Master Plan Demand and Transmission Capacity Update

Beaver Water District

Executive Summary

Lowell, Arkansas
February 2020
Project No. A19-0169

olsson

MASTER PLAN DEMAND AND TRANSMISSION CAPACITY UPDATE

Prepared for:

Beaver Water District

Lowell, Arkansas

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EXECUTIVE SUMMARY

Introduction and Scope of Services

In 2019, Beaver Water District (BWD) authorized Olsson, Inc. to update BWD's Master Plan regarding projected water demands and transmission capacity. Currently, BWD transmits water from high service pump stations at the existing treatment facilities through water transmission mains that are owned and operated by BWD's four customer cities (Bentonville, Rogers, Springdale, and Fayetteville). The existing treatment facilities are located on the east side of the service area. A previous Regional Growth Study, performed for BWD by others in 2006, identified the need for a future transmission point approximately six miles west of BWD's existing treatment facilities on the western side of the service area, since a majority of the region's growth in future design horizons was predicted to occur west of I-49. This future transmission system became known as the "Western Corridor".

BWD's four customer cities have also included the Western Corridor in their recent master plans. In 2011, Carollo in association with Olsson (formerly McGoodwin, Williams & Yates) prepared a preliminary design report for the Western Corridor Pipeline and Pump Station, including a preliminary transmission route. Since that time, Olsson has worked with BWD to assist in easement document preparation and to revise and refine the route due to continued development in the area.

The primary purpose of this study is to update the demand projections for the four customer cities and prepare a recommended implementation schedule and opinions of probable cost for transmission improvements, including the Western Corridor, as well as upgrades to the high service pump station at the existing water treatment plant. To accomplish this task, the scope of work included the creation and use of a hydraulic water model including all four cities.

Considering potential changes associated with the implementation of the Western Corridor, BWD's existing master plan was also evaluated and updated in a few key areas:

- Computational Fluid Dynamics (CFD) modeling of the existing high-service pump station wet well was completed to determine if the flow patterns in the wet well affect the performance of the existing and proposed pumps due to vortices, jets, etc. and to evaluate compliance with Hydraulics Institute standards.
- Contact time (CT) in the existing clearwell was evaluated to determine the need for improvements or modifications.

- Opinions of probable cost for recommended improvements and transmission main alternatives were developed.
- Existing opinions of probable cost for capital improvements identified in BWD's current master plan were reviewed and updated for current construction market pricing based on best judgement and available data.

Projected Water Demands

Future water demands were projected from current demands using future growth rates, and several factors were considered when determining the appropriate future growth rates for each customer city. Future demand growth rates were chosen based on (1) historical demand growth rates, (2) population growth rates, and (3) projected demand growth rates from the previous master plans for each city. These rates were used to project future average day demands. A maximum to average day ratio of 1.88 was chosen based on historical demand data and was used to determine the projected maximum day demands. Based on the results of the analyses, projected average day and maximum day demands for each of the customer cities are shown below.

Projected Future Water Demands

Year	Bentonville		Rogers		Springdale		Fayetteville		Total Demand	
	Average Day (MGD)	Maximum Day (MGD)	Average Day (MGD)	Maximum Day (MGD)	Average Day (MGD)	Maximum Day (MGD)	Average Day (MGD)	Maximum Day (MGD)	Average Day (MGD)	Maximum Day (MGD)
2019	10.1	19.0	10.4	19.5	18.0	33.9	17.0	32.0	**55.5**	**104.4**
2025	12.1	22.8	12.0	22.6	20.9	39.2	18.9	35.6	**63.9**	**120.2**
2030	14.1	26.5	13.6	25.5	23.5	44.3	20.7	38.8	**71.9**	**135.1**
2035	16.4	30.7	15.3	28.8	26.6	50.0	22.6	42.4	**80.9**	**151.9**
2040	19.0	35.7	17.3	32.4	30.0	56.4	24.7	46.3	**91.0**	**170.8**

Hydraulic Model Creation

To aide in the conceptual design of the future Western Corridor project, a hydraulic model was created that includes BWD's high service pump station facilities and the distribution systems of the four customer cities. This task was accomplished by obtaining and updating the existing models for each city and then combining them to develop one large model with current water demands. This new, combined model was calibrated to actual field conditions and was then used for the conceptual design of the Western Corridor.

Each customer city updates their hydraulic model and master plan on a slightly different cycle. Therefore, it was important to update current and future water demands for all four cities to ensure the combined model created for this project contains current data.

To determine what infrastructure updates were necessary for each city's model, Olsson met with staff from each customer city and reviewed their most recent water master plan. Through this process, infrastructure improvements that had been constructed since the models were last updated were identified and each city's planned CIP was reviewed. Proposed infrastructure that could have an impact on the design of the Western Corridor project was added to the model.

After 2019 demands were input into the current average and maximum day scenarios in the model, additional scenarios were created for the average and maximum days in five-year increments from 2025 through 2040.

Western Corridor Pipeline and Pump Station Conceptual Design

The hydraulic model was used to perform a conceptual design of the Western Corridor pipeline, which will convey treated water from the plant to the Western Corridor pump station via differential in head in lieu of pumping. Multiple alternative pipe diameters ranging from 48 to 72 inches were evaluated. Several factors were taken into consideration when selecting the recommended size including future capacity, water age, pipe velocity, and pipe pressure.

The size of the pipeline should have adequate capacity to meet demands and maintain pressure in the system while not having such excess capacity that could significantly increase water age in the system and thereby increase the formation of disinfection by-products (DBPs). The hydraulic water model indicates that instantaneous flow rates of approximately 36,000 gpm may occur in the Western Corridor pipeline at the 20-year design horizon. Based on the analysis, a pipeline with a nominal diameter of 60-inches will meet the demands of the system through the 20-year design horizon, while still providing some additional capacity to allow flexibility should demands be higher than anticipated.

Based on discussions with BWD, a maximum water age in the Western Corridor pipeline of 24 hours was chosen as a design parameter. Using the model, it was determined that either the City of Fayetteville or Springdale Water Utilities (SWU) will have sufficient demands in their system to turn the water over in a 60-inch pipeline in 24 hours or less regardless of when the other customer cities connect to the Western Corridor.

The velocity in the pipeline was also evaluated. Based on industry standards and discussions with pipe manufacturers, design parameters for the Western Corridor pipeline included maintaining water velocities under 7.5 feet per second (fps). Based on the flow rates through the Western Corridor pipeline predicted by the model, the use of pipeline diameters less than 60 inches resulted in velocities higher than 7.5 fps.

For the Western Corridor pump station, a single building housing all the pumps for the four customer cities is recommended. This design conserves space on the site, is more cost effective, and has greater simplicity of operation. While projected pump sizes were placed in the water model for analysis purposes, it is recommended that the pump sizes and pump station configuration be determined through a future preliminary engineering study that can take efficient operation, cost effectiveness, and other factors into consideration.

Hydraulic Modeling Results for Distribution System with Western Corridor

Using the hydraulic model and the conceptual design of the Western Corridor infrastructure, extended period simulations were performed to determine the impact of the Western Corridor on the system during different design horizons.

The model was first run with existing infrastructure and the planned high service pump upgrades at BWD to determine what year the Western Corridor will become necessary. Various large-diameter pipelines and storage tanks in each city were monitored to determine if each modeling scenario was likely to meet demands and maintain pressures in the system. The model indicates the addition of the Western Corridor before the 15-year design horizon will be necessary. When the Western Corridor was added to the model for the 15-year design horizon, the model indicated 15-year and 20-year demands were met with no issues maintaining pressures or filling and cycling tanks.

The water age at DBP sampling locations across all four cities decreased in several areas in the western region of the system and remained relatively unchanged in the rest of the system with the addition of the Western Corridor infrastructure; as such, the DBP levels in the system are unlikely to be negatively impacted by the implementation of the Western Corridor. Therefore, the addition of the Western Corridor and its associated infrastructure by the 15-year design horizon should allow the customer cities to meet their water demands through 2040.

Although meeting demands is one of the primary objectives for each city, there are other operating parameters in each system that need to be taken into consideration as well. Based on a recent water master plan study performed by others for SWU, the city’s current water system is in immediate need of assistance to meet demands and maintain pressures in the southern and western regions of the water service area. Based on the growing need to convey water to these regions and the limited corridors to construct new large diameter in-system transmission lines through the city, SWU has indicated they need to have the Western Corridor in operation by 2026 as an additional connection point in the western part of their system.

Based on the request from SWU, the Western Corridor was added to the 5-year and 10-year modeling scenarios. Since demands could be met throughout the system with the Western Corridor for these design horizons, the primary design consideration became the water age in the Western Corridor pipeline. Utilizing the hydraulic model, the water age was evaluated in the pipeline with only SWU connected. According to the analysis, a minimum flow rate through the Western Corridor pipeline of 5,000 gpm would be necessary to maintain a preferred water age of 24 hours or less. According to demand projections, SWU should have sufficient demand on an average day to meet this criterion for the 5-year design horizon.

The results of the model indicate if the Western Corridor were implemented for SWU at the 5-year design horizon and the other three cities at the 15-year design horizon, demands should be met and appropriate water age maintained for all four cities through the 20-year design horizon.

CFD Modeling of High Service Pump Station Wet Well

As demands increase throughout Northwest Arkansas, each city's high service pumps at BWD will require upgrades and/or replacements. It is possible that the changes to the pump arrangement could result in performance issues due to vortices, jets, etc. Thus, computational fluid dynamics (CFD) modeling was coordinated by Olsson and performed by Flow Science, Inc. to evaluate the existing high service pump station wet well and determine if the proposed changes in BWD's 2015 Master Plan would negatively impact the performance of the existing and proposed high service pumps. Scenarios were developed for both the existing pump configuration and the proposed future buildout configuration. For both scenarios, the flow path and velocity in the wet well, the velocity and attack angle at the pump intake bells, and the velocity differences at critical points in the pump shaft were analyzed to determine if they were in compliance with the Hydraulics Institute (HI) standards.

The CFD model indicates the open design of the wet well may allow some vortexing to occur in both the existing and future scenarios, and increased flow rates in the future could create more defined vortices in the wet well. The model also indicates that flow rates through the inflow pipes are somewhat unevenly distributed. The flow velocities at the pump intakes are generally within range, although the velocity is slightly too low for the two smallest pumps and pump 7-P-9 is anticipated to have high velocities in the future. In addition, the model indicates approach velocities are greater than current HI standards due to jets from the inflow pipes.

All pumps meet the current HI standard for attack angle and velocity differences. The pumps are slightly outside of the recommended range permitted by current HI standards for the height allowance and centerline distances.

Although the CFD model indicated that a few deviations from HI standards may exist, the current operation of the pumps is not problematic and any significant changes to the layout of the wet well may not be feasible to construct. In addition, these findings have not identified any critical needs. Therefore, no changes are recommended for the existing wet well.

Clearwell Contact Time Evaluation

Given the potential changes in clearwell operation that may occur in the future as additional high service pumps are added in the wet well and the Western Corridor is placed into service, an analysis was performed to determine how long the existing treatment facilities (before future treatment expansions or the addition of the Western Corridor) would be able to continue meeting CT requirements. A flow rate of 155 MGD was used in the analysis as that was determined to be the maximum flow rate through the clearwell when the high service pumps are at buildout and the backwash pumps are in operation. With this flow rate, the analysis indicates there should be no cases in which the CT drops below the minimum required amount unless multiple CT variables reach their historic extreme values simultaneously, which is an unlikely scenario.

Of the three CT variables that can be controlled (pH, clearwell depth, and chlorine residual concentration), pH appears to have the greatest impact on CT followed by disinfectant residual and then clearwell depth. Even given a conservative evaluation (with maximum flows during the winter and multiple variables simultaneously hitting historic extremes), the date for requiring additional clearwell volume to meet CT would be 2031, which is still later than the 2028 date projected by the 2015 Master Plan. This is likely due to the use of a minimum acceptable CT of 0.5 in the analysis, rather than the more conservative factor of 0.75 used in the 2015 Master Plan, in addition to other factors.

The Western Corridor is anticipated to be placed in operation beginning in 2026 and will reduce the flow through the existing clearwell. Actual operation of the Western Corridor at startup will involve sending a minimum of 5,000 gpm of treated water to the west to serve a portion of SWU’s demand and maintain a water age in the corridor of 24 hours or less. This will decrease the flow rate through the clearwell by 7.2 MGD. As the flow decreases, it will become easier to meet CT; thus, the implementation of the Western Corridor will delay the need for a new clearwell by two years. The sensitivity analysis shows that CT should be achievable in the existing clearwell past the planned 2030 date of the BWD plant expansion. If it is assumed a new clearwell would be required on the more conservative date of 2028 given by the 2015 Master Plan prior to the implementation of the Western Corridor, then the change in flow associated with the addition of the Western Corridor extends the life of the clearwell to 2030 at a minimum. When the plant expansion occurs, construction of a new clearwell would be preferable, regardless of CT, to maintain 10% of the plant’s daily treatment capacity as storage.

In summary, CT is not likely to be a controlling factor in the future development of BWD's facilities.

Western Corridor Implementation Schedule

Based on SWU's need for the Western Corridor by 2026, the following implementation schedule is recommended for the Western Corridor project. The schedule includes sufficient time for design and construction in order to place facilities in operation before 2026.

Western Corridor Implementation Schedule

Milestone Description	Start	End
Acquire Easements	2/1/2019	12/31/2020
Select Consultants & Negotiate Contract	10/1/2019	6/30/2020
Pre-Design and Environmental Studies	7/1/2020	6/30/2021
Detailed Design	7/1/2021	12/31/2022
Regulatory Review and Bid Phase	7/1/2022	6/30/2023
Construction	7/1/2023	12/31/2025

*FY - Beaver Water District Fiscal Year

Opinions of Probable Cost

Opinions of probable construction cost were developed for the Western Corridor infrastructure and are shown below. For conservative purposes, pricing for ductile iron pipe was used in the opinion of probable cost for the Western Corridor Pipeline. A more detailed analysis of pipe materials is recommended to determine the best value, including reliability, capacity, and cost, before beginning detailed design of the pipeline. Land acquisition costs were not included in the pipeline or pump station cost estimates but are expected to be approximately $4 million for the pipeline based on currently available easement costs and appraised values.

Western Corridor Cost Summary

Description	Pipeline	Pump Station
Construction	$49,100,000	$13,451,000
Contingencies	$10,960,000	$3,003,000
Total Probable Construction Cost	$60,060,000	$16,454,000
Engineering and Legal	$9,009,000	$3,291,000
Total Probable Project Cost	$69,069,000	$19,745,000
**All costs are in 2019 dollars. Costs exclude land acquisition and easements.*		

In addition to the conceptual design and opinion of probable cost of the Western Corridor, opinions of probable cost for BWD's other capital improvement projects were updated. BWD's current overall master plan was performed in 2015 and published in 2016 by Black & Veatch. Since that time, notable changes to construction costs have occurred. The scope of this study does not include evaluation of treatment and process improvements, but the CIP opinions of probable cost were updated to reflect current construction market pricing. The updated costs are summarized in Section 6.2 of the report and detailed in Appendix D.