LESSONS LEARNED INTEGRATING WASTEWATER HYDRAULICS AND PROCESS DESIGN

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This presentation will highlight lessons learned from recent hydraulics and wastewater process experiences during planning, design, construction, and startup phases of wastewater facility projects including work associated with the City of St Petersburg and Lee County.

Process and Hydraulic Evaluations Led to Important Recommendations to the City of St Petersburg

The City of Saint Petersburg experienced extreme wet weather events in 2015 and 2016, testing the capacities of their wastewater collection system and water reclamation facilities (WRFs). These events were assessed and a set of recommendations were developed to implement capacity improvements throughout their wastewater systems. As part of these capacity improvements recommendations, the City of Saint Petersburg implemented reclaimed water system and injection well improvements projects at the Southwest and Northwest WRFs (SWWRF and NWWRF) with design and construction of Phase 1 of the projects completed the 2017 rainy season. Phase 1 consisted of the design and construction of a new deep injection well and a new emergency diesel pump station at each facility to manage excess reclaimed water under extreme events. Later phases of this project included the design and construction of 2 more new injection wells at the SWWRF, capacity improvements to 5 existing injection wells at the SWWRF and NWWRF, and new piping to route reclaimed water to the new and rehabilitated injection wells.

As part of the injection well and reclaimed water improvements projects, effluent pump models to the existing and new injection wells were created during the design phases of the projects utilizing AFT Fathom, a fluid dynamic simulation software. The models were further calibrated during startup of the diesel pump stations with measured data. The diesel pumps were designed based on being able to achieve their design flow at the maximum permitted pressure for the new injection wells of 100 psi. However, during diesel pump and injection well startup testing, the new injection wells proved to be much more productive than originally assumed during design. This means that the underground receiving formation provided less resistance to flow and back pressure than originally assessed. This resulted in pump cavitation and priming issues during the first startup test of the diesel pumps at the NWWRF. Because of the cavitation and priming issues during the first test, the AFT Fathom model was updated to include actual observed backpressures from the new injection well at different flow rates to provide initial recommendations for how much the butterfly valves should be throttled on the discharge piping of the diesel pumps. Dezurik's Alpha 1 software was also used to confirm that throttling the butterfly valves to the recommended percent open would not cause the valves to cavitate. Partially closing the butterfly valves on the discharge piping resulted in an increase in the diesel pump discharge pressure during the second test and the pumps were able to achieve their design flow capacity without cavitation issues. Furthermore, based on Hydraulic Institute pump intake design standards, recommendations related to minimum submergence of the diesel pump station 42-inch suction piping header were developed to address the pump priming issues observed during the first startup test. This experience emphasizes the need to remain flexible in design and operation to ensure that unforeseen conditions during construction, startup, and operations can be managed successfully. The recalibration of the design tools during startup led to a working system that did not require further retrofits.

Recently, the City of St Petersburg has developed an Integrated Water Resources Master Plan (IWRMP) to provide recommendations to maintain the desired level of service for the water, wastewater, and reclaimed water systems for current conditions and for 2040 projections. By assessing these systems together, solutions can be optimized to support an overall water resource management strategy that is more cost effective while providing enhanced benefits to the utility and its ratepayers. As part of the IWRMP, collection system hydraulics, as well as WRF hydraulic and treatment capacity of each unit process was assessed. Preliminary recommendations for capacity improvement were provided for components that did not meet the desired levels of service. From this analysis,

deficiencies in aeration capacity in some of the aeration basins were identified and were then confirmed from developing wastewater process models for NWWRF and NEWRF, utilizing Envirosim's Biowin software. The IWRMP also involved studying the reclaimed distribution system, identifying capacity deficiencies and recommending potential areas for expansion of the reclaimed system to new customers. The capacity of the reclaimed distribution system was assessed for current peak hour demands and projected 2040 peak hour demands using the City's reclaimed distribution model developed in Innovyze's Infowater software. By assessing collection systems, treatment works, and reuse systems together, competing interests become evident and optimization in the recommendations lead to a better managed utility.

Lee County's New South East Water Reclamation Facility Design

At the end 2019, Lee County kicked off the design of their new South East Water Reclamation Facility. This greenfield facility is being designed to service a new projected growth area in Lee County. Preliminary design was recently completed and includes the development of a wastewater process model, hydraulic profile of the facility, and individual hydraulic models for each pump station. The wastewater process model was developed with Jacobs' Replica Process software to confirm sizing process calculations of the oxidation ditches, secondary clarifiers, effluent deep bed filters, and aerobic digesters. Much like commercially available packages such as Biowin, Replica Process is a wastewater process modeling software. However, it is also used as a detailed design tool and can quickly integrate with Jacobs' Replica Parametric Design software for project cost estimating and Replica Hydraulics for dynamic hydraulic modeling.

From development of the main process sizing, a hydraulic profile of the new WRF was developed for various flow scenarios. These flow scenarios included startup flow, average annual daily flow, and peak hour flow. The startup flow scenario is especially important to ensure minimum velocities are achieved in the headworks channels so that solids remain in suspension. Peak hour flow scenarios are particularly important to determine weir sizing and that basins have enough freeboard. With the development of the hydraulic profile, site layout, and process model, pump stations were sized based on required flows from the process model, water levels developed in the hydraulic profile and pipe lengths and routing estimated from the site layout.

During the Lee County preliminary design process, the models developed were segmented into separate hydraulic and treatment process models using various software. When a design change occurred, this change would often have to be updated in multiple if not all models. The updates at times were not simple changes and would be time consuming. Because of examples like this, there's a trend within our industry to integrate the separate wastewater process, hydraulic, aeration, and controls models into one system model. Enabling the ability to quickly update and evaluate the full effects of design changes or upgrades as well as being able to optimize and simulate operations and controls. These models can also be linked directly to plant PLCs in the field to test and tune programming against the models prior to starting the system, providing a significant reduction in startup time, risk, an increase in programming confidence and overall system understanding. Furthermore, these models can be developed to match plant SCADA interfaces to provide training to plant operators that can run through 'what if' scenarios in a non-risk 'flight simulator' like mode.

Biography

Claes is a licensed professional engineer and has 8 years of experience working on water and wastewater infrastructure projects. He has a special interest in continuing to learn more about wastewater design by creating discussions within the industry to challenge our current approaches to hydraulic and wastewater process design. In addition, Claes has a special interest in using integrated packages to solve complex engineering problems and advance the practice of the use of Digital Twins in the wastewater industry. Claes also is heavily involved with Engineers Without Borders and has supported efforts in Guatemala and the Dominican Republic associated with water supply projects where he brings his knowledge of hydraulic modeling to help communities that don't have access to clean drinking water.