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Engineers/Planners

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# FINAL TECHNICAL MEMORANDUM


**DATE:** January 13, 2010

**PROJECT:** 10-1124

**TO:** Mr. Tom Hickmann, P.E.,
Assistant Public Works Director, City of Bend, Oregon

**FROM:** Murray, Smith & Associates, Inc.

**CC:** Optimatics LLC.

**RE:** City of Bend Water System – Tetherow Development: Alternatives Analysis

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## Introduction and Purpose

This technical memorandum presents alternatives for providing adequate water supply and service pressure to the Tetherow development in the City of Bend under existing and build-out demand conditions. The City has observed that the Tetherow Pump Station, located on Skyline Ranch Road currently does not provide adequate supply and pressure. Pressures have dropped below 19 psi at the suction side of the pump station causing the pump station to automatically shut off during periods of high demand. Tetherow developers have expressed interest in further near term development in the area, requiring an evaluation of water system improvement alternatives to provide adequate pressure and supply to the development. The analysis presented in this memorandum evaluates the adequacy of the alternatives presented under current (2010) and future (build-out) conditions. The build-out analysis was completed as part of a water system optimization project by Optimatics, with the results presented in this memo.

Currently only a small part of the Tetherow Development has been developed or occupied. The purpose of this memo is to provide solutions for the near-term that are sized to ultimately supply build-out demands within the development. This analysis was completed

with the use of a hydraulic model that has been calibrated using field and SCADA information in 2009 and 2010. The model is considered to provide an accurate approximation of pressures and flows, however additional field verification should be used where appropriate prior to construction of improvements.

**Background**

A map of the Tetherow Development and surrounding areas is provided as Figure 1. Figure 1 shows existing water pressure zone boundaries in the area of the Tetherow Development as well as the existing water pipelines. It also indicates the spatial location and extent of the Tetherow Development. A large portion of the Tetherow Development is served by Zone 3 on the suction side of the Tetherow Pump Station. The remainder of the Tetherow Development is served by the Tetherow Pump Station (on the discharge side). The area served by the pump station constitutes the "Tetherow Zone", which is a higher hydraulic grade than Zone 3 or the Westwood Zone. The Tetherow Zone should not be confused with the same extent as the Tetherow Development, as the development covers an area much larger than the Tetherow Zone. In fact the majority of the development is located on the suction side of the pump station in Zone 3.

The section of Zone 3 serving the Tetherow Development is supplied by a single 12-inch connection to the rest of the City system at the intersection of Brokentop Drive, and Mt. Washington Drive. This portion of Zone 3 is referred to as "Zone 3 on the suction side of the pump station". This area serves the Tetherow Development as well as Zone 3 customers that are not part of the Tetherow Development. A "backup" connection from the Westwood Pressure Zone is available under low pressure conditions to serve the Tetherow Zone.

The existing water pipelines serving Zone 3 on the suction side of the pump station and the Tetherow Development represent only partial completion of the "originally planned" water distribution lines designed to feed the Tetherow Development and Tetherow Pump Station. This analysis evaluates the adequacy of the original plans with the City's updated hydraulic model, and incorporates new alternatives that provide adequate pressure and supply to customers in the Tetherow Development on both sides of the Tetherow Pump Station.

The system performance criteria adopted by the City of Bend require that a minimum of 40 psi be provided during domestic demand conditions, and 20 psi or greater pressure is available at service connections under fire flow conditions. Under no condition should pressures at the suction side of the pump station fall below 20 psi. Existing service connections are currently located close to the suction side of the pump station, making the regular domestic demand pressure criteria of 40 psi applicable at the suction side of the pump, unless improvements are made to serve those customers from the discharge side of the pump station.

This analysis utilizes the City of Bend's water distribution system hydraulic model in InfoWater with the EPANET hydraulic engine. The distribution system model was updated and calibrated as part of the ongoing "water system optimization" project. Contours for the

Tetherow Development were obtained from elevation data collected by WH Pacific in a local coordinate system in AutoCAD format. The data was spatially registered by the City of Bend using section corners from Deschutes County. The contours were used as the source of elevation data for the hydraulic model in the Tetherow Development. Elevation data for the pump station was taken from Tetherow Pump Station drawings, and agreed with the available contour data.

This evaluation does not include consideration of the adequacy of supply, or emergency storage needed to supply design demands, and is limited to the capacity of conveyance to satisfy system design standards for pressure and fire flows.

Under existing conditions the design fire flows for the Tetherow development include 1,500 gpm for Zone 3, located on the suction side of the pump station, and 1,750 gpm in the Tetherow Zone served by the pump station. The fire flow requirement of 1,750 gpm for the existing golf course club house was provided by City Staff based on an agreement with the local Fire Marshall. The 1,500 gpm fire flow requirement is the standard requirement for residential areas in the City of Bend. For build-out conditions the residential fire flow requirements remains the same at 1,500 gpm, however the requirement in the Tetherow Zone is increased to 3,750 gpm to accommodate future commercial development. Fire flow availability and residual pressures are evaluated under Maximum Day Demand conditions in the system using the City's hydraulic model. Existing Average Day Demand (ADD), Maximum Day Demand (MDD) and Peak Hour Demand (PHD) design values have been calculated as part of the ongoing master plan update work.

The total existing ADD in Zone 3 on the suction side of the pump station is less than 300 gpm, with less than 10 gpm in the Tetherow Zone itself. These numbers are based on 2008 billing records peaked to match production. Build-out demand on the suction side of Zone 3 is projected to be approximately 560 gpm with the Tetherow Zone at 107 gpm.

**Alternative Improvements**

Pressures within the Tetherow development are adequate under existing ADD conditions, but under MDD and most future conditions, pressures drop below criteria on the suction side of the pump station. Under PHD conditions, pressures on the suction side of the pump station drop below 20 psi and the pumps shut down, leaving the Tetherow Zone to be served through valving from the Westwood Zone.

Currently, head loss from the City's sources of supply to the Tetherow Pump station may exceed 110 ft, under high demand conditions. The surface water hydraulic grade line (HGL) feeding the Outback facilities is 4,010 ft. Flow and pressure control valves from the Outback facilities to Zone 3 reduce the HGL serving Zone 3 to approximately 3,995 ft. Hydraulic model analysis suggest that under ADD conditions the HGL is further reduced by pipe losses and minor losses to about 3,988 ft at the intersection of Mt. Washington Drive and Brokentop Drive, where a single 12-inch connection feeds Zone 3 on the suction side of the pump station. The HGL is still close to 3,988 ft immediately before the Tetherow Pump

Station under ADD as there is essentially little to no headloss under those low flow conditions. Under PHD conditions, the HGL is approximately 3,886 ft at the intersection of Brokentop Drive and Mt Washington Drive, and 3,877 ft at the pump station. The pump station is located at an elevation of approximately 3,877 ft, resulting in a PHD pressure at suction side of approximately 0 psi.

After initial evaluations it became apparent that the highest value solution would be to improve the upstream distribution system. This evaluation initially considered relocating the existing pump station, in addition to construction of pipeline improvements, however relocating the pump station would be costly and does not address the primary issue of limited conveyance to Zone 3 on the suction side of the pump station.

For these reasons improvement alternatives focus on reducing head-losses between the supply lines leaving the Outback facilities that ultimately serve Zone 3 and the Tetherow Development, with the construction of new connections and pipeline improvements serving the area of Zone 3 on the suction side of the pump station. Figure 1 provides a map of the location of potential improvements evaluated as part of this analysis.

Improvement T (shown in Figure 2) is the only alternative that represents a change in existing pressure zone boundaries. This improvement expands the boundary of the Tetherow Zone primarily using existing water pipelines. Under the existing operations, customers located north of the pump station are served by Zone 3. An existing 16-inch pipeline in Zone 3 primarily supplies water to the suction side of the pump station. An existing parallel 8-inch water line in Zone 3 serves customers near the pump station from Zone 3. As elevation increases heading south along Skyline Ranch Road toward the Tetherow Pump Station, it becomes more difficult to maintain adequate pressure in the existing Zone 3 lines. The proposed improvement T converts the parallel 8-inch Zone 3 pipeline to a Tetherow Zone pipeline, and serves customers close to the pump station off of the discharge side of the Pump Station (see Figure 2). Construction of a short segment of pipeline may be required, in addition to the closure of two existing Zone 3 valves to isolate the new Tetherow Zone boundary. This improvement also maintains the Zone 3 loop that runs through the Tetherow Zone, providing redundancy to portions of Zone 3. With this improvement, the required pressure in the Zone 3 pipelines close to the suction side of the pump station can be reduced from serving a minimum of 40 psi under domestic demand conditions to a minimum of 20 psi under all demand conditions.

A number of alternatives were generated and evaluated under both current and build-out conditions as shown in Figure 1 and Table 1.

**Table 1**
**Summary of Improvements Evaluated**

| Improvement | Size (inch) | Length (ft) | Description |
|---|---|---|---|
| A | Existing | 0 ft | Change closed valve status to provide flow from Zone 3 through zone 4K and provide individual PRVs to approximately ten customers in Zone 4K |
| A12 | 12-inch | 1,000 ft | Same as improvement A, with 8-inch pipeline upgraded to **12**-inch |
| B16 | 16-inch | 5,200 ft | Construct **16**-inch line from existing 16-inch on Skyline Ranch Rd to Skyliners Rd |
| B18 | 18-inch | 5,200 ft | Construct **18**-inch line from existing 16-inch on Skyline Ranch Rd to Skyliners Rd |
| G16 limited | 16-inch | 4,200 ft | Improve 12-inch section on Mt Washington Dr to **16**-inch |
| G24 limited | 24-inch | 4,200 ft | Improve 12-inch section on Mt Washington Dr to **24**-inch |
| G24 extended | 12-inch | 5,800 ft | Improve 12-inch section to **24**-inch, and continue improvement from Brokentop Dr and Mt Washington to Skyliners Rd, along Mt Washington Dr. |
| G30 extended | 30-inch | 5,800 ft | Improve 12-inch section to **30**-inch, and continue improvement from Brokentop Dr and Mt Washington to Skyliners Rd, along Mt Washington Dr. |
| D | 12-inch | 1,200 ft | Construct new **12**-inch pipeline |
| T | 8-inch | Less than 20 ft | Change the boundary of the Tetherow Zone, extending it to the intersection of Skene Tr and Skyline Ranch Road, primarily using existing pipelines. |

As noted above, hydraulic simulations were performed under MDD, PHD and fire flow conditions to identify what improvements or combinations of improvements provide adequate service. Alternatives were first evaluated to determine if minor improvements would provide adequate pressure to the area serving the Tetherow development, before including larger and more expensive improvements. The combination of all three of the lowest cost alternatives (A, D, T) did not result in adequate service pressure under existing conditions. Upsizing the 8-inch sections of piping through Zone 4K (A12) in addition to D and T, also did not provide adequate pressures.

Pipeline improvements along Mt Washington Drive (G improvements), or construction of a pipeline of at least 16-inches on Skyline Ranch Road connecting to Skyliners Road will be needed to adequately serve the area under existing conditions.

Once the required improvements were identified under existing conditions, Optimatics utilized the build-out hydraulic model to evaluate future ADD, MDD, PHD and fire flow scenarios. This analysis resulted in a set of improvements required to serve build-out conditions. Table 2 includes a summary of the improvements and sizing required under both existing and build-out conditions. Note that it is assumed that the pipe sizing required under

build-out conditions will be constructed. It should also be noted that other combinations of improvements identified in Table 1 were adequate under existing conditions, however only those that also worked under build-out conditions were included in Table 2.

**Table 2**
**Existing and Build-out Improvements**

| Improvement ID | Description | Size Required for Existing Conditions | Size Required for Build-out Conditions | Recommended Timing |
|---|---|---|---|---|
| A | Bypass of Zone 4K from Hosmer Lake Dr to Green Lakes Loop. | - | 12-inch | 2020 |
| B | Connection from Skyliners to Skyline Ranch Rd | 16-inch | 18-inch | 2011 |
| D | Connection from Skyline Ranch Rd to Brokentop Dr | - | 12-inch | Build-out |
| G | Extended option – parallel Mt Washington from Skyliners Rd to Flagline Dr; replace existing 12-inch from Flagline Dr to Brokentop Dr | - | 30-inch | Build-out |
| T | Shift customers along Bonneville Loop to Tetherow Zone with a new connection and closing a valve at Skene Tr | Required | 8-inch | 2011 |

## Conclusions

As shown in Table 2, there are no inexpensive solutions for solving the pressure issues in Tetherow, which is not unexpected, as the original plan included a 16-inch pipe along Skyline Ranch Road connecting to the supply piping on Skyliners Road. Due to the incremental cost increase of upsizing pipe, it is recommended that an 18-inch pipeline on Skyline Ranch Road be constructed, which will be adequate through build-out. It is also recommended that the proposed 18-inch line, connect to the 30-inch supply line on Skyliners Road. It is recommended that improvement T be implemented immediately, which modifies the boundary of the Tetherow Zone on the suction side of the Tetherow Pump Station as shown in Figure 2. The timing for improvements required at build-out (as shown in the table) will vary depending on the rate of development that occurs in Tetherow and should be reassessed in future planning projects to identify specific construction dates.

# FIGURE 1

City of Bend
Tetherow Development

## IMPROVEMENT ALTERNATIVES

January 2011

MSA Murray, Smith & Associates, Inc. Engineers/Planners

A

B

D

G Extended

G Limited

Tetherow Pump Station

Tetherow

Westwood Well

WESTWOOD RESERVOIR AND PUMP STATION

OVERTURF RESERVOIR WEST

OVERTURF RESERVOIR EAST

ROCK BLUFF RESERVOIR #1 AND ROCK BLUFF WELLS

WestW

0 375 750 1,500 2,250 3,000 Feet

LEGEND

Tank
Pump
Closed Pipe
Water Valve
Water Bodies
Tetherow Parcels

Pressure Zones: 3, 4A, 4G, 4H, 4I, 4J, 4K, 5, Tetherow, WestW

Pipes DIAMETER: <=4-inch, 6 to 8-inch, 10 to 12-inch, 14 to 18-inch, > 18-inch

N

**FIGURE 2**

City of Bend
Tetherow Pump Station

**IMPROVEMENT ALTERNATIVE**

January 2011

MSA
Murray, Smith & Associates, Inc.
Engineers/Planners

3

16-inch
16-inch
16-inch
Tetherow Pump Station
BONNEVILLE LOOP
SKYLINE RANCH RD
16-inch
16-inch
16-inch
Close Zone 3 Valve
8-inch
BONNEVILLE LOOP
Construct connection between 8-inch zone 3 and adjacent 8-inch Tetherow pipeline.
Tetherow
10-inch
BONNEVILLE LOOP

Close Zone 3 Valve
SKYLINE RANCH RD
CANNON CT
SKENE TR
SKENE TR
SKENE TR
CHRISMAN CT
3
BONNEVILLE LOOP
SKYLINE RANCH RD
Tetherow Pump Station
BONNEVILLE LOOP
Tetherow
SKYLINE RANCH RD
3

0 5 10 20 30 40 Feet

**LEGEND**

Tank
Closed Pipe
Pump
Water Bodies
Water Valve

**Pipes**
Pump Station

**PIPE ZONE**
3
Tetherow

**Pressure Zones**
3
Tetherow

N

# FINAL TECHNICAL MEMORANDUM

**DATE:** January 13, 2011

**PROJECT:** 09-1092

**TO:** City of Bend

**FROM:** Murray, Smith & Associates, Inc.

**RE:** Former Juniper Utility – Proposed Water System Improvements

REGISTERED PROFESSIONAL ENGINEER 81259 OREGON MAY 13, 2008 DAVID E. STANGEL

RENEWS: 6/30/12

## Background

The City of Bend has been working to incorporate the former Juniper Utility into the overall water system over the past several years. Of primary concern are the undersized and poor quality plastic pipes that serve as distribution mains in the system. The area is currently served by a parallel irrigation system which is scheduled to cease operation in 2018. This will cause peak summer time demand driven by outdoor water use to be provided through the potable system. Though no specific numbers are available, current peak irrigation use for the former Juniper Utility area is significantly higher than the approximately 200 gpm summer day demand served by the potable system. Summer irrigation related demands are anticipated to decrease once the irrigation is converted to the potable system as customers will be billed for the actual volume they use, however potable use will still increase significantly over current numbers.

Operation for the area is proposed to change from current conditions. This will include the following:

- The Tillicum Village area will be connected directly to Zone 4 (HGL 3,880') through four interconnections
- A dedicated pipeline from Murphy Pump Station to Zone 2 will be constructed
- The Murphy Pump Station will become the primary feed to Zone 2 and the remaining portion of Zone 3
- Two smaller variable frequency drive (VFD) pumps will be installed at Murphy Pump Station to supply low flow conditions
- The Hole 10 Wells will be utilized as a redundant source only and was not utilized during the fire flow analysis
- Shilo Well 3 will be pumped directly to Zone 4 through a dedicated pipeline

- Pines Mobile will be served by PRV in the interim, from the dedicated Zone 2 pipeline supplied by Murphy Pump Station
- Timber Ridge will continue to be served through PRV-69 near the railroad crossing along with a second PRV to be installed near the intersection of Country Club Drive and High Lead Drive

The City has defined the upgrades to the former Juniper Utility in two categories; those that provide supply and transmission to the overall area (Category 1), and those associated with the replacement of the existing substandard plastic piping with ductile iron piping in road right-of-ways, including associated fire hydrants (Category 2).

**Analysis**

Assumptions:

- Residential fire flows of 1,500 gpm are assumed for the entire former Juniper Utility area
- Hydrants spacing per City standards of 400 feet will be used to calculate the number of new hydrants required in the area, though no specific locations will be identified
- No pipe sizes other than 8-inch, 12-inch and 16-inch will be considered for improvements, with the exception of dead-end pipe segments less than 100 feet in length, which can be 6-inch
- Future fire flows in Zones 2 and 3 will assume that Hole 10 is not in operation and are being supplied by Murphy Pump Station
- All pipe replacements will be made in the road right-of-way
- Currently installed cross country piping will be abandoned in place with no costs associated with removing those pipes included in this analysis
- Two additional jockey pumps will be installed at Murphy Pump Station to serve winter and average day demands in Zones 2 and 3
- Some upsizing of piping will be paid for by the City as noted in this memo
- Pipe and PRV costs will be based on the "Updated Capital Improvement Project (CIP) Cost Estimates" memo by MSA dated October 22, 2009. It should be noted that recent construction bids have come in well below historical numbers, however for planning purposes it is recommended that planning level numbers be utilized that are consistent with longer term trends. All costs are in 2009 dollars.
- Fire flows are modeled under maximum day demand (MDD) conditions assuming that the Juniper Utility utilizes potable water for irrigation using the area's average day demand (ADD) to MDD ratio of approximately 5.0. This provides a factor of safety over current ADD to summer monthly ratios of approximately 2.0, identified in this area. Current ADD in the area outside of Tillicum and Nottingham is approximately 65 gpm, resulting in a MDD of 325 gpm. Overall Juniper Utility ADD is approximately100 gpm, resulting in an overall Future Juniper Utility MDD of 500 gpm.

- No future growth projections were made as part of this analysis, though the conservative nature of the ADD to MDD peaking factor is believed to account for some of the growth in this area.
- The piping associated with the Stonegate Development north of the Burlington Railroad is not included in this analysis as it is not part of the former Juniper Utility
- Nottingham will continue to be served from Zone 4. This area will be included in the replacement (Category 2) evaluation
- The 8-inch pipe on the south side of the Nottingham development that connects to piping on Brosterhous Road just north of the intersection with Button Brush Avenue will not be included in the hydraulics evaluation as this pipe will be abandoned
- The evaluation assumes the property at 20505 Murphy Road, is served by an individual service line PRV from the Zone 2 pipeline from Murphy Pump Station to Timber Ridge, once cross country piping is abandoned
- The fire flow target is to provide 1,500 gpm at all hydrants, however if fire flow values are within 200 gpm of that target on longer dead-end lines where looping is not possible, they will not be upgraded to a larger diameter that could cause water quality problems due to stagnant water

**Recommendations**

As discussed previously, the improvements are broken into Category 1 and Category 2. These improvements will also be referenced to the specific developments that they benefit. For example a transmission or Category 1 improvement that benefits Tillicum will not be associated with Timber Ridge. Table 1 includes a listing of the Category 1 improvements required to allow the former Juniper Utility area to provide 1,500 gpm fire flows under MDD conditions. This assumes that existing piping is utilized where possible. New hydrants will be installed at 400 foot spacing on all new piping installed under Category 1 and 2 improvements. Figure 1 shows the former Juniper Utility Area with existing piping and required Category 1 improvements.

The City has identified a number of improvements that will be upsized at no cost to the development to allow for future expansion of the system. The total estimated Category 1 Improvements total approximately $4.4 million with $3.6 million of those being directly associated with service to the former Juniper Utility.

Table 1. Category 1 Improvements

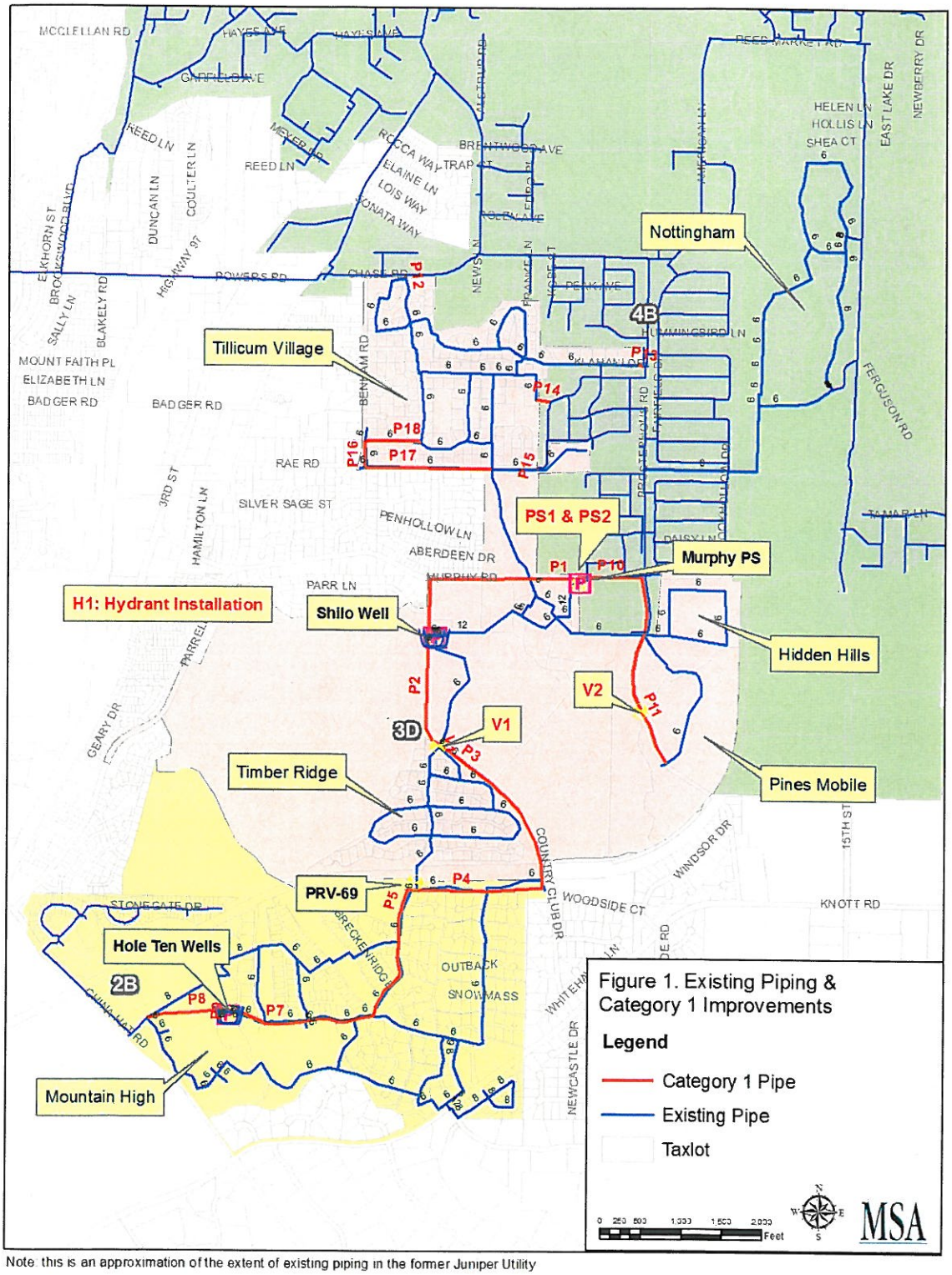
| ID*** | Description | Zone(s) Served | Developments Served* | Length (ft) | Cost Estimate** | Specific Notes |
|---|---|---|---|---|---|---|
| PS1 | 2 VFD Pumps @ Murphy PS | 2B & 3D | MH, TR, HH, PM | NA | $50,000 | Low Demand Pumps |
| PS2 | Murphy Surge Tank | 2B & 3D | MH, TR, HH, PM | NA | $50,000 | Based on 820 gallon size tank. No surge analysis has been completed |
| V1 | PRV Station on North side of Timber Ridge | 3D | TR | NA | $75,000 | |
| V2 | Temporary PRV Station on Brosterhous Road to serve Pines Mobile, set at 53 psi | 3D | PM | NA | $75,000 | To be removed once Category 2 Improvements in PM are installed |
| P1 | 12-inch pipe from Murphy PS to Shilo Wellhouse | 2B & 3D | MH, TR | 2,580 | $489,000 | |
| P2 | 16-inch pipe from Shilo Wellhouse to North end of Timber Ridge | 2B & 3D | MH, TR | 1,430 | $271,000/$342,000 | Upsizing from 12 to 16 paid for by City |
| P3 | 16-inch pipe from North end of Timber Ridge to Zone 2B | 2B & 3D | MH, TR | 2,950 | $561,000/$708,000 | Upsizing from 12 to 16 paid for by City |
| P4 | 12-inch pipe along Mountain High Loop | 2B & 3D | MH, TR | 860 | $163,000 | |
| P5 | 12-inch pipe along Mountain High Loop | 2B | MH | 1,800 | $342,000 | |
| P7 | 12-inch pipe along Mountain High Drive | 2B | MH | 1,830 | $348,000 | |
| P8 | 12-inch pipe along Mountain High Drive | 2B | MH | 1,020 | $0/$193,000 | Paid for by City |
| P9 | 12-inch connection to Shilo Wells | 2B | MH | 50 | $10,000 | |
| P10 | 16-inch pipe from Murphy PS along Murphy Road to Hidden Hills | 3D | HH, PM | 1,590 | $0/$381,000 | Paid for by City |
| P11 | 16-inch pipe along Brosterhous Road to Pines Mobile | 3D | PM | 1,790 | $340,000/$430,000 | City to pay for upsizing from 12 to 16 |
| P12 | 8-inch interconnect with Zone 4B | 4B | TIL | 40 | $10,000 | |
| P13 | 8-inch interconnect with Zone 4B | 4B | TIL | 100 | $13,000 | |

| ID*** | Description | Zone(s) Served | Developments Served* | Length (ft) | Cost Estimate** | Specific Notes |
|---|---|---|---|---|---|---|
| P14 | 8-inch interconnect with Zone 4B | 4B | TIL | 190 | $26,000 | |
| P15 | 8-inch interconnect with Zone 4B | 4B | TIL | 30 | $10,000 | |
| P16 | 8-inch fire flow related piping on Benhard Road | 4B | Til | 320 | $45,000 | |
| P17 | 8-inch fire flow related piping on Rae Road | 4B | Til | 1,550 | $217,000 | |
| P18 | 8-inch fire flow related piping on Illahee Drive | 4B | Til | 690 | $96,000 | |
| H1 | Installation of 47 new hydrants at 400 foot spacing | All | All | NA | $367,000 | Based on approximately 18,800 feet of new piping |
| | **Total** | | | | **$3,558,000/ $4,440,000** | |

* MH: Mountain High, TR: Timber Ridge, Hidden Hills, PM: Pine Mobile, TIL: Tillicum, NH: Nottingham

** If two numbers are presented, the first is the cost associated with the former Juniper Utility, the second is the total project cost. Minimum project cost assumed to be $10,000. Estimates are in 2009 dollars.

*** P6 does not exist in the capital improvements list.




Note: this is an approximation of the extent of existing piping in the former Juniper Utility

Category 2 improvements that replace poor quality plastic pipe in the road right-of-way within the former Juniper Utility are summarized in Tables 2-6, by area, including the total feet of pipe by diameter and the number of hydrants included. No Category 2 improvements have been identified for Hidden Hills. Lengths have been rounded to the nearest 100 feet and costs rounded to the nearest thousand dollars. Figure 2 shows the proposed system that includes abandoning the existing piping and depicts both the Category 1 and 2 improvements.

Table 2. Tillicum Village Category 2 Improvements

| Total Length (ft) 8-inch | Total Length (ft) 12-inch | Number of New Hydrants | Total Cost |
|---|---|---|---|
| 15,900 | 0 | 40 | $2,820,000 |

Table 3. Nottingham Category 2 Improvements

| Total Length (ft) 8-inch | Total Length (ft) 12-inch | Number of New Hydrants | Total Cost |
|---|---|---|---|
| 13,400 | 0 | 34 | $2,139,000 |

Table 4. Timber Ridge Category 2 Improvements

| Total Length (ft) 8-inch | Total Length (ft) 12-inch | Number of New Hydrants | Total Cost |
|---|---|---|---|
| 6,600 | 0 | 17 | $1,059,000 |

Table 5. Mountain High Category 2 Improvements

| Total Length (ft) 8-inch | Total Length (ft) 12-inch | Number of New Hydrants | Total Cost |
|---|---|---|---|
| 14,900 | 2,700 | 43 | $2,886,000 |

Table 6. Pines Mobile Category 2 Improvements

| Total Length (ft) 8-inch | Total Length (ft) 12-inch | Number of New Hydrants | Total Cost |
|---|---|---|---|
| 6,000 | 0 | 15 | $955,000 |

Total Category 2 Improvements are shown in Table 7 at approximately $9.9 million. Figure 2 shows all Category 1 and 2 Improvements along with the abandonment of all existing piping.

Table 7. Total Category 2 Improvements

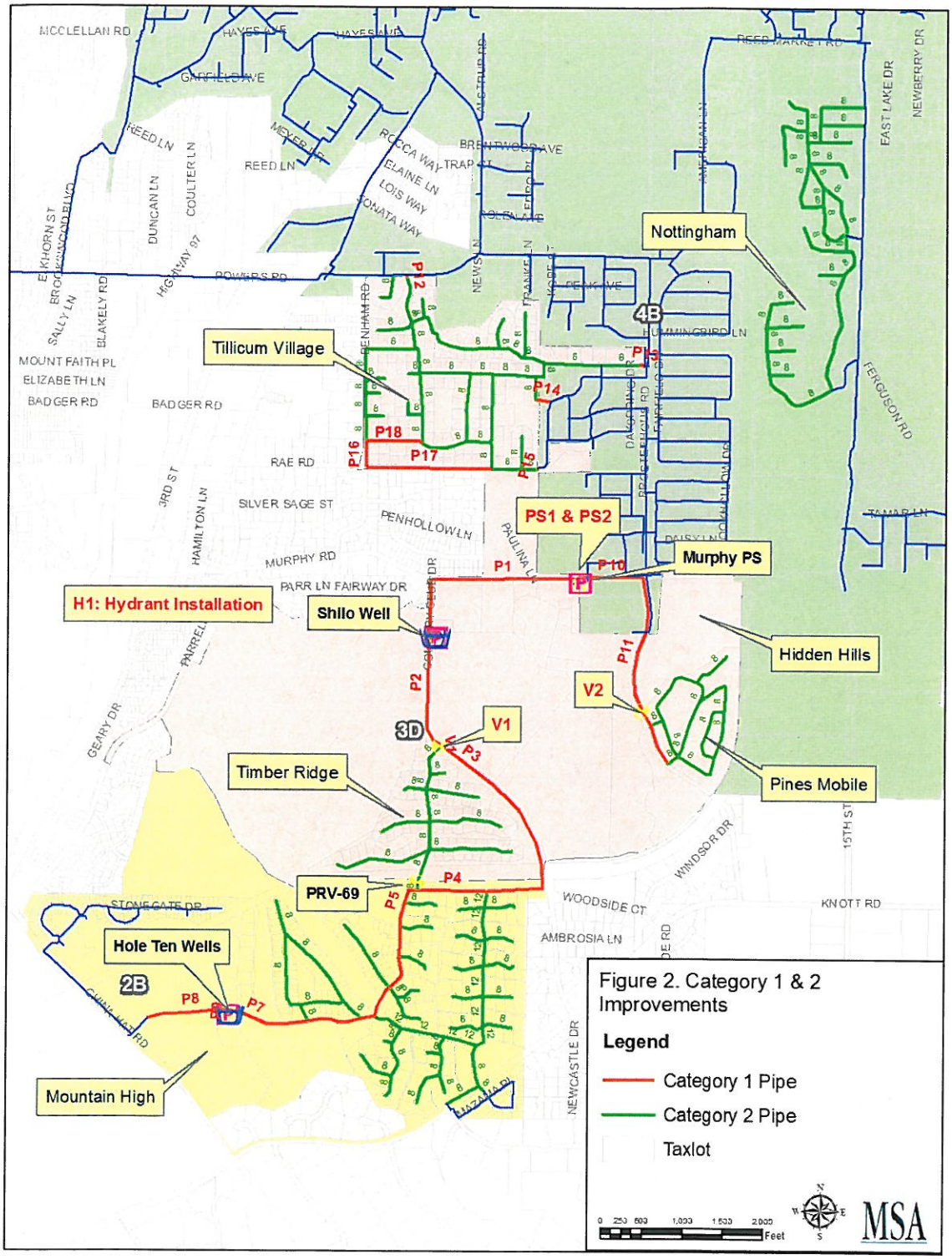
| Total Length (ft) 8-inch | Total Length (ft) 12-inch | Number of New Hydrants | Total Cost |
|---|---|---|---|
| 56,800 | 2,700 | 149 | $9,859,000 |

Table 8 includes an overall summary of costs in 2009 dollars for both Category 1 and 2 improvements associated with the former Juniper Utility.

Table 8. Total Category 1 and 2 Improvement Cost

| Category 1 Cost* | Category 2 Cost | Total Cost |
|---|---|---|
| $3,558,000 | $9,859,000 | $13,417,000 |

*Does not include upsizing costs paid by City


Nottingham
Tillicum Village
PS1 & PS2
Murphy PS
H1: Hydrant Installation
Shilo Well
Hidden Hills
V2
V1
Timber Ridge
Pines Mobile
PRV-69
Hole Ten Wells
Mountain High
P1
P2
P3
P4
P5
P7
P8
P10
P11
P12
P13
P14
P15
P16
P17
P18
4B
3D
2B
MCCLELLAN RD
REED LN
POWERS RD
BADGER RD
RAE RD
SILVER SAGE ST
PENHOLLOW LN
MURPHY RD
PARR LN
FAIRWAY DR
WOODSIDE CT
AMBROSIA LN
KNOTT RD
NEWCASTLE DR
WINDSOR DR
15TH ST
FERGUSON RD
EAST LAKE DR
NEWBERRY DR
Figure 2. Category 1 & 2 Improvements
Legend
Category 1 Pipe
Category 2 Pipe
Taxlot
0 250 500 1,000 1,500 2,000
Feet
MSA

# TECHNICAL MEMORANDUM

**DATE:** June 8, 2010

**PROJECT:** Water System Master Plan Update – Optimization Study

**TO:** Heidi Lansdowne/City of Bend, Elsie Mann/Optimatics, Mike Canning/Optimatics

**FROM:** Murray, Smith & Associates, Inc.

**RE:** Updated Capital Improvement Project (CIP) Cost Estimates

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## Purpose

The purpose of this technical memorandum is to present compiled, updated capital improvement (CIP) project cost estimate information for use in water system planning associated with the above referenced project.

## Introduction/Background

The City of Bend completed a Water System Master Plan Update in March of 2007. That plan included cost estimates for the various proposed water system capital improvement projects, such as reservoirs, pump stations and distribution mains. The current Water System Master Plan Update and Optimization Study work is intended to refine prior CIP recommendations and to provide updated project cost estimates. This technical memorandum compiles and presents 2009 CIP cost estimates for the current water system planning work.

This memo was updated in June of 2010 to include above ground concrete tanks per the City's request, however the basic cost information is still based on 2009 data to keep all numbers consistent.

## Cost Estimating Data

Updated estimated overall project costs for each improvement project recommendation associated with the current water system planning work have been developed and are presented herein. Itemized project cost estimate summaries and cost curves for certain proposed improvements are also included in this memorandum.

Cost estimates are based upon recent and historical experience with construction costs for similar work in the region and assume improvements will be accomplished by private contractors. Cost estimates represent opinions of costs only, acknowledging that final costs of

individual projects will vary depending on actual labor and material costs, site conditions, market conditions for construction, regulatory factors, final project scope, project schedule and other factors.

The project costs presented herein include estimated construction costs plus an aggregate 40 percent allowance for contingencies, engineering, administration and other project-related costs. Since construction costs change periodically, an indexing method to adjust present estimates in the future is useful. The Engineering News-Record (ENR) Construction Cost Index (CCI) is a commonly used index for this purpose. ENR provides monthly index estimates for 20 major U.S. metropolitan areas. The closest regional CCI provided by ENR is for Seattle, Washington. For purposes of future cost estimate updating, the August 2009 ENR CCI for Seattle, Washington of 8652 is referenced. It is relevant to note that the March 2007 Water Master Plan Update references the October 2006 ENR CCI for Seattle, Washington, of 8630, which is very close to the current CCI value. Consequently, some of the 2007 CIP estimates are presented herein, unchanged.

In recent years, especially in the current 2009 summer construction season, low bids for construction projects have generally been significantly lower than engineer's estimates. This year low bids have often been 20% to 50% lower than engineer's estimates. These significantly lower bids appear to reflect the current market conditions, resulting from one of the worst economic downturns in recent history. The recent bid numbers appear to reflect a highly competitive market, lower materials and labor costs, relatively low fuel costs, and the limited number of projects being advertised for bidding. Because the current construction bidding market reflects extraordinary economic conditions, it is inadvisable to rely heavily upon recent bid results in establishing long range planning cost estimates. Thus, while bid results from the 2009 construction season have been considered in developing project cost estimates, proposed estimated costs represent more of an average of project bid results over the past several years.

Updated water system capital improvement (CIP) project cost estimates for the following water system components are presented in tabular form herein:

- Groundwater Wells
- Partially Buried Concrete Reservoirs (construction on butte)
- Above Ground Concrete Reservoirs (minimal site work)
- Above Ground Welded Steel Reservoirs (construction on butte)
- Pump Stations
- Pressure Reducing Stations
- Distribution and Transmission Pipelines

Estimated costs for wells are presented in 1 MGD increments, cost curves are provided for reservoirs and pump stations and costs for pipelines are presented on a per linear foot basis.

40% of the construction cost has been added for contingency, administration and engineering to all estimates, in the following percentages respectively; 15%, 10%, 15%.

**Table 1**
**Groundwater Well - Project Cost Estimate Summary**

Groundwater well project cost estimates are based on the following assumptions:

No property acquisition costs are included, as it is generally assumed that wells will be constructed on City owned property, or property acquired at little or no cost to the project.
Estimated production of approx. 1 (mgd) with standby power generation equipment.
Well constructed to a depth of approximately 750 feet below ground surface (bgs) with 16-inch diameter steel casing, though depending on location, could vary between 400 and 1,100 feet bgs.
Construction by private contractors.

An ENR construction cost index of 8652 for Seattle, Washington (August 2009).

| Item No. | Description | Estimated Project Cost[1] |
|---|---|---|
| 1. | Mobilization | $45,000 |
| 2. | Well Construction (Drilling) | $300,000 |
| 3. | Site Work | $20,000 |
| 4. | Well House Structure | $150,000 |
| 5. | Yard Piping/Pump to Waste Facilities | $35,000 |
| 6. | Mechanical – Including Pump, Motor, Flow Meter, Control Valving and Appurtenances | $145,000 |
| 7. | Chlorination Facilities | $40,000 |
| 8. | Controls | $50,000 |
| 9. | Electrical | $65,000 |
| 10. | Landscaping/Fencing | $15,000 |
| 11. | Standby Power (Emergency Generator) | $100,000 |
| | Total Construction | $965,000 |
| | 40% Contingency, Administration & Engineering | $386,000 |
| | Total Project Cost | $1,351,000 |
| | USE | **$1,350,000** |

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

## Table 2
## 3.0 MG Partially Buried Concrete Reservoir - Project Cost Estimate Summary

Reservoir project cost estimates are based on the following assumptions:

No rock excavation included.
No property acquisition costs are included, as it is generally assumed that reservoirs will be constructed on City owned property, or property acquired at little or no cost to the project.
Construction by private contractors.
An ENR construction cost index of 8652 for Seattle, Washington (August 2009).

| Item No. | Description | Estimated Project Cost[1] |
|---|---|---|
| 1. | Reservoir Structure | $2,500,000 |
| 2. | Site Work | $750,000 |
| 3. | Drainage System – Including site storm drainage and reservoir overflow discharge | $200,000 |
| 4. | Access/Parking | $50,000 |
| 5. | Yard Piping | $175,000 |
| 6. | Electrical– Including reservoir telemetry | $75,000 |
| 7. | Landscaping/Fencing | $100,000 |
| 8. | Mob/Demob/Ins/Bonds | $250,000 |
| | Total Construction | $4,100,000 |
| | 40% Contingency, Administration & Engineering | $1,640,000 |
| | Total Project Cost | $5,740,000 |
| | USE | **$5,750,000** |

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

## Table 3
## 3.0 MG Above Ground Concrete Reservoir - Project Cost Estimate Summary

Reservoir project cost estimates are based on the following assumptions:

No rock excavation included.
No property acquisition costs are included, as it is generally assumed that reservoirs will be constructed on City owned property, or property acquired at little or no cost to the project.
Construction by private contractors.
An ENR construction cost index of 8652 for Seattle, Washington (August 2009).

| Item No. | Description | Estimated Project Cost[1] |
|---|---|---|
| 1. | Reservoir Structure | $2,500,000 |
| 2. | Site Work | $200,000 |
| 3. | Drainage System – Including site storm drainage and reservoir overflow discharge | $75,000 |
| 4. | Access/Parking | $50,000 |
| 5. | Yard Piping | $175,000 |
| 6. | Electrical– Including reservoir telemetry | $75,000 |
| 7. | Landscaping/Fencing | $100,000 |
| 8. | Mob/Demob/Ins/Bonds | $250,000 |
| | Total Construction | $3,425,000 |
| | 40% Contingency, Administration & Engineering | $1,370,000 |
| | Total Project Cost | $4,795,000 |
| | USE | **$4,800,000** |

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

## Table 4
## 3.0 MG Above Ground Welded Steel Reservoir - Project Cost Estimate Summary

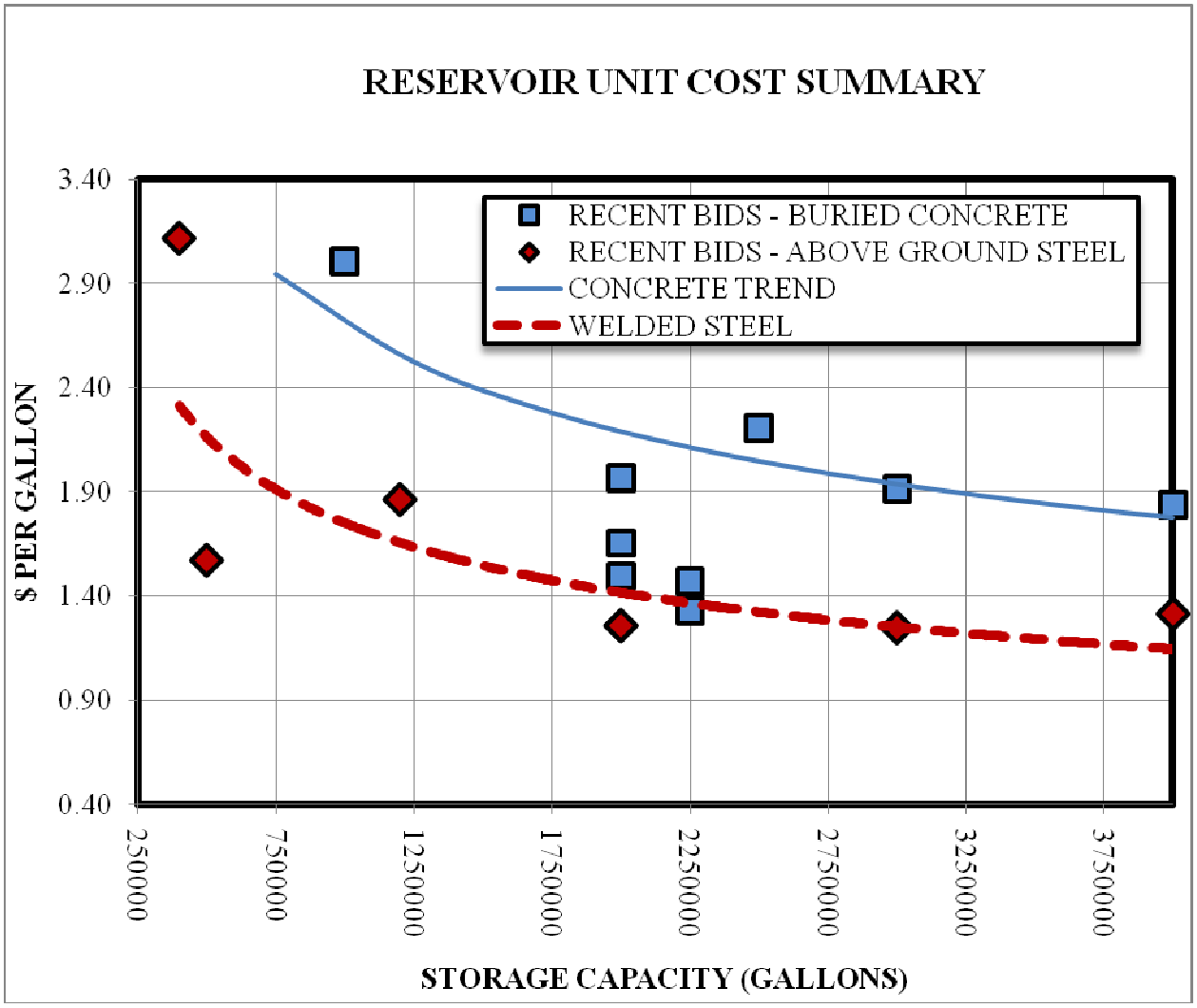
Reservoir project cost estimates are based on the following assumptions:

No rock excavation included, however significant cut and fill is included in the site work estimate, assuming construction on a hillside or butte
No property acquisition costs are included, as it is generally assumed that reservoirs will be constructed on City owned property, or property acquired at little or no cost to the project.
Construction by private contractors.
An ENR construction cost index of 8652 for Seattle, Washington (August 2009).

| Item No. | Description | Estimated Project Cost[1] |
|---|---|---|
| 1. | Reservoir Structure | $1,620,000 |
| 2. | Site Work | $450,000 |
| 3. | Drainage System – Including site storm drainage and reservoir overflow discharge | $75,000 |
| 4. | Access/Parking | $50,000 |
| 5. | Yard Piping | $175,000 |
| 6. | Electrical– Including reservoir telemetry | $75,000 |
| 7. | Landscaping/Fencing | $75,000 |
| 8. | Mob/Demob/Ins/Bonds | $155,000 |
| | Total Construction | $2,675,000 |
| | 40% Contingency, Administration & Engineering | $1,070,000 |
| | Total Project Cost | $3,745,000 |
| | USE | **$3,750,000** |

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

**Figure 1**
**Estimated Reservoir Unit Cost Curves – Concrete vs Welded Steel**




The above Figure 1 presents unit cost curves for both above ground welded steel and buried concrete reservoirs based on recent project bid results. Both of these costs assume construction on topography such as a butte. Even though the steel is assumed to be "above ground" it will require significant site work to construct on a hillside location. An above ground concrete tank (not constructed on a butte) would follow the same general trend as the buried concrete tanks with the curve shifted to intersect a point of a 3.0 mg tank costing $1.60 per gallon. Prior year bid results have been adjusted to 2009 values. Construction costs have been multiplied by 1.4 to include contingency, administration & engineering. The estimated project costs per gallon of storage are plotted against overall project costs for the two basic reservoir types. It should be noted that the above cost curves are approximations and they should be used only for general planning level estimations. Estimates for individual projects should be refined as additional project specific information may be available, such as actual field conditions, actual material and labor costs, final project scope, project implementation and other variables.

**Table 5**
**150 Horsepower (Hp) Pump Station - Project Cost Estimate Summary**

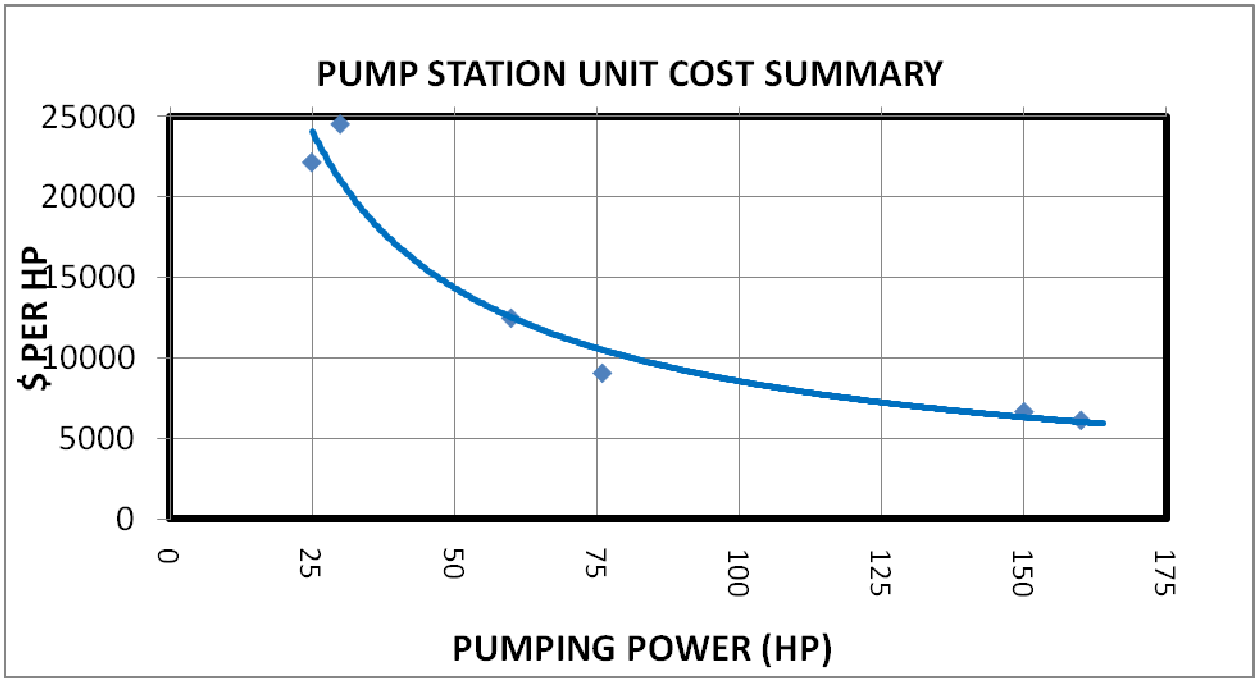
Pump station project cost estimates are based on the following assumptions:

No rock excavation included.
No property acquisition costs are included, as it is generally assumed that pump stations will be constructed on City owned property, or property acquired at little or no cost to the project.
Construction by private contractors.
An ENR construction cost index of 8652 for Seattle, Washington (August 2009).

| Item No. | Description | Estimated Project Cost[1] |
|---|---|---|
| 1. | Mobilization/Demobilization | $35,000 |
| 2. | Site Work | $35,000 |
| 3. | Structure | $160,000 |
| 4. | Yard Piping | $35,000 |
| 5. | Mechanical | $200,000 |
| 6. | Controls | $50,000 |
| 7. | Electrical | $75,000 |
| 8. | Standby Generator and Transfer Switch | $140,000 |
| 9. | Landscaping | $20,000 |
| | Total Construction | $715,000 |
| | 40% Contingency, Administration & Engineering | $286,000 |
| | Total Project Cost | $1,001,000 |
| | USE | **$1,000,000** |

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

**Figure 2**
**Estimated Pump Station Unit Cost Curve**




The above Figure 2 presents a unit cost curve for pump stations based on recent project bid results. The estimated project costs per pumping horsepower are plotted against overall project costs. As with the above reservoir cost curves this curve is based on approximations and should be used only for general planning level estimations. Estimates for individual projects should be refined as additional project specific information may be available, such as actual field conditions, actual material and labor costs, final project scope, project implementation and other variables.

## Table 6
## Pressure Reducing Stations - Project Cost Estimate Summary

Pressure reducing station project cost estimates are based on the following assumptions:
No property acquisition costs included, as it is assumed that PRVs will be constructed within the existing pipe easement and/or road right of way.
Construction by private contractors.
Station includes one 6-inch diameter pressure reducing valve and one 2-inch diameter pressure reducing valve.
An ENR construction cost index of 8652 for Seattle, Washington (August 2009).

| Item No. | Description | Estimated Project Cost[1] |
|---|---|---|
| 1. | Mobilization | $2,500 |
| 2. | Pressure Reducing Station Vault/Piping/Mechanical | $47,000 |
| 12. | Surface Restoration | $3,500 |
| | Total Construction | $53,000 |
| | 40% Contingency, Administration & Engineering | $21,200 |
| | Total Project Cost | $74,200 |
| | USE | **$75,000** |

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

**Table 7**
**Water System Piping - Project Cost Estimate Summary**

| Pipe Diameter | Cost per Linear Foot |
|---|---|
| 8-inch | $140 |
| 10-inch | $160 |
| 12-inch | $190 |
| 16-inch | $240 |
| 18-inch | $265 |
| 24-inch | $350 |
| 32-inch | $430 |
| 36-inch | $475 |

Water system piping project cost estimates are based on the following assumptions:

Construction includes ductile iron piping in roadways with pavement surface restoration
Rock excavation included in costs
No dewatering included
No property or easement acquisitions
No specialty construction included
A 40% contingency, administration and engineering allowance is included
Construction by private contractors
An ENR construction cost index of 8652 for Seattle, Washington (August 2009).

Notes: (1). The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.