The Secret of Our Success: The Effective Use of Planning and Design Tools for Tampa Bay Water's Master Water Plan

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Tampa Bay Water provides water to its six member governments: Hillsborough, Pinellas, and Pasco counties and the cities of Tampa, St. Petersburg, and New Port Richey. These governments in turn serve over 1.8 million residents of the Tampa Bay region.

In order to provide a new approach to planning for new water supply in the tri-county area, a resource development plan (RDP) was initiated in 1993. The RDP is based on a comprehensive analysis of current and future demand, supply sources, and facility capacities. It provides specific recommendations for developing new water supplies as an integrated water resource plan.

As a part of the RDP process, Tampa Bay Water's board of directors conducted public workshops from which five objectives for the recommended plan were established:

- aggressive conservation and increased reserve/rotational capacity
- diversified water-supply sources
- limited additional new groundwater beyond currently built and/or exchanged capacity
- increased drought-proof and drought-resistant components
- least cost consistent with the previous objectives

Based on these five objectives, the board developed a plan in 1994 from which Tampa Bay Water's master water plan was formulated.

During its 1996 session, the Florida Legislature directed Tampa Bay Water and its member governments to evaluate Tampa Bay Water's operations and make recommendations for improvements. An independent report to the legislature analyzed and confirmed the strength of a regional solution. The governance study submitted by Tampa Bay Water set forth specific recommendations that include specifying that Tampa Bay Water should be the region's exclusive provider of wholesale water; implementing Tampa Bay Water's master water plan for 20 years of future water supply; and utilizing millage from the Southwest Florida Water Management District (SWFWMD) for funding new water sources, if so directed by the legislature.

As a result of the governance study, the 1997 Florida Legislature passed Chapter 97-160, Section 30, Laws of Florida, which encouraged and facilitated the implementation of the study's recommendations submitted to the legislature. During 1997 and 1998, Tampa Bay Water and its member governments conducted multiple workshops; developed new governing documents for Tampa Bay Water, including the Amended and Restated Interlocal Agreement and Master Water Supply Contract to supersede existing contracts; and conducted extensive studies related to water rates, water quality, legal issues, title to real property, and an overall water-supply facility assessment.

Chapter 97-160, Laws of Florida, also requires that Tampa Bay Water and the SWFWMD work cooperatively in water-resource and water-supply development. Tampa Bay Water, its member governments, and the SWFWMD have entered into the Northern Tampa Bay New Water Supply and Groundwater Withdrawal Reduction Agreement (the Partnership Agreement), which calls for new water-resource and water-supply development to be implemented in two phases that would provide a total of 85 million gallons of new water supply for the tri-county region by the year 2007. This amount of new capacity is required in order to support the water demand of the growing region and to reduce pumping of groundwater as required by the Partnership Agreement.

Master Water Plan: System Configuration I

In order to meet the Partnership Agreement obligations, the System Configuration I Analysis was performed in 1998. This analysis evaluated project configurations that would provide for a minimum of 51 million gallons per day (mgd) by December 31, 2002, to satisfy the mandated wellfield pumping reductions. The water-supply and transmission projects approved in the analysis that are currently under construction or in operation include:

- 25-mgd seawater desalination facility and transmission main
- 66-mgd surface-water treatment plant
- Raw surface-water intake and pumping station at the Tampa Bypass Canal
- Raw surface-water intake and pumping station at the Alafia River
- 15-billion-gallon off-line reservoir
- 6-mgd Brandon Wellfield and transmission system
- 9-mgd groundwater treatment plant
- 84-inch finished-water transmission main
- 97-mgd finished-water high service pumping station
- 72-inch and 84-inch raw surface-water transmission mains

Planning and Design Tools

In order to develop a coordinated and integrated water-supply and transmission system, Tampa Bay Water and Black & Veatch used several tools to develop the appropriate design criteria and system objectives for the independent but interrelated supply and transmission projects. These tools included the following:

- A hydraulic model of the existing and proposed finished-water transmission system was used to determine operating conditions of existing and proposed facilities.
- A water-quality model was used to predict potential changes in delivered water quality associated with a combination of water-supply sources.
- A surface-water supply and reservoir yield model was used to predict the quantities of surface water available for withdrawal and the quantities of water available from an offline reservoir for a variety of operating conditions.
- Hydraulic models of the new surface-water system were used to determine operating conditions of the raw-water transmission facilities.

Transmission System Hydraulic Model

Black & Veatch developed a hydraulic model of Tampa Bay Water's existing system and calibrated the model using data collected from Tampa Bay Water's Supervisory Control and Data Acquisition (SCADA) system. The modeling software utilized was Cybernet® Versions 3.1 and WaterCAD® 6.0 for Windows. This comprehensive model includ-

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ed all pumping stations, storage reservoirs, primary transmission mains, wellfields, and control valves in the system.

During preliminary design and the early design phases, Black & Veatch used the model to evaluate the range of anticipated operating conditions for the Tampa Bay Water regional transmission system. The data generated from the model evaluations served in part as the hydraulic design conditions for the 97-mgd high-service pumping station at the regional facilities site and the 84-inch North Central Intertie. As the designs of these facilities progressed, model updates incorporated design revisions.

Throughout the design, the model updates included proposed pump curves and pump specifications to determine if the proposed pumps were adequate for the range of operating conditions. Upon the completion of construction, the pump curves from the actual pump performance tests were the final update to the model.

The high-service pumping station and North Central Intertie have been operational since the summer of 2002, and Tampa Bay Water collects and records flow and pressure data from its SCADA system in 15-minute intervals. Hydraulic analyses using this data have verified that the calibrated model results are consistent with actual operating conditions. Pump settings (on/off and speed factors), system supplies and demands, and other data are used as input into the model for extended period simulations; and predicted flows, pressures, and tank levels were compared to actual recorded values.

Figures 1 and 2 illustrate the model-predicted pressure and flows in the transmission system and the actual recorded pressure and flows in the transmission system. As seen in the figures, the model accurately predicts flows and pressures in the transmission system. **Figure 1** shows the modeled and actual pressure at a point in the Tampa Bay Water transmission system over a one-month period, and **Figure 2** shows the flows and pressures from the new high-service pumping station over the same period.

Model simulations of actual operating conditions were even successful in identifying an erroneous pressure gauge in the transmission system. The erroneous readings were discovered when the calibrated model results and the actual recorded values differed at a single location. Recently the model has been used to evaluate alternative pumping operations that can potentially result in significant energy cost savings. Modifications to the high-service pumping facilities and operations are underway to realize these energy cost savings.

Transmission System Water-Quality Model

The modeling software used for water-quality analyses was Cybernet® Version 3.1 and WaterCAD® Version 6.0 for Windows. This software package is capable of tracing a water-supply source, predicting the concentration of an individual water-quality constituent, and estimating the age of delivered water. Black & Veatch also developed a water-quality spreadsheet and database to perform specific calculations for numerous water-quality parameters.

The water-quality model was calibrated in 1999 and 2000 using total dissolved solids (TDS), total hardness, calcium hardness, total organic carbon (TOC), and iron. Sampling from the wellfields supplying water to the

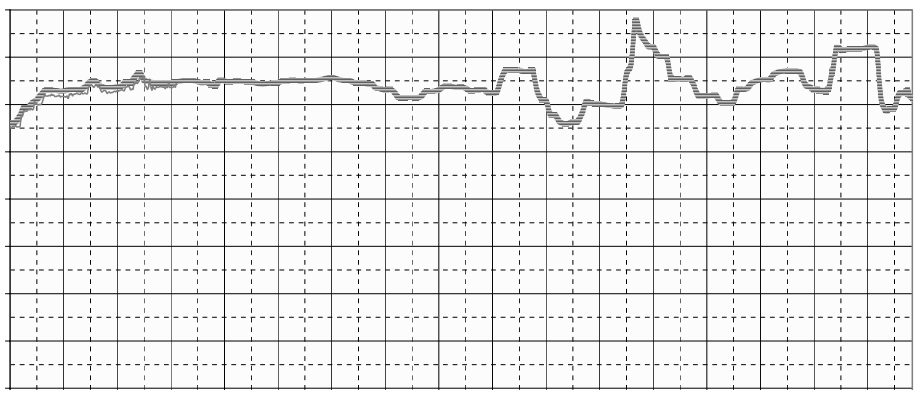
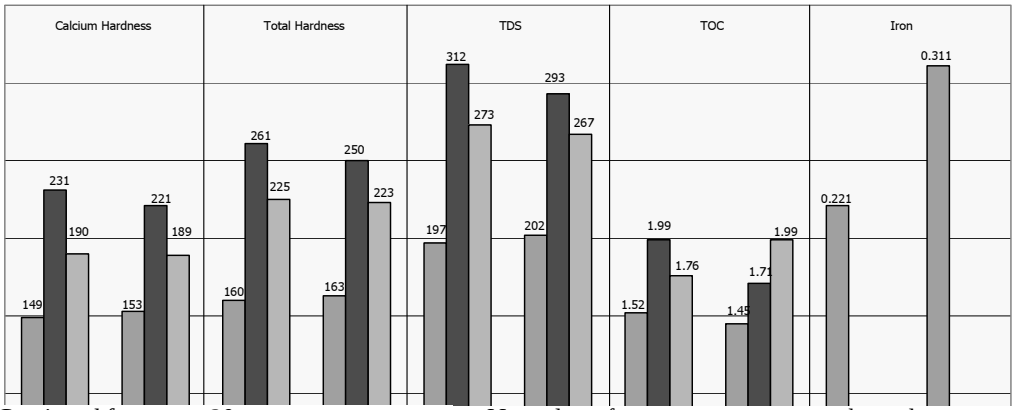


Figure 3
Source Water Quality Ranges



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regional transmission system was conducted for three consecutive days.

Sampling for the calibration effort included three locations in the transmission system. Sampling at these locations began on the same day as the wellfield sampling and continued for five days. The sampling duration at these locations was longer to account for travel time in the transmission system. The Tampa Bay Water SCADA system recorded wellfield production, pumping station operation, and delivery-point demands that were used as the hydraulic input for the model.

The recorded hydraulic data and actual source-water quality was input into the water-quality model, and the model predicted the delivered water quality at the sampling locations. A comparison of the predicted water quality at the sampling locations with the observed water quality verified the calibration of the model.

Figure 3 summarizes the differences in source-water quality for the parameters used in the calibration, and **Figure 4** compares the model-predicted results to the actual sampling results. Given that the new supplies are coming on line and on-line water-quality data is becoming available, Tampa Bay Water and Black & Veatch will perform another sampling program to update the model and re-verify the previous results of the model.

Subsequent to the new water-supply sources, such as the 66-mgd surface-water treatment plant that came on line in the fall of 2002, Tampa Bay Water and Black & Veatch have used the model to determine the distribution of sources being delivered to the wholesale customers of Tampa Bay Water. This model also is regularly used to evaluate transmission-system water quality and identify needed improvements.

One such improvement was the addition of a facility to raise alkalinity during periods of the year when the surface-water plant alkalinity is less than the transmission-system target alkalinity of 80 to 100 mg/l. This model is also used to evaluate potential water-quality impacts associated with the addition of new water supplies and proposed physical modifications to the regional transmission system.

Enhanced Surface-Water System Models

Two models have been developed and used for evaluations of the enhanced surface-water system. A hydraulic model of this system includes the three raw surface-water pumping stations, a 72-inch pipeline, 84-inch pipelines, and a 15-billion gallon reservoir. A reservoir mass balance model was developed and used throughout the planning and design stages of the surface-water treatment plant, regional reservoir, and the associated raw-water pumping stations and pipelines.

The hydraulic model was used in the preliminary design stages and its use is ongoing as the last components of the enhanced surface-water system are under construction. Model simulations were used to determine the hydraulic design criteria for the three pumping stations and three pipelines. The pumping stations range in pumping capacity from 50 to 150 mgd, and the pipelines range in diameter from 48 inches to 84 inches. Black & Veatch used the model to develop a range of operating conditions for the system that will accommodate future expansions at some of the pumping stations and the addition of a booster station, should additional raw-water

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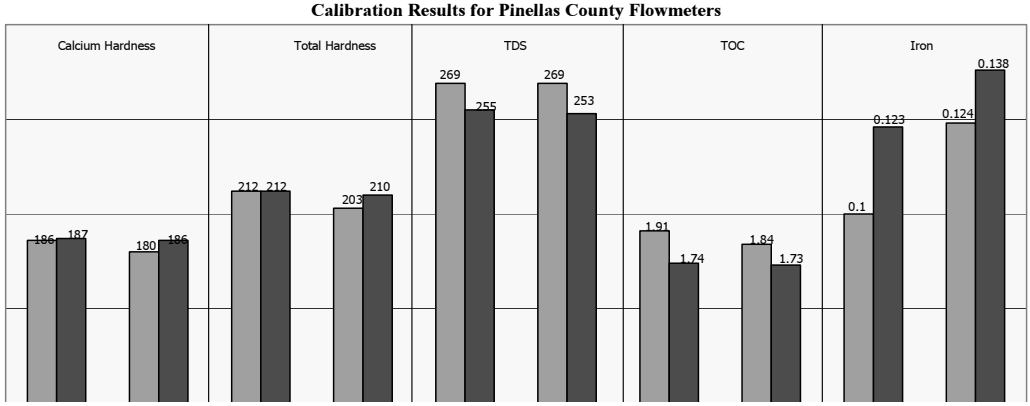
Figure 4
Calibration Results for Pinellas County Flowmeters



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supplies become available.

Two of the pumping stations located at the Tampa Bypass Canal and the Alafia River Pumping Station are operational, as are the 72-inch and 84-inch pipelines serving these two pumping stations. The remaining facilities are currently under construction.

The reservoir mass balance model was used to estimate the quantities of raw surface water that will be available for treatment and storage in the 15-billion-gallon reservoir. This model includes over 20 years of flow data from three raw-water sources: the Hillsborough River, the Tampa Bypass Canal, and the Alafia River. Withdrawals from these three sources were estimated by applying the permitted withdrawal schedules to the actual recorded flow data. This model was used in part to size both the reservoir and the surface-water treatment plant and to predict the overall yield of the entire system. The model also is used to evaluate the effects of proposed water-supply projects that could interface with the Enhanced Surface Water System.

Transient Hydraulic Modeling

Black & Veatch developed transient models of multiple independent systems that comprise the Tampa Bay Water supply and transmission system. These systems include the Brandon Wellfield and Brandon South Central Connection; the existing transmission system, including the recently constructed high-service pumping station at the regional facilities site and the new 84-inch finished-water transmission main; the Tampa Bypass Canal pumping station and pipeline; and the reservoir supply system.

The results of the transient analyses were used to develop control systems for mitigating surge and vacuum conditions associated with transient hydraulic events such as occur during a power failure. Recommended controls included pressure relief valves, air/vacuum valves, air chambers, and valve opening/closing speeds. Valve sizing and location were optimized with the models, and as design and construction progressed, alternative locations and sizes proposed by the project designers and/or contractors were evaluated.

Black & Veatch and Tampa Bay Water still utilize these models to evaluate their pumping operations to both improve operation of the system and protect the interconnected system from potentially damaging transient events.

Summary

Tampa Bay Water and Black & Veatch have successfully applied various planning and design tools to implement a $600-million capital improvement project consisting of two surface-water intakes and pumping stations, a 66-mgd surface-water treatment plant, a 15-billion-gallon reservoir, a 6-mgd groundwater wellfield, a 9-mgd groundwater treatment plant, a 25-mgd seawater desalination plant, and over 70 miles of new and finished-water transmission mains. Most of the projects have been completed and are in operation, and the actual operation of the new facilities has shown the results of the tools to be very accurate. These tools included the following:

- A hydraulic model of the existing and proposed finished-water transmission system was used to determine operating conditions of existing and proposed facilities. This model accurately predicted flows and pressures in the transmission system, and the startup of the new facilities verified the predicted operating pressures from the model simulations.
- Hydraulic models of the proposed new surface-water system were used to determine operating conditions of the raw-water transmission facilities.
- Transient models of the proposed raw- and finished-water transmission systems were used to determine the appropriate level of controls for mitigating transient (surge and vacuum) events. In addition to its value as a planning and design tool, this model has been used to identify the causes of pressure-surge events and identify corrective actions.
- A water-quality model was used to predict potential changes in delivered water quality associated with a combination of water-supply sources. A water-quality sampling program verified that the model was predicting concentrations consistent with actual concentrations measured in the field.
- A surface-water supply and reservoir yield model was used to predict the quantities of surface water available for withdrawal and the quantities of water available from an offline reservoir for a variety of operating conditions. This model was used to size the reservoir and surface-water supply and treatment facilities, in addition to estimating the yield from surface-water supplies.

During startup and operation, the planning and design tools have been shown to be very accurate and continue to serve Tampa Bay Water for evaluation of existing and proposed water-supply and transmission facilities.