Oregon
Theodore R. Kulongoski, Governor

Department of Land Conservation and Development
635 Capitol Street, Suite 150
Salem, OR 97301-2540
(503) 373-0050
Fax (503) 378-5518
www.lcd.state.or.us

NOTICE OF ADOPTED AMENDMENT

05/16/2012

TO: Subscribers to Notice of Adopted Plan or Land Use Regulation Amendments

FROM: Plan Amendment Program Specialist

SUBJECT: City of Bend Plan Amendment
DLCD File Number 002-11

The Department of Land Conservation and Development (DLCD) received the attached notice of adoption. Due to the size of amended material submitted, a complete copy has not been attached. A Copy of the adopted plan amendment is available for review at the DLCD office in Salem and the local government office.

Appeal Procedures*

DLCD ACKNOWLEDGMENT or DEADLINE TO APPEAL: Wednesday, May 30, 2012

This amendment was submitted to DLCD for review prior to adoption pursuant to ORS 197.830(2)(b) only persons who participated in the local government proceedings leading to adoption of the amendment are eligible to appeal this decision to the Land Use Board of Appeals (LUBA).

If you wish to appeal, you must file a notice of intent to appeal with the Land Use Board of Appeals (LUBA) no later than 21 days from the date the decision was mailed to you by the local government. If you have questions, check with the local government to determine the appeal deadline. Copies of the notice of intent to appeal must be served upon the local government and others who received written notice of the final decision from the local government. The notice of intent to appeal must be served and filed in the form and manner prescribed by LUBA, (OAR Chapter 661, Division 10). Please call LUBA at 503-373-1265, if you have questions about appeal procedures.

*NOTE: The Acknowledgment or Appeal Deadline is based upon the date the decision was mailed by local government. A decision may have been mailed to you on a different date than it was mailed to DLCD. As a result, your appeal deadline may be earlier than the above date specified. NO LUBA Notification to the jurisdiction of an appeal by the deadline, this Plan Amendment is acknowledged.

Cc: Damian Syrnyk, City of Bend
Gordon Howard, DLCD Urban Planning Specialist
Karen Swirsky, DLCD Regional Representative
Angela Lazarean, DLCD Urban Planner

<paa> YA/ph

☐ In person ☐ electronic ☐ mailed

DATE STAMP

DEPT OF

MAY 15 2012

LAND CONSERVATION AND DEVELOPMENT

For Office Use Only

FORM 2 DLCD Notice of Adoption

This Form 2 must be mailed to DLCD within **5-Working Days after the Final Ordinance is signed** by the public Official Designated by the jurisdiction and all other requirements of ORS 197.615 and OAR 660-018-000

Jurisdiction: **City of Bend**

Local file number: **PZ-11-154**

Date of Adoption: **5/2/2012**

Date Mailed: **5/9/2012**

Was a Notice of Proposed Amendment (Form 1) mailed to DLCD? ☒ Yes ☐ No Date: 7/1/2011

☒ Comprehensive Plan Text Amendment

☐ Comprehensive Plan Map Amendment

☐ Land Use Regulation Amendment

☐ Zoning Map Amendment

☐ New Land Use Regulation

☐ Other:

Summarize the adopted amendment. Do not use technical terms. Do not write "See Attached".

The adopted amendment includes a Goal 11 water public facility plan for the Bend urban growth boundary, and associated amendments to the text of Chapter 8, Public Facilities and Services, of the Bend Area General Plan.

Does the Adoption differ from proposal? Yes, Please explain below:

The proposed amendment from 2011 included Goal 11 public facility plans for both water and sewer. The City withdrew the sewer public facility plan from further consideration through a Notice of Withdrawal mailed on April 25, 2012. The adopted amendmeht includes only the Goal 11 public facility plan for water and General Plan text amendments.

Plan Map Changed from: **NA** to:

Zone Map Changed from: **NA** to:

Location: **NA** Acres Involved: **0**

Specify Density: Previous: **NA** New:

Applicable statewide planning goals:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
☒	☒	☐	☐	☐	☒	☐	☐	☒	☒	☒	☒	☐	☐	☐	☐	☐	☐	☐

Was an Exception Adopted? ☐ YES ☒ NO

Did DLCD receive a Notice of Proposed Amendment...

35-days prior to first evidentiary hearing? ☒ Yes ☐ No

If no, do the statewide planning goals apply? ☐ Yes ☐ No

If no, did Emergency Circumstances require immediate adoption? ☐ Yes ☐ No

DLCD file No. 002-11 (18883) [17038]

Please list all affected State or Federal Agencies, Local Governments or Special Districts:

Deschutes County, Arnold Irrigation District, Central Oregon Irrigation District, Swalley Irrigation District, Tumalo Irrigation District, Bend-LaPine School District, Bend Metro Parks and Recreation District.

Local Contact: **Damian Syrnyk, AICP Senior Planner** Phone: **(541) 312-4919** Extension:

Address: **710 NW Wall Street** Fax Number: - -

City: **Bend** Zip: **97701-** E-mail Address: **dsyrnyk@ci.bend.or.us**

ADOPTION SUBMITTAL REQUIREMENTS

This Form 2 must be received by DLCD no later than 5 working days after the ordinance has been signed by the public official designated by the jurisdiction to sign the approved ordinance(s)

per ORS 197.615 and OAR Chapter 660, Division 18

1. This Form 2 must be submitted by local jurisdictions only (not by applicant).
2. When submitting the adopted amendment, please print a completed copy of Form 2 on light green **paper if available**.
3. Send this Form 2 and **one complete paper copy** (documents and maps) of the adopted amendment to the address below.
4. Submittal of this Notice of Adoption must include the final signed ordinance(s), all supporting finding(s), exhibit(s) and any other supplementary information (ORS 197.615).
5. Deadline to appeals to LUBA is calculated **twenty-one (21) days** from the receipt (postmark date) by DLCD of the adoption (ORS 197.830 to 197.845).
6. In addition to sending the Form 2 - Notice of Adoption to DLCD, please also remember to notify persons who participated in the local hearing and requested notice of the final decision. (ORS 197.615).
7. Submit **one complete paper copy** via United States Postal Service, Common Carrier or Hand Carried to the DLCD Salem Office and stamped with the incoming date stamp.
8. Please mail the adopted amendment packet to:

ATTENTION: PLAN AMENDMENT SPECIALIST
DEPARTMENT OF LAND CONSERVATION AND DEVELOPMENT
635 CAPITOL STREET NE, SUITE 150
SALEM, OREGON 97301-2540

9. **Need More Copies?** Please print forms on 8½ -1/2x11 green paper only if available. If you have any questions or would like assistance, please contact your DLCD regional representative or contact the DLCD Salem Office at (503) 373-0050 x238 or e-mail **plan.amendments@state.or.us**.

ORDINANCE NO. 2185

AN ORDINANCE AMENDING THE TEXT OF CHAPTER 8 THE BEND AREA GENERAL PLAN, PUBLIC FACILITIES, AND ADOPTING A GOAL 11 WATER PUBLIC FACILITY PLAN FOR THE CITY OF BEND URBAN GROWTH BOUNDARY.

Findings

A. On July 1, 2011, the City submitted a Notice of Proposed Amendment pursuant to ORS 197.610 to the Oregon Department of Land Conservation and Development. The City's Notice proposed amendments to the text of Chapter 8, Public Facilities and Services, of the Bend Area General Plan and adoption of a Goal 11 Water Public Facility Plan.

B. Long Range Planning Staff caused notice to be published in the Bend Bulletin of an August 22, 2011 public hearing on August 2, 2011. Long Range Planning Staff conducted a work session with the Bend Planning Commission on August 8, 2011.

C. On August 22, 2011, the Bend Planning Commission conducted a public hearing on the Water Public Facility Plan, and the related amendments to Chapter 8 of the Bend Area General Plan. This hearing was continued three times, and hearings were held on September 16, October 10, and November 14, 2011. At the final hearing held on November 14, 2011, a majority of the Planning Commission voted to forward the proposed Water PFP and Chapter 8 amendments on to the City Council with a recommendation to approve.

D. The City Council held a public hearing on April 18, 2012 on the Water Public Facility Plan and related amendments to Chapter 8 of the Bend Area General Plan. Notice of the hearing before the City Council was published in the Bend Bulletin on March 29, 2012. The City Council has considered the evidence in the record, including the evidence and the testimony submitted at the public hearings.

Based on these findings,

THE CITY OF BEND ORDAINS AS FOLLOWS:

Section 1. Chapter 8 of the Bend Area General Plan, Public Facilities, dated November 1998 is repealed and replaced with the September 2011 version attached as Exhibit "A."

Section 2. The Goal 11 Water Public Facility Plan, attached as Exhibit "B" and dated September 2011, is adopted and incorporated by reference in the Bend Area General Plan.

Section 3. The City Council adopts the Findings in Support of the Adoption of the Goal 11 Water Public Facility Plan and the Supplemental Findings as findings supporting adoption of the Goal 11 Water Public Facility Plan and the related amendments to the text of Chapter 8 of the Bend Area General Plan, Public Facilities and Services.

First Reading April 18, 2012.

Second Reading May 2, 2012.

Adopted by roll call vote by the City Council on May 2, 2012.

YES: Tom Greene
Scott Ramsay
Mark Capell
Jodie Barram
Kathie Eckman
Mayor Jeff Eager

NO: Jim Clinton

Jeff Eager, Mayor

ATTEST:

Robyn Christie, City Recorder

Approved as to form:

Mary Winters, City Attorney

Bend Area General Plan

Chapter 8: Public Facilities and Services

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MAY 2012

Amended May 2, 2012 – Ordinance NS-2185

BEND AREA GENERAL PLAN

PREAMBLE

Consideration of the public and private facilities and services within the Bend Urban Growth Boundary is an important focus of the Plan. Several of these services — water, sanitary sewers, energy supplies, and communications — are the backbone needed to support and encourage urban level development. Other urban services such as refuse disposal, emergency services, and storm water disposal are also necessary parts of the mix of urban services. Although most of these facilities and services have a planning horizon greater than 20-years, they are still driven by the population and land use needs forecast in the General Plan.

GOALS

Adequate public facilities are the key to efficient and stable urban development. The goals below provide general guidance for maintaining and improving the level and quality of urban services as growth occurs in Bend. The citizens and elected officials strive:

- To have public and private utility systems provide adequate levels of service to the public at reasonable cost;
- For the city, county, and special districts to coordinate the provision of adequate urban services in an efficient and timely manner to support urban development;
- For new development to pay its fair share of the cost of major facilities needed to support development;
- To ensure that public services will not negatively impact the environment or the community; and
- To locate and operate public buildings and other public facilities to best serve the needs of the residents.



BEND AREA GENERAL PLAN

OVERVIEW

The Public Facilities and Services chapter describes existing facilities and utilities in Bend and also describes what city facilities are needed to meet projected growth. The listing of city water and sewer projects planned for and expected over the next twenty years provides a framework for decisions on when, where, and how public facilities will be provided to support the projected growth. The city will use the listing of projects as a basis for its annual capital improvement budget.

SANITARY SEWER FACILITIES AND SYSTEMS

The City's current public facility plan for sewer collection is the *1996 Utilities System Master Plan.* This plan identifies future improvements to the sewerage collection facilities required to serve long range growth in Bend. The system is designed to serve lands within the Urban Growth Boundary. Between 2007 and 2008, the City engaged in an update to the sewer collection system and the wastewater treatment plant. In 2007, a master plan for the collection system was completed to serve the existing urban growth boundary, the Urban Area Reserve identified in this plan, and potential areas for future expansion of the UGB. This plan was further amended in 2011 to focus on improvements that would be needed to serve the existing urban growth boundary. In 2008, a master plan for the wastewater treatment plant (a.k.a. water reclamation facility) was completed and identified needed improvements to the capacity and the function of the plant over the next 20 years.

Individual Systems

A 2007 Collection System Master Plan (CSMP) concluded there were more than 4,200 parcels within the Urban Growth Boundary (UGB) that were developed but not served by the City of Bend collection and treatment system. These individual systems can potentially create a non-point source of nitrogen based pollutants into the groundwater supply. Ultimately, connection to the city collection system will remove this pollutant stream and improve ground water quality. The concern is exacerbated due to the soil structure in the area. Generally speaking, ground in the urban area is not well suited for drain field disposal systems because the soils are relatively shallow over fractured lava rock.

The Deschutes Basin has a complex geology of fractured lava rock. The state, county, and city are concerned about the potential for ground water and surface water contamination from effluent that works its way into the rock from drill holes and individual drain field systems. The likelihood of contamination increases as the systems get older and more systems are installed. Protection of the water shed becomes increasingly difficult with the failed systems and porous ground structure.



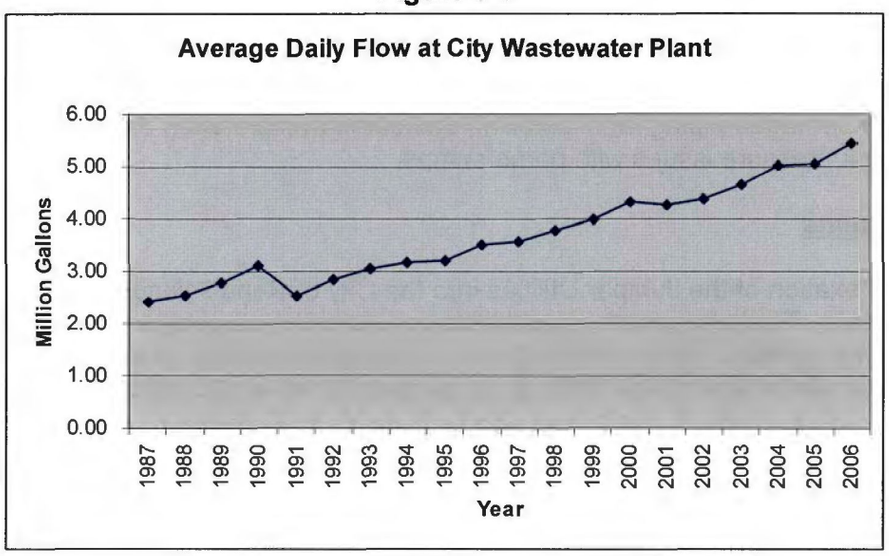
There are environmental, social and financial costs associated with failing individual sewage disposal systems. The possibility of local and regional public health risks from contaminated water systems represents both environmental and social costs. Replacing or expanding a drain field — if it can physically be done on a subdivision lot — can cost a homeowner thousands of dollars. The extension of the city's sewer system into subdivisions with drain field problems provides the best long term solution to protect the health, safety, and property of residents in the urban area.

Municipal System

The city completed its sewerage collection system and treatment plant in 1983. Since that time a number of upgrades have occurred in both the plant and collection system. The wastewater treatment plant has capacity for an average flow of approximately seven million gallons a day and in 2006 the average flow was about 5.6 million gallons a day. Figure 8-1 charts the average daily flows at the wastewater treatment plant.



Figure 8-1



In 1986, the disposal of septic tank wastes at the county landfill was curtailed and these wastes started to be disposed of at the city's wastewater treatment plant. Due to the increased volume of septic tank waste from throughout the county, the Bend treatment plant in 1992 was near capacity in its ability to process organic materials. Improvements were initiated to increase capacity. In recent years, a third digester was added; a gravity belt thickener and belt filter press were installed. In 2007 construction began on a new headworks facility as well as capacity enhancements to the existing digesters. Improvements to the biological treatment system and to the secondary clarification are expected through the facilities plan. The headworks facility was completed in 2008.

A master planning process was initiated in January 2007 to focus on necessary improvements to the city's Wastewater Treatment Facility. The master plan for the wastewater reclamation facility (WRF) was completed in 2008 by Carollo Engineering. The WRF Master Plan identifies short term and long term capacity improvements that will enable the City of Bend to minimize expansion costs by fully utilizing the existing facilities. Other facility improvements will continue to be undertaken to ensure plant sustainability. Eventually a full plant expansion will be required to ensure plant capacity and environmental compliance. This plan for the WRF was submitted to the Department of Land Conservation and Development in 2009. The Land Conservation and Development Commission (LCDC) acknowledged the 2008 plan for the WRF through Order 001795 in November 2010.

The major collection system needs within the urban area include increased capacity to stressed areas, rehabilitate aging pumping stations, install major interceptors in key areas,



and provide sewerage collection lines to existing developed areas within the urban growth boundary. Additionally, initiatives will be undertaken to improve collection subsystems throughout the nine area plans identified in the WRF master plan. The improvements will address problematic areas by replacing pressure systems with gravity installations, rehabilitating damaged piping, and installing dedicated pump station discharges so as to eliminate back pressure issues with home sumps.

Private Systems

After the annexation of the Juniper Utilities into the City of Bend sewage system, no private systems remain. The only private installations consist of home sumps connected to a pressure sewer system. The individual home pumps are primarily located on Awbrey Butte and Valhalla where sewer needs to be pumped uphill to get into a gravity pipe.

Sewer System Financing

Table 8.1 lists sewer facilities the city plans to construct through 2002 to support the projected growth and land uses in the Bend urban area. The description, location, timing and estimated cost of listed facilities may change as a result of subsequent design studies, capital improvement programs, environmental studies, and changes in funding sources. City facilities may be constructed earlier than planned by an owner/developer choosing to develop an area prior to the scheduled

The city has adopted System Development Charges (SDCs), as allowed under state law, to help pay for new facilities. SDCs are levied against all new uses at the time of development. These fees are earmarked for major system improvements identified in the city's SDC Project Lists such as interceptor lines and expansion of the wastewater treatment plant. SDC proceeds will be utilized to partially fund the improvements listed in Table 8-1.



Table 8-1
City Sewer System Projects (1997 dollars)

Approximate Year	Description of Project	Rough Cost for all projects
1997-98	Construct centrifuge at treatment plant Install gravity belt thickener at treatment plant Sludge handling / dewatering improvements at treatment plant Construct south canal gravity main interceptor line Design North UGB interceptor line	$2,615,000
1998-99	Construct 27" Brosterhous interceptor Start 21" Brosterhous interceptor Construct Rimrock Pump Station Construct River's Edge interceptor sewer Start Secondary clarifier #3 at treatment plant Start North UGB interceptor line	$1,898,000
1999-2000	Continue 21" Brosterhous interceptor Continue North UGB interceptor line Finish Secondary clarifier #3 at treatment plant Start anaerobic digester at treatment plant	$1,630,000
2000-01	Finish 21" Brosterhous interceptor Continue North UGB interceptor line Finish anaerobic digester at treatment plant Sunrise Village tie-in Start effluent polishing filter at treatment plant	$2,454,800
2001-02	Continue North UGB interceptor line Finish effluent polishing filter at treatment plant	$1,650,000

WATER FACILITIES AND SYSTEMS

The quality of water in the Bend urban area is a matter of major importance. Not only is water necessary for the needs of residential, commercial, and industrial users, but it supports many of the recreational and scenic opportunities that make the Bend area a desirable place to live.

In 2006, the city engaged in an update to the water system master plan to serve the existing urban growth boundary, the urban reserve area identified in this plan, and potential areas for future expansion of the UGB. This 2006 master plan followed the development and approval of a water management and conservation plan (WMCP) in 2004. The City relied on these documents, and water planning documents from the Avion



Water Company and Roats Water Company, to develop an updated Goal 11 water public facility plan (PFP) for the existing Bend UGB as of 2008. This 2011 Water PFP is incorporated by reference herein as the Goal 11 public facility plan for water and identifies those capital improvements needed to serve the existing and future development within Bend's UGB as of 2008.

Municipal System

The City of Bend is one of three water suppliers within the UGB. The city's water system in 2006 includes about 22,000 service connections. Since 1926, the City of Bend's main source of water has been from Bridge Creek in the Tumalo Creek watershed. Tumalo Creek originates on the eastern slopes of Ball Butte and Broken Top Mountain about 20 miles west of Bend in a protected watershed area, which lies within the Deschutes National Forest. Figure 8-2 shows the annual water use from 1998-2005 in acre feet. Figure 8-3 shows the annual water use pattern, using daily use data from 2005.

The Deschutes Watershed has excellent water quality, considering both chemical and bacteriological quality with only chlorination treatment. The water is a consistent 48□F. winter and summer, and is clear with the exception of slightly turbidity during periods of high runoff from the watershed. These periods occur only occasionally, and last only a few days. The 1986 Safe Drinking Water Act required that all surface water systems in the nation provide filtration unless stringent watershed control, raw water quality and disinfection systems were met. In 1992 the city demonstrated sufficient evidence to meet the criteria, and obtained an exemption from the Surface Water Treatment Rules contained in the 1986 Act. The Bridge Creek source can deliver up to 13.5 million gallons per day. The City supplements the Bridge Creek source with deep groundwater wells. In 2006 the city had 21 wells on line to supplement the Bridge Creek source. These wells increase the delivery capacity of the city system to approximately 36 million gallons per day. In addition, the city has 28.0 million gallons of reservoir storage. The city's 475 miles of water distribution system is primarily composed of ductile iron pipe.

The city water system historically provided metered service for industrial, commercial, and multifamily developments. However, the city was one of the last major water systems in the state to use flat rate (non-metered) billing for residential service connections. As of December 2004, the City has become fully metered for all customers. This included conversion to automated meter reading technology, as well as installation of premise isolation cross connection protection at every service connection as part of our Safe Drinking Water Program. In 2004, the City updated its required Water Management and Conservation Plan which outlines various conservation related benchmarks, in order to meet conditions by the Oregon Water Resources Department as part of obtaining new water rights to meet the needs of growth.



The city's 2007 Water System Master Plan Update identifies water supply, transmission, and storage needs throughout the city's service territory within the UGB. Additional wells, reservoirs, main transmission lines, and smaller distribution lines will be needed to meet the projected urban area growth.

Figure 8-2

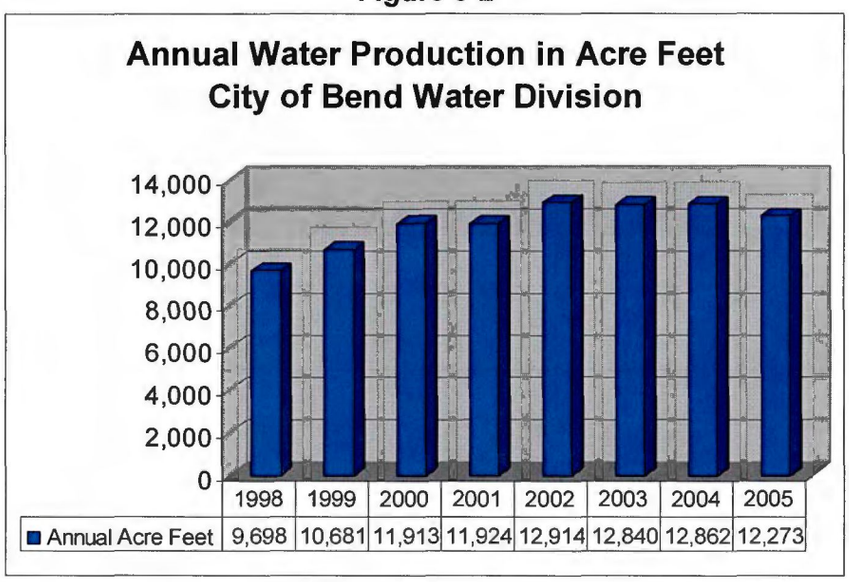
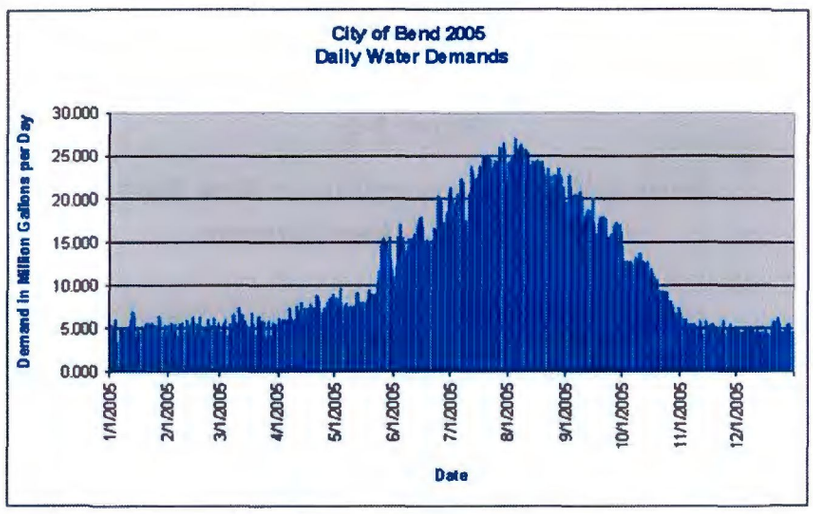


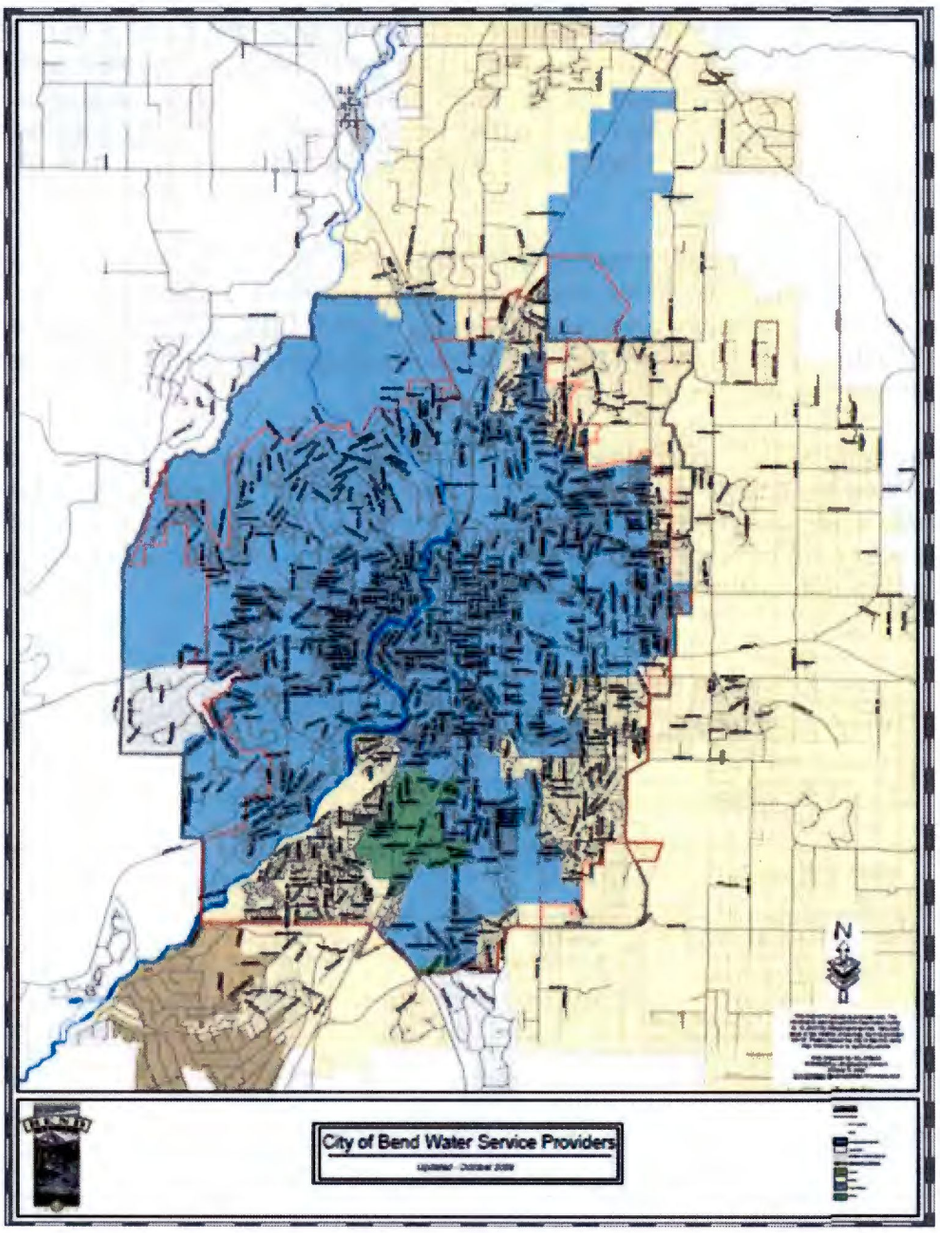
Figure 8-3



Private Providers

Currently, the City of Bend serves water to approximately 70% of the customers within the UGB. There are two private utilities supplying domestic water to the majority of the remaining customers. Approximately 9,200 service connections within the UGB are furnished domestic water through private water systems. Figure 8-4 shows the extent of both the city's service area (blue) and the private providers; Avion (light yellow or tan) and Roats (green). The City has entered into franchise agreements with Avian Water (See Ordinance NS-1514, as amended) and Roats Water Company (See Ordinance NS-1747) through which the City has agreed to Avion Water Company and Roats Water Company providing water to its customers in the city's boundary. Both franchise agreements have been incorporated into the City Code under Chapter 11, Franchises. In addition, the City's water system has inter-ties with both Avion and Roats, which also have inter-ties between their respective systems.

Figure 8-4
Water Utilities in the Bend Urban Growth Boundary



Water System Financing

Table 8-2 lists the various water improvement projects the city plans to construct through the year 2028 to support the projected growth and land uses in the Bend urban area. The description, location, timing and estimated cost of listed facilities may change as a result of subsequent design studies, capital improvement programs, environmental studies, and changes in funding sources. City facilities may be constructed earlier than planned by an owner/developer choosing to develop an area prior to the scheduled extension or expansion of facilities by the city.

The city has adopted System Development Charges (SDCs), as allowed under state law, to help pay for new facilities. SDCs are levied against all new uses at the time of development. These fees are earmarked for major system improvements identified in the city's 2007 Water System Master Plan Update such as reservoirs, wells, transmission lines, and treatment facilities.

As of fiscal year 2006-07, the water System Development Charge is 100 percent of the allowable maximum charge. The City Council determined that this rate reflects the proportionate share of system improvement costs that can be attributed to new growth. The remaining share of system improvement costs benefit the whole community and are collected as a part of the monthly user fees.

Table 8-2
City Water System Improvement Projects (2010 dollars)

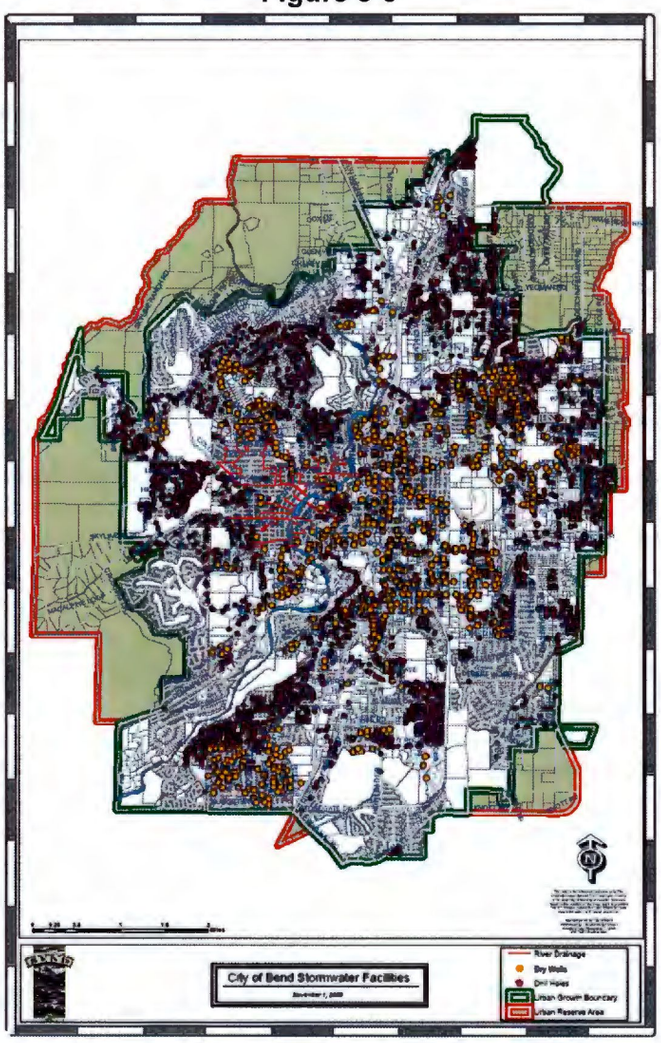
Cost Item	Project Costs, 2010 Dollars
"Surface Water Supply"	
13.5 MGD, membrane treatment, no hydro[1]	$57,750,000
Additional supply to meet 23 MGD (9.5 MGD)[2]	$12,825,000
New Groundwater Wells (35.7 MGD)	$45,490,000
New Storage (14.5 MG)	$24,130,000
New Pipe Improvements for Growth	$43,637,000
Pipe Improvements for Fire Flow	$11,458,000
Pump Station Expansion	$1,957,000
New Valves	$600,000
TOTAL	**$197,847,000**
Sources: Water System Master Plan Update Optimization Study (2011) Optimatics	



STORM DRAINAGE FACILITIES AND SYSTEMS

Within the urban area, both public and private drill holes and dry wells are used for disposal of the majority of surface drainage. The city has a limited storm drainage system that serves part of the west side of the river and downtown (See City of Bend Stormwater Facilities, Figure 8-5). This system drains to the Deschutes River.

Figure 8-5



Some domestic wells are in an area of a shallow water table that may be recharged by surface water such as irrigation canals and the river, or ground water. Disposing of stormwater using dry wells or drill holes in this area presents a potential for ground water contamination.

. The city, county, and state Department of Environmental Quality and Department of Water Resources have developed a program for storm drainage in the urban area that will protect the ground water resource. This program includes dry wells, the use of landscaping and swales to contain runoff, and requirements that surface drainage from developments must be retained on-site. In addition, the Central Oregon Intergovernmental Council (COIC) coordinated the development of the Central Oregon Stormwater manual (COSM). The Central Oregon Stormwater Manual adapts the best available stormwater management guidance from Oregon and Eastern Washington to create a reference for engineers, builders, and local government staff on the design and construction of runoff treatment and flow control facilities1.

Storm drain facilities must adequately prevent unauthorized flooding of public and private streets, facilities, and properties. Developments should be designed per the recommendations of the Stormwater Master Plan.

Water Quality and Stormwater Management

The City is required to meet the requirements of the federal Clean Water Act and federal Safe Drinking Water Act with respect to stormwater drainage. To do so, the City must successfully meet the requirements of its National Pollutant Discharge Elimination System (NPDES) Phase II Municipal Separate Storm Sewer System (MS4) Stormwater Permit and Total Maximum Daily Load (TMDL) requirements for drainages to surface waters, and its Underground Injection Control Water Pollution Control Facility permit requirements for drainage underground. The City is also committed to providing enhanced protection within its Drinking Water Protection Areas.

The City shall require implementation of stormwater pollution control measures and programs to reduce and control the discharge of pollutants into Bend's drywells, drillholes, storm drain system, the Deschutes River, Tumalo creek, and other natural drainages to the maximum extent practicable or as required per federal and state regulations. Stormwater pollution control measures cover the following main activities:

1 See Central Oregon Intergovernmental Council (COIC) website at: http://www.coic.org/cd/stormwater/index.htm.



- Public Education and Outreach on Stormwater Impacts
- Public Involvement and Participation
- Illicit Discharge Detection and Elimination
- Construction Site Stormwater Activities
- Post-construction Stormwater Management in New and Redevelopment
- Pollution Prevention for Municipal Operations
- Water Quality Monitoring
- Pollution Prevention in Drinking Water Protection Areas.

SOLID WASTE DISPOSAL

Solid waste disposal for the urban area occurs at one county facility, the Knott Landfill, just outside of the Urban Growth Boundary on the east side of 27th Street. Deschutes County studies estimate that Knott Landfill will reach capacity by the year 2025. However, the recent trend of 10 to 18 percent annual increases in municipal solid waste flows may shorten that lifespan.

A second landfill intended for construction debris and demolition material located adjacent to Simpson Avenue within the Urban Growth Boundary was in operation prior to 1997. This demolition landfill site owned by Deschutes County is about 80 acres in size, and abuts residential lands on the north, and west, and commercial development along its east and south sides.

Collection of solid waste is done by private providers under City and County franchises. In 2005, it was estimated that about 92 percent of the households in the Bend Urban Growth Boundary had signed up for a weekly collection service. The two garbage haulers in the Bend urban area, Bend Garbage and Cascade Disposal, provide weekly curb-side pickup of municipal solid waste and recyclable materials. Recyclables picked up at curb-side include aluminum, corrugated cardboard, paper bags, magazines and catalogs, newspaper, glass, plastic bottles, tin cans, mixed waste paper (junk mail and cereal boxes) and used motor oil.

The Department of Environmental Quality's 2005 Waste Diversion Report indicated that 160,707 tons of waste were deposited in Knott Landfill and 62,523 tons of waste were "diverted" (recycled by households and businesses either through curb-side service, or dropped off at the county's yard debris mulch program, as well as recycling occurring out of the solid waste system such as bottle bill returns and the scrap metal industry). When backyard composting and efforts in waste prevention and reuse are considered, the percentage of solid waste material being recycled increases from approximately 28 percent to approximately 34 percent.



OTHER URBAN UTILITIES

Electricity within the urban area is provided by Pacific Power and Central Electric Cooperative. Cascade Natural Gas Company provides natural gas service to most parts of the urban area. Adequate electric and natural gas resources exist to serve the Bend urban area through the planning period.

Local (land-line) telecommunication services are provided by Qwest. Many private companies compete to provide long distance and cellular phone services. Cable television service within the urban area is provided by Bendbroadband, which also provides phone and high-speed internet service. Private utility providers within the city limits operate under non-exclusive franchise agreements with the city.

PUBLIC BUILDINGS AND FACILITIES

Downtown Facilities

The Bend City Hall at the south end of downtown was built in 1989 and expanded in 1992. City Hall comprises an area of approximately 26,000 square feet. Also located at the south end of downtown are the Bend-La Pine School District Administrative offices, the Deschutes County historical museum, the Bend Public library, and other public buildings.

The County courthouse and various County offices are located in several buildings at the north end of the downtown area. A new 80,000 square foot administration building was constructed in 2004. Half of this facility is leased to the State Department of Human Services and Department of Justice.

The Bend Metro Parks and Recreation District offices are located between the Old Mill District and the Deschutes River.



Fire Department Facilities

The Bend Fire Department serves the city, the urban area, and some areas beyond the Urban Growth Boundary through the Rural Fire District service contract. The Bend Fire Department covers approximately 164 square miles for fire protection and 1,450 square miles for ambulance operations. The "Main Station" (Old Station 301) was built in 1920 and was located downtown at 5 NW Minnesota Avenue. After serving the Bend Fire Department as the main station and the administrative office for 80 years, the department moved out of the station in 2000 to its new location at 1212 SW Simpson Avenue in order to provide better, faster coverage for the community. Old Station 301 was remodeled and became a mixed-use facility including dining, retail, office and residential spaces. The Fire Administration Building at 1212 SW Simpson Avenue was constructed in 2000. It houses the department administrative, prevention and support staff. The "West Station" (Station 301) is also located at 1212 SW Simpson Avenue, on the west side of Bend near Century Drive. The station is 12,000 square feet in size and was built for a cost of $1.6 million in 2000. The "Tumalo Station" (Station 302) is located at 19850 4th Street in the unincorporated community of Tumalo, between Bend and Sisters. The station was built in the early 1970s. The "South Station" (Station 303) at 61080 County Club Drive was also built in 2000. The "East Station" (Station 304) at 62420 Hamby Road was built in 2003 and is the newest station. The "North Station" (Station 305) at 63377 Jamison Street was built in 2000 and is located on a seven-acre parcel next to the Deschutes County Sheriff's Office. Located behind Station 305, the department Training Center includes a five-story tower with attached garage, numerous training props, and a driver training area. The Training Center also features a classroom and training office building located near the tower. The Fire Department is planning on building a "Central Station" on the Pilot Butte City Campus within the next ten years in order to better serve the rapidly growing central-east section of Bend.

Law Enforcement Facilities

Law Enforcement services in the urban area are provided by the City of Bend Police Department and the Deschutes County Sheriff's Department. The Oregon State Police regional headquarters is also located in Bend. The City of Bend Police Department was located in City Hall until 2002, when a new 27,000 square foot building was constructed at the intersection of 15th Street and US Highway 20 to better accommodate and headquarter all police business. As with all other departments at the City, faster than anticipated growth has created a need for additional staff to serve the community and this has, in turn, created the need for additional space. As a result, the Police Building was expanded to include another 19,000 square feet, and now also houses the Bend Municipal Court. .

In 1997, Deschutes County constructed a new public safety complex off of Highway 20. Within this complex there is a 228-bed adult jail, the Sheriff's Office, the Adult Parole and



Probation offices and transitional housing. The County also constructed the Health and Human Services building off 27th Street on the east side of Bend. This building provides space for the County's Mental Health and Health Departments.

Public Works Facilities

The City's Public Works Facilities are located in three primary areas: The Pilot Butte Campus Site, which is located west of 15th Street between Highway 20 and Bear Creek Road, the Boyd Acres offices, and the Water Reclamation site, which is located northwest of the Bend Airport on McGrath Road. Numerous additional satellite facilities that house vehicles, utility equipment or materials are located throughout the service area.

The Pilot Butte City Campus site houses Public Works administration and all departmental divisions except Water Reclamation. City Council authorized a substantial master planning effort for this site in 2006 in order to determine space needs for the next twenty years for the Public Works, Police, Community Development and Fire Departments, all of whom will have facilities on the site.

The existing main Public Works building houses Public Works administration and provides crew spaces for the Street and Water Divisions. This 41,000 square foot building will likely undergo significant, phased-in changes in the next seven years in order to bring the building into Code and ADA compliance as well as provide for the anticipated 20 year needs of the department.

A new facility to house Public Transportation operations was recently constructed, at the southwest corner of the Pilot Butte Campus site. The construction was largely funded through a $4 million *ConnectOregon* grant, and includes a 5,500 square foot transit operations office, five vehicle maintenance bays and space for transit vehicle parking. The City's public transit program is operated by Cascade East Transit through Central Oregon Intergovernmental Council. The transfer of this program to COIC began in 2010 and was completed in 2011.

The Water Reclamation facility is located outside of the UGB on 1,600 acres northeast of Bend and includes eight main structures. A new Headworks building was constructed in 2008. This facility will be heated by hot water that is heated by methane gas captured from the waste products entering the facility. New facilities completed within the last five years include a new training building, a Level IV filtration facility and a new digester. The new facilities plan for the plant was completed in 2008, and acknowledged by the Land Conservation and Development in 2010. This plan provides for an expansion and upgrade plan for water reclamation to serve the City up to the year 2030.



The Bend Airport

The Bend Municipal Airport is located on 415 acres situated five miles east of the city limits of Bend. Owned by the City of Bend, the airport is located in Deschutes County and is currently outside the Bend Urban Growth Boundary. Airport facilities consist of a single instrument capable runway, 5005 feet in length, a full parallel taxiway, more than 60 hangar and industrial buildings, and parking facilities for aircraft and vehicles. The Bend Municipal Airport is identified by the Oregon Department of Aviation as a Category 2, High Activity Business/General Aviation airport, with approximately 200 based aircraft and an estimated 42,000 operations in 2005.

Over the past few years, demand at the Bend Airport has increased significantly. Continued business expansion by the existing tenants, the addition of Epic Aircraft in 2005, and continued growth and demand has wrought a dramatic increase in activity at the Airport. The corresponding demand for new services and facilities provides challenges to current funding levels.

Current improvements to the Airport infrastructure include the relocation of the single runway at the Airport to meet federal design standards and provide an adequate surface for the existing aircraft fleet mix. This project, beginning in 2007, is scheduled for completion in 2008. Following the runway relocation project, development of an eastside parallel taxiway will be planned for construction in 2009, with completion scheduled for the same year. At this time, it is anticipated that a new Airport Master Plan to clarify the future direction of the Airport and to meet future user needs will be initiated.

POLICIES

Sanitary Sewer Facilities and Systems

1. The city shall encourage development of serviced land prior to unserviced land or require the extension of sewer lines as part of any development within the UGB.

2. The city shall coordinate the provision of sewer service with other providers within the Urban Growth Boundary.

3. All development within the Urban Growth Boundary shall be sewered or provide for sewers through a binding sewer service agreement with the city.

4. No further special districts shall be formed to provide sewer service within the Urban Growth Boundary, nor shall any annexation be allowed to an existing district.



5. The city shall be the primary provider of sewage collection and treatment services for the Bend urban area.

6. To reduce the reliance on individual sewage disposal systems within the Urban Growth Boundary the city will assist established neighborhoods that commit to a sewage collection system by extending pressure or gravity lines to the subdivision.

Water Facilities and Systems

9. The City of Bend is the provider of water service for the City's service area under Statewide Planning Goal 11.

10. Avion Water Company is the provider of water service for its franchise area under Statewide Planning Goal 11 and pursuant to the franchise agreement between the City and Avion adopted under Ordinance NS 1514, as amended.

11. Roats Water Company is the provider of water service for its franchise area under Statewide Planning Goal 11 and pursuant to the franchise agreement between the City and Roats adopted under Ordinance NS 1747.

12. Within the urban planning area, public and private water systems shall be consistent with City Standards and Specifications for construction and service capabilities.

13. The City shall continue to coordinate with private providers and irrigation districts in matters of water concerns within the Urban Growth Boundary.

14. The City shall continue to implement a water conservation program that emphasizes education, enforcement, metering, and other methods to use water efficiently.

Storm Drainage Facilities and Systems

15. Dry wells or storm drains with appropriate water quality treatment using landscaping, retention ponds or other approved treatment controls shall be used for surface drainage control.

16. The preservation and use of natural drainage ways for storm drainage shall be required in new developments as much as possible.

17. Due to the lack of a defined drainage pattern for most of the urban area, development shall contain storm drainage on-site. In instances where containing storm drainage on-site would be impossible or impact public safety, the City shall enter into a specific agreement with a private party to adequately address the storm drainage.



18. The use of disposal systems shall be coordinated with the Oregon Department of Environmental Quality and Water Resources Department to protect ground water.

19. The City shall work to minimize the discharge of street run-off water directly into the Deschutes River.

20. Developments shall be designed to meet appropriate drainage quantity and quality requirements (e.g., meeting the requirements of the City's National Pollutant Discharge Elimination System MS4 Stormwater Permit, the City's Stormwater Master Plan and Integrated Stormwater Management Plan, and Total Maximum Daily Load requirements). Low impact site designs shall be encouraged.

21. Developments containing underground injection controls shall be designed, constructed, and maintained to meet the requirements of the Underground Injection Control program, including treatment; all underground injection controls shall be properly registered.

22. The City shall reduce the quantity of runoff and discharge of pollutants to the maximum extent practicable by integrating stormwater runoff controls into new development and redevelopment land use decisions. Controls may be required to minimize illicit discharges or pollutants of concern.

23. The City shall implement and enforce requirements for an erosion and sediment control program for public and private construction and post-construction activities.

24. All developments shall evaluate the potential of a land parcel to detain excess stormwater runoff and require incorporation of appropriate controls, for example through the use of detention facilities to address quantity, flow, and quality concerns.

25. The City shall seek efficiencies and consistency by working with other municipalities within Central Oregon on land use issues to address flood control and stormwater pollution prevention.

26. Hazard and resource areas with the following characteristics shall be considered unsuitable for urban development:

    - flood zones;
    - water supply watersheds; and
    - riparian corridors and natural drainageways.

27. Development on slopes in excess of 10 percent shall require special consideration to prevent construction-related and post-construction erosion.



28. The City shall regulate development near water courses to reduce erosion and pollution and to provide open, natural areas.

29. Land uses that pose a major threat to water quality, including commercial and industrial uses such as automobile dismantlers, waste transfer disposal facilities, light industries, and other uses that have a significant potential for pollution, shall not be located within the vicinity of stream, percolation facilities, reservoirs, drill holes or where pollutants could easily come in contact with flood waters, high groundwater, flowing rivers, or reservoirs. Such uses shall be required to reduce any threat of pollution to an insignificant level as a condition of approval.

30. As part of site approval, or as a condition on tentative maps, as necessary, the City shall require permanent stormwater pollution control site design or treatment measures or systems and an ongoing method of maintenance over the life of the project.

31. The City shall minimize particulate matter pollution through controls over new and redevelopment (including erosion and sediment controls on grading, quarrying, vegetation removal, construction, and demolition), industrial processes, parking lots and other activities that pose a threat to water quality.

32. The City shall apply the following stormwater protection activities to all new development and redevelopment proposals during the planning, project review, and permitting processes:

- Avoid conversion of areas particularly susceptible to erosion and sediment loss (e.g., steep slopes) and/or establish development guidance that identifies these areas and protects them from erosion and sediment loss. It is a general policy to limit grading permits or not allow grading in those areas susceptible to erosion from October through April.
- Seek to retain river and natural drainage channels in their natural state to prevent undue erosion of banks or beds.
- Preserve or restore areas that provide water quality benefits and/or are necessary to maintain riparian and aquatic biota.
- Promote site development that limits impact on and protects the natural integrity of topography, drainage systems, and water bodies.
- Promote integration of stormwater quality protection into construction and post-construction activities at all development sites.
- Require geotechnical site assessments whenever dry wells or other infiltration or injection is proposed.



33. The City shall work to reduce transportation-related sources of water pollution, particularly in stormwater pollution. Any means and actions that result in a reduction in vehicle-miles-traveled would benefit congestion and reduce both air and water pollution.

34. The City shall recognize and publicize the relationship between air pollution and water pollution in the deposition of airborne contaminants, including metals and fine particulate matter onto streets and other surfaces.

35. To minimize illicit discharge to stormwater and groundwater from septic systems, the City shall require lots with onsite sewage disposal to connect to the city sanitary sewer whenever state rules governing connection are met.

Solid Waste Disposal

36. The City and County shall encourage recycling beyond the level required by state law as an alternative to landfill disposal.

37. The County shall reduce dust and blowing refuse at the landfills in order to ensure as few adverse impacts as possible from these facilities.

38. The City shall explore methods, including mandatory garbage service, to gain 100 percent disposal of waste at designated landfill sites and discourage the dumping of wastes on public and private lands.

39. The City shall coordinate with Deschutes County on the creation of a new solid waste management plan.

Public Buildings and Facilities

40. Public buildings and facilities shall be located so as to provide convenient public use and to provide maximum service for the greatest economy. Governmental offices shall locate downtown when practicable. Other governmental facilities, reservoirs, landfills and correctional facilities shall be located in areas with good public access to principal streets.

41. The County Public Works facility shall be planned and zoned with a Public Facilities designation. The uses allowed at the site from among those uses listed in a Public Facility zone shall be limited to public works and transportation facilities and yards and public service uses in existing facilities as such facilities may be expanded and accessory uses thereto. Commercial or manufacturing uses shall not be allowed at this site.



City of Bend
Goal 11 Water Public Facility Plan
May 2012



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Purpose

The City of Bend has drafted this water public facility plan to satisfy Statewide Planning Goal 11, Public Facilities and Services, and its implementing rule at OAR 660-011. This plan shows the water public facility systems (as defined under OAR 660-011-0000(7)) for the City, Avion Water Company, and Roats Water Company satisfy Goal 11 and the implementing rule for the respective service areas in the 2008 Bend urban growth boundary (UGB). The water public facility plan (PFP) for the City consists of this document which specifically addresses the requirements of Goal 11 and its administrative rule, and draws on key elements from master plans and engineering documents developed for the City's system and for those of Avion and Roats.

In 2007, Murray, Smith, and Associates (MSA) prepared a water system master plan for the City of Bend. This plan covered the city's service territory in the UGB, and two areas outside of the Bend UGB. These areas included the city's Juniper Ridge property, north and east of Bend, and Tetherow, a Goal 8 destination resort located south and west of Bend. The City adopted this plan and a water master plan for the Bend Airport as the Goal 11 water public facility plan for Bend in 2009[1]. This PFP and the adopting ordinance were submitted to the Oregon Department of Land Conservation and Development in June 2009 to be reviewed alongside the city's proposed UGB expansion.

On November 3, 2010, the Oregon Land Conservation and Development Commission (LCDC) issued Order 001795 in which LCDC remanded the water PFP back to the City. LCDC agreed that the City could adopt a water PFP for the current (2008) UGB and if it does so, this plan must consider current and potential future land uses allowed under its acknowledged comprehensive plan[2]. However, LCDC also concluded that a PFP for the current UGB cannot address areas outside of the of the acknowledged urban growth boundary[3] in connection with the proposed UGB expansion. With respect to any expansion of the UGB, LCDC found that the city may, if it chooses, analyze water service for alternative areas considered for expansion under Goal 11, Goal 14, locational factor 2, and OAR 660-024-0060(8). This analysis would need to be adopted as part of the city's findings on any UGB expansion. In addition, the city could subsequently choose to either amend the existing water PFP or develop a new PFP that shows how water service would be provided to the areas in an acknowledged UGB expansion consistent with Goal 11 and the Goal 11 rule.

This water PFP, once adopted, will function as the water PFP for the land within the 2008 UGB only, consistent with Goal 11. Public facility systems are defined under OAR 660-011-0005(7) as those facilities of a particular type that combine to provide water, sewer, or transportation services. A "water system" is a system for the provision of piped water for human consumption subject to regulation under ORS 448.119 to 448.285. For the purposes of Division 11, a public facility system for water includes the following components: sources of water; treatment system; storage system; pumping system, and; primary distribution system.

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[1] See Ordinance NS-2111 – available online at http://www.ci.bend.or.us/city_hall/meeting_minutes/docs/PFP_ADOPTING_ORDINANCEfinal122908.pdf.
[2] See LCDC's Partial Acknowledgement/Remand Order 001795 at pages 96-113 for their disposition of the issues raised on appeal regarding the city's public facility plans. The order is available through the city's website: http://www.ci.bend.or.us/depts/community_development/ugb_expansion_information.html.
[3] The PFP may address areas outside the City currently served by City water, but not currently unserved areas outside the UGB.

Background

Three different water utilities provide potable water to citizens in the Bend UGB. These utilities are the City, Avion Water Company, and Roats Water Company. No special districts provide potable water within the Bend UGB. The City operates a public drinking water system (Public Water System Identification Number 4100100) that supplies water to its customers from both surface and ground water sources[4]. The City's water system is regulated by the Oregon Drinking Water Program under the Oregon Department of Human Services and the Oregon Water Resources Department. Both Avion and Roats are rate and service regulated private water utilities that are also regulated under the Oregon Public Utility Commission and Oregon Water Resources Department[5].

City of Bend Water Utility

The City's service area is the largest of the three utilities; it covers approximately 16,000 acres and includes 22,000 water meters and an estimated population of 62,800[6]. Figure 1 shows the City's current UGB and the location of its service area. The City holds 12 groundwater rights that authorize the use of groundwater at a rate of up to 68.2 cfs (44.1 mgd) for municipal purposes: 7 certificates and 5 permits[7]. In addition, the City holds six surface water rights that authorize a total use of up to 36.1 cfs (23.3 mgd) from Bridge Creek and Tumalo Creek for municipal purposes[8]. The City's seven water right certificates for the use of groundwater authorize the use of up to 31.7 cfs. The City's surface water rights are evidenced by four certificates, one permit, and one transfer. Two of the City's groundwater permits, G-16177 and G-16178, require mitigation. This requires purchasing water rights from other water right holders (i.e. irrigation districts) and putting that water back in stream permanently to offset additional groundwater pumping under these two rights.

The City of Bend's existing water system consists of a surface water intake facility, 23 groundwater production wells, 14 finished water storage reservoirs, 5 booster pump stations, transmission and distribution mains, and associated appurtenances such as control valves, pressure reducing valves, isolation valves, meters, and fire hydrants. The system includes eleven primary pressure zones serving water system customers ranging in elevation from approximately 3,450 feet to 4,160 feet above mean sea level (msl). Surface water is collected approximately 13 miles west of the City at the Bridge Creek Intake Facility located near the confluence of Bridge Creek and Tumalo Creek. Flows in Bridge Creek are supplemented by the diversion of natural springs located in the Tumalo Creek drainage basin. Spring flows are collected in a diversion pond and transferred through two parallel transfer pipes to a canal flowing to Bridge Creek. Raw water is then routed from the Bridge Creek Intake Facility approximately 11.5 miles via two parallel steel transmission pipelines measuring 14 inches and 16 inches in diameter to the Outback Site. In addition to the surface water source, the City currently has 9 groundwater production sites that include 23 wells located throughout the

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[4] See Water Management and Conservation Plan (2011), page 2-33.
[5] See Oregon Public Utility Commission website at http://www.puc.state.or.us/PUC/water/regcos.pdf.
[6] See Executive Summary page ES-2. Water Management and Conservation Plan (2011) for City of Bend. GSI Water Solutions inc. et al.
[7] Please note cfs = cubic feet/second and mgd = million gallons/day.
[8] See WMCP (2011) page 2-21 and Exhibit 2-18.

service area and at the Outback site westerly of the City. The total groundwater production capacity is approximately 31 million gallons per day (mgd).

The existing water distribution system includes eleven primary service areas, or pressure zones. A total of 15 storage reservoirs located throughout the water service area, including the 1.5 MG CT Basin at the Outback site, provide a total of approximately 30 million gallons (MG) of storage[9]. The City has two additional reservoirs Outback 1 (1.5 MG) and Outback 2 (2.95 MG) used for CT to meet state and federal requirements. The distribution system includes five booster pump stations designed to deliver water from one pressure zone to a higher zone. Finally, the water system is composed of various pipe materials in sizes up to 36 inches in diameter. The total length of piping in the service area is approximately 290 miles. The majority of the piping in the system is ductile iron, cast iron and steel. The steel pipes are 12 inches to 16 inches in diameter, with the majority of the pipe at 12 inches.

The City has existing interties (a.k.a. interconnections) with both the Avion and Roats water companies[10]. The City maintains an emergency intertie with the Avion Water Company. This intertie is located at the intersection of 27th Street and Bear Creek Road. This intertie is meant strictly for emergency purposes, such as fire events or emergency backup. The City has an agreement with the Avion Water Company to allow for future emergency water interties if requested by either water provider. It allows either utility to provide water to the other. Construction of the interconnection occurred in 2003. The City has yet to convey water through this interconnection except for flow testing purposes and will not rely on Avion to supply water to the City's customers on a day-to-day basis.

The City also has an intertie with the Roats Water System to meet the demands of a small portion of the former Juniper Utility Company service area (South Bend service area). The interconnection with the Roats Water System is located at the southern boundary of the City's system. Although this connection originally allowed Roats to serve domestic water in the former Juniper Utility service area, the City no longer purchases water from Roats. The interconnection is now considered for emergencies only.

Avion Water Company

Avion Water Company's service area is the second largest covering over 4,000 acres with an estimated 7,002 service connections and an estimated population of 15,796 persons served in the Bend UGB. Figure 2 shows Avion's service area, including that portion in the Bend UGB. Most of Avion's service territory is beyond the Bend UGB in Crook and Deschutes counties. Avion's water supply is ground water from the Deschutes Basin aquifer. Avion began acquiring water rights in its own name on May 21, 1969. As of today, there are 11 separate rights, including the most recent permit G-12788, which carries a priority date of May 18, 1992. The distribution relies on gravity, flowing from the south of Bend to the north end. Avion can currently pump 14.25 million gallons per day, and has 9.9 million in storage. The supply and storage system includes 11 production wells, 5 of which directly pump to reservoirs. The other 6 wells pump directly into mainlines. Water is stored in two concrete reservoirs with a third under construction; a number of smaller reservoirs serve existing developments outside Bend. The pipe system includes pipes as large as 24 inches in diameter.

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[9] CT stands for chlorine contact time.
[10] See 2011 Draft WMCP (2011), page 2-2.

Roats Water Company

Roats Water Company, the smallest of the three utilities, covers about 1,000 acres and has 2,640 customers in the Bend UGB[11]. Most of Roats' service territory is within the Bend UGB and surrounded by the City's service area and Avion's service area. In this PFP and in documents prepared for or by Roats, the service area within the UGB is referred to as Homeplace. Roats also provides water to Woodside Ranch, which is outside of the Bend UGB, and not contiguous to its service area in the Bend UGB. Roats relies on groundwater for its utility, and has seven (7) water right permits. Roats stores water in six (6) reservoirs. Water is also stored in ten wells. Of these ten wells, six (6) serve their Homeplace service area. Roats distributes water through a piping system that includes pipe from two (2) inches to 16 inches in diameter. An approximate 132,200 feet of pipe serves the Homeplace service area.

Goal 2 Planning Requirements

The City's decision to develop and adopt a water public facility plan must be consistent with state planning law and with the City's General Plan and Development Code. Statewide Planning Goal 2, Land Use Planning, requires the following for local government planning decisions.

- **Consistency** - The City's plans must be internally consistent and consistent with plans of county, state, and federal agencies, and special districts.

- **Factual Base** - The City's plans must be supported by an adequate factual base. For a legislative land use decision such as this Goal 11 PFP, an adequate factual base must be supported by substantial evidence. Substantial evidence exists to support a finding of fact when the record, viewed as a whole, would permit a reasonable person to make that finding.

- **Coordination** - The City's plan must also be coordinated with the relevant plans of the county, state, federal agencies, and special districts. A plan is "coordinated" when the needs of all levels of governments, semipublic and private agencies and the citizens of Oregon have been considered and accommodated as much as possible (See ORS 197.015(5)).

Coordination with special districts and private utilities was the basis for a number of issues raised in appeals and objections of the city's PFPs before LCDC. ORS 195.065 to 195.085 includes a number of requirements for cities to follow when coordinating with special districts on the provision of public facilities, like water. These requirements include cities entering into urban service provider agreements with special districts. LCDC found that the urban service provider agreement provisions of ORS 195.065 do not apply to either Avion Water Company or to Roats Water Company because they are not special districts under Oregon law.[12] Both companies are rate and service regulated private utilities. In addition, the requirements for

[11] See page 7, Roats Water Company Water Management and Conservation Plan (2007.
[12] See Partial Acknowledgement/Remand Order 001795, pages 105-108.

coordinating with urban service providers (e.g. a water district) and executing urban service provider agreements do not apply to irrigation districts organized under ORS 545[13].

However, ORS 197.015(5), Goal 2, and the Goal 11 rule for public facility planning require that the city coordinate with providers of public facilities, including private utilities within the City's UGB. OAR 660-011(1)(e) and (g) and 011-015 require the City to identify and to designate providers of water service in the water PFP. The water PFP must identify their service areas, and include an inventory and assessment of significant systems and projects to support the land uses within that area as provided in OAR 660-0010(a)-(d) and (f). The plans of the three water service providers are included as appendices to this PFP and include details on the service areas and sufficient descriptions of the systems to comply with Goal 11 and its implementing regulations.

City of Bend (adopted as appendices)

1. Water System Master Plan update, Final Report (2007) prepared by Murray, Smith, and Associates.
2. Water system master Plan Update Optimization Study (2011) prepared by Optimatics.
    a. See also the following tables from this document that are attached as a separate appendix to this PFP:
        i. Table 2.11 – Recommended new storage – Final Build-out solution
        ii. Table 2.12 – Recommended new wells – Final Build-out solution
        iii. Table 2.13 – Recommended new pumps – Final Build-out solution
        iv. Table 2.14 – Recommended new values – Final Build-out solution
        v. Table 2.18 – Total capital costs – Final Build-out Solution

3. Water Management and Conservation Plan (2011) prepared by GSI Water Solutions, Murray Smith and Associates, and HDR Engineering, Inc.

Avion Water Company (adopted as appendices)

1. Master Plan (2006) Avion Water Company.
2. Water Management and Conservation Plan (2004) Avion Water Company

Roats Water Company (adopted as appendices)

1. Water Management and Conservation Plan (2007) Roats Water Company
2. Modeling by MSA for Roats Water Company (2007)

[13] See Partial Acknowledgement/Remand Order 001795, pages 111-112, related discussion on coordination with Swalley Irrigation District specifically at pages 143-144.

Goal 11 Requirements for Public Facility Plan

Statewide Planning Goal 11 requires cities to develop a timely, orderly and efficient arrangement of public facilities and services to serve as a framework for urban and rural development[14]. The Land Conservation and Development Commission has adopted an administrative rule at OAR 660-011 that identifies what public facilities must be addressed under this rule and the requirements for completing a public facility plan[15]. This plan draws from a number of water planning documents to address the requirements for a PFP under Goal 11 and the Goal 11 rule, but only to the extent that these planning documents address land within the 2008 Bend urban growth boundary (UGB). The Council adopts this PFP and its appendices as the water public facility plan for the Bend UGB.

This Goal 11 PFP addresses water service for the area within the Bend UGB as of January 2009. The UGB is shown in Figure 1 in red. This plan does not propose water service to any area outside the 2008 UGB that does not already receive water service.

The Goal 11 administrative rule, OAR 660-011, lists certain elements that must be included in a Goal 11 public facility plan. These elements are listed at OAR 660-011-0010(1)(a) through (1)(g). The rule further requires that the local government preparing the PFP consider and describe how the PFP will guide and support the lands designated in the acknowledged comprehensive plan. For each service area, the following tables direct the reader to the appropriate sections and pages of the plans and reports listed under Section 2 of this report. Each table also considers and highlights how the respective planning documents provide data and information to satisfy the Goal 11 administrative rule requirements for a public facility plan. The purpose of the City's water master planning documents, as with any utility master plan documents, is to identify the infrastructure needs to meet increasing demands due to both population growth and changes in demands from the growing population. The projects identified in water master planning documents represent recommended improvements to the City's water infrastructure. The costs of these projects are presented as Class 5 estimates, meaning the project costs have an estimated level of accuracy of plus 100% to minus 50%. The planning documents identify these projects as certain investments that need to be made based on future demand and more detailed study. The recommended infrastructure improvements are typically tied to population projections by year. This is to best estimate when the population will reach a certain size by a given year so the City knows when certain projects will be needed.

However, because population is not easily measured year to year, a local government can make infrastructure investments that are unwarranted if the improvements are tied only to population projections. In addition, water use behavior can also change which can allow a larger population without increasing water demand. To ensure that the City makes improvements to the water infrastructure when they are needed, the City now relies on an approach that is consistent with the projected population growth, but is more advanced to projecting more specific timing of required investments for its water infrastructure. The City ties the timing of water infrastructure requirements to peak day demands. Peak day demands are easily and readily measured. This approach ensures that any investments made are directly tied to the actual demands and occur when they are actually needed. Tying the infrastructure investments to measured peak day demand allows required estimated investments to be postponed until they are needed.

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[14] See OAR 660-015-0000(11) at - http://www.oregon.gov/LCD/docs/goals/goal11.pdf.
[15] See OAR 660-011 at - http://arcweb.sos.state.or.us/rules/OARS_600/OAR_660/660_011.html.

Table 3.1 of the Optimization Study (2011) identifies water infrastructure investments needed in the next ten years. This table was developed using the population growth that was used in the UGB process, and based on historical water use patterns. Several factors have impacted, and may continue to impact the timing of when the actual peak day tied to the improvements is reached. The factors that have impacted peak day demands in recent years include, but are not limited to, the economic downturn, operational changes, and cooler weather. Other factors besides growth that can impact the timing of when the peak day is reached (and therefore the City's potential ability to defer investments) are changes in water use behavior. For several years, the City of Bend has seen the per capita demand decreasing, which has helped in making more efficient use of the City's water supply. Since the investments in Table 3.1 are tied to the peak day demand, the City can delay making these investments to some point in the future. For example, it was estimated that in 2012 peak day demand would be approaching 33 MGD and would require over $2 million in infrastructure investments to meet that peak day. In reality, the City's peak day is approximately 10 MGD less – or 23 MGD - and therefore the investments needed can be postponed until our peak day demands approach 33 MGD. As a result, the projects proposed in Table 3.1 may not be needed as forecasted. To pay for these projects, the City continually updates the five year capital investments that are estimated to be needed. Rate analysis is then developed and updated annually based on the five year capital needs to pay for these projects. As projects are delayed annually, rate analyses to pay for those also change annually to avoid collecting the money until a project is actually needed.

The City Council understands that the improvements identified in Table 3.1 are triggered by changes in maximum daily demand and average daily demand, both of which are expressed in million gallons per day. The City Council further understands that growth in water usage has been less than was estimated in the Optimization Study as a result of the economy, weather trends, and operational changes that have lowered peak day demand. To avoid financing improvements that are not yet needed, the Council is relying on the data in Table 3.1 for developing the following tables based on recommendations from the City Engineer, without tying the need for improvements to a specific year. The Council will follow the practice presented by the Public Works Department to schedule the improvements identified in Table 3.1 when maximum daily demand and average daily demand reach the levels that tie to the required improvement. To the extent that the Optimization Study is adopted as an appendix and contains specific yearly dates, it is the intent of this Master Plan that the following tables control for the timing of Short Term and Long Term Projects. Table 1.1 identifies projects that are already completed or estimated to be needed in the next five years. While the City estimates these projects may be needed in years 1 and 5 of the Water PFP, the City will not include these projects in the CIP until MDD and ADD reach levels that necessitate these improvements. Table 1.2 identifies the projects that are estimated to be required beyond the five year planning horizon for the CIP. These are long term projects, which may be required within years six through twenty.

In addition to Table 3.1, the City Council understands that the Optimization Study includes a series of tables that list improvements that will be needed for final build-out of the City's water utility service area. These improvements are presented in Tables 2.11 through 2.14, and Table 2.18. These tables list improvements for new storage, wells, pumps, valves, and total capital costs. Those improvements that are needed over the planning period area also reflected in Table 3.1, which was used to inform Tables 1.1 and 1.2 of this Water PFP.

The City Council's intent, as expressed above, is to ensure that the public investments for water

infrastructure are made when water consumption has reached levels necessitating these improvements. The Council is relying upon the work presented by Optimatics in the 2011 Optimization Study, and is choosing to work with a longer timeline that the one presented in Table 3.1 of the Optimization Study for financing these projects.

Table 1: Public Facility Plan components for City of Bend Service Area

Goal 11 and OAR 660-011-0005(1) consideration of land uses served by the PFP	See Sections 3 through 5 of 2007 Water System Master Plan. These sections include the analysis, based on the city's buildable lands inventory and population forecast that examines the city's water system, and acts the foundation for identifying future improvements to the storage and distribution systems. These documents show the city has considered the future existing and future lands uses contemplated under the Bend Area General Plan in developing this component of the water PFP for the Bend UGB.
OAR 660-011-0010, Required Elements	**Information or Location of information in Planning Documents Description of required elements**
OAR 660-011-0010(1)(a) inventory and General Assessment	See Section 2 (Pages 2-1 to 2-11) of 2007 Water System Master Plan; • Water supply and water rights • Groundwater production facilities • Pressure zones • Storage • Pumping stations • Miles of pipe by size See Figure 1 for a graphic representation of the location of facilities in the Bend service area See also Section 2.5, pages 17-20, including Table 2.4 – Demand nodes with pressures below 40 psi under existing peak hour conditions – of Opitmatics (2011) report.
OAR 660-011-0020, inventory requirements	See following tables in Section 2 • Table 2-1 for significant Groundwater Production Facilities • Table 2-3 for Storage Reservoir Summary • Table 2-4 for Existing Booster Pump Station Summary Section 6 includes proposed improvements to the surface water supply, storage, pumping stations, transmission piping, and distribution system. Overall, most of these facilities are in good condition. Section 6 identifies that improvements are needed in supply, storage, and distribution to maintain the condition of the respective facilities. The following sections of this table identify the relevant sections and pages of plans and planning documents in which the reader will find the improvements needed over the planning period.
OAR 660-011-0010 (1)(b)	See the following tables from Optimatics (2011) study: • Table 2.11 – Recommended new storage – Final Build-out

list of significant public facility projects	solution • Table 2.12 – Recommended new wells – Final Build-out solution • Table 2.13 – Recommended new pumps – Final Build-out solution • Table 2.14 – Recommended new values – Final Build-out solution • Table 2.18 – Total capital costs – Final Build-out Solution See also Tables 1.1 and 1.2 of this plan.
OAR 660-011-025, timing of required facilities	See Tables 1.1 and 1.2 of this plan. These tables draw on information presented in Table 3.1 of the Optimatics (2011) study.
OAR 660-011-0030, location of projects	See the following Figures from Chapter 3, Capital Improvements Plan – 10-year, from Optimatics (2011): • Figure 3.2 – Recommended phasing of Master Plan Improvements • Figure 3.3 – Phasing of Improvements – Southwest area; Outback, Tetherow, Westwood • Figure 3.4 – Phasing of Improvements – Southeast area; South Bend • Figure 3.5 – Phasing of Improvements – Zone 4b; Rock Bluff • Figure 3.6 – Phasing of Improvements – Level 5 east • Figure 3.7 – Phasing of Improvements – Level 5 west and Level 6 • Figure 3.8 – Phasing of Improvements – Awbrey Butte
OAR 660-011-0010 (1)(c) rough cost estimates	See the following tables from Optimatics (2011) Study: • Table 2.11 – Recommended new storage – Final Build-out solution • Table 2.12 – Recommended new wells – Final Build-out solution • Table 2.13 – Recommended new pumps – Final Build-out solution • Table 2.14 – Recommended new values – Final Build-out solution • Table 2.18 – Total capital costs – Final Build-out Solution See Tables 1.1 and 1.2 of this plan. The rough cost estimates are presented in these tables are based on 2009 unit costs developed by MSA in October 2009. For the purpose of addressing this rule, the City finds that the cost estimates listed in the forgoing tables are rough cost estimates under OAR 660-011-0010(1)(c).
OAR 660-011-0010 (1)(d) map or written	See Appendix A of 2007 Water System Master Plan, Figure 1, Existing Water System Map. This figure shows the city's service area and

description of projects' general location or service area	existing water system. For the general location of projects, please refer to the following Figures from Optimatics (2011) study: • Figure 3.2 – Recommended phasing of Master Plan Improvements • Figure 3.3 – Phasing of Improvements – Southwest area; Outback, Tetherow, Westwood • Figure 3.4 – Phasing of Improvements – Southeast area; South Bend • Figure 3.5 – Phasing of Improvements – Zone 4b; Rock Bluff • Figure 3.6 – Phasing of Improvements – Level 5 east • Figure 3.7 – Phasing of Improvements – Level 5 west and Level 6 • Figure 3.8 – Phasing of Improvements – Awbrey Butte
OAR 660-011-0010 (1)(g) discussion of funding mechanisms	Table 2.18 of Optimatics' 2011 study shows that the recommended improvements to the City's water system will cost, a final build out, an estimated $197,622,000. The 10-year master plan shown in Table 3.1 of this report identifies which of these improvements are needed during this 10-year period, and that these improvements will cost an estimated $38,790,000. The City's water utility program is funded through system development charges, and utility user fees. Systems Development Charges (SDC's) are fees charged to join or to extend an existing utility system. For the city's water utility, SDC's are projected to be $4,520 for FY 2011-12, and $4,565 for FY 2012-2013. Projected revenues from Water SDCs are $1,561,900 for the biennium. Utility user fees (a.k.a. rates) are used to provide for the on-going operation and maintenance of the Water utility as well as to pay for capital projects and debt service used to finance capital construction. Water Utility user fees are allocated to the respective Water fund. The City's 2011-2013 budget projects $27,726,000 in revenues from water utility user fees over the 2011-2013 biennium. In addition to utility rates and SDS's, the City's funding mechanisms for water include revenue streams from leasing of property to wireless telecommunications companies and the City's hydrant meter program. The City has also adopted a five-year capital improvement program (CIP) for water for 2011 through 2015. This program includes projects related to: (1) repair and maintenance, and; (2) growth. For repair and maintenance, the CIP budgets an average of $800,000 per year from 2011 to 2015. For growth related projects, the CIP budgets an average of $21,305,383 per year from 2011 to 2013. For 2014-15, the City budgeted an average of $2,088,875 per year.

Table 1.1. Master Plan Improvements Identified by Optimatics (2011) for City of Bend Water Utility - Short Term Projects (Years 1-5)

MDD (mgd)	ADD (mgd)	Pipes	Cost	Wells	Cost	Total Cost
29	12.8	*Juniper Ridge 16-inch connection on 18th	$1,292,000			$1,292,000
31	13.8	**Tetherow Improvements – B (Skyline Ranch 18-in main)	$1,434,000			$1,434,000
33	14.7	***Extend larger diameter pipe out of Pilot Butte on Lafayette to 11th, piping associated with new Awbrey well	$241,000	Awbrey	$1,944,000	$2,185,000

Source: Table 3.1 of the Optimization Study (2011)
Notes:
The five year period referred to in the title of this table is 2008-2012.
* A new lower cost approach for this project was found under further analysis and is currently under design. The new estimated cost for this project is approximately $150,000 and expected to be started in 2012.
**This project is complete and was designed and constructed by a local developer in 2011.
***This project is expected to be needed by 2012.

Table 1.2. Master Plan Improvements Identified by Optimatics (2011) for City of Bend Water Utility - Long Term Projects (Years 6-20)

MDD	ADD	Pipes	Cost	Wells	Cost	Total Cost
35	15.6	New parallel pipe near College PS in Level 3 New Level 5 pipe connection on Roanoke Site and discharge piping on new Level 5 Well east of Pilot butte	$1,169,000	New Level 5A	$2,721,600	$3,890,600
37	16.4	Parallel piping from Rock Bluff to Brookswood	$1,535,000			$1,535,000
39	17.3	Continue parallel piping from Rock Bluff to Brosterhous; open Zone 4B41 boundary at Reed Market	$2,940,000	Shilo	$2,721,600	$5,661,600
41	18.2	Parallel mains on Brosterhous and Reed Market, replacing piping along Wilson in Zone 4b	$1,742,000	New Level 6	$1,360,800	$3,102,000
43	19.1	Extend larger diameter piping out of Pilot Butte on Lafayette from 11th to 8th.	$402,000	New Level 5a	$2,721,600	$3,123,600
45	20.0	Parallel piping in Level 6 – Boyd Acres and Brinson Blvd; piping for Level 6 Well at Butler Market well; New Pilot Butte tank connection	$1,364,000	New Level 6	$2,721,600	$9,892,600*
47	20.9	Replace existing pipe along 8th from Lafayette to Seward	$1,000,000	New Level 5 A	$1,360,800	$2,360,800

49	21.8	Parallel main on Glassow and new main on Summit in Level 2; Replacement of piping on Norton and Olney in Level 5	$1,366,000	New Level 6	$2,721,600	$4,087,600`
* - The total cost for these improvements includes $5,807,000 for the Pilot Butte 4 tank.						
Source: Table 3.1 of the Optimization Study (2011) Note: The projects in Table 1.2 will be needed sometime between 2013-2028. These represent years 6 through 20 of this PFP.						

Table 2: Public Facility Plan Components for Avion Water Company Service Area

Goal 11 and OAR 660-011-0005(1) consideration of land uses served by the PFP	Chapter 4 of Avion's 2006 master plan includes an analysis of future water requirements based on their service area (See pages 17 through 23). Avion based their consideration of land uses on data on historic growth in their accounts, build-out of their portion of the UGB based on current zoning, and population forecasts.
OAR 660-011-0010, Required Elements	**Information or Location of information in Planning Documents**
OAR 660-011-0010(1)(a) inventory and General Assessment	See pages 10 to 11 of Avion Water Company master plan: • Water supply (See also pages 29-31) • Water storage (See also pages 32-34) • Distribution system (See also pages 36-38)
OAR 660-011-0020, inventory requirements	See Figure 2, mapped location of Avion's distribution system. Please note that this figure does show Avion's service area outside of the Bend UGB. For the purposes of preparing this PFP, the City relies on this figure in showing the location and sizes of distribution lines in the Bend UGB. See also: • Water supply (See also pages 29-31) • Water storage (See also pages 32-34) • Distribution system (See also pages 36-38) For the purpose of this PFP, the Avion Water Company's plans do not identify any facilities that are in poor conditions. For this plan, the facilities identified under Avion's water planning documents appear to be in good condition. The following sections of this table identify the relevant sections and pages of plans and planning documents in which the reader will find the improvements needed over the planning period.

OAR 660-011-0010 (1)(b) list of significant public facility projects	See Chapter 9 of Avion's 2006 master plan:
OAR 660-011-025, timing of required facilities	See Table 10.1, Short Term Improvements (pages 42-43) See Table 10.2, Long Term Improvements (pages 43-44) For the purpose of this PFP, short term projects are those identified in Table 10.1; long term projects are those projects identified in Table 10.2.
OAR 660-011-0030, location of projects	See Tables 10.1 and 10.2, pages 42 through 44
OAR 660-011-0010 (1)(c) rough cost estimates	See pages 42 – 44 of Avion's 2006 master plan: See Table 10.1 – Short term improvements See Table 10.2 – Long term improvements
OAR 660-011-0010 (1)(d) map or written description of projects' general location or service area	See pages 40-42 of Avion's 2006 master plan.
OAR 660-011-0010 (1)(g) discussion of funding mechanisms	Avion Water Company is an investor-owned public utility and regulated by the Public Utility Commission. See discussion of customer rates for funding at pages 25-26 of 2006 Master Plan.

Table 3: Public Facility Plan Components for Roats Water Company service area

Goal 11 and OAR 660-011-0005(1) consideration of land uses served by the PFP	See Section 5 of 2007 WMCP, Water Supply Element. Roats based their consideration of land uses on the City's 2025 population forecast, potential new residential and commercial accounts in their Homeplace service area. Roats has a study conducted in which 1,589 additional service connections could be established in their Homplace service area.
OAR 660-011-0010, Required Elements	**Information or Location of information in Planning Documents**
OAR 660-011-0010(1)(a) inventory and General Assessment	See pages 8, 12-15 of Roats 2007 WMCP
OAR 660-011-0020, inventory requirements	See Figure 3 – Roats service areas in Bend UGB (aka Homeplace). (also Exhibit 2-1 of Roats WMCP (2007)). See also Tables 2-7, 2-9, and 2-10 For the purposes of this PFP, the Roats water planning documents do not identify any facilities that are in poor condition. For this PFP, the facilities identified in their inventory appear to be in good condition. The following sections of this table identify the relevant sections and pages of plans and planning documents in which the reader will find the improvements needed over the planning period.
OAR 660-011-0010 (1)(b) list of significant public facility projects	See page 22 of Roats 2007 WMCP. Roats has not developed a capital improvements program, but has identified a long range supply plan that is an element of its WMCP.
OAR 660-011-025, timing of required facilities OAR 660-011-0030, location of projects	The City of Bend maintains an intertie (or interconnection) with Roats Water Company (See Section 2.6, Interconnections, at page 14 of Roast 2007 WMCP). As indicated above, Roats has not prepared a long-term capital improvements program. A review of the 2007 WMCP suggest that the growth potential is limited in the Roats' Homeplace service area, and that additional facilities will not be required to serve new connections at buildout. This addresses both 025 and 030 of OAR 660-011.
OAR 660-011-0010 (1)(c) rough cost estimates	Roats has not developed any rough cost estimates for its long range supply plan.

OAR 660-011-0010 (1)(d) map or written description of projects' general location or service area	See Exhibit 2-1 for the Homeplace System Map, which represents the services area in the Bend UGB. This exhibit describes the current system, including pipe locations and locations of storage.
OAR 660-011-0010 (1)(g) discussion of funding mechanisms	Like Avion, Roats is a rate and service regulated utility under the jurisdiction of the Oregon Public Utility Commission. See page 17 of the Roats WMCP for a discussion of Roats' rate structure for meter sizes. All connections in the Homeplace are metered.

Policy Statements for Water Providers

OAR 660-011-010(1)(e) requires that a public facility plan include policy statement(s) or urban growth management agreement(s) identifying the provider of each public facility system. If there is more than one provider with the authority to provide service within the area covered by the public facility plan, then the rule requires the designation of each provider. This section of the PFP proposes policy statements that identify the City, Avion, and Roats as the providers of water service within the Bend UGB for their respective service areas. The City has entered into franchise agreements with each utility for providing water service in areas of the UGB not already served by the City of Bend.

City of Bend. The City proposes to add the following **new** *language* to Chapter 8 of the Bend Area General Plan, Public Facilities and Services, as a policy identifying the City of Bend as a provider of water service in the City's UGB.

The City of Bend is the provider of water service for the City's service area in the Bend UGB under Statewide Planning Goal 11.

Avion Water Company. The City proposes to add the following **new** *language* to Chapter 8 of the Bend Area General Plan, Public Facilities and Services, as a policy identifying the Avion Water Company as a provider of water service in the City's UGB.

Avion Water Company is the provider of water service for Avion's franchise area in the Bend UGB under Statewide Planning Goal 11 and pursuant to the franchise agreement between the City and Avion adopted under Ordinance NS 1514, as amended[16].

Roats Water Company. The City proposes to add the following **new** *language* to Chapter 8 of the Bend Area General Plan, Public Facilities and Services, as a policy identifying the Roats Water Company as a provider of water service in the City's UGB.

Roats Water Company is a provider of water service for Roats' franchise area in the Bend UGB under Statewide Planning Goal 11 and pursuant to the franchise agreement between the City and Roats adopted as Ordinance NS 1747[17].

[16] See Bend Code 11-20.1, Water Service Franchise-Avion Water Company (Ordinance NS-1514, as amended) available online at: http://www.ci.bend.or.us/online_forms_and_documents/chapter_11_-_franchises.html.

[17] See Bend Code 11-21, Water Service Franchise-Roats Water Company (Ordinance NS-1747), available online at: http://www.ci.bend.or.us/online_forms_and_documents/chapter_11_-_franchises.html.

Urban Growth Management Agreement

The City has entered into a joint management agreement (JMA) with Deschutes County for planning in the Bend UGB. The City and County entered into this agreement on February 24, 1998[18]. Section (4)(a)(1) of the JMA states the City is responsible for textual changes in the BAGP or implementing ordinances within the UGB. Section (10)(B) states the City is responsible for the preparation, adoption, and amendment of the public facility plan required by ORS 197.712(2)(e) with the aid and assistance of the County. This same section goes on to say the City shall coordinate the preparation of the public facility plan with the County, special districts, state and federal agencies, and private providers of public facilities as required by ORS 660-011-015(2).

The proposed PFP is a textual change to the BAGP and represents a new element to the BAGP. In addition, the PFP includes proposed changes to the text of Chapter 8 of the BAGP. The PFP was developed in coordination with the other water service providers in the Bend UGB: Avion Water Company and Roats Water Company. Both water companies are private utilities that have service areas within the city and UGB. The City and these companies have entered into franchise agreements for the provision of these services in the UGB. There are no special districts that operate water systems, as that term is defined under Goal 11, within the UGB for the provision of piped water for human consumption subject to regulation under ORS 448. OAR 660-011-0015(4) is not applicable because the city is not receiving state agency funding for the development of this public facility plan. The PFP does rely on water management and conservation plans (WMCPs) prepared for or by the City, Avion, and Roats pursuant to OAR 690, Division 86.

[18] The JMA is available on-line at http://www.ci.bend.or.us/online_forms_and_documents/docs/CityCounty_IGA_Managed_services.pdf.

Figure 1 – Water Service Providers in Bend urban growth boundary

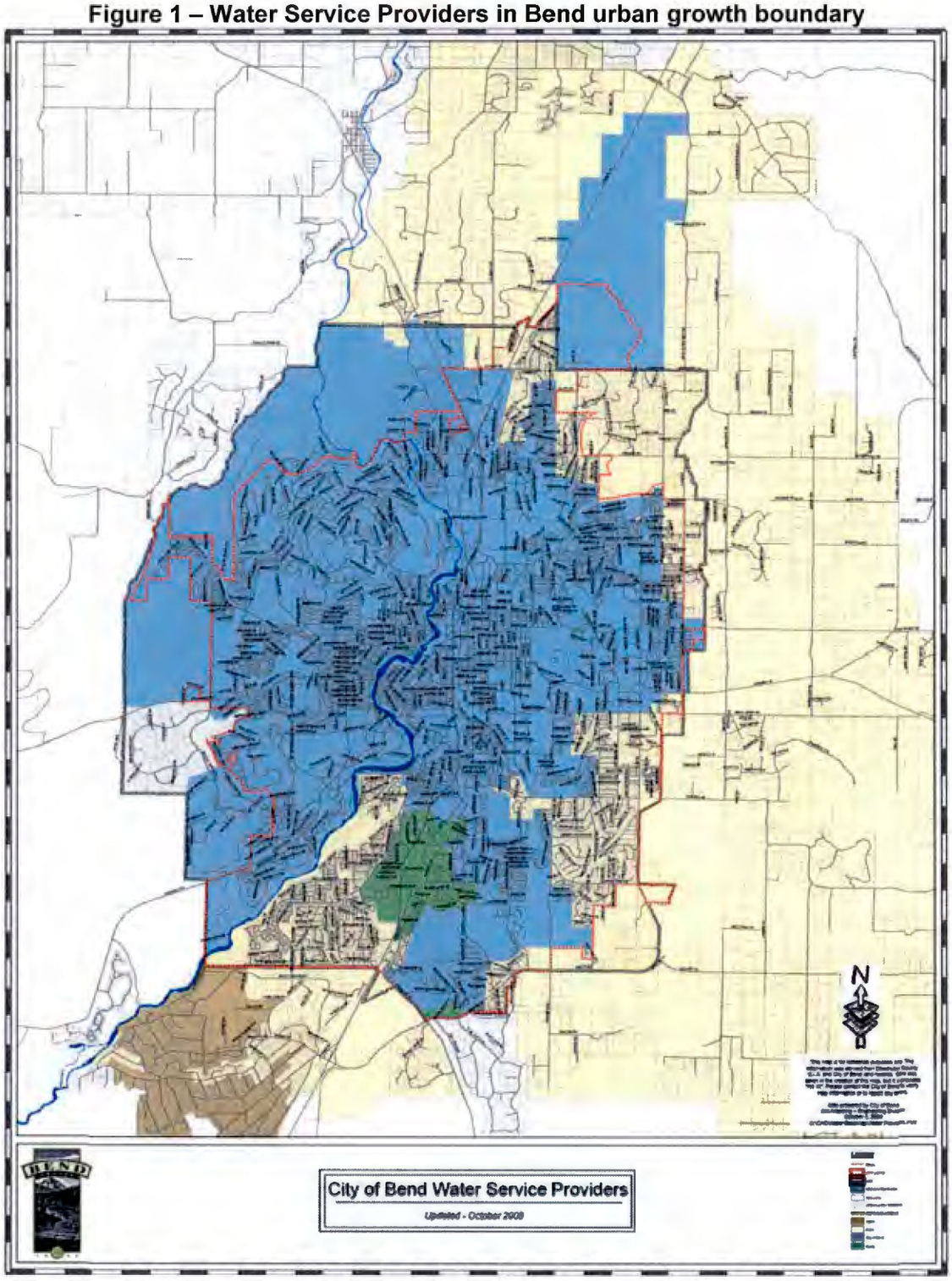


Figure 2 – Avion Water Company Service Area and Line Sizes (2006)

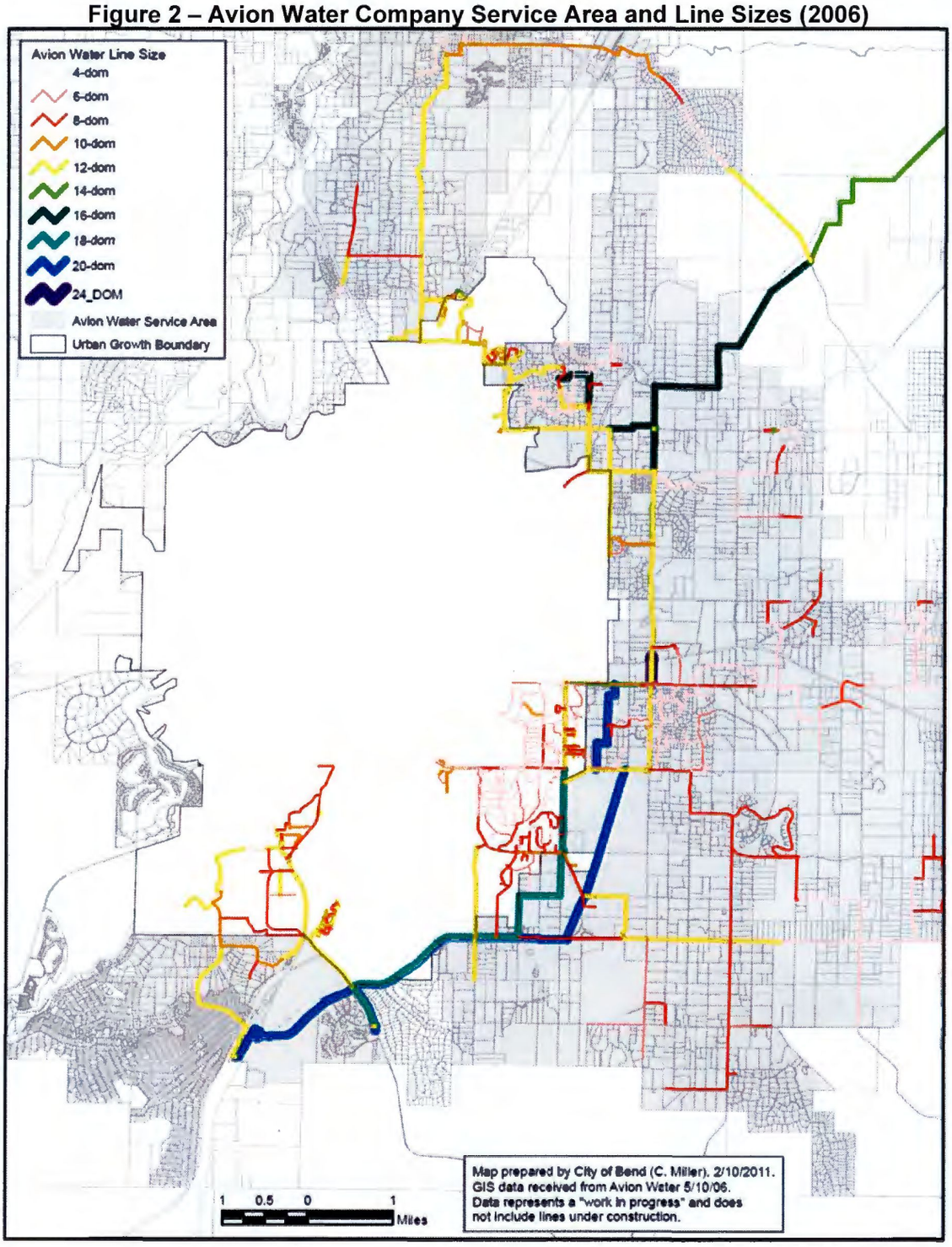
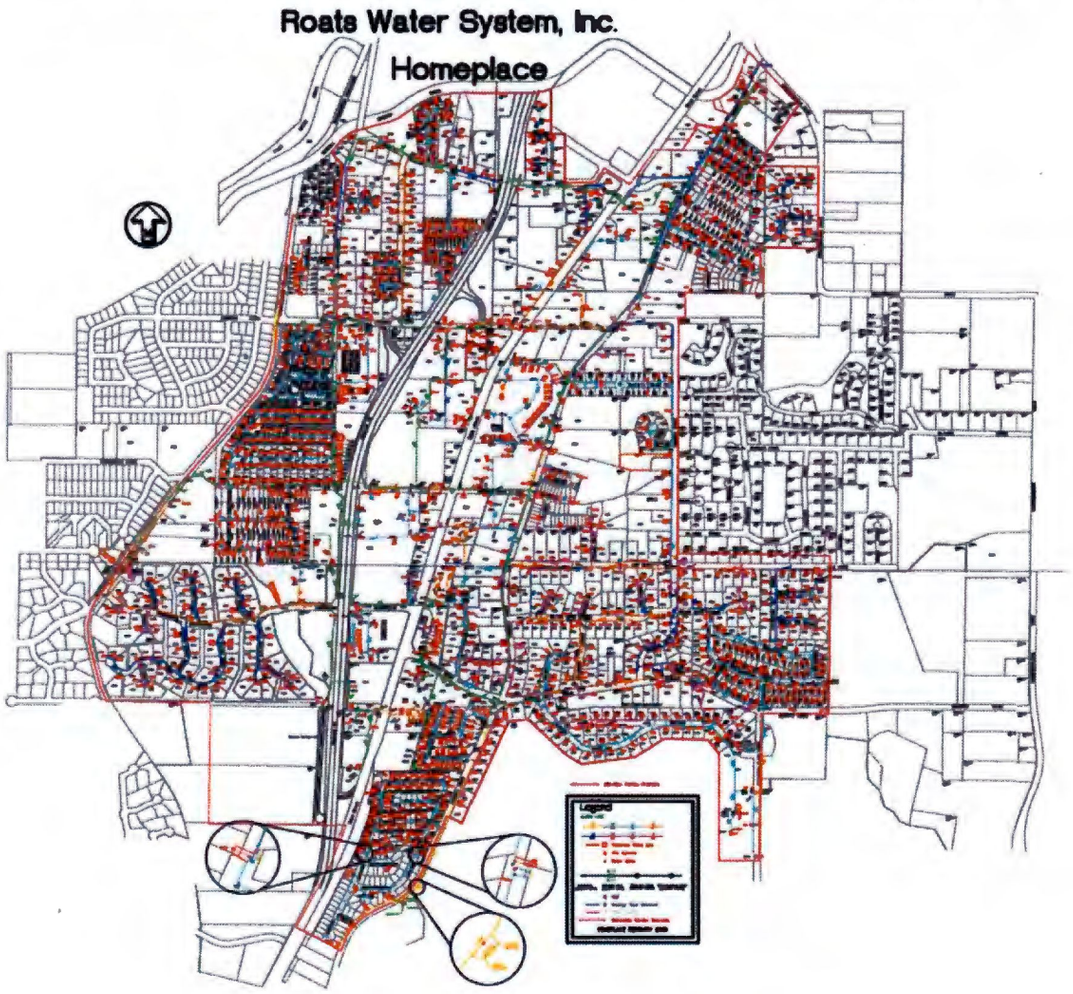


Figure 3: Roats Water Company Service Area and Line Sizes in Bend UGB



Appendices

A. City of Bend

1. Water System Master Plan update, Final Report (2007) prepared by Murray, Smith, and Associates.
2. Water system master Plan Update Optimization Study (2010) prepared by Optimatics. The following tables are enclosed as appendices to this public facility plan.
    a. Table 2.11 – Recommended new storage – Final Build-out solution
    b. Table 2.12 – Recommended new wells – Final Build-out solution
    c. Table 2.13 – Recommended new pumps – Final Build-out solution
    d. Table 2.14 – Recommended new values – Final Build-out solution
    e. Table 2.18 – Total capital costs – Final Build-out Solution

3. Water Management and Conservation Plan (2011) prepared by GSI Water Solutions, Murray Smith and Associates, and HDR Engineering, Inc.

B. Avion Water Company (adopted as appendices)

1. Master Plan (2006) Avion Water Company.
2. Water Management and Conservation Plan (2004) Avion Water Company

C. Roats Water Company (adopted as appendices)

1. Water Management and Conservation Plan (2007) Roats Water Company
2. Modeling by MSA for Roats Water Company (2007)

D. Agreement between the City of Bend and Deschutes County, Oregon for the Joint Management of the Bend Urban Area (1998).

Appendices (A)(2)(a) through (2)(f), Tables from Water System Master Plan Optimization Study (February, 2011)

Table 2.11 – Recommended new storage – Final Build-out Solution

Location	Storage construction:	New Volume (MG)	Cost
Outback 4 & 5	Above-ground Concrete	6.0	$7,020,000
College 3	Above-ground Concrete	1.0	$2,366,000
Tower Rock 2	Above-ground Concrete	2.0	$3,755,000
Rock Bluff 2	Above-ground Concrete	2.0	$3,755,000
Pilot Butte 4 (Level 5)	Buried Concrete	3.0	$5,807,000
Westwood (replace)	Above-ground Concrete	0.5	$1,427,000
Total Cost		**14.5**	**$24,130,000**

Table 2.12 – Recommended new wells – Final Build-out Solution

Location	Max Day Contribution (MG)	Maximum Flow Rate (gpm)	Pump Capacity (MGD)	Pump Head (ft)	Cost [2]
Expanded Outback Wells (#8-11)	5.8	4,000	5.8	~500	$7,776,000
New Overturf Well	1.4	1,000	1.4	~500	$1,944,000
Expanded Shilo Well (#2)[1]	1.3	1,400	2.0	~500	$2,721,600
Expanded Rock Bluff Wells (#4-6)	4.0	6,000	4.0	~400	$5,443,200
New Awbrey Wells (#1-4)	4.3	3,000	4.3	~500	$5,832,000
New East Level 5A Wells (#1-5)[3] In vicinity of Shirley Ct	7.1	4,900	7.1	~800	$9,525,600
New East Level 5B Wells (#1-2)[3] In vicinity of Paula Dr/Purcell Blvd	2.0	1,400	2.0	~800	$2,721,600
New Level 6 Wells (#1-4)[3] Butler Market Rd/Brinson Blvd	7.1	4,900	7.1	~800	$9,525,600
Total Well Cost	**34.3**		**35.7**		**$45,489,600**

1) Assumes Shilo Well 3 online, this is additional capacity
2) Includes cost of standby generator for each new well
3) These locations do not take into account issues related to potential groundwater contamination and 2 year time of travel

Table 2.13 – Recommended new pumps – Final Build-out Solution

Description	Existing Capacity	Maximum flow rate for new pumps	Cost
Tetherow Pump Station Replacing pumps 4, 5 & 6 *MD + fire flow = 4,000 gpm*	1 x 150 gpm 5 x 700 gpm	3 x 1,250 gpm (replace 3 700s)	$784,800
Murphy Pump Station Replacing pumps 3, 4 & 5 *MD + fire flow = 2,500 gpm*	5 x 300 gpm	3 x 1,000 gpm (replace 3 300s)	$959,400
Total Pump Station Cost			**$1,744,200**

Note: Cost based on maximum flow rate using cost rate curve developed by MSA. Cost for pump replacement or additional pumps in an existing station assumed 60% of cost for new pumps.

Table 2.14 – Recommended new valves – Final Build-out Solution

Description	Type	Status	Cost
New valve associated with new piping on Skyliners. Level 3 to Zone 4J/4A	PRV	Active	$75,000
PRV in new NW Development (reduce pressure for lower elevation areas north of butte)	PRV	Active	$75,000
New Level 5 to 6 connection at Division and Mt Washington	PRV	Active	$75,000
Connection from new NW development to Level 6	FCV	Active	$75,000
Level 3-4A connection near Westwood (helps fill the tank and provides emergency supply)	PRV	Active	$75,000
Second connection Zone 4B to Level 5 at Bear Creek Rd (assists fire flow)	PRV	Emergency	$75,000
New valve to assist with fire flow. Level 3 to Zone 4A north of Overturf	PRV	Emergency	$75,000
Second connection to Zone 7C	PRV	Emergency	$75,000
Total New Valve Cost			$600,000

Table 2.18 – Total Capital Costs – Final Build-out Solution

Cost Item	Cost
"Surface Water Supply"	
13.5 MGD, membrane treatment, no hydro[1]	$57,750,000
Additional supply to meet 23 MGD (9.5 MGD)[2]	$12,825,000
New Groundwater Wells (35.7 MGD)	$45,490,000
New Storage (14.5 MG)	$24,130,000
New Pipe Improvements for Growth	$43,625,000
Pipe Improvements for Fire Flow	$11,458,000
Pump Station Expansion	$1,744,000
New Valves	$600,000
TOTAL	**$197,622,000**

1) As per HDR Memo *Surface Water / Groundwater Cost Comparison, DRAFT*, September 2010. Costs for all other items are based on 2009 Unit Costs developed by MSA (October 2009). Estimated 2010 dollars for Surface Water Supply and 2009 dollars for remaining cost items are assumed equivalent and called 2009 dollars.

2) Assume met from additional wells at Outback, $1.35 million per MGD

Findings in Support of Adoption of the Goal 11 Water Public Facility Plan
For the Bend Urban Growth Boundary
September 2011
(with amendments proposed before the Bend City Council)

I. Purpose

These findings support a Goal 11 Water Public Facility Plan (PFP) for the City of Bend urban growth boundary (UGB). The Goal 11 Water PFP covers those areas already inside the Bend UGB served by the City, Avion Water Company, or Roats Water Company. The City is amending Chapter 8 of the Bend Area General Plan, Public Facilities and Services, to adopt the Water PFP as the City's Goal 11 public facility plan for water.

II. Action

The action addressed through these findings includes the amendments to Chapter 8 of the Bend Area General Plan dated September 2011. The amendments include adoption of the Goal 11 water public facility plan and its appendices as the Water public facility plan for the current Bend UGB. The Water PFP, dated September ~~June~~ 2011, relies on a number of appendices to demonstrate compliance with Goal 11, including:

A. City of Bend
1. Water System Master Plan update, Final Report (2007) prepared by Murray, Smith, and Associates.
2. Water system master Plan Update Optimization Study (2011) prepared by Optimatics.
3. Water Management and Conservation Plan (2011) prepared by GSI Water Solutions, Murray Smith and Associates, and HDR Engineering, Inc.

B. Avion Water Company
1. Master Plan (2006) Avion Water Company
2. Water Management and Conservation Plan (2004) Avion Water Company

C. Roats Water Company
1. Water Management and Conservation Plan (2007) Roats Water Company
2. Modeling by MSA for Roats Water Company (2007)

III. Applicable Criteria

Legislative land use decisions must comply with applicable provisions of the statewide land use planning goals, applicable statutes and administrative rules, and applicable unamended provisions of the comprehensive plan and implementing regulations. Legislative land use decisions must also be internally consistent.

For this action, the most directly applicable goal is Goal 11. Other applicable goals are addressed in these findings. ~~No statutes are applicable.~~ORS 197.712 requires that a public facility plan be developed for areas within an urban growth boundary with a population of 2,500 or more people. Goal 11 and the Goal 11 administrative rule implement this statute~~. The only administrative rules that are applicable are the regulations that implement Goal 11~~. (See OAR

Chapter 660-011 and 660-015-0000(11)). Applicable comprehensive plan policies of Bend Area General Plan are addressed. The only applicable implementing regulation is Bend Development Code 4.6.200, which provides requirements for text amendments. These findings address applicable goals, including Goal 11, the Goal 11 administrative rule at OAR 660-011, the requirements for a text amendment under Bend Development Code 4.6.200, and applicable plan policies of the Bend Area General Plan.

IV. Findings Addressing Statewide Planning Goal 11 (OAR 660-0015-0000(11)), Public Facilities and Services

Goal 11 -- To plan and develop a timely, orderly and efficient arrangement of public facilities and services to serve as a framework for urban and rural development.

FINDING: The water PFP furthers Goal 11 by being a plan for the development of water facilities within the existing UGB.

GUIDELINES, A. PLANNING

1. Plans providing for public facilities and services should be coordinated with plans for designation of urban boundaries, urbanizable land, rural uses and for the transition of rural land to urban uses.

FINDING: The preparation of the water PFP was coordinated with the planning for urban and urbanizable land in the current Bend urban growth boundary (UGB). For the water system plan, the planning period covered 2008 to 2028, and included assumptions used for the city's planning for the UGB. This coordination ~~for the City~~ is discussed ~~covered~~ in Section 3 of the 2007 Water System Master Plan prepared by MSA. For the Avion Water Company, this is covered in Chapter 4 of their 2006 Master Plan. For Roats Water Company, this coordination is documented in Chapter 5 of their 2007 Water Conservation and Management Plan (WMCP). These documents address the consideration of land uses served in their respective service areas.

2. Public facilities and services for rural areas should be provided at levels appropriate for rural use only and should not support urban uses.

FINDING: The proposed water PFP shows no expansion of service outside of the UGB other than to meet existing contractual commitments to provide water for non-urban uses. The City of Bend provides water service to certain limited areas outside of the Bend UGB. These include Widgi Creek, the Inn at the Seventh Mountain, and Tetherow Resort. The water planning documents relied upon to prepare the PFP present certain improvements to providing water service to these existing developments. These same planning documents do not propose new water service and improvements to rural areas outside of the Bend that would support new urban uses outside of the Bend UGB. Avion Water Company and Roats Water Company serve areas outside of the Bend UGB, as they are authorized to do. This water PFP focuses on the areas within the Bend UGB that are served by these utilities.

3. Public facilities and services in urban areas should be provided at levels necessary and suitable for urban uses.

FINDING: The proposed plan has been prepared to provide levels of service necessary and suitable for urban uses. Tables 1 through 3 of the water PFP cite where the City, Avion and Roats planning documents address consideration of the land uses served by the water PFP. The finding addressing (1) above identifies the respective sections or chapters of the respective planning documents that address how the planning for water service will be provided at levels necessary and suitable for urban uses.

4. Public facilities and services in urbanizable areas should be provided at levels necessary and suitable for existing uses. The provision for future public facilities and services in these areas should be based upon: (1) the time required to provide the service; (2) reliability of service; (3) financial cost; and (4) levels of service needed and desired.

FINDING: The water PFP shows that water facilities and services for each utility will be provided at levels necessary and suitable for existing uses. Tables 1 through 3 identify the respective planning documents that show how levels of facilities and services will be necessary and suitable for existing uses. In addition, each table addresses the requirements for a public facility plan under OAR 660-011-0010, which address elements (1) through (4).

5. A public facility or service should not be provided in an urbanizable area unless there is provision for the coordinated development of all the other urban facilities and services appropriate to that area.

FINDING: The provision of water service is already coordinated between the City, Avion, and Roats, and has been coordinated with the development and provision of other urban facilities and services for the Bend UGB. Goal 11 defines "urban facilities and services" as key facilities and appropriate types and levels of at least the following: police protection; sanitary facilities; storm drainage facilities; planning, zoning and subdivision control; health services; recreation facilities and services; energy and communication services; and community governmental services. The implementation of the water PFP through construction of new facilities and improvements will be coordinated with other key facilities in the Bend UGB, including sewer and street construction.

6. All utility lines and facilities should be located on or adjacent to existing public or private rights-of-way to avoid dividing existing farm units.

FINDING: . None of the proposed water facilities in the Water PFP divide existing farm units.

7. Plans providing for public facilities and services should consider as a major determinant the carrying capacity of the air, land and water resources of the planning area. The land conservation and development action provided for by such plans should not exceed the carrying capacity of such resources.

FINDING: The Water PFP relies on plans for each utility that document adequate water rights for the planning period. Each utility has prepared a water conservation and management plan that identifies current and future water rights needed or acquired for their respective utilities.

The water PFP relies on and refers to the discussion of water rights for each utility in Tables 1 through 3.

FINDING ON GOAL 11: The Water PFP is consistent with and implements Goal 11.

V. Findings Addressing OAR 660-011, Public Facilities and Planning

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660-011-0000
Purpose
The purpose of this division is to aid in achieving the requirements of Goal 11, Public Facilities and Services, OAR 660-015-0000(11), interpret Goal 11 requirements regarding public facilities and services on rural lands, and implement ORS 197.712(2)(e), which requires that a city or county shall develop and adopt a public facility plan for areas within an urban growth boundary containing a population greater than 2,500 persons. The purpose of the plan is to help assure that urban development in such urban growth boundaries is guided and supported by types and levels of urban facilities and services appropriate for the needs and requirements of the urban areas to be serviced, and that those facilities and services are provided in a timely, orderly and efficient arrangement, as required by Goal 11. The division contains definitions relating to a public facility plan, procedures and standards for developing, adopting, and amending such a plan, the date for submittal of the plan to the Commission and standards for Department review of the plan.

FINDING: The requirements of OAR 660-011 are applicable to the development of the Goal 11 Water PFP because the City has a population of greater than 2,500 persons within its UGB. The city has developed the Goal 11 water PFP to ensure that future urban development is guided and supported by types and levels of urban water facilities.

660-011-0010
The Public Facility Plan
(1) The public facility plan shall contain the following items:

(a) An inventory and general assessment of the condition of all the significant public facility systems which support the land uses designated in the acknowledged comprehensive plan;

FINDING: The Goal 11 Water PFP includes an inventory and general assessment of the condition of each utility's public facility systems. Tables 1 through 3 of the PFP identify where this information is located in the water planning documents of the City, Avion, and Roats. For the City, this information is in Section 2 of its 2007 Water System Master Plan. For Avion, this information is in its 2006 Master Plan at pages 10 to 11 and 29 through 38. For Roats, it's located in its 2007 water management and conservation plan.

(b) A list of the significant public facility projects which are to support the land uses designated in the acknowledged comprehensive plan. Public facility project descriptions or specifications of these projects as necessary;

FINDING: The Water PFP includes lists of significant public facility projects for the City and Avion Water Company. (*See* Tables 1 and 2.) For the City, significant public facility projects for

the water system are identified in Tables 1.1 and 1.2 of the Water PFP and Tables 2.18 ~~and 3.1~~ of the 2011 Optimatics study. For Avion Water Company, these improvements are listed in Chapter 9 of their 2006 Master Plan. Roats Water Company has not developed a list of any significant public facility projects needed to support land uses in its service area. Roats Water Company is a private utility that is regulated by the Oregon Public Utilities Commission and Water Resources Department. The City has no authority to require Roats to develop such a list and one is not necessary at this time due to the size of Roats' service area and its interconnections with the water systems of both the City and Avion. Roats' service area includes about 1,000 acres and 2,640 customers in the Bend UGB (See Water PFP, page 6). Roats' Homeplace service area is located in the Bend UGB and is surrounded by the City and Avion Water Company service area (See Figure 1 of the Water PFP). Roats has interconnections with both the City and Avion that have been designed for wholesale and emergency/fire flow purposes (See Roats 2007 WMCP, page 14). In addition, the City finds that Roats is not required to produce such a document because ORS 197.712(2)(e) refers to public projects in the context of requiring public facility plans, and Roats is a private provider of utility service.

(c) Rough cost estimates of each public facility project;

FINDING: The Water PFP identifies where the reader can find rough cost estimates in the respective planning documents of the utilities. For the City, these estimates are found in Tables 1.1 and 1.2 of the Water PFP and Tables 2.18 ~~and 3.1~~ of the 2011 Optimatics Study. –For Avion, these estimates are found at pages 42-44, Tables 10.1 and 10.2 of its 2006 master plan. As indicated under the finding addressing (b), Roats has not developed a list of significant public facility projects for which rough cost estimates must be developed.

(d) A map or written description of each public facility project's general location or service area;

FINDING: The Water PFP includes maps and written descriptions of utility's service area and, where applicable, future public facility projects. This information is identified in Tables 1 through 3 of the Water PFP. Figure 1 of the PFP identifies the respective service areas of the City, Avion, and Roats. Appendix A to the 2007 Water System Master Plan further identifies improvements to the City's water system. Pages 40 through 42 of Avion's 2006 Master Plan identify the service area and improvements for the Avion Water Company. Exhibit 2-1 of the 2007 WMCP identifies the service area and facilities for Roats Water Company. In addition to this exhibit, Roats has completed some modeling of their water system in 2007 which is Appendix (C)(1) of the Water PFP.

(e) Policy statement(s) or urban growth management agreement identifying the provider of each public facility system. If there is more than one provider with the authority to provide the system within the area covered by the public facility plan, then the provider of each project shall be designated;

FINDING: The Water PFP identifies the City, Avion and Roats as the water providers in the current Bend UGB and describes their service areas. Water PFP, page 13.

(f) An estimate of when each facility project will be needed; and

FINDING: The Water PFP includes estimates of when facility projects will be needed. Tables 1 through 3 of the PFP identify the timing of required facilities under OAR 660-011-025, and whether projects will be needed in the short-term or the long-term. ~~Table 1 identifies Table 3.1 of the 2011 Optimatics study as the pertinent document for the City's estimates of when facility projects will be needed.~~ Tables 1.1 and 1.2 identifies when projects will be needed for the City's utility area. Table 2 identifies Tables 10.1 and 10.2 of Avion's 2006 Master Plan as the pertinent document for Avion's estimates of when facility projects will be needed. As indicated above, Roats has not developed a long-term list of facility projects that will be needed over the planning period. The City finds that what the City and Avion have done to address this rule is sufficient because the respective services areas for these utilities include 20,000 acres of the 21,000 acres in the Bend UGB (95%). Roats' service area is the smallest and has interties with both the City and Avion Water Company (See Roats 2007 WMCP).

(g) A discussion of the provider's existing funding mechanisms and the ability of these and possible new mechanisms to fund the development of each public facility project or system.

FINDING: Tables 1 through 3 of the PFP discuss each water provider's existing funding mechanism and ability of these and possible new mechanism to fund improvement to each system. Table 1 discusses the City's funding mechanisms for its water system. Table 1 discusses the estimated costs for improvements to the City's water system, and also discusses utility user fees (a.k.a water rates) and system development charges as funding mechanisms for these improvements. Table 2 discusses Avion's funding mechanisms. Avion is an investor-owned utility and its rates are regulated by the Oregon Public Utility Commission. Avion's 2006 Master Plan provides additional discussion at pages 25 and 26. Table 3 discusses Roats funding mechanisms for its Homeplace service area. This table refers the reader to Table 17 of Roats' 2007 WMCP for a discussion of its rate structure for meter sizes. Like Avion, Roats is a rate and service regulated utility under the jurisdiction of the Oregon Public Utility Commission.

(2) Those public facilities to be addressed in the plan shall include, but need not be limited to those specified in OAR 660-011-0005(5). Facilities included in the public facility plan other than those included in OAR 660-011-0005(5) will not be reviewed for compliance with this rule.

(3) It is not the purpose of this division to cause duplication of or to supplant existing applicable facility plans and programs. Where all or part of an acknowledged comprehensive plan, facility master plan either of the local jurisdiction or appropriate special district, capital improvement program, regional functional plan, similar plan or any combination of such plans meets all or some of the requirements of this division, those plans, or programs may be incorporated by reference into the public facility plan required by this division. Only those referenced portions of such documents shall be considered to be a part of the public facility plan and shall be subject to the administrative procedures of this division and ORS Chapter 197.

FINDING: The Water PFP focuses on the public water facility systems intended to serve the Bend UGB. OAR 660-011-0005(1) defines a public facility plan as a support document or documents to a comprehensive plan. The Water PFP describes the water facilities that support the land uses designated in the Bend Area General Plan. The plan refers to water planning documents prepared by the City, Avion Water Company, and Roats Water Company which

provide the information required for a public facility plan under OAR 660-011-0010(1) above. The Water PFP describes the facilities intended to serve the Bend UGB.

660-011-0015
Responsibility for Public Facility Plan Preparation
(1) Responsibility for the preparation, adoption and amendment of the public facility plan shall be specified within the urban growth management agreement. If the urban growth management agreement does not make provision for this responsibility, the agreement shall be amended to do so prior to the preparation of the public facility plan. In the case where an unincorporated area exists within the Portland Metropolitan Urban Growth Boundary which is not contained within the boundary of an approved urban planning area agreement with the County, the County shall be the responsible agency for preparation of the facility plan for that unincorporated area. The urban growth management agreement shall be submitted with the public facility plan as specified in OAR 660-011-0040.

FINDING: Pursuant to Section 6.B. of the Agreement between the city and Deschutes County for the Joint Management of the Bend Urban Area (JMA), the City retains the authority to prepare and adopt public facility plans and amendments for utilities within the UGB and the Urban Reserve Boundary. Further, the Water PFP specifies the City, Avion, and Roats as the providers of water service in the Bend UGB.

(2) The jurisdiction responsible for the preparation of the public facility plan shall provide for the coordination of such preparation with the city, county, special districts and, as necessary, state and federal agencies and private providers of public facilities. The Metropolitan Service District is responsible for public facility plans coordination within the District consistent with ORS 197.190 and 268.390.

FINDING: The city has coordinated the preparation of this PFP with private providers of public facilities. The city has coordinated with the Avion Water Company and the Roats Water Company on the development of the PFP. This coordination includes relying on the water planning documents of Avion and Roats to address the requirements of Goal 11 and this implementing rule. City engineering staff also meets on a regular basis with the other private water companies to coordinate on providing service. No special districts provide potable water in the City; the only special districts with which the city has coordinated are irrigation districts formed to provide irrigation water for agriculture under ORS Chapter 545.

(3) Special districts, including port districts, shall assist in the development of the public facility plan for those facilities they provide. Special districts may object to that portion of the facilities plan adopted as part of the comprehensive plan during review by the Commission only if they have completed a special district agreement as specified under ORS 197.185 and 197.254(3) and (4) and participated in the development of such portion of the public facility plan.

FINDING: This rule is not applicable because there are no special districts formed that provide water service to areas within the Bend UGB. Goal 11 defines a water system as a system for the provision of piped water for human consumption subject to regulation under ORS 448.119 to 448.285. Four (4) irrigation districts organized under ORS 545 provide irrigation water to patrons within the UGB, but do not operate water systems as defined above under Goal 11.

(4) Those state agencies providing funding for or making expenditures on public facility systems shall participate in the development of the public facility plan in accordance with their state agency coordination agreement under ORS 197.180 and 197.712(2)(f).
FINDING: This rule is not applicable because no state agencies are providing funding for or making expenditures on the water public facility systems that are the subject of the Water PFP.

660-011-0020
Public Facility Inventory and Determination of Future Facility Projects
(1) The public facility plan shall include an inventory of significant public facility systems. Where the acknowledged comprehensive plan, background document or one or more of the plans or programs listed in OAR 660-011-0010(3) contains such an inventory, that inventory may be incorporated by reference. The inventory shall include:
(a) Mapped location of the facility or service area;
(b) Facility capacity or size; and
(c) General assessment of condition of the facility (e.g., very good, good, fair, poor, very poor).

FINDING: The Water PFP includesluces an inventory of significant public facilities systems. Tables 1 through 3 of the PFP list each provider's inventory of significant public facility systems. Table 1 lists the City's 2007 Water System Master Plan (See Tables 2-1, 2-2, and 2-4). Table 2 list Figure 2 of Avion's 2006 Master Plan as well as discussion on pages 29 through 38. Table 3 lists Roats's 2007 modeling of its water system (See Appendix (C)(1)).

(2) The public facility plan shall identify significant public facility projects which are to support the land uses designated in the acknowledged comprehensive plan. The public facility plan shall list the title of the project and describe each public facility project in terms of the type of facility, service area, and facility capacity.

FINDING: The Water PFP identifies the significant public facility projects that support land uses designated in the Bend Area General Plan. *See* Tables 1 through 3 of the PFP. Table 1 further identifies the relevant sections of the 2011 Optimatics study that list the significant public facility projects and the timing of these projects for the City's service area. Table 2 identifies Chapter 9 of Avion's 2006 Master Plan and Tables 10.1 and 10.2 to identify the list of significant public facility projects and the timing of these projects intended to serve Avion's service area. Table 3 identifies Section 5 of Roats's 2007 WMCP for the relevant consideration of land uses to be served in their Homeplace Service area. This report includes forgoing findings that address why Roats has not developed a long-term facility plan for its service area and its interconnections with the water systems of the City and Avion.

(3) Project descriptions within the facility plan may require modifications based on subsequent environmental impact studies, design studies, facility master plans, capital improvement programs, or site availability. The public facility plan should anticipate these changes as specified in OAR 660-011-0045.

FINDING: This rule is not a criterion for approval for the Water PFP. This report addresses OAR 660-011-045 in a subsequent finding.

660-011-0025
Timing of Required Public Facilities
(1) The public facilities plan shall include a general estimate of the timing for the planned public facility projects. This timing component of the public facilities plan can be met in several ways depending on whether the project is anticipated in the short term or long term. The timing of projects may be related directly to population growth, e.g., the expansion or new construction of water treatment facilities. Other facility projects can be related to a measure of the facility's service level being met or exceeded, e.g., a major arterial or intersection reaching a maximum vehicle-per-day standard. Development of other projects may be more long term and tied neither to specific population levels nor measures of service levels, e.g., sewer projects to correct infiltration and inflow problems. These projects can take place over a long period of time and may be tied to the availability of long-term funding. The timing of projects may also be tied to specific years.

(2) Given the different methods used to estimate the timing of public facilities, the public facility plan shall identify projects as occurring in either the short term or long term, based on those factors which are related to project development. For those projects designated for development in the short term, the public facility plan shall identify an approximate year for development. For those projects designated for development over the long term, the public facility plan shall provide a general estimate as to when the need for project development would exist, e.g., population level, service level standards, etc. Timing provisions for public facility projects shall be consistent with the acknowledged comprehensive plan's projected growth estimates. The public facility plan shall consider the relationships between facilities in providing for development.

(3) Anticipated timing provisions for public facilities are not considered land use decisions as specified in ORS 197.712(2)(e), and, therefore, cannot be the basis of appeal under ORS 197.610(1) and (2) or 197.835(4).

FINDING: The Water PFP contains the required timing estimates and classification of projects as short term or long term projects. See Tables 1 through 3 and materials cited in those tables. Table 1 identifies relevant sections of the 2011 Optimatics study for the City. Tables 1.1 and 1.2 further identify when projects will be needed. Table 2 identifies this information in Sections 9 and 10 from the 2006 Master Plan for Avion Water Company. Table 3 addresses Roats' Water Company's service area and its interconnections with the City and Avion Water Company.

660-011-0030
Location of Public Facility Projects
(1) The public facility plan shall identify the general location of the public facility project in specificity appropriate for the facility. Locations of projects anticipated to be carried out in the short term can be specified more precisely than the locations of projects anticipated for development in the long term.

FINDING: The Water PFP identifies the location of the public facilities projects. Tables 1 through 3 of the PFP identify the relevant water planning documents that provide the location of water public facility projects. Table 1 identifies the relevant figures from the 2011 Optimatics study for the City's' service area. Table 2 identifies Tables 10.1 and 10.2 from the 2006 Master Plan for Avion's Service area. Table 3 shows that while Roats has not developed a list of

significant public facility projects for its service area, due to the size of its service area and its interconnections with both the City and Avion, its short and long term supply needs can be met.

(2) Anticipated locations for public facilities may require modifications based on subsequent environmental impact studies, design studies, facility master plans, capital improvement programs, or land availability. The public facility plan should anticipate those changes as specified in OAR 660-011-0045.

FINDING: The water planning documents for the City and Avion each acknowledge that additional design work and studies will be required before the city develops a final design and location. Roats water planning documents have not proposed any short or long term facility projects.

660-011-0035
Determination of Rough Cost Estimates for Public Facility Projects and Local Review of Funding Mechanisms for Public Facility Systems
(1) The public facility plan shall include rough cost estimates for those sewer, water, and transportation public facility projects identified in the facility plan. The intent of these rough cost estimates is to:
(a) Provide an estimate of the fiscal requirements to support the land use designations in the acknowledged comprehensive plan; and
(b) For use by the facility provider in reviewing the provider's existing funding mechanisms (e.g., general funds, general obligation and revenue bonds, local improvement district, system development charges, etc.) and possible alternative funding mechanisms. In addition to including rough cost estimates for each project, the facility plan shall include a discussion of the provider's existing funding mechanisms and the ability of these and possible new mechanisms to fund the development of each public facility project or system. These funding mechanisms may also be described in terms of general guidelines or local policies.

FINDING: The Water PFP includes rough cost estimates. Tables 1 and 2 of the PFP identify the portions of the Water PFP that provide rough cost estimates for public facility projects. In addition, Tables 1 through 3 further discuss each utility's funding mechanisms.

(2) Anticipated financing provisions are not considered land use decisions as specified in ORS 197.712(2)(e) and, therefore, cannot be the basis of appeal under ORS 197.610(1) and (2) or 197.835(4).

FINDING: This rule is not an approval criterion for the proposal.

660-011-0040
Date of Submittal of Public Facility Plans
The public facility plan shall be completed, adopted, and submitted by the time of the responsible jurisdiction's periodic review. The public facility plan shall be reviewed under OAR Chapter 660, Division 25, "Periodic Review" with the jurisdiction's comprehensive plan and land use regulations. Portions of public facility plans adopted as part of comprehensive plans prior to the responsible jurisdiction's periodic review will be reviewed pursuant to OAR Chapter 660, Division 18, "Post Acknowledgment Procedures".

FINDING: The City proposes to submit this Water PFP through a post-acknowledgement plan amendment. This amendment will include adoption of the new Water PFP, and related amendments to Chapter 8 of the Bend Area General Plan, Public Facilities and Services, to recognize the plan and adopt new policies proposed in the PFP.

660-011-0045
Adoption and Amendment Procedures for Public Facility Plans
(1) The governing body of the city or county responsible for development of the public facility plan shall adopt the plan as a supporting document to the jurisdiction's comprehensive plan and shall also adopt as part of the comprehensive plan:
(a) The list of public facility project titles, excluding (if the jurisdiction so chooses) the descriptions or specifications of those projects;
(b) A map or written description of the public facility projects' locations or service areas as specified in sections (2) and (3) of this rule; and
(c) The policy(ies) or urban growth management agreement designating the provider of each public facility system. If there is more than one provider with the authority to provide the system within the area covered by the public facility plan, then the provider of each project shall be designated.

FINDING: The Water PFP is being adopted by the City Council as a supporting document to the Bend Area General Plan. The City Council is also adopting related and supportive amendments to Chapter 8 of the Bend Area General Plan, Public Facilities and Services, to recognize the Water PFP, and adopt the information required under (1)(a) through (1)(c) above. The amendments to Chapter 8 list the titles of the significant public facility projects intended to serve the Bend UGB. The PFP itself includes Figures 1 through 3, which identify the respective services areas of the City, Avion Water Company, and Roats Water Company. Finally, the PFP proposes policies to recognize the City, Avion, and Roats as the water service providers to the Bend UGB. The amendments to Chapter 8 include these policies.

(2) Certain public facility project descriptions, location or service area designations will necessarily change as a result of subsequent design studies, capital improvement programs, environmental impact studies, and changes in potential sources of funding. It is not the intent of this division to:
(a) Either prohibit projects not included in the public facility plans for which unanticipated funding has been obtained;
(b) Preclude project specification and location decisions made according to the National Environmental Policy Act; or
(c) Subject administrative and technical changes to the facility plan to ORS 197.610(1) and (2) or 197.835(4).

FINDING: The city understands that this rule is not an approval criterion, and clarifies that certain elements of projects listed in the water and/or sewer public facility plans may change, and that such changes are not subject to ORS 197.610(1) or (2) or 197.835(4).

(3) The public facility plan may allow for the following modifications to projects without amendment to the public facility plan:
(a) Administrative changes are those modifications to a public facility project which are minor in nature and do not significantly impact the project's general description, location, sizing, capacity, or other general characteristic of the project;

(b) Technical and environmental changes are those modifications to a public facility project which are made pursuant to "final engineering" on a project or those that result from the findings of an Environmental Assessment or Environmental Impact Statement conducted under regulations implementing the procedural provisions of the National Environmental Policy Act of 1969 (40 CFR Parts 1500-1508)or any federal or State of Oregon agency project development regulations consistent with that Act and its regulations.
(c) Public facility project changes made pursuant to subsection (3)(b) of this rule are subject to the administrative procedures and review and appeal provisions of the regulations controlling the study (40 CFR Parts 1500-1508 or similar regulations) and are not subject to the administrative procedures or review or appeal provisions of ORS Chapter 197, or OAR Chapter 660 Division 18.

FINDING: The city understands that this rule is not an approval criterion, and clarifies that certain elements of projects listed in the water and/or sewer public facility plans may change. This rule defines what changes are not subject to ORS Chapter 197 or OAR Chapter 660 Division 18.

(4) Land use amendments are those modifications or amendments to the list, location or provider of, public facility projects, which significantly impact a public facility project identified in the comprehensive plan and which do not qualify under subsection (3)(a) or (b) of this rule. Amendments made pursuant to this subsection are subject to the administrative procedures and review and appeal provisions accorded "land use decisions" in ORS Chapter 197 and those set forth in OAR Chapter 660 Division 18.

FINDING: The city understands that this rule is not an approval criterion; however, the city acknowledges that this rule establishes that the city's adoption of this ordinance amending the plans is subject to the review and appeal procedures accorded "land use decisions" in ORS Chapter 197 and those set forth in OAR Chapter 660 Division 18.

660-011-0050
Standards for Review by the Department
The Department of Land Conservation and Development shall evaluate the following, as further defined in this division, when reviewing public facility plans submitted under this division:

(1) Those items as specified in OAR 660-011-0010(1);

FINDING: The Water PFP includes the items specified in OAR 660-011-0010(1). Tables 1 through 3 of the PFP cite the applicable sections of this rule, and either provide the item or refer the reader to one of the water planning documents cited as an appendix to, and therefore part of, the Water PFP.

(2) Whether the plan contains a copy of all agreements required under OAR 660-011-0010 and 660-011-0015; and

FINDING: No agreements related to the provision of water service are required by OAR 660-011-0010 and 660-011-0015. The Water PFP recognizes the City, Avion Water Company, and Roats Water Company as the water service providers for the Bend UGB. There are no special districts organized under Oregon law to provide water service, as defined under Goal 11. The

City has entered into a Joint Management Agreement (JMA) between the City and Deschutes County regarding joint management of the Bend Urban Area. The JMA authorizes the City to prepare and adopt public facility plans and amendments for utilities within the UGB and the Urban Reserve Boundary. A copy of the JMA is included with this submittal.

(3) Whether the public facility plan is consistent with the acknowledged comprehensive plan.

FINDING: The Water PFP has been drafted to be consistent with the city's General Plan, as amended by the related amendments to Chapter 8. As amended, Chapter 8 identifies several goals, including that utility systems provide adequate levels of service to the public at a reasonable cost. The City finds that adoption of the proposed PFP furthers this goal by identifying the expected type, location, cost, and financing mechanisms for various public water facilities that are necessary to serve projected population growth.

FINDING ON OAR 660-011, PUBLIC FACILITIES AND PLANNING: The Water PFP is consistent with and implements OAR 660-011 Public Facilities and Planning.

VI. Findings on OAR 660-0015, Compliance with Statewide Planning Goals

Goal 1: Citizen Involvement.

To develop a citizen involvement program that insures the opportunity for citizens to be involved in all phases of the planning process.

FINDING: The City Planning Commission ~~is holding at least two~~has held four public hearings on this proposal, consistent with the City's acknowledged procedures for legislative amendments in Section 4.6.200 of the Development Code. Those hearings provided an opportunity for citizens to be involved in the adoption of the Water PFP. The City Council will hold one more hearing to consider public input on the Water PFP before making a final decision.~~/~~

Goal 2: Land Use Planning

To establish a land use planning process and policy framework as a basis for all decision and actions related to use of land and to assure an adequate factual base for such decisions and actions.

FINDING: The Water PFP has been developed with and supported by an adequate factual base. The City has coordinated review of the PFP with affected irrigation districts. The proposed Section II of these findings outlines the documents upon which the City is relying to adopt the PFP. The documents were developed by engineering firms or by the City, Avion Water Company, and Roats Water Company. These documents provide a factual base to show the Water PFP includes all necessary elements required under Division 11, specifically OAR 660-011-0010.

The City is coordinating the review of this proposal with affected local governments. These governments include irrigation districts whose facilities may be affected by the location of new water facilities. City last met with irrigation district staff on Thursday June 30, 2011, and showed

the district staff where they could find the draft water PFP and its supporting documentation on the city's website.

Goal 3: Agricultural Lands, and Goal 4: Forest Lands

FINDING: These goals are not applicable because the City proposes to adopt a Water PFP for the urban and urbanizable land in the Bend urban growth boundary. The purpose of the PFP is to ensure that future improvements to the water public facility systems in the current UGB can support the land uses contemplated under the Bend Area General Plan. The proposed PFP does not propose to provide new water service to agriculture or forest lands that are outside the Bend UGB. While a portion of the City's water system (water sources and delivery from the source to the City) is on forest lands, those are existing parts of the water system.

Goal 5: Natural Resources, Scenic and Historic Areas, and Open Spaces

To protect natural resources and conserve scenic and historic areas and open spaces.

FINDING: The Water PFP is intended to support the land uses allowed under the Bend Area General Plan. Any development of land uses allowed under the General Plan adjacent to Goal 5 resources identified under the General Plan will occur according to any adopted protection measures. The Water PFP does not propose any changes to any of the City's acknowledged protection measures.

Goal 6: Air, Water, and Land Resources Quality

To maintain and improve the quality of the air, water and land resources of the state.

FINDING: The Water PFP will maintain and improve the quality of the water resources of the state. The Water PFP relies on water management and conservation plans from each utility in the UGB to ensure that the water resources of the state are maintained. In addition, the Water PFP relies upon water planning documents for the City and the Avion Water Company that describe how water quality for each utility will be maintained.

Goal 7: Areas Subject to Natural Hazards

To protect people and property from natural hazards.

FINDING: This goal is not applicable because the Water PFP does not propose to provide water service to areas identified as Goal 7 natural hazards in the Bend UGB.

Goal 8: Recreational Needs

FINDING: The Water PFP plans for providing water service to parks and other facilities that provide recreational opportunities.

Goal 9: Economic Development

To provide adequate opportunities throughout the state for a variety of economic activities vital to the health, welfare, and prosperity of Oregon's citizens.

FINDING: The Water PFP plans for the continued provision of adequate water to economic land uses within the current Bend UGB.

Goal 10: Housing

To provide for the housing needs of citizens of the state.

FINDING: The Water PFP plans for water service to residential uses within the current Bend UGB.

Goal 11: Public Facilities and Services

To plan and develop a timely, orderly and efficient arrangement of public facilities and services to serve as a framework for urban and rural development.

FINDING: The Water PFP proposes a plan to develop a timely, orderly, and efficient arrangement of public water facilities and services to serve the land uses allowed under the Bend Area General Plan. As demonstrated above, in Sections III and IV, the PFP satisfies Goal 11 and its administrative rule at OAR 660-011.

Goal 12: Transportation

To provide and encourage a safe, convenient and economic transportation system.

FINDING: This goal is not applicable because the Water PFP does not propose any changes to the city's transportation system that would trigger review under Goal 12 or its administrative rule under OAR 660-012.

Goal 13: Energy Conservation

To conserve energy.

FINDING: This goal is not applicable because the Water PFP does not propose any changes to the land uses allowed under the Bend Area General Plan that would require more energy be used. The Water PFP continues to include a surface water source to avoid increasing energy consumption that would result from pumping from well sources if the surface water source was not used.

Goal 14: Urbanization

To provide for an orderly and efficient transition from rural to urban land use, to accommodate urban population and urban employment inside urban growth boundaries, to ensure efficient use of land, and to provide for livable communities.

FINDING: The Water PFP proposes improvements to the public water facility systems to support the land uses in the current Bend UGB. The Water PFP will support the orderly and efficient development of urban and urbanizable lands in the Bend UGB for future housing and employment.

FINDING REGARDING THE STATEWIDE PLANNING GOALS: The Water PFP is consistent with and implements all applicable statewide planning goals.

VII. Findings Demonstrating Compliance with Bend Area General Plan

Preface to the Bend Area General Plan, pages P-6 – P-7
The General Plan is a document that changes over time to reflect new information and new directions for the future. Amendments or additions to the General Plan text, exhibits, and policies go through a public hearing and review process before being adopted by the governing bodies. Changes and updates can be generated in at least six ways:

_ Regularly scheduled reviews and updates by the city and county. Every five years, beginning in the year 2000, the city and county will review the population growth, the housing mix and acreage needs, the industrial lands absorption, and the commercial lands absorption against the long-term forecasts in the General Plan. Other issues may also be evaluated during these regular views.

_ Preparation of more detailed refinement plans for neighborhoods or geographic areas. As provided for in Oregon land use law, the city or county may prepare more detailed land use and development plans for parts of the urban area that have large vacant or under-utilized parcels. Such refinement plans could address future street patterns and other utility systems, housing density and compatible uses, site and design standards, locations for parks, schools, and open space, and other land use issues.

_ Evaluation of land use topics required to be reviewed under the Oregon Land Conservation and Development Commissions periodic review of the General Plan. The state requires all local plans to be updated periodically to comply with applicable new state laws, administrative rules, or to incorporate new data available to the state.

_ Other state laws or legislative actions that require changes to the Plan outside of the normal periodic review cycle. The state legislature or the voter referendum/initiative process can require changes to local land use plans within a specific time period.

_ City or county response to new issues or changes. Issues that were unforeseen during the development of the plan can arise that have an impact on a particular neighborhood or the whole urban area. The city and county officials can direct staff to amend the Plan to address these issues.

_ Changes proposed by individuals or other agencies. A proposal by an individual, corporation, or public agency to change to the Plan text, land use map, other exhibits, or policies shall be considered as determined by the procedures ordinance. A person or agency proposing a change has the burden to demonstrate a public need and benefit for the change.

FINDING: This finding addresses the foregoing language from the Bend Area General Plan. The Water PFP fulfills a public need and provides a public benefit. The public need satisfied by

the adoption of the Water PFP is the need to have a water pubic facility plan that can serve the land uses contemplated and allowed under the Bend Area General Plan. The current PFP for water was completed in 1996, and adopted in 1998 with the Bend Area General Plan. The Water PFP relies on water system planning documents, including water management and conservation plans for the three utilities that serve patrons in the Bend UGB. The public benefit for the change includes the proposed improvements to the water systems of the City and Avion Water Company that will support the development of land uses allowed under the General Plan.

Chapter 1
Urban Planning Coordination
3. No new water or sewer service districts shall be created within the UGB without the concurrence of the city.

FINDING: The Water PFP does not propose to create new water service districts within the UGB. The Water PFP recognizes the City, Avion Water Company, and Roats Water Company as the existing water service providers for the Bend UGB.

Chapter 5
Public utilities and services (See related policies in Chapter 1, Plan Management and Citizen Involvement and Chapter 8, Public Facilities and Services.)

44. All residential areas shall be provided with community water and sewer services and other facilities necessary for safe, healthful, convenient urban living consistent with the density of development.

FINDING: The Water PFP includes planned improvements to the water systems within the existing Bend UGB to enable the continued provision of water service throughout the City to ensure safe, healthful, and convenient urban living consistent with the density of development.

FINDINGS ON BEND GENERAL PLAN: No other provisions of the Bend General Plan are applicable. The Water PFP is consistent with all applicable provision of Bend's comprehensive plan.

VIII. Findings on Compliance with Bend Development Code 4.6.200, Legislative Amendments

A. Applicability, Procedure and Authority. Legislative amendments generally involve broad public policy decisions that apply to other than an individual property owner. These include, without limitation, amendments to the text of the comprehensive plan and map, Development Code and changes in the zoning map not directed at a small number of properties. They are reviewed using the Type IV procedure in accordance with Chapter 4.1, Land Use Review and Procedures and shall conform to Section 4.6.600, Transportation Planning Rule Compliance. A Legislative Amendment may be approved or denied.

FINDING: The City proposes a legislative amendment to the text of the Bend Area General Plan and has followed the applicable procedures. This proposed amendment would amend the text of Chapter 8, Public Facilities and Services to recognize and incorporate by reference a Goal 11 Water Public Facility Plan for the Bend UGB.

B. Criteria for Legislative Amendments. The applicant shall submit a written narrative which explains how the approval criteria will be met. A recommendation or a decision to approve or to deny an application for a Legislative Amendment shall be based on all of the following criteria:

1. The request is consistent with the applicable State land use law;

FINDING: The findings under Sections III, IV, and V show the Water PFP is consistent with Goal 11, its administrative rule at OAR 660 Division 11, and the applicable statewide planning goals.

2. The request is consistent with the applicable Bend Area General Plan goals and policies;

FINDING: As demonstrated in Section VI, the Water PFP is consistent with the Bend Area General Plan.

3. The applicant can demonstrate a public need or benefit for the proposed amendment.

FINDING: The Water PFP fulfills a public need and provides a public benefit. The public need satisfied by the adoption of the Water PFP is the need to have a water pubic facility plan that can serve the land uses contemplated and allowed under the Bend Area General Plan. The current PFP for water was completed in 1996, and adopted in 1998 with the Bend Area General Plan. The Water PFP relies on water planning documents, including water management and conservation plans for the three utilities that serve patrons in the Bend UGB. The public benefit for the change includes the proposed improvements to the water systems of the City and Avion Water Company that will support the development of land uses allowed under the General Plan.

FINDING REGARDING BEND DEVELOPMENT CODE SECTION 4.6.200: The Water PFP is consistent with Bend Development Code Section 4.6.200.

Supplemental Findings of the Bend City Council in Support of Adoption of a Goal 11 Water Public Facility Plan for the Bend Urban Growth Boundary
April 2012

I. Purpose

The purpose of these findings is to respond to testimony on the proposed Water Public Facility Plan (PFP), which are now part of the record before the Bend City Council. The testimony includes a November 10, 2011 letter from Paul Dewey on behalf of Central Oregon Landwatch and testimony from other parties submitted into the record related to the Surface Water Improvement Project (SWIP) on or before the Bend Planning Commission's November 14, 2011 hearing.

II. Findings

A. Testimony related to Surface Water Improvement Project.

The Planning Commission received the following testimony directed toward the Surface Water Improvement project:

1. October 10, 2011 letter from Paul Dewey, Central Oregon Landwatch.
2. November 10, 2011 letter from Paul Dewey, Central Oregon Landwatch, including the following attachments:
    a. City of Bend Water Rate Increase Forecasts
    b. Economics white paper
    c. Facts concerning the Surface Water Improvement Project (November 4, 2011)
    d. Series of charts starting with Maximum Daily Demand
    e. Portland vs. Bend white paper
    f. March 16, 2011 White Paper from Bill Buchanan
3. November 10 2011 email from M. Teresa Lawrence
4. November 14, 2011 email from Barbara Kenyon
5. November 14, 2011 letter from Toby Bayard, Stop the Drain Campaign
6. November 14, 2011 testimony from Cheryl Stops, Petroleum Geologist
7. November 14, 2011 testimony from Douglas Werme
8. November 10, 2011 letter (submitted 11/14/2011) from Mark Yinger, Hydrogeologist
9. Several charts (Exhibits 6 through 10) submitted by Bill Buchanan 11/14/2011
10. November 14, 2011 Bend Creek Water Project: A Drain on Ratepayers and the River, submitted by Bill Buchanan

FINDING: The City Council understands that the above-referenced testimony raised the following issues before the Planning Commission, which are summarized below:

- the energy costs estimated for the SWIP;
- the potential impacts of the SWIP on Tumalo Creek;
- whether the SWIP was consistent with the goals of Chapter 8 of the Bend Area General Plan (BAGP), Public Facilities;
- whether the City should abandon its surface water rights and rely solely on groundwater;

- the consistency of the SWIP with the General Plan and Statewide Planning Goal 11, Public Facilities and Services;
- the relationship of the SWIP to the UGB expansion, Juniper Ridge, and Juniper Utilities;
- the costs of the SWIP;
- the reliability of surface water rights, and;
- the funding for the SWIP.

The Bend City Council has already made the decision to continue to use surface water as the primary source and approximately 50% of the City's annual water supply system, which is a dual source system. The City Council has also approved work on the City's Surface Water Project, by Resolutions 2814, 2817 and 2853, which will provide improvements to the existing surface water diversion and transportation system. The surface water diversion, treatment and delivery system has been part of all City water plans since the original surface water diversion in the 1920's. In addition, the City's Water Management and Conservation Plan (2011), which was approved by the Oregon Water Resource Department in accordance with the Oregon Administrative Rules Chapter 690, Division 86 Rules, includes an extensive discussion of water conservation and water management, as well as supply sources, service area and population, water usage, water rights and adequacy and reliability of the city's water system, to guide the wise use and stewardship of the City's water supply. The Rules require descriptions of the City's water sources; here, the primary water systems are groundwater and surface water from Bridge Creek and Tumalo Creek.

B. Findings Responding to November 10, 2011 letter from Paul Dewey, Central Oregon Landwatch.

1. The Water Public Facility Plan

FINDING: The November 10 letter raises two issues at the beginning regarding the Water PFP. One is that the description of water rights is not clear. The second is that cost estimates presented in the Optimization Study (2011) are not clearly described or accurate. With respect to the City's Water Utility, Table 1 of the Water PFP (September 2011) clearly directs the reader to the appropriate water planning documents. The Water PFP includes Section 2 of the 2007 Master Plan. Appendix C of the 2007 Master Plan lists/describes the City's Water Rights[1]. In addition, the City's water rights are more thoroughly described and analyzed, as required, in the City's Water Management and Conservation Plan to fulfill the requirements of the Oregon Water Resource Department, Chapter 690, Division 86 Rules. The Optimization Study (2011) cost estimates which are Class 5 estimates, satisfy the Goal 11 rule requirements for rough cost estimates under OAR 660-11 (See Findings addressing OAR 660-011-010(1)(c)).

[1] See Table C-1, City of Bend Water Rights Summary, Water System Master Plan Update Final Report (2007) Murray Smith and Associates.

2. PFP Consistency with the Bend Area General Plan and Tumalo Creek

FINDING: The November 10, 2011 letter argues the Water PFP is not consistent with the General Plan's direction for Tumalo Creek. The City Council finds that the proposed Water PFP is consistent with the General Plan, with respect to the General Plan's direction on Tumalo Creek. The following policies are those from the Bend Area General Plan that specifically mention actions that should or must be taken to benefit Tumalo Creek.

BAGP Chapter 2 Natural Features and Open Spaces

Deschutes Basin Study Policies
***
11. The city and county shall continue to replace the Tumalo water supply pipeline. When this pipeline is complete, gates should be installed at the intake, which would help stabilize withdrawals from Tumalo Creek.

12. The city and county and Tumalo Irrigation District shall explore options to improve in-stream flows and fish habitat in Tumalo Creek. Tumalo Irrigation District should consider apportioning their water draws to maximize the use of the Tumalo Feed Canal rather than the Columbia Southern Canal. This action should increase water flows through Shevlin Park and minimize the excessive water losses that now occur in the Columbia Southern Canal.

20. The city and county may require public access for any land use action adjacent to the Deschutes River and Tumalo Creek. Access may be limited to foot traffic only; other non-motorized traffic may be negotiated by the city or county.

25. The visual impact of excavations or structures that will be erected or substantially modified along the rimrocks bordering the Deschutes River or Tumalo Creek shall be minimized.

BAGP Chapter 3, Community Connections

Urban Trails
18. The city, county, irrigation companies, state and park district shall work together to develop a series of trails along the Deschutes River, Tumalo Creek, and the major canals so that these features can be retained as an asset in the urban growth boundary and urban reserve area.

BAGP Chapter 10, Natural Forces

Natural hazards
1. The city shall continue to apply their Flood Plain zoning regulations along the Deschutes River and Tumalo Creek based on the best available data.

The City Council finds that the November 10 letter does not identify specific actions the City has proposed taking that would be inconsistent with any of the above-referenced policies. To the extent that the comments suggests that continued use of the City's surface water source is inconsistent with the General Plan, those comments are not

supported by the language of the General Plan, which anticipates ongoing use of surface water (*see* Deschutes Basin Study Policy 11, which refers to replacing and clearly anticipates continued use of surface water.

3. Applicability of Statewide Planning Goal 5

FINDING: The November 10, 2011 letter argues that the SWIP triggers and requires the City comply with Statewide Planning Goal 5, Natural Resources, Scenic and Historic Areas, and Open Spaces. The letter further elaborates the City is required to and has not completed an economic, social, environmental, and energy (ESEE) analysis. The City Council finds that the Water PFP has not proposed or included proposed actions that would trigger compliance with the administrative rule implementing Goal 5 under OAR 660-023. The following text from the administrative rule outlines under what circumstances a local government must comply with Goal 5.

660-023-0250
Applicability

***
(3) Local governments are not required to apply Goal 5 in consideration of a PAPA unless the PAPA affects a Goal 5 resource. For purposes of this section, a PAPA would affect a Goal 5 resource only if:
(a) The PAPA creates or amends a resource list or a portion of an acknowledged plan or land use regulation adopted in order to protect a significant Goal 5 resource or to address specific requirements of Goal 5;
(b) The PAPA allows new uses that could be conflicting uses with a particular significant Goal 5 resource site on an acknowledged resource list; or
(c) The PAPA amends an acknowledged UGB and factual information is submitted demonstrating that a resource site, or the impact areas of such a site, is included in the amended UGB area.
***

The letter does not demonstrate, and the plan does not include or recommend the City take any action that would fall under (3)(a) through (3)(c) of OAR 660-023-0250. The Water PFP and its related amendments to Chapter 8 have been submitted to DLCD as a post-acknowledgement plan amendment (PAPA) under ORS 197.610. Neither the proposed PFP nor the amendments to the text of Chapter 8 create or amend a resource list or a portion of the General Plan or Development Code adopted to protect a significant Goal 5 resource. The Water PFP does not amend the Plan or the Development Code to allow new uses that would be conflicting uses with any significant Goal 5 source site or acknowledged list. Finally, the Water PFP and amendments to Chapter 8 do not amend the UGB.

Finally, the testimony raises the issue that the proposed Water PFP fails to satisfy the General Plan goal of "reasonable cost." It is unclear to what goal this testimony is referencing. Chapter 8 of the General Plan, Public Facilities and Services, begins with a number of goals regarding public facilities and services. One of these goals is to have public and private utilities provide adequate levels of service to the public at a reasonable cost. This term is not defined in the General Plan, and the November 10, 2011 testimony does not articulate a standard of "reasonable cost" and does not explain why the PFP does not meet this standard. The proposed Water PFP includes cost

estimates for several projects needed for the City's service area that are Class 5 estimates. The record contains the explanation from the City Engineer that the costs of these projects are considered a Class 5 estimate, meaning the project has an estimated level of accuracy of plus 100% to minus 50%. These cost estimates provide a basis from which the City can develop a budget for funding these improvements when they are needed. The PFP includes the required discussion of funding mechanisms under OAR 660-011-0010(1)(g).

4. The PFP satisfies the requirements of Goal 11

FINDING: The City Council finds that the proposed PFP satisfied Goal 11, and its implementing administrative rule at OAR 660-011. These findings are included in the September 2011 "Findings in Support of Adoption of the Goal 11 Water Public Facility Plan for the Bend Urban Growth Boundary."

OAR 660-011-0010(1)(g) requires "a discussion of the provider's existing funding mechanisms and the ability of these and possible new mechanisms to fund the development of each public facility project or system." The Water PFP describes the city's use of SDCs, utility rates, and the capital improvement program. Opponent's testimony does not define or identify a standard of adequacy for Goal 11 and why the proposed PFP does not meet this standard.

The November 10, 2011 letter challenges the legitimacy of the cost estimate of $57,750,000 for the surface water project as inadequate. The testimony indicates that the current expected costs of the project are $63-$72 million. The current cost estimates at 30% design for the pipeline and water treatment plant are $62.6 million and $5.6 million for hydroelectric and intake facilities, with further cost refinement expected at 60% design in early 2012. The City Council finds that as a Class 5 estimate for a specific CIP project, the estimate in the PFP is within the acceptable range of accuracy for this PFP, and that other financial, CIP, budgeting, rate-making, and policy-level decision making related to infrastructure are the appropriate processes for specific project funding. The Water PFP relies upon the Optimization Study (2011) by Optimatics which does explain how the costs were calculated for the respective projects. The City Council finds that this expert study was prepared in a manner that satisfied the requirements of the Public Works Department, and that the November 10, 2011 letter and the evidence upon which it relies undermines the credibility of this work.

With respect to funding mechanisms, the November 10 letter further argues that the PFP fails to satisfy OAR 660-011-0010(1)(g) because the description of funding mechanisms is terse, inadequate, and that the costs of the Surface Water Project should be further broken down. In addition, this testimony further alleges that city utility ratepayers will face substantial increase in utility rates as a result and that the cumulative effects of these and other rate increases should also be addressed. OAR 660-011-0010(1)(g) requires the following:

> ***(g) A discussion of the provider's existing funding mechanisms and the ability of these and possible new mechanisms to fund the development of each public facility project or system.***

This discussion required under (1)(g) is informed by the PFP including rough cost estimates. Such estimates are defined under OAR 660-011-0005(2) as approximate costs expressed in current-year (year closest to the period of public facility plan development) dollars. This definition goes on to state that it is not intended that project cost estimates be as exact as is required for budgeting purposes.

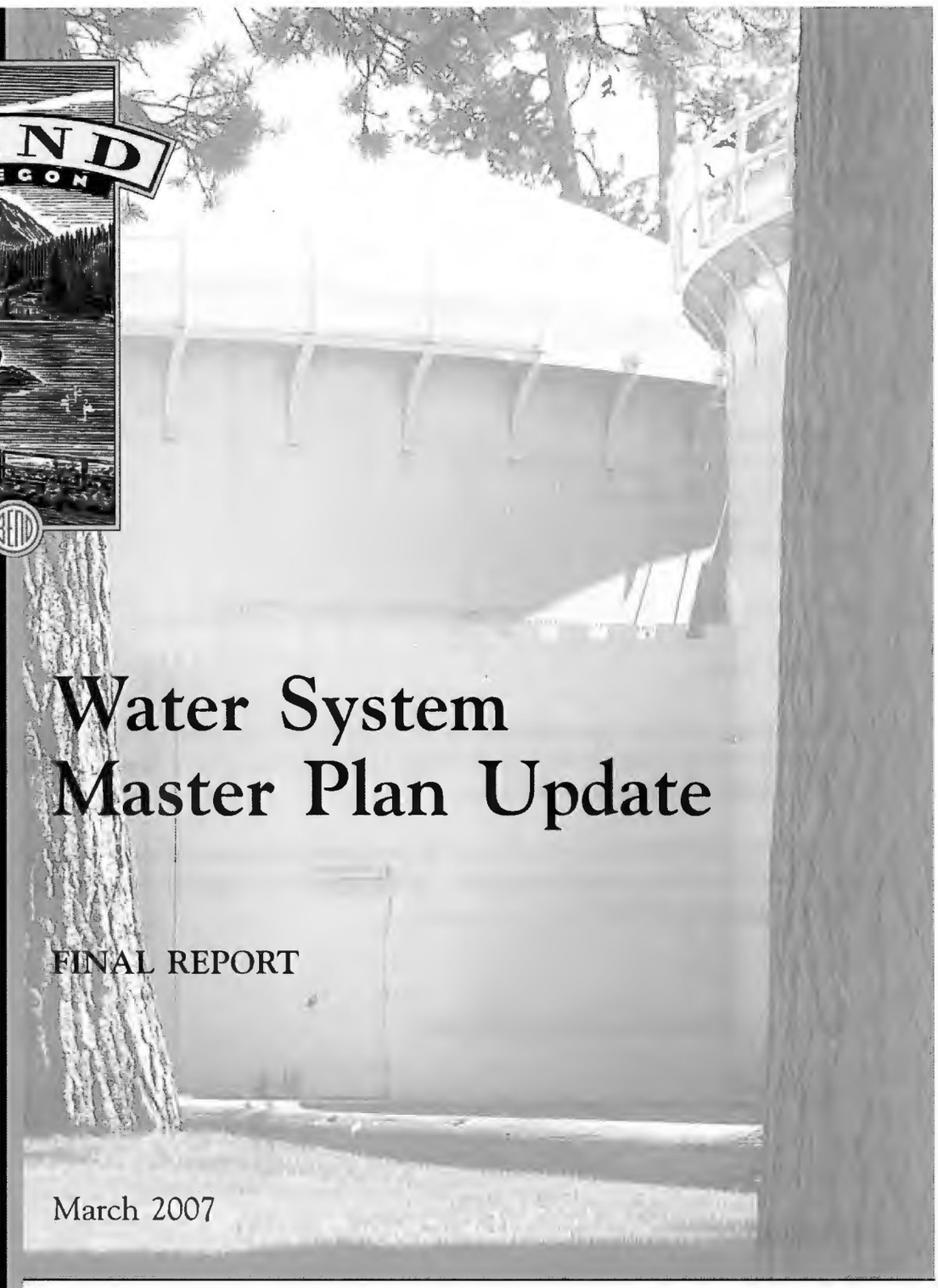
The City Council finds that the Water PFP satisfies OAR 660-011-0010(1)(g) by including an adequate discussion of the City's funding mechanisms and their ability to fund the development of each public facility project or system. These funding mechanisms include utility rates, system development charges, and the City's capital improvement program. The PFP discusses the costs of the project outlined in the PFP for the City's service area, and the current budget (2011-2013) for expected revenues from these funding mechanisms. As mentioned earlier, to ensure that the City makes improvements to the water infrastructure when needed, the City relies on a different approach to project the more specific timing of required investments for its water infrastructure. As explained by the City Engineer, the City ties the water infrastructure requirements to peak day demands. Peak day demands are easily and readily measured. This ensures that any investments made are directly tied to the actual demands and occur when they are actually needed. Since master plan documents often look at worst case scenarios for infrastructure needs, such as faster than anticipated growth or higher peak days, tying the infrastructure investments to measured peak day demand allows required estimated investments to be postponed until they are needed.

The letter further argues that the PFP is not shown to be "orderly and efficient," as required by Goal 11, when the extreme capital costs of the Surface Water Project are considered. This testimony argues that it would be far more orderly and efficient for the City to rely on its groundwater resource. The City Council finds that this testimony does not explain why the cost estimates for the Surface Water Project are extreme. For the City Council to consider costs extreme, the Council would need evidence upon which a reasonable person could conclude that the costs cited above are much higher for a project of this size and scope. The Council finds that this letter has not cited or provided such evidence. Further, the City Council finds that this testimony does not explain why it would be more efficient for the City to rely solely on groundwater. For the reasons already stated, the City Council finds that this discussion is beyond the scope of this PFP and is inconsistent with decades of City water system and utility planning and adopted documents.

The November 10 testimony argues that Surface Water Project listed in the Water PFP is not "reliable," and therefore violates both Goal 11 and the City's General Plan, because the watershed in which the Project is located will be the subject of a catastrophic fire. The City Council finds that this testimony does not cite to either the language of OAR 660-011 or Chapter 8 of the General Plan to provide some support for this position. The filtration treatment option for the Surface Water Project chosen by the City Council is specifically intended to protect water quality due to a turbidity event in event of a fire in the watershed. The City Council also finds that the source of surface water from the Tumalo Creek has been relied upon for almost 100 years. The City Council understands that City staff regularly coordinate with the United States Forest Service (USFS) to reduce the risk of fire in the watershed. The City Council finds that the assessment of risk is a policy choice and that the design options for the SWIP have adequately taken this into consideration.

Finally, the November 10 testimony argues that the Optimatics Report shows an analysis of areas outside of the UGB and that this violates Goal 11. The City Council finds that this is not correct. Page 9 of the Optimization Study clearly shows that a "Planning Area Boundary" that includes the City's utility boundary within the UGB. This same Planning Area Boundary includes some lands to the west and the north that are not included in the UGB. Goal 11 does not prohibit the analysis of areas for water service. The improvements proposed in the Report tables are intended to improvement delivery of water to the city's service area within the existing UGB. The only service improvements to areas outside the UGB are to those areas that are already served, including the Inn at the 7th Mountain and Widgi Creek.

Based on the forgoing Supplemental Findings, and the September 2011 Findings in Support of Adoption of the Goal 11 Water Public Facility Plan for the Bend Urban Growth Boundary, the City Council finds that Goal 11, and the Goal 11 administrative rule at OAR 660-011 have been satisfied.



Water System Master Plan Update

FINAL REPORT

March 2007

Murray, Smith & Associates, Inc.

CITY OF BEND, OREGON

MSA
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Engineers/Planners

121 S.W. Salmon, Suite 900 Portland, Oregon 97204-2949 PHONE 503.225.9010 FAX 503.225.9022

05-0765.104
March 7, 2007

Mr. Michael Miller
Assistant Public Works Director
Public Works Department
575 NE 15th Street
Bend, OR 97701

Re: City of Bend Water System Master Plan Update -- Final Report

Dear Mr. Miller:

In accordance with our agreement we have completed the engineering studies required for the preparation of the Water System Master Plan Update for the City of Bend. Our Final Report of these studies is transmitted herewith.

We wish to express our appreciation for the participation and cooperation of the City of Bend staff throughout the course of this study. Thank you for the opportunity to provide this service to the City of Bend.

Sincerely,

MURRAY, SMITH & ASSOCIATES, INC.

Kyle P. McTeague, P.E.
Project Manager

Brian M. Ginter, P.E.
Project Engineer

KPM:kpm

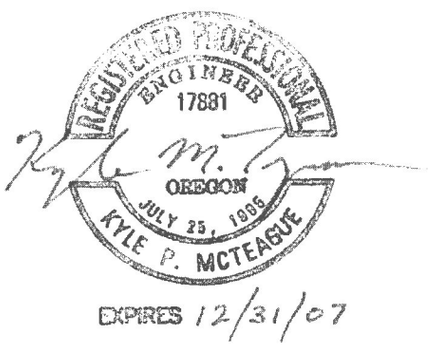
Enclosure

WATER SYSTEM MASTER PLAN UPDATE

FOR

CITY OF BEND, OREGON

March 2007





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ACKNOWLEDGMENTS

Appreciation is expressed to all who contributed to the completion of this report.

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EXECUTIVE SUMMARY

Introduction

The purpose of this Water Master Plan (WMP) is to provide the City of Bend a comprehensive planning document that provides basic information and guidance necessary for the sound stewardship of the municipal water system within its water service boundary. This plan is important because it:

- Compiles basic information relevant to the water system.
- Describes the basic functional parameters of the system.
- Presents planning and analysis criteria for system improvements and expansions.
- Highlights known system deficiencies.
- Describes and graphically illustrates recommended improvements.
- Presents basic cost information for general budgeting and the development of an adoptable 25-year capital improvements program (CIP).
- Provides a physical tool for informing customers and other interested parties of the existing system and proposed improvements.
- Serves as an invaluable resource for gaining public support for needed improvements.
- Facilitates logical planning decisions relative to other City programs.

How This Plan Should Be Used

This Water System Master Plan Update should be used in the following manner:

- This master plan should be viewed as a dynamic working document.
- The plan should be reviewed annually for the purpose of prioritizing and budgeting for needed improvements.
- Plan mapping should be updated periodically to reflect current development and constructed system upgrades.
- The plan hydraulic model should be used to coordinate and integrate developer-constructed system improvements.
- Specific recommendations set forth in this plan should be considered as conceptual only. Additional details and potential alternatives should be investigated and analyzed in the preliminary engineering phase of final project designs.
- Cost estimates should be considered as planning level only, and should be updated and refined with preliminary engineering and final project designs.
- This plan should be used as the guiding document for future water system improvements.

Authorization

In 2005, the firm of Murray, Smith & Associates, Inc. (MSA) was authorized by the City of Bend to prepare this Water System Master Plan.

Compliance

This plan complies with water system master planning requirements established under Oregon Administrative Rules (OAR) for Public Water Systems, Chapter 333, Division 61.

Planning Period

The planning period for this water system master plan is through the year 2030. Based on anticipated development rates and probable infill densities, saturation development within the existing service area and the Tetherow and Juniper Ridge areas is anticipated to occur near the end of the planning period. Saturation development, or build-out, occurs when all existing developable land within the service area has been developed, and all planning and facility sizing recommendations are based on saturation development conditions. The improvements presented in Section 6 of this report are recommended for implementation within the planning period (through 2030).

Study Area

The City of Bend currently serves water to approximately 53,000 people within the City limits, which at this time is the same as the Urban Growth Boundary (UGB). The remaining area within the City limits/UGB is served by two separate, private water providers, the Avion Water Company and Roats Water System. It is anticipated that areas outside of the current UGB will be incorporated into the City during the planning period of this report. These areas are currently being studied by the City, as part of the City of Bend Residential Lands Study, for inclusion in future expansions of the UGB and for designation of Urban Reserve Areas (URAs). For the purpose of this report, it is anticipated that the Tetherow and Juniper Ridge areas, both areas outside of the current City limits/UGB, will develop within the planning period of this study. Thus, the planning period service area includes the current service area within the UGB and the Tetherow development area as well as the Juniper Ridge area.

Oregon's Statewide Planning Goal No. 11 establishes requirements regarding public facilities planning. To comply with Goal 11 this plan provides a distinction between the facilities that are meant to serve areas within the existing UGB and those facilities intended to serve areas outside of the existing UGB. Where facilities are intended to eventually commingle service to areas both within the existing UGB and outside the existing UGB, those facilities can not be used to serve the later until they are included within the UGB.

Existing Water System

General

The City of Bend's existing water system consists of a surface water intake facility, 23 groundwater production wells, 14 finished water storage reservoirs, 5 booster pump stations, transmission and distribution mains, and associated appurtenances such as control valves, pressure reducing valves, isolation valves, meters, and fire hydrants. The system includes eleven primary pressure zones serving water system customers ranging in elevation from approximately 3,450 feet to 4,160 feet above mean sea level (msl).

Water Rights

Currently the City holds water rights totaling 51.9 million gallons per day (mgd) (80.35 cubic feet per second (cfs)). 28.6 mgd (44.24 cfs) of these water rights are groundwater water rights and 23.3 mgd (36.11 cfs) are surface water rights. Approximately 10.0 mgd of the City's surface water rights are junior rights and are only available during the wintertime. Furthermore, the City's surface water rights are further limited to approximately 7.6 mgd during the peak season in drought years to prevent impact to more senior rights.

Supply

Surface water is collected approximately 13 miles west of the City at the Bridge Creek Intake Facility located near the confluence of Bridge Creek and Tumalo Creek. Flows in Bridge Creek are supplemented by the diversion of natural springs located in the Tumalo Creek drainage basin. Spring flows are collected in a diversion pond and transferred through two parallel transfer pipes to a canal flowing to Bridge Creek. Raw water is then routed from the Bridge Creek Intake Facility approximately 11.5 miles via two parallel steel transmission pipelines measuring 14 inches and 16 inches in diameter to the Outback Site.

In addition to the surface water source, the City currently has 9 groundwater production sites that include 23 wells located throughout the service area and at the Outback site westerly of the City. The total groundwater production capacity is approximately 31 million gallons per day (mgd).

Pressure Zones

The City of Bend's existing water distribution system includes eleven primary service areas, or pressure zones. Pressure zones are generally defined by ground topography and designated by overflow elevations of water storage facilities or discharge hydraulic grades of pressure reducing or booster pumping facilities serving the zone. The highest elevation zone includes the top of Awbrey Butte, and the lowest elevation zone extends towards the northeasterly edge of the service area boundary.

Storage

The City of Bend has a total of 15 storage reservoirs located throughout the water service area, including the 1.5 mg CT Basin at the Outback site, providing a total of approximately 30 million gallons (MG) of storage.

Pumping

The City's distribution system includes five booster pump stations designed to deliver water from one pressure zone to a higher zone. The Awbrey Pump Station pumps from Zone 5 to Zone 1, the College Pump Station pumps from Zone 3 to Zone 2, the Westwood Pump Station pumps from the Westwood reservoir (Zone 4W) to the Westwood Service Area, the Scott Street Pump Station pumps from Zone 5 to Zone 4E, and the Murphy Pump Station pumps from Zone 4E (4 East) to Zone 3SB (3 South Bend).

Water System Piping

The City of Bend's water system is composed of various pipe materials in sizes up to 36 inches in diameter. The total length of piping in the service area is approximately 290 miles. The majority of the piping in the system is ductile iron, cast iron and steel. The piping in the former Juniper Utility Company (Zones 2SB and 3SB) is primarily small diameter, 2-inches to 6-inches polyvinyl chloride (PVC) pipe.

Water Demands

Existing Water Demands

Based on the City's historical water use, the water service area's total average daily demand has ranged from approximately 8.6 mgd to approximately 11.5 mgd since the year 1998. It appears that the per capita usage of water has decreased in recent years due to ongoing water conservation efforts and to the recent implementation of service meters for all customers.

Population and Water Demand Projections

The estimate of the population for the service area at saturation, or build out, was developed by analyzing comprehensive plan zoning classifications for all developed and undeveloped residential, commercial and industrial areas within the City's service area, and through the application of occupancy assumptions. These forecasts were developed in close coordination with City staff.

For the year 2005 the total maximum day demand was approximately 26.9 mgd. The maximum day demand is the anticipated demand for the "highest-use" day of the year. Based on historical system demands from 1998 through 2005, and on population projections, the total maximum day demand is estimated to be approximately 71.5 mgd at saturation

development. Based on historical water production records the peak hour demand is estimated to be equal to 1.5 times the Maximum Day Demand (MDD) (See Table ES-1).

Table ES-1
Population Projections and Water Demand Summary

Year	Water Service Area Population	Water Demand (mgd)		
		Average Day Demand (ADD)	Maximum Day Demand (MDD)	Peak Hour Demand [5]
2005	52,941	11.3 [1]	26.9 [2]	40.4
Saturation Development[6]	103,000	30.7 [3] [6]	71.5 [4] [6]	107.3[6]

Notes:
(1) Existing Average Day Demand based on 2005 water use records.
(2) Existing Maximum Day Demand based on 2005 water use records.
(3) Average Day Demand equals the Population multiplied by the estimated average daily per capita usage for the service area (250 gpcd).
(4) Maximum Day Demand equals the Population multiplied by the estimated maximum daily per capita usage for the service area (590 gpcd).
(5) Peak Hour Demand equals 1.5 times the Maximum Day Demand
(6) Includes Juniper Ridge ADD, MDD and Peak Hour Demand of 4.75, 10.67 and 16.0 mgd, respectively.

Planning and Analysis Criteria

Criteria for the analysis of the City of Bend water system are summarized as follows:

- The City's supply, treatment and transmission systems should be capable of providing estimated maximum day demands through the end of the 25-year planning period.
- Water storage capacity should provide for operational, fire, and emergency storage capabilities.
- Water storage capacity should be provided to each pressure zone where practical.
- Pressure zones should be established so that the maximum service pressures do not exceed 120 pounds per square inch (psi).
- The distribution system should be capable of delivering the maximum day demand while maintaining a minimum service pressure at the highest point in the service zone of 40 psi.
- Distribution main lines should be looped and should not be less than 8 inches in diameter unless there are no fire hydrants and/or is no potential for future extension of the main line.
- Pump stations that pump to a reservoir should be sized to supply the maximum day demand to the areas served.

- Constant pressure pumping systems should be capable of providing maximum day demands plus fire flows to the areas served.
- The distribution system should be capable of supplying adequate fire flows when the system is experiencing the maximum day demand while maintaining a minimum service pressure of 20 psi.
- Recommended minimum fire flows are 1,500 gallons per minute for residential zones, 2,500 gallons per minute for general commercial and industrial zones, and 3,500 gallons per minute for the Commercial Highway zone.

Water System Analysis

An analysis was conducted to evaluate the adequacy of the existing system, and to identify system improvements that would most efficiently serve to correct existing deficiencies and to provide for future growth. The analysis included an evaluation of pressure zone requirements and potentially beneficial adjustments, development and use of a hydraulic network computer model to evaluate the distribution system, evaluation of distribution storage and pumping requirements and how best to meet future capacity needs, and a general assessment of the condition of the existing distribution piping and pumping facilities.

The findings identified in the course of the analysis are as follows:

- The City will need to expand supply, storage and pumping capacities to satisfy growing demands through the 25-year study period.
- Available fire flow capacity is generally sufficient; however, certain system improvements should be implemented to bolster the City's ability to suppress potential fires, and to provide expanded capacity looking forward.
- Due to the existing robust aquifer beneath the City, water supply may be expanded in a geographically strategic manner to minimize the need for major transmission piping and to maximize the value of existing facilities.
- The robust nature of the aquifer allows the City significant flexibilities with respect to future service area expansions.
- The City could derive tremendous additional value from the robust aquifer by allocating a significant portion of emergency storage to this source, thereby offsetting the need to construct tank capacity for such storage.
- The City could benefit by developing a better geographic "balance" of facilities through the implementation of expanded supply and storage capacity easterly of the Deschutes River, where most of the capacity needs exist.

- Minimal pressure zone adjustments are required to satisfy service and fire demand needs looking ahead; however, it is suggested that further study be conducted to evaluate the integration of the former Juniper Utility Area in greater detail.

- The piping within the former Juniper Utility Area is generally undersized and of low quality and much of it should be programmed for replacement over the long term.

- Emergency backup power generation capabilities should be implemented at all groundwater well sites to help minimize risks relating to water supply during power failures.

Recommended Capital Improvements

This plan recommends supply and distribution system improvements to correct existing deficiencies and to provide for future service needs within the study area through the next 25 years. Two detailed system graphics were prepared that illustrate the existing distribution system and identify proposed improvements (see Figures 1 & 2 in Appendix A). In addition, a hydraulic profile graphic was developed to present a vertical representation of both existing and proposed facilities (see Figure 6-3 in Section 6). The recommendations include improvements to supply capacity, the distribution system piping, storage reservoirs, and pump station capacity.

The recommended system improvements include proposed additional storage reservoirs at Pilot Butte and Rock Bluff, as well as at the Juniper Ridge Area. In addition, pump station upgrades are proposed for the Westwood Pump Station, and a total additional supply capacity of approximately 40 million gallons per day is proposed. Planning level budget cost estimates for the recommended improvements have been developed. The plan outlines distribution system improvements through the end of the 25-year study period. A long-term financing plan is recommended to support the proposed distribution system capital improvement plan. Adequate system development fees should be established to collect needed funds from new customers for both existing facilities and for improvements that expand the capacity of the system.

Presented below in Table ES-2 is a summary of recommended water system improvements for supply and distribution system storage, pumping, and piping. Project cost estimates of recommended improvements are presented for capital improvement programming. The 25-year average annual capital requirement in 2006 dollars would be approximately $6,800,000 per year. An annual increase of roughly 3% for inflation should be applied to this estimate for future budgeting purposes.

Table ES-2
Summary of Estimated Water System Improvement Project Costs

Improvement Category	Project Costs, 2006 Dollars
Groundwater Supply Capacity Expansion	$48,360,000
Emergency Backup Power Generation Upgrades	$1,300,000
Surface Water Supply Improvements	$50,000,000
Storage Capacity Expansion	$21,100,000
Pumping Capacity Upgrades	$2,100,000
Transmission Piping Improvements	$7,680,000
Pressure Reducing Stations	$1,080,000
Water System Planning	$1,000,000
Distribution Piping Improvements	$37,400,000
GRAND TOTAL	$170,020,000
USE	$170,000,000

Cost Estimating Data

An estimated project cost has been developed for each improvement project recommendation presented in this study. Itemized project cost estimate summaries are presented in Appendix B. Project costs include construction costs and an allowance for administration, engineering, and contingencies.

The estimated costs included in this plan are planning level budget estimates presented in 2006 dollars. Since construction costs change periodically, an indexing method to adjust present estimates in the future is useful. The Engineering News Record (ENR) Construction Cost Index (CCI) is a commonly used index for this purpose. For purposes of future cost estimate updating, the October 2006 ENR CCI for Seattle, Washington of 8630 is referenced.

Water Management and Conservation Plan

The Oregon Administrative Rules (OAR) for Public Water Systems, Chapter 690, Division 86 requires water systems with water rights to submit a Water Management and Conservation Plan that documents current water conservation measures, provides a water curtailment plan,

evaluates long-term water supply planning and provides a water rights implementation schedule. The City recently completed a Water Management and Conservation Plan and it is understood that the City intends to update this plan approximately every five to ten years.

Financial Evaluation and Plan

A long-term financial planning evaluation and strategy is required to support the recommended capital improvement plan. The financial evaluation should include a cost-of-service analysis and income generating options that support an adequate funding source without placing an undue burden on existing customers. Adequate SDC's should be established to collect funds from new customers to pay for improvements that expand the capacity of the system. It is understood that a financial evaluation and plan is currently under way and information contained in this water system master plan update is intended to be used as needed for that plan.

Recommendations for Plan Implementation

It is recommended that the City take the following actions:

1. Formally adopt this study as the City of Bend's Water System Master Plan for the water service area.
2. Adopt the recommended system improvements described in Section 6 as part of the City's capital improvement plan (CIP) for the water service area.
3. Develop and adopt a financing plan to implement the capital improvements recommended in this study.
4. Review and update this plan within five to seven years to accommodate changed or new conditions.

Summary

Bend continues to experience steady population and water demand growth. This water system master plan evaluates the City water system's ability to adequately meet existing and future water needs. The ultimate completion of recommended improvements to the distribution and supply systems will ensure that the City has adequate supply, storage, pumping and distribution system piping capacity to meet these needs well into the future. The total estimated project costs of these improvements are approximately $170 million for the 25 year planning horizon. Approximately $6,800,000 per year should be budgeted over the next 25 years for the completion of the recommended projects. A financial planning and analysis study should be undertaken to determine the ultimate impact of the capital improvement program on City ratepayers and new development and to determine overall capital funding needs.

SECTION 1
INTRODUCTION

Authorization

In September 2005, the firm of Murray, Smith & Associates, Inc. was authorized by the City of Bend to prepare this Water System Master Plan Update.

Purpose

The purpose of this study is to perform a comprehensive analysis of the City of Bend's water supply and distribution system, to identify system deficiencies, to determine future water distribution system and supply requirements, and to recommend water system facility improvements that correct existing deficiencies and allow for future system expansion. Since the completion of the City's Utilities System Master Plan Update in 1999, the City has experienced population growth exceeding projections and has plans for expansion of the Urban Growth Boundary (UGB) to accommodate anticipated continued accelerated growth. This study will provide the City with the guidance needed for the sound stewardship of the water system over the next 25 years and beyond.

Compliance

This plan complies with water system master planning requirements established under Oregon Administrative Rules (OAR) for Public Water Systems, Chapter 333, Division 61.

Scope

The scope of work for this study includes the following work tasks:

- ***Information Compilation and Review*** – Compile and review existing information relevant to water master planning work, including previous water system master plan documents, record drawings of key facilities, reports and studies, planning data, water use data, population data, water rights documentation, information on neighboring water systems, working hydraulic computer models of City systems and interfacing adjoining systems, and other pertinent information.

- ***Model Evaluation*** – Evaluate the current City of Bend H20Net water system hydraulic model update, completed in July 2005, relative to the City's existing Utilities System Master Plan Update (completed in 1999) and current assumptions for development of supply and storage through the planning horizon.

- ***Juniper Utility System Model Integration*** – Integrate the City's existing H20Net model with H20Net model of the former Juniper Utility Company system.

- ***Hydraulic Model Start-up, Verification and Calibration*** – Investigate, verify and modify the existing hydraulic model so as to confirm that it is functioning properly and that it is appropriately reflecting existing City of Bend water system conditions as regards to the water master planning objectives. Conduct a water system operation review workshop with City staff to help establish and confirm critical operational input parameters that are important to hydraulic model verification, and performance. Complete hydraulic model calibration with City flow testing data to better match model outputs with observed and expected physical system performance.

- ***Water System Review*** – Conduct a field review of the City's major water system facilities to establish an "on the ground" understanding of existing facilities.

- ***Identification of System Deficiencies*** – Through field reviews and discussions with City engineers, operations and public works staff identify known deficiencies and/or problems within the existing water supply and distribution system. Conduct a workshop with City staff to inventory current known system deficiencies, relative to the water master planning work.

- ***Review Water Demand Forecasts*** – Review historical water consumption records and current water demand forecasts. Review and confirm short-term and long-term population estimates and water demand forecasts with City Public Works Department and Planning Department Staff.

- ***Review Future Service Area and Assess Water Demand Forecasts*** – Complete further analysis to verify the anticipated future service area and to asses water demand forecasts. Evaluate certain existing Urban Reserve Areas (URA's), as well as other areas under consideration by the City currently outside the Urban Growth Boundary (UGB), for inclusion in the future service area and analyze water demand forecasts for the future service area.

- ***Water Supply/Source Review*** – Conduct a brief review of current surface and groundwater supply sources relative to projected water demand forecasts and develop preliminary recommendations.

- ***Finished Water Storage Analysis*** – Review and evaluate requirements for finished water storage and develop recommendations for improvement. Review historical methodology for finished water storage volumes. Review and develop recommendations for overall storage requirements relative to water distribution system pressure zone and piping layouts, source development and ground topography within developable urban areas.

- ***Pressure Zone Analysis*** – Review and evaluate the existing pressure zone layout with respect to existing and planned future development in relation to topography. Confirm and/or establish acceptable elevation limits and service pressure limits for

each of the City's existing pressure zones. Illustrate proposed pressure zones on updated water master plan mapping.

- ***Water System Analysis Criteria Review*** – Review and update water system analysis criteria, including fire flows, residual pressures, and flow velocities.

- ***Water Distribution System Analysis*** – Update prior hydraulic modeling relative to updated recommendations on water supply and storage locations.
  - Analyze existing system using personal computer based MWHSoft H2ONet hydraulic analysis software to identify and confirm distribution system deficiencies. Consider both peak hour demand conditions and maximum day demand conditions combined with strategically applied fire demands.
  - Develop trial improvement alternatives to correct existing deficiencies and to provide for future system expansions to serve future development.
  - Analyze various trial alternative configurations and with City input, develop recommendations for improvements.
  - Develop an overall AutoCAD based water system map of the existing City of Bend system utilizing the mapping features of the hydraulic modeling software.
  - Develop overall AutoCAD based water system map of the proposed improved system showing improvements recommended for saturation development of the existing UGB and conceptual level improvements for proposed Urban Reserve Areas (URA's).

- ***Cost Estimates and Recommended Capital Improvements Program*** – Develop preliminary planning level cost estimates for recommended capital improvements. Work with City Staff on prioritizing capital improvements and developing a comprehensive water system improvements program.

- ***Water SDC Technical Assistance*** – Provide engineering support and technical assistance to the City and the City's financial consultant in the development of the water System Development Charge (SDC).

- ***Water System Master Plan*** – Prepare a bound Water System Master Plan document in draft and final form. Develop reporting narrative, data, tables, figures, illustrations and mapping to clearly present findings, recommendations and capital improvement program. Include an overall water system master plan update "wall-map" style figure. With City staff concurrence, submit the Water System Master Plan to the State of Oregon Department of Human Services – Drinking Water Division on the City's behalf for review and approval.

SECTION 2
EXISTING WATER SYSTEM

General

This section inventories and describes the City of Bend's existing water service area and water system facilities. Included in this section are discussions of existing surface water and groundwater supply facilities, pressure zones, storage reservoirs, pumping facilities, and distribution system piping.

Background and Study Area

The City of Bend's water supply, transmission, and distribution system currently provides potable water to approximately 53,000 people through residential, commercial, industrial and institutional services. The study area for this master plan includes the area that lies within the City of Bend's existing Urban Growth Boundary (UGB) not currently served by private water companies (Avion Water Company and Roats Water Company), as well as two areas outside of the current UGB that are anticipated to be developed during the study period (Tetherow and Juniper Ridge). While an expanded area is currently being studied by the City of Bend for proposed UGB expansion and designation as Urban Reserve Areas (URAs), Tetherow and Juniper Ridge are the only areas outside of the UGB included within the study area of this plan as they are the highest priority planning areas for the City at this time. Also, total saturation population projections completed as part of this report, that include these areas match relatively well with population projections recently prepared by other City planning interests.

The City of Bend's existing water system consists of a surface water intake facility, 23 groundwater wells, 15 finished water storage reservoirs, 5 booster pump stations, transmission and distribution mains, and associated appurtenances such as control valves, pressure reducing valves, isolation valves, meters, and fire hydrants. The system includes eleven primary pressure zones serving water system customers ranging in elevation from approximately 3,450 feet to 4,160 feet above mean sea level (msl).

Figure 1, "Existing Water System Map", in Appendix A illustrates the study area, current UGB, other nearby water systems, existing source, supply, storage and pumping facilities, transmission and distribution mains and pressure zones. Figure 1 is also a digital representation of the computerized distribution system hydraulic model used for the system analysis.

Source, Supply and Transmission System

General

The City of Bend supplies potable water to its customers from a surface water supply system that originates in the nearby Bridge Creek watershed and from 23 groundwater production

facilities located throughout the water system. A more detailed description of the City's water supply sources and water rights for these supply sources is presented below.

Water Rights

Currently the City holds water rights totaling 51.9 mgd (80.35 cfs). 28.6 mgd (44.24 cfs) of these water rights are groundwater water rights and 23.3 mgd (36.11 cfs) are surface water rights. Approximately, 10.0 mgd of the City's surface water rights are junior rights and are only available during the wintertime. Further discussion of the City's surface water supply is presented below. The City also has submitted two groundwater right applications for approximately 15.5 mgd (24 cfs) that are currently pending further action by the State of Oregon Water Resources Department and the City of Bend. A summary of the City's water rights is presented in Appendix C.

Surface Water Supply

Surface water is collected approximately 13 miles west of the City at the Bridge Creek Intake Facility located near the confluence of Bridge Creek and Tumalo Creek. Flows in Bridge Creek are supplemented by the diversion of natural springs located in the Tumalo Creek drainage basin. Spring flows are collected in a diversion pond and transferred through two parallel transfer pipes to a canal flowing to Bridge Creek. Raw water is then routed from the Bridge Creek Intake Facility approximately 11.5 miles via two parallel steel transmission pipelines measuring 14 inches and 16 inches in diameter to the Outback Site. Disinfection of the surface water supply is achieved at the Outback Site with the addition of chlorine. Raw surface water from the Bridge Creek Intake Facility is mixed with a chlorine solution and then flows through the CT Basin, a baffled reservoir designed specifically to eliminate short-circuiting and increase disinfectant contact time, and Outback Reservoir 1 before entering the distribution system. Further discussion of the storage facilities at the Outback site is presented later in this section.

The City of Bend has been granted an exemption from the Safe Drinking Water Act's Surface Water Treatment Rules by the Oregon State Health Division. This exemption is based on a review of the raw water quality in the Bridge Creek watershed and ongoing efforts by the City of Bend to protect this watershed. The exemption allows the City to forego the need for a water treatment facility for the surface water collected from the Bridge Creek watershed. The City is currently evaluating the sustainability of the exemption under the recently promulgated Long Term 2 Enhanced Surface Water Treatment Rule and investigating potential watershed and piping improvements to maintain the high level of raw water quality it currently enjoys.

The City holds water rights for 23.3 mgd of supply from the surface water source; however, the actual capacity of this source varies significantly throughout the year with seasonal stream flow fluctuations. As stipulated by the City's surface water supply rights, the available capacity of water to the City is limited by the actual stream flow so that water uses by more senior water rights are not impacted. For water system planning purposes, the capacity of individual sources available during the summer peak season, is used because

supply sources must be adequate to meet the larger demands experienced during this time of year. As documented in the City's October 2004 Water Management and Conservation Plan, it is understood that the actual reliable capacity of the City's surface water supply source during the peak season can be limited to 7.6 mgd in years where drought conditions are experienced due to minimum stream flow requirements. During the peak summer demand season, the capacity of this supply source is the limitation on the amount of supply available. This report uses this value for analysis associated with supply.

Groundwater Supply

The City currently has 9 groundwater production sites that include 23 wells located throughout the service area and at the Outback site. A table summarizing these groundwater production facilities is listed below in Table 2-1. This information was gathered from previous City efforts and discussions with City staff.

Finished Water Transmission Piping (Outback Site)

Four finished water transmission pipes transmit water from the Outback site to the City's distribution system. A 14-inch and 16-inch diameter pipeline transmit surface water from Outback Reservoir I to the Overturf Reservoir and Awbrey Reservoir, and a 16-inch and 36-inch diameter transmission main transmit groundwater from Outback Reservoir II to Pressure Zone 3. These facilities are discussed in further detail later in this Section and in Section 5.

The City is currently reconfiguring the piping at the Outback site so that the surface and groundwater supplies are blended at the Outback site and delivered to the distribution system through the four transmission mains.

Interties

The City of Bend has existing interties with two neighboring water service providers, the Roats Water System and the Avion Water Company. Bend relies on a connection with the Roats Water System to meet the demands of a small portion of the former Juniper Utility Company service area (South Bend service area). In addition, the City maintains an emergency intertie with the Avion Water Company. This intertie is meant strictly for emergency purposes, such as fire events or emergency backup. The City of Bend has an agreement with the Avion Water Company to allow for future emergency water interties if requested by either water provider.

Table 2-1
Groundwater Production Facility Summary

Groundwater Production Facility	Pump Size (hp)	Pump Type	Approx. Static Water Level (feet)	Capacity (mgd)
Awbrey Glenn (Copperstone)	250	Line Shaft Turbine	510	1.4
Bear Creek Well I	350	Line Shaft Turbine	629	1.5
Bear Creek Well II	350	Line Shaft Turbine	652	1.6
Outback I	150	Submersible	482	1.2
Outback II	150	Submersible	482	1.2
Outback III	250	Line Shaft Turbine	478	1.6
Outback IV	250	Line Shaft Turbine	482	1.6
Outback V	250	Line Shaft Turbine	486	1.8
Outback VI[1]	250	Line Shaft Turbine	480	1.8
Pilot Butte I	250	Line Shaft Turbine	743	1.2
Pilot Butte II	250	Line Shaft Turbine	734	1.1
Pilot Butte III	250	Submersible	786	1.3
River Well I	500	Line Shaft Turbine	360	2.8
River Well II	400	Line Shaft Turbine	242	2.8
Rock Bluff I	150	Line Shaft Turbine	393	1.2
Rock Bluff II	150	Submersible	395	1.1
Rock Bluff III	150	Line Shaft Turbine	395	1.2
Westwood	150	Submersible	283	1.0
Shiloh North	25	Submersible	335	0.2
Shiloh South	25	Submersible	335	0.2
Shiloh III	250	Line Shaft Turbine	355	2.2
Hole Ten North	150	Submersible	410	0.6
Hole Ten South	150	Submersible	412	0.6
Total Groundwater Supply Capacity (mgd)				**31.2**

Note: 1. Outback Well VI is currently under construction.

Pressure Zones

General

The City of Bend's existing water distribution system includes eleven primary service areas, or pressure zones. Pressure zones are generally defined by ground topography and designated by overflow elevations of water storage facilities or discharge hydraulic grades of pressure reducing or booster pumping facilities serving the zone. A summary of the City's pressure zones is presented in Table 2-2. A brief discussion of each pressure zone is presented below.

It should be noted that there are a number of small "subzones" throughout the City that are controlled by PRV connections to one of the eleven primary zones discussed below. For the purposes of analysis, these smaller "subzones" are considered a part of one of the eleven

primary zones where appropriate. A pressure zone analysis and recommendations are presented in Sections 5 and 6 of this report.

Table 2-2
Existing Pressure Zone Summary

Pressure Zone	Elevation Range Served (feet)	Primary Supply Source	Storage Reservoirs	Controlling Overflow Elevation (feet)	Approximate Pressure Range (psi)
1	3,970 – 4,160	Awbrey PS	Tower	4,244	30-120
2	3,830 – 4,010	College PS	College I and II	4,123	50-130
2SB	3,800 – 3,890	Hole 10 Wells	--	--	60-100
Westwood	3,840 – 3,940	Westwood Pump Station	Westwood Reservoir	3,872	50-100
3	3,730 – 3,860	Outback Site	CT Basin Outback I, II and III	4,011	65-120
3SB	3,730 – 3,790	Shiloh Wells/ Murphy PS	--	--	50-85
4W	3,640 – 3,750	Outback Site	Overturf I and II	3,871	50-100
4E	3,650 – 3,770	Bear Creek Wells Rock Bluff Wells	Pilot Butte II Rock Bluff I	3,879/3,880	50-100
5	3,540 – 3,680	River Wells Pilot Butte Wells	Awbrey Pilot Butte I and III	3,795	50-110
6	3,460 – 3,635	PRV	--	--	40-110
7	3,450 – 3,510	PRV	--	--	40-110

Pressure Zone 1

Pressure Zone 1 serves customers with ground elevations between roughly 3,970 and 4,160 feet. Service to customers in Pressure Zone 1 is provided by gravity from the Tower Rock Reservoir, the overflow elevation of which is 4,244 feet. Supply to this zone is provided from the Awbrey Booster Pump Station. Service pressures in Zone 1 are between approximately 30 and 120 psi. A certain number of customers in the higher elevations of Zone 1 have individual booster pump stations to increase service pressure to acceptable levels. Pressure Zone 1 currently serves a population of approximately 835.

Pressure Zone 2

Pressure Zone 2 serves customers with ground elevations between roughly 3,830 and 4,010 feet. Service to Pressure Zone 2 is provided by gravity from College Reservoirs I and II, the overflow elevations of which are 4,123 and 4,118 respectively, and from PRV connections from Pressure Zone 1. Supply to the zone is provided primarily through a pumped connection to the College Booster Pump Station in Zone 3. Pressures in Zone 2 are between approximately 50 and 130 psi. Zone 2 currently serves a population of approximately 1,000.

Pressure Zone 2SB (South Bend)

Pressure Zone 2SB represents the higher elevation areas of the former Juniper Utility Company that the City recently acquired. This zone serves customers with ground elevations between roughly 3,800 and 3,890 feet. Service to Pressure Zone 2SB is provided through a constant pressure pumped system. Supply is provided through Hole Ten Well North and South. Operating pressures in Zone 2SB generally range between approximately 60 and 100 psi. Zone 2SB currently serves a population of approximately 600.

Westwood Service Area

When the City assumed water service responsibilities for the Westwood neighborhood in the southwesterly portion of Bend it inherited an area operating with a hydraulic grade between Zone 2 and Zone 3. This pressure zone is supplied from a groundwater well, the Westwood Well, which pumps into a 0.5 million gallon (mg) ground level reservoir, the Westwood Reservoir. A continuous operation pump station, the Westwood Pump Station, provides constant pressure service to the zone from the Westwood Reservoir. The Westwood service area is also connected to Pressure Zone 3 via a 16-inch diameter main in Mt. Washington Drive. A normally closed isolation valve separates the Westwood service area from Pressure Zone 3.

Pressure Zone 3

Pressure Zone 3 serves customers with ground elevations between roughly 3,730 and 3,860 feet. Service to customers in Pressure Zone 3 is provided by gravity from Outback Reservoirs I, II and III, the overflow elevations of which are 4,011, and from PRV connections from Pressure Zone 2. Supply to the zone is provided primarily by the groundwater production wells at the Outback site. In addition, supply is provided from the Copperstone well within Zone 3. Service pressures in Zone 3 are between approximately 65 and 120 psi. Pressure Zone 3 currently serves a population of approximately 4,420.

Pressure Zone 3SB (South Bend)

Pressure Zone 3SB represents the relatively lower elevation areas of the former Juniper Utility Company that the City recently acquired. This zone serves customers with ground elevations between roughly 3,730 and 3,790 feet. Service to Pressure Zone 3SB is provided through a constant pressure pumped system. Supply is provided by Shiloh Wells "North", "South" & No. 3. Within Zone 3SB, the Murphy Pump Station can supply water from Zone 4E, and supply may be provided through a PRV connection from Zone 2SB. Operating

pressures in Zone 3SB generally range between approximately 50 and 85 psi. Zone 3SB currently serves a population of approximately 1,250.

Pressure Zone 4W (West)

Pressure Zone 4 represents two separate service areas on either side of the Deschutes River, connected by a 16-inch diameter pipeline with a normally closed valve. The area on the westerly side of the river operates at a hydraulic grade that is set by the overflow elevations of the Overturf reservoirs at 3,871 feet, and the area on the easterly side of the river operates at a hydraulic grade that is set by the overflow elevations of the Rock Bluff Reservoir at 3,879 and the Pilot Butte Reservoir II at 3,880 feet. Thus, for the purposes of this planning report these two areas are identified as Pressure Zone 4W (West) and Pressure Zone 4E (East).

Pressure Zone 4W serves customers with ground elevations between roughly 3,640 and 3,750 feet. As described above service to Pressure Zone 4W is provided by gravity from Overturf Reservoir I and Overturf Reservoir II. Supply to the zone is provided primarily from the Outback surface water and groundwater facilities, as well as through PRV connections from Zone 3. Service pressures in Zone 4W range between roughly 50 and 100 psi. Pressure Zone 4W currently serves a population of approximately 5,400.

Pressure Zone 4E (East)

Pressure Zone 4E serves customers with ground elevations between roughly 3,650 and 3,770 feet. Service to Pressure Zone 4E is provided by gravity from the Rock Bluff Reservoir and the Pilot Butte Reservoir II. Supply to the zone is provided primarily from groundwater wells at the Rock Bluff site, the Pilot Butte wells and the Bear Creek site. Supply may be pumped from Zone 5 via the Scott Street Pump Station as well as routed through PRV connections from Zone 3SB. Service pressures in Zone 4E range between roughly 50 and 100 psi. Pressure Zone 4E currently serves a population of approximately 8,750.

Pressure Zone 5

Pressure Zone 5 serves customers with ground elevations between roughly 3,540 and 3,680 feet. Service to customers in Pressure Zone 5 is primarily provided by gravity from the Awbrey Reservoir and the Pilot Butte I and III Reservoirs, the overflow elevations of which are 3,795, 3,782 and 3,782 respectively, and by PRV connections from Pressure Zone 4W and 4E. Supply to the zone is provided primarily by the City's surface water supply and groundwater production wells at the Outback site, in addition to Pilot Butte Wells 1, 2 & 3, and River Wells 1 & 2. Service pressures in Zone 5 range between approximately 50 and 110 psi. Pressure Zone 5 currently serves a population of approximately 20,890.

Pressure Zone 6

Pressure Zone 6 serves customers with ground elevations between roughly 3,460 and 3,635 feet. Service to customers in Pressure Zone 6 is provided by PRV connections from Pressure

Zone 4 and Pressure Zone 5. Currently there are no storage facilities serving Zone 6 directly by gravity. Storage for this zone is provided by reservoirs in higher elevation pressure zones. Supply to the zone is provided by the City's surface water source and various groundwater production wells located in higher elevation pressure zones. Service pressures in Zone 6 generally range between 40 and 110 psi, and this zone currently serves a population of approximately 8,320.

Pressure Zone 7

Pressure Zone 7 serves customers with ground elevations below 3,510 feet. Service to customers in Pressure Zone 7 is provided by PRV connections to Pressure Zone 6. Currently there are no storage facilities serving Zone 7 directly by gravity. Storage for this zone is provided by reservoirs in higher elevation pressure zones. Supply to the zone is provided by the City's surface water source and various groundwater production wells located in higher elevation pressure zones. Service pressures in Zone 7 generally range between 40 and 110 psi, and this zone currently serves a population of approximately 1,460.

Storage Reservoirs

The City of Bend has a total of 15 storage reservoirs located throughout the water service area providing 30.13 mg of storage throughout the distribution system, including the 1.5 mg CT Basin at the Outback site. Storage facility data was collected from previous reporting, discussions with City staff, and data provided by the City of Bend. A summary is presented in Table 2-3.

Pump Stations

The City's distribution system includes five booster pump stations designed to deliver water from one pressure zone to a higher zone. A brief summary of each pump station is presented in Table 2-4, including pump unit number and capacity, horsepower rating, and zones serviced.

Water System Piping

The City of Bend's water system is composed of various pipe materials in sizes up to 36 inches in diameter. The total length of piping in the service area is approximately 290 miles. The majority of the piping in the system is ductile iron, cast iron and steel. Table 2-5 presents a summary of pipe lengths by diameter.

The piping in the former Juniper Utility Company (Zones 2SB and 3SB) is primarily small diameter, 2-inches to 6-inches, pipe of material and workmanship that may not be suitable for the flow and pressure requirements of distribution system providing domestic and fire suppression water supply. Further analysis and recommendations for former Juniper Utility Company service area are presented in Sections 5 and 6.

Table 2-3
Storage Reservoir Summary

Reservoir Name	Reservoir Type	Capacity (mg)	Overflow Elevation (feet)	Floor Elevation (feet)	Source	Pressure Zone Served
Awbrey	Concrete	5.00	3,795	3,775	Surface Water	5
College I	Welded Steel	0.50	4,123	4,100	Surface Water	2
College II	Welded Steel	1.00	4,118	4,087	Surface Water	2
CT Basin	Bolted Steel	1.50	4,024	3,980	Surface Water	3
Outback I	Bolted Steel	2.00	4,011	3,976	Surface Water / Outback Wells	3
Outback II	Welded Steel	3.00	4,011	3,976	Outback Wells #3 - #6	3
Outback III	Welded Steel	3.63	4,011	3,982	Outback Wells #3 - #6	3
Overturf I	Riveted Steel	1.50	3,871	3,843	Outback Reservoir I	4
Overturf II	Riveted Steel	1.50	3,871	3,843	Outback Reservoir I	4
Pilot Butte I	Welded Steel	1.50	3,782	3,750	Pilot Butte Wells	5
Pilot Butte II	Welded Steel	1.00	3,880	3,840	Rock Bluff and Bear Creek	4E
Pilot Butte III	Concrete	5.00	3,782	3,758	Pilot Butte Wells	5
Rock Bluff	Welded Steel	1.50	3,879	3,841	Rock Bluff Wells	4E
Tower	Welded Steel	1.00	4,224	4,213	Surface Water	1
Westwood	Welded Steel	0.50	3,872	3,842	Westwood Well	Westwood
Total Storage Capacity		**30.13 MG**				

Table 2-4
Existing Booster Pump Station Summary

Pump Station	Unit	Capacity (gpm)	Motor Horsepower	Zones Serviced
Awbrey	1	1,200	200	Boosts water from Zone 5 to Zone 1
	2	1,200	200	
	3	1,200	200	
College	1	1,000	100	Boosts water from Zone 3 to Zone 2
	2	1,000	100	
Westwood	1	240	20	Boosts water from Westwood Reservoir to Westwood service area
	2	700	40	
	3	550	25	
	4	800	75	
Murphy	1	450	25	Boosts water from Zone 4E to Zone 3SB
	2	450	25	
	3	450	25	
	4	450	25	
	5	450	25	
Scott	1	1,250	50	Boosts water from Zone 5 to Zone 4E
	2	1,250	50	
	3	1,250	50	

Table 2-5
Water System Pipe Summary

Pipe Diameter (inches)	Pipe Length (miles)
2	1.3
4	3.0
6	53.8
8	116.1
10	25.5
12	62.3
14	0.7
16	23.5
24	1.1
30	1.1
36	2.8
Total	**291.2**

Note: Water System Pipe Summary only includes potable water piping systems.

Summary

This section presents a summary of the City of Bend's existing water system, including the supply system, storage and pumping facilities, and water system piping. Also included is a discussion of the existing water rights and pressure zones. Section 3 develops estimates of the future population and water demand requirements.

SECTION 3
SERVICE AREA, LAND USE AND WATER REQUIREMENTS

General

This section develops population projections and estimated water demand forecasts for the anticipated planning period. Population and water demand forecasts are developed from regional and City planning data, current land use designations, historical water demand records, previous City water supply planning efforts and discussions with City staff.

Service Area

The City of Bend currently serves water to approximately 53,000 people within the City limits, which at this time is the same as the Urban Growth Boundary (UGB). The remaining area within the City limits/UGB is served by two separate, private water providers, the Avion Water Company and Roats Water System. It is anticipated that areas outside of the current UGB will be incorporated into the city during the planning period of this report. These areas are currently being studied by the City, as part of the City of Bend Residential Lands Study, for inclusion in future expansions of the UGB and for designation of Urban Reserve Areas (URAs). For the purpose of this report, it is anticipated that the Tetherow and Juniper Ridge areas, both areas outside of the current City limits/UGB, will develop within the planning period of this study. Thus, the planning period service area includes the current service area within the UGB and the Tetherow development area as well as the Juniper Ridge area (see Figure 1 in Appendix A).

Oregon's Statewide Planning Goal No. 11 establishes requirements regarding public facilities planning. To comply with Goal 11 this plan provides a distinction between the facilities that are meant to serve areas within the existing UGB and those facilities intended to serve areas outside of the existing UGB. Where facilities are intended to eventually commingle service to areas both within the existing UGB and outside the existing UGB, those facilities can not be used to serve the later until they are included within the UGB.

Due to the apparently robust nature of the underground aquifer significant flexibility exists with respect to distribution system expansions. Since there does not appear to be physical limitations as to the geographic location of new groundwater production facilities system expansions have less impact on the existing system as compared to systems with limited supply sources. Thus, the total costs of the recommended capital improvement program presented herein would appear to require relatively modest adjustments to accommodate system expansions that are different than those identified for the Tetherow and Juniper Ridge areas.

Planning Period

The planning period for this water system master plan is through the year 2030. Based on anticipated development rates and probable infill densities, saturation development within the

existing service area and the Tetherow and Juniper Ridge areas is anticipated to occur near the end of the planning period. Saturation development, or build-out, occurs when all existing developable land within the service area has been developed, and all planning and facility sizing recommendations are based on saturation development conditions. The improvements presented in Section 6 of this report are recommended for implementation within the planning period (through 2030).

Land Use

Land use designations within the study area are established in the City of Bend General Plan. Existing land uses within the study area generally include residential, commercial, industrial and flood plain. Table 3-1 presents residential zoning designations, zone descriptions and maximum densities allowed by the General Plan and the City of Bend Zoning Ordinance which guide present and future land use and are the basis for the estimates of the ultimate service area population.

Table 3-1
Residential Land Use and Zoning Summary

Zone Designation	Zone Description	Maximum Density (Dwelling Units per Acre)
RH	Residential Urban High Density	43.0
RM	Residential Urban Medium Density	21.7
RS	Residential Urban Standard Density	7.3
RL	Residential Low Density	2.2

The population forecasts presented in this section include estimates of population to the year 2030. Through a review of existing land uses, development densities, population growth trends and discussions with City Planning Division staff it was determined that the existing UGB limits may approach saturation development within the planning period.

For the purposes of this plan, it is assumed that the UGB will be expanded prior to the end of the planning period to accommodate growth. As the City finalizes planning efforts currently underway, the demand distribution assumptions presented in this plan should be reviewed and updated if needed, especially as relates to the proposed URAs. It is anticipated the water distribution system improvements developed in this plan can accommodate minor adjustments in current zoning and densities without requiring significant modifications.

Population Estimates

Estimates of the existing and proposed population within the water system planning area were developed through discussions with City staff and through review of existing City of Bend planning data and population forecast data developed by Deschutes County.

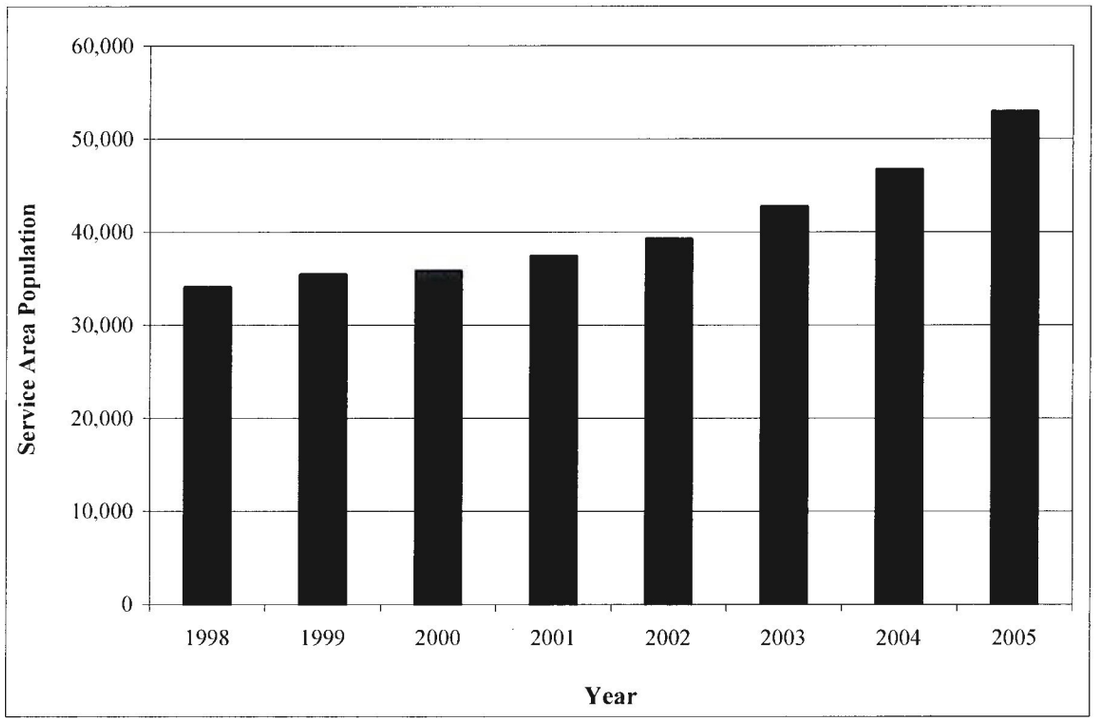
Historical Population

Historical population estimates for the City of Bend water service area were obtained from previous water system planning data and the Deschutes County Coordinated Population Forecast. The Deschutes County Coordinated Population Forecast estimates for the years 2000 through 2005 are estimates of the total population within the City. Previous water system planning studies, including the 2004 Water Management and Conservation Plan, have estimated that the percentage of the City population served by the City of Bend is approximately 68%. This percentage has been applied to the City-wide estimates to determine the historical population of Bend's water service area. The current population of the City's water service area was estimated by tabulating the number of developed dwelling units within the City's water service area. Table 3-2 and Figure 3-1 present a tabular and graphical summary of these historical population estimates.

Table 3-2
Service Area Historical and Current Population Summary

Year	Service Area Population
1998	34,090
1999	35,450
2000	35,900
2001	37,450
2002	39,270
2003	42,770
2004	46,711
2005	52,941

Figure 3-1
Service Area Population Summary



Population Forecasts

As discussed above, it is anticipated that the proposed City of Bend water service area will reach saturation development near the end of the planning period. As such, population forecasts for the ultimate, build-out condition of the water service area were developed for this study using the same methodology applied by the City of Bend Planning Department in the Residential Lands Study for the entire City. As City Planning Department staff complete the Residential Lands Study and update long-term population forecasts for the City, population forecasts may vary from those presented in this report. Since recommended improvements presented in this report are based on the ultimate needs of the service area, only the timing of improvements may need to be adjusted to meet anticipated growth patterns throughout the service area.

The ultimate population of the anticipated water service area is determined by evaluating the infill potential, or the capacity to support additional population of existing vacant land within the water service area and developed land that may be redeveloped into additional smaller lots. An analysis of each of these two infill mechanisms is presented below.

Vacant Land

As part of the Residential Lands study, City planning Department staff developed a Buildable Lands Inventory for the existing UGB. This data was used to determine the total area of vacant buildable land within the water service area. Vacant buildable land is defined as land with no existing residential dwelling units and assessed improvement value of less than $20,000 in the Deschutes County Assessor's Office records. Vacant lots with slopes of 25 percent or greater, within Water Overlay Zones or within areas identified as "Areas of Special Interest" are excluded from the vacant buildable lands.
The total area of vacant buildable land within the water service area for each type of residential zoning category is presented in Table 3-3. Table 3-3 also presents the maximum number of dwelling units that can be developed on this land in accordance with the City's Zoning Ordinance.

Table 3-3
Water Service Area Vacant Land Infill Summary

Zoning Designation (Maximum Density)	Vacant Acres	Maximum Potential Dwelling Units
RH (43 units/acre)	54	2,322
RM (21.7 units/acre)	146	3,168
RS (7.3 units/acre)	1,630	11,899
RL (2.2 units/acre)	2	4
Total	**1,832**	**17,393**

Note: Zoning designation descriptions are presented in Table 3-1.

Redevelopable Land

The City's Buildable Lands Inventory included an estimate of the area within the existing UGB that may be redeveloped. Several criteria were established to determine which lots were candidates for future redevelopment. In order to be considered as redevelopable in the inventory, a lot had to meet all three of the criteria below.

- A zoning designation of RH, RM, RS, or RL.
- An area greater than 0.5 acres in size
- An improvement value less than their land value.

The total area of redevelopable land within the water service area for each type of residential zoning category is presented in Table 3-4. Table 3-4 also presents the maximum number of dwelling units that can be developed on this land in accordance with the City's Zoning Ordinance.

Table 3-4
Water Service Area Redevelopable Land Infill Summary

Zoning Designation (Maximum Density)	Redevelopable Acres	Maximum Potential Dwelling Units
RH (43 units/acre)	0	0
RM (21.7 units/acre)	40	868
RS (7.3 units/acre)	280	2,044
RL (2.2 units/acre)	5	11
Total	***295***	***2,923***
Dwelling Units Replaced by Redevelopment		*331*
Net Additional Dwelling Units		**2,592**

Note: Zoning designation descriptions are presented in Table 3-1.

Saturation Development Forecast

Table 3-5 presents a summary of the water service area saturation development population based on the current population and the total additional population growth within the UGB that can be supported by existing vacant land and redevelopment. A population density of 2.4 people per dwelling unit was used based on 2000 U.S. Census Bureau data for the City. Table 3-5 also includes an estimate of the saturation population of the Juniper Ridge and Tetherow developments. The Juniper Ridge development is planned for primarily commercial and industrial development, although a residential component of approximately 5,000 people is anticipated for the saturation development of the service area. Given the mixed use nature of the residential component of the Juniper Ridge development and the uncertainty associated with ultimate development of this area, the population component of this development is not included in the saturation forecast presented below. Further discussion of the methodology for forecasting demands in the Juniper Ridge area is presented later in this section.

Table 3-5
Saturation Development Population Forecast Summary

Population Category	Dwelling Units	Population
Infill – Vacant Land	17,393	41,743
Infill – Redevelopable Land	2,592	6,221
Juniper Ridge	N/A	N/A
Tetherow	889	2,134
Existing Population		*52,941*
Estimated Saturation Development Population		**103,039**
USE		**103,000**

Note: Population estimate based on 2.4 people per dwelling unit.

Water Demand Estimates

General

The term "water demand" refers to all of the water requirements of the system including domestic, commercial, municipal, institutional and industrial as well as non-revenue water consumption. Water demand estimates were developed from a review of historical water consumption records provided by the City, previous water master planning efforts, and population forecasts presented earlier in this section. Demands are discussed in terms of gallons per unit of time such as gallons per day (gpd), million gallons per day (mgd) or gallons per minute (gpm). Demands are also related to per capita use as gallons per capita per day (gpcd).

Historical Water Demands

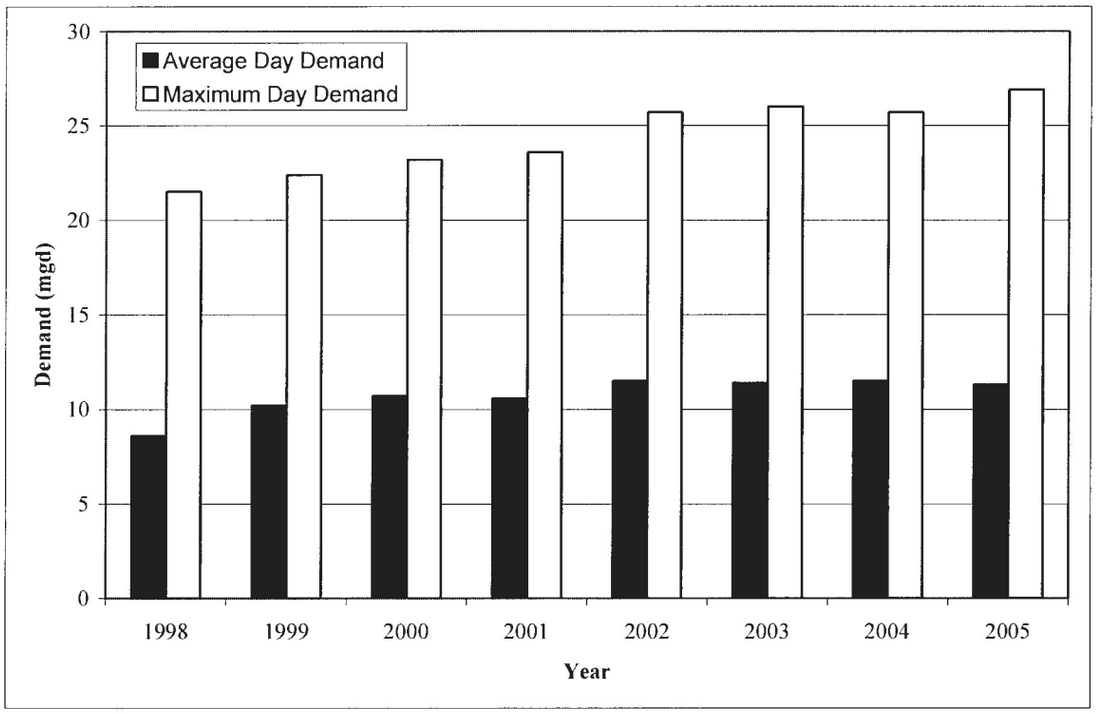
Historic water demand information was gathered from water demand data provided by the City, previous water master planning and the 2004 City of Bend Water Management and Conservation Plan. Table 3-6 and Figure 3-2 summarizes this data for the years 1998 through 2005 in tabular and graphical formats. The water use data presented in Table 3-6 is an estimate of the system-wide water usage (residential, commercial, industrial and institutional) and has been applied to the water service area population to determine a per capita water usage for the entire system. As such, the per capita water usage presented in this report does not represent actual water usage for individual water system customers and differs from the estimated residential per capita water usage of approximately 158 gpcd presented in the City's 2004 Water Management and Conservation Plan. Further discussion of the per capita water use presented in Table 3-6 is included later in this section.

Table 3-6
Historical Water Demand Summary

Year	Water Service Area Population	Historical Water Demands				
		Average Day Demand (ADD)		Maximum Day Demand (MDD)		Calculated Peaking Factor
		mgd	gpcd [1]	mgd	gpcd [1]	
1998	34,085	8.6	252	21.5	631	2.5
1999	35,451	10.2	288	22.4	632	2.2
2000	35,904	10.7	298	23.2	646	2.2
2001	37,454	10.6	283	23.6	630	2.2
2002	39,270	11.5	293	25.7	654	2.2
2003	42,772	11.4	267	26	608	2.3
2004	46,711	11.5	246	25.7	550	2.2
2005	52,941	11.3	208	26.9	508	2.4

Note: 1. Demands presented on a per capita basis represent system-wide demands and are not actual individual customer water use rates.

Figure 3-2
Water Demand Summary



Existing Water Demands

Based on historical water consumption patterns, the water service area's average daily demand (ADD) has ranged from approximately 298 gpcd to 208 gpcd. By placing emphasis on the most recent historical water usage patterns and historical populations, it is estimated that the water service area has an ADD of approximately 250 gpcd. The recent decrease in per capita water use rates would appear to be attributed both to recent water conservation efforts and to the implementation of service meters for all customers in recent years.

Recent maximum day water demand usage has ranged from 2.2 times to 2.5 times the average day demand, with an average of approximately 2.3. Placing emphasis on the most recent historical water usage patterns and historical populations, the water service area has a maximum day demand (MDD) of approximately 588 gpcd. As can be seen from Table 3-6 and Figure 3-2, the City has seen a significant reduction in MDD on a per capita basis. As with the reduction in the ADD above, this reduction is most likely attributed to the City's aggressive water conservation efforts in recent years, as well as implementation of water meters for all customers within the service area.

As discussed above, the demands presented on a per capita basis in this section are not actual individual customer water use rates but represent system-wide water use.

Water Demand Projections

Existing UGB and Tetherow

Future water demand estimates were developed by applying historical system-wide water use trends to the population forecasts previously presented. A significant increase in water demands is expected within the planning period as residential infill development and expansion of the UGB occurs.

For the purposes of this plan, estimated average daily water use is assumed to remain at approximately 250 gpcd and estimated maximum day water use is assumed to remain at approximately 590 gpcd.

Total estimated average and maximum day water demands for the City's water service area are developed by multiplying the estimated system-wide per capita usage by the anticipated population. To provide an estimate of peak hourly usage, a peak hour factor of 1.5 is applied to maximum day water demands.

Juniper Ridge

Demand forecasts for the Juniper Ridge Area were developed using previous reporting prepared by the City in conjunction with certain assumptions established with this water master plan. As per the 2004 Water Management and Conservation Plan (WMCP), the overall commercial demand for the total area inside the City's Urban Growth Boundary (UGB) for the year 2035 is estimated at approximately 8.4 mgd (Figure 5-3, page 5-7, WMCP).

It is assumed that the UGB will have reached build-out conditions by the year 2035. The reasoning for this assumption is as follows: The forecasted population for the entire City (both inside and outside the current UGB) for the year 2035 is 129,219 people (Table 5-1, page 5-2, WMCP), and the projected build out population of the area within the UGB is 95,242 people (page 3 of 4, Capacity of UGB for Housing Memorandum October 5, 2005).

The commercial demand for the entire City as per the WMCP was allocated to the area within the current UGB. This approach is conservative because the year 2035 commercial demand will likely include all of the area within the UGB plus certain areas outside of the current UGB.

The total area of land within the existing UGB zoned for commercial development is approximately 1876 acres (City of Bend General Plan). From the forecasted commercial demand of 8.4 mgd (5,830 gpm) and the total commercial acreage, an estimated commercial demand of 4,500 gpd per acre was developed (8.4 mgd/1876 acres = 4500 gpd/acre). The forecasted demand per acre was then applied to the net developable acreage in the Juniper Ridge development, assumed to be 70% of the gross acreage (1,516 acres* 0.70 *4500 gpd/acre = 4.8 mgd).

While this value is higher than typical commercial and industrial water use rates currently experienced in the City of Bend, it provides a conservative estimate that allows the City to plan for highly variable water use that can be experienced in future unanticipated commercial and industrial development in this area. Given the high degree of variability in industrial water usage, the forecasts presented herein are intended to be somewhat conservative. This approach is intended to help the City plan water system infrastructure that is capable of supporting a reasonably wide range of potential development interests. As planning for the Juniper Ridge area advances, water demand forecast for this area should be updated to confirm actual supply, storage and transmission needs.

Water Demand Projection Summary

Table 3-7 presents a summary of water demand forecasts for existing and saturation development conditions within the study area (UGB plus Tetherow and Juniper Ridge).

Table 3-8 summarizes water demand estimates for each pressure zone for the year 2005 and water demand projections for each pressure zone at saturation development of the study area.

Table 3-7
Population Projections and Water Demand Summary

Year	Water Service Area Population	Water Demand (mgd)		
		Average Day Demand (ADD)	Maximum Day Demand (MDD)	Peak Hour Demand [5]
2005	52,941	11.3 [1]	26.9 [2]	40.7
Saturation Development[6]	103,000	30.7 [3] [6]	71.5 [4] [6]	107.3[6]

Notes:
(1) Existing Average Day Demand based on 2005 water use records.
(2) Existing Maximum Day Demand based on 2005 water use records.
(3) Average Day Demand equals the Population multiplied by the estimated average daily per capita usage for the service area (250 gpcd).
(4) Maximum Day Demand equals the Population multiplied by the estimated maximum daily per capita usage for the service area (590 gpcd).
(5) Peak Hour Demand equals 1.5 times the Maximum Day Demand
(6) Includes Juniper Ridge ADD, MDD and Peak Hour Demand of 4.8, 10.7 and 16.0 mgd, respectively.

Table 3-8
Pressure Zone Water Demand Summary

Pressure Zone	Existing (mgd)			UGB Saturation Development (mgd)		
	Average Day Demand (ADD) [1]	Maximum Day Demand (MDD) [2]	Peak Hour Demand [3]	Average Day Demand (ADD) [4]	Maximum Day Demand (MDD) [5]	Peak Hour Demand [3]
1	0.18	0.42	0.64	0.3	0.8	1.2
2	0.22	0.51	0.76	0.6	1.4	2.0
2SB	0.13	0.31	0.46	0.7	1.6	2.4
Westwood	0.07	0.09	0.14	0.4	0.9	1.4
3 [6]	0.88	2.07	3.10	2.5	6.1	9.2
3SB	0.27	0.64	0.95	0.9	2.0	3.0
4W	1.17	2.74	4.11	2.6	6.1	9.1
4E	1.89	4.45	6.67	4.9	11.5	17.3
5	4.1	10.61	15.91	7.5	17.6	26.4
6	1.80	4.23	6.34	4.8	11.2	16.9
7	0.32	0.74	1.12	0.7	1.6	2.4
Juniper Ridge	--	--	--	4.8	10.7	16.0
TOTALS	**11.3**	**26.9**	**40.7**	**30.7**	**71.5**	**107.3**

Notes: (1) Average Daily Demand for existing conditions equals the population multiplied by the estimated average daily per capita usage for the service area in 2005 (216 gpcd).
(2) Maximum Day Demand for existing conditions equals the population multiplied by the estimated maximum daily per capita usage for the service area in 2005 (508 gpcd).
(3) Peak Hour Demand equals 1.5 times the Maximum Day Demand.
(4) Average Daily Demand for Saturation Development equals the Population multiplied by the estimated average daily per capita usage for the service area (250 gpcd).
(5) Maximum Day Demand for Saturation Development equals the Population multiplied by the estimated maximum daily per capita usage for the service area (590 gpcd).
(6) Pressure Zone 3 Saturation Development Demands include Tetherow.

Summary

This section presents a discussion of existing and projected land uses within the study area, estimates of the current and future water service area population and forecasts of future water demands. Section 4 outlines the planning criteria that, with the water demand estimates presented in this section, are used in the water system analysis presented in Section 5.

SECTION 4
PLANNING AND ANALYSIS CRITERIA

General

This section develops and presents the planning and analysis criteria and assumptions used for the water system analysis. Criteria and planning assumptions are presented for the City of Bend's water supply, treatment, distribution system, service pressures, and storage and pumping facilities. Recommendations for water needs for emergency fire suppression are also presented. The water demand forecasts developed in Section 3 are used in conjunction with the criteria presented in this section for the analysis of Bend's water system presented in Section 5.

Supply, Treatment and Transmission Criteria

The City's supply, treatment and transmission systems should be capable of providing estimated maximum day demands through the end of the 25-year planning period and beyond. For planning purposes the end of the 25-year planning period (year 2030) is anticipated to correspond with saturation build-out of the service area within the urban growth boundary (UGB), as well as saturation build-out of the proposed Tetherow development and proposed Juniper Ridge area (both URA's). This planning report recommends system improvements for ultimate build-out of the other remaining URA's and identifies them as "long-term" improvements (beyond 2030). Based on water demand estimates presented in Section 3, the supply system will need to be expanded to supply an average day demand of approximately 31.5 mgd and a maximum day demand of approximately 71.5 mgd in the year 2030. The current capacity of the supply system is approximately 38 mgd.

As described in Section 2 the City has both surface water and groundwater supply sources. Surface water is collected from Bridge Creek at the Bridge Creek Intake Facility from where it flows by gravity to first an overflow standpipe and then to the Contact "CT" Basin at the Outback Reservoir Site. Groundwater is withdrawn from the Deschutes Aquifer through 23 water production facilities located at 9 sites throughout the City and at the Outback Reservoir site westerly of the City. From these production facilities water is either pumped into finished water reservoirs or pumped directly into the distribution system piping. The City has been granted an exemption from the Surface Water Treatment Rules by the Oregon State Health Division. This exemption is based on a review of the water quality in the Bridge Creek watershed and the maintenance of this watershed. As such, the City currently has no need for a raw water treatment plant; however, the City currently chlorinates the surface water prior to distribution.

Distribution System Criteria

The water distribution system should be capable of operating within certain system performance limits, or guidelines, under several varying demand and operational conditions. The recommendations of this plan are based on the following performance guidelines, which

have been developed through a review of State requirements, American Water Works Association (AWWA) acceptable practice guidelines, operational practices of similar water providers, and discussions with City water system operations staff.

The recommended analysis criteria are as follows:

1. The distribution system should be capable of providing the peak hour demand while maintaining a minimum service pressure at any meter in the system of 40 pounds per square inch.

2. The distribution system should be capable of providing the recommended fire flow to a given location while, at the same time, supplying the maximum day demand and maintaining a minimum residual service pressure at any meter in the system of 20 pounds per square inch (psi). This is the minimum water system pressure required by the Oregon State Department of Human Services Drinking Water Program. Reservoirs are assumed to be approximately half-full during fire flow events.

It should be noted that the City has historically used 30 psi as the required minimum residual pressure during fire flow analyses for sizing new facilities. In addition, historically the City has assigned fire flow rates of 1,000 gpm for residential areas and 3,000 gpm for commercial/industrial areas. However, due primarily to the increase in the residential fire flow rate to 1,500 gpm and the increase in the maximum commercial fire flow rate to 3,500 gpm (Commercial Highway), the City has adjusted the required residual pressure to the State mandated 20 psi. These two modifications to analysis criteria appear to strike a good balance between satisfying life and safety interests with updated fire flow capacities, and providing sound economic solutions with a reasonable adjustment to residual pressures. The residential fire flow rate has been increased to 1,500 to match the International Building Code (IBC) for residential structures 3,000 square feet and larger, since homes of this size are allowed in residential zones throughout the City.

Recommended fire flows are identified in Table 4-2 below. The hydraulic computer analysis of the water system assumes that for fires greater than 1,500 gpm more than one hydrant will be operated. In addition, it is assumed that fire suppression through the operation of municipal fire hydrants within the Commercial Highway zone is supplemented with internal sprinkler fire suppression systems. The hydraulic analysis assumes fire flow rates of 2,500 gpm and 3,500 gpm for the various commercial and industrial zoning designations.
The above analysis criteria are established as water system performance requirements in the hydraulic computer model and proposed improvements are guided by how the system responds to such requirements. In addition, recommended water system improvements are guided by professional judgment and standards of practice.

While the computer model provides important information on system response to certain demand and proposed improvement scenarios, variables that are not included in the computer model are given a high degree of consideration as part of the distribution system analysis and for identifying recommended system improvements. Such variables include corridor/street characteristics, anticipated and ongoing developments, other City utility planning objectives,

project and overall program costs, City system planning philosophy, desired remedying of operation and maintenance issues, etc.

For the City of Bend water system looped water mains should normally be at least 8 inches in diameter except for short loops where 6-inch diameter mains are acceptable. Mains smaller than 6 inches in diameter are generally appropriate where no fire hydrant connections are required, if there are limited services on the main, or if the main is dead-ended and looping or future extension of the main is not anticipated. In addition, while not analyzed with the assistance of the hydraulic computer model the distribution system should be capable of supplying the peak hour demand while maintaining minimum service pressures of not less than approximately 70 percent of normal system pressures.

As discussed in Section 2, water distribution systems are typically separated into pressure zones or service levels to provide service pressures within an acceptable range to all customers. Bend's existing water service area is divided into eleven primary pressure zones. Pressure zones are established by ground topography and designated by overflow elevations of water storage facilities, outlet settings of pressure reducing facilities, or discharge pressures of booster pump stations serving the zone. Typically, water from reservoirs will serve customers by gravity within a specified range of ground elevations so as to maintain acceptable minimum and maximum water pressures at individual service connections. When it is not feasible or practical to have a separate reservoir serving each pressure zone, pumping facilities or pressure reducing facilities are used to serve customers in different pressure zones from a single reservoir.

Generally, 100 psi is considered the desirable upper pressure limit for any pressure zone and 40 psi the lower limit. Whenever feasible, it is desirable to achieve the 40 psi lower limit at the point of the highest fixture within a given building being served. Conformance to this pressure range may not always be possible or practical due to topographical relief, existing system configurations and economic considerations. In some areas system pressures of up to 120 psi are allowed, anticipating the need for individual pressure reducing valves (PRV's) to be installed at each service connection to help satisfy pressure requirements of the Uniform Plumbing Code. Table 4-1 summarizes the service pressure criteria used in the analysis of the water system.

Table 4-1
Recommended Service Pressure Criteria

Condition	Pressure (psi)
Minimum Service Pressure Under Fire Flow Conditions	20
Minimum Normal Service Pressure	40
Maximum Preferred Service Pressure	95
Maximum Service Pressure	120

Storage Volume

Water storage facilities should be in place to provide gravity fed supply to each pressure zone except in special cases where direct pumping can be justified. Storage facilities are provided for three purposes: operational storage (or "equalization storage"), emergency storage, and fire storage. The total storage required is the sum of these three elements. A brief discussion of each element is provided below.

Operational Storage

Operational storage is required to meet water system demands in excess of delivery capacity from the supply source to system reservoirs. Operational storage volume should be sufficient to meet normal system demands in excess of the maximum day demand and is generally considered as the difference between peak hour demand and maximum day demand (on a 24-hour duration basis). For Bend's water system, operational storage volume in the amount of 25 percent of maximum day demand is considered appropriate.

Emergency Storage

Emergency storage is intended to provide water during emergencies such as pipeline failures, equipment failures, power outages or natural disasters. While any number of emergencies may occur over time, it is prudent to plan for the anticipated emergency conditions that would have the greatest impact on water storage in the City. It is recommended that the criteria for emergency storage assume the single largest supply source, the City's surface water supply, is interrupted. This condition could potentially occur if perhaps there were a large enough fire in the Bridge Creek watershed. It should be noted that the criteria for emergency storage in portions of South Bend should assume that the single largest groundwater well site is out of service.

The amount of emergency storage for a water system can be highly variable depending upon an assessment of risk and the desired degree of system reliability. Provisions for emergency storage in other systems vary from none to a volume that would supply several day's maximum flow (maximum day demand (MDD)) or higher. Considering the region's risk of forest fires on one hand, and the City's recognized robust subsurface water source on the other hand, it would seem prudent to plan for sufficient emergency storage to accommodate two days of average day demands (ADD). It is acknowledged that this recommendation is somewhat more conservative than the single ADD recommended for emergency storage by prior reporting (see City of Bend 1999 Water Master Plan Update). However, this plan presents an efficient and "high value" program to developing storage that would support the somewhat more conservative approach as discussed below.

Because of how the City's water system is configured and how water sources are distributed, it is recommended that certain emergency storage volume requirements be provided by existing underground "storage" in the subsurface aquifer, rather than through costly constructed reservoir "tank" storage capacity. The City reports the belief that ample

quantities of groundwater are indeed broadly available and accessible throughout the City's urban planning area, as supported by prior studies. Thus, it is suggested that during the above described emergency condition, with the surface water source non-operational, the existing and proposed groundwater supply facilities could provide a significant volume of emergency storage to the City. By assuming that the subsurface aquifer could provide available emergency storage capacity, the needed additional constructed "tank storage" volume may be reduced significantly, potentially saving considerable costs for the City in the long-term. The analysis and recommendations presented in this report include this assumption and further discussion and analysis associated with this interest are presented in Section 5.

Fire Storage

While the water distribution system provides water for domestic uses, it is also expected to provide water for fire suppression. The amount of water recommended for fire suppression purposes is based on the size and duration of the anticipated fire which is typically associated with the local building type or land use of a specific location. Standard engineering practice is to assume that the largest fire for a given area may occur during maximum day demand conditions. This Master Plan Update presents a recommended capital improvements program that meets these requirements.

Table 4-2 presents assumptions for fire flows for distribution piping analysis. However, for fire storage analysis, fire flow assumptions have been increased assuming there is the potential for more than one fire occurring at a time. This approach assumes that two simultaneous fires may rely on the storage capacity of a single pressure zone, but are less likely to impact the same distribution system pipeline capacities. Thus, the storage analysis assumes fire flow rates of 3,000 gpm and 5,000 gpm, in lieu of 2,500 gpm and 3,500 gpm for the respective zoning designations presented in Table 4-2. The resultant fire storage for residential areas is 180,000 gallons, for commercial/industrial areas it is 540,000, and for the commercial highway zone it is 1,500,000 gallons.

Fire Flow Recommendations

A summary of fire flow recommendations by land use designation is presented in Table 4-2. The fire storage volume is determined by multiplying the recommended fire flow rate by the expected duration of that flow. The recommended fire flows were developed through a review of fire flow criteria adopted by the City, fire flow guidelines as developed by the AWWA, the Insurance Services Office (ISO) and recommended by the International Fire Code. It should be noted that for the recommended 3,000 gpm and 5,000 gpm fire flow rates presented in Table 4-2, the distribution system analysis assumed 2,500 gpm and 3,500 gpm respectively. The higher fire flow rates shown in Table 4-2 are used for storage capacity analysis only as a measure to help offset the potential risks for multiple simultaneous fires, heightened by the semi-arid environment in and around the City of Bend.

Table 4-2
Summary of Recommended Fire Flows and Fire Storage Volume

Zone	Zoning Description	Recommended Fire Flow Rate (gpm)	Duration (hours)	Recommended Fire Storage Volume (MG)
RS	Residential Urban Standard	1,500	2	0.18
RM	Residential Urban Medium	1,500	2	0.18
RH	Residential Urban High	1,500	2	0.18
CN	Commercial Neighborhood	2,500	3	0.54*
CC	Commercial Convenience	2,500	3	0.54*
CL	Commercial Limited	2,500	3	0.54*
CG	Commercial General	2,500	3	0.54*
CBD	Industrial Park	2,500	3	0.54*
IP	Industrial Light	2,500	3	0.54*
IG	Industrial General	2,500	3	0.54*
CH	Commercial Highway	3,500	5	1.50*

* The above table presents recommended fire flow rates for distribution piping analysis. The recommended fire storage volumes for commercial and industrial areas has been calculated based on adjusted fire flow rates of 3,000 gpm and 5,000 gpm in lieu of 2,500 gpm and 3,500 gpm for the respective zones identified above.

Pump Station Pumping Capacity

Firm pumping capacity requirements vary depending on how much storage is available to the service area of the pump station and the number of pumping facilities serving the particular service area. Firm pumping capacity is defined as a station's pumping capacity with the largest pump out of service (the most severe emergency operating condition). When storage facilities serve directly by gravity the same area served by the pump station, then it is recommended that a firm pumping capacity equal to the area's maximum day demand be implemented. If a constant pressure pumping system is implemented then the firm capacity is dependent upon the size of the area served. For smaller service areas the recommended firm pumping capacity should be equal to the area's peak instantaneous demand plus fire flow. For larger service areas the firm pumping capacity could be as low as the area's maximum day demand plus fire flow. Additionally, all constant pressure pumping systems should be equipped with emergency backup power generation facilities since backup storage water is not available for these areas by gravity flow only.

The City currently uses constant pressure (continuous operation) groundwater well or booster pump station pumping, without gravity fed supply, to serve part of the Westwood area as well as Zones 2 South Bend (2SB) and 3 South Bend (3SB). This type of constant pressure system is generally recommended for relatively small residential areas of up to perhaps 50 homes where gravity fed storage is impractical or significantly more costly. However,

implementing storage for the Westwood area as well as Zones 2 South Bend (2SB) and 3 South Bend (3SB) would not come without certain challenges.

Implementing strategically located elevated storage would be one option to serve these areas by gravity. However, due to aesthetic reasons, it is understood that the City of Bend desires to avoid constructing elevated storage tanks if other reasonable alternatives are available. Upon preliminary review, it would appear that there are options for implementing ground level storage for these areas. However, such may be more costly than maintaining system pressures and providing supply through continuous pumping systems.

Summary

The criteria developed in this section are used to assess the system's ability to provide adequate water service under existing conditions and to guide improvements needed to provide service for future water needs. Planning criteria for the supply system, distribution system, service pressures, and storage and pumping facilities are presented herein. Section 5 presents the analysis of the water distribution system based on the criteria provided in this section. Section 6 identifies proposed water system improvement recommendations and presents a recommended improvement program, including project cost estimates, intended for adoption as part of the City's comprehensive Capital Improvement Plan (CIP).

SECTION 5
WATER SYSTEM ANALYSIS

General

This section presents an analysis of Bend's water system based on the water demand forecasts presented in Section 3 and the analysis criteria developed in Section 4. This section provides an overview of the City's supply system, evaluates the existing service pressures, storage and pumping capacity requirements, and presents the findings of an analysis using a computerized hydraulic network analysis program. Through evaluation and analysis, system deficiencies were identified and improvement options have been developed. Section 6 presents a recommended water system improvement program that includes prioritized recommended improvements to correct system deficiencies and provide for system expansion.

Water Demands

As presented in Section 3, water demand estimates have been developed for saturation build-out of the service area within the urban growth boundary (UGB) as well as for Tetherow and Juniper Ridge, anticipated future service areas within the proposed urban reserve areas (URA's) (see Table 5-1). For planning purposes it is assumed that saturation build-out for these areas will occur near the end of the 25 year planning period.

Table 5-1
Population Projections and Water Demand Summary

Year	Water Service Area Population	Water Demand (mgd)		
		Average Day Demand (ADD)	Maximum Day Demand (MDD)	Peak Hour Demand [5]
2005	52,941	11.3 [1]	26.9 [2]	40.7
Saturation Development[6]	103,000	30.7 [3][6]	71.5 [4][6]	107.3[6]

Notes:
(1) Existing Average Day Demand based on 2005 water use records.
(2) Existing Maximum Day Demand based on 2005 water use records.
(3) Average Day Demand equals the Population multiplied by the estimated average daily per capita usage for the service area (250 gpcd).
(4) Maximum Day Demand equals the Population multiplied by the estimated maximum daily per capita usage for the service area (590 gpcd).
(5) Peak Hour Demand equals 1.5 times the Maximum Day Demand
(6) Includes Juniper Ridge ADD, MDD and Peak Hour Demand of 4.8, 10.7 and 16.0 mgd, respectively.

Table 5-2, "Pressure Zone Water Demand Summary" summarizes water demand estimates for each pressure zone for the years 2005 and 2030. These water demand estimates along with the planning criteria established in Section 4 are the basis for the analysis of the existing system and the development of recommended system improvements. The capacities of recommended improvements are based on estimated maximum day demands at saturation development unless otherwise noted. This approach is intended to help avoid the need to upgrade facilities to increase capacities for higher demands, prior to the end of their useful life span.

Table 5-2
Pressure Zone Water Demand Summary

Pressure Zone	Existing (mgd)			UGB Saturation Development (mgd)		
	Average Day Demand (ADD) [1]	Maximum Day Demand (MDD) [2]	Peak Hour Demand [3]	Average Day Demand (ADD) [4]	Maximum Day Demand (MDD) [5]	Peak Hour Demand [3]
1	0.18	0.42	0.64	0.3	0.8	1.2
2	0.22	0.51	0.76	0.6	1.4	2.0
2SB	0.13	0.31	0.46	0.7	1.6	2.4
Westwood	0.07	0.09	0.14	0.4	0.9	1.4
3 [6]	0.88	2.07	3.10	2.5	6.1	9.2
3SB	0.27	0.64	0.95	0.9	2.0	3.0
4W	1.17	2.74	4.11	2.6	6.1	9.1
4E	1.89	4.45	6.67	4.9	11.5	17.3
5	4.1	10.61	15.91	7.5	17.6	26.4
6	1.80	4.23	6.34	4.8	11.2	16.9
7	0.32	0.74	1.12	0.7	1.6	2.4
Juniper Ridge	--	--	--	4.8	10.7	16.0
TOTALS	**11.3**	**26.9**	**40.7**	**30.7**	**71.5**	**107.3**

Notes: (1) Average Day Demand for existing conditions equals the population multiplied by the estimated average daily per capita usage for the service area in 2005 (216 gpcd).
(2) Maximum Day Demand for existing conditions equals the population multiplied by the estimated maximum daily per capita usage for the service area in 2005 (508 gpcd).
(3) Peak Hour Demand equals 1.5 times the Maximum Day Demand.
(4) Average Day Demand for Saturation Development equals the Population multiplied by the estimated average daily per capita usage for the service area (250 gpcd).
(5) Maximum Day Demand for Saturation Development equals the Population multiplied by the estimated maximum daily per capita usage for the service area (590 gpcd).
(6) Pressure Zone 3 Saturation Development Demands include Tetherow.

Water Supply Analysis

Currently the total existing water supply capacity for the City is approximately 38.8 mgd, with a firm capacity of approximately 31.2 mgd. Based on water demand estimates presented in Section 3, during the planning period the supply system should be expanded by approximately 40.3 mgd such that the firm capacity satisfies total maximum day demands of approximately 71.5 mgd.

The term "firm capacity" is used to refer to the reliable capacity of a water system component. In the case of the City of Bend's water supply system there are a number of sources, consisting of the groundwater wells and the surface water source. For the purposes of this report the reliable capacity, or "firm capacity", of the supply system is the total capacity of all sources minus the largest source, which in this case is the surface water source. This methodology is good practice in that it helps reduce the risks of planning a system that has insufficient capacity in the various system components, and this approach is consistent with standard engineering practices and recommendations by the American Water Works Association.

As discussed prior, for the purposes of this planning work, the City's existing surface water source is currently considered at capacity. Since planning and analysis are based on maximum day demand conditions that occur during the hot summer period this report assumes an available capacity from the surface water source of 7.6 mgd, the lowest anticipated yield for that time of year. It is understood that the City is currently conducting a water source protection study and contemplating piping raw water from the watershed to the Outback site. While surface water source expansion opportunities exist, for planning purposes, this report assumes that such expansions will provide additional supply capacity outside of the summer peak use period. Thus, supply capacity expansions presented in this plan are proposed to be implemented through the construction of new groundwater wells. However, if any contemplated surface water supply expansions increase summer water supply then such expansions may certainly be implemented in lieu of certain proposed groundwater capacity expansions. To minimize pumping costs and take full advantage of the City's existing water rights, this plan promotes maximizing the use of surface water as it is available during the wetter periods of the year.

The City reports the belief that ample quantities of groundwater are indeed broadly available and accessible throughout the City's urban planning area, as supported by prior studies. The water supply analysis presented herein assumes that groundwater sources may be developed in certain convenient locations, relative to various distribution systems facilities. By withdrawing supply water at certain strategic locations the City may avoid the need to construct high cost transmission piping that might be required with an approach that focuses on more centralized source development. Groundwater development potential may then be validated through further hydrogeologic study or proven-out through a physical test well program. This planning work does not include a comprehensive water supply study and it is suggested that the City conduct further detailed analysis of supply alternatives as the supply system is expanded. Any determined variations from assumed conditions may then be addressed through subsequent updates and revisions to this Water Master Plan Update.

Pressure Zone Analysis

General

As discussed in Section 2, Bend's distribution system is currently separated into eleven primary service areas, or pressure zones. The planning criteria developed in Section 4 established acceptable service pressure limits throughout the City. These criteria are used to determine optimal operating elevations of proposed reservoirs and to evaluate service elevations for existing and proposed pressure zones. The water distribution system analysis performed as part of this report established that certain adjustments to pressure zone boundaries should be implemented to better serve certain areas.

Westwood Service Area

When the City assumed water service responsibilities for the Westwood neighborhood in the southwesterly portion of Bend it inherited an area operating with a hydraulic grade between Zone 2 and Zone 3. While the area is at elevations consistent with the surrounding Zone 3, the water system for this area was designed with the assumption that it would continue to operate at the higher pressures between Zone 2 and Zone 3. It is recommended that the City consider conducting further study outside of this report to evaluate the potential to transition the Westwood area to the existing Zone 3 service area. This adjustment of service pressures and zones could provide both benefits and drawbacks that should be thoroughly reviewed should the City consider such a change.

As part of the recommended additional study, the City should investigate the option to implement either elevated or ground level storage to serve the Westwood area, thereby transitioning this service area from a constant pressure pumped system to a more reliable, lower maintenance gravity fed service area. The existing topography westerly of the vicinity of the Westwood area is sufficient for locating a ground level reservoir; however, since a ground level reservoir currently exists near the Westwood Pump station, upgrading the existing pump station would initially appear to be the least costly alternative to expanding service capacity in the Westwood area. This report assumes that the City would continue with the current operating scenario and pressures for the existing Westwood area.

The Westwood Pump Station is a continuously operated pump station that supplies water from the ground level Westwood Reservoir to the Westwood Service Area at a hydraulic grade between Zone 2 and Zone 3. This pump station currently serves approximately 150 residential dwelling units. A southern portion of the proposed Tetherow development is at an elevation too high to be served by the surrounding Zone 3 system. Since this area is relatively close to the Westwood area and would be adequately served at the hydraulic grade of the Westwood area, it is recommended that this area be included in the Westwood Service Area.

The Tetherow development will add approximately 300 to 350 dwelling units and commercial and retail development to the Westwood Pump Station's service area. The maximum day demand at saturation development for this proposed expanded service area is approximately 0.9 mgd (625 gpm). The pump station must also be capable of supplying fire flow demands which are 2,500 gpm in the Tetherow development. Therefore, the recommended firm pumping capacity of the Westwood Pump Station is approximately 3,125 gpm. The existing firm pumping capacity is approximately 1,490 gpm. Recommendations for expansion of the Westwood Pump Station are discussed in Section 6.

Zone 4E/Zone 5

The second recommended pressure zone boundary adjustment is for a very small area at the interface of Zone 4E and Zone 5. It is recommended that a length of piping along NE 12th Street, from NE Revere Avenue to NE Seward Avenue, be transferred to Zone 4E from Zone 5 to provide sufficient fire flows and service pressures. This adjustment is accomplished quite simply by opening and closing existing isolation valves as needed.

In the future, as the City addresses the need to replace the Overturf reservoirs, it may best serve the City to implement new storage at this site with overflow elevations at 3,880 feet to match the static hydraulic grade of Zone 4E. This would allow Zones 4W and 4E to operate as a single pressure zone, by opening an existing isolation valve on the 16-inch diameter pipeline that connects the two zones. This scenario would improve the City's ability to circulate and move water more readily between the zones, thereby, improving supply options and fire flow capacities.

Juniper Ridge Area

The Juniper Ridge area just outside the northeasterly portion of the City is anticipated to operate with either one or two separate pressure zones. One pressure zone could serve the Juniper Ridge area at a hydraulic grade somewhat lower than the existing Zone 7 hydraulic grade. Alternatively, two pressure zones could be developed, extending the existing Zone 7 northerly into the southern half of the Juniper Ridge area, and implementing an additional Zone 8 to serve the lower elevation areas in the northern half of Juniper Ridge. The ground elevations within Juniper Ridge range from approximately 3,460 feet to 3,275 feet above mean sea level.

Additional storage capacity of approximately 4.2 mg, and additional supply capacity of roughly 10.7 mgd would be needed to serve the Juniper Ridge area at ultimate build-out. For planning purposes, the required storage for the Juniper Ridge area is split between a reservoir on the Juniper Ridge site and storage capacity in a planned reservoir on Pilot Butte. This assumes that the lower elevation northerly portion of Juniper Ridge, below approximately 3,380 feet, could be served from a 2.0 MG on-site reservoir, sited at roughly 3,460 feet. The remaining 2.2 MG of storage required to serve the southerly portion of Juniper Ridge above roughly 3,380 feet in elevation is included as a portion of the capacity of the 3.5 MG Pilot

Butte VI reservoir. This scenario avoids the need for constant pressure pumping facilities to serve the Juniper Ridge area.

The recommendations presented in this plan, and incorporated into the proposed CIP, include physical pipeline connections between Juniper Ridge water facilities and the existing City facilities to support the above described storage scenario, and to facilitate integration of the Juniper Ridge area with the existing City system. These pipeline connections consist of 2,600 linear feet of 12-inch diameter pipeline along Cooley Road and 6,900 linear feet of 16-inch diameter pipeline along 18th Street. In addition to these pipelines, which help connect the Juniper Ridge area to the existing City system, further pipeline improvements within the UGB are proposed to improve system capacities to serve the southerly portion of the Juniper Ridge area, utilizing improved storage capacity on Pilot Butte.

It is proposed that as planning for the Juniper Ridge area progresses, the City conduct further study, possibly including hydraulic water system analysis, to confirm proposed improvements match well with planned development.

Former Juniper Utility Area

The former Juniper Utility area presents certain challenges regarding integration with existing City facilities. The water system in the area was recently acquired by the City of Bend and it appears that the system was not originally planned for optimum integration with the City's water system.

The pressure zones in the former Juniper Utility area, Zones 2SB and Zone 3SB, operate at hydraulic grades inconsistent with the City's existing Zones 2 and 3. Adjusting pressure zone boundaries to better match the City's existing system would, among other benefits, potentially reduce long-term capital improvement costs and simplify operations. However, such modifications would appear to introduce certain challenges regarding service pressures, system vulnerabilities, etc.

This report presents a program that maintains existing pressure zone boundaries in the former Juniper Utility area while satisfying maximum day demands plus fire flows. This approach provides the City with relatively conservative estimated capital improvement costs looking forward. It is recommended that further study be conducted outside of this report to evaluate this interest in greater detail, and to present recommendations based on more in-depth analysis.

Zone 4E/Zone 3SB

Because of certain physical characteristics of the water system as discussed above, the City is currently challenged to provide sufficient fire flows to the former Juniper Utility area. To help supplement existing flows a pressure sustaining valve should be implemented to supply water from Zone 4E to the northerly portion of this area during fire flow conditions. This

valve would operate only during conditions that would allow Zone 4E to provide water to this area that normally operates at a higher hydraulic grade than Zone 4E.

Zones 2 South Bend (2SB) and 3 South Bend (3SB)

These two zones are currently operating as constant pressure pumped service areas. While such systems are generally more costly and less reliable in the long term than gravity fed systems, it is recommended that the City conduct further study, outside of this report, to assess alternatives for implementing local storage and changing these areas to gravity fed systems.

The existing topography in the vicinity of the South Bend area would appear to require approximately two miles of transmission piping to reach a suitable elevation for locating a ground level reservoir. The costs of such piping combined with the costs of a reservoir should be compared with the costs required for constant pressure pumping at saturation development, including the additional long-term operation and maintenance costs. It is suggested that both alternatives be further evaluated during the preliminary engineering phase of the proposed additional groundwater production facilities serving this area.

Zone 7

Currently Zone 7 includes three separate areas within the current UGB, and possibly including the Juniper Ridge area, depending on how development planning proceeds. The two smaller Zone 7 areas (one adjacent to Empire Avenue and the other near 27th Street) should be considered for partial or full transfer to the adjacent Zone 6 service area. Adjacent Zone 6 service areas are at relatively similar elevations as the two Zone 7 areas. If excessive pressures are of a concern for these areas, individual pressure reducing valves (PRV's) could be implemented. The potential benefits of transferring the two Zone 7 areas to Zone 6 include improved water system looping opportunities that may help improve fire flows and help avoid water quality issues. Also, some system PRV's may be eliminated, thereby reducing maintenance costs. One key interest is to extend the Zone 6 16-inch diameter transmission main from 27th Street, along the proposed Empire Avenue Extension, through to 18th Street and then north to Juniper Ridge. Keeping this pipeline as a Zone 6 line would help in water delivery to the Juniper Ridge area, in both improved flow and pressure characteristics.

Storage Capacity Analysis

General

The storage capacity analysis evaluates the City's existing water storage capacity and determines the recommended storage volume needs for the water service area. Estimated water storage volume requirements are based on the combined storage components for operational, fire and emergency purposes.

A key assumption incorporated into the analysis for the City of Bend's water system is the premise that a certain volume of emergency storage may be allocated to the City's subsurface aquifer water supply source. This assumption assumes that during an emergency condition a sufficient volume of supply water may be withdrawn from the aquifer via existing and proposed wells until the emergency condition passes. This assumption significantly reduces the amount of reservoir "tank storage" capacity needed for the City. Further discussion and analysis associated with this interest follows.

Storage Requirements

Based on water demand forecasts presented in Section 3 and the planning criteria identified in Section 4 the total volume of required storage by the end of the planning period (year 2030) is estimated at approximately 90.8 MG (see Table 5-3, "Storage Requirements").

Table 5-3
Storage Requirements

Pressure Zone	Fire [1] (MG)	Operational [2] (MG)	Emergency [3] (MG)	Total Required Storage (MG)
1	0.18	0.20	0.70	**1.08**
2	0.54	0.34	1.20	**2.08**
2SB	0.54	0.40	1.40	**2.34**
Westwood	0.54	0.23	0.80	**1.57**
3	0.54	1.53	5.39	**7.46**
3SB	0.54	0.50	1.77	**2.81**
4W	0.54	1.51	5.34	**7.39**
4E	1.50	2.89	10.17	**14.56**
5	1.50	4.40	15.51	**21.41**
6	1.50	2.81	9.90	**14.21**
7	0.54	0.40	1.40	**2.34**
7JR[4]	1.50	2.67	9.40	**13.57**
TOTALS	**9.96**	**17.88**	**62.98**	**90.82**

Notes: (1) Fire storage is based on the largest fire anticipated for each zone.
(2) Operational storage is calculated as 0.25 X MDD for each zone.
(3) Emergency storage is calculated as 2 X ADD for each zone.
(4) For analysis purposes the Juniper Ridge area is shown separate from Zone 7.

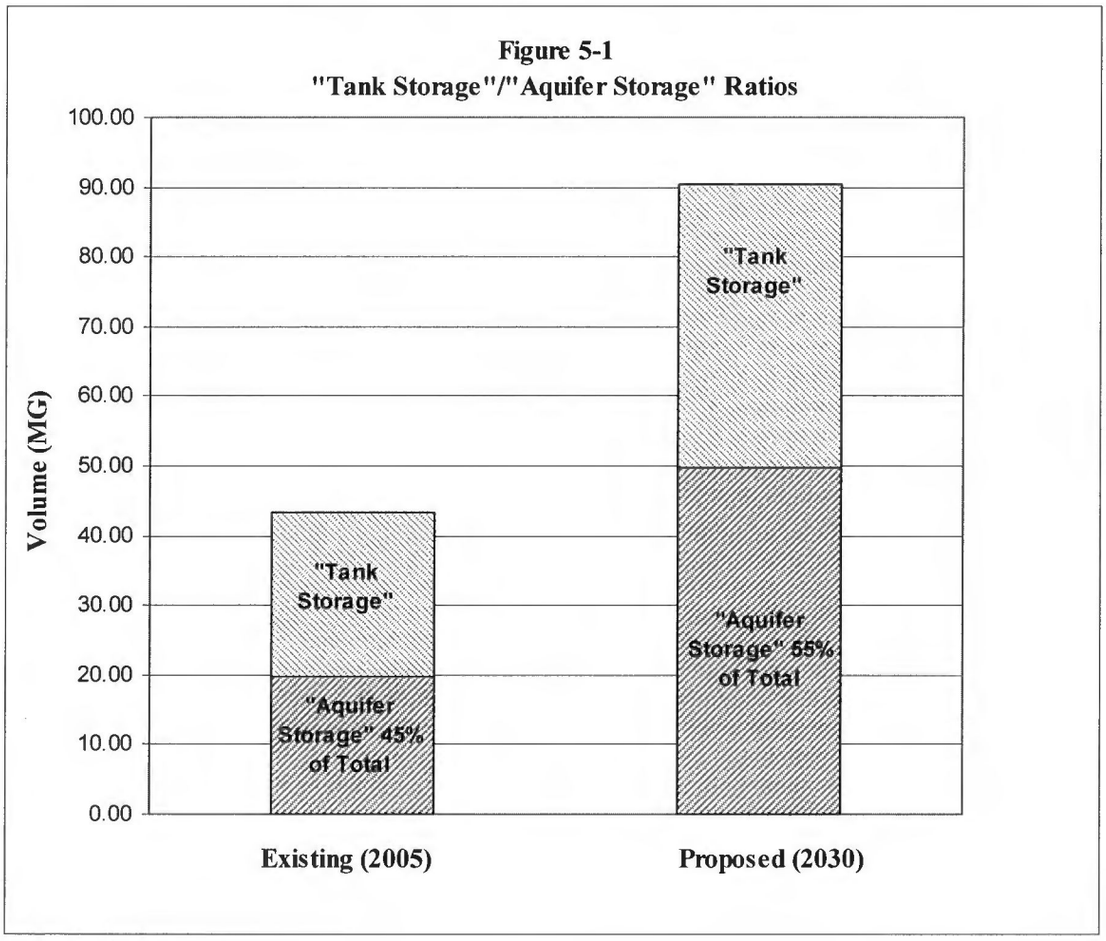
Storage Allocations ("Tank Storage" vs. "Aquifer Storage")

As mentioned previously, a key assumption incorporated into the storage analysis for the City of Bend's water system is the premise that a certain volume of emergency storage may be allocated to the City's subsurface aquifer water supply source. This idea is intended to simply reallocate some of the needed emergency storage capacity, typically provided by constructed storage tanks ("tank storage"), to the existing subsurface aquifer ("aquifer storage"). Emergency storage is that component of storage intended to provide water during emergencies such as pipeline failures, equipment failures, power outages or natural disasters. This approach results in tremendous cost savings to the City by reducing constructed "tank storage" costs. This approach also benefits the City by helping to minimize stagnation of storage water by reducing tank storage and increasing turnover of water in tanks, especially during the low use winter season.

Currently, the City allocates a significant portion of emergency storage capacity to the subsurface aquifer. For example, in the South Bend portion of the City most of the storage is

allocated to the subsurface aquifer, as tank storage is only drawn upon periodically through operation of the Murphy Pump Station when needed. Approximately 45% of the City's current total storage needs are allocated to the aquifer. This report recommends increasing that percentage to roughly 55% by the end of the 25-year planning period (see Figure 5-1, "Tank/Aquifer Storage Ratios").

Figure 5-1
"Tank Storage"/"Aquifer Storage" Ratios



As discussed above, the total volume of required storage by the end of the planning period (year 2030) is estimated at approximately 90.8 MG. As shown in Table 5-4, "Total Storage Allocations", today's storage requirements of approximately 43.3 MG are provided by existing firm "tank storage" capacity of 23.6 MG and existing "aquifer storage" capacity of approximately 19.7 MG. The firm storage capacity assumes that the City's largest storage facility, Awbrey Reservoir, is inoperable. As discussed above, the term "firm capacity" is used to refer to the reliable capacity of a water system component. The use of firm capacity for water system planning purposes is good practice in that it helps reduce the risks of planning a system that has insufficient capacity in the various system components, and this approach is consistent with standard engineering practices and recommendations by the American Water Works Association.

Approximately 47.5 MG of additional storage capacity will be required by the end of the planning period. For this additional capacity it is proposed that approximately 28.7 MG of existing well capacity be allocated as "aquifer storage" leaving a net required additional storage capacity of approximately 38.5 MG. As presented in Table 5-4, it is suggested that this needed additional capacity be provided by approximately 16.8 MG of additional "tank storage" and approximately 21.7 MG of additional well capacity ("aquifer storage"). Table 5-5 presents proposed allocations of required additional storage capacity by zone.

Table 5-4
Total Storage Allocations

		Current Storage (Year 2005) (MG)	**Future Storage (Year 2030) (MG)**
"Tank Storage"	Existing Firm Tank Storage Capacity	23.6	23.6
	Proposed Additional Tank Storage Capacity	--	**16.8**
"Aquifer Storage"	Existing Well Capacity Allocated to Storage	19.7	28.7
	Proposed Additional Well Capacity Allocated to Storage	--	**21.7**
	TOTALS	**43.3**	**90.8**

Note: (1) For planning purposes storage totals for 2005 are based on established planning level demands of 250 gpcd for Average Day Demands and 590 gpcd for Maximum Day Demands, rather than actual recorded demands for 2005.

Table 5-5
Allocations of Required Additional Storage Capacity by Zone

Pressure Zone	Total Additional Required Storage (MG)	Proposed Additional Storage (MG)	
		Proposed Additional Well Capacity	Proposed Additional "Tank Storage" Capacity
1	--	--	--
2	--	--	--
2SB	**2.34**	**2.34**	--
Westwood	--	--	--
3	--	--	--
3SB	**1.57**	**1.57**	--
4W	--	--	--
4E	**7.43**	--	**7.43**
5	--	--	--
6	**11.28**	**6.98**	**4.30**
7	**2.34**	**1.40**	**0.94**
7JR[(1)]	**13.57**	**9.40**	**4.17**
TOTALS	**38.53**	**21.69**	**16.84**

(1) For analysis purposes the Juniper Ridge area is shown separate from Zone 7.

The City's groundwater facilities include a high degree of redundancy and backup since there are a number of well sites, and the sites are physically separated from one another. A number of the well sites include emergency backup power generation capabilities and the City maintains some mobile power generation capabilities as well. Because this report recommends allocating a significant amount of the required emergency storage to the subsurface aquifer, emergency backup power generation capabilities should be implemented for all of the City's groundwater production sites.

Because of the understood availability of ample groundwater supply throughout the City, it is expected that the aquifer could reliably provide needed supply during the most extreme anticipated emergency scenario. As per the storage criteria presented in Section 4 the most extreme scenario is assumed to be one in which the surface water supply becomes inoperable, due to perhaps a fire in the Bridge Creek watershed. While a vulnerability assessment of the aquifer was not performed as part of this report it is acknowledged that this subsurface water supply source should not be considered immune to potential contamination or significant

depletion. However, if the aquifer were to become contaminated it is expected that the City would have sufficient time to respond and develop alternative supply sources if needed.

Through the end of the planning period (2030) the above approach, in conjunction with the demands and planning criteria identified in this report, would require minimum total additional "tank" storage capacity of approximately 11.3 MG. While it is acknowledged that risks associated with the above-described approach to storage allocation may be considered rather modest, the total recommended volume of additional "tank" storage is increased by 5.5 MG to a total of 16.8 MG as a measure to help offset such potential risks and to develop a desired reasonable balance between "tank storage" and "aquifer storage".

The total recommended additional "tank" storage volume is significantly less than the total volume required by a more conventional approach that may not allocate storage to the aquifer. The above approach allows the City to "kill two birds with one stone" by using the capacity of certain wells to satisfy both supply and storage needs. The 21.7 mgd of proposed additional well capacity intended to allocate storage to the aquifer also serves to meet planning period supply needs. In addition, the storage proposed for allocation to the aquifer is emergency storage with a peak withdrawal rate equal to the maximum day demand, not the higher rates typically required for fire suppression. Thus, the above methodology does not affect water rights interests any differently than would supply expansions for typical demand growth. As discussed above, the supply system should be expanded by approximately 40.3 mgd to meet year 2030 supply needs.

It should be noted that for the storage analysis portion of this study only, the projected population for Zone 1 has been adjusted downward. Because of the location and the development characteristics of much of Awbrey Butte that would be served by storage located in this zone, the actual population growth rate for these areas is anticipated to be somewhat slower than the average growth rate of the City. Pressure Zone 1 currently serves a population of approximately 835, and for identifying storage needs it is estimated that this zone will serve up to approximately 1,340 people by the year 2030. This estimate assumes saturation of infill development without redevelopment. However, the population projection methodology used for the other zones would result in a Zone 1 saturation development population of roughly 2,398. The Tower Rock reservoir with 1.0 million gallons of capacity will provide sufficient storage volume for the anticipated population of 1,340; however, as this planning reporting is updated in the future should it appear that the population for this area may potentially exceed 1,340 then additional storage should certainly be implemented.

Pumping Capacity Analysis

As represented in Section 4, pumping capacities should be adequate to supply the maximum day demand to the service area of the station if adequate gravity storage for the area exists. The criteria for direct pumping stations, where gravity supply is not available, are more stringent. Since mechanical equipment is subject to failure, supply capacity should be achieved with the largest pump out of service (firm capacity).

Direct pumping stations (continuously operating pumps or hydropneumatic systems without gravity storage) are normally used to supply small residential areas. Fire flow to areas served by direct pumping systems can be provided by fire pumps. These systems should be considered only for small areas where conventional supply from gravity storage is not practical or economical, or as an interim improvement until gravity service can be provided.

A brief discussion of the pumping capacity analysis by pump station is presented below, followed by Table 5-6, "Pumping Analysis Summary".

Awbrey Pump Station

The Awbrey Pump Station supplies water to Zone 1 from the Awbrey Reservoir and can supply Zone 2 through Zone 1. This pump station is the only supply to Zone 1 and therefore should be capable of supplying maximum day demands in this pressure zone. The Tower Reservoir is filled from the Awbrey Pump Station and supplies demands in excess of maximum day demands including fire flow. Maximum day demands in Zone 1 and Zone 2 at saturation development are approximately 2.15 mgd (1500 gpm). The existing firm capacity of the Awbrey Pump Station is adequate to meet the pumping capacity needs of Zone 1 and provide backup supply to Zone 2.

College Pump Station

The College Pump Station supplies water to Zone 2 from Zone 3. Zone 2 also receives water through several PRV connections from Zone 1. This pump station should be capable of supplying maximum day demands in this pressure zone without relying on supply from Zone 1. The College Reservoirs are filled from the College Pump Station and these reservoirs provide supply for Zone 2 demands that are in excess of maximum day demands including fire flow. Maximum day demands in Zone 2 at saturation development are approximately 1.36 mgd (950 gpm). The existing firm capacity of the College Pump Station is adequate to meet the pumping capacity needs of Zone 2.

Murphy Pump Station

The Murphy Pump Station supplies water to Zone 3 South Bend from Zone 4 East. Also, the Shiloh Wells pump directly into Zone 3 South Bend and a PRV connection supplies water to Zone 3 from Zone 2 South Bend. Zone 3 South Bend does not have gravity storage facilities, so the Murphy Pump Station and the Shiloh Wells must be capable of supplying maximum day demands plus fire flow to the pressure zone. The capacity of the Shiloh Wells is 2.59 mgd (1,800 gpm). The maximum day demands of Zone 3 South Bend at saturation development are approximately 2.01 mgd (1,400 gpm) and the maximum fire flow requirement for this pressure zone is 3,000 gpm. As presented above, it is recommended that approximately 1.57 mgd (1,090 gpm) of additional supply capacity be developed for this pressure zone. With the development of this supply capacity, the required firm pumping capacity of the Murphy Pump Station is the difference between the capacity of the groundwater wells and the ultimate domestic and fire flow demands, or approximately 1,510

gpm. The existing firm capacity of the Murphy Pump Station is adequate to meet the pumping capacity needs of Zone 3 South Bend.

Scott Pump Station

The Scott Pump Station supplies water from Zone 5 to Zone 4 East. The primary purpose of this pump station is to improve "turnover" in the Pilot Butte storage reservoirs during winter months when demands are low. The existing capacity of this pump station is adequate for this purpose.

Westwood Pump Station

As discussed above, the Westwood Service area should be enlarged to include certain portions of the proposed Tetherow development area. The Tetherow development will add approximately 300 to 350 dwelling units and commercial and retail development to the Westwood Pump Station's service area. The maximum day demand at saturation development for the expanded Westwood service area is approximately 0.9 mgd (625gpm). The pump station must also be capable of supplying fire flow demands which are 2,500 gpm in the Tetherow development. Therefore, the recommended firm pumping capacity of the Westwood Pump Station is approximately 3,125 gpm. The existing firm pumping capacity is approximately 1,490 gpm. Recommendations for expansion of the Westwood Pump Station are discussed in Section 6.

Table 5-6
Pumping Analysis Summary

Pump Station Facility	Existing Firm Pumping Capacity (gpm)	Saturation Development Pumping Capacity Requirement (gpm)	Recommended Additional Firm Pumping Capacity (gpm)
Awbrey Pump Station	2,400	1,500	**0**
College Pump Station	1,000	950	**0**
Murphy Pump Station	1,800	1,510	**0**
Scott Pump Station	2,500	N/A	**0**
Westwood Pump Station	1,490	3,125	**1,635**

Distribution System Analysis

General

A hydraulic network analysis computer program was used to evaluate the performance of the existing distribution system and to aid in the development of proposed system improvements. MWH Soft's H_2ONet network analysis program integrated with the AutoCAD platform was used to develop a digital base map of the water distribution system and perform analysis for

this report. The purpose of the computer network modeling is to determine pressure and flow relationships throughout the distribution system for a variety of critical hydraulic conditions. System performance and adequacy of existing facilities is then evaluated on the basis of water demand estimates developed in Section 3 and planning criteria presented in Section 4.

Hydraulic Model

The hydraulic model used to complete the hydraulic analysis of this master plan was developed by City staff and then updated by MSA. Recent system improvements have been added to the map from record drawings provided by the City. The hydraulic model was then used to perform the system analysis and to illustrate recommended improvements. The existing system is presented as Figure 1, "Existing Water System Map", in Appendix A. All pipes on Figure 1 are shown as "links" between "nodes" which represent pipeline junctions or changes in pipe size. Diameter, material type and length are specified for each pipe and approximate ground elevations are specified for each node. For drawing clarity only pipe diameters are illustrated.

Modeling Conditions

To simulate system operation under maximum usage conditions, it is necessary to determine the water usage anticipated for the highest water use day of the year. For this purpose, the maximum day demands at saturation development previously presented as part of Table 5-2, were distributed throughout the system.

The computer analysis was performed with all pressure zones simultaneously in operation and all reservoirs operating at half full. In order to use the computerized hydraulic model of the water system to assess system adequacy, several system conditions were examined. The adequacy of the system's major transmission piping to deliver water to certain portions of the City and the distribution system's ability to provide recommended fire flows throughout the City were analyzed.

All fire flow modeling was performed assuming that the system must be capable of providing the recommended fire flows while maintaining minimum pressures throughout the entire City water system of at least 20 psi.

Model Calibration

For a computer model to provide the most accurate results practical under test conditions it is essential that the model be calibrated with field conditions to reflect actual system operation. Model calibration was performed using actual measured demands distributed over the existing distribution system. Flow data from hydrant flow tests performed by City of Bend staff were compared to pressure and flow results obtained from modeled flows placed at the same locations. The Hazen-Williams roughness coefficients of the pipes and the distribution of demands from the nodes in the model were adjusted until the modeled flow test results fell within approximately ten to fifteen percent of the actual results. This is generally considered

an acceptable level of calibration for planning purposes. Based on the calibration results, a Hazen-Williams roughness coefficient or C-Factor ranging from 60 to 145 was used for all existing pipes, depending on material type and pressure zone. A C-Factor of 130 was used for all proposed pipes.

Modeling Results

Transmission System

The hydraulic analysis showed that the City's transmission system piping, or larger diameter piping (typically greater than 12-inches in diameter), is generally adequate to transmit water from the City's various water supply sources to storage reservoirs, from the storage reservoirs to the distribution system and between pressure zones. Through the analysis, two areas with inadequate transmission capacity were identified. These transmission system deficiencies are described below.

Outback Site to Pressure Zone 3

The City's surface water supply is routed to the Outback site. A major component of the City's groundwater supply source is located at the Outback site as well. Four water mains, parallel 14-inch diameter and 16-inch diameter pipes and parallel 16-inch diameter and 36-inch diameter pipes, transmit water from the Outback site to Pressure Zone 3 and to the Overturf and Awbrey Reservoirs. These transmission mains have inadequate capacity to meet future supply needs which include domestic and fire suppression flow demands for Pressure Zone 3, and supply to the Overturf Reservoirs and Awbrey Reservoir. The existing 14-inch and 16-inch diameter parallel pipes are aging steel mains and are believed to be reaching the end of their service life. For the purposes of the hydraulic analysis, it was assumed that these two mains would be replaced by a proposed 36-inch diameter main from the Outback site to the distribution system.

Rock Bluff Reservoir to Pressure Zone 4E

The Rock Bluff Reservoir provides gravity supply to Pressure Zone 4E from three existing groundwater supply wells located at the site. It is anticipated that additional storage and groundwater supply facilities will be developed at the Rock Bluff Reservoir site. Currently, a single 16-inch diameter transmission main supplies water from the Rock Bluff Reservoir site to Pressure Zone 4E. The hydraulic analysis showed that expanded transmission capacity will be needed to supply water from the Rock Bluff Reservoir site under saturation development conditions. The need for expanded transmission capacity in Pressure Zone 4E is a result of anticipated future domestic demands plus high fire suppression flow requirements in the commercial highway corridor in this area. It is anticipated that the size, timing and ultimate configuration of transmission system improvements from the Rock Bluff Reservoir site to Pressure Zone 4E will be coordinated and updated as further analysis of integrating the former Juniper Utility Company service area (Pressure Zones 3SB and 2SB) is completed.

Transmission System Improvements Summary

Transmission system improvements are proposed to increase capacity from the Outback site to Zone 3 distribution piping, and to increase capacity from the Rock Bluff reservoir site to Zone 4 East. The proposed transmission system improvements are indicated on Figure 2, "Proposed Water System Improvements Map", of Appendix A. Project cost estimates are presented in Appendix B.

Distribution System

The water system was analyzed under existing and saturation development maximum day demand conditions with fire suppression flow requirements as documented in Section 4. The major factors contributing to deficiencies in the distribution system's capacity are population growth and fire suppression requirements. A brief discussion of each of the key distribution system issues is presented below.

Population Growth

The City of Bend has in recent years experienced, and is expected to continue to experience, significant population growth. The future population growth throughout the study period is anticipated to occur as infill within the current UGB. This type of population growth will result in an increase in water demands throughout the system and can ultimately exceed the supply capacity of existing distribution system infrastructure.

With the significant recent development that has occurred within the City's water service area, the City has endeavored to evaluate, with each new development, water system improvement needs to serve existing and future customers. It is anticipated that with the verification, calibration and update of Bend's water system hydraulic model the City will be well equipped to plan for and implement future system expansions to meet the projected population growth and avoid future distribution system deficiencies.

Fire Suppression Requirements

The distribution system must be capable of maintaining acceptable system pressures while delivering peak domestic water demands and water for fire suppression. Recommended fire flow rate requirements have steadily increased to meet updated International Fire Code requirements, Insurances Services Office (ISO) audit findings, AWWA guidelines and increased development size and density within the City of Bend. The hydraulic analysis showed that a large number of the distribution system deficiencies were related to fire flow availability within older parts of the City, such as the area between the Deschutes River and Pilot Butte, and along Highway 97 and Highway 20 where major recent commercial development has occurred.

Pressures Zones 2SB and 3SB (the former Juniper Utility Company service area) also contain a large number of distribution system capacity deficiencies. As discussed in Section 2, the distribution system piping in this area largely consists of 2-inch through 6-inch diameter PVC pipe. This piping has inadequate capacity to meet domestic water demands and provide recommended fire flow capacity.

Distribution System Improvements Summary

Modeling results under maximum day demand conditions at saturation development indicate that improvements are required in order to provide recommended fire suppression flows while maintaining minimum service pressures. Fire flows were simulated throughout the study area based on the estimated fire suppression flow recommendations for land uses as presented in Section 4. The locations of proposed improvements are indicated on Figure 2, "Proposed Water System Improvements Map", in Appendix A. Pipe sizing recommendations and project cost estimates are presented in Section 6.

Summary

This section develops and presents an analysis of the City of Bend's water distribution system. The analysis found that additional water supply capacity, storage volume, pumping capacity and piping improvements are needed to adequately meet near term needs and to provide for system expansion in the future. Section 6 presents specific recommendations and a capital improvement plan that includes proposed project sequencing, phasing requirements and project cost estimates.

SECTION 6
RECOMMENDED WATER SYSTEM IMPROVEMENTS

General

This section presents recommended water system improvements for the City of Bend that provide for the correction of existing deficiencies and expansion of the distribution system to support anticipated future development. These improvements, based on the analysis and findings presented in Section 5 include proposed additional water supply capacity, storage volume, pumping capacity and piping improvements. All proposed system improvements are illustrated on Figure 2 in Appendix A, "Proposed Water System Improvements Map". Recommended water system improvements are presented for the 25-year study period (through year 2030). Recommended supply, storage and pumping improvements are shown on Figure 6-3 "Water Distribution System Hydraulic Profile".

Cost Estimating Data

An estimated project cost has been developed for each improvement project recommendation presented in this plan. Itemized project cost estimate summaries for certain proposed improvements are presented in Appendix B. Appendix B also includes a Distribution Piping Unit Project Cost Summary.

Cost estimates are based upon recent experience with construction costs for similar work in the region and assume improvements will be accomplished by private contractors. Cost estimates represent opinions of costs only, acknowledging that final costs of individual projects will vary depending on actual labor and material costs, site conditions, market conditions for construction, regulatory factors, final project scope, project schedule and other factors.

The project costs presented in this plan include estimated construction costs plus an aggregate 40 percent allowance for contingencies, engineering, administration and other project-related costs. Since construction costs change periodically, an indexing method to adjust present estimates in the future is useful. The Engineering News-Record (ENR) Construction Cost Index (CCI) is a commonly used index for this purpose. ENR provides monthly index estimates for 20 major U.S. metropolitan areas. The closest regional CCI provided by ENR is for Seattle, Washington. For purposes of future cost estimate updating, the October 2006 ENR CCI for Seattle, Washington of 8630 is referenced.

Recommended Improvements

General

Presented below are recommended water system improvements for supply, storage, pumping, and distribution system piping. The recommendations are presented by project type and size. A summary of estimated water system improvement project costs are presented in Table 6-2.

It is recommended that the City of Bend's water system capital improvement program be funded at approximately $6,800,000 annually.

Water System Planning

The City should complete updates to the Water Master Plan approximately every five years. An estimated cost of $100,000 for each update is included in the projected capital improvements program through the year 2030 for a total of $500,000. In addition, the City is required by the State of Oregon to update its Water Management and Conservation Plan (WMCP) every five to ten years. A budget estimate of $100,000 for each update is included in the Capital Improvements Program budget, assuming three updates for a total of $300,000. This report also allocates $200,000 for a water supply integrated engineering study for preliminary analysis of surface water supply improvement alternatives. It is understood that the City intends to move forward with this reporting in the short term. Thus, the total costs for water system planning through the year 2030, that are included in the Capital Improvements Program budget estimates herein, are estimated at approximately $1,000,000.

Water Supply

The water supply analysis presented in Section 5 establishes that the City must address the need for increased reliable water supply within the planning period to satisfy water demand requirements. Consistent with the City's recent expansions to the supply system, it is recommended that the City continue to pursue opportunities to develop additional groundwater supply thereby benefiting from this apparently robust available source. Specific recommendations for expansion of the supply system consist of adding new groundwater wells at strategic locations that provide the highest value to the City. However, it is understood that the City's surface water supply system is currently being studied for possible treatment and transmission improvements, and any potential opportunities for expanded surface water supply capacity should certainly be considered as well.

The water supply analysis determined that the City should expand the existing supply system, with a firm capacity of approximately 31.2 mgd, by an additional 40.3 mgd for a total firm capacity of 71.5 mgd. The project costs for groundwater production facilities are estimated at approximately $1,200,000 for each million gallons per day (mgd) of capacity (see Appendix B, Groundwater Well Project Cost Estimate Summary). Thus, the total costs for supply expansion through the year 2030 is estimated at approximately $48,360,000 (2006 dollars).

Figure 6-1, "Water Supply/Demand Schedule" presents a projected water supply and demand schedule for supply expansion through the year 2030. The "stair-step" line represents one potential approach to scheduling improvements; however, required capacity could be implemented in a number of ways to satisfy supply needs. Supply capacity expansion is shown in 1.0 to 4.0 mgd increments (one or more wells at a time); however, expansions should be implemented at increments necessary to satisfy system demands and as may be suitable for each particular project. The water demands shown in Figure 6-1 are based on an assumed consistent growth rate as required to reach the projected 2030 population presented

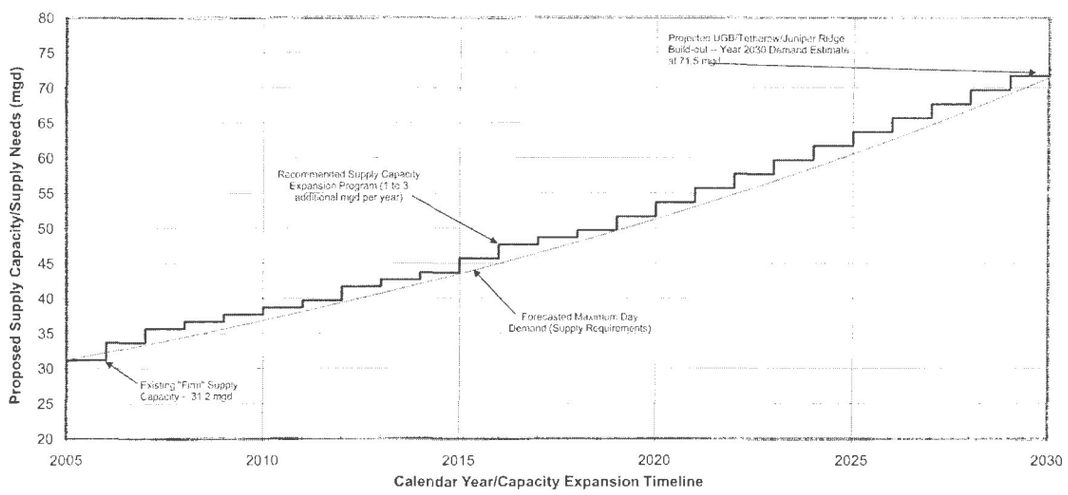
in Section 3. Both Figure 6-3, "Water Distribution System Hydraulic Profile", and Figure 2 in Appendix A, "Proposed Water System Improvements Map", identify proposed locations for new groundwater production facilities. On the graphics well symbols represent roughly 1.0 mgd each.

It is understood that of the 23 existing groundwater production wells, perhaps 10 can simultaneously be operated with emergency backup power generation facilities during a power outage. It is further understood that the City maintains several mobile emergency backup power generators and some of the wells have permanent "gen-sets" on-site. It is recommended that backup power generation facilities be implemented to provide for maximum day demands during a potential City-wide power outage. It is estimated that the project costs for implementing emergency backup power generation capabilities at the remaining existing groundwater production wells is approximately $100,000 per well, or a total of $1,300,000 (2006 dollars).

Surface Water Supply Improvements

As identified above, this report allocates $200,000 for a water supply integrated engineering study for preliminary analysis of surface water supply improvement alternatives. Existing aging raw water transmission pipelines will ultimately need to be replaced if the City continues to route water under pressure from the Bridge Creek watershed to the City. In addition, improvements may possibly include treatment facilities and power generation facilities. Once alternatives are evaluated and preliminary feasibility studies are completed then preliminary planning level cost estimates can be developed. Although the appropriate engineering studies have yet to be conducted, it is important that this Water System Master Plan Update include a rough preliminary surface water supply improvements program cost estimate for budgeting purposes. Since basic improvement concepts are very preliminary at this stage it is suggested that a budget amount of $50,000,000 be identified as a "placeholder" for preliminary Capital Improvement Program planning. This estimate should be refined as the water supply integrated engineering study is completed.

Figure 6-1
Water Supply/Demand Schedule



Distribution Storage Reservoirs

General

As presented in Section 5 the total recommended additional "tank storage" capacity through the planning period is approximately 16.8 MG. To satisfy such storage needs it is recommended that the City construct six finished water reservoirs by the end of the 25-year planning period. Table 6-1, "Recommended Reservoir Improvement Summary" below presents a summary of the recommended storage improvements and includes project cost estimates for each proposed reservoir.

Table 6-1
Recommended Reservoir Improvement Summary

Priority	Project Description	Estimated Project Cost
1	Rock Bluff II -- 3.0 MG Reservoir	$3,750,000
2	Pilot Butte IV -- 2.3 MG Reservoir	$2,900,000
3	Pilot Butte V -- 3.0 MG Reservoir	$3,750,000
4	Juniper Ridge -- 2.0 MG Reservoir	$2,600,000
5	Pilot Butte VI -- 3.5 MG Reservoir	$4,350,000
6	Rock Bluff III – 3.0 MG Reservoir	$3,750,000
	TOTAL	**$21,100,000**

(1) Recommended reservoir storage volumes have been rounded to the nearest 0.1 MG

3.0 MG Rock Bluff II Reservoir

It is recommended that a second reservoir be constructed at the Rock Bluff site to serve pressure Zone 4E (East) with a capacity of 3.0 MG. This reservoir will provided needed storage capacity for fire suppression and operational needs as Zone 4E approaches saturation development. Supply to this reservoir will be provided through existing and proposed groundwater production wells at the Rock Bluff site. The proposed overflow elevation for the reservoir is 3,879 feet above mean sea level (msl), the same elevation as the existing Rock Bluff I Reservoir. Estimated project costs for this reservoir are approximately $3,750,000.

2.3 MG Pilot Butte IV Reservoir

A 2.3 MG reservoir serving Zones 6 and 7 is recommended for implementation on Pilot Butte. This reservoir will provide needed storage capacity as Zones 6 and 7 further develop.

This reservoir will be connected to Zone 5; thus, supply to this reservoir will be provided by supply to Zone 5, and storage for Zones 6 and 7 will be provided through connections between Zones 5, 6 and 7. The proposed overflow elevation for the reservoir is 3,782 feet above mean sea level (msl), the same elevation as the existing Pilot Butte I & III Reservoirs. Estimated project costs for this reservoir are approximately $2,900,000.

3.0 MG Pilot Butte V Reservoir

It is recommended that a 3.0 MG reservoir be constructed on Pilot Butte to serve Zones 6 and 7. This reservoir will provide needed storage capacity as Zones 6 and 7 approach saturation development. This reservoir will be connected to Zone 5; thus, supply to this reservoir will be provided by supply to Zone 5, and storage for Zones 6 and 7 will be provided through connections between Zones 5, 6 and 7. The proposed overflow elevation for the reservoir is 3,782 feet above mean sea level (msl), the same elevation as the existing Pilot Butte I & III Reservoirs. Estimated project costs for this reservoir are approximately $3,750,000.

2.0 MG Juniper Ridge Reservoir

It is recommended that a 2.0 MG reservoir be constructed in the southerly portion of the Juniper Ridge area to serve the northerly portion of this UGB expansion area at saturation development. This report assumes that the water system for the Juniper Ridge area will be connected to the water system serving other portions of the City. Supply to this reservoir will be mostly provided by proposed new groundwater production wells proposed to be located in Juniper Ridge. The proposed overflow elevation for the reservoir is approximately 3,480, so that it may serve the northerly portions of Juniper Ridge below approximately 3,380 feet above mean sea level (msl). Estimated project costs for this reservoir are approximately $2,600,000. It should be noted that this recommendation is preliminary only, and as planning for this area is finalized, demand forecasts and storage needs should be updated to reflect actual anticipated development.

3.5 MG Pilot Butte VI Reservoir

A 3.5 MG reservoir serving pressure Zones 4E, 5, 6 and 7, including the southerly portion of the Juniper Ridge area is recommended for implementation on Pilot Butte. This reservoir will be connected to Zone 4E, and is proposed to have an overflow elevation of 3,880 feet above mean sea level (msl), similar to Pilot Butte II and the existing and proposed reservoirs at the Rock Bluff site at 3,879. Storage for Zones 5, 6 and 7 will be provided through connections between Zones 4E through 7. The Estimated project costs for this reservoir are approximately $4,350,000.

3.0 MG Rock Bluff III Reservoir

It is recommended that the City consider implementing a third reservoir at the Rock Bluff site to serve pressure Zone 4E (East). The total volume of this reservoir would be 3.0 MG. The Rock Bluff III reservoir would provide needed storage capacity for fire suppression and

operational needs as Zone 4E approaches saturation development. Supply to this reservoir will be provided through existing and proposed groundwater production wells at the Rock Bluff site. The proposed overflow elevation for the reservoir is 3,879 feet above mean sea level (msl), the same elevation as the existing Rock Bluff I Reservoir, as well as the proposed Rock Bluff II Reservoir. Estimated project costs for this reservoir are approximately $3,750,000. As an alternative to implementing an additional 3.0 MG at this location the City could construct a larger tank for the Pilot Butte VI Reservoir at perhaps 4.3 MG. Further study should be conducted to identify the best site for this storage as the need approaches.

Figure 6-2, "Water Storage Requirements Schedule" presents a projected schedule of water storage needs and possible sequence of improvements through the year 2030. The "stair-step" line represents one potential approach to scheduling improvements; however, required capacity could be implemented in a number of ways to satisfy storage needs. Storage capacity expansion is shown in 1.0 to 4.0 mgd increments (one or more wells or one reservoir at a time); however, expansions should be implemented at increments necessary to satisfy system demands and as may be suitable for each particular project. As discussed in Sections 3 and 5, projected water storage needs increase from roughly 43.3 MG to roughly 90.8 MG to satisfy the needs of saturation development by the year 2030, with approximately 30.7 MG allocated to the aquifer.

Land Acquisition

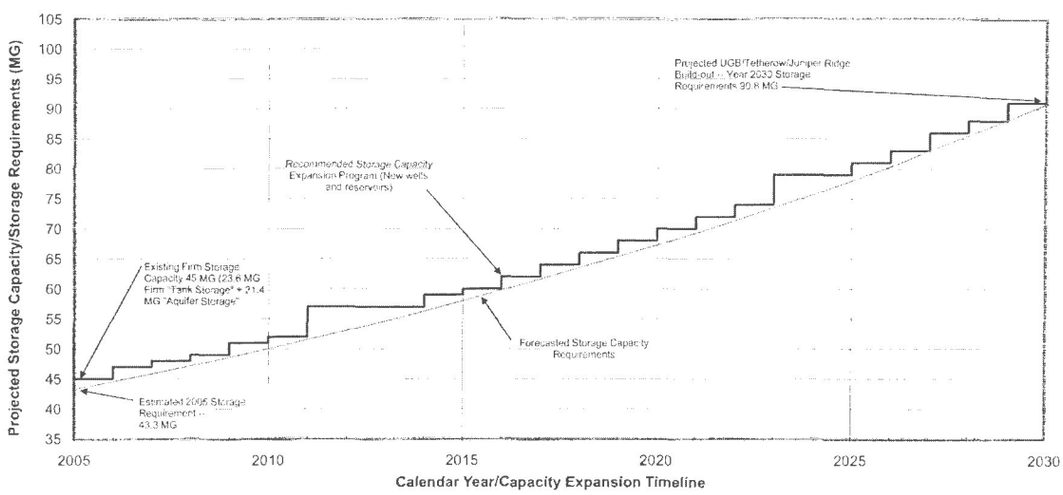
It is anticipated that some of the recommended facilities presented in this plan will require additional land to be acquired by the City. It is recommended that the City consider such additional land needs and begin any necessary acquisition process far in advance of the facility needs. For example, such land acquisition work should occur during the planning stages for the Juniper Ridge area so that development interests or other uses do not preclude construction of facilities.

With the exception of the proposed Juniper Ridge Reservoir and possibly the proposed Pilot Butte Reservoirs, it is understood that sufficient City land may be available at each of the above sites for implementing the recommended storage.

Pump Stations

In accordance with the Section 5 analyses, it is recommended that the Westwood Pump Station be upgraded. The recommended firm pumping capacity of the Westwood Pump Station is approximately 3,125 gpm. The existing firm pumping capacity is approximately 1,490 gpm; thus, this report recommends increasing the capacity of the pump station by approximately 1,635 gpm. For planning purposes it is assumed that the pump station would require complete reconstruction and it is estimated that total project costs for the pump station are approximately $2,100,000.

Figure 6-2
Water Storage/Requirements Schedule



Transmission Piping Improvements

Certain transmission piping improvements are recommended to improve transmission capacities. The recommended transmission piping improvements are shown on Figure 2 in Appendix A, "Proposed Water System Improvements Map". A list of transmission piping improvements is presented in Table B-10 in Appendix B. The total costs for transmission piping improvements through the 25-year planning period are approximately $7,680,000. While pipeline improvements up to 16-inches in diameter are proposed for integrating the Juniper Ridge area, these improvements are not categorized as transmission piping improvements by this report because they serve both distribution and transmission needs.

Distribution System Improvements

The analysis found that distribution system water line improvements are needed to improve fire flow capacities within the distribution system and also provide improved hydraulic transmission capacity and accommodate system expansion needs. Distribution system improvements are shown on Figure 2 in Appendix A, "Proposed Water System Improvements Map". The total costs for distribution piping improvements through the 25-year planning period are approximately $37,400,000. An estimated project cost is presented for each improvement in Table B-10 in Appendix B.

A pressure-sustaining valve connecting Zone 4E and Zone 3SB, located at the intersection of Chase Road and Mowich Drive, is included in the distribution system improvements. In addition a number of pressure reducing valves are proposed at various locations throughout the system. The estimated project costs for all pressure reducing/pressure sustaining valve stations is $1,080,000.

Service to Areas Outside UGB (Tetherow and Juniper Ridge)

Oregon Statewide Planning Goal No. 11 and Oregon Administrative Rules (OAR 660-0011) require facilities plans to make a clear distinction between those facilities that are required to serve areas within the UGB and those facilities needed to serve areas outside of the UGB. Two areas that are currently outside of Bend's UGB, the Tetherow area and the Juniper Ridge area, have been included within the study area of this master plan. Facilities required to serve both areas at saturation development have been identified in this report.

The Juniper Ridge area is a proposed UGB expansion area near the northeasterly boundary of the City. As identified in this plan 10.7 mgd of supply capacity and 4.2 MG of storage capacity will be needed to serve Juniper Ridge at saturation development. In addition, transmission piping improvements will be needed to properly integrate this area with the existing service area. Approximately 2,600 linear feet of 12-inch diameter piping along Cooley Road, and roughly 6,900 linear feet of 16-inch diameter piping along 18th Street are shown on Figure 2 in Appendix A. The total project costs for facilities to integrate Juniper Ridge are approximately $20,080,000, (10.7 mgd supply x $1.2M/mgd) + (storage @ $2.6M (Juniper Ridge Res.) + (2.2/3.5) x ($4.35M(portion of Pilot Butte Res. VI))) + (transmission

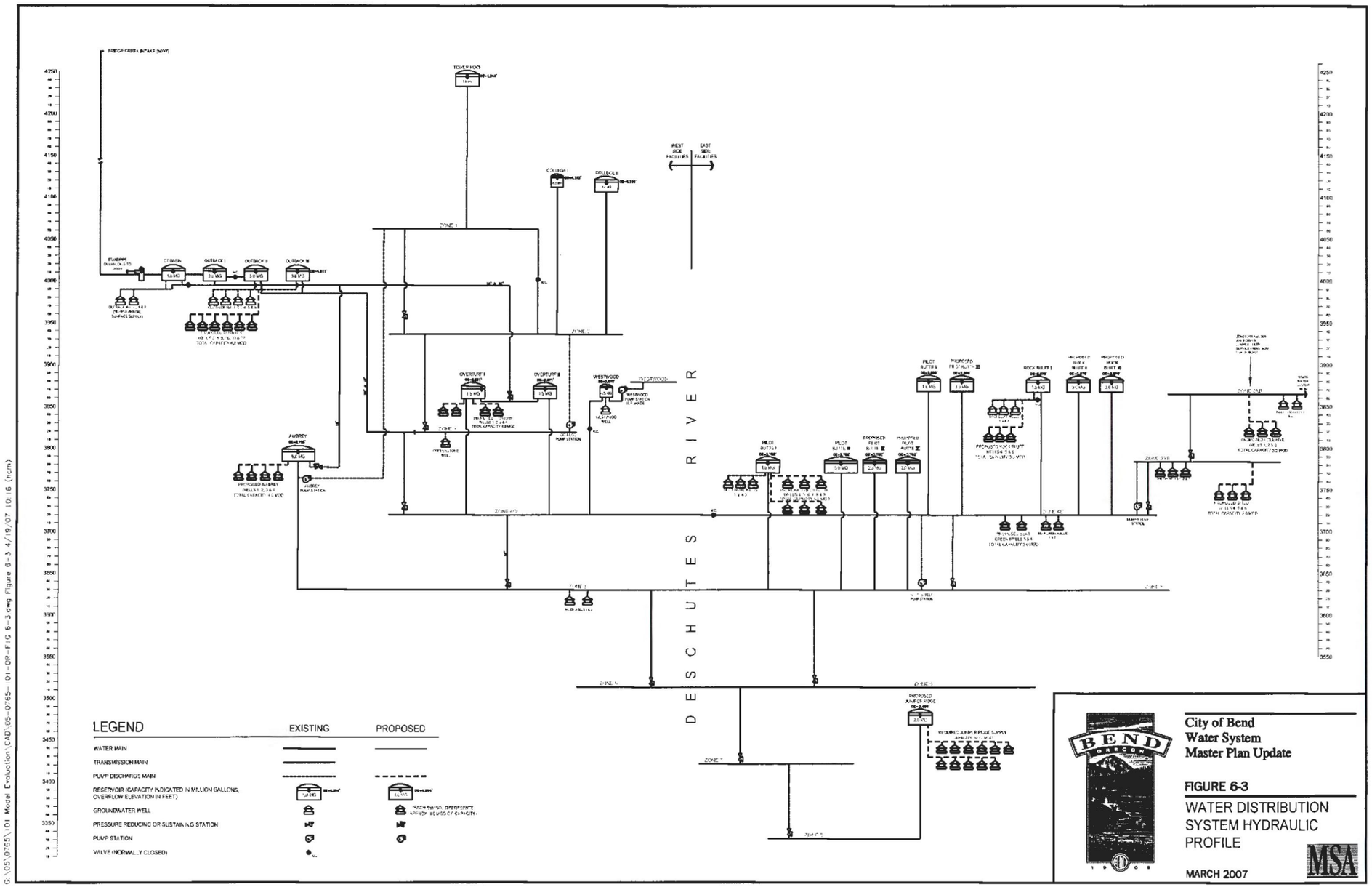
@ $1.9M). Distribution system improvements within the Juniper Ridge area are anticipated to be funded by development interests and thus are not included in the overall water system improvement cost estimates for incorporating Juniper Ridge.

Tetherow is a proposed UGB expansion area in the southwesterly portion of the City. It is anticipated that at saturation development this area will require approximately 1.3 mgd of supply capacity and 1.9 MG of storage capacity. The total project costs for these facilities are approximately $5,190,000, (1.3 mgd supply x $1.2M/mgd) + (1.9 MG storage x $1.28M/MG) + (Approx. 57% of Westwood P.S. upgrade (.57 x $2.1M)). Both transmission and distribution system improvements required to serve this area are anticipated to be funded by development interests, and thus are not included in the overall water system improvement cost estimates for incorporating the Tetherow area. Because of the location of Tetherow, supply, storage and pumping capacity improvements required for saturation development of this area are not presented as distinctly separate physical facilities in this report, but rather as "capacity expansions". This report allocates Tetherow supply capacity expansions to the Outback site (portion of the 4.8 mgd of supply improvements identified at the Outback site), and it allocates the Tetherow storage capacity expansion to the Rock Bluff site (portion of the 6.0 MG of storage improvements identified at the Rock Bluff site).

Summary

This section presents recommendations for improvements to the City's supply system, storage, pumping and distribution system. A summary of all the recommended improvements is presented in Table 6-4.

The total estimated project costs of the recommended improvements are approximately $170,000,000 over the 25-year planning horizon. It is recommended that the City's capital improvement program (CIP) be funded at approximately $6,800,000 (in 2006 dollars) annually for supply, storage, pumping and distribution system piping improvements.



City of Bend
Water System
Master Plan Update

FIGURE 6-3

WATER DISTRIBUTION SYSTEM HYDRAULIC PROFILE

MARCH 2007

MSA

G:\05\0765\101 Model Evaluation\CAD\05-0765-101-DR-FIG 6-3.dwg, Figure 6-3, 4/19/07 10:16 (hcm)

Table 6-2
Summary of Estimated Water System Improvement Project Costs

Improvement Category	Project Costs, 2006 Dollars
Groundwater Supply Capacity Expansion	**$48,360,000**
Emergency Backup Power Generation Upgrades	**$1,300,000**
Surface Water Supply Improvements	**$50,000,000**
Storage Capacity Expansion	**$21,100,000**
Pumping Capacity Upgrades	**$2,100,000**
Transmission Piping Improvements	**$7,680,000**
Pressure Reducing Stations	**$1,080,000**
Water System Planning	**$1,000,000**
Distribution Piping Improvements	**$37,400,000**
GRAND TOTAL	**$170,020,000**
USE	**$170,000,000**

The recommended system improvements have been developed based on the current condition of the system and anticipated development patterns. This plan should be re-evaluated periodically to reflect factors including available budget, completed projects, actual development patterns, changes to regulatory requirements and other new information. The plan should be re-evaluated every three to five years and, as part of the re-evaluation process, annual improvements should be identified for at least the next five-year period. Financial planning work is recommended to evaluate overall water system financial needs and to identify funding options and alternatives.

APPENDIX

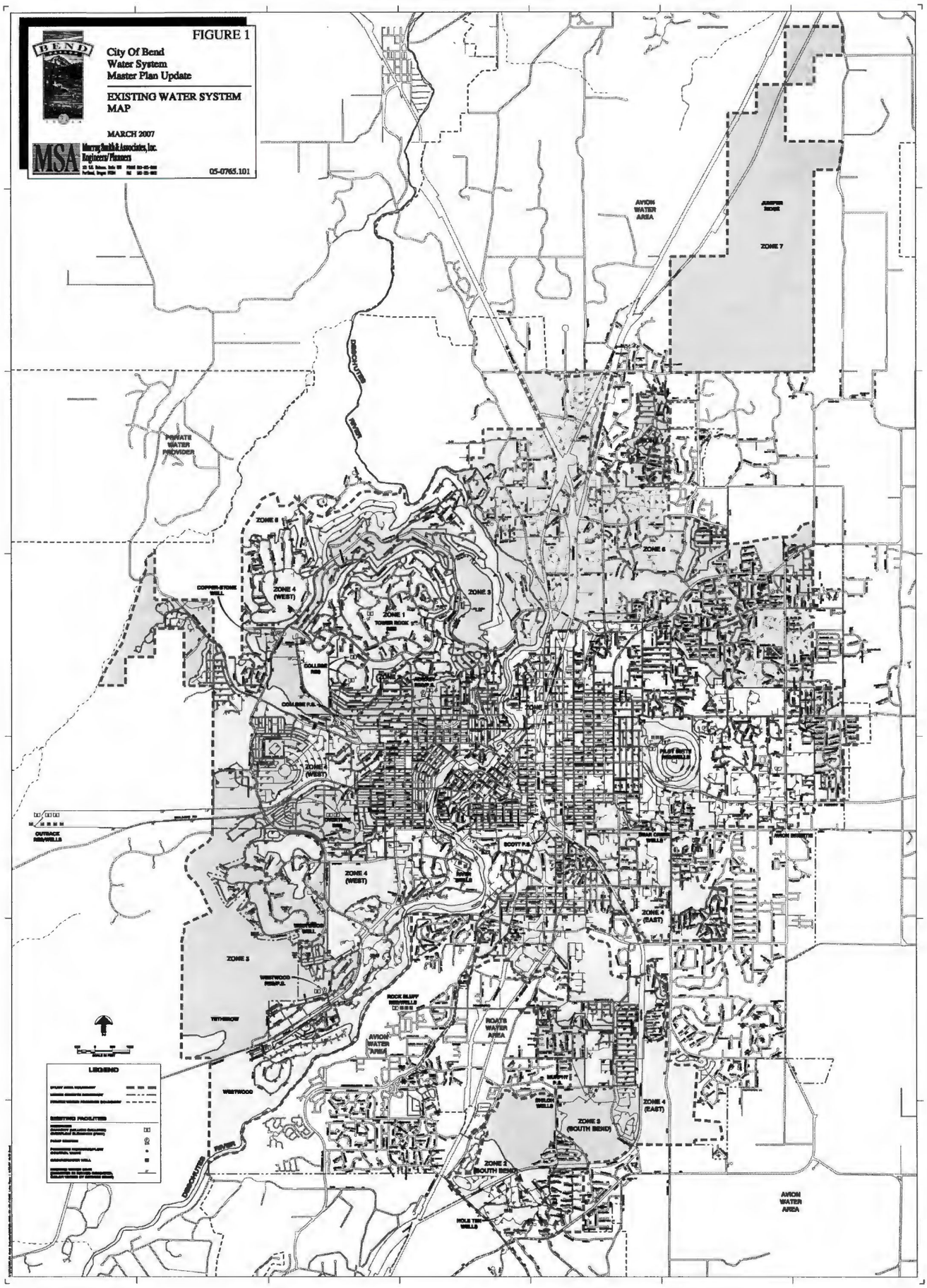


FIGURE 1
City Of Bend
Water System
Master Plan Update
EXISTING WATER SYSTEM MAP
MARCH 2007
Murray Smith & Associates, Inc.
Engineers/Planners
05-0765.101
AVION WATER AREA
ZONE 7
DESCHUTES RIVER
PRIVATE WATER PROVIDER
ZONE 8
ZONE 6
COPPER-STONE WELL
ZONE 4 (WEST)
ZONE 3
ZONE 1
TOWER ROCK RES
COLLEGE RES
COLLEGE P.S.
ZONE 4 (WEST)
OUTBACK RES/WELLS
SCOTT P.S.
ZONE 4 (WEST)
ZONE 4 (EAST)
ZONE 3
WESTWOOD RES/P.S.
TETHEROW
ROCK BLUFF RES/WELLS
ROATS WATER AREA
AVION WATER AREA
WESTWOOD
ZONE 4 (EAST)
ZONE 3 (SOUTH BEND)
ZONE 2 (SOUTH BEND)
HOLE TEN WELLS
AVION WATER AREA
LEGEND

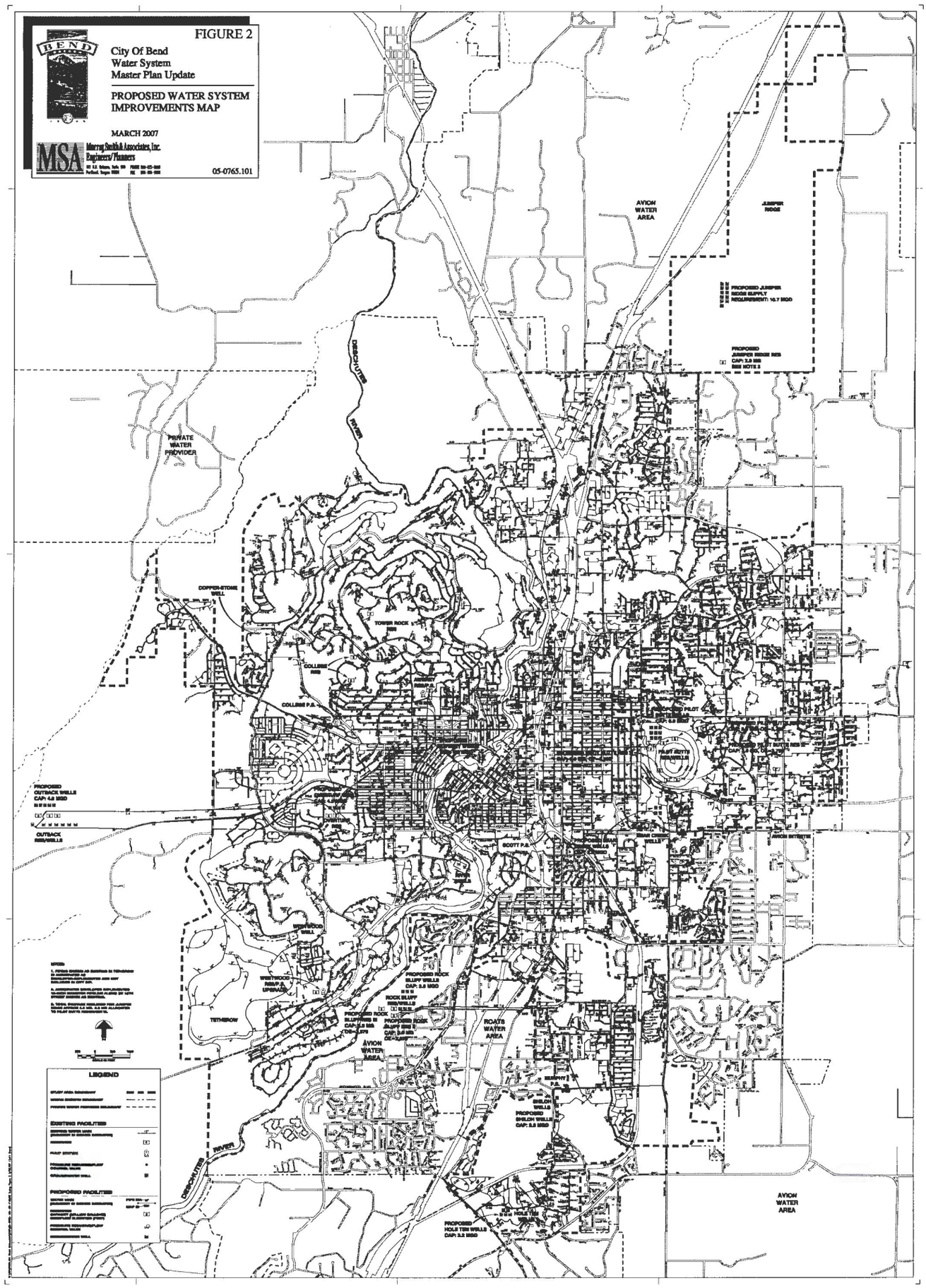


FIGURE 2
City Of Bend
Water System
Master Plan Update
PROPOSED WATER SYSTEM
IMPROVEMENTS MAP
MARCH 2007
Murray, Smith & Associates, Inc.
Engineers/Planners
05-0765.101
AVION WATER AREA
JUNIPER RIDGE
PROPOSED JUNIPER RIDGE SUPPLY REQUIREMENT: 10.7 MGD
PROPOSED JUNIPER RIDGE RES
DESCHUTES RIVER
PRIVATE WATER PROVIDER
COPPER-STONE WELL
TOWER ROCK RES
COLLEGE RES
COLLEGE P.S.
PROPOSED OUTBACK WELLS
OUTBACK RES/WELLS
SCOTT P.S.
AVION INTERTIE
WESTWOOD WELL
WESTWOOD RES/P.S. UPGRADE
TETHEROW
PROPOSED ROCK BLUFF WELLS
ROCK BLUFF RES/WELLS
ROATS WATER AREA
AVION WATER AREA
SHILOH WELLS
PROPOSED SHILOH WELLS
PROPOSED HOLE TEN WELLS
AVION WATER AREA
LEGEND
EXISTING FACILITIES
PROPOSED FACILITIES

MSA

APPENDIX B

APPENDIX B
COST ESTIMATES FOR WATER SYSTEM IMPROVEMENTS

Appendix B contains cost estimates for recommended improvements for supply, storage, pumping, and system piping. These cost estimates are based on the Engineering News Record Construction Cost Index for Seattle, Washington of 8630 (October 2006).

Table B-1
Groundwater Well Project Cost Estimate Summary

Groundwater well project cost estimates are based on the following assumptions:
No property acquisition costs included.
Construction by private contractors.
Estimated production of approx. 1 (mgd) with standby power generation equipment.
Well constructed to a depth of approximately 750 feet below ground surface (bgs) with 16-inch diameter steel casing.
An ENR construction cost index of 8630 for Seattle, Washington (October 2006).

Item No.	Description	Estimated Project Cost[1]
1.	Mobilization	$45,000
2.	Well Construction (Drilling)	$200,000
3.	Site Work	$25,000
4.	Well House Structure	$125,000
5.	Yard Piping	$25,000
6.	Mechanical – Including Pump, Motor, Flow Meter, Control Valving and Appurtenances	$200,000
7.	Chlorination Facilities	$40,000
8.	Controls	$30,000
9.	Electrical	$65,000
10.	Landscaping/Fencing	$20,000
11.	Standby Power (Emergency Generator)	$80,000
	Total Construction	$855,000
	40% Contingency, Administration & Engineering	$342,000
	Total Project Cost	$1,197,000
	USE	$1,200,000

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

Table B-2
3.0 MG Rock Bluff II Reservoir – Welded Steel
Project Cost Estimate Summary

Reservoir project cost estimates are based on the following assumptions:

No rock excavation included.
No property acquisition costs included.
Construction by private contractors.
An ENR construction cost index of 8630 for Seattle, Washington (October 2006).

Item No.	Description	Estimated Project Cost[1]
1.	Reservoir Structure	$1,620,000
2.	Site Work	$450,000
3.	Drainage System – Including site storm drainage and reservoir overflow discharge	$75,000
4.	Access/Parking	$50,000
5.	Yard Piping	$175,000
6.	Electrical– Including reservoir telemetry	$75,000
7.	Landscaping/Fencing	$75,000
8.	Mob/Demob/Ins/Bonds	$155,000
	Total Construction	$2,675,000
	40% Contingency, Administration & Engineering	$1,070,000
	Total Project Cost	$3,745,000
	USE	$3,750,000

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

Table B-3
2.3 MG Pilot Butte IV Reservoir – Welded Steel
Project Cost Estimate Summary

Reservoir project cost estimates are based on the following assumptions:

No rock excavation included.
No property acquisition costs included.
Construction by private contractors.
An ENR construction cost index of 8630 for Seattle, Washington (October 2006).

Item No.	Description	Estimated Project Cost[1]
1.	Reservoir Structure	$1,200,000
2.	Site Work	$425,000
3.	Drainage System – Including site storm drainage and reservoir overflow discharge	$75,000
4.	Access/Parking	$35,000
5.	Yard Piping	$120,000
6.	Electrical– Including reservoir telemetry	$75,000
7.	Landscaping/Fencing	$40,000
8.	Mob/Demob/Ins/Bonds	$100,000
	Total Construction	$2,070,000
	40% Contingency, Administration & Engineering	$828,000
	Total Project Cost	$2,898,000
	USE	$2,900,000

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

Table B-4
3.0 MG Pilot Butte V Reservoir – Welded Steel
Project Cost Estimate Summary

Reservoir project cost estimates are based on the following assumptions:

No rock excavation included.
No property acquisition costs included.
Construction by private contractors.
An ENR construction cost index of 8630 for Seattle, Washington (October 2006).

Item No.	Description	Estimated Project Cost[1]
1.	Reservoir Structure	$1,620,000
2.	Site Work	$450,000
3.	Drainage System – Including site storm drainage and reservoir overflow discharge	$75,000
4.	Access/Parking	$50,000
5.	Yard Piping	$175,000
6.	Electrical– Including reservoir telemetry	$75,000
7.	Landscaping/Fencing	$75,000
8.	Mob/Demob/Ins/Bonds	$155,000
	Total Construction	$2,675,000
	40% Contingency, Administration & Engineering	$1,070,000
	Total Project Cost	$3,745,000
	USE	$3,750,000

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

Table B-5
2.0 MG Juniper Ridge Reservoir – Welded Steel
Project Cost Estimate Summary

Reservoir project cost estimates are based on the following assumptions:

No rock excavation included.
No property acquisition costs included.
Construction by private contractors.
An ENR construction cost index of 8630 for Seattle, Washington (October 2006).

Item No.	Description	Estimated Project Cost[1]
1.	Reservoir Structure	$1,000,000
2.	Site Work	$400,000
3.	Drainage System – Including site storm drainage and reservoir overflow discharge	$90,000
4.	Access/Parking	$45,000
5.	Yard Piping	$110,000
6.	Electrical– Including reservoir telemetry	$75,000
7.	Landscaping/Fencing	$35,000
8.	Mob/Demob/Ins/Bonds	$90,000
	Total Construction	$1,845,000
	40% Contingency, Administration & Engineering	$738,000
	Total Project Cost	$2,583,000
	USE	$2,600,000

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

Table B-6
3.5 MG Pilot Butte VI Reservoir – Welded Steel
Project Cost Estimate Summary

Reservoir project cost estimates are based on the following assumptions:

No rock excavation included.
No property acquisition costs included.
Construction by private contractors.
An ENR construction cost index of 8630 for Seattle, Washington (October 2006).

Item No.	Description	Estimated Project Cost[1]
1.	Reservoir Structure	$2,000,000
2.	Site Work	$500,000
3.	Drainage System – Including site storm drainage and reservoir overflow discharge	$85,000
4.	Access/Parking	$75,000
5.	Yard Piping	$130,000
6.	Electrical– Including reservoir telemetry	$70,000
7.	Landscaping/Fencing	$70,000
8.	Mob/Demob/Ins/Bonds	$175,000
	Total Construction	$3,105,000
	40% Contingency, Administration & Engineering	$1,242,000
	Total Project Cost	$4,347,000
	USE	$4,350,000

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

Table B-7
3.0 MG Rock Bluff III Reservoir – Welded Steel
Project Cost Estimate Summary

Reservoir project cost estimates are based on the following assumptions:

No rock excavation included.
No property acquisition costs included.
Construction by private contractors.
An ENR construction cost index of 8630 for Seattle, Washington (October 2006).

Item No.	Description	Estimated Project Cost[1]
1.	Reservoir Structure	$1,620,000
2.	Site Work	$450,000
3.	Drainage System – Including site storm drainage and reservoir overflow discharge	$75,000
4.	Access/Parking	$50,000
5.	Yard Piping	$175,000
6.	Electrical– Including reservoir telemetry	$75,000
7.	Landscaping/Fencing	$75,000
8.	Mob/Demob/Ins/Bonds	$155,000
	Total Construction	$2,675,000
	40% Contingency, Administration & Engineering	$1,070,000
	Total Project Cost	$3,745,000
	USE	$3,750,000

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

Table B-8
Westwood Pump Station Upgrade
Project Cost Estimate Summary

Pump station project cost estimates are based on the following assumptions:

No rock excavation included.
No property acquisition costs included.
Construction by private contractors.
An ENR construction cost index of 8630 for Seattle, Washington (October 2006).

Item No.	Description	Estimated Project Cost[1]
1.	Mobilization/Demobilization	$70,000
2.	Site Work	$75,000
3.	Structure	$325,000
4.	Yard Piping	$75,000
5.	Mechanical	$425,000
6.	Controls	$75,000
7.	Electrical	$150,000
8.	Standby Generator and Transfer Switch	$250,000
9.	Landscaping	$50,000
	Total Construction	$1,495,000
	40% Contingency, Administration & Engineering	$598,000
	Total Project Cost	$2,093,000
	USE	$2,100,000

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

Table B-9
Piping Unit Project Cost[1] Summary

Pipe Diameter	Cost per Linear Foot
8-inch	$132
10-inch	$144
12-inch	$171
16-inch	$209
18-inch	$235
24-inch	$313

Project Cost Assumptions:

Rock excavation required for the bottom two feet of trench depth
No dewatering
No property or easement acquisitions
No specialty construction included
A 40% contingency, administration and engineering allowance included
Construction by private contractors
An Engineering News Record (ENR) construction cost index CCI for Seattle, Washington of 8630 (October 2006).
Add an additional 35% for construction with rock excavation the entire depth of trench

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

Table B-10
Piping Improvements
Project Cost Estimate Summary

Distribution and Fire Flow Capacity Improvements			
Map ID	**Length (feet)**	**Size (inches)**	**Estimated Project Cost [1]**
D-1	2,510	12	$429,200
D-2	960	16	$218,900
D-3	390	12	$66,700
D-4	820	12	$140,200
D-5	1,780	16	$405,800
D-6	820	10	$118,100
D-7	310	12	$53,000
D-8	110	12	$18,800
D-9	2,030	10	$292,300
D-10	110	8	$14,500
D-11	1,510	12	$258,200
D-12	130	12	$22,200
D-13	590	12	$100,900
D-14	3,530	10	$508,300
D-15	1,930	12	$330,000
D-16	160	8	$21,100
D-17	950	8	$125,400
D-18	130	8	$17,200
D-19	2,110	12	$360,800
D-20	170	10	$24,500
D-21	1,100	12	$188,100
D-22	1,130	8	$149,200
D-23	570	12	$97,500
D-24	440	16	$100,300
D-25	1,670	12	$285,600
D-26	2,220	10	$319,700
D-27	150	8	$19,800
D-28	530	8	$70,000
D-29	370	8	$48,800
D-30	380	8	$50,200
D-31	210	12	$35,900
D-32	390	10	$56,200
D-33	860	8	$113,500
D-34	270	12	$46,200
D-35	420	8	$55,400
D-36	660	8	$87,100
D-37	1,000	12	$171,000
D-38	1,640	12	$280,400
D-39	800	10	$115,200
D-40	650	10	$93,600
D-41	1,300	16	$296,400

Map ID	Length (feet)	Size (inches)	Estimated Project Cost [1]
D-42	320	10	$46,100
D-43	1,,600	16	$364,800
D-44	960	8	$126,700
D-45	950	16	$216,600
D-46	500	8	$66,000
D-47	790	10	$113,800
D-48	520	10	$113,760
D-49	380	8	$50,200
D-50	1,590	12	$271,900
D-51	100	8	$13,200
D-52	1,040	10	$149,800
D-53	650	10	$93,600
D-54	1,880	16	$428,600
D-55	1,600	16	$364,800
D-56	1,980	10	$285,100
D-57	1,610	12	$275,300
D-58	2,850	10	$410,400
D-59	2,180	10	$313,900
D-60	340	8	$44,900
D-61	770	10	$110,900
D-62	1,430	8	$188,800
D-63	1,500	8	$198,000
D-64	330	8	$43,600
D-65	990	8	$130,700
D-66	1,380	8	$182,200
D-67	1,020	8	$134,600
D-68	480	8	$63,400
D-69	340	8	$44,900
D-70	120	8	$15,800
D-71	540	8	$71,300
D-72	290	8	$38,300
D-73	1,010	8	$133,300
D-74	300	10	$43,200
D-75	580	8	$76,600
D-76	1,980	8	$261,400
D-77	630	8	$83,200
D-78	310	8	$40,900
D-79	270	12	$46,200
D-80	460	12	$78,700
D-81	300	8	$39,600
D-82	320	8	$42,200
D-83	1,440	12	$246,200
D-84	510	8	$67,300
D-85	440	8	$58,100
D-86	470	8	$62,000
D-87	370	8	$48,800

Map ID	Length (feet)	Size (inches)	Estimated Project Cost [1]
D-88	420	8	$55,400
D-89	1,290	10	$185,800
D-90	150	10	$21,600
D-91	210	10	$30,200
D-92	310	8	$40,900
D-93	830	8	$109,600
D-94	200	8	$26,400
D-95	1,080	8	$142,600
D-96	580	8	$76,600
D-97	2,460	8	$324,700
D-98	1,370	10	$197,300
D-99	1,280	8	$168,960
D-100	1,250	12	$213,800
D-101	1,960	10	$282,200
D-102	2,760	16	$629,300
D-103	1,620	10	$233,300
D-104	300	10	$43,200
D-105	170	12	$29,100
D-106	250	8	$33,000
D-107	2,820	18	$723,300
D-108	780	16	$177,800
D-109	380	8	$50,200
D-110	1,230	8	$162,400
D-111	1,120	8	$147,800
D-112	2,330	12	$398,400
D-113	190	12	$32,500
D-114	400	10	$57,600
D-115	1,410	10	$203,000
D-116	3,190	8	$421,100
D-117	310	12	$53,000
D-118	420	8	$55,400
D-119	620	10	$89,300
D-120	710	8	$93,700
D-121	830	12	$141,900
D-122	1,360	8	$179,500
D-123	1,510	8	$199,300
D-124	470	8	$62,000
D-125	1,070	8	$141,200
D-126	880	8	$116,200
D-127	730	8	$96,400
D-128	250	10	$36,000
D-129	260	8	$34,300
D-130	650	8	$85,800
D-131	100	10	$14,400
D-132	340	8	$44,900
D-133	370	10	$53,300

Map ID	Length (feet)	Size (inches)	Estimated Project Cost [1]
D-134	60	8	$7,900
D-135	230	8	$30,400
D-136	320	8	$42,200
D-137	250	8	$33,000
D-138	240	8	$31,700
D-139	100	10	$14,400
D-140	390	8	$51,500
D-141	240	8	$31,700
D-142	170	8	$22,400
D-143	410	8	$54,100
D-144	630	12	$107,700
D-145	1,580	8	$208,600
D-146	330	8	$43,600
D-147	300	8	$39,600
D-148	840	10	$121,000
D-149	300	8	$39,600
D-150	180	8	$23,800
D-151	510	8	$67,300
D-152	1,880	8	$248,200
D-153	490	10	$70,600
D-154	230	8	$30,400
D-155	2,060	8	$271,900
D-156	470	10	$67,700
D-157	650	10	$93,600
D-158	160	8	$21,100
D-159	210	12	$35,900
D-160	330	8	$43,600
D-161	2,160	10	$311,000
D-162	220	10	$31,700
D-163	290	12	$49,600
D-164	450	10	$64,800
D-165	860	8	$113,500
D-166	1,010	10	$145,400
D-167	650	8	$85,800
D-168	4,430	12	$757,500
D-169	500	8	$66,000
D-170	1,750	12	$299,300
D-171	1,850	18	$474,500
D-172	550	8	$72,600
D-173	1,000	16	$173,000
D-174	3,220	12	$550,600
D-175	440	10	$63,400
D-176	2,000	8	$264,000
D-177	290	8	$38,300
D-178	1,340	8	$176,900
D-179	1,690	8	$223,100

Map ID	Length (feet)	Size (inches)	Estimated Project Cost [1]
D-180	1,750	8	$231,000
D-181	2,160	8	$285,100
D-182	950	8	$125,400
D-183*	--	--	--
D-184	1,590	16	$275,100
D-185	590	10	$85,000
D-186*	--	--	--
D-187	300	8	$39,600
D-188	280	8	$37,000
D-189	670	12	$114,600
D-190	1,460	8	$192,700
D-191	420	8	$55,400
D-192*	--	--	--
D-193	1,360	10	$195,800
D-194	3,220	10	$463,700
D-195	140	12	$23,900
D-196	180	8	$23,800
D-197	730	8	$96,400
D-198	720	10	$103,700
D-199	390	8	$51,500
D-200*	--	--	--
D-201	1,440	8	$190,100
D-202	190	8	$25,100
D-203*	--	--	--
D-204	220	24	$75,200
D-205	470	8	$62,000
D-206	1,470	12	$251,400
D-207	620	8	$81,800
D-208	1,190	12	$203,500
D-209	690	12	$118,000
D-210	380	10	$54,700
D-211	720	10	$103,700
D-212	720	8	$95,000
D-213	450	8	$59,400
D-214	460	12	$78,700
D-215	540	12	$92,300
D-216	560	12	$95,800
D-217	1,860	10	$267,800
D-218*	--	--	--
D-219*	--	--	--
D-220	1,010	10	$145,400
D-221	900	8	$118,800
D-222	1,640	10	$236,200
D-223	1,130	10	$162,700
D-224	820	10	$118,100
D-225	310	10	$44,600

Map ID	Length (feet)	Size (inches)	Estimated Project Cost [1]
D-226	1,320	10	$190,100
D-227	650	10	$93,600
D-228	1,180	8	$155,800
D-229*	--	--	--
D-230	560	8	$73,900
D-231	840	10	$121,000
D-232	800	10	$115,200
D-233	120	12	$20,500
D-234	240	8	$31,700
D-235*	--	--	--
D-236	540	8	$71,300
D-237	890	10	$128,200
D-238	1,320	10	$190,100
D-239	1,610	12	$275,300
D-240*			
D-241	380	8	$50,200
D-242	600	8	$79,200
D-243	80	8	$10,600
D-244	1,190	12	$203,490
D-245	370	10	$53,300
D-246	620	10	$89,300
D-247*	--	--	--
D-248	360	8	$47,500
D-249	280	10	$40,300
D-250	240	12	$41,000
D-251	110	8	$14,500
D-252	1,680	12	$287,300
D-253*	--	--	--
D-254*	--	--	--
D-255	690	10	$99,400
D-256	240	10	$34,600
D-257*	--	--	--
D-258*	--	--	--
D-259	170	12	$29,100
D-260	190	10	$27,400
D-261	190	10	$27,400
D-262	970	12	$165,900
D-263	160	10	$23,000
D-264*	--	--	--
D-265	110	8	$14,500
D-266*	--	--	--
D-267	680	8	$89,800
D-268	1,050	8	$138,600
D-269	430	12	$73,500
D-270	260	8	$34,300
D-271	920	12	$157,300

Map ID	Length (feet)	Size (inches)	Estimated Project Cost [1]
D-272	2,720	8	$359,000
D-273	1,530	8	$202,000
D-274	2,760	8	$364,300
D-275	750	10	$108,000
D-276	640	12	$109,400
D-277	440	12	$75,200
D-278	2,400	12	$410,400
D-279	4,100	16	$709,300
D-280	6,900	16	$1,193,700
D-281	2,600	12	$444,600
		Distribution and Fire Flow Sub-Total	$37,389,110
		USE	***$37,400,000***
Transmission Capacity Improvements			
T-1	2,490	24	$851,600
T-2	3,470	24	$1,186,700
T-3	2,060	24	$704,500
T-4	7,870	36	$4,037,300
T-5	2,260	24	$772,900
T-6	370	24	$126,500
		Transmission Capacity Sub-Total	*$7,679,500*
		USE	***$7,680,000***
		GRAND TOTAL	**$45,080,000**

* Unused numbers

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

Table B-11
Proposed Pressure Reducing Stations
Project Cost Estimate Summary

Map ID	General Location	Size (inches)	Estimated Project Cost [1]
PRV1	Jill	8	$90,000
PRV2	Skyline Ranch	6	$75,000
PRV3	Aurora	8	$90,000
PRV4	Brogan Pl.	8	$90,000
PRV5	Flagline	8	$90,000
PRV6	Trenton Ave.	8	$90,000
PRV7	Emkay St.	6	$75,000
PRV8	Creek Rd.	8	$90,000
PRV9	Yates Dr.	6	$75,000
PRV10	Revere Ave.	6	$75,000
PRV11	Seward	6	$75,000
PRV12	Chase Rd.	8	$90,000
PRV13	Awbrey Rd.	6	$75,000
Total			**$1,080,000**

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will

depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

APPENDIX C
WATER RIGHTS SUMMARY

A tabular summary of the water rights held by the City of Bend are included in this appendix. The data presented in Table C-1 is summarized from water rights information presented in the City's Water Management and Conservation Plan (Economic and Engineering Services, Inc., October 2004) and the Initial Assessment of Water Supply and Mitigation Alternatives (Newton Consultants, Inc., September 2003). This data is presented herein to provide a record of the status of the water rights held by the City for the water supply sources discussed throughout this plan.

Table C-1
City of Bend Water Rights Summary

Source Type	Facility Name	Application, Permit or Certificate	Priority Date	Authorized Pumping Rate (cfs)	Total Rate (cfs) (mgd)	Status	Comments
Groundwater	Lava Island Wells	Permit G-4435	11/8/1968	7.75	7.75 (5.01)	Permit	No development under this right completed to date.
	Outback Wells	Permit G-11380	9/7/1990	10	10 (6.46)	Permit	
	Airport Well/Bear Creek #1						T-7845 & T-7852
	River Well #1 & 2	Permit G-4946	10/31/1971	2.7	16.04 (10.36)	Permit	
	River Well #1 & 2			0.9		Certificate 68702	Partially Perfected G-4946
	Pilot Butte #1 & 2			7.57		Permit	T-7009
	Copper Stone (Awbrey Glen)					Permit	
	Bear Creek #1 & 2			4.87		Permit	T-9408
	Westwood Well	Permit G-8565	12/22/1978	2.45	2.45 (1.58)	Permit	
	Rock Bluff Wells	G-11379	6/30/1989	8	8 (5.17)	Permit	
	Pilot Butte #3						T-8342
	Bear Creek 1, 2 & 3	Application 13097	8/22/1992	12	12 (7.75)	Pending	Subject to mitigation
	Pilot Butte 1, 2 & 3	Application 13098	8/22/1992	12	12 (7.75)	Pending	Subject to Mitigation
	Total Permitted and Pending Ground Water Rate				*68.24 cfs (44.08 mgd)*		
	Total Current Permitted Ground Water Rate				**44.24 cfs (28.58 mgd)**		
Surface Water	Bridge Creek	S-49823	12/12/1983	15	15.00 (9.69)	Permit	Junior right, unavailable during irrigation season
	Tumalo Creek	Court Decree	First Priority	6	21.113 (13.64)	Decree	Unrestricted
		S-31411	9/30/1900	4.5		Certificated	Limited during summer season based on Tumalo Creek flow.
			8/5/1900	2			
			6/1/1907	0.02			
		S-31665	9/30/1900	1.314		Certificated	
			4/28/1905	0.186			
			6/1/1907	1.103			
		Transfer B-112	10/29/1913	5.99		Certificated	
	Total Permitted Surface Water Rate				*36.113 cfs (23.33 mgd)*		
	Total Reliable Surface Water Rate Available to Supply MDD				**11.72 cfs (7.6 mgd)**		



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Optimatics

optimizing water systems

Water System Master Plan Update
Optimization Study

City of Bend, Oregon, Project No. WA09FA

Final Report

February 2011

Prepared by Optimatics in association with:

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

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Appendix D – Operations Optimization Report

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Executive Summary

The purpose of this report is to present the recommendations resulting from the Water Master Plan Update Optimization Study undertaken by Optimatics. The report outlines relevant data, constraints, assumptions and methodology employed in the development of the recommended Final Build-out Solution and Capital Improvement Plan (CIP). This study and report builds on the previous 2007 Water Master Plan Update developed by Murray, Smith & Associates, Inc. (MSA).

Authorization

Optimatics and sub-consultant MSA received authorization to undertake the Water Master Plan Update Optimization Study (City Project No. WA09FA) in March 2009.

Compliance

This report and the Water Master Plan Update Optimization Study are not intended to be a complete Master Plan as defined under Chapter 333, Division 61, of the Oregon Administrative Rules (OAR). Items the report does not cover in significant detail are:

- Status of water rights
- Current status of drinking water quality, compliance with regulatory water quality standards and future plans for water treatment
- Financing program for constructing improvements (e.g. user rates, system development charges, finance programs)

This report does cover level of service goals, present and future deficiencies, assessment of fire flow capacity in the system and the results of a comprehensive analysis using an optimized decision support process to evaluate alternatives that address system deficiencies now and in the future. The results of this study are a recommended set of system improvements to meet the needs of the system for at least 20 years. In addition, an associated implementation plan for the next 10 years is provided. The recommendations cover supply, storage, distribution facilities, and system operation.

Planning Period

The improvements recommended in this study cover the period from today until build-out. The CIP presented in Section 3 addresses the next 10 years of development to the year 2020.

Study Area and Existing System

The City of Bend, located in Central Oregon, serves approximately 75,000 residents. The City is fortunate to be located near water sources with excellent quality – groundwater from the substantial Deschutes Aquifer and surface water collected from the Cascade Mountains. Surface water supply is collected 13 miles from the City limits and delivered to the system via the Outback facility. Groundwater is extracted at nine well locations spread across the City. Facilities include 25 groundwater wells, 15 finished water storage reservoirs, 6 booster pump stations and approximately 420 miles of transmission and distribution mains. The Bend system is operationally complex; there are 80 control valve stations serving 7 primary pressure zones and numerous sub-zones.

Optimized Decision Support Process

For this Water Master Plan Update Optimization Study, the City employed an optimized decision support process to assist in the development of an unbiased, low-cost improvement plan based on the best available

data. An optimized decision support process involves all of the traditional planning steps including data collection, development of unit costs, hydraulic model update and calibration, and model analysis to evaluate different alternative solutions that will allow the system to meet demands in the future. Using optimization to assist the planning process allows for many more alternatives to be evaluated compared to trial-and-error modeling. This provides a number of benefits including a higher level of transparency in the recommended improvements, a better understanding of the impacts of different decisions and greater confidence that the plan represents the lowest-cost option considering both capital costs and life-time operating costs.

Project Scope

This comprehensive study involved a number of work steps:

Task 1 – Calibrate City of Bend Dynamic Water Model. The model update and calibration process was undertaken by Murray, Smith & Associates, Inc. (MSA) and is documented in their report titled *Water Model Development Documentation for Water System Optimization* (January 2011 – Appendix A)

Task 2 – Consequence of Failure Analysis. The consequence of failure analysis involved evaluation of the impact of pipe break events and isolation of breaks system-wide, with the aim of assisting the City to identify the areas of the system which are the most vulnerable (see Appendix B).

Task 3 – Development of the Optimization Model. This included development of the Design Data Summary (DDS) Report (Appendix C) and formulation of the optimization model to consider capital and operating decisions to meet current and future needs.

Task 4 – Optimization Study. The Optimization Study consisted of two parts – the first was an analysis of current system summer and winter operations (see Appendix D), and the second was the development of an optimized plan meeting build-out demand conditions.

Task 5 – Staged Implementation Plan. Evaluation of both the recommended existing fire flow improvements and the Build-out Master Plan improvements resulted in the development of a sequence of implementation that will ensure the system continues to provide adequate level of service and reliability in the near-term.

This report focuses on the outcomes of future plan development in Task 4 and the CIP developed in Task 5. Documentation related to Tasks 1 through 3, and the Operations Optimization is contained in the report appendices as noted.

Planning assumptions and criteria

The recommendations in this study were developed using specific design criteria that defined satisfactory system operation. These included minimum allowable pressure under both normal operation and fire flow conditions and maximum allowable velocity. A significant effort was made to develop a set of guidelines for the City to use with regards to emergency storage. The City chose to adopt the Washington Design Guidelines as the basis for defining storage requirements specific to the City of Bend to be used in this study.

A major assumption influencing the recommended Final Build-out Solution was the capacity of the surface water source. At the commencement of this study the City was investigating the potential of expanding the source to a maximum capacity of 23 MGD/36 cfs. It was agreed that the optimization analysis should determine how best to integrate this additional supply. However, later in the study it was revealed that the capacity of the surface water source would likely be much less; only 13.5 MGD/21 cfs. This information came to light after the Final Build-out Solution was finalized. The impact of a reduced surface water supply capacity (13.5 MGD/21 cfs) was evaluated as part of the development of the 10-year implementation plan.

Water demands

The projected water demands used in this study were developed by MSA. The average day, maximum day and peak hour demands for the existing, 10-year and build-out scenarios are summarized in Table E.1. MSA also analyzed historical data to develop diurnal patterns for extended period simulation and an appropriate peak hour demand factor to be used in this study.

The build-out demand values were developed based on medium residential development density within the proposed future urban growth boundary (UGB). The 10-year demand projection represents an approximately linear interpolation between current demand and projected build-out demand. The distribution of the 10-year demand was applied assuming that half of the growth in water demand to reach build-out demand at medium density within the current system facilities area (i.e. the existing UGB) will be realized.

Table E.1 – Projected future water demand summary

Year	Water Demand (MGD)		
	Average Day Demand (ADD)	Maximum Day Demand (MDD)	Peak Hour Demand (PHD)
2008 (1)	12.8	29.2	48.0
10-year projection (2)	21.7	48.8 (4)	87.9 (5)
Build-out Development (3)	37.1	83.5 (4)	150.3 (5)

Notes to Table E.1:

(1) Existing ADD, MDD & PHD based on 2008 water production records.

(2) 10-year ADD developed assuming half of the growth to meet build-out demand at medium density development would be realized within the existing UGB, plus half of growth to meet Tetherow build-out demand and Juniper Ridge at 294 acres.

(3) Build-out ADD assumes medium density development across the proposed UGB, plus Tetherow at 889 residential units and Juniper Ridge at 515 acres.

(4) MDD equals ADD x 2.25 (based on historical data, see Table 3.2 in the DDS report).

(5) PHD based on comparison of recorded peak hour and maximum day production values from 2008 and 2009. PHD:MDD factor agreed at 1.8.

Existing and future deficiencies

As part of this study, modeling analyses were undertaken to identify existing deficiencies in the Bend system. The consequence of failure analysis provided an indication of areas which are vulnerable to pipe break and isolation events. A system-wide fire flow analysis was conducted under existing and future demand conditions to determine where there are restrictions in the distribution system and the appropriate size for replacement pipes. When considering the future demand projections, a broad suite of improvement options were identified in discussions with City staff that would enable transmission of flow to growth areas in the system.

Recommended improvements

The recommended improvements were developed using a 'build to target' approach. This involves sizing capital improvements to meet projected build-out demands and then selecting the date of implementation for

the recommended improvements to enable to system to meet the desired level of performance in the interim years. The Final Build-out Solution consists of new supply, pipe, pump and storage facilities and is designed to meet the required design criteria under future maximum day demands.

The estimated cost of the improvements is presented in Table E.2. As mentioned above, the Final Build-out Solution was developed under the assumption that the surface water source would contribute 23 MGD/36 cfs. At the time of writing this report, the anticipated maximum flow from the surface water source at build-out is much less; only 13.5 MGD/21 cfs. For consistency, Table 2.18 shows the estimated cost of the surface water source at 13.5 MGD. The additional supply that was assumed to come from this source (9.5 MGD) has been included as a second line item and is assumed to be met from wells.

Table E.2 – Total Capital Costs – Final Build-out Solution

Cost Item	Cost
"Surface Water Supply"	
13.5 MGD, membrane treatment, no hydro[1]	$57,750,000
Additional supply to meet 23 MGD (9.5 MGD)[2]	$12,825,000
New Groundwater Wells (35.7 MGD)	$45,490,000
New Storage (14.5 MG)	$24,130,000
New Pipe Improvements for Growth	$43,625,000
Pipe Improvements for Fire Flow	$11,458,000
Pump Station Expansion	$1,744,000
New Valves	$600,000
TOTAL	**$197,622,000**

1) As per HDR Memo *Surface Water / Groundwater Cost Comparison, DRAFT*, September 2010. Costs for all other items are based on 2009 Unit Costs developed by MSA (October 2009). Estimated 2010 dollars for Surface Water Supply and 2009 dollars for remaining cost items are assumed equivalent and called 2009 dollars.

2) Assume met from additional wells at Outback, $1.35 million per MGD

The final step in this study was the phasing of improvements in the Final Build-out Solution over the next 10-years. Table E.3 summarizes the improvements that are recommended to meet increasing demands over the next 10 years. The improvements are broken down into pipe, well and storage improvements. No booster pump station upgrades are needed within the next 10 years. In addition to the improvements selected by the optimization, three emergency valves are recommended for implementation in the 10-year timeframe. Note that Table E.3 does not address improvements in the South Bend area as these were not evaluated as part of the optimization analysis (refer to Section 3.2.1 for more details). Table E.3 also does not include the cost of existing fire flow improvements, addressed below.

Figure E.1 shows a timeline of projected maximum day demand and recommended supply capacity increases for the next 10 years.

Table E.3 – Master Plan Improvements – Phasing for 10-year period
(Full details of these improvements can be found in Appendix G)

Year	MDD (MGD)	ADD (MGD)	Pipes	Cost	Tanks	Capacity	Cost	Wells	Capacity	Cost	Total Cost
Now	29	12.8	Juniper Ridge 16-inch connection on 18th *	$1,292,000							$1,292,000
2011	31	13.8	Tetherow improvements – B (Skyline Ranch 18-inch main) *, T (reconfiguration of the customers on the suction side of Tetherow PS). Open Zone 4J/4A boundary	$1,434,000							$1,434,000
2012	33	14.7	Extend larger diameter pipe out of Pilot Butte on Lafayette to 11th, piping associated with new Awbrey well	$241,000				Awbrey	1.5 MGD	$1,944,000	$2,185,000
2013	35	15.6	New parallel pipe near College PS in Level 3, new Level 5 pipe connection on Roanoke; site and discharge piping for new Level 5 Well east of Pilot Butte	$1,169,000				New Level 5 A (In vicinity of Shirley Ct)	2 MGD	$2,721,600	$3,890,600
2014	37	16.4	Parallel piping from Rock Bluff to Brookswood	$1,535,000							$1,535,000
2015	39	17.3	Continue parallel piping from Rock Bluff to Brosterhous; open Zone 4B/4I boundary at Reed Market	$2,940,000				Shilo	2 MGD	$2,721,600	$5,661,600
2016	41	18.2	Parallel mains on Brosterhous and Reed Market, replace piping along Wilson in Zone 4B	$1,742,000				New Level 6 (Butler Market/ Brinson Blvd)	1 MGD	$1,360,800	$3,102,800
2017	43	19.1	Extend larger diameter piping out of Pilot Butte on Lafayette from 11th to 8th	$402,000				New Level 5 A	2 MGD	$2,721,600	$3,123,600
2018	45	20.0	Parallel piping in Level 6 – Boyd Acres and Brinson Blvd; piping for Level 6 Well at Butler Market Well; New Pilot Butte tank connection	$1,364,000	Pilot Butte 4	3 MG	$5,807,000	New Level 6	2 MGD	$2,721,600	$9,892,600
2019	47	20.9	Replace existing pipe along 8th from Lafayette to Seward	$1,000,000				New Level 5 A	1 MGD	$1,360,800	$2,360,800
2020	49	21.8	Parallel main on Glassow and new main on Summit in Level 2; Replacement of piping on Norton and Olney in Level 5	$1,366,000				New Level 6	2 MGD	$2,721,600	$4,087,600
TOTAL				$14,485,000			$5,807,000			$18,273,600	$38,565,600
								Including 3 new valves		$225,000	**$38,790,600**

Note: All costs are based on 2009 unit costs developed by MSA (October 2009)

* Although it is understood that these improvements (Skyline Ranch Rd – Tetherow and 18th - Juniper Ridge) will be covered by the developer(s), full costs are presented here.

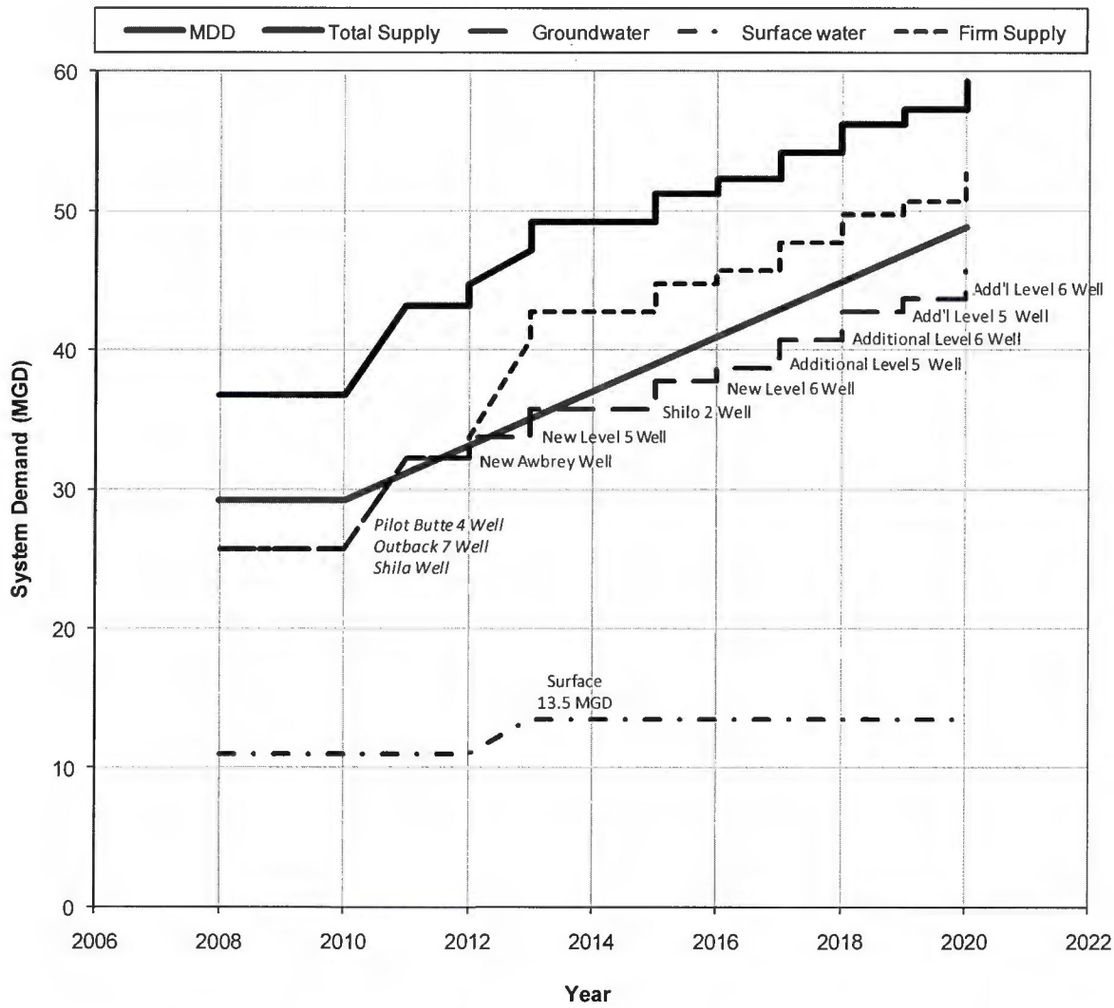


Figure E.1 – Projected MDD and supply capacity increases to year 2020

The fire flow improvements were treated separately. The cost of fire flow improvements to address existing deficiencies is $9.5 million (refer Appendix H). To assist in prioritizing the improvements, an 'available' fire flow analysis was performed to determine how much flow can be taken from the system at any point without drawing system pressures below 20 psi. The fire flow improvements were prioritized based on the following drivers:

- Only improvements addressing deficient hydrants in the existing system were included
- Initial sorting was based on the extent of flow deficiencies relative to zoned fire flow requirements. Further prioritization will be performed by the City of Bend.
- Information about the associated benefit, such as the number of customer parcels impacted by the improvement has been included in the analysis

Conclusions and Recommendations

It is recommended that the City adopt the recommendations in this study for the CIP and develop a financing plan for their implementation. The City should be aware that the improvements have been developed using a number of key assumptions. Changes to these assumptions may significantly affect the recommendations. In particular, the following assumptions influenced the recommended plan:

- **The rate and location of development and demand growth** – it was assumed that early growth would be located in the southeast, tied to the completion of the Southeast Interceptor
- **Surface water source capacity and timing of delivery system improvements** – as discussed in the report, there were changes to the surface water supply assumptions during this study. At this time it is uncertain what the capacity of the surface water supply will be in the future. The 10-year plan assumes a capacity of 13.5 MGD while the Final Build-out Solution was based on an ultimate capacity of 23 MGD. Any additional supply that is not realized will need to be made up by new wells. The location of these new wells may impact the associated transmission improvements. The costs presented here assume all additional groundwater would be located at Outback; no additional transmission costs are included for these wells.
- **Location of groundwater wells; issues of contamination and 2-year time of travel** – the issue of groundwater contamination was discussed at project meetings during this study but it was decided that new well locations should not be discounted based on this potential future restriction. If the restriction does come into force it will likely affect both existing and proposed new well locations and will have a significant impact on the system that extends beyond the issues of growth and supply addressed in this study.

Regardless of whether there are significant changes to the above assumptions, the City should review and update this plan within the next five to seven years.

The benefits of this study have been far reaching. At the outset, the City acknowledged that previous planning efforts had relied on data of variable quality. In addition, there had been little input from City Operations staff into the planning process. This study allowed the City to capitalize on its accomplishments in improved system data quality to develop a capital infrastructure plan that the City can be confident in. Also, Operations staff were involved throughout the study and provided valuable input and feedback. In addition to developing a set of improvements that meet future demands at least cost, the study provided insight into how to best operate the existing system to minimize energy costs and identified where the system is most vulnerable to pipe break events. The optimized decision support process allowed the City to investigate a wide range of options and test alternative scenarios related to well and storage locations, zone boundary modifications, how to address existing deficiencies and where it makes most sense to place new infrastructure based on the assumed timing and location of demand growth.

1 Introduction and Background

In March 2009, Optimatics and Murray, Smith & Associates, Inc. (MSA) were engaged by the City of Bend (the City) to undertake a comprehensive review and optimization of the City's Water Master Plan. MSA recently completed the Water System Master Plan (WSMP) Update in March 2007. The current study, referred to as the WSMP Update Optimization Study, involved reconstruction and calibration of the hydraulic model, assessment of pipe criticality, optimization of current operations for winter (representing non-irrigation season) and summer (representing irrigation season); and optimization of future infrastructure requirements.

1.1 System Background

The City of Bend is located east of the Cascade Mountains in Central Oregon. The climate is high desert with typically mild winters and warm dry summers. The City's population is approximately 81,000 and the City is responsible for delivery of potable supply to over 22,000 service connections, representing approximately 62,000 people served (2008 values, as per Bend Draft Water Management and Conservation Plan, 2011). Two other water providers serve potable water to customers in areas adjacent to the City's system – Roats Water System and Avion Water Company (see Figure 1.1).

The City is fortunate to be located near to water sources with excellent quality – groundwater from the substantial Deschutes Aquifer and surface water collected from the Cascade Mountains. Very little treatment of these supplies is required before delivery to customers.

Surface water supply is collected from an intake at Bridge Creek, 13 miles from the City limits. Bridge Creek flows are supplemented via an existing diversion of a natural spring that flows into the middle fork of Tumalo Creek. Transmission mains deliver this raw water supply from the intake at Bridge Creek to the Outback site where disinfection is carried out prior to distribution.

Bend currently operates 9 groundwater facilities throughout its service area, consisting of 25 wells which pump Deschutes Aquifer water to the system. Emergency interties also exist with the neighboring Avion and Roats water systems. The distribution system consists of approximately 420 miles of water main, 15 storage reservoirs and 6 booster pump stations. A large number of pressure reducing valves (PRVs) exist to limit maximum pressures in the system.

Elevations generally decrease from the foothills in the west towards the east and northeast. The Deschutes River crosses the city centrally from south to north. There are several prominent buttes in the service area. The distribution system is divided into a number of pressure levels based on elevation and the aim of maintaining service pressures between 40 pounds per square inch (psi) to 80 psi.

The highest level, Level 1, is located on Awbrey Butte. Supply from the Outback Reservoirs enters the system at Level 3 and is delivered to the Overturf Reservoirs and Awbrey Reservoir. Booster pumps lift to Levels 1 and 2. Levels 3, 4 and 5 are supplied via a combination of gravity surface water supply and groundwater pumping and Levels 6 and 7 are supplied from higher levels via PRVs. Level 4 is split into an east and a west section along the Deschutes River. There are a number of other small pressure zones near Awbrey Butte and Overturf, and along the eastern edge of the system.

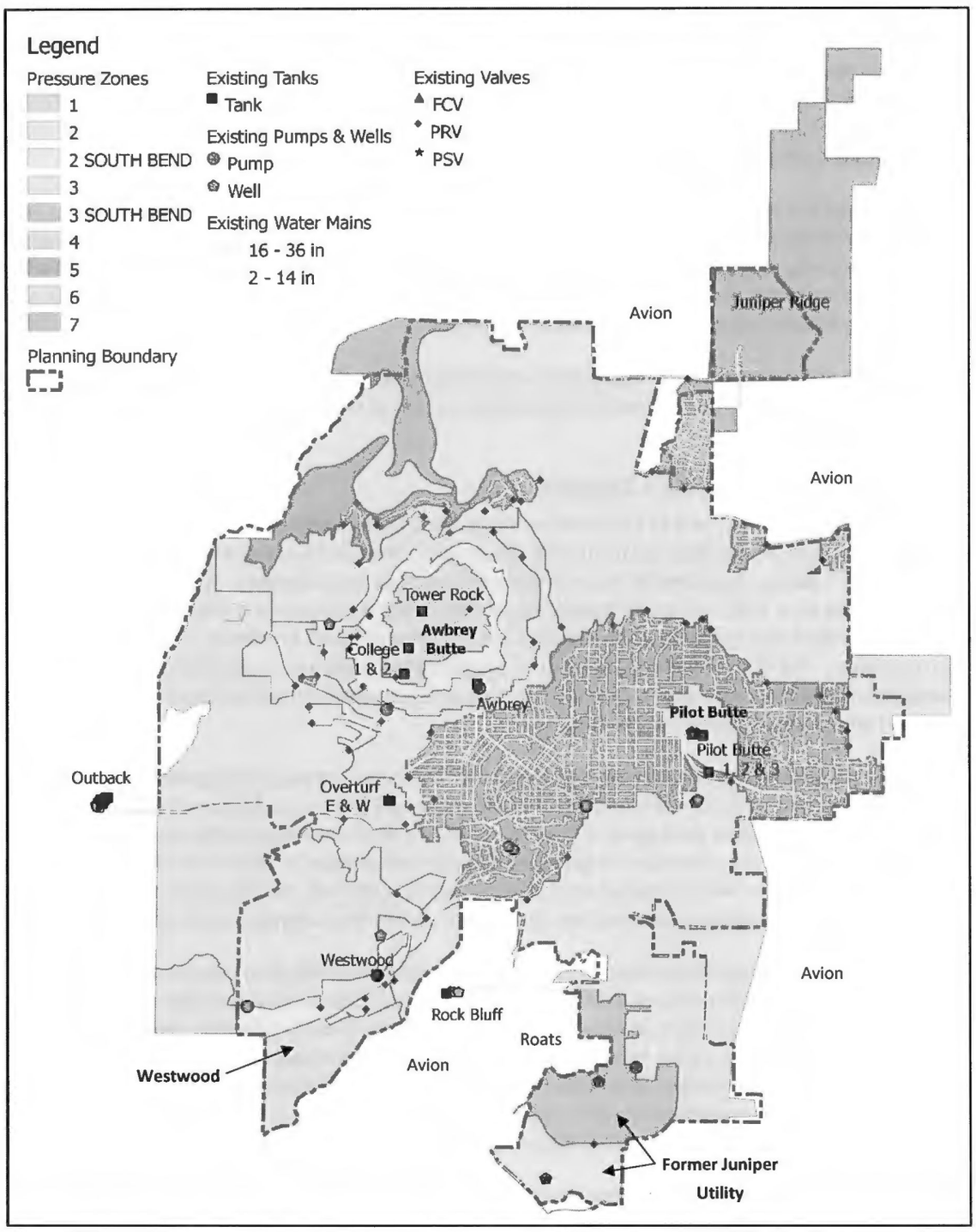


Figure 1.1 – Bend service area showing pressure levels and major supply and storage facilities

Over the last several years Bend has acquired two services areas: the Westwood Service area in the southwest corner of the system and the former Juniper Utility service area located in the southeast corner. The Juniper system, now typically referred to as South Bend, consists of two pressure levels which have similar hydraulic grades to Levels 2 and 3 in the main system. These southern areas are known as Zones 2B and 3D. Two groundwater facilities are located in this area – Hole Ten and Shilo. The new Murphy Pump Station facility connects South Bend to the main system.

The Westwood system (Zone 3C) is supplied from a groundwater well, ground storage and booster pump facility. The storage and booster pump facilities were intended to be temporary; this study has evaluated options for reconfiguring the operation of this zone. A recently commissioned booster station called Tetherow, designed to supply new development in the Tetherow area (Zone 2A), has the ability to supply Westwood if needed via a PRV station at the western end of Westwood.

Compared to many other systems supplying an equivalent number of customers, operation of the Bend Water System is complex, due primarily to the multiple sources of supply, large number of pressure zones and the associated PRVs.

1.2 Optimized Decision Support

For this Water Master Plan Update Optimization Study, the City has employed an optimized decision support process to assist in the development of low-cost, transparent infrastructure recommendations based on the best available data and supported by sound engineering analysis and judgement. The previous Master Plan Update completed in 2007 was a step forward for the City in that it improved on previous efforts; however, the City acknowledged that certain data were lacking and a number of inputs from the City were not coordinated with operations. The City recognized a need for improved data and analysis to provide water system operations recommendations and to ultimately develop a 10 year Capital Improvement Program (CIP) based on sound engineering analysis and planning.

At the time the previous master plan was completed the City was anticipating rapid growth. In the wake of the global financial crisis development effectively stopped, reducing System Development Charge (SDC) funds which support infrastructure development. The City required a better decision-making tool that would allow sound decisions to be made based on engineering analyses and provide confidence to decision makers by answering the myriad of 'what-if' scenario questions. To achieve this end, the City needed to gain a greater understanding of the existing system and how the system performance changes under dynamic conditions.

An optimized decision support process involves all of the traditional master plan steps including data collection, development of unit costs, hydraulic model update and calibration, and model analysis to evaluate different alternative solutions that will allow the system to meet demands in the future. Using optimization to assist the planning process allows for many more alternatives to be evaluated compared to trial-and-error modeling. This provides a number of benefits including a higher level of transparency in the recommended improvements, a better understanding of the impacts of different decisions or events and greater confidence that the plan represents the lowest cost option considering both capital and life-time operating costs.

For this project the optimization technique employed was an evolutionary algorithm based on the theory of natural selection and the survival of the fittest. The genetic algorithm (GA) is able to sort through millions of combinations of improvements, taking into account both cost and hydraulic performance to produce low-cost, hydraulically viable solutions meeting any number of design constraints. Once the optimization has been

formulated for a particular problem it is possible to run a myriad of scenarios testing different 'what-if' scenarios, providing decision makers with confidence in the selected solutions.

The decision support process for this optimization study included numerous points of contact with City staff via meetings and workshops as well as regular teleconference calls. Optimatics solicited staff feedback on the trends of various potential solutions as well as preferences for certain aspects of the solutions. The Project Team of Optimatics and MSA also brought their many years of experience and expertise to bear on each aspect of the study, drawing from strategies and problem-solving approaches which have been successful in their work on other water systems.

1.3 Purpose and Scope

The City's aim with the WSMP Update Optimization Study was to improve upon the 2007 WSMP Update through a model update, pipe criticality analysis, operations optimization and future capital improvements optimization. The intended outcomes of this work included more efficient system operations, improved levels of service and an optimized master plan based on best available data that minimizes capital and associated operating costs of future infrastructure improvements designed to meet future build-out demands. The capital improvement projects to be implemented in the first 10 years of the plan were to be prioritized to meet the City's near-term needs and be compatible with available funding.

This comprehensive study involved the following work steps

Task 6 – Calibrate City of Bend Dynamic Water Model

Task 7 – Consequence of Failure Analysis

Task 8 – Development of the Optimization Model

Task 9 – Optimization Study

Task 10 – Staged Implementation Plan

Task 1 – Calibrate City of Bend Dynamic Water Model

The model update and calibration process was undertaken by Murray, Smith & Associates, Inc. (MSA). MSA's report titled *Water Model Development Documentation for Water System Optimization* (January 2011, **Appendix A**) includes details of the model development from the City's GIS database and the calibration effort including spatial distribution of existing demands, steady-state and extended period simulation (EPS) analyses. The model update process ensured a one-to-one relationship with the GIS database, bringing value to the City not only for the tasks of this project but for all future uses of the model. Calibration of the Summer EPS Model was completed in September 2009. The calibration of the Winter EPS model was revised in January 2010 after new data was collected in December 2009.

As part of an amendment to the project, MSA also developed revised demand projections for build-out and year 2020. The new demand projections were necessary given the changes to the hydraulic model since the 2007 Master Plan Update was completed. Details of the demand projection are included in the MSA report. A summary of information in MSA's report that is pertinent to this study is provided in Sections 2.1 and 2.2. The full report is provided in **Appendix A**.

Task 2 – Consequence of Failure Analysis

The Consequence of Failure Analysis (Task 2) was performed during 2009 using an early version of the updated model developed by MSA. This model was a calibrated steady-state model. The consequence of failure analysis involved evaluation of the impact of pipe break events and isolation of breaks system-wide, with the aim of assisting the City to identify the areas of the system which are the most vulnerable.

In order to complete this analysis the model needed to include all the system shut-off valves; these are not usually included in a hydraulic model. The effort to ensure the model had a 1-1 relationship to the City's GIS data made the process of importing the shut-off valves straightforward.

The results of the consequence of failure analysis included the identification of vulnerable areas of the system and prioritization of each area based on factors such as impact to critical customers, number of customers affected and the extent of the hydraulic consequences such as resulting low pressures in the event of break or isolation. The results of these analyses were presented in a project update meeting on December 9, 2009. The final memorandum (March 2010) describing the outcomes of the analysis is provided in **Appendix B**.

Task 3 – Development of the Optimization Model

Task 3 included the development of the Design Data Summary (DDS) Report and agreement on the data, constraints and options to be considered in the optimization analysis. A number of revisions were made to this document as the study progressed and new information came to light. The final version of the DDS Report (March 2010) is provided in **Appendix C**; however, critical information is also included in the body of this report.

Task 4 – Optimization Study

The Optimization Study consisted of two parts – the first was an analysis of current system operations for winter (non-irrigation season from October 15 – April 15) and summer (irrigation season from April 15 to October 15). The second analysis was the development of an optimized master plan meeting build-out demand conditions. The master plan optimization analysis built upon the formulation and results of the operations optimization analysis.

Due to the extreme differences in demand between the two seasons, the initial Operations Optimization considered both summer and winter operating conditions. The aim of the Operations Optimization was to determine operational settings for wells, pumps, and valves that would minimize overall energy costs while maintaining current levels of service. A secondary aim was to improve water quality in storage reservoirs through increased turnover, particularly in the winter. The results of these analyses were initially presented and discussed with the City on December 9, 2009. A final set of optimization runs incorporating feedback from the City was completed and the results presented at a project workshop on March 17, 2010. The final memorandum outlining the outcomes of the Operations Optimization for summer and winter operations (September 2010) is provided in **Appendix D**.

This Final Report describes the formulation and summarizes the results and key trends of the second analysis, the final Build-out Optimization runs. The aim of the Build-out Optimization was to determine optimal capital improvement solutions, together with operational recommendations, which will enable the water system to effectively meet the projected demand, storage, and supply requirements at build-out. Within this aim, the optimized solutions were designed to maximize use of available surface water supply, adhere to

Bend's water rights for surface water and for groundwater, provide sufficient storage in the system to meet future operational needs, and required storage for standby, emergency and fire flow needs.

As an addendum to the original scope of work, a comprehensive fire flow deficiencies analysis was completed for both existing and build-out demand conditions. This analysis led to the development of a prioritized list of main replacement recommendations in addition to the master plan improvements.

Task 5 – Staged Implementation Plan

A key outcome for the City was a staged implementation plan for the next 10 years. Optimatics has evaluated both the recommended fire flow improvements and the Build-out Master Plan improvements to develop a sequence of implementation that will ensure the system continues to provide adequate level of service and reliability in the near-term. The 10-year Capital Improvement Plan (CIP) is outlined in Section 3.

A number of recent studies undertaken by the City have informed this Optimization study and are included in **Appendix F** of this report, specifically:

MSA, *City of Bend Water System – Tetherow Development: Alternatives Analysis*, January 2011

MSA, *Former Juniper Utility – Proposed Water System Improvements*, January 2011

MSA, *Updated Capital Improvement Project (CIP) Cost Estimates*, June 2010

MSA, *Water System Planning for the Juniper Ridge Development, Bend, Oregon*, September 2009 (included in **Appendix A**)

1.4 Acknowledgements

Optimatics would like to thank City staff for their input and guidance throughout this master planning study. In particular we would like to thank:

Tom Hickmann, P.E.; City Engineer, Assistant Public Works Director

Art Easton; Utilities Water Operations Supervisor

Patrick Griffiths; Water Resources Coordinator

Heidi Lansdowne, P.E.; Project Manager

Spencer Sanvitale; CAD/GIS Supervisor

Ken Vaughan; Modeling staff

In addition, significant support has been provided by our sub-consultant in this project, Murray, Smith & Associates, Inc. We are very grateful for the assistance of David Stangel, Managing Principal; Dawn Wirz, EIT; and Kyle McTeague, Principal Engineer for the input they have provided to this project.

2 Analysis of Requirements to Meet Build-out Demands

This section outlines the data, constraints, analysis and results of the Build-out Optimization runs. The analysis of the system under build-out demand conditions started in January 2010. Preliminary solutions were presented to the City at a project update meeting in March, and interim results were presented in a conference call in June. During these months there was significant communication among the City, Optimatics, and MSA, with major decisions ultimately made in collaboration with the City about the storage constraints, design peaking factor, and diurnal demand curves. Adjustments and refinements were made to the optimization formulation in accordance with the decisions, and a final set of runs were completed in August, 2010.

2.1 Hydraulic Model

The hydraulic model used in the development of the Build-out Master Plan is based on the calibrated summer extended period simulation (EPS) model developed by MSA, dated September 25, 2009. Full details of the model development and calibration are provided in MSA's report *Water Model Development Documentation for Water System Optimization* (January 2011 – **Appendix A**).

For the existing model, demands were distributed throughout the network based on the location of customer meters. Water meter address data was mapped and associated with the nearest model node serving the customers within each zone. Three demand distributions were ultimately developed; winter, summer and average day. Both the summer and winter demand distributions were analyzed in the Operations Optimization (refer **Appendix D**). This was necessary as demands vary widely over the year and consequently different operating strategies are required. The winter and summer distributions are based on customer billing records from representative months, while the average day distribution is an overall yearly average. In order to create a model for the master planning effort it was necessary to develop a set of demands and appropriate diurnal patterns representing maximum day and peak hour demands. This is discussed in the following section.

The model was developed with a one-to-one relationship to the GIS ensuring consistent identifiers for elements in both databases. To the extent possible this relationship has been maintained in the development of the build-out solutions. For example, if a new pipe splits an existing pipe, the existing pipe ID has been recorded in both sections of the split pipe to ensure it can be cross referenced to the GIS data.

As part of the calibration process MSA took care to ensure all PRV settings at zone boundaries were correctly recorded. The hydraulic model includes relevant operating rules for pumps and valves controlled via SCADA. For the future scenario new controls were added to well and booster pump facilities which the City anticipates will be controlled by SCADA in the future. The exact settings for these controls were evaluated in the optimization.

In order to use the model with Optimatics' optimization program, Optimizer, it was necessary to export the InfoWater model to EPANET format. This was completed using an export facility in InfoWater. The conversion was verified by comparing the hydraulic results from InfoWater and EPANET to ensure an accurate match.

2.2 Demand Forecast – Build-out and 10-year Scenarios

The MSA Water Model Development Documentation outlines development of projected water demands for both the build-out and 10-year (year 2020) demand scenarios.

The future demand forecast and spatial distribution of demands was revised a number of times since the first pass was presented by MSA in November 2009. Water demand projections were developed with consideration for both historical rates of water demand growth and the availability of developable and re-developable land within the existing UGB. Refinements were made to the assumed per capital consumption for residential customers, the per-acre usage rates for non-residential areas, and the spatial distribution of development growth in the early years of development.

The following data are relevant to the demand projections:

Residential demand: 172 gallons per capita day (includes a 10% factor for non-revenue water – the difference between revenue water and system production i.e. water for operational uses, meter inaccuracies, leakage etc.)

Non-residential demand: Assumed 64% of total demand associated with residential demand, 34% non-residential (as per 2008 billing record data). Total amount of non-residential demand calculated from the projected residential demand (Non-residential demand = 0.36/0.64 x Residential demand) and converted into a number of gallons per acre per day (gpapd) based on the projected area of developed non-residential parcels. This equates to 4,000 gpapd at build-out.

Tetherow: Build-out equates to 889 residential units

Juniper Ridge: Water use projections for the Juniper Ridge Development were consistent with those used in the MSA study *Water System Planning for the Juniper Ridge Development, Bend, Oregon* (September 2009) and equate to 4,500 gpapd.

The build-out demand values were developed based on medium residential development density within the proposed planning boundary. The planning boundary was developed in discussions between MSA and City planning and GIS staff. The extents of the existing UGB and the build-out planning boundary are presented in the MSA *Water Model Development Documentation* January 2011 (**Appendix A**), Figure 1.25. Figure 2.1 below presents the existing UGB (red), proposed UGB (blue) and the planning boundary (black) used in the development of the build-out demands. The areas where the planning boundary extends beyond the existing UGB are west and north of Awbrey Butte, and Tetherow. Areas of the existing UGB served by Avion and Roats Water Systems are not included in the City's planning boundary. The expected year at which build-out will be reached was discussed at a number of project meetings. Initially it was proposed that build-out be assumed to occur by the year 2030. However in discussions with City staff it was agreed that, based on the amount of demand in the build-out projection, it is unlikely that this will be realized in 20 years. It was agreed that a fixed year would not be assigned to the build-out projection but that build-out would be defined as the time when system demand reaches the demand associated with medium residential development within the proposed planning boundary.

The 10-year demand projection represents an approximately linear interpolation between current demand and projected build-out demand. The distribution of the 10-year demand was applied assuming that half of the growth in water demand to reach build-out demand at medium density within the current system facilities area (i.e. the existing UGB) will be realized.

The future demands were developed on a parcel basis, necessitating a method to populate the model with the demand information. Within the existing service area, the center point of each parcel was used to join parcel demand to the nearest model node serving the relevant pressure zone. As a result, the distribution of future demand differs slightly from the existing demand distribution, where demand was calculated at customer meters and then connected to the nearest model node.

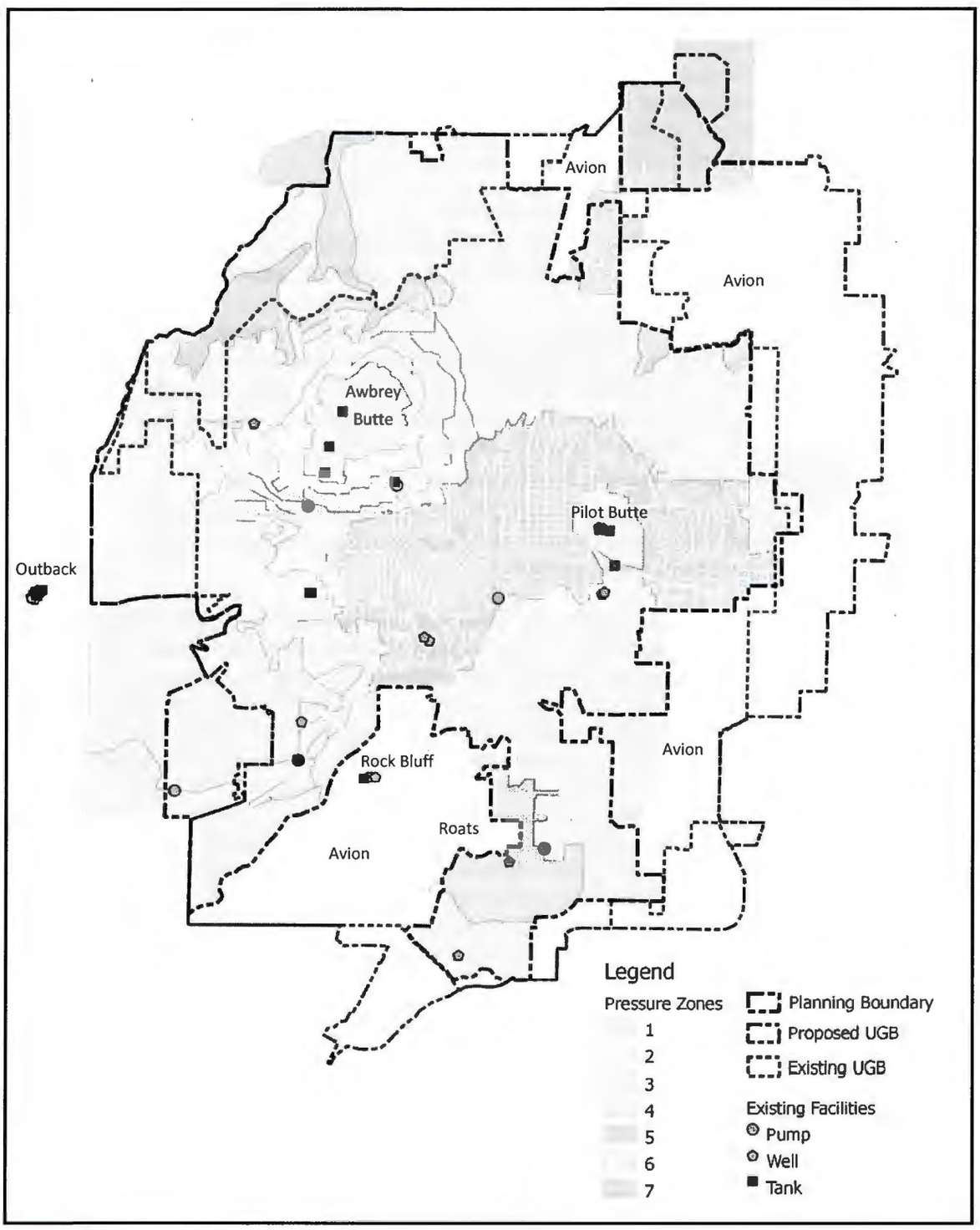


Figure 2.1 – Existing and Proposed UGBs and the Planning Boundary used in this study

The Tetherow and Juniper Ridge developments were treated separately. It was assumed that half of the growth associated with full development of Tetherow would be realized in the 10-year planning horizon. For the Juniper Ridge area it was assumed that Phase 1 (293 acres) would be realized in the 10-year timeframe and Phase 2 (an additional 222 acres) by build-out.

The resulting demand growth is concentrated in the east for the near-term 10 year analysis; 70% of the new demand is associated with Zone 4B, Level 5 and Level 6. The City anticipates near-term growth will occur along the Southeast Interceptor corridor. Development of the area north and west of Awbrey Butte (within the proposed UGB but outside the existing facilities boundary) will require significant new infrastructure, both for potable supply and wastewater collection. This is not seen as likely in the near term and is expected to be driven by developers.

The State of Oregon Department of Land Conservation and Development (DLCD) has advised Bend that their existing Master Plans for both the water and sewer networks must be amended to only cover development within the existing UGB. As described above, this study provided an opportunity for the City to revise their demand projections. The 10-year demand case only addresses development within the existing UGB (with a few noted exceptions: Tetherow and Buckingham Elementary School included, areas served by Avion and Roats not included). The build-out case – projected to occur beyond the 20-year master planning period, does consider development outside the existing UGB, however the differentiation between the 10-year and build-out improvements provides an indication of which improvements are solely related to development outside the UGB.

Design demand factors

Historical production records were reviewed to determine the typical ratio of maximum day demand (MDD) to average day demand (ADD) as well as the ratio of peak hour demand (PHD) to maximum day demand. At the commencement of the study, interrogation of the City's production records for the years 2006 to 2008 revealed a MDD:ADD demand ratio of 2.25. In the 2007 plan, a textbook value of 1.5 was used as the PHD:MDD peaking factor. For this study, records for 2008 and 2009 were reviewed to determine an appropriate PHD:MDD ratio (earlier City water demand data did not have the required resolution for this analysis). It was agreed with Bend staff that a peaking factor of 1.8 should be used with the projected demand scenarios for this study (slightly higher/more conservative than the observed PHD:MDD ratio in 2008 of 1.7). As this value is based on only two years of records it should be reviewed and revised as more data become available.

Table 2.1 shows the system-wide demand values for average day (ADD), maximum day (MDD) and peak hour demands (PHD) for the existing, 10-year and build-out scenarios. Figure 2.2 presents this information in graphical form. The demand values for build-out are higher than those considered in the 2007 Master Plan, shown in the last line of Table 2.1. Reasons for the increase in build-out demand include differences in the underlying assumptions of development density and the area served. In addition, the 2007 Master Plan used a textbook value for the PHD:MDD ratio. As mentioned above, recent City demand data showed the ratio to be much higher.

Table 2.1 – Projected future water demand summary

Year	Water Demand (MGD)		
	Average Day Demand (ADD)	Maximum Day Demand (MDD)	Peak Hour Demand (PHD)
2008 [1]	12.8	29.2	48.0
10-year projection [2]	21.7	48.8 [4]	87.9 [5]
Build-out Development [3]	37.1	83.5 [4]	150.3 [5]
Build-out Development in 2007 Master Plan	30.7	71.5	107.3 [5]

Notes to Table E.1:

(1) Existing ADD, MDD & PHD based on 2008 water production records.

(2) 10-year ADD developed assuming half of the growth to meet build-out demand at medium density development would be realized within the existing UGB, plus half of growth to meet Tetherow build-out demand and Juniper Ridge at 294 acres.

(3) Build-out ADD assumes medium density development across the proposed UGB, plus Tetherow at 889 residential units and Juniper Ridge at 515 acres. 2007 planning area was the existing UGB plus Tetherow and Juniper Ridge.

(4) MDD equals ADD x 2.25 (based on historical data, see Table 3.2 from the DDS report).

(5) PHD based on comparison of recorded peak hour and maximum day production values from 2008 and 2009. PHD:MDD factor agreed at 1.8. 2007 Master Plan value assumed textbook value of 1.5 x MDD

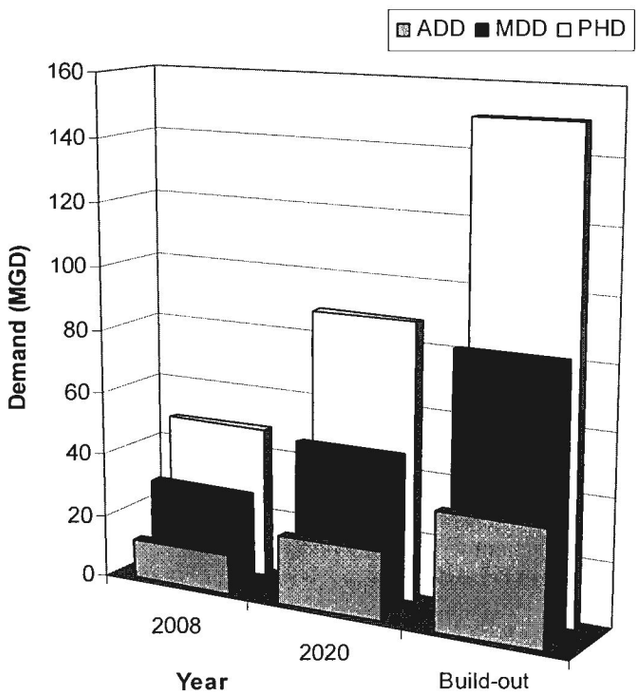


Figure 2.2 – Projected future water demand by year

Design demand curves

For the optimization analyses, diurnal curves were developed that allow simulation of MDD and PHD within a 24-hour evaluation to ensure appropriate sizing of facilities. Two idealized diurnal curves have been developed for use in existing and future simulations when identifying deficiencies and improvements. These curves reflect the shape of the curves identified during July 2009 (summer calibration) but result in a system-wide MDD to PHD factor of 1.8. A separate diurnal curve has been maintained for Zones 1 and 2 because the customer base is primarily residential and therefore usage is expected to vary more dramatically over a 24-hour MDD period due to summer irrigation demands. The recommended design diurnal curves are shown in Figure 2.3.

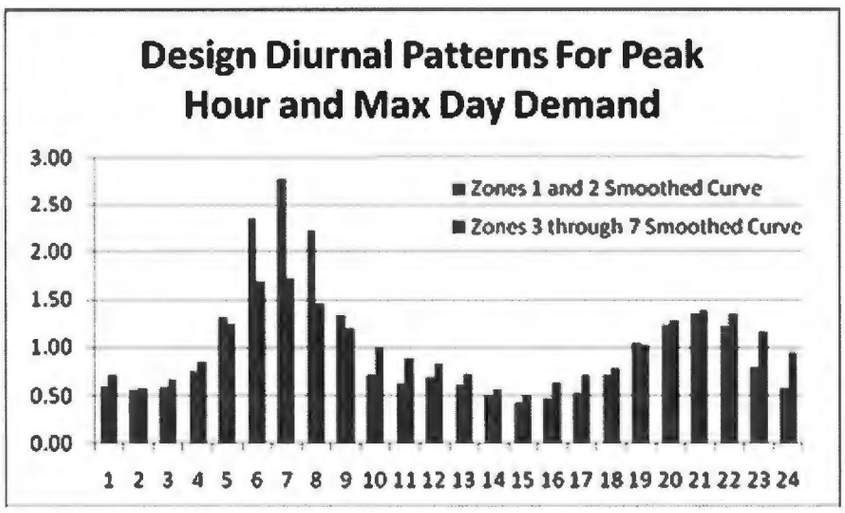


Figure 2.3 – Proposed design diurnal curves to simulate maximum day and peak hour demand (from MSA Report, August 2010)

2.3 Supply Assumptions

2.3.1 Current Sources and Water Rights

The City of Bend uses two sources of supply to meet customer demands – surface water collected in the Cascade Mountains and groundwater drawn from the Deschutes Aquifer.

Existing surface water rights total 23.3 MGD during the irrigation season (April 15 to October 15). However, during this time period one of Bend's surface water permits (S-49823) is very junior in priority date and not a reliable irrigation season source. Moreover, the remaining irrigation season surface water rights have annual volume limitations and are subject to curtailment by the Deschutes Basin Watermaster based on streamflow in Tumalo Creek and demand for water by Tumalo Irrigation District. With these variables (priority date, water right priority date, streamflow, and demand by downstream water users) the amount of water available during irrigation season could range from 23.3 MGD down to 7.2 MGD. During the non-irrigation season the City's surface water rights total 13.6 MGD.

Table 3.5 of the DDS Report (**Appendix C**) summarizes the existing surface water rights and Table 3.6 of the DDS Report summarizes the existing water rights for groundwater sources. The City's groundwater rights total 44.1 MGD. Table 2.2 below lists the existing groundwater facilities and capacities.

With the current surface water system infrastructure, the City is able to divert and deliver approximately 11.8 MGD into its distribution system. Based on historical data (2006 to 2008), during summer operation the Outback surface water facility typically runs at about 8-9 MGD and wells contribute 15 MGD to 20 MGD.

2.3.2 Future Source Options

Bend currently has rights to 21 cfs/13.6 MGD during the winter, but competing senior water rights and available streamflow may reduce availability during the irrigation season. Based on discussions at the April 2010 project update meeting, the Build-out Optimization was formulated under the assumption that 36 cfs/23 MGD will be available from the surface water source. One advantage of this approach to the Master Plan is that it ensures transmission piping is not undersized. This scenario was analyzed so as not to preclude future generations from the opportunity of developing more completely the City's existing water rights. The cost of this scenario is unknown at this time but could be compared to the cost of having groundwater meet the additional future demand needs, which would include securing and mitigating groundwater rights together with the capital and operations/maintenance costs of new wells in the system.

Since the Build-out Solution was finalized there have been changes to the City's understanding regarding the potential future capacity of the surface water source. It is now anticipated that the maximum flow rate that could be expected is 27 cfs/18 MGD, but is more likely to be 21 cfs/13.5 MGD. This information was incorporated into the analysis of the 10-year demand case to see how it impacts the needed size of piping to support transmission of supply from Outback. Once future plans for the surface water supply are more concrete, the recommendations for piping improvements from the Outback site should be re-evaluated to ensure they are appropriate.

As the system grows the City should ensure that a firm supply capacity equal to the anticipated maximum day demand is maintained. Firm capacity is calculated by summing the capacity of all continuously available sources, excluding the largest source. Based on the projected future water demand (Table 2.1) the supply system will need to be expanded to produce an average day demand of approximately 37.1 MGD and a maximum day demand of approximately 83.5 MGD under build-out conditions.

Existing (expected as of April 2011) supply capacity is 32.2 MGD from wells (excluding Rock Bluff 2) and 11.6 MGD from the surface water source. The surface water source is not a continuously available source as it can be rendered unavailable if an event such as a fire in the watershed causes the water to be excessively turbid. Current plans to upgrade the treatment facilities at Outback to include membrane treatment will increase the reliability of the surface source, potentially allowing at least a portion of the surface water capacity to be relied upon to meet firm supply capacity needs. In determining the necessary future supply capacity it has been assumed that, in the future, the surface water facility will be able to reliably provide 7.2 MGD (based on historical summer flow rates).

Further analysis of reliable well supply in the Bend system is provided in **Appendix E**.

Table 2.2 – Summary of Groundwater Well Capacity (expected April 2011)

Groundwater Production Facility	Zone Supplied	Rated Capacity (MGD)
COPPERSTONE_W	3	1.4
OUTBACK_W1	3	1
OUTBACK_W2	3	1.1
OUTBACK_W3	3	1.7
OUTBACK_W4	3	1.7
OUTBACK_W5	3	1.8
OUTBACK_W6	3	1.8
OUTBACK_W7	3	1.8
OUTBACK_W8	3	*Future*
WESTWOOD_W	4A	1
BEAR_CREEK_W1	4B	1.5
BEAR_CREEK_W2	4B	1.6
ROCK_BLUFF_W1	4B	1.2
ROCK_BLUFF_W2	4B	1.1
ROCK_BLUFF_W3	4B	1.2
PILOT_BUTTE_W1	5	1.2
PILOT_BUTTE_W2	5	*Decommissioned*
PILOT_BUTTE_W3	5	1.3
PILOT_BUTTE_W4	5 (4B emerg)	1.6
RIVER_W1	5	2.7
RIVER_W2	5	3
SHILOH_W1	3D	*Decommissioned*
SHILOH_W2	3D	*Decommissioned*
SHILOH_W3	3D/4B	2
HOLE_10_W1	2B	0.8
HOLE_10_W2	2B	0.8
Total Groundwater Capacity		33.3
Total In-service Capacity, 2010 (without Rock Bluff 2)		**32.2**

2.4 Fire Flow Requirements

Section 4.1.1 of the DDS describes the fire flow requirements for the Bend system. A residual pressure of 20 pounds per square inch (psi) must be maintained under fire flow conditions. Table 2.3 lists the fire flow requirements for the different land use types in the City, ranging from 1,500 gallons per minute (gpm) for residential structures up to 3,500 gpm for the Central Business District (CBD). MSA provided details of the land use categories that apply to each node in the hydraulic model, and these were used to determine the appropriate fire flow requirement. Figure 2.4 shows the model nodes color coded by fire flow rate.

Optimatics used the fire flow requirement data in a comprehensive fire flow analysis to determine where the system cannot meet the fire flow requirements under maximum day conditions. This analysis was performed under both existing and build-out demand conditions. Any fire flow that resulted in pressure below 20 psi was assessed and pipe replacements and/or new pipe connections were recommended to bring the system up to the 20 psi standard. Sections 2.8.14 and 4 contain more details about these recommended improvements.

Table 2.3 – Recommended fire flow rates

Land Use Code	Number of nodes	Definition	Fire Flow (gpm)
AOD	2	Airport Operations District	2,500
ARID	13	Aviation Related Industrial District	2,500
ASD	38	Aviation Support District	2,500
ASDRA	2	Aviation Support District Reserve Area	2,500
CB	41	Central Business District (CBD)	3,500
CC	57	Convenience Commercial District	2,500
CG	393	General Commercial District	2,500
CL	421	Commercial Limited	2,500
CN	3	Commercial Neighborhood	2,500
EFUTRB	13	Exclusive Farm Use Tumalo/Redmond/Bend	1,500
IG	130	General Industrial District	2,500
IL	678	Light Industrial District	2,500
IP	8	Industrial Park?	2,500
ME	67	Mixed Employment	2,500
MR	191	Mixed-use Riverfront (redevelopment of mill site properties)	2,500
PF	37	Public Facilities (Schools, Public Buildings, etc.)	2,500
PO	2	Professional Office	2,500
PO/RM/RS	4	Mixed Use Office/Residential	2,500
RH	206	High Density Residential	1,500
RL	40	Low Density Residential	1,500
RM	785	Medium Density Residential	1,500
RR10	48	Medium-10 Density Residential (RM-10)	1,500
RS	3,029	Standard Density Residential	1,500
SM	4	Surface Mining District	2,500
SR2-1/2	31	Suburban Low Density Residential (SR 2 ½)	1,500
UAR10	121	Area Reserve District	1,500
Total	**6,364**		

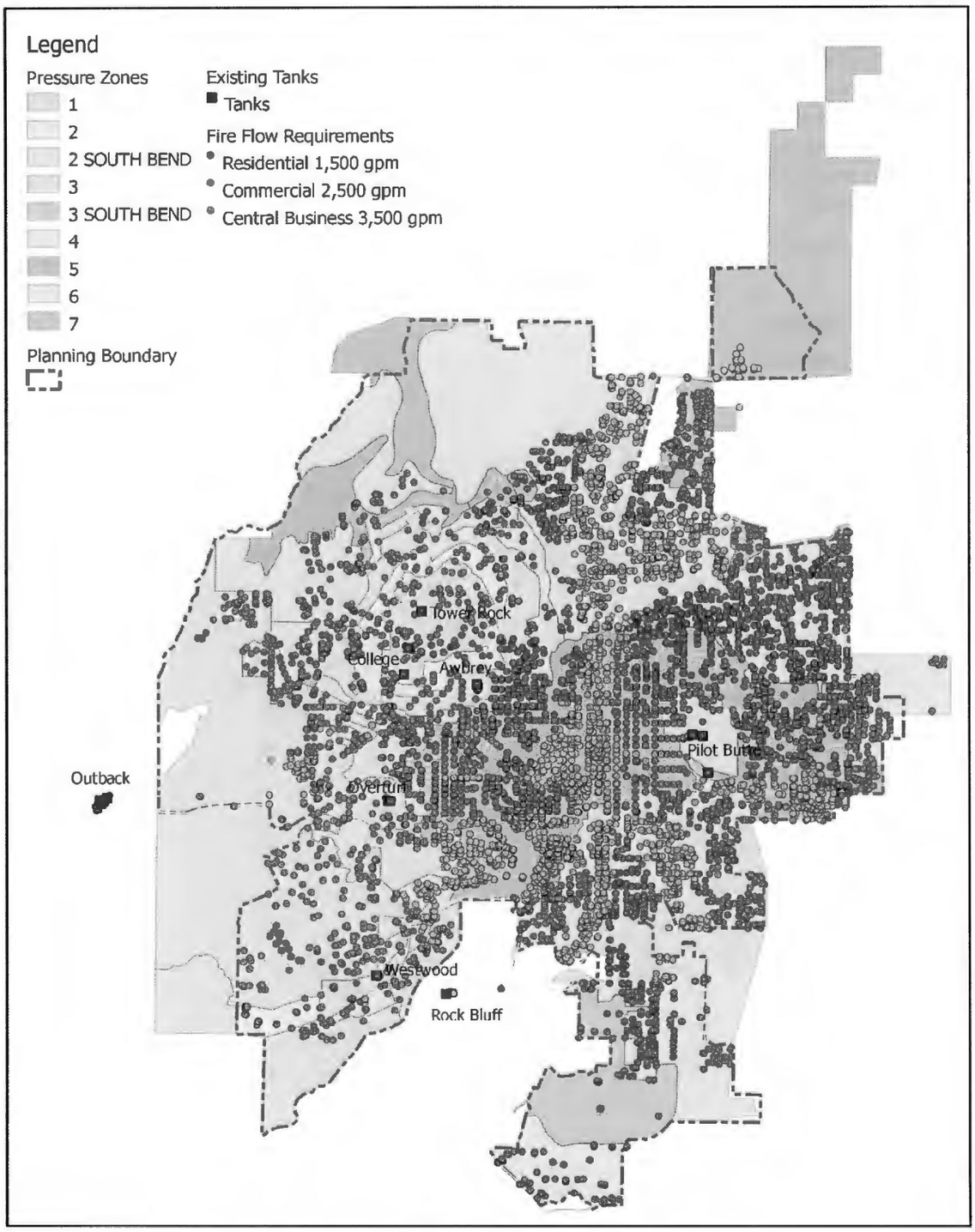


Figure 2.4 – Fire flow rates associated with each model node

2.5 Design Constraints

2.5.1 Pressure

All nodes in the model with customer demands are subject to the pressure criteria described in the DDS report. The minimum allowable pressure criterion is 40 psi. There are a number of locations where this minimum pressure is not met in the existing system under current peak hour conditions. Those locations that experience pressure below 40 psi under existing peak hour demand conditions are shown on Figure 2.5 and listed in Table 2.4.

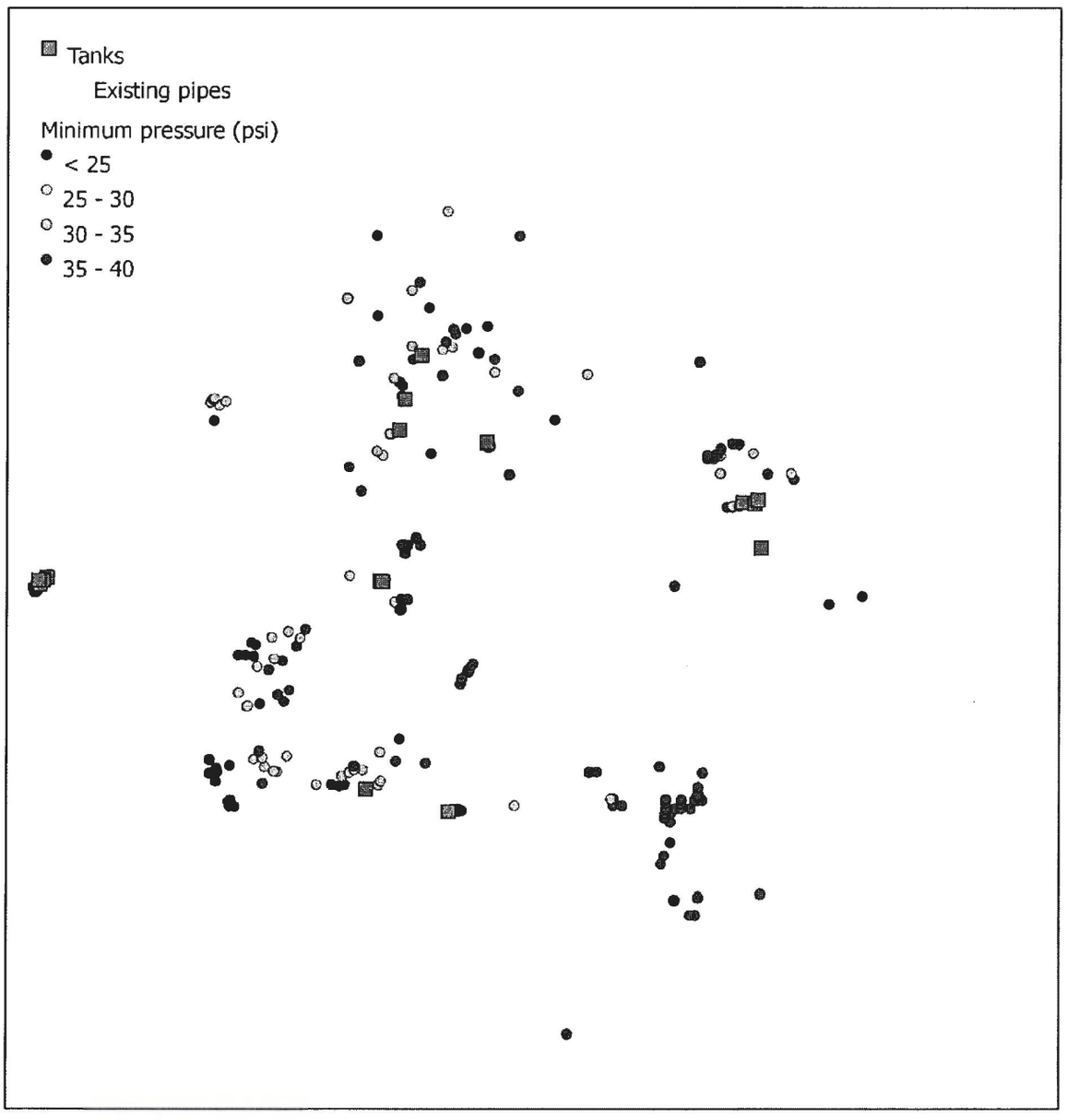


Figure 2.5 – Locations with pressure below 40 psi under existing peak hour demand conditions

Table 2.4 – Demand nodes with pressures below 40 psi under existing peak hour conditions

Node ID	Demand GPM	Elevation ft	Peak Hour Pressure psi	Zone and Location	
JCT-72	0.60	3870.04	3.12	Level 3	Tetherow suction
JCT-117	0.09	3870.04	4.43	Level 3	Tetherow suction
JCT-239	23.82	3869.86	19.01	Level 3	Tetherow suction
JCT-105	5.31	3869.80	20.71	Level 3	Tetherow suction
JCT-253	26.20	3869.88	21.39	Level 3	Tetherow suction
JCT-109	18.86	3869.80	22.43	Level 3	Tetherow suction
JCT-246	42.76	3869.88	22.48	Level 3	Tetherow suction
JCT-236	21.44	3869.88	22.48	Level 3	Tetherow suction
JCT-938	8.04	3610.71	23.76	Zone 6B	High elevation
JCT-3187	3.07	3973.80	27.64	Level 3	Awbrey Butte - west
JCT-124	30.39	3869.81	28.52	Level 3	Tetherow suction
JCT-896	8.52	3716.19	29.06	Zone 5B	Near PRV
JCT-223	95.60	3869.71	29.34	Level 3	Tetherow suction
JCT-714	1.98	3871.42	30.08	Zone 4C	Off Shevlin Park Rd/
JCT-1629	36.62	3948.05	30.33	Level 3	Overturf
JCT-3086	3.04	4102.68	30.63	Level 2	Awbrey Butte - east
JCT-114	15.78	3869.80	31.77	Level 3	Tetherow suction
JCT-256	66.27	3869.92	32.03	Level 3	Tetherow suction
JCT-112	44.43	3881.57	32.72	Level 3	Westwood
JCT-106	15.18	3881.57	32.74	Level 3	Westwood
JCT-119	25.74	3869.80	33.04	Level 3	Tetherow suction
JCT-3361	13.12	3609.78	33.70	Zone 6B	High elevation
JCT-125	12.69	3869.81	33.72	Level 3	Tetherow suction
JCT-234	46.67	3869.88	33.75	Level 3	Tetherow suction
JCT-591	6.66	3956.03	33.81	Level 3	Awbrey Butte - south
JCT-3112	27.32	4238.05	33.82	Level 1	Tower Rock
JCT-377	10.45	3957.95	33.84	Level 3	Overturf
JCT-4206	3.74	3746.09	33.84	Level 5	Pilot Butte
JCT-585	25.46	3956.01	34.68	Level 3	Awbrey Butte - south
JCT-3111	26.35	4238.05	34.69	Level 1	Tower Rock
JCT-259	45.2	3870.16	34.73	Level 3	Tetherow suction
JCT-255	22.85	3870.19	34.75	Level 3	Tetherow suction
JCT-4157	5.76	3750.42	34.85	Level 5	Pilot Butte
JCT-4228	12.92	3731.81	34.94	Level 5	Pilot Butte
JCT-260	28.36	3870.18	35.61	Level 3	Tetherow suction
JCT-245	31.6	3870.22	35.63	Level 3	Tetherow suction
JCT-221	54.24	3869.83	35.70	Level 3	Tetherow suction
JCT-3116	33.55	4240.70	35.83	Level 1	Tower Rock
JCT-1960	9.35	3778.73	35.85	Level 5	West - high elevation
JCT-1963	6.73	3778.77	35.86	Level 5	West - high elevation
JCT-1962	5.50	3778.77	35.87	Level 5	West - high elevation

Node ID	Demand GPM	Elevation ft	Peak Hour Pressure psi	Zone and Location	
JCT-3041	13.72	3961.65	36.25	Level 3	Near Awbrey
JCT-3307	2.10	3749.82	36.32	Zone 5D	High elevation
JCT-4199	10.25	3745.78	36.33	Level 5	Pilot Butte
JCT-228	32.57	3869.93	36.37	Level 3	Tetherow suction
JCT-2359	15.15	3957.28	36.45	Level 3	Near Awbrey
JCT-3078	18.05	4240.14	36.46	Level 1	Tower Rock
JCT-4220	4.03	3746.08	36.52	Level 5	Pilot Butte
JCT-1037	51.55	3881.57	36.93	Level 3	Westwood
JCT-2956	2.74	3764.68	37.02	Level 5	Pilot Butte
JCT-128	15.93	3869.81	37.18	Level 3	Tetherow suction
JCT-4207	0.46	3746.20	37.35	Level 5	Pilot Butte
JCT-4132	7.88	3750.26	37.36	Level 5	Pilot Butte
JCT-3131	19.09	4237.98	37.59	Level 1	Tower Rock
JCT-875	52.18	3974.34	37.70	Level 3	Awbrey Butte - west
JCT-3444	18.51	3841.55	37.93	Zone 4B	Rock Bluff
JCT-202	23.16	3869.83	38.06	Level 3	Tetherow suction
JCT-2287	2.80	3775.95	38.11	Level 5	Awbrey - west
JCT-3441	0.06	3852.04	38.15	Zone 4B	Rock Bluff - Murphy Suction
JCT-2571	9.30	3838.41	38.31	Zone 4B	Rock Bluff
JCT-2570	2.07	3838.41	38.31	Zone 4B	Rock Bluff
JCT-3425	1.03	3842.55	38.37	Zone 4B	Rock Bluff
JCT-1995	15.81	3778.70	38.43	Level 5	West - high elevation
JCT-1994	6.22	3778.70	38.43	Level 5	West - high elevation
JCT-3438	11.39	3841.58	38.45	Zone 4B	Rock Bluff
JCT-3098	56.4	4240.84	38.49	Level 1	Tower Rock
JCT-3436	23.33	3841.50	38.78	Zone 4B	Rock Bluff
JCT-3455	5.80	3841.55	38.80	Zone 4B	Rock Bluff
JCT-2742	7.49	3763.57	38.81	Level 5	South - Scott St suction
JCT-4268	10.06	3737.85	38.88	Level 5	Pilot Butte
JCT-195	28.59	3869.83	38.92	Level 3	Tetherow suction
JCT-3121	19.37	4238.09	39.04	Level 1	Tower Rock
JCT-1268	6.42	3778.14	39.06	Level 5	Southwest - high elevation
JCT-1296	2.54	3778.14	39.06	Level 5	Southwest - high elevation
JCT-4200	6.29	3746.17	39.07	Level 5	Pilot Butte
JCT-3195	18.54	3972.28	39.11	Level 3	Awbrey Butte - north
JCT-3437	16.56	3842.42	39.18	Zone 4B	Rock Bluff
JCT-2634	13.58	3838.45	39.19	Zone 4B	Rock Bluff
JCT-2622	6.03	3838.45	39.19	Zone 4B	Rock Bluff
JCT-3439	8.12	3842.60	39.26	Zone 4B	Rock Bluff - Murphy Suction
JCT-1925	2.43	3778.82	39.37	Level 5	West - high elevation
JCT-3445	10.45	3842.92	39.39	Zone 4B	Rock Bluff - Murphy Suction
JCT-574	14.18	3855.23	39.53	Zone 4A	Awbrey Butte
JCT-3469	0.89	3839.51	39.65	Zone 4B	Rock Bluff

Node ID	Demand GPM	Elevation ft	Peak Hour Pressure psi	Zone and Location	
JCT-3457	1.44	3843.53	39.66	Zone 4B	Rock Bluff - Murphy Suction
JCT-1034	7.92	3871.58	39.68	Zone 4I	
JCT-3143	39.38	4237.80	39.78	Level 1	Tower Rock
JCT-206	32.26	3869.84	39.79	Level 3	Tetherow suction
JCT-4266	12.31	3737.85	39.80	Level 5	Pilot Butte
JCT-3452	5.17	3839.86	39.80	Zone 4B	Rock Bluff - Murphy Suction
JCT-3141	36.59	4237.90	39.82	Level 1	Tower Rock
JCT-4241	2.93	3746.08	39.90	Level 5	Pilot Butte

In a many locations it would not be possible to maintain a pressure of 40 psi due to the relative elevation difference between the source or tank and the customer node. In these instances an exception was applied in the optimization analysis. Levels 1 and 2 on Awbrey Butte were subject to a reduced minimum allowable pressure of 30 psi. A number of other isolated nodes were excluded from the standard minimum pressure criterion and instead the optimization was simply required to maintain pressure above the existing peak hour pressure. Figure 2.6 highlights where modified pressure constraints were applied in the optimization.

Two significant areas - the suction side of Tetherow PS in Level 3 and to the east of Rock Bluff in Zone 4B - are highlighted as low pressure areas in the existing system model, however the optimization was required to lift pressures in these areas to 40 psi where possible.

2.5.2 Velocity

There are very few locations in the existing system where velocity exceeds 7 feet per second (fps). The aim of the optimization was to maintain this. New pipes were also required to maintain velocities below 7 fps. In order to ensure appropriate sizing of new infrastructure a penalty was applied if this criterion was not met in new pipes.

2.5.3 Tank Levels

As part of the Operations Optimization analyses completed in April 2010 (*Summer and Winter Operations Optimization Results* – **Appendix D**), the City identified aims for improved tank operation. Specifically, Bend operators want to be better able to maintain the level in the Pilot Butte Reservoirs under high demand conditions, and also improve tank turnover during winter conditions.

For the Build-out Optimization, the aim was to ensure tanks did not lose volume over a 24-hour period (i.e. they should return to their starting level), and also that necessary standby and fire flow storage was maintained. A comprehensive review of storage standards in Oregon, Idaho and Washington was completed to help the City develop a set of appropriate guidelines to determine storage volume needs in the water system.

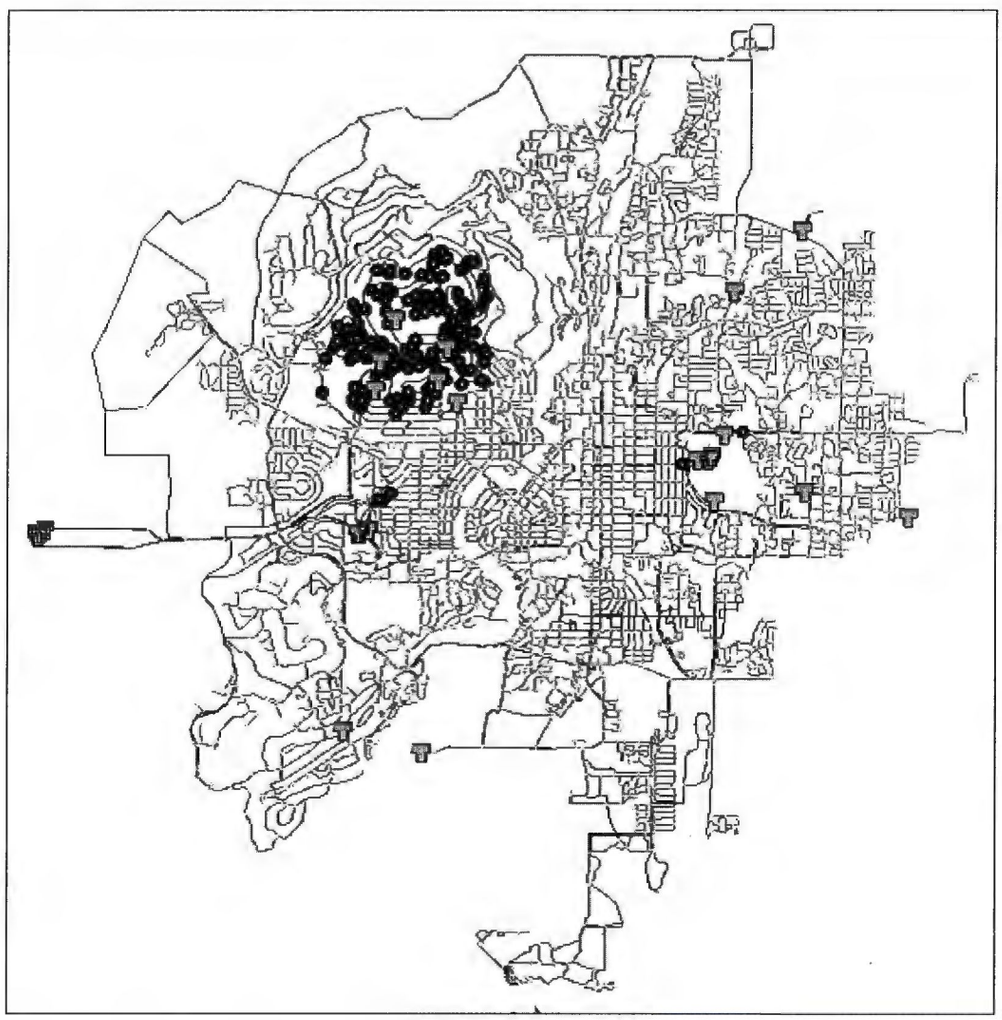


Figure 2.6 – Locations subjected to modified minimum allowable pressure criteria

2.5.4 Storage Requirements

A separate memorandum (*Review of storage standards and recommended storage guidelines for the City of Bend*, June 2010, contained in **Appendix E**) reviewed and summarized the applicable storage standards in neighboring states (Washington, Idaho and Oregon) and regions (Ten States Standards) and recommended guidelines to be adopted by the City for planning activities. After reviewing and discussing this information, Bend chose to adopt the Washington Design Manual guidelines. These guidelines are the most quantitative of those reviewed and provide a prescribed approach to estimating storage requirements.

Based on the analysis and calculations presented in the storage memorandum and discussions with Bend staff, the guidelines summarized in Table 2.5 are recommended for adoption in future planning activities.

Table 2.5 – Recommended storage component definitions for future planning activities

Upper Dead Operating Equalization	Estimate the combined operating, equalization and upper dead storage volumes as 35% x MDD. Planning Engineers must verify the necessary volume through hydraulic modeling. Modeling must verify that Standby and Fire storage volumes can be maintained under MDD conditions.
Standby	Ensure provisions for a standby volume of 2 x ADD. Wells may be relied on to offset the above-ground storage volume if the following conditions are met: - Only the capacity of wells that are located together with at least one or more reliable wells may be counted, with reliable capacity determined by the concept of firm capacity (largest well out of service) - Wells can be started automatically via SCADA - Wells have back-up power.
Fire	To be determined as per 2007 Master Plan, unless revised requirements are put in force (check with Fire Department): 2 hrs x 1,500 gpm = 0.18 MG Residential 2 hrs x 3,000 gpm* = 0.54 MG Commercial 2 hrs x 5,000 gpm* = 1.5 MG CBD **Higher rates for commercial/CBD zones account for chance of more than one fire occurring simultaneously* Given the significant potential to offset Standby storage with well supply, it is recommended that Bend not consider 'nesting' of standby and fire storage volumes.
Lower Dead	Assess based on a static pressure of 25 psi at all service connections.

A more in depth discussion of these categories can be found in the Storage Constraint Review Memorandum, **Appendix E**.

In making the decision to follow the Washington guidelines, the City considered the following important issues:

- Well reliability: historically the City has experienced problems with a number of wells, particularly on Pilot Butte. In the future it is expected that mechanical equipment will be more reliable; however, it would be undesirable to rely on 100% of the well capacity.
- Availability of back-up power under emergency conditions: relying on wells to meet standby storage needs places increased reliance on back-up power and mechanical infrastructure, and also on fuel supplies to power emergency generators. The City has advised that is entitled to preferential use of diesel supplies in the event of an emergency.
- The reliability of the aquifer: trends show that aquifer levels have declined from previous levels; however, the decline has not been significant. Bend will need to continue to monitor the aquifer levels and may need to revise how much this source is relied upon if levels drop in the future.

As the system grows, the City should monitor maximum day demands and ensure that a firm supply capacity (i.e. the sum of the capacity of all sources minus the capacity of the largest source) equal to MDD is maintained. It is recommended that all new wells be linked to SCADA, and able to be operated on back-up power.

Necessary above-ground storage to meet future operational and equalization needs should be evaluated with the help of a hydraulic model to ensure this component of storage is accounted for appropriately. Due to the need to maintain normal operating pressures above 40 psi throughout the system, there will always be some volume of above-ground storage available to meet standby needs.

Input from Operations staff indicated that the preference would be to maintain as much standby storage above ground as possible; water held above ground does not rely upon the availability of mechanical equipment and power to be delivered to the system. However from a practical standpoint, it would be difficult to find enough space to have all standby storage above ground, not to mention very expensive. An additional important consideration is water quality; it is inadvisable to install excessive amounts of storage due to potential lack of turnover and the associated potential for water quality degradation.

Given the distributed nature of supply in the Bend system, it is appropriate to capitalize on groundwater well assets to offset standby storage needs, within reason. The Washington guidelines provide a more defined way to determine the potential offset. Based on the Washington guidelines calculation, the current system maintains approximately 28% of the necessary emergency storage above-ground (see Table 2.6). The future recommendations for storage included here are comparable to this ratio.

The City should regularly review the Washington guidelines and reevaluate the ground water offset for standby storage as necessary. If changes are made to the Washington Design standards that form the basis of the recommended guidelines used here, or if data show that the aquifer is impacted in such a way that it becomes a less reliable source the percentage of groundwater used to offset stand by storage may need to be revised.

2.5.4.1 Comparison to 2007 Storage Recommendations

The Storage Constraint Review Memorandum (**Appendix E**) included a comparison of the recommended guidelines to the criteria applied in the 2007 Master Plan. There are some differences in the way that the contribution of groundwater is presented in each case. In the 2007 Master Plan, the contribution of groundwater was stated as a proportion of total storage needs (equalization, operating, standby and fire). This is slightly misleading, as groundwater should only be used to offset the standby component of storage. Operating storage should be maintained above ground. It is clearer to define the groundwater contribution as a percentage of the standby component only.

In the 2007 Master Plan, the assumed groundwater contribution at build-out was 55% of total storage, or 50 MG. This equates to 80% of the calculated standby requirement (as per the 2007 Master Plan) of 63 MG. As shown in Section 2.8.12, the Final Build-out Solution provides approximately 25% of standby storage above ground with the remainder (75% or 18.6 MG) being met from reliable groundwater wells.

Table 2.6 – Storage Volume Requirements, Available Storage and Offsets from Wells – Existing System (all volumes in MG)

Pressure Zone	A Existing Storage	C Dead Storage Level below which 20 psi cannot be Maintained	D Fire Suppression Based on land use in supported zones	B Standby Requirement 2 x ADD for zones supported by each storage	E Operating Volume Calculated from hydraulic model	F Standby Available =A-C-D-E	H Well Offset[3] 2 days x reliable well capacity	G Contribution to/from other zones	I Total Standby Capacity =F+H+G	J Standby Capacity ÷ Requirement = I/B
Level 1 [1]	1.0	0.15	0.18	0.76	0.17	0.50	n/a	0.26 From Level 3	0.76	100%
Level 2 [1]	1.5	n/a	0.54	0.81	0.46	0.46	n/a	0.35 From Level 3	0.81	100%
Level 3 [2], Tetherow, and Awbrey sub-zones	3.7	n/a	1.50	3.70	1.28	0.90	14.0 Outback	-11.20 To various	3.70	100%
Zone 4A, Westwood	3.3	0.17	0.54	2.04	0.94	1.64	0.0	0.4 From Level 3	2.04	100%
Zone 4B, South Bend	2.5	n/a	1.50	4.20	0.56	0.46	4.0 Hole Ten, Rock Bluff	0.00	4.46	106%
Level 5, 6 & 7	11.6	0.18	3.00	14.17	5.32	3.14	0.0	10.19 From Level 3, Zone 4B	13.33	94%
Totals	**23.6**	**0.49**	**7.26**	**25.68**	**8.73**	**7.10** (28% of standby requirement)	**18.0**	**0.00**	**25.10**	**98%[4]**

Note: This table is a simplified version of Table 9 in the Storage Constraint Review Memorandum (**Appendix E**). Please refer to the full table for more detail.

1) In the existing system, Levels 1 and 2 rely on pumping from Awbrey to make up their requirements. This booster pump station has back-up power and capacity to meet MDD + fire.

2) Outback 1 and 2 have not been counted towards Level 3 storage because they are required for chlorine contact.

3) Well offset only includes redundant wells on SCADA and with back-up power (locations as noted)

4) The slight storage deficit will be addressed either when the new surface water treatment comes online (freeing up Outback Reservoirs 1 & 2) or by adding SCADA and back-up power to existing wells (e.g. River Wells)

2.5.4.2 *Build-out System – Storage requirements*

Table 2.7 presents the estimated storage volumes that would be necessary under build-out conditions in each major pressure level, based on the various guidelines discussed above. The final column shows whether wells could be used to offset the requirements. The offset amount is double the firm standby well capacity, assuming wells can operate for two days to meet the 2 x ADD standby requirement. The optimization was configured to ensure minimum fire storage volumes were maintained across all storages, that tanks did not lose volume over a 24-hour period, and that minimum service pressures were maintained system-wide. These operating constraints ensure appropriate tank operating volumes and levels are maintained.

Table 2.7 – Estimated Storage Volume Requirements at Build-out and Potential Offset from Wells

Pressure Zone	A Dead Storage	B Fire Suppression (MG)	C Standby Requirement (MG)	D Estimated Operating & Equalization (MG)	E Total Storage (MG) =A+B+C+D	Potential Offset
Level 1 [1]	15%	0.18	1.2	0.5	1.8	All above ground
Level 2 [1]	n/a	0.54	1.5	0.6	2.6	All above ground
Level 3 [2], Tetherow, Westwood and Awbrey sub-zones	n/a	1.5	19.0	7.5	28.0	Above-ground storage and well offsets to standby
Zone 4A	34% of Westwood	0.54	3.2	1.3	5.0	Above-ground storage and well offsets to standby
Zone 4B and South Bend	n/a	1.5	12.2	4.8	18.6	Above-ground storage and well offsets to standby
Level 5, 6 & 7	n/a	3.0	37.1	14.6	54.7	Above-ground storage and well offsets to standby [2]
Totals		**7.3**[3]	**74.2**	**29.2**	**110.7**	

Notes to Table 2.7

1) It has been assumed that wells will not be used to offset standby storage requirements in Levels 1 and 2, due to their elevation and isolation. New storage is proposed at the Tower Rock and College 1 sites to meet the storage needs in these levels.

2) Additional capacity may come from the following sources: planned wells at Pilot Butte, new wells located in Zones 5 and 6, potential acquisition of Pine Nursery well, new wells at Awbrey, or additional capacity in higher zones.

3) The volume required for fire suppression does not change based on increasing demands. It is related to the number of pressure levels rather than demand.

2.6 Optimization Formulation

The optimization formulation process involves model analysis and configuration of the optimization software to link to the hydraulic model. Its purpose is to create a range of decision options aimed at achieving the optimization goals while maintaining or improving system hydraulic performance. The following sections outline the various decision options and hydraulic constraints considered in the Build-out Optimization.

2.6.1 Options

The process of identifying options to include in the optimization formulation involved review of previous master plan recommendations; assessment of the hydraulic model and analysis of system performance compared to specific design criteria; and discussion and brainstorming with City staff. The following sections outline pipe, storage, pump and well supply options developed and tested as part of the optimization formulation process.

2.6.1.1 Pipe options

The previous master plan identified a wide range of pipe improvement options to provide for transmission, distribution and fire flow needs. These were reviewed by Bend staff to determine which improvements remained valid options for consideration in the optimization – i.e. those that had not yet been constructed. It should be noted that the previous master plan was completed using a previous version of the hydraulic model; it was therefore necessary to reanalyze the system using the recently calibrated hydraulic model to confirm the location and extent of existing deficiencies.

In addition to those options from the 2007 Master Plan deemed suitable for inclusion in the optimization, Optimatics undertook a deficiencies analysis using the hydraulic model to develop new pipe options to evaluate in the optimization. With the projected build-out demands distributed to the hydraulic model nodes, Optimatics analyzed the model results to identify locations where there are bottlenecks or restrictions that hinder supply of surface water from Outback to the system; where other stressed mains and low pressures are occurring due to the projected increase in demand; and where new pipe should be located to meet new demand on the outskirts of the system.

Fire Flow Analysis

In addition to the general deficiencies analysis described above, a comprehensive fire flow analysis was performed at each of the nodes in the existing and build-out models to identify local deficiencies, primarily in smaller distribution mains. As noted in Section 2.4 above, each model node has been designated with a specific fire flow requirement based on land use. Optimatics performed a comprehensive fire flow analysis with this information under maximum day demand conditions, and then analyzed results on a zone-by-zone basis. Where the network fell below 20 psi, pipe upgrades (primarily replacement of existing pipe; in some cases a new connection was added) were added at specific locations at the minimum diameter to bring the pressures into compliance.

Many of the identified improvements from the fire flow analyses were fixed in the build-out model, as opposed to being considered as decision options, since they are purely driven by fire flow needs and do not impact transmission and distribution of supply. A handful of the fire flow improvements, primarily in Zone 4B and Level 5, were included in the optimization at a minimum size with the option to increase the size if it was shown to benefit the system in meeting future supply goals. Rather than fixing the diameters of these pipe options, the optimization was allowed to size them as appropriate – with minimum diameter equal to the diameter needed to meet fire flow requirements – in its search for optimal solutions.

The results of the fire flow analysis are presented in Sections 2.8.14 and 4.

Additional Pipe Options to Strengthen System and to Meet Growth

The Consequence of Failure and Operations Optimization analyses completed prior to the Build-out Optimization analyses provided insight into areas of the system which need to be strengthened and potential improvements that could be implemented to improve transmission and simplify system operations. Under future build-out demand conditions most areas of the system are projected to have an increase in demand compared to present maximum day conditions. There are also new demand centers located along the outskirts of the system (primarily in the northwest, in addition to Juniper Ridge in the northeast). Running the model under these conditions showed areas where new transmission and distribution mains will be needed to service new developments and move water effectively through the system.

The DDS Report (**Appendix C**) provides information on the pipe diameter ranges, assumed Hazen-Williams roughness coefficients (C-factors), and pipe unit costs used in the optimization analyses.

Figure 2.7 highlights the new pipe options formulated into the Build-out maximum day optimization. The different colors reflect the range of diameter sizes that the optimization was able to select for each option. These were based on engineering judgment and helped to streamline the overall optimization analysis.

2.6.1.2 Storage options

Throughout the course of this study there has been significant discussion related to future storage requirements. The previous master plan recommended that the City rely on groundwater to meet a portion of standby storage needs in the future. In this study the City desired to work with a more rigorous set of storage criteria based on a more stringent set of engineering guidelines. At first the approach was to assume that 100% of the standby storage needs would be provided through above-ground storage. The idea was that although the resulting cost of storage would be high, the approach would reveal the best locations in the system for placing additional above-ground storage. The total amount of this storage could then be scaled back as necessary based on certain factors – such as available dollars and the character and extent of future growth – and supplemented with groundwater in the event of emergency.

Based on this approach, Optimatics completed a survey of the entire service area to determine where storage could be placed. Various strategies were used to determine which levels and zones are in need of new storage, which have available sites, and which sites would benefit multiple zones in an emergency (given the presence of PRVs throughout the system and thus the ability to supply lower zones from higher zones). The review included both existing sites and new sites, and the option of pumped ground storage was considered (a ground level storage coupled with a booster pump station to lift supply to system pressure). Figure 2.8 shows the tank location options that were developed and subsequently evaluated in the optimization. The Storage Constraint Review Memorandum in **Appendix E** contains details of all the sites reviewed to determine the maximum storage volume potential in the system.

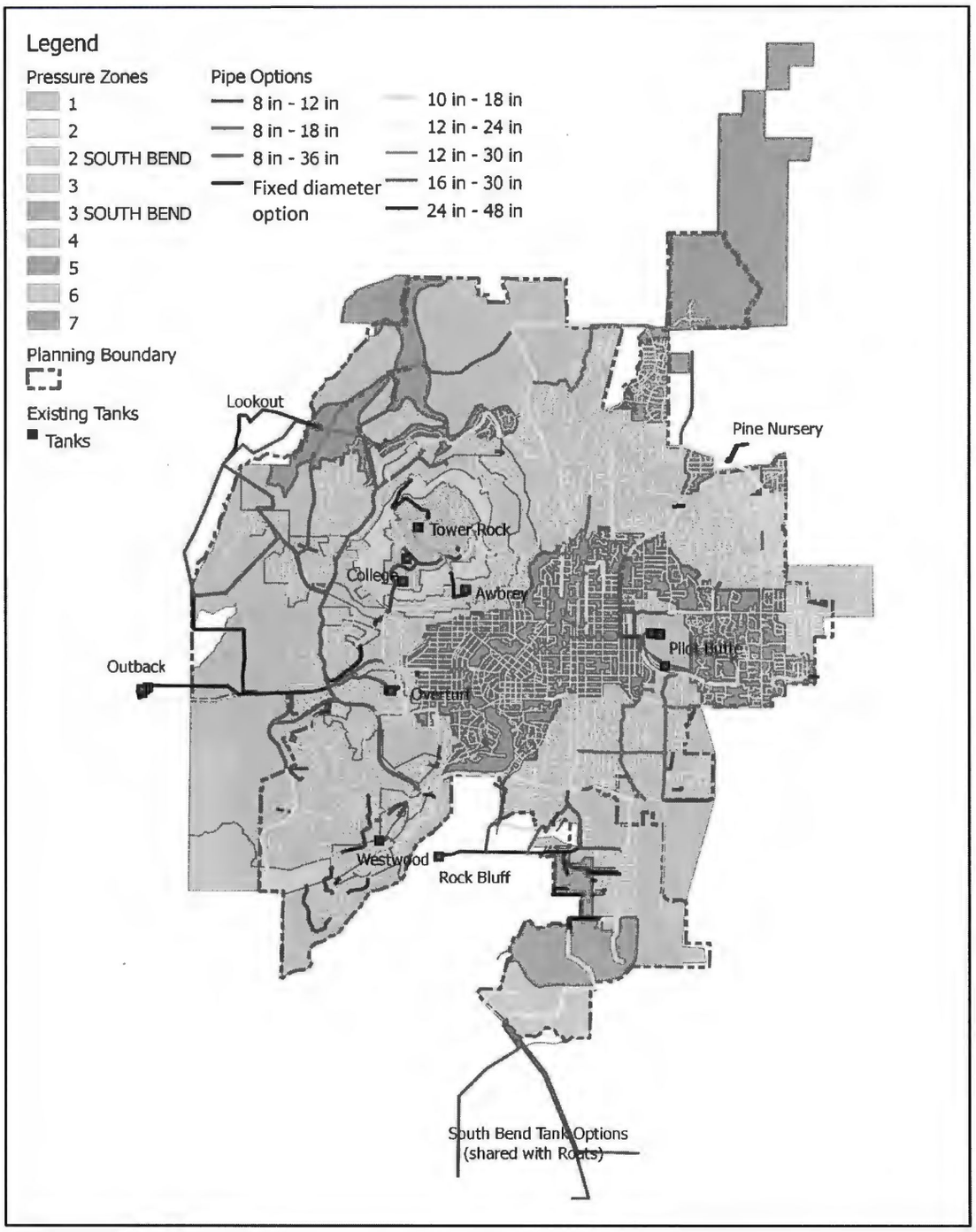


Figure 2.7 – New pipe options in Build-out optimization analysis

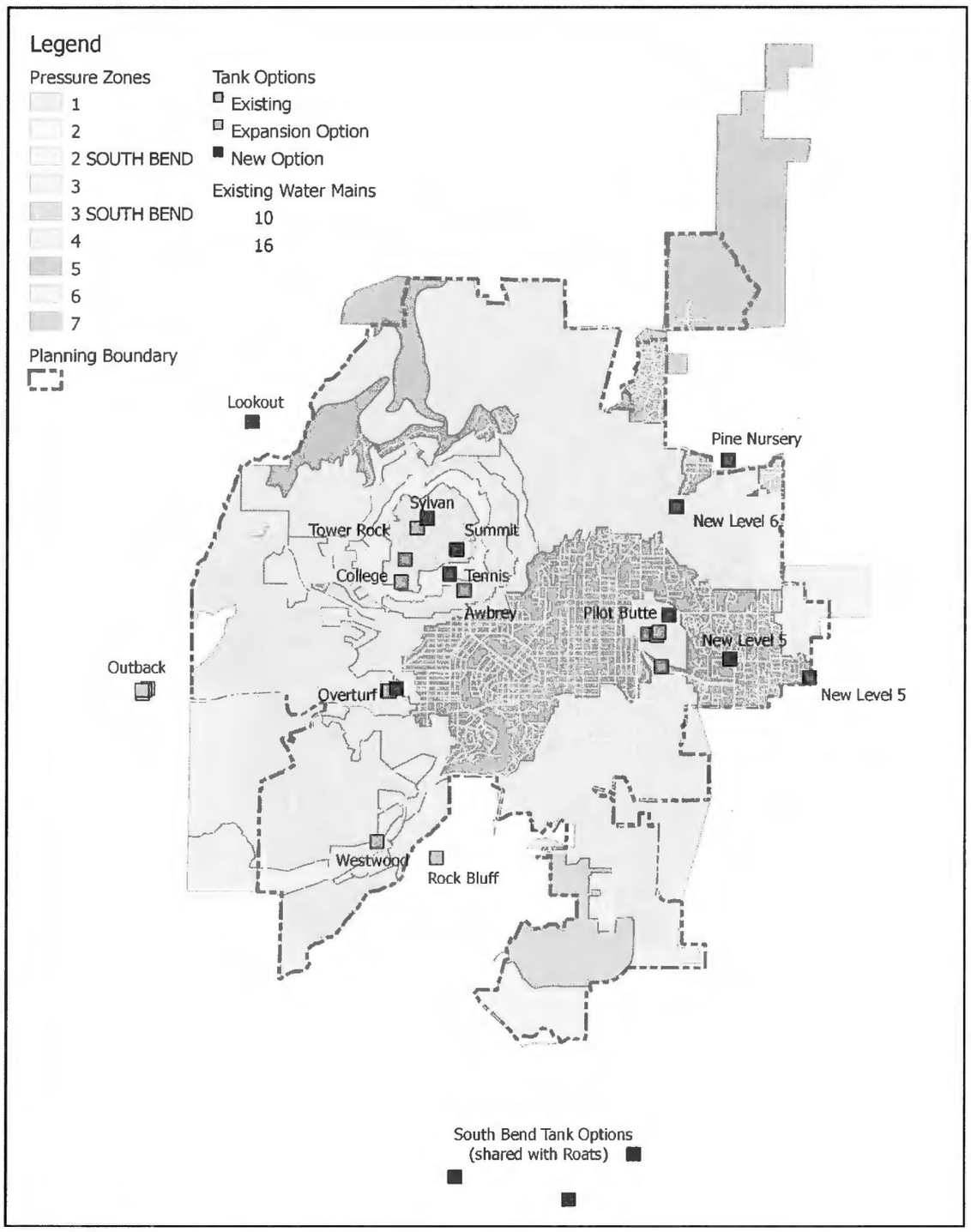


Figure 2.8 – Tank location options considered in the optimization

As discussed in Section 2.5.4, the City requested a review of storage criteria applied in Oregon and neighboring states and subsequently decided to adopt the Washington Design Manual guidelines for emergency storage. As a result, the Final Build-out Solution includes a modest increase in above-ground storage and benefits from the decision to rely on redundant and reliable groundwater wells to offset stand-by storage, therefore significantly reducing the cost of above ground storage. However, for the record, all the potential storage sites identified as part of the system storage review are discussed below.

Level 1 and 2

The 1.0-MG Tower Rock Reservoir serves Level 1, but given the existing PRV stations between Levels 1 and 2 and other smaller stations that reduce water from Level 2 to subzones of Level 3, additional storage in Level 1 could be made available to supply these lower zones in an emergency. City staff visited the Tower Rock site and confirmed that there is room to build additional storage there.

In addition to evaluating the expansion of existing storage amount at the Tower Rock site, two locations were indentified for new storage located in Level 1 that would support Levels 2 and 3 – Summit Park and Sylvan Park. Both parks have two side-by-side tennis courts which could conceivably have in-ground storage added beneath them. The storage would be rectangular in the shape of the court and be made of concrete. To determine the maximum available storage at each site if the tank were 30 feet deep, calculations were performed using dimensions of 100 feet by 60 feet per court. With two courts side by side, the total storage available is approximately 2.5 MG.

Level 3

An analysis of existing above-ground storage revealed a deficit in Level 3. This zone is an important zone for supplying lower zones. In general, existing elevations in the Level 3 network are not conducive to new storage. The best option is to build additional storage at the Outback site. This was formulated into the optimization as expansion of Outback Reservoir 3.

One potential new storage option, which would be filled from the Level 3 gradient via PRV and then serve downstream demands, is located off Lookout Drive to the northwest of the existing edge of the system. A volume of 2.5 MG was assumed for this tank option. The location is outside the UGB however, and was later removed from the potential storage options being considered.

Level 4

The existing overflow level in the Overturf Tanks, which serve Level 4A, is 3,871 feet. This is 9 feet below the 3,880-foot overflow level of Pilot Butte Reservoir 2, which serves Zone 4B. The idea of building a new tank at the Overturf site with a higher overflow elevation to match Pilot Butte 2 was considered in preliminary optimization runs. It was not favored however as restrictions in the Zone 4A mean that significant piping improvements would be needed to allow storage at Overturf to support demands in Zone 4B.

After review of the interim optimization run results, the idea of adding a buried tank at the Overturf site at Level 5 hydraulic grade was put forward. The tank would be filled from Zone 4B and new piping would connect it to Level 5 either to the north at Galveston or to the south at Century Drive.

An option to expand the existing storage at Rock Bluff, which serves Level 4B directly but whose volume would be available to supply Level 5 and lower zones in the event of emergency, was included in the optimization formulation. The City has existing plans for an additional 6 MG of storage at this site.

Levels 5, 6 and 7

Two new tank options were considered at the Pilot Butte site. The first was drawn from MSA's Final Technical Memorandum of the *Water System Planning for the Juniper Ridge Development* study. Given the total development assumption of 515 acres, a new storage tank was preliminarily designed to be 5.7 MG. It was sited just south of Neff Road at a Middle School land parcel. The design calls for the new tank to be filled from Level 5 via the existing 16-inch diameter main on Neff Road. There would be a dedicated supply line that leaves the tank and follows Neff Road east to Purcell Boulevard, then north along Purcell and connecting to the Level 6 piping at Curt Circle. This new tank and piping configuration was formulated into the optimization.

The second tank option at Pilot Butte is located on the northern face of the butte at Level 5 hydraulic grade. This site was proposed because there is an existing scar on the butte, so construction of a tank would encounter less public opposition. A new pipe would connect this tank to the newly installed 24-inch diameter main from Pilot Butte 1.

In addition to these elevated tank options, Optimatics and the City reviewed a number of vacant sites in Level 5 east of Pilot Butte and in Level 6 and identified four potential pumped ground storage locations. It was agreed that these storage options would be considered in conjunction with new groundwater wells. The well would fill the tank and a booster pump station would lift the supply to system pressure. This configuration would avoid inefficient filling of storage from the system and re-pumping to system pressure as well as address the need for new supply to the lower pressure levels.

South Bend

The final new storage option was sited south of the South Bend network on Deschutes National Forest land. MSA performed a review of the area south of the network and identified three potential sites. The middle of these three sites, located just west of the intersection of China Hat Road and Arnold Ice Cave Road, was chosen as the tank location to evaluate in the optimization. The tank would be filled by the Murphy Pump Station, and the storage would likely be shared with Roats Water System.

2.6.1.3 Well options

To meet the additional forecasted demand at build-out, new well supply will be needed in the system. During the Project Update meetings Bend staff identified locations in the system where new wells could be constructed as well as those existing well sites which could be expanded. The well options formulated into the optimization are described in the following subsections and highlighted on Figure 2.9.

Expansion of Outback Wells

The city has plans to implement additional wells at the Outback facility area. The water would move through the same process as existing well water at the site and then be fed by gravity into the system. Parallel pipe options from the Outback site into the system were included in the optimization formulation to be able to transmit the additional supply should these options be selected.

New Tetherow Well

A new well option was evaluated Level 3 north of the Tetherow pump station, near the intersection of Skyline Ranch Road and Seaton Loop.

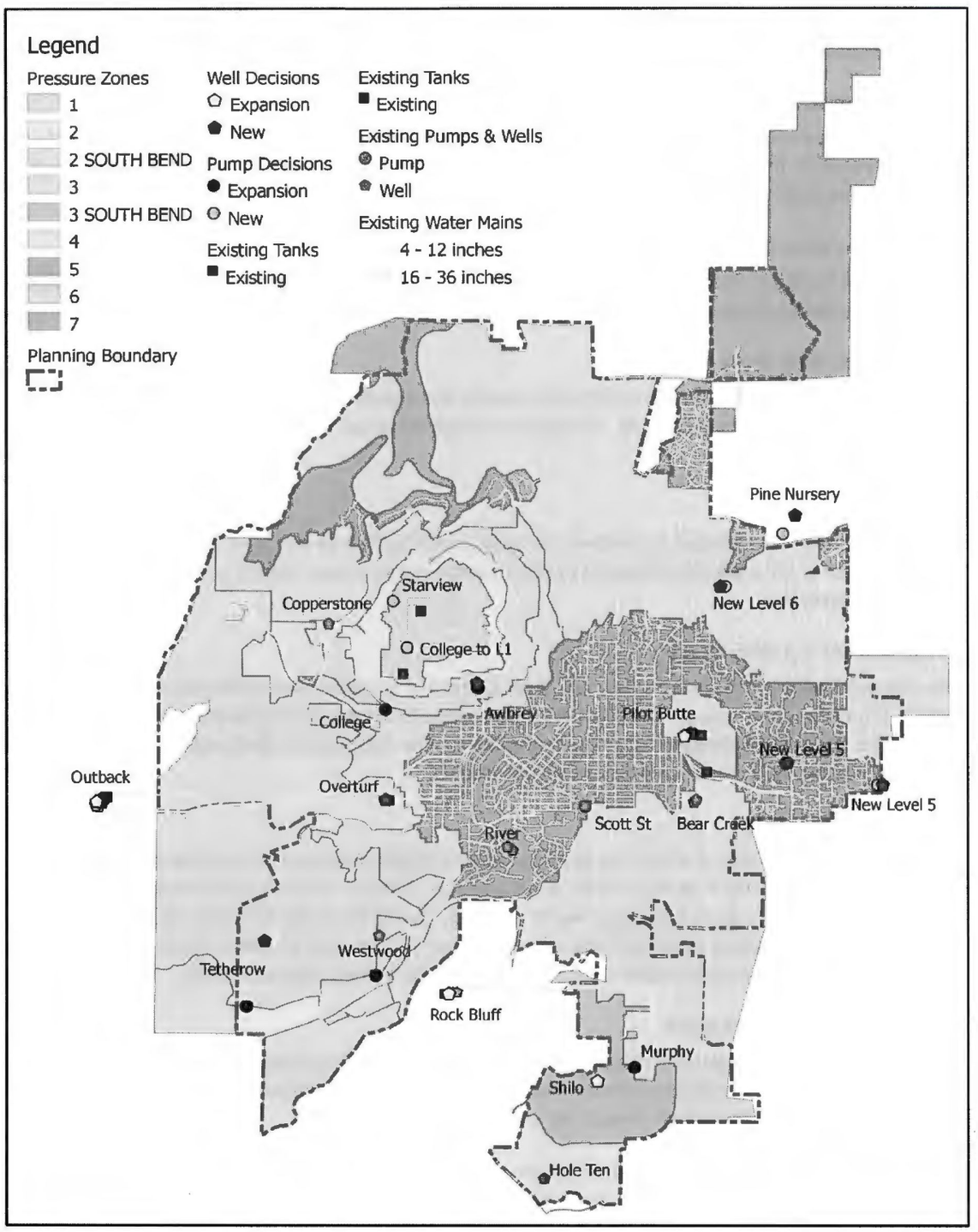


Figure 2.9 – Pump and Well options considered in the optimization

New Overturf Well

A new well option was added at the Overturf facility to provide additional supply to Level 4A.

Expansion of Rock Bluff Wells

An additional new well option was added at the Rock Bluff facility, which would expand the amount of well supply delivered to the system from this site to Level 4B. New parallel pipe options from the Rock Bluff facility into the system were also added to the optimization.

Expansion of Bear Creek Wells

Expansion of the Bear Creek Wells was considered in the interim runs; however the City reports that these wells have exhibited transmissivity issues, so the option was later removed from the optimization formulation.

Expansion of Shilo Wells

The City has recently re-commissioned the Shilo facility and installed a new 12-inch diameter pipe connection that allows this well to supply Zone 4B. The option to expand the well capacity at this site was evaluated in the optimization formulation.

New Awbrey Well

A new well option was added at the Awbrey facility to provide additional supply to Level 5. The City is uncertain whether there will be challenges to drilling a well at this site but wished to include the option in the optimization analysis.

Expansion of Pilot Butte Wells

The City has recently constructed a new well, Well 4, and has plans for three additional wells at this site (5, 6 and 7). The newly-constructed Pilot Butte Well 4 was added to the model and considered an 'existing' supply source. The additional wells were considered as options in the optimization. New parallel pipe options from the facility into the system were included in the optimization.

New Pine Nursery Well

A new well option was added at the Pine Nursery facility in the northeast on the assumption that the City could take over this facility from Bend Parks and Recreation District. There is a very small pump in place at the site, but the well has been tested to a higher capacity. Flow tests showed that the site can pump 1,800 gpm without dropping the level in the underlying aquifer. Bend would install a larger pump if it were to take over this facility; the optimization included the option to add more wells at this site.

New Well sites in Level 5 and 6

As part of the review of potential storage locations, two sites east of Pilot Butte in Level 5 and one site along Butler Market Road in Level 6 were identified as feasible locations for combined well and storage facilities. The option of only installing a well at each site was also evaluated.

Feedback from operations staff indicated that new wells in the east of the system would be a welcome addition to the system, not considering groundwater 2 year time of travel and groundwater contamination issues which had not been clearly discussed or evaluated at the time of this study. As demands increase it also makes sense to increase supply on this side of the system to limit the amount of supply that needs to be transferred from west to east and the associated costs for improving transmission capacity.

2.6.1.4 Pump station options

Level 2 to Level 1

Assessment of Bend's booster pumping operation in Levels 1 and 2 did not reveal significant opportunities for improvement with existing infrastructure. There is little 'pumping and dumping' through PRVs, so the operation is reasonably efficient. However, supplying Level 1 from Awbrey represents a high pumping head situation as water is lifted from Level 5 to Level 1. At the Project Update meetings in August 2009, the idea of adding a small booster station from Level 2 to Level 1 was discussed.

Two new pump station options were developed and added to the model in the operations runs. These options have been carried over as options to test in the Build-out optimization. The first option is in the vicinity of NW Starview Drive and NW Fitzgerald Court. Vertical Projects, LLC brought forth the idea of adding a small pump station here, where there is an existing pit, which could provide a redundant supply source for Level 1 (drawing from Level 2). A station was added to the model with a single 15-horsepower (hp) pump. Under current hydraulic conditions the operating point of this potential pump is 425 gpm at 140 feet of lift.

A second pump station option was added to the model at College 2 Reservoir. A short section of main is required to tie this station into Level 1 piping along Coe Court. This new station would also draw suction from Level 2 and supply Level 1, but it would be buffered by the reservoir storage.

The use of either new pump station option may reduce the existing pumping energy required to lift water to Level 1, allowing Awbrey to serve as a back-up under certain seasonal or other demand conditions. Another consideration when evaluating this option is the additional draw on the College Pump Station that would be required if Level 1 is supplied from Level 2.

College booster station expansion

To accommodate the potential for filling new or existing storage on Awbrey Butte via Level 2, an option to expand the capacity of the existing College Booster Station was added to the optimization. Flow rate choices were provided for the optimization to choose from in the evaluation of whether to select this station expansion, and if so, at what size. A new parallel pipe option was also added to the discharge side of the station to enable transmission of the additional flow if the expansion option is chosen.

Awbrey booster station expansion (drawing from Level 3 to Level 1)

The Awbrey booster station was formulated with an option to expand its existing pump capacity in order to supply new and existing storage in Level 1. New pipe options were added and configured to convey the additional flow to the existing Tower Rock tank. To save pump energy costs, the new pump option would draw from the existing 18-inch diameter Level 3 main on the inlet side of Awbrey Reservoir, rather than from the Reservoir (Level 5 grade line).

Westwood

The Westwood Pump Station facility was intended as a temporary facility; it is problematic and likely inefficient so Bend desired to investigate alternative ways to supply the Westwood Zone and neighboring zones. Ideas for alternative ways to supply customers in this area are discussed in Section 2.6.1.5.

Tetherow

The Tetherow Pump Station has sufficient capacity to meet existing needs; in fact it is oversized. In the future, however, new development in the Tetherow area may call for additional fire flow capacity to be provided. A fire flow rate of 3,500 gpm has been proposed which is currently the flow limit of this station. In order to maintain firm supply capacity (assuming largest pump out of service), it will be necessary to increase the capacity of some pumps in this station if the development proceeds.

South Bend

The hydraulic model was set up in accordance with the information contained in the *Former Juniper Utility – Proposed Water System Improvements* memoranda developed by MSA (included in **Appendix F**). Under these recommendations the Tillicum area is rezoned into Level 4B and the Murphy Pump Station becomes the primary source of supply for Zones 2B and 3D. As mentioned above, the Shilo Well was reconstructed to pump to Zone 4B through a new 12-inch diameter connection. The City is currently constructing new piping from the Murphy pump station to Zone 3D which will later be extended into Zone 2B. Currently the Hole Ten wells continue to supply Zone 2B (South Bend). Once the piping is in place the Murphy station will pump to Zone 2B, and the Hole Ten wells will operate only as an emergency supply facility.

Murphy

Similar to the Tetherow Pump Station, the Murphy pump station currently has adequate capacity to meet peak hour and fire flow demands. However, as demands increase in the future it will be necessary to increase the capacity of some pumps in order to ensure the station can still provide a firm capacity equal to maximum day plus fire flow.

2.6.1.5 Potential modification of Zone Boundaries

In line with Bend's desire to simplify the system and streamline pressure zones, Optimatics evaluated modifications to some zone boundaries. When assessing the feasibility of joining smaller pressure zones into larger neighboring zones, the aim is to ensure that service pressures are still above the minimum requirement and not more than 10 psi below current pressures. In some areas, combining zones into a higher pressure level would require installation of individual PRVs to customer connections which has an associated cost (assumed to be $1000/connection). The modifications considered in the optimization included changing PRV settings in combination with opening boundary pipes/valves, and/or adding new pipe to complete the merging of zones. Table 2.8 lists the options formulated into the optimization to improve system operations along selected zone boundaries.

Table 2.8 – Potential candidates for zone boundary modification

Option	Location	Purpose
Zone 4K into Level 3	Open connections on Flagline Court and Green Lakes Loop. Open PRV.	Increase circulation, suction pressure at Tetherow. Requires individual customer PRVs
Zone 4J into Zone 4A	Open boundary at NW Crossing Drive and Shevlin Park Road	Increase circulation
Zone 4I into Zone 4A	Open connections on SW Reed Market and Mt. Bachelor Drive	Reduce pumping volume at Westwood/Tetherow
Zone 4I into Zone 4B	Open connection at Route 372/Reed Market Rd	Reduce pumping volume at Westwood/Tetherow
Zone 4G into Zone 4A	New connection on Cascade Lakes Highway	Remove demand off Mt Washington Drive/Level 3 piping
Zone 4F into Zone 4A	New connection at NW Summerfield Road	Increase circulation
Internal connection,	Century Drive to Mammoth Drive	Improve supply redundancy for customers south of Century Drive along Sunshine Way and Mammoth Drive
Westwood into Level 3	New connections at Pine Hollow, Cobb Street or Bachelor View Road. Open existing connections northeast of Westwood PS. Supply highest elevation customers via Tetherow	Reduce reliance on Westwood PS, reduce energy needs, increase circulation

2.6.1.6 New Pressure Reducing and Flow Control Valves

Several new control valves were added to the hydraulic model at the boundaries of pressure zones where potential new pipe options were placed. These are described below and shown on Figure 2.10.

Level 1 into Level 3

As noted in the storage options section above, a new storage option at the Sylvan Park location was evaluated. The optimization was formulated with a new pipe option extending from this tank to Farewell Drive, west to Starview Drive, then north to Perspective Drive. Just before the intersection with the existing 24-inch diameter main on Perspective Drive, a new pressure reducing station was proposed as an option to reduce pressure from the Level 1 hydraulic gradient to Level 3.

Level 2 into Level 3

The storage options also included a new storage at Summit Park on the southeast side of Awbrey Butte. The tank would be supplied from Level 2 from new pipes along Summit Drive. On the discharge side of the new storage, new pipe would extend to Summit Drive, north and east on Summit to Wyeth Court, south and east along Wyeth Court to Powell Butte Loop and ending at the intersection of Powell Butte Loop and Awbrey Road. A new pressure reducing station just west of Awbrey Road would reduce pressure from Level 2 to Level 3.

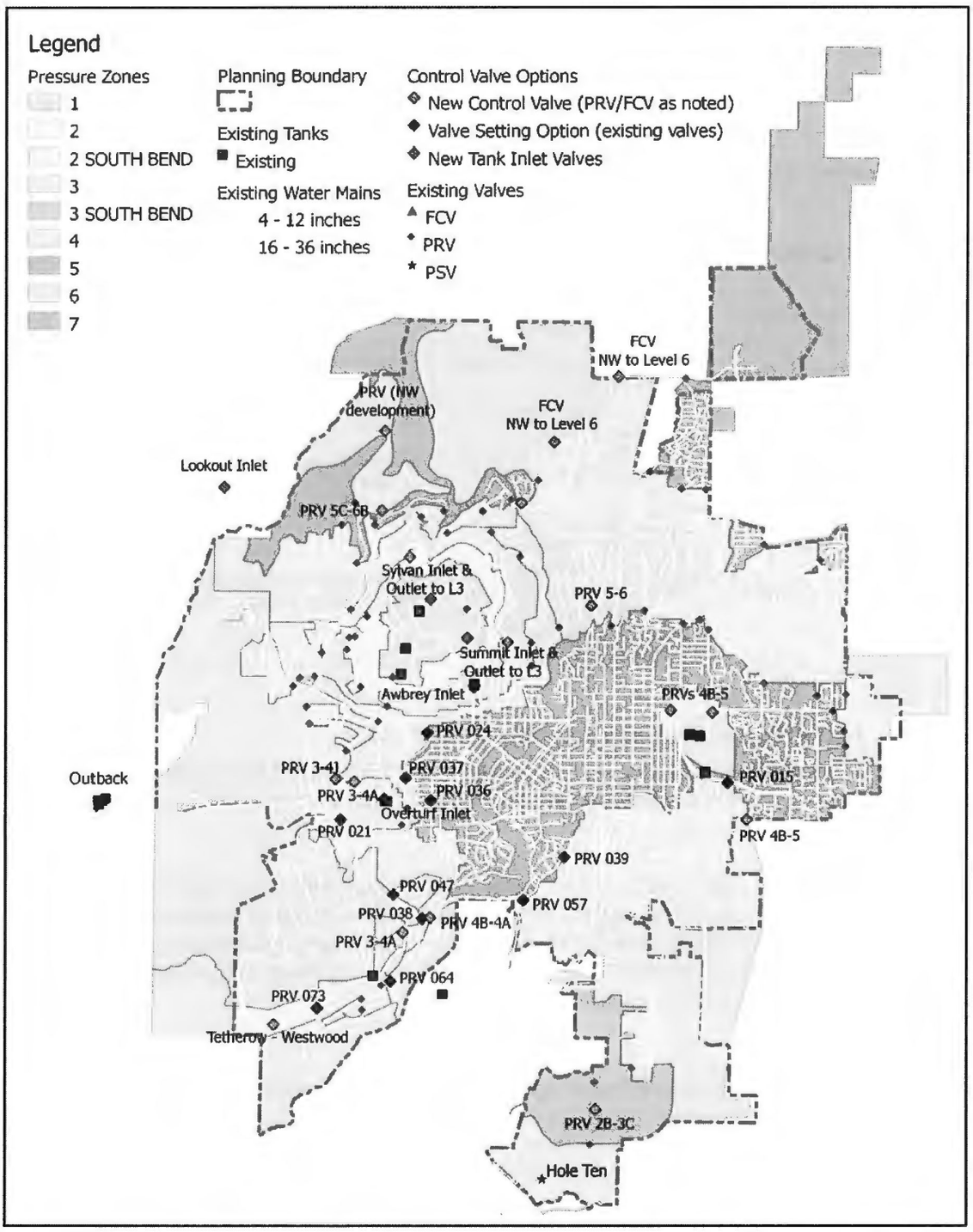


Figure 2.10 – New and existing valve decision options considered in the optimization

New valve option labels indicate from- and to- zones; existing valve labels indicate GIS IDs

Level 3 into Zone 4J

A new development is planned north of Skyliners and east of Mt Washington Drive that would be part of Zone 4J. A PRV connection from Level 3 was included in the model along with the new piping. Although the pipes were not sized in the optimization due to lack of information about the future demands in this area, the setting of the valve was evaluated.

Level 3 into Level 6

New pipe options were included in the optimization formulation to supply Level 3 on the north side of Awbrey Butte. One of these options was to extend Level 3 piping north and east beyond Pressure Reducing Station 67, following Glenbrook, to the interface with Level 6 at the river. A new pressure control station to reduce pressure in the supply from Level 3 to Level 6 was proposed to be located near NW Lower Village Road just south of the existing Pressure Reducing Station (GIS ID 79).

Level 5 into Level 6

There are new pipe options to strengthen the fire flow capacity of the network along the northern portion of Zone 5, as well as to convey additional supply from Level 5 into Level 6. A new pipe option and new pressure reducing station are proposed just between Level 5 and Level 6 along Highway 97 just after the split of Highway 97 and Highway 26, with the station reducing the pressure into Level 6.

Northwest Development connections

System projections for Build-out predict that new growth will take place primarily to the northwest and northeast of the existing service area. Development in the northwest will require significant new piping to convey the anticipated flow. Two new flow control valves were included in the model at the end the proposed piping connecting into Level 6. The aim was to determine whether there was benefit in using the new piping to assist with transmitting supply to the lower pressure levels. The optimization was formulated to evaluate the size of the pipes and settings on the valve connections to Level 6. The location of the first valve option is just north of the intersection of O B Riley Road and Glen Vista Road, and the second is on Cooley Road west of Hunnell Road.

2.6.1.7 Pressure Reducing and Flow Control Valve Setting Adjustments

The settings of a number of control valves were evaluated in the optimization. Table 2.9 shows the flow control and pressure reducing valves, current settings for flow / pressure for winter and summer conditions, and the range of setting options that the optimization was configured to evaluate to determine the most favorable settings.

The first two valves in Table 2.9 are the flow control valves (FCVs) that fill Overturf and Awbrey. Analysis of the existing system summer EPS model results showed that flow from Outback to these reservoirs fluctuates significantly, which often affects the available head in the transmission line. Controlling the rate of flow over a 24-hour period would provide a more constant driving head for the system and increased ability to incorporate surface water supply.

A key aim in the Operations Optimization was to improve the recovery of the Pilot Butte Reservoirs in Zone 5. The Build-out Optimization formulation also aimed to ensure all reservoirs maintain volume over the maximum day. Adjustments to the settings of valves on the boundary of Level 4 and Level 5 (Valve numbers/GIS IDs WAPRV024A, WAPRV036A, WAPRV037A, WAPRV015A, WAPRV015B, WAPRV039A and WAPRV057A) were evaluated to determine if modifications to the settings will improve the reservoir levels. In addition, the setting of the Athletic Club PRV (GIS ID WAPRV038A) was evaluated. The remainder of the PRV setting options in Table 2.9 relate to the potential zone boundary modifications discussed previously in Section 2.6.1.5.

Table 2.9 – Control valves with settings evaluated in the optimization

Valve ID	From Level / To Level
Overturf FCV	Level 3 to Level 4
Awbrey FCV	Level 3 to Level 5
WAPRV024A	Level 4A (West) to Level 5 - Newport & Juniper
WAPRV036A	Level 4A (West) to Level 5 - Cumberland and 15th
WAPRV037A	Level 4A (West) to Level 5 - 17th St. & Galveston
WAPRV038A	Level 3 to Level 4B (East) - Mt. Washington & Athletic Club
WAPRV015A	Level 4B (East) to Level 5 - Hwy 20 @ 1734
WAPRV015B	Level 4B (East) to Level 5 - Hwy 20 @ 1735
WAPRV039A	Level 4B (East) to Level 5 - Wilson & Bond
WAPRV057A	Level 4B (East) to Level 5 - Bond & Reed Market
WAPRV047A	Level 3 to Zone 4G - Chandler & Mt. Washington
WAPRV064A	Zone 3C (Westwood) to Zone 4I - Wild Rapids & Wild Rapids
WAPRV021A	Level 3 to Zone 4K - Green Lakes Loop
WAPRV073A	Zone 2A (Tetherow) to Zone 3C (Westwood) - Tetherow & Campbell

2.6.1.8 Booster Pump and Well Pump Controls

The changes to existing controls evaluated with the optimization include modifying initial status (on/off) of pump facilities as well as trigger levels for wells and booster stations based on storage levels. There are a number of decisions in the optimization which involved adding automatic controls to pumps which are currently manually operated. This has been done based on information from Bend indicating that SCADA could be added to control these pumps if it is shown to be beneficial in meeting Bend's operational goals. The targeted pumps were:

- Pilot Butte Well 3 (water lube)
- River Well 1
- River Well 2

Some existing wells are not suitable for control based on tank levels or system pressure; however the optimization was configured to evaluate whether or not these particular wells should be maintained and operated to meet future maximum day demands. The wells in question are Copperstone Well (submersible, runs to waste for 10-15 minutes on start up) and Pilot Butte Well 1 (oil lube, must be run to waste for 24 hours before use).

In addition to adding controls for the above wells, Optimatics evaluated changes to existing well controls at selected facilities. The logic behind introducing different control setting options for existing well relates to changing the priority of supply from different facilities. For example, the Scott Street Pump Station and Bear Creek Wells are both controlled by the level in Pilot Butte 2. For the optimization, Optimatics configured control options in the model that could make Scott Street the primary facility and Bear Creek the secondary supply facility.

Table 2.10 lists the current summer and winter controls for each pump and well facility evaluated in the optimization. The pumps and wells are grouped based on the tank which controls their operation. The range of settings (tank levels) that were tested with the optimization are listed in the final column. For new wells, the optimization was configured to select operation status (on or off) and the maximum flow rate at each site.

Table 2.10 – Control setting decisions

ID	Current tank level setting (ft)		Tank level setting options (ft)
	Winter	Summer	
TOWER ROCK RESERVOIR			
Awbrey Booster Pump 1 - On	27.5	28.9	24.5 - 27.5
Awbrey Booster Pump 1 - Off	29.5	29.5	26.5 - 29.5
Awbrey Booster Pump 2 - On	26	26	23 - 26
Awbrey Booster Pump 2 - Off	27.5	27.5	24.5 - 27.5
New Awbrey Pump Option - On	n/a	n/a	25 - 27
New Awbrey Pump Option - Off	n/a	n/a	27.1 - 29
AWBREY RESERVOIR			
Valve Inlet - Open	17	17	14 - 16
Valve Inlet - Closed	18	17.9	17 - 19
River Well 1 - On	n/a	n/a	14 - 16
River Well 1 - Off	n/a	n/a	16 - 18
River Well 2 - On	n/a	n/a	13 - 15
River Well 2 - Off	n/a	n/a	16 - 18
OVERTURF RESERVOIR			
Valve Inlet - Open	21.8	23	21.8 - 23.8
Valve Inlet - Closed	23	24.6	24 - 26
PILOT BUTTE RESERVOIR 1			
Pilot Butte Well 3 - On	n/a	n/a	22 - 24
Pilot Butte Well 3 - Off	n/a	n/a	26 - 29

Table 2.10 – Control setting decisions cont.

ID	Current tank level setting (ft)		Tank level setting options (ft)
	Winter	Summer	
PILOT BUTTE RESERVOIR 2			
Bear Creek Well 1 - On	35	35	33 - 35
Bear Creek Well 1 - Off	37	37	35 - 37
Bear Creek Well 2 - On	34	34	32 - 34
Bear Creek Well 2 - Off	36	36	34 - 36
Scott St Pump 1 - On	29	29	29 - 34
Scott St Pump 1 - Off	33	33	33 - 36
Scott St Pump 2 - On	31	31	31 - 35
Scott St Pump 2 - Off	35	35	35 - 37
Scott St Pump 3 - On	27	27	27 - 30
Scott St Pump 3 - Off	32	32	32 - 35
ROCK BLUFF RESERVOIR 1			
Rock Bluff Well 1 - On	34.9	34.9	32.9 - 34.9
Rock Bluff Well 1 - Off	37.2	37.2	35.2 - 37.2
Rock Bluff Well 3 - On	36	36	34 - 36
Rock Bluff Well 3 - Off	38.2	38.2	36.2 - 38.2

2.6.2 Method to estimate power costs in the optimization

As part of the Operations Optimization, an analysis was completed of historical well production and associated power costs. The analysis of data from year 2008 revealed an annual power cost for groundwater pumping of $603,000. For the same period the volume of groundwater pumped was approximately 2,600 million gallons (MG), resulting in a power cost per million gallons of $230/MG.

Optimatics has estimated that energy costs (that is, only those costs associated with kWh consumption) account for approximately 50% of total annual power costs. In the optimization the energy cost value for each facility has thus been doubled to approximate the overall power costs. In summary the following calculations have been used in the optimization:

The equation used to calculate pump power (kW) is: $P = C \times Q \times H / \eta$

Where: C = 0.0001886, Q = flow (gpm), H = head (ft), η = efficiency

The energy, E (kWh), used by a pump over time is: *E = P x t (hours of pumping)*

The cost of this energy requirement will then be: *Cost = E x Cost per kWh*

To determine system-wide power costs, the following approximation has been used:

Estimated annual power costs = Σ for all facilities [Daily energy cost per pump / Annual energy ratio] x Days in a year x Factor to represent total power costs

Where: *Annual energy ratio* = 2.25 for maximum day

Factor to represent total power costs = 2

Power costs have been projected over a 20-year design period and the net present value (NPV) calculated using a discount rate of 6%. This allowed the optimization to consider the trade-off between capital improvements and power costs over a longer time frame than a single year.

NOTE: Since the NPV and power cost values are a rough order of magnitude approximation only, the costs presented in the following sections simply represent annual energy costs for the scenarios evaluated.

2.7 Build-out Optimization Results

The layout of the Final Build-out Solution including pipe improvements (not including fire flow piping improvements, refer Section 2.8.14), new storage, new wells, new pumps and new valves is shown in Figure 2.11. The following sections provide additional information about the solution and discussion of observations made from the optimization run results and trends.

2.7.1 Recommend Improvements and Estimated Costs

Pipes

A full list of recommended piping improvements needed to satisfy projected build-out maximum day demand and integrate supply from surface and groundwater sources is provided in **Appendix G**. The estimated cost of these improvements is $43.6 million. This does not include costs associated with pipe improvements that are understood to be either recently constructed, under construction or planned for construction near term. This applies to:

- 24-inch diameter pipe from the Pilot Butte Reservoirs in Level 5 to the intersection of Lafayette and 12th street (replaces existing 12-inch pipe)
- A 12-inch diameter pipe from the Shilo Well facility to the suction side of Murphy Pump Station/ Zone 4B
- 12- and 16-inch diameter transmission main piping in the former Juniper Utility area from Murphy Pump Station to Mountain High (the optimization results confirmed MSA's recommendations for this area – as per *Former Juniper Utility – Proposed Water System Improvements*, January 2011, **Appendix F**)
- Piping connections to allow the Tillicum area to be supplied from Zone 4B (again as per MSA recommendations)

Upon review of the proposed recommendations, the City advised that the preference is to replace rather than parallel existing pipe alignments which require additional capacity. However, in some instances, parallel mains are recommended due to the importance of the existing line. The following major lines are recommended to have parallel mains installed:

- *Projects L3-2, L3-4 and L3-5, Outback site and along Skyliners to Skyline Ranch Road* – the piping out of Outback is key to maintaining supply to the city; shutting one of the lines down in order to replace it would have a bit impact on the system
- *Projects Z4B-1 and Z4B-2, Powers Road, Rock Bluff to Brosterhous (16-inch existing)* – the recommended size for a parallel main is 42-inches which would be near equivalent to constructing a new line. The existing 16-inch line is the only connection from Rock Bluff to Zone 4B and shutting it down would have a significant impact on the system. In fact, the City may wish to consider installing two new mains rather than a single 42-inch main next to the existing main for added redundancy.
- *Projects Z4B-3 and Z4B-7, Brosterhous/97 from Powers to Reed Market (12-inch existing)* – the City indicated that a dual line system would be beneficial along this route due to it being a high traffic volume area which includes a crossing of 3rd Street and a canal.

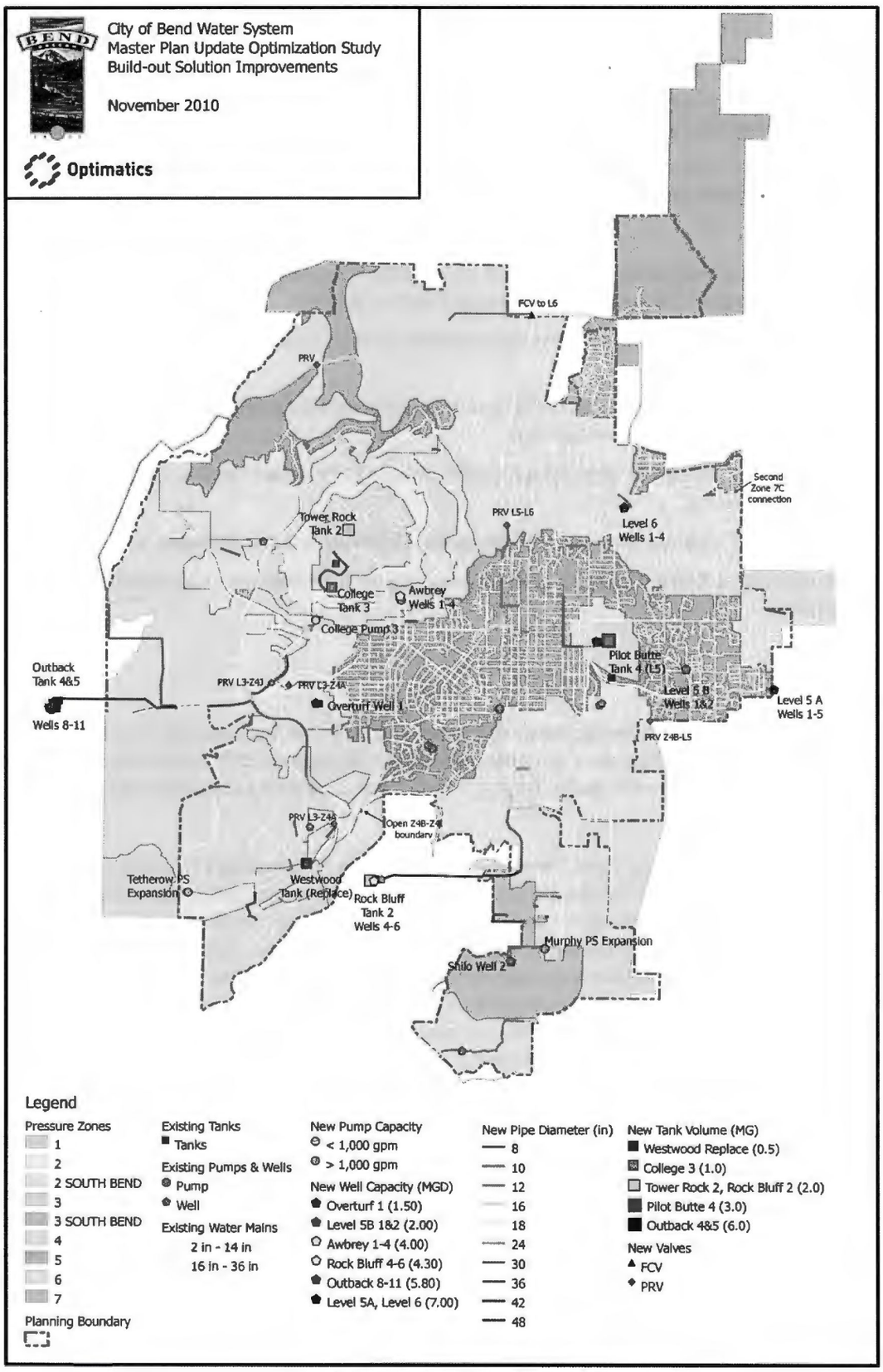


Figure 2.11 – Final Build-out Solution Layout

Note: A large scale version of this map is available in hardcopy at the end of this report, and in the electronic **Appendix I**

- *Project L6-3, Boyd Acres from Ross Rd to Brinson Blvd (16-inch existing)* – a relatively major line in an industrial area with plenty of right of way.
- *Project L6-2, Brinson from Butler Market to 18th* – this route includes two canal crossings, making a dual line system beneficial.

There are also some areas where a parallel pipe is unavoidable as the new pipe is in a different pressure zone to the existing pipe. The following locations fall into this category:

- *Project L2-1*, Glassow and Summit Drive between College 1 Reservoir and Coe Ct (creates a loop in Level 2)
- *Project L3-3*, Piping past College PS, from the suction side of College to downstream of PRV 002 (provides another way to fill Awbrey)
- *Project L3-2*, Shevlin Dr, at round-a-bout with Crossing Dr (similar to above, Level 3 connection, past Zone 4J/A piping)
- *Project L3-1*, Champanelle Way from Niagara to Green Lakes Loop (bypasses 4K)
- *Project L5-18*, Century Drive, Knoll to Simpson (creates a tie between Level 5 piping, past Zone 4B piping)

Storage

Five new storage tanks have been recommended in the Final Build-out Solution at the Pilot Butte, Outback, Rock Bluff, Tower Rock and College 1 tank sites. In addition it is recommended that the Westwood Tank be replaced, maintaining storage at this site. Table 2.11 lists the storage volumes at these sites and the associated costs.

The additional storage in Levels 1 and 2 is strictly not required for the purposes of meeting emergency storage needs. There is sufficient reliable supply capacity in Level 3 to meet the needs of that zone and offset the emergency storage requirements in Levels 1 and 2, via the Awbrey Pump Station. The Awbrey Pump Station has back up power and is sized to meet maximum day plus fire flow. However, given the isolation of Levels 1 and 2 due to their elevation and single reliable supply point, Optimatics recommends that the City consider meeting the emergency storage needs for these zones above ground. The recommended new storage volumes shown in Table 2.11 allow the two zones to be supplied by gravity for a period of time (up to two days of average day demand) under emergency conditions.

The Westwood tank was not selected to be overhauled, instead the optimization selected to decommission the tank (a lower cost option, the option to leave the tank in its existing condition was not considered). In order to maintain satisfactory pressure near the Westwood Tank site a new valve connection was recommended between Level 3 and Zone 4A at West Ridge Avenue, and the Westwood Well was selected to operate all day. However, these alternatives do not represent a reliable solution for Zone 4A, in particular for customers in the south of the zone, so Optimatics recommends that the City maintain a tank at this site.

Table 2.11 – Recommended new storage – Final Build-out Solution

Location	Storage construction:	New Volume (MG)	Cost
Outback 4 & 5	Above-ground Concrete	6.0	$7,020,000
College 3	Above-ground Concrete	1.0	$2,366,000
Tower Rock 2	Above-ground Concrete	2.0	$3,755,000
Rock Bluff 2	Above-ground Concrete	2.0	$3,755,000
Pilot Butte 4 (Level 5)	Buried Concrete	3.0	$5,807,000
Westwood (replace)	Above-ground Concrete	0.5	$1,427,000
Total Cost		**14.5**	**$24,130,000**

Wells

A total of 36 MG of new well capacity is recommended in the Final Build-out Solution. Table 2.12 lists the locations and capacities of new wells at existing and new sites. As noted in Section 2.3.2, the optimization assumed that the surface water source would contribute 23 MGD in the build-out scenario. If this does not eventuate, new wells in addition to those listed will be required to meet firm supply capacity needs.

Table 2.12 – Recommended new wells – Final Build-out Solution

Location	Max Day Contribution (MG)	Maximum Flow Rate (gpm)	Pump Capacity (MGD)	Pump Head (ft)	Cost [2]
Expanded Outback Wells (#8-11)	5.8	4,000	5.8	~500	$7,776,000
New Overturf Well	1.4	1,000	1.4	~500	$1,944,000
Expanded Shilo Well (#2)[1]	1.3	1,400	2.0	~500	$2,721,600
Expanded Rock Bluff Wells (#4-6)	4.0	6,000	4.0	~400	$5,443,200
New Awbrey Wells (#1-4)	4.3	3,000	4.3	~500	$5,832,000
New East Level 5A Wells (#1-5)[3] In vicinity of Shirley Ct	7.1	4,900	7.1	~800	$9,525,600
New East Level 5B Wells (#1-2)[3] In vicinity of Paula Dr/Purcell Blvd	2.0	1,400	2.0	~800	$2,721,600
New Level 6 Wells (#1-4)[3] Butler Market Rd/Brinson Blvd	7.1	4,900	7.1	~800	$9,525,600
Total Well Cost	**34.3**		**35.7**		**$45,489,600**

1) Assumes Shilo Well 3 online, this is additional capacity

2) Includes cost of standby generator for each new well

3) These locations do not take into account issues related to potential groundwater contamination and 2 year time of travel

Of note, the optimization did not select to add any new wells at Pilot Butte (Well 4 was assumed to be online). Increasing the supply from this site necessitated additional pipe upgrades to deliver the supply to Level 5 and north to Level 6. Instead, the optimization favored developing new wells east of Pilot Butte, effectively distributing the supply and reducing the need for additional piping.

In the Consequence of Failure Analysis the area east of Pilot Butte in Level 5 was shown to be vulnerable in the event of a pipe break along Neff Road. New wells in this area will help address this issue by providing supply locally.

In Level 6, two new well sites were evaluated, one being the existing well site at Pine Nursery. The optimization favored the alternative site near the intersection of Butler Market Road and Brinson Blvd, as this location did not require significant additional piping to connect the supply into the existing system. By comparison, the well at Pine Nursery would require a significant length of main to be installed to connect the supply to Level 6 piping.

Expansion of the River Well site was not considered as an option in the optimization. However, it is noted that these pumps are running forward on their curves in the Build-out Maximum Day scenario. Optimatics recommends that the City monitor the operation of these wells and when they are due for replacement evaluate the pump head requirements for the replacement pumps.

Pumps

Two pump stations are recommended to be expanded in the Final Build-out Solution; Tetherow and Murphy. These stations supply isolated areas of the system and therefore it is important to ensure there is sufficient redundancy at each. Table 2.13 lists the recommended capacity increases at each station and the estimated associated costs.

Table 2.13 – Recommended new pumps – Final Build-out Solution

Description	Existing Capacity	Maximum flow rate for new pumps	Cost
Tetherow Pump Station Replacing pumps 4, 5 & 6 *MD + fire flow = 4,000 gpm*	1 x 150 gpm 5 x 700 gpm	3 x 1,250 gpm (replace 3 700s)	$784,800
Murphy Pump Station Replacing pumps 3, 4 & 5 *MD + fire flow = 2,500 gpm*	5 x 300 gpm	3 x 1,000 gpm (replace 3 300s)	$959,400
Total Pump Station Cost			**$1,744,200**

Note: Cost based on maximum flow rate using cost rate curve developed by MSA. Cost for pump replacement or additional pumps in an existing station assumed 60% of cost for new pumps.

For the Tetherow and Murphy Pump Stations, upgrades will be needed in the future to ensure firm capacity of maximum day plus fire flow is maintained (largest pump out of service). This can be achieved by switching out some of the existing pumps for higher capacity pumps. Based on the projected demand and fire flow requirements, three 1,250 gpm pumps will be needed in place of three 700 gpm pumps at Tetherow, and three 1,000 gpm pumps in place of three 300 gpm pumps at Murphy.

The College Pump Station is stated to have two pumps with capacities of 1,050 gpm and 900 gpm respectively. MSA confirms that the SCADA indicates this station can produce 1,950 gpm, and this has been field verified by Bend Operations staff. However, the pump curves in the model do not match this flow; the second pump capacity is only 400 gpm (see Figure 2.12). When the model is next updated, the pump curves should be revised to match field data.

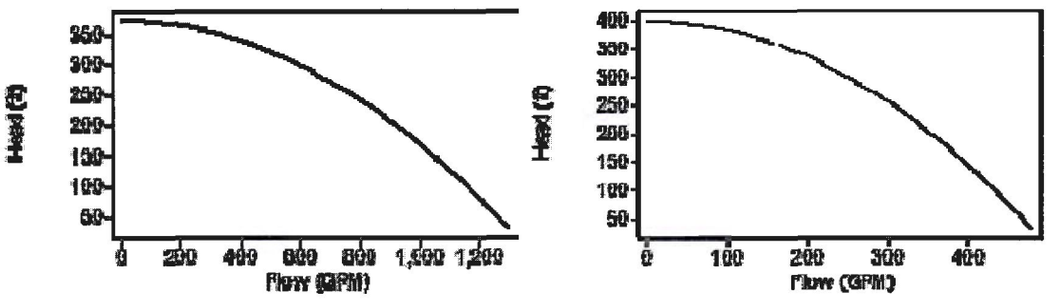


Figure 2.12 – College pump curves in the hydraulic model, Pump 1 right, Pump 2 left

All three pumps in the Scott Street Pump Station run in the build-out maximum day scenario. This pump station is not the sole source of supply to Zone 4B and thus is not as critical compared to Murphy Pump Station, for example. When the pumps at Scott Street reach the end of their useful life Optimatics recommends the City evaluate the typical operating points of these pumps to determine whether it makes sense to replace them with higher capacity pumps.

Valves

A number of new valves are recommended as part of the Final Build-out Solution; some to allow for additional supply to an area and others provide increased redundancy. Table 2.14 lists the new valves and associated costs. Although not required for hydraulic reasons (pressure, fire flow), based on the outcomes of the Consequence of Failure Analysis a new connection to Zone 7C Is recommended to provide a second supply to this area.

Table 2.14 – Recommended new valves – Final Build-out Solution

Description	Type	Status	Cost
New valve associated with new piping on Skyliners, Level 3 to Zone 4J/4A	PRV	Active	$75,000
PRV in new NW Development (reduce pressure for lower elevation areas north of butte)	PRV	Active	$75,000
New Level 5 to 6 connection at Division and Mt Washington	PRV	Active	$75,000
Connection from new NW development to Level 6	FCV	Active	$75,000
Level 3-4A connection near Westwood (helps fill the tank and provides emergency supply)	PRV	Active	$75,000
Second connection Zone 4B to Level 5 at Bear Creek Rd (assists fire flow)	PRV	Emergency	$75,000
New valve to assist with fire flow, Level 3 to Zone 4A north of Overturf	PRV	Emergency	$75,000
Second connection to Zone 7C	PRV	Emergency	$75,000
Total New Valve Cost			$600,000

In addition to the selection of new valves, the optimization evaluated the setting of a number of existing valves. In particular the optimization evaluated the settings for flow into Overturf and Awbrey Reservoirs, and the setting of the Athletic Club PRV. Further details of these operational decisions are discussed below.

2.8 Observations and Discussion

2.8.1 Westwood

The Final Build-out Solution recommends that the Westwood Pump Station be decommissioned and the Westwood Zone reconfigured such that higher elevation customers are supplied from Tetherow, and the remainder of the zone is absorbed into Level 3. There are a number of factors that contribute to this recommendation, as discussed below.

Operations advised that the Westwood pump station was implemented as a temporary facility and is in poor condition. The preference is to take it out of service if there is a way to work without it. Operations has successfully supplied all of Westwood (and 4H and 4I) from the Tetherow PS via the existing PRV (GIS ID WAPRV073) in the past. This operation is not recommend as a long-term solution as it does not capitalize on the fact that the lower elevation customers could be fed by gravity from Level 3, thereby reducing pumping costs.

The hydraulic model demonstrates that it will be difficult to maintain the level in the Westwood Reservoir in the future if the pump station stays in service. Under build-out maximum day conditions, it is not possible to maintain the level in the Westwood Tank if the pump station is running, unless significant improvements were made in Zone 4A. There are restrictions to filling the reservoir because of the single 12-inch diameter connection between Overturf and Westwood, and the limit of Westwood Well. Total demand in the Westwood/Zone 4H/Zone 4I area is 1.9 MGD for Max Day Build-out; this is more than double the existing maximum day demand of 0.75 MGD. The optimization favored taking the Westwood PS offline for the following reasons:

- Reduces cost of pumping
- Eliminates the need for improvements in Zone 4A and expansion of Westwood PS/Reservoir

In the near term, some customers in Zone 4I can be supplied from Zone 4B by opening up a connection to the main on Reed Market Road (GIS ID WV0012721). This was recommended as part of the operations optimization to reduce demand off the Westwood pump station. This is also recommended in the Final Build-out Solution. The PRV that supplies Zone 4I (Station 64) remains active; approximately 50% of the demand is supplied from Zone 4B and the remainder is met through the PRV via Zone 4H.

The proposed long term solution involves shifting lower elevation Westwood Zone customers to be supplied from Level 3 and higher elevation customers to be supplied from Tetherow. A number of small new connections are needed between Westwood and Level 3 and within Westwood itself to maintain looping and reliable supply. These are shown in Figure 2.13.

It is acknowledged that Westwood customers would see lower pressures if they are supplied from Level 3, on the order of 10 psi lower. This would not be acceptable for high elevation customers in the southwest (River Bluff Trail) and north (Cartmill Drive) of the Westwood Zone. The proposed solution has these two areas supplied from the Tetherow PS via a PRV and new piping. For the lower elevation customers, given they currently see pressures above 65 psi at peak hour (most are higher, around 80-90 psi), a lower pressure would be adequate and well above the 40 psi requirement.

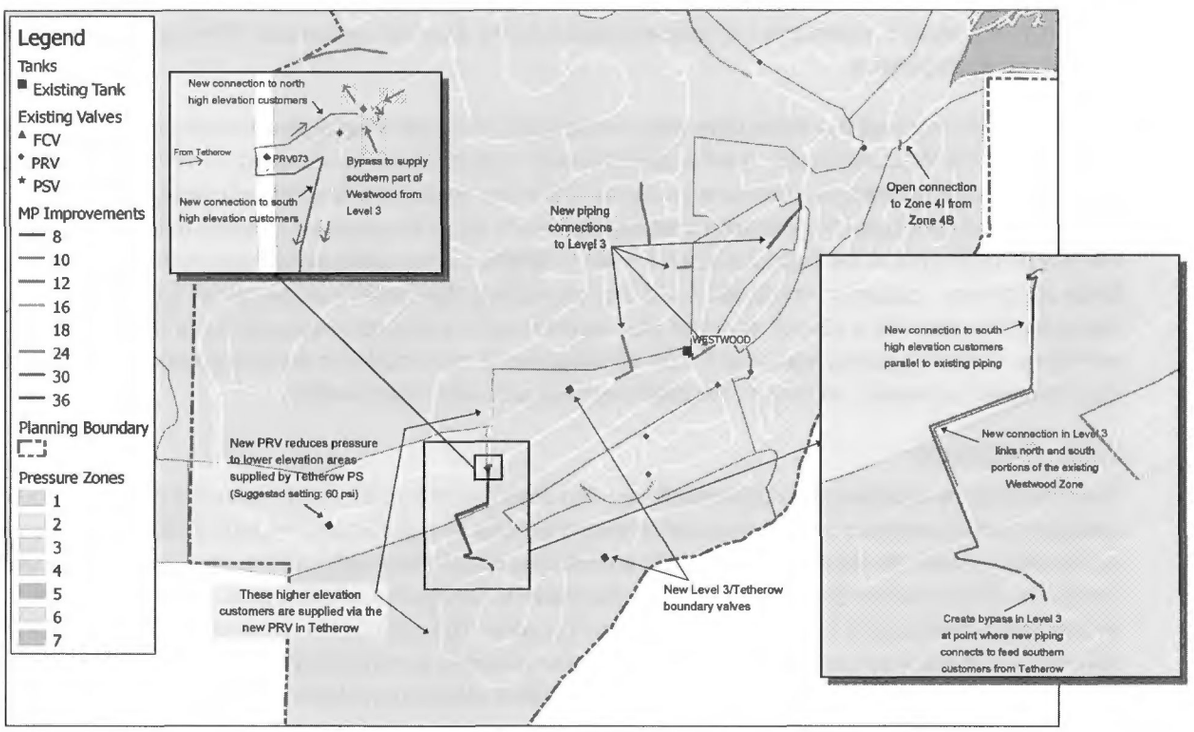


Figure 2.13 – Recommended boundary changes and piping improvements for the Westwood Zone

Redundancy and fire flow

The recommended solution for Westwood involves creating a boundary between Tetherow and Level 3 in Westwood. It is recommended that valves are installed that will facilitate flow from Level 3 to the Tetherow Zone, and vice-versa, in the event of an emergency.

It should be noted that the proposed solution places greater reliance on the Tetherow Pump Station and the piping which feeds the pump station. Without the Westwood pump station it will be impossible to supply the club house in Tetherow in the event that the Tetherow Pump station was out of service. Given that the pump station has a large number of pumps, there would have to be a significant incident to prevent any flow through this station. In reviewing the proposed recommendations, Operations indicated that the Tetherow pump station is believed to be reliable as it is new; obviously it will be important to maintain back-up power facilities to this station. Improvements recommended in Level 3 on the suction side of the pump station will also increase redundancy.

Operations also reported that there have been challenges in the past meeting fire flow requirements in the south-east of the Westwood zone. If the higher elevation customers are supplied from Tetherow as proposed, this will eliminate the observed pressure problems. If the City desires the flexibility of meeting fire flow at these locations from Level 3 some additional improvements would be required. Analysis of the model with a fire flow of 1,500 gpm at the highest elevation node in Westwood indicated a restriction in the piping near these customers – approximately 2,000 ft of 8 inch pipe along Mammoth Drive and River Bluff Trail. Replacing this pipe with a 12-inch diameter pipe would result in adequate pressures under fire flow conditions, assuming supply via Level 3. This improvement is not included in the Final Build-out Solution as it is not deemed necessary, so long as the other improvements are implemented.

2.8.2 Tetherow

The City currently experiences problems with the Tetherow Pump Station; in particular it is difficult to maintain adequate suction pressure to the pump station during periods of high demand. In June 2010 MSA completed a preliminary review of alternative solutions to address the suction-side deficiencies under existing demand conditions. Their results indicated a number of alternative solutions that satisfied peak hour and fire flow demand conditions both in Level 3 and in the Tetherow zone. The optimization analysis reviewed these solutions under build-out conditions. MSA issued a memorandum summarizing the recommendations for this area - *City of Bend Water System – Tetherow Development: Alternatives Analysis*, January 2011 - which is included in **Appendix F**.

The section of Level 3 that supplies the suction side of the Tetherow Pump Station is currently supplied by a single 12-inch diameter connection to the piping along Mt. Washington Drive at Brokentop Drive. In addition to the observed pressure problems under high demand conditions, the Consequence of Failure Analysis completed as part of the Optimization Study highlighted this area as particularly vulnerable in the event of a pipe break near the connection point. The improvements considered for this area are aimed at both increasing service pressure and improving redundancy.

The improvements have been designed to meet residential fire flow rates in Level 3 on the suction side of the pump station, as well as the following fire flow rates at the highest elevation point in the Tetherow zone:

- 1,750 gpm under existing demand conditions
- 3,500 gpm under future build-out demand conditions

MSA's analysis identified the following improvement options, which were subsequently evaluated in the optimization. The locations of these improvements are shown on Figure 2.14.

A – Either open valves to allow flow from Level 3 through Zone 4K and provide individual PRVs to approximately ten customers in Zone 4K, or alternatively install a 12-inch diameter, 1,000-foot connection bypassing Zone 4K.

B – Construct a new line from the existing 16-inch diameter line on Skyline Ranch Road connecting to the 36-inch diameter line on Skyliners Road

G limited – Improve 12-inch diameter, 4,200-foot section on Mt Washington Drive to at least 16-inch diameter or larger

G extended – Extend improvement along Mt. Washington Drive from Skyliners Road to Brokentop Drive

D – Construct a new 12-inch diameter, 1,200 foot pipeline connection between the 16-inch diameter main on Skyline Ranch Road to the 12-inch diameter line on Brokentop Drive

T – Change the boundary of the Tetherow Zone, extending it to the intersection of Skene Trail and Skyline Ranch Road, primarily by closing /opening valves on existing pipelines plus one new connection.

The optimization analysis indicated that all of the above improvements are needed under build-out conditions. The recommended sizing and timing is listed in Table 2.15.

Table 2.15 – Recommended improvements for the Tetherow area including Level 3 based on Build-out Optimization analysis results

Improvement ID	Description	Recommended Size Build-out conditions	Estimated Cost	Recommended Timing
A	Bypass of Zone 4K from Hosmer Lake Dr to Green Lakes Loop.	12-inch	$204,000	2020
B	Connection from Skyliners to Skyline Ranch Rd	18-inch	$1,431,000	2011
D	Connection from Skyline Ranch Rd to Brokentop Dr	12-inch	$218,000	Build-out
G	Extended option – replace piping in Mt Washington from Skyliners Rd to Brokentop Dr	36-inch 30-inch	$334,000 $2,135,000	Build-out
T	Shift customers along Bonneville Loop to Tetherow Zone with a new connection and closing a valve at Skene Tr	8-inch	$1,400	2011

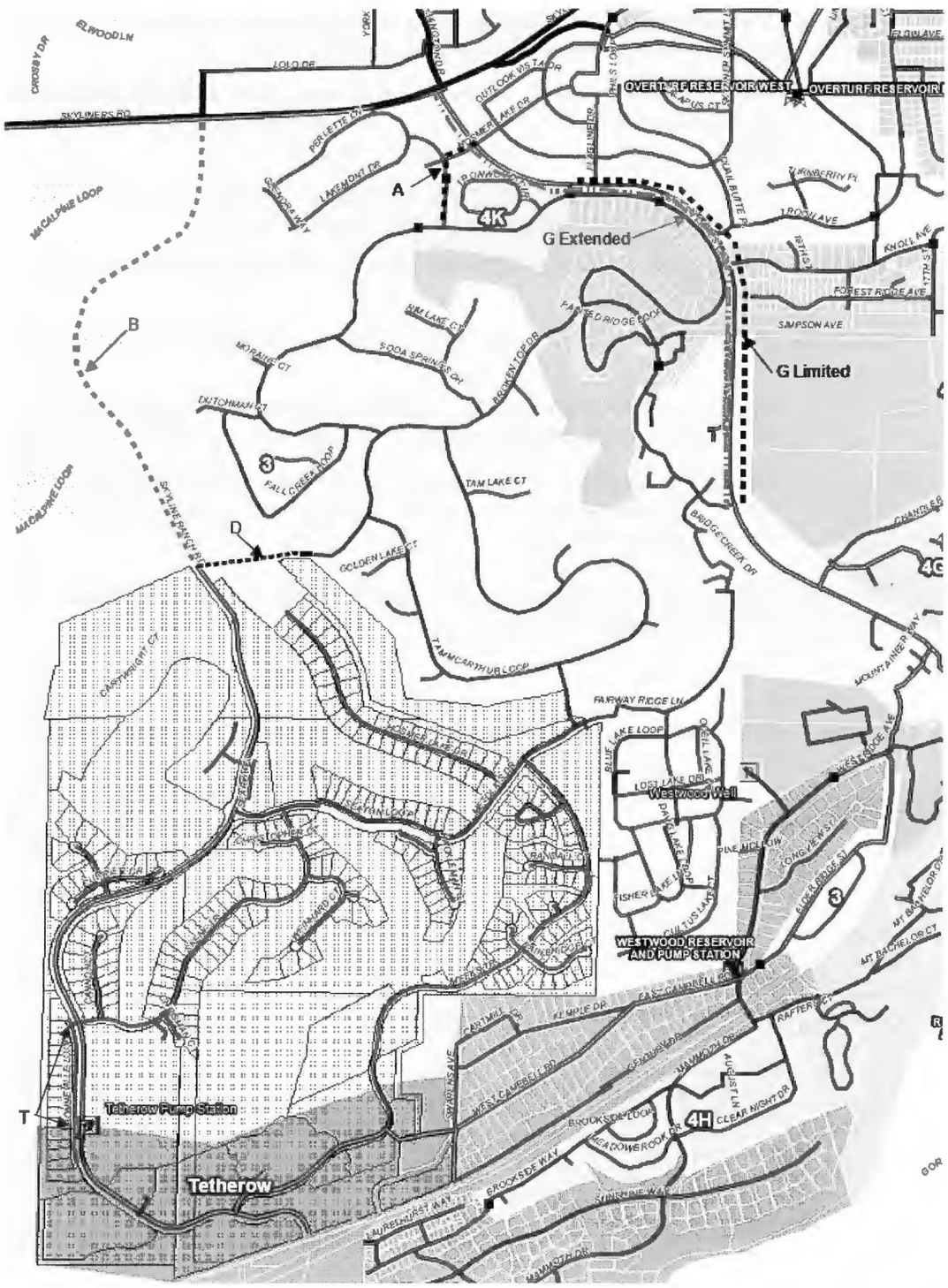


Figure 2.14 – Improvement Options for Tetherow area – per MSA Memo June 2010

2.8.3 Juniper Ridge Improvements

The optimization evaluated the option of a new tank in the vicinity of Pilot Butte at Level 6 hydraulic grade, as proposed by MSA in their evaluation of improvements needed to support the Juniper Ridge development (refer to MSA memo *Water System Planning for the Juniper Ridge Development, Bend, Oregon*, September 2009, **Appendix A**). In addition, the optimization evaluated the option of a tank at Level 5 hydraulic grade. This option was discussed at a number of project meetings and it was agreed it could be feasible if located on the north face of the butte and there would be less public opposition.

Given these two options, the optimization favored a tank located at the Level 5 hydraulic grade; it did not select to implement the Level 6 tank option. The Level 6 tank option was likely less favorable as it does not support Level 5 and would also require a significant length of new pipe to connect the outlet of the tank to Level 6.

The recommended volume of the Level 5 Pilot Butte Tank in the Final Build-out Solution is 3 MG; less than the proposed volume of 5.7 MG at Build-out for the Level 6 Juniper Ridge Tank. The 5.7 MG volume was calculated based on the needs of the Juniper Ridge development in isolation from the rest of the Bend system. The storage volumes proposed in the Final Build-out Solution reflect the needs of the entire system and take into account the ability to move supply from higher zones to lower zones to meet equalization, standby and fire suppression needs.

2.8.4 South Bend

Significant improvements are planned for the South Bend area (former Juniper Utility). MSA reviewed the area as part of a separate study and recommended new transmission and distribution piping improvements that will enable the City to provide satisfactory service under future maximum day demand and fire flow conditions. Although the distribution improvements were not reviewed as part of the optimization study, the transmission improvements were included in the optimization to verify the recommended sizes. The optimization also evaluated the operation of Murphy Pump Station, the Shilo Wells and the potential benefit of including a tank south of the region.

The model was set up as per the recommendations in MSA's Memorandum *Former Juniper Utility – Proposed Water System Improvements* (**Appendix F**). The changes to the existing system included:

- Tillicum rezoned into Zone 4B
- Shilo Wells pumping to Level 4 via new piping (12-inch diameter)
- New piping from Murphy Pump Station to the Shilo Wells and south to Mountain High.
  Phase 1: 16-inch diameter main south from Shilo to the Mountain High Loop.
  Phase 2: 12-inch diameter main from Mountain High Loop to Mountain High.
- Murphy Pump Station operating to supply Level 2 (Mountain High) with Level 3 being fed via existing PRV 69 and a new PRV at the northern end of Timber Ridge. Hole Ten wells emergency only

The proposed transmission piping sizes along Country Club Drive and Mountain High Loop in the Final Build-out Solution are consistent with those proposed by MSA (as noted above).

Storage tank

The option to build a storage tank sound of the Bend system that would be shared with Roats Water System was evaluated in the optimization. There are merits to this option including increased reliability for the South Bend area and reduced potential for pressure fluctuations due to operating a constant pressure pumped system. However, the feasible sites for storage are a significant distance from the existing piping and connecting a tank to the system would be costly. As a result, this option was never selected in the optimization solutions. In discussions with Bend staff it was agreed that the costs outweighed the benefits of this option.

2.8.5 Pilot Butte Wells

The City has existing plans for additional wells at the Pilot Butte site. The option to expand the well pumping capacity, up to the maximum allowed at this site, was considered in the optimization. No additional wells (after Well 4) were recommended as part of the Final Build-out Solution. Interim solutions that included new wells at this site required additional piping capacity (above what is currently proposed) to utilize the extra supply. As discussed in the following section, alternative well sites were evaluated east of Pilot Butte, and in Level 6. These sites were selected in preference to expanding capacity at Pilot Butte.

2.8.6 Storage and well supply at Rock Bluff

Interim solutions presented for the build-out scenario did not include any new storage at the Rock Bluff facility. However, a significant increase in the well capacity at this site was observed in the interim solutions (up to 8 MGD additional capacity). Given Operations' preference for maintaining storage above ground, and the fact that the City currently has plans for storage at this site, the hydraulic model was analyzed to determine an alternative solution at this site involving increased storage and a lower groundwater pumping rate. It was determined that a similar hydraulic performance could be achieved for a similar cost if the groundwater wells pumped at a lower rate for a longer period of time, and the total storage volume was increased by 2 MG. Given that the cost of these two options is very similar (within $1 million); the Final Build-out Solution includes the recommendation to build additional storage at Rock Bluff, together with new wells with a capacity of 4 MGD.

2.8.7 New Wells located in the east

Feedback from operations staff indicated that wells in the east would be a welcome addition to the system. The previous Master Plan also included a recommendation to build supply capacity in the east of the system. Note that this study did not consider the potential impact of groundwater contamination and 2-year time of travel.

Four potential new sites were evaluated, as discussed in Section 2.6.1.3 – two in Level 5 east of Pilot Butte, the Pine Nursery location (Level 6) and a site in Level six near the intersection of Butler Market Road and Brinson Boulevard. New well sites were assigned an additional cost ($1m) in the optimization formulation to account for the need to acquire land and set up a new facility. Despite this cost, the optimization favored implementing well capacity at these sites.

The City was interested to know what the impact would be if new well sites in Level 5 and 6 were not allowed as choices in the optimization. The optimization tested the sensitivity of the solutions to these options. The results indicated that without new wells in the east, additional piping on the order of $10 million would be necessary to transmit the supply from alternative sites. Since the total amount of supply that is needed remains the same regardless of where it is located, other costs related to new well and storage capacity were very similar.

Another observation from the sensitivity runs was that placing new wells on the east side of the system also reduced the tendency of the optimization solutions to rely on proposed new piping in the northwest to assist in transmitting supply to the northeast. This is illustrated in Figure 2.15. The addition of new piping capacity in the northwest is completely dependent on the timing and scope of new development.

City Engineering and Operations staff confirmed that, if the total number of wells is the same, having more well sites would not significantly increase operations and maintenance efforts. Since all new wells will be on SCADA they will not require manual starting. Given the above observations, the Final Build-out Solution includes the recommendation to install new wells in the east of the system.

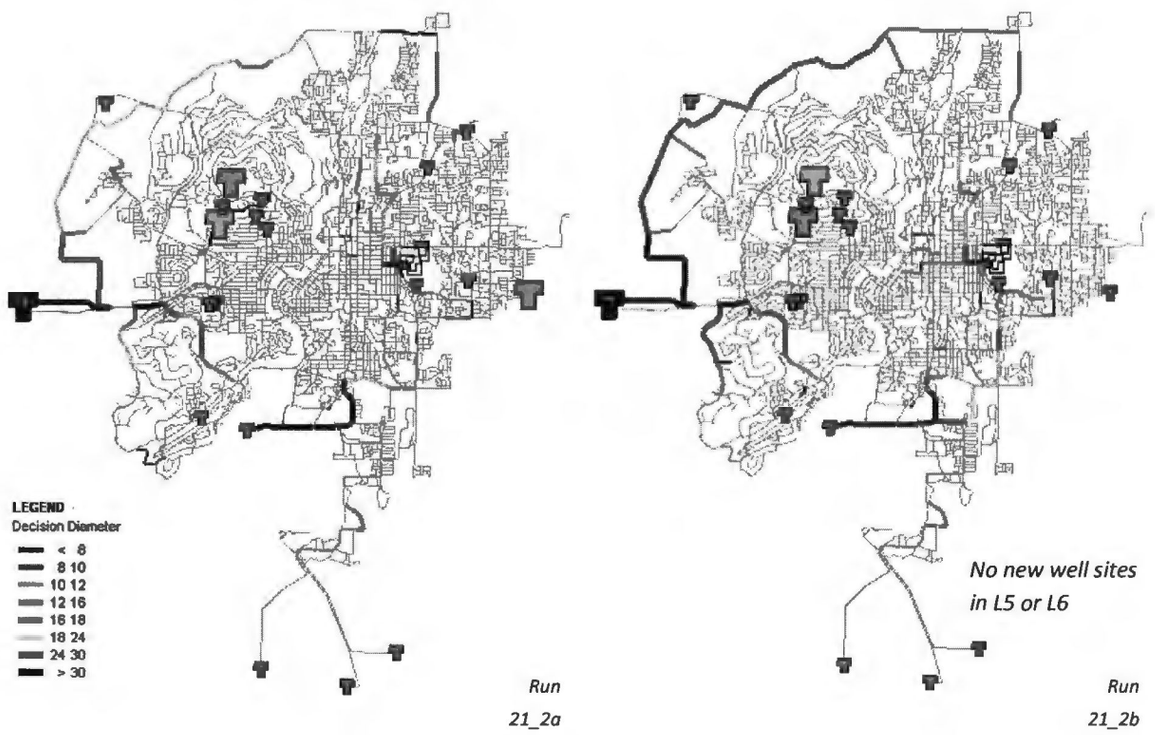


Figure 2.15 – Results of two scenario runs, one with the option to place wells in the east of the system (left), and one without (right)

2.8.8 Development Northwest of Awbrey Butte

The build-out demand projection assumes there will be new development west and north of Awbrey Butte. As shown on Figure 2.11, the proposed piping to serve these developments in the Final Build-out Solution follows a path outside of UGB; the routes follow existing roadways, however they are intended as placeholders only. If or when development occurs in this area it is anticipated that additional corridors will become available for new transmission pipes.

The assumption that growth will occur in the area northwest of Awbrey Butte affects the recommendations for the location of new supply and transmission infrastructure. Located close to the Outback facility, these new development areas are supplied solely from Outback, resulting in the need for new supply capacity and parallel mains. The optimization results also indicated that, assuming the northwest development does go ahead, there would be benefit in extending the transmission improvements all the way to tie into Level 6 near the Juniper Ridge development.

As part of the staging process to develop the 10-year CIP, Optimatics evaluated the need for additional transmission capacity under lower demand conditions. The results indicated that without the new development and if capacity at Outback remains close to the current capacity, there is no need to parallel the lines from Outback. If new capacity is added at Outback but the new northwest developments are not in place, the size of the parallel main can be significantly smaller than the current recommended size in the Final Build-out Solution. Given this information, the City should review the needed improvements in this area of the system in the future when more is known about the likely extent and location of new development.

2.8.9 Operational decisions

One key observation from the optimization results is that there was a trend towards minimizing the amount of supply transferred from Outback to the Overturf and Awbrey Reservoirs. New wells have been recommended at both the Overturf and Awbrey sites to help maintain the reservoir levels as demands increase. Flow into the tanks via the existing inlet valves is controlled in the Final Build-out Solution to minimize filling during peak demand periods. Awbrey does not receive inflow from Outback during the morning peak demand period. When Awbrey Reservoir is filling the flow rate is approximately 4,000 gpm. Conversely, Overturf Reservoir does fill during the morning, but at a reduced rate (less than 1,000 gpm).

The additional supply capacity at Outback is primarily diverted north to the new northwest development, and south via Mt Washington Drive to Zone 4B through the Athletic Club PRV. The setting of the Athletic Club PRV is recommended to increase as demand increases in Zone 4B. The proposed setting in the Final Build-out Solution is 80 psi. Operations expressed concern that raising the setting of the PRV would affect Rock Bluff and Pilot Butte 2 Reservoirs. This would be true under existing conditions; under the build-out scenario there is significantly more demand in Zone 4B and the model does not indicate that raising the setting will impact the operation of Rock Bluff or Pilot Butte 2.

The trigger level settings for pumps and wells that are based on reservoir levels were evaluated in the optimization. Due to the scenario being a build-out maximum day demand case, all existing wells were selected to operate to meet the high level of demand; there was little change to the trigger level settings for those pumps that are already controlled based on tank levels. It was assumed that the Pilot Butte Wells would be placed on SCADA and trigger level controls were developed for these pumps based on the level in Pilot Butte Reservoir 1 (lead pump on at 28 ft, off at 31 ft, lag pump on at 24 ft, off at 29 ft). As per the

Operations Optimization recommendations, the River Wells were configured to operate based on the level in the Awbrey Reservoir.

The Operations Optimization results indicated a benefit in running the Scott Street pump station in preference to the Bear Creek Wells. The head requirement of the booster pumps is much less than the wells, so the associated energy costs are less. In the build-out maximum day scenario it is necessary to run the Bear Creek wells in order to meet the supply requirements of the system. Under lower demand conditions it is still recommended that the Scott Street pumps run as the lead facility to fill Pilot Butte 2 Reservoir.

The new wells in Level 6 will likely need to be controlled based on system pressure in that zone. The new wells in Level 5 could be controlled based on the level in the Pilot Butte reservoirs, or they could be controlled based on system pressure in the area east of Pilot Butte. Operation of new wells located at existing storage facilities would be controlled based on the levels in the tank.

2.8.10 Flow from Outback

Figure 2.16 compares flow from the Outback facility in the 2008 Summer EPS Scenario and the Final Build-out Solution. In addition to the assumption that the surface water source will provide 23 MGD by build-out, 6 MGD of new well capacity is recommended at Outback to help meet the demands of new development. If, as seems most likely at the time of writing, the capacity of the surface water source is only 13.5 MGD, an additional 9.5 MGD of well capacity would need to be substituted at Outback to maintain the same flow from this facility in the Final Build-out Solution (bringing total new well supply at this site to 15.5 MGD). As mentioned in Section 2.8.8, a large proportion of the flow from Outback in the build-out scenario supplies new development northwest of Awbrey Butte (14 MGD under Build-out MDD).

It is not known whether the Outback site could support such a significant increase in well capacity, however, it was not possible to address this in the current study. The City should investigate the groundwater withdrawal limits at Outback. If the maximum potential well supply is significantly less, the Final Build-out Solution will need to be revised.

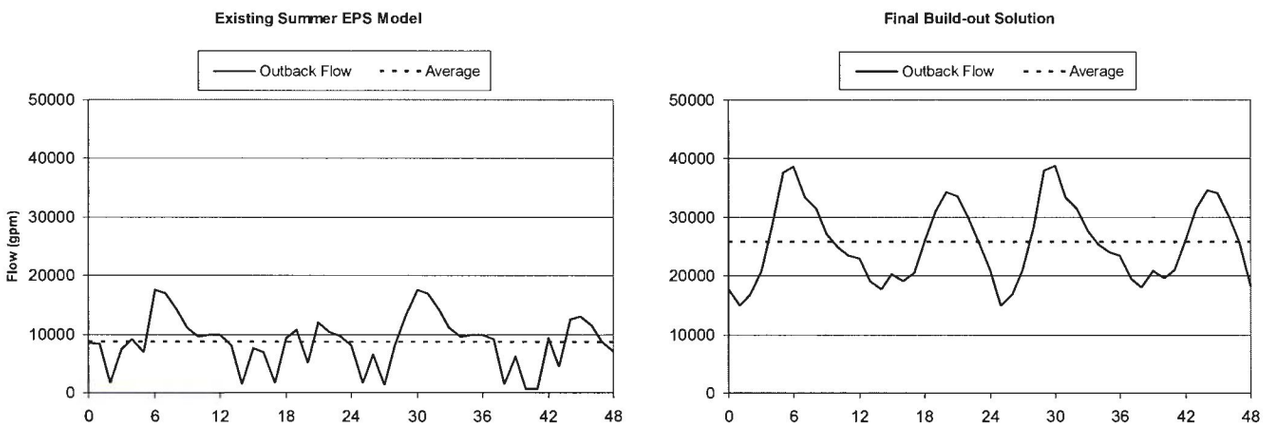
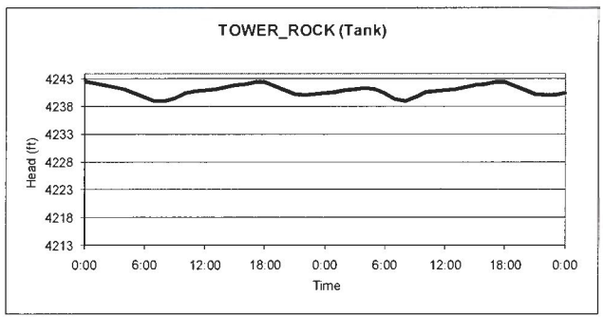
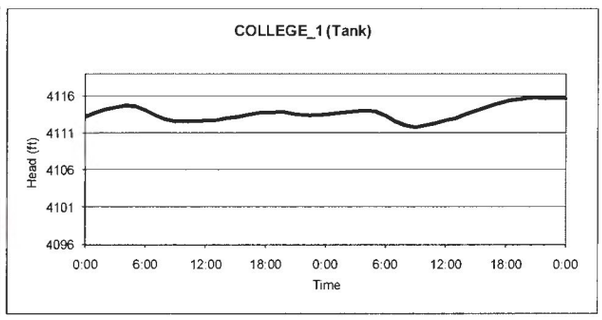


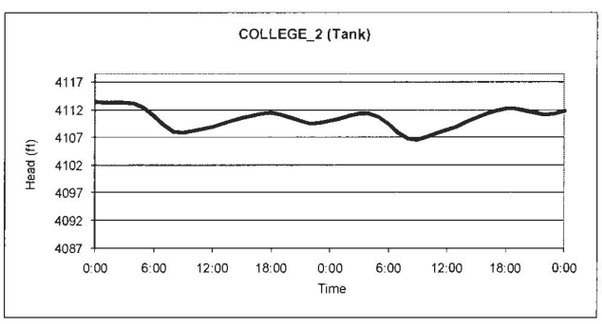
Figure 2.16 – Flow from Outback - Summer EPS scenario left, Final Build-out Solution right

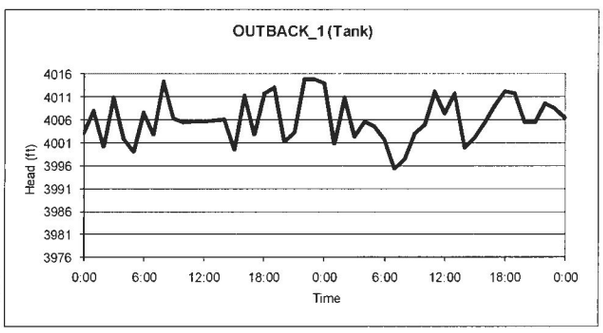
2.8.11 Reservoir levels

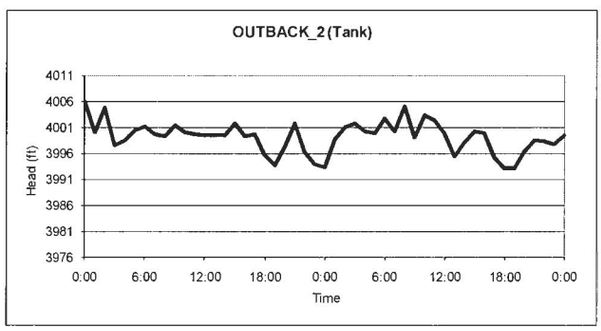
Optimization was constrained to ensure that storage tanks did not lose volume over a 24-hour period, that is, they should return to their start level by the end of the day. The following charts demonstrate how each tank level fluctuates over the course of two consecutive build-out maximum day demand scenarios.

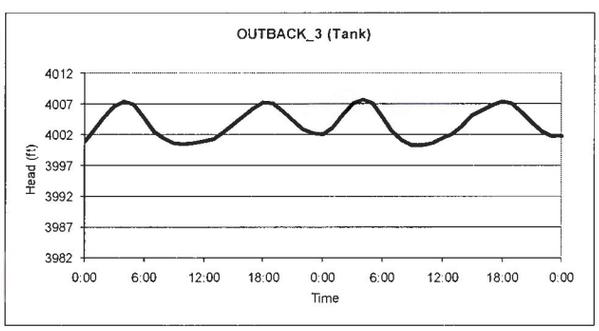


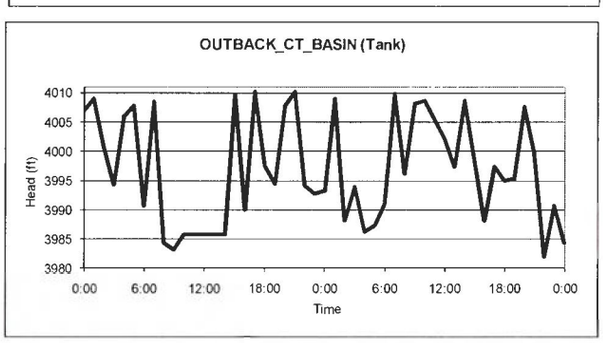


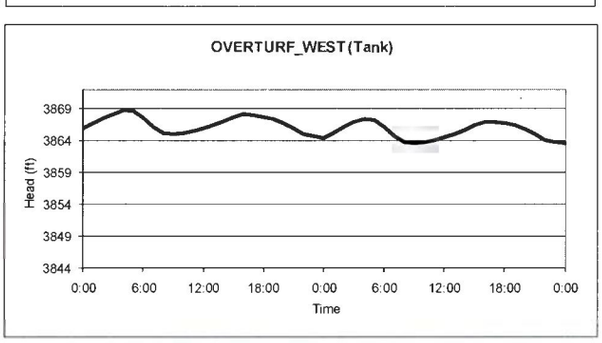












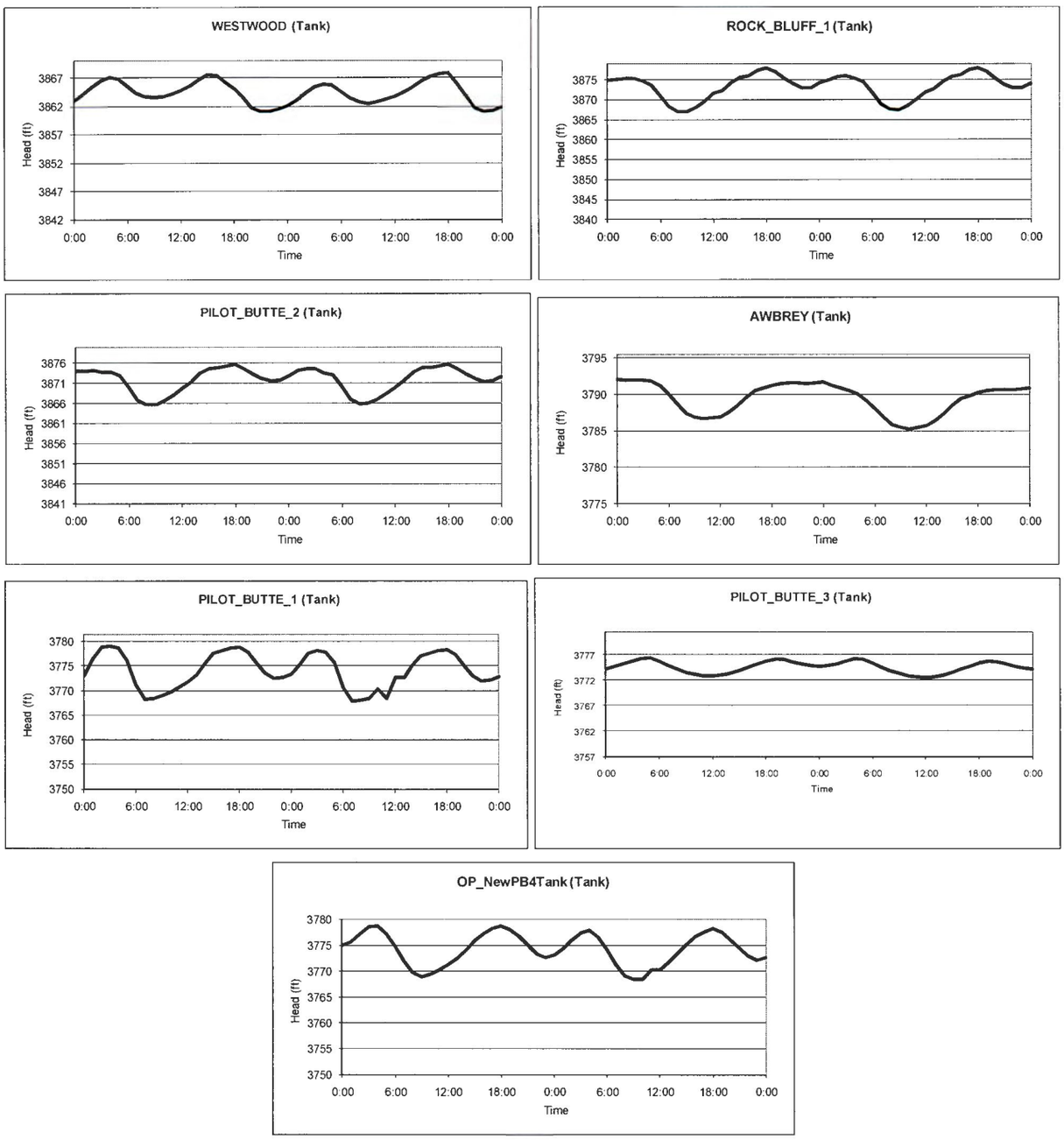


Figure 2.17 – Water levels in each tank in the Final Build-out Solution

2.8.12 Emergency Storage

As discussed in Section 2.5.4, the City decided to adopt the Washington Design Manual guidelines for determination of emergency storage in this study. The optimization was formulated to ensure that fire storage volume for each zone was maintained in above-ground storage. The resulting solutions were checked to ensure they include enough above-ground storage and reliable groundwater supply to meet standby storage requirements.

Table 2.16 contains a list of current and proposed future groundwater wells and their capacities at build-out and compares this to projected maximum day demand. The table then determines whether or not wells can be relied upon to meet emergency supply needs based on whether they are connected to SCADA and have back-up power. The table is grouped based on major supply areas: Levels 1, 2 and 3 (including all the pressure zones around Awbrey Butte); Zone 4A; Zone 4B; Levels 5, 6 and 7; and South Bend (Zones 2B and 3D). The capacity of redundant wells in the system is then compared to the emergency storage requirement of two times average day demand. The table demonstrates that there is ample reliable groundwater capacity to offset standby storage needs at build-out.

Table 2.17 lists the existing and proposed future storage volumes at each storage site. For each tank, the minimum water level observed during the maximum day simulation in the model is used to determine the amount of emergency storage in each tank. This is then compared to the required fire and standby storage volumes for the zones which are supported by each tank, or group of tanks. Finally, where there is a deficit, the table applies reliable groundwater supply to offset the storage requirement. Based on this analysis, approximately 25% of the overall standby storage requirements at build-out are provided by above ground storage in the Final Build-out Solution. This is consistent with the amount of standby storage maintained above ground in the existing system (refer Section 2.5.4)

2.8.13 System flows

Figure 2.18 shows the system schematic and flows from wells and through valves and pumps between zones in the Final Build-out Solution. The flows are based on operation during a Build-out Maximum Day.

Table 2.16 – Comparison of well capacity recommended in the Final Build-out Solution and demand by pressure level under projected build-out conditions

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
						=sum(F) Red => G<H				=F x I x J	discount non-redundant	=sum(L)	=M x 2 Red => N<O	
Production Facility	**Zone Supplied**	**Pump Size (hp) / Capacity (MGD)**	**Pump Type OR New Well Count**	**Approx. Static Water Level (feet)**	**Capacity (MGD)**	**Total Capacity MGD**	**Build-out MDD MGD**	**Future Back-up Power**	**Future SCADA Capability**	**Capacity Back-up + SCADA**	**Firm**	**Firm Capacity MGD**	**Supply Volume over 2 days**	**Standby 2xADD MGD**
Surface Water Source	**3**				**23.0**					**7.2**	**7.2**			
COPPERSTONE_W	3	250	Line Shaft Turbine	510	1.4			0	0	0.0	0.0			
OUTBACK_W1	3	150	Submersible	482	1.0			1	0	0.0	0.0			
OUTBACK_W2	3	150	Submersible	482	1.1			1	0	0.0	0.0			
OUTBACK_W3	3	250	Line Shaft Turbine	478	1.7			1	1	1.7	1.7			
OUTBACK_W4	3	250	Line Shaft Turbine	482	1.7			1	1	1.7	1.7			
OUTBACK_W5	3	250	Line Shaft Turbine	486	1.8			1	1	1.8	0.0			
OUTBACK_W6	3	250	Line Shaft Turbine	480	1.8			1	1	1.8	1.8			
OUTBACK_W7	3	250	Line Shaft Turbine	480	1.8			1	1	1.8	1.8			
OUTBACK_W8	*3*	*1.8 MGD*	*1*	*480*	*1.8*			*1*	*1*	1.8	0.0			
New Level 3 (Outback)	*3*	*1.3 MGD*	*3*	*480*	*3.9*	41.0	24.4	*0.67*	*1*	*2.6*	*2.6*	16.8	33.6	21.7
WESTWOOD_W	4A	150	Submersible	283	1.0			0	1	0.0	0.0			
New Level 4 (Overturf)	*4A*	*1.4 MGD*	*1*	*n/a*	*1.4*	2.4	3.6	*0.00*	*1*	*0.0*	*0.0*	0.0	0.0	3.2
BEAR_CREEK_W1	4B	350	Line Shaft Turbine	629	1.5			0	1	0.0	0.0			
BEAR_CREEK_W2	4B	350	Line Shaft Turbine	652	1.6			0	1	0.0	0.0			
ROCK_BLUFF_W1	4B	150	Line Shaft Turbine	393	1.2			1	1	1.2	1.2			
ROCK_BLUFF_W2	4B	150	Submersible	395	1.1			0	0	0.0	0.0			
ROCK_BLUFF_W3	4B	150	Line Shaft Turbine	395	1.2			1	1	1.2	0.0			
SHILOH_W3	4B	250	Line Shaft Turbine	355	2.0			1	1	2.0	0.0			
New Level 4 (Shilo)	*4B*	*1.0 MGD*	*2*	*355*	*2.0*			*0.50*	*1*	*1.0*	*1.0*			
New Level 4 (Rock Bluff)	*4B*	*1.3 MGD*	*3*	*395*	*3.9*	14.5	12.2	*0.67*	*1*	*2.6*	*2.6*	4.8	9.6	10.8
PILOT_BUTTE_W1	5	250	Line Shaft Turbine	743	1.2			0	0	0.0	0.0			
PILOT_BUTTE_W3	5	250	Submersible	786	1.3			0	0	0.0	0.0			
PILOT_BUTTE_W4	5 (4B emerg)	300	Line Shaft Turbine	702	1.6			1	1	1.6	0.0			
New Zone 5 (Awbrey)	*5*	*1.1 MGD*	*4*	*n/a*	*4.4*			*0.75*	*1*	*3.3*	*3.3*			
New Zone 5A (Pumped ground facilities)	*5*	*1.4 MGD*	*5*	*n/a*	*7.0*			*0.80*	*1*	*5.6*	*5.6*			
New Zone 5B (Pumped ground facilities)	*5*	*1.0 MGD*	*2*	*n/a*	*2.0*			*0.50*	*1*	*1.0*	*1.0*			
RIVER_W1	5	500	Line Shaft Turbine	360	2.7			1	1	2.7	2.7			
RIVER_W2	5	400	Line Shaft Turbine	242	3.0			1	1	3.0	0.0			
New Zone 6 (Pumped ground facilities)	*6*	*1.8 MGD*	*4*	*n/a*	*7.2*	30.4	41.7	*0.75*	*1*	*5.4*	*5.4*	18.0	36.0	37.1
HOLE_10_W1	2B	150	Submersible	410	0.8			1	1	0.8	0.8			
HOLE_10_W2	2B	150	Submersible	412	0.8	1.6	1.6	1	1	0.8	0.8	0.8	1.6	1.4
Existing Groundwater Supply Capacity (MGD) (excluding Rock Bluff 2)					**32.2**									
Total Future Groundwater Supply Capacity (MGD)					**66.9**	**66.9**				**45.4**	**33.2**	**33.2**	**66.4**	**74.2**
Total Supply Capacity (Ground and Surface) (MGD)					**89.9**	**89.9**	**83.5**			**52.6**	**40.4**	**40.4**	**80.8**	

Key to Table 2.16 :

New Well	Proposed details
Assumed future SCADA/Back-up power status	
Not counted, not redundant	

Notes to Table 2.16

1) Red text in Columns G and N indicates that the available capacity in a particular level is less than the required capacity. In all of these cases, however, supply is available from a higher zone to meet the deficit
2) Outback Wells 1 & 2 portable generator has capacity to run one well at a time
3) Two of Outback Wells 3, 4 & 5 can run on one generator
4) Outback Well 6 generator should operate three wells eventually
5) Generator at Rock Bluff is able to run two of the three wells at once
6) Rock Bluff 2 is always off
7) Shilo Wells are currently out of service. Shilo 3 was scheduled to have portable generator plug-in facilities following upgrade in Spring 2010
8) Pilot Butte 2 has been decommissioned
9) Generator confirmed at Pilot Butte 4, no generator at Pilot Butte 3

Table 2.17 – Assessment of available above-ground emergency storage compared to requirements

	A	B	C	D	E	F	G				H	I	J	K	L
Storage	**Storage Volume (MG)**	**Dead storage (static 25 psi)**	**Minimum level on MD**	**% Emerg Avail**	**Emergency Volume (MG)**	**Fire suppression (MG)**	**Standby Avail (MG)**	**--▸ Pumping → Direct/PRV**	**Zone**		**Standby Requirement 2xADD**	**Combined Standby**	***Offset from Wells w back-up power (2 days x MGD)***	**Allocation to/from other zones**	**Capacity div by Requirements**
		From model	From model	=C-B	=D*A		=E-F					=sum of H	*From Well Summary*		=(G+J+K)/I
TOWER_ROCK	1.0	15%	84%	69%	0.68	0.18	1.90		1		1.16	1.16		-0.50	120%
TOWER_ROCK_2	2.0	15%	84%	69%	1.39									To Level 2	
COLLEGE_1	0.5	0%	72%	72%	0.36				2		1.21	1.50		0.50	108%
COLLEGE_2	1.0	6%	63%	57%	0.58	0.54	1.13							From Level 1	
COLLEGE_3	1.0	0%	72%	72%	0.72										
									2A	Teh PS, 3	0.31	*in 3*	*Hole Ten*		
									2B	South Bend	0.54	*in 4B*	1.60		
Note: Assuming Outback 1 & 2 can contribute to standby given treatment upgrades															
OUTBACK_1	2.3	0%	60%	60%	1.37								*Outback, Copperstone*		
OUTBACK_2	3.0	0%	48%	48%	1.45				3		10.55	19.04	19.20	-5.00	116%
OUTBACK_3	3.7	0%	68%	68%	2.49	1.50	7.88							To 4A, 4B & 5	
OUTBACK_4/5	6.0	0%	68%	68%	4.07										
OUTBACK_CT_BASIN	1.5	100%	n/a, required for CT						3A		0.19	*in 2*			
									3B		0.10	*in 2*			
									3C	West W PS, 4A	0.99	*in 3*			
									7	N Awbrey Butte	0.99	*in 3*			
													Shilo		
									3D	South Bend	0.88	*in 2B*	0.00		
WESTWOOD	0.5	34%	68%	34%	0.16								*Westwood, New wells*		
OVERTURF_EAST	1.5	26%	74%	48%	0.69	0.54	1.01		4A		3.17	3.17	0.00	2.50	111%
OVERTURF_WEST	1.5	26%	74%	48%	0.69								From 3		
													Bear Creek, Rock Bluff, Shila (rezoned)		
ROCK_BLUFF_1	1.5	0%	69%	69%	1.07				4B		10.82	12.24	9.60	2.50	114%
ROCK_BLUFF_2	2.3	0%	69%	69%	1.62	1.50	1.82						From 3		
PILOT_BUTTE_2	1.0	0%	64%	64%	0.63										
									4C		0.30	*in 3*			
									4D		0.29	*in 3*			
									4E		1.63	*in 3*			
									4F		0.16	*in 3*			
									4G		0.24	*in 3*			
									4H	Off Westwood	0.19	*in 3*			
									4I	Off Westwood	0.54	*in 3*	*4A?*		
									4J		0.23	*in 3*			
									4K		0.06	*in 3*			
AWBREY	5.1	0%	58%	58%	2.97								*River, Pilot Butte, New Zone 5 wells*		
PILOT_BUTTE_1	1.5	12%	58%	46%	0.68				5				25.20	10.80	111%
PILOT_BUTTE_3	5.0	0%	64%	64%	3.20	3.00	5.18						From L6 wells		
OP_NewPB4Tank	3.0	0%	44%	44%	1.34										
									5A		0.02	*in 3*			
									5B		1.27	*in 3*			
									5C	With 4E	0.04	*in 3*			
									5D		0.09	*in 3*			
													New Zone 6 wells		
									6				10.80	-10.80	
														To Level 5	
									6A		0.77	*in 5*			
									6B		1.15	*in 3*			
Note: Green text indicates new storage volumes									6C	Juniper Ridge	3.75	*in 5*			
									7A	With 5B	0.61	*in 5*			
									7B		0.22	*in 5*			
									7C		0.17	*in 5*			
									7D		0.03	*in 5*			
Totals	**45.0**	**3.13**			**26.2**	**7.26**	**18.90**				**74.20**	**74.20**	**66.40**	**0.00**	**115%**
			Percentage of standby requirements being met above ground				**25%**						**89%**		

Notes:

Dashed and solid lines indicate how supply from reservoirs can be transferred to lower or higher zones (solid indicates gravity supply through PRVs, dashed lines indicate pumping)

Colors in Column I indicate which zones have been grouped together.

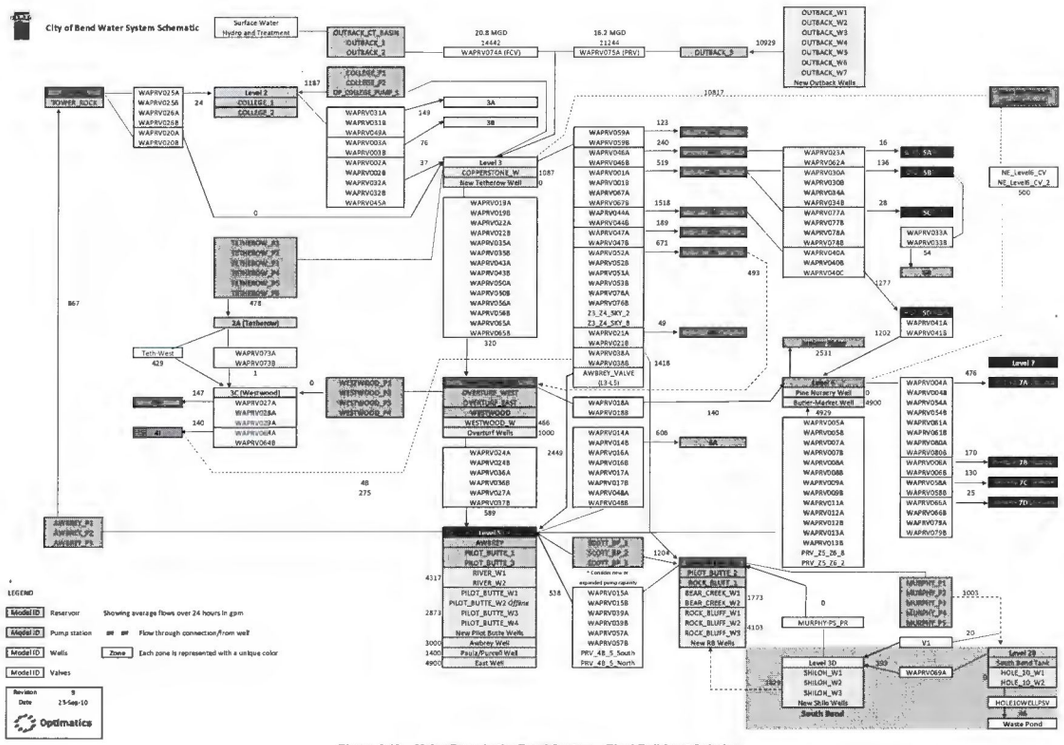


Figure 2.18 – Major flows in the Bend System – Final Build-out Solution

2.8.14 Fire Flow Improvements

The determination of fire flow improvement needs was carried out in an analysis separate from the optimization. The improvements were fixed in the model prior to evaluating the build-out scenario, except in instances where upsizing a replacement pipe would potentially provide benefit to the system in meeting maximum day or peak hour demands (this was relevant primary in Level 5).

Each zone was analyzed to determine which pipes needed to be replaced and at what size to ensure the fire flow could be provided at a residual pressure of 20 psi at every node. The improvements addressed all pipe deficiencies, regardless of whether the pipe served a hydrant or not. This analysis resulted in the identification of approximately 30 miles of fire flow improvements. All 2-inch diameter lines were assessed to determine what replacement size would meet fire flow requirements. Later a review of hydrant locations confirmed that no 2-inch diameter pipe has a hydrant connected to it, so these improvements are provided in a separate list and not included in the cost summary.

To assist in prioritizing the improvements, Optimatics also performed an 'available' fire flow analysis – looking at how much flow can be taken from the system at any point without drawing system pressures below 20 psi. Figure 2.19 shows the available flow at 20 psi calculated for each pipe in the system under existing maximum day demand conditions. The analysis did not take into account any losses or restrictions that may exist at hydrant laterals or hydrants themselves, but provides an indication of the system's capacity to convey flow which in turn makes it possible to see which improvements are most critical. This is in line with the approach used by commercial modeling packages such as InfoWater.

Prior to running the available flow analysis, Optimatics used a tool to snap hydrants to pipes in the model with reference to the hydrant coordinates and stub line information from the GIS. In this way the available flow analysis reported on both the flow available to the downstream end of each pipe and also to each hydrant in the system.

In order to come up with a final list of fire flow improvements, the results of the available flow analysis were used to determine which hydrants could not meet the required flow. Using this information, it was possible to determine which pipe improvements are needed to address hydrant deficiencies, and which are only required if new hydrants are installed on deficient lines. The total cost for replacement of mains addressing hydrant deficiencies under Build-out demand conditions is $11,458,000. A subset of these improvements is needed to address existing deficiencies. More detail of the existing system fire flow improvements is provided in Section 4.

A listing of the recommended pipe improvements addressing fire flow requirements is provided in **Appendix H**. Each improvement has been assigned a project reference, and related projects are grouped together under a single project reference. The listing in **Appendix H** includes and clearly identifies improvements that address existing deficiencies, as well as recommended replacement sizes addressing anticipated future deficiencies, undersized mains which do not currently have hydrants and 2-inch diameter mains.

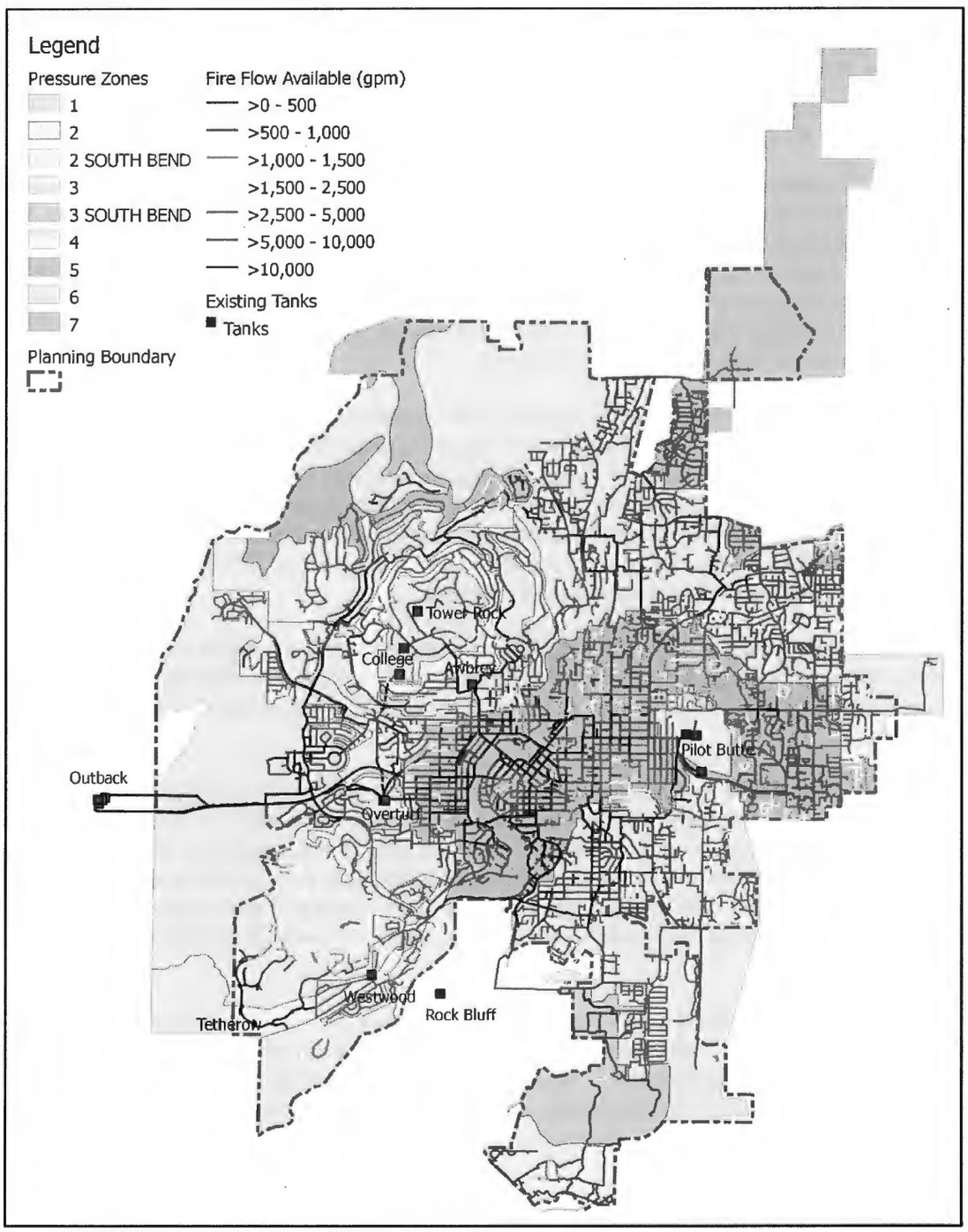


Figure 2.19 – Available flow at 20 psi residual pressure in the Bend System (existing maximum day demand conditions)

Note: a large version of this map is available in electronic **Appendix I**

Figure 2.20 shows the size of pipe replacements needed to address deficiencies under build-out demand conditions. Refer to Section 4 for details regarding the prioritization of these improvements. Figure 2.21 highlights deficient pipes that are not included in the prioritized list of pipe replacements because they are not related to deficient hydrants (2-inch mains, dead-end lines without a hydrant, or situations where the hydrant on the line is close to a larger main line and thus receives adequate flow). The cost of improving these pipes would likely be borne by a developer.

Fire flow improvements in the South Bend area were not explicitly addressed in the Master Plan Update Optimization Study. MSA completed a study of this area which recommended replacement of the existing poorly installed piping network with a new 8-inch diameter grid and appropriately spaced fire hydrants in conjunction with new transmission main which is currently under construction. These improvements will ensure the system can meet fire flow requirements to build-out.

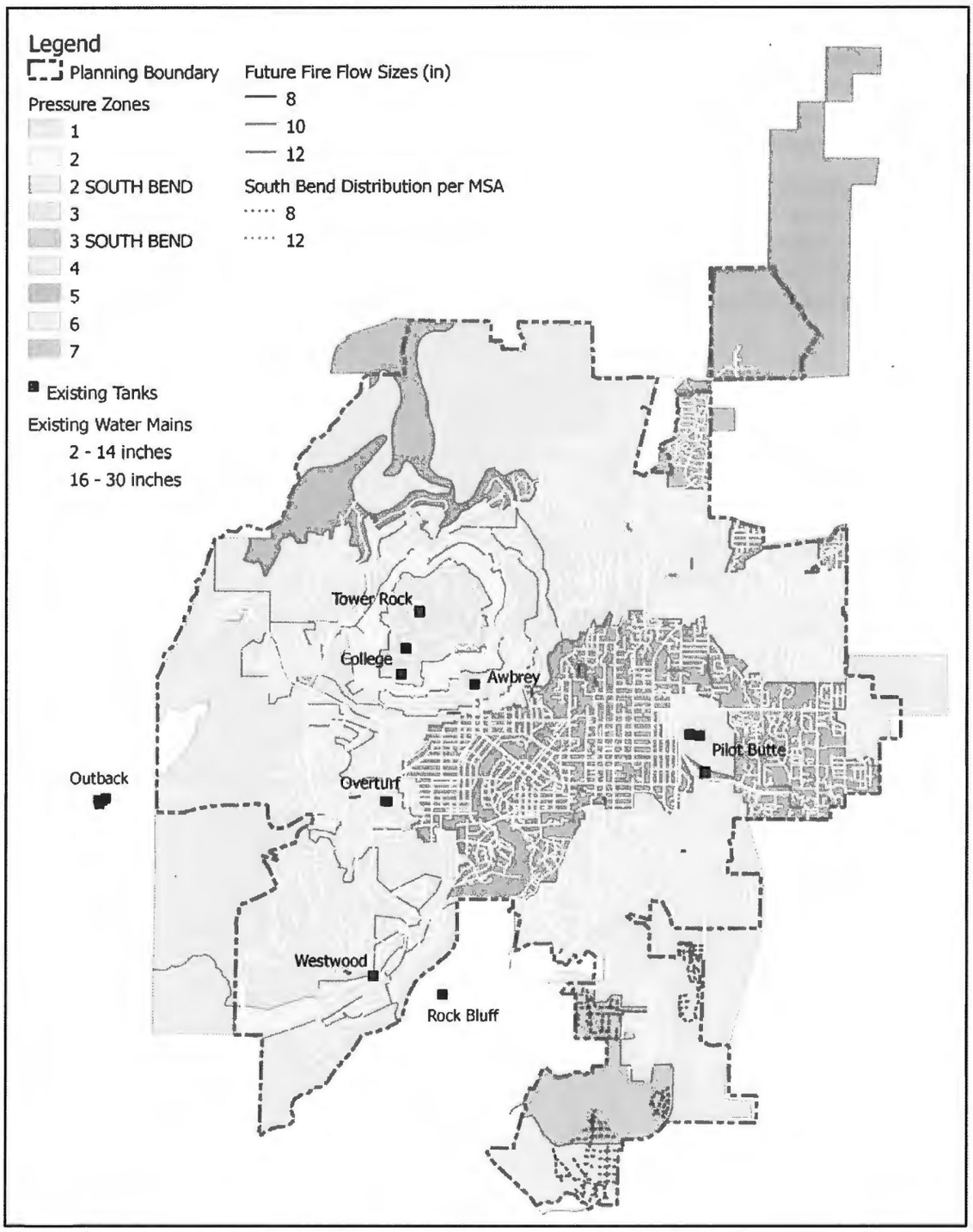


Figure 2.20 – Recommended minimum diameters for new pipes needed for system to meet fire flow conditions on future maximum day

Note: A large scale version of this map is available in the electronic **Appendix I**

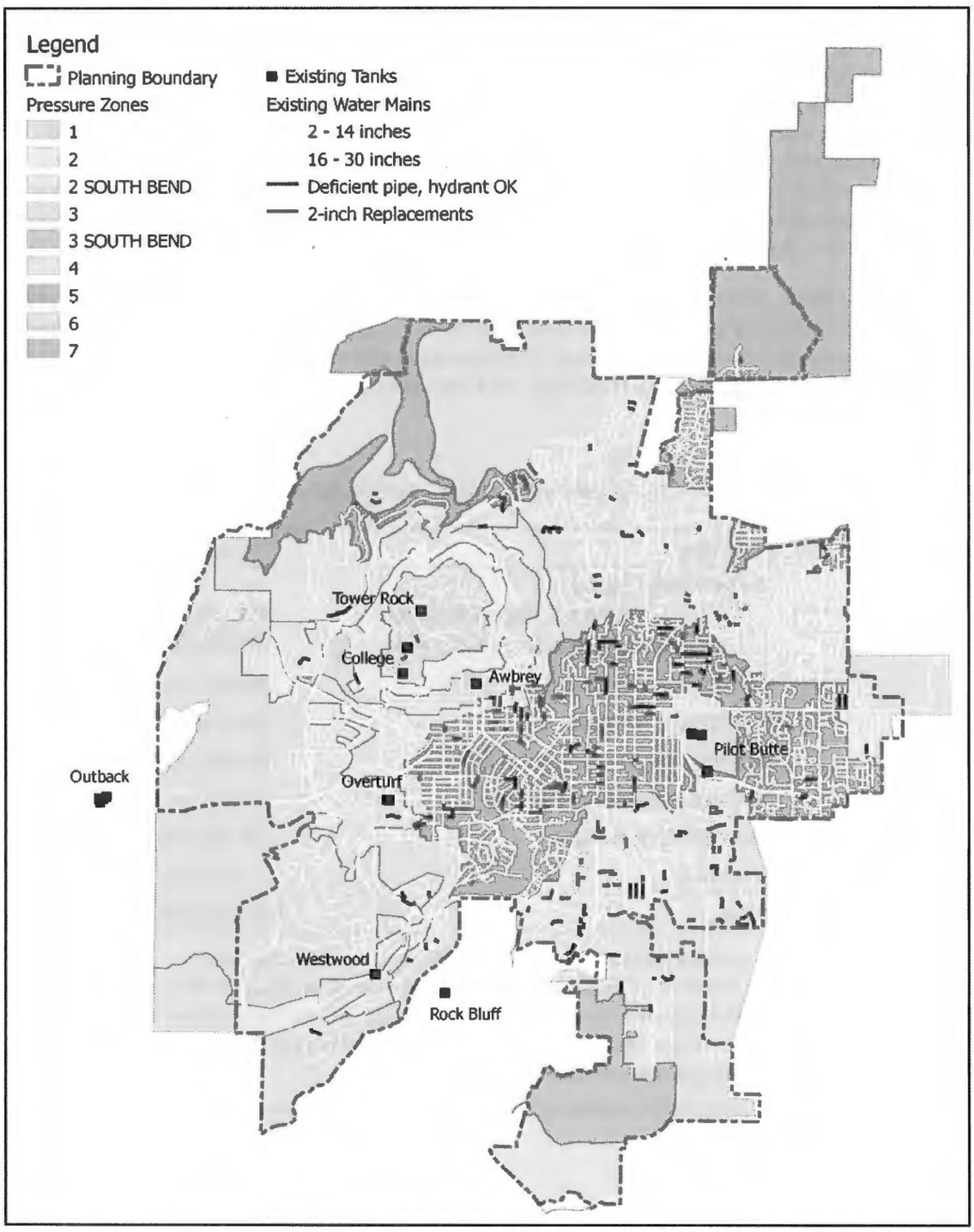


Figure 2.21 – Pipes which were identified as being deficient in meeting fire flow, but do not supply a hydrant, or the associated hydrant is not deficient (e.g. near larger main line)

Note: A large scale version of this map is available in the electronic **Appendix I**

2.8.15 Total Capital Costs

Table 2.18 lists the total estimated capital costs associated with the Final Build-out Solution. As mentioned above the Final Build-out Solution was developed under the assumption that the surface water source would contribute 23 MGD/36 cfs. At the time of writing this report, the anticipated maximum flow from the surface water source at build-out is much less; only 13.5 MGD/21 cfs. For consistency, Table 2.18 shows the estimated cost of the surface water source at 13.5 MGD (as per HDR's memorandum *Surface Water / Groundwater Cost Comparison, DRAFT*, September 2008). The additional supply that was assumed to come from this source (9.5 MGD) has been included as a second line item and is assumed to be met from wells at the Outback site. The cost of this supply has been calculated using a unit cost of $1.35m/MGD capacity.

As discussed above, it is not known whether the Outback site could support such a significant increase in well capacity, however, it was not possible to address this in the current study. The City should investigate the groundwater withdrawal limits at Outback. If the maximum potential well supply is significantly less than 26 MGD (existing 11 MGD plus 15.5 MGD new), the Final Build-out Solution will need to be revised.

Table 2.18 – Total Capital Costs – Final Build-out Solution

Cost Item	Cost
"Surface Water Supply"	
13.5 MGD, membrane treatment, no hydro[1]	$57,750,000
Additional supply to meet 23 MGD (9.5 MGD)[2]	$12,825,000
New Groundwater Wells (35.7 MGD)	$45,490,000
New Storage (14.5 MG)	$24,130,000
New Pipe Improvements for Growth	$43,625,000
Pipe Improvements for Fire Flow	$11,458,000
Pump Station Expansion	$1,744,000
New Valves	$600,000
TOTAL	**$197,622,000**

1) As per HDR Memo *Surface Water / Groundwater Cost Comparison, DRAFT*, September 2010. Costs for all other items are based on 2009 Unit Costs developed by MSA (October 2009). Estimated 2010 dollars for Surface Water Supply and 2009 dollars for remaining cost items are assumed equivalent and called 2009 dollars.

2) Assume met from additional wells at Outback, $1.35 million per MGD

3 Capital Improvements Plan – 10-year

3.1 Background

The final phase of the Water System Master Plan Update Optimization Study involved determining which improvements identified in the Final Build-out Solution will be necessary to maintain system performance over the next 10 years and prioritization of these improvements. As discussed in Section 2.2, an intermediate demand projection representing anticipated growth in the next 10 years was developed by MSA as part of this study. Throughout this study there has been discussion about the confidence the City has in the projected rate of development. Given the recent economic conditions it is likely that the "10-year" demand level may not be reached in the proposed timeframe. However it is prudent to be conservative with demand projections. To assist the City in planning their capital improvements, the recommendations in this section are not only tied to a year but also to a level of system demand. In this way the City can monitor how demands increase each year and time the implementation of capital upgrades appropriately.

3.1.1 10-year Demand projection

As described in Section 2.2, the 10-year demand projection represents an approximately linear interpolation between current demand and projected build-out demand. The distribution of the 10-year demand was applied assuming that half of the growth in water demand to reach build-out demand at medium density within the current system facilities area (i.e. the existing UGB) will be realized. The Tetherow and Juniper Ridge developments were treated separately. It was assumed that half of the growth associated with full development of Tetherow would be realized in the 10-year planning horizon. For the Juniper Ridge area it was assumed that Phase 1 (293 acres) would be realized in the 10-year timeframe.

The resulting projected demand growth is concentrated in the east; 70% of the new demand is associated with Zone 4B, Level 5 and Level 6. The City anticipates near-term growth will occur along the Southeast Interceptor corridor. Development of the area north and west of Awbrey Butte will require significant new infrastructure, both for potable supply and wastewater collection. This is not seen as likely in the near term and is expected to be driven by developers. Growth to the north and west of Awbrey Butte was assumed to occur after the first ten years.

3.1.2 General factors influencing the phasing of capital improvements

The City anticipates that properties along the Southeast Interceptor Corridor (i.e. Zone 4B) will be the first to develop in the near term. Currently the interceptor is planned to be in service by 2015.

As well as the anticipated location of near-term growth, a number of other factors have been taken into consideration in the development of the 10-year CIP. Some areas of the system have known deficiencies and have been given special focus. These areas are the Tetherow and Juniper Ridge developments and the South Bend area. Improvements that are related to Tetherow and Juniper Ridge have been flagged in the 'Needs/Relationship' column in the improvements listing (**Appendix G**).

The South Bend area was studied by MSA. The recommended improvements for this area are outlined in the memorandum *Former Juniper Utility – Proposed Water System Improvements*, January 2011 (**Appendix A**). The optimization analysis evaluated and verified the transmission piping improvements as recommended by MSA. These improvements are summarized in a separate listing in **Appendix G**.

A feature that will affect supply and storage requirements in the next five years is the timing of the surface water project. The assumption that there will be a significant increase in supply capacity at Outback, together with the potential for growth north of Awbrey Butte in the future, influenced the recommended size and location of a number of improvements in the Final Build-out Solution. One of the aims in developing the 10-year CIP was to gain an understanding of which improvements are necessary if the surface water source is not expanded or if the development northwest of Awbrey Butte does not occur. As discussed in Section 2.8.8, much of the new supply assumed to be in place at Outback by build-out would service new demands in the northwest. Until development occurs in this location, the City wants to know which improvements can be delayed or potentially downsized. To help answer this question, two different 10-year scenarios were evaluated in the optimization as discussed below.

3.1.3 Scenarios evaluated in the optimization analysis

To assist the development of the 10-year CIP, demand scenarios that could be evaluated in the hydraulic model were set up to be analyzed with the optimization program. To meet the needs of the intermediate demand scenario, the optimization was configured to select only from those improvements that were recommended in the Final Build-out Solution. In this way, a subset of the improvements needed to allow the system to operate under build-out conditions was identified to support the 10-year demands. This approach follows the concept of 'build to target' which aims to ensure that improvements made in the near-term will be appropriately sized to meet build-out conditions.

As discussed above, it was not until the time the 10-year CIP was being developed that it was known the surface water supply would unlikely be expanded to deliver 23 MGD. The maximum supply level could be 27 cfs/18 MGD but is more likely to be 21 cfs/13.5 MGD. The two 10-year demand case optimization runs were used to evaluate which improvements are needed with lower flows from Outback:

10-year demands (MDD 48.8 MGD) – Surface water providing 13.5 MGD

10-year demands (MDD 48.8 MGD) – Surface water providing 18 MGD.

A third analysis scenario with existing system demands (MDD 29.2 MGD) and surface water providing 11 MGD was used as point of comparison to the 10-year scenarios to identify near term improvement needs.

When assessing the scenario with the surface water at 18 MGD case, the optimization was allowed to resize the parallel mains out of Outback to see what diameter would be appropriate for a lower flow condition compared to what was evaluated at build-out.

3.2 Results

The existing MDD analysis highlighted which improvements will provide benefit in the near term. Comparing the two 10-year analyses revealed how the supply capacity at Outback impacts needed transmission improvements. For the purposes of the 10-year CIP recommendations presented here, it was assumed that the second phase of the surface water project will not be realized in the next 10-years. The improvements listing (**Appendix G**) contains notes on which improvements are required when supply capacity is added to the Outback site.

With the surface water capacity at 13.5 MGD under the 10-year demand scenario the optimization did not recommend implementation of new wells at Outback (beyond Well 7 which was assumed to be in place) and none of the parallel main options along Skyliners were selected. Instead, new wells are recommended in the eastern and central areas of the system; east of Pilot Butte, at Awbrey Reservoir, at Shilo and in Level 6.

In the scenario with surface water at 18 MGD, the optimization chose to implement the first section of parallel main from Outback at 18-inch diameter. This is significantly smaller than the proposed 48-inch diameter parallel main recommended in the build-out scenario which allows for integration of the increased supply at Outback and serves the development northwest of Awbrey Butte.

3.2.1 Cost Estimate and Layout Diagrams

Table 3.1 summarizes the improvements that are recommended to meet increasing demands over the next 10 years. This summary does not include improvements in the South Bend area (see below) as these were not evaluated in the optimization study. The improvements are broken down into pipe, well and storage improvements. No booster pump station upgrades are needed within the next 10-years. Three new valves should be implemented in the 10-year timeframe to improve redundancy in key areas of the system. These are the second connection from Zone 4B to Level 5 at Bear Creek Rd, the new valve to assist with fire flow between Level 3 to Zone 4A north of Overturf and the second connection to Zone 7C as shown in Table 2.14.

The timing of piping improvements is linked to the timing and location of new wells and storage. More detail on the piping improvements is provided in **Appendix G** and the relationship between the pipe, well and storage improvements are noted in the "Need/Relationship" column. Supporting files showing how costs for new pipes, storage and well capacity increases have been calculated are included in **Appendix I** (electronic).

A 16-inch connection is required along 18th Street to service fire flow demands in Juniper Ridge. It is understood that this will be implemented by the developer; however, the improvement remains in the list of piping improvements (flagged in the "Need/Relationship" column in **Appendix G**).

3.2.1.1 Improvements for the South Bend/Former Juniper Utility area

Improvements in the South Bend area are presented separately in Table 3.2. The optimization analyses verified the recommended transmission main sizes, but did not attempt to evaluate the distribution recommendations. Table 3.2 summarizes all the improvements identified by MSA for this area of the system (refer memorandum *Former Juniper Utility – Proposed Water System Improvements* in **Appendix F**). The main difference in the two estimates is due to slight differences in calculated pipe lengths in the two evaluations.

Improvements in the South Bend area are flagged as 'planned' or 'in ground' as follows:

- Connecting Tillicum into 4B – the City has advised that these connections are in the ground, however the optimization results indicated that an additional pipe connection at Dayspring Drive and Splendor Drive would benefit the system.
- Connection from Shilo to Zone 4B – the City advises this pipe is constructed. This improvement was not included in MSA's recommendations for South Bend (it was part of a separate set of recommendations), however it has been grouped together with the South Bend improvements here.
- New transmission piping in South Bend – the City has advised that piping from Murphy Pump Station to the Shilo Wells is in place. Piping from the Shilo Wells to the Timber Ridge PRV location is also constructed. Piping from northern side of Timber Ridge through to Mountain High is expected to be in place by 2012/2013.

There remains approximately $2.9 million worth of transmission and facility improvements, and $9.9 million of distribution improvements to be implemented in this area.

Table 3.1 – Master Plan Improvements – Phasing for 10-year period (refer Appendix G for more detail)

Year	MDD (MGD)	ADD (MGD)	Pipes	Cost	Tanks	Capacity	Cost	Wells	Capacity	Cost	Total Cost
Now	29	12.8	Juniper Ridge 16-inch connection on 18th *;	$1,292,000							$1,292,000
2011	31	13.8	Tetherow improvements – B (Skyline Ranch 18-inch main) *, T (reconfiguration of the customers on the suction side of Tetherow PS). Open Zone 4J/4A boundary	$1,434,000							$1,434,000
2012	33	14.7	Extend larger diameter pipe out of Pilot Butte on Lafayette to 11th, piping associated with new Awbrey well	$241,000				Awbrey	1.5 MGD	$1,944,000	$2,185,000
2013	35	15.6	New parallel pipe near College PS in Level 3, new Level 5 pipe connection on Roanoke; site and discharge piping for new Level 5 Well east of Pilot Butte	$1,169,000				New Level 5 A (In vicinity of Shirley Ct)	2 MGD	$2,721,600	$3,890,600
2014	37	16.4	Parallel piping from Rock Bluff to Brookswood	$1,535,000							$1,535,000
2015	39	17.3	Continue parallel piping from Rock Bluff to Brosterhous; open Zone 4B/4I boundary at Reed Market	$2,940,000				Shilo	2 MGD	$2,721,600	$5,661,600
2016	41	18.2	Parallel mains on Brosterhous and Reed Market, replace piping along Wilson in Zone 4B	$1,742,000				New Level 6 (Butler Market/ Brinson Blvd)	1 MGD	$1,360,800	$3,102,800
2017	43	19.1	Extend larger diameter piping out of Pilot Butte on Lafayette from 11th to 8th	$402,000				New Level 5 A	2 MGD	$2,721,600	$3,123,600
2018	45	20.0	Parallel piping in Level 6 – Boyd Acres and Brinson Blvd; piping for Level 6 Well at Butler Market Well; New Pilot Butte tank connection	$1,364,000	Pilot Butte 4	3 MG	$5,807,000	New Level 6	2 MGD	$2,721,600	$9,892,600
2019	47	20.9	Replace existing pipe along 8th from Lafayette to Seward	$1,000,000				New Level 5 A	1 MGD	$1,360,800	$2,360,800
2020	49	21.8	Parallel main on Glassow and new main on Summit in Level 2; Replacement of piping on Norton and Olney in Level 5	$1,366,000				New Level 6	2 MGD	$2,721,600	$4,087,600
TOTAL				$14,485,000			$5,807,000			$18,273,600	$38,565,600
								Including 3 new valves		$225,000	**$38,790,600**

Note: All costs are based on 2009 unit costs developed by MSA (October 2009)

* Although it is understood that these improvements (Skyline Ranch Rd – Tetherow and 18th - Juniper Ridge) will be covered by the developer(s), full costs are presented here.

Table 3.2 – South Bend Improvements Summary (refer Appendices F and G for more detail)

Model ID	Project ID	Location/Description	Length (ft)	Diameter (in)	Estimated Cost	Refined Timing	MSA Estimate *		
Tillicum – into 4B								*Length*	*Cost*
P12	Till-1	Tillicum connection - Mowitch & Chase	77	8	$10,735	In ground	P12	40	$10,000
P13	Till-2	Tillicum connection - Klahani & Brosterhous	62	8	$8,665	In ground	P13	100	$13,000
P14	Till-3	Tillicum connection - Killowan	145	8	$20,231	In ground	P14	190	$26,000
P15	Till-4	Tillicum connection - Rae & Jackson	23	8	$3,262	In ground	P15	30	$10,000
OP187	Till-8	Tillicum connection to Splendor	82	8	$11,500	2010	n/a		$0
P16	Till-5	Tillicum - Benham parallel	379	8	$52,990	Fire flow	P16	320	$45,000
P17	Till-6	Tillicum - Rae parallel	1,627	8	$227,772	Fire flow	P17	1,550	$217,000
P18	Till-7	Tillicum - Illahee parallel	673	8	$94,153	Fire flow	P18	690	$96,000
South Bend									$0
P1	Constructed	Murphy PS to Shilo	2,507	12	$476,311	In ground	P1	2,580	$489,000
OP173	Constructed	Shilo Well piping (P9 as per MSA)	10	12	$0	In ground	P9	50	$10,000
OP13	Constructed	Shilo to Level 4	3,256	12	$618,638	In ground	n/a		$0
P2	Constructed	Shilo to new Valve nth of Timber Ridge	1,433	16	$343,963	In ground	P2	1,430	$342,000
P3	SB-1	Country Club	3,204	16	$768,955	2012/13	P3	2,950	$708,000
P4	SB-2	Mountain High Loop	860	12	$163,448	2012/13	P4	860	$163,000
P5	SB-3	Mountain High Loop	740	12	$140,539	2012/13	P5	1,800	$342,000
P5A	SB-3	Mountain High Loop	1,045	12	$198,548	2012/13			$0
P7	SB-4	Mountain High Drive	841	12	$159,762	2012/13	P7	1,830	$348,000
P7A	SB-4	Mountain High Drive	548	12	$104,143	2012/13			$0
P7B	SB-4	Mountain High Drive	523	12	$99,463	2012/13			$0
P8	SB-4	Mountain High Drive	1,023	12	$194,353	2012/13	P8	1,020	$193,000
P10	SB-5	South Bend - Murphy to Brosterhous	1,527	16	$366,398	In ground	P10	1,590	$381,000
P11	SB-5	South Bend - Brosterhous to Pines Mobile	1,994	16	$478,531	2011/12	P11	1,790	$430,000
Pumps & Surge tank (PS1-2 VFD pumps at Murphy and PS2-Surge Tank)							PS1, PS2		$100,000
Valves (V1-North of Timber Ridge and V2-PRV at Brosterhous for Pines Mobile)							V1, V2		$150,000
Hydrants (H1 - 47 new hydrants at 400 ft spacing)							H1		$367,000
Total for Category 1 per MSA 11/20/09					**$4,542,359**				**$4,440,000**
Category 2 per MSA 11/20/09 (Distribution for Tillicum, Nottingham, Timber Ridge, Mountain High & Pines Mobile, including hydrants)									**$9,859,000**

*Per *Former Juniper Utility – Proposed Water System Improvements* January 2011 (contained in **Appendix F**)

3.2.2 Supply and demand; timing of new wells

Figure 3.1 shows a timeline of projected maximum day demand and recommended supply capacity increases for the next 10 years. There are three drivers that control groundwater supply needs:

Normal operation – ensure system operation is satisfactory (tanks operating over a normal range and system pressure at required levels) with all sources online under maximum day demands. This is confirmed for the future scenario through hydraulic modeling and was a key aim of the optimization.

Standby storage with groundwater offset – *ensure that the sum of above-ground standby storage* (volume below minimum operating level not including dead storage) and reliable groundwater well capacity meets or exceeds the standby storage requirements as per Washington guidelines. This has been confirmed through spreadsheet calculations.

Firm supply to meet MDD – Firm supply capacity is defined as the sum of the capacity of all sources, not including the largest source. Firm supply should be greater than or equal to maximum day demand.

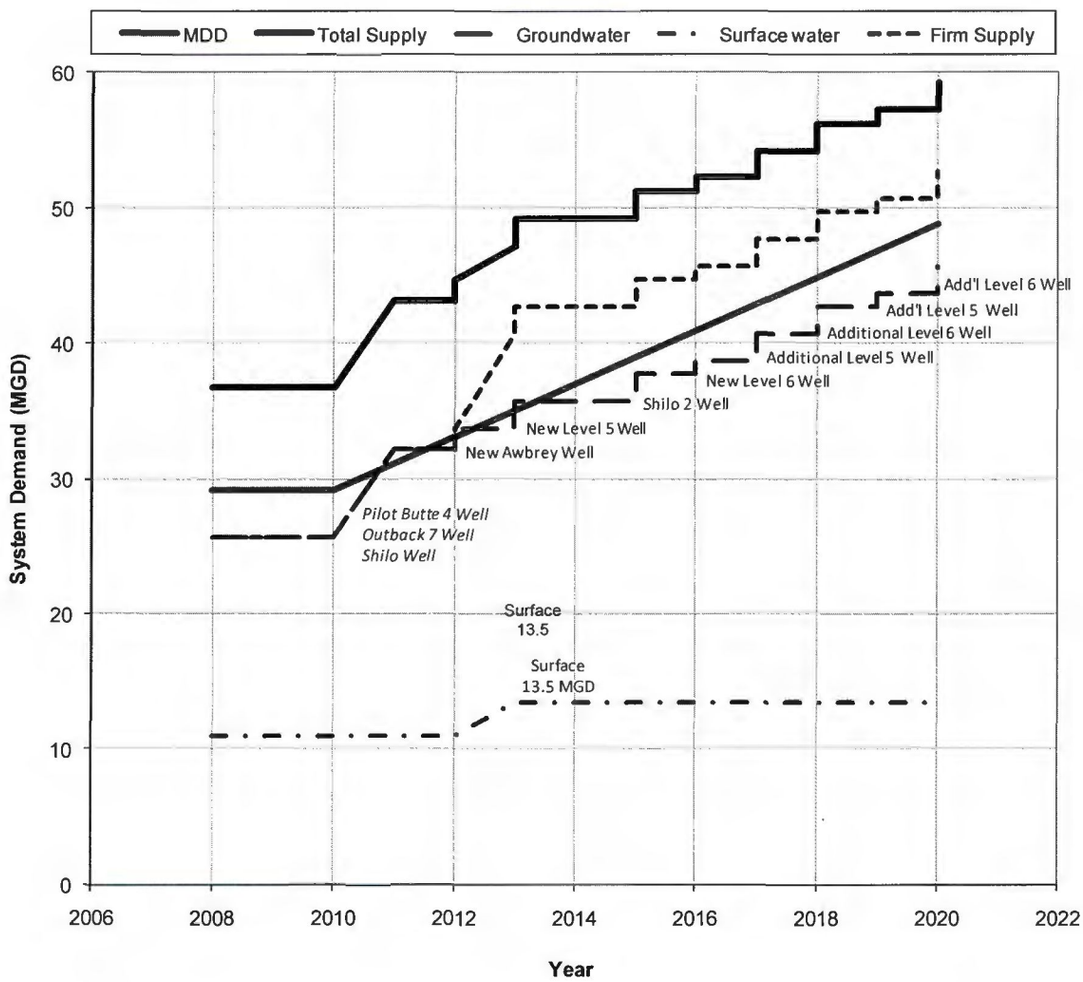


Figure 3.1 – Projected MDD and supply capacity increases to year 2020

The chart in Figure 3.1 shows total supply and firm supply. In the Bend system, the largest source is the surface water source. At the current time, this source can be taken out of service if there is an event in the watershed that increases turbidity. However, in the future, the City advised the limiting factor on the surface water source will be stream flow, as the proposed membrane treatment system will be able to operate during high turbidity events. It has been agreed that, for the purposes of determining firm supply capacity in this study, up to 7.2 MGD of surface water can be included in the calculations. The inclusion of some surface water in the firm supply calculations is shown by the dashed navy line on Figure 3.1.

The groundwater supply line (brown) must be in line with the projected MDD line until the surface water improvements are completed. The first increase in groundwater capacity comes from bringing Pilot Butte 4, Outback 7 and Shilo wells online. These wells will address the current firm supply deficit. In the following years it is recommended that new wells be implemented in Level 5, one near Awbrey Reservoir and one east of Pilot Butte.

The challenge in creating the staged CIP comes in not knowing whether and by how much demands will change prior to the surface water project being completed. To be conservative, Optimatics recommends the City include new wells in the plan as per Figure 3.1 and that the City carefully monitor demands to determine if it may be possible to delay the Awbrey and east Level 5 wells until after the surface water source improvements are completed. Although the improvements to the surface water source will assist in meeting firm supply needs, it will be necessary to implement more wells prior to the end of the 10-year CIP in order to meet the operating needs of the system, and to supplement standby storage needs as demands increase.

3.2.3 Observations and layout maps

Figure 3.2 below shows the entire system with the timing of all improvements recommended in the Final Build-out Solution highlighted. Figures 3.3 through 3.8 provide closer views of the improvements in the following areas: Southwest (Outback, Tetherow and Westwood); Southeast (South Bend), Zone 4B (Rock Bluff); Level 5 East; Level 5 West and Level 6; Awbrey Butte.

3.2.4 Emergency Storage

As discussed in Section 2.5.4, the City chose to adopt the Washington Design Guidelines as the basis for defining storage requirements specific to the City of Bend to be used in this study. The optimization was formulated to ensure that fire storage volume for each zone was maintained in above-ground storage. The resulting solutions were checked to ensure they include enough above-ground storage and reliable groundwater supply to meet standby storage requirements.

Table 3.3 contains a list of current and proposed groundwater well capacity in the 10-year Plan and compares this to projected maximum day demand in the 10-year demand scenario. The table indicates whether or not wells can be relied upon to meet standby supply needs based on whether they are connected to SCADA and have back-up power. The table is grouped based on major supply areas: Levels 1, 2 and 3 (including all the pressure zones around Awbrey Butte); Zone 4A; Zone 4B; Levels 5, 6 and 7; and South Bend (Zones 2B and 3D). The capacity of redundant wells in the system is then compared to the standby storage requirement of two times average day demand. The table demonstrates that there is a significant amount of reliable groundwater capacity that can be used to offset standby storage needs in the 10-year Plan.

Table 2.17 in Section 2.8.12 presented the standby storage needs in each zone and how they are met (by above-ground storage and groundwater well offsets) in the Final Build-out Solution. In a similar manner, Table 3.4 lists the existing and proposed future storage volumes at each storage site in the 10-year plan (the only new storage proposed in this timeframe is Pilot Butte 4). For each tank, the minimum water level observed during the maximum day simulation in the hydraulic model has been used to determine the amount of emergency storage in each tank. This is then compared to the required fire and standby storage volumes for the zones which are supported by each tank, or group of tanks. Finally, where there is a deficit, the table applies reliable groundwater supply to offset the storage requirement.

Based on the analysis summarized in Table 3.4, approximately 25% of the overall standby storage requirements for the 10-year demand scenario are provided by above-ground storage in the 10-year Plan. This is consistent with the amount of standby storage maintained above ground in the existing system (refer Section 2.5.4). Note that in the 2007 Master Plan, the assumed groundwater contribution at build-out was 55% of total storage, or 50 MG. This equates to 80% of the calculated standby requirement (as per the 2007 Master Plan) of 63 MG, meaning that only 20% of standby storage was met by above-ground storage.

Note that the upgrades to the surface water treatment system free up some of the existing Outback tanks to be counted towards standby storage. In the existing conditions analysis all three storages plus the CT Tank were discounted as they are required to meet the necessary chlorine contact time.

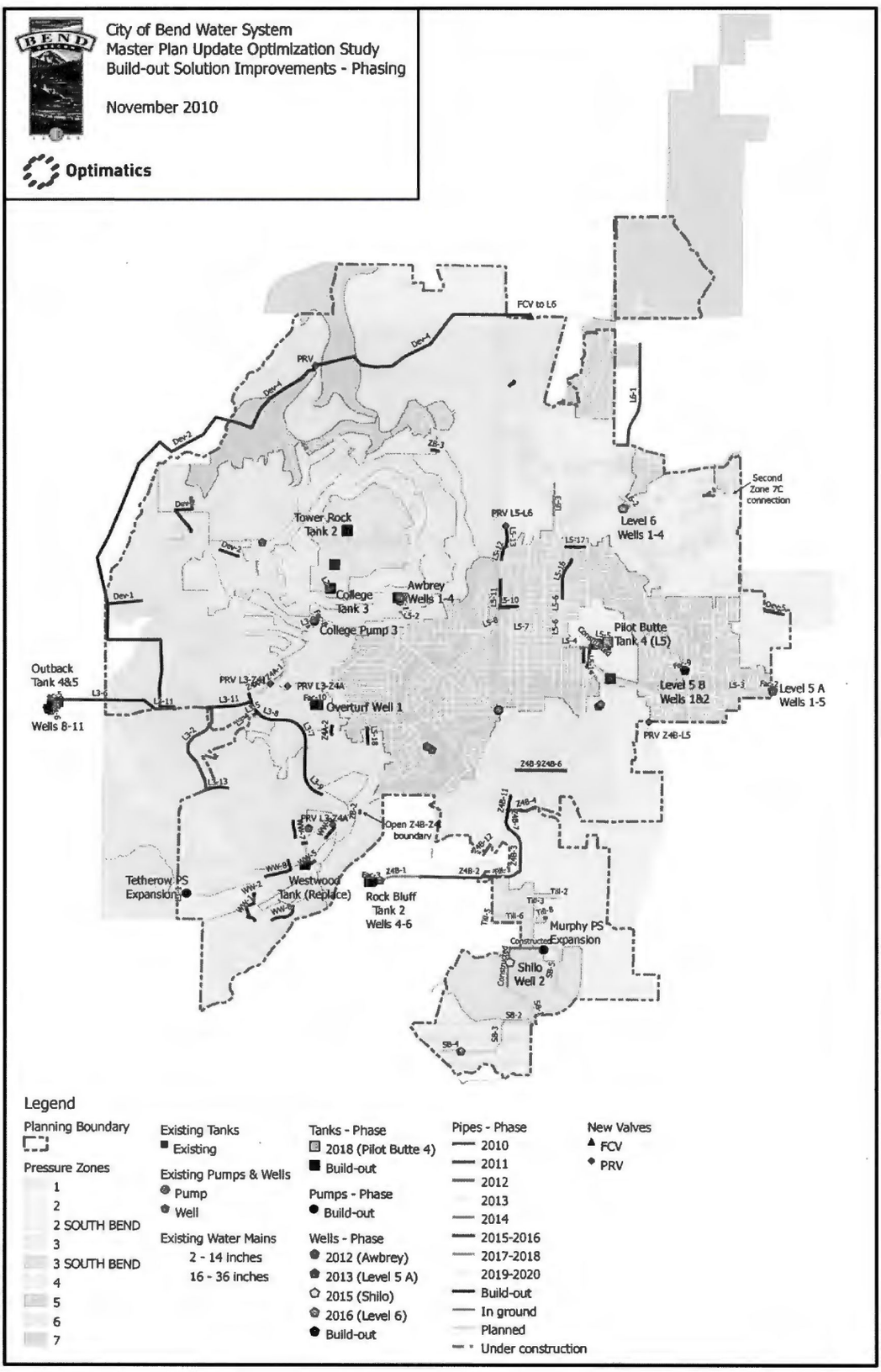


Figure 3.2 – Recommended phasing of Master Plan Improvements

Note: A large scale version of this map is available in hardcopy at the end of this report, and in the electronic **Appendix I**

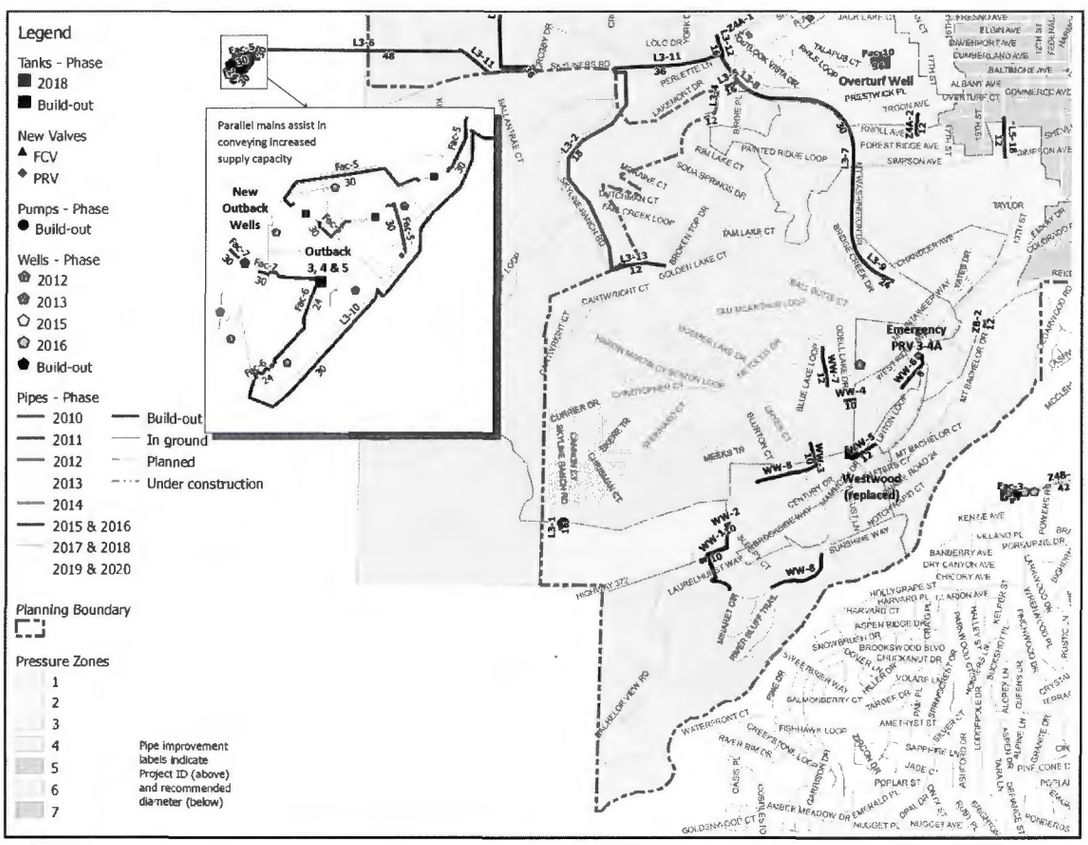


Figure 3.3 – Phasing of Improvements – Southwest area: Outback, Tetherow, Westwood

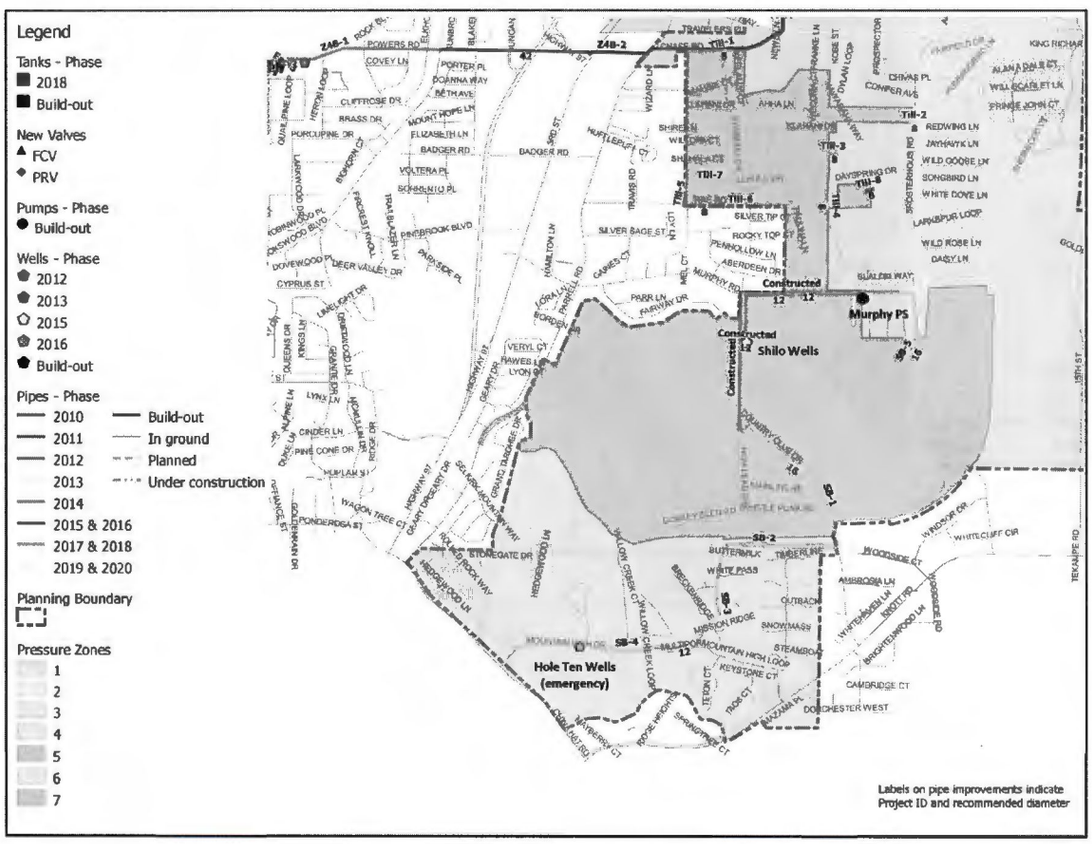


Figure 3.4 – Phasing of Improvements – Southeast area: South Bend

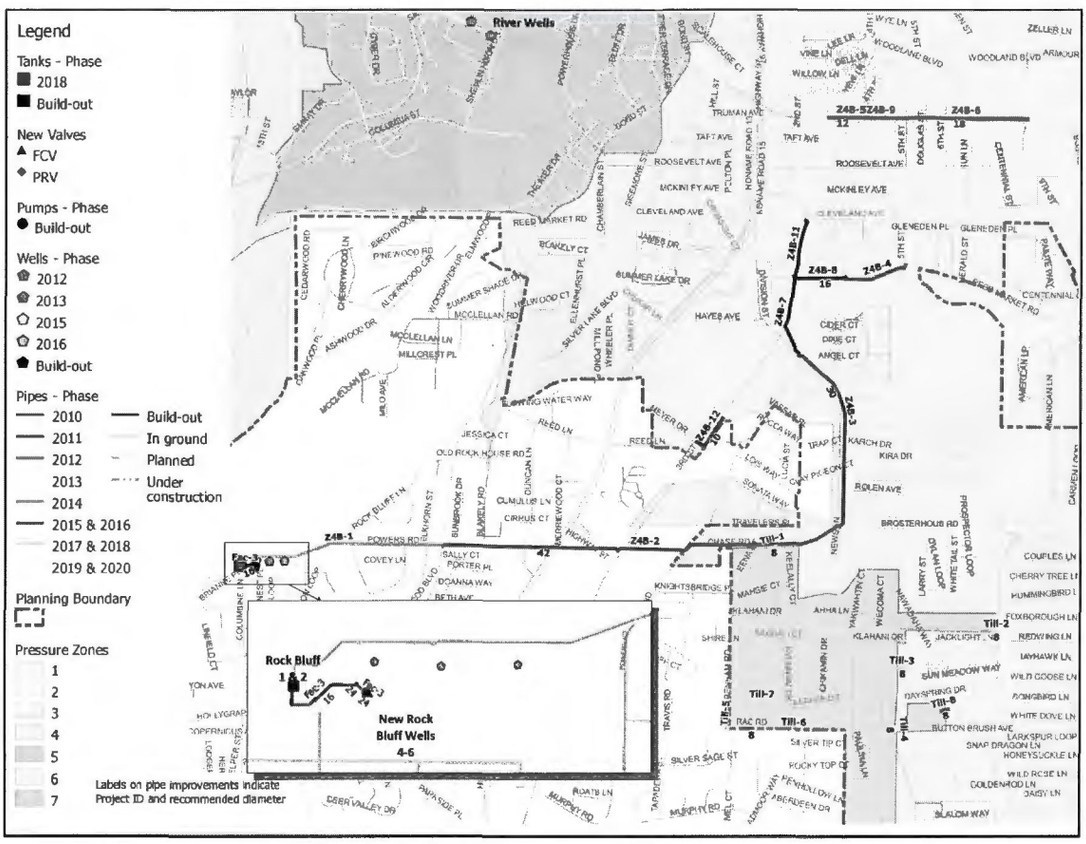


Figure 3.5 – Phasing of Improvements – Zone 4B, Rock Bluff

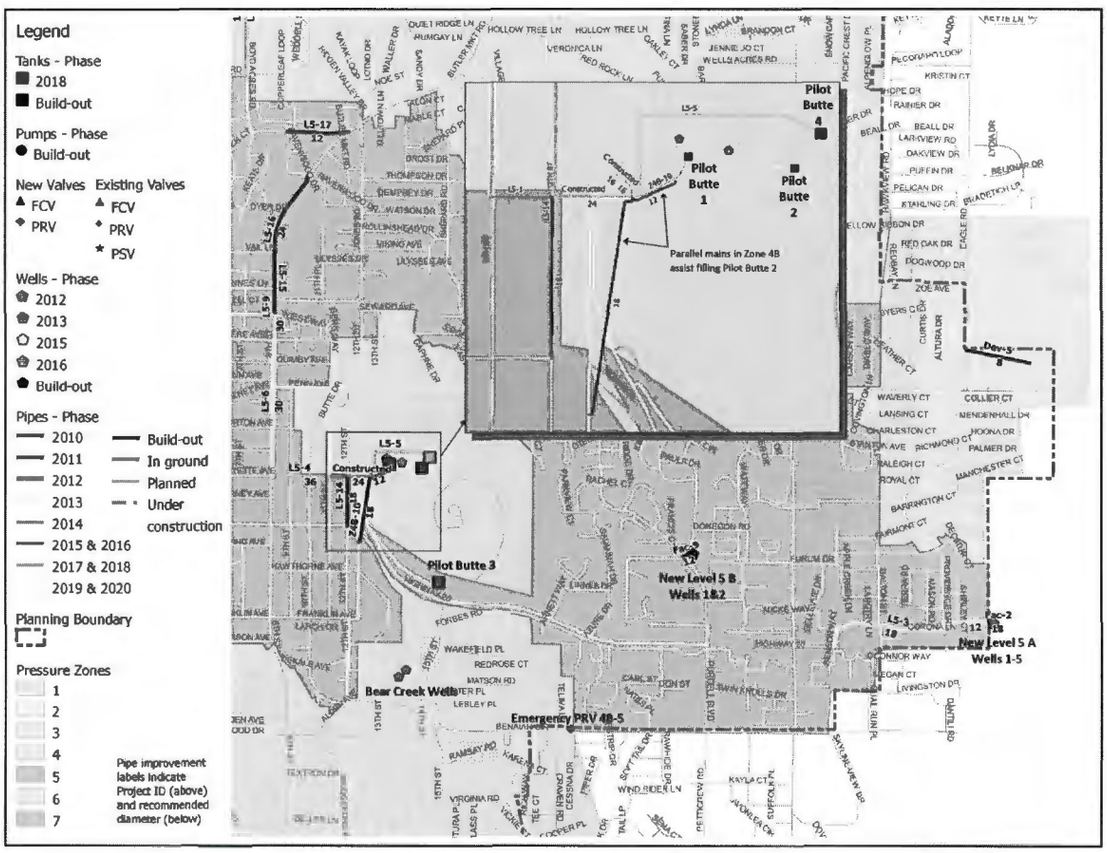


Figure 3.6 – Phasing of Improvements – Level 5 East

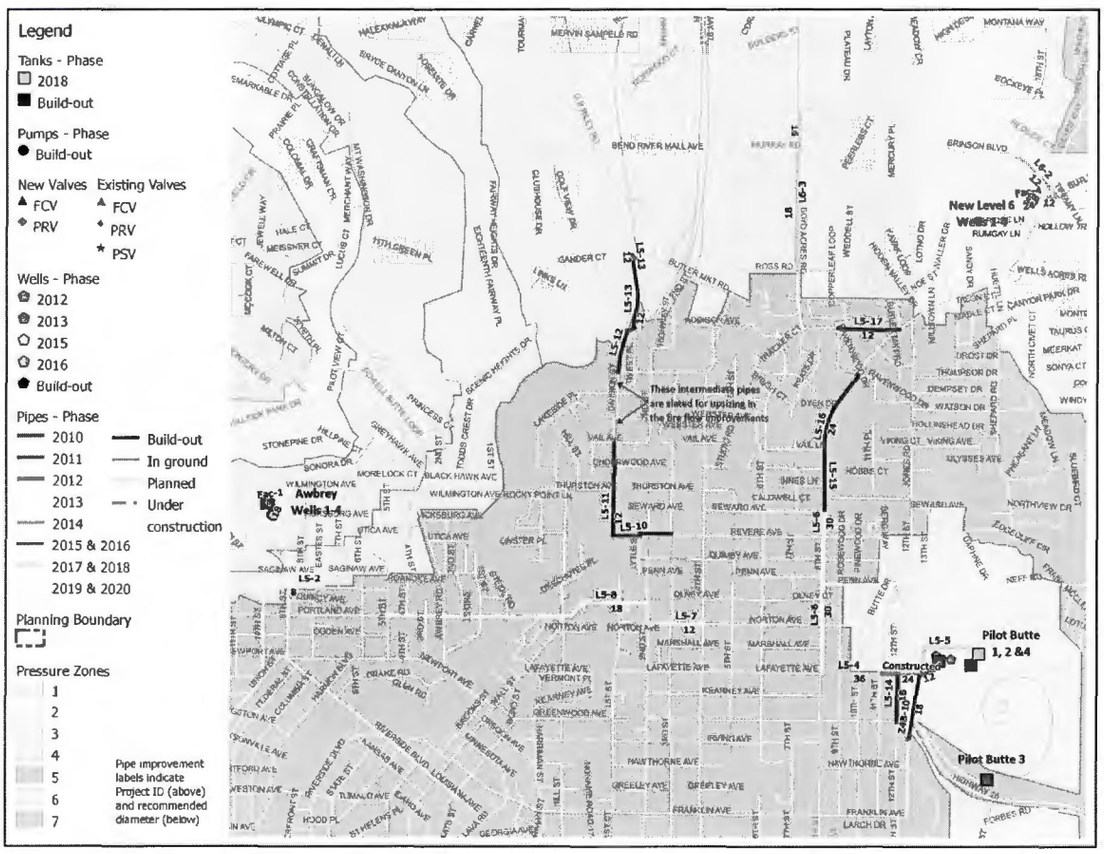


Figure 3.7 – Phasing of Improvements – Level 5 West and Level 6

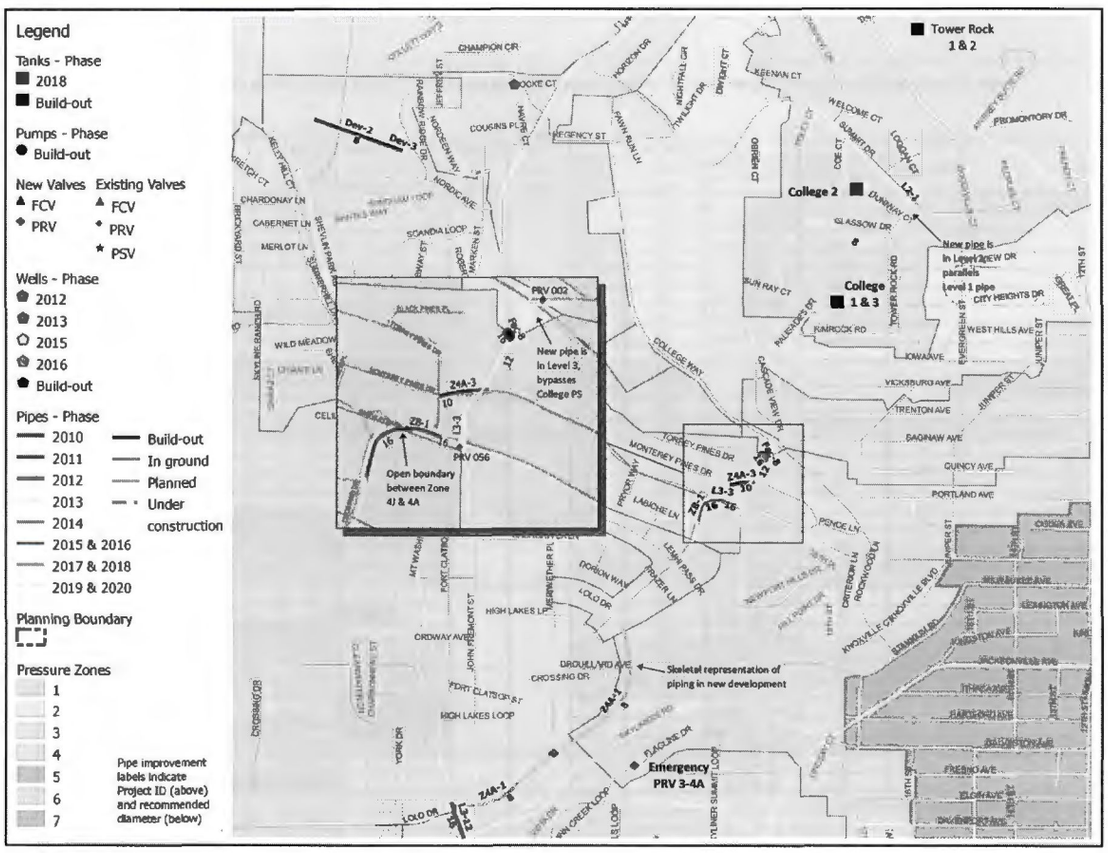


Figure 3.8 – Phasing of Improvements – Awbrey Butte

Table 3.3 – Comparison of well capacity recommended in the 10-year Solution and demand by pressure level under projected 10-year conditions

A	B	C	D	E	F	G =sum(F) Red -> G<H	H	I	J	K =FxJxJ	L discount non-redundant	M =sum(L)	N =Mx2 Red -> N<O	O
Production Facility	**Zone Supplied**	**Pump Size (hp) / Capacity (MGD)**	**Pump Type OR New Well Count**	**Approx. Static Water Level (feet)**	**Capacity (MGD)**	**Total Capacity MGD**	**Build-out MDD MGD**	**Future Back-up Power**	**Future SCADA Capability**	**Capacity Back-up + SCADA**	**Firm**	**Firm Capacity MGD**	**Supply Volume over 2 days**	**Standby 2xADD MGD**
Surface Water Source	**3**				**13.5**					**7.2**	**7.2**			
COPPERSTONE_W	3	250	Line Shaft Turbine	510	1.4			0	0	0.0	0.0			
OUTBACK_W1	3	150	Submersible	482	1.0			1	0	0.0	0.0			
OUTBACK_W2	3	150	Submersible	482	1.1			1	0	0.0	0.0			
OUTBACK_W3	3	250	Line Shaft Turbine	478	1.7			1	1	1.7	1.7			
OUTBACK_W4	3	250	Line Shaft Turbine	482	1.7			1	1	1.7	1.7			
OUTBACK_W5	3	250	Line Shaft Turbine	486	1.8			1	1	1.8	0.0			
OUTBACK_W6	3	250	Line Shaft Turbine	480	1.8			1	1	1.8	1.8			
OUTBACK_W7	3	250	Line Shaft Turbine	480	1.8			1	1	1.8	1.8			
OUTBACK_W8	*3*	*1.8 MGD*	*0*	*480*	*0.0*			*1*	*1*	*0.0*	*0.0*			
New Level 3 (Outback)	*3*	*1.4 MGD*	*0*	*480*	*0.0*	25.8	10.8	*0.00*	*1*	*0.0*	*0.0*	14.2	28.4	9.6
WESTWOOD_W	4A	150	Submersible	283	1.0			0	1	0.0	0.0			
New Level 4 (Overturf)	*4A*	*1.4 MGD*	*0*		*0.0*	1.0	2.6	*0.00*	*1*	*0.0*	*0.0*	0.0	0.0	2.3
BEAR_CREEK_W1	4B	350	Line Shaft Turbine	629	1.5			0	1	0.0	0.0			
BEAR_CREEK_W2	4B	350	Line Shaft Turbine	652	1.6			0	1	0.0	0.0			
ROCK_BLUFF_W1	4B	150	Line Shaft Turbine	393	1.2			1	1	1.2	1.2			
ROCK_BLUFF_W2	4B	150	Submersible	395	1.1			0	0	0.0	0.0			
ROCK_BLUFF_W3	4B	150	Line Shaft Turbine	395	1.2			1	1	1.2	0.0			
SHILOH_W3	*4B*	*250*	*Line Shaft Turbine*	*355*	*2.0*			*1*	*1*	*2.0*	*0.0*			
New Level 4 (Shilo)	*4B*	*1.0 MGD*	*2*	*355*	*2.0*			*0.50*	*1*	*1.0*	*1.0*			
New Level 4 (Rock Bluff)	*4B*	*1.7 MGD*	*0*	*355*	*0.0*	10.6	8.3	*0.00*	*1*	*0.0*	*0.0*	2.2	4.4	7.4
PILOT_BUTTE_W1	5	250	Line Shaft Turbine	743	1.2			0	0	0.0	0.0			
PILOT_BUTTE_W3	5	250	Submersible	786	1.3			0	1	0.0	0.0			
PILOT_BUTTE_W4	5 (4B emerg)	300	Line Shaft Turbine	702	1.6			1	1	1.6	0.0			
New Zone 5 (Awbrey)	*5*	*1.1 MGD*	*1*	*n/a*	*1.1*			*0.00*	*1*	*0.0*	*0.0*			
New Zone 5A (Pumped ground faci	*5*	*1.4 MGD*	*4*	*n/a*	*5.6*			*0.75*	*1*	*4.2*	*4.2*			
New Zone 5B (Pumped ground faci	*5*	*1.0 MGD*	*0*	*n/a*	*0.0*			*0.00*	*1*	*0.0*	*0.0*			
RIVER_W1	5	500	Line Shaft Turbine	360	2.7			1	1	2.7	2.7			
RIVER_W2	5	400	Line Shaft Turbine	242	3.0			1	1	3.0	0.0			
New Zone 6 (Pumped ground facilit	*6*	*1.8 MGD*	*3*	*n/a*	*5.4*	21.9	26.1	*0.67*	*1*	*3.6*	*3.6*	10.5	21.0	23.2
HOLE_10_W1	2B	150	Submersible	410	0.8			1	1	0.8	0.8			
HOLE_10_W2	2B	150	Submersible	412	0.8	1.6	1.0	1	1	0.8	0.0	0.8	1.6	0.9
Existing Groundwater Supply Capacity (MGD) (excluding Rock Bluff 2)					**32.2**									
Total Future Groundwater Supply Capacity (MGD)					**47.4**	**47.4**				**30.9**	**20.5**	**20.5**	**41.0**	43.3
Total Supply Capacity (Ground and Surface) (MGD)					**60.9**	**60.9**	**48.7**			**38.1**	**27.7**	**27.7**	**55.4**	

Key to Table 3.3:

New Well	Proposed details
Assumed future SCADA/Back-up power status	
Not counted, not redundant	

Notes to Table 3.3:

1) Red text in Columns G and N indicates that the available capacity in a particular level is less than the required capacity. In all of these cases, however, supply is available from a higher zone to meet the deficit
2) Outback Wells 1 & 2 portable generator has capacity to run one well at a time
3) Two of Outback Wells 3, 4 & 5 can run on one generator
4) Outback Well 6 generator should operate three wells eventually
5) Generator at Rock Bluff is able to run two of the three wells at once
6) Rock Bluff 2 is always off
7) Shilo Wells are currently out of service. Shilo 3 was scheduled to have portable generator plug-in facilities following upgrade in Spring 2010
8) Pilot Butte 2 has been decommissioned
9) Generator confirmed at Pilot Butte 4, no generator at Pilot Butte 3

Table 3.4 – Assessment of available above-ground emergency storage compared to standby & fire requirements – 10-year demand scenario

	A	B	C	D	E	F	G		H	I	J	K	L
Storage	Storage Volume (MG)	Dead storage	*Minimum* level on MD	% Emerg Avail	Emergency Volume (MG)	Fire suppression (MG)	Standby Avail (MG)	--▸ *Pumping* →Direct/PRV	Standby Requirement 2xADD	*Combined* Standby	*Offset from Wells w back-up power (2 days x MGD)*	Allocation to/from other zones	*Capacity div by* Requirements
		From Model	From Model	=C-B	=D*A		=E-F			=sum of H	*From Well Summary*		=(G+J+K)/I
TOWER_ROCK	1.0	15%	84%	69%	0.68	0.18	0.50	1	0.96	0.96		0.50	105%
												From Level 3	
COLLEGE_1	0.5	0%	75%	75%	0.38	0.54	0.42	2	0.95	1.15		0.80	106%
COLLEGE_2	1.0	6%	63%	57%	0.58							From Level 3	
								2A Teth PS, 3	0.15	*in 3*			
								2B South Bend	0.34	*in 4B*	*Hole Ten* 1.60		
OUTBACK_1	2.3	0%	58%	58%	1.33						*Outback, Copperstone*		
OUTBACK_2	3.0	0%	55%	55%	1.66	1.50	3.92	3	4.52	7.51	14.00	-10.00	105%
OUTBACK_3	3.7	0%	66%	66%	2.42							To 1, 2, 4A, 4B & 5	
OUTBACK_CT_BASIN	1.5	100%	n/a, required for CT					3A	0.11	*in 2*			
								3B	0.10	*in 2*			
								3C WestW PS, 4A	0.71	*in 3*			
								7 North Awbrey Bu	0.00	*in 3*			
											Shilo		
								3D South Bend	0.51	*in 2B*	0.00		
WESTWOOD	0.5	34%	68%	34%	0.16						*Westwood, New wells*		
OVERTURF_EAST	1.5	26%	79%	53%	0.76	0.54	1.05	4A	2.28	2.28	0.00	1.50	112%
OVERTURF_WEST	1.5	26%	72%	46%	0.67							From 3	
											Bear Creek, Rock Bluff, Shilo (rezoned)		
ROCK_BLUFF_1	1.5	0%	79%	79%	1.22	1.50	0.37	4B	7.37	8.22	4.40	7.20	146%
PILOT_BUTTE_2	*1.0*	*0%*	*67%*	*67%*	*0.66*							*From 3*	
								4C	0.27	*in 3*			
								4D	0.18	*in 3*			
								4E	0.44	*in 3*			
								4F	0.13	*in 3*			
								4G	0.15	*in 3*			
								4H Off Westwood	0.16	*in 3*			
								4I Off Westwood	0.32	*in 3*	*4A?*		
								4J	0.18	*in 3*			
								4K	0.05	*in 3*			
AWBREY	5.1	0%	54%	54%	2.76						*River, Pilot Butte, New Zone 5 wells*		
PILOT_BUTTE_1	1.5	12%	56%	44%	0.64	3.00	4.73	5	[illegible]	[illegible]	13.80	7.20	111%
PILOT_BUTTE_3	5.0	0%	62%	62%	3.11							From Level 6	
OP_NewPB4Tank	3.0	0%	41%	41%	1.23								
								5A	0.02	*in 3*			
								5B	0.07	*in 3*			
								5C With 4E	0.02	*in 3*			
								5D	0.07	*in 3*			
											New Zone 6 wells		
								6	[illegible]	[illegible]	7.20	-7.20	
								6A	0.49	*in 5*			
								6B	0.07	*in 3*			
								6C Juniper Ridge	1.85	*in 5*			
								7A With 5B	0.55	*in 5*			
								7B	0.22	*in 5*			
								7C	0.14	*in 5*			
								7D	0.02	*in 5*			
Totals	**33.6**	**2.83**			**18.3**	**7.26**	**11.00**		**43.32**	**43.32**	**41.00**	**0.00**	**137%**
							25%				95%		

Notes:

Dashed and solid lines indicate how supply from reservoirs can be transferred to lower or higher zones (solid indicates gravity supply through PRVs, dashed lines indicate pumping)

Colors in Column I indicate which zones have been grouped together.

4 Fire Flow Improvements addressing Existing Deficiencies

As discussed in Section 2.8.14, the determination of fire flow improvement needs was carried out in an analysis separate from the optimization. Each zone was analyzed to determine which pipes will need to be replaced and at what size to ensure that fire flow can be provided at a residual pressure of 20 psi at every node. This analysis was performed under both existing and future build-out demand conditions. To assist in prioritizing the improvements, an 'available' fire flow analysis was also performed to determine how much flow can be taken from the system at any point without drawing system pressures below 20 psi.

Key aims for the City in prioritizing the fire flow improvements were:

- Ensuring only improvements addressing deficient hydrants in the existing system were included in the list
- Developing a list of improvements that were sorted based on deficiency in terms of available flow compared to required fire flow in gallons per minute (gpm). The City will complete the final prioritization based on local factors such as number of customers impacted.
- Including information about the associated benefit, such as the number of customer parcels impacted by the improvement.

To develop the ordered list of fire flow improvements, the results of the available flow analysis were used to determine which hydrants could not meet their required flow. Using this information, it was possible to determine which pipe improvements are needed to address existing hydrant deficiencies, and which are only required if new hydrants are installed on deficient lines. A listing of the recommended pipe improvements addressing fire flow requirements is provided in **Appendix H**. The listing includes data related to:

- The location of the improvement (street address)
- GIS ID of hydrant connected to each pipe being recommended for replacement
- GIS ID of hydrant that was the key driver for each pipe improvement (the "critical hydrant"), and the associated fire flow requirement at that hydrant
- Whether or not the pipe recommended for replacement is a dead-end line
- The lowest pressure in the system calculated for each fire flow case without the improvements in place and the node at which that pressure was observed

The fire flow improvements have been listed in order of the severity of fire flow deficiency at existing hydrants. Related projects have been grouped together based on the critical hydrant they address. The fire flow available to a given hydrant based on the existing system analysis is compared to the requirement (based on zoning) and a deficiency has been calculated. All the projects have been sorted based on the calculated deficiencies.

The estimated cost of the recommended improvements addressing existing fire flow deficiencies is $9,485,000. At a review meeting in October 2010, City operations staff reviewed the top priority improvements identified in **Appendix H**. Final prioritization of the fire flow improvements was outside the scope of this project and will be completed by City staff.

As well as the improvements listing, **Appendix H** contains figures showing the location of the top 100 fire flow improvements (order based on existing deficiency) highlighting street names and land use zones.

Appendix H also includes information related to improvements that would be needed if new hydrants were to be installed on existing lines that are too small to support fire flow, such as 2-inch diameter mains. These improvements are grouped as follows:

1) Pipe improvements that address deficient lines but where the critical hydrant was not deficient (e.g. instances where the hydrant is near a larger main line and so can meet the requirement, but where the analysis demonstrated it was not possible to provide fire flow to the end of the line)
2) Pipe improvements that address pipes which cannot meet fire flow but do not currently serve hydrants
3) 2-inch main replacements

A review of all 2-inch mains determined that none serve hydrants (apart from 3 instances where the hydrant is close to the main line and it was subsequently confirmed each has a 6-inch stub from the main to the hydrant).

Appendix A – MSA Modeling Report

Appendix B – Consequence of Failure Analysis Report

Appendix C – Design Data Summary Report

Appendix D – Operations Optimization Report

Appendix E – Storage Constraint Review Memorandum

Appendix F – MSA Memoranda

Updated Capital Improvement Project (CIP) Cost Estimates

Former Juniper Utility – Proposed Water System Improvements

Tetherow Development: Alternatives Analysis

Appendix G – Master Plan Improvements – detail

Appendix H – Fire Flow Pipe Improvements

Appendix I (electronic)

- Hydraulic Models of Final Build-out Solution
- Electronic copies of full report and appendices

Draft
Water Management and Conservation Plan

January 3, 2011

Prepared for

City of Bend, Oregon

Prepared by

GSI Water Solutions, Inc.

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HDR Engineering, Inc.

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Appendix B HDR Water Conservation Opportunities Memorandum

Executive Summary

The City of Bend (City) completed its first Water Management and Conservation Plan (WMCP or the "Plan") in August 1998. The purpose of the Plan is to guide the development, financing, and implementation of water management and conservation programs and policies to ensure sustainable use of publicly owned water resources while the City plans for its future water needs. Development of this Plan was required by the City's Permits G-11379 and G-11380. The Oregon Water Resources Department (OWRD) issued a final order approving the City's Plan in May 1999, and required an update in 2004. The City submitted an updated WMCP on December 30, 2004. On February 28, 2005, OWRD issued a final order approving the updated Plan and requiring the next update by January 10, 2010.

This WMCP also was developed to meet the requirements of the City's Permits G-16177 and G-16178, which are conditioned to require an updated WMCP by January 1, 2010. Finally, the City's WMCP is submitted to meet the requirements of the final order approving an extension of time for the City's Permit G-8565. The November 15, 2007 final order required the City to submit a WMCP within 3 years from the date of the order. On September 29, 2009, OWRD extended the above-described deadlines for submitting the City's WMCP to January 3, 2011.

This WMCP fulfills the requirements of the Oregon Administrative Rules (OAR) adopted by the Water Resources Commission in November 2002 (OAR Chapter 690, Division 86). This Plan describes water management, water conservation, and curtailment programs to guide the wise use and stewardship of the City's water supply. The City also is submitting this Plan to gain access to water under its "extended permit" G-8565.

The Plan is organized into the following sections, each addressing specific sections of OAR Chapter 690, Division 86. Section 2 is a self-evaluation of the City's water supply, water use, water rights, and water system. The information developed for Section 2 is the foundation for the sections that follow. The later sections use this information to consider how the City can improve its water conservation and water supply planning efforts.

EXHIBIT ES-1
WMCP Organization

Section	*Requirement*
Section 1 – Water Supplier Plan	*OAR 690-086-0125*
Section 2 – Water Supplier Description	*OAR 690-086-0140*
Section 3 – Water Conservation Element	*OAR 690-086-0150*
Section 4 – Water Curtailment Element	*OAR 690-086-0160*
Section 5 – Water Supply Element	*OAR 690-086-0170*

Description of Municipal Water Supplier

The City's service area includes the City's current urban growth boundary (UGB), which includes most of the City of Bend, as well as the Tetherow Development and Juniper Ridge Development Phases 1 and 2. Two private water utilities, Avion Water Company and Roats Water System, Inc., serve the portions of the area within the UGB not served by the City's water system. The City's water system had approximately 22,000 meters serving residential and non-residential customers in 2009 and an estimated service area population of approximately 62,800.

The City's primary water sources are groundwater from the Deschutes Aquifer and surface water from Bridge Creek and Tumalo Creek. The City currently appropriates groundwater from the Deschutes Aquifer using 21 production wells associated with water rights. Groundwater levels in the City's wells are stable.

The City's surface water intake is located 11.5 miles west of the city limits on Bridge Creek in the Bridge Creek watershed. The surface water supply system was developed in the 1920s as an unfiltered, gravity-operated system. It provides approximately half of the City's annual water supply. Water diverted at the Bridge Creek intake facility consists of flows from the Bridge Creek watershed and flows from natural springs within the Tumalo Creek watershed that are conveyed into Bridge Creek. The City's Bridge Creek intake facility consists of a diversion structure that spans Bridge Creek and diverts water into two transmission mains. The diverted water is conveyed to the City's Outback site, which then sends the water to the onsite disinfection facility and into the City's water service area and distribution system. The City is now entering the design phase of a project to build a new treatment facility for the water it diverts from Bridge Creek and to replace the existing supply pipes.

The City holds 12 groundwater rights that authorize the use of groundwater at a rate of up to 68.2 cubic feet per second (cfs); 44.1 million gallons per day [mgd]) for municipal purposes: 7 certificates and 5 permits. In addition, the City holds six surface water rights that authorize a total use of up to 36.1 cfs (23.3 mgd) from Bridge Creek and Tumalo Creek for municipal purposes. The City's existing water right capacity is sufficient to meet its current peak water demands. The City's current water supply, however, is limited by stream flow, surface water right regulation, volume limitations on water rights, system capacity, and mitigation requirements in the Deschutes Groundwater Study Area.

Water Conservation

OWRD's WMCP rules require cities to have 5-year benchmarks for initiating or expanding conservation measures related to the following required conservation programs. A summary of the 5-year benchmarks is provided below, and in Exhibit ES-4 at the end of this Executive Summary.

Annual water audits. A water audit involves an accounting of all water entering and leaving the water distribution system to identify system leakage, as well as authorized or unauthorized water uses. For example, the City does not have a system to track unbilled consumption and its billing by customer class is unreliable. To resolve these issues, the City has established the following benchmarks.

5-year Benchmarks:

- The City will develop and implement an annual water audit program within the next 5 years. As part of this effort, the City will develop a method to calculate and track unbilled authorized consumption, which may include development of additional measurement methodology, to more accurately determine revenue and non-revenue water.
- The City also will reorganize and update customer classes and service codes, as well as work toward equipping all water meters with automated metering infrastructure (AMI).

System metering. The City's water system became fully metered in December 2004. In addition, all hydrant use within the Bend service area now requires metering, resulting in better tracking of non-fire-related hydrant water use.

5-year Benchmark:

- The City will continue to install meters at all new service connections.

Meter testing and maintenance. The City is testing and rebuilding all meters that exceed 2 inches. Each of these meters is checked and calibrated every 2 years or checked through computer analysis of customer usage each month. The City tests meters if requested by customers, and if the tested meter is found to be 3 percent above or below the proper reading, the meter is replaced.

Most residential meters are relatively new because of recent efforts to meter all residences. The City also is working to update its meters and expects to install 12,500 AMI by December 2010. Residential meters typically are replaced on a 15- to 20-year basis in accordance with American Water Works Association (AWWA) guidelines. The City is eliminating the 5/8 x ¾ inch meter so that base meters for residential units will be ¾ inch.

In 2008, the City installed a new master meter at the end of the Bridge Creek transmission line to measure the amount of surface water that it conveys into the distribution system.

5-year Benchmarks:

- The City will continue to replace all existing meters with the new AMI standard within the next 5 years.
- The City will use improved technology when upgrading or replacing existing source meters during the next 5 years.

Unit-based billing program. The City's customers are billed on the basis of the quantity of water use metered and a base fee. Customers pay a base fee based on meter size, which includes a quantity allowance of up to 4 ccf (ccf = 100 cubic feet). Customers also pay a per ccf unit rate for their monthly water use exceeding 4 ccf.

5-year Benchmarks:

- The City will continue to bill customers based, in part, on the quantity of water metered.

- The City intends to reduce the base quantity allowance from 4 ccf to zero ccf within the next 5 years.

Leak detection and repair. Most of the distribution system water mains are relatively new ductile iron pipe with low potential for excessive leakage, which were put in place during the City's recent period of rapid growth. Since 2004, City staff and contractors have conducted leak detection surveys of 45 to 50 miles of water mains. During 2005-2006, contractors conducting leak detection surveys found no sizable leaks, but did discover and repair two meters with small leaks. City staff have conducted leak detection using in-house electronic equipment and tested for leaks during valve and hydrant maintenance activities. In February 2009, the City tested the Bridge Creek transmission line for leakage. The City also works cooperatively with customers when leaks are discovered on the customer side of the meter, typically in the older galvanized service lines.

5-year Benchmarks:

- The City will continue to carry out leak detection surveys to monitor changes in pipe integrity over time.
- The City will continue to monitor customer consumption records for evidence of leaks and to work cooperatively with customers when leaks are discovered.
- The City will install AMI data technology at all of its meters, which will record hourly consumption and radio transmit that information to the City. This "real-time" information will help the City find and address leaks in the system on the customer side of the meter.

Public education. The City provides water conservation information through numerous media and programs. The City's WaterWise Web site (www.waterwisetips.org) focuses on water conservation and includes information on indoor water use, xeriscaping, rain gardens, and landscape watering. The City sponsored or participated in at least four public events per year during the last 5 years including school events, various summer fairs, and outdoor events throughout the spring, summer, and fall. The City also continues to provide conservation information to the public using fact sheets, publications, bill stuffers, City Edition Videos, and related outreach in partnership with the City Communications Manager. Finally, the City re-establish a position in its 2010 fiscal year budget to manage the City's water conservation benchmarks and to help develop, implement, and track related projects.

5-year Benchmarks:

- The City will continue to provide water efficiency and conservation outreach information to the public using print materials, radio, and video.
- The City will continue to update its Web site and outreach materials as needed.
- The City will explore the potential for development of cost-share partnerships between the City's three water utilities: water; stormwater, and wastewater. The water and stormwater utilities have the potential to jointly hire an employee that can serve both programs.

Technical and financial assistance. The City's technical and financial assistance program has had three components: large landscape program partnerships, large customer water audits, and indoor water use, which includes toilet tank leak detection and shower timers. The City has developed partnerships with customers that have large landscapes requiring irrigation to help them improve their water conservation. The City helps these partners by providing technical and financial assistance in a variety of formats.

Water audits for large customers analyze a customer's water use and identify ways to make water use more efficient. However, the City and water conservation studies[1] have found that audits generally are not cost-effective because customers are reluctant to pay for the audits or recommended improvements. As a result, the expense did not materialize into actual water savings.

The indoor water use component of the City's technical and financial assistance program has two components: toilet tank leak detection dye tablets and shower timers. To decrease leaks that occur on customer premises, the City distributed more than 2,500 toilet tank leak detection dye tablets per year during the past few years. Shower timers are intended to reduce both water and energy use by making shower users aware of their time in the shower. The City distributed more than 1,500 shower timers at schools and public events, and in the display booth set up in City Hall. They are also available by phone and e-mail request.

5-year Benchmarks:

- The City will continue efforts to develop and maintain WaterWise partnerships with large use customers during the next 5 years.
- The City will continue to distribute toilet tank leak detection dye tablets, shower timers, and related information to customers during the next 5 years.
- The City will conduct cost analyses aimed at the creation of cost-effective rebate programs within the next 5 years.
- The City will develop a pilot program for creation of water budgets for targeted customer groups, based on evapotranspiration data.
- The City will continue to fund and promote the use by all customers of the Agrimet weather station and its Web site, including a pilot project to place real time evapotranspiration data on the City Web site for use in creation of outdoor water use budgets.

Retrofit/replacement of inefficient fixtures. The City manages and maintains 136 landscape sites covering 439 acres, many of which require irrigation. Maintenance and management plans have been completed for all of these landscape sites. The City has retrofitted 66 of these sites with smart irrigation controllers. The City recently retrofitted 14 of those 66 sites as part of the City Landscape Retrofit Project. The sites of the 14 retrofits had their irrigation systems and/or landscapes altered or completely rebuilt to decrease maintenance and meet irrigation water savings goals, which often included reducing the area irrigated and xeriscaping.

[1] HDR Technical Memorandum, *Conservation Program for Water Management and Conservation Plan,* December 8, 2010.

5-year Benchmarks:

- The City will continue to pursue greater irrigation efficiency of its existing City-owned landscapes and all new landscapes so they will meet the latest specification and standards, which includes the use of smart irrigation controller technology, xeriscaping principles and other sustainable landscape practices.
- The City will study the cost effectiveness of implementing a toilet rebate replacement or incentive program based on the new voluntary federal high efficiency toilet (HET) standard.
- The City will become a partner in the U.S. Environmental Protection Agency (EPA) Water Sense Program and make related information available through its Web links, bill stuffers, and other methods.
- The City will provide a list of qualifying toilets that meet the various flush standards along with the creation of a toilet efficiency fact sheet.

Reuse, recycling, and non-potable water opportunities. The Resort at Pronghorn, located downhill of the City's wastewater treatment plant, obtains recycled water from the City. Level 4 treated effluent from the wastewater treatment plant enters infiltration ponds and a spray irrigation system that waters two golf courses during the irrigation season. The resort is not within the City's existing drinking water service area.

In July 2010, the City completed a scope of work for a full-scale feasibility study that will investigate increasing the use of recycled water both inside and outside the City's service area.

5-year Benchmark: During the next 5 years, the City will continue to look for opportunities to increase the use of recycled water.

Other measures.

- ***Irrigation Restrictions:*** The City currently has even-odd irrigation restrictions and time of day water restrictions in place. Even house numbers irrigate on even-numbered days and odd house numbers irrigate on odd-numbered days. Irrigation hours are 5 a.m. to 10 a.m. and 4 p.m. to 10 p.m. These policies were put in place many years ago when the City used a flat rate water billing system and were designed to keep reservoirs from being drained by unlimited water use. Code changes are now under consideration in the next fiscal year and may include a recommendation to move away from the even-odd day irrigation restriction system. The City would like to move exclusively to a time of day restriction that aims to provide an enforceable program that incentivizes smart water use, as well as off-peak irrigation time periods, to prevent or reduce the need for costly engineering improvements necessary to meet maximum demands in the morning and evening peaking periods.

  5-year Benchmark: Within the next 5 years, the City will evaluate adoption of modified irrigation restrictions based on time of day (hours that promote efficient water use).

- ***City Standards and Specifications:*** The City recognizes that conservation and water efficiency standards need to be included in City contracts with landscaping and irrigation

work, so the City currently is upgrading its related standards and specifications. The City also created a landscape standard.

5-year Benchmark: The City will continue to implement current landscape standards through related approval processes during the next 5 years.

- ***Collaboration among the City's water utility programs:*** The City has three water-related utilities and several areas of regulatory responsibilities, including water utility, water reclamation, and stormwater programs, that are related to more efficient use of water and the benefits of conservation. The City has implemented a communication effort encompassing all of these areas, which it has promoted as "WaterWise" programs. Collaborations include exploring how to combine funds from different programs to hire staff and present information on stormwater, safe drinking water, water conservation, and industrial pretreatment programs within the homepage of the City's WaterWise Web site and related efforts.

  5-year Benchmark: The City will continue to look for coordination opportunities to more efficiently communicate and implement related programs.

- ***Hydrant Meter Program for temporary and permanent water uses:*** Use of hydrants now requires a permit and use of a temporary metered fill station that also includes backflow protection. All water is measured and billed. In addition, the City has installed one permanent fill station that has the added feature of a card-lock billing system to address the use of multiple users at one location. Contractors have the option of bringing their own water trucks to the fill stations to fill up with water as needed, or using the hydrant meter boxes.

  5-year Benchmark: The City will continue to implement the hydrant meter program and related fill station.

- ***Review and implementation of the Water Conservation Analysis Project:*** In 2010, HDR Engineering (HDR) conducted a water conservation analysis project for the City to examine opportunities to enhance its existing water conservation program. HDR compiled demographic information for the City's service area, applied assumptions for customer participation rates for each conservation measure, calculated the savings achieved by shifting to more efficient hardware or behavior, and calculated the direct costs for those shifts. HDR developed four "conservation packages." These packages included (1) a conservation potential assessment of 37 of the 49 analyzed measures that were not mutually exclusive, which included both behavioral and "hardware" based measures; (2) hardware measures for both indoor and outdoor water conservation; (3) hardware measures for outdoor water conservation only; and (4) hardware measures for indoor conservation only.

  5-year Benchmark: During the next 5 years, the City will work with its Engineering Department and the City Council to develop capital improvement and conservation budgets to identify which conservation measures to fund and implement.

Water Curtailment

In the event of a water shortage, the City needs a detailed response plan based on predetermined objective criteria. The curtailment plan describes how the City will respond to specific water-shortage conditions. The City's curtailment plan presented in this WMCP has four distinct stages, each of which is triggered by one or more identified events. The four stages, increasing in order of severity, are summarized in **Exhibit ES-2**. Any of the initiating conditions described in Exhibit ES-2 will trigger the appropriate curtailment stage. Initiating conditions and response actions are described in detail in Section 4 of this WMCP.

EXHIBIT ES-2
Curtailment Stages 1 through 4

Curtailment Stages	Initiating Conditions
Stage 1: Water Shortage Alert	• Forecasts of below normal summer streamflows • Forecasts of above normal temperatures • Minor damage to transmission mains or distribution system • Minor mechanical or electrical malfunction at one to three wells
Stage 2: Mild Water Shortage **Demand Reduction Target:** **10 percent of MDD**	• Supply capacity is 91 to 100 percent of demand • Mechanical or electrical malfunction at four to seven wells • Extended periods of above normal temperatures or below normal streamflows • Declaration of drought by Governor pursuant to ORS 536.720 • Extensive damage to water supply infrastructure
Stage 3: Serious Water Shortage **Demand Reduction Target:** **20 percent of MDD**	• Supply capacity is 81 to 90 percent of demand • Mechanical or electrical malfunction at 8 to 12 wells • Imminent terrorist threat against supply system • Multiple failures to transmission mains or distribution system
Stage 4: Severe Water Shortage **Demand Reduction Target:** **40 percent of MDD**	• Supply capacity is less than 81 percent of demand • Loss of utility electrical service to wells • Fire in Bridge Creek watershed or near wells • Contamination of source of supply • Extensive damage to transmission, pumping, or treatment processes caused by natural disaster • Intentional acts or fire, contamination of source, or any other event resulting in an immediate, sustained deprivation of water supply

MDD = maximum day demand.
ORS = Oregon Revised Statute.

Water Supply

Consistent with the Optimatics Master Plan Update projections, the City used its Buildable Lands Inventory (BLI) database and water use data to develop demand projections. For the 2020 demand projection, the estimated number of dwelling units at medium density was multiplied by the estimated per capita usage. Then the demand for the non-residential areas along with Tetherow and Phase 1 of Juniper Ridge Developments were included to provide the projected 2010 average day demand (ADD) of 21.7 mgd. This equates to a yearly increase in average day demand of 0.74 mgd between 2010 and 2020. The projected 2030 ADD was developed by increasing demand by 0.74 mgd per year, which results in a 29.1 mgd ADD. Maximum day demands (MDD) were developed by applying a 2.25 MDD to ADD factor. The future demands are summarized in **Exhibit ES-3.**

EXHIBIT ES-3
Future Demands for the City's Water Service Area (mgd)

Year	ADD	MDD
2010	14.3	32.2[1]
2020	21.7	48.8
2030	29.1	65.5

[1] The City's actual 2010 MDD was approximately 20 percent less than the projected MDD for that year. The reduced demand compared to the projections is likely due to the cool, wet weather during the spring and summer of 2010, the City's recent efforts to optimize system operations, as well as less demand because of the current economic downturn.

The City holds surface water rights that authorize the use of up to 36.1 cfs (23.3 mgd). For the purposes of planning for the amount of surface water available to meet peak needs, the City evaluated historic stream flows in Tumalo Creek to establish a likely low-flow scenario. Under that evaluation it was determined that a stream flow of 42.5 cfs and a proportional share for the City of 11.5 cfs (7.4 mgd) should be the "firm" planning-level peak demand surface water supply. The City also holds groundwater rights authorizing use of 68.2 cfs (44.1 mgd). The City may need up to approximately 65.5 mgd to meet its MDD by 2030. The water supply provided by the City's existing water rights, however, currently can be relied upon only to provide approximately 51.8 mgd of supply during periods of high demand. Consequently, the City will need to fully exercise its existing water rights and may need additional water supply to meet its projected 2030 MDD.

Based on projected water demand growth, the City anticipates fully exercising all of its existing surface water and groundwater rights during the next 20-year planning period.

Exhibit ES-4 provides a summary of the City's water management and conservation measure 5-year benchmarks.

EXHIBIT ES-4
Summary of Water Management and Conservation Measure 5-year Benchmarks

Annual Water Audit • Develop and implement an annual water audit program. As part of this effort, develop a method to calculate and track unbilled authorized consumption, to more accurately determine revenue and non-revenue water. • Reorganize and update customer classes and service codes, as well as work toward equipping all water meters with automated metering infrastructure (AMI).
System-Wide Metering • Continue to install meters at all new service connections.
Meter Testing and Maintenance • Continue to replace all existing meters with the new AMI standard. • Use improved technology when upgrading or replacing existing source meters.
Rate Structure and Billing Program • Continue to bill customers based, in part, on the quantity of water metered. • Continue to reduce the base quantity allowance from 4 ccf to zero ccf. • Continue to send monthly bills and to provide water efficiency and conservation information to the public with periodic bill stuffers and electronic messaging with related conservation information and links to the City's conservation Web site.
Leak Detection and Repair • Continue to conduct leak detection surveys to monitor changes in pipe integrity over time. • Continue to monitor customer consumption records for evidence of leaks and to work cooperatively with customers when leaks are discovered. • Install AMI data technology at all of its meters, which will record hourly consumption and radio transmit that information to the City. This "real-time" information will help the City find and address leaks in the system on the customer side.
Public Education • Continue to provide water efficiency and conservation outreach information to the public using print materials, radio, and video. • Continue to update the City Web site and outreach materials as needed. • Explore the potential for development of cost-share partnerships between the City's three water utilities: water, stormwater, and wastewater. The water and stormwater utilities have the potential to jointly hire an employee that can serve both programs.
Technical and Financial Assistance • Continue efforts to develop and maintain WaterWise partnerships with large use customers. • Continue to distribute toilet tank leak detection dye tablets, shower timers, and related information to customers. • Conduct cost analysis aimed at the creation of cost-effective rebated programs. • Develop a pilot program for creation of water budgets for targeted customer groups, based on evapotranspiration data. • Continue to fund and promote the use by all customers of the Agrimet weather station and its Web site, including a pilot project to place real time evapotranspiration data on the City Web site for use in creation of outdoor water use budgets.

Retrofit/Replacement of Inefficient Fixtures

- Continue to pursue greater irrigation efficiency of its existing City-owned landscapes and all new landscapes so they will meet the latest specification and standards, which include the use of smart irrigation controller technology, xeriscaping principles, and other sustainable landscape practices.
- Study the cost effectiveness of implementing a toilet rebate replacement or incentive program based on the new voluntary federal High Efficiency Toilet (HET) standard.
- Become an EPA Water Sense Program partner and make related information available through its Web links, bill stuffers and other methods.
- Provide a list of qualifying toilets that meet the various flush standards along with the creation of a toilet efficiency fact sheet.

Reuse, Recycling, and Non-Potable Water Opportunities

- Continue to look for opportunities to increase the use of recycled water.

Other Measures

- **Irrigation Restrictions** - Evaluate adoption of modified irrigation restrictions based on time of day (hours that promote efficient water use).
- **City Standards and Specifications** - Continue to implement current landscape standards through related approval processes.
- **WaterWise Partnerships** - Continue to seek appropriate partnership opportunities based on current project priorities, budget, and staff time.
- **Collaboration Among City's Water Utilities** - Continue to look for coordination opportunities to more efficiently communicate and implement related programs.
- **Hydrant Meter Program for Temporary and Permanent Water Uses** - Continue to implement the hydrant meter program and related fill station.
- **Review and Implementation of Water Conservation Analysis Project** - Work with the City Council and the City's Engineering Department to develop capital improvement and conservation budgets to identify which conservation measures to fund and implement.

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1. Municipal Water Supplier Plan Elements

This section satisfies the requirements of OAR 690-086-0125.

This rule requires a list of affected local governments to whom the Plan was made available, and a proposed date for submittal of an updated Plan.

Introduction

The City of Bend (City) is located in Central Oregon at the eastern foothills of the Cascade Range. The City is noted for its scenic setting, year-round recreational activities, and growing economy. City residents benefit from a reliable supply of high-quality water for public health and sanitation, fire protection, recreation, and economic development. In recent years, the City has experienced significant growth, which has increased its demands for water. Effective water management and dedicated implementation of conservation measures can reduce water consumption, delay the need to develop additional water supplies, and reduce the volume of new water needed for municipal purposes.

The City completed its first Water Management and Conservation Plan (WMCP or the "Plan") in August 1998. Development of this Plan was required by the City's Permits G-11379 and G-11380. The Oregon Water Resources Department (OWRD) issued a final order approving the City's Plan in May 1999, and required an update in 2004. The City submitted an updated WMCP on December 30, 2004. On February 28, 2005, OWRD issued a final order approving the updated Plan and requiring the next update by January 10, 2010.

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The Plan is organized into the following sections, each addressing specific sections of OAR Chapter 690, Division 86. Section 2 is a self-evaluation of the City's water supply, water use, water rights, and water system. The information developed for Section 2 is the foundation for the sections that follow. The later sections use this information to consider how the City can improve its water conservation and water supply planning efforts.

Section	*Requirement*
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Section 2 – Water Supplier Description	*OAR 690-086-0140*
Section 3 – Water Conservation Element	*OAR 690-086-0150*
Section 4 – Water Curtailment Element	*OAR 690-086-0160*
Section 5 – Water Supply Element	*OAR 690-086-0170*

Affected Local Governments

OAR 690-086-0125(5)

The following governmental agencies may be affected by this WMCP:

- Deschutes County

Thirty days before submitting this WMCP to OWRD, the City made the draft Plan available for review by the affected local government listed above along with a request for comments related to consistency with the local government's comprehensive land use plan. The letter requesting comment and any comments received are in **Appendix A.**

Plan Update Schedule

OAR 690-086-0125(6)

The City anticipates submitting an update of this Plan within 10 years of the final order approving this Plan. As required by OAR Chapter 690, Division 86, a progress report will be submitted within 5 years of the final order.

Time Extension

OAR 690-086-0125(7)

The City is not requesting an extension of time to implement metering or a benchmark established in a previously approved Plan.

2. Municipal Water Supplier Description

This section satisfies the requirements of OAR 690-086-0140.

This rule requires descriptions of the City's water sources, service area and population, water rights, and adequacy and reliability of the existing water supply. The rule also requires descriptions of the City's customers and their water use, the water system, interconnections with other water suppliers, and quantification of system leakage.

Water Sources

OAR 690-086-0140(1)

The City's primary water sources are groundwater from the Deschutes Aquifer and surface water from Bridge Creek and Tumalo Creek. The City also obtains water from the Arnold Irrigation District (AID) for irrigation use within the former Juniper Utility service area.

Surface Water

The City's surface water intake is located 11.5 miles west of the city limits on Bridge Creek in the Bridge Creek watershed. This watershed lies within the Deschutes National Forest, which is owned by the U.S. Forest Service (USFS). The City has a 1926 agreement with the U.S. Department of Agriculture that designates municipal use as the highest and best use of the watershed. In addition, the City has a memorandum of understanding with the USFS that provides clear communication channels between signatories, controls human activity, and protects water quality through regulations and restrictions.

The City's surface water supply system was developed in the 1920s as an unfiltered, gravity-operated system. It provides approximately half of the City's annual water supply. Water diverted at the Bridge Creek intake facility consists of flows from the Bridge Creek watershed and flows from natural springs within the Tumalo Creek watershed that are conveyed into Bridge Creek. The City's Bridge Creek intake facility consists of a diversion structure that spans Bridge Creek and diverts water into two transmission mains, one of which was built in the 1920s and the other was built in the 1950s. The current combined capacity of these two mains is 18.2 cubic feet per second (cfs). The diverted water then is conveyed to the City's Outback site, which sends the water to the onsite disinfection facility and into the City's water service area and distribution system.

As a result of new U.S. Environmental Protection Agency (EPA) regulatory requirements, the City must begin to treat its surface water by October 2012. Consequently, the City must build a new surface water treatment facility. In addition, the pipes that supply the City's surface water are deteriorating and must be replaced. The City has completed a water supply alternatives analysis and now is entering the design phase of this project.

Groundwater

The City currently appropriates groundwater from the Deschutes Aquifer using 21 production wells associated with water rights. The City's records show that groundwater levels in the City's wells are stable.

Other Supply

The AID provides a portion of the water used for irrigation within the former Juniper Utility service area. Water from AID is delivered to ponds and mixed with groundwater supplied by the City. The City delivers the water to the irrigation customers. This irrigation water is non-potable and is transported in pipes separate from the drinking water supply system.

Avion Water Company (Avion) provides water to the Bend Municipal Airport, which is owned by the City, but is 8 miles outside of the current urban growth boundary (UGB). Avion provides water for this small water supply system, which provides water for domestic, commercial, fire protection, limited irrigation, and other typical municipal water uses within the Airport planning area. This system is not connected to the rest of the City's water supply system.

Interconnections with Other Systems

OAR 690-086-0140(7)

The City's drinking water system has one interconnection with the Roats Water System (Roats), which is located at the southern boundary of the City's system. Although this connection originally allowed Roats to serve domestic water in the former Juniper Utility service area, the City no longer purchases water from Roats. The interconnection is now considered for emergencies only.

The City also has one interconnection with Avion, which is located at the intersection of 27th Street and Bear Creek Road. The purpose of this interconnection is for emergencies only. It allows either utility to provide water to the other. Construction of the interconnection occurred in 2003. The City has yet to convey water through this interconnection except for flow testing purposes and will not rely on Avion to supply water to the City's customers on a day-to-day basis.

Water Supply Contracts

OAR 690-086-0140(1)

The City has a wholesale water supply contract with Avion. Under this contract, Avion provides wholesale water service only to the Bend Municipal Airport. The airport has a small isolated water system, which the City operates with water supplied by Avion.

The City does not have exchange agreements or intergovernmental cooperative agreements.

Current Service Area Description

OAR 690-086-0140(2)

The City's current service area appears in **Exhibit 2-1**. For purposes of making demand projections for this WMCP, the area shown is also the projected future service area. The City's service area includes the City's current UGB, which includes most of the City, as well as the Tetherow Development and the Juniper Ridge Development, Phases 1 and 2. Two private water utilities, Avion and Roats, serve the portions of the area within the UGB not served by the City's water system. According to 2009 billing data, the City's water system had approximately 22,000 meters serving residential and non-residential customers.

Although Certificate 85414 includes a place of use at the Bend Municipal Airport, and Airport Well #2 as an authorized point of appropriation, as described above, Avion provides water to the airport. Further, the water supply system at the airport does not connect with the City's municipal supply system because it is approximately 8 miles outside of the City's current UGB and the water service area. As a result, the water demands at the airport are not considered as part of this WMCP.

The City's 2009 service area population was estimated to be approximately 62,791. This population figure was developed using the following methodology. The estimated population for the City was obtained from Portland State University (PSU). Next, the populations for the Avion and Roats service areas within the City were determined as follows. The number of residential units was determined using county tax rolls plus approved 2008 building permits. The estimated number of residential units within these areas was multiplied by the occupancy rate of 94 percent and the average household size of 2.4 persons, which is based on 2000 census information. The City's service area population figure was reduced by these estimated populations residing in the Avion or Roats service areas within the City. For 2009, the PSU population estimate for the City is 82,280. The population within the City that is served by Avion or Roats was estimated to be 19,489. As a result, the estimated 2009 service area population for the City is 62,791 (82,280 - 19,489 = 62,791).

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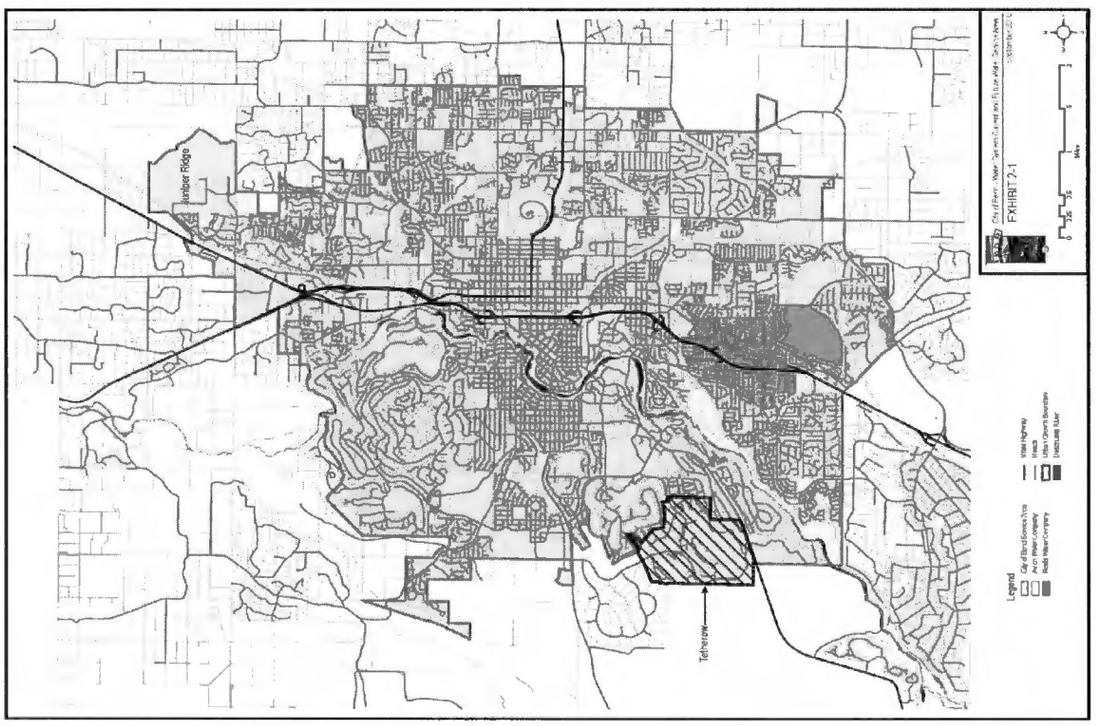
Juniper Ridge
Tetherow
Legend
EXHIBIT 2-1
Miles

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Records of Water Use

OAR 690-086-0140(4) and (9)

Methodology

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.[2] This method provides definitions and classifications for annual water production and consumption as shown in **Exhibit 2-2**. Knowing the magnitude of each category can assist a utility in estimating the financial impact of production, billing, and leak detection practices.

System input, shown in Column A of Exhibit 2-2, refers to the total quantity of water delivered to a distribution system from all sources: for example, water treatment plants or wells. The quantity of water generally is measured using large master meters located at key entry points into the distribution system. System input also is known as "production" and "demand." The system input volume must equal the sum of the authorized consumption and water losses that occur in the system (Column B of Exhibit 2-2).

EXHIBIT 2-2
Components of the IWA/AWWA Water Balance

<table>
<tr><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th></tr>
<tr><td rowspan="4">System Input Volume = Production = System Demand (measured at Master Meters)</td><td rowspan="2">Authorized Consumption</td><td>Billed Authorized Consumption</td><td>Billed metered consumption (including water exported to another system).
Billed unmetered consumption.</td><td>Revenue Water</td></tr>
<tr><td>Unbilled Authorized Consumption</td><td>Unbilled metered consumption.
Unbilled unmetered consumption.</td><td rowspan="3">Non-Revenue Water</td></tr>
<tr><td>Water Losses</td><td>Apparent Losses</td><td>Unauthorized consumption.
Data handling error.
Metering Inaccuracies.</td></tr>
<tr><td></td><td>Real Losses</td><td>Leakage from transmission and/or distribution mains.
Leakage and overflows at storage tanks.
Leakage from service connections up to a point of customer metering.</td></tr>
</table>

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

Authorized consumption is divided into billed and unbilled categories. Billed authorized consumption is equivalent to revenue water. Unbilled authorized consumption contributes to

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

non-revenue water and includes uses such as hydrant flushing and system flushing. Unbilled authorized consumption can be either metered or unmetered.

Water losses include both apparent losses and real losses. Apparent losses result from meter inaccuracies, error introduced by data entry or manipulation, and unauthorized consumption (such as illegal connection to the system). Real losses result when water is lost because of leaks, reservoir overflow, and evaporation. All water systems have some degree of real losses. OWRD's Water Management and Conservation Planning rules set a goal for municipal systems to have "system leakage" (real losses) equal to or less than 15 percent of total system input or demand, and if feasible, less than 10 percent.

Terminology

Production refers to the quantity of water delivered to a distribution system. By definition, production equals system demand.

Generally, demands and consumption in municipal systems are summarized in units of million gallons per day (mgd), but also may appear as cfs or gallons per minute (gpm). Annual or monthly values typically are reported in million gallons (MG). Water use per person or per capita typically is expressed in gallons per capita per day (gpcd).

The following terms are used to describe system demands:

- Average day demand (ADD) equals the total annual demand divided by 365 days.
- Maximum day demand (MDD) equals the highest system demand that occurs on any single day during a calendar year. It is also called the 1-day MDD or peak day demand.
- The 3-day maximum day demand (3-d MDD) equals the average of the daily demands that occurred on the day before, the day of, and the day after the MDD.
- Monthly demand refers to demand during a calendar month. This demand can be expressed as the total volume of water produced in a month, or as a daily demand value by dividing the total monthly volume by the number of days in the month.
- Maximum monthly demand (MMD) equals the highest monthly demand during a calendar year.
- Peaking factors are the ratios of one demand value to another. The most common and important peaking factor is the ratio of MDD to ADD.

Historic Water Demands

Water demands for the City's system from 2004 through 2009 appear in **Exhibit 2-3**. The data illustrate an increasing trend from 2004 through 2008, with a decline in demand during 2009.

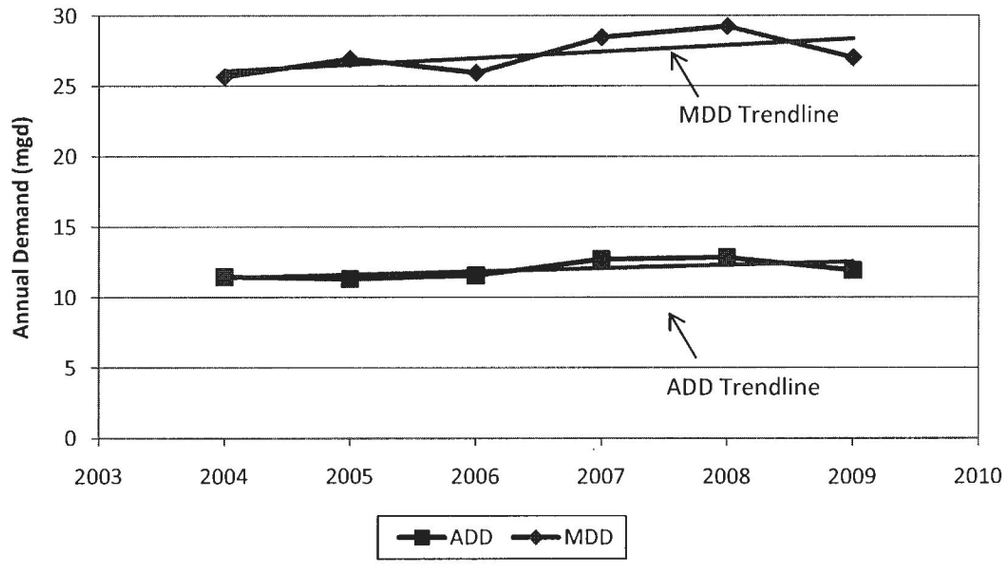
EXHIBIT 2-3
Historical Average Day, Maximum Day, 3-day Maximum Day Demands, and Peaking Factors

Year	Annual Volume Produced (MG)	ADD (mgd)	MDD (mgd)	3-d MDD (mgd)	Peaking Factor MDD:ADD
2004	4,195	11.5	25.7	25.5	2.2
2005	4,131	11.3	26.9	26.3	2.4
2006	4,222	11.6	26.0	25.8	2.2
2007	4,643	12.7	28.5	27.3	2.2
2008	4,700	12.8	29.2	27.9	2.3
2009	4,353	11.9	27.0	26.2	2.3
Average	**4,374**	**12.0**	**27.2**	**26.5**	**2.3**
Maximum	**4,700**	**12.8**	**29.2**	**27.9**	**2.4**

MG = million gallons
ADD = average day demand
mgd = million gallons per day
MDD = maximum day demand

Exhibit 2-4 displays the historic data and linear trends of the ADD and MDD from 2004 to 2009 for the system.

EXHIBIT 2-4
Historic and Trend Line ADD and MDD

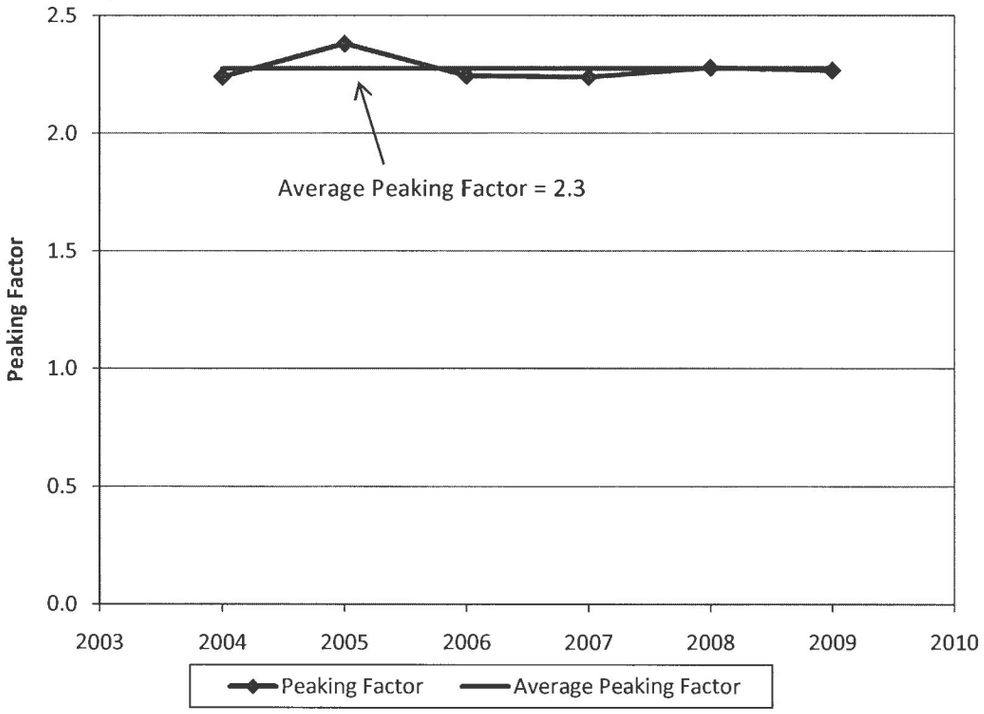


From 2004 to 2009, the ADD ranged from 11.3 to 12.8 mgd, with an average of 12.0 mgd. For the same period, the MDD ranged from 25.7 to 29.2 mgd, with an average of 27.2 mgd. As anticipated with municipal water systems, there is greater variation in the MDD than the ADD because of the sensitivity of the MDD to weather patterns. Hot and dry weather often results in more outdoor irrigation during that period, resulting in higher MDD values. Similarly wet, cool weather can cause the MDD to drop for a particular year.

If production approaches capacity for a short period of time, such as a single day, systems generally can use storage to meet demand. However, if high demand continues for a longer period, water shortages may result. The 3-day MDD gives an indication of the duration of the maximum demand period. From 2004 to 2009, the 3-day MDD ranged from 95 percent to 99 percent of the single MDD with an average 3-day MDD that was 97 percent of the single MDD. This indicates that periods of high demand typically last longer than a single day and that in its water supply planning efforts the City should make preparations to address maximum demand for multiple days.

Exhibit 2-5 graphically represents the ratio of the MDD to ADD for the years 2004 to 2009, which are the peaking factors from Exhibit 2-3. The peaking factor ranged from 2.2 to 2.4 with an average of 2.3. For use in projecting future demand in Section 5 of this WMCP, a peaking factor of 2.25 is used; this is a typical peaking factor for Central Oregon municipal water providers.

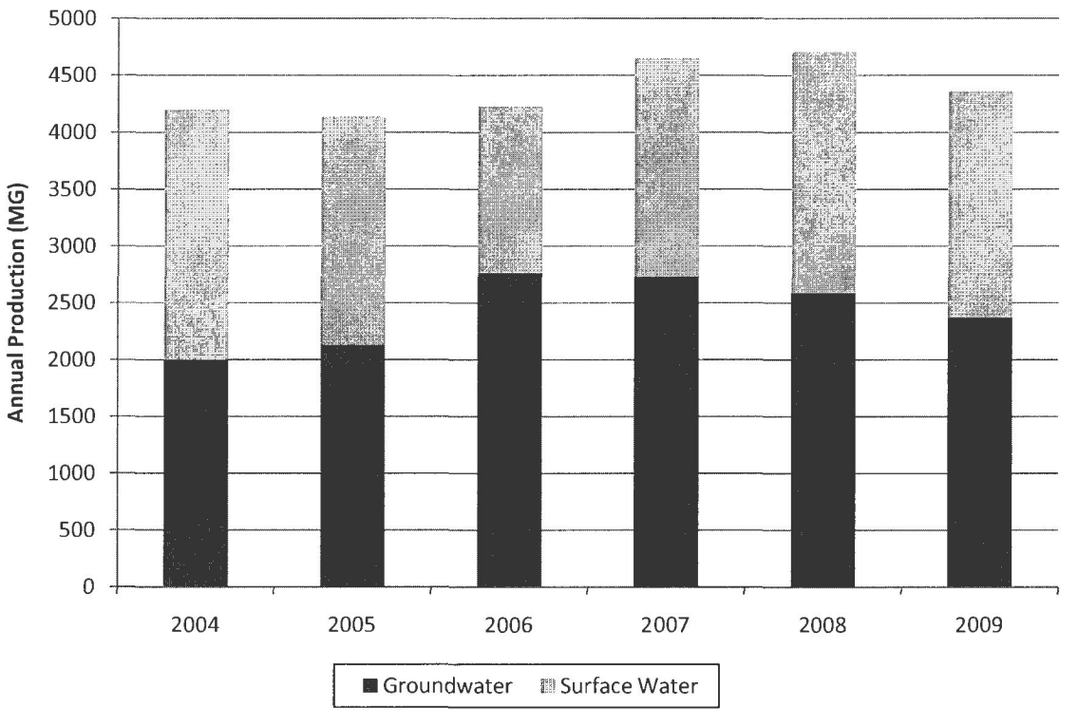
EXHIBIT 2- 5
Historic Peaking Factor (MDD to ADD Ratio)



Annual and Monthly Production

Exhibit 2-6 illustrates the annual production of surface water and groundwater. On average from 2004 through 2009, groundwater represented 56 percent of production, and surface water provided the remaining 44 percent. However, the ratio of groundwater to surface water production varies by time of the year.

EXHIBIT 2-6
Annual Production of Surface Water and Groundwater



As previously described, the City's surface water and groundwater sources each provide about one-half of the City's annual water supply. Surface water is used year-round to meet the City's base water demands, and groundwater is used when sufficient surface water supplies are not available. **Exhibit 2-7** illustrates the monthly production volumes from 2004 through 2009. Surface water provided the majority of the water supply during the fall and winter months. The percent of groundwater use increased substantially during the spring and summer months because of the rise in turbidity of the surface water, which limits usability; low flows in the surface water sources; and higher overall demand. As expected, the overall demand peaks in the summer months as a result of outdoor uses such as irrigation. The average MMD during the period from 2004 through 2009 was 732 MG.

EXHIBIT 2-7
Monthly Production of Surface Water and Groundwater

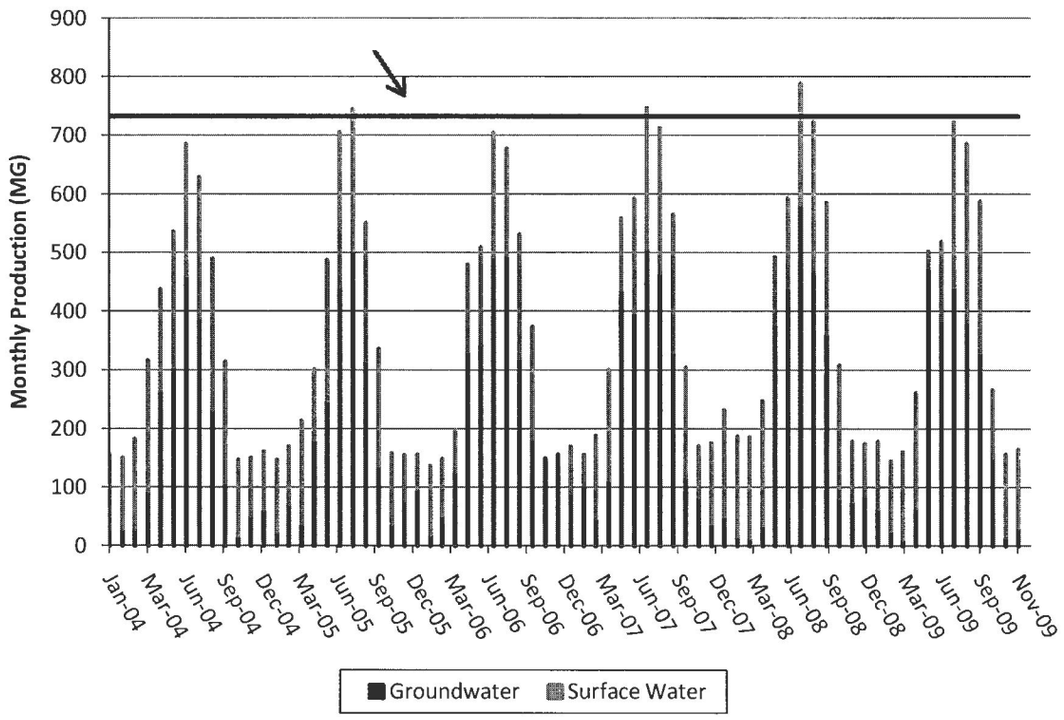
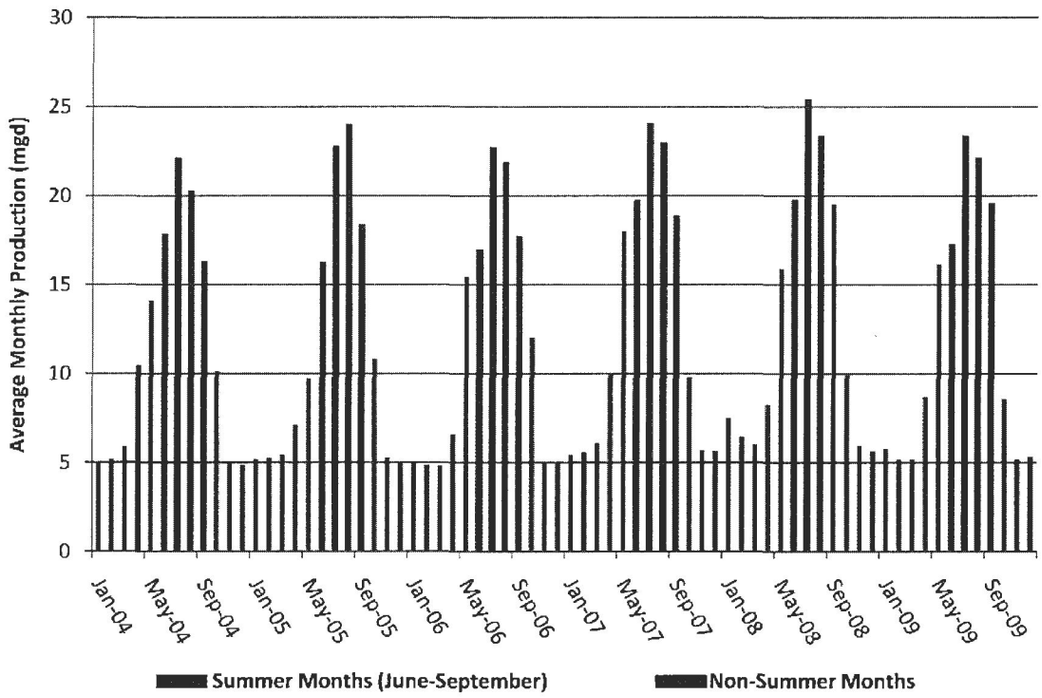


Exhibit 2-8 shows the average monthly demand, with the peak water use months from June through September highlighted in green. The average MMD was 23.6 mgd (732 MG) during the 6-year period and the peak month occurred in July every year except 2005, when it occurred in August. The peak summer period accounted for an average of 57 percent of demand, with the remaining demand spread across the other 8 months of the year.

EXHIBIT 2-8
Average Monthly Production



Per Capita Demands

Exhibit 2-9 shows the estimated ADD per capita demand within the City's water service area. The ADD represents use by all customer categories. Because the per capita demand includes all use by commercial, industrial, and municipal customers as well as residential customers, the calculated per capita demand values exceed the amounts of water actually used by a typical individual. Because of this fact, per capita demand calculations may show year-to-year trends, but are a poor metric to compare customers' water use to that of other communities. Moreover, per capita demand may not accurately portray year-to-year water use because the calculation does not take into account the difference in customer mix, climate, rainfall, current economic conditions, or specifics such as changes in hotel occupancy or large commercial or industrial uses that may not have any relationship to population or actual efficiency of use.

EXHIBIT 2-9
ADD Per Capita Demand

Year	ADD (mgd)	Population Served by City System	ADD per Capita (gpcd)
2004	11.5	51,535	222
2005	11.3	54,525	208
2006	11.6	57,443	201
2007	12.7	59,198	215
2008	12.8	61,736	207
2009	11.9	62,791	190

ADD = average day demand
mgd = million gallons per day
gpcd = gallons per capita per day

Authorized Consumption

Authorized consumption is equal to the metered and certain unmetered water use within the system. All customers are metered, however, authorized water consumed for activities such as fighting fires and system maintenance currently are not metered by the City. Maintenance use and water used for water quality purposes, such as system flushing, are tracked informally by the operations staff. To obtain a more accurate determination of revenue and non-revenue water, the City intends to review and develop a program to calculate and track unbilled authorized consumption as part of its water audit program, as further described in Section 3.

The City currently has two major customer categories – residential and non-residential. For 2008 and 2009, 86 percent of accounts were residential with the remaining 14 percent classified as non-residential. Residential customers include single-family and multi-family accounts, and non-residential customers include commercial, laundry, park, and school accounts. The City is working to improve the accuracy of its data and changes have been made to improve the 2008 and 2009 billing record data. The use of detailed consumption data before 2008 or with more customer class specificity was not used in developing this WMCP. The City understands the current shortcomings of its detailed consumption data and is making this a point of emphasis in its water management and conservation benchmarks regarding annual water audits. (See Chapter 3 for more details.)

Customer Characteristics and Water Use Patterns

OAR 690-086-0140(6)

Understanding the characteristics of customers within the system is important when analyzing water use and forecasting future demand and consumption patterns. **Exhibit 2-10** shows the number of meters by customer category for 2008 and 2009. The annual metered consumption by retail accounts during this period is shown in **Exhibit 2-11.** Although the quality of the City's data is not sufficient for detailed evaluation of water use by customer class, note that the City's *2005 Housing Needs Analysis City of Bend Residential Lands Study* indicated that 72 percent of households were single-family, leaving 28 percent that were multi-family.

The percent of total water used by the two major customer categories in 2009 is illustrated in the pie chart in **Exhibit 2-12.** Residential use comprised 61 percent of consumption with 31 percent of use by non-residential customers.

EXHIBIT 2-10
Number of Meters by Customer Category

	2008	2009
Residential	19,318	19,033
Non-residential	3,253	3,211
Total	**22,571**	**22,244**

EXHIBIT 2-11
Annual Consumption by Customer Category

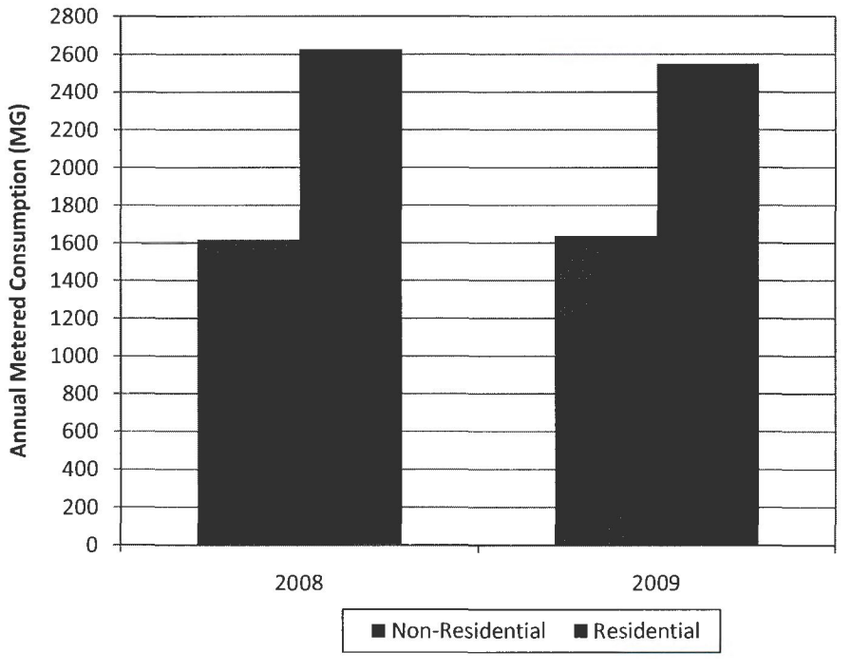
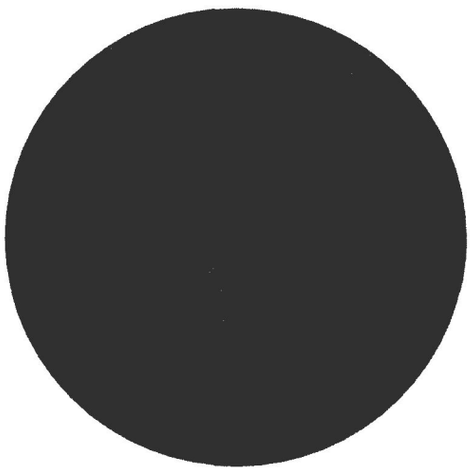


EXHIBIT 2-12
Percent Annual Consumption by Customer Category, 2009



The average monthly consumption by customer category for 2008 and 2009 is shown in **Exhibit 2-13.**

EXHIBIT 2-13
Monthly Water Consumption, 2008-2009

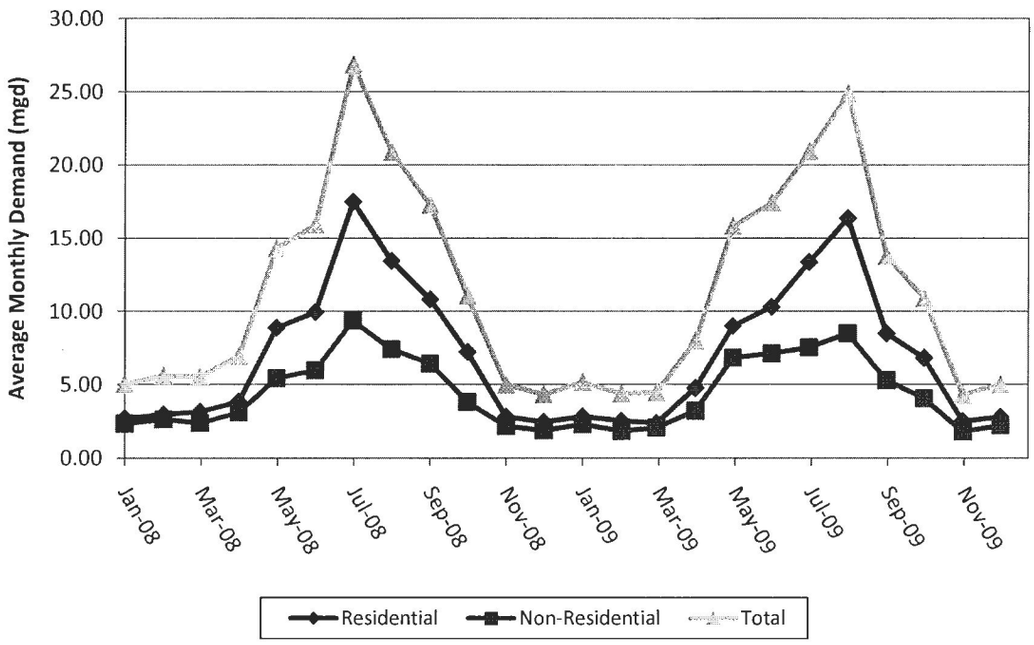


Exhibit 2-14 provides a comparison of the ADD for the residential customer category and for the non-residential customer categories during the last year of the analyzed period for this Plan and the City's previous Plan.

EXHIBIT 2-14
Current and Historic ADD by Customer Category

Customer Category	Average Day Demand (mgd)	
	2003[1]	**2009**
Residential	5.7[2]	7.0
Non-residential	5.7	4.9

[1] As provided in the City's 2004 approved WMCP; however, since that time continual refinements to customer categories have been made.

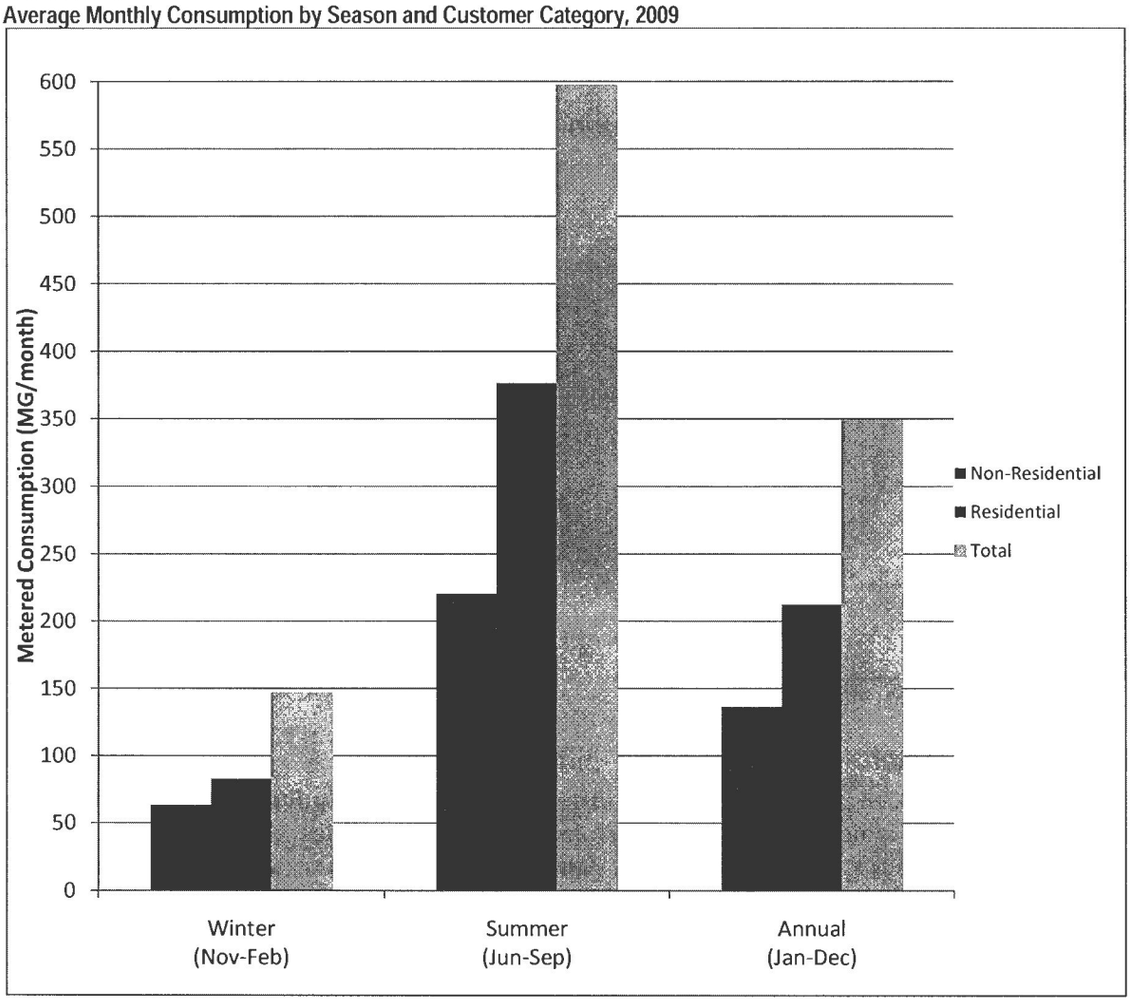
[2] Includes 0.35 mgd that was the estimated demand for non-metered residential use.

mgd = million gallons per day

The ADD for the residential category during 2009 was 12.6 mgd during summer months (June through September) and 2.8 mgd during winter months (November through February.) The ADD for non-residential categories during 2009 was 7.4 mgd during summer months and 2.1 mgd during winter months.

Exhibit 2-15 presents the average monthly consumption for the two major customer categories by season for 2009. For the purposes of this analysis, the summer months are defined as June through September and winter months are defined as November through February. The total average monthly consumption was 597 MG per month for summer months, and 146 MG per month for the winter months. The overall monthly average for the entire year was 349 MG per month. The summer season to winter season use ratio was 4.1.

EXHIBIT 2-15
Average Monthly Consumption by Season and Customer Category, 2009

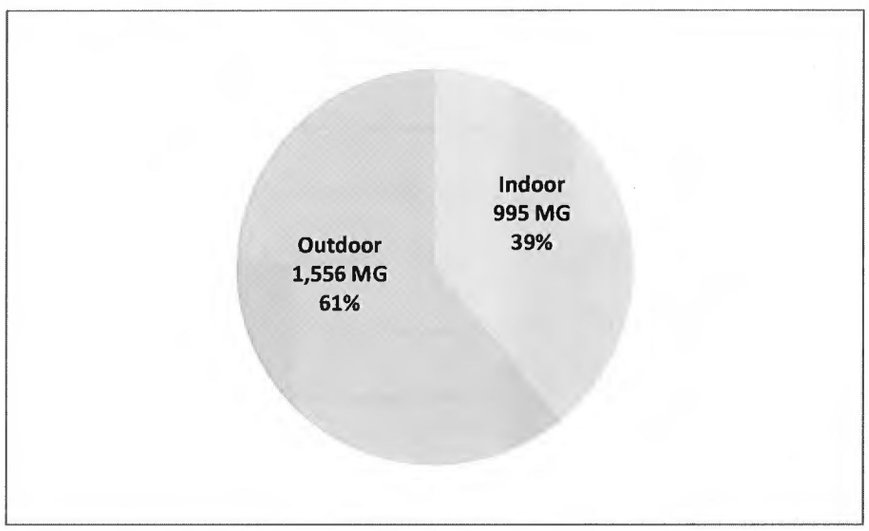


Indoor and Outdoor Water Use

To estimate indoor versus outdoor use, wintertime consumption was assumed to be representative of indoor water use (or at least to exclude outdoor irrigation) for residential customers. Non-residential customers were not included in the analysis because of the variability of types of customers within the non-residential category. The wintertime monthly average of 83 MG for residential users was multiplied by a 12-month period to determine the average annual indoor use of 996 MG. The outdoor use by residential customers was assumed to be the difference between total use and the calculated indoor use, resulting in outdoor annual average use of 1,556 MG. The results appear in **Exhibit 2-16.**

Indoor water use represented approximately 39 percent of annual water use by residential customers. Because outdoor use represents the majority of residential use, conservation measures focused on reducing outdoor use could substantially reduce average demand and peak season demand. Conservation efforts targeting indoor residential water use could have some impact on reducing overall average demands.

EXHIBIT 2-16
Estimated Annual Residential Indoor and Outdoor Use, 2009



Non-Revenue Water

The difference between production and authorized consumption is equivalent to a system's non-revenue water, which includes both apparent and real water losses. Apparent losses result from meter inaccuracies, error introduced by data entry or manipulation, and unauthorized consumption (illegal connection to the system or unauthorized use of a fire hydrant). Positive apparent losses would reduce the volume attributed to real losses. Conversely, because of the nature of these types of error, apparent losses may have negative values. If apparent losses are negative, real losses are underestimated. Apparent and real water losses often are expressed as a percentage of system production. Non-revenue water is equal to system losses plus any authorized but unbilled water use within a system.

Exhibit 2-17 presents the annual non-revenue water for 2008 and 2009. The exhibit also lists total production and consumption as well as the percent of non-revenue water. These percentages ranged from 4 percent to 10 percent, with an average of 7 percent. A valve maintenance and hydrant flushing program is completed about every 2 years and occurred in 2008, which likely contributed to a higher percentage that year. The City is not aware of any leaks in its system or significant losses of water.

The City currently does not have a systematic leak detection program; however, leakage is not believed to be a significant loss. Authorized unbilled water use for flushing, water quality testing, reservoir cleaning and draining, as well as reservoir leakage is calculated and tracked by the City's Operations staff, but not precisely metered so the exact percent contributed to the overall non-revenue water cannot be determined. This is a benchmark activity the City intends to include in its "water audit" improvements.

EXHIBIT 2-17
Historic Annual Non-revenue Water

Year	Production (MG)	Metered Consumption* (MG)	Water Losses (MG)	Percent
2008	4700	4242	458	10%
2009	4353	4189	164	4%
Average			**311**	**7%**

*Does not include unbilled authorized consumption such as hydrant flushing, water quality testing, etc.
MG = million gallons

City of Bend Water Rights

OAR 690-086-0140(5)

The City holds 12 groundwater rights that authorize the use of groundwater at a rate of up to 68.2 cfs (44.1 mgd) for municipal purposes: 7 certificates and 5 permits. In addition, the City holds six surface water rights that authorize a total use of up to 36.1 cfs (23.3 mgd) from Bridge Creek and Tumalo Creek for municipal purposes. **Exhibit 2-18** summarizes the City's water rights.

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City of Bend Water Rights

Date: 08/26/20

App Basin Number	Permit Number	Certificate or Transfer Number	Authorized Wells	Priority Date	Authorized Rate cfs	Authorized Rate (mgd)	Type of Beneficial Use	Maximum Withdrawal To Date		2020 Average Withdrawal		5-Year Average Withdrawal (2015-2019)		Authorized Date for Completion	Mitigation Credit	Notes
								Instantaneous (MG)	Annually (MG)	Daily (MG)	Monthly (MG)	Daily (MG)	Monthly (MG)			
Groundwater																
G-1220	G-1220	85444	Outback Well #5 Outback Well #6 Outback Well #2 Outback Well #4 Bear Creek Well #1 Airport Well #2	9/7/1961	10	6.5	Municipal	10	4.5					N/A -Contained	N/A	
G-5648	G-4946	85832	River Well #1 River Well #2	10/31/1967	8.5	5.5	Municipal	8.5	5.5					N/A -Contained	N/A	
G-5648	G-4946	85435	River Well #1 River Well #2	10/12/1971	3.7	1.7	Municipal	3.7	1.7					N/A -Contained	N/A	
G-5648	G-4946	85432	River Well #1 River Well #2 Evaporation Pilot Butte Well #2	10/12/1971	7.87	4.9	Municipal	12.7	6.9					N/A -Contained	N/A	
G-5648	G-4946	85433	River Well #1 River Well #2 Pilot Butte Well # Bear Creek Well #1 Bear Creek Well #2	10/13/1971	4.87	3.1	Municipal	4.87	3.1					N/A -Contained	N/A	
G-5825	G-4945	85431	A Well (Westwood)	12/22/1978	1.81	1.0	Quasi-Municipal	1.31	1.0					N/A - Contained (Partial portion of Permit G-4945)	N/A	
G-5825	G-4945		A Well (Westwood) Pilot Butte Well #4 Shevlin Well #3 Hole Ten Well #1 Hole Ten Well #2	12/22/1978	0.96	0.6	Quasi-Municipal							10/1/2020	N/A	Permit Amendment T-10941
G-11982	G-12709	85867	Rock Bluff Well #1 Rock Bluff Well #2 Rock Bluff Well #3	6/30/1989	4.76	3.7	Municipal	4.76	3.7					N/A - Contained (Partial portion of Permit G-12709)	N/A	
G-11942	G-11379		(Rock Bluff) Well #1 (Rock Bluff) Well #2 (Rock Bluff) Well #3 Pilot Butte Well #2	6/30/1989	3.84	2.5	Municipal			6.91	149.0	6.31	211.15	10/1/2038 - assumes application pending	N/A	Permit Amendment T-10941
G-12699	G-14177		Bear Creek Well #3 Bear Creek Well #4 Bear Creek Well #5 Outback #7 Tin Iels #3 Hole Ten 1 Hole Ten 2	9/27/1990	12	7.0	Municipal	0	0					4/04/2027	Obligation: 1,611.5; Assigned: 0.1	Limited by Master on annual volume of 3120 AF and corresponding subjective provided Permit Amendment T-11138
G-12699	G-14178		Pilot Butte Well #3 Pilot Butte Well #4 Pilot Butte Well #5 Outback #7 Tin Iels #3 Hole Ten 1 Hole Ten 2	9/27/1990	12	7.0	Municipal	0	0					8/2/2027	Obligation: 1,611.5; Assigned: 774.2k	Limited by Master on annual volume of 3120 AF and corresponding subjective provided Permit Amendment T-11138
G-9017	G-9021		Lava Island Well #1 Lava Island Well #2 Lava Island Well #3 Lava Island Well #4 Lava Island Well #5 Lava Island Well #6 Lava Island Well #7 Lava Island Well #8 Bear Creek Well #2 Outback Well #3 Outback Well #4 Outback Well #5 Outback Well #6 Pilot Butte Well #4 Shevlin Well #3 Hole Ten Well #1 Hole Ten Well #2	11/30/1989	7.75 cfs total; 0.895 0.88 0.88 0.89 0.97 0.97 0.87 0.875 N/A N/A N/A N/A N/A N/A N/A N/A N/A	5 mgd total: 6.0 6.0 6.0 6.0 6.0 6.0 6.0 6.0 N/A N/A N/A N/A N/A N/A N/A N/A N/A	Municipal							10/1/2038	N/A	Permit Amendment T-10941 & T-10941
			Total Authorized		57.9	44.1										
			Total Certificated		31.9	20.5										

[1] Priority date of 1/1/1905 is typo. Applications G-9644 and Permit G-4946 has priority date of 10/12/1971.
[2] Permit Amendment T-11138 in process.

Application Number	Permit Number	Certificate or Transfer Number	Facility/Location Name	Priority Date	Authorized Rate (cfs)	Authorized Rate (mgd)	Type of Beneficial Use	Maximum Withdrawal To Date		2009 Average Withdrawal		5-Year Average Withdrawal (2005-2009)		Authorized Date for Completion	Mitigation Credits	Notes
								Instantaneous (MG)	Annually (MG)	Daily (MG)	Monthly (MG)	Daily (MG)	Monthly (MG)			
Sugar Water																
S-47983	S-49823	65713	Bridge Creek to Unnamed Tributary of Middle Fork Tumalo Creek	12/12/1983	12.2	7.9	Municipal	0.2	7.9					N/A - Combined (Partial perfection of Permit S-49823)	N/A	
S-47985	S-49823		Bridge Creek to Unnamed Tributary of Middle Fork Tumalo Creek	12/12/1983	2.8	1.8	Municipal							10/1/1959	N/A	
Deschutes Vol. 1, Page 183	65524		Tumalo Creek	This right is senior to all other rights on Tumalo Creek	6	3.9	Domestic, Municipal	6	3.9					N/A - Combined	N/A	
Deschutes Vol. 1, Page 133	35411		Tumalo Creek	6/1/1900	2	1.29	Municipal	2	1.29	5.41	16.43	5.17	17.27	N/A - Combined	N/A	Period of use 1/18-10/15; Not to exceed 4.50 cfs and 521.7 AF/year
				9/1/1905	4.5	2.91		4.5	2.91						N/A	
				4/1/1907	0.65	0.61		0.65	0.61						N/A	
Deschutes Vol. 1, Page 128	35445		Tumalo Creek	9/1/1905	1.214	0.65	Municipal	1.214	0.65					N/A - Combined	N/A	Period of use 4/15-10/15; Not to exceed 2.50 cfs and 328.34 AF/year
				4/28/1905	0.186	0.12		0.186	0.12						N/A	
				4/1/1907	1.365	0.71		1.365	0.71						N/A	
Deschutes Vol. 1, Page 130	Transfer S-112		Tumalo Creek	10/29/1913	4/1-8/1: 3.43 cfs 5/1-8/15: 3.43 cfs 8/16-9/15: 5.99 cfs 9/1-10/1: 2.25 cfs 10/1-11/1: 2.43 cfs	4/1-8/1: 1.57 mgd 5/1-8/15: 2.09 mgd 8/16-9/15: 3.87 mgd 9/1-10/1: 2.07 mgd 10/1-11/1: 1.57 mgd	Municipal	6	6					10/1/1919	N/A	Period of use 4/1-11/1; Not to exceed 5.99 cfs and 1,908.5 AF/year
				Total Authorized	30.1	19.5										
				Total Combined	27.3	17.7										

Groundwater

The City's seven water right certificates for the use of groundwater authorize the use of up to 31.7 cfs. The City's most senior groundwater right certificates (68702, 85415, 85412, and 85413), have a priority date of October 13, 1971[3] and authorize the use of up to 0.9 cfs, 2.7 cfs, 7.57 cfs, and 4.87 cfs, respectively.

The City also holds water right Certificate 85411, which has a priority date of December 22, 1978, and authorizes the use of up to 1.51 cfs. This certificate was issued as the result of the partial perfection of Permit G-8565, which authorized the use of up to 2.45 cfs. The remaining portion (0.94 cfs) of Permit G-8565 continues to be in the water right development process as a permit. OWRD approved an application for an extension of time that extends the development timeline for Permit G-8565 to October 1, 2020.

In addition, the City holds water right Certificate 85559, which has a priority date of June 30, 1989, and authorizes the use of up to 4.16 cfs. This certificate was issued as the result of the partial perfection of Permit G-11379, which authorized the use of up to 8.0 cfs. The remaining 3.84 cfs portion of Permit G-11379 continues to be in the water right development process as a permit. The City filed an application for an extension of time with OWRD on October 31, 2003. That extension application is pending.

The City's most junior water right certificate is Certificate 85414, which has a priority date of September 7, 1990, and authorizes the use of up to 10 cfs.

Finally, the City holds three additional municipal water use permits that authorize the use of groundwater: Permits G-4435, G-16177, and G-16178. Permit G-4435 authorizes the use of up to 7.75 cfs of groundwater. OWRD extended the development timeline for Permit G-4435 until October 1, 2020. Permits G-16177 and G-16178 each have a priority date of August 27, 1992, and each authorizes water use at a rate of up to 12.0 cfs and volume of up to 3,223 acre-feet. OWRD issued these permits after the inception of the Deschutes Basin Mitigation Program and, accordingly, the City must provide mitigation credits to offset the impacts on surface water from use of groundwater under these permits. OWRD determined that each permit has a total mitigation obligation of 1,611.5 credits based on a consumptive use estimate of 50 percent. To date, 4.9 credits have been assigned to Permit G-16177 and 229.15 credits have been assigned to Permit G-16178.

Surface Water

The City's six surface water rights authorize the use of up to a total of 36.1 cfs (23.3 mgd) from the Bridge Creek and Tumalo Creek watersheds. The City's surface water rights are evidenced by four certificates, one permit, and one transfer.

The City's most senior surface water right is Certificate 85526, which authorizes the use of up to 6.0 cfs from Tumalo Creek. The certificate evidencing this water right does not provide a date of priority, but states instead that the "right is senior to all other rights on Tumalo Creek." The City acquired this water right as the result of a judgment of the Deschutes County Circuit Court in a case between the City of Bend and the Deschutes County Municipal Improvement District.

[3] Certificate 68702 appears to include a scrivener's error stating that its priority date is October 31, 1971, rather than October 13, 1971, as provided in Permit G-4946, from which the certificate was issued.

The City holds two additional surface water right certificates for the use of water from Tumalo Creek: Certificate 31411, which authorizes the use of up to 6.52 cfs; and Certificate 31665, which authorizes the use of up to 2.603 cfs. Both rights originated as multiple decreed rights for irrigation purposes, which were acquired by the City and transferred to municipal purposes. As a result, these certificates each have three different priority dates with a maximum authorized rate associated with each date. These rights also carry an annual volume limitation and a season of use limitation stemming from their origins as irrigation water rights.

The City's most junior municipal water right certificate is Certificate 85713, which authorizes the use of up to 12.2 cfs from Bridge Creek with any deficiency to be made up by appropriation from Tumalo Creek. This certificate was issued as the result of the partial perfection of Permit S-49823, which authorized the use of up to 15.0 cfs. The remaining 2.8 cfs portion of Permit S-49823 continues to be in the water right development process as a permit.

Finally, the City holds a water right evidenced by Transfer B-112. Under this transfer, the maximum authorized rate of diversion from Tumalo Creek varies by season from up to 2.43 cfs to 5.99 cfs. The right also has an annual volume limitation and a season of use because it was originally an irrigation right. Transfer B-112 changed the place of use, point of diversion, and character of use of two certificates for irrigation and domestic use. On May 18, 2009, OWRD approved an extension of time allowing until October 1, 2019 for the City to complete this transfer.

Juniper Utility Water Right

The City has possession of water right application G-13809, which was held by the former Juniper Utility, based on a condemnation proceeding. Title to the application and other Juniper Utility system property will not transfer until the case is complete; the judgment is entered and the City pays the award of just compensation into court. As a result, the Juniper Utility water rights are not considered as part of the discussion of the City's water rights or listed in Exhibit 2-18.

Aquatic Resource Concerns

The City's water supply is from both groundwater and surface water. Groundwater in the Deschutes Basin is not an OWRD-designated Critical Groundwater Area or Groundwater Limited Area. The City's surface water sources are Bridge Creek and Tumalo Creek to the west of Bend. **Exhibit 2-19** shows the listed fish species that occur in Bridge Creek and Tumalo Creek. Tumalo Creek is listed on Oregon Department of Environmental Quality's (DEQ) 303(d) list of impaired water bodies for the following parameters: alkalinity, ammonia, chloride, chlorophyll, dissolved oxygen, pH, phosphate, and temperature. Bridge Creek is 303(d) listed for temperature.

EXHIBIT 2-19
Native Fish Species that Occur in Bridge Creek and Tumalo Creek that are Listed as Sensitive, Threatened, or Endangered Under the Oregon or Federal Endangered Species Acts

Species	Evolutionarily Significant Unit (ESU)	Federal Listing	State Listing
Inland Columbia Redband Trout (*Oncorhynchus mykiss gairdneri*)	Range-wide	Sensitive	Sensitive – Vulnerable

- Federal ESA listed species (threatened and endangered) were obtained from http://www.nmfs.noaa.gov/pr/species/esa/fish.htm and http://ecos.fws.gov/tess_public/pub/stateListingIndividual.jsp?state=OR&status=listed
- Federal sensitive species were obtained from the Interagency Special Status/Sensitive Species Program (Oregon and Washington) at http://www.fs.fed.us/r6/sfpnw/issssp/agency-policy/
- State ESA listed species (threatened and endangered) were obtained from http://www.dfw.state.or.us/wildlife/diversity/species/threatened_endangered_candidate_list.asp
- State sensitive species were found at http://www.dfw.state.or.us/wildlife/diversity/species/docs/SSL_by_taxon.pdf

Evaluation of Water Rights/Supply

OAR 690-086-0140(3)

As previously described, the City's water supply is provided by its surface water and groundwater rights. The City holds water rights authorizing use of up to approximately 68.2 cfs (44.1 mgd) of groundwater from the Deschutes Aquifer and 36.1 cfs (23.3 mgd) of surface water from Bridge Creek and Tumalo Creek. The City's existing water right capacity is sufficient to meet its current peak water demands. The City's current water supply is, however, limited by stream flow, surface water right regulation, surface water quality events, volume limitations on water rights, system capacity, and mitigation requirements in the Deschutes Groundwater Study Area.

Surface Water

The amount of water available to satisfy the City's surface water rights is a function of water right priority date (seniority) and stream flow, as further described below.

A. Watermaster Distribution

Most of the City's surface water rights were originally irrigation water rights that the City acquired for municipal purposes. As a result, these rights have annual volume limitations and limit the use of water to the irrigation season. The City's surface water rights authorize the use of up to 36.1 cfs during the irrigation season and 21.0 cfs during the remainder of the year. Further, because these rights share priority dates with other irrigation water rights held by the Tumalo Irrigation District (TID), streamflows in Tumalo Creek are distributed between the City, TID, and the instream water rights that also originated from a TID irrigation water right during times of low flow.

For demonstration purposes, **Exhibits 2-20 and 2-21** describe the amount of water to which the City is entitled at different streamflows, as well as the amounts to which TID and the instream water rights are entitled.

EXHIBIT 2-20
Tumalo Creek Water Rights Distribution during Irrigation Season

Total stream flow	BEND	TID	INSTREAM
40	11.1	22.3	6.5
60	14.2	38.7	7.0
80	16.3	56.1	7.6
100	17.5	74.7	7.8
120	18.0	94.2	7.8
140	18.6	113.6	7.8
160	19.2	133.0	7.8
180	19.7	152.5	7.8
200	20.3	171.9	7.8
220	20.9	191.3	7.8
240	21.1	206.4	12.4

TID = Tumalo Irrigation District

EXHIBIT 2-21
Tumalo Creek Water Rights Distribution during Irrigation Season

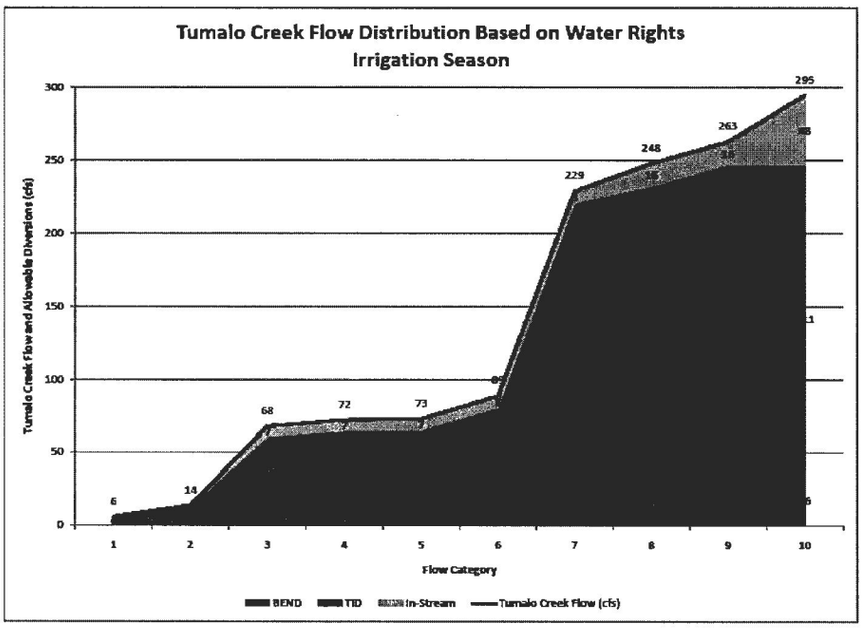

Exhibit 2-22 breaks down the water rights used by the City, TID, and instream water right by rate and priority date.

Exhibit 2-22
Tumalo Creek Water Rights Distribution by Priority Date

PRIORITY	MAX RIGHT IN CFS		
	BEND	TID	Instream
Unrestricted	6.000	0.000	0.000
August 5, 1900	2.000	5.645	0.178
September 1900	7.434	39.593	7.065
April 28, 1905	0.186	4.178	0.131
May 27, 1907	0.000	0.585	0.018
June 1, 1907	1.513	13.750	0.431
October 29, 1913	3.981	136.000	0.000
December 8 1961	0	11.3	7.800
December 12 1983	15.000	0.000	0.000
TOTAL	**36.114**	**211.051**	**15.623**

CFS = cubic feet per second

Flows in Tumalo Creek are influenced by snow melt. The flows typically peak during May and June, and are the lowest during September. Based on historic flow information provided by OWRD, the 80 percent exceedance flows (flows expected to be available 80 percent of the time, or 8 years out of 10) in Tumalo Creek above the Tumalo Feed Canal during September are calculated to be 52 cfs. At this flow, the City would be entitled to up to approximately 13 cfs under the watermaster's distribution schedule, which distributes water according to priority date among the City, TID, and the instream water rights. During July, which is typically the month during which the City has the highest maximum monthly demand, the 80 percent exceedance flows in Tumalo Creek are calculated to be 72 cfs. At this flow, the City would be entitled to up to approximately 15.6 cfs.

Under low-flow conditions in Tumalo Creek, the City's water use would be limited even further. Historic (7-day rolling average) stream flows of 42.5 cfs were observed in September 1945. Under such conditions, the City could expect to be limited to as little as 11.5 cfs (7.4 mgd).

B. Water Quality

Water quality also can affect the reliability of the City's surface water rights. Because the City currently does not filter its surface water, its use of surface water is vulnerable to turbidity events during spring melt and thunderstorms, and to other water quality problems that can result from forest fires or other causes. These events have the potential to degrade water quality to the point where some water quality standards are exceeded,

limiting the City's ability to use its surface water source. The City is currently in the process of addressing this problem by planning for installation of surface water treatment facilities.

C. Instream Water Rights

Three instream water rights have been established on Tumalo Creek. The two senior instream rights resulted from TID allocation of conserved water projects. The instream water right evidenced by Certificate 81332 has a priority date of December 8, 1961, and protects flows ranging from 1.7 cfs to 7.8 cfs from April through October at the Tumalo Feed Canal diversion. Because of its priority date, this instream right affects only the reliability of the City's Permit S-49823 and Certificate 85713, which have priority dates of December 12, 1983. The instream water right evidenced by Certificate 84351, however, has multiple priority dates ranging from August 5, 1900 to June 1, 1907. These priority dates are identical to several of the priority dates for the City's surface water rights. This right protects up to 2.0 cfs from April 15 to October 15 from the Tumalo Feed Canal diversion to Lake Billy Chinook. The third instream water right is evidenced by Certificate 73222 and has a priority date of October 11, 1990. This right protects flows year-round from the confluence of South Fork Tumalo Creek to the mouth. Because of its junior priority date, this instream rights does not affect the reliability of the City's water rights.

D. Over-all Reliability

Based on its priority, the City's water right Certificate 85526 is highly reliable. The certificate authorizes the use of up to 6 cfs (3.9 mgd) from Tumalo Creek year-round and is senior to all other water rights on the creek. As a result, this right is not subject to regulation when the streamflow falls below levels necessary to meet the needs of other existing water rights.

The City's water rights evidenced by Certificates 31411 and 31665 and Transfer B-112 have a number of limitations. First, water use under these rights, which originated as irrigation rights, is limited to the irrigation season (April 15 to October 15 for the certificates and April 1 to November 1 for Transfer B-112). Further, these rights have annual volume limitations: 821.7 acre-feet for Certificate 31411; 328.14 acre-feet for Certificate 31665; and 1923.5 acre-feet for Transfer B-112. Finally, as previously described, these rights are subject to regulation according to the watermaster's distribution schedule when streamflows are insufficient to meet the needs of existing water rights with the same or senior priority dates. In a typical year, regulation may occur in late summer (late July into September). As a result, the City is generally unable to divert water at the full rates authorized by these rights during the peak demand time of the year.

The City's Permit S-49823 and Certificate 85713, which resulted from partial perfection of this permit, have a priority date of December 12, 1983. Although these rights do not have a season of use or annual volume limitations, they are not reliable during the irrigation season because of their junior priority date. These rights will be the first to be regulated to meet the needs of senior consumptive water rights and instream water rights evidenced by Certificates 81332 and 84351. Because of the above-described limitations on the City's surface water rights, the City depends on its groundwater rights to help meet peak day

demand during the summer and other times when sufficient surface water is not available to meet the City's water needs.

Groundwater

The City holds groundwater rights authorizing use of up to approximately 68.2 cfs (44.1 mgd) of groundwater. According to the City's 2010 Optimatics study (*February 2010 Design Data Summary Report*), the total in-service groundwater well capacity is 41.5 cfs (approximately 26.8 mgd). Consequently, the City's use of its maximum authorized rate is limited by the current capacity of its wells.

The City holds seven certificated groundwater rights: Certificates 85414, 68702, 85415, 85412, 85413, 85411, and 85559. They authorize the use of a combined total of up to 31.71 cfs. These water rights provide the City with a reliable groundwater supply.

In addition, the City holds Permit G-8565, which authorizes the use of up to 0.94 cfs, and Permit G-4435, which authorizes the use of up to 7.75 cfs of groundwater. The City has obtained extensions of time allowing it until October 1, 2020 to complete development of both permits. These permits are expected to provide the City with a reliable water supply.

The City also holds Permit G-11379, which authorizes the use of up to 3.84 cfs. The current development timeline for this permit was October 1, 1998. An extension application for this permit is pending. The reliability of this permit could be reduced as a result of conditions included through the extension process.

Finally, the City holds groundwater Permits G-16177 and G-16178, each of which have a priority date of August 27, 1992 and authorize the use of water at a rate of up to 12.0 cfs and a volume of up to 3,223 acre-feet annually. Permits G-16177 and G-16178 each have a total mitigation obligation of 1,611.5 credits. To date, 234 credits have been assigned to Permits G-16177 and G-16178, which allows the use of up to 468 acre-feet of groundwater. To increase the volume of water appropriated for beneficial use under these permits, the City will need to secure additional mitigation credits. The need to mitigate for the use of water under these permits limits their reliability to some extent. The second increment in the City's incremental mitigation plan calls for the City to obtain an additional 1,126 acre-feet of mitigation. Further, the administrative rules implementing the mitigation program are scheduled to "sunset" on January 2, 2014. The City will be able to maintain the mitigation established before that date, but it is unclear how, or if, mitigation can be established after the program sunsets.

Summary

The City's groundwater rights appear to be reasonably reliable at present. The City's ability to increase its appropriation of groundwater, however, will be limited by its ability to obtain additional mitigation credits and the need for additional groundwater production capacity. The City's surface water Certificate 85526 is the most senior water right on Tumalo Creek and, accordingly, is highly reliable. The City's remaining surface water rights typically are regulated according to the watermaster's distribution schedule and the City is not able to divert the maximum rate authorized by its water rights. Currently, the City's surface water supply is vulnerable to water quality concerns.

System Description

OAR 690-086-0140(8)

The City operates a public drinking water system (Public Water System Identification Number 4100100) that supplies water to its customers from both surface and groundwater sources. **Exhibit 2-23** provides a schematic of the City's existing distribution system. **Exhibit 2-24** provides a schematic of the City's existing surface water diversion and conveyance system in the Tumalo Creek watershed. The surface water supply originates from Tumalo Creek and Bridge Creek, approximately 12 miles west of the City at the Bridge Creek Intake Facility. Tumalo Creek water is conveyed through two parallel transfer pipes to a canal flowing to Bridge Creek. The water is diverted at the Bridge Creek Intake Facility and the raw water is conveyed approximately 11.5 miles via two parallel pipes to the City's Outback site. The water is disinfected at the Outback site with the addition of chlorine and then flows through the CT Basin and Outback Reservoir 1. Four finished water transmission pipes transmit water from the Outback site to the City's distribution system. The groundwater supply originates from 21 existing wells associated with water rights.

The City's distribution system is comprised of 423 miles of pipe, 15 storage reservoirs, and 6 pump stations as well as associated appurtenances such as control valves, pressure reducing valves, isolation valves, meters, and fire hydrants. The system has nine primary pressure zones serving customers ranging in elevation from approximately 3,430 to 4,160 feet above mean sea level. Summaries of the pipelines, reservoirs, wells, and pump stations are presented in **Exhibits 2-25, 2-26, 2-27, and 2-28**, respectively.

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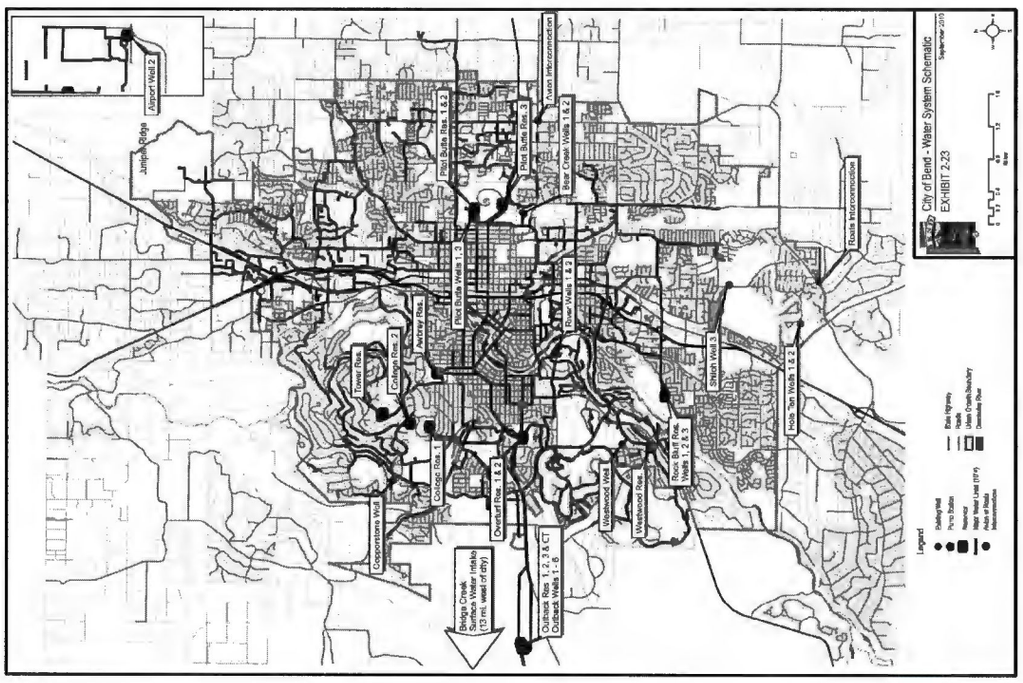
City of Bend - Water System Schematic
EXHIBIT 2-23
Legend
Airport Well 2
Juniper Ridge
Pilot Butte Res. 1 & 2
Pilot Butte Res. 3
Avion Interconnection
Bear Creek Wells 1 & 2
Pilot Butte Wells 1, 3
Airbrey Res.
Tower Res.
Cottage Res. 2
Cottage Res. 1
Copperstone Well
Overturf Res. 1 & 2
Bridge Creek Surface Water Intake (13 mi. west of city)
Outback Res. 1, 2, 3 & CT
Outback Wells 1 - 6
Westwood Well
Westwood Res.
Rock Bluff Res. Wells 1, 2 & 3
Shiloh Well 3
Hole Ten Wells 1 & 2
Roats Interconnection

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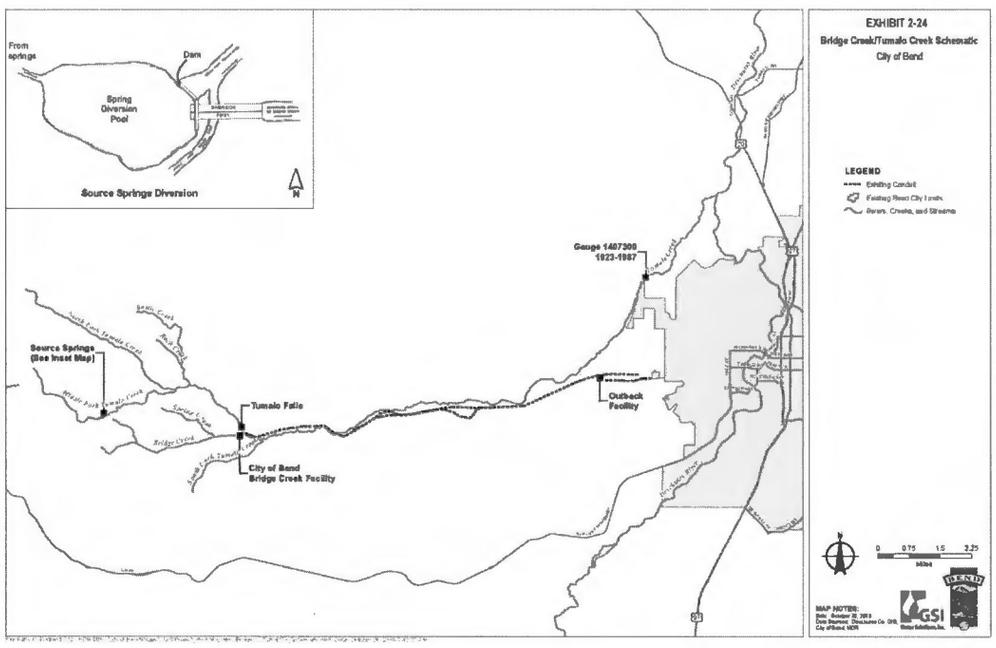
From springs
Dam
Spring Diversion Pool
Source Springs Diversion
N
Gauge 1407300 1923-1987
Source Springs (See Inset Map)
Tumalo Falls
City of Bend Bridge Creek Facility
Outback Facility
EXHIBIT 2-24
Bridge Creek/Tumalo Creek Schematic
City of Bend
LEGEND
Existing Conduit
Existing/Road City Limits
Rivers, Creeks, and Streams
0 0.75 1.5 2.25
Miles
MAP NOTES:
GSI

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EXHIBIT 2-25
Summary of Pipeline Sizes

Pipe Diameter (in)	Total Length (mi)	Percent of Total Pipeline
2	6	1.4%
4	5	1.1%
6	68	16.0%
8	188	44.3%
10	32	7.6%
12	79	18.7%
14	2	0.4%
16	34	8.1%
18	3	0.6%
24	3	0.7%
30	2	0.6%
36	3	0.6%
Total	**423**	**100%**

EXHIBIT 2-26
Summary of Reservoirs

Name	Volume (MG)	Elevation (ft)	Max Height (ft)
Awbrey	5.0	3,775	20.5
College 1	0.5	4,095.8	23.3
College 2	1.0	4,087.9	31.5
Outback 1	2.0	3,976	40.1
Outback 2	3.0	3,976	35.4
Outback 3	3.6	3,982	29.4
Outback Contact Basin	1.5	3,980	31
Overturf East	1.5	3,844	28
Overturf West	1.5	3,844	28
Pilot Butte 1	1.5	3,750	31.5
Pilot Butte 2	1.0	3,840.5	39.5
Pilot Butte 3	5.0	3,757.3	24.3
Rock Bluff 1	1.5	3,840	39
Tower Rock	1.0	4,213	31
Westwood	0.5	3,842	28

EXHIBIT 2-27
Summary of Existing Wells Associated with Water Rights for Bend's Municipal System

Well Description	Current Operational Capacity (gpm)
Bear Creek Well 1	1,050
Bear Creek Well 2	1,150
Copperstone Well	1,050
Hole Ten 1	800
Hole Ten 2	800
Outback Well 1	650
Outback Well 2	650
Outback Well 3	1,200
Outback Well 4	1,300
Outback Well 5	1,000
Outback Well 6	1,250
Pilot Butte Well 1	900
Pilot Butte Well 3	900
River Well 1	1,900
River Well 2	2,200
Shiloh Well 3	1,300
Airport Well 2[1]	285
Rock Bluff Well 1	750
Rock Bluff Well 2	700
Rock Bluff Well 3	900
Westwood Well	600

[1] Although Airport Well 2 is included in Certificate 85414 and this exhibit, this well is now used exclusively for fire flow events only as a backup to the wholesale water supply from Avion Water Company. The well does not provide water to the City's municipal water supply system.

EXHIBIT 2-28
Summary of Existing Pump Stations

Pump Description	Flow Rate* (gpm)	Total Capacity (gpm)	Firm Capacity (gpm)**
Awbrey Pump 1	950	3,490	2,150
Awbrey Pump 2	1,340		
Awbrey Pump 3	1,200		
College Pump 1	1,050	1,950	900
College Pump 2	900		
Murphy Road Pump 1	300	1,500	1,200
Murphy Road Pump 2	300		
Murphy Road Pump 3	300		
Murphy Road Pump 4	300		
Murphy Road Pump 5	300		
Scott Street Booster Pump 1	530	1,590	1,060
Scott Street Booster Pump 2	530		
Scott Street Booster Pump 3	530		
Tetherow Pump 1	150	3,650	2,950
Tetherow Pump 2	700		
Tetherow Pump 3	700		
Tetherow Pump 4	700		
Tetherow Pump 5	700		
Tetherow Pump 6	700		
Westwood Pump 1	390	2,390	1,490
Westwood Pump 2***	550		
Westwood Pump 3	900		
Westwood Pump 4	550		
* Flow rates indicate typical flow rates based on available SCADA data and model results if available to the nearest 50 gallons otherwise they are based on pump curves which may or may not be accurate.			
** Firm capacity is defined as the total installed capacity remaining with the largest pump at a facility out of service.			
*** Flow includes some recirculation through the Westwood Reservoir and pump station.			

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3. Municipal Water Conservation Element

This section addresses the requirements of OAR 690-086-0150(1) – (6).

This rule requires a progress report on conservation measures in the City's existing Plan, and a description of any additional conservation measures. The rule also requires descriptions of specific required conservation measures and benchmarks.

Current Conservation Measures

OAR 690-086-0150(1) and (3)

The City submitted a WMCP in 2004 that was approved by the OWRD on February 28, 2005 (Special Order Vol. 63, Pg. 279). **Exhibit 3-1** shows the required and additional conservation measured required by OAR 690-086-0150(4)-(6) that were included in the previously approved WMCP. Exhibit 3-1 also provides a progress report for each conservation measure.

EXHIBIT 3-1
City of Bend Previously Approved 5-year Benchmarks

Conservation Measure	2004 5-year Benchmark	Progress Report
System metering	• Fully meter Juniper Utility customers.	• System is fully metered. • All hydrant use within the Bend service area requires metering.
Meter testing and maintenance	• Periodic verification of all commercial meters exceeding 3-inch size. • Replace all small meters on a rolling 15- to 20-year cycle, or as needed based on billing data indicating inaccuracies. • Periodic verification of all source meters.	• The City is testing and rebuilding all meters that exceed 2 inches. Each of these meters is checked and calibrated every 2 years or checked through computer analysis of customer usage each month. • Small meters are replaced on a 15- to 20- year cycle, or as needed. • Several source meters have been replaced or upgraded.
Annual water audit	• Perform water audit accounting for uses and potential losses of water.	• The City approximated water produced vs. water sold in the recent Optimatics study (2010).
Leak detection and pipeline repair or replacement	• Periodic leak detection surveys—at least 10 miles of water mains. • Provide brochure to customers on using meters for leak detection; and distribute toilet tank leak detection dye tablets.	• Leak detection surveys have occurred for 45-50 miles of water mains since 2004. • The City distributed toilet leak tablets to more than 2,500 customers per year during the past few years.

Conservation Measure	2004 5-year Benchmark	Progress Report
	• Perform flow audit calculations to verify inflows match outflow, for each Bridge Creek transmission line.	• A flow audit on Bridge Creek transmission lines occurred in 2009 and the City installed a new master meter at the end of the line.
Rate structure and billing practices	• Continue to expand and refine water use data collection and analysis, and expand breakdown of customer classes.	• Customer classes and service coding remain to be reorganized and updated pending a software analysis and establishment of a process to replace antiquated utility billing software and related accounting modules.
	• City Council to decide on whether/how to modify rate structure.	• At the beginning 2008, the City Council decided to reduce the quantity allowance for metered customers from 6 ccf to 4 ccf. Customers pay a volume-based rate for monthly water use exceeding the allowance.
	• Continue to utilize customer bills to communicate water conservation messages and incentive programs.	• The City continues to provide information to the public with bill stuffers and new e-mail alerts. WaterWise is mentioned in almost every bill stuffer (monthly) and alert with at least one key message about water efficiency and conservation.
Technical and financial assistance programs	• Review even-odd day irrigation restrictions.	• Even-odd irrigation restrictions and time of day water restrictions are still in place awaiting optimization and engineering analysis to better understand potential peak day effects.
	• City-managed Greenwood Cemetery: install a Maxicom irrigation control system.	• The City completed a total retrofit of Greenwood and Pilot Butte Cemeteries. It installed smart irrigation controller timers, replaced sprinkler heads, and updated system piping.
	• City Landscape Retrofit Project: Budget for replacement of the landscape irrigation system at one site per year.	• The City Landscape Retrofit Project resulted in completion of at least 14 retrofits. A total of 66 City landscape sites are now retrofitted with smart irrigation controllers.
	• City Landscape sites: Complete maintenance and management plan.	• The City completed 136 maintenance and management plans for City landscape sites.
	• Bend-La Pine School District Irrigation Agreement: Partner with school districts to provide technical assistance to implement weather-based watering control at all new and existing sites.	• The City is providing technical assistance to the Bend-La Pine School District to fully meter sites, move off of irrigation district water, and upgrade and retrofit its irrigation systems.

Conservation Measure	2004 5-year Benchmark	Progress Report
	• Oregon State Parks Irrigation Agreement: At Pilot Butte State Park, City to provide technical assistance to implement weather-based watering control and operation of irrigation system.	• The Oregon State Parks Irrigation Agreement recently expired, but the State is still using the smart irrigation controller system at the park and incorporating native landscape design to decrease irrigation demand.
	• Water audits for selected large customers. Audits of turf fields will be completed as part of partnership described above.	• Water audits of large use customers were discontinued because of staffing, budget, coordination, and prioritization issues. However, the City still funded the Irrigation Association to provide training for Certified Landscape Irrigation Auditors and audited two schools in the Bend-La Pine School District.
	• Irrigation audits will also become part of standard contracts for City-funded irrigation improvement projects. Contracts will include performance standards and correction actions.	• Water auditing of City contracts decreased because of staffing, budget, coordination, and prioritization issues. The City's specifications and standards currently are being upgraded, and they still need to be included in City contracts.
	• Continue to expand water partnerships using weather-based irrigation technology including new large landscape partners.	• The City created WaterWise partnerships to install smart irrigation controllers with large use customers, but drastically scaled back the program in 2005 to address only a few cases.
Retrofit /replacement assistance	• Toilet retrofit program feasibility survey.	• The City decided not to conduct the survey because of staffing and budget limitations.
Water reuse, recycling, and non-potable water opportunities	• Perform a feasibility study of delivery of Level 4 effluent to irrigation canal system, with attendant exchange of water rights. Will be done in conjunction with ongoing discussion of water supply options between City and regional irrigation districts.	• The City completed a scope of work for the feasibility study in July 2010.

Additional Conservation Measures

OAR 690-086-0150(3)

In addition to the above-described conservation measures, the City has implemented the following conservation measures.

- The City's water utility and related "WaterWise" programs have become more integrated with other water-related utilities, such as stormwater and water reclamation.
- Significant efforts have been made to increase regional recognition that conservation is ongoing and important through participation in the Central Oregon Cities Organization, Bend 2030 process, and the Deschutes Water Alliance and its related work plans.
- The City maintains a display in the main lobby area at City Hall related to water use during the irrigation season.
- Since 2006, the City has distributed an estimated 1,500 shower timers to save water and energy.
- The City implemented a hydrant meter program. Permanent water fill stations and portable "card lock," accessed units attached to fire hydrant ports for use by contractors, were installed for construction and water hauling use. This program stopped unauthorized construction use.

Use and Reporting Program

OAR 690-086-0150(2)

The City has a water use measurement and reporting program that complies with the measurement standards in OAR Chapter 690, Division 85. The City's water use records can be found on the OWRD Web site (http://apps.wrd.state.or.us/apps/wr/wateruse.) The City currently measures surface water entering the distribution system at its Outback facility, and records surface water use daily. The City measures groundwater entering the distribution system at its pumps using meters and the SCADA system, and records groundwater use monthly.

Required Conservation Programs

OAR 690-086-0150(4)

OAR 690-086-0150(4) requires that all water suppliers establish 5-year benchmarks for implementing the following required conservation measures:

- Annual water audit
- System-wide metering
- Meter testing and maintenance
- Unit-based billing program
- Leak detection and repair (if system leakage exceeds 10 percent)
- Public education

5-year Benchmarks for Required Existing or Expanded Conservation Measures

The City currently addresses all of the required conservation measures. A summary of the 5-year benchmarks for required and additional conservation measures is provided below. During the next 5 years, the City plans to implement the following conservation measures required of all municipalities:

1. **Annual water audits.** A water audit involves an accounting of all water entering and leaving the water distribution system to identify system leakage, as well as authorized or unauthorized water uses. The City conducted basic water audits in the past, but these audits were difficult because the City was not fully metered, it did not closely track non-revenue water, and its customer classes and service codes needed to be revised because of inaccuracies. The City is working to remove these obstacles to its ability to conduct meaningful water audits. For example, the City does not have a system to track unbilled authorized consumption and its billing by customer class is unreliable. To address these issues, the City has established the following benchmarks.

   5-year Benchmarks:

   - The City will develop and implement an annual water audit program within the next 5 years. As part of this effort, the City will develop a method to calculate and track unbilled authorized consumption, which may include development of additional measurement methodology, to more accurately determine revenue and non-revenue water.
   - The City also will reorganize and update customer classes and service codes, as well as work toward equipping all water meters with automated metering infrastructure (AMI) meters.

2. **System-wide metering.** The City's water system became fully metered in December 2004. In addition, all hydrant use within the Bend service area now requires metering, resulting in better tracking of non-fire-related hydrant water use.

5-year Benchmark:

- The City will continue to install meters at all new service connections.

3. **Meter testing and maintenance.** The City is testing and rebuilding all meters that exceed 2 inches. Each of these meters is checked and calibrated every 2 years or checked through computer analysis of customer usage each month. The City tests meters if requested by customers, and if the tested meter is found to be 3 percent above or below the proper reading, the meter is replaced.

   Most residential meters are relatively new because of recent efforts to meter all residences. The City also is working to update its meters and expects to install 12,500 AMI meters by December 2010. Residential meters typically are replaced on a 15- to 20-year basis in accordance with AWWA guidelines. The City is eliminating the 5/8 x ¾ inch meter so that base meters for residential units will be ¾ inch.

   In 2008, the City installed a new master meter at the end of the Bridge Creek transmission line to measure the amount of surface water that it conveys into the distribution system.

   Source meters are verified when reservoirs are drained and filled each year, and their accuracy is verified using flow rates, pump curve data, and fill rates. Another verification of source meter accuracy occurs indirectly with daily chlorine testing throughout the system. Chlorine disinfection calculations rely on source meter accuracy; chlorination can stop or be reduced if a source meter fails or reads incorrectly. Inlet chlorine analyzer alarms are triggered by reduced chlorination levels, which notify on-call staff to address the problem. Several source meters have been replaced or upgraded within the past 5 years, but these new meters did not include the most advanced technology. However, the City now has a better understanding of the new technology available for metering, accordingly as certain wellfields are upgraded and refined, replacement meters will use improved technology and measure water use more accurately.

   5-year Benchmarks:

   - The City will continue to replace all existing meters with the new AMI standard within the next 5 years.
   - The City will use improved technology when upgrading or replacing existing source meters during the next 5 years.

4. **Unit-based billing program.** The City's customers are billed on the basis of the quantity of water use metered and a base fee. Customers pay a base fee according to meter size, which includes a quantity allowance of up to 4 ccf (ccf = 100 cubic feet). Customers also pay a per ccf unit rate for their monthly water use exceeding 4 ccf.

   In July 2008, the City Council decided to reduce the base quantity allowance for metered customers from 6 ccf to 4 ccf. At the same meeting, City staff also proposed a tiered rate structure, based on recommendations from the City's Water Rate Community Advisory

Committee. The City Council decided not to adopt this rate structure because of numerous concerns.

5-year Benchmarks:

- The City will continue to bill customers based, in part, on the quantity of water metered.
- The City intends to reduce the base quantity allowance from 4 ccf to zero ccf within the next 5 years.

5. **Leak detection and repair.** The City's average non-revenue water in 2008-2009 was 7 percent. Therefore, system leakage did not exceed 7 percent. Although the OWRD requires a leak detection and repair program only when leakage exceeds 10 percent, the City has a program to repair and replace water mains that leak.

   Most of the distribution system water mains are relatively new ductile iron pipe with low potential for excessive leakage that were put in place during the City's recent period of rapid growth. Since 2004, City staff and contractors have conducted leak detection surveys of 45 to 50 miles of water mains. During 2005-2006, contractors conducting leak detection surveys found no sizable leaks, but did discover and repair two meters with small leaks. City staff have conducted leak detection using in-house electronic equipment and tested for leaks during valve and hydrant maintenance activities. In February 2009, the City tested the Bridge Creek transmission line for leakage. The City also works cooperatively with customers when leaks are discovered on the customer side of the meter, typically in the older galvanized service lines.

   5-year Benchmarks:

   - The City will continue to conduct leak detection surveys to monitor changes in pipe integrity over time.
   - The City will continue to monitor customer consumption records for evidence of leaks and to work cooperatively with customers when leaks are discovered.
   - The City will install AMI data technology at all of its meters, which will record hourly consumption and radio transmit that information to the City. This "real-time" information will help the City find and address leaks in the system on the customer side of the meter.

6. **Public education.** The City provides water conservation information through numerous media and programs.

   Web site. The City as a whole has been working to upgrade its Web site and to continuously update the online information. The Water Division Web site includes information on billing, lawn and garden irrigation regulations, water service and billing, water meters, forms and documents related to water use, water system master plans, and links to the WaterWise Web site that addresses water conservation. The same upgrading and updating

work has been occurring with the City's WaterWise Web site (www.waterwisetips.org), which focuses on water conservation. The WaterWise Web site includes information on indoor water use, xeriscaping, rain gardens, and landscape watering. Publications have been continuously added to the Web sites and links have been changed regularly, added, or dropped as part of Web site management.

Public Outreach Through Events. The City sponsored or participated in at least four events per year during the last 5 years. Staffed events included: school events, various summer fairs, and outdoor events throughout the spring summer and fall. Water conservation materials provided to the public at these events have included publications, shower timers, and toilet leak detection tablets. Public speaking event requests vary each year. In addition, the City has sponsored or participated in school events and tours, but classroom visits and outreach at other events have been reduced because of staffing issues. Total contacts are estimated at 1,500 customers per year, based on literature taken by customers.

Furthermore, the City is increasing regional recognition that conservation is a priority by participating in the Central Oregon Cities Organization, Bend 2030 process, and the Deschutes Water Alliance.

Public Outreach Publications and Media. The City continues to provide information to the public using fact sheets, publications, its Web site, bill stuffers, City Edition Videos, and related outreach in partnership with the City Communications Manager. However, the creation of new or updated outreach materials has been significantly downscaled because of budget, staffing, and project priority changes.

The City continues to focus its water conservation outreach efforts on outdoor uses. The City maintains a display in the main lobby area at City Hall related to water use during the irrigation season. The City also developed an outdoor-oriented packet for its customers that includes WaterWise program handouts and rain gauges.

WaterWise Program. The City had to significantly reduce the WaterWise Program in 2005. This resulted in cuts in program staffing. The 2010 fiscal year budget re-established a new position at the program manager level to manage the City's water conservation benchmarks and to help develop, implement, and track related projects.

Customer Field Representative. The City discontinued the Customer Field Representative position in 2005 because of budget and management decisions. This position enforced the even-odd day watering restrictions and time-of-day watering restrictions, as well as addressed violations for wasting water. This work was based on drive-by monitoring and complaints to the City.

5-year Benchmarks:

- The City will continue to provide water efficiency and conservation outreach information to the public using print materials, radio, and video.
- The City will continue to update its Web site and outreach materials as needed.
- The City will explore the potential for development of cost-share partnerships between the City's three water utilities: water, stormwater, and wastewater. The

water and stormwater utilities have the potential to jointly hire an employee that can serve both programs.

Expanded Use under Extended Permits

OAR 690-086-0150(5)

This rule applies to municipal water suppliers that propose to expand or initiate diversion of water under an extended permit with a resource issue. The City has an extended permit (Permit G-8565), but this permit does not have resource issues as defined under 690-086-0140(5)(i). Furthermore, the City's average non-revenue water in 2008-2009 was 7 percent, and consequently, its system leakage is less than the 15 percent target specified by this rule. Nonetheless, the City has a leak detection and repair program under which City staff and contractors have conducted leak detection surveys of 45 to 50 miles of water mains since 2004.

Expanded Use under Extended Permits

OAR 690-086-0150(6)

Under OAR 690-086-0150(6), a water provider that serves a population greater than 7,500 must establish 5-year benchmarks for implementing a number of listed conservation measures or document that the measures are neither feasible nor appropriate. A summary of the 5-year benchmarks for additional conservation measures is provided in this section.

5-Year Benchmarks for Additional Conservation Measures

1. **Leak detection and pipeline repair and replacement.** The City's average non-revenue water in 2008-2009 was 7 percent. Therefore, system leakage does not exceed 10 percent. Although the OWRD only requires a leak detection and repair program to reduce leakage to 15 percent, or if feasible to 10 percent, the City has a program to repair and replace water mains that leak. The City's program is detailed in Leak Detection and Repair under OAR 690-086-0150(4).

   5-year Benchmark: As stated in Leak Detection and Repair under OAR 690-086-0150(4), the City will continue to conduct leak detection surveys to monitor changes in pipe integrity over time. The City will continue to monitor customer consumption records for evidence of leaks.

2. **Technical and financial assistance.** The City's technical and financial assistance program has had three components: large landscape program partnerships, large customer water audits, and indoor water use, which includes toilet tank leak detection and shower timers. Each of these previously used components and their related activities and accomplishments during the previous planning period is described in detail below.

City of Bend Large Landscape Program Partnerships
The City has developed partnerships with customers that have large landscapes requiring irrigation to help them improve their water conservation. The City helps these partners by providing technical and financial assistance in a variety of formats.

Bend Metro Parks & Recreation District
The City partnered with the Bend Metro Parks & Recreation District on various water conservation efforts. The City provided support to the district and included the district in its efforts to continue to move toward full use of new smart irrigation technologies.

Bend-La Pine School District
The City provided technical assistance to the Bend-La Pine School District to help fully upgrade and retrofit the district's irrigation systems after completion of a partial system audit. The City also provided technical assistance with development of new landscape standards and practices that the district recently adopted. When the district passed a recent bond levy, it used the new information to retrofit all major landscapes within the district.

Northwest Crossing Development, Palmer Homes
Like the Bend-La Pine School District, the Northwest Crossing development and Palmer Homes have adopted irrigation efficiency standards, such as the installation of smart irrigation controllers, use of pressure compensating irrigation sprinkler heads, and proper design and layout. These entities also advertised the use of smart irrigation controllers and efficient landscapes in their marketing materials. This included education efforts with preferred contractors and licensed landscapers doing work for their projects.

Oregon State Parks: Pilot Butte State Park
Through a now-expired agreement to deliver water to a large turf area at Pilot Butte State Park, the City was able to educate state staff and complete the first installation of a smart irrigation controller. The City provided Pilot Butte State Park with technical assistance and the required design standard information to implement use of the smart irrigation controller system at the park.

Water Audits for Large Use Customers
Water audits analyze a customer's water use and identify ways to make water use more efficient. The City funded the Irrigation Association to provide training for Certified Landscape Irrigation Auditors and more than 30 landscape professionals participated. The City invested approximately $5,000 on audit of sites at two schools in the Bend-La Pine School District. The district adopted some of the recommendations, including the use of smart irrigation controllers, proper nozzles, and head-to-head coverage. In addition, the schools now consider system zoning and pressure, have improved soil preparation, and use different turf varieties.

However, the City and water conservation studies[4] have found that audits generally were not cost-effective because customers are reluctant to pay for the audits or recommended improvements. As a result, the expense did not materialize into actual water savings.

Indoor Water Use
The Indoor Water Use component of the City's technical and financial assistance program has two components: toilet tank leak detection dye tablets and shower timers.

Toilet Tank Leak Detection Dye Tablets
To decrease leaks that occur on customer premises, the City distributes toilet tank leak detection dye tablets. The City has distributed toilet leak tablets to more than 2,500 customers per year during the past few years.

Shower Timers
Shower timers are small plastic devices that have a 5-minute sand-filled timer mounted to a rotating base. They are designed to adhere to the wall inside a shower using the attached suction cup and are rotated to start and restart the timer. The goal is to reduce both water and energy use by making shower users aware of their time in the shower. The City distributed more than 1,500 timers at schools and public events, and in the display booth set up in City Hall. Timers are also available by phone and e-mail request.

5-year Benchmarks:

- The City will continue efforts to develop and maintain WaterWise partnerships with large use customers during the next 5 years.
- The City will continue to distribute toilet tank leak detection dye tablets, shower timers, and related information to customers during the next 5 years.
- The City will conduct cost analysis aimed at the creation of cost-effective rebate programs within the next 5 years.
- The City will develop a pilot program for creation of water budgets for targeted customer groups, based on evapotranspiration data.
- The City will continue to fund and promote the use by all customers of the Agrimet weather station and its Web site, including a pilot project to place real time evapotranspiration data on the City Web site for use in creation of outdoor water use budgets.

3. Retrofit/replacement of inefficient fixtures.

City of Bend Landscapes
The City manages and maintains 136 landscape sites covering 439 acres, many of which require irrigation, and maintenance and management plans have been completed for all of

[4] HDR Technical Memorandum, *Conservation Program for Water Management and Conservation Plan,* December 8, 2010.

these landscape sites. Of these 136 landscape sites, 66 sites have been retrofitted with smart irrigation controllers. The City recently retrofitted 14 of those 66 sites as part of the City Landscape Retrofit Project. The sites of the 14 retrofits had their irrigation systems and/or landscapes altered or completely rebuilt to decrease maintenance and meet irrigation water savings goals, which often included reducing the area irrigated and xeriscaping. The City also completed a total retrofit of two cemeteries, including Greenwood and Pilot Butte Cemeteries. It replaced the original irrigation system with smart irrigation controlled timers and replacing sprinkler heads and related piping.

Toilet Efficiency
Many homes and business in the City were built before the federal high efficiency toilet (HET) standard of 1.6 gallons per flush was put in place in 1994. As a result, the need for a special program addressing toilet efficiency is reduced. The City considered conducting a retrofit program feasibility survey, but this did not occur because of staffing and budget limitations.

5-year Benchmarks:

- The City will continue to pursue greater irrigation efficiency of its existing City-owned landscapes and all new landscapes so they will meet the latest specification and standards, which includes the use of smart irrigation controller technology, xeriscaping principles, and other sustainable landscape practices.
- The City will study the cost effectiveness of implementing a toilet rebate replacement or incentive program based on the new voluntary federal HET standard.
- The City will become an EPA Water Sense Program partner and make related information available through its Web links, bill stuffers, and other methods.
- The City will provide a list of qualifying toilets that meet the various flush standards along with the creation of a toilet efficiency fact sheet.

4. **Water rate structure and billing schedule.** The City's water rate structure is related in part to its customers' water use. Customers pay a monthly base charge, which currently is based on meter size and includes a quantity allowance of 4 ccf before the quantity rate applies. Customers also pay a per unit rate for monthly water use exceeding 4 ccf.

   The City sends monthly bills to customers and supports water conservation by providing customers timely information about their water consumption. The City also includes water efficiency and conservation information with the bills. WaterWise is mentioned in almost every bill stuffer and content emphasizes at least one key message about water efficiency and conservation.

   5-year Benchmarks:

   - As stated in Unit-based Billing Program under OAR 690-086-0150(4), the City will continue to bill customers based, in part, on the quantity of water metered.
   - The City also will continue to send monthly bills and to provide water efficiency and conservation information to the public with periodic bill stuffers and electronic

messaging with related conservation information and links to the City's conservation Web site.

5. **Reuse, recycling, and non-potable water opportunities.** The Resort at Pronghorn, located down-gradient of the wastewater treatment plant, obtains recycled water from the City. Level 4 treated effluent from the wastewater treatment plant enters infiltration ponds and a spray irrigation system that waters two golf courses during the irrigation season. The City recently renewed its Water Pollution Control Facility permit with the DEQ that allows recycling of that City water. Pronghorn is not within the City's existing drinking water service area.

   In July 2010, the City completed a scope of work for a full-scale feasibility study that will investigate increasing the use of recycled water both inside and outside the City's service area.

   5-year Benchmark: During the next 5 years, the City will continue to look for opportunities to increase the use of recycled water.

6. **Other measures.**

   Irrigation Restrictions
   The City currently has even-odd irrigation restrictions and time of day water restrictions in place. Even house numbers water on even-numbered days and odd house numbers water on odd-numbered days. Irrigation hours are 5 a.m. to 10 a.m. and 4 p.m. to 10 p.m. No watering is allowed on the 31st day of the month. For a period of time, these policies were waived if someone installed an approved smart irrigation controller. These policies were put in place many years ago when the City used a flat rate water billing system and were designed to keep reservoirs from being drained by unlimited water use.

   Code changes are now under consideration in the next fiscal year and may include a recommendation to move away from the even-odd day irrigation restriction system, which is not currently enforced. The City would like to move exclusively to a time-of-day restriction that aims to provide an enforceable program that incentivizes smart water use, as well as off-peak irrigation time periods, to prevent or reduce the need for costly engineering improvements necessary to meet maximum demands in the morning and evening peaking periods.

   5-year Benchmark: Within the next 5 years, the City will evaluate adoption of modified irrigation restrictions based on time of day (hours that promote efficient water use).

   City Standards and Specifications
   The City recognizes that conservation and water efficiency standards need to be included in City contracts with landscaping and irrigation work, so the City currently is upgrading its related standards and specifications. The City also created a landscape standard, which is explained in an article in Water Efficiency Magazine called "There is no Silver Bullet" (available on the City's Web site).

   5-year Benchmark: The City will continue to implement current landscape standards through related approval processes during the next 5 years.

Other WaterWise Partnerships

The City has also partnered on water conservation-related efforts with: Oregon Department of Energy, Local Area Water Network, Palmer Homes, Earth Advantage, High Desert Green Industry Conference, Upper Deschutes Watershed Council, AWWA, Building Green Council and 3E Strategies, Central Oregon Builders Association, ReSource, Rebuild America, Oregon State University (OSU) Extension, Central Oregon Community College (COCC), Bend Garbage and Deschutes County, Oregon Landscape Contractors Association, irrigation districts, Central Oregon Cities Organization, Deschutes Coordination Group, Deschutes River Conservancy, Oregon Association of Water Utilities, and Oregon Water Utility Council. While the City has created successful partnerships, the City's WaterWise program was drastically scaled back in 2005 to address only a few cases, such that an emphasis on building partnerships needs to be re-incorporated into the WaterWise campaign efforts.

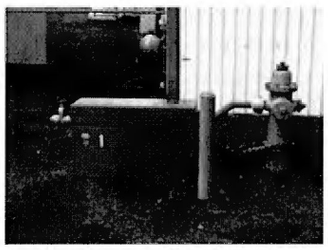
5-year Benchmark: The City will continue to seek appropriate partnership opportunities based on current project priorities, budget, and staff time.

Collaboration Among the City's Water Utility Programs

The City has three water-related utilities (water utility, water reclamation, and stormwater programs) and several areas of regulatory responsibilities that are related to more efficient use of water and the benefits of conservation. The City has implemented a communication effort encompassing all of these areas and has promoted it as "WaterWise" programs. Collaborations include exploring how to combine funds from different programs to hire staff and present information on stormwater, safe drinking water, water conservation, and industrial pretreatment programs within the homepage of the City's WaterWise Web site and related efforts.

5-year Benchmark: The City will continue to look for coordination opportunities to more efficiently communicate and implement related programs.

Hydrant Meter Program for Temporary and Permanent Water Uses



Use of drinking water through typical unmetered locations, such as fire hydrants, for construction and other public uses, now comes under the authority of the Hydrant Meter Program. Use of hydrants now requires a permit and use of a temporary metered fill station that also includes backflow protection. All water is measured and billed. In addition, the City has installed one permanent fill station that has the added feature of a card-lock billing system to address the use of multiple users at one location. Contractors have the option of bringing their own water trucks to the fill stations to fill up with water as needed, or using the hydrant meter boxes.

5-year Benchmark: The City will continue to implement the hydrant meter program and related fill station.

Review and Implementation of Water Conservation Analysis Project
In December 2010, HDR Engineering (HDR) completed a water conservation analysis project for the City to examine opportunities to enhance its existing water conservation program. HDR is a national architectural, engineering, and consulting firm with strong expertise in water utility planning, including water conservation planning, and has performed water conservation work for numerous Pacific Northwest utilities. HDR used its proprietary Water Conservation Measure Analysis Model to analyze conservation opportunities for the City. The model is an Excel-based tool that estimates water savings and costs for various pre-loaded conservation measures based on specific information about the municipality. HDR's Water Conservation Opportunities memorandum, which is provided in **Appendix B**, presents more detailed information about HDR's modeling process and results.

HDR compiled demographic information for the City's service area, applied assumptions for customer participation rates for each conservation measure, calculated the savings achieved by shifting to more efficient hardware or behavior, and calculated the direct costs for those shifts. HDR established customer participation rates using professional judgment based on its experience with other communities.

HDR developed four "conservation packages." These packages included: (1) a conservation potential assessment of 37 of the 49 analyzed measures that were not mutually exclusive, which included both behavioral and "hardware" based measures; (2) hardware measures for both indoor and outdoor water conservation; (3) hardware measures for outdoor water conservation only; and (4) hardware measures for indoor conservation only.

5-year Benchmark: During the next 5 years, the City will work with the City Council and the City's Engineering Department to develop capital improvement and conservation budgets to identify which conservation measures to fund and implement.

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4. Municipal Water Curtailment Element

This section satisfies the requirements of OAR 690-086-0160.

This rule requires a description of past supply deficiencies and current capacity limitation. It also requires inclusion of stages of alert and the associated triggers and curtailment actions for each stage.

Introduction

Curtailment planning is the development of proactive measures to reduce demand during supply shortages as the result of prolonged drought or system failure from unanticipated events including catastrophic events (flooding, landslides, earthquakes, and contamination), mechanical or electrical equipment failure, or events not under control of the City (for example, localized or area-wide power outages and intentional malevolent acts).

History of System Curtailment Episodes

OAR 690-086-0160(1)

Within the last decade, the City has not experienced water shortages resulting from system failure related to catastrophic events or mechanical or electric equipment failure. The City, however, routinely has experienced a reduction in its access to surface water during the peak-demand season because of reduced stream flows. As described in Section 2, most of the City's surface water rights share priority dates with water rights held by TID and instream water rights established by TID in the allocation of conserved water process, and OWRD regulates these rights according to its distribution schedule when flows in the Tumalo Creek Basin are insufficient to meet all of the existing water demand. In these circumstances, the City has increased its reliance on its groundwater sources. Consequently, the City has not been required to implement curtailment measures.

The City is currently able to use its groundwater rights as needed to meet its water demands. Future groundwater use may be limited by system (well) capacities and groundwater restrictions in the Deschutes Study Area.

The City also has experienced occasional short-duration interruptions to normal service delivery as a result of pipe or water main breaking, lightening striking wells, and other mechanical or electrical malfunctions of its water supply and delivery system. In these events, the City has relied on its unaffected water sources, either surface water or groundwater, during the service interruption.

Curtailment Stages and Event Triggers

OAR 690-086-0160(2) and (3)

Depending on the nature of the event that results in a water supply shortage and considering predecessor and successor conditions, this curtailment plan for the City is designed to be initiated and implemented in progressive stages.

Events causing this curtailment plan to be activated would include, but not be limited to, the following:

- Abnormal weather conditions preceding the peak summer supply season that present a high likelihood for below normal summer streamflows in Bridge and Tumalo Creeks
- Declaration of a drought for Deschutes County by the Governor pursuant to ORS 536.720
- Catastrophic natural disaster that damages individual critical facilities or extensive portions of the City's distribution system
- Mechanical or electrical malfunction of critical pumping facilities at the City's surface water intake or wells
- Interruption of local utility electrical service
- Terrorist act perpetrated on any of the City's critical facilities or storage reservoirs, or contamination of source water

The current major risk to the City's surface water supply is fire within the Tumalo Creek watershed. A fire would elevate turbidity levels in the creek above applicable water quality standards, and preclude the City from using its surface water supply until the water quality improved. The City currently is working to mitigate this risk by developing a water treatment plant which, depending on the design of the system, may enable the City to continue to use surface water during high-turbidity events.

The City's curtailment plan has four distinct stages, each of which is triggered by one or more of the events listed above and is grouped as shown in **Exhibit 4-1**.

EXHIBIT 4-1
Curtailment Stages 1 through 4

Curtailment Stages	Initiating Conditions
Stage 1: **Water Shortage Alert**	• Forecasts of below normal summer streamflows • Forecasts of above normal temperatures • Minor damage to transmission mains or distribution system • Minor mechanical or electrical malfunction at one to three wells
Stage 2: **Mild Water Shortage** **Demand Reduction Target:** **10 percent of MDD**	• Supply capacity is 91 to 100 percent of demand • Mechanical or electrical malfunction at four to seven wells • Extended periods of above normal temperatures or below normal streamflows • Declaration of drought by Governor pursuant to ORS 536.720 • Extensive damage to water supply infrastructure
Stage 3: **Serious Water Shortage** **Demand Reduction Target:** **20 percent of MDD**	• Supply capacity is 81 to 90 percent of demand • Mechanical or electrical malfunction at 8 to 12 wells • Imminent terrorist threat against supply system • Multiple failures to transmission mains or distribution system
Stage 4: **Severe Water Shortage** **Demand Reduction Target:** **40 percent of MDD**	• Supply capacity is less than 81 percent of demand • Loss of utility electrical service to wells • Fire in Bridge Creek watershed or near wells • Contamination of source of supply • Extensive damage to transmission, pumping, or treatment processes caused by natural disaster or any other event • Intentional acts or fire, contamination of source, or any other event resulting in an immediate, sustained deprivation of water supply

Authority

The City Manager is authorized to determine the need for water curtailment and to declare a water curtailment stage. Plan provisions will remain in effect until the City Manager terminates the curtailment requirement. Actions may be applied to the entire system, or only to those water use sectors, or in those geographic areas that are directly affected by any water supply shortage. The City Manager is responsible for execution of the curtailment plan provisions after a water curtailment stage is declared.

Curtailment Plan Implementation and Enforcement

OAR 690-086-0160(4)

Stage 1: Water Shortage Alert

Triggers for Stage 1 include minor damage to the City's distribution system, and minor malfunctions at one to three wells. Stage 1 will activate a program to inform customers of the potential for drought or the need for temporary reductions in consumption because of reasons other than drought. The City Manager will issue a general request for voluntary reductions in water use by all water users. The request will include a summary of the current water situation, the reasons for the requested reductions, and a warning that mandatory cutbacks will be required if voluntary measures do not sufficiently reduce water usage. Stage 1 public information program elements would include the following:

- Contact local media outlets and request that the public be informed about the potential for summer water shortages or temporary interruptions to normal service delivery.
- Post prepared public service announcements, including conservation tips, on the City's Web page.
- Provide notices on water bills or through utility bill inserts.

Stage 2: Mild Water Shortage

Triggers for Stage 2 include supply capacity of 91 to 100 percent of demand, and extensive damage to water supply infrastructure. Stage 2 status will activate a program to reduce nonessential water use. In addition to Stage 1 voluntary measures, Stage 2 elements would include the following:

- Prohibit filling swimming pools and ponds.
- Prohibit washing sidewalks, driveways, and patios.
- Prohibit pressure washing roofs, decks, or home siding unless such uses were contracted before implementation of this curtailment action and are demonstrated to the City Manager's satisfaction to be necessary for painting, repair, remodeling, or reconstruction.
- Prohibit using water for dust control unless it is shown to the City Manager's satisfaction that water used for dust control is needed to meet public health or safety requirements including, but not limited to, abatement of fire or sanitation hazards, or to meet air quality standards mandated by DEQ.
- Encourage customers to refrain from washing cars except at commercial washing establishments that recycle or reuse water.

Stage 3: Moderate Water Shortage

Triggers for Stage 3 include supply capacity of 81 to 90 percent of demand, and multiple failures in the joints of the City's transmission mains. The voluntary measures in Stage 2 become mandatory in Stage 3. In addition to Stage 2 measures, Stage 3 elements would include the following:

- Prohibit washing vehicles except by commercial establishments or fleet washing facilities that recycle the water in their washing process, except where health, safety, and welfare of the public are contingent on frequent vehicle cleaning, such as for garbage trucks, and vehicles that transport food, or otherwise required by law.
- Prohibit water line testing and flushing in connection with construction projects, except for critical water facilities.

Stage 4: Severe Water Shortage

Triggers for Stage 4 include supply capacity of less than 90 percent of demand, and extensive damage to transmission, pumping or treatment processes. In addition to the elements included in Stage 3, the City Manager may impose any other restrictions on water use or activities that may require the need for water supplies. Under Stage 4, all water use, except uses necessary for human consumption and sanitation needs, may be prohibited if necessary.

If the event renders water in the system unsafe to drink, the City will activate appropriate response protocols, notify the local news media to solicit their assistance in notifying customers, and contact law enforcement officials, as appropriate.

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5. Municipal Water Supply Element

This section satisfies the requirements of OAR 690-086-0170.

This rule requires descriptions of the City's current and future service area and population projections, demand projections for 10 and 20 years, and the schedule for when the City expects to fully exercise its water rights. The rule also requires comparison of the City's projected water needs and the available sources of supply, an analysis of alternative sources of water, and a description of required mitigation actions.

Delineation of Service Areas

OAR 690-086-0170(1)

The City's existing water system serves the current UGB and the Tetherow Development, excluding those areas served by Avion and Roats. The areas currently served within the UGB and Tetherow Development, including 294 acres in the Juniper Ridge planned area, were used in calculating the 10-year demand projection for this Plan. The same area, in addition to the remaining 221 acres of the Juniper Ridge planned area, was used to develop the 20-year demand projection for this Plan. The current and future service areas are shown in **Exhibit 5-1.**

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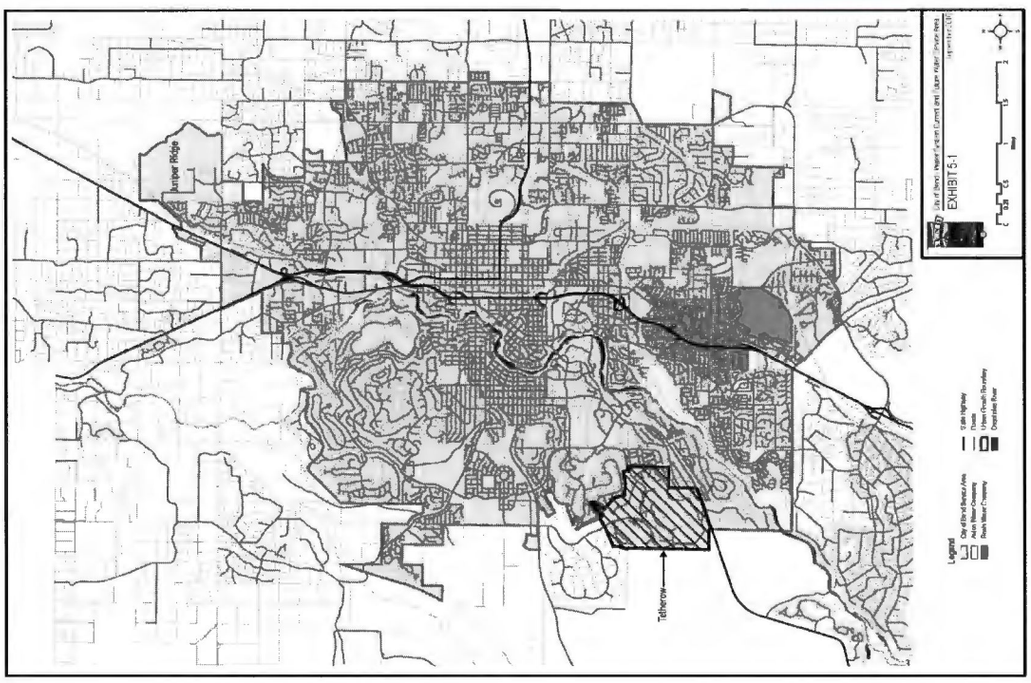
EXHIBIT 5-1
CITY OF BEND CURRENT AND FUTURE SERVICE AREA



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Population Projections

OAR 690-086-0170(1)

The 2004 to 2009 population for the City's water service area was estimated using the method described in Section 2. Future populations (2010 to 2030) within the City's service area were developed by increasing the service area population according to the annual growth rate for the City population as a whole. The annual growth rates for the City were those the City adopted from the Office of Economic Analysis' (OEA) April 2004 average annual growth rates for Deschutes County for 2000 to 2040. OEA bases its population forecast on demographic data, and assumptions about projected age-specific birth and age and sex-specific death rates for the existing population and in-migrants to the state and counties. (These growth rates were included in the *Deschutes County Coordinated Population Forecast 2000-2025.*)

Exhibit 5-2 summarizes the projected populations for 2020 and 2030.

EXHIBIT 5-2
Population Projections for the City of Bend and Bend Water Service Area

	2020	2030
City of Bend	104,501	123,567
Bend Water Service Area	79,748	94,298

These population projections were not used to develop the City's water demand forecasts. As described in detail below, demand forecasts were developed on the basis of projected land use development.

Demand Forecast

OAR 690-086-0170(3)

Future growth and water demand projections were calculated for the 2020 and 2030 planning horizons using growth rates from historical average water production records, as described in more detail below.

The specific spatial and water use data sets used in the development of demand projections for the City include:

- The Buildable Lands Inventory (BLI) database
- Planning and Land Use Information for the Tetherow Development
- Planning and Land Use Information for the Juniper Ridge Development
- 2008 water billing records for the City
- 1998-2008 production data for the City
- 2004 Deschutes County Coordinated Population Forecast

The City's BLI database indicates the total potential for, and spatial distribution of, residential growth based on low, medium, and high development densities; however, it does not indicate when it will occur. It also does not provide information on the density or rate of development for non-residential lands.

Build-out projections were generated for sizing ultimate water system infrastructure requirements as part of the City's Water System Master Plan Update Optimization Study; however, the date at which build-out occurs was not identified. Ten-year projections also were created as part of that project to assist in prioritizing the near-term improvements. To initially generate the 10-year projections, the following assumptions were made:

- Growth would be limited to the current urban growth boundary and Tetherow Development between 2010 and 2020.
- There would be a linear growth rate between 2010 and 2020.
- The BLI data would be used to spatially allocate demand.
- The ratio of residential to non-residential demand would remain constant through 2020.

The annual historic growth rate between 1998 and 2008 was calculated as shown in **Exhibit 5-3**, which illustrates that the City's growth in water demand has been highly variable during the past 10 years. At times, the City experienced rapid growth while at other times, a decline in water demand occurred. Overall, an average growth rate between 1998 and 2008 of more than 4 percent was measured.

EXHIBIT 5-3
Historical ADD and Percent Growth

Year	Historical ADD (mgd)	Annual % Growth
1998	8.6	
1999	10.2	18.60%
2000	10.7	4.90%
2001	10.6	-0.93%
2002	11.5	8.49%
2003	11.4	-0.87%
2004	11.5	0.88%
2005	11.3	-1.74%
2006	11.55	2.21%
2007	12.7	9.96%
2008	12.84	1.10%
Average		**4.3%**

ADD = average day demand

One of the primary challenges that the City faces in projecting future water demand is the lack of a precise service area population. An overall City population number is available; however, as previously described, the City does not serve water to the entire population. Therefore a per capita water usage number is difficult to calculate with certainty.

To calculate future demands using dwelling units identified in the BLI data, a gallons per capita per day per capita (gpcd) number was required. For planning purposes, the City assumes 2.4 people per household. A current per capita water usage was estimated by multiplying the number of active residential meters within the City's service area by 2.4 people per residential household and dividing by current water use for those meters. The per capita usage was calculated to be 172 gpcd, which includes a 10 percent peaking factor for non-revenue water (based on non-revenue water for 2008).

As described in the assumptions above, future non-residential water demand growth also was required. The basic assumption was made that the ratio of residential to non-residential water usage would remain constant through 2020. In 2008, non-residential demand accounted for 4.6 mgd of the 12.84 mgd overall demand in the City's service area, or 36 percent, based on customer billing records. Future non-residential water use rates were calculated at 4,000 gallons per acre per day, by using the existing calculated future non-residential demand divided by the non-residential acres to be developed. The one exception to this is the Juniper Ridge Development, where higher per acre water usage rates (4,500 gallons per acre per day) were used to accommodate the potential opportunity for water-intensive industry to develop there. While it is difficult to predict the water needs of future customers, the City has a duty to serve water within its service area. As a result, the City must be prepared to serve water to large industrial users with high water use needs should such water users locate within its service area.

To calculate the 2020 projections, the historical water demand growth rate of 4.3 percent was used as an overall 10-year target. To identify where the growth in the City is going to occur, the City's BLI data was used. The key was to identify a BLI-based development density that provided a 2020 demand similar to the 4.3 percent system-wide growth rate. For 2020 calculations, 2.4 people times 172 gpcd was multiplied by the number of parcels within the current UGB at medium density. Then the demand for the non-residential areas along with Tetherow Development and Phase 1 of the Juniper Ridge Development were included. The midpoint of demand between the median density developments value and existing demand yielded a spatial distribution of 2020 demand within the service area that was close to the total water demand target based on historical growth. The resulting demand is 21.7 mgd, compared to the 21.3 mgd generated by using a 4.3 percent per year growth rate. This yields a yearly increase in ADD of 0.74 mgd between 2010 and 2020.

Through discussions with City staff, it was determined that projecting the 4.3 percent per year growth through 2030 would generate demand numbers that were too aggressive. Lacking other information on when growth would occur, the 0.74 mgd per year growth through 2030 was determined to be the best available projection. This yields a 2030 ADD of 29.1 mgd, or 3.1 percent growth per year between 2010 and 2030.

Demand Projection Summary

Historical MDD factors also were developed for use in projecting future peak demands. The City's water system is designed so that the sources of supply equal or exceed MDD. Demands in excess of MDD are provided by storage tanks. Factors of 2.25 (MDD/ADD) for MDD were determined from historical data. The 2010, 2020, and 2030 ADD values and peaking factors were used to determine the future MDD projections.

See **Exhibits 5-4 and 5-5** for future ADD and MDD.

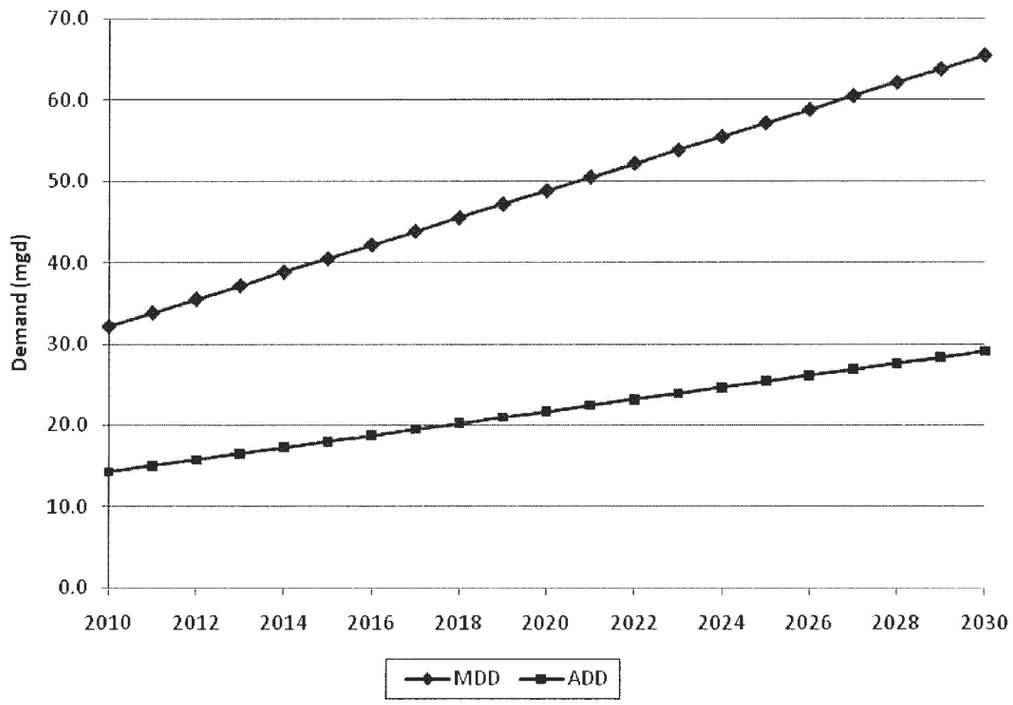
EXHIBIT 5-4
Future Demands for the City's Water Service Area (mgd)

Year	ADD	MDD
2010	14.3	32.2[1]
2020	21.7	48.8
2030	29.1	65.5

[1] The City's actual 2010 MDD was approximately 20 percent less than the projected MDD for that year. The reduced demand compared to the projections is likely due to the cool, wet weather during the spring and summer of 2010, the City's recent efforts to optimize system operations, as well as less demand due to the current economic downturn.

Using this annual growth rate of 0.74 mgd per year, the ADD values for each year from 2010 through 2030 were calculated and the peaking factors for MDD were used to obtain the values in **Exhibit 5-5.**

EXHIBIT 5-5
2010 to 2030 Projected Demands



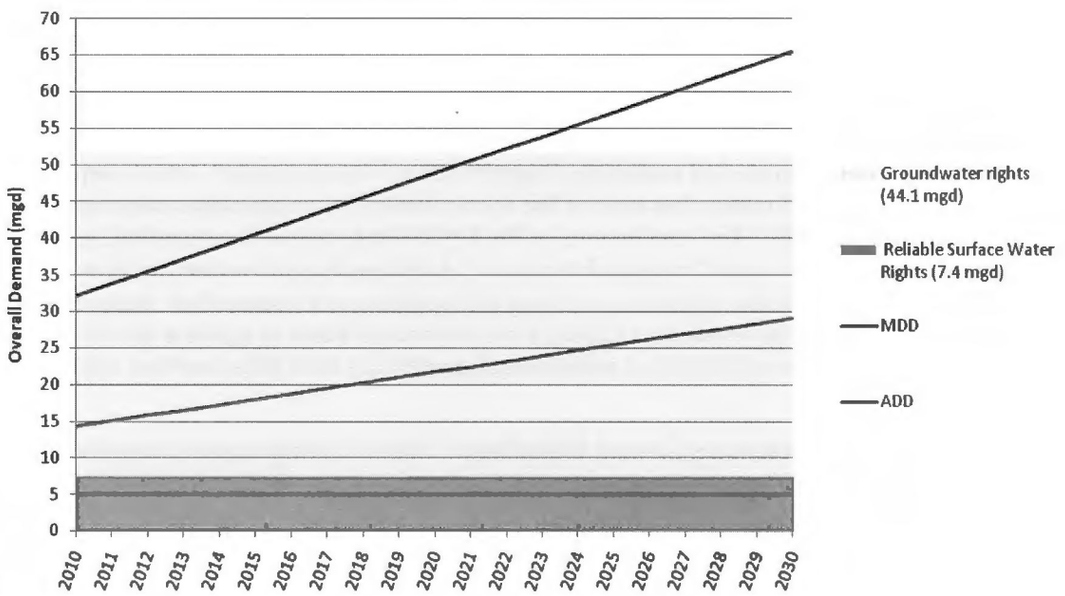
Schedule to Exercise Permits and Comparison of Projected Need to Available Sources

OAR 690-086-0170(2) and (4)

The City holds surface water rights that authorize the use of up to 36.1 cfs (23.3 mgd). As described in Section 2, the amount of surface water available to the City is directly related to the amount of flow in Tumalo Creek and the proportional distribution of that water between TID, instream water rights established as part of TID's conserved water projects, and the City. For the purposes of planning for the amount of surface water available to meet peak needs, the City evaluated historic stream flows in Tumalo Creek to establish a likely low-flow scenario. Under that evaluation it was determined that a stream flow of 42.5 cfs and a proportional share for the City of 11.5 cfs (7.4 mgd) should be the "firm" planning-level peak demand surface water supply. The City also holds groundwater rights authorizing use of 68.2 cfs (44.1 mgd). The City's surface water and groundwater rights combined provide a planning-level reliable water supply of 79.7 cfs (51.5 mgd).

Exhibit 5-6 shows the City's "firm" surface water and groundwater rights superimposed on the City's projected ADD and MDD. As shown in Exhibit 5-6, the City may need up to approximately 65.5 mgd to meet its MDD by 2030. The water supply provided by the City's existing water rights, however, currently can be relied on in a low-streamflow, high demand scenario to provide approximately 51.8 mgd of supply. Consequently, the City will need to fully exercise its existing water rights and may need additional water supply to meet its projected 2030 MDD.

EXHIBIT 5-6
Projected Demands and Reliable Supply under the City's Existing Water Rights



Based on projected water demand growth, the City anticipates fully exercising all of its existing surface water and groundwater rights during the next 20-year planning period.

As part of its effort to meet projected demand, the City will need access to the full amount of its Permit G-8565. Therefore, the City is requesting access to the 0.72 cfs of "green light water" under "extended permit" G-8565.

Alternative Sources

OAR 690-086-170(5)

OAR 690-086-0170(5) requires an analysis of alternative sources of water if any expansion or initial diversion of water allocated under existing permits is necessary to meet future water demand. During the next 20-year planning period, the City intends to expand or initiate diversion of water under existing Permits G-8565, G-11379, G-16177, and G-16178 to meet future water demands described above. (Groundwater permit G-4435 is fully developed and will be certificated in the near future.)

During the past several years, the City has spent significant resources evaluating its water supply needs and supply alternatives. Through a series of extensive water supply planning efforts, associated with the City's Watershed Source Water Improvements project, the City has affirmed its commitment to a dual source supply: gravity-fed surface water from Bridge and Tumalo Creeks under its existing water rights to meet base demands; and groundwater to meet current and future peak needs. As part of this process, the City has evaluated these supply sources in terms of cost, availability, reliability, feasibility, and likely environmental impacts.

Meeting future demand during the 20-year planning period from "new" surface water rights is not feasible. Surface water in the Deschutes Basin is fully appropriated and not available.

With respect to groundwater, obtaining a "new" groundwater right currently appears unlikely for the following reasons. In 2001, the U.S. Geological Survey (USGS) published a hydrologic study for the Deschutes Basin[5] and concluded that virtually all groundwater not consumptively used in the Upper Deschutes Basin discharges to surface water near Pelton Dam. Further, much of the Deschutes River is protected under the Oregon Scenic Waterways Act, which requires maintenance of the "free-flowing character of the scenic waterway in quantities necessary for recreation, fish and wildlife." The conclusions of the USGS study raised concern that new groundwater withdrawals could "measurably reduce" mandated scenic waterway flows. Therefore, OWRD adopted special rules providing for mitigation of stream flow impacts as a condition of granting new groundwater rights in the Deschutes Basin to address the scenic waterway concerns and the potential for substantial interference with other surface water rights.

OWRD's rules close the Deschutes Ground Water Study Area to further appropriation except for a cumulative total of 200 cfs maximum rate for final orders approving groundwater permit

[5] Gannett, M.W., Lite, Jr., K.E., Morgan, D.S., and Collins, C.A., 2001, Ground-water hydrology of the upper Deschutes Basin, Oregon: U.S. Geological Survey Water-Resources Investigations Report 00-4162 ("USGS Study"): http://pubs.usgs.gov/wri/wri004162/.

applications issued after the effective date of the rules. OWRD estimates that all 200 cfs of the "cap" have been claimed, meaning that other than applications already in the queue and under the 200 cfs cap, no new groundwater permits will be issued in the Deschutes Basin Ground Water Study Area. It is unclear whether this cap will be modified.

Further, OWRD's mitigation program rules are set to expire on January 2, 2014. It is difficult to predict whether legislation to extend the program (and perhaps to increase the cap) would be enacted. Without the legislation, and without an administrative program, it is unclear how OWRD would evaluate new groundwater permit applications in the Deschutes Basin.

Therefore, the full exercise of the City's existing permits is the most feasible and reliable alternative in the near term. Additionally, because the City must provide mitigation to offset the impacts of this groundwater use on surface water for its two newest and biggest permits, the likely environmental impacts of this water use are limited.

The following discussions analyze the extent to which the City can meet its projected water need through other alternatives.

Conservation Measures

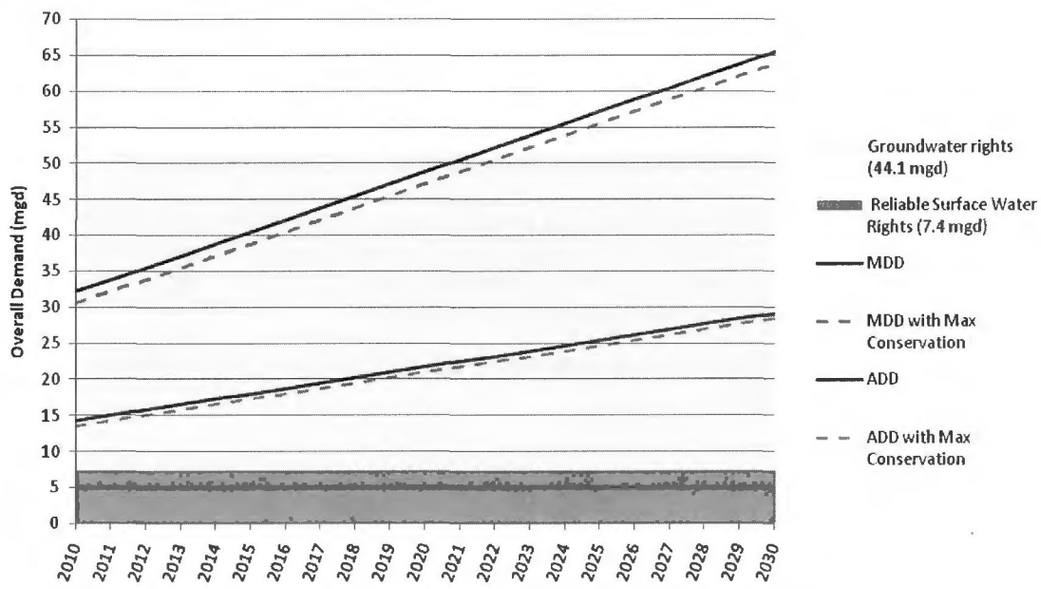
OAR 690-086-170(5)(a)

As described in Section 3, HDR developed a water conservation analysis evaluating 49 conservation measures to determine costs, predict participation rates, and evaluate water savings. HDR's analysis projected that if the City implemented the 37 conservation measures analyzed that were not mutually exclusive, the City could save 740,000 gallons per day (gpd) on an annual average basis, and 980,000 gpd on a peak season (April through October) basis. (Appendix B contains HDR's conservation analysis report.)

Exhibit 5-7 presents the total projected ADD and MDD compared to the City's reliable water rights, as well as the ADD and MDD considering implementation of all of these conservation measures. The latter demand projections were developed on the basis of HDR's conservation analysis. The ADD with conservation was estimated by reducing the projected ADD by 740,000 gpd. The projected MDD with conservation was estimated by multiplying the projected ADD with conservation values by the MDD/ADD peaking factor of 2.25. Although HDR projected these water use reductions to be the maximum savings during the course of a 10-year planning period, for the purposes of Exhibit 5-7, these savings rates were continued throughout the 20-year planning period for this WMCP to represent the maximum savings potential likely to be available through conservation.

HDR estimated the total direct cost for implementing all of these conservation measures to be approximately $3 million. This figure does not include staff and related overhead costs to implement the conservation measures. Because this cost exceeds its current conservation budget, the City will be working with the City Council during the next 5 years to develop capital improvement and conservation budgets and to determine which conservation measures to implement, as further described in Section 3.

EXHIBIT 5-7
Projected ADD and MDD and City of Bend Water Rights, Including Conservation



As shown in Exhibit 5-7, implementing all of the analyzed conservation measures that were not mutually exclusive would provide a slight reduction in the City's MDD. However, this reduction is not sufficient to alleviate the City's need to fully exercise its existing permits within the 20-year planning period.

Interconnections

OAR 690-086-170(5)(b)

The City currently has interconnections with Avion and Roats, as described in Section 2. The interconnections with Avion and Roats are considered only for emergency water supply conditions, so these interconnections are not being included as part of the City's water supply portfolio, and will not alleviate the City's need to fully exercise its existing water use permits described above within the 20-year planning period.

Cost Effectiveness

OAR 690-086-170(5)(c)

OAR 690-086-170(5)(c) requires an assessment of whether the projected water needs can be satisfied through other conservation measures that would provide water at a cost that is equal to or less than the cost of other identified sources. However, as described above, even if the

City implemented all of the non-mutually exclusive conservation measures considered by HDR as part of its Water Conservation Analysis Project (without regard to cost), the conservation savings would be insufficient to alleviate the City's need to fully exercise its existing water use permits during the 20-year planning period.

Quantification of Maximum Rate and Monthly Volume

OAR 690-086-0170(6)

OAR 690-086-0170(6) requires a quantification of the maximum rate of withdrawal and maximum monthly use if expansion or initial diversion of water allocated under an existing permit is necessary to meet demands in the 20-year planning horizon. The City anticipates expanding its use of the following permits: G-8565, G-11379, G-16177, and G-16178 to meet peak demands. As previously noted, groundwater permit G-4435 is fully developed and will be certificated in the near future. When calculating the maximum rate and monthly volume for each permit, the entire portion of the right in permit status was considered, rather than only the currently undeveloped portion of the right.

The City is projected to require the maximum authorized rate of 0.94 cfs for the portion of Permit G-8565 still in permit status within the next 20 years to meet the City's projected water demands. Assuming that this permit is used at the maximum rate 24 hours per day for 30 days during the maximum month, the maximum monthly volume for Permit G-8565 would be approximately 18.2 MG.

The City also anticipates requiring the full 3.84 cfs maximum authorized rate for Permit G-11379 within the next 20 years. Assuming that this permit is used at the maximum rate 24 hours per day for 30 days during the maximum month, the maximum monthly volume for Permit G-11379 would be approximately 74.4 MG.

In addition, the City anticipates requiring the full 12 cfs maximum authorized rate for Permit G-16177 within the next 20 years. Assuming that this permit is used at the maximum rate 24 hours per day for 30 days during the maximum month, the maximum monthly volume for Permit G-16177 would be approximately 232.7 MG. The volume of water appropriated under Permit G-16177 must be accompanied by the required corresponding mitigation.

Finally, the City anticipates requiring the full 12 cfs maximum authorized rate for Permit G-16178 within the next 20 years. Assuming that this permit is used at the maximum rate 24 hours per day for 30 days during the maximum month, the maximum monthly volume for Permit G-16178 would be approximately 232.7 MG. The volume of water appropriated under Permit G-16178 must be accompanied by the required corresponding mitigation.

Mitigation Actions under State and Federal Law

OAR 690-086-0170(7)

Under OAR 690-086-0170(7), for expanded or initial diversion of water under an existing permit, the water supplier is to describe mitigation actions it is taking to comply with legal requirements of the Endangered Species Act, Clean Water Act, and other applicable state or federal environmental regulations. The City currently is not required to take any mitigation actions under federal law. The City must provide mitigation credits as part of the Deschutes Basin Mitigation Program to offset the impacts to surface water of the consumptive portion of its use of groundwater under Permit G-16177 and Permit G-16178. The City has an approved incremental mitigation plan and will continue to use water under these two permits in compliance with the mitigation plan.

Alternative Sources

OAR 690-086-170(8)

OAR 690-086-0170(8) requires an analysis of alternative sources of additional water if acquisition of new water rights will be necessary within the next 20 years to meet the projected water demands. At this time, the City does not have any new water right applications pending. The City is currently engaged in two major projects that could have significant impacts on how the City provides water to meet projected demands. These studies are: (1) the Watershed Source Water Improvements and (2) Water System Master Plan Update Optimization Study – Final Report, Draft December 2010. In addition, the Deschutes Basin mitigation program "cap" of 200 cfs has been met and the program rules are scheduled to sunset January 2, 2014. Whether this program is extended will significantly affect how the City meets its future water demands. Moreover, during the next 5 years, the City will be developing capital improvement and conservation budgets and will be selecting and implementing additional conservation measures. Based on the results of these efforts, the City will reevaluate the supply necessary to meet projected demands, and reassess future water source alternatives. The City anticipates providing an updated water demand and source availability comparison that includes the City's long-term water supply source(s) with its 5-year update to this Plan.

Appendix A

Local Government Letter

GSI
Water Solutions, Inc.

December 1, 2010

Paul Blikstad, Senior Planner
Deschutes County - Planning Division
117 NW Lafayette Avenue
Bend, OR 97701

Subject: Water Management and Conservation Plan for the City of Bend

Dear Mr. Blikstad:

The City of Bend has developed a Draft Water Management and Conservation Plan (WMCP). The City has prepared this plan to fulfill the requirements of Oregon Administrative Rule Chapter 690, Division 86 of the Oregon Water Resources Department (OWRD).

Under these rules, a water supplier is required to make its draft plan available for review by each affected local government and seek comments relating to consistency with the local governments' comprehensive land use plans. Please find enclosed a copy of the City's Draft WMCP. Although we expect to make minor revisions to this document prior to submission to OWRD, any changes will not affect the plan's consistency with Deschutes County's comprehensive land use plan.

Please provide comments to me by no later than December 31, 2010. If the plan appears consistent with your agency's Comprehensive Land Use Plan, a letter response to that effect would be appreciated. You may send your comment to me at the address on this letterhead or e-mail them to me directly at: asussman@gsiwatersolutions.com.

If you have any questions, please feel free to contact me. My telephone number is 541-753-0745, extension 201. Thank you for your interest.

Sincerely,

Adam Sussman
Senior Water Resources Consultant

Enclosure

1600 Western Blvd., Suite 240 Corvallis, OR 97333 P: 541.753.0745 F: 541.754.4211 info@gsiwatersolutions.com www.gsiwatersolutions.com

Appendix B

HDR Water Conservation Opportunities Memorandum

Technical Memorandum

HDR

To:	**Patrick Griffiths and Ric Olson; City of Bend**
From:	**Kelly O'Rourke and Joe Miller; HDR, Inc.**
CC:	**Ronan Igloria; HDR, Inc.**
	Adam Sussman and Suzanne Moellendorf; GSI, Inc
Date:	**December 8, 2010 - FINAL**
Subject:	**Conservation Program for Water Management and Conservation Plan HDR Project #139138**

HDR performed a water conservation analysis project for the City of Bend. The purpose of the project was to examine opportunities to enhance Bend's existing water conservation program. The information will be used to potentially refine the City's program and to update portions of its *Water Management and Conservation Plan*. The work was done as a sub-consultant to GSI Water Solutions, Inc. (GSI). The scope of HDR's work focused on demand-side conservation measures.

This technical memorandum includes the following three sections:

1. **Conservation Background:** This section provides an overview regarding water conservation, which provides context for the analysis performed for this specific project. This section also summarizes Bend's current water conservation efforts.

2. **Analysis Methodology:** This section describes the methodology used to analyze the conservation measures, describes the conservation measures analyzed, documents key assumptions, and documents demographic and consumption data inputs.

3. **Results and Conclusions:** This section provides results of the initial analysis for each individual conservation measure, provides results of conservation "packages", and provides conclusions regarding the analysis. *(Section 3.6 contains the conclusions; for readers interested primarily in the conclusions please refer to that section, which begins on page 25.)*

1 Conservation Background

1.1 Conservation Overview

Water conservation is defined as the management of water resources so as to eliminate waste and maximize efficient use of the resource. Conservation can be divided into many categories, as shown in Table 1. It is important to understand these categories since the cost structure, longevity of savings, certainty of savings, and social impacts vary across the categories.

Table 1 Conservation Categories

Measures *(Saves water)*		Incentives *(Motivates Customers to save water)*		
Hardware	**Behavior**	**Educational**	**Financial**	**Regulatory**
More efficient equipment.	More efficient behaviors.	Explain why and how to save water.	Make saving water financially attractive.	Require conservation actions.
Example: Install high efficiency toilets.	*Example: Take shorter showers.*	*Example: Conservation tips brochure.*	*Example: Use inverted block rate structure.*	*Example: Require retrofit to code upon resale.*

Conservation is first divided into two categories: measures and incentives. Measures save water in and of themselves, while incentives motivate customers to save water. Measures are divided into hardware and behavior. Hardware measures entail using more efficient equipment, while behavioral measures entail promoting behavior changes toward more efficient practices. Hardware measures tend to be more expensive, but have longer lasting savings and a higher certainty of savings, compared to behavioral measures. Incentives can be divided into three categories: educational, financial, and regulatory. Educational incentives explain why and how to save water. Financial incentives make saving water financially attractive. Regulatory incentives are mandatory requirements for conservation actions. Examples for each type of measure and incentive are provided in Table 1.

Conservation can be achieved on both the supply-side and demand-side. Supply-side conservation is associated with a utility's conveyance and distribution infrastructure such as leak detection and repair. Demand-side conservation is associated with the water user such as homeowners installing high efficiency toilets.

A utility's conservation program should reflect the reasons why the utility is implementing conservation and the utility's water use patterns. Typical conservation drivers include: 1) meeting regulatory requirements, 2) demonstrating stewardship, 3) decreasing operating costs, 4) deferring/avoiding capital costs, and 5) extending available supplies. The utility's conservation drivers and water use patterns shape which measures and incentives to implement, the saving goal, the appropriate budget, and whether to focus on supply-side or demand-side efforts.

Table 2 shows how a utility's conservation driver determines the strategy for its conservation program.

Table 2 Conservation Driver Determines Conservation Strategy

Conservation Driver	Conservation Program Strategy
Meet Regulatory Requirement	Implement the required level of conservation.
Demonstrate Stewardship	Implement more than the required level of conservation.
Decrease Operating Costs	Implement conservation that is more cost-effective than the variable cost of supplying water.
Defer/Avoid Capital Costs	Implement the amount of conservation necessary to obtain the savings required to defer/avoid capital costs.
Extend Available Supplies	Implement conservation that is more cost-effective than the cost of developing new traditional supply.

1.2 Bend's Current Conservation Program

Most of the conservation drivers discussed above applies to Bend. The City is committed to meeting all regulatory requirements related to conservation. The City understands the environmental benefit of leaving water instream and in the aquifer and is interested in going beyond regulatory commitments to demonstrate strong stewardship of the resource. Bend is also interested in conservation as a mechanism to defer or avoid capital costs and to extend available supplies.

Bend's current conservation program features both supply-side and demand-side efforts and includes both measures and incentives. A summary of the major elements of the program are listed in Table 3. A more detailed summary of Bend's conservation program will be provided in the *Water Management and Conservation Plan* being prepared by GSI.

Table 3 Major Elements of Conservation Program

Supply-Side Elements	Demand-Side Elements
• Source and customer metering • Meter calibration and replacement • Annual system water audits • Pipeline leak detection	• Public education and outreach • Irrigation programs to promote and/or fund controllers, rain sensors, native plants, and audits • Toilet leak detection tablets

The materials and services budget for the City's conservation program is approximately $50,000 annually for communication and outreach. This does not include staffing costs. The City does not currently have budget allocated for direct costs such as rebates or hardware purchases.

2 Analysis Methodology

2.1 Basic Method

The methodology for determining water savings and costs for Bend is generally the same for all conservation measures. The basic method is to compile demographic information for Bend's service area, apply assumptions for customer participation rates for each conservation measure, calculate the savings achieved by shifting to more efficient hardware or behavior, and calculate the costs for those shifts.

HDR's proprietary Water Conservation Measure Analysis Model was used for this analysis. The model is an Excel-based tool that estimates the water savings and costs for various demand-side water conservation measures. The spreadsheet is pre-loaded with a set of commonly analyzed conservation measures. The spreadsheet is customized for clients by entering client-specific data (e.g., planning period, demographics, and water consumption) and selecting which of the pre-loaded measures should be analyzed. The spreadsheet analyzes the measures and provides summary tables and graphs. Various program "packages" can also be created based on the analyzed measures to represent potential conservation scenarios.

The costs for a conservation program can be divided into the three categories shown below. The HDR model only incorporates the direct costs incurred by the utility.

- **Direct Costs:** This includes rebates paid to customers (e.g., clotheswasher rebates), purchasing fixtures to give to customers (e.g., efficient showerheads), and paying for professional audits (e.g., outdoor irrigation audits).

- **Indirect Costs:** This includes marketing and distribution costs that necessary to implement the measures, such as graphic design, printing, postage, and advertising. The exact nature of the marketing and distribution techniques that will eventually be implemented is often unknown during the measure analysis work. Therefore, the indirect costs are not included in HDR's model. However, Bend should plan to budget for indirect costs, which, as a general rule, can be 10-20% of the direct costs.

- **Staff Costs:** This includes the salary and benefits for City staff assigned to plan, manage, and implement the conservation program. Some water utilities include staff costs in their official conservation budget, while others do not. Regardless of whether staff costs appear in the official conservation budget, the "opportunity cost" should be recognized in that staff time allocated to a conservation program is not available for other utility functions.

The initial results from the model are simply the outcomes of the analysis for every conservation measure, considered independently of the other measures. Those results, by themselves, do not indicate which measures should be implemented. The initial results must be coupled with Bend's conservation driver and screened through various criteria in order to determine which measures and/or groups of measures ("packages") are most appropriate.

2.2 Measures Analyzed

The measures analyzed for this project are described below.

- **Clotheswashers - Efficient Residential Capacity (In Unit):** Provide partial rebates to replace less efficient residential-capacity clotheswashers (located in housing units) with more efficient models. The participation rate for this measure was set at 25%. The direct cost is a $100 rebate per clotheswasher. The model assumes one rebate per participating household.
- **Clotheswashers - Efficient Residential Capacity (Common Area):** Provide partial rebates to replace less efficient residential-capacity clotheswashers (in common laundry areas) with more efficient models. The participation rate for this measure was set at 25%. The direct cost is a $100 rebate per clotheswasher. The model assumes one rebate for every five multifamily households for participating multifamily accounts.
- **Clotheswashers - Efficient Commercial Capacity:** Provide partial rebates to replace less efficient commercial-capacity clotheswashers with more efficient models. The participation rate for this measure was set at 25%. The direct cost is a $250 rebate per clotheswasher. The model assumes 12 rebates per participating non-residential account.
- **Clotheswashers - Decrease Partial Loads:** Encourage customers to reduce partial loads of laundry, thereby reducing the number of loads by 10%. The participation rate for this measure was set at 10%. There are no direct costs associated with this measure since most behavior measures do not have direct costs. However, this should not be viewed as a "no-cost" measure since the indirect costs for behavior measures can be significant.
- **Faucets - 0.5 gpm Bathroom Aerators (Residential):** Provide free 0.5 gpm bathroom faucet aerators, which for the residential customer category is more efficient than the maximum of 2.5 gpm allowed under the plumbing code. The participation rate for this measure was set at 10%. The direct cost is $1 per aerator. The model assumes 2.5 aerators per participating single family household and 1.5 aerators per participating multifamily household.
- **Faucets - 0.5 gpm Bathroom Aerators (Non-Residential):** Provide free 0.5 gpm bathroom faucet aerators, which for the non-residential customer category is the maximum allowed under the plumbing code. Brings non-code customers up to code. The participation rate for this measure was set at 30%. The direct cost is $1 per aerator. The model assumes 2.1 aerators per participating non-residential account.
- **Faucets - 1.0 gpm Bathroom Aerators:** Provide free 1.0 gpm bathroom faucet aerators, which for the residential customer category is more efficient than the maximum of 2.5 gpm allowed under the plumbing code. The participation rate for this measure was set at 25%. The direct cost is $1 per aerator. The model assumes 2.5 aerators per participating single family household and 1.5 aerators per participating multifamily household.
- **Faucets - 1.5 gpm Bathroom Aerators:** Provide free 1.5 gpm bathroom faucet aerators, which for the residential customer category is more efficient than the maximum of 2.5

gpm allowed under the plumbing code. The participation rate for this measure was set at 25%. The direct cost is $1 per aerator. The model assumes 2.5 aerators per participating single family household and 1.5 aerators per participating multifamily household.

- **Faucets - Decrease Use:** Encourage customers to reduce unnecessary faucet use, such as running the water while brushing teeth, thereby reducing combined bathroom and kitchen faucet use by 10%. The participation rate for this measure was set at 10%. There are no direct costs associated with this measure since most behavior measures do not have direct costs. However, this should not be viewed as a "no-cost" measure since the indirect costs for behavior measures can be significant.
- **Showerhead 1.5 gpm:** Provide free 1.5 gpm showerheads, which is more efficient than the maximum of 2.5 gpm allowed under the plumbing code. The participation rate for this measure was set at 25%. The direct cost is $3 per showerhead. The model assumes 2.0 showerheads per participating single family household, 1.5 showerheads per participating multifamily household, and 10 showerheads per participating non-residential account.
- **Showerhead 2.0 gpm:** Provide free 2.0 gpm showerheads, which is more efficient than the maximum of 2.5 gpm allowed under the plumbing code. The participation rate for this measure was set at 25%. The direct cost is $3 per showerhead. The model assumes 2.0 showerheads per participating single family household, 1.5 showerheads aerators per participating multifamily household, and 10 showerheads per participating non-residential account.
- **Showerheads - Decrease Use:** Encourage customers to reduce showering time by 10%. The participation rate for this measure was set at 10%. There are no direct costs associated with this measure since most behavior measures do not have direct costs. However, this should not be viewed as a "no-cost" measure since the indirect costs for behavior measures can be significant.
- **Spray Valves - 1.25 gpm Pre-Rinse Spray Valve:** Provide free, direct installation of 1.25 gpm pre-rinse spray valves, which is more efficient than the maximum of 1.6 gpm allowed under the plumbing code. Pre-rinse spray valves are used in commercial kitchens to rinse dishes prior to loading into dishwashers. The participation rate for this measure was set at 95%. The cost is $130 per spray valve. Due to the direct install nature of this measure, that cost includes both direct and indirect costs. The model assumes 1.5 spray valves per participating non-residential account.
- **Toilets - 1.28 gpf High Efficiency Toilets (HET):** Provide partial rebates to install High Efficiency Toilets (HETs), which is better than the maximum of 1.6 gpf allowed under the plumbing code. HETs are defined as toilets flushing at a maximum of 1.28 gpf. HETs include both dual flush toilets and pressure-assist tank style toilets. The participation rate for this measure was set at 10%. The direct cost is a $100 rebate per residential toilet and a $150 rebate per non-residential toilet. The model assumes 2.3 rebates per participating single family household, 1.8 rebates per participating multifamily household, and 4.2 rebates per participating non-residential account.

- **Toilets - 1.6 gpf Ultra Low Flow Toilets (ULFT):** Provide partial rebates to replace less efficient toilets with 1.6 gpf Ultra Low Flow Toilets (ULFT), which is the maximum allowed under the plumbing code. Brings non-code customers up to code. The participation rate for this measure was set at 30%. The direct cost is a $75 rebate per toilet. The model assumes 2.3 rebates per participating single family household, 1.8 rebates per participating multifamily household, and 4.2 rebates per participating non-residential account.
- **Toilets - Decrease Flushes:** Encourage customers to reduce unnecessary toilet flushing, such as flushing trash, thereby reducing toilet flushes by 10%. The participation rate for this measure was set at 10%. There are no direct costs associated with this measure since most behavior measures do not have direct costs. However, this should not be viewed as a "no-cost" measure since the indirect costs for behavior measures can be significant.
- **Toilets - Leak Detection:** Provide free toilet leak detection dye tablets to determine if toilets leak and provide information on how to fix leaks. The participation rate for this measure was set at 25%. The direct cost is $0.10 per packet of dye tablets. The model assumes 2.3 dye tablet packets per participating single family household and 1.8 dye tablet packets per participating multifamily household. Toilet leak detection dye tablets can be considered both a behavioral and a hardware measure. It fits the definition of a behavioral measure in that customers must take action to repair a found leak; it fits the definition of a hardware measure in that the fix to a leaky toilet is a piece of hardware. Bend staff classify it as a hardware measure and therefore it appears in the "hardware" packages.
- **Urinals - Waterless Models:** Provide partial rebates to install waterless urinals, which is better than the maximum of 1.0 gpf allowed under the plumbing code. The participation rate for this measure was set at 5%. The direct cost is a $150 rebate per urinal. The model assumes 2.1 rebates per participating non-residential account.
- **Urinals - 0.5 gpf Models:** Provide partial rebates to install 0.5 gpf urinals, which is better than the maximum of 1.0 gpf allowed under the plumbing code. The participation rate for this measure was set at 25%. The direct cost is a $100 rebate per urinal. The model assumes 2.1 rebates per participating non-residential account.
- **Urinals - 1.0 gpf Models:** Provide partial rebates to replace less efficient urinals with 1.0 gpf urinals, which is the maximum allowed under the plumbing code. Brings non-code customers up to code. The participation rate for this measure was set at 30%. The direct cost is a $100 rebate per urinal. The model assumes 2.1 rebates per participating non-residential account.
- **Irrigation Controllers - ET Model:** Provide partial rebates for evapotranspiration (ET) based irrigation controllers, which link irrigation to weather conditions. The participation rate for this measure was set at 25%. The direct cost is a $250 rebate per controller for single family customers and a $500 rebate per controller for multifamily and non-residential customers. The model assumes one rebate per participating single family household, multifamily account, and non-residential account.
- **Irrigation Controllers - Rain Sensors:** Provide free rain sensors, which turn off automatic irrigation systems when it is raining. This is only applicable to irrigation

systems that can use rain sensors. The participation rate for this measure was set at 25%. The direct cost is a $100 rebate per rain sensor. The model assumes one rebate per participating single family household, multifamily account, and non-residential account.

- **Lawn Dormant:** Encourage customers to let their lawn go dormant in the summer. It should be noted that allowing lawns to go dormant during the summer does not eliminate lawn watering completely. Dormant lawns still require some water to stay alive. The participation rate for this measure was set at 10%. There are no direct costs associated with this measure since most behavior measures do not have direct costs. However, this should not be viewed as a "no-cost" measure since the indirect costs for behavior measures can be significant.
- **Outdoor Audit:** Provide free irrigation audits to improve the efficiency of irrigation systems. Efficiencies can be achieved through hardware improvements or operational changes. The audits are performed by a contracted professional landscape irrigation auditor. The participation rate for this measure was set at 25%. The direct cost is $250 per audit for residential properties and $1,000 per audit for non-residential properties. The model assumes one audit per participating single family household, multifamily account, and non-residential account.
- **Outdoor Irrigation Kits:** Provide free outdoor irrigation kits with devices and information to improve the irrigation efficiency of manual irrigation techniques. Kits typically include items such as a watering timer and shut-off device, a spring-loaded hose nozzle, a rain gauge, hose washers, and a conservation brochure. The participation rate for this measure was set at 25%. The direct cost is $15 per kit. The model assumes one kit per participating single family household.

2.3 Key Assumptions

There are several key assumptions that are fundamental to the analysis. Those assumptions are explained below.

- **Planning Period:** A planning period of 2011 to 2020 (ten years) was used. The planning period is the period of interest for analyzing water conservation savings and costs. The planning period is different than the initial implementation period (see below). For example, Bend may distribute showerheads for five years (the initial implementation period), but may be interested in seeing how the savings and costs associated with those showerheads play out over 10 years (the planning period).

- **Initial Implementation Period:** An initial implementation period of 2011 to 2015 (five years) was used. The initial implementation period is the period when the conservation program will be implemented (aside from any renewals, see below). The initial implementation period is for the entire conservation program (i.e., all measures), rather than for any individual measure (e.g, just high-efficiency showerheads). Therefore, the last year of the initial implementation period is the last year that any one measure is initially implemented. A multi-year implementation period reflects the budgetary and administrative reality that Bend would most likely not implement all measures immediately.

- **Implementation Schedule:** After a one-year "ramp-up" period, an even-paced implementation schedule was assumed for all measures. The implementation schedule is the rate at which the measures are implemented during the initial implementation period. The measures were implemented to 8% of the potential customers in the first year and to 23% of the potential customers each of the remaining years. Therefore, the program reaches full implementation in the fifth year. This means that the gallons per day savings increase over the first five years, then remain constant. After the first year ramp-up period, an even implementation provides a consistent program budget for each year in the initial implementation period.

- **Renew Measure:** Measures are renewed if necessary to maintain savings over the planning period. Measure renewal is necessary if the measure lifespan is shorter than the planning period and if Bend wants to maintain the savings during the planning period. For example, the outdoor audit measure has a lifespan of five years, which means that since Bend's planning period is 10 years, the savings from the outdoor audits will disappear after five years unless Bend renews the measure and gives customers another outdoor audit in five years. Measure renewal has the benefit of maintaining savings, however it means that Bend pays to implement a measure more than once to the same customer.

- **Participation Rates:** Participation rates were selected to represent moderate program implementation levels. In the modeling analysis, participation rates represent the percent of target customers (those with the applicable hardware or behavior that have not already implemented the measure) that participate in the program. For example, for the HET toilet measure, the participation rate is the percent of customers that do not already have a HET toilet that are assumed to participate in Bend's HET toilet program. Participation rates are dependent on many factors including marketing and distribution techniques. Moderate level marketing and distribution techniques were assumed for the analysis.

  The participation rates are a subjective assessment of the relative attractiveness of the measures to customers. The rates were established using professional judgment based on HDR's experience with other communities. The following participation rates were used for the analysis:
  - 5% = unattractive to customers
  - 10% = not very attractive to customers
  - 25% = fairly attractive to customers
  - 30% = very attractive to customers

- **Free Riders:** The concept of free ridership was addressed in the analysis. Free riders are customers that participate in Bend's conservation program, even though they would have implemented the measure anyway. For example, a free rider is a customer who takes a rebate for an efficient clotheswasher, but who was going to buy that clotheswasher regardless of whether Bend offered a rebate program.

When free ridership is addressed in the analysis, the savings associated with free riders are excluded from the cost-effectiveness calculations, which provide a more accurate representation of the true cost-effectiveness of the conservation program. This impacts two values in the model: 1) "Savings for All Customers Over Measure Life (ccf)" and 2) "Cost per ccf Saved Over Measures Life." Those two numbers do not include water savings from free riders. Aside from those two numbers, all other numbers in the model include effects from free riders.

The free ridership percentages are a subjective assessment of the relative level of free ridership for measures. The percentages were established using professional judgment based on HDR's experience with other communities. The following free ridership percentages were used for the analysis:

- 5% = no reason to assume much free ridership
- 15% = higher level of free ridership is expected
- 25% = measures bringing customers up to current plumbing code

2.4 Demographic and Consumption Data Inputs

Demographic Data

The demographic data required for the model are provided in Table 4. The demographic data did not initially distinguish between single family and multifamily, but rather grouped those categories together as "residential." The model is not structured to accommodate a grouped "residential" category and therefore that category was split into single family and multifamily. As documented in footnote "b" to Table 4, that split was based on the 2005 *Housing Needs Analysis; City of Bend Residential Lands Study* which indicates that 72% of households in Bend are single family. This disaggregation is an approximation, but it is considered the best available data to complete the analysis.

Table 4 Demographics

Demographic Unit	First Initial Implementation Year ("Existing" Demographics)		Last Initial Implementation Year		Change Between First and Last Year ("Future" Demographics)	
Year	2011	a	2015	a	5	g
Single Family Households (SF HH) and Accounts	18,953	b	20,290	b	1,336	g
Persons Per SF HH	2.42	c	2.42	c	0.00	g
Multifamily Households (MF HH)	7,371	b	7,890	b	520	g
Multifamily Accounts	737	h	789	h	52	g
Persons Per MF HH	2.42	c	2.42	c	0.00	g
Non-Residential (NR) Accounts	3,217	d	3,444	d	227	g

Demographic Unit	First Initial Implementation Year ("Existing" Demographics)		Last Initial Implementation Year		Change Between First and Last Year ("Future" Demographics)	
Employees	45,362	e	48,560	e	3,198	g
Employees Per NR Account	14	f	14	f	0	g

a. Provided by client via Measure Selection worksheet.

b. Original numbers from GSI/MSA/City grouped SF and MF together. HDR split HHs between SF and MF based on Table 33 in 2005 *Housing Needs Analysis City of Bend Residential Lands Study,* which indicated 72% of HH are SF. Original footnote from GSI/MSA/City as follows: The City used the buildable lands/parcel inventory clipped to the COB water service area to estimate the number of residential households in 2010 (25,860). The inventory includes building permit applications that were received and approved (not constructed) as of Feb 1, 2008 and the City assumes that these units were built by 2010, thereby provide a good estimate for the 2010 number of residential households. Forecasted units were estimated by first summarizing the average annual number of permits issued over the reporting period for the City of Bend. The yearly average was then multiplied by 0.75 since only 75% of the City of Bend is within the City's water service area. Finally, this number (464 for all residential unit) was added each year to estimate the total number of dwelling units by type for the next 5 years, 2011 to 2015. The percent growth rates were: 1.79% from 2010 to 2011 and 7.05% total from 2011 to 2015.

c. Based on the US Census 2000.

d. Based on data from the utility billing system, MSA determined that the number of Non-residential Accounts in 2009 was 3,211. GSI then applied the residential households percent growth rates of 1.79% from 2010 to 2011 and 7.05% total from 2011 to 2015 (Footnote b) to the number of Non-residential Accounts in 2009 for the 2011 and 2015 projections.

e. Based on employment data from Oregon Employment Department, grown by factors consistent with the City of Bend's Economic Opportunities Analysis, the City estimated that the number of employee in 2008 was 44,564. GSI applied the residential households percent growth rates of 1.79% from 2010 to 2011 and 7.05% total from 2011 to 2015 (Footnote b) to the 2008 employment estimate for the 2011 and 2015 projections.

f. Calculation. Employees/NR Accounts

g. Calculation.

h. Professional judgment assuming 10 MF HH per MF account.

Consumption Data

The water consumption data required for the model are provided in Table 5. Water consumption data are used to calculate the Peak Season Increased Use (PSIU), which is the annual amount of water used in the summer months above the base use (i.e., winter water average use). The PSIU is used in the savings formulas for outdoor measures. Two years of water consumption data (2008-2009) for Bend are provided in Table 5. A graphical representation of that data, including the distinction between base use and the PSIU, is provided in Figure 1, Figure 2, and Figure 3.

Similar to the demographic data, the consumption data did not initially distinguish between single family and multifamily, but rather grouped those categories together as "residential." The consumption data was disaggregated using two main pieces of information: 1) the newly disaggregated Bend demographics separating single family and multifamily households, and 2) professional knowledge that a multifamily household typically uses approximately 85% of the consumption of a single family household. This disaggregation is an approximation and the confidence level of the results is reduced somewhat due to this data limitation. This issue only impacts measures with a "peak only" seasonality, since the consumption data is only used to estimate savings for "peak only" measures.

Table 5 Bend Water Consumption (gallons)

Month	Single Family		Multifamily		Non-Residential	
	2008	2009	2008	2009	2008	2009
Jan	63,061,419	66,253,728	20,845,302	21,900,538	72,549,267	71,806,549
Feb	62,456,394	59,312,417	20,645,308	19,606,049	73,693,802	57,261,091
Mar	73,536,334	55,809,549	24,307,844	18,448,157	73,794,355	64,263,994
Apr	86,620,499	111,083,908	28,632,887	36,719,403	93,245,306	99,878,693
May	207,036,509	209,789,572	68,437,068	69,347,109	168,454,780	211,931,167
June	224,516,421	240,333,592	74,215,150	79,443,604	179,263,127	220,964,837
July	407,803,042	311,850,603	134,801,561	103,083,949	290,600,681	233,671,889
Aug	313,766,104	381,582,191	103,717,129	126,134,113	229,720,447	263,698,319
Sep	244,361,307	198,182,035	80,774,987	65,510,173	193,055,297	164,186,426
Oct	168,694,298	159,110,827	55,762,837	52,594,968	118,701,616	126,121,857
Nov	63,803,523	58,413,802	21,090,609	19,309,007	65,212,374	56,025,527
Dec	57,366,708	65,333,699	18,962,884	21,596,417	58,401,851	68,732,407
Total	**1,973,022,559**	**1,917,055,923**	**652,193,568**	**633,693,486**	**1,616,692,904**	**1,638,542,756**

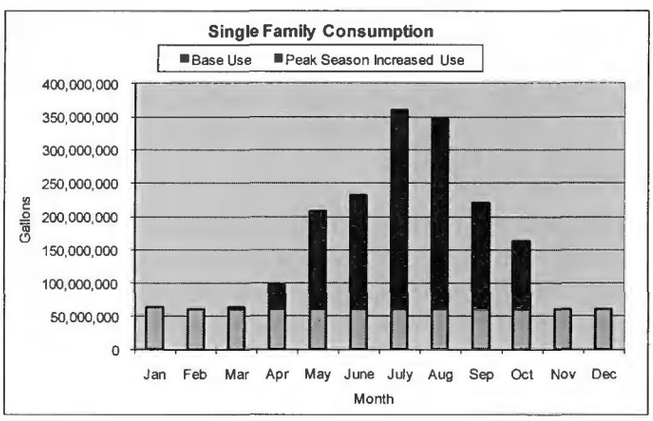


Figure 1 Single Family Consumption (2008-2009)

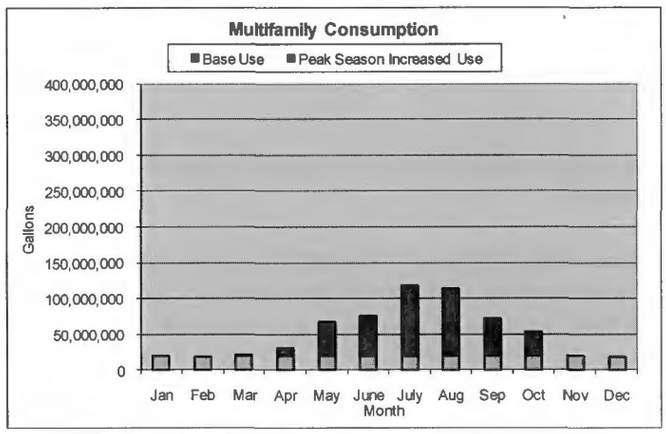


Figure 2 **Multifamily Consumption (2008-2009)**

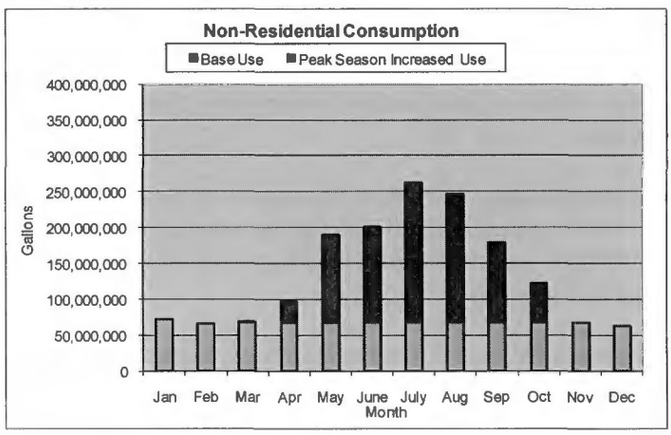


Figure 3 **Non-Residential Consumption (2008-2009)**

2.5 Developing Packages

The model's "package tool" was used to group subsets of measures that represent potential conservation scenarios for Bend. The decision of which packages to create, and which measures

to include in each package, is dependent on many factors including the following screening criteria:

- **Available Program Budget:** The conservation program budget impacts program choices. Bend has a current conservation budget of approximately $50,000 annually for communication and outreach and no budget for direct costs such as rebates or hardware purchases.

- **Magnitude of Annual Water Savings:** This is the annual savings in gallons per day at full implementation.

- **Magnitude of Peak Season Water Savings:** This is the peak season savings in gallons per day at full implementation. Note that peak season savings are obtained from both measures that obtain year-round savings (e.g. toilet rebates) and measures that only obtain savings during the peak season (e.g., irrigation system controllers).

- **Cost Effectiveness:** The cost-effectiveness of measures can range widely. For Bend, it ranges from $0.01 to $51.63 per ccf of saved water. Typically, indoor measures are more cost-effective than outdoor measures.

- **Customer Categories:** It may or may not be preferable to provide programs for each customer category (i.e., single family, multifamily, non-residential).

- **Certainty of Savings:** Measures that focus on hardware have a higher certainty of savings compared to measures that focus on behavior. Once a customer installs a piece of hardware (e.g., high-efficiency showerhead), the savings are generally assured for the lifespan of that hardware. However, if a customer enacts a water saving behavior (e.g., taking shorter showers), it is easy for the customer to convert back to their non-conserving behavior.

- **Administrative Complexity:** The impact on staff workload should be considered. Measures that could be implemented together (e.g., single family showerheads and single family bathroom faucet aerators) may have added value in workload efficiencies (as well as in cost efficiencies).

- **Customer Acceptance:** Certain measures may have higher customer acceptance. For example, when measures with different flow rates are analyzed, typically the models with higher flow rates have higher customer acceptance.

Examples of conservation packages that are frequently developed for utilities to consider include the following:

- **Savings Package:** Designed to meet a specific saving goal (e.g., saves X gpd).

- **Cost Package:** Designed to meet a specific budgetary constraint (e.g., costs $X per year).

- **Cost-Effectiveness Package:** Designed to include all measures that meet a certain cost-effectiveness threshold (e.g., measures that cost less than $X per ccf of saved water.

The packages developed for Bend are described below.

- **Package #1 – Conservation Potential Assessment:** This package was designed to show the maximum water savings available, given certain assumptions such as participation rates. This package is intended to provide a "high end" of potential savings. This package was assembled by including all of the analyzed measures, except that certain mutually exclusive measures have been omitted.

- **Package #2 – Hardware Measures – Indoor and Outdoor:** This package was designed to show the maximum water savings from hardware measures that the City is most interested in. The City has less interest in behavioral measures since their savings are less certain. This package was assembled by starting with Package #1 and omitting the behavioral measures and a few hardware measures.

- **Package #3 – Hardware Measures – Outdoor Only:** This package was designed to show the maximum water savings from outdoor hardware measures that the City is most interested in. This package was assembled by starting with Package #2 and omitting all indoor measures, which results in a package that contains only ET Controllers.

- **Package #4 – Hardware Measures – Indoor Only:** This package was designed to show the maximum water savings from indoor hardware measures that the City is most interested in. This package was assembled by starting with Package #2 and omitting all outdoor measures.

3 Results and Conclusions

3.1 Initial Results for Individual Measures

The results of the initial analysis for each individual measure are provided in Table 6. (The table is located at the end of this Tech Memo since it is 11 x 17 in size.) The results represent the highest level of water savings (and associated costs) that can be expected from each analyzed measure, given certain assumptions such as participation rates. It should be noted that additional savings might be obtainable from measures not included in the model, such as supply-side measures (e.g., leak detection) or more aggressive demand-side measures, however that would require continued spending.

The savings and costs in Table 6 are not totaled since there is some overlap due to mutually exclusive measures. For example, the analysis includes 0.5, 1.0, and 1.5 gpm faucet aerator measures. Those measures were analyzed independently of each other. Bend would most likely choose to implement only one of those measures, therefore the savings and costs from the non-selected measures need to be disregarded. If Bend implemented all three measures, the

participation rates (and thus savings and costs) for all three measures would need to be reduced. (See Section 3.2 for a package that omits overlapping measures.)

There are four sets of mutually exclusive measures, as described below:

- **Mutually Exclusive Set #1 - Residential Bathroom Faucet Aerators:** Three versions of residential bathroom faucet aerators were analyzed: 0.5 gpm, 1.0 gpm, and 1.5 gpm. All three versions are more efficient than the plumbing code of 2.5 gpm.

- **Mutually Exclusive Set #2 - Showerheads:** Two versions of showerheads were analyzed: 1.5 gpm and 2.0 gpm. Both versions are more efficient than the plumbing code of 2.5 gpm.

- **Mutually Exclusive Set #3 - Toilets:** Two versions of toilets were analyzed: 1.28 gpf and 1.6 gpf. The 1.6 gpf version brings customers up to the plumbing code and the 1.28 gpf version goes beyond code.

- **Mutually Exclusive Set #4 - Urinals:** Three versions of urinals were analyzed: waterless, 0.5 gpf, and 1.0 gpf. The 1.0 gpf version brings customers up to the plumbing code, while the other two versions go beyond code.

Key definitions related to Table 6 (as well as the similar tables for packages) are provided below:

- **Participating Customers:** The number of customers with the applicable fixture or behavior that have not already implemented the measure and that participate in the program. For example, the number of single family households with showers that do not already have an efficient model that participate in the utility's showerhead program. Note that the number of "potential" customers is the number of single family households; multifamily households or accounts; or non-residential accounts (as applicable for each measure), which is provided in Table 4 Demographics.

- **Savings Generating Customers:** The number of customers that generate savings. For measures that only require one step to achieve savings (e.g., toilet rebates), this is the same as the number of participating customers. For measures that require two steps to achieve savings, this is the number of customers that perform both steps and therefore achieve the savings. For example, the number of single family households that take the utility's showerhead and follow through and install it.

- **Devices / Rebates / Audits:** The number of devices, rebates, or audits that will be distributed or performed. For example, the number of toilet rebates. This number can be higher than the number of participating customers since often there are multiple fixtures per customer and due to renewals.

- **Savings for All Customers at Full Implementation (gpd):** This is the gallons per day savings for all customers once the program has been fully implemented. This value is presented for both the average annual and peak season time periods.

- **Savings for All Customers Over Measure Life (ccf):** This is the total savings, in 100s of cubic feet, that are obtained by the measure over the measure lifespan (or multiple lifespans if the measure is renewed). This is the savings number that is used to calculate the cost-effectiveness of the measure.

- **Total Direct Cost Over Planning Period:** This is the total direct cost for a measure over the planning period including the impacts of renewals if applicable. This number is a key input to the measure cost effectiveness calculation.

- **Direct Cost per CCF Saved Over Measure Life:** This is the cost effectiveness of the measure. It is calculated by dividing the "Savings For All Customers Over Measure Life (ccf)" into the "Total Direct Cost Over Planning Period." This number can be used to compare measures to one another, or to compare conservation to other sources of supply.

3.2 Package #1 – Conservation Potential Assessment

As described previously, this package was designed to show the maximum water savings available, given certain assumptions such as participation rates. This package is intended to provide a bookend of the high end of potential savings. As described previously, this package omits certain mutually exclusive measures. This allows the results to be summed for all the remaining measures. The decisions for which measures within a mutually exclusive set were included are explained below:

- **Mutually Exclusive Set #1 - Residential Bathroom Faucet Aerators:** The 1.0 gpm versions were included since they are more cost effective and save a larger volume of water, compared to the 1.5 and 0.5 gpm versions.

- **Mutually Exclusive Set #2 - Showerheads:** The 1.5 gpm versions were included since they are more cost effective and save a larger volume of water, compared to the 2.0 gpm version.

- **Mutually Exclusive Set #3 - Toilets:** The 1.28 gpf versions were included since they are more cost effective, compared to the 1.6 gpf version.

- **Mutually Exclusive Set #4 - Urinals:** The 0.5 gpf versions were included since they are more cost effective and save a larger volume of water, compared to the 1.0 gpf version. The waterless versions were excluded since they are often less acceptable to customers.

The results for Package #1 are shown in Table 7. (The table is located at the end of this Tech Memo since it is 11 x 17 in size.) The analysis estimates the package would save approximately 740,000 gallons per day (gpd) on an annual average basis and 980,000 gpd on a peak season

basis. The annual average savings number represents 6.2% of Bend's 2004-2009 average day demand. (The 2004 to 2009 average day demand is 12 mgd per Exhibit 2-3 in Bend's draft *Water Management and Conservation Plan*). The total direct cost of achieving those savings is estimated at approximately $3 million over the course of the ten-year planning period. Those total costs average to approximately $300,000 a year. However, as discussed below, the estimated annual costs vary throughout the planning period with higher annual costs toward the beginning and lower annual costs toward the end.

Several pie charts are provided to convey more information regarding the nature of the savings from this package. Figure 4 shows that nearly two-thirds of the savings are from the single-family customer category, with the remaining savings attributed to the multifamily and non-residential customer categories. Figure 5 shows that approximately two-thirds of the savings are associated with measures focused only on the peak season and one-third of the savings is associated with measures with year-round savings. Figure 6 shows that approximately half of the savings are associated with hardware measures and half with behavioral measures.

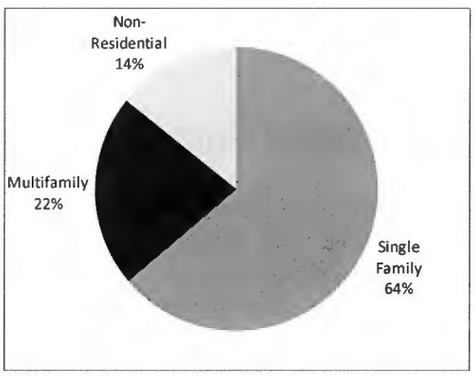


Figure 4 Savings by Customer Category (Package #1)

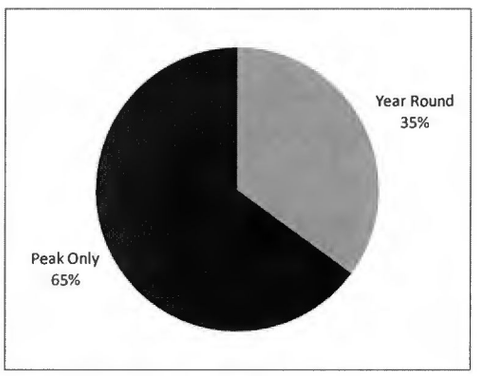


Figure 5 Savings by Seasonality (Package #1)

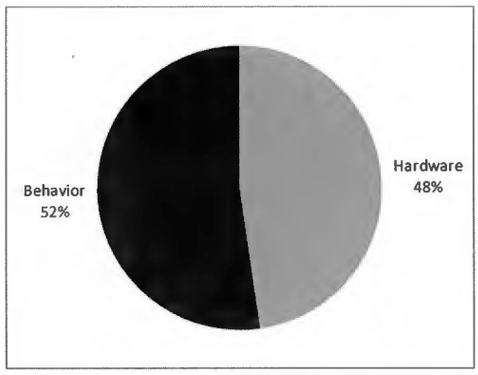


Figure 6 Savings by Hardware vs. Behavior (Package #1)

Figure 7 shows the gallons per day savings for each year. The figure shows how the gallons per day savings: 1) increase during the initial implementation period of 2011-2015, 2) reach their highest level by the last year of the initial implementation period, 3) stay at that level throughout the planning period until 2020, and 4) decline after the end of the planning period as the measures' lifespans expire and the measures are no longer renewed. Note that the savings could be preserved beyond the planning period, however that would require continued spending.

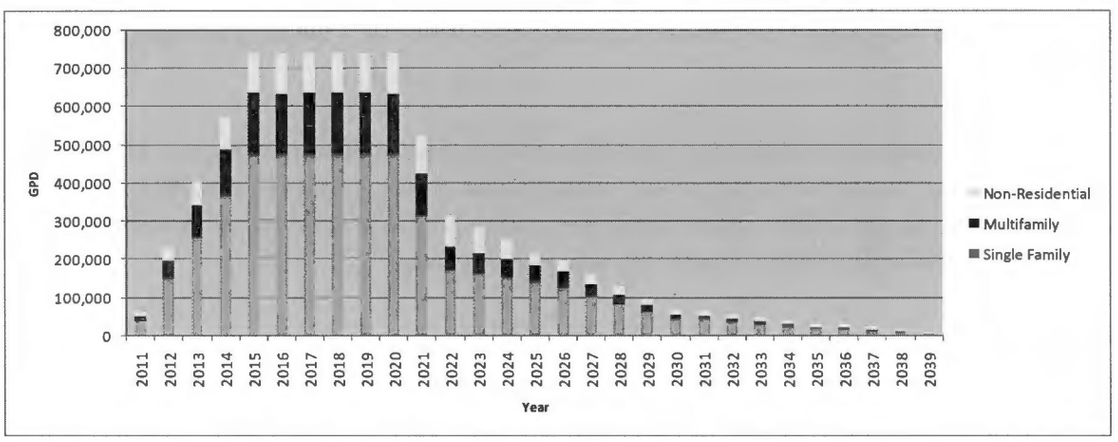


Figure 7 Total Savings Each Year (Package #1)

Figure 8 shows the total direct costs for each year during the planning period for each customer category. The figure shows how the costs: 1) are highest during the initial implementation period, 2) continue at a reduced level during the rest of the planning period due to measure renewal, and 3) end after the planning period. Note that the lower cost in the first year is due to the one-year "ramp-up" period, as described in Section 2.3 related to the implementation schedule.

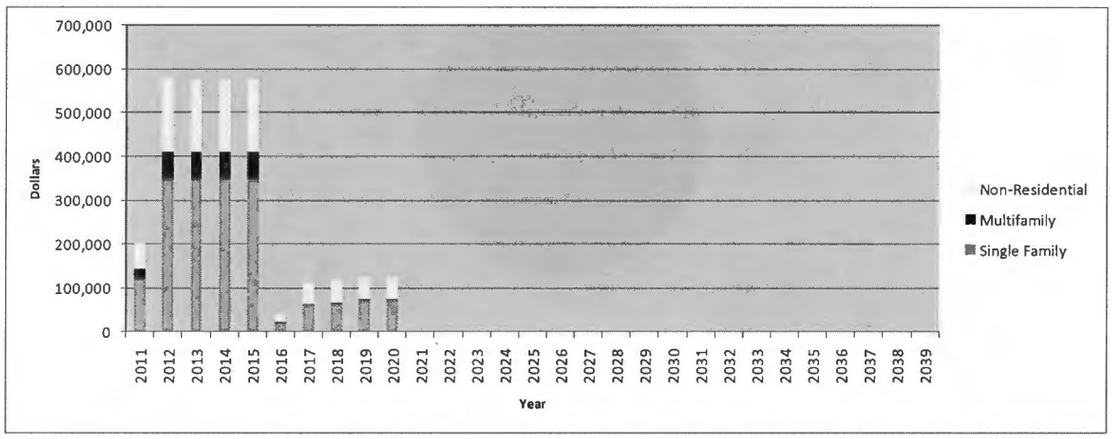


Figure 8 Total Direct Costs Each Year (Package #1)

3.3 Package #2 – Hardware Measures – Indoor and Outdoor

As discussed in Section 2.5, this package was designed to show the maximum water savings from hardware measures that are of most interest to the City. Note that this package includes toilet leak detection dye tablets which, as explained earlier, is considered a hardware measure by the City even though the HDR model technically classifies it as a behavioral measure

The results for Package #2 are shown in Table 8 (the table is located at the end of this Tech Memo since it is 11 x 17 in size). The analysis estimates the package would save approximately 296,000 gpd on an annual average basis and 337,000 gpd on a peak season basis. The total direct cost of achieving those savings is estimated at $1.9 million over the ten-year planning period.

Two pie charts convey information regarding the nature of the savings from this package. Figure 9 shows that the majority of the savings are from the single family category, with the remaining savings split between the multifamily and the non-residential sectors. Figure 10 shows the majority of savings are associated with measures with year-round savings, compared to measures with only peak season savings. By definition of the package, all of the savings are from hardware measures.

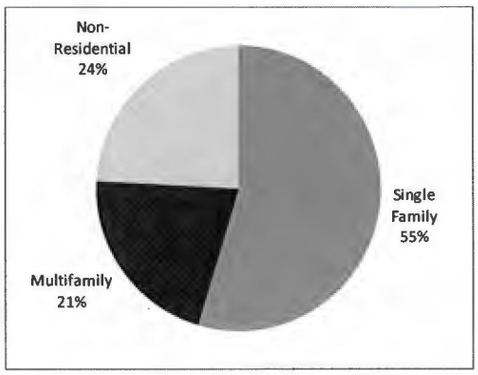


Figure 9 Savings by Customer Category (Package #2)

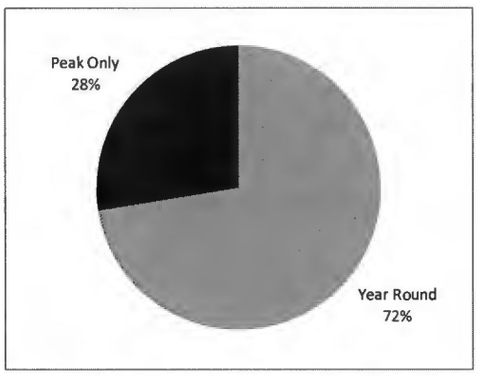


Figure 10 Savings by Seasonality (Package #2)

Figure 11 shows the gallons per day savings for each year, on an average annual basis. The pattern in the figure is similar to the pattern discussed under Package#1 - Conservation Potential Assessment.

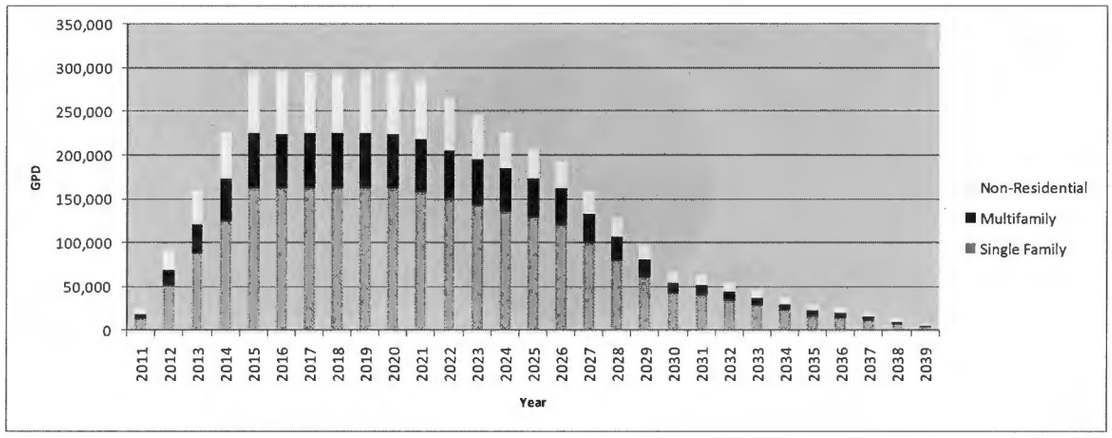


Figure 11 Total Savings Each Year (Package #2)

Figure 12 shows the direct costs for each year during the planning period for each customer category. Note that the lower cost in the first year is due to the one-year "ramp-up" period, as described in Section 2.3 related to the implementation schedule. Although it is not clearly shown in Figure 12, there are minor costs in years 2018 through 2020 due to measure renewal during the planning period.

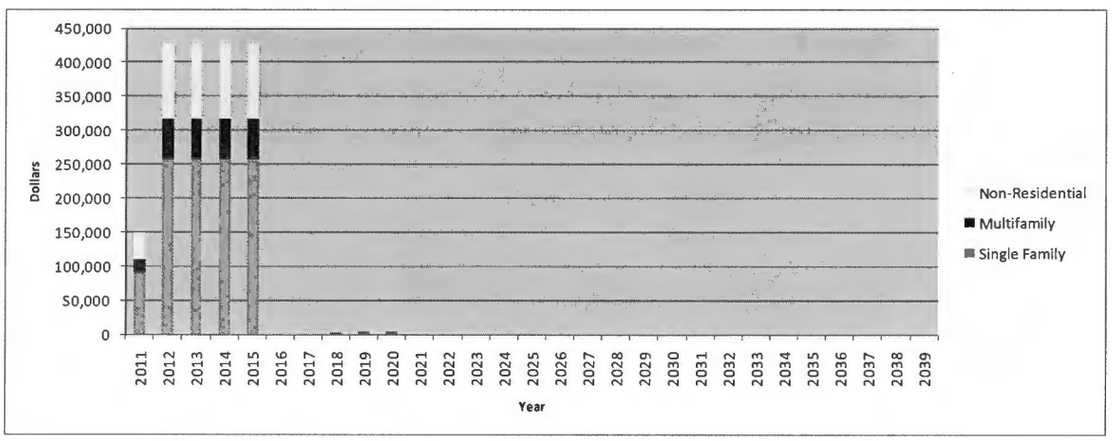


Figure 12 Total Direct Costs Each Year (Package #2)

3.4 Package #3 – Hardware Measures – Outdoor Only

This package was designed to show the maximum water savings from outdoor hardware measures that are of most interest to the City, which is limited to ET Controllers.

The results for Package #3 are shown in Table 9 (the table is located at the end of this Tech Memo since it is 11 x 17 in size). The analysis estimates the package would save approximately 81,000 gpd on an average annual basis and 122,000 gpd on a peak season basis. The total direct cost of achieving those savings is estimated at approximately $380,000 over the ten-year planning period.

Figure 13 shows that nearly half (46%) of the savings are attributed to the non-residential sector, while the single family sector accounts for 34% of the savings, and the remaining 20% of savings are attributed to the multifamily sector. By definition of the package, all of the savings are from hardware measures and are associated with measures focused only on the peak season.

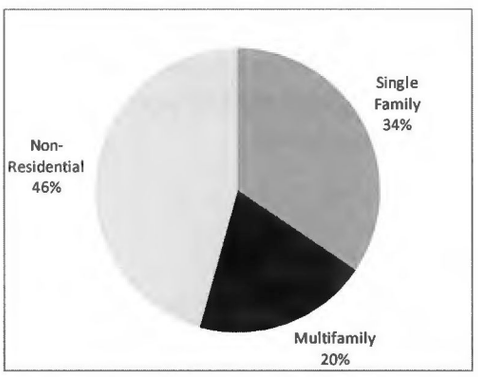


Figure 13 Savings by Customer Category (Package #3)

Figure 14 shows the gallons per day savings for each year, on an average annual basis. The pattern in the figure is similar to the pattern discussed under Package#1 - Conservation Potential Assessment. However, the savings decline more quickly after the end of the planning period since it was not necessary to renew measures during the planning period due to the interaction between the life span of ET controllers, the planning period, and the initial implementation period.

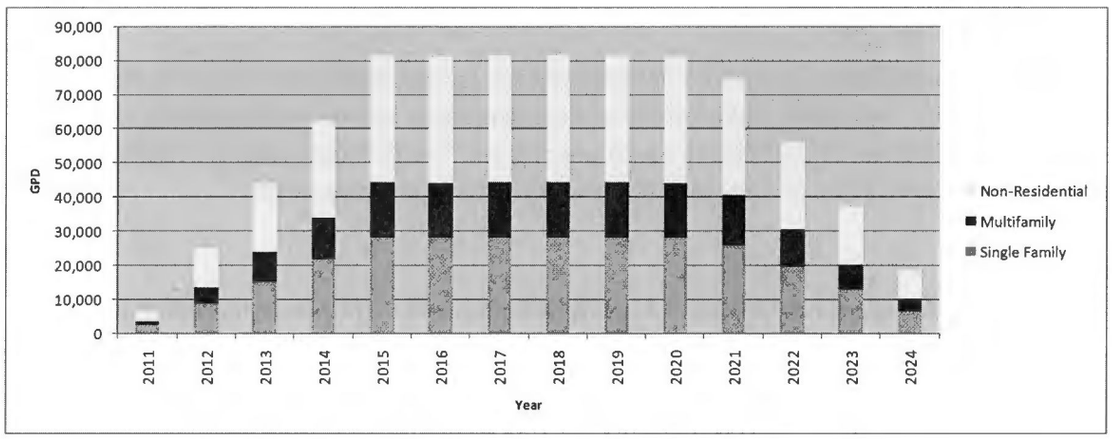


Figure 14 Total Savings Each Year (Package #3)

Figure 15 show the direct costs for each year during the planning period for each customer category. Note that the lower cost in the first year is due to the one-year "ramp-up" period, as described in Section 2.3 related to the implementation schedule.

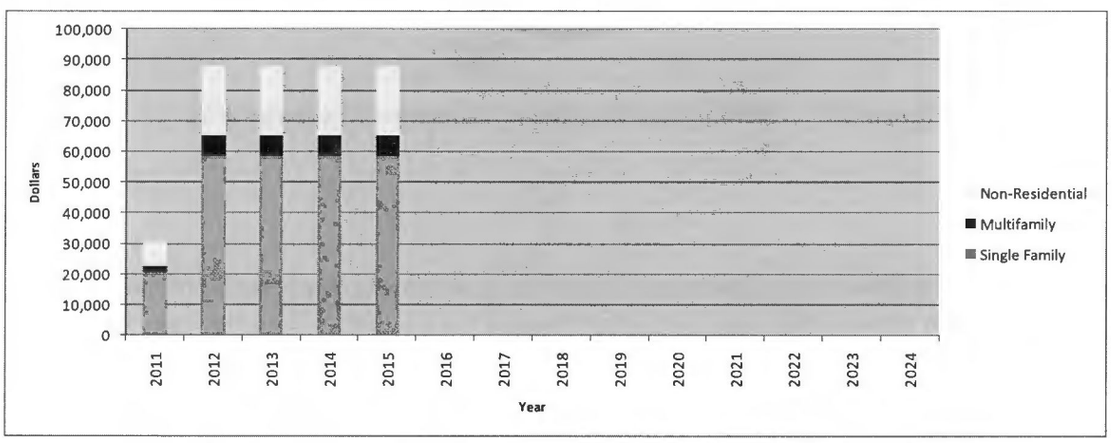


Figure 15 Total Direct Costs Each Year (Package #3)

3.5 Package #4 – Hardware Measures – Indoor Only

This package was designed to show maximum water savings for indoor hardware measures that are of most interest to the City.

The results for Package #4 are shown in Table 10 (the table is located at the end of this Tech Memo since it is 11 x 17 in size). The analysis estimates the package would save approximately 215,000 gpd on both an average annual and peak season basis. The saving are the same since the package only includes indoor measures. The total direct cost of achieving those savings is estimated at approximately $1.5 million over the ten-year planning period.

Figure 16 shows that 62% of the savings are from the single-family category, 22% from multifamily and the remaining 16% from the non-residential category. By definition of the package, all of the savings are from hardware measures and have year round savings.

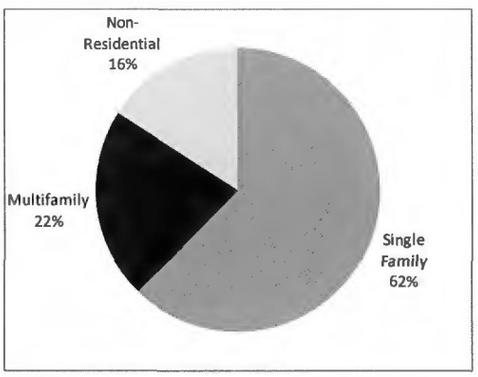


Figure 16 Savings by Customer Category (Package #4)

Figure 17 shows the gallons per day savings for each year, on an average annual basis. The pattern in the figure is similar to the pattern discussed under Package#1 - Conservation Potential Assessment.

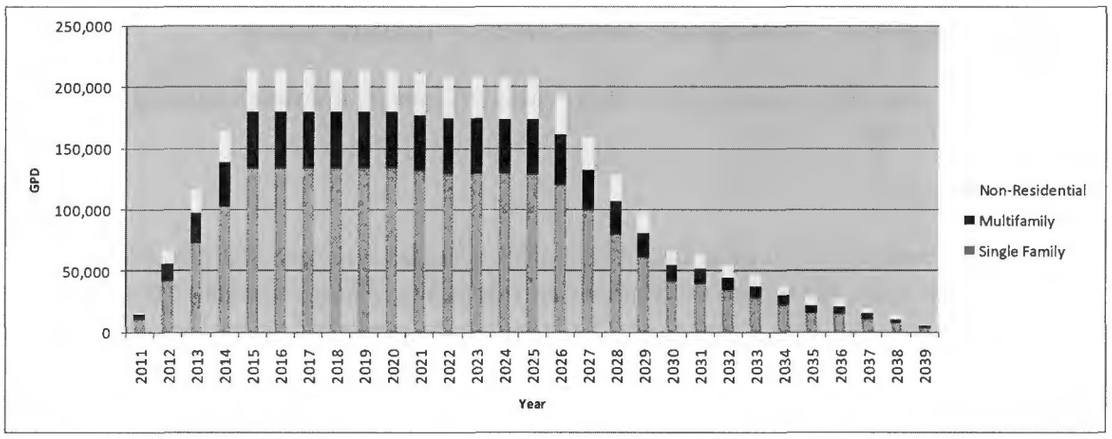


Figure 17 Total Savings Each Year (Package #4)

Figure 18 shows the direct costs for each year during the planning period for each customer category. Note that the lower cost in the first year is due to the one-year "ramp-up" period, as described in Section 2.3 related to the implementation schedule. Although it is not clearly shown in Figure 18, there are minor costs in years 2018 through 2020 due to measure renewal during the planning period.

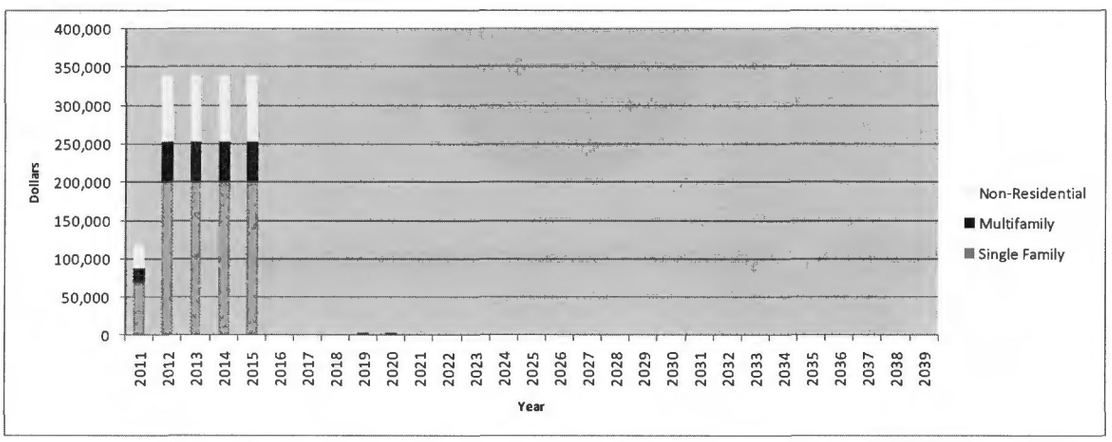


Figure 18 Total Direct Costs Each Year (Package #4)

3.6 Conclusions

A summary of the results from the conservation packages is provided in Table 11. A scatter plot of the average annual savings and the total direct cost over the planning period for each package is provided in Figure 19.

Table 11 Summary of Conservation Package Results

Package	Average Annual Savings		Peak Season Savings (gpd)	Total Direct Cost Over Planning Period	Direct Cost per CCF Saved Over Measure Life
	(gpd)	% of Average 2004-2009 Average Day Demand			
Package #1 - Conservation Potential Assessment	740,000	6.2%	980,000	$3,025,000	$0.80
Package #2 – Hardware Measures – Indoor and Outdoor	296,000	2.5%	337,000	$1,866,000	$0.93
Package #3 – Hardware Measures – Outdoor Only	81,000	0.7%	122,000	$381,000	$1.01
Package #4 – Hardware Measures – Indoor Only	215,000	1.8%	215,000	$1,485,000	$0.91

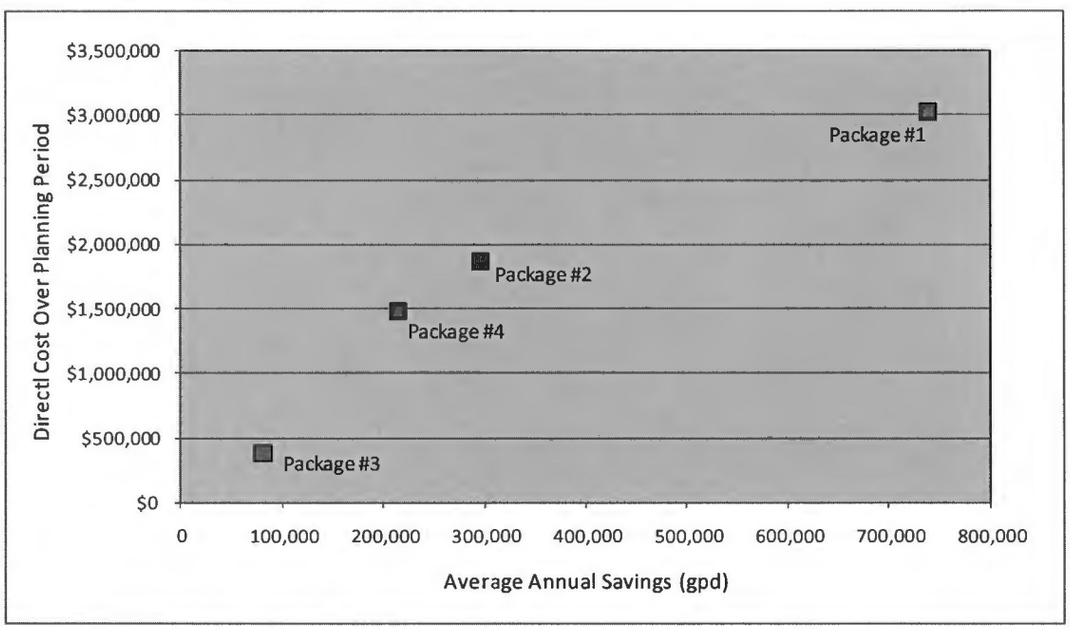


Figure 19 - Comparison of Savings and Costs

This information should be used in concert with Bend's conservation drivers, to determine which package, or subsets thereof, is the most appropriate to implement. Bend understands the environmental benefit of leaving water instream and in the aquifer and is interested in going beyond regulatory commitments to demonstrate strong stewardship of the resource. Bend is also interested in conservation as a mechanism to defer or avoid capital costs and to extend available supplies. As to the latter, the savings of each package should be compared to the volume of water needed to defer capital improvements or source development to determine if conservation can provide the volume of water needed. The direct costs and cost-effectiveness of each package should be compared to potential capital improvements and new sources to determine whether conservation is less expensive or more expensive than those more traditional solutions to water supply needs.

Even if conservation is not sufficient for Bend to avoid the need for capital improvements, the City will still want to implement conservation in order to meet State requirements and to be a good steward of the resource. In that case, each of the packages would be reasonable to implement from a cost effectiveness perspective since their cost effectiveness', which range from $0.80 to $1.01 per ccf of saved water, are all very reasonable. However, the total direct cost of every package is well beyond Bend's current conservation budget. Therefore, a desired conservation budget could be established and any of the packages could be scaled down to meet that budget by eliminating measures and/or decreasing the activity level of measures.

Table 6 Analysis Results – All Measures

Conservation Measure	Sector	Seasonality	Hardware vs Behavior	Customer Definition	PARTICIPATION[2]			SAVINGS			COSTS	
					All Customers			Savings For All Customers At Full Implementation (gpd)		Savings For All Customers Over Measure Life		
					Participating Customers	Savings Generating Customers	Devices / Rebates / Audits	Annual Average	Peak Season	CCF[1]	Total Direct Cost Over Planning Period	Cost per CCF Saved Over Measure Life
Clotheswashers - Efficient Res. Capacity (In Unit)	SF	Year Round	Hardware	SF Households	3,499	3,499	3,499	47,586	47,586	296,063	$349,900	$1.18
Clotheswashers - Efficient Res. Capacity (In Unit)	MF	Year Round	Hardware	MF Households	611	611	611	8,310	8,310	51,699	$61,100	$1.18
Clotheswashers - Efficient Res. Capacity (Common Area)	MF	Year Round	Hardware	MF Households	611	611	122	8,310	8,310	51,699	$12,220	$0.24
Clotheswashers - Efficient Comm. Capacity	NR	Year Round	Hardware	NR Accounts	7	7	84	9,408	9,408	58,533	$21,000	$0.36
Faucets - 0.5 gpm Bathroom Aerators	SF	Year Round	Hardware	SF Households	2,029	1,522	5,073	13,698	13,698	126,979	$5,070	$0.04
Faucets - 0.5 gpm Bathroom Aerators	MF	Year Round	Hardware	MF Households	789	592	1,184	3,434	3,434	31,821	$1,180	$0.04
Faucets - 1.0 gpm Bathroom Aerators	SF	Year Round	Hardware	SF Households	5,072	3,804	12,680	25,867	25,867	239,825	$12,680	$0.05
Faucets - 1.0 gpm Bathroom Aerators	MF	Year Round	Hardware	MF Households	1,973	1,480	2,960	6,512	6,512	60,366	$2,960	$0.05
Showerhead 2.0 gpm	SF	Year Round	Hardware	SF Households	5,072	3,804	10,144	18,259	18,259	126,966	$30,430	$0.24
Showerhead 2.0 gpm	MF	Year Round	Hardware	MF Households	1,973	1,480	2,960	7,104	7,104	49,390	$8,880	$0.18
Showerhead 2.0 gpm	NR	Year Round	Hardware	NR Accounts	43	32	430	6,400	6,400	44,850	$1,290	$0.03
Toilets - 1.28 gpf High Efficiency Toilets (HET)	SF	Year Round	Hardware	SF Households	2,029	2,029	4,667	16,232	16,232	188,117	$466,670	$2.48
Toilets - 1.28 gpf High Efficiency Toilets (HET)	MF	Year Round	Hardware	MF Households	789	789	1,420	6,312	6,312	73,151	$142,020	$1.94
Toilets - 1.28 gpf High Efficiency Toilets (HET)	NR	Year Round	Hardware	NR Accounts	344	344	1,455	6,777	6,777	78,543	$218,280	$2.78
Urinals - 0.5 gpf Models	NR	Year Round	Hardware	NR Accounts	689	689	1,457	4,893	4,893	45,363	$145,730	$3.21
Urinals - Waterless Models	NR	Year Round	Hardware	NR Accounts	138	138	292	1,946	1,946	18,042	$43,780	$2.43
Clotheswashers - Decrease Partial Loads	SF	Year Round	Behavior	SF Households	1,839	1,839	0	6,253	6,253	23,652	$0	$0.00
Clotheswashers - Decrease Partial Loads	MF	Year Round	Behavior	MF Households	642	642	0	2,183	2,183	8,257	$0	$0.00
Faucets - Decrease Use	SF	Year Round	Behavior	SF Households	2,029	2,029	0	6,899	6,899	26,096	$0	$0.00
Faucets - Decrease Use	MF	Year Round	Behavior	MF Households	789	789	0	1,736	1,736	6,566	$0	$0.00
Showerheads - Decrease Use	SF	Year Round	Behavior	SF Households	2,029	2,029	0	4,464	4,464	16,885	$0	$0.00
Showerheads - Decrease Use	MF	Year Round	Behavior	MF Households	789	789	0	1,736	1,736	6,566	$0	$0.00
Toilets - Decrease Flushes	SF	Year Round	Behavior	SF Households	2,029	2,029	0	4,870	4,870	18,420	$0	$0.00
Toilets - Decrease Flushes	MF	Year Round	Behavior	MF Households	789	789	0	1,894	1,894	7,163	$0	$0.00
Irrigation Controllers - ET Model	SF	Peak Only	Hardware	SF Households	1,020	1,020	1,020	28,066	42,100	130,107	$255,000	$1.96
Irrigation Controllers - ET Model	MF	Peak Only	Hardware	MF Accounts	57	57	57	16,202	24,304	75,110	$28,500	$0.38
Irrigation Controllers - ET Model	NR	Peak Only	Hardware	NR Accounts	195	195	195	37,191	55,787	172,407	$97,500	$0.57
Irrigation Controllers - Rain Sensors	SF	Peak Only	Hardware	SF Households	862	862	862	7,906	11,859	36,651	$86,200	$2.35
Irrigation Controllers - Rain Sensors	MF	Peak Only	Hardware	MF Accounts	48	48	48	4,548	6,822	21,083	$4,800	$0.23
Irrigation Controllers - Rain Sensors	NR	Peak Only	Hardware	NR Accounts	164	164	164	10,426	15,639	48,333	$16,400	$0.34
Outdoor Irrigation Kits	SF	Peak Only	Hardware	SF Households	2,847	2,135	4,384	19,584	29,376	97,878	$65,773	$0.67
Outdoor Audit	SF	Peak Only	Behavior	SF Households	1,034	259	2,068	7,127	10,690	32,973	$517,000	$15.68
Outdoor Audit	MF	Peak Only	Behavior	MF Accounts	57	14	114	3,980	5,969	18,777	$28,500	$1.52
Outdoor Audit	NR	Peak Only	Behavior	NR Accounts	196	49	392	9,345	14,018	43,323	$392,000	$9.05
Lawn Dormant	SF	Peak Only	Behavior	SF Households	1,725	1,725	0	253,180	379,770	957,710	$0	$0.00
Lawn Dormant	MF	Peak Only	Behavior	MF Accounts	55	55	0	83,309	124,964	315,136	$0	$0.00
Faucets - 0.5 gpm Bathroom Aerators	NR	Year Round	Hardware	NR Accounts	78	59	165	997	997	724	$160	$0.22
Toilets - 1.6 gpf Ultra Low Flow Toilets (ULFT)	SF	Year Round	Hardware	SF Households	977	977	2,247	22,961	22,961	33,612	$168,530	$5.01
Toilets - 1.6 gpf Ultra Low Flow Toilets (ULFT)	MF	Year Round	Hardware	MF Households	380	380	684	8,931	8,931	13,073	$51,300	$3.92
Toilets - 1.6 gpf Ultra Low Flow Toilets (ULFT)	NR	Year Round	Hardware	NR Accounts	166	166	702	9,827	9,827	14,386	$52,670	$3.66
Urinals - 1.0 gpf Models	NR	Year Round	Hardware	NR Accounts	62	62	131	440	440	322	$13,110	$40.68
Toilets - Leak Detection	SF	Year Round	Hardware	SF Households	981	491	71,866	9,034	9,034	45,101	$9,379	$0.21
Toilets - Leak Detection	MF	Year Round	Hardware	MF Households	382	191	14,203	3,514	3,514	17,562	$2,433	$0.14
Faucets - 1.5 gpm Bathroom Aerators	SF	Year Round	Hardware	SF Households	5,072	3,804	12,680	17,498	17,498	162,234	$12,680	$0.08
Faucets - 1.5 gpm Bathroom Aerators	MF	Year Round	Hardware	MF Households	1,973	1,480	2,960	4,294	4,294	39,805	$2,960	$0.07
Showerhead 1.5 gpm	SF	Year Round	Hardware	SF Households	5,072	3,804	10,144	34,997	34,997	243,352	$30,430	$0.13
Showerhead 1.5 gpm	MF	Year Round	Hardware	MF Households	1,973	1,480	2,960	13,616	13,616	94,663	$8,880	$0.09
Showerhead 1.5 gpm	NR	Year Round	Hardware	NR Accounts	43	32	430	12,160	12,160	85,216	$1,290	$0.02
Spray Valves - 1.25 gpm Pre-Rinse Spray Valve	NR	Year Round	Hardware	NR Accounts	123	123	369	14,539	14,539	67,397	$47,980	$0.71

SF – Single Family, MF – Multifamily, NR – Non-Residential

1. Savings from free riders have been omitted from this column, since this number is used in the cost-effectiveness calculation.
2. For the number of potential customers, look at the number of SF households, MF households, MF accounts, or NR accounts (as applicable) in Table 4 Demographics.

Table 7 Analysis Results – Package #1 Conservation Potential Assessment

Conservation Measure	Sector	Seasonality	Hardware / Behavior	Customer Definition	Participation: All Customers: Participating Customers	Participation: All Customers: [illegible] Customers	Participation: All Customers: Devices / Rebates / Audits	Savings: [illegible]	Savings: Peak Season	Savings: CCF[3]	Cost: [illegible] Cost Over Planning Period	Cost: [illegible]
Clotheswashers - Efficient Res. Capacity (In Unit)	SF	Year Round	Hardware	SF Households	3,499	3,499	3,499	47,586	47,586	296,063	$349,900	$1.18
Clotheswashers - Efficient Res. Capacity (In Unit)	MF	Year Round	Hardware	MF Households	611	611	611	8,310	8,310	51,699	$61,100	$1.18
Clotheswashers - Efficient Res. Capacity (Common Area)	MF	Year Round	Hardware	MF Households	611	611	122	8,310	8,310	51,699	$12,220	$0.24
Clotheswashers - Efficient Comm. Capacity	NR	Year Round	Hardware	NR Accounts	7	7	84	9,408	9,408	58,533	$21,000	$0.36
Faucets - 1.0 gpm Bathroom Aerators	SF	Year Round	Hardware	SF Households	5,072	3,804	12,680	25,867	25,867	239,825	$12,680	$0.05
Faucets - 1.0 gpm Bathroom Aerators	MF	Year Round	Hardware	MF Households	1,973	1,480	2,960	6,512	6,512	60,365	$2,960	$0.05
Toilets - 1.28 gpf High Efficiency Toilets (HET)	SF	Year Round	Hardware	SF Households	2,029	2,029	4,667	16,232	16,232	188,117	$466,670	$2.48
Toilets - 1.28 gpf High Efficiency Toilets (HET)	MF	Year Round	Hardware	MF Households	789	789	1,420	6,312	6,312	73,151	$142,020	$1.94
Toilets - 1.28 gpf High Efficiency Toilets (HET)	NR	Year Round	Hardware	NR Accounts	344	344	1,455	6,777	6,777	78,543	$218,280	$2.78
Urinals - 0.5 gpf Models	NR	Year Round	Hardware	NR Accounts	689	689	1,457	4,893	4,893	45,363	$145,730	$3.21
Clotheswashers - Decrease Partial Loads	SF	Year Round	Behavior	SF Households	1,839	1,839	0	6,253	6,253	23,652	$0	$0.00
Clotheswashers - Decrease Partial Loads	MF	Year Round	Behavior	MF Households	642	642	0	2,183	2,183	8,257	$0	$0.00
Faucets - Decrease Use	SF	Year Round	Behavior	SF Households	2,029	2,029	0	6,899	6,899	26,096	$0	$0.00
Faucets - Decrease Use	MF	Year Round	Behavior	MF Households	789	789	0	1,736	1,736	6,566	$0	$0.00
Showerheads - Decrease Use	SF	Year Round	Behavior	SF Households	2,029	2,029	0	4,464	4,464	16,885	$0	$0.00
Showerheads - Decrease Use	MF	Year Round	Behavior	MF Households	789	789	0	1,736	1,736	6,566	$0	$0.00
Toilets - Decrease Flushes	SF	Year Round	Behavior	SF Households	2,029	2,029	0	4,870	4,870	18,420	$0	$0.00
Toilets - Decrease Flushes	MF	Year Round	Behavior	MF Households	789	789	0	1,894	1,894	7,163	$0	$0.00
Irrigation Controllers - ET Model	SF	Peak Only	Hardware	SF Households	1,020	1,020	1,020	28,066	42,100	130,107	$255,000	$1.96
Irrigation Controllers - ET Model	MF	Peak Only	Hardware	MF Accounts	57	57	57	16,202	24,304	75,110	$28,500	$0.38
Irrigation Controllers - ET Model	NR	Peak Only	Hardware	NR Accounts	195	195	195	37,191	55,787	172,407	$97,500	$0.57
Irrigation Controllers - Rain Sensors	SF	Peak Only	Hardware	SF Households	862	862	862	7,906	11,859	36,651	$86,200	$2.35
Irrigation Controllers - Rain Sensors	MF	Peak Only	Hardware	MF Accounts	48	48	48	4,548	6,822	21,083	$4,800	$0.23
Irrigation Controllers - Rain Sensors	NR	Peak Only	Hardware	NR Accounts	164	164	164	10,426	15,639	48,333	$16,400	$0.34
Outdoor Irrigation Kits	SF	Peak Only	Hardware	SF Households	2,847	2,135	4,384	19,584	29,376	97,878	$65,773	$0.67
Outdoor Audit	SF	Peak Only	Behavior	SF Households	1,034	259	2,068	7,127	10,690	32,973	$517,000	$15.68
Outdoor Audit	MF	Peak Only	Behavior	MF Accounts	57	14	114	3,980	5,969	18,777	$28,500	$1.52
Outdoor Audit	NR	Peak Only	Behavior	NR Accounts	196	49	392	9,345	14,018	43,323	$392,000	$9.05
Lawn Dormant	SF	Peak Only	Behavior	SF Households	1,725	1,725	0	253,180	379,770	957,710	$0	$0.00
Lawn Dormant	MF	Peak Only	Behavior	MF Accounts	55	55	0	83,309	124,964	315,136	$0	$0.00
Faucets - 0.5 gpm Bathroom Aerators	NR	Year Round	Hardware	NR Accounts	78	59	165	997	997	724	$160	$0.22
Toilets - Leak Detection	SF	Year Round	Hardware	SF Households	981	491	71,866	9,034	9,034	45,101	$9,379	$0.21
Toilets - Leak Detection	MF	Year Round	Hardware	MF Households	382	191	14,203	3,514	3,514	17,562	$2,433	$0.14
Showerhead 1.5 gpm	SF	Year Round	Hardware	SF Households	5,072	3,804	10,144	34,997	34,997	243,352	$30,430	$0.13
Showerhead 1.5 gpm	MF	Year Round	Hardware	MF Households	1,973	1,480	2,960	13,616	13,616	94,663	$8,880	$0.09
Showerhead 1.5 gpm	NR	Year Round	Hardware	NR Accounts	43	32	430	12,160	12,160	85,216	$1,290	$0.02
Spray Valves - 1.25 gpm Pre-Rinse Spray Valve	NR	Year Round	Hardware	NR Accounts	123	123	369	14,539	14,539	67,397	$47,980	$0.71
Total					N/A	N/A	N/A	739,962	980,395	3,760,467	$3,024,785	$0.80

SF – Single Family, MF – Multifamily, NR – Non-Residential

1. Savings from free riders have been omitted from this column, since this number is used in the cost-effectiveness calculation.
2. For the number of potential customers, look at the number of SF households, MF households, MF accounts, or NR accounts (as applicable) in Table 4 Demographics.

Table 8 Analysis Results – Package #2 Hardware Measures: Indoor and Outdoor

Conservation Measure	Sector	Seasonality	Behavior	Customer Definition	All Customers			Savings For All Customers At Full Implementation (gpd)				
					Participating Customers	Customers	Devices / Rebates / Audits	Annual Average	Peak Season	CCF[1]	Cost Over Planning Period	
Clotheswashers - Efficient Res. Capacity (In Unit)	SF	Year Round	Hardware	SF Households	3,499	3,499	3,499	47,586	47,586	296,063	$349,900	$1.18
Clotheswashers - Efficient Res. Capacity (In Unit)	MF	Year Round	Hardware	MF Households	611	611	611	8,310	8,310	51,699	$61,100	$1.18
Clotheswashers - Efficient Res. Capacity (Common Area)	MF	Year Round	Hardware	MF Households	611	611	122	8,310	8,310	51,699	$12,220	$0.24
Clotheswashers - Efficient Comm. Capacity	NR	Year Round	Hardware	NR Accounts	7	7	84	9,408	9,408	58,533	$21,000	$0.36
Faucets - 1.0 gpm Bathroom Aerators	SF	Year Round	Hardware	SF Households	5,072	3,804	12,680	25,867	25,867	239,825	$12,680	$0.05
Faucets - 1.0 gpm Bathroom Aerators	MF	Year Round	Hardware	MF Households	1,973	1,480	2,960	6,512	6,512	60,365	$2,960	$0.05
Toilets - 1.28 gpf High Efficiency Toilets (HET)	SF	Year Round	Hardware	SF Households	2,029	2,029	4,667	16,232	16,232	188,117	$466,670	$2.48
Toilets - 1.28 gpf High Efficiency Toilets (HET)	MF	Year Round	Hardware	MF Households	789	789	1,420	6,312	6,312	73,151	$142,020	$1.94
Toilets - 1.28 gpf High Efficiency Toilets (HET)	NR	Year Round	Hardware	NR Accounts	344	344	1,455	6,777	6,777	78,543	$218,280	$2.78
Urinals - 0.5 gpf Models	NR	Year Round	Hardware	NR Accounts	689	689	1,457	4,893	4,893	45,363	$145,730	$3.21
Irrigation Controllers - ET Model	SF	Peak Only	Hardware	SF Households	1,020	1,020	1,020	28,066	42,100	130,107	$255,000	$1.96
Irrigation Controllers - ET Model	MF	Peak Only	Hardware	MF Accounts	57	57	57	16,202	24,304	75,110	$28,500	$0.38
Irrigation Controllers - ET Model	NR	Peak Only	Hardware	NR Accounts	195	195	195	37,191	55,787	172,407	$97,500	$0.57
Faucets - 0.5 gpm Bathroom Aerators	NR	Year Round	Hardware	NR Accounts	78	59	165	997	997	724	$160	$0.22
Toilets - Leak Detection	SF	Year Round	Hardware	SF Households	981	491	71,866	9,034	9,034	45,101	$9,379	$0.21
Toilets - Leak Detection	MF	Year Round	Hardware	MF Households	382	191	14,203	3,514	3,514	17,562	$2,433	$0.14
Showerhead 1.5 gpm	SF	Year Round	Hardware	SF Households	5,072	3,804	10,144	34,997	34,997	249,352	$30,430	$0.13
Showerhead 1.5 gpm	MF	Year Round	Hardware	MF Households	1,973	1,480	2,960	13,616	13,616	94,663	$8,880	$0.09
Showerhead 1.5 gpm	NR	Year Round	Hardware	NR Accounts	43	32	430	12,160	12,160	85,216	$1,290	$0.02
Total					N/A	N/A	N/A	295,986	336,716	2,007,601	$1,866,132	$0.93

SF – Single Family, MF – Multifamily, NR – Non-Residential

1. Savings from free riders have been omitted from this column, since this number is used in the cost-effectiveness calculation.
2. For the number of potential customers, look at the number of SF households, MF households, MF accounts, or NR accounts (as applicable) in Table 4 Demographics.

Table 9 Analysis Results –Package 3 Hardware Measures: Outdoor Only

Conservation Measure	Sector	Seasonality	Hardware vs Behavior	Customer Definition	PARTICIPATION: All Customers			SAVINGS: Savings For All Customers At Full Implementation (gpd)		SAVINGS: Savings For All Customers Over Measure Life	COSTS	
					Participating Customers	Savings Contributing Customers	Devices / Homes / Audits	Annual Average	Peak Season	CCF[1]	Total Direct Cost Over Planning Period	Cost per CCF Saved Over Measure Life
Irrigation Controllers - ET Model	SF	Peak Only	Hardware	SF Households	1,020	1,020	1,020	28,066	42,100	130,107	$255,000	$1.96
Irrigation Controllers - ET Model	MF	Peak Only	Hardware	MF Accounts	57	57	57	16,202	24,304	75,110	$28,500	$0.38
Irrigation Controllers - ET Model	NR	Peak Only	Hardware	NR Accounts	195	195	195	37,191	55,787	172,407	$97,500	$0.57
Total					N/A	N/A	N/A	81,460	122,190	377,624	$381,000	$1.01

SF – Single Family, MF – Multifamily, NR – Non-Residential

1. Savings from free riders have been omitted from this column, since this number is used in the cost-effectiveness calculation.
2. *For the number of potential customers, look at the number of SF households, MF households, MF accounts, or NR accounts (as applicable) in Table 4 Demographics.*

Table 10 Analysis Results – Package #4 Hardware Measures: Indoor Only

Conservation Measure	Sector	[illegible]	Behavior	Customer Definition	All Customers	[illegible]	Devices / Rebates / Audits	Savings For All Customers At Full Implementation (gpd) Annual Average	Peak Season	CCF[1]	Planning Period	[illegible]
Clotheswashers - Efficient Res. Capacity (In Unit)	SF	Year Round	Hardware	SF Households	3,499	3,499	3,499	47,586	47,586	296,063	$349,900	$1.18
Clotheswashers - Efficient Res. Capacity (In Unit)	MF	Year Round	Hardware	MF Households	611	611	611	8,310	8,310	51,699	$61,100	$1.18
Clotheswashers - Efficient Res. Capacity (Common Area)	MF	Year Round	Hardware	MF Households	611	611	122	8,310	8,310	51,699	$12,220	$0.24
Clotheswashers - Efficient Comm. Capacity	NR	Year Round	Hardware	NR Accounts	7	7	84	9,408	9,408	58,533	$21,000	$0.36
Faucets - 1.0 gpm Bathroom Aerators	SF	Year Round	Hardware	SF Households	5,072	3,804	12,680	25,867	25,867	239,825	$12,680	$0.05
Faucets - 1.0 gpm Bathroom Aerators	MF	Year Round	Hardware	MF Households	1,973	1,480	2,960	6,512	6,512	60,365	$2,960	$0.05
Toilets - 1.28 gpf High Efficiency Toilets (HET)	SF	Year Round	Hardware	SF Households	2,029	2,029	4,667	16,232	16,232	188,117	$466,670	$2.48
Toilets - 1.28 gpf High Efficiency Toilets (HET)	MF	Year Round	Hardware	MF Households	789	789	1,420	6,312	6,312	73,151	$142,020	$1.94
Toilets - 1.28 gpf High Efficiency Toilets (HET)	NR	Year Round	Hardware	NR Accounts	344	344	1,455	6,777	6,777	78,543	$218,280	$2.78
Urinals - 0.5 gpf Models	NR	Year Round	Hardware	NR Accounts	689	689	1,457	4,893	4,893	45,363	$145,730	$3.21
Faucets - 0.5 gpm Bathroom Aerators	NR	Year Round	Hardware	NR Accounts	78	59	165	997	997	724	$160	$0.22
Toilets - Leak Detection	SF	Year Round	Hardware	SF Households	981	491	71,866	9,034	9,034	45,101	$9,379	$0.21
Toilets - Leak Detection	MF	Year Round	Hardware	MF Households	382	191	14,203	3,514	3,514	17,562	$2,433	$0.14
Showerhead 1.5 gpm	SF	Year Round	Hardware	SF Households	5,072	3,804	10,144	34,997	34,997	243,352	$30,430	$0.13
Showerhead 1.5 gpm	MF	Year Round	Hardware	MF Households	1,973	1,480	2,960	13,616	13,616	94,663	$8,880	$0.09
Showerhead 1.5 gpm	NR	Year Round	Hardware	NR Accounts	43	32	430	12,160	12,160	85,216	$1,290	$0.02
Total					N/A	N/A	N/A	214,526	214,526	1,629,977	$1,485,332	$0.91

SF – Single Family, MF – Multifamily, NR – Non-Residential

1. Savings from free riders have been omitted from this column, since this number is used in the cost-effectiveness calculation.
2. For the number of potential customers, look at the number of SF households, MF households, MF accounts, or NR accounts (as applicable) in Table 4 Demographics.

Avion Water Company Inc.

Master Plan

2006



Expiration Date 6/30/08

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Chapter 1 Introduction

Chapter 1

Introduction

This report is a master plan for Avion Water Company Inc. It is supplementary to Avion's 2003 Water Management and Conservation Plan.

The following topics are covered:

- Water Requirements
- Regulatory and Service Goals
- Storage and Telemetry
- Distribution System
- Capital Improvement Plans

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Mike Miller: City of Bend.

Chapter 2 Executive Summary

Chapter 2

Executive Summary

This master plan provides an outline for possible development and upgrading of the existing Avion system. It outlines improvements and capital projects which Avion intends to implement to meet future and current needs of our customers and water system.

System Description

Avion Water Company is a public water system operated in Deschutes and Crook counties that currently serves around 10,500 customers.

The water supply is the Deschutes Basin aquifer. All of Avion's water is taken from this aquifer and the water does not require any chemical treatment. The system is gravity flow, flowing from the south end of Bend to the north end. There are various pressure reducing stations and booster stations throughout the system depending on location. Avion can currently pump 14.25 million gallons per day. Combined with 9.9 million in storage Avion has the production abilities for significant growth. In 2003 Avion produced an average of 3.28 million gallons per day while in 2006 Avion has averaged an estimated 5.07 million gallons per day to date. The peak day in 2006 was July 19th where Avion produced 13.55 million gallons.

Recommended Improvements

Avion Water has been providing safe drinking water and excellent service to the public since the late sixties. Over the past twenty years Avion has one of the best, if not the best, records of customer satisfaction of any privately owned publicly regulated utility. With continued expansion comes the need to upgrade Avion's existing facilities and install new ones. Recommended upgrades and improvements are listed in chapter 9 along with the deficiencies they address. This chapter also provides initial cost estimates for these projects. The total cost for implementing the improvements over the twenty year planning period is $5,000,000.00. This $5,000,000 is additional capital that Avion may need to acquire in addition to System Impact Fees that are paid by developers. The systems development fee is currently set at $1000 per lot. These fees are mandated by the PUC to be used for capital improvement projects.

Near Term Needs

1. Increase flow to the north end of the system. Avion is attempting to acquire a 3 acre easement near the intersection of Butler Market Rd and Hamehook Rd. The site will be used for placement of two 2.5 million gallon reservoirs, a large pumping station, and two high capacity (2000-3000gpm) wells. The site will tie into the main system on Hamehook Rd. Additionally there are plans to run a 24"

mainline from this site to Powell Butte to serve the future demands of that area. By creating this site Avion will effectively cut its system into two parts; one north of Highway 20 served by the new site supplemented with water from south of Highway 20, and the one south of Highway 20 which will supplement demand on the north end of the system. This site should be the main major improvement needed for the next 15-20 years, depending on growth. Current cost estimates are 2.3 million dollars for the first reservoir, pump station, one well, and all the site work required for the project. The financing of this project will be equity capital from stockholders and systems improvement charges from developers.

2. Add a new 12" main from Ponderosa to Brookswood. This line is approximately 4100 ft long and will cost an estimated $200,000. This would be financed at the same time and by the same method as the Dyer reservoir site. This will provide better service and increased supply during high demand periods west of Hwy 97.

3. Acquire the mitigation credits needed to satisfy Avion's two new water permits. The permits are for 10 cfs and 5cfs. Avion has entered into an agreement with Swalley Irrigation and has one pending with Central Oregon Irrigation which will allow Avion to acquire enough mitigation credits, through the DRC water bank, to satisfy the new permit requirements.

4. Upgrade the pumping capacity at the Ponderosa pump station, estimated cost $3000. This will provide better service and increased supply during high demand periods west of Hwy 97.

5. Increase the size of the middle Sundance reservoir by 20,000 gallons. The current size is not adequate on high water use days and adding on to the reservoir will remedy this. Estimated cost is $20,000.

6. Continue to add remote pressure monitoring equipment at all pressure reducing stations. Estimated cost is $20,000.

7. Purchase three new ½ ton pick up trucks for the service crew, estimated cost is $57,000.

8. Bring Brasada and the Powell Butte system on-line in the Wunderware control program. Estimated cost is $5,000. This will eliminate long travel times for the service crew and help reduce costs while increasing system control.

9. Re-wire Deschutes River Woods pump station to remove the intermittent telemetry signal interference. Estimated cost $2000.

10. Bring new well at Riverbend on-line, estimated cost $5,000.

11. Update Avion's Water Management and Conservation Plan before 2008. Completing this will keep Avion current on all state of Oregon requirements. No cost is listed since it will be completed by Avion's staff.

Long Term Significant Projects

1. Develop the Powell Butte water system to serve the estimated 7,000-9,000 customers in that area. Avion is currently negotiating a contract between three different developers who are interested in creating destination resorts in Powell Butte. The aquifer in the Powell Butte area is unreliable so the resorts have contacted Avion to provide domestic water service with shoulder season irrigation service. The initial estimates to get water to the various properties vary from $9,000,000-$12,000,000 depending on pipe costs. The main transmission line will run from Butler Market and Hamehook roads to near the intersection of Shumway and Halen roads. The interior facilities needed at the different properties will be laid out once the planning process is further along. Avion currently has 860,000 gallons of storage in Powell Butte. Avion estimates another 2-5 million gallons of storage will be needed, depending on final resort populations. The financing for this project will be provided by the resort developers.

2. Develop the second high capacity well (2000-3000gpm) at the Hamehook reservoir site. Estimated cost is $500,000.

3. Drill 2 new wells along Knott Rd. Avion currently has an easement which will allow 2 new wells and a pump station to be constructed. This will provide an estimated 4000 gpm once completed. Estimated cost is $219,000. The need to develop this site will be significantly decreased by the construction of the reservoir and wells north of Hwy 20. Depending on growth this site needs to be constructed in the next 10-20 years.

4. Increase the line from the Deschutes River Woods Reservoir to Baker Rd. from 12" to 18". Estimated cost is $170,000 for approximately 3000 ft of 18" water line.

5. Continually update the water model to reflect the field measured flows and pressures as accurately as possible.

Chapter 3 Description of Existing System

Chapter 3

Description of Existing System

History

Avion Water Company, Public Water System (PWS) #4100091, is a privately owned public utility that is regulated by the Oregon Public Utility (PUC) commission. Avion Water Company began in a small subdivision on the outskirts of Bend in 1968. Over the years Avion acquired various other small subdivisions throughout Deschutes and Crook counties. Avion was sold to the current ownership in 1987. Over the next five years all of the small systems outlying the Bend area was inter-tied to create the gravity flow system that exists today. The gravity flow system flows from the south side of Bend to the north side. There are three large reservoirs on the south side, totaling 9.8 million gallons of storage, which feed the system. The reservoirs and overall system are fed from 10 main production wells (See attached system map for more details) which can currently produce 14.25 million gallons per day. Over the past ten years the original main transmission lines have been upgraded from 12 inch to 18 and 24 inch. The total length of pipeline in the ground is approaching 350 miles in length.

Service Characteristics

Avion currently serves approximately 10,500 customers and has been experiencing 10% - 15% customer account growth per year. The winter months of 2006 saw an average of 100 new connections per month but that has dropped off significantly in July and August of 2006. There are currently 985 commercial accounts and 9,539 residential accounts. Based on 2.55 persons per household this is a customer population base of 24,324. The population estimate in the 2004 Water Management and Conservation Plan was for around 24,200 so we are following our predicted growth trend fairly closely.

Supply

The Deschutes Aquifer is the sole source for Avion Water. Static ground water levels have remained constant in all of our production wells and the water requires no treatment. According to the most recent USGS study of the basin there is more than enough water to meet the needs of the basin. Municipal and quasi-municipal use only accounts for approximately 2% of the water used annually in the basin. Avion currently has enough water rights to last through 2018 by current population estimates. The water from the aquifer is delivered to the main system by 11 production wells, 5 of which pump directly in to reservoirs, while the other 6 pump directly into mainlines. China Hat #1 and #2, DRW, Connestoga, and Sundance pump directly into reservoirs while Riverbend #1, Riverbend #3, Tekampe A, Tekampe B, Tekampe C, and Parrell Rd are wells with variable speed drives that pump directly into the system. The variable speed drives are required to prevent water hammer when the wells start. The 11 production wells produce a total of 10,940 gpm.

Storage

Avion's main storage facilities consist of 2 concrete reservoirs located on China Hat Rd and one bolted steel tank at Deschutes River Woods. They are 2.9 million, 4.6 million, and 2.4 million gallons respectively. The tops of the tanks are set to the same elevation so they float on the system. There are several small reservoirs located throughout the main system. They are the remnants of the neighborhood systems that were eventually inter-tied. The small reservoirs are as follows; Connestoga (140,000gal), Lower Sundance (30,000gal), Middle Sundance (20,000gal), Whispering Pines (50,000gal). The main reservoirs are fed from two well sites, two wells each at Deschutes River Woods and China Hat. All four of these wells are line shaft turbines. The other main well sites, Tekampe (3 wells), Riverbend (2 wells), Parrell, Connestoga, and Sundance are all deep well submersibles that pump directly into the system at various points (see attached map). The submersibles are all controlled with variable speed drives to prevent water hammer.

Distribution System

The system consists of various pipe sizes up to and including 24 inch. The system is mainly comprised of PVC pipe with almost all other type of piping represented in various small quantities.

The main transmission lines run south to north from the China Hat and DRW reservoirs. East of Highway 97 the lines are 18" and 20" to Stevens Rd and 20" from Stevens to Bear Creek Rd. From Bear Creek North there is a 24", 12" and a 14" to the entrance of the Christian Life Center along Hamby Rd. From this point the 12" and the 14" continue to Butler Market and Hamby Rd. From this point it splits into 12" heading west and 16" heading out to Pronghorn. East of Highway 97 has the Tekampe and Parrell Rd wells boosting flows and therefore indirectly boosting pressure on the west side of Hwy 97.

West of Hwy 97 a 12" transmission line runs from the DRW reservoir to Brookswood. Various 8" and 12" lines run north from Brookswood and Buck Canyon down to the Wood River Village subdivision. There is an additional 12" line that crosses Highway 97 at China Hat Rd which provides additional flow. Refer to the included maps for major pipeline location and sizes.

Avion Water Company is inter-tied with Roat's Water Company at two locations; one on Parrell Rd. just north of the Mountain Pines subdivision and again along Brookswood Blvd. just north of Larkwood Dr. Roat's Water system operates a well that produces 2000 gpm and empties into the DRW reservoir. Roat's is charged a wheeling fee for the amount of water used by their system. They are issued a water credit based off of water produced by their well subtracted from the water that passed through the two meters at the inter-ties.

Chapter 4 Water Requirements

Chapter 4

Water Requirements

Avion Water Company serves around 10,500 customers in the Bend / Redmond / Powell Butte area. Of these accounts only 960, or about 9%, are commercial accounts. The overall water use per capita has remained stable for the past few years and it is expected to remain so.

A summary of the water use statistics for 2003 and 2005 are listed below in tables 4.1A through table 4.4B. It is interesting to note that there was a slight increase in the peak per capita water usage and there was also a small decrease in non-peak water usage. We believe that this occurs because almost all the new houses constructed today are equipped with automatic irrigation systems, but also have water conserving appliances and fixtures installed. The new lots are much smaller than those that existed before but do not have any irrigation rights so they use domestic water to irrigate as opposed to canal water. Avion has approximately 798 irrigation customers, many of which are within the current urban growth boundary. As these lots are developed into subdivisions with smaller lots, 6 lots per acre, they will not have canal water available. This means they will have to irrigate with domestic water so we will probably see small increases in the peak per capita demand over the next several years. The 2005 statistics has the golf course use removed from it. There are two new courses the came into operation between 2003 and 2005. The two new courses are in the Pronghorn resort development and only need to use Avion water when the City of Bend's sewage treatment plant cannot produce level four effluent. In the beginning the plant struggled to produce the level four effluent required on a consistent basis but has improved greatly in its reliability in 2006. All golf course irrigation with domestic water is interruptible for public needs.

2005 & 2003 Water Use Summaries

TABLE 4.1A

2003 WATER USE STATISTICS SUMMARY

Total Year	159,801,517 cubic feet	3669 acre feet
Peak Month (August)	31,908,089 cubic feet	733 acre feet
Minimum Month (February)	4,521,053 cubic feet	104 acre feet
Average Daily	437,813 cubic feet	2,274 gpm
Peak Daily	1,529,108 cubic feet	7,944 gpm
Ave. Day to Peak Day Ratio		2.46
Peak Daily per Capita		546 gpd
Average Annual Daily per Capita		170 gpd
Non-peak Season Ave. Daily per Capita		94 gpd

(1) Non-peak season is defined as November 2002 through April 2003.
(2) December 2003 ignored in usage and time due to all usage being estimated

TABLE 4.1B

2005 WATER USE STATISTICS SUMMARY

Total Year	223,087,625 cubic feet	5,121 acre feet
Peak Month (August)	43,447,487 cubic feet	997 acre feet
Minimum Month (January)	6,345,269 cubic feet	146 acre feet
Average Daily	611,199 cubic feet	3,175 gpm
Peak Daily	1,799,099 cubic feet	9,346 gpm
Ave. Day to Peak Day Ratio		2.94
Peak Daily per Capita		573 gpd
Average Annual Daily per Capita*		178 gpd
Non-peak Season Ave. Daily per Capita		89 gpd

(1) Non-peak season is defined as January through April and November through December 2006.
* Usage for golf courses has been removed; two courses at Pronghorn and one at Lost Tracks.

Monthly Water Use Data

A tabulation of monthly water use for residential customers from July 1994 through December 1996 is shown on tables 4.2A and July 2001 through December 2005 on Table 4.2B. Data from these tables is useful to indicate the typical periods of minimum and maximum water use on a monthly basis.

The per capita water use is calculated from the number of residential connections with 2.55 people per residential connection. The average household size of 2.55 people per household is taken from the Deschutes County Comprehensive Plan (Telephone conversation with the Deschutes County Community Development Department). This household size estimate compares favorably to the Portland State University household size estimate of 2.65 people.

A key statistic shown in Tables 4.2A and 4.2B is that the average per capita water use during December 1995 equals 70 gallons per capita per day. A nearly identical per capita water use of 71 gallons occurred in January 1995, 75 gallons in January 2002, 75 gallons in January 2003, and 64 gallons in December 2005. 70 gallons per capita per day is the national average winter water flow determined from an Environmental Protection Agency needs survey of 270 Standard Metropolitan Statistical Area cities. Based on this comparison, winter water use in the Avion service area is shown to be essentially identical to the national average per capita water use when outside water use is excluded.

Short term declines of residential connections can be seen in the Table 4.2A and 4.2B which starts in almost every November and December. The decline appears odd in the context of steady growth seen during other months of the year. The reason for the decline is that many residents vacation for extended periods of time outside of Central Oregon, apparently to avoid the winter weather. The Avion PUC tariff allows Avion customers to disconnect the meters of vacant homes without a service charge so that freezing weather does not damage meters and service lines. In some years, the November and December decline is offset by new connections that have occurred by the following January. Although the reconnection process is gradual, the percentage of growth seen in April of almost every year is an indication that most services are reconnected by this month.

Usually only half of the meters are read for usage and half are estimated in the winter months, depending on snow cover. If snow cover is too great usage for the entire system is estimated at 700 cubic feet per residence. The average monthly diversions are listed below on table 4.2A and 4.2B

TABLE 4.2A

MONTHLY WATER USE DATA - 1994 TO 1996 AVION WATER COMPANY, INC

Date	No. of Residences	Population Served (1)	Cubic Feet per Month	Gal/Day per Residence	Gal/Capita per Day	Percent of Pop Growth per Month
Jul '94	5692	14,515	18,707,967	793	311	0.32%
Aug '94	5731	14,614	21,125,834	889	349	0.68%
Sep '94	5740	14,637	22,767,311	989	388	0.16%
Oct '94	5750	14,662	16,082,961	675	265	0.17%
Nov '94	5728	14,606	4,325,262	188	74	-0.38%
Dec '94	5714	14,571	4,630,400	196	77	-0.25%
Jan '95	5755	14,675	4,341,219	182	71	0.71%
Feb '95	5761	14,691	4,234,688	196	77	0.10%
Mar '95	5774	14,724	4,541,932	190	74	0.23%
Apr. '95	5838	14,887	7,226,440	309	121	1.10%
May '95	5854	14,928	6,873,643	283	111	0.27%
Jun '95	5900	15,045	12,788,415	540	212	0.78%
Jul '95	5934	15,132	17,315,196	704	276	0.57%
Aug '95	5959	15,195	19,331,810	783	307	0.42%
Sep '95	5976	15,239	19,983,699	834	327	0.28%
Oct '95	6004	15,310	17,097,795	687	269	0.47%
Nov '95	5998	15,295	5,863,301	244	96	-0.10%
Dec '95	5761	14,691	4,234,688	177	70	-4.11%
Jan '96	6016	15,341	4,875,784	196	77	4.24%
Feb '96	6033	15,384	6,132,620	262	103	0.28%
Mar '96	6064	15,463	7,076,338	282	110	0.51%
Apr.'96	6140	15,657	7,122,684	289	113	1.24%
May '96	6176	15,749	10,210,096	399	156	0.58%
Jun '96	6213	15,843	21,451,216	861	338	0.60%
Jul '96	6278	16,009	20,719,456	796	312	1.04%
Aug '96	6286	16,029	30,435,566	1,168	458	0.13%
Sep '96	6294	16,050	23,272,753	922	362	0.13%
Oct '96	6301	16,068	17,347,758	664	261	0.11%
Nov '96	6285	16,027	5,380,061	213	84	0.25%
Dec '96	6296	16,055	6,016,403	231	90	0.17%

1) Based on 2.55 people per residence.

TABLE 4.2B

MONTHLY WATER USE DATA - 2001 TO 2005 AVION WATER COMPANY

Date	No. Of Residences	Population Served (1)	Cubic Feet per Month	Gal/Day per Residence	Gal/Capita per Day	Percent of Pop Growth per Month
Jul '01	6872	17,524	22,257,019	782	307	0.40%
Aug '01	6870	17,518	21,519,290	756	296	-0.03%
Sep '01	6875	17,532	23,836,927	837	328	0.07%
Oct '01	6880	17,544	14,352,753	503	197	0.07%
Nov '01	6867	17,511	5,575,389	203	79	-0.19%
Dec '01	7085	18,067	7,746,400	264	104	3.08%
Jan '02	6824	17,402	5,380,427	190	75	3.68%
Feb '02	6823	17,399	5,010,245	196	77	0.10%
Mar '02	6847	17,460	4,685,023	165	65	0.35%
Apr. '02	6890	17,560	4,929,204	179	70	0.62%
May '02	6977	17,792	9,631,244	333	131	1.25%
Jun '02	6991	17,827	23,721,572	846	332	0.20%
Jul '02	7029	17,924	26,001,660	893	350	0.54%
Aug '02	7065	18,016	28,756,258	983	386	0.51%
Sep '02	7091	18,082	23,391,598	796	312	0.37%
Oct '02	7116	18,146	15,683,621	532	209	0.35%
Nov '02	7087	18,072	5,610,283	198	78	0.41%
Dec '02	7117	18,149	7,963,275	270	106	0.42%
Jan '03	7097	18,098	5,563,137	190	75	0.28%
Feb '03	7149	18,230	4,786,820	173	68	0.73%
Mar '03	7171	18,286	4,521,053	152	60	0.31%
Apr '03	7249	18,485	5,293,658	182	72	1.08%
May '03	7298	18,610	8,923,493	295	116	0.67%
Jun '03	7379	18,817	22,762,314	770	302	1.10%
Jul '03	7415	18,910	24,560,065	800	314	0.49%
Aug '03	7452	19,003	31,908,089	1034	406	0.50%
Sep '03	7519	19,174	25,681,624	852	334	0.89%
Oct '03	7551	19,256	17,369,943	555	218	0.42%
Nov '03	7548	19,248	7,002,604	231	91	0.04%
Dec '03	7562	19,284	1,428,717	81	19	0.19%
Jan '04	7558	19,273	5,240,673	167	65	-0.05%
Feb '04	7575	19,316	6,067,783	214	84	0.22%
Mar '04	7614	19,415	4,431,075	140	55	0.51%
Apr '04	7766	19,803	6,785,916	218	85	1.96%
May '04	7829	19,964	19,444,755	599	235	0.80%
Jun '04	7872	20,074	16,187,404	513	201	0.55%
Jul '04	7914	20,181	29,753,071	907	356	0.53%
Aug '04	7970	20,324	29,608,624	897	352	0.70%
Sep '04	8028	20,471	26,904,443	836	327	0.72%
Oct '04	8040	20,502	16,791,125	504	198	0.15%
Nov '04	8071	20,581	5,900,829	182	72	0.53%
Dec '04	8102	20,660	7,538,826	225	88	0.38%
Jan '05	8111	20,683	5,894,121	175	69	0.11%
Feb '05	8106	20,670	6,318,277	208	82	- 0.06%
Mar '05	8192	20,890	4,237,659	125	49	1.06%
Apr '05	8321	21,219	7,319,523	219	86	1.58%

Date	No. Of Residences	Population Served (1)	Cubic Feet per Month	Gal/Day per Residence	Gal/Capita per Day	Percent of Pop Growth per Month
May '05	8566	21,843	8,059,784	227	89	2.94%
Jun '05	8641	22,035	12,972,968	374	147	0.88%
Jul '05	8879	22,641	25,364,745	689	270	2.75%
Aug '05	8857	22,585	35,143,457	957	376	-0.25%
Sep '05	8927	22,764	30,237,777	845	331	0.79%
Oct '05	8995	22,937	18,072,033	486	191	0.76%
Nov '05	8964	22,858	7,321,276	204	80	-0.35%
Dec '05	8977	22,891	6,102,855	164	64	0.15%

1) Based on 2.55 people per residence.

Growth and Water Use Projections

The population growth projections made by the various entities (Portland State University, Deschutes County, etc.) are supported by the actual growth in water service connections being experienced by the Avion Water Company (See Table 4.3A and 4.3B). The population estimates are being outpaced by the actual growth.

Build Out Service Population

Build-Out Service Population: An estimate for the build-out population is based on the land use zoning that exists at this time. At best, any estimate of a build-out population will be a very rough approximation of a future population due to the many uncertainties of population densities overlaid on long term land uses. Land uses that can affect population density change almost yearly; this is especially true of the land uses in and near the Bend Urban Growth Boundary. Subdivision densities in the city of Bend and city UGB are shown on the City of Bend zoning map (see attached).

The residential lot density may tend to increase or decrease depending on economic conditions. Since 1995 the subdivisions outside and inside the city have increased in density; possibly as a result of shrinking land availability, the increasing availability of community sewer (inside the urban growth boundary) and from the high demand for residential lots. As land available for development in and around the UGB decreases, the density of the subdivisions will likely increase. Trends of this nature make the estimation of build-out populations difficult at best. The City of Bend has plans to expand the UGB in phases, the first of which is due to occur in 2007.

Other Long Term Growth Factors

Several major facilities are being planned from long range studies that could have a major impact on future water demands. The Bend-LaPine Public School District and the Oregon Division of State Lands have developed studies indicating major land development for parcels within the Avion service area.

The Bend-LaPine Public School District has projected the need for four to seven elementary schools, two to four middle schools and two to three new high schools in the Bend urban area by the year 2015. The final number of schools built will be dependent on the actual population growth during this period. Six of these schools could be expected to be built on the east side of the Bend urban area. Due to the lack of large land parcels available in the Bend urban area that could be developed for schools, it is probable that three to five of the schools will be built in the Avion service area. The

peak water demand for these schools would likely be in the range of 300 to 500 gallons per minute.

The Oregon Division of State Lands (DSL) has been aggressively pursuing the development of land managed by DSL throughout the State to increase the revenue from their land holdings. One of the land parcels being studied by DSL is known as "Section 11." The parcel is approximately 640 acres, located in the Avion service area along 27TH Street and Stevens road. Due to the current zoning, the parcel has initially been planned for the development of soccer and softball fields and general park use. Only a very small portion of the parcel is planned for development with the current zoning. The peak water demand for this development is estimated to be 300 gallons per minute. If the EFU zoning for this parcel is changed to allow a higher density development, the water demands could be six to eight times higher than this estimate.

Annual Historical Data

Historical water use for the Avion Water Company from 1984 to 2003 is shown in Table 4.3. The table presents average annual water use data for the residential and commercial user groups served by Avion. Avion Water Company did not have commercial accounts separated from residential accounts prior to 1993. The reason for this was that the Public Utility Commission (PUC) did not require Avion and other private water companies to keep separate accounts for commercial water users prior to 1993.

The growth rate of residential and commercial connections served by Avion, as presented in Tables 4.3A and 4.3B has increased at an average of 5.36 % per year since 1984 and the growth rate of water use has increased at an annual average rate of 7.71 %. Table 4.3B is the current estimate. The previous estimate is included to provide historical data. The customer rate has increased 0.36% while water use has decreased 0.12% since the 2003 data.

Tables 4.3A and 4.3B also illustrate the highly variable nature of water use from year to year. The large differences in yearly water use are attributed to irrigation water demand fluctuations. Years with higher than normal precipitation (1993, 1995, 2001) during the irrigation season results in significantly lower irrigation water use compared to years with below normal precipitation (1994, 1996, 2002, 2003) during the irrigation season (from April through October).

Unaccounted for Water

Most of Avion's pipe system has been installed since 1990 with gasketed PVC which is very reliable and greatly limits water loss. The industry standard for unaccounted for water is 10% or below. The percentage of unaccounted for water in 2005 was 7.92%. The unaccounted for water has been between 5%-8% for the past ten years so 2005 falls within the expected parameters and Avion continues to monitor these numbers to ensure that the percentage does not dramatically increase.

Demand Projections

Water demand forecasts for the next 10 and 20 year periods will be estimated from the growth rates experienced by the Avion Water Company from 1985 to the present. The premise of this approach is that since this period has been characterized by both low housing growth and relatively robust growth, it is a reasonable estimate of what may happen in the future. The new population predictions are higher than those previously

issued and with the unpredictable nature of the UGB and zoning changes it is hard to provide an accurate picture of future growth for Avion. It is safe to say that we expect our growth to continue at its rapid pace at least through 2010.

Tables 4.4A and 4.4B illustrate the population growth for Avion. Table 4.4A is from the 2003 Water Management and Conservation Plan based on a growth rate of 5.00% per year while table 4.4B is created from current data which shows a growth rate of 5.36%. From this data, the present water right of 11,305 gpm will be exceeded around year 2010 based on population growth. If water demand continues at an annual rate of 7.71%, the present maximum water right of 11,305 will be exceeded in 2008. If water use from water saving plumbing fixtures reduces the population based water demand by 2% per year, the water right will still be exceeded in the year 2010. Comparing the 2003 estimate with the current (2006) one it shows that the actual use will probably fall between the population and conservation based estimates.

Since the 2003 Water Management and Conservation Plan was written Avion has obtained the rights to 15 cfs in new water right permits and has certificated approximately one third of its existing rights. Avion now has a total of 40.2 cfs, or 18,042 gpm, in water rights available. The new permits do require mitigation and Avion has reached deals, in principle, with Swalley Irrigation and Central Oregon Irrigation to allow Avion to purchase mitigation credits yearly. This will allow Avion to purchase enough credits to provide for the mitigation required in the new permits, in the time allotted by the permits. With the new limit of 18,042 gpm Avion's water rights will be near their limit sometime around 2019 if usage is around the population / conservation base estimate, or around 2015 based on water demand growth (See table 4.4B). As stated earlier it appears from comparing the 2003 Water Management and Conservation Plan with the 2006 data the actual demand will fall somewhere between conservation base growth and population based growth.

TABLE 4.3A

Historical Water Use - 1984 to 2003

Avion Water Company, Inc.

	RESIDENTIAL			COMMERCIAL			METERED		ANNUAL GROWTH RATES	
YEAR	NO.OF SERVICES (Average)	ANNUAL WATER USE (cf)	AVERAGE ANNUAL DEMAND (cf)	NO. OF SERVICES (1) (average)	ANNUAL WATER USE (cf)	AVERAGE ANNUAL DEMAND (cf)	PEAK DAY DEMAND total gallons	gpm	SERVICES	USE (2)
1984	3265	54,044,399	16,553							
1985	3348	57,090,510	17,052						2.54%	5.64%
1986	3390	62,560,426	18,454						1.25%	9.58%
1987	3523	64,973,763	18,443						3.92%	3.86%
1988	3815	65,020,256	17,043						8.29%	0.07%
1989	4102	77,092,601	18,794						7.52%	18.57%
1990	4458	81,598,151	18,304						8.68%	5.84%
1991	4780	88,325,542	18,478						7.22%	8.24%
1992	5069	100,280,783	19,783						6.05%	13.54%
1993	5175	88,017,018	17,008	174	12,164,698	69,912	6,586,581	4,574	5.52%	-0.10%
1994	5429	113,870,642	20,975	219	18,404,951	84,041	7,007,002	4,866	5.59%	32.04%
1995	5650	103,752,924	18,363	244	22,096,605	90,560	7,700,002	5,347	4.36%	-4.86%
1996	6017	121,340,829	20,166	279	38,699,906	138,709	8,749,999	6,076	6.82%	27.17%
1997	6078	118,266,664	19457	319	34,246,435	107,356	8,835,370	6,136	1.60%	-4.94%
1998	6251	120,776,668	19321	375	34,922,150	93,126	8,662,458	6,195	3.58%	2.09%
1999	6455	135,492,016	20990	414	39,276,020	94,870	9,164,416	6,670	3.67%	12.25%
2000	6720	145,110,527	21594	471	40,498,149	85,983	9,872,436	6,965	4.69%	6.20%
2001	7085	149,119,035	21047	527	38,540,501	73,132	8,968,986	7,031	5.85%	1.10%
2002	7117	160,764,410	22589	612	49,618,217	81,076	10,039,837	7,888	1.54%	12.11%
2003	7562	159,800,517	21132	659	51,495,086	78,141	11,438,495	9,665	6.37%	0.43%
									5.00%	7.83%

1. Commercial water and residential water use was not accounted for separately prior to 1993.

2. Variations in water use are the result of climate, i.e. cool, wet summers result in less water use per connection.

TABLE 4.3B

Historical Water Use -1984 to 2005

Avion Water Company, Inc.

	RESIDENTIAL			COMMERCIAL				METERED		ANNUAL GROWTH RATES	
YEAR	NO.OF SERVICES	ANNUAL WATER USE (cf)	AVERAGE ANNUAL DEMAND (cf)	NO. OF SERVICES (1)	ANNUAL WATER USE (cf)	AVERAGE ANNUAL DEMAND (cf)	PEAK DAY DEMAND total gallons	gpm	SERVICES	USE (2)
1984	3265	54,044,399	16,553							
1985	3348	57,090,510	17,052						2.54%	5.64%
1986	3390	62,560,426	18,454						1.25%	9.58%
1987	3523	64,973,763	18,443						3.92%	3.86%
1988	3815	65,020,256	17,043						8.29%	0.07%
1989	4102	77,092,601	18,794						7.52%	18.57%
1990	4458	81,598,151	18,304						8.68%	5.84%
1991	4780	88,325,542	18,478						7.22%	8.24%
1992	5069	100,280,783	19,783						6.05%	13.54%
1993	5175	88,017,018	17,008	174	12,164,698	69,912	6,586,581	4,574	5.52%	-0.10%
1994	5429	113,870,642	20,975	219	18,404,951	84,041	7,007,002	4,866	5.59%	32.04%
1995	5650	103,752,924	18,363	244	22,096,605	90,560	7,700,002	5,347	4.36%	-4.86%
1996	6017	121,340,829	20,166	279	38,699,906	138,709	8,749,999	6,076	6.82%	27.17%
1997	6078	118,266,664	19,457	319	34,246,435	107,356	8,835,370	6,136	1.60%	-4.94%
1998	6251	120,776,668	19,321	375	34,922,150	93,126	8,662,458	6,195	3.58%	2.09%
1999	6455	135,492,016	20,990	414	39,276,020	94,870	9,164,416	6,670	3.67%	12.25%
2000	6720	145,110,527	21,594	471	40,498,149	85,983	9,872,436	6,965	4.69%	6.20%
2001	7085	149,119,035	21,047	527	38,540,501	73,132	8,968,986	7,031	5.85%	1.10%
2002	7117	160,764,410	22,589	612	49,618,217	81,076	10,039,837	7,888	1.54%	12.11%
2003	7562	159,800,517	21,132	659	51,495,086	78,141	11,438,495	7,944	6.37%	0.43%
2004	8102	174,654,524	21,557	729	58,420,011	80,137	10,934,318	7,593	7.42 %	10.31%
2005	8977	167,240,625	18,629	734	72,339,719	98,556	13,748,160	9,547	9.97%	2.79%
								Averages:	5.36%	7.71%

1. Commercial water and residential water use was not accounted for separately prior to 1993.

2. Variations in water use are the result of climate, i.e. cool, wet summers result in less water use per connection.

TABLE 4.4A
WATER DEMAND FORECAST-1998
AVION WATER COMPANY

				WATER DEMAND GROWTH	
YEAR	POPULATION (1)	RESIDENTIAL EQUIVALENT	POPULATION BASED gpm (2)	WATER USE BASED gpm (3)	CONSERVATION BASE gpm (4)
1996	15,814	6,202	6,076	6,076	
1997	16,707	6,552	6,419	6,682	
1998	17,651	6,922	6,782	7,348	6,646
1999	18,649	7,313	7,165	8,081	7,022
2000	19,702	7,726	7,570	8,886	7,419
2001	20,816	8,163	7,998	9,772	7,838
2002	21,992	8,624	8,450	10,746	8,281
2003	23,234	9,111	8,927	11,818	8,748

TABLE 4.4B
WATER DEMAND FORECAST-2006
AVION WATER COMPANY

				WATER DEMAND GROWTH	
YEAR	POPULATION (1)	RESIDENTIAL EQUIVALENT	POPULATION BASED gpm (2)	WATER USE BASED gpm (3)	CONSERVATION BASE gpm (4)
1996	16,055	6,296	6,076		
1997	16,313	6,397	6,136		
1998	16,897	6,626	6,015		
1999	17,516	6,869	6,365		
2000	18,337	7,191	6,856		
2001	19,411	7,612	6,229		
2002	19,709	7,729	6,972		
2003	20,964	8,221	7,944		
2004	20,660	8,831	7,593		
2005	24,763	9,711	9,547		
2006	26,931	10,561	9,407		
2007	28,375	11,127	9,911	10,132	9,712
2008	29,895	11,724	10,442	10,913	10,233
2009	31,498	12,352	11,002	11,755	10,782
2010	33,186	13,014	11,592	12,661	11,360
2011	34,965	13,712	12,213	13,637	11,969
2012	36,838	14,446	12,868	14,689	12,611
2013	38,813	15,221	13,558	15,281	13,287
2014	40,894	16,037	14,284	17,041	13,998
2015	43,086	16,896	15,050	18,355	14,749

TABLE 4.4B (Cont'd)
WATER DEMAND FORECAST-2006
AVION WATER COMPANY

			WATER DEMAND GROWTH		
YEAR	POPULATION (1)	RESIDENTIAL EQUIVALENT	POPULATION BASED gpm (2)	WATER USE BASED gpm (3)	CONSERVATION BASE gpm (4)
2016	45,395	17,802	15,857	19,770	15,540
2017	47,828	18,756	16,707	21,295	16,373
2018	50,392	19,762	17,602	22,936	17,250
2019	53,093	20,821	18,546	24,705	18,175
2020	55,939	21,937	19,539	26,609	19,148
2021	58,937	23,113	20,587	28,661	20,175
2022	62,096	24,351	21,690	30,871	21,256
2023	65,424	25,656	22,853	33,251	22,396
2024	68,931	27,032	24,078	35,815	23,596
2025	72,626	28,481	25,369	38,576	24,862

(1) 2006 population for Avion Water Company (From Table 4.3B with an annual growth of 5.36 %).

(2) Annual growth of 5.36 % from Table 4.3B.

(3) Annual growth of 7.71% from Table 4.3B.

(4) 2% reduction of population based water demand growth due to use of water saving plumbing fixtures.

Chapter 5 Regulatory and Service Goals

Chapter 5

Regulatory and Service Goals

Service Goals

Avion Water is an investor owned public utility that is regulated by the Public Utility Commission (P.U.C.) of Oregon and the Oregon Health Division (OHD). Rates and regulations for Avion's operations are set by the P.U.C. while the guidelines for providing safe drinking water (i.e. testing, construction standards, etc.) are regulated by the Oregon Health Division.

Avion has an excellent relationship with the P.U.C. and OHD and we work hard to keep it so. Avion has had only one at fault complaint, which was a procedural complaint not a service complaint, in the last five years which is an outstanding record.

Operational Criteria

Avion has provided excellent service fro the past 20 years because of increased standards for our facilities and operations. OHD requires a minimum of 20 psi service pressure at a residence but Avion designs new system additions to provide a minimum of 40 psi. Providing water at this pressure eliminates virtually all low pressure service calls during high demand periods. Storage facilities for the system are designed to provide adequate buffers for peak demand while not being so large as to cause water quality problems during low demand periods. All greater Avion facilities are being upgraded for remote monitoring and control. The main components, wells, reservoirs, and large pump stations, are all upgraded while smaller pump stations and pressure reducing stations are being upgraded each year. New subdivisions are designed to provide a minimum of 1000 gpm in fire flow and have fire hydrants per the fire marshals requirements. Fire flow requirements are sometimes greater for individual projects so main system upgrades are sometimes required, the cost of which is the responsibility of the projects developer.

Customer Rates

Avion is scheduled to submit a rate case before the Commission in early 2007. This will probably result in a slight rate increase due to increased energy and fuel costs along with general inflation. The current base rate is $20.82 for a ¾" x 5/8" water meter. The base rate increases based on AWWA residential equivalent multipliers for meters larger than ¾" x 5/8". The current commodity charge is $0.80 per 100 cubic feet used.

Regulatory Issues

The largest regulatory issues that affect Avion are the occasional attempts by the state legislature to require either chlorination of the systems water or adding fluoride to the water. Avion does not favor adding of anything to the water system. The physical chlorination / fluoridation of the system would not be difficult however the additional

testing and reporting requirements are cumbersome at best and will require hiring of more staff. Since Avion is a regulated public utility these costs would be passed on to the customer when the benefit and need for these procedures is not shown to be needed. This is especially the case for the addition of fluoride to the water supply. There are studies that show adding fluoride is helpful and there are studies that show fluoride is harmful. Avion will resist legislation that calls for adding of a chemical to the water supply when the results of its benefits are essentially inconclusive. Chlorination of the main system will probably be required at some point in the future when the system gets large enough to slow travel times of water from well head to service location. The current test results of the main system show that the water delivered is still of the highest quality.

Testing

Avion submits various drinking water tests to the Oregon Health Division (see chart below). Avion does not chlorinate or add any other chemicals to our water other than chlorinating new water lines and reservoirs prior to putting them in service. The groundwater produced in greater Avion's wells is of remarkable quality and consistency. There are almost no detectable contaminants in the water let alone contaminants in sufficient quantity to be above regulatory standards. All of the wells in the greater Avion system, at one time there were 54 of them, have all shown insignificant variability in test results. The conclusion is that the water in the Upper Deschutes Aquifer is of very high quality and consistency throughout the entire Bend area. There is additional information in chapter 6 regarding water quality.

Listed below is a schedule of testing for the greater Avion system. Avion has various satellite systems that generally consist of around 200 connections each but they are left out of this report for clarity.

Projected Sample Events

Greater Avion
PWSID# 00091

Source (A) China Hat Analysis	2006	2007	2008	2009	2010	2011	2012	2013	2014
Coli form Bacteria	300	300	300	300	300	300	300	300	
Nitrate	X	X	X	X	X	X	X	*	
Arsenic	X			X				*	
IOC								X	
SOC									**
VOC			X			X			
Lead & Copper				X			X		
Gross Alpha							X		
Radium							X		
Uranium				X					
CCR	X	X	X	X	X	X	X	X	

*Included in the IOC
**Waiver SOC's
This schedule is according to the Department Of Human Services web site, dhs.state.or.us/publichealth/dwp, for Avion Water Company.
This schedule reflects current regulations, subject to change when new regulations are implemented.
The prices on this schedule reflect current prices and are subject to change.
Please visit the DHS web site for sample scheduling for Avion Water Company and to keep up to date with current regulations and your sampling requirements.

Chapter 6 Water Supply

Chapter 6

Water Supply

This chapter describes Avion's water rights and its long term water supply needs.

Oregon Water Law

Oregon's water laws are based on first in time first in right, which means that people with the water rights that have the oldest priority date are the last people cut off from water when there is a shortage. These laws and rights are administered by the Oregon Water Resources Department (OWRD). While there have been significant changes to the administration and procedures for administering and acquiring these rights, the first in time first in right rule is still underlying principle of Oregon water rights.

Water rights issued for the Deschutes Basin, where Avion draws its water, now require any new water withdrawn from the basin to be mitigated for by returning water to the aquifer through various methods. There is currently a "water bank" being set up and administered by the Deschutes River Conservancy (DRC) which will hopefully provide for a uniform and easy way to acquire mitigation credits for the new permits. The water bank will provide a stable entity for transferring and purchasing mitigation credits while preventing water rights speculation. 2007 should be the test year for the operation of the water bank.

Water Quality

As mentioned in chapter 5 the quality of water in the Deschutes Basin is very good. Avion has a wellhead protection program that has identified potential contamination points of the systems production wells. This program identified some potential risks for contamination but that there is a very low probability of well contamination. The biggest risks are the Burlington Northern Railroad tracks by the DRW well site and the use of common fertilizers and pesticides by the general public. With the shallowest of Avion's wells being 400 feet deep the chance of any transients entering the water system from these sources is insignificant. Avion applied for and was granted waivers for Volatile Organic Contaminant (VOC) testing and Synthetic Organic Contaminant testing (SOC) for the greater Avion system. These waivers were granted after extensive study of the areas around the 10 production wells and the contamination hazards.

Avion's Water Rights

Avion currently has 40.2 cfs in ground water withdrawal rights which is equal to 18,042 gpm. Of the 40.2 cfs, 15 cfs is under two new permits acquired this year, 2006, and do require mitigation for the right to be exercised. Avion also has 25.2 cfs in existing water rights that do not need to be mitigated for, of which 8.86 cfs is certificated. Avion is also in the process of certificating the remaining 16.33 cfs which we expect to be certificated some time in early 2007.

The 15 cfs in new permits will need 452 acre-feet of mitigation to allow the new permits to be used. Avion already has 48 acre-feet so it will require 404 acre-feet of mitigation to be able to fully utilize both new permits. These new permits do allow for Avion to mitigate incrementally so all 404 acre-feet will not need to be purchased at once. Avion is entering into agreements with the local irrigation districts to purchase these credits; the amount varies per district and availability, each year through the DRC's water bank until both new permits are completely mitigated for. A full listing of Avion's water rights is available at OWRD.

Avion is also pursuing an aquifer recharge permit that has been held up for various administrative reasons and by various agencies. The permit has been in process for five years now and it looks like Avion will be able to pursue a recharge project for mitigation credit. If Avion is allowed a permit in this area it should provide at least 3000- 4000 acre feet of mitigation credits. Avion would shape the water right so it could be used from May through September which would allow a groundwater withdrawal somewhere between 11 cfs and 14 cfs.

Water Availability

Avion's sole source of water is the Deschutes Basin aquifer. According to the 2004 USGS ground water study of the Deschutes basin it recharges at a rate of 3500 cfs. Avion's wells are between 400 and 700 feet deep depending on location in the main system. The farther north and east the greater depth required to reach the water table. Avion's wells have had no recordable drop in water table measurements since they have been in service. In fact some of our wells actually have no draw down after the initial cone of depression which occurs at well startup. With all that said there is still the urgent need to manage the basins resources wisely. As stated earlier all new ground water permits issued in the Deschutes basin require mitigation which should offset any new ground water withdrawal. The mitigation from the major domestic users in the basin will still not have a major effect on water savings because it makes up approximately only 2% of total basin usage. Agriculture irrigation, which is the primary water user in the basin, is where large water conservation may be possible, weather it is economically feasible or not is another question. Overall there is not a shortage of water based on historical flows of the rivers in the basin, but politically there is. This is a larger policy question for the people of the area, not Avion Water to decide.

Long Term Needs

As stated earlier Avion has 40.2 cfs in water rights, of which 15 cfs needs to be mitigated for before they can be exercised. Of the 15 cfs which needs to be mitigated for 10 cfs is allowed to be used year round while 5 cfs is seasonal use. The seasonal permit is an acceptable way to "shape" a water right because the summer demands are six times greater than the winter time demands.

The major municipal water suppliers for the Bend / Redmond area are working on a water bank for purchasing mitigation credits in conjunction with the DRC, COI, and Swalley Irrigation. If the water bank functions as intended Avion will be allowed to purchase mitigation credits at a rate which will allow Avion to satisfy the two new permits in the time allotted.

The population / demand tables in chapter four show that Avion will reach the limits of its current water rights sometime between 2019 and 2020. If the aquifer recharge permit is allowed and the water bank operates as intended the urbanization of the irrigated lands surrounding Bend and Redmond will provide enough water rights for all the area domestic suppliers. If the surrounding urban areas do not develop it will mean that growth has stopped and with it the additional demand required for growth.

Avion's current pumping capacity is 10,939 gpm which will be exceeded by demand sometime in 2009 according to table 4.4B. This number is somewhat misleading because it does not take into account the systems storage capacity. With the storage taken into account and using a average maximum demand of 11,500 gpm the system can operate for 12 days before the reservoirs run dry. This should not be an issue as there are plans to add at least 2000 gpm in pumping capacity and 2.5 million gallons in storage in 2007.

Chapter 7 Storage and Telemetry

Chapter 7

Storage and Telemetry

Storage

Avion's main system reservoirs are all on the south end of Bend and their top elevation is set at 3957 ft. This allows the reservoirs to "float" on the system. These main reservoirs have a capacity of 9.9 million gallons and feed the system through gravity. There are also smaller reservoirs in Sundance, Connestoga Hills, and Sunset West subdivisions. The reservoir in Connestoga is 140,000 gallons and all the others vary between 40,000-20,000 gallons. For the purposes of this report the smaller reservoirs are considered irrelevant.

Site	Capacity	Elevation	Material
China Hat 1	2,900,000 gallons	3957 ft	Concrete
China Hat 2	4,600,000 gallons	3957 ft	Concrete
DRW	2,400,000 gallons	3957 ft	Steel

The China Hat 1 was constructed in 1992, China Hat 2 in 1995, and DRW in 2004. All of these structures are fairly young in their life cycle and with proper maintenance will last beyond the scope of this report.

As noted earlier, Avion is in the process of obtaining an easement and land use approval for a reservoir and well site located at Hamehook Rd. This site is planned to have an initial 2.4 million gallon above ground steel tank installed in 2007 with another 2.4 million gallon above ground steel tank installed before 2012. This will bring Avion's storage up to 14.7 million gallons. Placing these tanks north of Hwy 20 will alleviate pressure swings during high demand periods and provide water for the developments in Powell Butte. The pressure swings are a result of the destination resort Pronghorn taking water out of two four inch and eighteen two in meters for their two golf courses and landscaping when the City of Bend sewer plant cannot produce level four effluent. Additionally placing these tanks north of Hwy 20 will reduce the cost of installing a transmission line from Bend to Powell Butte by an estimated 1.2 million dollars. When the line to Powell Butte is completed the system will operate with an additional 3-4 million gallons of storage. This storage will be installed by the resort developments in Powell Butte. The size of the resort reservoirs is based on current population estimates provided by the resort developers. There is already 750,000 gallons of storage at the Brasada Ranch development which is a destination resort in Powell Butte. In combination with the anticipated storage in the Powell Butte area Avion will have approximately 19 million gallons of storage available. This will bring the total storage capacity up to 19 million gallons. The estimated peak day use in 2012 is 18.6 million gallons which will give Avion a peak day's storage available.

In conclusion, with the different well sites and power suppliers for those well sites it is extremely unlikely that Avion would lose all pumping capacity at once so the need to provide massive amounts of storage is not as critical as in systems that have only a single

source of water. The proposed timeline for adding storage works well with the projected future water demand.

Telemetry

Avion's system is controlled through radio communication using RTUs, and the Wunderware. The actual radio network is maintained by Central Mountain Communications. They are responsible for maintaining the transmitting system, obtaining the required FCC licenses, etc for Avion. Avion does not have any site hard wired; all communication is through radio transmission. This method has proved very reliable over the years and there are no plans to change it. All well on/off commands are based off the reservoir level in China Hat 2 providing a fixed point of operation for the production side of the system.

Wunderware is the program being used for command and control software. Avion has all major production wells, ten in all, operating with Wunderware software. There are 5,000 Wunderware tag names available of which only 486 are being used. With only 10% of program capacity used there is more than enough room for growth. The actual machines, the RTU, computer, and monitor at the main office are all on battery back ups with alarms that send notification of loss of power. There are also alarms in he program that notify of power loss at any site. The battery back up at the control center will last for one hour which gives enough time to redirect crews to change the system to a manual operation mode. Any one site can be operated manually, it just requires more man hours for monitoring and operation.

The option to upgrade to a hard wired connection from radio controls has been considered but has not been taken because the current system has been extremely reliable. Avion is in the process of upgrading all pressure reducing stations and booster stations so they have telemetry capability. This will allow Avion to monitor pressures and conditions throughout the entire system from a central location. These controls are in addition to the low / high level, no power, etc alarms that already exist at all production well sites and reservoirs.

Chapter 8 Distribution System

Chapter 8

Distribution System

Description of Existing System

Avion's main system is a gravity feed system from the reservoirs on the south side of Bend to the north side of Bend. The elevation difference is approximately 757 feet which translates to 328 psi. The main system has thirty four different pressure zones. These pressure zones are separated by pressure reducing stations that contain at least two pressure reducing valves per vault. The reason for two pressure reducing valves is that there is one small one for low demand in conjunction with a larger one for higher demand periods. Avion is still in the process of upgrading the system with a pressure relief valve that will be located in each pressure zone. All of the major pressure zones already have these valves installed. The pressure relief valves for all pressure zones have already been purchased and the updating program is in progress.

Along with the necessity for pressure reducing stations there is also the need for booster stations in several areas. These areas are generally east of the intersection of the Knott and Rickard Rd. There is a large booster station, capable of 7,000 gpm at 87 psi, at the intersection of Hamby and Neff Rd. This booster station only runs 45 to 30 days a year during peak hours.

Avion's service territory covers an immense amount of area, for example one pipe loop is 17 miles long. The total length of pipe in the ground is approaching 400 miles worth. Most of this is relatively new as Avion's largely rural service territory urbanizes. It is best to refer to the attached map for reference to specific areas and pipelines. Avion has satellite systems from just north of LaPine to north of Redmond to the Powell Butte area.

The outlying systems are too far to be connected any time in the near future, except the Powell Butte Area. It is anticipated that Avion will have a 20"- 24" water line from Bend to the Powell Butte area in the next five years. This effort will be financed largely by the developers who are interested in developing destination resorts in that area. This will add an additional 25 miles of major pipeline to the system just to reach the areas up for development.

Fire Flow

Fire flow varies through out the system depending upon location, time of day, and size of pipe in the ground. Avion tries to take fire flow data during peak demand periods to make sure we are able to provide the stated fire flow at any given time. Several areas on the north end of town have tested with capacities of 2900 gpm at 40 psi residual pressure. These areas are served by looped 12" pipe and are close to the reservoirs so they are expected to have large fire flow capabilities. A test conducted on the north end of the system at the intersection of Cooley and Hunnel Rd provided a fire flow of 2500 gpm at a residual pressure of 20 psi. Again the test was conducted during a high demand period.

The field results probably would have gone higher as the upstream PRV's opened, but the location of the test did not allow for a longer test because of limited space for water. Fire flow data is available for all points within the system where there are fire hydrants. There are 842 fire hydrants in the Avion system. These hydrants are inspected every 1 to 2 years for functionality and maintenance. Fire flow can be modeled at any point in the system but with 350 miles of pipe in the ground and a service territory that spans two counties it is better to provide fire flow for a specific location upon request.

The areas where the least flow is available is generally confined to the older neighborhoods in Avion which were constructed in the 60's and 70's, and are often piped with 2" ,4", and 6" lines, sometimes even smaller lines were used. These subdivisions generally have larger lots and are slowly subdividing as land values increase. When they subdivide Avion is requiring them to replace the existing water mains along their property lines with larger diameter ones. The cost of upgrading these neighborhoods to be able to provide 1000 gpm is cost prohibitive as a single project, but as they redevelop the system will be upgraded at that time.

System Model

The main system is computer modeled using Bentley Systems Water Gems. This program allows for AutoCad drawings to be combined with USGS digital elevation maps and ArcGIS data. This model has proven to be reasonably accurate, but as with all models, the results need to be carefully evaluated. The model can provide almost any type of hydraulic data for a given area or point in the system. With over 3000 nodes (pipe junctions) it is best to provide data for specific areas and specific conditions as requested by developers.

The product does have some limitations though. The program cannot model variable speed pumps in parallel. This means that pump stations are not modeled completely accurately, but by extrapolating the total output in volume and head, the pumps in parallel can be modeled as one pump. The model has generally been used to predict fire flow pressures and volume in various areas during peak demand. A base rate of 0.8 gpm per household is used for a typical residential demand.

The model results were generally between 5 and 10 psi difference of actual field data, depending on location. The majority of the data points were within 5 psi so this was acceptable. The model was run for peak day, average day, and maximum day scenarios. The maximum day scenario is the most helpful for identifying problem areas in the system since winter time flows are roughly six times less than peak summer flows. The areas where the least flow is available is generally confined to the older neighborhoods, those constructed in the 60's and 70's, that are piped with 2" and 4" lines. These subdivisions generally have larger lots and are slowly subdividing. When they subdivide Avion is requiring them to replace the water lines along their property lines with larger diameter ones.

The fire flow capabilities that the program estimates have proven to be very close to those found in the field. For example, as mentioned above, the fire flow at the intersection of Cooley and Hunnel Rd was estimated to be 2650 gallons per minute and the actual results were 2500 gpm at a 20 psi residual. The test was done on a high demand day in peak demand times.

Chapter 9 Capital Improvement Plan

Chapter 9

Capital Improvement Plan

Capital Improvements

Table 10.1 outlines a capital improvement plan (CIP) for Avion. The improvements are organized according to priority. The priority listed is somewhat fluid depending on where in Avion's service territory growth occurs. Table 10.2 outlines several long term goals which will depend on many variables to occur.

Avion's Deficiencies & Solutions

1. Dyer Reservoir

The Dyer reservoir site is the highest priority improvement. This site will effectively separate Avion into two systems; a north and a south system divided by Hwy 20. The north side will supplement the south side during peak demand periods alleviating pressure swings during high demand times. Developing this site eliminates the need to install large transmission lines from the intersection of Bear Creek and Ward Rd to the intersection of Butler Market and Hamehook Rd. It also will greatly improve service for customers north of Hwy 20.

2. Brookswood 12" Line

Since Roat's Water has become inter-tied with Avion there have been lower service pressures at and near the location of the inter-tie. Installing this 12" line will alleviate the lower pressures during high demand periods.

3. Mitigation Credits

The new water rights acquired by Avion require 454 mitigation credits by 2010. Avion already has 50 mitigation credits so we would need to purchase 101 credits each year until 2010. The estimated cost for this is $200,000 / year.

4. Ponderosa Pump Station

The ponderosa pump station will add additional capacity for the Roat's inter-tie and customers on the west side of Hwy 97. The pump station is not as critical as the addition of the 12" but it will again provide for better service during high demand times and also provide capacity for more growth.

5. Increase Middle Sundance Reservoir

The size of the middle Sundance reservoir has become inadequate as this older subdivision has approached build-out. The reservoir ran dry on three occasions in 2006,

all of which were on maximum demand days where the temperature was above 100 degrees. The current easement will allow an increase of 25,000 gallons which increases the reservoir from 30,000 gallons to 55,000 gallons. Since the subdivision has very few available lots, this increase will serve the subdivisions needs through build-out.

6. PRV Telemetry

Adding telemetry to all PRV sites is not as critical a project as the ones listed above but by adding telemetry at these sites Avion will greatly increase the system monitoring capability. Increasing this capability is important so the systems weak points and deficiencies can be better identified and addressed.

7. Increase/Replace Fleet

This just a simple matter of rotating older vehicles out of service and adding one more service truck to the fleet since Avion has added field personnel.

8. Powell Butte / Brasada Telemetry

Powell Butte / Brasada sites are located 45 minutes to an hour away from Avion's shop so it is important to have them controlled from the central computer system to alleviate travel times. There are automatic controls at each location but to change any parameters or turn them off requires a lot of man hours to accomplish. Having the controls centralized with the rest of Avion's system will save costs and provide better overall control and flexibility of the system.

9. Mediate Electrical Interference at DRW

There is a need to re-wire this pump station with shielded wire to prevent interference with the telemetry devices. This site has a large pump station and two production wells so eliminating this interference is a priority.

10. Riverbend Well #3

This well is almost complete and its production will provide more capacity west of Hwy 97. When completed the well will produce somewhere around 1100 gpm. The well will be completed sometime in late November.

11. Update Water Management and Conservation Plan

Updating this plan in 2008 is earlier than required by the state of Oregon but it is necessary to keep it current for water rights applications and transfers. Avion has been "cleaning up" all water rights requirements, documentation, and technical requirements.

This is a long process and having an up to date Water Management and Conservation Plan helps speed up the process.

Table 10.1- Short Term Improvements

No.	Project	Description	Cost Estimate	Comments
1.	Dyer Reservoir Site	A 2.5 million gallon reservoir w/ a 2000 gpm well and large capacity booster station	$2,300,000	Large scale project which will greatly enhance current service in all areas.
2.	12" Water Line-Brooks wood	12" water line from Riverbend well site to the PRV station on Brookswood	$200,000	Needed to boost pressures at interconnection points with Roat's Water.
3.	Acquire 100 mitigation credits per year	Avion needs 100 mitigation credits per year until 2010 to satisfy 2 new permits	$200,000 / year	The new "water bank" should allow Avion easy access to these credits.
4.	Upgrade Ponderosa pump station	Install a higher capacity pump in the ponderosa pump station	$3,500	Needed to boost pressures at interconnection points with Roat's Water.
5.	Increase Sundance reservoir capacity	Increase the capacity of the middle Sundance reservoir by 20,000 gallons	$20,000	During peak days the existing reservoir was inadequate.
6.	PRV Telemetry	Continue to upgrade PRV stations for remote monitoring	$20,000	Will provide more accurate data which will help in system design and modeling.
7.	Purchase 3 Fleet ½ ton service trucks	Purchase 3 new fleet ½ ton service rigs and rotate 3 rigs out of the fleet	$57,000	Needed to continue rotation of vehicles every year.

8.	Telemetry for Powell Butte / Brasada	Upgrade the wells and reservoirs in Powell Butte for telemetry	$5,000	Needed to reduce trips to area and improve reliability.
9.	Install Electrical interference filters in DRW pump house	Install line filters in DRW to prevent interference with telemetry readings	$2000	Needed to provide more reliable telemetry data from the site.
10.	Bring Riverbend Well #3 on-line.	New well construction that needs to be finished	$5000	Bring more capacity on-line
11.	Update Water Management and Conservation Plan	Update Water Management and Conservation Plan	$ 0.00 (In House)	Keep current with Oregon regulatory entities

Long Term Projects

Below is a list of longer term projects. The timeline for developing the long term projects has not been set. Of the long term projects listed the most likely to occur will be the continuing development in the Powell Butte area. The aquifer in the Powell Butte area is not reliable so any reasonably sized developments in that area will need a reliable water source. If the destination resort planning and development in this area continues Avion will be the major supplier to that area. If the resorts are built then the second reservoir at the Dyer site will be needed when the resort populations begin to reach build-out.

Table 10.2- Long Term Improvements

Project	Description	Cost Estimate	Comments
Powell Butte Developments	Continue to develop Powell Butte to accommodate destination resorts	$12-15,000,000	
Dyer Reservoir site well #2	Develop second high capacity well at Dyer site. Size will depend on need	$350-550,000	

Knott Rd wells	Develop 2 new submersible turbine wells on Knott Rd.	$200-400,000	
18" line from DRW reservoir to Brookswood	Install 18" Line from DRW reservoir to Brookswood.	$170,000	

Chapter 10 Appendix

Avion Water Company Inc

60813 Parrell Rd
Bend, OR 97702

Production Well GPM

Site	GPM	GPD
China Hat 1	1255	1,807,200.00
China Hat 2	1555	2,239,200.00
Parrell Road	1060	1,526,400.00
Riverbend 1	730	1,051,200.00
Riverbend 2	1100	1,584,000.00
Tekampe A	1334	1,920,960.00
Tekampe B	1240	1,785,600.00
Tekampe C	595	856,800.00
DRW	1860	2,678,400.00
Conestoga	110	158,400.00
Sundance	100	144,000.00
Total Greater Avion	10939	15,752,160.00

This is a final order in other than a contested case. This order is subject to judicial review under ORS 183.484. Any petition for judicial review must be filed within the 60 day time period specified by ORS 183.484(2). Pursuant to ORS 536.075 and OAR 137-004-0080 you may either petition for judicial review or petition the Director for reconsideration of this order. A petition for reconsideration may be granted or denied by the Director, and if no action is taken within 60 days following the date the petition was filed, the petition shall be deemed denied. In addition, under ORS 537.260 any person with an application, permit or water right certificate subsequent in priority may jointly or severally contest the issuance of the certificate at any time before it has issued, and after the time has expired for the completion of the appropriation under the permit, or within three months after issuance of the certificate.

STATE OF OREGON

COUNTY OF DESCHUTES

CERTIFICATE OF WATER RIGHT

THIS CERTIFICATE ISSUED TO

AVION WATER COMPANY, INC.
60813 PARRELL ROAD
BEND, OREGON 97702

confirms the right to use the waters of 10 WELLS in the DESCHUTES RIVER BASIN for QUASI-MUNICIPAL USE.

This right was perfected under Permit G-9975. The date of priority is JUNE 16, 1981. The amount of water to which this right is entitled is limited to an amount actually beneficially used and shall not exceed 950 GALLONS PER MINUTE, or its equivalent in case of rotation, measured at the wells.

The wells are located as follows:

China Hat Well #1: NE 1/4 NE 1/4, SECTION 29, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 400' SOUTH and 900' WEST from the NE corner of SECTION 29.

Conestoga Well (Well R): NE 1/4 NW 1/4, SECTION 22, TOWNSHIP 18 SOUTH, RANGE 13 EAST, W.M.; 370' SOUTH and 300' WEST from the N 1/4 corner of SECTION 22.

Parrell Road Well: SW 1/4 SW 1/4, SECTION 17, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 200' NORTH and 570' EAST from the SW corner of SECTION 17.

Riverbend #1 (Well 5): SW 1/4 NE 1/4, SECTION 19, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W. M.; 1380' SOUTH and 1500' WEST from the NE corner of SECTION 19.

Tekampe #1 (Well C-1): SE 1/4 NE 1/4, SECTION 21, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 2240' SOUTH and 310' WEST from the NE corner of SECTION 21.

Tekampe #2 (Well C-3): SE 1/4 NE 1/4, SECTION 21, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 2240' SOUTH and 325' WEST from the NE corner of SECTION 21.

Tekampe #3 (Well C-2): SE 1/4 NE 1/4, SECTION 21, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 2260' SOUTH and 315' WEST from the NE corner of SECTION 21.

Sundance Well #2 (Well -2): NW 1/4 NE 1/4, SECTION 31, TOWNSHIP 18 SOUTH, RANGE 13 EAST, W.M.; 1225' SOUTH and 1985' WEST from the NE corner of SECTION 31.

Riverbend #2 (Well B-2): SW 1/4 NE 1/4, SECTION 19, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 1360' SOUTH and 1490' WEST from the NE corner of SECTION 19.

Boonesborough-McGrath #2: SE 1/4 SE 1/4, SECTION 36, TOWNSHIP 16 SOUTH, RANGE 12 EAST, W.M.; 160' NORTH and 796' WEST from the SE corner of SECTION 36.

A description of the place of use to which this right is appurtenant is as follows:

S½ SE¼
NE¼ SE¼
SECTION 9

N½ NE¼
W ½
SECTION 14

S½
SECTION 15

NE¼
E½ NW¼
E½ SW¼
NE¼ SE¼
W½ SE
SECTION 16

NE¼
SECTION 22

N½ NE¼
SE¼ NE¼
NW¼
SE¼ SW¼
SE¼
SECTION 23

SW¼
W½ SE¼
SECTION 24

N½ NW¼
SE¼ NW¼
SECTION 25

N½ NE¼
SW¼ NE¼
N½ NW¼
SE¼ NW¼
NE¼ SW¼
SE¼
SECTION 26

TOWNSHIP 17 SOUTH, RANGE 12 EAST, W.M.

The wells shall be maintained in accordance with the General Standards for the Construction and Maintenance of Water Wells in Oregon.

The works shall include an airline and pressure gauge or an access port for measuring line, adequate to determine water level elevation in the well at all times.

The water user shall install and maintain a weir, meter, or other suitable measuring device and keep a complete record of the amount of ground water withdrawn.

The right to use water for the above purpose is restricted to beneficial use on the lands or place of use described.

Issued AUG 04 2006.

Phillip C. Ward, Director
Water Resources Department

Recorded in State Record of Water Right Certificates Number 82420.

G-10378.gc

This is a final order in other than a contested case. This order is subject to judicial review under ORS 183.484. Any petition for judicial review must be filed within the 60 day time period specified by ORS 183.484(2). Pursuant to ORS 536.075 and OAR 137-004-0080 you may either petition for judicial review or petition the Director for reconsideration of this order. A petition for reconsideration may be granted or denied by the Director, and if no action is taken within 60 days following the date the petition was filed, the petition shall be deemed denied. In addition, under ORS 537.260 any person with an application, permit or water right certificate subsequent in priority may jointly or severally contest the issuance of the certificate at any time before it has issued, and after the time has expired for the completion of the appropriation under the permit, or within three months after issuance of the certificate.

STATE OF OREGON

COUNTY OF DESCHUTES

CERTIFICATE OF WATER RIGHT

THIS CERTIFICATE ISSUED TO

AVION WATER COMPANY, INC.
60813 PARRELL ROAD
BEND, OREGON 97702

confirms the right to use the waters of 10 WELLS in the DESCHUTES RIVER BASIN for QUASI-MUNICIPAL USE.

This right was perfected under Permit G-9948. The date of priority is July 2, 1981. The amount of water to which this right is *entitled is limited to an amount actually beneficially used and shall not exceed 1,130 GALLONS PER MINUTE, or its* equivalent in case of rotation, measured at the wells.

The wells are located as follows:

China Hat Well #1: NE 1/4 NE 1/4, SECTION 29, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 400' SOUTH and 900' WEST from the NE corner of SECTION 29.

Conestoga Well (Well R): NE 1/4 NW 1/4, SECTION 22, TOWNSHIP 18 SOUTH, RANGE 13 EAST, W.M.; 370' SOUTH and 300' WEST from the N 1/4 corner of SECTION 22.

Parrell Road Well: SW 1/4 SW 1/4, SECTION 17, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 200' NORTH and 570' EAST from the SW corner of SECTION 17.

Riverbend #1 (Well 5): SW 1/4 NE 1/4, SECTION 19, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W. M.; 1380' SOUTH and 1500' WEST from the NE corner of SECTION 19.

Tekampe #1 (Well C-1): SE 1/4 NE 1/4, SECTION 21, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 2240' SOUTH and 310' WEST from the NE corner of SECTION 21.

Tekampe #2 (Well C-3): SE 1/4 NE 1/4, SECTION 21, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 2240' SOUTH and 325' WEST from the NE corner of SECTION 21.

Tekampe #3 (Well C-2): SE 1/4 NE 1/4, SECTION 21, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 2260' SOUTH and 315' WEST from the NE corner of SECTION 21.

Sundance Well #2 (Well -2): NW 1/4 NE 1/4, SECTION 31, TOWNSHIP 18 SOUTH, RANGE 13 EAST, W.M.; 1225' SOUTH and 1985' WEST from the NE corner of SECTION 31.

Riverbend #2 (Well B-2): SW 1/4 NE 1/4, SECTION 19, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 1360' SOUTH and 1490' WEST from the NE corner of SECTION 19.

Boonesborough-McGrath #2: SE 1/4 SE 1/4, SECTION 36, TOWNSHIP 16 SOUTH, RANGE 12 EAST, W.M.; 160' NORTH and 796' WEST from the SE corner of SECTION 36.

A description of the place of use to which this right is appurtenant is as follows:

N½ NE¼
SE¼ NE¼
NE¼ NW¼
S½ NW¼
S½
SECTION 18

SW¼ NE¼
N½ NW¼
SECTION 19
TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.

The wells shall be maintained in accordance with the General Standards for the Construction and Maintenance of Water Wells in Oregon.

The works shall include an airline and pressure gauge or an access port for measuring line, adequate to determine water level elevation in the well at all times.

The water user shall install and maintain a weir, meter, or other suitable measuring device and keep a complete record of the amount of ground water withdrawn.

The right to use water for the above purpose is restricted to beneficial use on the lands or place of use described.

Issued AUG 04 2006

Phillip C. Ward, Director
Water Resources Department

Recorded in State Record of Water Right Certificates Number 82419.

This is a final order in other than a contested case. This order is subject to judicial review under ORS 183.484. Any petition for judicial review must be filed within the 60 day time period specified by ORS 183.484(2). Pursuant to ORS 536.075 and OAR 137-004-0080 you may either petition for judicial review or petition the Director for reconsideration of this order. A petition for reconsideration may be granted or denied by the Director, and if no action is taken within 60 days following the date the petition was filed, the petition shall be deemed denied. In addition, under ORS 537.260 any person with an application, permit or water right certificate subsequent in priority may jointly or severally contest the issuance of the certificate at any time before it has issued, and after the time has expired for the completion of the appropriation under the permit, or within three months after issuance of the certificate.

STATE OF OREGON

COUNTY OF DESCHUTES

CERTIFICATE OF WATER RIGHT

THIS CERTIFICATE ISSUED TO

AVION WATER COMPANY, INC.
60813 PARRELL ROAD
BEND, OREGON 97702

confirms the right to use the waters of 10 WELLS in the DESCHUTES RIVER BASIN for QUASI-MUNICIPAL USE.

This right was perfected under Permit G-9946. The date of priority is FEBRUARY 27, 1981 FOR 1,595 GALLONS PER MINUTE (GPM) AND NOVEMBER 12, 1982 FOR 300 GPM. The amount of water to which this right is entitled is limited to an amount actually beneficially used and shall not exceed 1895 GPM, or its equivalent in case of rotation, measured at the wells.

The wells are located as follows:

China Hat Well #1: NE 1/4 NE 1/4, SECTION 29, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 400' SOUTH and 900' WEST from the NE corner of SECTION 29.

Conestoga Well (Well R): NE 1/4 NW 1/4, SECTION 22, TOWNSHIP 18 SOUTH, RANGE 13 EAST, W.M.; 370' SOUTH and 300' WEST from the N 1/4 corner of SECTION 22.

Parrell Road Well: SW 1/4 SW 1/4, SECTION 17, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 200' NORTH and 570' EAST from the SW corner of SECTION 17.

Riverbend #1 (Well 5): SW 1/4 NE 1/4, SECTION 19, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W. M.; 1380' SOUTH and 1500' WEST from the NE corner of SECTION 19.

Tekampe #1 (Well C-1): SE 1/4 NE 1/4, SECTION 21, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 2240' SOUTH and 310' WEST from the NE corner of SECTION 21.

Tekampe #2 (Well C-3): SE 1/4 NE 1/4, SECTION 21, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 2240' SOUTH and 325' WEST from the NE corner of SECTION 21.

Tekampe #3 (Well C-2): SE 1/4 NE 1/4, SECTION 21, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 2260' SOUTH and 315' WEST from the NE corner of SECTION 21.

Sundance Well #2 (Well -2): NW 1/4 NE 1/4, SECTION 31, TOWNSHIP 18 SOUTH, RANGE 13 EAST, W.M.; 1225' SOUTH and 1985' WEST from the NE corner of SECTION 31.

Riverbend #2 (Well B-2): SW 1/4 NE 1/4, SECTION 19, TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.; 1360' SOUTH and 1490' WEST from the NE corner of SECTION 19.

Boonesborough-McGrath #2: SE 1/4 SE 1/4, SECTION 36, TOWNSHIP 16 SOUTH, RANGE 12 EAST, W.M.; 160' NORTH and 796' WEST from the SE corner of SECTION 36.

A description of the place of use to which this right is appurtenant is as follows:

SE¼ SW¼
SW¼ SE¼
SECTION 34

NE¼ SW¼
S½ SE¼
SECTION 36

SE¼ SW¼
SECTION 35
TOWNSHIP 17 SOUTH, RANGE 12 EAST, W.M.

SW¼ SW¼
E½ SW¼
NW¼ SE¼
SECTION 31
TOWNSHIP 17 SOUTH, RANGE 13 EAST, W.M.

NE¼
NW¼
SW¼
W½ SE¼
SECTION 1

NW¼
SECTION 14

W½ NE¼
E½ NW¼
E½ SW¼
SECTION 15

NE¼
NE¼ NW¼
W½ NW¼
SW¼
SE¼
SECTION 2

SW¼ SE¼
SECTION 16

NE¼
E½ NW¼
N½ SE¼
SECTION 21

NE¼
E½ NW¼
SE¼
SECTION 3

W½ NW¼
W½ SW¼
SE¼ SW¼
SW¼ SE¼
SECTION 4

SW¼ SE¼
SECTION 22

N½ NE¼
SECTION 9

NE¼ NW¼
SECTION 27

ALL
SECTION 10

W½ NE¼
S½ NW¼
N½ SW¼
W½ SE¼
SECTION 12
TOWNSHIP 18 SOUTH, RANGE 12 EAST, W.M.

NE¼
NW¼ NW¼
SECTION 6
TOWNSHIP 18 SOUTH, RANGE 13 EAST, W.M.

The wells shall be maintained in accordance with the General Standards for the Construction and Maintenance of Water Wells in Oregon.

The works shall include an airline and pressure gauge or an access port for measuring line, adequate to determine water level elevation in the well at all times.

The water user shall install and maintain a weir, meter, or other suitable measuring device and keep a complete record of the amount of ground water withdrawn.

The right to use water for the above purpose is restricted to beneficial use on the lands or place of use described.

Issued NOV 04 2008

Phillip C. Ward, Director
Water Resources Department

Recorded in State Record of Water Right Certificates Number 82418.

STATE OF OREGON

COUNTIES OF DESCHUTES AND CROOK

PERMIT TO APPROPRIATE THE PUBLIC WATERS

THIS PERMIT IS HEREBY ISSUED TO

AVION WATER COMPANY, INC.
60813 PARRELL RD
BEND, OR 97702

The specific limits and conditions of the use are listed below.

APPLICATION FILE NUMBER: G-15851

SOURCE OF WATER: FOUR WELLS IN DESCHUTES RIVER BASIN

PURPOSE OR USE: QUASI-MUNICIPAL USE

MAXIMUM RATE/VOLUME: 5.0 CUBIC FEET PER SECOND, LIMITED TO A MAXIMUM ANNUAL VOLUME OF 643.0 ACRE FEET, FURTHER LIMITED BY THE CORRESPONDING MITIGATION PROVIDED

PERIOD OF USE: APRIL 15 THROUGH OCTOBER 15 OF EACH YEAR

DATE OF PRIORITY: OCTOBER 9, 2002

WELL LOCATIONS:

WELL #1 (MORNINGSTAR):	SW ¼ NW ¼, SECTION 30, T18S, R12E, W.M.; 254 FEET NORTH & 327 FEET WEST FROM SE CORNER OF THE SW 1/4 OF THE NW 1/4 CORNER, SECTION 30
WELL #2 (PARRELL):	SW ¼ SW ¼, SECTION 17, T18S, R12E, W.M.; 200 FEET NORTH & 580 FEET EAST FROM SW CORNER, SECTION 17
WELL #3 (CHINA HAT 1):	NE ¼ NE ¼, SECTION 29, T18S, R12E, W.M.; 400 FEET SOUTH & 900 FEET WEST FROM NE CORNER, SECTION 29
WELL #4 (CHINA HAT 2):	NE ¼ NE ¼, SECTION 29, T18S, R12E, W.M.; 400 FEET SOUTH & 1024 FEET WEST FROM NE CORNER, SECTION 29

of OAR Chapter 690, Division 505 (Deschutes Ground Water Mitigation Rules).

The first stage of incremental development has been met with 17.9 AF of mitigation water, being mitigation water resulting from Mitigation Project MP-41, an instream transfer; or suitable mitigation water that meets the requirements of OAR 690-505-0610(2)-(5), within the General Zone of Impact.

Mitigation water must be legally protected instream for instream use within the General Zone of Impact and committed for life of the permit and subsequent certificate(s). Regulation of the use and/or cancellation of the permit, or subsequent certificate(s) will occur if the required mitigation is not maintained.

If mitigation is from a secondary right for stored water from a storage project not owned or operated by the permittee, the use of water under this right is subject to the terms and conditions of a valid contract, or a satisfactory replacement, with the owner/operator of the storage project, a copy of which must be on file in the records of the Water Resources Department prior to use of water.

The permittee shall provide additional mitigation if the Department determines that average annual consumptive use of the subject appropriation has increased beyond the originally mitigated amount.

The permittee shall provide mitigation prior to each stage of development under the permit and in accordance with the standards under OAR 690-505-0610(2)-(5).

The permittee shall not increase the rate or amount of water diversion before increasing the corresponding mitigation.

The permittee shall seek and receive Department approval prior to changing the incremental permit development plan and related incremental mitigation.

The permittee shall report to the Department the progress of implementing the incremental permit development plan and related mitigation by not later than April 1 of each year.

In conjunction with Special Order Volume 63, Page 459, Final Order approving a Water Management and Conservation Plan, the permittee shall submit an updated Water Management and Conservation Plan pursuant to OAR Chapter 690, Division 86. The Director may approve

compliance with statewide land-use goals and any local acknowledged land-use plan.

The use of water shall be limited when it interferes with any prior surface or ground water rights.

Complete application of the water to the use shall be made on or before October 1, 2010. If the water is not completely applied before this date, and the permittee wishes to continue development under the permit, the permittee must submit an application for extension of time, which may be approved based upon the merit of the application.

Within one year after complete application of water to the proposed use, the permittee shall submit a claim of beneficial use, which includes a map and report, prepared by a Certified Water Rights Examiner (CWRE).

Issued March 9, 2006

Phillip C. Ward, Director
Water Resources Department

STATE OF OREGON

COUNTIES OF DESCHUTES AND CROOK

PERMIT TO APPROPRIATE THE PUBLIC WATERS

THIS PERMIT IS HEREBY ISSUED TO

AVION WATER COMPANY, INC.
60813 PARRELL RD
BEND, OR 97702

The specific limits and conditions of the use are listed below.

APPLICATION FILE NUMBER: G-15851

SOURCE OF WATER: FOUR WELLS IN DESCHUTES RIVER BASIN

PURPOSE OR USE: QUASI-MUNICIPAL USE

MAXIMUM RATE/VOLUME: 5.0 CUBIC FEET PER SECOND, LIMITED TO A MAXIMUM ANNUAL VOLUME OF 643.0 ACRE FEET, FURTHER LIMITED BY THE CORRESPONDING MITIGATION PROVIDED

PERIOD OF USE: APRIL 15 THROUGH OCTOBER 15 OF EACH YEAR

DATE OF PRIORITY: OCTOBER 9, 2002

WELL LOCATIONS:

WELL #1 (MORNINGSTAR):	SW ¼ NW ¼, SECTION 30, T18S, R12E, W.M.; 254 FEET NORTH & 327 FEET WEST FROM SE CORNER OF THE SW 1/4 OF THE NW 1/4 CORNER, SECTION 30
WELL #2 (PARRELL):	SW ¼ SW ¼, SECTION 17, T18S, R12E, W.M.; 200 FEET NORTH & 580 FEET EAST FROM SW CORNER, SECTION 17
WELL #3 (CHINA HAT 1):	NE ¼ NE ¼, SECTION 29, T18S, R12E, W.M.; 400 FEET SOUTH & 900 FEET WEST FROM NE CORNER, SECTION 29
WELL #4 (CHINA HAT 2):	NE ¼ NE ¼, SECTION 29, T18S, R12E, W.M.; 400 FEET SOUTH & 1024 FEET WEST FROM NE CORNER, SECTION 29

of OAR Chapter 690, Division 505 (Deschutes Ground Water Mitigation Rules).

The first stage of incremental development has been met with 17.9 AF of mitigation water, being mitigation water resulting from Mitigation Project MP-41, an instream transfer; or suitable mitigation water that meets the requirements of OAR 690-505-0610(2)-(5), within the General Zone of Impact.

Mitigation water must be legally protected instream for instream use within the General Zone of Impact and committed for life of the permit and subsequent certificate(s). Regulation of the use and/or cancellation of the permit, or subsequent certificate(s) will occur if the required mitigation is not maintained.

If mitigation is from a secondary right for stored water from a storage project not owned or operated by the permittee, the use of water under this right is subject to the terms and conditions of a valid contract, or a satisfactory replacement, with the owner/operator of the storage project, a copy of which must be on file in the records of the Water Resources Department prior to use of water.

The permittee shall provide additional mitigation if the Department determines that average annual consumptive use of the subject appropriation has increased beyond the originally mitigated amount.

The permittee shall provide mitigation prior to each stage of development under the permit and in accordance with the standards under OAR 690-505-0610(2)-(5).

The permittee shall not increase the rate or amount of water diversion before increasing the corresponding mitigation.

The permittee shall seek and receive Department approval prior to changing the incremental permit development plan and related incremental mitigation.

The permittee shall report to the Department the progress of implementing the incremental permit development plan and related mitigation by not later than April 1 of each year.

In conjunction with Special Order Volume 63, Page 459, Final Order approving a Water Management and Conservation Plan, the permittee shall submit an updated Water Management and Conservation Plan pursuant to OAR Chapter 690, Division 86. The Director may approve

compliance with statewide land-use goals and any local acknowledged land-use plan.

The use of water shall be limited when it interferes with any prior surface or ground water rights.

Complete application of the water to the use shall be made on or before October 1, 2010. If the water is not completely applied before this date, and the permittee wishes to continue development under the permit, the permittee must submit an application for extension of time, which may be approved based upon the merit of the application.

Within one year after complete application of water to the proposed use, the permittee shall submit a claim of beneficial use, which includes a map and report, prepared by a Certified Water Rights Examiner (CWRE).

Issued March 9, 2006

Phillip C. Ward, Director
Water Resources Department

AVION WATER COMPANY
PSI ZONES
2006

ZONE	LOW_P	HI_PSI
I-23	60	110
H-30	70	90
I-21	60	100
BI-20	60	120
BI-22	60	110
BC-28	40	110
C-29	60	70
B-26	60	10
B-27	60	100
B-25	70	110
I-17	60	100
B-19	60	100
ABI-1	60	110
IJ-16	70	110
J-13	70	134
J-7	65	85
AJ-14	60	110
AJ-7	65	120
AJ-12	75	115
AJ-9	70	109
AJ-11	60	80
AJ-10	60	65
A-8	70	115
A-16	70	80
A-6	65	85
A-7	65	100
AE-2	70	100
AE-1	65	105
B-24	85	110
A-4	60	70
A-5	44	80
A-3	62	118
KL-2	55	120
KL-1	70	120
K-3	50	120
K-4	60	120

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Mr. Jan Wick, President

Water Management and Conservation Plan

Fall 2004

Prepared by:

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Introduction

In order to understand the Updated Water Conservation & Management Plan which follows it is necessary to establish the basis upon which the plan has been drawn. The following information is intended to provide a full description of Avion's justification for its proposed Plan.

The elements of this introduction are as follows:

A. Utility Status of Avion
B. General Discussion of Source of Supply
C. Comparable rates in Deschutes County
D. General design requirements for Avion
E. Costs of water production
F. Sociological consequences
G. Impact of reduced water usage
H. Summary

A. Utility Status of Avion Water Company

Avion Water Company Inc. is an Oregon corporation and is a fully regulated Class A Water Utility Company. That is to say that the Oregon Public Utility Commission regulates all of the prices which Avion charges its customers for all services provided by Avion as well as the quality of service provided by Avion to its customers.

The basis for rate regulation is, in somewhat simplified form, as follows: Avion Water is permitted to recover from its customers all of it's operating costs for providing tariff services to its customers, along with the opportunity to earn a rate of return on it's net invested capital. The rate of return which is currently used by the Oregon Public Utility Commission in calculating Avion's rate structure is 10.5%. The rate of return may vary from time to time based upon economic calculations generally performed by the Commissions staff economists.
The rate making process generally consists of a request for rates by Avion to the Commission. Upon Avion's request for rates the Commission staff commences an investigation into Avion's capital structure, its operating costs, and its quality of service. The normal procedure includes audits of Avion's books and public hearings wherein relevant comments are invited from Avion's customers.

Upon agreement between Avion and the Commission staff with respect to operating costs and capital structure, and assuming that quality of service issues are satisfactory to the Commission staff, the total revenue required by the Company is usually agreed upon between the Commission staff and the Company.

When the total revenue requirement is agreed upon the Commission staff sets a proposed rate for the Company based closely upon the following formula; 60% of the revenue to which the Company is entitled is calculated to be realized from base rates charged to the Company's various classes of customers and 40% of the Company's revenue from a variable commodity charge based upon the amount of water consumed. The most recent rate structure applied by the OPUC used 55% of cost from base rates and 45% from commodity charge to generate total revenue requirement. The design encourages conservation even more than the standard design since using the current rate design increases commodity charges. If the Company and the Commission staff reach agreement upon the proposed rates, the Company and staff stipulate to a new rate which must be approved, based upon the staff testimony and the Company's testimony by the full Oregon Public Utility Commission. If a stipulated agreement could not be reached a contested rate case would ensue. In the past Avion has always reached a stipulated agreement with the Commission Staff.

Since 1989 Avion has attained the authorized rate of return on invested capital in only two years. The rate of return authorized by the commission is difficult to attain since the expenses used to generate the opportunity to achieve a rate of return are optimized.

It is essential for Avion to remain profitable in order to finance continued required improvements, repay existing capital debt, and continue to provide quality service to its customers.

B. General discussion of Source of Supply

Avion's sole source of supply is the Upper Deschutes Basin Aquifer.

A five year study conducted by the U.S. Geological Survey and the Oregon Water Resources Department of the Upper Deschutes Basin Aquifer, from which Avion withdraws all of its water supply, has revealed some significant findings with respect to the use of the resource.

The study has been completed and published since Avion's original Plan was submitted. The current calculations of the U.S. Geological Survey and OWRD indicate that less than 1% of the total annual recharge of the aquifer is pumped by all current uses. Further, ordinary variations in climate are such that the 1% utilized is undetectable in the river system. It is important to point out that stretches of the river system where lowest stream flows occur on the Deschutes

(Bend to Lower Bridge) are essentially not coupled to the ground water system, so pumping will not affect flows in these parts of the river.

The ground water resource is in fact abundant and current usage does not affect downstream uses in any detectable way. Climate is the only factor which affects measurable stream flow in the Upper Deschutes Basin, except for irrigation surface water uses which directly impact stream flows. Irrigation canal leakage has increased flows in the Crooked River over time. Avion uses only pumped ground water to serve its customers. Avion does, on a contract basis, deliver some surface water to customers and various Irrigation Districts for irrigation use only, but this water is not from an Avion ground water permit. According to the study the rate of annual recharge of the Upper Deschutes Basin Aquifer from, above Bend (excluding the Metolius Drainage system) is about 2,650 cubic feet per second, or 625,148,377,200 gallons per year. Avion currently pumps 1,694,374,144 gallons or about 1/369th of the recharge. If Avion reaches build-out and water consumption by our customers were to remain at approximately its current level, Avion customers would require approximately 6 times the current annual total. At the time of build out, whenever that is, Avion would serve approximately one half of the projected population of Deschutes County .The water pumped to Avion's customers would then have reached a total of about 7,960,400,000 gallons annually or about 1.27 per cent of the total annual recharge. This would equal approximately 0.84% (33 cfs) of the groundwater discharge near Madras (4000 cfs)

The amount pumped to Avion's customers does not accurately indicate the amount of "consumptive use". Clearly some portion of the water used by Avion's customers will return to the ground water table by percolation and run off.

The facts are that if Avion reaches the projected build out, and if the remaining areas of the County reach build out, the consequences of additional usage from the upper Deschutes Basin aquifer would not be measurable, although it can be estimated.

C. Comparable Water Rates For Deschutes County

Comparable water rates for suppliers of water in the area also served by Avion are:

Redmond: 81 cents per 100 cubic feet

Bend: 87 cents per 100 cubic feet

Roats: 72.2 cents per 100 cubic feet

Avion: 80 cents per 100 cubic feet.

It is apparent from these commodity charges above that Avion is now lower than other similar service providers in its service area except for Roats. There are a variety of reasons for the cost changes since the original plan. The greatest cause for the cost increases by Redmond and Bend is the need to fund capital projects to keep up with the rapid growth. Avion's commodity charge has not increased but the base charge per month has been increased to enable Avion to keep up with the rapid growth.

The current rate structure of Avion encourages water conservation. An example of the conservation practiced by our largest customer, the Lost Tracks Golf Course, is its reduction in annual use by 3,000,000 cubic feet from 1996 to 1997. Lost Tracks golf course charges for water service in 1997 was $75,506. The charges in 2003 was $73,116 which shows that even with an increased base rate Lost Tracks has continued to conserve water. The magnitude of the cost for water service to the golf course is more than sufficient to encourage best watering practice by the course. Several of Avion's other large water customers are in similar situations, such as the Bend-LaPine School District and Bend Metro Parks and Recreation District.

D. General Design Requirements for Avion

Avion Water needs to design is facilities to meet the following general requirements:

1. Fire flows must be met which dictates line size requirements, booster pump station capacities and storage capacity.

2. Storage facilities must be designed so as to meet peak daily demands.

3. Source pumping capabilities must meet peak daily demand.

4. All works must be constructed in accordance with the Oregon Department of Human Services Drinking Water Division standards, all applicable codes (UBC), and good engineering practice.

Peak daily demands for which Avion must design its pipeline sizes, pumping plant and booster station capacities, and storage capacities are the result of Avion's experience, generally accepted engineering practice, and Fire Codes of the Bend Rural Fire Department, City of Bend and Deschutes County Building Departments.

The events of 1990, the Awbrey Hall fire, and of 1996, the Skeleton Fire have provided Avion with data with respect to protracted area fires in very hot weather and the daily amounts of water required to cope with those circumstances.

The consumption figures reported in table: 4.5 do not include fire flow usage. During the Skeleton fire in August of 1996 the high temperature for the day was 100 degrees and the relative humidity was 7%. The wind was brisk and variable in direction. For a period of four days the fire was fought using Avion facilities. Avion supplied 1,000 gallons per minute continuously for the four day period. At the same time Avion must maintain sufficient water in storage and sufficient pumping capacity to provide fire water service to other areas. The direction of the fire was constantly changing, and many persons were watering the roofs of their homes and areas surrounding their homes. It is not possible to stop persons in these circumstances from using water. The peak consumption during the Awbrey Hall fire was 9,749,000 gallons per day. The average daily consumption for the month of the fire, including the water used during the fire, and all domestic and outside watering uses, was 7,588,601 gallons. The peak metered consumption was 8,749,000 gallons per day. Fire flow requirements for Avion also govern the construction of new facilities by Avion, and consequently the capital structure of Avion. Avion must construct pipelines, storage and pumping capacity to meet the most extreme conditions of fire and peak use. A commonly accepted standard for fire flow requirements and the standard used by Avion Water for design of its facilities is the National Board of Fire Underwriters formula for fire flow.

National Board of Fire Underwriters formula for fire flow:

$Q = 1{,}020\ \sqrt{P}(1-\sqrt{P}/100)$ where Q = gallons per minute P = population in thousands.

Avion currently has 7914 residential connections, and 712 commercial connections. The residential-population equivalents of all connections are estimated to be around 27,300. The requirement for fire flow from this formula is 5,051 gallons per minute.

The fire flow requirement at build out will be, if population for the service area reaches 100,000 population equivalents, 9,200 gallons per minute.

The significance of the above calculation is in two areas. If Avion fails to meet fire flow requirements the Insurance Services Organization will lower the fire rating of Avion's system causing increases in insurance rates for our customers. If Avion does construct facilities to meet fire flow the capital cost of the work must be paid for in consumer rates. Consumer rates are directly influenced by consumer water usage.

Avion's service pressures range from 45 psi to 95 psi at street mains. Fire flows are calculated at 20 psi residual. Since minimum urban and suburban fire flow are now 1,000 G.P.M., distribution main size will not be reduced substantially by reductions in irrigation demands. This is true because the pressure standards are different for fire flow and regular domestic service. Currently Avion's capital cost is about $19,000,000. In that capital cost only about $4,000,000 is invested in pumping plants, wells and storage. The balance is invested in pipelines.

Reduction in irrigation demands (summertime usage) would save capital cost only for wells and storage. The cost for mainlines would remain the same. Since the proportionate cost of storage and wells is so small compared to mainlines, it's clear that irrigation water sales subsidize fire flow capabilities, and power savings.

It is apparent that a reasonable balance must be struck between consumer use of water to generate revenue and consumer conservation to protect resources. Avion believes that the current balance built into Oregon Public Utility Rate structure meets the test of reasonable and feasible means to pay for necessary facilities to serve the publics need for fire service and its desire for balanced, moderate service rates.

E. Cost of Water Production

The variable cost for Avion to produce water is 9 cents per 100 cubic feet of water (750 gallons). The current tariff charge Avion is permitted for the sale of water is 80 cents per 100 cubic feet. All of Avion's profits and a significant portion of its operating costs are derived from water commodity charges.

F. Sociological Discussion

The discussion concerning the allocation of resources for the use of citizens is obviously an important one, but nevertheless, the remainder of this plan considers the following factors as being just as important, if not an over riding factor, in the design of the plan. The existence of trees, green areas, flowers, and lawns are a social good. They provide a pleasant living environment for all of the community, even though the plantings are often located on private property. Distressed communities have historically included within redevelopment plans increases in open spaces, trees and living plants. The guidelines for urban planning include numerous references to the general desirability of landscaping. The design criteria for most significant public works include mitigation of visual impacts through landscaping. Current planning requirements dictate ever increasing density of development to prevent urban sprawl. Within the context of quality of life, water supplied at reasonable price, if a supply is available at no harm to the environment, offers individuals the opportunity to mitigate the effects of crowding with landscaping. The community that is served by Avion is no different from any other in Oregon, except perhaps, that it is located in a semi-arid region with an abundant underground water supply.

G. Impact of Reduced Water Usage

Avion believes that its customers currently act in a manner that conserves water. The unit cost of water from Avion is not inexpensive. Avion believes that Avion customers are already prudent consumers. Anecdotal evidence to demonstrate Avion's customers water conservation practices exists. The winter of 1992-93 was very harsh in Central Oregon. Snow covered Bend for 100 consecutive days (an all time record). The summer of 1993 was cold and wet. Climatologists believe the unusually cool wet weather was a result of the eruption of Mt. Pinatubo in the Philippines. In any case the cool wet weather caused Avion's

customers to reduce irrigation water use substantially. Customers reduced water use due to weather by 20,800 Gallons per year per customer from the prior years use and 10,590 gallons per year from the average. The per-customer deviation from average was about -8%. The revenue lost was about $150,000, expense savings was about $15,000, which was mostly electricity. The weather driven conservation by Avion's customers caused Avion to suffer an operating loss for 1993. The operating loss had serious impact on Avion's financial health; Bank loans had to be renegotiated, and reserves of cash were depleted. Avion's bank loans were not rectified until the end of 1995 and cash reserves were not completely restored until the end of 1998. Avion owes the Oregon Department of Energy about $2,126,725. Avion has an obligation with ODOE to maintain reserves of $157,000. During 1993 those reserves were drawn down to $65,000.

A scheduled repayment of those reserves is being kept with ODOE approval which will restore the required reserve account by 1998. The reserve account is currently restored to the level it is required to be.

H. Summary

Avion's proposed conservation measures are all based upon the following general considerations: Prior to 1989 Avion's supply system consisted of 64 operating wells, a number of small storage facilities, and many small booster pump stations. The system due to its many pumping plants was difficult to operate and maintain. Service outages caused by pump failures were frequent. Only very limited fire flows were available. Customer Satisfaction was generally low and complaints to the Utility Commission frequent and often justified. In 1989 Avion's distribution system was altered to a gravity supply system for most customers, and fire flows were also provided to most customers. In 1993, 1995, 1999, 2003, and 2004 the gravity supply system was further extended to its current configuration.

The cost for the system redevelopment was about $8,500,000. The principal effects of the redevelopment have been as follows:

[1] The power cost for water production has fallen from $0.24 per 100 cu. ft. in 1989 to $0.09 per 100 cu ft in 1997. It is reasonable to assume that if the system had not been rebuilt, growth would have been the same. Avion has therefore saved millions of kilowatt hours which translate to water savings, as most of our power is generated by hydroelectric plants.

[2] The average cost for service per customer has increased mainly due to capital cost for new pipelines from approximately $19.00/ month to $29.30/ month. Avion's customers already are paying substantially for better service and power savings.

[3] Fire flow is generally available throughout the system.

[4] Customers satisfaction is high.

[5] Accountability for water pumped into the system and delivered from the system was established.

[6] The dollar value of power savings due to Avion's redevelopment of the water system was for 1997 $255,000. This savings indirectly measures water savings on the Columbia River.

[7] Per capita consumption on a total annual basis has only slightly increased from 1984 to the present.

Source of Supply: Source of supply is more than adequate to meet all of our projected or likely uses and the needs of all other users, with no perceived impact on the areas surface or ground water resources.

Cost of Measures: All of the cost for conservation measures will eventually be born by Avion's customers. Since Avion's customers already pay water rates similar to other customers in our area, all proposed conservation measures are the least cost option.

Due to its rate structure Avion assumes considerable financial risk simply due to normal weather fluctuations. Avion's customers, due to its rate structure, have substantial incentive to conserve, and in fact do so.

1. 690-86-140 Municipal Water Supplier Description

The water supplier description element shall include at least the following information:

a) Source(s) of water; including diversion, storage, and regulation facilities; exchange agreements; intergovernmental cooperation agreements, and water supply or delivery contracts;

Avion Water Company Inc. (Avion) began its formation as a private water service company in the late 1960's under the ownership of Paul Ramsay. Since that time, it has become the largest private water supply company in the State of Oregon. Presently Avion provides water to over 7,914 residential customers, and over 712 commercial/industrial accounts. The present water service area includes nearly 2,700 acres within the Urban Growth Boundary (UGB) for the City of Bend, and approximately 50,000 acres outside the Bend area UGB. Mr. Jan M. Wick has been the President of Avion since 1987.

Table 1.1 shows a complete listing of Avion's existing water rights and significant information. Avion began acquiring water rights in its own name on May 21, 1969. As of today, there are 11 separate rights, including the most recent permit G-12788, which carries a priority date of May 18, 1992. These rights provide for the use of a total of 39 wells throughout the service area, 31 of which are currently in active production. The other 8 wells are in "reserve" until needed. All of the wells develop water from the confined basalt aquifer which underlies most of the Central Oregon area.

Not including the additional quantity of water allowed under Permit G-12788, Avion's other 13 prior water rights allow a total appropriation of up to 12.08 cfs (over 5,400 GPM). As is described later in Section 4, Avion's peak-day demand for 1996 exceeded 13.5 cfs (6076 GPM). Permit G-12788 was issued by the Oregon Water Resources Department (OWRD) on August 31, 1996.

The G-12788 permit allows for a total maximum appropriation of 25.18 cfs (11,305 GPM) from the 39 wells for quasi-municipal use throughout the Avion service area, together with uses under the prior rights. The amount allowed is further limited to not exceed 14.26 cfs (6,400 GPM) until or unless a Water Management Plan that substantiates the need for water in excess of 6,400 GPM is submitted by the permittee and approved by OWRD. That plan has been submitted to, and accepted by OWRD in 1998. The maximum daily water usage in 2003 was 11,438,495 gallons/day. This translates to 7,944 GPM or 17.70 cfs, which is under the maximum allowed by the permit G-12788.

Other permit conditions include requirements to measure and report all withdrawals, to submit a plan to monitor and report water level information and to allow for regulation of the use in the event of excessive groundwater level

declines or substantial interference with surface water users or scenic waterway flows. Avion has submitted the required ground-water monitoring plan, which has been approved.

1.a. Existing Supply;

As mentioned in the introduction above, Avion relies upon a single water source, the area's vast basalt aquifer. All wells develop water from this source. Water level measurements have been taken periodically since Avion began, and a more systematic and regular measurement program has been in place for the past several years. No long-term significant groundwater level declines have been noted in Avion wells. The US Geological Survey, in cooperation with OWRD and other state, federal, and local agencies has conducted a comprehensive groundwater study in the Upper Deschutes Basin. Information released in the study bears out the Avion experience with water levels. The study states no long-term declines in ground-water levels that can be attributed to pumping or other human activities are observable in the area. Further data was reported regarding the average annual recharge occurring to this groundwater flow system. It is now estimated that, averaged over the entire year, over 4,000 cubic feet per second of water is recharged. About 3,500 cfs of this is from natural infiltration of precipitation, and about 500 cfs is from canal leakage and on-farm losses, primarily from irrigation district water application throughout the area. Preliminary data also shows that the groundwater flow system discharges to the Deschutes River occur far downstream from Bend where the needs of existing water rights, scenic, and in-stream flow needs are typically met at all times of the year. There is no present indication of the development of any future water supply problems from this source.

1.b. Water System & Storage Facilities;

The present system is schematically displayed in Figure 1.1. The map shows the locations of all current and proposed pipelines, wells, reservoirs and pump stations. This schematic was prepared as part of Avion's 20-year Master Plan as required by the Oregon Health Division (OHD). This portion of the plan has been approved by OHD.

The system includes approximately 310 miles of main lines, all of which are PVC construction of various diameters up to 20 inches. For the past 5 years, Avion has averaged about 350 new residential and 35 commercial service additions per year (see Section 4). Over 8.58 miles of line extensions were completed in 2003 to accommodate this growth. The Avion well system is entirely interconnected, allowing for maximum flexibility in water delivery and protection against shortages caused by pump or individual well failures. There are 6 existing reservoirs with a total storage capacity of nearly 6.9 million gallons. This would provide adequate stored water supplies to meet the 2003 peak-day system demand for 12 hours. Plans are being developed to add an additional 5 million gallons of storage over the next 10 years. In the event of an

extended system-wide power loss, the existing storage would provide up to 2 days of water for meeting basic household and health and safety needs. As further discussed in Section 3, restrictions would be placed on all non-essential uses in the event of such a catastrophe.

The system currently has six pumping stations (Table 1.2) that consist of a total of 11 high production wells. About 20 additional wells are at the ready to serve as backup sources of supply, to come on line as the rapid increases in system demand dictate, or if a primary supply well goes down. In addition, there are 8 "reserve" wells that would be prepared for use should the need arise. The 11 production wells have a pumping capacity of about 19.87 cfs (8,918 GPM).

Table 1.2

Pump Station Capacities

Well Site	Location	Capacity (GPM)	# of Wells
1	Tekampe Road	2785	3
2	Parrell Road	830	1
3	Conestoga	92	1
4	Riverbend	1055	2
5	China Hat	2845	2
6	Sundance	100	1
7	Deschutes River Wood	1211	1
	Totals	8918	11

1.c. Transfer and Exchange Agreements;

No transfer or exchange agreement exists between Avion and any other agency. Avion does have a franchise agreement with the City of Bend regarding service territory (see attached map, Fig 1.1).

2. A delineation of the current service areas and an estimate of the population served and a description of the methodology(ies) used to make the estimate;

2.a. A delineation of the current service area;

Avion's current service area is shown on the Avion Service Territory map (see attached map, Fig 1.1).

2.b. An estimate of the population served and a description of the methodology(ies) used to make the estimate;

The current population served is estimated on table 4.4B and is based on 2.55 people per household. The person per household number was obtained from the Deschutes County Planning Department.

3. An assessment of the adequacy and reliability of the existing water supply considering potential limitations on continued or expanded use under existing water rights resulting from existing and potential future restrictions on the communities water supply;

The adequacy and reliability of the existing water supply and its potential limitations and restrictions are discussed in paragraph *1.a.* of this section.

4. A quantification of the water delivered by the water supplier that identifies current and available historic average annual water use, peak seasonal use, and average peak day use;

A summary of the water use statistics for 1996 and 2003 are listed below in tables 1.3A and 1.3B.

1996 & 2003 Water Use Summaries

TABLE 1.3A

1996 *WATER USE STATISTICS SUMMARY*

Total Year	160,040,735 cubic feet	3,674 acre feet
Peak Month (August)	30,435,566 cubic feet	699 acre feet
Minimum Month (January)	4,875,784 cubic feet	112 acre feet
Average Daily	438,467 cubic feet	2,278 gpm
Peak Daily	1,169,786 cubic feet	6,076 gpm
Ave. Day to Peak Day Ratio		2.67
Peak Daily per Capita		545 gpd
Average Annual Daily per Capita		162 gpd
Non-peak Season Ave. Daily per Capita		95 gpd

(1) Non-peak season is defined as November 1995 through April 1996.

TABLE 1.3B

2003 *WATER USE STATISTICS SUMMARY*

Total Year	159,801,517 cubic feet	3669 acre feet
Peak Month (August)	31,908,089 cubic feet	733 acre feet
Minimum Month (February)	4,521,053 cubic feet	104 acre feet
Average Daily	437,813 cubic feet	2,274 gpm
Peak Daily	1,529,108 cubic feet	7,944 gpm
Ave. Day to Peak Day Ratio		2.46
Peak Daily per Capita		546 gpd
Average Annual Daily per Capita		170 gpd
Non-peak Season Ave. Daily per Capita		94 gpd

(1) Non-peak season is defined as November 2002 through April 2003.
(2) December 2003 ignored due to usage being estimated.

5. A tabular list of water rights held by the municipal water supplier that includes the following information:

See table 1.4 for the information in questions **5 (a), 5(b),** and **5(e).**

Table 1.4

Record Number	Well # under Permit G-12788 If Applicable	Well # under original permit	Original Permit #	Certificate # If any	Priority Date	Quantity Under Permit Original CFS	Remarks Special Conditions
1	A Bob Smith	A	6-12788		5/18/92	*	
2	B-1 River Bend	Well #5	G-9948QM		7/2/81	0.72	
3	B-2 River Bend	B-2	G-12788		4/18/92	*	
4	C-1 Tekampe-B	Site F Well #1	G-9948QM		2/27/81 11/12/82	1.34	
5	C-2 Tekampe-C	Site F Well #2	G-9948QM		2/27/81 11/12/82	0.53	
6	C-3 Tekampe-A	C-3	G-12788	#65353	5/18/92	*	
7	D-1 Sunset West	Well #1	G-9948QM	#65353	4/1/81	0.09	
8	D-2 Sunset West	Well #2	G-9948QM	#65353	4/1/81	0.09	
9	D-3 Sunset West	Well #3	G-9269QM		4/1/81	0.13	
10	E-1 Ridge	Well #3	G-9948QM		7/2/82	0.72	

11	E-2 Ridge	E-2	G-12788		5/18/92	*
12	F-1 Woodriver	Well #1	G-9217QM	#65352	2/11/81	0.56
13	F-2 Woodriver	Well #2	G-9217QM	#65352	2/11/81	0.56
14	G-1 Daly Estates	Site B Well #1	G-9946QM		2/27/81 11/12/82	0.29
15	G-2 Daly Estates	Site B Well #2	G-9946QM		2/27/81 11/12/82	0.29
16	H-1 Avion	Site A Well #1	G-9946QM		2/27/81 11/12/82	0.1
16	H-1 Avion	Site A Well #1	G-4608GD G-3889GD	#57052 #57052	5/12/69 10/17/66	0.015 0.045
17	H-2 Avion	Site A Well #2	G-9946QM	#57054	2/27/81 11/12/82	0.27
17	H-2 Avion	Site A Well #2	G-4608GD	#57054	5/21/69	0.06
18	I Eagle	Site E Well #1	G-9975QM		6/16/81	0.45
19	J Deschutes Market	Site A Well #1	G-9975QM		6/16/81	0.39
20	K Brookside	Site D Well #1	G-9975QM		6/16/81	0.33
21	L Swalley	Site C Well #1	G-9975QM		6/16/81	0.17
22	M Ranch Village	Site G Well #1	G-9975QM		6/16/81	0.22
23	O Cody Road	Well #1	G-11972		1/13/83	0.12
24	P Donna Lane	Well #2	G-11972		1/13/83	0.12
25	Q Peterman	Well #Q	G-12788		5/18/92	*
26	S 94th and Pony	Well #1	G-9341QM		4/8/81	0.22
27	T Hunnell Road	T	G-12788		5/18/92	*
28	V Pohaku	Well #3	G-9341QM		4/8/81	0.22
29	X Sylvan Knolls	Well #1	G-9971- Group		5/29/81	0.17
30	Y-Sylvan Loop Boonesborough	Well #2	G-9971		5/29/81	0.22
31	Z-1 Mc Grath	1-Feb	G-12788		5/18/92	*
32	Z-2 Mc Grath	1-Feb	G-12788		5/18/92	*

33	A-1 Buena Ventura	Well #3	G-9971- Group	5/29/81	1.09
34	A-2 Gosney	Well #1	G-9981- Group	11/19/81	0.18
35	N-1 Sundance	N-1	G-12788	5/18/92	*
36	N-2 Sundance	N-2	G-12788	5/18/92	*
37	R Conestoga	Well #1	G-9284QM	3/11/81	0.37
38	U East Villa	Site F	G-9975	6/18/81	0.33
39	W Glacier View	Well #2	G-9341	4/8/1981	0.22
40	#1 Larkwood	Well #1	G-9948	7/2/81	0.334
41	Romaine- Mahogany	Well #2	G-9948	7/2/81	0.334
42	Romaine- Mahogany	Well #4	G-9948	7/2/81	0.04
43	Ronald Acres	Site B Well 12	G-9975	6/16/81	0.22
44	Country Sunset	Site C	G-9946	2/27/81 11/12/82	0.28
45	Skyview Terrace	Site D	G-9946	2/27/81 11/12/82	0.28
46	Paulina View	Site E	G-9946	2/27/81 11/12/82	0.028
47	Dobbins	Site G	G-9946	2/27/81 11/12/82	0.27
48	Somerset	Site H	G-9946	2/27/81 11/12/82	0.41
	Total CFS				12.08

(a) Application, permit, transfer, and certificate numbers (as applicable);

(b) Priority date(s);

(c) Source(s) of water;

The Aquifer for all permits is the upper Deschutes Basin Aquifer.

(d) Types of beneficial uses specified in the right;

All water rights are listed as quasi-municipal other than numbers 29, 30, 33, and 34 which are listed as group domestic.

(e) Maximum instantaneous and annual quantity of water allowed under each right;

(f) Maximum instantaneous and annual quantity of water diverted under each right to date;

All the rights for the greater Avion system have been grouped under permit G-12788 which allows for 11,305 gpm and the total diversions are listed on tables 1.5A, 1.5B, and table 4.5.

(g) Average monthly and daily diversions under each right for the previous year, and if available for the previous five years;

See tables 1.5A, 1.5B and table 4.5 for this information.

Monthly Historical Water Use Data

A tabulation of monthly water use for residential customers from July 1994 through December 1996 is shown on tables 1.5A and July 2001 through December 2003 on Table 1.5B. Data from these tables is useful to indicate the typical periods of minimum and maximum water use on a monthly basis.

The per capita water use is calculated from the number of residential connections with 2.55 people per residential connection. The average household size of 2-5 people is taken from the Deschutes County Comprehensive Plan.(Telephone conversation w/ Bill the Deschutes County Community Development Department) This household size estimate compares favorably to the Portland State University household size estimate of 2.65 people.

A key statistic shown in Tables 1.5A and 1.5B is that the average per capita water use during December 1995 equals 70 gallons per capita per day. A nearly identical per capita water use of 71 gallons occurred in January 1995, 75 gallons in January 2002, and 75 gallons in January 2003. 70 gallons per capita per day is the national average winter water flow determined from an Environmental Protection Agency needs survey of 270 Standard Metropolitan Statistical Area cities. Based on this comparison, winter water use in the Avion service area is shown to be essentially identical to the national average per capita water use when outside water use is excluded.

Short term declines of residential connections can be seen in the Table 1.5A and 1.5B data that starts almost every November and December. The decline appears odd in the context of steady growth seen during other months of the year. The reason for the decline is that many residents vacation for extended periods of time outside of Central Oregon to apparently avoid the winter weather. The Avion PUC tariff agreement allows Avion to disconnect the meters of vacant homes without a service charge so that freezing weather does not damage meters and service lines. In some years, the November and December decline is offset

by new connections that have occurred by the following January. Although the reconnection process is gradual, the percentage of growth seen in April of almost every year is an indication that the services are reconnected by this month. The only aberration in the data is December 2003 and this was due to an extremely snowy winter. Usually half of the meters are read and half of the meters are estimated in the winter months. The inordinate amount of snow on the ground in December 2003 required that all meters be estimated.

The average monthly diversions are listed below on table 1.5A and 1.5B

TABLE 1.5A

MONTHLY WATER USE DATA - 1994 TO 1996 AVION WATER COMPANY, INC

Date	No. of Residences	Population Served (1)	Cubic Feet per Month	Gal/Day per Residence	Gal/Capita per Day	Percent of Pop Growth Per Month
Jul '94	5692	14,515	18,707,967	793	311	0.32%
Aug '94	5731	14,614	21,125,834	889	349	0.68%
Sep '94	5740	14,637	22,767,311	989	388	0.16%
Oct '94	5750	14,662	16,082,961	675	265	0.17%
Nov '94	5728	14,606	4,325,262	188	74	-0.38%
Dec '94	5714	14,571	4,630,400	196	77	-0.25%
Jan '95	5755	14,675	4,341,219	182	71	0.71%
Feb '95	5761	14,691	4,234,688	196	77	0.10%
Mar '95	5774	14,724	4,541,932	190	74	0.23%
Apr. '95	5838	14,887	7,226,440	309	121	1.10%
May '95	5854	14,928	6,873,643	283	111	0.27%
Jun '95	5900	15,045	12,788,415	540	212	0.78%
Jul '95	5934	15,132	17,315,196	704	276	0.57%
Aug '95	5959	15,195	19,331,810	783	307	0.42%
Sep '95	5976	15,239	19,983,699	834	327	0.28%
Oct '95	6004	15,310	17,097,795	687	269	0.47%
Nov '95	5998	15,295	5,863,301	244	96	-0.10%
Dec '95	5761	14,691	4,234,688	177	70	-4.11%
Jan '96	6016	15,341	4,875,784	196	77	4.24%
Feb '96	6033	15,384	6,132,620	262	103	0.28%
Mar '96	6064	15,463	7,076,338	282	110	0.51%
Apr.'96	6140	15,657	7,122,684	289	113	1.24%
May '96	6176	15,749	10,210,096	399	156	0.58%
Jun '96	6213	15,843	21,451,216	861	338	0.60%
Jul '96	6278	16,009	20,719,456	796	312	1.04%
Aug '96	6286	16,029	30,435,566	1,168	458	0.13%
Sep '96	6294	16,050	23,272,753	922	362	0.13%
Oct '96	6301	16,068	17,347,758	664	261	0.11%
Nov '96	6285	16,027	5,380,061	213	84	0.25%
Dec '96	6296	16,055	6,016,403	231	90	0.17%

1) Based on 2.55 people per residence.

TABLE 1.5B

MONTHLY WATER USE DATA - 2001 TO 2003 AVION WATER COMPANY, INC

Date	No. Of Residences	Population Served (1)	Cubic Feet per Month	Gal/Day per Residence	Gal/Capita per Day	Percent of Pop Growth Per Month
Jul '01	6872	17,524	22,257,019	782	307	0.40%
Aug '01	6870	17,518	21,519,290	756	296	-0.03%
Sep '01	6875	17,532	23,836,927	837	328	0.07%
Oct '01	6880	17,544	14,352,753	503	197	0.07%
Nov '01	6867	17,511	5,575,389	203	79	-0.19%
Dec '01	7085	18,067	7,746,400	264	104	3.08%
Jan '02	6824	17,402	5,380,427	190	75	3.68%
Feb '02	6823	17,399	5,010,245	196	77	0.10%
Mar '02	6847	17,460	4,685,023	165	65	0.35%
Apr. '02	6890	17,560	4,929,204	179	70	0.62%
May '02	6977	17,792	9,631,244	333	131	1.25%
Jun '02	6991	17,827	23,721,572	846	332	0.20%
Jul '02	7029	17,924	26,001,660	893	350	0.54%
Aug '02	7065	18,016	28,756,258	983	386	0.51%
Sep '02	7091	18,082	23,391,598	796	312	0.37%
Oct '02	7116	18,146	15,683,621	532	209	0.35%
Nov '02	7087	18,072	5,610,283	198	78	0.41%
Dec '02	7117	18,149	7,963,275	270	106	0.42%
Jan '03	7097	18,098	5,563,137	190	75	0.28%
Feb '03	7149	18,230	4,786,820	173	68	0.73%
Mar '03	7171	18,286	4,521,053	152	60	0.31%
Apr '03	7249	18,485	5,293,658	182	72	1.08%
May '03	7298	18,610	8,923,493	295	116	0.67%
Jun '03	7379	18,817	22,762,314	770	302	1.10%
Jul '03	7415	18,910	24,560,065	800	314	0.49%
Aug '03	7452	19,003	31,908,089	1,034	406	0.50%
Sep '03	7519	19,174	25,681,624	852	334	0.89%
Oct '03	7551	19,256	17,369,943	555	218	0.42%
Nov '03	7548	19,248	7,002,604	231	91	0.04%
Dec '03	7562	19,284	1,428,717	81	19	0.19%

1) Based on 2.55 people per residence.

(h) Currently authorized date for completion of development under each right; and

The water rights listed above have been combined under permit G-12788 which has the development date of December 1999. An extension was applied for in October 1999 and the extension was returned to us in the fall of 2004 for re-submittal due to OWRD changing its format for extension application.

(i) Identification of any streamflow-dependent species listed by a state or federal agency as sensitive, threatened or endangered that are present in the source, any listing of the source as water quality limited and the water quality parameters for which the source was listed, and any designation of the source as being in a critical groundwater area.

There are currently no known species threatened or otherwise endangered in Avion's water source. The water source is not listed as water quality limited at this time, nor will it be in the foreseeable future. There is no designation of the source as being in a critical ground water area.

6. A description of customers served including other water suppliers and the estimated numbers; general water use characteristics of residences, commercial and industrial facilities, and any other uses; and a comparison of the quantities of water used in each sector with the quantities reported in the water suppliers previously submitted water management and conservation plan and progress reports;

6.a. A description of customers served including other water suppliers and the estimated numbers;

The water demand forecast in section 4 provides this information. Section 4 presents existing lot sizes by various categories, use patterns for winter and summer water use for all classes of customers, and historic patterns of use.

6.b. General water use characteristics of residences, commercial and industrial facilities, and any other uses;

The water demand forecast in section 4 provides this information.

6.c. A comparison of the quantities of water used in each sector with the quantities reported in the water suppliers previously submitted water management and conservation plan and progress reports;

See table 4.5 and tables 1.3A and 1.3B.

7. Identification and description of interconnections with other municipal supply systems;

Several interconnections currently exist between Avion Water Company and other suppliers. Avion Water and the City of Bend have two interconnections which are in place for emergency use by either system as needed. Avion Water has an additional 3 interconnections with Roats Water for emergency purposes as well. See attached map for interconnection details. The valves are exercised biannually to insure that they are in proper working order.

8. A schematic of the system that shows the sources of water, storage facilities, treatment facilities, major transmission and distribution line,

pump stations, interconnections with other municipal supply systems, and existing and planned future service area; and

Appended is a Master Plan map of Avion Water Company's existing system which includes all of Avion's facilities. The Master Plan has been approved by the State of Oregon Health Division and is on file with the Oregon Utility Commission.

9. A quantification and description of system leakage that includes any available information regarding the locations of significant loss.

Current system loss is approximately 6.7%, well below the required standards. There are currently no single identifiable locations of significant loss. See table 2.2 for more information.

2. 690-86-150 Municipal Water Conservation Element

The water conservation element shall include at least the following:

(1) A progress report on the conservation measures scheduled for implementation in a water management and conservation plan previously approved by the department, if any;

There was no specific water conservation measures scheduled for implementation in the plan submitted in 1998. The continuing education programs for the public are ongoing, see sections 2.4 for more information on specific conservation measures.

(2) A description of the water supplier's water use measurement and reporting program and a statement that the program complies with the measurement standards in OAR chapter 690, division 85, that a time extension or waiver has been granted, or that the standards are not applicable;

It is believed that Avion has previously implemented known supply management practices that are reasonably available. The Avion system is modern and highly efficient. All water entering the system is fully metered, as are all deliveries. A thorough water audit is conducted annually. Recent audits have demonstrated losses averaging 6.27% annually, with monthly lows at about 4%, system-wide, of which 1-2% can be attributed to unavoidable meter error. An additional, unquantifiable, component that contributes to this figure is water used for emergency fire fighting purposes and for the periodical hydrant flushing activities required by the State Fire Marshall. As an example, the Awbrey Hall fire in 1990 consumed an estimated 1500 GPM continuously for 4 days, and this type of use contributes to the loss figure because fire flows are not metered.

Avion has an active supply-side meter calibration and replacement program. All wells on the incoming side are tested biennially, see attached letter from Jeremy Griffin, District 11Watermaster regarding well flow testing. Tests of the Avion water supply has consistently shown the pH levels to be within the 6.9- 7.1 range, and no sand or other particles exist which would cause wear on a meter. On the demand side, customers' service meters are checked by running monthly computer checks of billings. If any customer's use either increases or decreases by 15% over that customer's average use for the same month over the previous 3 years, the meter is pulled, replaced and tested.
As discussed in Section 1, all supply lines are PVC material, with life expectancies approaching 500 years. Leaks which develop in these lines are invariably catastrophic failures, which are detected and repaired immediately.

Over 700 of Avion's customers have irrigation and or stock water rights from surface water that is delivered by an irrigation district. Precise figures cannot be

determined, but demand for Avion water is significantly reduced by this practice.

Avion believes it has accomplished all reasonable water supply management opportunities available at this time, and complies with OAR 690 Division 85

(3) A description of other conservation measures, if any, currently implemented by the water supplier, including any measures required under water supply contracts;

During 1989 Avion implemented a long term conservation plan. The plan's first phase was funded by and Oregon Department of Energy loan in the amount of $3,300,000. The first phase of the plan cost $3,700,000.

The plan called for the replacement of numerous booster pumps and wells with a gravity supply system to the majority of Avion's customers. The first phase of the plan resulted in Avion receiving the Governor's Energy Award for 1990(attached). During 1993, 1995, and 1997 the remaining phases of the plan were implemented. The final phases of the plan extended gravity service to all of Avion's customers within the service area of this management plan. The total construction cost of the plan has been $6,250,000. Prior to the implementation of the plan the electrical power cost for each 100 cubic feet of water delivered was about 24 cents. The power cost for each 100 cubic feet of water delivered is now about 9 cents. The kilowatt hours used were, prior to the implementation plan, was about 6 kilowatt hours per 100 cubic feet of water delivered, the current power consumed per 100 cubic feet of water delivered is about 2.25 Kilowatt hours. The gravity delivery system has saved about $1,538,000 in power costs and about 40,000,000 kilowatt hours. Since the power purchased by Avion is generated by BPA, the kilowatt hours saved translates directly to water savings on the Columbia River generating system.

The cost for the conservation measures taken is embedded in Avion's rate structure and is not easy to perfectly define. It is, however, possible to arrive at a cost figure which approximates the true cost of the energy savings. The cost for capital to improve the efficiency which is paid for by Avion's customers is about $1,000,000 per year. The power savings associated with the cost is about $255,000 per year, or about 6,375,000 kilowatt hours at Avion's current rate of water delivery .There are other cost savings which accrue to Avion's customers such as reduced operations and maintenance costs, and reduced fire insurance costs. Avion's customers further enjoy better service since far fewer service outages failures occur, since the systems operation is no longer dependent upon large numbers of booster pumps.

Nevertheless, Avion's customers subsidize the energy saving program at this time. The precise subsidy cannot be defined. In the long term, with growth in numbers of customers and amount of water used the energy savings program will economically justify itself and an even greater benefit to the Columbia

River generating system will continue to occur. It is clear that Avion's customers already participate in expensive and effective conservation efforts.

Avion's rate structure, as described in its tariffs and approved by the PUC (see introduction), is a flat structure, with no allowances for volume discounts. Although not as punitive to excessive use as an inverted block structure or seasonal rate might be, it encourages conservative use more than some other methods. Basically, the formula allows Avion to recover its actual costs for water deliveries, plus a "reasonable" rate of return on capital investments in the system. Approximately 55% of Avion revenue is generated from its allowed "base" charge and 45% from commodity sales.

The commodity charge is currently $0.80 per 100 cubic feet. All records and accounts are closely audited by the PUC.
The process of rate-setting is strictly controlled by law, under the oversight of the PUC. While it might be possible to restructure the current rates to one that more strongly encourages conservation, it is not believed to be in the best interest of the company or its customers at this time. PUC is not aware of any private water purveyor who has attempted to adopt alternative rate structures to date.

Avion, like all private utilities, is in the business to make a profit. If Avion's customers use significantly less water, the company would be forced to pursue higher rates. The only cost savings to Avion in reduced water use would be through reduced power consumption, which represents only about 10% of our total costs. The other 90% consists of fixed costs, such as staff, buildings, equipment, billing, etc. The likely result is that the customers would end up paying the same for their efforts. In addition, the glowing information about the area's groundwater coming from the Deschutes study (see Section 1.3) has been widely disseminated. We believe it would be impossible to sell an aggressive conservation program, given this combination of circumstances.

(4) A description of the specific activities, along with a schedule that establishes five-year benchmarks, for implementation of each of the following conservation measures that are required of all municipal water suppliers:

2000 – 2002: Avion cooperated with local government and private water companies in the area to present and staff a water conservation booth at the Deschutes County Fair. The staff handed out water conservation fliers, lawn watering gauges, and various irrigation accessories.

2002: Avion staffed a booth at the 2002 home show promoting water conservation.

2002- Present: Member of L.A.W.N. (Local Area Water Network) a group which promotes water conservation through television commercials and ads in the local papers.

Avion water is using the conservation based GPM flow as a bench mark for conservation. Comparing the 1996 prediction with the actual numbers produced shows that Avion is meeting its goal of 2% reduction in usage. The revised estimates use the current-use numbers so Avion will have a clearer picture of weather or not conservation goals are being met in the future. All water use predictions are still subject to the environment and several hot dry years in a row will skew the numbers away from conservation based use. See attached information in the back of this report for conservation pamphlets etc.

(a) An annual water audit that includes a systematic and documented methodology for estimating any un-metered authorized or unauthorized uses;

An annual water audit is already in place. With the current measuring systems in place Avion Water can determine the total amount of water produced and the total amount of commercial and residential water sales. From these two numbers it can be determined the amount of water lost to leakage, meter error, and new construction activities. For example the difference between the water sold and the water produced for 2003 was 6.72%, well within the required 10% loss.

(b) If the system is not fully metered, a program to install meters on all un-metered water service connections. The program shall start immediately after the plan is approved and shall identify the number of meters to be installed each year with full metering completed within five years of approval of the water management and conservation plan;

Avion Water is fully metered.

(c) A meter testing and maintenance program;

Avion Water has a meter testing and maintenance plan in place.

(d) A rate structure under which customers bills are based, at least in part, on the quantity of water metered at the service connections;

Avion's rate structure has a base rate and a charge based on the amount of water used. The current residential rate structure is a $20.82 base rate and $0.80 per 100 cubic feet of water used.

(e) If the annual water audit indicates that system leakage exceeds 10 percent, a regularly scheduled and systematic program to detect leaks in the transmission and distribution system using methods and technology appropriate to the size and capabilities of the municipal water supplier; and

Avion system loss is currently 6.72% which is well below the required 10%. The average loss for the last 4 years is 7.75%.

(f) A public education program to encourage efficient water use and the use of low water use landscaping that includes regular communication of the supplier's water conservation activities and schedule to customers;

Attached are examples of Avion's informational hand-outs to its customers. It is Avion's opinion that the information contained therein is the best available information. Avion does include selected pamphlets in its annual newsletter and at the beginning of each planting and irrigation season (The end of March or early April). Avion will publish the information by means of one full page advertisement in the Bend Bulletin annually. The cost for this advertisement is currently $1,500.

It is Avion's intention to provide ongoing education to our customers with respect to best watering practices, landscaping and planting techniques, and best watering times through media and newsletter resources. The goal of our efforts will be to gradually reduce water use through education. See section 2.4 for more examples of Avion's on-going education efforts.

If, for instance, all of Avion's customers reduced water usage by 10% immediately Avion would lose 4.5% of its gross revenue. In order to remain profitable Avion would need to generate the lost revenue from increased base rates (see above). In the event that Avion's customers gradually reduce water usage and Avion's customer base continues to grow as it has in the past the cost for conservation measures can be born by the growth in revenue due to the addition of new customers.

(5) If the municipal water supplier proposes to expand or initiate diversion of water under an extended permit for which resource issues have been identified under OAR 690-086-0140(5)(i), a description of the specific activities, along with a schedule that establishes five-year benchmarks, for implementation of a system-wide leak repair or line replacement program to reduce system leakage to no more than 15 percent or sufficient information to demonstrate that system leakage currently is no more than 15 percent;

Not applicable.

(6) If the municipal water supplier serves a population greater than 1,000 and proposes to expand or initiate diversion of water under an extended permit for which resource issues have been identified under OAR 690-086-0140(5)(i), or if the municipal water supplier serves a population greater than 7,500, a description of the specific activities, along with a schedule that establishes five-year benchmarks, for implementation of each of the following measures; or documentation showing that implementation of the measures is neither feasible nor appropriate for ensuring the efficient use of water and the prevention of waste;

(a) A system-wide leak repair program or line replacement to reduce system leakage to 15 percent, and if the reduction of system leakage to 15 percent is found to be feasible and appropriate, to reduce system leakage to 10percent;

Avion will eventually have to acquire more water rights to meet the increasing demand; however our current system leakage is less than 15%. See table 2.2 below.

Table 2.2

System Loss

Year	Total Water Produced (cf)	Total water Sold	% Loss
2001	200,490,721	187,659,536	6.40%
2002	223,056,562	210,382,627	5.68%
2003	226,505,467	211,295,603	6.72%

Avion Water Company is currently well within the 10% leak standard.

(b) Technical and financial assistance programs to encourage and aid residential, commercial and industrial customers in implementation of conservation measures;

Avion already provides technical support for any commercial or residential customer who is interested in assistance. Avion provides newsletters and pamphlets that provide assistance or provides the resources for the customers to assist them in conservation measures. The newsletters and pamphlets encourage our customers to conserve. See section 2.4 for more information.

(c) Supplier financed retrofitting or replacement of existing inefficient water using fixtures, including distribution of residential conservation kits and rebates for customer investments in water conservation;

Avion Water Company Inc. is not a municipality and does not have the authority under the current tariff to require any of its customers to upgrade their existing facilities or plumbing. The amount of capital required to survey all homes built under previous plumbing codes and perform upgrades is not financially feasible for Avion Water Co, nor is it likely to ever be. All capital costs born by Avion are eventually passed on to the rate payer due to the nature of utility companies making a large scale Avion financed replacement program a dubious venture at best. We do encourage our current customers take all conservations measures they are able to. Avion water has adopted a policy of distributing low flow sprinkler heads to our customers at no charge to them along with the newsletters that provide information on the best way to irrigate. Avion's winter usage is approximately 6 times less than our summer usage which means that our customers are using a large percentage of their domestic water for irrigation. Distributing low flow sprinkler heads will help ensure that irrigating landscaped

areas will be done in the most efficient manner. To replace old plumbing fixtures with the most water efficient ones will require 1) A survey of each household; 2) Purchasing parts; 3) installing parts; 4) any required warranty work on the installed parts; 5) the Homeowner's approval to do this work. The cost estimate is as follows: 2 hours ($50/hour) per house for survey = 2*50*9055 (current customer count) = **$905,000**; Parts (estimated at $50/house) = 9055*50 = **$452,750**; Installation (3 hours / house, 50% require work) = 50*3*9055*.50 = **$679,125**; Warranty work (5% required, 2 hours / house) = 50*2*9055*.5*.05 = **$22,637.50**.
Total cost to replace existing plumbing = **$2,059,512.50**.

This will save an estimated 684,000 gallons of water per year; (1,900,000 gallons winter usage (no irrigation)* 60% used by non-water saving households* 5% water savings month * 12 months) = **1,900,000*.60*.05*12 = 684,000 gallons per year**.

The cost per gallon = $2,059,512.50/684,000 = $3.01 / gallon.

Avion currently pumps water for $.09 / gallon which means that the conservation measures would not benefit the customer. Additionally Avion is currently spending all of our yearly resources on keeping up with the tremendous growth in Central Oregon. Many of Avion's existing customers are outside the UGB, when the boundary is moved out the trend has been to develop these older subdivisions to higher density ones. As this happens older houses will be replaced with the more efficient newer ones.

(d) Adoption of rate structures, billing schedules, and other associated programs that support and encourage water conservation;

Avion's rate structure is determined by the PUC of Oregon. Avion does not plan to increase rates or adopt inverted rate schedules. There is no indication of unreasonable waste present in current water use statistics and no reason for actions which will further increase water rates. See section 2.4 for the other programs that Avion has initiated or joined to help promote conservation.

(e) Water reuse, recycling and non-potable water opportunities; and

There are no significant water reuse alternatives available at a reasonable cost. The regional sewage treatment plant owned by the City of Bend is several miles from any significant Avion customer using large amounts of irrigation water. The plant is also downhill from all of our customers. The cost for 8" diameter pipeline (the minimum size required to move significant water quantity) is about $225,000 per mile. The cost to bring treated water to Lost Tracks Golf Course would be about $2,000,000 and the water would have to be pumped 400 vertical feet. The cost for electricity to bring the effluent to the site would be almost identical with current cost plus the capital cost of the pipeline would need to be paid. Before reuse the wastewater may also require additional treatment at a

significant cost. There is not a reasonably cost effective reuse option available to Avion.

Avion initiated negotiations between the City of Bend and the Pronghorn development which resulted in Pronghorn using reclaimed water from the City sewer treatment plant to irrigate its two golf courses instead of Avion's potable water. This arrangement saves millions of gallons in potable water and hundreds of kilowatt hours per year.

(f) Any other conservation measures identified by the water supplier that would improve water use efficiency.

There are none at this time.

Renumbered from 690-086-0140(2)

3. 690-086-0160 Municipal Water Curtailment Element

The water curtailment element shall include at least the following:

(1) A description of the type, frequency and magnitude of supply deficiencies within the past 10 years and current capacity limitation. The description shall include an assessment of the ability of the water supplier to maintain delivery during long-term drought or other source shortages caused by a natural disaster, source contamination, legal restrictions on water use, or other circumstances;

As discussed in Section 1, Avion's water source has been such that the available supply of water has never been reduced to the point that supply shortages have occurred. Although minor seasonal fluctuations in water levels do occur, even the effects of the recent long-term, severe drought situation has not impacted well production or static water levels to a measurable degree. Further, the preliminary findings of the Upper Deschutes Basin groundwater study by U.S. Geological Survey strongly indicate that such problems are extremely unlikely to occur in the foreseeable future.

The system is totally interconnected through the 31 current production wells. As other wells are constructed or come on line, they too will be piped into the common system. As such, if individual wells or pumps fail, only temporary inconveniences result which are easily corrected with minor adjustments. Staff is available on an on-call basis at all times to repair neighborhood line breaks or to make necessary system adjustments.

Two possible scenarios that would require some level of use curtailment are 1) a hazardous waste spill at or near a well site; or 2) an area-wide, extended power outage. Although these are unlikely, it is prudent to have a plan in place to deal with the emergency with the least amount of disruption. It is also possible that emergencies might occur that are nearly unimaginable based upon past experience alone.

In the first scenario noted above, the design of the Avion system would prevent any significant disruption of service. The production of other, unaffected wells would be adjusted, and the well at the site of the contamination would be shut down until cleanup was completed, and testing demonstrated the water supply was safe.

Scenario 2 would result in an immediate need for drastic reductions in water use in order to assure the longest possible time to restore power while providing for minimal health and safety allocations. The electrical supply is further protected from outages, because Avion is served by two different utilities on two different power grids. Some of the production well sites are served by Central Electric Cooperative and others by PP&L. It thus remains highly unlikely both systems would experience area-wide outages at the same time.

(2) A list of three or more stages of alert for potential shortage or water service difficulties. The stages shall range from a potential or mild alert, increasing through a serious situation to a critical emergency;

Avion has adopted a four stage rationing plan (see Table 3.1) to be invoked in the event of an unanticipated water supply shortage. The plan includes both voluntary and mandatory rationing, depending upon the cause, severity and anticipated duration of the shortage. Again, given the nature of Avion's source, it is anticipated that any emergency would be of a relatively short-term nature, but, if it occurs, would be likely to prompt severe mandatory restrictions.

Table 3.1
Avion Water Company
Water Rationing Stages and Reduction Goals

Shortage Condition	*Stage*	*Reduction Goal*	*Type of Rationing*
Up to 15%	I	15%	Voluntary
15-25%	II	25%	Voluntary
25-35%	III	35%	Voluntary
35-50%	IV	50% or greater	Mandatory

Avion, being a private water utility, lacks the regulatory authority to enforce rationing by its customers. If shortages at the Stage I, II or III levels persist for extended periods, and voluntary reductions by all customers are unsuccessful, Avion may have to seek assistance from the PUC in order to enforce the reductions. Avion's tariff allows for the placement of restrictions on "sprinkling and other outside uses" in the event of an emergency and Oregon Health Division statutes impose restrictions by use type. Such restrictions must be non-discriminatory and proven to be necessary. Notice must be provided to the customers and to the PUC in a prescribed manner in writing. Avion's monthly water use data shows that summer use averages are 3 to 4 times the average amounts used in the winter months. It therefore seems clear that significant percentage reductions of total use during the high use period of the year could be easily achieved through reductions of outside watering use on a voluntary basis. As a water purveyor, Avion is responsible for providing minimum health and safety needs for their customers at all times.

(3) A description of pre-determined levels of severity of shortage or water service difficulties that will trigger the curtailment actions under each stage

of alert to provide the greatest assurance of maintaining potable supplies for human consumption; and

Table 1.2 lists Avion pump station capacities. The failure of any one of the pump stations would not require any emergency reductions in consumption. Avion's standards for design and construction provide that all systems be redundant, so that one failure will not lead to shortages.
If Avion's water service were curtailed by natural disaster or massive equipment failure the alert levels in paragraph (2) above would be implemented as required.

(4) A list of specific standby water use curtailment actions for each stage of alert ranging from notice to the public of potential alert, increasing through limiting nonessential water use, to rationing and/or loss of service at the critical alert stage.

In the event of water supply shortages, Avion would initiate a number of actions to inform their customers of the level of the emergency and, under Stages I-III, the requested levels of voluntary reductions. Such actions would include notices in billing mailings and local media (radio/television and newspaper) notices.

If a Stage IV emergency occurs, it is most likely the City of Bend and other area purveyors would be experiencing similar difficulties. Therefore, the costs of media notices could be shared.

(1).Public service announcements through the local media, including frequent updates on the extent, severity, anticipated duration and steps to be taken.

(2).Within the next 6 months, Avion will determine whether any of their larger customers (i.e. commercial) may have alternate sources, flexible use capabilities or otherwise have interruptible service. Within the next year, contracts will be negotiated with these customers that would potentially provide for significant reductions of use in times of shortage without interruption to the majority of Avion services. Avion contract with Lost Track Golf Course (our largest customer) is already interruptible in case of supply emergency.

(3).With the approval of the Public Utilities Commission, Avion will seek to incorporate the following into their operating authorities:

a) Moratoriums on new service connections during shortages;
b) Ability to adopt and enforce a "No Waste" policy;
c) Ability to impose a special "Water Rationing Rate" that encourages conserving use during shortages.

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4. 690-086-0170 Municipal Water Supply Element

The water supply element shall include at least the following:

(1) A delineation of the current and future service areas consistent with state land use law that includes available data on population projections and anticipated development consistent with relevant acknowledged comprehensive land use plans and urban service agreements or other relevant growth projections;

Service Area

Figure 1.1 illustrates the zoning areas, Urban Growth Boundary (UGB) and the service boundaries for the Avion Water Company, Roats Water Company and the City of Bend. Information used to develop Figure 1.1 was generated from the Deschutes County Geographical Information System data base. The service boundary shown is based on the area that Avion Water Company is able to serve and is an area that would be difficult or impossible for other water purveyors to serve. The Avion service area within the UGB is designated to be served by Avion through a franchise agreement with the City of Bend. The areas shown in white (without a cross-hatch pattern) are served by Juniper Water Company (now operated by the City of Bend), Roats Water Company or the City of Bend.

Tables 4.1A and 4.2A are tabulations of the acreage both inside and outside the Bend Urban Growth Boundary for the various land-use zones that are within the Avion service boundary. The intent of these tables is to indicate the total land area and zoning that is available within the Avion service area. A legend for the zone abbreviations is shown in Appendix A. The land uses allowed in these zones are predominately for residential and commercial uses. Schools, parks, golf courses and similar institutional type uses are allowed, and have been built, within these land use zones.

TABLE 4.1
SERVICE AREA INSIDE UGB
AVION WATER COMPANY

ZONE	TOTAL ACRES
CH	35.9
IL	81.7
RL	1,900
RM	60.80
RS	600
TOTAL	2678.4

TABLE 4.2
SERVICE AREA OUTSIDE UGB
AVION WATER COMPANY

ZONE	TOTAL ACRES
CC	4.3
CH	65.7
CL	2.9
EFUAL	8,287.3
EFUHR	1.5
EFUTRB	19,050.0
F1	29.8
F2	228.7
FP	164.5
IG	0.49
IL	68.6
M	.007
MAU-I0	8,606.9
OS&C	310.2
PF	86.9
PO	1.4
RC	4.9
RH	0.06
RI	55.9
RL	1,914.5
RM	29.7
RRI0	6,243.9
RS	1,943.8
SM	389.6
SR 2 1/2	851.7
UARI0	1,210.0
TOTAL	49,553.26 Acres

Customer Base

The Avion Water Company customer base consists of residential, commercial and institutional users. As used in this analysis, institutional users are public facilities such as schools and government offices. For accounting purposes Avion classifies both commercial and institutional users as commercial users. There are no true industrial users served by Avion that use a significant water volume as part of an industrial process.

Residential uses in the Avion service area are typically single family homes on lots that are usually larger than those found within a city. Even with a moderate amount of landscaping this type of residential service can be expected to create a higher peak water demand from irrigation requirements than a comparable urban residential lot. There have been changes to the lot types and size as the urban growth boundary has been expanded. These lots often have irrigation systems installed by the builders and the new subdivisions are required to have green spaces which are also irrigated. The new lots and subdivisions use domestic water to irrigate with in the majority of cases. Even with the increased irrigating and required green spaces the annual average per capita use has only increased from 162 GPD to 170 GPD.

Few multifamily dwellings are served by Avion. Multifamily dwelling units tend to have fewer people per dwelling unit and have a lower irrigation demand per person than a single family residence. Overall, this may tend to level out the higher water use of larger lots. The minimal number of multifamily dwelling units also tends to increase the average number of people per household over that seen in the city of Bend for example. Commercial connections within the Avion Water Company consist of a broad category of users that includes a variety of commercial businesses, including a golf course, and institutional uses such as schools. Irrigation water demand from the commercial users is a significant portion of the Avion peak demand water service requirements. The commercial water user's peak demand is estimated to be approximately 24% of the total water system peak demand.

Avion Growth Compared to County Population Projections

The expected population growth for Deschutes County has been estimated from four sources shown in table 4.6A. The most recent (2004) population growth estimate is shown on table 4.6B. Portland State University, the Oregon Office of Economic Analysis, Deschutes County, and Woods and Poole were participants in the original study. The 2004 study was a coordinated effort by Deschutes County, the City of Bend, the City of Redmond, the City of Sisters, and the Oregon Department of Land Conservation and Development. The first year of estimated growth projected in this study is 2005 so no comparisons can currently be made between Avion's growth and the future projections. The comparisons will be made with the 1996 study. The Deschutes County population estimated by the study for the year 2000 is 113,231. The actual population was 116,600, which is 2.89% above the largest forecast.

The Portland State University growth rate of 13.52% from 1995 to 2000 was exceeded by an actual Avion growth rate of 15.92% (an average annual rate of 5.00 %). Woods and Poole, the State of Oregon, and Deschutes County's projected growth rates were 13.06%, 16.9%, and 16.61% respectively. The Avion growth rate falls in-between the various groups' estimates, however the growth of Deschutes County has been way above all the estimates at 20.89%. Avion Water did not see this amount of growth because we do not serve the City of Redmond or LaPine, although Avion does serve some outlaying areas of both locations. Current estimates for 2004 show that Avion will have an additional 578 residential customers by the end of the year. This translates to a 7.1% increase in customers which is the 5th highest since 1984 and the largest single year growth since 1990. 2005 is expected to be another high percentage increase due to the amount of construction that the Bend area is experiencing.

Additional residential growth experienced by Avion during 1990-1995 can be attributed to the connections of existing homes to Avion water system, in other words an existing population base. Residential connections of existing homes in the Avion service area were made in the following areas during this period.

Jarvis Water System (1993)

The Jarvis Water System consisted of a single well and cistern. The system had never been approved by the Health Division and had been extended by a Mr. Jarvis, now dead, to 51 homes. After Mr. Jarvis' death the well failed. Pursuant to an Oregon Utility Commission Order Avion extended lines to the homes and is now providing service. No water rights came with the system.

Ince Water System (1996)

The Ince Water System consisted of 10 existing homes connected a well and cistern constructed by Mr. Ince. The system had received no approval by any agency. Mr. Ince wished to retire. Avion absorbed the Ince system, suspended the use of all Ince facilities except water lines and Avion is now the sole water purveyor for this system. No water rights came with the system. The system served 10 existing homes.

Lovestone Water System (1996)
The Lovestone Water System consisted of a single well and cistern which served 18 existing homes. The system had been approved by the Health Division but was failing due to an insufficient water supply. The system had not properly maintained its water rights. The system is now a part of Avion Water Company served by Avion wells.

The above described scenarios are anecdotal descriptions of a significant part of Avion's growth pattern. Due to a wide variety of factors which include bank financing requirements, well failures, dissatisfaction with hauled water cistern systems, increasing prosperity within our area, and increasing property values,

scenarios as described above occur on a regular basis. There is almost no time when Avion does not have a line extension project to service existing homes underway.

As a practical matter there is no other regional water supplier to the unincorporated area of Deschutes County surrounding Bend other than Avion Water Company. Due to the initial cost of creating a water supply system it is unlikely if not impossible for new systems to be constructed. The facts are that in the past few years existing small systems are ceasing operations and Avion is assuming the operations of those systems. From time to time the systems have appropriate water rights, but in general the systems are small and do not have water rights or Health Division approval.

The following list is an estimate of the number of existing homes connected to the Avion Water Company system from 1992 to the 1996.

1992	35
1993	51
1994	40
1995	42
1996	48

The following information is submitted in order further indicate how Avion Water Company growth in the unincorporated service area surrounding Bend has occurred.

Old Bend Redmond Highway -Line extension 1994 and 1995

During the summer of 1994 Wally Walker, a resident on Old Bend Redmond Highway approximately 800 feet north of the intersection of Rogers Road and Old Bend Highway, experienced a well failure at his residence. Mr. Walker is an excavator by profession. Instead of repairing his well Mr. Walker extended an existing eight inch diameter Avion water line from the intersection of Rogers Road and Old Bend Redmond Highway to his residence.

As a result of Mr. Walker's extension, Mr. Tom Temple further extended the line 800 feet to his existing residence so that he could cease relying upon irrigation water and hauled water for his domestic water service. As a result of Mr. Temple's line extension a group of ten existing home owners further north along the Old Bend Redmond Highway extended the mainline to reach all of their residences replacing existing well services with Avion service and replacing cistern and hauled water services with Avion service.

A further property owners group connected to the extended line on Old Bend Redmond Highway adding an additional five customers.

From 1994 through 1996 the mainline along Old Bend Redmond Highway has been extended over one mile and 20 users have been added to Avion's system

which users were existing homes at the time of line construction. Many of the homes had been in existence for over 20 years.

Rim Fire and Back Alley Road (1993)

In 1993 a property owners group consisting of 17 existing home owners formed a group and extended Avion Water Company's mainline from Rickard Road south along Arnold Loop Road, Back Alley Road and Rim Fire Road for approximately two miles. As a result of the line extension 17 existing homes were added to Avion's service and 7 new homes have subsequently been constructed on previously existing lots.

As described above, connections of existing individual homes to the Avion system can be traced to economics. Existing rural homes that have had potable water supplied from local irrigation districts or are using hauled water (water trucked to the home site) are forced by lending institutions to acquire a safe and dependable water source if the property is refinanced or sold. Connection to the Avion water system is the preferable choice in these situations. Homes with small private wells have also requested to have an Avion connection when the cost of repairs to the existing well or delivery system is not cost effective.

It is estimated that there are currently 2,500 residents in the Avion service area that have their potable water supplied from irrigation districts. All of these residents are potential future Avion customers and eventually all of these residents will be connected to the Avion system.

The probable reason for most of the connections of existing homes to the Avion system is the result of more stringent drinking water regulations resulting from the EPA Safe Drinking Water Act (SDWA). Subdivisions, such as Sundance, are choosing to be served by Avion rather than deal with the costly and complex requirements of the SDWA.

Also during the period from 1990 to 1994 several large commercial users were connected to the Avion system. The large commercial accounts that were new additions to the Avion system are:

Lava Ridge Elementary School, 1994. Elk Meadow Elementary School, 1994
High Desert Middle School, 1994. Lost Tracks Golf Course, 1994.

During the summer these four connections are estimated to have a peak day demand of over 1 million gallons per day. This peak water demand is primarily for turf irrigation and represents approximately 11% of the peak day water demand for 1996.

Commercial connections to the Avion system for these types of uses can be expected to continue into the future. Residential construction also currently continues to progress at a fast rate. Twelve subdivisions have recently been completed and the lots are being built on while the infrastructure for fifteen new

subdivisions is currently under way. There are also an additional sixteen subdivisions that are in the planning process and expect to be under way soon. There are no large commercial projects in Avion territory as of yet, but the continued growth suggests they will be coming. The largest section of growth that Avion will see will be residential and the additional schools that will be needed to accommodate this growth.

Growth Projections Summary

In summary, the population growth projections made by the various entities as shown in Tables 4.6A and 4.6B are supported by the actual growth in water service connections being experienced by the Avion Water Company. In fact the 1997 population estimates are being outpaced by the actual growth. Furthermore, the estimated water use from anticipated commercial growth in the Avion service area is reasonable based on the actual construction underway for schools and recreation facilities.

Build Out Service Population

Build-Out Service Population: An estimate for the build-out population is based on the land use zoning that exists at this time. At best, any estimate of a build-out population will be a very rough approximation of a future population due to the many uncertainties of population densities overlaid on long term land uses. Land uses that can affect population density change almost daily; this is especially true of the land uses in and near the Bend Urban Growth Boundary. Subdivision densities in the city of Bend and city UGB are shown on the City of Bend zoning map (see attached Fig 1.1).

The residential lot density may tend to increase or decrease depending on economic conditions. Since 1995 the subdivisions outside and inside the city have increased in density; possibly as a result of shrinking land availability, the increasing availability of community sewer (inside the urban growth boundary) and from the high demand for residential lots. As land available for development in and around the UGB decreases, the density of the subdivisions will likely increase. Trends of this nature make the estimation of build-out populations difficult at best. The City of Bend has expanded and now the UGB and the City limits are the same.

Tables 4.3A and 4.3B lists the actual number of lots that exist(ed) within the current Avion Water Company service area in 1996 and 2003. The actual number of lots served by Avion in the future will increase whenever customers approach Avion and request water service.

TABLE 4.3A 1996

RESIDENTIAL LOTS IN CURRENT SERVICE AREA

AVION WATER COMPANY

LOT SIZE	TOTAL NO. OF LOTS
0- 10,000 square feet	696
10,000 -20,000 square feet	1,549
20,000 -43,560 square feet	3,602
1- 5 acres	3,866
5 acres and greater	1,987
Total	**11,700**

1) Lot count from Deschutes County GIS system.

TABLE 4.3B 2003

RESIDENTIAL LOTS IN CURRENT SERVICE AREA

AVION WATER COMPANY

LOT SIZE	TOTAL NO. OF LOTS
0- 10,000 square feet	2,281
10,000 -20,000 square feet	1,685
20,000 -43,560 square feet	2,643
1- 5 acres	3,324
5 acres and greater	2,023
Total	**11,956**

1) Lot count from Deschutes County GIS system.

The build-out population for the Avion Water District service area may range from 80,000 to 120,000 people based on the land availability shown in Tables 4.1 and 4.2, the residential lot density that could occur, and the commercial development possible.

Other Long Term Growth Factors

Several major facilities are being planned from long range studies that could have a major impact on future water demands. The Bend-LaPine Public School District and the Oregon Division of State Lands have developed studies indicating major land development for parcels within the Avion service area.

The Bend-LaPine Public School District has projected the need for four to seven elementary schools, two to four middle schools and two to three new high schools in the Bend urban area by the year 2015. The final number of schools built will be dependent on the actual population growth during this period. Six of these schools could be expected to be built on the east side of the Bend urban area. Due to the lack of large land parcels available in the Bend urban area that

could be developed for schools, it is probable that three to five of the schools will be built in the Avion service area. The peak water demand for these schools would likely be in the range of 300 to 500 gallons per minute. There have already been 2 new schools built on the east side of the Bend urban area since this study was last done, Pine Ridge and Sky View Middle Schools.

The Oregon Division of State Lands (DSL) has been aggressively pursuing the development of land managed by DSL throughout the State to increase the revenue from their land holdings. One of the land parcels being studied by DSL is known as "Section 11." The parcel is approximately 640 acres, located in the Avion service area along 27TH Street and Stevens road. Due to the current zoning, the parcel has initially been planned for the development of soccer and softball fields and general park use. Only a very small portion of the parcel is planned for development with the current zoning. The peak water demand for this development is estimated to be 300 gallons per minute. If the EFU zoning for this parcel is changed to allow a higher density development, the water demands could be six to eight times higher than this estimate. Avion is currently pursing a 2 acre easement on this land for future reservoir, well, and pump station sites.

(2) An estimated schedule that identifies when the water supplier expects to full exercise each of the water rights and water use permits currently held by the supplier;

Annual Historical Data

Historical water use for the Avion Water Company from 1984 to 2003 is shown in Table 4.5. The table presents average annual water use data for the residential and commercial user groups served by Avion. The Avion Water Company did not have commercial accounts separated from residential accounts prior to 1993. The reason for this was that the Public Utility Commission (PUC) did not require Avion and other private water companies to keep separate accounts for commercial water users prior to 1993.

The growth rate of residential and commercial connections served by Avion, as presented in Tables 4.4A and 4.4B has increased at an average of 5.00 % per year since 1984 and the growth rate of water use has increased at an annual average rate of 7.83 %.

The rate of service growth fluctuates with the Central Oregon economy. 1985 and 1986 were years of slow growth in Central Oregon and the Avion Water Company service growth rate reflects this in that the annual growth was 2.54% and 1.92% respectively. Since 1988 the Avion growth rate for new connections has increased an average of 5.46 % per year. The explanation of the annual growth rate of water use exceeding the service connection growth rate is believed to be the result of increased green space irrigation demands previously mentioned. This appears to be compounded by the hot, dry weather patterns that have occurred during some years; most recently 1994, 1996, 2002, and 2003.

Tables 1.5A and 1.5B illustrate the highly variable nature of water use from year to year. The large differences in yearly water use are attributed to irrigation water demand fluctuations. Years with higher than normal precipitation (1993, 1995, 2001) during the irrigation season results in significantly lower irrigation water use compared to years with below normal precipitation (1994, 1996, 2002, 2003) during the irrigation season (from April through October). Per capita water use is analyzed in later sections.

(3) Based on the information provided in section 1 of this rule, an estimate of the water supplier's water demand projections for 10 and 20 years, and at the option of the municipal water supplier, longer periods:

Water forecasts for the Avion Water Company will be estimated for 10 and 20 year periods and for build-out. An estimate will also be made to determine when the present maximum water right of 11,305 gallons per minute will be exceeded.

Water demand forecasts for the next 10 and 20 year periods will be estimated from the growth rates experienced by the Avion Water Company from 1985 to the present. The premise of this approach is that since this period has been characterized by both low housing growth and relatively robust growth, it is a reasonable estimate of what may happen in the future. As explained earlier the Avion growth rate has ranged from 5% to 15% higher than the Deschutes County population projections to a little below them. The higher Avion growth rate in 1990-1995 is believed to be due to the absorption of existing housing into the Avion water delivery system unlike our current growth which is almost entirely from new construction. The trend of absorbing existing housing into the Avion water delivery system will continue at a slow rate as well as the continued growth of commercial development and new housing, therefore the growth rate of the Avion system will continue at a fast pace. The new population predictions are higher than those previously issued and with the unpredictable nature of the UGB and zoning changes it is hard to provide an accurate picture of future growth for Avion. It is safe to say that we expect our growth to continue at its rapid pace at least through 2005.

Tables 4.4A and 4.4B illustrate the population growth for the Avion system from 1996 to the year 2003 based on a growth rate of 5.65% per year for the 1998 forecast and 5.00% for the 2003 forecast.

From this data, the present water right of 11,305 gpm will be exceeded by the year 2010 based on population growth. If water demand continues at an annual rate of 7.83%, the present maximum water right of 11,305 will be exceeded in 2008. If water use from water saving plumbing fixtures reduces the population based water demand by 2% per year, the water right will still be exceeded in the year 2010.

TABLE 4.4A
WATER DEMAND FORECAST-1998
AVION WATER COMPANY

				WATER DEMAND GROWTH	
YEAR	*POPULATION* (1)	*RESIDENTIAL EQUIVALENT*	*POPULATION BASED gpm* (2)	*WATER USE BASED gpm* (3)	*CONSERVATION BASE gpm* (4)
1996	15,814	6,202	6,076	6,076	
1997	16,707	6,552	6,419	6,682	
1998	17,651	6,922	6,782	7,348	6,646
1999	18,649	7,313	7,165	8,081	7,022
2000	19,702	7,726	7,570	8,886	7,419
2001	20,816	8,163	7,998	9,772	7,838
2002	21,992	8,624	8,450	10,746	8,281
2003	23,234	9,111	8,927	11,818	8,748

(1) Average 2004 population for the Avion Water Company
(From Table 4.5 with an annual growth of 5.65 %.)
(2) Annual growth of 5.56 % from Table 4.5.
(3) Annual growth of 9.97% from Table 4.5.
(4) 2% reduction of population based water demand growth due to use of water saving plumbing fixtures.

TABLE 4.4B
WATER DEMAND FORECAST-2004
AVION WATER COMPANY

				WATER DEMAND GROWTH	
YEAR	*POPULATION* (1)	*RESIDENTIAL EQUIVALENT*	*POPULATION BASED gpm* (2)	*WATER USE BASED gpm* (3)	*CONSERVATION BASE gpm* (4)
1996	16,055	6,296	6,076		
1997	16,313	6,397	6,136		
1998	16,897	6,626	6,015		
1999	17,516	6,869	6,365		
2000	18,337	7,191	6,856		
2001	19,411	7,612	6,229		
2002	19,709	7,729	6,972		
2003	20,964	8,221	7,944	7,944	
2004	22,012	8,632	8,341	8,566	8,174
2005	23,112	9,064	8,758	9,237	8,583
2006	24,268	9,517	9,656	9,960	9,463

TABLE 4.4B (Cont'd)
WATER DEMAND FORECAST-2004
AVION WATER COMPANY

				WATER DEMAND GROWTH	
YEAR	*POPULATION* (1)	*RESIDENTIAL EQUIVALENT*	*POPULATION BASED gpm* (2)	*WATER USE BASED gpm* (3)	*CONSERVATION BASE gpm* (4)
2007	25,482	9,993	10,139	10,692	9,936
2008	26,756	10,493	10,646	11,529	10,433
2009	28,094	11,017	11,178	12,432	10,954
2010	29,498	11,568	11,737	13,405	11,502
2011	30,973	12,416	12,324	14,455	12,078
2012	32,522	13,391	12,940	15,587	12,681
2013	34,148	14,061	13,587	16,807	13,315
2014	35,855	14,764	14,266	18,123	13,981
2015	37,648	15,502	14,980	19,542	14,680
2016	39,530	16,277	15,729	20,975	15,414
2017	41,507	16,277	16,515	22,617	16,185
2018	43,582	17,091	17,341	24,388	16,994
2019	45,761	17,946	18,208	26,298	17,844
2020	48,050	18,434	19,119	28,357	18,737
2021	50,453	19,786	20,075	30,577	19,674
2022	52,975	20,775	21,079	32,972	20,657
2023	55,624	21,813	22,133	35,553	21,690
2024	58,405	22,904	23,239	38,337	22,774
2025	61,325	24,049	24,401	41,339	23,913

(1) Average 2004 population for the Avion Water Company
(From Table 4.5 with an annual growth of 5.0 %.)
(2) Annual growth of 5.0 % from Table 4.5.
(3) Annual growth of 7.83% from Table 4.5.
(4) 2% reduction of population based water demand growth due to use of water saving plumbing fixtures.

(4) A comparison of the projected water needs and the sources of water currently available to the municipal water supplier and to any other suppliers to be served considering the reliability of existing sources;

No new water sources are contemplated for Avion. The results of the upper Deschutes Basin Study indicate that Avion should be able to rely upon the upper Deschutes Basin Aquifer to fulfill all water source requirements. Avion will

need to continue to develop new wells as demand increases and will need to secure additional water rights between 2008 -2010.

(5) If any expansion or initial diversion of water allocated under existing permits is necessary to meet the needs shown in section (3) of this rule, and analysis of alternative sources of water that considers availability, reliability, feasibility, and likely environmental impacts. The analysis shall consider the extent to which the projected water needs can be satisfied through:

(a) Implementation of conservation measures identified under OAR 690-086-0150;

See sections 2.3 and 2.4 for conservation measures that have been implemented.

(b) Interconnection with other municipal supply systems and cooperative regional water management; and

As previously discussed no permanent interconnection with the City of Bend is feasible due to their chlorination needs and the restrictive cost of constructing chlorination stations for Avion.

(c) Any other conservation measures that would provide water at a cost that is equal to or lower than the cost of other identified sources.

Since there is currently only one source of water available to Avion Water Co. there is no way to compare any conservation measures with alternate sources of water which does not exist.

(6) If any expansion or initial diversion of water allocated under existing permits is necessary to meet the needs shown in section (3) of this rule, a quantification of the maximum rate and monthly volume of water to be diverted under each of the permits.

The current maximum amount of water diverted allowed under permit G-12788 is 11,305 GPM. Permit G-12788 is the only permit with which water is diverted for the greater Avion water system. See table 1.1 for further water right information.

(7) For any expansion or initial diversion of water under existing permits, a description of mitigation actions the water supplier is taking to comply with legal requirements including but not limited to the Endangered Species Act, Clean Water Act, Safe Drinking Water Act; and

No mitigation actions are required under the current permit unless the water table drops 25 feet and the area is designated a critical groundwater area. According to the U.S. Geological Survey and the Oregon Water Resources Department study of the Upper Deschutes Basin Aquifer the groundwater is not

in danger of being designated a critical groundwater area, nor are there currently any legal requirements regarding the Endangered Species Act, Clean Water Act, and the Safe Drinking Water Act which affect permit G-12788.

(8) If acquisition of new water rights will be necessary within the next 20 years to meet the needs shown in section (3) of this rule, and analysis of alternative sources of the additional water that considers availability, reliability, feasibility and likely environmental impacts and a schedule of development of the new sources of water. The analysis shall consider the extent to which the need for new water rights can be eliminated through:

Table 4.5 indicates that Avion will exhaust current water rights between 2008 and 2010. Table 4.5 also includes an estimate of conservation impacts.

From this data, the present water right of 11,305 gpm will be exceeded by the year 2010 based on population growth. Comparing the table 4.4A with table 4.4B it is noted that Avion's water use is below the 1998 Conservation Base water estimate. This shows that water saving plumbing and low flow irrigation systems is having an impact on water usage. If water demand continues at an annual rate of 7.83% the present maximum water right of 11,305 will be exceeded in 2008. If water use from water saving plumbing fixtures reduces the population based water demand by 2% per year, the current water right will be exceeded in the year 2010.

A simple engineering analysis of the cost of developing additional water supply by drilling new wells and using the ground water supply versus further conservation measures or reuse follows. The most reliable available water supply source available to Avion is the Upper Deschutes Basin Aquifer. The supply available from the aquifer is not threatened, nor does the use of the aquifer endanger stream flows. The costs for reuse options as discussed in paragraph 2.6(e) are many times greater than the cost to develop new wells. The approximate cost to develop a new well with a capacity of 1,500 gallons per minute including all pumps and electrical work is about $250,000.00. Each mile of pipeline constructed to develop the reuse option costs about $225,000. There are no reuse opportunities available to Avion which are less than several miles from the sites needing irrigation water. All reuse water due to the location of the City of Bend's treatment plant would need to be pumped up hill to an irrigation site. Depending on the type of reuses, there could also be significant costs for upgrading wastewater treatment. It is obvious that the most feasible solution to additional supply requirement is to simply drill new wells.

(a) Implementation of conservation measures identified under OAR 690-086-0150;

The conservation measures discussed in section 2 are currently being implemented.

(b) Inter-connection with other municipal supply systems and cooperative regional water management; and

The only possible interconnection with a municipal supply system and Avion is the City of Bend. No long term interconnection with the City of Bend supply is contemplated. The City of Bend, since it uses surface water in its supply system, must maintain chlorine residual in its water. Avion uses no surface water and is not required to chlorinate. If City and Avion supplies were mingled Avion would then be required to chlorinate. At present, that would mean the construction of 6 chlorination stations and subsequent operation and maintenance. Detailed estimates of the cost to chlorinate have not been made but would be very significant and cause rate increases for Avion's customers.

Since the City of Bend does not enjoy a great surplus of water, little advantage and significant cost would result from interconnection, since this plan was issued in 1997 there has not been any significant change in this situation. Avion's operating systems are reliable and include redundancy in the event of equipment failure. No environmental impact of any significant magnitude is foreseen from Avion's current or future operations, other than a positive one. Bend currently has air quality problems due to excessive particulates in the air from time to time. The existence of lawns and landscaping tend to mitigate this problem.

(c) Any other conservation measures that would provide water at a cost that is equal to or lower than the cost of other identified sources.

There are currently no conservation measures that will provide water at an equal or lesser cost than Avion's current rates.

5. 690-086-0125 Additional Requirements

(5) A list of the affected local governments to whom the draft plan was made available pursuant to 0120(6) and a copy of any comments on the plan provided by the local governments.

The plan was made available to the City of Bend and to the Deschutes County Community Development Department. Deschutes County has responded with a letter of support which has been inserted into the back of this report. The City of Bend has not responded even though repeated attempts were made to contact them.

(6) A proposed date for submittal of an updated plan within no more than 10 years based on the proposed schedule for implementation of conservation measures, any relevant schedules for other community planning activities, and the rate of growth or other changes expected by the water supplier; or an explanation of why submittal of an updated plan is unnecessary and should not be required by the Department; and

An updated plan will be submitted between 2008 and 2010 when existing water rights are forecast to be reached.

(7) If the municipal water supplier is requesting additional time to implement metering as required under OAR 690-086-0150(4)(b) or a benchmark established in a previously approved plan, documentation showing additional time is necessary to avoid unreasonable and excessive costs.

Not Applicable.

TABLE 4.5
Historical Water Use -1984 *to* 2003
Avion Water Company, Inc.

	RESIDENTIAL			COMMERCIAL			METERED		ANNUAL GROWTH RATES	
YEAR	NO.OF SERVICES (Average)	ANNUAL WATER USE (cf)	AVERAGE ANNUAL DEMAND (cf)	NO. OF SERVICES (1) (average)	ANNUAL WATER USE (cf)	AVERAGE ANNUAL DEMAND (cf)	PEAK DAY DEMAND total gallons	gpm	SERVICES	USE (2)
1984	3265	54,044,399	16,553							
1985	3348	57,090,510	17,052						2.54%	5.64%
1986	3390	62,560,426	18,454						1.25%	9.58%
1987	3523	64,973,763	18,443						3.92%	3.86%
1988	3815	65,020,256	17,043						8.29%	0.07%
1989	4102	77,092,601	18,794						7.52%	18.57%
1990	4458	81,598,151	18,304						8.68%	5.84%
1991	4780	88,325,542	18,478						7.22%	8.24%
1992	5069	100,280,783	19,783						6.05%	13.54%
1993	5175	88,017,018	17,008	174	12,164,698	69,912	6,586,581	4,574	5.52%	-0.10%
1994	5429	113,870,642	20,975	219	18,404,951	84,041	7,007,002	4,866	5.59%	32.04%
1995	5650	103,752,924	18,363	244	22,096,605	90,560	7,700,002	5,347	4.36%	-4.86%
1996	6017	121,340,829	20,166	279	38,699,906	138,709	8,749,999	6,076	6.82%	27.17%
1997	6078	118,266,664	19457	319	34,246,435	107,356	8,835,370	6,136	1.60%	-4.94%
1998	6251	120,776,668	19321	375	34,922,150	93,126	8,662,458	6,195	3.58%	2.09%
1999	6455	135,492,016	20990	414	39,276,020	94,870	9,164,416	6,670	3.67%	12.25%
2000	6720	145,110,527	21594	471	40,498,149	85,983	9,872,436	6,965	4.69%	6.20%
2001	7085	149,119,035	21047	527	38,540,501	73,132	8,968,986	7,031	5.85%	1.10%
2002	7117	160,764,410	22589	612	49,618,217	81,076	10,039,837	7,888	1.54%	12.11%
2003	7562	159,800,517	21132	659	51,495,086	78,141	11,438,495	9,665	6.37%	0.43%
									5.00%	7.83%

1. Commercial water use was not accounted for separate from the residential services prior to 1993.
Commercial water use has only been accounted for due to a Public Utilities Commission requirement beginning in 1993.

2. Variations in water use are the result of climate, i.e. cool wet summers result in less water use per connection.

TABLE 4.6A

1997 *DESCHUTES COUNTY POPULATION FORECASTS AVION WATER COMPANY*

SOURCE

YEAR	Portland State University		Woods and Poole (Bend Economic Fact Book)		State of Oregon Office of Economic Analysis		Deschutes County Coordinated Population Forecast	
	Population	Growth %	Population (1)	Growth %	Population	Growth %	Population%	Growth %
1990	74,958				76,066		74,958	
1995	92,245	18.74%	97,860		94,100	19.16%	94, 100	20.34%
2000	106,671	13.52%	112,560	13.06%	112,846	16.61%	113,231	16.90%
2005	117,887	9.51%	130,980	14.06%	132,829	15.04%	132,239	14.37%
2010	128,868	8.52%	149,660	12.48%	151,230	12.17%	151,431	12.67%
2015			168,560	11.21%	167,231	9.57%	167,911	9.81%
2020					181,448	7.84%	182,353	7.92%
2025					190,697	4.85%		
2030					197,004	3.20%		
2035					201,495	2.23%		
2040					204,889	1.66%		

(1) The initial year of population forecast by Woods and Poole is 1996.

TABLE 4.6B

2004 *DESCHUTES COUNTY POPULATION FORECASTS 2000 -2025 AVION WATER COMPANY*

SOURCE

YEAR	Bend UGB		Redmond UGB		Sisters UGB		Non-Urban County		
	July 1st Forecast	Five Yr. Change	July 1st Forecast	Five Yr. Change	July 1st Forecast	Five Yr. Change	July 1st Forecast	Five Yr. Change	Total County
2000	52,800		15,505		975		47,320		116,600
2005	69,004	30.69%	21,240	36.99%	1,777	82.26%	53,032	12.07%	145,053
2010	81,242	17.74%	26,975	27.00%	2,405	35.34%	59,127	11.49%	169,749
2015	91,158	12.21%	32,710	21.26%	3,003	24.86%	65,924	11.50%	192,795
2020	100,646	10.41%	38,445	17.53%	3,776	25.74%	73,502	11.50%	216,369
2025	109,389	8.69%	44,180	14.92%	4,688	24.15%	81,951	11.49%	240,208

Appendix A

Zoning Designations for Tables 4.1 and 4.2

Deschutes County Zoning Designations

AD	AIRPORT DEVELOPMENT
EFUAL	EFU-ALFALFA SUBZONE
EFUHR	EFU-HORSE RIDGE SUBZONE
EFULA	EFU-LA PINE SUBZONE
EFULB	EFU-LOWER BRIDGE SUBZONE
EFUSC	EFU-SISTERS/CLOVERDALE SUBZONE
EFUTE	EFU-TERREBONNE SUBZONE
EFUTRB	EFU-TUMALO/REDMOND/BEND SUBZONE
FP	FLOOD PLAIN
F1	FOREST USE 1
F2	FOREST USE 2
MUA10	MULTIPLE USE AGRICULTURAL – 10 ACRE MINIMUM
OS&C	OPEN SPACE AND CONSERVATION
PC	PLANNED COMMUNITY
RD	RESEARCH AND DEVELOPMENT
RI	RURAL INDUSTRIAL
RR10	RURAL RESIDENTIAL – 10 ACRE MINIMUM
RSC	RURAL SERVICE CENTER
RSR – 5	RESIDENTIAL 5 ACRE MIN
SM	SURFACE MINING

CITY OF BEND DESIGNATIONS

CB	CENTRAL BUSINESS DISTRICT
CC	COMMERCIAL CONVENIENCE
CG	COMMERCIAL GENERAL
CH	COMMERCIAL HIGHWAY
CL	COMMERCIAL LIMITED
CN	COMMERCIAL NEIGHBORHOOD
IG	INDUSTRIAL GENERAL
IL	INDUSTRIAL LIMITED
MR	MIXED USE RIVERFRONT
PF	PUBLIC FACILITIES
RH	RESIDENTIAL HIGH DENSITY
RL	RESIDENTIAL LOW DENSITY
RM	RESIDENTIAL MEDIUM
RS	RESIDENTIAL STANDARD DENSITY
SM	SURFACE MINE
SR2 ½	RESIDENTIAL SUBURBAN LOW DENSITY
UAR10	URBAN AREA RESERVE 10 ACRE MIN

LA PINE DESIGNATION

LPC	LA PINE COMMERCIAL DISTRICT
LPFP	LA PINE FLOOD PLAIN DISTRICT
LPI	LA PINE INDUSTRIAL DISTRICT
LPR	LA PINE RESIDENTIAL DISTRICT
LPST	LA PINE SEWER TREATMENT & DISPOSAL AREA

REDMOND DESIGNATIONS

C1	STRIP SERVICE COMMERCIAL
C2	CENTRAL BUSINESS DISTRICT COMMERCIAL
C3	SPECIAL SERVICE COMMERCIAL
C4	LIMITED SERVICE COMMERCIAL
C5	TOURIST COMMERCIAL
FG	FAIRGROUNDS
M1	LIGHT INDUSTRIAL
M1 –(AC)	LIGHT INDUSTRIAL – AIRPORT CONTROL
M2	HEAVY INDUSTRIAL
OSPR	OPEN SPACE AND PARK RESERVE
R1	LIMITED RESIDENTIAL
R2	LIMITED RESIDENTIAL
R3	LIMITED RESIDENTIAL
R4	GENERAL RESIDENTIAL
R5	HIGH DENSITY RESIDENTIAL

Addendum 1

Summer vs. Winter Flow Ratios for Central Oregon Water Providers

Summer / winter flow comparison between Avion Water Company, the City of Bend, and the City of Redmond.

	Summer (Avg. GPD)	Winter (Avg. Gpd)	Ratio of Summer /Winter
Bend	16,000,000	5,100,000	3.14
Redmond	9,900,000	1,900,000	5.21
Avion	4,771,412	1,363,546	3.50

Summer is defined as months when the irrigation canals are running, April – October. Winter is November – March. The 2003 data was used for Avion Water's calculations. December 2003 was omitted due to large snowfall that year and all reads were estimated. If December 2003 is included the ratio for Avion becomes 4.13. The actual water used for December would show in the 2004 data as soon as the meters were able to be read, therefore making the average winter usage correct. Since 2004 data was not entered into this report leaving December 2003 out was statistically correct.

Cost / Benefit Analysis of Mitigation Credits vs. Conserved Water vs. Irrigation

Currently one mitigation credit can be purchased from various local entities for $2500 per acre-foot of water. The following is the cost of gallon of water for the $2500 spent for the mitigation credit;
1 acre-foot = 43,560.17 ft^3
43,560.17 ft^3 = 325,851.88 gallons
Cost per Gallon = $2500 / 325,851.88 gallons = $0.0077 / Gallon

The conservation measures to refit houses with updated plumbing would cost $3.01 / Gallon. To compare this more accurately we will calculate the conservation measures annual worth over a period of 20 years with a 6% MARR.

AW (6%) = $3.01(A | P 6, 20) = $0.2624 / Gallon.

Irrigation Costs per year:

Swalley Irrigation = 119.2 Acre-ft Cost = $28,738.07 Cost per Gallon = $0.0007

Arnold Irrigation = 101.98 Acre-ft Cost = $29,134.27 Cost per Gallon = $0.0009

COI Irrigation = 487.09 Acre-ft Cost = $57,453.92 Cost per Gallon = $0.0004

This does not include our pumping costs which we will put equal to pumping our domestic water at $0.09 / gallon. With these costs it is obvious that purchasing mitigation credits is currently the cost efficient way to obtain more water. Avion is currently considering investing $7000 in partnership with Bend, Redmond and the other local water suppliers to produce a 32 page, color booklet on xeriscape (low water landscaping) which will be mailed to all the providers' customers.

Oregon
Theodore R. Kulongoski, Governor

Water Resources Department
SOUTH CENTRAL REGION
Watermaster, District 11
1340 NW Wall St. Ste. 100
Bend, OR 97701
Ph: 541-388-6669
Fax: 541-388-5101
www.wrd.state.or.us

November 1, 2004

Adam Sussman
Water Resources Department
Salem, Oregon

RE: Avion Water System

Dear Adam,

I met with Jan Wick of Avion Water Company to determine whether the current metering of his wells was in compliance with the District 11 Watermaster's office. He is presently in the process of applying for an extension of time with the Department for one of his groundwater permits. The Department asked him to prove he has gained compliance of his permit conditions, which include the metering of his points of appropriation.

Avion currently has a flow meter that they take to the various wells to calibrate the flow at which they pump. Once they calibrate the flow using different coefficients for variables, such as pipe size and roughness, they use a computer to track exactly how long each well is run. From this they have been able to supply the Department with water use reporting information, as per their permit condition. I watched them calibrate the flow for one of their wells on November 1, 2004 and found it to be scientifically acceptable. From the Watermaster's office perspective this is acceptable since they can check any well on request and we currently do not require permit holders to report on the rate at which they pump, only the duty. I informed Avion that we retain the right to require permanent flow meters in the future if the current flowmeters are not working to our standards. Please contact me if you require further explanation.

Thank You,

Jeremy Giffin
District 11 Watermaster

cc: Jan Wick, Avion Water Company

Community Development Department

Planning Division Building Safety Division Environmental Health Division

117 NW Lafayette Avenue Bend Oregon 97701-1925
(541)388-6575 FAX (541)385-1764
http://www.co.deschutes.or.us/cdd/

December 7, 2004

Mr. Jan Wick, President
Avion Ware Company, Inc.
60813 Parrell Road
Bend, OR 97702

RE: Water Management and Conservation Plan

Dear Mr. Wick:

Thank you for the opportunity to review your 2004 Water Management and Conservation Plan. It appears that the figures and assumptions you have used in estimating population growth in your service area are reasonable and consistent with the adopted County Coordinated Population Forecast for the period form 2004 to 2025. You have considered the numerous variables including potential increased development density and future development of land that is currently outside of the urban growth boundary.

Deschutes County is involved in water planning efforts in the Upper Deschutes Basin and supports and encourages all conservation efforts undertaken by Avion Water Company.

Sincerely,
DESCHUTES COUNTY PLANNING DIVIION

Catherine Morrow, Principal Planner

Water Management and Conservation Plan
Roats Water System, Inc.

November, 2007

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Roats Water System, Inc.
Water Management and Conservation Plan Contents

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Summary

Roats Water System, Inc. presents its 2007 Water Management and Conservation Plan to the Water Resources Department and all interested parties. Roats Water System, Inc. is submitting this plan as an update to the previous plan, which was submitted in 1997.

This is a plan for Roats Water System, Inc. to follow in order to manage allocated water resources wisely and to develop a strategy for meeting future water supply needs.

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Section 1: Overview

1.1 General System Description

Roats Water System, Inc. is a privately owned water company that began as a small water system in 1963. The company provides water service in and around the southern portion of the City of Bend.

Bend is in Central Oregon, east of the Cascade Mountains, in an area commonly described as high desert. Annual precipitation averages 11.8 inches per year, with most of that coming in the form of snow. The Deschutes River, which flows north to the Columbia River, drains the immediate area.

Over 87 percent of Roats' connections service residential customers, both single family and multi-family homes. These residential consumers use 72 percent of all water produced. Commercial customers comprise the remainder of the service connections, and use about 26 percent of the water produced. The remaining 2 percent is used for flushing and fire flow.

Roats Water System serves two separate geographical areas, both near the south part of the City of Bend. They are called Homeplace and Woodside Ranch. They serve a total of approximately 3310 customers. The two service areas are not connected to each other.

1.2 Proposed Progress Report and Update Schedule

Following the Administrative Rules, Roats Water System, Inc. proposes to submit a progress report in 2012 to review water use progress. Roats plans to submit the next update of the Water Management and Conservation Plan ten years from now, in 2017.

1.3 Summary of Data Sources

Most of the data used in this Water Management and Conservation plan were obtained from Roats Water System, Inc. records, including pumping records, billing records, and historical data relating to connections and demand. The population estimates are based on 2000 US Census information. The information on the Homeplace Distribution System Pipeline Inventory was obtained from a water model of Roats Water Homeplace System developed by Murray, Smith, and Associates in Portland, Oregon.

1.4 Document Organization

This Water Management and Conservation Plan is organized into the following sections:

Section 2: Description of Roats Water System
Section 3: Water Conservation Element
Section 4: Water Curtailment Element
Section 5: Water Supply Element

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1.5 Review by Affected Local Governments

This Water Management and Conservation Plan was made available in draft form to the City of Bend Development Department and the Deschutes County Development Department. No comments were received within the 30-day comment period.

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Section 2: Supplier Description

2.1 Service Area and Population

Roats Water System, Inc. presently serves drinking water to about 3310 customers, 2640 in the Homeplace service area and 670 in the Woodside Ranch service area. These population estimates were obtained from the 2000 US Census that found Deschutes County had 2.50 persons per household.

Homeplace (HMP) currently serves 1056 residential connections and 154 commercial connections. Residential connections represent 87 percent of the services in this area, and commercial connections the other 13 percent. Homeplace is comprised of single-family homes, multi-family residences, several apartment complexes, and commercial connections.

Woodside Ranch (WSR) currently serves 268 residential connections. There are no commercial connections in Woodside Ranch, and the area is comprised entirely of single-family homes.

Table 2-1 details the number of service connections over the past five years.

Table 2-1: Roats Water System Service Connections

Year	HMP Residential	HMP Commercial	WSR Residential	Total Service Connections
2002	606	148	267	1021
2003	643	147	268	1058
2004	703	143	266	1112
2005	883	143	268	1294
2006	1023	139	269	1431

Analysis of this data shows Roats Water System has experienced 40.2 percent growth in the number of service connections over the past five years.

The Central Oregon area has experienced phenomenal growth recently, and the increase in the number of Homeplace residential connections is a reflection of this growth. Over the past five years, Homeplace has grown by 68.8 percent. However, Woodside Ranch is a planned development that was largely completed in the 1970's, and as such the number of connections remains largely unchanged. Commercial connections have declined by 6.1 percent over the past five years, but are expected to increase as several commercial projects are in the planning stages.

Exhibit 2-1 and Exhibit 2-2 are detailed maps of the Homeplace and Woodside Ranch service areas.

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2.2 Source of Supply

There are ten wells connected to Roats water distribution system. The locations of these wells are shown in Exhibit 2-3. These wells draw water from the deep regional aquifer below the central Deschutes basin to supply the water for Roats Water System. It is estimated that this aquifer is recharged at a rate of 2,763 cubic feet per second.

The withdrawal of water from these ten wells is governed by a series of water rights. Table 2-2 describes these rights, including permit numbers, priority date, permitted date, and other relevant information.

Table 2-2: Roats Water System Water Rights Summary

Permit Number	Priority Date	Certificate	Rate (cfs)	Use	Notes	Authorized Completion Date
G-1890	03/23/1961	81657	0.66*	Quasi-Municipal	Well 1	N/A
G-3128	12/22/1965	81672	0.56**	Quasi-Municipal	Well 2	N/A
G-11323	11/06/1989	--	1.10	Quasi-Municipal	Wells 5, 6, 7, 8	10/1/2010
G-12526	08/10/1992	--	0.25	Quasi-Municipal	Well 3	10/01/2018
G-12526	08/10/1992	--	0.85	Quasi-Municipal	Well 4	10/01/2018
G-12526	08/10/1992	--	0.95	Quasi-Municipal	Well 9	10/01/2018
G-12526	08/10/1992	--	0.95	Quasi-Municipal	Well 10	10/01/2018

*Originally composed of 0.50 domestic and 0.16 irrigation, since reclassified as quasi-municipal
**Originally composed of 0.50 domestic and 0.06 irrigation, since reclassified as quasi-municipal

Wells 5, 6, 7, 8 are located in the Woodside Ranch service area. Wells 1-4 and 9-10 are located in the Homeplace Service Area. Well 10 is the newest addition to the system, it was completed in June 2006.

Roats Water System, Inc. has access to quasi-municipal use water totaling 3.44 mgd (5.32 cfs), with 2.73 mgd (4.22 cfs) in the Homeplace service area and 0.71 mgd (1.10 cfs) in the Woodside Ranch service area. The existing water supply does not have any issues with drawdown conditions, water quality concerns, or endangered species.

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2.3 Summary of Recent Use

2.3.1 Average Annual Use

Table 2-3 summarizes the average annual production from each of Roats Water System's ten wells over the past five years. Well 10 was completed in June 2006. All wells are individually metered, with the exception of 5 and 6, which are currently combined.

Table 2-3: Roats Water System Summary of Recent Water Production (millions of cubic feet)

Well	Permit	2002	2003	2004	2005	2006	Avg. % Supply
1	G-1890	6.01	3.61	3.46	4.00	0.77	8.57
2	G-3128	1.58	0.50	0.38	0.38	0.16	1.41
3	G-12526	2.14	2.11	2.07	1.87	1.96	4.65
4	G-12526	13.87	15.95	14.89	15.63	9.25	32.72
5 & 6	G-11323	7.22	6.50	5.82	4.02	4.72	13.01
7	G-11323	1.38	0.79	5.04	3.10	3.97	6.34
8	G-11323	8.82	6.90	6.09	5.66	4.46	14.85
9	G-12526	2.55	3.16	4.88	3.21	1.65	7.30
10	G-12526	N/A	N/A	N/A	N/A	33.84	11.14
Total		**43.57**	**39.52**	**42.63**	**37.87**	**60.78**	
Average Day		**0.12**	**0.11**	**0.12**	**0.10**	**0.17**	

2.3.2 Seasonal Usage

For the Homeplace portion of the system, a review of usage between 2002 and 2006 indicates a peak day demand of 2.45 cubic feet per second, which occurred July 27, 2006. In the Woodside Ranch system, the peak day usage was 1.74 cfs, which occurred July 31, 2006. In general, usage peaks in late July each year.

Figure 2-1 provides a graphical summary of Homeplace peak system usage between July 11, 2006 and September 20, 2006. Figure 2-2 provides a graphical summary of the Woodside Ranch peak system usage between June 21, 2006 and September 20, 2006.

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Figure 2-1: Homeplace Peak Usage

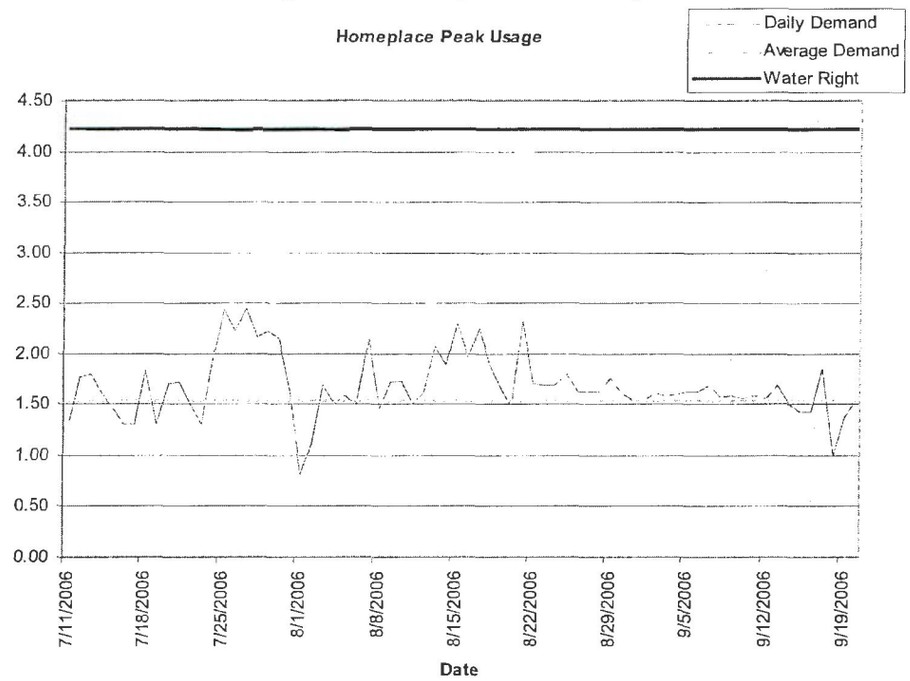
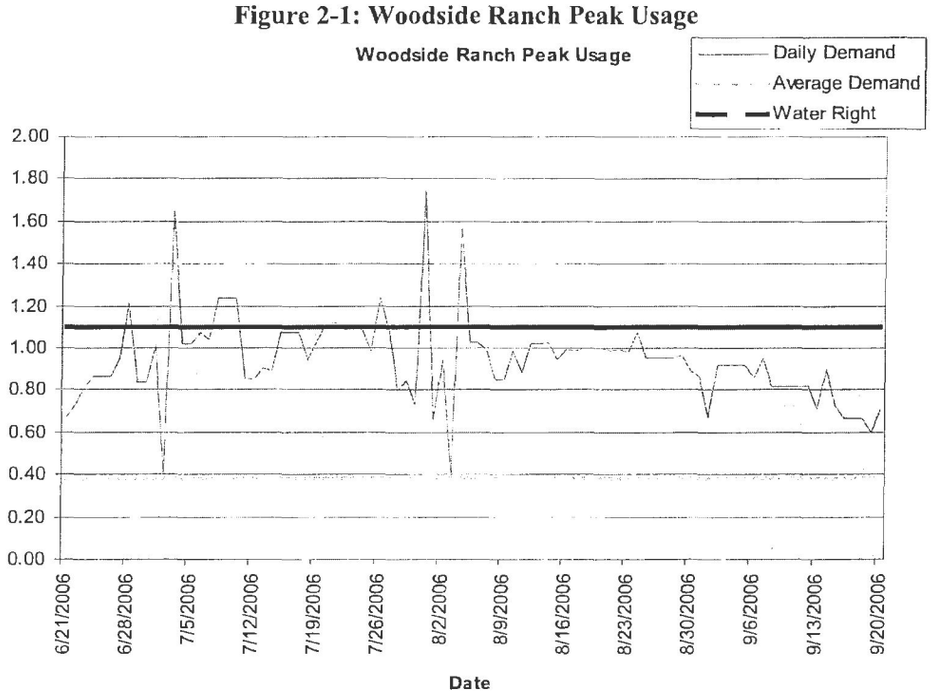


Figure 2-1: Woodside Ranch Peak Usage



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2.4 Water Customers Served

Roats Water System serves residential, commercial, and fireflow customers. Residential customers represent at least one dwelling unit. Single family, multi-family, condominiums, apartments, and mobile homes are included in this class. The commercial class represents the commercial customers, and fireflow accounts are dedicated to providing fireflow in the event of an emergency. Fireflow accounts are not metered and are used only in the event of an emergency.

Table 2-4 displays the water use per service connection in each service category for the past five years

Table 2-4: Average Water Use per Service Connection by Service Category (cubic feet per year)

Year	HMP Residential	HMP Commercial	WSR Residential
2002	20,212	66,012	43,014
2003	18,538	70,323	43,036
2004	17,294	68,383	43,824
2005	13,809	66,539	40,606
2006	15,521	70,198	42,246

Table 2-5 illustrates the estimated percentage of indoor and outdoor use for Roats Water System in Homeplace and Woodside Ranch. This data was obtained by projecting wintertime use to twelve months, and assuming that wintertime use was strictly indoor use.

Table 2-5: Estimated Percentage of Indoor and Outdoor Use

	Indoor Use	Outdoor Use
Homeplace Residential	42.6 %	57.4 %
Homeplace Commercial	61.4 %	38.6 %
Woodside Ranch	24.3 %	75.7 %

Table 2-6 illustrates the average top five private commercial accounts over the last five years. The primary use for Bend Factory Stores and WalMart is outdoors, to meet mandatory landscaping requirements.

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Table 2-6: Roats Water System Average Top Five Accounts
Average Use (cubic feet per day)

	2002	2003	2004	2005	2006
Bend Factory Stores	1,047	1,056	1,263	1,016	1,420
Classic Car Wash	363	1,347	1,730	1,173	1,465
LaQuinta Inn	1,076	3,160	914	941	972
Scandia Mobile Park	1,173	1,050	1,107	1,338	1,293
WalMart	905	1,418	1,065	862	1,160
Total	**4,563**	**8,031**	**6,079**	**5,330**	**6,310**

2.5 Facilities Description

2.5.1 Source/Treatment

All wells are currently in compliance with the state drinking water standards outlined under Oregon Administrative Rules. None of the wells have significant concentrations of any of the analytes tested, and the water is not treated.

2.5.2 Transmission/Distribution

Roats Water System, Inc. has a network of pipe ranging from 2-inches to 16-inches in diameter. The approximate total length of each size of pipe in the Homeplace distribution system is listed in table 2-7. This information was obtained from the water model developed by Murray, Smith and Associates in Portland.

Table 2-7: Approximate Total Length of Pipe by Size in Homeplace

Pipe Size (Inches)	Approximate Total Length (feet)
1	400
1.25	500
2	13,800
3	100
4	13,200
6	15,000
8	55,900
10	300
12	30,200
16	2,800
Total	**132,200**

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Table 2-8 displays the approximate length of pipe by size in the Woodside Ranch distribution system. This information was obtained from Roats Water System records.

Table 2-8: Approximate Total Length of Pipe by Size in Woodside Ranch

Pipe Size (Inches)	Approximate Total Length (feet)
4	6,000
6	36,300
Total	**42,300**

2.5.3 Water Storage

Roats Water System has six reservoirs totaling 3.58 million gallons. The locations of each reservoir are shown in Exhibit 2-1 and 2-2. Summaries of available storage for each reservoir are provided in Table 2-9.

Table 2-9: Roats Water Storage Summary

Reservoir Number	Location	Supply	Storage in Gallons
1	Hamilton Lane	Wells 1 and 2	50,000
2	Brookswood Blvd	Wells 4 and 9	320,000
3	Pinebrook	Well 3	60,000
4	N. Woodside Rd	Wells 5 and 6	60,000
5	S. Woodside Rd	Wells 7 and 8	90,000
6	Deschutes River Woods	Well 10	2,500,000

2.5.4 Pump Stations

The capacities of the pump stations located at each well are listed in Table 2-10.

Table 2-10: Roats Water Summary of Pump Capacities

Well Number	Flow (GPM)	Flow (CFM)	Notes
1	280	37	
2	515	69	
3	113	15	
4	210	28	
4	2000	267	Standby Diesel
5	115	15	
6	115	15	
7	157	21	
8	337	45	
9	325	43	
10	2250	301	

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The current water delivery capacity for the Homeplace System is 5.32 mgd (8.22 cfs) under normal circumstances and with the standby diesel pump running, the delivery capacity is 8.20 mgd (12.67 cfs). In Woodside Ranch the current delivery capacity is 1.04 mgd (1.60 cfs).

2.6 Innterconnections

Roats Water System's distributions systems in Homeplace and Woodside Ranch have interconnections designed for both wholesale and emergency/fire flow purposes.

Homeplace
In the Homeplace system there are five interconnections to other water systems. These connections are with the City of Bend water system and also the Avion Water Company.

City of Bend Connections

1) Country Club Drive 6" connection: This 6" connection is a non-metered emergency only connection. Valves are always valved off and clearly marked to instruct service personnel not to open valves unless an emergency situation should arise. Water can be sent from either utility in the event of an emergency.

2) Rae Road 2" connection: There is a 2" connection to the City of Bend water system that is always valved off and clearly marked to show service personnel what the valves is used for. It is a non-metered and emergency use only valve. Either utility could benefit from the connection in the event of a service disruption.

Avion Water Company Connections

1) Parrell Road Vault: At the intersection of Parrell Road and Grand Targhee is the main connection and feed to Roats. The connection is a gravity fed 12" main that feeds our 16" line that runs north and south along Parrell Road. At the vault are a 12" and 3" pressure reducing valves which are always valved on. Water can only flow from Avion Water's mains to ours. One of two intake points from the Joint Venture agreement with Avion Water Company, all water taken is metered.

2) Brookswood Vault: Located at our Brookswood pumping station is a 8" connection to Avion Water Company's mains that run north/south along Brookswood Blvd. The connection is always valved on and is gravity fed pressure. One of two intake points from our Joint Venture agreement with Avion Water Compay, all water taken in is metered.

3) Powers Road Connection: At the intersection of Powers Road and Brookswood Blvd is a third connection to the Avion system. The valve is for emergency

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purposes only and is non-metered. The connection will be used as a third intake point after a vault and pressure reducing valves are placed at the site.

Woodside Ranch

1) Knott Road Connection: The Knott Road connection is a one way feed from the Roats Woodside Ranch system to the City of Bend's system at the Mountain High Subdivision. At the site are two connections. One is 6" pressure reducing valve designed for fire flow situations only. There is also a metered 3" connection for wholesale purposes.

2) Blue Ridge Subdivision: Also on the Woodside Ranch subdivision is a 6" pressure reducing valve interconnection that is designed for fire flow purposes only. This connection also aids the City of Bend's Mountain High water system.

2.7 System Efficiency

Unaccounted for water has been consistently less than ten percent over the past five years. This number is computed by taking the difference between the metered withdrawals at the wells and the recorded use at billing. A summary of water audit findings for the past five years is shown in Table 2-11 and 2-12.

Table 2-11: Unaccounted for Water as a Percent of Production: Homeplace

Year	Total Production (CF)	Total Use (CF)	% Unaccounted for
2002	26,149,573	23,568,243	9.87
2003	25,326,915	23,726,680	6.31
2004	25,689,556	23,277,550	9.06
2005	25,082,550	22,951,754	8.50
2006	26,995,822	25,700,980	4.80

Table 2-12: Unaccounted for Water as a Percent of Production: Woodside Ranch

Year	Total Production (CF)	Total Use (CF)	% Unaccounted for
2002	17,425,451	16,431,661	5.70
2003	14,182,010	13,462,669	5.07
2004	16,952,700	15,921,199	6.08
2005	12,790,180	12,297,683	3.85
2006	13,143,490	11,927,672	9.25

Roats currently does not measure water used for flushing and fire, and therefore the percent of water unaccounted for listed above contains the approximately two percent of water that is used for these purposes. Clearly, the percent of water lost to leaks each year is well under ten percent.

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Section 3
Conservation Element

In 1997 Roats Water System, Inc. submitted a Water Management and Conservation Plan to the Water Resources Department, describing conservation measures available to Roats Water System.

3.1 Previous Efforts

Roats Water System, Inc. has a history of practicing water conservation and encouraging conservation by consumers.

Every consumer connection in Homeplace and Woodside are metered. Each month, water use at each connection is compared with the same period during the previous year, as well as the previous month. This allows detection of leaks that may exist on consumer's premises, as well as signaling meters that may need replacement. Free leak detection visits are offered to consumers by request.

Roats Water System, Inc. regularly inspects tanks and reservoirs for leakage.

Roats Water System, Inc. has an active distribution system leak detection program in effect. The entire system is carefully monitored for leaks, and then repairs or replacements are made immediately.

Two measures were identified for implementation in the previous conservation plan: rate structure incentives and customer education. The rate structure was addressed in our 2005 rate case. Consumer education is an area that could certainly be improved. With the tremendous growth experienced by Roats Water System over the past five years, the company was forced to focus on development of the system. The growth has slowed, and Roats Water System is now able to focus on other areas, such as consumer education.

3.2 Water Use and Reporting

In 1992, a commitment was made to collect and maintain detailed records of water used and water pumped. Records are kept on a daily basis of all water pumped. Wells are individually metered, with the exception of 5 and 6, which are combined. Records are kept on a month basis of water used, and separate records are maintained for residential and commercial consumers. Roats Water System is able to record the instantaneous volume of water pumped at all of our wells.

Roats Water System's water use reporting is done in compliance with Oregon Administrative Rule 690, Division 85. The report is submitted annually on the form provided by the Water Resources Department and the "Flow Meter Method" is used. There have been no withdrawals that were not recorded, and the measurement program meets the 15 percent accuracy requirements.

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3.3 Rate Structure and Metering

Roats Water System's current rates are a flat rate base charge dependent on the size of the meter, and a usage charge dependent on water consumed. The current base rate ranges from $26.80 for a 5/8 inch or 3/4 inch meter, up to $49.58 for a two inch meter. Usage is billed in a uniform rate structure at $0.762 per 100 cubic feet.

All connections in both Homeplace and Woodside Ranch are metered. The meters are read on a monthly basis.

3.4 Additional Conservation Measures

Roats Water System, Inc. has undertaken several conservation measures that were not mentioned in the 1997 plan.

Roats Water has recently developed a website where conservation material is available.

Roats Water System has actively eliminated numerous dead end lines on the system.

3.5 Planned Conservation Measures

The conservation program described was developed after careful analysis of both the Homeplace and Woodside Ranch systems. The systems are separate and have different conservation needs, so they will be addressed individually.

Homeplace

The water rights available meet current and projected demands in Homeplace. Homeplace is comprised mainly of single-family homes on relatively small lots. Usage is fairly evenly split between indoor and outdoor use. Most of the homes in the area are new, with efficient plumbing.

Planned conservation activities in Homeplace include:
1) Institute a yearly conservation mailing to be sent with the Consumer Confidence Reports
2) Institute a meter testing program. Test 10% of the oldest devices each year to determine accuracy. Replace if accuracy is less than 90%.

Woodside Ranch

Woodside Ranch has exceeded the daily allotment a few times during peak usage. Usage in Woodside Ranch is estimated to be nearly 76% outdoors. When the Woodside Ranch delivery system was constructed, it was anticipated there would be a supplementary irrigation system. Conservation measures in Woodside should focus on consumer education, and specifically on consumer education about efficient outdoor use.

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Planned conservation activities in Woodside include:
1) Institute a yearly conservation mailing to be sent with the Consumer Confidence Reports
2) Institute a meter testing program. Test 10% of the oldest devices each year to determine accuracy. Replace if accuracy is less than 90%.
3) Print notices on the bills for the months of April-September to remind customers of outdoor conservation measures.

The above-mentioned conservation methods, in combination with existing measures, are expected to reduce demand by 5%. The greatest savings should come from the meter testing and maintenance program in both Homeplace and Woodside Ranch.

3.6 Benchmarks

Table 3-1 illustrates benchmarks for the planned and ongoing conservation measures at Roats Water System.

Table 3-1: Conservation Benchmarks

Benchmark	Date	Frequency
Ongoing		
Visual Inspection of Reservoirs		Bi-annually, in March and September
Meter Testing Program		Per Request
Leak Detection Visits		Per Request
System Leak Detection		Annual inspection, repairs as needed
Elimination of Dead-End Lines		As possible
Conservation Section on Website		Update annually
Planned		
Conservation Mailing	06/08	Annually, include with CCRs
Meter Testing Program	03/08	Annually
Notice on Bills in Woodside	04/08-09/08	Annually

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Section 4
Curtailment Plan Element

Roats Water System has experienced no supply deficiencies in either the Homeplace or Woodside Ranch systems in the past. However, it is recognized that some sort of catastrophe, such as earthquake or contamination of the water supply, could occur. Additionally, a severe long lasting drought could conceivably bring supply limitations. It is clear that the available water supply is large enough that a water supply shortage would have to be substantial for it to impact the ability to meet current or projected demand.

4.1 Available Resources

In the event of a water emergency, Roats Water System has several options to ensure an adequate supply of water for its customers.

In the Homeplace system, the first line of defense would be the 2.88 million gallons of storage available, though the actual volume of water in storage varies with usage. It cannot be assumed that all reservoirs would be full in the event of an emergency.

Secondly, Roats Water System has emergency interties with Avion Water Co. and with the City of Bend. There are 15,120 gallons per minute available from these interties.

In the event that other water suppliers simultaneously experience water shortages, Roats Water System has developed a Curtailment Plan.

In Woodside Ranch, the first option in the event of an emergency would be the 150,000 gallons of available storage. The second option would be enactment of the curtailment plan, and the third option would be re-plumbing the intertie with the City of Bend to allow water to be pumped into Woodside.

4.2 Emergency Response

Currently, the Homeplace system could be fed exclusively by Well 10, exclusively by the other Homeplace wells (1-4 and 9), or by some combination of the two. The Homeplace wells and Well 10 would have to fail simultaneously to constitute a water emergency. Roats Water System defines a Homeplace water emergency as any time when the main wells would all be lost.

In Woodside Ranch, an emergency would be defined as loss of any two wells for greater than 24 hours. Extra pumps are kept on site at the Woodside wells to expedite replacement should any pumps go down.

4.3 Curtailment Plan

Table 4-1 describes Roats Water System's curtailment plan. Included with the plan are three stages of alert, the trigger for each stage, the reduction goal, and the curtailment

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measures to be implemented at each stage. Capacity is defined as the total rate of water accessible at any given time through Roats Water System wells.

Table 4-1: Roats Water System Proposed Curtailment Plan

Stage	Usage Trigger	Goal	Curtailment Measures
Potential	80% of capacity	Awareness and 5% usage reduction	• Activate Curtailment Plan • Distribute Informational brochures on conservation • Post signs in public locations • Customer outreach through website and local media • Voluntary reduction in irrigation: encourage even and odd street numbers to water on even or odd fourth days • Flushing lines for essential needs only
Moderate	90% of capacity	10% usage reduction	• Continue with Potential measures except as listed below • Mandatory Irrigation schedule • Eliminate line flushing, construction use, and park irrigation • Pools closed • Request businesses and homeowners reduce use by 10% • Hosing of pavement or use in new construction not permitted except as necessary for public health
Critical	95% of capacity	15% usage reduction	• Continue Moderate stage measures except as noted below • No use of Roats supplied water outdoors

4.4 Staff Responsibilities

The following staff will have the following responsibilities in the event the curtailment plan is implemented: Lisa Martin, Office Manager: Coordinate distribution of conservation materials to customers and public education efforts. Mike Miller, Service Manager: Work with businesses and residential customers to reduce consumption. Glenn Topliff, Safety and Compliance Manger: Monitor new construction usage and determine flushing needs. Casey Roats, Vice President: Oversee all aspects of the curtailment plan.

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Section 5
Water Supply Element

5.1 Future Service Area

Roats Water System's present population is estimated at 2640 in the Homeplace system and 670 in Woodside Ranch. Other water service providers surround both Homeplace and Woodside Ranch, so expansion of the service area is unlikely. Future demand will come from development within the current service area.

A study of the Homeplace water system was performed to estimate the number of connections at full build out. A count of potential new services was taken of the undeveloped lots, with zoning ordinances and buildable area taken into consideration. The study found Homeplace could potentially have 1589 service connections.

Woodside Ranch is a development with clearly defined borders. Based on the number of lots, build out would be 275 service connections.

According to the Deschutes County Coordinated Population Forecast, the City of Bend is projected to grow by 34.60% between 2010 and 2025. Assuming Roats Water System follows the same growth pattern, build out would be reached in the next ten years in Woodside Ranch, and Homeplace would be approaching build out by 2026. Table 5-1 illustrates the projected growth in the number of service connections over the next twenty years.

Table 5-1: Roats Water System Projected Growth

Year	HMP Residential	HMP Commercial	WSR Residential	Total Service Connections
2006	1023	139	269	1431
2016	1200	163	275	1638
2026	1376	187	275	1838

5.2 Future Demand

Future demand will increase as the number of residential and commercial accounts increase. Assuming that newer, more efficient plumbing fixtures and other conservation methods in Homeplace reduce overall usage by 5%, the projected daily demand is show in Table 5-2.

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Table 5-2: Roats Water System Projected Daily Demand (cubic feet per second)

Year	HMP Residential	HMP Commercial	WSR Residential	Total Demand
2006	0.50	0.31	0.36	1.17
2016	0.56	0.35	0.36	1.27
2026	0.64	0.40	0.36	1.40

The average annual demand in Woodside Ranch should remain steady through the next twenty years, as Woodside is already very near build-out. The demand in Homeplace is expected to increase by 25% over the next twenty years.

There should be no change in the fire flow demand, unless a fire that requires extremely large volumes of water were to occur.

5.3 Long Range Supply Plan

The current delivery capability in the Homeplace System is adequate for the projected needs. Recommendations in Homeplace include increasing the size of a few sections of pipe to provide increased fire flows. Additionally, elimination of dead end lines is a priority.

The current delivery capability in the Woodside Ranch water system exceeds the projected demand. Another 0.4 cfs Water Right should be pursued so the full supply is supported by water rights. Additionally, storage in Woodside Ranch should be increased to a minimum of 525,000 gallons. This would provide three days of average use.

5.4 Schedule for Beneficial Use

In order to solidify the water rights, Roats Water System, Inc. has developed the following timcline for applying beneficial use and certification of each right. Currently, only the G-1890 and G-3128 rights are certified.

Table 5-3: Roats Water System Water Right Completion

Permit Number	Priority Date	Certificate	Rate (cfs)	Use	Notes	Completion Date
G-1890	03/23/1961	81657	0.66*	Quasi-Municipal	Well 1	N/A
G-3128	12/22/1965	81672	0.56**	Quasi-Municipal	Well 2	N/A
G-11323	11/06/1989	--	1.10	Quasi-Municipal	Wells 5, 6, 7, 8	10/1/2010
G-12526	08/10/1992	--	3.0	Quasi-Municipal	Well 3, 4, 9, 10	10/01/2018

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Exhibit 2-1: Map of Roats Water System, Homeplace

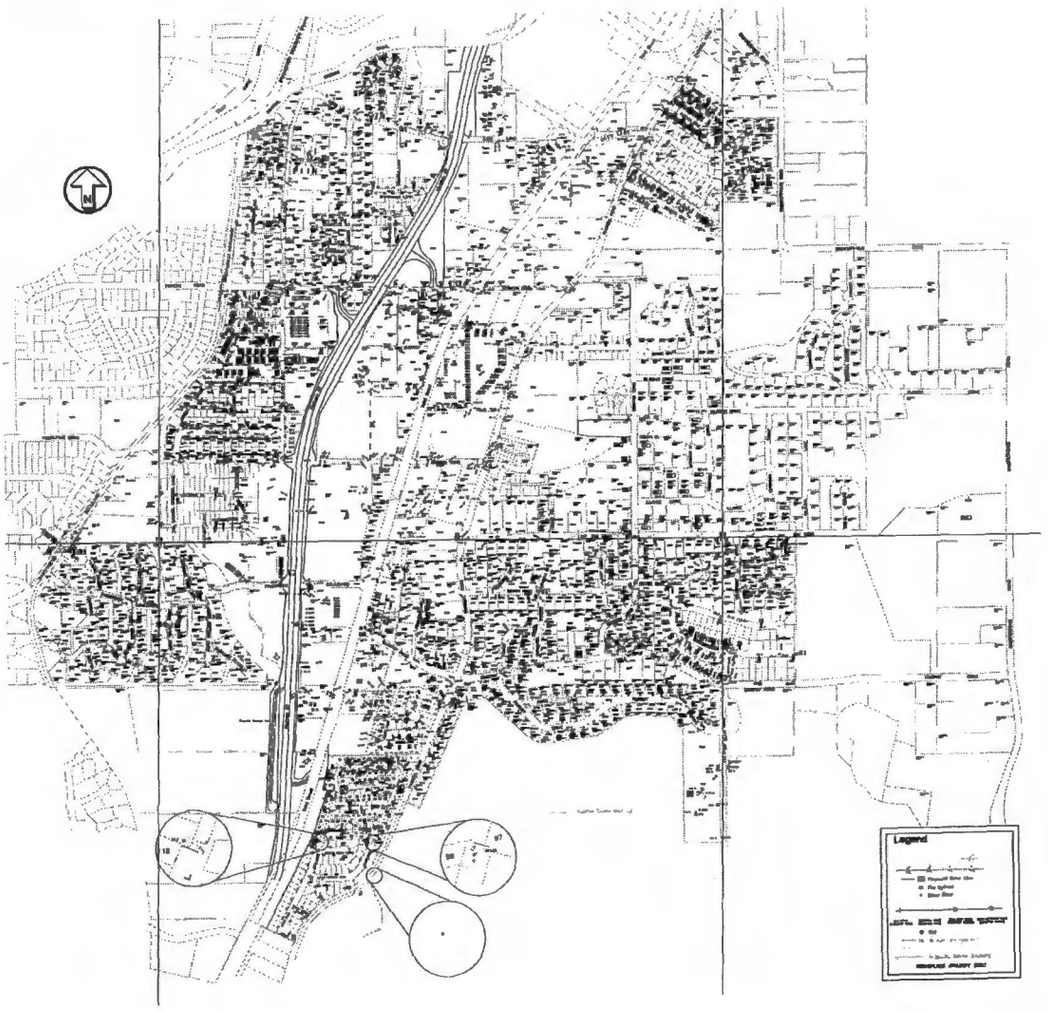

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Exhibit 2-2: Map Roats Water System, Woodside Ranch

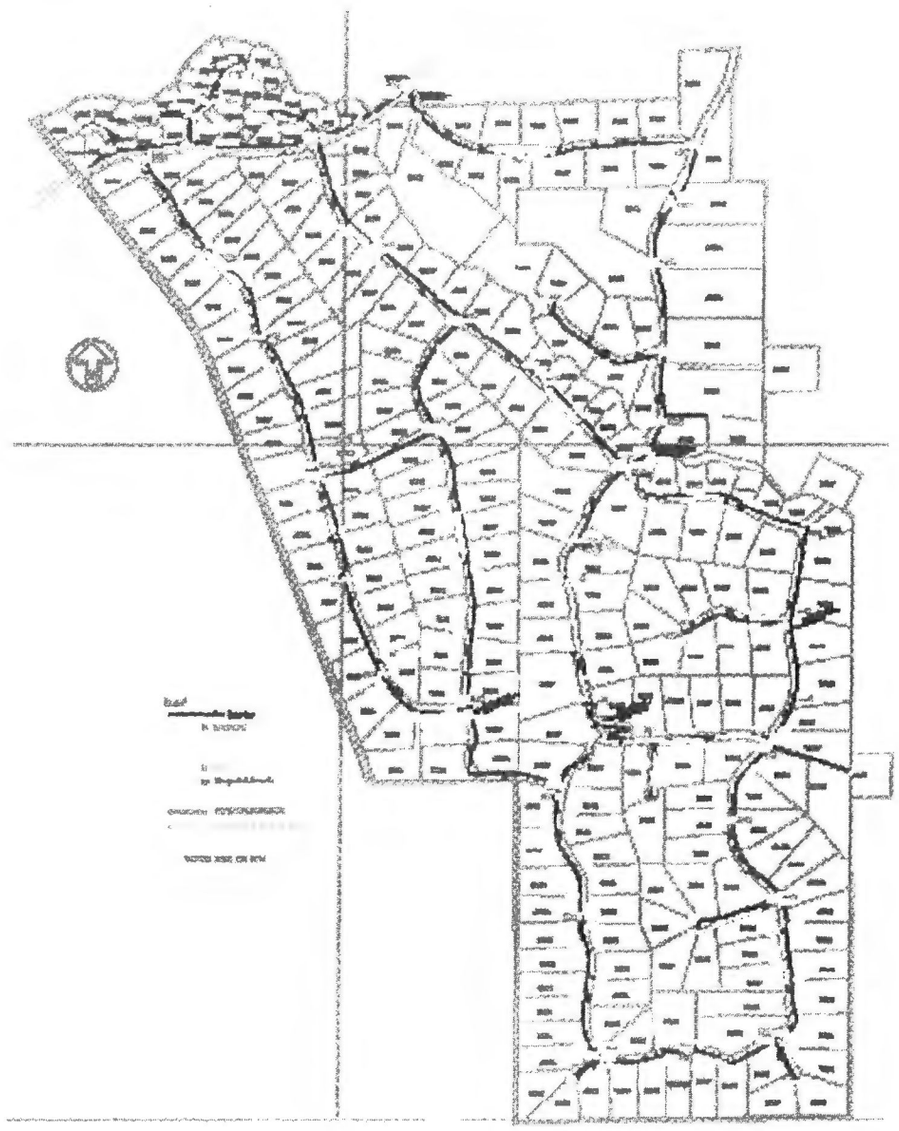

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Exhibit 2-3: Well Location

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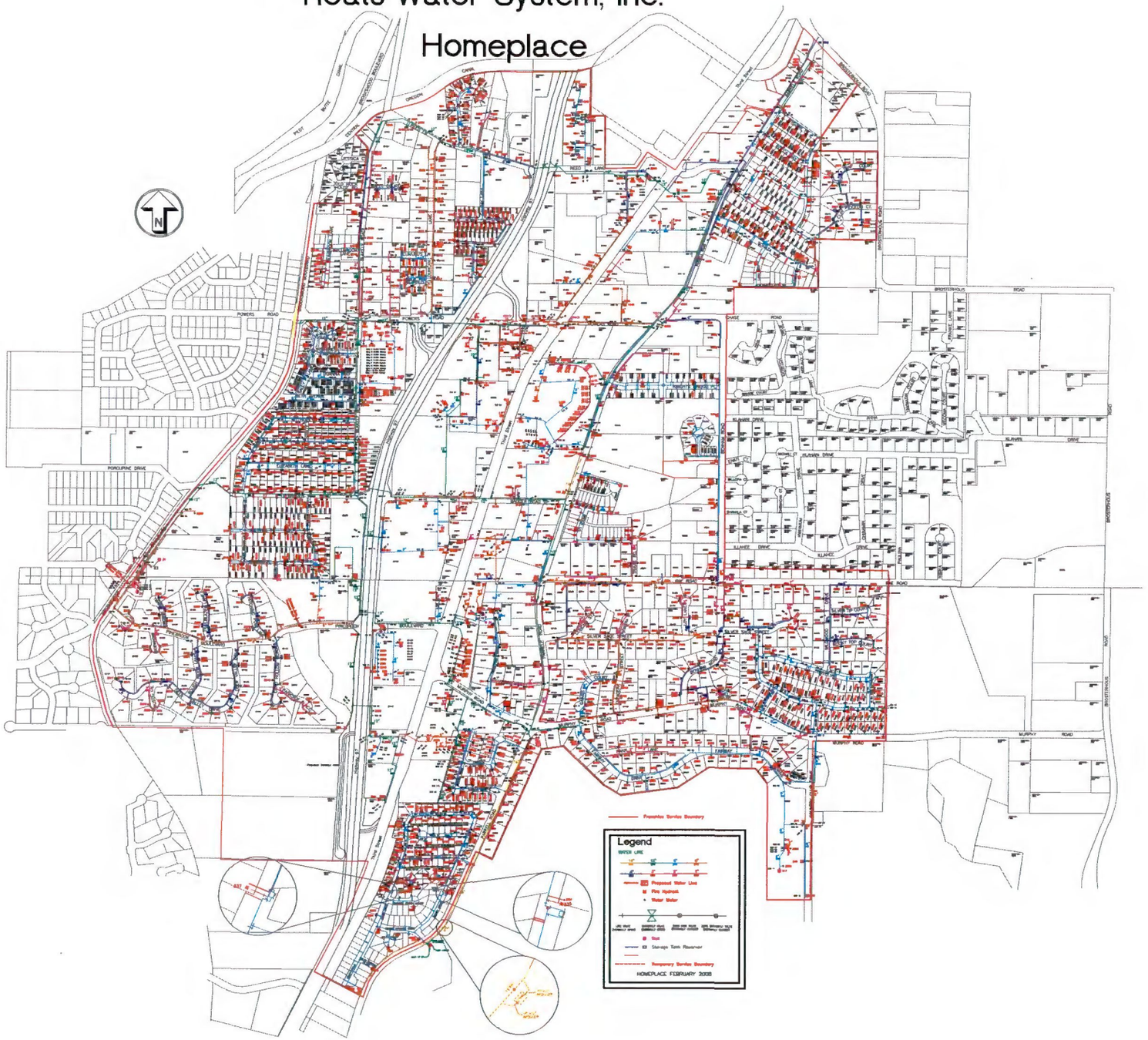
Roats Water System, Inc.

Homeplace



WATER SERVICE FRANCHISE - AVION WATER COMPANY (ORDINANCE NO. NS-1514, as amended)

Section 1: Short Title.

This ordinance shall be known as the "Avion Water Service Franchise." The purpose of this ordinance is to promote and ensure the efficient allocation, regulation and use of domestic water and its provision to Bend residents and to avoid duplication of facilities, capital expenditure and other related resources.

Section 2: Definitions.

For the purpose of this ordinance, the following terms shall have the meaning provided below:

(1) "City" is the City of Bend, Oregon.

(2) "Company" is Avion Water Company, the grantee of the rights under this franchise, and its successors or assigns.

(3) "Council" is the City Council of the City of Bend.

(4) "Person" means any person, firm, partnership, association, corporation, company or organization of any kind.

(5) "Facilities" shall mean all real property, fixtures and equipment used by Company in the provision of water services throughout its system, whether located inside or outside of City, and includes, but is not limited to, main transmission lines, distribution systems and all other things used in the provision of water services by Company.

(6) "Urban Growth Boundary" shall mean those properties within City's present city limits and the Urban Growth Boundary as they now exist and as they may change from time to time in the future.

Section 3: Grant of Authority.

City grants to Company the right and privilege to construct, erect, operate and maintain its facilities, in, upon, along, across, above, over and under the streets, alleys, and public ways now laid out or dedicated, and all extensions thereof, and additions thereto, for the provision of water services in City. This franchise is nonexclusive in that the City reserves the right to operate a water system within the public ways and to grant a similar use of streets, alleys and public ways to another person. The City will not serve new customers within the Company's Water Service Area, unless the Company will not serve the customer(s) or the utility is not providing service that meets the standards of a public water utility. The City will not provide service to new customers within the Company's water service area without first providing the Company ten days written notice. This notice shall not be required in the case of an emergency.

Section 4: Compliance with Laws, Rules and Regulations.

At all times during the term of this franchise, Company shall comply with all applicable laws, rules and regulations of the United States of America, the State of Oregon, and the City of Bend; including appropriate agencies and subdivisions thereof. Company shall be subject to the lawful exercise of the police power of City and to such reasonable regulations as City may from time to time hereafter adopt. Company shall have 30 days after written notice to remedy any non-compliance. If any non-compliance cannot reasonably be remedied within 30 days, City shall not declare a default for non-compliance provided Company is taking reasonable steps to remedy the non-compliance as soon as is reasonably practicable. This 30 day notice requirement shall not apply in emergency-type situations where the preservation of public health, safety or welfare requires that immediate action be taken.

Section 5: Company Liability, Indemnification of City and Insurance.

(1) Company shall at all times conduct its operations under this franchise, including installation, construction or maintenance of its facilities, in a safe and workmanlike manner so as not to present a danger to the public or City.

(2) Company shall pay, save harmless and indemnify City from any loss or claim against City on account of or in connection with any activity of Company in the construction, operation or maintenance of its facilities and services.

(3) This franchise shall not be effective until Company secures, and shall at all times be conditioned upon Company maintaining, a comprehensive liability insurance policy which shall contain the following provisions:

(a) Bodily injury policy limits of $500,000 for each person and $500,000 for each occurrence.

(b) Property damage policy limits of $500,000.

(c) An endorsement for completed operations coverage.

(d) A designation of City, its officers, agents and employees, as an additional insured for liability arising from or in connection with this franchise.

(e) An endorsement requiring 10 days' written notice to City prior to the cancellation of the insurance coverage.

(f) A certificate evidencing insurance as described in this ordinance shall be deposited with City.

(g) In the event that City's tort liability limits are raised by the Oregon Legislature to exceed the limits described in this Section, Company shall obtain and maintain insurance in the amount of City's tort liability limits.

Section 6: Facilities and Service Standards.

For the term of this franchise, Company shall construct, operate and maintain its facilities and provide services as follows:

(1) Company shall provide its customers with good quality water services; and supply potable water to its customers in compliance with all applicable laws, rules and regulations.

(2) Company shall construct and maintain those portions of its facilities that are located within the City of Bend and within the Urban Growth Boundary surrounding the City, as it exists and changes, in compliance with City and State standards for the provision of the service. Compliance with City standards shall include, but not be limited to:

(a) Standards for construction and installation of the water system, including the use of C-900 or ductile iron pipe and restoration of City streets.

(b) Provision of standard City fire flows throughout the water system, subject to verification by the Fire Department with notice. At least annually or upon request by the City, the Company will provide the City with a written report of individual hydrant conditions.

(c) City inspection and approval of system design and installation pursuant to generally accepted practices and standards in the water utility area.

(d) Compliance with City construction standards shall be required only for facilities which are constructed or installed after the commencement of this franchise.

(3) Company shall maintain and improve its facilities according to generally accepted practices and standards in the regional water utility industry.

(4) Company's service to properties within the City shall be confined to the properties shown on the map entitled "Water Service Area Exhibit" which is marked EXHIBIT A, Amended July, 2007 attached hereto and incorporated by reference herein. Company shall not serve any other properties within the City. Exhibit A, Amended July, 2007, shall replace the existing water service area allocation between the City of Bend and Company.

[NOTE: Exhibit A is located in City of Bend Ordinance Book directly preceding Ordinance No. NS-2060.]

Company shall not serve any other properties within the Urban Growth Boundary.

(5) Unless prohibited by law or the Oregon Public Utilities Commission, in cases where City provides sewer services to a Company customer, Company agrees to terminate the service of Company's customer, at the request of City, if the customer becomes delinquent in the payment of the customer's sewer service bill.

Section 7: Company Rules.

Company shall have authority to promulgate such reasonable rules and regulations governing the conduct of its business as shall be reasonably necessary to enable Company to exercise its rights and perform its obligations under this franchise, and to assure uninterrupted service to its customers. Company rules and regulations shall be subject to the provisions of this ordinance and any other governmental regulations. A copy of said rules and all amendments thereto shall be filed with the Office of City Manager.

Section 8: Conditions on Street Occupancy.

Company agrees to comply with the following conditions:

(1) Use. All facilities installed by Company within the Urban Growth Boundary after the date of this ordinance shall be so located as to cause minimum interference with the proper use of streets, alleys and other public ways and places, and to cause minimum interference with the rights or reasonable convenience of property owners who adjoin any of the streets, alleys or other public ways or places. Company shall obtain street cut permits for all street cuts and shall comply with the provisions of City's street cut ordinance.

(2) Restoration. In case of any disturbance of pavement, sidewalk, driveway or other surfacing by Company, Company shall, at its own cost and expense and in a manner approved by City, replace and restore all paving, sidewalk, driveway or surface of any street or alley disturbed, in as good condition as before the disturbance. If Company fails to make restoration as required, City shall cause the repairs to be made at the expense of Company.

(3) Relocation. City may require Company to change the location of any facility within the public right of way when the public convenience requires such change or removal and the expense thereof shall be paid by Company. City shall give Company reasonable notice of any changes required and Company shall have a reasonable time within which to make the requested change. If Company refuses to make the change requested by City or does not make the change within a reasonable time after the request of City, City may make the change and collect the cost of making said change from Company.

(4) Placement of Facilities. Company shall not place its facilities where they will interfere with any existing gas, electric or telephone fixture or sewer or water facility. All facilities placed in the City street shall be placed as City directs.

Section 9: Notice of Intent to Sell.

Company shall not enter into any binding agreement to sell, assign, dispose of or transfer in any manner whatsoever any interest in this franchise, nor transfer, permit transfer of controlling interest in the Company, without first providing to the City sixty (60) days written notice of Company's intent to sell.

Section 10: Transfer of Franchise.

Company shall not sell, assign, dispose of or transfer in any manner whatsoever any interest in this franchise or in the technical facilities used with this franchise, nor transfer or permit transfer of controlling interest in Company without prior written approval of Council. Such approval shall be based upon the following criteria: Company shall be required to demonstrate to the satisfaction of the Council that Company's proposed purchaser, assignee or transferee has such financial and managerial resources as are sufficient to maintain the then current quality of service and to comply fully with the terms of this franchise prior to the Council granting such approval. Such approval, based upon the above criteria, shall not be unreasonably withheld by the Council. If the PUC approves the transfer, the transfer shall be presumed to be reasonable.

Section 11: City Right in Franchise.

City shall have the right to inspect all construction or installation of Company facilities, subject to the provisions of this ordinance and to make such inspections as it shall find necessary to ensure compliance with governing laws, rules and regulations.

Section 12: Franchise Fee.

Company shall pay the franchise fee established by Section 3.112 of the Bend Code. A comparable fee shall be paid by the City's water utility. For purposes of calculating the franchise fee, the term "gross operating revenue" in Bend Code Section 3.112 shall mean all Company income recognized by the Oregon Public Utility Commission for rate setting purposes. The franchise fee provided herein is subject to Public Utility Commission approval.

Section 13: Rate and Services Regulation.

City shall not regulate Company's rates so long as Company's rates are regulated by the Oregon Public Utility Commission or comparable governmental entity.

Section 14: Company Records and Reports.

Company shall keep accurate books of account at an office within the State of Oregon throughout the term of this franchise. Company shall produce its books of account for inspection by City at any time during normal business hours, after reasonable notice by City, and City may audit Company's books from time to time. City may require periodic reports from Company relating to its operation and revenue within City. Prior to requesting periodic reports, City shall first review the annual report submitted by Company to the P.U.C.

Section 15: System Data.

Company shall maintain, at a local office, current maps and other operational data relating to its facilities and system operations in the City of Bend. City may inspect these maps and data at any time during normal business hours.

Section 16: Enforcement of Franchise.

City and Company shall have all remedies provided by law, including termination of this franchise, to enforce the terms and conditions of this franchise. Failure to enforce any provision of this ordinance shall not be construed as a waiver of a breach of any other term, condition or obligation of this ordinance.

Section 17: Franchise Term.

This franchise is granted for a term of 20 years beginning with the acceptance by Company of the amendment to the franchise adopted by the Bend City Council in July, 2007.

Section 18: Acceptance of Franchise.

Within 30 days from the effective date of this ordinance, Company shall file with the City Recorder a written, unconditional acceptance of this franchise and all of its terms and conditions. If Company fails to do so, this ordinance shall be void and of no effect whatsoever.

Section 19: Franchise a Contract.

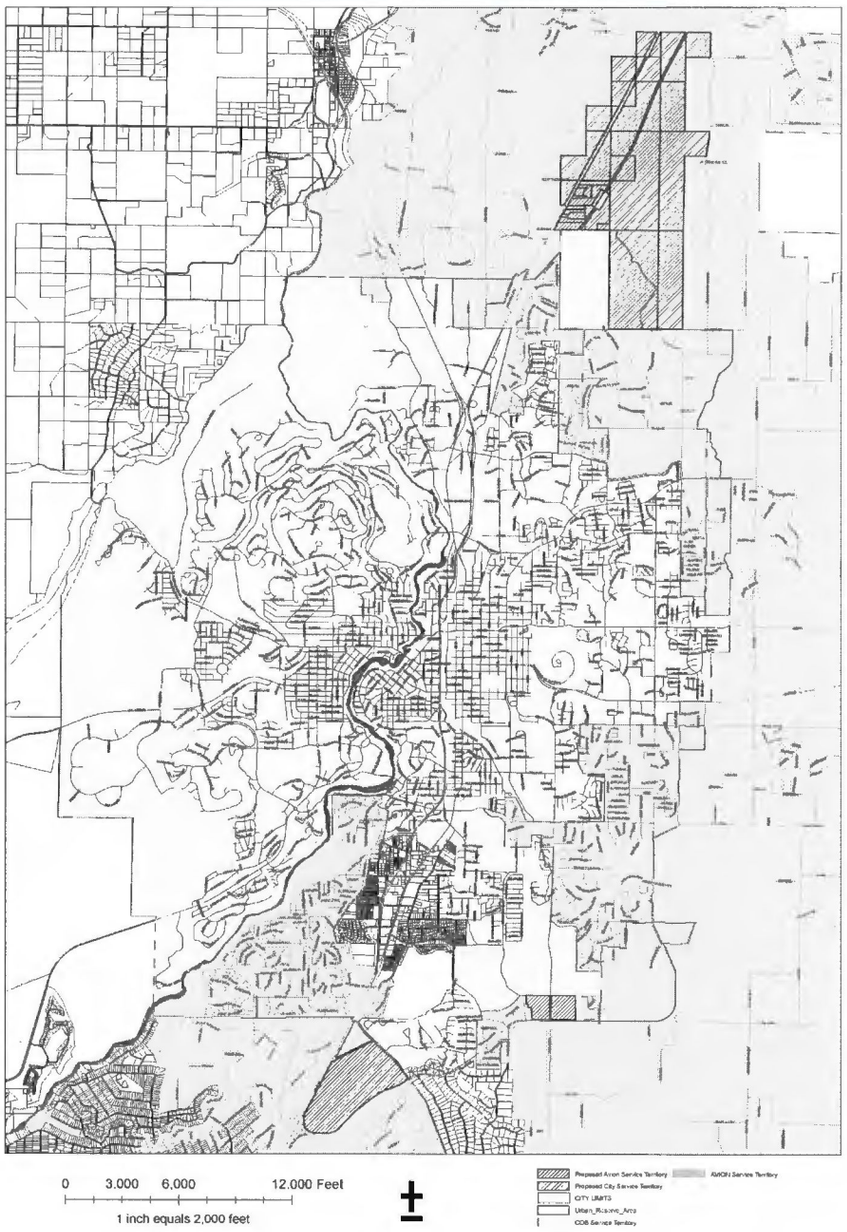
City and Company intend that this franchise shall constitute a contractual obligation between City and Company with respect to Company's service and facilities outside of City and within the Urban Growth Boundary. The parties contemplate that the City's corporate limits will expand through annexation within the Urban Growth Boundary throughout the term of this franchise through City's annexation of properties within the Urban Growth Boundary. The parties intend that the terms and conditions of this franchise shall apply to Company's activities outside the City limits, but within the Urban Growth Boundary, as a contractual obligation so that as properties served by Company are annexed there will not be any significant difference in facilities or service standards.

Section 20: Constitutionality.

If any section, subsection, sentence, clause or portion of this ordinance is for any reason held invalid or is rendered unconstitutional by court of competent jurisdiction, such portion shall be deemed a separate, distinct, and independent provision and such holding shall not affect the constitutionality of the remaining portion hereof. If for any reason the franchise fee is invalidated or amended by the act of any court or governmental agency, then the highest reasonable franchise fee allowed by law shall be the franchise fee allowed by this franchise.

[Section 11-20.1 through 11-20.19 added by Ordinance No. NS-1514, passed June 20, 1990]
[Sections 11-20.6 and 11-20.16 amended by Ordinance No. NS-1549, passed November 6, 1991]
[Section 11.20.1 through 11.20.20 amended by Ordinance No. NS-1748, passed June 7, 2000]
[Section 12 amended by Ordinance No. NS-1997, passed February 1, 2006]
[Sections 6 and 17 amended by Ord. Ns-2060, passed July 2, 2007]

Avion Water Company Inc / City of Bend
Proposed Service Territory Exchange 2007



[Exhibit A Amended by Ord. NS-2060, passed July 2, 2007]

WATER SERVICE FRANCHISE - ROATS WATER SYSTEM, INC. (ORDINANCE NS-1747)

Section 1: Short Title.

This ordinance shall be known as the "Roats Water System Franchise." The purpose of this ordinance is to promote and ensure the efficient allocation, regulation and use of domestic water and its provision to Bend residents and to avoid duplication of facilities, capital expenditure and other related resources.

Section 2: Definitions.

For the purpose of this ordinance, the following terms shall have the meaning provided below:

(1) "City" is the City of Bend, Oregon.

(2) "Company" is Roats Water System, Inc., the grantee of the rights under this franchise, and its successors or assigns.

(3) "Council" is the City Council of the City of Bend.

(4) "Person" means any person, firm, partnership, association, corporation, company or organization of any kind.

(5) "Facilities" shall mean all real property, fixtures and equipment used by Company in the provision of water services throughout its system, whether located inside or outside of City, and includes, but is not limited to, main transmission lines, distribution systems and all other things used in the provision of water services by Company.

(6) "Urban Growth Boundary" shall mean those properties within City's present city limits and the Urban Growth Boundary as they now exist and as they may change from time to time in the future.

Section 3: Grant of Authority.

City grants to Company the right and privilege to construct, erect, operate and maintain its facilities, in, upon, along, across, above, over and under the streets, alleys, and public ways now laid out or dedicated, and all extensions thereof, and additions thereto, for the provision of water services in City. This franchise is non-exclusive in that the City reserves the right to operate a water system within the public ways and to grant a similar use of streets, alleys and public ways to another person. The City will not serve new customers within the Company's Water Service Area, unless the Company will not serve the customer(s) or the utility is not providing service that meets the standards of a public water utility. The City will not provide service to new customers within the

Company's water service area without first providing the Company ten days written notice. This notice shall not be required in the case of an emergency.

Section 4: Compliance with Laws, Rules and Regulations.

At all times during the term of this franchise, Company shall comply with all applicable laws, rules and regulations of the United States of America, the State of Oregon, and the City of Bend; including appropriate agencies and subdivisions thereof. Company shall be subject to the lawful exercise of the police power of City and to such reasonable regulations as City may from time to time hereafter adopt. Company shall have 30 days after written notice to remedy any non-compliance. If any non-compliance cannot reasonably be remedied within 30 days, City shall not declare a default for non-compliance provided Company is taking reasonable steps to remedy the non-compliance as soon as is reasonably practicable. This 30 day notice requirement shall not apply in emergency-type situations where the preservation of public health, safety or welfare requires that immediate action be taken.

Section 5: Company Liability, Indemnification of City and Insurance.

(1) Company shall at all times conduct its operations under this franchise, including installation, construction or maintenance of its facilities, in a safe and workmanlike manner so as not to present a danger to the public or City.

(2) Company shall pay, save harmless and indemnify City from any loss or claim against City on account of or in connection with any activity of Company in the construction, operation or maintenance of its facilities and services.

(3) This franchise shall not be effective until Company secures, and shall at all times be conditioned upon Company maintaining, a comprehensive liability insurance policy which shall contain the following provisions:

(a) Bodily injury policy limits of $500,000 for each person and $500,000 for each occurrence.

(b) Property damage policy limits of $500,000.

(c) An endorsement for completed operations coverage.

(d) A designation of City, its officers, agents and employees, as an additional insured for liability arising from or in connection with this franchise.

(e) An endorsement requiring 10 days' written notice to City prior to the cancellation of the insurance coverage.

(f) A certificate evidencing insurance as described in this ordinance shall be deposited with City.

(g) In the event that City's tort liability limits are raised by the Oregon Legislature to exceed the limits described in this Section, Company shall obtain and maintain insurance in the amount of City's tort liability limits.

Section 6: Facilities and Service Standards.

For the term of this franchise, Company shall construct, operate and maintain its facilities and provide services as follows:

(1) Company shall provide its customers with good quality water services; and supply potable water to its customers in compliance with all applicable laws, rules and regulations.

(2) Company shall construct and maintain those portions of its facilities that are located within the City of Bend and within the Urban Growth Boundary surrounding the City, as it exists and changes, in compliance with City and State standards for the provision of the service. Compliance with City standards shall include, but not be limited to:

(a) Standards for construction and installation of the water system, including the use of C-900 or ductile iron pipe and restoration of City streets.

(b) Provision of standard City fire flows throughout the water system, subject to verification by the Fire Department with notice. At least annually or upon request by the City, the Company will provide the City with a written report of individual hydrant conditions.

(c) City inspection and approval of system design and installation pursuant to generally accepted practices and standards in the water utility area.

(d) Compliance with City construction standards shall be required only for facilities which are constructed or installed after the commencement of this franchise.

(3) Company shall maintain and improve its facilities according to generally accepted practices and standards in the regional water utility industry.

(4) Company's service to properties within the City shall be confined to the properties shown on the map entitled "Water Service Area Exhibit (__)" which is marked EXHIBIT A, attached hereto and incorporated by reference herein. Company shall not serve any other properties within the City.

(5) Unless prohibited by law or the Oregon Public Utilities Commission in cases where City provides sewer services to a Company customer, Company agrees to terminate

the service of Company's customer, at the request of City, if the customer becomes delinquent in the payment of the customer's sewer service bill.

Section 7: Company Rules.

Company shall have authority to promulgate such reasonable rules and regulations governing the conduct of its business as shall be reasonably necessary to enable Company to exercise its rights and perform its obligations under this franchise, and to assure uninterrupted service to its customers pursuant to Company's rules and regulations. Company rules and regulations shall be subject to the provisions of this ordinance and any other governmental regulations. A copy of said rules and all amendments thereto shall be filed with the Office of City Manager.

Section 8: Conditions on Street Occupancy.

Company agrees to comply with the following conditions:

(1) Use. All facilities installed by Company within the Urban Growth Boundary after the date of this ordinance shall be so located as to cause minimum interference with the proper use of streets, alleys and other public ways and places, and to cause minimum interference with the rights or reasonable convenience of property owners who adjoin any of the streets, alleys or other public ways or places. Company shall obtain street cut permits for all street cuts and shall comply with the provisions of City's street cut ordinance.

(2) Restoration. In case of any disturbance of pavement, sidewalk, driveway or other surfacing by Company, Company shall, at its own cost and expense and in a manner approved by City, replace and restore all paving, sidewalk, driveway or surface of any street or alley disturbed, in a good condition as before the disturbance. If Company fails to make restoration as required, City shall cause the repairs to be made at the expense of Company.

(3) Relocation. City may require Company to change the location of any facility within the public right of way when the public convenience requires such change or removal and the expense thereof shall be paid by Company. City shall give Company reasonable notice of any changes required and Company shall have a reasonable time within which to make the requested change. If Company refuses to make the change requested by City or does not make the change within a reasonable time after the request of City, City may make the change and collect the cost of making said change from Company.

(4) Placement of Facilities. Company shall not place its facilities where they will interfere with any existing gas, electric or telephone fixtures or sewer or water facility. All facilities placed in the City street shall be placed as City directs.

Section 9: Notice of Intent to Sell.

Company shall not enter into any binding agreement to sell, assign, dispose of or transfer in any manner whatsoever any interest in this franchise, nor transfer, permit transfer of controlling interest in the Company, without first providing to the City sixty (60) days written notice of Company's intent to sell.

Section 10: Transfer of Franchise.

Company shall not sell, assign, dispose of or transfer in any manner whatsoever any interest in this franchise or in the technical facilities used with this franchise, nor transfer or permit transfer of controlling interest in Company without prior written approval of Council. Such approval shall be based upon the following criteria: Company shall be required to demonstrate to the satisfaction of the Council that Company's proposed purchaser, assignee or transferee has such financial and managerial resources are sufficient to maintain the then current quality of service and to comply fully with the terms of this franchise prior to the Council granting such approval. Such approval, based upon the above criteria, shall not be reasonably withheld by the Council. If the PUC approves the transfer, the transfer shall be presumed to be reasonable.

Section 11: City Right in Franchise.

City shall have the right to inspect all construction or installation of Company facilities, subject to the provisions of this ordinance and to make such inspections as it shall find necessary to ensure compliance with governing laws, rules and regulations.

Section 12: Franchise Fee.

Company shall pay the franchise fee established by Section 3.112 of the Bend Code. A comparable fee shall be paid by the City's water utility. For purposes of calculating the franchise fee, the term "gross operating revenue" in Bend Code Section 3.112 shall mean all Company income recognized by the Oregon Public Utility Commission for rate setting purposes. The franchise fee provided herein is subject to Public Utility Commission approval.

Section 13: Rate and Service Regulation.

City shall not regulate Company's rates so long as Company's rates are regulated by the Oregon Public Utility Commission or comparable governmental entity.

Section 14: Company Records and Reports.

Company shall keep accurate books of account at an office within the State of Oregon throughout the term of this franchise. Company shall produce its books of account for inspection by City at any time during normal business hours, after reasonable notice by City, and City may audit Company's books from time to time. City may require periodic reports from Company relating to its operations and revenue within City. Prior to requesting periodic reports, City shall first review the annual report submitted by Company to the P.U.C.

Section 15: System Data.

Company shall maintain, at a local office, current maps and other operational data relating to its facilities and system operations in the City of Bend. City may inspect these maps and data at any time during normal business hours.

Section 16: Enforcement of Franchise.

City and Company shall have all remedies provided by law, including termination of this franchise, to enforce the terms and conditions of this franchise. Failure to enforce any provision of this ordinance shall not be construed as a waiver of a breach of any other term, condition or obligation of this ordinance.

Section 17: Franchise Term.

This franchise is granted for a term of 20 years beginning with the acceptance of this franchise by Company.

Section 18: Acceptance of Franchise.

Within 30 days from the effective date of this ordinance, Company shall file with the City Recorder a written, unconditional acceptance of this franchise and all of its terms and conditions. If Company fails to do so, this ordinance shall be void and of no effect whatsoever.

Section 19: Franchise a Contract.

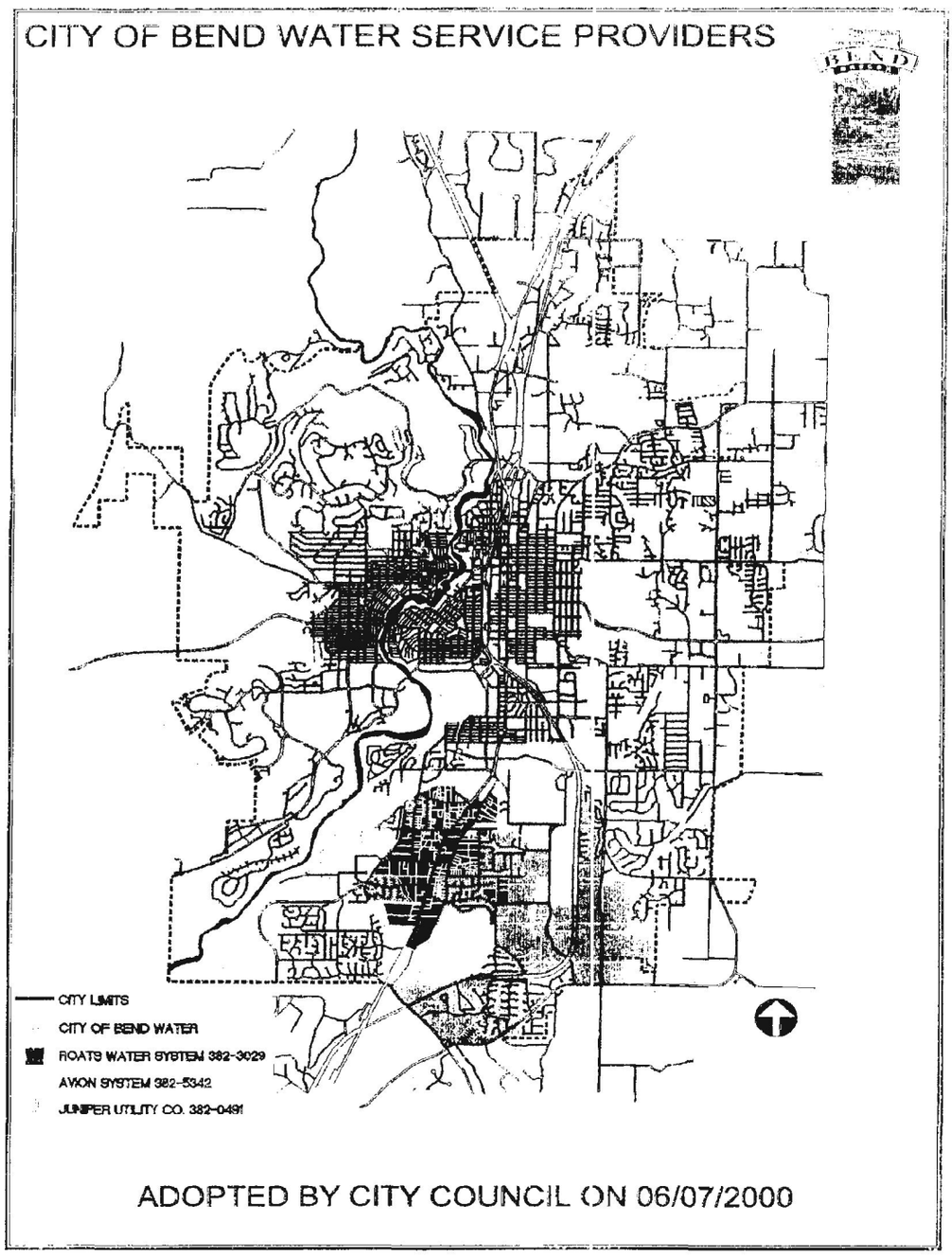
City and Company intend that this franchise shall constitute a contractual obligation between City and Company with respect to Company's service and facilities outside of City and within the Urban Growth Boundary. The parties contemplate that the City's corporate limits will expand through annexation within the Urban Growth Boundary throughout the term of this franchise through City's annexation of properties within the Urban Growth Boundary. The parties intend that the terms and conditions of this franchise shall apply to Company's activities outside the current City limits, but within the Urban Growth Boundary, as a contractual obligation so that as properties served by Company are annexed there will not be any significant difference in facilities or service standards.

Section 20: Constitutionality.

If any section, subsection, clause or portion of this ordinance is for any reason held invalid or is rendered unconstitutional by a court of competent jurisdiction, such portion shall be deemed a separate, distinct, and independent provision and such holding shall not affect the constitutionality of the remaining portion hereof. If for any reason the franchise fee is invalidated or amended by the act of any court or governmental agency, then the highest reasonable franchise fee allowed by law shall be the franchise fee allowed by this franchise.

11.21 BEND CODE

[Section 11.21.1 through 11.21.20 added by Ord. NS-1747, passed June 7, 2000]
[Section 12 amended by Ord. NS-1996, passed February 1, 2006]


CITY OF BEND WATER SERVICE PROVIDERS
CITY LIMITS
CITY OF BEND WATER
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AVION SYSTEM 382-5342
JUNIPER UTILITY CO. 382-0491
ADOPTED BY CITY COUNCIL ON 06/07/2000

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635 CAPITOL STREET, NE – SUITE 150
SALEM, OR 97301-2540

Country of Destination: /Pays de destination: