FINAL REPORT

Wastewater (Collection System) and Water System Master Plan

CITY OF REDMOND OREGON
SINCE 1910

prepared by
CH2MHILL

in cooperation with
GSI Water Solutions, Inc.
Crawford Engineering Associates

December 2007


Final Report

Wastewater (Collection System) and Water System Master Plan

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City of Redmond, Oregon

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Introduction

The City of Redmond owns and operates the wastewater and water utilities serving the city's residents. This master plan report presents plans for improving and expanding the water system and for the collection portion of the wastewater system. It recommends capital improvements to guide expansion of these systems to meet the needs when urban growth boundary (UGB) buildout occurs, which is expected in 2030. The plans also present conceptual approaches for addressing the needs to the limits of the Urban Reserve Area (URA).

The last master plan updates for these systems were completed in 2000. At that time, the city served a population of 13,700 and anticipated a buildout UGB population of 36,000 in 2020. As of July 2006, the city served a population of 23,500. The UGB buildout population was revised in 2007 to 58,000 in 2030. The city added approximately 2300 acres to the UGB in 2006 and created the URA totaling 5,600 acres.

Wastewater Plan

The City of Redmond's wastewater system includes both a collection system (that is, the pipelines and pump stations located throughout the city) and treatment facilities (the water pollution control facility—WPCF). This master plan addresses only the collection portion of the City's wastewater system. Planning for expanding and improving the WPCF was completed in another project and is summarized in the *WPCF Final Draft Facilities Plan Update* (November 2004).

Existing System

Redmond's 2006 wastewater service area encompassed approximately 5,800 acres and contained almost 800,000 feet of pipelines. The system included 13 sewer lift stations that collect gravity flows from subdivisions or developments and discharge through force mains into gravity sewer mains. The collection system conveys sanitary flows and, occasionally, stormwater to the WPCF with very little rainfall-induced infiltration and inflow.

Wastewater Flows

The average daily wastewater flow for the period 2000-2006 was 80 gallons per capita per day (gpcd). The 2006 winter time (non-irrigation season) flow was approximately 1.9 million gallons per day (mgd). The estimated future average daily flow is approximately 6.9 mgd in year 2030, and the year 2030 peak hour flow estimate is 9.4 mgd. These future system-wide flows were calculated by the collection system computer model using projected land use and population values. These flow values do not include stormwater flows that enter the system periodically when the operators divert flow to the sanitary system as allowed by the WPCF discharge permit.

Modeling Analysis

A hydraulic model of the sewer system was developed to analyze the collection system during dry weather conditions. The model included pipelines 10 inches or greater in diameter, except when smaller diameter pipelines were essential to complete connections within the system.

A major city investment, the collection system computer model provides for a reliable and comprehensive understanding of existing and projected requirements within the wastewater service area. With this investment, the city now has a tool that calculates the collection system infrastructure required to meet the planning criteria adopted by the city. The model can be used on an ongoing basis to evaluate hydraulic impacts to the system caused by proposed developments. It is anticipated that city planners, engineers, and operations staff will all find value in the use of the model to evaluate proposed improvements and problem areas.

The software package used for the model is commercially available and is commonly used in the industry. The geographic information system (GIS) interface used with the model is compatible with other mapping, CAD, and pipeline condition assessment software used by the city.

The system modeling results showed that the city has no significant existing deficiencies, an uncommon finding for planning efforts of this kind. Redmond benefits from its climate and the integrity of the existing system--two factors that reduce infiltration and inflow. In communities where wet weather causes substantial flow increases in the collection system, capital improvement plans often include major capital expenditures for addressing deficiencies and planning for growth. Additionally, conservative design criteria used for planning and design of the existing system has proven to be good insurance that is now paying dividends in the lack of required upgrades.

The future collection system model was sized using the historically observed wastewater flow generation value of 80 gpcd, and was also run at a more conservative 120 gpcd as a sensitivity analysis to evaluate performance. The future system was seen to operate without overflows even under the more conservative 120 gpcd, which provides the city with additional confidence that the proposed improvements will meet design criteria with a reasonable factor of safety.

The design criteria used for evaluation of the existing and new system are summarized as follows:

- **Calibration data.** Flow monitoring data collected by the city were used to calibrate the existing conditions model, which was then modified for future conditions.
- **Land use and associated hydraulic loading**. Wastewater flow generation (gallons per acre per day) was based on land use types.
- **Population in service area.** Portland State University population projections were used for the service area.
- **Hydraulic criteria (minimum pipe slopes; "full-flow" and velocity criteria).** Minimum pipe slopes per City of Redmond standards were used, with new minimum pipe slopes developed for larger-diameter pipelines that were not covered by the standards (27-, 30-, and 36-inch diameter sizes). All pipes were sized to convey the peak flow at 80 percent

full. In gravity sewers, the minimum slope and pipe diameter were selected to maintain 2 feet per second under full flow conditions. Force mains were sized for minimum velocity of 3 feet per second under peak design flows.

- **Pump station design criteria.** The city's pump station design criteria were modified during the course of this planning project. The new criteria adopted during this plan are the use of wet wells with a 60-minute storage volume under peak flow conditions. The 60-minute duration allows time for crews to respond to equipment failures.

Alternative Analysis

The topography of the Redmond wastewater service area is suitable for gravity sewer service using interceptors that cover the entire UGB and URA. It is expected that some existing local and regional pump stations will be required to continue discharge into some of these interceptors, but several pump stations can be removed from service after the interceptors are constructed. The approach for planning major conveyance facilities in this master plan was to rely on gravity interceptors in lieu of large pump stations with shallow force mains. This approach is the city's preference, has been used successfully to date, and was favorable in the present worth analyses.

In one area of the far west interceptor (near W Antler Avenue and NW Maple Avenue), a cost-benefit analysis was performed to compare a relatively deep gravity interceptor with a lift station and shallow force main. The intent of such an analysis was to determine if the lower capital cost and higher operating costs of the pump station (and shallow force main) offset the higher capital cost of a deep gravity interceptor. Using the methods described in the master plan, the gravity interceptor option at this deep excavation location pays off in a reasonable timeline and is the recommended approach.

For all other conveyance alternatives, the main alternative analysis was in the optimization of the vertical and horizontal alignment to provide the required service with the least excavation required. City engineering staff provided significant input and helped to provide the final alignment with their knowledge of the local topography and land use.

Recommended Improvements

To allow for growth and increased flows in the collection system, four interceptor projects were recommended as a result of the hydraulic modeling and planning assumptions made during this course of work. Layout of the interceptors was based on existing available mapping, and refinement of the alignments was performed through iterations with city engineering staff. These four recommended projects consist of the following:

- Westside interceptor (partially constructed as of 2007)
- Eastside interceptor (partially constructed as of 2007)
- Far west interceptor
- Far east interceptor

Capital Improvements Plan

A capital improvements plan (CIP) was prepared identifying these interceptor projects and several other smaller projects to meet the required wastewater collection system needs. These projects are broken down into discrete segments and costs prepared based on installed depth, blasting requirements, pipe size, surface restoration, and other factors described in the costing methodology section of this master plan.

The priority for implementation of these recommended improvements is noted for each segment in Appendix C. Nearly all recommended projects are growth-driven, so city planners and engineers will need to regularly evaluate sewer service requirements for proposed development. Use of the sewer model on an ongoing basis will be useful in evaluating alternatives and assessing the existing system. A number of projects are required to meet buildout condition flows. No immediate or 5-year deficiencies are identified in the model, although it is recognized that the model does not include many small local sewers that might have capacity issues. For these local sewers, it is recommended that collections staff monitor and identify potential capacity issues through the ongoing inspection program and community reports.

The eastern URA is outside the UGB, but planning was performed to develop concepts for how this area may be provided with sewer service. The far east interceptor will be the primary means of providing sewer service to the eastern URA.

The majority of the west side URA is included in the 2006 UGB expansion. A northwest portion of the URA will require pumping to the far west interceptor.

The costing approach for wastewater projects is intended to provide overall project costs (including engineering, construction, and city administration) and is based on a rigorous costing methodology developed and validated by the City of Portland Bureau of Environmental Services. The worksheet tool prepared for this master plan can be updated by city staff to reflect the impact of updated construction cost indices, current bid climate, and recently observed bid values. The costs developed in this report are based on an *Engineering News-Record* Seattle Construction Cost Index for January 2007 of 8626.

TV Inspection Program

Television inspection of the entire collection system is recommended to monitor condition and to guide operations and maintenance (O&M) activities and future planning evaluations. Development of a recurring TV inspection program, coupled with the city’s new Granite XP asset management software, will allow more effective deployment of O&M resources and is expected to improve service.

City Flow Monitoring Plan

A city-wide flow monitoring plan is recommended to identify the most beneficial locations for deployment of continuous flow monitoring devices. The city’s current practice of maintaining and collecting the flow monitor data has been generally acceptable for the modeling effort conducted for this master plan, but additional rigor could be added to the flow monitoring process. A rain gauge with recording capability is recommended to be located at City Hall and at the WPCF.

Water Plan

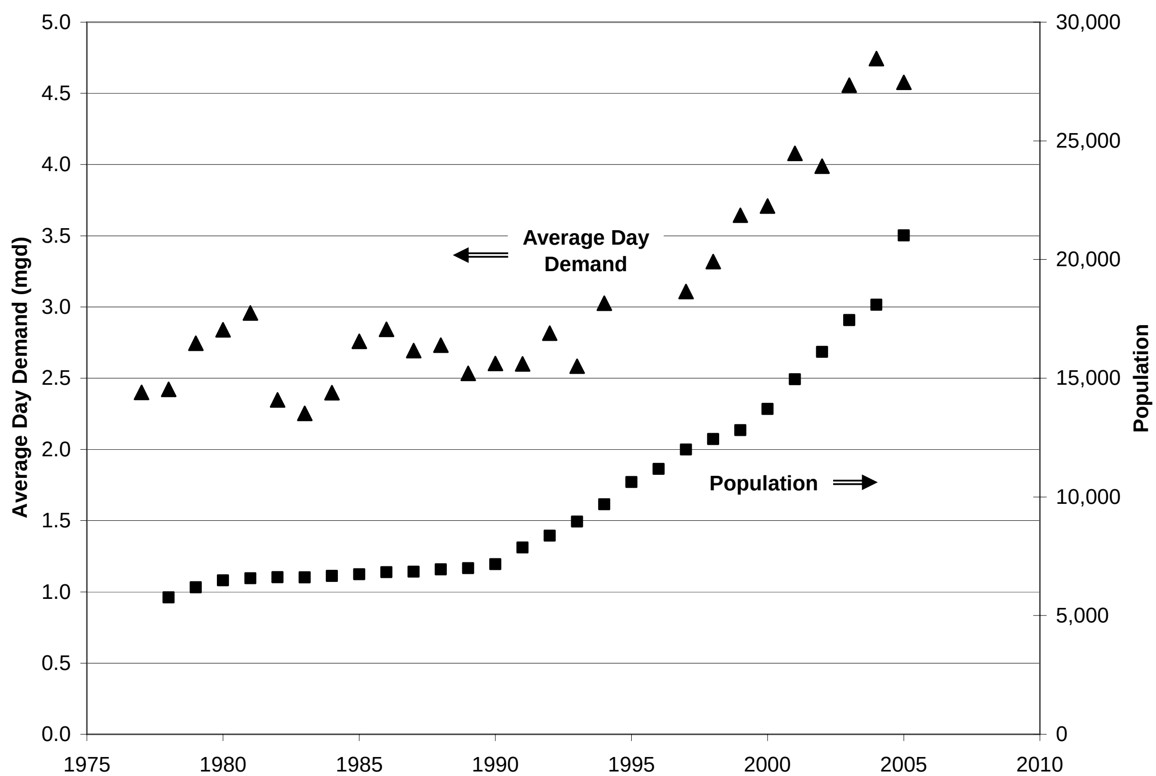
The city’s water system is classified as a public, community system, and is subject to regulation under the federal Safe Drinking Water Act Amendments and Oregon’s rules for public water systems. It has been assigned the state and federal Public Water System Identification No. 4100693.

Water Use

After remaining nearly unchanged from the late 1970s through 1993, water use in Redmond began to increase rapidly in the mid-1990s, corresponding to a period of rapid population growth. Exhibit ES-1 illustrates the significant growth in both population and water use since that time. As of 2007, the annual average demand was slightly less than 5 mgd. The highest single day (maximum day demand), which occurred during the summer irrigation season, was approximately 11 mgd for 2007.

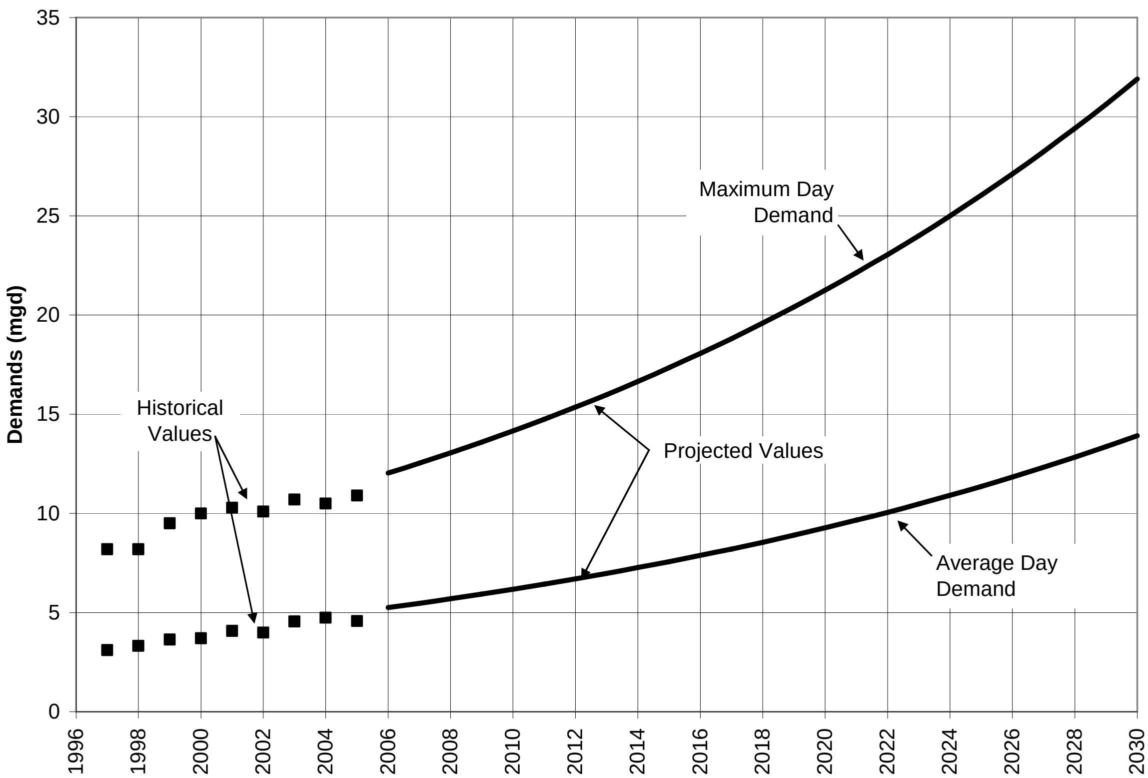
On a per capita basis, the average use was approximately 240 gpcd. During the peak summertime period, the per capita use was 550 gpcd. These per capita values represent the total system demand, whether for residential, commercial, industrial, or governmental use, divided by the service population.

EXHIBIT ES-1
Average Day Demand Records for 1977-2005
Redmond Wastewater (Collection System) and Water System Master Plan



The water demands in Redmond are expected to nearly triple from 2005 to 2030. The average day demand (ADD) is projected to increase from 5.0 mgd in 2005 to 14 mgd in 2030. The maximum day demand (MDD) is projected to increase from 11.6 mgd in 2005 to 32 mgd in 2030. Exhibit ES-2 illustrates the average and maximum day projections to 2030.

EXHIBIT ES-2
Redmond Demand Projections
Redmond Wastewater (Collection System) and Water System Master Plan



Regulatory Review

Community water systems are governed by rules developed by the U.S. Environmental Protection Agency (EPA) for implementation of the Safe Drinking Water Act Amendments. Oregon, as a primacy state, is required to implement water quality regulations at least as stringent as EPA's rules. For the most part, Oregon has adopted identical regulations to those at the federal level. Additional Oregon rules are highlighted in the regulatory section of this report.

Redmond's water system complies with all state and federal rules. The federal government recently adopted the Groundwater Rule. The requirements of this rule become fully effective by 2014. It is possible, but unlikely, that this rule would force the city to add treatment for the wells.

Water Supply Status and Protection

Before 1988, the City of Redmond obtained drinking water from a combination of surface water and groundwater sources. In 1988, the city converted its system to obtain 100 percent of its drinking water supply from groundwater wells completed hundreds of feet deep.

The city's groundwater supply is composed of six production wells, with a seventh to begin operation in 2008. The wells range in depth from 330 to 860 feet below ground surface in a highly permeable volcanic and sedimentary sequence known as the Deschutes Formation.

The surface facilities at each well location consist of a pump house that encloses the automated controls, mechanical systems, and chlorination systems. The chlorination systems are housed in separate rooms containing 150-pound gas cylinders. In normal operations, wells are cycled on and off to meet system demands.

The existing wells provide an excellent long-term public water supply. The aquifer that provides groundwater to the city's wells is large in areal extent and is highly permeable. Annual recharge to the aquifer is high and measurements of long-term water level trends show no apparent declines in groundwater levels that would suggest water is being over-appropriated. Additionally, the quality of water is excellent. However, the following management actions are recommended to help protect both the quantity and quality of this valuable water supply:

- Develop and implement a drinking water protection plan to reduce the potential for contamination of the groundwater supply.
- Implement a water level monitoring program at non-pumping wells in the Redmond vicinity to track long-term groundwater level trends.

Expansion of the City's Water Supply

The city plans to add wells as needed to meet projected growing demands. This is illustrated in Exhibit ES-3, which displays both firm and total well production capacity compared to the projected MDD. Firm capacity represents the total capacity minus the production from the largest well. It is recommended that the city use firm capacity as the basis for planning new additions, as shown on this chart, because it is reasonable to expect that one well may be off-line for extended periods for mechanical repairs or other reasons.

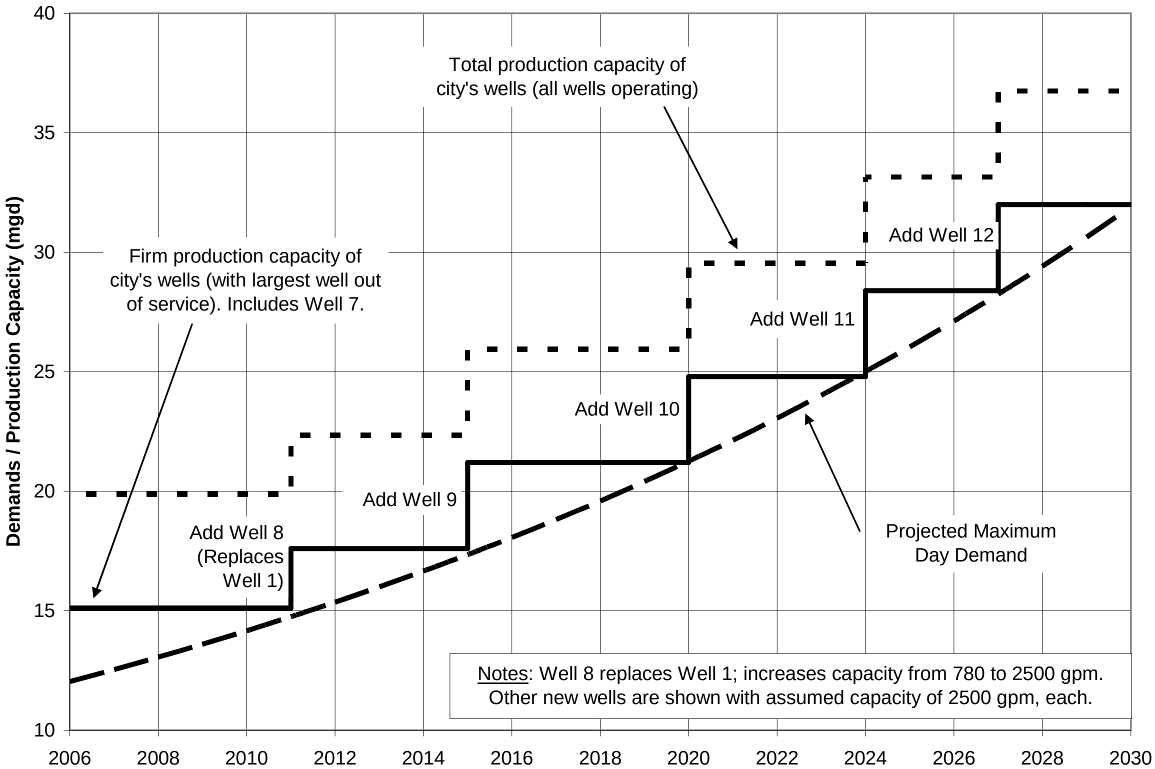
Water Rights

Under currently held municipal use groundwater permits and certificates, the city is authorized to appropriate 12.8 mgd. A comparison of the capacity of Wells 1–7 (a total of 19.4 mgd and a firm capacity of 15.1 mgd) to the amount of water authorized under existing municipal use groundwater rights (12.8 mgd) indicates that the city is limited by water rights and not well production capacity. The city has taken steps to address this by submitting new municipal use groundwater permit applications.

The city's existing municipal use groundwater permits and certificates vary in priority date from September 5, 1969, to November 25, 1991. None of these existing rights are subject to the Oregon Water Resources Department's (OWRD's) mitigation requirements in the Deschutes Basin. The most junior (that is, the newest) of these permits (permit G-12401, priority date November 25, 1991) does contain a condition that may allow OWRD to regulate the use in favor of the Deschutes River State Scenic Waterway flows. However, this condition (which is in several permits in the basin) has not been implemented by OWRD to date.

The greatest protection afforded by Oregon water law lies in obtaining water right certificates, which lock in the city's place in the water appropriation line and its privileges as a municipal water provider. Therefore, all water right processes should be diligently tracked and completed by the city to ensure the protection of its existing water rights.

EXHIBIT ES-3
Well Capacity Chart
Redmond Wastewater (Collection System) and Water System Master Plan



The city's 2007 MDD is nearing its current groundwater water rights capacity of 12.8 mgd. In anticipation of the need for additional water rights capacity, in January 1999 the city submitted a new water rights application for the use of 25 cubic feet per second (cfs) (16.2 mgd). Given the stable and sustainable aquifer in the Redmond area, developing additional wells to maximize the use proposed under G-14908 should be feasible. Application G-14908 is currently under review by OWRD, with permit issuance to likely occur in 2008. When approved, Application G-14908, in combination with the city's existing permits and certificates, will provide the city with 29 mgd of water rights capacity, sufficient to meet projected MDD beyond the year 2030.

Application G-14908 is subject to OWRD's Deschutes Basin Groundwater Mitigation rules, which means that prior to permit issuance the city will need to provide mitigation to offset potential groundwater pumping impacts on the Lower Deschutes River. The city's proposed mitigation will come from a combination of city-held surface water irrigation rights and surface water irrigation rights acquired through the Central Oregon Water Bank, a partnership between Swalley Irrigation District, Central Oregon Irrigation District, the Deschutes River Conservancy, and several mitigation buyers including the City of Redmond. The water system CIP, included in the appendices to this report, includes an estimated cost for mitigation.

Storage

The current storage facilities are adequate to provide peaking, fire, and emergency storage to customers, with a slight surplus. Based on the design criteria that the city has adopted, the projected storage deficit at 2030 will be 11.8 million gallons (MG). At least three future reservoirs are currently being planned within the system between now and 2030 to meet this deficit.

Distribution System Analysis

The city's water distribution system was evaluated under existing and future conditions using a hydraulic modeling software package. A hydraulic model is an electronic representation of the pipes and facilities included in a distribution system. The model is used to predict flows and friction losses in pipes, along with pressures and hydraulic grades at different points in the system.

Pipelines

As has been shown by the existing and future hydraulic analyses, the city has few overall deficiencies in terms of low pressures or high velocities. A number of localized fire flow deficiencies were noted and will be addressed; however, these deficiencies are primarily caused by older undersized pipelines that were installed when fire flow requirements were lower.

One of the city's goals is to ensure that adequate redundancy and transmission capacity exists in the system so that if a single large pipeline or well is out of service, water can still be supplied to all customers without any significant difference in pressure or quality. To meet this goal, a number of pipeline enhancements were identified to establish a minimum 12-inch-diameter pipeline grid that connects all sources of supply and runs from east to west and north to south. This pipeline grid, along with a dispersed network of wells, will create a significant level of redundancy and flexibility for future growth, regardless of where it occurs.

Water System Capital Improvements Plan

The master plan report presents a detailed projects list update for Redmond's water system. The total cost for all projects identified for the 2007-2015 period is $21.5 million. The highest cost projects consist of the following:

- Several sections of 12-inch transmission mains
- Replacement of old and undersized pipe in the downtown area
- Completion of the Well 7 pump station
- Addition of Wells 8 and 9 as demands grow
- Addition of a storage tank located by Well 7
- Purchase of mitigation credits to allow use of the city's new water rights permit.

SECTION 1

Introduction

1.1 Purpose

This report documents the master plans that the City of Redmond developed for its wastewater collection system and water system. The city evaluated these systems to address any current deficiencies and to plan improvements needed to protect public health and the environment, address regulatory requirements, and prepare for future growth expected in the area. The planning horizon for this report is the buildout of the urban growth boundary (UGB), which is expected to occur by approximately 2030.

The last master plan updates for these systems were completed in 2000. At that time, the city served a population of 13,700. As of July 2006, the city's population had reached 23,500.

The City of Redmond's wastewater system includes both a collection system (that is, the pipelines and pump stations located throughout the city), and treatment facilities (the water pollution control facility—WPCF). This master plan addresses only the collection portion of the City's wastewater system. Planning for expanding and improving the WPCF was completed in another project and is summarized in the *WPCF Final Draft Facilities Plan Update* (November 2004).

1.2 Study Area

The study area includes existing wastewater and water systems within the city limits (current service area), future expansion of the systems to the UGB along the west and north sides of the city, and future expansion of the system into the urban reserve area (URA) northeast of the city. These areas are shown in Exhibits 1-1a and 1-1b (located at the end of the section, as are all map exhibits).

1.3 Acknowledgements

The following were key individuals in this master planning effort:

City of Redmond

Mike Caccavano, P.E., City Engineer (Project Manager for Master Plans)
Chris Doty, P.E., Public Works Director
Shannon Taylor, Wastewater Divisions Operations Manager
Pat Dorning, Water Division Supervisor

CH2M HILL Team

Paul Berg, P.E., Project Manager and Water Plan Lead
Brady Fuller, P.E., Wastewater Plan Lead

David Crawford, P.E., Crawford Engineering Associates, Wastewater Modeling Lead
Mark Anderson, P.E., Wastewater Plan Engineer
David Stangel, P.E., Water Modeling Lead
David Livesay, R.G., GSI Water Solutions, Inc., Hydrogeologist

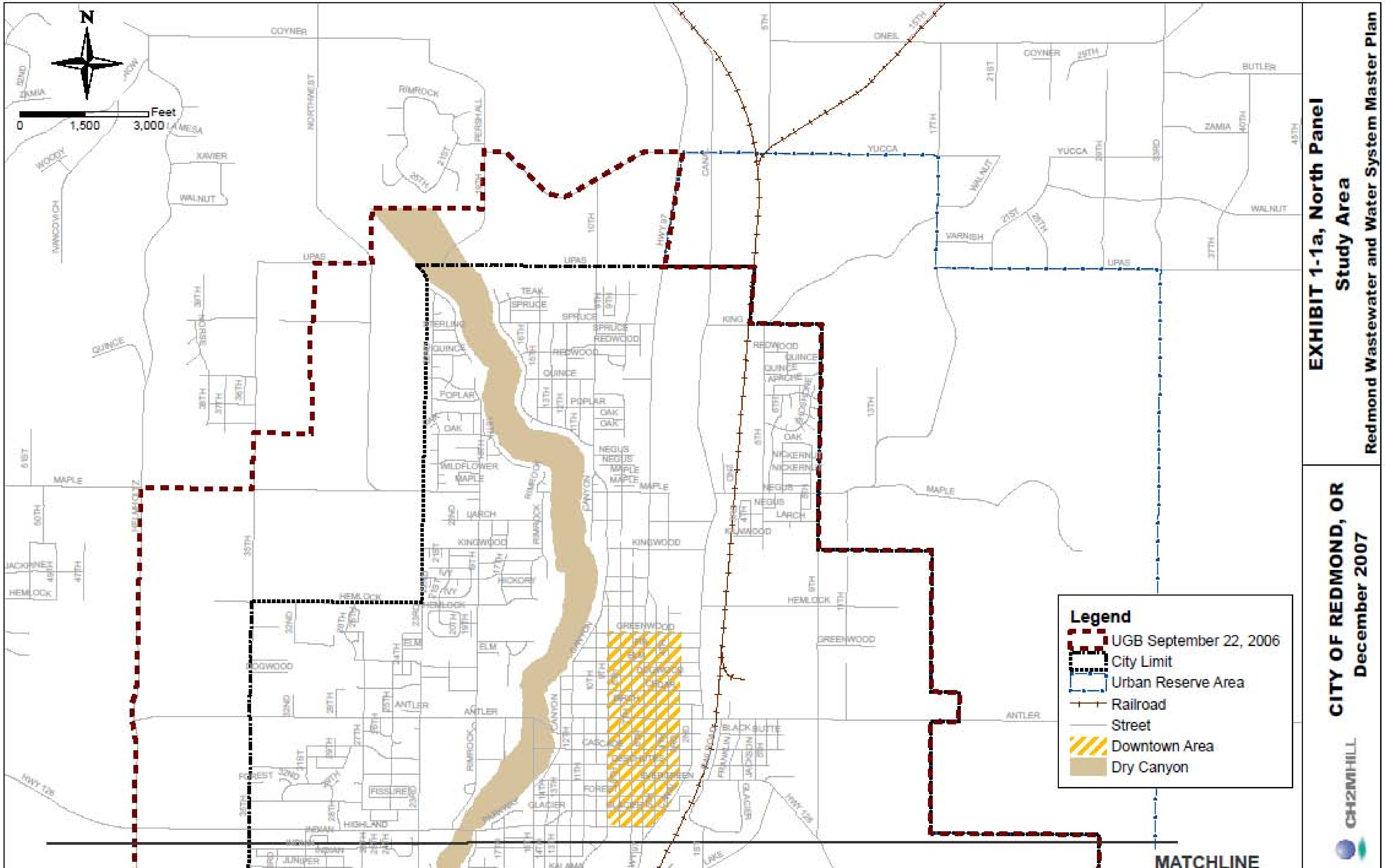


EXHIBIT 1-1a, North Panel
Study Area
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City Limit
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Railroad
Street
Downtown Area
Dry Canyon
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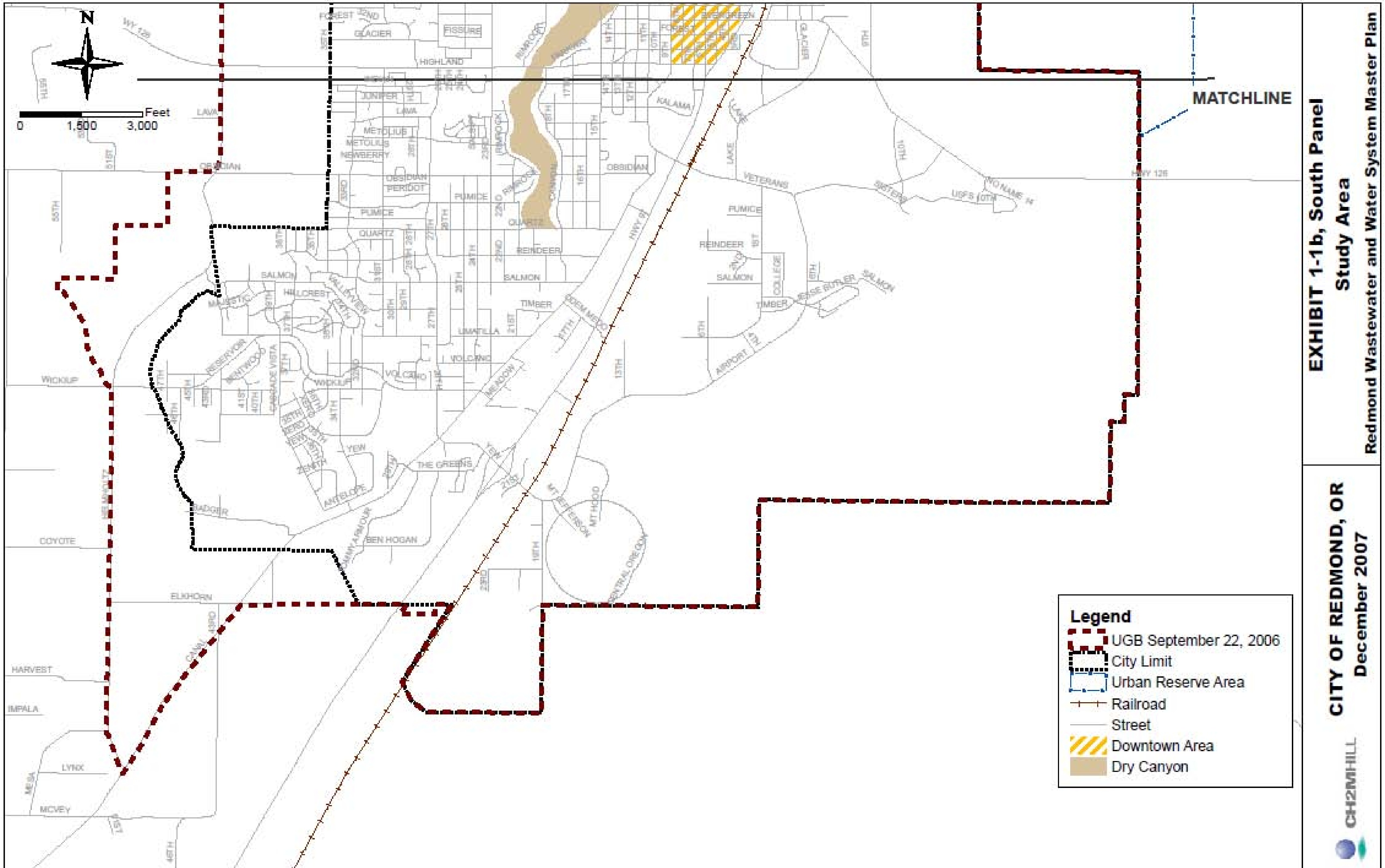
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SECTION 2

Population Growth Planning

2.1 Service Population

The city's water and wastewater systems serve nearly every building and resident within the city limits and very few facilities located outside of the city limits. The number of potential customers located within the city limits and not served by these utilities is estimated to be less than one hundred. Similarly, the number of customers located outside of the city limits is estimated to be less than one hundred. Therefore, it is reasonable to set the water and wastewater service populations equal to the city population.

The city population was obtained from the Portland State University Population Research Center web page. The value for July 1, 2006, was 23,500. The city's population growth rate averaged 7.3 percent for 1995–2005, 9.9 percent for 2004 and 2005, and nearly 12 percent for 2006.

The population estimates used in the wastewater and water system evaluations vary because the methodologies employed reflect the differences between the delivery systems. Wastewater systems are designed based on generation, whereas water system sizing is driven by demand. The methodologies used maintain the conservative nature of the analysis to ensure the consequent improvement plans were developed to provide sufficient capacity to meet community growth requirements.

2.2 Land Use Trends and Projections

The City of Redmond commercial district extends along U.S. Highway 97. The areas west of this are primarily residential. The areas east include most of the city's industrial zoning. The Redmond Municipal Airport is located to the southeast. The northern portion of the city is divided by Dry Canyon, the length of which lies in a north-south direction. The downtown area is located in the middle of the urban area between Dry Canyon and the railroad.

Existing zoning patterns for the study area are shown in Exhibit 2-1, which is based on the city's current comprehensive plan. Zoning is expected to stay the same into the future. The zoning category for the area colored brown on the map at the north end of the city in Exhibit 2-1 is yet to be decided. Current development of parcels within the city limits was determined by referring to the city tax lot database. Tax lots with improvements valued more than $500 were considered to be occupied and in use. Those lots valued at $500 or less were considered vacant. (The tax lot improvement values are mapped in Figure 6 of Appendix A.) When planning for future conditions for the wastewater system, it was assumed the vacant lots will be developed (excepting open spaces and parks).

2.3 Water Use Projection Methodology and Criteria

The per capita approach was used for projecting demands within Redmond's water system. Recent per capita average day demand (ADD) and maximum day demand (MDD) values (ADD: 240 gallons per capita per day [gpcd]; MDD: 550 gpcd) were applied to population projections for Redmond to estimate future demands. The rate of population growth was obtained from a recent city planning study.

The June 2004 EcoNW study for Redmond ("Findings in Support of Population Forecast") estimated annual city population growth rates of 3.97 percent for 2005 through 2025 and then 2.20 percent for 2026 through 2055. However, the city revised the buildout UGB population and time period to buildout following the expansion of the UGB that was formalized in 2007. Based on the density of the newly expanded UGB, the city now estimates a UGB buildout population of 58,000 and that this will be reached in 2030. A population of 58,000 in year 2030 was used as the basis for this master plan.

An additional assumption for the water demand projections was that the ratio of residential to commercial/industrial water use will remain constant throughout the planning period. Said differently, it was assumed that the recent per capita values will remain constant through the planning period. These per capita values compare all water used in the system, whether for residential, commercial, or industrial use, to the population. If the mix of residential to commercial/industrial water use changes, this will result in inaccurate water demand projections.

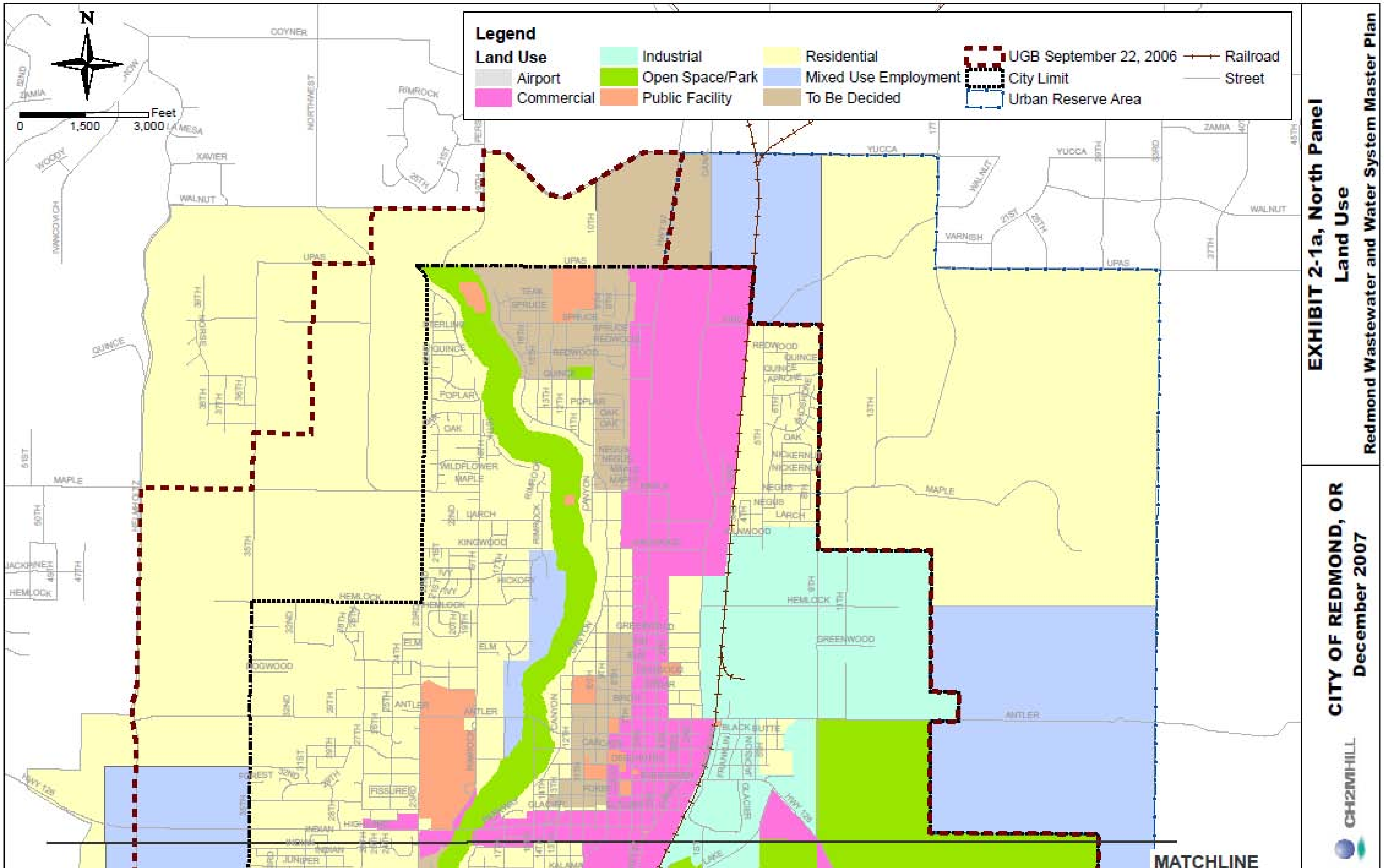
The estimated population growth rate is one of the most critical factors for projecting future water demands. The city should regularly check the actual rate of growth compared to the projected rate of growth. The city should also track per capita demands to determine if the above assumptions remain valid. If the ratio of commercial/industrial-water-use to residential-water-use changes, this will result in changes in per capita use. It could either increase or decrease per capita use, and such customer changes could also impact average per capita use differently than maximum day per capita use. The other major factor is the role of conservation. The city will develop a Water Management and Conservation Plan in the coming years. The city may achieve both supply-side and demand-side savings, resulting in declines in per capita use.

The criteria used for developing water use projections for Redmond are summarized in Exhibit 2-2.

EXHIBIT 2-2
Water Demand Projection Criteria
Redmond Wastewater (Collection System) and Water System Master Plan

Item	Value	Units	Source/Reasoning
Base year	2005		Last complete year of records for the city at time the study was being prepared
Base year (2005) ADD	5.0424	mgd	Based on average day demand trendline for 1997-2005
Base year (2005) MDD	11.5555	mgd	Based on maximum day demand trendline for 1997-2005
Per capita ADD	240	gpcd	Rounded value based on 2003-2005
Per capita MDD	550	gpcd	Rounded value based on 2003-2005
Unaccounted-for water rate	12	%	Average for June 3-May 6. City may be able to reduce this value in future. However, reasons for unaccounted-for water are uncertain and, therefore, the magnitude of potential reduction is unknown
Base year (2005) population	21,010		From PSU Population Research Center and city records
Buildout UGB population	58,000		Estimated by city based on UGB expansion that was completed in 2007. City set period for this master plan as buildout of UGB.
Date that buildout population is reached	2030		Estimated by city

mgd = million gallons per day; gpcd = gallons per capita per day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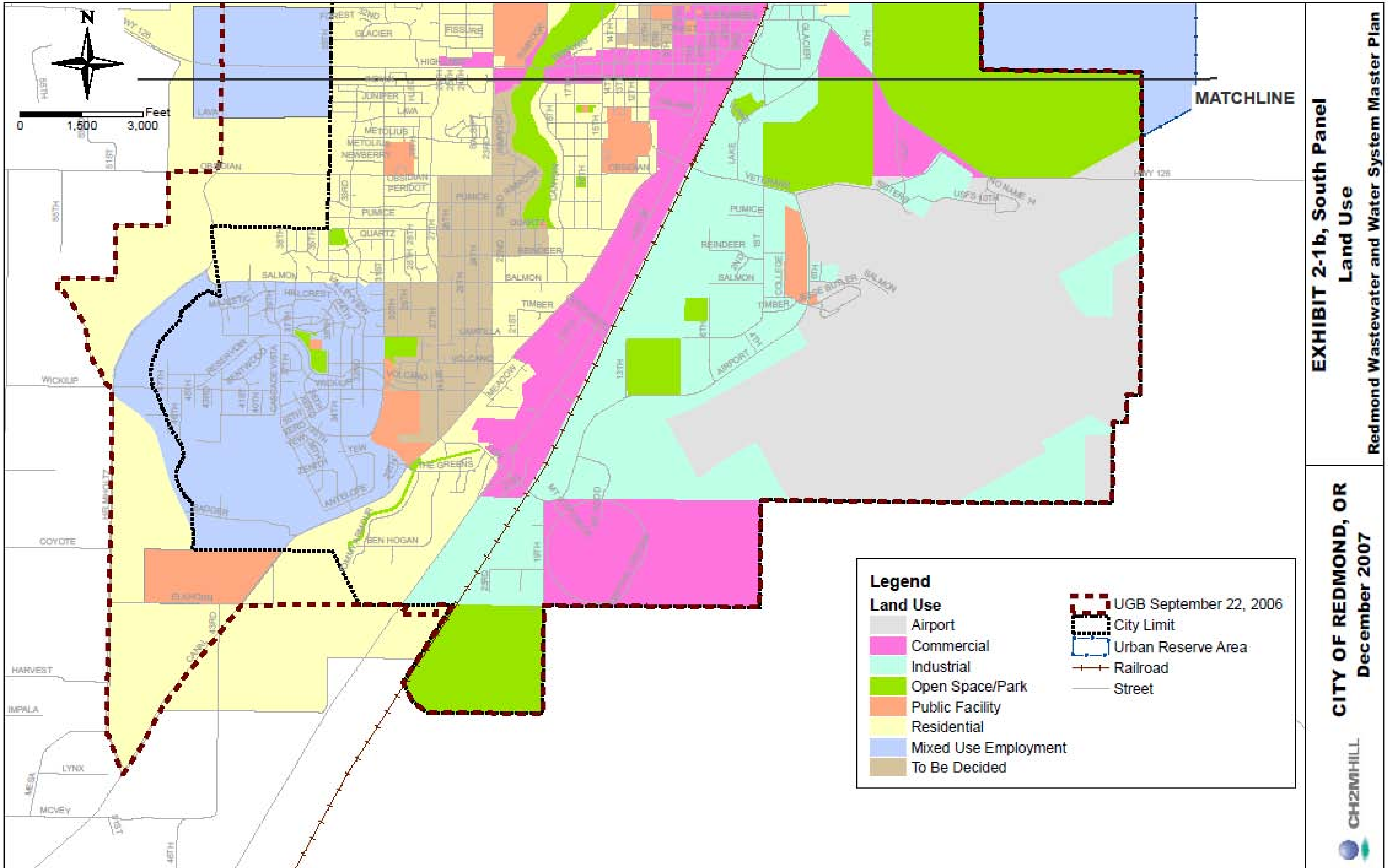
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SECTION 3

Wastewater System Plan

3.1 Existing Collection System Description

The City of Redmond operates a separated sanitary sewer system that conveys wastewater from the different sectors of the city to the Redmond Water Pollution Control Facility (WPCF) at the north end of the service area. The separated system designation means that sanitary and stormwater flows are not purposely combined in the same sewer pipe.

As shown in Exhibit 3-1, the existing City of Redmond wastewater service area is bounded by the Urban Growth Boundary (UGB) on all sides, with the City Limits boundary aligning with the UGB generally on the south and east. The 2006 service area encompasses approximately 5,800 acres. Approximately 7,800 customer accounts are served within this service area (based on water meters in service).

As of 2006, the city operated 13 pump stations that collect sewage from subdivisions or developments and discharge through force mains into gravity sewer mains. Information about the pump stations is provided in Exhibit 3-2. The existing sewer system pipelines are inventoried in Exhibit 3-3.

The city does not have an extensive stormwater collection system. Instead, underground injection controls (dry wells), and valved interconnections between the storm and sanitary system are used throughout the city. Therefore, during significant storm events, which are infrequent, the operators relieve street flooding by opening valves to divert stormwater to gravity sanitary sewer pipelines as is specifically allowed in the city's discharge permit for the Redmond WPCF. The operators remove additional stormwater in some areas by using the city's vacuum trucks to collect the stormwater and transport it to the WPCF or gravity sewer pipelines. The combined storm/sanitary flows that reach the sewer pipelines are conveyed to the Redmond WPCF for treatment.

3.2 System Analysis

An XP-SWMM (Version 10.5) model of the Redmond wastewater collection system was developed to evaluate potential capacity deficiencies for existing and future conditions. Model development and modeling results are described below. Additional information about the methodology is described in the City of Redmond Sanitary Sewer Model Overview and Review Technical Memorandum (Crawford Engineering Associates, June 13, 2007) provided in Appendix A.

3.2.1 Model Development

Development of the sewer model entailed defining and mapping the collection system, estimating existing and future sewage flows, and calibrating the model to best represent the collection system for hydraulic analysis.

Definition of the collection system was based primarily on existing City of Redmond geographic information system (GIS) data about manholes, pipelines, pump stations, and tax lots. The model was constructed to include pipelines 10 inches or greater in diameter, except when smaller diameter pipelines were essential to the connectivity of the system. Also, some 10-inch or greater pipelines were not included as individual elements of the model because their flows were aggregated to a single subbasin flow input, as in a small subdivision.

Collection system data were reviewed, and some apparent data conflicts were resolved by city staff by researching as-built and other information. Some collection system infrastructure data remained missing because of incomplete as-built records but this did not prevent adequate modeling of the system.

The "existing condition" model was adapted to include interceptors, pump stations, other collection system infrastructure improvements already underway in fall 2006. The following information was included so that the 'existing condition' model generally represented the condition of the collection system as of January 2007:

- Collection system data were current as of August 2006. This data set included as-built drawings for recently completed projects plus GIS data available as of August 2006.
- Model included collection system infrastructure if plans had been approved for construction
- Westside interceptor was included (from SW Timber Avenue to the north through town to the connection with main plant interceptor)
- Summit Crest "Line D" from Obsidian Road to Summit Crest was included
- "Line D" was included, from SW Wickiup Avenue and Helmhotz Way north to the connection with the Westside Interceptor.
- Four pump stations were included (Sterling, Antler, Yew, and Nolan)

To develop existing sewage flow estimates, the service area (within the city limits) was subdivided into 103 subbasins ranging in size from 5 to 650 acres with an average subbasin size of approximately 66 acres. To develop future sewage flow estimates, the service area was extended to include areas outside the city limits and subdivided into 119 subbasins (103 subbasins within the existing service area and 16 new subbasins to extend service to the URA boundary) ranging in size from 5 to 728 acres with an average basin size of about 86 acres. The subbasins were defined taking into account land use types (such as open spaces), vacant land, and population density.

Subbasin characteristics were developed from the following types of data:

- Land use. Obtained from the city of Redmond tax lot database in August 2005 and through discussions with city staff. This data is understood to be current as of July 2005.
- Water use. Obtained from city water meter billing data. Winter (December 2005 through February 2006) data were used to limit irrigation use from the accounting. Large water users were identified as potential sewer flow point sources.

- Population data. Obtained from 2000 U.S. Census Bureau data tables and maps of census blocks plus Portland State University population projections. For purposes of this study the planning horizon is 2030 for a population of 58,000 within the UGB and a baseline population 23,500 in 2006.

3.2.1.1 Rainfall Derived Infiltration and Inflow

Redmond WPCF influent flow data from January 2000 to September 2006 were reviewed for indications of rainfall-derived infiltration and inflow (RDII). Annual precipitation in the area is about 8.8 inches. The nearest source of available rainfall data is the Roberts Field-Redmond Municipal Airport (RDM), which is located 2 miles southeast of downtown Redmond. The Redmond WPCF (located about 2.2 miles northeast of downtown Redmond) influent flow data records showed no discernible rainfall response except for an exceptional event in June 2006. (Refer to *City of Redmond Sanitary Sewer Model Overview and Review* provided in Appendix A for more information about the exceptional event.) On the basis of this review and consultation with City staff, it was determined that RDII was not a significant issue and that use of a design storm in the sewer modeling was unnecessary.

3.2.1.2 Existing Flows

Existing subbasin average day flows were estimated based on land use category and water use rates. To do this, water meter records were used to determine average water use by land use category (per capita per day for residential categories and per acre per day for all other categories). Winter water meter records were used to eliminate irrigation water use, which would not be returned in the sanitary sewer system. This method used water meter records from December 2005 to February 2006, which were aligned with tax lot addresses. Based on water use by land use category, the average system-wide flow was determined to be approximately 1.98 mgd. This is consistent with the recorded average winter Redmond WPCF influent flow of about 1.9 mgd.

3.2.1.3 Future Flows

Future subbasin sewer flows were estimated using City of Redmond Planning Department maps that show the projected number of units (dwelling units) per acre for land use types within undeveloped areas of the urban growth boundary. Each unit is assumed to represent 2.6 persons (based on 2000 U.S. Census Bureau data for number of people and number of households for Redmond). The future average per capita flow was assumed to be 80 gallons per day. This was calculated by dividing the existing Redmond WPCF average winter influent flow of approximately 2 mgd by a population of 25,000 (based on current City of Redmond estimated population for 2006 and confirmed as a reasonable estimate in consultation with city staff). Following this approach, the estimated future system-wide average daily flow is 6.9 mgd in 2030. The corresponding peak hour flow estimate for 2030 is 9.4 mgd.

These estimates for future flows do not include stormwater flows that enter the system periodically when operators divert stormwater to the sanitary system as permitted by Oregon DEQ. Consequently, they are lower than the estimates provided in the city’s November 2004 *WPCF Final Draft Facilities Plan Update.* The estimates in this previous plan included stormwater diverted to the sanitary sewer. It was considered more appropriate to plan system improvements without these interconnections since the city plans to abandon them.

The total flow at the plant for the UGB plus URA areas is estimated as follows: (note that the projected population for future flows, including the URA of 2,260 acres, is 78,000.)

- average daily = 9.5 mgd
- peak hour = 12.6 mgd
- minimum hour = 4.0 mgd

The 80 gallons per day per capita (gpcd) is a reasonable per capita wastewater generation value when compared to other cities and literature values if seasonal groundwater and rainfall derived inflow and infiltration is omitted. However, the proposed improvements were modeled with flows representing 120 gpcd as a check. It was found that the 120 gpcd flows can be conveyed throughout the system except for a minor capacity constraint in the local system just to the southeast of Antler Lift Station. No significant capacity problems were indicated with using the 120 gpcd rate. It was concluded that the higher rate of 120 gpcd may be prudent to use for local system designs but not for system-wide evaluations or major trunk sewers.

The peak flow recorded in 2006 was 9.6 mgd during a storm event on June 13, 2006. This event started at about 1:45 p.m. with flows climbing to the peak at about 3:50 p.m. and returning to normal (about 2 mgd) at 11:30 p.m. (The elevated flows are associated with direct connections between the stormwater system and the sanitary system. These direct connections come from catch basins that are valved into the sanitary sewer and opened by city operators when required to alleviate surface flooding associated with intense precipitation events. It is understood that these connections will be limited or removed in the future.) Recently (August 30, 2007), a peak flow of over 8 mgd was recorded at the WPCF as a result of an intense thunderstorm. The storm cross-connections were left open during the summer and because of staff attention being diverted to the power outages at lift stations, the cross connection valves were not closed.

Future land use conditions for areas within the current sewer service boundaries were estimated by assuming the same population densities and sewer flow rates as for developed lots within a sewer basin. Lots assumed to be undeveloped were identified from property tax rolls with undeveloped lots having a property improvement value of less than $500. The current tax lot improvement values were obtained from the city tax lot database.

The designation of flows per equivalent dwelling unit can be calculated as follows. From census data each dwelling unit has 2.6 persons. At 80 gpcd, this is 2.6 x 80 = 208 gallons per day per EDU. Depending on zoning the gallons per acre may be determined. The residential zoning allows for 5.6 residences per acre so the flow generation would be 208 x 5.6 = 1,165 gallons per day per acre. Commercial flow generation ranges from 850 gallons per acre per day (gpad) to 1650 gpad, based on water meter data. The city’s land use descriptions do not identify “industrial” uses but the “mixed use” zone flow generation is 350 gpad.

3.2.1.4 Model Calibration

City staff performed flow monitoring at selected sites to obtain data to characterize flows from subbasins with different land use types. Also, the temporary monitoring was performed to compare results for older neighborhoods with newer, growing neighborhoods.

Monitoring equipment included city-owned and city-maintained ISCO Model 2150 units. These are considered as state of the art units that are capable of providing reliable data.

As monitoring data became available during the winter of 2006-2007, it was possible to compare flows from basin types and flows predicted by the estimation method for sewer basins and used in the hydraulic model. The monitored data and modeled flows simulated matches within reasonable expectations at most sites.

However, smaller basin comparisons showed a possible need to use multiple diurnal curves in the model or unique patterns for specific industrial users. To address this, sewer downstream of the two largest users (PCC Schlosser and Eberhard Creamery) were monitored to determine local conditions. These diurnal patterns were subsequently incorporated into the model. At other locations, the differences between the model and monitoring flows were not found to be significant enough to warrant adding this complexity to the model at this time. However, for modeling site specific developments, it is recommended that the nature of the development be forecasted and estimates of the diurnal pattern be determined, particularly the maximum flow expected during the day.

3.2.2 Modeling Results

Peak flows were used to evaluate the collection system. The model modulated the average flow of each basin by the system's diurnal pattern.

The capacity criteria used to identify potential system deficiencies were as follows:

- Manhole freeboard. Freeboard is the difference between the modeled maximum water surface elevation at the manhole and the manhole rim elevation. If freeboard is ≤ 8 feet, this indicates potential sewer surcharging. If it is < 2 feet, this indicates a high risk of flooding.
- Qratio > 1.2. The Qratio criterion is a comparison of modeled peak flows with sewer full pipe flow capacity. The design flow of a pipe segment is defined by the full pipe flow as calculated using Manning's equation. Maximum flow for circular pipes occurs at 94 percent full and is a little less than 1.1 times full pipe flow. Therefore, if a Qratio is greater than 1.2, it indicates that the pipe is at risk and in most cases is surcharged. Different Qratio-value ranges were used as indications about ranges of pipe capacity from *no additional capacity* to *excess capacity*. *Excess capacity* is available capacity. Ratios of approximately 1.2 indicate no additional capacity is available. Ratios in the range of 0.8 to 1.2 indicate an evaluation should be performed to see if additional capacity is needed given land use and development in the basin. Ratios less than 0.5 indicate significant *excess capacity*.

For existing conditions, the modeling showed that the collection system does not have any significant capacity deficiencies once projects identified in the 2002 master plan are fully implemented. For details refer to the *City of Redmond Sanitary Sewer Model Overview and Review* provided in Appendix A.

For future conditions, it was assumed that improvements recommended by the previous master plan were implemented. As with existing conditions, the modeling demonstrated that the collection system will provide sufficient capacity through year 2030 during peak flow conditions (with assumption of 80 gpcd unit flow rates for new areas). Using the higher unit flow of 120 gpcd, the unit flow rates in the area around Antler Pump Station exceed the hydraulic design criteria for gravity sewers and may need further evaluation in the future depending on the quantity of intercepted flows by the Eastside Interceptor and how flows are routed from undeveloped areas in the far eastern portions of the system.

3.3 Design Criteria

System design criteria and standards were used in development of this master plan to provide consistent, minimum level of service in the planned sewer system and to facilitate planning, design, and construction of improvement projects. The Oregon Department of Environmental Quality (DEQ) has minimum requirements and guidelines for the design and review of sewer pipelines and raw sewage lift stations as described in Division 52 of the Oregon Administrative Rules (OAR). City design parameters were obtained from the City's Public Works Department Standards and Specifications, April 2003. Where state or city guidelines did not exist, national standards, such as those published by the Hydraulic Institute and other organizations, were followed.

3.3.1 Gravity Sewers

At a minimum, DEQ requires sewer pipelines to pass design peak flow, including infiltration, and recommends pipes be sized for ultimate development of tributary areas. DEQ guidelines state sewer design should be based upon initial and ultimate flows. In planning exercises, flows should be broken down into domestic, industrial, and infiltration/inflow fractions with a peaking factor applied to domestic and industrial fractions. The city’s 1994 master plan used high per capita and peaking factors resulting in some pipes with “extra” capacity that has become evident with actual system operation. For the analyses performed as part of this master plan, the collection sewers were sized to flow 80 percent full for design peak flow using a peaking factor of 1.4. The 1.4 peaking factor was calculated as the hourly moving average of the monitoring data Peaking factor is defined in this case as the ratio of peak hour diurnal flow to average day diurnal flow. The 80 percent full criterion represents a recommendation for “full flow” design criteria. The city may elect to size pipes with full flow capacity greater than or less than 80 percent full to allow for sediment and debris allowances, velocity requirements, sewer air movement in the pipe headspace, or other reasons. The 80 percent design criterion is common in the industry and provides a margin of safety in the constructed system.

Best practices for sewer design require sizing pipes with a minimum diameter of 8 inches and a minimum cover of 30 inches. The city requires a minimum scouring and cleansing velocity of 2 feet per second (fps). Exhibit 3-4 shows the minimum gradient for gravity sewers ranging from 0.6 percent slope (slope of 0.6 feet vertical per 100 feet horizontal) for 6-inch pipe to 0.08 percent slope for 24-inch diameter pipe. These slopes are consistent with industry practice for sewer design. All velocities exceed 2 fps when flowing full at these minimum slopes. All velocities exceed 1.6 fps when the pipes are flowing at 25 percent of full.

3.3.2 Pump Stations

Pump stations are required to pass peak hourly flow including domestic and industrial flow, and an allowance for infiltration and inflow. The city's 2003 Standard Specifications identify requirements for pump station design including:

- Wet well operating capacity of 5 minutes multiplied by one pump flow rate.
- Emergency capacity in addition to the operating wet well capacity of at least 30 minutes times the peak flow rate.
- Pump cycle time from "pump off" to "pump on" shall not be less than 10 minutes.
- Stations should be sized for immediate flow requirements with the ability to expand to the ultimate requirement.
- Stations shall be sized to handle solids of up to 3-inch spheres. Station must pass the peak hourly flow with the largest unit out of service (as required by OAR).

These wet well sizing requirements generally provide an acceptable basis of design, but wet well designs in accordance with the Hydraulic Institute or standards and recommendations in *Pumping Station Design* (Sanks, 2006) are recommended. Oregon DEQ does not have standards for wet well sizing, but national and other regional standards dictate sewage pump station wet wells should be designed to provide acceptable pump intake conditions, adequate storage volume to prevent excessive frequency of motor starts when using constant speed pumps for solids bearing liquids (Hydraulic Institute Pump Intake Design, 1998), and sufficient depth for pump control, while minimizing solids deposition (Washington State Department of Ecology, Criteria for Sewage Works and Design, 1998, p C2-4).

The city's current 30-minute sewage wet well storage volume criteria allows some time for a service crew to respond to pump station equipment failures before wastewater backs up into the system. City operations staff indicated that a 60 minute storage volume would allow adequate time for response as more pump stations are brought on-line in the system. For this reason, a 60 minute storage time is recommended, though odor and corrosion concerns should be evaluated by city staff on a case by case basis. A corrosion resistant lining for the wet wells is recommended. If the 60-minute criteria results in a storage volume within the operating range of the pump station (that is, between high and low level floats or within the variable speed operating range), then the pump station will exceed the minimum wet well volume that the Hydraulic Institute standards would allow and the longer detention time leads to excessive odor generation and solids deposition in these wet wells. If the 60-minute storage volume is located outside the operating range, then odor generation and solids deposition can be addressed by following the guidelines of the Hydraulic Institute on *Pumping Station Design.*

Regional pump stations should be provided with backup power source and sufficient redundancy (pumps can pass design flow with largest unit out of service) to allow wet well sizing to be optimized for pump station performance and cost-effective construction. The city may choose to develop and adopt pump station design standards that allow staff to evaluate capital and operation and maintenance costs and ultimate pump station configuration on a case-by-case basis.

The need for onsite standby power should also be reviewed depending on the maximum expected period of annual power outage, facility size, available wet well and system storage capacity, and proximity to sensitive areas. Power outages shall not result in raw sewage discharges or bypass to waters of the state and facilities, or procedures must be in place to prevent discharge or bypass, such as standby power, storage, or an auxiliary fuel fired pump.

3.3.3 Force Mains

The minimum recommended force main size is 3 inches although it is acknowledged that DEQ recommends at least 4 inches in diameter. The city may choose to require a minimum 4-inch diameter force main even in low flow conditions to facilitate cleaning and reduce likelihood of plugging. Like gravity sewers, force mains should also be designed to provide adequate cleansing velocities. Force mains as small as 3-inch diameter should only be allowed where adequate scouring velocities correspond to a relatively low design flow rate. The city standard is a minimum velocity of 3 fps, with the velocity never exceeding 8 fps. Optimum velocities for reducing maintenance costs and preventing accumulation of debris lie between 3.5 and 5 fps.

3.4 Evaluation of Alternatives

The expected primary growth areas to be served in the future are the eastern and western URAs located outside the western and northeastern city limits, respectively. Very few future capacity deficiencies in the existing system were identified in the model, thus the majority of the collection system improvements are driven by growth outside the existing service area. Areas outside the city limits cannot be served until the existing collection system is expanded and new lines are installed. These include the Eastern URA east of NE 13th Street and north of Antler, and the Western URA west of Northwest Way and North of NW Hemlock Avenue, and west of SW 35th Street and north of Obsidian Avenue.

Four major future interceptors were laid out to serve future growth based on available contour information and will flow by gravity from the south to the Redmond WPCF in the north. The proposed interceptors allow sewer service to new and existing areas while reducing the number of new lift stations and allowing elimination of some existing lift stations. A far west pump station will be required to convey flows from the canyon east of Helmholtz Way to the WPCF. These alignments are preliminary and they will be refined through additional survey and the predesign process.

Two of the four major interceptors had been identified in the previous master plan. They will provide future capacity for growth within the city limits. These were partially constructed as of August 2007. These and other interceptor lines are shown in Exhibit 3-5. These two interceptors are described in the following paragraphs:

- Westside Interceptor: The Westside Interceptor will serve the western half of the city and will flow from Yew and SW 27th Street, north along 27th Street to Elm Avenue. The design for this interceptor was being completed as of August 2007.
- Eastside Interceptor: A portion of the Eastside Interceptor was completed in 2007. It will follow the railroad right-of-way from the airport to the north. The Eastside Interceptor

collects flows from a number of east-west sewers to prevent overloading the Dry Canyon interceptor when the east side is fully developed.

The other two interceptors will provide future capacity for growth generally in the western and eastern URA, as well as portions of the undeveloped lands within the UGB. These are also shown in Exhibit 3-5.

- Far West Interceptor: The Far West Interceptor will provide service for development in the Western URA, and 2006 UGB expansion and will run from the southern corner of the URA north to Spruce Avenue and then east to the WPCF.
- Far East Interceptor: The Far East Interceptor is needed to serve future growth in the Eastern URA.

Existing pump stations that can be eliminated by the addition of future gravity service interceptors are, Hayden Ranch, Reindeer, Umatilla, Sterling Pointe, Future Greenwood, Majestic, Lawson Crossing, and Waverly Pump Stations. These are located along the Eastside Interceptor that runs coincident with the railroad right-of-way.

Proposed sewers were laid out such that depths are generally less than 20 feet below existing grade. Areas of deeper cover exist along the proposed Far West Interceptor between W Antler Avenue and NW Maple Avenue parallel to NW 35th Street. For this area, a cost-benefit analysis of a 1.3 mgd pump station and force main was evaluated and compared to the cost for a deeper, gravity line. See Appendix B for the detailed presentation of the cost-benefit analysis for this improvement. Based on a comparison of life cycle costs, which considered the higher operations and maintenance needs of the pump station, the gravity option was the most cost effective alternative with payoff occurring in approximately year 23. This payoff is not a near-term payoff and predesign activities for this interceptor may refine project costs to such a level that the pump station alternative appears more attractive from a present worth basis.

Future capacity deficiencies were identified in the existing system as those pipes with a modeled Qratio of 1.0 or greater with future flows. These lines range in length from 8 to 430 feet and are generally located south of E Antler Avenue and east of the railroad, and just south of the Redmond WPCF. These pipes will need to be replaced to serve future needs.

3.5 Sewer Collection and Conveyance Improvements

3.5.1 Recommended Projects List

This section summarizes the collection system improvements discussed in the previous section and presents a recommended projects list for Redmond’s collection system. As noted earlier, if growth occurs as projected, additional infrastructure capacity will be needed beyond the city limits and in select areas within the existing system. As development occurs, existing connections should be changed to the new interceptors.

It may be possible to take advantage of excess capacity in the existing system with interim gravity pipelines or pump stations prior to construction of new pipelines and pump stations. One example of a permanent gravity line would be in the south area (near South Canal Boulevard and SW Badger Avenue,) which, instead of connecting to the Westside interceptor, would be served by Line D by extending a new gravity sewer. A 30-foot deep excavation would be required to connect to the Westside Interceptor, but a more shallow excavation could occur to connect to Line D.

Another interim improvement that could be considered is to pump flows from the area of SW 39th Street and Obsidian and SW Helmholtz Way to the Westside Interceptor (or another gravity line on NW 35th Street).

The recommended capital improvements inside the UGB are listed in Exhibit 3-6a. Recommended capital improvements within the URA are listed in Exhibit 3-6b. These exhibits are condensed versions of the exhibits shown in Appendix C which give detailed project data for each pipe segment and facility recommended.

The recommended capital improvements were ranked by priority. The first priority is to address existing capacity deficiencies; second is to address capacity deficiencies anticipated within 5 years. The third priority is to address capacity deficiencies at buildout conditions; fourth is to address improvements and expansion driven by growth. As shown in Appendix C, Exhibit 1 and 2, none of the improvements were ranked first or second priority, and only about a dozen were ranked third priority. The majority of the projects are fourth priority.

The major new interceptors are proposed to be constructed in four phases corresponding with expected development. These include the Far West Interceptor, Westside Interceptor, Far East Interceptor, and Eastside Interceptor. Phasing follows construction from downstream to upstream reaches. Phase 1 includes the first quarter of the Far West Interceptor from Maple Avenue to the WPCF, the Westside Interceptor, and the East Interceptor from the existing Hayden Ranch Pump Station to King Way and NE 5th Street. Phase 2 involves extension of the Far West Interceptor from Maple Avenue to just north of Highland Avenue and the Eastside Interceptor from Hayden Ranch Pump Station to Hemlock Avenue. Following this, the remainder of the Eastside Interceptor and the Far East Interceptor will be constructed in Phase 3 to serve growth in the eastern portion of the city and Eastern URA. The Far West Interceptor will also be extended from Highland Avenue to Wickiup Avenue in Phase 3. Phase 4 incorporates capacity for buildout conditions and ultimate development. This phase extends the Far West Interceptor to serve the southwestern corner of the URA from SW Wickiup Avenue to the UGB.

Appendix C presents a detailed capital improvements plan, including phasing of the interceptors. Appendix D provides profiles for the Far West and Far East Interceptors.

The phasing for projects was estimated based on the anticipated sequence of development. The implementation schedule for the projects will be adjusted to match the actual sequence of development that occurs. New sewers should be in place when existing lines reach surcharging conditions under peak flows. The anticipated sequence is that development will trigger system improvements within the city limits first and then the northern regions of the URA. If growth occurs differently, the phasing plan and connections to the existing collection system should be revisited.

An understanding of existing system conditions is necessary to plan for and design future improvements. Television inspection of the whole system is recommended with a priority for pipes identified with low velocities and a history of sedimentation and debris. Low pipe velocity can lead to sediment deposition problems in the pipe and increased maintenance costs. Development of a recurring TV inspection program, coupled with the city's new Granite XP asset management software, will allow more effective deployment of operation and maintenance resources and is expected to improve service.

A city-wide flow monitoring plan is recommended so as to identify the most beneficial locations for deployment of continuous flow monitoring devices. Continuous flow monitoring data will guide maintenance activities and will help refine planning for increasing the system capacity. It is understood that the city rotates monitors on a few major trunk sewers. The city's practice of maintaining and collecting the flow monitor data has been generally acceptable for the modeling effort that was conducted for this master plan, but additional rigor could be added to the flow monitoring process. One approach would be to engage a flow monitoring contractor to plan, establish, and document a formal flow monitoring program and establish standard operating procedures for regular calibration, raw data review, equipment maintenance, data QA/QC and data validation, responses to alarm conditions, and data warehousing. A rain gauge with recording capability is recommended to be located at City Hall and at the WPCF.

3.5.2 Cost Background

A critical element of a planning project is to determine an appropriate cost estimating methodology. It is the purpose of this cost estimating methodology to provide planning-level cost estimates for the projects identified as capital improvements under this master plan.

3.5.2.1 Introduction

In every planning project, it is necessary to estimate project construction costs, operations and maintenance costs for proposed facilities, and allowances for engineering, administrative costs, and contingencies. These initial estimates of project construction costs are important since they are used for budgeting CIP projects for the future. At the alternative analysis and planning stage, project-specific detailed engineering data are limited to preliminary design criteria and layouts, so costing methods must be developed to make use of this limited engineering data in best approximating project construction costs. This section establishes the criteria that were used in completing alternative analyses and preparing order-of-magnitude construction cost estimates at the alternative analysis and planning stage.

A methodology developed by CH2M HILL for another collection system planning project in Oregon has been modified for application to the City of Redmond because it presents a framework for assigning and documenting costs at the master planning project stage.

3.5.2.2 Economic Evaluation

Limited alternative evaluations were performed during this master plan. For those alternatives evaluated, a present-worth cost was developed for each alternative. Factors that affect present worth include initial costs, replacement costs, salvage value, and annual costs. The present worth of an alternative is the dollar value that, if invested now at given interest (discount) rate, would provide exactly the funds required to pay all present and future costs. Present-worth calculations were based on a discount rate of 2.5 percent and an economic life as outlined in Exhibit 3-7.

This discount rate is the difference between City of Redmond's anticipated rate for 20-year revenue bonds and the rate of inflation. The assumed bond rate is 7.5 percent and the inflation rate is 5 percent. The discount rate represents the real cost of capital for City of Redmond.

Construction and operating costs for the facilities were based on design criteria and modeled layouts. Estimates were prepared using the construction costs of similar facilities when possible. Operations and maintenance costs were based on a labor rate of $40 per hour (which includes a supervisor and overhead) and an electrical power cost of $0.09 per kilowatt-hour.

3.5.2.3 Types of Cost Estimates

The Association for the Advancement of Cost Engineering, International (AACE International) has developed definitions for levels of accuracy commonly used by professional cost estimators. AACE International recently changed the estimate classification levels from the traditional three (order-of-magnitude, budget, and definitive) to five levels. These five levels are called Class 5 through Class 1, with Class 1 being the best expected level of accuracy. The cost estimates included in this report are considered to be Class 4.

According to the definitions of AACE International, the Class 4 Estimate is defined as an estimate that is prepared based on limited information, where the preliminary engineering is from 1 to 5 percent complete. Detailed strategic planning, business development, project screening, alternative scheme analysis, confirmation of economic and or technical feasibility, and preliminary budget approval are needed to proceed. Examples of estimating methods used would be equipment and or system process factors, scale-up factors, and parametric and modeling techniques. The expected accuracy ranges for this class estimate are –15 to –30 percent on the low side and +20 to +50 percent on the high side.

The cost estimates shown have been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project and resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. Therefore, the final project costs will vary from the estimates presented here. Because of these factors, project feasibility, benefit/cost ratios, risks, and funding needs must be carefully reviewed prior to making specific financial decisions or establishing project budgets to help ensure proper project evaluation and adequate funding.

3.5.2.4 Basis for Adjustment of Costs over Time

Any cost estimate is time sensitive. Future changes in the costs of the components of construction will cause changes in the costs presented in the exhibits of this report. Because these costs are time sensitive, they are typically associated with a present time costing index that allows one to monitor and reflect the change of construction costs over time. The costs developed in this report are based on an *Engineering News-Record* Seattle Construction Cost Index for January 2007 of 8626. The costs presented in this report may be updated to future date costs by applying the ratio of the current cost index at that time to 8626. Because the relative cost-effectiveness of alternative projects can be expected to change only slightly with changes in the estimated costs, alternative selection decisions based on comparisons of present costs will produce valid results for at least 5 years. At that time, O&M and construction costs should be reviewed and updated as appropriate.

3.5.2.5 Basis for Development of Sewer Costing Tables

The following is a description of the process used to develop the sanitary pipeline costing tables included in this report. The purpose of this narrative is to aid the user in understanding the scope included in the costing and the assumptions and methodology used in the development of the tables. In addition, this provides a procedure for future updating of the tables to fill a unique project-specific need or as a periodic global update.

Given the non-detailed nature of the master plan, the costing was parametric, that is, the unit prices for each type of improvement were categorized based on basic size or features, and not explicitly estimated as a detailed construction bid would be. The major parameters were pipe material type, pipe diameter, and depth of installation. Simplifying assumptions were made concerning some variable elements (manhole and lateral spacing, for example) and allowances are made on a linear foot basis to cover these elements and others. Because of their project-specific nature and variability, some parameters were outside of the scope of the estimate.

The General Conditions allowance specifically includes the following items:

- Bonds, insurance, licenses, and permits
- Move in personnel and equipment
- Set up all offices, buildings, and facilities
- All required construction facilities
- Demobilization including removal of all facilities and clean up
- All other work not included in other bid items

The following items are specifically included in the lineal foot price:

- Excavation, hauling, and disposal
- Labor
- Asphalt cement (AC) pavement removal and replacement including AC base
- Shoring and shoring design (> 20 feet deep)
- Materials and equipment for excavation, installation, compaction, etc.
- Pipe and pipe installation including bedding and backfill
- Laterals and lateral installation
- Manhole and manhole installation
- Overhead and profit

The following items are considered incidental and therefore are included in the costing for the installation of sewer pipe in city streets:

- Clearing and grubbing
- Adjustment of incidental structures to grade
- Landscaping
- Restoration and cleanup
- Removal and replacement of curbs, driveways, and sidewalks

The following major areas are excluded from the unit cost tables and must be added by the project estimator on a project specific basis (as has been done for the Capital Improvement Plan summary tables in Appendix C):

- Traffic Control—a highly variable and project-specific element that will vary by location, type of traffic, and volume of traffic.
- Rock and concrete excavation must be added on a project-specific basis since it is also highly variable and not suited to general assumptions. For planning purposes, rock excavation was assumed to be required below a depth of 3 feet for all pipeline alignments. A cost of $20/cubic yard could be assumed for areas where blasting appeared feasible, and $80/cubic yard where proximity of pipelines to denser urban areas made blasting not feasible. The $80/cubic yard value was used for all trenches and refinement of allowable blasting locations can be performed based on city input.
- Foundation stabilization is not included and must be added where required.
- Controlled density fill (CDF) backfill—all backfill is assumed to be granular imported materials.
- Trench dewatering—another highly variable and project-specific element should be added where required.
- Erosion control.
- Tunneling, boring, and jacking are not included.
- Land acquisition—All work is assumed to be completed within the right-of-way; therefore, land acquisition is not an issue.
- Other excluded items that may potentially be costly include, but are not limited to, flow diversion, contaminated media, public involvement, right-of-way acquisition, noise abatement, public art allowance, permits (special), utility relocations, and interagency costs.

Standard Trench Quantities

The following assumptions were made during the development of the quantities:

- Trench depth is the total depth of excavation to the bottom of the pipe bedding.
- Trench width is the minimum clear width allowed by the ODOT standard specifications. The approach includes 10 inches for trench shoring width rounded to the nearest wider half-foot increment.
- Pipe zone depth is the pipe outside diameter plus 18 inches.
- Quantity of asphalt removal equals trench width plus 12 inches (6 inches each side of trench). It should be noted here that the costing tables include saw cutting asphalt to the trench width to help hold the trench sides and prevent raveling during construction and re-cutting prior to trench patching with asphalt. Quantity of AC replacement equals removal width, multiplied by length, multiplied by a depth of 5 inches.

- Excavation volume is the trench depth multiplied by the trench width multiplied by the trench length.
- Spoils volume is the excavation volume swelled by 20 percent for being in a loose condition.
- Shoring is quantified for one side of trench only to agree with Means' costing convention, which calculates shoring requirements on a square foot basis. (RSMeans Construction Data, 2007).
- Pipe zone volume is trench width multiplied by pipe zone depth minus pipe volume multiplied by length.
- Above zone volume is excavation volume minus the sum of pipe volume and pipe zone volume.
- AC base volume is asphalt removal width times 8 inches depth.

Standard Sewer Costing Worksheets

Sewer costs were developed for each combination of pipe type, pipe diameter, and trench depth by incorporating the quantities developed with unit costing from R. S. Means Building Construction Cost Data 2002 and R. S. Means Site Work & Landscape Cost Data 2002. All unit prices include overhead and profit margin for the installing contractor. The Subtotal Direct Construction Cost is increased by the multipliers shown. They are as follows:

- General Conditions @ 10 percent
- Waste allowance @ 5 percent
- Construction contingency @ 25 percent
- Construction management, inspection, and testing @ 15 percent
- Design @ 10 percent
- Public involvement (PI), instrumentation and controls (I&C), easements, and environmental oversight @ 3 percent
- Startup and closeout @ 1 percent

3.5.2.6 Summary

Exhibits 3-8 and 3-9 summarize the construction and operation and maintenance costs for each component presented in the previous sections.

3.5.3 Conceptual Planning for Urban Reserve Area

Sewer service may be provided to the URA through the use of gravity interceptors and trunk sewers. The Far East Interceptor and a trunk sewer extending east on Negus Avenue in the vicinity of Hayden Ranch Pump Station are configured to provide service to nearly the entire URA.

Phasing for these improvements should be tied to planned development in the URA. The planning criteria known during preparation of this master plan indicate that this area may not develop immediately. For this reason, these URA area sewer improvements were assigned to Phase 3 of the development plan. However, if development in the URA should proceed earlier and sewer service is required, service to the URA could be provided either through the Far East Interceptor as described above, or by a pump station that could serve the initially-developed portion of the URA and discharge into the existing system. This potential sewer pump station was considered as an alternative in the master plan SWMM model and might be located near the southern end of the URA east of the extension of SW Glacier Avenue.

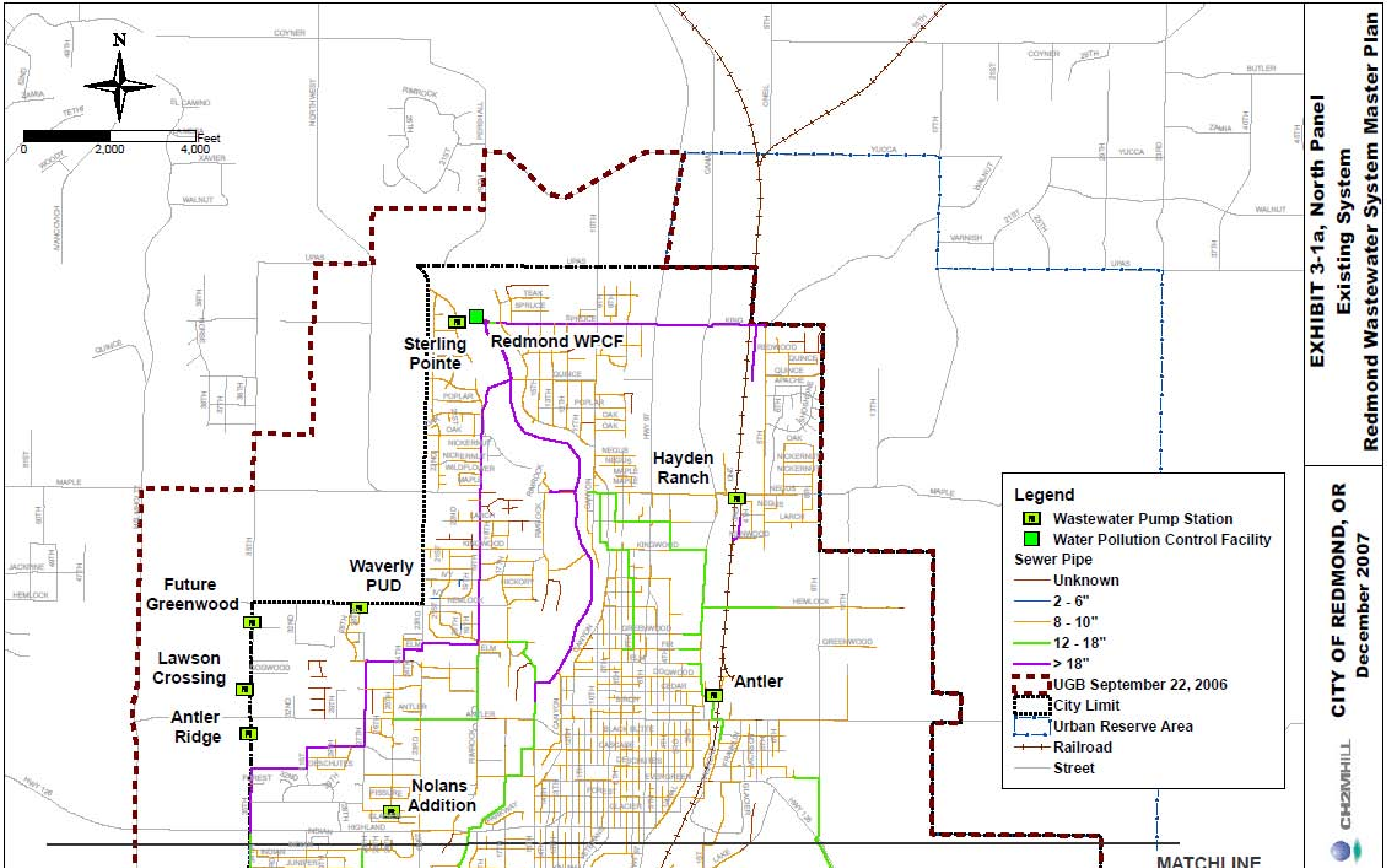


EXHIBIT 3-1a, North Panel
Existing System
Redmond Wastewater System Master Plan
CITY OF REDMOND, OR
December 2007
CH2MHILL
N
0
2,000
4,000
Feet
Sterling Pointe
Redmond WPCF
Hayden Ranch
Waverly PUD
Future Greenwood
Lawson Crossing
Antler Ridge
Antler
Nolans Addition
MATCHLINE
Legend
Wastewater Pump Station
Water Pollution Control Facility
Sewer Pipe
Unknown
2 - 6"
8 - 10"
12 - 18"
> 18"
UGB September 22, 2006
City Limit
Urban Reserve Area
Railroad
Street

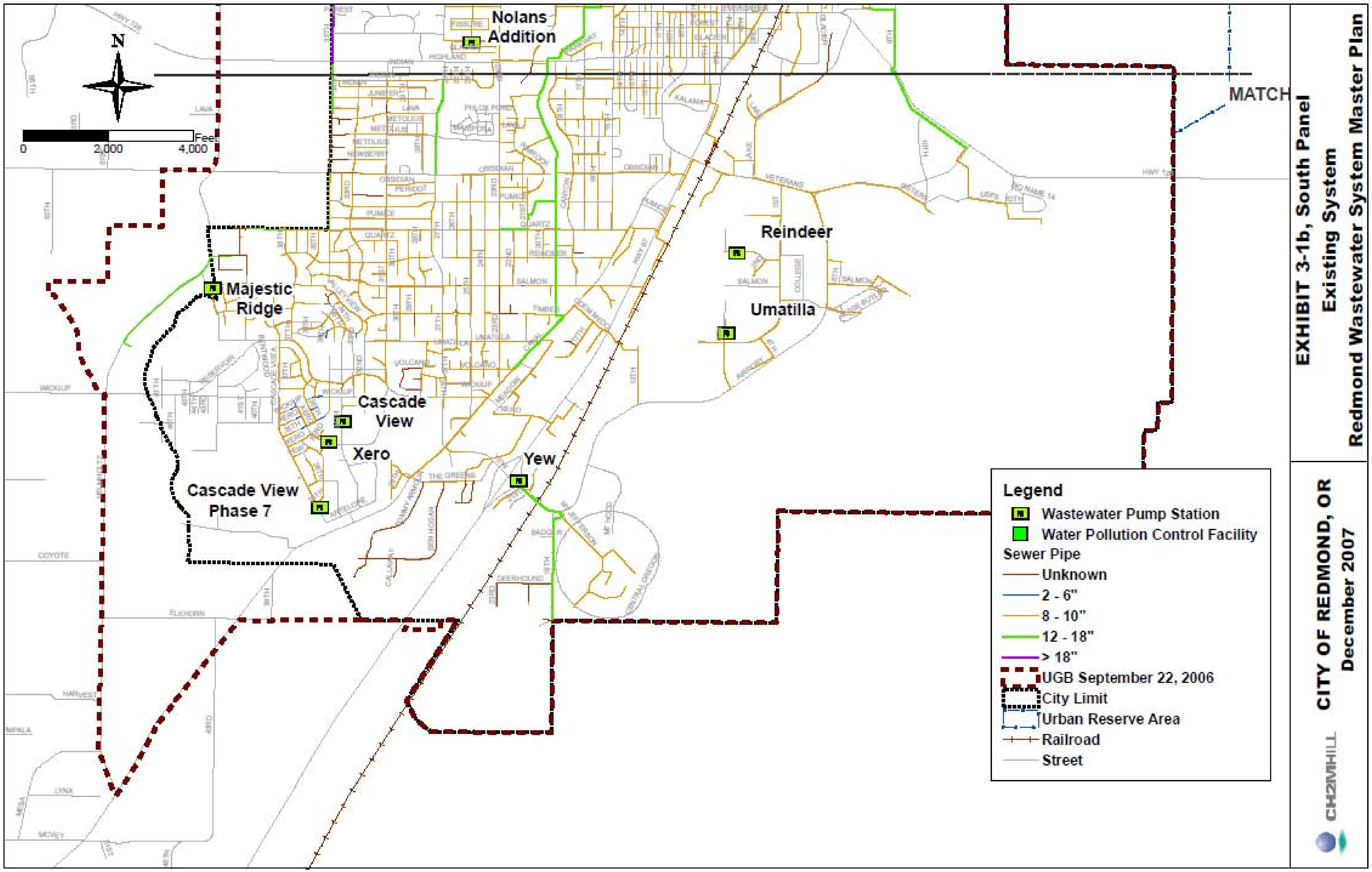


EXHIBIT 3-1b, South Panel
Existing System
Redmond Wastewater System Master Plan
CITY OF REDMOND, OR
December 2007
CH2MHILL
N
0
2,000
4,000
Feet
MATCH
Nolans Addition
Majestic Ridge
Reindeer
Umatilla
Cascade View
Xero
Yew
Cascade View Phase 7
Legend
Wastewater Pump Station
Water Pollution Control Facility
Sewer Pipe
Unknown
2 - 6"
8 - 10"
12 - 18"
> 18"
UGB September 22, 2006
City Limit
Urban Reserve Area
Railroad
Street

EXHIBIT 3-2
Wastewater Pump Station Operator Conditions
Redmond Wastewater (Collection System) and Water System Master Plan

Pump Station	Address	GIS ID Number	Pump No.	Design Total Dynamic Head (ft)	Design Flow (gpm)	Measured Flow (gpm)	Total Pump Station Flow (gpm)	Status
Antler	125 NE Antler Ave	9	1	25	700	795	701	
			2	25	700	701	-	
Cascade View	3250 SW 34th St	2	1	20 (estimated from GIS)	45	45	45	
			2	20 (estimated from GIS)	45	45	-	
Cascade View Phase 7	3850 SW 35th Pl	14	1	102	120	86	86	
			2	102	120	90	-	
Hayden Ranch	1555 NE 3rd St	24	1	16	80	226	212	
			2	16	80	212	-	
Majestic Ridge	4334 SW Salmon Ave	10	1	118	88	143	124	
			2	118	88	124	-	
Nolans Addition	2498 SW Glacier Ave	6	1	25	250	257	257	
			2	25	250	268	-	
Reindeer	356 SW Reindeer Ave	8	1	28	95	144	127	
			2	28	95	127	-	
Sterling Pointe	2810 NW 19th St	16	1	69	200	181	180	
			2	69	200	180	-	
Umatilla	2654 SW 6th St	20	1	36	140	118	79	
			2	36	140	79	-	

EXHIBIT 3-2
Wastewater Pump Station Operator Conditions
Redmond Wastewater (Collection System) and Water System Master Plan

Pump Station	Address	GIS ID Number	Pump No.	Design Total Dynamic Head (ft)	Design Flow (gpm)	Measured Flow (gpm)	Total Pump Station Flow (gpm)	Status
Xero	3515 SW Xero Ave	1	1	81	120	158	151	
			2	81	120	151	-	
Yew	3715 SW Airport Way	3	1	26	520	497	503	
			2	26	520	503	-	
Waverly PUD	SE corner of NW Hemlock Ave and NW	NA	1	23.6	66	112	100	New station. Will be online August 2007. Discharges to manhole MH08C016.
			2	23.6	66	100	-	
Antler Ridge	3565 W Antler Ave	28	1	62.5	118	195	188	New station. Will be decommissioned August 2007. Discharges to manhole MH17B023.
			2	62.5	118	188	-	
Lawson Crossing	SE corner of NW 35th St and NW Dogwood Ave	27	1	87	132	192	192	New station. Will be online August 2007. Discharges to manhole MH17B023.
			2	87	132	204	-	

Note: All measured data in this table obtained from city field testing records provided July 18, 2007.

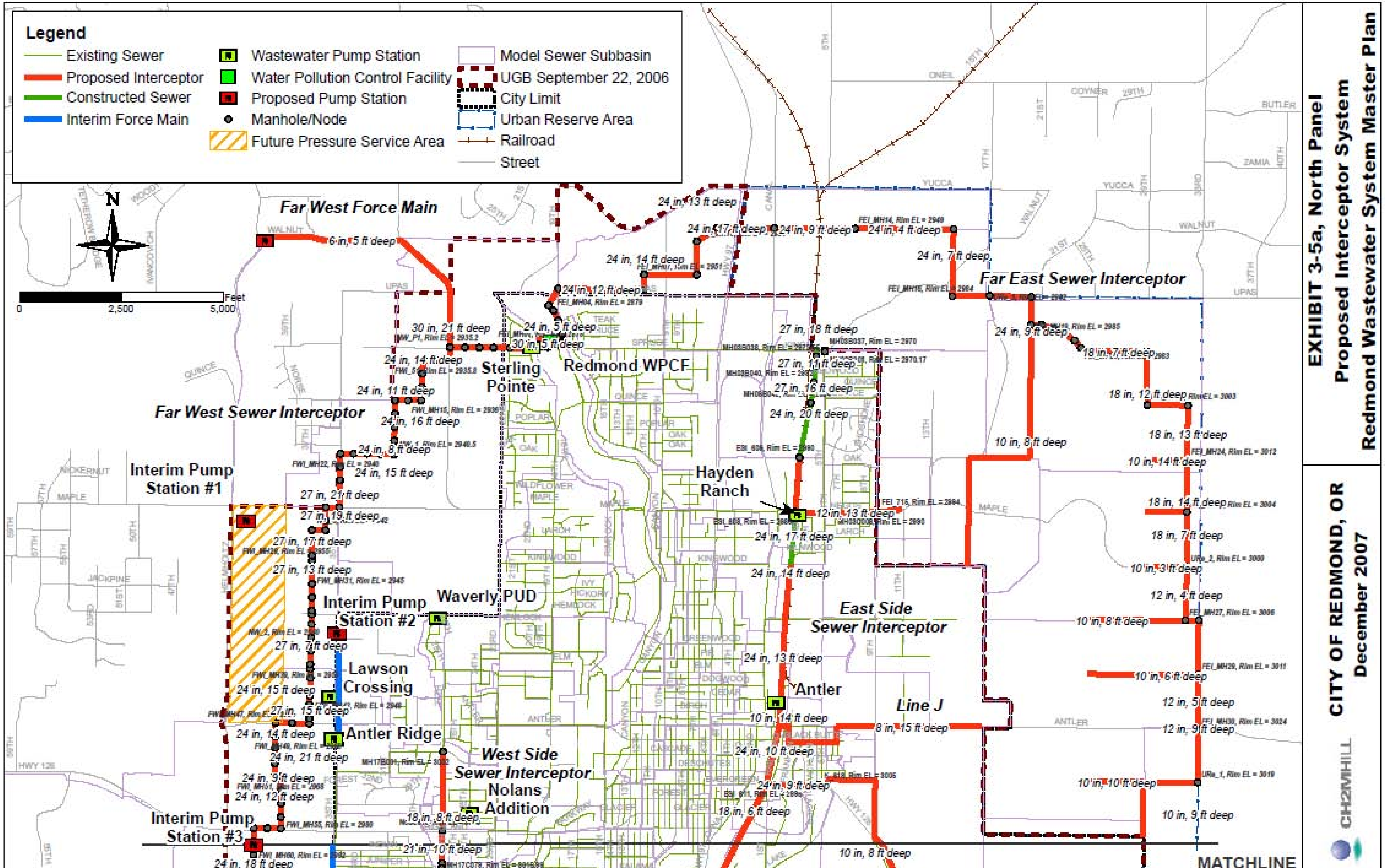
EXHIBIT 3-3
Existing Wastewater System Pipeline Inventory
Redmond Wastewater (Collection System) and Water System Master Plan

Size (inches)	Length (%)	Length (feet)	Pipe Material											
			PVC		Concrete		Steel		Ductile Iron		HDPE		Material Unknown	
			%	feet	%	feet	%	feet	%	feet	%	feet	%	feet
4	11.9	94,380	-	-	-	-	-	-	-	-	-	-	100.0	94,380
6	1.4	10,766	19.3	2,080	-	-	-		-	-	-	-	80.7	8,686
8	56.9	451,687	59.0	266,473	32.3	145,981	0.1	408	-	-	-	-	8.6	38,825
10	5.0	39,538	46.5	18,370	52.1	20,595	-	-	-	-	-	-	1.4	573
12	2.5	20,055	57.0	11,441	40.0	8,026	-	-	-	-	-	-	2.9	588
14	0.0	110	-	-	-	-	-	-	100.0	110	-	-	-	-
15	2.2	17,185	22.1	3,791	72.8	12,509	-	-	-	-	-	-	5.1	885
18	1.2	9,874	25.9	2,561	74.1	7,313	-	-	-	-	-	-	-	-
24	9.1	72,203	92.8	67,010	7.2	5,193	-	-	-	-	-	-	-	-
27	0.4	3,303	100.0	3,303	-	-	-	-	-	-	-	-	-	-
30	1.0	8,305	42.3	3,516	-	-	-	-	-	-	57.7	4789	-	-
Missing Data	8.4	66,493	0.5	301	0.4	281	-	-	-	-	-	-	-	65,911
Total	**100.0**	**793,899**	**47.7%**	**378,846**	**25.2%**	**199,898**	**0.1%**	**408**	**0.0%**	**110**	**0.6%**	**4,789**	**26.4%**	**209,848**

EXHIBIT 3-4
Minimum Grade for Gravity Sewers
Redmond Wastewater (Collection System) and Water System Master Plan

Pipe Inner Diameter (inches)	Slope (ft/100 ft)
6	0.6
8	0.4
10	0.25
12	0.19
15	0.14
18	0.11
21	0.09
24	0.08
27	0.08

Source: City of Redmond, Public Works Department, Standards and Specifications, April 2003


Legend
Existing Sewer
Proposed Interceptor
Constructed Sewer
Interim Force Main
Wastewater Pump Station
Water Pollution Control Facility
Proposed Pump Station
Manhole/Node
Future Pressure Service Area
Model Sewer Subbasin
UGB September 22, 2006
City Limit
Urban Reserve Area
Railroad
Street
N
0 2,500 5,000 Feet
Far West Force Main
Far West Sewer Interceptor
Interim Pump Station #1
Interim Pump Station #2
Interim Pump Station #3
Sterling Pointe
Redmond WPCF
Hayden Ranch
Waverly PUD
Lawson Crossing
Antler Ridge
West Side Sewer Interceptor
Nolans Addition
Antler
Far East Sewer Interceptor
East Side Sewer Interceptor
Line J
MATCHLINE
EXHIBIT 3-5a, North Panel
Proposed Interceptor System
Redmond Wastewater System Master Plan
CITY OF REDMOND, OR
December 2007
CH2MHILL

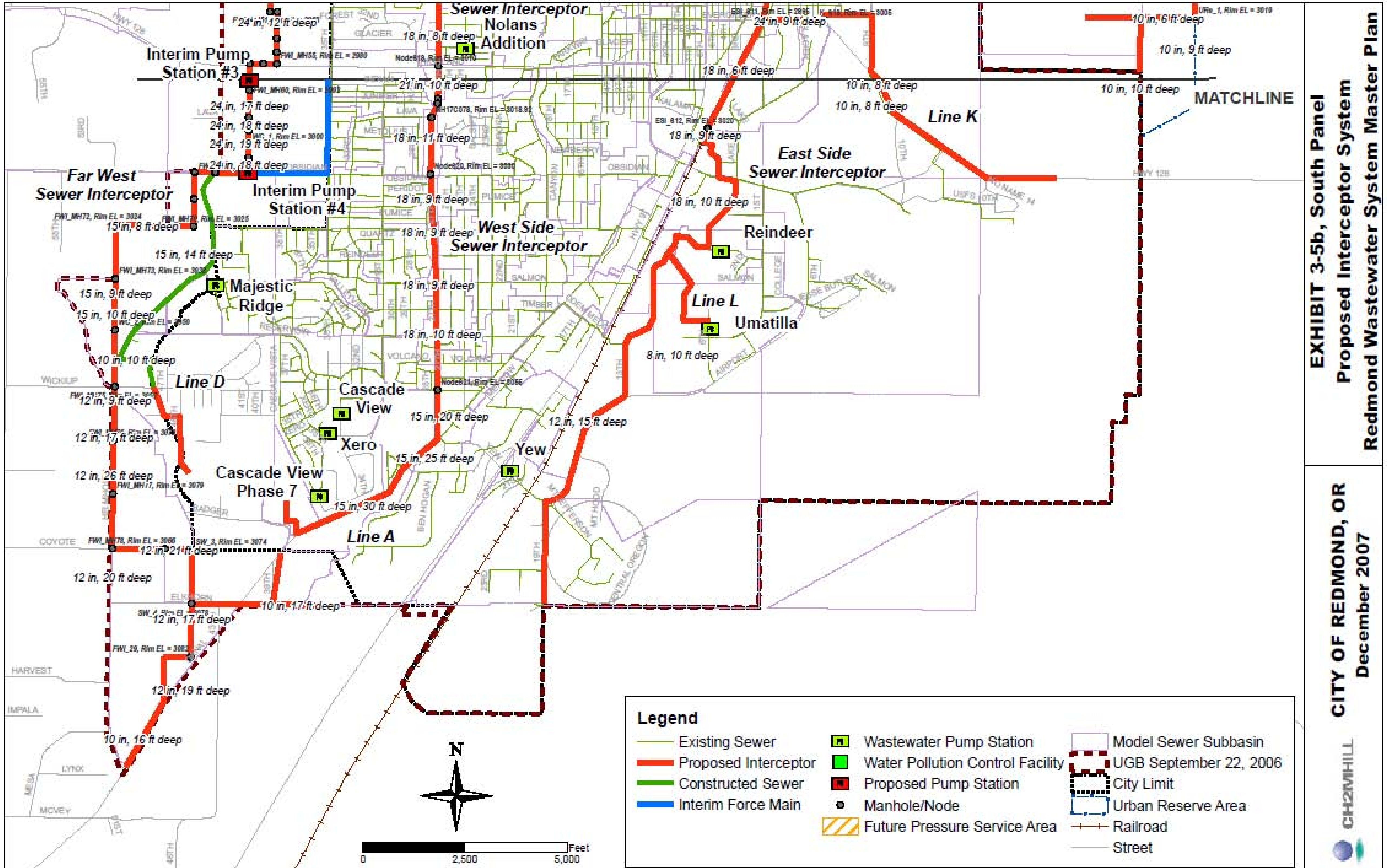


EXHIBIT 3-5b, South Panel
Proposed Interceptor System
Redmond Wastewater System Master Plan
CITY OF REDMOND, OR
December 2007
CH2MHILL
MATCHLINE
Sewer Interceptor
Nolans Addition
Interim Pump Station #3
Interim Pump Station #4
Far West Sewer Interceptor
West Side Sewer Interceptor
East Side Sewer Interceptor
Majestic Ridge
Cascade View
Xero
Cascade View Phase 7
Yew
Reindeer
Umatilla
Line K
Line L
Line D
Line A
Legend
Existing Sewer
Proposed Interceptor
Constructed Sewer
Interim Force Main
Wastewater Pump Station
Water Pollution Control Facility
Proposed Pump Station
Manhole/Node
Future Pressure Service Area
Model Sewer Subbasin
UGB September 22, 2006
City Limit
Urban Reserve Area
Railroad
Street
N
0
2,500
5,000
Feet

EXHIBIT 3-6A
Wastewater Collection System Recommended Projects List for UGB Buildout
Redmond Wastewater (Collection System) and Water System Master Plan

Pipelines				
Length (ft.)	**Average Depth of Bury (ft.)**	**Diameter (in.)**	**Total Estimate**	**Location**
Far West Interceptor				
30	6	30	$0	Between Sterling Pointe Pump Station and Redmond Water Pollution Control Facility
33	6	30	$15,000	Between Sterling Pointe Pump Station and Redmond Water Pollution Control Facility
25	5	30	$11,000	Between Sterling Pointe Pump Station and Redmond Water Pollution Control Facility
86	5	30	$38,000	Between Sterling Pointe Pump Station and Redmond Water Pollution Control Facility
175	6	30	$77,000	Between Sterling Pointe Pump Station and Redmond Water Pollution Control Facility
230	12	30	$146,000	Parallel to NW Spruce Ave, west of Sterling Pointe Pump Station
136	19	30	$103,000	Parallel to NW Spruce Ave, east of NW 22nd St at Sterling Pointe Pump Station
400	18	30	$302,000	Parallel to NW Spruce Ave, east of NW 22nd St
400	20	30	$304,000	Parallel to NW Spruce Ave, west of NW 22nd St
350	24	30	$270,000	Parallel to NW Spruce Ave, east of Northwest Way
350	25	24	$245,000	Parallel to NW Spruce Ave, east of Northwest Way
373	23	30	$286,000	Parallel to NW Spruce Ave, east of Northwest Way
330	21	30	$252,000	Along Northwest Way, south of NW Spruce Ave
325	19	24	$221,000	Parallel to and south of NW Spruce Ave, west of Northwest Way
325	15	24	$192,000	Parallel to and south of NW Spruce Ave, west of Northwest Way
330	12	24	$179,000	Parallel to and west of Northwest Way, south of NW Spruce Ave
330	14	24	$181,000	Parallel to and west of Northwest Way, south of NW Spruce Ave
332	16	24	$197,000	Parallel to and west of Northwest Way, south of NW Spruce Ave
317	14	24	$173,000	Parallel to and south of NW Spruce Ave, west of Northwest Way
317	9	24	$129,000	Parallel to and south of NW Spruce Ave, west of Northwest Way
330	7	24	$120,000	Parallel to and east of NW 35th St, north of NW Maple Ave
330	8	24	$134,000	Parallel to and east of NW 35th St, north of NW Maple Ave
330	11	24	$178,000	Parallel to and east of NW 35th St, north of NW Maple Ave
330	15	24	$195,000	Parallel to and east of NW 35th St, north of NW Maple Ave

EXHIBIT 3-6A

Wastewater Collection System Recommended Projects List for UGB Buildout

Redmond Wastewater (Collection System) and Water System Master Plan

Pipelines				
Length (ft.)	**Average Depth of Bury (ft.)**	**Diameter (in.)**	**Total Estimate**	**Location**
Far West Interceptor, continued				
330	17	24	$223,000	Parallel to and south of NW Oak Ave, east of NW 35th St
330	15	24	$195,000	Parallel to and south of NW Oak Ave, east of NW 35th St
330	16	24	$196,000	Parallel to and south of NW Oak Ave, east of NW 35th St
330	17	27	$222,000	Parallel to and south of NW Oak Ave, east from NW 35th St
331	16	27	$201,000	Along NW 35th St north of NW Maple Ave
340	19	27	$231,000	Along NW 35th St north of NW Maple Ave
330	22	27	$248,000	Along NW 35th St north of NW Maple Ave
320	21	27	$240,000	Along NW 35th St north of NW Maple Ave
330	18	27	$223,000	Along NW Maple Ave, west of NW 35th St
330	18	27	$223,000	Parallel to and west of NW 35th St, south of NW Maple Ave
240	20	27	$164,000	Parallel to and west of NW 35th St, south of NW Maple Ave
330	16	27	$221,000	Parallel to and south of NW Maple Ave, west of SW 35th St
330	13	27	$187,000	Parallel to and west of NW 35th St, south of NW Maple Ave
330	17	27	$222,000	Parallel to and west of NW 35th St, south of NW Maple Ave
90	22	27	$68,000	Parallel to and west of NW 35th St, south of NW Maple Ave
240	19	27	$163,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave
330	13	27	$187,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave
330	13	27	$187,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave
320	13	27	$181,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave
90	13	27	$51,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave
250	10	27	$124,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave
330	7	27	$140,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave
100	7	27	$43,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave
230	9	27	$114,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave
330	14	27	$188,000	Parallel to and west of NW 35th St, north of W Antler Ave
110	17	27	$74,000	Parallel to and west of NW 35th St, north of W Antler Ave

EXHIBIT 3-6A
Wastewater Collection System Recommended Projects List for UGB Buildout
Redmond Wastewater (Collection System) and Water System Master Plan

Pipelines				
Length (ft.)	Average Depth of	Diameter (in.)	Total Estimate	Location
Far West Interceptor, continued				
230	17	27	$155,000	Parallel to and west of NW 35th St, north of W Antler Ave
330	15	27	$199,000	Parallel to and west of NW 35th St, north of W Antler Ave
110	14	27	$63,000	Parallel to and west of NW 35th St, north of W Antler Ave
220	17	24	$149,000	Parallel to and west of NW 35th St, north of W Antler Ave
330	21	24	$227,000	Parallel to and west of NW 35th St, north of W Antler Ave
130	21	24	$90,000	Parallel to and west of NW 35th St, north of W Antler Ave
410	20	24	$280,000	Along W Antler Ave, west of SW 35th St
410	17	24	$277,000	Along W Antler Ave, west of SW 35th St
330	15	24	$195,000	Parallel to and east of SW Helmholtz Way, south of W Antler Ave
330	15	24	$195,000	Parallel to and east of SW Helmholtz Way, south of W Antler Ave
330	14	24	$181,000	Parallel to, east of SW Helmholtz, south of W Antler Ave
330	12	24	$179,000	Parallel to, east of SW Helmholtz, south of W Antler Ave
166	9	24	$68,000	Parallel to, north of SW Highland, east of SW Helmholtz
330	12	24	$179,000	Parallel to, east of SW Helmholtz, north of SW Highland
330	16	24	$196,000	Parallel to, east of SW Helmholtz, north of SW Highland
330	16	24	$196,000	Parallel to, east of SW Helmholtz, north of SW Highland
280	16	24	$166,000	Parallel to, east of SW Helmholtz, north of SW Highland
330	15	24	$195,000	Along SW Highland Ave, east of SW Helmholtz Way
330	14	24	$181,000	Along SW Highland Ave, east of SW Helmholtz Way
330	17	24	$223,000	Parallel to, east of SW Helmholtz, south of SW Highland
330	18	24	$224,000	Parallel to, east of SW Helmholtz, south of SW Highland
330	17	24	$223,000	Parallel to, east of SW Helmholtz, north of SW Obsidian
330	17	24	$223,000	Parallel to, east of SW Helmholtz, north of SW Obsidian
330	17	24	$223,000	Parallel to, east of SW Helmholtz, north of SW Obsidian
330	17	24	$223,000	Parallel to, east of SW Helmholtz, north of SW Obsidian

EXHIBIT 3-6A
Wastewater Collection System Recommended Projects List for UGB Buildout
Redmond Wastewater (Collection System) and Water System Master Plan

Pipelines				
Length (ft.)	**Average Depth of Bury (ft.)**	**Diameter (in.)**	**Total Estimate**	**Location**
Far West Interceptor, continued				
330	18	24	$224,000	Parallel to, east of SW Helmholtz, north of SW Obsidian
380	19	24	$259,000	Parallel to, east of SW Helmholtz, north of SW Obsidian
805	22	24	$555,000	Along SW Obsidian Ave, east of SW Helmholtz Way
512	21	15	$248,000	Along SW Obsidian Ave, west of SW Helmholtz Way
660	14	15	$306,000	Parallel to and approximately 3000 feet east of SW 55th St, south of SW Obsidian Ave
660	14	15	$306,000	Parallel to and approximately 3000 feet east of SW 55th St, south of SW Obsidian Ave
633	11	15	$219,000	Parallel to and approximately 2000 feet west of SW Quartz Ave
1,280	8	15	$390,000	Parallel to and approximately 3000 feet west of SW Quartz Ave
1,320	10	15	$453,000	Parallel to and east of SW 55th St, north of SW Wickiup Ave
1,320	9	15	$449,000	Parallel to and east of SW 55th St, north of SW Wickiup Ave
1,320	9	12	$430,000	Along SW Helmholtz Way, north of SW Wickiup Ave
1,320	17	12	$601,000	Along SW Helmholtz Way, south of SW Wickiup Ave
1,320	26	12	$694,000	Along SW Helmholtz Way, north of SW Coyote Ave
1,320	20	12	$670,000	Along SW Helmholtz Way, north from SW Coyote Ave
1,320	19	12	$666,000	East from the terminus of SW Coyote Ave
650	21	12	$332,000	Parallel to and approximately 1300 feet east of SW Coyote Ave
1,320	17	12	$601,000	Parallel to and east of SW Helmholtz Way, north of SW Elkhorn Ave
1,210	17	10	$550,000	Along SW Elkhorn Ave, west of SW 39th St
350	19	12	$162,000	Parallel and west of SW 43rd St between SW Canal Blvd and SW Elkhorn Ave
778	17	10	$354,000	Along SW Elkhorn Ave between SW 39th St and SW Canal Blvd
1,260	17	10	$573,000	Along SW 39th St between SW Canal Blvd and SW Elkhorn Ave
1,350	17	10	$614,000	East from SW Elkhorn Ave and SW 39th St
655	16	10	$296,000	Parallel to and south of SW Elkhorn Ave, west of SW Canal Blvd
1,098	16	10	$496,000	North from SW Canal Blvd, parallel to SW Helmholtz Way
1,844	16	10	$832,000	Along SW Canal Blvd, northeast of SW Helmholtz Way
46,375			**$24,454,000**	

EXHIBIT 3-6A
Wastewater Collection System Recommended Projects List for UGB Buildout
Redmond Wastewater (Collection System) and Water System Master Plan

Pipelines				
Length (ft.)	**Average Depth of Bury (ft.)**	**Diameter (in.)**	**Total Estimate**	**Location**
West Side Interceptor				
1,950	10	21	$647,000	Along SW 27th Street, between SW Highland Avenue and SW Cascade Avenue
348	8	18	$110,000	Along SW 27th Street, between SW Indian Ave and Juniper
120	8	18	$38,000	Along SW 27th Street, south of Juniper
375	8	18	$119,000	Along SW 27th Street, between Juniper and SW Lava
440	8	18	$139,000	Along SW 27th Street, between SW Indian Avenue and SW Highland Avenue
1,850	11	18	$777,000	Along SW 27th Street, between SW Obsidian Avenue and SW Lava Avenue
2,050	9	18	$726,000	Along SW 27th Street, between SW Salmon Avenue and SW Obsidian Avenue
3,800	9	15	$1,500,000	Along SW 27th Street, between SW Salmon Avenue and SW Obsidian Avenue
10,933			**$4,056,000**	

Far East Interceptor				
50	8	36	$29,000	Link to Redmond Water Pollution Control Facility
220	5	27	$70,000	Link to Redmond Water Pollution Control Facility
100	5	24	$32,000	Link to Redmond Water Pollution Control Facility
212	5	24	$68,000	Parallel to and west of NW Canyon Dr, north of NW Spruce Ave
350	5	24	$111,000	Parallel to and west of NW Canyon Dr, north of NW Spruce Ave
260	5	24	$83,000	Parallel to and west of NW Canyon Dr, north of NW Spruce Ave
180	4	24	$57,000	Along Dry Canyon floor, north of Redmond Water Pollution Control facility
480	8	24	$194,000	Crossing Dry Canyon Ridge, west of NW Upas Ave
2,090	12	24	$1,128,000	Parallel to NW Upas Ave, west of NW 10th St
370	14	24	$202,000	Parallel to and west of NW 10th St, north of NW Upas Ave
1,294	13	24	$703,000	North of NW Upas Ave, crossing NW 10th St
820	13	24	$445,000	Parallel to and east of NW 10th St, south of NW Pershall Way
600	14	24	$328,000	South of NW Pershall Way, east of NW 10th St
445	17	24	$300,000	Parallel to and south of NW Pershall Way, west of Hwy 97
7,471			**$3,750,000**	

EXHIBIT 3-6A
Wastewater Collection System Recommended Projects List for UGB Buildout
Redmond Wastewater (Collection System) and Water System Master Plan

Pipelines				
Length (ft.)	**Average Depth of Bury (ft.)**	**Diameter (in.)**	**Total Estimate**	**Location**
East Side Interceptor				
200	18	27	$135,000	Along BNSF Railroad ROW south of NE King
230	7	27	$97,000	Along BNSF Railroad ROW south of NE King
360	11	27	$180,000	Along BNSF Railroad ROW north of NE Redwood
400	16	27	$242,000	Along BNSF Railroad ROW between NE Redwood and NE Quince
130	17	27	$80,000	Along BNSF Railroad ROW at NE Quince
1,300	17	24	$773,000	Along BNSF Railroad ROW north of NE Negus
1,530	20	24	$1,045,000	West of NE 5th Street north from NE Shoshone
1,350	14	24	$737,000	Parallel and west of 3rd Street from NE Kilnwood Lane to NE Negus
1,250	13	24	$604,000	Along BNSF Railroad ROW north of NE Hemlock to NE Kilnwood Lane
55	10	12	$19,000	Along NE Negus Way, east of the railroad ROW
400	8	12	$129,000	Along NE Negus Way, between NE 11th St and NE 9th St
1,000	13	12	$392,000	Along NE Negus Way, between NE 9th St and NE 7th St
216	10	12	$71,000	Along NE Negus Way, between NE 6th St and NE 5th St
172	12	12	$67,000	Along NE Negus Way, west of NE 5th St
470	10	12	$155,000	Along NE Negus Way, west of NE 5th St
2,600	13	24	$1,257,000	Along BNSF Railroad ROW south of NE Hemlock
1,500	10	24	$712,000	Along BNSF ROW from SE Evergreen Ave to E Antler Ave
3,000	6	18	$822,000	Along BNSF ROW from Kalama Ave to SE Evergreen Ave
2,000	9	18	$829,000	Along BNSF ROW from Kalama Avenue south of SE Evergreen Avenue
4,830	10	18	$2,015,000	From BNSF ROW north of SW Veterans Way, east on SW Veterans Way, then south to SW 6th St and SW Reindeer Ave
2,770	10	8	$825,000	North from the north end of SW 13th St to approximately 1,000 ft west of SW Reindeer Ave
7,200	15	12	$4,778,000	South on SE 13th St continuing south on SE Airport Way, along SE 19th St to city limit
32,963			**$15,964,000**	
Line A				
5,300	20	15	**$2,550,000**	Area west of Cascade View Phase 7 PS, along SW Canal Blvd to SW 27th St

EXHIBIT 3-6A
Wastewater Collection System Recommended Projects List for UGB Buildout
Redmond Wastewater (Collection System) and Water System Master Plan

Pipelines				
Length (ft.)	**Average Depth of Bury (ft.)**	**Diameter (in.)**	**Total Estimate**	**Location**
Line D				
9,900	14	15	**$4,587,000**	South along SW Helmholtz Way, between SW Obsidian Ave & SW Xero Ave, south on SW 46th St south of SW Xero Ave
Line J				
5,750	15	8	**$2,056,000**	East along E Antler Ave from SE Railroad Blvd, south to SE Black Butte Blvd, east on SE Black Butte Blvd, north on SE 6th St, east on E Antler Ave
Line K				
9,790	8	10	**$3,137,000**	East along SE Evergreen Ave from BNSF ROW, south on SE 9th St, then SW on Hwy 126
Line L				
2,730	10	8	**$814,000**	From approximately 1,000 ft west of SW Reindeer Ave to SW 6th St, north of SW Umatilla Ave
Gravity Pipe Replacement				
428	11	12	$165,000	Between Railroad Blvd and SE Franklin Street, between SE Black and SE Cascade
14	5	12	$4,000	Between NW 19th and NW Canyon (W of 2807 NW Canyon & E of 3100 NW 19th)
8	8	15	$3,000	S of 830 NW Maple ln, & N of midpoint of 1334 NW 9th & 1333 NW 8th St
309	8	10	$89,000	E from 365 SE Ridge Way to 545 SE Deschutes (W of Canal)
167	6	10	$42,000	E from South of 649 SE Evergreen Ave block to W of 639 SE Evergreen Ave block
369	6	10	$93,000	half way between 436 and 439 blocks of SE Deschutes Ave to S of 251 SE 5th St
130	7	10	$33,000	E from 545 SE Deschutes Ave (W of Canal) to E of Canal (N of 436 SE Deschutes)
341	6	10	$85,000	S of 251 SE 5th St to N of 211 SE 5th St..
414	7	21	$133,000	Parallel to 2663 to 2545 NW Canyon Dr Property lines. W of these properties
21	10	12	$7,000	Starts halfway between 353 SE Railroad Blvd & 216 SE Railroad Blvd to SW of 216 SE Railroad block
180	10	12	$59,000	NW of 208 SE Franklin St to SW of 228 SE Franklin St (parallel to the W property line of these two blocks). Between 229 SE and 208 SE Franklin St
2,380			**$713,000**	
Grand Total			**$57,494,000**	

EXHIBIT 3-6A
Wastewater Collection System Recommended Projects List for UGB Buildout
Redmond Wastewater (Collection System) and Water System Master Plan

Pipelines				
Length (ft.)	**Average Depth of Bury (ft.)**	**Dia-meter (in.)**	**Total Estimate**	**Location**
Far East Interceptor				
960	17	24	$647,000	Parallel to and south of NE Yucca Ave, between NW Canal Blvd and Hwy 97
1,982	9	24	$806,000	Parallel to and south of NE Yucca Ave, east of NW Canal Blvd
2,420	4	24	$759,000	Parallel to and south of NE Yucca Ave, west of NE 17th St
1,650	7	24	$597,000	Parallel to NE 17th St, crossing NE King Way
910	8	24	$368,000	West from NE Upas Ave, west of NE 17th St
1,290	8	24	$521,000	Along NE Upas Ave between NE 21st Dr and NE 17th St
670	9	24	$273,000	Running north-south, south of NE Upas Ave
627	8	10	$201,000	Running north-south, east of NE Negus Way
177	8	24	$72,000	Running east-west, south of NE Upas Ave and east of NE Negus Way
1,320	8	10	$423,000	Running north-south, east of NE Negus Way
1,301	8	10	$417,000	Running north-south, east of NE Negus Way
1,499	8	10	$481,000	Running east-west, north of NE Maple Ave from NE Negus Way
1,318	8	10	$423,000	Parallel to and east of NE 11th St, north of NE Maple Ave
1,331	8	10	$427,000	Parallel to and east of NE 11th St, south of NE Maple Ave
270	8	24	$109,000	Running east-west, south of NE Upas Ave and east of NE Negus Way
346	8	24	$140,000	Running east-west, south of NE Upas Ave and east of NE Negus Way
350	8	24	$142,000	Running east-west, south of NE Upas Ave and east of NE Negus Way
235	6	24	$85,000	Running east-west, south of NE Upas Ave and east of NE Negus Way
135	4	24	$43,000	Running east-west, south of NE Upas Ave and east of NE Negus Way
1,320	7	18	$413,000	Running east-west, south of NE Upas Ave and east of NE Negus Way
1,320	12	18	$559,000	Running north-south, south of NE Upas Ave
990	11	18	$416,000	Parallel to and south of NE Upas Ave, east of NE Negus Way
1,320	13	18	$635,000	Running north-south, south of NE Upas Ave
1,006	14	10	$448,000	Running east-west, north of NE Maple Ave
1,320	14	18	$639,000	Running north-south, north of E Antler Ave
1,320	7	18	$413,000	Running north-south, north of E Antler Ave
1,012	9	10	$328,000	Running east-west, north of NE Maple Ave

EXHIBIT 3-6A
Wastewater Collection System Recommended Projects List for UGB Buildout
Redmond Wastewater (Collection System) and Water System Master Plan

Pipelines				
Length (ft.)	**Average Depth of Bury (ft.)**	**Dia-meter (in.)**	**Total Estimate**	**Location**
Far East Interceptor, continued				
1,320	4	12	$325,000	Running north-south, north of E Antler Ave
1,045	3	10	$221,000	Running east-west, from east end of NE Maple Ave
1,020	6	10	$255,000	Running east-west, north of E Antler Ave and east of SE 11th St
330	5	12	$82,000	Running east-west, north of E Antler Ave and east of SE 11th St
1,570	8	10	$453,000	Running east-west, north of E Antler Ave and east of SE 11th St
1,320	5	12	$328,000	Running north-south, north of E Antler Ave and east of SE 9th St
1,340	9	12	$436,000	Running north-south, north of E Antler Ave and east of SE 9th St
1,350	6	10	$337,000	Running east-west, north of E Antler Ave and east of SE 9th St
1,360	8	10	$436,000	Running east-west, north of E Antler Ave and east of SE 9th St
1,300	9	10	$421,000	Running north-south, south of E Antler Ave and east of SE 9th St
1,320	6	10	$330,000	Running east-west between Hwy 126 and E Antler Ave, east of SE 9th St
1,320	10	10	$431,000	Running east-west between Hwy 126 and E Antler Ave, east of SE 9th St
1,320	10	10	$431,000	Running north-south between Hwy 126 and E Antler Ave, east of SE 9th St
44,314			**$15,271,000**	

New Pressure Pipe				
6,440	5	6	**$1,406,000**	East from Walnut Ave and NW 38th St to Northwest Way, south along Northwest Way to Upas Ave

Pump Stations				
NA	NA	NA	**$489,000**	Walnut Ave and NW 38th St (Note that 15% was used for engineering estimate in lieu of 10% for this project)

Grand Total	**$17,166,000**

EXHIBIT 3-7
Economic Life for Major Facility Plan Components
Redmond Wastewater (Collection System) and Water System Master Plan

Component Type	Economic Life
Land	Permanent
Wastewater conveyance structures (including collection systems, outfall pipes, interceptors, force mains,)	50 years
Other structures (including lift station structures, and site work)	40 years

EXHIBIT 3-8
Summary of Unit and O&M Costs
Redmond Wastewater (Collection System) and Water System Master Plan

Component	Unit Cost	Construction or Capital Cost	Annual O&M Cost	Unit Cost Source
Land Acquisition (for relatively small and local areas)	$15 per square foot	Capital	$1,350/acre	Residential lot value (available advertisements June 2007)
Acquisition of Permanent Easements	$0.75 per square foot	Capital	$1,000/acre	Industry experience
New and Replacement Pipe ≤ 36-inch Diameter	Based on diameter and depth	Construction	$0.42/linear foot	Industry experience

EXHIBIT 3-9
Pipeline Unit Price Total Construction Costs (Enr Cci = 8626, January 2007)
Redmond Wastewater (Collection System) and Water System Master Plan
(Note: unit prices provided only for diameter/depth combinations in CIP. These unit prices include allowances for General Conditions: 10%, Waste Allowance: 5%, and 25% contingency. Other multipliers are added to each project in the detail cost breakdown in Appendix C.)

	Depth to Bottom of Trench									
Pipe Size	**4 ft**	**6 ft**	**8 ft**	**10 ft**	**12 ft**	**15 ft**	**18 ft**	**20 ft**	**24 ft**	**28 ft**
6" PVC			$176	$202	$229	$274	$316			
8" PVC	$134	$158	$182	$208	$235	$280	$322			
10" PVC		$175	$202	$231	$261	$310	$358			
12" PVC	$149	$176	$203	$233	$262	$312	$360	$359	$398	
15" PVC		$190	$216	$246	$275	$325	$374			
18" PVC		$194	$224	$256	$288	$343	$393	$426		
21" PVC		$255	$290	$265						
24" PVC		$217	$265	$301	$336	$395	$449	$485	$557	
27" PVC		$250	$281	$320	$355	$414	$468	$498	$556	$614
30" PVC		$290	$325	$365	$405	$472	$529	$562	$567	$626
367" PVC		$344	$387	$432	$480	$559	$609	$647	$656	$724

SECTION 4

Water System Plan

4.1 Existing System Description

The City of Redmond operates a community water system serving the residents of the city. The system has been assigned the state and federal Public Water System Identification No. 4100693.

Exhibit 4-1 provides an overview schematic of the system.

4.1.1 Service Area and Population

The Redmond water system serves nearly every resident within the city limits and very few customers located outside of the city limits. Therefore, the service population is considered equal to the city population, which for July 1, 2006, was 23,500 according to the Portland State University Population Research Center.

4.1.2 Water Use

The city's system provides an average of nearly 5 million gallons per day (mgd) of drinking water to the community. Water use has increased significantly over the past 10 years as the population of the city has doubled.

Redmond's demands show a marked increase during the summer months because of outdoor irrigation. The maximum summer day demand is approximately 2.4 times the annual average. The highest recorded single day demand for the system was 11.0 mgd in 2007.

About 75 percent of water use in Redmond system is by residential customers, with the remaining 25 percent used by commercial, industrial, and governmental customers.

4.1.3 Water Supply

The city has obtained 100 percent of its water supply from groundwater through drilled wells since 1988. Prior to that year, the city used a combination of surface and groundwater.

The city holds water right permits and certificates that authorize use of up to 12.8 mgd of water. The city has a pending water right permit application that would allow for an additional 16.2 mgd.

4.1.4 Water Quality, Treatment, and Drinking Water Regulations

The water quality from the city's wells is excellent and requires almost no treatment. The city does add chlorine at each wellhead at a rate of approximately 0.5 milligrams per liter (mg/L). This provides a residual of 0.2 to 0.3 mg/L as a minimum throughout the system. The chlorination systems use 150-pound gas cylinders as their supply.

The city's water quality complies with all current drinking water standards. All recent samples for coliform bacteria, the most general indicator of bacteriological water quality, have been negative, indicating that no bacteria were found. The city typically samples

20 different locations within the system every month for coliform bacteria and to measure chlorine residuals.

It is anticipated that the city's water will comply with the newly promulgated Stage 2 Disinfection By-Products Rule. This rule requires that samples must comply with the standards of 80 micrograms per liter (µg/L) for trihalomethanes and 60 µg/L for haloacetic acids at all locations. To date, the highest measured values in the city's system have been 1.6 µg/L for trihalomethanes and 7.4 µg/L for haloacetic acids. Most samples have been well below these values or even below laboratory detection limits.

4.1.5 Distribution System

The distribution system is divided into three service zones, as described in Exhibit 4-2. The topography generally slopes from south to north so that the highest zone, Zone 1, is located at the south end of the city. Most of the city, including the downtown area, lies within Zone 2. Zone 3 is the lowest elevation zone and is located at the north end of the city. Exhibit 4-3 provides an overview map of the city's existing water system.

4.1.6 Wells and Pump Stations

Redmond currently has six operating wells. Well 6, the most recent, went into production in 2006. For the period of 2000-2005, Wells 5 (40 percent) and 3 (24 percent) contributed the majority of the water to the system. Well 7 has been drilled and tested but was not yet equipped with a pump as of November 2007. The city expects to complete Well 7 in 2008.

Exhibit 4-4 summarizes the pump stations and wells that pump water into the city's system. The system has five booster pump stations. Two of the stations, Forked Horn Butte Pump Stations 1 and 2, provide service to Zone 1 (High Pressure Zone). Another station, Forked Horn Butte Storage Reservoir Pump Station, lifts water from Zone 2 (3180 Zone) into the Forked Horn Butte Storage Reservoir, which has a higher overflow elevation of 3,220 feet.

The Innovation Park Pump Station draws water from Reservoirs 4 and 5, which are supplied by Well 6, and pumps this water into Zone 2. The fifth station is the Antler Avenue Pump Station, containing two sets of pump options; the first allows water to be pumped back into Zone 2 and the second provides fire water to a dedicated fire system that serves a local industrial area.

The city has installed a sufficient number of wells to serve current maximum day conditions and will be bringing Well 7 on line in 2008, which will pump approximately 2,000 gpm into the system. A 5,000-gpm booster pump station and ground level reservoir will be constructed at the Well 7 site in the future to allow for a wide range of flows from average to fire flow to be provided in that portion of the system. Initially, Well 7 will pump directly into the distribution system.

4.1.7 Storage

Distribution storage is provided from five reservoirs, all of which serve Pressure Zone 2. Together, they provide a total of 10 million gallons (MG) of storage, or approximately the city's 2006 maximum day demand. Two 2.0-MG reservoirs are located next to Well 6 in the southeast. Two 2.0-MG reservoirs are part of the Forked Horn Butte System, which is located to the southwest. The fifth reservoir is the Antler Reservoir, located in the east-central area of the city.

4.1.8 Distribution Pipe

Redmond's distribution system is composed of 140 miles of pipelines. This represents about $63 million in replacement costs in today's dollars. Approximately 65 percent of the pipe is polyvinyl chloride (PVC). Approximately 25 percent of the pipe is steel. The remainder includes cast iron, copper, and ductile iron.

As shown in Exhibit 4-5, the pipelines range in diameter from 1 to 24 inches, with roughly half the total number of lineal feel of pipeline 8 inches in diameter. Pipeline materials by diameter are shown in Exhibit 4-6, with corresponding pipeline lengths. The system's pipeline materials are summarized in Exhibit 4-7.

4.2 Design Criteria

Utilities establish design and operating criteria to assure standardization and consistency within the system. Exhibit 4-8 shows the recommended design and operating criteria for Redmond's water system that were updated and compiled as part of this master plan. In some cases, the criteria selections are considered preliminary and the City of Redmond will need to continue to evaluate and finalize appropriate criteria.

A number of design criteria, such as fire flows, storage requirements, and pipe sizing, were used as a basis for determining capital improvement needs for the city's system in this master plan.

Other criteria are not critical for developing a master plan, but do provide guidance to the city for evaluating detailed designs of improvements. These include criteria for hydrant spacing, valve spacing, pipe materials, and emergency power connections for pump stations.

The operating criteria primarily relate to maintaining and using existing facilities. Examples of operating criteria include valve exercising, record keeping, and flushing.

4.3 Water Requirements

4.3.1 Water Use History

This section describes recent water use with Redmond and presents projections for future water use. The projections are based on the population growth estimates presented in Section 2 of this report.

4.3.2 Definition of Terms

Demand refers to total water use, the sum of metered consumption (residential, commercial, governmental and industrial), unmetered uses (for example, fire fighting or hydrant flushing), and water lost to leakage, reservoir overflow, and evaporation.

When discussing daily or annual water use, the terms *demand* and *production* are used synonymously in this report. Both refer to all water supplied to the system, which is the sum of metered and unmetered use. Demand equals production because both terms refer to all water that is delivered from the wells to the distribution system.

Metered use or *consumption* refers to the portion of water use that is recorded by customer meters.

Connection refers to a metered connection to a customer of Redmond.

Unaccounted-for water refers to the difference between production and consumption. Unaccounted-for water includes unmetered hydrant use, other unmetered uses, and water lost to evaporation, reservoir overflow, and leakage. Meter inaccuracies (both production and customer) also contribute to unaccounted-for water.

Specific *demand* terms include the following:

- *Average day demand (ADD):* total annual production divided by 365 days
- *Maximum day demand (MDD):* the highest system demand that occurs in any single day of a calendar year
- *Maximum monthly demand (MMD):* the highest monthly production during a calendar year
- *Peak hour demand (PHD):* highest hourly demand that is experienced

MDD is an important value for water system planning. The wells must be capable of meeting the MDD. If the MDD exceeds the combined supply capacity on any given day, storage levels will be reduced. Consecutive days at or near the MDD will result in a water shortage.

The most common units for expressing demands are million gallons per day (mgd). One mgd is equivalent to 695 gpm or 1.55 cubic feet per second (cfs). Units of million gallons (MG) are also used.

4.3.3 Meter History

All of the city’s water customers have been metered since 1985. The earliest year of data evaluated in this master plan for water requirements was 1975.

4.3.4 Average and Maximum Demands

After remaining nearly unchanged from the late 1970s through 1993, water use in Redmond began to increase at a rapid rate in the mid-1990’s, corresponding to a period of rapid population growth. Exhibit 4-9 displays the service population and ADD for 1977–2005. Exhibit 4-10 and Exhibit 4-11 provide tabular and graphical data for the more recent period of 1997–2005. The ADD nearly doubled during the period of 1993–2005. The highest value of 4.7 mgd occurred in 2004, though the 2005 value was almost equal at 4.6 mgd. The trend for this period was an annual increase of approximately 0.20 mgd (200,000 gallons per day), which represents a growth rate of approximately 5 percent.

Exhibit 4-10 also documents the MDD records for 1997-2005. These are shown graphically in Exhibit 4-12. Over this 9-year period, the MDD has increased from 8.2 mgd (which occurred in both 1997 and 1998) to a high of 10.9 mgd in 2005. The trend for the period has been an increase of 0.34 mgd (340,000 gallons per day) per year.

4.3.4.1 Seasonal Demands

Exhibit 4-13 displays monthly demand records from January 2000 through mid-2006. Outdoor irrigation contributes to significantly higher demands in the summer months. The average winter monthly demand for 2004–2005 (November through March) was 2.1 mgd, while the average summer monthly demand for 2005 (May through September) was 7.4 mgd, or about three and one-half times the average for the winter months.

The MMD has occurred in July or August during the years 2000-2005. The MMD for 2005, which occurred in August of that year, was 9.7 mgd. Since demand is equal to production, by definition, this indicates that the average production from the city's well during this month was 9.7 mgd.

For 2000 through 2005, the water use during the five summer months (May through September) has averaged 68 percent of the total annual use.

4.3.4.2 Peaking Factors

Peaking factors provide a further approach to characterizing the water use within the city. As shown in Exhibit 4-10, the MDD:ADD peaking factor averaged 2.5 for 1997-2005. It dropped slightly to 2.3 for the last 3 full years of record (2003-2005). This peaking is another representation of the additional water use in the summer months for outdoor irrigation.

4.3.5 Per Capita Demands

Per capita values represent the total system demand divided by the service population. Therefore, they include commercial, industrial, and governmental demands as well as residential demands.

Exhibit 4-10 lists the per capita values based on the service population. Exhibit 4-14 displays the per capita ADD values and Exhibit 4-15 displays the per capita MDD values.

The per capita ADD has gradually declined during recent years. The average for 2004 and 2005 was 240 gallons per capita day (gpcd). With greater emphasis being placed on conservation, it is reasonable to estimate future demands using 240 gpcd even though most of the recent years exceeded this value.

The per capita MDD has shown a more consistent decline over the years 1997–2005. The average for the whole period was approximately 650 gpcd. However, the linear regression indicates an annual decline of approximately 20 gpcd and the average for 2004–2005 was 550 gpcd.

For purposes of projecting future demands, the following per capita values (based on the averages for 2004–2005) will be used:

- Per capita ADD = 240 gpcd
- Per capita MDD = 550 gpcd

4.3.6 Consumption

Redmond tracks customer use according to the following three categories: single family residential, multi-family residential, and commercial. Exhibit 4-16 and Exhibit 4-17 display monthly consumption by these three categories for July 2003 through June 2006. Single family residential represents the majority of system use, ranging from 50 to 70 percent of the total. The percentage of use by single family residential customers increases slightly during the summer months. Multi-family residential customers use 10 to 15 percent of the total, and commercial customers use 20 to 30 percent of the total.

4.3.7 Unaccounted-for Water

A comparison of the demand data with the consumption data provides a value for the unaccounted-for water, which is the difference between production and metered use. The percentage of unaccounted-for water equals the production minus the metered use, divided by the production. The causes of unaccounted-for water may include meter inaccuracies, evaporation, reservoir overflows, unmetered hydrant use, unmetered customer use, and leakage.

Exhibit 4-18 illustrates the unaccounted-for water data for June 2003 through May 2006. The data for the years 2004 and 2005 are summarized in Exhibit 4-19.

The monthly values have ranged from approximately -30 percent to +40 percent, with an average of 12 percent. It is believed that the negative values occur because the meter readings are not aligned exactly with the first and last days of each month. (The consumption values were shifted back by 1 month to align more closely with the timing for the production values, but this did not align the two sets of figures exactly.)

The amount of unaccounted-for water in calendar year 2004 was 317 MG, which was 18 percent of production. In calendar year 2005, these values were 238 MG or 14 percent.

The average of 12 percent for June 2003–May 2006 exceeds the Oregon Water Resources Department’s (OWRD’s) goal of 10 percent or less for unaccounted-for water for municipalities. In addition, the city’s values for 2004 and 2005 averaged higher, at 16 percent. Because of this, the city will be required to develop benchmarks to reduce the rate of unaccounted-for water when it develops a Water Management and Conservation Plan. OWRD will require the city to submit a Water Management and Conservation Plan when the city implements water rights actions, such as claims of beneficial use or transfers. The city is working toward reducing the unaccounted-for water rate in advance of preparing the plan. The city began to implement an automatic meter reading (AMR) in 2007, a program that will provide specific information for tracking customer use patterns and unaccounted-for water. The city also began to require hydrant meters when hydrants are being used for construction.

4.3.8 Projected Water Demands

The approach to projecting water demands was presented in Section 2, with a summary of projection criteria provided in Exhibit 2-2. The projections are based on an average per capita use of 240 gpcd and a maximum per capita use of 550 gpcd. They assume a UGB buildout population of 58,000 and that this population is reached in 2030.

Using these values, water demands in Redmond are expected to nearly triple from 2005 to 2030. The ADD is projected to increase from 5.0 mgd in 2005 to 14 mgd in 2030. The MDD is projected to increase from 11.6 mgd in 2005 to 32 mgd in 2030. Exhibit 4-20 illustrates the average and maximum day projections to 2030.

4.4 Regulatory Review

Community water systems are governed by rules developed by the U.S. Environmental Protection Agency (EPA) for implementation of the Safe Drinking Water Act Amendments. Oregon, as a primacy state, is required to implement water quality regulations at least as stringent as EPA's rules. For the most part, Oregon has adopted identical regulations to those at the federal level. Additional Oregon rules are highlighted in this section.

Because Redmond's water system uses only groundwater, the only applicable regulations are those related to groundwater and the distribution system. Redmond complies with all current state and federal standards.

4.4.1 Groundwater Rule

All of Redmond's water supply is obtained from groundwater. The city currently uses six wells, with a seventh to begin service in 2007. All of the wells are considered to withdraw from the same aquifer. The city's groundwater source is subject to the recently adopted federal Groundwater Rule. It was published in the federal register on November 8, 2006. It requires the following actions:

1. **Sanitary surveys**. States must conduct sanitary surveys by December 31, 2012, for community systems with groundwater sources to determine if the system has significant deficiencies. The rule states that significant deficiencies "include, but are not limited to defects in design, operation, or maintenance, or a failure or malfunction of the sources, treatment, storage or distribution system that the State determines to be causing or have the potential for causing the introduction of contamination into the water delivered to consumers." Although EPA received comments during the rule development that indicated the word "potential" was too general and that the sanitary survey requirement allowed for individual states to interpret the rule differently from one another, the sanitary survey component was included in the final rule. The implications of this aspect of the rule are uncertain because of the subjectivity that is involved.

   Corrective actions, consisting of treatment improvements or wellhead improvements, are required if significant deficiencies are identified. These deficiencies may either be determined by the state during the sanitary survey process or based on the presence of fecal coliform in source water sampling (see item that follows).

2. **Source water monitoring**. Additional source water sampling will be triggered if total coliform bacteria are detected in the source water. The rule stipulates that a groundwater system with a positive total coliform sample, unless it provides 4-log treatment of viruses, must conduct sampling of each groundwater source for fecal indicators (E coli, enterococci, or coliphage). The discussion of treatment to achieve 4-log inactivation of viruses is provided below.

3. **Treatment technique requirements**. The rule requires groundwater systems to comply with treatment technique requirements if a significant deficiency is identified during the sanitary survey or if the system tests positive for fecal contamination during the follow-up monitoring.

4. **Compliance monitoring**. If treatment is required, the water system must conduct compliance monitoring to demonstrate treatment effectiveness.

Redmond currently applies chlorine at each wellhead. However, some of the city's wells pump directly to customers, rather than through a storage tank first. Therefore, the contact time between the point of chlorine addition and use of the water may be insufficient to guarantee a 4-log inactivation of viruses, if this level of treatment was required. The Groundwater Rule could impact Redmond's system by requiring this level of treatment. This possibility seems remote because the city has had no recent total coliform positive samples, the wells are relatively deep and appear to have been constructed using proper techniques to protect against contamination, and the state has not identified other concerns in past sanitary surveys.

4.4.2 Distribution Regulations

4.4.2.1 State Requirements

Oregon's drinking water regulations have requirements that indirectly relate to distribution water quality, including backflow prevention program rules, operator certification rules, and product acceptability criteria.

In general, the state's rules govern the quality of water and not the manner in which it is distributed. However, the rules do contain a limited number of standards with storage and piping criteria:

- Distribution piping shall be designed and installed so that the pressure measured at the property line of any user shall not be reduced below 20 pounds per square inch (psi) (Oregon Administrative Rule [OAR] 333-061-0050(9)(e)).
- Wherever possible, dead ends shall be minimized by looping. Where dead ends are installed, blow-offs of adequate size shall be provided for flushing (OAR 333-061-0050(9)(h)).
- Wherever possible, distribution pipelines shall be located on public property. Where pipelines are required to pass through private property, easements shall be obtained from the property owner and shall be recorded with the county clerk (OAR 333-061-0050(9)(a)).
- Wherever possible, booster pumps shall take suction from reservoirs to avoid the potential for negative pressures on the suction line, which could result when the pump suction is directly connected to a distribution main. Pumps that take suction from distribution mains shall be provided with a low-pressure cutoff switch on the suction side set at no less than 20 psi (OAR 333-061-0050(8)(a, b)).

The state's rules also include construction standards that must be met when new projects are designed and constructed. Construction standards are found in OAR 333-061-0050. Redmond generally complies with all of these standards. The recommended projects list in this master plan includes some new pipelines to reduce the number of dead end lines.

4.4.2.2 Federal Regulations

Redmond complies with the following federal regulations related to water distribution:

- Total Coliform Rule (TCR) (1989)
- Lead and Copper Rule (1991)

There is one new rule that regulates distribution water quality, the Stage 2 Disinfection By-Product Rule (Stage 2 DBP Rule). This rule was promulgated in 2006.

Total Coliform Rule. The TCR's primary goal is to maintain microbial quality in finished and distributed drinking water supplies. Total coliform includes both fecal coliform and *E. coli.* The maximum contaminant level goal (MCLG) for total coliform was set to zero. Compliance with the maximum contaminant level (MCL) is based on the presence or absence of total coliform in a sample (as opposed to coliform density as in previous rules). Redmond is required to collect a minimum of 20 samples per month, based on its service population. Redmond has complied with the TCR since its promulgation.

Lead and Copper Rule. The Lead and Copper Rule applies to all community water systems. The rule developed MCLGs and action levels for both lead and copper in drinking water. The major difference between this regulation and other distribution regulations is that the water must be monitored at customers' taps, not at sampling stations. Lead and copper monitoring must initially occur every 6 months and twice each calendar year at locations with the highest risk of contamination resulting from the following:

- Piping with lead solder installed after 1982
- Lead water service lines
- Lead piping in buildings and homes

For compliance, the samples at the customers' taps must not exceed the following action levels:

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

Redmond has consistently complied with the Lead and Copper Rule. Since 1993, the city has conducted eight rounds of sampling. The highest 90th percentile concentration for lead was 0.0031 mg/L, well below the action level of 0.015 mg/L. The highest 90th percentile copper concentration was 0.09 mg/L, well below the action level of 1.3 mg/L.

Because of compliance with the lead and copper action levels, Redmond is on a reduced sampling schedule. Repeat sampling is required only every 3 years.

Stage 2 Disinfection By-Product Rule. The purpose of the Stage 2 DBP Rule is to reduce peak disinfection byproduct concentrations in the distribution system and eliminate areas where customers receive excessive levels of DBPs. DBPs include trihalomethanes (THMs) and haloacetic acids (HAA5). The concentrations of DBPs fluctuate based on changes in raw water quality, variations in treatment, chlorine concentrations, and water age, and have been found to vary geographically in distribution systems. Previous rules governing DBPs determined compliance based on an average for samples collected throughout the distribution system. This averaging meant that some geographic locations could occasionally or even regularly exceed the MCLs for DBPs, and yet the system remained in compliance. The Stage 2 DBP Rule eliminates this possibility by requiring compliance at all geographic locations. The rule requires the following:

- Completion of an initial distribution system evaluation (IDSE) to determine sites with high DBPs. This evaluation report is due 2 years following promulgation of the final rule. Redmond has applied for a waiver, titled 40/30 certification, which reduces the amount of monitoring required for the IDSE. To qualify for 40/30 certification, every individual sample taken during Stage 1 monitoring must have total trihalomethane (TTHM) concentrations ≤ 40 µg/L, and five regulated total haloacetic acids (HAA5) concentrations ≤ 30 µg/L. Redmond should qualify for this 40/30 certification because the highest values measured to date are 7.4 µg/L for TTHMs and 1.5 µg/L for HAA5.

- Compliance with TTHM and HAA5 MCLs of 80 and 60 µg/L, respectively, based on a locational running annual average (LRAA). Average concentrations of TTHMs and HAA5s at each sampling site must comply with the MCLs. Compliance will be in two stages. Stage 2A allows for relaxed MCLs at each location. Stage 2B, which is proposed to begin 6 years following promulgation, will require compliance with the current MCLs of 80 µg/L for TTHMs and 60 µg/L for HAA5s at all locations. Redmond should comply with these requirements based on the historically low values that have been measured in the system.

4.5 Supply Analysis

4.5.1 Water Supply Description

Before 1988, the City of Redmond obtained drinking water from a combination of surface water and groundwater sources. In 1988, the city converted its system to obtain 100 percent of its drinking water supply from groundwater wells completed hundreds of feet deep.

The city's groundwater supply is composed of six production wells, with a seventh to begin operation in 2008. Exhibit 4-21 provides a description of the main features of the city's wells. Water well reports or drilling logs are included for Wells 1-7 in Appendix E. The well locations are shown in Exhibit 4-3. The wells have generally been sited to minimize interference with one another and to provide water throughout the distribution system. Their locations were also selected based on property ownership and availability.

The wells range in depth from 330 to 860 feet below ground surface (bgs) in a highly permeable volcanic and sedimentary sequence known as the Deschutes Formation. The oldest well in the system, Well 1, was drilled in 1969 and is the shallowest well (330 feet deep) in the system. According to the water well report for this well, the surface seal is 1 inch in thickness, which does not meet the current well construction standards of a 2-inch minimum seal thickness. It also has a lower production rate (approximately 800 gpm) than other wells in the system. This is likely because of its relatively shallow depth. In contrast, the most recently drilled well, Well 7, completed in 2006, is 862 feet deep and pump tests conducted on this well indicate it can yield up to 3,000 gpm and possibly more.

The surface facilities at each well location consist of a pump house that encloses the automated controls, mechanical systems, and chlorination systems. The chlorination systems are housed in separate rooms containing 150-pound gas cylinders. In normal operations, wells are cycled on and off to meet system demands. During start up periods, water produced in the first few minutes after the wells are operating, is pumped to waste into dry wells located outside the pump houses.

Based on a review of Oregon water well reports and a tour of the facilities, all of the city wells appear to be in good condition and suitable for continued use.

4.5.2 Well Production History

As illustrated in Exhibit 4-22, Wells 3, 4, and 5 have contributed the majority of the water to the system since 1999. The operators manually select the active wells, which then start and stop based on reservoir levels and pressures within the system.

4.5.3 Water Rights

4.5.3.1 Introduction to Oregon Water Law

Under Oregon water law, with few exceptions, the use of public water (both ground and surface water) requires a water right permit from the OWRD. The administration of water rights by OWRD is based on the doctrine of prior appropriation. Under this doctrine, in times of shortage the first person to have obtained a water right permit (the senior appropriator) is the last to be limited in low water conditions. The date of application for the water right permit usually establishes the "priority date" or place in line of an appropriator. In water-short times, the senior appropriator can demand the full amount of their water right regardless of the needs of junior appropriators. If there is surplus beyond the needs of the senior appropriator, the next most senior appropriator can take as much as needed to satisfy their right and so on down the line until there is no surplus. A state officer (OWRD Watermaster) oversees which junior appropriators must stop using water so that senior users can be satisfied.

In addition to monitoring water uses to protect senior water rights, OWRD seeks to conjunctively manage the state's surface water and groundwater users. In many areas groundwater and surface water interact—using one source may impact users of another. Where a junior groundwater appropriator may impact a senior surface water appropriator (due to quantified pumping impacts on the surface water source) OWRD may have authority to regulate the junior groundwater appropriator. In the Deschutes Basin, this comes into effect largely through OWRD's effort to protect surface water rights designated to protect fishery resources in the Deschutes River and its tributaries (instream water rights) and streamflows established to meet the objectives of the Deschutes River State Scenic Waterway. Under current OWRD rules, new groundwater uses in a large portion of the Deschutes Basin (including the Redmond area) require mitigation to off-set potential impacts to surface water flows on the Deschutes River and its tributaries.

The right to use water is first granted in the form of a water use permit. The permit describes the priority date, the amount of water that can be used, the location and type of water use, and often a number of water use conditions. The permit allows the water user to develop the infrastructure needed to put the water to full beneficial use. When the report of beneficial use, called a Claim of Beneficial Use (COBU), is approved by OWRD, a water right certificate is issued confirming the status of the right. Obtaining a water right certificate is the best way to ensure the protection of the use. Municipal water use certificates are not subject to cancellation due to non-use.

Water right permits typically have timelines for making full beneficial use of the water. If more time is needed than provided in the permit, the permit holder may request an extension of time from OWRD. In the past, extensions of time were routinely granted by OWRD. Under current rules, an extension of time may involve an analysis of what would happen to state and federally listed fish species if the undeveloped portion of the permit were to be used.

There are two different application processes that allow modification of a water right. When a water right is in the permit phase (still being developed), through an application for a permit amendment, the permit holder may modify the water use by changing the location of use and the point where water is appropriated. Under a water right certificate, through an application for a water right transfer, the water right holder can modify the location of use, the point where water is diverted and the type of use made under the water right.

4.5.3.2 City of Redmond Water Rights

The City of Redmond holds several water rights that authorize the use of groundwater, surface water, and water stored in the city’s sewage effluent storage reservoir. Overall, based on its water rights and water sources, the City of Redmond appears to have a favorable water supply outlook. Exhibit 4-23 provides a summary of these water rights and their current status.

4.5.3.3 Existing Municipal Use Groundwater Water Rights

As described above, the city uses groundwater for 100 percent of its municipal water supply needs. Under currently-held municipal use groundwater permits and certificates, the city is authorized to appropriate 8,920 gpm or 12.84 million gallons per day. These water rights authorize the city to use a variety of wells, and, depending on the specific water right, allow use of a combination of Wells 1 through Well 6. Over time, steps have been taken to add additional wells to the city’s existing water rights to ensure the maximum development of the water rights and to provide flexibility in how the city appropriates and delivers water. For example, a recent water right transfer (T-10162) added Well 6 to certificates 80232 and 80233 and permit amendment application T-10163 proposes to add Well 6 to permit G-12401.

A comparison of the capacity of Wells 1–7 (approximately 19.4 mgd) to the amount of water authorized under existing municipal use groundwater rights (12.84 mgd) indicates that the city is limited by water rights and not well production capacity. The city’s recent maximum day demand of nearly 12 mgd is approaching the 12.84 mgd water rights limitation. The city has taken steps to address this by submitting new municipal use groundwater permit applications.

The city’s existing municipal use groundwater permits and certificates vary in priority date from September 5, 1969, to November 25, 1991. None of these existing rights are subject to OWRD’s mitigation requirements in the Deschutes Basin. The most junior (that is, the newest) of these permits (permit G-12401, priority date November 25, 1991) does contain a condition that may allow OWRD to regulate the use in favor of the Deschutes River State Scenic Waterway flows. However, this condition (which is in several permits in the basin) has not been implemented by OWRD to date.

Given the relative seniority of the city’s existing water rights, and as described below in more detail, the stable and sustainable aquifer in the Redmond area, it is unlikely that the city’s existing municipal use groundwater rights will be subject to regulation by OWRD for senior users.

As seen in the water right summary, Exhibit 4-23, the majority of the city's municipal groundwater water rights are in the midst of one regulatory process or another at OWRD, ranging from the potential need for an extension of time to needing a Claim of Beneficial Use approved and a certificate issued. The greatest protection afforded by Oregon water law lies in obtaining water right certificates, which lock-in the city's place in the water appropriation line and its privileges as a municipal water provider. Therefore, all water right processes should be diligently tracked and completed by the city to ensure the protection of its existing water rights.

4.5.3.4 Pending Municipal Use Groundwater Water Right

The city's maximum day demand reached 11 mgd in 2007, which is approaching its groundwater water rights limit of 12.84 mgd. In anticipation of the need for additional water rights capacity, in January 1999, the city submitted Application G-14908. Application G-14908 requests the use of 25 cfs (16.16 mgd) for municipal use within the City of Redmond. The application proposes a combination of existing well capacity associated with Wells 1–7 and future Wells 8–11. As described in Subsection 4.5.4, the aquifer serving the city appears to have sufficient capacity to support development under Application G-14908. OWRD was still reviewing the application in November 2007 when this plan was being completed. It is expected that the permit will be issued in the spring of 2008. Application G-14908, in combination with the city's existing permits and certificates, will provide the city with 29 mgd of water rights capacity.

Application G-14908 is subject to OWRD's Deschutes Basin Groundwater Mitigation rules, which means that prior to permit issuance the city will need to provide mitigation to off-set potential groundwater pumping impacts on the Lower Deschutes River. Under OWRD's mitigation rules, holders of municipal water use permits can either provide mitigation all at once or provide it incrementally to coincide with incremental permit development. As part of Application G-14908, the city is required to have an approved mitigation plan on file with OWRD that describes where mitigation will come from and the planned amounts and timing of mitigation.

Mitigation is typically provided through the transfer of irrigation water rights to instream use. The city's proposed mitigation will come from a combination of city-held surface water irrigation rights and surface water irrigation rights acquired through the Central Oregon Water Bank, a partnership between Swalley Irrigation District, Central Oregon Irrigation District (COID), the Deschutes River Conservancy, and several mitigation buyers including the City of Redmond. Under the current mitigation rules, mitigation is based on the consumptive use portion of the proposed use, measured in acre-feet. Therefore, new groundwater permits in the Deschutes Basin that provide mitigation are generally not subject to regulation in favor of senior surface water users or the Deschutes River State Scenic Waterway.

4.5.3.5 Mitigation Requirements[1]

A joint study of ground water resources in the upper Deschutes Basin by OWRD and the U.S. Geological Survey (USGS) determined that there is a direct hydraulic connection

[1] The information in this subsection was substantially provided by Newton Consultants, Inc., via their email (November 2007) to the City of Redmond, and is used with permission.

between groundwater and surface water within the Deschutes Groundwater Study Area (Gannett et al., 2001). The OWRD concluded that groundwater uses within the study area have potential for substantial interference with surface water rights and will measurably reduce scenic waterway flows unless mitigation is provided in accordance with the Oregon Administrative Rules Chapter 690, Division 505.0600. Groundwater permit applications filed with the OWRD after 1995 must therefore account for mitigation requirements in accordance with OAR 690.505.0600.

Mitigation is intended to offset the impacts of groundwater withdrawals on surface water flows. Mitigation can be accomplished by obtaining mitigation credits or by implementing a mitigation project that generates and transfers mitigation water to instream use.

A mitigation credit is a unit of measure to account for mitigation water, in acre-feet, made available by a mitigation project. One mitigation credit is one acre-foot of mitigation water. Mitigation credits can be purchased from the Deschutes Water Exchange. OWRD awards 1.8 mitigation credits (1 acre-foot = 1 mitigation credit) per acre of irrigation water right. Mitigation credits are determined and awarded by the OWRD according to OAR 690-521. Mitigation does not apply to the total volume of groundwater withdrawn from an aquifer. The mitigation obligation is determined according to the amount of a ground water withdrawal that is actually consumed (consumptive use).

Consumptive use is the OWRD's determination of the amount of a groundwater use that does not return to the hydrologic system in the Deschutes Basin. Consumed groundwater is water that is lost to the basin through transpiration, evaporation, or movement to another basin. Consumptive use is determined by multiplying a consumptive use factor times the total annual volume of groundwater to be beneficially used under a ground water permit. The consumptive use factor generally applied by OWRD to average, year-round municipal and quasi-municipal use is 40 percent. A factor of 40 percent is the consumptive use factor in OWRD's Proposed Final Order for Redmond's water right application G-14908.

The City of Redmond's calculated consumptive use in 2005 and 2006 was 49 and 50 percent, respectively. These figures are derived from the city's monthly well water production, wastewater flow, and the reclaimed water use data for the 2005 and 2006 water years shown in Appendix F. These are preliminary calculations. Based on further discussions with OWRD, a factor ranging from 40 to 50 percent may be applied to application G-14908.

Any proposed new ground water permit issued by OWRD will require mitigation to offset potential groundwater pumping impacts. Therefore, the City of Redmond will need to provide mitigation for groundwater withdrawals under new permits that will allow withdrawals to exceed 12.84 mgd, the city's capacity under its current water rights.

As illustrated in Exhibit 4-13, the city's water use varies significantly according to season. The maximum day demand, which occurs in July or August, may be four times the minimum use during the winter months. Water rights must be sufficient to meet the maximum day demand. The city's projected maximum day demand in year 2030 is approximately 32 mgd. This value slightly exceeds the sum of the city's existing water rights (12.84 mgd) plus permit application G-14908 (16.16 mgd), which together total 29.00 mgd.

The mitigation obligation is based on the annual production under the water right. For example, if the city withdrew 5,000 acre-feet under permit G-14908, the mitigation obligation would be 2,500 acre-feet (or 2,500 mitigation credits) based on a consumptive use factor of 50 percent. In this case, the corresponding number of irrigation water rights that would be needed (based on 1.8 mitigation credits per acre of irrigation water right) would be 1,389 acres.

The city currently holds 1,106 acres of surface water rights with the COID and plans to transfer these water rights to instream use in order to provide mitigation for water withdrawals under new permits. With respect to the preceding example, the city would be able to meet 1,106 acres of its mitigation obligation by means of these surface water rights, leaving 283 acres (1,389-1,106+283) that would require additional mitigation purchases. The true mitigation purchase required depends on the final consumptive use factor and actual demands within the city.

4.5.3.6 Other City of Redmond Water Rights

In addition to the municipal use groundwater rights described above, the city holds existing surface water rights for approximately 339 acres of irrigation and 767 acres for municipal uses via the COID. The city also has a pending groundwater application for irrigation of 94.2 acres and municipal use at the Juniper Golf Course. Permit issuance for this application will be contingent upon the city providing mitigation under OWRD’s mitigation rules for the Deschutes Basin. Finally, the city holds a municipal use surface water right (Certificate 2016, priority date April 22, 1912) that authorizes the use of up to 2 cfs (1.29 mgd) from the Deschutes River.

4.5.4 Description of the Aquifer

All of the city wells are completed in a thick sequence of interbedded volcanic lava flows and sediments known as the Deschutes Formation. This sequence is composed of highly permeable volcanic and sedimentary deposits that are the most highly used groundwater bearing units in the Deschutes Basin (Gannett and Lite, 2004). The geology of the Deschutes Formation may vary locally, but overall, the high permeability of the geologic materials makes it a reliable aquifer. The consistently high well yields from the city’s wells reflect the uniform productivity of this geologic formation. The most significant factor controlling well yield in the Redmond area appears to be the depth of the wells.

The hydraulic characteristics of the city wells have been estimated by pumping tests conducted at Wells 3 and 4. A pumping test at Well 3, documented by the United States Geological Survey (Gannett et al. 2001), consisted of pumping the well at approximately 1,100 gpm for 3 days and monitoring the response in the pumping well and an observation well located 350 feet away. After three days of pumping, the drawdown in the observation well was less than 0.2 feet, and the measured drawdown in the pumping well also was low and dominated by well losses. The resulting analysis of the tests at Wells 3 and 4 provide estimated transmissivities from 10^3 to 10^5 feet^2/day, and storage coefficients in the range of 10^{-2}. The storage coefficient values are questionable given minimal drawdown measured in the pumping tests. Regardless, the hydraulic parameters for the aquifer are consistent with the geologic materials and reflect the high permeability of the aquifer and the resulting high well yields.

4.5.4.1 Groundwater Recharge and Flow

Groundwater in the Deschutes Basin is recharged primarily by infiltration of precipitation (rainfall and snowmelt), leakage from canals, infiltration of irrigation water that has percolated below the root zone, and leakage from streams. Additionally, stormwater drainage wells are commonly used to manage stormwater runoff. The volume of recharge from these drainage wells is not significant compared to other recharge sources; however this water could affect groundwater quality because of chemicals in urban stormwater runoff related to street and parking lot runoff, fertilizers, and pesticides.

Groundwater flow maps compiled by the USGS (Gannett and Lite, 2004) indicate the general direction of groundwater flow beneath the city is westerly toward the Deschutes River. The hydraulic gradient appears to be very low in this area because of the high permeability of the aquifer materials, the relatively flat topography, and the distance from significant recharge areas such as Newberry Crater and the Cascade Mountains. On a localized scale, this general flow pattern may be modified by recharge from canal leakage, groundwater pumping, and changes in formation permeability.

4.5.4.2 Groundwater Fluctuations and Long-Term Water-Level Trends

Groundwater levels in the Deschutes Basin fluctuate in response to seasonal and long-term variations in natural recharge, canal leakage, and operation of pumping wells. In managing the groundwater resource, it is important that that water-level trends are evaluated to identify whether groundwater levels are stable or declining. Declining groundwater levels may indicate that groundwater withdrawals exceed recharge rates, which could affect the long-term sustainability of the groundwater supply.

At this time, there are no data that indicate long-term water-level declines are occurring. The USGS reports that water levels in the Bend and Redmond area show no influence from groundwater pumping (Gannett, et al. 2001). Large amounts of groundwater in these areas are pumped, yet no pumping-related seasonal or long-term trends are apparent in observation wells. It is likely that pumping impacts are low and are masked by the effects of canal leakage and natural variability of recharge.

4.5.4.3 Groundwater Quality

Groundwater quality from the Redmond wells is excellent with no reports of taste or odor problems. A comprehensive water quality study of the Upper Deschutes Basin included a sample from the Redmond area (Caldwell et al., 1997). The results indicate low groundwater temperatures (52°F), and low total dissolved solids and hardness. Routine sampling conducted by the city confirms published findings that natural groundwater quality is high and well suited as a public water supply.

City staff indicated that water pumped from Well 2 degases (bubbles) when it reaches atmospheric pressures. Testing conducted by the city indicates that the water is releasing oxygen and it is not methane or other gases. This condition is typically caused by cracks or leaks in pump columns; however, the city reports this has occurred since the well was first put in service and has not decreased with pump replacements. Regardless of the source of the air bubbles, the city should be aware that entrained air in a piping system may cause excessive corrosion of piping.

A source water assessment report for the city was completed in May 2005 by the Oregon Department of Human Services Drinking Water Program and Oregon Department of Environmental Quality Water Quality Division. This report provides information on the wells and aquifer conditions that are used to reach conclusions about the susceptibility of the drinking water source to contamination. The findings indicate that Wells 1, 2, and 3 are considered highly sensitive to contamination. This determination was made because of the following factors:

- Substandard surface seal thickness at Well 1
- Unconfined nature of the aquifer and high permeability of the overlying soils
- Detections of low concentrations of organic compounds measured in 1993 (chloroethylene in Well 2 and dichloromethane in Well 3)
- Occurrence of nitrate, below the MCL but above typical background levels, at Wells 1 and 2

Additionally, the city reported that a low concentration of chloroethylene was also measured in Well 7 during the water quality sampling that was conducted following completion of the well drilling in 2006.

All chemical detections have been below applicable drinking water standards and have not been considered health concerns. However, the presence of these chemicals in groundwater indicates recharge from a nearby, human-influenced surface source and suggests that wells may be subject to surface contamination.

Because of the highly permeable nature of the geologic materials in the Redmond area and the apparent lack of a protective confining layer above the aquifer, the aquifer is vulnerable to potential contamination from leaking fuel tanks, stormwater injection wells, industrial activities, and agricultural activities in the vicinity of or upgradient of the wells. The state's evaluation concluded that at least some wells are highly susceptible to surface contamination.

4.5.5 Supply Conclusions and Recommendations

The existing wells operated by the city provide an excellent long-term public water supply. The aquifer that provides groundwater to the city's wells is large in areal extent and is highly permeable. Annual recharge to the aquifer is high and measurements of long-term water level trends by the USGS show no apparent declines in groundwater levels that would suggest water is being over-appropriated. Additionally, the quality of water is excellent and highly suited as a public water supply.

Based on the research completed for this water master plan, no critical near-term improvements were identified. However, the following management actions are recommended to help protect both the quantity and quality of this valuable water supply:

1. Develop and implement a drinking water protection plan to reduce the potential for contamination of the groundwater supply. As described in the preceding paragraphs, the city's wells are susceptible to surface contamination. The city's groundwater supply is a critical and valuable resource—it is incumbent upon the city to initiate protective actions to minimize the potential for negative water quality impacts to this supply. Past

detections of trace levels of organic contaminants coupled with the state's assessment that at least some wells are highly susceptible to surface contamination underscore that preemptive actions by the community are of paramount importance. Groundwater protection plans include strategies that focus on public education and implementation of best management practices (BMPs) for businesses, households, and stormwater management. Examples of BMP categories include:

- Employee education on spill response
- Pollution prevention tax credits to encourage responsible behaviors by commercial facilities
- Investigation of privately held wells located in and near the city, particularly those up-gradient of the city's wells, to determine whether they pose a potential pathway of contamination into the aquifer. If they are abandoned, make sure that abandonment has been performed in accordance with state regulations.
- Household hazardous waste collection to encourage responsible behaviors by citizens
- BMP fact sheets for businesses (dry cleaners, auto repair shops, and other potential sources of pollutants)

In developing its groundwater protection plan, Redmond should recognize that the time of travel map provided by the Oregon Drinking Water Program may imply a greater level of certainty than can be reasonably asserted from the data and approach used to develop the map. The time of travel bands are shown to be quite narrow. In reality, the 2-year, 5-year, and 10-year influence areas may be much larger. This uncertainty has implications for the land use activities in the influence zones and the actions that the city might undertake to protect its groundwater resource. Protective actions should extend beyond the narrow bands shown on the time of travel map.

The State of Oregon currently does not require a formal protection program. However, many communities in Oregon are implementing these programs on a voluntary basis. Communities that have developed drinking water protection strategies include Medford, Portland, Salem, Sandy, and Springfield.

2. Implement a water level monitoring program at non-pumping wells in the Redmond vicinity to track long-term groundwater level trends. While there is no empirical evidence that water levels are declining in the Redmond area, early detection of such trends is critical to implement management actions to prevent significant declines. Declining groundwater levels may become a local and regional concern as recharge from the irrigation canals is reduced by the replacement of canals with pipelines. At a minimum, water levels should be measured and recorded semi-annually (in the fall and spring) at three to four locations within the city to understand the seasonal fluctuations caused by recharge and withdrawals.

4.5.6 Planned Expansion of the City's Groundwater Supply

The city plans to incrementally expand its well supply to meet projected growing demands. This is illustrated in Exhibit 4-24, which displays both firm and total well production capacity compared to the projected maximum day demand. Firm capacity represents the total capacity minus the production from largest single well (as of 2007, Well 5 at 3,000 gpm). It is recommended that the city use firm capacity as the basis for planning new additions, as shown on this chart, because it is reasonable to expect that one well may be off-line for mechanical repairs or other reasons. With seven (and eventually, more) wells, it cannot be assumed that all wells will be available 100 percent of the time. The firm capacity planning approach also provides the city with a backup plan should contamination be found in a well. This would allow the city to remove such a well from service while still having capacity to meet demands within the city.

Following completion of Well 7 (scheduled for 2008), the expansion plan identifies that the next increment of supply will come from replacing Well 1 with a new well (Well 8) at the same location. Well 8 should be drilled to a depth of approximately 600 to 800 feet and constructed with a 16-inch well casing. It is recommended the outer annulus is sealed to a depth of at least 300 feet. To meet projected demands, Well 8 should come on line by 2011.

Well 9 is needed by 2015. The planned location for Well 9 is near the school site in the southwest area of the city, near SW Elkhorn Avenue and SW 43rd Street. This location is strategic from the standpoint of providing fire flows to this area. The area is somewhat isolated topographically, because of Forked Horn Butte, and it would otherwise be expensive to install a looped pipe system with sufficient capacity to meet fire flows.

As indicated in Exhibit 4-24, Wells 10, 11, and 12 will be needed to provide adequate supply to meet UGB buildout demands. These wells are needed by 2020, 2024, and 2027, respectively, to meet the projected maximum day demand. It is anticipated that at least Well 10, and possibly Well 11, will be located on the west side of Dry Canyon to increase the supply on that side and to reduce the need for additional pipe connections across the canyon. Locating Wells 10 and 11 on the west side of the canyon will increase system reliability since the west side will not be so dependent on Wells 2-6, which are all located east of the canyon.

The exact well locations can be flexible, dictated by factors such as the location of growth within the city, property availability, wellhead protection zoning and concerns, location of distribution mains, and hydrogeologic factors. The city should, however, purchase well sites many years prior to the projected dates for when the wells are needed to obtain sites that are favorable for meeting these criteria.

4.5.7 Water Supply References

Caldwell, R.R. and Triune, M. 1997. *Groundwater and Water Chemistry Data for the Upper Deschutes Basin, Oregon.* U.S. Geological Survey Open File Report 97-197.

Gannett, M.W. and Lite, Jr., K.E. 2004. *Simulation of Regional Groundwater Flow in the Upper Deschutes Basin, Oregon*. Water Resources Investigation Report 03-4195.

Gannett, M.W., Lite, Jr., K.E., Morgan, D.S. and Collins, C.A. 2001. *Groundwater Hydrology of the Upper Deschutes Basin, Oregon*. Water Resources Investigation Report 00-4162.

Lite Jr. K.E., and Gannett, M.W. 2002. *Geologic Framework of the Regional Groundwater Flow System in the Upper Deschutes Basin, Oregon*. Water Resources Investigation Report 02-4015.

4.6 Distribution System Analysis

The distribution system was evaluated under existing and future conditions using a hydraulic modeling software package. A hydraulic model is an electronic representation of the pipe and facilities included in a distribution system. The model is used to predict flows and friction losses in pipes along with pressures and hydraulic grades at different points in the system.

4.6.1 Model Development

The city has made a significant investment in developing geographic information system (GIS) layers for its infrastructure over the past few years. The GIS pipe layer was used as the base source of data to construct the hydraulic model. The city's hydraulic model runs in an EPANet (United States Environmental Protection Agency public domain software) based environment, which is the industry standard. The city's model includes all pipes with the exception of hydrant and service laterals.

Demands were allocated to the model under existing conditions by linking customer meter records to the actual meter locations and assigning that demand to the nearest model node. MDDs were developed using historical system information for peak daily production. PHDs were estimated by using available historical data. Future demands were developed by projecting the UGB buildout population and then allocating where that growth was going to occur both within the existing service area and within the urban growth boundary. Significant growth is expected on the west and southwest portions of the city between 2006 and the UGB buildout, which is projected to occur in 2030.

Elevations were assigned using 2-foot contour information available for the city's service area. Information was collected for each facility and input into the model. This information included well groundwater levels, pump curves at boosters and wells, reservoir dimensions, pressure reducing valve sizes and settings, and operational set points at pumps.

4.6.2 Model Calibration

One of the critical steps in the development of a hydraulic model is that of calibration, which is done to ensure that the modeled conditions and results match the actual conditions and results. For calibration, the field pressures and flows are compared with model predicted pressures and flows. This process often identifies incorrect pipe diameter data and locations where pipe layouts are incorrectly represented. It can also be a good indicator of where closed or partially closed valves might exist in the system. Pipe friction factors are sometimes adjusted based on pipe size and material in order to get agreement between the model and field.

Calibration of the Redmond water system model was accomplished through the joint efforts of city and CH2M HILL staff. Pressure and flow data were collected during the summer of 2006 to supplement available data. In general, the model predicted very similar pressures and flows compared to those measured in the field. This analysis is documented in Appendix F.

4.6.3 Model Analysis

The model network was analyzed for existing (2006) and for UGB buildout conditions for ADD, MDD, PHD, and fire flow demands. The UGB buildout to a population of 58,000 people is expected to be reached in 2030.

As illustrated in Exhibit 4-1, the distribution system is divided into three primary service zones. The largest is Zone 2, where all wells and reservoirs are located. There is also an upper zone serving Forked Horn Butte customers and two smaller zones fed by pressure-reducing valves (PRVs) on the north end of the system.

The city's water distribution system consists primarily of a 12-inch grid with some larger 16- and 18-inch transmission mains and many smaller 4-, 6-, and 8-inch pipes serving local customers. As mentioned previously, Zone 2 serves the majority of the system and all wells and reservoirs are located in that zone. In general, the city has developed a 12-inch pipe grid that connects the reservoirs and wells and allows for good redundancy and transmission capability within the system.

Two barriers to the movement of water exist in the system. The first and most significant is Dry Canyon that runs north to south through the middle of the service area. Dry Canyon's location has resulted in limited east to west pipes. The city currently has four crossings of 12 inches or greater, which provide adequate flow capacity. However, all existing wells are located in Dry Canyon or to the south or east of it. Future well development is targeted for the west side of the city, which will provide additional redundancy for that area.

The second restriction is the railroad that runs north and south and generally parallel to Highway 97. The city pipes that cross the railroad tend to be smaller because they are older pipelines that were installed when fire flow requirements were lower. As in the case of Dry Canyon, additional well locations on the west side of the city will help reduce the need for additional railroad crossings in the future. The city has plans to replace the small diameter pipeline that crosses the railroad near Antler Road and Evergreen Street with a 12-inch line in 2007.

The downtown core also contains some older, undersized pipelines from the same time when fire flow requirements were lower. The pipeline grid in this area will be strengthened by a new north-south pipe along 9th Street and some localized fire flow improvements.

4.6.4 Existing Conditions (2006) Modeling Results

The results of the hydraulic analyses show that during existing ADD and MDD conditions, the majority of the customers' service pressure is greater than 35 psi, thus meeting the minimum service pressure requirements. Exhibit 4-25 presents the modeling results for existing (2006) MDD conditions. The areas with pressure lower than 35 psi are around tanks where few customer connections exist. Many locations in the system exhibited pressures greater than 80 psi under all conditions. High pressures in the area north of Maple Avenue will be addressed by installing a PRV at Northwest 19th Street and Maple Avenue.

The PHD analyses indicated that some areas will experience low pressures (less than 35 psi) but only in a small area in Pressure Zone 1, west of the Forked Horn Butte Tank, east of SW Cascade Vista Drive, and North of SW Yew Lane. The minimum service pressure in this area was 25 psi. The primary cause for the low pressure is the elevation of this area compared to the hydraulic grade line of the pressure zone and not head loss in the transmission mains. This area is served by variable speed pump stations that could be adjusted to provide a higher set pressure. However, customers on the lower edges of the zone could experience pressures higher than 90 psi if this change is made. No current plans are in place to address the isolated low or high pressure areas.

No pipes exceeded the maximum velocity criteria during ADD, MDD, or PHD 2006 conditions.

4.6.5 Future Conditions (UGB Buildout) Modeling Results

The future service area and future pipeline grid is presented in Exhibit 4-26. The new areas will be served by a proposed grid of 12- and 16-inch piping as shown in the exhibit.

From existing demands, a typical consumption for each land use type was developed. This water consumption was applied to undeveloped and future service areas using the proposed land use.

The future supply assumptions are listed in Exhibit 4-27. Future ADD conditions show adequate service pressure for all service connections (greater than 35 psi) with the exception of those described in the existing conditions discussion. The minimum service pressure located in a small upper portion of Pressure Zone 1 is lower than 30 psi. No plans are currently in place to increase pressure in Pressure Zone 1 because this would produce higher pressures in the lower portions of the zone. The results for the UGB buildout MDD conditions are presented in Exhibit 4-28. No pipes exceeded the maximum velocity criteria during ADD, MDD, or PHD for this future scenario.

4.6.6 Fire Flow Analysis

The hydraulic model was used to determine the maximum available fire flow at hydrant locations, maintaining a minimum pressure of 20 psi through the system during MDD conditions for existing and future demands. All available system supplies were used as needed, depending on where the fire flow location was being evaluated in the system. The single pump connected to the distribution system at the Antler Booster Station Facility was operated during the fire flow analysis.

The city’s criteria for fire flow are 1,500 gpm in residential areas, 2,500 gpm in commercial areas and areas with schools, and 3,500 gpm in industrial areas. Exhibit 4-29 shows the fire flow requirement for existing and future service areas.

During fire flow simulations, some areas within the system failed to meet the fire flow requirements. Exhibit 4-30 presents the maximum fire flow available (while maintaining 20 psi during MDD conditions) for existing and future conditions. No additional areas of fire flow deficiency were identified under future conditions. In general, the existing water system is capable of providing adequate fire fighting protection in most areas. A few exceptions exist, such as the downtown core that has older, smaller piping with commercial fire flow requirements. The locations of the areas where the required fire flows were not met are also presented in the exhibit.

All fire flow deficiencies were evaluated with a number of potential improvements to address those issues. Fire flow improvements were prioritized within the capital improvement plan based on the magnitude of the deficiency and the number of customers that are impacted. If all capital improvement projects that have been identified as part of this analysis are implemented, the city's fire flow criteria will be met at all locations.

4.6.7 Recommended Distribution System Improvements

The city's mission is to ensure adequate and reliable supply to all customers, in a cost-effective manner. The distribution system evaluation indicates that the city has done an excellent job in terms of providing adequate pumping, storage, and pipelines. This section describes the specific distribution projects that are proposed over the next 20 years that will enable the city to continue to provide reliable service.

Exhibit 4-31 provides a map of the system showing the proposed projects. The facility locations shown on this map are approximate. The city may revise the locations and also the facility sizes based on property ownership, conflicts with other utilities, development patterns, or other factors that are in the city's best interests.

4.6.8 Pumping and Well Supply

The city has installed sufficient well capacity to serve current maximum day conditions. Well 7, which was drilled in 2006, is scheduled to be brought on line in 2008. It will provide an additional 2,000 gpm of supply.

In the next 20 years, a 5,000-gpm booster pump station will be constructed at the Well 7 site. With this addition, it will be possible to convey a wide range of flows from ADD to fire flow in that portion of the system.

The replacement of Well 1 is the next proposed supply project. The proposed project consists of drilling a new well, which will be labeled as Well 8, next to Well 1. It will increase production from approximately 780 gpm at the existing Well 1 to an anticipated 2,500 gpm for a new well drilled at this location. The planned improvement will also provide back up power generation at that location. The Well 1 location is strategic as it provides supply for the north and west areas of the city, an area served only by Well 1 and where significant growth is projected.

A new well (Well 9) is proposed at the school site north of SW Elkhorn Avenue and SW 47th Street. The estimated yield is 2,500 gpm. It will provide supply to the southern portion of Zone 2, where growth is projected.

Three additional 2,500-gpm wells are projected to meet UGB buildout demands. The first two should be located on the west side of the system and the third in the northeast area. There is some flexibility as to where the wells are located. The two west-side wells should be in the general area of Obsidian Avenue to Maple Avenue and Helmholtz Way to 23rd Street. All future wells should be sited on looped 12-inch pipelines to avoid overly high pressure losses.

The city is aware that there a number of privately-owned wells located on the west side, within the UGB. These wells or other land-use or land-ownership factors may interfere with siting new wells in this area. It could be possible to serve this growing area of the city with wells located on the east side, but to do so would require larger diameter transmission pipelines than the ones shown in this plan.

A future Pressure Zone 1 booster station is planned at the Forked Horn Butte System Reservoir 2 site. This would replace the existing Forked Horn Butte Booster Station 2 that will be nearing the end of its useful life in the next 20 years. This booster station will pump directly from the proposed Forked Horn Butte System Reservoir 2 and pump into the existing 12-inch pipeline that runs along SW Reservoir Drive.

4.6.9 Storage

The current storage facilities are adequate to provide peaking, fire, and emergency storage to customers, with a slight surplus. Based on the design criteria that the city has adopted, shown in Exhibit 4-32, the projected storage deficit at 2030 will be 11.8 MG. At least three future reservoirs are currently being planned within the system between now and 2030 to meet this deficit.

The next reservoir project that has been identified uses a newly acquired piece of property on Forked Horn Butte that would include a tank and new booster pump station to lift water to Pressure Zone 1. The reservoir is proposed as either two 2-MG tanks or one 4-MG tank. This facility would be constructed with an overflow of 3,180 feet and would float on Zone 2 similar to the existing Forked Horn Butte System Reservoir. It will be connected to a new 18-inch pipeline along SW Volcano Avenue. The reservoir and booster pump station site is just north of the intersection of SW Reservoir Drive and SW Volcano Avenue.

The Well 7 site will accommodate two 3.5-MG ground level reservoirs. This facility will operate the same as the Well 6 facility, as it will be filled by the well and then water will be pumped from the tank into the system by a booster pump station. This facility will be located at 450 N.E. 11th Street and will also serve Pressure Zone 2.

A total of 4 MG of storage at Forked Horn Butte plus two 3.5 MG reservoirs at Well 7 will provide 11 MGs of additional storage. This essentially meets the projected storage deficit of 11.8 MG for 2030. Storage requirements are primarily based on system demands.

Exhibit 4-33 lists the reservoirs, including their overflow elevations, volume, material type, and installation date.

4.6.10 Pipelines

As has been shown by the existing and future hydraulic analyses, the city has few overall deficiencies in terms of low pressures or high velocities. A number of localized fire flow deficiencies have been noted and will be addressed; however, these deficiencies are primarily caused by older undersized pipelines that were installed when fire flow requirements were lower.

One of the city’s goals is to ensure that adequate redundancy and transmission capacity exists in the system so that if a single large pipeline or well is out of service, water can still be supplied to all customers without any significant difference in pressure or quality. To meet this goal, a number of pipeline enhancements were identified to establish a minimum 12-inch-diameter pipeline grid that connects all sources of supply and runs from east to west and north to south. This pipeline grid along with a dispersed network of wells will create a significant level of redundancy and flexibility for future growth regardless of where it occurs.

Pipe improvements for redundancy and growth have been grouped into three primary areas: (1) west and south of Forked Horn Butte, (2) west side (3) Well 7 vicinity and east.

4.6.10.1 West and South of Forked Horn Butte

A significant amount of growth is projected around the south and west sides of Forked Horn Butte. This area will be primarily served by Pressure Zone 2, based on ground elevations. In order to extend Pressure Zone 2 to this portion of the system, a new pipeline will be constructed along Helmholtz Way that will ultimately extend south to SW Elkhorn Avenue. As mentioned previously, a new well is proposed at or near the school site in this area and the proposed Forked Horn System Reservoir 2 facility will connect to the pipeline along Helmholtz Way.

4.6.10.2 West Side

The area that is projected to have the majority of the residential growth over the next 20 years is on the west side of the system, primarily north of SW Quartz Avenue and west of 23rd Street. Some commercial development is projected between Obsidian Avenue and Highway 126 that will require higher fire flows.

A 16-inch pipeline will be extended north along Helmholtz Way to Antler Avenue from the large pipe around Forked Horn Butte to serve those areas. A 12-inch pipeline will be extended north of Antler Avenue along Helmholtz Way and 35th Street to Maple Avenue. Other 12-inch piping additions in the area west of Dry Canyon will be required to maintain the overall integrity of the grid along 23rd Street, Hemlock Avenue, and Antler Avenue.

The proposed Pressure Zone 3a that currently serves the area north of Maple Avenue and west of Dry Canyon will be extended with a 12-inch pipeline along Northwest Way to Upas Avenue. An additional PRV will be required at the intersection of Maple Avenue and Northwest Way to serve Pressure Zone 3a. A significant portion of the piping on the west side of the system is anticipated to be constructed by developers as the location of future development will drive the timing of much of the infrastructure in that area.

4.6.10.3 Well 7 Vicinity and East Side

The system on the east side of Dry Canyon is the oldest portion of the city's system. Some of the challenges to moving water in that area center on older small mains and the north-south barriers of Highway 97 and the railroad.

The proposed Well 7 will have pumping capacity in the 2,500-gpm range. Future addition of a tank and pump station will increase the instantaneous pumping rate to approximately 5,000 gpm. This will require an upgrade in piping both north and south of that facility to distribute this flow rate. This station is served by a 24-inch pipeline that was installed in 2005 to the central area of the city.

A new pipe improvement running north to Maple Avenue will provide some needed redundancy. New commercial development along Highway 97 north of Maple Avenue will also benefit from that improvement.

Upgrades and additions of piping along Antler Avenue near the Antler Reservoir and another north of Evergreen Way along SE 9th Street, will improve the conveyance capacity in those areas. A new 12-inch main along NW 9th Street from Highland Avenue to Maple

Avenue will greatly strengthen the older downtown core where many of the undersized pipes exist as well as provide a central large diameter north-south conduit east of the canyon.

4.6.11 Fire Flow

In general, fire flow fighting capability is very good in the system. This is primarily because of two factors; the significant amount of looping that exists and the excellent operating pressures that are present in the system. The operating pressure that is typically in excess of 70 psi in most parts of the system allows for a significant amount of headloss in any one area before low pressures are encountered under fire flow conditions. A number of specific fire flow improvements have been identified which are primarily focused on the areas around or in the downtown core and on the east side in industrial areas with high fire flow requirements. Exhibit 4-31 shows the recommended fire flow improvements.

4.7 Water System Capital Improvements Plan

This section summarizes the water system improvements discussed in the preceding sections and presents a water system projects list for Redmond's water system. This list addresses capital needs that are proposed for meeting growth through the UGB buildout, which is anticipated to occur in 2030.

The reviews of water rates and funding alternatives, as required by the state's Drinking Water Program master planning rules, are provided in a separate report, which will be completed and made available subsequent to the master plan report.

4.7.1 Water System Projects List

Exhibit 4-34 presents the proposed water system projects list update for Redmond. The individual projects include those that have been described in the technical sections of this report, and in some cases, projects that Redmond has previously identified as needed. Further details for the projects listed in this table are provided in Appendix G.

Exhibit 4-34 indicates priority levels for the pipeline projects. The first priority is to increase residential fire flows to 1,000 gpm or greater throughout the service area. The second and third priorities also relate to fire flows, but are focused on providing higher fire flows to commercial and industrial areas. The fourth priority includes those projects that will be needed as new developments are added to the city.

The timing for the new wells depends on demand growth, as illustrated in Exhibit 4-24. The timing for the reservoir and pump station improvements is also dictated by demand growth. The three valve projects—the addition of pressure reducing or check valves—will increase system redundancy.

4.7.2 Project Cost Background

The project cost estimates are considered rough order-of-magnitude estimates. Actual costs will vary by plus 50 percent to minus 30 percent, depending on the final project scope, the bidding climate, and other variable factors.

The project cost estimates are given in January 2007 dollars at an approximate *Engineering News-Record* Construction Cost Index for Seattle Area value of 8626. Before finalizing the funding for a project, it will be necessary to update the cost estimate to current costs and to develop a preliminary design to further define the project.

A unit cost of $10 per diameter inch per foot was used for estimating pipeline costs. This results in a unit cost of $80 per foot for 8-inch pipe, $100 per foot for 10-inch pipe, $120 per foot for 12-inch pipe, and $160 per foot for 16-inch pipe. These unit costs assume a typical rock depth in Redmond of 2-3 feet below ground surface.

The only exceptions to this unit cost were for the four pipeline replacement areas shown in Exhibits 4-31 and 4-34. The unit cost for these pipe groups was increased from $10 to $12 per diameter inch per foot to account for construction in congested areas and the need to make many service line and hydrant re-connections.

An allowance of 15 percent was added to construction estimates to account for engineering and administrative costs. This allowance was applied to all projects equally and therefore, does not take into account design complexities, extra levels of permitting, or other factors that are specific to projects that might result in higher engineering and administrative costs.

4.8 Conceptual Planning for Urban Reserve Area

Using the hydraulic model and considering the proposed distribution system shown in Exhibit 4-31, a conceptual plan was developed for service to the URA boundary. This is illustrated in Exhibit 4-35. The conceptual plan generally consists of a 12-inch piping grid that is located to facilitate connection with existing or proposed pipes within the UGB. An additional well location is shown in the northeast area. These projects are not included in the water systems project list, which provides planning through the buildout of the UGB.

The 12-inch grid is sufficient for providing residential fire flows. If the future zoning for the URA differs from residential and thereby requires higher fire flows, further analyses should be performed to confirm that this grid provides acceptable levels of fire flows.

EXHIBIT 4-1
Redmond Water System Schematic
Redmond Wastewater (Collection System) and Water System Master Plan

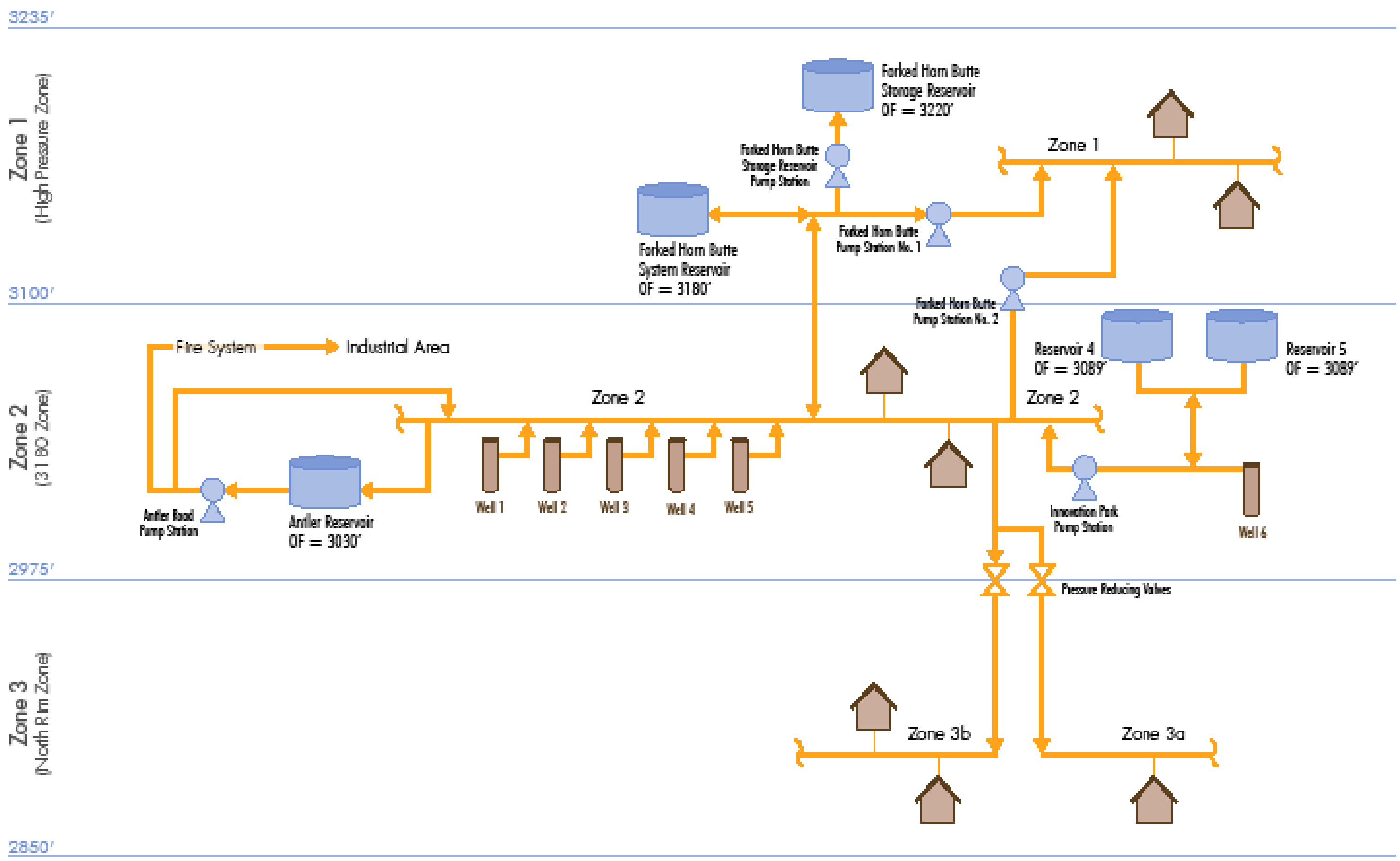


EXHIBIT 4-2
Water System Service Zones
Redmond Wastewater (Collection System) and Water System Master Plan

Service Zone Label	Lower Customer Elevation	Upper Customer Elevation
Zone 1 (High Elevation Zone)	3,100 feet	3,235 feet
Zone 2 (3180 Zone)	2,975 feet	3,100 feet
Zone 3 (North Rim Zone)	2,850 feet	2,975 feet

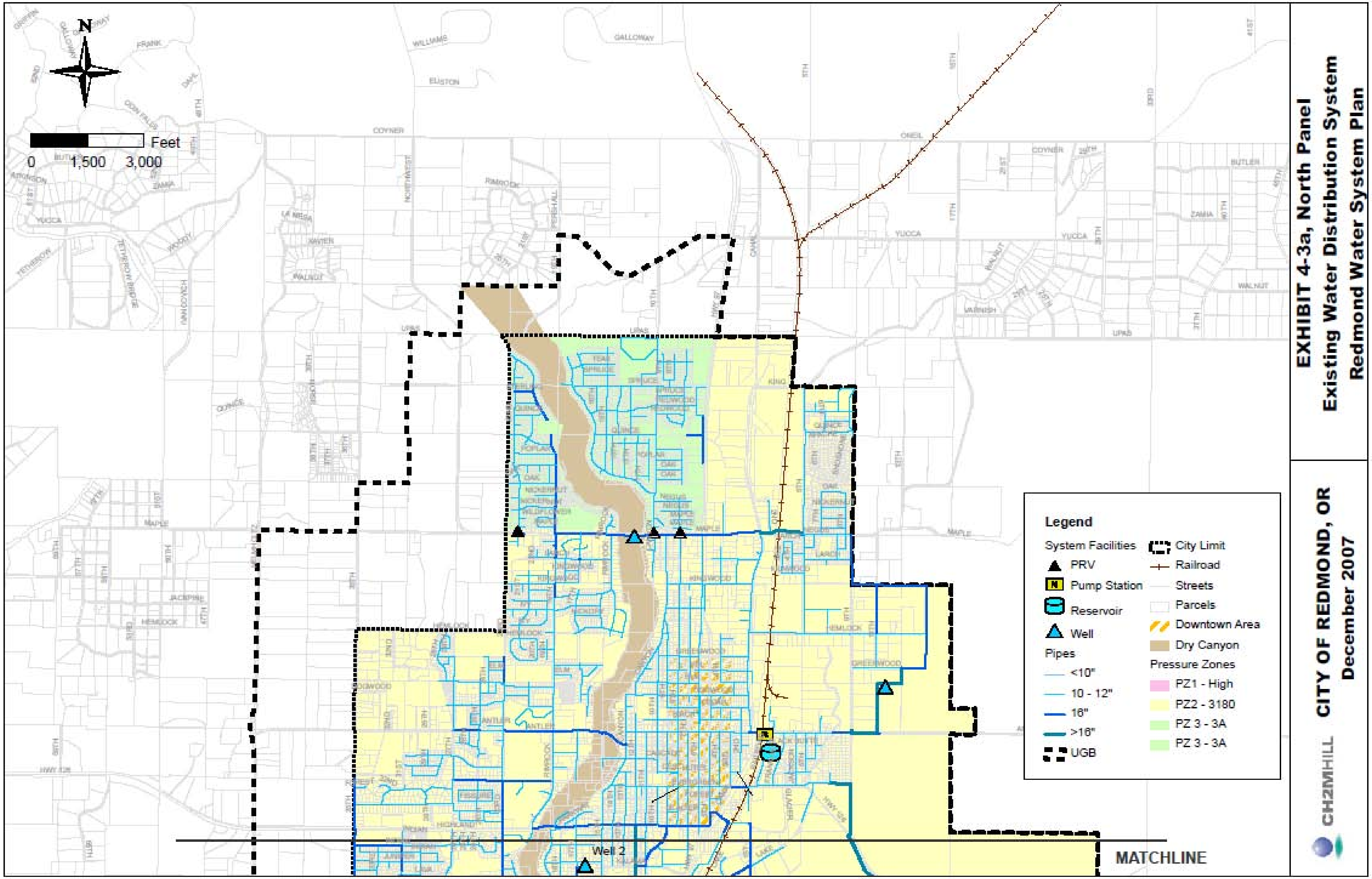


EXHIBIT 4-3a, North Panel
Existing Water Distribution System
Redmond Water System Plan
CITY OF REDMOND, OR
December 2007
CH2MHILL
N
Feet
0 1,500 3,000
Legend
System Facilities
PRV
Pump Station
Reservoir
Well
Pipes
<10"
10 - 12"
16"
>16"
UGB
City Limit
Railroad
Streets
Parcels
Downtown Area
Dry Canyon
Pressure Zones
PZ1 - High
PZ2 - 3180
PZ 3 - 3A
PZ 3 - 3A
Well 2
MATCHLINE

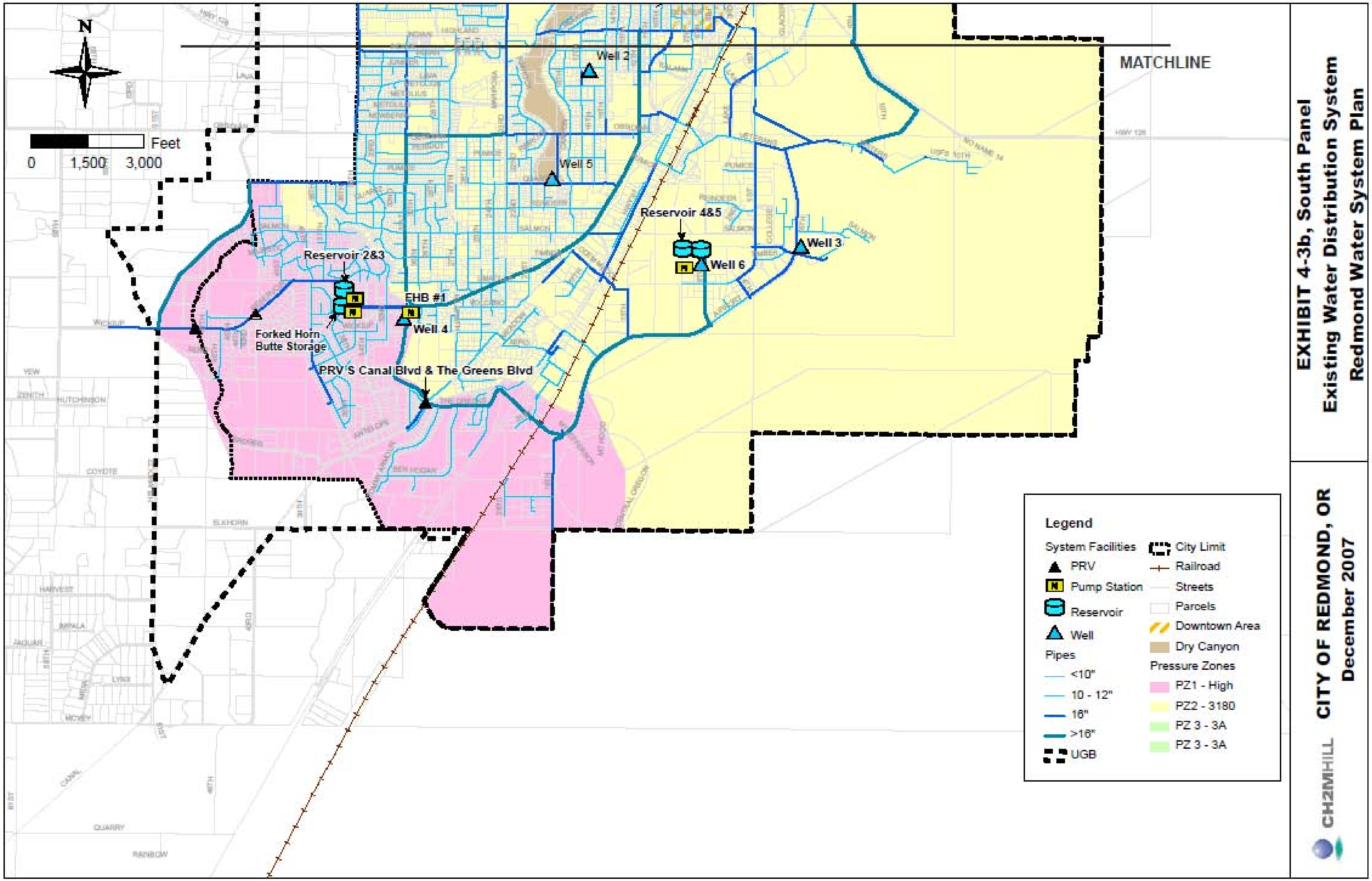

N
Feet
0
1,500
3,000
MATCHLINE
Well 2
Well 5
Reservoir 4&5
Well 3
Well 6
Reservoir 2&3
FHB #1
Well 4
Forked Horn
Butte Storage
PRV'S Canal Blvd & The Greens Blvd
Legend
System Facilities
PRV
Pump Station
Reservoir
Well
Pipes
<10"
10 - 12"
16"
>16"
UGB
City Limit
Railroad
Streets
Parcels
Downtown Area
Dry Canyon
Pressure Zones
PZ1 - High
PZ2 - 3180
PZ 3 - 3A
PZ 3 - 3A
EXHIBIT 4-3b, South Panel
Existing Water Distribution System
Redmond Water System Plan
CITY OF REDMOND, OR
December 2007
CH2MHILL

EXHIBIT 4-4
Existing Well and Pump Stations
Redmond Wastewater (Collection System) and Water System Master Plan

Facility	Description	Capacity (gpm)	Year Installed
Well 1	Supplies Pressure Zone 2	780	1969
Well 2	Supplies Pressure Zone 2	800	1975
Well 3	Supplies Pressure Zone 2	1,125	1987
Well 4	Supplies Pressure Zone 2	2,000	1985
Well 5	Supplies Pressure Zone 2	2,500	1999
Well 6	Fills the Well 6 Ground Level Storage Tanks	2,000	2006
Well 7	Supplies Pressure Zone 2[a]	2,500	2007
Well 6 Booster Station	Supplies Pressure Zone 2	4,000	2006
Antler Booster Station	Supplies Pressure Zone 2[b]	2,200	1964
Forked Horn Butte Booster Station 1	Supplies Pressure Zone 1 from Pressure Zone 2	5,000	2006
Forked Horn Butte Booster Station 2	Supplies Pressure Zone 1 from Pressure Zone 2	1,500	1984
System Reservoir Booster Station	Transfers water from the System Reservoir to the Storage Reservoir	4,000	2001

[a] Once the Well 7 Ground Storage Tank and Booster Station are constructed, Well 7 will fill the reservoir.

[b] Typically only used for fire flows. Additional pumps (2@2,500 gpm) are located at the booster station that supplies a dedicated industrial fire flow system.

EXHIBIT 4-5
Distribution System Pipeline Inventory by Diameter
Redmond Wastewater (Collection System) and Water System Master Plan

Nominal Diameter	Length (feet)
Not documented	744
1	323
2	10,497
4	28,367
6	117,900
8	371,787
10	62,762
12	84,079
14	7,915
16	9,269
18	41,383
20	61
24	3,046
Total	**738,133 feet 140 miles**

EXHIBIT 4-6
Distribution System Pipeline Inventory
Redmond Wastewater (Collection System) and Water System Master Plan

Nominal Diameter	Material	Length (feet)
1	Steel	323
2	Copper	83
2	PVC	714
2	Steel	9,462
2	Unknown	238
4	Ductile iron	18
4	PVC	11,102
4	Steel	17,207
6	Cast iron	8,137
6	Ductile iron	557
6	Other	16
6	PVC	28,778
6	Steel	79,453
6	Unknown	959
8	Cast iron	7,777
8	Ductile iron	1,611
8	Other	21
8	PVC	345,656
8	Steel	16,722
10	Cast iron	169
10	Ductile iron	324
10	PVC	33,357
10	Steel	28,912
12	Cast iron	1,722
12	Ductile iron	10,265
12	PVC	53,302
12	Steel	18,756
12	Unknown	34
14	Ductile iron	7,512
14	Steel	403
16	Ductile iron	7,389
16	PVC	1,504
16	Steel	376
18	Cast iron	1,604
18	Ductile iron	24,047
18	PVC	4,832
18	Steel	10,901
20	Steel	61
24	Ductile iron	2,704
24	PVC	343
Not documented	Ductile iron	2
Not documented	PVC	182
Not documented	Steel	73
Not documented	Unknown	486

EXHIBIT 4-7
Distribution System Pipeline Inventory by Material
Redmond Wastewater (Collection System) and Water System Master Plan

Material	Length (feet)
Cast iron	19,408
Copper	83
Ductile iron	54,429
Other	38
PVC	479,770
Steel	182,665
Unknown	1,717
Total	738,151

EXHIBIT 4-8
Design and Operating Criteria
Redmond Wastewater (Collection System) and Water System Master Plan

No.	Item	Redmond Criteria	Applicable Regulations	Typical Practice	Basis	Discussion
1	Residential fire flows	1,500 gpm	Oregon Drinking Water Program (DWP): maintain 20 psi at all times	1,000 gpm (minimum) for 2 hr, at a minimum residual pressure of 20 psi, superimposed over maximum day demands	ISO, the nation's leading source for ranking fire suppression effectiveness, downgrades a community's insurance rating unless at least 1,000 gpm is available for 2 hr for houses situated such that the spacing between houses is 11 to 30 feet. (Note: ISO requires 1,500 gpm for 2 hr if spacing is ≤ 10 ft)	*Recommended Standards for Water Works* ('Ten States Standards') indicates that fire flows shall meet ISO standards. California Administrative Code requires 750 gpm minimum for residential one story, single family dwellings on average sized lots, and 2,000 gpm for more densely built areas, apartments, and light commercial. Oregon has no flow requirements, but does require 20 psi at all times. ISO standards also call for residual pressure of 20 psi.
2	Residential fire storage volumes	180,000 gallons (1,500 gpm for 2 hr)		120,000 gallons	Equal to 1,000 gpm for 2 hr, based on ISO criteria.	
3	Commercial and school fire flows	2,500 gpm		3,500 gpm (minimum) for 3 hr, at a minimum residual pressure of 20 psi superimposed over maximum day demands; located in zone where need occurs	ISO downgrades a community's insurance rating unless at least 3,500 gpm is available for 3 hr for habitational buildings such as schools. This category also includes care centers and light commercial.	See discussion for residential fire flows. No Oregon requirements.
4	Commercial and school fire storage volumes	450,000 gallons (2,500 gpm for 3 hr)		630,000 gallons	Equal to 3,500 gpm for 3 hr, based on ISO criteria.	
	Highway 97 industrial fire flow	3,500 gpm				
	Highway 97 industrial fire storage volume	840,000 gallons (3,500 gpm for 4 hr)				
5	Hydrant spacing	400 ft is current standard		1,000 ft maximum	ISO credits hydrants for up to 1,000 gpm if located within 300 ft of structure, for 670 gpm if located 301 to 600 ft from structure, and for 250 gpm if located from 601 to 1,000 ft from structure. A spacing of 1,000 ft maximum would ensure at least 1,000 gpm is available to each house.	No Oregon requirements
6	Hydrant type	Comply with AWWA C502 with one 4.5-inch steamer and two 2.5-inch hose nozzles.		Provide at least one large pumper outlet.	ISO downgrades fire hydrants that do not have at least one large pumper outlet.	

EXHIBIT 4-8
Design and Operating Criteria
Redmond Wastewater (Collection System) and Water System Master Plan

No.	Item	Redmond Criteria	Applicable Regulations	Typical Practice	Basis	Discussion
7	Residential piping: sizes and looping	Minimum mainline size is 8 inches. Fire hydrant required at end. Hydrant lines may be 6 inches up to maximum length of 400 ft. Looping required wherever possible.		12-inch diameter outer loops (for ≤ 1-mile square), 8-inch diameter internal grid, and 6-inch diameter in cul-de-sacs (for < 250 feet length). Limit velocities to approximately 6 fps for peak hr demands. Limit velocities to 10 fps for fire flows.	Follows Washington Administrative Code (for sizes; silent on velocities). Meets OARs (minimize dead ends) and Ten States Standards (minimum of 6-inch diameter mains).	Several states require a minimum of 6-inch diameter mains, and indicate that dead end lines shall be minimized. Proliferation of cul-de-sacs means that the criterion of allowing 6-inch diameter dead end mains up to 250 feet in length may result in a system that is not well-looped. Therefore, it is critical to confirm acceptability of dead end lines using hydraulic model.
8	Transmission mains: sizing	Evaluate on a case-by-case basis, based on allowable headloss. Velocities up to 8-10 fps are acceptable for peak hr demands. Minimum pipe size for industrial areas is 12-inch.		Evaluate on a case-by-case basis, based on allowable headloss. Velocities up to 8-10 fps are acceptable for peak hr demands.	Peak hr demands are uncommon, and sizing a transmission main for velocities of 8-10 fps will result in lower velocities a large percentage of the time.	Washington states that transmission lines shall be designed to maintain ≥ 35 psi, except when directly adjacent to storage tanks.
9	Operating pressures	Normal (any time except during fire flows): 40–80 psi. Minimum for fire flows: 20 psi. Pressures measured at service connection (meter).	Oregon: minimum is 20 psi	Normal (any time except during fire flows): 40 - 80 psi. Minimum for fire flows: 20 psi. Pressures measured at service connection (meter).	Oregon requires a minimum of 20 psi at all times, as do most states. The 40-80 psi normal range is a reasonable target, recognizing that it may be acceptable in some cases for the minimum to drop below 40 psi and still provide acceptable service.	Oregon is silent on pressure except for the 20 psi minimum. Washington requires 30–110 psi, California 25–125 psi, Texas > 35 psi, and Pennsylvania 25–125 psi. Ten States Standards indicates that normal working pressures should be 60–80 psi, and not less than 35 psi.
10	Equalization storage volume	25% of maximum day demand		25% of maximum day demand	A typical value for community water systems.	Only general guidance is provided by states, indicating that equalization storage should consider daily use patterns.
11	Emergency storage volume	1x ADD		Varies from 1x ADD to 1x MDD, depending on reliability of a system's supply.		Washington regulations indicate that emergency storage may be reduced when there is a second independent supply, such as multiple wells
12	Total storage	Equalization volume plus fire or plus emergency (using whichever is larger).		Sum of fire, equalization, and emergency storage volumes —or—equalization volume plus fire or plus emergency (using whichever is larger).		Washington codes allow a system to provide the total of the equalization storage plus the larger of the emergency or fire volumes. This approach assumes that a fire will not occur concurrently with an emergency failure.
13	Valve exercising	Exercise all valves on a 4-year cycle.		Once per year for valves ≥ 12 inches.	Annual valve exercising is commonly recommended for all valves; however, this is probably not practical. Focus on critical valves.	States do not provide guidance on valve exercising.

EXHIBIT 4-8
Design and Operating Criteria
Redmond Wastewater (Collection System) and Water System Master Plan

No.	Item	Redmond Criteria	Applicable Regulations	Typical Practice	Basis	Discussion
14	Water age/chlorine residual/heterotrophic plate counts (HPC)	Daily monitoring of system free chlorine residual. Water age and chlorine residual not a problem.		Measurable free chlorine residual; HPC counts < 100 colony forming units (CFU)/mL.	The critical water age is system-specific. EPA has a value for HPC as a non-regulated surrogate of 500 CFU/mL. A value of 100 CFU/mL is, therefore, considered conservative in protecting water quality. Together with maintaining a measurable chlorine residual, these are the best available practices for ensuring safe drinking water in the distribution system.	Probably not an issue in Redmond because of the low level of organics in the groundwater.
15	Booster pump station sizing	Provide MDD over 24 hours, with largest pump out of service.		Provide MDD over 24 hours, with largest pump out of service.	A typical value for community water systems.	
16	Number of pumps in booster pump stations	A minimum of three (two active; one standby).		A minimum of three (two active; one standby).	A typical value for community water systems.	
17	Pipe materials	Ductile iron or PVC.		Use ductile iron pipe as standard. (May be reasonable to consider high-density polyethylene (HDPE) or steel for large transmission lines, with cathodic protection for steel lines.)	Ductile iron pipe is the industry standard, with PVC also commonly used.	
18	Backflow prevention standards	Fulfill Oregon's rules.		Fulfill Oregon's rules.	Oregon's backflow rules are comprehensive and defensible.	
20	Water use record keeping	Track average day, maximum day, and monthly total demands. Document and summarize annually. Track within individual service levels to extent possible. Install meters to monitor flows entering and leaving service zones. Develop monthly and annual numbers for unaccounted water.	Oregon Drinking Water Program (DWP) has some record-keeping requirements.	Track average day, maximum day, and monthly total demands. Document and summarize annually. Track within individual service levels to extent possible. Install meters to monitor flows entering and leaving service zones. Develop monthly and annual numbers for unaccounted water.	These data are very helpful for planning purposes, and are time-consuming or impossible to generate if not recorded on a regular basis.	
21	Main Flushing	Goal is to flush 1/3 of the system each year in conjunction with city's hydrant testing program.		Every 6 months for dead end and problem areas; goal for entire system is once every 4 years.		Use flush end to get 5 fps: 4-inch for 6-inch line; 6-inch for 8-inch line.

EXHIBIT 4-8
Design and Operating Criteria
Redmond Wastewater (Collection System) and Water System Master Plan

No.	Item	Redmond Criteria	Applicable Regulations	Typical Practice	Basis	Discussion
22	Reservoir inspection/cleaning	Inspection (and possible cleaning) every 2-5 years.		Inspections every 5 years using divers; cleaned only as inspection shows need.		
23	Reservoir turnover	Set goal as 3–5 days, but realize that it may not be feasible to achieve this goal.		Set goal as 3–5 days, but realize that it may not be feasible to achieve this goal.	AWWA recommends complete turnover every 3–5 days.	Depends on water quality. Probably not as critical in Redmond because of high quality groundwater.
24	Use of closed-end pumping systems in place of reservoir storage	Closed-end pumping is used in the Forked Horn Butte Area because gravity is not practical (PD).		15 or fewer homes preferred on a dead-end; 30 homes maximum.	Although it is desirable to serve all customers with gravity storage, there may be an unacceptably high cost to serve small groups of homes with a reservoir, and using a reservoir for this application may result in stagnant water.	
25	Isolation valving	Maximum of 4 valves to close in order to isolate segment.		Maximum of 4 valves to close in order to isolate segment.	Typical water system practice.	
26	Number of services on an isolation segment	Not more than 30 homes maximum.		Not more than 30 homes maximum.	Typical water system practice.	
27	Poor quality water resulting from installing fire hydrants at the end of a dead end line, often the result of installing a hydrant on the opposite side of the road from the water main	Hydrants required at end of pipelines.		Install dead end hydrants as close as possible to pipeline.	Good practice to reduce stagnant water.	
28	Installation of flush ends on dead end mains in cul-de-sacs	Use hydrants for flushing.		Use flush ends for dead end mains.	Good practice to reduce stagnant water.	
29	Provision of emergency generators for pump stations	Provide for all pump stations		Only provide for closed end pump stations (those serving an area without gravity storage).	Provides reliability for closed end systems; otherwise, storage tank provides needed reliability.	
30	Pump stations: backup power connections	Standby generators at most facilities.		Provide as standard for new pump stations.	Low cost to include in new pump station designs.	

EXHIBIT 4-8
Design and Operating Criteria
Redmond Wastewater (Collection System) and Water System Master Plan

No.	Item	Redmond Criteria	Applicable Regulations	Typical Practice	Basis	Discussion
31	Reservoir design: inlet/outlet piping	Provide separate inlet/outlet piping for all new reservoirs; include inlet riser pipe (keep top below normal operating level so as not to introduce extra pumping head) and separate inlet and outlet horizontally.	Oregon Department of Human Services (DHS): "When a single inlet/outlet pipe is installed and the reservoir floats on the system, provisions shall be made to insure an adequate exchange of water to prevent degradation of the water quality…" (OAR 333-061-0050 (7))	Provide separate inlet/outlet piping for all new reservoirs; include inlet riser pipe (keep top below normal operating level so as not to introduce extra pumping head) and separate inlet and outlet horizontally.		
32	Drinking water materials and additives	Comply with ANSI/NSF Standard 60 and 61.	Comply with ANSI/NSF Standard 60 and 61.	Comply with ANSI/NSF Standard 60 and 61.	Meet Oregon drinking water regulations.	
33	Master plan: update schedule	Annual minor updates; more significant review every 5 years; comprehensive review every 10 years.		Annual minor updates; more significant review every 5 years; comprehensive review every 10 years.		
34	5-Year capital improvements plans (CIPs)	Proposed: Annual updates; ensure that 5-year plans follow general guidelines of the master plan. Plan shall be within financial guidelines of water division, and shall be balanced and prioritized so that rate increases are justified.		Proposed: Annual updates; ensure that 5-year plans follow general guidelines of the master plan. Plan shall be within financial guidelines of water division, and shall be balanced and prioritized so that rate increases are justified		

EXHIBIT 4-9
Average Day Demand Records for 1977-2005
Redmond Wastewater (Collection System) and Water System Master Plan

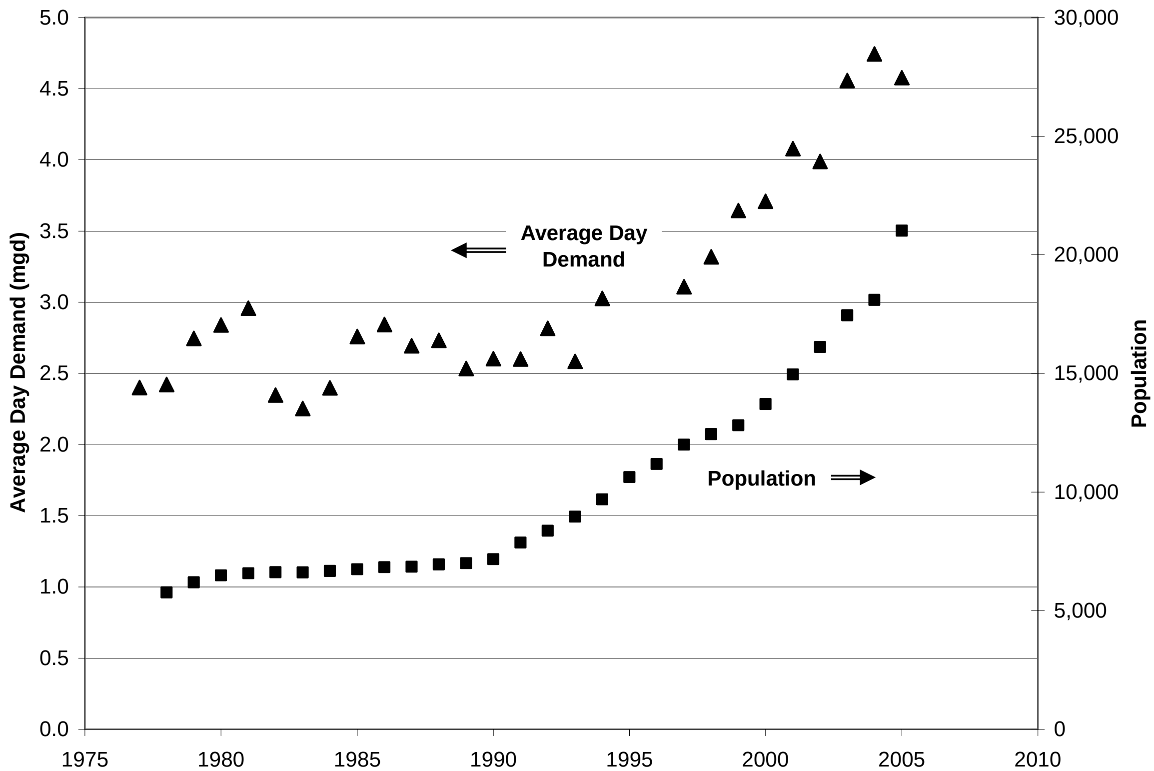


EXHIBIT 4-10
Average and Maximum Day Demands, 1997-2005
Redmond Wastewater (Collection System) and Water System Master Plan

Year	Population	Total Annual Production (MG)	ADD (mgd)	MDD (mgd)	ADD Per Capita (gpcd)	MDD Per Capita (gpcd)	MDD: ADD Peaking Factor
1997	11,990	1,135	3.1	8.2	259	684	2.6
1998	12,435	1,212	3.3	8.2	267	659	2.5
1999	12,810	1,330	3.6	9.5	284	742	2.6
2000	13,705	1,358	3.7	10.0	271	730	2.7
2001	14,960	1,489	4.1	10.3	273	688	2.5
2002	16,110	1,456	4.0	10.1	248	627	2.5
2003	17,450	1,664	4.6	10.7	261	613	2.3
2004	18,100	1,736	4.7	10.5	262	580	2.2
2005	21,010	1,671	4.6	10.9	218	519	2.4
Average, for 1997-2005					**260**	**649**	**2.5**
Average, for 2003-2005					**247**	**571**	**2.3**

EXHIBIT 4-11
Average Day Demands, 1997-2005
Redmond Wastewater (Collection System) and Water System Master Plan

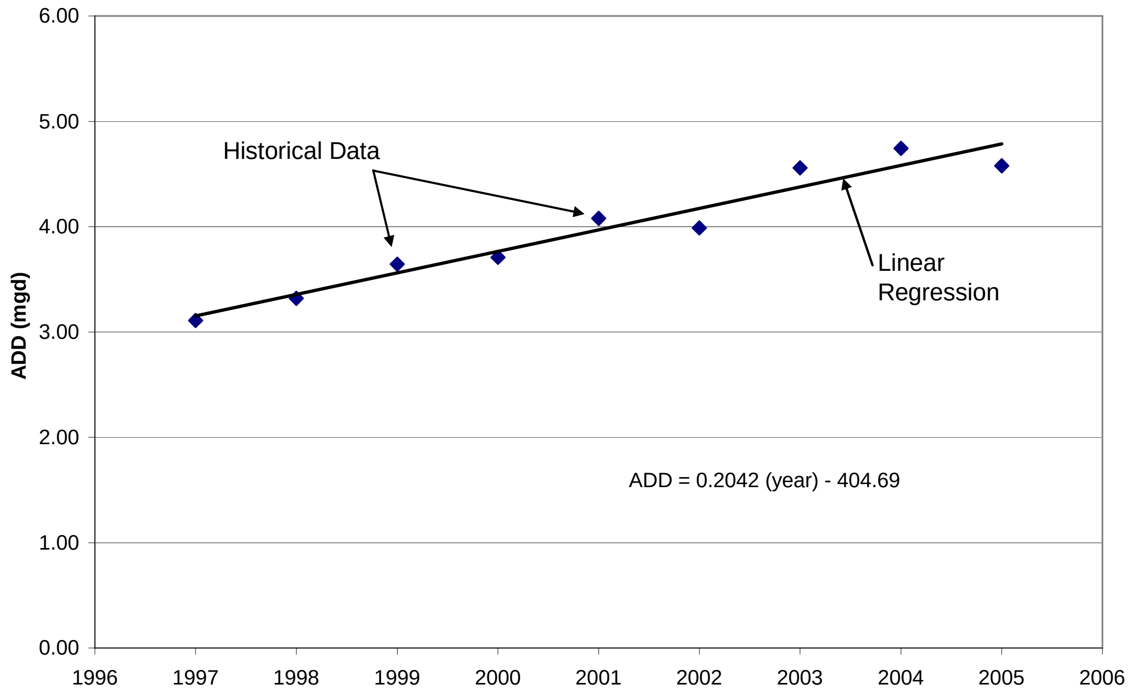


EXHIBIT 4-12
Maximum Day Demands, 1997-2005
Redmond Wastewater (Collection System) and Water System Master Plan

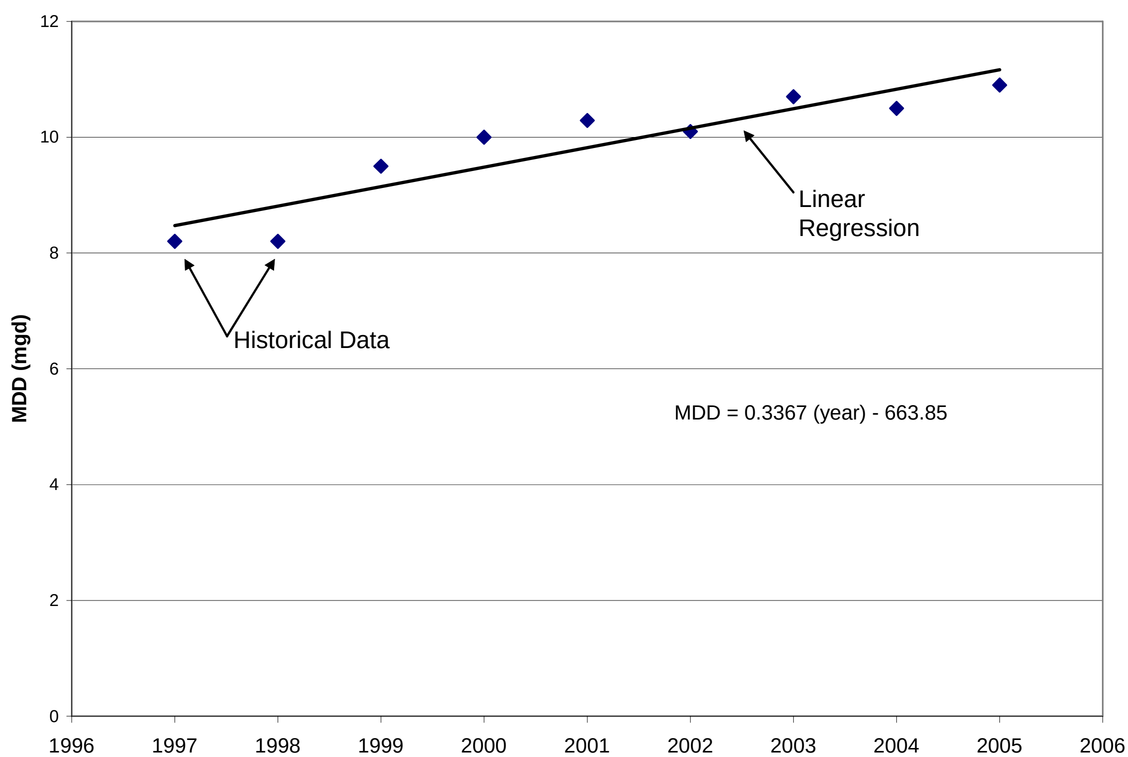


EXHIBIT 4-13
Monthly Demand Records for 2000-2006
Redmond Wastewater (Collection System) and Water System Master Plan

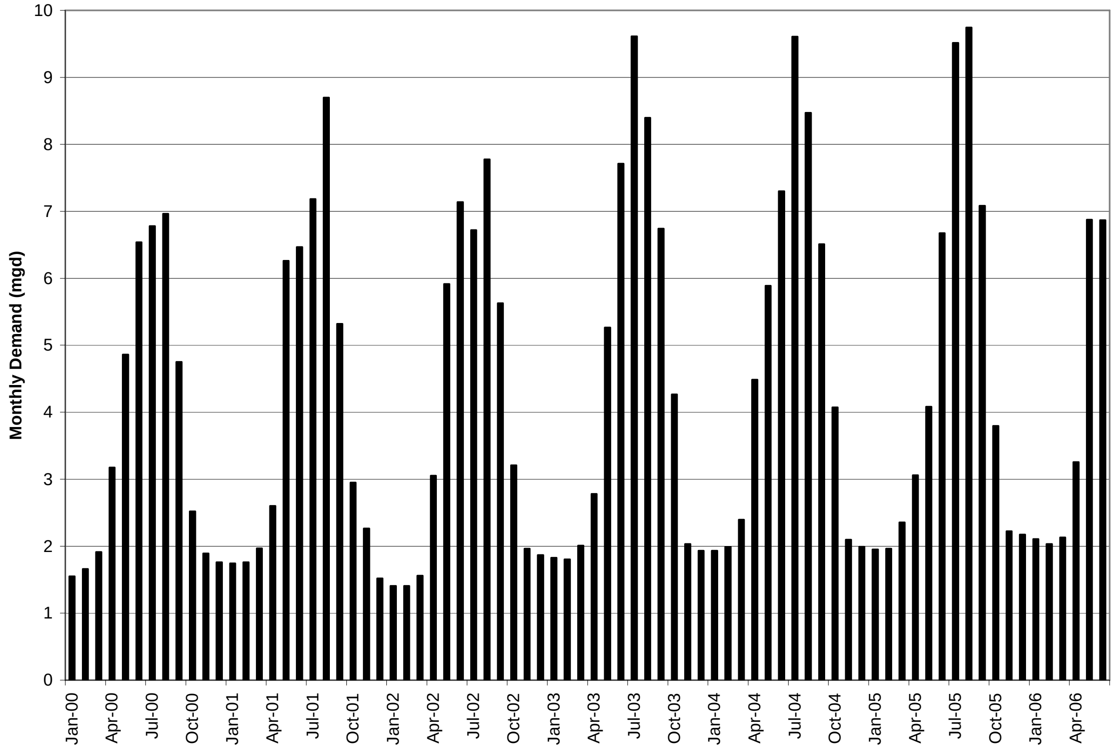


EXHIBIT 4-14
Per Capita Average Day Demand, 1997-2005
Redmond Wastewater (Collection System) and Water System Master Plan

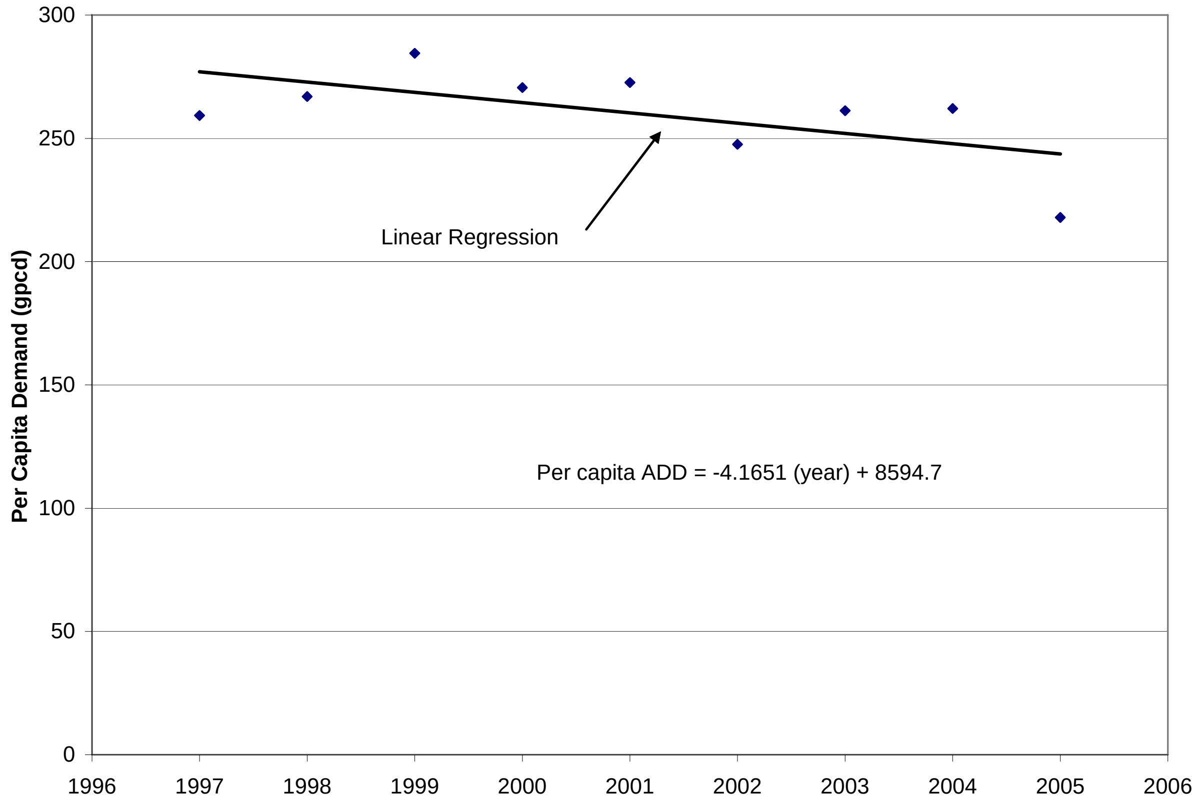


EXHIBIT 4-15
Per Capita Maximum Day Demand, 1997-2005
Redmond Wastewater (Collection System) and Water System Master Plan

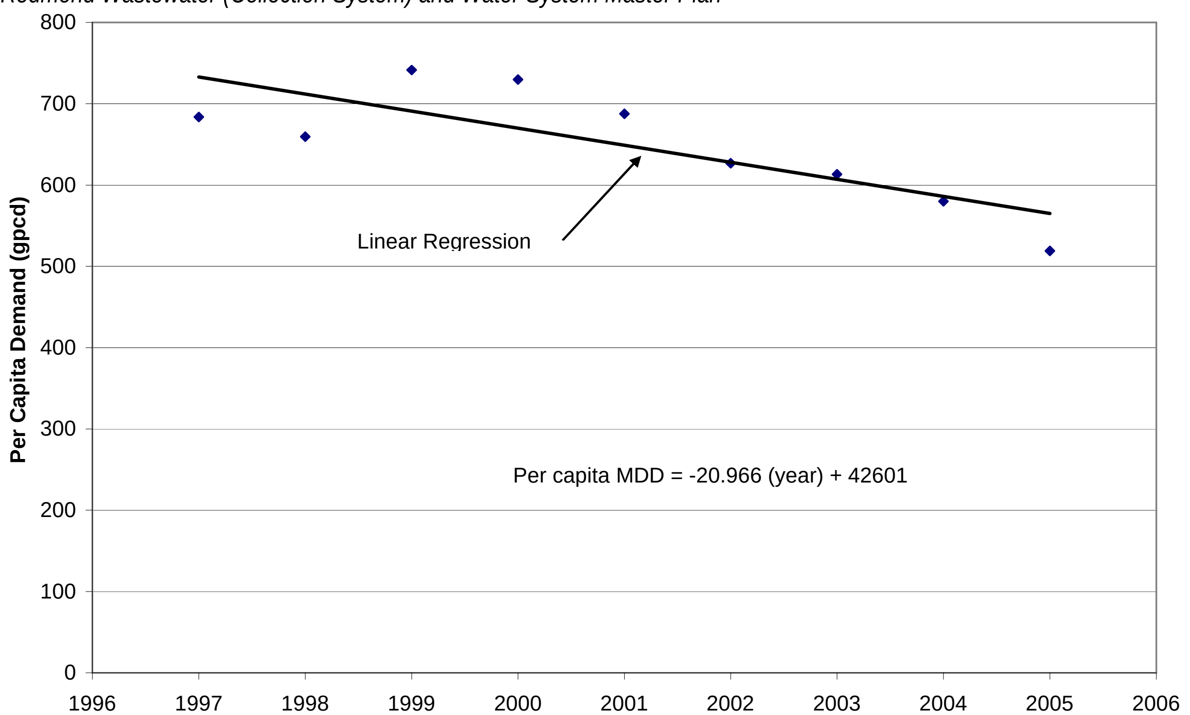


EXHIBIT 4-16
Monthly Metered Use by Customer Category from July 2003 to June 2006
Redmond Wastewater (Collection System) and Water System Master Plan

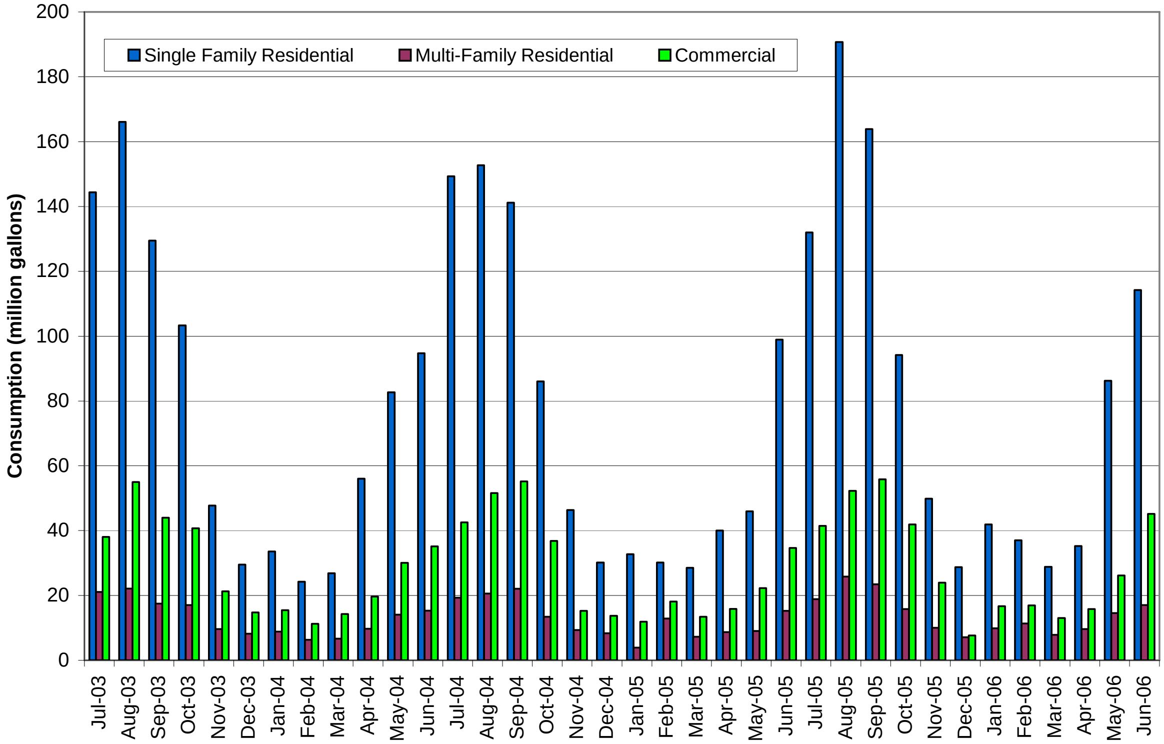


EXHIBIT 4-17
Monthly Metered Use by Customer Category from July 2003 to June 2006
Redmond Wastewater (Collection System) and Water System Master Plan

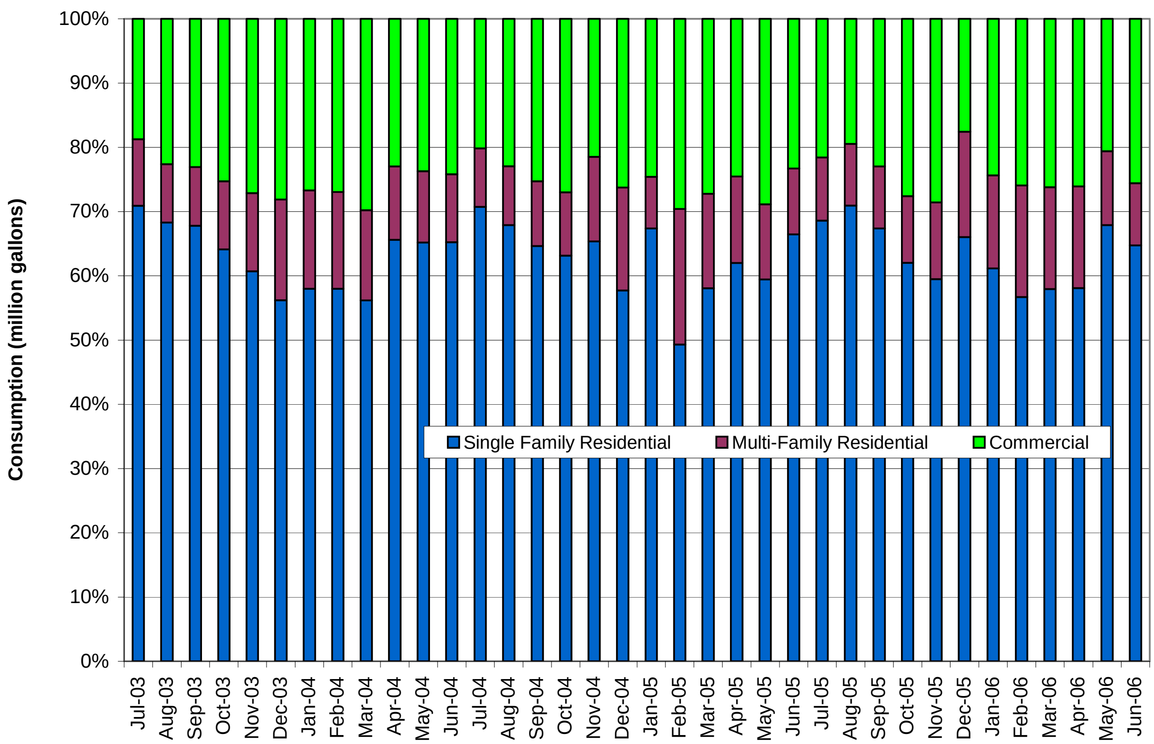


EXHIBIT 4-18
Redmond Monthly Unaccounted-for Water Rates (July 2003 - April 2006)
Redmond Wastewater (Collection System) and Water System Master Plan

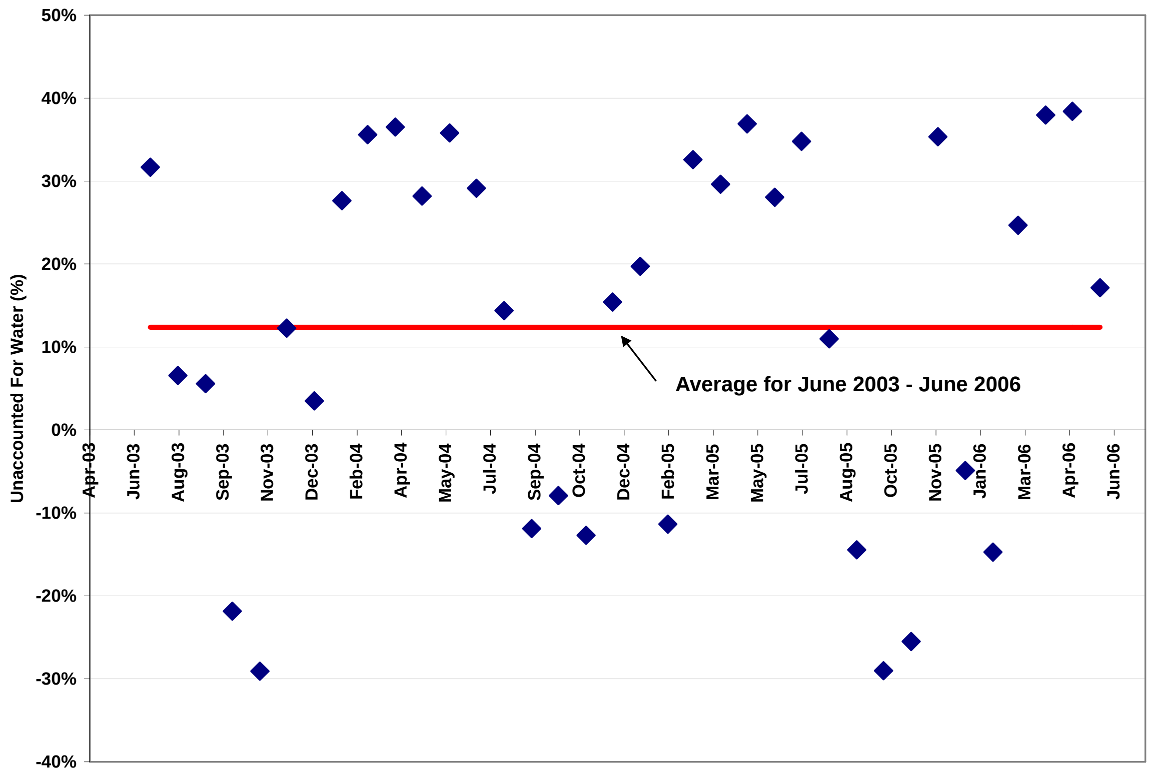


EXHIBIT 4-19
Unaccounted-for Water for 2004 and 2005
Redmond Wastewater (Collection System) and Water System Master Plan

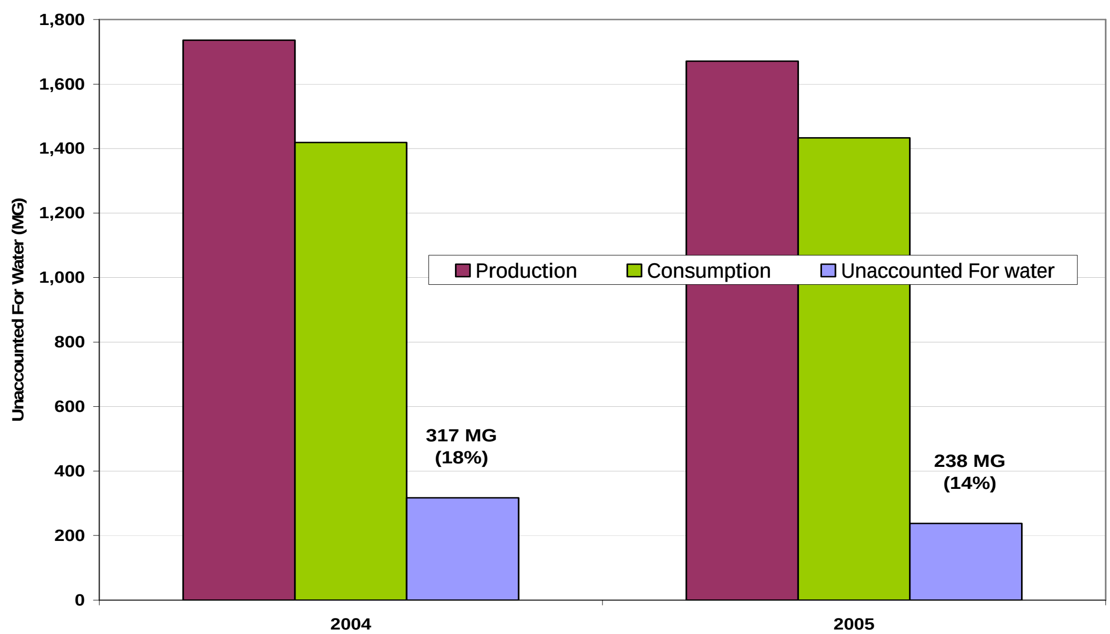


EXHIBIT 4-20
Redmond Demand Projections
Redmond Wastewater (Collection System) and Water System Master Plan

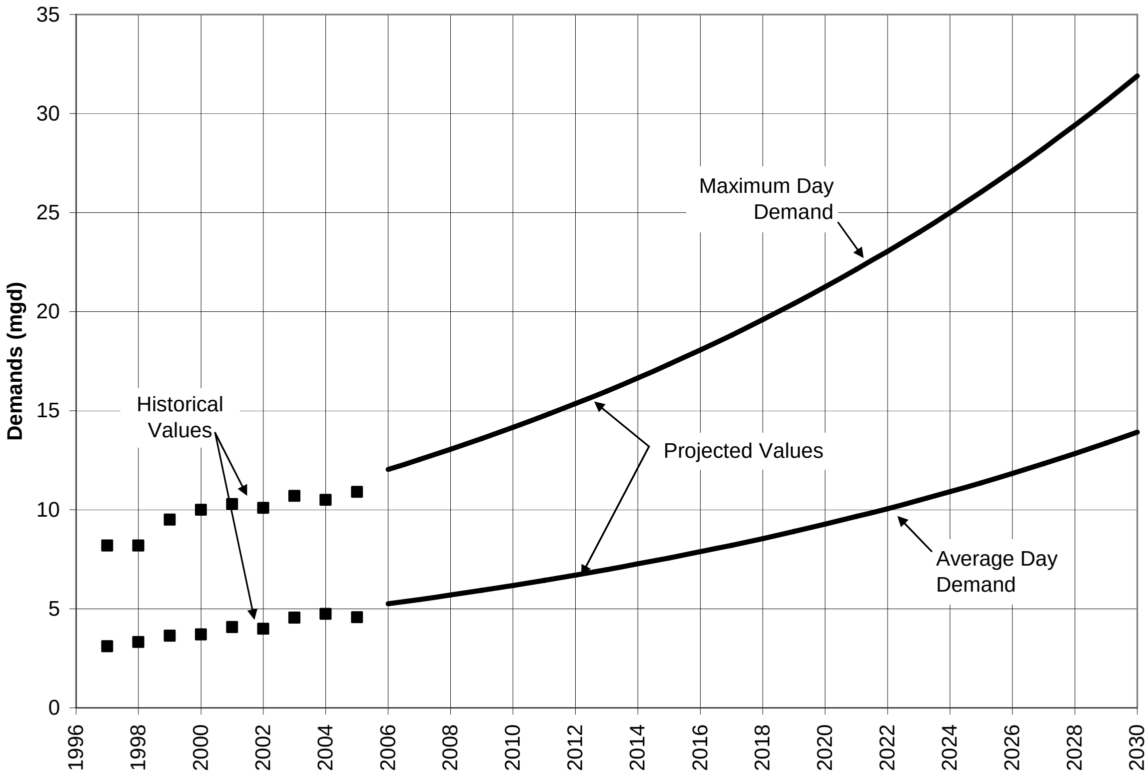


EXHIBIT 4-21
Well Description Summary
Redmond Wastewater (Collection System) and Water System Master Plan

No.	Recent Use Pattern	Area of City	Completion Date	Depth of Well (ft, bgs)	Depth of Grout Seal (ft, bgs)	Casing Diameter (in)	Pump Setting (ft, bgs)	Pump Motor Size (hp)	Approx. Well Capacity (gpm)	Approx. Static Water Level (ft, bgs)
1	Apr-Sep	North	July 1969	330	29	12	238	150	780	186
2	Apr-Sep	Northwest	Feb 1975	452	280	14	410	250	800	277
3	Year-round	Southeast	Sept 1979	452	32	14	437	200	1,100	317
4	Apr-Sep	Southwest	May 1986	765	50	18/12	575	600	2,800	362
5	Year-round	West	March 1995	802	400	16	370	600	3,000	259
6	(no history)	So-Central	Dec 2003	867	399	16	430	300	2,500	336
7	New	East	Dec 2006	862	322	16	425	300	2,500	326
					Total, gpm				**13,480**	
					Total, mgd				**19.4**	
					Total Firm Capacity, gpm				**10,480**	
					Total Firm Capacity, mgd				**15.1**	

1. All wells include meters, pressure gauges, pump to waste, and gas chlorination systems.
2. All wells are equipped with vertical turbine type pumps.
3. All wells pump into the 3180 Service Zone.
4. bgs = below ground surface.

EXHIBIT 4-22
Water Well Production History
Redmond Wastewater (Collection System) and Water System Master Plan

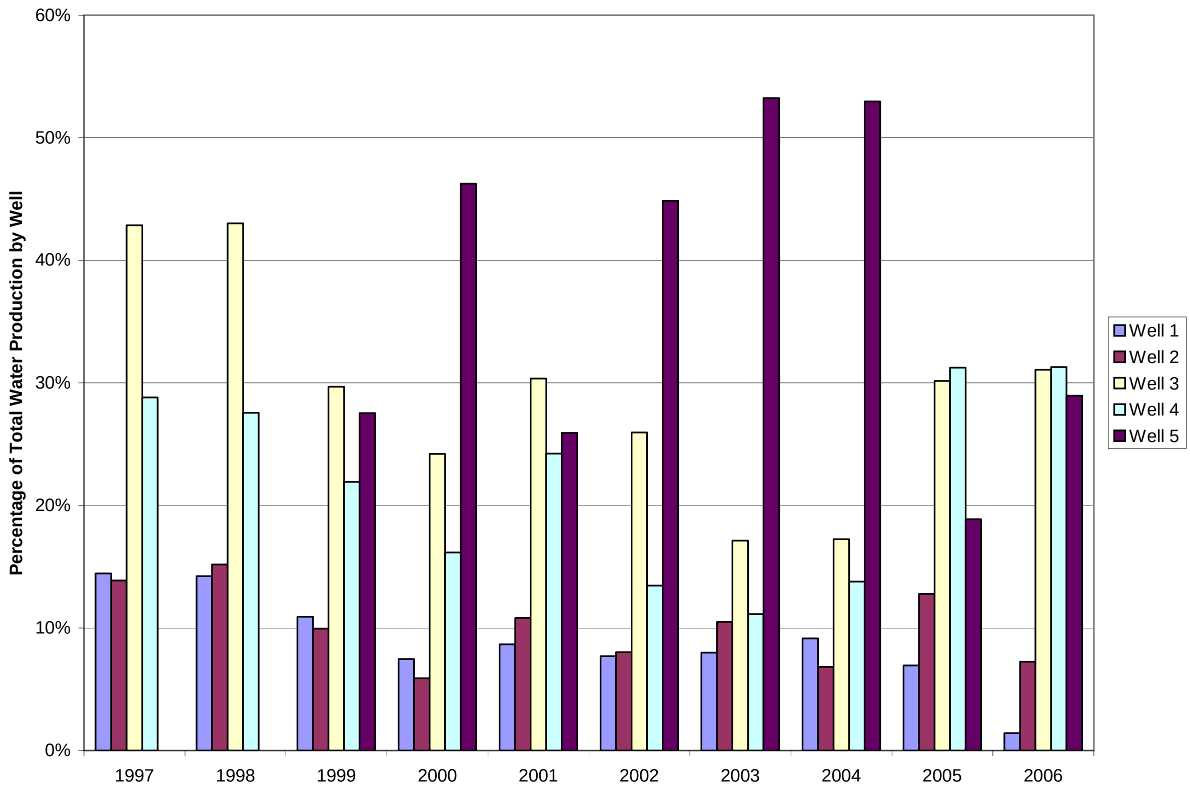


EXHIBIT 4-23
Redmond Water Rights Study
Redmond Wastewater (Collection System) and Water System Master Plan

Water Right			Priority Date	Quantity Authorized			Beneficial Use	Authorized Wells	Status/Comments
Application	**Permit**	**Certificate**		**cfs**	**gpm**	**mgd**			
Existing Municipal Groundwater Rights									
G-4981	G-4700	(80232) T-10162	September 5, 1969	2.22	996	1.43	Municipal	1, 2, 4, 5, 6	Certificate 80232 was cancelled upon approval of T-10162 adding Well 6 Change under T-10162 must be made by October 1, 2012
G-6865	G-6793		March 27, 1975	3.3	1,481	2.13	Municipal	1, 2, 4, 5	Claim of Beneficial Use (partial use) pending May need Extension of Time to finish permit development.
G-9462	G-8866	82751	November 7, 1979	2.45	1,100	1.58	Municipal	3	Certificated
G-11439	G-10544	(80233) T-10162	September 25, 1985	6.9	3,097	4.46	Municipal	1, 2, 4, 5, 6	Certificate 80233 was cancelled upon approval of T-10162 adding Well 6 Change under T-10162 must be made by October 1, 2012
G-12731	G-12401		November 25, 1991	5	2,244	3.23	Municipal	1, 2, 4, 5 Well 6 proposed by T-10163	Claim of Beneficial Use (partial use) pending May need Extension of Time to finish permit development Permit Amendment (T-10163) pending at OWRD
Subtotal of existing groundwater rights				***19.87***	***8,918***	***12.84***			
Pending Municipal Groundwater Rights									
G-14908			January 13, 1999	25	11,221	16.16	Municipal	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	Awaiting Proposed Final Order Permit issuance contingent upon mitigation
Subtotal of pending groundwater rights				***25***	***11,221***	***16.16***			
Total of existing and pending groundwater rights				**44.87**	**20,139**	**29.00**			
Existing Municipal Surface Water Rights									
S-2231	S-1177	2016	April 22, 1912	2	898	1.29	Municipal	N/A, Source is Deschutes River	Certificated
Total of surface water rights				**2**	**898**	**1.29**			

EXHIBIT 4-23
Redmond Water Rights Study
Redmond Wastewater (Collection System) and Water System Master Plan

Water Right			Priority Date	Quantity Authorized			Beneficial Use	Authorized Wells	Status/Comments
Application	**Permit**	**Certificate**		**cfs**	**gpm**	**mgd**			
Existing and Pending Irrigation Water Rights									
R-60935	R-8336	59048	October 23, 1980	286 ac-ft of stored effluent			Storage for irrigation	N/A	Certificated
S-61422	S-46323	59050	March 20, 1981	286 ac-ft of stored effluent			Irrigation of 141.8 acres	N/A	Certificated
G-13181	G-13181		November 10, 1992	0.78	350	0.50	Supplemental irrigation of 67.1 acres	Old Juniper well	Claim of Beneficial Use pending
G-16749			November 6, 2006	1.502	674	0.97	Irrigation/municipal 94.2 acres	Golf Club well	Awaiting Initial Review by OWRD
Total of irrigation (acres)							**209 ac. existing and 67.1 ac. pending**		

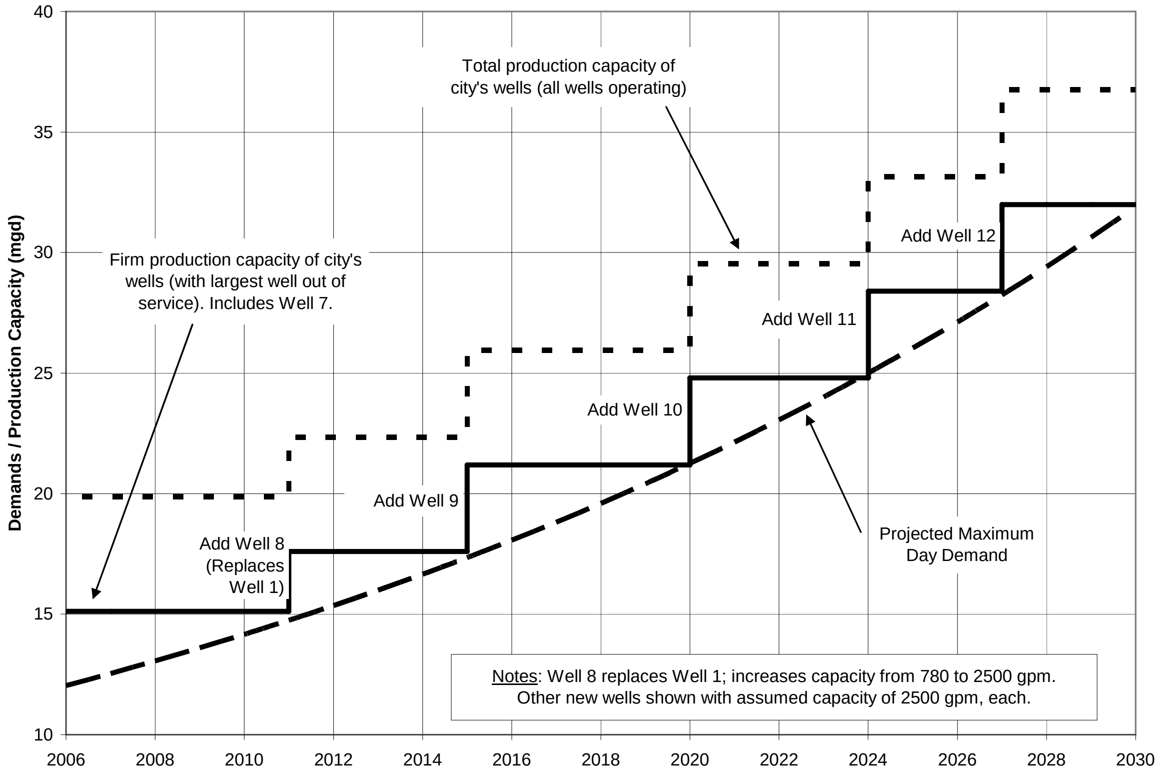
Abbreviations:

cfs = cubic feet per second

gpm = gallons per minute

mgd = million gallons per day

EXHIBIT 4-24
Well Capacity Chart
Redmond Wastewater (Collection System) and Water System Master Plan



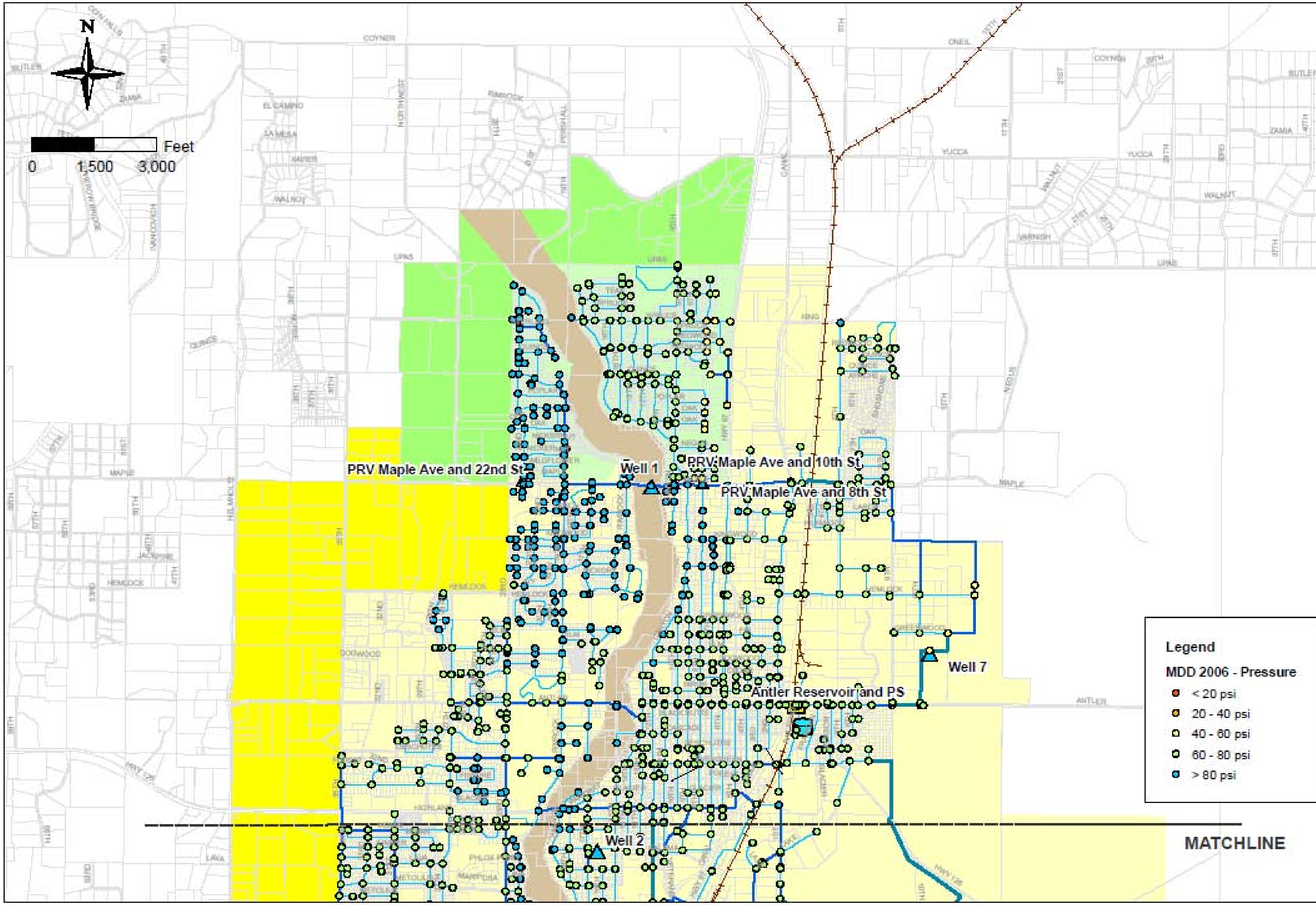


EXHIBIT 4-25a, North Panel
Existing (2006) MDD Pressure Results
Redmond Water System Plan

CITY OF REDMOND, OR
December 2007

CH2MHILL

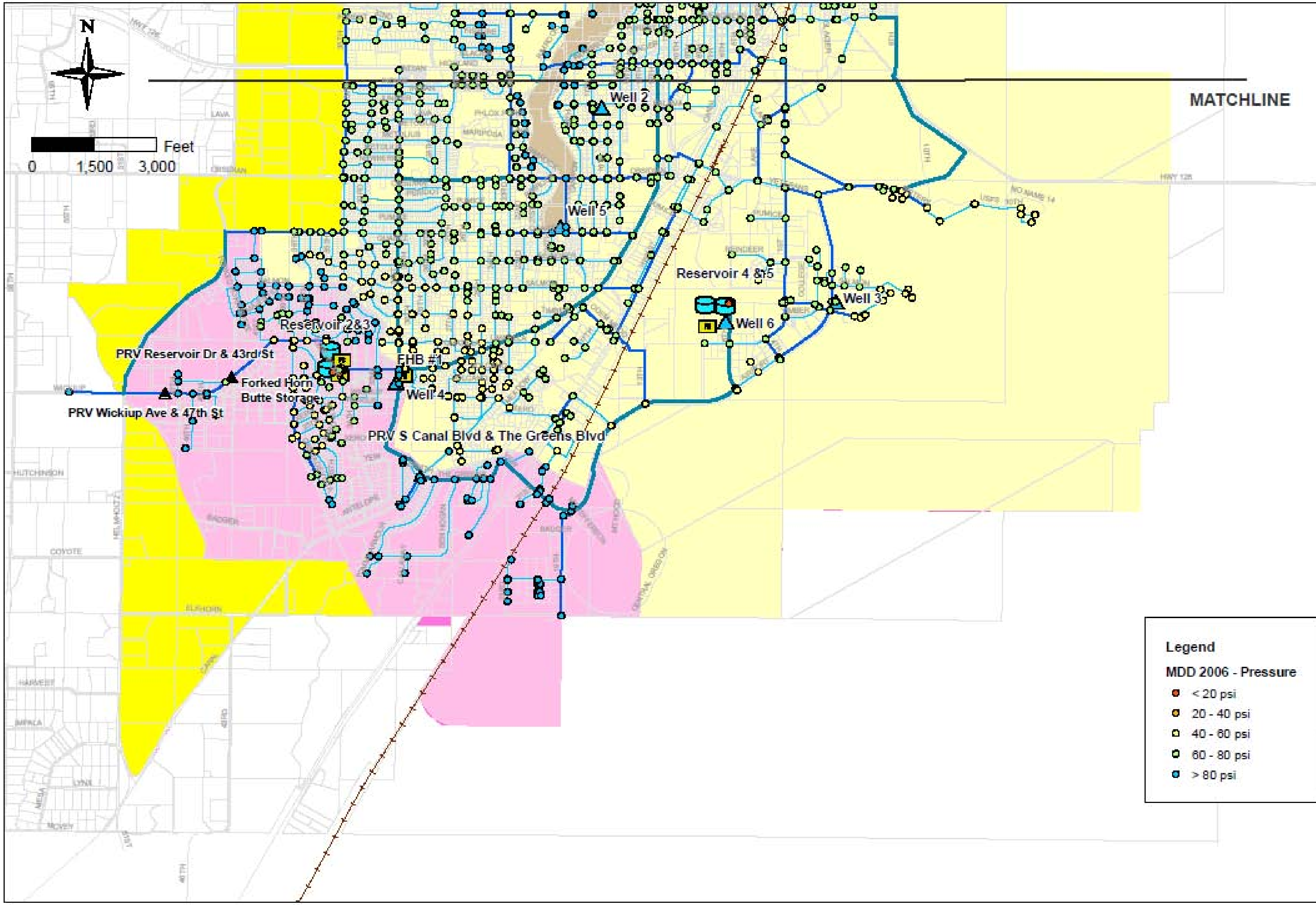


EXHIBIT 4-25b, South Panel
Existing (2006) MDD Pressure Results
Redmond Water System Plan

CH2MHILL
CITY OF REDMOND, OR
December 2007

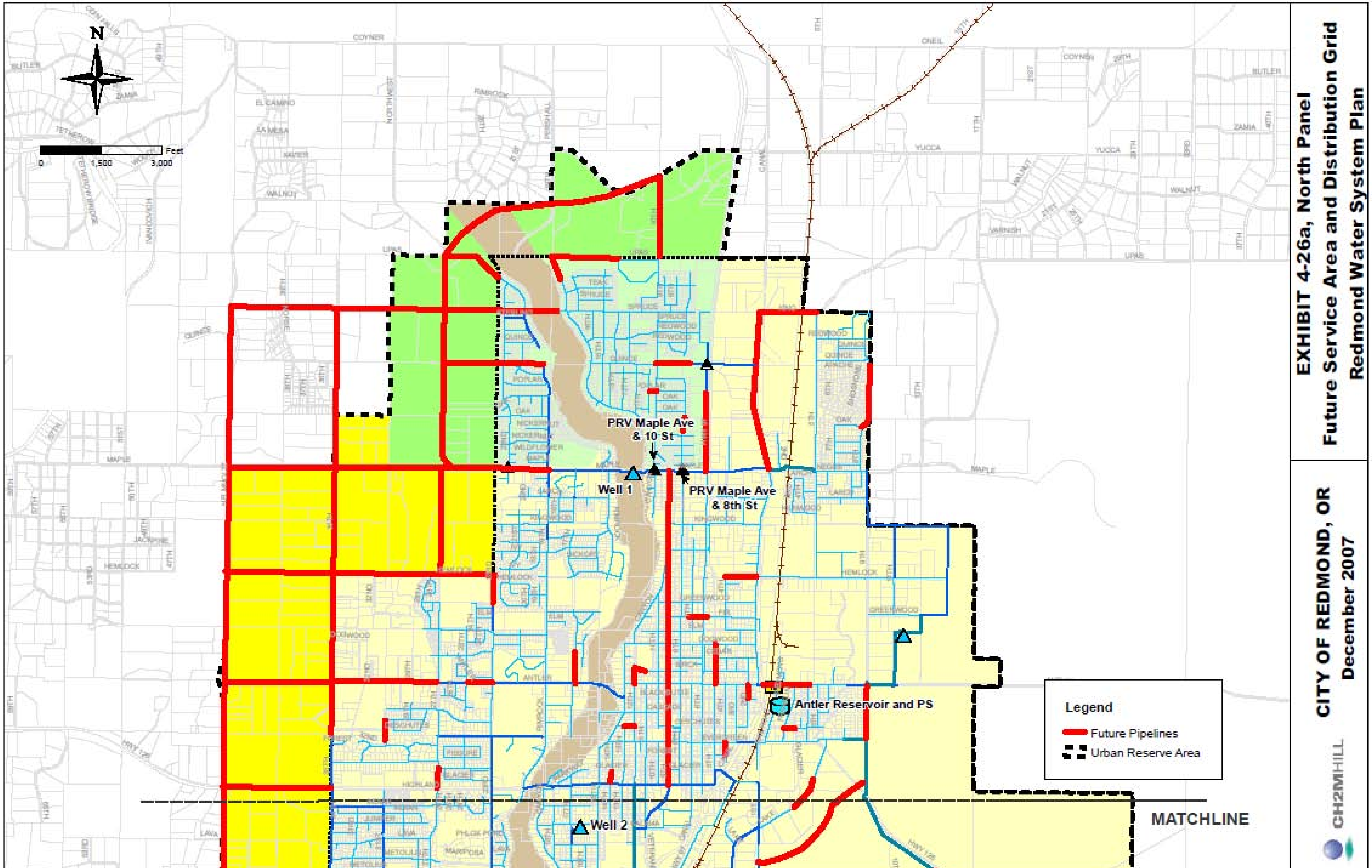


EXHIBIT 4-26a, North Panel
Future Service Area and Distribution Grid
Redmond Water System Plan
CITY OF REDMOND, OR
December 2007
CH2MHILL
N
Feet
0 1,500 3,000
PRV Maple Ave & 10 St
PRV Maple Ave & 8th St
Well 1
Well 2
Antler Reservoir and PS
MATCHLINE
Legend
Future Pipelines
Urban Reserve Area

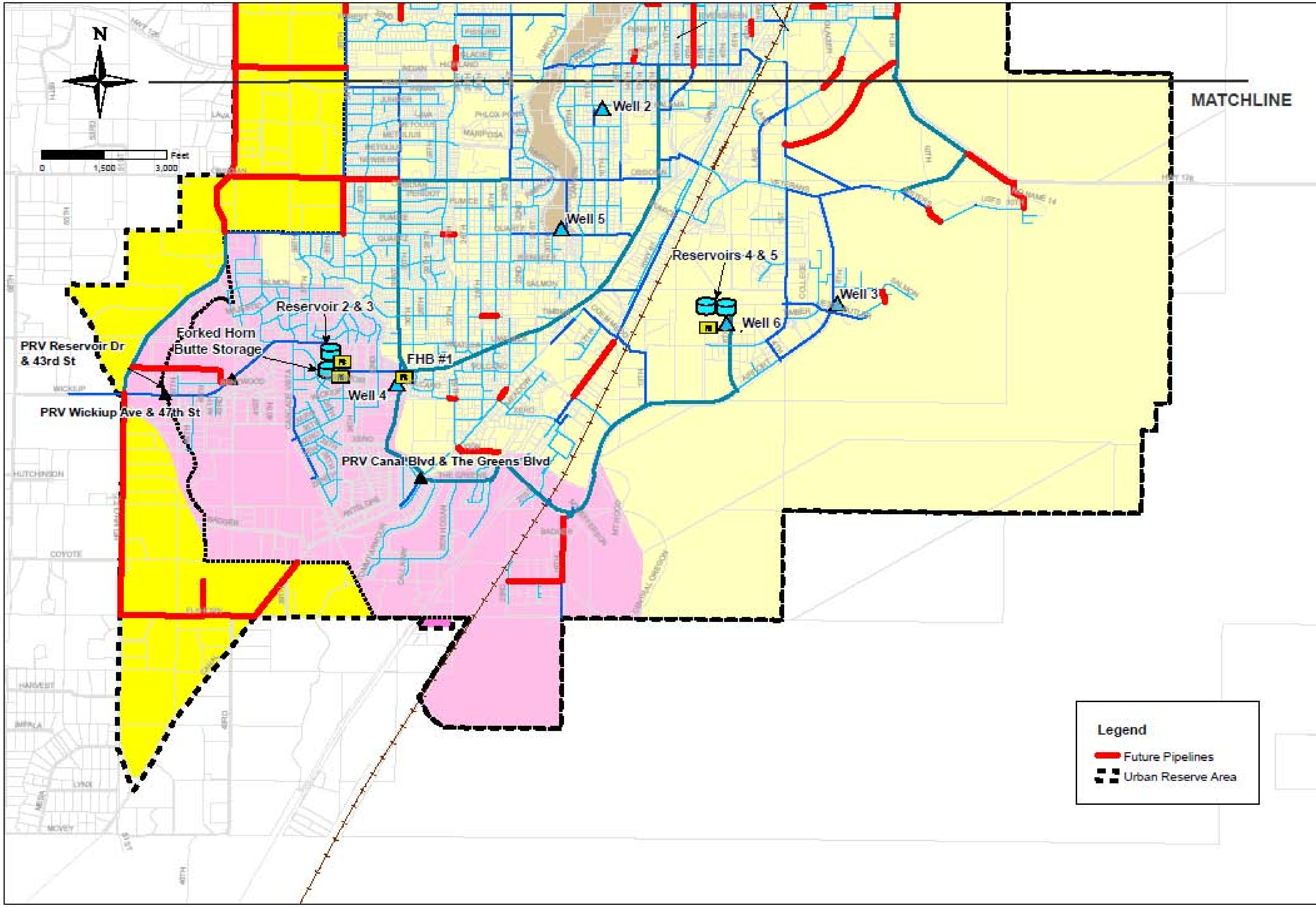


EXHIBIT 4-26b, South Panel
Future Service Area and Distribution Grid
Redmond Water System Plan

CITY OF REDMOND, OR
December 2007

CH2MHILL

EXHIBIT 4-27
Future Supply
Redmond Wastewater (Collection System) and Water System Master Plan

Supply Source	Capacity (gpm)
Abandon Well 1	0
Well 2	800
Well 3	1,100
Well 4	2,800
Well 5	3,000
Well 6	2,500
Well 7	2,500
Well 8 (replacement for Well 1)	2,500
Well 9	2,500
Well 10	2,500
Well 11	2,500
Well 12	2,500
2030 Total Capacity	**25,200**
2030 Firm Capacity	**22,200**
2030 MDD Demand	**22,200**

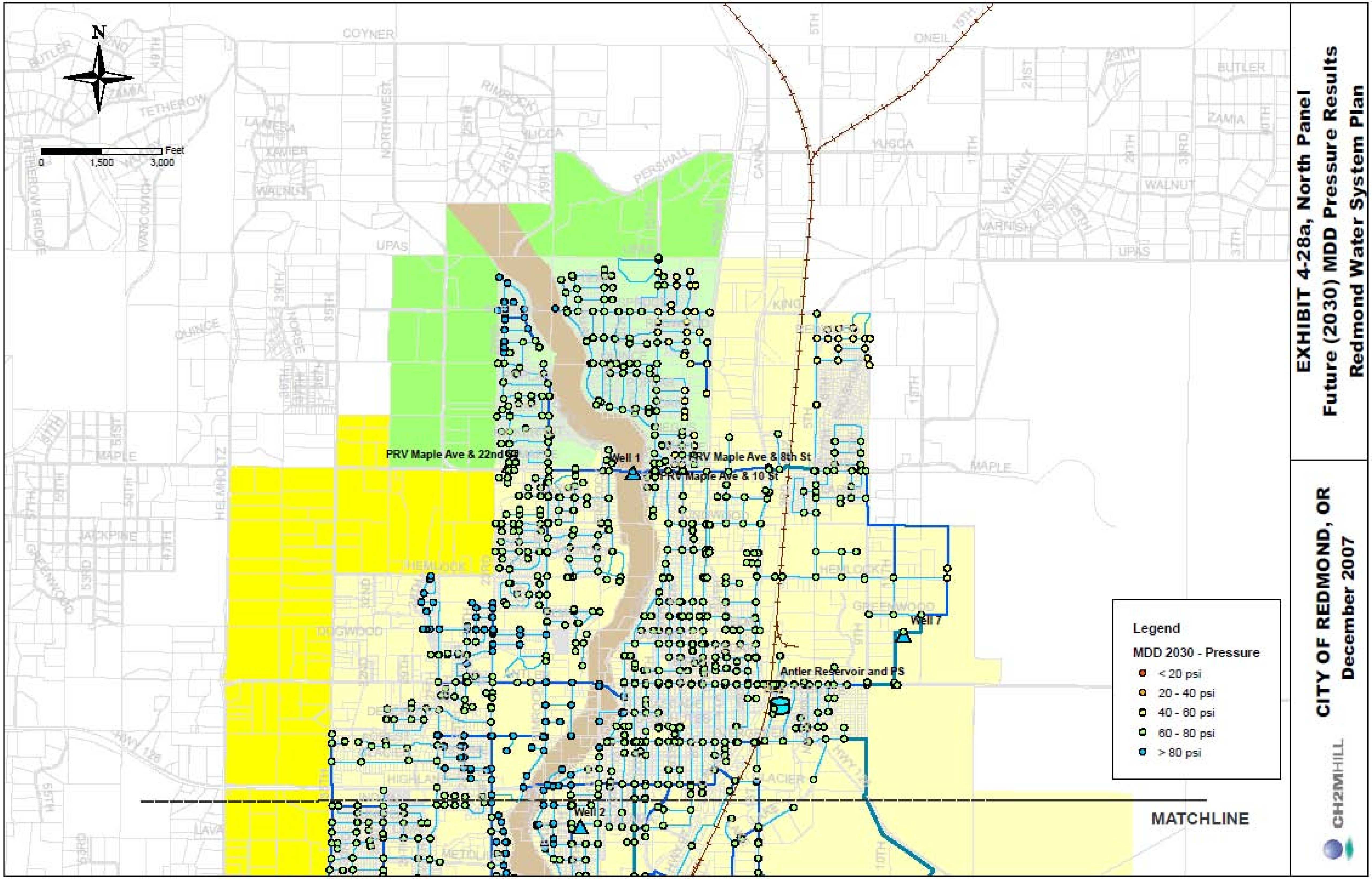


EXHIBIT 4-28a, North Panel
Future (2030) MDD Pressure Results
Redmond Water System Plan
CITY OF REDMOND, OR
December 2007
CH2MHILL
N
Feet
0
1,500
3,000
Legend
MDD 2030 - Pressure
< 20 psi
20 - 40 psi
40 - 60 psi
60 - 80 psi
> 80 psi
MATCHLINE
PRV Maple Ave & 22nd St
Well 1
PRV Maple Ave & 8th St
PRV Maple Ave & 10 St
Well 7
Antler Reservoir and PS
Well 2
COYNER
ONEIL
BUTLER
ZAMIA
TETHEROW
YUCCA
WALNUT
UPAS
QUINCE
MAPLE
JACKPINE
HEMLOCK
DOGWOOD
GREENWOOD
HELMHOLTZ
HWY 126
LAVA
RIMROCK
PERSHALL
CANAL
VARNISH
KING
HIGHLAND
GLACIER

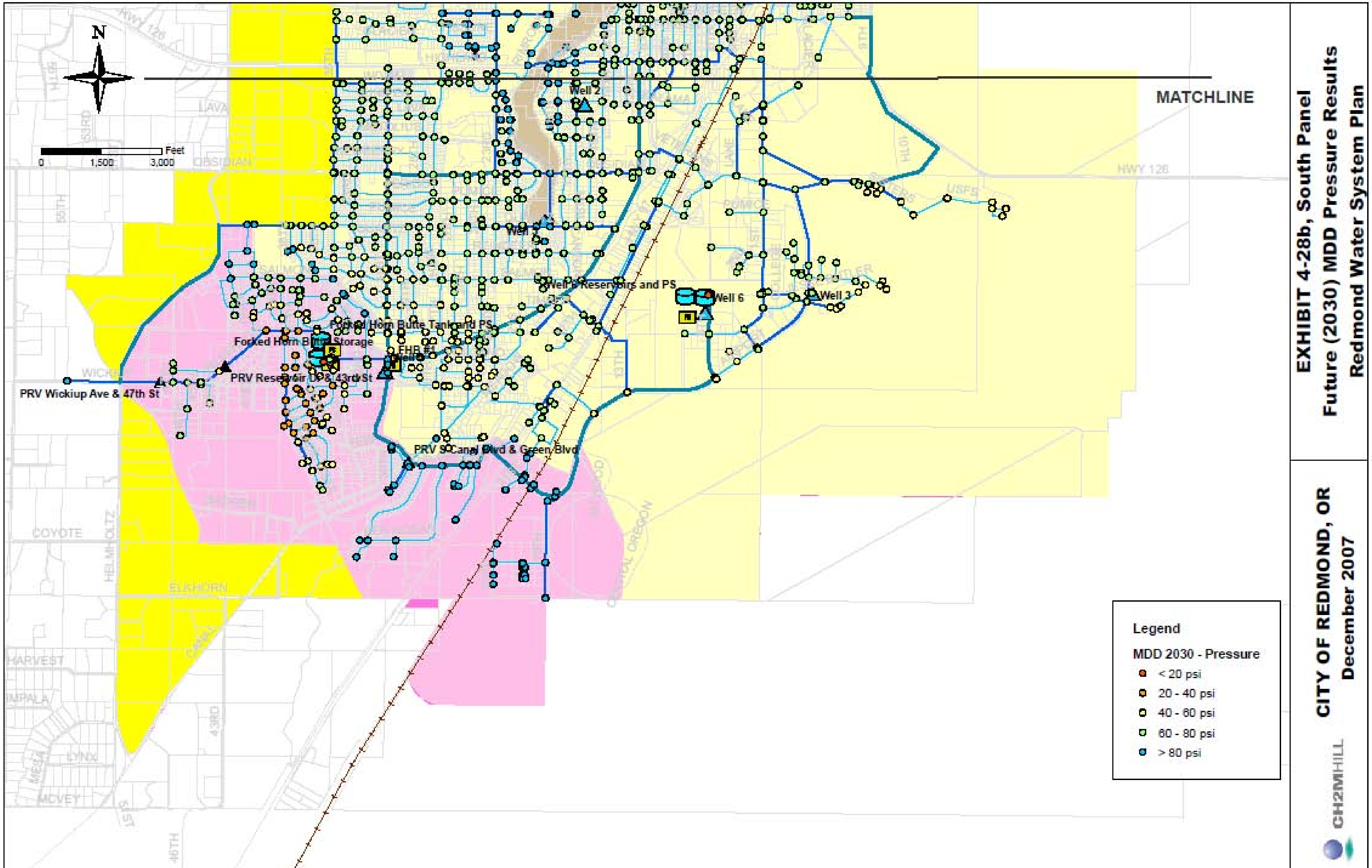


EXHIBIT 4-28b, South Panel
Future (2030) MDD Pressure Results
Redmond Water System Plan
CITY OF REDMOND, OR
December 2007
CH2MHILL
MATCHLINE
N
Feet
0
1,500
3,000
Legend
MDD 2030 - Pressure
< 20 psi
20 - 40 psi
40 - 60 psi
60 - 80 psi
> 80 psi
Well 2
Well 6
Well 3
Well 5 Reservoirs and PS
Forked Horn Butte Tank and PS
Forked Horn Butte Storage
FHB #1
PRV Reservoir DP & 43rd St
PRV Wickiup Ave & 47th St
PRV S Canal Blvd & Green Blvd
HWY 126
COYOTE
ELKHORN
HARVEST
IMPALA
LYNX
MCVEY
OBSIDIAN
LAVA
CANAL
HELMHOLTZ
43RD
46TH
51ST
10TH
13TH
USFS

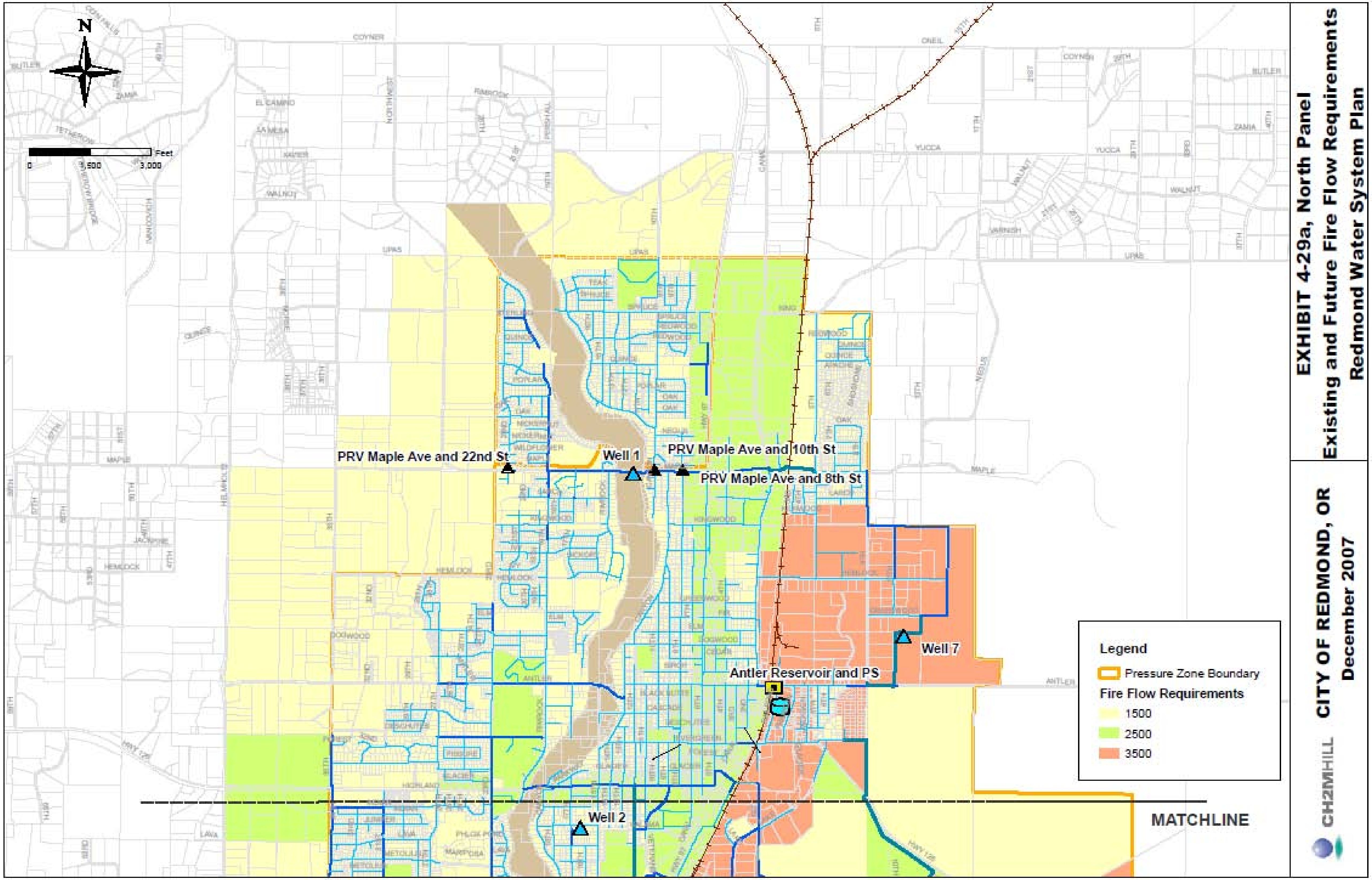
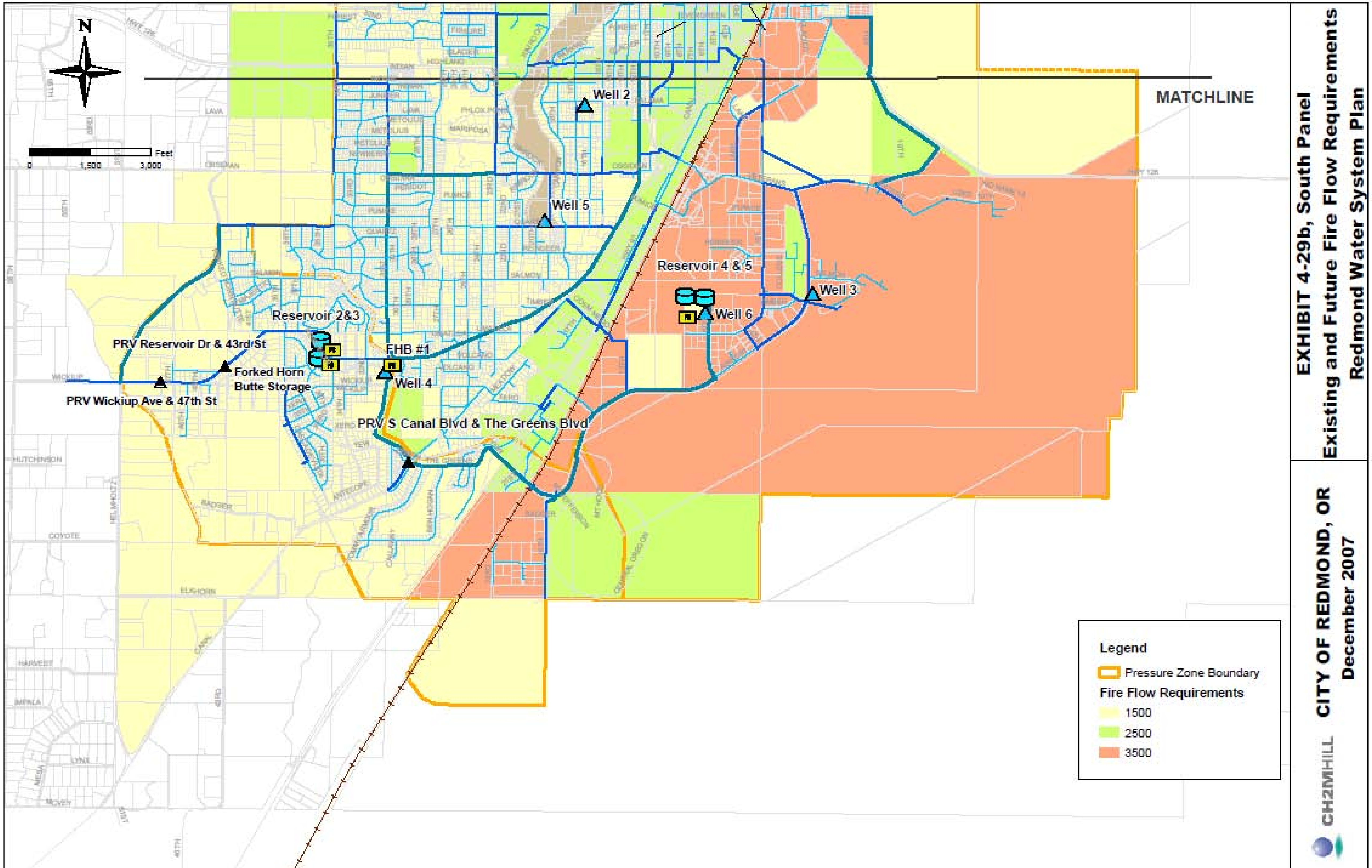


EXHIBIT 4-29a, North Panel
Existing and Future Fire Flow Requirements
Redmond Water System Plan
CITY OF REDMOND, OR
December 2007
CH2MHILL
Legend
Pressure Zone Boundary
Fire Flow Requirements
1500
2500
3500
PRV Maple Ave and 22nd St
Well 1
PRV Maple Ave and 10th St
PRV Maple Ave and 8th St
Well 7
Antler Reservoir and PS
Well 2
MATCHLINE
N
Feet
0
1,500
3,000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MATCHLINE
Well 2
Well 5
Well 3
Well 6
Reservoir 4 & 5
Reservoir 2&3
FHB #1
Well 4
PRV Reservoir Dr & 43rd St
Forked Horn
Butte Storage
PRV Wickiup Ave & 47th St
PRV S Canal Blvd & The Greens Blvd
Legend
Pressure Zone Boundary
Fire Flow Requirements
1500
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3500
EXHIBIT 4-29b, South Panel
Existing and Future Fire Flow Requirements
Redmond Water System Plan
CITY OF REDMOND, OR
December 2007
CH2MHILL

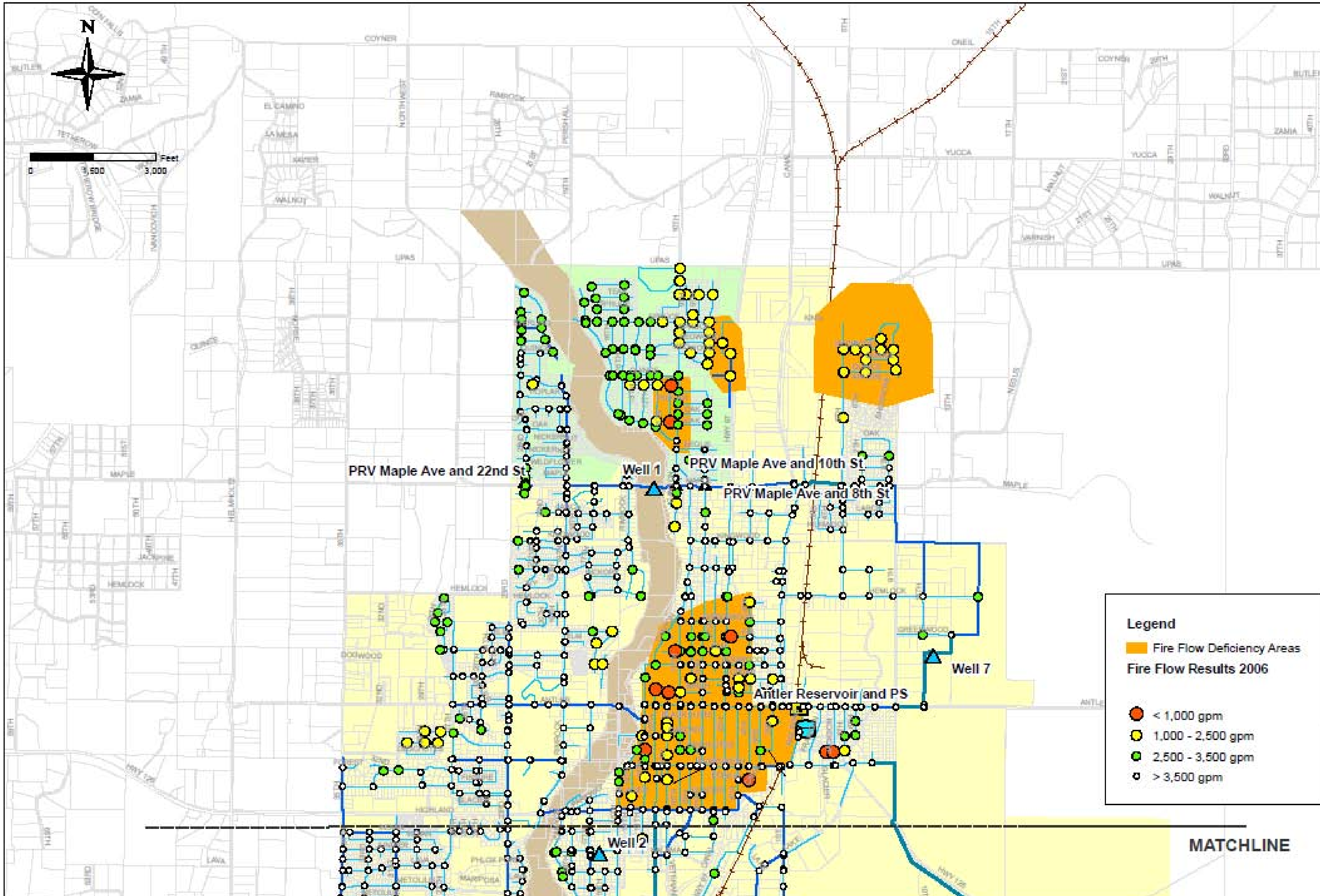

EXHIBIT 4-30a, North Panel
Fire Flow Availability and Deficiency Areas
Redmond Water System Plan

CITY OF REDMOND, OR
December 2007

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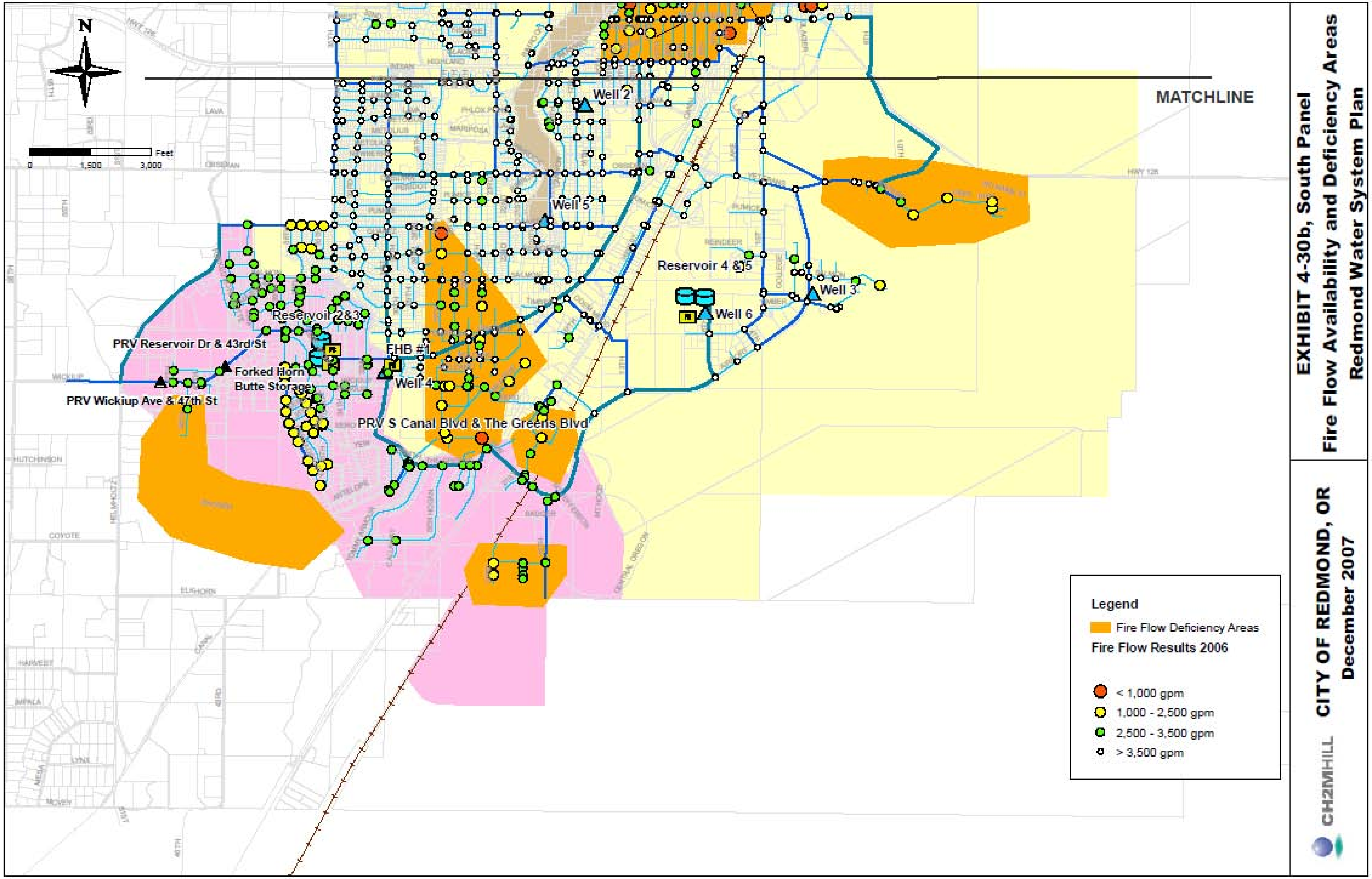
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Fire Flow Availability and Deficiency Areas
Redmond Water System Plan
CITY OF REDMOND, OR
December 2007
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Well 3
Well 6
Well 4
Reservoir 4 & 5
Reservoir 2&3
FHB #1
PRV Reservoir Dr & 43rd St
Forked Horn Butte Storage
PRV Wickiup Ave & 47th St
PRV S Canal Blvd & The Greens Blvd
Legend
Fire Flow Deficiency Areas
Fire Flow Results 2006
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1,000 - 2,500 gpm
2,500 - 3,500 gpm
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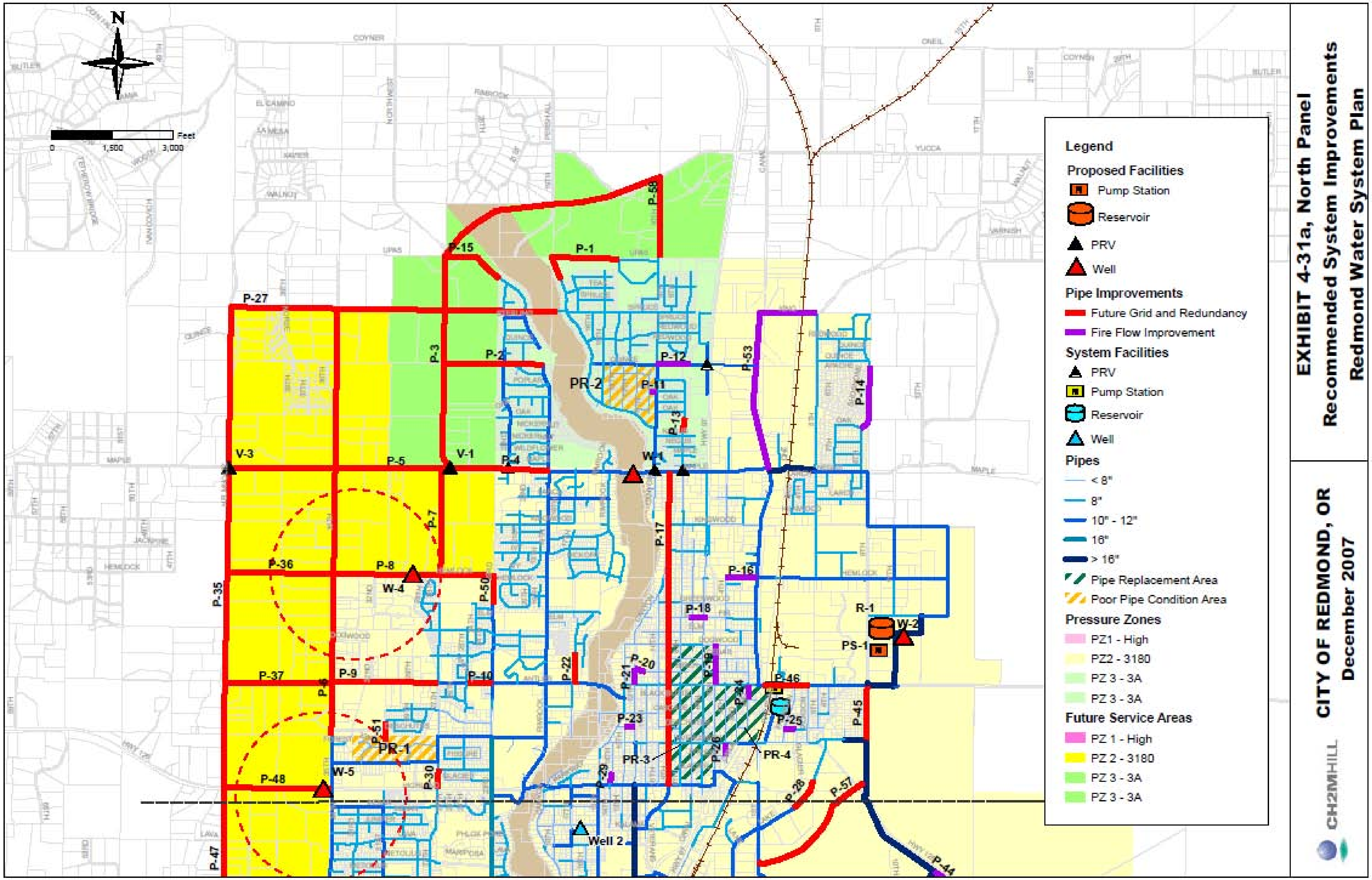
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Recommended System Improvements
Redmond Water System Plan
CITY OF REDMOND, OR
December 2007
CH2MHILL
Legend
Proposed Facilities
Pump Station
Reservoir
PRV
Well
Pipe Improvements
Future Grid and Redundancy
Fire Flow Improvement
System Facilities
PRV
Pump Station
Reservoir
Well
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10" - 12"
16"
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Pipe Replacement Area
Poor Pipe Condition Area
Pressure Zones
PZ1 - High
PZ2 - 3180
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Future Service Areas
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W-4
W-5
Well 2
R-1
PS-1
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EL CAMINO
LA MESA
WALNUT
MAPLE
HEMLOCK
YUCCA
BUTLER
ONEIL
COYNER

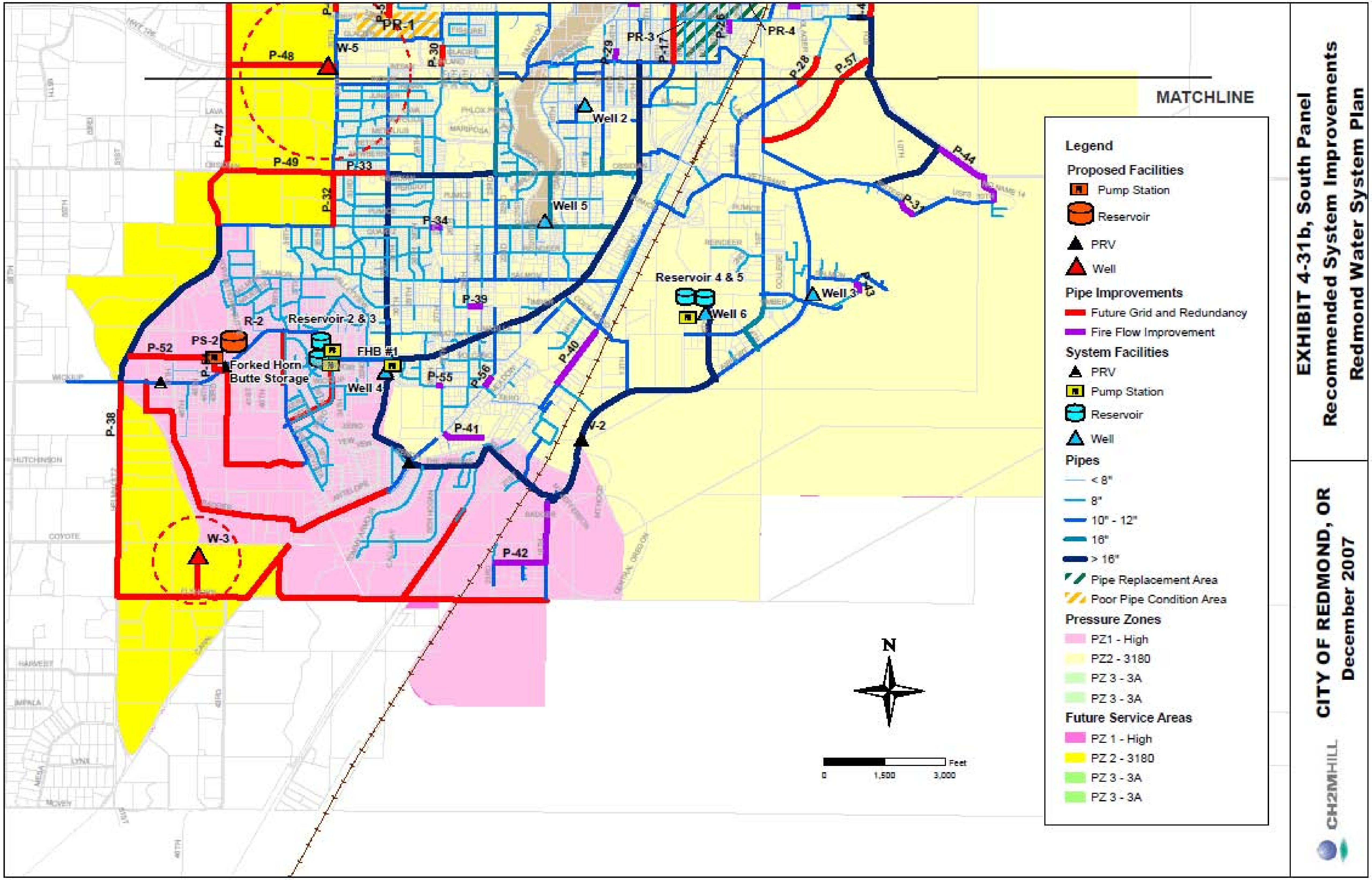
EXHIBIT 4-31b, South Panel
Recommended System Improvements
Redmond Water System Plan
CITY OF REDMOND, OR
December 2007
CH2MHILL
MATCHLINE
Legend
Proposed Facilities
Pump Station
Reservoir
PRV
Well
Pipe Improvements
Future Grid and Redundancy
Fire Flow Improvement
System Facilities
PRV
Pump Station
Reservoir
Well
Pipes
< 8"
8"
10" - 12"
16"
> 16"
Pipe Replacement Area
Poor Pipe Condition Area
Pressure Zones
PZ1 - High
PZ2 - 3180
PZ 3 - 3A
PZ 3 - 3A
Future Service Areas
PZ 1 - High
PZ 2 - 3180
PZ 3 - 3A
PZ 3 - 3A
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PR-3
PR-4
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P-47
P-49
P-33
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P-29
P-17
P-26
P-28
P-57
P-44
P-31
P-34
P-39
P-43
P-40
P-52
P-38
P-55
P-56
P-41
P-42
Well 2
Well 5
Well 3
Well 4
Well 6
Reservoir 4 & 5
Reservoir 2 & 3
R-2
PS-2
FHB #1
Forked Horn
Butte Storage

EXHIBIT 4-32
Existing and Future Storage Needs
Redmond Wastewater (Collection System) and Water System Master Plan

Year	Total System Volume (MG)	MDD (mgd)	Equalization (= 0.25 x MDD)	Emergency (= 1 x ADD)	Fire	Total Need	Surplus/(Deficit) Compared to Existing Volume
2006	10.0	12.0	3.0	5.2	0.84	8.2	1.8
2030	10.0	31.9	8.0	13.9	0.84	21.8	(11.8)

ADD = average day demand
MDD = maximum day demand

EXHIBIT 4-33
Reservoirs
Redmond Wastewater (Collection System) and Water System Master Plan

No.	Name	Volume (million gallons)	Overflow Elevation (feet)	Material Type	Installation Date
1	Well 6, Reservoir 1	2.0	3089	Steel	2006
2	Well 6, Reservoir 2	2.0	3089	Steel	2006
3	Antler	2.0	3030	Steel	1964
4	Forked Horn Butte System	2.0	3180	Concrete	2001
5	Forked Horn Butte Storage	2.0	3220	Concrete	1985
6	Forked Horn Butte System Tank 2	4.0	Proposed: 3180	Proposed: Concrete	2008-2015
7	Well 7, Reservoir 1	3.5	Proposed: 3083.5	Proposed: steel	2015-2028

EXHIBIT 4-34
Water System Projects List
Redmond Wastewater (Collection System) and Water System Master Plan

					Pipelines			
Implementation Phase	**ID**	**Project Type**	**Reason for Improvement**	**Fire Flow Priority for Pipelines[1]**	**Length (ft.)**	**Diameter (in.)**	**Total Estimate**	**Location**
2021-2025	P-1	Pipe	Growth and redundancy	4	2,250	8	$207,000	East from Northwest Way and NW Upas Ave to NW 22nd St
2016-2020	P-2	Pipe	Growth and redundancy	4	2,450	12	$339,000	East from Northwest Way and NW 22nd St to NW 19th St, north of NW Quince Ave
2021-2025	P-3	Pipe	Growth and redundancy	4	5,300	12	$732,000	Northwest Way between NW Maple Ave and NW Upas Ave
2016-2020	P-4	Pipe	Growth and redundancy	4	1,340	12	$186,000	Along NW Maple Ave from NW 23rd St to NW 19th St
2026-2030	P-5	Pipe	Growth and redundancy	4	3,950	12	$546,000	Along NW Maple Ave from NW 35th St to NW 22nd St
2021-2025	P-6	Pipe	Growth and redundancy	4	7,630	12	$1,054,000	Along NW 35th St from NW Maple Ave to SW Evergreen Ave
2021-2025	P-7	Pipe	Growth and redundancy	4	2,580	12	$357,000	Along Northwest Way from NW Maple Ave to Hemlock Ave
2021-2025	P-8	Pipe	Growth and redundancy	4	3,990	12	$551,000	Along NW Hemlock Ave from NW 35th St to NW 23rd St
2016-2020	P-9	Pipe	Growth and redundancy	4	2,600	12	$359,000	Along W Antler Ave from NW 35th St to NW 27th St
2016-2020	P-10	Pipe	Growth and redundancy	4	610	12	$84,000	Along W Antler Ave from NW 25th St to NW 23rd St
2007-2015	P-11	Pipe	Fire flow	2	180	8	$17,000	West from west end of NW Poplar Pl to existing 4-inch pipe east of NW 11th St
2007-2015	P-13	Pipe	Redundancy and fire flow	3	340	8	$32,000	Along NW 8th St from NW Negus Pl to NW Oak Pl
2016-2020	P-14	Pipe	Fire flow	3	1,630	8	$150,000	South from east end of NE Quince Ave to intersection of NE 8th St and NE Oak Pl
2021-2025	P-15	Pipe	Growth and redundancy	4	1,560	12	$216,000	East from Northwest Way and NW Upas Ave to intersection of NW 22nd St and NW 19th St
2007-2015	P-16	Pipe	Fire flow	2	770	12	$106,000	West 769 feet from NW Canal Blvd and NE Hemlock Ave
2007-2015	P-17	Pipe	Redundancy and replacement of poor condition pipe	1	7,800	12	$1,077,000	Along NW 9th St from NW Maple Ave to SW Highland Ave
2007-2015	P-18	Pipe	Fire flow	2	440	8	$41,000	Along NW Fir Ave from west of NW 7th St to mid-block between NW 6th St and NW 5th St
2007-2015	P-19	Pipe	Fire flow	3	990	8	$91,000	Along NW 5th St from W Antler Ave to NW Dogwood Ave
2007-2015	P-20	Pipe	Fire flow	1	270	8	$26,000	270 ft along NW Birch Ave from NW 12th St
2007-2015	P-21	Pipe	Fire flow	1	380	8	$35,000	Along NW 12th St from NW Birch Ave to W Antler Ave
2007-2015	P-22	Pipe	Growth and redundancy	4	780	8	$72,000	North from W Antler Ave between SW 17th St and SW 15th St to south end of cul-de-sac
2007-2015	P-23	Pipe	Fire flow	1	260	8	$25,000	Along SW Deschutes Ave from SW 12th St to SW 13th St
2007-2015	P-24	Pipe	Fire flow	2	330	12	$46,000	Along SW 2nd St from SW Black Butte Blvd to W Antler Ave
2007-2015	P-25	Pipe	Fire flow	2	290	8	$27,000	Along SE Deschutes Ave from SE Franklin Ave to SE Warsaw St
2007-2015	P-26	Pipe	Fire flow	2	320	8	$30,000	Along SW 4th St from SW Forest Ave to SW Evergreen Ave

EXHIBIT 4-34
Water System Projects List
Redmond Wastewater (Collection System) and Water System Master Plan

					Pipelines			
Implementation Phase	**ID**	**Project Type**	**Reason for Improvement**	**Fire Flow Priority for Pipelines[1]**	**Length (ft.)**	**Diameter (in.)**	**Total Estimate**	**Location**
2007-2015	P-27a	Pipe	Redundancy	4	2,800	12	$387,000	NW Spruce Ave, between Northwest Way and NW Helmholtz Way; NW Helmholtz Way between NW Spruce Ave and NW Maple Ave
2026-2030	P-27b	Pipe	Growth	4	7,700	12	$1,063,000	
2007-2015	P-28	Pipe	Growth and redundancy	4	860	10	$99,000	Along SE Lake Rd between SE 1st St and E Hwy 126
2007-2015	P-29	Pipe	Fire flow	2	260	8	$25,000	Along SW 14th St from SW Highland Ave to SW Glacier Ave
2016-2020	P-30	Pipe	Growth and redundancy	4	500	8	$46,000	Along SW 27th St from SW Glacier Ave to SW Highland Ave
2007-2015	P-31	Pipe	Fire flow	3	460	12	$64,000	Along SW 10th St from USFS Dr to south end of SW 10th St
2016-2020	P-32	Pipe	Growth and redundancy	4	1,320	12	$182,000	Along SW 35th St from SW Obsidian Ave to SW Quartz Ave
2016-2020	P-33	Pipe	Growth and redundancy	4	1,320	16	$243,000	Along SW Quartz Ave from SW 35th St to SW 31st St
2007-2015	P-34	Pipe	Fire flow	1	280	8	$26,000	Along SW Quartz Ave from SW 27th St to SW 27th Pl
2026-2030	P-35	Pipe	Growth and redundancy	4	7,920	12	$1,093,000	East on NW Maple Ave from NW 35th St to NW Helmholtz Way, south on NW Helmholtz Way to W Antler Ave
2021-2025	P-36	Pipe	Growth and redundancy	4	2,710	12	$374,000	NW Hemlock Ave between NW Helmholtz Way and NW 35th St
2026-2030	P-37	Pipe	Growth and redundancy	4	2,660	12	$367,000	W Antler Ave between NE Helmholtz Way and NW 35th St
2021-2025	P-38	Pipe	Growth and redundancy	4	1,240	16	$228,000	South from the south end of SW 47th St to SW Badger Ave, east along SW Badger Ave to SW Canal Blvd
2016-2020	P-39	Pipe	Fire flow	3	370	8	$35,000	Along SW Timber Ave from SW 25th St to SW 24th St
2007-2015	P-40	Pipe	Fire flow	1	1,640	12	$227,000	Along S Hwy 97 from SW Wickiup Ave to SW Odem Medo Way
2007-2015	P-41	Pipe	Fire flow	1	1,030	10	$119,000	Along SW Yew Ave between SW Canal Blvd and the Hwy 97 on ramp
2007-2015	P-42	Pipe	Fire flow	2	2,800	16	$516,000	SW 19th St, east of Central Oregon Dr
2007-2015	P-43	Pipe	Fire flow	2	270	12	$37,000	End of SE Salmon Ave
2007-2015	P-44	Pipe	Fire flow	2	2,100	16	$387,000	Parallel to E Highway 126, east of SE Veterans Way
2016-2020	P-45	Pipe	Growth and redundancy	4	1,300	18	$270,000	SE 9th St between E Antler Ave and SE Evergreen Ave
2016-2020	P-46	Pipe	Growth and redundancy	4	1,150	16	$212,000	Along E Antler Ave from NW Canal Blvd to NE 9th St
2026-2030	P-47	Pipe	Growth and redundancy	4	6,780	16	$1,248,000	SW Helmholtz Way between W Antler Ave and Quartz
2021-2025	P-48	Pipe	Growth and redundancy	4	2,680	12	$371,000	Connecting SW Helmholtz Way and W-5, south of Highland
2021-2025	P-49	Pipe	Growth and redundancy	4	2,680	16	$494,000	SW Obsidian Ave between SW Helmholtz Way and SW 35th St
2021-2025	P-50	Pipe	Growth and redundancy	4	670	12	$92,000	NW 23rd St between NW Fir Ave and NW Hemlock Ave

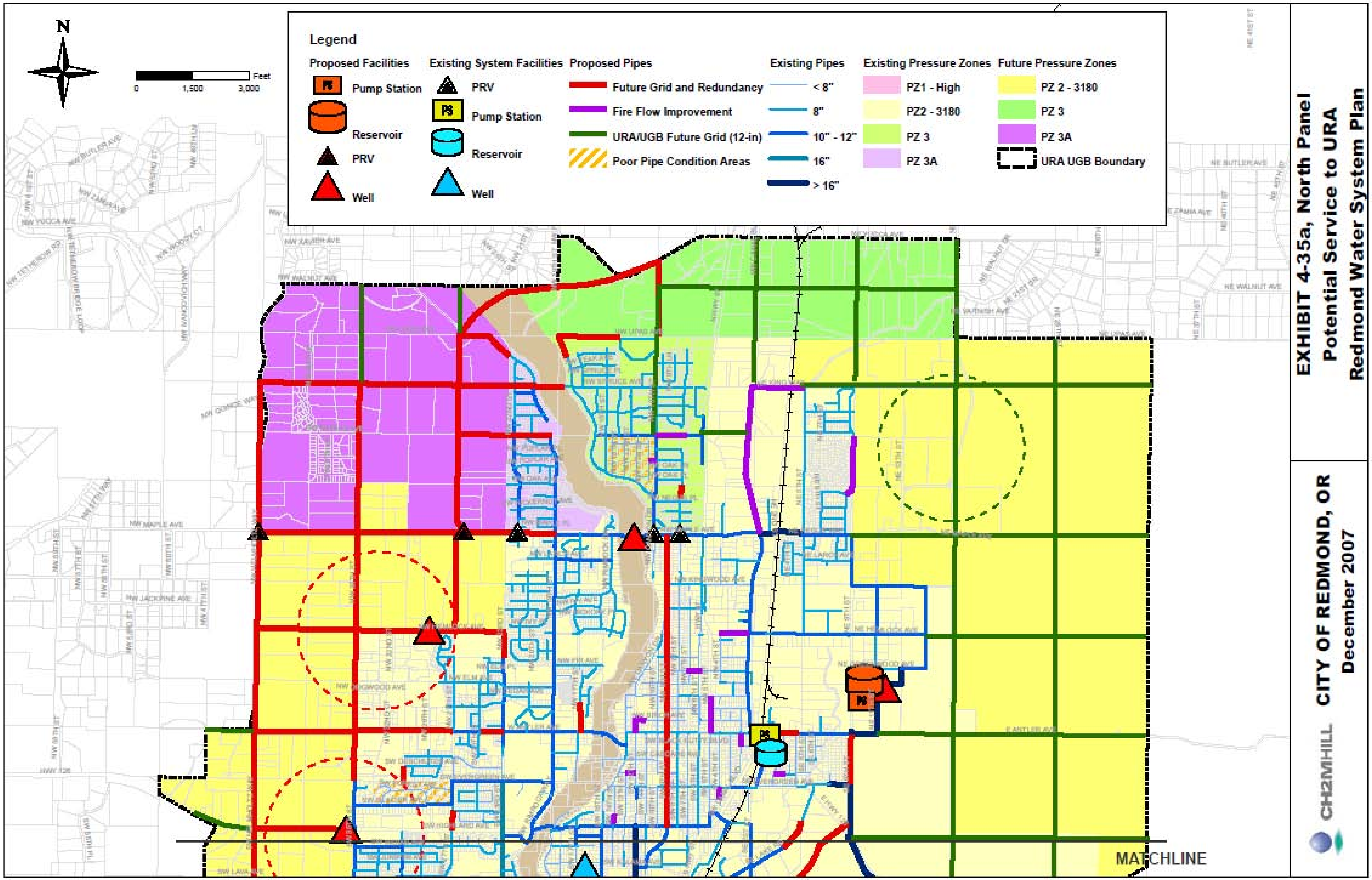
EXHIBIT 4-34
Water System Projects List
Redmond Wastewater (Collection System) and Water System Master Plan

					Pipelines			
Implemen-tation Phase	**ID**	**Project Type**	**Reason for Improvement**	**Fire Flow Priority for Pipe-lines[1]**	**Length (ft.)**	**Dia-meter (in.)**	**Total Estimate**	**Location**
2007-2015	P-51	Pipe	Growth and redundancy	4	480	8	$44,000	SW 31st St between Deschutes and Forest
2021-2025	P-52	Pipe	Growth and redundancy	4	2,060	18	$419,000	Along E Antler Ave from NW Canal Blvd to NE 9th St and new FHB reservoir
2016-2020	P-53	Pipe	Growth and redundancy	4	5,400	12	$696,000	Along NW Canal Blvd, from NW Maple Ave to NE King Way and Along NE King Way to NE 5th St
2021-2025	P-54	Pipe	Growth and redundancy	4	440	12	$61,000	From PS-2 along SW Volcano Ave to SW Reservoir Dr
2007-2015	P-55	Pipe	Fire flow	1	170	8	$17,000	Along SW Wickiup Ave between SW 28th St and SW 27th St
2007-2015	P-56	Pipe	Fire flow	1	330	8	$30,000	Along SW Canal Blvd between SW Wickiup Ave and SW 23rd St
2007-2015	P-57	Pipe	Growth and redundancy	4	3470	12	$479,000	Located in southeast area of system
2021-2025	P-58	Pipe	Growth and redundancy	4	7,880	12	$1,088,000	
2007-2015	PR-1	Pipe Replace-ment (6"-8" PVC)	Poor pipe condition		7,500	8	$828,000	Area between SW 27th St and SW 35th St and between W Antler Ave and SW Glacier Ave
2007-2015	PR-2	Pipe Replace-ment (6"-8" PVC)	Poor pipe condition		5,700	8	$630,000	Area between NW 10th St to NW 15th St and between NW Quince Ave and NW Canyon Dr
2007-2015	PR-3	Pipe Replace-ment (1"-6") in down-town area	Undersized and poor condition steel pipes		9,720	8	$1,073,000	Between Highland St. and Greenwood St., and between 3rd St. and 9th St.
2007-2015	PR-4	Pipe Replace-ment east of down-town	Undersized and poor condition steel pipes		5,480	8	$605,000	Between Antler St. and Evergreen St., and between 5th St. and the railroad tracks
2007-2015	W-2	Complete Well 7	Supply increase				$1,472,000	NE 11th Street south of NE Glenwood Ave
2007-2015	W-1	Well 8	Supply increase				$2,323,000	NW Maple Ave west of NW Canyon Dr
2007-2015	W-5	Well 9	Supply increase				$2,323,000	New school well site, vicinity of SW Elkhorn Ave and SW 43rd St
2016-2020	W-4	Well 10	Supply increase				$2,323,000	NW Hemlock Ave, west of NW 28th St
2021-2025	W-3	Well 11	Supply increase				$2,323,000	SW Quartz Ave and SW 31st St
2026-2030	W-6	Well 12	Supply increase				$2,323,000	

EXHIBIT 4-34
Water System Projects List
Redmond Wastewater (Collection System) and Water System Master Plan

					Pipelines			
Implemen-tation Phase	**ID**	**Project Type**	**Reason for Improvement**	**Fire Flow Priority for Pipe-lines[1]**	**Length (ft.)**	**Dia-meter (in.)**	**Total Estimate**	**Location**
2007-2015	R-1	Well 7 Reservoir	Future storage. Volume = 3.5 MG. Steel				$4,025,000	NE 11th Street south of NE Greenwood Ave
2021-2025	R-2	Forked Horn Butte Reservoir	Future storage. Volume = 4.0 MG. Prestressed concrete tank				$6,440,000	Near Wickiup Ave. and 45th Street. (Partially buried tank)
2007-2015	PS-1	Well 7 Pump Station	Future supply				$1,955,000	NE 11th Street south of NE Glenwood Ave
2021-2025	PS-2	Pump Station	Supply to Zone 1				$621,000	
2007-2015	V-1	Pressure Reducing Valve (PRV)	Locate on zone boundary, in NW area.				$58,000	Northwest Way and Maple Ave
2007-2015	V-2	Check Valve	Located in SE, at boundary PZ2 to PZ3.				$58,000	SE Airport Way between Mt Jefferson DR and Mt Hood Dr
2026-2030	V-3	Pressure Reducing Valve (PRV)	Pressure zone boundary - west side				$58,000	NW Maple Ave and NW Helmholtz Way
						TOTAL	**$46,900,000**	

Notes:
1. Pipe Priority Level:
   1 = Residential Fire Flow Improvement, less than 1,000 gpm available
   2 = Commercial or Industrial Fire Flow Improvement, less than 75% of required flow available
   3 = Fire Flow Improvement, more than 75% of required flow available
   4 = Not driven by fire flow deficiency
2. Cost index: ENR CCI Seattle Area = 8626 (January 2007)
3. Project P-12, a 12-inch pipe on NW Quince Ave., between NW 10th St. and NW 7th St., was constructed in summer 2007 as the master plan was being completed. It was therefore deleted from list.
4. This water projects list does not show purchase costs for water rights mitigation credits. They are included in the CIP table that is provided in an appendix.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Proposed Facilities
Pump Station
Reservoir
PRV
Well
Existing System Facilities
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Pump Station
Reservoir
Well
Proposed Pipes
Future Grid and Redundancy
Fire Flow Improvement
URA/UGB Future Grid (12-in)
Poor Pipe Condition Areas
Existing Pipes
< 8"
8"
10" - 12"
16"
> 16"
Existing Pressure Zones
PZ1 - High
PZ2 - 3180
PZ 3
PZ 3A
Future Pressure Zones
PZ 2 - 3180
PZ 3
PZ 3A
URA UGB Boundary
MATCHLINE
EXHIBIT 4-35a, North Panel
Potential Service to URA
Redmond Water System Plan
CITY OF REDMOND, OR
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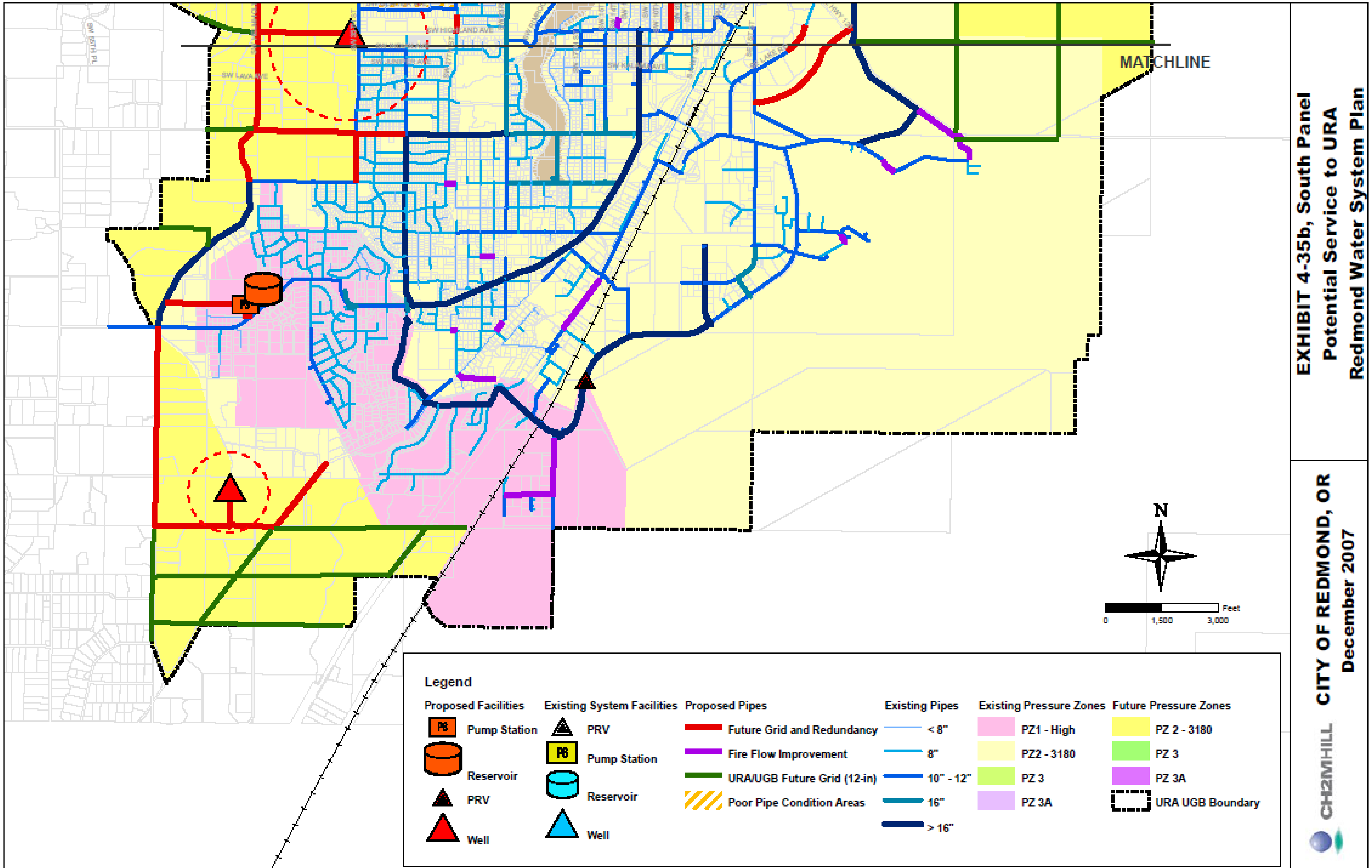
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Proposed Facilities
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Reservoir
PRV
Well
Existing System Facilities
PRV
PS Pump Station
Reservoir
Well
Proposed Pipes
Future Grid and Redundancy
Fire Flow Improvement
URA/UGB Future Grid (12-in)
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Existing Pipes
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8"
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16"
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Existing Pressure Zones
PZ1 - High
PZ2 - 3180
PZ 3
PZ 3A
Future Pressure Zones
PZ 2 - 3180
PZ 3
PZ 3A
URA UGB Boundary
EXHIBIT 4-35b, South Panel
Potential Service to URA
Redmond Water System Plan
CITY OF REDMOND, OR
December 2007
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APPENDIX A

Wastewater System Model Development, Analysis, Results, and Recommendations

City of Redmond

Sanitary Sewer Model

Overview and Review

June 13, 2007

Crawford Engineering Associates

Introduction

In consultation with the City of Redmond, Crawford Engineering Associates, Inc. (CEA) developed an XP-SWMM model of the Redmond wastewater collection system to evaluate potential capacity deficiencies for existing and future conditions. The planning horizon for this effort was 2026.

CEA performed this work as a subcontractor to CH2M HILL for the City of Redmond Water Master Plan and Public Facilities Plan Update and Wastewater (Collection System) Master Plan and Public Facilities Plan Update.

Development of the sewer model entailed defining and mapping the collection system, estimating existing and future sewage flows, and calibrating the model to best represent the collection system for hydraulic analysis. These steps in the development of the model are described separately below, followed by an outline of the analysis criteria used and a summary of the results.

Definition and Mapping of the Collection System

Definition of the collection system was based primarily on existing City of Redmond geographical information system (GIS) data consisting of manholes, pipelines, pump stations, and tax lots. The model was constructed to include pipelines 10 inches or greater in diameter, except when smaller diameter pipelines were essential to the connectivity of the system. Also, some 10-inch or greater pipelines were not included as individual elements of the model because their flows were aggregated to a single subbasin flow input, as in a small subdivision. The wastewater collection system is shown in Figure 1; the modeled and not-modeled elements are indicated. Different symbols are used on the figure to show manholes that were not modeled.

The following infrastructure information was incorporated into the collection system model with modifications to GIS tables if data variables were missing:

- Manhole data
  - Manhole unique name
  - Rim elevation
  - Invert elevation
- Pipe data
  - Unique name
  - Upstream (US) and downstream (DS) manhole names (connectivity)
  - Diameter, length, US invert, DS invert, and slope
  - Pipelines were assumed to be circular with a Manning's Roughness of 0.013

Collection system data were reviewed, and missing or inconsistent data were corrected. Corrections were labeled with an added comment field in GIS tables. Typical data corrections were rim elevation (extracted from GIS grid created from contour maps), manhole invert elevation (extracted from pipe inverts), US and DS manhole names, and pipe inverts. Pipe lengths were determined based on GIS distance from US and DS manholes. City staff researched as-built and other information to fill in missing data.

A field was added to the GIS tables to aid selection of pipelines and manholes to include in the model. Based on the contents of the selection field, data checks were performed to find missing or inconsistent data.

With GIS selection and links to database tables, the model was constructed by importing from the database table that identifies the manholes and pipes selected. Pump station data were added separately. Force main data were not entered into the model. Model data tables created are generic and will work with most of the standard model systems available. The City has not yet decided on a modeling system software.

Estimation of Sewage Flow

To develop existing sewage flow estimates, the service area (within the city limits) was subdivided into 103 subbasins ranging in size from 5 to 650 acres with an average sewer basin size of about 66 acres. To develop future sewage flow estimates, the service area was extended to include areas outside the city limits and subdivided into 119 subbasins ranging in size from 5 to 728 acres with an average sewer basin size of about 86 acres. The subbasins shown in Figure 2 were defined taking into account land use types (such as open spaces), vacant land, and population density. The subbasins are named by the manhole identification numbers of the manholes they drain to. The tax lot GIS table was extended by adding a field that contained the sewer basin manhole number.

Subbasin characteristics were developed from the following types of data:

- Land use. Obtained from the City of Redmond tax lot database and through discussions with City staff.
- Water usage. Obtained from City water meter billing data. Winter (December 2005 through February 2006) data were used to limit irrigation usage from the accounting. Development of sewage flows from the water meter data is described in Attachment 1. This included identification of large water users to potentially add to the model as sewer flow point sources.
- Population data. Obtained from 2000 U.S. Census Bureau data tables and maps of census blocks.

Rainfall Derived Infiltration and Inflow

Redmond WPCF influent flow data from January 2000 to September 2006 were reviewed for indications of rainfall derived infiltration and inflow (RDII). Annual precipitation in the area is about 8.8 inches. The nearest source of available rainfall data is the Roberts Field-Redmond Municipal Airport (RDM), which is located 2 miles southeast of downtown Redmond. The Redmond WPCF (located about 2.2 miles NE of downtown Redmond) influent flow data records showed no discernible rainfall response except for an exceptional event in June 2006 (described below under Calibration). On the basis of this review and consultation with City staff, it was determined that RDII was not a significant issue and that use of a design storm in the sewer modeling was unnecessary.

Existing Flows

In general, flows within 10 percent are believed the best possible estimates achievable from census, land use, or unit rates data. Existing subbasin base flows were developed three different ways for comparison:

- **Based on per capita flows using population estimates from census block data**. Example census block data are shown in Figure 3. With this method, the number of people per household from the census block data was overlaid with the tax lots in each subbasin. Flows were then calculated using 100 gallons per capita per day. The flows from this method accumulated to approximately 2.03 million gallons per day (mgd) (that is, the flow average delivered to the Redmond WPCF).
- **Based on land use category and water usage rates**. With this method, water meter records were used to determine average water usage by land use category (per capita per day for residential categories and per acre per day for all other categories). The average land use water usage rates applied are shown in Figure 4. This method used water meter records from December 2005 to February 2006, which were aligned with tax lot addresses (see Attachment 1 for a description of how this was done). Based on water usage by land use category, the average system-wide flow was determined to be approximately 1.98 mgd.
- **Based on land use unit rates**. With this method, the flows were determined by using City of Redmond typical land use unit sewer flow rates. The average system-wide flow was determined to be approximately 2.03 mgd.

The results of each of these methods were found to be consistent with the recorded average winter Redmond WPCF influent flow of about 1.9 mgd. The average monthly flow trend for Redmond WPCF is shown in Figure 5.

The method based on land use category and water usage rates was selected for use in the modeling. The resulting base flow estimates for the subbasins are shown in Table 1.

Future Flows

Future subbasin flows were estimated using City of Redmond Planning Department maps that show the projected number of units (dwelling units) per acre for land use types within undeveloped areas of the urban growth boundary. Each unit is assumed to represent 2.6 persons (based on U.S. Census Bureau data for number of people and number of households for Redmond). The future average per capita flow was assumed to be 80 gallons per day. In early phases of the study, 100 gallons per capita per day (gpcd) was used, but monitoring of treatment plant flows and evaluation of water use data indicated that 80 gpcd is a more representative value. The 80 gpcd value was calculated by dividing the existing Redmond WPCF average winter influent flow of approximately

2 mgd by an estimated City of Redmond population of 25,000. This population estimate, which was developed based on 2000 census data by filling in the system for development using similar population densities, was confirmed as a reasonable estimate in consultation with city staff. The estimated future subbasin flows are shown in Table 2. The estimated future system-wide base flow is about 6.9 mgd.

Future land use conditions for areas within the current sewer service boundaries were estimated by assuming the same population densities and sewer flow rates as for developed lots within a sewer basin. Lots assumed undeveloped were identified from property tax rolls with undeveloped lots having a property improvement value of less than $500. The current tax lot improvement values shown in Figure 6 were obtained from the city tax lot database. Those few lots with a recorded improved value of $5 to $500 are shown in yellow in Figure 6 east of the Antler Pump Station and west of the Cascade View Pump Station. Those with $0 improved values are shown in white.

Calibration

City staff performed flow monitoring at selected sites to obtain data to characterize flows from subbasins with different land use types. Also, the temporary monitoring was performed to compare results for older neighborhoods with newer, growing neighborhoods. This monitoring is planned to continue at selected sites with ultimately establishing more permanent sites at key locations to monitor the change in flows within parts of the system over time.

As monitoring data became available during the winter of 2006-2007, it was possible to compare flows from basin types and flows predicted by the estimation method for sewer basins and used in the hydraulic model. The monitored data and modeled flows simulated matches within reasonable expectations at most sites. Monitored flows (5-minute "raw" data) and average hour monitored flows were compared with modeled flows for all basins in Figures 7 through 13. Average hour monitored flows were used to see how well the flows corresponded with modeled flows without the highly variable "spikes" in the monitoring data. The variability is most likely due to the low depths and high velocities in the system. The monitoring equipment will have difficulties at lower depths in accurately measuring velocity. Monitoring data are checked when obtained with comparison between what flow is reported using depth and velocity (continuity) and expected flow using depth, pipe slope, and roughness (using Manning's equation). In most cases, both flow estimation methods produced similar results, but there were exceptions. Monitor data confidence will improve as experience is gained in siting monitors, set-up, and in interpretation of data.

The modeled base flows showed good correspondence with the average hour monitored flows, but in general were a little higher. Generally, the modeled flow values enveloped the maximum ranges of monitoring data and matched the average monitor data diurnal patterns.

However, smaller basin comparisons showed a possible need to use multiple diurnal curves in the model or unique patterns for specific industrial users. To address this, sewers downstream of the two largest water users (PCC Structural and Eberhard Creamery) were monitored to determine local conditions. The model flows at Eberhard Creamery are compared with monitoring data in Figure 14. The differences between model and monitoring flows at other locations were not significant enough to warrant adding this complexity to the model at this time. However, for modeling site specific developments it is recommended that the nature of the development be forecasted and estimates of the diurnal pattern be determined, particularly the maximum flow expected during the day.

Although a design storm was not used in the development of the model, the rainfall data from the June 10–17, 2006, storm (recorded at the RDM Airport) were graphed with Redmond WPCF influent flow data for that time period and compared with modeling results. This exceptional storm caused flooding in the streets of downtown and other parts of Redmond. In fact, it is reported to have flooded the City Engineer’s office by 2 inches. As shown in Figure 15, the modeled flows correspond closely with recorded flows—except for the high flows recorded on June 13. The exceptional high flow corresponds with the opening of sanitary sewer manhole covers and the limited interconnections between storm inlets and the sanitary system to drain streets flooded by the storm.

The city does not have an extensive stormwater collection system. Therefore, during significant storm events, which are infrequent, street flooding is relieved by opening sanitary sewer manhole covers. During the June 2006 storm, the city used the sanitary sewer system to drain flooded areas. As a result, within an hour, the WPCF influent flow increased from 2 to 9 mgd. The WPCF was able to treat these increased flows but anecdotal evidence exists that implies several manholes along the main trunk to the WPCF surcharged and flooded.

Hydraulic Analysis Criteria

Peak flows were used to evaluate the collection system. The model modulated the average flow of each basin by the system’s diurnal pattern.

The capacity criteria used to identify potential system deficiencies were as follows:

- Manhole freeboard ≤ 2 to 8 feet. Freeboard is the difference between the modeled maximum water surface elevation at the manhole and the manhole rim elevation. If it is ≤ 8 feet, this indicates potential sewer surcharging. If less than 2 feet, there is a high risk of flooding. A range of values was used to illustrate increasing higher risks of flooding.
- Qratio > 1.2. The Qratio is a comparison of modeled peak flows with sewer full pipe flow capacity. The design flow of a pipe segment is defined by the full pipe flow as calculated using Manning’s equation. Maximum flow for circular pipes occurs at 94 percent full and is a little less than 1.1 times full pipe flow. Therefore, if a Qratio is greater than 1.2, it indicates that the pipe is at risk and in most cases that it is

surcharged. Different Qratio-value ranges were used as indications about ranges of pipe capacity from *no additional capacity* to *excess capacity*. *Excess capacity* is available capacity. Ratios about 1.2 indicate no additional capacity is available. Ratios in the range of 0.8 to 1.2 indicate an evaluation should be performed to see if additional capacity is needed given land use and development in the basin. Ratios less than 0.5 indicate significant *excess capacity*.

Model Results

For existing conditions, the modeling showed that the collection system does not have any significant capacity deficiencies. Figure 16 shows the model results. The worst ten manholes (that is, those with the lowest freeboards) are listed in the table across the top of Figure 15. The worst ten pipelines (that is, those with the highest Qratios) are listed in the table across the bottom of Figure 16.

For future conditions, it was assumed that improvements recommended by the previous master plan were implemented. As with existing conditions, the modeling demonstrated that the collection system will provide sufficient capacity.

Table 1
Base Flow Based on Land Use and Rates from Water Use

Subbasin	Airport	C1	C2	C3	C4	C5	FG	M1	M2	OSPR	PARK	PF	R1	R2	R3	R4	R5	Base Flow (gpd)
Unit Rate		861.4	1696.3	1059.7	984.1	1000.0	110.5	331.3	341.6	0.0	0.0	0.0	90.8	102.0	86.0	40.8	88.3	
	677.9	183.3	23.9	0.0		0.2		357.2	223.4	251.9			0.3	1563.6	0.2	223.2	13.0	
MH03B001																97.8		3989
MH03C008								14.0								47.0	3.9	6922
MH04A001		11.2													120.6			19983
MH04A017		13.3													0.0			11452
MH04B001															113.5			9760
MH04B019															36.8			3168
MH04B020												25.3			172.8			14853
MH04C020										0.8	4.0		278.5		4.2			25645
MH04C044		14.2											31.5		239.2			35668
MH04D012		8.6								0.8			19.7		215.0			27651
MH04D017		13.2		24.1									93.8					45397
MH04D053		36.8		10.1												29.2		43601
MH05A015													28.2					2558
MH05D008										0.4			14.7			4.0		1495
MH05D017													8.6					779
MH08A031													35.5			18.9		3989
MH08C001																43.7		1782
MH08D028																59.5		2428
MH08D030																10.4		426
MH08D039												18.9				81.5		3325
MH08D046																123.4		5033
MH08D074																34.1		1391
MH08D076																15.7		642
MH09A006													85.7					7781
MH09A011		8.6								2.4			163.2				80.0	29256
MH09A025		13.3	8.7	2.7													154.3	42710
MH09A049		1.9		19.6				10.1									163.8	40182
MH09A069		14.2		2.5														14923
MH09B001													42.1					3820
MH09B004													43.2					3923
MH09B051										1.0				3.1				315
MH09C011										6.8				51.4		6.8		5519
MH09C021														16.0		202.0		9872
MH09C057													50.6					4597
MH09C075													80.0					7264
MH09D042			12.0									6.7			197.4		6.5	37854
MH09D049														0.9		337.7		13872
MH09D067			8.4									2.6	36.0		108.0		13.4	27977
MH09D105			2.3					11.9									287.3	33208
MH10B008								25.5	17.0									14237
MH10B012									22.6									7709
MH10B031								4.3									2.2	1632
MH10C007									20.2									6907
MH10C009			26.5														11.7	45995
MH10C011									24.9									8516
MH10C016								2.5	64.7							7.5		23232
MH15B013			3.6						10.4									9639

Table 1
Base Flow Based on Land Use and Rates from Water Use

Subbasin	Airport	C1	C2	C3	C4	C5	FG	M1	M2	OSPR	PARK	PF	R1	R2	R3	R4	R5	Base Flow (gpd)
MH15B017								0.3	13.1							33.9		5956
MH15B024									23.5									8024
MH15B047								5.9								1.4		2015
MH15B054								4.7								61.0		4034
MH15C010						13.5		17.4		436.5								19222
MH15D004									70.9		5.8							24223
MH16A028			8.8									4.2			76.0			21469
MH16A031			14.0		5.6							5.0			84.7		13.8	37810
MH16A033		8.6	29.6									0.2						57571
MH16A120			9.7									0.0						16423
MH16B047										2.9	5.4	0.3	117.5		129.1			21768
MH16B052					4.1					18.4	7.9	35.6	115.2	59.5	45.1		442.6	63541
MH16B064					7.3					0.1	5.8	28.2	43.2					11085
MH16C034					15.8					2.3		19.9	112.1				628.6	81212
MH16C049		11.0								4.6	1.8	14.4	148.9				214.1	41885
MH16D027								64.8	38.3									34527
MH17A015					5.7											409.1		22293
MH17A037																17.0		694
MH17A055																44.2		1804
MH17B001																98.9		4035
MH17B023																163.1		6656
MH17C013																155.9		6359
MH17C046																195.2	1.9	8137
MH17C051																113.1	14.6	5907
MH17C078																9.0		369
MH17C082																53.0		2162
MH17C101												12.4				103.3		4213
MH17D013					10.1					0.4					2.9	0.0	55.1	15052
MH17D033										27.3					21.5	75.9		4941
MH20A003															316.4	7.5		27508
MH20A021															416.6		92.4	43971
MH20A049															8.8		292.2	26546
MH20A051		40.6								0.3	6.4		15.7		59.6		206.0	59695
MH20A064										4.4					280.1	0.0		24081
MH20B008																600.8		24513
MH20B041																343.1		13998
MH20B056											3.1			45.4		641.4		30797
MH20C032														255.6	215.3	12.0		45065
MH20C058											11.7			858.6				87543
MH20D009											0.6	33.1		3.6	115.2	136.5		15843
MH20D013											9.7	2.8			298.6	44.8	21.4	29387
MH20D022		56.5									3.8					261.7		59350
MH20D031		53.4						80.8			20.4						6.4	73382
MH20D033															37.8		230.3	23579
MH21A024								49.0										16228
MH21A033								147.0			28.3							48692
MH21B039		26.1															56.1	27419
MH22B009	564.6							2.2				24.4						723
MH29A029		21.4					287.8	137.4										95786
Total	564.6	352.7	123.6	59.0	48.6	13.5	287.8	577.8	305.6	509.4	114.9	234.1	1563.9	1294.0	3315.2	4701.1	2998.7	1980371

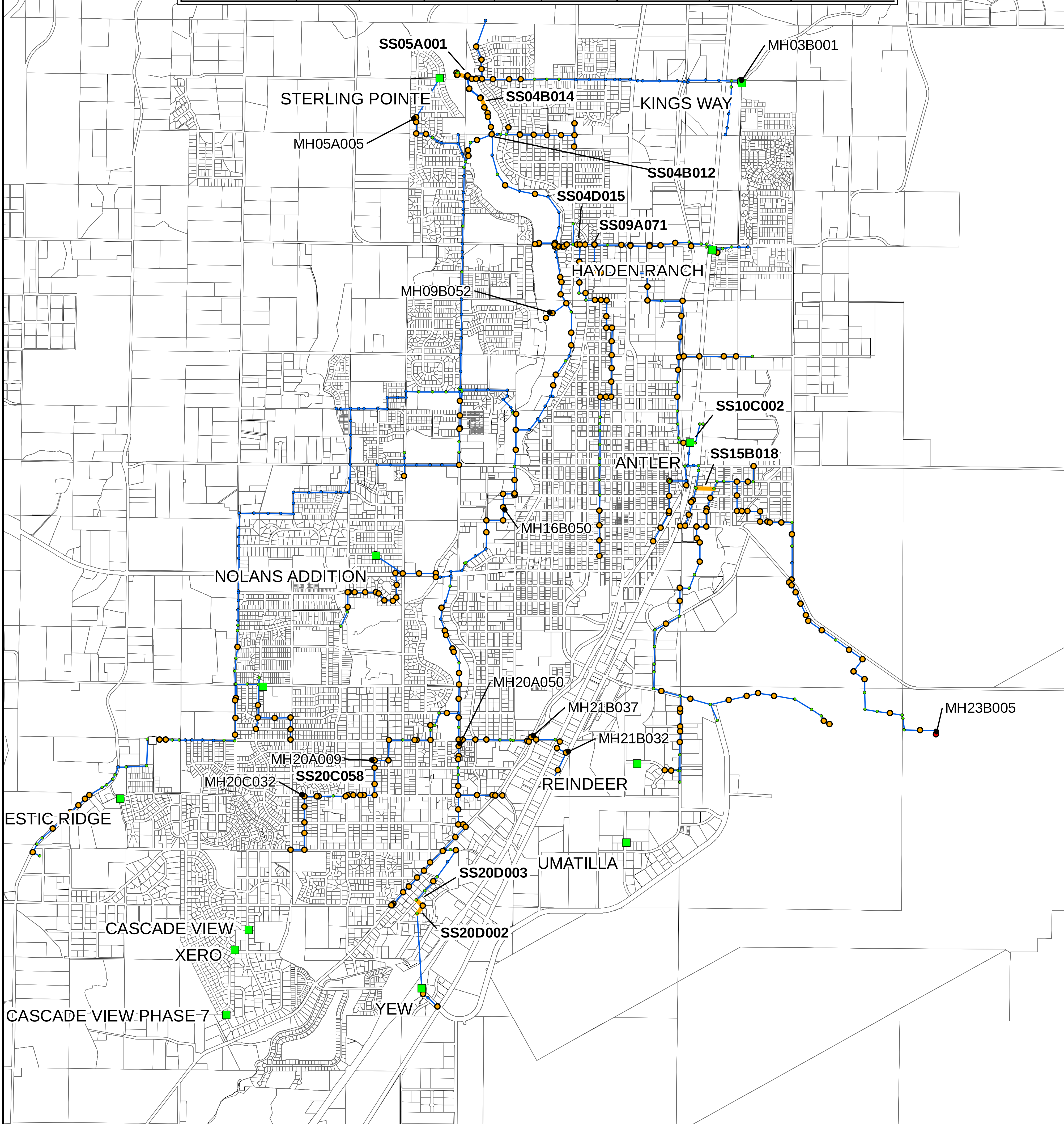
Table 2
Future Subbasin Flows

All Land use area					C1	C2	C3	C4	C5	FG	M1	M2	OSPR	PARK	PF	R1	R2	R3	R4	R4_3_6	R4_5_6	R4_5_9	R5					
					850.0	1642.4	1031.9	972.3	1000.0	110.5	331.3	341.6	0.0	0.0	0.0	111.7	140.5	92.2	142.1				97.6					
					850.0	1642.4	1031.9	972.3	1000.0	110.5	331.3	341.6	0.0	0.0	0.0	111.7	140.5	92.2	142.1				97.6					1.0
					1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	5.0	4.1	7.1	3.9				9.5					
					850.0	1642.4	1031.9	972.3	1000.0	110.5	331.3	341.6	0.0	0.0	580.0	557.4	572.0	652.5	557.4	748.8	1164.8	1227.2	930.9	580.0	0.0			
SwrBasin	CountOfMAPINFO_ID	Total Of ACRES	<>	AIRPORT	C1	C2	C3	C4	C5	FG	M1	M2	OSPR	PARK	PF	R1	R2	R3	R4	R4_3_6	R4_5_6	R4_5_9	R5	School	Water			
	1464.0	18685.4	17342.8	1066.4									251.9												24.3			
D_569	114.0	24.9																	24.9									13861.7
D_577	147.0	434.0																		325.9		38.9		69.2				331888.0
D_589	135.0	74.6															32.3		42.3									42028.4
Ind_01	3.0	35.0									35.0																	11593.5
MH03B001	272.0	72.8																	72.8									40552.0
MH03B034	10.0	72.2			47.3														24.9									54073.6
MH03B035	5.0	22.1			22.1																							18805.4
MH03C008	237.0	98.7									52.2								29.7				16.8					49497.3
MH04A001	92.0	25.9			11.2													14.8										19119.1
MH04A017	88.0	36.0			13.3													22.7										26130.3
MH04A043	12.0	63.1			63.1																							53673.0
MH04A044	9.0	36.2			36.2																							30783.2
MH04B001	130.0	26.9																26.9										17581.7
MH04B019	38.0	8.6																8.6										5596.6
MH04B020	152.0	72.9													25.3			47.5										45713.9
MH04C020	129.0	44.9											0.8	4.0		36.1		3.9										22655.5
MH04C044	95.0	46.3			14.2											3.8		28.3										32651.2
MH04D012	95.0	26.8			8.6								0.8			4.6		12.8										18204.7
MH04D017	64.0	42.8			13.2		24.1									5.5												39132.3
MH04D053	26.0	68.0			41.7		10.1												16.2									54924.5
MH05A015	114.0	25.0														25.0												13929.3
MH05D008	191.0	56.8											0.4			45.4			11.1									31483.4
MH05D017	96.0	25.6														25.6												14258.0
MH08A031	172.0	76.7														36.7			40.0									42739.4
MH08C001	30.0	85.7																	85.7									47744.0
MH08D028	107.0	26.3																	26.3									14652.7
MH08D030	29.0	7.6																	7.6									4250.1
MH08D039	152.0	48.0													18.9				29.1									27192.1
MH08D046	88.0	19.0																	19.0									10571.8
MH08D074	65.0	43.5																	43.5									24274.2
MH08D076	97.0	14.2																	14.2									7894.5
MH09A006	27.0	8.7														8.7												4829.2
MH09A011	111.0	33.9			8.6								2.4			19.7							3.2					21255.1
MH09A025	70.0	35.1			13.3	8.7	2.7																10.4					38073.0
MH09A049	24.0	41.3			1.9		19.6				8.8												11.0					34995.9
MH09A069	18.0	16.9			14.3		2.5																					14788.0
MH09B001	43.0	13.7														13.7												7659.6
MH09B004	20.0	10.1														10.1												5641.5
MH09B051	15.0	16.1											1.0				15.1											8639.4
MH09C011	20.0	32.8											6.8				24.4		1.6									14854.8
MH09C021	75.0	48.5															3.6		44.9									27074.9
MH09C057	27.0	5.8														5.8												3206.8
MH09C075	40.0	12.3														12.3												6861.9
MH09D042	131.0	34.7				12.0									6.7			15.3					0.7					34214.5
MH09D049	303.0	70.3															4.4		66.0									39272.4
MH09D067	87.0	21.3				8.4									2.6	2.6		6.6					1.1					22065.3
MH09D105	106.0	36.9				2.3					11.9												22.7					28811.4
MH10B008	9.0	42.5									25.6	17.0																14261.9
MH10B012	36.0	229.7										229.7																78474.6
MH10B031	82.0	15.6									4.3												11.3					11931.9
MH10C007	2.0	20.2										20.2																6907.2
MH10C009	148.0	27.6				27.0																	0.6					44845.8
MH10C011	30.0	24.9										24.9																8516.0
MH10C016	37.0	83.5									2.5	80.1							0.9									28703.5
MH15B013	19.0	15.0				4.6						10.4																11091.4
MH15B017	82.0	19.4									0.3	13.1							6.0									7942.2
MH15B024	2.0	23.5										23.5																8023.9
MH15B047	37.0	8.3									5.9								2.4									3300.5
MH15B054	47.0	11.0									4.7								6.3									5068.8
MH15C010	7.0	467.5			188.1				13.6		265.8																	261571.5
MH15D004	24.0	76.8										70.9		5.8														24223.3
MH16A028	93.0	17.2				8.8									4.2			4.1										19608.8
MH16A031	150.0	33.3				14.0		5.6							5.0			7.8					0.9					37328.1
MH16A033	75.0	53.9			9.2	43.3									0.2								1.2					80156.3
MH16A120	54.0	11.8				11.8									0.0													19397.4
MH16B047	113.0	29.1											2.9	5.4	0.3	11.1		9.4										12495.6
MH16B052	137.0	108.6						4.1					18.4	7.9	35.6	10.9	5.8	4.1					21.8					57016.6
MH16B064	33.0	45.3						7.3					0.1	5.8	28.2	3.8												25560.3
MH16C034	278.0	92.3						15.8					2.3		19.9	13.9							40.5					72300.7
MH16C049	146.0	68.5			10.8								4.6	1.8	14.4	16.3							20.5					45743.1
MH16D027	59.0	103.0									64.8	38.3																34526.7
MH17A015	168.0	35.1						5.7											29.4									21928.6

Table 2
Future Subbasin Flows

All Land use area					C1	C2	C3	C4	C5	FG	M1	M2	OSPR	PARK	PF	R1	R2	R3	R4	R4_3_6	R4_5_6	R4_5_9	R5					
					850.0	1642.4	1031.9	972.3	1000.0	110.5	331.3	341.6	0.0	0.0	0.0	111.7	140.5	92.2	142.1				97.6					
					850.0	1642.4	1031.9	972.3	1000.0	110.5	331.3	341.6	0.0	0.0	0.0	111.7	140.5	92.2	142.1				97.6					1.0
					1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	5.0	4.1	7.1	3.9				9.5					
					850.0	1642.4	1031.9	972.3	1000.0	110.5	331.3	341.6	0.0	0.0	580.0	557.4	572.0	652.5	557.4	748.8	1164.8	1227.2	930.9	580.0	0.0			
SwrBasin	CountOfMAPINFO_ID	Total Of ACRES	<>	AIRPORT	C1	C2	C3	C4	C5	FG	M1	M2	OSPR	PARK	PF	R1	R2	R3	R4	R4_3_6	R4_5_6	R4_5_9	R5	School	Water			
MH17A037	16.0	4.8																	4.8									2688.9
MH17A055	37.0	56.4																	56.4									31453.5
MH17B001	126.0	36.7																	36.7									20442.9
MH17B023	87.0	73.3																	73.3									40879.7
MH17C013	124.0	18.4																	18.4									10236.7
MH17C046	148.0	30.4																	28.2				2.2					17806.5
MH17C051	157.0	46.4																	36.1				10.3					29722.3
MH17C078	48.0	10.3																	10.3									5721.9
MH17C082	103.0	14.9																	14.9									8321.6
MH17C101	64.0	31.2													12.4				18.8									17655.4
MH17D013	61.0	31.2						10.1					0.4					0.4	0.5				19.9					28821.8
MH17D033	111.0	95.9											27.3					22.7	45.9									40365.0
MH20A003	133.0	39.3																38.2	1.1									25518.0
MH20A021	227.0	71.4																59.6					11.8					49889.4
MH20A049	87.0	34.7																0.7					34.0					32094.3
MH20A051	24.0	12.0											0.3	6.4				5.2										3400.6
MH20A064	134.0	54.2											4.4					40.3	9.5									31581.1
MH20B008	203.0	33.4																	33.4									18628.1
MH20B041	184.0	31.4																	31.4									17477.0
MH20B056	254.0	47.6												3.1			10.6		33.9									24975.5
MH20C032	296.0	73.7															47.6	24.7	1.5									44141.2
MH20C058	444.0	179.3												11.7			167.7											95915.8
MH20D009	168.0	125.0											20.1	0.6	13.0		6.5	32.4	52.4									61553.3
MH20D013	159.0	50.7												9.7	2.8			28.0	7.8				2.4					26480.2
MH20D022	317.0	244.8			56.5								27.4	3.8					157.1									135585.6
MH20D031	50.0	650.7			53.4						576.3			20.4									0.4					236765.5
MH20D033	59.0	31.8																3.4					28.4					28678.0
MH21A024	18.0	49.0									49.0																	16228.0
MH21A033	68.0	191.0									162.7			28.3														53892.5
MH21B014	59.0	40.9			1.2											2.0							37.6					37170.7
MH21B033	32.0	39.4			32.4																				7.0			27531.9
MH21B039	31.0	30.7			24.9																		5.8					26577.8
MH22B009	3.0	591.1		564.6							2.2				24.4													14860.2
MH29A029	45.0	446.6			21.4					287.8	137.4																	95541.8
N_1	18.0	174.4																				174.4						214061.3
Node621	6.0	40.4																		40.4								30222.1
NW_1	67.0	727.8											37.6									690.2						847022.1
NW_2	13.0	117.8																			117.8							137251.4
NW_3	4.0	37.9																						37.9				21963.3
NW_P1	126.0	448.1																				448.1						549926.6
NW_P2	9.0	157.1			39.4																117.7							170605.6
SW_1	11.0	41.3																		41.3								30888.1
SW_4	23.0	299.1																				299.1						367109.9
WC_1	81.0	512.8			512.8																							435882.3
WC_2	12.0	228.3																				228.3						280178.7
WC_2_1	2.0	24.0																				24.0						29436.1
WC_2_2	1.0	14.6																				14.6						17865.5
		10205.2	0.0	564.6	1259.2	140.9	59.0	48.6	13.6	287.8	1409.2	528.2	158.1	114.9	214.0	313.6	317.9	468.3	1316.9	407.5	235.5	1917.6	315.5	107.1	7.0			6911639.4

NODENAME	GRELEV	DIURNAL	QDWF	QINST	MAXWSEL	FREEBOARD	DURFLOOD	DURSURCHAR
MH23B005	3064.100	0	0.000	0.000	3061.500	2.600	0.000	0.000
MH20C032	3044.000	DWF	36356.000	0.000	3040.984	3.020	0.000	0.000
MH09B052	2929.500	0	0.000	0.000	2926.337	3.160	0.000	0.000
MH21B037	3009.420	0	0.000	0.000	3006.048	3.370	0.000	0.000
MH21B032	3019.890	0	0.000	0.000	3016.390	3.500	0.000	0.000
MH05A005	2940.720	0	0.000	0.000	2937.181	3.540	0.000	0.000
MH20A009	3018.000	0	0.000	0.000	3014.371	3.630	0.000	0.000
MH20A050	2990.000	0	0.000	0.000	2986.262	3.740	0.000	0.000
MH16B050	2955.750	0	0.000	0.000	2951.997	3.750	0.000	0.000
MH03B001	2970.170	DWF	13300.000	0.000	2966.380	3.790	0.000	0.000



NAME	DIAMETER	LENGTH	SLOPE	ROUGHNESS	QFULL	QMAX	QRATIO	MAXVEL	MINVEL	MAXWSELUS	MAXWSELDS
SS15B018	0.833	428.005	0.280	0.013	0.600	0.520	0.872	1.340	0.000	2980.703	2980.164
SS09A071	1.250	7.544	0.160	0.013	1.180	1.000	0.845	2.210	0.000	2962.563	2962.462
SS04B014	2.000	414.240	0.120	0.013	4.010	3.380	0.844	1.970	0.000	2874.178	2873.792
SS20D002	0.833	226.940	0.280	0.013	1.130	0.860	0.754	2.280	0.000	3027.431	3026.649
SS20C058	0.667	48.132	0.400	0.013	0.350	0.240	0.689	1.480	0.000	3036.865	3036.726
SS10C002	1.250	136.733	0.160	0.013	2.590	1.510	0.585	2.570	0.000	2983.645	2983.301
SS04D015	1.250	71.001	0.160	0.013	2.540	1.480	0.582	2.970	0.000	2956.590	2956.188
SS20D003	0.833	198.147	0.280	0.013	1.160	0.590	0.511	2.090	0.000	3026.583	3025.918
SS05A001	2.000	235.682	0.120	0.013	7.800	3.680	0.472	2.830	0.000	2872.804	2872.102
SS04B012	2.000	47.563	0.120	0.013	7.330	3.380	0.461	2.540	-1.980	2874.974	2874.899

Pump Station

Manholes

FREEBOARD

- 0 - 3
- 3 - 8
- 8 - 12
- > 12

Sewer pipes

QRATIO

- 0 - 0.7
- 0.7 - 1.2

Taxlot

City Limits March 1, 2005

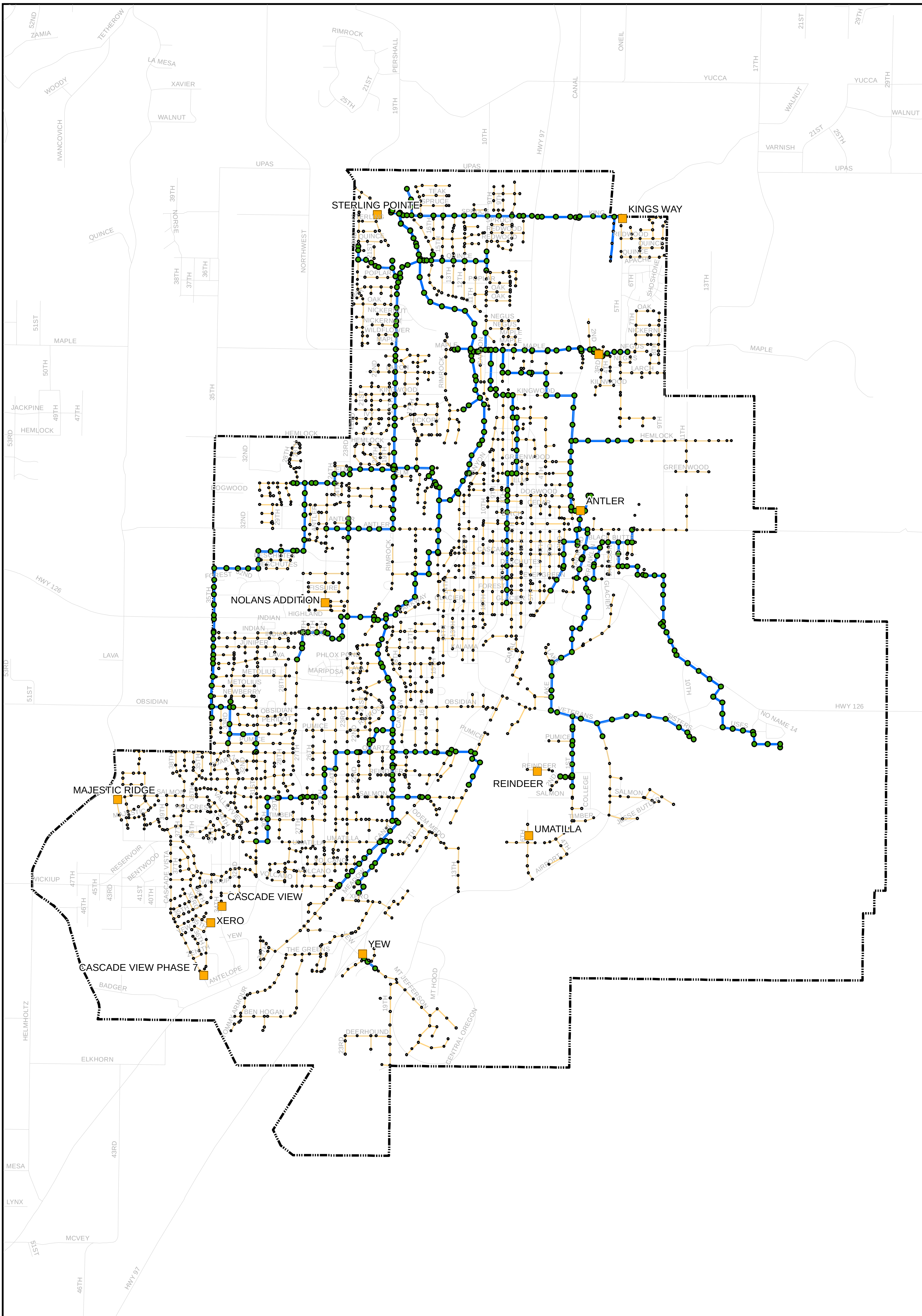
N

0 2,100 4,200

Feet

Figure 16
Model Results
for Existing Conditions
City of Redmond
Wastewater Collection
System

Q:\RedmondOrCityof\345980\GIS\PDX_GIS_MAP_DOCS\05_09_07_Redmond_WW_FIGURE5.mxd



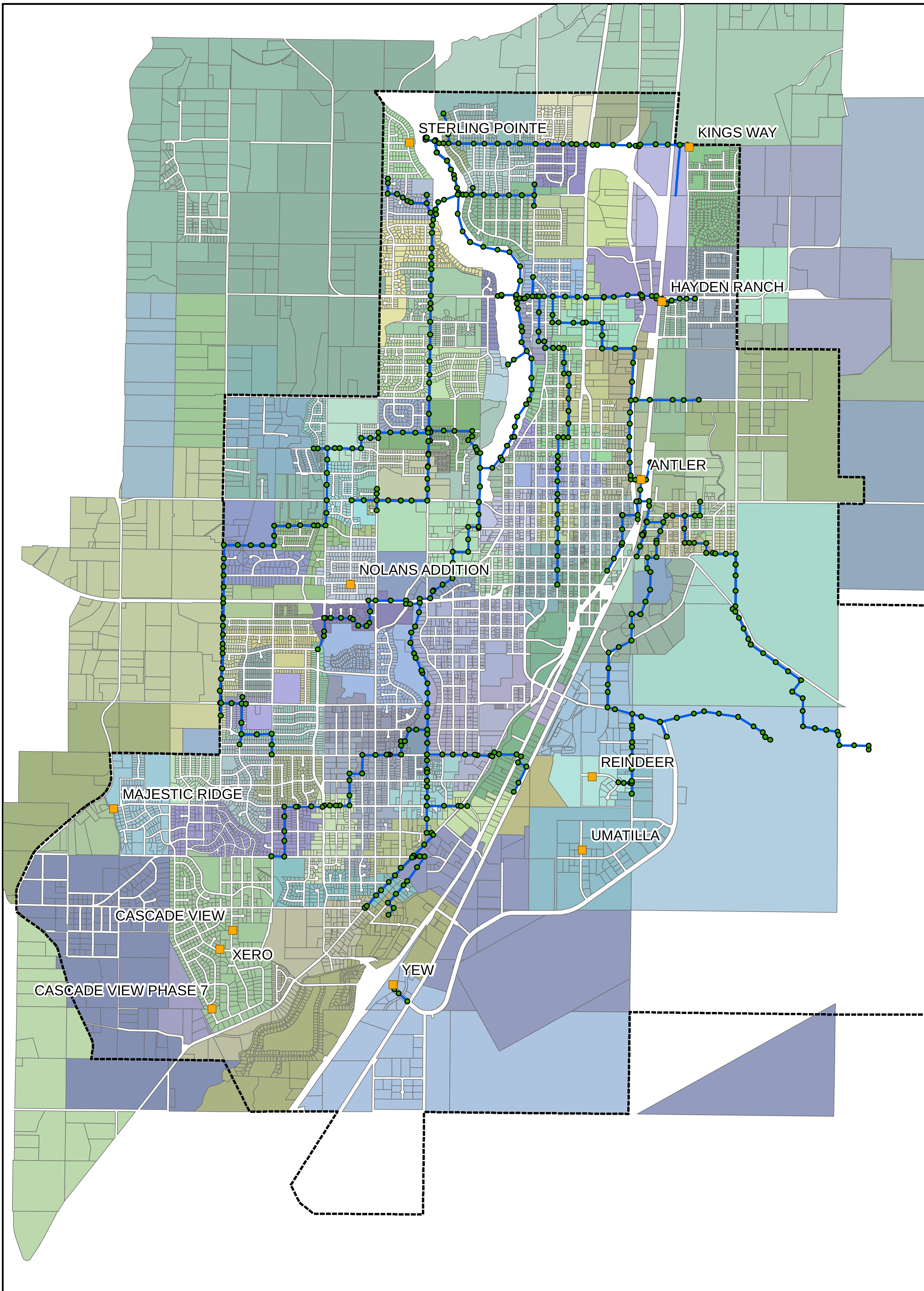
- Pump Stations
- Manholes Modeled
- Manholes Not Modeled
- Modeled Sewerlines
- Not Modeled Sewerlines
- Street
- City Limits March 1, 2005

N

0 2,000 4,000
Feet

Figure 1
Modeled System
(Based on 2006 Manhole & Pipe Data)
City of Redmond
Wastewater Collection
System

Q:\RedmondOrCityof\345980\GIS\PDX_GIS_MAP_DOCS\output\05_09_07_Redmond_WW_Figure1_1.mxd



Pump Stations
Manholes Modeled
Sewerlines Modeled
Subbasin
City Limits

N

0 2,000 4,000
Feet

Figure 2
Modeled System and Subbasins
(Based on Existing 2006 Pipe Data)
City of Redmond
Waste Water Collection System

Q:\RedmondOrCityof\345980\GIS\PDX_GIS_MAP_DOCS\output\05_09_07_Redmond_WW_Figure2.mxd

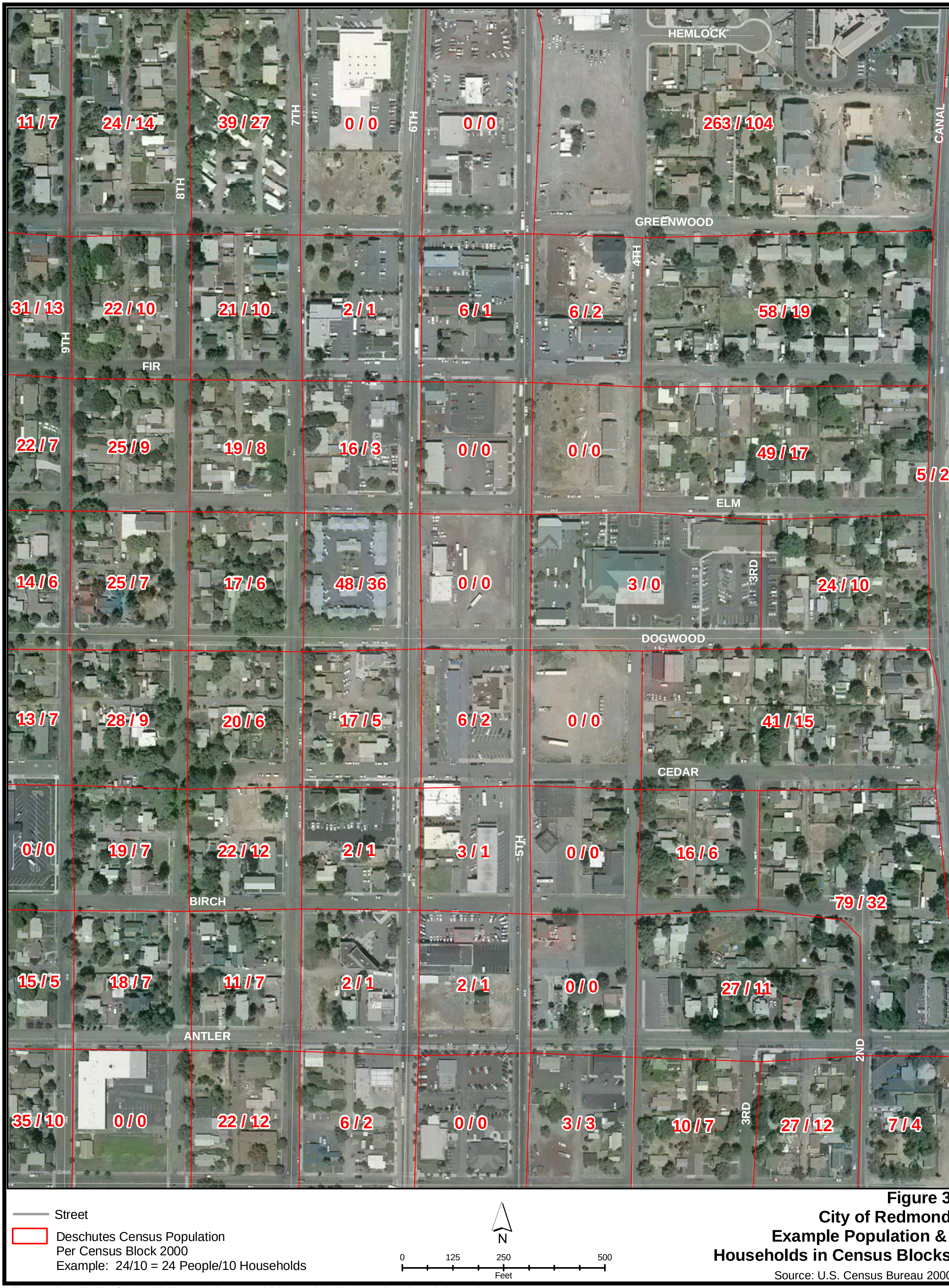


Figure 3
City of Redmond
Example Population & Households in Census Blocks

Source: U.S. Census Bureau 2000

File:Q:\RedmondOrCityof\345980\GIS\PDX_GIS_MAP_DOCS\out put\05_09_07_RedmondPopulation.mxd

Figure 4: Average Water Use by Land Use Category
City of Redmond

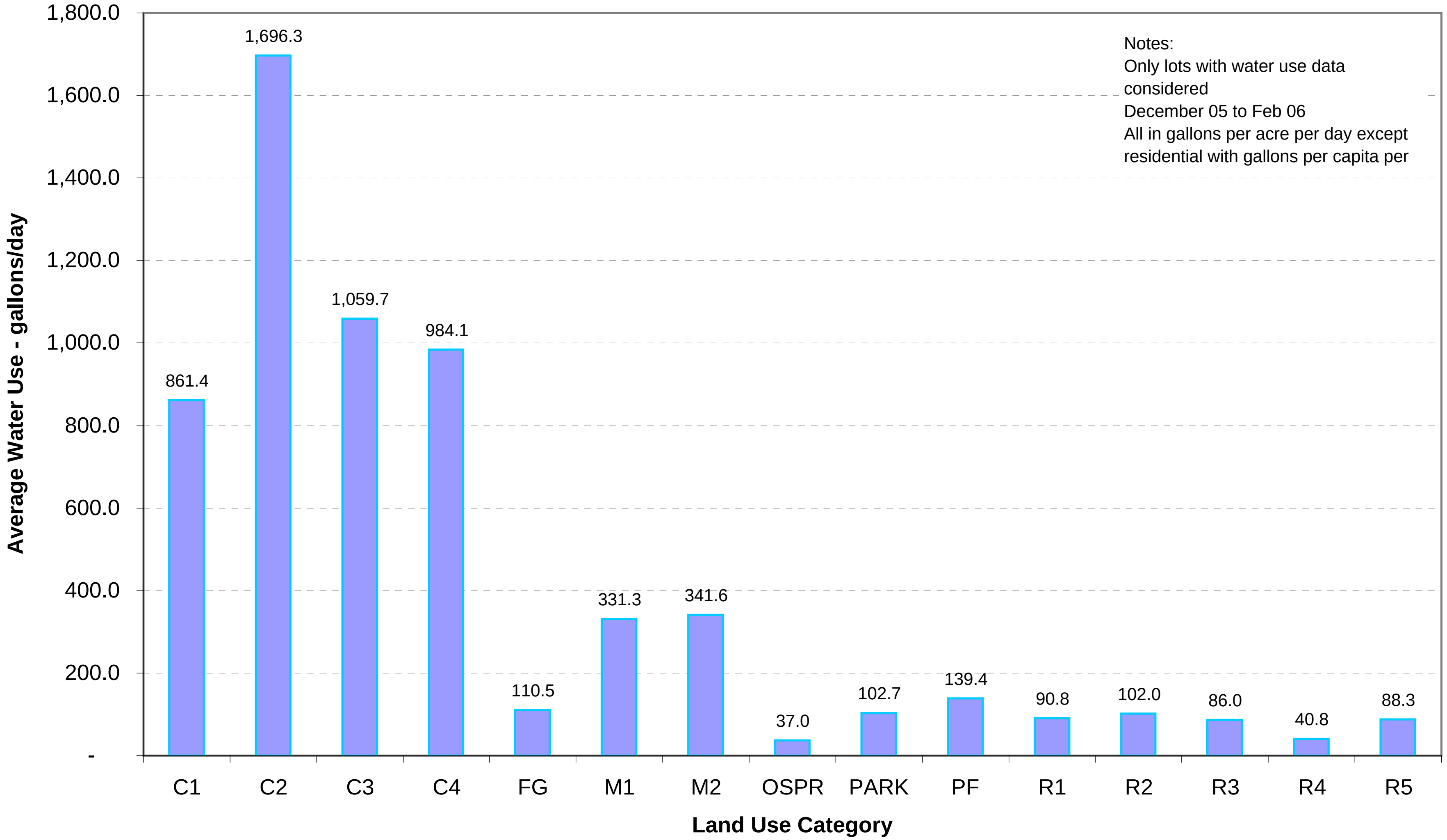
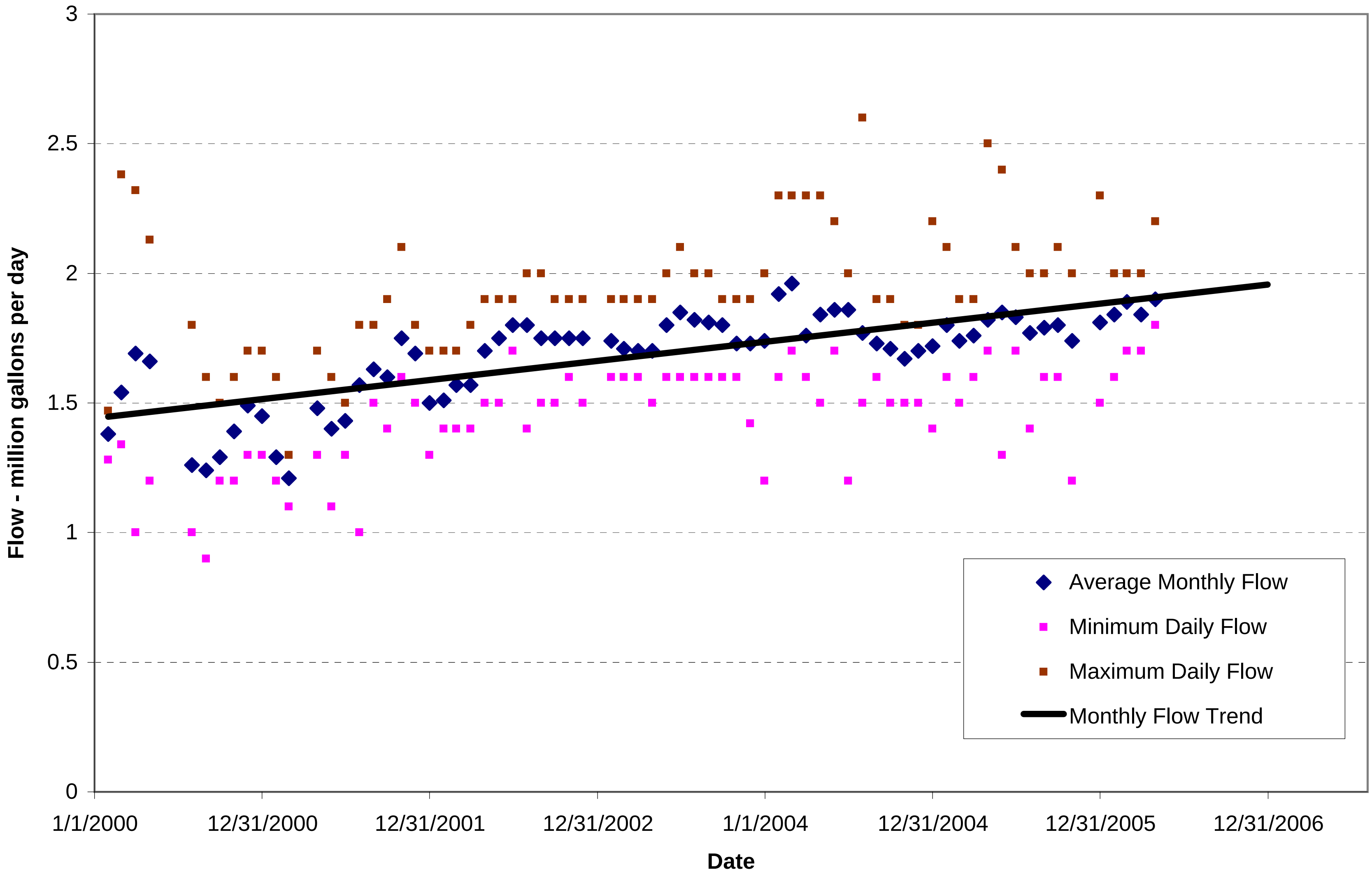


Figure 5: Redmond Monthly Flows (mgd)



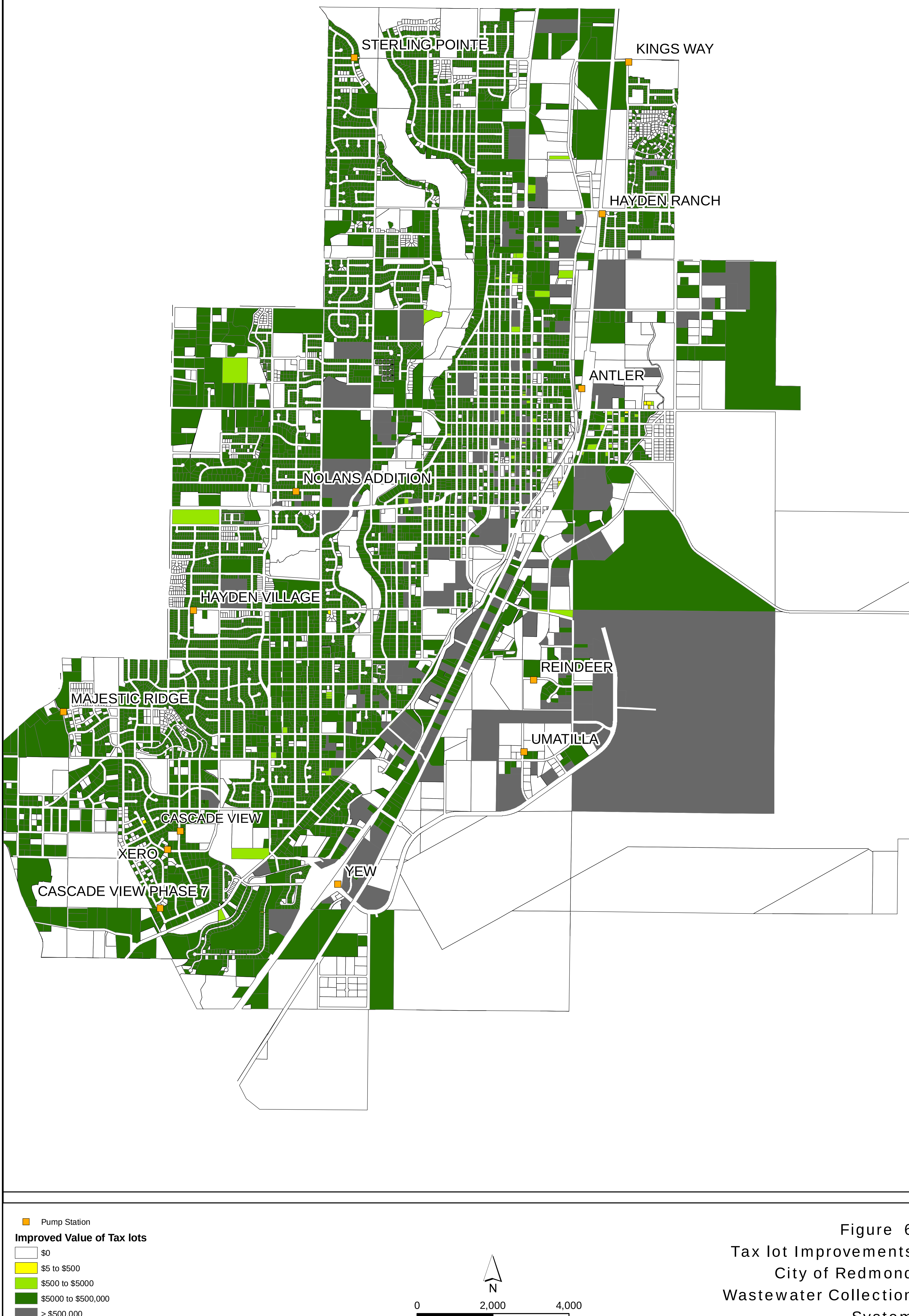


Figure 6
Tax lot Improvements
City of Redmond
Wastewater Collection
System

Q:\RedmondOrCityof\345980\GIS\PDX_GIS_MAP_DOCS\output\05_09_07_Redmond_WW_Figure3.mxd

Figure 7

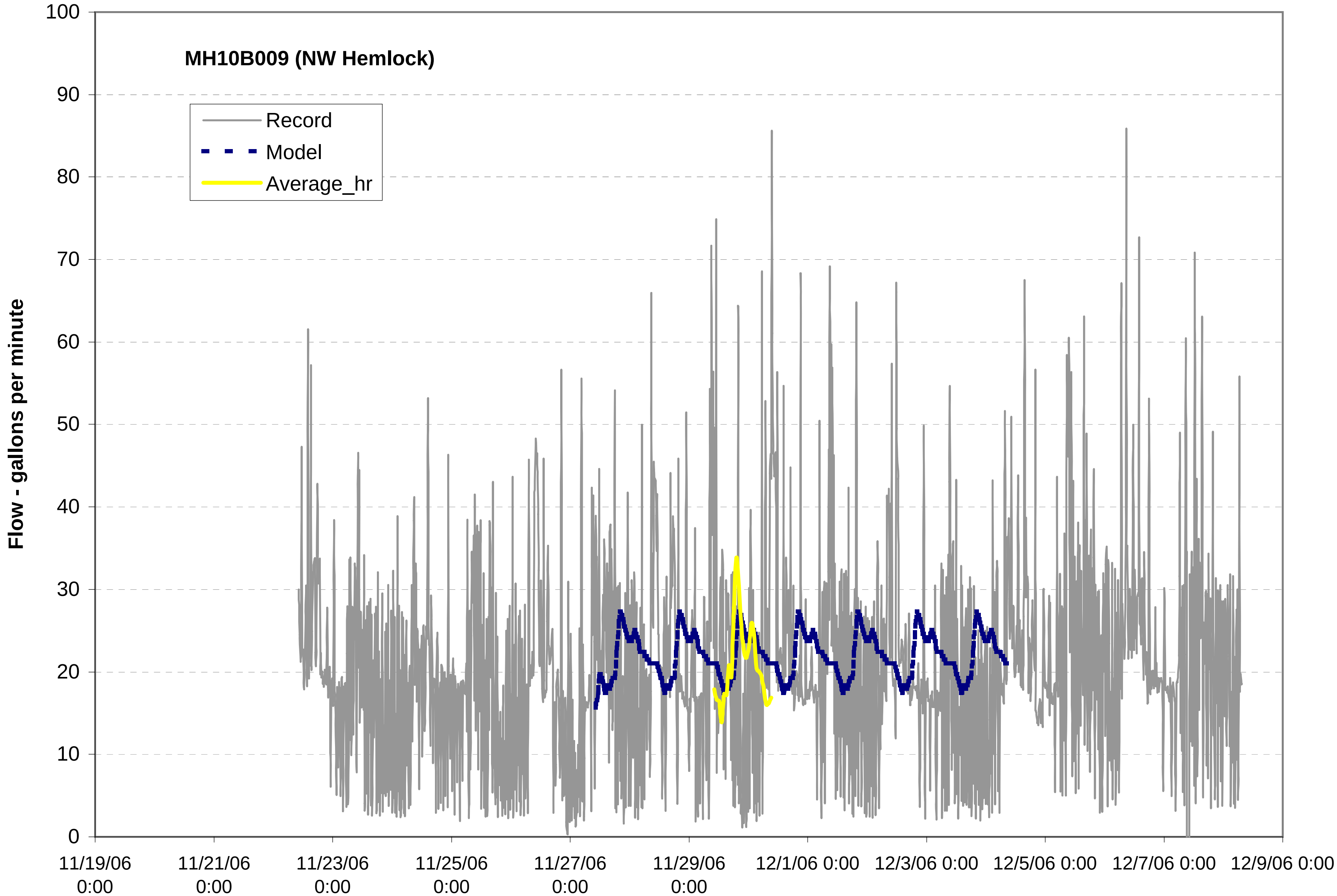

MH10B009 (NW Hemlock)
Record
Model
Average_hr
Flow - gallons per minute
100
90
80
70
60
50
40
30
20
10
0
11/19/06 0:00
11/21/06 0:00
11/23/06 0:00
11/25/06 0:00
11/27/06 0:00
11/29/06 0:00
12/1/06 0:00
12/3/06 0:00
12/5/06 0:00
12/7/06 0:00
12/9/06 0:00

Figure 8

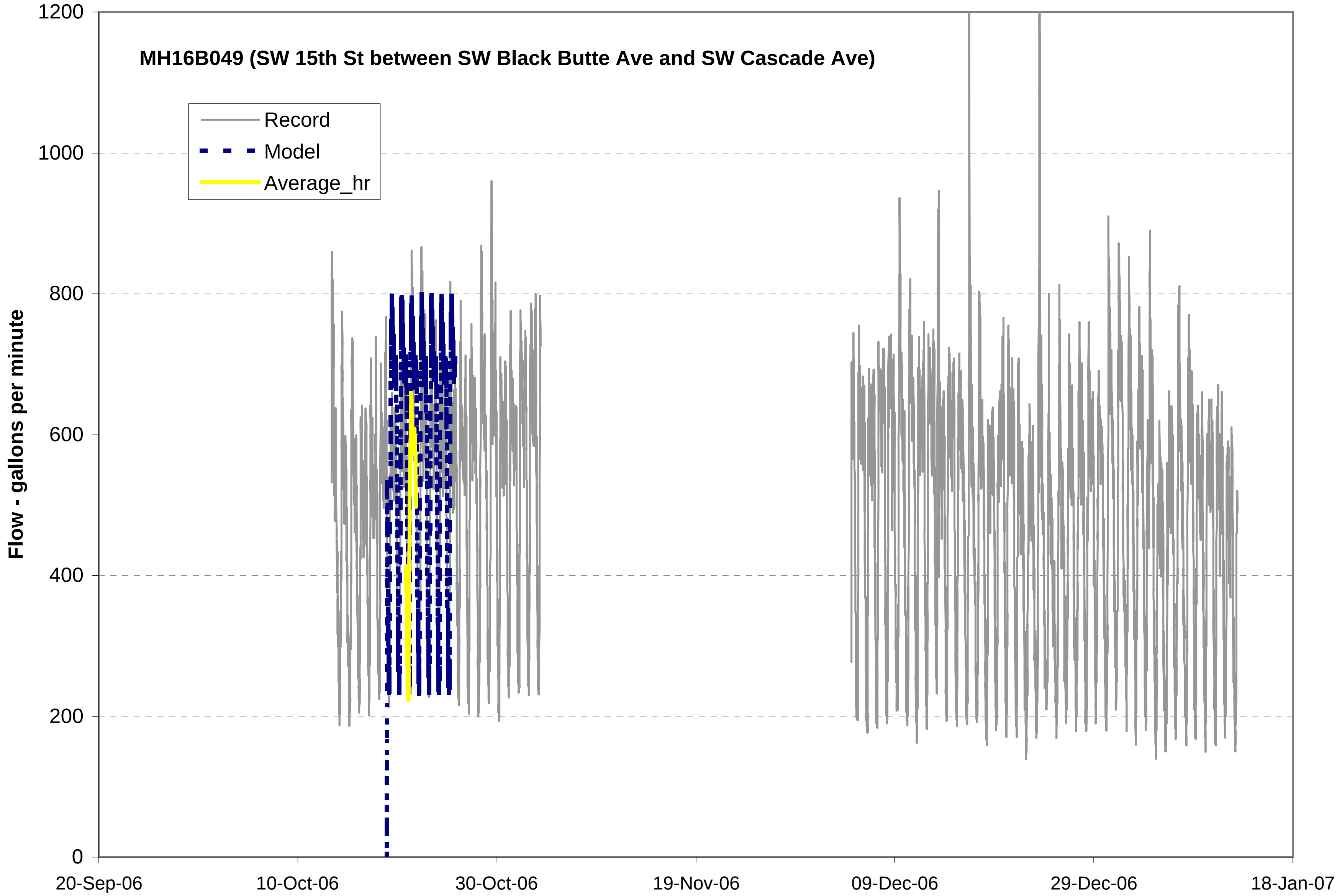

MH16B049 (SW 15th St between SW Black Butte Ave and SW Cascade Ave)
Record
Model
Average_hr
Flow - gallons per minute
1200
1000
800
600
400
200
0
20-Sep-06
10-Oct-06
30-Oct-06
19-Nov-06
09-Dec-06
29-Dec-06
18-Jan-07

Figure 9

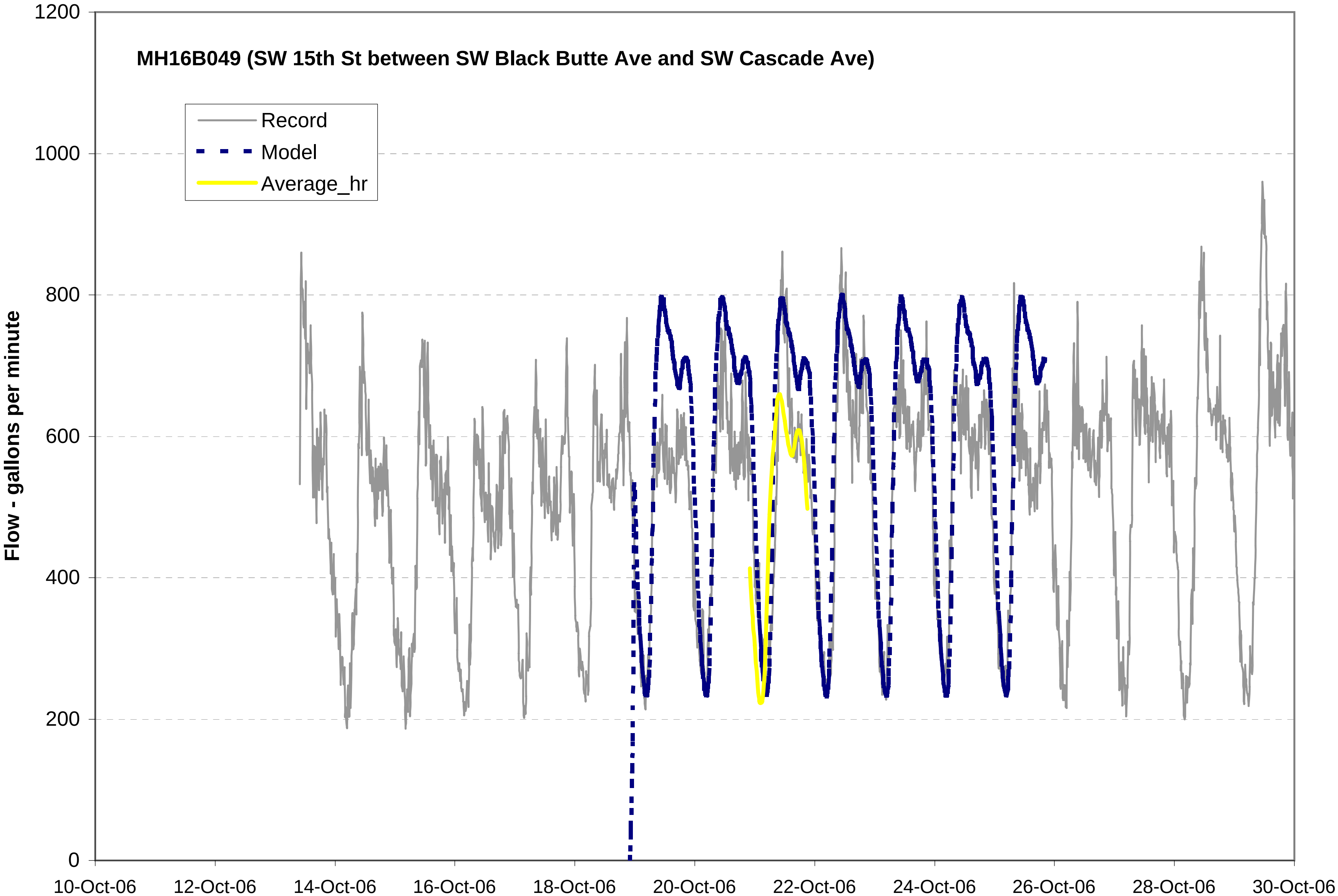

MH16B049 (SW 15th St between SW Black Butte Ave and SW Cascade Ave)
Record
Model
Average_hr
Flow - gallons per minute
1200
1000
800
600
400
200
0
10-Oct-06
12-Oct-06
14-Oct-06
16-Oct-06
18-Oct-06
20-Oct-06
22-Oct-06
24-Oct-06
26-Oct-06
28-Oct-06
30-Oct-06

Figure 10

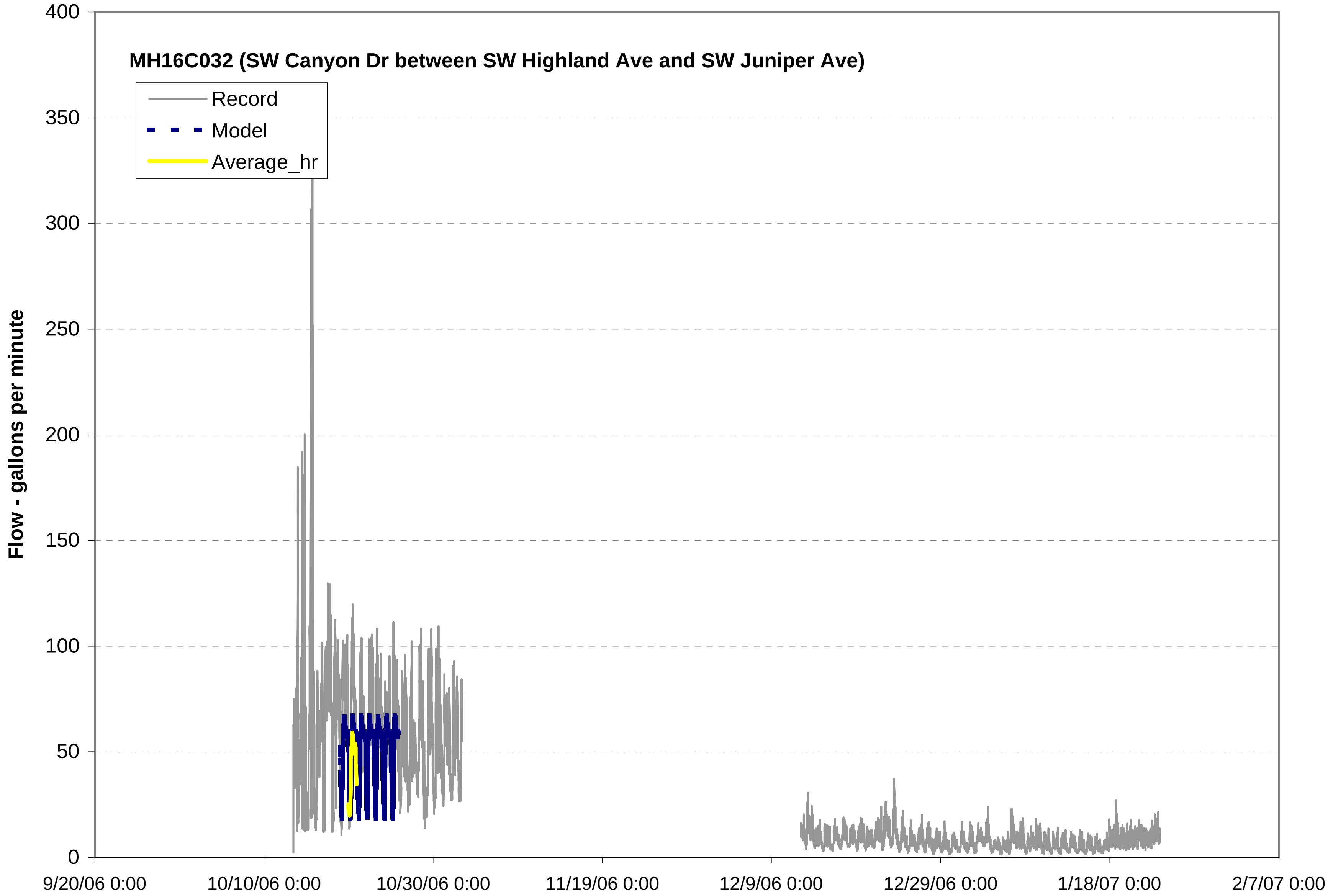

MH16C032 (SW Canyon Dr between SW Highland Ave and SW Juniper Ave)
Record
Model
Average_hr
Flow - gallons per minute
400
350
300
250
200
150
100
50
0
9/20/06 0:00
10/10/06 0:00
10/30/06 0:00
11/19/06 0:00
12/9/06 0:00
12/29/06 0:00
1/18/07 0:00
2/7/07 0:00

Figure 11

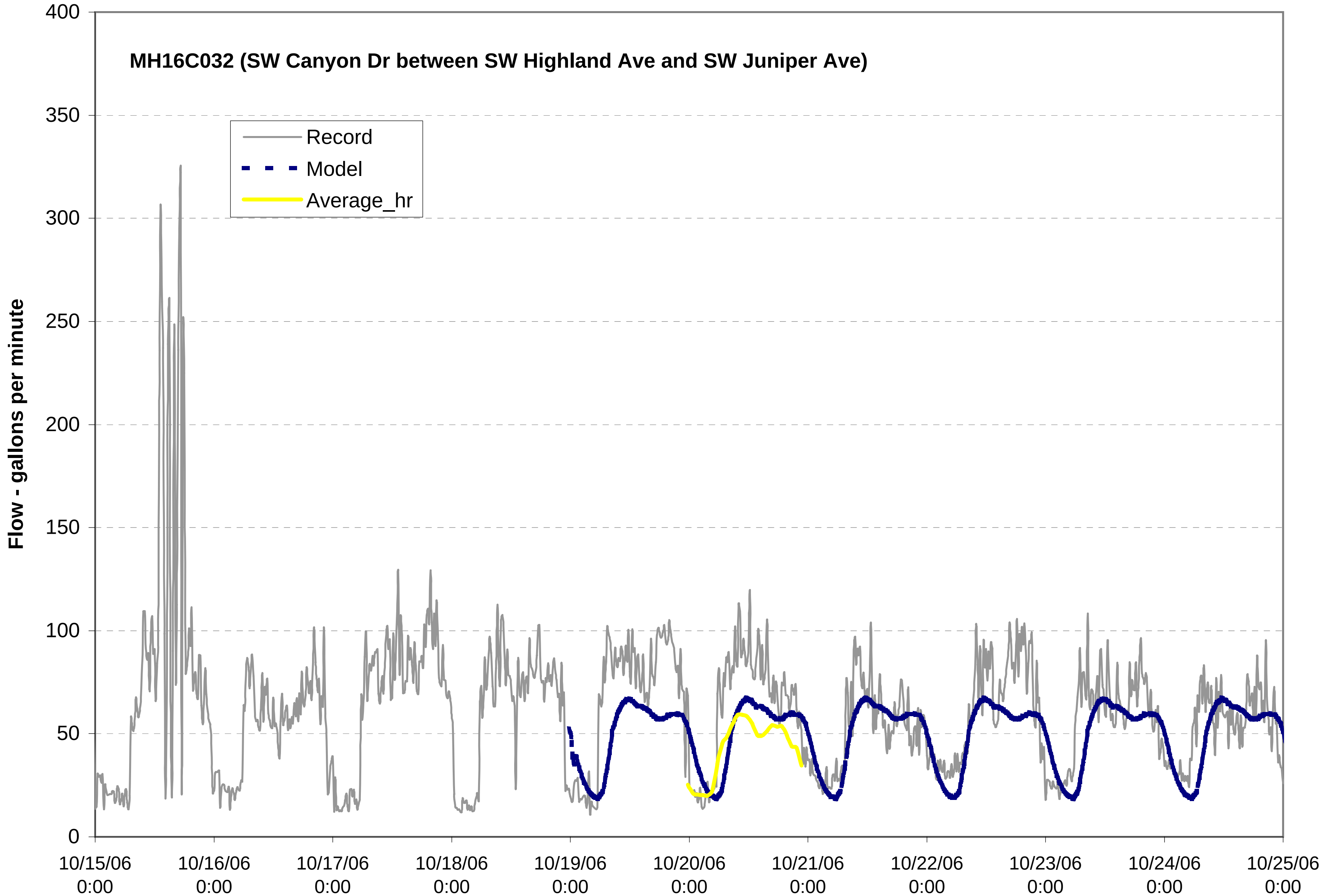

MH16C032 (SW Canyon Dr between SW Highland Ave and SW Juniper Ave)
Record
Model
Average_hr
Flow - gallons per minute
0
50
100
150
200
250
300
350
400
10/15/06 0:00
10/16/06 0:00
10/17/06 0:00
10/18/06 0:00
10/19/06 0:00
10/20/06 0:00
10/21/06 0:00
10/22/06 0:00
10/23/06 0:00
10/24/06 0:00
10/25/06 0:00

Figure 12

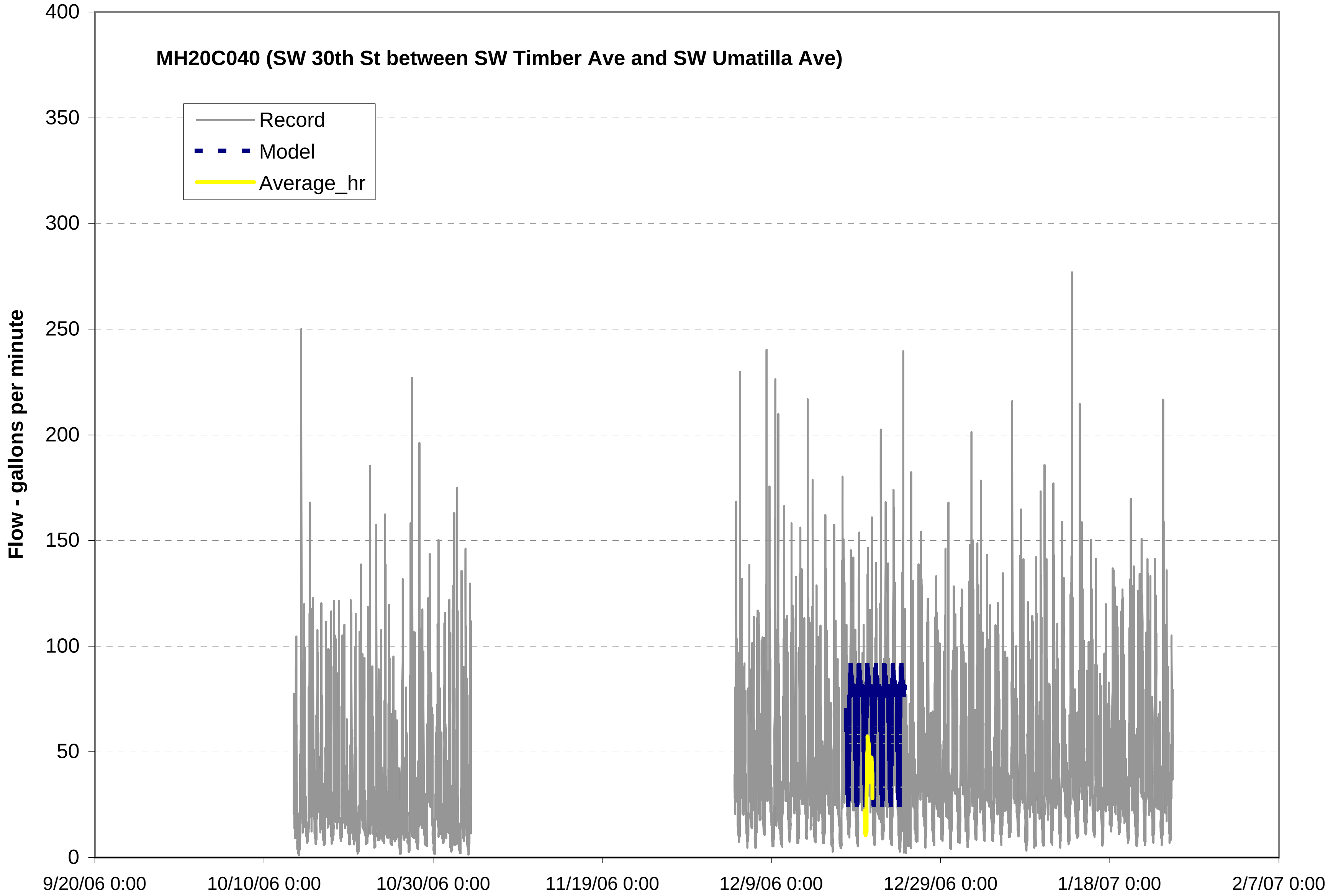

MH20C040 (SW 30th St between SW Timber Ave and SW Umatilla Ave)
Record
Model
Average_hr
Flow - gallons per minute
400
350
300
250
200
150
100
50
0
9/20/06 0:00
10/10/06 0:00
10/30/06 0:00
11/19/06 0:00
12/9/06 0:00
12/29/06 0:00
1/18/07 0:00
2/7/07 0:00

Figure 13

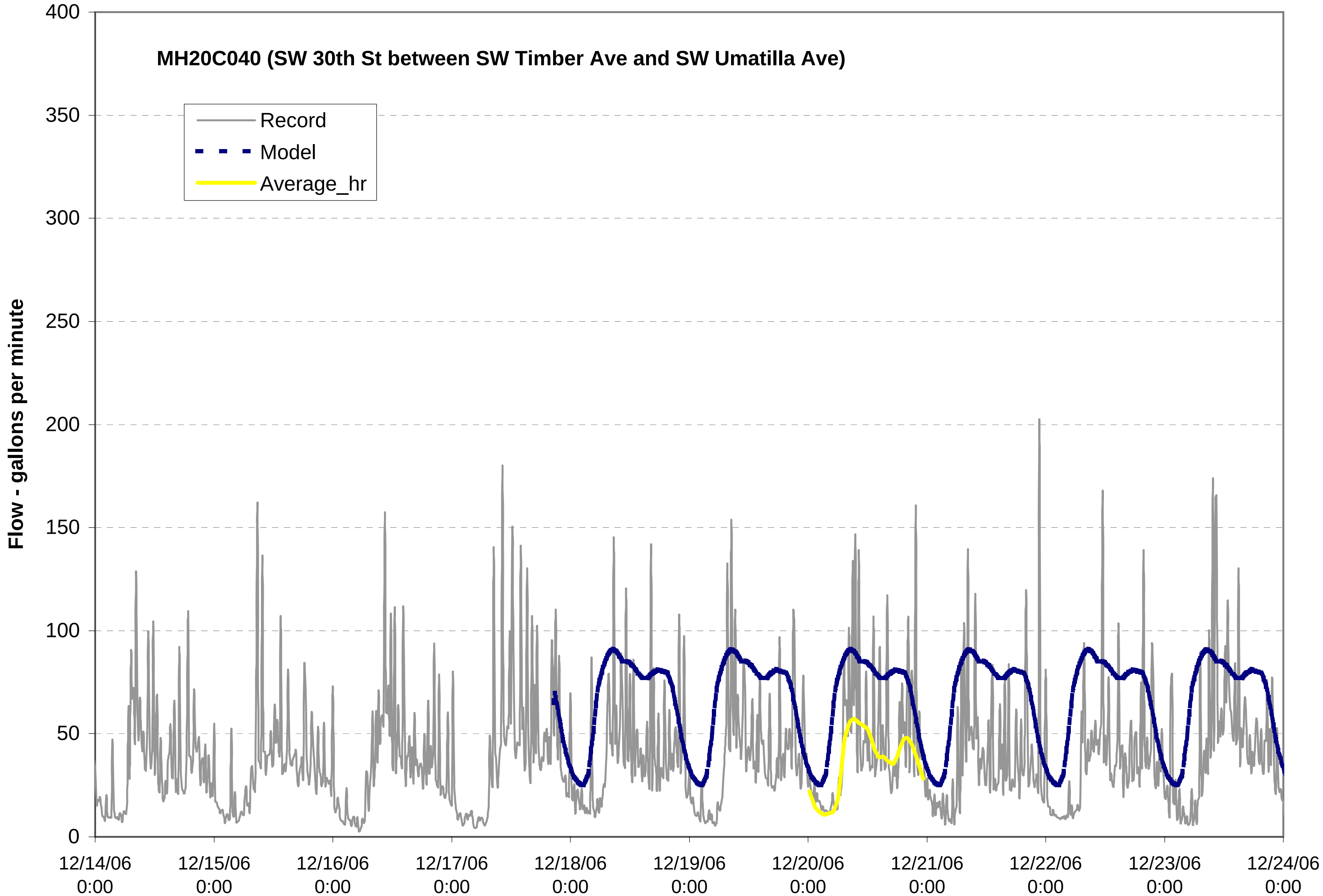

MH20C040 (SW 30th St between SW Timber Ave and SW Umatilla Ave)
Record
Model
Average_hr
Flow - gallons per minute
400
350
300
250
200
150
100
50
0
12/14/06 0:00
12/15/06 0:00
12/16/06 0:00
12/17/06 0:00
12/18/06 0:00
12/19/06 0:00
12/20/06 0:00
12/21/06 0:00
12/22/06 0:00
12/23/06 0:00
12/24/06 0:00

Figure 14

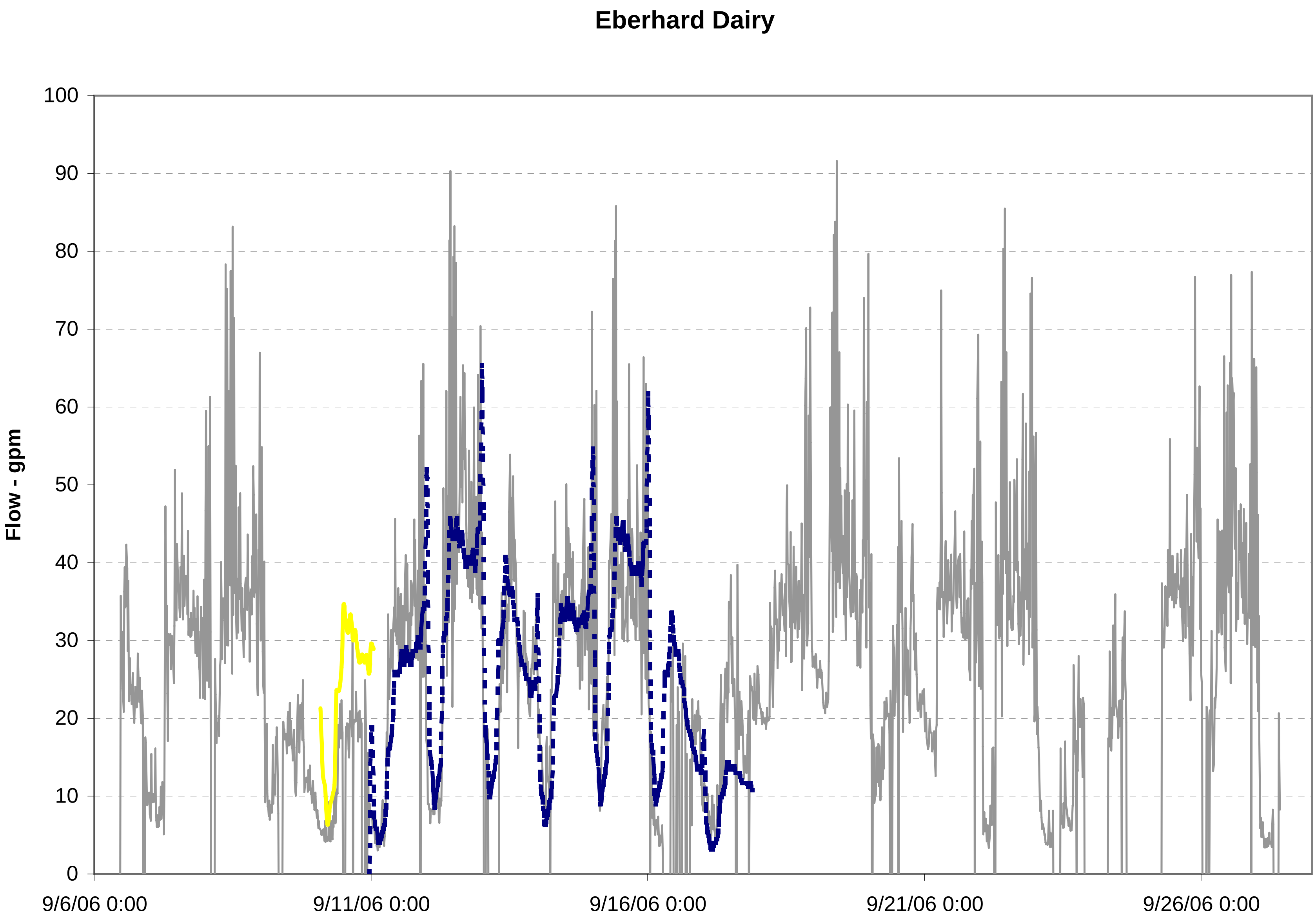
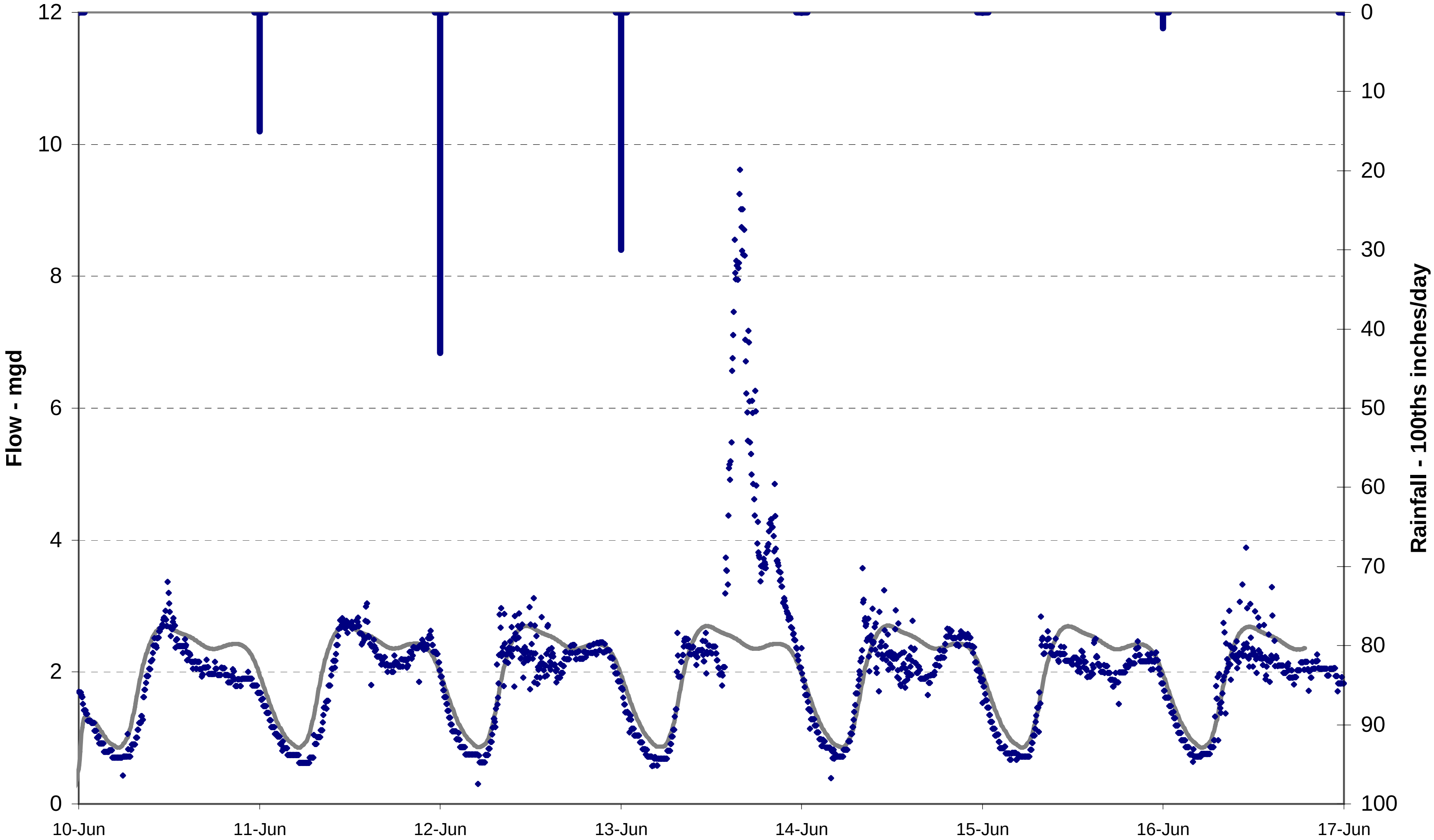

Eberhard Dairy
Flow - gpm
100
90
80
70
60
50
40
30
20
10
0
9/6/06 0:00
9/11/06 0:00
9/16/06 0:00
9/21/06 0:00
9/26/06 0:00

Figure 15: Redmond WWTP
Total Influent Flow - Recorded and Modeled



Attachment 1: Water Meter Data

Attachment 1
City of Redmond
Water Meter Locations and Data

In determining large water users and dischargers to the sanitary sewer system it is customary to retrieve and inspect water use data. Mark Chambers (City of Redmond) obtained water meter and use data for December 2005 through February 2006 to aid in determining both sanitary base flow and large users. Unfortunately, water meters were not mapped. Therefore, water use data could not be assigned to individual sewer basins. However, the meter data contained addresses that could be used to map the meters.

The 3 months of water use data were combined into a single database file with the meter "Location ID" as a unique index. This resulted in 7,754 meter locations. Each month had a different number of meters in the file. The differences in meter counts are shown Table 1.

Table 1: Difference in number of meters

Month	December	January	February
December	--	301	337
January	558	--	406
February	329	153	--

The average water use over the winter was about 2.1 mgd which is consistent with the Redmond Water Pollution Control Facility flow records (average of about 1.9 mgd). The largest 20 users are given in Table 2, with the largest (PCC Structural) using 4,160 ccf (about 39,000 gpd). The second largest (Eberhard Creamery) has a more consistent monthly use of about 32.000 gpd.

Table 2: Top 20 Water Users (100 cubic feet [ccf])

locationID	Address	Dec 05 Use	Jan 06 Use	Feb 06 Use	Winter Use
4236	345 NE HEMLOCK AVE	28	3034	1098	4160
3642	235 SW EVERGREEN AVE	1012	1005	1488	3505
16344	2521 NW CEDAR AVE	172	157	2776	3105
4256	1253 NW CANAL BLVD	369	513	1472	2354
9562	1515 NW FIR AVE	559	635	636	1830
2780	340 SW RIMROCK DR	408	585	527	1520
2758	675 SW RIMROCK DR	115	736	534	1385
7162	1201 SW 28TH ST	298	458	438	1194
13540	438 NW 19TH ST	225	480	339	1044
13332	1253 NE GREENWOOD AVE	295	301	442	1038
5808	2633 SW OBSIDIAN AVE	320	366	313	999
4234	345 NE HEMLOCK AVE	370	187	383	940
20570	515 NE SHOSHONE DR	143	432	358	933
2820	1822 SW ANTLER AVE	255	265	291	811

Table 2: Top 20 Water Users (100 cubic feet [ccf])					
locationID	Address	Dec 05 Use	Jan 06 Use	Feb 06 Use	Winter Use
17614	2200 NW CLIFFSIDE WAY	380	174	253	807
4886	1705 S HWY 97	242	282	271	795
1392	351 NW MAPLE AVE	269	241	272	782
9542	528 NW 17TH ST	222	297	252	771
8192	2630 SW 17TH PL	208	287	238	733
13724	944 SW VETERANS WAY	246	208	261	715

The first step in determining meter location was modifying the structure of the meter data table to combine the street prefix and suffix with the address field to produce a full street address field similar to that given in the parcel data. Linking meter address to parcel addresses produced 6,925 matches (approximately 90 percent of the addresses found). The address match to parcels produces polygons, representing the parcel, which can be used for meter location and for subbasin definition. The centroid of the parcels could be used to create a point for the meter location rather than a polygon.

The second step was to link the unmatched meter addresses (829 locations) through an on-line/interactive third party geocoding service. The service was able to match the remaining meter locations without interpolation at most locations. At 192 locations, the address was different enough to require interaction with the user to select an appropriate address match. The difference is illustrated below where the first address is the meter information and the second is the address found in the geocoding service.

456	231 W Antler Ave	231 NW ANTLER AVE
458	406 W Antler Ave	406 SW ANTLER AVE
762	123 SE Jackson St	123 SE JACKSON AVE
764	145 SE Jackson St	145 SE JACKSON AVE
1066	623 W Antler Ave	623 NW ANTLER AVE
1072	719 W Antler Ave	719 NW ANTLER AVE
1074	737 W Antler Ave	737 NW ANTLER AVE
1094	708 W Antler Ave	708 SW ANTLER AVE
9832	2522 SE Jessie Butler Cir	2522 SE JESSE BUTLER AVE
1390	1485 N Highway 97	1485 N HWY 97
1634	923 W Antler Ave	923 NW ANTLER AVE
1636	937 W Antler Ave	937 NW ANTLER AVE
1654	936 W Antler Ave	936 SW ANTLER AVE
1656	850 W Antler Ave	850 SW ANTLER AVE
2046	241 W Antler Ave	241 NW ANTLER AVE
2232	1034 W Antler Ave	1034 SW ANTLER AVE
2244	1108 W Antler Ave	1108 SW ANTLER AVE

Example of address matching using geocoding service.

The combination produced a map of meter locations as shown in Figure 1. The two data files were sent to Mark Chambers and CH2M HILL for their use. Additional discussion is required to set data field structure, address error checks, and add future meter information.

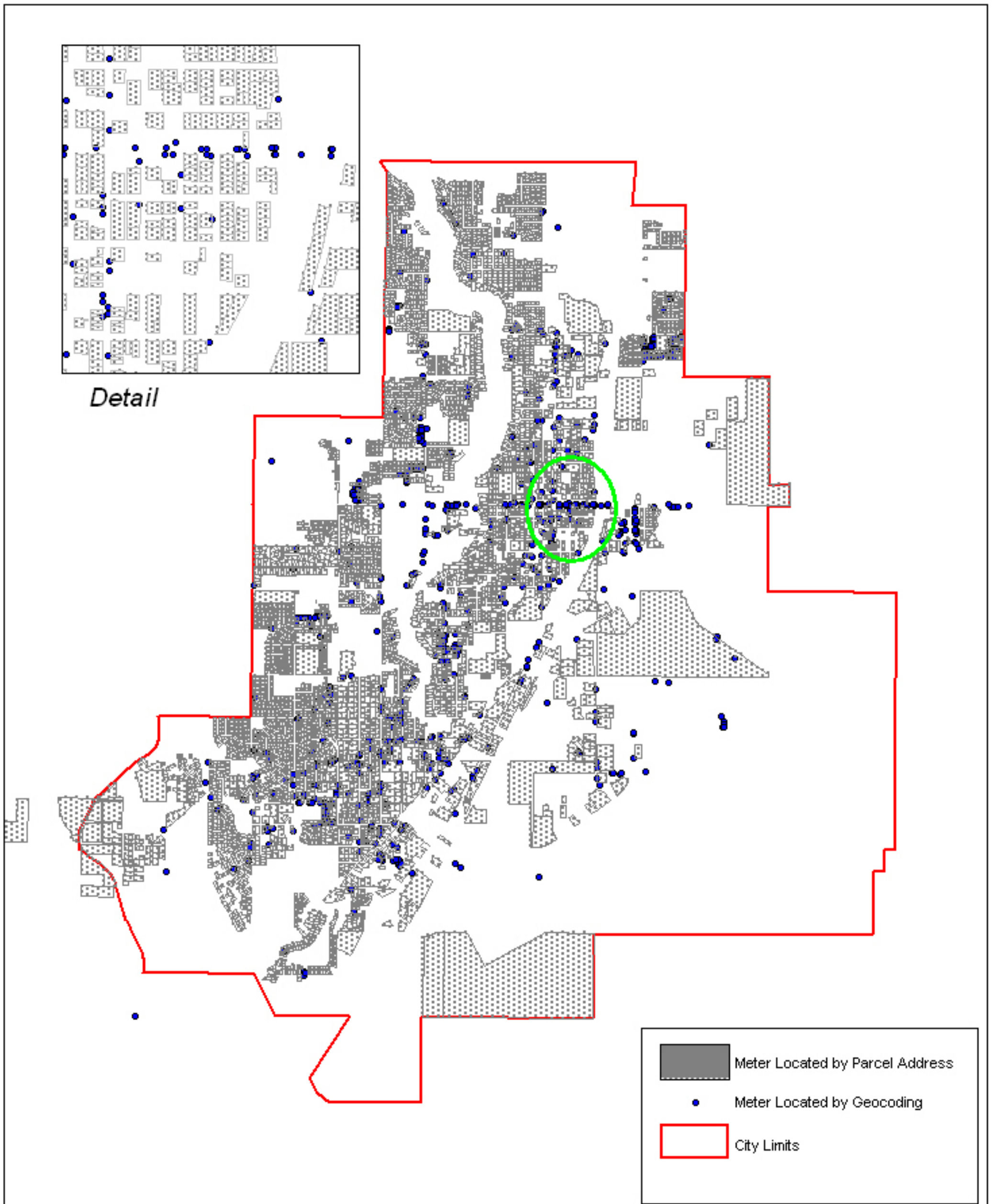


Figure 1
Water Meter Location

APPENDIX B

Cost-Benefit Analysis for Pump Stations and Force Mains Versus Deep Gravity Sewers

Appendix B

Redmond Wastewater Collection System Master Plan

Cost-Benefit Analysis for Pump Stations and Force Mains Versus Deep Gravity Sewers

Life Cycle Period, years:	40
Discount Rate Assumed:	2.5%
ENR CCI:	8626
Cost Input Variables:	
Electric Power, $/kwh	$0.090
Labor, $/hr	$40.00
Annual Conveyance Maintenance, $/foot	$1.05

Option A. Gravity - Capital Construction Cost

No.	Item Description	Depth	Quantity	Unit	Unit Cost	Total Cost
1	Link646, 15" dia. PVC, avg depth 16', in street	16	657	LF	$383	$251,315
2	Link647, 15" dia. PVC, avg depth 5', out of street	5	666	LF	$215	$143,141
3	Link648, 15" dia. PVC, avg depth 12', out of street	12	667	LF	$321	$213,885
4	Link649, 15" dia. PVC, avg depth 17', out of street	17	666	LF	$435	$290,031
5	Link650, 15" dia. PVC, avg depth 5', out of street	5	675	LF	$215	$145,075
6	Link651, 15" dia. PVC, avg depth 17', out of street	17	1314	LF	$435	$572,223
7	Link652, 15" dia. PVC, avg depth 17', out of street	17	758	LF	$435	$330,095
8	Manholes (included in unit price)			EA	$5,296	$0
					Subtotal:	$1,945,763
					Contingency @ 30%:	$ 583,729
					Subtotal:	$2,529,492
					Mobilization @ 10%:	$ 252,949
					Total Construction Cost:	**$2,782,400**
					Engineering @ 10%:	$ 417,360
					Construction Management @ 8%:	$ 222,592
					Permits, Legal & Admin @ 15%:	$ 278,240
					Total Estimated Project Cost:	**$3,700,000**

Option A. Gravity - Annual O&M Cost

No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Inspection and Maintenance	5,403	LF	$1.05	$5,669
				Total Estimated Annual O&M Cost:	**$5,700**
				Total Estimated Present Worth O&M:	**$140,000**

Appendix B

Redmond Wastewater Collection System Master Plan

Cost-Benefit Analysis for Pump Stations and Force Mains Versus Deep Gravity Sewers

Option B. Pump Station and Force Main - Capital Cost

No.	Item Description	Depth	Quantity	Unit	Unit Cost	Total Cost
1	8-inch diameter force main, average depth 5'	5	5,403	LF	$199	$1,073,716
2	Pump Station property acquisition		500	SF	$15	$7,500
3	Pump Station (1.3 MGD average flow, 130' TDH)		1	LS	$500,000	$500,000
					Subtotal:	$1,581,216
					Contingency @ 30%:	$474,365
					Subtotal:	$2,055,581
					Mobilization @ 10%:	$205,558
					Total Construction Cost:	**$2,261,100**
					Engineering @ 15%:	$339,165
					Construction Management @ 8%:	$180,888
					Permits, Legal & Admin @ 15%:	$226,110
					Total Estimated Project Cost:	**$3,010,000**

Option B. Pump Station and Force Main - Annual O&M Cost

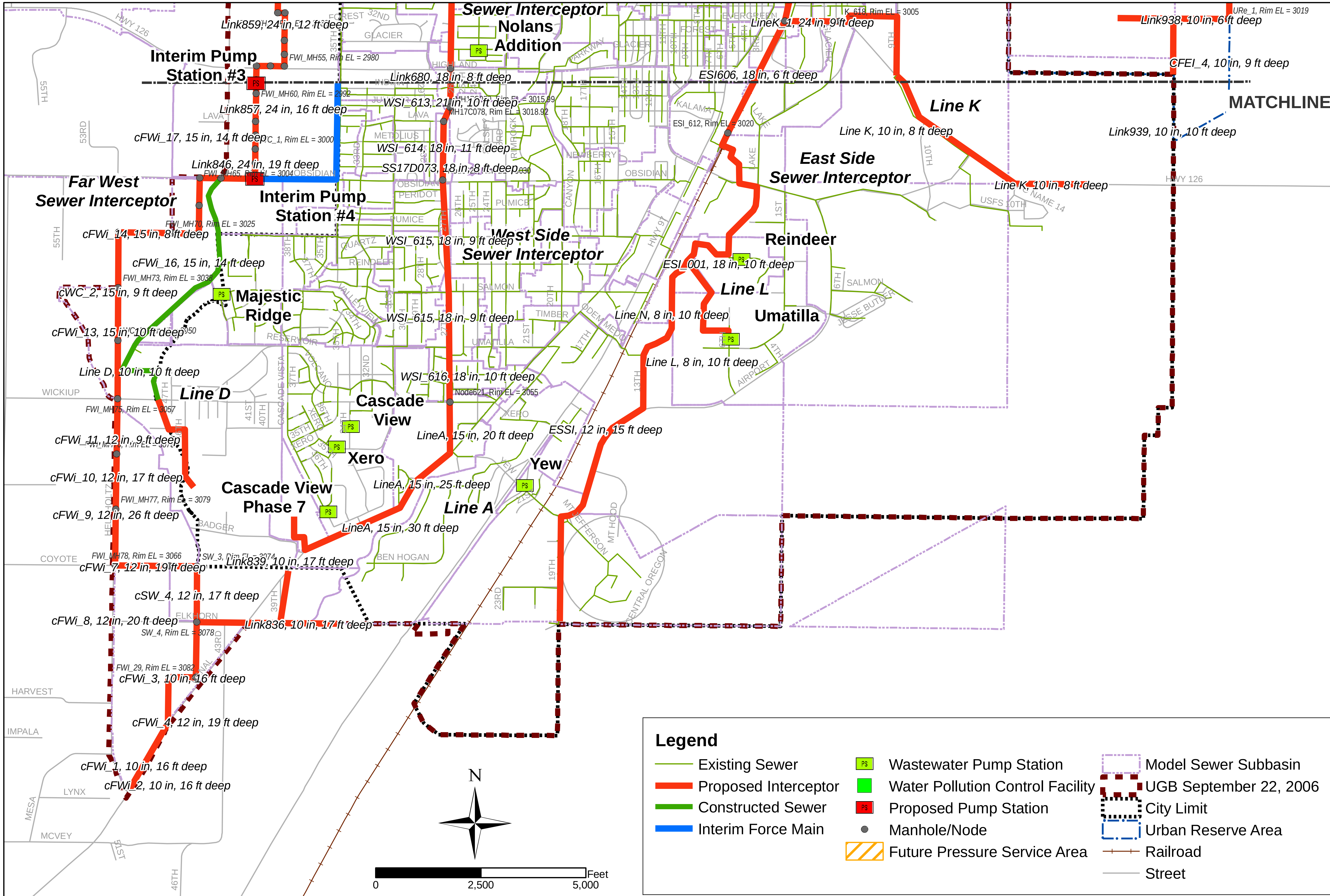
No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Power	326,648	KW-HR	$0.09	$29,398
2	Force Main Maintenance	5403	LF	$1.05	$5,669
3	Pump Station Maintenance	150	HR	$40	$6,000
4	Pump Station Miscellaneous Supplies	1	LS	$12,000	$12,000
				Total Estimated Annual O&M Cost:	**$53,100**
				Total Estimated Present Worth O&M:	**$1,330,000**

Present Worth Comparison for Options A and B

	Capital Cost	Present Worth Annual O&M	Total Present Worth
Option A. Gravity Sewer	$3,700,000	$140,000	$3,840,000
Option B. Pump Station and Force Main	$3,010,000	$1,330,000	$4,340,000

APPENDIX C

Wastewater Capital Improvements Plan



Redmond Wastewater System Master Plan

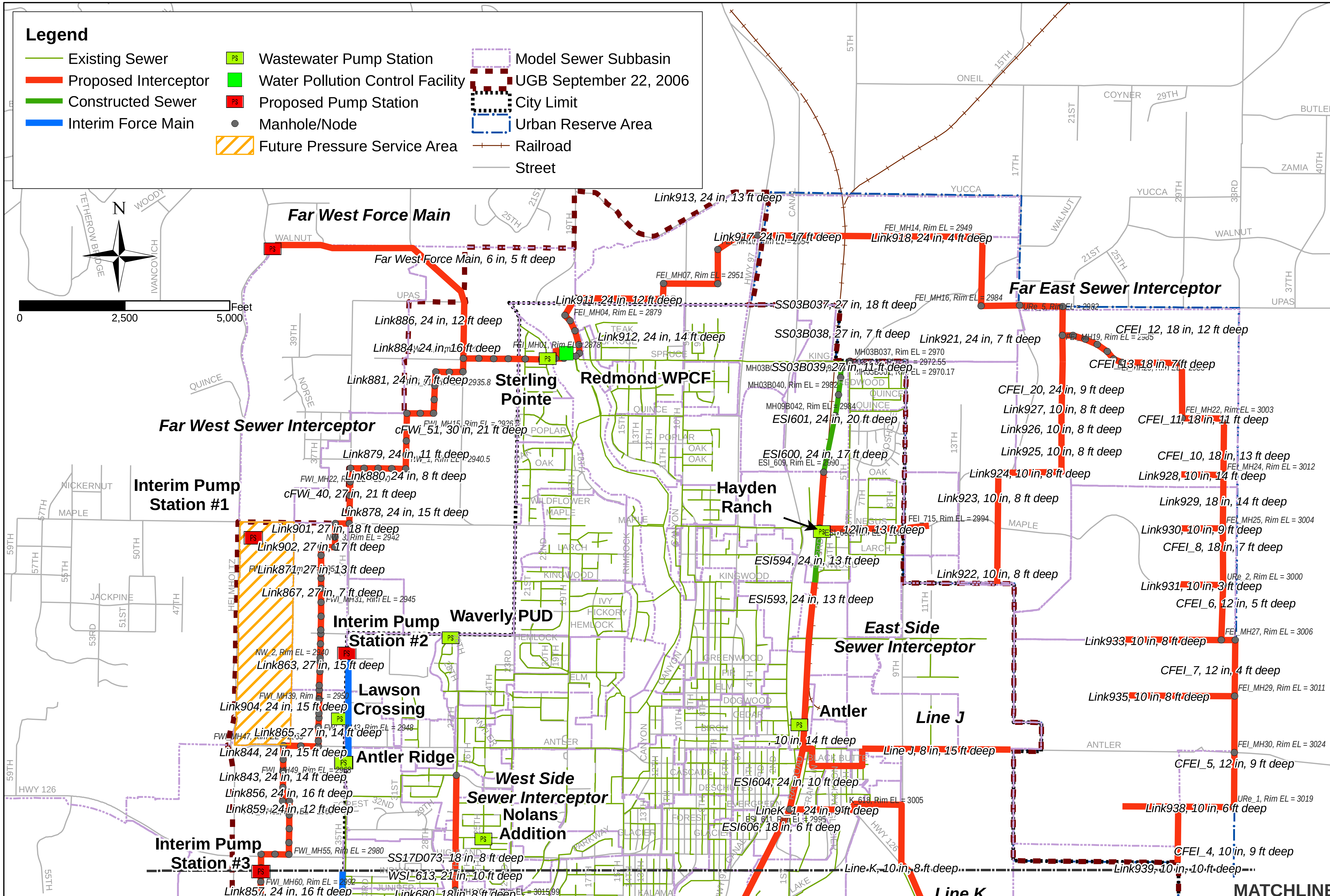
Proposed Interceptor System

South Panel

CITY OF REDMOND, OR

December 2007

CH2MHILL



North Panel
Proposed Interceptor System
Redmond Wastewater System Master Plan

CITY OF REDMOND, OR
December 2007

CH2MHILL

APPENDIX C, EXHIBIT 1

Wastewater Collection System UGB Buildout Project List (Costs based on ENR CCI Seattle = 8626

Project Type	Implemen-tation Phase	Model ID	Improve-ment Description	Reason for Improve-ment	Priority	Allocations		Pipelines			"Local" 8-inch sewer cost, 10 feet deep	Incremental Cost exceeding "local" sewer cost	Total Project Cost	Costs			Location	Unit Price	Engin. & Admin.	Traffic Control unit price	Rock Excava- tion Unit Price	Found. Stabil.	CDF Fill	Trench Dewatering	Erosion Control	Tunneling Boring, Jacking	Land Acquis-ition	Utility relo-cation	Total Unit Price
						Upgrade Existing	Growth	Length (ft.)	Average Depth of Bury (ft.)	Diameter (in.)	Unit Price ($/ft)	Unit Price ($/ft)	Project Unit Price ($/ft)	Construc-tion	Allowance for Eng. & Admin.	Total Estimate			10%	per LF	per LF	per LF	per LF	per LF	per LF	per LF	per LF	per LF	
Far West Interceptor	2007-2015	Link943	Sewer	Growth	4	0%	100%	30	6	30	$262	$174	$436	$12,600	$1,400	$14,000	Between Sterling Pointe Pump Station and Redmond Water Pollution Control Facility	$ 371	$37	$9	$9	$0	$0	$0	$10	$0	$0	$0	$ 436
	2007-2015	Link944	Sewer	Growth	4	0%	100%	33	6	30	$262	$174	$436	$13,500	$1,500	$15,000	Between Sterling Pointe Pump Station and Redmond Water Pollution Control Facility	$ 371	$37	$9	$9	$0	$0	$0	$10	$0	$0	$0	$ 436
	2007-2015	Link677	Sewer	Growth	4	0%	100%	25	5	30	$262	$171	$433	$9,900	$1,100	$11,000	Between Sterling Pointe Pump Station and Redmond Water Pollution Control Facility	$ 371	$37	$9	$6	$0	$0	$0	$10	$0	$0	$0	$ 433
	2007-2015	CFEI_54	Sewer	Growth	4	0%	100%	86	5	30	$262	$171	$433	$34,200	$3,800	$38,000	Between Sterling Pointe Pump Station and Redmond Water Pollution Control Facility	$ 371	$37	$9	$6	$0	$0	$0	$10	$0	$0	$0	$ 433
	2007-2015	CFEI_53	Sewer	Growth	4	0%	100%	175	6	30	$262	$174	$436	$69,300	$7,700	$77,000	Between Sterling Pointe Pump Station and Redmond Water Pollution Control Facility	$ 371	$37	$9	$9	$0	$0	$0	$10	$0	$0	$0	$ 436
	2007-2015	Link895	Sewer	Growth	4	0%	100%	230	12	30	$262	$371	$633	$131,400	$14,600	$146,000	Parallel to NW Spruce Ave, west of Sterling Pointe Pump Station	$ 534	$53	$9	$27	$0	$0	$0	$10	$0	$0	$0	$ 633
	2007-2015	Link894	Sewer	Growth	4	0%	100%	136	19	30	$262	$495	$757	$92,700	$10,300	$103,000	Parallel to NW Spruce Ave, east of NW 22nd St at Sterling Pointe Pump Station	$ 628	$63	$9	$47	$0	$0	$0	$10	$0	$0	$0	$ 757
	2007-2015	Link893	Sewer	Growth	4	0%	100%	400	18	30	$262	$492	$754	$271,800	$30,200	$302,000	Parallel to NW Spruce Ave, east of NW 22nd St	$ 628	$63	$9	$44	$0	$0	$0	$10	$0	$0	$0	$ 754
	2007-2015	Link892	Sewer	Growth	4	0%	100%	400	20	30	$262	$496	$758	$273,600	$30,400	$304,000	Parallel to NW Spruce Ave, west of NW 22nd St	$ 626	$63	$9	$50	$0	$0	$0	$10	$0	$0	$0	$ 758
	2007-2015	Link891	Sewer	Growth	4	0%	100%	350	24	30	$262	$508	$770	$243,000	$27,000	$270,000	Parallel to NW Spruce Ave, east of Northwest Way	$ 626	$63	$9	$62	$0	$0	$0	$10	$0	$0	$0	$ 770
	2007-2015	Link890	Sewer	Growth	4	0%	100%	350	25	24	$262	$435	$697	$220,500	$24,500	$245,000	Parallel to NW Spruce Ave, east of Northwest Way	$ 557	$56	$9	$65	$0	$0	$0	$10	$0	$0	$0	$ 697
	2007-2015	Link889	Sewer	Growth	4	0%	100%	373	23	30	$262	$505	$767	$257,400	$28,600	$286,000	Parallel to NW Spruce Ave, east of Northwest Way	$ 626	$63	$9	$59	$0	$0	$0	$10	$0	$0	$0	$ 767
	2007-2015	cFWi_51	Sewer	Growth	4	0%	100%	330	21	30	$262	$499	$761	$226,800	$25,200	$252,000	Along Northwest Way, south of NW Spruce Ave	$ 626	$63	$9	$53	$0	$0	$0	$10	$0	$0	$0	$ 761
	2007-2015	Link888	Sewer	Growth	4	0%	100%	325	19	24	$262	$418	$680	$198,900	$22,100	$221,000	Parallel to and south of NW Spruce Ave, west of Northwest Way	$ 557	$56	$9	$47	$0	$0	$0	$10	$0	$0	$0	$ 680
	2007-2015	Link887	Sewer	Growth	4	0%	100%	325	15	24	$262	$326	$588	$172,800	$19,200	$192,000	Parallel to and south of NW Spruce Ave, west of Northwest Way	$ 485	$49	$9	$36	$0	$0	$0	$10	$0	$0	$0	$ 588
	2007-2015	Link886	Sewer	Growth	4	0%	100%	330	12	24	$262	$278	$540	$161,100	$17,900	$179,000	Parallel to and west of Northwest Way, south of NW Spruce Ave	$ 449	$45	$9	$27	$0	$0	$0	$10	$0	$0	$0	$ 540
	2007-2015	Link885	Sewer	Growth	4	0%	100%	330	14	24	$262	$284	$546	$162,900	$18,100	$181,000	Parallel to and west of Northwest Way, south of NW Spruce Ave	$ 449	$45	$9	$33	$0	$0	$0	$10	$0	$0	$0	$ 546
	2007-2015	Link884	Sewer	Growth	4	0%	100%	332	16	24	$262	$329	$591	$177,300	$19,700	$197,000	Parallel to and west of Northwest Way, south of NW Spruce Ave	$ 485	$49	$9	$39	$0	$0	$0	$10	$0	$0	$0	$ 591
	2007-2015	Link883	Sewer	Growth	4	0%	100%	317	14	24	$262	$284	$546	$155,700	$17,300	$173,000	Parallel to and south of NW Spruce Ave, west of Northwest Way	$ 449	$45	$9	$33	$0	$0	$0	$10	$0	$0	$0	$ 546
	2007-2015	Link882	Sewer	Growth	4	0%	100%	317	9	24	$262	$144	$406	$116,100	$12,900	$129,000	Parallel to and south of NW Spruce Ave, west of Northwest Way	$ 336	$34	$9	$18	$0	$0	$0	$10	$0	$0	$0	$ 406
	2007-2015	Link881	Sewer	Growth	4	0%	100%	330	7	24	$262	$99	$361	$108,000	$12,000	$120,000	Parallel to and east of NW 35th St, north of NW Maple Ave	$ 301	$30	$9	$12	$0	$0	$0	$10	$0	$0	$0	$ 361
	2007-2015	Link880	Sewer	Growth	4	0%	100%	330	8	24	$262	$141	$403	$120,600	$13,400	$134,000	Parallel to and east of NW 35th St, north of NW Maple Ave	$ 336	$34	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 403
	2007-2015	Link879	Sewer	Growth	4	0%	100%	330	11	24	$262	$275	$537	$160,200	$17,800	$178,000	Parallel to and east of NW 35th St, north of NW Maple Ave	$ 449	$45	$9	$24	$0	$0	$0	$10	$0	$0	$0	$ 537
	2007-2015	Link878	Sewer	Growth	4	0%	100%	330	15	24	$262	$326	$588	$175,500	$19,500	$195,000	Parallel to and east of NW 35th St, north of NW Maple Ave	$ 485	$49	$9	$36	$0	$0	$0	$10	$0	$0	$0	$ 588
	2007-2015	Link877	Sewer	Growth	4	0%	100%	330	17	24	$262	$412	$674	$200,700	$22,300	$223,000	Parallel to and south of NW Oak Ave, east of NW 35th St	$ 557	$56	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 674
	2007-2015	Link876	Sewer	Growth	4	0%	100%	330	15	24	$262	$326	$588	$175,500	$19,500	$195,000	Parallel to and south of NW Oak Ave, east of NW 35th St	$ 485	$49	$9	$36	$0	$0	$0	$10	$0	$0	$0	$ 588
	2007-2015	Link875	Sewer	Growth	4	0%	100%	330	16	24	$262	$329	$591	$176,400	$19,600	$196,000	Parallel to and south of NW Oak Ave, east of NW 35th St	$ 485	$49	$9	$39	$0	$0	$0	$10	$0	$0	$0	$ 591
	2007-2015	cFWi_41	Sewer	Growth	4	0%	100%	330	17	27	$262	$410	$672	$199,800	$22,200	$222,000	Parallel to and south of NW Oak Ave, east from NW 35th St	$ 556	$56	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 672
	2007-2015	Link874	Sewer	Growth	4	0%	100%	331	16	27	$262	$343	$605	$180,900	$20,100	$201,000	Along NW 35th St north of NW Maple Ave	$ 498	$50	$9	$39	$0	$0	$0	$10	$0	$0	$0	$ 605
	2007-2015	Link873	Sewer	Growth	4	0%	100%	340	19	27	$262	$416	$678	$207,900	$23,100	$231,000	Along NW 35th St north of NW Maple Ave	$ 556	$56	$9	$47	$0	$0	$0	$10	$0	$0	$0	$ 678
	2007-2015	Link900	Sewer	Growth	4	0%	100%	330	22	27	$262	$489	$751	$223,200	$24,800	$248,000	Along NW 35th St north of NW Maple Ave	$ 614	$61	$9	$56	$0	$0	$0	$10	$0	$0	$0	$ 751
	2007-2015	cFWi_40	Sewer	Growth	4	0%	100%	320	21	27	$262	$486	$748	$216,000	$24,000	$240,000	Along NW 35th St north of NW Maple Ave	$ 614	$61	$9	$53	$0	$0	$0	$10	$0	$0	$0	$ 748
	2016-2020	cNW_P2	Sewer	Growth	4	0%	100%	330	18	27	$262	$413	$675	$200,700	$22,300	$223,000	Along NW Maple Ave, west of NW 35th St	$ 556	$56	$9	$44	$0	$0	$0	$10	$0	$0	$0	$ 675
	2016-2020	Link901	Sewer	Growth	4	0%	100%	330	18	27	$262	$413	$675	$200,700	$22,300	$223,000	Parallel to and west of NW 35th St, south of NW Maple Ave	$ 556	$56	$9	$44	$0	$0	$0	$10	$0	$0	$0	$ 675
	2016-2020	cFWi_38	Sewer	Growth	4	0%	100%	240	20	27	$262	$419	$681	$147,600	$16,400	$164,000	Parallel to and west of NW 35th St, south of NW Maple Ave	$ 556	$56	$9	$50	$0	$0	$0	$10	$0	$0	$0	$ 681
	2016-2020	cFWi_37	Sewer	Growth	4	0%	100%	330	16	27	$262	$407	$669	$198,900	$22,100	$221,000	Parallel to and south of NW Maple Ave, west of SW 35th St	$ 556	$56	$9	$39	$0	$0	$0	$10	$0	$0	$0	$ 669
	2016-2020	Link903	Sewer	Growth	4	0%	100%	330	13	27	$262	$302	$564	$168,300	$18,700	$187,000	Parallel to and west of NW 35th St, south of NW Maple Ave	$ 468	$47	$9	$30	$0	$0	$0	$10	$0	$0	$0	$ 564
	2016-2020	Link902	Sewer	Growth	4	0%	100%	330	17	27	$262	$410	$672	$199,800	$22,200	$222,000	Parallel to and west of NW 35th St, south of NW Maple Ave	$ 556	$56	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 672
	2016-2020	cFWi_36	Sewer	Growth	4	0%	100%	90	22	27	$262	$489	$751	$61,200	$6,800	$68,000	Parallel to and west of NW 35th St, south of NW Maple Ave	$ 614	$61	$9	$56	$0	$0	$0	$10	$0	$0	$0	$ 751
	2016-2020	Link872	Sewer	Growth	4	0%	100%	240	19	27	$262	$416	$678	$146,700	$16,300	$163,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave	$ 556	$56	$9	$47	$0	$0	$0	$10	$0	$0	$0	$ 678
	2016-2020	Link871	Sewer	Growth	4	0%	100%	330	13	27	$262	$302	$564	$168,300	$18,700	$187,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave	$ 468	$47	$9	$30	$0	$0	$0	$10	$0	$0	$0	$ 564
	2016-2020	Link870	Sewer	Growth	4	0%	100%	330	13	27	$262	$302	$564	$168,300	$18,700	$187,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave	$ 468	$47	$9	$30	$0	$0	$0	$10	$0	$0	$0	$ 564
	2016-2020	Link869	Sewer	Growth	4	0%	100%	320	13	27	$262	$302	$564	$162,900	$18,100	$181,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave	$ 468	$47	$9	$30	$0	$0	$0	$10	$0	$0	$0	$ 564
	2016-2020	cFWi_35	Sewer	Growth	4	0%	100%	90	13	27	$262	$302	$564	$45,900	$5,100	$51,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave	$ 468	$47	$9	$30	$0	$0	$0	$10	$0	$0	$0	$ 564
	2016-2020	Link868	Sewer	Growth	4	0%	100%	250	10	27	$262	$233	$495	$111,600	$12,400	$124,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave	$ 414	$41	$9	$21	$0	$0	$0	$10	$0	$0	$0	$ 495
	2016-2020	Link867	Sewer	Growth	4	0%	100%	330	7	27	$262	$160	$422	$126,000	$14,000	$140,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave	$ 355	$36	$9	$12	$0	$0	$0	$10	$0	$0	$0	$ 422
	2016-2020	cNW_2	Sewer	Growth	4	0%	100%	100	7	27	$262	$160	$422	$38,700	$4,300	$43,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave	$ 355	$36	$9	$12	$0	$0	$0	$10	$0	$0	$0	$ 422
	2016-2020	Link866	Sewer	Growth	4	0%	100%	230	9	27	$262	$231	$492	$102,600	$11,400	$114,000	Parallel to and west of NW 35th St, south of NW Hemlock Ave	$ 414	$41	$9	$18	$0	$0	$0	$10	$0	$0	$0	$ 492
	2016-2020	Link865	Sewer	Growth	4	0%	100%	330	14	27	$262	$305	$567	$169,200	$18,800	$188,000	Parallel to and west of NW 35th St, north of W Antler Ave	$ 468	$47	$9	$33	$0	$0	$0	$10	$0	$0	$0	$ 567
	2016-2020	cFWi_33	Sewer	Growth	4	0%	100%	110	17	27	$262	$410	$672	$66,600	$7,400	$74,000	Parallel to and west of NW 35th St, north of W Antler Ave	$ 556	$56	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 672
	2016-2020	Link864	Sewer	Growth	4	0%	100%	230	17	27	$262	$410	$672	$139,500	$15,500	$155,000	Parallel to and west of NW 35th St, north of W Antler Ave	$ 556	$56	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 672
	2016-2020	Link863	Sewer	Growth	4	0%	100%	330	15	27	$262	$340	$602	$179,100	$19,900	$199,000	Parallel to and west of NW 35th St, north of W Antler Ave	$ 498	$50	$9	$36	$0	$0	$0	$10	$0	$0	$0	$ 602

Project Type	Implemen-tation Phase	Model ID	Improve-ment Description	Reason for Improve-ment	Priority	Allocations: Upgrade Existing	Allocations: Growth	Pipelines: Length (ft.)	Pipelines: Average Depth of Bury (ft.)	Pipelines: Diameter (in.)	"Local" 8-inch sewer cost, 10 feet deep: Unit Price ($/ft)	Incremental Cost exceeding "local" sewer cost: Unit Price ($/ft)	Total Project Cost: Project Unit Price ($/ft)	Costs: Construc-tion	Costs: Allowance for Eng. & Admin.	Costs: Total Estimate	Location	Unit Price	Engin. & Admin. 10%	Traffic Control unit price per LF	Rock Excava- tion Unit Price per LF	Found. Stabil. per LF	CDF Fill per LF	Trench Dewatering per LF	Erosion Control per LF	Tunneling Boring, Jacking per LF	Land Acquis-ition per LF	Utility relo-cation per LF	Total Unit Price
	2016-2020	cFWi_32	Sewer	Growth	4	0%	100%	110	14	27	$262	$305	$567	$56,700	$6,300	$63,000	Parallel to and west of NW 35th St, north of W Antler Ave	$ 468	$47	$9	$33	$0	$0	$0	$10	$0	$0	$0	$ 567
	2016-2020	Link862	Sewer	Growth	4	0%	100%	220	17	24	$262	$412	$674	$134,100	$14,900	$149,000	Parallel to and west of NW 35th St, north of W Antler Ave	$ 557	$56	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 674
	2016-2020	Link861	Sewer	Growth	4	0%	100%	330	21	24	$262	$424	$686	$204,300	$22,700	$227,000	Parallel to and west of NW 35th St, north of W Antler Ave	$ 557	$56	$9	$53	$0	$0	$0	$10	$0	$0	$0	$ 686
	2016-2020	cFWi_31	Sewer	Growth	4	0%	100%	130	21	24	$262	$424	$686	$81,000	$9,000	$90,000	Parallel to and west of NW 35th St, north of W Antler Ave	$ 557	$56	$9	$53	$0	$0	$0	$10	$0	$0	$0	$ 686
	2016-2020	Link841	Sewer	Growth	4	0%	100%	410	20	24	$262	$421	$683	$252,000	$28,000	$280,000	Along W Antler Ave, west of SW 35th St	$ 557	$56	$9	$50	$0	$0	$0	$10	$0	$0	$0	$ 683
	2016-2020	Link840	Sewer	Growth	4	0%	100%	410	17	24	$262	$412	$674	$249,300	$27,700	$277,000	Along W Antler Ave, west of SW 35th St	$ 557	$56	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 674
	2016-2020	Link844	Sewer	Growth	4	0%	100%	330	15	24	$262	$326	$588	$175,500	$19,500	$195,000	Parallel to and east of SW Helmholtz Way, south of W Antler Ave	$ 485	$49	$9	$36	$0	$0	$0	$10	$0	$0	$0	$ 588
	2016-2020	Link904	Sewer	Growth	4	0%	100%	330	15	24	$262	$326	$588	$175,500	$19,500	$195,000	Parallel to and east of SW Helmholtz Way, south of W Antler Ave	$ 485	$49	$9	$36	$0	$0	$0	$10	$0	$0	$0	$ 588
	2016-2020	Link843	Sewer	Growth	4	0%	100%	330	14	24	$262	$284	$546	$162,900	$18,100	$181,000	Parallel to and east of SW Helmholtz Way, south of W Antler Ave	$ 449	$45	$9	$33	$0	$0	$0	$10	$0	$0	$0	$ 546
	2016-2020	Link842	Sewer	Growth	4	0%	100%	330	12	24	$262	$278	$540	$161,100	$17,900	$179,000	Parallel to and east of SW Helmholtz Way, south of W Antler Ave	$ 449	$45	$9	$27	$0	$0	$0	$10	$0	$0	$0	$ 540
	2016-2020	Link860	Sewer	Growth	4	0%	100%	166	9	24	$262	$144	$406	$61,200	$6,800	$68,000	Parallel to and north of SW Highland Ave, east of SW Helmholtz Way	$ 336	$34	$9	$18	$0	$0	$0	$10	$0	$0	$0	$ 406
	2016-2020	Link859	Sewer	Growth	4	0%	100%	330	12	24	$262	$278	$540	$161,100	$17,900	$179,000	Parallel to and east of SW Helmholtz Way, north of SW Highland Ave	$ 449	$45	$9	$27	$0	$0	$0	$10	$0	$0	$0	$ 540
	2016-2020	Link858	Sewer	Growth	4	0%	100%	330	16	24	$262	$329	$591	$176,400	$19,600	$196,000	Parallel to and east of SW Helmholtz Way, north of SW Highland Ave	$ 485	$49	$9	$39	$0	$0	$0	$10	$0	$0	$0	$ 591
	2016-2020	Link857	Sewer	Growth	4	0%	100%	330	16	24	$262	$329	$591	$176,400	$19,600	$196,000	Parallel to and east of SW Helmholtz Way, north of SW Highland Ave	$ 485	$49	$9	$39	$0	$0	$0	$10	$0	$0	$0	$ 591
	2016-2020	Link856	Sewer	Growth	4	0%	100%	280	16	24	$262	$329	$591	$149,400	$16,600	$166,000	Parallel to and east of SW Helmholtz Way, north of SW Highland Ave	$ 485	$49	$9	$39	$0	$0	$0	$10	$0	$0	$0	$ 591
	2021-2025	Link855	Sewer	Growth	4	0%	100%	330	15	24	$262	$326	$588	$175,500	$19,500	$195,000	Along SW Highland Ave, east of SW Helmholtz Way	$ 485	$49	$9	$36	$0	$0	$0	$10	$0	$0	$0	$ 588
	2021-2025	Link854	Sewer	Growth	4	0%	100%	330	14	24	$262	$284	$546	$162,900	$18,100	$181,000	Along SW Highland Ave, east of SW Helmholtz Way	$ 449	$45	$9	$33	$0	$0	$0	$10	$0	$0	$0	$ 546
	2021-2025	Link853	Sewer	Growth	4	0%	100%	330	17	24	$262	$412	$674	$200,700	$22,300	$223,000	Parallel to and east of SW Helmholtz Way, south of SW Highland Ave	$ 557	$56	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 674
	2021-2025	Link852	Sewer	Growth	4	0%	100%	330	18	24	$262	$415	$677	$201,600	$22,400	$224,000	Parallel to and east of SW Helmholtz Way, south of SW Highland Ave	$ 557	$56	$9	$44	$0	$0	$0	$10	$0	$0	$0	$ 677
	2021-2025	Link851	Sewer	Growth	4	0%	100%	330	17	24	$262	$412	$674	$200,700	$22,300	$223,000	Parallel to and east of SW Helmholtz Way, north of SW Obsidian Ave	$ 557	$56	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 674
	2021-2025	Link850	Sewer	Growth	4	0%	100%	330	17	24	$262	$412	$674	$200,700	$22,300	$223,000	Parallel to and east of SW Helmholtz Way, north of SW Obsidian Ave	$ 557	$56	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 674
	2021-2025	Link849	Sewer	Growth	4	0%	100%	330	17	24	$262	$412	$674	$200,700	$22,300	$223,000	Parallel to and east of SW Helmholtz Way, north of SW Obsidian Ave	$ 557	$56	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 674
	2021-2025	Link848	Sewer	Growth	4	0%	100%	330	17	24	$262	$412	$674	$200,700	$22,300	$223,000	Parallel to and east of SW Helmholtz Way, north of SW Obsidian Ave	$ 557	$56	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 674
	2021-2025	Link847	Sewer	Growth	4	0%	100%	330	18	24	$262	$415	$677	$201,600	$22,400	$224,000	Parallel to and east of SW Helmholtz Way, north of SW Obsidian Ave	$ 557	$56	$9	$44	$0	$0	$0	$10	$0	$0	$0	$ 677
	2021-2025	Link846	Sewer	Growth	4	0%	100%	380	19	24	$262	$418	$680	$233,100	$25,900	$259,000	Parallel to and east of SW Helmholtz Way, north of SW Obsidian Ave	$ 557	$56	$9	$47	$0	$0	$0	$10	$0	$0	$0	$ 680
	2021-2025	Link845	Sewer	Growth	4	0%	100%	805	22	24	$262	$427	$689	$499,500	$55,500	$555,000	Along SW Obsidian Ave, east of SW Helmholtz Way	$ 557	$56	$9	$56	$0	$0	$0	$10	$0	$0	$0	$ 689
	2021-2025	cFWi_18	Sewer	Growth	4	0%	100%	512	21	15	$262	$222	$484	$223,200	$24,800	$248,000	Along SW Obsidian Ave, west of SW Helmholtz Way	$ 374	$37	$9	$53	$0	$0	$0	$10	$0	$0	$0	$ 484
	2021-2025	cFWi_17	Sewer	Growth	4	0%	100%	660	14	15	$262	$201	$463	$275,400	$30,600	$306,000	Parallel to and approximately 3000 feet east of SW 55th St, south of SW Obsidian Ave	$ 374	$37	$9	$33	$0	$0	$0	$10	$0	$0	$0	$ 463
	2021-2025	cFWi_16	Sewer	Growth	4	0%	100%	660	14	15	$262	$201	$463	$275,400	$30,600	$306,000	Parallel to and approximately 3000 feet east of SW 55th St, south of SW Obsidian Ave	$ 374	$37	$9	$33	$0	$0	$0	$10	$0	$0	$0	$ 463
	2021-2025	cFWi_15	Sewer	Growth	4	0%	100%	633	11	15	$262	$84	$346	$197,100	$21,900	$219,000	Parallel to and approximately 2000 feet west of SW Quartz Ave	$ 275	$28	$9	$24	$0	$0	$0	$10	$0	$0	$0	$ 346
	2021-2025	cFWi_14	Sewer	Growth	4	0%	100%	1,280	8	15	$262	$42	$304	$351,000	$39,000	$390,000	Parallel to and approximately 3000 feet west of SW Quartz Ave	$ 246	$25	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 304
	2021-2025	cFWi_13	Sewer	Growth	4	0%	100%	1,320	10	15	$262	$81	$343	$407,700	$45,300	$453,000	Parallel to and east of SW 55th St, north of SW Wickiup Ave	$ 275	$28	$9	$21	$0	$0	$0	$10	$0	$0	$0	$ 343
	2021-2025	cWC_2	Sewer	Growth	4	0%	100%	1,320	9	15	$262	$78	$340	$404,100	$44,900	$449,000	Parallel to and east of SW 55th St, north of SW Wickiup Ave	$ 275	$28	$9	$18	$0	$0	$0	$10	$0	$0	$0	$ 340
	2021-2025	cFWi_11	Sewer	Growth	4	0%	100%	1,320	9	12	$262	$63	$325	$387,000	$43,000	$430,000	Along SW Helmholtz Way, north of SW Wickiup Ave	$ 262	$26	$9	$18	$0	$0	$0	$10	$0	$0	$0	$ 325
	2026-2030	cFWi_10	Sewer	Growth	4	0%	100%	1,320	17	12	$262	$193	$455	$540,900	$60,100	$601,000	Along SW Helmholtz Way, south of SW Wickiup Ave	$ 359	$36	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 455
	2026-2030	cFWi_9	Sewer	Growth	4	0%	100%	1,320	26	12	$262	$263	$525	$624,600	$69,400	$694,000	Along SW Helmholtz Way, north of SW Coyote Ave	$ 398	$40	$9	$68	$0	$0	$0	$10	$0	$0	$0	$ 525
	2026-2030	cFWi_8	Sewer	Growth	4	0%	100%	1,320	20	12	$262	$246	$508	$603,000	$67,000	$670,000	Along SW Helmholtz Way, north from SW Coyote Ave	$ 398	$40	$9	$50	$0	$0	$0	$10	$0	$0	$0	$ 508
	2026-2030	cFWi_7	Sewer	Growth	4	0%	100%	1,320	19	12	$262	$243	$505	$599,400	$66,600	$666,000	East from the terminus of SW Coyote Ave	$ 398	$40	$9	$47	$0	$0	$0	$10	$0	$0	$0	$ 505
	2026-2030	cFWi_6	Sewer	Growth	4	0%	100%	650	21	12	$262	$249	$510	$298,800	$33,200	$332,000	Parallel to and approximately 1300 feet east of SW Coyote Ave	$ 398	$40	$9	$53	$0	$0	$0	$10	$0	$0	$0	$ 510
	2026-2030	cSW_4	Sewer	Growth	4	0%	100%	1,320	17	12	$262	$193	$455	$540,900	$60,100	$601,000	Parallel to and east of SW Helmholtz Way, north of SW Elkhorn Ave	$ 359	$36	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 455
	2026-2030	Link838	Sewer	Growth	4	0%	100%	1,210	17	10	$262	$192	$454	$495,000	$55,000	$550,000	Along SW Elkhorn Ave, west of SW 39th St	$ 358	$36	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 454
	2026-2030	cFWi_4	Sewer	Growth	4	0%	100%	350	19	12	$262	$199	$461	$145,800	$16,200	$162,000	Parallel and west of SW 43rd St between SW Canal Blvd and SW Elkhorn Ave	$ 359	$36	$9	$47	$0	$0	$0	$10	$0	$0	$0	$ 461
	2026-2030	Link837	Sewer	Growth	4	0%	100%	778	17	10	$262	$192	$454	$318,600	$35,400	$354,000	Along SW Elkhorn Ave between SW 39th St and SW Canal Blvd	$ 358	$36	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 454
	2026-2030	Link839	Sewer	Growth	4	0%	100%	1,260	17	10	$262	$192	$454	$515,700	$57,300	$573,000	Along SW 39th St between SW Canal Blvd and SW Elkhorn Ave	$ 358	$36	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 454
	2026-2030	Link836	Sewer	Growth	4	0%	100%	1,350	17	10	$262	$192	$454	$552,600	$61,400	$614,000	East from SW Elkhorn Ave and SW 39th St	$ 358	$36	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 454
	2026-2030	cFWi_3	Sewer	Growth	4	0%	100%	655	16	10	$262	$189	$451	$266,400	$29,600	$296,000	Parallel to and south of SW Elkhorn Ave, west of SW Canal Blvd	$ 358	$36	$9	$39	$0	$0	$0	$10	$0	$0	$0	$ 451
	2026-2030	cFWi_2	Sewer	Growth	4	0%	100%	1,098	16	10	$262	$189	$451	$446,400	$49,600	$496,000	North from SW Canal Blvd, parallel to SW Helmholtz Way	$ 358	$36	$9	$39	$0	$0	$0	$10	$0	$0	$0	$ 451
	2026-2030	cFWi_1	Sewer	Growth	4	0%	100%	1,844	16	10	$262	$189	$451	$748,800	$83,200	$832,000	Along SW Canal Blvd, northeast of SW Helmholtz Way	$ 358	$36	$9	$39	$0	$0	$0	$10	$0	$0	$0	$ 451

Project Type	Implemen-tation Phase	Model ID	Improve-ment Description	Reason for Improve-ment	Priority	Allocations: Upgrade Existing	Allocations: Growth	Pipelines: Length (ft.)	Pipelines: Average Depth of Bury (ft.)	Pipelines: Diameter (in.)	"Local" 8-inch sewer cost, 10 feet deep: Unit Price ($/ft)	Incremental Cost exceeding "local" sewer cost: Unit Price ($/ft)	Total Project Cost: Project Unit Price ($/ft)	Costs: Construc-tion	Costs: Allowance for Eng. & Admin.	Costs: Total Estimate	Location	Unit Price	Engin. & Admin. 10%	Traffic Control unit price per LF	Rock Excava- tion Unit Price per LF	Found. Stabil. per LF	CDF Fill per LF	Trench Dewatering per LF	Erosion Control per LF	Tunneling Boring, Jacking per LF	Land Acquis-ition per LF	Utility relo-cation per LF	Total Unit Price
								46,375						**$22,021,200**	**$2,446,800**	**$24,468,000**													
West Side Interceptor	2007-2015	WSI_613	Sewer	Growth	4	0%	100%	1,950	10	21	$262	$69	$331	$582,300	$64,700	$647,000	Along SW 27th Street, between SW Highland Avenue and SW Cascade Avenue	$ 265	$27	$9	$21	$0	$0	$0	$10	$0	$0	$0	$ 331
	2007-2015	SS17D073	Sewer	Growth	4	0%	100%	348	8	18	$262	$53	$315	$99,000	$11,000	$110,000	Along SW 27th Street, between SW Indian Ave and Juniper	$ 256	$26	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 315
	2007-2015	SS17D072	Sewer	Growth	4	0%	100%	120	8	18	$262	$53	$315	$34,200	$3,800	$38,000	Along SW 27th Street, south of Juniper	$ 256	$26	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 315
	2007-2015	SS17D071	Sewer	Growth	4	0%	100%	375	8	18	$262	$53	$315	$107,100	$11,900	$119,000	Along SW 27th Street, between Juniper and SW Lava	$ 256	$26	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 315
	2007-2015	Link680	Sewer	Growth	4	0%	100%	440	8	18	$262	$53	$315	$125,100	$13,900	$139,000	Along SW 27th Street, between SW Indian Avenue and SW Highland Avenue	$ 256	$26	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 315
	2007-2015	WSI_614	Sewer	Growth	4	0%	100%	1,850	11	18	$262	$158	$420	$699,300	$77,700	$777,000	Along SW 27th Street, between SW Obsidian Avenue and SW Lava Avenue	$ 343	$34	$9	$24	$0	$0	$0	$10	$0	$0	$0	$ 420
	2007-2015	WSI_615	Sewer	Growth	4	0%	100%	2,050	9	18	$262	$92	$354	$653,400	$72,600	$726,000	Along SW 27th Street, between SW Salmon Avenue and SW Obsidian Avenue	$ 288	$29	$9	$18	$0	$0	$0	$10	$0	$0	$0	$ 354
	2007-2015	WSI_616	Sewer	Growth	4	0%	100%	3,800	9	15	$262	$133	$395	$1,350,000	$150,000	$1,500,000	Along SW 27th Street, between SW Salmon Avenue and SW Obsidian Avenue	$ 325	$33	$9	$18	$0	$0	$0	$10	$0	$0	$0	$ 395
WSI Totals								**10,933**						**$3,650,400**	**$405,600**	**$4,056,000**													
Far East Interceptor	2021-2025	Link948	Sewer	Growth	4	0%	100%	50	8	36	$262	$311	$573	$26,100	$2,900	$29,000	Link to Redmond Water Pollution Control Facility	$ 490	$49	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 573
	2021-2025	Link942	Sewer	Growth	4	0%	100%	220	5	27	$262	$55	$316	$63,000	$7,000	$70,000	Link to Redmond Water Pollution Control Facility	$ 265	$27	$9	$6	$0	$0	$0	$10	$0	$0	$0	$ 316
	2021-2025	Link946	Sewer	Growth	4	0%	100%	100	5	24	$262	$55	$316	$28,800	$3,200	$32,000	Link to Redmond Water Pollution Control Facility	$ 265	$27	$9	$6	$0	$0	$0	$10	$0	$0	$0	$ 316
	2021-2025	Link947	Sewer	Growth	4	0%	100%	212	5	24	$262	$55	$316	$61,200	$6,800	$68,000	Parallel to and west of NW Canyon Dr, north of NW Spruce Ave	$ 265	$27	$9	$6	$0	$0	$0	$10	$0	$0	$0	$ 316
	2021-2025	Link907	Sewer	Growth	4	0%	100%	350	5	24	$262	$55	$316	$99,900	$11,100	$111,000	Parallel to and west of NW Canyon Dr, north of NW Spruce Ave	$ 265	$27	$9	$6	$0	$0	$0	$10	$0	$0	$0	$ 316
	2021-2025	Link909	Sewer	Growth	4	0%	100%	260	5	24	$262	$55	$316	$74,700	$8,300	$83,000	Parallel to and west of NW Canyon Dr, north of NW Spruce Ave	$ 265	$27	$9	$6	$0	$0	$0	$10	$0	$0	$0	$ 316
	2021-2025	Link908	Sewer	Growth	4	0%	100%	180	4	24	$262	$52	$314	$51,300	$5,700	$57,000	Along Dry Canyon floor, north of Redmond Water Pollution Control facility	$ 265	$27	$9	$3	$0	$0	$0	$10	$0	$0	$0	$ 314
	2021-2025	Link910	Sewer	Growth	4	0%	100%	480	8	24	$262	$141	$403	$174,600	$19,400	$194,000	Crossing Dry Canyon Ridge, west of NW Upas Ave	$ 336	$34	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 403
	2021-2025	Link911	Sewer	Growth	4	0%	100%	2,090	12	24	$262	$278	$540	$1,015,200	$112,800	$1,128,000	Parallel to NW Upas Ave, west of NW 10th St	$ 449	$45	$9	$27	$0	$0	$0	$10	$0	$0	$0	$ 540
	2021-2025	Link912	Sewer	Growth	4	0%	100%	370	14	24	$262	$284	$546	$181,800	$20,200	$202,000	Parallel to and west of NW 10th St, north of NW Upas Ave	$ 449	$45	$9	$33	$0	$0	$0	$10	$0	$0	$0	$ 546
	2021-2025	Link914	Sewer	Growth	4	0%	100%	1,294	13	24	$262	$281	$543	$632,700	$70,300	$703,000	North of NW Upas Ave, crossing NW 10th St	$ 449	$45	$9	$30	$0	$0	$0	$10	$0	$0	$0	$ 543
	2021-2025	Link913	Sewer	Growth	4	0%	100%	820	13	24	$262	$281	$543	$400,500	$44,500	$445,000	Parallel to and east of NW 10th St, south of NW Pershall Way	$ 449	$45	$9	$30	$0	$0	$0	$10	$0	$0	$0	$ 543
	2021-2025	Link916	Sewer	Growth	4	0%	100%	600	14	24	$262	$284	$546	$295,200	$32,800	$328,000	South of NW Pershall Way, east of NW 10th St	$ 449	$45	$9	$33	$0	$0	$0	$10	$0	$0	$0	$ 546
	2021-2025	Link915	Sewer	Growth	4	0%	100%	445	17	24	$262	$412	$674	$270,000	$30,000	$300,000	Parallel to and south of NW Pershall Way, west of Hwy 97	$ 557	$56	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 674
FEI Totals								**7,471**						**$3,375,000**	**$375,000**	**$3,750,000**													
East Side Interceptor	2007-2015	SS03B037	Sewer	Growth	4	0%	100%	200	18	27	$262	$413	$675	$121,500	$13,500	$135,000	Along BNSF Railroad ROW south of NE King	$ 556	$56	$9	$44	$0	$0	$0	$10	$0	$0	$0	$ 675
	2007-2015	SS03B038	Sewer	Growth	4	0%	100%	230	7	27	$262	$160	$422	$87,300	$9,700	$97,000	Along BNSF Railroad ROW south of NE King	$ 355	$36	$9	$12	$0	$0	$0	$10	$0	$0	$0	$ 422
	2007-2015	SS03B039	Sewer	Growth	4	0%	100%	360	11	27	$262	$236	$498	$162,000	$18,000	$180,000	Along BNSF Railroad ROW north of NE Redwood	$ 414	$41	$9	$24	$0	$0	$0	$10	$0	$0	$0	$ 498
	2007-2015	SS03B040	Sewer	Growth	4	0%	100%	400	16	27	$262	$343	$605	$217,800	$24,200	$242,000	Along BNSF Railroad ROW between NE Redwood and NE Quince	$ 498	$50	$9	$39	$0	$0	$0	$10	$0	$0	$0	$ 605
	2007-2015	SS03B041	Sewer	Growth	4	0%	100%	130	17	27	$262	$346	$608	$72,000	$8,000	$80,000	Along BNSF Railroad ROW at NE Quince	$ 498	$50	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 608
	2007-2015	ESI600	Sewer	Growth	4	0%	100%	1,300	17	24	$262	$332	$594	$695,700	$77,300	$773,000	Along BNSF Railroad ROW north of NE Negus	$ 485	$49	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 594
	2007-2015	ESI601	Sewer	Growth	4	0%	100%	1,530	20	24	$262	$421	$683	$940,500	$104,500	$1,045,000	West of NE 5th Street north from NE Shoshone	$ 557	$56	$9	$50	$0	$0	$0	$10	$0	$0	$0	$ 683
	2016-2020	ESI603	Sewer	Growth	4	0%	100%	1,350	14	24	$262	$284	$546	$663,300	$73,700	$737,000	Parallel and west of 3rd Street from NE Kilnwood Lane to NE Negus	$ 449	$45	$9	$33	$0	$0	$0	$10	$0	$0	$0	$ 546
	2016-2020	ESI594	Sewer	Growth	4	0%	100%	1,250	13	24	$262	$221	$483	$543,600	$60,400	$604,000	Along BNSF Railroad ROW north of NE Hemlock to NE Kilnwood Lane	$ 395	$39	$9	$30	$0	$0	$0	$10	$0	$0	$0	$ 483
	2016-2020	ESI_Negus	Sewer	Growth	3	50%	50%	55	10	12	$262	$66	$328	$17,100	$1,900	$19,000	Along NE Negus Way, east of the railroad ROW	$ 262	$26	$9	$21	$0	$0	$0	$10	$0	$0	$0	$ 328
	2016-2020	FEi_717	Sewer	Growth	3	50%	50%	400	8	12	$262	$60	$322	$116,100	$12,900	$129,000	Along NE Negus Way, between NE 11th St and NE 9th St	$ 262	$26	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 322
	2016-2020	FEi_716	Sewer	Growth	3	50%	50%	1,000	13	12	$262	$130	$392	$352,800	$39,200	$392,000	Along NE Negus Way, between NE 9th St and NE 7th St	$ 312	$31	$9	$30	$0	$0	$0	$10	$0	$0	$0	$ 392
	2016-2020	SS10B046	Sewer	Growth	3	50%	50%	216	10	12	$262	$66	$328	$63,900	$7,100	$71,000	Along NE Negus Way, between NE 6th St and NE 5th St	$ 262	$26	$9	$21	$0	$0	$0	$10	$0	$0	$0	$ 328
	2016-2020	SS03C008	Sewer	Growth	3	50%	50%	172	12	12	$262	$127	$389	$60,300	$6,700	$67,000	Along NE Negus Way, west of NE 5th St	$ 312	$31	$9	$27	$0	$0	$0	$10	$0	$0	$0	$ 389
	2016-2020	Link715	Sewer	Growth	3	50%	50%	470	10	12	$262	$66	$328	$139,500	$15,500	$155,000	Along NE Negus Way, west of NE 5th St	$ 262	$26	$9	$21	$0	$0	$0	$10	$0	$0	$0	$ 328
	2021-2025	ESI593	Sewer	Growth	4	0%	100%	2,600	13	24	$262	$221	$483	$1,131,300	$125,700	$1,257,000	Along BNSF Railroad ROW south of NE Hemlock	$ 395	$39	$9	$30	$0	$0	$0	$10	$0	$0	$0	$ 483
	2021-2025	ESI604	Sewer	Growth	4	0%	100%	1,500	10	24	$262	$212	$474	$640,800	$71,200	$712,000	Along BNSF ROW from SE Evergreen Avenue to E Antler Avenue	$ 395	$39	$9	$21	$0	$0	$0	$10	$0	$0	$0	$ 474
	2021-2025	ESI606	Sewer	Growth	4	0%	100%	3,000	6	18	$262	$12	$274	$739,800	$82,200	$822,000	Along BNSF ROW from Kalama Avenue to SE Evergreen Avenue	$ 224	$22	$9	$9	$0	$0	$0	$10	$0	$0	$0	$ 274
	2021-2025	ESI607	Sewer	Growth	4	0%	100%	2,000	9	18	$262	$152	$414	$746,100	$82,900	$829,000	Along BNSF ROW from Kalama Avenue south of SE Evergreen Avenue	$ 343	$34	$9	$18	$0	$0	$0	$10	$0	$0	$0	$ 414
	2021-2025	ESI_001	Sewer	Growth	4	0%	100%	4,830	10	18	$262	$155	$417	$1,813,500	$201,500	$2,015,000	From BNSF ROW north of SW Veterans Way, east on SW Veterans Way, then south to SW 6th St and SW Reindeer Ave	$ 343	$34	$9	$21	$0	$0	$0	$10	$0	$0	$0	$ 417
	2021-2025	LineN	Sewer	Growth	4	0%	100%	2,770	10	8	$262	$36	$298	$742,500	$82,500	$825,000	North from the north end of SW 13th St to approximately 1,000 ft west of SW Reindeer Ave	$ 235	$23	$9	$21	$0	$0	$0	$10	$0	$0	$0	$ 298
	2021-2025	ESSI	Sewer	Growth	4	0%	100%	7,200	15	12	$262	$402	$664	$4,300,200	$477,800	$4,778,000	South on SE 13th St continuing south on SE Airport Way, along SE 19th St to city limit	$ 554	$55	$9	$36	$0	$0	$0	$10	$0	$0	$0	$ 664
ESI Totals								**32,963**						**$14,367,600**	**$1,596,400**	**$15,964,000**													
Line A	2007-2015	LineA	Sewer	Growth	4	0%	100%	**5,300**	20	15	$262	$219	$481	**$2,295,000**	**$255,000**	**$2,550,000**	Area west of Cascade View Phase 7 PS, along SW Canal Blvd to SW 27th St	$ 374	$37	$9	$50	$0	$0	$0	$10	$0	$0	$0	$ 481
Line D	2007-2015	LineD	Sewer	Growth	4	0%	100%	**9,900**	14	15	$262	$201	$463	**$4,128,300**	**$458,700**	**$4,587,000**	South along SW Helmholtz Way, between SW Obsidian Ave and SW Xero Ave, south along SW 46th St south of SW Xero Ave	$ 374	$37	$9	$33	$0	$0	$0	$10	$0	$0	$0	$ 463
Line J	2021-2025	LineJ	Sewer	Growth	4	0%	100%	**5,750**	15	8	$262	$96	$357	**$1,850,400**	**$205,600**	**$2,056,000**	East along E Antler Ave from SE Railroad Blvd, south to SE Black Butte Blvd, east on SE Black Butte Blvd, north on SE 6th St, east on E Antler Ave	$ 275	$28	$9	$36	$0	$0	$0	$10	$0	$0	$0	$ 357

						Allocations		Pipelines			"Local" 8-inch sewer cost, 10 feet deep	Incremental Cost exceeding "local" sewer cost	Total Project Cost	Costs				Unit Price	Engin. & Admin.	Traffic Control unit price	Rock Excava- tion Unit Price	Found. Stabil.	CDF Fill	Trench Dewatering	Erosion Control	Tunneling Boring, Jacking	Land Acquis- ition	Utility relo- cation	Total Unit Price
Project Type	Implemen- tation Phase	Model ID	Improve- ment Description	Reason for Improve- ment	Priority	Upgrade Existing	Growth	Length (ft.)	Average Depth of Bury (ft.)	Diameter (in.)	Unit Price ($/ft)	Unit Price ($/ft)	Project Unit Price ($/ft)	Construc-tion	Allowance for Eng. & Admin.	Total Estimate	Location		10%	per LF	per LF	per LF	per LF	per LF	per LF	per LF	per LF	per LF	
Line K	2021-2025	LineK	Sewer	Growth	4	0%	100%	**9,790**	8	10	$262	$58	$320	**$2,823,300**	**$313,700**	**$3,137,000**	East along SE Evergreen Ave from BNSF ROW, south on SE 9th St, then SW on Hwy 126	$ 261	$26	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 320
Line L	2021-2025	LineL	Sewer	Growth	4	0%	100%	**2,730**	10	8	$262	$36	$298	**$732,600**	**$81,400**	**$814,000**	From approximately 1,000 ft west of SW Reindeer Ave to SW 6th St, north of SW Umatilla Ave	$ 235	$23	$9	$21	$0	$0	$0	$10	$0	$0	$0	$ 298
Gravity Pipe Replacement	2007-2015	SS15B018	Sewer	Capacity	3	0%	100%	428	11	12	$262	$123	$385	$148,500	$16,500	$165,000	Between Railroad Blvd and SE Franklin Street, between SE Black and SE Cascade	$ 312	$31	$9	$22	$0	$0	$0	$10	$0	$0	$0	$ 385
	2007-2015	SS04B059	Sewer	Capacity	3	0%	100%	14	5	12	$262	$0	$248	$3,600	$400	$4,000	Between NW 19th and NW Canyon (W of 2807 NW Canyon & E of 3100 NW 19th)	$ 203	$20	$9	$5	$0	$0	$0	$10	$0	$0	$0	$ 248
	2007-2015	SS09A071	Sewer	Capacity	3	0%	100%	8	8	15	$262	$41	$303	$2,700	$300	$3,000	S of 850 NW Maple in, & N of midpoint of 1554 NW 9th & 1553 NW 8th St.	$ 246	$25	$9	$14	$0	$0	$0	$10	$0	$0	$0	$ 303
	2007-2015	SS15B047	Sewer	Capacity	3	0%	100%	309	8	10	$262	$26	$288	$80,100	$8,900	$89,000	E from 365 SE Ridge Way to 545 SE Deschutes Ave (W of Canal)	$ 231	$23	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 288
	2007-2015	SS15B049	Sewer	Capacity	3	0%	100%	167	6	10	$262	$0	$250	$37,800	$4,200	$42,000	E from South of 649 SE Evergreen Ave block to W of 639 SE Evergreen Ave block	$ 202	$20	$9	$10	$0	$0	$0	$10	$0	$0	$0	$ 250
	2007-2015	SS15B039	Sewer	Capacity	3	0%	100%	369	6	10	$262	$0	$250	$83,700	$9,300	$93,000	half way between 436 and 439 blocks of SE Deschutes Ave to S of 251 SE 5th St	$ 202	$20	$9	$10	$0	$0	$0	$10	$0	$0	$0	$ 250
	2007-2015	SS15B046	Sewer	Capacity	3	0%	100%	130	7	10	$262	$0	$253	$29,700	$3,300	$33,000	E from 545 SE Deschutes Ave (W of Canal) to E of Canal (N of 436 SE Deschutes)	$ 202	$20	$9	$12	$0	$0	$0	$10	$0	$0	$0	$ 253
	2007-2015	SS15B038	Sewer	Capacity	3	0%	100%	341	6	10	$262	$0	$249	$76,500	$8,500	$85,000	S of 251 SE 5th St to N of 211 SE 5th St..	$ 202	$20	$9	$8	$0	$0	$0	$10	$0	$0	$0	$ 249
	2007-2015	SS04B014	Sewer	Capacity	3	0%	100%	414	7	21	$262	$59	$321	$119,700	$13,300	$133,000	Parallel to 2663 to 2545 NW canyon Dr Property lines. W of these properties	$ 265	$27	$9	$10	$0	$0	$0	$10	$0	$0	$0	$ 321
	2007-2015	SS15B015	Sewer	Capacity	3	0%	100%	21	10	12	$262	$67	$329	$6,300	$700	$7,000	Starts halfway between 353 SE Railroad Blvd & 216 SE Railroad Blvd to SW of 216 SE Railroad block	$ 262	$26	$9	$22	$0	$0	$0	$10	$0	$0	$0	$ 329
	2007-2015	SS15B030	Sewer	Capacity	3	0%	100%	180	10	12	$262	$66	$328	$53,100	$5,900	$59,000	NW of 208 SE Franklin St to SW of 228 SE Franklin St (parallel to the W property line of these two blocks). Between 229 SE and 208 SE Franklin St	$ 262	$26	$9	$20	$0	$0	$0	$10	$0	$0	$0	$ 328
Gravity Pipe Replacement Totals								**2,380**						**$641,700**	**$71,300**	**$713,000**													
													Total			**$57,508,000**													

Phase:

Notes:
1. Pipe Priority Level:

1 = Current Capacity Deficiency
2 = Capacity Deficiency within 5 years
3 = Capacity Deficiency at Buildout
2. Alignment 4 = Growth Driven Improvement

APPENDIX C, EXHIBIT 2

Wastewater Collection Sytem URA Buildout Project List (Costs based on ENR CCI Seattle = 8626

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Project Type	Implemen-tation Phase	Model ID	Improve-ment Description	Reason for Improve-ment	Priority	Allocations: Upgrade Existing	Allocations: Growth	Pipelines: Length (ft.)	Pipelines: Average Depth of Bury (ft.)	Pipelines: Dia-meter (in.)	"Local" 8-inch sewer cost, 10 feet deep: Unit Price ($/ft)	Incremental Cost exceeding "local" sewer cost: Unit Price ($/ft)	Total Project Cost: Project Unit Price ($/ft)	Costs: Construc-tion	Costs: Allowance for Eng. & Admin.	Costs: Total Estimate	Location
Far East Interceptor	2021-2025	Link917	Sewer	Growth	4	0%	100%	960	17	24	$262	$412	$674	$582,300	$64,700	$647,000	Parallel to and south of NE Yucca Ave, between NW Canal Blvd and Hwy 97
	2021-2025	Link919	Sewer	Growth	4	0%	100%	1,982	9	24	$262	$144	$406	$725,400	$80,600	$806,000	Parallel to and south of NE Yucca Ave, east of NW Canal Blvd
	2021-2025	Link918	Sewer	Growth	4	0%	100%	2,420	4	24	$262	$52	$314	$683,100	$75,900	$759,000	Parallel to and south of NE Yucca Ave, west of NE 17th St
	2021-2025	Link921	Sewer	Growth	4	0%	100%	1,650	7	24	$262	$99	$361	$537,300	$59,700	$597,000	Parallel to NE 17th St, crossing NE King Way
	2021-2025	Link920	Sewer	Growth	4	0%	100%	910	8	24	$262	$141	$403	$331,200	$36,800	$368,000	West from NE Upas Ave, west of NE 17th St
	2021-2025	CFEI_21	Sewer	Growth	4	0%	100%	1,290	8	24	$262	$141	$403	$468,900	$52,100	$521,000	Along NE Upas Ave between NE 21st Dr and NE 17th St
	2021-2025	CFEI_20	Sewer	Growth	4	0%	100%	670	9	24	$262	$144	$406	$245,700	$27,300	$273,000	Running north-south, south of NE Upas Ave
	2021-2025	Link927	Sewer	Growth	4	0%	100%	627	8	10	$262	$58	$320	$180,900	$20,100	$201,000	Running north-south, east of NE Negus Way
	2021-2025	CFEI_19	Sewer	Growth	4	0%	100%	177	8	24	$262	$141	$403	$64,800	$7,200	$72,000	Running east-west, south of NE Upas Ave and east of NE Negus Way
	2021-2025	Link926	Sewer	Growth	4	0%	100%	1,320	8	10	$262	$58	$320	$380,700	$42,300	$423,000	Running north-south, east of NE Negus Way
	2021-2025	Link925	Sewer	Growth	4	0%	100%	1,301	8	10	$262	$58	$320	$375,300	$41,700	$417,000	Running north-south, east of NE Negus Way
	2021-2025	Link924	Sewer	Growth	4	0%	100%	1,499	8	10	$262	$58	$320	$432,900	$48,100	$481,000	Running east-west, north of NE Maple Ave from NE Negus Way
	2021-2025	Link923	Sewer	Growth	4	0%	100%	1,318	8	10	$262	$58	$320	$380,700	$42,300	$423,000	Parallel to and east of NE 11th St, north of NE Maple Ave
	2021-2025	Link922	Sewer	Growth	4	0%	100%	1,331	8	10	$262	$58	$320	$384,300	$42,700	$427,000	Parallel to and east of NE 11th St, south of NE Maple Ave
	2021-2025	CFEI_18	Sewer	Growth	4	0%	100%	270	8	24	$262	$141	$403	$98,100	$10,900	$109,000	Running east-west, south of NE Upas Ave and east of NE Negus Way
	2021-2025	CFEI_17	Sewer	Growth	4	0%	100%	346	8	24	$262	$141	$403	$126,000	$14,000	$140,000	Running east-west, south of NE Upas Ave and east of NE Negus Way
	2021-2025	CFEI_16	Sewer	Growth	4	0%	100%	350	8	24	$262	$141	$403	$127,800	$14,200	$142,000	Running east-west, south of NE Upas Ave and east of NE Negus Way
	2021-2025	CFEI_15	Sewer	Growth	4	0%	100%	235	6	24	$262	$97	$358	$76,500	$8,500	$85,000	Running east-west, south of NE Upas Ave and east of NE Negus Way
	2021-2025	CFEI_14	Sewer	Growth	4	0%	100%	135	4	24	$262	$52	$314	$38,700	$4,300	$43,000	Running east-west, south of NE Upas Ave and east of NE Negus Way
	2021-2025	CFEI_13	Sewer	Growth	4	0%	100%	1,320	7	18	$262	$51	$312	$371,700	$41,300	$413,000	Running east-west, south of NE Upas Ave and east of NE Negus Way
	2021-2025	CFEI_12	Sewer	Growth	4	0%	100%	1,320	12	18	$262	$161	$423	$503,100	$55,900	$559,000	Running north-south, south of NE Upas Ave
	2021-2025	CFEI_11	Sewer	Growth	4	0%	100%	990	11	18	$262	$158	$420	$374,400	$41,600	$416,000	Parallel to and south of NE Upas Ave, east of NE Negus Way
	2021-2025	CFEI_10	Sewer	Growth	4	0%	100%	1,320	13	18	$262	$219	$481	$571,500	$63,500	$635,000	Running north-south, south of NE Upas Ave
	2021-2025	Link928	Sewer	Growth	4	0%	100%	1,006	14	10	$262	$183	$445	$403,200	$44,800	$448,000	Running east-west, north of NE Maple Ave
	2021-2025	Link929	Sewer	Growth	4	0%	100%	1,320	14	18	$262	$222	$483	$575,100	$63,900	$639,000	Running north-south, north of E Antler Ave
	2021-2025	CFEI_8	Sewer	Growth	4	0%	100%	1,320	7	18	$262	$51	$312	$371,700	$41,300	$413,000	Running north-south, north of E Antler Ave
	2021-2025	Link930	Sewer	Growth	4	0%	100%	1,012	9	10	$262	$61	$323	$295,200	$32,800	$328,000	Running east-west, north of NE Maple Ave
	2021-2025	CFEI_7	Sewer	Growth	4	0%	100%	1,320	4	12	$262	$0	$245	$292,500	$32,500	$325,000	Running north-south, north of E Antler Ave
	2021-2025	Link931	Sewer	Growth	4	0%	100%	1,045	3	10	$262	$0	$211	$198,900	$22,100	$221,000	Running east-west, from east end of NE Maple Ave
	2021-2025	Link934	Sewer	Growth	4	0%	100%	1,020	6	10	$262	$0	$250	$229,500	$25,500	$255,000	Running east-west, north of E Antler Ave and east of SE 11th St
	2021-2025	Link932	Sewer	Growth	4	0%	100%	330	5	12	$262	$0	$248	$73,800	$8,200	$82,000	Running east-west, north of E Antler Ave and east of SE 11th St
	2021-2025	Link933	Sewer	Growth	4	0%	100%	1,570	8	10	$262	$26	$288	$407,700	$45,300	$453,000	Running east-west, north of E Antler Ave and east of SE 11th St
	2021-2025	CFEI_6	Sewer	Growth	4	0%	100%	1,320	5	12	$262	$0	$248	$295,200	$32,800	$328,000	Running north-south, north of E Antler Ave and east of SE 9th St
	2021-2025	CFEI_5	Sewer	Growth	4	0%	100%	1,340	9	12	$262	$63	$325	$392,400	$43,600	$436,000	Running north-south, north of E Antler Ave and east of SE 9th St
	2021-2025	Link936	Sewer	Growth	4	0%	100%	1,350	6	10	$262	$0	$250	$303,300	$33,700	$337,000	Running east-west, north of E Antler Ave and east of SE 9th St
	2021-2025	Link935	Sewer	Growth	4	0%	100%	1,360	8	10	$262	$58	$320	$392,400	$43,600	$436,000	Running east-west, north of E Antler Ave and east of SE 9th St
	2021-2025	CFEI_4	Sewer	Growth	4	0%	100%	1,300	9	10	$262	$61	$323	$378,900	$42,100	$421,000	Running north-south, south of E Antler Ave and east of SE 9th St
	2021-2025	Link938	Sewer	Growth	4	0%	100%	1,320	6	10	$262	$0	$250	$297,000	$33,000	$330,000	Running east-west between Hwy 126 and E Antler Ave, east of SE 9th St
	2021-2025	Link937	Sewer	Growth	4	0%	100%	1,320	10	10	$262	$64	$326	$387,900	$43,100	$431,000	Running east-west between Hwy 126 and E Antler Ave, east of SE 9th St
	2021-2025	Link939	Sewer	Growth	4	0%	100%	1,320	10	10	$262	$64	$326	$387,900	$43,100	$431,000	Running north-south between Hwy 126 and E Antler Ave, east of SE 9th St
FEI Totals								**44,314**						**$13,743,900**	**$1,527,100**	**$15,271,000**	
New Pressure Pipe	2021-2025	Far West FM	Sewer	Growth	4	0%	100%	6,440	5	6	$262	$0	$218	**$1,265,400**	**$140,600**	**$1,406,000**	East from Walnut Ave and NW 38th St to Northwest Way, south along Northwest Way to Upas Ave
Pump Stations	2021-2025	Far West	Lift Station	Growth	4	0%	100%	NA	NA	NA	NA	NA	NA	**$415,650**	**$73,350**	**$489,000**	Walnut Ave and NW 38th St (Note that 15% was used for engineering estimate in lieu of 10% for this project)
													Total			**$17,166,000**	

Model ID	Unit price from table	Eng. & Admin. (10%)	Traffic Control unit price (per LF)	Rock Excavation Unit Price (per LF)	Found. Stabil. (per LF)	CDF Fill (per LF)	Trench De-watering (per LF)	Erosion Control (per LF)	Tunneling Boring, Jacking (per LF)	Land Acquisi-tion (per LF)	Utility relocation (per LF)	Total Unit Price
Link917	$ 557	$56	$9	$41	$0	$0	$0	$10	$0	$0	$0	$ 674
Link919	$ 336	$34	$9	$18	$0	$0	$0	$10	$0	$0	$0	$ 406
Link918	$ 265	$27	$9	$3	$0	$0	$0	$10	$0	$0	$0	$ 314
Link921	$ 301	$30	$9	$12	$0	$0	$0	$10	$0	$0	$0	$ 361
Link920	$ 336	$34	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 403
CFEI_21	$ 336	$34	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 403
CFEI_20	$ 336	$34	$9	$18	$0	$0	$0	$10	$0	$0	$0	$ 406
Link927	$ 261	$26	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 320
CFEI_19	$ 336	$34	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 403
Link926	$ 261	$26	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 320
Link925	$ 261	$26	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 320
Link924	$ 261	$26	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 320
Link923	$ 261	$26	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 320
Link922	$ 261	$26	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 320
CFEI_18	$ 336	$34	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 403
CFEI_17	$ 336	$34	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 403
CFEI_16	$ 336	$34	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 403
CFEI_15	$ 301	$30	$9	$9	$0	$0	$0	$10	$0	$0	$0	$ 358
CFEI_14	$ 265	$27	$9	$3	$0	$0	$0	$10	$0	$0	$0	$ 314
CFEI_13	$ 256	$26	$9	$12	$0	$0	$0	$10	$0	$0	$0	$ 312
CFEI_12	$ 343	$34	$9	$27	$0	$0	$0	$10	$0	$0	$0	$ 423
CFEI_11	$ 343	$34	$9	$24	$0	$0	$0	$10	$0	$0	$0	$ 420
CFEI_10	$ 393	$39	$9	$30	$0	$0	$0	$10	$0	$0	$0	$ 481
Link928	$ 358	$36	$9	$33	$0	$0	$0	$10	$0	$0	$0	$ 445
Link929	$ 393	$39	$9	$33	$0	$0	$0	$10	$0	$0	$0	$ 483
CFEI_8	$ 256	$26	$9	$12	$0	$0	$0	$10	$0	$0	$0	$ 312
Link930	$ 261	$26	$9	$18	$0	$0	$0	$10	$0	$0	$0	$ 323
CFEI_7	$ 203	$20	$9	$3	$0	$0	$0	$10	$0	$0	$0	$ 245
Link931	$ 175	$17	$9	$0	$0	$0	$0	$10	$0	$0	$0	$ 211
Link934	$ 202	$20	$9	$9	$0	$0	$0	$10	$0	$0	$0	$ 250
Link932	$ 203	$20	$9	$6	$0	$0	$0	$10	$0	$0	$0	$ 248
Link933	$ 231	$23	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 288
CFEI_6	$ 203	$20	$9	$6	$0	$0	$0	$10	$0	$0	$0	$ 248
CFEI_5	$ 262	$26	$9	$18	$0	$0	$0	$10	$0	$0	$0	$ 325
Link936	$ 202	$20	$9	$9	$0	$0	$0	$10	$0	$0	$0	$ 250
Link935	$ 261	$26	$9	$15	$0	$0	$0	$10	$0	$0	$0	$ 320
CFEI_4	$ 261	$26	$9	$18	$0	$0	$0	$10	$0	$0	$0	$ 323
Link938	$ 202	$20	$9	$9	$0	$0	$0	$10	$0	$0	$0	$ 250
Link937	$ 261	$26	$9	$21	$0	$0	$0	$10	$0	$0	$0	$ 326
Link939	$ 261	$26	$9	$21	$0	$0	$0	$10	$0	$0	$0	$ 326
Far West FM	$ 176	$18	$9	$6	$0	$0	$0	$10	$0	$0	$0	$ 218
Far West												

n Phase:
5
0
5
0

Notes:

1. Pipe Priority Level:

1 = Current Capacity Deficiency
2 = Capacity Deficiency within 5 years
3 = Capacity Deficiency at Buildout

APPENDIX D

Far West and Far East Interceptor Profiles

Appendix D Explanatory Narrative

The pipeline profiles shown in Exhibits 1 and 2 of Appendix D represent the pipeline alignments plotted along with ground surface data that was taken from two separate sources.

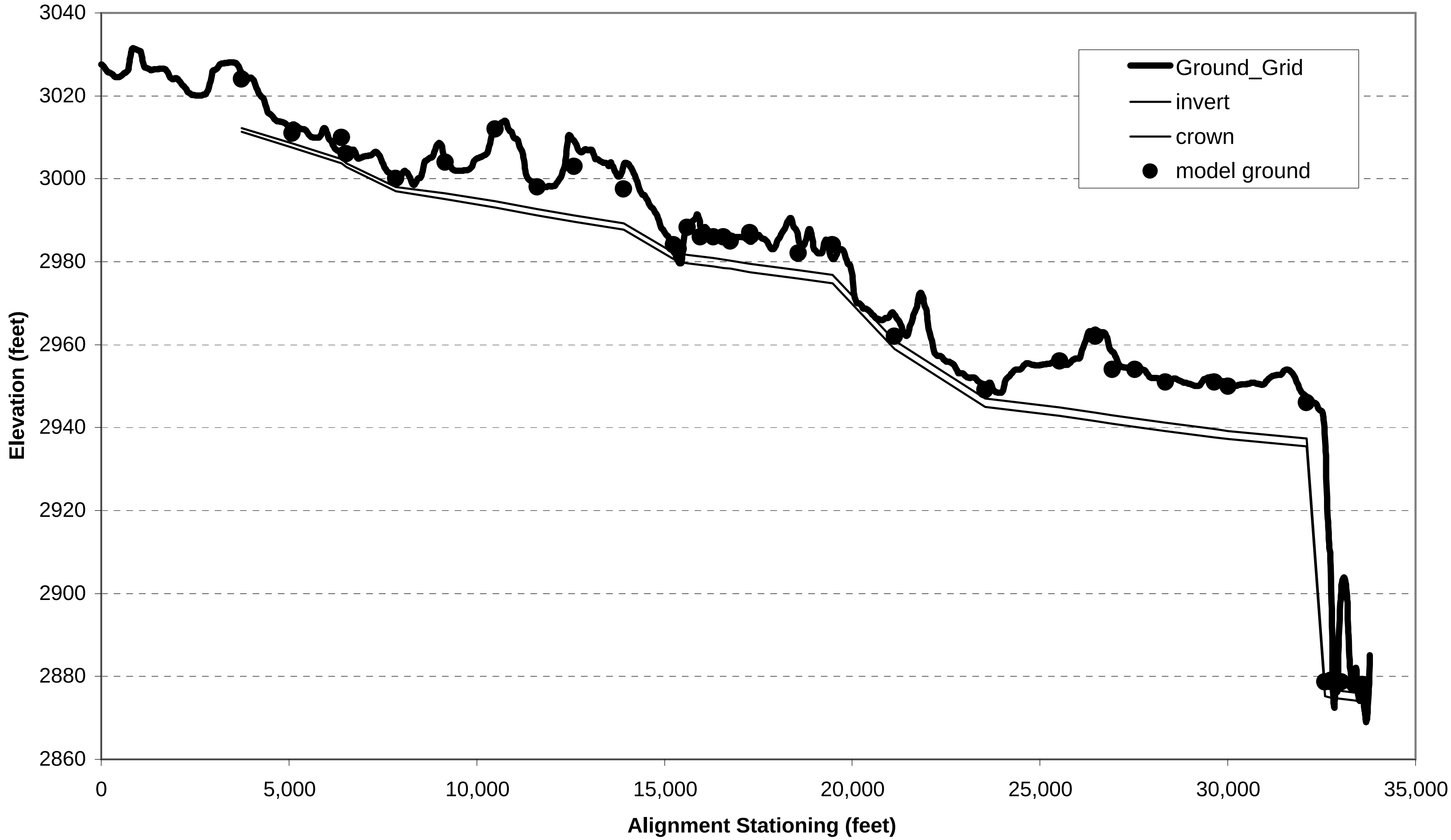
The "Ground Grid" data series are the ground elevation values extracted from 5-foot sided cells created from 2-foot contours of the city. The profile generated in XP-SWMM uses a line tracing of the sewer route through the grid and extracts the data at equal intervals depending on the length of the line (1000 points were extracted along each interceptor). Where the slopes are steep (such as at canyon walls) the grid interpretation is less accurate.

The proposed interceptor alignments are outside the available contouring (and hence the grid) in a few reaches. For these fringe areas, the grid elevation was assumed to be similar to the closest grid points by moving the alignment perpendicular to fall within the grid. This modified the reach lengths and the profiles reflect this adjustment.

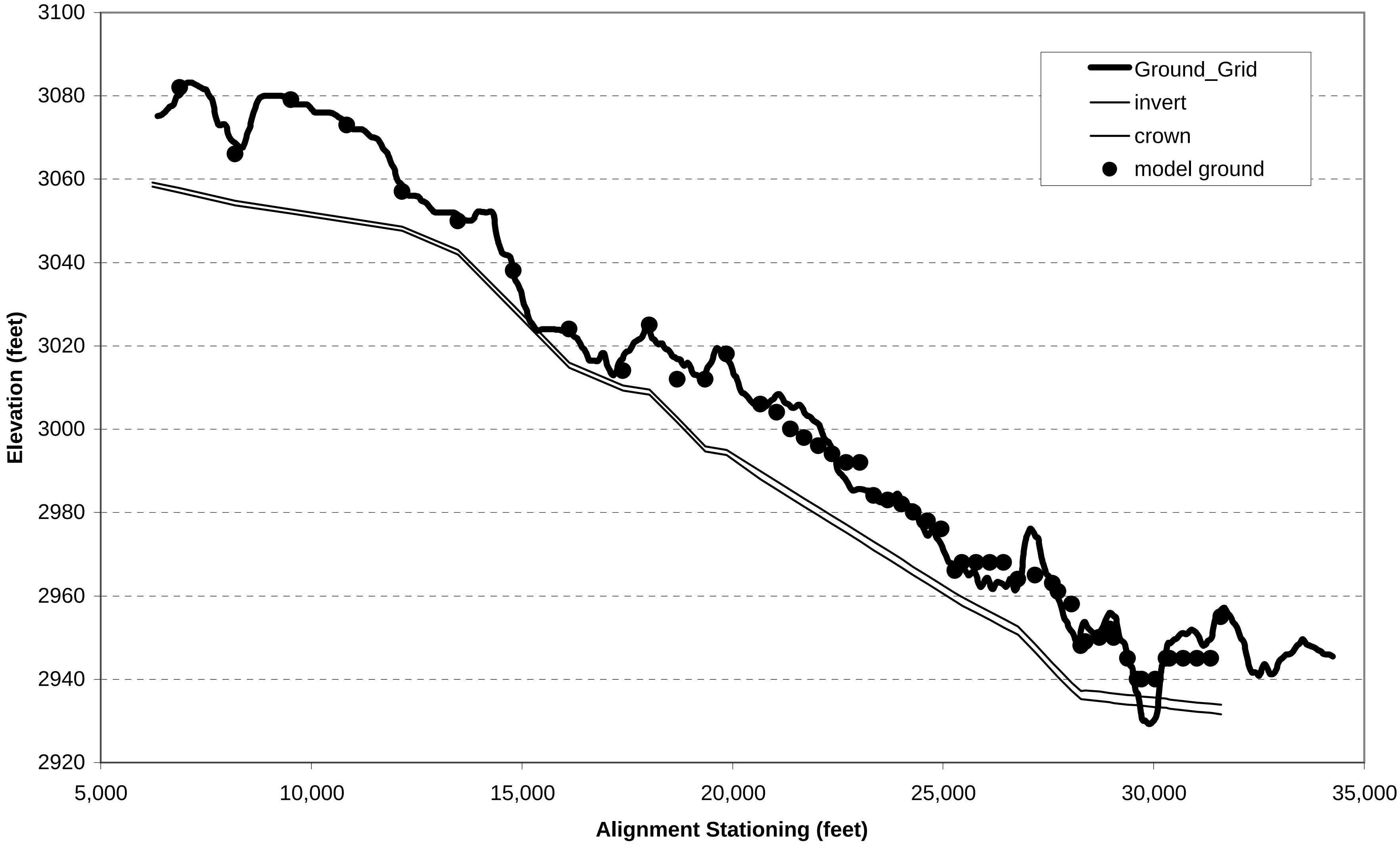
The "Model Ground" data series are the manhole rim elevations as set in the model. To develop the ground elevation profile, a straight line was drawn between manhole rims to represent the model ground elevations, an approach that is less detailed than the grid extracted values.

These two lines diverge at locations along the alignment, which is not problematic. When preliminary design work for the projects begins, manhole locations, alignment, and appropriate manhole rim and invert elevations will be established based on project-specific survey data.

Appendix D, Exhibit 1
Far East Interceptor



Appendix D, Exhibit 2
Far West Interceptor



APPENDIX E
Water Well Reports

(as required by ORS 537.765) WATER WELL REPORT
Instructions for completing this report are on the last page of this form

51647 Pg 1 of 3 (START CARD) # 101989

(1) OWNER: Well Number: #5

Name City of Redmond WELL 5
Address P.O. Box 726
City Redmond State OR Zip 97756

(2) TYPE OF WORK: EP-E

[X] New Well [ ] Deepening [ ] Alteration (repair/recondition) [ ] Abandonment

(3) DRILL METHOD:

[ ] Rotary Air [ ] Rotary Mud [X] Cable [ ] Auger
[ ] Other

(4) PROPOSED USE:

[ ] Domestic [X] Community [ ] Industrial [ ] Irrigation
[ ] Thermal [ ] Injection [ ] Livestock [ ] Other

(5) BORE HOLE CONSTRUCTION:

Special Construction approval [ ] Yes [X] No Depth of Completed Well 802 ft.
Explosives used [ ] Yes [X] No Type ______ Amount ______

HOLE Diameter	From	To	SEAL Material	From	To	Amount sacks or pounds
26"	0	802	Cement	0	100	297 Sacks
26"	0	802	Cement	370	400	66 sacks

How was seal placed: Method [ ] A [ ] B [X] C [ ] D [ ] E
[ ] Other
Backfill placed from 100 ft. to 375 ft. Material Bentonite
Gravel placed from 400 ft. to 802 ft. Size of gravel #8 SilicaRes

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	16"	+2	507	.375	[X]	[ ]	[X]	[ ]
	16"	547	567	.375	[ ]	[ ]	[ ]	[ ]
	16"	797	802	.375	[ ]	[ ]	[ ]	[ ]
Liner:					[ ]	[ ]	[ ]	[ ]

Final location of shoe(s) ______

(7) PERFORATIONS/SCREENS:

[ ] Perforations Method ______
[X] Screens Type Stainless Material 316L

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
507	547	.080		16"	Pipe	[X]	[ ]
567	797	.080		16"	Pipe	[ ]	[ ]

(8) WELL TESTS: Minimum testing time is 1 hour

[X] Pump [ ] Bailer [ ] Air [ ] Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
2300	2.5'	360	24 hr.

Temperature of Water 57 Depth Artesian Flow found ______
Was a water analysis done? [X] Yes By whom Coffee Labs
Did any strata contain water not suitable for intended use? [X] Too little
[ ] Salty [ ] Muddy [ ] Odor [ ] Colored [ ] Other ______
Depth of strata: 208

(9) LOCATION OF WELL by legal description:

County Deschutes Latitude ______ Longitude ______
Township 15S N or S. Range 13E E or W. of WM.
Section 20AA NE ¼ NE ¼
Tax Lot 2900 Lot ______ Block ______ Subdivision ______
Street Address of Well (or nearest address) 19th & Quartz Ave.

(10) STATIC WATER LEVEL:

259 ft. below land surface. Date 3/23/98
Artesian pressure ______ lb. per square inch. Date ______

(11) WATER BEARING ZONES:

Depth at which water was first found 208

From	To	Estimated Flow Rate	SWL
208	209	30+	208
275	405	1000	208
536	802	9000	259

(12) WELL LOG:

Ground elevation ______

Material	From	To	SWL
Gray Basalt	0	39	
Red & Black Cinders	39	40	
Brown Ash & Cinders	40	45	
Brown Basalt	45	48	
Gray Basalt	48	54	
Brown Ash	54	55	
Gray Basalt	55	81.5	
Gray Tuff	81.5	86	
Hard Gray Basalt	86	101.5	
Gray Volcanic Conglomerate	101.5	124	
Brown Ash Conglomerate	124	125	
Fracture Lost Cuttings (Grouted)	125	131	
Brown Conglomerate	131	136	
Brown & Gray Lava with Ash	136	157	
Gray Basalt & Ash	157	159	
Red Ash (Soft)	159	161	
Brown & Gray Basalt & Ash	161	167	
Hard Gray & Brown Basalt	167	172	
Soft Brown Ash	172	174	
Gray Basalt Medium Hard	174	177	
Brown & Gray Basalt with Brown Ash	177	184	
Brown & Gray Basalt with Gray Ash	184	190	
Redish Brown Ash with Broken Basalt	190	204	
Brown Lava with Ash	204	208	
Continued on next page			

Date started 8/29/97 Completed 3/23/95

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to my best knowledge and belief.

RECEIVED JUL 1 1998 WATER RESOURCES DEPT. SALEM, OREGON

Signed ______ WWC Number ______ Date ______

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

Signed Robert Buck WWC Number 1385 Date 4-27-98
Western Water Development Corporation

ORIGINAL & FIRST COPY - WATER RESOURCES DEPARTMENT SECOND COPY - CONSTRUCTOR THIRD COPY - CUSTOMER

Instructions for completing this report are on the last page of this form.

5164 (START CARD) # 101989

(1) OWNER: Well Number: WELL 5 EP-E

Name City of Redmond
Address
City State Zip

(2) TYPE OF WORK:
☐ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☐ No Depth of Completed Well ___ ft.
Explosives used ☐ Yes ☐ No Type ___ Amount ___

HOLE			SEAL			
Diameter	From	To	Material	From	To	Amount sacks or pounds

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☐ Other
Backfill placed from ___ ft. to ___ ft. Material
Gravel placed from ___ ft. to ___ ft. Size of gravel

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
Liner:					☐	☐	☐	☐

Final location of shoe(s)

(7) PERFORATIONS/SCREENS:
☐ Perforations Method
☐ Screens Type Material

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time

Temperature of Water ___ Depth Artesian Flow found ___
Was a water analysis done? ☐ Yes By whom
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other
Depth of strata:

(9) LOCATION OF WELL by legal description:
County ___ Latitude ___ Longitude ___
Township 15S N or S. Range 13E E or W. of WM.
Section 20AA ¼ ¼
Tax Lot ___ Lot ___ Block ___ Subdivision ___
Street Address of Well (or nearest address)

(10) STATIC WATER LEVEL:
___ ft. below land surface. Date
Artesian pressure ___ lb. per square inch. Date

(11) WATER BEARING ZONES:
Depth at which water was first found

From	To	Estimated Flow Rate	SWL

(12) WELL LOG:
Ground elevation

Material	From	To	SWL
Red Cinders WB (sealed off)	208	209	208
Brown Lava with Ash	209	226	208
Hard Gray Lava with Ash	226	235	208
Brown Conglomerate	235	245	208
Gray Conglomerate	245	275	208
Brown Conglomerate WB	275	305	208
Brown Lava with Gray Ash WB	305	325	208
Brown & Gray Conglomerate WB	325	342	208
Brown Lava & Ash WB	342	366	208
Brown Conglomerate with Ash Wb	366	389	208
Brown & Gray Conglomerate	389	405	208
Brown Lava with Ash	405	425	208
Gray Conglomerate with Brown Basalt	425	439	208
Hard Gray Lava with Brown Ash	439	459	208
Medium Hard Gray Lava some Ash	459	480	208
Hard Gray Lava with Ash	480	508	208
Hard Gray Basalt	508	536	208
Broken Lava, Sand, Gravel WB	536	565	259
Silty Sand & Lava Chunks WB	565	608	259
Brown,Gray Broken Lava Hard WB	608	681	259
Brown Sand & Gravel WB	681	691	259
Brown Vesicular Lava WB	691	706	259
Medium Gray Basalt WB	706	710	259
Brown Vesicular Basalt	710	714	259
Continued on next page			

Date started 8-21-97 Completed 3-23-98

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to my best knowledge and belief.

RECEIVED JUL 1 1998 WATER RESOURCES DEPT. SALEM, OREGON

Signed ___ WWC Number ___ Date ___

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1385
Signed ___ Date ___
Western Water Development Corporation

ORIGINAL & FIRST COPY - WATER RESOURCES DEPARTMENT SECOND COPY - CONSTRUCTOR THIRD COPY - CUSTOMER

Instructions for completing this report are on the last page of this form

5164

(START CARD) # 101989

Page 3 of 3

(1) OWNER: Well Number: WELL 5 EP-E

Name City of Redmond

Address

City State Zip

(2) TYPE OF WORK:

[ ] New Well [ ] Deepening [ ] Alteration (repair/recondition) [ ] Abandonment

(3) DRILL METHOD:

[ ] Rotary Air [ ] Rotary Mud [ ] Cable [ ] Auger

[ ] Other

(4) PROPOSED USE:

[ ] Domestic [ ] Community [ ] Industrial [ ] Irrigation

[ ] Thermal [ ] Injection [ ] Livestock [ ] Other

(5) BORE HOLE CONSTRUCTION:

Special Construction approval [ ] Yes [ ] No Depth of Completed Well ft.

Explosives used [ ] Yes [ ] No Type Amount

HOLE Diameter	From	To	SEAL Material	From	To	Amount sacks or pounds

How was seal placed: Method [ ] A [ ] B [ ] C [ ] D [ ] E

[ ] Other

Backfill placed from ft. to ft. Material

Gravel placed from ft. to ft. Size of gravel

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					[ ]	[ ]	[ ]	[ ]
Liner:					[ ]	[ ]	[ ]	[ ]

Final location of shoe(s)

(7) PERFORATIONS/SCREENS:

[ ] Perforations Method

[ ] Screens Type Material

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						[ ]	[ ]

(8) WELL TESTS: Minimum testing time is 1 hour

[ ] Pump [ ] Bailer [ ] Air [ ] Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time

Temperature of Water Depth Artesian Flow found

Was a water analysis done? [ ] Yes By whom

Did any strata contain water not suitable for intended use? [ ] Too little

[ ] Salty [ ] Muddy [ ] Odor [ ] Colored [ ] Other

Depth of strata:

(9) LOCATION OF WELL by legal description:

County Latitude Longitude

Township 15S N or S. Range 13E E or W. of WM.

Section 20AA ¼ ¼

Tax Lot Lot Block Subdivision

Street Address of Well (or nearest address)

(10) STATIC WATER LEVEL:

ft. below land surface. Date

Artesian pressure lb. per square inch. Date

(11) WATER BEARING ZONES:

Depth at which water was first found

From	To	Estimated Flow Rate	SWL

(12) WELL LOG:

Ground elevation

Material	From	To	SWL
Gray Broken Lava Hard WB	714	738	259
Brown Vesicular Lava Pinholes WB	738	765	259
Brown & Gray Lava WB	765	783	259
Soft Brown Conglomerate WB	783	802	259

RECEIVED
JUL - 1 1998
WATER RESOURCES DEPT.
SALEM, OREGON

Date started 8-21-97 Completed 3-23-98

(unbonded) Water Well Constructor Certification:

I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to my best knowledge and belief.

WWC Number

Signed Date

(bonded) Water Well Constructor Certification:

I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1385

Signed Date

Western Water Development Corporation

ORIGINAL & FIRST COPY - WATER RESOURCES DEPARTMENT SECOND COPY - CONSTRUCTOR THIRD COPY - CUSTOMER

54981 H

Well #1

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the STATE ENGINEER, SALEM, OREGON 97310 within 30 days from the date of well completion.

RECEIVED AUG 13 1969 STATE ENGINEER SALEM, OREGON

WATER WELL REPORT
STATE OF OREGON
(Please type or print)
(Do not write above this line)

State Well No. 15/13-9c
State Permit No.

(1) OWNER: WELL 1 EP-A
Name CITY OF REDMOND ORE
Address CITY HALL REDMOND ORE

(2) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary ☐ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

CASING INSTALLED: Threaded ☐ Welded ☒
16 OD " Diam. from 0 ft. to 29 ft. Gage 250
12" " Diam. from 0 ft. to 300 ft. Gage 250
" Diam. from ft. to ft. Gage

PERFORATIONS: Perforated? ☒ Yes ☐ No.
Type of perforator used FACTORY
Size of perforations ¼ in. by 2 in.
3200 perforations from 200 ft. to 300 ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS: Well screen installed? ☐ Yes ☒ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(8) WATER LEVEL: Completed well.
Static level 168 ft. below land surface Date 7-15-69
Artesian pressure lbs. per square inch Date

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? GEO-BAKER
Yield: 500 gal./min. with NO ft. drawdown after 5 hrs.
1300 " ~~20~~ 40 " 72 "
1400 " 73 " 2 "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 54 Was a chemical analysis made? ☒ Yes ☐ No

(10) CONSTRUCTION:
Well seal—Material used CEMENT - GROUT
Depth of seal 29 ft.
Diameter of well bore to bottom of seal 18 in.
Were any loose strata cemented off? ☐ Yes ☒ No Depth
Was a drive shoe used? ☐ Yes ☒ No
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ...

(11) LOCATION OF WELL:
County DESC Driller's well number 1
NE ¼ NW ¼ Section 9 T. 15 S R. 13 E
Bearing and distance from section or subdivision corner

(12) WELL LOG: Diameter of well below casing 12"
Depth drilled 330 ft. Depth of completed well 300
Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level as drilling proceeds. Note drilling rates.

MATERIAL	From	To	SWL
OVER BURDEN	0	5	
HARD LAVA	5	17	
BOULDER CONG-	17	20	
SOFT LAVA	20	38	
HARD RED LAVA	38	50	
BROKEN RED LAVA	50	56	
HARD GREY LAVA	56	78	
RED CONG	78	85	
MED HARD RED LAVA	85	96	
HARD BLUE LAVA	96	108	
SOFT BROWN LAVA	108	118	
SOFT CONG	118	125	
SOFT GREY LAVA	125	133	
CREVIS	133	140	
CAVING BOULDER CONG.	140	152	
SAND STONE	152	175	
SOFT LAVA	175	185	
WATER BEARING SAND	185	199	7
HARD BLUE BASALT	199	220	
RED CLINDERS	220	235	
WATER BEARING PUMICE	235	265	
COARSE GRAVEL	265	270	
SILTY SAND	270	330	1

Work started 4-11 1969 Completed 7-15 19
Date well drilling machine moved off of well 7-15 19

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] [signature] (Drilling Machine Operator) Date 8-1 19
Drilling Machine Operator's License No. 320

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
NAME JACKSON DRILLING (Person, firm or corporation) (Type or print)
Address REDMOND ORE.
[Signed] [signature]

STATE ENGINEER, SALEM, OREGON 97310
within 30 days from the date
of well completion.

STATE OF OREGON
(Please type or print)
(Do not write above this line)

FEB 18 19__ STATE ENGINEER

State Well No. ....
State Permit No. ....

(1) OWNER:
Name City of Redmond WELL 2
Address Redmond, Oregon EP-B

(2) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary ☐ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

(5) CASING INSTALLED: Threaded ☐ Welded ☒
16" Diam. from +2 ft. to 280 ft. Gage .250
14" Diam. from 255 ft. to 433 ft. Gage .250
...." Diam. from .... ft. to .... ft. Gage ....

(6) PERFORATIONS: Perforated? ☒ Yes ☐ No.
Type of perforator used Factory slot
Size of perforations 6 in. by 1/8 in.
2,000 perforations from 255 ft. to 423 ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

(7) SCREENS: Well screen installed? ☐ Yes ☒ No
Manufacturer's Name ....
Type .... Model No. ....
Diam. .... Slot size .... Set from .... ft. to .... ft.
Diam. .... Slot size .... Set from .... ft. to .... ft.

(8) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? H. & H. Drilling, Inc.
Yield: 1174 gal./min. with 35 ft. drawdown after 29 hrs.
" " " "
" " " "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water 52 Depth artesian flow encountered .... ft.

(9) CONSTRUCTION:
Well seal—Material used Portland Cement
Well sealed from land surface to 280 ft.
Diameter of well bore to bottom of seal 18 to 280 in. (20 to 40' 28" 18")
Diameter of well bore below seal ~~18~~ 16 in.
Number of sacks of cement used in well seal 34½ Yards sacks
Number of sacks of bentonite used in well seal .... sacks
Brand name of bentonite
Number of pounds of bentonite per 100 gallons of water .... lbs./100 gals.
Was a drive shoe used? ☐ Yes ☒ No Plugs .... Size: location .... ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? potable depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☒ No Size of gravel: ....
Gravel placed from .... ft. to .... ft.

(10) LOCATION OF WELL:
County Deschutes Driller's well number
NW ¼ SW ¼ Section 16 T. 15 S R. 13 East W.M.
Bearing and distance from section or subdivision corner

(11) WATER LEVEL: Completed well.
Depth at which water was first found 278 ft.
Static level 265 ft. below land surface. Date 2-14-75
Artesian pressure lbs. per square inch. Date

(12) WELL LOG: Diameter of well below casing 16 to bottom
Depth drilled 452 ft. Depth of completed well 452 ft.

Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. *Report each change in position of Static Water Level and indicate principal water-bearing strata.*

MATERIAL	From	To	SWL
Top Soil	0	4	
Mild Brown Lava	4	15	
Brown Conglomerate	15	85	
Pumice	85	95	
Tan Conglom.	95	157	
Loose Black Cinders	157	164	
Hard Black Lava	164	205	
Red Cinders	205	225	
Black Sand	225	236	
Brown Sandstone	236	278	
Water bearing Brown Sandstone	278	400	265
Hard Clay stone	400	427	
Tan " with some sand small gravel	427	433	
Hard Clay stone	433	449	
Black Basalt	449	452	

Work started 2-15 1974 Completed 2-14 1975
Date well drilling machine moved off of well 2-14 1975

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] (signature) (Drilling Machine Operator) Date 2-14, 1975
Drilling Machine Operator's License No. 558

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Name H. & H. DRILLING, INC. (Person, firm or corporation) (Type or print)
Address P.O. Box 51 Redmond, Oregon 97756
[Signed] (signature) (Water Well Contractor)
Contractor's License No. 488 Date 2-14, 1975

(USE ADDITIONAL SHEETS IF NECESSARY)

SP*45656-119

APR. 26. 2006 9:18AM NO. 684 P. 8

WATER RESOURCES DEPARTMENT,
SALEM, OREGON 97310
within 30 days from the date of well completion.

WELL #3

WATER WELL REPORT
STATE OF OREGON
(Please type or print)
(Do not write above this line)

State Well No. ______
State Permit No. ______

(1) OWNER:
Name City of Redmond EP-C
Address City Hall
Redmond, Oregon 97756

(2) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary ☐ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

(5) CASING INSTALLED: Threaded ☐ Welded ☐
16 " Diam. from +3 ft. to 32 ft. Gage .250
14 " Diam. from +8" ft. to 452 ft. Gage .375
" Diam. from ft. to ft. Gage

(6) PERFORATIONS: Perforated? ☒ Yes ☐ No.
Type of perforator used Factory
Size of perforations 3/16 in. by 4 in.
2,000 perforations from 347 ft. to 452 ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS: Well screen installed? ☐ Yes ☒ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(8) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? Valley Pump
Yield: 1100 gal./min. with 345 ft. drawdown after 24 hrs.
" " " "
" " " "
Bailer test - gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water 61* Depth artesian flow encountered ft.

(9) CONSTRUCTION:
Well seal—Material used Cement
Well sealed from land surface to 32 ft.
Diameter of well bore to bottom of seal 20 in.
Diameter of well bore below seal 20 in.
Number of sacks of cement used in well seal 38 sacks
How was cement grout placed? pressure grouted

Was a drive shoe used? ☐ Yes ☒ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☒ Yes ☐ No Size of gravel: 1/2" minus
Gravel placed from 340 ft. to 452 ft.

(10) LOCATION OF WELL:
County Deschutes Driller's well number
¼ ¼ Section 22 T. 15S R. 13E W.
Bearing and distance from section or subdivision corner

(11) WATER LEVEL: Completed well.
Depth at which water was first found 318
Static level 315 ft. below land surface. Date 9-21
Artesian pressure lbs. per square inch. Date

(12) WELL LOG: Diameter of well below casing ---
Depth drilled 452 ft. Depth of completed well 452

Formation: Describe color, texture, grain size and structure of materi[als] and show thickness and nature of each stratum and aquifer penetrat[ed] with at least one entry for each change of formation. Report each chang[e in] position of Static Water Level and indicate principal water-bearing str[ata]

MATERIAL	From	To	SWL
Top Soil	0	4	
Lava & Lava Cinder	4	27	
Brown Conglomerate	27	46	
Diced Lava	46	49	
Lava, Fissured	49	63	
Brown Conglomerate	63	65	
Diced Lava/ with some red	65	80	
Brown Conglomerate	80	85	
Broken Lava	85	97	
Brown Conglomerate	97	107	
Grey-Brown Lava Conglomerate	107	121	
Cindered Conglomerate/Red-Brn	121	127	
Grey Lava Conglomerate	127	155	
Lava Conglomerate/ with Red Rock & Some Cinders	155	160	
Dark Grey Broken Lava	160	170	
Brown Conglomerate/mild gravl	170	175	
Brown Sandstone	175	205	
Dark, Mild Sandstone	205	215	

Work started 7-13 19 79 Completed 9-23 19 7[9]
Date well drilling machine moved off of well 9-23 19 7[9]

Drilling Machine Operator's Certification:
This well was constructed under my direct supervisio[n]. Materials used and information reported above are true to [my] best knowledge and belief.
[Signed] [signature] (Drilling Machine Operator) Date 9-27, 19..
Drilling Machine Operator's License No. 967

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report [is] true to the best of my knowledge and belief.
Name Orvall Buckner Well Drilling, Inc. (Person, firm or corporation) (Type or print)
Address 1686 N.E. Negus Way, Redmond, Ore. 9775[6]
[Signed] [signature] (Water Well Contractor)
Contractor's License No. 608 Date 9-27 19 7

APR. 20. 2000 9:10AM

WATER RESOURCES DEPARTMENT, SALEM, OREGON 97310
within 30 days from the date of well completion.

STATE OF OREGON
(Please type or print)
(Do not write above this line)

NO. 004

State Well No.
State Permit No.

(1) OWNER: WELL 3 EP-C

Name City of Redmond
Address City Hall
Redmond, Oregon 97756

(2) TYPE OF WORK (check):

New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:

Rotary ☐ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(4) PROPOSED USE (check):

Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

(5) CASING INSTALLED: Threaded ☐ Welded ☐

16" Diam. from + ft. to ft. Gage .250
" Diam. from ft. to ft. Gage
" Diam. from ft. to ft. Gage

(6) PERFORATIONS: Perforated? ☐ Yes ☐ No.

Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS: Well screen installed? ☐ Yes ☒ No

Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(8) WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☒ Yes ☐ No If yes, by whom? Valley Pump
Yield: 1100 gal./min. with ft. drawdown after hrs.
" " " "
" " " "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water Depth artesian flow encountered ft.

(9) CONSTRUCTION:

Well seal—Material used Cement
Well sealed from land surface to 32 ft.
Diameter of well bore to bottom of seal 20 in.
Diameter of well bore below seal 20 in.
Number of sacks of cement used in well seal 38 sacks
How was cement grout placed? Pressure grouted

Was a drive shoe used? ☐ Yes ☒ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☒ Yes ☐ No Size of gravel:
Gravel placed from ft. to ft.

(10) LOCATION OF WELL:

County Deschutes Driller's well number
¼ ¼ Section 22 T. 15S R. 13E W.M.
Bearing and distance from section or subdivision corner

(11) WATER LEVEL: Completed well.

Depth at which water was first found 318 ft.
Static level ft. below land surface. Date
Artesian pressure lbs. per square inch. Date

(12) WELL LOG: Diameter of well below casing

Depth drilled 452 ft. Depth of completed well 452 ft.

Formation: Describe color, texture, grain size and structure of materials and show thickness and nature of each stratum and aquifer penetrated with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL	From	To	SWL
Dk. Mild Sandstone/traces of			
Tufted Ash	215	232	
Broken Rock	232	237	
Sandstone Conglomerate	237	248	
Coarse, Colored Sandstone	248	265	
Dk. Grey, Mild Lava	265	288	
Lt. Grey, Mild Lava	288	304	
Dk. Broken Basalt/with Brown			
Clay Strips	304	318	Wat
" "/ with Dk. Brwn Clay-			
stone & Orange/Brown Clayston	318	327	
Sandstone/with Tufted Ash	327	360	
Black Cinders/with Polished			
Sand & Gravel-some color	360	375	Water
Dark Brown Sandstone	375	403	
Sand & Gravel-Colored	403	410	311-
Dark Brown Sandstone, possib-	410	452	
ly some Water-Bearing			

Work started 7-13 1979 Completed 9-23 1979
Date well drilling machine moved off of well 9-23 1979

Drilling Machine Operator's Certification:

This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.

[Signed] (Drilling Machine Operator) Date 9-27, 1979

Drilling Machine Operator's License No. 967

Water Well Contractor's Certification:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Name Orvail Buckner Well Drilling, Inc. (Person, firm or corporation) (Type or print)
Address 1686 N. E. Negus Way, Redmond, Oregon 97

[Signed] (Water Well Contractor)

Contractor's License No. 608 Date 9-27, 1979

RECEIVED
JUL 12 1985
WATER RESOURCES DEPT
SALEM, OREGON

Pg. 1 of 3

DESC 407

Sec. 22 'CAN'

Pee WM 10

15S/13E-22bd

STATE OF OREGON
WATER WELL REPORT
(as required by ORS 537.765)

PLEASE TYPE or PRINT IN INK

(for official use only)

WELL 4
EPD

(1) OWNER:
Name City of Redmond
Address City Hall
City Redmond State Oreg. 97756

(2) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary Air ☐ Driven ☐
Rotary Mud ☐ Dug ☐
Cable ☒ Bored ☐

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Thermal: Withdrawal ☐ Reinjection ☐
Other: Piezometric ☐ Grounding ☐ Test ☐

(5) CASING INSTALLED: Steel ☒ Plastic ☐ Threaded ☐ Welded ☒
18" Diam. from +3 ft. to -718½ ft. Gauge .375
" Diam. from ft. to ft. Gauge

LINER INSTALLED: Steel ☒ Plastic ☐ Threaded ☐ Welded ☒
12" Diam. from 707½ ft. to 765 ft. Gauge .250

(6) PERFORATIONS: Perforated? ☐ Yes ☒ No
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS: Well screen installed? ☒ Yes ☐ No
Manufacturer's Name Johnson
Type P.S. (see pg. 3 for full screen info) Model No.
Diam. 18 Slot Size .050 Set from 533.5 ft. to 553.5 ft.
Diam. 12 Slot Size .050 Set from 735 ft. to 755 ft.

(8) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? Buckner Pump
Yield: 1300 gal./min. with 40 ft. drawdown after 72 hrs.
Air test gal./min. with drill stem at ft. hrs.
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water 54° Depth artesian flow encountered ft.

(9) CONSTRUCTION: Special standards: Yes ☐ No ☒
Well seal—Material used Portland Cement
Well sealed from land surface to 50 ft.
Diameter of well bore to bottom of seal 24 in.
Diameter of well bore below seal 24 in.
Amount of sealing material 85 sacks ☒ pounds ☐
How was cement grout placed? Pumped

Was pump installed? no Type HP Depth ft.
Was a drive shoe used? ☐ Yes ☒ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of Water? depth of strata
Method of sealing strata off
Was well gravel packed? ☒ Yes ☐ No Size of gravel: Monterey #8
Gravel placed from 520 ft. to 765 ft.
¾" gravel from 50' to 520'

(10) LOCATION OF WELL by legal description:
County Deschutes SE ¼ NW ¼ of Section 20
Township 15S (Township is North or South), Range 13E (Range is East or West) WM.
Tax Lot Lot Block Subdivision
MAILING ADDRESS OF WELL (or nearest address) unknown

(11) WATER LEVEL of COMPLETED WELL:
Depth at which water was first found 362 ft.
Static level 362 ft. below land surface, Date 5-24-85
Artesian pressure lbs. per square inch. Date

(12) WELL LOG: Diameter of well below casing
Depth drilled 765 ft. Depth of completed well 765 ft.
Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL	From	To	SWL
Top Soil, Sandy	0	2	
Broken Lava Conglomerate	2	8	
Lava Conglomerate	8	27	
Broken Lava, Cindery	27	30	
Red-Black Lava, Solid	30	55	
Pumice Conglomerate	55	60	
White Pumice	60	92	
Cindery Black Rock	92	97	
Red-Black Cindery Rock	97	105	
Cinders & Clinkers	105	113	
Red Cinders	113	122	
Cinders& Lava Rock	122	126	
Black Basalt	126	137	
Red- Black Basalt, Broken	137	143	
Hard, Black Basalt	143	247	
Red Cinders, Soft	247	251	
Black Basalt	251	254	
Red Cinders	254	345	
Brown Sandstone, Mild	345	365	
Brown Sandstone, Coarser	365	374	
Brown Sandstone W/Pea Gravel	374	385	

Date work started 11-27-84 /completed 5-25-85
Date well drilling machine moved off of well 5-25 19 85

(unbonded) Water Well Constructor Certification (if applicable):
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] [signature] Date 6-6 19 85

(bonded) Water Well Constructor Certification:
Bond 10596951 (number) Issued by: AMWEST (Surety Company Name)
On behalf of Buckner Pump Service (type or print name of Water Well Constructor)

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
(Signed) Robert Buckner (Water Well Constructor)
(Dated) June 6, 1985

NOTICE TO WATER WELL CONSTRUCTOR
The original and first copy of this report are to be filed with the

WATER RESOURCES DEPARTMENT, SALEM, OREGON 97310
within 30 days from the date of well completion.

SP*45656-590

STATE OF OREGON
WATER WELL REPORT
(as required by ORS 537.765)

RECEIVED
JUL 12 1985
WATER RESOURCES DEPT
SALEM, OREGON

WELL 4
EP-D

PLEASE TYPE or PRINT IN INK

 15S/13E-22DK

(for official use only)

(1) OWNER:

Name City of Redmond
Address City Hall
City Redmond State Oreg. 97756

(2) TYPE OF WORK (check):

New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:

Rotary Air ☐ Driven ☐
Rotary Mud ☐ Dug ☐
Cable ☒ Bored ☐

(4) PROPOSED USE (check):

Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Thermal: Withdrawal ☐ Reinjection ☐
Other: Piezometric ☐ Grounding ☐ Test ☐

(5) CASING INSTALLED:

Steel Threaded ☐ Plastic ☐ Welded ☒

18" Diam. from +3 ft. to 718½ ft. Gauge .375
" Diam. from ft. to ft. Gauge

LINER INSTALLED: Steel Threaded ☒ ☐ Plastic ☐ Welded ☒

12" Diam. from 707½ ft. to 765 ft. Gauge .250

(6) PERFORATIONS:

Perforated? ☐ Yes ☒ No
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS:

Well screen installed? ☒ Yes ☐ No.
Manufacturer's Name Johnson
Type P.S. (see pg. 3 for full screen info) Model No.
Diam. 18 Slot Size .050 Set from 533.5 ft. to 553.9 ft.
Diam. 12 Slot Size .5 Set from 735 ft. to 755 ft.

(8) WELL TESTS:

Drawdown is amount water level is lowered below static level

Was a pump test made? ☒ Yes ☐ No If yes, by whom? Buckner Pump
Yield: 1300 gal./min. with 40 ft. drawdown after 72 hrs.

Air test gal./min. with drill stem at ft. hrs.
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water 54° Depth artesian flow encountered ft.

(9) CONSTRUCTION:

Special standards: Yes ☐ No ☒
Well seal—Material used Portland Cement
Well sealed from land surface to 50 ft.
Diameter of well bore to bottom of seal 24 in.
Diameter of well bore below seal 24 in.
Amount of sealing material 85 sacks ☒ pounds ☐
How was cement grout placed? Pumped

Was pump installed? no Type HP Depth ft.
Was a drive shoe used? ☐ Yes ☒ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of Water? depth of strata
Method of sealing strata off
Was well gravel packed? ☒ Yes ☐ No Size of gravel: Monterey #8
Gravel placed from 520 ft. to 765 ft.

¼ gravel from 50' to 520'

(10) LOCATION OF WELL by legal description:

County Deschutes SE ¼ NW ¼ of Section 20 of
Township 15S (Township is North or South), Range 13E (Range is East or West) WM.
Tax Lot Lot Block Subdivision
MAILING ADDRESS OF WELL (or nearest address) unknown

(11) WATER LEVEL of COMPLETED WELL:

Depth at which water was first found 362 ft.
Static level 362 ft. below land surface. Date 5-24-85
Artesian pressure lbs. per square inch. Date

(12) WELL LOG:

Diameter of well below casing
Depth drilled 765 ft. Depth of completed well 765 ft.

Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL	From	To	SWL
Dk. Brwn. Sandstone & Blk. Sand	385	396	
Dk.Brwn.Sandstone-blk.Sand more firm	396	450	
Brwn. Sandstone-finer Sand some clay bonding	450	455	
Dk. Brown Sandstone, some multi-colored pea gravels, possible water-465-485'	455	528	
Grey-Brwn. Tufted Ash Layer Firm	528	540	
Sandstone Conglomerate, Slow Drilling Gravels-Dk. Brwn	540	565	
Med. Brwn. Sandstone	565	590	
Fine graned w/some clay bondg Dk. Brwn. Sandstone, Coarser Sands	590	620	
Coarse, DK. Brwn. Sandstone w/½" minus pea gravels	620	645	
Coarse DK. Brwn. Sandstone W/ more gravel-harder	645	650	
Finer Grained Sandstone	650	697	

Date work started 11-27-84 completed 5-25-85
Date well drilling machine moved off of well 5-25 19 85

(unbonded) Water Well Constructor Certification (if applicable):
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.

[Signed] [signature] Date 6-6 19 85

(bonded) Water Well Constructor Certification:
Bond 10596951 (number) Issued by: AMWEST (Surety Company Name)
On behalf of Buckner Pump Service (type or print name of Water Well Constructor)

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

(Signed) (Water Well Constructor)
(Dated) June 6, 1985

NOTICE TO WATER WELL CONSTRUCTOR
The original and first copy of this report are to be filed with the WATER RESOURCES DEPARTMENT, SALEM, OREGON 97310 within 30 days from the date of well completion.

SP*45656-690

RECEIVED
JUL 12 1985
WATER RESOURCES DEPT
SALEM, OREGON

STATE OF OREGON
WATER WELL REPORT
(as required by ORS 537.765)

Pg. 3 of 3

15S/13E-22bd
(for official use only)

PLEASE TYPE or PRINT IN INK

WELL 4
EP-D

(1) OWNER:
Name City of Redmond
Address City Hall
City Redmond State Oreg. 97756

(2) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary Air ☐ Driven ☐
Rotary Mud ☐ Dug ☐
Cable ☒ Bored ☐

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Thermal: Withdrawal ☐ Reinjection ☐
Other: Piezometric ☐ Grounding ☐ Test ☐

(5) CASING INSTALLED: Steel ☒ Threaded ☐ Plastic ☐ Welded ☒
18" Diam. from +3 ft. to 718½ ft. Gauge .375
" Diam. from ft. to ft. Gauge

LINER INSTALLED: Steel ☒ Threaded ☐ Plastic ☐ Welded ☒
12" Diam. from 707½ ft. to 765 ft. Gauge .250

(6) PERFORATIONS: Perforated? ☐ Yes ☒ No
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS: Well screen installed? ☒ Yes ☐ No
Manufacturer's Name Johnston
Type P.S. Model No.
Diam. 18 Slot Size .050 Set from 533.5 ft. to 553.5 ft. and 593.5' to 633.5' and 688.5 to 708.5'
Diam. 12 Slot Size .050 Set from 735 ft. to 755 ft.

(8) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom?
Yield: 1300 gal./min. with 40 ft. drawdown after 72 hrs.
Air test gal./min. with drill stem at ft. hrs.
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water 54* Depth artesian flow encountered ft.

(9) CONSTRUCTION: Special standards: Yes ☐ No ☒
Well seal—Material used Portland cement
Well sealed from land surface to 50 ft.
Diameter of well bore to bottom of seal 24 in.
Diameter of well bore below seal 24 in.
Amount of sealing material 85 sacks ☒ pounds ☐
How was cement grout placed? Pumped

Was pump installed? no Type HP Depth ft.
Was a drive shoe used? ☐ Yes ☒ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of Water? depth of strata
Method of sealing strata off
Was well gravel packed? ☒ Yes ☐ No Size of gravel: Monterey #8
Gravel placed from 520 ft. to 765 ft.
3/4" gravel from 50' to 520'

(10) LOCATION OF WELL by legal description:
County Deschutes ¼ ¼ of Section 20 of
Township 15S (Township is North or South), Range 13E (Range is East or West), WM.
Tax Lot Lot Block Subdivision
MAILING ADDRESS OF WELL (or nearest address) unknown

(11) WATER LEVEL of COMPLETED WELL:
Depth at which water was first found 362 ft.
Static level 362 ft. below land surface. Date 5-24-85
Artesian pressure lbs. per square inch. Date

(12) WELL LOG: Diameter of well below casing
Depth drilled 765 ft. Depth of completed well 765 ft.
Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL	From	To	SWL
Sand & Some Gravels-unstable (water between 695-715)	697	710	362
Sandstone-Brwn W/some tuff ash and whites	710	728	362
Brown Sandstone W/ more Cinders, Sands and Gravels	728	754	362
Dk. Grey Basalt	754	765	362

Date work started 11-27-84 completed 5-25-85
Date well drilling machine moved off of well 5-25-85 19

(unbonded) Water Well Constructor Certification (if applicable):
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] [signature] Date 6-6, 19 85

(bonded) Water Well Constructor Certification:
Bond 10596951 (number) Issued by: AMWEST (Surety Company Name)
On behalf of Buckner Pump Service (type or print name of Water Well Constructor)

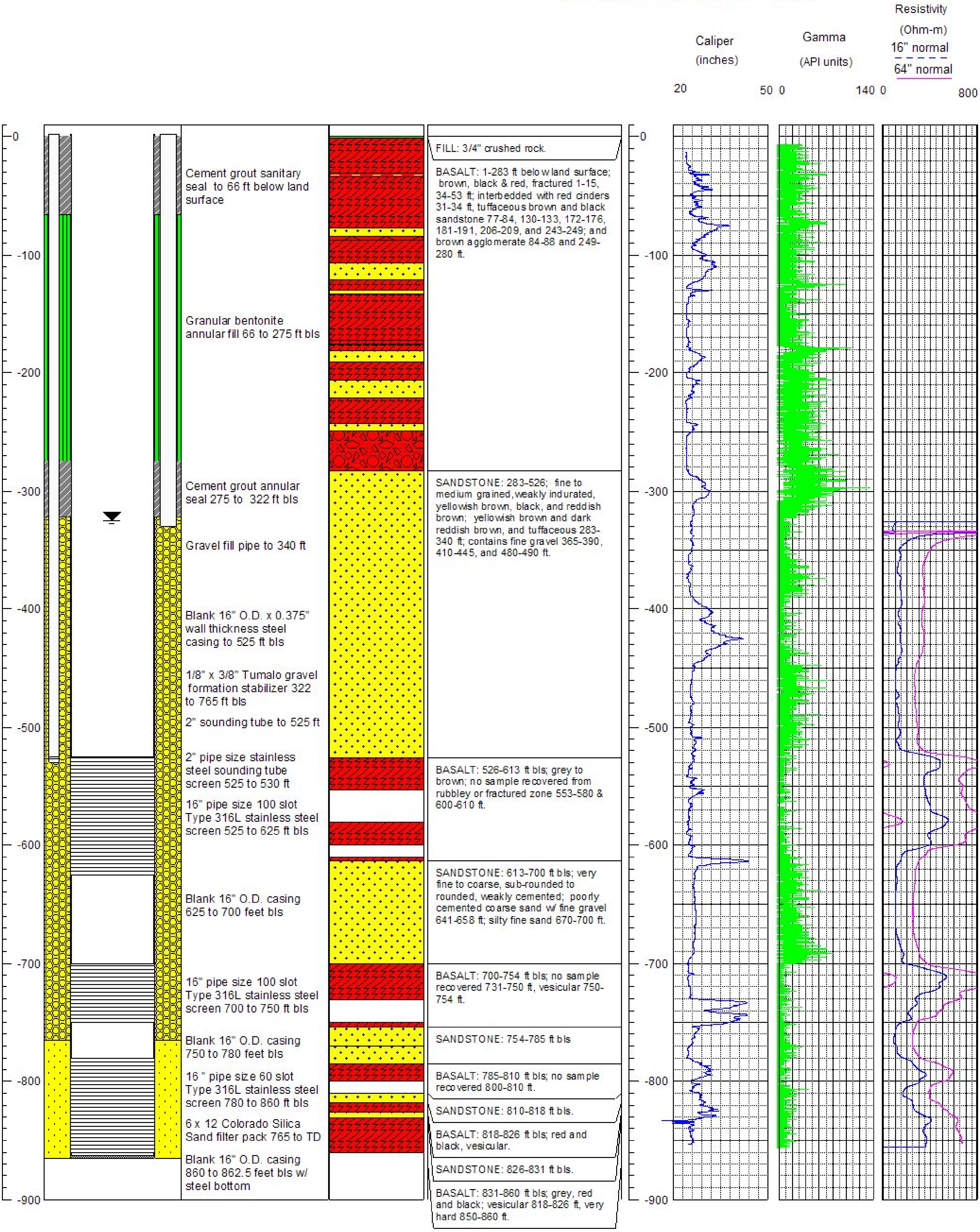
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
(Signed) (Water Well Constructor)
(Dated) June 6, 1985

NOTICE TO WATER WELL CONSTRUCTOR
The original and first copy of this report are to be filed with the
WATER RESOURCES DEPARTMENT, SALEM, OREGON 97310
within 30 days from the date of well completion.

ECO:LOGIC Engineering
10381 Double R Blvd.
Reno, Nevada 89521

Phone: 775-827-2311
FAX: 775-827-2316

Well: City of Redmond Well 7
Drilling Contractor: Western Water Development
Date Drilling Started: 7/8/06
Date Completed: 11/21/06
Well Depth: 869 feet
Borehole Diameter: Nominal 26 inches



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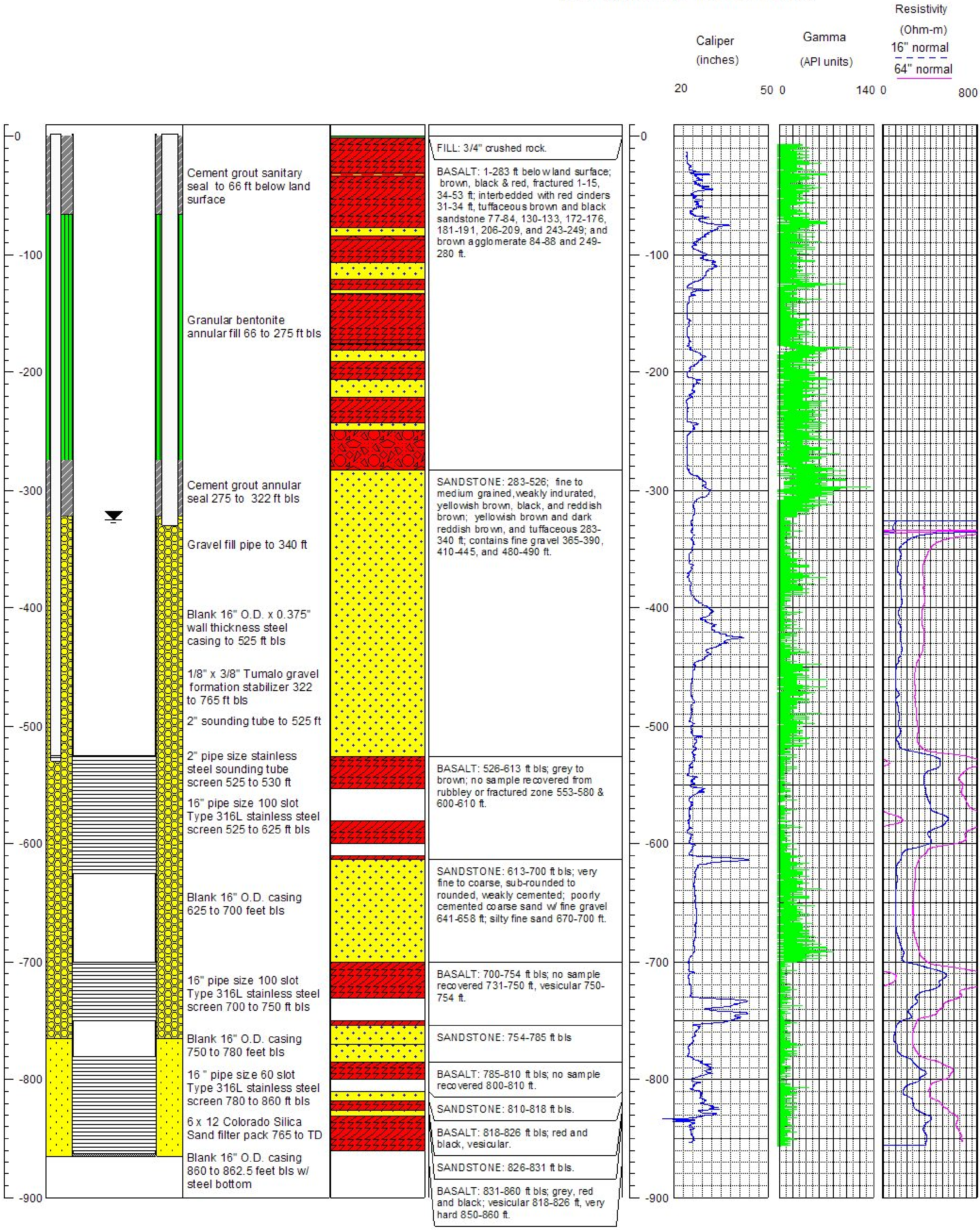

APPENDIX F

Mitigation Calculations for Water Rights

Appendix F. Mitigation Calculations for Water Rights

EXHIBIT F-1

Redmond Well Water Production and Consumptive Use (2005-2006)[1]

Redmond Wastewater (Collection System) and Water System Master Plan

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Days per Month	31	30	31	31	28	31	30	31	30	31	31	30	
Water Use By Month[2] (MG)													
2006	117.71	66.74	67.32	65.32	56.87	66.03	97.72	206.28	212.94	293.63	284.09	210.03	
2005	126.33	62.94	61.75	60.47	54.91	72.99	91.80	122.48	206.91	294.94	302.07	212.51	
Wastewater Monthly Average Daily Flow[3] (MGD)													
2006	1.74	1.78	1.81	1.84	1.89	1.84	1.9	1.9	1.9	1.861	1.91	1.84	
2005	1.67	1.7	1.7	1.8	1.74	1.76	1.82	1.85	1.83	1.771	1.79	1.8	
Wastewater Monthly Flow (MG)													
2006	53.94	53.4	56.11	57.04	52.92	57.04	57	58.9	57	57.69	59.21	55.2	
2005	51.77	51	52.7	55.8	48.72	54.56	54.6	57.35	54.9	54.90	55.49	54	
Reclaimed Water Use[4] (MG)													
2006	14.05	0	0	0	0	0	1.98	4.10	22.70	40.18	14.41	22.69	
2005	0	0	0	0	0	0	1.98	4.10	22.70	40.18	14.41	22.69	
Consumptive Use (Water Use flow + Reclaimed Water -- Wastewater Flow) (MG)													
2006	77.8	13.3	11.2	8.3	4.0	9.0	42.7	151.5	178.6	276.1	239.3	177.5	
2005	74.6	11.9	9.0	4.7	6.2	18.4	39.2	69.2	174.7	280.2	261.0	181.2	
Consumptive Use (Water Use flow + Reclaimed Water -- Wastewater Flow) (Acre-Feet)													**TOTAL**
2006	239	41	34	25	12	28	131	465	548	847	734	545	3650
2005	229	37	28	14	19	57	120	212	536	860	801	556	3469
Consumptive Use ([Water Use flow + Reclaimed Water -- Wastewater Flow] ÷ Water Use x 100) (%)													**AVERAGE**
2006	66.1	20.0	16.6	12.7	6.9	13.6	43.7	73.4	83.9	94.0	84.2	84.5	50.0

Appendix F. Mitigation Calculations for Water Rights

EXHIBIT F-1

Redmond Well Water Production and Consumptive Use (2005-2006)[1]

Redmond Wastewater (Collection System) and Water System Master Plan

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
2005	59.0	19.0	14.7	7.7	11.3	25.2	42.7	56.5	84.4	95.0	86.4	85.3	48.9
						Redmond Population from Redmond Web Page							
2006						23,500							
2005						21,110							
						Per Capita Water Use (gpcd)							**AVERAGE**
2006	162	95	92	90	86	91	139	283	302	403	390	298	203
2005	193	99	94	92	93	112	145	187	327	451	462	336	216

Notes:

1. Information in this table provided by Newton Consultants, Inc. (November 2007)
2. From Oregon Water Resources Department Water Use Report Webpage
3. From DEQ Discharge Monitoring Report Summary
4. From the City of Redmond

Appendix G
Water System Model Calibration

Exhibit G-1

Redmond Water Distribution Model Calibration Summary

Pressure Zone	Test ID	Ground Elevation		MODEL ID		Field HGL	Model Static HGL	Field Static Pressure	Model Static Pressure	Field Flow Pressure	Model FF Pressure	Discharge Flow Rate	Error Results				Confidence
													Static Pressure		FF Pressure		
		hydrant	model	Flow	Pressure	ft	ft	psi	psi	psi	psi	gpm	%	psi	%	psi	
PZ-3	1		2,948	3838	1839	3109	3106	70	67	61	59	1230	4%	3	3%	2	HIGH
PZ-3	2		2,962	5592	5642	3112	3108	65	63	50	58	2000	3%	2	16%	8	HIGH
PZ-3A	12		2,944	266	12545	3179	3169	102	99	71	63	2460	3%	3	11%	8	HIGH
PZ-3A	13	2,956	2,956	477	6698	3189	3170	101	93	75	67	2420	8%	8	11%	8	MEDIUM
PZ-2_3180	3		2,985	4388	4502	3179	3174	84	82	51	61	1580	3%	2	20%	10	HIGH
PZ-2_3180	4		2,988	9877	12308	3174	3172	81	80	60	67	2120	2%	1	12%	7	HIGH
PZ-2_3180	5		2,988	223	223	3175	3171	81	79	48	58	2020	2%	2	21%	10	HIGH
PZ-2_3180	6	3,028	3,022	880	11231	3192	3176	71	66	48	53	2020	6%	5	10%	5	HIGH
PZ-2_3180	7	2,996	2,994	1076	3145	3174	3179	78	80	57	73	1500	3%	2	28%	16	MEDIUM
PZ-2_3180	8		3,026	10416	5148	3185	3184	69	69	61	62	2280	0%	0	2%	1	HIGH
PZ-2_3180	9		3,058	10860	5396	3196	3193	60	59	41	37	1780	2%	1	10%	4	HIGH
PZ-2_3180	10		3,006	2853	2853	3181	3181	76	76	69	65	2420	0%	0	6%	4	HIGH
PZ-2_3180	11		3,008	6436	6431	3174	3180	72	74	66	62	2280	3%	2	6%	4	HIGH
PZ-2_3180	20		3,004	6181	6181	3188	3181	80	77	75	n/a	n/a	4%	3	n/a	n/a	MEDIUM
PZ-2_3180	14		2,970	790	787	3175	3170	89	88	66	64	2320	2%	1	3%	2	HIGH
PZ-2_3180	15	3,044	3,060	6949	6953	3189	3181	63	59	59	54	1960	6%	4	8%	5	HIGH
PZ-2_3180	16		3,052	11019	1656	3200	3190	64	67	50	54	1720	5%	3	8%	4	HIGH
PZ-2_3180	19		3,106	28	20	3376	3325	117	111	69	65	2320	5%	6	6%	4	HIGH
PZ-1_High	17	3,084	3,084	13291	13291	3312	3327	99	99	74	75	2080	0%	0	1%	1	HIGH
PZ-1_High	18	3,187	3,200	7856	7871	3330	3326	62	60	32	35	1780	3%	2	9%	3	HIGH

HIGH	17
MEDIUM	3
LOW	0
TOTAL	20

APPENDIX H

Water Capital Improvements Plan

EXHIBIT H-1
Water System Capital Improvements Plan

					Allocations		Pipelines		Costs			Cost Allocation for Pipelines			
Implemen-tation Phase	**ID**	**Improvement Description**	**Reason for Improvement**	**Fire Flow Priority for Pipelines**	**Upgrade Existing**	**Adds Capacity**	**Length (ft.)**	**Diameter (in.)**	**Construction or Mitigation**	**Allowance for Engineering & Administration**	**Total Estimate**	**Serves Immediate Area**	**Additional for Growth**	**Notes**	**Location**
2007-2015	P-11	Pipe	Fire flow	2	25%	75%	180	8	$14,000	$3,000	$17,000	$17,000	$0		West from west end of NW Poplar Pl to existing 4-inch pipe east of NW 11th St
2007-2015	P-13	Pipe	Redundancy and fire flow	3	0%	100%	340	8	$27,000	$5,000	$32,000	$32,000	$0		Along NW 8th St from NW Negus Pl to NW Oak Pl
2007-2015	P-16	Pipe	Fire flow	2	25%	75%	770	12	$92,000	$14,000	$106,000	$71,000	$35,000		West 769 feet from NW Canal Blvd and NE Hemlock Ave
2007-2015	P-17	Pipe	Redundancy and replacement of poor condition pipe	1	0%	100%	7,800	12	$936,000	$141,000	$1,077,000	$718,000	$359,000		Along NW 9th St from NW Maple Ave to SW Highland Ave
2007-2015	P-18	Pipe	Fire flow	2	25%	75%	440	8	$35,000	$6,000	$41,000	$41,000	$0		Along NW Fir Ave from west of NW 7th St to mid-block between NW 6th St and NW 5th St
2007-2015	P-19	Pipe	Fire flow	3	25%	75%	990	8	$79,000	$12,000	$91,000	$91,000	$0		Along NW 5th St from W Antler Ave to NW Dogwood Ave
2007-2015	P-20	Pipe	Fire flow	1	25%	75%	270	8	$22,000	$4,000	$26,000	$26,000	$0		270 ft along NW Birch Ave from NW 12th St
2007-2015	P-21	Pipe	Fire flow	1	75%	25%	380	8	$30,000	$5,000	$35,000	$35,000	$0		Along NW 12th St from NW Birch Ave to W Antler Ave
2007-2015	P-22	Pipe	Growth and redundancy	4	0%	100%	780	8	$62,000	$10,000	$72,000	$72,000	$0		North from W Antler Ave between SW 17th St and SW 15th St to south end of cul-de-sac
2007-2015	P-23	Pipe	Fire flow	1	25%	75%	260	8	$21,000	$4,000	$25,000	$25,000	$0		Along SW Deschutes Ave from SW 12th St to SW 13th St
2007-2015	P-24	Pipe	Fire flow	2	75%	25%	330	12	$40,000	$6,000	$46,000	$31,000	$15,000		Along SW 2nd St from SW Black Butte Blvd to W Antler Ave
2007-2015	P-25	Pipe	Fire flow	2	25%	75%	290	8	$23,000	$4,000	$27,000	$27,000	$0		Along SE Deschutes Ave from SE Franklin Ave to SE Warsaw St
2007-2015	P-26	Pipe	Fire flow	2	25%	75%	320	8	$26,000	$4,000	$30,000	$30,000	$0		Along SW 4th St from SW Forest Ave to SW Evergreen Ave
2007-2015	P-27a	Pipe	Redundancy	4	0%	100%	2,800	12	$336,000	$51,000	$387,000	$258,000	$129,000	Eastern portion, from 27th east across Dry Canyon	NW Spruce Ave, between Northwest Way and NW Helmholtz Way; NW Helmholtz Way between NW Spruce Ave and NW Maple Ave
2007-2015	P-28	Pipe	Growth and redundancy	4	0%	100%	860	10	$86,000	$13,000	$99,000	$79,000	$20,000		Along SE Lake Rd between SE 1st St and E Hwy 126
2007-2015	P-29	Pipe	Fire flow	2	75%	25%	260	8	$21,000	$4,000	$25,000	$25,000	$0		Along SW 14th St from SW Highland Ave to SW Glacier Ave
2007-2015	P-31	Pipe	Fire flow	3	75%	25%	460	12	$55,000	$9,000	$64,000	$43,000	$21,000		Along SW 10th St from USFS Dr to south end of SW 10th St
2007-2015	P-34	Pipe	Fire flow	1	25%	75%	280	8	$22,000	$4,000	$26,000	$26,000	$0		Along SW Quartz Ave from SW 27th St to SW 27th Pl
2007-2015	P-40	Pipe	Fire flow	1	25%	75%	1,640	12	$197,000	$30,000	$227,000	$151,000	$76,000		Along S Hwy 97 from SW Wickiup Ave to SW Odem Medo Way
2007-2015	P-41	Pipe	Fire flow	1	75%	25%	1,030	10	$103,000	$16,000	$119,000	$95,000	$24,000		Along SW Yew Ave between SW Canal Blvd and the Hwy 97 on ramp
2007-2015	P-42	Pipe	Fire flow	2	75%	25%	2,800	16	$448,000	$68,000	$516,000	$258,000	$258,000		SW 19th St, east of Central Oregon Dr
2007-2015	P-43	Pipe	Fire flow	2	25%	75%	270	12	$32,000	$5,000	$37,000	$25,000	$12,000		End of SE Salmon Ave
2007-2015	P-44	Pipe	Fire flow	2	25%	75%	2,100	16	$336,000	$51,000	$387,000	$194,000	$193,000		Parallel to E Highway 126, east of SE Veterans Way
2007-2015	P-51	Pipe	Growth and redundancy	4	0%	100%	480	8	$38,000	$6,000	$44,000	$44,000	$0		SW 31st St between Deschutes and Forest
2007-2015	P-55	Pipe	Fire flow	1	25%	75%	170	8	$14,000	$3,000	$17,000	$17,000	$0		Along SW Wickiup Ave between SW 28th St and SW 27th St
2007-2015	P-56	Pipe	Fire flow	1	25%	75%	330	8	$26,000	$4,000	$30,000	$30,000	$0		Along SW Canal Blvd between SW Wickiup Ave and SW 23rd St

EXHIBIT H-1
Water System Capital Improvements Plan

Implementation Phase	ID	Improvement Description	Reason for Improvement	Fire Flow Priority for Pipelines	Allocations		Pipelines		Costs			Cost Allocation for Pipelines		Notes	Location
					Upgrade Existing	Adds Capacity	Length (ft.)	Diameter (in.)	Construction or Mitigation	Allowance for Engineering & Administration	Total Estimate	Serves Immediate Area	Additional for Growth		
2007-2015	P-57	Pipe	Growth and redundancy	4	0%	100%	3470	12	$416,000	$63,000	$479,000	$319,000	$160,000		Located in southeast area of system
2007-2015	PR-1	Pipe Replacement (6"-8" PVC)	Poor pipe condition		100%	0%	7,500	8	$720,000	$108,000	$828,000				Area between SW 27th St and SW 35th St and between W Antler Ave and SW Glacier Ave
2007-2015	PR-2	Pipe Replacement (6"-8" PVC)	Poor pipe condition		100%	0%	5,700	8	$547,000	$83,000	$630,000				Area between NW 10th St to NW 15th St and between NW Quince Ave and NW Canyon Dr
2007-2015	PR-3	Pipe Replacement (1"-6") in downtown area	Undersized and poor condition pipe		100%	0%	9,720	8	$933,000	$140,000	$1,073,000			Replacement of old, small diameter pipelines in downtown area, which result in low fire flow and lack of reliability	
2007-2015	PR-4	Pipe Replacement east of downtown	Undersized and poor condition pipe		100%	0%	5,480	8	$526,000	$79,000	$605,000			Replacement of 4" and 6" steel lines located between Antler St. and Evergreen St., and 5th St. and the railroad.	
2007-2015	PS-1	Well 7 Pump Station	Future supply		0%	100%			$1,700,000	$255,000	$1,955,000			Based on 5,000 gpm pumping capacity. 3 pumps, each 2500 gpm x 185 ft. Approx. 175 hp each.	NE 11th Street south of NE Glenwood Ave
2007-2015	R-1	Well 7 Reservoir	Future storage. Volume = 3.5 MG. Steel tank.		0%	100%			$3,500,000	$525,000	$4,025,000			At grade, welded steel, 3.5 MG tank	NE 11th Street south of NE Greenwood Ave
2007-2015	V-1	Pressure Reducing Valve (PRV)	Locate on pressure zone boundary, in northwest area.		75%	25%			$50,000	$8,000	$58,000			Allows for transfer of water from PZ 2 to PZ 3.	Northwest Way and Maple Ave
2007-2015	V-2	Check Valve	Located in southeast, at boundary between PZ2 and PZ3.		75%	25%			$50,000	$8,000	$58,000			Allows fire flows from PZ 2 into PZ 3 during high fire flow demands.	SE Airport Way between Mt Jefferson DR and Mt Hood Dr
2007-2015	W-1	Well 8	Supply increase		0%	100%			$2,020,000	$303,000	$2,323,000			Assumes that new well is drilled next to Well 1.	NW Maple Ave west of NW Canyon Dr
2007-2015	W-2	Complete Well 7	Supply increase		0%	100%			$1,280,000	$192,000	$1,472,000			Cost is for well pump and wellhead improvements, only. Well drilling and testing was completed in 2006.	NE 11th Street south of NE Glenwood Ave
2007-2015	W-5	Well 9	Supply increase		0%	100%			$2,020,000	$303,000	$2,323,000			Cost is for well drilling and testing, and for well pump & wellhead improvements	New school well site, vicinity of SW Elkhorn Ave and SW 43rd St
2007-2015	M-1	Mitigation credits purchase	To enable use of additional water rights		0%	100%			$2,025,000	$0	$2,025,000			Estimated purchase cost for mitigation credits from the Deschutes Water Exchange to allow the use of groundwater under a new permit	
2007-2015	**Phase 1 Subtotal**		**$21,500,000**												
2016-2020	P-10	Pipe	Growth and redundancy	4	50%	50%	610	12	$73,000	$11,000	$84,000	$56,000	$28,000		Along W Antler Ave from NW 25th St to NW 23rd St
2016-2020	P-14	Pipe	Fire flow	3	25%	75%	1,630	8	$130,000	$20,000	$150,000	$150,000	$0		South from east end of NE Quince Ave to intersection of NE 8th St and NE Oak Pl
2016-2020	P-2	Pipe	Growth and redundancy	4	0%	100%	2,450	12	$294,000	$45,000	$339,000	$226,000	$113,000		East from Northwest Way and NW 22nd St to NW 19th St, north of NW Quince Ave
2016-2020	P-30	Pipe	Growth and redundancy	4	0%	100%	500	8	$40,000	$6,000	$46,000	$46,000	$0		Along SW 27th St from SW Glacier Ave to SW Highland Ave
2016-2020	P-32	Pipe	Growth and redundancy	4	50%	50%	1,320	12	$158,000	$24,000	$182,000	$121,000	$61,000		Along SW 35th St from SW Obsidian Ave to SW Quartz Ave
2016-2020	P-33	Pipe	Growth and redundancy	4	50%	50%	1,320	16	$211,000	$32,000	$243,000	$122,000	$121,000		Along SW Quartz Ave from SW 35th St to SW 31st St
2016-2020	P-39	Pipe	Fire flow	3	25%	75%	370	8	$30,000	$5,000	$35,000	$35,000	$0		Along SW Timber Ave from SW 25th St to SW 24th St

EXHIBIT H-1
Water System Capital Improvements Plan

Implemen-tation Phase	ID	Improvement Description	Reason for Improvement	Fire Flow Priority for Pipelines	Allocations: Upgrade Existing	Allocations: Adds Capacity	Pipelines: Length (ft.)	Pipelines: Diameter (in.)	Costs: Construction or Mitigation	Costs: Allowance for Engineering & Administration	Costs: Total Estimate	Cost Allocation for Pipelines: Serves Immediate Area	Cost Allocation for Pipelines: Additional for Growth	Notes	Location
2016-2020	P-4	Pipe	Growth and redundancy	4	0%	100%	1,340	12	$161,000	$25,000	$186,000	$124,000	$62,000		Along NW Maple Ave from NW 23rd St to NW 19th St
2016-2020	P-45	Pipe	Growth and redundancy	4	0%	100%	1,300	18	$234,000	$36,000	$270,000	$120,000	$150,000		SE 9th St between E Antler Ave and SE Evergreen Ave
2016-2020	P-46	Pipe	Growth and redundancy	4	75%	25%	1,150	16	$184,000	$28,000	$212,000	$106,000	$106,000		Along E Antler Ave from NW Canal Blvd to NE 9th St
2016-2020	P-53	Pipe	Growth and redundancy	4	0%	100%	5,400	12	$648,000	$48,000	$696,000	$464,000	$232,000	Home Depot	Along NW Canal Blvd, from NW Maple Ave to NE King Way and Along NE King Way to NE 5th St
2016-2020	P-9	Pipe	Growth and redundancy	4	0%	100%	2,600	12	$312,000	$47,000	$359,000	$239,000	$120,000		Along W Antler Ave from NW 35th St to NW 27th St
2016-2020	W-4	Well 10	Supply increase		0%	100%			$2,020,000	$303,000	$2,323,000			Cost is for well drilling and testing, and for well pump & wellhead improvements	NW Hemlock Ave, west of NW 28th St
2016-2020	M-2	Mitigation credits purchase	To enable use of additional water rights		0%	100%			$2,025,000	$0	$2,025,000			Estimated purchase cost for mitigation credits from the Deschutes Water Exchange to allow the use of groundwater under a new permit	
2016-2020	**Phase 2 Subtotal**		**$7,200,000**												
2021-2025	P-1	Pipe	Growth and redundancy	4	0%	100%	2,250	8	$180,000	$27,000	$207,000	$207,000	$0		East from Northwest Way and NW Upas Ave to NW 22nd St
2021-2025	P-15	Pipe	Growth and redundancy	4	0%	100%	1,560	12	$187,000	$29,000	$216,000	$144,000	$72,000		East from Northwest Way and NW Upas Ave to intersection of NW 22nd St and NW 19th St
2021-2025	P-3	Pipe	Growth and redundancy	4	0%	100%	5,300	12	$636,000	$96,000	$732,000	$488,000	$244,000		Northwest Way between NW Maple Ave and NW Upas Ave
2021-2025	P-36	Pipe	Growth and redundancy	4	0%	100%	2,710	12	$325,000	$49,000	$374,000	$249,000	$125,000		NW Hemlock Ave between NW Helmholtz Way and NW 35th St
2021-2025	P-38	Pipe	Growth and redundancy	4	0%	100%	1,240	16	$198,000	$30,000	$228,000	$114,000	$114,000		South from the south end of SW 47th St to SW Badger Ave, east along SW Badger Ave to SW Canal Blvd
2021-2025	P-48	Pipe	Growth and redundancy	4	0%	100%	2,680	12	$322,000	$49,000	$371,000	$247,000	$124,000		Connecting SW Helmholtz Way and W-5, south of Highland
2021-2025	P-49	Pipe	Growth and redundancy	4	0%	100%	2,680	16	$429,000	$65,000	$494,000	$247,000	$247,000		SW Obsidian Ave between SW Helmholtz Way and SW 35th St
2021-2025	P-50	Pipe	Growth and redundancy	4	0%	100%	670	12	$80,000	$12,000	$92,000	$61,000	$31,000		NW 23rd St between NW Fir Ave and NW Hemlock Ave
2021-2025	P-52	Pipe	Growth and redundancy	4	0%	100%	2,060	18	$371,000	$48,000	$419,000	$186,000	$233,000		Along E Antler Ave from NW Canal Blvd to NE 9th St and new FHB reservoir
2021-2025	P-54	Pipe	Growth and redundancy	4	0%	100%	440	12	$53,000	$8,000	$61,000	$41,000	$20,000	Needed to connect PS-2 to existing system	From PS-2 along SW Volcano Ave to SW Reservoir Dr
2021-2025	P-58	Pipe	Growth and redundancy	4	0%	100%	7,880	12	$946,000	$142,000	$1,088,000	$725,000	$363,000		
2021-2025	P-6	Pipe	Growth and redundancy	4	0%	100%	7,630	12	$916,000	$138,000	$1,054,000	$703,000	$351,000	Northern portion is outside of current UGB. Cannot be constructed unless the UGB is expanded.	Along NW 35th St from NW Maple Ave to SW Evergreen Ave
2021-2025	P-7	Pipe	Growth and redundancy	4	0%	100%	2,580	12	$310,000	$47,000	$357,000	$238,000	$119,000		Along Northwest Way from NW Maple Ave to Hemlock Ave
2021-2025	P-8	Pipe	Growth and redundancy	4	0%	100%	3,990	12	$479,000	$72,000	$551,000	$367,000	$184,000		Along NW Hemlock Ave from NW 35th St to NW 23rd St
2021-2025	PS-2	Pump Station	Supply to Zone 1		100%	0%			$540,000	$81,000	$621,000			Based on 1,500 gpm pumping capacity. 3 pumps, each 750 gpm x 185 ft. Approx. 50 hp each.	

EXHIBIT H-1
Water System Capital Improvements Plan

					Allocations		Pipelines		Costs			Cost Allocation for Pipelines			
Implementation Phase	**ID**	**Improvement Description**	**Reason for Improvement**	**Fire Flow Priority for Pipelines**	**Upgrade Existing**	**Adds Capacity**	**Length (ft.)**	**Diameter (in.)**	**Construction or Mitigation**	**Allowance for Engineering & Administration**	**Total Estimate**	**Serves Immediate Area**	**Additional for Growth**	**Notes**	**Location**
2021-2025	R-2	Forked Horn Butte Reservoir	Future storage. Volume = 4.0 MG. Prestressed concrete tank. (Partially buried.)		0%	100%			$5,600,000	$840,000	$6,440,000			One partially buried, prestressed concrete, 4.0 MG tank. (Alternative may be two tanks at 2.0 MG each--cost for this would be higher.)	
2021-2025	W-3	Well 11	Supply increase		0%	100%			$2,020,000	$303,000	$2,323,000			Cost is for well drilling and testing, and for well pump & wellhead improvements	SW Quartz Ave and SW 31st St
2021-2025	M-3	Mitigation credits purchase	To enable use of additional water rights		0%	100%			$2,025,000	$0	$2,025,000			Estimated purchase cost for mitigation credits from the Deschutes Water Exchange to allow the use of groundwater under a new permit	
2012-2025	**Phase 3 Subtotal**		**$17,700,000**												
2026-2030	P-27b	Pipe	Growth	4			7,700	12	$924,000	$139,000	$1,063,000	$709,000	$354,000	Western portion, from 27th west to Helmholtz St. Cannot be constructed unless UGB is expanded.	
2026-2030	P-35	Pipe	Growth and redundancy	4	0%	100%	7,920	12	$950,000	$143,000	$1,093,000	$729,000	$364,000	Cannot be constructed outside of UGB unless UGB is expanded.	East on NW Maple Ave from NW 35th St to NW Helmholtz Way, south on NW Helmholtz Way to W Antler Ave
2026-2030	P-37	Pipe	Growth and redundancy	4	0%	100%	2,660	12	$319,000	$48,000	$367,000	$245,000	$122,000		W Antler Ave between NE Helmholtz Way and NW 35th St
2026-2030	P-47	Pipe	Growth and redundancy	4	0%	100%	6,780	16	$1,085,000	$163,000	$1,248,000	$624,000	$624,000		SW Helmholtz Way between W Antler Ave and Quartz
2026-2030	P-5	Pipe	Growth and redundancy	4	0%	100%	3,950	12	$474,000	$72,000	$546,000	$364,000	$182,000		Along NW Maple Ave from NW 35th St to NW 22nd St
2026-2030	V-3	Pressure Reducing Valve (PRV)	Pressure zone boundary along on west edge		75%	25%			$50,000	$8,000	$58,000				NW Maple Ave and NW Helmholtz Way
2026-2030	W-6	Well 12	Supply increase		0%	100%			$2,020,000	$303,000	$2,323,000			Cost is for well drilling and testing, and for well pump & wellhead improvements	
2026-2030	M-4	Mitigation credits purchase	To enable use of additional water rights		0%	100%			$2,025,000	$0	$2,025,000			Estimated purchase cost for mitigation credits from the Deschutes Water Exchange to allow the use of groundwater under a new permit	
2026-2030	**Phase 4 Subtotal**		**$8,700,000**												
								TOTALS	**$48,900,000**	**$6,100,000**	**$55,000,000**				
								TOTAL WITHOUT MITIGATION CREDITS			**$46,900,000**				

Notes:
1. Project types (ID codes):
    P = pipeline
    PR = pipe replacement
    W = well
    R = reservoir (tank)
    V = valve (pressure reducing or check)
    M = purchase of mitigation credits, to allow use of water rights
2. Pipe Priority Level:
    1 = Residential Fire Flow Improvement, less than 1,000 gpm available
    2 = Commercial or Industrial Fire Flow Improvement, less than 75% of required flow available
    3 = Fire Flow Improvement, more than 75% of required flow available
    4 = Not driven by fire flow deficiency
3. Cost index: ENR CCI Seattle Area = 8626 (January 2007)

EXHIBIT H-1
Water System Capital Improvements Plan

					Allocations		Pipelines		Costs			Cost Allocation for Pipelines			
Implemen-tation Phase	ID	Improvement Description	Reason for Improvement	Fire Flow Priority for Pipelines	Upgrade Existing	Adds Capacity	Length (ft.)	Diameter (in.)	Construction or Mitigation	Allowance for Engineering & Administration	Total Estimate	Serves Immediate Area	Additional for Growth	Notes	Location

4. A 15% allowance was included for engineering and administration. This may be inadequate for some projects, especially for those with involved designs, significant permitting, or requiring high levels of services during construction.
5. Allowance cost for purchase of mitigation credits was provided by city. Actual costs may vary.
6. Project P-12, a 12-inch pipe on NW Quince Ave., between NW 10th St. and NW 7th St., was constructed in summer 2007 as the master plan was being completed.