SECTION 6
WATER STORAGE REQUIREMENTS

General

This section documents the evaluation of the City of West Linn's (City's) distribution system water storage needs and establishes City-wide water storage requirements as well as storage requirements for the City's six (6) pressure zones. Included in this section is a summary of the City's existing storage reservoirs, a presentation of three (3) storage criteria evaluation methodologies and recommendations to meet the City's storage needs based on the selected analysis methodology.

The findings and conclusions of the supply evaluation presented in Section 5 are incorporated in this section in the development of a comprehensive storage and supply needs strategy. Recommended system improvements for storage and supply needs are presented in Section 8 where the Capital Improvement Plan (CIP) and Capital Maintenance Plan (CMP) are documented and discussed in detail.

Background

Drinking water distribution system storage is an essential component of a water system that serves to:

- Equalize demands on supply sources, booster pump stations and transmission mains.
- Stabilize system flows and service pressures.
- Provide reserve capacity in the distribution system for emergencies.
- Provide reliable "on demand" capacity to meet fire suppression needs.

There are six (6) distribution system storage reservoirs in the City's water system with a combined usable storage volume, or capacity, of 5.5 million gallons (mg). Table 6-1 summarizes the name, location, capacity, overflow elevation and pressure zone served by each of these storage reservoirs.

Criteria Methodology Development

General

A general review of local and regional approaches to establishment of water storage requirements was completed to determine the most appropriate methodology to apply to the City's water system. Three (3) specific approaches were identified for consideration:

- Method No. 1 – Three-Component Methodology
- Method No. 2 – Washington State Department of Health Methodology
- Method No. 3 – System Performance Methodology

Table 6-1
Reservoir Summary

Reservoir Name	General Location	Usable Capacity (mg)	Overflow Elevation (ft)	Pressure Zone Served
Bolton	Skyline Drive	2.0	440	Bolton
Horton	Horton Road & Santa Anita Drive	1.5	731	Horton
Rosemont	Suncrest Drive	0.4	860	Rosemont
Bland	Bland Circle	0.5	585	Bland
Willamette	Salamo Road	0.6	351	Willamette
View Drive	View Drive	0.5	328	Robinwood

A discussion of the key elements, advantages and disadvantages of each method is presented below.

Three-Component Methodology (Method No. 1)

The three-component methodology considers the three (3) primary uses, or components, of distribution system storage and considers the volume of storage necessary for each of those components. The total volume of storage required is the sum of the three (3) component volumes. The three (3) components are:

- *Operational Storage:* Operational storage is required to meet water system demands in excess of delivery capacity from the supply source to system reservoirs. Operational storage volume should be sufficient to meet normal system demands in excess of the maximum day demand (MDD) and is generally considered as the difference between peak hour demand and MDD (on a 24-hour duration basis).
- *Fire Suppression Storage:* Fire suppression storage should be provided to meet the single most severe fire flow demand within each pressure zone. The required fire suppression storage volume is based on the recommended fire flow rate and the expected duration of that flow.
- *Emergency Storage:* Emergency storage is provided to supply water from storage during emergencies such as pipeline failures, equipment failures, power outages or natural disasters. The amount of emergency storage provided can be highly variable depending upon an assessment of risk and the desired degree of system reliability. Provisions for emergency storage in other systems vary from none to a volume that would supply a maximum day's flow or higher.

The three-component methodology has historically been used by the City to establish the water storage requirement. The primary advantage of this methodology is that it is fairly simple to apply and allows policymakers latitude in establishing emergency storage requirements relative to acceptable levels of risk. This simplicity and flexibility are also this methodology's major disadvantage. Emergency storage volume requirements are typically subjective and based on typical industry practice rather than a rigorous, methodical assessment of vulnerability and risk.

Washington State Department of Health Methodology (Method No. 2)

The Washington State Department of Health (DOH) has developed and documented a multiple-component methodology for determining water storage requirements that is used by all water system providers in the State of Washington. This methodology is similar to Method No. 1, in that it considers several storage components and the total water storage volume required is based on the sum of the individual components. This methodology contains four (4) storage components that must be considered and also includes a structured, objective process for determining the storage volume needed for each component. The four (4) components and the method for calculating the storage volume required for each is presented below:

- *Equalizing Storage:* When the source pumping capacity cannot meet the periodic daily (or longer) peak demands placed on the water system, equalizing storage must be provided as a part of the total storage for the system and must be available at 30 psi to all service connections. The volume required depends upon several factors, including peak diurnal variations in system demand and source production capacity. The equation for calculating the required volume of equalization storage is presented below:

$$ES = (PHD - Q_S)(150\ \text{min.}),\ \textit{but in no case less than zero.}$$

Where: **ES** = *Equalizing storage component, in gallons.*

PHD = *Peak hourly demand, in gpm.*

Q_S = *Sum of all installed and active source of supply capacities, except emergency sources of supply, in gpm.*

- *Operational Storage:* Operational storage is the volume of the reservoir devoted to supplying the water system while, under normal operating conditions, the sources of supply are in "off" status. The operational storage volume should be approximately 2.5 times the capacity of the largest pump, or the volume of water in the reservoir between the height of the "pump on" and "pump off" set points, whichever is greater.
- *Standby Storage:* The purpose of standby storage, or emergency storage, is to provide a measure of reliability should sources fail or when unusual conditions impose higher demands than anticipated. The volume recommended for systems served by one (1) source may be different than for systems served by multiple sources as described in the following equations:

- Water Systems with a Single Source: The recommended volume for systems served by a single source of supply is two (2) times the system's *average day demand* (ADD) to be available to all service connections at 20 psi.

$$SB_{TSS} = (2\ days)(ADD)$$

Where: SB_{TSS} = *Total standby storage component for a single source system, in gallons;*

ADD = *Average day demand*

- Water Systems with Multiple Sources: The recommended volume for systems served by multiple sources should be based upon the following equation:

$$SB_{TMS} = (2\ days)(ADD) - t_m\ (Q_S - Q_L)$$

Where: SB_{TMS} = *Total standby storage component for a multiple source system; in gallons*

ADD = *Average day demand for the system*

Q_S = *Sum of all installed and continuously available source of supply capacities, except emergency sources, in gpm.*

Q_L = *The largest capacity source available to the system, in gpm.*

t_m = *Time that remaining sources are pumped on the day when the largest source is not available, in minutes. (Unless restricted otherwise, this is generally assumed to be 1440 minutes.)*

- *Fire Suppression Storage:* Fire suppression storage should be provided to meet the single most severe fire flow demand within each pressure zone. The required fire suppression storage volume is based on the recommended fire flow rate and the expected duration of that flow.

The four-component methodology mandated by the Washington State DOH is advantageous to use because it is objective, easy to apply and understand, and provides a standardized, industry-accepted approach to determining storage needs. This methodology does not directly consider variations in system configuration or risk and redundancy to determine appropriate system storage requirements relative to acceptable levels of service under emergency conditions.

System Performance Methodology (Method No. 3)

The system performance methodology is similar to the two (2) previous methodologies in that it considers the different uses for stored water to calculate the total volume of storage needed. This methodology differs in that it takes a more holistic look at those uses and considers all of the components in the water system that function to meet those uses. Specifically, there are three (3) key concepts that distinguish this methodology:

- Booster pump stations supplying the system, or an individual pressure zone, can supply system demands and meet fire suppression requirements if the facilities have a high level of reliability (firm capacity to meet demands and standby power to keep pump station operational in an emergency) and redundancy (more than one (1) facility with firm capacity to meet demands supplies the system/zone).
- Under emergency conditions, storage in a higher level pressure zone may be available to supply a lower zone, if supply to the higher zone is from a different pressure zone than the lower one (1) experiencing the emergency and appropriately sized pressure reducing stations exist to transmit supply to the lower zone.
- Under certain emergency conditions, it may be acceptable to consider a reduced level of service for the water system. For example, if a major earthquake were to result in the loss of the Horton Pump Station and the View Drive Pump Station simultaneously then it may not be reasonable to expect the water system to still supply MDD and fire suppression flow in the Rosemont pressure zone. An acceptable reduced level of service that still provides for public health and safety would be to supply enough water to meet ADD and typical residential fire suppression flows (1,000 gpm for two (2) hours).

While Method No. 3 is more complex than the other two (2) alternatives, it has several key advantages. This methodology recognizes that it is prudent to develop redundant supply facilities throughout the system, that pressure zone interconnectivity provides greater operational flexibility, especially in an emergency, and that it may not be economical or even feasible to maintain normal levels of service under certain emergency conditions with a low likelihood of occurrence.

Preliminary Criteria Screening Process

A general overview of the three (3) methodologies discussed above was reviewed with City staff in preparation for presentations to the Utility Advisory Board (UAB) and the City Council. The ultimate direction from the City Council was to proceed with Method No. 3; however, at least two (2) alternatives should be developed with one (1) of those alternatives focused on providing storage to meet any system performance requirements.

Storage Analysis

General

A detailed storage analysis using Method No. 3 and considering the direction of the City Council is presented below. Two (2) separate approaches to addressing system performance needs were evaluated under existing conditions and under saturation development conditions. The first approach, Approach A, considers providing additional storage volume as the primary means of meeting system performance requirements. Approach B considers system configuration, vulnerabilities and operational flexibility in selecting appropriate storage, booster pumping and transmission system improvements to meet system performance requirements.

System Performance Requirements

While the City may consider further evaluation of reduced system performance requirements in the future, this analysis assumes that reduced levels of service under certain emergency conditions will not be acceptable. As such, for the entire City water system and for individual pressure zones, the system performance requirement is to have adequate supply and storage to meet MDD conditions while simultaneously supplying fire suppression needs in each pressure zone. The maximum fire suppression flow requirement for each pressure zone is 3,000 gpm for 3 hours. Throughout this analysis, it is assumed that only one (1) fire flow condition is occurring at any given time in the system.

It is prudent to consider typical operating conditions for the existing reservoirs, and to recognize that the reservoirs may not be full when an emergency condition exists. For this analysis, it is assumed that all distribution reservoirs are three-fourths (3/4) full.

For future reference, a tabulation of likely emergency conditions and potential reduced system performance responses is presented in Table 6-2. Should the City wish to consider the adoption of reduced levels of service under certain emergency conditions, the next step would be to further define the types of emergency conditions that could occur and the likelihood of these events occurring (recurrence interval). This information would be used to allow policy-makers to assess the risks of accepting reduced levels of service.

System-Wide Storage Requirements

System performance requirements and related storage volume needs are evaluated on a system-wide basis, considering water demand and fire suppression needs relative to the City's supply from the South Fork Water Board (SFWB) and the City of Lake Oswego emergency supply connection as documented in Section 5. Table 6-3 summarizes the MDD, fire suppression flow needs, and the supply capacity available under normal and emergency conditions. Under normal and emergency conditions, the analyses presented throughout this section consider the MDD condition for one (1) day and assume that the City's supply capacity is adequate to refill storage volume used for fire suppression. The emergency condition presented in the table below assumes a loss of the City's SFWB supply for one (1) day. Under emergency conditions it is assumed that emergency supply from the City of Lake Oswego Intertie is unavailable under MDD conditions. It is assumed that the City will address outage durations in excess of one (1) day through the implementation of water curtailment measures. Based on this analysis, the City has a current and future supply deficit under emergency conditions that must be addressed through storage or development of additional reliable emergency supply capacity.

Table 6-2
Potential Reduced System Performance Requirement Consideration Summary

Condition	Recurrence Interval	System Performance Requirement
Normal Operation	--	MDD + Fire Flow
Distribution Pump Station Out of Service for 24 Hours (Bolton, Horton, Willamette or View Drive)	1 to 5 Year	MDD + Fire Flow
Minor Earthquake - Distribution Pump Station Out of Service for 48 Hours	10 Years	MDD + Fire Flow
Moderate Earthquake – Willamette River crossing out of service for 30 days	100 Years	Peak Season Demand (~1.25 times the ADD) + Fire Flow
Extensive Earthquake – Supply Outage for 30 Days and One (1) or More Distribution Pump Stations Out of Service	500 Years	ADD + Reduced Fire Flow

Table 6-3
System-Wide Performance Requirement Summary

Year	MDD (mg) [1]	Fire Flow (mg) [2]	Total Supply Need (mg) [3]=[1]+[2]	Normal Supply Capacity [1] (mg) [4]	Emergency Supply Capacity[2] (mg) [5]	Normal Supply Deficit (mg) [6]=[3]-[4]	Emergency Supply Deficit (mg) [7]=[3]-[5]
Current	8.1	0.5	8.6	9.5	0.0	(0.9)	8.6
2015	8.6	0.5	9.1	9.5	0.0	(0.4)	9.1
2030	9.7	0.5	10.2	9.5	0.0	0.7	10.2
Saturation Development	10.0	0.5	10.5	9.5	0.0	1.0	10.5

Notes:
1. Normal supply capacity is based on the assumed capacity of the City's finished water transmission main from the Division Street Pump Station across the Willamette River. The actual capacity of this transmission main under typical conditions is 10 mgd, but a reduction in capacity may be expected under certain emergency conditions.
2. Emergency supply capacity is the total available capacity of the City's Lake Oswego Emergency Intertie Pump Station, assumed to be 0.0 under maximum daily demand conditions.

Table 6-4 summarizes the overall supply/storage deficit in the system under normal and emergency conditions from current through saturation development demands. Based on the summary presented in Table 6-4, the City does not currently have adequate storage to meet system-wide needs under emergency conditions. Further analysis of individual pressure zone storage needs presented in this section may result in a need for greater storage volumes to meet individual pressure zone performance requirements.

As identified in Table 6-4, a future system-wide deficit of 6.4 mg is anticipated because of a lack of firm reliable peak season emergency supply. Three (3) alternative solution approaches have been identified to address this deficiency recognizing that replacement of the Bolton Reservoir is a critical need given the age and condition of this facility, and that construction of a new Bolton Reservoir will be part of all alternatives. These alternatives solution approaches are briefly summarized and discussed below.

Table 6-4
System-Wide Supply and Storage Deficit Summary

Year	Normal Conditions			Emergency Conditions		
	Supply Deficit [1] (mgd)	Storage Volume [2] (mg)	Overall Deficit (mgd)	Supply Deficit[1] (mgd)	Storage Volume [2] (mg)	Overall Deficit (mgd)
Current	0	4.1	0	8.6	4.1	4.5
2015	0	4.1	0	9.1	4.1	5.0
2030	0.7	4.1	0	10.2	4.1	6.1
Saturation Development	1.0	4.1	0	10.5	4.1	6.4

Notes: 1. See Table 6-3 for development of supply deficit.
2. Assumes distribution system reservoirs are three-fourths full.

Solution Approach A: Construction of a New 8.4 mg Bolton Reservoir

This approach includes the replacement of the existing Bolton Reservoir with a new 8.4 mg reservoir. The existing 2.0 mg Bolton Reservoir is in need of replacement and based on a conceptual level review of the existing site it appears that it may be possible to construct a new 8.4 mg reservoir on the site. The most economical and practical reservoir configuration on the existing site is a circular reservoir. Construction of a large reservoir may be complicated by site constraints and require the use of unique reservoir layout, shape and configuration features in addition to the use of specialty construction and shoring techniques that will result in higher construction and overall project costs.

A variant of this solution approach is to construct a circular reservoir at the existing Bolton Reservoir site and to construct an additional reservoir or reservoirs elsewhere in the Bolton Pressure Zone. This variant approach could prove costly and controversial as the need for an adequately sized site at the right ground elevation may result in significant local and neighborhood impacts as well as still potentially higher project costs.

Solution Approach B: Build back-up supply from SFWB

This approach includes the construction of a new 2.0 mg or larger reservoir at the Bolton Reservoir site to replace the existing 2.0 mg Bolton reservoir and to address the highest vulnerability of the existing supply system from SFWB. The SFWB's current master plan has recommended a number of improvements to increase the reliability of its supply system.

The element with the highest vulnerability of the City's supply system is the City's existing 24-inch diameter transmission main, including the Willamette River crossing on the I-205 Bridge. Constructing a parallel supply main from the Division Street Pump Station to the Bolton Reservoir, including a sub-surface crossing of the Willamette River, would provide a reliable back up to the existing transmission main. Based on a preliminary review of potential project costs, this approach has the highest probable cost of the approaches under consideration.

Solution Approach C: Improve the Emergency Supply Capacity and Reliability of the Lake Oswego Emergency Supply Connection

This solution approach includes developing a coordinated emergency supply plan that allows the City to fully meet its emergency supply capacity needs through the existing emergency supply connection from the City of Lake Oswego's water system in the Robinwood neighborhood near Lake Oswego's water treatment plant. The City's existing emergency supply connection to Lake Oswego is interruptible and its delivery capacity is dependent on Lake Oswego's supply and demand conditions at the time of the City's need. Under peak use, high demand conditions the actual capacity of this connection may approach zero as Lake Oswego's current maximum water demands are approaching the existing supply system's capacity.

The City of Lake Oswego is currently in discussions with the City of Tigard concerning long-term-water supplies. An element of these discussions includes the construction of a transmission system intertie that connects the City of Portland supply to Tigard through the Washington County Supply Line in such a way that water, which originates at the City of Portland's 50 mg Powell Butte Reservoir, could flow by gravity into Lake Oswego's Waluga Service Zone. With this supply Lake Oswego would have the ability to supply the City and meet its own demand needs at the same time by off-setting demands from the Lake Oswego treatment plant with supplies from the Tigard/Portland intertie. With the Tigard/Lake Oswego emergency supply connection operational Lake Oswego could supply an equal amount of water to the City through the West Linn/Lake Oswego supply connection. A preliminary review indicates that this connection may have a hydraulic capacity in excess of 6 mgd, potentially making an equal amount available to the City in an emergency event. Pursuing this option involves negotiating intergovernmental agreements (IGA) and probable participation in funding a portion of the transmission system intertie improvement. A preliminary review of potential project costs associated with this approach indicates that it has a lower cost than Approaches A and B.

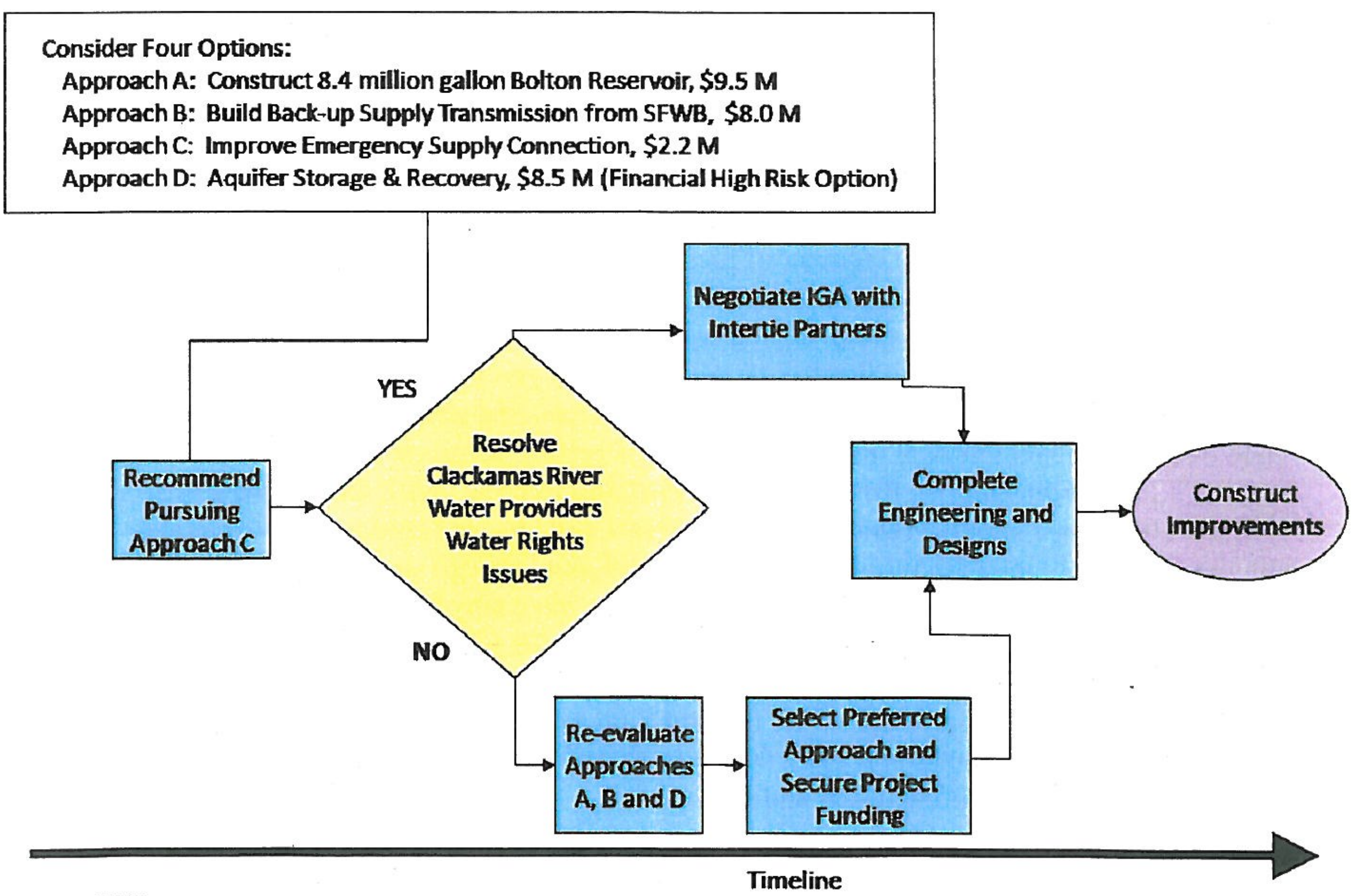
Solution Approach D: Aquifer Storage and Recovery (ASR)

Section 5 presented a preliminary evaluation of the hydrogeologic feasibility of implementing ASR that found the potential development of ASR, while not fatally flawed, presents many uncertainties and risks. Further evaluation of ASR feasibility requires conducting exploratory drilling and testing programs which may cost approximately $8 to $9 million. While immediately pursuing further evaluation of ASR it is not recommended it should be considered as a water supply management option as the City further develops its supply and storage options.

System Wide Storage and Supply Evaluation Summary

The four (4) solution approaches presented above provide varying degrees of certainty, risks and costs. Based on input from and discussions with City staff and policy makers it is recommended that Solution Approach C be pursued. Once fully developed and implemented, this approach most economically meets the City's supply and reliability needs. The successful implementation of this approach requires the resolution of ongoing water rights discussions with a number of Clackamas River water users, primarily, the City of Lake Oswego. Figure 6-1 presents a decision tree diagram summarizing the recommended supply system strategy for the City.

Figure 6-1
Supply Approach Decision Tree



Pressure Zone Storage Requirements

The analysis presented above for the entire City water system was repeated for each individual pressure zone to determine if adequate supply and storage existed under normal and emergency conditions. A summary of the analysis by pressure zone is presented in Tables 6-5 and 6-6. For pressure zones supplying higher level pressure zones, the MDD represents the actual demand in that pressure zone plus the MDD demand of all other pressure zones supplied from that zone. For example, the Bolton pressure zone MDD includes the MDD of all other pressure zones since the entire SFWB supply to the City is delivered through the Bolton pressure zone, although not necessarily through the Bolton Reservoir except in conditions where the SFWB supply is out of service. Given this condition, the Bolton pressure zone analysis is the same as the system-wide analysis and is not repeated in Tables 6-5 and 6-6. For the purpose of the pressure zone analysis, it is assumed that the system-wide deficiency discussed above is addressed and water is available to supply the other pressure zones from the Bolton pressure zone.

Based on the analysis presented in Table 6-5, all of the pressure zones in the City's water system have a current and future supply deficit under emergency conditions that must be addressed through existing storage volumes, if available, or through the development of increased emergency supply capacity through redundant pumped supply and system interties and/or construction of additional storage volume.

Two (2) approaches to address the current and future supply and storage deficits presented in Table 6-6 are discussed below. Both approaches include system improvements that, if implemented, would result in adequate supply and storage through saturation development. Specifically, each approach addresses the following pressure zone supply and storage deficits at saturation development:

- 0.4 mg in the Robinwood pressure zone
- 0.8 mg in the Willamette pressure zone
- 0.7 mg in the Horton pressure zone
- 0.3 mg in the Bland pressure zone
- 0.8 mg in the Rosemont pressure zone

Both approaches also consider the anticipated need to replace the Bolton Reservoir due to concerns over the age of the reservoir, usable capacity and maintenance of the floating cover.

Table 6-5
Pressure Zone Performance Requirement Summary

Year	MDD (mg) [1]	Fire Flow (mg) [2]	Total Supply Need (mg) [3]=[1]+[2]	Normal Supply Capacity [1] (mg) [4]	Emergency Supply Capacity[2] (mg) [5]	Normal Supply Deficit (mg) [6]=[3]-[4]	Emergency Supply Deficit (mg) [7]=[5]-[3]
Bolton Pressure Zone							
See System-Wide Analysis (Table 3)							
Robinwood Pressure Zone							
Current	1.6 (0.6)	0.5	2.1 (1.1)	3.1	0.5	(1.0)	0.6
2015	1.7 (0.7)	0.5	2.2 (1.2)	3.1	0.5	(0.9)	0.7
2030	1.9 (0.8)	0.5	2.4 (1.3)	3.1	0.5	(0.7)	0.8
Saturation Development	2.0 (0.8)	0.5	2.5 (1.3)	3.1	0.5	(0.6)	0.8
Willamette Pressure Zone							
Current	2.2	0.5	2.7	2.6	1.6	0.1	1.1
2015	2.3	0.5	2.8	2.6	1.6	0.2	1.2
2030	2.6	0.5	3.1	2.6	1.6	0.5	1.5
Saturation Development	2.7	0.5	3.2	2.6	1.6	0.6	1.6
Horton Pressure Zone							
Current	3.1 (2.1)	0.5	3.6 (2.6)	4.3	1.3	(0.7)	1.3
2015	3.2 (2.2)	0.5	3.7 (2.7)	4.3	1.3	(0.6)	1.4
2030	3.6 (2.5)	0.5	4.1 (3.0)	4.3	1.3	(0.2)	1.7
Saturation Development	3.8 (2.6)	0.5	4.3 (3.1)	4.3	1.3	0	1.8
Bland Pressure Zone							
Current	0.6	0.5	1.1	1.4	0.5	(0.3)	0.6
2015	0.6	0.5	1.1	1.4	0.5	(0.3)	0.6
2030	0.7	0.5	1.2	1.4	0.5	(0.2)	0.7
Saturation Development	0.7	0.5	1.2	1.4	0.5	(0.2)	0.7
Rosemont Pressure Zone							
Current	1.9	0.5	2.4	6.2	1.7	(3.8)	0.7
2015	2.0	0.5	2.5	6.2	1.7	(3.7)	0.8
2030	2.2	0.5	2.7	6.2	1.7	(3.5)	1.0
Saturation Development	2.3	0.5	2.8	6.2	1.7	(3.4)	1.1

Notes:
1. MDD = Rosemont pressure zone MDD
2. Normal supply capacity = Firm capacity of the Horton Pump Station and View Drive Pump Station
3. Emergency supply capacity = Firm capacity of View Drive Pump Station

Table 6-6
Pressure Zone Supply and Storage Deficit Summary

Year	Normal Conditions			Emergency Conditions		
	Supply Deficit [1] (mgd)	Storage Volume [2] (mg)	Overall Deficit (mgd)	Supply Deficit [2] (mgd)	Storage Volume (mg)	Overall Deficit (mgd)
Bolton Pressure Zone						
See System-Wide Analysis (Table 4)						
Robinwood Pressure Zone						
Current	0	0.4	0	0.6	0.4	0.2
2015	0	0.4	0	0.7	0.4	0.3
2030	0	0.4	0	0.8	0.4	0.4
Saturation Development	0	0.4	0	0.8	0.4	0.4
Willamette Pressure Zone						
Current	0.1	0.8	0	1.1	0.8	0.3
2015	0.2	0.8	0	1.2	0.8	0.4
2030	0.5	0.8	0	1.5	0.8	0.7
Saturation Development	0.6	0.8	0	1.6	0.8	0.8
Horton Pressure Zone						
Current	0	1.1	0	1.3	1.1	0.2
2015	0	1.1	0	1.4	1.1	0.3
2030	0	1.1	0	1.7	1.1	0.6
Saturation Development	0	1.1	0	1.8	1.1	0.7
Bland Pressure Zone						
Current	0	0.4	0	0.6	0.4	0.2
2015	0	0.4	0	0.6	0.4	0.2
2030	0	0.4	0	0.7	0.4	0.3
Saturation Development	0	0.4	0	0.7	0.4	0.3
Rosemont Pressure Zone						
Current	0	0.3	0	0.7	0.3	0.4
2015	0	0.3	0	0.8	0.3	0.5
2030	0	0.3	0	1.0	0.3	0.7
Saturation Development	0	0.3	0	1.1	0.3	0.8

Notes: 1. See Table 6-5 for development of supply deficit.
2. Assumes distribution system reservoirs are three-fourths full.

Approach A – Storage Only

Approach A considers the construction of additional storage facilities to address the long-term supply and storage deficits discussed above. Where feasible, storage improvements are configured to address deficits in more than one (1) pressure zone. Approach A improvements are listed below:

- *Bolton Reservoir Replacement:* Construction of a new ground level 2.5 mg reservoir to replace the existing Bolton Reservoir would address the current issues with the long-term maintenance of the Bolton Reservoir as well as addressing the 0.5 mg deficit in the Willamette pressure zone. The capacity of the Bolton Reservoir Replacement will depend on a number of factors as previously discussed.
- *0.4 mg View Drive Reservoir No. 2:* Construction of a new ground level 0.4 mg reservoir to supplement the existing View Drive Reservoir would address this pressure zone deficit.
- *0.3 mg Bland Reservoir No. 2:* Construction of a new ground level 0.3 mg reservoir in the Bland pressure zone would address this pressure zone deficit.
- *1.5 mg Rosemont Reservoir No. 2:* Construction of a new elevated 1.5 mg reservoir in the Rosemont pressure zone would address the deficit in the Rosemont and Horton pressure zones (supply from the Rosemont pressure zone to the Horton pressure zone is feasible through several PRV connections). Alternatively, a separate 0.7 mg ground level reservoir to serve the Horton pressure zone could be constructed, reducing the required volume of the Rosemount pressure zone to 0.8 mg.

Approach B – Storage and Emergency Supply Improvement

Approach B considers the construction of additional storage facilities as well as the development of expanded, reliable emergency supply facilities to address the long-term supply and storage deficits discussed above. Where feasible, improvements are configured to address deficits in more than one (1) pressure zone. Approach B improvements are listed below:

- *Bolton Reservoir Replacement:* Construction of a new ground level reservoir to replace the existing Bolton Reservoir would address the current issues with the long-term maintenance of the Bolton Reservoir as well as the 0.8 mg deficit in the Willamette pressure zone and the 0.4 mg deficit in the Robinwood pressure zone. The capacity of the Bolton Reservoir Replacement will depend on a number of factors as previously discussed. For the purposes of this analysis, it is recommended that a 4.0 mg reservoir be constructed to replace the existing Bolton Reservoir. This reservoir volume provides replacement capacity for the existing Bolton Reservoir of 2.0 mg, addresses the combined storage deficit of the Willamette and Robinwood pressure zones of 1.2 mg and provides an additional 0.8 mg of storage to offset emergency supply needs. Further refinement of the required capacity should be completed based on the outcome of discussions with neighboring water suppliers to secure reliable peak season emergency supply capacity.

- *0.3 mg Bland Reservoir No. 2:* Construction of a new ground level 0.3 mg reservoir in the Bland pressure zone would address this pressure zone deficit.
- *Bland Intertie Supply to Rosemont:* Construction of a new booster pump station at the Bland Reservoir site to supply the Rosemont pressure zone would address the deficiency in the Rosemont and Horton pressure zones by providing adequate emergency supply capacity. Included with this improvement is a provision for installation of backup power supply to operate the pump station during an emergency.

Water Storage Requirement Summary

Based on the analysis presented above, two (2) alternative approaches have been developed to address current and future storage volume needs in the City's water system. These two (2) alternative approaches were presented to, and reviewed by City staff, the UAB and the City Council. The City Council directed that the development of recommended system improvements be based on Approach B. It was further directed to pursue development of reliable emergency supply capacity with the cities of Lake Oswego, Tigard and others in accordance with Solution Approach C. The recommended improvements and associated project costs are documented in Section 8 which presents the recommended Capital Improvements Plan (CIP) and Capital Maintenance Plan (CMP).

Summary

This section documents the analysis of water storage requirements for the City's water system. The section includes development and selection of a storage criteria methodology and analysis of storage requirements for current and future demand conditions. The findings and recommendations developed and presented in this section are included as part of comprehensive capital improvement and system maintenance recommendations presented in Section 8.