August 2010

City of Forest Grove
Water Master Plan Update

city of forest grove

HDR

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Prepared with:

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Executive Summary

Purpose

The purpose of this plan is to evaluate the City of Forest Grove water system facilities to: (i) determine water supply requirements using updated population and water demand forecasts; (ii) identify distribution system deficiencies; (iii) identify options to meet water supply needs; (iv) recommend water system improvements and estimate associated improvement costs; and (v) update the City's 2000 Water Master Plan (WMP) document.

Existing Water System

The City of Forest Grove water system serves residential, commercial, and industrial consumers, primarily within the existing City limits. A limited number of customers are located along Gales Creek to the west of the City

Water Rights

The City of Forest Grove owns several live flow (i.e. not from stored water releases) water rights that can be used in conjunction with its JWC water supply. Forest Grove has three certificates authorizing use of live flow of up to 2.80 cubic feet per second (cfs) from branches of Clear Creek, a tributary of Gales Creek, for municipal purposes. The priority dates for these rights range from March 29, 1917, to July 27, 1939. Forest Grove also holds a water right certificate for the use of 4.46 cfs from Gales Creek for municipal use with a priority date of February 14, 1947. Forest Grove holds permit S-40615 which authorizes the City use of up to 2.43 cfs from Roaring Creek, and 2.83 cfs from Clear Creek for municipal purposes, and 33 cfs from the Tualatin River. Permit S-40615 has an April 28, 1976 priority date. In 2008, the City modified a claim of beneficial use (COBU) for permit S-40615 to split out the Tualatin River portion. The City received a certificate for the Tualatin River portion from Oregon Water Resources Department (OWRD). At this point, the COBU for Roaring Creek and Clear Creek portion is sitting in the OWRD file, but the Tualatin River portion has been certificated.

In addition, the City of Forest Grove has contract water rights with the Bureau of Reclamation in Hagg Lake (Scoggins Reservoir; 4,500 acre-feet annually) and owns water rights for stored water in Barney Reservoir (500 acre-feet annually). The City also has a buy-back option for 800 acre-feet for annual use Barney Reservoir

City of Forest Grove Water System

The City has intake facilities within the Clear Creek watershed on Clear Creek, Roaring Creek, Thomas Creek, Deep Creek and Smith Creek. During the summer, this supply is limited by the low flows in the creeks and drops to as low as approximately 1.5 million gallons per day (mgd) – less than half of the current certificated water rights the City has from the watershed. The 16-inch diameter raw water transmission main from the Clear Creek basin intake facilities to the City WTP is approximately seven miles long. There is a booster pump station along the 16-inch diameter raw water transmission main between the Clear Creek watershed and the City's WTP. City staff estimates the gravity capacity of the raw water main at approximately 2.7 mgd. The booster pump station can increase flows to the plant up to approximately 3.7 mgd.

The City of Forest Grove Water Treatment Plant has a firm plant capacity of 3.7 mgd, but is closer to 3.5 mgd when accounting for backwash operations. The plant is of conventional design, consisting of rapid mix, flocculation, sedimentation, and rapid sand filtration.

Filtered water is piped by gravity to the City's Main Reservoir (with nominal storage volume of 4.27 million gallons [MG]) covered reservoir located adjacent to the WTP prior to distribution. The City's 1.0 MG David Hill Reservoir was constructed in 1985. The facility is located on David Hill Road just outside the city limits.

The City of Forest Grove has three pumping facilities: (i) raw water booster pump station along the transmission main to the City WTP (described above); (ii) David Hill Pump Station; and (iii) Watercrest Pump Station. The David Hill PS was the primary means to pump water from the Main (lower) Pressure Zone to the David Hill Reservoir. The City now uses the Watercrest PS as the primary pump station feeding the David Hill Reservoir and Upper Pressure Zone. The David Hill PS is now used as the back-up.

The water distribution system is comprised of piping ranging in size up to 24 inches in diameter with pipe types including cast iron, ductile iron, copper, steel, wrought iron, galvanized iron, and polyvinyl chloride (PVC). Newer distribution piping is primarily ductile iron. The distribution system contains approximately 78 miles of distribution main pipelines.

Joint Water Commission Supply, Transmission, and Storage

The City of Forest Grove is a party of the Joint Water Commission (JWC), which also includes Cities of Hillsboro, Beaverton, and the Tualatin Valley Water District. The JWC is a joint operation for the transmission, treatment, and storage of municipal and industrial water owned by the member agencies. The City of Forest Grove uses the JWC water supply typically to meet peak demands in the summer season, and in the winter months when the City's water treatment plant needs maintenance.

The JWC water treatment plant is located on Spring Hill Road south of Forest Grove and draws water from an intake on the Tualatin River. The JWC plant is a conventional rapid mix, flocculation, sedimentation, and rapid sand filter design with a current capacity of 75 mgd. The City currently has a 13.33% ownership in the WTP capacity which is equivalent to 9.975 mgd. Finished water from the JWC plant is stored in the two 20 MG Fern Hill Reservoirs located near the JWC plant. A 72-inch diameter JWC transmission main was constructed in 2001 primarily to serve Hillsboro and Tualatin Valley Water District. This line runs through the east side of the City of Forest Grove, and includes an 8-inch tee and valve at Mountain View Lane and Heather Street which could serve as a manually-operated emergency intertie in the future. JWC water is supplied from the Fern Hill Reservoir to the City of Forest Grove through approximately 8,000 feet of 24-inch diameter transmission main jointly owned by the City of Forest Grove and the City of Hillsboro. A pressure reducing, flow control and metering station located on 10th Avenue regulates the supply pressure to match that of the City-owned water facilities and controls the flow rate of JWC water supplied to the City. The City maintains ownership of 5.3 MG of the two JWC 20 MG Fern Hill Reservoirs located near the JWC treatment plant. However, only 2.8 MG is available for the City's in-town storage use based on operational agreements with JWC.

Pressure Zones and Service Areas

The City of Forest Grove water system supplies three pressure zones and an outside service area. The Main (Lower) Pressure Zone includes most of the City of Forest Grove (over 5,900 connections). The reservoir at the City WTP site and the pressure reducing station on the JWC supply line hydraulically serve the main pressure zone. The Intermediate (182 connections) and Upper Pressure Zones (593 connections) are located in the northwest corner of the City. These pressure zones are served from the Main Pressure Zone by the David Hill PS and Watercrest PS and the David Hill Reservoir. The upper

pressure zone is directly served by the reservoir while the intermediate pressure zone requires pressure reducing stations to provide appropriate service pressures. The Gales Creek Service Area is outside of the City of Forest Grove (57 connections). This service area includes the water customers originally served off the 16-inch raw water supply line running along Gales Creek to the City of Forest Grove WTP.

Planning Data

The planning data used in this plan are intended to be consistent and are not meant to supersede the City's Comprehensive Plan or information developed by the City's Planning Department. The City decided to use a 40-year planning period (2010 to 2050) to complete this Water Master Plan update. The service area identified for this plan is the area encompassed by the City of Forest Grove Urban Growth Boundary (UGB) as defined on the City's current Comprehensive Plan Map. Existing land uses within the study area include residential, commercial and industrial, public, semi-public and institutional, and parks and open space.

Urban Reserve Areas and Regional Growth Perspective

Urban Reserve Areas (URA) are the lands outside an urban growth boundary that will provide for future expansion over a long-term period. These three primary urban reserve areas were considered in the WMP update:

- **Purdin Road Urban Reserve Area** – located to the north of the western half of the existing City limits; over 300 acres of largely industrial zoned land, with some mixed use and residential acreage; most of the development is anticipated to occur in 20 to 30 years (2030 to 2040).
- **David Hill Urban Reserve Area** – located to the west and in higher elevation area of the existing City limits; over 180 acres of primarily residential and some limited commercial acreage; most of the development is anticipated to occur in 25 to 30 years (2035 to 2040).
- **North Water Planning Area** (not adopted as URA by Metro as of June 2010) – located to the north of the eastern half of the existing City limits; over 1,200 acres of largely industrial zoned land, with mixed use and residential acreage this area was included in the WMP update as part of the "high demand scenario" only; the City does not anticipate development to occur in this area before 2040, if at all.

Information provided by the City's planning department for the purposes of the WMP Update was used to define the land absorption timeline within the URAs and redevelopment within the City UGB.

The City developed the population and water demand forecast for the WMP update to account for "low, medium and high" growth scenarios. For consistency, the WMP update based the forecast on information from the *Economic Opportunity Analysis* and the land absorption analysis with some modifications based on best professional judgment from the City's Planning Department staff. Population data is needed for water master planning, because it provides the basis for forecasting growth in water demand – especially with respect to residential water demands.

The water demand forecast used for the WMP update is a "dis-aggregated" approach whereby the major customer classes are forecasted separately and then added together for the total water demand over the planning period. The advantage of this approach over a simple "per-capita" approach is that factors specific to each customer class can be accounted for and effects on demand better understood, e.g. land use change or development patterns, and water use factors. Based on the information from the historical water use analysis the following bullets summarize the planning basis for the water demand forecast:

- Residential per capita water use = (residential+multi-family water use)/City population = 75 gpcd
  - Single family = 72% of total residential demand (ADD)
  - Residents per dwelling = 2.60
- Large Water Users
  - Industrial: ADD = 0.41 mgd (Merix, Westak, Gray & Company, and Lieb Cold Storage)
  - Commercial: ADD = 0.062 mgd (Rose Grove Mobile Homes)
  - Large users are subtracted from total sector demands to calculate water use factors, and not assumed to change over the planning period
- Per acre water use = (Consumption/Total acreage)
  - Commercial = 1,600 gpad
  - Industrial = 650 gpad
  - Public (school and city) = 310 gpad
- Industrial reserve = 0.25 mgd (for Scenarios A and B) and 0.5 mgd (for Scenario C) starting 2015
- Non-revenue water = (Production-Consumption)/Production = 12%
- Peaking factor (average day demand [ADD] x Peaking Factor = maximum day demand [MDD])
  - Residential = 2.0
  - Commercial/Industrial = 1.5
  - City/School = 2.0
- Water savings rate from conservation (over planning period)
  - Residential, school, and city conservation: 0.5% - 2.5% for ADD
  - Commercial/industrial conservation: 0.25% - 1.25% for ADD
  - Residential, school and city conservation: 0.5% - 2.5% for MDD

Consistent with the population forecasting scenarios discussed above, a range of scenarios representing "low, medium, and high" demand forecasts was prepared. The three scenarios are largely defined by the population and land absorption analysis:

Scenario A – Low growth - Infill and Increased Density Only

- "Build-out" is approached within current City limits (2031); growth rate then reduces for the remainder of the planning period;
- Zoning and land use does not significantly change over the planning period;
- No expansion of UGB.

Scenario B – Moderate growth – Infill, Redevelopment and Urban expansion

- Less moderate residential growth in the near-term within City limits; Purdin Rd. area and David Hill area expansion based on land absorption analysis defined by City;
- Land absorption timeline defines commercial and industrial growth in the redevelopment, Purdin Rd. and David Hill areas.

Scenario C – High Growth – Redevelopment and Urban expansion with North Area Concept

- Moderate residential growth in the near-term within City limits; Purdin Rd. area and David Hill area expansion based on land absorption analysis defined by City; growth rate further increases when North Water Planning Area land is available (beyond 2040) (assumed for water supply planning only) ;
- Land absorption timeline is used to distribute residential, commercial and industrial growth in the redevelopment, Purdin and David Hill areas.

The results of the demand forecast are summarized in **Table ES-1** for the milestone periods for all three scenarios. The demands are allocated throughout the service area (and pressure zones) using a combination of metered account data and land use designation using GIS analysis. **Figure ES-1** shows the demand forecast curves of each scenario for the entire planning period.

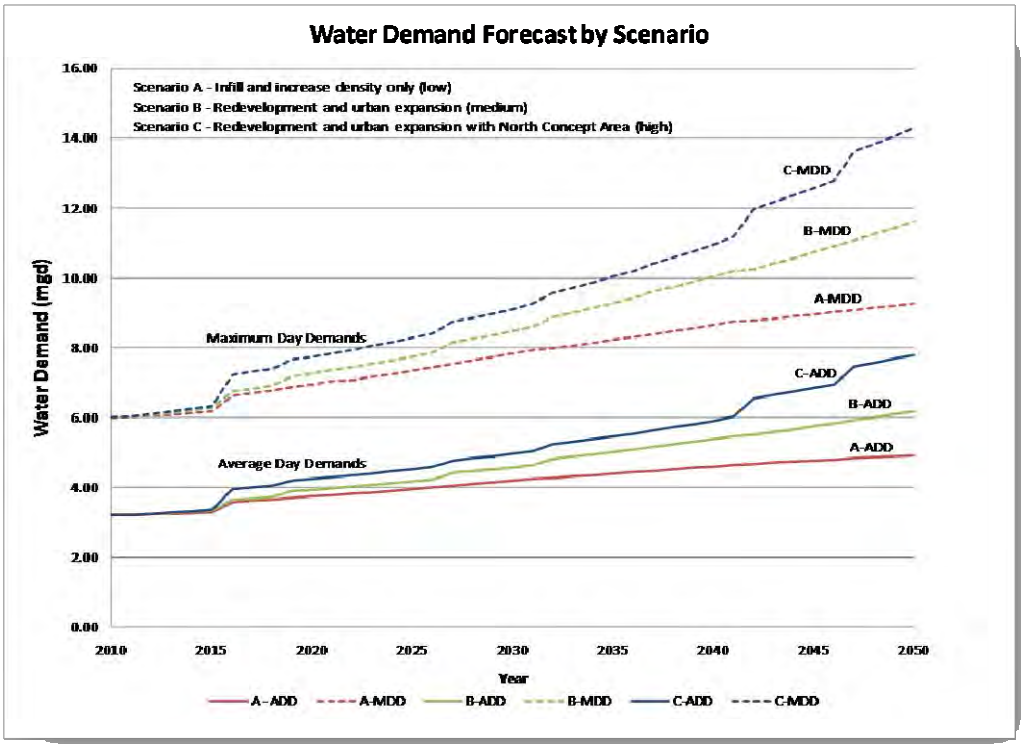
Table ES-1: Summary of Demand Forecast Results (million gallons per day)

Year	Scenario A		Scenario B		Scenario C	
	ADD	MDD	ADD	MDD	ADD	MDD
2010	3.20	6.02	3.20	6.02	3.20	6.02
2017	3.62	6.70	3.69	6.83	4.00	7.31
2030	4.19	7.83	4.57	8.47	4.96	9.11
2050	4.93	9.28	6.19	11.62	7.80	14.30

ADD – average day demand; MDD – maximum day demand

Scenario A water demands are conservative in that no growth in the City's service area is allowed. Scenarios B and C both allow growth to URAs, allowing greater residential and industrial/commercial demands growth. Within the first milestone period (2017), the maximum day water demands are not significantly different (a range of ~ 0.60 mgd) between the low and high demand scenarios. However, the result is a difference of over 5 mgd MDD between the low (A) and high (C) scenarios by the end of the planning period (2050). As discussed in Section 4, Scenario B water demand forecast is the basis for the system analysis as the medium growth scenario. In particular, the City is forecasted to have a maximum day water demand increase of almost 5.6 mgd over the 40 year planning period.

Figure ES-1 – Annual Water Demand Forecast by Scenario



Planning Criteria and System Requirements

Infrastructure planning criteria used to evaluate the City of Forest Grove water system facilities are based on industry standards and requirements from Oregon Department of Human Services (per ORS 333-61-060). The infrastructure planning criteria were used in conjunction with the hydraulic model developed for this master plan to identify existing and future system deficiencies throughout the system.

- **Supply and Transmission.** The supply and transmission systems must be capable of providing treated water to the City of Forest Grove water system to meet the estimated maximum daily demands (MDD) through the end of the planning period. For purposes of developing the CIP, the City is using Scenario B for maximum day demand as the planning criteria.
- **Storage.** Water storage facilities should be provided in each pressure zone except in special cases where direct pumping can be justified. Storage facilities are provided for three purposes: operating storage, fire storage, and emergency storage. The City adopted the following storage criteria for this WMP Update:
    - Operating Storage = 25% of maximum day demand;
    - Fire suppression storage = most severe fire flow demand (volume) within the area served by the storage facility;
    - Emergency Storage = 75% of maximum day demand.
- **Distribution system.** The system performance guidelines presented below have been developed consistent with State requirements, American Water Works Association acceptable practice guidelines, and operational practices of similar communities.
    - Provide maximum day demand while maintaining a minimum service pressure at any meter in the pressure zone of 40 pounds per square inch (psi).
    - Provide required fire flow to a given location while at the same time supplying the maximum day demand and maintaining a minimum residual service pressure at any meter in the pressure zone of 20 psi.
    - Provide peak hour demand while maintaining service pressures at not less than 30 psi.

System Analysis

Supply Analysis

In general, the City of Forest Grove has sufficient raw water supply and water rights to meet demand over the entire planning period (through 2050). Even under the most aggressive demand growth assumptions, additional raw water is not needed until after 2045, when maximum day demands exceed the peak supply capacity from the Clear Creek watershed and Barney and Scoggins reservoir stored water releases. However, by 2023 the maximum day demands exceed the current supply transmission capacity of the 24-inch line from the JWC source at Fern Hill reservoir.

The reliable summer stream flow from the Clear Creek watershed (including Gales Creek) is 1.5 mgd (from historical observation and data), which is significantly lower than the allowed rate of diversion of 8.1 mgd. The raw water supply analysis in this plan assumes that the stored water from Barney and Scoggins reservoirs is used by the City only during the peak demand season (May 1 – October 31 = 184 days). **Table ES-2** summarizes the estimated monthly stored water release flows available for use by the City based on historical JWC production used by the City. These are the values used to evaluate the raw water supply available to meet maximum day demands.

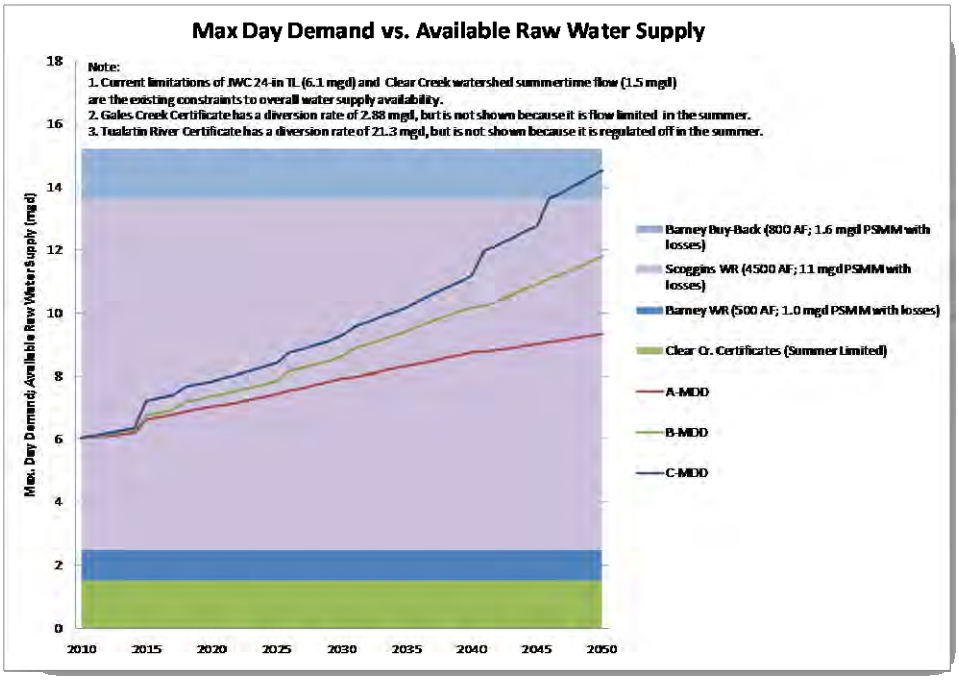
Table ES-2: Peak Season Monthly Stored Water Release Factors and Flows

Month	Peak Season Release Factor	Barney Reservoir Average Release Flow[(1)] (mgd)	Scoggins Reservoir Average Release Flow[(2)] (mgd)	*Current* Available Stored water release flow (mgd)	Barney Buy-Back Average Release Flow[(3)] (mgd)
May	0.4	0.27	3.0	**3.2**	0.43
June	0.8	0.54	5.9	**6.5**	0.86
July	1.2	0.82	8.9	**9.7**	1.3
August[(4)]	1.5	1.0	11.1	**12.1**	1.6
September	1.4	0.95	10.4	**11.3**	1.5
October	0.7	0.51	5.5	**6.1**	0.81

(1) Barney Reservoir peak season average release flow = 0.68 mgd.
(2) Scoggins Reservoir peak season average release flow = 7.41 mgd.
(3) Barney buy-back (future) peak season average release flow = 1.42 mgd.
(4) August values are used as the basis for comparing stored water available against max. day demands.

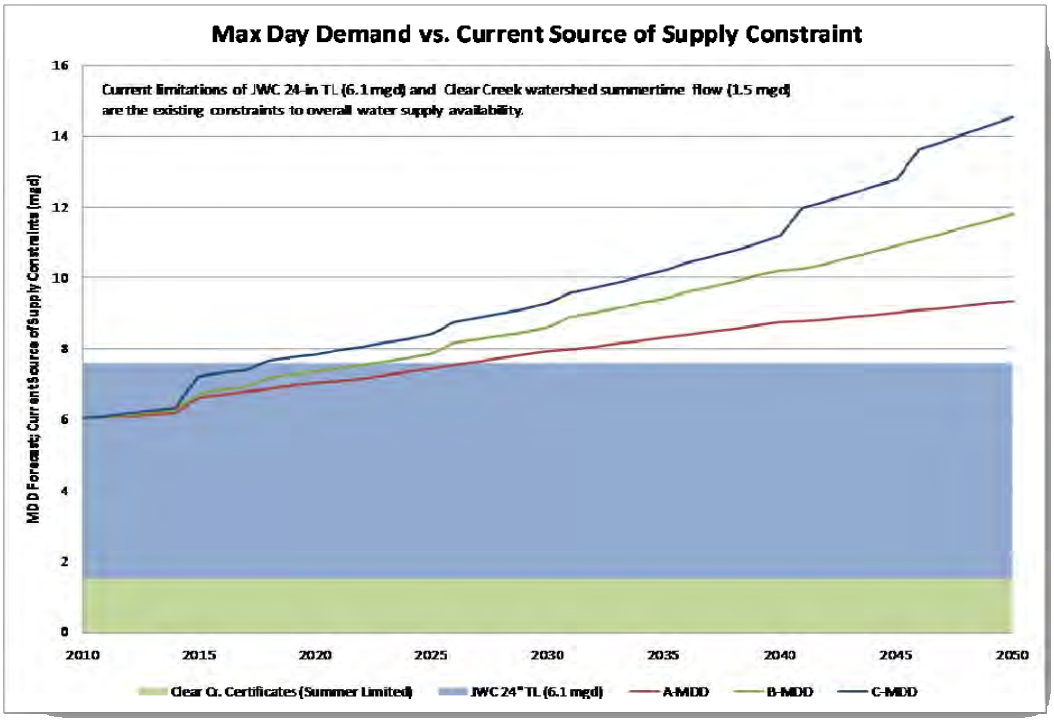
Figure ES-2 illustrates the comparison of the City's currently available raw water supply to the forecasted maximum day demand. Forest Grove has sufficient water rights and storage ownership to meet maximum day demands for the entire planning period (2050) under Scenario B, and through year 2046 under the most aggressive growth scenario assumed in Scenario C. In this case, including the Barney buy-back option would provide sufficient water beyond the 2050 planning period. The City would still have the Gales Creek certificated water right to use for longer-term needs.

Figure ES-2 – Comparison of Maximum Day Demands to Available Raw Water Supply



The limiting supply factors for the City are the JWC transmission capacity of 6.1 mgd, and the 1.5 mgd reliable summertime capacity from the Clear Creek watershed. The City's forecasted demand will exceed the 7.6 mgd combined supply capacity by approximately year 2023. **Figure ES-3** illustrates the limiting supply factors and compares them to the maximum day demand forecast scenarios.

Figure ES-3 — Comparison of Forecast Maximum Day Demand to Limiting Supply Factors



Based on the analysis described above, ***the City needs to increase its transmission capacity to deliver finished water from its JWC supply from Fern Hill Reservoir by year 2023*** based on the moderate growth scenario (B). This period shortens to year 2018 if more aggressive growth conditions occur (under Scenario C). A transmission line with capacity of 6 mgd would be sufficient to meet long-term demands through 2050 if the City continues to use its own WTP (limited by streamflow availability to 1.5 mgd in the summer period).

The City does not need new sources of supply in the next 40 years. Current raw water supplies are projected to be sufficient to meet forecasted demands through the planning period (2050). If the higher growth scenario occurs (Scenario C), the City may need to pursue the Barney buy-back option after year 2045, and would need to consider other supply options, including further increasing transmission capacity from the JWC supply.

While new supply sources are not needed in the near-term, ***the City should continue to track and update water supply options to improve the reliability and redundancy of their source of supply***, especially as part of the recommended "water rights strategy" for their Gales Creek water right.

Summary of Water Supply Recommendations

The following is summary of the recommendation to address the City's water supply needs. The order of the recommendations listed is generally based on chronological need. Specific capital improvement projects and studies are included in the CIP discussion in Section 7:

- ***Complete a "Water Rights Strategic Plan"*** to address how to utilize the Gales Creek water right (certificated) with the objective of maximizing use of the City's WTP, increasing supply redundancy and reliability. The Strategic Plan should incorporate opportunities for optimizing use of the City's water rights in JWC operations to improve reliability and redundancy of its current supply sources. Additionally, this strategic plan should explore ways to strategically develop longer-term supply with JWC partners in looking ahead beyond the 2050 planning period.
- ***Complete a Tualatin Valley Irrigation District Supply Options Study*** specifically evaluating the feasibility and cost-effectiveness of using TVID irrigation line to wheel water along Purdin Road to the Forest Grove WTP in order to maximize the operations the City's plant during low flow periods.
- ***Complete Forest Grove WTP improvements (near-term and long-term)*** to improve operations and safety. The recommended improvements are not intended to increase WTP capacity. Additional recommendations may be necessary based on findings from the TVID Supply Options Study. The near-term improvements for safety should be implemented within the next two years. Long-term improvements for the residuals collection and plate settlers can be extended beyond 10 years.
- ***Install Emergency Intertie with the JWC 72-inch North Transmission Line*** to improve reliability and ability to address emergency fire suppression needs.
- ***Design and construct 18" parallel finished water transmission line from JWC Fern Hill Reservoir*** to increase delivery capacity by 6 mgd (to 12 mgd). This total will allow for the City's current JWC WTP ownership of 10 mgd, and allow the capacity to deliver the flows from a future Barney buy-back option (1.08 mgd).
- ***Continue re-evaluation of supply strategies on a regular basis (every 3 years)*** based on updated water demand forecast (WMP update process) and conclusions from the Water Rights Strategic Plan, and continuing planning by the Joint Water Commission and Tualatin Basin Water Supply Project. The supply strategy evaluation should consider the need for additional Barney Reservoir buy-back.

Storage Analysis

The results of the storage analysis are discussed below. The lower pressure zone (LPZ) includes the existing City service area in the LPZ and the development in the Purdin Road URA. The existing storage serving the LPZ includes 4.27 MG at the Forest Grove WTP and 2.8 MG from the JWC Fern Hill Reservoir, for a total of 7.07 MG. The analysis shows no need to build new storage for the LPZ until late in the 20-year planning horizon. Based on the storage criteria, the LPZ will have a storage deficiency of 1.8 MG by 2030, and a total of 4.3 MG by 2050.

The intermediate pressure zone (IPZ) and upper pressure zone are analyzed together because the IPZ is relatively small and would not realistically be served by its own reservoir. Development in the David Hill URA is forecast to occur after 2030 consistent with the City's land absorption analysis. The analysis considers storage needed to serve the IPZ and UPZ, and the case where additional storage could serve the IPZ-UPZ and David Hill URA development. The existing storage serving the IPZ and UPZ includes 1.0 MG at the David Hill Reservoir. Based on the storage criteria, the IPZ and UPZ have a current storage deficiency of 0.06 MG, which increases to 0.12 MG by 2017, 0.32 by 2030, and up to 0.54 MG by 2050. The David Hill URA has a storage deficiency of 0.90 MG by the end of the planning period.

Any new storage built to serve deficiencies in the UPZ-IPZ can be built at a higher elevation to allow it to also serve the David Hill URA in the future. However, the most cost-effective and feasible approach to storage is dependent on land availability and costs, and available funding from the City in the near-term. For the purposes of the capital improvement program, it is recommended to follow the more incremental approach to storage. However, if low cost land in the David Hill Area is available (see Figure 6-6), the City should re-evaluate this recommendation. **Table ES-3** summarizes the recommended storage improvements for each pressure zone. The following improvement projects are recommended to address storage requirements:

Table ES-3: Recommended Storage Improvements by Pressure Zone

Year	Lower Pressure Zone	Upper and Intermediate Pressure Zones	David Hill URA
2010	N/A	N/A	N/A
2017	N/A	0.30 MG(1)	N/A
2030	2.25 MG	0.30 MG(1)	N/A
2050	2.25 MG	N/A	1.0 MG

Note: Units in million gallons; analysis assumes JWC storage and Fern Hill Reservoir is available.
(1) City may decide to build a 0.60 MG tank by 2015 rather than phasing two smaller tanks of 0.30 MG.

If low cost land in the David Hill URA is available (see **Figure 6-6**), the City should re-evaluate this recommendation; in addition, if the Hilltop area within the UGB or David Hill URA develops faster within the next 20 years, the City may consider accelerating the 1 MG reservoir.

Distribution System Analysis

A new water distribution system model was developed for this WMP update in Bentley WaterGEMS platform. The new hydraulic model was developed "from the ground up" and relied on the most recent distribution system data maintained by the City in their GIS database. The model was generally limited to 4-inch and larger in diameter water lines. In addition to pipeline improvements, the model was updated to include the pump stations, pressure reducing valves, and reservoirs. **Table ES-4** lists the modeling scenarios that were analyzed using the WaterGEMS model developed for the Water Master Plan Update. The scenarios are based on standard practice and design criteria described in Section 5.3. All modeling scenarios apply Scenario B demand forecast as discussed above.

Table ES-4: Summary of Hydraulic Modeling Scenarios

Scenario	Design Criteria	Supply	Demand Period
1. Max. Day Demand	Min. 40 psi	FG WTP + JWC	2010, 2017, 2030
2. Max. Day Demand + Fireflow	Min. 20 psi	FG WTP + JWC	2010, 2017, 2030
3. Peak Hour Demand	Min. 30 psi	FG WTP + JWC	2010, 2017, 2030
4. Average Day Demand (FG WTP only)	Min. 40 psi	FG WTP	2010, 2017, 2030
5. Storage siting analysis @ MDD	Min. 40 psi	FG WTP + JWC	2050
6. Transmission (David Hill & Purdin Rd.) @ MDD	Min. 40 psi	FG WTP + JWC	2050
7. Transmission to North Water Planning Area @ MDD	Min. 40 psi	FG WTP + JWC	2050

Notes:

- *Other primary design criterion is to consider max. flow velocities in the distribution system (5-8 fps).*
- *The storage siting analysis can actually be completed as part of Scenario 1, but listed separately emphasize some additional considerations that the City might request for siting criteria.*

A summary of the hydraulic modeling results from the scenarios modeled in **Table ES-4** is presented below:

- *Maximum Day Demand; City Supply and JWC Supply* -- The results of this scenario indicated that all service pressures would be maintained above 40 psi during maximum day demand conditions. Service pressures dropped below 50 psi in only a few areas.
- *Fire flows during peak day demand; City Supply and JWC Supply* -- The results of this scenario indicated that fire flow requirements and maximum day demand were not satisfied at all locations to maintain a minimum residual pressure of 20 psi throughout the system.
    - **East-side Commercial-Industrial zone (area between TV Hwy. – 24th Ave. – Yew St.)** – The City has commercial fireflow requirements of 3,500 gpm. The existing pipelines in this area are typically 8-inches. Up-sized pipes to 10-inches would increase flow capacity. Additionally, the 10-inch pipeline along Mountain View Lane could be up-sized from 10-inches to 12-inches to increase fireflow for the Neil Armstrong Middle School.
    - **School and semi-public areas (various locations)** – several areas near schools show fireflow deficiencies based on the fireflow requirement of 4,500 gpm. These areas include Tom McCall Middle School (Pacific Ave. & E Pl.); Pacific University campus (Pacific Ave.-College Way-Cedar St.); Neil Armstrong Middle School (Mountain View Hwy.). The pipelines in these areas should be upsized (typically one standard pipe diameter increment).
    - **Residential dead-end and small diameter pipelines (various locations)** – several areas associated with hydrants at dead-end roads or with small (2-inch) lines had deficiencies to meet the 1,000 gpm fireflows. The pipeline areas should be upsized (typically one standard diameter increment; with a minimum of 6-inches used for all residential-zoned areas).
- *Peak hour demand; City Supply and JWC Supply* -- The results of this scenario indicated that during peak hour demand conditions, all service pressures would be maintained at no less than 30 psi. These results were considered adequate and no additional piping improvements were recommended due to this model run.
- *Average Day Demand (curtailment) + Fireflow; City Supply Only* -- The results of this scenario indicated that all service pressures would be maintained above 20 psi , with the exception of the area to the southeast near Poplar Lane and Mountain View Lane. These results were considered adequate and no additional piping improvements were recommended. Because this scenario is considered an emergency scenario with the JWC supply off-line, an emergency intertie at 72-inch North Transmission Line was evaluated to address the fireflow needs in the southeast section of the City. Adding the intertie addresses the fireflow needs, and has been identified as a recommended improvement to address this issue, as well as to generally provide added reliability to the City's access to JWC supply.

Summary of Distribution System Recommendations

The following are recommendations to address distribution system deficiencies. In general, the distribution system recommendations are needed to increase the hydraulic capacity of the distribution system, in particular to provide adequate fire flows.

- Complete pipe replacement projects based on the need to address deficiencies in meeting the "MDD + Fireflow" conditions. All of the replacements are in the lower pressure zone, with a majority in the eastside industrial area. The projects should be coordinated with any redevelopment activities, in particular those around Pacific Ave.

- Install David Hill Road waterline to supply water to the future David Hill URA and reservoir.
- Pump station and PRV to supply water to the David Hill URA reservoir and allow water to feed into UPZ.
- Emergency Intertie at 72-inch NTL.

Recommended Capital Improvement Program

This Water Master Plan Update includes a recommended capital improvement program for the City of Forest Grove that provides for the correction of existing deficiencies and expansion of the water system to support anticipated future development. The City's adopted Capital Improvements Program for 2010-2015 includes preliminary projects and cost estimates for projects identified in the short term; and includes longer-term projects based on the 40-year planning period.

It should be noted that not all of projects included in the CIP were a direct result of analysis from completed for this WMP update. Some of the projects are on-going projects or commitments identified by the City for the Joint Water Commission, Tualatin Basin Water Supply Project, or other operation and maintenance activities. Furthermore, not all of the CIP projects are infrastructure related; the CIP also includes specific studies or plans that the City would like to track for their operating budget. The CIP projects are divided into the following general improvement categories:

- ***Source of Supply, Transmission and Interties*** – address identified issues and deficiencies related to water source and transmission facilities.
- ***Treatment*** – address identified issues and deficiencies at the water treatment plant.
- ***Finished Water Storage*** – address identified issues and deficiencies related to storage needs and associated facilities.
- ***Distribution and Piping System*** – address identified issues and deficiencies related to the distribution and piping system, including pump stations and pressure reducing stations.
- ***Miscellaneous Projects and Studies*** – address identified studies needed for evaluating feasibility of recommended projects or developing long-term strategies for the water system.
- ***Joint Water Commission –*** known or anticipated improvements needed for JWC facilities.
- ***Tualatin Basin Water Supply Project*** – known or anticipated commitments for TBWSP planning or facilities.
- ***Contingency Funds –*** set asides for major repair and replacement of infrastructure.

Table ES-5 presents a summary of the comprehensive water system CIP, including the expenditures by year over the planning period. For the CIP projects identified, project prioritization was based on identified system deficiencies, and discussions and workshops with City personnel. Projects addressing system deficiencies were given the highest priority and are shown with an estimated date within the next 5 years. Other projects are listed in chronological order based on the associated "project driver." Predesign and final design phases should be initiated prior to this date to ensure that the project is completed to meet system needs.

The City has an on-going renewal and replacement program to address older pipe (i.e., pipelines approaching their design life). The City also conducts Clear Creek watershed maintenance activities. These were not included in the CIP table, as they are tracked and budgeted under a separate maintenance budget. These budgets are generally paid for through customer rate fees.

Projects designed to address current system deficiencies are assumed not to be growth related. Projects that only address future demand needs are designated to be 100% growth related.

Table ES-6: Water System Capital Improvement Program – City of Forest Grove

CIP No.	Project Code	Capital Improvement	Present Worth Cost (2010)	Anticipated Implementation Fiscal Year	Project "Driver"	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	Anticipated Cost 2018-2030	Anticipated Cost 2031-2050
Source of Supply, Transmission and Interties														
	SR01	Water Rights Strategic Plan	$ 30,000	2012	Supply Reliability		$ 30,900							
	SR02	TVID Supply Option Study	$ 45,000	2013	Supply Reliability			$ 47,741						
W50	SR03	JWC North Transmission Line Emergency Intertie at Heather St.	$ 250,000	2016	Supply Reliability						$ 289,819			
	SR04	JWC Parallel Supply Line (18" - 6 mgd capacity)	$ 3,500,000	2020	New development (SDC)								$ 4,566,706	
	SR05	Raw Water Booster Station Upgrade	$ 200,000	TBD	Existing system (Rates)									
	SR06	Raw Water Transmission Line Replacement (15 year remaining life)	$ 2,500,000	TBD	Existing system (Rates)									
W47	SR07	Gales Creek Source Improvements	$ 2,500,000	TBD	Supply Reliability									
	SR08	*TVID Supply Plan transmission extension*	TBD	TBD	Pending MS-01									
W8	SR09	JWC Barney Reservoir Buy-Back	$ 1,500,000	TBD	New development (SDC)									
	SR10	TBWSP water supply future buy-in	TBD	TBD	New development (SDC)									
Not assigned	SR11	Scoggins Siesmic Retrofit	$ 4,900,000	TBD	Existing system (Rates)									
	SR12	JWC ASR Future buy-in	TBD	TBD	New development (SDC)									
	SR13	Watershed Road Improvements	$ 20,000	Annual	Existing system (Rates)	$ 20,000	$ 20,600	$ 21,218	$ 21,855	$ 22,510	$ 23,185	$ 23,881	$ 372,969	$ 942,347
	SR14	Fish Screen at Fern Hill Pump Station	$ 320,000	TBD	Existing system (Rates)									
	SR15	Raw Water Pipeline	$ 2,700,000	TBD	Existing system (Rates)									
Treatment														
	TR01	WTP safety and operations improvements	$ 30,000	2013	Existing system (Rates)			$ 31,827						
	TR02	Mechanical sludge/residuals collection system	$ 150,000	2016	Existing system (Rates)						$ 173,891			
	TR03	Plate settlers and launder replacement	$ 700,000	2018	Existing system (Rates)								$ 860,912	
	TR04	TVID Supply Treatment modifications (pending MS-01)	TBD	TBD	New development (SDC)									
W3	TR05	Forest Grove WTP Major Maintenance	$ 10,000	Annual	Maintenance (Rates)	$ 10,000	$ 10,300	$ 10,609	$ 10,927	$ 11,255	$ 11,593	$ 11,941	$ 186,485	$ 471,174
Finished Water Storage (in-town)														
W31	ST01	Land Acquisition for Upper Zone storage	$ 100,000	2012	New development (SDC)		$ 103,000							
W32	ST02	Land Acquisition for Lower Zone storage	$ 100,000	2017	New development (SDC)								$ 119,405	
W32	ST03	Land Acquisition for David Hill Area	$ 100,000	2040	New development (SDC)									$ 235,657
W31	ST04	0.30 MG Upper Reservoir 1	$ 350,000	2013	New development (SDC)			$ 371,315						
W31	ST05	0.30 MG Upper Reservoir 2	$ 350,000	2025	New development (SDC)								$ 529,406	
W32	ST06	2.25 MG Lower Reservoir	$ 2,130,000	2020	New development (SDC)								$ 2,779,167	
W32	ST07	2.25 MG Lower Reservoir (Purdin Rd. area)	$ 2,130,000	2040	New development (SDC)									$ 5,019,485
W32	ST08	1.0 MG David Hill Reservoir	$ 950,000	2045	New development (SDC)									$ 2,595,310
	ST09	Davd Hill URA Pump station	$ 350,000	2045	New development (SDC)									$ 956,167
	ST10	David Hill URA PRV	$ 200,000	2045	New development (SDC)									$ 546,381
Distribution and Piping System														
	DP01-DP29	Flow/pressure improvements	$ 1,900,000	2011-2017	Existing system (Rates)		$ 200,000		$ 200,000	$ 100,000	$ 200,000			
W48	DP33	David Hill Rd. Waterline	$ 240,000	2011	New development (SDC)	$ 240,000								
	DP34	Purdin Rd. expansion area distribution main upgrade	$ 750,000	2040	New development (SDC)									$ 1,767,424
	DP35	Watercrest Road Pump Station Upgrade	$ 75,000	TBD	Existing system (Rates)									
	DP36	David Hill Pump Station Upgrade (additional pump)	$ 75,000	2040	New development (SDC)									$ 176,742
W6	DP37	Industrial Area -23rd/24th	$ 246,400	2015	New development (SDC)					$ 277,325				
W2	DP38	Line Oversizing Participation	$ 50,000	Annual	New development (SDC)	$ 50,000	$ 51,500	$ 53,045	$ 54,636	$ 56,275	$ 57,964	$ 59,703	$ 932,423	$ 2,355,868
		Capital Improvement Projects Total	**$ 29,451,400**		**Total**	**$ 320,000**	**$ 416,300**	**$ 535,755**	**$ 287,418**	**$ 467,366**	**$ 756,452**	**$ 95,524**	**$ 10,347,473**	**$ 15,066,555**

Table ES-6: Water System Capital Improvement Program – City of Forest Grove (continued)

CIP No.	Project Code	Capital Improvement	Present Worth Cost (2010)	Anticipated Implementation Fiscal Year	Project "Driver"	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	Anticipated Cost 2018-2030	Anticipated Cost 2031-2050
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W50	SR03	JWC North Transmission Line Emergency Intertie at Heather St.	$ 250,000	2016	Supply Reliability						$ 289,819			
	SR04	JWC Parallel Supply Line (18" - 6 mgd capacity)	$ 3,500,000	2020	New development (SDC)								$ 4,566,706	
	SR05	Raw Water Booster Station Upgrade	$ 200,000	TBD	Existing system (Rates)									
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	DP01-DP29	Flow/pressure improvements	$ 1,900,000	2011-2017	Existing system (Rates)		$ 200,000		$ 200,000	$ 100,000	$ 200,000			
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		Capital Improvement Projects Total	**$ 29,451,400**		**Total**	**$ 320,000**	**$ 416,300**	**$ 535,755**	**$ 287,418**	**$ 467,366**	**$ 756,452**	**$ 95,524**	**$ 10,347,473**	**$ 15,066,555**

TABLE OF CONTENTS

List of Acronyms iv
Executive Summary ES-1
1 Introduction 1-1
1.1 Purpose 1-1
1.2 Compliance 1-1
1.3 System History and Background 1-1
1.4 Water Utility Policies 1-4
1.5 Related Plans 1-4
1.6 Scope of Master Plan Update 1-5
2 Existing Water System 2-1
2.1 Forest Grove Water Rights 2-1
2.2 City of Forest Grove Raw Water Supply, Transmission, and Treatment System 2-6
2.3 Joint Water Commission Supply 2-7
2.4 Interties 2-8
2.5 Storage Facilities 2-8
2.6 Pumping Facilities 2-9
2.7 Pressure Zones/Service Areas 2-10
2.8 Distribution System 2-11
2.9 Telemetry and Supervisory Control System 2-12
3 Planning Data 3-1
3.1 Planning Period 3-1
3.2 Service Area and Land Use 3-1
3.3 Urban Reserve Areas and Regional Growth Perspective 3-4
3.4 Population Forecasting 3-5
4 Water Supply Requirements 4-1
4.1 Historical Water Use 4-1
4.2 Non-revenue Water 4-3
4.3 Large Water Users 4-4
4.4 Water Conservation 4-4
4.5 Water Demand Forecast Methodology 4-8
4.6 Water Demand Forecast Results 4-9
4.7 Fire Flow Requirements 4-12
5 Planning Criteria and System Requirements 5-1
5.1 Water Supply and Transmission System Criteria 5-1

5.2 Storage Criteria 5-2
5.3 Distribution System Criteria 5-3
6 Water System Analysis 6-1
6.1 Source of Supply Analysis 6-1
6.2 Water Quality and Regulatory Compliance 6-13
6.3 Storage Analysis 6-16
6.4 Distribution System Analysis 6-20
7 Capital Improvement Program 7-1
7.1 Cost Estimating Criteria 7-1
7.2 Recommended Plan 7-1
7.3 Project Prioritization 7-6

LIST OF TABLES

Table 2-1: City of Forest Grove Water Rights 2-5
Table 2-2: Stored Water Rights – Source Water to JWC Facilities 2-5
Table 2-3: Forest Grove WTP Process Summary 2-7
Table 2-4: Current Participation in the JWC Treatment Plant 2-8
Table 2-5: Forest Grove Storage Ownership 2-8
Table 2-6: Operating Data of Existing Storage Facilities 2-9
Table 2-7: Pressure Zone / Service Area Characteristics 2-10
Table 2-8: Summary of Existing Pressure Reducing Stations 2-11
Table 3-1: Forest Grove Land Absorption Analysis Summary 3-5
Table 3-2: Historical Service Area Population 3-6
Table 3-3: Summary of Population Forecast Results 3-7
Table 4-1: Historical Water Production (2005-2009) 4-1
Table 4-2: Historical Metered Water Consumption by Customer Class – Annual (2006-2008) 4-2
Table 4-3: Historical Metered Water Consumption by Customer Class – Monthly (2006-2008) 4-2
Table 4-4: Summary of Water Use Factor Derivation (2006-2008) 4-3
Table 4-5: Historical Peaking Factor (2006-2008) 4-3
Table 4-6: Non-Revenue Water Estimate (2006-2008) 4-4
Table 4-7: Water Use of Largest Non-Residential Customers (2006-2008) 4-4
Table 4-8: Forest Grove Required Water Conservation Measures per OAR 690-086-0150(4) 4-5
Table 4-9: Forest Grove Additional Water Conservation Measures per OAR 690-086-0150(6) 4-6
Table 4-10: Summary of Water Savings Assumptions Throughout Planning Period 4-7
Table 4-11: Summary of Demand Forecast Results (mgd) 4-9
Table 4-12: Summary of Monthly Demand Forecast (Scenario B - mgd) 4-11
Table 4-13: Summary of Land Use Designations and Fire Flow Requirements 4-12
Table 5-1: Supply and Transmission System Requirements (Scenario B) 5-1
Table 5-2: Storage Requirements by Pressure Zone 5-3
Table 5-3: Service Pressure Requirements 5-3
Table 6-1: Water Rights and Seasonal Flow Limits for Sources of Supply to the Forest Grove Water Treatment Plant 6-2

Table 6-2: Water Rights and Seasonal Flow Limits for Supply from Stored Water (Joint Water Commission) 6-2
Table 6-3: Peak Season Monthly Stored Water Release Factors and Flows 6-3
Table 6-4: Recommended near-term and long-range WTP projects 6-12
Table 6-5: Storage Evaluation by Pressure Zone 6-16
Table 6-6: Recommended Storage Improvements by Pressure Zone 6-19
Table 6-7: Summary of Hydraulic Modeling Scenarios 6-21
Table 7-1: Source of Supply, Transmission and Intertie Improvements 7-3
Table 7-2: Treatment Improvements 7-3
Table 7-3: Storage Improvements 7-4
Table 7-4: Distribution and Piping Improvements 7-5
Table 7-5: Miscellaneous Projects and Studies 7-6
Table 7-6: Water System Capital Improvement Program – City of Forest Grove 7-7

LIST OF FIGURES

Figure 1-1 – City of Forest Grove Vicinity Map 1-3
Figure 2-1 –Water Supply Features 2-3
Figure 2-2 – Water System Schematic 2-4
Figure 3-1 – Service Area and Zoning 3-3
Figure 3-2 – Population Forecast Scenarios 3-8
Figure 4-1 – Annual Water Demand Forecast by Scenario 4-10
Figure 4-2 – Monthly Average Day Demand – Scenario B 4-11
Figure 6-1 – Comparison of Maximum Day Demands to Available Raw Water Supply 6-4
Figure 6-2 – Comparison of Monthly Average Day Demands to Available Raw Water Supply 6-5
Figure 6-3 – Comparison of Forecast Maximum Day Demands with Current Supply Infrastructure Constraints 6-6
Figure 6-4 — Comparison of Forecast Maximum Day Demand to Limiting Supply Factors 6-7
Figure 6-5 – Comparison of Forecast Monthly Average Day Demand to Current Sources of Supply 6-8
Figure 6-6 – General Location of Reservoir to Serve David Hill URA 6-18
Figure 6-7 – Locations of System Deficiencies Not Meeting MDD + Fireflow Conditions 6-25
Figure 7-1 – Distribution System Recommendations 7-9

APPENDICES

Appendix A Copy of City of Forest Grove Code Related to Water Utility Operations
Appendix B Spreadsheet Tables of the Population Forecast
Appendix C Spreadsheet Tables of Water Demand Forecast
Appendix D Spreadsheet Tables of Supply Analysis
Appendix E Evaluation of Storage Criteria
Appendix F Hydraulic Model Development and Output

LIST OF ACRONYMS

ac	acres
ADD	average day demand
AMR	automated meter reading
ASR	Aquifer Storage and Recovery
BW	backwash
CCP	concrete cylinder pipe
cfs	cubic feet per second
CIMP	Capital Improvement Master Plan
CIP	capital improvement program
COBU	claim of beneficial use
CPA	conservation potential analysis
CWS	Clean Water Services
D/DBPR	Disinfectants/Disinfection Byproducts Rule
DBP	disinfection byproduct
DEQ	Department of Environmental Quality
DHS	Department of Human Services
EEC	Events and Education Committee
EOA	Economic Opportunity Analysis
EPA	Environmental Protection Agency
ET	evapotranspiration
FBRR	Filter Backwash Recycling Rule
FG	Forest Grove
FGL&P	Forest Grove Light & Power
fps	feet per second
FS	fire suppression
ft	feet
GIS	Geographical Information System
gpad	gallons per acre per day
gpcd	gallons per capita per day
gpd	gallons per day
gpm	gallons per minute
GWUDI	Groundwater under the Direct Influence of Surface Water
HAA5	five haloacetic acids
hp	horsepower
HPC	heterotrophic plate count

I&C	Instrumentation and Control
IDSE	Initial Distribution System Evaluation
IGA	Intergovernmental Agreement
IOC	Inorganic Chemicals
IPZ	intermediate pressure zone
IWSS	Integrated Water Supply Study
JWC	Joint Water Commission
LCR	Lead and Copper Rule
LPZ	lower pressure zone
LRAA	locational running annual average
MCL	maximum contaminant level
MCLG	Maximum Contaminant Level Goal
MDBP	Microbial and Disinfection Byproduct
MDD	maximum day demand
MF	Multifamily
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
N4A	TVID irrigation line
NTL	North Transmission Line
NTU	nephelometric turbidity unit
OAR	Oregon Administrative Rules
ORS	Oregon Revised Statutes
OWRD	Oregon Water Resources Department
PRV	pressure reducing valve
PS	Pump Station
psi	pounds per square inch
PVC	polyvinyl chloride
R&R	Renewal and Replacement
RML	Residential Medium-Low Density
RWPC	Regional Water Providers Consortium
SCADA	Supervisory Control and Data Acquisition
SDC	system development charge
SDWA	Safe Drinking Water Act
sf	Square Foot
SOC	Synthetic Organic Chemicals
SWTR	Surface Water Treatment Rule

TBD	to be determined
TCR	Total Coliform Rule
TTHM	Total Trihalomethane
TVID	Tualatin Valley Irrigation District
TVWD	Tualatin Valley Water District
UGB	Urban Growth Boundary
UPZ	Upper Pressure Zone
URA	Urban Reserve Area
WMCP	Water Management and Conservation Plan
WMP	Water Master Plan
WR	Water Rights
WTP	Water Treatment Plant

1 Introduction

1.1 Purpose

The purpose of this plan is to evaluate the City of Forest Grove water system facilities to: (i) determine water supply requirements using updated population and water demand forecasts; (ii) identify distribution system deficiencies; (iii) identify options to meet water supply needs; (iv) recommend water system improvements and estimate associated improvement costs; and (v) update the City's 2000 Water Master Plan (WMP) document.

1.2 Compliance

This plan complies with the water system master planning requirements established under Oregon Revised Statutes (ORS) Section 333-61-060 with the exception of paragraph (5)(b)(G) which address financing issues that are beyond the scope of this study.

1.3 System History and Background

The City of Forest Grove is located in Washington County, Oregon to the west of the Cities of Portland, Hillsboro and Cornelius. **Figure 1-1** shows the location of the City. Several water bodies are in the vicinity of the City including Clear Creek, Gales Creek and Council Creek, and the Tualatin River; and two major water impoundments of Barney Reservoir and Hagg Lake (Scoggins Reservoir).

The first public water system for the City of Forest Grove was built circa 1908. A water intake was constructed on Clear Creek, a tributary of Gales Creek. A transmission line, constructed of logs with a ten-inch hole bored through the center, conveyed water from the intake to the present site of the water treatment facility (Buxton Hill). Here it was stored in a concrete reservoir built at the same time as the intake and transmission line. This reservoir is still in use as the settling basin for the water treatment plant.

In 1947, a new five-million gallon water reservoir was constructed at the Buxton Hill site (now known as Watercrest Road site). In 1947-48 a water treatment plant was built at the site. This was one of the first rapid sand filter treatment facilities built in Oregon. It could produce 1.7 million gallons of treated water in a 24-hour day. During the fall of 1978, the 30-year old water treatment plant was shut down for rebuilding. Construction was completed in the spring of 1980 and the plant again started treating water from the Clear Creek watershed with a firm capacity of approximately 3.7 million gallons per day (mgd). It has since received system upgrades including mechanical and limited structural improvements and additions to the rapid mixer, chemical building, flocculation basin and filter-to-waste facilities. The City's distribution system has also expanded, and now includes approximately 78 miles of water main serving nearly 5,600 customers. The City of Forest Grove water system serves residential, commercial, and industrial consumers, mostly within the existing City limits.

Realizing the need to meet their cities' growing water demands, the Cities of Forest Grove and Hillsboro formed the Joint Water Commission (JWC) in 1976 under an ORS 190 agreement. The current members of the JWC include Cities of Forest Grove, Hillsboro, Beaverton and the Tualatin Valley Water District. The JWC provides the primary potable water supply to approximately 425,000 customers including approximately 50% of the City of Forest Grove's water supply needs on an annual volume basis. Most of Forest Grove's JWC supply is used during the peak water demand season from May through September. The City plans to continue its membership in the JWC into the foreseeable future.

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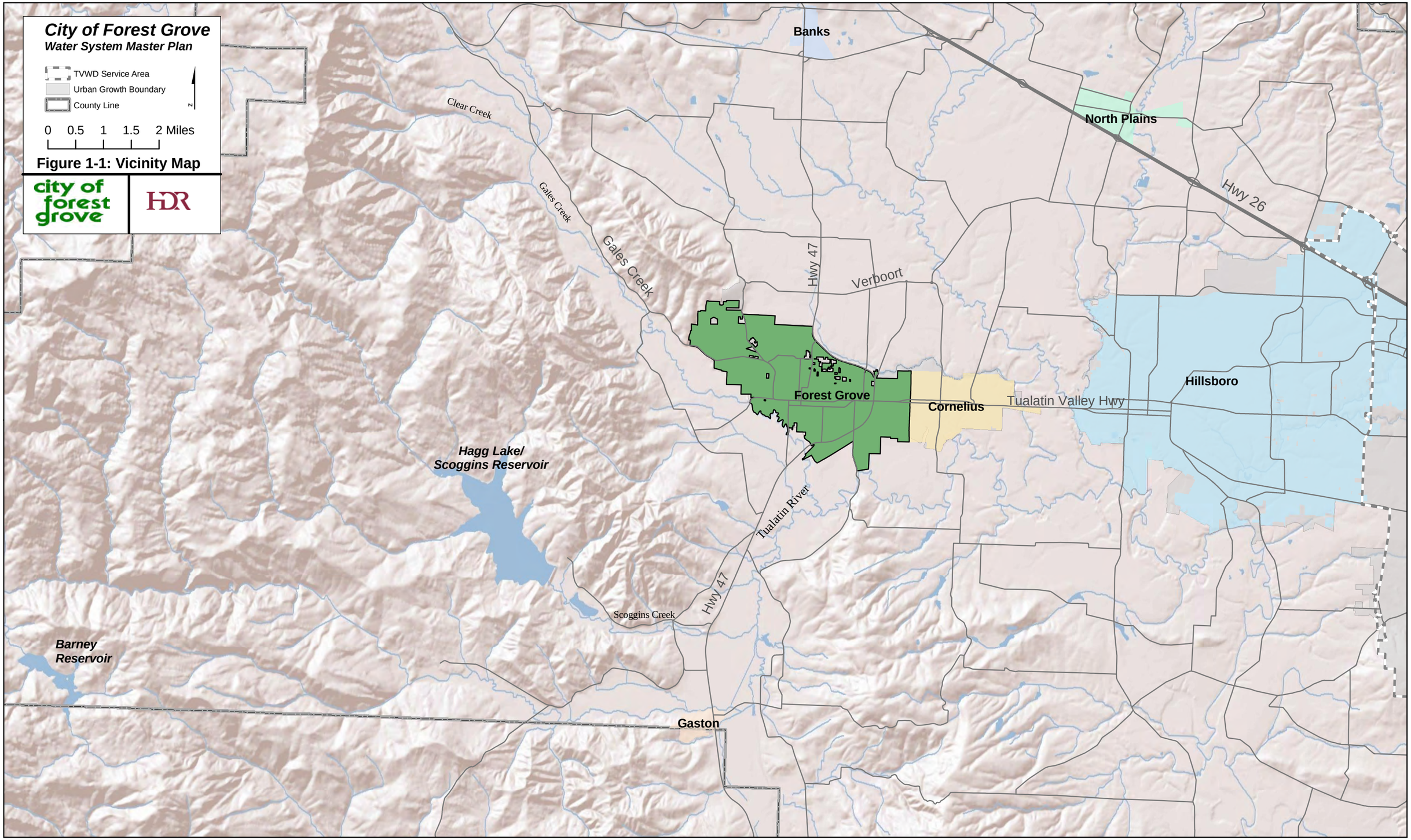
City of Forest Grove
Water System Master Plan
TVWD Service Area
Urban Growth Boundary
County Line
N
0 0.5 1 1.5 2 Miles
Figure 1-1: Vicinity Map
city of forest grove
HDR
Banks
North Plains
Hwy 26
Clear Creek
Gales Creek
Gales Creek
Hwy 47
Verboort
Forest Grove
Cornelius
Tualatin Valley Hwy
Hillsboro
Hagg Lake/
Scoggins Reservoir
Tualatin River
Hwy 47
Scoggins Creek
Barney
Reservoir
Gaston

1.4 Water Utility Policies

Chapter 3.800-3.812 and 4.005-4.135 of the City of Forest Grove Municipal Code defines the Forest Grove Water Utility policies and regulations. A copy is included in **Appendix A**.

1.5 Related Plans

In completing the City's Water Master Plan Update, several related plans were reviewed for pertinent considerations. The following are brief descriptions of the key plans:

- **Joint Water Commission *Capital Improvement Master Plan*** – *2009. Prepared by Black and Veatch.* The JWC Capital Improvement Master Plan (CIMP) identifies and defines capital improvements that will enable the JWC to serve future population growth and development within their members' service areas. The JWC facilities include the 75 mgd JWC water treatment plant, 40 million gallon (MG) Fern Hill Reservoirs, and transmission lines, all of which the City of Forest Grove owns a share. JWC members are responsible for a funding plan to improve, maintain, and operate JWC facilities according to the percentage ownership. The City is involved in the capital improvement planning.
- **Joint Water Commission *Water Management and Conservation Plan*** – *2009. Prepared by CH2M-Hill.* In 2003, the JWC submitted a Water Management and Conservation Plan to fulfill the latest requirements of OAR 690-086 to extend JWC's water rights permit. In 2009, the JWC prepared the required update to the 2003 WMCP, which includes a description of the JWC members' water conservation program, curtailment program, and water supply description, including demand forecast, and water rights information and plans.
- **City of Forest Grove *Long-term Economic Opportunities Analysis*** – *2009. Prepared by Johnson Reid*. The City completed a land needs analysis as part of the process to update the Comprehensive Plan. The study included information on land use and population growth analysis through year 2060.
- **City of Forest Grove *Comprehensive Plan***. The Comprehensive Plan documents the City's generalized, coordinated land use map and policies and links all man-made and natural systems and activities (including the water system) relating to the use of lands. The City is updating its Comprehensive Plan that was written in 1979, which was approved by the state in 1983. The Comprehensive Plan update and periodic review will document the City's land use and building regulations and vision through the year 2030. Information used for the WMP update is consistent with the latest information that the City is using to update the Comprehensive Plan.
- **City of Forest Grove *Integrated Water Supply Study*** – *2003. Prepared by Murray Smith and Associates.* The Integrated Water Supply Study (IWSS) was prepared as a follow-up to the 2000 Forest Grove Water Master Plan, and focused on the City's water supply, raw water transmission, and treatment facilities. The study considered water supply strategies and recommended improvements to the City's water treatment plant and raw water transmission pipeline. Some of the supply recommendations and improvements have been completed, while others remain on the City's capital improvement program and are addressed as part of this plan.

1.6 Scope of Master Plan Update

The major components of the scope of work for this Water Master Plan Update include the following:

- Coordinate with existing City of Forest Grove projects including: comprehensive planning and zoning studies, coordination with Washington County, current and on-going system improvements, and decisions with JWC.
- Outline facility inventory, including treatment plant, finished water storage, and finished water transmission components. Prepare a map of the facility inventory in hydraulic profile form.
- Develop City of Forest Grove's year 2050 demand forecast by customer class based on historical water use, demand reductions from conservation identified in the 2009 JWC WMCP, and input/decisions from a planning criteria workshop.
- Identify water supply options available to the City and screen against Forest Grove's future projected water demands and evaluation criteria in coordination with Joint Water Commission and Tualatin Basin Water Supply Project.
- Prepare a hydraulic model of the existing City of Forest Grove finished water transmission system to calculate expected flows and pressures under alternative improvement or operating scenarios.
- Identify system deficiencies and improvement alternatives through the 2050 planning horizon. Assess the existing transmission, storage, treatment and distribution system, and determine the timing of needed improvements using the projected demands and hydraulic model.
- Prepare a capital improvement program including improvements anticipated each year through the planning horizon.
- Prepare draft/final Water Master Plan document incorporating all work products from the project.

2 Existing Water System

This section describes existing City of Forest Grove water system facilities. The City of Forest Grove water system serves residential, commercial, and industrial consumers, primarily within the existing City limits. A limited number of customers are located along Gales Creek to the west of the City.

The City of Forest Grove water system has several sources and potential sources of water supply including:

- City of Forest Grove System
- Joint Water Commission Supply
- Gales Creek Water Rights
- Intertie with City of Cornelius Water System

An overview illustration of various water supply features is attached as **Figure 2-1**. **Figure 2-2** provides a schematic of the City's water system. A description of key water supply, transmission, treatment and distribution facilities follows.

2.1 Forest Grove Water Rights

The City of Forest Grove owns several live flow (i.e., not from stored water releases) water rights that can be used in conjunction with its JWC water supply. Forest Grove has three certificates authorizing use of live flow of up to 2.80 cfs from branches of Clear Creek, a tributary of Gales Creek, for municipal purposes. The priority dates for these rights range from March 29, 1917, to July 27, 1939. Forest Grove also holds a water right certificate for the use of 4.46 cfs from Gales Creek for municipal use with a priority date of February 14, 1947. Forest Grove holds permit S-40615 which authorizes the City use of up to 2.43 cfs from Roaring Creek, and 2.83 cfs from Clear Creek for municipal purposes, and 33 cfs from the Tualatin River. Permit S-40615 has an April 28, 1976 priority date. In 2008, the City contracted with GSI Water Solutions to modify a claim of beneficial use (COBU) for permit S-40615 to split out the Tualatin River portion. The City received a certificate for the Tualatin River portion from Oregon Water Resources Department (OWRD). At this point, the COBU for Roaring Creek and Clear Creek portion is sitting in the OWRD file, but the Tualatin River portion has been certificated. **Table 2-1** summarizes the City's water rights.

In addition, the City of Forest Grove has contract water rights with the Bureau of Reclamation in Hagg Lake (Scoggins Reservoir) and owns water rights for stored water in Barney Reservoir. City water rights for Barney Reservoir and Hagg Lake are summarized in **Table 2-2**. These water rights are used for the City's Joint Water Commission supply (discussed in Section 2.3 below).

Prior to 1976, the Watts Pump Station pumped water from Gales Creek to the City's WTP through a 16-inch diameter steel pipe. Both the pump station and the transmission pipe, however, were abandoned when Forest Grove partnered with Hillsboro to form the JWC.

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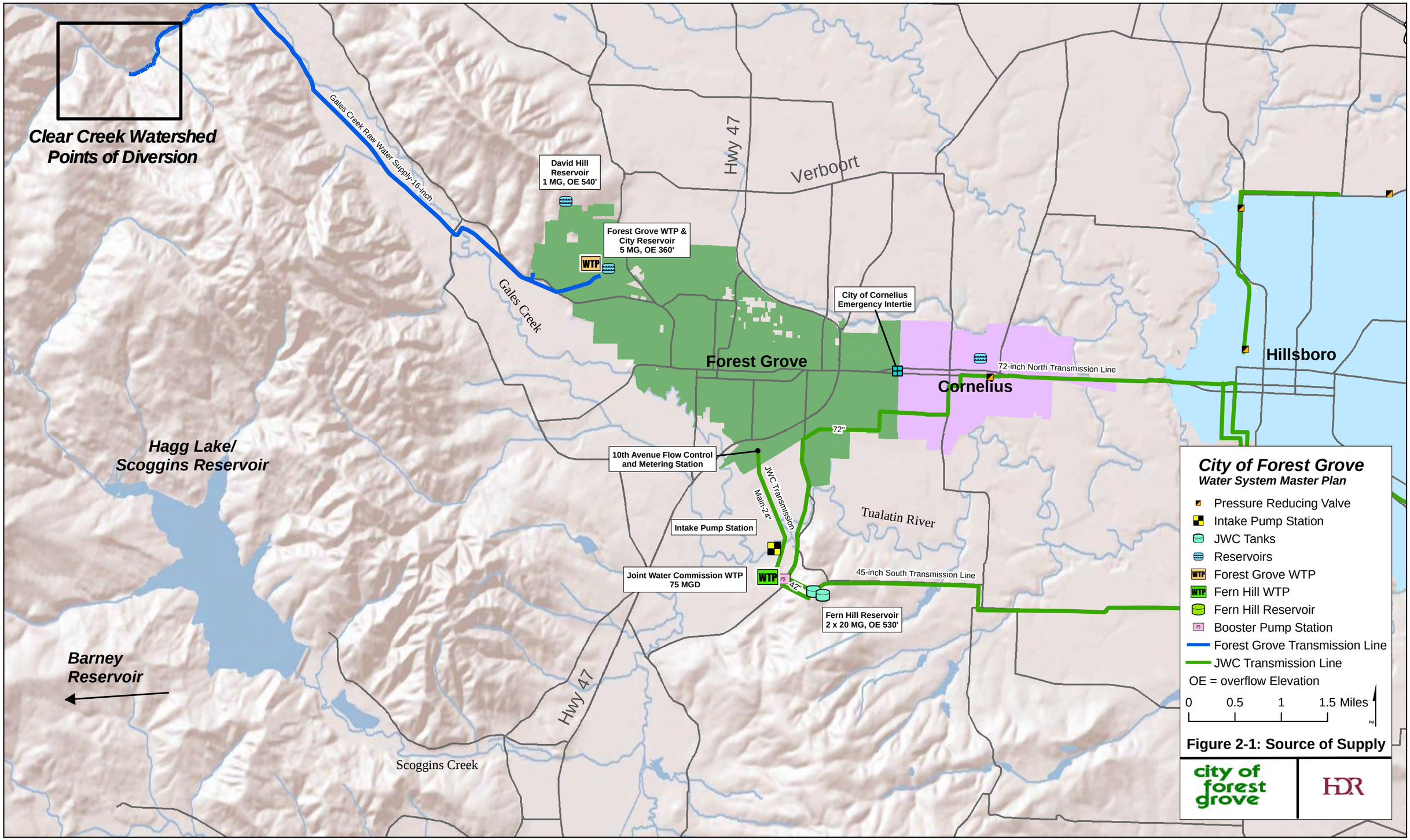

Figure 2-1: Source of Supply

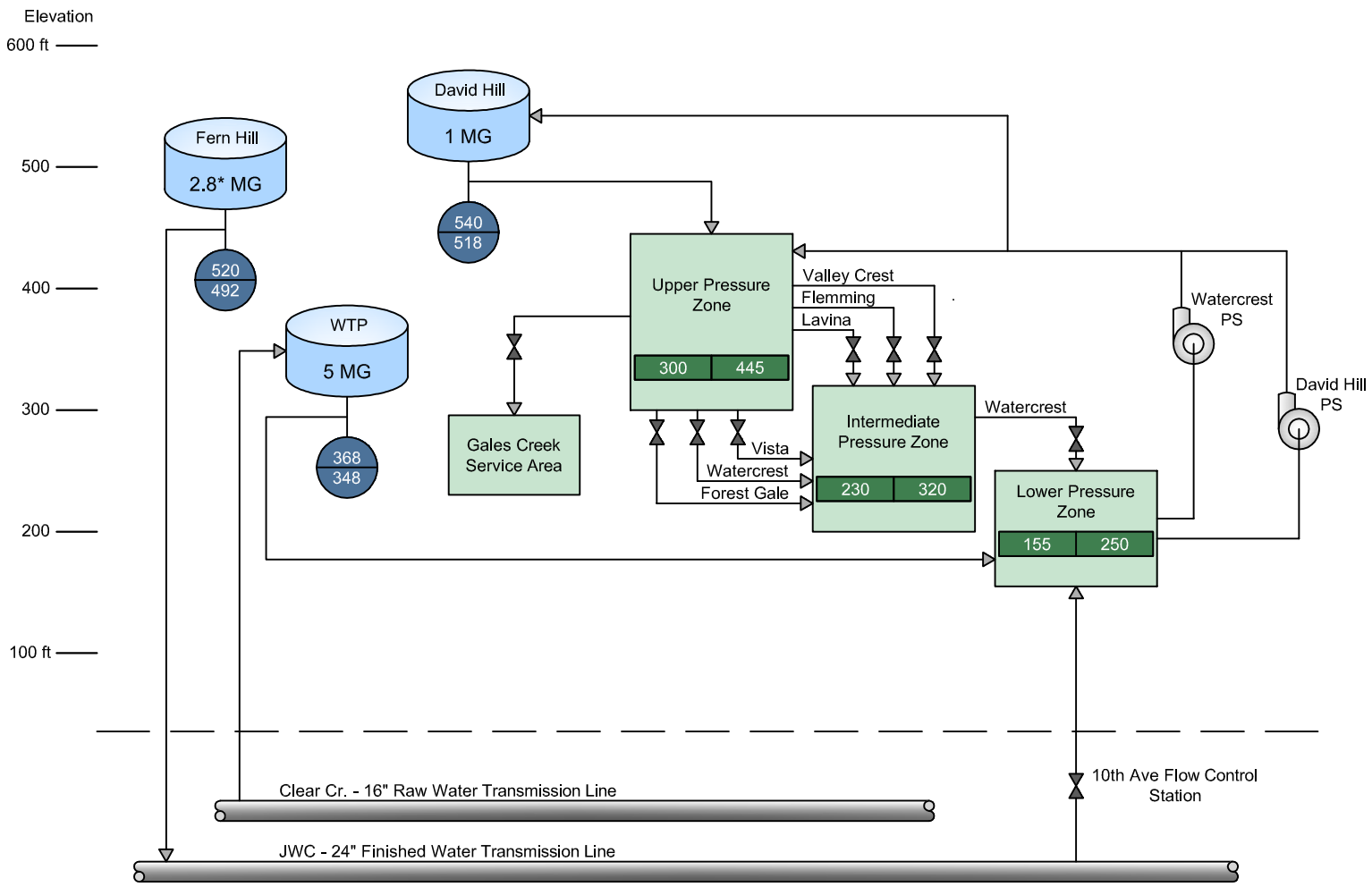

Figure 2-2: System Schematic

LEGEND

X / Y — Tank Overflow Elevation (ft) / Tank Base Elevation(ft)

Pressure Zone Minimum Elevation (ft)

XXX | YYY

Pressure Zone Maximum Elevation (ft)

Pressure Reducing Station

*Total Fern Hill storage ownership is 5.3 MG based on 13.33% share; 40% of storage is for JWC WTP operational storage

Table 2-1: City of Forest Grove Water Rights

Source	Priority Date	Application/ Permit/ Certificate No.	Type of Beneficial Use	Authorized Rate (cfs)[1]	Status
Branches of Clear Creek	3/29/1917	A: S-5460 P: S-3318 C: 2194	Municipal	0.80 cfs (0.52 mgd)	Certificated
Four Branches of Clear Creek	4/16/1935	A: S-15790 P: S-12034 C: 13471	Municipal	1.00 cfs (0.65 mgd)	Certificated
Branches of Clear Creek	7/27/1939	A: S-18298 P: S-13944 C: 13797	Municipal	1.00 cfs (0.65 mgd)	Certificated
Gales Creek	2/14/1947	A: S-22251 P: S-17549 C: 85513	Municipal	4.46 cfs (2.88 mgd)	Certificated
Roaring Creek & Clear Creek	4/28/1976	A: S-54203 P: S-40615	Municipal	2.43 cfs (1.57 mgd) 2.83 cfs (1.83 mgd)	Claim of beneficial use submitted
Tualatin River	4/28/1976	C: 85916	Municipal	33.0 cfs (21.3 mgd)	Certificated

Notes:
cfs – cubic feet per second
mgd – million gallons per day
A-application; P-permit; C-certificate
(1) No volume limits in water right..

Table 2-2: Stored Water Rights – Source Water to JWC Facilities

Description	Stored Water Right (acre-feet)
Barney Reservoir (Current)	500
Barney Reservoir (Buy-back option) *	800
Hagg Lake (Scoggins Reservoir)**	4,500
Total (Without buy-back)	5,000
Total (With buy-back)	5,800

** Barney Reservoir water right buy-back option requires a 4-year prior notification by the City to the JWC and the Tualatin Valley Water District.*

*** Forest Grove has a contract with Bureau of Reclamation for use of the stored water.*

2.2 City of Forest Grove Raw Water Supply, Transmission, and Treatment System

The water source for the City of Forest Grove's treated water supply system is the Clear Creek watershed. The City owns 4,300 acres within this watershed.

2.2.1 City Intake and Transmission Facilities

The City has intake facilities within the Clear Creek watershed on Clear Creek, Roaring Creek, Thomas Creek, Deep Creek and Smith Creek. The City's water rights within this Clear Creek watershed (not including the Gales Creek certificate and Roaring Creek permit) total 5.63 cubic feet per second (cfs), or 3.65 mgd, which is the approximate rated capacity of the City's water treatment plant (WTP). During the summer, this supply is reportedly limited by the low flows in the creeks and drops to as low as approximately 1.5 mgd, as measured by the raw water flow meter at the City WTP. The main intake facilities (Clear Creek, Roaring Creek and Thomas Creek) are in good condition. In 2005, the City completed Clear Creek diversion structure upgrades and a new fish ladder.

The 16-inch diameter raw water transmission main from the Clear Creek basin intake facilities to the City WTP is approximately seven miles long and is concrete cylinder pipe (CCP). There is a booster pump station along the 16-inch diameter raw water transmission main between the Clear Creek watershed and the City's WTP. The station was constructed in 1979 and consists of a single pump housed in a semi-buried structure. The City did not operate this pump station when there were customers served off the raw water transmission main because of the resulting pressure drop to these services when the pump station was on. These services are now disconnected from the raw water main and are served as part of the Gales Creek Service Area. The City now operates the raw water booster pump station when water demand exceeds the gravity capacity of the raw water transmission main. City staff estimate the gravity capacity of the raw water main at approximately 1,900 gallons per minute (gpm), or 2.7 mgd. The booster pump station can increase flows to the plant up to approximately 3.7 mgd. As noted above, however, this supply is source-limited during low flow periods.

2.2.2 City Water Treatment Plant

The City of Forest Grove Water Treatment Plant was originally constructed in 1948 and was expanded in 1979. The expansion provided a firm plant capacity of 3.7 mgd, according to City staff the capacity of the plant is closer to 3.5 mgd when accounting for backwash. For the purposes of the water supply analysis the firm capacity of 3.7 mgd is used. The plant is of conventional design, consisting of rapid mix, flocculation, sedimentation, and rapid sand filtration. **Table 2-3** summarizes the WTP process components. The plant utilizes alum as its primary coagulant. The flocculation basin contains horizontal mounted, paddle wheel type flocculators. The sedimentation basin is a single basin design. A small low head pumping station lifts the settled water from the sedimentation basins up to the filters. The filters are gravity fed rapid sand filters. The filters are backwashed into the sludge lagoons. Chlorine is fed at one or both of two feed points to achieve the required disinfection credits: raw water and filter influent. Filtered water is piped by gravity to the City's 5.0 MG (4.27 MG is the nominal storage volume) covered reservoir located adjacent to the WTP prior to distribution.

Sludge from the sedimentation basin is pumped into one of the two sludge lagoons which are separated by a concrete wall. Water treatment plant modifications were completed in 2006, which involved primarily mechanical and limited structural improvements and additions to the rapid mixer, chemical building, flocculation basin and filter-to-waste facilities. The overall capacity of the WTP was not changed. The City also recently installed a new package dewatering system which was put online in March 2010. This system will eliminate the need for hauling sludge from the lagoons, resulting in a significant reduction in operations costs.

Table 2-3: Forest Grove WTP Process Summary

Unit Process/Parameter	Design Criteria / Process Components	Comments
Nominal Capacity	3.7 mgd (2,600 gpm)	Based on 5 gpm/sf filter loading rate
Process Control	Pilot filter, streaming current, particle count, turbidity, jar-testing	Plant has adequate process control instrumentation and equipment; the pilot filter and streaming current detector are reportedly very reliable indicators of coagulation effectiveness
Rapid Mix	In-line mechanical mixer	Replaced existing static mixer with in-line mechanical mixer in 2006 WTP improvements

2.3 Joint Water Commission Supply

As discussed previously, the City of Forest Grove is a party of the Joint Water Commission. The JWC is a joint operation for the transmission, treatment, and storage of municipal and industrial water owned by the member agencies. While the JWC members jointly operate the supply, the JWC does not own the water supply. The JWC does own the treatment plant and transmission lines, and shares ownership of the Tualatin River intake facility with the Tualatin Valley Irrigation District. The City of Forest Grove uses the JWC water supply typically to meet peak demands in the summer season, and in the winter months when the City's water treatment plant needs maintenance.

2.3.1 JWC Treatment, Storage and Transmission

The JWC water treatment plant is located on Spring Hill Road south of Forest Grove and draws water from an intake on the Tualatin River which is jointly owned by the JWC and the Tualatin Valley Irrigation District. The JWC plant is a conventional rapid mix, flocculation, sedimentation, and rapid sand filter design. Finished water from the JWC plant is stored in the two 20 MG Fern Hill Reservoirs located near the JWC plant.

A 45-inch diameter transmission main routed easterly from the JWC Fern Hill Reservoir originally was constructed to serve Hillsboro and Beaverton. This line presently also delivers water to the Tualatin Valley Water District. A 72-inch diameter JWC transmission main was constructed in 2001 primarily to serve Hillsboro and Tualatin Valley Water District. This line runs through the east side of the City of Forest Grove, and includes an 8-inch tee and valve at Mountain View Lane and Heather Street which could serve as a manually-operated emergency intertie in the future.

2.3.2 Forest Grove/Hillsboro Joint Transmission Main

JWC water is supplied from the Fern Hill Reservoir to the City of Forest Grove through approximately 8,000 feet of 24-inch diameter CCP transmission main jointly owned by the City of Forest Grove and the City of Hillsboro. A pressure reducing, flow control and metering station located on 10th Avenue, south of the Tualatin Valley Highway, regulates the supply pressure to match that of the City-owned water facilities and controls the flow rate of JWC water supplied to the City. This station is housed in an above ground cinder block building with two pressure reducing valves (18-inch and 8-inch diameter) and an in-

line propeller meter. The operation of the pressure reducing station is discussed in more detail in the Telemetry and Control System discussion of this section.

2.3.3 JWC Capacity

As described in Section 1, the JWC was originally established in 1976 by the City of Hillsboro and the City of Forest Grove for a total treatment capacity of 20 mgd. Since that time, the City of Beaverton and the Tualatin Valley Water District (TVWD) joined the JWC, and the total treatment capacity has been expanded to 75 mgd. **Table 2-4** presents a summary of historic City participation in the JWC Treatment Plant. The City currently has a 13.33% ownership in the WTP capacity which is equivalent to 9.975 mgd based on the current 75 mgd capacity of the JWC WTP. Capital costs of the JWC are often allocated to partners based on their percent ownership, unless another arrangement among the partners is agreed to.

Table 2-4: Current Participation in the JWC Treatment Plant

Total Capacity (mgd)	Party	Approximate Capacity Ownership (mgd)	% Ownership
75	Forest Grove	10	13.3
	Hillsboro	35	46.7
	Beaverton	19	25
	TVWD	11	15

2.4 Interties

While the City of Forest Grove's Clear Creek source of supply and water treatment plant do not supply or connect to other systems, the City does maintain a six-inch emergency intertie with the City of Cornelius. The emergency intertie is located at Heather Street at the City boundary.

2.5 Storage Facilities

The storage facilities serving the City of Forest Grove water system are summarized in **Table 2-5**.

Table 2-5: Forest Grove Storage Ownership

Facility	Storage Volume (million gallons)
Main Reservoir (WTP site)*	4.27
JWC Fern Hill Reservoir ownership	5.3 (2.8**)
David Hill Reservoir	1.0

** Based on Engineering drawing dimensions of tank.*
***Fern Hill storage ownership = 5.3 MG; however, available storage = 2.8 MG = (13.33% x 40 MG) x 60%, because JWC Intergovernmental Agreement (IGA) specifies 40% of JWC storage is allocated for JWC WTP operations.*

The City's 5 MG reservoir at the WTP site is the main reservoir for the City. This reservoir was constructed in 1948 as part of the original water treatment plant project. The reservoir is rectangular and has a split tank design allowing for dewatering and maintenance of either chamber without interruption of system operation. The overall dimensions of the reservoir are 152 feet by 304 feet with a concrete wall dividing the basin into two equal square halves.

The City's 1 MG David Hill Reservoir was constructed in 1985. The facility is located on David Hill Road just outside the city limits to the northwest. The reservoir is covered and is constructed mostly below ground on a sloping hillside. The reservoir is a 96-foot by 76-foot reinforced concrete structure.

The City also maintains ownership of 5.3 MG from the two JWC 20 MG Fern Hill Reservoirs located near the JWC treatment plant. However, based on the agreement within JWC, 40% of the storage volume in the Fern Hill Reservoirs is for the JWC WTP operation; therefore 2.8 MG is available for the City's in-town storage use.

A summary of the overflow, operating, and bottom elevations for the reservoirs serving the City of Forest Grove water system is included in **Table 2-6**. Operating elevations shown in **Table 2-6** indicate the approximate normal water level in the reservoir.

Table 2-6: Operating Data of Existing Storage Facilities

Reservoir	Elevation (feet above mean sea level)		
	Overflow	Operating	Bottom
Main Reservoir at WTP Site	368	365	348
1 MG David Hill Reservoir	540	534	518
40 MG JWC Fern Hill Reservoir	520	515	492

2.6 Pumping Facilities

The City of Forest Grove has three pumping facilities:

- Raw water booster pump station along the transmission main to the City WTP.
- David Hill Pump Station.
- Water Crest Road Pump Station.

The raw water booster pump station is described in detail earlier in Section 2.2.1. The other two finished water pump stations are described below.

The David Hill Pump Station (PS) is located approximately 1,400 feet west of Thatcher Road on David Hill Road. This pump station is an above-ground structure constructed in 1985. The pump station houses two vertical 25 horsepower (hp) turbine can-type pumps manufactured by Peabody-Floway. Both pumps have a 400 gpm capacity and pump water from the Main (lower) Pressure Zone to the David Hill Reservoir, through 10-inch and 12-inch diameter ductile iron piping. The pumps are controlled by the level of the David Hill Reservoir.

The David Hill PS replaced the stand-by pump station that is located just south of the WTP on Watercrest Road. After David Hill PS was constructed the Watercrest PS was used only for emergency back up. However, in 2006 the pumps at the Watercrest PS were upgraded as part of the water treatment plant modifications. Because these pumps are more efficient than those in the David Hill PS, the City now uses the Watercrest PS as the primary pump station feeding the David Hill Reservoir and Upper Pressure Zone. The David Hill PS is now used as the back-up. The Watercrest PS currently has one

pump with a provision for a second pump and is housed in a partially buried concrete vault. The pump is a centrifugal type with 280 gpm capacity.

2.7 Pressure Zones/Service Areas

The City of Forest Grove water system supplies the following pressure zones and outside service area:

- Main (Lower) Pressure Zone.
- Intermediate Pressure Zone.
- Upper Pressure Zone.
- Gales Creek Service Area.

The characteristics of these pressure zones and service area are described in the following paragraphs and summarized in **Table 2-7**.

Table 2-7: Pressure Zone / Service Area Characteristics

Pressure Zone / Service Area	Elevation Range (ft)	Service Area (ac)	No. Connections
Main (Lower) Pressure Zone	< 270	1685	5967
Intermediate Pressure Zone	270 – 330	51	182
Upper Pressure Zone	330 - 440	121	593

2.7.1 Main (Lower) Pressure Zone

The Main (Lower) Pressure Zone includes most of the City of Forest Grove. The reservoir at the City WTP site and the pressure reducing station on the JWC supply line hydraulically serve the main pressure zone. As discussed above, the overflow elevation of the reservoir at the City WTP site is 368 feet. As a result, the main pressure zone includes the areas with ground elevations below 270 feet for a minimum service pressure of approximately 40 pounds per square inch (psi).

2.7.2 Intermediate and Upper Pressure Zones

The Intermediate and Upper Pressure Zones are located in the northwest corner of the City. These pressure zones are served from the Main Pressure Zone by the David Hill PS and Watercrest PS and the David Hill Reservoir. Water quantity supplied to these zones is measured through meters installed at the pump stations.

As discussed above, the overflow elevation of the David Hill Reservoir is 540 feet. The upper pressure zone serves the areas between ground elevations of approximately 300 feet and 440 feet for a minimum service pressure of approximately 40 psi. The intermediate pressure zone serves the areas between ground elevations of approximately 270 feet and 330 feet. The upper pressure zone is directly served by the reservoir while the intermediate pressure zone requires pressure reducing stations at each connection to the upper pressure zone to provide appropriate service pressures.

There are six pressure reducing stations between the upper pressure zone and the intermediate pressure zone. All six pressure reducing stations are in underground vaults and use 6-inch Golden Anderson pressure reducing valves for main valves and include smaller parallel valves for low flow operations. One pressure reducing station is installed between the intermediate and lower zones, and only opens during fire flow conditions. The locations and pressure set-points of the pressure reducing stations are summarized in **Table 2-8**. The pressure settings for the seven stations are set so that the valves operate in a programmed sequence. Staggering the opening pressure of the valves avoids erratic

hydraulic operation, thereby limiting wear and extending the life of the valves. Primary valve operation is periodically rotated from one station to another to maintain uniform value service life.

There is also a small area (approximately 45 acres) at the northwest perimeter of the City that is higher than elevation 440 feet which cannot currently be served by the existing water system. This area will be developed as part of the David Hill Urban Reserve Area (discussed in Section 3).

Table 2-8: Summary of Existing Pressure Reducing Stations

Location	Upstream Pressure (psi)	Downstream Pressure Setpoint (psi)
2906 Watercrest Drive (from IPZ to LPZ)	94/92	62/61
3222 Valley Crest Way	100/98	64/60
Lavina Drive & Forest Gale Dr.	109	67/65
3214 Watercrest Drive	108/105	64/62
3130 Forest Gale Drive	108/106	64/62
3145 Fleming Place	106/104	60/58
3151 Vista Drive	112/111	70/64

2.7.3 Gales Creek Service Area

The Gales Creek Service Area is outside of the City of Forest Grove. This service area includes the water customers originally served off the 16-inch raw water supply line running along Gales Creek to the City of Forest Grove WTP. Due to the Oregon Administrative Rules (OAR) Chapter 333 surface water treatment regulations, water customers can no longer be served off the raw water line. As a result, a treated water distribution system was installed in 1994 to serve the Gales Creek Service Area.

As of this plan update, the current Gales Creek Service Area consists of 57 service connections, most of which are residential customers; the Gales Creek Elementary School is also a customer. The connections are served off a network of 1¼-inch to 6-inch diameter polyvinyl chloride (PVC) pipe; the majority of this piping is 4-inch diameter pipe. The City continues to provide water service to this area and track water use with a single meter to the service area.

The Gales Creek Service Area experiences undesirable pressure fluctuations. City staff suspects that there may be unauthorized, and therefore unmetered, connections to this service network that may increase peak instantaneous demands on the system beyond intended design, and thus, may be significantly contributing to excessive pressure fluctuations. City staff also report potential high water leakage within this service network.

2.8 Distribution System

The water distribution system is comprised of piping ranging in size up to 24 inches in diameter with pipe types including cast iron, ductile iron, copper, steel, wrought iron, galvanized iron, and PVC. Existing cast iron water mains were constructed mostly in the 1950s and 1960s. Newer distribution piping is primarily ductile iron. The distribution system contains approximately 78 miles of distribution main pipelines. Approximately 24,000 feet of new pipe have been installed since 2000. The distribution system contains 555 fire hydrants.

2.9 Telemetry and Supervisory Control System

The City of Forest Grove has various telemetry and control facilities in place within its water system. Water level sensing equipment at the David Hill Reservoir signals the pumps at the David Hill and Watercrest pump stations. The pumps at David Hill and Watercrest pump stations operate on a lead/lag basis. As the reservoir level drops, the first pump is signaled to start. Should the reservoir level continue to drop, the second pump is signaled to start. Both pumps then continue operating until the pump shutoff level is reached. Certain status alarms from the pump station facilities are also connected by telemetry to the City's Water Treatment Plant. A high/low reservoir level alarm from the David Hill Reservoir is signaled to the Forest Grove Water Treatment Plant, as is a common alarm signaling either electrical power failure or telecommunication system failure. The raw water booster station is connected by telemetry to the City's Water Treatment Plant with a spread spectrum radio which provides on/off and high pressure/low suction and failure-to-start feedback.

The City's pressure reducing and metering facility, located at the south end of Forest Grove on the 24-inch diameter supply line from the JWC Plant, is equipped with a flow indicator/totalizer/recorder. Telemetry equipment at the station also signals flow information back to the Joint Water Commission Treatment Plant.

The City implemented telemetry and control system improvements in 1992 and additional improvements in 2006. Prior to these improvements, the pressure reducing station on the JWC supply line was set to a constant downstream pressure that resulted in a hydraulic grade line slightly higher than that provided by the reservoir at the treatment plant. Downstream of the pressure reducing valve there is a manually operated butterfly valve that was used to throttle the flow into the system, allowing the reservoir at the plant to fill without overpressurizing the distribution system.

Improvements to the control system allow the City water supply to be used as much as possible and the JWC supply to be used to meet any peaking water demands. These improvements included the installation of a telephone based Supervisory Control and Data Acquisition (SCADA) system. The control system is located at the City WTP and is remotely connected to the pressure reducing and metering station on 10th Avenue. The control system is currently programmed to control the flow through the pressure reducing station by modulating the pressure setting based on a flow rate that City operators set for the JWC supply. This control system changed the operation of the pressure reducing station to operate more as a flow control station than as a strict pressure reducing station.

For most of the year, the City WTP water production can keep up with water demand and the pressure reducing valve at the 10th Avenue station is primarily closed. When the City WTP cannot keep up with demand, the City operators continually update the control system to signal the flow required of the JWC supply. If there is a power failure, the pressure reducing valve is programmed to return to its original operation of pressure reduction based on hydraulic conditions with a downstream pressure setting of 82 psi.

3 Planning Data

Water system planning needs to meet requirements of the Oregon Drinking Water Program (OAR 333-661) and the state's Department of Land Conservation and Development goals (Goal 11). This section presents a discussion of the planning data and system design criteria to evaluate the City of Forest Grove water system. The planning period and service area define the extent of the planning. Land use designations and population data factor in the overall water demand of the water system as discussed in Section 4. It should be noted that the planning data, land use designations and growth scenarios are for water supply and infrastructure planning only. To the extent possible, the planning data used in this plan are intended to be consistent and are not meant to supersede the City's Comprehensive Plan or information developed by the City's Planning Department.

3.1 Planning Period

The City's previous Water Master Plan completed in 2000 estimated that ultimate development of the service area would occur by approximately 2034. However, the most recent comprehensive planning and economic opportunity analysis for the City of Forest Grove included expansion of the City's service area through development in urban reserves well beyond 2034. Furthermore, the Joint Water Commission, which the City of Forest Grove is a member, recently completed a Capital Improvement Master Plan through year 2050. For these reasons, the City decided to complete this Water Master Plan update for a 40-year planning period from 2010 to 2050. Within this planning period, the City defined the years 2017 and 2030 as intermediate milestone periods for capital improvement program scheduling in the WMP Update.

3.2 Service Area and Land Use

The service area identified for this plan is the area encompassed by the City of Forest Grove Urban Growth Boundary (UGB) as defined on the City's current Comprehensive Plan Map[1] (last updated 1989-1992). The current service area is generally bounded to the north by Council Creek, to the west and south by Gales Creek, and to the east by the City of Cornelius. **Figure 3-1** shows the major features in the vicinity of the City of Forest Grove, including the City limits, City water service area, UGB, urban reserve areas (URA), and major land uses. As discussed in Section 2 of this report, the City also supplies water to the service connections within the Gales Creek service area, which is outside of the City UGB.

Land use designations within the study area are established in the City of Forest Grove Comprehensive Plan. Existing land uses within the study area include residential, commercial and industrial, public, semi-public and institutional, and parks and open space (see **Figure 3-1**). The Comprehensive Plan guides present and future land use and is the basis for the estimation of the ultimate service area population. The last formal review and resolution adopting the City's Comprehensive Plan was in 1992. However, the Comprehensive Plan is currently being updated. This water master plan update includes evaluation of higher density zoning in certain areas of the City, and incorporates recent policy guidance on zoning and development on the fringes of the current UGB, as well as in the recently designated URAs.

[1] As of the completion of the WMP Update, the City's Comprehensive Plan is currently going through an update which started in November 2007.

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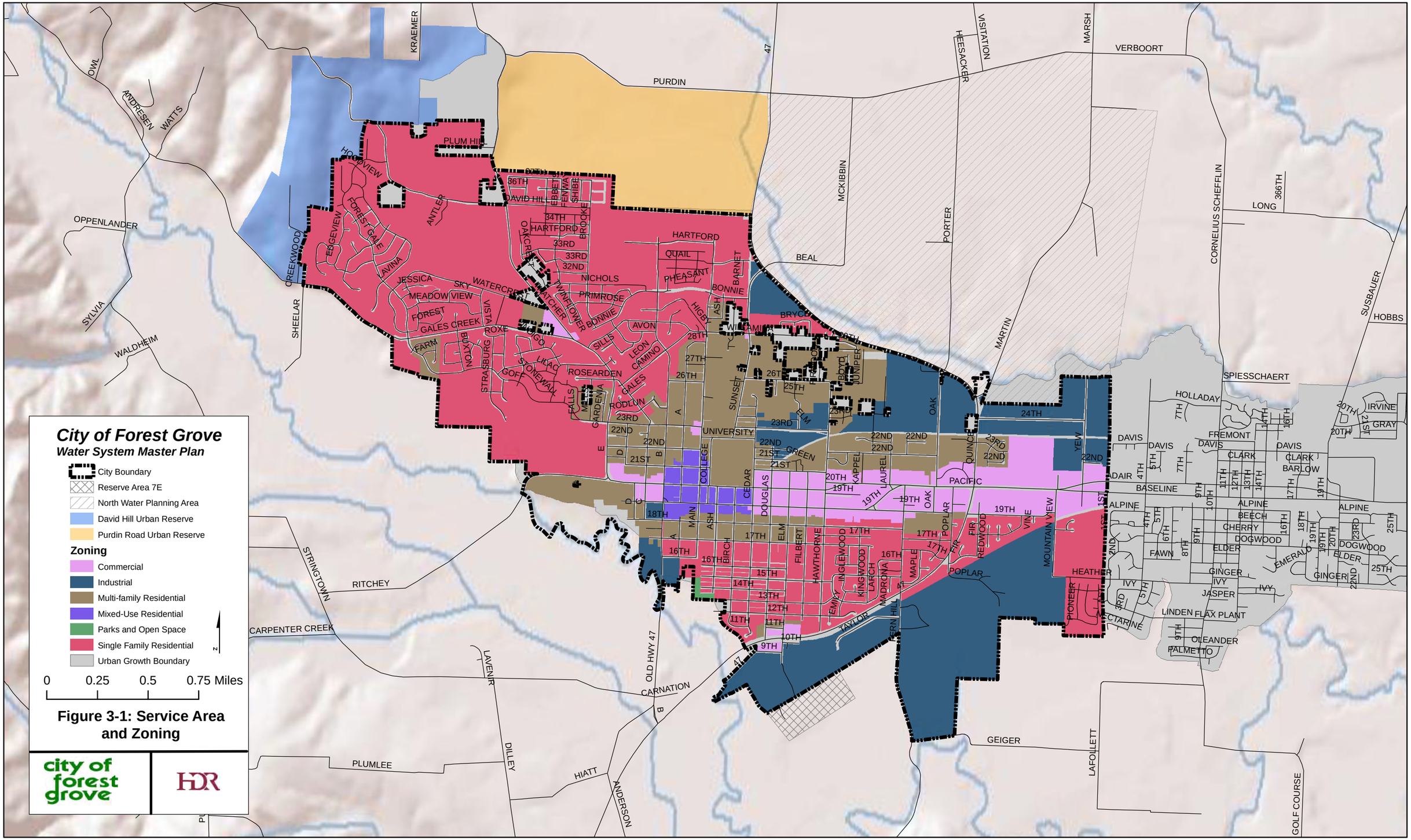


Figure 3-1: Service Area and Zoning

city of forest grove

HDR

3.3 Urban Reserve Areas and Regional Growth Perspective

URAs are the lands outside an urban growth boundary that will provide for future expansion over a long-term period as adopted by Metro, the regional government entity in the Portland metropolitan area with authority to regulate land use planning. During the WMP Update, Metro was in the process of reviewing and updating the URA plan, and the City of Forest Grove was in discussions with Metro on the growth and development expectations of the URAs around the City[2]. Three URA's border the City UGB as shown in **Figure 3-1**. These three primary urban reserve areas were considered in the WMP update:

- **Purdin Road Urban Reserve Area** – located to the north of the western half of the existing City limits; over 300 acres of largely industrial zoned land, with some mixed use and residential acreage; most of the development is anticipated to occur in 20 to 30 years (2030 to 2040).
- **David Hill Urban Reserve Area** – located to the west and in higher elevation area of the existing City limits; over 180 acres of primarily residential and some limited commercial acreage; most of the development is anticipated to occur in 25 to 30 years (2035 to 2040).
- **North Water Planning Area** (not adopted as URA by Metro as of June 2010) – located to the north of the eastern half of the existing City limits; over 1,200 acres of largely industrial zoned land, with mixed use and residential acreage. This area was included in the WMP update as part of the "high demand scenario" only; the City does not anticipate development to occur in this area before 2040, if at all. This area was included to compare the City's current raw water supply to an extreme demand scenario to determine if Forest Grove should consider participating with other partners in long-term water supply planning.

In addition to these URAs, the City included redevelopment concepts in the land absorption analysis. The City defined 6 areas for redevelopment around the town center, Pacific Avenue, and Oak Street. The redevelopment will be primarily for residential use, increasing the residential density and population within the City's current City limits. The earliest redevelopment in these areas is expected to occur within 5 to 10 years in the Town Center (2015-2020). Additional redevelopment will occur throughout the planning period, with a peak in redevelopment occurring in the 15-25 year time frame (2025-2035).

Information provided by the City's planning department for the purposes of the WMP Update was used to define the land absorption timeline within the URAs and redevelopment within the City UGB. The timeline is consistent with the current planning vision in the on-going Comprehensive Plan update, at the time of this WMP update. The land absorption analysis is summarized in **Table 3-1**, and was used in the population forecast and water demand forecast.

The dwelling yield was used as the basis for population increase associated with the URAs in addition to the base population growth percentage for the City. This is discussed further in Section 3.4. The developable acres were used as the basis for the timing and area of growth in commercial and industrial water demand. This is discussed further in Section 4.5.

[2] ***Metro Council*** *officially approved the designation of urban reserves areas on June 10, 2010, including areas around the City of Forest Grove. The designation means these lands can be considered for expansion into the urban growth boundaries over the next 50 years.*

Table 3-1: Forest Grove Land Absorption Analysis Summary

Use	Gross Developable Acres	Net Developable Acres	Estimated Dwelling Yield	Estimated Job Yield	Absorption (Time Frame)
Purdin Road Urban Reserve Area					
Industrial	203	162	N/A	2,745	20 – 30 years*
Office Park	36	29	N/A	1,092	20- 30 years
Mixed Use	24.5	19.6	N/A	216	20 -30 years
Mixed Use	24.5	19.6	490	N/A	20-30 years
R-5**	27.3	21.8	190	N/A	20 – 30 years
RML**	11.7	9.4	113	N/A	20 – 30 years
David Hill Urban Reserve Area					
Commercial	10	8	N/A	88	30+ years
RML**	21	16.8	202	N/A	30+ years
R-7**	158	119	737	N/A	25 – 30 years
North Water Planning Area					
Industrial		1003	N/A	N/A	40+ years
Residential		214	2054	19,382	40+ years
Public Use		28	N/A	N/A	40+ years
Redevelopment Areas (within City's UGB)					
Town Center	N/A	N/A	25	20	5 to 10 years
			150	100	10 to 20 years
			150	100	20 to 30 years
			125	80	30 to 40 years
Oak Street (East)	28	22	100	N/A	10 to 20 years
			500		20 to 30 years
			750		30+ years
Oak Street (West)	62	50	1,978	N/A	200 units w/in 15-years 500 units w/in 20 years 1,100 units w/in 30 yrs. 1,978 units 30+ years
Cedar Node	11	8.6	346	N/A	173 units 10 - 15 years 173 units 15 – 25 years
Quince/Pacific	N/A	N/A	50	N/A	10 - 15 years
Pacific Corridor	varies by site	varies by site	300	730	15 – 20 years

**The City lacks large industrial sites (50 – 100+ acres). Conversion of reserve land to accommodate the needs of large lot industrial users may be required before the 20-year time frame depending on demand for such sites and approval of an urban growth boundary amendment by Metro.*

*** R-5 =Residential 5,000 sq. ft per unit; R-7 = Residential 7,000 sq. ft per unit; RML =Residential Medium-Low Density*

3.4 Population Forecasting

Population data is needed for water master planning, because it provides the basis for forecasting growth in water demand – especially with respect to residential water demands. The past three years of population data was obtained from the City of Forest Grove from 2006 to 2008 to derive recent population growth rate trends for the City. **Table 3-2** presents a summary of the population from 2006 to 2008, when the average growth rate over the period was near 2.5 percent. (Note: at the time the population data was being analyzed the City did not have the final 2009 population available.) This growth rate is consistent with the long-term average annual growth rate of the City of Forest Grove of 2% over the past two decades, based on the 2000 WMP.

Table 3-2: Historical Service Area Population

Year	Population	Growth
2006	20,380	
2007	20,775	1.9%
2008	21,465	3.3%

In addition, the City of Forest Grove recently completed an extensive land use planning study, which involved analysis of potential urban growth and population growth scenarios and land use planning. The study is documented in the *City of Forest Grove Economic Opportunity Analysis* (Johnson Reid, 2009). During completion of the *Economic Opportunity Analysis* – and continuing through the development of this WMP Update – economic circumstances at the global, national, state and local levels significantly shifted and continue to do so making forecasting and trend analysis for population and other economic factors less certain.

In response, the City decided to develop the population forecast for the WMP update to account for "low, medium and high" growth scenarios, to better refine water demand. For consistency, the WMP update based the forecast on information from the *Economic Opportunity Analysis* and the land absorption analysis *(see **Table 3-1**)* with some modifications based on best professional judgment from the City's Planning Department staff. The population forecast scenarios are as follows:

Scenario A – Low growth - Infill and Increased Density Only

- Residential growth transition from 0.5% to 2.0% from 2010 to 2016; residential growth is constant 2.0% (Economic Opportunity Analysis [EOA] Baseline growth rate) until "build-out" is approached within current City limits (2031); growth then reduces to 1.5% (to 2041); then 1.0% for the remainder of the planning period
- Non-residential demand remains constant within City limits/UGA, i.e. zoning and land use does not significantly change over the planning period
- No expansion of UGB; this means residential growth is absorbed by infill and increasing residential density.

Scenario B – Moderate growth – Infill, Redevelopment and Urban expansion

- Residential growth transition from 0.5% to 2.0% from 2010 to 2013; residential growth is constant at 2.0% (EOA Baseline growth rate) until Purdin Rd. and David Hill expansion starts (2014-2030); then growth rate increases to 2.3% (EOA Moderate growth rate) (2031-2050); additional residential growth is based on land absorption analysis provided by City
- Land absorption timeline is used to distribute dwelling totals over time; number of dwellings from Table 3-1
- Number of dwelling units is multiplied by 2.6 residents per dwelling to calculate equivalent population in addition to residential growth rate above
- Land absorption timeline is used to calculate the acreage of commercial and industrial growth in the redevelopment, Purdin Rd. and David Hill areas; distribution over time is based on a linear annual interpolation
- Expansion of UGB for Purdin Rd. and David Hill areas using Land Absorption Analysis table; residential growth is absorbed by expansion and infill and increasing residential density.

Scenario C – High Growth – Redevelopment and Urban expansion with North Water Planning Area

- Residential growth transition from 0.5% to 2.0% from 2010 to 2012; residential growth is constant at 2.0% (EOA Baseline growth rate) until redevelopment occurs within City limits

(2013-2020); then growth rate increases to 2.3% (EOA Moderate growth rate) until Purdin Rd. and David Hill expansion starts (2021-2030); then growth rate increases to 2.6% (EOA Aggressive growth rate) when North Water Planning Area land is available (2031-2050); additional residential growth is based on land absorption analysis provided by City

- Land absorption timeline is used to distribute dwelling totals over time; number of dwellings from **Table 3-1** is multiplied by 2.6 residents per dwelling to calculate equivalent population in addition to an assumed 1.5% "baseline" growth
- Land absorption timeline is used to calculate the acreage of commercial and industrial growth in the redevelopment, Purdin Rd. and David Hill areas; distribution over time is based on a linear annual interpolation
- Expansion of UGB for Purdin Rd. and David Hill areas using Land Absorption Analysis **Table 3-1**; residential growth is absorbed by expansion and infill and increasing residential density
- North Water Planning Area also develops to add to residential and non-residential demands after year 2040.

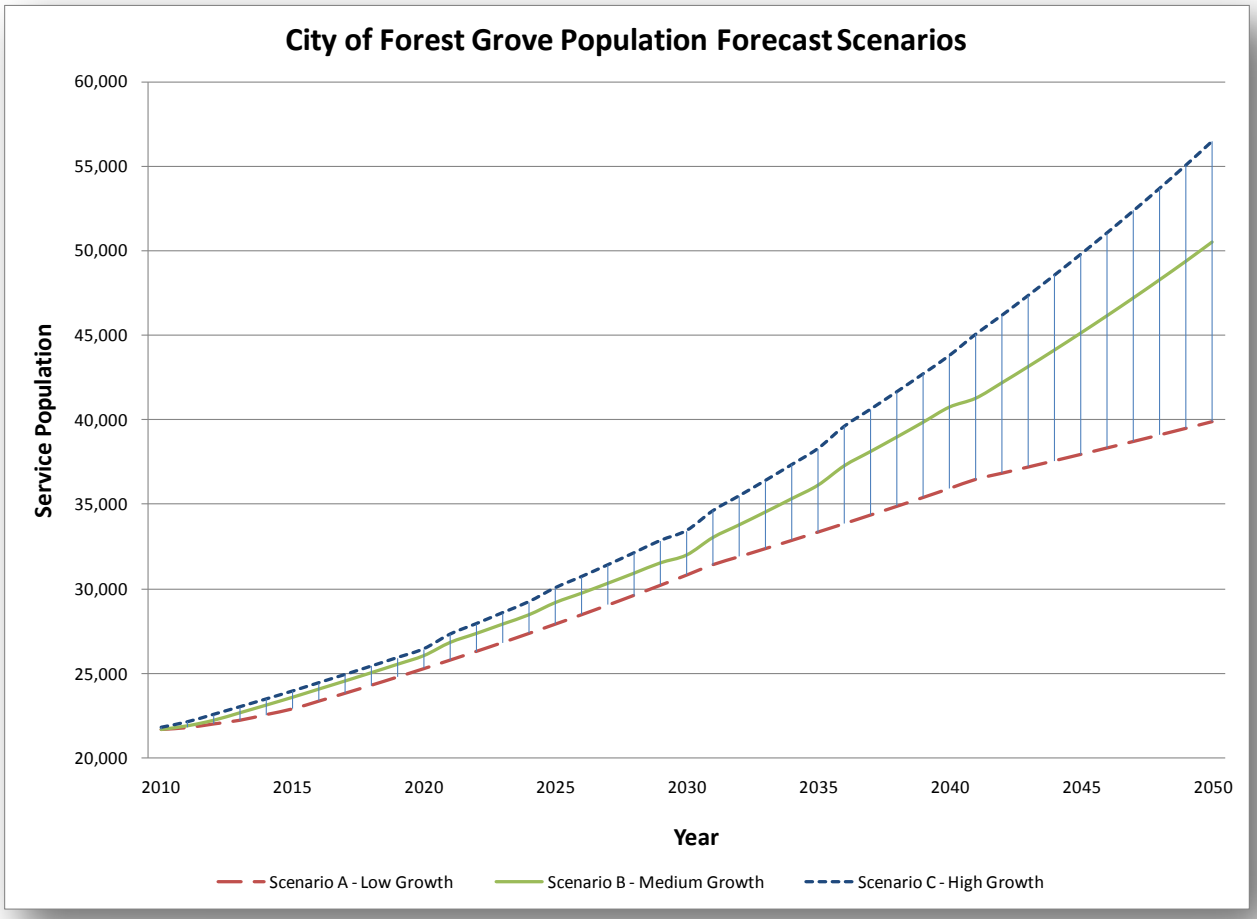
The results of the population forecast are shown in **Table 3-3** for the milestone periods (2010, 2017, 2030, and 2050). **Figure 3-2** shows the range of the population forecast through the planning period based on the three scenarios. **Appendix B** includes detailed calculation tables and results for the population forecast. The population forecast information is used subsequently in the water demand forecast for the WMP Update (see Section 4 – Water Requirements). The population and water demand forecasts included three scenarios to account for the uncertainty.

Table 3-3: Summary of Population Forecast Results

Year	Scenario A	Scenario B	Scenario C
2010	21,700	21,700	21,700
2017	23,800	24,500	24,900
2030	30,800	32,000	33,400
2050	39,900	50,500	56,500

Scenario A population is conservative in that no growth in the City's service area is allowed, and population increase results in higher population density, which constrains any significant growth. Scenarios B and C both allow growth to URAs. The result is a difference of almost 16,000 people at year 2050 between the low (A) and high (C) scenarios. As discussed in Section 4, the Scenario B population forecast is the basis for the system analysis as the medium growth scenario. In particular, the City is forecasted to have a population increase of almost 29,000 over the 40 year planning period. Again, the population forecast provides the basis for calculating the increase in water demand based on a per capita water use methodology described further in Section 4.

Figure 3-2 – Population Forecast Scenarios



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4 Water Supply Requirements

This section presents a review and analysis of recent historical water use data and the development of the water demand forecast. This section also describes other water requirement issues including non-revenue water, water conservation, and estimates of water needs for emergency fire suppression.

The term "demand" refers to all the water requirements of the system including residential, commercial, industrial, municipal, and institutional, as well as unaccounted-for water. Demands are discussed in terms of volume per unit of time such as gallons per day (gpd), mgd, or gpm. Demands are also related to per capita use as gallons per capita per day (gpcd) and to commercial and industrial use in terms of gallons per acre per day (gpad).

4.1 Historical Water Use

The City had recently updated their water billing system and water use data prior to July 2005 was considered less reliable. As a result, the City decided to use historical consumption data from the period July 2005-June 2009. Water production data was available from a longer period, but the period of overlap for calculating water use factors was for calendar years 2006-2008. Table 4-1 summarizes metered water production from the Forest Grove Water Treatment Plant (FG WTP) and metered demand from the Joint Water Commission supply (from 10th Ave. meter) from 2005 to 2009. The average production from the FG WTP is 1.63 mgd, and the average demand from the JWC 10th Ave meter is 1.48 mgd. The total average day demand is 3.11 mgd.

Historically the FG WTP supplies anywhere from 40% to 60% of total demand – with the average being near 50% over the past decade. There is not a clear trend that FG WTP is needing to provide more or less water, rather the amount FG WTP provides is dependent on specific conditions within the City's water supply system or JWC's operations.

Table 4-1: Historical Water Production (2005-2009)

	Average	2009	2008	2007	2006	2005
FG WTP (MG)	595	639	654	671	433	579
JWC (MG)	542	404	546	515	704	539
Total Production (MG)	1,137	1,043	1,200	1,186	1,137	1,119
Total Production (mgd)	**3.11**	**2.86**	**3.29**	**3.25**	**3.11**	**3.06**

* *Note, in 2006 total production from Forest Grove WTP was taken off line for a period for upgrades and improvements. As a result, total annual production was lower than other years.*
MG – Million gallons; mgd – million gallons per day

Table 4-2 and **Table 4-3** summarize historical water consumption by customer class from 2006 to 2008 (billing data was not complete for the entire 2009 at the time this analysis was completed). Total consumption from 2006 to 2008 averaged 2.8 mgd for average day demand. As the data shows, the primary water use in the City is for residential and multi-family residential purposes, comprising an average of 57% of metered consumption. Commercial and industrial use averaged 33% of metered consumption, while public use (school and city) averaged 10% of metered consumption. These percentages do not include non-revenue water, which is discussed in Section 4.2.

Table 4-2: Historical Metered Water Consumption by Customer Class – Annual (2006-2008)

Customer Class (MG)	Average	2008	2007	2006
Residential	421	416	416	432
Multi-family	163	163	161	165
Commercial	144	145	145	142
Industrial	191	179	189	206
School	59.1	56.8	62.2	58.2
City	46.7	43.3	44.6	52.1
Total Consumption	1,026	1,003	1,018	1,055
Total Consumption (mgd)	**2.81**	**2.75**	**2.79**	**2.89**

Table 4-3: Historical Metered Water Consumption by Customer Class – Monthly (2006-2008)

Month	Res. (mgd)	MF (mgd)	Comm. (mgd)	Ind. (mgd)	City (mgd)	School (mgd)	Total (mgd)	Monthly scaling factor*
January	0.80	0.38	0.28	0.47	0.08	0.06	2.07	0.74
February	0.86	0.40	0.31	0.53	0.08	0.07	2.26	0.81
March	0.73	0.36	0.27	0.44	0.06	0.08	1.95	0.69
April	0.81	0.40	0.29	0.50	0.07	0.08	2.15	0.77
May	0.84	0.37	0.28	0.45	0.06	0.09	2.09	0.74
June	1.27	0.46	0.41	0.55	0.14	0.17	3.00	1.07
July	1.76	0.55	0.47	0.50	0.22	0.20	3.69	1.31
August	2.06	0.61	0.63	0.66	0.22	0.32	4.50	1.60
September	1.83	0.58	0.60	0.56	0.25	0.34	4.15	1.48
October	1.20	0.46	0.50	0.62	0.16	0.27	3.21	1.14
November	0.92	0.42	0.40	0.53	0.10	0.14	2.51	0.89
December	0.76	0.37	0.30	0.47	0.08	0.11	2.09	0.74

** Monthly scaling factor is the ratio of the total metered consumption for that month divided by the annual average metered consumption; the monthly scaling factor accounts for the seasonal (monthly) variation in water use.*

Water use factors are "per unit" values derived from historical water use to calculate water demands for each customer class. In particular, the residential water use factor is based on dividing the total residential water use (single- and multi-family combined) by the population served to derive a "gallons per capita per day" (gpcd) value. The single-family proportion is based on the billing records which indicates single-family comprises approximately 72% of total residential metered consumption. Non-residential water use factors (commercial, industrial, school and city) are defined on a "gallons per acre per day" (gpad), which is calculated by dividing the total water use in that customer class by the acreage for the corresponding land use type (commercial, industrial, school and city). The water use factors are then multiplied by the forecasted population (for residential demand) and acreage (for non-residential demand) in future years to calculate the water demand for that customer class.

Data in **Table 4-2** was used to derive individual average month demand scaling factors and the peak season (May-October) demand scaling factor of 1.22 times average day demand. This data is used in the supply analysis considering seasonal water demand against available supply on a monthly or seasonal basis.

The most recent land use designation was used and assumed to not have changed significantly over the past three years. **Table 4-4** summarizes the water use factors by customer class and the historical data used to derive them. Data from years 2006- 2008 were used to derive the water use factors for residential.

Table 4-4: Summary of Water Use Factor Derivation (2006-2008)

Customer Class		2008	2007	2006
Population		21,465	20,775	20,380
Commercial Acreage*		212	212	212
Industrial Acreage*		210	210	210
Public Acreage (School and City)*		912	912	912
Derived Water Use Factors	**Average****	**2008**	**2007**	**2006**
Residential per capita (gpcd) (1)	75	73.9	76.1	80.3
Commercial Per acre (gpad) (2)	1,600	1,604	1,612	1,576
Industrial Per acre (gpad) (3)	650	638	674	732
Public per acre (gpad) (4)	310	301	321	331

** Acreages based on Geographical Information System (GIS) analysis of current land use (2010) and assumed to have remained relatively constant through the past 4 years.*

*** Average is based on 2-significant digits.*

(1) Calculated by dividing annual residential water use by population for each year.

(2) Calculated by dividing total annual commercial water use (reduced by largest water user portion – see Section 4.3) by total acreage (212 acres) of commercial land use for each year.

(3) Calculated by dividing total annual industrial water use (reduced by largest water user portion – see Section 4.3) by total acreage (210 acres) of industrial land use for each year.

(4) Calculated by dividing annual public (city and school) water use by total acreage (912 acres) of public land use for each year

The historical peaking factors, defined as the ratio of maximum day demand (MDD) to average day demand (ADD), are summarized in **Table 4-5**. The demands are based on the total production data from the Forest Grove WTP and JWC. The maximum day demand occurred either in July or August in the years 2006 to 2009.

Table 4-5: Historical Peaking Factor (2006-2008)

	Average	2009	2008	2007	2006
Maximum Day Demand	6.49	6.33	6.67	6.52	6.43
Average Day Demand	3.13	2.86	3.29	3.25	3.11
Peaking Factor (MDD/ADD)	**2.08**	**2.21**	**2.03**	**2.01**	**2.07**

For planning purposes it was assumed that a peaking factor of 2.0 applies to the residential customer class; while the commercial/industrial peaking factor is 1.5, because demands are considered to be less influenced by seasonal irrigation demands. The public use class is also defined to be 2.0 because demands in this class are assumed to more similar to residential demands with respect to irrigation demands (e.g., parks and landscaping).

4.2 Non-revenue Water

Non-revenue water is that water which leaves the system unmetered or is measured inaccurately. This includes such uses as fire fighting, main flushing, water system construction projects, water main breaks and leaks, street flushing, unmetered usage, improperly registering meters and unauthorized or unrecorded connections to the system. It is generally considered within the water works industry that a level of non-revenue water of less than 15 percent is acceptable and five percent is excellent.

As part of this plan update, the City provided historical water sales data to update the analysis of non-revenue water using the period 2006 to 2008. As shown in **Table 4-6**, non-revenue water ranged from

7% in 2006 to 16% in 2008. Based on discussions with the City staff, it was decided that a 12% non-revenue water would be used for planning and analysis purposes in this update.

Table 4-6: Non-Revenue Water Estimate (2006-2008)

	2008	2007	2006
Total Production (MG)	1,200	1,186	1,137
Total Production (mgd)	3.29	3.25	3.11
Total Consumption (MG)	1,003	1,018	1,055
Total Consumption (mgd)	2.75	2.79	2.89
Non-revenue water (MG)	197	167	81.1
Non-revenue water (mgd)	0.54	0.46	0.22
% Non-revenue water	**16%**	**14%**	**7%**

It is recommended that the City continue to track non-revenue water and continue the City's non-revenue water reduction program that includes leak detection and repair, meter calibration, the elimination of unmetered connections, and systematic main replacements. It is recommended that the City continue to pay particular attention to the Gales Creek Service Area which, as reported in Section 2, could be a significant source of non-revenue water.

4.3 Large Water Users

The City of Forest Grove serves several relatively large commercial and industrial customers. To allow more accurate distribution system analysis and better understanding of forecasting future commercial and industrial demands, an analysis of the billing data from 2006 to 2008 was used to identify the largest water customers. **Table 4-7** shows the five largest non-residential water customers. Together, these five customers account for approximately 15% of the City's total demand.

Table 4-7: Water Use of Largest Non-Residential Customers (2006-2008)

Customer	Class	2008-2009 (MG)	2007-2008 (MG)	2006-2007 (MG)	Average ADD (mgd)	Acres
Merix	Ind.	72.2	90.1	93.1	0.233	44.0
Westak	Ind.	22.9	26.6	25.9	0.069	3.5
Gray & Co.	Ind.	17.9	18.4	22.5	0.054	4.2
Lieb	Ind.	17.6	21.4	17.1	0.051	11.8
Rose Grove Mobile Homes	Comm.	20.8	23.3	23.6	0.062	

4.4 Water Conservation

Water conservation is generally defined as the implementation of short-term and long-term measures to reduce the demand for water, improve efficiency in its use, and reduce losses and waste. Water conservation can be implemented through voluntary programs, incentive programs, and regulatory measures. Voluntary programs consist of promoting increased public awareness of the value of water, the methods and benefits of water conservation, and increasing water use efficiency. The water purveyor can provide information on water-saving plumbing fixtures and fixture altering devices, lawn watering, and water efficient landscaping. Water audits can be performed for both residential and commercial/industrial customers to point out specific methods of reducing water use. Incentive

programs include adopting rate structures that promote conservation and distribution of water saving devices such as high efficiency shower heads, faucet aerators, toilet tank water displacement bags, leak detection tablets, and informational brochures.

4.4.1 Existing Water Conservation Program

Oregon Administrative Rules adopted by the Water Resources Commission in November 2002 (OAR Chapter 690, Division 86) describe water management, water conservation, and curtailment programs to guide the wise use and stewardship of water resources. The City's current water conservation program was recently documented in the JWC Water Management and Conservation Plan (WMCP) (CH2M-Hill, 2009). Highlights of the City's water conservation program are presented below.

The City of Forest Grove has a water use measurement and reporting program that complies with the measurement standards in OAR Chapter 690, Division 85. The city's water use records can be found on the OWRD webpage. (http://www.wrd.state.or.us/OWRD/WR/water_use_report.shtml). OAR 690-086-0150(4) requires all municipal water suppliers to implement a particular set of conservation measures. **Table 4-8** includes descriptions of Forest Grove's conservation implementation to date and 5-year benchmarks for these measures as documented in the JWC WMCP (CH2M-Hill, 2009).

Table 4-8: Forest Grove Required Water Conservation Measures per OAR 690-086-0150(4)

Measure Category	Description	Benchmark
Annual water audit	The city measures unaccounted-for water as the difference between: (1) Forest Grove water treatment plant plus delivered flow from JWC water treatment plant, and (2) water sold to customers. The calculation is based on monthly records. Historically, unaccounted water has ranged from 10 percent to 15 percent. The city implemented a new accounting system in 2005, which will improve its ability to estimate unaccounted for water.	By 2011, improve water audit record keeping, and consider ways of changing computer software to better compare and report water use.
Metering	Forest Grove is completely metered.	Continue to meter all connections.
Meter testing and maintenance	Forest Grove tests 40 compound meters on an annual basis to check for accuracy. The city also has a meter replacement program in which all meters, including residential and commercial meters, are replaced every 15 years. In addition, Forest Grove has installed about 100 AMR meters as a test, and has contracted to purchase more.	Evaluate the results of the AMR test and determine whether to convert all residential meters to automated meter reading (AMR) and how best to use that system to provide customers with real-time use information.
Rate structure	Forest Grove has a volumetric rate for each of the four customer classes (single-family residential, multi-family residential, commercial, and industrial). The single family rate (which accounts for approximately 47 percent of consumption) is a three-tier increasing-block structure.	Continue a volumetric rate for each customer class, and will continue its three-tier rate structure for the single-family customer category.
Leak detection	Twelve percent of Forest Grove's distribution system is sonically leak tested annually. Approximately 1 percent of the distribution is replaced on an annual basis.	Continue its current leak detection and repair program.
Public Education	Forest Grove holds an annual open house at which there is a water conservation table and indoor and outdoor conservation kits are distributed. In addition, the city participates in various events coordinated by the Regional	• Continue the public education activities described above. • By 2012, Forest Grove will expand its website to include

Measure Category	Description	Benchmark
	Water Providers Consortium (RWPC) and JWC Events and Education Committee (EEC) (see above). In addition, the city offers two RWPC school presentations per year. Conservation information is included with water bills. The city's website includes conservation information and tips.	more water conservation information including a link to evapotranspiration (ET) data.

In addition to the required measures, OAR 690-086-0150(6) requires municipal water suppliers serving a population greater than 7,500 to implement an additional set of conservation measures or to provide documentation showing that implementation of the measures is neither feasible nor appropriate. Again, the 2009 JWC WMCP documented the City's additional measures, which are presented in **Table 4-9**.

Table 4-9: Forest Grove Additional Water Conservation Measures per OAR 690-086-0150(6)

Measure Category	Description	Benchmark
System-wide leak repair	Forest Grove implemented the recommendations of the 2000 WMP, for replacement of 6-10 inch diameter pipe. The 2009 through 2013 budget is approximately $1.4M (in 2009 dollars). A full inspection of the water system is conducted every four years. In addition to this scheduled program, the city's public works department conducts visual inspections and follows up on customer complaints of water leaks. If a leak is identified, the water line is replaced.	Continue current system-wide leak repair program.
Technical and financial assistance	Forest Grove has implemented a leak repair incentive program. If a leak that has resulted in a bill increase is identified and repaired by the resident, the city will investigate the issue on a case-by-case basis and refund at the commercial rate, currently $1.51 per 1,000 gallons. In addition, Forest Grove Light and Power (FGL&P) conducts a home energy audit program, during which auditors install low flow showerheads and faucet aerators.	Evaluate expanding the current home energy audit program to include more water conservation consultation.
Retrofits and replacement	Forest Grove provides a rebate for low-water-use washing machines and dishwashers in partnership with FGL&P.	Evaluate the potential costs, market penetration, and water savings from expansion of the rebate program to also include toilets, landscape equipment, and weather-based irrigation controllers.
Rate structures and billing schedules	See Table 4-8. In addition to the described rate structure, Forest Grove will continue its program of providing conservation messages on its water bills.	See Table 4-8.
Water reuse and recycling	Clean Water Services (CWS) provides these services in Washington County. CWS is working with the Department of Environmental Quality (DEQ) and exploring new water reuse opportunities.	Continue to forward customer and business inquiries on water reuse and recycling to CWS.

4.4.2 Anticipated Water Savings

The City of Forest Grove has implemented a variety of conservation measures and plans significant program enhancements over the next several years. The program has been effective in decreasing the per-capita water use from 168 gpcd in 2003 to 131 gpcd in 2007[3], a 22 percent reduction (CH2M-Hill, 2009). As documented in Section 4.4.1, the City of Forest Grove is continuing to implement the water conservation program with benchmarks to increase its effectiveness.

It was beyond the scope of work for this WMP update to do a detailed conservation potential analysis (CPA). However, based on the trends in decreasing per capita water use and the experience of the consultant in conducting CPAs with similar communities[4], water savings from conservation have been assumed for purposes of water demand forecasting. The residential and public users were assumed to have slightly more water savings than the commercial/industrial users due to the nature and target customers of the City's conservation measures. Furthermore, the residential and public uses were assumed to have added water savings due to programs targeting irrigation use under maximum day demand periods. In particular, the following assumptions were made on the level of water savings by customer class (**Table 4-10** summarizes the assumptions for progressively increasing the water savings):

- Baseline residential, school, and city conservation: 0.5% - 2.5% over planning period (ADD)
- Baseline commercial/industrial conservation: 0.25% - 1.25% over planning period (ADD)
- Additional residential, school and city conservation: 0.5% - 2.5% over planning period (MDD)

The percentages shown in **Table 4-10** are multiplied by the current water use factor for each customer class (e.g., 75 gallons per capita per day for residential; 1,600 and 650 gallons per acre per day for commercial and industrial, respectively).

Table 4-10: Summary of Water Savings Assumptions Throughout Planning Period

Customer Class	Percent Savings for Average Day Demand (ADD)	Percent Savings for Maximum Day Demand (MDD)	Planning Year
Residential School City	0.5%	0.5%	2010-2014
	1.0%	1.0%	2015-2020
	1.5%	1.5%	2021-2030
	2.0%	2.0%	2031-2040
	2.5%	2.5%	2041-2050
Commercial Industrial	0.25%	N/A	2010-2014
	0.50%		2015-2020
	0.75%		2021-2030
	1.0%		2031-2040
	1.25%		2041-2050

It should be noted that the water savings assumptions are considered for planning purposes only to account explicitly for water conservation in the water demand forecast (Section 4.5). In the City's situation, water supply is not a critical need in the short-term, and a robust and quantitative evaluation

[3] *The per capita values are based on aggregated water use, rather than the dis-aggregated analysis presented in Table 4-5, where the residential per capita of 75 gpcd is based on single- and multi-family residential uses only.*
[4] *HDR recently completed conservation potential analyses for Cities of Hillsboro, Beaverton, and Corvallis. Water savings from the various program scenarios are typically in this range.*

of water conservation versus developing new supply was not a priority at the time the WMP update was prepared. However, a more detailed analysis of water savings should be completed to better understand the effectiveness of the conservation program and the cost-benefit of developing new supply in the future versus more aggressive water conservation.

4.5 Water Demand Forecast Methodology

The demand forecast used for the WMP update is a "dis-aggregated" approach whereby the major customer classes are forecasted separately and then added together for the total water demand over the planning period. The advantage of this approach over a simple "per-capita" approach is that factors specific to each customer class can be accounted for and effects on demand better understood, e.g. land use change or development patterns, and water use factors. This is useful as long as appropriate data is available. In the case of this update, the City wanted to account for specific land absorption analysis results and development plans in the water master plan.

Based on the information from the historical water use analysis the following bullets summarize the planning basis for the water demand forecast:

- Residential per capita water use = (residential+multi-family water use)/City population = 75 gpcd
  - Single family = 72% of total residential demand (ADD)
  - Residents per dwelling = 2.60
- Large Water Users
  - Industrial: ADD = 0.41 mgd (Merix, Westak, Gray & Company, and Lieb Cold Storage)
  - Commercial: ADD = 0.062 mgd (Rose Grove Mobile Homes)
  - Large users are subtracted from total sector demands to calculate water use factors, and not assumed to change over the planning period
- Per acre water use = (Consumption/Total acreage)
  - Commercial = 1,600 gpad
  - Industrial = 650 gpad
  - Public (school and city) = 310 gpad
- Industrial reserve = 0.25 mgd (for Scenarios A and B) and 0.5 mgd (for Scenario C) starting 2015
- Non-revenue water = (Production-Consumption)/Production = 12%
- Peaking factor (average day demand [ADD] x Peaking Factor = maximum day demand [MDD])
  - Residential = 2.0
  - Commercial/Industrial = 1.5
  - City/School = 2.0
- Water savings rate from conservation (over planning period)
  - Residential, school, and city conservation: 0.5% - 2.5% for ADD
  - Commercial/industrial conservation: 0.25% - 1.25% for ADD
  - Residential, school and city conservation: 0.5% - 2.5% for MDD

Consistent with the population forecasting scenarios presented in Section 3.3, a range of scenarios representing "low, medium, and high" demand forecasts was prepared. The three scenarios are largely defined by the population and land absorption analysis (refer to Section 3.3 for details):

Scenario A – Low growth - Infill and Increased Density Only

- "Build-out" is approached within current City limits (2031); growth rate then reduces for the remainder of the planning period;
- Zoning and land use does not significantly change over the planning period;
- No expansion of UGB.

Scenario B – Moderate growth – Infill, Redevelopment and Urban expansion

- Less moderate residential growth in the near-term within City limits; Purdin Rd. area and David Hill area expansion based on land absorption analysis defined by City;
- Land absorption timeline defines commercial and industrial growth in the redevelopment, Purdin Rd. and David Hill areas.

Scenario C – High Growth – Redevelopment and Urban expansion with North Water Planning Area

- Moderate residential growth in the near-term within City limits; Purdin Rd. area and David Hill area expansion based on land absorption analysis defined by City; growth rate further increases when North Water Planning Area land is available (beyond 2040) (assumed for water supply planning only) ;
- Land absorption timeline is used to distribute residential, commercial and industrial growth in the redevelopment, Purdin and David Hill areas;

Detailed spreadsheets showing the forecasting parameters and assumptions are presented in **Appendix C**. For the purpose of the system analysis and capital improvement planning, the results of Scenario B are used. Scenarios A and C provide comparison and context to account for the uncertainty in the demand forecast.

As mentioned earlier in this Section, there are residential water customers outside of the City Limits in the "Gales Creek Service Area." Billing data was used to account for demand from the Gales Creek Service area, and the number of connections and the population are assumed not to change over the planning period.

4.6 Water Demand Forecast Results

The results of the demand forecast are summarized in **Table 4-11** for the milestone periods for all three scenarios. The demands are allocated throughout the service area (and pressure zones) using a combination of metered account data and land use designation using GIS analysis. **Figure 4-1** shows the demand forecast curves of each scenario for the entire planning period.

The spatial allocation of water demands are discussed in Section 6 as part of the distribution system model analysis. The allocation is based on land use and meter (customer account) data.

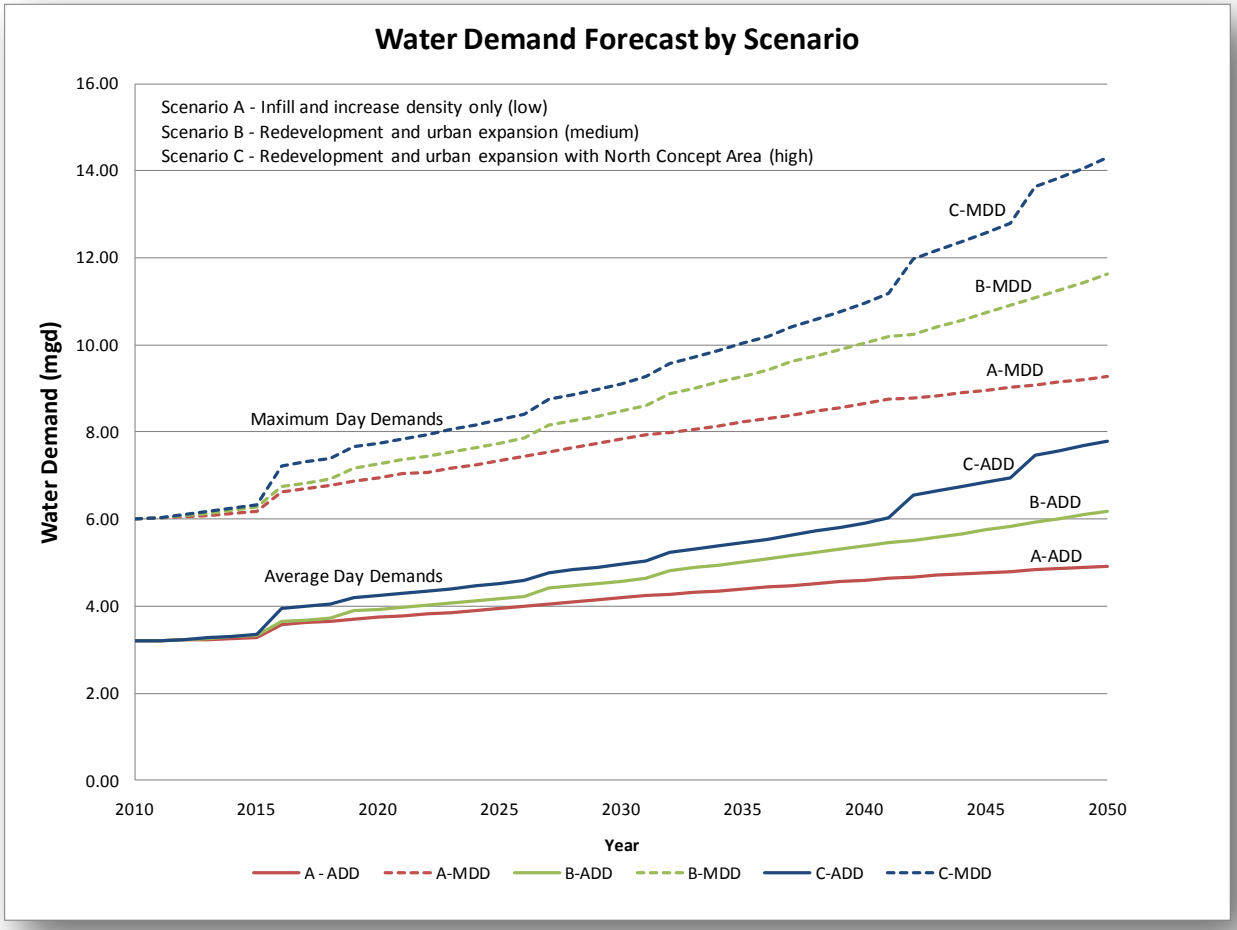
Table 4-11: Summary of Demand Forecast Results (mgd)

Year	Scenario A		Scenario B		Scenario C	
	ADD	MDD	ADD	MDD	ADD	MDD
2010	3.20	6.02	3.20	6.02	3.20	6.02
2017	3.62	6.70	3.69	6.83	4.00	7.31
2030	4.19	7.83	4.57	8.47	4.96	9.11
2050	4.93	9.28	6.19	11.62	7.80	14.30

Recall Scenario A water demands are conservative in that no growth in the City's service area is allowed. Scenarios B and C both allow growth to URAs, allowing greater residential and industrial/commercial demands growth. Within the first milestone period (2017), the maximum day water demands are not

significantly different (a range of ~ 0.60 mgd) between the low and high demand scenarios. However, the result is a difference of over 5 mgd MDD between the low (A) and high (C) scenarios by the end of the planning period (2050). As discussed in Section 4, Scenario B water demand forecast is the basis for the system analysis as the medium growth scenario. In particular, the City is forecasted to have a maximum day water demand increase of almost 5.6 mgd over the 40 year planning period.

Figure 4-1 – Annual Water Demand Forecast by Scenario



The critical time frame for near-term capital improvement planning occurs in the first 5 to 7 years (i.e., the 2017 milestone period). As **Figure 4-1** shows, the range of water demands are small within this portion of the planning period. The sudden increase in demand at 2015 is a result of an assumed large industrial development (industrial reserve). This timing may or may not occur, but generally the idea is that no large industrial development is expected to occur within the next 5 years.

Further out into the planning period, the uncertainties around the forecasting parameters are greater, producing a greater range of demands – in particular, the uncertainty around the timing and development of the urban reserve areas (and notably the North Water Planning Area in Scenario C).

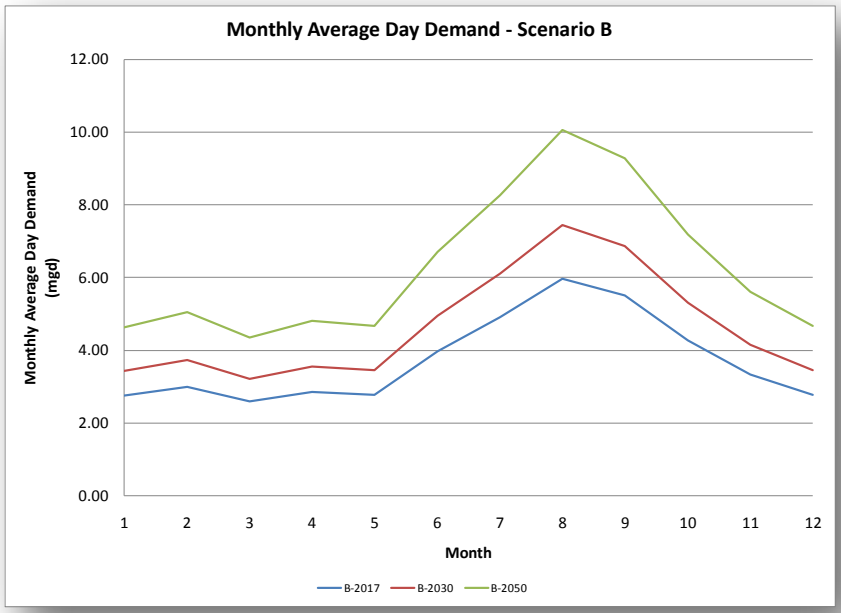
Most of the demand increase over the planning period is due to residential demand growth. For the most part, step increases in commercial and industrial demands are based on the assumed "trigger" of the industrial reserve in 2015 timeframe (for development within the UGB) and the 2025 and 2030 timeframe from URA development.

Table 4-12 summarizes the average monthly demand using Scenario B assumptions. As expected, the months of August and September have the highest seasonal demands. **Figure 4-2** illustrates the seasonal demand curves during the three milestone years. There is a "spike" in demand during the month of February, which is an artifact of the 2006-2008 data used. It is expected that the demands from December through February remain relatively "flat." The monthly demands are used in the supply evaluation.

Table 4-12: Summary of Monthly Demand Forecast (Scenario B - mgd)

Month	2017	2030	2050
January	2.75	3.43	4.64
February	3.00	3.74	5.06
March	2.59	3.22	4.36
April	2.85	3.55	4.81
May	2.77	3.45	4.67
June	3.98	4.95	6.70
July	4.90	6.10	8.26
August	5.97	7.44	10.07
September	5.51	6.86	9.29
October	4.27	5.31	7.19
November	3.33	4.14	5.61
December	2.77	3.45	4.67

Figure 4-2 – Monthly Average Day Demand – Scenario B



4.7 Fire Flow Requirements

In addition to providing water for residential, commercial and industrial uses, Forest Grove's water system also provides water for emergency fire suppression. The amount of water required on an emergency basis for fire suppression purposes is related to the local building type and the land use of the specific location within the distribution system. Fire flow requirements are concentrated in a specific area and are typically much greater in magnitude than the normal maximum demand present in that local area; therefore, adequate hydraulic capacity must be provided for these large, though occasional, fire flow demands. Additionally, adequate storage capacity must be provided to supply water for fire suppression. Fire flow durations recommended by the National Fire Protection Association can be used with the recommended fire flows to determine the required storage component to support fire flows. Both fire flow durations and fire related storage for each land use designation are presented in **Table 4-13**.

Table 4-13: Summary of Land Use Designations and Fire Flow Requirements

Land Use Designation	Recommended Fire Flow (gpm)	Fire Flow Duration (hours)	Fire Flow Volume (MG)
Residential			
Low density	1,000	2	0.12
Medium density	2,000	2	0.24
High density	3,000	3	0.54
Commercial			
Central business district	3,500	3	0.63
Commercial auto	4,500	4	1.08
Commercial heavy	4,500	4	1.08
Commercial neighborhood	3,000	3	0.54
Industrial			
Light industrial	3,000	3	0.54
General industrial	4,500	4	1.08
Institutional			
Public	2,500	2	0.3
Semi-public	4,500	4	1.08

5 Planning Criteria and System Requirements

This section describes the infrastructure planning criteria used to evaluate the City of Forest Grove water system facilities. The criteria are based on industry standards and requirements from Oregon Department of Human Services (per ORS 333-61-060). The infrastructure planning criteria were used in conjunction with the hydraulic model developed for this master plan to identify existing and future system deficiencies throughout the system. The criteria described in this section are the basis from which the City has developed the capital improvement program (CIP) in this master plan.

5.1 Water Supply and Transmission System Criteria

The supply and transmission systems must be capable of providing treated water to the City of Forest Grove water system to meet the estimated MDD through the end of the planning period. The supply system requirements for existing (2010), short-term (2017), and long-term (2030) planning, based on the defined water demand forecast scenarios estimates are presented in Section 4. For purposes of developing the CIP, the City is using Scenario B for maximum day demand as the planning criteria, as presented in **Table 5-1**. The other demand scenarios provide context for evaluating improvement projects in terms of the uncertainty in future demands.

For this WMP update, the City is also considering water supply source requirements for year 2050 for strategic planning purposes. Unlike the previous water master plan, the City is not planning for "ultimate development saturation of the service area" because of the planned long-term expansion of the urban growth boundary into the urban reserve areas.

Table 5-1: Supply and Transmission System Requirements (Scenario B)

Year	Maximum Day Demand – Scenario B (mgd)		
	Lower Pressure Zone	Upper and Intermediate Pressure Zone	Total Maximum Day Demand
2010	5.51	0.51	6.02
2017	6.25	0.58	6.83
2030	7.78	0.69	8.47
2050	10.34	1.28	11.62

In addition to the specific planning criteria for supply and transmission presented in **Table 5-1**, the evaluation of the water supply evaluation in this WMP update has the following objectives:

- Improve supply reliability and redundancy, considering the City's Clear Creek source, the JWC supply, and other regional source options and coordination issues;
- Optimize use of existing supply sources and infrastructure, including the City's existing water rights certificates and permits, and use of the City of Forest Grove water treatment plant;
- Identify cost-effective supply alternative(s).

5.2 Storage Criteria

Water storage facilities should be provided in each pressure zone except in special cases where direct pumping can be justified. A discussion of direct pumping follows later in this section regarding distribution system criteria. Storage facilities are provided for three purposes: operating storage, fire storage, and emergency storage. The total storage required is the sum of these three elements. A brief discussion of each element is provided below.

5.2.1 Operating Storage

Operating storage is required to meet water system demands in excess of delivery capacity from the supply source(s). For the lower pressure zone, required operating storage is a function of supply available from both the City of Forest Grove water treatment system and the JWC water treatment system relative to system demand. Similarly, for the intermediate and upper pressure zones, operating storage is a function of the pumping and transmission capacity of the system supplying the upper storage reservoir and the system demand characteristics.

5.2.2 Fire Storage

Standard engineering practice is to assume that a critical fire situation may occur during maximum day demand conditions. Under this scenario, fire storage should be provided to meet the single most severe fire flow demand within the area (pressure zone) served by the storage facility. The fire storage volume required is determined by multiplying the fire flow rate by the duration of that flow. Specific fire flow quantity and duration recommendations by land use type are presented in Section 4.7.

5.2.3 Emergency Storage

In addition to the above described storage components, emergency storage is often provided to supply water from storage during emergencies such as pipeline failures, equipment failures, power outages, or natural disasters. The amount of emergency storage provided can be highly variable depending upon an assessment of risk and the desired degree of system reliability. Some nearby communities with single source systems and no emergency back-up have adopted an emergency storage goal equal to three average days demand. Other systems, which benefit from multiple emergency back-up capabilities, may include no emergency storage component in their storage requirement calculation methodology.

5.2.4 Summary of Storage Criteria

Based on a review and comparison of the planning criteria used in the City of Forest Grove's 1989 Water Master Plan and 2000 Water Master Plan, and accepted water industry practice and guidelines, the City is using the following storage criteria for this WMP Update:

- Total Storage Volume (for each pressure zone)
    - Operating Storage = 25% of maximum day demand;
    - Fire suppression (FS) storage = most severe fire flow demand (volume) within the area served by the storage facility;
    - Emergency Storage = 75% of maximum day demand; fire suppression storage for a given pressure zone is the maximum requirement for that pressure zone based on zoning.

Appendix D documents the evaluation of the various storage criteria used in the City's past water master plans, the specific system conditions and improvements considered to establish the storage criteria.

The Scenario B demand forecast (Section 4. 6) is used as the basis for maximum day demands in the analysis. The criteria and analysis assumes that the City of Forest Grove contracted JWC storage at Fern

Hill reservoir is available for the City's use (2.8 MG). Furthermore, the analysis assumes that the North Water Planning Area is not included for the capital improvement program, because there is not enough certainty of the development timeline for this area. **Table 5-2** presents the storage facility requirements by each pressure zone.

Table 5-2: Storage Requirements by Pressure Zone

Pressure Zone and Planning Period	MDD (mgd)	Operating Storage (MG)	Fire Storage (MG)	Emergency Storage (MG)	Total Storage Required (MG)
Lower Zone					
2010	5.51	1.38	1.08	4.14	**6.6**
2017	6.25	1.58	1.08	4.75	**7.3**
2030	7.78	1.98	1.08	5.93	**8.9**
2050	10.34	2.63	1.08	7.88	**11.4**
Intermediate and Upper Zone					
2010	0.51	0.13	0.54	0.39	**1.1**
2017	0.58	0.15	0.54	0.44	**1.1**
2030	0.69	0.17	0.63	0.53	**1.3**
2050	0.91	0.23	0.63	0.69	**1.5**
David Hill					
2010	0.00	0.00	0.00	0.00	**0.0**
2017	0.00	0.00	0.00	0.00	**0.0**
2030	0.00	0.00	0.00	0.00	**0.0**
2050	0.37	0.09	0.54	0.28	**0.9**

5.3 Distribution System Criteria

Aspects of water distribution systems that are typically assigned system criteria are service pressures, distribution piping, and pump stations. The criteria defined in this section are used to evaluate whether the City's distribution system has deficiencies in meeting the minimum requirements. The results of the analysis against these criteria are presented in Section 6.

5.3.1 Service Pressure Criteria

Water distribution systems are separated into pressure zones or service levels to provide acceptable service pressures to system customers. Service pressure criteria must be met within each pressure zone. **Table 5-3** presents service pressure requirements of the distribution system.

Table 5-3: Service Pressure Requirements

Condition	Pressure Limit (psi)
Minimum Service Pressure under fire flow conditions	20
Minimum service pressure at peak hour demand	30
Minimum normal service pressure	40
Maximum service pressure	100

5.3.2 Distribution Piping Criteria

The water distribution system should be capable of operating within specific system performance limits, or guidelines, under several demand conditions. The system performance guidelines presented below have been developed consistent with State requirements, American Water Works Association acceptable practice guidelines, and operational practices of similar communities. These guidelines also incorporate the service pressure criteria discussed above.

The distribution system should be capable of providing the maximum day demand while maintaining a minimum service pressure at any meter in the pressure zone of 40 psi.

The distribution system should be capable of providing the required fire flow to a given location while at the same time supplying the maximum day demand and maintaining a minimum residual service pressure at any meter in the pressure zone of 20 psi. This is the minimum water system pressure required by the Oregon State Health Division.

The distribution system should be capable of providing the peak hour demand while maintaining service pressures at not less than 30 psi.

Looped water mains should normally be at least 8 inches in diameter except for short loops where 6-inch diameter mains are acceptable. Mains smaller than 6 inches in diameter are generally appropriate where no fire hydrant connections are required, if there are limited services on the main, or if the main is dead-ended and looping or future extension of the main is not anticipated.

5.3.3 Pump Station Criteria

Pump station capacities should be adequate to supply the maximum day demand to the service area of the station. Since mechanical equipment is subject to failure, this supply capacity should be achieved assuming that the largest pump is out of service. For stations that supply reservoirs, standby power in case of normal power failure is not normally considered necessary. Standby power for stations that supply water by direct pumping is essential.

Direct pumping stations (continuously operating pumps or hydropneumatic systems without gravity storage) are normally used to supply small residential areas of up to approximately twenty homes. Fire flow to areas served by direct pumping or hydropneumatic systems can be provided by fire pumps. These systems should be considered only for small areas where conventional supply from gravity storage is not practical or economical, or as an interim operational program until gravity service can be provided. Direct pumping stations are not currently part of the City's system.

6 Water System Analysis

This section presents the evaluation of the City of Forest Grove's water system against the planning criteria and objectives presented in Section 5 and the planning data and water demand forecast presented in Sections 3 and 4, respectively. The evaluation is conducted for the City's source of supply (water rights, treatment, and transmission) and overall distribution system (storage, pipelines, and pump stations). A new water system hydraulic model was developed for this WMP update and was the primary basis for analyzing the distribution system. This section presents the system deficiencies and recommended improvements, plans and strategies to address them. This information is then used to develop the capital improvement program presented in Section 7.

6.1 Source of Supply Analysis

In general, the City of Forest Grove has sufficient raw water supply and water rights to meet demand over the entire planning period (through 2050). Even under the most aggressive demand growth assumptions, additional raw water is not needed until after 2045, when maximum day demands exceed the peak supply capacity from the Clear Creek watershed and Barney and Scoggins reservoir stored water releases. However, by 2023 the maximum day demands exceed the current supply capacity, namely the finished water transmission capacity of 24-inch line from the JWC source at Fern Hill reservoir.

As described in Section 2, the City of Forest Grove presently relies on two sources for water supply: (i) City of Forest Grove treated water from the City's Clear Creek Watershed; and (ii) JWC treated water from the Barney Reservoir (Upper Trask River)/Hagg Lake (Tualatin River) source. The supply and transmission system requirements developed in Section 5 determined the need for approximately 6.8 mgd by 2017, 8.5 mgd by 2030, and 11.6 mgd by 2050. The ability of both of the City's sources of supply to meet these future demands are constrained to varying degrees by available streamflow (hydrology), water rights, or existing infrastructure. These issues are discussed in the following sections with recommendations for near-term and long-term supply improvements to meet the planning criteria and broader supply objectives presented in Section 5.1 and **Table 5-1**. **Appendix D** presents the spreadsheet tables used to evaluate the supply needs.

6.1.1 Water Rights Limitations

As discussed in Section 2.1, the City of Forest Grove holds several water rights from tributaries in the Clear Creek watershed. Three of the water rights are *certificated* with a total instantaneous rate of 2.80 cfs (1.82 mgd). The City also has a water right *permit* for Clear Creek and Roaring Creek (tributary to Clear Creek) for 5.26 cfs (3.40 mgd). Although the City does not divert directly from Gales Creek with the existing system, the City has a certificated water right for Gales Creek of 4.46 cfs (2.88 mgd). Therefore, in total the City has approximately 8.1 mgd of water rights available on an average rate basis to supply the Forest Grove WTP.

The reliable summer stream flow from the Clear Creek watershed (including Gales Creek) is 1.5 mgd (from historical observation and data), which is significantly lower than the allowed rate of diversion of 8.1 mgd. This hydrologic limitation of the Clear Creek watershed is a key limiting factor for the City's ability to expand their supply source to the Forest Grove WTP. The seasonal flow limit on Gales Greek is not known, and a flow availability analysis was beyond the scope of this WMP update. However, a preliminary study completed by the City in 2007, concluded that limited instream flows will result in restrictions to direct diversion from Gales Creek at least 50% of the time and restrictions from

environmental constraints (temperature) resulting in restrictions most of the summer period. **Table 6-1** summarizes the water rights and seasonal flow limits for these sources to the Forest Grove WTP.

Because of the constraints on use of the Gales Creek water right certificate, the City is considering options to transfer or lease the Gales Creek water right. The City has identified the need to conduct a formal "water rights strategy" around the Gales Creek water right. Further discussion of this strategy is presented in Section 6.1.4.

Table 6-1: Water Rights and Seasonal Flow Limits for Sources of Supply to the Forest Grove Water Treatment Plant

Sources for Forest Grove WTP	Permit/Cert.	Rate (cfs)	Rate (mgd)	Seasonal Flow Limit (1) (mgd)
Clear Creek Tribs	c. 2194	0.8	0.52	
Clear Creek Tribs	c. 13471	1	0.65	
Clear Creek Tribs	c. 13797	1	0.65	1.5(2)
Roaring Creek	p. S-40615	2.43	1.57	
Clear Creek	p. S-40615	2.83	1.83	
Gales Creek	c. 85513	4.46	2.88	Uncertain(3)
Total		**12.5**	**8.1**	

Notes:

(1) Seasonal flow limit is the lowest flow in the summer based on hydrology watershed yield; flow value limits the amount of water available to less than the allowed water right rate.

(2) 1.5 mgd value based on historical observation and record by City for summer period; typically observed in the month of August.

(3) Streamflow availability study was beyond the scope of this update, but flow and environmental restrictions are expected based on historical regulations of other diversions in the basin.

Table 6-2 summarizes the water rights for these sources from the JWC. The annualized yields from the JWC stored water are based on the City's water rights or ownership share of the stored volume.

Table 6-2: Water Rights and Seasonal Flow Limits for Supply from Stored Water (Joint Water Commission)

Sources for JWC WTP	Permit/Cert.	Quantity	Annual Average rate(1) (mgd)	Average Peak Season Release Rate(2) (mgd)	Average Peak Season Release rate with flow reduction/losses(3) (mgd)
Barney Reservoir	c. 81022	500 acre-ft	0.45	0.79	0.68
Scoggins Reservoir	by contract	4,500 acre-ft	4.02	7.97	7.41
Barney Buy-back option	by contract	800 acre-ft	0.71	1.42(4)	1.08(4)
Tualatin River	Certificate	33 cfs	21.33	N/A(5)	N/A(5)

Notes:

(1) Storage volume divided by 365 days; average storage release flows assuming a constant rate over the entire year.

(2) Storage volume divided by 184 days of the peak season period (May 1 – October 31); average storage release flows assuming a constant rate over the peak season only.

(3) Storage volume release over the peak season with loss/reduction factors accounted for: (i) Barney Reservoir: 24% of total storage volume = 2% dead pool + 15% ODFW fish flow + 2% "blow-by" + 5% transmission and treatment loss; (ii) Scoggins Reservoir: 7% of storage volume = 2% "blow by" + 5% transmission and treatment loss.

(4) For the purpose of this analysis, the loss/reduction factors are also applied to the Barney buy-back storage.

(5) *The Tualatin River water right is a junior water right and is regulated off during the peak season period. It is assumed for this analysis that it is not available for peak season use.*

On a strictly volumetric basis, the City has sufficient water rights through the end of the planning period (2050) when comparing to the annual average demand. However, the City's supply sources and demand are seasonally variable with the maximum day demand occurring in the late summer period. The source of supply design criteria defined in Section 5 call for comparing the maximum day demands to the City's available raw water supply and transmission capacity.

The raw water supply analysis in this plan assumes that the stored water from Barney and Scoggins reservoirs is used by the City only during the peak demand season (May 1 – October 31 = 184 days). Furthermore, the amounts of stored water released by month are scaled according to patterns similar to the historic use of JWC production water by the City during the peak season period. That is, Forest Grove uses more stored water in July, August, and September relative to the "shoulders" of the peak season during May, June, and October.

Table 6-3 summarizes the monthly stored water release factors based on historical JWC production used by the City. The *peak season average* release flow from Barney and Scoggins reservoir is *multiplied by each factor* to calculate the average stored water release flow for that month (the value assumes that all of the stored water owned or contracted by the City is available for release). For example, the peak season average release flow for Scoggins reservoir (with loss reduction) is 7.41 mgd. In August, the City is assumed to use 1.5 x 7.41 mgd = 11.1 mgd on an average basis for the month.

Table 6-3: Peak Season Monthly Stored Water Release Factors and Flows

Month	Peak Season Release Factor	Barney Reservoir Average Release Flow(1) (mgd)	Scoggins Reservoir Average Release Flow(2) (mgd)	*Current* Available Stored water release flow (mgd)	Barney Buy-Back Average Release Flow(3) (mgd)
May	0.4	0.27	3.0	**3.2**	0.43
June	0.8	0.54	5.9	**6.5**	0.86
July	1.2	0.82	8.9	**9.7**	1.3
August(4)	1.5	1.0	11.1	**12.1**	1.6
September	1.4	0.95	10.4	**11.3**	1.5
October	0.7	0.51	5.5	**6.1**	0.81

Notes:

*(1) Barney Reservoir peak season average release flow = 0.68 mgd (see **Table 6-2**).*
*(2) Scoggins Reservoir peak season average release flow = 7.41 mgd (see **Table 6-2**).*
*(3) Barney buy-back (future) peak season average release flow = 1.42 mgd (**Table 6-2**).*
(4) August values are used as the basis for comparing stored water available against max. day demands.

The City's own Forest Grove WTP receiving water from the Clear Creek watershed is limited to 1.5 mgd during the peak demand period. Therefore, in the raw water supply analysis presented below, the maximum day demand for any year is compared against the sum of 1.5 mgd (Clear Creek watershed) + August release flow (JWC production from stored water = 12.1 mgd currently; and 13.7 mgd with the Barney buy-back).

Figure 6-1 illustrates the comparison of the City's currently available raw water supply to the forecasted maximum day demand. Forest Grove has sufficient water rights and storage ownership to meet maximum day demands for the entire planning period (2050) under Scenario B, and through year 2046 even under the most aggressive growth scenario assumed in Scenario C. In this case, including the

Barney buy-back option would provide sufficient water beyond the 2050 planning period. The City would still have the Gales Creek certificated water right to use for longer-term needs.

Figure 6-2 illustrates the seasonal water used and assumed stored water release scenario using the assumed release factors in **Table 6-3**. Again, the results show the City has sufficient existing raw water supply to meet long-term supply needs. **Figure 6-2** also illustrates that Forest Grove has "excess water rights" during the December through April period ("off-peak" season). The City should consider opportunities for "trading" or transferring these water rights for opportunities to gain peak demand supply.

In both of these figures, the Tualatin River water rights that the City owns are not shown because they are junior water rights in the basin, and are only available during the winter (higher water flow) months. They are regulated off by Oregon Water Resources Dept. during the summer.

Figure 6-1 – Comparison of Maximum Day Demands to Available Raw Water Supply

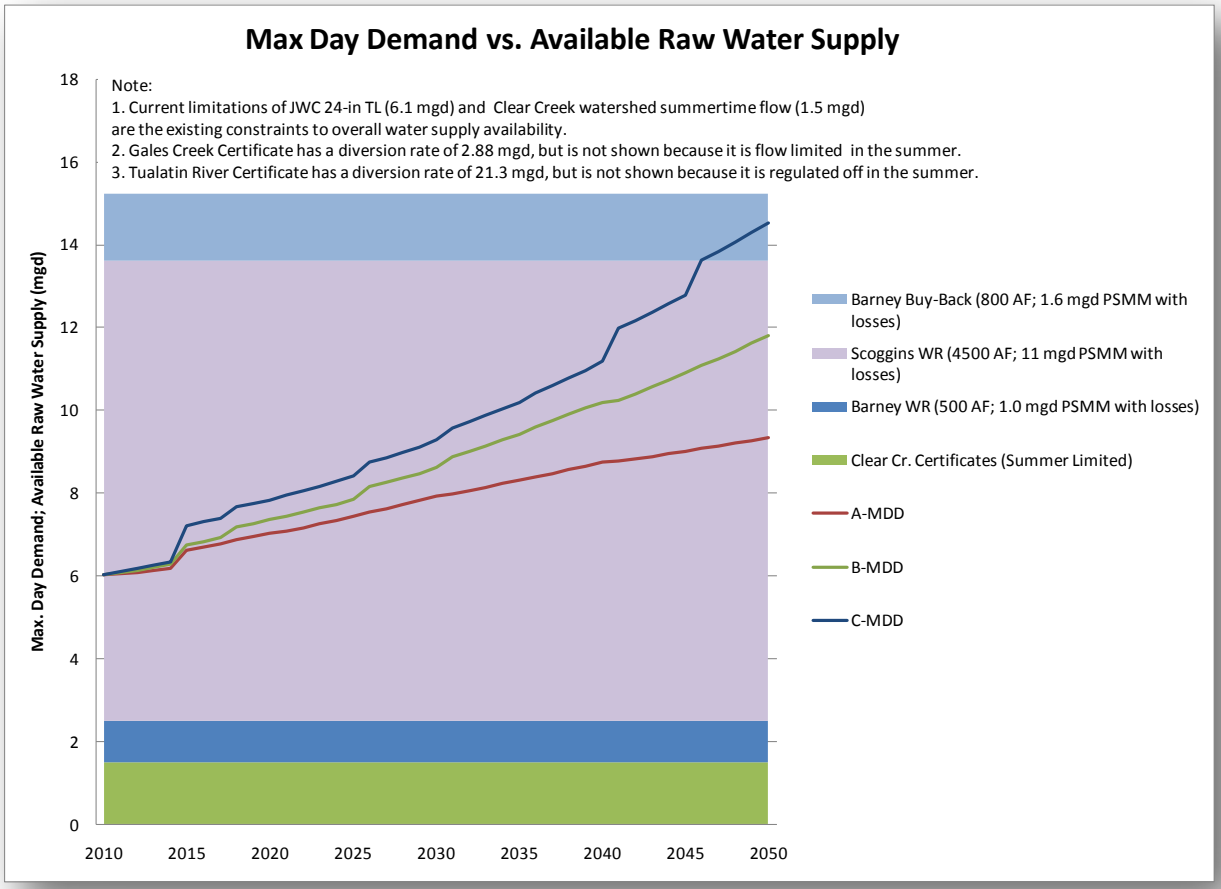
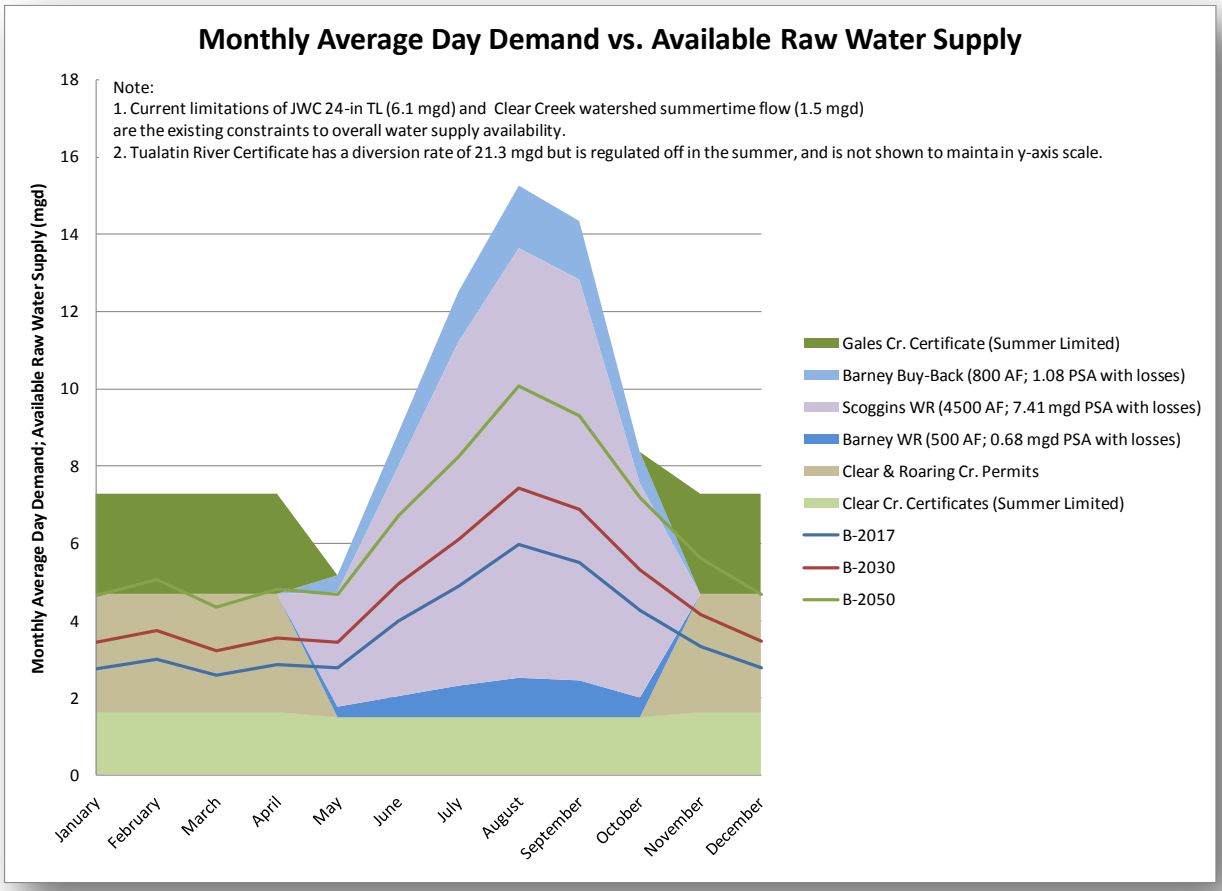


Figure 6-2 – Comparison of Monthly Average Day Demands to Available Raw Water Supply



In summary , while the City has adequate water rights and raw water supply to meet long-term demands, the source of supply to the City's WTP is constrained by the available streamflows during the peak demand season (1.5 mgd). The City should develop a water rights strategy to address the "unused" Gales Creek water right certificate, and potentially identify opportunities to take advantage of "under-utilized" winter water rights, including those that the City owns on the Tualatin River.

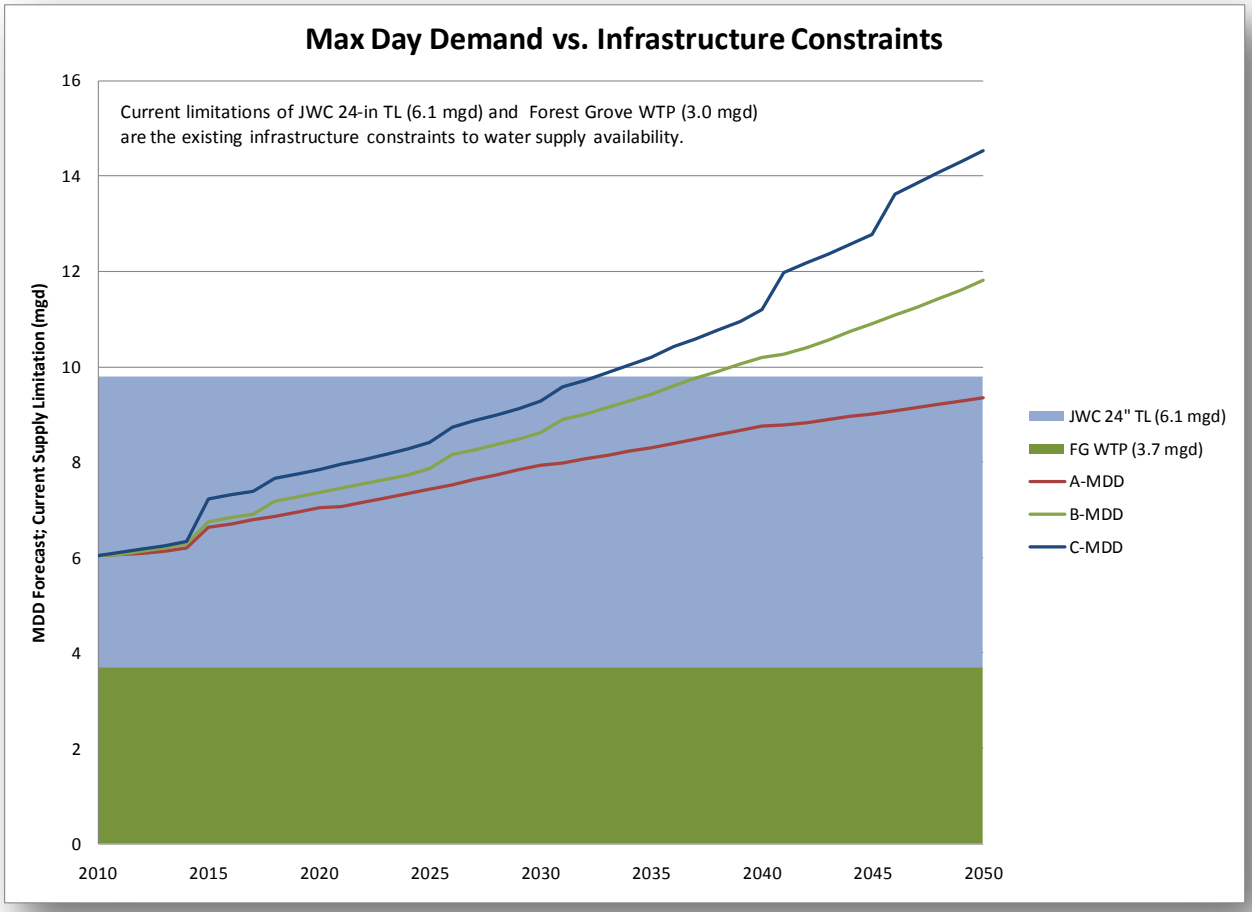
6.1.2 Water Supply Infrastructure Limitations

The Forest Grove WTP has a nominal capacity of ~3.7 mgd. Furthermore, the 16" raw water transmission line from the Clear Creek watershed with operation of the booster pump has approximately the same capacity. The City of Forest Grove owns approximately 10 mgd of treatment capacity at the JWC WTP based on 13.33% of the current 75 MGD maximum JWC WTP capacity. However, the amount of supply from the JWC is constrained by the City's 50% ownership share of the 24-inch transmission main from the JWC Fern Hill Reservoir. JWC WMP (2009) determined the capacity of the 24" Transmission to be 12.2 mgd at 6 feet per second (fps) or 16.2 mgd at 8 fps. For the purposes of the supply evaluation, the smaller capacity is used to be conservative. Therefore, the City of Forest Grove is limited to approximately 6.1 mgd (50% of 12.2 mgd) from the JWC supply by the transmission capacity. Based on this discussion above, the limiting factor for supply based on infrastructure limits are:

- 3.7 mgd from raw water transmission and WTP capacity from the Clear Creek watershed.
- 6.1 mgd from 24-inch transmission from JWC Fern Hill Reservoir to 10th Ave. metering station.

Figure 6-3 shows a comparison of the forecast maximum day demand to 2050, against the current available supply as constrained by infrastructure. By 2038, the existing infrastructure would limit the ability to deliver adequate supply to the City based on Scenario B (moderate growth) demands. This assumes that the City's WTP capacity can be fully utilized, *which is not currently the case because of limited summer flows.*

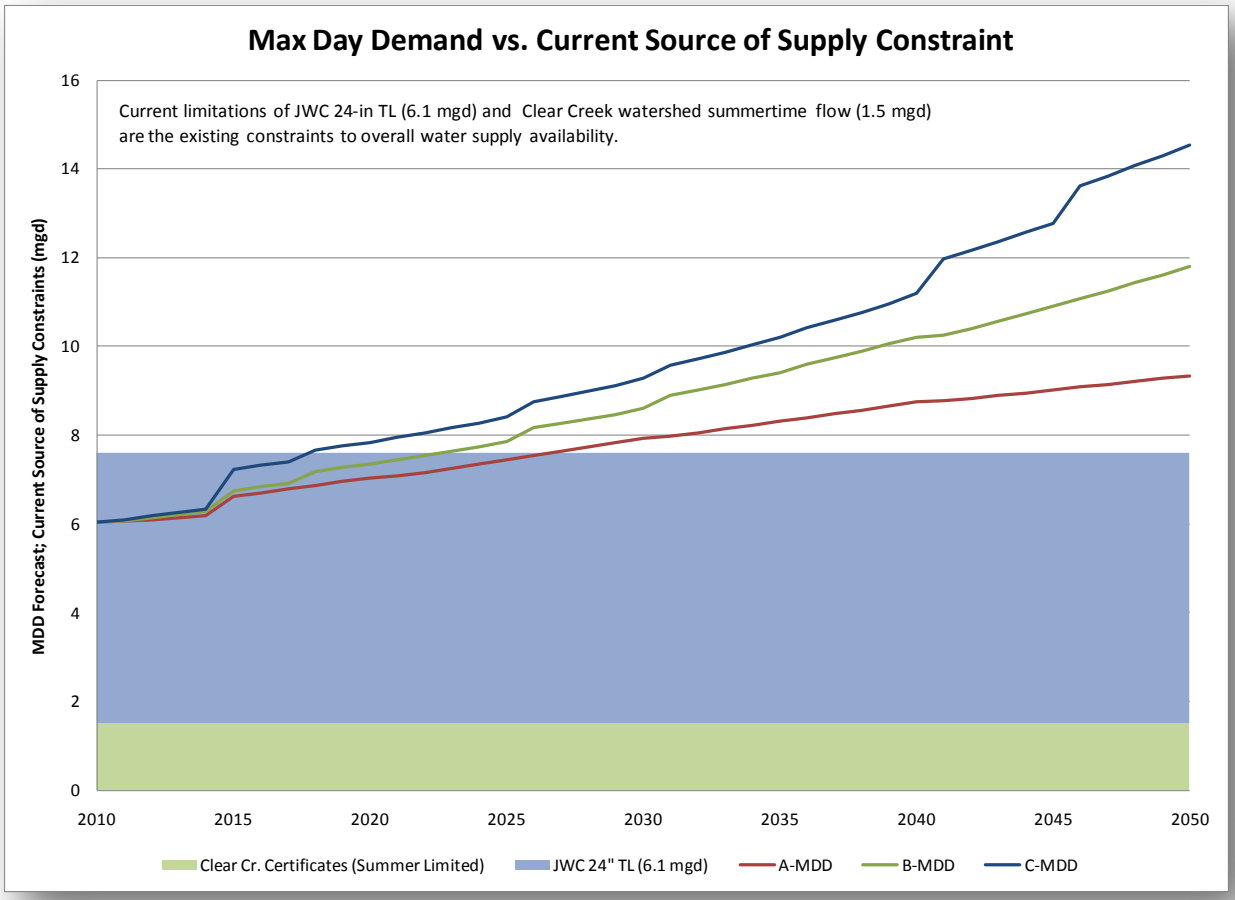
Figure 6-3 – Comparison of Forecast Maximum Day Demands with Current Supply Infrastructure Constraints



6.1.3 Annual and Seasonal Supply Availability

Combining the discussions above, the limiting supply factors for the City are the JWC transmission capacity of 6.1 mgd, and the 1.5 mgd reliable summertime capacity from the Clear Creek watershed. The City's forecasted demand will exceed the 7.6 mgd combined supply capacity by approximately year 2023. **Figure 6-4** illustrates the limiting supply factors and compares them to the maximum day demand forecast scenarios.

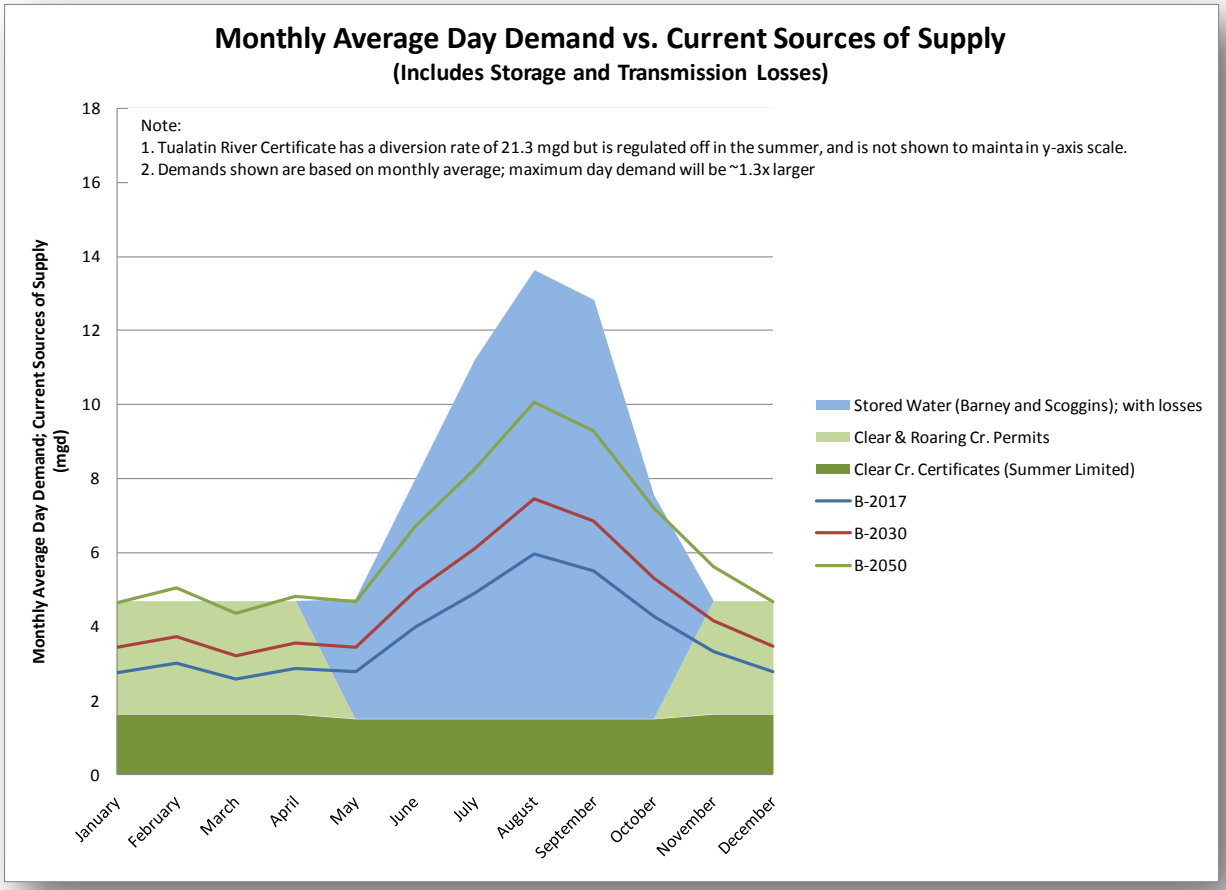
Figure 6-4 — Comparison of Forecast Maximum Day Demand to Limiting Supply Factors



Based on the limiting supply factors, it is recommended that Forest Grove pursue the purchase of additional supply line capacity from the City of Hillsboro or construct additional transmission capacity from the JWC Fern Hill Reservoir to extend the supply capacity. It is unlikely that the City of Hillsboro would reduce their share of the ownership of the 24-inch transmission line, so the City should budget to build a parallel 18-inch line along the existing alignment with a capacity of 6.0 mgd by 2023. The total transmission capacity from JWC would increase to ~12 mgd – allowing 2 mgd of "cap space" for additional JWC treatment plant ownership. With this increased transmission capacity from the JWC source, the limiting factor to the JWC supply would be the JWC treatment ownership of 10 mgd. The total supply capacity to the City at this point would be 11.5 mgd, comprised of 1.5 mgd from the City's WTP and 10 mgd ownership in JWC WTP. The City could utilize the remaining 2 mgd capacity of the new transmission line (12 mgd total transmission capacity minus 10 mgd treatment ownership) by maximizing use of their storage ownership from Barney and Scoggins reservoirs (12.1 mgd peak season month in August; refer to **Table 6-3**). With the additional transmission line capacity (parallel 18-inch line), the total available supply to the City would be 13.6 mgd, assuming the Clear Creek supply remains at 1.5 mgd (limited by water availability) and increased the transmission capacity of 12.1 mgd from the JWC supply. This would supply the year 2050 maximum day demand of ~11.6 mgd under Scenario B. Additional supply options would need to be evaluated to meet the higher demand assumptions under Scenario C, which forecasts 14.5 mgd in 2050. Additional supply options are discussed in Section 6.1.4.

Figure 6-5 shows a similar comparison using the monthly average day demands. **Figure 6-5** also shows how the City's current supplies are used conceptually to meet their seasonal (monthly) demands. The City can rely on its own WTP (to full use of Clear Creek water rights) to meet their non-peak season demands, and then rely on the JWC supply (limited to 6.1 mgd from the transmission capacity) to supplement their Clear Creek supply (limited to 1.5 mgd during the peak season).

Figure 6-5 – Comparison of Forecast Monthly Average Day Demand to Current Sources of Supply



6.1.4 Supply Analysis Summary and Review of Other Supply Options

Based on the analysis described above, ***the City needs to increase its transmission capacity to deliver finished water from its JWC supply from Fern Hill Reservoir by year 2023*** based on the moderate growth scenario (B). This period shortens to year 2018 if more aggressive growth conditions occur (under Scenario C). A transmission line with capacity of 6 mgd would be sufficient to meet long-term demands through 2050 if the City continues to use its own WTP (limited by streamflow availability to 1.5 mgd in the summer period).

The City does not need new sources of supply in the next 40 years. Current raw water supplies are projected to be sufficient to meet forecasted demands through the planning period (2050). If the higher growth scenario occurs (Scenario C), the City may need to pursue the Barney buy-back option after year 2045, and would need to consider other supply options, including further increasing transmission capacity from the JWC supply.

While new supply sources are not needed in the near-term, ***the City should continue to track and update water supply options to improve the reliability and redundancy of their source of supply***, especially as part of the recommended "water rights strategy" for use of the Gales Creek water right and Tualatin River water right.

The following supply options were reviewed as part of the supply evaluation.

Additional JWC Supply. As discussed above, the City has adequate supply from an ownership or water rights stand-point. The buy-back option for Barney can provide additional reliable supply, but is not a critical need within the next 30 to 40 years. Forest Grove does not have any critical need to buy-into further expansion of the JWC WTP, even under the more aggressive demand forecast until year 2045. However, the City should continue its current ownership and develop plans to add transmission from the JWC, as well as an intertie with the 72-inch North Transmission Line (NTL) to add redundancy and reliability to their system. As discussed in Section 6.4, the intertie to the NTL can also address emergency fire flow demands. As the City continues to update their long-term water demands, the City needs to keep in mind the time restrictions to buy-in to the JWC system improvements.

Tualatin Valley Water District Irrigation Lines. The City has had concept-level discussions with TVID in March 2010 regarding the potential feasibility of using TVID irrigation pipelines to wheel raw water to the Forest Grove's WTP. In particular, the TVID irrigation line (N4A) is a 21-inch line that runs along Purdin Road and crosses Thatcher Road. The concept is to tap into N4A line with a pipeline to the FG WTP (for immediate treatment or storage in a reservoir.) Based on initial discussions with TVID, flow rates on the order of 2 mgd are likely to be available based on excess capacity in the pipeline. However, the actual excess flow capacity would need to be evaluated. In addition, water may be wheeled at night to further maximize flow rate (when irrigation demands are lower). In this scenario, Forest Grove's own water rights (stored water in Barney/Scoggins) would be used. The wheeling rate discussed with TVID would be on the order of $40 per acre-foot of water.

Other concepts were discussed with TVID, but were considered not likely feasible. For the purposes of this WMP update, the following options are <u>not</u> identified as supply alternatives for further consideration:

- Use of the 15-inch irrigation line south of the City has limited excess capacity, and CWS is currently wheeling water at a rate of 1 cfs to Gales Creek for flow augmentation purposes. CWS would like to increase to 2 cfs (or as high as possible), but testing shows limited to no capacity in pipeline.
- Lease/transfer Gales Creek water right to CWS in exchange for the 1-2 cfs they are currently wheeling through the TVID southern line. It is not certain that water is actually available in Gales Creek during the period that CWS would like the water instream. In addition, transmission of water from the southern TVID line to the City's WTP is much further than the N4A line.

Based on these initial concepts, it is recommended that the City conduct a more detailed feasibility analysis for wheeling water through the N4A line to the City's WTP. Some of the specific technical issues to consider in the feasibility study include: (i) pressure from TVID intake to FG WTP and whether pumping is needed; (ii) cost to build transmission from end of N4A to FG WTP; (iii) monthly flow rate available (excess capacity in the line) and excess capacity in the pipeline; and (iv) water quality and treatment considerations potentially affecting current WTP operations.

Aquifer Storage and Recovery (ASR). The Joint Water Commission is currently evaluating the feasibility of installing ASR wells for regional use by the JWC members. Because the City of Forest Grove does not have a near-term need for supply, the City opted out of participating in the ASR Program study.

However, as discussed previously, the City has excess winter water rights that could be utilized by the JWC including the Gales Creek water right, while the City benefits from additional incremental summer-time supplies to meet peak demands. The City should continue to track the JWC ASR program studies and evaluate the benefits of future participation, especially after the recommended Water Rights Strategic Plan is completed.

Other Options Not Considered Further.

- **Raw Water Storage (Off-line).** The 2002 WMP completed a cursory evaluation of potential suitable sites for raw water storage within the City's watershed. The City has concluded that there are no opportunities to develop meaningful raw water storage in the adjacent watersheds. This option is not identified as a supply alternative for further consideration.
- **City of Hillsboro, Haines Falls Slow Sand Filter Treated Water Supply.** The Haines Falls slow sand filter plant and "Cherry Grove Supply Line" is not currently used by the City of Hillsboro. However, Hillsboro approached Forest Grove about potentially acquiring the Hillsboro Haines Falls Upper Water Supply System in trade for JWC supply capacity. In 2006, after a cursory review by the City of the potential benefits to Forest Grove, the City decided not to pursue the proposal from Hillsboro. The primary reasons for Forest Grove not pursuing the offer are: (i) Hillsboro's proposal did not include securing long-term access to the water rights currently used to serve that plant; (ii) uncertain customer demands; (iii) different water quality; and (iv) significant infrastructure deterioration and need for replacement. This option is not identified as a supply alternative for further consideration.

6.1.5 Forest Grove Water Treatment Plant

The Forest Grove WTP is a nominal 3.75 mgd conventional water treatment facility that incorporates the following major unit processes: rapid mix, flocculation, sedimentation, filtration, and disinfection. In 2003, the City contracted with Murray Smith and Associates, Inc. and CH2M Hill to conduct a water treatment plant evaluation. The evaluation included comprehensive investigations of the plant facilities and provided recommendations related to regulatory compliance and for improvements of process, structural, and electrical, and instrumentation and control (I&C) components. The observations and recommendations from this evaluation are summarized in the 2003 City of Forest Grove Integrated Water Supply Study. To facilitate the development of the City's capital improvements plan, the study recommendations for plant improvements were divided between first priority/short range and secondary priority/long range projects.

HDR engineers visited the Forest Grove WTP on April 23, 2010 to document and review projects that have been completed since the completion of the 2003 study. In addition, other needed improvements not identified in the 2003 study were discussed with City staff. The following major process improvements and modifications recommended in the 2003 study were constructed during the 2005 upgrade:

- Replacement of mechanical rapid mixer with pumped diffusion system
- Replacement of fluoride dry feeder with a sodium fluoride saturator
- Addition of filter-to-waste option
- Modifications to recycle water piping and chemical addition for compliance with Filter Backwash Recycle Rule requirements

The 2003 study also identified several projects intended to improve plant reliability, performance, and solids removal that had the potential to reduce plant down-time throughout the year required during periods of poor raw water quality or for routine maintenance:

- Addition of 2nd stage of flocculation, mechanical sludge removal, and soda ash for improved pretreatment performance
- Backwash pond upgrades and mechanical sludge removal to increase capacity and reduce down-time for maintenance activities
- Addition of 2nd redundant backwash supply pump to improve plant reliability in the event the existing sole pump fails

The plant currently removes sludge from the sedimentation basin every two months, requiring a shutdown between 24 and 48 hours each time. In addition, the plant shuts down periodically during springtime heavy rainfalls that result in significantly higher raw water turbidities that overwhelm the plant's treatment capabilities. Plant down-time attributed to sludge removal activities and poor raw water quality ranges between 12 and 20 days per year. During these periods, all system water is provided by the JWC source. The construction of the David Hill Booster Pump Station in 2008 added to the system's ability to draw from the JWC source during periods of plant down-time.

In general, improvements to flocculation, sludge removal, and chemical addition will have some benefit to pretreatment performance but alone are not sufficient to optimize solids removal prior to filtration. In order to maintain operation through spikes in raw water turbidity, the City should consider replacing the sedimentation basin effluent launders and retrofitting the basin with high-rate settling, such as tube or plate settlers. Given the relatively small percentage of time the plant is off-line, the investment in pretreatment improvements would not be justified by the resulting benefit of maintaining plant operation during these events. However, if the City decides to increase the plant capacity in the future via addition of a new water source, pretreatment improvements should be evaluated and implemented to address variable raw water quality and increase treatment capacity.

Long range recommendations to the plant's residuals collection and management system identified in the 2003 study included mechanical sludge removal for the sedimentation basin and enlargement of the backwash water ponds. Enlargement of the ponds would increase sludge storage capacity by incorporating vertical side walls. The City historically has relied on a local farm to accept sludge from the ponds, which is removed and hauled to the farm during a window of time in the spring that is determined by the farmer. Due to restrictions in the times available to accept solids, concerns over the long-term viability of depending on this method, and removal and hauling costs, the City decided to invest in dewatering equipment (filter drum) at the plant in early 2010. The filter drum processes sludge from the ponds at a rate of 5 gpm producing a cake that is picked up and hauled for disposal by City truck.

Mechanical sludge removal is recommended to reduce maintenance efforts and plant down-time and optimize existing sedimentation basin capacity and settling performance; however, any upgrades to the sedimentation basin should be carefully planned with any future basin retrofits to ensure the systems are compatible.

Regarding the recommendation to install a second, redundant backwash supply pump, the City has not proceeded with installing a second pump due to space restrictions in the existing filter gallery where the existing backwash supply pump is located. The City should consider purchasing a second pump that could serve as a "shelf" back-up to avoid the lead time needed to procure a new pump in the event the

existing pump fails. A second, more cost-effective option would be to maintain spare parts for the backwash supply pump and complete routine preventive maintenance.

Improvements to the electrical and I&C systems implemented in response to the 2003 study recommendations included movement to RS View client and installation of a new filter effluent chlorine analyzer and coagulated water streaming current monitor. The 2003 study included several recommendations for miscellaneous structural repairs and rehabilitation. The City has incorporated these repairs during the 2005 plant upgrades and during routine maintenance activities.

The projects described in this section, as well as several near-term projects needed to improve safety and plant performance and reliability, are included in **Table 6-4** along with estimated ranges of costs.

Table 6-4: Recommended near-term and long-range WTP projects

Recommended Project	Estimated Cost Range
Near-Term Improvements (within 5 years)	
Finished water vault safety improvements (environmental sensor "sniffer," air ventilation system, associated controls)	$3,000-5,000
Demo and remove old out-of-service surge tank from filter gallery area	$4,000-8,000
Replace valves in Filter Gallery (~10 valves) – City has been gradually replacing all the valves in the filter gallery with ~10 remaining and intends to include 2-3 each year in the annual budget for the plant	
Filter media and underdrain inspection (determine if filter media and/or underdrain system (clay Leopold blocks) need replacement)	$8,000-10,000
Filter Backwash Supply Pump spare parts	$2,000-5,000
Replace 12" check valve on suction side of backwash (BW) pump	$4,000-$10,000
Long-Range Improvements	
Mechanical sludge/residuals collection system in sedimentation basins	$150,000
Plate settlers and launder replacement	$500,000-700,000

6.1.6 Summary of Water Supply Recommendations

The following is summary of the recommendation to address the City's water supply needs. The order of the recommendations listed is generally based on chronological need. Specific capital improvement projects and studies are included in the CIP discussion in Section 7:

- ***Complete a "Water Rights Strategic Plan"*** to address how to utilize the Gales Creek water right (certificated) with the objective of maximizing use of the City's WTP, increasing supply redundancy and reliability. The Strategic Plan should incorporate opportunities for optimizing use of the City's water rights in JWC operations to improve reliability and redundancy of its current supply sources. Additionally, this strategic plan should explore ways to strategically develop longer-term supply with JWC partners in looking ahead beyond the 2050 planning period.
- ***Complete a Tualatin Valley Irrigation District Supply Options Study*** specifically evaluating the feasibility and cost-effectiveness of using TVID irrigation line to wheel water along Purdin Road to the Forest Grove WTP in order to maximize the operations the City's plant during low flow periods.

- ***Complete Forest Grove WTP improvements (near-term and long-term)*** to improve operations and safety. The recommended improvements are not intended to increase WTP capacity. Additional recommendations may be necessary based on findings from the TVID Supply Options Study. The near-term improvements for safety should be implemented within the next two years. Long-term improvements for the residuals collection and plate settlers can be extended beyond 10 years.
- ***Install Emergency Intertie with the JWC 72-inch North Transmission Line*** to improve reliability and ability to address emergency fire suppression needs (discussed further in Section 6.4).
- ***Design and construct 18" parallel finished water transmission line from JWC Fern Hill Reservoir*** to increase delivery capacity by 6 mgd (to 12 mgd). This total will allow for the City's current JWC WTP ownership of 10 mgd, and allow the capacity to deliver the flows from a future Barney buy-back option (1.08 mgd).
- ***Continue re-evaluation of supply strategies on a regular basis (every 3 years)*** based on updated water demand forecast (WMP update process) and conclusions from the Water Rights Strategic Plan, and continuing planning by the Joint Water Commission and Tualatin Basin Water Supply Project. The supply strategy evaluation should consider the need for additional Barney Reservoir buy-back.

6.2 Water Quality and Regulatory Compliance

Compliance with regulatory requirements related to the Safe Drinking Water Act and revisions was reviewed in the 2003 Integrated Water Supply Study prepared by Murray Smith and Associates. The following section is intended to provide an update on compliance and water quality issues since the 2003 study was completed.

This section provides a general overview of current drinking water regulations under the Oregon Drinking Water Quality Act (OAR 333-061 – Rules for Public Water Systems) and Forest Grove's current compliance status. In addition, potential future regulations are discussed with considerations for potential implications to Forest Grove. This regulatory summary is current as of July 2010.

6.2.1 Safe Drinking Water Act (SDWA)

The Environmental Protection Agency (EPA) has developed interrelated regulations to ensure inactivation of microbial pathogens while maintaining control of disinfectant residual levels and the formation of disinfection byproducts (DBPs) in drinking water. These rules are collectively known as the Microbial and Disinfection Byproduct (MDBP) Rules. These regulations are intended to address the complex risk trade-offs between the two different types of contaminants. The EPA has adopted a negotiated rulemaking process to develop these rules, involving interested groups, or "stakeholders" from the water industry, environmental and public health groups, and local, State, and federal government agencies. The following sections provide a brief summary of the regulations, historical compliance, and potential implications for the Forest Grove WTP.

6.2.2 Surface Water Treatment Rule (SWTR)

The SWTR establishes treatment techniques instead of maximum contaminant levels (MCLs) for the control of *Giardia*, viruses, heterotrophic plate count (HPC) bacteria, and *Legionella*. Turbidity limits depend on the filtration method employed in its removal. Treatment must achieve at least 99.9 percent (3-log) removal or inactivation of Giardia and 99.99 (4-log) removal or inactivation of viruses.

The Forest Grove WTP provides conventional treatment through a combination of flocculation, sedimentation, and filtration processes and thus is credited with 2.5-log removal of *Giardia*. Inactivation of viruses and the remaining 0.5-log *Giardia* is achieved using free chlorine, which is applied to the filter influent.

The Interim Enhanced SWTR revised the SWTR in 1998 to address the protozoan pathogen *Cryptosporidium*. Key provisions established by this rule include:

- A Maximum Contaminant Level Goal (MCLG) of zero for *Cryptosporidium.*
- 2-log *Cryptosporidium* removal requirements for systems that filter.
- Strengthened combined filter effluent turbidity performance standards of 1.0 nephelometric turbidity unit (NTU) as a maximum and 0.3 NTU as the 95th percentile monthly, based on 4-hour monitoring for treatment plants using conventional treatment or direct filtration.
- Requirements for individual filter turbidity monitoring.
- Disinfection benchmark provisions to assess the level of microbial protection provided as facilities take the necessary steps to comply with new disinfection byproduct standards.
- Inclusion of Cryptosporidium in the definition of Groundwater under the Direct Influence of Surface Water (GWUDI) and in the watershed control requirements for unfiltered public water systems.
- Requirements for covers on new finished water reservoirs.
- Sanitary surveys for all surface water systems regardless of size.

As discussed in the 2003 Integrated Water Supply Study, the City of Forest Grove is in full compliance with the 1998 SWTR.

The Long Term 2 Enhanced SWTR was promulgated in 2006 adding the following new requirements for public water systems serving over 10,000 people:

- Source water sampling to establish raw water concentrations of *Cryptosporidium*, which in turn can trigger additional treatment requirements for *Cryptosporidium*
- Potential additional *Cryptosporidium* inactivation/removal requirements.
- Incorporation of a multibarrier disinfection strategy.

The City completed source water monitoring for *Cryptosporidium* in February 2010. The results placed the City in the “Bin 1” classification, which requires no additional treatment for *Cryptosporidium*. The City has no uncovered reservoirs and no unfiltered water supplies, so no further action or treatment facilities will be needed to comply with the requirements of the Long Term 2 Enhanced SWTR. The City will need to repeat source water monitoring for *Cryptosporidium* beginning in 2016 to re-determine their bin classification.

6.2.3 Filter Backwash Recycling Rule (FBRR)

The final FBRR, promulgated in 2001, applies to all public water systems that use surface water and employ conventional or direct filtration and also recycle water within the plant. This rule requires the three major recycle streams (spent filter backwash water, sludge thickener supernatant and liquids from dewatering processes) to pass through all treatment processes, and therefore these recycle streams must be returned prior to chemical addition and coagulation. Prior to the passage of this rule, the plant recycled settled wash water from the backwash water ponds to the first stage of flocculation after the point of coagulant addition. During the 2006 upgrades, new chemical addition points for alum and polymer were added to the recycle water line for compliance with the FBRR.

6.2.4 Disinfectants and Disinfection Byproducts Rule (D/DBPR)

The Federal Total Trihalomethane Rule (TTHM Rule) was published on the Federal Register in November 1979; Oregon adopted the MCLs established in this law in September 1982. The purpose of the rule was to limit exposure to chemical byproducts of disinfection treatment formed during disinfection treatment practices. The TTHM Rule set an MCL for TTHM of 0.10 milligrams per liter (mg/L) based on a running annual average of quarterly sampling in the distribution system. However, these MCLs were superseded when the State of Oregon adopted the Stage 1 Disinfectants/Disinfection Byproducts Rule (D/DBPR) on July 15, 2000. The Stage 1 D/DBPR added an MCL of 0.060 mg/L for five haloacetic acids (HAA5), and reduced the MCL for TTHMs to 0.080 mg/L. The Stage 2 D/DBPR was promulgated by the EPA on January 4, 2006 and built on the Stage 1 rule by requiring that compliance be based on locational running annual averages (LRAAs) rather than a system-wide average of all sample locations. In addition, the Stage 2 D/DBPR required systems to revisit sample locations and perform more DBP sampling to determine sample locations that are most representative of worst-case DBP water quality.

To comply with the requirements of the Stage 2 D/DBPR, the City of Forest Grove chose to conduct the Initial Distribution System Evaluation (IDSE) to identify potential new DBP sampling points. The IDSE plan and results report were submitted to and approved by the EPA in 2009. During the period 2000 through April 2010, the City has never had a sample exceed the respective MCLs for HAA5 or TTHMs with the majority of samples below 50% of the MCLs. No issues related to compliance with the D/DBPR are anticipated when compliance moves to LRAAs in 2013.

6.2.5 Total Coliform Rule (TCR)

In order to comply with the Total Coliform Rule, Oregon Department of Human Services (DHS) requires that the City collect a minimum of 20 samples per month from representative sites throughout the distribution system. If a routine sample is positive for total coliform, the City must collect a set of three repeat samples: one from the original site, one within five service connections upstream of the original site, and one within five service connections downstream of the original site.

The repeat samples must be collected within 24 hours of notification of the positive result. Further, any routine or repeat coliform positive samples must be analyzed for the presence of fecal coliform or *E. coli* as an indicator organism. When a system learns of the presence of fecal coliform or *E. coli*, the system must notify the State by the end of the same day.

The City has maintained excellent compliance with the TCR. In the past ten years (2000 through July 2010), the City has never had a routine or repeat sample test positive for fecal coliforms. During this period, two routine samples have tested positive for total coliforms, though the repeat samples did not show a positive result for total or fecal coliforms.

6.2.6 Lead and Copper Rule (LCR)

In 1991, the Lead and Copper Rule (LCR) was promulgated by the EPA to reduce lead and copper concentrations in drinking water. Oregon adopted the LCR on December 7, 1992, without exception. The Lead and Copper rule established action levels for lead and copper set at 0.015 mg/L and 1.3 mg/L, respectively. Lead and copper regulations, under the Oregon Drinking Water Quality Act, require utilities to implement optimal corrosion control treatment that minimizes the lead and copper concentrations at user's taps, while ensuring that the treatment efforts do not cause the water system to violate other existing water regulations.

Utilities are required to conduct monitoring for lead and copper from taps in "high risk" homes. Two rounds of initial sampling were required during 1992-94, collected at 6 month intervals; annual sampling was required after these initial efforts. Following this initial 3-year period of sampling, samples are to be

taken every 3 years. The action level for either compound is "exceeded" when, in a given monitoring period, more than 10 percent of the samples are greater than the action level.

Sampling requirements of the LCR are based on the population served by the utility. For the service area of the City, which has a combined population of between 10,001 and 100,000, Oregon law requires 60 initial sampling sites; subsequent monitoring could be reduced to 30 sites provided initial sampling efforts demonstrate that lead and copper action levels are not exceeded. Water systems unable to meet action levels must either integrate corrosion control strategies into their treatment process train, or develop an alternate source of water.

A review of the records indicates that the City has consistently met this regulation. Since beginning monitoring for the LCR, the City has always been under the 90th percentile values of the action levels for lead and copper. As a result, the City qualifies for reduced monitoring (30 samples collected every 3 years). The last round of LCR samples was collected in July of 2008. For this sample round, the 90th percentile results for lead and copper were 0.0050 mg/L and 0.2000 mg/L, respectively.

6.2.7 Synthetic Organic and Inorganic Chemicals (SOCs/IOCs)

A review of the records indicated that the City has consistently met this regulation.

6.3 Storage Analysis

The results of the storage analysis are presented in **Table 6-5** based on the storage criteria (Section 5.2). Additional tables of the analysis are included in **Appendix E**. A discussion of the results for each pressure zone is presented in the following subsections.

Table 6-5: Storage Evaluation by Pressure Zone

Year	MDD (mgd)	Existing Storage(1) (MG)	Operational Storage(2) (MG)	Emergency Storage(3) (MG)	Fire Suppression(4) (MG)	Total Required (MG)	Total Storage Deficiency (MG)
Lower Pressure Zone							
2010	5.52	7.07	1.38	4.14	1.08	6.6	**N/A**
2017	6.33	7.07	1.58	4.75	1.08	7.3	**N/A**
2030	7.91	7.07	1.98	7.16	1.08	8.9	**1.8**
2050	10.51	7.07	2.63	7.88	1.08	11.4	**4.3**
Intermediate and Upper Pressure Zone							
2010	0.52	1.0	0.13	0.39	0.54	1.1	**0.06**
2017	0.59	1.0	0.15	0.44	0.54	1.1	**0.12**
2030	0.70	1.0	0.17	0.53	0.63	1.3	**0.32**
2050	0.92	1.0	0.23	0.69	0.63	1.6	**0.54**
David Hill URA							
2010	0.00	0.0	N/A	N/A	N/A	N/A	**N/A**
2017	0.00	0.0	N/A	N/A	N/A	N/A	**N/A**
2030	0.00	0.0	N/A	N/A	N/A	N/A	**N/A**
2050	0.37	0.0	0.09	0.28	0.54	0.90	**0.90**

Notes:

1) *7.07 MG serving LPZ includes existing 4.27 MG Main Reservoir at WTP and share of JWC 2.8 MG Fern Hill Reservoir. 1.0 MG serving IPZ-UPZ includes existing David Hill Reservoir.*
2) *Operational storage = 0.25 x MDD*
3) *Emergency Storage = 0.75 x MDD*
4) *Fire suppression storage for LPZ = 4500 gpm x 4 hours (commercial heavy); IPZ-UPZ = 3500 gpm x 3 hours (commercial neighborhood), increasing to 3500 gpm x 3 hours (commercial business) in 2030.*

6.3.1 Lower Pressure Zone and Purdin Road URA

The lower pressure zone (LPZ) includes the existing City service area in the LPZ and the development in the Purdin Road URA. As discussed in the demand forecast (Section 4.6), development in the Purdin Road URA is forecast to occur after 2017 consistent with the City's land absorption analysis. The existing storage serving the LPZ includes 4.27 MG at the Forest Grove WTP and 2.8 MG from the JWC Fern Hill Reservoir, for a total of 7.07 MG. The analysis shows no need to build new storage for the LPZ until late in the 20-year planning horizon. Based on the storage criteria, the LPZ will have a storage deficiency of 1.8 MG by 2030, and a total of 4.3 MG by 2050. While the storage deficiency is shown to occur in 2030 in **Table 6-5**, the City should begin planning for the storage improvements by approximately 2020 or 2025 to allow time for engineering and construction.

The North Water Planning Area would also be in the LPZ. However, for the purposes of the WMP update and capital improvement program, the North Water Planning Area URA was not included in the storage analysis. City staff expect the North Water Planning Area development timeline to occur closer to the end of the 2050 planning period (if not beyond this period), and too uncertain to include in the analysis.

Additional LPZ storage may be provided through the addition of new City of Forest Grove storage facilities (near the City's existing water treatment plant and reservoir complex), through City participation in future JWC storage system expansions, or through a combination of the two. The storage at the Forest Grove WTP is located on the west side of the City and a majority of the service connections are to the east. As demand increases and development/redevelopment occurs in the LPZ, additional storage in the east side of the City could be advantageous, especially with respect to fire suppression storage and improving low pressures zones. However, because of the elevation differences, an elevated tank would be required and pump facilities would be needed. The added operation and maintenance costs would be a factor. Should development occur in the North Water Planning Area, the City should consider building more "local" storage for the LPZ in the east side of the City.

The development of storage for the LPZ would be as follows:

- **Build additional storage in the lower pressure zone of 2.25 MG by 2020** (and additional storage of 2.25 MG by 2040 at the same general location/property). The City should acquire property north of and adjacent to the City's water treatment plant, because of the operational and land availability advantages for phased reservoir construction. The goal is to acquire property directly adjacent to the City's existing water treatment plant and main reservoir complex, with proper topography and land area to accommodate a potential 4.5 MG storage with an overflow elevation matching that of the existing main reservoirs.

6.3.2 Intermediate and Upper Pressure Zone and David Hill URA

The intermediate pressure zone (IPZ) and upper pressure zone are analyzed together because the IPZ is relatively small and would not realistically be served by its own reservoir. The two zones are delineated by six pressure reducing valves (PRV). The existing storage serving the IPZ and UPZ includes 1.0 MG at the existing David Hill Reservoir.

Based on the storage criteria, the IPZ and UPZ have a current storage deficiency of 0.06 MG, which increases to 0.12 MG by 2017, 0.32 by 2030, and up to 0.54 MG by 2050. It should be noted that part of the UPZ is at elevations higher than the existing David Hill Reservoir can provide adequate service pressures. This area (referred to as the "Hilltop" area) lies within the existing UGB above approximately 440 feet is about 45 acres in area.

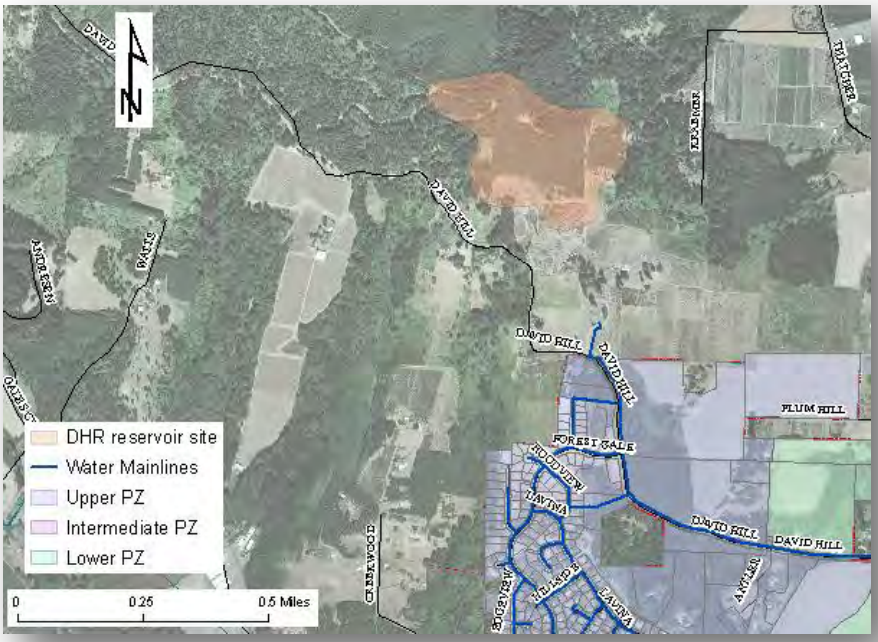
Development in the David Hill URA is forecast to occur after 2030, consistent with the City's land absorption analysis. The David Hill URA development will be at higher elevation than the existing David

Hill Reservoir overflow elevation can serve and additional pumping facilities would be required. The analysis considered storage needed to serve the IPZ and UPZ, and also the case where additional storage could serve both the IPZ-UPZ and David Hill URA development. In the latter case, any new storage would be built at a high enough elevation to allow it to serve deficiencies in the UPZ-IPZ, as well as the David Hill URA in the future.

The storage deficiencies identified are relatively small and depending on the land available to site new storage, it may be more cost-effective to build the required long-term storage earlier in the planning period rather than build incremental storage over the entire planning period. Furthermore, the required storage for the IPZ-UPZ is small enough over the 20-year period that a site could be selected to accommodate the required storage to serve the IPZ-UPZ in the short-term *and* the David Hill URA over the long-term.

Figure 6-6 shows the general location of the reservoir to meet the pressure and storage requirements in both the David Hill URA and the UPZ. If a reservoir is located in this area, a pump station would be needed to deliver the water to this new reservoir, and a PRV would be needed to reduce pressures flowing into the UPZ.

Figure 6-6 – General Location of Reservoir to Serve David Hill URA



Note: Hydraulic model was used to determine location of reservoir to meet pressure requirements in David Hill URA. Refer to Section 6.4.2.

One option for the development of storage for the IPZ-UPZ would be as follows:

- **Build additional storage of 0.6 MG in the vicinity of existing David Hill Reservoir**. The required storage over the planning period can be met in phased construction of two 0.30 MG reservoirs by 2013 and 2025. However, the City may decide to build a single 0.60 MG reservoir at the

recommended location by 2015. The costs will be higher in the near-term but overall present worth costs could be lower.

- **Build 1.0 MG of new storage at higher elevation to serve David Hill URA by 2045.** Site reservoir elevation at 693 ft. Pump station would be required to fill reservoir from UPZ, and PRV would be needed to allow storage to serve UPZ.

Another option would be to build two tanks of 0.75 MG in two phases (by 2017 and 2050, respectively) in the David Hill URA area. The first 0.75 MG tank built by 2017 could be used to address the IPZ-UPZ storage deficiencies through the 2050 planning period (0.54 MG by 2050). Building the 0.75 MG in the David URA would allow storage to meet pressure requirements throughout the entire UPZ. The second 0.75 MG tank built some time after 2030 can be used to meet the storage requirements for the David Hill URA as growth continues in this area. The combined 1.5 MG of storage from these reservoirs would serve the storage requirements of the combined David Hill URA and IPZ-UPZ through the end of the 2050 planning period. If the City decides to build a higher elevation reservoir in the David Hill URA in the near-term, the City will have to distinguish the portion used to serve current deficiencies (water rates) and new development (system development charges). While in the long-run this option could be lower cost than building separate reservoirs for the IPZ-UPZ and David Hill URA, a drawback of this approach is the potential water quality issues that could arise from lack of turn-over of water in the reservoirs (prior to the higher demands occurring when David Hill URA develops).

6.3.3 Summary of Storage Recommendations

The most cost-effective and feasible approach to storage is dependent on land availability and costs and available funding from the City in the near-term. For the purposes of the capital improvement program, it is recommended to follow the more incremental approach to storage for the following reasons:

- uncertainty in the actual development timeline in the David Hill URA allows the City to build storage more as-needed, since there is sufficient “lead-time” before the David Hill URA storage is needed;
- lower potential for water quality issues in large tanks relative to the demand projections;
- lower near-term rate impacts;

Table 6-6 summarizes the recommended storage improvements for each pressure zone. The following improvement projects are recommended to address storage requirements:

Table 6-6: Recommended Storage Improvements by Pressure Zone

Year	Lower Pressure Zone	Upper and Intermediate Pressure Zones	David Hill URA
2010	N/A	N/A	N/A
2017	N/A	0.30 MG(1)	N/A
2030	2.25 MG	0.30 MG(1)	N/A
2050	2.25 MG	N/A	1.0 MG

Note: Units in million gallons; analysis assumes JWC storage and Fern Hill Reservoir is available.
(1) City may decide to build a 0.60 MG tank by 2015 rather than phasing two smaller tanks of 0.30 MG.

If low cost land in the David Hill URA is available (see **Figure 6-6**), the City should re-evaluate this recommendation; in addition, if the Hilltop area within the UGB or David Hill URA develops faster within the next 20 years, the City may consider accelerating the 1 MG reservoir.

6.4 Distribution System Analysis

6.4.1 Piping

The City is conducting a main renewal and replacement program and replaces main lines based on their estimated remaining service life. The vast majority of new piping installed in the City distribution system is ductile iron. Ductile iron offers durability with respect to exposure to mechanical damage, and service life which can extend beyond 100 years. The City's Renewal and Replacement (R&R) Program generally utilizes ductile iron piping.

Some portions of the existing distribution system are comprised of steel pipe. Piping of this material typically has moderate corrosion rates if the coating is not damaged during installation, and a normal service life in the range of 50 years can be generally expected. It should be noted that some sections of the existing steel pipe are likely to require repairs or replacements within the 20-year planning horizon.

As discussed in the 2000 WMP, "isolated sections of the existing distribution system are comprised of galvanized iron pipe in sizes 4-inch in diameter or smaller. Galvanized iron pipe is particularly susceptible to internal and external corrosion. Internal corrosion results in lower water quality and increased customer complaints due to "red water." External corrosion results in leaks, typically in the form of multiple pinholes. The service life of this pipe can vary greatly with the water chemistry and soil conditions and can be as short as 10 years. Piping replacement should be programmed to replace all the galvanized iron pipe in the distribution system."

In addition to the R&R program, it is recommended that the City initiate a formal asset management program to formalize and optimize the current R&R program. The City has a relatively advanced GIS database of the water system and would benefit from an "asset management program" review to identify opportunities for expanding their capabilities of tracking assets and linking with their finance program. The JWC and other members have already begun similar efforts and the City can identify opportunities to leverage those activities.

6.4.2 Hydraulic Model Development and Analysis

The system model developed for the 2000 Water Master Plan (in WaterCAD 5.0) was updated for this WMP update in Bentley WaterGEMS platform. This platform was chosen during a model selection workshop with City staff based on their preferences and anticipated use of the model. The new hydraulic model was developed "from the ground up" and relied on the most recent distribution system data maintained by the City in their GIS database. The GIS database allowed efficient development of the pipe network comprising the water distribution system, as well as the supplemental data including pipe length, pipe diameter, pipe material, ground and junction elevations.

The model was generally limited to 4-inch and larger in diameter water lines. In addition to pipeline improvements, the model was updated to include the pump stations, pressure reducing valves, and reservoirs. This will enable the model to be used to simulate different operational scenarios. **Appendix F** includes a summary of the model features, and revised model with labeled pipes and junctions. **Appendix F** also includes summary tables of the pipe network characteristics.

Demand Allocation. GIS analysis was used to allocate water demands by customer class (single and multi-family residential, commercial, industrial, and public) by tax lot based on zoning data. Each node in the model network was allocated a portion of the parcel demand based on proximity to the node. The water demands for largest water users (as identified in Section 4.3) were assigned to specific nodes based on their account address.

Calibration. The goal of model calibration is to adjust the model parameters to reflect operational conditions within the actual system. City staff performed ten fire flow tests at hydrants in various locations around the City to provide data with which to calibrate the computer model. The calibration process attempts to correlate the drop in static pressure to residual pressure in field observations to the model results to within 5 psi. HDR prepared a tech memo with recommended locations, field data sheets, and test guidelines. The hydrant testing memo and results of the hydrant testing are included in **Appendix F**.

Calibration of the model was done by simulating these tests in the model and comparing model results to those observed in the field. Since individual fire hydrants are not included in the system model, pressures and flows observed at the model junctions closest to the hydrant test locations were used for comparison. Also, the model junction pressures did not take into consideration pressure losses through fire hydrants. Thus, reported pressures from the model were higher than those measured in the field. For a hydrant flow of about 600 gpm, typical losses through a fire hydrant (from main to outlet) are about 5 psi. Final model junction pressure was determined by subtracting this loss from the reported model junction pressure.

Model Scenarios. Table 6-7 lists the modeling scenarios that were analyzed using the WaterGEMS model developed for the Water Master Plan Update. The scenarios are based on standard practice and design criteria described in Section 5.3. All modeling scenarios apply Scenario B demand forecast as discussed above.

Table 6-7: Summary of Hydraulic Modeling Scenarios

Scenario	Design Criteria	Supply	Demand Period
1. Max. Day Demand	Min. 40 psi	FG WTP + JWC	2010, 2017, 2030
2. Max. Day Demand + Fireflow	Min. 20 psi	FG WTP + JWC	2010, 2017, 2030
3. Peak Hour Demand	Min. 30 psi	FG WTP + JWC	2010, 2017, 2030
4. Average Day Demand (FG WTP only)	Min. 40 psi	FG WTP	2010, 2017, 2030
5. Storage siting analysis @ MDD	Min. 40 psi	FG WTP + JWC	2050
6. Transmission (David Hill & Purdin Rd.) @ MDD	Min. 40 psi	FG WTP + JWC	2050
7. Transmission to North Water Planning Area @ MDD	Min. 40 psi	FG WTP + JWC	2050

Notes:

- *Other primary design criterion is to consider max. flow velocities in the distribution system (5-8 fps).*
- *The storage siting analysis can actually be completed as part of Scenario 1, but listed separately emphasize some additional considerations that the City might request for siting criteria.*

For all scenarios except fireflow scenarios the water elevation in the reservoir at the City's WTP was set at 365 feet, the David Hill reservoir was set at 534 feet. For fire flow scenarios the reservoirs were set at 1 foot above minimum elevations. For the scenarios that included the JWC supply, the 10th Avenue station was modeled as a flow control valve.

Analysis scenarios are listed and described below. Graphical results are presented in **Appendix F** and system deficiencies are discussed in Section 6.4.3.

1) *Maximum day demand; City Supply and JWC Supply* -- This scenario was used to evaluate the system response to maximum day demand when the system is supplied from both the reservoir at the City WTP and the JWC supply. The system must be capable of providing the maximum day demand while maintaining a minimum service pressure of 40 psi throughout the system. This scenario meets the first distribution criteria presented in Section 5.

2) *Fire flows during maximum day demand; City Supply and JWC Supply* -- This scenario was used to evaluate the system response to fire flows during maximum day demand when the system is supplied from both the reservoir at the City WTP and the JWC supply. The system must be capable of providing the required fire flow and the maximum day demand while maintaining a minimum residual pressure of 20 psi throughout the system. This scenario meets the second distribution criteria presented in Section 5.

3) *Peak hour demand; City Supply and JWC Supply* -- This scenario was used to evaluate the system response to the peak hour demand when the system is supplied from both the reservoir at the City WTP and the JWC supply. Peak hour demand is assumed to be 2.18 times the maximum day demand based on data from the 2000 WMP, and confirmation with City staff. The system must be capable of providing the peak hour demand while maintaining a minimum residual pressure of 30 psi throughout the system. This scenario meets the third distribution criteria presented in Section 5.

4) *Average day demand; City Supply Only* -- This scenario was used to determine that the system can maintain a minimum of 40 psi pressure during average day demand when the only supply to the system is the reservoir at the City WTP. Average day demand is assumed because water curtailment would be initiated by the City if the JWC supply were to off line for a significant period. The purpose was to determine how well pressures would be maintained if the City operators were unable to immediately adjust the JWC supply 10th Avenue flow control station.

5) *Storage siting*. The hydraulic model was used to verify locations in the David Hill URA that would meet the pressure needs of the David Hill URA and UPZ. Using MDD 2050, the model was used to determine elevation of tank that provides 40 psi in David Hill URA. Elevation for David Hill URA (represented by one single node in the model) was set at 600 feet.

6) *Scenarios 6 and 7* considered the main transmission lines for delivering water to the urban expansion areas. The analysis identified existing main lines (e.g., greater than 12 inches) that can be extended to the urban expansion areas where demand nodes will be allocated for year 2050 demands for those areas. No distribution system was defined within the urban expansion areas. The purpose of the modeling analysis was to evaluate the pressure and flow impacts within the existing distribution system.

Based on the source of supply evaluation and discussions with the City staff, the distribution system analysis did not consider any new sources of supply besides the existing FG WTP and JWC supply through the 10th Ave. metering station. The source of supply evaluation did not identify any near-term need for new supplies. However, the model has capabilities to evaluate this in the future.

6.4.3 Distribution System Modeling Results

Appendix F includes the key results and output from the other modeling scenarios where system deficiencies were identified. A summary of the results are described as follows:

- *Maximum Day Demand; City Supply and JWC Supply* -- The results of this scenario indicated that all service pressures would be maintained above 40 psi during maximum day demand conditions. Service pressures dropped below 50 psi in only a few areas.
- *Fire flows during peak day demand; City Supply and JWC Supply* -- The results of this scenario indicated that fire flow requirements and maximum day demand were not satisfied at all locations to maintain a minimum residual pressure of 20 psi throughout the system. **Figure 6-7** shows the locations of the current system deficiencies based on the 2010 demands under the MDD + fireflow condition.

- **East-side Commercial-Industrial zone (area between TV Hwy. – 24th Ave. – Yew St.)** – The City has commercial fireflow requirements of 3,500 gpm. The existing pipelines in this area are typically 8-inches. Up-sized pipes to 10-inches would increase flow capacity. Additionally, the 10-inch pipeline along Mountain View Lane could be up-sized from 10-inches to 12-inches to increase fireflow for the Neil Armstrong Middle School.
- **School and semi-public areas (various locations)** – several areas near schools show fireflow deficiencies based on the fireflow requirement of 4,500 gpm. These areas include Tom McCall Middle School (Pacific Ave. & E Pl.); Pacific University campus (Pacific Ave.-College Way-Cedar St.); Neil Armstrong Middle School (Mountain View Hwy.). The pipelines in these areas should be upsized (typically one standard pipe diameter increment).
- **Residential dead-end and small diameter pipelines (various locations)** – several areas associated with hydrants at dead-end roads or with small (2-inch) lines had deficiencies to meet the 1,000 gpm fireflows. The pipeline areas should be upsized (typically one standard diameter increment; with a minimum of 6-inches used for all residential-zoned areas).

- *Peak hour demand; City Supply and JWC Supply* -- The results of this scenario indicated that during peak hour demand conditions, all service pressures would be maintained at no less than 30 psi. These results were considered adequate and no additional piping improvements were recommended due to this model run.
- *Average Day Demand (curtailment) + Fireflow; City Supply Only* -- The results of this scenario indicated that all service pressures would be maintained above 20 psi , with the exception of the area to the southeast near Poplar Lane and Mountain View Lane. These results were considered adequate and no additional piping improvements were recommended. Because this scenario is considered an emergency scenario with the JWC supply off-line, an emergency intertie at 72-inch North Transmission Line was evaluated to address the fireflow needs in the southeast section of the City. Adding the intertie addresses the fireflow needs, and has been identified as a recommended improvement to address this issue, as well as to generally provide added reliability to the City's access to JWC supply.

6.4.4 Summary of Distribution System Recommendations

The following are recommendations to address distribution system deficiencies. In general, the distribution system recommendations are needed to increase the hydraulic capacity of the distribution system, in particular to provide adequate fire flows. The individual projects and cost estimates for each are presented in Section 7.

- Complete pipe replacement projects based on the need to address deficiencies in meeting the "MDD + Fireflow" conditions. The locations are identified in **Figure 6-7**. All of the replacements are in the lower pressure zone, with a majority in the eastside industrial area. The projects should be coordinated with any redevelopment activities, in particular those around Pacific Ave.
- Install David Hill Road waterline to supply water to the future David Hill URA and reservoir.
- Pump station and PRV to supply water to the David Hill URA reservoir and allow water to feed into UPZ.
- Emergency Intertie at 72-inch NTL.

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Scenario 2: Maximum Day Demand + Fireflow
Locations of System Deficiencies

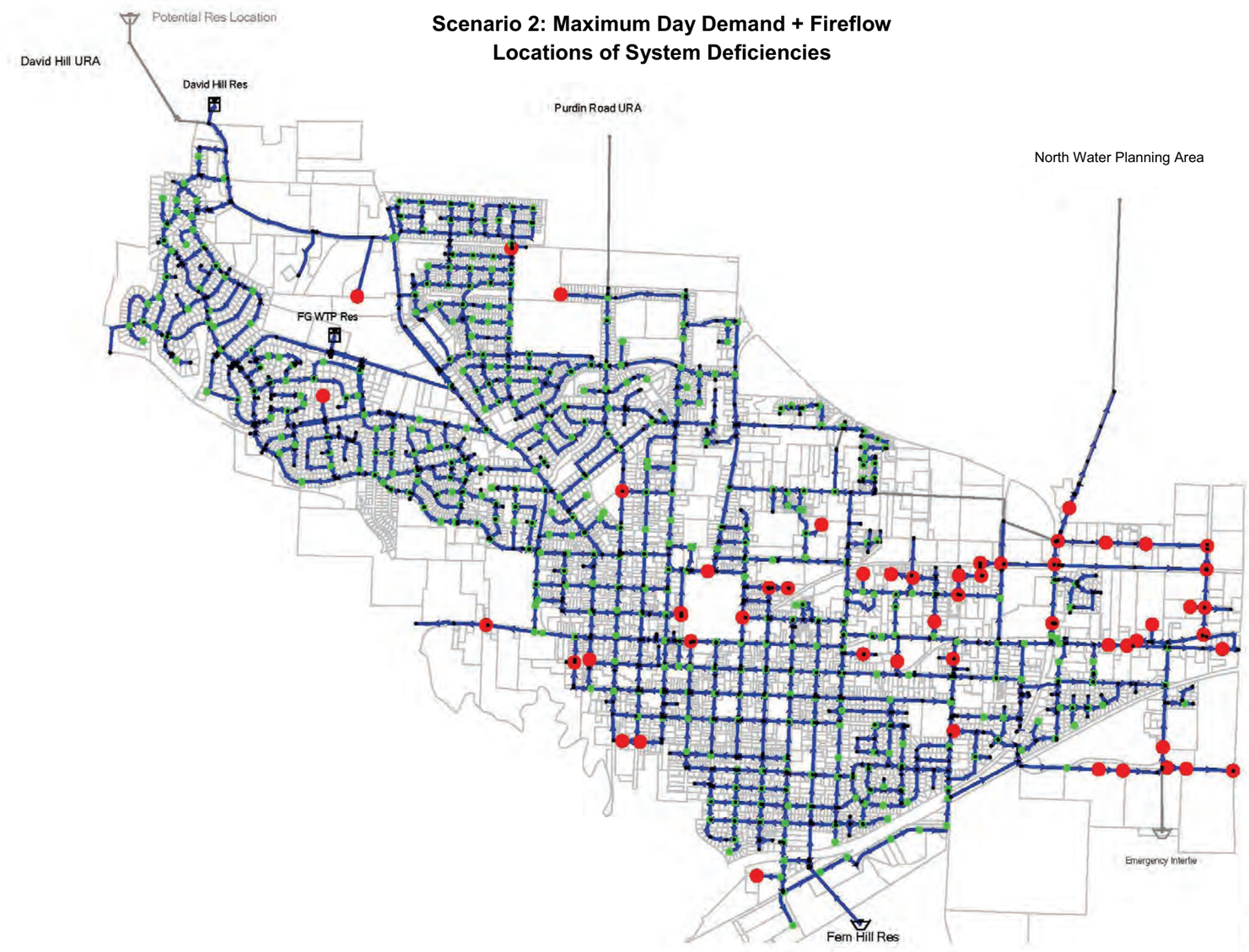


Figure 6-7

Locations of System Deficiencies under 2010 Maximum Day Demand with Fireflow

= Sufficient flow and pressure at hydrant location

= Insufficient flow or residual pressure at hydrant location

city of forest grove HDR

7 Capital Improvement Program

This section presents a recommended capital improvement program for the City of Forest Grove that provides for the correction of existing deficiencies and expansion of the water system to support anticipated future development. Proposed improvements are based on the recommendations presented in Section 6 for the water supply facilities, storage reservoirs, pump stations, and the water distribution system. The City's adopted Capital Improvements Program for 2010-2015 includes preliminary projects and cost estimates for projects identified in the short term. However, due to budget deadlines, the adopted CIP is generalized, whereas this section provides more detail and explanation.

It should be noted that not all of the CIP projects discussed in this section were a direct result of analysis described in Section 6. Some of the projects are on-going projects or commitments identified by the City for the Joint Water Commission, Tualatin Basin Water Supply Project, or other operation and maintenance activities.

7.1 Cost Estimating Criteria

Cost estimates are presented for recommended capital improvements. These cost estimates are based on observed trends of recent construction costs in the area and assume the work will be accomplished by private contractors. Presented cost estimates represent engineering opinions of cost only, as final costs of the projects will vary depending upon labor and material costs, market conditions for construction, regulatory requirements, final project scope and design, project schedule and other factors. Planning level costs are expected to be within +50% to –30% of actual costs.

The estimated costs presented in this plan are planning level budget estimates that are based on construction costs, and estimates for land acquisition where necessary. Unit costs were obtained from HDR cost data, RSMeans®, and equipment suppliers. Unit costs for pipelines were compared to those used in the previous Master Plan and found to be similar. The cost estimate includes a 30% construction contingency and 20% allowance for engineering and administration costs for all non-pipeline projects. Since construction costs change with time, an indexing method to adjust estimates to future dollars is useful. All estimates are in 2009 dollars and are indexed to an Engineering News Record, Construction Cost Index of 8800.

7.2 Recommended Plan

Only system problems identified from analysis for this WMP update and recommended alternatives discussed in Section 6 are presented in summary **Table 7-1** to **Table 7-5**. However not all of the CIP projects are infrastructure related; the CIP also includes specific studies or plans that the City would like to track for their operating budget. The CIP projects are divided into the following general improvement categories:

- ***Source of Supply, Transmission and Interties*** – address identified issues and deficiencies related to water source and transmission facilities.
- ***Treatment*** – address identified issues and deficiencies at the water treatment plant.
- ***Finished Water Storage*** – address identified issues and deficiencies related to storage needs and associated facilities.

- ***Distribution and Piping System*** – address identified issues and deficiencies related to the distribution and piping system, including pump stations and pressure reducing stations.
- ***Miscellaneous Projects and Studies*** – address identified studies needed for evaluating feasibility of recommended projects or developing long-term strategies for the water system.
- ***Joint Water Commission –*** known or anticipated improvements needed for JWC facilities.
- ***Tualatin Basin Water Supply Project*** – known or anticipated commitments for TBWSP planning or facilities.
- ***Contingency Funds –*** set asides for major repair and replacement of infrastructure.

7.2.1 Source of Supply, Transmission and Interties

Source and transmission improvement recommendations are summarized in **Table 7-1**. SR01 is needed to develop an overall water rights strategy around the City's Gales Creek water right. The strategy from that work can affect how the City approaches several future water supply options. SR02 is a study to evaluate the feasibility of pursuing wheeling water through TVID irrigation lines to the City's WTP. Findings from this study will affect the need for SR08 and TR04. SR03 is needed to provide reliability of JWC supply, and also addresses emergency fireflow needs in the southeast area of the City. SR04 addresses the long-term transmission need from JWC supply. SR05 and SR06 are long-term improvements needed to address the end of design life of raw water transmission facilities. The remaining projects (SR08 to SR12) are included to allow the City to track longer-term supply options that the City has available, because the City does not have near-term supply needs. All of the projects address needs due to growth (SDCs), with the exception of the raw water upgrade/replacement (SR05 and SR06).

Table 7-1: Source of Supply, Transmission and Intertie Improvements

Project ID	Project	Estimated Cost
SR01	Water Rights Strategic Plan(1)	$30,000
SR02	TVID Supply Options Study(1)	$30,000
SR03	JWC North Transmission Line Emergency Intertie at Heather St. (1,2)	$250,000
SR04	18-inch Ductile Iron Parallel Supply Line from JWC Fern Hill Reservoir(2)	$3,500,000
SR05	Raw Water Booster Station Upgrade(2)	$200,000
SR06	16" Raw Water Transmission Line Replacement(2)	$2,500,000
SR07	Gales Creek Diversion Improvements(2)	$2,500,000
SR08	TVID Supply Transmission Line(3)	TBD
SR09	JWC Barney Reservoir Buy-Back(3)	TBD
SR10	TBWSP Water Supply Buy-In(3)	TBD
SR11	Scoggins Seismic Retrofit(3)	TBD
SR12	JWC ASR Future Buy-in(3)	TBD
	Total (not including TBD items)	**$9,025,000**

Notes:

(1) Project identified in the 2010 WMP Update system analysis.

(2) Project identified from previous/other studies by City or JWC commitment. Anticipated implementation year of these projects are "to be determined" (TBD)

(3) Potential project identified from previous/other studies based on future need or feasibility. Costs and anticipated implementation year of these projects are "to be determined" (TBD).

7.2.2 Treatment

Treatment recommendations based on the analysis presented in Section 6.3 are presented in **Table 7-2**. **Table 6-4** lists near-term and long-term WTP needs. The near-term items are consolidated as "TR01 – WTP safety and operations improvements" in **Table 7-2**. The long-term needs are listed as separate projects (TR02 and TR03). TR04 is included pending the conclusions from TVID Supply Options Study (SR02). TR05 is included to track future major repair/rehabilitation needs at the WTP for structural, electrical and instrument & control facilities. Regular maintenance and operations activities (e.g., sludge removal, valve replacement, etc.) are not included in **Table 7-2**, and assumed to be budgeted and tracked under a separate maintenance budget by the City. TR01, -02, -03, and -05 represent regular maintenance needs (rates), while TR04 addresses growth needs (SDCs).

Table 7-2: Treatment Improvements

Project ID	Project	Estimated Cost
TR01	WTP safety and operations improvements(1)	$30,000
TR02	Mechanical sludge/residuals collection system in sedimentation basins(1,2)	$150,000
TR03	Plate settlers and launder replacement(1,2)	$700,000
TR04	TVID Supply Treatment Modifications(3)	TBD
TR05	Major Maintenance (structural, electrical and I&C repairs and/or rehabilitation)(3)	$10,000 (annual)
	Total (not including TBD or annual costs)	**$890,000**

Notes:

(1) Project identified in the 2010 WMP Update system analysis.

(2) Project identified from previous/other studies by City or JWC commitment. Anticipated implementation year of these projects are "to be determined" (TBD)
(3) Potential project identified from previous/other studies based on future need or feasibility. Costs and anticipated implementation year of these projects are "to be determined" (TBD).

7.2.3 Storage Improvements

Storage recommendations are shown in **Table 7-3**. These recommendations address current and future storage needs. ST01, ST02 and ST03 represent planning level land acquisition costs for near-term and long-term storage needs. ST04 and ST05 are the two-phase storage construction to meet needs for the UPZ. ST06 and ST07 are the two-phase construction of tanks to meet needs for the LPZ. Finally ST08 is the storage tank and associated pump station and PRV to fill and supply from the tank between the UPZ and David Hill URA. ST02 and ST06 address current deficiencies (rates), while the other storage projects address storage needs due to growth (SDCs).

Table 7-3: Storage Improvements

Project ID	Project	Estimated Cost
ST01	Land acquisition for Upper Zone storage	$100,000
ST02	Land acquisition for Lower Zone storage	$100,000
ST03	Land acquisition for David Hill URA storage	$100,000
ST04	0.30 MG Upper Reservoir 1	$350,000
ST05	0.30 MG Upper Reservoir 2	$350,000
ST06	2.25 MG Lower Zone Reservoir 1	$2,130,000
ST07	2.25 MG Lower Zone Reservoir 2	$2,130,000
ST08	1.0 MG David Hill Reservoir	$950,000
ST09	David Hill URA Pump Station	$350,000
ST10	David Hill-UPZ PRV	$200,000
	Total	**$6,760,000**

Notes: All projects identified in the 2010 WMP Update system analysis.
Land acquisition costs should be considered as a place-holder cost. A land value assessment should be completed for more accurate land purchase costs.

7.2.4 Distribution and Piping System

Distribution system recommendations are shown in **Table 7-4** and **Figure 7-1**. As discussed in Section 6, model results showed several areas where fire flows were inadequate. DP01 through DP32 address deficiencies in the fire flow. Recommended improvements consist of increasing pipeline size and improving system looping. DP33 and DP34 are distribution mains needed in the future to meet development anticipated to occur in the David Hill URA and Purdin Rd. areas, respectively. DP35 through DP37 were identified by the City in previous studies to address growth. All of the projects address immediate fire flow deficiencies, but have been sized to be able to meet the long-term system demands.

Table 7-4: Distribution and Piping Improvements

Project ID	Project	Estimated Cost
DP01	Looping from Hartford Dr. to Brooke St.; 10" line; 1,000 ft. (1)	$98,800
DP02	Looping from 26th Ave. to Camino Dr. on B St.; 8" line; 800 ft. (1)	$70,700
DP03	Upsize from 8" to 12" line; 910 ft. on 1274 SW Pacific Rd(1)	$101,700
DP04	Looping from C St. to D St. on 19th Ave.; 8" line; 270 ft. (1)	$23,900
DP05	Upsize from 6" to 10" line; 920 ft.; 16th Ave and B St(1)	$90900
DP06	Upsize from 6" to 8" line; 460 ft.; 16th Ave and A St(1)	$40,600
DP07	Looping from Pacific Ave. to 21st Ave on College Way; 8" line; 450 ft. (1)	$39,800
DP08	Looping from Parking Lot to Elm St.; 8" line; 300 ft. (1)	$26,500
DP09	Upsize from 6" to 8" line; 325 ft.; 22nd Ave near Hawthorne St(1)	$28,700
DP10	Looping from 22nd Pl to 22nd Ave through Bard Park	$30,900
DP11	Looping from Willamina Ave. to 26th Ave; on 24th Ave; 8" line; 1,178 ft. (1)	$104,100
DP12	Looping from Boyd Lane to Oak St. on 24th Ave.; 10" line; 2,800 ft(1)	$276,600
DP13	Looping from Oak St. to Quince St. on 24th Ave.; 12" line; 1,030 ft(1)	$115,100
DP14	Upsize from 1" to 8" line; 700 ft; Oak St and rail(1)	$61,900
DP15	Upsize from 8" to 12" line; 2,790 ft; Quince St and 24th Ave(1)	$311,900
DP16	Upsize from 8" to 12" line; 1,320 ft; Heather St. (1)	$147,600
DP17	Upsize from 10" to 12" line; 640 ft; NW Martin Rd(1)	$71,500
DP18	Looping from hydrant at 4011 Pacific Ave to other side of Pacific Ave	$9,700
DP19	Upsize from 6" to 10" line; 320 ft; 1st St and 4th St(1)	$31,600
DP20	Upsize from 6" to 8" line; 270 ft; 22nd Ave and 7th St(1)	$23,900
DP21	Upsize from 8" to 10" line; 530 ft; 17th Ave and Maple St(1)	$52,400
DP22	Upsize from 6" to 8" line; 240 ft; 2900 19th Ave(1)	$21,200
DP23	Looping from 19th Place to Pacific Ave.; 8" line; 310 ft. (1)	$27,400
DP24	Upsize from 6" to 10" line; 490 ft; 9th Ave and Carnation Rd(1)	$48,400
DP25	Upsize from 6" to 8" line; 20 ft; 19th Pl and Maple St(1)	$1,800
DP26	Upsize from 6" to 8" line; 315 ft; 2150 Laurel St(1)	$27,800
DP27	Upsize from 6" to 8" line from Laurel St and 22nd Ave to 22nd Pl cul-de-sac	$105,200
DP28	Looping from Green Ct. to 22nd Ave on 22nd Ave.; 10" line; 350 ft. (1)	$34,600
DP29	Looping from hydrant to NW Thatcher Rd; 8" line; 700 ft. (1)	$61,900
DP30	Upsize from 6" to 8" line; 460 ft; Buxton Ct(1)	$40,700
DP31	Upsize from 2" to 12" line; 530 ft; Nehalem Hwy and University Ave(1)	$59,200
DP32	Upsize from 6" to 8" line; 470 ft; 21st Ave and Cedar St(1)	$41,500
DP33	David Hill Rd. Waterline (supply future development) (2)	$240,000
DP34	Purdin Rd. URA Waterline (supply future development) (1)	$750,000
DP35	Water Crest Rd. Pump Station Upgrade(2)	$75,000
DP36	David Hill Pump Station Upgrade(2)	$75,000
DP37	Industrial Area (23rd/24th) Ave. mains(2)	$246,000
	Total	**$3,614,500**

Notes:

(1) Project identified in the 2010 WMP Update system analysis.

(2) Project identified from previous/other studies by City or JWC commitment. Anticipated implementation year of these projects are "to be determined" (TBD)

7.2.5 Miscellaneous Projects and Studies

Table 7-5 lists miscellaneous projects and studies that do not directly impact the primary water system infrastructure, but have been recommended as important to the City's optimizing the operation and maintenance of the water system. Projects are also included that are "accounted" for in the water capital improvements program (CIP), but which do not affect the water system directly.

Table 7-5: Miscellaneous Projects and Studies

Project ID	Project	Estimated Cost
MS01	Water Master Plan Update (every 6 years)	$125,000
MS02	Asset Management Program Development Analysis	$100,000
MS03	Drinking fountains in City Buildings	$15,000
MS04	Emergency water dispensers	$10,000
	Total	**$250,000**

7.2.6 Joint Water Commission and Tualatin Basin Water Supply Project Commitments

The City of Forest Grove has identified several on-going commitments with the Joint Water Commission and the Tualatin Basin Water Supply Projects based on previous studies and planning. The City goes through an annual budgeting process with the JWC and updates the City's internal Water CIP accordingly. Because of this separate and parallel process, the specific projects included in the 2010 WMP update are "snap shots" in time based on the current planning and agreements by the City with the JWC and TBWSP partners. The projects are listed in **Table 7-6**, but have not been identified with CIP "project codes." The City maintains a separate CIP ID number for these projects.

7.3 Project Prioritization

Table 7-6 presents a summary of the comprehensive water system CIP, including the expenditures by year over the planning period. For the CIP projects identified, project prioritization was based on identified system deficiencies, and discussions and workshops with City personnel.

Projects designed to address current system deficiencies are assumed not to be growth related. Projects that only address future demand needs are designated to be 100% growth related. **Table 7-6** includes a column for "project drivers" that identifies whether the projects are related to:

- New development – to be paid for by system development charges;
- Current system needs – to be paid for through customer rate fees;
- Supply reliability – to be paid for through customer rate fees

The City has an on-going renewal and replacement program to address older pipe (i.e., pipelines approaching their design life). The City also conducts Clear Creek watershed maintenance activities. These were not included in the CIP table, as they are tracked and budgeted under a separate maintenance budget. These budgets are generally paid for through customer rate fees.

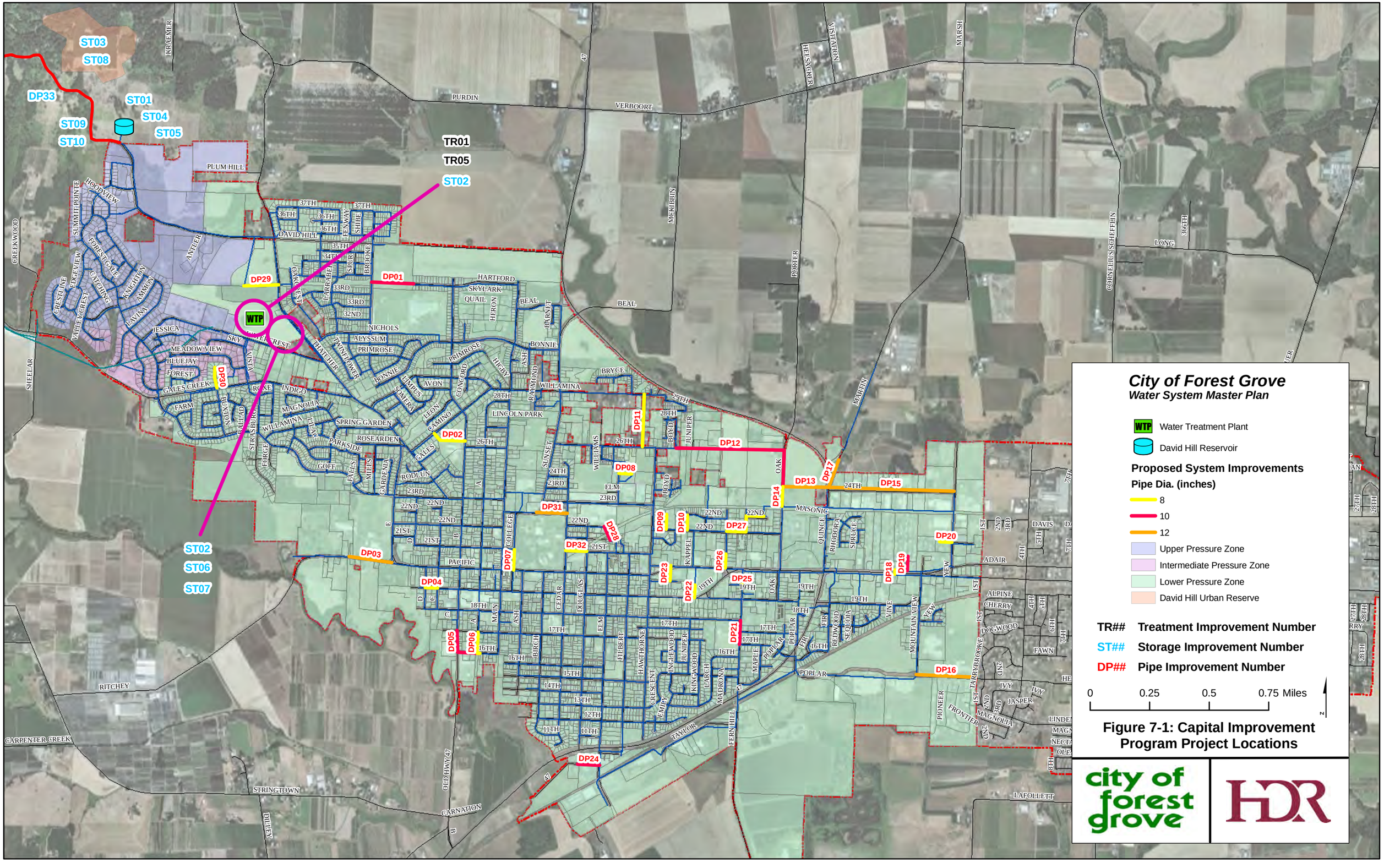
Projects addressing system deficiencies were given the highest priority and are shown with an estimated date within the next 5 years. Other projects are listed in chronological order based on the associated "project driver." Predesign and final design phases should be initiated prior to this date to ensure that the project is completed to meet system needs.

Table 7-6: Water System Capital Improvement Program – City of Forest Grove

CIP No.	Project Code	Capital Improvement	Present Worth Cost (2010)	Anticipated Implementation Fiscal Year	Project "Driver"	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	Anticipated Cost 2018-2030	Anticipated Cost 2031-2050
Source of Supply, Transmission and Interties														
	SR01	Water Rights Strategic Plan	$ 30,000	2012	Supply Reliability		$ 30,900							
	SR02	TVID Supply Option Study	$ 45,000	2013	Supply Reliability			$ 47,741						
W50	SR03	JWC North Transmission Line Emergency Intertie at Heather St.	$ 250,000	2016	Supply Reliability						$ 289,819			
	SR04	JWC Parallel Supply Line (18" - 6 mgd capacity)	$ 3,500,000	2020	New development (SDC)								$ 4,566,706	
	SR05	Raw Water Booster Station Upgrade	$ 200,000	TBD	Existing system (Rates)									
	SR06	Raw Water Transmission Line Replacement (15 year remaining life)	$ 2,500,000	TBD	Existing system (Rates)									
W47	SR07	Gales Creek Source Improvements	$ 2,500,000	TBD	Supply Reliability									
	SR08	*TVID Supply Plan transmission extension*	TBD	TBD	Pending MS-01									
W8	SR09	JWC Barney Reservoir Buy-Back	$ 1,500,000	TBD	New development (SDC)									
	SR10	TBWSP water supply future buy-in	TBD	TBD	New development (SDC)									
Not assigned	SR11	Scoggins Siesmic Retrofit	$ 4,900,000	TBD	Existing system (Rates)									
	SR12	JWC ASR Future buy-in	TBD	TBD	New development (SDC)									
	SR13	Watershed Road Improvements	$ 20,000	Annual	Existing system (Rates)	$ 20,000	$ 20,600	$ 21,218	$ 21,855	$ 22,510	$ 23,185	$ 23,881	$ 372,969	$ 942,347
	SR14	Fish Screen at Fern Hill Pump Station	$ 320,000	TBD	Existing system (Rates)									
	SR15	Raw Water Pipeline	$ 2,700,000	TBD	Existing system (Rates)									
Treatment														
	TR01	WTP safety and operations improvements	$ 30,000	2013	Existing system (Rates)			$ 31,827						
	TR02	Mechanical sludge/residuals collection system	$ 150,000	2016	Existing system (Rates)						$ 173,891			
	TR03	Plate settlers and launder replacement	$ 700,000	2018	Existing system (Rates)								$ 860,912	
	TR04	TVID Supply Treatment modifications (pending MS-01)	TBD	TBD	New development (SDC)									
W3	TR05	Forest Grove WTP Major Maintenance	$ 10,000	Annual	Maintenance (Rates)	$ 10,000	$ 10,300	$ 10,609	$ 10,927	$ 11,255	$ 11,593	$ 11,941	$ 186,485	$ 471,174
Finished Water Storage (in-town)														
W31	ST01	Land Acquisition for Upper Zone storage	$ 100,000	2012	New development (SDC)		$ 103,000							
W32	ST02	Land Acquisition for Lower Zone storage	$ 100,000	2017	New development (SDC)								$ 119,405	
W32	ST03	Land Acquisition for David Hill Area	$ 100,000	2040	New development (SDC)									$ 235,657
W31	ST04	0.30 MG Upper Reservoir 1	$ 350,000	2013	New development (SDC)			$ 371,315						
W31	ST05	0.30 MG Upper Reservoir 2	$ 350,000	2025	New development (SDC)								$ 529,406	
W32	ST06	2.25 MG Lower Reservoir	$ 2,130,000	2020	New development (SDC)								$ 2,779,167	
W32	ST07	2.25 MG Lower Reservoir (Purdin Rd. area)	$ 2,130,000	2040	New development (SDC)									$ 5,019,485
W32	ST08	1.0 MG David Hill Reservoir	$ 950,000	2045	New development (SDC)									$ 2,595,310
	ST09	Davd Hill URA Pump station	$ 350,000	2045	New development (SDC)									$ 956,167
	ST10	David Hill URA PRV	$ 200,000	2045	New development (SDC)									$ 546,381
Distribution and Piping System														
	DP01-DP29	Flow/pressure improvements	$ 1,900,000	2011-2017	Existing system (Rates)		$ 200,000		$ 200,000	$ 100,000	$ 200,000			
W48	DP33	David Hill Rd. Waterline	$ 240,000	2011	New development (SDC)	$ 240,000								
	DP34	Purdin Rd. expansion area distribution main upgrade	$ 750,000	2040	New development (SDC)									$ 1,767,424
	DP35	Watercrest Road Pump Station Upgrade	$ 75,000	TBD	Existing system (Rates)									
	DP36	David Hill Pump Station Upgrade (additional pump)	$ 75,000	2040	New development (SDC)									$ 176,742
W6	DP37	Industrial Area -23rd/24th	$ 246,400	2015	New development (SDC)					$ 277,325				
W2	DP38	Line Oversizing Participation	$ 50,000	Annual	New development (SDC)	$ 50,000	$ 51,500	$ 53,045	$ 54,636	$ 56,275	$ 57,964	$ 59,703	$ 932,423	$ 2,355,868
		Capital Improvement Projects Total	**$ 29,451,400**		**Total**	**$ 320,000**	**$ 416,300**	**$ 535,755**	**$ 287,418**	**$ 467,366**	**$ 756,452**	**$ 95,524**	**$ 10,347,473**	**$ 15,066,555**

Table 7-6: Water System Capital Improvement Program – City of Forest Grove (continued)

CIP No.	Project Code	Capital Improvement	Present Worth Cost (2010)	Anticipated Implementation Year	Project "Driver"	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	Anticipated Cost 2017-2030	Anticipated Cost 2030-2050
Miscellaneous Projects and Studies														
	MS01	Water Master Plan Update (every 6 years)	$ 125,000	2017	Existing system (Rates)							$ 149,257		
	MS02	Asset Management Program	$ 100,000	2013	Existing system (Rates)			$ 106,090						
W54	MS03	Drinking Fountains - City Buildings	$ 15,000	2011	Existing system (Rates)	$ 15,000								
W53	MS04	Emergency Water Dispensers	$ 10,000	2011	Existing system (Rates)	$ 10,000								
		Miscellaneous Projects and Studies Total	**$ 250,000**		**Total**	**$ 25,000**	**$ -**	**$ 106,090**	**$ -**	**$ -**	**$ -**	**$ 149,257**	**$ -**	**$ -**
Joint Water Commission Commitments														
W10	JWC01	JWC WTP Pilot Study	$ 13,790	2011	Existing system (Rates)	$ 13,790								
W17	JWC02	On-site Power Generation	$ 63,318	2011	Existing system (Rates)	$ 63,318								
Not assigned	JWC03	Filter Replacement	$ 13,330	2011	Existing system (Rates)	$ 13,330								
Not assigned	JWC04	WTP Re-use	$ 9,331	2011	Existing system (Rates)	$ 9,331								
Not assigned	JWC05	Electrical Assessment	$ 13,997	2011	Existing system (Rates)	$ 13,997								
W29	JWC06	Seismic WTP, Short-Term	$ 44,000	2011	Existing system (Rates)	$ 4,000		$ 40,000						
W29	JWC07	Seismic WTP, Longer-Term	$ 360,000	2017	Existing system (Rates)							$ 429,859		
W19	JWC08	Conservation/Management Plan	$ 2,000	2011	Existing system (Rates)	$ 2,000								
Not assigned	JWC09	Quonset Hut	$ 15,080	2012	Existing system (Rates)		$ 15,532							
W11	JWC10	Water Rights	$ 9,331	2011	Existing system (Rates)	$ 9,331								
W31	JWC11	JWC Enterprise Asset Management	$ 33,000	TBD	Existing system (Rates)									
Not assigned	JWC12	Fern Hill CL2	$ 39,990	2012	Existing system (Rates)		$ 41,190							
W10	JWC13	Ozone retrofit	$ 1,800,000	2018	Existing system (Rates)								$ 2,213,773	
W25	JWC14	Clearwell	$ 560,000	2018	Existing system (Rates)								$ 688,729	
W26	JWC15	Pump Station	$ 160,000	2018	Existing system (Rates)					$ -			$ 196,780	
W22	JWC16	Rapid Mix	$ 48,667	2016	Existing system (Rates)						$ 56,418			
W24	JWC17	Thickener	$ 133,000	2016	Existing system (Rates)						$ 154,183			
W26	JWC18	WTP Major Maintenance	$ 80,000	Annual	Existing system (Rates)			$ 80,000	$ 82,400	$ 84,872	$ 87,418	$ 90,041	$ 1,406,237	$ 3,553,011
Not assigned	JWC19	JWC WTP Expansion Phase 3	$ 2,700,000	TBD	New development (SDC)									
W23	JWC20	JWC Water Master Plan Update (every 5 years)	$ 25,000	2015	Existing system (Rates)					$ 28,138				
		JWC Commitments Total	**$ 6,123,834**		**Total**	**$ 129,097**	**$ 56,722**	**$ 120,000**	**$ 82,400**	**$ 113,010**	**$ 298,020**	**$ 519,900**	**$ 4,505,519**	**$ 3,553,011**
		Total CIP	**$ 35,825,234**			**$ 474,097**	**$ 473,022**	**$ 761,845**	**$ 369,818**	**$ 580,376**	**$ 1,054,472**	**$ 764,680**	**$ 14,852,992**	**$ 18,619,565**
		Notes:												
		Interest rate assumed for future worth cost calculations is 3%	*3%*											
		[1] Includes annual maintenance contingency costs for raw water transmission ($10,000), pipeline renewal and replacement ($75,000), and WTP ($10,000)												
		[2] Specific budgets for JWC equipment reserves beyond the 2010-2011 are not included in the CIP table because the JWC adopts specific budgets on an annual basis and may not be the same as the schedule outlined in the 2009 JWC Master Plan.												
Contingency Funds														
		FG Capital Contingency	$ 100,000	Annual	Maintenance (Rates)	$ 100,000	$ 103,000	$ 106,090	$ 109,273	$ 112,551	$ 115,927	$ 119,405		
		FG Maintenance Contingency[1]	$ 160,000	Annual	Maintenance (Rates)	$ -	$ 164,800	$ 169,744	$ 174,836	$ 180,081	$ 185,484	$ 191,048		
		Debt Reserve Contingency	$ 415,000	Annual	Maintenance (Rates)	$ 415,000	$ 415,000	$ 415,000	$ 415,000	$ 415,000	$ 415,000	$ 415,000		
		JWC Equipment Reserve Contingency[2]	$ 333,250	Annual	Maintenance (Rates)	$ 333,250	$ 333,250	$ 333,250	$ 333,250	$ 333,250	$ 333,250	$ 333,250		
		Contingency Fund Total	$ 1,008,250			$ 848,250	$ 1,016,050	$ 1,024,084	$ 1,032,359	$ 1,040,882	$ 1,049,661	$ 1,058,704	$ -	$ -


City of Forest Grove
Water System Master Plan
WTP Water Treatment Plant
David Hill Reservoir
Proposed System Improvements
Pipe Dia. (inches)
8
10
12
Upper Pressure Zone
Intermediate Pressure Zone
Lower Pressure Zone
David Hill Urban Reserve
TR## Treatment Improvement Number
ST## Storage Improvement Number
DP## Pipe Improvement Number
0 0.25 0.5 0.75 Miles
N
ST03
ST08
DP33
ST01
ST04
ST05
ST09
ST10
TR01
TR05
ST02
ST06
ST07
WTP
DP01
DP02
DP03
DP04
DP05
DP06
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DP09
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DP28
DP29
DP30
DP31
DP32
PURDIN
VERBOORT
PLUM HILL
DAVID HILL
HARTFORD
BEAL
NICHOLS
ALYSSUM
PRIMROSE
BONNIE
BRYCE
WILLAMINA
LINCOLN PARK
SPRING GARDEN
ROSEARDEN
MASONIC
ADAIR
ALPINE
CHERRY
DOGWOOD
FAWN
IVY
JASPER
MAGNOLIA
LAFOLLETT
RITCHEY
CARPENTER CREEK
STRINGTOWN
CARNATION
TAYLOR
POPLAR
PACIFIC
CREEKWOOD
SHEELAR
KRAEMER
ANTLER
HOODVIEW
SUMMIT POINTE
FOREST GALE
EDGEVIEW
CRESTLINE
VALLEY CREST
CATCHING
KNIGHTON
AMMON
LAVINA
JESSICA
MEADOW VIEW
BLUEJAY
FOREST
GALES CREEK
FARM
BUXTON
STRASBURG
FORGE
GOFF
MILLS
GARDENA
RODLUN
PARKSIDE
INDIGO
MAGNOLIA
WILLAMINA
SKY VISTA
THATCHER
TWINFLOWER
BONNIE
LIMPUS
SOMERA
LEON
CAMINO
AVON
CONCORD
HIGBY
ASH
RAYMOND
BOYD
JUNIPER
SUNSET
WILLIAMS
ELM
KAPPEL
QUINCE
RHODORA
SPRUCE
OAK
COLLEGE
CEDAR
DOUGLAS
BIRCH
HILBERT
HAWTHORNE
CRESCENT
EMILY
INGLEWOOD
KINGWOOD
LARCH
MADRONA
MAPLE
FIR
REDWOOD
SEQUOIA
VINE
MOUNTAIN VIEW
VIEW
TARRYBROOKE
PIONEER
FRONTIER
FERN HILL
OLD HWY 47
DILLEY
MARTIN
MARSH
VISITATION
HEESACKER
MCKIBBIN
PORTER
CORNELIUS SCHEFFLIN
LONG
366TH
DAVIS
47
Figure 7-1: Capital Improvement Program Project Locations
city of forest grove
HDR

Appendix A

Copy of City of Forest Grove Code Related to Water Utility Operations

FOREST GROVE CODE

TABLE OF CONTENTS

CHAPTER 3 PUBLIC IMPROVEMENTS

SECTION	DESCRIPTION	PAGE
WATER SYSTEM DEVELOPMENT CHARGES		
3.801	Purpose	20
3.802	Scope	20
3.803	Definitions	20
3.804	Method of Establishing System Development Charge	20
3.805	Authorized Expenditures	21
3.806	Expenditure Restrictions	21
3.807	Improvement Plan	21
3.808	Collection of Charge	21-22
3.809	Segregation and Use of Revenue	22
3.810	Administrative Review Procedure	22
3.811	Prohibited Connection	22
3.812	Construction	22

WATER CONNECTION CHARGES

3.800 **Water Connection Charges.**

(1) Each applicant for a new connection to the water system shall pay to the City a sum to cover the cost of the connection, including the meter, meter box, fittings and labor, as fixed by the Council by resolution. Title to all of the property installed by the City for the water connection and metering shall remain in the City.

(2) Each applicant for a fire service connection to the water system shall pay to the City Manager a connection fee. The amount charged for the connection shall be fixed by the Council by resolution.

(3) The connection shall not be made until the charges have been fully paid in advance.

(4) Charges in this Section are not covered by the annual fee adjustment. (Ord. 1991-09, 09/09/91; Ord. 1994-01, 02/14/94))

WATER SYSTEM DEVELOPMENT CHARGES

3.801 Purpose.

The purpose of the system development charge (SDC) is to impose a portion of the cost of capital improvements for water storage, transmission, treatment and distribution upon hose customers of the City who create the need for or increase the demands on capital improvements by connection to the water system. (Ord. 1994-01, 02/14/94)

3.802 Scope.

The SDC imposed by this Ordinance is separate from and in addition to any applicable tax, assessment, charge or fee otherwise provided by law or imposed as a condition of development or based upon the ownership of property.

3.803 Definitions.

As used in Sections 3.801 – 3.812, the following words and terms mean as follows:

Capital Improvements. Facilities or assets used for water storage, transmission, treatment and distribution.

Improvement Fee. A fee defined by ORS 223.299(2) for costs associated with capital improvements to be constructed after the date the fee is adopted.

Reimbursement Fee. A fee defined by ORS 223.299(3) for costs associated with capital improvements constructed or under construction on the date the fee is adopted.

System Development Charge. A reimbursement fee, an improvement fee or a combination thereof assessed or collected at the time of increased usage or connection to the system. “System development charge” includes that portion of a system connection charge that is greater than the amount necessary to reimburse the City for its average cost of inspecting and installing connections to the water system. “System development charge” does not include fees assessed or collected as part of a local improvement district or a charge in lieu of a local improvement district assessment or the costs of complying with requirements or conditions imposed by a land use decision.

3.804 Method of Establishing System Development Charge.

System development charge shall be established or revised by resolution.

3.805 **Authorized Expenditures.**

(a) Reimbursement fees shall be applied only to capital improvements for the City's water system including expenditures relating to repayment of indebtedness.

(b) Improvement fees.

(1) Improvement fees shall be spent only on capacity increasing capital improvements, including expenditures relating to repayment of future debt for the improvements. An increase in system capacity occurs if a capital improvement increases the level of performance or service provided by existing facilities or provided new facilities. The portion of the improvements funded by improvement fees must be related to demands created by development.

(2) A capital improvement being funded wholly or in part from revenues derived from the improvement fee shall be included in the plan adopted by the City pursuant to Section 3.807.

(c) Notwithstanding subsections (a) and (b) of this section, SDC revenue may be expended on the direct costs of complying with the provisions of this Ordinance; including the costs of developing SDC methodologies and providing an annual accounting of SDC expenditures.

3.806 **Expenditure Restrictions.**

(a) SDC shall not be expended for costs associated with the construction of administrative office facilities that are more than an incidental part of other capital improvements.

(b) SDC shall not be expended for costs of the operation or routine maintenance of capital improvements.

3.807 **Improvement Plan.**

The City shall adopt a plan that:

(a) Lists the capital improvements that may be funded with improvement fee revenues;

(b) Lists the estimated cost and time of construction of each improvement;

(c) Describes the process for modifying the plan.

3.808 **Collection of Charge.**

(a) The SDC is payable upon issuance of a permit to connect to the water system.

(b) If connection is made to the water system without an appropriate permit, the SDC is immediately payable upon the earliest date that a permit was required.

(c) The City Manager shall collect the applicable SDC from the

applicant prior to issuance of a permit that allows connection to the water system.
(d) The City Manager shall not allow a connection to the water system until the charge has been paid in full.

3.809 **Segregation and Use of Revenue.**
(a) All funds derived from the SDC shall be segregated by accounting practices from all other funds of the City. The SDC shall be used for no purpose other than those set forth in Section 3.805 of this Ordinance.
(b) The City Manager shall provide the City of Forest Grove with an annual accounting, based on the City's fiscal year, showing the total amount of SDC revenues collected for each type of facility and the projects funded from each account.

3.810 **Administrative Review Procedure.**
(a) Any customer or other interested person aggrieved by a decision made by the City Manager under this Ordinance relating to the expenditure of SDC revenues, may appeal the decision or the expenditure to the City Council by filing a written request with the City Manager describing with particularity the decision of the City Manager or the expenditure from which the person appeals.
(b) An appeal of an expenditure must be filed within two years of the date of the alleged improper expenditure. Appeals of any other decision must be filed within ten (10) days of the date of the decision.
(c) The City Council shall determine whether the City Manager's decision or the expenditure is in accordance with this Ordinance and the provisions of ORS 223.249 to 223.314, inclusive, and may affirm, modify or overrule the decisions. If the City Council determines that there has been an improper expenditure of SDC revenues, the City Council shall direct that a sum equal to the misspent amount shall be deposited within one year to the credit of the account or fund from which it was spent.
(d) A legal action challenging the methodology adopted by the City shall not be filed later than 60 days after the adoption of the SDC.

3.811 **Prohibited Connection.**
No person, firm or corporation shall connect to the water system of the City unless the SDC has been paid.

3.812 **Construction.**
The rules of statutory construction contained in ORS Chapter 174 are adopted and by this reference made a part of this Ordinance.

FOREST GROVE CODE

TABLE OF CONTENTS

CHAPTER 4 UTILITIES

SECTION	DESCRIPTION	PAGE
WATER REGULATIONS		
4.005	Restricting Sprinkling	1
4.010	Water System Control	1
4.015	Water Meters	1
4.020	Meter Installation Record	1
4.025	Service Pipes; Meters	1-2
4.035	Water Rates	2
4.040	Delinquent Accounts	2
4.045	Abandonment of Service	2
4.050	Inspection; Shutoff	3
4.055	Water Main Installation and Connections	3
WATER SUPPLY CROSS CONNECTION CONTROL POLICY		
4.100	Purpose and Scope	4
4.105	Responsibility	4
4.110	Definitions	4-8
4.115	Requirements	8-12
4.120	Cross-Connection Inspections	12-13
4.125	Backflow Preventer Testing Program	13-14
4.130	Liability	14
4.135	Penalties	14

CHAPTER 4

UTILITIES

WATER REGULATIONS

4.005 **Restricting Sprinkling.**
(1) The City Manager may, by giving written notice to the water consumer or by advertising for one issue in a newspaper published in the City, restrict the hours for sprinkling or discontinue sprinkling altogether for as long as the City Manager deems necessary, when there is a scarcity of water.
(2) No person shall use water contrary to the terms of notice issued in compliance with subsection (1).

4.010 **Water System Control.**
The Council shall have absolute control and supervision of the municipal water system and may, from time to time, promulgate rules and regulations and employ help as it deems necessary for the management and operation of the system.

4.015 **Water Meters.**
No person shall take water from the municipal water system other than for municipal purposes or to extinguish fires except through the water meters.

4.020 **Meter Installation Record.**
A record of all installations of water meters shall be maintained, including the name of the consumer, the location of the property, and the date of the installation. This record shall be filed with the recorder of the City.

4.025 **Service Pipes; Meters.**
(1) The City shall place service pipes from the most accessible main to the point most convenient for furnishing water to the consumer. The City shall supply service pipes with meters and meter boxes, which shall be under the control, and remain the property, of the City.
(2) Installation of water meters shall be made by the City, and the size of the meter to be installed shall be determined by the City Engineer.

3) All water consumers shall at their own expense connect with the outlet provided with an approved service pipe, including stop and waste valve of approved quality. The connecting pipe for residences shall not be less than three-quarters of an inch in diameter. The service pipes shall be placed not less than 12 inches underground and shall be kept in good repair.
(4) No person shall be allowed to connect or attach or reconnect any pipe to the City mains or service pipes or make any alteration in any pipe or pipes so connected without authority from the Council or its authorized agent.
(5) Where water service is available from the City and one or more other agencies within the corporate limits of the City, applicants desiring water service shall connect to the City of Forest Grove water system unless waived by the City Manager.

4.035 **Water Rates.**
(1) All consumers of water shall pay for the service and water at reasonable rates fixed by the Council by resolution.
(2) Rates in this Section are not covered by the annual fee adjustment.

4.040 **Delinquent Accounts.**
(1) All charges for water furnished by the City shall be due and payable within 15 days after the date of the bill. If not so paid, they shall become delinquent and service may be disconnected. Any consumer whose service has been disconnected shall not be reinstated until the full amount of the delinquent water bill has been paid. In addition, the consumer shall pay a fee to be fixed by the Council by resolution for reinstatement and service connection.
(2) All unpaid water charges shall be a lien in favor of the City upon each lot or parcel of land or other property served and shall be collected as other liens of the City are enforced.

4.045 **Abandonment of Service.**
If charges for water furnished by the City are delinquent for a period of 12 months or if water service has been discontinued for a period of 12 months without payment of the fee required for discontinuance of service, the service shall be deemed abandoned and the water meter removed by the City. Thereafter, reconnection of water service shall be at the then-prevailing rate for water service connection.

4.050 **Inspection; Shutoff.**
All buildings in which City water is used shall be subject to reasonable inspection. In case of accident, or for the purpose of making repairs or extensions to the water system, water may be cut off without notice to the consumer and the City shall not be liable for the damages on account of the water being cut off.

4.055 **Water Main Installation and Connections.**
(1) If the City Engineer determines, in order to serve additional areas beyond a given subdivision, that the size of the water main to be installed should be greater than is necessary to serve the subdivision or parcel of real property, the City shall be responsible for the additional cost. The cost shall be ascertained by computing the cost of installation of water mains required to serve the area and determining the cost of installation of the larger-size main required. The difference in cost shall be paid by the City.
(2) All water main installations shall be in accordance with prevailing City standards and specifications.
(3) Water services supplied by an agency other than the City of Forest Grove within the city limits of Forest Grove may be connected to the Forest Grove water system at no charge for service of equal size. If a larger service is requested or required, a credit shall be allowed in an amount equal to the fee for connection of the existing service.
(4) Applicants desiring water service for property that did not participate in the financing of the water main serving such property shall pay a water main construction fee in amount to be fixed by the Council by resolution. This fee shall be in addition to the water connection charge specified in Section 4.030. This fee is not covered by the annual fee adjustment.
(5) No connections to City water lines shall be allowed outside the corporate limits of the City.

WATER SUPPLY CROSS CONNECTION CONTROL POLICY

4.100 **Purpose and Scope.**

The purpose of Code Sections 4.100 to 4.135 is:

(1) To protect the public potable water supply of Forest Grove from the possibility of contamination or pollution by isolating within the customer's internal distribution system(s) or the consumer's private water system(s) such contaminants or pollutants that could backflow into the public water systems;

(2) To promote the elimination or control of existing cross connections, actual or potential, between the consumer's in-plant potable water system(s) and nonpotable water system(s), plumbing fixtures and industrial piping systems; and

(3) To provide for the maintenance of a continuing program of cross connection control which will systematically and effectively prevent the contamination of pollution of all potable water systems.

4.105 **Responsibility.**

The Director of Public Works shall be responsible for the protection of the public potable water distribution system from contamination or pollution due to the backflow of contaminants or pollutants through the water service connection. If, in the judgment of the Public Works Director, an approved backflow prevention assembly is required at the customer's water service connection or within the customer's private water system for the safety of the water system, the Director or designee shall give written notice to the customer to install approved backflow prevention assembly(s) at specific location(s) on the customer's premises. The customer shall immediately install the approved assembly(s) at the customer's own expense. Failure, refusal, or inability on the part of the customer to install, have tested and maintain the assembly(s) shall be grounds for discontinuing water service to the premises until the requirements have been satisfactorily met.

4.110 **Definitions**.

As the purposes of Sections 4.100 to 4.135, the following words and terms mean as follows:

Approved. Accepted by the Director and/or Oregon State Health Division applicable specifications stated or cited in this ordinance, or as suitable for the proposed use.

Auxiliary water supply. Any water supply on or available to the premises other than the water purveyor's approved public water supply will be considered an auxiliary water supply. These auxiliary waters may include water from another purveyor's public potable water supply, or any natural source, such as a well, spring, river, stream, etc., or "used waters" or "industrial fluids." These waters may be contaminated or polluted or they may be objectionable and constitute an unacceptable water source over which the water purveyor does not have sanitary control.

Backflow. The reversal of the normal flow of water caused by either backpressure or backsiphonage.

Backflow preventer. An assembly or means designed to prevent backflow.

(1) Air-gap. The unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet supplying water to a tank, plumbing, fixture, or other device and the flood level rim of said vessel. An approved air-gap shall be at least double the diameter of the supply pipe, measured vertically, above the overflow rim of the vessel; and in no case less than one inch.

(2) Reduced pressure principle assembly. An assembly of two independently acting, approved check valves together with a hydraulically operating, mechanically independent differential pressure relief valve, located between the check valves and at the same time below the first check valve. The unit shall include properly located test cocks and tightly closing shut-off valves at each end of the assembly. The entire assembly shall meet the design and performance specifications as determined by a laboratory and a field evaluation program resulting in an approval by a recognized and Oregon State Health Division-approved testing agency for backflow prevention assemblies. The assembly shall operate to maintain the pressure in the zone between the two check valves at an acceptable level less than the pressure between the pressure on the public water supply side of the assembly. At cessation of a normal flow, the pressure between the two check valves shall be less than the pressure on the public water supply side of the device. In case of leakage of either of the check valves, the differential relief valve shall operate to maintain the reduced pressure in the zone between the check valves by discharging to the atmosphere. When the inlet pressure is two pounds per square inch or less, the relief valve shall open to the

atmosphere. To be approved, these assemblies must be readily accessible for in-line testing and maintenance and be installed in a location where no part of the assembly will be submerged.

(3) Double check valve assembly. An assembly of two independently operating, approved check valves with tightly closing shut-off valves on each end of the check valves, plus properly located test cocks for the testing of each check valve. The entire assembly shall meet design and performance specifications as determined by a laboratory and a field evaluation program resulting in an approval by a recognized and State Health Division-approved testing agency for backflow prevention assemblies. To be approved, these assemblies must be readily accessible for in-line testing and maintenance.

Backpressure. The flow of water or other liquids, mixtures, or substances, under pressure, into the distribution pipes of a potable water supply system from any source other than the intended source.

Backsiphonage. The flow of water or other liquids, mixtures, or substances into the distribution pipes of a potable water supply system from any source other than the intended source.

Contamination. An impairment of the quality of the potable water by sewage, industrial fluids, or waste fluids, compounds or other materials, to a degree which creates an actual or potential hazard to public health through poisoning or through the spread of disease.

Cross Connection. Any actual or potential physical connection or arrangement of piping or fixtures between two otherwise separate piping systems, one of which contains potable water and the other nonpotable water, or industrial fluids of questionable safety, through which, or because of which, backflow may occur into the potable water system. This would include any temporary connections, such as swing connections, removable Sections, four-way plug valves, spools, dummy Sections of pipe, swivels or change-over devices or sliding multi-port tubes.

Cross-Connection-Controlled. A connection between a potable water system and a nonpotable water system with an approved backflow prevention assembly properly installed and maintained so that it will continuously afford the protection commensurate with the degree of hazard.

Cross-Connection Control by Containment. The installation of an approved backflow prevention assembly at the water service connection to any customer's premises where it is not physically and economically feasible to find and permanently eliminate or control all

actual or potential cross connections within the customer's water system; or, it shall mean the installation of an approved backflow prevention assembly on the service line leading to and supplying a portion of the customer's water system where there are actual or potential cross connections which cannot be effectively eliminated or controlled at the point of the cross connection.

Director of Public Works or "Director". The Director is authorized and is responsible for implementation of an effective cross-connection control program and for the enforcement of the provisions of this Code.

Hazard, Degree of. The term is derived from an evaluation of the potential risk to public health and the adverse effect of the hazard upon the potable water system.

(1) Hazard, health. Any condition, device, or practice in the water system and its operation which could, in the judgment of the Director, create a danger to the health and well-being of the water consumer.

(2) Hazard, plumbing. A plumbing type cross connection in a consumer's potable water system that has not been properly protected by an approved air-gap or approved backflow prevention assembly.

(3) Hazard, pollutional. An actual or potential threat to the physical properties of the water system or to the potability of the public or the consumer's water system that would constitute a nuisance, be aesthetically objectionable, or could cause damage to the system or its appurtenances, but would not be dangerous to health.

(4) Hazard, system. An actual or potential threat of severe physical damage to the public potable water system or the consumer's potable water system or of a pollution or contamination which would have a protracted effect on the quality of the potable water in the system.

Industrial Fluids System. Any system containing a fluid or solution which may be chemically, biologically, or otherwise contaminated or polluted in a form or concentration that would constitute a health, system, pollutional or plumbing hazard if introduced into an approved water supply. This may include, but not be limited to: polluted or contaminated waters; all types of process waters and "used waters" originating from the public potable water system which may have deteriorated in sanitary quality; chemicals in fluid form; plating acids and alkalines; circulating cooling waters connected to an open cooling tower and/or towers that are chemically or biologically treated or

stabilized with toxic substances; contaminated natural waters such as from wells, springs, streams, rivers, irrigation canals, or systems, etc.; oils, gases, glycerine, paraffins, caustic and acid solutions and other liquid and gaseous fluids used in industrial or other purposes or for fire-fighting purposes.

Pollution. The presence of any foreign substance (organic, inorganic, or biological) in water which tends to degrade its quality so as to constitute a hazard or impair the usefulness or quality of the water to a degree which does not create an actual hazard to the public health but which does adversely and unreasonably affect such waters for domestic use.

Water, nonpotable. Water that is not safe for human consumption or is of questionable potability.

Water, potable. Water that, according to recognized standards, is safe for human consumption.

Water, service connection. The terminal end of a service connection from the public potable water system; i.e., where the water purveyor loses jurisdiction and sanitary control over the water at its point of delivery to the customer's water system. If a meter is installed at the end of the service connection, then the service connection shall mean the downstream end of the meter. There should be no unprotected takeoffs from the service line ahead of any meter or any backflow prevention assembly located at the point of delivery to the customer's water system. Service connection shall also include water service connection from a fire hydrant and all other temporary or emergency water service connections from the public potable water system.

Water, used. Any water supplied by a water purveyor from a public potable water system to a consumer's water system after it has passed through the point of delivery and is no longer under the sanitary control of the water purveyor.

4.115 Requirements.

(1) Water system:

(A) The water system shall be considered to be composed of two parts: the utility system and the customer system.

(B) The utility system shall consist of the source facilities and the distribution system and shall include all facilities of the water system that are under the complete control of the utility, up to the point where the customer's system begins.

(C) The source shall include all components of the facilities utilized in the production, treatment, storage, and delivery of water to the distribution system.

(D) The distribution system shall include the network of conduits used for the delivery of water from the source to the customer's system.

(E) The customer's system shall include those parts of the facilities beyond the termination of the utility distribution system that are utilized in conveying utility-delivered water to points of use.

(2) Policy:

(A) No water service connection to any premises shall be installed or maintained by the water purveyor unless the water supply is protected as required by state laws and regulations and this ordinance. Service of water to any premises shall be discontinued by the Director/Water Surveyor if:

(1) a backflow prevention assembly required by this ordinance is not installed, tested and maintained; or

(2) it is found that a backflow prevention assembly has been removed or by-passed; or

(3) an unprotected cross connection exists on the premises.

Service will not be restored until such conditions are corrected.

(B) An approved backflow prevention assembly shall be installed on each domestic, fire, or irrigation service line to a customer's water system at or near the property line or immediately inside the building being served; but, in all cases, before the first branch line leading off the service line wherever the following conditions exist:

(1) When premises have an auxiliary water supply that is not or may not be of safe bacteriological or chemical quality and is not acceptable as an additional source by the Director, the public water system shall be protected against backflow by installing an approved backflow prevention assembly in the service line(s) appropriate to the degree of hazard.

(2) When industrial fluids or other objectionable substances are handled in a manner that creates an actual or potential hazard to the public water system, the public
system shall be protected against backflow by installing an approved backflow prevention assembly in the service line appropriate to the degree of hazard. This shall include the handling of process waters and waters originating from the utility system that have been subject to deterioration in quality.

(3) When premises have (a) internal cross connection(s) that cannot be permanently corrected or controlled; or (b) intricate plumbing and piping

arrangements; or (c) where entry to all parts of the premises is not readily accessible for inspection, making it impracticable or impossible to ascertain whether or not dangerous cross connections exist, the public water system shall be protected against backflow by installing an approved backflow prevention assembly in the service line.

(C) The type of protective assembly required under subsection (2)(B) of this Section shall meet all Oregon State Health Division standards in addition to the requirements of this Code. The type of protective devices required will depend on the existing degree of hazard, as follows:

(1) On premises where there is an auxiliary water supply as stated in subsection (2)(B)(1) of this Section and it is not subject to any of the following rules, the public water system shall be protected by an approved air-gap separation or an approved reduced pressure principle backflow prevention assembly.

(2) On premises where there is water or substance that would be objectionable, but not hazardous to health, if introduced into the public water system, the public water system shall be protected by an approved double check valve assembly.

(3) On premises where there is any material dangerous to health that is handled in a manner that creates an actual or potential hazard to the public water system, the public water system shall be protected by an approved air-gap separation or an approved reduced pressure principle backflow prevention assembly. Examples of premises where these conditions will exist include sewage treatment plants, sewage pumping stations, chemical manufacturing plants, hospitals, mortuaries, and plating plants.

(4) On premises where there are "uncontrolled" cross connections, either actual or potential, the public water system shall be protected by an approved air-gap separation or an approved reduced pressure principle backflow prevention assembly at the service connection.

(5) On premises where, because of security requirements or other prohibitions or restrictions, it is impossible or impractical to make a complete in-plant cross-connection survey, the public water system shall be protected against backflow from the premises by

either an approved air-gap separation or an approved reduced pressure principle backflow prevention assembly on each service to the premises.

(D) Any backflow prevention assembly required by this Code shall be a model and size approved by the Director and the State Health Division. The term "Approved Backflow Prevention Assembly" shall mean an assembly that has been manufactured in full conformance with the standards established by the American Water Works Association (A.W.W.A.) entitled:

AWWA C506-84 Standards for Reduced Pressure Principle and Double Check Valve Backflow Prevention Devices, or latest revision; and, have met completely the laboratory and field performance specifications of the Foundation of Cross-Connection and Hydraulic Research (F.C.C.C. & H.R.) of the University of Southern California established by specifications of backflow prevention assemblies - Section 10 of the most current issue of the "Manual of Cross-Connection Control."

The A.W.W.A. and F.C.C.C. & H.R. standards and specifications have been adopted by the State of Oregon Health Division and are hereby adopted by the City of Forest Grove.

(E) Customers or users at premises where back-flow prevention assemblies are installed shall have certified inspections and operational tests made at least once per year. The Director may require certified inspections at more frequent intervals. These inspections and tests shall be at the expense of the water user and shall be performed by the assembly manufacturer's representative, water department personnel, or by a certified tester approved by the State Health Division. The Director shall ensure that these tests are made in a timely manner. The customer or user shall notify the Director in advance when the tests are to be undertaken so that an official representative may witness the tests if so desired. These assemblies shall be repaired, overhauled or replaced at the expense of the customer or user whenever such assemblies are found to be defective. Records of tests, repairs, and overhauls shall be kept and copies given to the Director.

(F) All presently installed backflow prevention assemblies that do not meet the requirements of this Section but were approved at the time of installation and have been properly maintained, shall, except for the inspection and maintenance requirements under subsection (2)(E) of this Section, be excluded form the requirements of these rules so long as the Director is assured that they will satisfactorily protect the utility system. Whenever the existing device is moved from the present location or requires more than minimum maintenance, or when the Director finds that the maintenance constitutes a hazard to health, the unit shall be replaced by an approved backflow prevention assembly meeting the requirements of this Section.
(G) The Director may specify the location and methods of installation of all backflow prevention devices.
(H) Any installation, corrective measure, disconnection, or other change to a backflow prevention device shall be at the sole expense of the owner or water customer. The cost of any change required in the City's system outside the property (i.e., between the meter and the supply line) and any charges for cut-off or disconnection shall be added to the charges against the premises that necessitated the expenditures.
(I) Any person operating any mobile apparatus that uses the City water system or water from any premises within the City must provide for backflow prevention. These provisions are stated in subsections (2)(C), (2)(D), (2)(E), and (2)(G) of this Code.

4.120 **Cross-Connection Inspections.**
(A) No water shall be delivered to any structure hereafter built within the City or within areas served by City water until the structure has been inspected by the City for possible cross connections and has been approved as being free of cross connections.
(B) The customer's system shall be open for inspection at all reasonable times to authorized representatives of the City to determine whether cross connections or other structural or sanitary hazards, including violations of these regulations, exist. When such conditions become know, the Director shall deny or immediately discontinue service to the premises by provided for a physical break in the service line until the customer has corrected the condition in conformance with State and City laws relating to plumbing and water supplies. All inspections as stipulated in this Section shall be made by and at the expense of the City.

(C) In accordance with Section 4.050 of the code, authorized employees of the City shall have free access at proper hours of the day, to all parts of buildings or premises for the purpose of inspecting the condition of the pipes, fixtures, and other appurtenances, and the manner in which the water is being used.
(D) If access to the premises is refused, the City shall discontinue water service to the premises.

4.125 **Backflow Preventer Testing Program.**
(A) Any backflow prevention device that may be required by the City or the state to be installed on property for the protection of the water supply shall be tested at the time of installation and, anytime the device is moved or relocated, immediately after relocation or moving. The property owner must forward the results of such testing to the City Department of Community Development within ten days of the date of installation or relocation.
(B) The property owner must order and cause to be performed, a test of each backflow prevention device annually, or within 30 days after the anniversary date of the initial testing. The City may require more frequent testing in order to assure that the device is properly functioning in those installations which present a serious health hazard as determined by the City.
(C) If the Department of Community Development has not received the results of the test within 30 days of the anniversary date for annual testing or within 10 days of the date of the device, or the date of City's discovery that the device was installed without testing as applicable, the City may order the test and add the cost of the test onto the property owner's water bill.
(D) If the results of the test ordered by the City or the property owner indicate that repairs are necessary, the repairs must be made and a new test made and results of the test forwarded the City Department of Community Development within ten days of the date of the first test. If the Office of Community Development has not received evidence of the repairs and the results of the second test within ten days of the first test, the City may have the repairs made and second test made and add the cost to the property owner's water bill.
This Section applies to all tests and repairs until the tests show the backflow preventer device is functioning properly.
(E) The City, in accordance with Sections 4.105 and 4.115(2)(A), may discontinue the water service of any person who refused or fails to pay for testing or repair, and have the charges added to the customer's water bill.

(F) All tests required to be performed under this Section must be performed by a tester certified by the state.

4.130 Liability.

Sections 4.100 to 4.135 of this Code shall not be construed to hold the City responsible for any damage to persons or property by reason of inspection or testing, or the failure to inspect or test.

4.135 Penalties.

(A) A person who fails to install or provide for the testing of a backflow prevention device or who violates any provision of Sections 4.100 to 4.135 of this Code, or who fails to comply with an order thereunder, shall severally for each violation and noncompliance be guilty of a code violation. The imposition of one penalty for a violation shall not excuse the violation or permit it to continue. In addition, each day the violation continues constitutes a separate violation.

(B) Any person who is in violation of Sections 4.100 to 4.135 of this Code shall be required to correct or remedy such violation or defect. The application of the above penalty shall not prevent the enforced removal of prohibited conditions; and, in addition to other remedies, the City may file an action to enforce this ordinance. (Ord. 1986-07, 06/23/87)

Appendix B

Spreadsheet Tables of the Population Forecast

City of Forest Grove - Water Master Plan Update (2010)
Summary of Population Forecast Results

	Scenario A - Low Growth	Scenario B - Medium Growth	Scenario C - High Growth
2010	21,680	21,680	21,788
2011	21,789	21,897	22,115
2012	22,006	22,225	22,557
2013	22,227	22,670	23,008
2014	22,560	23,123	23,468
2015	22,898	23,586	23,938
2016	23,356	24,071	24,430
2017	23,823	24,552	24,918
2018	24,300	25,042	25,416
2019	24,786	25,543	25,924
2020	25,282	26,054	26,442
2021	25,787	26,834	27,310
2022	26,303	27,366	27,932
2023	26,829	27,921	28,581
2024	27,366	28,473	29,232
2025	27,913	29,193	30,054
2026	28,471	29,749	30,716
2027	29,041	30,336	31,413
2028	29,621	30,934	32,125
2029	30,214	31,544	32,854
2030	30,818	32,010	33,444
2031	31,435	33,048	34,614
2032	31,906	33,794	35,499
2033	32,385	34,558	36,407
2034	32,870	35,345	37,344
2035	33,363	36,145	38,300
2036	33,864	37,294	39,611
2037	34,372	38,138	40,625
2038	34,887	38,994	41,657
2039	35,411	39,869	42,716
2040	35,942	40,765	43,803
2041	36,481	41,290	45,060
2042	36,846	42,206	46,183
2043	37,214	43,166	47,357
2044	37,586	44,147	48,561
2045	37,962	45,151	49,797
2046	38,342	46,177	51,064
2047	38,725	47,228	52,365
2048	39,113	48,303	53,700
2049	39,504	49,402	55,069
2050	39,899	50,540	56,487

Scenario A - Population Forecast - City of Forest Grove Water Master Plan Update (2010)

Year	Growth Rate	Population	Effective Dwelling Units	Increase in Effective Dwelling Units	Assumed persons per dwelling	Actual Dwelling Units	"density"	
2006		*20,380*	7,838		2.6	7384	2.760	
2007	*1.9%*	*20,775*	7,990	152		7655	2.714	
2008	*3.3%*	*21,465*	8,256	265		7800	2.752	
2009	0.5%	21,572	8,297	41				
2010	0.5%	21,680	8,339	41				
2011	0.5%	21,789	8,380	42				
2012	1.0%	22,006	8,464	84				
2013	1.0%	22,227	8,549	85				
2014	1.5%	22,560	8,677	128				
2015	1.5%	22,898	8,807	130				
2016	2.0%	23,356	8,983	176				
2017	2.0%	23,823	9,163	180				
2018	2.0%	24,300	9,346	183				
2019	2.0%	24,786	9,533	187				
2020	2.0%	25,282	9,724	191				
2021	2.0%	25,787	9,918	194				
2022	2.0%	26,303	10,117	198				
2023	2.0%	26,829	10,319	202				
2024	2.0%	27,366	10,525	206				
2025	2.0%	27,913	10,736	211				
2026	2.0%	28,471	10,950	215				
2027	2.0%	29,041	11,169	219				
2028	2.0%	29,621	11,393	223				
2029	2.0%	30,214	11,621	228				
2030	2.0%	30,818	11,853	232	As build-out population is reached, the growth slows to 1.5% for 5 years and further slows to 1% through the planning per			
2031	2.0%	***31,435***	12,090	237				
2032	1.5%	31,906	12,272	181				
2033	1.5%	32,385	12,456	184				
2034	1.5%	32,870	12,642	187				
2035	1.5%	33,363	12,832	190				
2036	1.5%	33,864	13,025	192				
2037	1.5%	34,372	13,220	195				
2038	1.5%	34,887	13,418	198				
2039	1.5%	35,411	13,620	201				
2040	1.5%	35,942	13,824	204				
2041	1.5%	36,481	14,031	207				
2042	1.0%	36,846	14,171	140				
2043	1.0%	37,214	14,313	142				
2044	1.0%	37,586	14,456	143				
2045	1.0%	37,962	14,601	145				
2046	1.0%	38,342	14,747	146				
2047	1.0%	38,725	14,894	147				
2048	1.0%	39,113	15,043	149				
2049	1.0%	39,504	15,194	150				
2050	1.0%	39,899	15,346	152				
Total Increase		**18,434**	**7,090**					

Scenario B - Population Forecast - City of Forest Grove Water Master Plan Update (2010)

Residential Dwellings

	Town Center	Oak St. - E	Oak. St - W	Cedar Node	Quince/Pacific	Pacific Corridor	Purdin Rd.	David Hill	Yearly Total	Total Dwelling Increase	Population Growth (2.6 per dwelling)	Minimum growth rate (w/o redevelopment and URA)	Population at baseline growth rate (w/o redevelopment and URA)	Scenario B Population (Land Absorption-Based)	Effective growth rate	Effective Dwelling Units	Increase in Effective Dwelling Units	Assumed persons per dwelling	
											2.6								
2008													*21,465*	*21,465*		7,800		2.6	
2009									0	0	0	0.5%	21,572	21,572	0.50%	8,297	497		
2010									**0**	**0**	**0**	0.5%	21,680	21,680	0.50%	8,339	41		Slightly quicker increase in growth than Scenario A in early years to EOA 2% mid-scenario
2011									0	0	0	1.0%	21,897	21,897	1.00%	8,422	83		
2012									0	0	0	1.5%	22,225	22,225	1.50%	8,548	126		
2013									0	0	0	2.0%	22,670	22,670	2.00%	8,719	171		Baseline growth rate applies through planning period until Purdin Rd and David Hill Areas "open"
2014									0	0	0	2.0%	23,123	23,123	2.00%	8,894	174		
2015									0	0	0	2.0%	23,586	23,586	2.00%	9,071	178		
2016	5								5	5	13	2.0%	24,058	24,071	2.06%	9,258	186		
2017	**5**								**5**	**10**	**13**	2.0%	24,539	24,552	2.00%	9,443	185		
2018	5								5	15	13	2.0%	25,029	25,042	2.00%	9,632	189		
2019	5								5	20	13	2.0%	25,530	25,543	2.00%	9,824	193		
2020	5								5	25	13	2.0%	26,041	26,054	2.00%	10,021	196		
2021	15	10	40	30	10				105	130	273	2.0%	26,561	26,834	3.00%	10,321	300		
2022	15	10	40	30	10				105	235	273	2.0%	27,093	27,366	1.98%	10,525	204		
2023	15	10	40	35	10				110	345	286	2.0%	27,635	27,921	2.03%	10,739	213		
2024	15	10	40	35	10				110	455	286	2.0%	28,187	28,473	1.98%	10,951	213		
2025	15	10	40	35	10	60			170	625	442	2.0%	28,751	29,193	2.53%	11,228	277		
2026	15	10	60	18		60			163	788	423	2.0%	29,326	29,749	1.90%	11,442	214		
2027	15	10	60	18		60			163	951	423	2.0%	29,913	30,336	1.97%	11,668	226		
2028	15	10	60	18		60			163	1114	423	2.0%	30,511	30,934	1.97%	11,898	230		
2029	15	10	60	18		60			163	1277	423	2.0%	31,121	31,544	1.97%	12,132	235		
2030	**15**	**10**	60	**18**					**103**	**1380**	**267**	2.0%	31,743	32,010	1.48%	12,312	179		
2031	15	50	60	18			78		221	1601	574	2.3%	32,474	33,048	3.24%	12,711	399		Increase in growth to 2.3% medium growth rate once the Purdin Rd and David Hill areas "open"
2032	15	50	60	18			78		221	1822	574	2.3%	33,220	33,794	2.26%	12,998	287		
2033	15	50	60	18			78		221	2043	574	2.3%	33,984	34,558	2.26%	13,292	294		
2034	15	50	60	18			80		223	2266	579	2.3%	34,766	35,345	2.28%	13,594	303		
2035	15	50	60	18			80		223	2489	579	2.3%	35,566	36,145	2.26%	13,902	308		
2036	15	50	60				80	145	350	2839	910	2.3%	36,384	37,294	3.18%	14,344	442		
2037	15	50	60				80	148	353	3192	917	2.3%	37,221	38,138	2.26%	14,668	325		
2038	15	50	60				80	148	353	3545	917	2.3%	38,077	38,994	2.24%	14,998	329		
2039	15	50	60				80	148	353	3898	917	2.3%	38,952	39,869	2.25%	15,334	337		
2040	15	50	60				80	148	353	4251	917	2.3%	39,848	40,765	2.25%	15,679	345		
2041	12	75	95					20	202	4453	525	2.3%	40,765	41,290	1.29%	15,881	202		
2042	12	75	87					20	194	4647	504	2.3%	41,702	42,206	2.22%	16,233	353		
2043	12	75	87					20	194	4841	504	2.3%	42,662	43,166	2.27%	16,602	369		
2044	12	75	87					20	194	5035	504	2.3%	43,643	44,147	2.27%	16,980	377		
2045	12	75	87					20	194	5229	504	2.3%	44,647	45,151	2.27%	17,366	386		
2046	12	75	87					20	194	5423	504	2.3%	45,673	46,177	2.27%	17,761	395		
2047	12	75	87					20	194	5617	504	2.3%	46,724	47,228	2.27%	18,165	404		
2048	12	75	87					20	194	5811	504	2.3%	47,799	48,303	2.28%	18,578	413		
2049	12	75	87					20	194	6005	504	2.3%	48,898	49,402	2.28%	19,001	423		
2050	**17**	**75**	87					**20**	**199**	**6204**	**517**	2.3%	50,023	50,540	2.30%	19,438	438		
											Total Increase		28,558	29,075		11,638			

Scenario C - Population Forecast - City of Forest Grove Water Master Plan Update (2010)

Year	Growth Rate	Scenario C Baseline Population	Scenario B Land Absorption rate	North Area Concept	Scenario C Total Population	Dwelling Units	"density"		
2006		*20,380*				7384	2.760		
2007	*1.9%*	*20,775*				7655	2.714	2.742	
2008	*3.3%*	*21,465*				7800	2.752		
2009	0.5%	21,572	0		21,572	7,868			
2010	1.0%	21,788	0		21,788	7,946			Quicker increase in growth rate than Scenarios A or B to EOA mid-scenario of 2%
2011	1.5%	22,115	0		22,115	8,065			
2012	2.0%	22,557	0		22,557	8,227			
2013	2.0%	23,008	0		23,008	8,391			
2014	2.0%	23,468	0		23,468	8,559			
2015	2.0%	23,938	0		23,938	8,730			
2016	2.0%	24,417	13		24,430	8,905			
2017	2.0%	24,905	13		24,918	9,083			
2018	2.0%	25,403	13		25,416	9,265			
2019	2.0%	25,911	13		25,924	9,450			
2020	2.0%	26,429	13		26,442	9,639			
2021	2.3%	27,037	273		27,310	9,861			Growth rate increases to 2.3% medium growth scenario once major redevelopment occurs within city
2022	2.3%	27,659	273		27,932	10,087			
2023	2.3%	28,295	286		28,581	10,319			
2024	2.3%	28,946	286		29,232	10,557			
2025	2.3%	29,612	442		30,054	10,800			
2026	2.3%	30,293	423		30,716	11,048			
2027	2.3%	30,990	423		31,413	11,302			
2028	2.3%	31,702	423		32,125	11,562			
2029	2.3%	32,431	423		32,854	11,828			
2030	2.3%	33,177	267		33,444	12,100			
2031	2.6%	34,040	574		34,614	12,415			Increase in growth to EOA assumpion of 2.6% once the Purdin Rd and David Hill areas "open"
2032	2.6%	34,925	574		35,499	12,737			
2033	2.6%	35,833	574		36,407	13,068			
2034	2.6%	36,765	579		37,344	13,408			
2035	2.6%	37,721	579		38,300	13,757			
2036	2.6%	38,701	910		39,611	14,115			
2037	2.6%	39,708	917		40,625	14,482			
2038	2.6%	40,740	917		41,657	14,858			
2039	2.6%	41,799	917		42,716	15,244			
2040	2.6%	42,886	917		43,803	15,641			
2041	2.6%	44,001	525	534	45,060	16,047			
2042	2.6%	45,145	504	534	46,183	16,465			
2043	2.6%	46,319	504	534	47,357	16,893			
2044	2.6%	47,523	504	534	48,561	17,332			
2045	2.6%	48,759	504	534	49,797	17,782			
2046	2.6%	50,026	504	534	51,064	18,245			
2047	2.6%	51,327	504	534	52,365	18,719			
2048	2.6%	52,662	504	534	53,700	19,206			
2049	2.6%	54,031	504	534	55,069	19,705			
2050	2.6%	55,436	517	534	56,487	20,218	Dwelling increase =	12,418	

Appendix C

Spreadsheet Tables of Water Demand Forecast

Scenario A - Water Demand Forecast City of Forest Grove Water Master Plan Update (2010)

			(see Scenario A Population Worksheet)		*Ratio of SF:Total Res.* *72%*					*Ratio of SF:Total Res.* *80%*	
	Per capita water use (gpd)	Residential conservation savings	Total Population	*Total Residential ADD (mgd)*	Single Family ADD (mgd)	Multi-Family ADD (mgd)	MDD Peaking Factor	MDD Conservation Factor	*Total Residential MDD (mgd)*	Single Family MDD (mgd)	Multi-Family MDD (mgd)
2009	75	0.50%	21,572	***1.610***	1.159	0.451	2.08	0.50%	***3.332***	2.665	0.666
2010	75	0.50%	21,680	***1.618***	1.165	0.453	2.08	0.50%	***3.348***	2.679	0.670
2011	75	0.50%	21,789	***1.626***	1.171	0.455	2.08	0.50%	***3.365***	2.692	0.673
2012	75	0.50%	22,006	***1.642***	1.182	0.460	2.08	0.50%	***3.399***	2.719	0.680
2013	75	0.50%	22,227	***1.659***	1.194	0.464	2.08	0.50%	***3.433***	2.746	0.687
2014	75	0.50%	22,560	***1.684***	1.212	0.471	2.08	0.50%	***3.484***	2.787	0.697
2015	75	1.00%	22,898	***1.700***	1.224	0.476	2.08	1.00%	***3.501***	2.801	0.700
2016	75	1.00%	23,356	***1.734***	1.249	0.486	2.08	1.00%	***3.571***	2.857	0.714
2017	75	1.00%	23,823	***1.769***	1.274	0.495	2.08	1.00%	***3.642***	2.914	0.728
2018	75	1.00%	24,300	***1.804***	1.299	0.505	2.08	1.00%	***3.715***	2.972	0.743
2019	75	1.00%	24,786	***1.840***	1.325	0.515	2.08	1.00%	***3.790***	3.032	0.758
2020	75	1.00%	25,282	***1.877***	1.352	0.526	2.08	1.00%	***3.865***	3.092	0.773
2021	75	1.50%	25,787	***1.905***	1.372	0.533	2.08	1.50%	***3.903***	3.122	0.781
2022	75	1.50%	26,303	***1.943***	1.399	0.544	2.08	1.50%	***3.981***	3.185	0.796
2023	75	1.50%	26,829	***1.982***	1.427	0.555	2.08	1.50%	***4.061***	3.249	0.812
2024	75	1.50%	27,366	***2.022***	1.456	0.566	2.08	1.50%	***4.142***	3.314	0.828
2025	75	1.50%	27,913	***2.062***	1.485	0.577	2.08	1.50%	***4.225***	3.380	0.845
2026	75	1.50%	28,471	***2.103***	1.514	0.589	2.08	1.50%	***4.309***	3.447	0.862
2027	75	1.50%	29,041	***2.145***	1.545	0.601	2.08	1.50%	***4.395***	3.516	0.879
2028	75	1.50%	29,621	***2.188***	1.576	0.613	2.08	1.50%	***4.483***	3.587	0.897
2029	75	1.50%	30,214	***2.232***	1.607	0.625	2.08	1.50%	***4.573***	3.658	0.915
2030	75	1.50%	30,818	***2.277***	1.639	0.637	2.08	1.50%	***4.664***	3.732	0.933
2031	75	2.00%	31,435	***2.310***	1.664	0.647	2.08	2.00%	***4.710***	3.768	0.942
2032	75	2.00%	31,906	***2.345***	1.688	0.657	2.08	2.00%	***4.780***	3.824	0.956
2033	75	2.00%	32,385	***2.380***	1.714	0.666	2.08	2.00%	***4.852***	3.882	0.970
2034	75	2.00%	32,870	***2.416***	1.740	0.676	2.08	2.00%	***4.925***	3.940	0.985
2035	75	2.00%	33,363	***2.452***	1.766	0.687	2.08	2.00%	***4.999***	3.999	1.000
2036	75	2.00%	33,864	***2.489***	1.792	0.697	2.08	2.00%	***5.074***	4.059	1.015
2037	75	2.00%	34,372	***2.526***	1.819	0.707	2.08	2.00%	***5.150***	4.120	1.030
2038	75	2.00%	34,887	***2.564***	1.846	0.718	2.08	2.00%	***5.227***	4.182	1.045
2039	75	2.00%	35,411	***2.603***	1.874	0.729	2.08	2.00%	***5.305***	4.244	1.061
2040	75	2.00%	35,942	***2.642***	1.902	0.740	2.08	2.00%	***5.385***	4.308	1.077
2041	75	2.50%	36,481	***2.668***	1.921	0.747	2.08	2.50%	***5.410***	4.328	1.082
2042	75	2.50%	36,846	***2.694***	1.940	0.754	2.08	2.50%	***5.464***	4.371	1.093
2043	75	2.50%	37,214	***2.721***	1.959	0.762	2.08	2.50%	***5.519***	4.415	1.104
2044	75	2.50%	37,586	***2.749***	1.979	0.770	2.08	2.50%	***5.574***	4.459	1.115
2045	75	2.50%	37,962	***2.776***	1.999	0.777	2.08	2.50%	***5.630***	4.504	1.126
2046	75	2.50%	38,342	***2.804***	2.019	0.785	2.08	2.50%	***5.686***	4.549	1.137
2047	75	2.50%	38,725	***2.832***	2.039	0.793	2.08	2.50%	***5.743***	4.594	1.149
2048	75	2.50%	39,113	***2.860***	2.059	0.801	2.08	2.50%	***5.800***	4.640	1.160
2049	75	2.50%	39,504	***2.889***	2.080	0.809	2.08	2.50%	***5.858***	4.687	1.172
2050	75	2.50%	39,899	***2.918***	2.101	0.817	2.08	2.50%	***5.917***	4.734	1.183

	Commercial Per acre water use	Industrial Per acre water use	C/I conservation savings	Existing Commercial Acres	Existing Industrial Acres	Redevelopment Comm. Acres	Purdin Rd. URA Comm. Acres	David Hill URA Comm. Acres	Redevelopment Ind. Acres	Purdin Rd. URA Ind. Acres
2009	1,600	650	0.25%	210	146	0	0	0	0	0
2010	1,600	650	0.25%	210	146	0	0	0	0	0
2011	1,600	650	0.25%	210	146	0	0	0	0	0
2012	1,600	650	0.25%	210	146	0	0	0	0	0
2013	1,600	650	0.25%	210	146	0	0	0	0	0
2014	1,600	650	0.25%	210	146	0	0	0	0	0
2015	1,600	650	0.50%	210	146	0	0	0	0	0
2016	1,600	650	0.50%	210	146	0	0	0	0	0
2017	1,600	650	0.50%	210	146	0	0	0	0	0
2018	1,600	650	0.50%	210	146	0	0	0	0	0
2019	1,600	650	0.50%	210	146	0	0	0	0	0
2020	1,600	650	0.50%	210	146	0	0	0	0	0
2021	1,600	650	0.75%	210	146	0	0	0	0	0
2022	1,600	650	0.75%	210	146	0	0	0	0	0
2023	1,600	650	0.75%	210	146	0	0	0	0	0
2024	1,600	650	0.75%	210	146	0	0	0	0	0
2025	1,600	650	0.75%	210	146	0	0	0	0	0
2026	1,600	650	0.75%	210	146	0	0	0	0	0
2027	1,600	650	0.75%	210	146	0	0	0	0	0
2028	1,600	650	0.75%	210	146	0	0	0	0	0
2029	1,600	650	0.75%	210	146	0	0	0	0	0
2030	1,600	650	0.75%	210	146	0	0	0	0	0
2031	1,600	650	1.00%	210	146	0	0	0	0	0
2032	1,600	650	1.00%	210	146	0	0	0	0	0
2033	1,600	650	1.00%	210	146	0	0	0	0	0
2034	1,600	650	1.00%	210	146	0	0	0	0	0
2035	1,600	650	1.00%	210	146	0	0	0	0	0
2036	1,600	650	1.00%	210	146	0	0	0	0	0
2037	1,600	650	1.00%	210	146	0	0	0	0	0
2038	1,600	650	1.00%	210	146	0	0	0	0	0
2039	1,600	650	1.00%	210	146	0	0	0	0	0
2040	1,600	650	1.00%	210	146	0	0	0	0	0
2041	1,600	650	1.25%	210	146	0	0	0	0	0
2042	1,600	650	1.25%	210	146	0	0	0	0	0
2043	1,600	650	1.25%	210	146	0	0	0	0	0
2044	1,600	650	1.25%	210	146	0	0	0	0	0
2045	1,600	650	1.25%	210	146	0	0	0	0	0
2046	1,600	650	1.25%	210	146	0	0	0	0	0
2047	1,600	650	1.25%	210	146	0	0	0	0	0
2048	1,600	650	1.25%	210	146	0	0	0	0	0
2049	1,600	650	1.25%	210	146	0	0	0	0	0
2050	1,600	650	1.25%	210	146	0	0	0	0	0

Scenario A - Water Demand Forecast Table

David Hill URA Ind. Acres	Total Comm. Acres	Total Ind. Acres	Current Large Commercial (mgd)	Current Large Industrial (mgd)	Large Industrial Reserve (mgd)	Total Comm. ADD (mgd)	Total Ind. ADD (mgd)	*Total C/I ADD (mgd)*	MDD Peaking Factor	MDD Conservation Factor	*Total C/I MDD (mgd)*		Per acre water use	City conservation savings	Existing City Acres	Redevelopment City Acres	Purdin Rd. URA City Acres	David Hill URA City Acres	Total City Acres	*Total City ADD (mgd)*	MDD Peaking factor	MDD Conservation Factor
0	210	146	0.062	0.407	0	0.335	0.095	***0.90***	1.5	0%	***1.348***	2009	310	0.50%	500	0	0	0	500	***0.154***	2	0.50%
0	210	146	0.062	0.407	0	0.335	0.095	***0.90***	1.5	0%	***1.348***	**2010**	310	0.50%	500	0	0	0	500	***0.154***	2	0.50%
0	210	146	0.062	0.407	0	0.335	0.095	***0.90***	1.5	0%	***1.348***	2011	310	0.50%	500	0	0	0	500	***0.154***	2	0.50%
0	210	146	0.062	0.407	0	0.335	0.095	***0.90***	1.5	0%	***1.348***	2012	310	0.50%	500	0	0	0	500	***0.154***	2	0.50%
0	210	146	0.062	0.407	0	0.335	0.095	***0.90***	1.5	0%	***1.348***	2013	310	0.50%	500	0	0	0	500	***0.154***	2	0.50%
0	210	146	0.062	0.407	0	0.335	0.095	***0.90***	1.5	0%	***1.348***	2014	310	0.50%	500	0	0	0	500	***0.154***	2	0.50%
0	210	146	0.062	0.407	0.25	0.334	0.094	***1.15***	1.5	0%	***1.722***	2015	310	1.00%	500	0	0	0	500	***0.153***	2	1.00%
0	210	146	0.062	0.407	0.25	0.334	0.094	***1.15***	1.5	0%	***1.722***	2016	310	1.00%	500	0	0	0	500	***0.153***	2	1.00%
0	210	146	0.062	0.407	0.25	0.334	0.094	***1.15***	1.5	0%	***1.722***	**2017**	310	1.00%	500	0	0	0	500	***0.153***	2	1.00%
0	210	146	0.062	0.407	0.25	0.334	0.094	***1.15***	1.5	0%	***1.722***	2018	310	1.00%	500	0	0	0	500	***0.153***	2	1.00%
0	210	146	0.062	0.407	0.25	0.334	0.094	***1.15***	1.5	0%	***1.722***	2019	310	1.00%	500	0	0	0	500	***0.153***	2	1.00%
0	210	146	0.062	0.407	0.25	0.334	0.094	***1.15***	1.5	0%	***1.722***	2020	310	1.00%	500	0	0	0	500	***0.153***	2	1.00%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.720***	2021	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.720***	2022	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.720***	2023	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.720***	2024	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.720***	2025	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.720***	2026	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.720***	2027	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.720***	2028	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.720***	2029	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.720***	**2030**	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.718***	2031	310	2.00%	500	0	0	0	500	***0.152***	2	2.00%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.718***	2032	310	2.00%	500	0	0	0	500	***0.152***	2	2.00%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.718***	2033	310	2.00%	500	0	0	0	500	***0.152***	2	2.00%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.718***	2034	310	2.00%	500	0	0	0	500	***0.152***	2	2.00%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.718***	2035	310	2.00%	500	0	0	0	500	***0.152***	2	2.00%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.718***	2036	310	2.00%	500	0	0	0	500	***0.152***	2	2.00%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.718***	2037	310	2.00%	500	0	0	0	500	***0.152***	2	2.00%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.718***	2038	310	2.00%	500	0	0	0	500	***0.152***	2	2.00%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.718***	2039	310	2.00%	500	0	0	0	500	***0.152***	2	2.00%
0	210	146	0.062	0.407	0.25	0.333	0.094	***1.15***	1.5	0%	***1.718***	2040	310	2.00%	500	0	0	0	500	***0.152***	2	2.00%
0	210	146	0.062	0.407	0.25	0.332	0.094	***1.14***	1.5	0%	***1.717***	2041	310	2.50%	500	0	0	0	500	***0.151***	2	2.50%
0	210	146	0.062	0.407	0.25	0.332	0.094	***1.14***	1.5	0%	***1.717***	2042	310	2.50%	500	0	0	0	500	***0.151***	2	2.50%
0	210	146	0.062	0.407	0.25	0.332	0.094	***1.14***	1.5	0%	***1.717***	2043	310	2.50%	500	0	0	0	500	***0.151***	2	2.50%
0	210	146	0.062	0.407	0.25	0.332	0.094	***1.14***	1.5	0%	***1.717***	2044	310	2.50%	500	0	0	0	500	***0.151***	2	2.50%
0	210	146	0.062	0.407	0.25	0.332	0.094	***1.14***	1.5	0%	***1.717***	2045	310	2.50%	500	0	0	0	500	***0.151***	2	2.50%
0	210	146	0.062	0.407	0.25	0.332	0.094	***1.14***	1.5	0%	***1.717***	2046	310	2.50%	500	0	0	0	500	***0.151***	2	2.50%
0	210	146	0.062	0.407	0.25	0.332	0.094	***1.14***	1.5	0%	***1.717***	2047	310	2.50%	500	0	0	0	500	***0.151***	2	2.50%
0	210	146	0.062	0.407	0.25	0.332	0.094	***1.14***	1.5	0%	***1.717***	2048	310	2.50%	500	0	0	0	500	***0.151***	2	2.50%
0	210	146	0.062	0.407	0.25	0.332	0.094	***1.14***	1.5	0%	***1.717***	2049	310	2.50%	500	0	0	0	500	***0.151***	2	2.50%
0	210	146	0.062	0.407	0.25	0.332	0.094	***1.14***	1.5	0%	***1.717***	**2050**	310	2.50%	500	0	0	0	500	***0.151***	2	2.50%

Scenario A - Water Demand Forecast Table

Total City MDD (mgd)		Per acre water use	School conservation savings	Existing School Acres	Redevelopment School Acres	Purdin Rd. URA School Acres	David Hill URA School Acres	Total School Acres	*Total School ADD (mgd)*	MDD Peaking Factor	MDD Conservation Factor	*Total School MDD (mgd)*
0.307	2009	310	0.50%	500	0	0	0	500	***0.1542***	2	0.50%	***0.3069***
0.307	**2010**	310	0.50%	500	0	0	0	500	***0.1542***	2	0.50%	***0.3069***
0.307	2011	310	0.50%	500	0	0	0	500	***0.1542***	2	0.50%	***0.3069***
0.307	2012	310	0.50%	500	0	0	0	500	***0.1542***	2	0.50%	***0.3069***
0.307	2013	310	0.50%	500	0	0	0	500	***0.1542***	2	0.50%	***0.3069***
0.307	2014	310	0.50%	500	0	0	0	500	***0.1542***	2	0.50%	***0.3069***
0.304	2015	310	1.00%	500	0	0	0	500	***0.1535***	2	1.00%	***0.3038***
0.304	2016	310	1.00%	500	0	0	0	500	***0.1535***	2	1.00%	***0.3038***
0.304	**2017**	310	1.00%	500	0	0	0	500	***0.1535***	2	1.00%	***0.3038***
0.304	2018	310	1.00%	500	0	0	0	500	***0.1535***	2	1.00%	***0.3038***
0.304	2019	310	1.00%	500	0	0	0	500	***0.1535***	2	1.00%	***0.3038***
0.304	2020	310	1.00%	500	0	0	0	500	***0.1535***	2	1.00%	***0.3038***
0.301	2021	310	1.50%	500	0	0	0	500	***0.1527***	2	1.50%	***0.3008***
0.301	2022	310	1.50%	500	0	0	0	500	***0.1527***	2	1.50%	***0.3008***
0.301	2023	310	1.50%	500	0	0	0	500	***0.1527***	2	1.50%	***0.3008***
0.301	2024	310	1.50%	500	0	0	0	500	***0.1527***	2	1.50%	***0.3008***
0.301	2025	310	1.50%	500	0	0	0	500	***0.1527***	2	1.50%	***0.3008***
0.301	2026	310	1.50%	500	0	0	0	500	***0.1527***	2	1.50%	***0.3008***
0.301	2027	310	1.50%	500	0	0	0	500	***0.1527***	2	1.50%	***0.3008***
0.301	2028	310	1.50%	500	0	0	0	500	***0.1527***	2	1.50%	***0.3008***
0.301	2029	310	1.50%	500	0	0	0	500	***0.1527***	2	1.50%	***0.3008***
0.301	**2030**	310	1.50%	500	0	0	0	500	***0.1527***	2	1.50%	***0.3008***
0.298	2031	310	2.00%	500	0	0	0	500	***0.1519***	2	2.00%	***0.2977***
0.298	2032	310	2.00%	500	0	0	0	500	***0.1519***	2	2.00%	***0.2977***
0.298	2033	310	2.00%	500	0	0	0	500	***0.1519***	2	2.00%	***0.2977***
0.298	2034	310	2.00%	500	0	0	0	500	***0.1519***	2	2.00%	***0.2977***
0.298	2035	310	2.00%	500	0	0	0	500	***0.1519***	2	2.00%	***0.2977***
0.298	2036	310	2.00%	500	0	0	0	500	***0.1519***	2	2.00%	***0.2977***
0.298	2037	310	2.00%	500	0	0	0	500	***0.1519***	2	2.00%	***0.2977***
0.298	2038	310	2.00%	500	0	0	0	500	***0.1519***	2	2.00%	***0.2977***
0.298	2039	310	2.00%	500	0	0	0	500	***0.1519***	2	2.00%	***0.2977***
0.298	2040	310	2.00%	500	0	0	0	500	***0.1519***	2	2.00%	***0.2977***
0.295	2041	310	2.50%	500	0	0	0	500	***0.1511***	2	2.50%	***0.2947***
0.295	2042	310	2.50%	500	0	0	0	500	***0.1511***	2	2.50%	***0.2947***
0.295	2043	310	2.50%	500	0	0	0	500	***0.1511***	2	2.50%	***0.2947***
0.295	2044	310	2.50%	500	0	0	0	500	***0.1511***	2	2.50%	***0.2947***
0.295	2045	310	2.50%	500	0	0	0	500	***0.1511***	2	2.50%	***0.2947***
0.295	2046	310	2.50%	500	0	0	0	500	***0.1511***	2	2.50%	***0.2947***
0.295	2047	310	2.50%	500	0	0	0	500	***0.1511***	2	2.50%	***0.2947***
0.295	2048	310	2.50%	500	0	0	0	500	***0.1511***	2	2.50%	***0.2947***
0.295	2049	310	2.50%	500	0	0	0	500	***0.1511***	2	2.50%	***0.2947***
0.295	**2050**	310	2.50%	500	0	0	0	500	***0.1511***	2	2.50%	***0.2947***

			12%	12%		
	Total Consumptive ADD (mgd)	Total Consumptive MDD (mgd)	Unaccounted-for-Water ADD	Unaccounted-for-Water MDD	*Total ADD*	*Total MDD*
2009	2.817	5.294	0.384	0.722	***3.201***	***6.016***
2010	2.825	5.310	0.385	0.724	***3.210***	***6.035***
2011	2.833	5.327	0.386	0.726	***3.220***	***6.054***
2012	2.850	5.361	0.389	0.731	***3.238***	***6.092***
2013	2.866	5.395	0.391	0.736	***3.257***	***6.130***
2014	2.891	5.446	0.394	0.743	***3.285***	***6.189***
2015	3.155	5.830	0.430	0.795	***3.585***	***6.625***
2016	3.189	5.900	0.435	0.805	***3.624***	***6.705***
2017	3.224	5.972	0.440	0.814	***3.663***	***6.786***
2018	3.259	6.045	0.444	0.824	***3.703***	***6.869***
2019	3.295	6.119	0.449	0.834	***3.744***	***6.953***
2020	3.332	6.195	0.454	0.845	***3.786***	***7.039***
2021	3.357	6.225	0.458	0.849	***3.815***	***7.073***
2022	3.395	6.303	0.463	0.859	***3.858***	***7.162***
2023	3.434	6.382	0.468	0.870	***3.902***	***7.253***
2024	3.474	6.463	0.474	0.881	***3.947***	***7.345***
2025	3.514	6.546	0.479	0.893	***3.993***	***7.439***
2026	3.555	6.631	0.485	0.904	***4.040***	***7.535***
2027	3.597	6.717	0.491	0.916	***4.088***	***7.633***
2028	3.640	6.805	0.496	0.928	***4.137***	***7.733***
2029	3.684	6.895	0.502	0.940	***4.186***	***7.835***
2030	3.729	6.986	0.508	0.953	***4.237***	***7.939***
2031	3.760	7.023	0.513	0.958	***4.273***	***7.981***
2032	3.794	7.094	0.517	0.967	***4.312***	***8.061***
2033	3.830	7.166	0.522	0.977	***4.352***	***8.143***
2034	3.865	7.239	0.527	0.987	***4.392***	***8.226***
2035	3.902	7.312	0.532	0.997	***4.434***	***8.310***
2036	3.938	7.387	0.537	1.007	***4.475***	***8.395***
2037	3.976	7.464	0.542	1.018	***4.518***	***8.481***
2038	4.014	7.541	0.547	1.028	***4.561***	***8.569***
2039	4.052	7.619	0.553	1.039	***4.605***	***8.658***
2040	4.091	7.699	0.558	1.050	***4.649***	***8.749***
2041	4.114	7.716	0.561	1.052	***4.675***	***8.768***
2042	4.141	7.770	0.565	1.060	***4.706***	***8.830***
2043	4.168	7.825	0.568	1.067	***4.736***	***8.892***
2044	4.195	7.880	0.572	1.075	***4.767***	***8.955***
2045	4.223	7.936	0.576	1.082	***4.799***	***9.018***
2046	4.251	7.992	0.580	1.090	***4.830***	***9.082***
2047	4.279	8.049	0.583	1.098	***4.862***	***9.147***
2048	4.307	8.106	0.587	1.105	***4.894***	***9.212***
2049	4.335	8.164	0.591	1.113	***4.927***	***9.278***
2050	4.364	8.223	0.595	1.121	***4.960***	***9.344***

Scenario B - Water Demand Forecast City of Forest Grove Water Master Plan Update (2010)

			(see Scenario B Population Worksheet)		*Ratio of SF:Total Res.* *72%*					*Ratio of SF:Total Res.* *80%*	
	Per capita water use (gpd)	**Residential conservation savings**	**Total Population**	***Total Residential ADD (mgd)***	**Single Family ADD (mgd)**	**Multi-Family ADD (mgd)**	**MDD Peaking Factor**	**MDD Conservation Factor**	***Total Residential MDD (mgd)***	**Single Family MDD (mgd)**	**Multi-Family MDD (mgd)**
2009	75	0.50%	21,572	***1.610***	1.159	0.451	2.08	0.50%	***3.332***	2.665	0.666
2010	75	0.50%	21,680	***1.618***	1.165	0.453	2.08	0.50%	***3.348***	2.679	0.670
2011	75	0.50%	21,897	***1.634***	1.177	0.458	2.08	0.50%	***3.382***	2.705	0.676
2012	75	0.50%	22,225	***1.659***	1.194	0.464	2.08	0.50%	***3.433***	2.746	0.687
2013	75	0.50%	22,670	***1.692***	1.218	0.474	2.08	0.50%	***3.501***	2.801	0.700
2014	75	0.50%	23,123	***1.726***	1.242	0.483	2.08	0.50%	***3.571***	2.857	0.714
2015	75	1.00%	23,586	***1.751***	1.261	0.490	2.08	1.00%	***3.606***	2.885	0.721
2016	75	1.00%	24,071	***1.787***	1.287	0.500	2.08	1.00%	***3.680***	2.944	0.736
2017	75	1.00%	24,552	***1.823***	1.313	0.510	2.08	1.00%	***3.754***	3.003	0.751
2018	75	1.00%	25,042	***1.859***	1.339	0.521	2.08	1.00%	***3.829***	3.063	0.766
2019	75	1.00%	25,543	***1.897***	1.366	0.531	2.08	1.00%	***3.905***	3.124	0.781
2020	75	1.00%	26,054	***1.934***	1.393	0.542	2.08	1.00%	***3.983***	3.187	0.797
2021	75	1.50%	26,834	***1.982***	1.427	0.555	2.08	1.50%	***4.062***	3.249	0.812
2022	75	1.50%	27,366	***2.022***	1.456	0.566	2.08	1.50%	***4.142***	3.314	0.828
2023	75	1.50%	27,921	***2.063***	1.485	0.578	2.08	1.50%	***4.226***	3.381	0.845
2024	75	1.50%	28,473	***2.103***	1.514	0.589	2.08	1.50%	***4.310***	3.448	0.862
2025	75	1.50%	29,193	***2.157***	1.553	0.604	2.08	1.50%	***4.419***	3.535	0.884
2026	75	1.50%	29,749	***2.198***	1.582	0.615	2.08	1.50%	***4.503***	3.602	0.901
2027	75	1.50%	30,336	***2.241***	1.614	0.627	2.08	1.50%	***4.591***	3.673	0.918
2028	75	1.50%	30,934	***2.285***	1.645	0.640	2.08	1.50%	***4.682***	3.746	0.936
2029	75	1.50%	31,544	***2.330***	1.678	0.652	2.08	1.50%	***4.774***	3.819	0.955
2030	75	1.50%	32,010	***2.365***	1.703	0.662	2.08	1.50%	***4.845***	3.876	0.969
2031	75	2.00%	33,048	***2.429***	1.749	0.680	2.08	2.00%	***4.951***	3.961	0.990
2032	75	2.00%	33,794	***2.484***	1.788	0.695	2.08	2.00%	***5.063***	4.051	1.013
2033	75	2.00%	34,558	***2.540***	1.829	0.711	2.08	2.00%	***5.178***	4.142	1.036
2034	75	2.00%	35,345	***2.598***	1.870	0.727	2.08	2.00%	***5.295***	4.236	1.059
2035	75	2.00%	36,145	***2.657***	1.913	0.744	2.08	2.00%	***5.415***	4.332	1.083
2036	75	2.00%	37,294	***2.741***	1.974	0.768	2.08	2.00%	***5.587***	4.470	1.117
2037	75	2.00%	38,138	***2.803***	2.018	0.785	2.08	2.00%	***5.714***	4.571	1.143
2038	75	2.00%	38,994	***2.866***	2.064	0.802	2.08	2.00%	***5.842***	4.674	1.168
2039	75	2.00%	39,869	***2.930***	2.110	0.821	2.08	2.00%	***5.973***	4.779	1.195
2040	75	2.00%	40,765	***2.996***	2.157	0.839	2.08	2.00%	***6.108***	4.886	1.222
2041	75	2.50%	41,290	***3.019***	2.174	0.845	2.08	2.50%	***6.123***	4.899	1.225
2042	75	2.50%	42,206	***3.086***	2.222	0.864	2.08	2.50%	***6.259***	5.007	1.252
2043	75	2.50%	43,166	***3.156***	2.273	0.884	2.08	2.50%	***6.401***	5.121	1.280
2044	75	2.50%	44,147	***3.228***	2.324	0.904	2.08	2.50%	***6.547***	5.237	1.309
2045	75	2.50%	45,151	***3.302***	2.377	0.924	2.08	2.50%	***6.696***	5.357	1.339
2046	75	2.50%	46,177	***3.377***	2.431	0.945	2.08	2.50%	***6.848***	5.478	1.370
2047	75	2.50%	47,228	***3.454***	2.487	0.967	2.08	2.50%	***7.004***	5.603	1.401
2048	75	2.50%	48,303	***3.532***	2.543	0.989	2.08	2.50%	***7.163***	5.731	1.433
2049	75	2.50%	49,402	***3.613***	2.601	1.012	2.08	2.50%	***7.326***	5.861	1.465
2050	75	2.50%	50,540	***3.696***	2.661	1.035	2.08	2.50%	***7.495***	5.996	1.499

	Commercial Per acre water use	**Industrial Per acre water use**	**C/I conservation savings**	**Existing Commercial Acres**	**Existing Industrial Acres**	**Redevelopment Comm. Acres**	**Purdin Rd. URA Comm. Acres**	**David Hill URA Comm. Acres**	**Redevelopment Ind. Acres**	**Purdin Rd. URA Ind. Acres**
2009	1,600	650	0.25%	210	146	0	0	0	0	0
2010	1,600	650	0.25%	210	146	0	0	0	0	0
2011	1,600	650	0.25%	210	146	0	0	0	0	0
2012	1,600	650	0.25%	210	146	0	0	0	0	0
2013	1,600	650	0.25%	210	146	0	0	0	0	0
2014	1,600	650	0.25%	210	146	0	0	0	0	0
2015	1,600	650	0.50%	210	146	0	0	0	0	0
2016	1,600	650	0.50%	210	146	2	0	0	0	0
2017	1,600	650	0.50%	210	146	0	0	0	0	0
2018	1,600	650	0.50%	210	146	0	0	0	0	162
2019	1,600	650	0.50%	210	146	0	0	0	0	0
2020	1,600	650	0.50%	210	146	0	0	0	0	0
2021	1,600	650	0.75%	210	146	5	0	0	0	0
2022	1,600	650	0.75%	210	146	0	0	0	0	0
2023	1,600	650	0.75%	210	146	0	0	0	0	0
2024	1,600	650	0.75%	210	146	0	0	0	0	0
2025	1,600	650	0.75%	210	146	0	0	0	0	0
2026	1,600	650	0.75%	210	146	78	0	0	0	0
2027	1,600	650	0.75%	210	146	0	0	0	0	0
2028	1,600	650	0.75%	210	146	0	0	0	0	0
2029	1,600	650	0.75%	210	146	0	0	0	0	0
2030	1,600	650	0.75%	210	146	0	0	0	0	0
2031	1,600	650	1.00%	210	146	10	49	0	0	0
2032	1,600	650	1.00%	210	146	0	0	0	0	0
2033	1,600	650	1.00%	210	146	0	0	0	0	0
2034	1,600	650	1.00%	210	146	0	0	0	0	0
2035	1,600	650	1.00%	210	146	0	0	0	0	0
2036	1,600	650	1.00%	210	146	0	0	0	0	0
2037	1,600	650	1.00%	210	146	0	0	0	0	0
2038	1,600	650	1.00%	210	146	0	0	0	0	0
2039	1,600	650	1.00%	210	146	0	0	0	0	0
2040	1,600	650	1.00%	210	146	0	0	0	0	0
2041	1,600	650	1.25%	210	146	8	0	8	0	0
2042	1,600	650	1.25%	210	146	0	0	0	0	0
2043	1,600	650	1.25%	210	146	0	0	0	0	0
2044	1,600	650	1.25%	210	146	0	0	0	0	0
2045	1,600	650	1.25%	210	146	0	0	0	0	0
2046	1,600	650	1.25%	210	146	0	0	0	0	0
2047	1,600	650	1.25%	210	146	0	0	0	0	0
2048	1,600	650	1.25%	210	146	0	0	0	0	0
2049	1,600	650	1.25%	210	146	0	0	0	0	0
2050	1,600	650	1.25%	210	146	0	0	0	0	0

Scenario B - Wated Demand Forecast

David Hill URA Ind. Acres	Total Comm. Acres	Total Ind. Acres	Current Large Commercial (mgd)	Current Large Industrial (mgd)	Large Industrial Reserve (mgd)	Total Comm. ADD (mgd)	Total Ind. ADD (mgd)	*Total C/I ADD (mgd)*	MDD Peaking Factor	MDD Conservation Factor	*Total C/I MDD (mgd)*		Per acre water use	City conservation savings	Existing City Acres	Redevelopment City Acres	Purdin Rd. URA City Acres	David Hill URA City Acres	Total City Acres	*Total City ADD (mgd)*	MDD Peaking factor	MDD Conservation Factor
0	210	146	0.062	0.407	0	0.335	0.095	***0.899***	1.5	0%	***1.348***	2009	310	0.50%	500	0	0	0	500	***0.154***	2	0.50%
0	210	146	0.062	0.407	0	0.335	0.095	***0.899***	1.5	0%	***1.348***	**2010**	310	0.50%	500	0	0	0	500	***0.154***	2	0.50%
0	210	146	0.062	0.407	0	0.335	0.095	***0.899***	1.5	0%	***1.348***	2011	310	0.50%	500	0	0	0	500	***0.154***	2	0.50%
0	210	146	0.062	0.407	0	0.335	0.095	***0.899***	1.5	0%	***1.348***	2012	310	0.50%	500	0	0	0	500	***0.154***	2	0.50%
0	210	146	0.062	0.407	0	0.335	0.095	***0.899***	1.5	0%	***1.348***	2013	310	0.50%	500	0	0	0	500	***0.154***	2	0.50%
0	210	146	0.062	0.407	0	0.335	0.095	***0.899***	1.5	0%	***1.348***	2014	310	0.50%	500	0	0	0	500	***0.154***	2	0.50%
0	210	146	0.062	0.407	0.25	0.334	0.094	***1.148***	1.5	0%	***1.722***	2015	310	1.00%	500	0	0	0	500	***0.153***	2	1.00%
0	212	146	0.062	0.407	0.25	0.338	0.094	***1.151***	1.5	0%	***1.726***	2016	310	1.00%	500	0	0	0	500	***0.153***	2	1.00%
0	212	146	0.062	0.407	0.25	0.338	0.094	***1.151***	1.5	0%	***1.726***	**2017**	310	1.00%	500	0	0	0	500	***0.153***	2	1.00%
0	212	308	0.062	0.407	0.25	0.338	0.199	***1.256***	1.5	0%	***1.884***	2018	310	1.00%	500	0	0	0	500	***0.153***	2	1.00%
0	212	308	0.062	0.407	0.25	0.338	0.199	***1.256***	1.5	0%	***1.884***	2019	310	1.00%	500	0	0	0	500	***0.153***	2	1.00%
0	212	308	0.062	0.407	0.25	0.338	0.199	***1.256***	1.5	0%	***1.884***	2020	310	1.00%	500	0	0	0	500	***0.153***	2	1.00%
0	217	308	0.062	0.407	0.25	0.345	0.199	***1.262***	1.5	0%	***1.893***	2021	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	217	308	0.062	0.407	0.25	0.345	0.199	***1.262***	1.5	0%	***1.893***	2022	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	217	308	0.062	0.407	0.25	0.345	0.199	***1.262***	1.5	0%	***1.893***	2023	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	217	308	0.062	0.407	0.25	0.345	0.199	***1.262***	1.5	0%	***1.893***	2024	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	217	308	0.062	0.407	0.25	0.345	0.199	***1.262***	1.5	0%	***1.893***	2025	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	295	308	0.062	0.407	0.25	0.468	0.199	***1.386***	1.5	0%	***2.079***	2026	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	295	308	0.062	0.407	0.25	0.468	0.199	***1.386***	1.5	0%	***2.079***	2027	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	295	308	0.062	0.407	0.25	0.468	0.199	***1.386***	1.5	0%	***2.079***	2028	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	295	308	0.062	0.407	0.25	0.468	0.199	***1.386***	1.5	0%	***2.079***	2029	310	1.50%	500	0	0	0	500	***0.153***	2	1.50%
0	295	308	0.062	0.407	0.25	0.468	0.199	***1.386***	1.5	0%	***2.079***	**2030**	310	1.50%	500	0	96	0	596	***0.182***	2	1.50%
0	354	308	0.062	0.407	0.25	0.561	0.198	***1.478***	1.5	0%	***2.217***	2031	310	2.00%	500	0	0	0	596	***0.181***	2	2.00%
0	354	308	0.062	0.407	0.25	0.561	0.198	***1.478***	1.5	0%	***2.217***	2032	310	2.00%	500	0	0	0	596	***0.181***	2	2.00%
0	354	308	0.062	0.407	0.25	0.561	0.198	***1.478***	1.5	0%	***2.217***	2033	310	2.00%	500	0	0	0	596	***0.181***	2	2.00%
0	354	308	0.062	0.407	0.25	0.561	0.198	***1.478***	1.5	0%	***2.217***	2034	310	2.00%	500	0	0	0	596	***0.181***	2	2.00%
0	354	308	0.062	0.407	0.25	0.561	0.198	***1.478***	1.5	0%	***2.217***	2035	310	2.00%	500	0	0	0	596	***0.181***	2	2.00%
0	354	308	0.062	0.407	0.25	0.561	0.198	***1.478***	1.5	0%	***2.217***	2036	310	2.00%	500	0	0	0	596	***0.181***	2	2.00%
0	354	308	0.062	0.407	0.25	0.561	0.198	***1.478***	1.5	0%	***2.217***	2037	310	2.00%	500	0	0	0	596	***0.181***	2	2.00%
0	354	308	0.062	0.407	0.25	0.561	0.198	***1.478***	1.5	0%	***2.217***	2038	310	2.00%	500	0	0	0	596	***0.181***	2	2.00%
0	354	308	0.062	0.407	0.25	0.561	0.198	***1.478***	1.5	0%	***2.217***	2039	310	2.00%	500	0	0	0	596	***0.181***	2	2.00%
0	354	308	0.062	0.407	0.25	0.561	0.198	***1.478***	1.5	0%	***2.217***	2040	310	2.00%	500	0	0	0	596	***0.181***	2	2.00%
0	370	308	0.062	0.407	0.25	0.585	0.198	***1.501***	1.5	0%	***2.252***	2041	310	2.50%	500	0	0	0	596	***0.180***	2	2.50%
0	370	308	0.062	0.407	0.25	0.585	0.198	***1.501***	1.5	0%	***2.252***	2042	310	2.50%	500	0	0	0	596	***0.180***	2	2.50%
0	370	308	0.062	0.407	0.25	0.585	0.198	***1.501***	1.5	0%	***2.252***	2043	310	2.50%	500	0	0	0	596	***0.180***	2	2.50%
0	370	308	0.062	0.407	0.25	0.585	0.198	***1.501***	1.5	0%	***2.252***	2044	310	2.50%	500	0	0	0	596	***0.180***	2	2.50%
0	370	308	0.062	0.407	0.25	0.585	0.198	***1.501***	1.5	0%	***2.252***	2045	310	2.50%	500	0	0	0	596	***0.180***	2	2.50%
0	370	308	0.062	0.407	0.25	0.585	0.198	***1.501***	1.5	0%	***2.252***	2046	310	2.50%	500	0	0	0	596	***0.180***	2	2.50%
0	370	308	0.062	0.407	0.25	0.585	0.198	***1.501***	1.5	0%	***2.252***	2047	310	2.50%	500	0	0	0	596	***0.180***	2	2.50%
0	370	308	0.062	0.407	0.25	0.585	0.198	***1.501***	1.5	0%	***2.252***	2048	310	2.50%	500	0	0	0	596	***0.180***	2	2.50%
0	370	308	0.062	0.407	0.25	0.585	0.198	***1.501***	1.5	0%	***2.252***	2049	310	2.50%	500	0	0	0	596	***0.180***	2	2.50%
0	370	308	0.062	0.407	0.25	0.585	0.198	***1.501***	1.5	0%	***2.252***	**2050**	310	2.50%	500	0	0	0	596	***0.180***	2	2.50%

Scenario B - Wated Demand Forecast

Total City MDD (mgd)		Per acre water use	School conservation savings	Existing School Acres	Redevelopment School Acres	Purdin Rd. URA School Acres	David Hill URA School Acres	Total School Acres	Total School ADD (mgd)	MDD Peaking Factor	MDD Conservation Factor	Total School MDD (mgd)
0.307	2009	310	0.50%	500	0	0	0	500	0.1542	2	0.50%	0.3069
0.307	2010	310	0.50%	500	0	0	0	500	0.1542	2	0.50%	0.3069
0.307	2011	310	0.50%	500	0	0	0	500	0.1542	2	0.50%	0.3069
0.307	2012	310	0.50%	500	0	0	0	500	0.1542	2	0.50%	0.3069
0.307	2013	310	0.50%	500	0	0	0	500	0.1542	2	0.50%	0.3069
0.307	2014	310	0.50%	500	0	0	0	500	0.1542	2	0.50%	0.3069
0.304	2015	310	1.00%	500	0	0	0	500	0.1535	2	1.00%	0.3038
0.304	2016	310	1.00%	500	0	0	0	500	0.1535	2	1.00%	0.3038
0.304	2017	310	1.00%	500	0	0	0	500	0.1535	2	1.00%	0.3038
0.304	2018	310	1.00%	500	0	0	0	500	0.1535	2	1.00%	0.3038
0.304	2019	310	1.00%	500	0	0	0	500	0.1535	2	1.00%	0.3038
0.304	2020	310	1.00%	500	0	0	0	500	0.1535	2	1.00%	0.3038
0.301	2021	310	1.50%	500	0	0	0	500	0.1527	2	1.50%	0.3008
0.301	2022	310	1.50%	500	0	0	0	500	0.1527	2	1.50%	0.3008
0.301	2023	310	1.50%	500	0	0	0	500	0.1527	2	1.50%	0.3008
0.301	2024	310	1.50%	500	0	0	0	500	0.1527	2	1.50%	0.3008
0.301	2025	310	1.50%	500	0	0	0	500	0.1527	2	1.50%	0.3008
0.301	2026	310	1.50%	500	0	0	0	500	0.1527	2	1.50%	0.3008
0.301	2027	310	1.50%	500	0	0	0	500	0.1527	2	1.50%	0.3008
0.301	2028	310	1.50%	500	0	0	0	500	0.1527	2	1.50%	0.3008
0.301	2029	310	1.50%	500	0	0	0	500	0.1527	2	1.50%	0.3008
0.359	2030	310	1.50%	500	0	1.2	0	501	0.1530	2	1.50%	0.3015
0.355	2031	310	2.00%	500	0	0	0	501	0.1523	2	2.00%	0.2984
0.355	2032	310	2.00%	500	0	0	0	501	0.1523	2	2.00%	0.2984
0.355	2033	310	2.00%	500	0	0	0	501	0.1523	2	2.00%	0.2984
0.355	2034	310	2.00%	500	0	0	0	501	0.1523	2	2.00%	0.2984
0.355	2035	310	2.00%	500	0	0	0	501	0.1523	2	2.00%	0.2984
0.355	2036	310	2.00%	500	0	0	0	501	0.1523	2	2.00%	0.2984
0.355	2037	310	2.00%	500	0	0	0	501	0.1523	2	2.00%	0.2984
0.355	2038	310	2.00%	500	0	0	0	501	0.1523	2	2.00%	0.2984
0.355	2039	310	2.00%	500	0	0	0	501	0.1523	2	2.00%	0.2984
0.355	2040	310	2.00%	500	0	0	0	501	0.1523	2	2.00%	0.2984
0.351	2041	310	2.50%	500	0	0	0	501	0.1515	2	2.50%	0.2954
0.351	2042	310	2.50%	500	0	0	0	501	0.1515	2	2.50%	0.2954
0.351	2043	310	2.50%	500	0	0	0	501	0.1515	2	2.50%	0.2954
0.351	2044	310	2.50%	500	0	0	0	501	0.1515	2	2.50%	0.2954
0.351	2045	310	2.50%	500	0	0	0	501	0.1515	2	2.50%	0.2954
0.351	2046	310	2.50%	500	0	0	0	501	0.1515	2	2.50%	0.2954
0.351	2047	310	2.50%	500	0	0	0	501	0.1515	2	2.50%	0.2954
0.351	2048	310	2.50%	500	0	0	0	501	0.1515	2	2.50%	0.2954
0.351	2049	310	2.50%	500	0	0	0	501	0.1515	2	2.50%	0.2954
0.351	2050	310	2.50%	500	0	0	0	501	0.1515	2	2.50%	0.2954

			12%	12%		
	Total Consumptive ADD (mgd)	Total Consumptive MDD (mgd)	Unaccounted-for-Water ADD	Unaccounted-for-Water MDD	Total ADD	Total MDD
2009	2.817	5.294	0.384	0.722	3.201	6.016
2010	2.825	5.310	0.385	0.724	3.210	6.035
2011	2.841	5.344	0.387	0.729	3.229	6.073
2012	2.866	5.395	0.391	0.736	3.257	6.130
2013	2.899	5.463	0.395	0.745	3.294	6.208
2014	2.933	5.533	0.400	0.755	3.333	6.288
2015	3.206	5.935	0.437	0.809	3.643	6.745
2016	3.245	6.014	0.443	0.820	3.688	6.834
2017	3.281	6.088	0.447	0.830	3.728	6.918
2018	3.422	6.320	0.467	0.862	3.889	7.182
2019	3.459	6.397	0.472	0.872	3.931	7.269
2020	3.497	6.475	0.477	0.883	3.974	7.358
2021	3.550	6.557	0.484	0.894	4.034	7.451
2022	3.589	6.637	0.489	0.905	4.079	7.542
2023	3.630	6.721	0.495	0.916	4.125	7.637
2024	3.671	6.805	0.501	0.928	4.172	7.732
2025	3.724	6.913	0.508	0.943	4.232	7.856
2026	3.889	7.183	0.530	0.980	4.420	8.163
2027	3.933	7.272	0.536	0.992	4.469	8.264
2028	3.977	7.363	0.542	1.004	4.519	8.367
2029	4.022	7.455	0.548	1.017	4.570	8.472
2030	4.086	7.584	0.557	1.034	4.643	8.618
2031	4.240	7.821	0.578	1.067	4.818	8.888
2032	4.295	7.933	0.586	1.082	4.881	9.015
2033	4.351	8.048	0.593	1.097	4.945	9.145
2034	4.409	8.166	0.601	1.114	5.010	9.279
2035	4.468	8.286	0.609	1.130	5.077	9.415
2036	4.552	8.458	0.621	1.153	5.173	9.611
2037	4.614	8.584	0.629	1.171	5.244	9.755
2038	4.677	8.712	0.638	1.188	5.315	9.900
2039	4.742	8.844	0.647	1.206	5.388	10.049
2040	4.808	8.978	0.656	1.224	5.463	10.202
2041	4.852	9.022	0.662	1.230	5.514	10.252
2042	4.919	9.158	0.671	1.249	5.590	10.407
2043	4.989	9.300	0.680	1.268	5.670	10.568
2044	5.061	9.445	0.690	1.288	5.751	10.733
2045	5.135	9.594	0.700	1.308	5.835	10.903
2046	5.210	9.747	0.710	1.329	5.920	11.076
2047	5.286	9.902	0.721	1.350	6.007	11.253
2048	5.365	10.062	0.732	1.372	6.097	11.434
2049	5.445	10.225	0.743	1.394	6.188	11.619
2050	5.529	10.394	0.754	1.417	6.283	11.811

Scenario C - Water Demand Forecast City of Forest Grove Water Master Plan Update (2010)

	Per capita water use (gpd)	Residential conservation savings	Total Population *(see Scenario C Population Worksheet)*	*Total Residential ADD (mgd)*	Single Family ADD (mgd) *Ratio of SF:Total Res. 72%*	Multi-Family ADD (mgd)	MDD Peaking Factor	MDD Conservation Factor	*Total Residential MDD (mgd)*	Single Family MDD (mgd) *Ratio of SF:Total Res. 80%*	Multi-Family MDD (mgd)
2009	75	0.50%	21,572	***1.610***	1.159	0.451	2.08	0.50%	***3.332***	2.665	0.666
2010	75	0.50%	21,788	***1.626***	1.171	0.455	2.08	0.50%	***3.365***	2.692	0.673
2011	75	0.50%	22,115	***1.650***	1.188	0.462	2.08	0.50%	***3.416***	2.732	0.683
2012	75	0.50%	22,557	***1.683***	1.212	0.471	2.08	0.50%	***3.484***	2.787	0.697
2013	75	0.50%	23,008	***1.717***	1.236	0.481	2.08	0.50%	***3.553***	2.843	0.711
2014	75	0.50%	23,468	***1.751***	1.261	0.490	2.08	0.50%	***3.625***	2.900	0.725
2015	75	1.00%	23,938	***1.777***	1.280	0.498	2.08	1.00%	***3.660***	2.928	0.732
2016	75	1.00%	24,430	***1.814***	1.306	0.508	2.08	1.00%	***3.735***	2.988	0.747
2017	75	1.00%	24,918	***1.850***	1.332	0.518	2.08	1.00%	***3.810***	3.048	0.762
2018	75	1.00%	25,416	***1.887***	1.359	0.528	2.08	1.00%	***3.886***	3.109	0.777
2019	75	1.00%	25,924	***1.925***	1.386	0.539	2.08	1.00%	***3.964***	3.171	0.793
2020	75	1.00%	26,442	***1.963***	1.414	0.550	2.08	1.00%	***4.043***	3.234	0.809
2021	75	1.50%	27,310	***2.018***	1.453	0.565	2.08	1.50%	***4.134***	3.307	0.827
2022	75	1.50%	27,932	***2.063***	1.486	0.578	2.08	1.50%	***4.228***	3.382	0.846
2023	75	1.50%	28,581	***2.111***	1.520	0.591	2.08	1.50%	***4.326***	3.461	0.865
2024	75	1.50%	29,232	***2.160***	1.555	0.605	2.08	1.50%	***4.424***	3.540	0.885
2025	75	1.50%	30,054	***2.220***	1.599	0.622	2.08	1.50%	***4.549***	3.639	0.910
2026	75	1.50%	30,716	***2.269***	1.634	0.635	2.08	1.50%	***4.649***	3.719	0.930
2027	75	1.50%	31,413	***2.321***	1.671	0.650	2.08	1.50%	***4.754***	3.804	0.951
2028	75	1.50%	32,125	***2.373***	1.709	0.665	2.08	1.50%	***4.862***	3.890	0.972
2029	75	1.50%	32,854	***2.427***	1.748	0.680	2.08	1.50%	***4.973***	3.978	0.995
2030	75	1.50%	33,444	***2.471***	1.779	0.692	2.08	1.50%	***5.062***	4.050	1.012
2031	75	2.00%	34,614	***2.544***	1.832	0.712	2.08	2.00%	***5.186***	4.149	1.037
2032	75	2.00%	35,499	***2.609***	1.879	0.731	2.08	2.00%	***5.319***	4.255	1.064
2033	75	2.00%	36,407	***2.676***	1.927	0.749	2.08	2.00%	***5.455***	4.364	1.091
2034	75	2.00%	37,344	***2.745***	1.976	0.769	2.08	2.00%	***5.595***	4.476	1.119
2035	75	2.00%	38,300	***2.815***	2.027	0.788	2.08	2.00%	***5.738***	4.591	1.148
2036	75	2.00%	39,611	***2.911***	2.096	0.815	2.08	2.00%	***5.935***	4.748	1.187
2037	75	2.00%	40,625	***2.986***	2.150	0.836	2.08	2.00%	***6.086***	4.869	1.217
2038	75	2.00%	41,657	***3.062***	2.204	0.857	2.08	2.00%	***6.241***	4.993	1.248
2039	75	2.00%	42,716	***3.140***	2.261	0.879	2.08	2.00%	***6.400***	5.120	1.280
2040	75	2.00%	43,803	***3.220***	2.318	0.901	2.08	2.00%	***6.563***	5.250	1.313
2041	75	2.50%	45,060	***3.295***	2.372	0.923	2.08	2.50%	***6.682***	5.346	1.336
2042	75	2.50%	46,183	***3.377***	2.432	0.946	2.08	2.50%	***6.849***	5.479	1.370
2043	75	2.50%	47,357	***3.463***	2.493	0.970	2.08	2.50%	***7.023***	5.618	1.405
2044	75	2.50%	48,561	***3.551***	2.557	0.994	2.08	2.50%	***7.201***	5.761	1.440
2045	75	2.50%	49,797	***3.641***	2.622	1.020	2.08	2.50%	***7.385***	5.908	1.477
2046	75	2.50%	51,064	***3.734***	2.689	1.046	2.08	2.50%	***7.573***	6.058	1.515
2047	75	2.50%	52,365	***3.829***	2.757	1.072	2.08	2.50%	***7.766***	6.212	1.553
2048	75	2.50%	53,700	***3.927***	2.827	1.100	2.08	2.50%	***7.964***	6.371	1.593
2049	75	2.50%	55,069	***4.027***	2.899	1.128	2.08	2.50%	***8.167***	6.533	1.633
2050	75	2.50%	56,487	***4.131***	2.974	1.157	2.08	2.50%	***8.377***	6.701	1.675

	Commercial Per acre water use	Industrial Per acre water use	C/I conservation savings	Existing Commercial Acres	Existing Industrial Acres	Redevelopment Comm. Acres	Purdin Rd. URA Comm. Acres	David Hill URA Comm. Acres	North Area Comm. Acres	Redevelopment Ind. Acres
2009	1,600	650	0.25%	210	146	0	0	0	0	0
2010	1,600	650	0.25%	210	146	0	0	0	0	0
2011	1,600	650	0.25%	210	146	0	0	0	0	0
2012	1,600	650	0.25%	210	146	0	0	0	0	0
2013	1,600	650	0.25%	210	146	0	0	0	0	0
2014	1,600	650	0.25%	210	146	0	0	0	0	0
2015	1,600	650	0.50%	210	146	0	0	0	0	0
2016	1,600	650	0.50%	210	146	2	0	0	0	0
2017	1,600	650	0.50%	210	146	0	0	0	0	0
2018	1,600	650	0.50%	210	146	0	0	0	0	0
2019	1,600	650	0.50%	210	146	0	0	0	0	0
2020	1,600	650	0.50%	210	146	0	0	0	0	0
2021	1,600	650	0.75%	210	146	5	0	0	0	0
2022	1,600	650	0.75%	210	146	0	0	0	0	0
2023	1,600	650	0.75%	210	146	0	0	0	0	0
2024	1,600	650	0.75%	210	146	0	0	0	0	0
2025	1,600	650	0.75%	210	146	0	0	0	0	0
2026	1,600	650	0.75%	210	146	78	0	0	0	0
2027	1,600	650	0.75%	210	146	0	0	0	0	0
2028	1,600	650	0.75%	210	146	0	0	0	0	0
2029	1,600	650	0.75%	210	146	0	0	0	0	0
2030	1,600	650	0.75%	210	146	0	0	0	0	0
2031	1,600	650	1.00%	210	146	10	49	0	0	0
2032	1,600	650	1.00%	210	146	0	0	0	0	0
2033	1,600	650	1.00%	210	146	0	0	0	0	0
2034	1,600	650	1.00%	210	146	0	0	0	0	0
2035	1,600	650	1.00%	210	146	0	0	0	0	0
2036	1,600	650	1.00%	210	146	0	0	0	0	0
2037	1,600	650	1.00%	210	146	0	0	0	0	0
2038	1,600	650	1.00%	210	146	0	0	0	0	0
2039	1,600	650	1.00%	210	146	0	0	0	0	0
2040	1,600	650	1.00%	210	146	0	0	0	0	0
2041	1,600	650	1.25%	210	146	8	0	8	50	0
2042	1,600	650	1.25%	210	146	0	0	0	0	0
2043	1,600	650	1.25%	210	146	0	0	0	0	0
2044	1,600	650	1.25%	210	146	0	0	0	0	0
2045	1,600	650	1.25%	210	146	0	0	0	0	0
2046	1,600	650	1.25%	210	146	0	0	0	50	0
2047	1,600	650	1.25%	210	146	0	0	0	0	0
2048	1,600	650	1.25%	210	146	0	0	0	0	0
2049	1,600	650	1.25%	210	146	0	0	0	0	0
2050	1,600	650	1.25%	210	146	0	0	0	0	0

Scenario C - Water Demand Forecast

Purdin Rd. URA Ind. Acres	David Hill URA Ind. Acres	North Area Ind. Acres	Total Comm. Acres	Total Ind. Acres	Current Large Commercial (mgd)	Current Large Industrial (mgd)	Large Industrial Reserve (mgd)	Total Comm. ADD (mgd)	Total Ind. ADD (mgd)	*Total C/I ADD (mgd)*	MDD Peaking Factor	MDD Conservation Factor	*Total C/I MDD (mgd)*		Per acre water use	City conservation savings	Existing City Acres	Redevelopment City Acres	Purdin Rd. URA City Acres	David Hill URA City Acres	Total City Acres	*Total City ADD (mgd)*
0	0	0	210	146	0.062	0.407	0	0.335	0.095	***0.899***	1.5	0%	***1.348***	2009	310	0.50%	500	0	0	0	500	***0.154***
0	0	0	210	146	0.062	0.407	0	0.335	0.095	***0.899***	1.5	0%	***1.348***	**2010**	310	0.50%	500	0	0	0	500	***0.154***
0	0	0	210	146	0.062	0.407	0	0.335	0.095	***0.899***	1.5	0%	***1.348***	2011	310	0.50%	500	0	0	0	500	***0.154***
0	0	0	210	146	0.062	0.407	0	0.335	0.095	***0.899***	1.5	0%	***1.348***	2012	310	0.50%	500	0	0	0	500	***0.154***
0	0	0	210	146	0.062	0.407	0	0.335	0.095	***0.899***	1.5	0%	***1.348***	2013	310	0.50%	500	0	0	0	500	***0.154***
0	0	0	210	146	0.062	0.407	0	0.335	0.095	***0.899***	1.5	0%	***1.348***	2014	310	0.50%	500	0	0	0	500	***0.154***
0	0	0	210	146	0.062	0.407	0.5	0.334	0.094	***1.398***	1.5	0%	***2.097***	2015	310	1.00%	500	0	0	0	500	***0.153***
0	0	0	212	146	0.062	0.407	0.5	0.338	0.094	***1.401***	1.5	0%	***2.101***	2016	310	1.00%	500	0	0	0	500	***0.153***
0	0	0	212	146	0.062	0.407	0.5	0.338	0.094	***1.401***	1.5	0%	***2.101***	**2017**	310	1.00%	500	0	0	0	500	***0.153***
162	0	0	212	308	0.062	0.407	0.5	0.338	0.199	***1.506***	1.5	0%	***2.259***	2018	310	1.00%	500	0	0	0	500	***0.153***
0	0	0	212	308	0.062	0.407	0.5	0.338	0.199	***1.506***	1.5	0%	***2.259***	2019	310	1.00%	500	0	0	0	500	***0.153***
0	0	0	212	308	0.062	0.407	0.5	0.338	0.199	***1.506***	1.5	0%	***2.259***	2020	310	1.00%	500	0	0	0	500	***0.153***
0	0	0	217	308	0.062	0.407	0.5	0.345	0.199	***1.512***	1.5	0%	***2.268***	2021	310	1.50%	500	0	0	0	500	***0.153***
0	0	0	217	308	0.062	0.407	0.5	0.345	0.199	***1.512***	1.5	0%	***2.268***	2022	310	1.50%	500	0	0	0	500	***0.153***
0	0	0	217	308	0.062	0.407	0.5	0.345	0.199	***1.512***	1.5	0%	***2.268***	2023	310	1.50%	500	0	0	0	500	***0.153***
0	0	0	217	308	0.062	0.407	0.5	0.345	0.199	***1.512***	1.5	0%	***2.268***	2024	310	1.50%	500	0	0	0	500	***0.153***
0	0	0	217	308	0.062	0.407	0.5	0.345	0.199	***1.512***	1.5	0%	***2.268***	2025	310	1.50%	500	0	0	0	500	***0.153***
0	0	0	295	308	0.062	0.407	0.5	0.468	0.199	***1.636***	1.5	0%	***2.454***	2026	310	1.50%	500	0	0	0	500	***0.153***
0	0	0	295	308	0.062	0.407	0.5	0.468	0.199	***1.636***	1.5	0%	***2.454***	2027	310	1.50%	500	0	0	0	500	***0.153***
0	0	0	295	308	0.062	0.407	0.5	0.468	0.199	***1.636***	1.5	0%	***2.454***	2028	310	1.50%	500	0	0	0	500	***0.153***
0	0	0	295	308	0.062	0.407	0.5	0.468	0.199	***1.636***	1.5	0%	***2.454***	2029	310	1.50%	500	0	0	0	500	***0.153***
0	0	0	295	308	0.062	0.407	0.5	0.468	0.199	***1.636***	1.5	0%	***2.454***	**2030**	310	1.50%	500	0	96	0	596	***0.182***
0	0	0	354	308	0.062	0.407	0.5	0.561	0.198	***1.728***	1.5	0%	***2.592***	2031	310	2.00%	500	0	0	0	596	***0.181***
0	0	0	354	308	0.062	0.407	0.5	0.561	0.198	***1.728***	1.5	0%	***2.592***	2032	310	2.00%	500	0	0	0	596	***0.181***
0	0	0	354	308	0.062	0.407	0.5	0.561	0.198	***1.728***	1.5	0%	***2.592***	2033	310	2.00%	500	0	0	0	596	***0.181***
0	0	0	354	308	0.062	0.407	0.5	0.561	0.198	***1.728***	1.5	0%	***2.592***	2034	310	2.00%	500	0	0	0	596	***0.181***
0	0	0	354	308	0.062	0.407	0.5	0.561	0.198	***1.728***	1.5	0%	***2.592***	2035	310	2.00%	500	0	0	0	596	***0.181***
0	0	0	354	308	0.062	0.407	0.5	0.561	0.198	***1.728***	1.5	0%	***2.592***	2036	310	2.00%	500	0	0	0	596	***0.181***
0	0	0	354	308	0.062	0.407	0.5	0.561	0.198	***1.728***	1.5	0%	***2.592***	2037	310	2.00%	500	0	0	0	596	***0.181***
0	0	0	354	308	0.062	0.407	0.5	0.561	0.198	***1.728***	1.5	0%	***2.592***	2038	310	2.00%	500	0	0	0	596	***0.181***
0	0	0	354	308	0.062	0.407	0.5	0.561	0.198	***1.728***	1.5	0%	***2.592***	2039	310	2.00%	500	0	0	0	596	***0.181***
0	0	0	354	308	0.062	0.407	0.5	0.561	0.198	***1.728***	1.5	0%	***2.592***	2040	310	2.00%	500	0	80	0	676	***0.205***
0	0	450	420	758	0.062	0.407	0.5	0.664	0.487	***2.119***	1.5	0%	***3.179***	2041	310	2.50%	500	0	0	0	676	***0.204***
0	0	0	420	758	0.062	0.407	0.5	0.664	0.487	***2.119***	1.5	0%	***3.179***	2042	310	2.50%	500	0	0	0	676	***0.204***
0	0	0	420	758	0.062	0.407	0.5	0.664	0.487	***2.119***	1.5	0%	***3.179***	2043	310	2.50%	500	0	0	0	676	***0.204***
0	0	0	420	758	0.062	0.407	0.5	0.664	0.487	***2.119***	1.5	0%	***3.179***	2044	310	2.50%	500	0	0	0	676	***0.204***
0	0	0	420	758	0.062	0.407	0.5	0.664	0.487	***2.119***	1.5	0%	***3.179***	2045	310	2.50%	500	0	0	0	676	***0.204***
0	0	450	470	1208	0.062	0.407	0.5	0.743	0.775	***2.487***	1.5	0%	***3.730***	2046	310	2.50%	500	0	0	0	676	***0.204***
0	0	0	470	1208	0.062	0.407	0.5	0.743	0.775	***2.487***	1.5	0%	***3.730***	2047	310	2.50%	500	0	0	0	676	***0.204***
0	0	0	470	1208	0.062	0.407	0.5	0.743	0.775	***2.487***	1.5	0%	***3.730***	2048	310	2.50%	500	0	0	0	676	***0.204***
0	0	0	470	1208	0.062	0.407	0.5	0.743	0.775	***2.487***	1.5	0%	***3.730***	2049	310	2.50%	500	0	0	0	676	***0.204***
0	0	0	470	1208	0.062	0.407	0.5	0.743	0.775	***2.487***	1.5	0%	***3.730***	**2050**	310	2.50%	500	0	0	0	676	***0.204***

Scenario C - Water Demand Forecast

MDD Peaking factor	MDD Conservation Factor	*Total City MDD (mgd)*		Per acre water use	School conservation savings	Existing School Acres	North Area School Acres	Purdin Rd. URA School Acres	David Hill URA School Acres	Total School Acres	*Total School ADD (mgd)*	MDD Peaking Factor	MDD Conservation Factor	*Total School MDD (mgd)*
2	0.50%	***0.307***	2009	310	0.50%	500	0	0	0	500	***0.1542***	2	0.50%	***0.3069***
2	0.50%	***0.307***	**2010**	300	0.50%	500	0	0	0	500	***0.1493***	2	0.50%	***0.2970***
2	0.50%	***0.307***	2011	300	0.50%	500	0	0	0	500	***0.1493***	2	0.50%	***0.2970***
2	0.50%	***0.307***	2012	300	0.50%	500	0	0	0	500	***0.1493***	2	0.50%	***0.2970***
2	0.50%	***0.307***	2013	300	0.50%	500	0	0	0	500	***0.1493***	2	0.50%	***0.2970***
2	0.50%	***0.307***	2014	300	0.50%	500	0	0	0	500	***0.1493***	2	0.50%	***0.2970***
2	1.00%	***0.304***	2015	300	1.00%	500	0	0	0	500	***0.1485***	2	1.00%	***0.2940***
2	1.00%	***0.304***	2016	300	1.00%	500	0	0	0	500	***0.1485***	2	1.00%	***0.2940***
2	1.00%	***0.304***	**2017**	300	1.00%	500	0	0	0	500	***0.1485***	2	1.00%	***0.2940***
2	1.00%	***0.304***	2018	300	1.00%	500	0	0	0	500	***0.1485***	2	1.00%	***0.2940***
2	1.00%	***0.304***	2019	300	1.00%	500	0	0	0	500	***0.1485***	2	1.00%	***0.2940***
2	1.00%	***0.304***	2020	300	1.00%	500	0	0	0	500	***0.1485***	2	1.00%	***0.2940***
2	1.50%	***0.301***	2021	300	1.50%	500	0	0	0	500	***0.1478***	2	1.50%	***0.2911***
2	1.50%	***0.301***	2022	300	1.50%	500	0	0	0	500	***0.1478***	2	1.50%	***0.2911***
2	1.50%	***0.301***	2023	300	1.50%	500	0	0	0	500	***0.1478***	2	1.50%	***0.2911***
2	1.50%	***0.301***	2024	300	1.50%	500	0	0	0	500	***0.1478***	2	1.50%	***0.2911***
2	1.50%	***0.301***	2025	300	1.50%	500	0	0	0	500	***0.1478***	2	1.50%	***0.2911***
2	1.50%	***0.301***	2026	300	1.50%	500	0	0	0	500	***0.1478***	2	1.50%	***0.2911***
2	1.50%	***0.301***	2027	300	1.50%	500	0	0	0	500	***0.1478***	2	1.50%	***0.2911***
2	1.50%	***0.301***	2028	300	1.50%	500	0	0	0	500	***0.1478***	2	1.50%	***0.2911***
2	1.50%	***0.301***	2029	300	1.50%	500	0	0	0	500	***0.1478***	2	1.50%	***0.2911***
2	1.50%	***0.359***	**2030**	300	1.50%	500	0	1.2	0	501	***0.1481***	2	1.50%	***0.2918***
2	2.00%	***0.355***	2031	300	2.00%	500	0	0	0	501	***0.1474***	2	2.00%	***0.2888***
2	2.00%	***0.355***	2032	300	2.00%	500	0	0	0	501	***0.1474***	2	2.00%	***0.2888***
2	2.00%	***0.355***	2033	300	2.00%	500	0	0	0	501	***0.1474***	2	2.00%	***0.2888***
2	2.00%	***0.355***	2034	300	2.00%	500	0	0	0	501	***0.1474***	2	2.00%	***0.2888***
2	2.00%	***0.355***	2035	300	2.00%	500	0	0	0	501	***0.1474***	2	2.00%	***0.2888***
2	2.00%	***0.355***	2036	300	2.00%	500	0	0	0	501	***0.1474***	2	2.00%	***0.2888***
2	2.00%	***0.355***	2037	300	2.00%	500	0	0	0	501	***0.1474***	2	2.00%	***0.2888***
2	2.00%	***0.355***	2038	300	2.00%	500	0	0	0	501	***0.1474***	2	2.00%	***0.2888***
2	2.00%	***0.355***	2039	300	2.00%	500	0	0	0	501	***0.1474***	2	2.00%	***0.2888***
2	2.00%	***0.403***	2040	300	2.00%	500	1	0	0	502	***0.1476***	2	2.00%	***0.2894***
2	2.50%	***0.398***	2041	300	2.50%	500	0	0	0	502	***0.1469***	2	2.50%	***0.2864***
2	2.50%	***0.398***	2042	300	2.50%	500	0	0	0	502	***0.1469***	2	2.50%	***0.2864***
2	2.50%	***0.398***	2043	300	2.50%	500	0	0	0	502	***0.1469***	2	2.50%	***0.2864***
2	2.50%	***0.398***	2044	300	2.50%	500	0	0	0	502	***0.1469***	2	2.50%	***0.2864***
2	2.50%	***0.398***	2045	300	2.50%	500	0	0	0	502	***0.1469***	2	2.50%	***0.2864***
2	2.50%	***0.398***	2046	300	2.50%	500	0	0	0	502	***0.1469***	2	2.50%	***0.2864***
2	2.50%	***0.398***	2047	300	2.50%	500	0	0	0	502	***0.1469***	2	2.50%	***0.2864***
2	2.50%	***0.398***	2048	300	2.50%	500	0	0	0	502	***0.1469***	2	2.50%	***0.2864***
2	2.50%	***0.398***	2049	300	2.50%	500	0	0	0	502	***0.1469***	2	2.50%	***0.2864***
2	2.50%	***0.398***	**2050**	300	2.50%	500	0	0	0	502	***0.1469***	2	2.50%	***0.2864***

	Total Consumptive ADD (mgd)	Total Consumptive MDD (mgd)	12% Unaccounted-for-Water ADD	12% Unaccounted-for-Water MDD	*Total ADD*	*Total MDD*
2009	2.817	5.294	0.384	0.722	***3.201***	***6.016***
2010	2.828	5.317	0.386	0.725	***3.214***	***6.042***
2011	2.853	5.368	0.389	0.732	***3.242***	***6.100***
2012	2.886	5.436	0.393	0.741	***3.279***	***6.177***
2013	2.919	5.506	0.398	0.751	***3.317***	***6.256***
2014	2.954	5.577	0.403	0.760	***3.356***	***6.337***
2015	3.477	6.354	0.474	0.867	***3.951***	***7.221***
2016	3.517	6.434	0.480	0.877	***3.996***	***7.312***
2017	3.553	6.509	0.485	0.888	***4.038***	***7.397***
2018	3.695	6.742	0.504	0.919	***4.199***	***7.662***
2019	3.733	6.820	0.509	0.930	***4.241***	***7.750***
2020	3.771	6.899	0.514	0.941	***4.285***	***7.840***
2021	3.830	6.994	0.522	0.954	***4.353***	***7.948***
2022	3.876	7.088	0.529	0.967	***4.405***	***8.054***
2023	3.924	7.186	0.535	0.980	***4.459***	***8.166***
2024	3.972	7.285	0.542	0.993	***4.514***	***8.278***
2025	4.033	7.409	0.550	1.010	***4.583***	***8.419***
2026	4.206	7.695	0.574	1.049	***4.779***	***8.744***
2027	4.257	7.801	0.581	1.064	***4.838***	***8.864***
2028	4.310	7.908	0.588	1.078	***4.898***	***8.987***
2029	4.364	8.019	0.595	1.093	***4.959***	***9.112***
2030	4.437	8.167	0.605	1.114	***5.042***	***9.280***
2031	4.600	8.422	0.627	1.148	***5.228***	***9.570***
2032	4.666	8.554	0.636	1.166	***5.302***	***9.721***
2033	4.732	8.690	0.645	1.185	***5.378***	***9.875***
2034	4.801	8.831	0.655	1.204	***5.456***	***10.035***
2035	4.871	8.974	0.664	1.224	***5.536***	***10.197***
2036	4.968	9.170	0.677	1.250	***5.645***	***10.421***
2037	5.042	9.322	0.688	1.271	***5.730***	***10.593***
2038	5.118	9.477	0.698	1.292	***5.816***	***10.769***
2039	5.196	9.635	0.709	1.314	***5.905***	***10.949***
2040	5.300	9.846	0.723	1.343	***6.023***	***11.189***
2041	5.765	10.546	0.786	1.438	***6.552***	***11.984***
2042	5.847	10.712	0.797	1.461	***6.645***	***12.173***
2043	5.933	10.886	0.809	1.485	***6.742***	***12.371***
2044	6.021	11.065	0.821	1.509	***6.842***	***12.574***
2045	6.112	11.248	0.833	1.534	***6.945***	***12.782***
2046	6.572	11.988	0.896	1.635	***7.469***	***13.623***
2047	6.667	12.181	0.909	1.661	***7.577***	***13.842***
2048	6.765	12.379	0.922	1.688	***7.687***	***14.067***
2049	6.865	12.582	0.936	1.716	***7.801***	***14.298***
2050	6.969	12.792	0.950	1.744	***7.919***	***14.537***

Derivation of Water Use Factors

Population (2008)	21465				
Consumption by Sector (2008-2009)					
		No. Accounts by Sector (2008-2009)	**Total Consumption (Gallons)**	**Total Consumption (mgd)**	**Percent of Total Consumption**
Residential		5,624	420,029,300	1.151	43%
Multi-family		295	164,230,900	0.450	17%
Commercial		375	145,484,400	0.399	15%
Industrial		26	161,309,500	0.442	16%
School		37	59,076,700	0.162	6%
City		41	34,662,700	0.095	4%
Total		**6,357**	**984,793,500**	**2.698**	**100%**

Total Water Production (metered)

	2009	2008	2007	2006	2005	
FG total prod. (MG)	639.112	654.223	670.766	433.041	579.085	595.245
JWC total prod. (MG)	404.223	546.036	515.097	703.668	539.554	541.716
Total Production (gal)	***1,043,335,000***	***1,200,259,000***	***1,185,863,000***	***1,136,709,000***	***1,118,639,000***	1,136,961,000
Total Production (mgd)	***2.86***	***3.29***	***3.25***	***3.11***	***3.06***	3.11
Customer Class Water Consumption (metered)						
Residential		415,701,700	416,149,300	432,126,100	421,325,700	
Multi-family		163,452,200	160,609,500	165,221,000	163,094,233	
Commercial		144,829,800	145,554,200	142,289,600	144,224,533	
Industrial		179,147,900	189,359,200	205,572,300	191,359,800	
School		56,782,200	62,176,500	58,239,300	59,066,000	
City		43,346,500	44,562,400	52,067,500	46,658,800	
Total Consumption (gal)		***1,003,260,300***	***1,018,411,100***	***1,055,515,800***	1,025,729,067	1025729066.67
Total Consumption (mgd)		***2.75***	***2.79***	***2.89***	2.81	2.81
Unaccounted-for-Water (gal)		**196,998,700**	**167,451,900**	**81,193,200**		148547933.33
Unaccounted-for-Water (mgd)		***0.54***	***0.46***	***0.22***		0.41
% Unaccounted-for-Water		***16%***	***14%***	***7%***		0.1256

2008-2009				
Large Users	**Sector**	**Consumption (gallons)**	**Percent of Total Sector**	**ADD (mgd) 3-year average**
Merix	Ind	72,280,000	45%	0.233
Westak	Ind	22,905,500	14%	0.069
Gray & Co.	Ind	17,851,000	11%	0.054
Lieb	Ind	17,573,100	11%	0.051
Rose Grove MH	Com	20,809,600	14%	0.062
Homestead	Com	11,465,800	8%	0.033
Commonwealth	Com	10,602,000	7%	0.032

		2008-2009	2007-2008	2006-2007		Acres
Merix	Ind	72,280,000	90,060,000	93,060,000	0.233	44.0
Westak	Ind	22,905,500	26,596,000	25,895,400	0.069	3.5
Gray & Co.	Ind	17,851,000	18,385,000	22,539,000	0.054	4.2
Lieb	Ind	17,573,100	21,367,300	17,096,200	0.051	11.8
Rose Grove MH	Com	20,809,600	23,318,300	23,649,400	0.062	
Homestead	Com	11,465,800	11,420,600	13,320,000	0.033	
Commonwealth	Com	10,602,000	10,987,000	13,460,100	0.032	

Population		21,465	20,775	20,380
Commerical Acres		212	212	212
Industrial Acres		210	210	210
School/City (public) Acres		912	912	912
Water Use Factors	Average			
Residential per capita (gpd)	76.8	73.9	76.1	80.3
Comm. Per acre	1597.2	1,604	1,612	1,576
Ind. Per acre	681.1	638	674	732
Public	317.6	301	321	331

Appendix D

Spreadsheet Tables of Supply Analysis

Annual Supply Analysis - City of Forest Grove Water Master Plan Update (2010)

Peak Season with Reduction Factors for Drought										0.68	7.41			1.08									
Peak Month Release Flow (x 1.5)										1.01	11.12			1.61									
Peak Day Release Flow (x 2.0)										1.35	14.82			2.15								0.88	16.17
							Units in mgd																
	Demands						Water Rights Limitations								Infrastructure Limitations						Current Supply with Drought and Losses		
Year	A - ADD	A-MDD	B-ADD	B-MDD	C-ADD	C-MDD	Clear Cr. Cert. (1.81 mgd)	Gales Cr. Cert. (2.88 mgd)	Tualatin River (21.3 mgd)	Barney WR (500 AF; 1.0 mgd PSMM with losses)	Scoggins WR (4500 AF; 11 mgd PSMM with losses)	Clear Cr. Perm. (1.83 mgd)	Roaring Cr. Perm. (1.57 mgd)	Barney Buy-Back (800 AF; 1.6 mgd PSMM with losses)	FG WTP (3.7 mgd)	JWC WTP (~10 mgd)	JWC 24" TL (6.1 mgd)	FG 16" TL (4.7 mgd)	Gales Cr. Diversion (3 mgd)	Clear Cr. Diversion (3.7 mgd)	Clear Cr. *Certificates* (Summer Limited)	Clear & Roaring Cr. *Permits*	Stored Water (Barney and Scoggins)
2010	3.21	6.03	3.21	6.03	3.21	6.04	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2011	3.22	6.05	3.23	6.07	3.24	6.10	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2012	3.24	6.09	3.26	6.13	3.28	6.18	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2013	3.26	6.13	3.29	6.21	3.32	6.26	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2014	3.29	6.19	3.33	6.29	3.36	6.34	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2015	3.59	6.63	3.64	6.74	3.95	7.22	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2016	3.62	6.70	3.69	6.83	4.00	7.31	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2017	3.66	6.79	3.73	6.92	4.04	7.40	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2018	3.70	6.87	3.89	7.18	4.20	7.66	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2019	3.74	6.95	3.93	7.27	4.24	7.75	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2020	3.79	7.04	3.97	7.36	4.29	7.84	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2021	3.81	7.07	4.03	7.45	4.35	7.95	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2022	3.86	7.16	4.08	7.54	4.40	8.05	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2023	3.90	7.25	4.13	7.64	4.46	8.17	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2024	3.95	7.34	4.17	7.73	4.51	8.28	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2025	3.99	7.44	4.23	7.86	4.58	8.42	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2026	4.04	7.54	4.42	8.16	4.78	8.74	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2027	4.09	7.63	4.47	8.26	4.84	8.86	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2028	4.14	7.73	4.52	8.37	4.90	8.99	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2029	4.19	7.83	4.57	8.47	4.96	9.11	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2030	4.24	7.94	4.64	8.62	5.04	9.28	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2031	4.27	7.98	4.82	8.89	5.23	9.57	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2032	4.31	8.06	4.88	9.02	5.30	9.72	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2033	4.35	8.14	4.94	9.15	5.38	9.88	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2034	4.39	8.23	5.01	9.28	5.46	10.03	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2035	4.43	8.31	5.08	9.42	5.54	10.20	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2036	4.48	8.39	5.17	9.61	5.65	10.42	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2037	4.52	8.48	5.24	9.75	5.73	10.59	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2038	4.56	8.57	5.32	9.90	5.82	10.77	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2039	4.60	8.66	5.39	10.05	5.90	10.95	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2040	4.65	8.75	5.46	10.20	6.02	11.19	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2041	4.68	8.77	5.51	10.25	6.55	11.98	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2042	4.71	8.83	5.59	10.41	6.64	12.17	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2043	4.74	8.89	5.67	10.57	6.74	12.37	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2044	4.77	8.95	5.75	10.73	6.84	12.57	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2045	4.80	9.02	5.83	10.90	6.95	12.78	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2046	4.83	9.08	5.92	11.08	7.47	13.62	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2047	4.86	9.15	6.01	11.25	7.58	13.84	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2048	4.89	9.21	6.10	11.43	7.69	14.07	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2049	4.93	9.28	6.19	11.62	7.80	14.30	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2050	4.96	9.34	6.28	11.81	7.92	14.54	1.81	2.88	21.3	1.01	11.12	1.83	1.57	1.61	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09

Monthly Supply Analysis - City of Forest Grove Water Master Plan Update (2010)

Ave. Annual	0.45	4.02	0.71				
Peak Season	0.89	7.97	1.42	1.629	3.06		
Peak Season with Losses	0.68	7.41	1.08	1.35		8.0885	

	A-mgd (Demand Forecast by Month)			B-mgd (Demand Forecast by Month)			C-mgd (Demand Forecast by Month)			Water Rights Limitations								Infrastructure Limitations						Current Water Rights and Hydrology			Current Infrastructure and Hydrology	
Month	2017	2030	2050	B-2017	B-2030	B-2050	C-2017	C-2030	C-2050	Clear Cr. Cert. (1.81 mgd)	Gales Cr. Cert. (2.88 mgd)	Tualatin River (21.3 mgd)	Barney WR (500 AF; 0.68 mgd PSA with losses)	Scoggins WR (4500 AF; 7.41 mgd PSA with losses)	Clear Cr. Perm. (1.83 mgd)	Roaring Cr. Perm. (1.57 mgd)	Barney Buy-Back (800 AF; 1.08 PSA with losses)	FG WTP (3.7 mgd)	JWC WTP (~10 mgd)	JWC 24" TL (6.1 mgd)	FG 16" TL (4.7 mgd)	Gales Cr. Diversion (3 mgd)	Clear Cr. Diversion (3.7 mgd)	Clear Cr. *Certificates* (Summer Limited)	Clear & Roaring Cr. *Permits*	Stored Water (Barney and Scoggins); with losses	FG WTP (3.7 mgd)	24" TL (6.1 mgd)
January	2.70	3.13	3.66	2.75	3.43	4.64	2.98	3.72	5.84	1.81	2.88	21.3	0	0	1.83	1.57	0	3.7	9.9975	6.1	4.7	3	3.7	1.81	3.06	0	3.7	6.1
February	2.95	3.41	3.99	3.00	3.74	5.06	3.25	4.06	6.38	1.81	2.88	21.3	0	0	1.83	1.57	0	3.7	9.9975	6.1	4.7	3	3.7	1.81	3.06	0	3.7	6.1
March	2.54	2.94	3.44	2.59	3.22	4.36	2.80	3.50	5.49	1.81	2.88	21.3	0	0	1.83	1.57	0	3.7	9.9975	6.1	4.7	3	3.7	1.81	3.06	0	3.7	6.1
April	2.80	3.24	3.80	2.85	3.55	4.81	3.09	3.86	6.06	1.81	2.88	21.3	0	0	1.83	1.57	0	3.7	9.9975	6.1	4.7	3	3.7	1.81	3.06	0	3.7	6.1
May	2.72	3.15	3.68	2.77	3.45	4.67	3.00	3.74	5.88	1.81	2.88	21.3	0.27	2.96	1.83	1.57	0.43	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	3.24	1.5	6.1
June	3.91	4.52	5.29	3.98	4.95	6.70	4.31	5.38	8.45	1.81	2.88	21.3	0.54	5.93	1.83	1.57	0.86	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	6.47	1.5	6.1
July	4.82	5.57	6.52	4.90	6.10	8.26	5.31	6.63	10.41	1.81	2.88	21.3	0.82	8.89	1.83	1.57	1.30	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	9.71	1.5	6.1
August	5.87	6.79	7.95	5.97	7.44	10.07	6.47	8.08	12.69	1.81	2.88	21.3	1.02	11.12	1.83	1.57	1.62	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	12.14	1.5	6.1
Septembe	5.42	6.26	7.33	5.51	6.86	9.29	5.97	7.45	11.71	1.81	2.88	21.3	0.95	10.37	1.83	1.57	1.51	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	11.33	1.5	6.1
October	4.19	4.85	5.67	4.27	5.31	7.19	4.62	5.77	9.06	1.81	2.88	21.3	0.51	5.55	1.83	1.57	0.81	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	6.06	1.5	6.1
November	3.27	3.78	4.43	3.33	4.14	5.61	3.60	4.50	7.07	1.81	2.88	21.3	0	0	1.83	1.57	0	3.7	9.9975	6.1	4.7	3	3.7	1.81	3.06	0	3.7	6.1
December	2.73	3.15	3.69	2.77	3.45	4.67	3.00	3.75	5.89	1.81	2.88	21.3	0	0	1.83	1.57	0	3.7	9.9975	6.1	4.7	3	3.7	1.81	3.06	0	3.7	6.1

Peak Season Supply Analysis - City of Forest Grove Water Master Plan Update (2010)

							Ave. Annual	0.45	4.02	0.71													
							Peak Season	0.89	7.97	1.42													
							Peak Season with Reduction Factors for Drought	0.68	7.41	1.08											0.88		4.47
							Units in mgd																
	Demands						Water Rights Limitations								Infrastructure Limitations						Current Supply with Drought and Losses		
Year	A - ADD	A-PSD	B-ADD	B-PSD	C-ADD	C-PSD	Clear Cr. Cert. (1.81 mgd)	Gales Cr. Cert. (2.88 mgd)	Tualatin River (21.3 mgd)	Barney WR (500 AF; 0.68 mgd PSA with losses)	Scoggins WR (4500 AF; 7.41 mgd PSA with losses)	Clear Cr. Perm. (1.83 mgd)	Roaring Cr. Perm. (1.57 mgd)	Barney Buy-Back (800 AF; 1.08 PSA with losses)	FG WTP (3.7 mgd)	JWC WTP (~10 mgd)	JWC 24" TL (6.1 mgd)	FG 16" TL (4.7 mgd)	Gales Cr. Diversion (3 mgd)	Clear Cr. Diversion (3.7 mgd)	Clear Cr. *Certificates* (Summer Limited)	Clear & Roaring Cr. *Permits*	Stored Water (Barney and Scoggins)
2010	3.21	3.95	3.21	3.95	3.21	3.95	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2011	3.22	3.96	3.23	3.97	3.24	3.99	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2012	3.24	3.98	3.26	4.01	3.28	4.03	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2013	3.26	4.01	3.29	4.05	3.32	4.08	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2014	3.29	4.04	3.33	4.10	3.36	4.13	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2015	3.59	4.41	3.64	4.48	3.95	4.86	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2016	3.62	4.46	3.69	4.54	4.00	4.92	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2017	3.66	4.51	3.73	4.59	4.04	4.97	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2018	3.70	4.56	3.89	4.78	4.20	5.16	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2019	3.74	4.61	3.93	4.83	4.24	5.22	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2020	3.79	4.66	3.97	4.89	4.29	5.27	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2021	3.81	4.69	4.03	4.96	4.35	5.35	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2022	3.86	4.75	4.08	5.02	4.40	5.42	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2023	3.90	4.80	4.13	5.07	4.46	5.48	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2024	3.95	4.86	4.17	5.13	4.51	5.55	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2025	3.99	4.91	4.23	5.21	4.58	5.64	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2026	4.04	4.97	4.42	5.44	4.78	5.88	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2027	4.09	5.03	4.47	5.50	4.84	5.95	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2028	4.14	5.09	4.52	5.56	4.90	6.02	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2029	4.19	5.15	4.57	5.62	4.96	6.10	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2030	4.24	5.21	4.64	5.71	5.04	6.20	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2031	4.27	5.26	4.82	5.93	5.23	6.43	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2032	4.31	5.30	4.88	6.00	5.30	6.52	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2033	4.35	5.35	4.94	6.08	5.38	6.61	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2034	4.39	5.40	5.01	6.16	5.46	6.71	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2035	4.43	5.45	5.08	6.24	5.54	6.81	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2036	4.48	5.50	5.17	6.36	5.65	6.94	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2037	4.52	5.56	5.24	6.45	5.73	7.05	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2038	4.56	5.61	5.32	6.54	5.82	7.15	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2039	4.60	5.66	5.39	6.63	5.90	7.26	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2040	4.65	5.72	5.46	6.72	6.02	7.41	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2041	4.68	5.75	5.51	6.78	6.55	8.06	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2042	4.71	5.79	5.59	6.88	6.64	8.17	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2043	4.74	5.83	5.67	6.97	6.74	8.29	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2044	4.77	5.86	5.75	7.07	6.84	8.42	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2045	4.80	5.90	5.83	7.18	6.95	8.54	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2046	4.83	5.94	5.92	7.28	7.47	9.19	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2047	4.86	5.98	6.01	7.39	7.58	9.32	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2048	4.89	6.02	6.10	7.50	7.69	9.46	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2049	4.93	6.06	6.19	7.61	7.80	9.60	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09
2050	4.96	6.10	6.28	7.73	7.92	9.74	1.81	2.88	21.3	0.68	7.41	1.83	1.57	1.08	3.7	9.9975	6.1	4.7	3	3.7	1.5	0	8.09

Supply Analysis - Seasonal Factors

				Peak Season - 184 days (May-Oct)					
	Average (Release) Flow (mgd)	**Average Flow (cfs)**	**Ac-ft/yr**	**Peak Season Ave. Release Flow (mgd)**	**Drought Year Available flow (65.8%)**	**Drought Year including other losses (42.7%)**	**Storage and Transmission Losses (76% Barney; 93% Scoggins**	**Peak Month Release Flow (x 1.5)**	**Peak Day Release Flow (x 2.0)**
Barney Reservoir	0.45		500	0.89	0.58	0.38	0.67	1.01	1.35
Scoggins Reservoir	4.02		4,500	7.97	5.24	3.40	7.41	11.12	14.82
Buy Back Option	0.71		800	1.42	0.93	0.60	1.08	1.61	2.15
Clear Creek watershed	2	3.1	2,240						
Gales Creek	5	7.7	5,601						
Total	12.18		13,642						

Drought year available flow based on Tualatin Basin Water Supply Feasibility Study: 3816 AF available to FG rather than 5800 AF

Barney Dead Pool	2%
Barney ODFW	15%
Barney Blow by	2%
Barney STT losses	5%
	24%

Scoggins Blow by	2%
Scoggins STT losses	5%
	7%

	JWC \Peak Month (MG)	**JWC \Peak Month (mgd)**	**JWC \Peak Season ave. (mgd)**	**average daily JWC (mgd)**	**production peak month factor**	**Production peak day factor (x1.3)**
2009	89.1	2.97	1.82	1.11	1.6	2.1
2008	123.7	4.12	2.43	1.50	1.7	2.2
2007	92.7	3.09	2.01	1.41	1.5	2.0
2006	108.0	3.60	3.01	1.93	1.2	1.6
2005	106.1	3.54	1.91	1.48	1.9	2.4
2004	110.3	3.68	2.31	1.65	1.6	2.1
2003	101.3	3.38	2.18	1.58	1.6	2.0
2002	97.7	3.26	2.19	1.75	1.5	1.9
2001	88.2	2.94	1.97	1.52	1.5	1.9
2000	90.3	3.01	1.82	1.35	1.7	2.2
				Ave. 00-09:	**1.6**	2.0
				Ave. 06-09:	**1.5**	2.0

JWC Peak Season Production (MG)										
	2009	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**	**2000**
May	16.5	15.1	21.9	94.0	24.2	38.4	14.4	35.5	32.4	21.7
June	33.7	41.3	39.6	108.0	29.4	62.8	71.8	51.3	42.8	53.8
July	89.1	123.7	87.0	97.6	76.2	110.3	100.1	82.3	70.7	69.7
August	86.3	105.5	92.7	96.7	106.1	99.6	101.3	97.7	88.2	90.3
September	75.6	95.7	82.6	92.5	70.3	65.7	79.8	79.1	78.0	55.6
October	32.9	66.3	46.0	64.5	44.5	47.6	33.1	56.6	50.8	42.8
Monthly Ave. Vol (MG)	55.7	74.6	61.6	92.2	58.4	70.7	66.7	67.1	60.5	55.7
Peak Season Total Vol (MG)	334.1	447.6	369.9	553.3	350.6	424.3	400.5	402.5	363.0	334.0
Peak Season Ave. Rate (mg	1.82	2.43	2.01	3.01	1.91	2.31	2.18	2.19	1.97	1.82

	2009	**2008**	**2007**	**2006**	**Peak Month Average**	**Peak Month Release Factor**	**Barney WR (500 AF; 0.68 mgd PSA with losses)**	**Scoggins WR (4500 AF; 7.41 mgd PSA with losses)**	**Barney Buy-Back (800 AF; 1.08 PSA with losses)**
May	16.5	15.1	21.9	94.0	0.6	0.4	0.27	2.96	0.43
June	33.7	41.3	39.6	108.0	1.3	0.8	0.54	5.93	0.86
July	89.1	123.7	87.0	97.6	3.2	1.2	0.82	8.89	1.30
August	86.3	105.5	92.7	96.7	3.1	1.5	1.02	11.12	1.62
September	75.6	95.7	82.6	92.5	2.8	1.4	0.95	10.37	1.51
October	32.9	66.3	46.0	64.5	1.6	0.7	0.51	5.55	0.81
Peak Season Ave Vol (MG)	334.1	447.6	369.9	553.3	2.1		0.69	7.47	1.09
							0.7	7.5	1.1

Monthly Demands

	Average Monthly Total Demand (2006-2008) (gal/mo)						
	Res	MF	Com	Ind	City	School	Total
January	24,808,800	11,834,933	8,763,067	14,714,467	2,334,767	1,829,733	64,285,767
February	24,075,267	11,311,567	8,755,500	14,913,633	2,329,033	1,962,900	63,347,900
March	22,613,600	11,144,600	8,398,900	13,777,800	1,965,567	2,531,700	60,432,167
April	24,214,933	11,865,467	8,677,633	15,108,133	2,122,800	2,545,367	64,534,333
May	25,945,500	11,589,233	8,555,567	13,911,133	2,009,133	2,678,200	64,688,767
June	38,190,300	13,713,467	12,258,400	16,403,733	4,168,633	5,183,967	89,918,500
July	54,443,200	16,996,533	14,667,500	15,494,333	6,832,000	6,101,733	114,535,300
August	63,735,133	19,015,367	19,562,767	20,552,400	6,875,433	9,870,800	139,611,900
September	54,798,967	17,341,133	17,995,033	16,764,000	7,564,700	10,174,500	124,638,333
October	37,237,900	14,355,633	15,432,400	19,146,900	4,972,767	8,515,567	99,661,167
November	27,550,733	12,537,667	11,931,533	15,964,700	2,988,667	4,283,433	75,256,733
December	23,711,367	11,388,633	9,226,233	14,608,567	2,495,300	3,388,100	64,818,200

		Monthly Average Day Demand (2006-2008) (mgd)								
	Month	**Res**	**MF**	**Com**	**Ind**	**City**	**School**	**Total**	**Monthly factor**	
31	January	0.80	0.38	0.28	0.47	0.08	0.06	**2.07**	**0.74**	181
28	February	0.86	0.40	0.31	0.53	0.08	0.07	**2.26**	**0.81**	184
31	March	0.73	0.36	0.27	0.44	0.06	0.08	**1.95**	**0.69**	
30	April	0.81	0.40	0.29	0.50	0.07	0.08	**2.15**	**0.77**	
31	May	0.84	0.37	0.28	0.45	0.06	0.09	**2.09**	**0.74**	
30	June	1.27	0.46	0.41	0.55	0.14	0.17	**3.00**	**1.07**	
31	July	1.76	0.55	0.47	0.50	0.22	0.20	**3.69**	**1.31**	
31	August	2.06	0.61	0.63	0.66	0.22	0.32	**4.50**	**1.60**	
30	September	1.83	0.58	0.60	0.56	0.25	0.34	**4.15**	**1.48**	
31	October	1.20	0.46	0.50	0.62	0.16	0.27	**3.21**	**1.14**	
30	November	0.92	0.42	0.40	0.53	0.10	0.14	**2.51**	**0.89**	
31	December	0.76	0.37	0.30	0.47	0.08	0.11	**2.09**	**0.74**	
								2.81		
								2.81		
								PSD factor	**1.22**	

	A-mgd	B-mgd	C-mgd	B-Peak (1.25)	B-Non Peak (0.8)
2010	3.21	3.21	3.21	4.01	2.57
2017	3.66	3.73	4.04	4.66	2.98
2030	4.24	4.64	5.04	5.80	3.71
2050	4.96	6.28	7.92	7.85	5.03

	A-mgd (Demand Forecast by Month)			**B-mgd (Demand Forecast by Month)**			**C-mgd (Demand Forecast by Month)**		
	2017	**2030**	**2050**	**2017**	**2030**	**2050**	**2017**	**2030**	**2050**
January	2.70	3.13	3.66	2.75	3.43	4.64	2.98	3.72	5.84
February	2.95	3.41	3.99	3.00	3.74	5.06	3.25	4.06	6.38
March	2.54	2.94	3.44	2.59	3.22	4.36	2.80	3.50	5.49
April	2.80	3.24	3.80	2.85	3.55	4.81	3.09	3.86	6.06
May	2.72	3.15	3.68	2.77	3.45	4.67	3.00	3.74	5.88
June	3.91	4.52	5.29	3.98	4.95	6.70	4.31	5.38	8.45
July	4.82	5.57	6.52	4.90	6.10	8.26	5.31	6.63	10.41
August	5.87	6.79	7.95	5.97	7.44	10.07	6.47	8.08	12.69
September	5.42	6.26	7.33	5.51	6.86	9.29	5.97	7.45	11.71
October	4.19	4.85	5.67	4.27	5.31	7.19	4.62	5.77	9.06
November	3.27	3.78	4.43	3.33	4.14	5.61	3.60	4.50	7.07
December	2.73	3.15	3.69	2.77	3.45	4.67	3.00	3.75	5.89

Appendix E

Evaluation of Storage Criteria

Storage Analysis Calculations by Pressure Zone - City of Forest Grove Water Master Plan Update (2010)

1989 Method 1 OS = 20% MDD; ES = 90% MDD; FS = 1.08 MG (4500 gpm x 4 hours)
2000 Method 2 OS = 20% MDD; ES = 60% MDD for LPZ and 85% MDD for UPZ; FS = 1.08 MG *Low Storage*
Method 3 OS = 25% MDD; ES = 75% MDD; FS = 1.08 MG (4500 gpm x 4 hours)
Method 4 OS = 25% MDD; ES = 2 x ADD; FS = 1.08 MG (4500 gpm x 4 hours)
Method 5 3 x ADD *High Storage*

1.10
3.30
1.08

No NCUR	Lower Pressure Zone (reduced JWC storage)				Storage Requirements					Additional Storage Needed				
	ADD	MDD	Fire Storage	Existing Storage	Method 1	Method 2	Method 3	Method 4	Method 5	Method 1	Method 2	Method 3	Method 4	Method 5
2010	2.93	5.51	1.08	6.4	7.1	5.5	6.6	8.3	8.8	0.74	-0.92	0.19	1.91	2.38
2017	3.37	6.25	1.08	6.4	8.0	6.1	7.3	9.4	10.1	1.55	-0.32	0.93	2.99	3.72
2030	4.20	7.78	1.08	6.4	9.6	7.3	8.9	11.4	12.6	3.24	0.90	2.46	5.01	6.19
2050	5.52	10.34	1.08	6.4	12.5	9.4	11.4	14.7	16.6	6.05	2.95	5.02	8.31	10.16

	Lower Pressure Zone (with JWC storage)				Storage Requirements					Additional Storage Needed				
	ADD	MDD	Fire Storage	Existing Storage	Method 1	Method 2	Method 3	Method 4	Method 5	Method 1	Method 2	Method 3	Method 4	Method 5
2010	2.93	5.51	1.08	7.8	7.1	5.5	6.6	8.3	8.8	-0.66	-2.32	-1.21	0.51	0.98
2017	3.37	6.25	1.08	7.8	8.0	6.1	7.3	9.4	10.1	0.15	-1.72	-0.47	1.59	2.32
2030	4.20	7.78	1.08	7.8	9.6	7.3	8.9	11.4	12.6	1.84	-0.50	1.06	3.61	4.79
2050	6.11	11.54	1.08	7.8	13.8	10.3	12.6	16.2	18.3	5.97	2.51	4.82	8.38	10.52

No NCUR	Lower Pressure Zone (with JWC storage)				Storage Requirements					Additional Storage Needed				
	ADD	MDD	Fire Storage	Existing Storage	Method 1	Method 2	Method 3	Method 4	Method 5	Method 1	Method 2	Method 3	Method 4	Method 5
2010	2.93	5.51	1.08	7.8	7.1	5.5	6.6	8.3	8.8	-0.66	-2.32	-1.21	0.51	0.98
2017	3.37	6.25	1.08	7.8	8.0	6.1	7.3	9.4	10.1	0.15	-1.72	-0.47	1.59	2.32
2030	4.20	7.78	1.08	7.8	9.6	7.3	8.9	11.4	12.6	1.84	-0.50	1.06	3.61	4.79
2050	5.52	10.34	1.08	7.8	12.5	9.4	11.4	14.7	16.6	4.65	1.55	3.62	6.91	8.76

	IPZ				Storage Requirements					Additional Storage Needed				
	ADD	MDD	Fire Storage	Existing Storage	Method 1	Method 2	Method 3	Method 4	Method 5	Method 1	Method 2	Method 3	Method 4	Method 5
2010	0.063	0.12	0.54	1.0	0.7	0.7	0.7	0.7	0.2	-0.34	-0.34	-0.34	-0.31	-0.81
2017	0.072	0.13	0.54	1.0	0.7	0.7	0.7	0.7	0.2	-0.32	-0.32	-0.33	-0.28	-0.78
2030	0.086	0.16	0.54	1.0	0.7	0.7	0.7	0.8	0.3	-0.29	-0.29	-0.30	-0.25	-0.74
2050	0.11	0.21	0.54	1.0	0.8	0.8	0.7	0.8	0.3	-0.24	-0.24	-0.25	-0.19	-0.67

	UPZ				Storage Requirements					Additional Storage Needed				
	ADD	MDD	Fire Storage	Existing Storage	Method 1	Method 2	Method 3	Method 4	Method 5	Method 1	Method 2	Method 3	Method 4	Method 5
2010	0.21	0.40	0.54	1.0	1.0	1.0	0.9	1.1	0.6	-0.04	-0.04	-0.06	0.06	-0.37
2017	0.24	0.45	0.54	1.0	1.0	1.0	1.0	1.1	0.7	0.01	0.01	-0.01	0.14	-0.27
2030	0.29	0.53	0.63	1.0	1.2	1.2	1.2	1.3	0.9	0.19	0.19	0.16	0.34	-0.13
2050	0.38	0.70	0.63	1.0	1.4	1.4	1.3	1.6	1.1	0.36	0.36	0.33	0.55	0.13

	UPZ + IPZ				Storage Requirements					Additional Storage Needed				
	ADD	MDD	Fire Storage	Existing Storage	Method 1	Method 2	Method 3	Method 4	Method 5	Method 1	Method 2	Method 3	Method 4	Method 5
2010	0.27	0.51	0.54	1.0	1.1	1.1	1.1	1.2	0.8	0.08	0.08	0.05	0.22	-0.18
2017	0.32	0.58	0.54	1.0	1.2	1.2	1.1	1.3	0.9	0.15	0.15	0.12	0.32	-0.05
2030	0.37	0.69	0.63	1.0	1.4	1.4	1.3	1.6	1.1	0.36	0.36	0.32	0.55	0.12
2050	0.49	0.91	0.63	1.0	1.6	1.6	1.5	1.8	1.5	0.58	0.58	0.54	0.83	0.46

	DHR				Storage Requirements					Additional Storage Needed				
	ADD	MDD	Fire Storage	Existing Storage	Method 1	Method 2	Method 3	Method 4	Method 5	Method 1	Method 2	Method 3	Method 4	Method 5
2010	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00
2017	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00
2030	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00
2050	0.18	0.37	0.54	0.0	0.9	0.9	0.9	1.0	0.5	0.93	0.93	0.91	1.00	0.55

	UPZ + DHR				Storage Requirements					Additional Storage Needed				
	ADD	MDD	Fire Storage	Existing Storage	Method 1	Method 2	Method 3	Method 4	Method 5	Method 1	Method 2	Method 3	Method 4	Method 5
2010	0.21	0.40	0.54	1.0	1.0	1.0	0.9	1.1	0.6	-0.04	-0.04	-0.06	0.06	-0.37
2017	0.24	0.45	0.54	1.0	1.0	1.0	1.0	1.1	0.7	0.01	0.01	-0.01	0.14	-0.27
2030	0.29	0.53	0.63	1.0	1.2	1.2	1.2	1.3	0.9	0.19	0.19	0.16	0.34	-0.13
2050	0.56	1.07	0.63	1.0	1.8	1.8	1.7	2.0	1.7	0.76	0.76	0.70	1.01	0.67

	UPZ + DHR + IPZ				Storage Requirements					Additional Storage Needed				
	ADD	MDD	Fire Storage	Existing Storage	Method 1	Method 2	Method 3	Method 4	Method 5	Method 1	Method 2	Method 3	Method 4	Method 5
2010	0.27	0.51	0.54	1.0	1.1	1.1	1.1	1.2	0.8	0.08	0.08	0.05	0.22	-0.18
2017	0.32	0.58	0.54	1.0	1.2	1.2	1.1	1.3	0.9	0.15	0.15	0.12	0.32	-0.05
2030	0.37	0.69	0.63	1.0	1.4	1.4	1.3	1.6	1.1	0.36	0.36	0.32	0.55	0.12
2050	0.67	1.28	0.63	1.0	2.0	2.0	1.9	2.3	2.0	0.97	0.97	0.91	1.29	1.01

No NCUR	Total System (no JWC storage)				Storage Requirements					Additional Storage Needed				
	ADD	MDD	Fire Storage	Existing Storage	Method 1	Method 2	Method 3	Method 4	Method 5	Method 1	Method 2	Method 3	Method 4	Method 5
2010	3.20	6.02	1.08	6.0	7.7	5.9	7.1	9.0	9.6	1.70	-0.10	1.10	2.99	3.60
2017	3.69	6.83	1.08	6.0	8.6	6.5	7.9	10.2	11.1	2.59	0.54	1.91	4.17	5.07
2030	4.57	8.47	1.08	6.0	10.4	7.9	9.6	12.3	13.7	4.40	1.86	3.55	6.34	7.71
2050	6.19	11.62	1.08	6.0	13.9	10.4	12.7	16.4	18.6	7.86	4.38	6.70	10.37	12.57

No NCUR	Total System (with JWC storage)				Storage Requirements					Additional Storage Needed				
	ADD	MDD	Fire Storage	Existing Storage	Method 1	Method 2	Method 3	Method 4	Method 5	Method 1	Method 2	Method 3	Method 4	Method 5
2010	3.20	6.02	1.08	8.8	7.7	5.9	7.1	9.0	9.6	-1.10	-2.90	-1.70	0.18	0.80
2017	3.69	6.83	1.08	8.8	8.6	6.5	7.9	10.2	11.1	-0.21	-2.26	-0.89	1.37	2.27
2030	4.57	8.47	1.08	8.8	10.4	7.9	9.6	12.3	13.7	1.60	-0.94	0.75	3.54	4.91
2050	6.19	11.62	1.08	8.8	13.9	10.4	12.7	16.4	18.6	5.06	1.58	3.90	7.57	9.77

Storage Demand Allocation by Pressure Zone - City of Forest Grove Water Master Plan Update (2010)

	Total		Current City Limit		LPZ		IPZ		UPZ		DHUR		PRUR		NCUR	
	ADD Total	MDD Total	ADD Total	MDD Total	ADD	MDD	ADD	MDD	ADD	MDD	ADD	MDD	ADD	MDD	ADD	MDD
2010	3.2	6.02	3.20	6.02	2.93	5.51	0.06	0.12	0.21	0.40	0.000	0.000	0.000	0.000	0.000	0.000
2017	3.69	6.83	3.69	6.83	3.37	6.25	0.07	0.13	0.24	0.45	0.000	0.000	0.000	0.000	0.000	0.000
2030	4.57	8.47	4.39	8.09	4.01	7.40	0.09	0.16	0.29	0.53	0.000	0.000	0.184	0.377	0.000	0.000
2050	6.19	11.62	5.69	10.60	5.21	9.69	0.11	0.21	0.38	0.70	0.183	0.375	0.315	0.645	0.585	1.199

5.51	0.51	6.02	6.02
6.25	0.58	6.83	6.83
7.78	0.69	8.47	8.47
10.34	1.28	11.62	11.62

	Pressure Zone				
Landuse	**Upper**	**Intermediate**	**Lower**	**Gales Cr**	Total
SR Res	142165	49518.5	951732.8	21583.7	1165000
MF Res	-	-	453000	-	453000
Comm	95.6	-	331551.6	3352.9	335000
Ind	-	-	95000	-	95000
Pac Uni	-	-	83050.5	-	83050.5
SD #15	8002.4	151.9	62995.2	-	71149.5
City	6864.4	4404.5	142731.1	-	154000
Large User	-	-	407000	-	407000
Total	157127.3	54074.8	2527061.3	24936.6	2763200
Percent	5.7%	2.0%	91.5%	0.9%	100.0%

Urban expansion demand (need to subtract from total ADD)

	David Hill			Purdin			North Concept (Scenario C)		
	R	C	I	R	C	I	R	C	I
2010	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	49	162	0	0	0
2050	937	0	0	794	100	0	0	0	900

Residential	75	2.6
Commercial	1600	
Industrial	650	

	David Hill			Purdin			North Concept (Scenario C)		
	R	C	I	R	C	I	R	C	I
2010	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0.0784	0.1053	0	0	0
2050	0.182715	0	0	0.15483	0.16	0	0	0	0.585

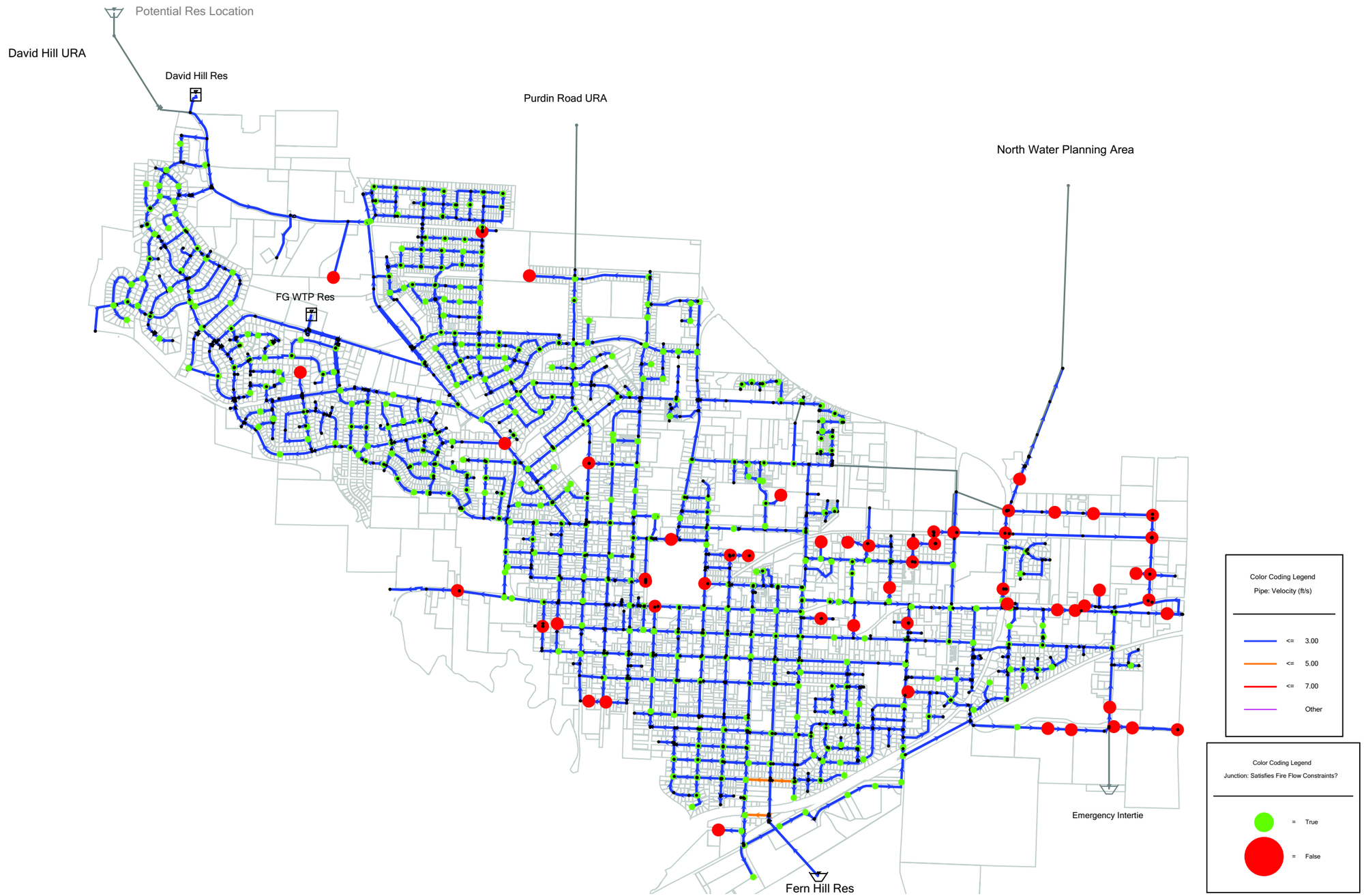
	ADD		
Totals	**David Hill**	**Purdin**	**North Concept**
2010	0	0	0
2017	0	0	0
2030	0	0.1837	0
2050	0.182715	0.31483	0.585

MDD		
David Hill	**Purdin**	**North Concept**
0	0	0
0	0	0
0	0.376585	0
0.37456575	0.6454015	1.19925

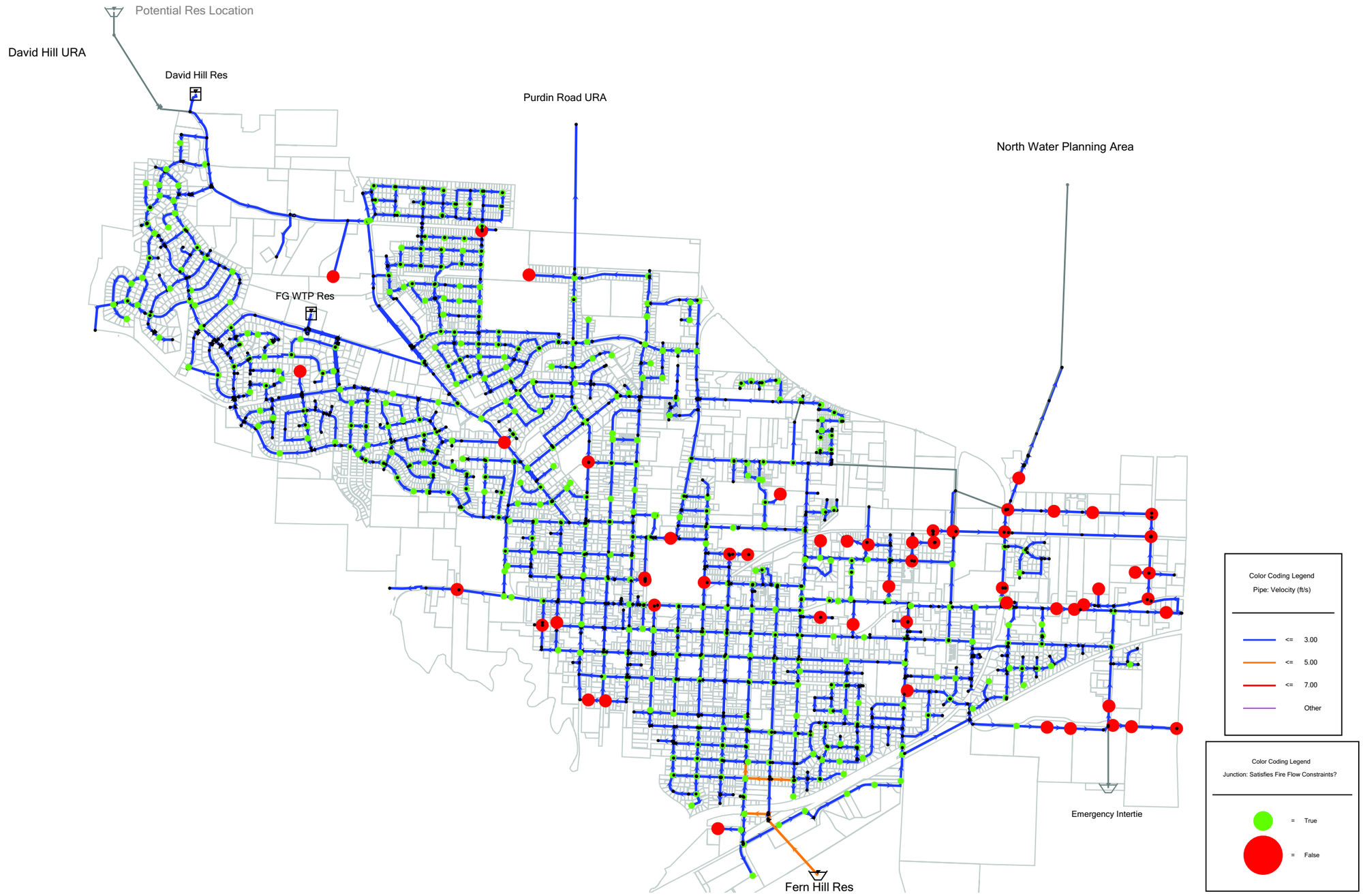
Appendix F

Hydraulic Model Development and Output

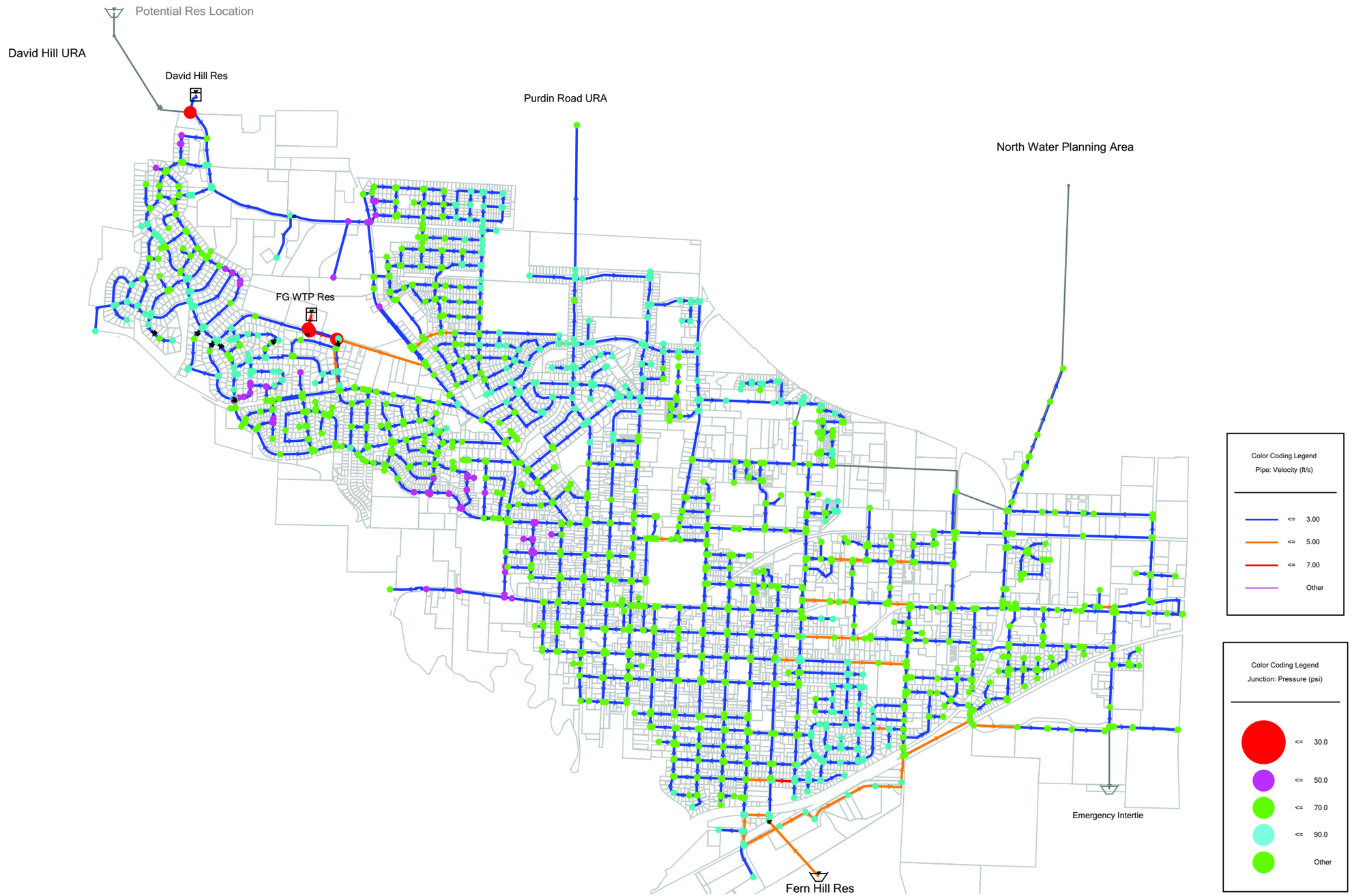
Scenario: Scenario 2 - MDD 2017 + Fireflow



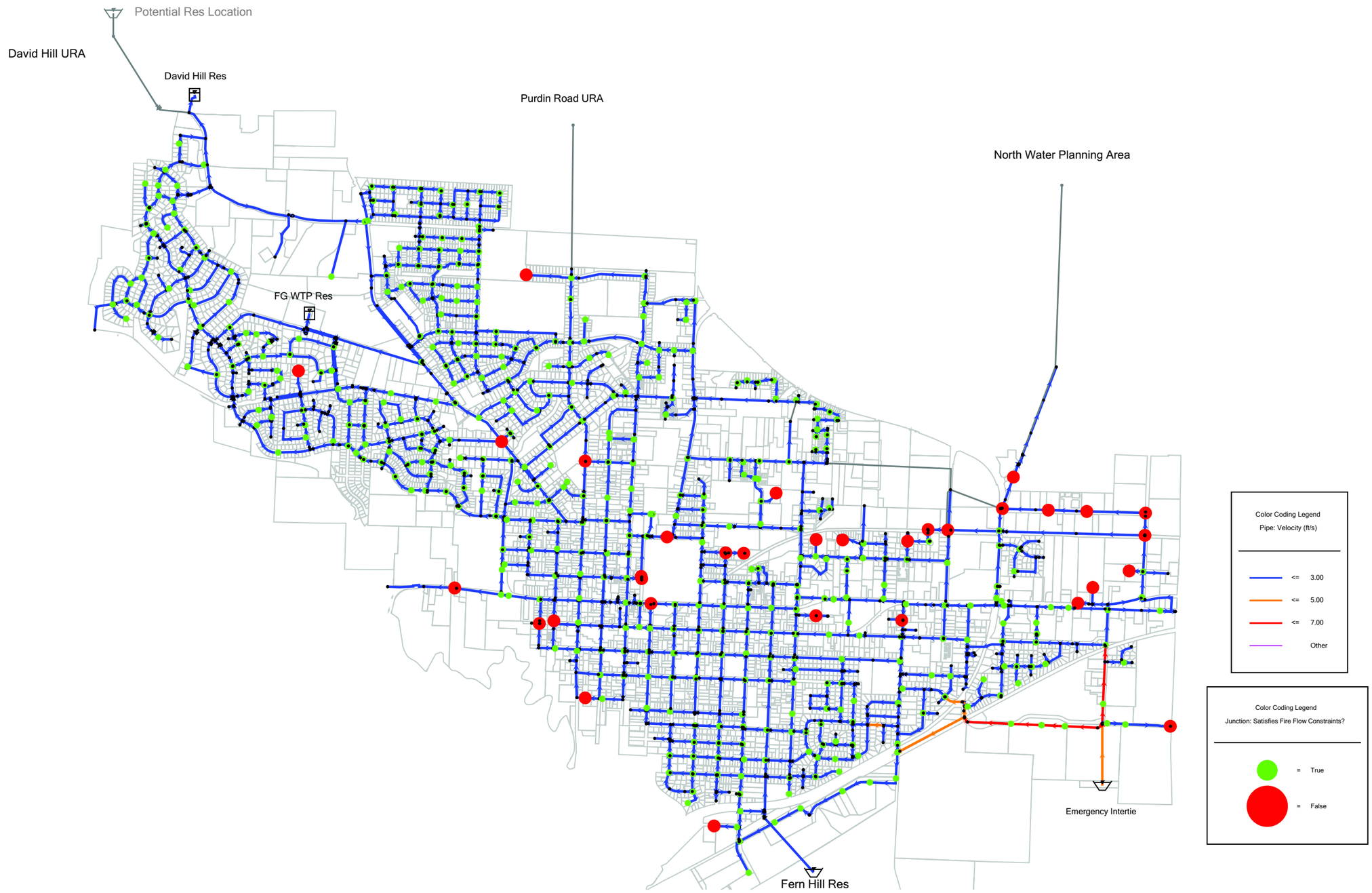
Scenario: Scenario 2 - MDD 2030 + Fireflow



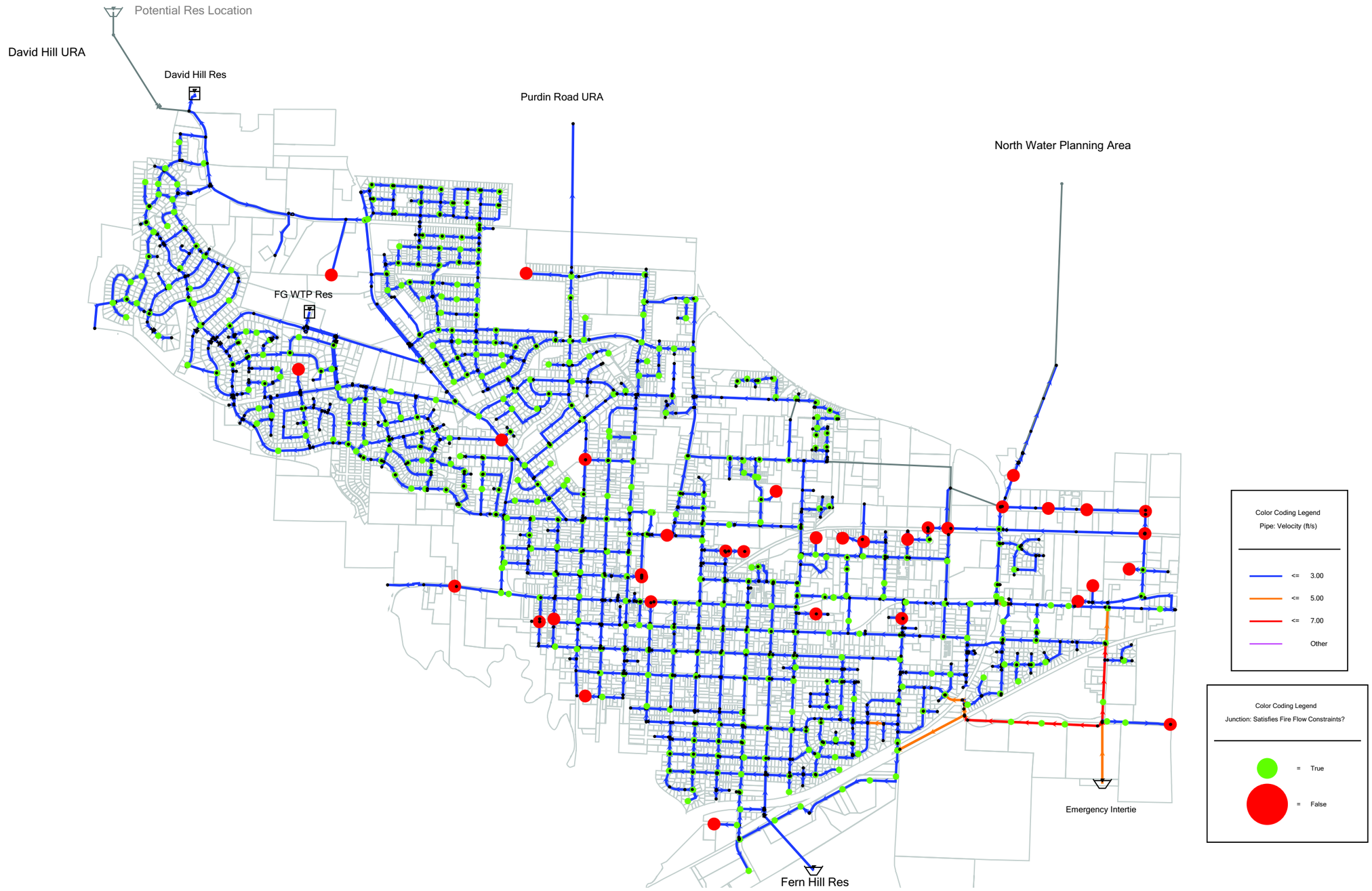
Scenario: Scenario 3 - PHD 2030



Scenario: Scenario 4 - ADD 2010 + Fireflow



Scenario: Scenario 4 - ADD 2030 + Fireflow



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