Canaan, VT and Stewartstown, NH Shared Wastewater Treatment Facility, Pump Station, and Energy Efficiency Improvements

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Abstract: The Towns of Canaan, Vermont and Stewartstown, New Hampshire operate a shared wastewater treatment facility, which required significant upgrades. The existing facilities were 40 years old and although a few upgrades were performed in the 90s, the facilities were not performing well, did not meet Life Safety codes, and required significant maintenance. The economical upgrade met all of the goals of the Client by providing for simple operation and maintenance requirements, meeting the Life Safety codes, eliminating confined spaces, lowering of electrical power costs, and meeting discharge parameters through production of high quality effluent.

The new Canaan, VT and Stewartstown, NH Shared Wastewater Treatment Facility

Background

The Town of Canaan, Vermont operates municipal wastewater collection and treatment facilities that serve the Towns of Canaan, Vermont and Stewartstown, New Hampshire. The two towns are separated by the Connecticut River, which is the boundary between the states. The wastewater treatment facility (WWTF) is located in Canaan. Each town operates and maintains their own collection system and they are jointly responsible for the operation of the WWTF. The purpose and scope of the project was to evaluate the pump stations and WWTF in Canaan, Vermont and to recommend and implement improvements in order to continue to meet discharge permit limits as well as stabilize or reduce operation and maintenance (O&M) costs in the future.

Existing Facilities

The existing facilities that made up the collection and treatment system included the sewers and four pump stations in Canaan, the sewers and two pump stations in Stewartstown, and the WWTF that serves both towns. The original sewers, pump stations, and WWTF were constructed in 1973 to serve Canaan and Beecher Falls. In 1981, the WWTF was expanded and upgraded to accept Riverside and West Stewartstown, and the sewers and pump stations in Stewartstown were constructed. Because the design life of facilities is approximately 20 years, the infrastructure in Canaan and Stewartstown was overdue for replacement.

Facilities Evaluation

Based on a review of the WWTF flow records, excess inflow/infiltration in the collection system was not indicated, and the existing VC and DI sewers had adequate capacity for present and projected flows. All the pump stations were beyond their design life. Although they had been maintained as required to keep the stations operating, most of the equipment was old and parts were no longer available.

The existing control building was not in compliance with current safety regulations

With the existing confined space regulations, the traditional wet well–dry pit station was classified a "permit required" confined space. Another regulation, NFPA-820, made the dry pit portion of the pump stations an explosion-proof area, creating the potential for conditions that could create an explosion. Since the pump stations were constructed prior to these regulations, the dry pit portion of the pump stations was not explosion-proof. Minor maintenance on the dry pit portion did not require the station to be converted to explosion-proof; however, any major upgrade, such as recommended in the study, would require the station be upgraded to meet the current regulations.

All the pumps had adequate capacity for the flow received but were undersized to provide adequate flushing velocity in the force mains. Pump Station #1 discharged to a 4-inch DI force main, for which the flow rate should have been approximately 90 gpm. The ejector discharged 55 gpm. Pump Stations #2, #3, and #4 discharged to 6-inch DI force mains. The pumping rate should have been approximately 190 gpm, yet the pump stations discharged at 150, 160, and 165 gpm, respectively.

At the WWTF, the aerated lagoons were in relatively good condition; however, there had been recent problems with the "Biloac" aeration system. The aeration tubing had experienced longitudinal cracks that led to ruptured diffusers and loss of aeration. A broken aeration tube was sent for evaluation, the results of which indicated a very weak design that was susceptible to longitudinal failure. Due to the age of the aeration system and the weak design, it was recommended the aeration system be replaced. The rest of the facilities were beyond their useful life: the Control Building was not in compliance with current safety regulations and was extremely energy inefficient; the brick veneer was made from interior brick and required covering with mortar to keep the bricks from breaking and falling off; the access and egress to all below grade areas, particularly the macerator, were a safety issue; and any major upgrade, including new pumps, aeration blowers, or the like, would require that the entire Control Building be upgraded to explosion-proof. In addition, wastewater treatment processes and construction had progressed substantially since the facility was built. Apart from the aerated lagoons, it was recommended that the facilities be abandoned and replaced with updated treatment processes and equipment as well as modern, energy efficient buildings.

Alternatives Considered

Alternatives considered to upgrade the pump stations included renovation of the existing wet well–dry pit to include conversion to an explosion-proof dry pit, conversion to submersible pumps with a separate valve vault, and conversion to wet well mounted, suction lift pumps. Converting to explosion-proof included refurbishing and upgrading the equipment, controls, electrical, and HVAC in the dry pit. The conversion to submersible pumps required the wet well to be modified, and submersible pumps on a rail system be installed in the wet well. A new valve vault would have to be installed. With the existing location of the pump stations, the new valve vault would be located where the existing dry pit was, which would require demolition of the dry pit. Conversion of the pump stations to wet well mounted, suction lift pumps included modification of the wet well to accept the new pumps and piping. All the pumps and valves would be housed in an enclosure that was installed on the existing wet well, and the existing dry pit would be demolished. All three options included adding an emergency generator with transfer switch and raising the wet well above flood elevation, if required.

Pump Station #1 (PS#1)

PS#1 station was a pneumatic ejector. The operator indicated it functioned extremely well and that the preference would be for it to remain an ejector. PS #1 did not have an emergency generator and transfer switch, and the entrance tube to PS#1 was approximately 3.5 feet lower than the 100-year flood elevation. To maintain PS#1 as an ejector would require extending the entrance tube four feet, installing a generator and transfer switch on a platform above the flood elevation, and upgrading the ejector, controls, electrical, and HVAC to explosion-proof. Converting PS#1 to submersible pumps was also evaluated. It would require converting the existing ejector to a valve vault and raising it above flood elevation, converting the influent manhole to a wet well, and adding an emergency generator and transfer switch. Based on efficacy and estimated costs, it was recommended to upgrade PS#1 with submersible pumps in a new wet well with adjacent valve vault.

Pump Station #2 (PS#2)

All three conversion options were evaluated for PS#2. PS#2 did not have an emergency generator and was well below the 100-year flood elevation. Factors considered in the evaluation included costs, the anticipated life of the option, and operator safety. Conversion to wet well mounted, suction lift pumps was cost-prohibitive and excluded as an option. Converting the dry pit to explosion-roof would still classify it as a confined space due to potential hazards including drowning and electrocution, and the dry pit required the operator to enter the space to make daily checks of the equipment. The submersible pump option also required daily checks; however, these checks could be completed above grade without having to enter a confined space. The existing structures included a concrete wet well and a steel dry pit can. The concrete could be expected to last 50 years or longer, and the steel can was protected from corrosion by a pair of sacrificial magnesium anodes which had never been checked; therefore, the expected life of the steel can was unknown. New or upgraded facilities are designed to last for 20 years. With the uncertainty of the remaining life of the existing steel can and the confined space safety concern, it was recommended to convert PS#2 to submersible pumps.

Pump Stations #3 and #4 (PS#3 and PS#4)

All three conversion options were evaluated PS#3 and PS#4. The two pump stations were not below the 100-year flood elevation, and both had emergency generators. Conversion to wet well mounted, suction lift pumps was cost-prohibitive and excluded as an option. The factors considered in the evaluation of the options were the same as PS#2 and included costs, the anticipated life of the option, and operator safety. Since these stations were the same as PS#2, all the factors and concerns were the same. Therefore, it was recommended that both PS#3 and PS#4 be converted to submersible pumps.

Enclosed VFD driven aeration blowers and insulated air piping for aerating of lagoons

Wastewater Treatment Facility

The process train for the upgraded wastewater treatment facility included influent pumping, fine screen, grit removal, aerated lagoon treatment, and chlorine disinfection. Associated processes included septage receiving and lagoon sludge removal. The options considered for influent pumping were submersible pumps and wet well mounted, suction lift pumps. Because the application of the wet well mounted, suction lift pumps was at the extreme end of the suction lift capability, the submersible pumps were recommended based on cost and application. The influent screening consisted of the installation of a fine screen in a new building. Due to the facility size, the standard quarter inch fine screen was recommended. Alternatives considered for grit removal were vortex grit separation and aerated grit chamber. Because they both required approximately the same amount of space and removed and processed grit with equal efficiency, the aerated grit chamber was the recommended alternative due to cost.

One of the odor-reducing solar-powered floating lagoon mixers

The three aerated lagoons were in good condition. A new diffused aeration system was installed in all three lagoons in 1998, but in the summer of 2010, problems developed with the aeration tubing. As previously discussed, the design of the aeration system tubing was weak and susceptible to cracking. Therefore, it was recommended that the aeration system be replaced with a new, fine bubble, diffuser system. An alternative for energy savings that was evaluated included installation of solar mixers in the lagoons to reduce the required amount of forced aeration. While they are not true aerators, solar mixers turn over lagoons and expose the wastewater to air on the lagoon surface. The State of New Hampshire, Department of Environmental Services (NHDES) directed a study of solar powered mixing at three New Hampshire treatment plants, the objective of which was to evaluate the reduction of energy consumption while maintaining treatment. All three facilities included in the

Solar mixer in operation at lagoon

study maintained or improved treatment while significantly reducing energy consumption. From the NHDES study, the Pittsfield, New Hampshire wastewater treatment facility was closest in size to the Canaan plant. The study showed about a 45% reduction in energy use after installation of the solar powered mixers. The Exeter, New Hampshire wastewater treatment facility, which is a much larger facility, also saved approximately 45%. In addition, the Pittsfield operator indicated that the plant was achieving better effluent quality with the mixers installed.

Besides energy and cost savings, the installation of solar powered mixers was expected to produce additional benefits. Both Pittsfield and Colebrook saw improved effluent quality, and Colebrook could operate only two of their three aerators for most of the year while still meeting discharge permit limits. With the average flow and load at Canaan, it was expected that aeration in Lagoons #1 and #2 would be further reduced with the solar powered mixers, saving additional energy and further reducing the payback period. The solar powered mixers also improved nitrogen removal — improving effluent nitrogen quality — and reduced sludge production through mixing. The mixing also subjects the sludge to aerobic and anaerobic digestion, the combination of which reduces the amount of accumulated sludge in the lagoons, which in turn reduces the frequency and cost of sludge removal. Even with a potentially long payback period of 13 years, the solar powered mixers were recommended for energy savings, effluent quality improvement, and sludge reduction.

There were no options besides chlorine disinfection considered. The lagoon effluent quality (maximum day TSS of 50mg/l) combined with Vermont's stringent E. coli limits (77/100ml instantaneous maximum) excluded the use of ultraviolet light (UV) disinfection. The new chlorine contact tank was designed to modern standards, include flash mixing of the chlorine, and provide chemical pumps capable of applying varying doses of chlorine based on flow and chlorine residual. There is an effluent flow measuring system at the end of the chlorine contact tank, and the entire tank is enclosed in a structure to make it fully accessible during the winter.

Installation of innovative septage receiving station

Septage Receiving

The WWTF receives approximately 250,000 gallons of septage per year from homes and businesses in both Vermont and New Hampshire. The existing system separated the solids, removed them to a composting operation, and discharged the liquid to the WWTF. Two options for septage receiving were evaluated. The first option was to install a complete septage treatment plant in a septage receiving facility, which proved to be cost prohibitive. The second option, which was recommended and implemented, was to install a septage receiving tank with a bar rack, and discharge the septage to the influent pump station for treatment in the new headworks. The septage receiving tank screens the septage through a bar rack with 1½ inch spacing, meters the septage, and discharges to the influent pump station. The septage is mixed in the wet well with incoming wastewater and pumped to the headworks, where it is screened and degritted then discharged to the lagoons for treatment. In the lagoons, the septage is dispersed throughout the lagoon by the solar powered mixers, which reduces the shock load and enhances treatment.

Sludge Removal


Sludge Sled


Geobag

Historically, lagoon systems have removed sludge when the depth reaches about two feet and can begin to affect the aeration system, which is an expensive process involving a lot of time and effort on the part of the operator. The usual sequence is for the operator to take the lagoon out of service, remove as much wastewater as possible, and then bring in a contractor to remove, dewater, and dispose of the sludge. Typically, this is done every five to ten years. Depending on the size of the facility, the cost for the contractor can range from $100,000 to $300,000, and most systems are unprepared for this major expense. A local dewatering firm was contacted to estimate the cost of removing and disposing of sludge from the Canaan lagoons. Based on an average depth of 1.5 feet in the three lagoons, the estimated cost was $150,000.

However, a new system for lagoon sludge removal was evaluated and installed. The system was developed around a floating sludge pump with a submerged sludge scoop, or sludge sled. The sludge sled is pulled back and forth across the lagoon by a winch, and the collected sludge is pumped to a remote discharge point. After the sludge sled has made a pass across the lagoon, the winch system is relocated and makes another pass until the lagoon has been covered. The portability of the 155-pound sludge sled enables it to be easily moved and to be utilized to remove sludge from lagoon systems annually. Also, depending on the type of aeration system, it can remove sludge without taking the lagoon out of service. The sludge removed from the lagoon is then pumped to a frac tank where it is mixed with a polymer to aid dewatering. From the frac tank, the mixture is pumped to a permeable geotextile bag, or "geobag," for dewatering. The water is separated from the solids and returned to the lagoon. Depending on the size of the lagoon and the amount of sludge generated, a geobag may be able to handle a few years' worth of sludge. The geobag is allowed to freeze, which releases additional water from the sludge and increases the solids content to 20% or more. The solids are then removed and disposed of, usually in a landfill, but can be land applied if a permitted site is available. The estimated cost of the sludge sled system was $52,000 and represented significant cost savings for the two Towns.


Insulated concrete formed walls

Energy Alternatives

Energy efficient, low maintenance structures are a primary concern of any new construction. The structures utilized for the Canaan WWTF have walls constructed with insulated concrete forms for energy efficiency and fiber-cement siding for low maintenance. The roofs are trusses with a standing seam metal roof for low maintenance and R-42 insulation in the ceilings for energy efficiency. The new structures include the Headworks and the Control Building. The existing Control Building was demolished and a storage building built on the foundation.

As part of this WWTF upgrade, a biomass boiler was installed for heating the facilities from a central location. Insulated heat lines run from the central boiler to the adjacent buildings. Additional energy alternatives utilized include a heat exchanger on the influent force main that recovers heat from the influent wastewater and provides part of the heating load for the Headworks. Waste heat from the blowers is used to supply part of the heating load for the Control Building.

The new Control Building including the wood pellet storage silo

Project Outcome

The upgrade of the WWTF and pump stations has provided the Towns with an energy efficient facility that meets all regulatory requirements with reduced O&M costs. The new pumps are more efficient and require less energy, and the new blowers with VFDs save even more energy by controlling dissolved oxygen levels in the lagoons. The addition of the solar powered mixers has further reduced the amount of energy required for the blowers. The new Control Building and Headworks are well insulated, reducing the amount of energy required to heat the buildings. They also have energy efficient lighting to aid in energy conservation.

The project had a Total Project Cost of $4.12 million. Tata & Howard team members helped the Towns secure a $2.412 million low-interest, long-term loan, and $1.69 million in grant funds from the U.S. Department of Agriculture (USDA) Rural Development in order to build the new facility. The project was completed in 2015, and the upgrade to the 40-year old treatment facility and four pump stations resulted in a simple, energy-efficient, and operator-safe facility that produces a high-quality effluent.