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Ohio Section

American Water Works Association

Elyria Solids Handling Project "Makes the Cake"

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Introduction

The City of Elyria had conducted studies to replace its lime and alum chemical feed systems with Aluminum Chlorohydrate (ACH) as a means of reducing chemical costs and the volume of thickened solids being trucked daily to its wastewater plant for dewatering and disposal. The original plant was constructed on the shores of Lake Erie, to supply finished water to the City of Elyria approximately 8 miles to the south.

In the past 20 years, the City had already completed construction of a new Intake, Raw Water Pumping Station, upgrades to its clarifiers and filters Attenuation Basin, and SCADA system. A new High Service Pumping Station capable of delivering 22 MGD and improvements to its clearwells were completed by 2010.

The City of Elyria selected Burgess & Niple to conduct a comprehensive chemical optimization study. A Capital Improvements Plan (CIP) approach was proposed that would not only address the City's goals and objectives to optimize the chemical feed systems to improve water quality, but also evaluate options to improve the reliability and overall performance of the Flash Mix, Flocculation, Settling, and Solids Handling facilities.

Although thickened solids were being trucked off-site to the City's wastewater treatment plant, concerns about rising trucking costs, volume restrictions, and disposal options needed to be addressed in the CIP. New solids thickening and dewatering facilities will eliminate hauling to the WWTP and allow the City to have dewatered sludge cake picked up and taken directly to an approved landfill.

CIP Planning Process

The CIP creates a roadmap that provides the path to rehabilitation, renovation, repair, and replacement of existing and outdated facilities based on their condition, performance, O&M costs, and reliability. A recommended plan of improvements was developed with each project being scored, ranked, and then prioritized based on need, costs, and benefits.

Using the results of treatability studies conducted by the City, B&N completed the study in two phases; Phase I included preparation of a Preliminary Design Report (PDR), which addressed chemical optimization of aluminum chlorohydrate (ACH), potassium permanganate, zinc orthophosphate, and powder-activated carbon. The PDR also evaluated modifications/additions to the rapid mix, flocculation and settling basins to maximize the rated plant capacity and improve water quality through chemical and process optimization. The report included preliminary designs of the improvements, cost estimates, and a schedule for implementation of the recommended improvements in Phase II.

Phase II included preparation of construction plans and specifications to construct a

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250,000-gallon sludge thickener tank and a sludge dewatering building to house a 100-GPM centrifuge and two 20 CY sludge containers. The results of the pilot studies during preliminary design were used to size sludge dewatering equipment and sizing of the sludge thickener. The Solids Handling Facilities were bid in early 2016.

Existing Conditions

The Ohio Environmental Protection Agency (OEPA) Approved Rated Capacity for the City of Elyria Water Treatment Plant is currently 22.0 MGD. An overview of the plant is provided to familiarize the reader with the water treatment processes used to treat the raw water drawn from Lake Erie.

Mechanically Cleaned Screens: Two mechanically cleaned screens are located at the lower level of the pump house. The newer screen is 8 feet wide with 3/8-inch openings and is rated for 30.0 MGD.

Raw Water Low Service Pumps: Four raw water pumps that were installed prior to a 1967 plant upgrade when two new pumps (Nos. 6 and 8) were installed. Recently new electric motors and VFD controls were installed. Maximum pumping capacity is 27.8 MGD with the largest pump out of service. Pumping rates for the Raw Water Pumps are as follows:

- **No. 1, 5, and 6 – 6.5 MGD or 4,514 GPM**
- **No. 2 – 7.8 MGD or 5,417 GPM**
- **No. 3 – Removed**
- **No. 4 – 7.0 MGD or 4,861 GPM**
- **No. 7 – Future**
- **No. 8 – 11.0 MGD or 7,640 GPM**

Rapid Mix Basin: At the Elyria WTP, rapid mixing is accomplished in two chambers, each 10 feet, 4 inches square and have a 15.5-foot sidewater depth (SWD) with a volume of 12,400 gallons.

Lime, Alum, Powdered Activated Carbon (PAC), and Fluoride were being fed in the raw water channel upstream of the rapid mix chambers and prior to flocculation. Overfeeding the chemicals resulted from the various chemicals being fed at the same location. Modifications were recommended to improve chemical mixing by reconfiguring the rapid mix basin and reducing the detention time from 140 seconds to the recommended 30 seconds.

Flocculators: Horizontal shaft paddle mixers provide 32 minutes of detention time at the design average daily flow of 22.0 MGD. The flocculators are 66 feet long, 16 feet wide and have a SWD of 15.5 feet. Rated capacity for this process is 23.5 MGD with all four units online and a 30-minute detention time as required by TSS.

Sedimentation Basins: There are four below grade sedimentation basins. Two of the basins are 39 feet wide by 195 feet long, and two are 41.5 feet wide by 260 feet long. Sidewater depth in all four basins is approximately 13 feet and 15.5 feet respectively. Detention time through the settling basins, under Average Daily Flow (ADF) conditions with all tanks in operation is 4 hours and meets TSS for sedimentation. Each tank has two sludge hoppers approximately 20 feet wide with a minimum of two sludge draw-off points. A low dividing wall separates the two sludge collection zones.

The location of Sedimentation Basins Nos. 1 and 2 in relationship to the Flocculators and the difference in geometry between the four tanks result in challenges to equalize the flow and solids loading among the four Sedimentation Basins.

Filters: The Filter Building houses 10 mixed media filters with porous tile underdrains, providing a total filter area of approximately 7,208 SF. With all ten filters in service, the capacity is 20.7 MGD at a filtration rate of 2.0 GPM/square foot. With the largest filter out of service, the rated capacity at 2.0 GPM/square foot is 18.7 MGD. Pilot tests are planned to run the filter at higher surface loading rates for OEPA approval.

Backwash Pumps: Backwash water will be drawn from directly from the clearwell. A new backwash pump rated for 12,950 GPM has been provided in the new High Service Pump Building

Attenuation Basins: Two Attenuation Basins provide a combined capacity of 164,000 gallons. is currently limited to two backwash volumes per day or approximately 188,000 GPD (1.6% of the current 12 MGD ADF). The City was interested in increasing this to the 10% maximum allowed by the OEPA backwash water recycle rule.

Recycling settled supernate flows from the Attenuation Basin back to the Raw Water Pump Station (RWPS) via an existing 12-inch gravity drain line. Backwash water can be pumped to

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the City of Lorain sewer in an emergency. Settled solids are pumped to the Head House Sludge Storage Tanks for disposal.

High Service Pumps: A new High Service Pump facility with a rated capacity of 33.0 MGD was constructed in 2015. The new building will house four new high service pumps to be rated as follows:

- Pump No. 1 — 5,500 GPM (8.0 MGD)
- Pump No. 2 and 4 — 10,500 GPM (15.0 MGD)
- Pump No. 3 — 6,950 GPM (10.0 MGD)

Clearwells: There are three clearwells with a total capacity of 3.2 MG. One clearwell has a capacity of 1.2 MG and the other two hold 1.0 MG each. The clearwells can be operated in series or parallel.

Solids Storage Tanks: Two sludge storage tanks were housed in the Head House Building at the Elyria WTP. The four-story building housed the original concrete backwash water reservoir on 4th floor of the building. Two 61,300-gallon sludge storage tanks, each 20' x 20' x 11' side water depth (SWD) were designed to receive settled solids that were pumped from the sedimentation basins. Three sludge transfer pumps are in the basement piping gallery. Thickened sludge is drawn from the hopper and pumped to 5,500-gallon sludge tanker trucks. Sludge containing 3-4% solids was being hauled off-site to the Elyria WWTP, where it is combined with their WWTP sludge prior to dewatering and disposal. A telescoping valve is provided in each tank to decant from 3,000 to 15,000 gpd (1 to 5 feet) of clear supernate to the City sewer.

Basis of Design Report

The Basis of Design Report (BDR) included the findings, conclusions, and recommendations to upgrade the existing Rapid Mix, Flocculation, Sedimentation, and Attenuation Basins, and construct new Sludge Thickening and Dewatering facilities. The BDR included improvements needed to increase the rated capacity of the plant from 22 MGD to 29 MGD by making modifications to the Rapid Mix Tank, Flocculation Basins, Sedimentation Basins, and Attenuation Basin. This article focuses on the design and construction of a sludge thickener and centrifuge to dewater solids and produce a sludge cake that could be directly transported to a landfill for final disposal.

Solids from the Sedimentation and Attenuation Basins would be sent directly to a new Sludge Thickener adequately sized to handle 30 days of thickened solids. A new centrifuge would be provided to dewater 100 GPM of 4% thickened sludge. Spiral screw conveyors would be used to transfer sludge cake to one of two 15 CY dumpsters housed inside a new masonry Solids Handling Building. The lower level serves as a pipe gallery with pumps to draw thickened sludge from the new thickener sludge hopper and feed it to a new centrifuge.

Decant from the dewatering operation would be returned to the Raw Water PS or sent to the City sewer in case of an emergency Harmful Algal Bloom (HAB) event that would prohibit recycling the flow. Solids for the Attenuation Basin would be thickened and then pumped the new Thickener. The existing Sludge Storage Tanks (SST) provide additional storage capacity and can be used to allow for unloading and storing trucked-in sludge from other facilities. Piping is provided for emergency filling of tanker trucks for off-site disposal in the event of an extended outage of the centrifuge.

Sludge Dewatering Pilot Tests

A pilot test of the sludge dewatering equipment would be conducted to establish design parameters for sizing the new centrifuge system. A Request for Proposals was issued, soliciting vendors interested prequalifying their dewatering equipment to participate in a 4-day demonstration using ACH sludge pumped from the existing sedimentation basins to the existing sludge thickener tanks.

A. Centrifuge Parameters	
A. Number of Centrifuges:	*One*
B. Minimum Solids Capture Rate:	*97.5%*
C. Maximum Polymer Usage:	*25 pounds (active) per ton dry solids*
D. Maximum Capacity of Solids Handling:	*1,000 lbs./hr. (dry solids)*
E. Maximum Operating Cycle:	*4 days per week, 7 hours per day*
B. Sludge Type	*ACH potable water settled solids*
C. Dewatering	
A. Sludge Solids Content in Feed:	*2.5 to 4.0% dry solids*
B. Throughput Solids:	*1,000 lbs./hour (dry solids)*
C. Maximum Hydraulic Loading Rate:	*100 gallons per minute (GPM)*
D. Minimum Solids in Cake Discharge:	*25% Dry Solids @2% Feed*

The City elected to proceed with pre-purchasing the dewatering equipment prior to start of detailed design. A Centrifuge Procurement RFP document was prepared, including contract documents and technical specifications outlining the test protocol, equipment specifications, and selection criteria. Operation design criteria to size the unit included operating ranges for feed rates, solids concentrations, quantities, solids capture, cake moisture, power and chemical consumption reporting.

The bid form required the listing capital equipment cost, estimated annual operating costs, and associated costs for spare parts, extended warranty cost, and annual maintenance contract. A total life cycle cost evaluation formula was provided to establish the equivalent annual cost for each bidder.

Each vendor was provided with the designated trial runs to be performed over a 3-day demonstration period. Test results with feed rates, solids concentrations, machine speed, cake moisture, capture rate, polymer dosage, and power consumption were reported. Each vendor could run trials using polymers besides the two anionic and cationic polymers specified. Each vendor submitted a priced proposal for their equipment showing capital and O&M costs. Costs for spare parts and an extended warranty were also provided.

Three vendors successfully met the minimum performance levels needed to be deemed a "qualified bidder." The City raised concerns about their potential risks of pre-purchasing the equipment. The RFP was cancelled, and the project proceeded as a conventional design-

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bid-build project. Each bidding contractor was required to base their bid on one of the three “prequalified” centrifuge manufacturers.

Design Phase

Selecting Site Location. During design, three alternate locations on the plant site were considered. One location was too far removed from the sedimentation basins. The second location was eliminated due to clearances from overhead power lines that would have required relocation of the main 69 KV feed to the plant. The third site provided a central location but was bounded on the west by a 7-story high, 90-year old, masonry H.S. Pump Building, a plant stormwater outfall sewer located 10-feet off the building, and the 54” raw water main that wraps around the north and east sides sf the proposed new facilities.

Records indicated a pre-1900 clearwell and filter building in the vicinity of the proposed site. Soil borings did not encounter any old foundations, but drilled caissons were needed to support the south wall of the Solids Handling Building (SHB). To protect the existing 54” raw water main and the Old High Service PS foundations, soldier beams and lagging were used to protect the adjacent structures. The drilled caissons were also used to retain the existing driveway for sludge hauling trucks.

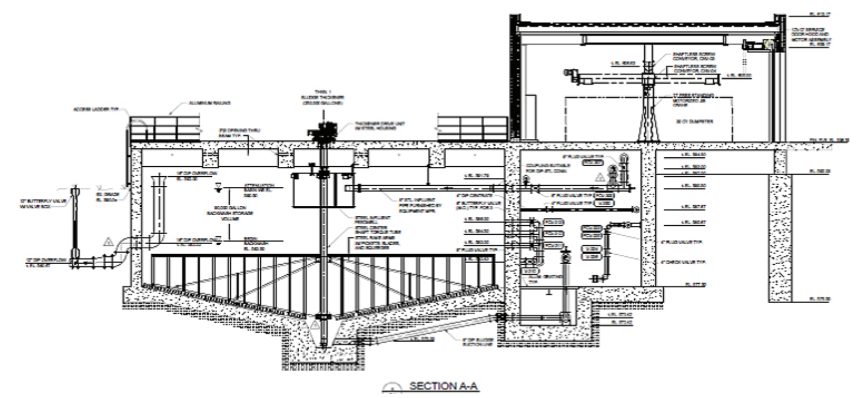
New Solids Handling Building. A new masonry building was constructed to house the centrifuge sludge pumps, sludge dewatering equipment, conveying equipment, polymer feed equipment, two 15 CY sludge containers,

and electrical control panels. The architecture reflects the style of the nearby old and new High Service Pump Buildings, as well as the Head House, and Chemical Building. Insulated cavity walls, window units, and precast concrete roof deck protect against cold winds off the lake. A Pump Gallery is provided beneath the first floor of the building to house the sludge pumps, solids grinder, decant/centrate pumps, piping, and flow control valves.

New Sludge Thickener. The final design included constructing a 230,000-gallon sludge thicker that is 48 feet in diameter, with an 18-foot SWD, and a concrete deck spanning the width of the tank. The 48-foot diameter octagonal-shaped

tank eliminates the need for large corners fillets. Vertical pickets are attached to the rake arms to aid in solids compaction and convey the sludge to a 5-foot deep center sump. Settled solids are concentrated from approximately 2.5% solids to 4% - 6% solids, prior to being pumped to the centrifuge for dewatering. An optical sludge blanket meter detects the interface between the clear supernatant and thickened sludge. Three 8-inch pipes are used to decant supernate into a separate decant/centrate pump clearwell.

Decant/Centrate Pumps. Two 200 GPM Decant/Centrate pumps return the centrate from the



centrifuge and the supernate decanted from the thickener back to the RWPS clearwell. Each Decant Pump has motor-operated valves and magnetic flow meters to measure the flow being pumped to the RWPS. In the event of a HAB event, all decant and centrate flow will be pumped back to the City sewer via the existing 8-inch force main that discharges into sample manhole.

Sludge Pumps to Feed Centrifuge. Two 150 GPM variable speed positive displacement sludge pumps convey thickened sludge with 3-4% solids at a rate of 50-100 GPM to the centrifuge. The sludge passes through a grinder and is metered before entering the centrifuge where polymer and carry water were added at the inlet to the centrifuge.

Polymer System. Two pre-packaged polymer feed systems are equipped with a progressive cavity pump to feed an NSF-approved anionic polymer into a mixing chamber where dilution water is added to create a 0.5% solution that is fed to the inlet of the centrifuge. Tests were conducted to optimize the polymer feed rate to provide a clear centrate and granular sludge cake.

Centrifuge. An Andritz D4L centrifuge with an 18-inch diameter bowl sits on a 5-foot high service platform to allow solids to drop into a spiral screw conveyor. The centrifuge can dewater 1,000 lbs./day of dry solids and produce a cake with 25- 35% solids in the sludge. The centrifuge speed and torque can be adjusted to produce the optimal sludge cake solids concentration. A PLC-based control panel with Operator Interface Terminal (OIT) monitors and controls the startup and cleaning operations of the centrifuge, the sludge feed pumps, polymer feed system, and conveyor system.

Sludge Cake Spiral Screw Conveyors. Four spiral screw conveyors direct the sludge cake

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vertically, then overhead to discharge into one of two 15 CY dumpsters. A pivoting conveyor slowly moves back-and-forth in an arc to continuously fill a container. When full, the conveyor reverses direction and starts to fill the second dumpster.

At design flow, the centrifuge will operate 14 hours per week and process a maximum of 1,000 lbs./hour of dry solids 25%-35% sludge cake, requiring approximately 7 hours to fill a 15 CY dumpster to its maximum 40,000 pound allowable hauling weight.

Attenuation Basin for Settling of Filter Backwash Water: Two Attenuation Basins, each 20' W x 55" L x 10.5' SWD, providing storage and settling for 90,700 gallons of backwash water. The plant typically backwashes two filters per day that average 75,000-90,000 gallons per backwash. Once an Attenuation Basin is full, the solids can settle out are pumped to the new Sludge Thickener.

Supernate is returned to the RWPS clearwell by a gravity drain or pumped by the new 1,050 GPM pump decant pump P-3 through an existing 12-inch force main. Settled backwash solids are pumped to the new sludge thickener for dewatering.

An 8-inch flow control valve and magnetic flow meter are used to regulate the recycle flow to less than 10 percent of plant actual flow allowed by Ten State Standards. Pump P-3 can be throttled to recycle 540,000 GPD or 340 GPM of backwash water from six of the 12 filters. If all 12 filters were backwashed, Pump P-3 is designed to recycle 1.08 MGD or 770 GPM to the RWPS, which is within OEPA's maximum allowable return rate to the RWPS clearwell at current ADF.

Figure 1 provides a schematic flow diagram of sludge lines and the various discharges from Decant Pumps P-1, P-2, and P-3 to sewers and manholes that are connected to the City sewer. All sanitary flow will be recorded with the existing meter in MH D and sampled at Sample MH C.

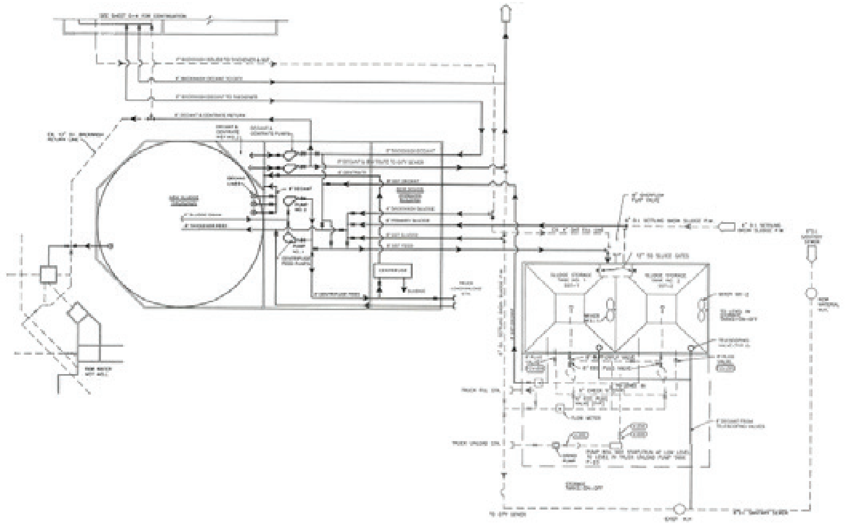

Figure 1 Schematic Process Flow Diagram

SCADA

New PLC-based control panels are provided in the Attenuation Building to control the new recycle pump, sludge pumps, levels, flows, and control valves. In the Head House, a new PLC panel controls two new sludge transfer pumps for the truck fill operation, new grinder, and levels in the Sludge Storage Tanks.

In the Solids Handling Building, a new PLC panel controls the sludge thicker drive, sludge pumps, centrate pumps, grinder, conveyors and polymer feed systems. The new Centrifuge Control Panel is fully integrated with the plant SCADA system. Twenty-three motor operated flow control valves are provided to direct flows from the settling basins, Head House, and Attenuation Basins to the Thickener. Magnetic flow meters measure flow rates and recorded and totalized using the plant SCADA system.

Construction Issues

While drilling of the caissons, the abandoned masonry walls and concrete filter bottom slab and roof of the clearwell were encountered. The new building was shifted southward by one foot to construct the caissons. Old walls were demolished and the clearwell was filled with low strength concrete.

As excavation proceeded for the thickener, the 5 KV electrical feed from the main plant substation to the old high service pump building was encountered and had to be relocated between the sheet piling and the 54" water main. New ductbank for the 5 KV electrical cables, 480-volt power, and 120 and control wiring were run between the existing substation and HSPS. Wiring was swapped over during several scheduled outages, and then the old ductbank and wiring were demolished.

Construction Cost

The $5 million improvement project took 20 months to complete and has been in full operation for over two years.

Acknowledgements

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