Willamette Water Supply Program
Preliminary Design Project Summary Report
Version 2 – Final

July 8, 2016
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Acronyms

AACEi Association for the Advancement of Cost Engineering [International]
AF Agricultural and Forestry
AWWA American Water Works Association
BPA Bonneville Power Administration
CDC Community Development Code
CML cement mortar lining
CPR Cornelius Pass Road
D diameter
DEQ Oregon Department of Environmental Quality
DW Darcy Weisbach
EFC Exclusive Forest and Conservation
EFU Exclusive Farm Use
Envision™ Envision Sustainable Infrastructure Rating System
ESA Endangered Species Act
FD Future Development
fps feet per second
FWPS Finished water pump station
GIS Geographic Information Systems
H horizontal
HDD horizontal directional drilling
HGL hydraulic grade line
Hillsboro City of Hillsboro
Hwy highway
ISI Institute for Sustainable Infrastructure
LiDAR Light Detection And Ranging
LOS level of service
MG million gallons
MGD million gallons per day
Mt. Mount
NPDES National Pollutant Discharge Elimination System
O&M operations and maintenance
ODOT Oregon Department of Transportation
ODW Oregon Department of Water
OSHA Occupational Safety and Health Administration
Partners Currently defined as TVWD and Hillsboro, others may join in the future
PCC Project Coordination Committee
PGD permanent ground displacement
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS</td>
<td>pump station</td>
</tr>
<tr>
<td>PS&amp;E</td>
<td>plans, specifications, and cost estimate</td>
</tr>
<tr>
<td>psi</td>
<td>pounds per square inch</td>
</tr>
<tr>
<td>PSR</td>
<td>Project Summary Report</td>
</tr>
<tr>
<td>PV</td>
<td>present value</td>
</tr>
<tr>
<td>RLIS</td>
<td>Regional Land Information System</td>
</tr>
<tr>
<td>RWPS</td>
<td>raw water pump station</td>
</tr>
<tr>
<td>STL</td>
<td>South Transmission Line</td>
</tr>
<tr>
<td>t</td>
<td>pipe wall thickness</td>
</tr>
<tr>
<td>TAC</td>
<td>Technical Advisory Committee</td>
</tr>
<tr>
<td>TBD</td>
<td>to be determined</td>
</tr>
<tr>
<td>TDH</td>
<td>total dynamic head</td>
</tr>
<tr>
<td>THPRD</td>
<td>Tualatin Hills Parks and Recreation Department</td>
</tr>
<tr>
<td>TM</td>
<td>Technical Memorandum</td>
</tr>
<tr>
<td>Tualatin</td>
<td>City of Tualatin</td>
</tr>
<tr>
<td>TVWD</td>
<td>Tualatin Valley Water District</td>
</tr>
<tr>
<td>UGB</td>
<td>urban growth boundary</td>
</tr>
<tr>
<td>URA</td>
<td>urban reserve area</td>
</tr>
<tr>
<td>V</td>
<td>vertical</td>
</tr>
<tr>
<td>VE</td>
<td>Value Engineering</td>
</tr>
<tr>
<td>WRWTP</td>
<td>Willamette River Water Treatment Plant</td>
</tr>
<tr>
<td>WWSP</td>
<td>Willamette Water Supply Program</td>
</tr>
<tr>
<td>WTP</td>
<td>water treatment plant</td>
</tr>
</tbody>
</table>
Executive Summary

Tualatin Valley Water District (TVWD), the City of Hillsboro (Hillsboro) (together as the Partners), and several other potential partners are developing the Willamette Water Supply Program (WWSP or Program). The new water supply system will provide water to more than 300,000 residents and some of the state’s largest employers for at least the next 100 years. The system is planned to be online by 2026. The program consists of three major components: the Willamette River Water Treatment Plant (WRWTP), a transmission system consisting of over 30 miles of large diameter pipelines, and 30 million gallons (MG) of water storage.

The purpose of the Preliminary Design Project is to lay the foundation for design of the transmission system. Work with Partners and potential partners includes:

- Establishing required capacity of the transmission system, comprised of delivery locations with required flow rates and water pressures (participation in this study does not indicate a decision to participate in WWSP)
- Identifying potential sites for water storage reservoirs, taking into account technical requirements, impacts to the environment and the community, and overall cost
- Establishing a preferred pipeline route, based on resilience, impacts to the environment and the community, conflicts with existing utilities, the need to acquire properties, and the cost of construction
- Developing a preliminary design of the pipeline that identifies specific property needs and potential environmental impacts
- Developing design guidelines that set consistent standards for the future pipeline design project
- Estimating costs to construct the new transmission system based on design, geotechnical, and other information available at this time
- Developing a permitting strategy that lays the foundation for successful implementation of the Program
- Conducting work in alignment with the Institute for Sustainable Infrastructure (ISI) Envision™ rating system to the extent practicable.

Key Outcomes

Key outcomes of the Preliminary Design Project corresponding to the above objectives are as described herein.

Defining Transmission System Capacity and Hydraulic Level-of-Service

Current and potential partners identified hydraulic level-of-service (LOS) by defining their preferred delivery locations, flow rates, and water pressures under normal and emergency operating conditions at individual service locations. WWSP asked potential partners to participate for planning purposes only; their participation in this study does not indicate a decision to participate in the WWSP. The resulting total system capacity is 105.7 million gallons per day (MGD), though due to interim delivery points, the total capacities at the farthest reaches of the system are much less. Capacities will be refined as further information on partner participation is available.
Identifying Potential Water Storage Reservoir Sites

Potential sites for terminal storage were identified through a three-step process that included identifying the minimum elevation (500 feet) and preliminary capacity for two tanks (two, 15-MG reservoirs to be located on one site). The site evaluation considered 15 criteria in the following six categories: system compatibility (hydraulics), social/community impacts, opportunities/benefits, environmental/permitting, access and constructability, and O&M considerations. WWSP team members will continue to identify and investigate reservoir sites beyond the scope of the Preliminary Design Project and therefore both the higher and lower bounds of the potential sites were considered in this design work.

Identifying the Preferred Pipeline Route

The preferred pipeline route was identified based on a four-step process that considered 35 criteria in the following nine categories: comparative costs, social/community, opportunities/benefits, environmental/permitting/cultural resources, system compatibility, system resiliency, constructability, operations and maintenance, and agricultural impacts. The routing process actively engaged agencies affected by the project, through over 25 coordination and feedback meetings, and the broader public through both live and on-line open houses. A key focus was on identifying opportunities to “piggyback” pipeline construction with other infrastructure/transportation projects to reduce costs and impacts to the community; the identified route includes over 7.5 miles of secured and projected piggybacking opportunities and many more miles are likely to become opportunity projects over the next 10 years.

The preferred pipeline route is shown in Map ES-1. The first section (the Main Stem) is a 66-inch diameter pumped pipeline that extends approximately 16 miles from the WRWTP in Wilsonville, through or near the Cities of Tualatin, Sherwood, Tigard, and Beaverton to water storage reservoirs on Cooper Mountain. The remainder of the system flows via gravity from the water storage reservoirs, splitting into the Western and Eastern extensions. The Western Extension extends north through the new South Hillsboro Community Planning Area primarily along Cornelius Pass Road up to Highway 26 and has diameters ranging from 30 to 66 inches. The Eastern Extension extends east from Cornelius Pass Road to the Cedar Hills area in Beaverton and has diameters ranging from 42 to 54 inches.

It is anticipated that the preferred pipeline route and diameters will be adjusted over time, accounting for changes in opportunity projects or other new information that becomes available.

Developing a Preliminary Design for the Pipeline

The preliminary pipeline design advances the preferred route by identifying a specific location (alignment), within or adjacent to the roadway, along the preferred route. The focus of the preliminary design was two-fold. The first goal was to identify needs for permanent and temporary construction easements, such that the Program can move forward with securing those easements. The second was to identify impacts to natural resources sufficient to move forward with permitting efforts.

The resulting preliminary design includes plan, profile, and special crossing sheets. The sheets include available LiDAR-based contour information plus tax lots and existing utilities.

Establishing Pipeline Design Standards

Program design guidelines set the standards for final pipeline and appurtenance design by providing design processes, criteria, details, and specifications to maintain consistency during final design and
construction. Project-specific design guidelines were created through a collaborative workshop-based process and refined after implementation on the SW 124th Avenue Pipeline project, which is a portion of the WWSP Main Stem pipeline. The guidelines address pipe and appurtenance design, geotechnical and seismic guidance and criteria, corrosion control, future condition assessment, cost estimating, application of Envision™ criteria, and also provide specifications and detail drawings.

The design guidelines were envisioned to be a living document, updated periodically to reflect current Program needs.

**Estimating Transmission System Construction Costs**

A Class 3 cost estimate was prepared for the Preliminary Design. This level of cost estimate, as defined by AACEI (formerly Association for the Advancement of Cost Engineering [International]), is for projects at a 10- to 40-percent level of definition and uses a detailed, unit cost approach with an expected accuracy range of -10 to -20 percent on the low end and +10 to +30 percent on the high end. The opinion of probable cost for the Preliminary Design (pipeline and water storage reservoirs only) is $387.8M for Alternate 1 and $363.7M for Alternate 2. These values represent base year cost including base cost and contingency.

**Developing a Permitting Strategy**

The permitting strategy included identification of the permitting-related elements and risks associated with the proposed route, resource crossings, and storage alternatives. The strategy also includes evaluations of natural resources, cultural resources, and land use within the Program area. The key elements of the permitting strategy are a summary of the environmental permitting and other regulatory requirements the Program will encounter, a description of the federal nexus and lead federal agency for the Program (U.S. Army Corps of Engineers), and a review of the natural resources, cultural resources, and land use along the proposed route.

**Next Steps**

As the Partners move forward with implementing the Program, there are numerous steps to be taken. Immediate next steps that advance the specific work conducted as part of the Preliminary Design Project include:

- **Value Engineering (VE)** – Further study and implementation of VE alternatives.
- **Easement and Property Acquisition** – Move forward with acquisition of easements for pipeline construction and reservoir site.
- **Confirmation of Opportunity Projects** – Continue to work with local agencies to confirm timing of opportunity projects and reach agreement on planned partnerships.
- **Refinement of Design Criteria** – Refine planning criteria based on confirmed partner participation, development of operational scenarios, and confirmed reservoir sites. This includes hydraulic design criteria, pipe wall thickness, air valve criteria, and pipe design calculations.
- **Operational and Control Criteria** – Develop operational and control philosophy and criteria for the transmission pipeline (including demand management at turn-outs), terminal reservoir operations, and pump operation at the WRWTP. This includes defining the distributed control system and components of the pipeline to support the system (e.g., conduit for fiber optic data communication).
- Permitting Strategy Implementation – Submit federal permit application and work with local agencies proactively to fulfill jurisdictional requirements.
Map ES-1. Reservoir Sites 2/3 - Preferred Route with Pipeline Diameters

Willamette Water Supply
Our Reliable Water
PREFERRED PIPELINE ROUTES:
Pipeline routes shown are subject to refinement as designs develop.

<table>
<thead>
<tr>
<th>Segment Description</th>
<th>Take-out Diameter (IN)</th>
<th>1½&quot; Pipe Diameter (IN)</th>
<th>1&quot; Pipe Diameter (IN)</th>
<th>½&quot; Pipe Diameter (IN)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservoir to HWY 26</td>
<td>36 (TVWD)</td>
<td>15</td>
<td>10</td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td>HWY 26 to CST</td>
<td>36 (TVWD)</td>
<td>15</td>
<td>10</td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td>CST to Reservoir</td>
<td>36 (TVWD)</td>
<td>15</td>
<td>10</td>
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<tr>
<td>Reservoir to CST</td>
<td>36 (TVWD)</td>
<td>15</td>
<td>10</td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td>CST to HWY 26</td>
<td>36 (TVWD)</td>
<td>15</td>
<td>10</td>
<td>6.5</td>
<td></td>
</tr>
</tbody>
</table>

LEGEND
Reservoir Sites 2/3

DRAFT PREFERRED ALIGNMENTS:
SECTION 1
SECTION 2
SECTION 3
SECTION 4
BAY 124TH AVENUE EXTENSION

WATER SERVICE AREAS:
- CITY OF HILLSBORO
- TUALATIN VALLEY WATER DISTRICT (TVWD)
- URBAN GROWTH BOUNDARY (UGB)
- STREAMS

BASE MAP SOURCE: METRO-RUS (FEB. 2015).
1.0 Introduction

Tualatin Valley Water District (TVWD) and the City of Hillsboro (Hillsboro) (the Partners) are collaborating to develop the mid-Willamette River at Wilsonville as an additional water supply source. There is enough water for today from existing sources, but steps need to be taken now to have an adequate water supply to meet future demands and provide greater reliability.

Other water providers in the region are also looking at their options for future participation. Potential partners include the Cities of Beaverton, Tualatin, and Tigard. Potential demands for these agencies have been included in the evaluations described in this report. These demands are included for planning purposes only and do not indicate any decision on the part of these agencies to participate in the Willamette Water Supply Program (WWSP).

Anticipating the long-term need for a new water source, TVWD and Hillsboro began years ago to prepare for this need and the necessary investment. Other water sources in the region were considered by TVWD and Hillsboro in separate analyses; the mid-Willamette River (at Wilsonville) was the preferred source identified from both analyses. The options TVWD and/or Hillsboro evaluated included a Southern Willamette option, wholesale purchase from the Portland Water Bureau, expansion of the existing Joint Water Commission supply through the Tualatin Basin Water Supply Project, and a Northern Groundwater system. The mid-Willamette River at Wilsonville offers significant benefits: excellent water quality, redundancy, ownership and control of the supply, year-round reliability, and better value.

In addition to the water supply source, this system will serve to enhance the resiliency of the water supply for the area in the event of a natural disaster such as a severe Cascadia Subduction Zone earthquake expected in the region.

The WWSP proposes to provide water to more than 300,000 residents and some of the state’s largest employers for at least the next 100 years. The Program schedule, current as of 2016, is:

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>Preliminary Design complete, Program Manager on board</td>
</tr>
<tr>
<td>2016</td>
<td>Permitting and continue with existing opportunity projects</td>
</tr>
<tr>
<td>2016-2025</td>
<td>Design and Construction</td>
</tr>
<tr>
<td>2026</td>
<td>System online</td>
</tr>
</tbody>
</table>

1.1 System Components

As shown in Figure 1, the WWSP includes three main components:

- **Willamette River Water Treatment Plant (WRWTP)**, located in Wilsonville near Interstate 5 adjacent to the existing WTP, also the location of the intake structure, raw water pump station (RWPS), and finished water pump station (FWPS)

- **Transmission pipeline**, over 30 miles of pipe ranging in diameter from 66 inches
to 36 inches (for Sites 2/3 reservoir) and 54 inches to 30 inches (for Site 11 reservoir) to deliver water to both Hillsboro Water and TVWD within the cities of Hillsboro and Beaverton

- **Terminal reservoir**, two, 15-MG tanks for storage located on Cooper Mountain, two Tier 1 (most preferred) sites are under evaluation

**Figure 1. WWSP System Components**

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### 1.2 Preliminary Design Project Objectives

The Preliminary Design project consisted of two phases, the Planning Phase and the Preliminary Design Phase. The goals of the Planning Phase were as follows:

- Establish the hydraulic LOS requirements for the reservoir storage system
- Establish the hydraulic LOS for the pipeline transmission system
- Perform preliminary hydraulic evaluations to establish the system configuration, reservoir elevation, and a diameter for the Main Stem
1.3 Scope of the Project Summary Report

This Project Summary Report (PSR) provides an overview of the Program’s technical work to date. The PSR summarizes the memoranda and decisions to-date as well as providing copies of the memoranda in the appendices. General organization of the document is:

- Section 1. Introduction to Program and components
- Section 2. Planning Phase evaluations, including preliminary hydraulic evaluations, reservoir siting, pipeline routing, and preliminary cost estimates and cash flow projections
- Section 3. Design guidelines established for the Program to assist future designers in creating consistent plans, specifications, and estimates to develop a unified system
- Section 4. Preliminary Design development of two potential reservoir sites and the preferred pipeline alignment, including updated hydraulics, cost estimate, and summary of alignment issues, both opportunities and constraints
Section 5. Permitting activities, including strategy developed for the Program’s natural resources reviewers

Section 6. Unresolved planning and preliminary design items that are recommended for discussion prior to final design

Section 7. Appendices with referenced documents
2.0 Planning Phase

The planning phase of the Preliminary Design project covered the period from September 2013 through March 2015. During this period, components of the program were being developed in parallel, with hydraulic evaluations, reservoir siting, and pipeline routing ongoing concurrently. A more linear progression (e.g., planning of one component is completed prior to the next being started) was not possible due to the interrelated nature of the components. Assumptions evolved over the planning period as the understanding of the various program components progressed.

Key outcomes of this phase of the project were:

1. Established capacities and required delivery pressures for the transmission system
2. Established minimum reservoir elevation and capacity requirements
3. Created project-specific criteria for selection and evaluation of reservoir sites and pipeline routes in alignment with Envision™ certification requirements
4. Evaluated a broad corridor within the west metro area using project-specific criteria to develop a preferred pipeline route
5. Evaluated potential sites within the Cooper Mountain, Bull Mountain, and Mount (Mt) Williams areas to select two Tier 1 reservoir sites
6. Developed preliminary cost estimates and cash flow projections for the program
7. Prepared an application for Envision™ “plan review” recognition

2.1 Hydraulic Level of Service Requirements

2.1.1 Transmission System Capacity and Delivery Pressures

The hydraulic LOS is defined as the flow rates and pressures required at individual service locations by each Partner (or potential partner). Desired transmission system capacities and delivery pressures were identified by each of the current and potential WWSP Partners. The assumed overall capacity of the Program for this analysis is 105.7 million gallons per day (MGD), as shown in Table 1.
Table 1. Partners and Requested Capacity

<table>
<thead>
<tr>
<th>Partner</th>
<th>Capacity (MGD)</th>
<th>Percent Share of Overall Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>TVWD</td>
<td>56.5</td>
<td>53.5%</td>
</tr>
<tr>
<td>Hillsboro</td>
<td>36.2</td>
<td>34.2%</td>
</tr>
<tr>
<td>Beaverton</td>
<td>8.0</td>
<td>7.6%</td>
</tr>
<tr>
<td>Tualatin</td>
<td>5.0</td>
<td>4.7%</td>
</tr>
<tr>
<td>Total</td>
<td>105.7</td>
<td>100%</td>
</tr>
</tbody>
</table>

1 Capacity requirements as indicated by individual WWSP Partners
2 Information for potential partners included for planning purposes only and do not indicate a decision to participate in the WWSP.

The geographic locations at which the WWSP Partners would receive the flows in Table 1 were based on LOS information provided by the respective Partners, as shown in Table 2. The Partners had the opportunity to request flows under both “normal” and “emergency” conditions. The conditions are non-additive; emergency conditions represent separate sets of conditions and are not in addition to normal conditions. The required capacity of each section (as defined as the length of pipe between two subsequent service locations) was determined based on the maximum required capacity under both normal and emergency operating conditions for each Partner. For example, the City of Hillsboro desires the ability to deliver a flow of 10 MGD to the end of the Western Extension under emergency conditions, whereas under normal conditions no flow is anticipated to this location; the capacity of this section allocated to Hillsboro is 10 MGD. Table 2 includes notes describing how the LOS flows at each segment of the pipeline were defined based on demands at each service location. It should be noted that the flows in the Western and Eastern extensions are not additive due to the desired redundancy by TVWD. Figure ES-1 includes a graphic showing the geographic locations of demands at each service location.

The flow capacities shown in Table 1 and Table 2 are defined as the “design flow rates” for their respective pipe sections. Some analyses of the Main Stem (pumped pipeline) also included evaluation of a maximum flow rate of 120 MGD, such that the pumped pipeline could accommodate conditions associated with an “all pumps on” condition.
## Table 2: Summary of Demands and Withdrawal Locations Based on LOS Requests

<table>
<thead>
<tr>
<th>Section Description</th>
<th>Approx. Length (ft)</th>
<th>Service Location Demand (MGD)</th>
<th>LOS Pipe Flow (MGD)</th>
<th>TVWD Share</th>
<th>Hillsboro Share</th>
<th>Beaverton Share&lt;sup&gt;1,2&lt;/sup&gt;</th>
<th>Tualatin Share&lt;sup&gt;3&lt;/sup&gt;</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Stem</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WRWTP to Tualatin-Sherwood Rd.</td>
<td>-</td>
<td>5 (Tualatin)</td>
<td>105.7</td>
<td>56.5</td>
<td>36.2</td>
<td>8.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Tualatin-Sherwood Rd. to Reservoir</td>
<td>-</td>
<td>None</td>
<td>100.7</td>
<td>56.5</td>
<td>36.2</td>
<td>8.0</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Common Outlet</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reservoir to 209th/Farmington</td>
<td>4,610</td>
<td>18 (TVWD)</td>
<td>100.7</td>
<td>56.5</td>
<td>36.2</td>
<td>8.0</td>
<td>-</td>
<td>LOS is reduced by the 18 MGD delivery to TVWD at 209&lt;sup&gt;th&lt;/sup&gt;/Farmington</td>
</tr>
<tr>
<td>209th/Farmington to Cornelius Pass Road/Rosa</td>
<td>6,970</td>
<td>10 (Hillsboro)</td>
<td>82.7</td>
<td>38.5</td>
<td>36.2</td>
<td>8.0</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Rosa to Kinnaman</td>
<td>4,350</td>
<td>None</td>
<td>72.7</td>
<td>38.5</td>
<td>26.2</td>
<td>8.0</td>
<td>-</td>
<td>LOS is reduced by 10 MGD delivery to Hillsboro at Cornelius Pass/Rosa.</td>
</tr>
<tr>
<td><strong>Western Extension</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kinnaman to Alexander</td>
<td>3,200</td>
<td>10 (Hillsboro)</td>
<td>37.0</td>
<td>12.0</td>
<td>25.0</td>
<td>-</td>
<td>-</td>
<td>Along with 12 MGD for TVWD, assumes up to 25 MGD to serve Hillsboro emergency demand; able to serve 10 MGD at Alexander with at least 15 MGD remaining to serve Cornell or Evergreen take-out.</td>
</tr>
<tr>
<td>Alexander to South Transmission Line (STL)</td>
<td>450</td>
<td>25 (Hillsboro-emergency)</td>
<td>37.0</td>
<td>12.0</td>
<td>25.0</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>STL to Cornell</td>
<td>21,110</td>
<td>10 (Hillsboro)</td>
<td>27.0</td>
<td>12.0</td>
<td>15.0</td>
<td>-</td>
<td>-</td>
<td>Along with 12 MGD for TVWD, assumes Hillsboro will take up to 10 MGD at Cornell or up to 15 MGD at Evergreen, but will not take more than 15 MGD at any time from STL to Evergreen.</td>
</tr>
<tr>
<td>Cornell to Evergreen</td>
<td>2,510</td>
<td>15 (Hillsboro)</td>
<td>27.0</td>
<td>12.0</td>
<td>15.0</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Evergreen to Hwy 26</td>
<td>2,510</td>
<td>10 (Hillsboro-emergency)</td>
<td>12 (TVWD)</td>
<td>22.0</td>
<td>12.0</td>
<td>10.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Section Description</td>
<td>Approx. Length (ft)</td>
<td>Service Location Demand (MGD)</td>
<td>LOS Pipe Flow (MGD)</td>
<td>TVWD Share</td>
<td>Hillsboro Share</td>
<td>Beaverton Share</td>
<td>Tualatin Share</td>
<td>Notes</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>---------------------</td>
<td>--------------------------------</td>
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<td>------------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Eastern Extension</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>All flows to Eastern Extension assumed to be delivered at endpoint. Specific delivery locations for Beaverton were not defined.</td>
</tr>
<tr>
<td>Kinnaman to BPA at Millikan</td>
<td>21,400</td>
<td>None</td>
<td>38.0</td>
<td>30.0</td>
<td>-</td>
<td>8.0</td>
<td>-</td>
<td>Information in this table based on information provided on the following dates, by agency: TVWD – March 2015; City of Hillsboro - March 2015; City of Beaverton – March 2014; City of Tigard – October 2013; City of Tualatin – March 2015.</td>
</tr>
<tr>
<td>BPA at Millikan to Walker</td>
<td>10,530</td>
<td>38 (TVWD/Beaverton)</td>
<td>38.0</td>
<td>30.0</td>
<td>-</td>
<td>8.0</td>
<td>-</td>
<td>Information for potential partners included for planning purposes only and do not indicate a decision to participate in the WWSP.</td>
</tr>
</tbody>
</table>

1. Information in this table based on information provided on the following dates, by agency: TVWD – March 2015; City of Hillsboro - March 2015; City of Beaverton – March 2014; City of Tigard – October 2013; City of Tualatin – March 2015.

2. Information for potential partners included for planning purposes only and do not indicate a decision to participate in the WWSP.

3. It is anticipated additional supply locations along the Eastern Extension would be used by the City of Beaverton if they choose to participate in the WWSP. These locations were not identified in the level of service requirements as they were dependent on the pipeline routing, which had not been completed.

4. The service location demands shown are located at the end of each section of pipeline. For example, the first section of the Main Stem is from the WRWTP to Tualatin-Sherwood Road and the shown service location demand (5 MGD) is located at Tualatin-Sherwood Road.
2.1.2 Required Capacity at the WRWTP Intake

A preliminary evaluation of potential demands at the WRWTP intake was conducted based on demand information provided by current and potential partners in the WRWTP. The intake serves partners in the existing WRWTP, the WWSP, and other potential future partners. These current and potential partners include TVWD and the Cities of Wilsonville, Hillsboro, Sherwood, Beaverton, Tualatin, and Tigard. The primary purpose of the demand evaluation was to make a preliminary determination of whether a second WRWTP intake would be required, to confirm the transmission system capacity needs, and support development of the permitting strategy.

The projected demands at the intake are documented in the *Willamette River Water Treatment Plant Intake Water Demands Technical Memo* (TM; Appendix A - 2)

The current intake structure has a capacity of 70 MGD, and can be expanded to approximately 140 MGD with new screens. Beyond this 140 MGD capacity, more significant modifications to the intake may be required, as described in the memorandum *Preliminary Evaluation of WRWTP Intake Screen Capacity Alternatives* dated January 21, 2014 and prepared by MWH (not provided). A preliminary evaluation of potential expansion options for the existing WRWTP intake and Raw Water Pump Station was conducted, as documented in the *Willamette River Water Treatment Plant Intake Screen Evaluation* (Appendix A - 1). These evaluations have since been superseded by evaluations conducted as part of the ongoing WRWTP Master Plan Project.

2.2 Preliminary Hydraulics

The preliminary hydraulics goals were to:

- Develop hydraulic design criteria
- Identify a minimum reservoir elevation
- Evaluate the appropriate diameter for the Main Stem pipeline
- Identify preliminary diameters for gravity portions of the system to support development of preliminary cost estimates and evaluations

All preliminary hydraulic modeling was performed using InfoWater modeling software. Preliminary hydraulics were performed on assumed pipeline routes, as the preferred route was being developed in parallel. The assumed route varied among the specific hydraulic analyses as the understanding of the route evolved.

2.2.1 Hydraulic Criteria

Hydraulic criteria for the WWSP transmission system are described in *the Hydraulic Criteria TM* (Appendix D - 6). The criteria and their rationales are summarized in Table 3. Note, the Hazen-Williams method was used only for the preliminary hydraulic analyses. The Darcy-Weisbach (DW) method was used for the final hydraulics analyses, as described in Section 4.1. Criteria were based on a spiral-welded steel pipeline with cement mortar lining (CML). CML has a lower velocity limit than other pipe linings (such
as polyurethane), but it is the standard lining and preferred by the Program, except in special conditions.

Table 3. Hydraulic Criteria for Preliminary Hydraulic Evaluations

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Value</th>
<th>Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Pipeline Velocity</td>
<td>10 feet per second (fps)</td>
<td>Velocities in excess of 15 fps have been shown to erode CML. It is generally accepted practice to set an absolute maximum velocity in a pipe with CML at 12 fps and to not exceed 10 fps in design conditions.</td>
</tr>
<tr>
<td>Preliminary Hazen Williams C factor</td>
<td>130</td>
<td>Based on recommendations for aged steel pipe in the American Water Works Association M11 Steel Pipe – A Guide for Design and Installation, Fourth Edition, 2004 (referred to as AWWA M11 in this document), C factor was reduced to account for minor losses, which were not explicitly calculated during the preliminary hydraulics phase. (Note: Assumption used for preliminary hydraulic evaluations only.)</td>
</tr>
</tbody>
</table>

2.2.2 Identification of Main Stem Diameter

Evaluation of the Main Stem diameter was performed in two phases. First, a conceptual present value (PV) evaluation was performed, as documented in the Hydraulic Criteria TM (Appendix D - 6). Later, a more detailed PV analysis incorporating a Monte Carlo simulation was performed, as documented in the Final Main Stem Present Value Analysis (Appendix D - 3). Only the results of the later analysis are summarized here.

The Main Stem PV analysis evaluated the PV of capital and operational costs for 24 scenarios, incorporating: four potential flow projections representing different scenarios for partner participation; two potential pipeline routes representing the longest and shortest of the shortlisted pipeline routes; and three potential diameters (60, 66, and 72 inches). The costs included estimated pumping costs, based on estimated daily demands over a 100-year period, and estimated pipeline construction costs. The evaluation did not include differences in construction costs for the Finished Water Pump Station, non-construction costs, nor costs for potential increases in pipe wall thicknesses associated with higher operating pressures.

Based on the above assumptions, the 66-inch pipe diameter has the lowest PV cost for the respective demand and route scenarios in the analysis. However, the PV differential is relatively small. Over the 100-year period used for the analysis, the PV difference between the 72-inch and 66-inch pipe diameter is approximately $3.4 million (M) for the lowest flow scenario and shorter route, and a smaller difference ($0.6M) at the highest flow scenario and the longer route. The 60-inch-diameter option was comparable to the 72-inch-diameter option for PV cost, but it offers the least amount of flexibility in terms of meeting future levels-of-service demand. Thus, the TAC chose not to consider it further.

A summary of the relative advantages and disadvantages of the 66- and 72-inch diameters is provided in Table 4. Based on this analysis, the Executive Committee made a decision on February 24, 2015 to use a 66-inch diameter for the SW 124th Avenue Project, which was being designed concurrently with the WWSP Preliminary Design
The 66-inch diameter was used for the remainder of the Preliminary Design Project as a placeholder with the understanding that the final selected diameter may change in the future as partnerships and other factors are resolved.

Table 4. Summary of Relative Advantages of 66-inch and 72-inch Main Stem Diameters

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Advantage</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Capital Cost</td>
<td>X</td>
<td>66-inch diameter reduces initial capital cost by an estimated amount of $9M to $11M*</td>
</tr>
<tr>
<td>Future Flexibility</td>
<td>X</td>
<td>72-inch diameter provides greater future capacity to accommodate demands from additional Partners or future demands beyond current projections. The ability to build infrastructure in an already built environment is challenging, and will only be more challenging in the future.</td>
</tr>
<tr>
<td>Water Quality</td>
<td>X</td>
<td>Smaller, 66-inch diameter will decrease water age, which may allow the partners to use lower minimum flows.</td>
</tr>
</tbody>
</table>

*Cost information based on assumptions at the time of the analysis, as documented in Final Main Stem Present Value Analysis (Appendix D - 3)

An additional hydraulic analysis was performed to determine the pipe wall thickness for the SW 124th Avenue project pipeline (Appendix D - 5). The analysis evaluated a range of parameters, including a maximum flow rate of 120 MGD and Reservoir Site 11, to bracket the possible final condition (including reservoir elevation, flow rate, pipeline length and diameter). For the 124th Avenue project, several reaches of pipe were increased to a pipe wall thickness of 7/16 inch (versus 3/8 inch). The conditions evaluated resulted in a potential range of thicknesses between 5/16-inch and 1/2-inch. The cost differential for the pipe diameters considered used quotes from Northwest Pipe in August 2015 for the 124th Avenue Project, and updated in March 2016. Costs include fabricated 66-inch-diameter welded steel pipe, lining, and coating. The estimated pipe cost differential between 66-inch pipe with 3/8-inch versus 7/16-inch wall is $285,000 per mile of pipe (16.8 percent).

2.2.3 Identification of Minimum Reservoir Elevation

A hydraulic evaluation was conducted to identify the minimum reservoir elevation for the terminal reservoir, as documented in the Terminal Storage Evaluation TM (Appendix B - 2). Results of the preliminary evaluation were presented to the TAC on November 20,
2013 and a decision was made to base the reservoir siting on an assumed ground elevation of 470 feet.

The hydraulic evaluation for the Western and Eastern extensions was conducted in InfoWater based on the following key constraints:

- Hydraulic gradeline of 450 feet at the terminus of both the Western and Eastern extensions, upstream of pressure reducing valve stations and other required valves at each service location.
- Water level assumed to be 30 feet above the ground elevation. This could represent either a full tank with a 30-foot water depth, or a taller tank operating below its overflow.
- C factor of 130, with a further localized headloss of 10 percent. This assumption changed in later analyses to a C factor of 130, including minor losses, as stated in Table 3 above.
- Representative pipeline route and hydraulic LOS were documented in Appendix B - 2. These differ somewhat from the final hydraulic LOS requirements and the preferred route.

The results of the hydraulic evaluation are shown in Figure 2. The figure shows the required pipeline diameters for Western and Eastern extensions as a function of the reservoir hydraulic grade line (HGL; feet)\(^2\). These curves have a characteristic shape with a distinct “knee” as highlighted in Figure 2, from Appendix D - 4. As you move to the left of the knee, the required pipeline diameters increase rapidly. In this area, it only takes a small increase in reservoir HGL to drive an increase in pipeline diameter. To the right of the knee, the curve stretches out with larger elevation changes required to allow the pipeline to be downsized.

For both the Western and Eastern extensions, the knee of the curve occurs at a reservoir HGL around 500 feet, corresponding to diameters of 66 and 48 inches respectively, for the Western and Eastern extensions (based on assumptions at the time of the analysis). The reservoir HGL of 500 feet was established as the minimum HGL for the initial search for reservoir sites, assuming the ground elevation would be 30 feet below the reservoir water surface HGL.

It was recognized that the selected minimum HGL does not necessarily represent the “optimal” reservoir elevation in terms of present value. However, as few reservoir sites are available, it was anticipated that other factors may drive reservoir selection and that setting a more inclusive minimum elevation would provide more options. The TAC decided to delay evaluation of the present value of various reservoir elevations until specific sites had been identified. The information could then be considered in combination with other factors. That evaluation was documented in the Reservoir Present Value Analysis TM (Appendix D - 2), and is discussed in Section 4.

---

\(^2\) This represents the water surface elevation below the overflow elevation of the tank. At the time of this analysis, the assumed operating water level relative to the overflow had not been identified. It was later assumed to be 3 feet below overflow based on Partner direction. This is the assumption used in the final hydraulic analysis to size the gravity lines.
2.2.4 Eastern Extension Configuration Evaluation

An evaluation of two possible configurations of the Eastern Extension was conducted, as documented in the Final *Eastern Extension Configuration TM* (Appendix D - 1). The alternatives evaluated included one with the Eastern Extension as an independent pipeline from the terminal reservoir, with a section that parallels the Main Stem (parallel pipe configuration), and one with the Eastern Extension connecting directly to the Main Stem, upstream of the water storage reservoirs (direct connect configuration).

The evaluation found that the direct connect configuration would reduce construction costs and avoid difficulties associated with parallel pipeline construction. Water age was evaluated and this configuration was considered reasonable as long as flows to the Western and Eastern extensions were managed for water age during low flow periods. Based on this evaluation, the direct connect configuration was incorporated into the routing evaluation (though the point of connection was ultimately revised from that presented in Appendix D - 1).

2.2.5 Key Outcomes

The preliminary hydraulic evaluation determined the following parameters to be used for completing the conceptual design:
2.3 Reservoir

A key mission of the planning and conceptual design was to evaluate potential reservoir locations to determine the preferred site(s). The evaluation was performed using a multistep process:

- Reservoir bottom elevation: minimum of 470 feet (local HGL of 500 feet)
- Selection of a Main Stem diameter of 66 inches for planning purposes.

**Key decision:**

- Reservoir bottom elevation: minimum of 470 feet (local HGL of 500 feet)
- Preliminary Main Stem diameter of 66 inches.

---

Figure 3. Reservoir Tier 1 Sites: Selection to Conceptual Design Process
Determining a preferred terminal storage site was considered a critical path decision because of the ongoing community planning for the South Cooper Mountain area and the interconnection with transmission main alignments. The first step was defining reservoir volume, followed by identifying appropriate sites (based on their elevation range), and then evaluating the potential sites against Program siting criteria.

### 2.3.1 Level of Service and Sizing Criteria

The following decisions were made by the TAC related to LOS:

- Use a total volume of 30 MG for the terminal reservoir preliminary design analyses, and 15 MG storage volume as the basis for a conceptual footprint for screening potential sites. The concept is that more than one site may be needed to meet the desired total storage volume.

- Define 470 feet ground surface elevation for screening potential sites for the water storage tank corresponding with a minimum overflow elevation range of 500 feet, as described above in Section 2.2.5.

The Level-of-Service for Terminal Reservoir (Task 4.5) – TM (Appendix B - 5) provides details on storage volume considerations for the terminal reservoir.

For the purposes of the WWSP, the components of storage include:

- **Operational storage** to provide water to meet peak demands, thus limiting changes to the WRWTP production rate during the course of a day.

- **Emergency storage** to meet emergency scenarios related to the Willamette Supply System. This is considered separate from in-town emergency storage already provided by the distribution system.

- **Distribution system storage** to meet in-town storage needs for the individual partners. This can be to meet fire suppression or emergency storage needs defined by individual in-town storage criteria. Hillsboro requested 10 MG of distribution storage.

The TAC examined different scenarios to consider operational, emergency, and distribution storage, based on typical guidance and accounting for Hillsboro’s request for 10 MG of distribution storage. The 30 MG of storage option was identified as the solution that met Partner needs for minimum build-out volume. Additional discussion is located in Appendix B - 2.

### 2.3.2 Initial screening

Potential sites were identified using a minimum ground elevation and parcel size derived from the LOS and hydraulic criteria (Appendix B - 2). A desktop analysis was used to identify potential sites applying a preferred ground elevation range of 470 to 550 feet and minimum parcel size of 4 acres. The 550-foot maximum ground surface elevation was initially selected to focus on sites that limit additional pumping from the treatment plant.
The 4-acre area was based on an assumed circular tank with a 30-foot-high water column, including buffer areas. The TAC later decided to include another site above this elevation threshold, as an “opportunity site” after the initial pipeline routing assessment was completed (refer to Section 2.3.5).

The initial site screening identified 60 sites with ground elevation above 470 feet and having a parcel size of at least 4 acres. Applying the 550-foot maximum ground elevation criteria and eliminating parcels containing significant riparian and/or ravine areas reduced the number to 10 sites.

### 2.3.3 Defining Evaluation Criteria

In order to determine the best options, or Tier 1 sites, from the 10 reservoir sites, evaluation criteria were needed to understand the benefits of each site. Evaluation criteria were developed to address 6 major issues/questions and the resulting agreed-upon 15 criteria are listed below in Table 5.

Cost was not included as a criterion for screening or selecting the preferred site. Specific criteria were then defined with input from the TAC, engineering team, environmental permitting and land use specialists, and the public information/public outreach team. In defining the criteria, consideration was given to how each criterion could be used to differentiate the parcels from each other. The criteria were also reviewed for consistency with the Envision™ rating system. Draft criteria were discussed with the TAC over the course of three meetings from December 2013 to February 2014.

**Table 5. Reservoir Evaluation Categories**

<table>
<thead>
<tr>
<th>Category</th>
<th>Criteria (and rationale)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System Compatibility (Hydraulics)</strong></td>
<td></td>
</tr>
</tbody>
</table>
| → Does the site meet LOS requirements for the reservoir? | • Ground elevation (preferred elevation range to meet LOS)  
• Parcel area and dimensions (area to accommodate minimum of 30 MG volume with a desired target of 45 MG total volume. Target volumes were based on LOS workshops conducted with TAC (November 6 and 20, 2014) |
| **Social/Community Impacts** |  |
| → Does a reservoir at the site negatively impact the surrounding community? | • Potential visual and local character impacts to neighbors and nearby community  
• Potential encumbrances and conditions, constraints, or restrictions on a parcel  
• Potential impacts to neighbors and nearby community during construction of reservoir  
• Potential downstream consequences of reservoir failure |
| **Opportunities/Benefits** |  |
| → Does locating a reservoir on the site provide benefit to the property owner or surrounding community? | • Available property (ability to acquire property for permanent use for reservoir)  
• Opportunity for community benefits |
### 2.3.4 Additional Sites

During project development, other potential reservoir sites, in addition to the initial Tier 1 sites (see Section 2.3.5) were identified although they were outside the original search area and/or elevation range (Appendix B - 2). The Partners decided to consider other sites outside the elevation range of the initial screening criteria, because of the uncertainty associated with acquiring or securing the limited number of Tier 1 sites. In particular, the Partners discussed the opportunities presented by the Mt. Williams site owned by the City of Beaverton, and the Cach Nature Park and Sunrise Park sites on Bull Mountain owned by the City of Tigard. The sites were evaluated as documented at a TAC meeting on February 9, 2015 (Appendix B - 4). In summary:

- **Bull Mountain** – located southwest of Cooper Mountain, the Cach Nature Park and Sunrise Park sites are on the west face of Bull Mountain at about 460-foot elevation up to 620 feet. This site was not pursued further because the distance of the site from the necessary delivery points increased required pipe diameters north of the reservoir site and therefore significantly increased anticipated project cost.

- **Mt. Williams** – located east of Cooper Mountain, the site is owned by City of Beaverton and has a maximum ground elevation of 420 feet. Hydraulic analysis
indicates that the Mt. Williams site can supply the Eastern Extension demands and meet the 450 ft. HGL LOS at the end of the line. However, the storage volume would be less than desired, and this reservoir site could not sufficiently serve the Western Extension. This site has potential to be an add-on site for storage along the Eastern Extension, should the option be desired in the future.

Based on these evaluations, the Bull Mountain site was sidelined from further consideration. The Mt Williams site was also sidelined from further consideration as the Program’s main terminal reservoir site. However, this site may provide an opportunity to increase storage capacity within the transmission system in the future, if needed.

2.3.5 Initial Identification of Tier 1 Sites

The technical evaluation grouped the potential sites into three tiers (1, 2, and 3) based on relative rating of the site for each criterion. The sites with the best overall ratings were identified as Tier 1 sites. While not formally removed from further consideration, the TAC decided to sideline the Tier 2 and Tier 3 sites until the Tier 1 sites were confirmed to be not viable.

The initial evaluation of the 10 candidate sites in February 2014 was modified with input received at the TAC meeting in April 2014, as well as early information obtained during public outreach activities. Based on that input, Sites 1, 2, 3, and 9 (and ultimately Site 11) were identified as the Tier 1 sites. Site 11 did not meet the initial ground elevation site screening (too high). However, the TAC later decided to include it as an “opportunity site” after the initial pipeline routing assessment was completed, because of the relatively large property area, potential benefits of minimizing tunneling under Grabhorn Road, and reduction of pipe size of the Western Extension.

As of June 2014, the candidate sites were categorized into tiers as follows (sites with * were later sidelined as Tier 2 sites as explained in the following sections):

- Tier 1: Sites 1*, 2*, 3, and 9*
- Tier 2: Sites 4, 6
- Tier 3: 5, 7, 8, 10
- Opportunity site: Site 11

After the Tier 1 sites were selected, the public outreach team and right-of-way consultants were authorized to contact the Tier 1 property owners to assess availability of the property for purchase/acquisition. As design progresses, willingness to sell and further consideration of the criteria described in Section 2.3.3 will inform the ultimate site selection.

2.3.6 Reservoir Present Value Analysis

The Terminal Reservoir Site Present Values Analysis TM (Appendix D - 2) documents the present value (PV) analysis summarized in this section. The purpose of the PV analysis was to understand the capital and pumping cost differences among the Tier 1 sites and the Site 11 opportunity site. The evaluation included four sites: Site 1, Sites 2/3 (included as a single combined site for the purposes of the PV analysis as the assumed
costs associated with the two sites were the same)\(^3\), Site 9, and Site 11. The assumed piping configurations varied among the sites, as documented in the memorandum. Sites 1, 2/3, and 9 were all assumed to be at an overflow elevation of 500 feet, while Site 11 had an assumed overflow elevation of 580 feet. (These overflow elevations were later revised for preliminary design.)

Key findings of the PV analysis were as follows:

- Sites 2/3 had the lowest PV of all the sites.
- The PV for Site 11 was $15M more than Sites 2/3 (within 3 percent). The two options had very similar capital costs. Site 11 had lower pipeline construction costs as the higher elevation meant smaller required diameters, however, reservoir construction costs for Site 11 were higher due to site constraints and buried construction in rock. Site 11 had greater operational costs due to the increased pumping head required.
- The PV for Site 1 was $15M more than Sites 2/3 (within 3 percent). The higher cost was due to the pipeline alignment to reach the site required either a tunnel or a longer route around Cooper Mountain via Clark Hill Road.
- The PV for Site 9 was $45 to 60M greater than for Sites 2/3, due to increased capital cost including longer transmission lines and tunnel plus larger pipe diameters.

Based on the outcome of this evaluation, Site 9 was re-designated to Tier 2, and Site 11 was re-designated as a Tier 1 site. The reservoir PV analysis findings were not intended or used to select a preferred reservoir site. The PV findings were just one factor in the overall evaluation of reservoir sites (e.g., community impacts/benefits, impacts to downstream locations, and willingness to sell by the owner).

### 2.3.7 Key Outcomes

Based on the reservoir PV analysis, four Tier 1 sites remained, consisting of Sites 1, 2, 3 and 11. Site 1 was moved to Tier 2 based on conversations with Tualatin Hills Parks and Recreation Department (THPRD) that identified significant constraints to building a reservoir on Site 1. Site 3 as a stand-alone site fulfills requirements for the reservoir (minimum storage volume of 30 MG) without Site 2. Site 2 also fulfills the reservoir requirements, though tank construction would be more challenging due to sloping terrain. A summary of the status of the remaining Tier 1 sites is included in Table 6.

---

\(^3\) Sites 2 and 3 were combined for the purpose of the present value analysis only, because they are directly adjacent to each other. The assumed pipeline lengths associated with the two sites, and reservoir properties (overflow elevation and size/volume) were the same for the purposes of the analysis.
Table 6. Tier 1 Reservoir Sites

<table>
<thead>
<tr>
<th>Tier 1 Reservoir Site</th>
<th>Evaluation Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Site 2 allows a single normal height 15 MG reservoir plus another 15 MG reservoir of similar height located at a lower elevation due to the sloping terrain or a taller tank to maintain the same overflow elevation as proposed for tanks on Site 3.</td>
</tr>
<tr>
<td>3</td>
<td>Site 3 meets the minimum elevation requirements and has flexibility to increase the overflow elevation from 500 to around 520 feet; has reduced pumping requirements due to its lower elevation (relative to Site 11); and can accommodate all 30 MG within the site.</td>
</tr>
<tr>
<td>11</td>
<td>Site 11 is the highest elevation Tier 1 site with a possible overflow elevation of 590 to 610 feet; this reduces the necessary pipeline diameters north of the site (on the gravity side of the system) due to the additional elevation at Site 11; and can accommodate all 30 MG within the site.</td>
</tr>
</tbody>
</table>

Ultimately, the Program chose to include Tier 1 sites (Sites 2, 3, and 11) in the preliminary design, as described in Appendix B - 2. The selection of a preferred reservoir site will include further discussion with property owners to determine willingness to sell, as well as further consideration of the criteria described in Section 2.3.3 as design progresses.

2.4 Transmission Pipeline

A key mission of the planning and conceptual design was to evaluate potential transmission pipeline routes to determine a preferred route for the Program and complete preliminary design. The transmission main alignment extends north from the WRWTP in Wilsonville to a new reservoir located in the South Cooper Mountain Area, and from the reservoir to the Partner connection points in Hillsboro at Cornelius Pass Road and Sunset Highway, as well as in Beaverton in the vicinity of Highway 217 and Tualatin Valley Highway. For the route alternatives evaluation, the transmission line was separated into four sections:

- Section 1 – WRWTP to SW 124th Avenue
- Section 2 – SW 124th Avenue to the reservoir
- Section 3 – Reservoir to Hillsboro
- Section 4 – Reservoir to Beaverton

The evaluation was performed using a multistep process, illustrated in Figure 4 and described in this section. The preliminary design is discussed in Section 4.0.
2.4.1 Evaluation Process

Identifying the preferred alternative was a process that involved deliberate steps to identify and evaluate alternatives. The first step included a desktop review of possible routes, considering nearly every road right-of-way between Wilsonville and Hillsboro/Beaverton. These were screened for available road width, elevation, known resiliency issues (such as large gas transmission lines or avoidable seismic issues), and known environmental or cultural resources impacts. The remaining set of alternatives was further investigated and became the preliminary list of viable routes. Through field
reconnaissance and discussions with neighboring local agency staff the list was refined to develop the technically feasible routes. These routes went through a screening process with Program specific criteria (discussed in Section 2.4.2) to determine which alternatives would have the fewest implementation challenges. These routes became the shortlisted routes and all others were sidelined.

### 2.4.2 Evaluation Criteria

A list of selection criteria for evaluation of the transmission pipeline route for the Willamette Supply Preliminary Design project was developed and provided in the Final Route Selection Criteria TM (Appendix C - 1). The criteria were developed to help review and objectively evaluate the candidate alternatives. The criteria were developed with input from stakeholders that included the owner, engineering team, environmental permitting specialists, land use experts, and individuals likely to be impacted by the project from the community. Also, Envision™ criteria were consulted to verify that the Program’s route selection criteria would support future Envision™ certification. The criteria were refined with stakeholder input and applied to candidate routes.

Table 7 provides the criteria categories used to evaluate potential transmission main alignments. Some of the criteria categories are stand-alone, while others may have two or more sub-criterion that fall under the same general issue. More detail is provided in the Preferred Route and Summary Matrices TM (Appendix C - 3). The criteria were
submitted to the Partners for approval in *Decision Memo #6 Pipeline Route Selection Criteria* (Appendix C - 2).

**Table 7. Categories for Criteria Evaluation**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social/community impacts</td>
<td>A combination of congestion and community impacts, impacts to critical facilities (e.g., fire stations, hospitals) or community facilities (e.g., schools, churches, recreation centers), known opportunities to provide community enhancements, and areas deemed “no-cut” by the community due to sensitivity of the resource or recent construction</td>
</tr>
<tr>
<td>Opportunities/benefits</td>
<td>Known proposed road projects, available property along alignment, proposed developments that may provide new roads for pipeline alignments, or other project benefits that the alignment may have for the community</td>
</tr>
<tr>
<td>Environmental impacts/permitting/cultural resources</td>
<td>Impacts to wetlands or waterways, amount of impact to Endangered Species Act-listed (ESA-listed) or sensitive species, wildlife refuge impacts, likelihood of uncovering cultural resources, other agency right-of-way (e.g., Oregon Department of Transportation [ODOT], BPA, railroad), and availability of discharge locations for pipeline appurtenances</td>
</tr>
<tr>
<td>System compatibility</td>
<td>Adjacency to reservoir site, access and proximity to connection points (turnouts), compatibility with system hydraulics (particularly excess length of pipe or localized high points)</td>
</tr>
<tr>
<td>System resiliency</td>
<td>Geologically active areas (seismic risk), high consequence foreign utilities (large/high pressure natural gas or petroleum mains and water transmission mains), accessibility of the pipe and appurtenances after a seismic event</td>
</tr>
<tr>
<td>Constructability</td>
<td>Available right-of-way, adequate construction access, likelihood of geotechnical challenges, large utility conflicts, known future utilities, and availability of detours and right-of-way width for traffic control</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Access to pipeline and appurtenances, known future right-of-way changes that would limit access</td>
</tr>
<tr>
<td>Agricultural impacts</td>
<td>Avoid and minimize impacts to adjacent lands designated as either Exclusive Farm Use (EFU), Exclusive Forest and Conservations (EFC) or Agricultural and Forestry District (AF-20) which implement Oregon Revised Statutes to protect agricultural and forest lands</td>
</tr>
<tr>
<td>Comparative Costs</td>
<td>The estimated difference in cost between alternatives, based off the lowest cost alternative (the base cost)</td>
</tr>
</tbody>
</table>
Table 8 defines the individual criteria.

Table 8. Evaluation Criteria for Pipeline Routing

<table>
<thead>
<tr>
<th>Criteria/Risk</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Social/Community Impacts</strong></td>
<td></td>
</tr>
<tr>
<td>Congestion/community impacts</td>
<td>Number of driveways, traffic volume, major intersections</td>
</tr>
<tr>
<td>Impact critical facilities</td>
<td>Hospitals, fire stations, emergency services</td>
</tr>
<tr>
<td>Community facilities</td>
<td>Schools, churches, community centers, parks, large employers</td>
</tr>
<tr>
<td>Opportunity for community</td>
<td>Add value or benefit to the community</td>
</tr>
<tr>
<td>enhancement</td>
<td></td>
</tr>
<tr>
<td>“No-cut” areas</td>
<td>Sensitive community areas that should not be impacted</td>
</tr>
<tr>
<td><strong>Opportunities/Benefits</strong></td>
<td></td>
</tr>
<tr>
<td>Proposed road projects</td>
<td>Piggy back/joint project opportunities</td>
</tr>
<tr>
<td>Available property</td>
<td>Properties currently for sale that provide key sites for</td>
</tr>
<tr>
<td></td>
<td>staging/tunneling shaft locations</td>
</tr>
<tr>
<td>Proposed development</td>
<td>Piggy back/joint project opportunities</td>
</tr>
<tr>
<td>Other project benefits</td>
<td>Other project benefits and opportunities</td>
</tr>
<tr>
<td><strong>Environmental Impacts/Permitting/Cultural Resources</strong></td>
<td></td>
</tr>
<tr>
<td>Wetland/waterway impacts</td>
<td>Amount of jurisdictional wetland/waterway impacted</td>
</tr>
<tr>
<td>ESA-listed or sensitive species</td>
<td>Amount of impact to ESA-listed or sensitive species</td>
</tr>
<tr>
<td>impacts</td>
<td></td>
</tr>
<tr>
<td>Wildlife refuge impacts</td>
<td>Cross or impact designated Wildlife Refuge Area</td>
</tr>
<tr>
<td>(U.S. Fish and Wildlife)</td>
<td></td>
</tr>
<tr>
<td>Archeology/cultural resources</td>
<td>Amount of impact to archeology/cultural resources</td>
</tr>
<tr>
<td>impacts</td>
<td></td>
</tr>
<tr>
<td>ODOT</td>
<td>Cross or within ODOT right-of-way</td>
</tr>
<tr>
<td>Bonneville Power Administration</td>
<td>Cross or within utility right-of-way</td>
</tr>
<tr>
<td>(BPA)</td>
<td></td>
</tr>
<tr>
<td>Railroad crossing</td>
<td>Cross or within railroad right-of-way</td>
</tr>
<tr>
<td>County</td>
<td>Cross or within county right-of-way</td>
</tr>
<tr>
<td>Community/city</td>
<td>Cross or within city right-of-way</td>
</tr>
<tr>
<td>Discharge locations</td>
<td>Available discharge locations for low point drains and blow-offs</td>
</tr>
<tr>
<td><strong>System Compatibility</strong></td>
<td></td>
</tr>
<tr>
<td>Terminal Reservoir</td>
<td>Accessibility and proximity, available right-of-way width</td>
</tr>
<tr>
<td>Connection points</td>
<td>Accessibility and proximity to connection points</td>
</tr>
<tr>
<td>System hydraulics</td>
<td>Compatibility (mostly related to topography)</td>
</tr>
</tbody>
</table>
### Criteria/Risk Definition

<table>
<thead>
<tr>
<th>Criteria/Risk</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System Resiliency</strong></td>
<td></td>
</tr>
<tr>
<td>Geologically active areas</td>
<td>Does the alignment cross seismically active areas, liquefaction areas, or Peak Ground Acceleration transitions (e.g., rock to silt)?</td>
</tr>
<tr>
<td>High consequence foreign utilities</td>
<td>Are there existing high consequence foreign utilities such as large/high pressure natural gas or petroleum mains, and water transmission mains that would share the alignment?</td>
</tr>
<tr>
<td>Transmission main accessibility</td>
<td>In the event of a seismic event, will the transmission main be accessible?</td>
</tr>
<tr>
<td>affected by seismic event</td>
<td></td>
</tr>
<tr>
<td><strong>Constructability</strong></td>
<td></td>
</tr>
<tr>
<td>Available right-of-way</td>
<td>Adequate available right-of-way either existing or associated with an opportunity project</td>
</tr>
<tr>
<td>Construction access</td>
<td>Ability of construction traffic to access work site and deliver materials</td>
</tr>
<tr>
<td>Geotechnical</td>
<td>Favorable or unfavorable geotechnical conditions</td>
</tr>
<tr>
<td>Utility conflicts</td>
<td>Conflicts with larger gravity lines, highly congested utility corridors, gas mains</td>
</tr>
<tr>
<td>Future utilities</td>
<td>Planned future utilities that will impact available right-of-way</td>
</tr>
<tr>
<td>Traffic control</td>
<td>Available detour routes and right-of-way width</td>
</tr>
<tr>
<td><strong>O&amp;M</strong></td>
<td></td>
</tr>
<tr>
<td>Access</td>
<td>Ability of O&amp;M to access and maintain facilities</td>
</tr>
<tr>
<td>Future right-of-way changes</td>
<td>Future right-of-way changes will affect access to the transmission main</td>
</tr>
<tr>
<td><strong>Agricultural Impacts</strong></td>
<td></td>
</tr>
<tr>
<td>Agricultural impacts</td>
<td>Cross or within areas zoned EFU, EFC, or AF-20</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td></td>
</tr>
<tr>
<td>Capital cost</td>
<td>Cost to construct</td>
</tr>
<tr>
<td>O&amp;M cost</td>
<td>Life-cycle cost of O&amp;M</td>
</tr>
</tbody>
</table>

A simplified scale of “+”, “0”, “-” was preferred over a numeric approach to improve transparency and create information that is more representative of the benefits and risks of each site. The goal of using the three-tier scale is to highlight the relative desirability of each option compared to the other options, while using supporting qualitative and quantitative information to describe the relative merits. This process does not result in an overall "score" for each site, but a ranking of the options based on relative attributes of the alignments being considered.

### 2.4.3 Short-Listing of Routes

Route selection was a three-step process of evaluation, narrowing down the potential routes by obstacles and impacts (e.g., community, environmental, and political) and
implementation challenges. Over 100 alternative routes and sub-routes were considered for the project (Appendix C - 3). The alternatives were evaluated based on the criteria previously described and ratings were recorded in matrices of routing criteria and the “+”, “0”, “-” scoring. The matrix approach allowed for comparison of alternative routes to highlight which had the fewest implementation obstacles and which had more risks.

The first evaluation resulted in the shortlisted routes that provided three or four options in each major reach of the project (WRWTP to SW 124th Avenue, SW 124th Avenue to the reservoir, reservoir to Hillsboro, and reservoir to Beaverton). The shortlisted routes were determined to have the fewest obstacles for approval and were submitted to the Partners in Decision Memo #8A Shortlisted Pipeline Routes (included in Appendix C - 3) on September 9, 2014 for Partner endorsement. Routes that had been evaluated and were not shortlisted were sidelined, recognizing that although they are not preferred at this time, they may be needed in the future as the area continues to develop.

The shortlisted routes (as shown in Figure 5 and Figure 6) were presented to the community to collect feedback from both the public stakeholders and neighboring local agencies. Following these processes, the preferred route was developed from the endorsed shortlisted routes.

2.4.4 Agency Coordination and Public Involvement

Public involvement activities set the stage for positive public interactions. Public involvement personnel are likely the first people the interested public will see as the face of the project. Advance coordination allows for time to tell the story of the Program to establish the need and benefits with the community. Agency coordination with the various agencies and municipalities affected by proposed improvements provides opportunities to build a project in everyone’s best interests.

2.4.4.1 Agency Coordination

The WWSP spans two counties, six municipalities, and many other districts. Most of the jurisdictions impacted by construction activities will not be served by the Program. Understanding jurisdictional concerns and taking advantage of already planned development and roadway project opportunities may lessen the construction impact of the WWSP on the communities.

Agency coordination meetings were held with the following jurisdictions on the dates listed in Table 9. In addition to agencies and meetings listed in Table 9, coordination with regulatory agencies is ongoing; coordination with regulatory agencies to date is described in Appendix G - 1.

Table 9: Agency Coordination Meetings

<table>
<thead>
<tr>
<th>Agency</th>
<th>Meeting Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonneville Power Administration</td>
<td>December 15, 2014</td>
</tr>
<tr>
<td></td>
<td>March 3, 2015</td>
</tr>
<tr>
<td></td>
<td>June 11, 2015</td>
</tr>
<tr>
<td></td>
<td>August 19, 2015</td>
</tr>
</tbody>
</table>
### Agency Meeting Dates

<table>
<thead>
<tr>
<th>Agency</th>
<th>Meeting Dates</th>
</tr>
</thead>
</table>
| City of Beaverton     | June 27, 2014  
|                       | July 31, 2014  
|                       | December 2, 2014  
|                       | January 6, 2015  |
| City of Hillsboro     | May 12, 2014  
|                       | October 15, 2014  
|                       | March 2, 2015  |
| City of King City     | June 10, 2014  
|                       | January 15, 2015  |
| City of Sherwood      | June 11, 2014  
|                       | January 9, 2015  |
| City of Tigard        | June 5, 2014  
|                       | January 6, 2015  |
| City of Tualatin      | June 12, 2014  
|                       | December 29, 2014  |
| City of Wilsonville   | May 13, 2015  |
| Kinder Morgan         | October 27, 2014  |
| NW Natural Gas        | October 2, 2014  |
| ODOT                  | June 12, 2014  
|                       | December 18, 2014  |
| TriMet                | November 17, 2014  |
| Washington County     | June 9, 2014  
|                       | January 30, 2015  |

Coordination meetings will continue with a refined list of agencies as final designs are developed.

#### 2.4.4.2 Open Houses

Public open houses were held in several locations in the project area to reach a wide geographic area.

- Seven public open houses were held September - November 2014 throughout the project area to unveil the project and seek feedback on possible pipeline routes. The pipeline routes shared at the public open houses were the short-listed routes as shown in Figure 5 and Figure 6. A virtual open house also was held.

- Attendance at the open houses was moderate, and included activists, community leaders, project neighbors, students, and elected and appointed officials. The online open house was viewed by over 580 people.
• The main benefit identified by participants was coordinating pipeline construction with other improvement projects.

• The main concerns were construction impacts on traffic congestion and neighbors, and Willamette River water quality.

• Feedback included some comments on specific potential routes and suggestions for alternate pipeline routes.

Generally, attendees were supportive of the project and understood the need. They had questions, but offered limited comments on the possible pipeline routes. Most concerns were related to transportation impacts of the potential routes in the area of Farmington Road through Hillsboro. Concerns related to impacts on nearby schools and residences also were raised. Attendance and interest were comparable to when TVWD and Hillsboro were studying the Willamette River as an additional water supply source. Project concerns included water quality, traffic disruption, and impacts on residential areas and businesses. Possible benefits included the opportunity to coordinate construction with other improvement projects, especially transportation; upgrading water, sewer, and stormwater lines; and building bicycle and pedestrian paths.

After preliminary design, outreach will continue with a focus on introducing the public to the preferred route. Outreach to the general public may include informational mailings, live and/or virtual open houses, and/or articles and announcements in community publications. Additionally, outreach will include contacting landowners to facilitate site investigations needed to support further design efforts.

2.4.5 Preferred Route

Over 100 alternative routes and sub-routes were considered for the project (Appendix C - 3). The alternatives were evaluated based on the criteria previously described and ratings were recorded in matrices of routing criteria and the “+”, “0”, “-” scoring. The first evaluation resulted in the shortlisted routes that provided 3 or 4 options in each major reach of the project (WRWTP to SW 124th Avenue, SW 124th Avenue to the reservoir, reservoir to Hillsboro, and reservoir to Beaverton; as shown in Figure 5 and Figure 6). The shortlisted routes were determined to have the least obstacles for approval and were submitted to the Partners in Decision Memo #8A Shortlisted Pipeline Routes (included in Appendix C - 3) on September 9, 2014. Routes that had been evaluated and not shortlisted were sidelined, recognizing that although they are not preferred at this time, they may be needed in the future as the area continues to develop.

The recommended preferred route is made up of the preferred shortlisted routes within each section of the project area based on the criteria evaluation and public feedback. The preferred route has fewer implementation challenges than other options and is aligned with many future opportunity projects with local agencies. The selection of the preferred route from the shortlisted routes was the first time that construction cost was considered as a factor in route selection.

The preferred route was recommended in the Draft Preferred Route and Summary Matrices TM submitted January 30, 2015; the route was approved by the Partners on February 24, 2015. A Final version is provided in Appendix C - 3.
The preferred route (as shown in Figure 7) is generally:

- Willamette River WTP through Wilsonville on Kinsman Road, Boeckman Road, 95th Avenue, Ridder Road, Garden Acres Road and Grahams Ferry Road
- The SW 124th Avenue new rural arterial connection north of Wilsonville to Tualatin
- From Tualatin to Sherwood on Tualatin-Sherwood Road
- Between Sherwood and the reservoir sites on SW Roy Rogers Road, SW Scholls Ferry Road, SW Tile Flat Road, and SW Grabhorn Road
- From reservoir Sites 2/3 to SW 209th Avenue and SW Farmington Road via SW Koehler and Clark Hill roads
- From reservoir Site 11 to SW 209th Avenue and SW Farmington Road via SW Grabhorn Road
- Through the South Hillsboro Community Planning Area on SW 209th Avenue, SW Rosedale Road, and the proposed Cornelius Pass Road extension through the proposed SW Kinnaman Road extension where the Main Stem splits for the Western and Eastern extensions
- Western Extension: through Hillsboro on Cornelius Pass Road, SW Baseline Road, SW 205th Avenue to NW 206th Avenue, NW Amberwood Drive, and Cornelius Pass Road
- Eastern Extension: through unincorporated Washington County and Beaverton via SW Kinnaman Road, SW Farmington Road, SW 160th Avenue, SW Millikan Way, SW Schottky Trail, SW Terman Road, SW Hocken Avenue, SW Jenkins Road, and to NW Walker Road through an existing City of Beaverton utility easement

**Key decision:**

The Partners endorsed the recommended preferred route on February 25, 2015
Figure 5. Project Map with Sections Labeled

Section 1

Section 2

Section 3

Section 4

Reservoir Area

SW 124th Ave.

(full size image in Appendix C - 3)
Figure 6. Project Map with Recommended Preferred Route and Shortlisted Routes

(full size image in Appendix C - 3)
Figure 7. Project Map with Recommended Preferred Route

(full size image in Appendix C - 3)
2.5 Cash Flow Evaluation

The Final Fall Cash Flow Analysis for Willamette Supply Preliminary Design TM (Appendix E - 1) was prepared for use by the WWSP Partners in their respective financial forecasting and planning. The scope of the analysis included updating the capital and non-construction costs and timing of infrastructure components based on current Program understanding. Program timing was based on current understanding of the Program schedule and included construction of Program components beginning in 2015 with completion by the end of 2025. Cash flow related to O&M was not included in the analysis.

Assumptions were developed with TAC and Project Coordination Committee (PCC) members at the Cash Flow Workshop on September 17, 2014. Initial assumptions were provided at the Cash Flow Workshop based on current available data and past experience. These assumptions were discussed and then modified according to TAC and PCC feedback during the workshop. The stated assumptions reflect the decisions made at the Cash Flow Workshop for the purposes of this Cash Flow Analysis. These assumptions and related details can be found in Appendix E - 1.

A previous cash flow analysis was provided in June 2014 to provide interim updates to the estimated capital and non-construction costs. The Interim Cash Flow Analysis for Willamette Supply Predesign TM is included as Appendix E - 2.

2.5.1 Non-construction Costs

To support distribution of cash flows, costs associated with the Program were separated into two distinct categories within the cash flow analysis. The specific assumptions regarding project and Program level costs are summarized in Table 10 and Table 11, respectively.

Project level costs are assigned to specific projects, and are therefore distributed according to specific project start and end dates, per the Program schedule Table 11. Project level, non-construction costs are based on typical industry assumptions. Preliminary assumptions were developed and presented at the Cash Flow Workshop, where final assumptions were agreed to by the Partners.
Table 10. Project Level Costs

<table>
<thead>
<tr>
<th>Project Cost</th>
<th>% of Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contingency(^1)</td>
<td>30-40%</td>
</tr>
<tr>
<td>Engineering Design(^2)</td>
<td>8-12%</td>
</tr>
<tr>
<td>Construction Management(^3)</td>
<td>6-12%</td>
</tr>
<tr>
<td>Internal Costs(^4)</td>
<td>3%</td>
</tr>
<tr>
<td>Program Oversight(^5)</td>
<td>2%</td>
</tr>
</tbody>
</table>

\(^1\) Contingency costs vary depending on type and complexity of project; assumed to be 40% for the transmission pipelines because the route had not yet been determined; contingency for remaining projects was assumed to be 30%.

\(^2\) Engineering design costs vary depending on type and complexity of project; assumed to be 8% for pipelines, 10% for reservoir, and 12% for the intake, WTP and pump stations.

\(^3\) Construction management costs vary depending on type and complexity of project; assumed to be 6% for pipelines, 8% for reservoir and 12% for the intake, WTP and pump stations.

\(^4\) Internal costs represent the cost of the Partners to pay their own staff to manage and administer projects.

\(^5\) Oversight by the Program Manager at the project level; includes tracking, reporting, and coordinating specific project elements as they pertain to the program.

Table 11. Program Level Costs

<table>
<thead>
<tr>
<th>Program Cost</th>
<th>Cost ($M 2014)</th>
<th>Start Date(^{10})</th>
<th>End Date(^{10})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programmatic Permitting(^1)</td>
<td>$8.5</td>
<td>2015</td>
<td>2026</td>
</tr>
<tr>
<td>Public Involvement/Public Outreach(^2)</td>
<td>$3.5</td>
<td>2015</td>
<td>2026</td>
</tr>
<tr>
<td>Public Affairs(^3)</td>
<td>$1.7</td>
<td>2015</td>
<td>2026</td>
</tr>
<tr>
<td>Attorney Fees(^4)</td>
<td>$1.2</td>
<td>2015</td>
<td>2026</td>
</tr>
<tr>
<td>Land Use Process (10 x $200k)(^5)</td>
<td>$2.0</td>
<td>2016</td>
<td>2022</td>
</tr>
<tr>
<td>Land Acquisition(^6)</td>
<td>$8.0</td>
<td>2015</td>
<td>2016</td>
</tr>
<tr>
<td>Right-of-way/Easements(^7)</td>
<td>$20.0</td>
<td>2017</td>
<td>2019</td>
</tr>
<tr>
<td>Program Management(^8)</td>
<td>3%</td>
<td>2015</td>
<td>2026</td>
</tr>
<tr>
<td>Program Reserve(^9)</td>
<td>10%</td>
<td>2015</td>
<td>2026</td>
</tr>
</tbody>
</table>

\(^1\) All permitting costs are assigned at the Program level (not project level) and include such items as National Environmental Policy Act, ESA, and project-level permits specific to local jurisdictions ($750k/year).

\(^2\) Costs for Public Involvement/Public Outreach were provided by the Program’s current consultant team ($300k/year).

\(^3\) Costs for Public Affairs were provided by the Program’s current consultant team ($144k/year).

\(^4\) Attorney fees are estimates only and included in consideration of project/Program risks ($100k/year).

\(^5\) Assumes land use process with ten different entities.

\(^6\) Land acquisition cost based on requirements for Tualatin River crossing and reservoir site (both locations still unknown, costs are estimates only).

\(^7\) Right-of-way/Easements costs associated with pipeline routing.

\(^8\) Expressed as a percentage of the total Program construction cost, in addition to project level oversight.

\(^9\) Expressed as a percentage of the total Program construction cost; previous Program estimates have not included this line item; intended to address Program risks.

\(^10\) Start and end dates expressed as fiscal year (July 1 – June 30).
2.5.2 Infrastructure Components

The total Program construction cost estimate is based on infrastructure components that make up the proposed system. These components include raw water pump station (RWPS) and intake structure, WTP and finished water PS, pipelines, and reservoir. Appendix E - 1 contains the details of the cash flow evaluation for each infrastructure component.

2.5.3 Cash Flow Summary

The estimated total project cost (in August 2014 dollars) is provided in Table 12.

Table 12. Phase 1 Estimated Project Costs (through 2026)\(^1\)

<table>
<thead>
<tr>
<th>Component</th>
<th>Construction Cost(^1) ($M 2014)</th>
<th>Project Cost(^2) ($M 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RWPS and Intake</td>
<td>$4.8</td>
<td>$6.1</td>
</tr>
<tr>
<td>WTP and Finished Water PS</td>
<td>$176.8</td>
<td>$228.1</td>
</tr>
<tr>
<td>Pipelines</td>
<td>$401.3</td>
<td>$476.7</td>
</tr>
<tr>
<td>Reservoir</td>
<td>$53.2</td>
<td>$65.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$636.1</strong></td>
<td><strong>$776.3</strong></td>
</tr>
</tbody>
</table>

\(^1\) Does not include program costs  
\(^2\) Includes estimated non-construction costs associated with each project

The estimated total Program cost, through 2026, is provided in Table 13.

Table 13. Total Estimated Program Costs (through 2026)

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost ($M 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction(^1)</td>
<td>$636.1</td>
</tr>
<tr>
<td>Project Level Non-Construction Costs</td>
<td>$140.2</td>
</tr>
<tr>
<td>Program Costs(^2)</td>
<td>$67.0</td>
</tr>
<tr>
<td>Program Reserve</td>
<td>$63.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$907.0</strong></td>
</tr>
</tbody>
</table>

\(^1\) Includes 30-40% contingency  
\(^2\) Program costs include costs for the WWSP Preliminary Design and the WTP Master Plan

The total estimated cost share for each Partner for Phase 1 (through 2026) is provided in Table 14. Additional cost share information is presented in Appendix D of the Final Fall Cash Flow Analysis for Willamette Supply Preliminary Design TM (Appendix E - 1).
Table 14. Total Program Cost Shares (Through 2026 Only)

<table>
<thead>
<tr>
<th>Partner</th>
<th>Cost ($M 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TVWD</td>
<td>$523.1</td>
</tr>
<tr>
<td>Hillsboro</td>
<td>$276.5</td>
</tr>
<tr>
<td>Beaverton¹</td>
<td>$78.8</td>
</tr>
<tr>
<td>Tualatin¹</td>
<td>$28.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$907.0</strong></td>
</tr>
</tbody>
</table>

¹ Information for potential partners included for planning purposes only and does not indicate a decision to participate in the WWSP.

The estimated cash flows for each Partner by year, through 2026, are indicated in Table 15. Additional cost share information is presented in Appendix D of the FINAL Fall Cash Flow Analysis for Willamette Supply Preliminary Design TM (Appendix E - 1).

Table 15. Phase 1 Estimated Cash Flows by Partner (through 2026; August 2014 dollars)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TVWD</td>
<td>$5.3</td>
<td>$9.4</td>
<td>$12.0</td>
<td>$15.7</td>
<td>$14.1</td>
<td>$45.6</td>
<td>$74.4</td>
<td>$57.5</td>
<td>$72.1</td>
<td>$100.6</td>
<td>$115.7</td>
<td>$0.7</td>
</tr>
<tr>
<td>Hillsboro</td>
<td>$3.4</td>
<td>$6.1</td>
<td>$7.9</td>
<td>$8.9</td>
<td>$7.1</td>
<td>$23.4</td>
<td>$38.4</td>
<td>$29.6</td>
<td>$30.2</td>
<td>$55.5</td>
<td>$65.6</td>
<td>$0.4</td>
</tr>
<tr>
<td>Beaverton²</td>
<td>$0.8</td>
<td>$1.3</td>
<td>$1.7</td>
<td>$2.4</td>
<td>$2.1</td>
<td>$6.4</td>
<td>$10.3</td>
<td>$8.0</td>
<td>$11.8</td>
<td>$15.9</td>
<td>$18.0</td>
<td>$0.1</td>
</tr>
<tr>
<td>Tualatin²</td>
<td>$0.5</td>
<td>$0.7</td>
<td>$0.8</td>
<td>$1.1</td>
<td>$0.9</td>
<td>$1.2</td>
<td>$1.7</td>
<td>$1.4</td>
<td>$5.6</td>
<td>$7.1</td>
<td>$7.6</td>
<td>$0.05</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$9.9</td>
<td>$17.6</td>
<td>$22.4</td>
<td>$28.1</td>
<td>$24.2</td>
<td>$76.6</td>
<td>$124.7</td>
<td>$96.4</td>
<td>$119.7</td>
<td>$179.2</td>
<td>$206.8</td>
<td>$1.3</td>
</tr>
</tbody>
</table>

¹ Indicates fiscal year (July 1 through June 30)
² Information for potential partners included for planning purposes only and does not indicate a decision to participate in the WWSP.

2.6 Envision™

The WWSP coordinated with the Institute for Sustainable Infrastructure (ISI) to develop a pilot pre-certification process for Envision™, which ISI termed “Envision Plan Review” (EPR) for the purpose of this pilot approach. Evaluation of the Program compared with the Envision™ system is documented in the Envision Evaluation TM (Appendix G - 2).

Envision™ is designed to be applied during final design and construction of a project. However, many of the significant decisions that shape a project are made during the planning phase. The goal of developing a process with ISI to use Envision™ during planning is to help evaluate the decisions that result in a more sustainable project that better meets the needs of the communities.

EPR enables the program to gain benefits from Envision review of credits, and set the framework for future design and construction phases. The preliminary design team used the EPR process during the planning phase of WWSP to inform evaluation of pipeline routes, selection of reservoir sites, and development of design guidelines. The process is similar to design level Envision™ verification process, but fewer credits are assessed at
the planning phase. HDR prepared EPR documentation only for those credits deemed to be “assessable” at this stage of preliminary design. These assessable credits were agreed to by TVWD, HDR, and ISI.

Developing the approach for planning level Envision™ recognition was a multistep process:

- **Envision™ Workshop**
  - Discuss benefits and approach
  - Determine Program interest in pursuing pre-certification
- **Credit Evaluation Workshop**
  - Overview of credits that apply to WWSP
  - Documentation needed and estimated score
- **Conversations with ISI**
  - Formulation of EPR process
  - Discussion of final recognition or acknowledgement format and level
- **Preparation of the EPR documentation and submittal package**

Working through the EPR process with the preliminary design team and ISI has set the stage for pursuing full Envision™ recognition, if deemed beneficial by the WWSP Partners during completion of the individual design and construction projects. The program design guidelines include recommendations of implementable steps that support the Partners’ potential goal of Envision™ certification. The *Envision™ Strategy TM* is provided in Appendix G - 3.
3.0 Design Guidelines

Program design guidelines set the standards for final pipeline and appurtenance design by providing design processes, criteria, details, and specifications to maintain consistency during final design and construction. The design guidelines focused on the pipeline portion of the Program because the Partners plan to phase design and construction over the next ten years and creating consistency between each individual design package is important for operation of the system. The WRWTP and the terminal reservoir are each unique facilities and do not require a set of standard design guidelines. The conceptual design for the reservoirs was developed to support property acquisition, permitting, system hydraulics, and cost estimating.

The design guidelines summary is current as of the date of this PSR. Designers should refer to the full design guidelines document for the most up-to-date information. The design guidelines were envisioned to be a living document, updated periodically to reflect current Program needs.

Key takeaways:

- Project-specific design guidelines were created through a collaborative process to guide future design teams.
- Design guidelines used for development of the SW 124th Avenue Pipeline project.

3.1 Transmission Pipeline

For the WWSP, program design guidelines were established using a workshop-based process to develop a single set of standards from the Partners’ staff. Separate from other program meetings and discussions, development of the design guidelines required eight, four-hour workshops to discuss the partners’ preferences of pipeline and appurtenance design; establish the frequency of pipeline access manways and mainline valves; size the access ports; and develop Program-specific pipe, appurtenance, and corrosion protection details.

The design guidelines include the following topics:

- Transmission pipeline (steel pipe design, trench design, pipe joints, fittings, corrosion control, disinfection, and testing)
- Appurtenances (general considerations, manways, air valves, blow-offs, main line valves, vaults)
- Seismic design guidelines
- Geotechnical engineering (investigations, design, and construction considerations)
- Trenchless crossings (crossing types, methods, design, related seismic and geotechnical concerns, casing pipe, shafts, and construction considerations)
- Utility crossings
3.1.1 Pipeline Material

Early during Program development, spiral welded steel pipe generally conforming to AWWA C200 was selected as the preferred pipe material for the transmission piping for the Program. Steel pipe presents several key advantages over other possible choices, including:

- **Longevity**: steel pipelines frequently have a life of 50 or more years
- **Ductility**: can accommodate some ground movement in seismic hazard areas
- **Joint type**: can be optimized based on local hazards and expected seismic ground deformations
- **Design**: steel pipelines do not need to use standard fitting angles and joints can be deflected to accommodate curves streamlining the final alignment
- **Readily available from multiple suppliers.**

The decision to use steel pipe satisfies the Program’s goal of preserving the quality of life in our communities by protecting public health and safety through delivery of reliable, high-quality water.

3.1.2 Pipeline Design Criteria

Steel pipe design for water transmission mains is outlined in the AWWA M11. The standards developed for the WWSP and documented in the Program design guidelines are founded on this document and modified in some cases based on project requirements, experience, and owner’s preference.

The design guidelines outline the design theory for the WWSP transmission line. The design of steel pipe is based on the required:

- **Working pressure**
- **Transient pressure**
• Test pressure
• Pump shutoff pressure based on the established maximum design shutoff HGL with pipeline protection control measures implemented

The pipe wall thickness and steel grade decisions also require consideration of the allowable tension stress in the steel and external loading conditions. Trench design including the minimum cover, backfill materials and compaction, buoyancy concerns, and live loads post-construction affect pipe design. Finally, the criteria for determining pipe joints and fitting types are provided. Criteria are summarized in guidance for corrosion protection design and disinfection and testing. Design guidance is included in Table 16.

Included in the preliminary design drawings is a system profile that includes ground surface over the proposed pipeline, overall pipeline profile, locations of major appurtenances, hydraulic grade lines for the system based on each of the Tier 1 reservoir sites, and an indication of pipeline pressure along the alignment. Using the system profile and considering the pipeline design criteria, designers can determine the required wall thickness for any section of pipe in the Program.
Table 16. Pipeline Design Criteria Summary (welded steel pipe)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Design Criteria</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working pressure</td>
<td>Based on final hydraulics and transient hydraulic analysis, location specific</td>
<td>Design Guide 2.1.2.1</td>
</tr>
<tr>
<td>Transient pressures</td>
<td>Limited to 1.33 times the working pressure</td>
<td>Design Guide 2.1.2.2</td>
</tr>
<tr>
<td>Test pressures</td>
<td>Determined as 1.25 times the working pressure. Not to exceed 62.5 percent of yield for mortar- or polyurethane-coated</td>
<td>Design Guide 2.1.2.3</td>
</tr>
<tr>
<td>Allowable tension stress in steel</td>
<td>Maximum yield of 42,000 pounds per square inch (psi) for mortar-lined pipe</td>
<td>Design Guide 2.1.2.4</td>
</tr>
<tr>
<td></td>
<td>Maximum yield of 52,000 psi for polyurethane-lined pipe</td>
<td></td>
</tr>
<tr>
<td>External loadings</td>
<td>Design for future cover plus traffic conditions. Consider hydrostatic and seismic loads where appropriate</td>
<td>Design Guide 2.1.2.5</td>
</tr>
<tr>
<td>Maximum allowable deflection</td>
<td>Determined as 75 percent of the AWWA M11 limits considering pipe coating/lining type</td>
<td>Design Guide 2.1.2.6</td>
</tr>
<tr>
<td>Handling</td>
<td>Mortar lined: maximum D/t = 230</td>
<td>Design Guide 2.1.2.7</td>
</tr>
<tr>
<td></td>
<td>Polyurethane lined: maximum D/t = 288</td>
<td></td>
</tr>
<tr>
<td>Deflection determination</td>
<td>Dependent on site conditions</td>
<td>Design Guide 2.1.2.8</td>
</tr>
<tr>
<td>Buckling</td>
<td>Assume hydrostatic depth is to top of final grade in all locations except in locations where there is known standing water above final grade or potential for flooding. Use the same approach as AWWA M11 to analyze buckling. For internal vacuum pressure (Pv) use 14.7 psi (full vacuum). If the calculated allowable buckling pressure is exceeded, proceed with an iterative mitigation strategy by improving the pipe trench embedment zone and/or increasing the cement mortar lining up to ¾-inch thick unless approved by owner. Finally, if those strategies do not work combine them with increasing the steel wall thickness. The goal is to evaluate and optimize the overall system and choose the most cost-effective engineered solution.</td>
<td>Design Guide 2.1.2.9</td>
</tr>
</tbody>
</table>

Information current as of 2015, Design Guidelines Version 1
3.1.3 Appurtenances

The Design Guidelines outline the appurtenance design requirements for the WWSP. General considerations include current and future traffic when locating appurtenances. Vaults should be located outside of traffic areas whenever possible. When vaults must be located in a traffic area, lids and openings should be placed in islands, shoulders, or at a minimum, between the wheel paths.

Accessibility by ladders, safety climbs, platforms, and guardrails must meet Occupational Safety and Health Administration (OSHA) and Owner safety requirements. Provide a minimum of two access points per vault; one for ventilation and equipment access and the other for personnel via a permanent ladder.

Piping in vaults should be exposed and concrete-encased piping should be lined and coated in accordance with the main pipeline per Specification 40 20 13. Provide electrical isolation and cathodic protection between dissimilar metals.

Traffic-rated vaults should be required near or under roads. Traffic-rated vaults should be designed per American Association of State Highway and Transportation Officials HS-20 standards and flush with the ground. Vaults in undeveloped areas should protrude 2 feet above finish ground. Refer to Details D-28, D-29, D-30, and D-45.

Consider buoyancy when designing manholes and vaults.

General appurtenances included in the WWSP are:

- Manways
- Air valves
- Blow-offs
- Main line valves
- Vaults

Details about these appurtenances can be found in the WWSP Design Guidelines (Appendix F - 1) as well as Table 17.

Designers should consider the specifics of their project in applying the standard details. Consideration should be given to the potential for liquefaction within the section being designed and the need to accommodate the anticipated settlement. In the case of blow-offs the transmission main pressure should be considered to determine the need for energy dissipation at each location. The standard details should include variations in an effort to allow designers to meet the needs of their section yet maintaining the intent of common facilities.
<table>
<thead>
<tr>
<th>Type</th>
<th>Purpose</th>
<th>Design Criteria</th>
<th>Reference</th>
</tr>
</thead>
</table>
| Manways  | Provide access for the contractor during construction and future access for the operations staff | • Spaced at approximately 2,000 feet.  
• Full-access manways included at all air valves and main line valves  
• Outlets installed at less than 15 percent grade  
• Avoid areas of high traffic | Details D-20, D-21  
Design Guide 3.2 |
| Air valves | Allow venting of air during filling, draining, and operation of the pipeline; admit air during a break in the pipeline or surge condition, and discharging air during normal operation | • Locate at high points and intermediate high points  
• Provide additional air valves as recommended in the Hydraulic Transient Analysis TM  
• Size vacuum valve functions for a 30-inch rupture (size of manway) in the transmission line  
• Design for draining operations - water velocities not to exceed a drain rate of 1.3 fps and fill rate of 0.5 fps  
• Size for differential pressure across orifice not to exceed 5 psi  
• Use dual air valve assemblies in lieu of air valves greater than 12 inches | Detail D-32, D-33  
Specs 40 50 35  
Design Guide 3.3 |
| Blow-offs | Provide points for draining and flushing the pipeline; located at low points, and intermediate low points, in the line and locations with useable drainages | • Target pipeline drain time (per discrete pipeline segment): 24 hours  
• Target maximum drain velocity for a transmission pipeline: 1.3 fps  
• Target maximum discharge velocity for cement mortar-lined blow-off piping: 15 fps | Detail D-28, D-29, D-30  
Design Guide 3.7 |
| Main Line Valves | Used to either isolate or allow water into specific sections of the pipeline or water delivery points for operation or maintenance purposes | • Mainline valves should be pressure-rated butterfly valves  
• Provide a main line isolation valve:  
• In accordance with preliminary design drawings  
• At locations to facilitate pipeline drain times  
• Downstream of turnouts  
• Upstream and downstream of river crossings  
• Upstream and downstream of fault lines  
• Outside of intersections  
• Direct-buried unless adjacent to another appurtenance requiring location in a vault | Design Guide 3.5 |
| Vaults   | Vaults are components of most appurtenances                              | • Varies by application and location                                             | Design Guide 3.6 |
3.1.4 Geotechnical Design Guidelines

Each final design project should include a geotechnical investigation. The geotechnical investigation will form the basis for geotechnical design and recommendations for all aspects of the project. The investigation should be initiated with a detailed review of existing geologic information and site development history along the alignment, followed by detailed field mapping. This should be followed by a multi-phase subsurface investigation and laboratory testing program. Multiple phases of exploration should be conducted to capture and quantify geotechnical risks and uncertainty along the alignment. The Design Guidelines outline key investigation criteria for the final design projects.

More details regarding geotechnical considerations can be found in the WWSP Design Guidelines Version 1 (Appendix F - 1).

3.1.5 Seismic Design Guidelines

For pipeline seismic design, the primary considerations are transient loading/strain and permanent ground displacement (PGD). Transient loading is the shaking hazard by seismic wave propagation and the amplifications due to surface soil conditions and topography. PGD is the ground failure resulting from surface fault rupture, landslide and slope failure, soil liquefaction and lateral spreading, and differential settlement.

During the pipeline design process, the effects of axial tensile/compressive deformations and transverse bending/shear deformations of the pipeline caused by transient loading and PGDs should be evaluated and analyzed. Depending on the extent of the findings and the Program LOS goal, appropriate seismic hazard mitigation schemes can be developed and may consist of:

- Localized adjustment of pipeline alignment to avoid or minimize seismic hazards
- Selection of appropriate pipeline material, section, joint and backfill to accommodate the anticipated seismic stress and strain
- Use of special seismic resilient pipe and/or flexible joints
- Pile support or ground improvement use consideration
- System redundancy consideration
- Rapid response plan development for emergency repair and bypass

The primary seismic hazards for the trenchless crossings are ground shaking and ground deformation associated with liquefaction and lateral spread. Detailed liquefaction analyses are required to determine zones susceptible to liquefaction and the extent of possible settlements and lateral spread due to liquefaction. Preliminary results are included in Appendix F - 4. The effects of large axial tensile/compressive deformations and transverse bending/shear deformations caused by liquefaction and lateral spreading should be evaluated and analyzed as part of the final design process.

More details regarding seismic considerations can be found in the WWSP Design Guidelines Version 1 (Appendix F - 1). The WWSP Seismic Resiliency TM (Appendix F -
3.1.6 Trenchless Crossings, Special Crossing Areas

At many points along the WWSP preferred route are existing features that prevent standard open-trench installation of the WWSP transmission pipeline. The factors that influence the type of trenchless crossing include:

- Type of feature being crossed (e.g., railroad, highway, wetland, creek, river)
- Geotechnical analysis of subsurface conditions
- Length of crossing (e.g., short for railroad and highways or long river crossings)

This section presents design criteria pertaining to trenchless crossings for the WWSP Program. This design document includes the following:

- Trenchless methods applicable to this project
- Siting criteria for locating alignments and shafts
- Design criteria for the trenchless crossing and casing
- Construction considerations

Trenchless crossings along the WWSP are described herein as either shallow or deep crossings.

3.1.6.1 Shallow Crossings

Shallow crossings for the WWSP project generally include undercrossings for railroads, major roadways, and major utilities along the alignment. Shallow crossings are generally anticipated to be less than 25 to 30 feet deep to the pipe invert and require relatively simple shoring designs and limited groundwater control efforts. Where possible, the crossing will be sited in line with the pipeline to avoid horizontal transitions along the alignment.

Trenchless methods appropriate for shallow crossings primarily include pipe jacking, pipe ramming, and auger boring. These methods and specific design criteria associated with them are discussed in *WWSP Design Guidelines Version 1* (Appendix F - 1).

3.1.6.2 Deep Crossings

Deep crossings associated with the WWSP project include the Tualatin River and tributary stream crossings. Specific streams include Butternut Creek, Beaverton Creek, Rock Creek, and Chicken Creek. Pipeline installation across these waterways using open cut methods is generally not acceptable for several reasons ranging from seismic and slope stability hazards to jurisdictional wetlands and waterways, and ESA species impacts. Deep crossings may also include undercrossings for major roadways due to utility constraints or geological conditions. The Tualatin River Crossing was evaluated in a separate geotechnical memo located in Appendix F - 3.
3.1.6.3 Trenchless Methods

Table 18 identifies feasible trenchless installation methods for different types of anticipated crossings for the WWSP project. The recommended trenchless methods for each type of crossing are highlighted in green. Due to the large diameter of the WWSP pipelines, horizontal directional drilling (HDD) is not considered feasible for a single pipeline installation. The HDD method is technically feasible for multiple smaller parallel pipelines that achieve equivalent hydraulic performance as a single larger pipe. Hydraulic and construction/staging area impacts from multiple pipelines limit the feasibility of HDD methods.

Table 18. Summary of Crossing Types and Feasible Trenchless Methods

<table>
<thead>
<tr>
<th>Type of Crossing</th>
<th>Pipe Ramming</th>
<th>Auger Bore, Jack and Bore</th>
<th>Pipe Jacking</th>
<th>Micro-tunneling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railroad</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Major roadway</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Creek (minor)</td>
<td>Possible</td>
<td>Possible</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Creek/river (major)</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Wetland</td>
<td>Possible</td>
<td>Possible</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Major utility</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Green shade Recommended trenchless methods for each type of crossing are highlighted in green.

✓ Feasible but not recommended trenchless methods for each type of crossing have a check mark.

“Possible” Trenchless methods that are not feasible and not recommended but are possible if project-specific requirements exist are labeled “possible.”

Blank Trenchless methods that are not recommended are blank.

More details regarding trenchless crossings can be found in the WWSP Design Guidelines Version 1 (Appendix F - 1).

3.1.7 Utility Coordination

The preliminary design drawings include utility data that was acquired through Geographic Information System (GIS) sources, from record drawings, and from utility owners. Physical location of utilities was not performed for the preliminary design but field reconnaissance was conducted in an attempt to generally confirm the data. The alignment of the WWSP pipelines was established based on available information and it should be recognized that during final design adjustments will be warranted to resolve
conflicts with existing utilities. Designers should be required to physically locate existing utilities within their sections as part of the final design effort.

Designers are responsible for coordinating with utility companies during design to identify and accurately locate existing utilities that cross or are parallel to proposed WWSP facilities.

The datum of the maps or drawings should be compared with the Washington County standard datum and adjustments made to the data taken from the maps or drawings, if necessary, prior to transferring to the plan and profile sheets. Overlooking this datum adjustment could result in errors when evaluating utility conflicts.

Data provided by utility companies in the form of utility maps and as-built drawings should be compared against field-located utilities to verify that all existing utilities records are requested.

### 3.1.7.1 Special Concerns Related to Existing Utilities

Several utilities could affect the pipeline profile, public convenience, safety, and project costs if not located accurately. Special attention will be required in locating and indicating these utilities on plan and profile sheets. These utilities include:

- Large diameter water lines (18-inch or greater)
- Storm drainage pipelines and facilities (especially over 24 inches)
- Sanitary sewer service connections and sanitary sewer pipelines (especially over 18 inches)
- Sanitary sewer force mains
- Underground communication lines
- Overhead and underground powerlines
- Gas lines over 4 inches and high pressure gas transmission lines
- Petroleum transmission lines
- Utilities to be installed by developers during design/construction

More details regarding utility coordination can be found in the *WWSP Design Guidelines Version 1* (Appendix F - 1).
4.0 Preliminary Design

The WWSP preliminary design was developed in accordance with the project Design Guidelines and specific technical analyses developed to support preliminary design. For the terminal reservoir site, a conceptual level design was performed for each of the preferred Tier 1 sites. Likewise, the preliminary design of the pipeline includes an alignment for Reservoir Sites 2/3 plus an alternative alignment for Reservoir Site 11, when different. The pipe diameters required for each reservoir site are noted on the drawings.

The technical analyses performed for this preliminary design include:

- Geotechnical data report (Appendix F - 11) and analysis of geotechnical conditions memorandum (Appendix F - 2)
- System steady-state hydraulics
- System transient hydraulics for the pumped portion of the WWSP

The preliminary design documents refine the planning and concepts developed in the previous section to establish a set of plans that the Program can use for several purposes:

- Permitting
- Right-of-way and easement discussions
- Establishing a base cost estimate for final design
- Supporting final design development with consistent pipeline design concepts
- Identify specific design/construction packages

Key takeaways:

- The *Updated Seismic Hazards Evaluation* TM (Appendix F - 4) is based on local geotechnical information and provides innovative and explicit options to future designers for selecting mitigation technologies in seismic hazard areas.
- Preliminary design plans, specifications, and estimate (PS&E) support the Program in permitting, right-of-way, and planning.
- Concept-level designs for each Tier 1 reservoir site support property acquisition and permitting activities.
4.1 **System Hydraulics**

This section summarizes the hydraulic evaluation used for the preliminary design of the WWSP transmission system. This evaluation builds on the preliminary hydraulic evaluation used to support identification of a terminal reservoir site, as described in the *Terminal Storage Evaluation TM* (Appendix B - 2). The updated hydraulic evaluation was conducted for the two Tier 1 reservoir sites, Sites 3 and 11. Until the Partners’ acquisition of one or both of the sites is certain, the preliminary design proceeded with both reservoir sites as independent options.
The hydraulic evaluation for the preliminary design had four major outcomes:

- Hydraulic profile of the pumped system (Main Stem)
- System curve of the pumped system (Main Stem)
- Sizing (diameter) of the gravity system (Western and Eastern extensions)
- Transient (surge) analysis for the pumped system

Details of the analysis for the first three topics are presented in the *Final Updated Hydraulic Evaluation* (Appendix D - 4). The transient analysis and results are presented in the *Final WWSP Preliminary Design Hydraulic Transient Analysis* (Appendix D - 7).

### 4.1.1 Hydraulic Capacity

The design flow rate for each section of pipe was assumed consistent with the hydraulic LOS requirements established by the WWSP’s current and potential Partners. Representative water demands for potential Partners are included for planning purposes only and do not constitute a decision to participate in the WWSP.

The hydraulic LOS requirements were described in the *Terminal Storage Evaluation TM* (Appendix B - 2) and are summarized in Figure 9 and Figure 10. In the evaluation of the pumped system, the 5 MGD demand for the City of Tualatin shown in Figure 9 and Figure 10 was not withdrawn at the shown location, but instead was assumed to be conveyed through to the terminal reservoir sites. This assumption is conservative and would have a minor impact on the HGL along the pipeline. For the gravity system, flows were as described in Figure 9 and Figure 10. Within this section, the LOS flows are referred to as design flows.
Figure 9. Reservoir Sites 2/3 - Preferred Route with Pipeline Diameters
Figure 10. Reservoir Site 11 - Preferred Route with Pipeline Diameters
4.1.2 Pipeline Profile and Sizing for Hydraulic Evaluation

The pipeline follows the preferred route, as described in the Final Recommended Preferred Route TM (Appendix C - 3). Top of pipe was assumed to be 7 feet below the ground surface. At crossings, top of pipe was assumed to be three times the pipeline diameter below creek thalweg. Side slopes were projected to intersect at the approximate creek thalweg location.

The diameter of the Main Stem was assumed to be 66 inches, consistent with the Executive Committee decision on February 24, 2015 for the 124th Avenue Project. For the gravity system, pipeline diameters were identified based on calculated head losses, using standard pipe sizes in 6-inch increments. The diameter was assumed to be consistent between each service location. The one exception was on the Eastern Extension, where a diameter change was allowed approximately two-thirds along its length, at the intersection of Millikan Way and the BPA right-of-way. This option was included due to the long length of the Eastern Extension and anticipation that additional service locations may be added in the future.

The gravity pipelines were sized to optimize hydraulic efficiency using available head from the reservoirs and minimizing the pipeline diameters while not exceeding 10 fps in the pipeline. The maximum pipeline flow velocity was set at 10 fps based on protection of the cement mortar lining. This assumption was documented in the WWSP Hydraulic Criteria TM (Appendix D - 6). Flows through the gravity pipelines (Western and Eastern Extensions) are regulated with control structures at each delivery point (locations shown in Figure 9 and Figure 10).

4.1.3 Hydraulic Profile of Pumped System (Main Stem)

System hydraulic profiles were developed for the Main Stem (pumped) pipeline from the WRWTP to each of the potential terminal reservoir sites (Sites 3 and 11). Profiles were generated for the static condition, design flow, and maximum flow. For purposes of the preliminary design, the design flow for the Main Stem is defined to be 105.7 MGD and the maximum flow is defined to be 120 MGD and represents an “all pumps on” condition.

Analyses were conducted for two reservoir overflow elevations for each of the two potential reservoir sites. Those overflow elevations are 500 and 520 feet for Site 3 and 590 and 610 feet for Site 11. Only results for the higher overflow elevations are included herein; results for the alternate overflow elevations are included in Appendix D - 4. Note, the hydraulic analysis discussion presented in this section was completed specifically for Site 3. However, the 500- and 520-foot overflow elevations also apply to Site 2. Site 2 constraints are discussed further in Section 4.2.12.

The analysis identified areas where predicted pipeline pressures exceed 250 psi. The Design Guidelines (Appendix F - 1) assumed pressures would not exceed 250 psi based on earlier assumptions for reservoir overflow elevation and design flow. Areas with pressures exceeding 250 psi are limited to the pipeline section closest to the WRWTP and deeper crossings. In these selected areas, the ability of appurtenances to meet projected pressures should be evaluated and modifications made as needed.
Figure 11 shows the system hydraulic profile for reservoir Site 3 with an overflow of 520 feet at the design flow. Graphs for static and maximum flows are included in Appendix D - 4. Each profile includes three lines: hydraulic grade line, elevation at top of pipe, and pressure head in the pipeline, from the WRWTP up to the terminal reservoir. Key results were as follows:

- Maximum head under static conditions is 371.5 feet based on clearwell water surface elevation of 148.5 feet.
- At the design flow, the maximum pipeline pressure is 254 psi and occurs at the crossing of Wilsonville Road near the WRWTP. Pressures are below 250 psi at all other locations.

Figure 12 shows the system hydraulic profile for reservoir Site 11 for an overflow elevation of 610 feet at the design flow. Graphs for static and maximum flow are included in Appendix D - 4. Key results were as follows:

- The maximum head under static conditions is 461.5 feet, based on a clearwell water level of 148.5 feet.
- At the design flow, the maximum pressure is 297 psi and occurs at the WRWTP and Wilsonville Road crossing. Calculated pipeline pressures exceed 250 psi from the start of the alignment near the WRWTP up to SW 95th Avenue (approximately the first 8,750 feet of the pipeline), and also at the Tualatin River and Rock Creek crossings.

Pump shutoff pressures could increase the pressure in sections of the Main Stem pipeline upstream of the reservoir. These pressures would be higher than working pressures and are a significant design factor in some reaches of the pipeline. Mitigating pump shutoff head is a design parameter not only for the Main Stem pipeline, but also for the pumps in the system. For purposes of the preliminary design, pump shutoff head pipeline protection control criteria are included in the pipe design criteria in the WWSP Design Guidelines (Appendix F - 1). The pump shutoff head pipeline protection criteria are used as a basis to determine pipe wall thicknesses along the Main Stem. Table 19 lists the pipe wall thickness by segment for the Main Stem using this criteria. The analysis and findings are included in Pump Shutoff Head Pipeline Protection Control TM (Appendix D - 8).
Table 19. Main Stem Pipe Wall Thickness Based on Working Pressure and Pump Shutoff Head Control

<table>
<thead>
<tr>
<th>Start Station</th>
<th>End Station</th>
<th>Pipe Thickness (fractional inches)</th>
<th>Pipe Thickness (decimal inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>120+70</td>
<td>132+62</td>
<td>1/2</td>
<td>0.5000</td>
</tr>
<tr>
<td>132+62</td>
<td>135+50</td>
<td>9/16</td>
<td>0.5625</td>
</tr>
<tr>
<td>135+50</td>
<td>201+78</td>
<td>1/2</td>
<td>0.5000</td>
</tr>
<tr>
<td>201+78</td>
<td>308+78</td>
<td>7/16</td>
<td>0.4375</td>
</tr>
<tr>
<td>308+78</td>
<td>312+78</td>
<td>3/8</td>
<td>0.3750</td>
</tr>
<tr>
<td>312+78</td>
<td>321+75</td>
<td>7/16</td>
<td>0.4375</td>
</tr>
<tr>
<td>321+75</td>
<td>374+50</td>
<td>3/8</td>
<td>0.3750</td>
</tr>
<tr>
<td>374+50</td>
<td>423+50</td>
<td>7/16</td>
<td>0.4375</td>
</tr>
<tr>
<td>423+50</td>
<td>451+50</td>
<td>3/8</td>
<td>0.3750</td>
</tr>
<tr>
<td>451+50</td>
<td>539+00</td>
<td>7/16</td>
<td>0.4375</td>
</tr>
<tr>
<td>539+00</td>
<td>599+00</td>
<td>3/8</td>
<td>0.3750</td>
</tr>
<tr>
<td>599+00</td>
<td>618+00</td>
<td>7/16</td>
<td>0.4375</td>
</tr>
<tr>
<td>618+00</td>
<td>628+00</td>
<td>3/8</td>
<td>0.3750</td>
</tr>
<tr>
<td>628+00</td>
<td>707+00</td>
<td>7/16</td>
<td>0.4375</td>
</tr>
<tr>
<td>707+00</td>
<td>803+00</td>
<td>3/8</td>
<td>0.3750</td>
</tr>
<tr>
<td>803+00</td>
<td>808+55</td>
<td>5/16</td>
<td>0.3125</td>
</tr>
<tr>
<td>808+55</td>
<td>938+00</td>
<td>3/8</td>
<td>0.3750</td>
</tr>
<tr>
<td>938+00</td>
<td>1001+00</td>
<td>5/16</td>
<td>0.3125</td>
</tr>
</tbody>
</table>
Figure 11. Pipeline Hydraulic Profile, Reservoir Site 3, Overflow Elevation of 520 feet, at Design Flow of 105.7 MGD
Figure 12. Pipeline Hydraulic Profile, Reservoir Site 11, Overflow Elevation of 610 feet, at Design Flow of 105.7 MGD
4.1.4 System Curve

Hydraulic system curves were developed for pumping to the two reservoir sites with roughness coefficients representing new and old pipe. A clearwell elevation of 148.5 feet was used for the analysis. The assumed DW roughness coefficient for new pipe was 0.0108 and 0.0117 for old pipe. Table 20 summarizes the system head curve results for these four scenarios. The total dynamic head (TDH) is reported at the design flow rate of 105.7 MGD. Figure 13 and Figure 14 show the system curves for both old and new pipe for Sites 3 and 11, respectively.

Table 20. System Head Curve Results

<table>
<thead>
<tr>
<th>Reservoir Site</th>
<th>Roughness</th>
<th>Upstream HGL (feet)</th>
<th>Static Head (feet)</th>
<th>TDH (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 3 (520 feet overflow)</td>
<td>Old</td>
<td>670.4</td>
<td>371.5</td>
<td>521.9</td>
</tr>
<tr>
<td></td>
<td>New</td>
<td>660.2</td>
<td>371.5</td>
<td>511.7</td>
</tr>
<tr>
<td>Site 11 (610 feet overflow)</td>
<td>Old</td>
<td>767.7</td>
<td>461.5</td>
<td>619.2</td>
</tr>
<tr>
<td></td>
<td>New</td>
<td>757.0</td>
<td>461.5</td>
<td>608.5</td>
</tr>
</tbody>
</table>
Figure 13. System Head Curve (SHC), Pump to Reservoir Site 3, 520 Feet Overflow Elevation

System Head Curve (Site 3; Overflow 520-ft)

- Old Pipe
- New Pipe
- Design Flow rate
Figure 14. System Head Curve (SHC), Pump to Reservoir Site 11, 610 Feet Overflow Elevation

System Head Curve (Site 11; Overflow 610-ft)

- Old Pipe
- New Pipe
- Design Flow Rate

Flow Rate (mgd) vs. Total Dynamic Head (ft)
4.1.5 **Gravity System Hydraulics**

The gravity system hydraulic analysis established appropriate pipe diameters for sections of transmission system consisting of common outlet piping extending from the reservoir and the Western and Eastern extensions. Pipeline diameters were based on head loss calculation using the DW equation and associated local (minor) losses at identified fittings, changes in diameter, and appurtenances. As defined by the Partners in the LOS requirements, the water level in the reservoirs was assumed to be 3 feet below the reservoir overflow. This assumption includes consideration of operating pressures being lower than design pressures under some operational conditions. The velocity criterion assumes a maximum velocity of 10 feet per second. Identified diameters for the gravity pipelines are summarized in Table 21. Evaluations were conducted for two reservoir overflow elevations for each of the two potential reservoir sites. Those overflow elevations are 500 and 520 feet for Site 3 and 590 and 610 feet for Site 11. Only results for the higher overflow elevations are included herein; results for the alternate overflow elevations are included in Appendix D - 4.

**Table 21. Impact of Reservoir Location on Pipe Diameters**

<table>
<thead>
<tr>
<th>Pipeline Section</th>
<th>Site 3 at 520 ft</th>
<th>Site 11 at 610 ft</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common Outlet</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reservoir to 209th/Farmington</td>
<td>66</td>
<td>54</td>
</tr>
<tr>
<td>209th/Farmington to Cornelius Pass/Rosa</td>
<td>66</td>
<td>54</td>
</tr>
<tr>
<td>Rosa to Kinnaman</td>
<td>66</td>
<td>48</td>
</tr>
<tr>
<td><strong>Western Extension</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kinnaman to Alexander</td>
<td>48</td>
<td>42</td>
</tr>
<tr>
<td>Alexander to South Transmission Line</td>
<td>48</td>
<td>42</td>
</tr>
<tr>
<td>South Transmission Line to Cornell</td>
<td>48</td>
<td>36</td>
</tr>
<tr>
<td>Cornell to Evergreen</td>
<td>36</td>
<td>30</td>
</tr>
<tr>
<td>Evergreen to Hwy 26</td>
<td>36</td>
<td>30</td>
</tr>
<tr>
<td><strong>Eastern Extension</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kinnaman to BPA @ Millikan</td>
<td>54</td>
<td>42</td>
</tr>
<tr>
<td>BPA @ Millikan to Walker</td>
<td>48</td>
<td>42</td>
</tr>
</tbody>
</table>

Excess head available at the ends of the Western and Eastern extensions are presented in Table 22. The values are based on the identified diameters shown in Table 21. The excess head represents the ability of the system to accommodate changes in the final selected elevation of the terminal reservoir, additional head loss due to additional fittings or appurtenances, or reductions in pipe sizing for short sections to resolve constructability concerns.
### Table 22. Excess Head at each Terminus by Reservoir Site

<table>
<thead>
<tr>
<th>Pipeline Section</th>
<th>Site 3 at 520 ft</th>
<th>Site 11 at 610 ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excess Head (feet)</td>
<td>Excess Head (feet)</td>
<td></td>
</tr>
<tr>
<td>Western Extension</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Eastern Extension</td>
<td>7</td>
<td>23</td>
</tr>
</tbody>
</table>

#### 4.1.6 Transient Analysis

A transient analysis was conducted for the Main Stem pipeline with Sites 3 and 11 for the terminal reservoir. Hydraulic transient computer models were used to perform pump power failure and pump start-up simulations for the WTP PS to either of the two reservoir sites. As part of the analysis, surge control measures were developed to protect the integrity of the transmission main following pump power failure at the WTP PS. Details of the analysis are documented in the *WWSP Preliminary Design Hydraulic Transient Analysis* (Appendix D - 7)

The analysis confirmed vapor cavity formation and potential collapse in the transmission main, pipeline over pressurization, and combination air valve slam following pump power failure at the WTP PS. The analysis recommends that a total pressurized surge tank volume of at least 19,000 cubic feet be included at the WTP PS. For example, this can be six pressurized surge tanks each with a diameter equal to 12 feet and length of 28 feet (23,685 gallons per tank). During steady state operating conditions, each pressurized surge tank should maintain an air volume equivalent to 40 percent of the total tank volume. Horizontal, vertical, or spherical pressurized surge tanks equipped with a compressor for level control should be suitable for installation at the WTP PS. If the Site 3 reservoir is selected, each pressurized surge tank should have a rated pressure of at least 350 psi, and if the Site 11 reservoir is selected the pressurized surge tanks should have a rated pressure of at least 400 psi.

Surge control in addition to the recommended pressurized surge tanks should not be required for the transmission main following a loss of power to the pumps at the WTP PS. This is true for operation of the duty pumps, operation of both duty pumps, and operation of the standby pump prior to pump power failure. Variable frequency drives or pump control valves could be installed at the PS to control the rate of flow increase on pump start-up.

The recommendations from the analysis should be re-evaluated/updated as the design of the WTP PS and transmission main proceeds through detailed design, because they are dependent on the selected pumps, motors, valves, and transmission main profile.

#### 4.2 Tier 1 Reservoir Sites Conceptual Design

The terminal reservoir is in the conceptual design phase, because a final decision on the preferred terminal reservoir site could not be made at this stage of the WWSP. Geotechnical and other site-specific field data were not available as site acquisition
options for Sites 2, 3 and 11 are on-going at the time of this report. The scope of work called for developing conceptual design for Sites 3 and 11 only. The scope was later amended to include developing conceptual layout alternatives for Site 2 primarily to assess whether the site was worth pursuing as a Tier 1 site. The terminal reservoir sites have common traits and requirements for design (e.g., assumed geotechnical conditions, piping, and appurtenances). However, other aspects of the conceptual design differ between the sites (e.g., the tank layout and visual mitigation). The design criteria and assumptions for the conceptual design of the terminal reservoir for Sites 3 and 11 are discussed by topic in the subsections below, with site-specific issues for each criteria/topic highlighted. The conceptual layout alternatives for Site 2 are discussed separately in Section 4.2.12.

4.2.1 Site Descriptions

The Site 3 parcel is approximately 9.8 acres in area. Existing ground surface elevations range from approximately 480 to 530 feet. Several residential homes, the Cooper Mountain Nature Park, and undeveloped private land border the parcel.

Site 11 consists of two parcels with a combined area of approximately 7.8 acres. The existing ground surface elevations range from approximately 580 to 625 feet. Site 11 is surrounded by existing residences. The two parcels comprising Site 11 each have existing residential homes. It is assumed from preliminary communications with property owners that one existing home would remain after construction of the reservoir, while the other residential structures on the site would be removed.

4.2.2 Zoning Development and Construction Permitting

Sites 3 and 11 are both within unincorporated Washington County. Site 3 is outside the existing urban growth boundary (UGB) but within the urban reserve area (URA), while Site 11 is within the UGB. The discussion in this subsection is specific to the terminal reservoir site, and is intended to be consistent with the overall WWSP permitting strategy developed in the preliminary design phase. A more detailed permitting review and continued agency coordination will be needed once the overall project is defined for the predesign and design of the selected site.

4.2.2.1 Zoning Development

Zoning information for Sites 3 and 11 is provided below:

- Site 3
  - Zoning: Agricultural and Forestry (AF-20)
  - Land use procedure: Type II

- Site 11
  - Zoning: Future Development (FD-20)
  - Land use procedure: Type II

Based on the zoning designation for the two sites, construction of a public utility facility is not prohibited by the Washington County Community Development Code (CDC). Public
utilities are permitted through a Type II (for Site 3) or Type III (for Site 11) land use permitting process. If the Review Authority determines the applicant meets all of the applicable standards of the CDC, which may include conditions of approval, then the application can be approved.

4.2.2.2 Construction Permits

Permit approvals and/or coordination will need to occur with Washington County. The following standards from the CDC are key considerations for the layout of the terminal reservoir:

- **Setbacks** - same for Sites 3 and 11—30 feet in the front yard, 30 feet in the street side yard, 10 feet in the (non-street) side yard, and 20 feet in the rear yard (FD-20 zoning allows 25 feet).

- **Height limitations** – maximums are 35 feet (with an additional 25 feet allowed for appurtenances) in the FD, AF, and Exclusive Farm Use (EFU) zones.

Specific visual screening or landscape requirements for this type of facility were not identified in the CDC.

Washington County permits anticipated for the terminal reservoir are listed in Table 2 of *Willamette Water Supply Program Environmental, Land Use and Cultural Resources Review* (Appendix G - 1).

The National Pollutant Discharge Elimination System (NPDES) 1200-C permit would be required for construction activities, including clearing, grading, and excavation that disturb 1 or more acres of land. This permit would be issued by the Oregon Department of Environmental Quality (DEQ) and requires submittal of an application form, stormwater plan, and an erosion and sediment control plan.

Key sections and applicable standards of the CDC, Article IV – Development Standards are highlighted below.

- **Section 406 Building, Siting and Architectural Design, for Special Uses as determined by the Review Authority**

- **Section 407 Landscape Design - Special Uses of Section 430, as required by Section 407-4, including Tree Preservation and Removal and as determined by the Review Authority**

- **Section 409-5 Private Driveways and Private Streets Outside the UGB. Private streets (driveways), or portions thereof, shall demonstrate adequate accessibility for emergency vehicles. The private street (driveway) shall comply with the access road requirements of the Oregon Fire Code**

- **Section 410 Grading and Drainage. For structures prior to issuance of a building permit**

- **Section 411 Screening and Buffering requirements outside the Urban Growth Boundary shall be determined by the Review Authority based on impact to surrounding uses**
• Section 413 Parking and Loading as applicable to and necessary for Special Use Permits as determined by the Review Authority; maximum parking requirements in Section 413-13.2 do not apply to development outside of an UGB

• Section 414 Signs as determined by the Review Authority

• Section 417 Irrigation only applies when 407 (Landscape Design) applies

• Section 418 Setbacks

• Section 419 Height within 20 feet of another primary district with a lower height restriction, the height restriction of the adjacent district shall apply

• Section 421 Floodplain and Drainage Hazard Area Development

• Section 422 Significant Natural Resources

• Section 423 Environmental Performance Standards

• Section 426 Erosion Control

4.2.3 Standards

New construction of potable water tanks are subject to regulations enforced by the Oregon Department of Human Services Office of Drinking Water (ODW). In addition to AWWA the applicable portions of the Waterworks Standards for new storage tanks are listed below. Additionally, the tank should be constructed using NSF-61 certified materials and disinfected prior to being placed into service. All tank coatings or linings should be installed in accordance with the manufacturer’s instructions.

The terminal reservoir should meet the following standards:

1. Vents and other openings should be constructed and designed to prevent the entry of rainwater or runoff, and birds, insects, rodents, or other animals.
2. At least one sampling tap should be available to enable representative sampling of the water in the tank that will be entering the transmission system; the tap should be protected against freezing.
3. A tank should not be designed, constructed, or used for any activity that creates a contamination hazard.

Final design drawings and specifications for the terminal reservoir should meet the following:

1. Constructed in accordance with AWWA standards, which are hereby incorporated by reference
2. Constructed of an impervious material that prevents the movement of water into or out of the reservoir
3. Covered with a rigid structural roof made of impervious material that prevents the movement of water or other liquids into or out of the reservoir
4. Equipped with at least one separate inlet and outlet (internal or external), and designed to minimize short-circuiting and stagnation of the water flow through the reservoir
5. Equipped with drainage facilities that allow the reservoir to be drained and all residual sediment removed, along with an overflow device; the reservoir drainage
facilities and overflow device should not be connected directly to a sewer or storm drain and should be free of cross-connections

6. Equipped with controls to maintain and monitor reservoir water levels

7. Equipped to prevent access by unauthorized persons

8. Designed to allow authorized access and adequate lighting of reservoir interior for inspections, cleaning or repair

9. Equipped with isolation valves, and designed and operated to allow continued distribution of water when the reservoir is removed from service; isolation valves should be located within 100 feet of the tank

10. Designed and constructed to prevent the entry of surface runoff, subsurface flow, or drainage into the reservoir

11. Designed to prevent corrosion of the interior walls of the reservoir

12. For a subsurface or partially buried tank:
   a. Protected against flooding (both reservoir and vents)
   b. Equipped with underdrain facilities to divert any water in proximity to the reservoir away from the reservoir
   c. Sited a minimum of 50 feet horizontally from a sanitary sewer and 100 feet horizontally from any other waste facilities or force main
   d. Provided with a minimum of two groundwater level monitoring wells drilled to a depth at least 20 feet below the reservoir bottom and sited within 100 feet and on opposite sides (upgrade and downgrade) of the reservoir

4.2.4 Tank Type and Material

For the preliminary design phase, the WWSP terminal reservoir is defined to be 30 MG divided into two independent 15-MG tanks to allow individual tanks to be taken offline for maintenance. For purposes of the conceptual design, the terminal reservoir is assumed to be made of prestressed (AWWA D110/D115), cast-in-place or conventionally reinforced, cast-in-place concrete.

Welded steel type was not selected primarily because it cannot be partially buried limiting flexibility in site grading and ability to hide the tank. Welded steel also provides less capital cost advantages over concrete (prestressed or conventionally reinforced) for the size/volume of the WWSP terminal reservoir. Finally, welded steel tanks require periodic recoating of the interior and exterior surface for additional maintenance costs resulting in a higher total life cycle cost.

Prestressed concrete is a cost-effective and durable form of construction for potable water tanks designed to prevent cracking of concrete to minimize potential leakage. For prestressed concrete tanks, AWWA D110 applies to circular tanks, while AWWA D115 applies to circular and non-circular tanks. The advantage of prestressed concrete over conventionally reinforced concrete is its greater assurance against crack formation when the tank is full. Type D110 is common along the west coast. However, contractor experience with Type D115 is limited in this region.

For construction excavation, an additional 15 feet from the outside of the tank surface is assumed for the conceptual design. Prestressed concrete Type D110 tanks are typically manufactured using machine-wrapped circumferential prestressing technique. An additional 15 feet from the outside of the tank surface is sufficient for wrapping and
erecting for cast-in-place construction. Tanks may be cast monolithically or made in pre-cast units and assembled on site with post-tensioning. Conventionally reinforced or Type D115 concrete tanks could be constructed within a similar or smaller construction excavation area.

4.2.5 Geotechnical Conditions

No geotechnical borings or analysis was conducted for either site as part of the Preliminary Design scope of work. Without site-specific geotechnical data available for the conceptual design, the general assumption is that both Tier 1 sites provide stable subsurface conditions for the proposed reservoir development. This is based on data compiled by McMillen Jacobs for the pipeline alignment analysis for nearby sections, as well as the other studies conducted on Cooper Mountain. This includes the Grabhorn Reservoir Replacement Study (HDR, 2013) and JWC ASR Phase 1 Program Study (HDR, 2010). The WWSP Geotechnical Analysis TM (Appendix F - 2) includes geotechnical data compiled for the pipeline alignment.

Based on the available information, unconsolidated soils are assumed to be shallow (less than 10 feet), and the subgrade is assumed to consist of weathered basalt or intact basalt bedrock of the Columbia River Basalt Unit that is known to underlie Cooper Mountain.

Construction of the proposed project is assumed to require temporary slopes to facilitate construction of below-ground improvements. The basalt is assumed to allow for construction excavation slope of 0.5 Horizontal : 1 Vertical (H:V). During the design phase, a geotechnical investigation should be conducted to determine maximum cut slope requirements; where mitigation, such as rock bolting, would be needed for grading the cut slope; and whether seasonal construction constraints are necessary (i.e., dry times of year to allow exposed excavation).

Slope reinforcement can include construction of retaining walls (i.e., installation of soil nails, construction of soldier pile, or construction of tieback walls). When final grading plans for the proposed tank are developed during future design stages of the project, slope stabilization measures, if needed, should be evaluated to provide recommendations for limiting slope height or reinforcing slopes to improve slope stability. If the stability of adjoining improvements, walls, or other structures is endangered by excavation operations, support systems such as shoring, bracing, or underpinning may be required to provide structural stability and protect personnel working within the excavation.

All temporary excavations and temporary slopes to facilitate construction of below-ground improvements must comply with applicable local, state, and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards. Construction site safety is the responsibility of the Contractor, who should be solely responsible for the means, methods, and sequencing of construction operations to maintain a safe working environment.
4.2.6 Site Piping

The terminal reservoir will require the following pipelines: (i) inlet/outlet pipeline that brings water to the reservoir from the Main Stem and conveys water from the reservoir to the Eastern and Western extension pipelines; (ii) an overflow that discharges water to the reservoir drain via an air gap; and (iii) a drain to facilitate periodic maintenance that requires completely draining the reservoir. A pressurized potable water line may be constructed on site for tank cleaning and landscaping use, which can be defined during later predesign/design of the reservoir.

4.2.6.1 Inlet and Outlet

For both Sites 3 and 11, the inlet/outlet piping is aligned parallel to the south side of the parcels, and graded following construction to facilitate future access. The terminal reservoir is planned to be served by 66-inch inlet and outlet pipes for Site 3 and 66-inch inlet and 54-inch outlet for Site 11. The inlet pipe connects the Main Stem pipeline located west of the tanks along Grabhorn Road. Flow into each of the (15-MG) terminal reservoirs is planned to be split using a tee to inlet pipes to each reservoir on the site.

Valve vaults should be located near the inlet pipe entry to each of the reservoirs. The top of the valve vault should match the access road’s finished grade so that each terminal reservoir can be individually bypassed. The valve vault should include isolation valves so that the terminal reservoir may be bypassed for reservoir maintenance.

The outlet piping within the tank can be approximately 4 inches above the tank floor. Under normal operations, the penetration should allow any debris or sediment that may enter the tank to accumulate below the pipe to prevent its entrance into the distribution system. To allow the tank to be completely drained (in addition to the dedicated drain pipe – see Section 4.2.6.2), this 4-inch section can be a removable spool\(^4\). Once the tank is drained to 4 inches above the floor, the spool can be removed to allow the tank to drain completely. When the water level in the tank approaches the spool height, the tank should be disinfected.

4.2.6.2 Overflow and Drain

Overflow pipe from each reservoir at the site can be discharged toward Grabhorn Road for both Sites 3 and 11. For Site 3, however, it may be preferable to discharge to the drainage channel to the east, as shown in the conceptual design. In any case, the overflow line would discharge to a detention facility, sized to accommodate the time for operators to respond to a high level alarm in the tanks (discussed further below in this section).

\(^4\) The removal spool is a push-on joint that can be installed on the outlet pipe. It sticks up above the floor of the tank to provide a minimum water depth of 4 inches at the highest point in the center of the tank. It can be removed if the tank is to be completely drained. The spool is more commonly used in design with combined outlet and drain pipe to prevent the bottom of the tank from being exposed unintentionally, which would require the tank to be disinfected. Because the conceptual design drawing in this case is shown with a separate outlet and drain pipe, the removable spool is shown as an option.
The overflow can be comprised of a weir or box that serves as an automatic, emergency drain system should the tanks be accidentally overfilled. A full capacity overflow pipe should connect through an air gap to the tank drain. A dedicated drain located at the reservoir invert should allow the tank to be completely emptied. An air gap should be provided to prevent cross connection between the reservoir's overflow piping and the drain pipe. The air gap for the overflow and drain system should, at a minimum, be double the overflow diameter. The end of the overflow pipe should include a duckbill check valve to prevent animals or debris from getting into the tank via the overflow pipe.

The drain pipe should have its own floor penetration and can be 18 inches in diameter. It may be installed into a small depression or sump. When the tank is periodically cleaned, the depressed drain should allow the accumulated sediment to exit the tank. The drain should be above grade with a blind flange connection for a portable pump and concrete pad to set on.

The drain flow should be discharged to a detention basin constructed on-site. The overflow should connect and discharge to the same detention basin. The detention facility can be constructed to the south of the tanks at Site 3 and to the west of the tanks at Site 11.

At the time this PSR was submitted, no meetings have occurred with Washington County to define discharge requirements or constraints (i.e., flow capacity of receiving drainage channel) from the detention basin. As part of the permitting strategy, a program service provider letter will be requested during later predesign/design phase for the reservoir to determine specific requirements for discharge.

The detention volumes shown in the conceptual design drawings (i.e., 0.87 MG for Site 3 and 0.61 MG for Site 11) are sized conservatively compared to potential detention volume needs from preliminary overflow criteria estimated to be less than 0.5 MG.

Flow from the detention basin should be routed to a dechlorination vault. Flow discharge from this point should be off site; either to the adjacent drainage channel (to the east at Site 3) or stormwater conveyance along Grabhorn Road (to the west at Sites 3 and 11). Overflow discharge off-site would need to be permitted through Washington County (or Clean Water Services for Site 11 if routed north toward Clean Water Services service area).

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5 Based on input from DN Tanks, the feasible largest size pipe through a wall is a 36-inch-diameter. Thus, multiple smaller diameter pipes may be installed rather than one, large (66-inch) overflow pipe.

6 At the time of this draft PSR submittal, a meeting was being planned with the Program's permitting consultant, Washington County, and Clean Water Services to have discussions on issues to be addressed in the next phase of design, specifically related to: stormwater detention on site; overflow into the stormwater detention system; duration of the overflow event if the tanks are full; and the emergency operations nature of this type of event; and any unique aspects of the sites related to drainage and runoff.

7 The detention basin volume is based largely on time to shut off valve at the WTP after an overflow alarm is triggered. The time period includes physical time to respond and valve shut-off time to avoid a pressure surge condition. For conceptual planning purposes a time period of 5 to 15 minutes is often assumed. One semi-empirical approach is to use shut-off time = 10 x L / a; where L is length of pipe and 'a' is wave speed. For a buried steel pipe 'a' is assumed to be 3,200 fps and Main Stem length from WTP to the reservoir is approximately 115,000 feet (Sites 2/3) to 118,000 feet (Site 11). Using a safety factor 2.0, the shut-off time is approximately 12 minutes. At the peak flow of 105 MGD and shut-off time of 12 minutes, the detention volume is approximately 0.45 MG (~59,000 cubic feet).
area) where downstream capacity of receiving channels would determine final detention requirements.

4.2.6.3 Potable Water Line

A pressurized potable water line may be constructed based on final design determination from the preferred operation and maintenance approach, and the extent and type of landscaping used at the site. Reasonable preliminary criterion for the potable water line is for 100 gpm flow rate (e.g., 3- to 4-inch water line) for cleaning and other maintenance activities. Irrigation water supply for landscaping could be provided with this pipeline size. At both Sites 3 and 11, the potable water line could be extended from nearby water mains serving the residential properties. A reduced pressure zone backflow preventer would need to be maintained.

4.2.7 Appurtenances

4.2.7.1 Tank Circulation

To avoid deterioration of water quality caused by low turnover, stagnation, and potential loss of chlorine residual, the terminal reservoir inlet and outlet should be configured to provide tank circulation with proper inlet velocity and thorough mixing. Several companies have developed methods for tank circulation that can be implemented within the terminal reservoir. For purposes of the conceptual design, the reservoir should be equipped with a mechanical mixing system (e.g., PAX or Red Valve Tideflex). A mixing system should be evaluated and selected during final design.

The Red Valve Tideflex (static) system was assumed for the purposes of the conceptual design. It consists of duckbill check valves that act as variable diameter nozzles attached to a manifold installed inside of the storage tank. The single manifold on the bottom of the tank is constructed with two sets of elastomeric duckbill check valves, one on each side of the inlet manifold pipe, to increase inlet velocity and turbulence inside the tank. The Tideflex system would operate via the inlet water pressure and no outside energy source would be required. It also would be completely stationary and not include any moving equipment. Incoming water from the transmission system would be routed into the tank and flow through the Tideflex assembly to thoroughly mix with the water already present in the tank.

4.2.7.2 Other Appurtenances

Terminal reservoir appurtenances include interior access ladder, exterior stairs, safety climb devices, access hatches and handrail, roof vent, sample nozzles, and drainage sump. Detailed criteria and specifications, including material type, should be determined during the design phase, once the final decisions on tank type, and O&M criteria/preferences are defined. Generally, materials for hatches are specified as aluminum or steel, and ladders are specified as stainless steel. Stairs may be specified as stainless steel or concrete steps

- **Ladders and Fall Protection.** Each reservoir should be constructed with at least one exterior stairway and one interior ladder for maintenance and operations
personnel. The interior of each reservoir should be complete with a ladder that extends to the floor. A crane system should be provided for hoisting equipment into and out of the reservoir. The exterior ladder should have an anti-climb cage to prevent unauthorized access to the top of the reservoir. The ladders and stairs should follow all OSHA design requirements. The design should ensure security from vandal access and be easily maintained and accessed by operators.

- **Access Hatches.** The top of each reservoir should include at least two access hatches for operations personnel and equipment. Padlocks and intrusion alarms should be provided for each access hatch. The primary access hatch should be adjacent to the exterior stairs and would provide access to the internal ladder. The area surrounding the hatch should be enclosed by a guardrail for safety. A second access hatch should be provided on the roof of each reservoir to facilitate construction and future maintenance operations. The second hatch will be 180 degrees opposite from the main access hatch. This hatch should be smaller and serve as a secondary access point, but would not have a ladder. It should be covered with a solid plate bolted to the access hatch curb.

- **Roof Vent.** The roof vent should be designed to prevent tampering and limit the opportunity of adding foreign material to the reservoir.

- **Water Quality Sampling.** The reservoir should have a water sampling station on the exterior of the reservoir. The sampling station should be constructed of stainless steel and contain at least three sampling locations to collect water at different heights in the reservoir.

- **Level Control and Monitoring.** The reservoir level should be controlled using a combination altitude/pressure sustaining flow control valve and flow meter. The level in the reservoir and demand in the system should be monitored by SCADA and used to advise operators for setting the production and finished water pumping rate from the water treatment plant. Specific flow control for filling the reservoir will be defined as part of the later predesign/design phase of the reservoir.

A drainage collection system should be constructed under each reservoir to detect and observe leaks or to control groundwater. The specific design of the drainage collection system should be defined as part of the later predesign/design phase of the reservoir. The design should include a signal for presence of leakage and allow the area of the reservoir with leakage to be identified.

### 4.2.8 Environmental and Community Factors

During the terminal reservoir site screening process, a high-level desk-top environmental assessment was completed using Metro Title 13 data. No field surveys or other verification was conducted. Site visits will be needed to confirm environmental conditions on the site(s) carried into further design. However, for the purposes of preliminary design, sufficient information is known about site conditions to suggest differences in preliminary design to address visual impacts and stormwater conditions. Additional
environmental evaluations will be conducted once property access has been granted to the sites.

4.2.8.1 Visual Impacts

Visual impacts will need to be addressed at both sites. Screening and buffering requirements are noted in Washington County Community Development Code Article IV (411 Screening and Buffering). For Site 3, the primary mitigation is anticipated to be for the residences to the north and viewshed impacts from the south. For Site 11, the primary mitigation is anticipated to be for the residential neighbors (in particular the current land owners with residences to the east of the tanks). The visual impact for Site 11 from Grabhorn Road also is a significant consideration.

To mitigate visual impacts, a soil berm could be placed around the entire exposed perimeter of the tank (primarily to the west, south and east at Site 3, and to the west at Site 11). For purposes of the conceptual design, a berm slope of 2H:1V is shown against the tank wall maintaining a minimum 10-foot clearance from the top of the berm to the top of the tank roof for security purposes. The height of exposed reservoir wall can be reduced if other security and access restrictions are added. As an option, the exposed part of the reservoir wall can be painted or have architectural features added to reduce the aesthetic impact to the watershed. In addition, visible retaining walls can be constructed with texturing and coloring to resemble natural rock.

The re-vegetation plan will need to conform to mitigation requirements, and can be developed as part of visual impact mitigation during the design phase. Due to the existing tree cover east (and south) of Site 3, tree removal will be required. The trees should be replaced as required by permit. All trees not noted for removal should be protected in place. All construction activities occurring within the tree drip-line will require special protection or removal depending on the extent of disturbance.

4.2.8.2 Stormwater

All stormwater runoff and drainage should comply with DEQ Water Quality Standards as noted in Washington County Community Development Code Article IV (423-10 Drainage and Waste Water).

Paved (impervious) area at the terminal reservoir site should be sloped toward catch basins. A minimum 1 percent slope should be maintained along pavement slopes and sloped away from the reservoirs to prevent ponding. Clear areas should be aggregate base or native material to allow infiltration for drainage control. A v-ditch may be provided at the base of reservoir as a secondary drainage measure.

Stormwater should be routed to on-site treatment and detention basin with discharge to the adjacent drainage channel at Site 3, or to Grabhorn Road at Site 11. Specific stormwater management requirements would be permitted through Washington County. For Site 11, if stormwater is discharged to conveyance going north along Grabhorn Road then Clean Water Services would need to be engaged for permit approval. Specific stormwater best management practices can be developed during design phase when consultation and permits are obtained.
4.2.9 Access and Security

4.2.9.1 Permanent Access Road

Permanent access to the site is through Grabhorn Road to the west of each parcel. In the Washington County 2020 Transportation Plan, the functional classification of Grabhorn Road is collector and Stone Creek Drive is a local street. The County is updating the plan for the 2035 Transportation Plan. According to the Draft Washington County Functional Classification and Lane Numbers map (March 17, 2014), no changes are proposed for Grabhorn Road.

The access road from Grabhorn Road is routed along the southwest corner at both sites to provide access to the reservoirs. For Site 11, space limitations require that the reservoir access road be shared with the access road for the residence to the east of the tanks (refer to Sheet C-03). The access road is coincident with the pipeline corridor to provide access to valve vaults associated with the yard piping. The pipe corridor between valves and the reservoir could remain at construction grades with surfacing placed to facilitate future access.

The access road width is 20 feet to provide sufficient clearance for the two large diameter inlet/outlet pipelines with wider areas for vehicle turnout/turnaround points. The maximum slope of the access road at Site 11 is 16.0 percent while the maximum slope at Site 3 is 6.8 percent before flattening out at the parking/valve vault area. The access road should be designed to meet the Oregon Fire Code standards to allow emergency rescue vehicles to reach the vault locations. Parking area can be accommodated at both sites. Cross-slopes for drainage are 2 percent. The access road and parking can have gravel or paved surface.

Access to the reservoir roof is not included for security reasons, but this can be accommodated at both sites if desired. Access to the roof could be provided by backfilling the excavation area with lightweight fill and constructing a road adjacent to the reservoir. Site 3 is near the Cooper Mountain Nature Park, which includes walking trails that can be connected to the site. As a result of tank installation at this location, a trail could be routed to the site and around the tank. This feature could be incorporated into the design during the design phase if agreements are developed with THPRD.

4.2.9.2 Security Considerations

Reservoir hatches and access points should be secured, armed with intrusion detection, and video cameras could be installed around the site, if desired. The roadway to the terminal reservoir site should be open to the public; however there should be no through access via a secondary trail, unless agreements are made with THPRD or Washington County to include trail features as part of mitigation or the land use permitting process. Access to the top of the reservoirs for operator personnel should be via a staircase attached to the side of the tank. The bottom stairway access point could be secured with a chain link fence to prevent unauthorized access. The reservoirs should be partially buried and maintain a minimum 10-foot vertical exposure around the perimeter to prevent public access to the reservoir roof. Additionally, the horizontal distance between the roof of the tank and the surrounding grade could be kept to 10 feet to prevent anyone...
from jumping onto the tank. As an additional deterrent, a high safety guard fence could be installed on the embankment wall surrounding the tank. Security features noted in this section may be modified to incorporate visual mitigation plans.

4.2.10 Construction

All grading and drainage activities should occur pursuant to the provisions of Chapter 14.12 of the Washington County Code, and CDC Article IV (Section 410 Grading and Drainage).

4.2.10.1 Temporary Access and Easements during Construction

All construction traffic to the sites should be limited to two access points likely located on the southwest and northwest corners of both sites from Grabhorn Road. At Site 3, a separate access road may also be built on the north side from Stone Creek Drive. The access point on the southwest corner of the sites would become the permanent access road from Grabhorn Road. Due to the combined residential access needs and recreational resources on Cooper Mountain, construction traffic may not be permitted on Saturdays, Sundays, or holidays.

4.2.10.2 Erosion Control and Stormwater Management

Construction activity resulting in a land disturbance of more than 1 acre will require an erosion control permit from Washington County prior to starting any project grading and excavation activities.

4.2.10.3 Temporary Soil Storage and Soil Reuse

As proposed, the proposed reservoir would cover most of the open area at either site. This would result in space constraints for construction activities and storage. An off-site staging area for lay down and storage could occur on the Site 2 property across from Site 3 for either Site 3 or Site 11. Other sites may be identified during the later predesign/design phase. Similarly, soil used for backfill after construction may be able to be temporarily stored on Site 2. Only the amount of soil needed to return to the site that meets the design specifications should be stored in this location.

Soils not meeting specifications should be sent off-site. For example, an agreement could be made with Glacier Northwest, Inc., operator of Cobb Quarry on Cooper Mountain near the two reservoir sites. If construction of the two tanks is sequenced at the site, soils excavated for the first tank constructed could be stockpiled where the second tank will go with surplus soils hauled off site. For the second tank a temporary holding area should be identified.

4.2.10.4 Tree Removal

Tree removal will be required at both sites, and particularly along the eastern portion of Site 3. The trees will be replaced as required by Washington County. All trees not noted for removal must be protected in place by the contractor. Any trees damaged or removed during construction without approval would need to be replaced. All
construction activities occurring within the tree drip-line will likely require special protection or removal depending on the extent of disturbance.

4.2.11 Operation and Maintenance

Concrete tanks do not require protective coatings; however the concrete tanks can have the exterior painted for aesthetics to reduce visibility. Periodic cleaning is recommended over the life of the reservoirs. When required, the reservoir interior should be cleaned by divers who can access the reservoir while filled with stored finished drinking water (refer to appurtenances discussion for access options). Each reservoir has dedicated drains at the reservoir invert at a small depression to allow the tank to be completely emptied. Additionally, this depression should allow the washdown water from tank cleaning to be completely emptied during tank maintenance procedures requiring the tank to be emptied. Tank cleaning may be conducted with divers without draining the tank. Facilities for this type of cleaning would need to be provided around the access hatches.

4.2.12 Site 2 Conceptual Layout Alternatives

After conceptual designs of Sites 3 and 11 were completed, the Program Management Team requested that HDR develop conceptual layouts for Site 2 to evaluate whether to move forward with further Site 2 investigations and property acquisition discussions. HDR prepared two TM's included in Appendix B - 6 and Appendix B - 7 to support the Program Team’s evaluation: (i) Site Terminal Reservoir Conceptual Design; and (ii) Site 2 Terminal Reservoir Hydraulics Assessment. Both memos are dated June 15, 2016.

During a workshop conducted in April 7, 2016 with Program Management Team members, evaluation criteria and concepts were developed that took into account Site 2 conditions as follows:

- Overflow elevation for the Site 2 reservoir was assumed to be 520 feet with a target volume of 30 MG similar to criteria used for Site 3; options for a single 15 MG reservoir were considered.
- Due to existing ground elevations, the lowest floor elevation of 470 feet was considered. The 470-foot floor elevation corresponds to a water column of 50 feet. A maximum reservoir height of 55 feet was considered (assuming a freeboard of 5 feet).
- Layout concepts were limited to circular reservoirs. Non-circular reservoirs did not provide much advantage in terms of storage volume versus footprint in the space available at Site 2.

4.2.12.1 Conceptual Layout Alternatives

Based on the criteria, four reservoir concept layouts were developed during the April 7, 2016 workshop. Plan and profile drawings of the four conceptual layouts are included in Site Terminal Reservoir Conceptual Design TM (Appendix B - 6). A key challenge for Site 2, is that some of the alternative conceptual layouts require the reservoir be built partially on cut fill (native material) and partially on engineered fill. Thus, mitigation would be needed to address potential differential settlement.
Due to the existing ground elevations, none of the Site 2 alternatives provides the full 30 MG of storage above the 490-foot elevation. However, the alternative layouts provide opportunities that the Program can take advantage of if Site 2 reservoir(s) are built:

- The additional storage volume can be phased in (either before or after Site 3 reservoirs are developed). This could provide an additional 15 MG storage if the smallest Site 2 alternative is developed.
- Storage below the 490 ft. HGL provided by some of the alternatives can be utilized under low demand periods (i.e., early in the Program life or during non-peak periods later in the Program life), or could provide additional emergency storage.

One major difference between Site 2 and Site 3 is that the reservoir(s) will be more visible for at Site 2. If viewshed impacts become a major concern from neighbors and stakeholders, Site 2 likely could pose greater permitting challenges for this site.

Cost information is presented in Appendix B - 6. Cost of building storage volume at Site 2 is not significantly different than for Site 3; however, the cost per gallon of storage volume above the 490-foot elevation is greater for Site 2 than Site 3. Increases in reservoir costs due to taller reservoirs at Site 2 are generally offset by reduced excavation costs for Site 2 compared to Site 3. This assumes that foundation and settlement mitigation options would be needed for both and the relative cost impacts would be similar for both Sites 2 and 3, and the relative cost impacts would be similar.

4.2.12.2 Hydraulic Assessment

The lower portion of the stored volume (i.e., HGL below 490 feet) for the Site 2 reservoir alternatives will not meet the adopted level-of-service (LOS) demands if the same pipeline diameters derived for Site 3 reservoir are maintained. However, the Partners recognize that water stored in the lower portions of the reservoir can still provide (gravity) flow at the defined turn-outs that may be less LOS demands. A hydraulic assessment was conducted to understand flows that can be available or delivered under the lower HGL conditions, e.g., during the early part of the Program life (before build-out demands are achieved) or during low demand periods after build-out demands are achieved.

The hydraulic assessment approach agreed on during the April 7, 2016 workshop was to determine the reduced flow rates in the Western Extension gravity line needed to meet the adopted LOS of 450 feet HGL at the end point of the gravity transmission line. A target reservoir HGL of 480 feet was agreed to during the workshop as a reasonable lower end of the operational water level for the reservoir with a floor elevation of 470 feet. The analysis assumes that pipeline diameters are the same as those adopted in the preliminary design for Site 3. Flow reduction scenarios were applied to the LOS flows adopted in the preliminary design for the Western Extension intended to meet the 450 foot HGL.

Based on the hydraulic assessment results, a reservoir HGL in the 480-foot range can meet the 450 HGL at the end of the Western Extension when LOS demands (flows) in each segment of the Western Extension are reduced to 50 percent of LOS flow for each segment (the segment from Evergreen to Hwy 26 was reduced by 73 percent for one of
the scenarios to 6 MGD). The hydraulic assessment also demonstrates that a taller reservoir with floor elevation below 490 feet allows the lower portion of the storage volume to provide gravity flow that could still meet LOS pressures in the early part of the Program life (before build-out demands are achieved) or during low demand periods even after build-out demands are achieved.

The memo *Site 2 Terminal Reservoir Hydraulics Assessment, July 15, 2016* included in Appendix B - 7 includes details of the analysis and results.

### 4.3 Preliminary Pipeline Design

The preferred route was developed using an iterative process of criteria development and successive evaluations. These evaluations located the transmission pipeline on a preferred route accurate to the road level. The preliminary design determined the location of the pipeline within the road – designers looked in detail at the road/area and known subsurface obstructions to locate the pipe and minimize utility relocations and environmental, land use, and community impacts. This section describes the background information used to develop the preliminary design and a summary of the pipeline parameters that are a function of the system hydraulics. This information will need to be expanded during final design to complete the full pipe design, refer to the list in Section 6.0. The focus of the preliminary design was to support:

- Permitting including land use and agricultural impacts
- Right-of-way and easement discussions
- Establishing a base cost estimate for final design
- Supporting final design development with consistent pipeline design concepts

#### 4.3.1 Base Mapping

The base mapping developed for the preliminary design project included:

- Contours based on Light Detection And Ranging (LiDAR) flown for the 2014 Oregon LiDAR Consortium Metro project in the Program area received additional processing to:
  - Derive planimetric shapes
  - Derive 2-foot contours
  - Prepare the data delivery in Oregon State Plane North (FIPS 3601); North American Vertical Datum of 1983 (NAVD83); National Geodetic Vertical Datum of 1929 (NGVD29); units of International Feet (Appendix F - 6)

- Utility base mapping produced for the project from:
  - Murray Smith and Associates’ database of local agency utilities
  - NW Natural Gas transmission and distribution system maps
  - Record drawings in select locations
Field reconnaissance

Other supporting information, including:

- Tax lots and right-of-way (Metro Regional Land Information System [RLIS] data)
- Building footprints (Metro RLIS data)
- Floodplain approximate limits (Metro RLIS data)
- BPA infrastructure (ArcGIS through ESRI online)

4.3.2 **Alignment (Pipe Location) Development Criteria**

The design team developed the criteria in Table 23, to initially guide refinement of the pipeline route to develop the preliminary design. These criteria were used as starting points for pipeline location and engineering judgment was ultimately used to set the pipeline alignment. Specific information on land use criteria is summarized in Section 4.3.3.

**Table 23. Pipe Alignment Criteria**

<table>
<thead>
<tr>
<th>Design Concern</th>
<th>Guideline</th>
</tr>
</thead>
</table>
| Wet utilities                   | - Distance from sanitary sewer: 10-foot clearance (less if sewer is deeper than waterline  
- Distance to storm drain: 10-foot clearance  
- Waterlines, if over 24 inches, maintain 5-foot clearance  
- Note, clearances are outside diameter to outside diameter |
| Dry utilities                   | - Limited information available for buried fiber optic, gas, and communication, avoid when possible                                                                                                                                                                                                                                         |
| Overhead power                  | - Power transmission lines, avoid and meet BPA requirements for BPA infrastructure  
- Power distribution, avoid when possible                                                                                                                                                                                                                                                                 |
| Right-of-way and property lines | - A width of 25 feet to the centerline of the pipeline (50-foot total width) from ROW is ideal for construction for pipe diameters 66-inch through 30-inch. The minimum construction area without a permanent easement on adjacent property is 17 feet to centerline of the pipeline (34-foot total width) from ROW for pipe diameters 66-inch through 48-inch. The minimum construction area without a permanent easement on adjacent property is 16 feet to centerline of the pipeline from ROW for pipe diameters 42-inch through 30-inch. |
| Waterways and wetlands          | - Avoid if possible  
- Open-trench construction has a greater effect on jurisdictional features and sensitive species, if present, than trenchless construction. Based on engineering constraints (e.g., geotechnical considerations, space constraints, construction cost) or permitting recommendations (e.g., potential for restoration project, sensitive species) obtained from David Evans and Associates with input from Oregon Department of    |
### 4.3.3 Alignment (Pipe Location) Development Criteria Specific to Land Use

Pipeline location (alignment) will be governed by future engineering and design considerations as well as existing and future conditions (e.g., utilities, planned future development, land use requirements). Oregon land use laws regulating lands with resource designations that would apply to the WWSP also were used in refining the pipeline route into alignments.

Washington County has zoned much of its agricultural land as EFU or AF-20 and implements ORS 215.213 to protect and regulate agricultural lands. Washington County designates forest lands as Exclusive Forest and Conservation (EFC). In general, the term “resource lands” is collectively used to refer to lands designated EFU, EFC, AF-20 and the term “EFU land” is used to refer collectively to lands designated as either EFU or AF-20.

Washington County Code and state statute allow only certain non-farm uses of EFU lands. Because a portion of the proposed WWSP is located within incorporated or urban areas as well as unincorporated areas of Washington County within resource lands, the Program must take ORS 215.213, and specifically ORS 215.275(2), into consideration when determining the pipeline location within the proposed alignment. The ability for the Program to satisfy these statutes will depend in part on whether the WWSP is: fully within the existing or future ROW, entirely outside of the existing or future ROW, or a combination thereof.

Specifically, ORS 215.283(1)(c) allows utility facilities necessary for public services, as defined by ORS 215.275, on EFU lands. However, to satisfy that statute, an applicant must demonstrate, according to ORS 215.275(2), that reasonable alternatives for proposed locations have been considered and that it is necessary for a utility to be sited within EFU lands in order to provide the service. An applicant must demonstrate the necessity of siting a utility in the EFU based on one or more of the following factors:

1. Technical and engineering feasibility (ORS 215.275(2)(a));
2. The proposed facility is locationally dependent. A utility facility is locationally dependent if it must cross land in one or more areas zoned for EFU in order to...
achieve a reasonably direct route or to meet unique geographical needs that cannot be satisfied on other lands (ORS 215.275(2)(b));

(c) Lack of available urban and nonresource lands (ORS 215.275(2)(c));

(d) Availability of existing ROWs (ORS 215.275(2)(d));

(e) Public health and safety (ORS 215.275(2)(e)); or

(f) Other requirements of state or federal agencies (ORS 215.275(2)(f)).

Cost of the facility is allowed in the assessment of whether a utility facility is “necessary.” However, cost cannot be the sole reason for placing a proposed facility on EFU lands, and land costs cannot be a part of a cost consideration. Additionally, if the proposed facility results in significant changes to farm practices, including the costs of those practices, then the applicant must mitigate and minimize those effects. Agricultural land disturbed or damaged by the proposed action must also be restored, as nearly as possible, to pre-existing conditions.

The Final Land Use and Rural Impacts TM (Appendix F - 10) detailed the assessment of the WWSP with respect to ORS 215.213 and demonstrates the necessity for siting the WWSP on resource lands. Table 24 provides a summary of guidelines and justifications for placement of the pipe outside the ROW and within agricultural lands.

Table 24: Guidelines for Off-ROW Justifications

<table>
<thead>
<tr>
<th>Category</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORS 215.275(2)(a): Technical and Engineering Feasibility</td>
<td>Assuming a minimum 34-foot construction zone (17 feet on either side of the centerline of the pipe) was used, can the pipe be safely constructed within the ROW without extensive relocation of existing utilities?</td>
</tr>
<tr>
<td></td>
<td>• Yes – Place pipe within the ROW.</td>
</tr>
<tr>
<td></td>
<td>• No – Place pipe outside the ROW. If within EFU, EFC or AF-20 zoning,</td>
</tr>
<tr>
<td></td>
<td>provide justification to permit use.</td>
</tr>
<tr>
<td>ORS 215.275(2)(b): Locational Dependency</td>
<td>Is a straight line connecting two points necessary for engineering reasons (e.g., for gravity flow in a pipe) or other reasons (e.g., straight line is more cost effective)?</td>
</tr>
<tr>
<td></td>
<td>• No – Place pipe within the ROW.</td>
</tr>
<tr>
<td></td>
<td>• Yes – Place pipe outside the ROW. If within EFU, EFC or AF-20 zoning,</td>
</tr>
<tr>
<td></td>
<td>provide justification to permit the use.</td>
</tr>
<tr>
<td></td>
<td>Is it an appurtenance for the pipeline?</td>
</tr>
<tr>
<td></td>
<td>• No – Place within the ROW.</td>
</tr>
<tr>
<td></td>
<td>• Yes – Place appurtenance outside the ROW. If within EFU, EFC or AF-20 zoning,</td>
</tr>
<tr>
<td></td>
<td>provide justification to permit the use.</td>
</tr>
<tr>
<td>ORS 215.275(2)(c): Lack of Available Urban and Nonresource Lands</td>
<td>Were routes through the UGB investigated and were they available?</td>
</tr>
<tr>
<td></td>
<td>• Yes – Place pipe within the ROW.</td>
</tr>
<tr>
<td></td>
<td>• No – Place pipe outside the ROW. If within EFU, EFC or AF-20 zoning,</td>
</tr>
<tr>
<td></td>
<td>provide justification to permit the use.</td>
</tr>
</tbody>
</table>
Table 24: Guidelines for Off-ROW Justifications

<table>
<thead>
<tr>
<th>Category</th>
<th>Justification</th>
</tr>
</thead>
</table>
| ORS 215.275(2)(d): Availability of Existing ROW | Assuming a minimum 34-foot construction area, is sufficient space within the ROW available to safely construct the pipe without extensive relocation of existing utilities?  
- Yes – Place pipe within the ROW.  
- No – Place pipe outside the ROW. If within EFU, EFC or AF-20 zoning, provide justification to permit the use. |
| ORS 215.275(2)(e): Public Health and Safety | Can the pipeline be constructed within the existing ROW without lane or full-roadway closures?  
- No – Provide justification to permit the use.  
- Yes – Place pipe within the ROW.  
Would lane or full-roadway closures adversely affect travel time for emergency responders or cause long delays to mass transportation options (e.g., modifications to bus routes or stops)?  
- No – Place pipe within the ROW.  
- Yes – Provide justification to permit the use.  
Do lane or full-roadway closure timing adversely affect the construction schedule (e.g., reduced work hours, short durations for roadway closures do not provide sufficient time to construct the pipeline cost effectively)?  
- No – Place pipe within the ROW.  
- Yes – Provide justification to permit the use.  
Does work within the ROW require lane closures and modifications that negatively affect traffic safety and increase potential for construction-related vehicle accidents?  
- No – Place pipe within the ROW.  
- Yes – Provide justification to permit the use. |
| ORS 215.275(2)(f): Other Requirements of State or Federal Agencies | Has other state or federal agencies required alternative routes, so as to avoid a wetland, a waterway, or a perpendicular crossing of a ROW, and would a location within EFU, EFC or AF-20 zoned land comply with these requirements?  
- No – Place pipe within the ROW.  
- Yes – Provide justification to permit the use. |

4.3.4 Program Geotechnical Conditions

As part of the preliminary design, general Program area geotechnical and seismic conditions were evaluated. The goals of these analyses were to refine the current geotechnical and seismic hazard knowledge along the preferred pipeline route to better understand risks to the pipeline.

The regional geology of the WWSP pipeline was assessed and included in the WWSP Geotechnical Analysis TM (Appendix F - 2). This TM locates the WWSP alignment within the southeast portion of the Tualatin Basin. The Tualatin Basin is classified as a structural depression originally made up of Columbia River Basalt and covered over time with various weathered sediment. More specific details regarding the history of the regional geology can be found in Appendix F - 2.
The geological setting of the WWSP alignment includes fills, recent alluvium, coarse-grained flood deposits (gravel/sand), fine-grained flood deposits (Willamette Silt), basalt (fresh, weathered, and residuals), and Hillsboro Formation (clayey deposits). Sources of geotechnical information include Department of Geology and Mineral Industries boring database and Tualatin Basin subsurface model, Washington County bridge borings (along SW Roy Rogers Road and Cornelius Pass Road), ODOT bridge borings (along Highways 26 and 217), City of Wilsonville borings (Barber and Kinsman), and the City of Beaverton borings (new Hocken Avenue bridge).

The preliminary design's exploration program included seven borings along the preferred pipeline route. These borings were generally located at major crossing locations and extended to depths ranging from 65 to 125 feet. Key geotechnical findings were listed at these locations:

- Wilsonville Road crossing:
  - Coarse-grained flood deposits (gravel and sand) to 56 feet
  - Hillsboro Formation clay deposit below coarse-grained flood deposits
  - Groundwater at 13 feet below ground surface

- North of Kinsman Road and Barber Road:
  - Coarse-grained flood deposits (gravel and sand) to 33 feet
  - Hillsboro Formation clay deposit below coarse-grained flood deposits
  - Groundwater at 6 feet below ground surface

- Chicken Creek crossing:
  - Fine-grained flood deposits (silt) to 75 feet
  - Possible buried creek channel (zero blow materials)
  - Weathered siltstone below fine-grained flood deposits
  - Groundwater at 21 feet below roadway

- Tualatin River crossing:
  - Fine-grained flood deposits (silts and fine sand) to 66 to 78 feet
  - Hillsboro Formation clay below fine-grained flood deposits
  - Groundwater ranges between 12 and 20 feet below ground surface

- Rock Creek Crossing at Amberwood Road:
  - Fine-grained flood deposits (silts and fine sand) to 70 feet
  - Hillsboro Formation clay deposit below fine-grained flood deposits
  - Groundwater at 16 feet below roadway

- Beaverton crossing:
  - Fine-grained flood deposits (silt) to 45 feet
4.3.5 **Hazardous Material Corridor Study**

A preliminary hazardous material corridor study was performed for the preferred route. It did not reveal any significant issues that would require adjusting the route. A Phase I study is recommended for the entire final alignment. The *WWSP Hazardous Materials Corridor Study* (Appendix F - 5).

4.3.6 **Seismic Hazard Mitigation**

Seismic hazard mitigation for the WWSP needs to be tailored to the condition. It was a stated objective of the Partners to maintain the transmission main capable of conveying water after a major seismic event. It was further acknowledged by the Partners that some repair may be needed after a major seismic event; however the intention would be to limit the repairs to linings to the greatest extent practicable. Consideration has been given to maintaining a supply of repair pipe sections, but it is recognized that after a major seismic event the ability to implement repairs may be difficult. Refer to Appendix F - 1 and Appendix F - 4 for additional information.

While no fault crossings have been identified to pose a risk to the transmission main, several other conditions likely will pose a risk to the transmission main that will require attention. Those risks are as follows.

- **Transition from hard rock to soil** – at several locations it may be expected that this condition will exist. Namely within the limits of the SW 124th Avenue extension and likely in the area of Cooper Mountain along Grabhorn Road. Detailed geotechnical investigations may identify additional areas where such transitions will occur. When a transition from hard rock to soil occurs the designers, with the help of their geotechnical engineers, should make provisions to allow the buried pipeline to transition gradually through the interface and avoid stress concentrations in the pipe. Strengthened pipe joints, thickened pipe walls, special excavation and bedding details, and/or flexible linings may be options to be considered by the designer.

- **Lateral spread** – Areas of lateral spread have been identified at several locations along the pipeline alignment. The areas of potential lateral spread are primarily at creek and river crossings. Mitigation of lateral spread should avoid lateral spread by crossing the area using trenchless construction; locating the pipe beneath the area of lateral spread and the launching and receiving pits for the trenchless construction outside of the areas of lateral spread. Alternatively, where it is not...

- Hillsboro Formation clay deposit below fine-grained flood deposits
- Groundwater at 10 feet below roadway

Geohazard maps are included in the preliminary design in the *WWSP Preliminary Design Seismic Hazards Assessment TM* (Appendix F - 4). These maps were primarily based on published geologic geohazard maps, as well as LiDAR topographic data. These geohazard maps should be reviewed and updated as additional information is obtained during the final design. Geologic mapping and geotechnical investigation results are discussed in the following sections.
possible to totally avoid an area of lateral spread, such as the crossing of Chicken Creek where aerial or other means are employed, the pipe supporting buttresses on either side of the creek crossing should be designed to withstand the expected lateral spread and associated forces.

- **Seismic induced liquefaction** – A significant portion of the pipeline is expected to be located in areas of liquefiable soils. Preliminary analysis performed by McMillen Jacobs Associates indicated that settlement where liquefiable soils exist could vary from 2 to 12 inches. The designer should evaluate the potential for settlement within their areas based on more detailed geotechnical information and consider measures to accommodate the expected movement of the pipeline. Mitigation measures may include strengthened joints, flexible joints, thickened pipe wall, improved pipe foundation (pilings), and/or possibly areas of flexible linings.

### 4.3.7 Preliminary Design Criteria

At this preliminary design stage, not all pipeline design parameters could be determined. Standard criteria are listed in Table 25. Note, hydraulic capacities of individual pipelines vary along their length due to intermediate service locations; where appropriate, ranges are provided in the table.

<table>
<thead>
<tr>
<th>Design Criteria</th>
<th>Results</th>
</tr>
</thead>
</table>
| Hydraulic capacity | Main Stem (pressurized flow) capacity* = 105.7 to 100.7 MGD  
                    | Main stem (gravity flow) capacity* = 100.7 to 72.7 MGD  
                    | Western Extension* = 38 to 22 MGD  
                    | Eastern Extension = 38 MGD |
| Diameter | Main Stem (pressure) inside diameter is 66 inches  
            | Gravity side pipe inside diameters are based on values shown in Table 21, using the following reservoir overflow elevations:  
            | Sites 2/3 = 520 feet  
            | Site 11 = 610 feet |
| Materials | Transmission pipeline to be spiral-welded steel. Appurtenances such as air valve outlet piping and blow-offs will be restrained ductile iron pipe.  
            | Steel pipe will be cement mortar lined and polyurethane coated. *(Polyurethane coated per AWWA C222 (2008 or latest edition), with exceptions as noted in the Design Guidelines (Appendix F - 1) when approved by WWSP. Mortar-lined per AWWA C205 (2007 or latest edition) with exceptions as noted in the Design Guidelines (Appendix F - 1) when approved by WWSP)*  
            | Consideration may be given to using polyurethane lining in areas where extreme settlement is anticipated due to seismically induced liquefaction. |
| Working pressure | Will vary by location and reservoir site selected, refer to preliminary design drawings for preliminary HGL information |
### Design Criteria

<table>
<thead>
<tr>
<th>Design Criteria</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum cover</td>
<td>7 feet from proposed/finished ground</td>
</tr>
<tr>
<td>Pipe wall thickness</td>
<td>Based on AWWA M11 and AWWA C200, as modified in the WWSP Design Guidelines.</td>
</tr>
<tr>
<td>Joint design</td>
<td>Double-welded lap joints</td>
</tr>
<tr>
<td></td>
<td>Reinforced joints may be considered where extreme settlement is anticipated due to seismically induced liquefaction</td>
</tr>
<tr>
<td>Fittings</td>
<td>Consistent with AWWA M-11 guidelines</td>
</tr>
</tbody>
</table>

* Ranges shown for the segments of the transmission line represent the range of flows in each segment. For example, the Main Stem range in the pressurized segment refers to 105.7 MGD at the base reducing to 100.7 MGD at the terminus of the Main Stem.

### 4.4 Property Needs

Early in the Program, it was a stated desire to avoid and/or minimize impacts to resources as well as the need for property or easement acquisition by placing the WWSP transmission main within existing public ROWs. In some areas however, technical factors related to constructability, lack of available ROWs, and/or impacts to existing utilities, traffic, and the public would require use of land outside of public ROW. In these areas, it was decided to expand the alignment into land adjacent to the roadways identified in the preferred route analysis. In other areas, the desire to avoid and/or minimize impacts and property or easement acquisition would constrain the available work zone. Additional analysis of the potential impacts to sensitive land use zones (e.g., EFU districts, AF districts) will inform future revisions to the alignment.

One of the key goals of the Preliminary Design project is developing an understanding of the permanent and temporary easements that will be needed. Installing a large diameter pipe requires proportionately large work area. The work zones are based on the diameter of pipe being installed, likely 66 inches down to 36 inches. Figure 15 and Figure 16 provide an estimate of how much area is needed for construction in unconstrained work zones (where sufficient ROWs and/or property is available) and constrained work zones (where the desire or need to minimize and/or avoid impacts or property acquisition limits the space available for construction). The figures are included in the *WWSP Design Guidelines Version 1* (Appendix F - 1).
The total public right-of-way, permanent easement, and temporary construction easement widths should meet or exceed the minimum work area widths in these figures.

Estimated property needs are tabulated in Appendix F - 8.

4.5 Opinion of Probable Construction Cost Summary

This section presents the opinion of probable construction costs for the preliminary design of the transmission system. These costs reflect only a portion of the overall
program costs. An overall program baseline cost estimate has been prepared separately by Program staff based partially on the information contained in the opinion of probable construction costs presented here. Appendix F - 9 includes the associated TM that documents the methods and assumptions for the following:

- Methodology for segmenting project
- Development of the cost library
- Validating data
- Major assumptions

The overall project is divided into distinct sections to provide flexibility in reporting costs. The sections are tied to specific areas as defined in the preferred route. Most construction costs and associated non-construction costs can be summarized by the following sections:

Section 1: WRWTP to SW 124th Extension
Section 2: SW 124th Extension to Reservoir Site 3
Reservoir Site 3: Site 3 to Farmington Road at SW 209th (Alternate 1)
Reservoir Site 11: Site 11 to Farmington Road at SW 209th (Alternate 2)
Section 3a: Farmington Rd. to Extension Split at Kinnaman Rd.
Section 3b: Extension Split at Kinnaman Rd. to NW Cornelius Pass Rd.
Section 4: Extension Split at Kinnaman Rd. to SW Walker Rd.

Major assumptions made when developing the opinion of probable construction cost include:

- Market Adjustment Factors above and beyond the typical contractor mark-ups and current but normal escalation factors.
- Labor unit prices reflect a burdened rate and include items such as workers compensation, unemployment taxes, social security, fringe benefits, and medical insurance.
- Unit costs reflect direct construction costs excluding the contractor's mark-ups for overhead and profit.
- General contractor overhead is assumed to be 12 percent of construction cost, profit of 7 percent, and construction bond of 1.5 percent.
- Escalation is excluded from this opinion of probable construction cost
- ROW costs are excluded from this opinion of probable construction cost
- Owner Professional Services (e.g., final design, project management) are excluded from this opinion of probable construction cost

The total cost is comprised of the following components:

- **Base Year** (BY) cost is considered the expected construction cost in current year
dollars excluding escalation and risk. Typically, base cost is escalated to year of expenditure to determine base escalated costs. For the PSR, escalation is developed and applied outside of this estimate.

- **Contingency factors** are applied by general construction categories. Contingency values are determined using AACEi recommendations as a guideline. This estimate most closely reflects a Class 3 estimate per AACEi 18R-97. This estimate class is predominantly used to set preliminary budget amounts, and is characterized with a range of 10 percent to 40 percent project definition. This estimate class is also characterized by an upper contingency range of 10 percent to 30 percent.

Table 26 provides a summary of total base year cost including base construction cost and contingency by alternate.

<table>
<thead>
<tr>
<th>Alternate 1 - Reservoir Site 3</th>
<th>Base Cost</th>
<th>Contingency</th>
<th>Total BY Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservoir Area 1 (Site 3)</td>
<td>$50,162,895</td>
<td>$9,730,880</td>
<td>$59,893,775</td>
</tr>
<tr>
<td>Section 1</td>
<td>$40,000,505</td>
<td>$7,817,737</td>
<td>$47,818,242</td>
</tr>
<tr>
<td>Section 2</td>
<td>$110,247,522</td>
<td>$21,850,534</td>
<td>$132,098,056</td>
</tr>
<tr>
<td>Section 3a</td>
<td>$22,015,268</td>
<td>$4,191,012</td>
<td>$26,206,281</td>
</tr>
<tr>
<td>Section 3b</td>
<td>$54,785,494</td>
<td>$10,637,560</td>
<td>$65,423,054</td>
</tr>
<tr>
<td>Section 4</td>
<td>$52,243,657</td>
<td>$9,785,601</td>
<td>$60,029,258</td>
</tr>
<tr>
<td><strong>Grand Total (rounded)</strong></td>
<td><strong>$327,455,000</strong></td>
<td><strong>$64,013,000</strong></td>
<td><strong>$391,469,000</strong></td>
</tr>
</tbody>
</table>
### Alternate 2 - Reservoir Site 11

<table>
<thead>
<tr>
<th>Reservoir Area 2 (Site 11)</th>
<th>Reservoir Site 11 to Farmington Road at SW 209th</th>
<th>Base Cost</th>
<th>Contingency</th>
<th>Total BY Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$45,565,990</td>
<td>$8,837,478</td>
<td>$54,403,468</td>
<td></td>
</tr>
</tbody>
</table>

| Section 1 | Willamette River Water Treatment Plant to SW 124th Extension | $40,000,505 | $7,817,737 | $47,818,242 |

| Section 2 | SW 124th Extension to Reservoir Site 3 | $110,247,522 | $21,850,534 | $132,098,056 |

| Section 3a | Farmington Road to Extension Split at Kinnaman Road | $19,496,091 | $3,687,725 | $23,183,817 |

| Section 3b | Extension Split at Kinnaman Road to NW Cornelius Pass Road | $48,583,526 | $9,400,583 | $57,984,109 |

| Section 4 | Extension Split at Kinnaman Road to SW Walker Road | $43,393,609 | $8,431,996 | $51,825,604 |

| Grand Total (rounded) | $307,287,000 | $60,026,000 | $367,313,000 |

### 4.6 Final Design Implementation

The WWSP preliminary design includes more than 30 miles of pipeline and preferred terminal reservoir sites. The goals were to understand the requirements for final design, especially concerning:

- Permitting
- Right-of-way and easement discussions
- Establishing a base cost estimate for final design
- Supporting final design development with consistent pipeline design concepts

To support these goals, this section discusses known opportunities and constraints and unresolved issues for moving from preliminary design to final design.

#### 4.6.1 Opportunities and Constraints: Reservoir Sites

The selection of one of the Tier 1 sites, Sites 2/3 or Site 11, will have different impacts on the downstream piping, operational costs, and site layouts. Each site also has unique opportunities and constraints. Key differences between the two sites are included in Table 27.

<table>
<thead>
<tr>
<th>Table 27. Opportunities and Constraints at Reservoir Sites 2/3 and 11</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Characteristic</strong></td>
</tr>
<tr>
<td>Elevation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Characteristic</td>
</tr>
<tr>
<td>-----------------------------</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Visual impacts</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td>Site constraints</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Community enhancement</td>
</tr>
<tr>
<td>opportunities</td>
</tr>
</tbody>
</table>

For additional information, see Appendix G - 4.

4.6.2 Roadway Project Partnering Opportunities

Construction of a water supply system of the magnitude of the WWSP impacts a number of areas and traverses several communities and individual properties. These communities and individual property owners may have projects that present opportunities to advance the WWSP by reducing cost, eliminating conflicts, reducing community impact, or providing enhancements to the community. Proposed projects within the WWSP project areas with potential to improve the likelihood of success of the project should be identified and brought forward to the Program for consideration. These opportunities may include:

- Development projects that allow for co-location and construction in undeveloped areas
- Construction with a proposed road project to reduce restoration cost and allow for construction in a less impeded area
- Properties that are currently for sale in the vicinity of the proposed transmission main that may serve as right-of-way, staging areas, or otherwise enhance the potential for success and/or reduce construction costs
• Potential community enhancements to improve the areas impacted and provide value to a community that might not otherwise receive benefit from the project

• Other opportunities that may add value to the project, improve community acceptance, or facilitate implementation of the project

Opportunities are listed in the Opportunities and Constraints table discussed in the following section and provided in Appendix G - 4.

4.6.3 Opportunities and Constraints

The public’s perception of the WWSP’s success will be closely tied to construction impacts in the community. Using opportunity projects to their full advantage may alleviate the number of construction-related traffic issues along the alignment and minimize the amount of continual construction within communities. Opportunity projects would be roadway projects that are coincident with the preferred route and present the opportunity to collaborate during construction to accomplish both infrastructure updates concurrently.

Opportunity projects have two main categories: those with known timing and those that do not yet have funding and timing secured. Opportunities are noted in the Opportunity and Constraint Table (Appendix G - 4), including available information about project extents, timing, and lead agency.

The most significant opportunity projects along the preferred route are:

• South Hillsboro Community Planning Area located along the proposed extension of Cornelius Pass Road south of Tualatin Valley Highway. The road is proposed to be built in sections as the area develops. The first project likely will break ground in 2016 and development continues through 2026. Construction of the WWSP pipeline in the new road is advantageous from the perspectives of both cost and future maintenance efforts.

• The Riverside Terrace development along Roy Rogers Road near Scholls Ferry Road has construction scheduled to begin in 2016 (broke ground as of the date of this report). The development east of Roy Rogers Road north of Bull Mountain Road includes a central boulevard that, if timed correctly, could be an alternative to Roy Rogers Road for this short section. The specific timing for this development is not known.

• Coffee Creek industrial area development along SW Garden Acres Road includes expansion/development of the area. The existing road is narrow and does not connect to Day Road. Project is partially funded, but timing is currently unknown.

• Cornelius Pass Road through Hillsboro. The preferred route deviates from its course on Cornelius Pass Road at Baseline Road. The reason for this deviation is data gaps regarding the potential for a trenchless crossing of Beaverton Creek in the limited available right-of-way. Depending on the selected reservoir site, it may be possible to construct the WWSP pipeline to one side of the road. Utilizing this route alternative could save just over 1 mile of pipeline over the 205th/206th section. This was not pursued during preliminary design as pipe diameters were
speculative in this area and the crossing will be challenging due to the following reasons:

- Bridge replaced in mid-2000s and built to edge of right-of-way.
- Structures are located on three of the four corners of the bridge.
- Bridge is on piles, precluding a trenchless crossing under the bridge structure

- Millikan Road Area in Beaverton. During development of the trenchless crossing plan for the Millikan Road area, an option was conceived that would significantly reduce roadway impacts and reduce the number of trenchless crossings required in this area. The concept was supported by the project geotechnical engineers and successfully vetted with permitting staff for permitability. The concept utilizes open spaces for construction of the transmission pipeline instead of road right-of-way and has the potential to save nearly 0.25 miles of pipeline construction.
5.0 Permitting Strategy

The permitting strategy included identification of the permitting-related elements and risks associated with the proposed route. The strategy also includes evaluations of the natural resources, land use, and cultural resources within the Program area.

A permit acquisition strategy was developed to include the following:

- List of required permits and recommendations for preferred permit acquisition approach
- Input into project schedule to identify critical path permit tasks
- Anticipated information needs necessary to complete the permit application process
- Coordination strategy for key stakeholders
- Key milestones and decision points
- Permitting issues and requirements associated with different alignment options and terminal storage sites
- Permitting risks and opportunities associated with segmenting development of the WWSP
- Anticipated permitting costs and processing timelines specific to the preferred alignment
- General mitigation requirements and opportunities
- Recommendations on when and how best to proceed with each of the required permits.

The Permitting Team met with representatives from relevant Native American Tribes, and state, federal, and local agencies to develop a WWSP Permitting Strategy. The Permitting Strategy identified the approach and structure for gaining long-term stakeholder and agency buy-in on permit acquisitions, and identified a range of suitable mitigation measures, and permit conditions that will likely be included in permits for the Program.

Key takeaways for the permitting strategy are:

- Summary of the environmental permitting and other regulatory requirements the Program will encounter
- Federal nexus and lead federal agency for the Program (U.S. Army Corps of Engineers)
- Land use review
- Cultural resources review

The permitting strategy document is located in Appendix G - 1.
6.0 Unresolved Items

The following items are unresolved at the close of the preliminary design and recommended as follow-up items for Program development and final design:

- Hold open houses for the preferred route
- Solidify the timing of opportunity projects and their partnering potential
- Work with local agencies to incorporate the WWSP transmission pipe in their planning documents
- Confirm the Program’s ultimate reservoir volume
  - Evaluate the need for the Mt Williams reservoir site for additional storage capacity
  - Evaluate the proposed reservoir operations scheme for water level ranges (ultimately for operational agreements)
- Select a preferred reservoir site(s) and perform site visits to evaluate environmental conditions on the site(s) carried into further design
- Revisit the hydraulics calculations for the final partnership agreements and the final LOS
- Confirm the turn out/delivery locations for the Program Partners
- Perform the final transient hydraulic analyses for the final alignment with refined information for the WRWTP pump station and surge tanks
- Determine the seismic LOS for the Program
- With final design information, compare crossing types and alignments to determine if changes are needed to proposed right-of-way or easement acquisitions
- Confirm the transmission pipeline diameter for the Main Stem
7.0 Appendices:

Printed appendices provided in separate volumes.

Appendix A. Background

Appendix A - 1 WRWTP Intake Screen Evaluation TM
Appendix A - 2 WRWTP Intake Demands TM
Appendix A - 3 Tonquin Decision Memo #7

Appendix B. Reservoir

Appendix B - 1 Reservoir Evaluation Criteria TM
Appendix B - 2 Terminal Storage Evaluation TM
Appendix B - 3 Reservoir Criteria Decision Memo #10
Appendix B - 4 Additional Reservoir Hydraulics PowerPoint
Appendix B - 5 Level-of-Service for Terminal Reservoir TM
Appendix B - 6 Site 2 Terminal Reservoir Conceptual Design TM
Appendix B - 7 Site 2 Terminal Reservoir Hydraulics Assessment TM

Appendix C. Pipeline

Appendix C - 1 Route Selection Criteria TM
Appendix C - 2 Pipeline Route Selection Criteria Decision Memo #6
Appendix C - 3 Preferred Route and Summary Matrices TM

Appendix D. Hydraulics

Appendix D - 1 Eastern Extension Analysis TM
Appendix D - 2 Reservoir Present Value Analysis TM
Appendix D - 3 Main Stem Present Value Analysis TM
Appendix D - 4 Updated Hydraulic Evaluation TM
Appendix D - 5 124th Avenue Pipe Wall Thickness TM
Appendix D - 6 WWSPD Hydraulic Criteria TM
Appendix D - 7 WWSP Prelim Design Hydraulic Transient Analysis
Appendix D - 8 Pump Shutoff Head Pipeline Protection Control TM

Appendix E. Financial

Appendix E - 1 Fall Cash Flow Analysis TM
Appendix E - 2 Interim Cash Flow Analysis TM

Appendix F. Preliminary Design

Appendix F - 1 WWSP Design Guidelines
Appendix F - 2 WWSP Geotechnical Analysis TM
Appendix F - 3 WWSP Tualatin River Crossing Evaluation-TM
Appendix F - 4 Updated WWSP Seismic Hazards Evaluation TM
Appendix F - 5 WWSP Hazardous Materials Corridor Study Report
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Appendix G - Other

Appendix G - 1 Willamette Water Supply Program Environmental, Land Use and Cultural Resources Review
Appendix G - 2 Envision Evaluation TM
Appendix G - 3 WWSP Envision Strategy TM
Appendix G - 4 WWSP Opportunities and Constraints Maps and Tables
Appendix A. Background

Appendix A - 1 WRWTP Intake Screen Evaluation TM
Prepared by MWH. TM documents the preliminary technical evaluation of the ability to expand the capacities of the existing intake and raw water pump station systems at the Willamette River Water Treatment Plant (WRWTP) to a maximum of 186 MGD (288 cfs) capacity. The current approved screening capacity is 70 MGD (108 cfs), and ultimate design capacity of the intake and plant is 120 MGD (186 cfs) design capacity.

Appendix A - 2 WRWTP Intake Demands TM
Prepared by HDR. TM documents the Willamette River Water Treatment Plant (WRWTP) intake water demands for the purpose of supporting the Willamette Water Supply Program (WWSP). Demand information is provided by Partners and potential partners.

Appendix A - 3 Tonquin Decision Memo #7
Prepared by HDR. Memo documents the decision authorizing HDR to proceed with Final Design in parallel with design of road improvements by Washington County Land Use and Transportation (WCLUT), and authorizes TVWD and Hillsboro to execute a Memorandum of Understanding with WCLUT outlining objectives of final design and general terms of future construction cost shares. The decision makes the Tonquin Rd – Grahams Ferry Pipeline part of 124th Ave Pipeline project.
Appendix B. Reservoir

Appendix B - 1 Reservoir Evaluation Criteria TM
Prepared by HDR. TM documents the criteria for evaluating sites for the proposed Terminal Reservoir, based on discussions with the TAC and other WWSP consultants.

Appendix B - 2 Terminal Storage Evaluation TM
Prepared by HDR. TM documents the terminal storage evaluation completed for the WWSP Preliminary Design project. Information from related tasks including TAC meeting presentations, decision memoranda, and supporting technical memoranda is incorporated into the TM. Key elements in this memo include: storage volume and hydraulic grade line to meet level-of-service requirements, site screening and evaluation criteria to identify candidate sites and choose a preferred site, basis for including additional site, additional analysis and communications to support the short-listed preferred site, and next steps for addressing these short-listed preferred sites.

Appendix B - 3 Reservoir Criteria Decision Memo #10
Prepare by HDR. Memo documents the decision approving the site evaluation criteria for WWSP terminal reservoir, evaluation criteria for potential terminal reservoir sites, incorporating Envision principles and input from PI team on evaluation criteria.

Appendix B - 4 Additional Reservoir Hydraulics PowerPoint
Prepared by HDR. PowerPoint documents the analysis conducted by HDR to evaluate additional sites (Mt. Williams and Bull Mountain) identified by the TAC for the terminal reservoir. PowerPoint slides were presented to the TAC on February 10, 2015. TAC decided not to include these sites on the Tier 1 list.

Appendix B - 5 Level-of-Service for Terminal Reservoir TM
Prepared by HDR. TM documents the level-of-service concepts and storage volume criteria for WWSP terminal storage reservoir. The general material in the TM was presented and discussed at the October 23, 2013 TAC meeting. Level-of-service includes storage volumes associated with operational, emergency and distribution system storage desired by the Partners.

Appendix B - 6 Site 2 Terminal Reservoir Conceptual Design TM
Prepared by HDR. TM documents the Site 2 conceptual reservoir layouts and criteria, and planning-level opinions of cost based on workshop discussions and decisions.

Appendix B - 7 Site 2 Terminal Reservoir Hydraulics Assessment TM
Prepared by HDR. TM documents the hydraulic assessment for Site 2 reservoir alternatives, and the reduced flow rates in the Western Extension gravity line needed to meet the adopted level-of-service (LOS) hydraulic grade line (HGL) of 450 feet at the end point of the gravity transmission line.
Appendix C. Pipeline

Appendix C - 1 Route Selection Criteria TM
Prepared by HDR. TM documents the selection criteria for evaluation of the transmission pipe alignment. The final criteria incorporate comments received from the February 5, 2014 TAC meeting, Partners, and reviews conducted on the Draft Project Summary Report.

Appendix C - 2 Pipeline Route Selection Criteria Decision Memo #6
Prepared by HDR. Memo documents the decision to adopt the pipeline route selection criteria.

Appendix C - 3 Preferred Route and Summary Matrices TM
Prepared by HDR. TM documents the analysis and supporting data used to determine the recommended preferred route for the WWSP. TM also includes the Decision Memo #8A – Shortlisted Pipeline Routes.
Appendix D. Hydraulics

Appendix D - 1 Eastern Extension Analysis TM
Prepared by HDR. TM documents the analysis to evaluate directly connecting the Eastern extension transmission line to the Main Stem transmission line.

Appendix D - 2 Reservoir Present Value Analysis TM
Prepared by HDR. TM documents the terminal reservoir evaluation present value analysis. The purpose of the present value analysis is to understand the cost implications of variations in capital and life-time pumping costs among the terminal reservoir sites, and to determine whether significantly greater or lower costs should be factors in identifying the preferred site(s).

Appendix D - 3 Main Stem Present Value Analysis TM
Prepared by HDR. TM documents the Main Stem transmission line present value analysis. The purpose of the PV analysis is to support selection of the pipe diameter for the Main stem by calculating the PV costs over a 100-year project life.

Appendix D - 4 Updated Hydraulic Evaluation TM
Prepared by HDR. TM documents the analysis and results of an updated hydraulic evaluation of the transmission system for the Willamette Water Supply Program (WWSP). TM includes evaluation of two Tier 1 reservoir sites, Sites 3 and 11. The TM documents the hydraulic profile and working pressures for the Main Stem (pumped) pipeline from the WRWTP to each of the Tier 1 terminal reservoir sites. It also establishes appropriate pipe diameters for sections of the gravity portion of the transmission system.

Appendix D - 5 124th Avenue Pipe Wall Thickness TM
Prepared by HDR. TM documents proposed revisions to the design flow of the 124th Avenue Transmission Main (pipeline) and resultant impacts on the steel pipe wall thickness. The purpose of the analysis is to investigate impacts to the pipe design if the pipe wall thickness was designed to accommodate an emergency flow rate of 120 million gallons per day (MGD).

Appendix D - 6 WWSPD Hydraulic Criteria TM
Prepared by HDR. TM documents the hydraulic design criteria for selecting the appropriate pipe diameter to deliver required system flows. Criteria include: velocity of water in the pipeline, roughness coefficient, pumped systems, gravity systems.

Appendix D - 7 WWSP Prelim Design Hydraulic Transient Analysis
Prepared by Northwest Hydraulic Consultants. TM documents the analysis and findings of the hydraulic transient analysis for two potential scenarios for delivering water from the WRWTP Pump Station to either the Site 3 Reservoir (Scenario 1) or Site 11 Reservoir (Scenario 2) for the WWSP. Surge control measures were developed to protect the integrity of the transmission main following pump power failure at the WTP Pump Station.
Appendix D - 8 Pump Shutoff Head Pipeline Protection Control TM

Prepared by HDR. TM documents the pump shutoff head pipeline protection control hydraulic grade line (HGL) to be used as part of the pipe design criteria found in the WWSP Design Guidelines.
Appendix E. Financial

Appendix E - 1 Fall Cash Flow Analysis TM
Prepared by HDR. TM documents the preliminary cash flow analysis requested by the Partners for their respective financial forecasting and planning. The analysis includes updating the capital and non-construction costs and timing of infrastructure components based on Program understanding at the time of the analysis (approximately 60% of scope completed).

Appendix E - 2 Interim Cash Flow Analysis TM
Prepared by HDR. TM documents the “interim” cash flow analysis requested by TVWD to inform the rate discussions with its Board of Commissioners. The interim cash flow analysis is based on the current definition of the WWSP at the time of the analysis (approximately 40% of scope completed). This analysis was a precursor to the analysis under the Fall Cash Flow Analysis (Appendix E - 1).
Appendix F. Preliminary Design

Appendix F - 1 WWSP Design Guidelines
Prepared by HDR. The WWSP Design Guidelines document the standards that govern the design, modification, or addition to the transmission system to be followed and maintained through the life of the WWSP.

Appendix F - 2 WWSP Geotechnical Analysis TM
Prepared by McMillen Jacobs Associates. TM documents results of the preliminary geotechnical evaluation of the geotechnical conditions along the preferred pipeline route of the WWSP. The study characterizes the general subsurface conditions and evaluates potential geotechnical and seismic/risk issues, and preliminary design and construction recommendations for the pipeline and trenchless crossings.

Appendix F - 3 WWSP Tualatin River Crossing Evaluation-TM
Prepared by McMillen Jacobs Associates. TM documents evaluation of trenchless construction methods for the pipeline crossing under the Tualatin River along southwest Roy Rogers Road.

Appendix F - 4 Updated WWSP Seismic Hazards Evaluation TM
Prepared by McMillen Jacobs Associates. TM documents the analysis and results of the preliminary evaluation of the seismic hazard potentials and their characterizations in the area along the preferred pipeline route of the WWSP.

Appendix F - 5 WWSP Hazardous Materials Corridor Study Report
Prepared by Shannon and Wilson. Report documents the analysis and results of the preliminary evaluation of the hazardous materials and their characterizations in the area along the preferred pipeline route of the WWSP.

Appendix F - 6 Initial LIDAR Assessment TM
Prepared by HDR. TM documents the preliminary usability assessment of the 2007 LiDAR data designated for use in the WWSP design. The assessment is based on the data collection report submitted to the Oregon Department of Geology & Mineral Industries, the Oregon Department of Forestry, and the Puget Sound LiDAR Consortium in June 2009 by Watershed Sciences, Inc. (Quantum Spatial).

Appendix F - 7 WWSP Seismic Resiliency TM
Prepared by HDR. TM documents the findings of a review of existing literature to collect, evaluate, and summarize published technical papers addressing pipeline design, emphasizing structural performance during a seismic event.

Appendix F - 8 WWSP Submittal Easement Table
Prepared by HDR. Tables document the permanent easements and temporary construction easements identified for the transmission line alignment.
Appendix F - 9 Opinion of Probable Construction Cost for Preliminary Design
Prepared by HDR. TM outlines the methodology and development of the current capital opinion of probably construction cost by Section.

Appendix F - 10 Land Use TM
Prepared by HDR. TM summarizes routing criteria and assessment process, describes the alignment development and determination of locations where the pipeline is outside of the right-of-way, and provides justification for unavoidable effects to land adjacent to the right-of-way.

Appendix F - 11 Geotechnical Data Report
Prepared by Shannon and Wilson. Report documents data collected through geotechnical explorations. Seven geotechnical explorations were performed along the proposed alignment for six trenchless under-crossings.
Appendix G. Other

Appendix G - 1 Willamette Water Supply Program Environmental, Land Use and Cultural Resources Review
Prepared by DEA. Outlines Environmental Review, Land Use Review, and Cultural Resources Review conducted to identify anticipated permitting requirements.

Appendix G - 2 Envision Evaluation TM
Prepared by HDR. TM documents recommendations for incorporating Institute for Sustainable Infrastructure Envision guidelines into the WWSP project. These include benefits Envision brings to the project to help with stakeholders and public acceptance, opportunities to enhance sustainable infrastructure design, and initial high-level assessment of how the current project would score under an Envision verification process.

Appendix G - 3 WWSP Envision Strategy TM
Prepared by HDR. TM documents the strategy for applying Envision to the WWSP to meet objective; and achieving pre-certification as part of Preliminary Design, and potential full verification. The strategy includes an Envision approach workshop with the Partners, Envision credit evaluation, Envision pre-certification, and any additional documentation needed to successfully complete the Envision Plan review.

Appendix G - 4 WWSP Opportunities and Constraints Maps and Tables
Prepared by HDR. Tables and figures document opportunities and constraints to partner with other agency projects that could offer alternatives for segments of the pipeline alignment.