TITLE: The Saddle Creek RTB – A Storage and Treatment Solution for CSO

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ABSTRACT
The City of Omaha Public Works Department is undertaking a major water quality improvement program called *Clean Solutions for Omaha,* or *CSO!* which will improve water quality in Omaha's rivers and streams by capturing or treating 85% of the average annual combined sewage volume through a series of projects. One of the major projects as part of this program is the Saddle Creek Retention Treatment Basin. The purpose of the Saddle Creek Retention Treatment Basin (SCRTB) Project is to capture combined sewage and store or treat it during wet weather events. This paper describes how wet weather storage and treatment technology was applied to attenuate excessive flows for the purposes of meeting the Long-Term Control Plan requirements for control of combined sewer overflows.

KEYWORDS: Combined Sewer Overflow, Disinfection, Wet Weather

INTRODUCTION
The Saddle Creek Retention Treatment Basin (SCRTB) is a significant project that is part of the City of Omaha's water quality program called *Clean Solutions for Omaha,* or *CSO!* The SCRTB is located adjacent to the Little Papillion Creek and S 64th Avenue. Refer to Figure 1 for a Project Site Location Map. Prior to construction of the SCRTB, untreated combined sewage overflowed into the Little Papillion Creek (LPC) from the City's CSO 205 outfall structure over 65 times per year. With the new facility in place, combined sewage will be diverted to the RTB to receive grit and screenings removal, disinfection, solids settling, and dechlorination before being discharged back to LPC. In 2011, the City of Omaha, in association with engineering consultants Wade Trim, Inc., Brown and Caldwell, Kirkham Michael, Alley Poyner Macchietto Architecture, Alvine Engineering, and Vireo (the Design Team), began planning and design activities for the SCRTB project. Construction commenced in Spring 2019 and the SCRTB is anticipated to start operations in late summer of 2023.

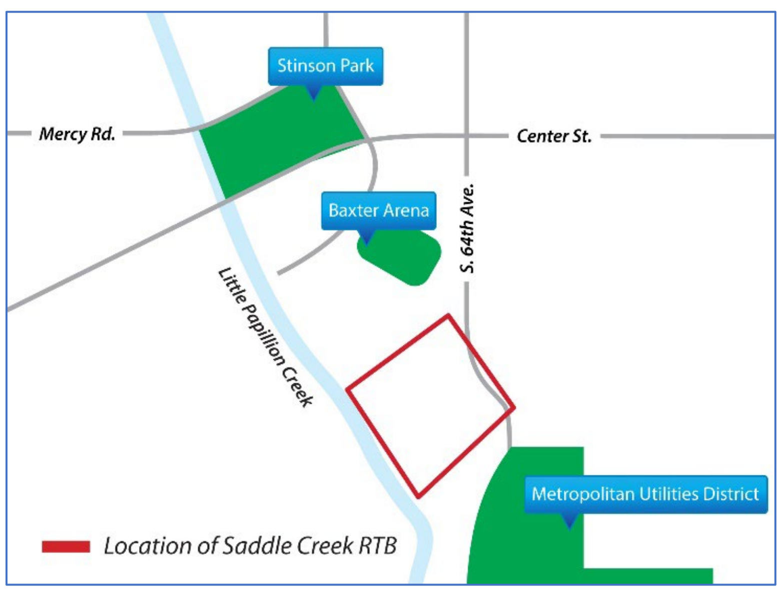

Figure 1 – Site Location Map

Upon completion, the SCRTB will provide storage and equivalent to primary treatment of combined sewage flows up to the permitted design flow rate of 160 million gallons per day (MGD) (605,700 cubic meters per day) with the ability to screen, remove grit, and disinfect flows up to 320 MGD (1,211,300 cubic meters per day). Lower volume flows will be captured within the basin and will be pumped into the Little Papillion Creek Interceptor (LPCI) and conveyed to the Papillion Creek Water Resource Recovery Facility (PCWRRF) for full secondary treatment. Larger volume flows will receive grit and screenings removal, disinfection, solids settling, and dechlorination before being discharged to the LPC. The facility will result in a significant reduction in the volume of untreated CSO, total suspended solids (TSS), and E coli bacteria entering the LPC.

METHODOLOGY

Facility Overview

The SCRTB facility consists of a 3.3 million gallon (MG) (12,500 cubic meter) underground concrete storage basin, with grit removal, mechanical screening, chemical disinfection and dechlorination, gravity effluent discharge, a dewatering pump station, as well as Headworks, Operations, and Chemical Buildings. It also includes a diversion structure, sewers, odor control, stormwater BMPs, driveways, and other appurtenances. Refer to Figure 2 for a Process Flow Diagram illustrating the various features of the RTB facility below ground.

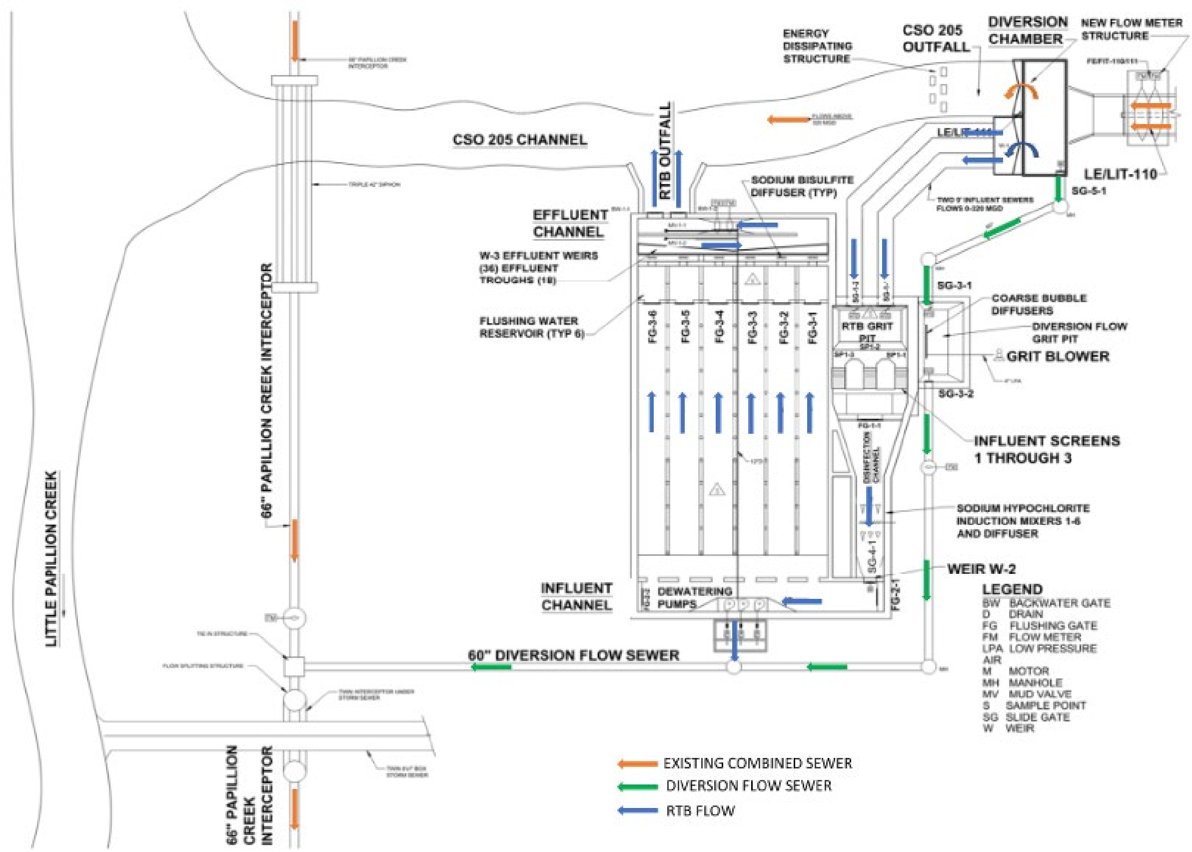

Figure 2 – Process Flow Diagram

The facility will operate during wet weather events. Prior to the completion of the SCRTB project, an existing dry weather diversion weir directed dry weather and a portion of wet weather flow, up to 22 million gallons per day (MGD) (83,300 cubic meters per day), was sent to the existing Dupont Grit Facility which directed flow to the LPCI, which ultimately conveyed flow to the Papillion Creek Water Resource Recovery Facility (PCWRRF) for full secondary treatment. Prior to this project, any excess flow was discharged untreated to the CSO 205 Channel and eventually the LPC.

The existing dry weather diversion pipes will be abandoned as part of this project and replaced with a new 60-inch (152 cm) sewer named the Diversion Flow Sewer, which will pass through a grit removal pit within the new facility's Headworks Building. Upon completion of the SCRTB, the existing Dupont Grit Facility will be demolished. The diversion weir will send flows into the 60-inch Diversion Flow Sewer and ultimately the LPCI through a slide gate which modulates flow up to approximately 60 MGD (223,300 cubic meters per day) using real time control based on measured flowrate in the 60-inch sewer and level measured at a manhole on the LPCI. Flows in excess of 60 MGD, or other allowable capacity through the flow control gate, will overflowing a weir within the diversion chamber and enter into two 108-inch sewers which provide influent flow into the RTB.

This new diversion chamber will divert wet weather flow up to the peak treatment design flow of 160 MGD (605,700 cubic meters per day) to the RTB. This diversion chamber configuration ensures that flow rates up to the design flow can pass through the RTB and does not increase the risk of upstream flooding during larger events. Captured volume remaining in the tank after a wet weather event will be pumped into the LPCI and conveyed to. Flows greater than the facility capacity will be routed around the RTB and discharged untreated into the LPC.

Dry weather flow and some wet weather flows up to approximately 60 MGD (227,100 cubic meters per day) will pass into the Diversion Flow Grit Pit, located within the Headworks Building. For flows passing through the RTB, large grit and other heavy materials will drop out via gravity into the RTB Grit Pit, also located in the Headworks Building, prior to entering the screen channels. Downstream of the RTB Grit Pit, mechanically cleaned screens will provide for the removal of objectionable solids with the intent of protecting downstream equipment and controlling floatables.

Disinfection must result in an effluent that meets E. coli and total residual chlorine (TRC) permit limits. Liquid sodium hypochlorite and sodium bisulfite will be used for disinfection and dechlorination. Above ground improvements include a building to house controls, grit and screening equipment, and disinfection/dichlorination chemicals. Refer to Figure 3 for a rendering of the finished facility.

Figure 3 – Rendering of Saddle Creek RTB

Facility Hydraulics

A detailed hydrologic and hydraulic modeling evaluation was conducted as a part of the design development. The CSO 205 flows and volumes were calculated using a calibrated InfoWorks Collection System model. Water levels in the LPC and the existing CSO 205 Channel were modeled using the U.S. Army Corps of Engineers (USACE) software, the Hydrologic Engineering Center River Analysis System (HEC-RAS). Flows within the LPC were modeled using the USACE Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) software. Field data consisting of rainfall, flow metering, and creek levels was obtained for use in validating the model representations.

Continuous simulations of RTB treatment performance were conducted for precipitation inputs for the Representative Year, defined by the LTCP as 1969. Design peak flows were determined in consideration of volumetric capture requirements. Assessments were conducted of the need for pumping during high creek levels and determined that a significant improvement in treatment performance was not expected and thus concluded that pumping was unnecessary.

Facility geometry for weirs and channel dimensions was established with the intent of minimizing the potential for increasing the upstream risk of basement backups and street flooding in the collection system tributary to CSO 205 during high influent flows or elevated LPC levels. Physical modeling of the facility with a focus on the diversion weir geometry was performed to confirm aspects of the expected hydraulic performance. This resulted in a recommendation for a 9-inch-high (23 cm) containment curb at the outfall of the Diversion Chamber to account for splashing observed during the physical modeling.

Design Flows and Influent Characteristics

The design flow of 160 MGD (605,700 cubic meters per day), with a 30-minute detention time, was used to size the settling tank volume. Table 1 presents a summary of the design flows and volumes for the RTB facility.

Table 1
RTB Design Flows and Volumes

Description	**Value**
Design Flow for Volumetric Capture and Equivalence to Primary Treatment	160 MGD (605,700 cubic meters per day)
Equivalent to Primary Treatment Detention Time at 160 MGD	30 min
Settling Tank Volume	3.3 MG (12,500 cubic meters)
Hydraulic and Chemical Feed Design Flow	320 MGD (1,211,300 cubic meters per day)

The facility is also designed to pass 320 MGD (1,211,300 cubic meters per day) of flow to provide for additional future treatment capacity. To better understand the characteristics of combined sewage expected during wet weather events from the CSO 205 outfall, a flow sampling and bench scale testing program was conducted during the conceptual RTB design phase. Both dry and wet weather flow samples were collected, and pollutant parameters analyzed in the lab. Influent pollutant loading characteristics were documented for six (6) storm events sampled at CSO 205 in the late spring and summer of 2011. The sampling work confirmed that the characteristics of the CSO flow were typical as compared to findings at other similar CSOs and RTB installations. Jar testing of samples also displayed rapid solids settling characteristics. Sampling results also indicated that sodium hypochlorite was an adequate disinfectant that could achieve required bacteria kills in less than 15 minutes. Bench scale testing did highlight the potential for first flush loads that could require higher than typical dosages of disinfectant to achieve adequate treatment.

During the design, a review of the metered and predicted flows from modeling simulations in the 66-inch Little Papillion Creek Interceptor (LPCI) indicated that there is available capacity in the interceptor to take additional wet weather flow. An analysis was conducted to evaluate the costs and benefits of sending up to approximately 59 (227,100 cubic meters per day) of additional flow during wet weather events directly to the LPCI prior to full utilization of the RTB. This approach would provide an opportunity to achieve operations and maintenance cost savings at the facility. This evaluation determined that construction of a 60-inch (152 cm) sewer along with grit removal would provide significant performance benefits along with immediate O&M savings by reducing the frequency of RTB operation. Thus, this approach was incorporated into the facility design. Permanent flow metering on the 60-inch (152 cm) Diversion Flow Sewer and on the 66-inch (168 cm) LPCI has been installed to allow for optimized control of flow diverted.

Design Configuration Overview

The major components in the SCRTB facility include the following features. Refer to Figure 2 for a Process Flow Diagram illustrating these features.

Diversion Chamber - The basic functions of the Diversion Chamber are to direct wet weather flows in excess of the capacity of the 60-inch (152 cm) Diversion Flow Sewer and/or the capacity of the downstream sewer system into the facility, and to "shunt" flows in excess of the RTB design flow to the CSO 205 Channel. The layout of the Diversion Chamber ensures that the design flow for the SCRTB can be diverted into the facility without resulting in adverse impacts on upstream sewer hydraulics.

Figure 4 shows a plan view and Figure 5 shows a profile view of the Diversion Chamber. The major components of the Diversion Chamber include a dry weather diversion weir and a subsequent wet weather overflow sill. Flows that exceed the capacity of the 60-inch (152 cm) Diversion Flow Sewer and/or the capacity of the downstream sewer system overflow the Dry Weather Diversion Weir into the RTB. Flows greater than the RTB capacity overflow the Wet Weather Overflow Sill and the containment curb to the CSO 205 Channel without significant hydraulic losses.

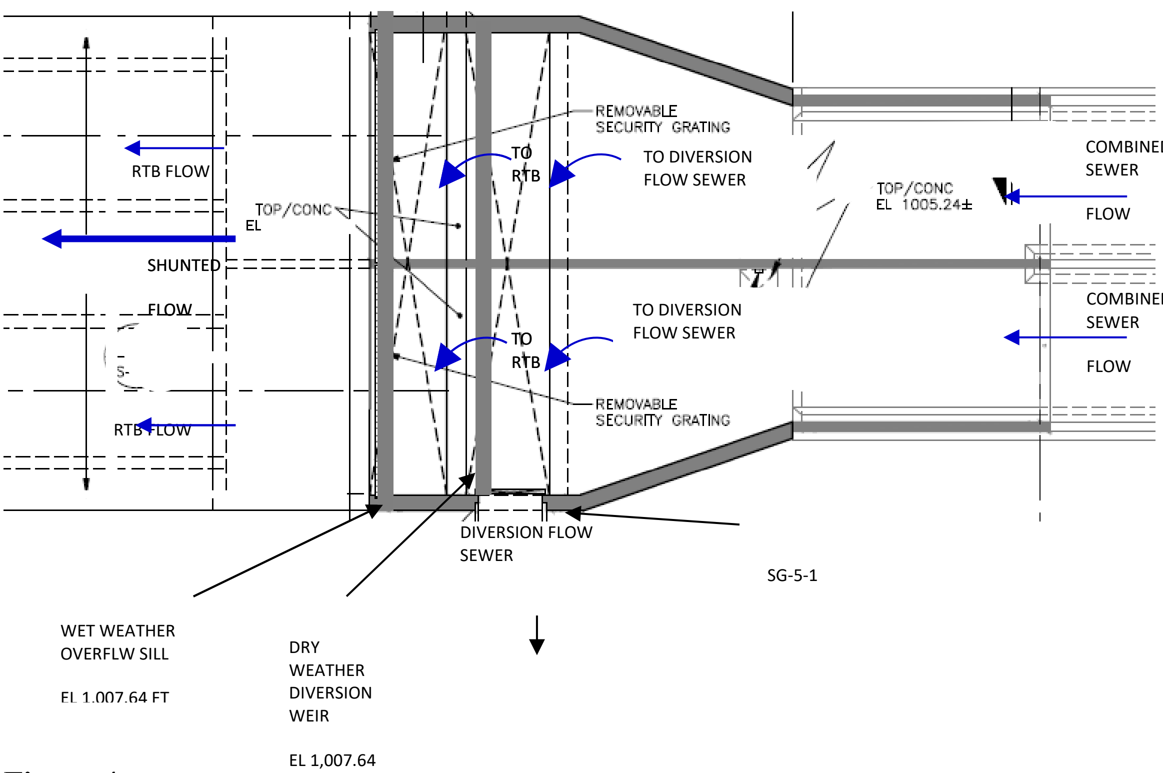

Figure 4
Plan View of Diversion Chamber

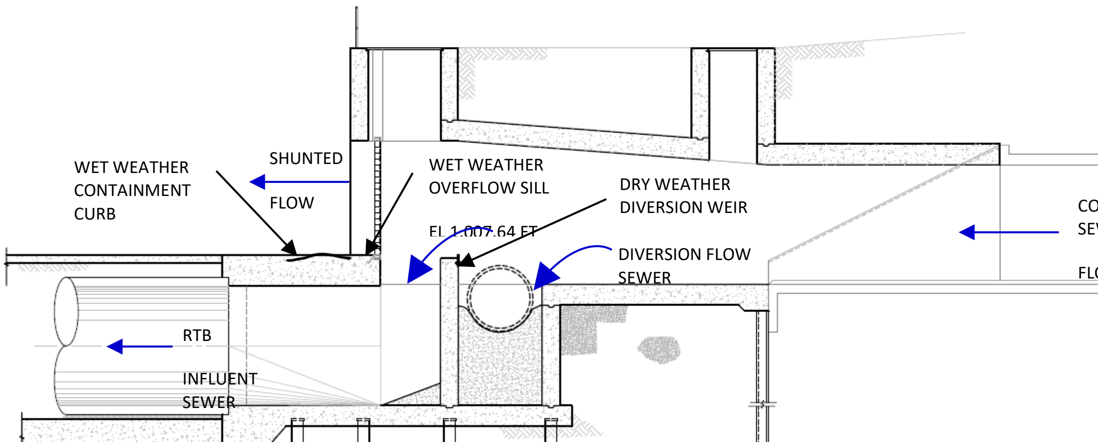

Figure 5
Diversion Chamber Profile

Grit Removal - Flows passing through the Headworks are subject to removal of large grit and floatable material. High levels of grit are expected from the area tributary to CSO 205. Grit that has accumulated in the road drainage system eventually makes its way into the SCRTB for proper handling. The new headworks facility includes two grit removal facilities. The Diversion Flow Grit Pit located on the alignment of the 60-inch (152 cm) Diversion Flow Sewer removes grit from dry weather flow and some wet weather flows on a continuous basis. A cover system and aeration system are provided for the Diversion Flow Grit Pit to help control odors. The RTB Grit Pit is larger and receives flow through the twin 108-inch (274 cm) wet weather pipes from the Diversion Chamber during wet weather events that enter the RTB facility. Grit is removed from the grit pits via clamshell bucket on an overhead crane system and is deposited in containers to be hauled offsite for proper disposal by City vehicles. High-pressure water hoses and water cannons are provided within the Grit and Screening area for washdown of the Headworks area post-event.

Grit is removed from both grit pits via clamshell bucket to be hauled offsite to the City of Omaha's Missouri River Water Resource Recovery Facility (MRWWRF) by City vehicles for proper handling. Refer to Figure 6 below for a plan view of the grit removal system.

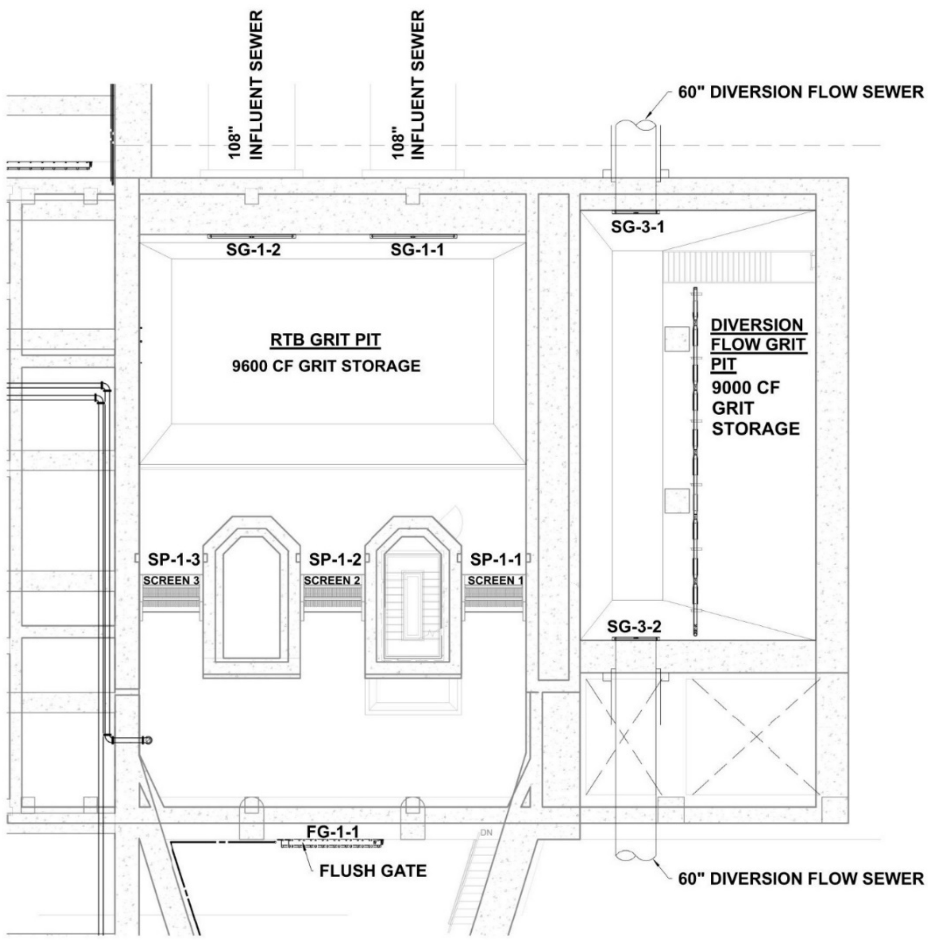

Figure 6
Grit Removal Plan View

Screening - CSOs commonly contain a high level and wide variety of objectionable floating material and suspended solids. Mechanical screens are provided as part of the SCRTB facility for removal of solids and floatable materials from the combined sewage**.**

The screens used at the SCRTB experience a wide range of hydraulic conditions and must be able to operate efficiently over the entire range of flows while limiting head loss to an acceptable level. The influent screens are located downstream from the RTB Grit Pit. The screens are configured in a nearly vertical position. Screenings are collected onsite using lugger containers, which are hauled offsite to by City vehicles for proper handling.

Three (3) stainless steel multi-rake screens are provided at the SCRTB with a screen opening size of ¾-inch (19 mm). Each screen is provided with multiple rakes that are attached to a chain, resulting in rapid cleaning of bars to reduce clogging, or blinding. Variable Frequency Drives (VFDs) are provided for variable speed control. Refer to Picture 1 for a photo of the Headworks/Screening area.

Picture 1
Headworks/Screening Area

Disinfection - During an event, sodium hypochlorite (SHC) is dosed into the Disinfection Channel immediately downstream of the mechanical screens. The liquid chemical is stored in four (4) 12,500-gallon (47,320-liter) Fiber Reinforced Plastic (FRP) storage tanks located in the Chemical Building. Six (6) chemical induction mixers and one diffuser located in the Disinfection Channel are provided to adequately mix the SHC with the incoming combined sewer flow. The SHC is metered to the induction mixers and diffuser by means of four (4) low flow and four (4) high flow peristaltic hose pumps. Refer to Picture 2 for a photo of the SHC area of the Chemical Building.

Picture 2
SHC Area of Chemical Building

Dechlorination - Total Residual Chlorine (TRC) in the RTB effluent is reduced by application of sodium bisulfite (SBS). The SBS chemical is stored in three (3) FRP 5,300-gallon (20,100-liter) storage tanks (two (2) duty, one (1) standby)) located in the Chemical Building. Twelve (12) diffusers located just upstream of the RTB effluent weirs are provided for injection of SBS into the effluent flow and provide adequate mixing prior to discharge to the Little Papillion Creek. The SBS is metered to the diffusers by means of four (4) low flow and four (4) high flow peristaltic hose pumps. TRC analyzers, discussed elsewhere in this manual, are provided in the RTB basin at two mid-point locations to provide information for controlling the SBS dose rate and at the RTB Outfall to confirm adequate dechlorination. A Total Residual Sulfite (TRS) Analyzer has been provided for operators to confirm adequate dechlorination and to be used for potential adjustments to sodium bisulfite chemical dosing, as well. TRC and TRS Analyzers are located in one of the Sample Rooms within the Operations Building. Refer to Picture 3 for a photo of the SBS area of the Chemical Building.

Picture 3
SBS Area of Chemical Building

Settling Basin - A single, 120-foot (36.6-meter) wide by 205-foot-long (62.5-meter) basin with storage volume of approximately 3.3 MG (12,500 cubic meters) is provided. The floors are sloped toward the dewatering pump station sump, and flushing has been provided for cleaning of the bottom of the channel after wet weather events. The settling basin consists of an Influent Channel with the Dewatering Pump Station, the Settling Basin itself, effluent weir troughs, and an Effluent Channel. Refer to Figure 7 for an interior view of the Settling Basin.

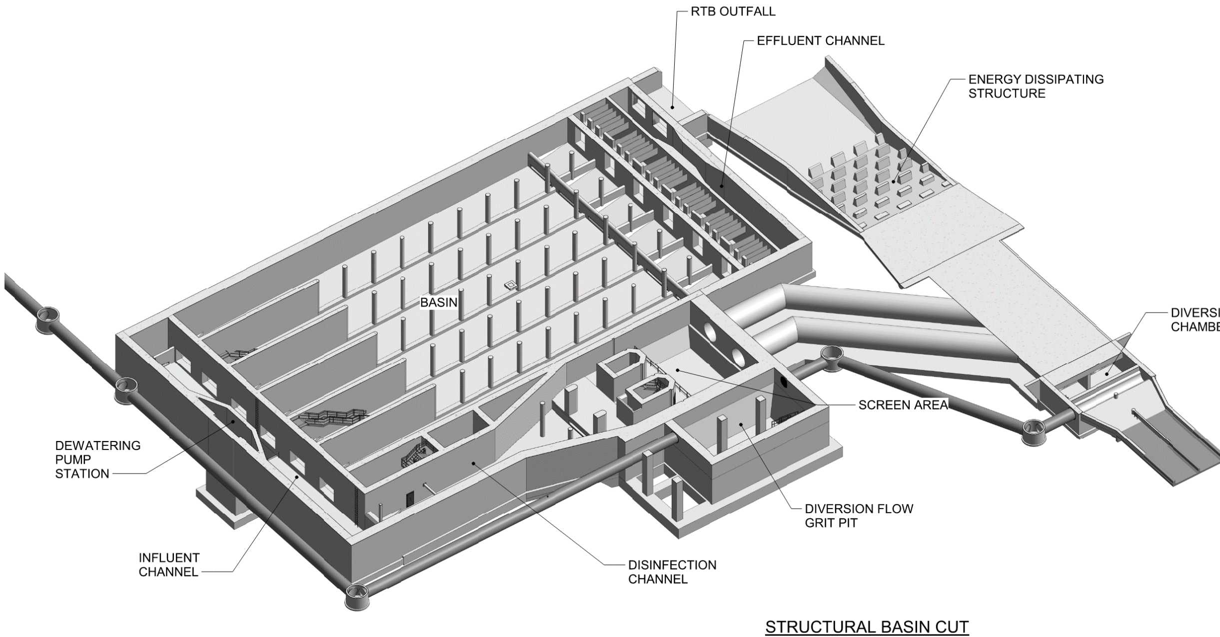

Figure 7 -Settling Basin Interior View

Dewatering - Three (3) 2.4 MGD (6,300 liters per minute) submersible non-clog pumps (two (2) duty and one (1) standby) installed on rails and provided with variable frequency drives (VFDs) are provided to dewater the RTB within 24 hours of the conclusion of a wet weather event. The submersible pumps are located in a dewatering sump in the center of the Influent Channel. The submersible pumps discharge flows through three 8-inch (20 cm) discharge pipes with magnetic flow meters to a chamber and then flows by gravity to the 60-inch (152 cm) Diversion Flow Sewer. A level sensor and flow meter are provided to determine the available capacity in the LPCI, which is then used in the control of the dewatering pump permissive to start and for pump speed.

Flushing - A flushing gate system consisting of hydraulically operated flap gates, storage reservoirs provided by a short concrete wall, and floors sloped back to the dewatering sump are included in the SCRTB facility for cleaning of settled debris including organic solids and some grit after wet weather events. Nine (9) stainless steel flushing gates with reservoirs are provided. Six (6) are located in the Basin, two (2) are located in the Influent Channel, and one (1) is located in the Disinfection Channel. Combined sewage from the wet weather event (provided the wet weather event has sufficient volume to overtop the reservoir walls) and/or supplementary non-potable (service) water consisting of a combination of potable water sources or rainwater harvesting can be used for flushing water.

Odor Control - A granular activated carbon system is provided for odor control of foul air from the Headworks and Diversion Flow Grit Pit areas. The granular activated carbon media are housed in two (2) radial flow, 13-foot (4-meter) diameter, and 20-foot-high (6-meter) inert fiber-reinforced plastic (FRP) vessels. A total of two (2) backward curved constant speed centrifugal

FRP fans are provided, with one fan exhausting 53,000 cfm (1,500 cubic meter per minute) from the Headworks Building, and the second fan exhausting 1,200 cfm (34 cubic meter per second) from the Diversion Flow Grit Pit. The two fans each have a dedicated intake system from their respective areas and discharge into a common discharge header, which directs the airflow equally between the two odor control vessels. The fans are each provided with sound attenuation to reduce the radiated noise emitted by the fans. Ductwork is provided for potential future addition of a fan and odor control vessel to serve the basin, if later determined to be required.

Building and Site Improvements – Constructed over the top of the basin is a two-story Operations Building with basement. This building containing control, mechanical, electrical, and sampling and testing equipment, as well as office space for full-time dedicated staff, including RTB operations staff, as well as other department staff. Connected to the Operations Building on the east side is the Headworks Building and on the west side is the Chemical Building. Building architecture was designed to blend with neighboring facilities.

Site improvements included an access drive, stormwater BMPs including a bioretention basin and hydrodynamic separator manholes, underground utilities, and improvements to the existing CSO 205 channel. Channel improvements include construction of a reinforced concrete trapezoidal channel with energy dissipation blocks upstream of the RTB effluent discharge, and natural channel stabilization downstream of the RTB effluent discharge.

RESULTS

Design was completed in 2018, and a construction contract in the amount of approximately $90 Million was awarded to Hawkins Construction Company after completion of an extensive contractor outreach program, contractor prequalification, and competitive bidding with three responsive bids received within the City’s budget. Construction began in April 2019. Wade Trim is currently providing construction management services. The project is scheduled for Substantial Completion in late Summer 2023. Refer to Picture 4 for a construction progress photo from April 2021, showing the interior of the underground RTB structure prior to completion of the roof slab. Refer to Picture 5 for a construction progress photo from March 2023 showing the above-ground facility at near-completion.

Picture 4 – Construction Progress – April 2021

Picture 5 – Construction Progress – March 2023

CONCLUSIONS

The project's innovative use of a "gravity in, gravity out" design for the RTB facility allowed for a reduction in pumping of significant flows into the basin. The use of real time controls and smart sewer technology will allow this facility to operate efficiently and effectively over a wide range of conditions, which have been evaluated through extensive hydraulic modeling and development of process control strategies. The use of instrumentation for flow and level measurement used in process control must incorporate redundancy and be flexible to allow for changes in available technology and must be compatible with other technologies being used at the facility and within the collection and treatment system.

Innovations during the construction of the facility have included the use of cloud-based photo documentation management including webcam, drone photography, and site and building progression photos; extensive groundwater and geotechnical instrumentation monitoring; and 3D modeling and reality capture technology.

REFERENCES

City of Omaha Project Website: (https://omahacso.com/projects/saddlecreekrtb/)