HOW TO SAVE COSTS AND IMPROVE SUSTAINABILITY WHILE REDUCING EFFLUENT NITROGEN

Donna Kaluzniak, CEP, Utility Director, City of Atlantic Beach, Florida
John E. Collins, Jr., P.E., J. Collins Engineering Associates, LLC
W. David Lassetter, P.E., Electrical Engineer

Introduction

As a result of a Total Maximum Daily Load (TMDL) and Basin Management Action Plan (BMAP) for nitrogen in the Lower St. Johns River, the City of Atlantic Beach was required to reduce the total nitrogen load from its two wastewater treatment plants (WWTPs) by at least 61,792 pounds per year. The Florida Department of Environmental Protection (FDEP) included an Administrative Order with the City’s wastewater permit. The compliance schedule required improvements to be completed by December 31, 2012 and operational levels attained by October 1, 2013.

During planning and design, the City and its engineers looked at ways to reduce capital costs for the project. In addition, the City wished to examine the potential to improve sustainability and operational cost savings by reducing energy, water and fuel usage. Life-cycle efficiencies were considered at every stage of the project.

By making these factors a priority up front, the City’s engineers were able to design a system to reduce capital expenditures while providing a “green” project that included major reductions in electrical power and water use, more efficient sludge treatment, and reduced operating costs.

Background

The City of Atlantic Beach Public Utilities Department serves a population of approximately 23,000 within an area of approximately 5 square miles in Northeast Florida. The service area includes an area outside the Atlantic Beach limits in the City of Jacksonville called the Buccaneer service area.

When the BMAP was completed, the City owned two WWTPs. One treatment facility was a 1.9 MGD Sequencing Batch Reactor plant located in the Buccaneer district, while the other facility was a 3.0 MGD Extended Aeration plant at the south end of the service area in Atlantic Beach. Both WWTPs discharged effluent to the St. Johns River near the mouth of the river.

Major options considered to meet the TMDL limits included upgrading both WWTPs; eliminating the smaller Buccaneer WWTP and sending the flow to the Atlantic Beach WWTP; or sending the Buccaneer flow to the large nearby utility, JEA.
A detailed analysis showed the best option would be to upgrade the Atlantic Beach WWTP, eliminate the Buccaneer WWTP and send that flow to the Atlantic Beach WWTP.
Treatment Plant Flows

Over the last 10 years, flows from both plants had dropped significantly due to several factors. After the City implemented an inclining block rate structure for potable water, water demands were reduced due to conservation. In addition the City implemented an ongoing program to reduce inflow/infiltration using cured-in-place pipe and sewer line replacements. And finally, the economic downturn resulted in several large abandoned mobile home parks left vacant instead of redeveloped.

This set of circumstances resulted in reduced treatment plant flows, with current wastewater influent flows averaging approximately 1.8 MGD from a high value of 2.6 MGD in 2004.

Figure 2

![Annual Average Daily Flow](image)

Sludge Treatment and Odor Control Issues

Through an Interlocal Agreement with the City of Jacksonville, Atlantic Beach had no landfill tipping fees for sludge disposal. During project design, it appeared that tipping fees might be on the horizon. Therefore, the engineers were asked to perform a sludge treatment study to determine if improvements in sludge treatment and dewatering would be beneficial.

A biosolids study showed the most cost effective option for the City would be to modify existing tankage to enhance sludge digestion and thickening and replace the City’s antiquated drying beds with a centrifuge for dewatering.

In addition, the City wanted to reduce odors at the WWTP. An odor control study was performed and odor control facilities were added to the project as well.
Project Description:

The final project consisted of:

Atlantic Beach WWTP:
- Additional screens at headworks (influent structure)
- Construction of a splitter box and internal baffle walls in 4 existing aeration basins
- Installation of fine bubble diffusers, low-horsepower mixers, D.O. meters, automated air valves, and recycle pumps in the basins
- Replacement of 9 existing Hoffman blowers with 4 high efficiency turbo blowers
- Construction of a climate-controlled electrical room
- Modifications to an existing digester to consolidate sludge thickening and digestion
- Installation of fine-bubble diffusers, low-horsepower mixers, and automated air valves in the digester/thickener that shares air from new blowers at WWTP process (eliminated separate blowers for sludge treatment)
- New sludge dewatering building with centrifuge, polymer feed system, conveyor, loading area, and climate-controlled electrical room
- New, more efficient yard lights
- Electrical and SCADA Integration
- Replacement of older VFDs and controls in Master Pumping Station including conversion to a PID wet well level control system
- Rehabilitation of existing clarifiers and replacement of all slide gates located in the WWTP
- New odor control unit and odor collection piping system to capture emissions from the headworks and sludge treatment areas.

Figure 3
Buccaneer WWTP:
- Construction of a new Master Lift Station with VFD control
- Proper demolition and abandonment of existing WWTP

Force Main:
- Construction of over 12,500 linear feet of 12-inch and 18-inch force main using combination of open cut and directional drill.

Total Project Cost, including engineering & studies = $10.5 Million

**Capital Cost Savings**

Capital costs were saved by abandoning one WWTP, reusing existing tankage and force mains, obtaining a re-rate of plant design capacity from DEP, using a unique procurement process and financing the project with a Water Management District grant and DEP-SRF Loan.

1. The decision to eliminate the Buccaneer WWTP saved capital upgrade costs that would have been necessary to provide adequate treatment in the future.

2. Re-rating to increase design flow capacity - As part of the final design and permitting, the Atlantic Beach WWTP was rerated by DEP from 3.0 to 3.5 MGD due to improved treatment efficiencies. The re-rating achieved significant cost savings as it allowed the City to use the existing aeration tanks and clarifiers vs. constructing additional tanks. Based on population projections, the re-rated WWTP should not need expansion for the next 20 years.

3. Existing concrete tank structures were reused for nitrogen removal by retrofitting equipment and adding baffle walls in the aeration basins to create the necessary anoxic zones.

4. Sludge treatment was consolidated from several tanks to one tank. An existing digester was converted to a sludge digestion and thickening tank by adding mixers and diffusers and modifying existing baffle walls.

5. To determine the most cost effective route for the new force main to pump flow from the Buccaneer WWTP to Atlantic Beach, 16 piping routes were analyzed. The most cost effective route was chosen, which reused over 5,000 linear feet of existing force main by reversing flow direction.

6. A unique procurement process for the major equipment was used. A Request for Cost/Qualifications Proposal (RFCQP) for Selected Major WWTF Equipment was issued to at least three manufacturers of each piece of major equipment used in the project. The major equipment items included in the RFCQP process included high efficiency turbo blowers, mixers, recycle pumps, filters and diffusers. The invitation was sent to equipment suppliers that had to meet certain criteria. These selected equipment
manufacturers were invited to submit a bid price along with technical data (including recommended maintenance items and schedule).

Each Proposer/Equipment Supplier was required to submit the "Equipment Prices and Technical Data Bid Form" that was included in RFCQP. The completed form provided details of the key equipment capital costs (which was later inserted into the construction contract), technical information, replacement part costs and installations/references.

After receiving the bids, technical data was analyzed to determine life cycle cost for each piece of equipment. The equipment with the lowest life cycle cost was included in the project specifications, along with the guaranteed bid price for that equipment. Equipment suppliers had to guarantee the pricing for the contractor. In addition, a five-year warranty was required for all of the major equipment.

7. Project financing included a $1 million grant from the St. Johns River Water Management District. The remaining costs were financed with a DEP-SRF Loan, saving interests costs for the project construction.

**Sustainability**

**Electrical Efficiency**

Future sustainability and cost savings were important project considerations. The City requested a thorough electrical study be conducted as part of the project to reduce energy usage. The study identified several ways to save energy that were incorporated into the design.

Some of the process improvements, such as the fine bubble diffusers were completed in mid-2011. Remaining cost-saving improvements were completed in 2012, and the Buccaneer WWTP was abandoned in October 2012.

The chart below shows a drop of nearly 3 million kilowatt hours per year from 2010 to the project completion date.

**Figure 4**

![Kilowatt Hours for Wastewater Treatment](chart)
The success in reducing electrical consumption in the City’s Wastewater Collection & Treatment System is due to:

1. **Reduction in Quantity of 125 HP Blowers Operating** – The reduction in the use of blowers was related to two factors:
   - D.O. probes, automated air valves, efficient fine-bubble diffusers and low-horsepower mixers were installed in the process and sludge treatment basins resulting in better operational control and reduced energy use
   - Installation of high efficiency high speed dual vane control blowers (integral speed increasing gearbox with variable diffusers for regulating flow and pressure).

By installing strategically placed automatic valves and consolidating the sludge treatment process into one tank, five (5) large, inefficient blowers were eliminated from the process. Nine (9) existing 125 HP blowers were replaced with four (4) high efficiency dual vane blowers that provided air to both the WWTF and Sludge Treatment Process. Previously the sludge treatment and WWTP process had separate blower facilities.

The previous electrical usage for blower operation was about 2.4 Million KWH/yr plus a 4,034 KW Demand which resulted in a $223,000/yr operating cost for blowers. After the improvements in the WWTF and Sludge Treatment Facility, the electrical consumption was approximately 1.1 Million KWH/yr plus a Demand of 1,900 KW for an annual cost of $107,000 to operate the blowers.

Today under normal circumstances, the WWTP and Sludge operations only requires one (1) of the turbo blowers for the entire treatment process, including sludge treatment.

**Figure 5**

High Efficiency Turbo Type Blowers
2. **Manage & Reduce City’s Electrical Demand Charges** - A specialized electrical program was created, with a load shedding feature to prevent large electrical loads from operating simultaneously. This program reduces the demand portion of the City’s electric bill.

![Figure 6](image)

3. **Manage & Reduce Effluent Pumping Costs** - The Atlantic Beach WWTP pumps effluent through a combined force main used by three Duval County beach cities. Since the effluent force main is shared with three utilities, the discharge pressure in the effluent pump force main varies depending on pumping rates from each utility and also based on tide level. The effluent pump station operation is based on the level in the effluent pond. During each pumping cycle, the operating pumps will run at high speed when the discharge force main pressure is high, and will operate at low speed when the discharge force main pressure is low. To minimize the amount of high speed pumping, the existing effluent pump station level controls were modified to provide a separate low pressure pump stop level, below the existing lead pump stop level. As a result, during periods of low force main pressure, the lead pump would operate at low speed and pump down the effluent pond to a lower elevation. This would increase the available storage volume in the pond and delay the need to pump during periods of high force main pressure.

Based on the existing effluent pump curves, the pump motor horsepower required at the high speed and low speed design point on any of the three effluent pumps is:
- Approximately 55 HP at a flow rate of 2,800 GPM (High Speed)
- Approximately 18 HP at a flow rate of 2,375 GPM (Low Speed)
Therefore the energy required at low speed is approximately 38.5% of the energy required at high speed.

Electrical and instrumentation modifications to the existing effluent pumps were implemented during construction to allow the City to monitor effluent main pressure and to discharge with the pumps operating at the low speed. This feature resulted in lower pump operating costs.

**Figure 7**

*Effluent Pump Trend Chart*

4. Existing yard lighting was replaced with energy-efficient lighting.

5. The reduced electrical demand allowed for the elimination of one 300 KW emergency generator, and the replacement of a second existing 300 KW generator with a smaller 100 KW generator, which saves diesel fuel as well as maintenance costs.

6. After a hydraulic analysis was conducted, WW flows from 5 existing Buccaneer lift stations that were actually closer to the Atlantic Beach WWTP could be redirected or “flow shed” through existing force mains directly to the Atlantic Beach WWTP. The analysis determined that the pump station flows could be redirected with only some minor modifications. This redirected WW flow represented approximately 35-40% of the current Buccaneer collection system. This precluded having to repump this wastewater all the way from WWTP #2 (Buccaneer Plant). By doing so, power consumption at the Buccaneer Master Lift Station was reduced, as those flows do not have to be re-pumped.
Fuel Savings

The biosolids study determined that replacing the existing wedgewire drying beds with a centrifuge for dewatering would reduce costs for transport and disposal of sludge.

The centrifuge provides a much drier product, resulting in fewer trips to landfill and reduced tipping fees should they be implemented.

The chart below shows the huge drop in diesel fuel consumption from an average of 5,939 to 2,269 gallons per year after eliminating the Buccaneer WWTP #2 and installing the centrifuge. The City was able to use a larger roll-off container due to the drier solids as well, which reduced landfill trips even more.

![Figure 8](image)

Water Conservation

An in-plant reuse system saves 4 million gallons/year of potable water.

In addition, the City is now in the process of constructing a 0.5 MGD reclaimed water system to provide reuse to a neighboring golf course and subdivision.

Conclusion

Utilities can make sustainability and cost savings a consideration up front. Doing so allows their engineers to use experience and creativity to make those issues integral to the design.

By looking at all facets of the project, including procurement and financing, utility managers and engineers can find ways to help the environment and save costs for utility customers.
As an example, the City’s TMDL project removes over 70,000 pound of total nitrogen from the St. Johns River each year – while reducing potable water use by 4 million gallons and lowering energy consumption by more than 3 million KWH per year.

Figure 9

Being sustainable helps reduce costs as well, with an annual operating cost reduction of over $300,000 per year for electrical power, water and fuel. The table below compares Fiscal Year 2011 costs (before the TMDL Project) for power, water and fuel with those of Fiscal Year 2013 (one year of data after project completion). In addition, by eliminating the Buccaneer WWTP, over $100,000 per year is saved on contractual services and supplies.

Table 1

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<th>Description</th>
<th>FY11 Cost</th>
<th>FY13 Cost</th>
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<td>Electrical Power</td>
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<td>Water</td>
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<tr>
<td>Diesel</td>
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<td><strong>Total</strong></td>
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<td><strong>$220,084</strong></td>
<td><strong>$319,434</strong></td>
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In summary, designing for sustainability can result in overall increases in efficiencies and reductions in both capital and O&M costs.