

WATER SUPPLY CHALLENGES FOR AN ISLAND COMMUNITY

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Abstract. The Town of Edisto Beach is a small island community located south of Charleston, SC. The Town’s water system serves approximately 2,300 customers. As with many resort communities, the summer population and water consumption is approximately three times that of the winter months. The water system needs to meet the peak summer demand while maintaining service at a reasonable cost for year round residences.

Edisto Beach’s water system consists of six wells, a 100,000 gallon elevated storage tank, a 200,000 gallon ground storage tank and two booster pumps. These resources are located throughout the service area, which contributes to some of the issues encountered with the water system. The three major challenges for the town are adequate hydrant flows to all sectors of the service area, increasing pumping capacity, and better control and monitoring of the water system.

All well and booster pump operations are controlled by the water levels in the elevated storage tower. Modeling indicated that two booster pumps, located about 4.5 miles from the elevated storage tank, are not activated quickly in response to a fire flow demand. Consequently, the water pressure and particularly the fire flows available to the off island service area served primarily by booster pumps might be less than desirable until the water level in the tower dropped low enough to activate these pumps. The town is concerned that this critical time might be lost during a fire.

In order to increase pumping capacity, the existing 6 wells were evaluated based on current pumping rates and specific capacities to determine candidates worthy of well pump replacement. Well# 1 was increased from 125 GPM up to 250 GPM in pumping capacity.

In order to better monitor the water system, the town is currently evaluating the addition of a SCADA system that can monitor and control resources, record water use trends, and generate reports and maintenance schedules.

INTRODUCTION

The purpose of this paper is to discuss common challenges and solutions that island communities encounter providing safe and reliable drinking water. Safe, reliable drinking water as well as fire protection is a critical component of a productive and thriving community. The challenges and solutions presented here are typical of smaller water systems and tailored for water systems isolated from large metropolitan areas including island communities. This paper addresses the areas of water distribution, supply, and operation.

BACKGROUND AND RELATED WORK

Edisto Beach is located in Colleton County South Carolina, approximately a one hour drive south of Charleston. The town is approximately 7 square miles in size. Most of the parcels on the island are developed with single family homes. The island also contains condominiums and commercial establishments that are present in an amount that is typical for an island community. The water service area is confined to the island itself except for a small portion located just off the island near the state park. Though the 2000 census revealed a population of only 641 for Edisto Beach, the existing water system has many more customers, approximately 2,300, most of which consist of beach rentals.

The town of Edisto Beach has a total of six supply wells located at various locations throughout the service area that supply the system. Pumping capacities range from 90 GPM up to 495 GPM.

Water storage for the town consists of one 100,000 gallon elevated storage tank located on the island itself and one 200,000 gallon ground storage tank located just inland near the state park.

Wells 4 and 5 are located adjacent to and fill the ground storage tank. Two booster pumps are located at the base of the ground storage tank and pump water from the ground storage tank into the distribution system.
Water distribution lines range from 2” to 10” in diameter and are composed of PVC and DIP. Edisto Beach also has approximately 133 fire hydrants strategically located throughout the island.

The wells and booster pumps are controlled by the water level in the elevated storage tank. The telemetry can be explained briefly in the following manner. Once the water level in the tank drops to 21 ft, a large and a small resource are turned on. If the level in the tank continues to drop to 20 ft, an additional large and an additional small resource are turned on. If the level in the tank continues to drop to 18 ft, the final large and small resource will be turned on. Large resources are considered Well# 6 (495 GPM) and Booster Pumps 1 and 2 (350 GPM each). Small resources are Wells # 1, 2, and 3. All of the resources are rotated at each start to prevent excessive run times.

Key Challenges

Due to the large amount of vacationers visiting the island, water demands can fluctuate greatly. Edisto Beach used 201,702,000 gallons of water for 2007. The peak month for demand during the calendar year is the month of July, when water usage averaged approximately 943,600 gallons per day (GPD). July’s water usage is three times the winter demand. The highly fluctuating demand requires the ability to adjust system operating parameters. The three major challenges for the town are adequate hydrant flows to all sectors of the service area, increasing pumping capacity, and better control and monitoring of the water system. These three challenges can become more difficult to address since the island is essentially built out and not many parcels are available for construction of new water system infrastructure (tanks, wells, booster pumps, etc.).

Adequate Fire Flows to all Sectors of the Service Area. Water systems ideally have two operational characteristic that are relatively consistent throughout the distribution system: fire flow and pressure. Fluctuations in either of these parameters are unavoidable since lower pressures and fire flows will be encountered the further away from the energy source (tank, well, booster pump, etc.). However, system design should try to minimize these discrepancies as much as possible.

Based on the physical layout of the system, there was a concern that several hydrants located off island down Palmetto Road near the state park may have inadequate fire flows. Fire hydrants located near the booster pumps would not be able to produce desirable fire flows without the booster pumps in operation. These hydrants located near the booster pumps with questionable flow rates are as much as 4.5 miles from the elevated storage tank. Since the current system operation is such that the wells and booster pumps are controlled by the water level in the elevated storage tank a scenario exists where hydrants near the booster pumps would not have enough energy from the elevated storage tank alone to provide the necessary fire flows. Earth Tech obtained and reviewed the hydrant test results from Bishop Hydrant Service conducted over the span of several days in the months of August 2006 and September 2007. Unfortunately, other water systems parameters during the period of hydrant testing including the elevated storage tank water level and which well pumps and/or booster pumps were operating were unavailable. These parameters are important because it is difficult to tell how the resources (wells and booster pumps) impact the various hydrants. Approximately 133 fire hydrants were tested and inspected. The hydrant test results indicated that at the time of testing, the Town of Edisto Beach has adequate system pressure to produce satisfactory fire flows. All the hydrants tested within the water system met the minimum DHEC requirement of 500 GPM with a 20 psi residual pressure, most showing significantly higher flows at much higher residual pressures. Out of 133 fire hydrants, there were no hydrants that tested below 750 GPM of fire flow. Fire flows centered mostly around 900 to 1200 GPM, which meet AWWA recommendations for needed fire flow.

Out of 133 fire hydrants located in the Edisto Beach water system, only 4 hydrants produced less than 900 GPM during the fire flow testing. Most these hydrants are located off the island near the state park and Palmetto Road. In addition, these hydrants producing the lowest flow are also in areas where the space between buildings are the greatest, typically over 31 feet; therefore, these hydrants also meet AWWA recommendations for fire flow.

However, since, system parameters were not available at the time of hydrant flushing, it was necessary to model the water system to determine if the booster pumps were in operation during the hydrant flushing and testing, which was highly likely due to the high flows produced, as well as to evaluate the performance of off island hydrants.

Adequate Supply. Small towns need to have enough supply capacity for fire protection without having an excessive number of wells that will lead to increased maintenance costs. The following was the yield from each of wells and the booster pumps if they were all operating at the same time, at a system pressure of 60 psi (a full elevated storage tank):

- Well 1: 130 GPM
- Well 2: 135 GPM
- Well 3: 90 GPM
- Booster Pump 1: 350 GPM
- Booster Pump 2: 350 GPM
- Well 6: 495 GPM

Total Water System Production at 60 psi: 1,550 GPM

With a total water production of 1,550 GPM and based on a fire flow demand of 500 GPM plus a peak hour demand of 1,600 GPM, the well pumps alone are deficient by 550 GPM. Subsequently, based on the existing elevated storage capacity of 100,000 gallons, the town could fight a fire for approximately 180 minutes during July 4th at 7:00 pm in the evening, the peak demand hour during the year. This meets the minimum DHEC requirement.

As previously noted, 500 GPM of fire flow is only the minimum requirement. 1,000 GPM is the recommended fire flow based on the AWWA recommendations for the majority of the structures on the island based on the dwelling spacing. This would increase the total usage under the worst case scenario (a fire on peak hour of peak day) to 2,600 GPM. Under this scenario, the system production would be deficient by 1050 GPM, and the town could fight the fire for 95 minutes utilizing the additional storage in the elevated tower, while still supplying the peak domestic demand of 1600 GPM. This is less than the ideal recommended capacity which would allow the town to be able to fight a fire at peak hour on the peak day for 2 hours with a fire flow of 1,000 GPM.

**Better Control and Monitoring of the Water System.**
The current water system wells and booster pumps can be controlled only by the water level in the elevated storage tank or if the operator manually turns on the wells and pumps. In the event of a fire, the water system operator must be notified and must travel to the elevated storage tank to access the well pump controls. Installation of a Supervisory Control and Data Acquisition (SCADA) system would resolve this response challenge. A comprehensive SCADA system would have the advantage of allowing any or all pumps to be turned on from a remote location – an operator would not be required to go to the elevated storage tower, and remain there for the duration of the fire fighting effort. This would greatly enhance the response time, effectiveness and utilization of the water supply for the fire fighting effort, while maintaining domestic flows to the rest of the system.

**EVALUATION AND CONSIDERATION OF ALTERNATIVES**

**Modeling Existing Water System**
The results from the hydrant tests did not indicate which resources (wells and / or booster pumps) were in operation during the time of testing. It was necessary to run the WaterCAD model provided by the town in order to evaluate hydraulically how the water system operated.

The model was configured to reflect a fire scenario occurring at 7:00 pm on July 4th. This would be the peak demand for a year. The peak hour demand was 1,600 GPM for domestic flow plus 1,000 GPM for fire flow for a total of 2,600 GPM. With the baseline demand of 2,600 GPM established, it was then necessary to evaluate hydrants in this fire scenario at various locations throughout the town while using different resources. The following four scenarios for source water were evaluated:

- Fighting a fire utilizing the elevated storage tank (EST) only
- Fighting a fire utilizing the elevated storage tank, well #6, and well #1
- Fighting a fire utilizing the elevated storage tank, booster pump, well #1 and well #3
- Fighting a fire utilizing the elevated storage tank, booster pump, well #1, well #3, and well # 6

With only using the energy in the elevated storage tank, with no wells or booster pumps operating, the modeling revealed that the following hydrants didn’t meet 1,000 GPM during a fire event:

- Fire Hydrant # 19 – intersection of Portia Street and Jungle Road
- Fire Hydrant # 107 – intersection of 174 and Jungle Road
- Fire Hydrant # 128 – near the end of Palmetto Road

Turning on Well # 1 and Well # 6 raised the flows somewhat but not enough to bring the system into compliance. It wasn’t until the booster pump was turned on that the residual systems pressures exceeded the 20 psi minimum when pumping 1,000 GPM.

All of the hydrants with questionable flows are located either on the east end of the island, or off island on Palmetto Road, closer to the booster pump system and further from the elevated storage tank. Simply put, the further away a hydrant is located heading east from the elevated storage tank, the less influence the elevated storage tank has on that hydrant’s discharge and the more the influence the booster pumps have on that hydrant’s discharge.

**Increasing Water Supply**
Wells 1, 2, 3, and 6 were evaluated to determine whether more capacity could be achieved by replacing the
well pumps. No substantial benefit is obtained by modifying wells 4 and 5 since they do not directly contribute to the distribution system but rather pump into the ground storage tank.

Drawdown test results were reviewed for 2006, 2007, and 2008. The ideal well would be one with a high specific capacity, which indicates that the well has additional drawdown capability. Wells 2 and 3 had low specific capacities, which make them poor choices for upgrade since likelihood of getting additional flow out of the existing wells is small. Well 6 is already a large well (40 HP), has significant capacity, and is fairly new.

Drawdown tests revealed that Well 1 had a large specific capacity. If the well pump and motor were replaced by a larger capacity pump, Well #1 production could be increased by 130 GPM, essentially doubling the capacity of the well. That would increase the overall system pumping capacity to 1,680 GPM and allow the town to fight a fire at 1,000 GPM during peak demand for an additional 14 minutes, for a total of 109 minutes. This approaches the AWWA recommended fire flow for 2 hours at peak hour demand.

This evaluation assumes that all well and booster pumps are operating during a fire supporting the system demands and also assumes a static system pressure of 60 psi. The well and booster pump capacities will increase as the system pressure drops, which is likely in a fire scenario and will allow for additional time to fight a fire.

In July of 2008, Edisto Beach Well #1, an existing 10 HP submersible pump, was replaced with a new 20 HP Goulds 5THC submersible pump which essentially doubled Well 1’s pumping capacity from 135 GPM up to 250 GPM. This will allow the town to fight a fire at the peak demand of the year (around Independence Day) for 109 minutes.

Control and Monitoring of the Water System

The SCADA system can be configured to monitor the elevated tower and ground storage tank, and each well site, indicating flow rates, pumping duration, times of pumping, and any alarm conditions. All this information can be sent to a laptop computer, allowing instant access to the entire system from a remote location. Currently, the operators must go out to each well to determine the pump run time and total flows, but no information is available on when the peaks occur or what the water demand is at that time. As indicated in the discussion on hydrant testing, knowing what pumps are operating during each test, and further, being able to initiate a certain pump operation and determine its effect on each hydrant flow, would be extremely valuable information. This could be easily done with a SCADA system.

The SCADA can also automate report preparation, by compiling the needed information and developing the report in the preconfigured format. This will free up staff from a very time consuming and tedious task, and allow for more time for system analysis rather than compiling data. Trends can be spotted, pump capacities and well yield monitored. In short, SCADA is a vital component of running a water utility and its addition is highly recommended.

There are two basic types of SCADA systems: (1) proprietary systems that can be serviced by licensed technicians of that one manufacturer, and (2) what is called open architecture systems that can be programmed and serviced by a number of technicians. The controls that the Town of Edisto Beach currently has are manufactured by a proprietary vendor. However, evaluation has indicated that these controls can communicate with an open architecture system so they could still be utilized regardless of whether the Town chose to remain with a proprietary system or purchase an open architecture system.

At the time of this report, the town is pursuing installing a comprehensive SCADA System to include one additional laptop computer, licenses for two laptops, Human Machine Interface (HMI) software and programming, interface with the existing Master Terminal Unit (MTU), and training for one day. The exact configuration and monitoring points will be designated to provide the water system staff the necessary tools to operate, monitor, analyze and improve the water system operation. Fire response will be greatly improved, which in itself is an excellent reason to automate operations with a SCADA system.

Consideration will be given as well to eventually integrating the wastewater operation into the SCADA system.

CONCLUSIONS

Fire Flows

The modeling results revealed that fire hydrants located east of Portia Street will be unable to adequately fight a fire if the booster pumps are off. The head loss between the elevated storage tank to the eastern portions of the system would be so large that hydrants located east of Portia Street would not be able to produce a sufficient discharge to adequately fight a fire without the flows and energy added to the system from the booster pumps.

In the event of a fire, the current scenario requires a person to manually monitor the tank water levels and to turn on wells and/or booster pumps as necessary. With the booster pumps in operation, the eastern portion of the town has adequate fire flows. The major disadvantage of the current control configuration is that there could be a delay from when a fire occurs and when the wells and / or booster pumps are turned on, since someone has to
physically go to the control panel to initiate resources. It also requires one person to be located at the control panel for the entire duration of the fire.

Supply Increase
The chances of a fire occurring at peak hour of a peak day are small. Nonetheless the extra capacity achieved by increasing Well 1’s production is added protection for the town.

SCADA System
The town is currently pursuing installing a SCADA system that would allow an operator to control the wells and booster pumps via a wireless laptop. That would allow an operator to turn on any combination of wells and booster pumps necessary to maintain system pressures from essentially any location.

LITERATURE CITED
