AWWA Texas Water 2007

Lake Tawakoni Water Supply Project, Design and Construction Issues for Fast-Tracking a $100 million Water Transmission Project

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ABSTRACT

Since its formation in 1951, the North Texas Municipal Water District has been charged with developing a reliable water supply source for its 13 member cities and 46 other customers (some direct and some indirect), including more than 1.5 million people in portions of north Texas. The District's service area covers portions of Collin, Dallas, Denton, and Kaufman Counties and all of Rockwall County. Recent long-range water supply planning efforts have identified significant increases in water demands that must be met through a corresponding increase in available raw water supply. Compounding the need for raw water is the fact that the North Texas region is currently in the second year of a drought that is the worst on record since the 1950s, with the District's primary water supply reservoir, Lake Lavon, falling some 17 feet in water surface elevation since mid-2005.

In an effort to supplement available supplies, the District contracted for 50,000 acre-feet of water per year from the Sabine River Authority in Lake Tawakoni, located approximately 45 miles east of Dallas in October 2005. Given current drought conditions and ominous rainfall forecasts, the District has requested that the infrastructure needed to transfer this water from Lake Tawakoni to Lake Lavon be in service no later than October 1, 2007, to prevent further water restrictions and possible water rationing. The infrastructure needed includes approximately 30 miles of 54 and 60-inch-diameter transmission pipeline and two pump stations, each with a raw water pumping capacity of 75 MGD. The estimated project cost is $100 million. Critical path issues for meeting the highly accelerated schedule include overall project team coordination; route selection; environmental permitting considerations; easement and property acquisition; power supply; equipment delivery; and construction of multiple project components simultaneously. The focus of this paper will be a discussion of the major project components and design features that will enable the construction of the multi-million dollar project on a highly accelerated schedule.

INTRODUCTION

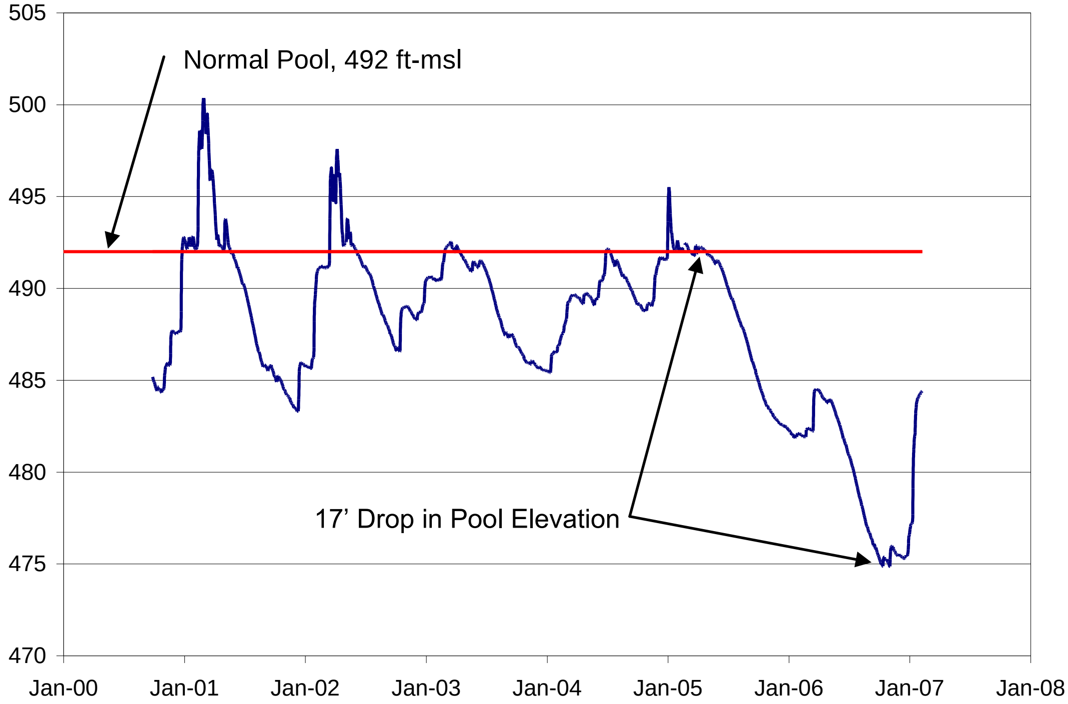
The North Texas Municipal Water District is a water supply and reclamation district created by an act of the Texas Legislature in 1951. The District generally serves a five county, 1,975 square-mile area encompassing portions of Collin, Dallas, Denton and Kaufman Counties, and all of Rockwall County. The District provides treated water to 13 member cities and 46 other customers (some direct and some indirect), which have a combined population of more than 1.5 million people. The District supplies wholesale treated water to one of the fastest growing areas in the United States. Some cities in the District's service area have experienced nearly 10% compounded growth rates in the last 10 years.

The District currently obtains its raw water supply from Lake Lavon, Lake Texoma, Lake Chapman, and reuse of treated wastewater effluent from the Wilson Creek Regional Wastewater Treatment Plant. Currently, the District has approximately 274,000 acre-feet of permitted water rights from all sources combined. Raw water from Lake Texoma is diverted via a 90 million gallons per day (MGD) pump station and 25 miles of 72-inch pipe to the West Prong of Sister Grove Creek near Howe, Texas. Once discharged into the West Prong of Sister Grove Creek, the water diverted from Lake Texoma then flows by gravity to Lake Lavon. Raw water from Lake Chapman is diverted via a 110 MGD pump station on Lake Chapman and pumped through 39 miles of 84-inch pipeline to Hickory Creek, where Lake Chapman water flows into the Pilot Grove Creek arm of Lake Lavon. Treated effluent from Wilson Creek WWTP is discharged into the East Fork arm of Lake Lavon. The District already has gone to great effort to move significant volumes of raw water to Lake Lavon from surrounding reservoirs. The District is constantly and continuously exploring all available avenues and options to obtain additional water supplies to meet their ever growing demands. The addition of 50,000 acre-feet from Lake Tawakoni is the most recent example and is the focus of this paper.

PROJECT NEED / PROJECT DESCRIPTION

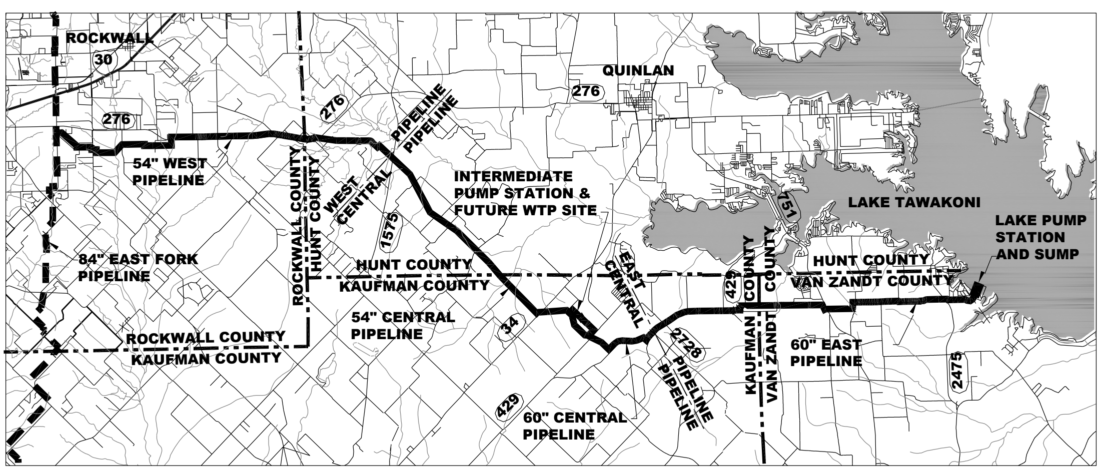
In an effort to supplement available supplies, the District contracted for 50,000 acre-feet of water per year in October 2005 from the Sabine River Authority in Lake Tawakoni, located approximately 45 miles east of Dallas. Given current drought conditions and ominous rainfall forecasts, the District has requested that the infrastructure needed to transfer this water from Lake Tawakoni to Lake Lavon be in service no later than October 1, 2007, to prevent further water restrictions and possible water rationing. As shown in Figure 1, Lake Lavon, the District's primary raw water supply source, has dropped as much as 17 feet in elevation since mid-2005. Rain in early 2007 has produced an increase in elevation; however, the lake is still more than seven feet below normal pool.

Figure 1. Lake Lavon Pool Elevation



The infrastructure needed to convey the Tawakoni water to Lake Lavon includes approximately 30 miles of 54 and 60-inch-diameter raw water transmission pipeline and two pump stations, each with a raw water pumping capacity of 75 MGD. As shown in Figure 2, these facilities will connect to the District’s East Fork Raw Water Conveyance Pipeline, which is currently under construction, to convey additional raw water from a constructed wetland near Combine, Texas, to Lake Lavon.

Figure 2. Overall Project Area



Each of the project components is described in more detail below, followed by a discussion of the various construction bid packages/contracts used to accelerate the schedule and a project update.

PROJECT COMPONENTS AND KEY DESIGN ELEMENTS

The major project components are listed below. Each is discussed in more detail in the following sections.

- Lake Tawakoni Pump Station and Intake: The Lake Pump Station includes an electrical substation with provisions for temporary power, four 25 MGD (1750 hp) vertical turbine pumps installed in a circular wet well with a firm capacity of 75 MGD, two variable frequency drives and a connection to an existing raw water intake pipeline.
- Intermediate Pump Station: The Intermediate Pump Station includes an electrical substation with provisions for temporary power, three 22.5 MGD (1500 hp) horizontal split-case pumps, and a 6 MG ground storage tank.
- Tawakoni Raw Water Pipeline: The Raw Water Pipeline includes approximately 12 miles of 60" pipeline between the Lake Pump Station and the Intermediate Pump Station Ground Storage Tank and about 18 miles of 54" pipeline between the Intermediate Pump Station and the East Fork Conveyance Pipeline connection.

Lake Tawakoni Pump Station and Intake

Prior to beginning design of the pump station, an evaluation of multiple sites on Lake Tawakoni was completed. All of the sites considered were within a few miles of each other along the western shore of the lake. A matrix was used to rate each option based on several key factors (a rating of "5" being the best and "1" being the worst). These factors are included in the matrix provided in Table 1 and are discussed below.

Environmental Conflicts/Permitting: This criterion evaluates the need for environmental permitting at each site. As shown by the relative weighting of each criterion, this was considered one of the most important factors in selecting a site. A site with minimal environmental permitting requirements would be ranked higher than a site requiring notification of the US Army Corps of Engineers. Nationwide Permits in many cases require no Corps notification, Regional Permits can take months to obtain and require some Corps involvement, while individual permits can take a year or more and require a high level of Corps involvement.

Time Required for Construction: This criterion evaluates the magnitude and complexity of the facilities required and therefore the length of time it will take to construct them. Because of the accelerated schedule, a facility that can be constructed quickly is considered desirable.

Distance to Deep Water: A study was completed to asses the reliability of an intake on Lake Tawakoni at a given elevation. For reference, the normal pool elevation of Lake Tawakoni is 437.5 ft-msl. The study modeled the drought of record with projected water use and sedimentation through 2060. The study indicated that the lake does not drop below 390 ft-msl during the 696-month study period and drops below

400 ft-msl in only 4 months out of 696, or is over 99% reliable. Based on this study, access to water at elevation 400 ft-msl was considered necessary since this would be the only access point for the District to Lake Tawakoni. This criterion indicates the size and magnitude of the proposed intake, which contributes to overall construction schedule. The further the facility is from deep water, the longer the intake piping, and the longer the construction duration and the greater the cost.

Table 1. Lake Pump Station Site Comparison Matrix

Item	Criteria	Weight	Site Options				
			Dew Point	Terrell	Autumn Point	Spring Point	Dallas
1	Distance to Deep Water (400' MSL)	10%	4	2	5	3	1
2	Distance to Electrical Service	10%	1	2	3	4	5
3	Additional Pipeline Length	10%	1	2	3	4	5
4	Environmental Conflicts / Permitting	20%	4	5	1	1	3
5	Time Required for Construction	20%	4	5	2	2	4
6	Site Access	10%	3	4	1	1	4
7	Flooding Potential	5%	2	3	4	3	3
8	Conflicts w/ Public	5%	5	4	1	1	4
9	Ability to Purchase Property	5%	4	5	1	1	2
10	Room for Expansion	5%	4	3	2	1	5
Totals		**100%**	**3.25**	**3.75**	**2.20**	**2.10**	**3.60**

Distance to Electrical Service: Keeping the accelerated project schedule and overall cost in mind, the distance to electrical service was considered a key component in the evaluation of options. The extension of power lines is not only costly, but also very time consuming when utilities are required to obtain certification for new facilities from the Texas Public Utilities Commission. Therefore, a site that is closer to an existing power supply is ranked higher than one that is further away.

Additional Pipeline Length: This criterion considers primarily the impact to the overall construction cost of the pipeline required to connect the pump station to the main transmission pipeline alignment. A shorter pipeline is not only less costly to construct, but would result in lower power costs and also may reduce easement acquisition time by reducing the number of affected landowners.

Site Access: Existing access to the site is critical since large trucks and equipment will be required to construct the facilities. If existing access is not adequate, new roads may be required, which could involve lengthy coordination with local governments for right-of-way or roadway improvements.

Other Factors: Several other factors considered in the evaluation included flooding potential, public involvement issues, the availability of land, and room for expansion.

As shown in the decision matrix, the Terrell Site was the highest ranked option and ultimately the site selected for the pump station. This option was deemed the most desirable because it is located on a peninsula with two existing pump stations. The two existing pump stations share an existing intake on Lake Tawakoni. By agreement, the District will be able to connect to the existing intake piping on shore by constructing a vertical shaft over the intake pipe and tapping the pipe to connect it to the Lake Tawakoni Pump Station wet well. This will eliminate the need for Corps of Engineers notification and individual 404 permitting, since no construction will occur in the lake. Not only will on-shore construction eliminate lengthy environmental permitting, but it will also allow construction to proceed quickly since nothing will be required in the lake.

Figures 3 and 4 provide a general floor plan and section of the proposed facility. Major components of the facility include the 14-foot-diameter intake vault with 72-inch-diameter suction pipe, 36-foot-diameter wet well, four 25 MGD vertical turbine pumps with 30-inch and 60-inch-diameter discharge piping, pump control ball valves and a 60-inch-diameter discharge header.

Figure 3. Lake Tawakoni Pump Station Floor Plan

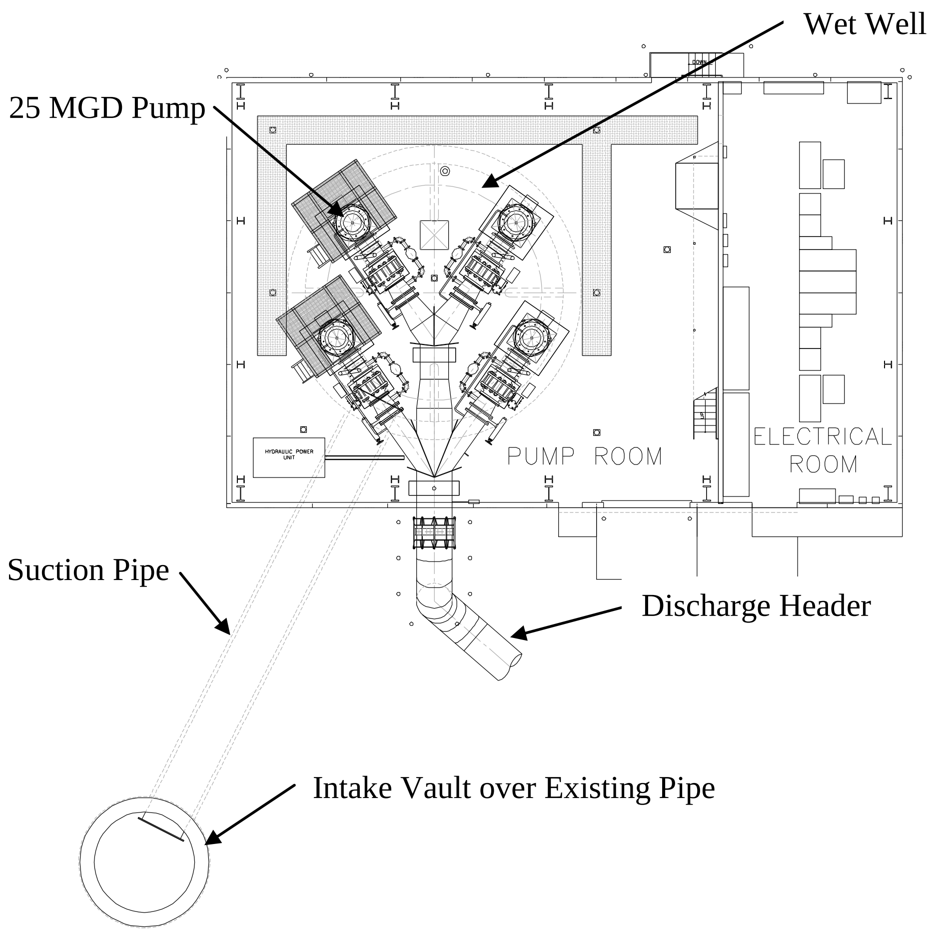
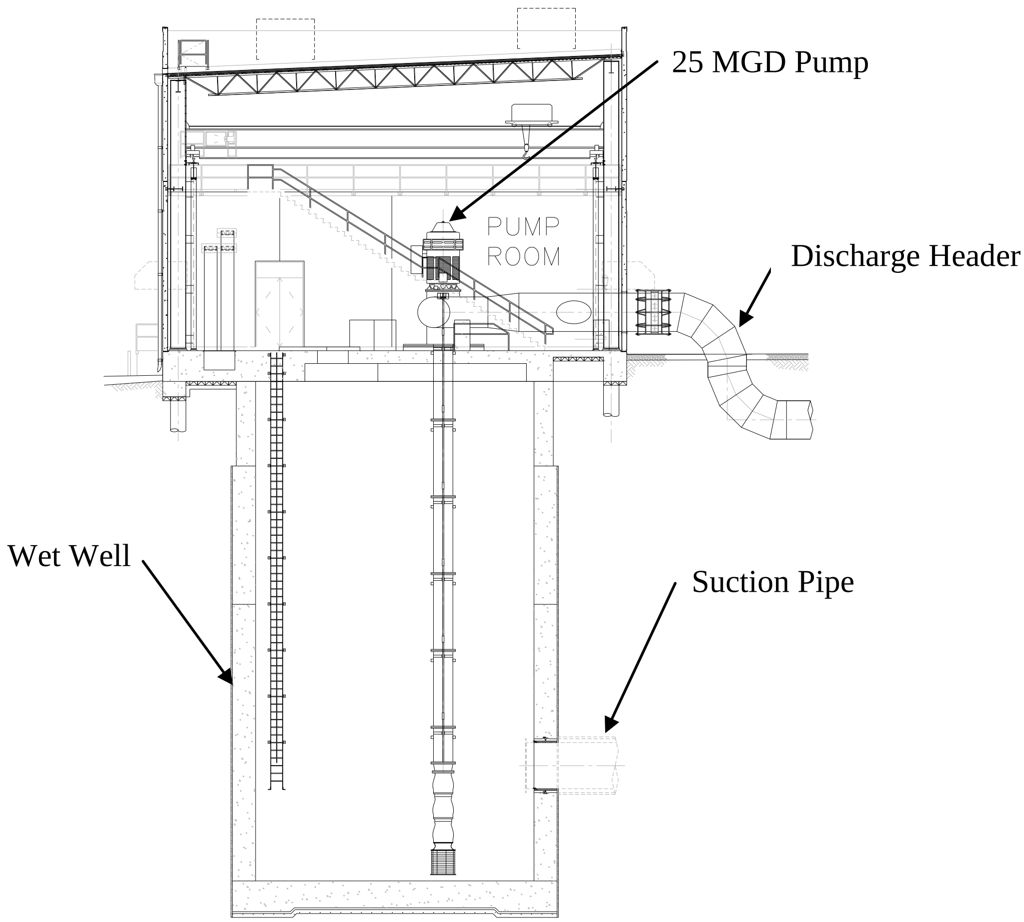


Figure 4. Lake Tawakoni Pump Station Section



Also considered in the design were provisions for interconnects between the District's new raw water pump station and the yard piping for the two existing pump stations. These interconnects were included as a way to improve raw water supply reliability for the other utilities and to improve the likelihood of reaching an agreement to share the use of the existing intake facility.

Intermediate Pump Station

Similar to the Lake Tawakoni Pump Station, early design efforts were focused on locating a site. While selection of a site at the lake generally centered on avoiding environmental impacts and permitting, selection of a site for the Intermediate Pump Station was largely driven by the site's access to future customers, the availability of power supply and the availability of land for a future water treatment plant in the District's South Treated Water Distribution System. A matrix approach was again used to aid in the selection of a location, with potential options ultimately narrowed to two that were considered in the final analysis. Each criterion was weighted based on relative importance and the options compared for each criterion (a "1" indicates the site meets the specified criterion, a “0” indicates it does not). The final matrix and descriptions of the key criterion are provided in Table 2 below.

Table 2. Intermediate Pump Station Site Comparison Matrix

Decision Criteria	Weight	East WTP Site		West WTP Site	
		Rating	Points	Rating	Points
Topography	5%	1	5	1	5
Available Land	15%	1	15	0	0
Site Access for Trucks	5%	1	5	1	5
Power Supply	30%	0	0	1	30
Hydraulics	10%	1	10	1	10
Access to Future Customers	30%	1	30	0	0
Cost	5%	0	0	1	5
Totals	**100%**		**65**		**55**

<u>Access to Future Customers:</u> Given the District’s general operating philosophy of being a regional water provider, access to potential customers was considered a high priority in locating a site for the future water treatment plant and pump station. The pump station and treatment plant will be located on the same site to allow for conversion of the station from raw water to treated water pumping in phases as the water treatment plant is constructed.

<u>Power Supply:</u> Similar to the Lake Tawakoni Pump Station, the distance to electrical service was considered a key component in the evaluation of options from both a cost and schedule perspective. At the Intermediate Pump Station, this became a key factor since electrical service in both locations would require significant coordination with service providers and eventually the Texas Public Utilities Commission.

<u>Available Land:</u> Because a future treatment plant will be constructed at the site, enough land is required to accommodate the Intermediate Pump Station and the future treatment plant facilities. Preliminary layouts indicated that a site of at least 100 acres was required to accommodate the proposed facilities. Another consideration in evaluating available land was the owner’s willingness to sell, since quick negotiations would reduce rework during design if site acquisition were to fall through.

<u>Other Factors:</u> Other factors considered in the evaluation of sites included treatment plant and overall system hydraulics, site topography and the ability to construct a gravity-driven treatment process, site access, and land cost.

As shown in the matrix above, the East WTP Site was ranked the highest and ultimately selected for final design. This site is situated in the heart of numerous water supply corporations, special utility districts, and other utilities that have expressed an interest in purchasing water from the District's proposed plant. In addition, the site is located in an area where the local utility was planning expansion of their electrical distribution system and construction of a new substation. This will greatly reduce the time needed to secure permanent power at the location, since upgrades to the system in this area were already in the early planning stages. Finally, a landowner was identified where a site of adequate size could be obtained quickly.

Figures 5 and 6 provide a general floor plan and section of the proposed facility. Major components of the facility include the 6 MG ground storage tank (not shown), the 60-inch-diameter by 36-inch-diameter suction manifold piping, three 22.5 MGD horizontal split-case pumps with three empty slots for the addition of pumps during conversion of the station from raw to treated water, the 54-inch by 36-inch discharge manifold piping with pump control ball valves, and an electrical room.

Figure 5. Intermediate Pump Station Floor Plan

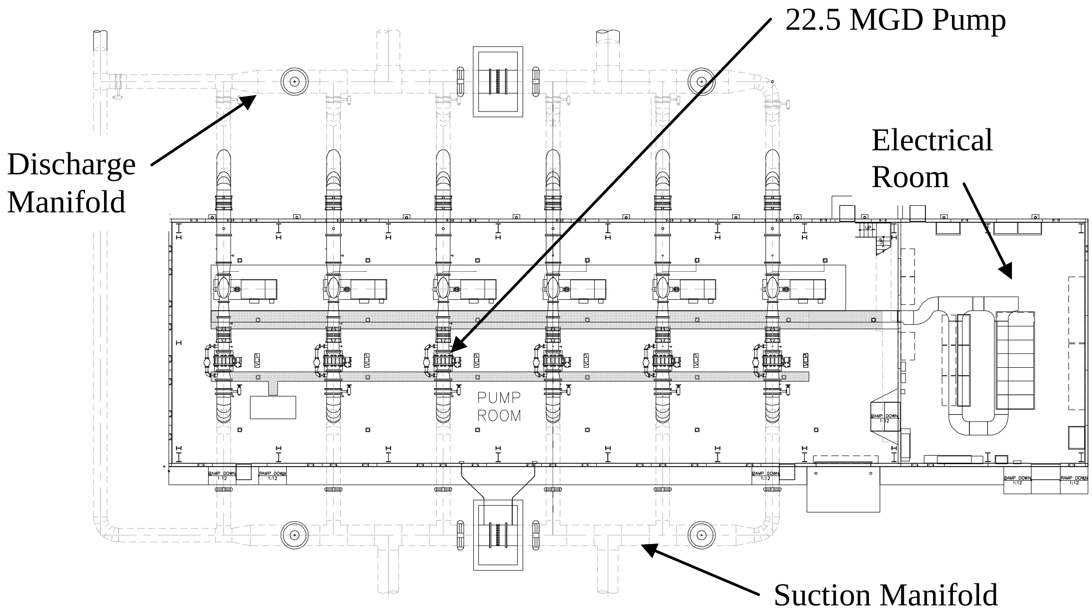
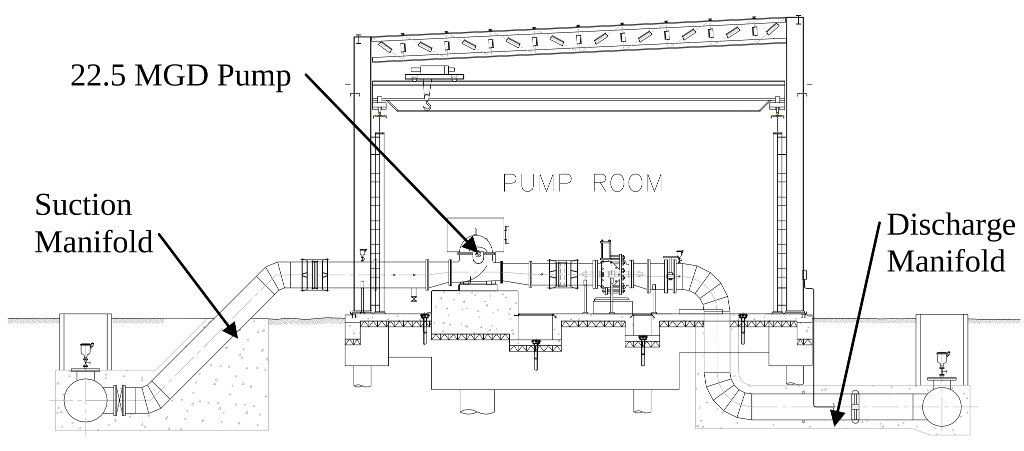


Figure 6. Intermediate Pump Station Section



Tawakoni Pipeline

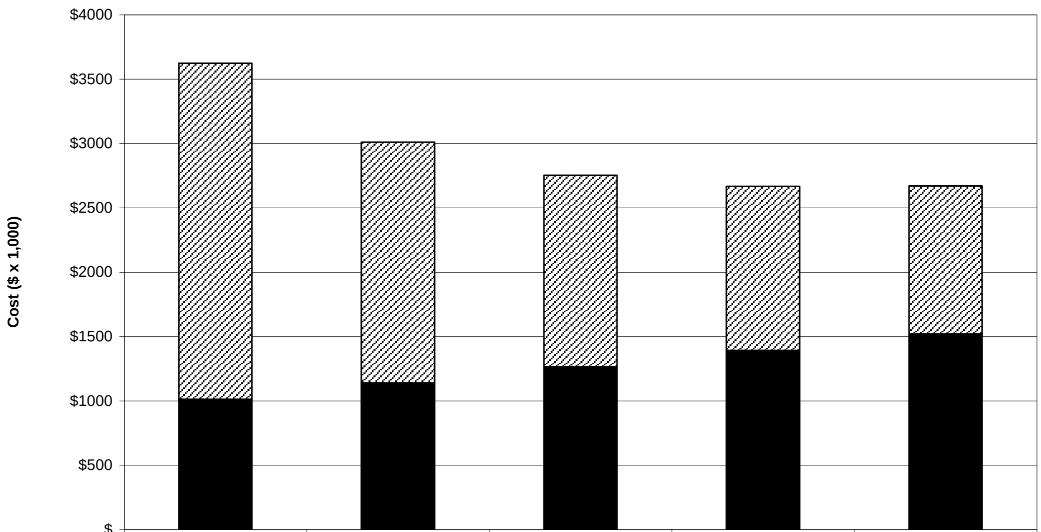
Selection of the pipeline alignment was primarily dependent on the locations of the Lake and Intermediate Pump Sites. Once these sites were determined, alternative pipeline alignments were explored in an effort to select a direct route and to minimize environmental permitting and potential land owner issues. Preliminary alignments were generally designed to follow existing roads, utility corridors, and major property boundaries. Once a general alignment was selected, pipeline route evaluation land classifications were developed to compare specific routes along the proposed alignment. Land classifications included: Rural-Open, Rural-Wooded, Urban-Congested, Creek Crossings, Road Crossings, and Tunnel Crossings. Installation cost factors were developed to take into account the varying costs of pipeline construction for the different land classifications. Costs for land acquisition of 40-ft permanent and 60-ft construction easements were also considered in the comparison of alignment options.

A pipe diameter cost optimization analysis was conducted to compare annual power (pumping) costs and capital costs for different pipe sizes and flow conditions. Two independent sections of the pipeline were evaluated, including the section from the Lake Pump Station to the Intermediate Pump Station Ground Storage Tank and the section from the Intermediate Pump Station to the connection to the East Fork Conveyance Pipeline. Assumptions used in the optimization study included a service life of 25 years, a discount factor of 5%, and a power cost of $0.08 per kilowatt-hour (kWh).

For the section of pipe between the lake and the ground storage tank, the optimization is relatively straightforward. An ideal operating scenario would be to pump the total 50,000 acre-feet at 75 MGD. This would result in continuous pumping over about a seven month period. As shown in Figure 7, the annualized cost of the 60”, 66” and 72” pipeline are virtually the same. The District selected a 60” pipeline since bids would certainly be lower for the smaller diameter option and power costs may be able to be negotiated at a rate lower than the assumed $0.08 per kWh.

For the section of pipeline between the Intermediate Pump Station and the East Fork Conveyance Pipeline, the optimization study was completed given the proposed phasing of the project from raw to treated water. In the initial years (through 2009) the pipeline this section of the pipeline will convey 75 MGD over a seven month period as described above for the section from the lake to the ground storage tank. In 2010, the pipeline will carry about 40 MGD, as 35 MGD will be diverted to the District’s proposed water treatment plant. By 2015, the pipeline will be converted to a treated water pipeline carrying about 35 MGD to a portion of the District’s South Treated Water Distribution System. Using the service life, debt service and power cost assumptions described above and the proposed phasing of the flows to be carried by the pipeline, the optimization study indicates that a 54” pipeline is the most economical size. The results of this analysis are presented in Figure 8.

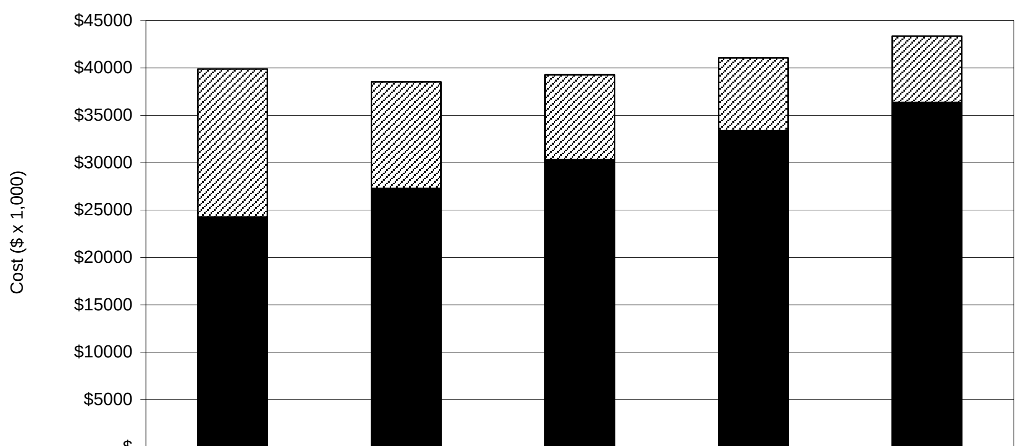
Figure 7. Pipe Optimization, Lake Pump Station to Ground Storage Tank



	48	54	60	66	72
Annual Power Cost	$2,610,308	$1,870,581	$1,487,114	$1,274,637	$1,150,335
Annual Debt Service	$1,012,435	$1,138,989	$1,265,544	$1,392,098	$1,518,652

Pipe Diameter

Figure 8. Pipe Optimization, Intermediate Pump Station to East Fork Pipeline



	48	54	60	66	72
PV, Annual Power Cost	$15,623,047	$11,239,749	$8,967,497	$7,708,447	$6,971,892
PV, Capital Cost	$24,246,000	$27,276,750	$30,307,500	$33,338,250	$36,369,000

Pipe Diameter

In summary, the Raw Water Pipeline includes approximately 12 miles of 60” pipeline between the Lake Pump Station and the Intermediate Pump Station Ground Storage Tank and about 18 miles of 54” pipeline between the Intermediate Pump Station and the East Fork Conveyance Pipeline connection. The pipeline was alternately bid to be constructed as either Polyurethane Coated Steel Pipe (AWWA C200) or Bar-Wrapped Concrete Cylinder Pipe (AWWA C303). Appurtenances for the pipeline include combination air and vacuum valves, blowoff (drain) valves, pig launching vaults, and rectifier stations for an impressed current cathodic protection system.

CONSTRUCTION CONTRACTS

To meet a design and construction schedule of 22 months (10 months for design and 12 months for construction) for a project of this scope, the project was divided into multiple bid packages. A natural separation would be to divide the project into three separate construction contracts, one for each pump station and one for the pipeline. However, given long lead times for equipment and limited time for construction the project was ultimately designed and bid in seven different contracts. Each of these is listed below with a brief discussion of the impacts to project design and construction time.

- Contract 1 – Substation Electrical Equipment: This contract was originally included to facilitate timely procurement of the large substation transformers required at each pump station site. The lead times on this equipment were quoted at more than 12 months during early conversations with suppliers. Ultimately this contract was removed from the project, as the District was able to coordinate temporary power at the sites to operate the pump stations until permanent power could be provided by the utilities.
- Contract 2 – Pumps, Control Valves, and Variable Frequency Drives: Discussions with equipment suppliers indicated lead times on this equipment at about 12 months. System hydraulics and preliminary design of the facilities was completed in about five months. Considering the 12 month delivery schedule, the equipment is scheduled to be on site in July of 2007. This will allow two to three months for installation to meet the October 2007 in-service date of the raw water supply system.
- Contract 3 – Lake Pump Station Sump and Intake: This contract includes the below-grade facilities at the Lake Tawakoni Pump Station, including the pump station intake and connection to the existing intake pipeline and construction of the pump station wet well. Design time for these facilities spanned about seven months. By separating this work from the overall pump station construction, bidding and construction could occur as soon as design was complete instead of waiting until the complete pump station facility was designed. This saved as much as three months in design time and allowed construction to begin in October 2006.
- Contract 4 – Lake and Intermediate Pump Station: Contract 4 includes the above-ground pump station facilities at the lake and the entire Intermediate Pump Station and ground storage tank construction. Several issues were considered when evaluating the feasibility of combining these two sites into a single contract. A single point of responsibility was desired so that completion of the stations could be managed more effectively, operation of the system would be simplified since all electronics and programming would be completed by the same entity, and the likelihood of problems during construction would be reduced since only large contractors would have the bonding capacity to bid the combined project. Design of these facilities was completed on a 10-month schedule, allowing 12 months for construction.

- Contract 5 – West Pipeline: The West Pipeline includes about 10 miles of the 54-inch-diameter pipeline. Pipeline contracts of not more than 10 miles were selected to keep construction schedules to about nine months. Additional consideration was given to delaying the bidding of the pipelines as long as possible to allow the District more time to acquire easements for the project. As such, the West Pipeline design and survey was completed in October 2006 to allow time for pipe procurement; but construction could not start until late February 2007 to allow time for easement acquisition.
- Contract 6 – Central Pipeline: The Central Pipeline included about 8 miles of 54-inch-diameter pipe and 2 miles of 60-inch-diameter pipe. Design and survey for this contract was completed in November 2006, with construction beginning in February 2007.
- Contract 7 – East Pipeline: The East Pipeline includes about 10 miles of 60-inch-diameter pipeline. Similar to Contract 6, design and survey for this contract was completed in November 2006, with construction beginning in February 2007.

PROJECT COST AND SCHEUDLE SUMMARY

Table 3 provides a summary of key dates, bid amounts and other project costs for the proposed facilities.

Table 3. Bid Totals and Key Dates

Contract	Bid Date	Estimated Completion	Bid Amount
Contract No. 2, Equipment Pre-Selection	06/19/06	07/1/07	$ 4,180,000
Contract No. 3, Lake Sump & Intake	08/01/06	03/01/07	$ 2,850,000
Contract No. 4, Pump Stations	10/19/06	01/01/08	$ 16,680,000
Contract No. 5, West Pipeline	10/26/06	10/15/07	$ 17,330,000
Contract No. 6, Central Pipeline	11/15/06	10/15/07	$ 15,200,000
Contract No. 7, East Pipeline	11/02/06	10/15/07	$ 17,320,000
Subtotal Construction			**$ 73,560,000**
Total Power Supply			**$ 12,110,000**
Miscellaneous, Right-of-Way, and Professional Services			**$ 11,680,000**
Total Project Cost			**$ 97,350,000**

PROJECT UPDATE

Construction for all phases of the Lake Tawakoni Water Supply Project is underway. Equipment included in Contract 2 is on order and is currently being manufactured with scheduled deliveries in July 2007. Construction of the Lake Pump Station Sump and Intake is nearing completion and facilities at the Intermediate Pump Station site are progressing. Pipe for all three pipeline contracts is being manufactured in nearby Grand Prairie, Texas, with the first deliveries scheduled for March 2007. Photographs of construction activities as of the writing of this paper are included below for reference.

Contract 3, Lake Pump Station Sump and Intake

Photo 1.
Sump excavation and suction pipe

Photo 2.
Sump floor concrete pour

Photo 3.
Intake vault liner plate at surface

Photo 4.
Intake vault shaft excavation

Contract 4, Lake and Intermediate Pump Stations

Photo 1.
6 MG tank perimeter drain piping

Photo 2.
6 MG tank overflow piping

Photo 3.
6 MG tank foundation reinforcing

Photo 4.
6 MG tank wall construction

Photo 5.
6 MG tank

Photo 6.
Intermediate PS excavation