Design – Build of SBR/Upflow Filter WWTP to Achieve ENR Limits – A Case Study

Peter F. Schuler, PE, Brown and Caldwell, 309 E Morehead St. Suite 160, Charlotte, NC 28202
Cheryl Robitzch, PE, The Haskell Company
Diana Rose, Naval Support Facility Indian Head, MD

ABSTRACT

The existing 0.5-MGD Sewage Treatment Plant (STP) operated by the U.S. Navy on Naval Support Facility (NSF) Indian Head, Maryland was originally constructed in the 1960’s to treat a mix of industrial and municipal wastewater to achieve 30:30 limits for BOD and TSS. Impending Chesapeake Bay Initiative (CBI) nutrient requirements along with aging infrastructure required complete replacement of the STP with a new highly automated and aesthetically pleasing facility.

A design-to-budget approach was used to select the design-build (DB) team that provided the Navy with the best perceived value for $12.5 million. The new STP included new headworks, influent pump station, continuous inflow Sequencing Batch Reactors (SBRs), upflow denite filters, UV disinfection, post aeration, aerated digesters and a LEED-Silver Control Room / Laboratory. In addition, demolition of the majority of the existing STP was required to provide room for the new STP and to allow the facility to meet Maryland Department of the Environment’s (MDE) storm water regulations. In fact, the impermeable area at the site was less post construction, which resulted in a small number of Water Quality Credits.

This paper will discuss all aspects of the project including: the design-build (DB) approach and how it worked from the perspective of different stakeholders, the LEED process and how the DB approach facilitated it, and a general overview of the design/construction/startup of the new STP. The new STP has withstood a 5.9 magnitude earthquake, Hurricane Irene, a tornado and a biblical flooding event in the first two months of operation. Although there have been brief excursions while the STP has operated in SuperStorm mode (at flows of >2.0 mgd), it has performed well during the first three months of operation with the average day effluent has had a TN = <3.5 mg/L and a TP < 0.15 mg/L.

KEYWORDS

Design-Build, SBR, Upflow Filter, ENR, Chesapeake Bay, Indian Head, Navy, LEED

INTRODUCTION

The existing 0.5-MGD Sewage Treatment Plant (STP) operated by the U.S. Navy on Naval Support Facility (NSF) Indian Head, Maryland was originally constructed in the 1960’s to treat a mix of industrial and municipal wastewater generated on the base to achieve 30:30 limits for BOD and TSS. The existing STP included headworks, equalization (EQ) basin, influent pump station, aeration basins, secondary clarifiers, chlorination and dechlorination facilities, blower building, gravity thickener, an aerobic digester and a control building. In addition, several abandoned unit processes (primary clarifiers, secondary clarifiers, and drying beds) were also located on the 3 acre site. The STP was located in a small valley with a storm water conveyance channel running along the east side of the majority of the STP unit processes.

Another consultant conducted a comprehensive assessment of the remaining useful life of the existing STP unit processes and their ability to achieve the CBI requirements of a total nitrogen (TN) of < 4.0 mg/L and a total phosphorus (TP) of <0.3 mg/L. They determined that the existing STP required essentially complete replacement with the exception of the EQ basin, blower building, aerobic digester and conversion of the existing aeration tanks to additional aerobic digesters. The new STP included a new
diversion box to divert high flows or high strength wastewater to the EQ tank, headworks (relocated screen), an influent pump station, two continuous inflow sequencing batch reactors (SBRs), two post equalization basins with pumps, six Blue Water upflow denite filters, two flow through UV disinfection units, a post aeration tank and chemical feed systems (sodium hydroxide, sodium acetate, ferric chloride, and glycerin). They developed very prescriptive bidding documents that consisted of 30% drawings and a detailed specification book that was over 6 inches thick. These documents were used to procure a design-build (DB) team using a design to budget approach.

The design-build team of Haskell / Brown and Caldwell was selected over two other DB teams to design and construct the new STP for a cost of approximately $12.5 million based on the bidding documents. One of the key reasons that our team was selected was due to our decision to raise the SBR tanks out of the ground and construct them on auger cast piles rather than to try to construct the tanks in waterlogged soils below the water table. Other key components of this project were that we had to achieve a LEED silver rating for the Laboratory / Control building and the strict Maryland Department of the Environment (MDE) storm water requirements.

**DESIGN OF IMPROVEMENTS**

Brown and Caldwell (BC) used a BioWin simulation model to confirm the sizing of the SBRs that was developed by Sanitaire. We wanted to make sure that the SBRs could handle most of the removal of the influent nitrogen compounds and that the Blue Water filters would not be required to carry the bulk of the load as shown Table 1 and Figures 1 and 2.

<table>
<thead>
<tr>
<th>Effluent Parameter</th>
<th>Avg. at 10° C (mg/L)</th>
<th>Avg. at 12° C (mg/L)</th>
<th>Avg. at 15° C (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia</td>
<td>0.67</td>
<td>0.64</td>
<td>0.54</td>
</tr>
<tr>
<td>Nitrate</td>
<td>2.90</td>
<td>2.95</td>
<td>3.08</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>6.02</td>
<td>6.01</td>
<td>6.04</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>1.67</td>
<td>1.68</td>
<td>1.76</td>
</tr>
</tbody>
</table>

![Figure 1. BIOWIN Predicted SBR Effluent Nitrate Concentrations](image)
It should be noted that these simulation models were run without the addition of supplemental carbon (glycerin) to the SBRs and allowed the Blue Water upflow filters to reduce the nitrate remaining in the SBR effluent from 3 to 4 mg/L to approximately 1 mg/L and to remove the phosphorus through the addition of ferric chloride.

STARTUP AND CURRENT PERFORMANCE OF IMPROVEMENTS

After all of the manufacturers had certified the installations of the equipment, Haskell conducted a functional test on each unit process. The functional testing was performed by filling each tank with clean water to the level indicated on the hydraulic profile to simulate the average daily flow to the STP. Each system was then tested in automatic mode for 16 hours to demonstrate that it worked. Flow was continually cycled through the STP utilizing temporary bypass piping / pumping from the post aeration tank to the new headworks. The clean water tests were completed at the end of May 2011.

The Navy then trucked in 50,000 gallons of return activated sludge (RAS) from the Mattawoman Wastewater Treatment Plant located in Charles County, MD about 10 miles from the Indian Head STP on June 7-9, 2011. The RAS was pumped into the RAS tanks, fed a combination of raw wastewater and Micro-C glycerin, and aerated to maintain the viability of the microbiology until the morning of June 10, 2011 when the raw wastewater flow was diverted to the new STP. The effluent from the new STP was pumped into the old STP to ensure that all permit limits would be achieved. The new STP was able to achieve the 30:30 limits for BOD and TSS immediately with the average for the first week being 3 and 6 mg/L, respectively. In addition, the ammonia in the effluent was <0.5 mg/L within one day of startup. One week after startup, the old STP was turned off and the effluent from the new STP was discharged to the Potomac River. It took about a month for the effluent TN to achieve the CBI limits of <4 mg/L.

Figures 3 and 4 illustrate the performance of the new STP over the first year of operation. It should be noted that some of the erratic performance exhibited over the first several months of operation were due to refinements necessary in the chemical dosages to the filters, extreme high flow events that lasted for several days, and attempts to treat an industrial wastewater generated on the base that was not supposed to be treated by this STP. Since February 2012, the STP has averaged a TN of <2 mg/L and a TP of 0.15 mg/L.
Figure 3. Effluent Nitrogen Compounds – July 2011 to July 2012

Figure 4. Effluent Phosphorus Compounds – July 2011 to July 2012
STORM WATER REQUIREMENTS

A storm drainage channel ran through the site that conveyed runoff from a large drainage area of the naval base upstream of the STP. Haskell/BC was required to maintain this storm drainage channel throughout the construction, which required the installation of permanent sheeting to install the SBRs and Main Process Building containing the filters and the UV system.

This project was also subject to MDE’s redevelopment criteria, which required that there be a net reduction in impervious area / storm water runoff from the conditions that existed prior to the start of the construction project. In addition, MDE would not allow the use of storm water detention ponds because they believe that owners do not maintain them and that over time they will not perform as initially designed. The project team was able to achieve a net reduction in impervious area and received a water quality credit of 164 sq ft. by demolishing all of the unused unit processes (sand drying beds, primary clarifiers, old headworks, an old secondary clarifier, chemical storage and feed areas, an old lab building, chlorination/dechlorination tanks) and the use of porous pavers to construct the new parking lot adjacent to the new Laboratory / Control Building. In addition, the project team was able to convince MDE that any rain that fell on open top tanks received treatment and did not cause runoff and was therefore considered not “impervious”. A graphic presentation of the calculations is shown in Figure 5. Yellow represents impervious area at both the start / completion of project, green represents impervious area that became pervious, and purple represents pervious area that became impervious.

Figure 5. Graphical Representation of Impervious / Pervious Surfaces

The project team was also able to achieve the Navy’s goal of keeping the site disturbance to less than 1 acre to avoid obtaining a separate Storm Water NPDES permit, which would have added 6 months to the project. This was achieved by BC/Haskell working together to ensure that a minimal amount of site area would be disturbed and yet the facilities could be constructed. Additionally, the Navy allowed Haskell to use an existing gravel lot near the construction site for laydown and storage of equipment and materials.
to reduce the area required on the project site for laydown and storage. The contractor trailers were located on a gravel area adjacent to the site the remained from a previous construction project, so it did not count towards disturbed area.

LEED CERTIFICATION PROCESS

The Navy required that the BC/Haskell team achieve a minimum of LEED Silver for the new Control/Lab Building. Due to occupancy requirements, this was the only structure constructed for the new STP that was eligible for LEED certification. Our team identified possible LEED credits on the LEED Credit Checklist as part of the proposal and managed the design and construction process to ensure that the facility would receive the maximum possible credits. Points were received in the following areas:

- Sustainable Sites – 8 points
- Water Efficiency – 4 points
- Energy and Atmosphere – 4 points
- Materials and Resources – 6 points
- Indoor Environmental Quality – 10 points
- Innovation and Design – 4 points
- **Total = 36 points = SILVER LEED**

The project team feels that the use of the design-build delivery method significantly helped us to achieve LEED Silver for the new Control/Lab Building because BC/Haskell were able to work together to achieve the end goal. The project team held meetings at each stage of design and during construction to ensure that we were on track to achieve LEED Silver. Some of the sustainable ideas that were incorporated into this project are as follows:

- Landscaping that required no irrigation, porous pavement, and low flow fixtures that decreased water use by 37%.
- 20% of the building materials contained recycled content
- 85% of the construction waste was diverted from landfills
- Low VOC paints, coatings, adhesives, and sealants were used on the project.
- The use of UV disinfection eliminated the need for chlorine and sulfur dioxide gas disinfection and received a point for Innovation and Design.
- 45% of the building materials were extracted, harvested, recovered or manufactured within 500 miles of the project site.
- 99% of the regularly occupied spaces have access to views and day lighting.

PROS AND CONS OF THE DESIGN BUILD PROCESS

This section of the paper summarizes the pros and cons of the design-build (DB) process as it relates to this project. Overall, the use of the design-build delivery method for this project was considered a huge success by all parties with the possible exception of the bridging consultant. The DB process assisted the team with achieving LEED Silver, provided a single point of responsibility for the Navy, and the majority of the team worked extremely well together. The following is a summary of the pros and cons at various stages of this project:

**Request for Proposal RFP:** The RFP was a design to budget type of project that required the DB team to provide the Navy with the best value possible for $12.5 million. This was positive because it discouraged low bidding and the “best value” proposal wins the project. Our team raised the SBR tanks and the associated filter building out of the ground and constructed it on auger cast piles, which allowed us to save approximately $600,000 and achieve the budget the Navy desired. However, this was a calculated risk, since the RFP was very prescriptive and did not assign the risk of deviating from the RFP to the DB Team. Therefore, we followed the RFP (30% design) to the letter even if we knew there was better ways to do it. The prescriptive RFP that did not assign risk to the DB team for deviations from the
30% design resulted in 26 modifications and approximately $700,000 in change orders. Most of this cost was due to the SBRs being undersized in the 30% design, because the backwash water from the filters and other recycle streams were not accounted for. In addition, the 30% design was based on a peak wet weather flow (PWWF) of 1.7 mgd, but the DB team determined through discussions with the STP operators that the true PWWF was really 2.5 mgd.

**Design and Construction:** During the actual design and construction process the Navy, BC and Haskell worked together to overcome the challenges of the 30% design documents. This included splitting the project into two phases to allow Haskell to demolish the unused unit processes and install the auger cast piles while BC completed design of the remainder of the new facility. This approach allowed the design / construction of this project to be completed ahead of the required MDE completion date without any permit violations. We also worked together to modify the solids treatment scheme during the construction period to incorporate the existing gravity thickener into the final design rather than demolish it.

**CONCLUSIONS**

The general conclusion is that this project was very successful for the following reasons:

- The new STP is achieving ENR level effluent with a TN of 2 mg/L and a TP of <0.15 mg/L.
- LEED Silver Certification was received for the Control / Lab Building.
- Difficult storm water requirements were met and a small number of water quality credits were granted due to the compact design.
- All parties involved felt the DB process was a success.