
Executive Summary

SECTION 1
EXECUTIVE SUMMARY

Introduction

The City of Baker City (City) owns and operates a public drinking water system that serves a population of just under 10,000 people. This Water Facility Plan (WFP) documents key water system information and provides analysis and recommendations that inform infrastructure development and operational decisions by City staff.

How This Plan Should Be Used

This WFP serves as the guiding document for future water system improvements, and should:

- Be reviewed annually to prioritize and budget needed improvement projects.
- Have mapping updated regularly to reflect development and construction.
- Have its specific project recommendations regarded as conceptual. (The location, size and timing of projects may change as additional site-specific details and potential alternatives are investigated and analyzed in the preliminary engineering phase of project design.)
- Have its cost estimates updated and refined with preliminary engineering and final project designs.

Scope of Work

The City selected Murray, Smith & Associates, Inc. (MSA) to develop a WFP for its drinking water system. The scope of work for this WFP includes the following major tasks and deliverables:

- Describe the City's existing water system.
- Develop and calibrate a hydraulic model.
- Develop population and water demand projections.
- Develop performance criteria for use in identifying deficiencies and sizing improvements.
- Evaluate the water system's hydraulic capacity to identify deficiencies for 5-year and 20-year planning horizons.
- Identify an ongoing repair and replacement schedule for supply and distribution mains.
- Identify a strategy for adding new groundwater supply sources and expanding aquifer storage and recovery (ASR) options.
- Evaluate compliance with regulations and alternatives for treatment.

- Review hydraulic operating conditions of the primary water supply lines and evaluate the existing hydroelectric facility and options for new hydroelectric facilities.
- Develop project recommendations and cost estimates for a capital improvement plan (CIP).
- Conduct a high-level evaluation of the adequacy of the City's current rate structure to pay for the identified improvements.

Organization of the WFP

This WFP is organized into seven sections, as described in Table 1-1. Detailed technical information and support documents are included in the appendices.

Table 1-1
WFP Organization

Section	Description
1 – Executive Summary	Purpose and scope of the WFP and summary of key components of each part of the document.
2 – Existing System Description	Description of the service area and overview of the existing system and facilities.
3 – Water Requirements	Population projections and water demand estimates for existing and future service areas.
4 – System Analysis	Overview of system performance criteria. Discussion of supply, storage, and pumping capacity, and distribution system hydraulic analysis and deficiencies for existing and future planning horizons.
5 – Groundwater Capacity Expansion Evaluation	Evaluation of alternatives to add additional groundwater supply to the system.
6 – Water Quality and Regulations	Assessment of the system's compliance with water quality regulations. Review of surface water filtration costs and recommendations for alternative disinfection techniques.
7 – Capital Improvement Plan	Improvement project recommendations including cost estimates and timeframe for implementation.
8 – Financial Summary	High-level evaluation of adequacy of rates and user fees to fund water system improvements.

Existing System Description

The City-owned water system has over 77 miles of distribution pipe and serves approximately 9,890 people through 4,579 residential and non-residential service

connections. The City's primary water supply is from a 10,000-acre watershed located up to 10 miles west of the City within the Elkhorn Mountains. Water is collected from 13 intakes and flows by gravity through transmission lines to the water treatment and reservoir facility located west of the City. The majority of the water flows through a hydropower generator located near the treatment facility. The City also has one active groundwater well, that operates as an aquifer storage and recovery (ASR) facility. Surface water is injected into the well usually from November through June, and is then recovered during peak use periods to augment the surface water supply. The ASR is used primarily for surface water storage, but also serves to mitigate aesthetic water quality issues resulting from high levels of iron and manganese in the native groundwater.

The City began treating its water through an Ultraviolet Treatment Facility (UVTF) in 2014 and also disinfects with chlorine prior to UV treatment. In addition to the 4.5 million gallon (MG) chlorine contact chamber, the City maintains a storage reservoir in each of the system's pressure zones with a 3 MG storage reservoir in the Main pressure zone and a 70,000 gallon reservoir in the Scenic Vista pressure zone. There is one booster pump station in the system that provides supply to the Scenic Vista Zone from the Main Zone.

As part of this planning process, MSA developed a water system hydraulic model for use in evaluating flows and pressures in the system. The water system hydraulic model was created based on existing hard copy and CAD maps along with input from City staff. The water infrastructure database that was developed as part of the hydraulic model will be used to populate the City's newly created Geographic Information System (GIS).

Water Requirements

Population growth and water demand projections were developed for 5-year and 20-year planning horizons. Current water demands were developed using historical customer billing records and water production data. Some discrepancies in production metering were discovered, which can partially be accounted for by overflow events at the 4.5 MG chlorine contact chamber. It is recommended that additional metering and calibration be done to improve the accuracy of production values. Improved source metering will allow the City to more accurately determine the amount of non-revenue water that is occurring and help focus future efforts relative to leak detection and customer meter replacement.

Portland State Population Research Center data was used to estimate population growth, which has been flat over the past 50 years and is anticipated to remain low. A 0.3 percent per year growth rate was used for the 20-year planning horizon to reflect historical trends while allowing for some additional system growth. A 0.3 percent growth rate adds another 600 people to the service area in the 20-year horizon.

Using the estimated production volume and 2014 population, the average per capita demand in the system is 247 gallons per day. This value along with population projections was used to determine the water demand projections for average daily demand (ADD), maximum day demand (MDD) and peak hour demand (PHD) in Table 1-2.

Table 1-2
Demand Projections

Year	Population Estimate	ADD (mgd)	MDD (mgd)	PHD (mgd)
2015	9,890	2.4	9.4	14.1
2020	10,039	2.5	9.8	14.7
2035	10,501	2.6	10.1	15.2

The location of anticipated growth was based on work done by Kittelson & Associates in 2013 as part of the Transportation System Plan, which identified growth by traffic analysis zone (TAZ) in the system. The TAZ information along with verification by City staff was used to locate the increased population and associated water demand spatially throughout the system.

System Analysis

The water system analysis includes an evaluation of water supply, storage and pumping capacity compared to regulatory and industry criteria outlined in Table 1-3. A calibrated hydraulic model was developed to assess existing pressure zones, service pressure and distribution main capacity.

Table 1-3
Performance Criteria

System Attribute	Evaluation Criterion
Water Supply	Firm supply capacity under MDD[1]
Distribution Storage	Sum of operational, equalization, fire and emergency storage
Pump Stations and Wells	Redundant pumps Capacity to meet MDD+ fire flow[2] At least two independent sources of power
Service Pressure	20 pounds per square inch (psi) minimum during MDD + fire flow 40 psi minimum during PHD 40-80 psi target operating range
Distribution Piping	8-inch minimum future pipe diameter (exception: 6-inch for short, dead-end mains without fire service)
Fire Suppression[3]	Residential: 1,500 gallons per minute (gpm) for 2 hours Commercial/Industrial: 2,500-4,000 gpm for 4 hours

[1] *Firm capacity: the total production capacity with one UV treatment train out of service.*
[2] *If fire storage is available in the pressure zone then supply equaling MDD is required.*
[3] *For all fire flow evaluations, it is assumed that flow for a single fire at a time must be available.*

The following general conclusions were developed through the water system analysis and subsequent validation with City staff:

Supply

- The City has adequate total and firm capacity (one train of UVTF out of service) to meet existing and future demands.
- Although there is adequate supply to meet MDD for the forecasted 20-year period, the City is concerned about the lack of redundancy to meet demand if the surface water supply was compromised. As a result, the City is exploring options to expand the groundwater supply including drilling one or two new wells. The implementation of ASR will be assessed at any new wells to help reduce iron and manganese aesthetic issues in the groundwater.

Storage

- The City has adequate distribution storage for existing and future conditions if Scenic Vista fire flow requirements are met by a future pump station and piping upgrade.

Pumping

- The Main Zone is supplied entirely by gravity from the 3 MG Reservoir and has no pumping facilities. The Scenic Vista Pump Station does not have adequate capacity to supply projected MDD plus fire flow for existing or future needs. Piping improvements would also be required to convey fire flow pumping capacity.

Distribution System

- Due to their proximity to the 3 MG Reservoir and similar elevations, customers near the tank and along Indiana Avenue experience low pressures during MDD and PHD scenarios. The area of low pressure expands slightly under future demand conditions. These customers may benefit from individual booster pumps to increase service pressure.
- A limited number of customers in the northwest portion of the system may require individual pressure reducing valves to protect onsite plumbing as they experience pressure above 100 psi.
- Some portions of the system cannot provide adequate fire protection while maintaining pressures above 20 psi during MDD conditions. Some of the fire flow deficiencies may be resolved by obtaining flow from nearby hydrants. The fire department should be made aware of any hydrants with inadequate fire protection and the City should consider color coding hydrants according to the National Fire Protection Association standards.
- Improvements should be implemented for locations where fire flow cannot be provided and nearby hydrants are not available to supplement flows. The prioritization of these improvements should be revisited over time to evaluate the severity and impact of the deficiency.

Condition Based Replacement Programs

- The City is prioritizing the replacement of the supply lines that are old and have high water leakage rates. The City has already replaced portions of the Elk Creek and Mountain Lines and will continue to replace the remaining portions of these lines over the next 20 years.
- If adequate rate based funding can be developed an overall distribution pipe replacement program should be implemented to address approximately 4,100 feet per year based on a pipe life of 100 years. Pipe replacement prioritization should consider factors such as pipe age, material, leaks and small diameter mains in addition to the location of other utility replacement projects and street improvements.
- Approximately 100 water meters per year are currently replaced, which should be increased to approximately 230 per year to provide a 20 to 30 year overall replacement cycle for customer meters.

Groundwater Capacity Expansion Evaluation

The City would like to develop an additional 2.5 million gallons per day (mgd) in groundwater capacity to improve the resiliency of the water supply. The objective is to develop additional redundant capacity approximately equal to ADD in the case the City lost the ability to utilize all or most of its surface water supply. The groundwater well would also be available to augment the surface supply during peak demand periods or when other facilities are out of service for maintenance purposes.

The City currently holds five groundwater rights, including four certificates and a new permit, authorizing appropriation of up to 7.03 mgd. Of this, 6.69 mgd is authorized for municipal uses and 0.34 mgd for supplemental irrigation use. Only one of the City's groundwater rights is connected to an operating, City-owned well, which is the Reservoir Well. Use of any of the other groundwater rights requires acquiring or drilling one or more wells.

Several areas were considered for the location of new groundwater wells. These included locations along the supply lines as well as within the distribution system. The desirability of the locations were compared based on hydrogeologic potential, access to the existing distribution infrastructure, water rights, water quality, land ownership and operational considerations.

Two final locations were identified, one around the golf course and another off Bridge Street. Some additional testing and hydrogeologic evaluation will need to be completed to determine the preferred location. One additional groundwater well is recommended for construction in the near term.

The City should work to reclassify its existing water rights as a wellfield allowing all wells to be used as points of diversion for available rights. This increases the flexibility to use any

combination of the wells in the system in the future. Additionally, the City should consider implementing ASR at any new wells and evaluate the potential to optimize its existing ASR.

Water Quality and Regulations

The City's goal is to deliver water to its customers that complies with all Safe Drinking Water Act requirements, as administered through the Oregon Health Authority Drinking Water Services. The City water system is in compliance with the water quality regulations. Ahead of the compliance schedule, the City added ultraviolet treatment to its system in 2014 to treat its surface water supply.

The City's groundwater quality meets regulations, however the aesthetic quality is less desirable largely due to concentrations of manganese, hydrogen sulfide and iron in exceedance of secondary drinking water standards. While these secondary exceedances do not pose health risks to City customers, they do create taste, odor and staining issues. The use of ASR at the Reservoir Well has effectively reduced the levels of iron and manganese entering the distribution system. Any future wells should consider utilizing ASR to reduce the aesthetic water quality issues. If ASR is not available at future wells, treatment for iron and manganese may be desirable to improve the aesthetics of the water.

Currently the City uses chlorine gas for disinfection. Primarily for health and safety reasons, it is recommended that the existing chlorine gas be replaced with on-site sodium hypochlorite generation. The disinfection systems which have been identified in the WFP include redundant components as required by State regulations.

The City has considered implementing membrane filtration of the surface water supply, in the event of high levels of sediment, such as after a fire in the watershed. This is a very high cost option for maintaining the surface water supply. A lower cost option that is recommended as part of this WFP to improve supply is to develop additional groundwater wells to meet demand under emergency conditions.

Capital Improvement Plan

The CIP describes projects identified to address existing and future capacity deficiencies and to plan for ongoing repair and replacement of aging infrastructure. Identified CIP projects are grouped into two implementation timeframes; 1 to 5 years and 6 to 20 years. CIP projects are summarized in Tables 1-4 and 1-5.

The CIP includes $6.2 million in improvement projects over the 5-year horizon and $33.4 million over the 6- to 20-year horizon.

Supply Projects

- Although there is adequate supply capacity to meet MDD over the 20-year period, the City is concerned about the lack of redundancy should the surface water supply be compromised. As a result, it is recommended that one new well be drilled in the 5-year horizon and another within the next 20 years. If possible these wells should be designed with ASR capability.

Supply Pipeline Projects

- A large portion of the 40 miles of surface water supply piping is old and has high leakage rates. The City has started replacement of these transmission pipes and will continue replacement over the next 20 years, with a goal of on average, one mile of pipeline per year. The City intends to self-perform most of this work with available manpower during the summer construction months.

Distribution Pipeline Projects

- Based on industry standard guidance, a 100-year replacement was identified as an aspirational goal for the City to replace distribution piping. A 100-year schedule requires approximately 4,100 feet of pipe be replaced each year. Replacement projects should prioritize identified fire flow deficient areas, undersized (less than or equal to 4-inch) and older cast iron piping. Projects should be identified annually using these criteria along with road work coordination or other underground utility work. Due to funding limitations, this pipe replacement is not expected to begin until the 6- to 20-year horizon.

Hydropower Projects

- The City currently operates a hydropower facility that captures elevation difference between the Forebay facility and the treatment facility. There is an equivalent elevation difference between the Elk Creek Settling Tank and Forebay that is not currently captured for hydropower. It may prove cost effective in the 6- to 20-year timeframe to expand the hydropower capability, but this should be evaluated based on a number of factors including: supply line condition, estimated flow through the facility, power purchase price, and the availability of funding to construct the facility.

Pump Station Projects

- The existing Scenic Vista Pump Station needs to be replaced or significantly expanded along with some piping in the zone to provide adequate fire flow within the 20-year horizon.

Other Projects

- The City has a number of ongoing customer meter and hydrant replacement projects that need to increase to meet industry standard replacement rates.
- Existing production meters should be connected to the SCADA system and the meter at the discharge of the 3 MG Tank needs to be repaired or replaced.
- Disinfection should be converted from chlorine gas to an on-site sodium hypochlorite generation system to reduce health and safety risks.
- A full financial evaluation is recommended in the near term to ensure the City can fund the identified CIP.
- Monitor the three existing anode beds on the cathodic protection system for the Goodrich and Marble Creek Lines and replace when necessary.
- Regular updates to the WFP and financial plan are recommended over the 20-year timeframe.

Table 1-4
Summary of 5-year CIP Projects (Years 1-5)

Project Type	ID	Name	Description	Total Cost[1]
Supply	W-1	Golf Course Well	New well and associated piping at the golf course to replace the existing Golf Course Well and provide supply redundancy. Identified at approximately 1,400 gpm, 550 ft of head.	$2,295,000
	W-2	Reservoir Well Rehab	Rehabilitation of the Reservoir Well to address encrustation of the liner.	$110,000[2]
	S-1	Groundwater Services Support	Professional services for supply capacity expansion through hydrogeologic testing, water rights transfer, and ASR optimization.	$60,000
	S-2	Supply Pipeline	Continued replacement of the Mountain Line with 20 to 30 inch pipe.	$500,000/year[3]
Distribution Pipeline	P-1	High School Fire Flow Improvement	Address fire flow deficiency by creating a loop around high school field by adding new and replacing old piping with 8-inch. (530 ft)	$108,000
	P-2	Estes St. River Crossing Fire Flow Improvement	Address fire flow deficiency by adding new pipe to cross Powder River on Estes St. and replace 4-inch pipe in Estes St. with 8-inch pipe. (900 ft)	$212,000
	P-3	Clifford St. Dead-end & River Crossing Fire Flow Improvement	Address fire flow deficiency by replacing 4-inch dead-end on Clifford St. with new 8-inch pipe and an 8-inch crossing of Powder River on Washington St. (580 ft)	$135,000
	P-4	East St. Extension Fire Flow Improvement	Address fire flow deficiency by extending piping on East St. between Campbell St. and D St. with new 8-inch pipe. (735 ft)	$144,000
	P-5	Oregon St. Loop Fire Flow Improvement	Address fire flow deficiency by looping Oregon St. and Foothill Dr. with 8-inch pipe across State Highway 7. (410 ft)	$104,000
Other	O-1	Financial Evaluation	Complete financial evaluation and rate study.	$25,000
	O-2	Miscellaneous System Improvements	Meter replacement, hydrant replacement, pipe extensions, SCADA improvements, etc.	$100,000/year
	O-3	3MG Flow Meter	New flow meter at the discharge of the 3MG Tank.	$40,000
5-Year Total				**$6,233,000**
Annual Average				**$1,246,600**

[1] *Total Cost: Project estimates are based on the type and size of projects identified in this WFP and in accordance with the guidelines of AACE International Class 5 Estimates, with a typical accuracy of -30% to +50%. Project estimates are based on 2015 dollars and include design, construction, and site-specific information (unless noted otherwise) as described in Appendix C.*

[2] *Cost only includes material, labor, contractor and professional services. Does not include contingency, mobilization or other fees.*

[3] *The City generally self-performs supply pipeline replacement, so cost is for pipe and materials only and does not include design or construction and does not represent a total project cost.*

Table 1-5
Summary of 20-year CIP Projects (Years 6-20)

Project Type	ID	Name	Description	Total Cost[1]
Supply	W-3	Bridge Street Well	New groundwater well off Bridge Street to provide supply redundancy. Cost includes property acquisition and mainline extensions. Identified at approximately 1,400 gpm, 550 ft of head.	$3,070,000
	S-2	Supply Pipeline	Continued replacement of the Mountain Line with 20 to 30 inch pipe.	$500,000/year[2]
	S-3	Groundwater Services Support	Professional services for hydrogeologic testing.	$40,000
Distribution Pipeline	P-6 thru P-10	Distribution Pipe Replacement	Annual pipe replacement program and address remaining fire flow deficiencies.	$870,000/year
	P-11	Development Contingent Distribution Pipe Expansion	New 12-inch pipe along Best Frontage Road, across I-84 along Highway 86 and down Cedar Road.	$2,928,000
	P-12	Development Contingent Distribution Pipe Expansion	New 12-inch pipe along Highway 30 and Chico Road.	$1,817,000
Hydro power	H-1	Forebay Hydropower Facility	New 6 mgd hydropower facility at Forebay.	$1,736,000
Pump Station	PS-1	Scenic Vista Zone Fire Flow Improvement	Replace existing pump station with new facility and associated piping to add fire flow capacity.	$1,174,000
Other	O-2	Miscellaneous System Improvements	Meter replacement, hydrant replacement, pipe extensions, SCADA improvements, etc.	$100,000/year
	O-4	Water Facility Plan Update	Water Facility Plan Update and Financial Evaluation (Year 10).	$125,000
	O-5	On-site Sodium Hypochlorite	Replace chlorine gas disinfection with on-site sodium hypochlorite generation.	$452,000
	O-6	Anode System Replacement	Replace all three anode beds on Goodrich and Marble Creek Lines	$50,000
15-Year Total				**$33,442,000**
Annual Average				**$2,229,467**

[1] *Total Cost: Project estimates are based on the type and size of projects identified in this WFP and in accordance with the guidelines of AACE International Class 5 Estimates, with a typical accuracy of -30% to +50%. Project estimates are based on 2015 dollars and include design, construction, and site-specific information (unless noted otherwise) as described in Appendix C.*

[2] *The City generally self-performs supply pipeline replacement, so cost is for pipe and materials only and does not include design or construction and does not represent a total project cost.*

Financial Summary

The City has a number of CIP projects to fund over the next 20 years. Additionally, the City will begin paying back the loan for the UVTF constructed in 2014. These expenditures are in addition to the regular costs associated with staffing, operating and maintaining the water system. This WFP does not include a detailed financial strategy. A general summary of the revenue and expenses and near-term improvements is included.

Revenue

- In fiscal year (FY) 2014-2015 the City generated approximately $2.2 million from water sales. Of this, $1.8 million was generated from base meter charges and $0.4 million from volume based usage fees.
- The City is not growing significantly and new customer fees only accounted for $37,000 in FY 2014-2015, which is similar to prior years.
- The monthly meter charge for nearly all residential and commercial customers ranges from $32.37 to $32.85.

Expenses

- In fiscal year (FY) 2014-2015 the water system expenses were approximately $2.2 million. Of this, $1.4 million was dedicated to operations and maintenance costs and paying staff salaries and benefits.
- In 2014-2015, $760,000 was dedicated to paying for the UVTF. Annual loan repayments of $125,000 will begin in FY 2015-2016.
- The City endeavors to maintain $100,000 to $200,000 in contingency each year to cover unforeseen costs.

Capital Projects

- The 5-year CIP has $6.2 million in projects recommended. More than half of the expense is to improve supply redundancy by drilling another well and replacing the old surface water transmission piping. This does not include funding for the ongoing replacement of the distribution system, which is currently slated to begin in the 6- to 20-year horizon depending on funding.

Funding Sources

- In addition to raising rates or revenue bond, there are a number of State funding options including the Safe Drinking Water Revolving Loan Fund, Drinking Water Source Protection Fund, Special Public Works Fund, Water/Wastewater Fund. Each funding source has requirements that would need to be evaluated to determine project eligibility.

The City will need to raise water rates and where available, pursue other funding sources, to make necessary investments in the system. An immediate 25% rate increase would generate

enough revenue over 5 years to pay for a new groundwater well at a cost of $2.25 million. The City could also decide to borrow money to fund capital projects, however the payback of a loan would also require support through a rate increase.

It is recommended that the City implement a 10% rate increase immediately upon adoption of this WFP. After the financial evaluation, budgeted to occur in FY 2016-2017, the City should use the recommendations from that study to structure a long-term financial strategy to cover the expenses and projects identified in the CIP in addition to maintaining a healthy reserve for unforeseen projects.

Summary and Overall WFP Recommendations

This WFP constituted a significant investment of time and resources for City staff. This WFP utilized industry standard approaches by compiling and converting information to a GIS database and utilizing hydraulic modeling software to identify system deficiencies and refine recommended improvement projects.

Collecting and compiling system data allowed for a more accurate and comprehensive look at the water system as a whole than what was previously available. The hydraulic modeling allowed for the evaluation of water system alternatives based on system hydraulics. The capital projects that have been identified provide a plan, phased over the next 20 years that will enable the City to continue providing quality water to its customers.

As a result of this WFP, the following recommendations are made:

- Implement short term (1-5 year) improvements as identified in the CIP to address existing capacity and condition issues.
- Implement at least a 10% rate increase immediately and commission a financial evaluation to determine a sound rate and fee structure to fund improvement projects and ongoing system operations.
- Continue improving the quality of available water system information and reassess long-term improvements (beyond 5 years) using future WFP updates, the soon to be developed GIS, hydraulic model and water consumption and production data.

Murray, Smith & Associates, Inc.
Engineers/Planners

Section 2

Existing System Description

SECTION 2
EXISTING SYSTEM DESCRIPTION

Introduction

This section provides an overview of the system location, service area, and existing water system infrastructure.

Location and Climate

The City of Baker City (City) is in Baker County, located in the northeast corner of Oregon approximately 74 miles west of the Oregon-Idaho Border. Interstate 84 runs to the City's east, 21st Street to its west, Hughes Lane to its north, and the hillsides to the south. Elevations within the City vary from 3,400 to 3,700 feet. Figure 2-1 at the end of this section presents a map of Oregon showing the City's location. The study area encompasses the lands within the urban growth boundary (UGB).

The City has a semi-arid climate, a high percentage of sunshine, and well-defined seasons. The yearly precipitation averages 10.6 inches of rain and 26.6 inches of snow. The average annual temperature is 46ºF, with temperatures ranging from a normal high of 85ºF in summer to an average winter low of 17ºF.

Watershed

The City lies at the south end of the oval shaped Baker Valley, which varies from 5 to 10 miles in width and extends 17 miles to the northwest. The valley is drained northward by the Powder River, which is joined by Sutton Creek at the south edge of Baker City as the two streams emerge from the foothills. The valley is relatively flat with foothills that sharply rise around the valley. The barren foothills are dominated by forested mountains and peaks on the west and east sides of the valley, which rise to elevations between 5,200 and 6,500 feet. Major peaks in the Blue Mountains to the west and north and Wallowa Mountains to the northeast range from 8,000 to 10,000 feet.

Water Service Area

City limits includes approximately 6.78 square miles (4,350 acres) and the current UGB encompasses 7.68 square miles (approximately 4,915 acres). For the purposes of this Water Facility Plan (WFP), the current water service area includes the area within the city limits and the UGB. The public water system currently supplies water for approximately 9,890 people through 4,579 residential and commercial connections.

Existing System

Each of the water system's facilities are described in the following paragraphs and illustrated

in Figures 2-2, 2-3 and 2-4 at the end of this section.

Water Supply

The potable water for the City's system is supplied by groundwater and surface water sources. Currently there are 13 surface water intakes and 2 groundwater wells. One of the wells is active and is used for aquifer storage and recovery (ASR) and the other well, located by the golf course, has failed.

Surface Water

Since the early 1900s, the City's primary water source has been a 10,000-acre watershed located 10 miles west of the City inside the Elkhorn Mountains, largely within the national forest.

In 1912, City administrators and the U.S. Department of Agriculture entered into a cooperative agreement to conserve and protect the City's water supply. In 1944, they signed a supplemental agreement that included a $1,000-per-year deposit of City funds into Forest Service accounts to help protect and monitor the watershed area. In 1991, a Memorandum of Understanding between the City and the Wallowa-Whitman National Forest reaffirmed the intent of the 1912 agreement, aiming to maintain or improve the present quality and volume of the water supplied by the watershed. This MOU was updated in 2015 to more accurately reflect the current policies and procedures used to manage the watershed. The updated MOU is currently pending approval from the U.S. Forest Service.

All water is collected from 13 different intakes and gravity-fed into the reservoir system, with no additional pumping required. Two transmission lines bring water from the watershed down to the power generation, water treatment and reservoir storage location. The Goodrich Transmission Line, built in 1961, collects water from Goodrich Creek and the Goodrich Reservoir. This line has a capacity of 6 million gallons per day (mgd). Goodrich Reservoir is an impounding reservoir that holds 210 million gallons (MG). The Goodrich Dam was reconstructed in 1961. Water is released from the dam and flows down Goodrich Creek to the transmission line intake structure located approximately 2.25 miles below the dam.

The second transmission line is the old Mountain Line. In the late 1800's and early 1900's, this section of the Mountain Line was converted from an open ditch to a flume and then from a flume to a concrete pipeline. It collects water from several intakes in the watershed, and has a capacity of approximately 4.5 mgd. Utilizing available elevation head, this line operates a hydroelectric power plant at the reservoir site and provides a source of income for the City. A recent certification of the hydropower facility is in Appendix A. Figure 2-2 shows a map of the water supply pipelines and locations of the intakes.

Groundwater Wells

A summary of the City's wells and water rights are in Table 2-1.

Reservoir Well/ASR Well (BAKE 1148/51221/51307)

The City's primary groundwater supply well, the Reservoir Well, was constructed in 1977 as a backup to the City's surface water supply system and is located at the City's water treatment plant and storage facility. The well was completed to a depth of 800 feet and produces water from aquifers within the Powder River Volcanic geologic unit. Historic information indicates the well would initially produce approximately 1,000 gallons per minute (gpm) when first operated and the yield of the well would decline during the season of operation. In addition, aesthetic native groundwater quality issues would generate customer complaints shortly after use of the well was initiated. Historic aesthetic groundwater quality issues appear to have been related to relatively high hardness and manganese concentrations.

The City rehabilitated and retrofitted the Reservoir Well for ASR operations in 2004 to address water quality issues and increase the reliable capacity of the well by increasing its efficiency and mitigating declining groundwater levels that were apparently the cause of seasonal reductions in yield. The City began storing water sourced from its primary surface water supply system through ASR in the well starting in 2005. Following rehabilitation of the well and initiation of ASR, well capacity has increased to its current level of 1,600 gpm, and customer water quality complaints related to water from the well have ceased.

Golf Course Well (BAKE 1153)

This well was also constructed in 1977 as a source of irrigation water for the Baker City Municipal Golf Course (currently Quail Ridge Golf Course) and to serve as a backup water supply for the City. The well was completed to a depth of 349 feet and also produces water from aquifers within the Powder River Volcanic geologic unit. Historic information indicates the well historically has produced approximately 300 gpm and the aesthetic quality of groundwater from the well was objectionable, similar to the Reservoir Well. Based on water use reports from Oregon Water Resources Department (OWRD), the well has not been used since 2000. If it was to be used again, the City may replace the well because its location in the golf course parking lot is not conducive for security purposes or for operation and maintenance activities. Currently this well has failed and is not in service.

Table 2-1
Wells

		Reservoir Well (ASR Well)		Golf Course Well[1]	
Water Right Information	Application	G-8381	ASR Permit #001	G-8510	G-11771
	Permit	G-7635		G-7830	G-10922
	Certificate	51748		54983	68683
	Priority Date	8/19/1977	N/A	10/31/1977	12/14/1987
	Use	Municipal	Municipal	Supplemental Irrigation	Municipal
	Rate (cfs)	5.3	4.46	0.53	0.57
	Rate (gpm)	2,379	2,000	238	254
Well Information	Well Log ID Number	BAKE 1148/51221/51307		BAKE 1153	
	Well Depth (ft bgs)[2]	800		349	
	Static Water Level (ft bgs)	257		85	
	Static Water Level Date	3/22/2014		9/15/1977	
	Date of Construction	7/30/1977		9/15/1977	
	Aquifer	Powder River Volcanics		Powder River Volcanics	
	Well Log Pump Test Rate (gpm)	1,800		320	
	Current Pumping Rate (gpm)	1,600		N/A	

[1]*Golf Course Well is currently not in service.*
[2]*ft bgs = feet below ground surface.*

UV Treatment Facility

In 2014, the City constructed a UV Treatment Facility (UVTF) to comply with the EPA's Long Term 2 Enhanced Surface Water Treatment Rule. The UVTF is situated hydraulically between the 4.5 MG Chlorine Contact Chamber and the 3.0 MG storage reservoir. It contains three 16-inch UV treatment trains (2 duty and 1 standby) each with a treatment capacity of 6 mgd and has a firm capacity of 12 mgd. Water entering the UVTF is diverted to one of the three UV treatment trains, where the flow rate through each train is measured by an electromagnetic flow meter and controlled by an automatic flow control valve. Flows through the UV facility are adjusted based on measured water levels in the 3.0 MG storage reservoir according to user-programmable set points in the Supervisory Control and Data

Acquisition (SCADA) system. In addition, a booster pump located in the UVTF sends UV-treated water to the Reservoir Well for ASR injection and storage during the winter and spring months.

Pressure Zones

The main part of the distribution system is served by a single pressure zone, with the hydraulic grade line (HGL) set by the overflow of the 3.0 MG Main Reservoir at 3,647.70 feet. Pressures in this zone range from 29 to 104 psi (static pressure, no frictional loss calculated). The second pressure zone in the system is established by the Scenic Vista Reservoir, with an overflow elevation of approximately 3,781 feet. The reservoir is served via the Scenic Vista Pump Station which is supplied by water from the Main Pressure Zone. Pressures in the Scenic Vista Zone range from 45 to 77 psi.

Distribution Storage Reservoirs

The City currently has two storage facilities within their water system. The Main Reservoir is a 3.0 MG pre-stressed concrete tank with a dome roof constructed in 1961. The Scenic Vista Reservoir is a 70,000 gallon welded steel tank rebuilt in 2012. Table 2-2 provides a summary of the two storage facilities.

Table 2-2
Storage Facilities

Reservoir	Year Built	Construction	Volume (MG)	Pressure Zone Served	Floor Elevation (feet)	Overflow Elevation (feet)
Main	1961	Pre-stressed Concrete	3.0	Main	3,620.68	3,647.70
Scenic Vista	Rebuilt 2012	Welded Steel	0.07	Scenic Vista	3,758.00	3,781.00

Pump Station

There is currently one pump station within the water system that pumps from the Main Pressure Zone to the Scenic Vista Reservoir. The pump station contains two pumps that typically operate one at a time and cycle between lead and lag. This upper pressure zone services eight connections. Table 2-3 presents relevant attributes for the Scenic Vista Pump Station. This pump station is not capable of providing fire flow.

Table 2-3
Pump Station

Pump Station	Number of Pumps	Horsepower (hp)	Total Capacity (gpm)	Suction Zone	Discharge Zone	Pump Elev. (feet)
Scenic Vista	2	5	100	Main	Scenic Vista	3,635

Backup Power

In 2014 the City installed backup power at the Main Reservoir, Well and UVTF site. A 200 KW diesel generator was brought online with the UVTF in November 2014. The generator also provides backup power to the Scenic Vista Pump Station.

Distribution Pipe

The City's water distribution piping includes over 77 miles of pipe. The majority of the pipes vary from 2 to 30 inches in diameter and are composed of 40 percent cast iron and 60 percent ductile iron. New water mains are typically constructed using ductile iron. A few smaller pipelines ranging from 1 inch to 2.5 inches in diameter have been installed with copper, galvanized, PEX, and high-density polyethylene pipe materials.

The water system's physical characteristics are summarized based on information from the City's Geographic Information System (GIS) water system layer, which has been developed as part of this overall planning effort. The GIS was created based on a conversion of historical computer aided drafting (CAD) layers, hard copy mapping, and operator input, and was augmented with field data collection. Pipe installation year is based on input from City staff, who reviewed available existing information. All ductile iron pipe was installed from the mid-1980s to the present. A large portion of the cast iron pipe was installed in the 1970s and early 1980s in conjunction with road paving projects. Other cast iron pipe in the system is up to 70 years old.

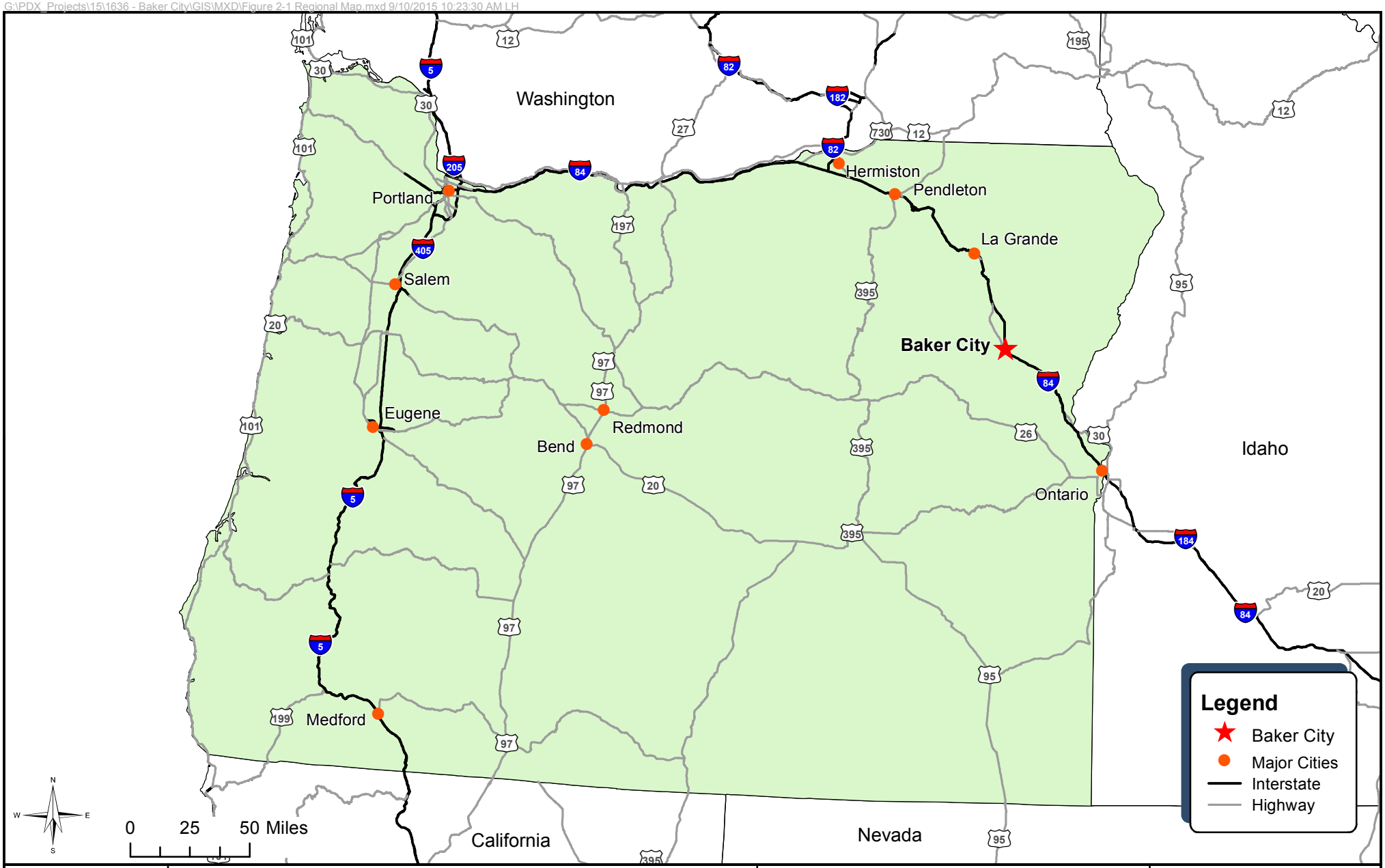
SCADA System

The status of the water system is monitored and controlled through a SCADA system that continuously monitors conditions and various parameters at the ASR well, Chlorine Contact Chamber, UV Treatment Facility, the Main and Scenic Vista Reservoirs, and the Scenic Vista Pump Station. The information is displayed at the operator's workstations, and the system sounds an alarm if conditions are not meeting standards.

Summary

The City's existing water service area covers approximately 7.7 square miles within the current city limits and UGB. Elevations within the water service area range between 3,400 and 3,700 feet. The water system is divided into two pressure zones serving approximately 9,890 people through 4,579 residential and commercial service connections.

The water is supplied from one ASR well and 13 surface water intakes that travel either from the Mountain Line or Goodrich Transmission Line to the WTP site. The water is disinfected using chlorine, run through the UVTF, stored in the Main Reservoir, and then sent to the distribution system. The distribution system consists of approximately 77 miles of pipeline and includes 1 pump station and two distribution storage reservoirs.



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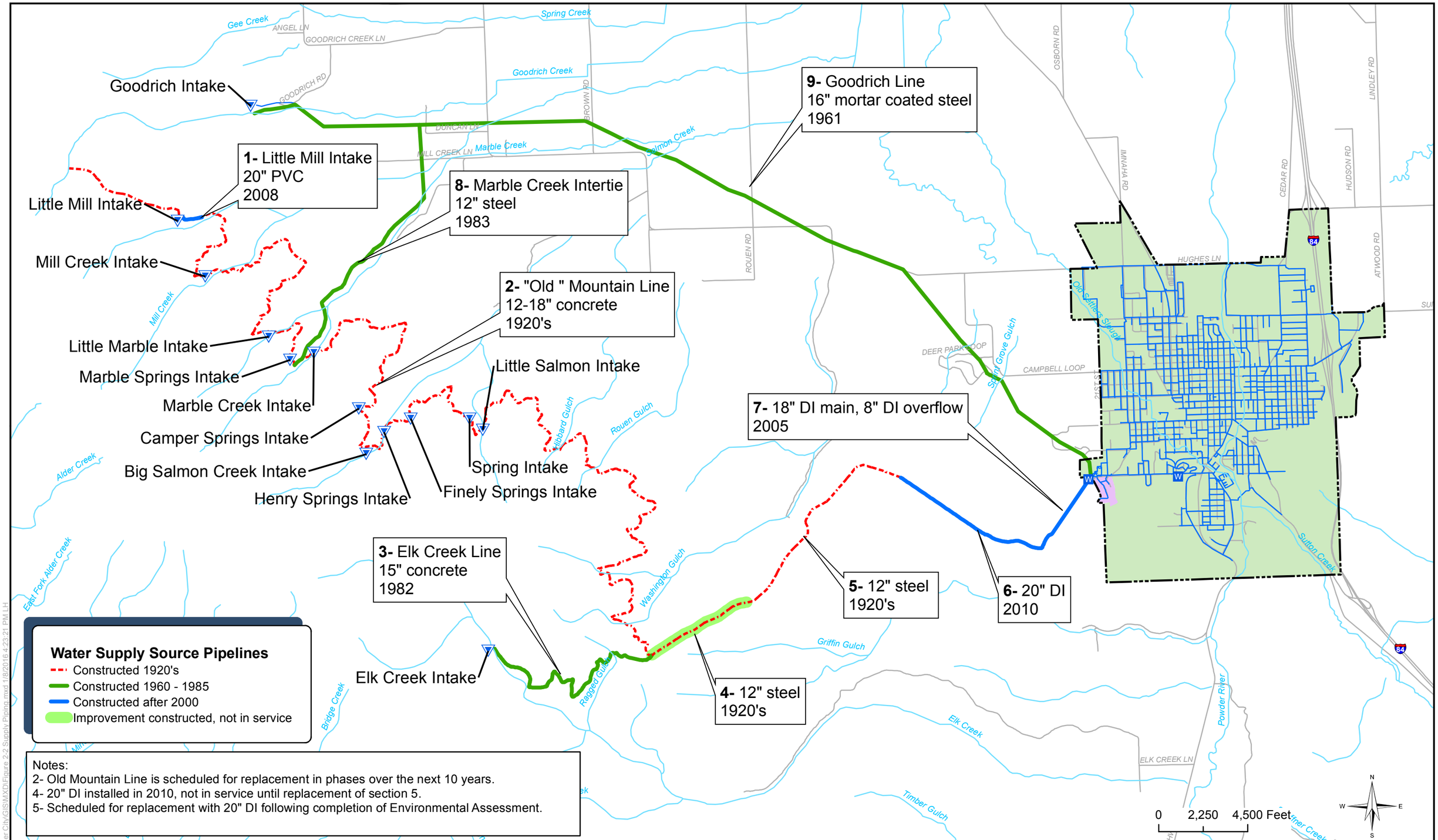
City of Baker City
Water Facility Plan

Figure 2-1
Regional Map

BAKER CITY OREGON
EST. 1874



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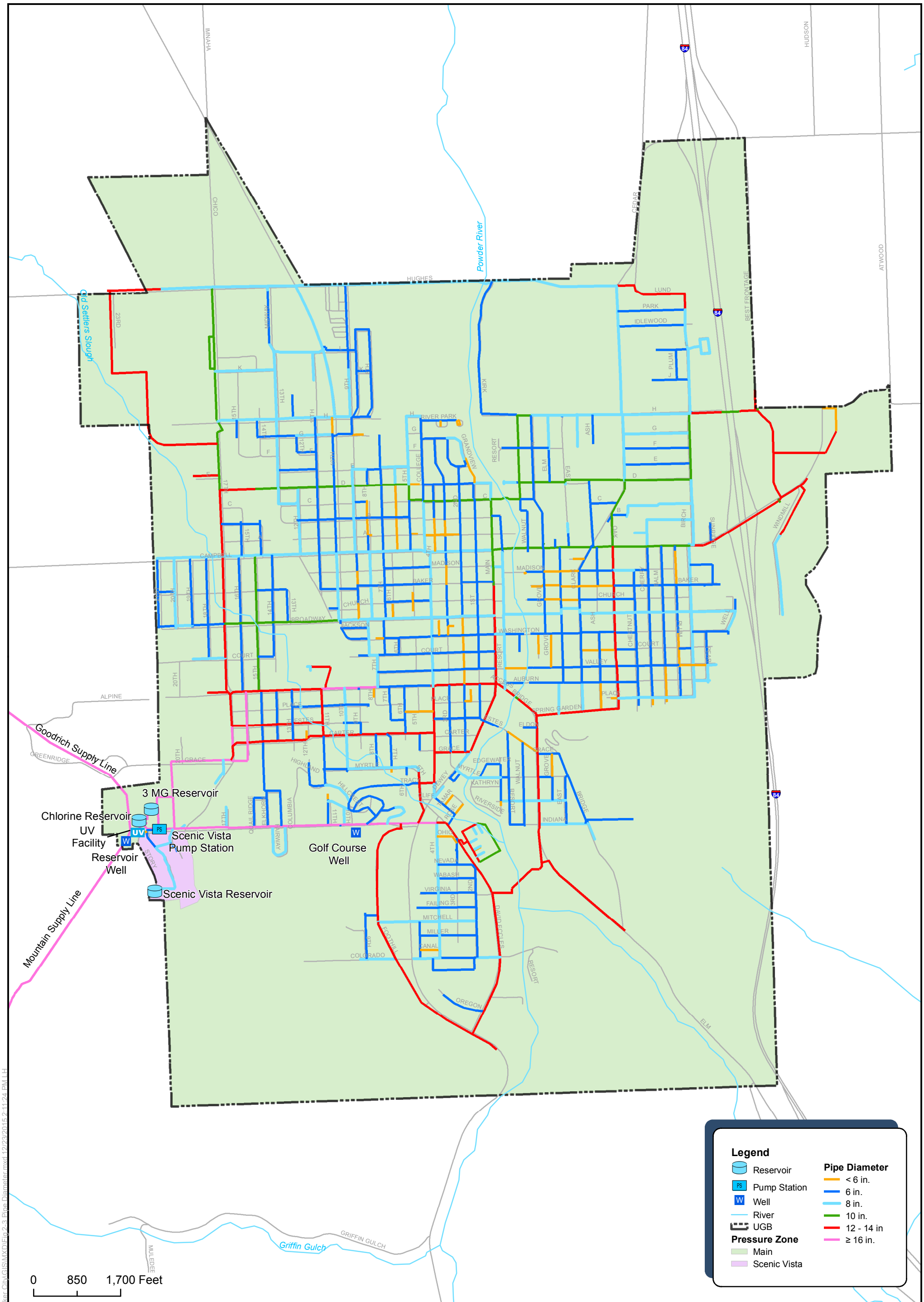
Water Facility Plan

Figure 2-2
Water Supply
Source Piping

BAKER CITY OREGON EST. 1874

February 2016 15-1636



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City of Baker City
Water Facility Plan

Figure 2-3
Pipe Diameter

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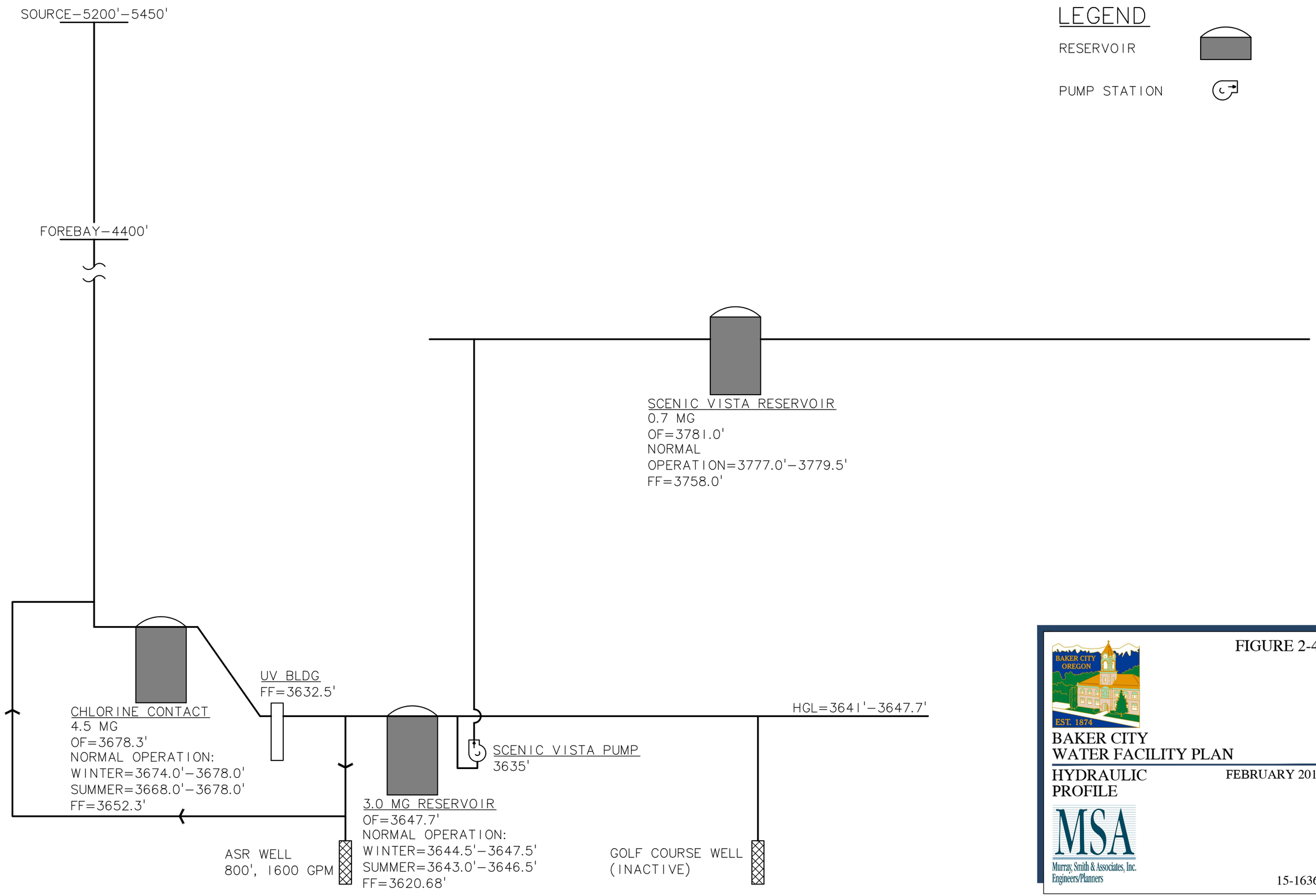

FIGURE 2-4

BAKER CITY WATER FACILITY PLAN

HYDRAULIC PROFILE

FEBRUARY 2016

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15-1636

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Engineers/Planners

Section 3

Water Requirements

SECTION 3
WATER REQUIREMENTS

Introduction

Water infrastructure planning requires the development of future water demands. This information has two primary purposes in water facility planning: identifying the amount of water supply required, and to size piping and related water facilities. There are several possible methods for the development of future demands, depending on what forecasting information is available. For the City of Baker City (City), which is predominantly residential in nature, the use of population projections provides a valuable tool for performing the calculations. Existing water demand is described by developing a per capita usage rate, which is the total existing demand divided by the number of people served. Future population projections multiplied by the per capita water usage yields future water demand. In the City's case, per capita demand has increased since the population has not significantly changed in decades but production has increased.

In addition to calculating future total system demand, the spatial allocation of that demand within the system is important for evaluating infrastructure across locations throughout the system. As part of the development of the Transportation System Plan (TSP) update in 2013, Kittelson & Associates, Inc. provided information for traffic analysis zones (TAZ), which identify location specific population growth that can be used to determine locations for future water demand and to size infrastructure within specific areas of the system. This section outlines historical population and water use information and spatially allocated future water demands.

Definition of Terms

Demand

Demand refers to the total system production, which is the quantity of water, obtained from the water supply source(s) during a given time period, required to meet the needs of domestic, commercial, industrial, and public use and for firefighting, system losses, and other miscellaneous applications. Demands are normally discussed and quantified in terms of flow rates, such as million gallons per day (mgd) or gallons per minute (gpm).

Any terms involving a volume of water delivered during a specific period are called flow rates. Flow rates pertinent to the analysis and design of water systems are as follows:

- Average Daily Demand (ADD): the total volume of water delivered to the system in a year, divided by 365 days
- Maximum Day Demand (MDD): the maximum volume of water delivered to the system during any single day

- Peak Hour Demand (PHD): the maximum volume of water delivered to the system during any single hour

As noted, these demands are typically quantified in units of mgd or gpm. The following conversion factors determine flow rates in other units:

- 1 mgd = 694 gpm = 1.55 cubic feet per second (cfs)
- 1 gpm = 60 gallons per hour (gph) = 1,440 gallons per day (gpd)
- 1 cfs = 449 gpm = 0.646 mgd

Volumetric conversions are:

- 1 cubic foot (cf) = 7.481 gallons (gal)
- 1 gal = 0.134 cf

Consumption

Consumption refers to the actual volume of water used by (and typically billed to) customers, measured at their connections to the water distribution system. City consumption is measured in units of hundred cubic feet (ccf).

Peaking Factors

Relationships between the ADD and other demand parameters, such as the MDD and PHD, are expressed as peaking factors (PF). As an example, the MDD may have a peaking factor of 2.2 (i.e., MDD = 2.2 x ADD).

Sources of Existing Data

City staff supplied existing water production and customer billing record data as well as historical data. The Portland State Population Research Center (PSPRC) provided population data.

Historical Water Production

The volume of water produced is from the watershed or pumped from the Reservoir Well. The supply is chlorinated, treated at the Ultraviolet Treatment Facility (UVTF) and sent to the distribution system via the 3.0 million gallon (MG) storage reservoir. The production meter is located in the mixing vault before the Chlorine Contact Chamber, as shown in Figure 3-1. The UV meter is located upstream of the UV reactors in the UVTF which supplies water to the Reservoir Well for aquifer storage and recovery (ASR) injection.

Production volumes reported in this plan are from the production meter that accounts for water conveyed to the mixing vault since this is the primary source of historical production

data. However, the City discovered a discrepancy between the production and UV meters. The UVTF came online in November 2014 and therefore limited meter data is available at this facility, but for the available data, the production meter reads higher volumes than the UV meter. Issues that could be causing the high reading include meter calibration, water loss from valves and/or leaks from the 4.5 MG Chlorine Contact Chamber Reservoir, and overflow events. The City does know that there are intermittent overflow events from the 4.5 MG Reservoir due to demand changes and/or excess surface water conveyed from the watershed, but does not currently measure the amount of water overflowing from the tank. Additionally, the 4.5 MG Reservoir has a small, but consistent flow from the drain line to a downstream manhole.

The overall goal is to establish the amount of water actually conveyed to the distribution system. To calculate this volume, the ASR injection volume, volume from overflow events (calculated based on operator field data) and an approximation of the meter discrepancy calculated from comparing the production and UV meters are subtracted from the production meter volumes.

Figure 3-1
System Schematic

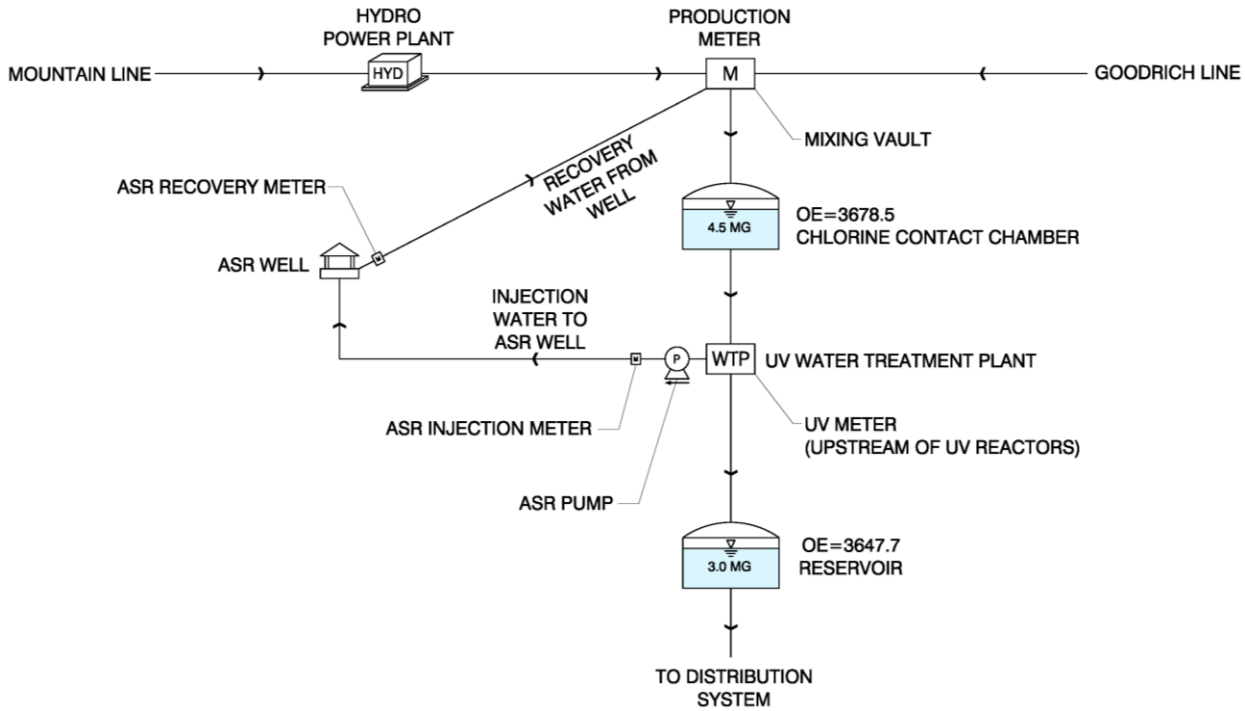


Table 3-1 presents a summary of monthly water production records for the years 2012 through 2014. ADD, MDD, and the associated peaking factors for each year appear in Table 3-2. The average peaking factor is used in the plan to calculate future MDD from ADD values. Since hourly data is not available to determine PHD, a standard peaking factor of 1.5 is used to calculation PHD from MDD.

Table 3-1
Historical Water Production (MG)

Month	2012	2013	2014
January	24.1	35.5	31.8
February	22.1	34.2	27.5
March	27.5	73.8	52.4
April	26.6	80.2	82.0
May	68.5	114.3	130.3
June	163.2	116.2	169.8
July	155.5	174.8	189.9
August	159.5	131.0	151.9
September	108.8	80.6	111.2
October	45.1	33.0	51.9
November	30.1	27.1	24.6
December	30.6	31.5	31.1
Well Production	40.8	101.8	18.9
Surface Production	820.8	830.4	1035.5
Total Production	**861.6**	**932.2**	**1054.4**
ASR Injection	0.0	77.3	100.0
Meter Losses[1]	45.2	48.9	55.4
Overflow Events [2]	10.0	10.0	10.0
Total Production to Distribution System	**806.4**	**796.8**	**889.0**

[1] Meter Losses account for approximated discrepancies at the production meter
[2] Estimate of water that overflows the 4.5 MG Chlorine Contact Chamber Reservoir

Table 3-2
Historical Average and Maximum Demands

Year	ADD (mgd)	MDD (mgd)	PHD[1] (mgd)	MDD PF (MDD/ADD)	PHD PF (PHD/MDD)
2012	2.2	7.6	11.4	3.5	1.5
2013	2.2	13.3	19.9	6.1	1.5
2014[2]	**2.4**	10.1	15.2	4.2	1.5
Average				**3.9[3]**	**1.5**

*[1] Hourly data is not available, so a standard peaking factor of 1.5*MDD was used to calculate PHD*
[2] 2014 ADD data is used as a baseline for future projections
[3] 2013 cryptosporidium hit impacted demand, so 2013 is not included in average calculations

Historical Water Consumption

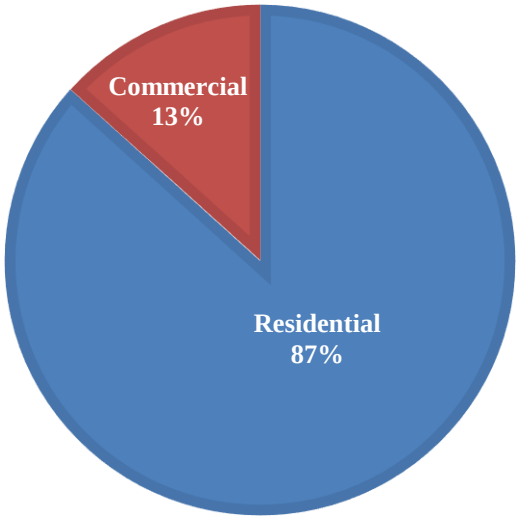
Customers

The majority of the City's water customers are residential. They comprise 3,969 connections of the total 4,579. Residential use makes up the vast majority of billed water demand and drives both the average annual and the peak usage. The commercial customers make up 13 percent of the total connections with large users consisting of Sunridge Inn, Department of Corrections and Behlen Manufacturing. The non-residential use in the system primarily supports commercial, governmental, and institutional users that have water use trends similar to residential users. Little heavy industry exists in the City, limiting the tendency for flat overall water usage or peaks at different times than typical residential users. As a result, future peak water demand has been calculated based on population growth and a per capita average of all-system demand, including residential and non-residential use. Table 3-3 and Figure 3-2 provide a summary of system connections by meter size and type.

Table 3-3
Summary of Connections

Meter Size	Number of Connections
Residential Total	**3,969**
5/8"	3,301
3/4"	562
1"	105
1 1/2"	1
Commercial Total	**610**
5/8"	294
3/4"	109
1"	89
1 1/2"	25
2"	76
3"	11
4"	6
Total Connections	**4,579**

Figure 3-2
Connections by Customer Class



Revenue Consumption

A majority of the customers in the system are metered and billed for their water use. The amount of revenue water, measured by the volume of water billed is in Table 3-4. The amount of revenue water increased in 2014, but not to a degree that accounts for the large increase in production volume. Other factors affecting the increased production may include increased water use from non-revenue users or leaks within the WTP site and/or distribution

system. Specific recommendations related to identifying the differences between the water produced and what is metered are provided at the end of this section.

Table 3-4
Historical Revenue Usage

	2012	2013	2014
Annual Revenue Billed (MG)	652	644[1]	670

[1] *August 2013 crypto entered into distribution system, water demand dropped*

Non-Revenue Consumption

Overall water use within the system consists of revenue customers, non-revenue customers, and water losses within the system. The International Water Association (IWA) and the American Water Works Association (AWWA) have published and promoted a water audit methodology that has been widely recognized and adopted throughout the water industry. This method provides definitions and classifications for annual water production and consumption, seen in Table 3-5. As seen in Column E, "non-revenue" water is the unbilled component of production. It is the difference between the volume of water produced and the volume of water sold to customers. As Column C indicates, non-revenue water is comprised of authorized and unauthorized consumption. Unbilled authorized consumption includes water used for flushing mains, fighting fires, and certain municipal users such as parks. Non-revenue water can also result from inaccurate meters (both customer and production), unmetered connections, theft, and leaks in the system.

Table 3-5
Components of the IWA/AWWA Water Balance

A	B	C	D	E
System Input Volume = Production = System Demand	**Authorized Consumption**	Billed Authorized Consumption	• Billed metered consumption (including water exported to another system) • Billed unmetered consumption	**Revenue Water**
		Unbilled Authorized Consumption	• Unbilled metered consumption • Unbilled unmetered consumption	**Non-Revenue Water**
	Water Losses	Apparent Losses	• Unauthorized consumption • Data handling error • Metering Inaccuracies	
		Real Losses	• Leakage from transmission and/or distribution mains • Leakage and overflows at storage tanks • Leakage from service connections up to a point of customer metering	

AWWA. Manual of Water Supply Practices M36. *Water Audits and Loss Control Programs, Third Edition*, 2009.

The City has a number of metered customers that are not billed for their usage. The large non-revenue water users are the golf course, cemetery, and sports complex. Conservation measures should be evaluated to reduce water used by these three large users. One possibility is switching the large users to non-potable water sources. Other metered non-revenue customers include the fire station, police station, City Hall, and parks. Use in 2014 by these large non-revenue customers is in Table 3-6.

Table 3-6
Largest Metered Non-Revenue Users (2014)

Customer	Usage (MG)	Percent usage of total non-revenue meters (%)
Golf Course[1]	29	26
Mt Hope Cemetery	43	39
Sports Complex	18	16
Other[2]	21	19
Total	**111**	**100**

[1]*Golf Course received about half its supply before treatment, which is not included in these production volumes. As of 2015, the Golf Course is not receiving any water before treatment.*
[2]*Fire station, police station, City Hall, Parks, etc.*

Total Water Use

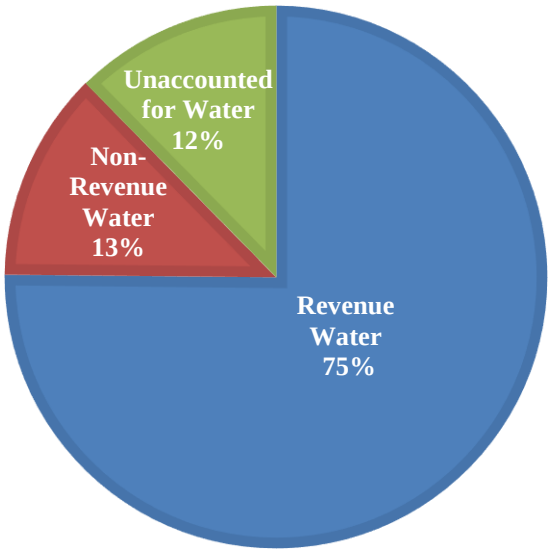
The difference between the volume of water produced and the metered water used (comprised of revenue and non-revenue customers) is the unaccounted for water in the system. Table 3-7 and Figure 3-3 show the amount of each component of water in the City system.

Table 3-7
Water Balance Usage (2014)

	(MG)	(%)
Revenue[1]	670	75
Non-Revenue[1]	111	13
Unaccounted	108	12
Total Production to Distribution System	889	100

[1]*Metered volumes*

Figure 3-3
2014 Water Production Distribution



Historical Population

The population of the City and the surrounding area has not grown significantly since the 1940s according to US Census Data from 1870 to 2010 and PSPRC data from 2011 to 2014. Table 3-8 shows a summary of historical City population.

Table 3-8
City Historical Population

Year	Population
1870	312
1880	1,258
1890	2,604
1900	6,663
1910	6,742
1920	7,729
1930	7,858
1940	9,342
1950	9,471
1960	9,986
1970	9,354
1980	9,471
1990	9,140
2000	9,860
2010	9,828
2011	9,846
2012	9,841
2013	9,769
2014	9,890

Historical Per Capita Demand

The per capita demand within the system is calculated as the total production divided by the population served. Table 3-9 shows ADD and MDD per capita demand for the years 2012 through 2014.

Table 3-9
Historical Per Capita Demand

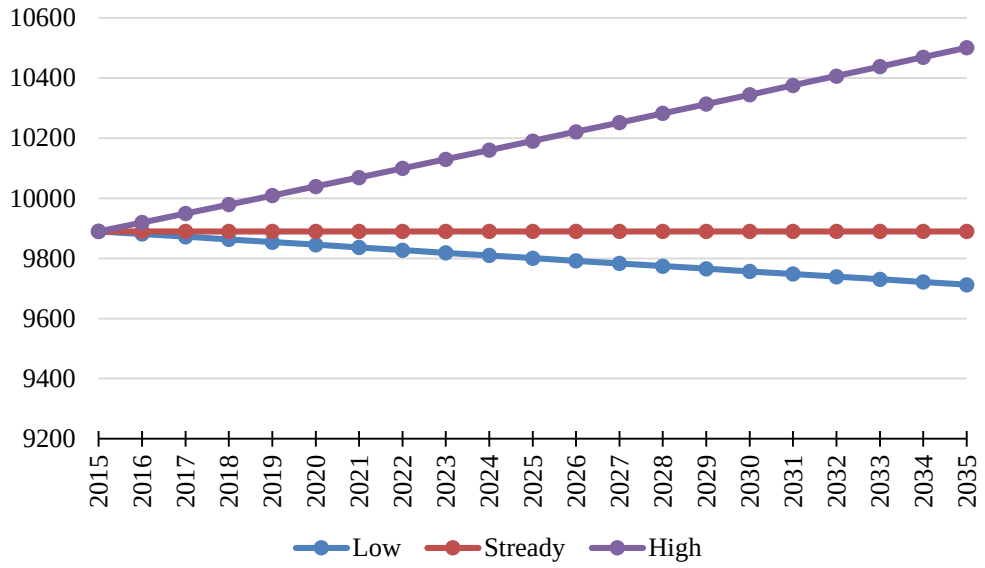
Year	Population[1]	ADD (gpcpd)[2]	MDD (gpcpd)
2012	9,841	225	772
2013	9,769	224	1,361
2014[3]	9,890	**247**	1,021

[1] Population figures are based on Portland State Population Research Center
[2] gpcpd = gallons per capita per day
[3] 2014 ADD Data is used as a baseline for future projections

Population Projections

The PSPRC data will be used to determine the overall City population growth. As noted, the City's population has stayed relatively constant for the last 75 years with small increases and declines over the years. The method used for analyzing population projections included three possible scenarios that yield low, medium, and high growth patterns. Based on PSPRC data, the low growth would result in a decline in population of 0.09 percent per year and high growth would result in a 0.3 percent increase each year. Historical population remains approximately constant over time and were the basis for the medium growth pattern. The population from the different growth rates are shown in Figure 3-4.

Figure 3-4
Population Growth Rates



The 0.3 percent per year high growth rate as identified by the PSPRC was used to project the future population of the water service area. This predicts an additional 600 people in the 20-year horizon. Table 3-10 lists current, 5-year and 20-year horizon population projections.

Table 3-10
Population Projections

Year	Population Estimate
2015	9,890
2020	10,039
2035	10,501

For this plan, it is important to predict not only how much growth will occur, but also where that growth will occur between the current, 5-year, and 20-year horizon. As part of the 2013 TSP update, Kittelson & Associates, Inc. provided the City with an update to the 20-year TAZ growth projections. The urban growth boundary (UGB) is split into 16 TAZs, shown in Figure 3-5 (located at the end of the section). Based on the TAZ data and City input, the growth is expected to occur primarily in Zones 10, 11, 13, 15 and 16. The growth will be a mix of residential and commercial. The residential units are typically single-family homes and the commercial units are a mix of things such as warehouses, retail, a truck stop and hospital upgrades.

Water Demand Projections

Evaluation of the information with the City identified the 2014 per capita demand of 247 gpd as the basis for projecting future demands. Using the per capita demand and population projections, along with peaking factors, Table 3-11 shows water demand projections for ADD, MDD and PHD.

Table 3-11
Demand Projections

Year	Population Estimate	ADD (mgd)	MDD (mgd)	PHD (mgd)
2015	9,890	2.4	9.4	14.1
2020	10,039	2.5	9.8	14.7
2035	10,501	2.6	10.1	15.2

Recommendations

It should be noted that the 25 percent of current water production estimated as non-revenue and unaccounted water use is high compared to other Oregon utilities and above the recommended levels for water systems. However, due to discrepancies in meter data and the lack of metering data in some cases, the first step in addressing the 25 percent non-revenue water involves improving data collection. Recommendations to improve the accuracy of data are described below.

Metering & Reservoir Sensors

Within the current system, additional production metering is needed at the UVTF to understand how much water is received from the supply lines versus what is conveyed to the distribution system.

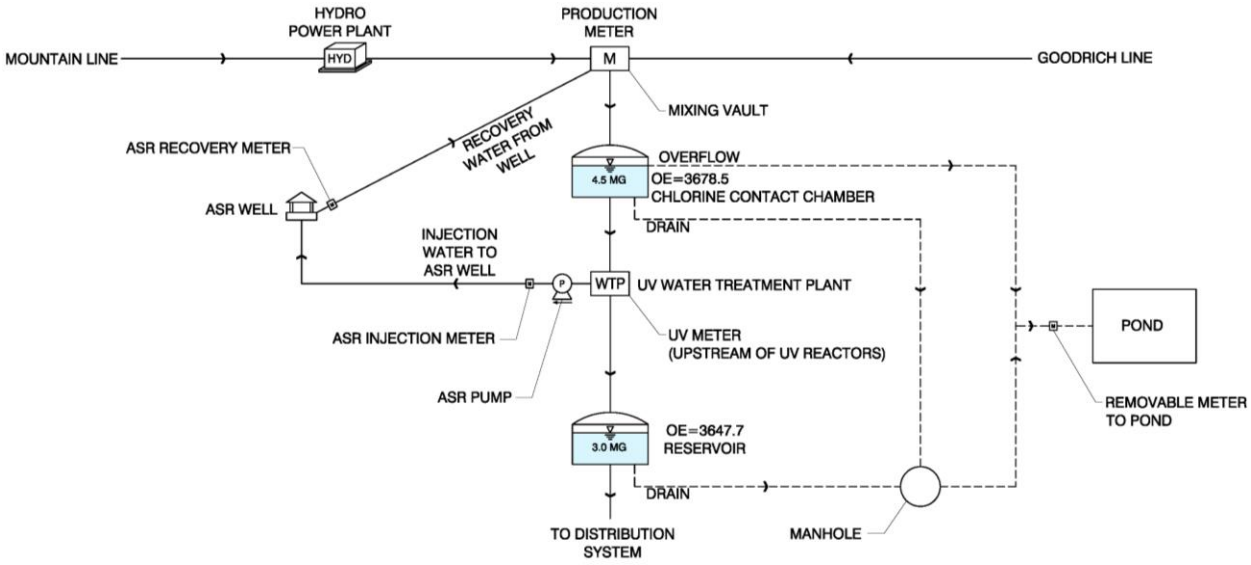
Another source of uncertainty in non-revenue water is from overflow events and leakage at the 4.5 MG Chlorine Contact Chamber. Currently the overflow and drain from the 4.5 MG and 3.0 MG reservoirs are conveyed to a pond as shown in Figure 3-6. The amount of water leaving the reservoir is not measured because a meter at the weir before water enters the

pond was removed since it is not effective due to wintertime freezing. City staff determined it would be difficult to place additional meters on the overflow and drain pipelines.

Leakage from the 4.5 MG reservoir drain can be visually monitored in a downstream manhole. The City estimates leakage occurs at a constant rate of approximately 4 gpm, year-round. Overflow events occur intermittently throughout the year, but are difficult to measure. The City identified that the level sensor in the 4.5 MG Reservoir currently cannot read above typical operation levels. It is recommended the level sensor at the 4.5 MG Reservoir be installed at a higher elevation, if possible, to capture the actual reservoir level during an overflow event. If the current meter cannot read the range of flows required by moving it higher, it is recommended the sensor be replaced. The ability to record the proper elevation of the reservoir when it is above the overflow level would allow the City to accurately estimate the volume of water that goes to waste during an overflow event.

A few non-revenue customers who are not metered and estimated to use small amounts of water should be metered in the distribution system. Once all non-revenue customers are metered, a more accurate assessment of system "leakage" can be completed.

Figure 3-6
Overflow and Drain Pipe Route



Calibration of Existing Meters

There are discrepancies between the production meter and the UV meter. This may be a calibration issue. Calibration of the meters is recommended to help determine the actual production volumes. The City should also assess the age and accuracy of large customer meters such as the golf course, cemetery, and hospital and determine if these meters should be calibrated or potentially replaced.

Meter Replacement Program

Currently the City replaces over 100 of its oldest meters each year. The typical life cycle of a meter is around 20 years. To replace the 4,500 connections in the City system over 20 years, it is recommended that the City increase its replacement rate to around 225 meters each year. Updating meters can also reduce unaccounted water that is due to meter inaccuracy.

Leak Detection Program

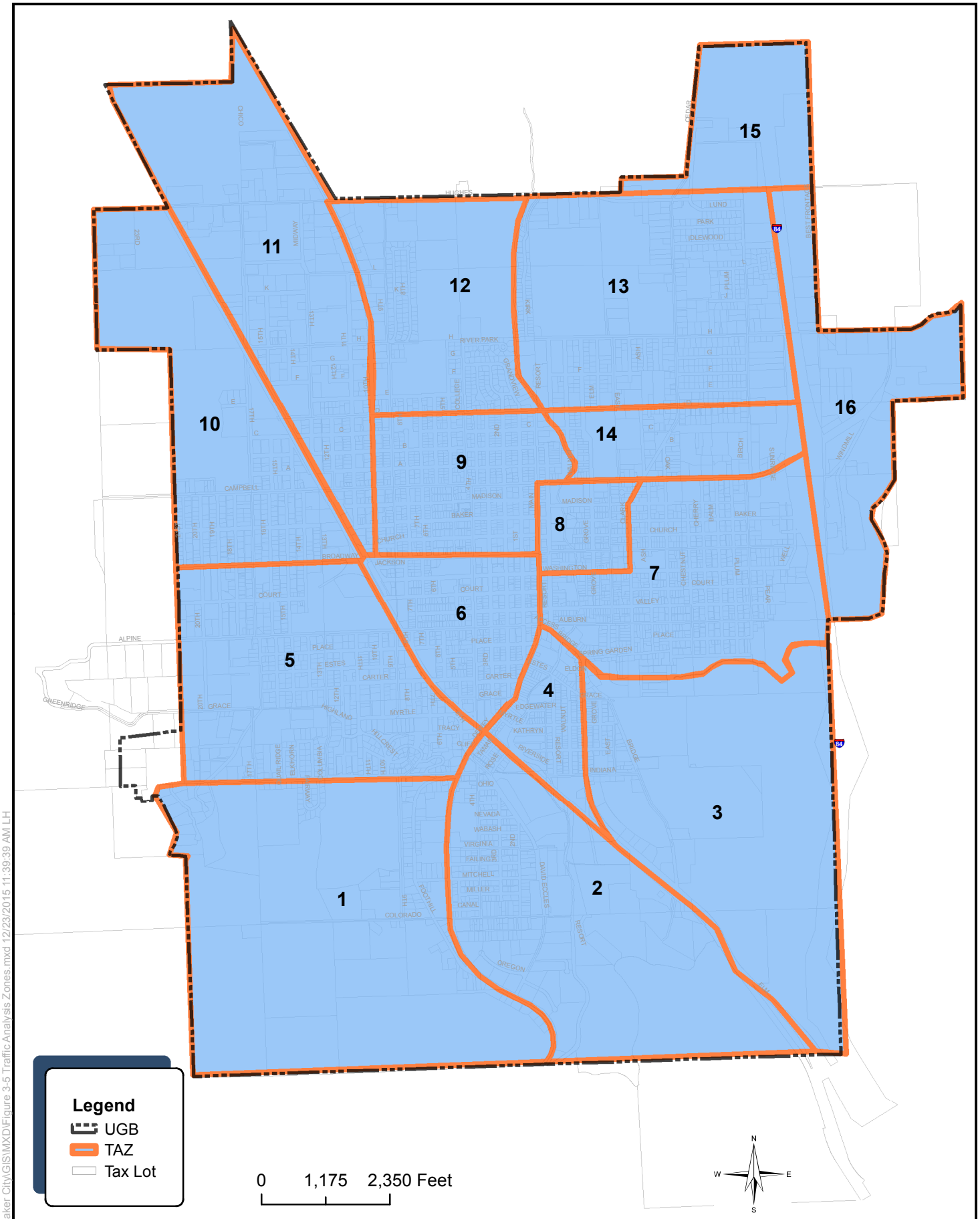
If the above items do not reduce the unaccounted water, the City should consider implementing a leak detection program for the distribution system.

Non-revenue Demands

A large amount of the non-revenue demand is for irrigation water needs. It is recommended that conservation measures be evaluated from a cost/benefit perspective to identify those, which may be beneficial for the City to implement, such as providing non-potable water for irrigation use.

Summary

This section has projected population growth and corresponding demands. The projected future water demands are based on the high PSPRC growth rate projection and can be considered somewhat conservative. It is important to note that projecting population and corresponding water demand is challenging in a situation where historical population has remained steady but production has recently increased. While the projected demands for the next 20 years will be useful to evaluate the hydraulic capacity of the system and identify improvements, the actual timing of those improvements should be scrutinized depending on the actual production values in the next few years, particularly as improvements related to source and customer metering are implemented. The high percentage of unaccounted for and non-revenue water warrants further investment by the City in metering (non-revenue customers, sources, and revenue customer meter replacement), possible leak detection, and an ongoing evaluation of water use trends.



MSA
Murray, Smith & Associates, Inc.

City of Baker City Water Facility Plan

Figure 3-5 Traffic Analysis Zones

BAKER CITY OREGON EST. 1874

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February 2016 15-1636

Murray, Smith & Associates, Inc.
Engineers/Planners

Section 4

System Analysis

SECTION 4
SYSTEM ANALYSIS

Introduction

This section describes the results of the City of Baker City's (City's) water system analysis including; supply, storage, pumping and distribution. The performance criteria used to determine what constituted a deficiency are also presented. The drinking water demands presented in Section 3-Water Requirements are used in conjunction with performance criteria to assess water distribution system characteristics, including supply, storage and pumping capacity, along with pipe capacity, service pressures, and emergency fire flow availability. This section provides the basis for recommended distribution system improvements presented in Section 7- Capital Improvement Plan.

Performance Criteria

The water distribution system is intended to operate within certain performance parameters under varying customer demand and operational conditions. The analysis conducted as part of this plan utilized the performance criteria summarized in Table 4-1. These criteria have been developed through a review of federal Safe Drinking Water Act requirements, Oregon Health Authority Drinking Water Services requirements, American Water Works Association (AWWA) acceptable practice guidelines, Ten States Standards and the Washington State *Water System Design Manual*.

Table 4-1
Performance Criteria

System Attribute	Evaluation Criterion	Value
Water Supply	Firm Supply Capacity[1]	MDD[2]
Distribution Storage	Total Distribution Storage Capacity	Sum of dead, operational, equalization, fire & emergency storage, see Table 4-3
Pump Station	Minimum No. of Pumps	2
	Capacity	MDD + Fire Flow[3]
	Emergency Power	At least two independent sources[4]
Service Pressure	Minimum during MDD + Fire Flow	20 psi
	Minimum during PHD[5]	40 psi
	Target Range	40-80 psi[6]
	Maximum	100 psi, 80 psi preferred
Distribution Piping	Maximum Velocity during MDD	5 ft/sec
	Maximum Velocity during PHD or Fire Flow	10 ft/sec
	Maximum Headloss	6 ft per 1,000 ft of pipe
	Minimum Pipe Diameter	8-in, except 6-in for short, dead-end mains without fire service
Fire Suppression	Hydrant Spacing	300 to 500 ft
	Available Fire Flow Requirements	Residential: 1,500 gpm for 2 hours Commercial/Industrial: 2,500 – 4,000 gpm for 4 hours

[1] *Firm capacity: the total production capacity with one UV treatment train out of service.*
[2] *MDD = Maximum day demand: the maximum volume of water delivered to the system during any single day.*
[3] *If fire storage is available in the pressure zone then supply equaling MDD is required.*
[4] *Each pump station should have two sources of power, one from the main power grid and a secondary source to power the pumps when the electrical grid is down.*
[5] *PHD = Peak hour demand: the maximum volume of water delivered to the system during any single hour of the maximum demand day.*
[6] *This is a target range, however due to topography not all customer pressures fall within this range and to address individual high or low pressure situations the City recommends installation of individual pressure reducing valves or booster pumps.*

Supply Analysis

Supply Criteria

To adequately meet system demands, supply facilities must be capable of providing MDD with the largest source out of service.

Existing Supply Sources

The City currently has surface water and groundwater sources of supply. The surface water is supplied by a number of intakes located throughout the watershed and conveyed to the City through the Goodrich and Mountain Lines, which have a capacity of 6.0 and 4.5 mgd respectively. The City has water rights for four wells, as discussed further in Section 5-Groundwater Capacity Expansion Evaluation, but currently only pumps from the Reservoir Well as the other wells are either inaccessible or the pumping mechanisms are missing. After construction in 1977, the initial reported capacity of the Reservoir Well was approximately 1,000 gpm, and the aesthetics of produced water were reported to be poor due to iron and manganese. In 2004 the well was rehabilitated and retrofitted for aquifer storage and recovery (ASR) purposes, although it can also pump native groundwater under its water right certificate. Currently it is used as an ASR well, which has improved water quality and the capacity has increased to approximately 1,600 gpm (2.3 mgd).

Currently all supply is routed through the City's 4.5 MG chlorine contact chamber and the Ultraviolet Treatment Facility (UVTF). The UVTF has three 16-inch UV treatment trains (2 duty and 1 standby) each with a capacity of 6 mgd for a firm capacity of 12 mgd. Since all supply currently flows through the UVTF from the chlorine contact chamber, the firm capacity of supply to the distribution system is set by the UVTF at 12 mgd.

Supply Results

Table 4-2 shows the existing and projected demand compared with the current capacity, which indicates that the City has adequate supply over the 20-year horizon.

Table 4-2
Supply Analysis

Timeframe	Existing	5-Year	20-Year
Existing Firm Source Capacity	12.0	12.0	12.0
MDD	9.4	9.8	10.1
Surplus/(Deficit)	**2.6**	**2.2**	**1.9**

Although there is adequate supply to meet MDD, the City is concerned about the lack of redundancy to meet demand if the surface water supply became compromised, such as in the case of an emergency like a forest fire in the watershed. As a result, the City is exploring options to expand the groundwater supply and better utilize its water rights through the development of one or more new wells. More detail on groundwater supply options are provided in Section 5.

Storage Capacity Analysis

Storage Criteria

Finished water reservoirs typically provide four storage components: operational, equalization, fire suppression, and emergency storage. The total storage required is the sum of these four components plus any dead storage that is not usable under standard operations. Required storage volumes in million gallons (MG) were calculated according to the following criteria:

- *Dead Storage* – based on maintaining minimum 20 psi at the customer meter where applicable, or a minimum of 2 feet above the bottom of the tank, whichever is greater

- *Operational Storage* – assumed to be the typical operating range when pumps turn on or off in the system
    - *Main Zone* = 3 feet (3643.5' to 3646.5')
    - *Scenic Vista Zone* = 2.5 feet (3777.0' to 3779.5')

- *Equalization Storage* – the amount of peak hour demand (PHD) exceeding supply to the pressure zone, provided for 150 minutes
    - *Main Zone* = PHD – (150 min * firm source capacity with one train of UVTF out of service)
    - *Scenic Vista Zone* = PHD – (150 min * firm capacity at Scenic Vista pump station)

- *Fire Storage* – largest fire flow demand within the pressure zone, multiplied by the duration of that flow
    - *Main Zone* = 4,000 gpm for 4 hours = 960,000 gallons
    - *Scenic Vista Zone* = 1,500 gpm for 2 hours = 180,000 gallons ,fire flow assumed to be provided through booster pumping capacity (See Pumping Analysis below)

- *Emergency Storage* – two times the average daily demand (ADD) minus the firm capacity of all supplies to the zone operating for 24 hours, but not less than 200 gallons per day (gpd) per equivalent residential unit (ERU)
    - *Main Zone* = 200 gpd * 4,562 ERUs = 912,400 gallons
    - *Scenic Vista Zone* = 200 gpd * 8 ERUs = 1,600 gallons

Both the Main Zone and Scenic Vista Zone have firm supply capacity greater than double the ADD, so the minimum requirement of 200 gpd per ERU was used to determine the minimum emergency storage. ERUs were calculated for the Main Zone by taking the estimated residential ADD of the zone and dividing it by the number of residential customer connections to determine the demand per ERU and then dividing the entire zone ADD by

number of gallons per ERU to determine the number of ERUs in the zone. The Scenic Vista Zone serves 8 residential customers, resulting in 8 ERUs for that zone.

Storage Results

Required distribution storage capacities under existing and future conditions for the City's pressure zones are summarized in Table 4-3. Since the emergency and fire suppression storage are both for infrequent, extreme conditions, they can be nested allowing the City to provide the larger of the two. This nesting assumption should be reviewed with the fire marshal for fire planning purposes. The Main Reservoir has adequate capacity to meet storage requirements through the 20-year planning horizon. Although fire flow for the Scenic Vista Zone is proposed to be provided through future pumping improvements, if supplied from storage, an additional 125,000 gallons would be needed to meet fire storage requirements.

Table 4-3
Storage Analysis

Storage Component (MG)	Main Zone			Scenic Vista Zone		
	Current (2015)	5-Year	20-Year	Current (2015)	5-Year	20-Year
Dead	0.23	0.23	0.23	0.006	0.006	0.006
Operational	0.35	0.35	0.35	0.007	0.007	0.007
Equalization	0.21	0.27	0.33	0.000	0.000	0.000
Fire Suppression	0.96	0.96	0.96	0.000[1]	0.000[1]	0.000[1]
Emergency	0.91	0.95	0.99	0.002	0.002	0.002
TOTAL Required[2]	1.75	1.81	1.90	0.015	0.015	0.015
Existing Storage	3.00	3.00	3.00	0.070	0.070	0.070
Surplus/(Deficit)	**1.25**	**1.19**	**1.10**	**0.055**	**0.055**	**0.055**

[1]*Fire suppression assumed to be provided through future booster pump station upgrade.*
[2]*Fire Suppression and Emergency storage are nested so only the larger component is included in total.*

Pumping Analysis

Pumping Criteria

The Scenic Vista Zone is the only pump station in the City's system. The Scenic Vista Zone is supplied by gravity from the Scenic Vista Reservoir. Pressure zones with adequate gravity storage to provide fire flow make it unnecessary to plan for fire flow or peak hour demand capacity from pumps serving the zone. However, when the Scenic Vista Zone was created and the storage built, it was not intended to provide fire flow capacity, which the City and residents in the zone are aware of. As a result, the Scenic Vista Pump Station does not have sufficient firm capacity to meet the MDD plus fire flow for all customers in the Scenic Vista

Zone nor is there adequate piping to convey fire flows. The City and residents are aware of the deficiency and there are no near term plans to upgrade the Scenic Vista Pump Station.

Pumping Results

The Scenic Vista Pump Station is able to utilize backup power supply from the generator at the UVTF and has two pumps that can each meet MDD, but does not have adequate capacity to supply projected MDD plus fire flow through the 20-year planning horizon as summarized in Table 4-4. If a fire flow pump is added at the Scenic Vista Pump Station, pipe improvements would be required to convey the increased flow capacity.

Table 4-4
Scenic Vista Pump Station Analysis

Pumping Capacity (gpm)		Pumping Requirement (gpm)				Pumping Surplus/(Deficit) (gpm)		
		Criteria	Existing (2015)	5-Year	20-Year	Existing (2015)	5-Year	20-Year
Total	100	Fire Flow	1,500	1,500	1,500	**(1,480)**	**(1,481)**	**(1,482)**
Firm	50	MDD[1]	30	31	32			
		Total	1,530	1,531	1,532			

[1]*Based on billing records ratio, 0.5% of system-wide demand*

Distribution System Analysis

Hydraulic Model Development

A steady-state hydraulic network model was developed and used to evaluate the performance of the existing and future distribution system and identify potential piping improvements. The purpose of the model was to determine pressure and flow relationships throughout the distribution system for a variety of demand, supply and emergency conditions. The model was developed from available computer aided drafting (CAD) data using InfoWater software, which uses the EPANet hydraulic calculation engine. Several iterations of data review were conducted with City staff to verify pipe sizes and connectivity.

The model was calibrated to match field data to ensure it could accurately predict “real world” conditions. The existing system was then analyzed to identify hydraulic deficiencies under current and future demand conditions.

Demand

Existing customer demand was allocated throughout the system by linking customer billing records to the surveyed meter locations, which were then linked to the nearest demand node

within the model. The billing records were then scaled to match water production records. Future water demand locations were estimated based on input from the City and allocated to an appropriate model node.

Model Calibration

Model calibration typically involves adjusting model parameters to match field data, such as pressure and flow measurements recorded at system fire hydrants. The required level of model accuracy can vary according to the intended use of the model, the type and size of water system, the available data, and the way the system is controlled and operated.

The model's accuracy depends on the quality of the data available for the distribution system. Accurate system modeling assumes correct pipe connectivity, diameter, internal roughness and length. Knowing the status of system facilities, including pumps and reservoirs, referred to as "boundary conditions" is also critically important during calibration.

Hydrant flow tests to collect both pressure and flow data, were conducted at 26 locations between April 17th and April 22nd 2015. Flow testing was conducted in both pressure zones and spatially distributed to provide calibration points throughout the system. The calibration's confidence level was evaluated using the criteria shown in Table 4-5.

Table 4-5
Calibration Confidence

Confidence Level	Static Test Percent Error	Residual Fire Flow Pressure Difference
High	0 – 5%	≤10 psi
Medium	5 – 10%	10-20 psi
Low	> 10%	>20 psi

The first component of model calibration is to match field-measured static pressure with model simulated pressure. Ideally, model results would be identical to those measured in the field, however, for any system a portion of the data describing the distribution system will be inaccurate or unverified, and some assumptions will be required. During steady state calibration, demand distribution, system connectivity, service elevations, boundary conditions and any assumptions used to develop the model are verified.

The second component of calibration utilizes fire flow tests to verify pipe diameters, connectivity and friction factors along with system boundary conditions such as pump operation and reservoir level. Fire flow testing consists of recording static pressure at a hydrant and then "stressing" the system by flowing an adjacent hydrant. While the adjacent hydrant is flowing, residual pressure is measured at the first hydrant to determine the pressure drop that occurs when the system is "stressed". Boundary condition data, such as reservoir levels and pump on/off status, must also be known to accurately model the system conditions during the time of the flow test. The recorded time of each fire hydrant flow test

was used to collect boundary condition information from the City's system supervisory control and data acquisition (SCADA) system.

The initial model facilities were set up based on information extracted from existing CAD as-built drawings and system maps. CAD data provided the spatial location and connectivity of the distribution system along with diameter attributes and in some cases pipe material. Pipe material information was not available for all pipes and the majority of the system was assumed to be cast or ductile iron based on the available information and input from the City. Pipe age was also provided by the City and based on material and age, the roughness factor for each pipe was calculated.

System elevations were not included in CAD attributes and were extracted from USGS data sets. Elevations were verified during the calibration process and specific locations were adjusted based on input from the City. Both the elevation and pipe friction factor assumptions that were made during model creation for the system were verified during the calibration process. In addition, several corrections were made to model connectivity to ensure that the model accurately reflected the current distribution system. Calibration results are presented in Table 4-6.

Overall system calibration was very good. All of the static tests are within 5% of the measured pressure (High confidence category). Three fire flow tests had a pressure drop differential greater than 10 psi and 19 locations have a drop differential less than 5 psi between the model and the field measurement. The results of the calibration allow the model to be used for planning level efforts with high confidence.

Table 4-6
Calibration Confidence Results

Test ID	Hydrant ID	Model ID	Static Test Percent Error	Flow Test Pressure Drop Differential
1	388RA	J7	-1.0%	3.0
2	184LA	J91	-0.5%	1.4
3	96LA	J382	-2.1%	-12.8
4	150XA	J192	-0.9%	2.1
5	12LB	J576	-1.9%	-2.8
6	319OA	J745	-3.9%	5.3
7	235NB	J905	-1.8%	-9.2
8	240XA	J881	-4.8%	-10.7
9	219RA	J1020	0.9%	-2.5
10	292BC	J1012	0.6%	1.7
11	213LA	J923	-1.9%	-3.0
12	75LB	J430	-3.1%	-3.3
13	203RA	J58	-0.1%	2.5
14	160LA	J180	-1.0%	-1.9
15	30RA	J250	0.4%	-1.7
16	261RA	J747	-1.2%	-1.4
17	229RC	J954	1.4%	-1.1
18	260RC	J823	2.1%	-1.4
19	106LB	J388	0.8%	-2.0
20	271RC	J519	0.8%	5.7
21	288RA	J742	1.1%	-0.2
22	56LA	J485	3.9%	-2.0
23	326RA	J631	1.8%	-1.4
24	205XC	J47	0.7%	7.1
25	401PA	J1084	-4.2%	11.2
26	208LC	J834	-0.7%	-4.8

Modeling Conditions

System analysis was performed under existing, 5-year and 20-year ADD, MDD, PHD and MDD plus fire flow conditions. Each scenario tests the distribution system's ability to provide service while meeting the criteria outlined below and summarized in Table 4-1. Where the system could not meet the criteria, deficiencies were identified and used to develop the improvement projects outlined in Section 7.

Facilities

For distribution system modeling of ADD, MDD and PHD scenarios, distribution storage

reservoirs are modeled with storage reservoirs drawn down to simulate hydraulic grade lines where operational and equalization storage components are removed. This results in the Main Reservoir at 80% full, and the Scenic Vista Reservoir 98% full. For fire flow simulations the fire flow storage is removed at the Main Reservoir, putting it at 68% full. Since the Scenic Vista Reservoir does not contain fire flow storage, and with equalizing, operational and emergency storage removed, the tank is still 96% full. However, to be conservative, the analysis was run with the Scenic Vista Reservoir 50% full under fire flow scenarios.

Distribution System Criteria

Service Pressure

Distribution system performance was assessed based on the following service pressure criteria (summarized in Table 4-1).

- Maintain minimum pressure of 40 psi at service connections under ADD, MDD and PHD conditions.
- Maintain a minimum service pressure of 20 psi under MDD plus fire flow conditions.
- Keep static pressure within the distribution system below 100 psi and, where possible, below 80 psi.

Pipe Flow Velocity and Headloss

Pipe flow velocity and headloss criteria were also used during the distribution system analysis to indicate areas of undersized piping. These criteria were considered secondary compared to service pressure and did not necessarily dictate system improvements, however they provide a valuable guide for identifying undersized piping in the system and the prioritization of system improvements. Distribution piping was assessed based on the following criteria:

- Velocity below 5 feet per second (fps) under ADD and MDD conditions.
- Velocity below 10 fps under PHD or fire flow conditions.
- Maximum headloss of 6 feet per 1,000 feet of pipe.

Fire Flow

Fire flows are assigned based on the customer meter type as shown in Table 4-7, with 1,500 gpm required for residential properties, and 2,500 gpm for commercial and industrial properties. Four existing large industrial/commercial properties were assigned a fire flow of 3,500 gpm based on input from the City. 4,000 gpm was assigned for schools. Additional information on specific fire flow demands was provided by the City. The fire flow for each location is shown in Figure 4-1 at the end of the section.

Table 4-7
Model Fire Flow Assignments

General Property Type Classification	Fire Flow Requirement (gpm)
Residential	1,500
Commercial & Industrial	2,500
Large Commercial & Industrial	3,500
Schools	4,000

Distribution System Results

A detailed system analysis was performed to assess the ability of the City's existing distribution system to provide water for current and future demands in addition to emergency fire suppression. The City's distribution system has two pressure zones, the Main Pressure Zone, and the Scenic Vista Pressure Zone. The Main Zone hydraulic grade line (HGL) is established by the overflow elevation of the Main Reservoir, while the Scenic Vista Zone is pumped from the Main Zone and the HGL is established by the overflow elevation of the Scenic Vista storage tank. There are no pressure reducing valves in the distribution system.

The City's pressure zones provide adequate pressure for the majority of customers under all demand scenarios, however small areas of the system do not have pressures within the desirable ranges under various demand conditions. Many of the low or high pressure locations are due to their high or low elevation relative to the supplying reservoir. Typically these locations have individual service line pressure reducing valves or booster pumps to improve pressure and protect plumbing fixtures.

Average Daily Demand

Under existing average daily demand, most of the system operates at pressures between 80 and 100 psi. Several service locations on Pocahontas Avenue and Hughes Lane experience pressures just over 100 psi. If they don't already exist, these locations may benefit from individual pressure reducing valves. There are also service locations near the reservoirs that meet the minimum pressure of 20 psi, however are lower than the target 40 psi service pressure. These customers may benefit from individual booster pumps. Since demand is projected to increase very little, the pressures under 5- and 20-year demands are similar across the system to those under existing conditions. The ADD results are in Figure 4-2 at the end of the section.

Maximum Day Demand

The distribution system performs well under both existing and future maximum day demand scenarios. There is very minor variation in the pressures between existing, 5- and 20-year MDD conditions, however no locations are below 20 psi or above 100 psi. As discussed

earlier, there are a few low pressure locations along Indiana Avenue and locations close to the Main Reservoir. Although none of the locations violate minimum pressure requirements, they are below the 40 psi target service pressure. These locations may benefit from individual booster pumps to increase service pressure. Figure 4-3, at the end of the section, shows the MDD results.

Peak Hour Demand

Under existing peak hour demand, the majority of the system is within the target range. One location near the Main Reservoir has pressure below 20 psi. Several service locations along Indiana Avenue from the Main Reservoir to the intersection with State Highway 7 experience pressure over 20 psi, but less than 40 psi along with locations near 9th Street and Colorado Avenue and at the end of Windmill Road. When projected 5- and 20-year demand is applied the same areas experience low pressures. In addition, under 20-year PHD, pressures drop slightly below 40 psi along State Highway 7, south of the intersection with David Eccles Road. The 20-year PHD results, are shown in Figure 4-4 at the end of the section.

Fire Flow Analysis

Fire flow analysis was performed under existing, 5- and 20-year growth horizons while providing MDD. The same deficiencies that are observed using existing demand are observed under future demand conditions, since little demand growth is projected. No new deficiencies occur under future conditions, however available fire flow at already deficient locations is slightly lower in future scenarios.

Thirteen out of the approximately 800 fire flow locations that were simulated did not meet the fire flow demands while maintaining 20 psi of residual pressure. Figure 4-5 (at the end of the section) shows deficient locations and the fire flow deficit while maintaining 20 psi residual pressure. All but one of these locations also experience pipe velocity exceeding 10 fps under fire flow conditions.

Deficiencies were evaluated individually and categorized depending on the severity of the deficiency, proximity of an adequate secondary fire hydrant and the impact and extent of the improvements required to meet fire flow requirements. A recommended action has been assigned to each category. This information is summarized in Table 4-8 and Figure 4-6 (at the end of the section).

Table 4-8
Fire Flow Deficiency Categories

Classification	Description	Recommended Action
1	Improvement necessary and has higher priority based on severity and impact of deficiency, system impact and benefit of improvement.	Improvement recommended within 10-year CIP.
2	Improvement necessary, but has lower priority based on severity and impact of deficiency, system impact and benefit of improvement.	Improvement recommended within 20-year CIP.
3	Adequate fire flow is available at an alternate hydrant(s) within 500 ft.	No improvement recommended. Fire department should be made aware of available fire flow and alternate hydrants.

Condition Based Replacement Programs

The City understands the importance of having ongoing maintenance programs for all aspects of the water system. Recent efforts have been focused on replacement of the City's supply lines which are generally old and in poor condition. Additional programs have begun to address hydrant and meter replacement. A comprehensive distribution piping replacement program is planned, however has not yet been implemented. Regular maintenance and replacement efforts are underway at the City's UVTF, Reservoir Well, Scenic Vista Booster Station and Reservoirs.

Pipe Replacement

Supply Piping

The City has almost 40 miles of supply piping, shown in Figure 4-7 at the end of the section. Although the exact age of most of the piping is unknown, much of it is over eighty years old and has significant system loss, particularly the section between the Little Mill Intake and the Elk Creek Settling Tank. The City has started to replace sections of the piping and plans to focus on replacing the majority of the supply lines over the next 20 years, with the exception of the Goodrich Line, Marble Creek Intertie, and Elk Creek Line, which are newer.

To date two sections from Elk Creek Settling Tank to Forebay have been replaced (Figure 4-7, segments 3 and 4), but segment 4 is not yet in service. The section of pipe between them (Figure 4-7, segment 6) is primarily on land under Bureau of Land Management (BLM)

control. The BLM segment is currently undergoing an environmental assessment and will be replaced when that process is completed. The City plans to put the segment 4 pipe into service once the segment 6 pipe replacement work is complete.

The City also replaced approximately 1,300 feet of piping starting at the Little Mill Intake (Figure 4-7, segment 1). The City previously purchased about one mile of PVC pipe to continue replacing the Mountain Line starting at the end of the 1,300 feet already replaced down from the Little Mill Intake. As funding allows, sections of this Mountain Line (Figure 4-7, segment 5) will continue to be replaced with the goal of about one mile per year. After finishing the existing Mountain Line, priority will be given to completely replacing the Goodrich Diversion and pipe from this point down to the Little Mille Intake, which was crushed during previous construction and is not currently in operation. (Figure 4-7, segment 7) to allow water from Goodrich Lake to flow through either supply line.

The City is also considering the implementation of a second hydropower facility. A brief summary of the hydropower options is in Appendix B. The second facility would likely be located on the Mountain Line at Forebay. It is proposed that this facility would be constructed after the remaining portions of the Mountain Line between the Elk Creek Settling Tank and Forebay are replaced, enabling the line to handle the 700 feet of head and to minimize frictional losses. Once this facility is constructed it would be advantageous from a power production standpoint for the City to divert as much supply through the Mountain Line as possible during all portions of the year. The connection from the Goodrich Diversion to the Little Mill Intake would support this goal by allowing water stored in the Goodrich Lake to be diverted through the Mountain Line and conveyed through both the proposed and existing hydropower facilities. The expansion of the ASR program at one or more new wells would also benefit the City from a hydropower production standpoint allowing more water to be conveyed to the distribution system during low demand periods in the winter, spring and fall when additional surface water may be available.

Distribution Piping

In general the City's distribution piping is in good condition, though areas of undersized (less than or equal to 4-inch) and older cast iron piping exist. The City provided information on the pipe condition and size that is presented in Figure 4-8 at the end of the section. This information is cross-referenced with the fire flow and pressure analysis results to prioritize improvements in Section 7.

Once the critical supply line piping is replaced over the next several years, the City would like to implement an overall distribution system replacement program. Industry standard typically recommends a 100-year pipe life replacement cycle. With the City's 77 miles of pipe, this results in an annual replacement of about 4,100 feet of pipe per year. The City can use the condition and undersized pipe information in Figure 4-8 and other factors, such as road repair, break location or fire flow deficiencies to determine how to prioritize pipes for replacement. This would likely begin when adequate funding is available after year 5 of the Capital Improvement Plan.

Meter Replacement

As meters age they typically begin to underreport the amount of water that flows through them, resulting in lost revenue for the City. The City currently replaces approximately 100 customer meters per year. The City currently has approximately 4,600 meters. The City would like to increase the number of meters replaced per year to 230 consistent with the industry standard of a 20 to 30 year overall replacement schedule.

Hydrant Replacement

The City currently replaces 3 hydrants on average per year. The City may consider increasing the number of hydrants that are replaced if greater numbers become inoperable.

Operations and Maintenance Requirements

The City currently performs a number of operations and maintenance (O&M) programs on a regular basis, as indicated in Table 4-9. Most of these tasks are completed by City staff, although some are contracted to outside professionals. The Oregon Water Resources Department inspects the Goodrich Reservoir Dam annually. Each task will continue to maintain the system and most of the system improvements will fit within existing O&M procedures, however additional O&M procedures will need to be incorporated as new facilities are added. When new wells are constructed, they will need to be added to the O&M procedures, including maintaining and calibrating the chlorinator and monitoring and servicing the mechanical systems and components at the well pump house.

Most of these tasks occur regularly and are built into the system O&M budget. However, replacement of the anode beds only occurs approximately every 20 to 30 years. There are three anode beds within the system to provide cathodic protection along the Goodrich and Marble Creek Lines. One was replaced in 2010 and the other two were last replaced in the 1980s, so all should be monitored and replaced when necessary within the 20-year horizon.

Table 4-9
O&M Procedures

System	Task Description	Frequency
Source & Supply	Inspect dam at Goodrich Reservoir	annually
	Clean screens at diversion and intakes	weekly or as needed
	Exercise valves at intakes and drain lines	annually
	Test rectifiers on cathodic protection for Goodrich and Marble Creek Lines	quarterly
	Full system inspection of cathodic system	annually
	Replacement of anode beds	as needed (approximately every 20 years)
	Inspect Mountain Line for leaks or damage	weekly
	Cut roots out of Mountain Line	annually or as needed
Treatment	Maintain/calibrate chlorine regulators	annually
	Exercise backup generator	weekly w/o load, quarterly under load
	Inspect/service backup generator	semi-annually
	Inspect/service ASR booster pump	annually
	Exercise valves at reservoirs and in UVTF	annually
	Clean UV reactors and quartz sleeves	annually or as needed
	Replace UV lamps	after 14,000 hrs of run time or as needed
	Calibrate pH, chlorine, and UVTF monitors	quarterly
	Calibrate UV sensors	monthly
	Maintain turbidimeter	as needed
	Monitor for alarms	daily
Distribution	Exercise valves	annually
	Flush hydrants	annually

Summary

This section presents the water system analysis and identifies deficiencies based on performance criteria summarized in Table 4-1. The analysis identifies limited storage and distribution system deficiencies under existing and future conditions as presented below.

Supply Analysis Summary

- The City has adequate total and firm capacity (one train of UVTF out of service) to meet existing and future demands.
- Although there is adequate supply to meet MDD for the forecasted 20 year period, the City is concerned about the lack of redundancy to meet demand if the surface water supply was compromised. As a result, the City is exploring options to expand the groundwater supply including drilling one or two new wells. The implementation of

ASR will be assessed at any new wells to help reduce iron and manganese aesthetic issues in the groundwater.

Storage Analysis Summary

- The City has adequate distribution storage for existing and future conditions if Scenic Vista fire flow requirements are met through a future pump station and piping upgrade.

Pumping Analysis Summary

- The Main Zone has no pumping facilities. The Scenic Vista Pump Station does not have adequate capacity to supply projected MDD plus fire flow for existing or future needs. Piping improvements would also be required to convey fire flow pumping capacity.

Distribution System Analysis Summary

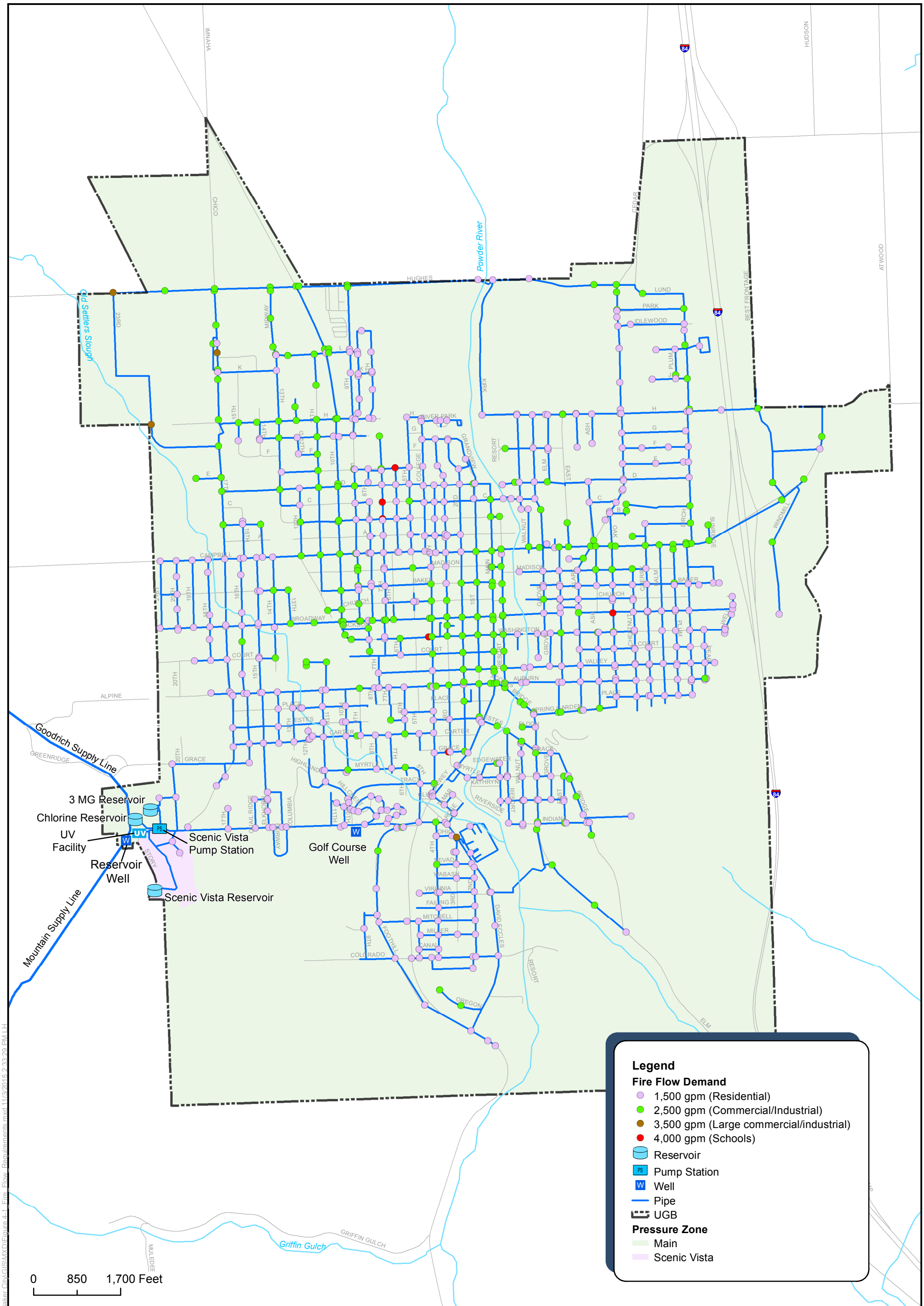
- The City's two pressure zones generally provide adequate service pressures between 40 and 80 psi to water customers.
- A limited number of customers may benefit from individual service pressure reducing valves or booster pumps to help maintain pressure between 40 and 80 psi.
- One customer near the Main Reservoir experiences less than 20 psi under PHD conditions and a limited number of customers nearby along Indiana Avenue experience service pressure less than 40 psi during existing MDD and PHD scenarios. The area of low pressure expands slightly under future demands conditions. These customers may benefit from individual booster pumps to increase pressure.
- A limited number of customers in the northwest end of the system may require individual pressure reducing valves to protect plumbing installations as they experience pressure greater than 100 psi.
- Some of the fire flow deficiencies may be resolved by obtaining flow from nearby hydrants that provide adequate flow. The fire department should be made aware of these locations and the City should consider color coding hydrants according to the National Fire Protection Association standards to ensure they utilize hydrants with adequate flow.
- Improvements should be implemented for locations where fire flow requirements are not available and nearby hydrants are not adequate to meet fire flow requirements. The prioritization of these improvements should be revisited over time and based on severity and impact of the deficiency and the system impact and benefit of the improvement.

Condition Based Replacement Programs

- The City is prioritizing the replacement of the supply lines that are old and have high water leakage rates. The City has already replaced portions of the Elk Creek and Mountain Lines and will continue to replace the remaining portions of these lines over the 20-year horizon.
- If adequate rate based funding can be developed an overall distribution pipe replacement program should be implemented to address approximately 4,100 feet per year based on a pipe life of 100 years. Pipe replacement prioritization should consider factors such as age, material, leaks and small diameter mains.
- Approximately 100 water meters per year are currently replaced which should be increased to approximately 230 per year to provide a 20 to 30 year system replacement cycle for all customer meters.

Operations and Maintenance Requirements

- The City should continue performing its O&M procedures and update tasks as new facilities are added to the system.
- Monitor the three existing anode beds on the cathodic protection system for the Goodrich and Marble Creek Lines and replace when necessary.



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Water Facility Plan

Figure 4-1
Fire Flow Requirements

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Goodrich Supply Line
3 MG Reservoir
Chlorine Reservoir
UV Facility
Reservoir Well
Scenic Vista Pump Station
Golf Course Well
Scenic Vista Reservoir
Mountain Supply Line
Old Settlers Slough
Powder River
Griffin Gulch

Legend

ADD Pressure Results
- 20 - 40 psi
- 40 - 80 psi
- 80 - 100 psi
- 100 - 105 psi
- Pump Station
- Well
- Pipe
- UGB

Pressure Zone
- Main
- Scenic Vista

0 850 1,700 Feet

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Figure 4-2
ADD Results

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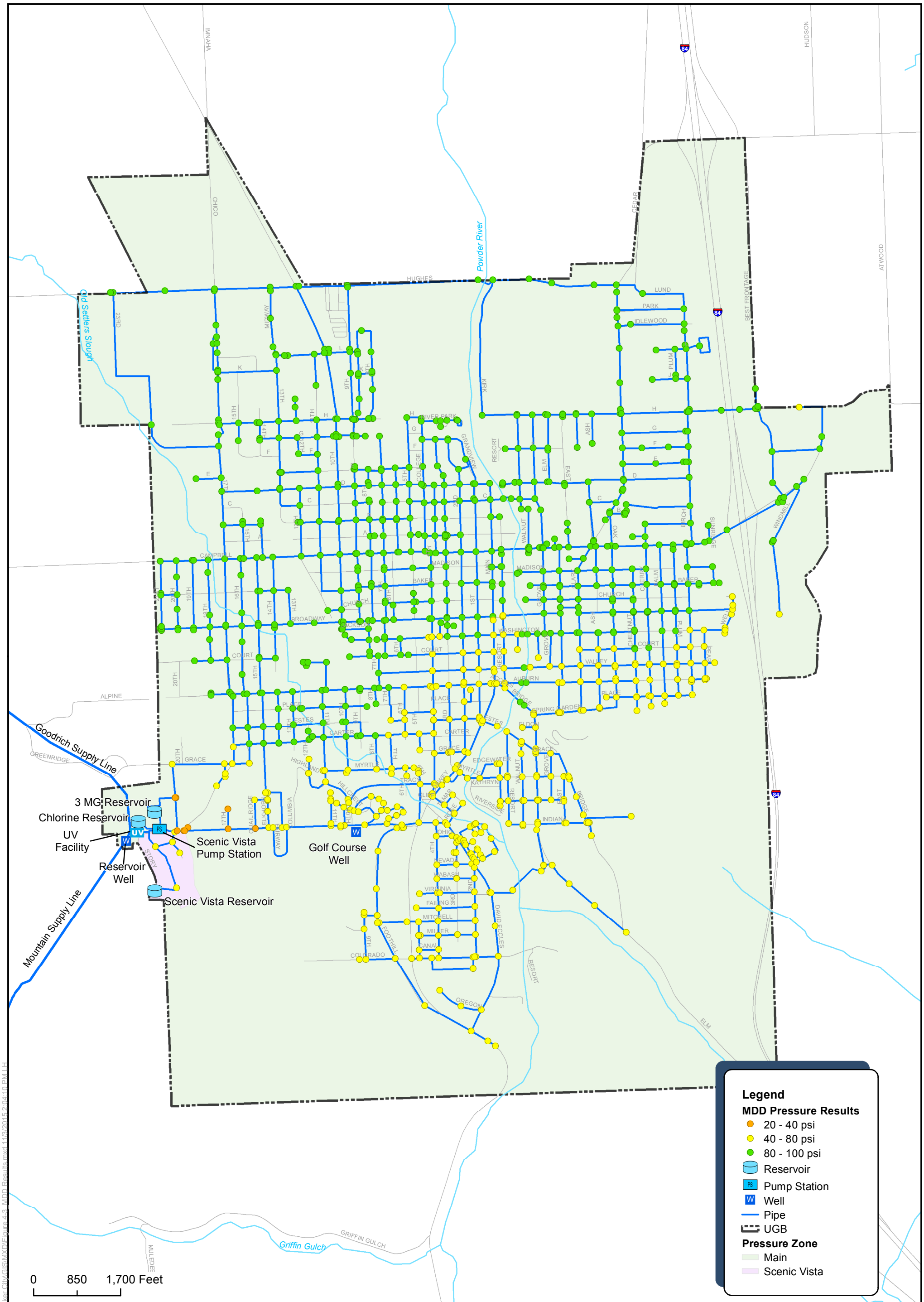

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Figure 4-3
MDD Results

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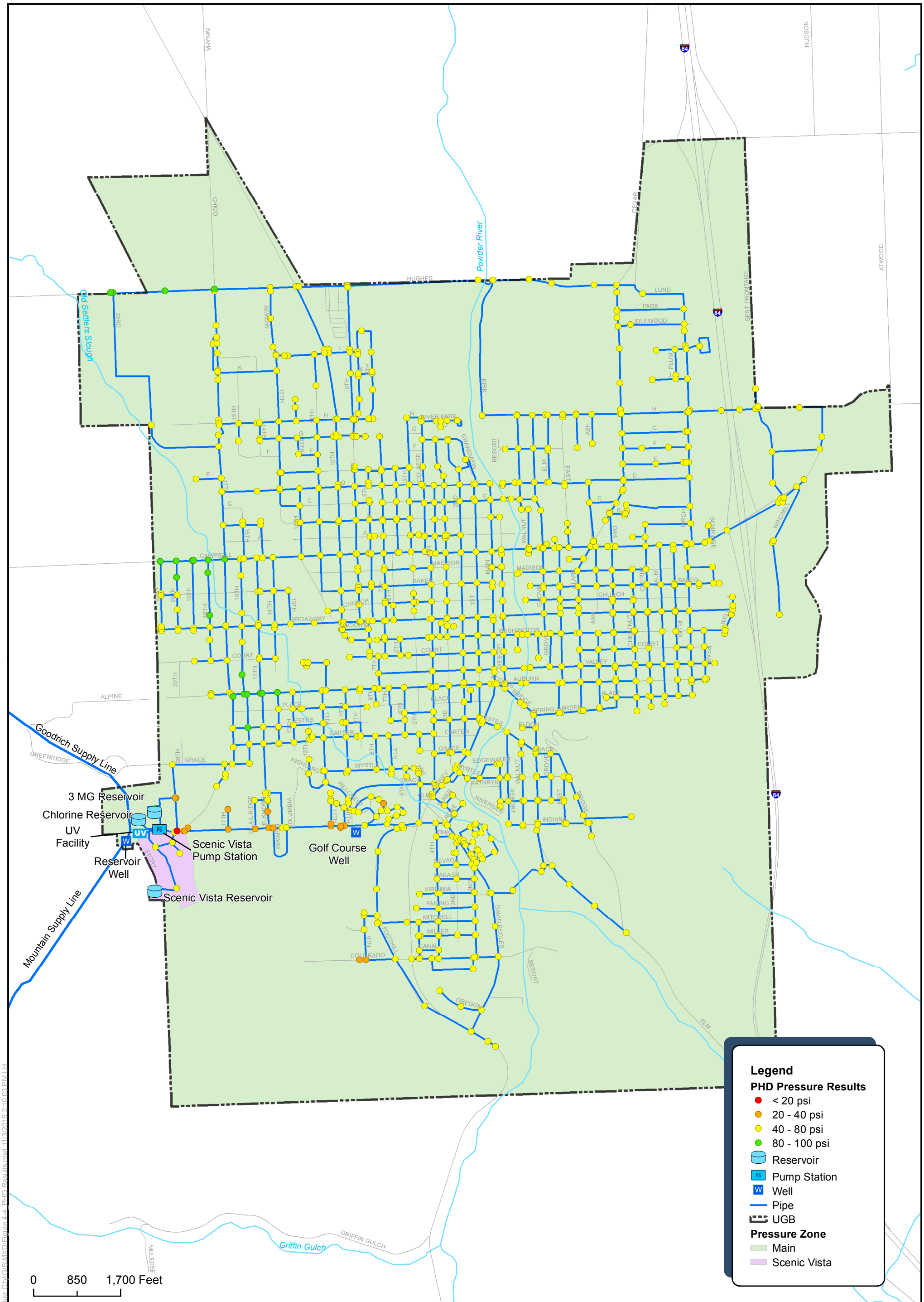

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Figure 4-4
PHD Results

BAKER CITY OREGON EST. 1874

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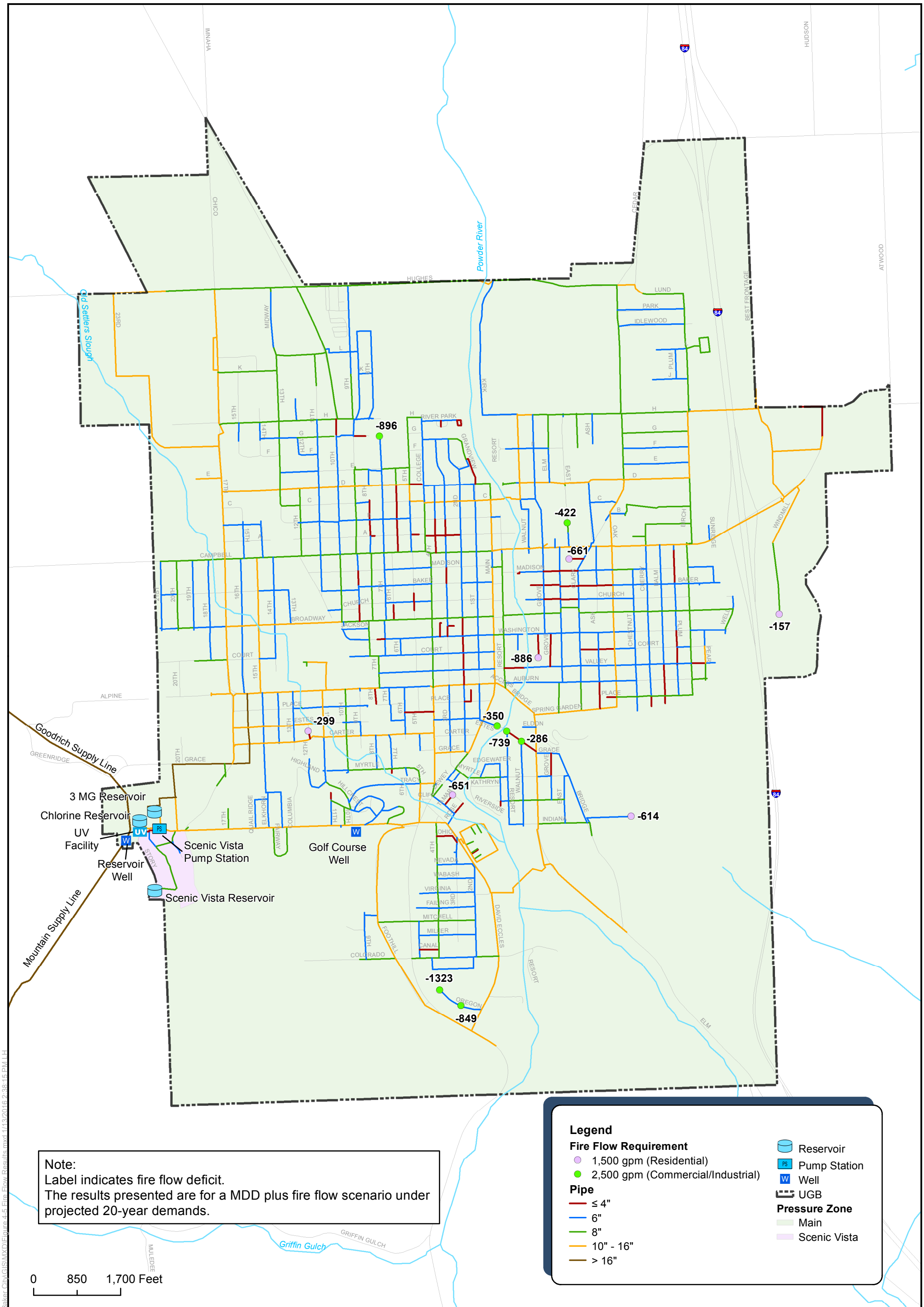

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Figure 4-5
MDD + Fire Flow Results

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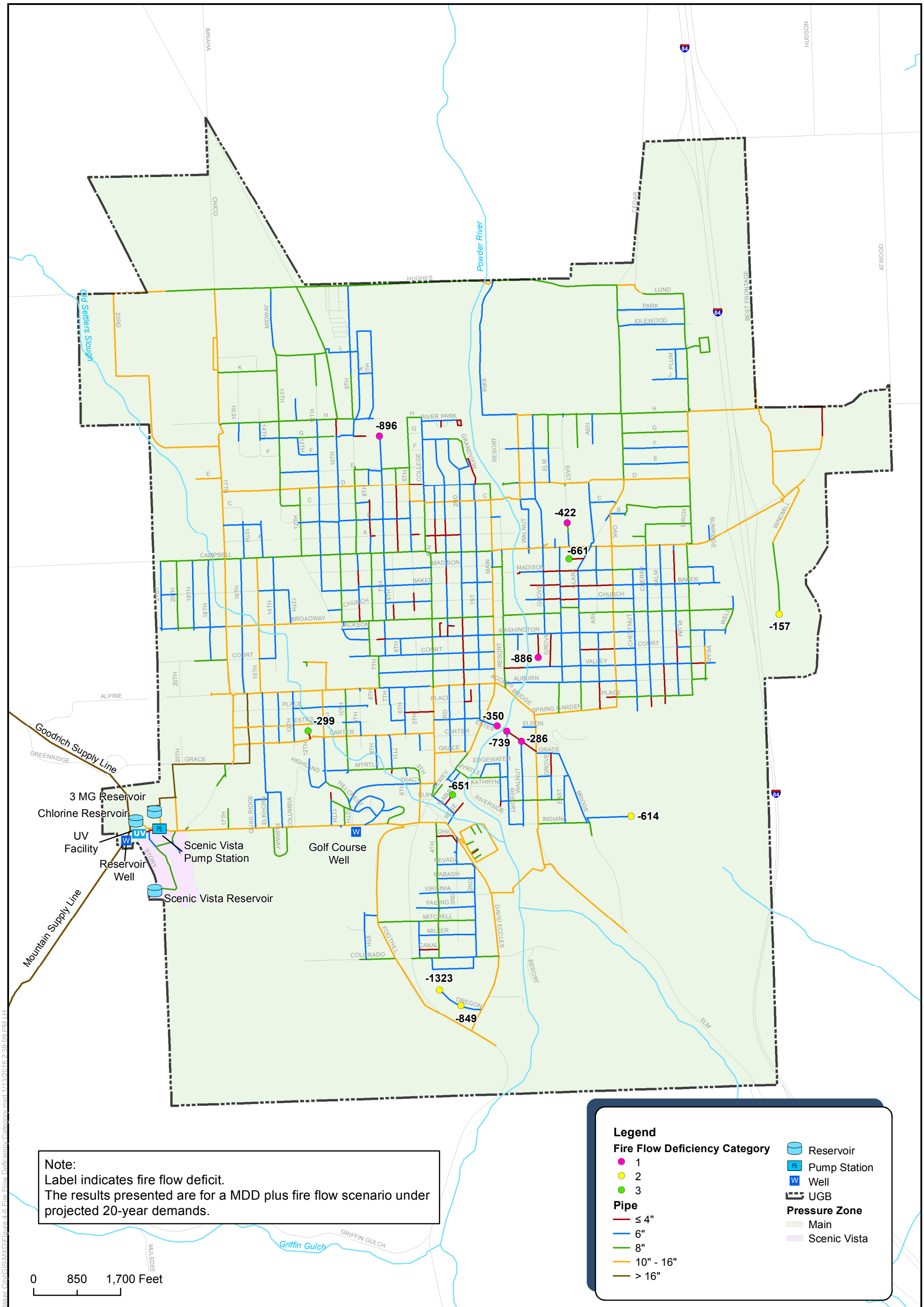

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Figure 4-6
Fire Flow
Deficiency Category

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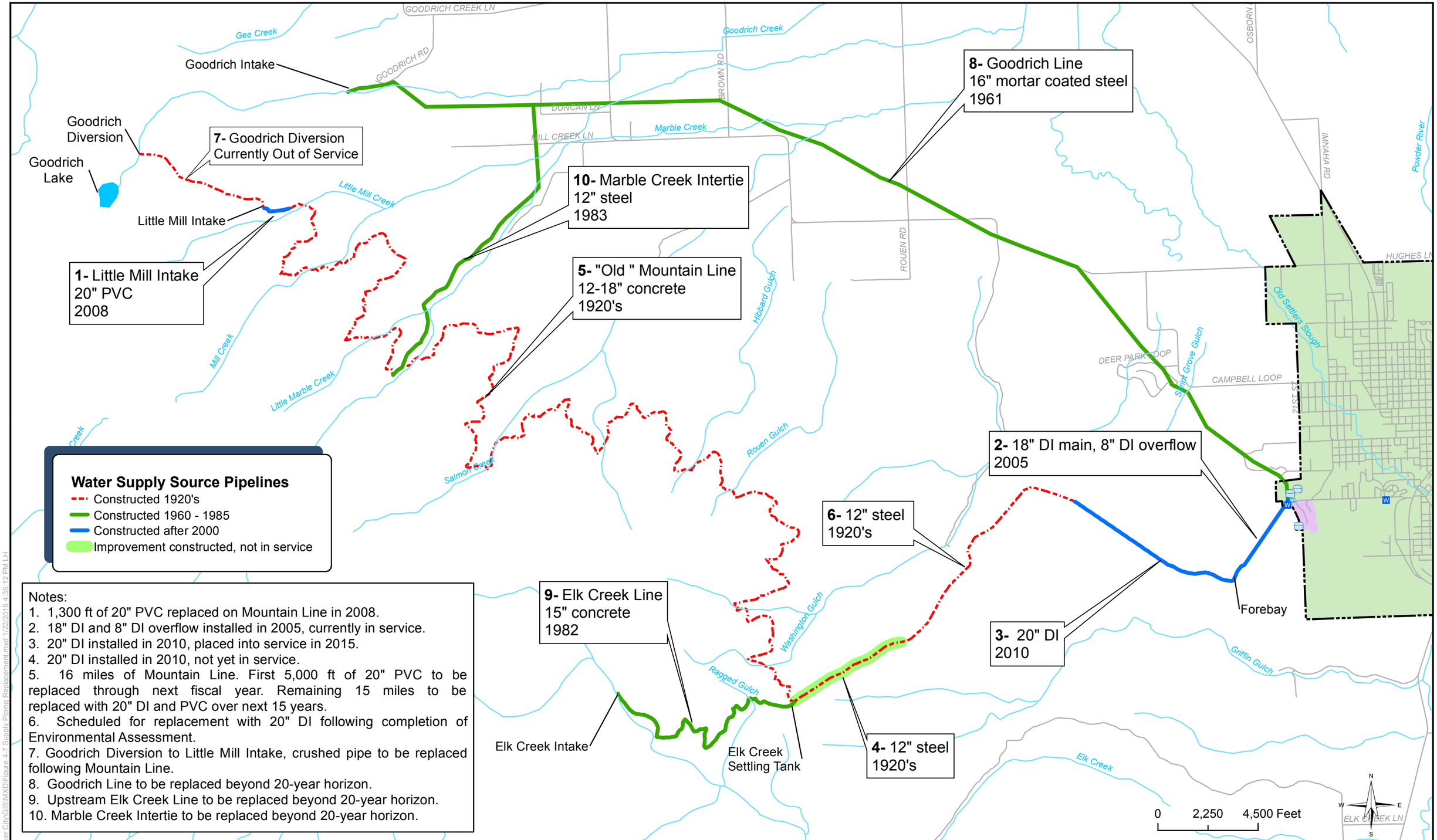

Notes:
1. 1,300 ft of 20" PVC replaced on Mountain Line in 2008.
2. 18" DI and 8" DI overflow installed in 2005, currently in service.
3. 20" DI installed in 2010, placed into service in 2015.
4. 20" DI installed in 2010, not yet in service.
5. 16 miles of Mountain Line. First 5,000 ft of 20" PVC to be replaced through next fiscal year. Remaining 15 miles to be replaced with 20" DI and PVC over next 15 years.
6. Scheduled for replacement with 20" DI following completion of Environmental Assessment.
7. Goodrich Diversion to Little Mill Intake, crushed pipe to be replaced following Mountain Line.
8. Goodrich Line to be replaced beyond 20-year horizon.
9. Upstream Elk Creek Line to be replaced beyond 20-year horizon.
10. Marble Creek Intertie to be replaced beyond 20-year horizon.

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Figure 4-7
Water Supply
Pipe Replacement

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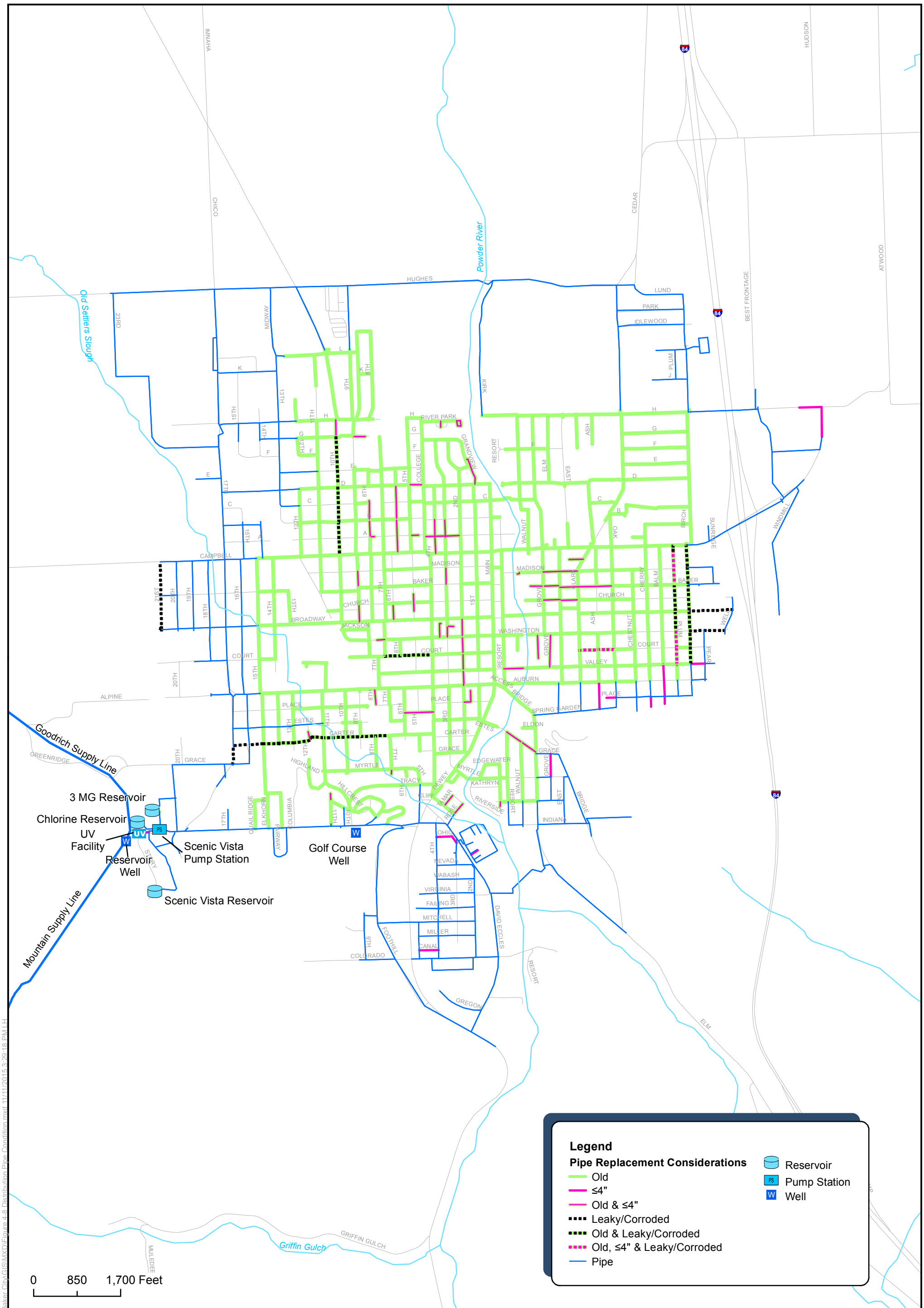

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Figure 4-8 Distribution Pipe Replacement Considerations

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Engineers/Planners

Section 5

Groundwater Capacity Expansion Evaluation

SECTION 5
GROUNDWATER CAPACITY EXPANSION EVALUATION

Introduction

This section summarizes an evaluation of the feasibility of expanding the City's groundwater supply source capacity. GSI Water Solutions, Inc. (GSI) prepared this evaluation on behalf of the City and under subcontract to MSA as an element of this Water Facility Plan update. The City's goal is to develop 2.5 million gallons per day (mgd) of additional supply capacity from a groundwater source for the purpose of enhancing the overall resiliency of the City's water supply. The objective is to develop additional and redundant capacity approximately equal to the projected future average daily demand (ADD) to augment or replace the City's primary surface supply in case of seasonal shortfalls (e.g., drought) or a long-term interruption in supply (e.g., fire in watershed). The additional capacity, when combined with the existing groundwater/ASR well, would total approximately 5 mgd of redundant capacity.

The evaluation summarized in this section included the following general steps:

1. Assessing the condition and the short and long-term capacity and reliability of the City's existing groundwater assets, including groundwater rights and aquifer storage and recovery (ASR) system.
2. A desktop assessment of the feasibility of developing 2.5 mgd of new groundwater source capacity, including identifying more or less favorable areas for development of a new groundwater source on the basis of hydrogeologic potential, distribution system capacity, water use and demand, water rights, key uncertainties, costs and benefits.
3. Developing recommendations and a roadmap for permitting, drilling, testing, and constructing system improvements to bring the new groundwater capacity online.

Hydrogeologic Setting

This section briefly summarizes key aspects of the hydrogeology of the Baker City area to provide background and context for the evaluation of groundwater supply expansion alternatives. Detailed descriptions of the geology and hydrogeology can be found in several United States Geological Survey and Oregon Department of Geology and Mineral Industries reports (Lystrom, Nees, and Hampton, 1967 and Brooks, McIntyre, and Walker, 1976), as well as previous feasibility work completed prior to the development of the City's Reservoir Well (Newcomb, 1973) and ASR system (GSI, 2003, 2005) at that location.

Baker City is located against the southern margin of the Baker Basin, a northwest-trending structural basin drained by the Powder River and tributary streams. The geology of the southern portion of the Baker Basin includes three general groupings of geologic units from oldest to youngest: older, fractured pre-Tertiary igneous, metamorphic, and sedimentary rocks, Miocene-aged interlayered basaltic and andesitic flows and near-vent facies of the

Powder River Volcanics (PRV), and unconsolidated alluvial (basin-fill) sediments. While the occurrence of groundwater and mechanisms of flow in the PRV and pre-Tertiary rocks may differ, these two units are sufficiently connected to be considered one aquifer unit. The general characteristics of each of these geologic units are further described below. A compilation showing the distribution of these general geologic units, subunits and geologic structures in the vicinity of the City is shown in Figure 5-1 at the end of this section.

Pre-Tertiary Rocks

Pre-Tertiary rocks include a fractured crystalline assemblage of granitic and meta-igneous and meta-sedimentary rocks south and west of the City. This unit is present along the Mountain Conveyance Line alignment and adjacent to the Goodrich Conveyance Line. Rocks comprising this unit tend to be dense, have little primary permeability and produce water mostly from fractures. Wells completed in this unit are anticipated to have low yield. The Oregon Department of Water Resources (OWRD) has indicated that it considers this unit to be hydraulically connected to the PRV and therefore considers the unit to be the same aquifer in terms of water right appropriation. Water quality data for this unit are sparse but are likely to be similar or of lower quality than PRV groundwater.

Powder River Volcanics (PRV)

The Miocene-aged PRV consist of compound basalt and andesite lava flows and tuffaceous sediments of the late Miocene eruptive centers between Baker City and the Grande Ronde River. This unit is present beneath alluvial sediments underlying the City and to the south, southeast, and southwest of the City on the fringe of the basin. Geologic faults present along the margins of the basin in the vicinity of the City may compartmentalize the PRV aquifer while vertically connecting units. Evidence of a negative (no-flow) hydraulic boundary from testing of the Reservoir Well may indicate the influence of one or more mapped faults in the area. The PRV is draped over pre-Tertiary Rocks and appears to thin appreciably or may be truncated on the upthrown side of the basin-bounding faults.

The PRV hosts productive aquifers, as is the case with the City's Reservoir Well, and several other productive wells (e.g., David Eccles Road and CalPac wells) in the City. The quality of water from wells completed in this unit is generally good from a regulatory perspective, although concentrations of several constituents render the aesthetic quality objectionable, as noted by Newcomb (1973). Water quality data, where available, indicate water from the PRV is slightly to moderately hard with a slightly alkaline pH. Concentrations of manganese in native groundwater exceeded the secondary standard of 0.05 milligrams per liter (mg/L) for all PRV wells in the vicinity of the City with water quality data reviewed for this evaluation. The presence of hydrogen sulfide and concentrations of iron in exceedance of the secondary standard of 0.3 mg/L also were noted in several wells (Newcomb, 1973). The high levels of iron and manganese in the groundwater were a primary driver for implementing ASR, which is described in more detail below.

Alluvial Sediments

This geologic unit consists of alluvial sediments deposited in the valley by streams flowing out of the mountains and debris shed from the mountain front (e.g., talus and debris flows). The alluvial basin-fill sediments are comprised of stream channel gravels, sands, and silts. It also includes unconsolidated colluvium material (debris deposited at the base of slopes by gravity). This unit is present across the floor of Baker Valley, and extends to the north, northwest, and northeast of the City. The sediments host a distinct and separate aquifer system, which is recharged by direct infiltration of precipitation and seepage from streams along the mountain front, and discharges to streams in the basin. Because groundwater in the alluvial sediments is in direct connection with surface water in the basin and surface water in the basin is fully-appropriated and the Powder River has been designated a Wild and Scenic River, the OWRD is not issuing new water rights for this aquifer. The aquifer hosted by the alluvial sediments is termed the Alluvial Aquifer for convenience in the remainder of this document.

Existing Groundwater and ASR Supply

This section summarizes the status and capacity of the City's existing groundwater source of supply. The City developed a groundwater supply source to supplement its surface sources by conducting a well siting study (Newcomb, 1973), and applying for a water right and drilling the Reservoir Well in 1977. The initial reported capacity of the well was approximately 1,000 gpm, and the aesthetics of produced water were reported to be poor. The well was rehabilitated and retrofitted for ASR purposes and is currently used as an ASR well to recover stored surface water, although it also can be pumped under authorization of its water right certificate. ASR testing has demonstrated that stored surface water recovered from the Reservoir Well is aesthetically better quality than native groundwater and the City has maintained residual stored water to mitigate native groundwater quality. The City also holds other municipal and irrigation water rights, and has in the past operated a well to irrigate the municipal golf course under two of these water rights.

Water Rights

The City currently holds five groundwater rights, including four certificates and a new permit as shown in Table 5-1. The City's five water rights authorize appropriation of up to 7.03 mgd (4,881 gpm). Of this authorized capacity, 6.69 mgd (4,643 gpm) is authorized for municipal uses and 0.34 mgd (238 gpm) for supplemental irrigation use. The City also holds a permit (#001) to operate its ASR system with an authorized recovery rate of 2.88 mgd. The City, in total, has 9.91 mgd of groundwater-related water right capacity if it were to recover stored water using the Reservoir Well under its ASR permit. Consequently, the City can develop more physical groundwater capacity through construction of additional wells and completion of a water right transfer to appropriate up to the total authorized groundwater right capacity.

All but one of the City's water rights list the PRV aquifer, whereas the newest (Permit G-17741) lists the pre-Tertiary Rocks as the appurtenant aquifer. However, OWRD considers the pre-Tertiary Rocks to be hydraulically connected to the PRV. Therefore, a new well for the City may be constructed in either geologic unit, as long as the well is constructed similarly to existing wells on a given permit, and with similar water levels.

Four of the City's groundwater rights (certificates 54983, 68683 and 23384 and new Permit G-17741) list wells that are either no longer in service, not owned by the City or have not been constructed. Consequently, use of water under each of these rights would require acquiring or drilling one or more wells that are completed in the PRV or pre-Tertiary Rocks and completion of a water right transfer through OWRD to allow use of a new well under the City's water rights.

Table 5-1
Water Rights

		Reservoir Well (ASR Well)		Golf Course Well		CalPac Well	Proposed Well
Water Right Information	Application	G-8381	ASR Permit #001	G-8510	G-11771	U-639	G-17741
	Permit	G-7635		G-7830	G-10922	U-584	N/A
	Certificate	51748		54983	68683	23384	N/A
	Priority Date	8/19/1977	N/A	10/31/1977	12/14/1987	11/16/1953	12/6/2013
	Use	Municipal	Municipal	Irrigation	Municipal	Municipal	Municipal
	Rate (cfs)	5.3	4.46	0.53	0.57	2.25	2.23
	Rate (gpm)	2,379	2,000	238	254	1,010	1,000
Well Information	Well Log ID Number	BAKE 1148/51221/51307		BAKE 1153		BAKE 1164	N/A
	Aquifer	Powder River Volcanics		Powder River Volcanics		Powder River Volcanics	Granite (MzPza)/ Powder River Volcanics
	Approximate Pumping Rate (gpm)	1,600		320		1,050	N/A
	Reported Specific Capacity (gpm/ft)	14		2.3		Unknown	N/A

Groundwater and ASR System

Groundwater System

The Reservoir Well is the City's sole operating well, although the City owns one other inoperable well at the golf course (BAKE 1153). The reported maximum capacity of the Reservoir Well is 1,900 gpm and reportedly averages around 1,600 to 1,700 gpm for longer pumping periods during ASR recovery operations. Prior to implementing ASR, the yield of the well would reportedly decrease after sustained pumping, likely because of seasonal declines in groundwater levels. Sustained long-term pumping in excess of stored volumes and without periodic injection should therefore be expected to result in diminished yield, at least on a seasonal basis. Late season ASR recovery data indicate diminished well yield, but appear to be a result of reduced demands and partial closure of valves to restrict the pumping rate. For the purposes of this evaluation, the initial groundwater pumping capacity after the ASR storage account is exhausted is assumed to be approximately 1,600 gpm. On a longer term basis, a lower yield may be more realistic and the anticipated long-term yield of the well should be evaluated for the purposes of understanding the available capacity should groundwater become the primary source for a long period of time. However, on the basis of this initial assumption, the City holds a minimum of approximately 4.74 mgd in unutilized groundwater right capacity that can be used to develop an additional groundwater supply source. Of this amount, 4.40 mgd is for municipal uses (including irrigation) and 0.34 mgd for supplemental irrigation uses.

The City intends to replace the Golf Course Well which has not been used for some time. Prior to becoming inoperable, the Golf Course Well could produce approximately 320 gpm (0.46 mgd) and was operated under a municipal water right and supplemental irrigation right. A replacement well at the golf course with sufficient capacity and constructed to municipal well standards could serve dual purposes: reduce demands on surface sources and the Ultraviolet Treatment Facility (UVTF) by supplying irrigation demands of the golf course, and provide a backup and supplemental municipal source.

Several existing supply wells present in the southern portion of the City have been considered for municipal supply use, including the CalPac (BAKE 1164) and David Eccles Road (BAKE 1163) Wells. Both of these wells show records of being highly productive. The City holds the water right certificate for the CalPac Well, however do not own the site or associated equipment. At least one of these wells (David Eccles Road Well) is not constructed to current municipal supply standards and possibly both. A summary of other existing wells either owned by, or of potential interest to the City is provided in Table 5-2.

ASR System

The City began developing its ASR system in 2003 to improve the reliable pumping capacity and water quality of its Reservoir Well. The City began ASR pilot cycle testing under Limited License 009 in 2004 after rehabilitating and retrofitting the Reservoir Well in

2003/2004. Based on successful ASR cycle testing through 2007, the City applied for an ASR permit. OWRD issued ASR Permit #001 to the City in 2009.

Permit #001 authorizes the City to inject up to 200 million gallons (MG) per year at rates up to 1,300 gpm (1.86 mgd). The City may recover stored water at rates of up to 2,000 gpm (2.9 mgd). Successive ASR injection and recovery cycles have improved water quality and the capacity of the well is approximately 1,600 gpm (2.3 mgd) over longer durations with peak rates of up to 1,900 gpm (2.72 mgd) reported early in a recovery cycle. The City typically operates the well at injection rates of approximately 800 gpm and recovery rates of between 1,000 and 1,700 gpm. The well is authorized to pump under the ASR permit to recover stored water at a maximum rate of 2,000 gpm or under its water right certificate at a rate of 2,379 gpm.

Prior to 2015, ASR source water consisted of disinfected surface water from the City's Mountain and Goodrich lines. The City brought the UVTF online in November 2014 to treat its surface source. Presently, source water is treated at this facility, disinfected and then delivered to the ASR well for injection. Water recovered from the ASR well is also disinfected and then routed through the UV plant prior to delivery to the distribution system.

Table 5-2
Wells of Interest

	Golf Course Well	David Eccles Road Well	CalPac Well
Well Log ID Number	BAKE 1153	BAKE 1163	BAKE 1164
Well Depth (ft bgs)[1]	349	650	578
Static Water Level (ft bgs)	85	8	39.3
Static Water Level Date	9/15/1977	11/5/1965	3/15/1949
Date of Construction	9/15/1977	11/9/1965	1949
Notes	Currently inoperable; City intends to replace. Advancing deeper in the PRV likely would increase the productivity and yield of the replacement well	Industrial supply well on former lumber mill property. Well casing is perforated in alluvial sediments and PRV. Construction does not meet current well standards and reconstruction is likely infeasible.	Industrial supply well completed in 1936. Well is cased through the overlying sediments into the PRV. City holds the water right for this well, but does not own the well or well site property. Presence and nature of well seal is unknown; Reconstruction to install well seal and/or replace casing may be necessary to bring the well up to current standards.

[1] *ft bgs = feet below ground surface.*

Groundwater Source Capacity Development Alternatives

Introduction and Approach

This evaluation of alternatives for groundwater source capacity development focuses on four general areas identified primarily on the basis of the presence of existing suitable distribution infrastructure, land availability and/or potential need for source capacity. The four areas, shown on Figures 5-1 and 5-2 (shown at the end of this section), include:

- The Goodrich Conveyance Line
- The Mountain Conveyance Line
- The West/Southwest Area
- The East Area

It should be noted that the West/Southwest and East Areas are generally assumed to be within the City's current distribution system and could provide water directly to the system (after chlorination). Wells developed along the Goodrich or Mountain Conveyance Lines would be connected directly into the supply pipelines and conveyed to the City's UVTF prior to use in the distribution system.

Each area was evaluated on the basis of hydrogeologic potential, available infrastructure, water rights, water quality, land ownership and operational considerations. The following section summarizes the assessment of the potential of each area, including potential benefits, risks, key unknowns, work needed to address uncertainties and verify the groundwater supply capacity potential and costs. Evaluation of each area also includes consideration of whether a well in the area could be used for ASR to improve yield and/or water quality. A key conclusion common to all four areas is that the City's existing water rights likely could be transferred to a well located within the identified areas that is completed in the PRV or pre-Tertiary rocks.

Goodrich Conveyance Line

The Goodrich Conveyance Line diverts water stored in the City's reservoir at Goodrich Lake from Goodrich Creek and conveys it to the City's storage reservoir and UVTF. The conveyance line runs southeast along the southwestern edge of the Baker Valley to the City (Figure 5-1). Development of a source along the alignment of the Goodrich Conveyance Line was evaluated because it provides readily available gravity conveyance to the City's reservoir facilities.

The majority of the area along the conveyance alignment is mantled by alluvial and terrace sediments, except near town where pre-Tertiary rocks and the PRV crop out. The alluvial sediments are presumed to be underlain by pre-Tertiary rocks and the PRV along the alignment; however, the distribution of the PRV beneath the sediments is not well understood because most existing wells in the vicinity of this conveyance line are completed

within the alluvial aquifer (Figure 5-2). The few wells completed within bedrock aquifers are generally for domestic supply purposes and thus are relatively shallow with low yields. Consequently, the potential productivity of the PRV or pre-Tertiary aquifers near the conveyance line is not known.

Water quality data are not available from wells in this area; however, there is a relatively high probability that groundwater derived from bedrock in this area would have similar chemistry as wells near the City.

The overall potential for developing a high-capacity groundwater source in the vicinity of the Goodrich Conveyance Line area is low to moderate. The PRV appears to underlie the alluvial sediments along at least a portion of the alignment but is currently unexplored. The level of uncertainty in the assessment is high because of the lack of information, although the uncertainty is less near the City because of closer proximity to deeper wells and known favorable hydrogeologic conditions.

A new well installed in this area would be upstream of the City's UVTF. Therefore, treatment would need to be installed at the wellhead to treat raw surface water from the Goodrich Line to be able to implement ASR in this location to store water and manage water quality aesthetics. The level of required treatment prior to use for ASR would need to be evaluated, but at a minimum would require chlorination before recharge. Power would need to be installed at the site, potentially requiring installation of new power lines over significant distances. Additionally, winter time accessibility to a site in this location may be a challenge.

Ideally, additional assessment of the potential for developing a high-capacity groundwater source in the Goodrich Conveyance Line area would be done including drilling and testing one or more test wells at select locations to address the lack of information related to aquifer thickness and distribution, productivity, and water quality. However, due to the high cost of drilling a test well in the area (estimated at around $400,000 to $475,000), the City may opt to take the calculated risk of proceeding directly with drilling a production well.

Mountain Conveyance Line

The Mountain Conveyance Line conveys water from several diversions located in the hills west-southwest of the City. The conveyance line contours through several drainages and then zigzags in a general east-northeasterly direction to the reservoir and UVTF (Figure 5-1). Similar to the Goodrich Conveyance Line, the rationale for developing a source in this area is that it provides readily available gravity conveyance to the City's reservoir facilities

The City's existing water rights could likely be transferred to a well located within this area that is completed in the PRV or pre-Tertiary rocks. Pre-Tertiary rocks are exposed in the western part of the area along this conveyance alignment. The eastern and southern portion of the area is mantled by PRV; however, the PRV is likely thin on the west side of the faults defining the edge of the basin, and thus possibly less productive than in the City. Very few

wells exist in the vicinity of the Mountain Conveyance Line alignment; those that were identified are clustered within the PRV in closer proximity to the City and are generally shallow domestic wells with low yields. Consequently, the potential productivity of the PRV or pre-Tertiary aquifers near the conveyance line is not known, but is suspected to be low. Water quality data are not available from wells in this area, though the probability that groundwater derived from bedrock in this area would have similar chemistry as wells near the City is relatively high.

The overall potential for developing a high-capacity groundwater source in the vicinity of the Mountain Conveyance Line area is low because of the presence of the pre-Tertiary rocks, and the PRV present in the vicinity of the alignment, although uncharacterized, appears thin. The overall level of certainty in the assessment is low with regard to the potential to develop a high capacity source in the pre-Tertiary rocks, and moderate to high in the PRV because of the lack of information.

A disadvantage of siting a well along the Mountain Conveyance Line is that treatment would need to be installed at the wellhead to treat raw surface water should the City desire to implement ASR in this location to store water and manage water quality aesthetics. Similar to the Goodrich Conveyance Line, the level of required treatment prior to use for ASR would need to be investigated, but at a minimum would require chlorination before recharge. Power would need to be installed at the site, potentially requiring installation of new power lines over significant distances. Additionally, winter time accessibility to a site in this location may be a challenge.

Should the City determine that there are compelling reasons to develop a groundwater source in the vicinity of the Mountain Conveyance Line area, additional assessment would be done including drilling and testing one or more test wells at select locations to address the lack of information related to aquifer thickness and distribution, productivity, and water quality. However, due to the high cost of drilling a test well in the area (estimated at around $400,000 to $475,000), the City may opt to take the calculated risk of proceeding directly with drilling a production well.

West/Southwest Area

This area encompasses the southern portion of the City, including the locations of the City's Reservoir Well and Golf Course Well and the proposed location of the well listed on the City's new groundwater permit (G-17741). The area also hosts several other existing and historically productive wells, including the David Eccles Road Well (BAKE 1163), CalPac Well (BAKE 1164) and Paul Hill Well (1,100 gpm). The David Eccles Road Well is completed in alluvial sediments and the PRV aquifer, and the CalPac Well is completed entirely in the PRV. Reported yields of these wells range from 1,050 gpm (CalPac Well) to 2,000 gpm (David Eccles Road Well). The reported specific capacities are 7 to 20 gpm/ft. Water quality data are available from a few wells completed in the PRV. The quality of water from wells completed in this unit is generally good, although concentrations of several constituents (e.g., manganese, iron and hydrogen sulfide) render the aesthetic quality

objectionable, as noted earlier in the section describing the PRV unit.

The City's existing water rights could likely be transferred to a well located within this area. The advantages of locating a well in this area are; (1) the presence of existing distribution conveyance capable of accommodating a 2.5 mgd source, (2) the PRV aquifer is known to be productive, and (3) the well would be located downstream of the UVTF so treated source water would be available to conduct ASR at the well, if desired. Another potential consideration is that the City irrigates two large parcels in this area, the golf course and the cemetery. Raw water from a well(s) sited at one or both of these facilities could be used to irrigate one or both parcels and reduce the demand on the surface sources and UVTF.

The overall potential for developing a high-capacity groundwater source in the West/Southwest Area is high, based on the substantial thicknesses of productive PRV and several existing high-capacity wells completed in this area. The overall level of uncertainty in the assessment is moderate. Primary uncertainties for developing a high-capacity groundwater source in this area include (1) amount of potential interference from existing wells (e.g., the Reservoir Well), and (2) the hydraulic effect of faults mapped in the area. Addressing these uncertainties is important for understanding the overall feasibility of developing an additional 2.5 mgd of supply within this area.

The PRV aquifer is highly confined, meaning that the effects of pumping a well propagate relatively long distances. For example, well interference estimates suggest that interference drawdown at the location of the Golf Course Well from pumping the Reservoir Well for long durations should be between 50 and 100 feet. Simultaneous operation of a new well and the Reservoir Well with this magnitude of interference would substantially affect the yields of both.

Several faults that bound the edge of the valley transect this area (Figure 5-1). These faults create vertical offsets and potentially separate aquifer compartments in the PRV and pre-Tertiary rocks, which could reduce potential interference effects between wells located in separate compartments. Previous monitoring of the Golf Course Well and Paul Hill Well during testing and ASR operations of the Reservoir Well indicated minor to no hydraulic response at those wells. The lack of response between the Paul Hill Well and Reservoir Well suggests that the fault mapped between the two wells hydraulically separates the two wells. The same fault is mapped between the Reservoir Well and several other wells, including the Golf Course, David Eccles Road and CalPac wells. While a hydraulic response from operating the Reservoir Well has not been identified in the Golf Course Well, it is unknown whether the lack of response in the Golf Course Well is because of the fault or because the Golf Course Well is completed in a shallower water-producing zone. Consequently, water level monitoring in the Golf Course and either the David Eccles or CalPac wells in the area during operation of the Reservoir Well (injection and/or recovery) is recommended to verify whether faulting compartmentalizes the aquifer and the degree of interference to be expected between the Reservoir Well and a new well.

East Area

The East Side Area is located east of Interstate 84 in an area of potential future growth. This area is on the distal end of the City's distribution system and connected to the main part of the system by two lines under the interstate. The advantages of a new source in this area are that (1) it would provide redundancy to this area in case of disruption to the connections across the freeway, and (2) the connection to this area from the main part of the distribution system would allow water to be pushed in either direction, providing benefit to the system on the west side of the freeway and allowing use of the well for ASR. The City's existing water rights could likely be transferred to a well located within this area that is completed in the PRV or pre-Tertiary rocks.

Alluvial and volcanoclastic sediments are exposed in this area, and appear to be underlain by the PRV. Three existing wells were identified in the area (BAKE 1079, BAKE 1080 and BAKE 52344), providing some limited information regarding aquifer conditions. BAKE 1079 and BAKE 1080 were reported to have capacities of 2,200 and 1,500 gpm, respectively. Although all three of the wells bottom out in basalts of the PRV, they also are open to consolidated volcanic-derived sediments related to the PRV and it is unclear how much water is produced from the PRV versus sediments. Basalts of the PRV are found at significantly greater depths (500 to 700 feet bgs) in this area than in the West/Southwest Area, which potentially would increase well construction costs.

Some water quality data are available for this unit. Limited water quality data included elevated total dissolved solids and temperatures (66 to 78 degrees F) and the presence of hydrogen sulfide. Concentrations for several constituents (e.g., manganese and iron) were not reported, but are expected to be elevated based on the similarities with chemistries reported for the PRV wells in the West/Southwest Area. This area may have somewhat elevated potential for less desirable water quality characteristics.

The overall potential for developing a high-capacity groundwater source in the East Area is moderate. Several high-capacity wells exist in this area; however, the quantity of water drawn from the PRV in each of these wells, and thus the productivity of the PRV is unknown. The overall level of uncertainty in the assessment is correspondingly moderate to high. The amount of water derived from the PRV in existing wells in the area is unknown, and thus the productivity of the unit is similarly unknown.

On the basis of the identified uncertainties, the following investigation work is recommended prior to drilling a high-capacity supply well:

- Locate existing wells and test for production and water quality.
- Review water rights and evaluate existing wells for possible interference.
- Evaluate need for test well(s) and complete and test, as needed.

ASR

Existing ASR Operations

The City has been using ASR at its Reservoir Well to improve long-term yield and the quality of water delivered from the well when using it for supplemental and backup purposes. The City's ASR permit imposes two conditions that restricts the period of recharge and subordinates priority for the City's use of water for ASR recharge, placing limitations on the City's ability to divert water under existing water rights for ASR purposes, regardless of priority date. These conditions reduce the City's operational flexibility and potentially reduce the volume of water available to the City for ASR storage in its Reservoir Well. Evaluation of the feasibility of modifying these conditions merit consideration.

Another potential aspect of the current ASR system that might merit review and improve the efficiency of the overall water system is that UV treatment of water recovered from the ASR well appears to be redundant and unnecessary from a health or regulatory standpoint. An evaluation is recommended for whether a cost-effective alternative to the re-treatment of recovered ASR water is required. This would allow for more raw surface water to be treated and potentially reduce operational expenses.

ASR Expansion

Native groundwater from a well completed in the PRV likely would result in aesthetic and potential operational issues if put directly into the distribution system without treatment beyond chlorination. Similar to the City's existing ASR system, ASR could be used to improve water quality from a production well without installation of costly wellhead treatment (other than chlorination). Another potential benefit would be to sustain long-term aquifer yields where compartmentalization exacerbates drawdown. For these reasons, it is recommended that an evaluation is done of the feasibility of ASR operations at any new groundwater supply source.

Pilot testing and implementation of ASR at new wells would be completed under a new limited license separate from the City's existing ASR permit. Many feasibility and operational elements are well understood through the City's existing ASR system, and this knowledge should facilitate the feasibility evaluation and permitting. However, the ability of the City to implement ASR at one or more new production wells will depend in part on the availability of excess treated water from the City's surface sources. Currently the operational and physical constraints controlling the amount of water available for additional ASR recharge are not well understood and need further evaluation. OWRD has developed funding in recent years to offset costs associated with ASR feasibility evaluations and ASR project implementation costs that should be evaluated if the City expands its current ASR program.

Alternatives Evaluation

Three of four areas reviewed for this study have reasonable potential for developing 2.5 mgd

of groundwater source capacity and merit further evaluation as alternatives: the Goodrich Conveyance Line, the Southwest/West Area and the East Area. The Mountain Line alternative is not considered further in this evaluation because it has low potential of success and the cost of the feasibility analysis is high. In evaluating risks and benefits associated with each alternative, some additional factors were considered, including:

1. Siting a well(s) in the vicinity of large irrigation demands and using the well to supply those needs. This has several benefits, including (1) reducing the demand on surface sources; (2) reducing demand on the UVTF; and (3) exercising the well more regularly. The areas with larger irrigation uses include the municipal golf course, the cemetery, and the sports complex. The golf course and cemetery are located within the Southwest/West Area, and the sports complex is located on the north end of the City.
2. Achieving the goal of an additional 2.5 mgd of groundwater source capacity will likely require completion of more than one well, which would increase exploratory investigation costs for those areas where information regarding aquifer productivity and quality is sparse.
3. Implementation of ASR to improve water quality and address potential aquifer capacity limitations is limited to areas where treated source water is available.

Goodrich Conveyance Line Area

This alternative consists of installing one or more supply wells in the vicinity of the Goodrich Conveyance Line, and conveying the groundwater with raw surface water to the City's reservoir and UVTF. The City owns a property adjacent to the line that could be used to site a well. The advantages and disadvantages of this alternative are as follows:

<u>Advantages</u>

- The City's existing water rights could be transferred to a well completed in the PRV in this area.
- The Goodrich Line could be used to gravity-convey water from the source to the City.
- The City owns property along the line.
- Potentially suitable aquifers are present along at least a portion of the line.

<u>Disadvantages</u>

- Raw water from the well(s) would unnecessarily take up UVTF capacity, reducing available capacity for raw surface water.
- ASR could not be implemented in this area unless separate treatment for injection source water is installed because the area is upstream of the City's surface water UVTF.
- Probable long distance to available power and difficult wintertime access.

- The cost to evaluate uncertainties are high because the characteristics of the aquifer and potential well yields in this area are poorly understood.

West/Southwest Area

This alternative consists of installing one or more supply wells in the southwest or southern edge of the City. Water from the well(s) would be introduced directly into the distribution system after disinfection. The advantages and disadvantages of this alternative are as follows:

Advantages

- The City's existing water rights could be transferred to a well completed in the PRV in this area.
- The City owns property in this area, including two pieces that have significant irrigation demands (golf course and cemetery).
- Several high-capacity wells completed in the PRV exist in this area suggesting that the potential for siting a supply well with good yield is relatively high.
- Suitable conveyance is generally available for distributing produced water and delivering ASR source water.

Disadvantages

- Raw water from the well(s) likely would have aesthetic water quality issues, necessitating either installing wellhead treatment or implementing ASR to improve water quality.
- Some additional field evaluation is necessary to address uncertainties regarding the effects of potential interference and boundaries on well yields. The approximate cost to complete this evaluation is $20,000.

East Area

This alternative consists of installing one or more supply wells on the east side of I-84, and putting the water into the distribution system in that area. The advantages and disadvantages of this alternative are as follows:

Advantages

- The City's existing water rights could be transferred to a well completed in the PRV in this area.
- A source located in this area would provide redundancy in the event that the mains under the highway serving this area were rendered inoperable.
- Potentially suitable aquifers are present.
- ASR in this area would increase circulation in this isolated portion of the distribution system, improving water quality and reducing the potential for stagnation.

Disadvantages

- Raw water from the well(s) likely would have aesthetic water quality issues, necessitating either installing wellhead treatment or implementing ASR to improve water quality.
- Some additional field evaluation is necessary to address uncertainties regarding water quality and aquifer yield. The cost for an initial assessment of water quality and well yield potential involving testing, water quality sampling and potentially flow profiling of existing wells (assuming accessible) is between $40,000 and $60,000. Should this work be inconclusive, test drilling may be necessary.
- A test well, if the City elected to drill one, for a single site would cost approximately $400,000 to $475,000, or possibly more considering the depth to the PRV in this location. Due to the cost of a test well, the City might opt to assume the risk of proceeding directly to a production well.
- The cost to drill a production well will likely be significantly increased because the PRV aquifer is at greater depths than on the west side of the City and towards the mountain front.

Recommendations and Timeline

The following recommendations are made for expanding the City's groundwater supply based on our assessment of available information and data. These recommendations include assessing the City's existing ASR system to evaluate the potential for additional capacity, water right permitting modifications to increase operational flexibility, and locations for siting future groundwater supply wells to increase the City's cumulative groundwater supply and ASR capacity.

Optimize Current ASR System

Based on discussions with City staff and preliminary review of available project data, it is recommended that an evaluation be completed to optimize the Reservoir Well ASR performance and operational flexibility. Specifically, recommended are the following:

1. Evaluate Reservoir Well ASR performance data and operational characteristics to assess potential efficiencies in ASR operations.
2. Assess ASR source water availability, particularly during shoulder seasons to understand availability of water for increasing storage volumes at Reservoir Well and at new wells.
3. Evaluate the potential to complete administrative ASR permitting changes to enhance flexibility of ASR operations. This may include discussions with OWRD/DEQ/OHA regarding changes in water quality sampling frequencies and timing to reduce costs during short-term injection cycles and assess the potential to reduce limitations within the City's ASR permit related to diversions for aquifer recharge.

Estimated Timeline to Complete:

- 6 to 8 months

Water Rights

The City holds multiple groundwater right certificates, each separately authorizing use of the Reservoir Well, the Golf Course Well, and the CalPac Well. Although the Reservoir Well is currently used for ASR, recovering stored water at pumping rates up to 2,000 gallons per minute. The water right associated with the Reservoir Well also allows native groundwater pumping at a rate of 2,379 gpm, in addition to water stored using ASR. The groundwater rights associated with the Golf Course and CalPac wells allow a pumping rate of 254 gpm and 1,010 gpm, respectively, for municipal purposes. These wells are not currently available to be used for municipal purposes and therefore their groundwater authorizations have not been fully utilized in recent years. The City also has a newly approved water right application for 1,001 gpm at a future well location, providing a total, non-ASR municipal water right portfolio of 4,644 gpm.

Through the water right transfer process, OWRD allows adding a well(s) to an existing groundwater right(s) in the same aquifer, thereby permitting use of the well at the rate and volume of pumping allowed by the water right(s). For water right holders with multiple groundwater rights and multiple wells completed in the same aquifer, such as the City, this allows the flexibility to use any combination of the wells at the cumulative rate and volume authorized by the water rights. Completing a water right transfer application to add all of the City's wells as points of appropriation to each of the City's water rights, including proposed well locations for potential development in the near future is recommended. Additionally, the City's recent groundwater permit could be amended to include existing or proposed well locations. Completing this transfer will allow a maximum groundwater pumping rate of 4,644 gpm by use of any combination of the City's wells.

Estimated Timeline to Complete

- Transfer Application Preparation and Processing: 12 to 14 months

Groundwater Capacity Expansion

To meet the City's goal of developing 2.5 mgd of additional resilient supply capacity from a groundwater source, the following are recommended:

1. Drill one or more new wells, as needed, to develop the 2.5 mgd of long term capacity.
    - Based on the evaluation, locate the new well(s) within the West/Southwest Area, near either the golf course or the cemetery.
    - Potential well interference with the City's Reservoir Well is uncertain, which could diminish well yield at both the Reservoir Well and the new well. To assess potential well interference, groundwater level monitoring at the existing Golf Course Well and the David Eccles Road Well, if possible, are

recommended to assess observed interference from the Reservoir Well at those locations prior selection of a final well site. Although the existing Golf Course Well is not completed to the same depth as a proposed new well and the David Eccles Road Well is located approximately ½ mile east of the cemetery, water level data during ASR activities at the Reservoir Well may provide information beneficial to selection of either the Golf Course or cemetery as the preferred initial site, and will provide valuable information for design of the new well.

- For costing purposes, the well is assumed to be approximately 700 to 1,000 feet deep with a 300 to 400 foot seal and a 16-inch finished diameter.

2. Given the likely aesthetic water quality issues with native groundwater and other potential benefits of aquifer recharge including short term well yield, implementation of ASR at new wells is recommended. This recommendation is contingent on the availability of surface water for future recharge use. As described previously, it is likely that a new ASR limited license will need to be sought from OWRD for ASR pilot testing at new wells.

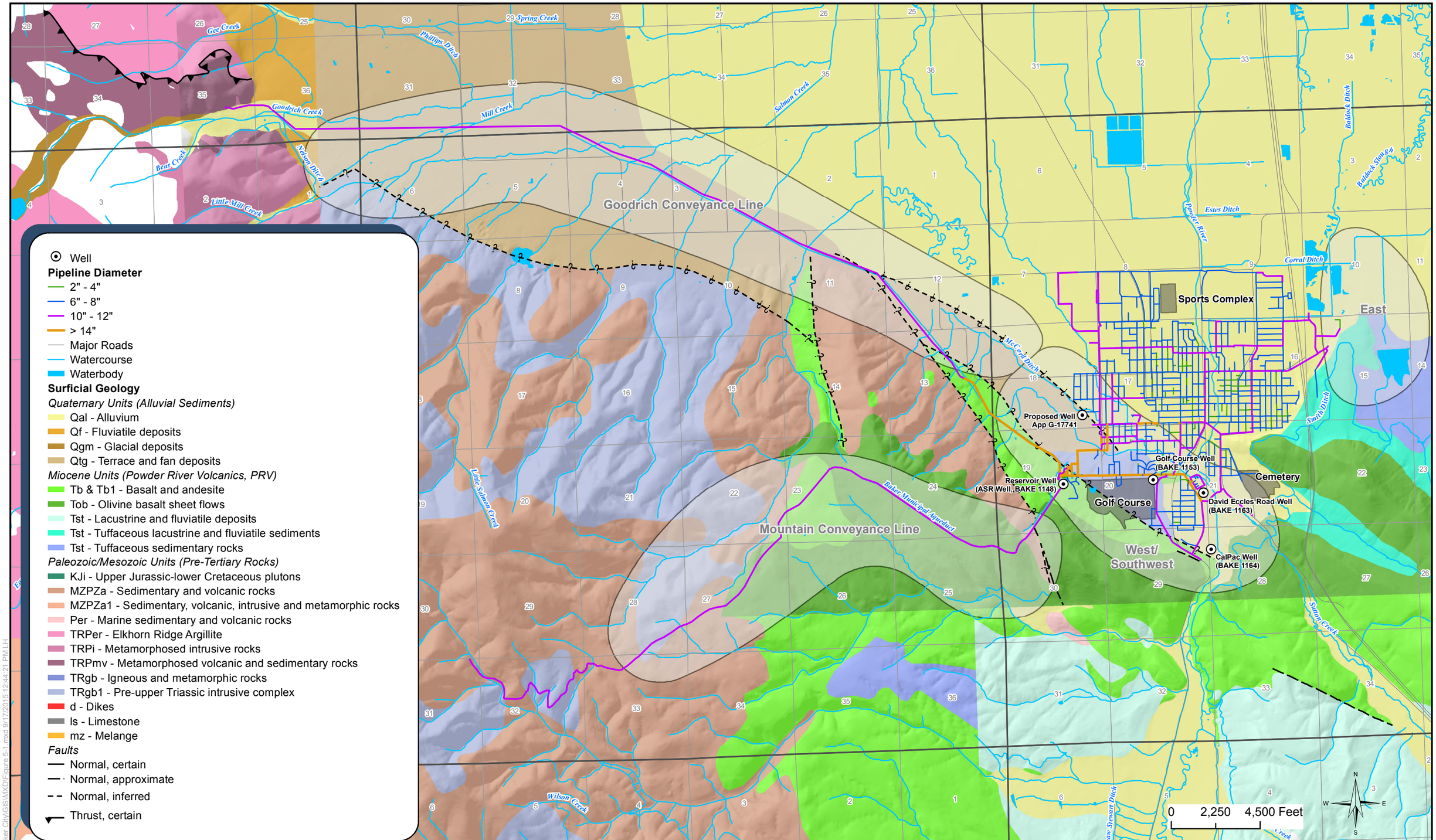
Estimated Timeline to Complete

- Groundwater Level Monitoring Prior to Drilling: 6 months
- Drilling and Testing: 8 to 10 months per well
- ASR Limited License Application Preparation and Processing: 10 to 12 months
- Pump Station Design & Construction:12 to 18 months

Roadmap

The following sequencing of the tasks outlined above is proposed:

- Initiate groundwater level monitoring at the Golf Course Well and the David Eccles Road Well, if possible, to evaluate interference at those locations from ASR activities at the Reservoir Well. Preferably, levels would be monitored continuously by pressure transducers and augmented with periodic manual water levels.
- Simultaneous to groundwater level monitoring, complete the ASR operational optimization tasks, capacity development assessment and initiate water right transfers to add existing and proposed well locations to all water rights. Conducted concurrently, the interference evaluation, ASR operation assessment, and water right transfer process could be completed in approximately 12 to 14 months.
- Once a site is selected based on the well interference evaluation, the City should complete well drilling and any testing and proceed with assessment of ASR and Limited License application with OWRD. Initial phases of well construction bid documents and well design could be started near the completion of the preliminary tasks above to reduce the overall project schedule.
- Based on well capacity and testing information, assess the need to move forward with a second well at the preferred remaining well site.



GSI Water Solutions, Inc.

MSA Murray, Smith & Associates, Inc.

City of Baker City
Water Facility Plan

Figure 5-1
Surficial Geology

BAKER CITY OREGON EST. 1874

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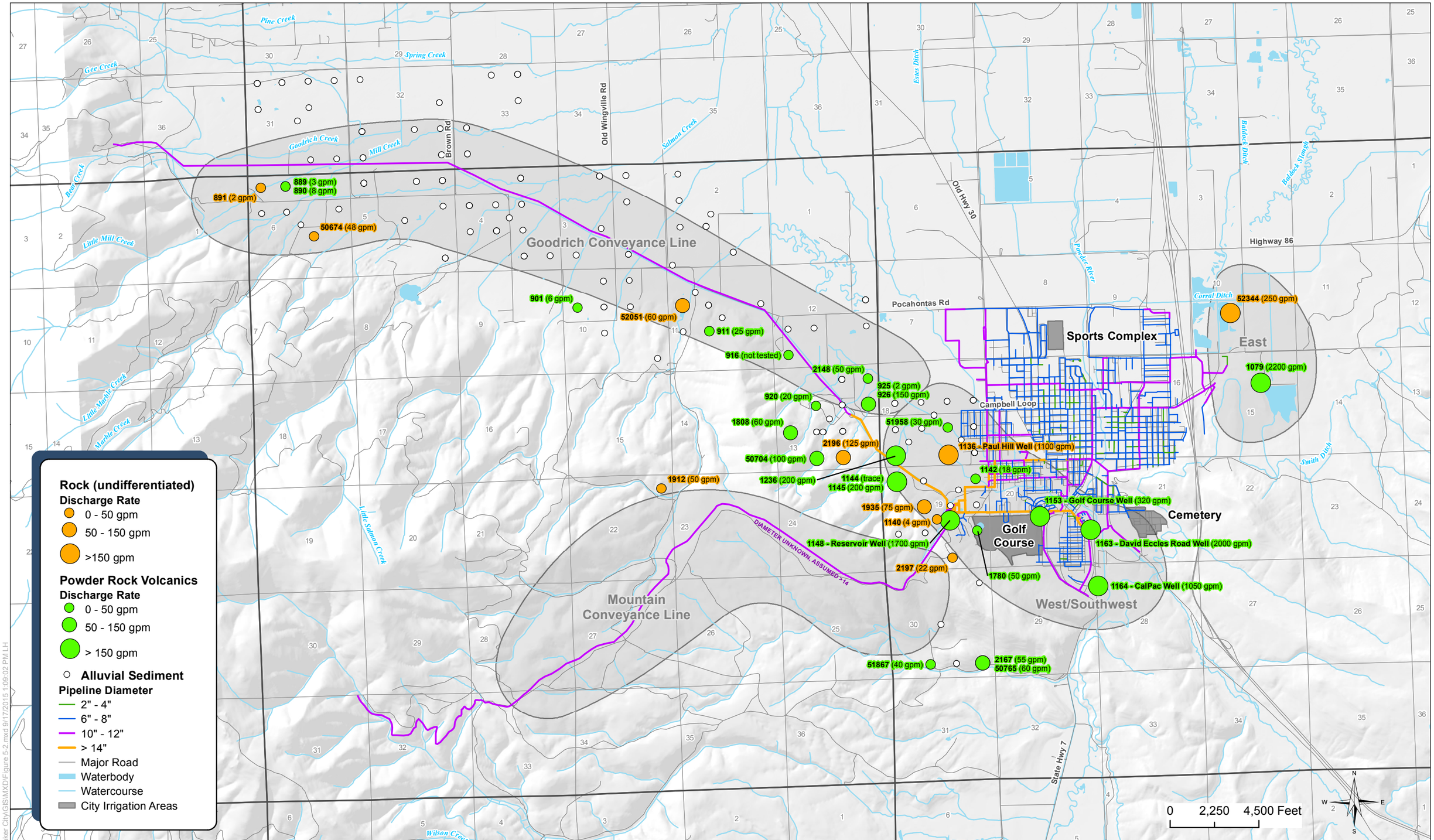

GSI Water Solutions, Inc.

MSA Murray, Smith & Associates, Inc.

City of Baker City
Water Facility Plan

Figure 5-2
Well Capacities

BAKER CITY OREGON EST. 1874

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February 2016 15-1636

Murray, Smith & Associates, Inc.
Engineers/Planners

Section 6

Water Quality and Regulations

SECTION 6
WATER QUALITY AND REGULATIONS

Introduction

Both state and federal agencies regulate public drinking water systems. For the federal government, the U.S. Environmental Protection Agency (EPA) establishes standards for water quality, monitoring requirements, and procedures for enforcement. Oregon, as a primacy state, has been given the primary authority for implementing EPA's rules within the state. The state agency which administers most of EPA's drinking water rules is the Oregon Health Authority (OHA), Drinking Water Services (DWS). DWS rules for water quality standards and monitoring are adopted directly from EPA. The DWS is required to adopt rules at least as stringent as federal rules; to date, the DWS has elected not to implement more stringent water quality or monitoring requirements. The City's goal is to deliver water to its customers that complies with all Safe Drinking Water Act requirements, as administered through the Oregon Health Authority Drinking Water Services.

In some areas not directly related to water quality, DWS rules cover a broader scope than EPA rules. These areas include general construction standards, cross connection control, backflow installation standards, and other water system operation and maintenance standards. The complete rules governing the DWS in the State of Oregon are contained in Oregon Administrative Rules (OAR) Chapter 333, Division 61, and Public Water Systems.

Drinking Water Regulations

The Safe Drinking Water Act (SDWA) was originally enacted in 1974 by Congress to ensure the quality of America's drinking water. In 1986, the SDWA was reauthorized and changed significantly. In 1996, Congress reauthorized the SDWA and made further changes. The SDWA contains the following assignments and programs for the EPA and states to administer including:

- State revolving loan fund for water system construction
- Public notification reports
- Source water assessment and protection
- Monitoring reductions based on source water protection
- Mandatory certification of operators

All of these assignments have been implemented by the EPA and the states. Progress on evaluation of potential contaminants continues with the unregulated contaminant sampling requirements and health effects research.

Disinfectants/Disinfection By-Products Rule

The Disinfectants/Disinfection By-Products (D/DBPs) rule and the Stage 1 D/DBP rule apply to all Community Water Systems and Non-Transient Non-Community Water Systems that treat water with a chemical disinfectant for primary or residual treatment. This rule is currently in effect and regulates Total Trihalomethanes (TTHMs) and Haloacetic Acids (HAA5s), which include:

TTHMs	HAA5s
Trichloromethane (chloroform)	Monochloroacetic acid
Tribromomethane (bromoform)	Dichloroacetic acid
Bromodichloromethane	Trichloroacetic acid
Dibromochloromethane	Monobromoacetic acid
	Dibromoacetic acid

The maximum contaminant level (MCL) for TTHMs and HAA5s in the Stage 1 D/DBP rule are typically calculated as the running annual average of quarterly samples at four distribution system sites per plant or entry point. The MCL for several constituents are listed in Table 6-1.

Table 6-1
Disinfectants/Disinfection By-Products Rule Constituent Summary

Constituent	MCL/Requirement (mg/L)
Chlorine/Chloramine	4.0
Bromate	0.010
Chlorite	1.0
TTHMs	0.080
HAA5s	0.060

The Stage 2 D/DBPs is a relatively recent rule that maintains the MCL levels established in the Stage 1 D/DBP rule and added maximum contaminant level goals (MCLGs) for four TTHMs and three HAA5s. The most significant change in the Stage 2 D/DBP is the requirement that the MCL be calculated on the locational running annual average of quarterly samples taken at locations to be determined by an Initial Distribution System Evaluation. The compliance sites consist of locations where high TTHMs are found, locations where high HAA5s are found and average detention time sites within the distribution system. The number of sites is based on the type of source water and population served. The rule provides for reduced monitoring for systems with very low disinfection by-products based on two years of existing data.

The City is currently in the compliance monitoring phase of Stage 2 and there are no anticipated compliance issues for the City under the D/DBP Rule.

Total Coliform Rule

The Total Coliform Rule (TCR) applies to all surface water and groundwater systems. Total coliforms include both fecal coliforms and *E. coli*. The MCLG for total coliforms is zero. Compliance with the MCL is based on the presence or absence of total coliforms in a sample. The MCL for systems analyzing less than 40 samples per month is that no more than one of the monthly samples may have total coliforms present.

Monthly monitoring requirements are based on the population served and based on the City's service area, it must collect 10 samples per month. A system must collect a set of repeat samples for each positive total coliform result and have it analyzed for total coliforms.

The City is currently meeting all applicable requirements for the Total Coliform Rule. It is important to maintain active circulation of water throughout the distribution system, in both pipes and reservoirs so as to retain a chlorine residual. The absence of chlorine residual and accumulation of sediments contribute to bacterial growth, which in turn can result in failure to comply with the TCR. Chlorine residuals in the City's system tend to be lower on the east side of town where demand is lower and there are more dead-ends. The City may want to consider looping current dead end pipes and flushing mains that have low demand to improve chlorine residuals.

Lead and Copper Rule

On June 7, 1991, the EPA published maximum contaminant level goals and regulations for lead and copper. In April 2000, the EPA Lead and Copper Rule Minor Revisions (LCRMR) took effect. The Lead and Copper Rule (LCR) regulation requires lead and copper to be monitored at consumers' taps every 6 months. One monitoring period is equivalent to six months, and two monitoring periods are required per calendar year (that is, January to June and July to December). The LCRMR did not change the action levels and they did not change the basic requirements to optimize corrosion control and, if needed, treat source water, deliver public education, and replace lead service lines. In October 2007, the EPA published the Short-term Revisions which added criteria for reduced sampling frequency for systems in compliance.

Water samples at the customer's tap are required to be taken at high-risk locations, which are defined as homes with the following conditions:

- Lead solder installed after 1982
- Lead service lines
- Lead interior piping

For a water system to comply with the LCR, the samples at the customer's tap must not exceed the following action levels:

- Lead - 0.015 mg/L detected in the 90th percentile of all samples
- Copper -1.3 mg/L detected in the 90th percentile of all samples

If the action levels are exceeded for either lead or copper, the water system is required to collect source water samples and submit the data with a treatment recommendation to the State. Additionally, if the action level is exceeded, the water system is required to present a public education program to its customers within 60 days of learning the results. The public education program must be continued as long as the water system exceeds the action levels.

All systems that exceed the lead or copper action level and all systems serving more than 50,000 persons are required to conduct corrosion control studies and optimize corrosion control at the customer tap. Corrosion control studies must compare the effectiveness of pH and alkalinity adjustment, calcium adjustment, and addition of a phosphate or silica-based corrosion inhibitor. In addition to lead and copper, systems which exceed the lead or copper action levels are required to monitor other water quality parameters.

After performing a corrosion control study, water systems are required to develop a corrosion control treatment plan based on study results and monitoring data and submit this plan to the DWS for approval. Once the treatment plan is approved by the State, the purveyor will have 24 months to install the optimal corrosion control treatment and 12 months to collect follow-up samples. Once monitoring has shown that corrosion control is effective, the regulatory agency will assign values for water quality parameters to be used to ensure that corrosion treatment is effective.

The City is currently on a reduced monitoring schedule per agreement with DWS for lead and copper at customer taps, collecting 20 samples every three years, and is meeting all applicable requirements of the Lead and Copper Rule.

Surface Water Treatment Rule

The Surface Water Treatment Rule (SWTR) was implemented in 1989 to reduce the potential for pathogenic contamination in drinking water. The rule has been updated multiple times with the last rule implemented in 2006. It applies to all public water systems that use surface water or groundwater under the direct influence of surface water. The SWTR addresses:

- Criteria under which filtration is required
- Performance criteria for filtration
- Disinfection requirements for both filtered and unfiltered systems
- Monitoring requirements for all surface water supplies

The SWTR started by requiring that source waters be treated to achieve a minimum 3-log (99.9%) removal and/or inactivation of *Giardia* cysts and a 4-log (99.99%) removal and/or

inactivation of enteric viruses. A 2-log (99%) removal of cryptosporidium has also been added to the rule.

The City is exempt from the requirement to filter, however the City is required to disinfect and monitor in accordance with the SWTR.

Watershed Protection

The SWTR also developed watershed protection requirements for filtered and unfiltered systems. Source protection is the first barrier in reducing drinking water contaminants. Watershed protection is a particularly important barrier for protection against organisms in unfiltered systems that rely on surface water.

Under the SWTR, public water systems must maintain a watershed control program that minimizes potential for source water contamination by viruses, Cryptosporidium oocysts and *Giardia* cysts. A watershed control program must accomplish the following objectives:

- Characterize watershed ownership and hydrology
- Identify characteristics of the watershed and activities within the watershed that might have an adverse effect on water quality
- Monitor the occurrence of activities which may have an adverse effect on source water quality

The public water system must demonstrate, through ownership and/or written agreements with landowners within the watershed, that it can control all human activities which may have an adverse impact on microbiological quality of the source water. Both natural and human-caused sources of watershed contamination to be controlled are listed in the EPA guidance manual for watershed protection. These sources include wild animal populations, wastewater treatment plants, grazing animals, feedlots and recreational activities.

The public water system must also be subject to an annual on-site inspection to assess the watershed control program and disinfection treatment process. A report of the on-site inspection summarizing all findings must be prepared every year.

The City had a cryptosporidium hit in 2010 and in 2013 the presence of cryptosporidium resulted in a cryptosporidiosis outbreak. The outbreak occurred during the monitoring phase, prior to the compliance deadline of October 2016 and prior to installation of the Ultraviolet Treatment Facility (UVTF) in November 2014. With the upgraded treatment, the City is currently in compliance with the SWTR.

Groundwater Rule

The Groundwater Rule (GR) took effect in Oregon in December 2009. The GR applies to all systems using groundwater that is not mixed and treated to the same standard as surface

water. Sanitary surveys are required every 3 years for most community water systems. Systems are required to notify the State if they will provide compliance monitoring reports that demonstrate 4-log inactivation of viruses or complete triggered source monitoring. Source water monitoring is required for systems that do not treat to 4-log viral inactivation and is triggered by a total coliform (TC) positive sample in the distribution system. One sample must be taken within 24 hours of a TC positive result at each source on-line at the time the TC sample was taken. Triggered source monitoring is not required for systems that demonstrate 4-log viral inactivation and submit monthly compliance monitoring reports.

If the State identifies significant deficiencies in a sanitary survey, corrective action is required and can consist of correcting deficiencies, providing an alternative source of water, eliminating the source of contamination, or providing treatment for the 4-log inactivation of viruses.

Although Marble Springs is classified as a groundwater source, it mixes with and is disinfected with the surface water supply. The Reservoir Well is the City's only active groundwater well. However, all water pumped from the well is currently mixed with surface water and treated at the UVTF to the same standard as the surface water. The City is evaluating additional groundwater sources to provide redundant supply and could require testing under the GR if any groundwater is pumped into the distribution system without treatment equivalent to the surface water source.

Chemical Contaminant Rules

The Chemical Contaminant Rules have been implemented in phases starting in 1987 and updated thereafter to cover 65 contaminants in three groups including inorganic, synthetic organic and volatile organic chemicals.

The City currently meets all requirements and tests for 50 organic chemicals.

Secondary Regulations

Starting in 1979, the secondary regulations are non-mandatory, not enforced standards set for 15 contaminants that are not health risks, but impact the aesthetic quality of water in areas such as taste, color and odor.

The City currently tests for secondary contaminants and has levels of iron and manganese in its groundwater supplies that present aesthetic concerns. The City uses aquifer storage and recovery (ASR) to inject treated surface water into the well to recover during high demand periods. The injection of surface water into the aquifer has reduced the levels of iron and manganese in the groundwater pumped from the ASR well. The City is considering the implementation of ASR at future groundwater wells if adequate recharge water can be obtained during non-irrigation months.

Future Drinking Water Regulations

The 1996 SDWA amendments require that the EPA maintain a Contaminant Candidate List (CCL) that contains contaminants not currently subject to any regulations, but that are known or anticipated to occur in public water systems. Largely based on review of the CCL, every five years the EPA is mandated to issue a new list of no more than 30 unregulated contaminants to be monitored by public water systems. The EPA uses the Unregulated Contaminant Monitoring program to collect data for contaminants that do not have health-based standards set under the SDWA but are suspected to be present in drinking water. The Unregulated Contaminant Monitoring Rule 3 (UCMR 3) was enacted by the EPA in May 2012, requiring monitoring for 28 chemicals and two viruses between 2013 and 2015. UCMR 3 requires different levels of monitoring based on the number of customers served by the water system. All systems serving over 10,000 people must sample for List 1 contaminants, but only 800 representative systems serving under 10,000 people will monitor for these contaminants. Only 480 systems serving 10,000 or fewer people will be required to monitor the List 2 contaminants.

The EPA also makes a regulatory determination on at least five contaminants from the most recent CCL to determine if they should initiate a process to develop a national primary drinking water regulation for a specific contaminant. The data collected under UCMR contributes to the regulatory decisions regarding contaminants. In addition the EPA is required to review each existing national primary drinking water regulation at least once every six years and revise them if appropriate. Through these processes new or revised regulations can be introduced.

As a system serving under 10,000 people, the City is not currently one of the representative smaller systems participating in the UCMR. No specific future regulatory requirements are known at this time that would impact City compliance. Should the regulations for iron or manganese change, the City's groundwater sources could be impacted. However, the City plans to continue to use ASR to mitigate these issues in the native groundwater. Additionally, if the City customer population goes above 10,000 water quality monitoring requirements will change.

The City should remain aware of the potential for changes in drinking water regulations, including testing requirements and, as it has in the past, adapt to regulatory adjustments to maintain its goal to deliver consistent water quality to its customers and to comply with all SWDA requirements, as administered through DWS.

Chlorination Alternatives

Currently the City uses chlorine gas for disinfection purposes. Primarily for health and safety reasons it is recommended that the existing chlorine gas disinfection system be replaced. Generally there are six different secondary disinfection treatments for maintaining a chlorine residual in the distribution system: chlorine gas, hypochlorination, chlorine dioxide, chloramines, on-site hypochlorite generation and tablet chlorinators. Due to

effectiveness, safety and maintenance advantages, it is recommended the City replace the current system with a sodium hypochlorite system. The City would have two options for implementing a sodium hypochlorite system using either on-site generation or bulk delivery. Whichever system is selected, redundant chlorination components are required by OAR for any unfiltered surface water sources.

On-Site Chlorine Generation

On-site generation systems are manufactured as automated package systems that typically include a brine tank, an oxidant tank, a water softener, a water heater, a brine proportioner or rectifier and electrolyte cells. Electrical current is used to produce a dilute sodium hypochlorite solution from a brine (dissolved salt) solution. This process uses a saturated brine solution from which a proportioning pump withdraws brine and water to make a 3% salt solution. The dilute salt solution is transferred to electrolytic cells, where a dilute sodium hypochlorite solution (0.8%) is generated; this strength of hypochlorite is less than 1/6 the strength of household bleach. Sodium hypochlorite may be generated based on storage tank level, and the dosing system may be flow-paced. The solution can be stored, with no risk of degradation, until it is ready to use. Sodium hypochlorite may increase the water's pH which tends to reduce the disinfection effectiveness, so dosing levels will need to be monitored to produce the desired disinfection.

Since the product of on-site chlorine generation is dilute and the feedstock is a brine solution, the building is not subject to hazardous material regulations. Further, staff do not have to contend with hazardous chemical handling issues. The only by-product of the reaction is hydrogen gas, and it is produced in quantities which are significantly less than the fire and building code action levels. The hydrogen is safely vented to the atmosphere by piping from the electrolyte cells and storage tank to the outdoors.

Bulk Delivery

Bulk sodium hypochlorite is sold as a 12.5% concentrated solution in 5, 15 and 53-gallon drums or in bulk delivery (typically 4,300 gallons). A gallon of 12.5% solution provides the equivalent of 1.04 pounds of chlorine gas. Unlike the dilute product of on-site generation, bulk sodium hypochlorite is subject to degradation in strength. Degradation rates increase with increasing concentration, temperature, and the presence of iron, copper, cobalt, nickel, or other impurities. Chemical degradation can lead to the need to vary the chemical feed rate and maintenance problems associated with the generation of gas. A common practice for preservation of the bulk liquid is dilution to a 6-8% concentration and temperature control of the storage facility if the bulk solution will be stored for more than a month. As with hypochlorite generated on-site, the bulk sodium hypochlorite solution may increase the water's pH which tends to reduce the disinfection effectiveness, so dosing levels will need to be monitored to produce the desired disinfection.

Sodium hypochlorite is a listed hazardous liquid and can require H7 occupancy regulations when more than 500 gallons are stored in one location. In addition, staff handling the liquid

must take special precautions. Rubber gloves, eyewash stations, and showers are the minimum required safety equipment.

A complete disinfection system would include multiple 53-gallon drums or a holding tank and transfer pump, a dosing pump system and electronic controls.

Recommendation

On-site generation of 0.8% sodium hypochlorite is a safer alternative since the only chemical required for delivery is sodium chloride salt and the hypochlorite solution generated is about 15 times more dilute than a 12.5% solution. Capital costs are higher for on-site generation but operating costs are typically lower, therefore a life cycle analysis is generally required to determine if it is more economical than 12.5% solution. Should the City wish to consider this option, a life cycle cost comparison and a more detailed assessment of the non-monetary considerations for this application should be conducted as part of a preliminary design study.

Iron and Manganese Treatment Analysis

City wells have shown high levels of iron and manganese, which are not a health hazard, but impact the quality and customer satisfaction with the water, resulting in the City's desire to mitigate the iron and manganese levels. Currently ASR is being used to condition the aquifer and improve the quality of the groundwater delivered to the system.

The City may decide to construct additional groundwater wells to provide redundancy for the surface water supply. Any new wells are likely to be high in iron and manganese and require treatment or ASR conditioning. While ASR has worked on the City's current production well, construction of traditional treatment may be required to manage iron and manganese in native groundwater should the City be unable to implement ASR at new wells. If treatment is necessary, there are five general alternatives that may be considered for reduction of iron and manganese: oxidation/filtration, cation exchange, reverse osmosis, sequestration and biological removal. Each of these is described briefly below.

Oxidation/Filtration

Oxidation converts the iron and manganese from soluble forms to forms that precipitate out of solution. The oxidized, precipitated contaminants in the treated water are then filtrated through a granular media. Manganese-oxide media – such as Greensand or Pyrolusite – that combine adsorptive and catalytic properties with granular media filtration properties, are commonly used to remove iron and manganese to acceptable levels. Chlorine and potassium permanganate are most commonly used to oxidize the dissolved iron and manganese in the source water. This technology yields good results at high and low concentration of manganese and iron although the filtration time increases when treating high concentrations. The oxidation process is pH sensitive which may require additional chemicals to control.

Cation Exchange

Through cation exchange, dissolved iron and manganese ions are replaced in the source water by sodium or potassium ions. The iron and manganese adsorb to the cation exchange media, releasing sodium or potassium into the treated water. When the media's capacity to adsorb iron and manganese is exhausted, it is regenerated using either sodium or potassium chloride. Over time, the media's ability to be regenerated declines and the media must be replaced. Sodium is the most common exchange cation. If increased sodium concentration in the treated water is a concern, potassium may be used. However, the cost for potassium salt is much higher. This system is suitable for the removal of small quantities of iron and manganese (iron, manganese, or a combination of the two should not exceed 0.3 mg/l).

Reverse Osmosis

Reverse osmosis uses high pressure to pass water through semi-permeable membranes to separate the water from the dissolved solids. The iron, manganese and other dissolved solids remain on the pressurized side of the membrane creating a concentrated waste stream and water – largely free of iron, manganese and other dissolved solids – passes through the membrane. Water treated in this manner may be very deteriorative due to the low total dissolved solids content. To control corrosion in the distribution system, it may be necessary to treat the water further prior to distribution. This adds to the cost and complexity of operations.

Sequestration

Sequestration is the only treatment technique that does not actually remove the constituents from the water. In this approach, low levels of dissolved iron and manganese are treated by the addition of phosphate to the source water. Phosphate allows the dissolved metals to stay in solution, delaying the precipitation of oxidized manganese and iron, thereby mitigating water quality issues. It is recommended that this technique not be used if the combined concentration of iron and manganese exceeds 0.3 mg/l. In addition, sequestration is problematic in distribution systems that have multiple sources. Where these different sources meet and mix within the system, the sequestration process may cease to function properly and aesthetic issues may once again arise within the mixing zone.

Biological Removal

For biological removal to be effective, raw water is aerated to raise the dissolved oxygen concentration to a range where biological oxidation takes place. The source water is then filtered through a system containing iron and manganese bacteria for metals reduction. Iron and manganese bacteria require different environmental conditions for optimal growth, typically resulting in a two part filtration process to remove iron and manganese. The pH must be adjusted between these two filters and may need to be adjusted prior to the first filter as well. Along with the bacteria's sensitivity to temperature and backwashing effects, the need for pH adjustment increases the system's operational complexity. A pH level above 7.0

is needed to make manganese removal possible and a pH level between 6.0 and 8.0 is needed for iron removal. These systems may generate a sludge that settles more easily than chemically oxidized water.

Recommendation

Oxidation/Filtration treatment is the most common recommendation for iron and manganese problems due to its robust ability to handle low or high concentration and it is commonly the most cost effective solution in the long term. Should the City wish to consider implementation of iron and manganese treatment, a life cycle cost comparison and a more detailed assessment of the alternatives for each water supply source should be performed during a preliminary design to verify the correct option is implemented.

Membrane Filtration Plant Analysis

One of the City's ongoing concerns is the impact of a widespread fire within the watershed. Such an event could cause subsequent runoff to be high in sediment and therefore unusable in the City's currently unfiltered system. To utilize water high in sediment for potable purposes, the City would be required to filter prior to treatment and distribution. In order to gain a better understanding of the costs to implement filtration, the City had HDR Engineering, Inc. provide a cost estimate for membrane filtration in a November 2009 Technical Memorandum titled "Disinfection Options to Comply with LT2ESWTR." That memorandum focused primarily on options for disinfection and provided a cost estimate for a filtration plant, should filtration become necessary. Few details were provided about the assumptions that were made in developing the membrane filtration cost estimate. It did indicate that the plant capacity was assumed to be 12 mgd with an average operating capacity of 4 mgd.

Membrane filtration was the most expensive option reviewed and recommended only if the unfiltered status of the source water was threatened. The capital cost estimate provided by HDR for membrane filtration was $17.7 million in June 2009 dollars. It included a construction contingency of 30% of the base construction cost estimate plus engineering design and construction services estimated at 25% of construction costs. Escalated to July 2015 dollars, the $17.7 million cost is estimated at $21.2 million.

Without knowing the details of whether the construction cost estimate included any modifications to raw water intake and transmission facilities or any finished water storage, it is difficult to evaluate this estimate. However, this is a reasonable cost estimate for a new 12 mgd membrane filtration plant assuming the following:

- Includes a new building for housing the filter equipment, complete with all required electrical, plumbing and HVAC facilities.

- Covers all membrane filtration equipment and all ancillary treatment equipment including storage and feed systems for pre- and post-membrane treatment and chemical clean-in-place systems for membrane maintenance.
- Covers all instrumentation and controls equipment and integration.
- Building is of standard slab on grade construction with concrete masonry unit walls and no significant improvements required to improve the subgrade.
- Building does not require any costly architectural finishes to accommodate location in an historic district or other architecturally sensitive area.
- Covers civil site work on a relatively level, readily constructible green field site.
- Includes the yard piping located on the site.
- Utilities are nearby, including access road, storm sewer, sanitary sewer and three phase power.

It would be reasonable to assume that the cost estimate does not cover:

- Property acquisition for the filtration plant site.
- Significant length of new or upgraded access road to accommodate a remote facility.
- Extending three phase power service a significant distance to accommodate a remote facility.
- A new intake or significant modifications to the existing intake.
- New raw or finished water transmission piping or significant modifications to existing piping.

Summary

Water Quality Regulations

The 1974 SDWA and later amendments authorize the EPA to establish standards for water quality. In Oregon these standards are administered by the OHA DWS. The Baker City water system is regulated by and in compliance with the following water quality regulations:

- Disinfectants/Disinfection By-Products Rule
- Total Coliform Rule
- Lead and Copper Rule
- Surface Water Treatment Rule
- Groundwater Rule
- Chemical Contaminant Rules
- Secondary Regulations
- Unregulated Contaminant Rule

Chlorination Alternatives

Currently the City uses chlorine gas for disinfection treatment. Primarily for health and safety reasons it is recommended that the existing chlorine gas disinfection system be replaced. Due to effectiveness, safety and maintenance advantages, it is recommended the City replace the current system with an on-site generation sodium hypochlorite system (including redundant components). Should the City wish to consider this option, a life cycle cost comparison and a more detailed assessment of the non-monetary considerations for this application should be made during a preliminary design study.

Iron and Manganese Treatment

City wells have shown high levels of iron and manganese, which are not a health hazard, but impact the quality and customer satisfaction with the water, resulting in the City's desire to mitigate the iron and manganese levels. The City should continue to utilize ASR to mitigate the iron and manganese levels in the Reservoir Well and any new wells. If adequate recharge water is not available for ASR or the aquifer conditioning does not prove effective at future sites, oxidation/filtration treatment is recommended. Oxidation/filtration is the most common recommendation for iron and manganese problems due to its robust ability to handle a wide range of concentrations and it is commonly the most cost effective solution in the long term. Should the City wish to consider implementation of iron and manganese treatment, a life cycle cost comparison and a more detailed assessment of the alternatives for each water supply source should be performed during a preliminary design to verify the correct option is implemented.

Membrane Filtration Plant Cost

HDR Engineering, Inc. provided a cost estimate for membrane filtration in a November 2009 Technical Memorandum titled "Disinfection Options to Comply with LT2ESWTR." The costs are based on a plant capacity of 12 mgd and are estimated at $17.7 million in 2009 dollars. The estimate included a contingency of 30% of the base construction cost estimate plus engineering design and construction services estimated at 25% of construction costs. The cost escalated from June 2009 dollars to July 2015 dollars is $21.2 million.

The primary driver for the implementation of membrane filtration is to enable the City to utilize surface water with high levels of sediment after a fire in the watershed. An initial lower cost supply option would be to develop additional groundwater wells within the system to provide a minimum level of redundancy during a catastrophic watershed fire. While groundwater alone may not be able to meet maximum day demands, a reliable average day source should be able to be developed that could supply the system during an emergency event. Per the analysis performed in Section 5-Groundwater Source Capacity Expansion Evaluation, it is believed that one or two additional groundwater wells can be developed in the City's service area to provide redundancy for the surface water supply and help meet peak summer demands.

Murray, Smith & Associates, Inc.
Engineers/Planners

Section 7

Capital Improvement Plan

SECTION 7
CAPITAL IMPROVEMENT PLAN

Introduction

This section describes the recommended water system improvements to the City of Baker City's (City's) service area to address deficiencies identified in Section 4-System Analysis and Section 5-Groundwater Capacity Expansion Evaluation. It includes projects recommended under 1- to 5 and 6- to 20-year planning horizons in addition to longer-term supply and distribution pipe replacement. The recommended improvement projects are shown in Figure 7-1 and summarized in Tables 7-1 and 7-2. The total cost of projects within the 1- to 5-year timeframe is approximately $6.2 million and within the 6- to 20-year timeframe is approximately $33.4 million.

Cost Estimates

All project descriptions and estimates represent AACE International Class 5, planning-level accuracy and opinions of costs (+50%, -30%). These cost estimates adhere to the definitions and dictates in OAR 660-011-0005(2) and 660-011-0035 for public facilities planning. Total project costs will depend on actual labor and material costs, site conditions, competitive market conditions, regulatory requirements, project schedule, and other factors. During the design phase, final sizing, location and project components should be verified and a Preliminary Engineering Report completed. As part of the Preliminary Engineering Report or predesign, the cost estimate should be refined. Therefore, project feasibility and any associated risks should be carefully reviewed prior to making specific financial decisions or establishing yearly project budgets to help ensure adequate project funding.

All project costs presented in this Water Facility Plan (WFP) are developed in 2015 dollars, using the 2015 RSMeans Heavy Construction Cost Data, City input, construction costs for similar projects across the Northwest, and local contractor and supplier rates. The project costs presented in this WFP include estimated construction charges, and allow for contingency, permitting, legal, administrative, and engineering fees. Costs do not typically include any land or right-of-way acquisition (except Bridge Street Well Costs). Construction costs are based on the preliminary concepts and layouts of the water system components developed during the system analysis. The detailed cost methodology is presented in Appendix C. The City performs a significant amount of its pipeline replacement, particularly for supply piping, so only material costs are included for supply piping. To be conservative, distribution piping costs assume contracted engineering and labor.

Project Descriptions

The City generally has a well looped distribution system which provides acceptable pressures to customers, with relatively few deficient locations. There are a number of locations in the system with undersized, poor quality and older mains that should be replaced over time. The

City is planning to implement a long term distribution system pipe replacement program in the 20 year timeframe if adequate funding can be identified. In some locations inadequate fire flows are available due to a lack of looping, small mains or both. The City is planning to install a new groundwater well in the next 5 years and depending on the location, some additional piping may be required to ensure adequate transmission is in place to distribute the water. The City also intends to continue to replace the remaining portions of the Mountain Line supply piping. As part of this WFP the evaluation of constructing an additional hydropower facility at Forebay was completed and is recommended for consideration in the 20 year Capital Improvement Plan (CIP). Based on the hydropower analysis (See Appendix B), no improvements to the existing hydropower facility are recommended in the near-term.

Based on the overall system analysis, the following projects are recommended:

- One or two new well facilities
- Replacement of the remaining portions of the Mountain Line
- Implement long term distribution pipe replacement program
- New hydropower facility at Forebay
- Scenic Vista Pump Station upgrade

Projects are depicted in Figure 7-1 and are described below. As the City annually reviews system needs and budget constraints, the list of projects to be constructed may vary from the recommendations in this section. A near term rate study is recommended to assist the City in evaluating alternative rate and user fee structures and for determining a short and long term financial strategy. It is also recommended that the City update this WFP and associated CIP periodically to ensure projects meet current system requirements.

The CIP is not anticipated to result in environmental impacts, although individual projects could result in temporary impacts during construction. The City is required to comply with environmental permitting and provide mitigation measures in compliance with all local, state and federal environmental regulations.

Supply Projects

Although there is adequate supply to meet MDD for the forecasted 20 year period, the City is concerned about the lack of redundancy to meet demand if the surface water supply was compromised. As a result, it is recommended the City expand the groundwater supply by drilling one new well in the 5-year timeframe and another well within the 20-year timeframe.

If feasible, these wells should be designed to allow for aquifer storage and recovery (ASR) similar to the City's existing Reservoir Well. ASR should help reduce iron and manganese aesthetic issues in the groundwater. The potential well locations are discussed in detail in Section 5. The recommended locations include the golf course and near Bridge Street, as shown in Figure 7-1. The well costs, depending on location are between $2.3 and $3.1

million. These costs assume that the City foregoes drilling a test well since the costs to drill a test well are significant, similar to those of a full production well. The golf course location is estimated to cost less than the Bridge Street location. The Bridge Street location would require property acquisition (property costs are included in this project only) and several hundred feet of piping to connect it into the existing system, where the golf course location is near a major water transmission main. As a result, the golf course location has been recommended as the initial site, however the final siting will be determined through additional hydrogeologic testing.

Professional services to improve and expand the City's water supply are needed including: hydrogeologic testing, optimization of the existing ASR operation, transfer of water rights and coordination with Oregon Water Resources Department, as described in Section 5. Most of these services will occur prior to or coincident with constructing the first new well. The cost of the services outside of those included in the new well project cost is estimated at $60,000 over the next five years

Due to uncertainty related to the ultimate production capacity of a new well, the timing and need for a second well should be assessed once the new facility is operational.

The existing Reservoir Well will require some rehabilitation and maintenance in the 5-year horizon to address encrustation. The funding for these projects will likely be a combination of operations and maintenance and capital funds depending on the availability of funding.

Supply Pipeline Projects

Most of the City's 40 miles of surface water supply piping is old and has high leakage rates. The City has started to replace the supply piping, however still has a significant amount of piping to install prior to completion. The replacement of a final section of piping between the Elk Creek Settling Basin and Forebay is required prior to the installation of any additional hydropower generation at the Forebay site. The City plans to continue work on the Mountain Line in subsequent years based on available funding. The City plans to self-perform the construction work on the supply lines. The rate of installation will be impacted by seasonal conditions, specific installation conditions, staffing availability and to a lesser degree material costs. Based on a recent vendor quote, the material cost (2015 dollars) for 20-inch ductile iron piping without any fittings, is $388,000 per mile. The City's goal is to install at least one mile of pipe per year.

Distribution Pipeline Projects

Based on industry standard guidance and conversations with City staff an aspirational goal of replacing the distribution system piping on a 100-year schedule was identified. The analysis of the system's distribution piping concluded that the City should replace approximately 4,100 feet (0.77 miles) of distribution pipeline per year, starting with the identified fire flow deficiencies, undersized (less than or equal to 4-inch) and older cast iron piping, as identified in Section 4. Specific projects have been identified at fire flow deficient locations. City staff

has provided input relative to the prioritization of the fire flow improvements. Pipe replacement projects should be identified annually using the mentioned criteria, in coordination with road work or other underground utility work. At a 100-year pipe life replacement cycle, the distribution pipeline replacement program is estimated to cost approximately $870,000 annually. Although it will not be fully funded in the first five years, the City intends to do replacements as funding allows.

Based on the projections in Section 3-Water Requirements, although minimal growth is anticipated, most of the growth within the City is expected to occur in the northern half of the urban growth boundary. Two projects are recommended to expand the system in this area. These projects are recommended beyond the 5-year horizon, but should be built in cooperation with development in these areas.

Hydropower Projects

The City currently operates a hydropower facility near the Ultraviolet Treatment Facility (UVTF). The facility captures the elevation difference between the Forebay facility and the UVTF. There is a generally equivalent elevation difference between the Elk Creek Settling Tank and Forebay that is currently not captured for hydropower. Adding a new 6 mgd hydropower facility at Forebay would capture this energy and approximately double the power generating capacity. This project is estimated to cost approximately $1.7 million, with just over a 20 year return on investment, assuming a $0.06/kWH electricity sale rate. As noted above, an additional section of the Mountain Line between the Elk Creek Settling Tank and Forebay must be replaced prior to the implementation of hydropower. A new facility at Forebay may be worthwhile within the 20-year horizon based on improvement status of the Mountain Line supply piping, estimated flow through the facility, a reassessment of the power purchase price, and availability of funding options to build the facility. An updated analysis of the hydropower options and any details of a selected option should be evaluated prior to implementation of a hydropower project.

Pump Station Projects

As mentioned in Section 4, the Scenic Vista area does not currently have adequate fire flow protection. When the Scenic Vista Zone was created, it was not intended to provide fire flow capacity, which the City and residents in the zone are aware of. In order to provide adequate fire flows, the existing pump station would need to be replaced or significantly expanded and some piping within the zone would need to be replaced with larger conduit. The cost for this improvement is estimated at $1.2 million and recommended within the 20-year horizon.

Other Projects

In addition to the facility and pipeline projects mentioned, the City has a number of ongoing system projects including customer meter and hydrant replacements. As mentioned in Section 4, the City would like to increase the replacement rates for these programs based on industry standards. The three anode beds will also need to be replaced within the 20-year

timeframe. The City also needs to connect the existing production meters to the supervisory control and data acquisition (SCADA) system and replace the meter at the discharge of the 3MG Tank. Additionally, the City should plan to update this WFP and have another financial evaluation done. As mentioned in Section 6-Water Quality and Regulations, to minimize safety concerns, the City should transition from chlorine gas disinfection to on-site sodium hypochlorite production (including redundant components) at the chlorine reservoir.

In addition to the proposed projects, the City has ongoing debt repayment for the UVTF of approximately $125,000 annually over the next 20 years which must be funded. A brief financial summary is included in Section 8-Financial Summary, providing a high level overview of the City's current water system financial status. A comprehensive water rate study is recommended in 2016 which would include the evaluation of alternative rate structures and an update in user fees. The water rate study is critical to ensuring the City can fund the identified CIP.

Improvements by Timeframe

Recommended projects to be implemented by 2020 (years 1 to 5) and 2035 (years 6 to 20) are summarized in Tables 7-1 and 7-2. The tables present each project ID, name, description, and total cost. The proposed locations of improvements in Figure 7-1 and these tables are based on conceptual data available when this WFP was prepared. The actual location, routing, type, or size of any project may vary from what is shown, because of actual physical conditions, the timing of development, the availability or cost of rights-of-way or easements, final engineering design considerations, or other similar reasons. To the extent any planned future water improvement is shown on private property, the location is only approximate and does not constrain or limit development on that property.

Table 7-1
Summary of 5-year CIP Projects (Years 1-5)

Project Type	ID	Name	Description	Total Cost[1]
Supply	W-1	Golf Course Well	New well and associated piping at the golf course to replace the existing Golf Course Well and provide supply redundancy. Identified at approximately 1,400 gpm, 550 ft of head.	$2,295,000
	W-2	Reservoir Well Rehab	Rehabilitation of the Reservoir Well to address encrustation of the liner.	$110,000[2]
	S-1	Groundwater Services Support	Professional services for supply capacity expansion through hydrogeologic testing, water rights transfer, and ASR optimization.	$60,000
	S-2	Supply Pipeline	Continued replacement of the Mountain Line with 20 to 30 inch pipe.	$500,000/year[3]
Distribution Pipeline	P-1	High School Fire Flow Improvement	Address fire flow deficiency by creating a loop around high school field by adding new and replacing old piping with 8-inch. (530 ft)	$108,000
	P-2	Estes St. River Crossing Fire Flow Improvement	Address fire flow deficiency by adding new pipe to cross Powder River on Estes St. and replace 4-inch pipe in Estes St. with 8-inch pipe. (900 ft)	$212,000
	P-3	Clifford St. Dead-end & River Crossing Fire Flow Improvement	Address fire flow deficiency by replacing 4-inch dead-end on Clifford St. with new 8-inch pipe and an 8-inch crossing of Powder River on Washington St. (580 ft)	$135,000
	P-4	East St. Extension Fire Flow Improvement	Address fire flow deficiency by extending piping on East St. between Campbell St. and D St. with new 8-inch pipe. (735 ft)	$144,000
	P-5	Oregon St. Loop Fire Flow Improvement	Address fire flow deficiency by looping Oregon St. and Foothill Dr. with 8-inch pipe across State Highway 7. (410 ft)	$104,000
Other	O-1	Financial Evaluation	Complete financial evaluation and rate study.	$25,000
	O-2	Miscellaneous System Improvements	Meter replacement, hydrant replacement, pipe extensions, SCADA improvements, etc.	$100,000/year
	O-3	3MG Flow Meter	New flow meter at the discharge of the 3MG Tank.	$40,000
5-Year Total				**$6,233,000**
Annual Average				**$1,246,600**

[1] *Total Cost: Project estimates are based on the type and size of projects identified in this WFP and in accordance with the guidelines of AACE International Class 5 Estimates, with a typical accuracy of -30% to +50%. Project estimates are based on 2015 dollars and include design, construction, and site-specific information (unless noted otherwise) as described in Appendix C.*

[2] *Cost only includes material, labor, contractor and professional services. Does not include contingency, mobilization or other fees.*

[3] *The City generally self-performs supply pipeline replacement, so cost is for pipe and materials only and does not include design or construction and does not represent a total project cost.*

Table 7-2
Summary of 20-year CIP Projects (Years 6-20)

Project Type	ID	Name	Description	Total Cost[1]
Supply	W-3	Bridge Street Well	New groundwater well off Bridge Street to provide supply redundancy. Cost includes property acquisition and mainline extensions. Identified at approximately 1,400 gpm, 550 ft of head.	$3,070,000
	S-2	Supply Pipeline	Continued replacement of the Mountain Line with 20 to 30 inch pipe.	$500,000/year[2]
	S-3	Groundwater Services Support	Professional services for hydrogeologic testing.	$40,000
Distribution Pipeline	P-6 thru P-10	Distribution Pipe Replacement	Annual pipe replacement program and address remaining fire flow deficiencies.	$870,000/year
	P-11	Development Contingent Distribution Pipe Expansion	New 12-inch pipe along Best Frontage Road, across I-84 along Highway 86 and down Cedar Road.	$2,928,000
	P-12	Development Contingent Distribution Pipe Expansion	New 12-inch pipe along Highway 30 and Chico Road.	$1,817,000
Hydro power	H-1	Forebay Hydropower Facility	New 6 mgd hydropower facility at Forebay.	$1,736,000
Pump Station	PS-1	Scenic Vista Pump Station	Replace existing pump station with new facility and 260 ft of 8-inch piping to add fire flow capacity.	$1,174,000
Other	O-2	Miscellaneous System Improvements	Meter replacement, hydrant replacement, pipe extensions, SCADA improvements, etc.	$100,000/year
	O-4	Water Facility Plan Update	Water Facility Plan Update and Financial Evaluation (Year 10).	$125,000
	O-5	On-site Sodium Hypochlorite	Replace chlorine gas disinfection with on-site sodium hypochlorite generation.	$452,000
	O-6	Anode System Replacement	Replace all three anode beds on Goodrich and Marble Creek Lines	$50,000
15-Year Total				**$33,442,000**
Annual Average				**$2,229,467**

[1] *Total Cost: Project estimates are based on the type and size of projects identified in this WFP and in accordance with the guidelines of AACE International Class 5 Estimates, with a typical accuracy of -30% to +50%. Project estimates are based on 2015 dollars and include design, construction, and site-specific information (unless noted otherwise) as described in Appendix C.*

[2] *The City generally self-performs supply pipeline replacement, so cost is for pipe and materials only and does not include design or construction and does not represent a total project cost.*

Watershed Supply

FIGURE 7-1

City of Baker City
Water Facility Plan

Capital Improvement Plan

MSA
Murray, Smith & Associates, Inc.
Engineers/Planners

Goodrich Lake

S-2 20"

Distribution System
(See inset map)

Goodrich Supply Line

Mountain Supply Line

3 MG Reservoir O-3
O-5
Chlorine Reservoir
UV Facility
Reservoir Well
PS-1
Scenic Vista Pump Station
W-2
Scenic Vista Reservoir
Golf Course Well
W-1
W-3
H-1

Distribution System

P-1 8"
P-2 8"
P-3 8"
P-4 8"
P-5 8"
P-6 12"
P-7 8"
P-8 6"
P-9 8"
P-11 12"
P-12 12"
12"
16"

Watershed Supply
(See large map)

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Unmapped 1-5 Year Projects
1. S-1: Groundwater Services Support to expand supply, water rights and ASR.
2. O-1: Financial Evaluation
3. O-2: Misc. System Improvements including meter and hydrant replacement, SCADA improvements, etc.

Unmapped 6-20 Year Projects
1. S-3: Groundwater Services Support to expand supply, water rights and ASR.
2. P-10: Annual distribution pipe replacement program recommended at a rate of 4,100 ft/year.
3. O-2: Misc. System Improvements including meter and hydrant replacement, SCADA improvements, etc.
4. O-4: Water Facility Plan Update in year 10.
5. O-6: Anode bed replacement.

Legend

1-5 Year CIP Projects
- Well
- Pipelines

6-20 Year CIP Projects
- Hydropower
- Production Meter
- Pump Station
- Sodium Hypochlorite Generation
- Well
- Pipelines

Existing System

Pipe Diameter
- ≤ 4"
- 6" - 8"
- 10" - 15"
- ≥16"
- Reservoir
- Well
- Pump Station
- UGB

0 825 1,650 Feet

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Murray, Smith & Associates, Inc.
Engineers/Planners

Section 8

Financial Summary

SECTION 8
FINANCIAL SUMMARY

Introduction

The City has a number of important water system projects to fund over the next 20 years. At a minimum these projects include; paying back the loan for the recently constructed Ultraviolet Treatment Facility (UVTF), replacing aging portions of the supply pipelines, constructing a new groundwater well and beginning to replace piping within the distribution system. These projects are in addition to the regular costs associated with staffing, operating and maintaining a water system. In order to fund these improvements an increase in the water rates and fees assessed by the City will be required. This Water Facility Plan (WFP) is focused on developing detailed guidance for investments the City needs to make over the next 5 years, which include repayment of the UVTF loan, replacement of the supply lines and the construction of a new groundwater well.

The scope of the WFP does not include the development of a detailed financial strategy. This section is meant to provide a general summary of the City's current revenue and expenses in comparison with the near-term costs for improvements.

Revenue

In Fiscal Year (FY) 2014-2015 the City generated approximately $2.2 million in revenue from water sales, which is their primary source of funding. Of the $2.2 million approximately $1.8 million was generated from base meter charges. The difference between $2.2 million and $1.8 million is the revenue resulting from volume based usage charges. As noted earlier in the WFP, the City is not growing significantly; therefore new customer fees do not generate significant revenue. To illustrate this point, the City generated approximately $37,000 in new customer related fees in FY 2014-2015 which is similar to prior years.

The monthly base meter charge for residential and commercial customers with 5/8", 3/4" and 1" meters are $32.37, $32.37 and $32.85 respectively. These meter sizes comprise 4,460 out of the 4,579 customers in the system, and therefore generate the majority of the City's water revenue.

Expenses

In FY 2014-2015 the City's budgeted expenses were approximately $2.2 million. A large portion of the budget ($1.4 million) was dedicated to regular operations and maintenance costs and paying staff salaries and benefits. An additional $760,000 was dedicated to paying for the UVTF. Loan repayment will begin in FY 2015-2016.

The City obtained a $2 million State of Oregon low interest loan to pay for the UVTF, with $250,000 of that being forgivable. In FY 2015-2016 and for the subsequent 20 years the City will pay approximately $125,000 per year to retire the debt associated with the UVTF loan.

In addition to the planned expenses, the City maintains $100,000 to $200,000 in contingency each year in the budget to cover the cost of unforeseen events and projects.

Capital Projects

Based on existing revenue and expenses, in future years the City will have approximately $675,000 ($2,200,000 – $1,400,000 – $125,000 = $675,000) to invest in new capital projects, excluding any contingency. This assumes no change in rates, customer count or water usage trends. Understanding it is not reasonable to assume all things stay constant into the future, including the cost to maintain staff and purchase materials, this calculation provides only an approximate order of magnitude dollar amount which would be available for funding additional capital improvement projects (CIP).

Currently Proposed Near-Term (1-5 year) Capital Projects

As noted above, a primary objective for the City in the near term is to replace portions of the aging Mountain and Elk Creek Supply Lines. In general the City is planning to invest approximately $500,000 per year in capital costs for these projects. On average an additional $100,000 per year in hydrant, meter and distribution system related piping projects are also required. The $100,000 does not address the ongoing overall replacement of the distribution system which is currently slated to begin in the 6 to 20 year timeframe depending on funding.

In addition to funding the UVTF loan repayment and replacing the water supply piping, the City needs to construct a new groundwater well in the next 5 years to provide redundancy for the surface water supply. The estimate to construct a new well, depending on location, is between $2 million and $3 million. The cost of the well is beyond what is currently supported by the City's water revenue.

Funding Sources

The City may fund the CIP from a variety of sources. In general, these sources can be summarized as: 1) governmental grant and loan programs; 2) publicly issued debt; and 3) cash resources and revenues. Options within each of these sources are described below.

Government Loan and Grant Programs

Oregon State Safe Drinking Water Financing Program

Annual grants from the U.S. Environmental Protection Agency (EPA) and matching state resources support the Safe Drinking Water Fund. The program is managed jointly by

Oregon Health Authority Drinking Water Services and Oregon Infrastructure Finance Authority (IFA). The Safe Drinking Water Fund program provides low-cost financing for construction and/or improvements of public and private water systems. This is accomplished through two independent programs; Safe Drinking Water Revolving Loan Fund (SDWRLF) for collection, treatment, distribution and related infrastructure, and Drinking Water Source Protection Fund (DWSPF) for sources of drinking water improvements prior to the water system intake.

SDWRLF lends up to $6 million per project, with a possibility of subsidized interest rate and principal forgiveness for a Disadvantaged Community. The standard loan term is 20 years or the useful life of project assets, whichever is less, with interest rates at 80 percent of the current state/local bond rate. The maximum award for the DWSPF is $100,000 per project.

Special Public Works Fund

The Special Public Works Fund (SPWF) program provides funding for the infrastructure that supports job creation in Oregon. Loans and grants are made to eligible public entities for the purpose of studying, designing and building public infrastructure that leads to job creation or retention.

Water systems are listed among the eligible infrastructure projects to receive funding. The SPWF is comprehensive in terms of the types of project costs that can be financed. As well as actual construction, eligible project costs can include those incurred in conducting feasibility and other preliminary studies and for the design and construction engineering.

The SPWF is primarily a loan program. Grants can be awarded, up to the program limits, based on job creation or on a financial analysis of the applicant's capacity for carrying debt financing. The total loan amount per project cannot exceed $10 million. The IFA is able to offer discounted interest rates that typically reflect low market rates for very good quality creditors. In addition, the IFA absorbs the associated costs of debt issuance thereby saving applicants even more on the overall cost of borrowing. Loans are generally made for 20-year terms, but can be stretched to 25 years under special circumstances.

Water/Wastewater Fund

The Water/Wastewater Fund was created by the Oregon State Legislature in 1993. It was initially capitalized with lottery funds appropriated each biennium and with the sale of state revenue bonds since 1999. The purpose of the program is to provide financing for the design and construction of public infrastructure needed to ensure compliance with the Safe Drinking Water Act or the Clean Water Act.

Eligible activities include costs for constructing improvements for expansion of drinking water, wastewater or stormwater systems. To be eligible a system must have received, or is likely to soon receive, a Notice of Non-Compliance by the appropriate regulatory agency, associated with the Safe Drinking Water Act or the Clean Water Act. Projects also must

meet other state or federal water quality statutes and standards. Funding criteria include projects that are necessary to ensure that municipal water and wastewater systems comply with the Safe Drinking Water Act or the Clean Water Act. The funding recipient must also certify that a registered professional engineer will be responsible for the design and construction of the project.

The Water/Wastewater Fund provides both loans and grants, but it is primarily a loan program. The loan/grant amounts are determined by a financial analysis of the applicant's ability to afford a loan including the following criteria: debt capacity, repayment sources and other factors.

The Water/Wastewater Fund financing program's guidelines, project administration, loan terms and interest rates are similar to the Special Public Works Fund program. The maximum loan term is 25 years or the useful life of the infrastructure financed, whichever is less. The maximum loan amount is $10 million per project through a combination of direct and/or bond funded loans. Loans are generally repaid with utility revenues or voter-approved bond issuance. A limited tax general obligation pledge may also be required. Certain entities may seek project funding within this program through the sale of state revenue bonds.

Public Debt

Revenue Bonds

Revenue bonds are commonly used to fund utility capital improvements. The bond debt is secured by the revenues of the issuing utility and the debt obligation does not extend to other City resources. With this limited commitment, revenue bonds typically require security conditions related to the maintenance of dedicated reserves referenced as bond reserves and financial performance measures which are added to the bond debt as service coverage. In order to qualify to sell revenue bonds, the City must show that the net revenue defined as total revenue less operating and maintenance expense, for the water fund is equal to or greater than a standard factor, typically 1.2 to 1.4 times the annual revenue bond debt service. This factor is commonly referred to as the coverage factor, and is applicable to revenue bonds sold on the commercial market. There is no bonding limit, except the practical limit of the utility’s ability to generate sufficient revenue to repay the debt and meet other security conditions. In some cases, poor credit may impair a community’s ability to acquire and use revenue bonds.

Revenue bonds incur relatively higher interest rates than government programs, but due to the highly competitive nature of the low-interest government loans, revenue bonds are assumed to be a more reliable source of funding as they typically can be obtained by most communities.

Water Fund Cash Resources and Revenues

The City's financial resources available for capital funding include rate funding and cash reserves. The City does not maintain large cash reserves for capital projects. Without a revision in the overall rate structure to shift more of the customer meter charges to volume based usage fees, the City's primary option to generate more revenue is to raise the base meter charge. In general terms, a 10% increase in base rates (approximately $3.24/month for most customers) will generate approximately $180,000 in additional yearly revenue. Similarly a 25% increase in base rates (approximately $8.10/month for most customers) will generate approximately $450,000 in additional yearly revenue.

Summary and Recommendations

In order to continue providing high quality and dependable water service, the City will be required to raise customer water rates and potentially obtain other funding. With the development of this WFP the City has identified a specific strategy for improvements over the next 5 years and a general approach for years 6 through 20. The improvements identified in Section 7-Capital Improvement Plan for design and construction over the next 5 years exceed the City's revenue.

A 25% rate increase would generate approximately $450,000 in additional yearly revenue assuming all variables remain constant. An immediate 25% rate increase would generate enough revenue over 5 years to pay for a new groundwater well with costs not to exceed $2.25 million. Again, these calculations are not intended to replace a formal rate study and provide a single potential option for increasing revenue. The City may decide to borrow money to fund required capital projects in the near-term, however will be required to prove their revenue generating capacity is adequate to pay the debt over time by raising rates. Borrowing money up front could allow the City to implement a series of smaller rate increases instead of implementing an immediate 25% increase.

A comprehensive rate and new user fee study is proposed for FY 2016-2017 at a cost of $25,000. It is recommended that the City enact a rate increase of at least 10% immediately upon adoption of this WFP. The subsequent study will allow for the evaluation of multiple rate structure changes and rate increase options. This study will also enable the City to determine the optimal distribution of rates and fees for existing and new customers.

Appendix A

Power Engineers Hydro Facility Engineering Certification

August 26, 2015

CITY OF BAKER CITY

Hydro Facility Engineering Certification

Site Visit Report

PROJECT NUMBER:
139628

PROJECT CONTACT:
Shawn Crea
EMAIL:
screa@powereng.com
PHONE:
208-788-0341

POWER ENGINEERS

Site Visit Report

PREPARED FOR: CITY OF BAKER CITY
PREPARED BY: SHAWN CREA
208-788-0341
SCREA@POWERENG.COM

REVISION HISTORY		
DATE	REVISED BY	REVISION
08/26/15	SCrea	A

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PURPOSE

The City of Baker City, Oregon desires to sell power to Idaho Power, produced from the city's hydro facility. Idaho Power requires an independent engineer to perform a facility inspection and execute *Engineer's Certification of Operation & Maintenance Policy*, and *Engineer's Certification of Design & Construction Adequacy.* After 3 years of operation, then a *Engineer's Certification of Ongoing Operations & Maintenance* must be executed, and every three years thereafter, for the term of the Energy Sales Agreement (ESA). The site visit of the facilities and review of the documentation is to support that certification process.

CITY HALL VISIT

A meeting was held in Baker City, OR, on August 13, 2015 at City Hall with Michelle Owen, Director of Public Works; Doug Schwin, City Engineer; Shawn Crea, Robert Anderson and Jeff VanSickel – all of POWER Engineers, Inc. The following water system overview was provided:

The hydroelectric plant is provided water via the Old Mountain Pipeline, which collects water from a portion of the 10,000 acre watershed. There are twelve (12) diversions serving the Old Mountain Pipeline (ref. Figure 4-1, 'Existing Watershed', by Anderson Perry & Associates, Inc.) The hydroelectric plant receives water at approximately 320 psig. A needle valve adjusts flow rate to maintain pressure. The hydroelectric plant discharges water to the water treatment facility, and then to a 4.5 MG municipal water storage tank.

The Old Mountain Pipeline system currently consists of some concrete and some PVC pipeline. All concrete pipeline is being replaced by PVC pipeline over the next 10 years. Starting in June 2016, after an EAA is completed, the City will begin replacing the concrete pipe with PVC at a rate of approximately one mile per year.

DOCUMENTS REVIEWED

The following documents were reviewed at City Hall to support the certification process.

- Capital Electric Co., October 16, 1913 Electric Equipment Sales Agreement and bond
  - 1- 100KVA 900 RPM 2300 V Gen
  - 1- 5KW 1800 RPM exciter
  - Panel
  - 3-25KVA regulators, transformers
- J.D. Sutter Company, Contract of Sale, November 5, 1913
  - Water wheel
  - Henry wheel
  - Steel disc wheel with removable bronze buckets
- Report for City of Baker City, OR Public Works Department.
  - Hydro Generator
  - Safety upgrades and improvements by: Electro Tech Engineering, Inc – April, 2009
    - 2008, Pelton wheel was reconditioned
- Forebay to Valve building, waterline replacement
  - Waterline replacement drawings – Feb 05
    - Sheets 1, 4, 5, 7, 10
- Existing Watershed, Fig 4-1 Anderson Perry & Associates, Inc – no date

- Individual Project reports (Maintenance)
    - $4,502.72 1/1/12-12/31/12 Hydro Electric Misc
    - $2,653.04 1/1/13-06/30/14 Hydro Electric Misc
    - $1,463.28 1/1/11-12/31/11 Hydro Electric Misc
    - $1,908.28 1/1/10-12/31/10 Hydro Electric Misc
    - $2,610.63 06/24/14- NA Hydro Electric Misc
    - $4,371.68 06/23/15- NA Hydro Electric Misc
- City of Baker City, OR
    - Water Facilities Plan, by Anderson Perry & Associates – 2000
        - Purpose: "….to provide the city with planning guidelines to meet the needs for water facilities over the 20 year planning period."
            - Average watershed production
- Small Hydro Generation
    - Reconnaissance Report
    - CH2M Hill, August 1978
- Operation, Maintenance and Process Safety Manual

HYDROELECTRIC FACILITIES VISIT

The hydro powerhouse was visited to demonstrate viability of facility operation, and to view the condition of the equipment and facility. Jake Jones (operator) allowed water to the pelton turbine, "warmed up" the system, built oil pressure to approximately 50psig, and synchronized to the grid, producing approximately 90KW. This startup sequence took about 20 minutes to complete.

The masonry structure housing the electrical generation equipment, at the time of the inspection, was found to be in fair condition. The structure showed wear and deterioration consistent with the age of the building. Several modifications had been made to the structure over the years to help facilitate the plant operations. The observed modifications did not appear to impede the lateral or gravity systems of the building. The building as a whole appeared sound and able to meet its current performance level.

The foundations supporting the generation unit showed minor surface spalling and cracking. At the time of the inspection the depth and width of the cracks appeared negligible. Due to the nature of rotating equipment to produce vibration, the foundation cracks should be monitored. If the cracks appear to be active and growing the appropriate repairs should be made. The foundations as observed were in adequate condition for continued operation of the generation unit.

The mechanical equipment – pelton turbine, governor, piping and valves, and necessary shields around rotating equipment – was all in working order and in suitable condition as validated by the successful operation demonstration.

The electrical distribution equipment and the visible cabling and control wiring at the hydro powerhouse appeared to be in satisfactory condition. Much of the installed electrical equipment at the powerhouse is very old equipment, but the equipment appears to be in satisfactory working condition and appears to be maintained on a regular basis. The generator appeared to be in satisfactory working condition and was able to sync to the grid without any apparent issues. The generator control system also includes very old equipment, but appears to function correctly and is in satisfactory working condition. All electrical equipment safety shields and electrical enclosure covers were installed correctly during the site visit.

Michelle Owen, Jake Jones, Shawn Crea, Robert Anderson and Jeff VanSickel drove to the Elk Creek diversion, which is the closest diversion to the City. The Elk Creek Intake diversion was inspected as a typical collection device for supplying water by way of the Old Mountain Pipeline to the power generation unit. While viewing the diversion, Jake operated the pipeline intake valve and cleaned the diversion screen.

The Elk Creek Intake is one of 12 intakes that feed the Old Mountain Pipeline. Improvements were made to the collection system diversions during the mid-1980s and early 1990s. At the time of the site inspection, the Elk Creek Intake diversion showed no substantial defects. The concrete displayed surface weathering as would be typical of exposure to freeze- thaw cycles. The weir, gates, and collection components all appeared to be in good condition. No signs of erosion around or undercutting of the diversion structure were visible. The Elk Creek intake diversion appeared to be in good condition and competent for continued service.

It is significant to mention that the water collection system's primary purpose is municipal water supply, and that maintenance of these systems are driven by that need, rather than a need to generate power. The hydro facility benefits from a higher basic need of the water.

INSPECTION SUMMARY & COMMENTS

The hydroelectric facility, conveyance system, and interconnection facilities are all in working order and successful startup and operation was demonstrated. There are conveyance system upgrades ongoing, and planned and scheduled for the future.

The Energy Sales Agreement is for 1,000,000 kWh, per year. At 8760 hours per year, a constant output of 114 kW would be required, assuming 100% plant availability. At 320 psig inlet pressure, and an *assumed* overall efficiency of 85%, 697 gpm is required through the hydro plant, or 1,003,791 gallons per day. A more realistic plant availability is 90%, or 7,884 hours of operation, and an average output of 126 kW would be required, with a flow of 906 gpm, or 1,304,631 gallons per day. Historical records show that the Old Mountain Line water supply *averages* 2.11 mgd. While the records also show that watershed production *has* dropped below the 1.3 mgd necessary, these periods are short and any production shortfall can be easily offset when the water supply is greater most of the year. Historical records also show that the hydroelectric unit is capable of producing the power output necessary to achieve the averages to meet the energy sales agreement. Ongoing maintenance will be critical to keep the hydro plant availability high for the 15 year term of the ESA.

We note that there was a lack of records and specifics concerning hydroelectric facility maintenance. City staff explained that the City was currently transitioning to a new document management system, and that there was not access to all records at this time. After 3 years of operation after the PPA is executed, an independent Engineer will need to provide the *Engineer's Certification of Ongoing Operations & Maintenance*, per Idaho Power requirements. Detailed maintenance records will be required at that time and the City should establish a maintenance records retention system specifically for the hydroelectric plant system.

Murray, Smith & Associates, Inc.
Engineers/Planners

Appendix B

Hydroelectric Analysis

Memorandum

SOAR TECHNOLOGIES, INC.
14961 NE 95th Street Redmond, WA 98052
Phone: 425.861.8870 / Fax: 425.882.7318
www.soartechinc.com

To: David Stangel, P.E.

From: Michael Maloney, P.E.

CC: Nathan Smith, P.E.

Date: November 25, 2015

Subject: Hydroelectric Analysis for Baker City, OR

Introduction

The City of Baker City (City) currently operates a hydroelectric facility located near the Water Treatment Facility Site. The hydro facility has been operated for approximately 100 years, although the City has used or sold the power in different capacities over that time. Currently only about half of the elevation head along the City's Mountain supply line is captured by the existing facility, being the section downstream of the Forebay facility. The City is considering constructing another facility to capture the head along the Mountain Line upstream of the Forebay facility. This memo evaluates the options to add additional hydropower capacity.

Water System Analysis

Surface water is supplied from the City's 10,000 acre watershed through a number of diversions. Water is transported to town either by the Goodrich or the Mountain pipeline. There are 12 diversions on the Mountain pipeline collecting surface water. Water from the pipeline is treated at the water treatment facility and is consumed by City users or utilized to charge the ASR well for future use. Figure 1 shows the estimated water through the Mountain Pipeline. The Mountain Pipeline flow was estimated by assuming 70 percent of measured total flow May through October and 100 percent the rest of the year. Actual Mountain Pipeline flows were not measured. A meter was been recently installed on the Mountain Pipeline and more accurate measurements may be available in the future.

Figure 2 shows the percent of time water flow occurs. Both the total system flow and the flow estimated through the Mountain Pipeline are shown.

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Figure 1, Estimated Flow Through the Mountain Pipeline

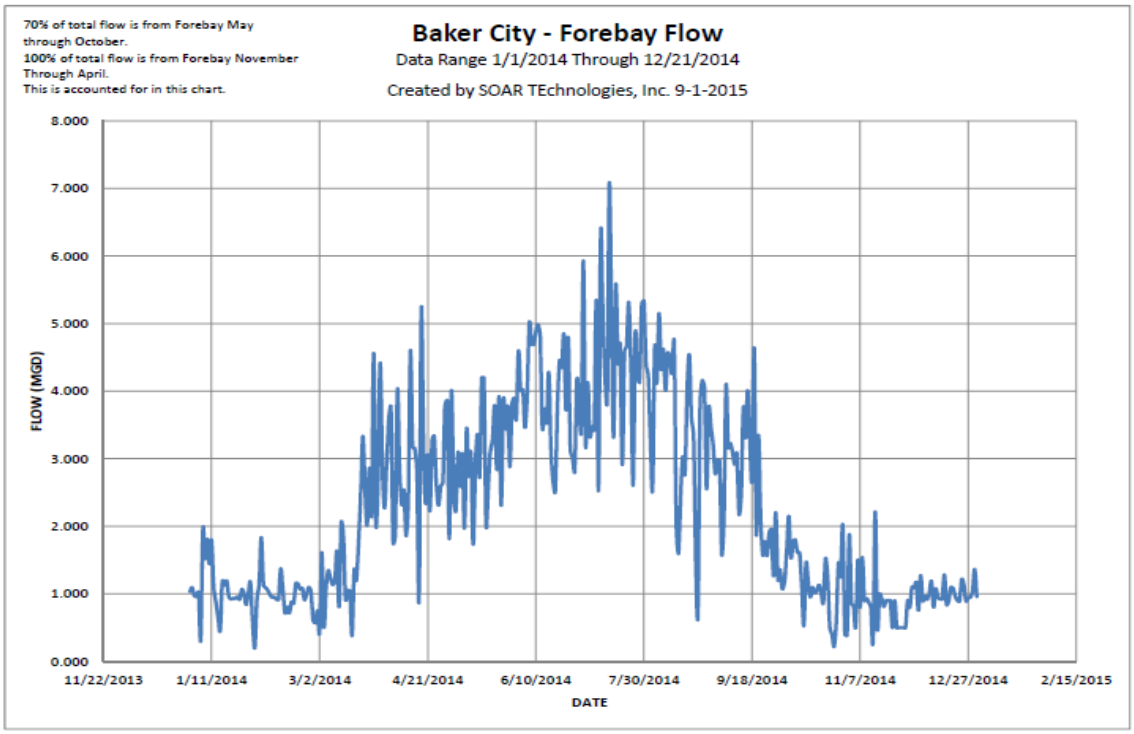
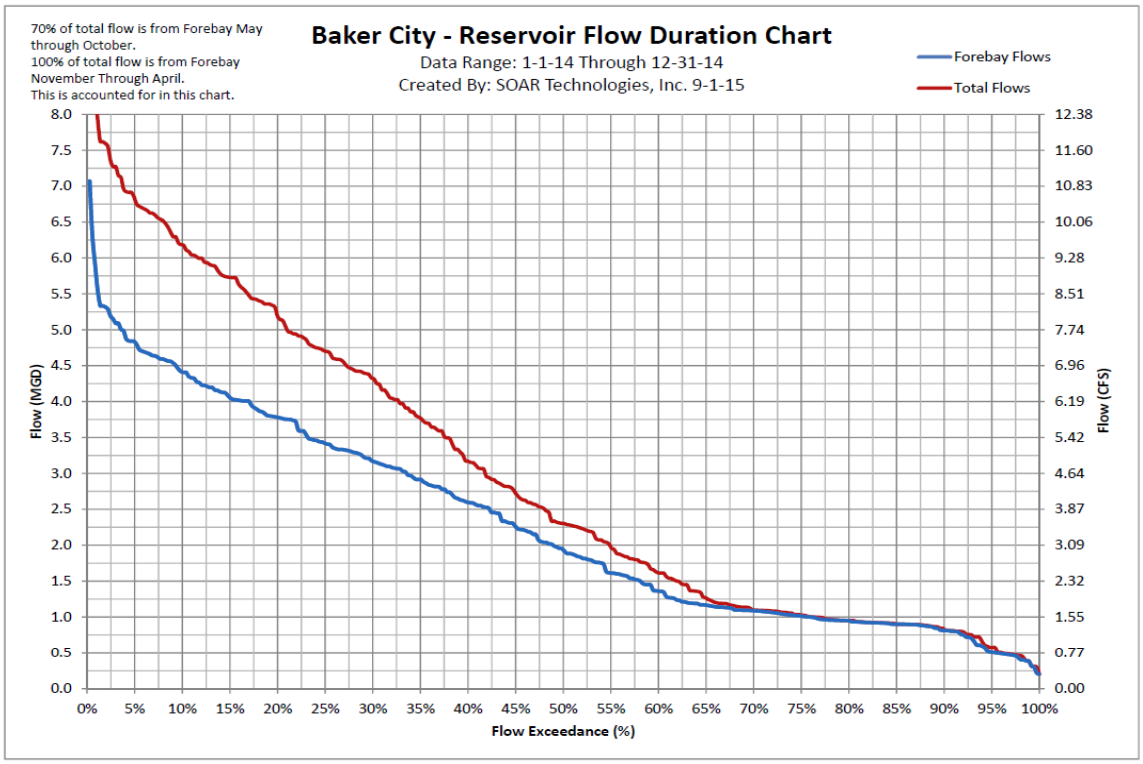


Figure 2, Percent of Time Flow Occurs



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Hydro Site Opportunities

The following sites were considered for power generation opportunities:

1. Mountain Pipeline (between Elk Creek Settling Tank and Forebay)
2. Goodrich Pipeline
3. Marble Creek Pipeline
4. ASR Well

Of the potential opportunities, the Mountain Pipeline (section between Elk Creek Settling Tank and Forebay) presents the best unrealized power generation possibility. The Goodrich line does not have adequate elevation drop. Water through the Marble Creek Pipeline is seasonal and the water is better used by sending it down the Mountain Pipeline to the Elk Creek Settling Tank. One section of the Mountain Pipeline requires replacement prior to implementation of hydroelectric at Forebay in order to maximize the available head. Hydropower generation is not feasible at the ASR site because the water must be pumped in order to recharge the Reservoir Well.

Power Generation Analysis

In 2014 the overall average flow through the City's existing hydro facility was just under 2 MGD. This value was used as an estimate for calculating the potential energy generating capacity. The energy produced from the water is calculated from the flow and head (water pressure) available at a specified location of a possible hydro plant. This is determined from the elevation change between the locations and the amount of headloss in the pipe segments between the locations. The section of pipeline analyzed is from the Elk Creek Settling Tank through Forebay to the existing hydroelectric facility at the Water Treatment Facility Site. The attributes of the pipe segments between the Elk Creek Settling Tank and the existing hydropower facility are shown in Table 1. This assumes, that all piping between the Elk Creek Settling Tank and Forebay is 20-inch ductile iron (One segment is currently 12-inch, but planned for replacement). Table 2 illustrates the headloss in each pipe segment at various flow rates.

Table 1, Pipe Segments (by MSA)

Key Locations	Elevation (ft)	ID	Length (ft)	Diameter (in)	Material	Roughness
Elk Creek Settling Tank	5,129					
		2	5,975	20	DI	130
		3[1]	12,540	20	DI	130
		4	9,000	20	DI	130
Forebay	4,428					
		5	4,621	18	DI	130
Pelton Wheel	3,689					

[1]*Segment 3 is currently 12-inch pipe, but is planned for replacement with 20-inch pipe.*

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Table 2, Headloss Calculation Summary (by MSA)

Flow (MGD)	Headloss (ft)					
	Segment 2	Segment 3	Segment 4	Elk Creek to Forebay Segments 2-4	Forebay to Pelton Wheel Segment 5	Total Segments 2-5
0.5	0	0	0	1	0	1
1	1	1	1	3	1	4
1.5	1	3	2	6	2	8
2	2	5	4	11	3	14
2.5	4	7	5	16	5	21
3	5	10	7	23	6	29
3.5	7	14	10	30	9	39
4	8	18	13	39	11	50
4.5	10	22	16	48	14	62
5	13	27	19	59	16	75
5.5	15	32	23	70	20	90
6	18	37	27	82	23	105

The static head from Elk Creek Settling Tank to Forebay is 701 feet. At a flow of 6 MGD the head is estimated to be 619 feet or a 12% head loss. The static head from Forebay to the existing hydro is 739 feet of head. At a flow of 6 MGD the available head in this section is estimated to be 716 feet or a 3% head loss. Headloss through the supply piping under a 2 MGD flow is significantly lower than 6 MGD, resulting in some additional power generating capacity.

Power Generation Options

Three options were looked at for installing additional hydro generation between the Elk Creek Settling Tank and Water Treatment Facility. The options considered are:

1.) Replacing or upgrading the existing hydro facility at the Water Treatment Facility Site
2.) Installing a new hydro at the Forebay site, or
3.) Installing a single hydro plant at the Water Treatment Facility Site. The third option is a possibility however the recently replaced pipeline from Forebay to the Water Treatment Facility Site would need to be replaced to handle the full water pressure from the Elk Creek Settling Tank.

Option 1A does not make any adjustments to power generation at the existing hydro plant. It is estimated the maximum flow at the existing hydro plant is approximately 2.5 MGD. Power generation is about 180 KW. The energy produced is estimated to be 1,049,000 KWHs using the Forebay flow duration information. Measured power generation for the existing hydro is 996,400 KWHs for year 2014.

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Option 1B is to replace the existing hydro unit with one rated for a maximum flow of 6 MGD. The hydro is estimated to produce 1,382,000 KWH with a turbine-generator producing up to 440 KW.

Option 2 is to install hydro generation at the Forebay site. Hydroelectric generation with a design flow of approximately 6 MGD will generate about 360 KW. The energy produced is estimated to be 1,242,000 KWHs. Installing a hydro generation at Forebay approximately doubles the City's current energy production.

Option 3 is to replace the existing hydro with a single hydro turbine at designed flow of 6 MGD and static head of 1,440 feet which will generate about 785 KW. The energy produced is estimated to be 2,610,000 KWH. The supply piping would be tight lined at Forebay to maintain pressure. The lower section from Forebay to the existing hydro will need to be replaced to a higher class of pipe to be able to handle the full head from the Elk Creek Settling Tank.

Hydro Implementation and Revenue
Table 3 shows the summary of each option, assuming the City can sell power at $0.06/KWH. Costs are capital investment and do not include ongoing maintenance costs.

Table, Hydro Construction and Revenue Estimates

Option & Description	Estimated KWH	Revenue ($/Yr)	Estimated Cost	Simple ROI (Years)
OPTION 1A				
Leave existing hydro as-is	1,049,000	$62,940	$0	0
OPTION 1B				
Replace the existing hydro	1,382,000	$82,920	$1,447,000	17
OPTION 2				
Install hydro at Forebay site	1,242,000	$74,520	$1,736,000	23
OPTION 1A and OPTION 2				
Use existing Hydro and install Forebay hydro	2,291,000	$137,460	$1,736,000	23
OPTION 1B and OPTION 2				
Replace existing hydro and install Forebay hydro	2,624,000	$157,440	$3,183,000	20
OPTION 3				
Single hydro at Reservoir hydro site	2,610,000	$156,600	$3,813,000	24

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City Power Usage

Normally it is best to use the power generated to cover the City's load with the available Power Purchase Agreements (PPAs). It may be possible to restructure the power interconnection to allow using the hydro generation to cover the Water Treatment Facility and associated energy requirements. This is dependent on the PPA signed with the power utility.

Analysis of the Options

Option 1A with Option 2 is recommended as the least cost with the best Return-On-Investment (ROI) if installing new hydro equipment. This combination of options, while having a slightly longer ROI than replacing the existing hydro and installing hydro at Forebay, represents the lowest additional capital cost investment for the most significant increase in power generating capacity. The recommendation is to simply leave the existing hydro in place and install hydro at Forebay. In the future the existing hydro could either be updated by replacing the controls and updating the turbine or by replacing the existing hydro facility in its entirety.

Appendix C

Cost Estimating Methodology and Assumptions

APPENDIX C
COST ESTIMATING METHODOLOGY AND ASSUMPTIONS

Introduction

This appendix summarizes the approach used in development of unit costs and project costs used in the Capital Improvement Plan (CIP) for the City of Baker City (City) Water Facility Plan (WFP).

Cost Estimating

The probable costs estimated for each improvement are based on average costs from the 2015 RS Means Heavy Construction Cost Data (RSMeans), City input, construction costs for similar projects across the Northwest, and information provided by local suppliers. All costs identified in this section reference U.S. dollars. The *Engineering News Record Construction Cost Index* basis is 10,037 (20-City Average, July 2015).

Project cost estimates were prepared in accordance with the guidelines of AACE International, formerly the Association for the Advancement of Cost Engineering International. (*AACE International Recommended Practice No. 56R-08 Cost Estimate Classification System - As Applied For The Building and General Construction Industries - TCM Framework: 7.3 - Cost Estimating and Budgeting Rev. December 31, 2011*). The project cost estimates in this WFP are categorized Class 5, as defined by AACE International:

> *Class 5 estimates are generally prepared based on very limited information, and subsequently have wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systemic manner.*
>
> *Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc.*
>
> *Typical accuracy ranges for Class 5 estimates are -20% to -30% on the low side, and +30% to +50% on the high side, depending on the construction complexity of the project, appropriate reference information and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks.*

All project descriptions and cost estimates in this WFP represent planning-level accuracy and opinions of costs (+50%, -30%). During the design phase of each improvement project,

project definition, scope and specific information (e.g., pipe diameter and length) should be verified. The final cost of individual projects will depend on actual labor and material costs, site conditions, competitive market conditions, regulatory requirements, project schedule and other factors. Because of these factors, project feasibility and risks must be carefully reviewed prior to making specific financial decisions or establishing project budgets to help ensure proper project evaluation and adequate funding.

The project costs presented in this WFP include estimated construction costs, and allowances for permitting, legal, administrative and engineering fees. A contingency factor is also added to each cost to help account for any unanticipated components of the project costs. Construction costs are based on the preliminary concepts and layouts of the system components developed during the system analysis.

Total estimated project costs were developed through a progression of steps and multiple methodologies. The steps included development of component unit costs, construction costs and, finally, project costs. The component unit cost includes the sum of materials, labor and equipment of a project's basic features. The construction cost is the sum of component costs and mark-ups to determine the probable cost of construction (i.e., the contractor bid price). The project cost is the sum of construction costs with additional cost allowances for engineering, legal and administrative fees to determine the total project cost to the City.

The following costs are not included:

- Land or right-of-way acquisition
- Water System studies, planning or modeling
- Borrowing or finance charges during the planning, design, or construction of assets
- Improvements to distribution or treatment facilities in response to changes in regulatory standards or rules
- Remediation or fines associated with system violations

Component Unit Costs

Pipelines

The estimates for water system piping include the costs for pipe, fittings, valves and water service connections. The pipe material assumed for new waterlines was CL 51 Ductile Iron with push on joints for 4- to 24-inch pipe.

For all pipeline installations including new and replacement projects, the cost is based on a cover depth of four feet and includes:

- Excavation

- Waste of the material associated with the trenching (which includes haul, load and dump fees)
- Imported bedding and zone material
- Native backfill (which includes minimal haul and compaction of material)
- Fittings and valves (30% of pipe costs)
- Testing and disinfection (as a percentage of total cost)

For replacement of existing waterlines additional costs include:

- Abandonment of the existing pipe
- Replacement of water service lines (10% of pipe costs)

As the diameter of pipe and the trench width increase, the costs also increase. Therefore, a specific cost has been identified for each pipe diameter. See Table C-1 for costs for both new pipe and replacement of existing pipe.

Table C-1
Water Pipeline Costs per Linear Foot

Pipe Diameter (inch)	New ($/linear foot)	Replacement ($/linear foot)
4	$43	$44
6	$39	$40
8	$53	$55
10	$60	$63
12	$75	$78
14	$90	$94
16	$102	$107
18	$115	$120
20	$130	$137
24	$158	$165

Special Pipe Crossings

Special pipe crossings are required for crossing the river, railroads and highways, or areas where traditional open cut construction is not possible. An additional 100% is applied to pipeline costs for any projects with these conditions.

Surface Restoration

Surface restoration of construction sites is required to complete every project. As with the pipe installation costs, the surface restoration costs increase with the size of pipe, due to the larger trench that will need to be excavated. Therefore, a unit surface restoration cost has been developed for each pipe diameter. Table C-2 tabulates costs for surface restoration. The tables are separated to define costs associated with local and arterial asphalt roadways and unpaved surfaces. The surface restoration is developed from local supplier and RSMeans costs.

Table C-2
Surface Restoration Costs per Linear Foot

Pipe Diameter (inch)	Surface Condition Cost ($/linear foot)		
	Arterial[1]	Local[2]	Unpaved[3]
4	$30	$26	$3
6	$30	$26	$3
8	$30	$26	$3
10	$30	$26	$3
12	$30	$26	$3
14	$30	$26	$3
16	$30	$26	$3
18	$30	$26	$3
20	$31	$26	$3
24	$33	$28	$3

[1] *Road repair and replacement along trench. 6-inch asphalt and 4 inches of ¾-inch minus and 8 inches of 2-inch minus.*
[2] *Road repair and replacement along trench. 4-inch asphalt and 4 inches of ¾-inch minus and 8 inches of 2-inch minus.*
[3] *Repair and replacement of trench using rock backfill to ground surface along trench cross-country.*

Facility

Facility project costs were developed for each individual facility project. For each facility, the project cost includes basic site, civil, mechanical, electrical, and instrumentation and control facilities.

Construction Cost Allowances

The construction cost is the sum of materials, labor, equipment, mobilization, contractor's overhead and profit, and contingency for each project. Tables C-3 and C-4 present the additional allowances associated with the construction costs and project costs, respectively.

Traffic Control

Traffic control will be required for all projects that occur in roadways. The cost and level of effort for traffic control should be evaluated based on the scope and size of each project and as local conditions at the time of construction dictate. For planning purposes, the cost of traffic control is estimated at 0.5% for low traffic control areas or 2% for high traffic control areas depending on project location. Traffic control mark-up accounts for the cost of signage, flagging and temporary barriers, street widening, pavement markings, lane delineators and lighting at flagging locations.

Erosion Control

Erosion control will be required for all projects. For planning purposes, the erosion control is estimated at 1% of the construction costs. Erosion control mark-up accounts for materials and practices to protect adjacent property, storm water systems, and surface water in accordance with regulatory requirements. The level of effort and cost for erosion control depends on the size and scope of a project, and the local conditions at the time of construction.

Construction Contractor Overhead and Profit

A 10% mark-up accounts for the contractor's indirect project costs and anticipated profit.

Construction Mobilization

A 10% mobilization mark-up accounts for the cost of the contractor's administrative and direct expenses to mobilize equipment, materials and labor to the work site.

Construction Contingency

A 30% increase was added in each project's construction cost to account for a contingency factor to cover the uncertainties inherent to planning-level development. The contingency is provided to account for factors such as:

- Unanticipated utilities
- Relocation and connection to existing infrastructure
- Minor elements of work not addressed in component unit cost development
- Details of construction
- Changes in site conditions
- Variability in construction bid climate

The contingency excludes:

- Major scope changes such as end product specification, capacities and location of project
- Extraordinary events such as strikes or natural disasters
- Management reserves
- Escalation and currency effects

A summary of construction mark-ups is provided in Table C-3.

Table C-3
Additional Construction Costs

Additional Cost Factor	Percent
Low Traffic Control	0.5%
High Traffic Control	2%
Erosion Control	1%
Contractor Overhead and Profit	10%
Mobilization	10%
Contingency	30%

Total Project Cost

The total project cost is the sum of construction cost with additional cost allowances for engineering, legal, and administrative fees. Table C-4, shown below, presents the cost allowances for each additional project cost. The engineering costs include design and surveying. Construction administration is the cost associated with managing the construction of the project. The administrative and legal costs are those associated with the City providing financial and legal oversight of the contract.

Table C-4
Summary of Additional Costs

Additional Cost Factor	Percent
Construction Administration	5%
Engineering	15%
Legal and Administrative	10%

MSA

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