Tualatin Valley Water District

TVWD Long-Term Water Supply Planning
Technical Memorandum 3 – Economic and Financial Evaluation

To: TVWD Board of Commissioners

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RE: **Technical Memorandum 3 – Economic and Financial Evaluation – *FINAL***

1.0 INTRODUCTION

Tualatin Valley Water District (TVWD) is evaluating long-term water supply options to serve projected water supply needs through 2050. As part of the effort, TVWD staff worked with HDR to prepare economic, risk, and financial analyses. The economic and risk analyses were based on a long-term economic model that calculated the present value (PV) of each option. The financial analyses were based on a 30-year financial forecast of required cash flows and borrowing requirements to finance each option.

The current water supply evaluation efforts are summarized in a series of six technical memoranda. The purpose of this memorandum is to summarize the results of the economic, risk, and financial analyses for the TVWD Board of Commissioners (Board).

Several TMs prepared as part of the *City of Hillsboro's Water Master Plan Update* (Black & Veatch, 2012) were used in preparing this TM and are referenced within the text:

- *TM-8 – Summary of Water Supply Development Options* (Final, dated December 7, 2011
- *TM-9A – Hillsboro Water Supply Options Cost Estimating Detail* (Final, dated June 7, 2012)
- *TM-9B – Approach to Incorporating Cost Risk into the Financial Model (*Final, dated February 13, 2012)
- *TM-9C – Phasing of Water Supply Options* (Final, dated June 4, 2012
- *TM 9D – Economic Analysis* (Draft, dated June 7, 2012)
- *TM 9E* – Cost Share and NPV Analysis (Final, dated October 23, 2012)

2.0 SOURCE OPTIONS AND PLANNING SCENARIOS

The economic, risk, and financial analyses were applied to four long-term water supply options. These four options are presented in *TM 1 – Introduction and Supply Options*.

3.0 CAPITAL COSTS

Capital costs for the supply options are based on analysis by CH2M HILL which are documented in Hillsboro's *TM-9A – Hillsboro Water Supply Options Cost Estimating Detail*, dated June 7, 2012. The major components for each supply option are categorized as follows:

- Seismic improvements and dam raise (40 feet for Tualatin Basin Water Supply Project [TBWSP] option; and 9 feet for other options)

- Raw water river intake, pump station, and pipeline
- Water treatment plant
- Wells (Northern Groundwater option only)
- Booster pump station (finished water)
- 20-MG terminal reservoir
- Transmission lines

Table 1 on the following page summarizes the major capital cost components of the four supply options evaluated by TVWD.

Some refinements to the supply options as presented in Hillsboro's TM-8 (prepared by Black & Veatch) were made to the supply options to reflect more recent discussions with Hillsboro and TVWD that more accurately represent likely supply configurations. These changes are shown in updated figures for each of the supply options, included in *TM 1 – Introduction and Supply Options.* A brief discussion of each of the refinements is presented below.

Dam Costs. A correction was made to the total portion of the 40-foot dam raise allocated to municipal and industrial (M&I) users. The cost allocations shown in Hillsboro's TM 9C had Tualatin Valley Irrigation District (TVID) paying 54.5% of both the seismic portion and the dam raise portion of the overall costs. This was corrected to have TVID pay a share of the seismic portion only, increasing the M&I portion of the dam raise cost to $267,400,000.

Transmission Piping. Two refinements were made to the transmission piping for the Portland Supply option. The first refinement was to increase the capacity of the main transmission line from the Powell Butte Reservoirs to Hazeldale from 38 MGD to 46 MGD, to take into account required capacity to serve the Metzger area of TVWD. The diameter of this pipeline was increased from 48 to 54 inches, to maintain the same flow velocity in the pipeline. The cost for this segment was then scaled linearly according to the old and new diameters.

The second refinement eliminated the transmission piping between Hazeldale and the terminal storage reservoir, assuming that terminal storage could be located closer to the planned transmission lines. The cost for this segment was subtracted from the overall transmission line cost. The overall impact of these two refinements is a decrease to $472,411,000 for the cost of transmission piping for this option.

No changes were made to the transmission piping costs for the TBWSP. Only 25 MGD of the 80 MGD capacity of the STL2 is required to meet the projected transmission deficit, with the remainder used to replace existing capacity. Cash flows were refined for the TBWSP to have all transmission piping implemented in 2028, rather than a portion of piping implemented in 2021.

Future piping for individual partners was not included in this study. For the Mid-Willamette at Wilsonville option, additional transmission piping from the terminal storage reservoir to the West Hills area of the TVWD system is needed by TVWD.

Booster Pump Stations. Through the evaluation of cost shares, it was identified that the cost estimates presented in Hillsboro's TM-9A were missing the final booster pump station (boosting water from head at the terminal reservoir to overcome the head in the JWC transmission system) in the Mid-Willamette at Wilsonville option. The cost estimate for the booster pump station for the Portland Supply option was used to estimate the costs of this missing pump station; these costs were added onto the costs shown for booster pumping in Hillsboro's TM-9C.

Table 1: Summary of Total Capital Costs for TVWD Supply Options (Construction and Non-construction)

Component	Portland Supply	Mid-Willamette at Wilsonville	Tualatin Basin Water Supply Project	Northern Groundwater
Seismic improvements and dam raise[(1)]	$16,400,000	$16,400,000	$267,400,000	$16,400,000
Raw water river intake, pump station, and pipeline	N/A	$9,146,000	$250,875,000	N/A
Water treatment plant	$65,075,500	$85,625,313 + $17,125,063 (times 3 additional phases)	$174,375,000 + $58,125,000 (times one additional phase)	$183,315,860 + $26,187,980 (times 3 additional phases)
Wells	N/A	N/A	N/A	$30,062,500 + $6,012,500 (times 3 additional phases)
Booster pump station (finished water)	$9,564,500	$34,938,800	$4,375,000	$15,940,600
20 MG terminal reservoir	$15,840,500	$15,840,500	$15,321,250	$15,840,500
Transmission lines	$472,410,547 (+ $269,798,125 if TVWD only participating)	$319,689,500 $84,649,842 (to TVWD West Hills)	$140,500,000	$353,001,818 + $3,639,194 (times 3 additional phases)
Non-construction costs[(2)]	$316,150,519	$225,856,100	$141,696,250	$284,634,590

Notes:

(1) Tualatin Basin Supply option requires a 40-foot dam raise and all other options require a 9-foot dam raise. All options require seismic improvements ($83,400,000). The Federal cost share of the total cost shown is $472,600,000.

(2) Based on information from Hillsboro's TM-9C (Black & Veatch, June 4, 2012); includes total for all phases of supply option of non-construction services (20% of construction), easement acquisition, and property acquisition.

4.0 PROJECT PHASING

Project phasing of the supply options was based on information presented by Black and Veatch in Hillsboro's *TM-9C Phasing of Water Supply Options*, dated June 4, 2012. The phasing was refined based on TVWD's demands and timing for supply needs. In particular, TVWD's initial need for supply occurs in year 2026, so the initial construction of supply infrastructure for each supply option starts in year 2023 and is completed in 2026. The initial "Phase 1" and "Phase 2" construction periods in Hillsboro's TM-9C and the associated costs, were combined into a single phase for TVWD. The timing for subsequent expansion for treatment and transmission piping remained the same in later phases according to the original timing in Hillsboro's TM-9C. Table 2 presents a summary of the phasing and total cost allocation by supply option used in the cost analysis.

Table 2: Summary of Supply Option Phasing and Total Costs

	Non-Construction	Dam Construction	Wells	River Intake and Pumping	Water Treatment Plant	Booster Pumping Stations	20 MG Reservoir	Pipelines
Portland Supply								
Initial phase with 20 MGD WTP	$149,841,488 (2015-2022) $156,758,591 (2023-2028)	$16,400,000 (2023-2026)	N/A	N/A	$52,873,763 (2024-2028)	$4,782,050 (2025-2026)	$15,840,500 (2026-2027)	$269,798,125 (2022-2026)
Expansion period for WTP	$9,550,440 (2029-2033)	N/A	N/A	N/A	$12,201,638 (2034-2037)	N/A	N/A	N/A
Mid-Willamette at Wilsonville								
Initial phase with 50 MGD WTP	$207,187,688 (2015-2021) $5,524,616 (2022-2026)	$16,400,000 (2023-2026)	N/A	$9,146,000 (2025)	$85,625,313 (2023-2026)	$34,938,800 (2025-2026)	$15,840,500 (2025-2026)	$319,689,500 (2023-2026)
3 expansion phases for WTP	$4,381,266 @ (2027-2031) (2033-2037) (2041-2045)	N/A	N/A	N/A	$17,125,063 @ (2027-2031) (2033-2037) (2041-2045)	N/A	N/A	N/A
TBWSP								
Initial phase with 60 MGD WTP	$117,514,07 (2015-2021) $15,538,517 (2023-2028)	$267,400,000 (2022-2025)	N/A	$250,875,000 (2018-2021)	$174,375,000 (2023-2026)	$4,375,000 (2025-2026)	$15,231,250 (2025-2026)	$140,500,000 (2025-2028)
Expansion period for WTP	$8,643,662 (2035-2037)	N/A	N/A	N/A	$58,125,000 (2036-2037)	N/A	N/A	N/A
Northern Groundwater								
Initial phase with 50 MGD WTP and wells	$248,394,916 (2015-2021) $9,059,919 (2022-2026)	$16,400,000 (2023-2026)	$30,062,500 (2024-2025)	N/A	$181,315,860 (2023-2026)	$15,940,600 (2025)	$15,840,500 (2026-2027)	$353,001,818 (2023-2026)
3 expansion phases for well field and piping	$9,059,919 @ (2027-2031) (2033-2037) (2041-2045)	N/A	N/A	N/A	N/A	N/A	N/A	$3,639,194 @ (2029) (2036) (2044)

Notes: Values shown are total costs in 2012 dollars for each supply option component and the year planned for construction (when costs would be incurred). For those components with more than one range of years for a single cost, each range of years indicates the period for the expansion phase with the costs being the same for each expansion.

5.0 OPERATION AND MAINTENANCE COSTS

Hillsboro's *TM-9A – Hillsboro Water Supply Options Cost Estimating Detail*, dated June 7, 2012 also provided O&M costs with additional breakdown provided in this TM. All treatment costs were based on 2012 budgets for the JWC WTP. Estimated O&M cost breakdowns are described in Table 3. Additional information on the projected Portland wholesale rates used for the economic evaluation is presented in Attachment A.

Table 3: Anticipated Operations and Maintenance Costs

Supply	Costs ($/CCF) [1,2]	
	Chemicals	Power[3]
Tualatin Basin Supply [4]	$0.046	$0.070
Mid-Willamette at Wilsonville	$0.046	$0.140
Portland Supply [5,6]	$0.000	$0.000
Northern Groundwater	$0.046	$0.178

(1) CCF – hundred cubic feet of water; MGD – million gallons per day.
(2) All power costs based on total electric load connected at build-out (80 MGD additional capacity) and unit cost of $0.0730/kWh. Cost interpolated linearly for intermediate flows.
(3) Based on total connected electrical loads at build-out as follows: TBWSP – 4,280 kW; Willamette Wilsonville – 8,546 kW; and Northern Groundwater – 10,885 kW.
(4) O&M costs based on 2012 JWC WTP budget with total cost of $0.39/CCF, including fixed and variable O&M costs. All costs in 2012 dollars. TBWSP O&M costs also include estimated pump-back costs. Total pump-back energy requirements were based on modeling conducted by MWH as part of the TBWSP. Requirements were assumed to be the average of the "moderate" and "conservative" scenarios. The moderate scenario assumed 50% of build-out demands and less aggressive pump-back targets, resulting in total annual energy usage of 5.5 M KW*hr. The conservative scenario assumed build-out demands and aggressive pump-back targets, resulting in total annual energy usage of 8.9 M kW*hr.
(5) Portland O&M costs based on additional treated supply of 30 MGD and total new capacity of 80 MGD. Treatment, power and chemical costs apply to treated supply to Hillsboro only. The analyses assumes TVWD will continue to receive Portland water as is.
(6) Portland wholesale cost assumed to be $0.951/CCF in 2012. This rate is TVWD's wholesale rate from Portland in FY2012-13. The rate was adjusted in future years to take into account changes in total demands on the Portland system due to projected decrease in Tigard usage and increases in JWC usage; 95% of Portland costs were assumed to be fixed.
(7) Northern Groundwater option also includes periodic renewal and replacement costs of $10 million in 2030 and $14 million in 2040.

Fixed O&M costs and chemical costs were updated based on the planned FY 2012/13 operating budget for the JWC WTP. At the current JWC WTP capacity of 75 MGD, the fixed O&M budget is $3,537,000 (net of chemical and utilities costs). The following formula was used to calculate the fixed O&M cost for the water treatment facilities in each of the supply options:

$$Cost_{new} = Cost_{old} \times (1 + 0.25 \times (Capacity_{new} - Capacity_{old})/(Capacity_{old}))$$

Where: $Cost_{new}$ = *Fixed O&M cost for the year of evaluation*
$Cost_{old}$ = *Fixed O&M cost at 75 MGD*
$Capacity_{new}$ = *Capacity of WTP for year of evaluation*
$Capacity_{old}$ = *Capacity of the existing JWC WTP (75 MGD)*

Chemical cost at the JWC WTP for FY 2012/13 is projected at $642,000 at a total projected flow of 13,950,000 CCF, which is $0.046/CCF. This unit cost for chemicals was applied as variable costs to projected annual water usage in each year for each supply option.

6.0 ECONOMIC AND FINANCIAL ASSUMPTIONS

A number of values were varied within the economic and financial models. For general assumptions and variables, HDR researched historical indices to develop estimates for our projections. These estimates are described in Table 4.

Table 4: Variables Within the Economic Evaluation of Water Supply Options

Variable	Distribution	Expected Values
Capital project cost	Triangular distribution based on level of overall cost risk, as described in Hillsboro's TM 9B.	Varies by project risk level
Construction cost escalation	Construction Cost Index, Annual Averages (1930-2011); Engineering News Record.	4.76%
Variable O&M (power and chemicals) cost escalation	Average Retail Rate of Electricity for the Industrial Sector; Energy Information Administration.	5.23%
Fixed O&M cost escalation	General inflation (calculated average increase in gross domestic product, 1929-2011).	3.09%
Portland wholesale rate escalation	Average Annual Rate of Growth in Average Wholesale Rate, (2008-2013).	4.85%

7.0 APPROACH FOR CAPITAL COST SHARE ANALYSIS

The capital costs used in the analyses included the total regional costs—including the costs of serving other regional partners. To make the analyses relevant for TVWD, the team calculated TVWD's share of the cost for the major components of each supply options. These calculations are referred to as "cost shares."

TVWD's cost shares were generally derived based on projected water supply deficits through 2050.[1] For each JWC partner, the deficit in 2050 was calculated based on projected demands, net of existing treated supply capacity. Cost shares were then calculated based on TVWD's proportion of the total projected deficit. The general approach to calculating the cost shares for each major component is described below. Cost share calculations are shown in Attachment B.

Seismic Improvements and Dam Raise. The TBWSP option includes a 40-foot dam raise of Scoggins Dam and all other options include a 9-foot raise. Seismic improvements are required for all options. For the dam raise component of the 40-foot raise, TVWD's cost share is based on the ownership percentage stated in the Intergovernmental Agreement (IGA) associated with the TBWSP, which is 43.4% for TVWD. With Federal participation ($472,600,000) in the seismic improvements, TVWD's cost share is reduced to 29.9%. TVWD does not have any existing contract ownership of the stored volume, and therefore has no cost share for the Scoggins Dam seismic improvements for the other options.

[1] The demands are presented in *TM 2 – Population and Water Demand Projections.*

Raw Water Intake, Pump Station, and Pipeline. The cost share calculation for the "raw water intake, pump station, and pipeline" varies depending on the supply option. In general, the cost share for this component is based on TVWD's proportion of the projected water supply deficit as of 2021 to meet year 2050 projected demands. TVWD's current treatment capacity is 12.5 MGD with a 2050 demand of 61.4 MGD, leaving a deficit of 48.9 MGD. The combined deficit of the TVWD and Hillsboro is 80.25 MGD in 2050. TVWD's share is calculated by dividing 48.90 MGD by 80.25 MGD, which results in a 60.9% share based on total water supply deficit of the JWC partners that have a deficit in 2050. TVWD's share is further adjusted for the Mid-Willamette at Wilsonville option, because Hillsboro is paying an additional $2.5 million as buy-in to the existing Wilsonville Water Treatment Plant intake.[2] This buy-in would be paid by Hillsboro to TVWD, and becomes a "credit" to TVWD in calculating TVWD's cost of this option[3]. The resulting adjusted cost share for TVWD taking this credit into account is 33.6% for the Mid-Willamette at Wilsonville option.

The TBWSP option assumes that 50% of total cost for the raw water intake, pump station, and pipeline component applies to the raw water storage expansion and 50% applies to the water treatment plant improvements. That is, TVWD's cost share is based on TVWD's ownership in the raw water storage expansion (43.4%) times 50% of the component cost, plus TVWD's projected proportional ownership in the JWC WTP in 2050 (40.1%; including existing capacity) times 50% of the component cost. The value of 40.1% is based on the TVWD's 2050 demand of 61.40 MGD out of a projected total JWC demand of 153.3 MGD.

Because there is no need for additional raw water improvements, the Portland Supply option and Northern Groundwater options include no costs for the "raw water intake, pump station, and pipeline" component.

Water Treatment Plant. All of the supply options identify phased expansion of water treatment capacity, as described in Hillsboro's TM 9C (and adjusted by TVWD as documented in this TM). In general, the cost share for each expansion phase is based on the percentage of the total supply deficit met by the expansion before the next phase of expansion is needed. For example, the first phase of water treatment plant expansion for all options is adequate until 2026. Therefore, the cost share for the first phase of treatment expansion is based on the 2026 supply deficits. TVWD's 2026 demand is 48.0 MGD, with a supply deficit of 35.5 MGD net of the TVWD's existing 12.5 MGD capacity. The total JWC supply deficit in 2026 is 50.55 MGD net of the JWC WTP's existing 75 MGD capacity. TVWD's cost share (70.23%) for the first phase of the treatment expansion is calculated by the ratio of the TVWD's deficit (35.5 MGD) to the total deficit (50.55 MGD) addressed by the expansion.

These calculations are completed for each phase for expansion using the deficit values for the period by when the next phase of expansion is needed. The specific phases are detailed in Hillsboro's TM 9C. For the Portland Supply option, Hillsboro is responsible for 100% of costs for all treatment expansions; hence detailed cost share calculations were not required.

[2] The buy-in is based on assumptions included in the City of Hillsboro analyses and does not reflect the actual value (or even the carrying costs) of the facilities. The actual buy-in will be determined through negotiations with Hillsboro and could be significantly higher.

[3] This value is based on the capacity proportion of TVWD's available capacity assuming Hillsboro's capacity share is 36.6 MGD and TVWD's capacity share is 43.4 MGD. Existing water treatment plant (WTP) facilities include intake, intake pipeline, raw water wet well and raw water pump station building (excluding existing pumps).

Wells (Northern Groundwater option only). This component only applies to the Northern Groundwater option. Since the timing of the well expansion phasing coincides with the water treatment plant expansion (one year offset), and it addresses the supply deficit similarly, the basis for calculating cost share for the wells is the same as the corresponding water treatment plant expansion.

20-MG Terminal Reservoir. TVWD's cost share for the new 20-MG Terminal Storage is based on TVWD's share of the water supply deficit in 2050. This is the same cost share as the raw water intake, pump station, and pipelines. The same cost share of 60.9% is applied to all options.

Booster Pump Station (finished water). The methods to calculate cost share for the finished water booster pumping vary depending on the supply option, in part because finished water pumping at the treatment plant is included within the treatment plant costs for some options, and in the booster pumping costs for others. Approaches to cost shares on each option are as follows:

- TBWSP option needs a booster pump station to increase capacity of the existing STL, thereby delaying implementation of the STL2 until 2028. As with the water treatment plant expansion method, the cost share is calculated using the percent of the total deficit met by the booster pump based on 2028 demands. In this case, TVWD has a 2028 peak-day demand of 49.1 MGD, and total transmission capacity of 43.0 MGD, leaving a deficit of 6.1 MGD. This results in 92.4% TVWD cost share for this booster pump station.

- Mid-Willamette at Wilsonville option needs a booster pump station at the new water treatment plant. Same as the calculation for cost share of the intakes, the cost share for this booster pump is based on the proportion of 2050 supply deficit met by the new supply (60.9%).

- Mid-Willamette at Wilsonville and Portland supply options need a booster pump station for the Hillsboro extension line. The cost share for this booster pump is based on the total capacity desired by each partner. In this case, the analysis assumed that TVWD would need 12 MGD out of a total capacity of 36 MGD. This results in a 33.3% share for TVWD for this booster station.

- The Northern Groundwater option includes two pump stations, one at the water treatment facility and the second along the transmission line, with 50% of the total capacity in each station. The first station is included in the water treatment cost; whereas the second pump station is included in the booster pump station cost. TVWD's cost share for the booster pump station is the same as for the intakes (60.9%) based on proportion of 2050 supply deficit.

Transmission Lines. The methods to calculate cost share for the transmission lines vary depending on the supply option:

- TBWSP require the STL2 to increase transmission capacity from Fern Hill Reservoir to Hazeldale. The cost share for the STL2 is based on the transmission deficit met by the new pipeline in 2050. TVWD's deficit is 18.40 MGD (61.4 MGD demand – 43.0 MGD current transmission capacity), out of a total pipeline capacity of 80 MGD. The portion of the STL2 capacity that is needed for new capacity is 25 MGD. The major portion of the 80 MGD

capacity of the STL2 (55 MGD) is not needed to meet projected transmission needs and is instead allocated to redundancy (potential replacement of existing STL capacity). Based on its transmission capacity deficit of 18.4 MGD, TVWD's share of the *new capacity* is 73.6%, based on its deficit of 18.4 MGD; but in terms of the cost share of the total capacity cost, TVWD's share is 23.0%, or 18.4 MGD divided by the full 80 MGD.

- Mid-Willamette at Wilsonville supply and Northern Groundwater options require a new transmission line from their respective WTPs (or wells for the Northern Groundwater option) to the terminal storage reservoir (or Hillsboro connection for the Northern Groundwater option). TVWD's cost share for these lines is based on the 2050 supply deficit (69.0%), same as for the intakes for these options.

- Mid-Willamette at Wilsonville option requires a transmission line from terminal storage location to Hazeldale. The cost share for these lines is based on the supply deficit taking into account that 30 MGD of TVWD's demands will be met through the Willamette Eastern Extension pipeline. In this case, TVWD's deficit is 18.90 MGD, out of a total deficit of 50.25 MGD, resulting in a cost share of 37.6% for TVWD.

- The Portland option requires a 54-inch transmission line from Powell Butte to Hazeldale based on a deficit of 45.5 MGD in 2050 accounting for the existing capacity of the Washington County Supply Line (WCSL). A portion of the length of this transmission line needs to be up-sized to 54-inch (Powell Butte to TVWD's Portland meter). The costs derived in Hillsboro's TM-9A for this portion of the transmission line were scaled according to the adjusted pipeline diameter. For TVWD, the current transmission capacity from the JWC and WCSL is 47.2 MGD with 2050 demand of 61.4 MGD, leaving a deficit of 14.2 MGD. TVWD's current transmission capacity is 12.50 MGD from JWC and 34.7 MGD from WCSL. The combined deficit of the TVWD and Hillsboro is 45.5 MGD in 2050. TVWD's share is calculated by dividing 14.20 MGD by 45.5 MGD, which results in a 31.2% from Powell Butte to Hazeldale.

- All of the supply options have a new transmission line from Hazeldale to the North Transmission Line (except for the Northern Groundwater Option where the line only goes from the Beaverton meter to Hillsboro connection). It assumed that TVWD desired 12 MGD out of the total 36 MGD, which include 22 MGD for Hillsboro and 2 MGD for Beaverton. The cost share for this line is based on the total capacity desired by each partner to deliver water to their meter. In this case, TVWD is assumed to require 12 MGD out of a total capacity of 36 MGD. This results in a 33.3% cost share for TVWD for these transmission lines.

Operations and Maintenance Costs. O&M costs were divided into fixed and variable cost components. As most of the O&M costs are associated with treatment, the cost shares for the fixed costs were based on projected water treatment plant ownership in each option. For example, TVWD is projected to require 64.2% of the initial WTP expansion in the TBWSP supply option; a cost share of 64.2% was applied to fixed O&M costs for the years 2021 (year of implementation of Phase 1) through 2036 (year before implementation of the next expansion phase). Variable O&M costs were calculated as a cost per CCF based on projected total annual usage in each year.

8.0 ECONOMIC EVALUATION OF OPTIONS

This section presents the economic evaluation using a present value for the TVWD cost share. This economic evaluation was conducted for each of the four supply options: Portland Supply, Mid-Willamette at Wilsonville, TBWSP, and Northern Groundwater. Additional economic analyses were also conducted for the scenario where only TVWD pursued the Portland supply, and a scenario assuming no federal cost share were available for the TBWSP option. This results in a total of six economic evaluations.

The cost estimates and cost share calculations involve assumptions that yield uncertainty or "cost risk." In many cases, the risks are not symmetrical. In other words, the risk of a higher cost, for example, may be greater than the risk of a lower costs. This is typical in large capital project planning. These analyses accounts for this with risk-adjusted cost evaluations.

8.1 TVWD Cost Share Summary

Based on the cost share analysis described in Section 7, the cost share results are summarized in Table 5 on the following page. TVWD's cost share is presented by water supply option and for each major component of the option. The cost share is presented in terms of percent and by non-construction and construction costs (2012 dollars).

Table 5: TVWD Cost Share Summary

	TBWSP	TBWSP (no-Fed)	Willamette Supply	Portland Supply	Portland Supply (TVWD-only)	Northern Groundwater
Seismic/Dam Raise						
TVWD Cost Share (%)	29.9%	43.4%	0%	0%	0%	0%
TVWD Cost Share ($)	$ 79,856,000	$321,160,000	$ -	$ -	$ -	$ -
River Intake/PS, Pipeline						
TVWD Cost Share (%)	41.7%	41.7%	33.6%	0%	0%	0%
TVWD Cost Share ($)	$104,680,335	$104,680,335	$ 3,073,453	$ -	$ -	$ -
Water Treatment Plant (+ Wells for Northern Groundwater option)						
Phase 1 (%)	*64.2%*	*64.2%*	*67.2%*	*0.0%*	*0.0%*	*67.2%*
Phase 2 (%)	*51.0%*	*51.0%*	*50.5%*			*50.5%*
Phase 3 (%)			*50.2%*			*50.2%*
Phase 4 (%)			*49.6%*			*49.6%*
TVWD Cost Share ($)	$141,644,074	$141,644,074	$ 83,269,901	$ -	$ -	$ 191,757,842
Booster Pump Station						
TVWD Cost Share (%)	92.4%	92.4%	53.4%	33.3%	33.3%	60.9%
TVWD Cost Share ($)	$ 4,043,561	$ 4,043,561	$ 18,649,691	$ 3,188,033	$ 3,188,033	$ 97,131,144
20 MG Reservoir						
TVWD Cost Share (%)	60.9%	60.9%	60.9%	60.9%	60.9%	60.9%
TVWD Cost Share ($)	$ 9,280,913	$ 9,280,913	$ 9,652,149	$ 9,652,149	$ 9,652,149	$ 9,652,149
Transmission Lines						
TVWD Cost Share (%)	26.4%	26.4%	50.6%	31.4%	100%	58.4%
TVWD Cost Share ($)	$ 37,106,050	$ 37,106,050	$161,667,465	$148,522,221	$269,798,125	$211,472,279
Total TVWD Construction Cost Share ($)	$376,610,933	$617,914,933	$276,312,659	$161,362,403	$282,638,307	$510,013,414
Non-construction Costs						
TVWD Cost Share (%)	44.5%	46.9%	58.4%	27.9%	27.9%	58.7%
TVWD Cost Share ($)	$ 63,082,998	$ 66,401,883	$131,989,765	$ 88,064,285	$ 88,064,285	$161,175,474
Total TVWD Cost Share ($)	$439,693,931	$684,316,816	$408,302,424	$249,426,688	$370,702,592	$671,188,888

8.2 Present Value

The PV for each water supply option is presented in Table 6, with capital and O&M costs presented separately in Table 7 and Table 8, respectively. Included in each table are rankings for each option in order of least cost to highest cost. PV brings all future costs into a present-day cost basis using a discount rate, which is an estimate of a utility's weighted average cost of capital over time. The discount rate used in this analysis is 5.5%. Capital and O&M cash flows for the options are presented in Attachments C and D, respectively.

As shown in Table 6, TBWSP is projected to be the least-cost option (total including capital and O&M) for TVWD cost share, and is approximately $1 million less expensive than the next least

expensive options (Portland option with Hillsboro as a partner).[4] The Mid-Willamette at Wilsonville and Northern Groundwater options are next least expensive for TVWD (total) cost share. The highest cost option is the Portland Supply option, assuming TVWD is the only participant.

Table 6: Comparison of Projected Total Cash Flows

	Net Present Value Analysis			
Scenario	Net Present Value	Rank	% from Lowest	Diff. from Lowest
TBWSP	$961,000,000	1	0.0%	$0
Willamette-Wilsonville	964,000,000	3	0.3%	3,000,000
Portland - TVWD only	1,208,000,000	6	25.7%	247,000,000
Portland	962,000,000	2	0.2%	1,000,000
TBWSP - No Fed.	1,201,000,000	5	25.0%	240,000,000
Northern Groundwater	1,177,000,000	4	22.5%	216,000,000

Table 7: Comparison of Projected Cash Flows for Capital Costs

	Net Present Value Analysis			
Scenario	Net Present Value	Rank	% from Lowest	Diff. from Lowest
TBWSP	$420,000,000	4	76.3%	$182,000,000
Willamette-Wilsonville	383,000,000	3	60.8%	145,000,000
Portland - TVWD only	357,000,000	2	49.5%	118,000,000
Portland	238,000,000	1	0.0%	0
TBWSP - No Fed.	661,000,000	6	177.2%	422,000,000
Northern Groundwater	565,000,000	5	136.8%	326,000,000

Table 8: Comparison of Projected Cash Flows for O&M Costs

	Net Present Value Analysis			
Scenario	Net Present Value	Rank	% from Lowest	Diff. from Lowest
TBWSP	$540,000,000	1	0.0%	$0
Willamette-Wilsonville	580,000,000	3	7.4%	40,000,000
Portland - TVWD only	851,000,000	6	57.5%	311,000,000
Portland	724,000,000	5	33.9%	183,000,000
TBWSP - No Fed.	540,000,000	1	0.0%	0
Northern Groundwater	612,000,000	4	13.2%	72,000,000

8.3 Findings for Economic Evaluation of Options

This technical memo presents the TVWD cost share for four water supply options: Portland Supply, Mid-Willamette at Wilsonville, TBWSP, and Northern Groundwater. Additional cost analysis was also

[4] The City of Hillsboro as determined that it will not pursue the Portland option. Therefore, the only viable Portland option is TVWD without a partner. This option is presented merely for convenience.

conducted for the scenario where only TVWD was pursuing the Portland supply, and a scenario assuming no Federal cost share was available for the TBWSP option. Cost information was based on those developed as part of the *City of Hillsboro's Water Master Plan Update* in 2012, with the refinements discussed above. TVWD's cost share of each major component of the supply options were derived based on the appropriate application of existing contract share, treatment or transmission capacity and water demand information. In the analysis, an economic evaluation of cost risks or uncertainty in capital and O&M cost estimates was considered. TBWSP at a total risk-adjusted cost of $961 million ($420 million capital cost) is projected to be the least-cost option (total including capital and O&M) for TVWD cost share, and is approximately $7 million less expensive than the next least expensive options (Portland option).

9.0 RISK EVALUATION OF OPTIONS

As part of the overall evaluation of options, the team prepared a preliminary evaluation of the risks[5] of each water supply option using a statistical technique called Monte Carlo Analysis. Monte Carlo Analysis is a well-established technique of including risk into quantitative analyses. The analyses used for TVWD incorporate the risks described in Hillsboro's TM 9B. Outputs from the Monte Carlo Analysis are presented in Attachment E.

Each water supply option includes construction of improvements such as wells, dams, raw water intakes and pumping, water treatment plants, booster pumping stations, storage reservoirs, and raw and finished water pipelines. Each of the improvements included have a risk of the actual implementation costs being greater or less than anticipated costs ("cost risk"). The cost risks vary among the different types of improvements. For the improvements under consideration in this evaluation, the overall cost risk varies due to two main factors: project-type cost risk and design-completion cost risk. Definitions of the three types of risk being used for this evaluation are provided in Table 9.

Table 9: Definitions of the three types of cost risk

Project-type Cost Risk	Intended to capture the fact that some types of projects have an inherently higher risk of actual costs differing from estimated costs. For this evaluation, *project-type cost risk* is the inherent risk associated with each project type based on a planning level of design. For example, water treatment plant projects on existing sites have a low inherent risk because the site is already secured and conditions are well understood. Whereas dams have a high inherent risk, being vulnerable to significant unknowns such as rock availability.
Design-completion Cost Risk	Intended to capture the fact that some projects are further along in the design process than others, with projects ranging from conceptual to pre-design level of completion. Projects at a lower level of design completion were considered to have a higher risk of future cost increases.
Overall Cost Risk	Combination of the previous two factors, intended to capture the overall risk of future costs differing from current estimates.

[5] We acknowledge that there are many other types of project risks other than cost (e.g., schedule, ability to acquire water rights). These other risks are evaluated in TM 4 as part of the overall evaluation of the options and are not assessed here.

It is important to note that this analysis evaluated the cost risk only. A more detailed risk analysis should be conducted on the selected alternative as part of a broader value-engineering assessment.

9.1 Project-Type Cost Risk

Project-type cost risks were evaluated for each project type included in the options. Each project type was assigned a rating of low, medium, or high cost risk. A preliminary evaluation is summarized in Table 10.

Table 10: Assessment of project-type cost risk based on projects being at a planning level of design

Project Type	Preliminary evaluation of project-level risk
Wells	Medium
Dam construction	High
Raw intake and pumping	
Tualatin River	High
Willamette River	Medium
Water Treatment Plant	
Existing site	Low
New site (no site yet identified)	Medium
Booster Pump Stations	Low
20 MG Reservoir	
Existing site	Low
No site identified	Medium
Pipelines	
Anticipated average conditions	Medium
Anticipated challenging conditions (difficult traverse or heavily urbanized)	High

9.2 Design-Completion Cost Risk

Design-completion cost risks were evaluated for each individual improvement included in the options. Each improvement was assigned a level of design completion as follows:

- Conceptual – Assigned to improvements for which no planning study has yet been completed.
- Planning – Assigned to improvements for which a planning study has been completed.
- Pre-design – Assigned to improvements for which preliminary design has been completed.

The preliminary evaluations of design-completion cost risk are summarized in Table 11.

Table 11: Assessment of design-completion cost risk

Component	TBWSP	Mid-Willamette at Wilsonville	Portland Supply	Northern Groundwater
Wells	N/A	N/A	N/A	Conceptual
Dam construction	Planning	Conceptual	Conceptual	Conceptual
Raw intake and pumping	Planning	Pre-design	N/A	N/A
Water treatment facilities	Conceptual	Planning	Conceptual	Conceptual
Booster pump stations	Conceptual	Conceptual	Conceptual	Conceptual
20 MG reservoir	Conceptual	Conceptual	Conceptual	Conceptual
Pipelines	Conceptual	Planning	Conceptual	Conceptual

9.3 Overall Cost Risk

Overall cost risks were then evaluated for each improvement included in the options analysis, based on a combination of the project-type and design-completion cost risks and engineering judgment. The preliminary evaluations of overall cost risk are presented in Table 12. For each project, the table shows the overall cost risk in bold text, as well as the project-type and design-completion cost risks in parentheses.

Table 12: Assessment of overall cost risk

Component	Overall Cost Risk (Project-type Cost Risk/Design-completion Cost Risk)			
	TBWSP	**Mid-Willamette at Wilsonville**	**Portland Supply**	**Northern Groundwater**
Wells	**N/A**	**N/A**	**N/A**	**Medium** (M/C)
Dam construction	**High** (H/PL)	**High** (H/C)	**High** (H/PL)	**High** (H/PL)
Raw intake and pumping	**High** (H/PL)	**Low** (M/PD)	**N/A**	**N/A**
Water treatment facilities	**Low** (L/C)	**Low** (L/PL)	**Medium** (M/C)	**High** (M/C)
Booster pump stations	**Low** (L/C)	**Low** (L/C)	**Low** (L/C)	**Low** (L/C)
20 MG reservoir	**Medium** (M/C)	**Medium** (M/C)	**Medium** (M/C)	**Medium** (M/C)
Pipelines	**Medium** (M/C)	**Medium** (M/PL)	**High** (H/C)	**High** (H/C)
Project-type Cost Risk defined as: L – Low; M – Medium; or H – High. Design-completion Cost Risk defined as: C – Conceptual; PL – Planning level; or PD – Pre-design completed.				

9.4 Application of Overall Cost Risk

Based on the evaluation of overall cost risk, a triangular probability distribution was applied to the capital cost for each individual project within the economic risk model. The probability ranges associated with each level of overall cost risk are summarized in Table 13.

Table 13: Distributions applied to each overall cost risk level

Level of overall cost risk	Applied cost variability	
	Low	**High**
Low	-5%	+10%
Medium	-10%	+20%
High	-20%	+40%
Variability applied as a triangular distribution, with the current cost estimate at the peak of the triangle.		

9.5 Findings from Risk Analysis

The risk analyses confirmed the overall findings from the economic analysis. Detailed outputs from the cost risk model are provided in Attachment 1. The Mid-Willamette at Wilsonville option was

consistently the least-cost option. Close to it was the Portland option that assumes Hillsboro would participate.

Figure 1 presents the relative distributions of the PV of each of the supply options analyzed. The risk analysis suggests that the relative risks for the TBWSP with Federal Funding, the Mid-Willamette at Wilsonville, and the Portland Supply with Partners are the least-cost options. The results are consistent with the findings from the PV analysis.

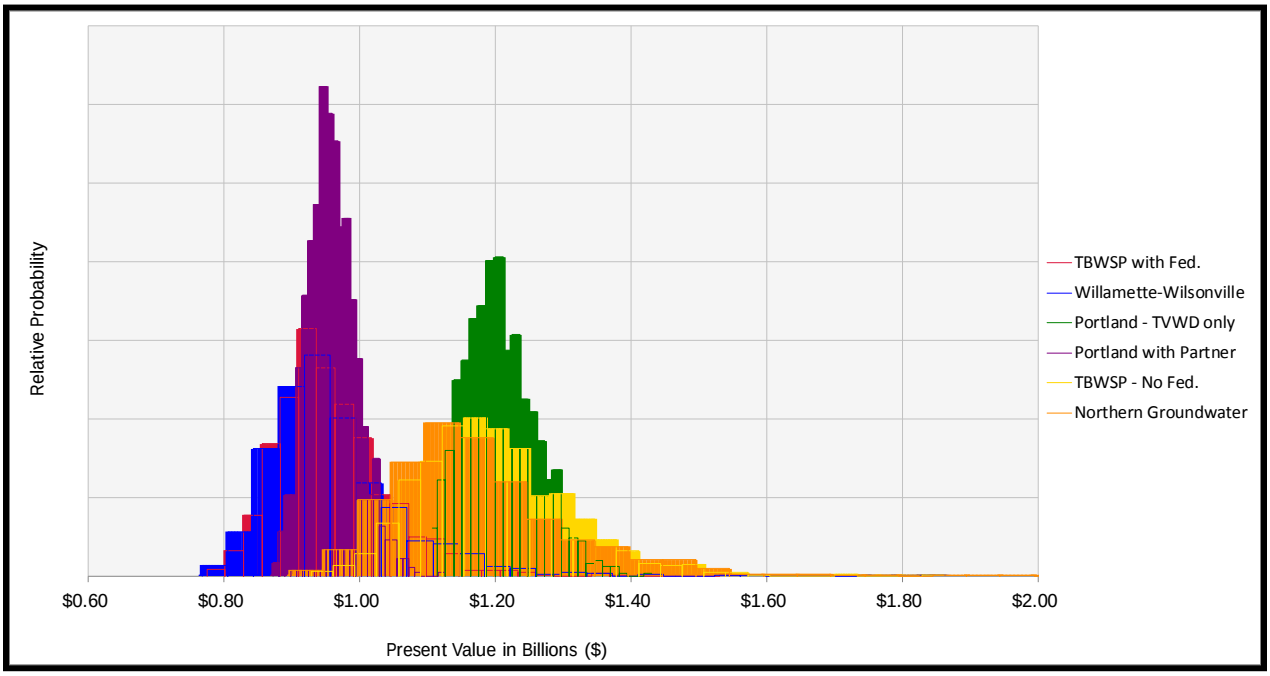

Figure 1: Relative Distribution of PV for Supply Options

The information presented in Figure 1 includes several supply options that overlap and are somewhat difficult to read. For ease of presentation, Figure 2 presents a cumulative probability distribution for four of the options.

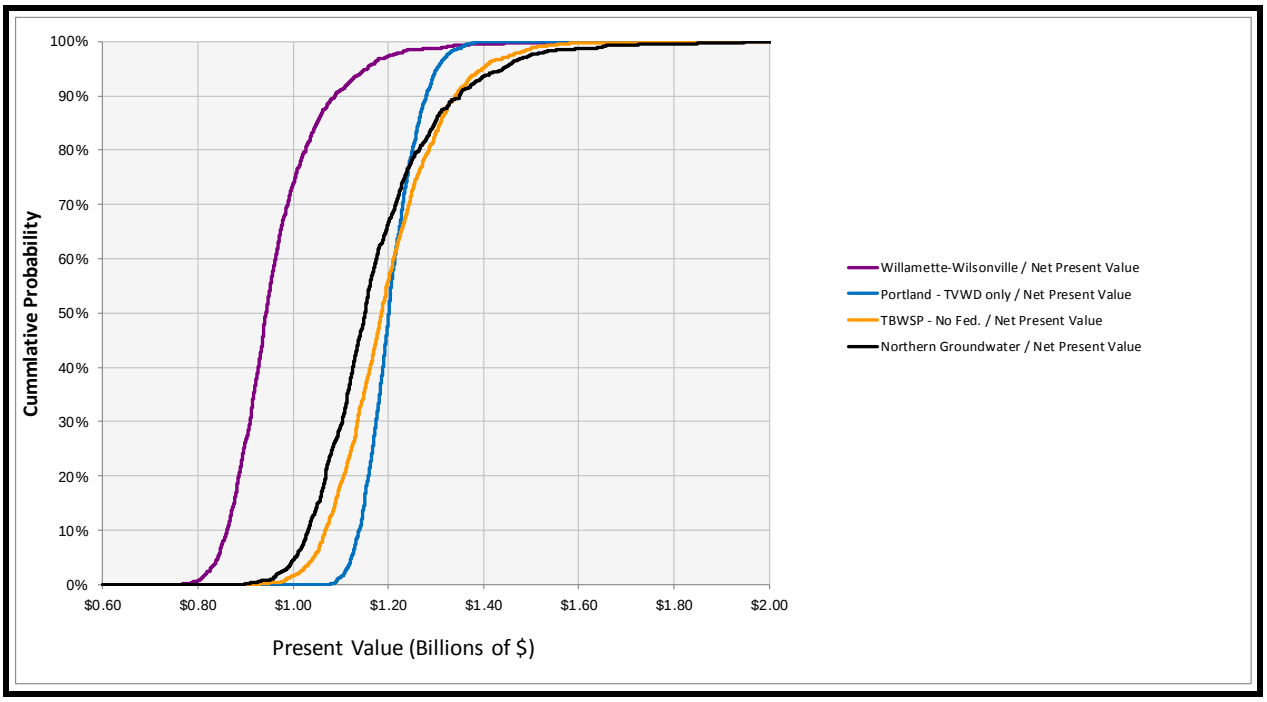

Figure 2: Cumulative Probability Distribution of PV by Supply Option

10.0 FINANCIAL EVALUATION OF OPTIONS

The economic and risk evaluation looked at the overall cost of each supply option using a PV framework. In addition to evaluating the PV, the team evaluated the relative impacts on water rates that would be expected from each of the supply options. This evaluation is referred to as the financial evaluation because it looks at the impacts of financing decisions on the water supply options.

The exact financing arrangement for TVWD's future water supply option will be determined after that selection is made. The exact financing arrangements will be determined in conjunction with other capital and operating requirements of TVWD at that time. To focus the technical analyses on the specific issue of selecting a water supply option, the team compared the relative rate impacts of implementing TVWD's then-expected capital improvements plan along with TVWD's 2007 preferred water supply option (TBWSP with Federal Funding) to each of the other water supply options. The baseline for comparing water rates is the likely future increase or decrease in costs beyond those that would be expected for the *TBWSP 2007 Decision*. The cost associated with the *TBWSP 2007 Decision* is based on the costs presented in Table 5 assuming the federal funding for seismic upgrades to Hagg Lake.

The analyses included approximately $287.4 million in non-water supply CIP through 2038. That CIP was added to the capital costs for each water supply option presented in Table 5 of this TM to set the total funding requirements for the supply option.

The CIP was combined with projections of operating expenses for the water supply option, and current forecasts of adjusted operating expenses for TVWD to develop a 30-year financial forecast of revenue

requirements. The difference between each water supply option and TBWSP 2007 Decision were then compared.

Figure 3 presents the results of the analyses. The values shown in the graph are the expected impact on monthly bills above or below the baseline TBWSP 2007 Decision. The values are not cumulative, but rather the values shown on the vertical axis of Figure 3 are to total impact on the bill for the corresponding year on the horizontal scale.

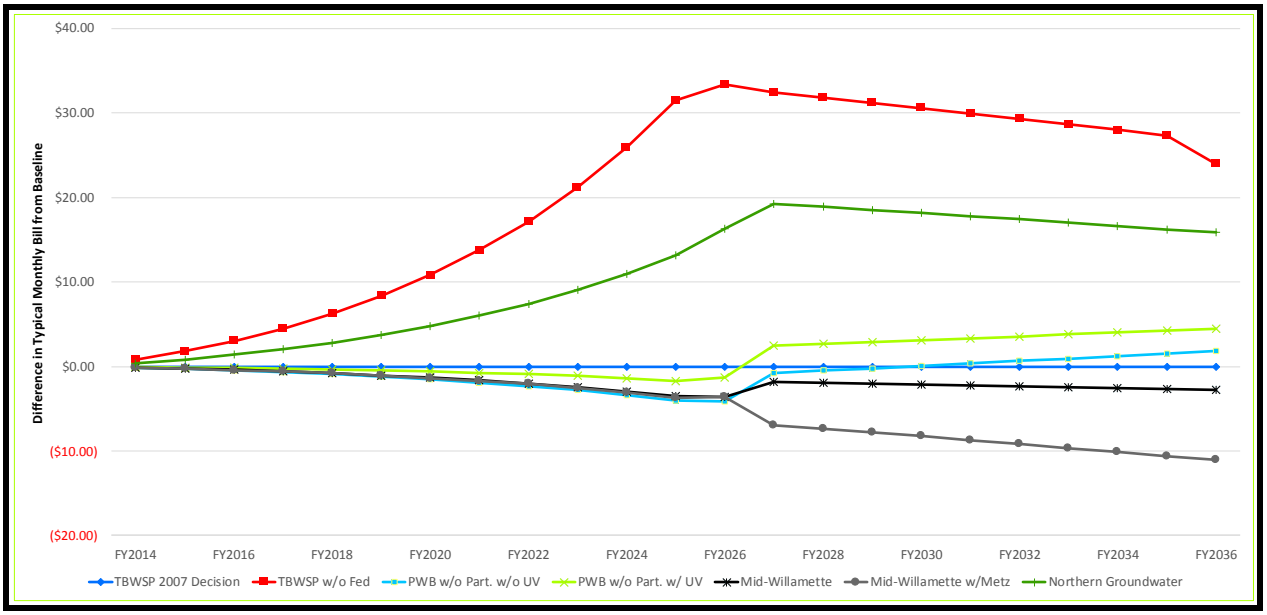

Figure 3: Comparison of Rate Impacts of Water Supply Options

11.0 SUMMARY OF FINDINGS

The differences among the water supply options for the economic, risk, and financial analyses suggest three options have the least cost. These least-cost options are the TBWSP with federal funding, Portland supply with Hillsboro as a partner, and the Mid-Willamette at Wilsonville. Neither the Portland supply with Hillsboro as a partner nor the TBWSP with federal funding appear to be viable options. Of the remaining options considered viable, the Mid-Willamette at Wilsonville option is least expensive with lowest future rate impacts. Therefore, non-economic criteria, as discussed in *TM 4 – Non-financial Criteria Evaluation*, may well be more important to the overall decision.