Executive Summary
Master Plan Update

This update was undertaken to revise the water storage standard. The changes listed below largely result from the storage change. Also, the population estimates used in the 1999 Master Plan have been adjusted to reflect census data and newer Geographical Information System (GIS) data.

Section 2:
The 1999 Master Plan estimated a build-out population of 38,000 and used a population of 32,000 (estimate for the year 2015 planning window) to size facilities. This has been revised by careful analysis of the available land by the City's GIS and using the latest census data. The new estimate for build-out is 29,611. The revised plan will design for facilities to build-out.

Section 3:
The water usage table, 3-1 was updated to reflect the four years since the 1999 plan. The overall usage rates are consistent. However, peak day usage in the Rosemont zone was observed in the summer of 2003 at a higher level as noted on page 3-3. This is a problem for the Rosemont zone because of its dependence on pumping.

Section 4:
As noted in section two, there is no longer a need for three planning horizons as the build-out population will be used to develop improvements.
Table 4-1 was revised to show that maximum fire flow demands will not be increased in the Bland, Robinwood and Rosemont zones. These values reflect historic levels and were concurred to by the Tualatin Valley Fire and Rescue.
The proposed storage criteria of 1.57 average demand days is presented here.

Section 5:
This section was updated to reflect project work completed since 1999. The intertie with Lake Oswego was improved (p 5-8), The Bland Zone was interconnected with the Horton zone (p 5-11), and the Horton pump station was upgraded (p 5-13).

Section 6:
The evaluation of the existing system was generally updated to reflect maintenance and work accomplished since 1999. Specifically, the transmission main crossing the I-205 bridge was upgraded (p 6-2), Horton reservoir was recoated (exterior) and the foundation repaired (p 6-2,3), Bolton and Horton pump stations were improved with extra capacity and back-up power (p 6-4), and Willamette pump station was improved with back-up power (p 6-5).
The comparison of the storage reservoirs to planning criteria portion (p 6-7 to 6-10) was revised to account for the change in planning criteria from 1999 (with one average day emergency storage) to the proposed 1.57 ADD standard. The 1999 plan shows an existing deficiency of 3.0 Million Gallons (MG), and a deficit of 4.6 MG at year 2015. Using the revised criteria, the deficit at build-out is 1.01 MG (p 6-10).

The vulnerability and risk assessment portion (p 6-13 to 6-20) was updated to reflect the seismic upgrade of the transmission main crossing the I-205 bridge and remove reference to Oregon City storage used by South Fork.
Table 6-6 was updated to show the updated capacity of the Horton pump station and the additional pumping needs for the Bolton and Horton pump stations because of the lack of storage for the Rosemont zone (775 gpm extra at Bolton, 920 gpm extra at Horton).
The role of the Lake Oswego intertie pump station is reviewed on p 6-35. Notwithstanding the inherent reliability of stored water over pumped, the intertie provides the equivalent of 1.09 ADD storage currently (firm pumping capacity) and 0.80 ADD storage at build-out (firm) with up to 1.28 ADD available (both pumps running). The agreement with Lake Oswego governing the intertie has been updated and adopted by all parties.

Sections 7-10:
These sections deal primarily with the capital projects and are not updated except for the project list. Attached is the Capital Maintenance and Improvement Project list for the revised master plan. The 1999 plan did not include maintenance projects. Other changes are the reduced reservoir sizes, a new pump station at View Drive for the Rosemont zone, the new 30" transmission main across the I-205 bridge has been removed, and projects have been updated to reflect current conditions.

Section 1
Introduction

The City of West Linn currently receives its water as a wholesale customer of the South Fork Water Board (SFWB). SFWB is an ORS 190 (Intergovernmental Agreement) agency jointly owned by the cities of West Linn and Oregon City. The source water is the Clackamas River. The SFWB operates a conventional water treatment plant. This plant is located on the south side of the Clackamas River near its confluence with the Willamette River. The SFWB system includes an intake, the water treatment plant, and a transmission pipeline to a pump station located on Division St. in Oregon City. The City of West Linn's water system includes:

- a master meter from the SFWB system,
- a single 24" transmission line from the Division St. Pump Station which crosses the Willamette River on the I-205 bridge,
- approximately 100 miles of distribution and transmission pipelines,
- six reservoirs, three pump stations, 17 pressure reducing valves, and other facilities.

The City also maintains an emergency intertie with the City of Lake Oswego from its water treatment plant which is located in West Linn.

The City of West Linn undertook a comprehensive analysis of its water system in the 1982 (Comprehensive Water System Plan; Murray, Smith and Associates, 1982). A brief update to that plan was prepared in 1987 (Murray, Smith and Associates, 1987). The 1982 plan projected growth in water demand to 7.85 million gallons a day (mgd) by the year 2000 and identified over $6,000,000 in projects which needed to be built to meet those demands. While some of those projects have been built and are in operation, others from the 1982 plan remain to be constructed. In June of 1996, the West Linn Water Rate Review Task Force (WLWRTF) recommended, as one of twelve recommendations, "that a new water master plan should be developed and followed...". This Master Plan fulfills that recommendation. This Master Plan is also required to partially fulfill the requirements of Goal 11, Public Facilities and Services, of the State of Oregon land use program. This Goal requires the City " to plan and develop a timely, orderly and efficient arrangement of public facilities and services to serve as a framework for urban and rural development".

This Master Plan is intended to be a recommended plan and long-term guide for the development of the City's water system. It is not intended to be a specific list of required projects. While projects are listed in this Master Plan as being scheduled for construction in a given year, this is intended only to provide a general guideline of priorities, relationships between projects, ties to levels of growth, and understanding of maintenance priorities. Each year the City should review the Master Plan and adopt a

specific Capital Improvement and Capital Maintenance Program which incorporates the general guidelines of the Master Plan into the specific activities for that year. The Master Plan should also be reviewed and updated every five years to account for changing circumstances and new information.

The Draft of this Master Plan was reviewed by the Oregon Health Division (OHD), the State regulatory agency for drinking water systems. In a letter dated June 1, 1998, OHD found that "...this Master Plan meets the criteria of OAR 333-61-060 (5), and is approved" (Curry, 1998).

This update was undertaken primarily to implement a new water storage standard. The plan was generally updated to reflect the latest information and completed projects.

SCOPE OF WORK

The general scope of work for this project was to update the Water Master Plan. The scope included tasks to:

- Review and develop new forecasts of population and water demands,
- Develop planning criteria to be used in evaluating the existing system and future system expansions,
- Evaluate the existing system for deficiencies compared to the planning criteria,
- Identify the system improvements needed to support anticipated growth and development and provide means to anticipate system improvements before growth is constrained,
- Prepare a Capital Improvement Program and a Capital Maintenance Program based on the evaluation of existing and future facilities,
- Prepare a study of unaccounted-for water and make recommendations to reduce the level of unaccounted-for water,
- Conduct a public involvement program associated with the development of the Master Plan.

Determining water system rates or financing mechanisms were not a part of the Scope of Work for this Master Plan.

The South Fork Water Board, which supplies water to the City of West Linn, recently completed a Water Master Plan for its system (Montgomery Watson, 1997). The SFWB Master Plan covers the supply system for the City of West Linn and should be read in conjunction with the City's Water Master Plan to obtain a complete picture of the

City's water system. Improvements and other recommendations from the SFWB Master Plan are not repeated in this document.

AUTHORIZATION

Montgomery Watson was selected to prepare this Master Plan by the City in response to a Request for Proposals from the City of West Linn dated October 10, 1996. A contract authorizing the work was signed and dated January 27, 1997.

Section 2
Population Forecast

Water demand forecasts generally rely on estimating two key parameters - the population that is to be served and the amount of water each member of that population is likely to consume. The level of effort and sophistication that goes into estimating those two parameters can vary substantially. At one end of the spectrum are detailed econometric models that relate specific consumption patterns to individual types of water users and uses and forecasts future populations based on many trends. At the other end of the spectrum are simple calculations using broad regional averages of consumption and population growth. While the level of data and other information that is required across this spectrum of approaches varies, the need to estimate the two fundamental components of the forecast remains constant in all approaches. This Section provides the estimate for population that will be used in the West Linn Water Master Plan.

ESTIMATED CURRENT AND PROJECTED POPULATION

Using its Geographical Information System (GIS), the City of West Linn conducted an in-depth analysis of the projected growth using updated information on zoning vacant land, City growth policies and development potential (City of West Linn Planning Department, Unit Tracking Report, December 23, 1999 - latest update January 29, 2003). The household unit count provided by this report was converted to a population by using census data from the Center for Population Research and Census, Portland State University (PSU). This census data indicates that single-family (SF) households average 2.760 people and multi-family (MF) households average 1.537 people. As of Jan 1, 2003 the population was calculated to be 23,730.

Table 2-1 shows the result of the Unit Tracking report and the population using the PSU data. "Lots of record" refers to existing subdivided lots, currently without housing units, that may be built on without additional Planning Department approval. The Unit Tracking report estimates a build out population of 29,610 (9,073 SF and 2,972 MF) with an average of 2.453 people per household. (The tracking report provides an upper range of build-out population, estimated assuming a persons per household figure of 2.65 (a previous estimate from PSU). The population using this number is 31,919).

TABLE 2 - 1
CITY OF WEST LINN
JANUARY 1, 2003 POPULATION DATA

Zone	Number of Single-Family Households	Number of Multi-Family Households	Lots of record	Potential Lots	Current Population[1]	Population with Lots of Record	Build-out Population
Horton	1974	234	243	463	**5,808**	**6,404**	**7,540**
Rosemont	1530	686	121	492	**5,277**	**5,574**	**6,781**
Willamette	1356	599	32	393	**4,663**	**4,742**	**5,706**
Bolton	1213	577	75	257	**4,235**	**4,419**	**5,049**
Robinwood	655	40	39	122	**1,869**	**1,965**	**2,264**
Bland	550	234	44	118	**1,878**	**1,986**	**2,275**
TOTAL	**7278**	**2370**	**554**	**1845**	**23,730**	**25,089**	**29,610[2]**

1. Current population includes 66 units (182 people) outside current city limits but receiving water service.
2. Build-out population presented in Unit Tracking report as a range from 29,610 to 31,919.

Recent historical population estimates for the City of West Linn are also available from data provided by the Center for Population Research and Census, Portland State University (PSU). The PSU data represents estimates of population on July 1st of each year within the West Linn City limits. Their estimates are based on census counts published by the U.S. Census Bureau every ten years. Annual estimates between census counts are derived by analyzing supplemental data, including economic changes, building permits, vehicle registrations, annexations, and other data. The PSU population estimates for the City from 1991 through 2002 are shown in Table 2-2.

TABLE 2 - 2
West Linn City Limits
Recent Historical Population Estimate
PSU Data Base

YEAR	POPULATION	% ANNUAL GROWTH
1991	17,160	-
1992	17,645	2.83
1993	18,185	3.06
1994	18,860	3.71
1995	19,370	2.70
1996	19,960	3.05
1997	20,415	2.28
1998	21,405	4.85
1999	21,900	2.31
2000	22,440	2.47
2001	23,090	2.90
2002	23,430	1.47

PREVIOUS POPULATION ESTIMATES

The last time the City of West Linn conducted a comprehensive Water Master Plan was in 1982 (Murray, Smith & Associates, 1982). At that time, the 1980 census population for the City was 12,956 with an estimated additional 300 persons served by the water system but outside the City limits, for a total of 13,256 persons served by the water system.

There have been several previous forecasts of population for the City of West Linn. The 1982 Water Master Plan (MSA, 1982) forecast a year 2000 population of 23,100 based on the West Linn's Comprehensive Plan in effect at that time and the rate of growth in the late 1970's and early 1980's. It also forecast an ultimate build-out population of 58,000 persons, again based on the City's Comprehensive Plan at that time.

In 1996, the City updated its System Development Charges (SDCs). That report (Financial Consulting Solutions Group, 1996) utilized the 38,200 build-out population from the 1989 Sewer Master Plan and assumed that 85% of that population would be achieved by the year 2015. That resulted in a year 2015 forecast population of 32,470.

The population calculations prepared for the 1999 Sanitary Sewer Master Plan Update (Bookman-Edmonston, 1999) forecast a build-out population of 29,397 occurring by the year 2017. To be conservative, a build-out population of 32,000 was used.

In addition to maintaining a detailed data base of the population, households and employment in 1994, Metro also prepared a Portland metropolitan region forecast of population for the year 2015. This forecast was prepared based on a detailed evaluation including employment, demographic, and growth data. This forecast was prepared on a region-wide basis. Once this forecast was completed, Metro went through a process of allocating the growth predicted by that forecast, to specific communities within the region. This allocation does not represent a direct forecast of the growth in the community. Instead, it is a reasonable proportionate share of the forecast regional growth. Metro projected a 2015 population of 25,731 including all persons served by the West Linn water system, both inside and outside the current City limits. They do not include population for any future areas that have been designated by Metro as areas of future urban growth, called urban reserve areas (URAs).

SUMMARY OF POPULATION ESTIMATES

While there is uncertainty in the build-out projection, there is even more uncertainty in the rate at which or the pattern in which this build-out will be attained. Of all the forecasts for the year 2015, the Metro 2015 allocation provides the lowest estimate, at less than 26,000 persons. The historic rate of growth in the City provides an estimate of between 28,000 and 32,000 persons by 2015. The analysis of potential for development of open lots within the City provides an estimate of between approximately 29,000 and 32,000 people at build-out. This is consistent with the population estimate of the 1999 Sewer Master Plan. The recommended population for water system analysis will be the same with build-out anticipated in the next 20 years.

Section 3
Water Demand Projections

In Section 2, the population for the City of West Linn was forecast. In this Section, those population projections are utilized along with historical water demand information for West Linn to forecast future water demands. These demand forecasts will be utilized in the facilities planning for the Water System Master Plan.

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

As indicated in Section 2, the level of effort and sophistication that goes into estimating water demands can vary substantially. The demand projection in this Section relies upon historical information from the City and engineering judgment. In making a projection, it is important to understand the use of that projection. For this Water System Master Plan, the demand projections must be large enough so that the facilities that are planned will be adequate to cover future water needs in the community. At the same time, the demand forecast must not be too large, as then the planned facilities will also be too large, and unnecessarily expensive. The balance between these two concerns must be found. It is also important to understand that these projections are for planning purposes only. The final sizing and capacity of the recommended facilities should be evaluated against growth trigger points and reviewed during individual project predesign to determine their appropriate sizing and other design criteria.

HISTORICAL WATER DEMANDS

As described in Section 1, the City of West Linn receives its water supply from the South Fork Water Board (SFWB). Table 3 - 1 summarizes the SFWB's supply meter records for West Linn from 1991 through 2002.

Water supply from the SFWB to the City of West Linn is metered through a master meter owned by the City. The City of West Linn's Supervisory Control and Data Acquisition (SCADA) system records daily total flows as well as instantaneous minimum and maximum daily flows. Annual, maximum monthly and maximum daily production data are shown in this Table. The population values in this Table are from the Center for Population Research and Census at Portland State University, for the city limits of West Linn as listed in Table 2 - 2, with the addition of an estimated 560 persons served

by the water system outside the City limits added for 1995 and 1996. Per capita demands are calculated by taking the production numbers and dividing by the corresponding populations. Included within these per capita usage rates are all water uses including residential, commercial, municipal, industrial, institutional, and unaccounted-for water.

These per capital consumption figures are calculated as a City-wide average. There may be significant variation in per capita consumption within areas of the City depending on nature of the development present, the amount of new development compared to established development, and other factors. Per capita consumption figures could be developed by individual service zone areas if the City's water system had supply meters to record the amount of water used in each zone. While the City has several such meters at the outlet of pump stations, it does not have these meters system-wide. While such meters would be useful from the perspective of understanding system operation, they are unlikely to be cost-effective to install solely for this purpose.

As can be seen in Table 3 - 1, the peak day per capita consumption in West Linn varies considerably over this period, from a low of 249 gpcd to a high of 335 gpcd. For comparison purposes, the peak day per capita consumption over the same period for Oregon City varied from 285 to 381 gpcd. For 1994, the per capita consumption in the South service area of Clackamas River Water was 342 gpcd.

Table 3 – 1
West Linn Historical Water Demand Summary

					Per Capita Demand, gpcd		
Year	Population Served	Annual Average of Daily Demand (mgd)	Maximum Monthly Demand (mgd)	Maximum Daily Demand (mgd)	Average Annual	Maximum Monthly	Maximum Daily
1991	17,160	2.51	4.25	5.33	146	248	311
1992	17,645	2.62	4.53	5.59	148	257	317
1993	18,165	2.47	3.67	4.52	136	202	249
1994	18,860	2.85	4.92	6.31	151	261	335
1995	19,930	2.72	4.47	5.72	136	224	287
1996	20,520	2.84	4.75	6.5	138	231	317
1997	20,975	2.79	4.52	6	133	215	286
1998	21,965	2.99	5.38	6.54	136	245	298
1999	22,200	3.09	5.08	6.21	139	229	280
2000	22,740	3.16	5.75	6.79	139	253	299
2001	23,390	3.29	4.97	6.17	141	212	264
2002	23,730	3.26	5.79	6.79	137	244	286
				Ave:	140	235	294

Water consumption is primarily residential. The approximate distribution of water consumption by customer class over the period of 1990 to 1995 is shown in Table 3 - 2.

Table 3 -2
Distribution of Water Consumption by Customer Class

Customer Class	Percent of Total Consumption
Single Family	**80**
Multi-Family and Apartments	**9**
Commercial	**5**
Irrigation	**1**
Public Facilities	**5**

WATER DEMAND FORECASTS

Per Capita Consumption

The water demand forecasts that are developed in this study will be used in the planning of future upgrading and expansion of the City of West Linn's water supply system. If the water demand forecasts are too far above the actual future water demand, then there is a danger that the facilities that are planned for the future will be larger and more expensive, than needed. If the demand projections are too far below the actual future water demand, then there is the danger that the facilities that are planned for the future will be inadequate.

Predicting future water use has several inherent uncertainties. Per capita consumption in a community is influenced by many factors and can vary widely even between adjacent neighborhoods. Among the factors which cause this variability are the relative mix between residential, commercial and industrial users; the amount and type of landscaping; the area of lots which is irrigated; the use of automatic irrigation systems; the kind of irrigation systems that are used; the age of plumbing facilities in homes; the size of families in the neighborhood; and the amount of multifamily housing compared to single family housing. Indeed, a recent calculation of peak day per capita demand in the Horton and Rosemont pressure zones within the City showed a variation of approximately 225 to 375 gpcd between the two zones. A peak day usage of 404 gpcd was observed in July of 2003 in the Rosemont zone (overall usage that day was 311 gpcd). In addition, the peak demand in any given year is greatly influenced by the weather. The amount and frequency of summer rains and the temperature and duration of summer hot spells will vary substantially from year to year. Thus, the per capita consumption in any community can vary significantly from year to year as shown in Table 3 - 1.

Possible future changes in per capita consumption can occur due to conservation programs, the reduction (or increase) in unaccounted-for water, and changes in the mix of residential, industrial, and commercial water use. This latter change can occur if a large manufacturing facility were to locate in or leave the City. The water demand characteristics of future residential growth also may not replicate the water demand characteristics of historical residential use, due to differences in lot sizes, landscaping, and the number and nature of water using fixtures. Denser development tends to have lower per capita consumption than more spread out development. New neighborhoods tend to have higher per capita consumption than more established neighborhoods due to the construction activity, new lawns, and a greater prevalence of automatic sprinkling systems.

As shown in Table 3 - 1, the recent historical average daily per capita demand ranges from approximately 133 gpcd in 1997 to approximately 151 gpcd in 1994, a variation of about 10%. As can be also be seen from this Table, the estimated peak day per capita consumption for the City as a whole varied from a low of 249 gpcd in 1993 to a high of 335 gpcd in 1994, a variation of about 25 - 30 %. Three of the twelve years shown in this Table have a City-wide peak day consumption of around 315 gpcd and eight of the twelve years have peak day per capita consumption considerably less than 335 gpcd.

While the peak day per capita consumption can vary significantly from year to year due to the weather, there tends to be an upper limit in a community to the per capita consumption. Based on the distribution of the citywide values, it would not be unreasonable to expect peak day per capita consumption values up to approximately 5% higher than shown in this Table 3 -1 under extreme weather conditions. Thus, the City-wide peak day per capita consumption could be as high as around 350 gpcd in a particularly hot year, even though the historical high over the last several years has been 335 gpcd.

Recommended Per Capita Consumption

The decision as to which peak day per capita consumption value to use relates to the desired level of system reliability. There is often a relationship between the level of reliability and cost - higher levels of reliability require higher costs. As described in section 4 of this plan, equalization storage and pump station capacity is determined based on peak day usage. The reliability of local distribution system components, such as transmission and distribution pipelines and local pump stations and tanks, tend to be designed toward the upper end of a reliability range. Using a higher level for peak day per capita consumption provides a higher degree of certainty that even in the most extreme weather conditions, adequate water will be available. This higher consumption value will result in more costly facilities, however. Other methods of dealing with extreme peaks in demand include reliance on temporary curtailment of water use or interties to other sources.

If the high peak day demand of 335 gpcd that has been seen in the last twelve years were to be used for design purposes, it is likely that between one year in ten and one year in twenty will see a peak day per capita consumption higher than that value. If the 350 gpcd figure were to be used, it is likely that not more than one year in twenty would see a peak day per capita consumption greater than that value.
It is also anticipated that as denser development continues in the City and the effects of regional conservation measures take place, this level of per capita use should likely decrease. **Thus, for the ultimate build-out population projection for the City, the lower peak day per capita consumption figure of 335 gpcd is recommended. For the Rosemont zone, where equalization storage is not available, peak hour demand (versus average peak day demand) becomes an issue. For this zone, the measured peak hour demand registered on the day that usage was 404 gpcd will be used to determine the pumping capacity needed into the zone.**

TABLE 3 - 3
CITY OF WEST LINN
SUMMARY OF PROJECTED WATER DEMANDS

YEAR	2002	BUILD-OUT
POPULATION	23,730	32,000
PEAK DAY PER CAPITA CONSUMPTION (GPCD)	335	335
AVERAGE DAY PER CAPITA CONSUMPTION (GPCD)	140	140
AVERAGE DAILY DEMAND (MGD)	3.32	4.48
PEAK DAY DEMAND (MGD)	7.95	10.72

It must be recognized that these estimates are predictions based on the best information available at this time, and should be subject to continuous updating and adjustment based on the actual water demand that the City experiences over time.

Section 4
Planning Criteria

This Section presents the planning and analysis criteria that are recommended for the evaluation of the existing facilities and in planning any new facilities for the City of West Linn. It must be recognized that these planning criteria are not hard and fast rules that must be exactly adhered to in order to provide a reliable water system. They are simply standards by which the system can be judged for the purposes of planning capital improvement and capital maintenance projects under most circumstances. There may be instances where deviations from these criteria are reasonable and justifiable based on specific circumstances. In addition, it may be appropriate for the City to have specific Design Code requirements that deviate from these master capital planning criteria. The City should review its Design Code and determine whether changes are appropriate to it once this Water System Master Plan has been adopted.

PLANNING PERIOD

This Water System Master Plan considers two planning horizons. First, deficiencies of the existing system are identified. Then, a detailed evaluation is conducted for the expected population at build-out. The impacts on the water system of growth and development in the community are analyzed over this time period. Over the period to build-out, staging of facilities corresponding to incremental levels of growth are evaluated. Two population projections, a low and a high, were prepared for build-out. The Master Plan evaluates the system for both of these projections. Finally, the impacts of growth and development at anticipated ultimate build-out population and development of the City are analyzed. The population and water demand forecasts for these periods are given in Sections 2 and 3, respectively. Improvements should be timed based on the actual population growth which occurs and not on the specific years listed in this Water System Master Plan.

PLANNING AREA

The planning area for the Master Plan is the limit of the current City of West Linn water system. This includes all areas within the City limits and areas outside the City limits but within the Metro Urban Growth Boundary (UGB) in the Tanner Basin. The planning area does not consider impacts on the current water system of service to land in the Metro Urban Reserve Area (URAA) that is adjacent to the City of West Linn.

DESIGN CRITERIA

Service Pressure

The minimum pressure that must be maintained in the system per State of Oregon Health Division (OHD) standards is 20 pounds per square inch (psi) (46 ft). This pressure must be maintained even during a fire flow event on a peak demand day. The existing system has been designed around tank and reservoir elevations that typically provide maximum and minimum service pressures between 170 psi (393 ft) and 45 psi (104 ft) respectively. The typical operating pressures obtained from the existing tanks and reservoirs should be maintained. Each of these pressure conditions will be evaluated with system reservoir/tank levels three-fourths full.

Source

The main source of supply should be capable of providing the projected peak day demand. It should meet this demand with firm capacity - that is, with the largest pump, filter or other component of the system out of service. The City should also have an emergency source of supply that is capable of providing the average day demand for the length of time that the primary source of supply is out of service, such period lasting up to a week. This emergency source could be provided through an intertie, storage, a secondary source, or other methods.

Transmission Pipelines

Transmission pipelines are considered as those greater than or equal to 10-inches in diameter. Pipeline flow velocities in transmission pipelines should be less than 5 feet per second (fps). All water transmission pipelines greater than or equal to 24-inches in diameter should be capable of providing peak day demands. All other transmission pipelines should be capable of supplying peak hour demands.

Distribution Pipelines

Distribution pipelines should be sized to serve peak hour demands and fire flow requirements with system reservoirs/tanks three-fourths full. Flow velocities for a distribution system pipeline should be below 10 fps and headloss in the pipeline should be below 10 ft per 1000 ft of pipeline. Minimum pipeline diameter for new distribution pipes will be 6-inches. Pipeline diameters smaller than 6-inches will be identified as inadequate for fire flow conditions. Any pipeline below 6-inches should be upgraded before being equipped with a fire hydrant. A 6-inch line with a fire hydrant should be part of a looped system or be no more than 500 feet in length.

Pressure Reducing Stations

Pressure reducing stations should meet the criteria of supplying the peak hour demand within the continuous flow rating of the valve. The fire flows through a pressure reducing station should be adequately delivered within the intermittent flow rating of the valve.

Pump Stations

Pump stations should be sized for a firm capacity equal to the peak day demand. Firm capacity is defined as the capacity of the pump station with the largest pump out of service.

For reliability, power supplies to pump stations should have either two sources of primary power feed, or one main source and standby or emergency power. The secondary power supply should be sized so that available pumping capacity is equal to average day demand, or fire flow, whichever is greater.

Storage

Storage facilities in water systems are generally provided for four purposes - equalization storage, operational storage, fire storage, and emergency storage. The total storage required in any tank or reservoir is the sum of these four components plus the dead storage (the volume of the tank that is unavailable to use due to physical constraints). The components of storage are described as follows:

Equalization Storage

This storage is needed in a water system to meet water system demands in excess of the transmission/pumping delivery capacity from the supply source to the reservoir. The volume of equalization storage required is a function of supply system capacity, transmission piping capacity between reservoirs and pump stations, and system demand characteristics. Equalization storage is generally less expensive to provide than increased treatment, pumping and transmission piping capacity beyond that required to meet maximum day demands. Equalization storage volume should be sufficient to meet peak hour demands in excess of the maximum daily demand. Equalization storage volume in the amount of 20 to 30 percent of maximum daily demand is typical, and for this Master Plan, 25 percent of peak day demand is assumed for equalization storage.

Operational Storage

This storage may be needed if the supply source does not continuously deliver supply. Operational storage would be required, for example, if the supply system were only operated over part of a day with the supply coming from storage during the remaining part of the day. Indeed, the SFWB operates the supply system in this manner much of the year, running its water treatment plant overnight to take advantage of lower power rates, and then shutting the plant off during the day and supplying water to West Linn from storage. SFWB maintains storage for this purpose. The City of West Linn, however, does not operate its distribution system in a manner that requires additional operational storage beyond equalization storage, and thus, no additional operational component of storage is recommended in this Master Plan beyond that supplied by the SFWB.

Fire Storage

Fire storage is provided to meet the single most severe fire flow demand within the system or 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.

Residential fire flows are 1000 gpm for 2 hours and can be applied at any fire hydrant in the pressure zone. Commercial, industrial, and multi-family fire flows can be applied at any fire hydrant within areas that have appropriate land use zoning and may be specific to the zoning and actual facilities in place. The City has recently established a 3,000 gallons per minute (gpm), three-hour duration, fire flow throughout the City for commercial, industrial, and multi-family areas (Joiner, 1998). The current fire flow requirements are the result of recent building and fire code changes and efforts to retrofit West Linn schools with sprinklers that have allowed lower fire flows in some zones of the City. The Bland and Robinwood Zones, which previously had fire flow requirements less than 3,000 gpm, will be allowed to maintain those same fire flow requirements of 2,000 gpm for 2 hours. The Rosemont Zone will maintain its current fire flow requirement of 2500 gpm for 2 hours. No development will be allowed in these zones exceeding the approved fire flow.

TABLE 4 - 1
MAXIMUM FIRE FLOW DEMANDS BY PRESSURE ZONE

ZONE	FLOW RATE (GPM)	DURATION (HR)	VOLUME (MG)
Horton	3,000	3	0.54
Rosemont	2,500	2	0.30
Willamette	3,000	3	0.54
Bolton	3,000	3	0.54
Robinwood	2,000	2	0.24
Bland	2,000	2	0.24

Emergency Storage

This storage is provided to supply water from storage during emergencies such as power outages, equipment failures, pipelines failures or natural disasters. The amount of emergency storage provided can be highly variable and is dependent upon an assessment of risk and the desired degree of system reliability. Detailed vulnerability analysis and risk assessments are not within the scope of this study. However, a summary level vulnerability analysis and risk assessment was conducted for this Master Plan (see Section 6).

It is also desirable, although not required, that storage be provided from at least two separate storage reservoirs or is available through pumping or gravity from a secondary reservoir at a different elevation. This provides for continuous operations during maintenance, repairs or reconstruction or modifications to any single reservoir.

Proposed Storage Criteria

The water system at a minimum must be able to provide enough storage so to meet peak hour demands (equalization) and concurrently provide for fire flows. This minimum is equivalent to 1.21 Average Demand Days (ADD) system-wide for the City of West Linn. The existing system has been able to provide this level of storage and includes some excess capacity that is available as emergency storage in addition to that provided by Southfork and through the Lake Oswego intertie.

The proposed standard is to maintain the current level of storage, specified in Average Demand Days (ADD), adding capacity as needed for additional population. The standard is:

1.57 ADD based on the existing average per capita demand of 140 gallons per day. The population used; 25,089 as of Jan 1, 2003 (Table 2 – 1), includes undeveloped lots of record.

The standard is applied city-wide in recognition of the connectivity of the system. Bolton reservoir acts as a hub for the system and supplies water to each of the other reservoirs. Robinwood reservoir is the only reservoir that cannot share its storage with another reservoir. As shown in section 6, Robinwood reservoir provides approximately the proposed level of storage at buildout.

The demand level must be monitored on regular basis. If existing users were to change their usage the storage need will change. Also, the existing fire flow levels must be maintained.

Section 5
Existing System Description

GENERAL DESCRIPTION

As described in Section 1, the City of West Linn currently receives its water as a wholesale customer of the South Fork Water Board (SFWB). The City then maintains and operates the transmission and distribution system to its water customers.

SUPPLY SYSTEM

History of the SFWB

Prior to 1915, drinking water for the Oregon City area came from the Willamette River. As a consequence of a serious outbreak of typhoid in 1913, the Oregon City Commission formed the "Pure Mountain Water League" and directed it to find a new source of drinking water. In January 1914, the League recommended that the city draw its water from the South Fork of the Clackamas River by constructing a new water line from the proposed diversion to Oregon City. In March, the Oregon City Commission accepted the City of West Linn's request for a one-third share in the project. As a result, the South Fork Water Board (SFWB) was formed and voters passed a $325,000 water bond measure to construct the pipeline.

Under the supervision of the newly created SFWB, an 18-inch diameter pipeline was constructed to a site near Memaloose Creek, about 3,000 feet upstream from the confluence of the South Fork and the main stem of the Clackamas River, at an elevation of 820 feet. The first water began to flow by gravity through the system on October 7, 1915, supplying up to 3 million gallons per day (mgd). The only treatment provided to the water was chlorination.

In 1939 and 1940, the SFWB joined with the federal Works Projects Administration (WPA) to extend a new 24-inch pipeline upstream from Memaloose Creek to a point above a waterfalls known as "high falls" by means of a series of tunnels through the rock bluffs. This effort raised the system's intake to an elevation of 1,050 feet, increasing the water pressure and capacity available to users of the system.

By the early 1950's, population growth was causing a greater demand for water than could be satisfied by the capacity of the "Mountain Line". The option of constructing additional pipelines to the South Fork of the Clackamas River and to Memaloose Creek was compared to the option of constructing a new intake on the lower Clackamas River and a water treatment plant. Voters chose the lower Clackamas River option as less

expensive and more practical. The new water treatment plant was constructed in 1958 in the Park Place area near the intersection of Hunter Avenue and Forsythe Road. In addition to the treatment plant, facilities at that time included an intake just off Clackamas River Road, a pipeline up the hill from the river to the treatment plant site, a transmission pipeline from the treatment plant to Oregon City and West Linn, and a pump station to boost treated water to higher elevations of both Oregon City and West Linn.

The "Mountain Line" continued to supplement the SFWB water supply until October, 1985. At that time it was shut down because of escalating repair costs to the pipeline and because of failure of that water supply to meet strengthened federal and state drinking water quality standards for turbidity without costly treatment improvements. The water treatment plant on Hunter Avenue was expanded and modified in 1975 and 1986. In late 1996, a new water intake on the Clackamas River sized for 42.6 mgd with an initial firm pumping capacity of 21 mgd and improvements to the Division Street Pump Station for a firm pumping capacity of 17 mgd, were completed.

Clackamas River Basin Characteristics

The Clackamas River basin, which is used for supply by the SFWB, covers approximately 936 square miles south and east of metropolitan Portland. From its headwaters in the Cascades just south of Mt. Hood, the Clackamas River flows approximately 60 miles northwesterly to its discharge into the Willamette River near Oregon City. The basin extends to the divide of the Cascade Range.

There are a few reservoirs along the Clackamas including the largest, North Fork Reservoir, which are operated by Portland General Electric for hydropower. It is estimated that the average flow in the river is in excess of 1,550 cfs (1,000 mgd) and the minimum flow is approximately 450 cfs (290 mgd). In addition to the SFWB, Clackamas River Water, Southwood Park Water District, Lake Grove Water District, Glen Morrie Coop Association, Sunrise Water Authority, Oak Lodge Water District, as well as the cities of Gladstone, Estacada and Lake Oswego receive some or all of their drinking water from the Clackamas River.

While the drainage basin of the Clackamas River is significantly smaller than the drainage basins of the Columbia and Willamette Rivers, the basin is still subject to influences such as forestry, agriculture and urban land uses. Approximately 70 percent of the drainage basin is within National Forest areas. Forestry practices occur within these areas. Some agricultural activity is found within the basin as are some cities and industries. The lower reaches of the Clackamas are experiencing rapid growth and development which can influence overall water quality.

Information from Oregon Department of Environmental Quality (ODEQ) (Montgomery Watson, February, 1994) indicates there are no major point source discharges to the Clackamas River. Major domestic facilities are defined as discharging more than 1

million gallons per day (mgd) and/or serving a population greater than 10,000. However, ODEQ does identify 31 minor discharges from the various classifications (agricultural, domestic and industrial), 11 of which are stormwater industrial discharges and four are wastewater treatment plant effluents. All of the discharges are within the lower reach (30 miles) of the river, mostly upstream of the SFWB intake. The upper reaches are entirely within National Forests.

"Nonpoint source" pollution can be a significant contributor of the overall pollutant load to the Clackamas River and its tributaries during periods of rainfall. Forestry practices can introduce sediment from erosion and also herbicides and fertilizers associated with replantings. Although it has not been well documented in the Clackamas River system, agricultural land use has the potential to create water quality problems as well. These agricultural uses can include nurseries, crops, animal feed lots and dairies.

Raw Water Quality

The most comprehensive summary of information on the quality of the raw Clackamas River water is contained in the Regional Water Supply Plan (Montgomery Watson. February, 1994). General physical, inorganics, dissolved oxygen and nutrients, microbiological, organics, radionuclides, and taste and odor causing compounds for the period of 1988 through 1993 were summarized in that report.

The turbidity of the Clackamas River water is relatively low during the dry season and can fluctuate widely during the rainy periods of the year. During the floods in February 1996, the maximum turbidities that were recorded were over 500 NTU at river intakes. Typically, these high turbidities last for a few days depending upon the severity and duration of the rainfall event. Minimum turbidities are approximately 1 to 2 NTU during the summer months. The pH of the Clackamas River fluctuates throughout the year. Typically, the pH decreases during winter as rainfall increases and the pH increases during the summer months. Normal pH values appear to fall within the range of 7.0 to 8.3 most of the year. The temperature of the river water varies according to the season. Normal wintertime lows are 5°C and normal summertime highs are 21°C, but extreme temperatures of 1.0°C and 24°C have been recorded.

Tables 5 - 1 and 5 - 2 present summaries of inorganic water quality parameters for which monitoring occurs on the Clackamas River. The inorganic parameters of concern include some which are regulated under Federal and State drinking water regulations and some which are not.

The primary sources of bacterial loading to the river include wastewater treatment plant discharges, surface runoff from urban and agricultural sources, and storm water discharges. Raw water bacteriological water quality on the Clackamas River is monitored by the Clackamas River Water plant to define a baseline and for trending. Limited monitoring data collected by ODEQ in 1987 at the Highway 213 bridge

indicated that fecal coliform concentrations in the river ranged from 3 organisms per 100 mL in June to 2,400 per 100 mL in September.

TABLE 5 - 1

GENERAL INORGANICS CONCENTRATIONS IN THE CLACKAMAS RIVER

Data From Water Treatment Plants (1988 - 1993)

Parameter	Observed Range (mg/L)	MCL (mg/L)
Alkalinity	6.0 - 31.5	NA
Hardness	9.0 - 26.0	NA
Calcium	NR	NA
Magnesium	NR	NA
Sodium	2.13 - 4.1	NA
Potassium	NR	NA
Sulfate	NR	250*
Phosphorus	NR	NA
TKN	NR	NA
Ammonia	NR	NA
Chloride	0.5 - 5.3	250*
Manganese	0.005 - 0.01	0.05*
Silica	NR	NA
Iron	<0.005 - 0.087	0.3*
Aluminum	NR	0.05 - 0.2*

* These are secondary regulated compounds with suggested maximum limits. Aluminum was added as part of Phase II.

NA: Not Applicable
NR: Not Recorded

TABLE 5-2

REGULATED INORGANICS CONCENTRATIONS IN THE CLACKAMAS RIVER

Data From Water Treatment Plants On River (1988 - 1993)

Parameter	Observed Range (mg/L)	Federal MCL (mg/L)
Inorganics (Primary)		
Arsenic	<0.005	0.05
Lead	NR	treatment technique
Barium	<0.005	2
Cadmium	<0.002	0.005
Chromium	<0.005	0.1
Fluoride	<0.14	4
Mercury	<0.0002	0.002
Nitrate (as N)	NR	10
Nitrite (as N)	NR	1
Total Nitrate&Nitrite (as N)	0.13 - 1.3	10
Selenium	<0.002	0.05
Antimony	NR	0.006
Beryllium	<0.0005	0.004
Cyanide	NR	0.2
Nickel	NR	0.1
Thallium	NR	0.002

NR: Not Recorded

The only available data regarding radionuclides in the Clackamas River are routine laboratory tests for gross alpha radiation at the WTPs. All test results have indicated 0.0 pCi/L with a acceptable counting error of +/- 0.3 pCi/L. Routine samples of the finished waters have been analyzed for various pesticides, all of which were below detection limits.

Many regulated and many unregulated volatile organic compounds are routinely analyzed in the finished waters from the water treatment plants on the Clackamas. Test results indicate that all compounds have been below detection limits. Other toxins

like dioxins and furans have been monitored in the finished water at some of the water treatment facilities. None have been detected.

Watershed Management

During the late 1980s, various entities formed the "Clackamas River Watershed Management Program Task Force". These entities included the public water systems in Clackamas County, OHD and Clackamas County. The purpose of this task force was to develop a program for the Clackamas Watershed and to maintain and improve the watershed, which should result in the protection for the present and future generations. As a consequence of those efforts, a Watershed Council has now been formed. This Council has representatives of various stakeholders with an interest in watershed management in the basin, including several water suppliers. The Council now has funding for a part-time staff support person.

Water Rights

The South Fork Water Board holds five water rights on the Clackamas River and its tributaries. These rights are the most senior municipal rights on the river and its tributaries except for a small intervening right on the Clackamas River held by the City of Gladstone. All of the SFWB's rights pre-date a major instream right held by the Oregon Water Resources Department (OWRD). The total permitted withdrawal rate for all of the permits is 116.0 cubic feet per second (cfs) or 74.98 million gallons per day (mgd). During periods of low natural streamflows (summertime), the permitted withdrawals cannot be accomplished as there are insufficient streamflows to support the authorized withdrawal amounts. It is estimated that the actual maximum withdrawal rate for all five rights during such periods is 80.0 cfs or 51.71 mgd. At the present time, the SFWB has the right to withdraw at the new intake up to 66.0 cfs or 42.6 mgd. .

Existing SFWB Facilities

The South Fork Water Board owns and operates water supply facilities consisting of two river intakes on the Clackamas River, both of which include a raw water pumping station, a water treatment plant located in the Park Place area of Oregon City, a finished water pumping station, and raw and finished water transmission pipelines. The SFWB also has a system control and data acquisition (SCADA) system to provide for system operation and control.

The SFWB recently (1996) completed construction of a new intake and raw water pumping station on the south bank of the Clackamas River directly north of the water treatment plant. The new intake is located on South Clackamas River Drive approximately 500 feet downstream of the old intake. The intake diverts water from the river and pumps it to the water treatment plant. The intake screens, structure,

mechanical, piping and electrical systems were designed for an ultimate nominal capacity of 42.6 mgd.

The raw water pumping station contains four vertical turbine pumps with space for a fifth pump. The present firm pumping capacity of the station with one of the largest pumps out of service is approximately 21 mgd. The intake structure is equipped with fish screens to prevent fish from entering the pump station wetwell. Under present regulatory requirements, up to 82 cfs or 53 mgd can be passed through the screens.

The SFWB's old intake and raw water pump station is located approximately 500 feet upstream of the new intake on the south bank of the Clackamas River. Presently, the SFWB is maintaining the facility in operating condition as an emergency standby intake facility to backup the new intake.

A raw water transmission main connects the new and old intakes to the water treatment plant. As part of the original system development in 1954, a 27-inch concrete cylinder pipe raw water transmission main approximately 1,800 feet in length was constructed between the old intake and the water treatment plant. This main is presently in service. As part of the construction of the new intake, a new 42-inch diameter steel raw water transmission main approximately 600 feet in length was constructed from the new intake easterly along South Clackamas River Drive, connecting to the 27-inch main.

The SFWB water treatment plant (WTP) is located along Hunter Avenue on a bluff to the south of the Clackamas River intake/pump station. The WTP, which has a rated production capacity of 20 mgd, was originally constructed in 1958 and improvements/modifications were made in 1975 and in 1986. Historically, the maximum day treated water production has been 18.3 mgd on August 11, 1996.

A 30-inch diameter finished water transmission main approximately 8,200 feet in length connects the water treatment plant to the Division Street Pump Station. The Division Street Pump Station, which was recently upgraded (1996), is located in Oregon City near the intersection of Division Street and Penn Lane. The station pumps finished water to Oregon City's Reservoir No. 2 through a 24-inch diameter transmission main. The present firm pumping capacity of the station with one of the pumps out of service is 17.0 mgd.

Transmission to the City of West Linn

The City of West Linn's connection to the SFWB system occurs on the discharge side of the Division Street Pump Station, through a master meter currently owned by the City and a 24-inch diameter transmission main. West Linn's data management system and the SFWB's SCADA system record daily total flows as well as instantaneous minimum and maximum daily flows. As part of the recent pump station upgrading, the SFWB constructed a pressure control station on the supply main to the City of West Linn directly across Division Street from the station. This system limits the maximum

pressure of the SFWB's supply at its point of delivery to West Linn so that the West Linn gravity system is not overpressurized during operation of the pump station.

The 24-inch diameter transmission main proceeds across the Interstate 205 bridge from the Division Street Pump Station and connects to the City of West Linn's distribution system at the west end of the bridge. The transmission system was designed to have a capacity of approximately 13 million gallons per day.

Emergency Intertie

In 1984, the Cities of West Linn and Lake Oswego and the SFWB entered into an intergovernmental agreement to construct, operate and maintain an intertie between the Lake Oswego water supply system and the West Linn and SFWB system. An 18-inch diameter intertie between the Lake Oswego system and the 24-inch diameter transmission line in West Linn was constructed. The intertie was improved in 2001 with the addition of a Pump Station with two pumps rated at 2200 gpm each and the plumbing for a third pump.

Activation of the intertie may be accomplished only by the mutual consent of the involved parties. The pump station provided water to West Linn from November 2001 to April 2002 during the I-205 transmission main upgrade.

DISTRIBUTION SYSTEM

Distribution System Water Quality

As a public water supply system (ID Number 4100944), the City of West Linn must comply with the drinking water regulations administered by the Oregon Health Division (OHD). Part of these regulatory requirements include a periodic sanitary survey conducted by the State of Oregon to review the operating condition of the water system. The most recent survey was completed by the State in March, 2002 and concluded that (Letter dated March 12, 2002 from Debra Lambeth, to Jim Whynot):

> "The water system appears to be in good operating condition and well maintained. No significant deficiencies were noted."

The City completes all the distribution system monitoring which is required by the State as well as additional tests which are needed to confirm adequate system operation:

- Distribution coliform samples are taken twice a month from thirteen sites spread throughout the City. No violations of the coliform rule have ever occurred.
- Chlorine residuals are taken along with the coliform monitoring. One chlorine residual and one pH measurement is taken in the distribution system daily. Chlorine residuals typically range from 0.7 to 1.2 mg/l, with the low in 1996 of 0.3 mg/l. This

is well above the regulatory requirement of maintaining a detectable residual at all times.

- Synthetic organic compounds, pesticides, herbicides, asbestos, inorganic contaminants, and radionuclides have all been monitored for as required by the State, with no problems detected.

- West Linn has received approval along with Oregon City and the SFWB for consolidated monitoring and compliance with the Lead and Copper Rule. The systems have qualified for reduced levels of monitoring based on the low levels found in previous samplings. Ongoing pH monitoring is being used to assure operational adequacy of the corrosion treatment.

- Over the period of 1992 through 1996, Total Trihalomethane levels in the distribution system of West Linn ranged from 15 to 40 ug/l, with most of the values in the range of 20-30 ug/l. Current regulatory requirements are 80 ug/l. The City is also monitoring Haloacetic Acids (HAA's) which became regulated in 1998.

The Safe Drinking Water Act (SDWA), the federal legislation which governs all water systems, was reauthorized in 1996. Over the next several years a number of new regulatory requirements for the City will come into effect as a consequence of the revised statute. Examples include the HAA regulations referred to above and a requirement for distribution of a Consumer Confidence Report summarizing water quality information about the water system, which has been distributed to all customers every year beginning in 1999.

The City conducts a water quality customer complaint program. When customers call with complaints, a complaint form is completed which records the type of complaint, location, and other pertinent information. A field investigation may be conducted if warranted. The City also maintains a cross-connection control program. It has adopted standards by ordinance and maintains an annual testing and inspection program using certified testers.

Pipelines

The distribution system network is comprised of over 104 miles of pipes in sizes up to 24-inches in diameter. The pipe types include asbestos cement, cast iron, ductile iron, copper, steel, polyvinyl chloride, and galvanized iron. The oldest pipes in the system probably date back to 1915 when the SFWB was first developed. Table 5-3 summarizes the amount of pipeline which is present in the system by the diameter of the pipe.

Table 5 - 3
Summary of Pipeline Sizes

Diameter	Lineal Feet in System	% of Total Pipeline
Less than 6-inch	70,145	13.0
6	253,812	46.2
8	108,300	19.7
10	33,780	6.0
12	16,503	3.0
14	14,742	2.7
15	9,659	1.7
16	16,159	2.9
20	3,447	0.6
24	14,626	2.7
TOTAL	549,575	100

Reservoirs and Tanks

The system has a total storage capacity of 5.5 million gallons spread across six storage reservoirs and tanks. Table 5 - 4 summarizes information about these reservoirs.

Table 5 -4
Summary of Reservoir Capacities

Name	Year Built	Capacity (million gallons)	Type	Overflow Elevation (ft)	Diameter (ft)	Height (ft)
Bolton	1913	2.0	Concrete on grade, with liner and cover	440		
Horton	1974	1.5	Steel, On Grade	730.5	80	40
Rosemont	1991	0.4	Steel Tower	860	53	110
Bland Circle	1981	0.5	Steel, On Grade	585	43	48
Willamette	1970	0.6	Steel, On Grade	351	48	43
View Drive	1967	0.5	Steel, On Grade	328	60	24

The Bolton Reservoir, located on Skyline Drive, was constructed in 1913 as part of the original supply from the SFWB. It is a concrete slab-on grade reservoir with 2:1 (horizontal : vertical) side slopes. A liner was installed in 1989. Prior to the liner

placement the floor panels were patched on an ongoing basis. Areas of exposed rebar in the floor were patched just prior to the Hypalon liner placement. A Hypalon cover was placed over the reservoir in 1995. The floating cover is equipped with an access hatch. Piping serving the reservoir consists of an 18-inch steel inlet/outlet pipe. An old 10-inch connection was abandoned due to a landslide northeast of the reservoir. The reservoir water surface is normally below the hydraulic grade line of the transmission line from the SFWB. All electrical and telemetry associated with the reservoir is at the Bolton Pump Station. The reservoir supplies water to the Bolton Pump Station in addition to its own Bolton Pressure Zone service area. The nominal 2.5 million gallon capacity of the reservoir is reduced to 2.0 million gallons available to the water system due to the position of the common inlet/outlet pipe.

The Horton Reservoir is located at the intersection of Horton Road and Santa Anita Drive. It is a ground level steel reservoir. The inlet pipe is 14-inch diameter and extends from the distribution system to the reservoir. A 14-inch outlet /suction pipe extends from the wall of the reservoir to the adjacent Horton Pump Station. This pipe exits the reservoir and goose-necks up to the Horton Pump Station at 4 to 5 feet above the floor elevation of the Reservoir. This configuration reduces the effective pump storage by approximately 190,000 gallons. A 10-inch pipe connects the inlet and suction pipes. The existing light for the reservoir site has been abandoned and a street light provides lighting for the reservoir. Telemetry consists of a level transducer located in the pump station instead of in the reservoir itself. The level has to be mathematically adjusted to read true water elevation. The reservoir is filled by the Bolton Pump Station and supplies water to the Horton Pump Station in addition to its own Horton Pressure Zone service area.

The Rosemont Tower is an elevated steel, spheroid tower located on Suncrest Drive. It supplies water to the Rosemont Pressure Zone service area. The enclosed area of the reservoir pedestal is used to house all electrical and telemetry systems for the reservoir. The apron also houses radio broadcasting equipment for fire and emergency calls. Piping for the elevated reservoir includes a single 18-inch ductile iron pipe from Suncrest Drive, a steel inlet/outlet and an overflow pipe inside the reservoir. The pipes extend vertically up into the spheroid. All visible piping systems appear to be in good condition and operating properly. Site access is through a small landscaped area. Site security is provided at the base of the pedestal with a locking door.

The Bland Circle Reservoir is a ground level steel reservoir located on Bland Circle and serves the Bland Pressure Zone. It is supplied by the Willamette Pump Station from the Willamette Reservoir. A 10-inch common inlet/outlet pipe serves the reservoir. A 10-inch gate valve is used to isolate the reservoir. The Bland Pressure Zone was connected to the Horton Pressure Zone with a manually operated intertie in the summer of 2003. This intertie is used to supplement the Bland Zone during peak usage with approximately 100,000 gal per day.

The Willamette Reservoir is a ground level steel reservoir located on Salamo Road in the Willamette area. Flow to the reservoir is through a 10-inch pipe. The reservoir serves the Willamette Pressure Zone and the Willamette Pump Station. A new altitude valve and vault were constructed on the inlet/outlet pipe to control flow into the reservoir. A 16-inch suction pipe extends out the south side of the reservoir and serves as the main suction for the pump station. A 14-inch by 10-inch cross has also been cut into the 10-inch inlet/outlet pipe and provides suction for the adjacent pump station if the reservoir is taken out of service. Site lighting is provided by a light mounted on the roadway above the reservoir and pump station. A chain link security fence extends only partially around the site.

The View Drive Reservoir is a ground level steel reservoir on View Drive in the Robinwood area. It serves the Robinwood Pressure Zone. Piping includes a common 10-inch inlet/outlet pipe which connect to a valve box near the reservoir. The vault contains two 10-inch pipes which tee off from the inlet/outlet pipe. One of the pipe runs includes an altitude valve to close the reservoir when full. The other pipe includes a check valve to allow water to flow out of the reservoir when the pressure in the system drops. The tank flow is regulated using an adjacent PRV and altitude valve located in the distribution system. Site improvements include a short gravel access and parking area and a chain link security fence. Limited access exists around the reservoir.

Pump Stations

The water system includes three pump stations. Information about those stations is summarized in Table 5 - 5. The nominal firm capacity is the capacity of the pump station with the largest pump out of service. The actual firm capacity may be less than the nominal capacity due to the fact that the rated flow of each pump individually may not be achieved when all pumps are in operation.

The Bolton Pump Station is located adjacent to the Bolton Reservoir and was constructed in the early 1970's. The facility consists of four (4) vertical turbine pumps mounted in the floor above a concrete clearwell. The clearwell of the station and the Bolton Reservoir are interconnected and supplied from an 18-inch transmission main which is connected to the 24-inch diameter transmission main from the SFWB. Above grade portions of the station are frame construction, with a wood truss roof and composition shingles. The roofing was upgraded in 1992. Upgrades to the pumps were performed in 1983. The Station pumps water to the Horton Reservoir through a 14-inch diameter transmission main. The level in the Horton Reservoir controls the pumps. The 6-inch pump discharge pipes include a plug valve for isolation and an angle pump control valve that provides the necessary startup head for the pumps.

Improvements to expand the Bolton Pump Station to meet future demands were completed in March 1999. These improvements consisted of constructing a new pump station at the site of the existing pump station. This new pump station was initially

equipped with two, 1,500 gpm pumps, along with space for future addition of two more 1,500 gpm pumps. The pump station also included a emergency, standby diesel generator to provide power in case of a power failure.

Table 5 - 5
Summary of Existing Pump Station Capacities

Name	Pump Configuration (gpm)	Total Installed Capacity (gpm)	Firm Capacity (gpm)*
Bolton**	3@ 750; 1@ 500; 2@1,500	5,750	3,325
Horton	2@ 1300; 2@ 1000	4,600	2,670
Willamette	3 @ 500	1,500	1,075
Intertie	2 @ 2200	4,500	2,500

* Measured capacity with largest pump off line.
** Includes capacity of both existing and new Bolton Pump Stations.

The Horton Pump Station is a concrete and frame structure located adjacent to the Horton Reservoir. Pumps 2 and 3 were replaced in 2000. Pump No. 1 was placed in service in 1974. Pump No. 4 was installed in 1991. A new composition roof was installed on the structure in 1996. The station pumps to the Rosemont Tower. The level in the Tower controls the operation of the pumps. Suction for the station is taken from the Horton Reservoir at a point 4 to 5 feet above the reservoir floor. Site improvements include the graded parking area around the pump station and the gravel access road. The back wall of the pump station serves as a retaining wall to support the back slope of the site.

The Willamette Pump Station is a concrete structure constructed in 1994 and located adjacent to the Willamette Reservoir. It pumps water to the Bland Circle reservoir that controls the operation of the pumps. The station has three vertical turbine pumps, which sit in pump cans mounted in the floor. The roofing system is a pitched truss support system with ribbed metal roofing. Suction for the station is taken directly off of the Willamette Reservoir, through a 16-inch pipe. A 14-inch pipe directly off of the reservoir inlet/outlet pipe can provide secondary suction flow.

Other Facilities

The system includes 17 pressure reducing stations, creating 13 subzones. These stations reduce the pressure from the main zones within the system to acceptable

levels in areas of lower elevation. These areas would have unacceptably high pressures if operated directly off the pressures of the main zones.

Instrumentation and Controls

The City recently completed installation of a new System Control And Data Acquisition (SCADA) system. This system is used to control and monitor the pumps, tanks, and other components of the water system. The SCADA system records flows, pressures, elevations and other information that is useful in controlling daily operations and understanding how the system works.

Meters

There are approximately 7,000 water meters throughout the water system. Over 96% of these meters are residential, 5/8 X ¾-inch meters. Most of the remaining meters are 1-inch, 1 ½ -inch, and 2-inch meters which serve multifamily, apartments, commercial, and public facilities. There are less than 20 meters system-wide that are 3 -inches or greater in size.

ORGANIZATION AND MANAGEMENT

Staffing

The West Linn system is operated by a Water Operations Supervisor, a water quality control person, and four water distribution system operating personnel. The Water Operations Supervisor reports to the Public Works Director, who has responsibility for sanitary sewers, storm water, solid waste and recycling, transportation, and vehicle maintenance in addition to water operations. Engineering support is provided by the Engineering Division of Public Works, which also supports the other operating functions of the City. Overall system management responsibility extends from the Public Works Director to the City Manager and the City Council.

The water system is classified by the State Health Division as a Water Distribution System - Level 3. The State requires that the operator of such a system have a Level 3, Water Distribution operator certification. The current Water Operations Supervisor has this level of certification. Other members of the water operations staff have Level 1 and Level 2 certification. Three of the operations personnel are also certified as Cross Connection Control Inspectors and one of them is certified as a Tester.

Standards, Codes, and Plans

The City maintains several sets of standards, codes and plans that are important for the long-term operation of the system. The City maintains Utility Design and Construction Standards that govern the installation of pipelines, fire hydrants, and other system components by developers and others who build pieces of the water system. It also maintains Water Regulations which describe rates, water shut-off procedures, water curtailment authorities, and cross connection control authorities. The City has adopted an operational policy for emergency response in the event of contamination of the City's water distribution system. The City also has a water curtailment plan for use in times of water shortages that describes which water uses will be curtailed under various circumstances.

Budget

The total yearly operating and maintenance budget for the water system is approximately $3,000,000. For the 2002 - 03 fiscal year, 31% of that budget was for payments to the South Fork Water Board for purchase of the water supply. The remainder of the budget goes to personnel costs for the water system employees and required ongoing training and certification (18%); utility bills to run the pump stations and other facilities (4%); materials for meter installation, main repair, facility repair and vehicle upkeep (5%); accounting and billing (4%); engineering and administrative support (6%); and various miscellaneous administrative and other costs (10%). In addition to the operating and maintenance budget, approximately $350,000 has generally been budgeted for Capital Maintenance Projects such as main replacement and reservoir painting.

Rates

The City currently bills its customers every other month. The units of measure which is used is a hundred cubic feet, or "ccf" (1ccf = 100 cubic feet = 748 gallons. The bimonthly charge by water meter size is shown in Table 5 - 6. A typical residential home has a ¾" meter. Included in the bimonthly charge is use of up to 14 ccf (10,472 gallons) of water. For each additional ccf of water use, a commodity charge of about $1.30 is incurred.

Table 5 - 6
City of West Linn Water Rates
June 2003

Meter Size	Bimonthly Charge*
¾"	$22.78
1"	27.00
1 1/2"	32.44
2"	39.58
4"	70.20
6"	104.40
8"	138.64
10"	174.02

* Includes 14 ccf per bimonthly period. Additional water use is $1.30/ccf

Table 5 – 7 summarizes a comparison of area water rates from communities which purchase water from a wholesale supplier. The comparison was completed December 17, 2003. The survey shows that although West Linn is at the high end of the wholesale rate paid for water, the typical residential and commercial water bill in West Linn is among the lowest of the surveyed communities.

Table 5-7
Comparison of Water Bills and Wholesale Water Rates
As of December 15, 2003

Community	Wholesale Rate ($/ccf)	Typical Residential[1] (10 ccf) Bill ($)	Typical Commercial[2] (50 ccf) Bill ($)
South Fork Water Board			
Oregon City	0.546	28.40	99.60
West Linn	**0.535**	**15.29**	**69.40**
CRW - South	0.648	31.45	75.00
Portland			
Gresham	0.716	24.64	94.30
Lorna Water Co	0.702		
Pleasant Home WD	0.744	22.50	103.70
Powell Valley WD	0.688	20.90	82.10
Rockwood WD	0.702	22.08	95.94
Burlington WD	0.867	40.5	160.5
Valley View WD	1.077	28.25	112.25
West Slope WD	1.048	29.33	127.60
Tualatin Valley WD	0.757	21.40	121.85
City of Tualatin	0.757	19.40	83.50
Clackamas WD			
Mt. Scott	0.52157	20.90	82.10
Oak Lodge	0.40625	15.40	82.64
Gladstone	.57286	14.59	58.57
CRW - North	na	18.75	64.50

(1) Assumes a 5/8" x ¾" meter
(2) Assumes a 1" meter

Fiscal Policies

The City most recently amended its fiscal policies in February, 1995. These policies call for the water enterprise fund to meet the operating obligations of the water system and for system development charges to fund additional increments of capital improvements to meet the needs of growth. The City is to adopt a Five Year Capital Improvement Plan each year.

Section 6
Evaluation of the Existing System

The City of West Linn's water system which was described in Section 5 was evaluated in several ways in this updated Water Master Plan. These methodologies included field inspection of key facilities; a comparison of key facilities to the planning criteria; a hydraulic model of the system; and a review of other issues and information. The results of these evaluations are given in this section. Capital improvements and other recommendations based on this evaluation are given in Sections 8 and 10.

FIELD OBSERVATION OF KEY FACILITIES

Elements of the City of West Linn's water system have been in service since 1913. As with any water system, on-going operations and maintenance efforts are required to keep the system functioning. As time goes by, system elements such as motors and control systems, valves and coatings can wear out or become obsolete, thus reducing the effectiveness of that segment of the system. In order to evaluate the current condition of some of the key components of the City's water system, qualitative, field observations were conducted on these key elements by Montgomery Watson personnel. Input was also obtained from West Linn water operations personnel, who accompanied Montgomery Watson on the field visits. The purpose of the evaluation was to observe the general condition of the facilities and to provide recommendations for potential improvements that need to be performed as part of the Capital Improvement and Capital Maintenance Programs. The observation reflects conditions as noted at the time of the fieldwork, July 1997 and updated as of Sept 2003. The observations are not intended to be a detailed evaluation, a safety inspection, or to serve any other purpose.

Criteria were defined for the evaluation prior to the inspection of the facilities. In general, the key elements of each type of facility, i.e. reservoir, were listed and a scoring system from 1 (worst) to 10 (best) was defined for each element. The elements of each facility were then field observed and rated. The field work sheets for each facility are included in Appendix C.

Facilities in the City of West Linn water system that were observed were the Bolton, Horton and Willamette Pump Stations; the Bolton, Horton, Rosemont, Willamette, Bland Circle, and View Drive Reservoirs; and two Pressure Reducing Valve Stations (PRVs).

Transmission Main

In early 1996, an analysis was conducted of the existing 24-inch diameter water transmission pipeline located on the I-205 bridge (MSA, 1996). This analysis identified several deficiencies to the pipeline, including excessive bowing of pipe support beams, potential inadequacy of the pipe support system under earthquake conditions, lack of catwalks and access ladders for personnel access on major portions of the pipeline, leaking pipe joint couplings, and the need for painting. A two-phase plan for repairs was proposed. The first phase would complete work that could be conducted with only minor shutdowns of the pipeline. The second phase would conduct work which requires extensive pipeline shutdown, but could not be accomplished until the City has adequate storage in West Linn, an alternative supply or agreement to use its intertie with the City of Lake Oswego for an extended period.

The work was completed in 2002, including improving the Lake Oswego intertie by adding a pump station so that the second phase could be completed.

Reservoirs

Bolton Reservoir

Both the liner and floating cover for the Bolton Reservoir appear to be in good condition and have 15 to 20 years of service life remaining. Exposed concrete shows some spalling and some localized cracking that may warrant some surface patching.

A separate inlet and outlet pipe would enhance circulation in the reservoir and possibly improve water quality, although maintenance personnel indicate the reservoir currently maintains a 0.8 mg/l chlorine residual. One method to enhance circulation of flow would be to extend the 18-inch inlet/outlet pipe farther into the reservoir and place a flap gate on the end of the pipe. A tee with a check valve would be placed in the pipe near the entrance to the reservoir. Inflow would enter the reservoir at the flap gate and outflow would exit at the check valve. The discharge area of the drain from the reservoir recently received some needed improvements.

The most serious issue concerning the Bolton Reservoir is the instability of the north slope of the reservoir, which exhibits evidence of previous landslide movement. On-going monitoring of this site shows no indication of instability.

Horton Reservoir

The exterior surface of the Horton Reservoir was repainted in 2002 and the ring footing resealed. Exposed piping appears to be in good condition and the piping and valves are all operating correctly. In 1999 divers verified that the reservoir lining is in good condition.

Large trees are on site behind the reservoir. Roots from these trees are growing under the reservoir and are beginning to affect the reservoir, lifting the ring footing. Grading around the reservoir to accommodate its painting in 2002 alleviated this problem.

Rosemont Reservoir

The ring footing, steel support columns, and steel shell of the Rosemont Reservoir all appear to be in excellent condition. The electrical and telemetry systems also appear to be in good condition. All visible piping appears to be in good condition and operating properly. Both the lining and coating system appear to be in good condition. A very small amount of biological growth (algae) is visible on the north side of the spheroid and pedestal.

Willamette Reservoir

The steel tank of the Willamette Reservoir appears to be in good condition. The steel plate and welds for the wall are in serviceable condition. Some slight spalling of the ring footing concrete is occurring. Cathodic protection was installed in 2002 when the reservoir was recoated (exterior and interior).

Exposed piping appears to be in good condition. Operations staff indicated that the piping and valves were all operating correctly. The site lighting provided by a light mounted on the roadway above the reservoir has limited effectiveness due to its location and a security fence extends only partially around the site. These could be improved.

Bland Circle Reservoir

The steel tank of the Bland Circle Reservoir appears to be in good condition. The steel plate and welds for the wall are in serviceable condition. This reservoir has a cathodic protection system. Field observations of the structure indicated some cracking of the ring footing concrete. The seismic anchor straps are located within 2 inches of the outside edge of the ring footing and do not appear to have adequate cover to avoid damage to the footing in a seismic event. Operations staff indicated that the piping and valves were all operating correctly.

Connections/splices for the area light wiring is exposed and may not meet code. An intrusion alarm is not included in the reservoir monitoring and should be added. The pressure transducer for level monitoring is mounted 4 feet above the reservoir floor and must be manually adjusted to true zero. This could be corrected.

The reservoir coating system is being attacked by biological growth (algae) and oxidation (UV and oxygen). Areas of the coating are showing rusting of the steel reservoir shell.

View Drive (Robinwood) Reservoir

The reservoir steel shell and concrete ring footing of the View Drive Reservoir appear to be in very good condition. Seismic anchors are included in the ring footing and also appear to be in good condition. Piping for the reservoir appears to be operating adequately. All elements of the electrical/telemetry system appear to be operating correctly. The exterior coating that was applied in 1991 appears to be in good condition. However, overhanging tree limbs are adding to the deterioration of the coating system.

Pump Stations

Bolton Pump Station

The existing Bolton Pump Station is a concrete and frame structure. It was undersized for current demands and was slated for improvement and expansion. The concrete condition appears to be good in the Bolton Pump Station for the age of the structure. The original plans do not show baffling between the pump suctions. Baffles would reduce the possibility of interference (formation of vortices) between the pump suctions, which are spaced close together.

The electrical system for the existing pump station was old and did not meet the latest Electrical Code requirements. Improvements were also needed to the power supply. The existing service was only 500 amps. Pump No. 1 has an older motor design that requires approximately twice the power as pumps No. 2 and 3. . Backup power source was inadequate. The construction of a new pump station at the site addressed these problems with the existing pump station. The new pump station was configured for four 1,500 gpm pumps to supply build-out need. Two of the pumps are installed, the third pump is planned to replace the existing pumps in the old pump station. The need for the fourth pump is anticipated at build-out. The old pump station will be phased out as new pumping capacity is added to the new pump station.

The old Bolton Pump Station shares the problem with the Bolton Reservoir of a potentially unstable slope to the north. This slope should be stabilized.

Horton Pump Station

The Horton Pump Station is a concrete and frame structure that appears to be in good condition. The Pump Station was upgraded in 1999-2000 with the addition of two new 1300 gpm pumps (pump no. 2 and 3) and the replacement of pump No. 1 with the old pump No. 2 (750 gpm). The new capacity is 2,670 gpm (firm). Additional improvements were made to the telemetry system and a backup power generator was installed.
Suction for the pump station comes from the Horton Reservoir through a suction pipe that exits the reservoir 4 to 5 feet above the reservoir floor. Lowering the suction to pull water off the bottom of the reservoir would add 170,000 gallons of reservoir capacity under pumping conditions.

Willamette Pump Station

The Willamette Pump Station is a concrete structure constructed in 1994. It appears to be in good condition, with electrical, telemetry, piping, and pumps systems functioning well. A backup power generator was installed in 2001 to provide power for all pumps.

Pressure Reducing Valves (PRV's)

While only two of the PRV stations in the system were inspected, operating personnel report that these facilities are, in general, functioning well. However, PRV's located below elevation 175 feet are experiencing flooding from high groundwater. Under flooded conditions it would be difficult to perform routine maintenance. Submerged water piping provides a potential for contamination entering the water system if leaks or other problems occur. Sealing PRV vaults and providing sump pumps to dry the vaults would improve this situation.

Recommended Improvements

Based on the field evaluation of these facilities, the following recommendations are made for Capital Maintenance and Capital Improvement Projects. It is recommended that several categories of ongoing projects be defined to implement the recommendations over time. Other, specific one-time projects are recommended and are listed below. In addition to these Capital projects, several ongoing operational and maintenance recommendations are made. These include pressure washing of reservoirs to remove biological growth, removal of tree roots and overhangs, lowering of level transducers to read reservoir level directly without adjustments, and routine exercising of key valves and natural gas drives.

Reservoir Lining and Coating Evaluation and Repair - Aging lining and coating systems on the reservoirs need to be evaluated to determine if they contain lead paint. The existing systems have been in service for more than 20 years. Most coating systems have a normal service life of 15 to 20 years and thus, the coatings on most all of the reservoirs are at the upper end of their service life. Paint systems of the 1970's were usually high in lead content. Recent health regulatory requirements limit the use of lead in paints and define rigid removal and disposal requirements for replacement of such coating systems. Coal tars were also used extensively in the 70's for lining systems. Coal tar does not now have approval for use in contact with drinking water systems due to carcinogens that may leach from the coatings.

The first step in upgrading the coatings on the reservoirs is an evaluation of the existing lining and coating material used for each reservoir. The evaluation would determine the potential hazards at each reservoir and look at the effort and costs for upgrading the coatings. Then, the coatings on each reservoir can be upgraded according to a defined schedule.

Reservoir Seismic Evaluation and Repair - The current level of structural restraints for seismic events varies considerably from reservoir to reservoir. A site-specific evaluation for each reservoir needs to be performed using the most recent seismic zone criteria. The evaluation would verify the structural anchorage needed to protect the reservoirs from damage or movement during a seismic event. Once the evaluation is complete, the repairs needed for each reservoir should be made.

PRV Vault Improvements - All of the Pressure Reducing Valves vaults that have high levels of groundwater in them should be sealed and equipped with sump pumps to dry the vaults. A paint coating system to protect valves and piping in the vaults from corrosion should be provided.

Bolton Reservoir Slide Stabilization and Other Landslide Monitoring - The north slope of the Bolton Reservoir site should be investigated concerning the land movement. Improvements to stabilize this slope from further movement and potential failure should be undertaken. Landslides along the 24-inch transmission main on Abernathy in Oregon City and above the County Shops should continue to be monitored for potential movement and the need for stabilization.

Bolton Reservoir Improvements - Site drainage should be collected and conveyed away from the slope failure area to the north. Improvements to the inlet piping to improve circulation should be constructed. A simple method to enhance circulation is to extend the 18-inch inlet/outlet pipe further into the reservoir and equip it with a tee and check valve at one end and a flap gate at the other. Improvements to the altitude valve at the reservoir should be conducted.

Horton Reservoir Repair - A new level transducer should be installed in the reservoir. Seismic evaluation and anchoring of this reservoir could be conducted at the same time as these repairs are completed. Installation of a new outlet pipe from the base of the reservoir to the pump station to eliminate the existing goose-neck would add capacity during an emergency. Cathodic protection and coating replacement may also be needed, and could be evaluated at the same time.

COMPARISON OF SOURCE TO PLANNING CRITERIA

The recent Water System Master Plan for the South Fork Water Board (SFWB) (Montgomery Watson, 1997) estimated that the combined ultimate buildout peak day water demand for Oregon City and West Linn was 51.6 mgd. This demand would not be reached until some time after the year 2050. As discussed in Section 5, the SFWB has water rights that will total to this amount, even in low flow periods. Thus, there is adequate water to serve the City of West Linn from this source to buildout of the City's population.

COMPARISON OF STORAGE RESERVOIRS TO PLANNING CRITERIA

Alternative Planning Criteria

A new planning criteria will be implemented, that is maintaining the current storage level (including undeveloped lots of record) of 1.57 Average Day Demand (ADD). In comparison, the 1982 master plan criteria was 20% of peak day plus fire flow (about 1.21 ADD) and the 1999 master plan criteria was 25% of peak day plus fire flow plus one average day demand (about 2.66 ADD).

Storage Calculations

Table 6 - 1 presents the storage calculation for each major zone with the system using the proposed planning criteria and equalization and fireflow requirements for both existing and buildout system demand. System demand is determined from the population estimates from section 2 and the per capita consumption data from section 3. Several points must be noted about this information:

- The Willamette, Bolton, and Robinwood reservoirs all serve areas of the City which are served by the head of the SFWB supply system.

- Because of the piping arrangement at the outlet of the Bolton Reservoir, this reservoir serves primarily as a clearwell for pumping at the Bolton Pump Station. The Bolton Pressure Zone will always draw storage from the SFWB supply system prior to drawing from the Bolton Reservoir.

- The planning criteria calls for fire flow requirements to be met from storage, and not from pumping.

Table 6 – 1
Storage
Under Existing Conditions
Independent Zones (without SouthFork system storage)

	Existing Conditions					
Zone	Available Storage (MG)	Current Population (Water Users)	Fireflow (MG)	Equalization (25% Peak day demand) (MG)	Equalization plus Fireflow (MG)	Ave days in storage
Bolton	2	4235	0.54	0.35	0.89	3.37
Horton	1.5	5808	0.54	0.49	1.03	1.84
Rosemont	0.4	5277	0.3	0.44	0.74	0.54
Robinwood	0.5	1869	0.24	0.16	0.40	1.91
Willamette	0.6	4663	0.54	0.39	0.93	0.92
Bland	0.5	1878	0.24	0.16	0.40	1.90
Totals:	5.5	23730			4.4	1.66

From Table 6 – 1 shows that looking at each zone independently there are existing deficiencies in the Rosemont and Willamette Zones under the minimum standard of Equalization plus Fireflow. However, since the system is interconnected, both of these zones are supplied from other zones that have excess capacity. The Willamette Zone is supplied from the Bolton Zone (or from SouthFork) and the Rosemont Zone is supplied by pumping from the Horton Zone. Fire flows for Willamette Zone can also be supplied via gravity from the Bland reservoir through a pressure reducing station installed in 1999. The Horton Zone supplies the equalization storage for the Rosemont Zone so that fire flows are available via gravity from the Rosemont reservoir.

The proposed storage standard of 1.57 ADD is based on the existing population supplemented with the population that existing undeveloped lots of record may occupy. Table 6 – 2 provides the data for this population.

Table 6 – 2
Storage
Under Existing Conditions
Current Population with Lots of Record
Interdependent Zones (without SouthFork system storage)

	Existing Conditions					
Zone	Available Storage (MG)	Current Population (with Lots of Record)	Fireflow (MG)	Equalization (25% Peak day demand) (MG)	Equalization plus Fireflow (MG)	Ave days in storage
Bolton	2.0 less 1.03	4419	0.54	0.37	0.91	1.57
Horton	1.5 less .092	6404	0.54	0.54	1.08	1.57
Rosemont	0.4 plus .745	5574	0.3	0.47	0.77	1.47
Robinwood	0.5	1965	0.24	0.16	0.40	1.82
Willamette	0.6 plus .442	4742	0.54	0.40	0.94	1.57
Bland	0.5 less .063	1986	0.24	0.17	0.41	1.57
Totals:	5.50	25089			4.5	1.57

The available storage shown in Table 6 – 2 shows the flexibility of the system because of the topography and pump stations that interconnect the reservoirs (with the exception of Robinwood). All zones meet the minimum level of equalization plus fireflow. The overall Average Demand Day is 1.57. As described in Section 4, it is desirable to have an emergency supply of one average day demand. The 1.57 ADD standard provides about 30% of the average day demand as emergency storage. From Table 3 – 1, the average day demand is about 3.3 MG. Buildout average day demand is calculated to be 4.5 MG.

Table 6 – 3 provides similar data for the buildout population (the high side of the population range used)

Table 6 - 3
Storage
with Buildout Population
Independent Zones (without SouthFork system storage)

	Buildout Conditions						
Zone	Available Storage (MG)	Population (Water Users) High Range	Fireflow (MG)	Equalization (25% Peak day demand) (MG)	Equalization plus Fireflow (MG)	Ave days in storage	Additional Storage Needed for 1.57 ADD (MG)
Bolton	2	5623	0.54	0.47	1.01	2.54	-0.76
Horton	1.5	7721	0.54	0.65	1.19	1.39	0.20
Rosemont	0.4	7496	0.3	0.63	0.93	0.38	1.25
Robinwood	0.5	2267	0.24	0.19	0.43	1.58	0.00
Willamette	0.6	6306	0.54	0.53	1.07	0.68	0.79
Bland	0.5	2506	0.24	0.21	0.45	1.43	0.05
Totals:	5.5	31919				1.23	1.52

Table 6 - 3 summarizes the storage deficits by zone under the proposed Master Plan storage criteria. An additional 1.01 MG (using low range BO population of 29,610) to 1.52 MG (high range population) storage is needed at buildout to maintain 1.57 ADD. The table does not include any storage volume from the SFWB supply system for the Bolton Zone.

At buildout, all zones except Bolton and Robinwood will need additional storage. The storage can be provided from several locations because of the interconnectivity of the city-wide system.

Comparison of Storage Requirements to Other Communities

A survey of several local and regional utilities was made to determine how the City's proposed storage criteria compares. The local utilities surveyed include Beaverton, Lake Oswego, Oregon City, Sherwood, Tigard, Tualatin Valley Water District, Clackamas River Water, Eugene, and Corvallis. Table 6-4 summarizes the results. Five of the surveyed utilities have operational and fire storage component criteria, with varying volumes. Four of those utilities also have emergency storage criteria. Two of the surveyed utilities rely on the State of Oregon's previous standard of 3 times the average day demand to define their storage needs, and the remaining two have no defined storage criteria.

Table 6-4
Storage Survey

Utility	Population Served	Average Day Demand (mgd)	Peak Day Demand (mgd)	Actual Storage (mgal)	Storage Requirement (Based on Criteria)	Ration of Storage Goal to Avg Day Demand	Storage Criteria
West Linn Existing Criteria (1982)	23,730	3.3	7.95	5.5	3.99	1.21	Equalization: 20% of maximum day Fire: maximum fire demand per zone based on land use
West Linn Proposed Criteria	23,730	3.3	7.95	5.5	5.2	1.57	1.57 average days
Tualatin Valley Fire District No. 10							
Beaverton	66,000	6.6	19.5	27.3	19.8	3	3 average days
Lale Oswego	35,000	6	13	20.5	15.3 mgal + fire	3.1	Equalization: 25% of peak day/zone Fire: maximum fire demand per zone based on land use Emergency: 2 average days
Oregon City	21,000	2.4	6.2	17	7.61	3.2	Equalization: 25% of peak day/zone Fire: maximum fire demand per zone based on land use
Sherwood	10,050	1.1	2.2	2		1.8	Undefined, more storage planned
Tigard	44,000	6	13.3	24.5	17.9	3	3 average days (although storage used to meet peak day)
Tualatin Valley Water District	156,000	22.6	44.7	53		2.3	Undefined
Other Regional Utilities							
CRW: North System (Includes wholesale customers)	35,000	11.3	22.7	18	22.8	2	Equalization: 24% of average day Operational: None Fire: 0.36-3.0 mgal per zone based on land use Emergency: 1.5 average days
CRW: South System	15,000	1.7	3.8	5.2	6	2	same as above
Eugene	145,000	29	71.8	75	101	3.5	Equalization: 1 maximum day Fire Flow: varies per zone, > 1 average day
Corvallis	50,000	7.5	15	23.1	18	2.4	Equalization: 20% maximum daily Fire: maximum fire demand per zone based on land use Emergency: 3 curtailed water days (assumes Will. Plant Out)

Emergency Storage Vulnerability and Risk Assessment

To assess what level of emergency storage would be needed, a summary vulnerability and risk assessment of the City's system was conducted. Several studies have been done on water system risk and associated supply outages and system demands in other locations. The most recent and most pertinent to West Linn's system is the on-going System Vulnerability Assessment (SVA) currently underway for the Portland Water Bureau (PWB). Findings from that Portland Water Bureau study were applied to West Linn's system to assess vulnerabilities and likelihood of loss of supply.

Hazards

In order to identify the likelihood of loss of service, appropriate hazards applicable to the West Linn system must be evaluated. The following hazards have been identified for the West Linn system:

- Earthquake,
- Landslide,
- Floods,
- Volcanic activity,
- Large fire (wildfire or large commercial fire), and
- Loss of supply created by
  - Loss of Division Street pump station,
  - Loss of Willamette River transmission line crossing, and
  - Water quality event at SFWB plant.

Natural hazards, such as earthquake, landslide, volcanic activity and large fire are generally low likelihood, high impact events. However, events in Oakland (major fire), and San Francisco, and Los Angeles, California, and Kobe, Japan (earthquakes) have demonstrated the difficulty for water systems to meet water demands during these events, and the extended period of effects the damage has on the water systems. As a result, it is prudent to consider the risk and potential damage associated with these events.

Loss of supply could be created by natural events, such as earthquake damage to storage, pump station, or transmission facilities, or by operational stress caused by compromised water quality at the SFWB plant. These hazards are also addressed in this section.

The Portland SVA study considered hazard events within a 1,000-year recurrence interval. Portland decided that natural events outside the 1000-year recurrence interval would be too unlikely to plan for or design against. Portland decided that mitigation

actions will be undertaken for all events with a 100-year recurrence interval or less. They also decided that for those events with a 100 to a 1,000-year recurrence interval, mitigation would be evaluated on a case-by-case basis. Where costs are not too great and the impacts of the events are severe, then mitigation would be undertaken. These same recurrence intervals are assumed in this evaluation.

Potential Loss Caused by Earthquake

The SVA Study for Portland summarized potential earthquake damage based on the recurrence interval of earthquakes. To extrapolate conclusions made in the SVA to facility vulnerability in West Linn, peak ground acceleration values for West Linn were compared to downtown Portland. The USGS National Seismic Hazard Mapping Project lists the probabilistic ground motion values by zip code. Assuming zip codes 97068 for the City of West Linn and 97201 for downtown Portland, the probabilistic ground motion values were found to be approximately equal. For the purposes of this initial evaluation, it is assumed the earthquake effects on the West Linn's system can be reasonably approximated by the conclusions made in the Portland water system. A more detailed evaluation of the potential for earthquake impacts, is recommended to validate the conclusions here.

The SVA study measured earthquake risk by recurrence interval instead of by Richter Scale. The peak ground acceleration produced by an earthquake is the factor affecting facility damage. An earthquake can occur at a lower Richter Scale near a given location and produce the same peak ground acceleration as a large Richter Scale event at a location farther away. As a result, recurrence intervals of peak ground acceleration were used in this evaluation.

Minor Earthquake: 10 to 50 year recurrence interval

The SVA found earthquakes with a 10 to 50 year recurrence interval are expected to be mild, with minimal impact on the PWB system components. It is expected that the West Linn system would have minimal impact from mild earthquakes. However, localized power outages could occur. The system's ability to respond to power outages is discussed in the power outage section.

Moderate Earthquake: 100-year recurrence interval

The SVA classified earthquakes with a 100-year recurrence interval as moderate magnitude events, and concluded that the Portland groundwater pump station and one or less Willamette River crossings could experience structural damage as a result. The SVA did not predict the likelihood of a regional power outage associated with a moderate earthquake. A loss of regional power is not assumed in this evaluation.

Typically, 100-year events such as storms and floods are the recurrence interval events used to design public facilities. An earthquake with a 100-year recurrence interval is a common event used for seismic design.

West Linn's Willamette River crossing has experienced stress and structural damage during the 1998-1999 winter season. A field inspection conducted as by Murray Smith and Associates in 1996 indicated excessive bowing of pipe support beams and potentially inadequate supports under earthquake conditions. With structural enhancements completed in 2002, the pipeline (and bridge) are not vulnerable to a moderate earthquake.

Field inspection in 1997 indicated the base ring of the Horton Reservoir is in need of repair and there are no seismic anchors installed. Without repair and seismic upgrade, Horton Reservoir is likely vulnerable to a moderate magnitude earthquake. Repair of the Horton Reservoir following a moderate earthquake is expected to take several weeks to repair.

The Bland Circle Reservoir is in good condition, but field inspection found the seismic anchor straps are located within 2 inches of the outside edge of the ring footing. Although damage to the footing could occur during a seismic event, the reservoir is expected to survive a moderate earthquake, with limited damage. However, reservoir outage may be required for a several weeks to repair any damage that occurs.

The hillside slope below the Bolton Reservoir has been identified to have a high landslide potential and movement of the slope has occurred as recently as the 1996-1997 winter season. The risk of further movement is not significantly affected by earthquake, however. The reservoir is expected to survive a moderate earthquake with minimal damage.

The vulnerable facilities discussed in this section are the Willamette River crossing, Horton Reservoir, and Bland Circle Reservoir. The Willamette River crossing could be out for several months to repair a complete break of the pipeline. The reservoirs could be out of service for several weeks for repair, depending upon the extent of damage.

The Bolton Reservoir, Willamette Reservoir, View Drive Reservoir, Rosemont Reservoir, Horton Pump Station, and Willamette Pump Station were found in good condition and with adequate seismic support during the 1997 field inspection. It is assumed that a moderate earthquake will have minimal impact on these facilities.

Extensive Earthquake: 500-year recurrence interval

The SVA concluded a large magnitude earthquake would cause extensive damage to the PWB system, including significant damage to 3 of 7 Willamette River crossings. The analysis also predicted highly probable regional power outages.

For the City of West Linn, an extensive earthquake is expected to result in serious damage to the vulnerable facilities discussed in the moderate earthquake section. The impact of an extensive earthquake would likely result in a regional power outage, likely for several days, and an extended period of facility outage on the order of months.

Potential Loss Caused by Landslide

The raw water pipeline between the SFWB river intake and the plant is in a landslide area. Loss of the raw water pipeline could require several days for a temporary fix; a more permanent fix would require a few months to complete. The SFWB has recently had a geotechnical assessment and review of the pipeline route and has determined that the likelihood of loosing the pipeline is low.

The Bolton reservoir site is in an area of slope movement. The slope is most vulnerable during very wet seasons when the hillside becomes saturated. Movement of the slope has been detected as recently as the 1997-1998 winter season. Significant movement of the slope could cause extensive damage to the reservoir, which would drain the stored water and remove the reservoir from service. Reservoir damage could range from structural cracks to extensive damage; outage could require as much as six months to a year to repair or rebuild the reservoir.

The Bolton Pump Station sits on the same site as the Bolton Reservoir. The new pump station sits on the opposite side of the reservoir from the slope and is not expected to be at risk from a landslide at the site. Since a back-up power supply is located at the Bolton pump station, it is expected to be a critical facility in the event of a power outage.

Potential Loss Caused by Flooding

The source of supply is not at great risk of flooding. The SFWB river intake was designed above the 100-yr Clackamas River flood stage. The SFWB plant sits high above the flood stage; the plant is a conventional treatment plant capable of treating high turbidity events associated with flooding. The Division St. Pump Station and associated reservoirs sit high above the flood stage.

None of West Linn's distribution system facilities are expected to be at high risk of damage caused by flooding.

Volcanic Activity

Volcanic activity is not expected to adversely affect the treatment capabilities of the SFWB conventional treatment plant. Ash fall from Mt. Hood would have to travel from the upper Clackamas River, through the reservoirs on the Clackamas River where a significant portion of the ash would settle out, and through the lower Clackamas River. It is expected that the SFWB treatment plant would be capable of handling the heightened turbidity following a volcanic event. In addition, the SVA found that the

volcanic event that could affect the Bull Run supply would have to be greater than a 500-year event. Since the SFWB plant is significantly less vulnerable than Bull Run, the risk to volcanic activity is assumed to be very low.

Storage Loss Caused by Large Fire

There are several areas of land to the west of West Linn and within the city limits that are covered by dense forest. In drought conditions these areas could be vulnerable to forest fire. However, the individual areas covered by forested growth are not large enough by themselves to be expected to spread out of the control of the West Linn fire system. The system is not expected to be at great risk of wild fire.

The system is designed to fight commercial and residential fires within the city limits. The system is not at greater risk of development fire than the typical utility. However, if a combination of peak demand conditions and loss of one or more facilities stressed the system, a fire demand within the system could be difficult to supply.

Loss of Supply

A number of factors could result in the loss of water supply to West Linn. These include an adverse water quality event that would shut down the SFWB plant, loss of the Division Street Pump Station, or loss of the Willamette River crossing transmission line.

A water quality event capable of shutting the plant down would be either a *Cryptosporidium* or *Giardia* outbreak, or a chemical spill in the Clackamas River. It is anticipated that a plant outage caused by a water quality event could require several days to return the plant to operable conditions, depending on the event. Since the Lake Oswego supply is also the Clackamas River, it would also be vulnerable to these events. Therefore, it may not be a reliable back-up supply during a water quality event.

The vulnerability of the Division Street Pump Station was evaluated based on mechanical dysfunction, structural damage, or power outage. Mechanical dysfunction would have to be extensive to remove the entire pump station from service and is unlikely. Structural damage is also unlikely. The pump station is designed to meet seismic standards for the region and would be expected to withstand moderate to extensive earthquake events. The pump station has power feeds from two separate substations, which substantially reduces the risk of a loss of power. If one regional supply is lost, the power supply can be switched to the second substation. The Division Street Pump Station is at low risk of damage and loss of capacity. However, in the unlikely event the Division Street Pump Station is out of service, West Linn would have to rely entirely on its distribution system storage and its connection to Lake Oswego for the duration of the outage.

The Willamette River crossing pipeline is the most vulnerable component in the West Linn system The recent improvements to the Willamette River crossing lower its vulnerability to moderate to extensive earthquake activity. It is assumed a complete break of the pipeline would require approximately 30 days to repair. The repair would include removal of the damaged portion of pipe, replacement with a new section of pipe, and reattachment. During that period, West Linn would rely on its Lake Oswego connection and storage reservoirs to supply water to its customers.

Role of Intertie with Lake Oswego Supply

West Linn has an existing intertie with Lake Oswego with a design delivery capacity of 5.76 mgd. The intertie is available as a back-up supply to the City's SFWB supply. Assuming the Lake Oswego supply is available and operable in the event of an emergency, the supply is considered adequate to provide an emergency back-up source.

During regional emergencies such as water quality events, major earthquakes, or regional power outages, Lake Oswego could have similar emergencies. In those events, Lake Oswego would have to draw on its limited connections with the Portland Water Bureau and the City of Tigard. However, regional water quality emergencies, which are considered to be low risk events, would not be likely to affect Portland or Tigard water supplies. Regional power outages are expected to last no more than two days, which would allow both the City of West Linn and Lake Oswego to rely on emergency water storage supplies. It is assumed that the greatest risk of regional loss of supply would be caused by a major earthquake event. The recurrence interval for a major earthquake is greater than a 100-years, which is outside of typical design event guidelines. Moderate earthquakes associated with the 100-year recurrence interval would cause limited damage to older facilities, expected in focused areas; it is expected that emergency repairs could be made to key facilities in the region to provide limited water supplies to the City of West Linn.

Power Outage

Back-up power generation is available at the Bolton Pump Station. The Bolton Pump Station is a critical facility during a power outage since it provides flow to the upper zones. There is sufficient back-up power at the Horton and Willamette Pump Stations to power each complete pump station. The system could operate during a power outage by relying on a combination of its back-up power and emergency storage. As discussed in the previous section, the Division Street Pump Station has a redundant power supply from an additional substation, and is expected to remain in service during a regional power outage.

Vulnerability Assessment Conclusions

The results of the vulnerability and risk assessment are summarized in Table 6-5.

Table 6-5
Summary of Vulnerability Assessment

HAZARD	VULNERABILITY
MINOR EARTHQUAKE	Local power outage
MODERATE EARTHQUAKE	Horton Reservoir, Bland Circle Reservoir
EXTENSIVE EARTHEQUAKE	River crossing, Horton Reservoir, Bland Circle Reservoir, general power outage
FLOODS	Little to none
LANDSLIDE	SFWB raw water line, Bolton Reservoir
VOLCANIC ACTIVITY	Little to none
LARGE FIRE	Low, unless in combination with extensive earthquake
LOSS OF DIVISION ST. PS	Low
LOSS OF WILLAMETTE RIVER CROSSING	High – could require 30 days to repair
WATER QUALITY EVENT AT SFWB	Low – but if occurs, likely to impact Lake Oswego alternative source
LOSS OF OREGON CITY 10 MG RES	Low
LOSS OF POWER	Low

The system is at greatest risk of loss of the Willamette River crossing and earthquake damage to selected facilities. The Willamette River crossing could result in a loss of supply, which would require West Linn to rely on its connection to Lake Oswego and its distribution system storage for the duration of the outage.

Depending upon the seasonal demand conditions, the emergency storage that has been proposed in the Master Plan could provide 8 to 36 hours of supply.

Several conclusions can be drawn from the vulnerability analysis:

- The repair and seismic upgrade of West Linn's Willamette River transmission pipeline crossing significantly improved West Linn's system reliability.
- Seismic upgrades of vulnerable facilities to meet current design standards would prepare West Linn against moderate earthquake damage.
- Development of emergency storage supplies and continued operation of back-up power sources would provide West Linn with increased reliability.

Role of Emergency Storage

The risk assessment indicates the system is most vulnerable to moderate to heavy earthquake events resulting in major facility outages and loss of supply. In an emergency, an instantaneous transition to alternative sources would not be likely. Emergency storage would "buy" time to allow a disconnection of damaged facilities or lost supplies, and provide a smooth transition to alternative sources.

Factors Influencing Provision of Storage

Several factors will influence the timing and methodology of providing the needed storage:

- The existing Bolton Reservoir is an old concrete-lined reservoir. A floating cover was installed a few years ago. The reservoir sits at the top of a known landslide that has had recent movement. The expected remaining life of this reservoir is no more than 20 years, when it will be over 100 years old, and could be less due to the slide. Therefore, the City should plan on replacing the Bolton Reservoir with a new reservoir, once the existing reservoir reaches the end of its service life. This would occur sometime after the year 2015.

- Previous City review of reservoir options have determined that the storage volume for the Willamette Zone should be provided at the site of the Bland Circle Reservoir, as a part of Bland Circle Reservoir No. 2.

- In the past, the Horton Pump Station has been relied upon to provide fire storage because the volume of the storage in the Rosemont Zone was inadequate. In 1997 however, the City reduced the fire flow requirement in the Rosemont Zone to 2,500 gpm for 2 hours because no existing structure, or planned future structure, exceed that fire flow requirement. At this fire flow requirement, the Rosemont Tower is adequate to provide fire storage alone.

COMPARISON OF PUMP STATIONS TO PLANNING CRITERIA

A summary of the pumping requirements for each pump station is presented in Table 6 - 6. The nominal firm capacity shown is the rated capacity of the pump station with the largest pump out of service. The actual firm capacity will be different than the nominal because pumps will operate at different points on their operating curve. The current modeled firm capacity shown is the actual firm capacity of the station as predicted in the hydraulic model described below. This table includes the capacity of both the new and existing Bolton Pump Station. The pumping demand on the Horton and Bolton Pump Stations is influenced by the lack of equalization storage in the Rosemont Zone. The low build-out demand is used in the table because the sizing considerations will not

be materially different if the high build-out demand numbers were used. Deficiencies have been rounded to the nearest 5 gpm.

As Table 6 - 6 shows, the Willamette Pump Station is adequate until buildout. The Bolton Pump Station was recently expanded with space for two additional pumps. One of the pumps will replace pumps at the old pump station, the other additional pump will be needed at buildout.

Table 6 - 6
Pump Station Capacity Evaluation

Pump Station	Current Total Installed Capacity (gpm)	Current Nominal Firm Capacity (gpm)	Current Modeled Firm Capacity (gpm)	Existing Deficiency (gpm)	Buildout Deficiency (gpm)
Willamette	1500	1000	1075	none	none
Bolton	5750	4250	3325	none	1,775
Horton	4600	3900	2670	none	1,170

COMPARISON OF PIPELINES TO PLANNING CRITERIA

Approximately 13% of the City's distribution system consists of pipeline less than 6-inches in diameter. This pipeline does not meet the planning criteria of a minimum of 6-inchs for pipelines. It is recommended that all of these pipelines be replaced over time with new pipeline of at least 6-inches diameter. In addition, some of the existing 6-inch diameter pipeline have fire hydrants or may not be part of a looped system. It is estimated that about 5% of the 6-inch diameter pipeline may be in this category and not identified for replacement through the hydraulic model (see below) because fire flow criteria were not investigated on each pipeline in the system due to constraints of time and effort in the modeling. Thus, a total of approximately 83,000 feet of pipeline is recommended for replacement in a Mains Program. Approximately 5,000 feet of pipeline is replaced each year.

HYDRAULIC MODEL EVALUATION

Model Development

The existing and future systems were hydraulically modeled in order to evaluate capacities and develop recommended improvements. The hydraulic model chosen for the analysis was H2ONET, which runs within AutoCAD to present input and output of the model, using EPANET to perform the hydraulic calculations. The distribution system was digitized using the City's electronic basemap, including all pumps, storage

tanks, PRVs, and pipelines greater than 6 inches in diameter. Also included in the model were 4-inch diameter and 2-inch diameter pipelines needed to close loops in the model. A total of approximately 104 miles of pipeline are included in the model.

The H2ONET software uses databases to store input and output for each facility. The input databases for nodes (locations where two pieces of pipeline in the model intersect) included elevation, demand, and pressure zone. Pipeline input databases included diameter, length, and roughness, or C-factor (based on material and age of pipeline). Storage tank databases included elevations and storage volumes; pump stations included pump curves; and PRVs included pressure settings and diameter sizes.

The model was calibrated using 1996 demand data and SCADA data for verifying facility operations, including storage tank levels, pressures at pump stations and PRVs and flows throughout the system. Table 6 - 11 shows the locations where the calibration data was collected. Table 6 - 12 shows the comparison of the calibrated model results to the actual field data which was collected. Over 80% of the modeled calibration points were within 3 percent of the measured values and all were within 6 percent. This is well within the standard 5 -10 percent that most models achieve.

The calibration of the model was a "steady-state" calibration. That is, the model was calibrated assuming that flows, reservoir levels, pumping rates, and other system conditions are occurring at a constant rate, or steady-state condition. While this assumption is adequate for planning purposes and determining the overall condition of the system for Capital Improvement Program development, it is not adequate to use the model as an ongoing operational tool. A dynamic calibration called an "extended period simulation" (EPS), should be conducted in future if the City wishes to use the hydraulic model to assist in optimizing operations. In an EPS model simulation, the fluctuations of reservoir levels, pumping rates, and other system variables, which occur over the course of a day, are simulated. The City's SCADA system allows for the collection of the data needed to develop an EPS model.

Table 6 - 7
Locations Where Calibration Data Was Collected

Run	Date &Time	Location - Static Hydrant # 1	Location - Static Hydrant # 2	Location - Flow Hydrant
1	7/10/97 9:20 AM	12th Street at Volpp Street	Volpp Street	Volpp Street at 9th Street
2	7/10/97 10:20 AM	Tanner Creek	*Static and Residual Off Flow Hydrant	Bus Barn
3	7/10/97 10:50 AM	Edgewater at Failing Street	Failing Street	Failing Street
4	7/10/97 11:15 AM	Palomino Way at Saddle Ct	Palomino Way at Saddle Ct	Palimino Way East of Saddle Ct
5	7/10/97 11:45 AM	Wildwood Drive	Wildwood Drive	Wildwood Drive
6	7/10/97 1:35 PM	River View Drive East of Rock Ridge Drive	River View Drive at Rock Ridge Drive	River View Drive at Fairhaven Street
7	7/10/97 2:05 PM	Miles Drive	Miles Drive	Miles Drive at Rosemont Road
8	7/10/97 2:25 PM	6111 Churchill Downs Drive	Churchill Downs Drive and Pinto Ct	Bay Meadows Drive at Churchill Downs Drive
9	7/10/97 2:45 PM	Ridgebrook Drive at Suncrest Ave	Ridgebrook Drive	Parkview Ct
10	7/10/97 3:00 PM	Skye Parkway at Troon Drive	Skye Parkway and Skye Ct	Skye Parkway at Leigh Ct
11	7/10/97 3:30 PM	Arbor Drive at Marie Ct	Arbor Drive at Shady Hollow Way	Arbor Drive
12	7/11/97 9:00 AM	Mark Lane	Mark Lane East of Lowell Ave	Mark Lane at Munger Drive

Demand Allocation

Demand projections were based on population, as presented in Section 3, and were developed for: (1) the existing system; (2) buildout. Demands were developed for each individual pressure subzone, based on population projections and landuse within that zone. Demands were allocated to model nodes based on the landuse at each node. In certain areas where new development may occur but where existing infrastructure is absent and no specific information on development pattern was available, the layout of a pattern of pipelines and demand nodes to serve the area had to be assumed as a placeholder. Once specific development plans have been identified, this assumed pattern will need to be reviewed and reevaluated.

Table 6 - 8
Comparison of Model Results to Field Calibration Data

Run	Hydrant #1 Static Pressure % Difference	Hydrant #1 Residual Pressure % Difference	Hydrant #2 Static Pressure % Difference	Hydrant #2 Residual Pressure % Difference
1	0.8	-1.2	0	-2.0
2	-1.8	0	-.9	-1.2
3	1.2	0	-2.2	0
4	0	0	0	1.5
5	0	3.0	-.8	3.0
6	0	0	-.7	1.2
7	1.3	4.9	1.3	3.8
8	0	-5.9	0	2.3
9	1.3	0	0	0
10	0	-6.1	0	1.7
11	0	0	-1.3	3.4
12	0	-2.2	0	4.7
13	-1.2	-4.9	-1.1	-4.9

System Deficiencies Analysis

Each of the planning horizons were evaluated using the planning criteria presented in Section 4. Pump stations and storage tanks have defined design capacities, as presented in Section 5. Pipelines, however, function as part of a larger network and must be evaluated through modeling for various demand scenarios. Two demand scenarios were investigated:

(1) peak hour demands, and
(2) maximum day demands plus fire flows.

For the second scenario, one fire flow at a time was applied to each of the seventeen pressure subzones using a residential fire flow of 1,000 gpm. The system was also evaluated for non-residential fires modeled in each of the five zones using the following flows:

- Horton: Industrial/Commercial fire, 3,000 gpm,
- Rosemont: 3,000 gpm,
- Willamette: Industrial/Commercial fire, 3,000 gpm,
- Bolton: Industrial/Commercial fire, 3,000 gpm,
- Robinwood: Residential, 2,000 gpm, and 3,000 gpm commercial in selected areas

- Bland : Residential, 2,000 gpm and 3,000 gpm commercial in selected areas.

Where industrial or commercial fire flows are established, the fire flow modeling occurred at the location of the specific industrial or commercial facility which would generate the high fire flow.

The following planning criteria were used to identify deficiencies in pipelines:

Peak Hour Demand Scenarios
- Transmission pipelines (10-inch diameter and larger) with velocities greater than 5 fps on peak day demands;
- Distribution pipelines with velocities greater than 10 fps on peak hour demands; and
- Pressures less than 45 psi or greater than 120 psi.

Maximum Day Demand Plus Fire Flow Scenarios
- Pressures less than 20 psi or greater than 120 psi.

The system-wide peak day demand used in the analysis was 6.5 mgd as defined in Section 2. The system wide peak hour demand, which corresponds to a flow of twice the peak day demand, was 0.54 mgh. All existing pumps, storage facilities, and operational settings were modeled to evaluate the existing system. Supply from SFWB was modeled as a constant 6.5 mgd input.

Capital Improvement Development

The analysis of the system and recommended improvements to correct deficiencies were developed in a step-by-step process. First, the existing system was evaluated for deficiencies under both the peak hour demand and the peak day demand plus fire flow scenarios. The improvements needed to remedy these existing deficiencies were then incorporated into the model. Improvements may include new reservoirs, expanded pump stations, redefining zone boundaries, valve setting adjustments, and parallel pipelines. The improved system became the basis for the next analysis of future planning horizons. This approach prevents redundant modeling of deficiencies of the existing system.

Identified System Deficiencies

Model analysis showed that the existing system has deficiencies at peak hour primarily in the Bolton and Rosemont Zones, with other deficiencies in the Bland and Willamette Zones. Capital improvements to correct these deficiencies were identified. Analysis of the system for the existing peak day demand plus fire flows scenario identified deficiencies in the Willamette, Bland, Bolton, Rosemont and Robinwood Zones. Many 6-inch lines throughout the system also registered as having velocities above the planning criteria during a fire on a peak day. However, these pipelines were not

identified for improvement because the pressure remained above the 20 psi criteria and no harm would result from the high velocities due to the short duration of the event.

Analysis of the future demands showed deficiencies in all zones. In several cases, enlargement of an improvement that was required for the existing system, also relieved the future deficiency. The pipeline capital improvements that were identified, the existing or future deficiency that was relieved by the improvement, and the costs for each pipeline capital improvement are presented in Table 6 - 18. The basis for the pipeline unit costs shown in Table 6 - 18 is presented in Section 7.

With two exceptions, improvements were assumed to replace the existing pipeline. Mains along Hillcrest Dr. in the Rosemont Zone and Willamette Falls Dr. in the Willamette Zone were assumed to parallel relatively new existing pipelines in good condition that are assumed to remain in the ground. In all other cases any existing pipeline was replaced with a new pipeline.

In addition to capital improvements, two other types of improvements were made to the system to relieve deficiencies. The first such improvement is re-zoning. Low pressures found near pressure zone boundaries were eliminated by connecting customers to a higher zone. Re-zoning corrected deficiencies on Imperial Dr. (subzone 3), Haskins Rd. (subzone 2 and Palomino Wy (subzone 6), and eliminated the need for capital improvement projects. The second improvement involved the adjustment of PRV settings to raise pressures. The PRV settings that were used in the model are presented in Table 6 - 9. Prior to rezoning, it is important to investigate the actual pressures at these locations to assure that pressures will not exceed plumbing code maximums without installation of individual pressure regulators.

TABLE 6 - 9
RECOMMENDED SYSTEM VALVE ADJUSTMENTS

Valve	Location, Zone	Recommended Setting (psi)
1-1	Willamette Falls Dr. / Willamette	83
1-2	Killarney / Willamette	50
4-1	Hood St. / Bolton	76
4-2	Broadway St / Bolton	45
4-3	Buck St & Failing St. / Bolton	52
4-4	Dillow Dr / Bolton	51
5-1	Clark St.	62
5-2	Oregon City Blvd	44
7-1	Bridgeview Dr / Horton	50
8-1	Horton Rd / Horton	79
10-2a	View Dr. / Rosemont	8-15
11-1	View Dr. / Rosemont	45
11-2	Upper Midhill Dr. / Rosemont	60
12-1	Marylhurst Cr. / Rosemont	50
13-1	Valley View Dr. / Rosemont	67
13-2	Hillcrest Dr. / Rosemont	62
13-3	Marylhurst Dr / Rosemont	58
13-4	Stonehaven Dr. / Rosemont	85
13-5	Troon Dr. / Rosemont	Closed 67
14-1	Carriage Wy / Bolton	47
16-1	Buck St. & Davenport / Bolton	84
16-2	Barclay Dr. / Bolton	79
16-3	Lowry Dr. / Bolton	88
16-4	Mark Lane / Bolton	70
100-1	Marylhurst Ct / Rosemont	60
PRV	Derby St	53
PRV- .	Salamo Dr. / Rosemont (Cascade Summit)	45
PRV-	Apollo Rd	75
Valve	Division St. PS	97
Valve	Mapleton PRV	63
Valve PRV	Mapleton TCV Greene St	Open 25

Low pressures were also identified near storage reservoirs where elevations of the distribution system service are so close to the storage tank that pressures cannot meet the planning criteria. For these locations, no capital improvements were identified as being helpful in alleviating these conditions. If customers are not experiencing problems, then no action is warranted. If in the future some customers do experience problems, a case-by-case review of the options should be made. Rezoning, booster pumps and other options may be available if the problem warrants such action.

UNACCOUNTED FOR WATER AND PILOT LEAK DETECTION SURVEY

As part of this Master Plan, an unaccounted for water and pilot leak detection survey was conducted. The pilot leak detection was conducted the week of March 31, 1997. The unaccounted for water survey was based upon the period of February, 1996 through February, 1997. This survey was then updated based on 1997 and 1998 data. The pilot leak detection was conducted by Heath Consultants Incorporated, as a subconsultant to Montgomery Watson. The pilot leak detection project evaluated a subset of the City's distribution system piping for leaks. Heath Consultants also assisted in the unaccounted for water survey (Heath Consultants, 1997). The unaccounted for water survey seeks to measure both supply and use, to arrive at an estimate of the water that may be lost. A discussion of these steps is given below.

Water Supply

The City of West Linn purchases its water from the South Fork Water Board (SFWB). Over the period of March, 1996 through February, 1997, the City purchased 1,373,420 hundred cubic feet (ccf) of water, or an average of 114,451.7 ccf per month. (Units of water measure in this subsection will be ccf because that is the unit of measure which is used in residential flow metering and billing by the City.) Table 6 - 10 shows the monthly water purchase over this period from the SFWB. Adjustments must potentially be made to the water supply figures to account for source meter errors, changes in reservoir and tank storage, and other contributions or losses.

The meter that measures the source water from the SFWB is a magnetic flow meter that was installed only a couple of years ago. This type of meter, when properly installed, is considered to be highly accurate. The installation of the meter was reviewed and determined to be correct. Thus, no correction for source meter inaccuracy was made to the supply.

In some cases, changes in reservoir or tank levels can effect the measurement of the amount of water that is supplied. However, the City maintains its tanks and reservoirs at close to full levels, and therefore the volume of any potential reservoir changes within the City's supply system over the one-year period considered in the survey is very small. It is assumed to be about 400 ccf (equivalent to a 2 foot change in reservoir elevation at all storage reservoirs in the system).

Table 6 - 10
Monthly Water Purchase from SFWB, March 1996 - February, 1997

Month	Volume (ccf)
March	79,880
April	92,647
May	91,257
June	132,219
July	196,658
August	188,663
September	124,465
October	91,043
November	88,422
December	97,500
January	100,080
February	90,588

No other contributions or losses in supply were identified during this period. Table 6 - 11 summarizes the adjusted total water supply.

Table 6 - 11
Adjusted Total Water Supply

DESCRIPTION	SUBTOTAL (ccf)	TOTAL (ccf)
Total Metered Supply		**1,373,420**
Adjustment to Total Supply		
Source Meter Error	0	
Change in Reservoir Level	400	
Other Contributions or Losses	0	
Total Adjustments		**400**
Total Adjusted Supply		**1,373,020**

Measured Metered Water Use

Over the same period of March 1996 through February, 1997, the metered water use in the City of West Linn system was 1,105, 357 ccf, or an average of 92,113.1 ccf per month. Table 6 - 17 shows the metered water sales per month for the period.

As with water supply, there are potential adjustments due to meter inaccuracies in customer meters and adjustments due to the difference in time period between when the water meter was read and billed, and the time the water usage occurred, or meter reading lag-time. An estimated 379 ccf were billed during this period but used previously and must be subtracted from the metered water use.

Table 6 - 12
Metered Water Sales Over the Period March, 1996 through February, 1997

MONTH	VOLUME (ccf)
March	71,083
April	54,083
May	69,984
June	68,562
July	87,904
August	167,005
September	154,829
October	137,190
November	88,636
December	69,888
January	70,507
February	65,686
TOTAL	**1,105,357**

Meter Inaccuracies

There are no records, meter test results or other information on the accuracy of the water meters in the City of West Linn's system. With the exception of approximately 20 meters, all the meters in the City's system are 2-inch or smaller. Typically, if residential meters are inaccurate, they will under-register from between 5% and 15%. Larger meters may under-register by considerably more. For the purposes of this unaccounted for water survey, it was assumed that system-wide, meters are under-registering on average by 3%. This figure was derived by assuming that ten percent of the meters are under-registering by 5%, ten percent of the meters are under-registering by 10% and ten percent of the meters are under-registering by 15% while the remaining meters all are accurate. Thus, over the survey period, this under-registering could represent a loss of 33,160 ccf.

The City currently replaces residential water meters when they fail. It currently costs the City between $50 and $75 to replace a residential meter, including labor and the cost of the materials. Testing residential meters typically cost from $25 - $50 per meter. Thus, there is no cost incentive to test a residential meter instead of replacing it. However, the question is, when should it be replaced - at failure, or prior to that time. If a meter under-registers by 10%, the typical monthly registration is 10 ccf, and the cost of water is $1.00 per ccf, then the lost revenue of the meter becomes $1.00 a month. Payback on replacement of the meter under these assumptions for West Linn is then 50 to 75 months, or 4 to 6 years. If the typical residential meter in the West Linn system is under-registering for this period of time prior to failure, then it would be cost effective to replace it prior to failure. This is why some systems replace residential meters on a scheduled of every 15 - 20 years. If the meter does not under-register to this extent, then it may be more cost effective to continue to replace meters at failure.

The City currently replaces about 300 meters per year in conjunction with leak repairs and other maintenance activity. Table 6 - 13 summarizes the adjusted meter water use for the City.

Table 6 - 13
Adjusted Metered Water Use, March 1996, through February, 1997

Unadjusted Metered Water Sales		**1,105,357**
Adjustments to Metered Water Use		
Meter Lag Time	379	
Meter Errors	33,160	
Total Adjustments to Metered Sales		**32,781**
Corrected Total Metered Use		**1,138,138**

Authorized Unmetered Water Uses

There are a number of authorized water uses that are not metered in a water system. These uses and estimated volumes of water use from them are shown in Table 6 - 14.

Table 6 - 14
Estimated Authorized Unmetered Water Uses, March 1996, February, 1997

DESCRIPTION	SUBTOTAL (ccf)	TOTAL (ccf)
Firefighting & Training (est.)	310	
Main Flushing (est.)	55	
Storm Drain Flushing (records)	103	
Sewer Cleaning (records)	138	
Street Cleaning (records)	35	
Unmetered Schools	0	
Unmetered Landscaping	0	
Decorative Water Facilities	0	
Unmetered Swimming Pools	0	
Unmetered Construction Water (est)	2400	
Water Quality and Other Testing	0	
Other Unmetered Uses	0	
Total Authorized Unmetered Use		**3041**

Water is drawn from the City's distribution system from fire hydrants for fire suppression, testing fire equipment, firefighting training, and hazardous materials reduction. Based on the City's records, an estimated 310 ccf of water was used for these purposes over the period.

Water is used from the distribution system to flush water mains from hydrants and blowoffs in response to customer complaints and water quality concerns. Water may also be used from these hydrants and mains for flushing storm sewers, sanitary sewers, and street cleaning. Based on the City's records, a total of 55 ccf are estimated for water main flushing, 103 ccf for storm drain flushing, 35 ccf for street cleaning and 138 ccf for sewer cleaning over the period. Some systems also maintain unmetered free-flowing water sample taps for water quality monitoring purposes. While the City does maintain several dedicated water quality sampling taps, these are not free-flowing taps.

In some areas, water systems may provide water to schools, parking strip media landscaping, decorative fountains, and public swimming pools without being metered. No such uses have been identified in the City of West Linn's system.

Another typical unmetered use of water from the system is for construction. The City began to meter construction use in 1999.

Water Losses

Heath Consultants conducted sonic leak detection testing on approximately 16.2 miles of the distribution system. This represents approximately 15% of the 104 miles of pipeline in the system. The areas that were surveyed were chosen because they were the older areas of the City and were the most suspected to have leaks. The sonic tests identified a total of 13 potential leaks. Each of the identified sites was then dug up and inspected for leakage. Of the 13 sites, eight were found to have leaks when they were excavated. The total flow from the leaks was found to be 23 gpm. If the rate of leakage found in the pilot test (23 gpm over 16.2 miles of pipeline) were to be extrapolated throughout the City, total expected leakage in the pipelines would be 153 gpm, or 107,331 ccf per year. This leakage would represent about 7.8% of the total water supply from the SFWB for that period. A leakage rate of around 8% in pipelines is the mid-range of the typical 5-15% rate for most systems.

Other water losses can occur through evaporation of water from open storage reservoirs, illegal connections to the water system, malfunctioning distribution system controls, purposeful overflow of reservoirs for water quality or operational purposes, theft of water, and seepage and leaks from storage reservoirs. Of these potential sources, only leakage for reservoir seepage (at the Bolton Reservoir) is expected to occur. Assuming a leakage rate of 5 gpm, the estimated leakage is 3,513 ccf over the twelve month period. These are shown in Table 6 - 15.

Table 6 - 15
Water Losses, March 1996 Through February, 1997

DESCRIPTION	SUBTOTAL (ccf)	TOTAL (ccf)
Accounting Procedure Errors		
Main Leaks	107,331	
Evaporation	0	
Illegal Connections	0	
Malfunctioning Distribution System Controls	0	
Reservoir Overflows	0	
Reservoir Seepage and Leaks	3,513	
Survey Leakage	0	
Theft	0	
TOTAL IDENTIFIED WATER LOSSES		**110,844**

Summary of Unaccounted-For Water Survey

Based on a total adjusted water supply over the survey period of 1,373,020 ccf and a corrected metered water use of 1,138,138 ccf, the total unmetered water use is 234,882 ccf, or about 17 % of the water supply. The water losses that are estimated based on current data account for 110, 884 ccf or about 8% of the water supply. Based on current data, the authorized water uses which are unmetered account for 3,041 ccf, or about 0.2% of the supply. The remainder of the unmetered water, a bit less than 9%, is unaccounted-for. This is summarized in Table 6 - 16.

Table 6 - 16
Summary of Unaccounted For Water Survey, March, 1996 Through February, 1997

DESCRIPTION	SUBTOTAL (ccf)	TOTAL (ccf)
Total Adjusted Water Supply		**1,373,020**
Corrected Metered Water Use	1,138,138	
Total Unmetered Water Use		**234,882**
Unmetered Water Use - %		**17.1%**
Authorized Unmetered Water Use	3,041	
Identified Water Losses	110,884	
Identified Water Losses - %		**8.1%**
Total Water Use		**1,252,063**
Total Unaccounted For Water		**120,957**
Unaccounted For Water - %		**8.8%**

There are several possibilities to explain the unaccounted-for water:

- Other portions of the system may be leaking at greater rates than the portions that were surveyed in the pilot leak test. If system-wide leakage were at 12% instead of the 8% found in the pilot test, then another 3-4% of the unmetered water would be accounted-for.
- The existing meters may be significantly underregistering. If the meters were all registering 10% low instead of the 3% assumed in this analysis, an additional 5% of the supply would be accounted-for.
- Authorized, but unmetered uses may be greater than have been estimated in this survey. Little data is available for these uses.

Data from the full year of 1997 and 1998 were recently also reviewed to determine whether the water loss was changing over time. Table 6 – 17 summarizes the data from these years and compares it to the data during the water loss study. This shows that the water loss has been constant over the last three years.

Table 6-17
Summary of Unaccounted-for Water

Year	Total Volume of Water Purchased from SFWB (MG)	Total Volume of Water Billed to City Customers (MG)	Unmetered Water Use (%)	Water Losses (%) As Identified In Study	Unaccounted for Water Use (%)
Study –1996	1,027	851	17	8	9
1997	1,019	827	19	8	11
1998	1,063	876	18	8	10

Recommendations

Based on this survey, the following recommendations have been made to develop more information on unaccounted-for water and ultimately reduce system water losses.

- A leak repair log is being maintained. The estimated quantity of water that is being lost by each leak which is found and repaired, whether from the routine leak detection program or as a part of other activities, is recorded.

- Unmetered water use reports is being maintained as part of the monthly operating logs. Water uses such as pump lubrication, main flushing, fire hydrant inspections,

tank cleaning and draining, etc. are recorded so as to maintain accurate unmetered water use statistics.

- Records on the amount of water used for fire fighting, hydrant flushing, and fire training should be maintained to record unmetered water use.

- All large meters (3-inch or greater) that are presently not outfitted with test ports, should be so fitted, and then tested on an annual basis.

- A pilot test program of small meters should be conducted. Fifty to 100 small meters representing the various models and ages (with an emphasis on older meters) in the system should be removed and tested to determine what the typical average rate of underregistering is in the system, and at what point it will become economical to replace them. For the moment, it is assumed that these meters should be replaced on a 20 year cycle.

- A program of metering construction water use has been implemented with a dedicated, metered water station.

REVIEW OF OTHER INFORMATION AND ISSUES

Emergency Supply/ Source Reliability

The intertie with the water treatment plant operated by the City of Lake Oswego is designed to provide 5,000 gpm of emergency supply. Currently there are two 2,500 gpm pumps installed with space for a third (current firm capacity of 2,500 gpm, future 5,000 gpm). The planning criteria in Section 4 of this Master Plan indicates that the emergency supply should be able to meet average day demand requirements. Section 3 identified the average day demand to be 3.32 MG. Buildout average day demand is calculated to be 4.48 MG. The intertie with Lake Oswego will supply 3.6 MGD (firm-tested) and up to 5.76 MGD (two pumps-tested). Thus, the intertie with the City of Lake Oswego is able to supply the desired one average day demand.

The City recently (Fall 2003) updated its agreement with the City of Lake Oswego to assure that all necessary contractual provisions for the intertie are in place.

However, there are circumstances where the Lake Oswego plant may not be able to provide the required emergency supply to West Linn. The Lake Oswego plant uses the Clackamas River as its source, just as the SFWB plant does. If the cause of the supply outage to West Linn is due to a contamination event or flood or other problem associated with the Clackamas River source, then it is possible that the Lake Oswego plant will be out of service at the same time as the SFWB plant. If the supply outage is localized to the SFWB plant, is caused by loss of the transmission pipeline across the Willamette on the Interstate 205 bridge, or by a landslide in the vicinity of Atkinson Park where the transmission pipeline is known to be vulnerable to such an occurrence, then

the Lake Oswego plant is likely to be available to provide the emergency supply. If the problem is associated with the SFWB plant, however, the Lake Oswego plant will be called upon to supply not only West Linn, but also Oregon City. In that circumstance, less water would be available to West Linn.

An outage at the SFWB plant due to contamination of the river or flooding is likely to last only for a couple of days. The Water Master Plan which the SFWB recently completed (Montgomery Watson, 1997) calls for SFWB to maintain storage for at least one day average demand to protect against such outages. All of the SFWB's current storage is located in Oregon City.

A second supply line from the SFWB across the Willamette River to the City is not needed to meet buildout demand. However, construction of this second line would serve to improve the reliability of the source. The crossing of the Willamette River on the I-205 bridge is perhaps the most vulnerable piece of the transmission system as documented in the 1996 Report (MSA, 1996) discussed earlier in this Section. There are many considerations in selecting a route for a second transmission pipeline. In addition to the vulnerability of the crossing, issues include the location of a potential of a SFWB storage reservoir in West Linn, the availability of transmission pipeline at a different crossing location, and the nature of rock and other material through which a new crossing would have to pass.

Service Replacement

An ongoing program of water service renewal should be provided for in the Capital Maintenance Program. It is assumed that water services will be replaced on a 75 year cycle. With approximately 7,000 services in the system, this would result in replacement of approximately 90 services a year. Services are currently replaced (if needed) in conjunction with main replacements.

Water Quality

The water quality of the both the Clackamas River supply and the West Linn distribution system is excellent. The monitoring program in the West Linn system meets State requirements and is designed to anticipate and correct problems. No other upcoming regulations are anticipated to cause compliance problems for the City of West Linn. However, the City should anticipate and prepare for other upcoming regulations, such as the Consumer Confidence Report, which will be required as a consequence of the 1996 reauthorization of the Safe Drinking Water Act.

Operator Certification

The City's water system is classified as a Level 3 Distribution System by the State Health Division. A Level 3 system must be operated by an operator with a Water

Distribution - Level 3 certification. The City must plan for and develop operators with the Level 3 certification.

Rate Structure

The current rate structure includes 14 ccf of water use within the flat bimonthly rate. This is an amount that many residential customers will use during a two month period. As a result, customers do not have any incentive to minimize water use. It is recommended that the next time the City modifies its water rates, that it move to a cost-of-service methodology which incorporates a service charge for customer and meter related costs, and a commodity charge for the use of all amounts of water. The City may wish to consider conservation-inducing, inclining block rate structures for the commodity charge. Many communities in the metropolitan region have done this, particularly during the summer months in order to reduce summer peak day demands. Under these rate structures, those who use relatively high amounts of water pay a larger share of the total costs of providing water to all. The City may also wish to review its charges and procedures for recovering costs of unmetered, authorized water uses, such as construction water.

Conservation Programs

Because the City is a wholesale customer of the SFWB, any reduction in water use will result in a direct reduction of purchased water costs. Thus, an effective conservation program is an important element in maintaining low water rates for City customers. While the City currently provides conservation related information to its customers and the impacts are felt of naturally occurring conservation from plumbing code modifications which mandate low flow showers, faucets and toilets, the City's conservation program is not fully developed.

A major reason for this lack of full development is the City's appropriate goal of being coordinated with the broader Portland regional conservation effort. Because many conservation programs are more effective if conducted on a wider service area basis, the water providers in the region have established the Columbia-Willamette Regional Conservation Coalition to coordinate conservation efforts. While the Portland Regional Water Supply Plan completed in 1996 identified some overall conservation goals for the region, it did not establish specific program components for various entities to meet those goals. As a result, the Conservation Coalition is in the process of a two-year effort to better determine the specific conservation targets that are achievable in the various parts of the region, the specific conservation program elements which will achieve those targets, the cost-effectiveness of conservation elements, and the monitoring programs required to assure that the targets are in fact being met. The City of West Linn should participate in this Coalition effort. When the information from the Coalition work is available, the City should use it to expand its own conservation programs. In the interim, the City should provide public information about wise water use and begin to prepare for adoption of potential conservation program elements, such

as landscape ordinances and industrial, commercial and residential water audits, in addition to the leak detection and rate structure evaluations discussed elsewhere in this section.

Staffing Level

A detailed evaluation of the staffing levels and needs and organizational structure for the water system is not included in the Scope of Work of this Master Plan. However, several general comments can be provided.

The organizational structure which the City maintains of a water crew under an operational branch, and engineering support provided by an engineering branch of a Public Works Department is typical of many cities the size of West Linn. It is a means of efficiently using limited personnel resources to satisfy a number of municipal operating needs.

Current staffing levels appear to be able to adequately maintain and operate the existing facilities and system. However, it appears that the staff have very little time to conduct efforts which go beyond the routine maintenance and operation to more long-term goals of improving the system. Recommendations such as increased leak detection work, better record keeping of unmetered water uses, and evaluation of the impacts of upcoming water regulations, which are contained in this Master Plan, are unlikely to be able to be implemented with the current staffing levels. The City should review its staffing levels and increase staffing as needed in order to implement the recommendations of this Master Plan.

Urban Reserve Area

A detailed evaluation of the impacts of the Metro designated Urban Reserve Area adjacent to the City is beyond the scope of this Master Plan. Capital Improvements needed for the water system within the current service area are not designed to accommodate urbanization outside the service area.

WATER CMP-CIP PROJECTS 6/04

Project No.	Project/Location	Length (FT)	Existing Material	Existing Size	Proposed Size	Estimated Cost	Local or System?	Extra Capacity and Infill?	Asset life remaining	SDC allocation	SDC PORTION	CITY PORTION
CAPITAL MAINTENANCE PROJECTS												
PW0307	Marylhurst Dr. - 2310 - View Dr.	1100	GALV	1 & 2	8	$96,200	Local	Yes	<25%	0%	$0	$96,200
PW0306	Nolan - Short to Ridder	650	WI	2.5	6	$40,000	Local	Yes	<25%	0%	$0	$40,000
PW0305	Charman - Simpson to Canemah to Riverview	800	STL	4	6	$69,400	Local	Yes	<25%	0%	$0	$69,400
PW0401	Norfolk - Sunset to Lancaster	500	STL	4	6	$43,400	Local	Yes	<25%	0%	$0	$43,400
PW0402	Warwick - Norfolk to Cornwall	700	STL	4	6	$60,800	Local	Yes	<25%	0%	$0	$60,800
PW0403	Lancaster - Cornwall to Exeter	900	STL	4	6	$67,900	Local	Yes	<25%	0%	$0	$67,900
PW0404	Walden St. - Riverview to Clark	400	STL	4	6	$34,700	Local	Yes	<25%	0%	$0	$34,700
PW0405	Tumwater - Riverview to 2255 Leonard	650	WI	3.5	6	$56,400	Local	Yes	<25%	0%	$0	$56,400
PW0406	Riverview - Sunset to Walden	1100	STL	4	6	$95,500	Local	Yes	<25%	0%	$0	$95,500
PW0407	Long - Clark to Exeter	1100	STL	4 & 6	8	$110,600	System	No	<25%	0%	$0	$110,600
PW0501	Ridge Lane - 4020 to end.	900	GALV	1.5 & 2	2	$68,000	Local	No	<25%	0%	$0	$68,000
PW0503	Grove - Holly to end	650	GALV & CI	4, 2, & 1.5	8, 6, & 2	$49,100	Local	Yes	<25%	19%	$9,491	$39,609
PW0504	Holly - 43 to River	1100	GALV & WI	4 & 3.5	8 & 6	$83,000	Local	Yes	<25%	19%	$16,044	$66,956
CMP-18	Nixon - 18920 Nixon to 18320 Nixon	1700	GALV	2.5 & 2	8, 6, & 4	$128,300	Local	Yes	<25%	19%	$24,800	$103,500
PW0505	Bolton Pump in new station				1500 gpm	$85,700	System	Yes	<25%	0%	$0	$85,700
CMP-19	Trillium at Old River Dr	250	GALV	2 & 3/4	4	$18,900	Local	No	<25%	0%	$0	$18,900
CMP-20	Calaroga Circle	1780	GALV & AC	2 & 6	6	$134,300	Local	Yes	<25%	19%	$25,960	$108,340
CMP-21	Marylhurst Ct	380	GALV	2.5	4	$28,700	Local	Yes	<25%	19%	$5,548	$23,152
CMP-22	16th St. - WFD to 8th to Dollar	650	GALV	4	6	$49,100	Local	Yes	<25%	19%	$9,491	$39,609
CMP-23	Shady Hollow Way	910	GALV	3	6	$68,700	Local	Yes	<25%	19%	$13,280	$55,420
CMP-24	Cherokee Ct	360	GALV	2	4	$27,200	Local	No	<25%	0%	$0	$27,200
CMP-25	Chippewa Ct (near end)	90	GALV	2	2	$6,800	Local	No	<25%	0%	$0	$6,800
CMP-26	Robinview Ct	250	GALV	2	2	$18,900	Local	No	<25%	0%	$0	$18,900
CMP-27	Parkwood Way	450	GALV	2	6	$34,000	Local	No	<25%	0%	$0	$34,000
CMP-28	Parkwood Place	220	GALV	1.5	2	$16,600	Local	No	<25%	0%	$0	$16,600
CMP-29	Steamboat Way	100	GALV	1	1	$7,500	Local	No	<25%	0%	$0	$7,500
CMP-30	Robert Moore St.	450	GALV	3.5	6	$34,000	Local	No	<25%	0%	$0	$34,000
CMP-31	4622 Mapleton Dr	260	GALV	2	2	$19,600	Local	No	<25%	0%	$0	$19,600
CMP-32	Maple Ct	210	GALV	2	2	$15,800	Local	No	<25%	0%	$0	$15,800
PW0311	Alley between 5th/6th Ave (14th to 15th St)	640	GALV	1&1.5	6	$48,300	Local	Yes	<25%	19%	$9,336	$38,964
PW0311	Alley between 5th/6th Ave (12th to 14th St)	680	GALV	3	6	$51,300	Local	Yes	<25%	19%	$9,916	$41,384
CMP-33	14th St - 8th Ave to WFD	150	WI	3.5	6	$11,300	Local	No	<25%	0%	$0	$11,300
PW0409	10th St at 5th Ave	400	GALV	1.5	6	$30,200	Local	Yes	<25%	19%	$5,838	$24,362
CMP-34	Failing St (end)	140	GALV	2	2	$10,600	Local	Yes	<25%	19%	$2,049	$8,551
CMP-35	Buck St (Holmes to Johnson)	570	GALV & STL	4&1.5	6 & 2	$43,000	Local	Yes	<25%	19%	$8,312	$34,688
CMP-36	Hood St (north of Burns)	250	GALV	2	2	$18,900	Local	Yes	<25%	19%	$3,653	$15,247
CMP-37	Broadway (off WFD)	280	GALV	2	2	$21,100	Local	No	<25%	0%	$0	$21,100
CMP-38	Sunset Ave - Norfolk to Exeter	420	STL	4	6	$31,700	Local	Yes	<25%	19%	$6,128	$25,572
CMP-39	Sunset Ave (1775-1875)	260	GALV	1	4 or 6	$19,600	Local	Yes	<25%	19%	$3,789	$15,811
CMP-40	Sunset Ave (Sunset Ct to Alder St)	530	STL	4	4 or 6	$40,000	Local	Yes	<25%	19%	$7,732	$32,268
CMP-41	Reed St	370	GALV	1	2	$27,900	Local	Yes	<25%	19%	$5,393	$22,507
CMP-42	Chestnut St	170	GALV	2.5	2	$12,800	Local	Yes	<25%	19%	$2,474	$10,326
CMP-43	Sinclair (North end)	140	GALV	1	2	$10,600	Local	Yes	<25%	19%	$2,049	$8,551
CMP-44	Kantara Ct	270	GALV	1.5 & 3/4	2	$20,400	Local	Yes	<25%	19%	$3,943	$16,457
CMP-45	Kantara Ct. - Wildwood Dr. to End	1000	PVC	2	2	$75,500	Local	Yes	<25%	19%	$14,594	$60,906
CMP-46	Bland reservoir painting inside and out		STL	.5 MG		$104,000	Local	No	<25%	0%	$0	$104,000
CMP-47	Asbestos cement pipe replacement	59310	AC	4,6,8,& 10	4,6,8,& 10	$5,180,000	Mix	Yes	<25%	19%	$1,001,294	$4,178,706
					CMP Total:	**$7,326,300**				**Subtotal**	**$1,191,115**	**$6,135,185**

WATER CMP-CIP PROJECTS 6/04

Project No.	Project/Location	Length (FT)	Existing Material	Existing Size	Proposed Size	Estimated Cost	Local or System?	Extra Capacity and Infill?	Asset life remaining	SDC allocation	SDC PORTION	CITY PORTION
CAPITAL IMPROVEMENT PROJECTS												
	Reservoirs											
CIP-7	Horton/Rosemont on existing site				.6 MG	$730,000	System	Yes	New	100%	$730,000	$0
CIP-8	Bland No. 2/Willamette on existing site				.1 MG	$190,000	System	Yes	New	100%	$190,000	$0
CIP-9	Bolton Reservoir replacement, existing site				2.4 MG	$3,010,000	System	Yes	New	16.7%	$500,000	$2,510,000
	Pump Stations											
CIP-10	Bolton Pump in new station				1500 gpm	$85,700	System	Yes	New	100%	$85,700	$0
CIP-11	View Dr. (new pump station)				1170 firm	$560,000	System	Yes	New	100%	$560,000	$0
	Willamette Main Improvements											
PW0502	Volpp St. - From 9th to end	800	GALV	1	8 & 4	$101,000	Local	Yes	<25%	0%	$0	$101,000
PW0311	Knapp's Alley 14th to 16th St	730	GALV	4	12	$133,000	System	Yes	<25%	12%	$15,960	$117,040
PW0409	1-1a: WFD-10th to Knapp's Alley	430	CI & DI	6	12	$79,000	System	Yes	<25%	12%	$9,480	$69,520
PW0311	1-1b: Knapp's Alley, 12th to 14th St	400	CI	4	12	$73,000	System	Yes	<25%	12%	$8,760	$64,240
CIP-13	1-2: Blankenship Ostman to DeBok	2400	CI	6	10	$362,000	System	Yes	<50%	100%	$362,000	$0
CIP-14	2-1a: Dollar St (19th to Ostman)	1200	CI	6	8	$151,000	System	Yes	<50%	100%	$151,000	$0
CIP-15	3-1a: New 8" Distribution Main	4000			8	$503,000	System	Yes	New	100%	$503,000	$0
CIP-16	WFD 19th to Britton	630	WI	3.5	12	$115,000	System	Yes	>25%	75%	$86,250	$28,750
CIP-17	Debok - Blankenship to Troy Ct.	3300	CI	6	8	$415,000	System	Yes	>50%	44%	$181,563	$233,438
CIP-18	Village Park Pl.	500	CI	6	8	$63,000	Local	No	>50%	0%	$0	$63,000
CIP-19	12th, Volpp St., and 9th	5400	CI	6	8	$679,000	System	Yes	>50%	44%	$297,063	$381,937
CIP-20	8th Ave. - Dollar St. to 13th St.	800	CI	4	6	$87,000	Local	Yes	<50%	56%	$48,333	$38,667
CIP-21	WFD - Ostman to 19th	1100	CI	4	8	$138,000	System	Yes	<50%	75%	$103,500	$34,500
CIP-22	Johnson Rd. - Blankenship to Meadowview Ct.	1600	CI	6	8	$201,000	Local	Yes	<50%	44%	$87,937	$113,063
CIP-23	10th St. - 5th Ave. to 4th Ave.	450	PVC	2	6	$49,000	Local	Yes	<50%	19%	$9,472	$39,528
PW0409	7th St. - 5th Ave to WFD	460	CI	4	6	$50,000	Local	No	<50%	0%	$0	$50,000
	Willamette Falls Dr transmission main											
PW0506	Will Falls Dr. 1-3c (phase 2) Sunset to I-205 crossing	2500	CI	8	20	$683,000	System	Yes	<50%	100%	$683,000	$0
CIP-24	Will Falls Dr Trans Improve (3-3) (phase 3)	4100	CI	10	16	$999,000	System	Yes	<50%	61%	$608,766	$390,234
	Subzone 16 Main Improvements											
CIP-25	1-4a: Mark Ln, Lowell	1300	CI	6	8	$163,000	System	Yes	<50%	44%	$71,313	$91,687
CIP-26	1-4b: Jolie Pt, Larson Ave	2600	CI	6	8	$327,000	System	Yes	<50%	44%	$143,062	$183,938
CIP-27	1-4c: Dillow Dr and Failing St	2500	CI	6	8	$314,000	System	Yes	<50%	44%	$137,375	$176,625
CIP-28	Maple Terr.	500	CI	4	8	$63,000	Local	No	<50%	0%	$0	$63,000
CIP-29	Magone Ln.	350	DI	4	6	$30,000	Local	Yes	>50%	19%	$5,799	$24,201
	Rosemont Main Improvements											
CIP-30	Rosemont Rd - Shannon Lane to Summit St	1920	CI	6	8	$241,000	System	Yes	>50%	44%	$105,438	$135,562
CIP-31	Marylhurst Dr. - Sky Pk Wy to Marylhurst Ct.	900	AC	6	10	$109,000	System	Yes	>50%	50%	$54,500	$54,500
CIP-32	View Dr. pump station to Suncrest	2600			10	$393,000	System	Yes	New	100%	$393,000	$0
CIP-33	Horton P.S. to Santa Anita	310	DI	12	14	$64,000	System	Yes	>50%	100%	$64,000	$0
CIP-34	3-9: Suncrest	2000	AC	8	10	$302,000	System	Yes	<50%	50%	$151,000	$151,000
CIP-35	View Dr. - PRV Station to Kantara	1500	AC	6	8	$189,000	Local	Yes	<50%	44%	$82,687	$106,313
CIP-36	Sky Pk Wy w/ PRV station	900			8	$113,000	System	Yes	New	44%	$49,438	$63,562
CIP-37	Stonehaven to Marylhurst Dr.	250			8	$31,000	Local	Yes	New	19%	$5,992	$25,008
CIP-38	Marylhurst Cir.	1200	AC	4	6	$130,000	Local	No	<50%	0%	$0	$130,000
CIP-39	Shannon Lane - Rose Park Dr. to End	250	STL	6	4	$22,000	Local	No	<50%	0%	$0	$22,000
CIP-40	3-13b: Weatherhill Rd (8")	800			8	$101,000	System	Yes	New	100%	$101,000	$0
	Robinwood Main Improvements											
CIP-41	LO Intertie to View Dr Reservoir	4000	AC	10	12	$730,000	System	Yes	<50%	100%	$730,000	$0
CIP-42	Elmran - Trillium to Calaroga	950	GALV	4	8	$119,000	System	Yes	<25%	75%	$89,250	$29,750
CIP-43	1-9: View Dr	1200	AC, CI	4 & 6	8 & 6	$151,000	System	Yes	<50%	25%	$37,750	$113,250
CIP-44	3-12: Mapleton	900	AC	4	6	$98,000	System	Yes	<50%	56%	$54,444	$43,556
CIP-45	Old River Dr. - Riverside Ct. to River Edge	650	DI	6	8	$82,000	Local	Yes	>50%	100%	$82,000	$0
	Bolton Main Improvements											
CIP-46	Web West A to Bolton Reservoir	2000	STL	18	18	$569,000	System	Yes	<50%	19%	$109,988	$459,012
CIP-47	2-2a: Broadway (Buse to Webb)	1900	STL	18	18	$541,000	System	Yes	<50%	19%	$104,575	$436,425
CIP-48	2-2b: Webb (Broadway to West "A")	350	STL	18	18	$100,000	System	Yes	<50%	19%	$19,330	$80,670
CIP-49	River St. - 5350 to 5687	2100	CI	4	6	$228,000	Local	Yes	>50%	19%	$44,072	$183,928
CIP-50	Bella St.	300	CI	4	6	$33,000	Local	Yes	>50%	19%	$6,379	$26,621
CIP-51	Skyline Circle	500	CI	4	6	$54,000	Local	Yes	>50%	0%	$0	$54,000
CIP-52	Buse St. Broadway to 43	800	STL & CI	20	20	$268,000	System	Yes	<50%	19%	$50,920	$217,080
	Bolton PS Discharge Improvements											
CIP-53	3-6a: Summit	1600	CI	12	16	$390,000	System	Yes	>50%	100%	$390,000	$0
	Bland Main Improvements											
CIP-54	3-2: Salamo/Haskins				8 & 10	$220,000	System	Yes		100%	$220,000	$0
	Horton Main Improvements											
CIP-55	Bolton Pump Station to Summit	1600			12	$292,000	System	Yes	New	100%	$292,000	$0
CIP-56	Cornwall (below Sunset)	630	GALV	1&1.5	8	$79,000	Local	Yes	<25%	19%	$15,271	$63,729
CIP-57	Pimlico Way Loop	200			6	$15,000	Local	Yes	New	100%	$15,000	$0
CIP-58	3-7: Lower Bland Cir	1100			8	$417,000	System	Yes	New	100%	$417,000	$0
CIP-59	Parker 18" to Horton P.S.	3000			8	$377,000	System	Yes	New	100%	$377,000	$0
					CIP TOTAL:	**$16,811,700**				**CIP SUBTOTAL:**	**$9,641,365**	**$7,170,332**
										SDC TOTAL (CMP + CIP):	**$10,832,480**	
					CIP +CMP TOTAL:	**$24,138,000**				**CITY TOTAL (CMP+CIP):**		**$13,305,517**