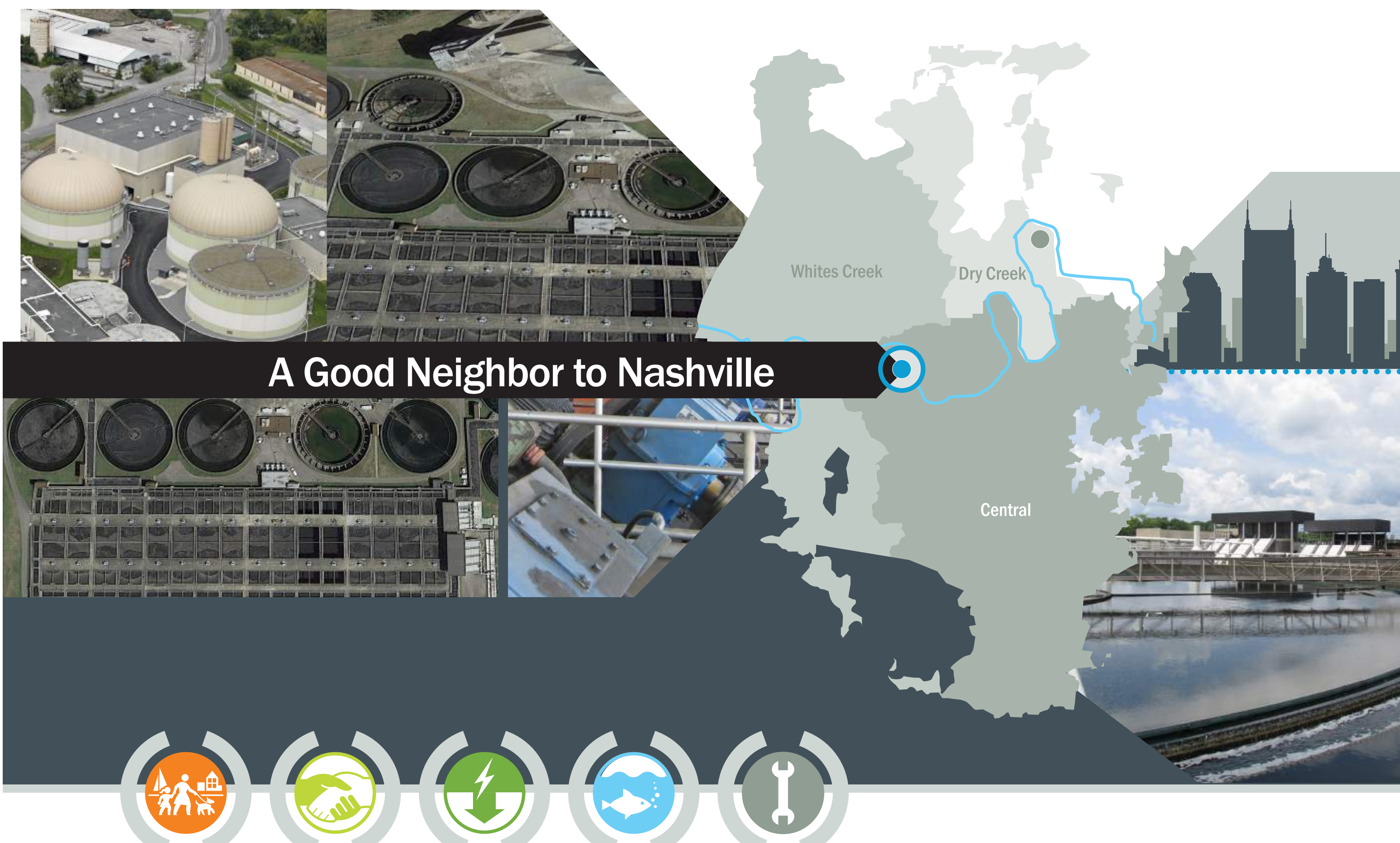
Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction

Basis of Design Report



Public Safety

Community Partnership

Sustainability

Water Quality

Reliability

INAL

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Technical Memoranda

List of Abbreviations

ACM	Asbestos Containing Material
ADWF	average dry weather flow
AOR	Actual Oxygen Requirement*
AT	Aeration tank
ATS	automatic transfer switch
AWWA	American Water Works Association
BC	Brown and Caldwell
BNR	biological nutrient removal
BODR	Basis of Design Report
BPW	bulk product wastes
C/C	centrate and condensate
C&D	construction and demolition
CCT	chlorine contact tank
CERP	Contingency and Emergency Response Plan
CFD	Computational fluid dynamics
CGP	Construction General Permit
CIPP	cured in place pipe
CIS	close-interval surveys
CMAR	Construction Manager at Risk
CPS	Central Pump Station
COPT Project	CWWTP Improvements & CSO Reduction project
COPT Study	Central Optimization Study Project
CSO	Combined Sewer Overflow
CSS	combined sewer system
CWN	Clean Water Nashville Overflow Abatement Program
CWWTP	Central Wastewater Treatment Plant
DAFT	dissolved air flotation thickener
DAPC	Division of Air Pollution Control
DBP	disinfection byproducts
DCS	distributed control system
DCVG	direct current voltage gradient
DIP	ductile iron pipe
DMR	discharge monitoring report
DO	dissolved oxygen
DOT	Department of Transportation
DSST	digested sludge storage tank
EDS	Electrical Distribution System
EFTU	Excess Flow Treatment Unit
EPA	Environmental Protection Agency
EPSC	erosion prevention and sediment control
EQ	Equalization
FAT	First Avenue Tunnel
FEA	finite element analysis
FFE	finished floor elevation
FM	forcemain
FOG	fats, oils, and grease
gpd/sq. ft.	gallons per day per square foot
gpm	gallons per minute
GIP	green infrastructure practices
GPR	Ground Penetrating Radar
HMI	human machine interface
HVAC	heating, ventilation, and air conditioning
IBC	International Building Code
ID	induced draft
IR	infrared
LBP	lead-based paint
LID	low-impact development
LTCP	long term control plan
MCC	motor control center
MGD	million gallons per day
ML	mixed liquor
MLSS	mixed liquor suspended solids
MOP	manual of practice
MOPO	maintenance of plant operations
MWS	Metro Water Services
NAAQ	National Ambient Air Quality
NPDES	National Pollutant Discharge Elimination System
NPV	net present value
OC	on center
OSHA	Occupational Safety & Health Administration

P&ID	process & instrumentation diagrams
PAA	peracetic acid
PCB	polychlorinated biphenyl
PF	peaking factor
PPA	power purchase agreement
PPE	personal protective equipment
PRV	Pressure Reducing Valve
PS	pump station
PSIG	pounds per square inch gage
PST	primary settling tank
PV	Photovoltaic
PVC	polyvinyl chloride
PWWF	Peak Wet Weather Flow
RAS	return activated sludge
RMP	risk management plan
RCP	reinforced concrete pipe
RCRA	Resource Conservation and Recovery Act
RVAT	reduced voltage autotransformer starter
SAB	South Aeration Basin
SAT	Second Avenue Tunnel
SC	secondary clarifier
Scfm	standard cubic feet per minute
SOP	standard operating procedures
SOR	surface overflow rate
SOTE	Standard Oxygen Transfer Efficiency*
SSO	sanitary sewer overflow
SST	South Settling Tank
TDEC	Tennessee Department of Environment and Conservation
TDH	total dynamic head
TM	Technical Memorandum
TSCA	Toxic Substances Control Act
TSS	total suspended solids
UV	ultraviolet
UVT	UV transmittance
V	volts
VCP	vendor control panel
VFD	variable frequency driver
w.c	water column
WAS	waste activated sludge
WEF	Water Environment Federation
WSE	Water Surface Elevations
XRF	X-ray fluorescence

Introduction

Introduction

The following Basis of Design Report (BODR) presents the basis of design for the Central WWTP Capacity Improvements and CSO Reduction Project (COPT Project). The COPT Project will increase the wet weather treatment capacity of the Central WWTP by 100 million gallons per day (MGD), primarily by optimizing existing processes, and will reduce combined sewer overflows (CSO) from the upstream collection system.

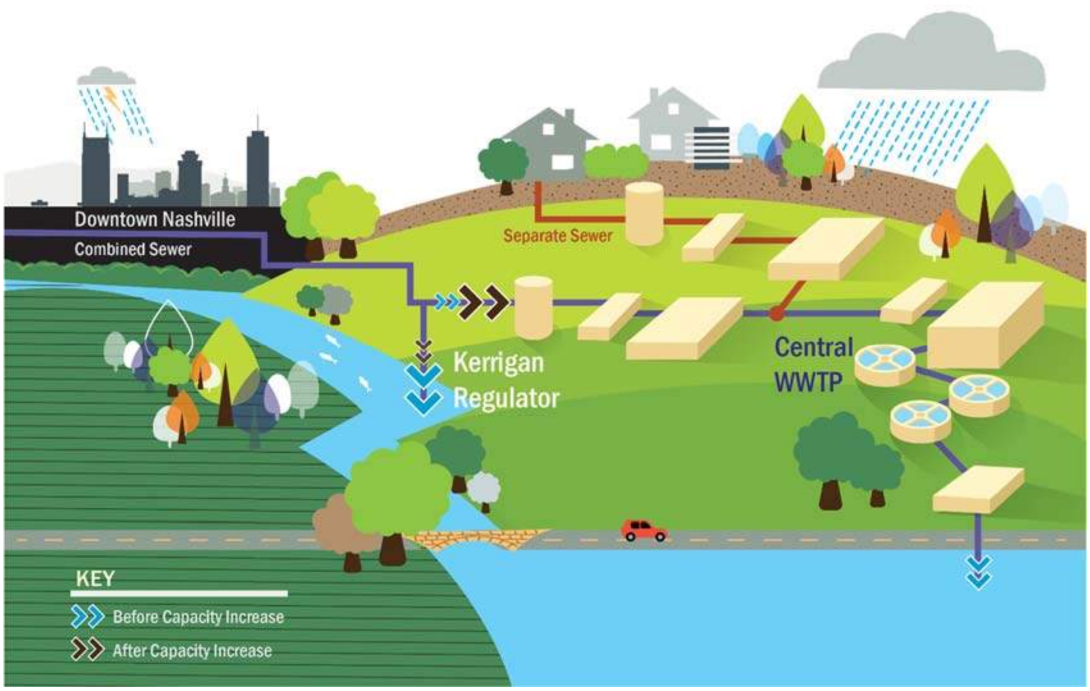
The COPT Project is a critical component of Metro Water Services' (MWS) Clean Water Nashville Overflow Abatement Program (CWNOAP) and Long Term Control Plan (LTCP) to reduce overflows into the Cumberland River and achieve the requirements of the Consent Decree which was promulgated by the US Environmental Protection Agency (EPA), Department of Justice (DOJ), and Tennessee Department of Environment and Conservation (TDEC) in 2009.

In addition to addressing requirements of the Consent Decree the project seeks to:

- Improve the overall public safety of the community by implementing non-chemical UV disinfection
- Provide sustainable and green community buffers and improvements
- Reduce energy and chemical consumption and improve operational efficiency
- Create a more robust, flood-resistant system by adding flood protection systems and mitigation measures

The COPT Project builds on the water quality improvements realized over the past 20 years and further demonstrates MWS's commitment of providing safe drinking water and water-based recreational opportunities to the residents of Nashville.

Visit http://www.cleanwaternashville.org to learn more about the CWNOAP.



The downtown Nashville combined sewer collects surface water from roads and wastewater from homes and businesses and transports these flows to the Central WWTP for treatment. The COPT Project will reduce CSOs at the Kerrigan outfall by increasing the wet weather treatment capacity of the Central WWTP by 100 million gallons per day.

About the COPT Project

The proposed COPT Project improvements are based on the previously prepared Central Optimization Study (COPT Study) which is referenced throughout this report. The COPT Study (BC, 2014) identified limiting factors in each of the CWWTP's unit processes and confirmed that peak wet weather secondary treatment capacity could be significantly increased through upgrades to the existing headworks, biological treatment, and secondary clarification systems without building new tankage.

Through process and hydraulic improvements, the CWWTP's peak wet weather secondary treatment capacity will be increased from 250 MGD to an estimated maximum of 350 MGD. Reconfiguration of the existing excess flow treatment unit (EFTU) to provide EQ storage for quickly rising CSO flows in addition to treatment will allow the CWWTP to accommodate all flow from the upgraded Central Pumping Station and offset the costly storage infrastructure previously proposed in the LTCP to achieve CSO reduction goals.

In addition to increasing the capacity of the CWWTP, this project provides MWS with an opportunity to "fix" existing operational issues and process configurations, eliminate gaseous chlorine disinfection and its associated safety risks, and improve the operability, maintainability, and overall reliability of the WWTP based on input from the plant staff. Substantial long-term energy savings resulting from improved treatment efficiency are also anticipated.

Additional Project Information:

Design Engineers:

- Brown and Caldwell – Capacity and Facility Improvements
- Hazen and Sawyer – New CSO Headworks and Wet Weather Flow Equalization

Estimated Project Cost:

- $270 million

Estimated Project Duration:

- Detailed Design - 24 months (beginning late 2016)
- Construction – 36 months (beginning TBD)

The basis of design for the proposed COPT Project improvements presented in this BODR as outlined in the following section.

About the BODR

The COPT Project BODR is organized as follows:

1. Introduction (this section)
2. Process Area Overview Key Map – Provides a location of the site and plant layout
3. Summary of Improvements Map – Provides a high-level summary of the improvements and associated costs.
4. Process Area Figures – Aerial photos with brief "background/solution" summaries for key improvements for each process area. Associated benefits and costs are stated. In the electronic version, direct hyperlinks to other relevant sections within the BODR are also included.
5. Process Flow Diagrams – Graphical representations of the COPT Project process improvements

6. Regulatory Design Criteria – Includes relevant design criteria for each process area as well as TDEC design criteria and how the COPT Project intends to comply with them.
7. Scope Table – A table that concisely describes the scope of improvements that served as the basis for the opinion of probable construction cost.
8. Schedule – The overall schedule of design and construction for the proposed improvements.
9. Technical Memoranda – Each process area has a Technical Memo that provides the detailed basis of design for the proposed improvements and further guidance that will be utilized during detailed design and construction.

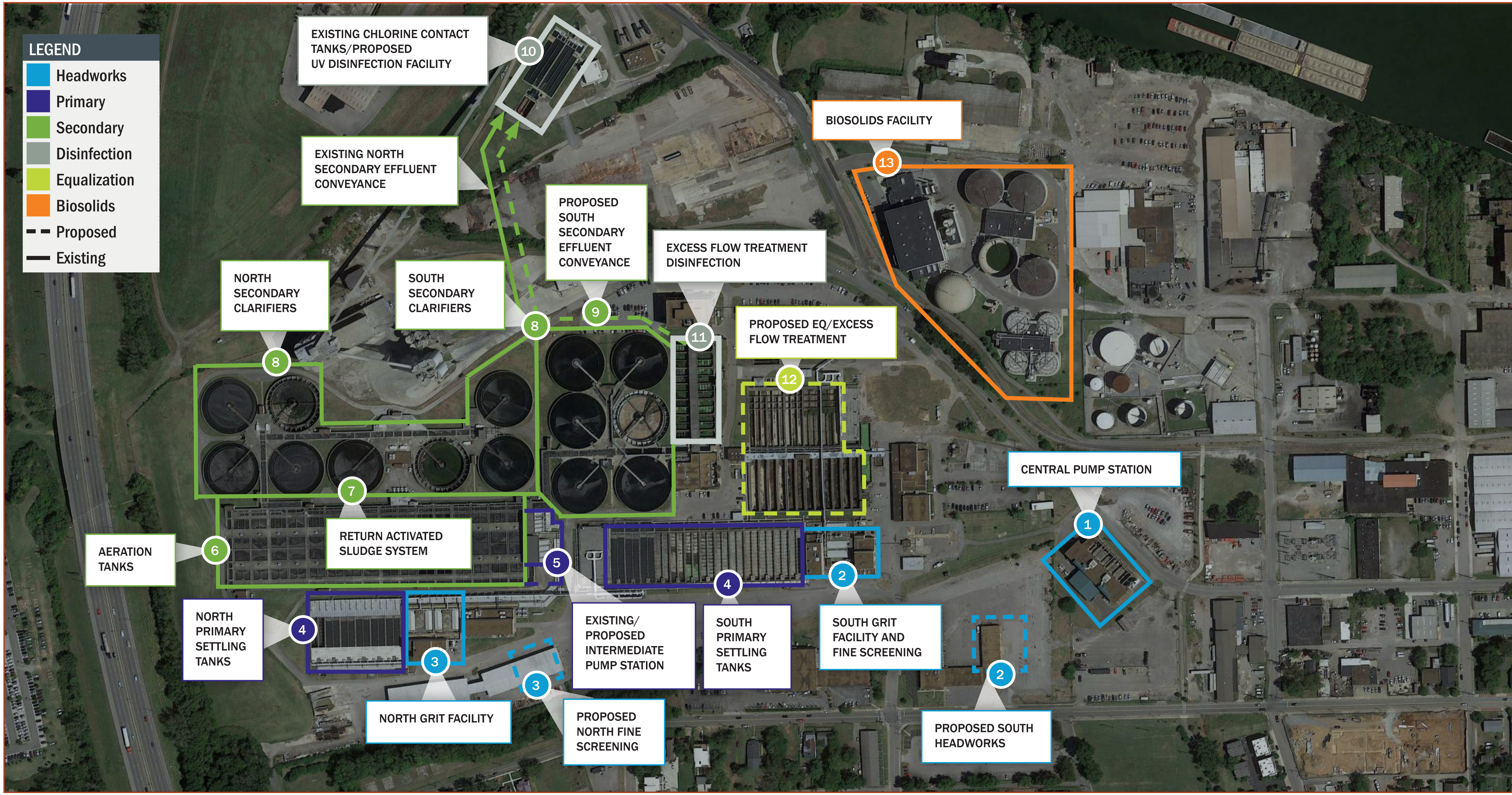
Notes to the Reader:

Proposed improvements for the south grit removal facility were evaluated and narrowed to two potential options by the design team consisting of engineering groups from Brown and Caldwell (BC) and Hazen and Sawyer. It was determined by the design team that the costs and constructability of each option were to be evaluated further by the CMAR prior to making the final decision on options to pursue for this area; thus, the two basic options are presented. An option that includes a new grit removal facility is presented in TM #2 – South Headworks. An option that retrofits new grit removal equipment into the existing aerated grit tank structures is presented in TM #3B – North and South Grit Removal.

Process Area Overview

Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Process Area Overview



Summary of Improvements

Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

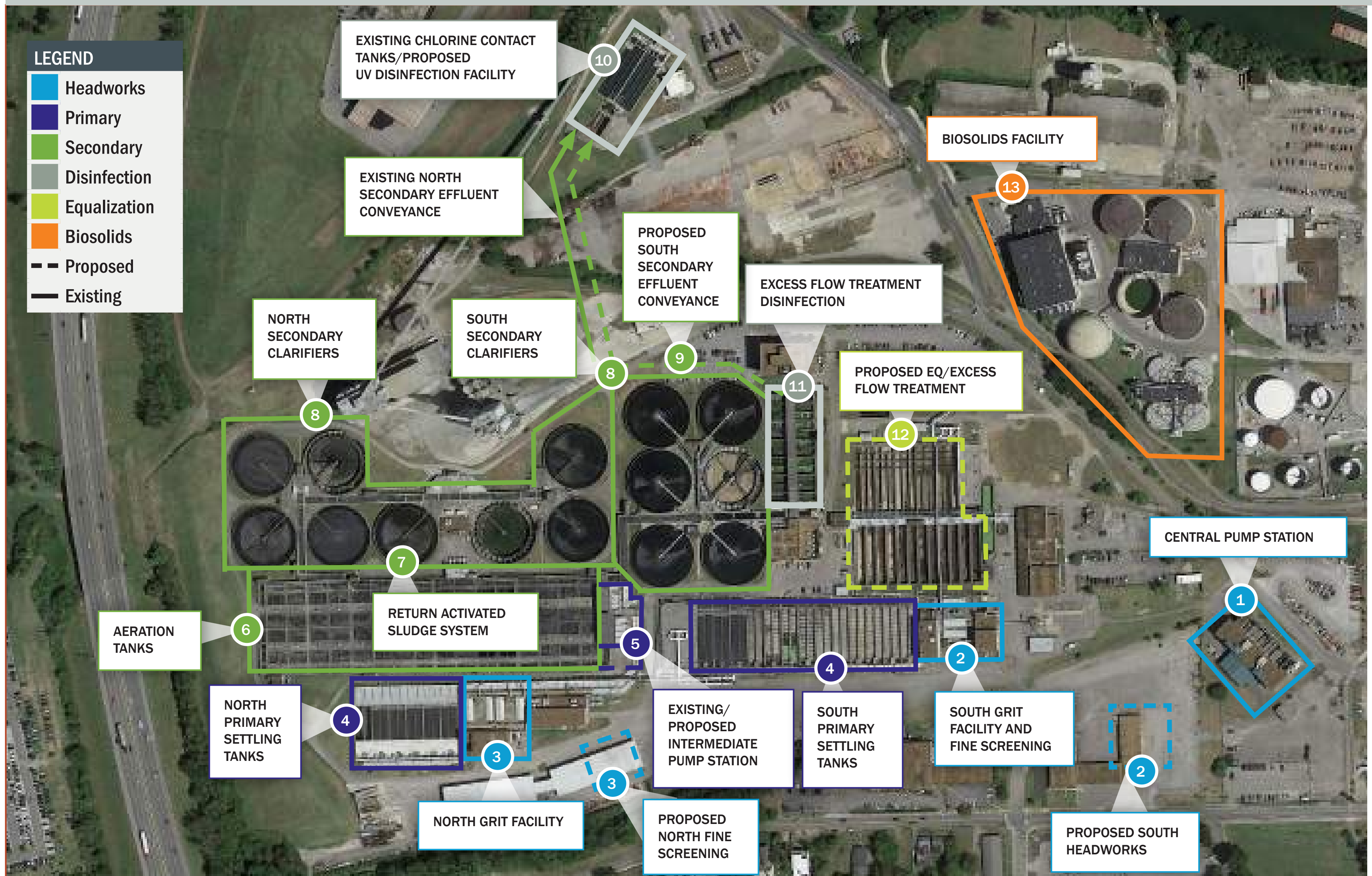
Summary of Improvements

The COPT Project will increase the secondary treatment capacity of the CWWTP from 250 MGD to 350 MGD. Through hydraulic and process optimization, this 100 MGD of additional capacity will be achieved primarily within the existing plant footprint.

Key Benefits and Success Factors:

Public Safety
Community Partnership
Sustainability
Water Quality
Reliability

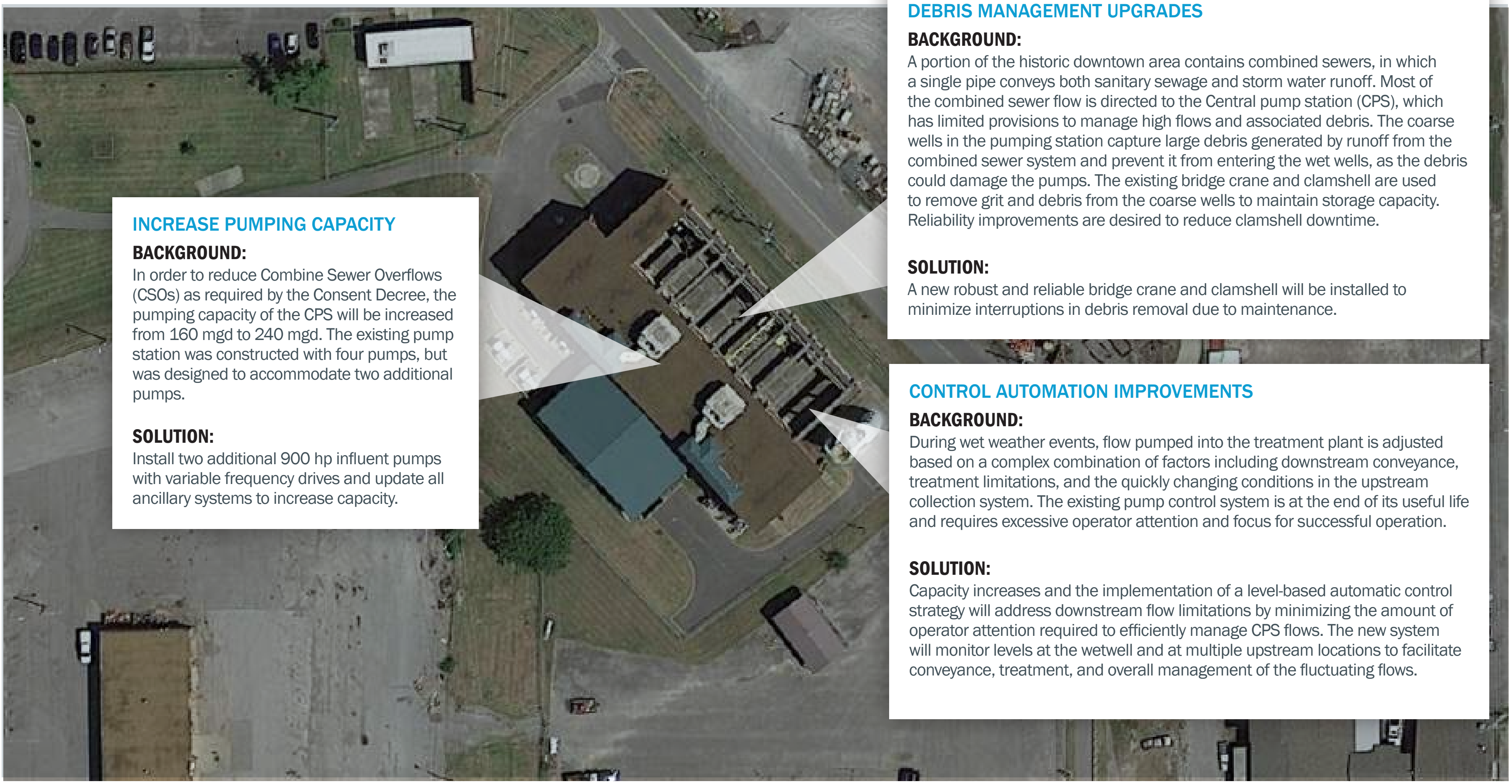
OVERALL BODR COST: $270M



	Technical Memoranda	BODR level cost:
1	**CENTRAL PUMP STATION** - Increased pumping capacity - Debris management upgrades - Control automation improvements	$5M
2	**SOUTH HEADWORKS** - Grit removal system improvements - Fine and coarse screening upgrades	$33M
3	**NORTH HEADWORKS** - Grit removal system improvements - Fine-screening facility - Influent flow measurement improvements	$32M
4	**PRIMARY SETTLING TANKS** - Improved solids capture - Enhanced odor control - Peak flow management	$6M
5	**INTERMEDIATE PUMP STATION** - Increased pumping capacity - Influent flow modifications - Reliability improvements	$13.5M
6	**AERATION SYSTEM** - Passive flow split - Process upgrades - Aeration blowers upgrades	$34M
7	**RETURN ACTIVATED SLUDGE SYSTEM** - RAS pumping and force main improvements - RAS distribution and process control improvements	$12.5M
8	**SECONDARY CLARIFIERS** - Improved operability and flow splitting - Process optimization - Increased capacity	$17M
9	**SOUTH SECONDARY EFFLUENT CONVEYANCE** - All secondary effluent routed to one disinfection location	$3M
10	**UV DISINFECTION FACILITY** - One disinfection location - Safer, non-chemical ultraviolet disinfection	$26M
11	**EXCESS FLOW TREATMENT (DISINFECTION)** - Peracetic acid disinfection - Primary equivalent treatment	$1.5M
12	**EQUALIZATION** - Flow equalization/attenuation for peak flows	$18M
13	**BIOSOLIDS IMPROVEMENTS** - Enhanced solids capture - Digester optimization - Flood mitigation	$3.8M
	ADDITIONAL SITE-WIDE IMPROVEMENTS - Sustainable Initiatives - Electrical primary power improvements - Flood mitigation - Structural improvements - General site improvements	$65M

Process Area Figures

Central Pump Station



INCREASE PUMPING CAPACITY

BACKGROUND:

In order to reduce Combine Sewer Overflows (CSOs) as required by the Consent Decree, the pumping capacity of the CPS will be increased from 160 mgd to 240 mgd. The existing pump station was constructed with four pumps, but was designed to accommodate two additional pumps.

SOLUTION:

Install two additional 900 hp influent pumps with variable frequency drives and update all ancillary systems to increase capacity.

DEBRIS MANAGEMENT UPGRADES

BACKGROUND:

A portion of the historic downtown area contains combined sewers, in which a single pipe conveys both sanitary sewage and storm water runoff. Most of the combined sewer flow is directed to the Central pump station (CPS), which has limited provisions to manage high flows and associated debris. The coarse wells in the pumping station capture large debris generated by runoff from the combined sewer system and prevent it from entering the wet wells, as the debris could damage the pumps. The existing bridge crane and clamshell are used to remove grit and debris from the coarse wells to maintain storage capacity. Reliability improvements are desired to reduce clamshell downtime.

SOLUTION:

A new robust and reliable bridge crane and clamshell will be installed to minimize interruptions in debris removal due to maintenance.

CONTROL AUTOMATION IMPROVEMENTS

BACKGROUND:

During wet weather events, flow pumped into the treatment plant is adjusted based on a complex combination of factors including downstream conveyance, treatment limitations, and the quickly changing conditions in the upstream collection system. The existing pump control system is at the end of its useful life and requires excessive operator attention and focus for successful operation.

SOLUTION:

Capacity increases and the implementation of a level-based automatic control strategy will address downstream flow limitations by minimizing the amount of operator attention required to efficiently manage CPS flows. The new system will monitor levels at the wetwell and at multiple upstream locations to facilitate conveyance, treatment, and overall management of the fluctuating flows.

benefits

Water Quality | Reliability | Sustainability

- **Water Quality:** Increases treatment capacity and reduces CSOs
- **Reliability:** Replaces aging equipment with latest technology
- **Sustainability:** Enhanced automatic operation promotes more efficient pumping

see more:

Central Pump Station TM // Process Flow Diagram

BODR Level Cost: $5 M

Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

South Headworks

DEBRIS AND GRIT REMOVAL IMPROVEMENTS

BACKGROUND:
Existing screening and grit removal in the south headworks facility has limited hydraulic capacity and poor removal efficiencies. During storm events, large quantities of grit and debris generated by runoff from combined sewers enter the plant via the Central Pump Station (CPS). Downstream rags and debris negatively impact operational reliability and increase maintenance costs.

SOLUTION:
Coarse screens will be installed in a new facility and the existing grit removal system will be replaced. Fine screens will be installed to reduce debris entering treatment facilities.

benefits

Water Quality · Reliability · Sustainability

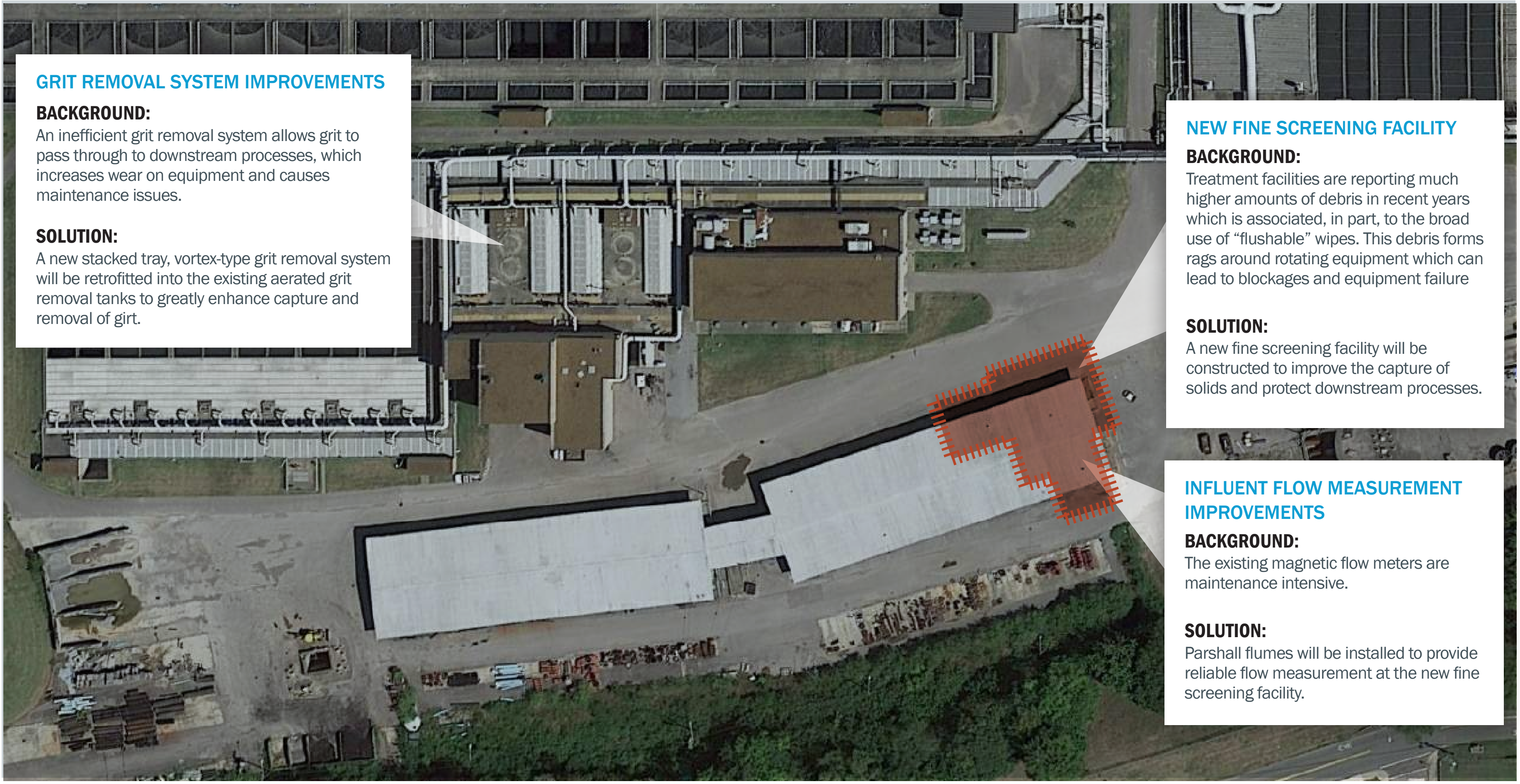
- **Water Quality:** Increases hydraulic capacity of south influent area to accommodate increases to CPS peak flow rates which will reduce CSOs
- **Reliability:** Decreases downstream grit/rag deposition and increases treatment reliability
- **Sustainability:** Uses existing buildings to minimize capital construction costs and preserve facility footprint for future use

see more:
South Headworks TM // Process Flow Diagram

BODR Level Cost: $33 M

Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

North Headworks



GRIT REMOVAL SYSTEM IMPROVEMENTS

BACKGROUND:
An inefficient grit removal system allows grit to pass through to downstream processes, which increases wear on equipment and causes maintenance issues.

SOLUTION:
A new stacked tray, vortex-type grit removal system will be retrofitted into the existing aerated grit removal tanks to greatly enhance capture and removal of girt.

NEW FINE SCREENING FACILITY

BACKGROUND:
Treatment facilities are reporting much higher amounts of debris in recent years which is associated, in part, to the broad use of “flushable” wipes. This debris forms rags around rotating equipment which can lead to blockages and equipment failure

SOLUTION:
A new fine screening facility will be constructed to improve the capture of solids and protect downstream processes.

INFLUENT FLOW MEASUREMENT IMPROVEMENTS

BACKGROUND:
The existing magnetic flow meters are maintenance intensive.

SOLUTION:
Parshall flumes will be installed to provide reliable flow measurement at the new fine screening facility.

benefits

Water Quality

Reliability

- **Reliability:** Increased grit and debris removal reduces maintenance problems
- **Water Quality:** Effective grit and debris removal to protect treatment processes

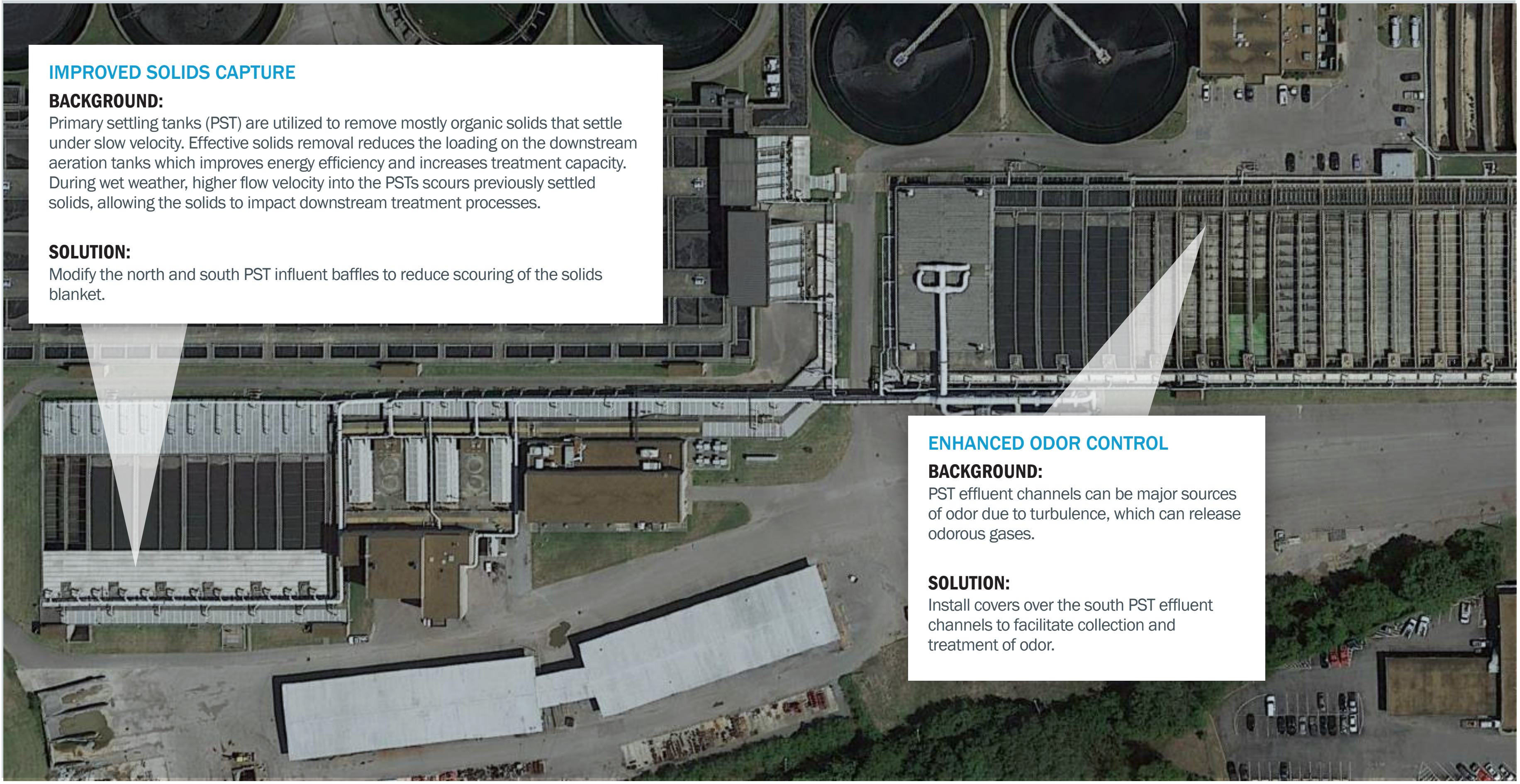
see more:

North Headworks TM // Process Flow Diagram

BODR Level Cost: $32M

Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Primary Settling Tanks



IMPROVED SOLIDS CAPTURE

BACKGROUND:
Primary settling tanks (PST) are utilized to remove mostly organic solids that settle under slow velocity. Effective solids removal reduces the loading on the downstream aeration tanks which improves energy efficiency and increases treatment capacity. During wet weather, higher flow velocity into the PSTs scours previously settled solids, allowing the solids to impact downstream treatment processes.

SOLUTION:
Modify the north and south PST influent baffles to reduce scouring of the solids blanket.

ENHANCED ODOR CONTROL

BACKGROUND:
PST effluent channels can be major sources of odor due to turbulence, which can release odorous gases.

SOLUTION:
Install covers over the south PST effluent channels to facilitate collection and treatment of odor.

benefits

Water Quality

Sustainability

Community Partnership

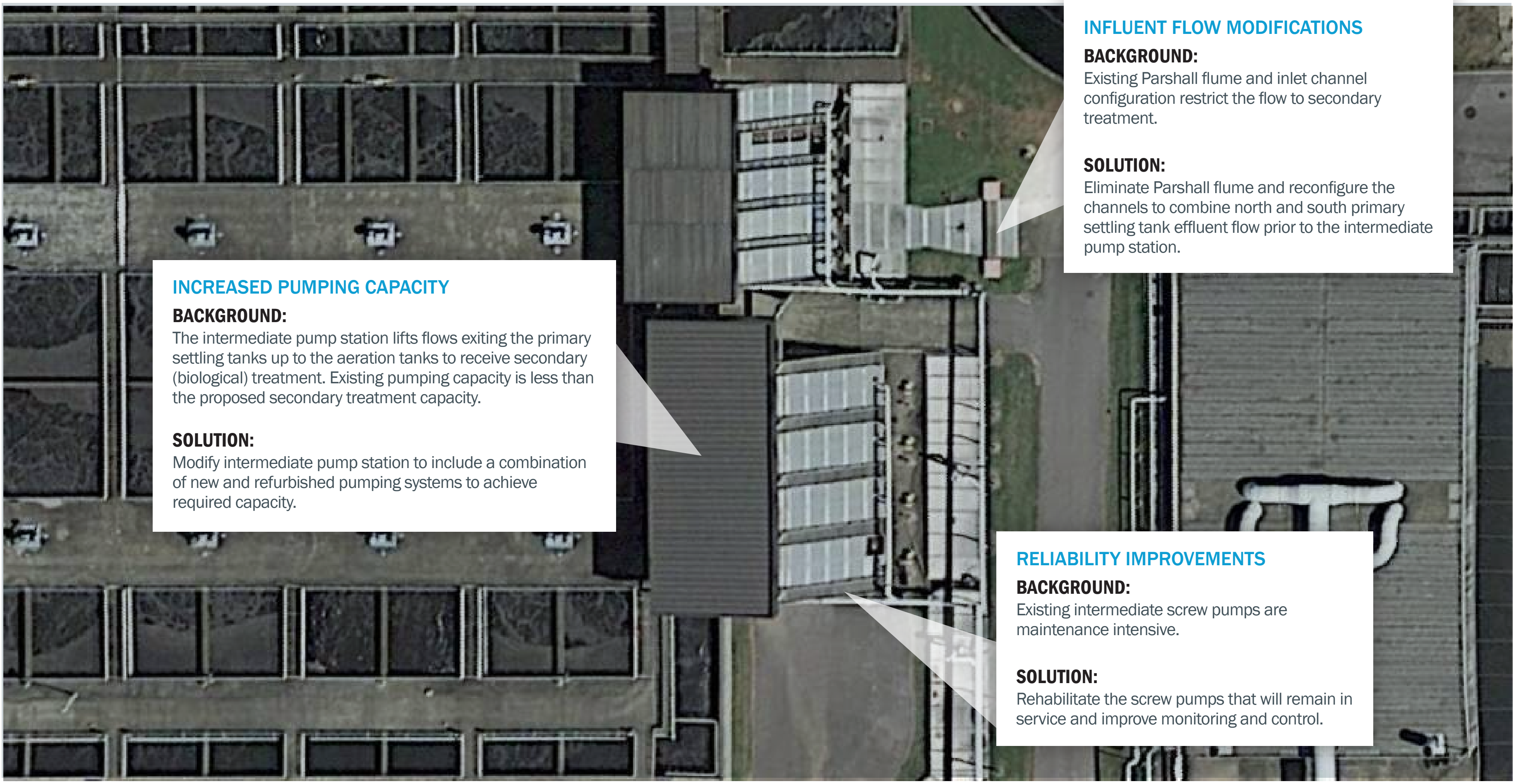
- **Water Quality:** New baffles improve process efficiency and increase capacity of PSTs
- **Sustainability:** Increased solids capture reduces energy consumption required for treatment
- **Community Partnership:** Installation of odor control covers captures and controls odor

see more:

Primary Settling Tanks TM // Process Flow Diagrams

BODR Level Cost: $6M

Intermediate Pump Station



INCREASED PUMPING CAPACITY

BACKGROUND:
The intermediate pump station lifts flows exiting the primary settling tanks up to the aeration tanks to receive secondary (biological) treatment. Existing pumping capacity is less than the proposed secondary treatment capacity.

SOLUTION:
Modify intermediate pump station to include a combination of new and refurbished pumping systems to achieve required capacity.

INFLUENT FLOW MODIFICATIONS

BACKGROUND:
Existing Parshall flume and inlet channel configuration restrict the flow to secondary treatment.

SOLUTION:
Eliminate Parshall flume and reconfigure the channels to combine north and south primary settling tank effluent flow prior to the intermediate pump station.

RELIABILITY IMPROVEMENTS

BACKGROUND:
Existing intermediate screw pumps are maintenance intensive.

SOLUTION:
Rehabilitate the screw pumps that will remain in service and improve monitoring and control.

benefits

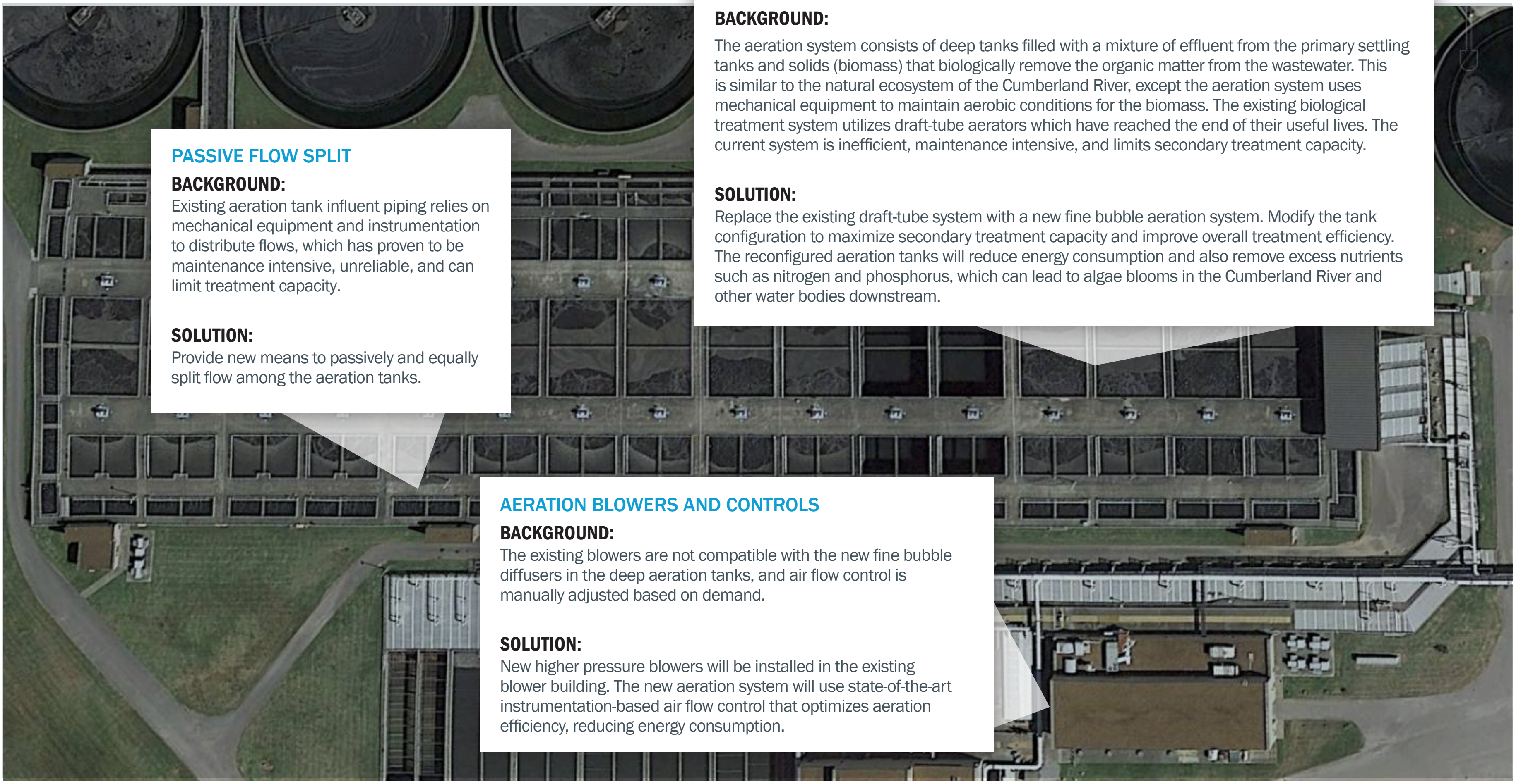
Water Quality Reliability Sustainability

- **Water Quality:** Increased pumping capacity will reduce overflows
- **Reliability:** Implements more reliable and automatic equipment
- **Sustainability:** New and more efficient pumps reduce energy usage

see more:
Intermediate Pump Station TM // Process Flow Diagram

BODR Level Cost: $13.5M

Aeration System



FINE BUBBLE AERATION SYSTEM

BACKGROUND:

The aeration system consists of deep tanks filled with a mixture of effluent from the primary settling tanks and solids (biomass) that biologically remove the organic matter from the wastewater. This is similar to the natural ecosystem of the Cumberland River, except the aeration system uses mechanical equipment to maintain aerobic conditions for the biomass. The existing biological treatment system utilizes draft-tube aerators which have reached the end of their useful lives. The current system is inefficient, maintenance intensive, and limits secondary treatment capacity.

SOLUTION:

Replace the existing draft-tube system with a new fine bubble aeration system. Modify the tank configuration to maximize secondary treatment capacity and improve overall treatment efficiency. The reconfigured aeration tanks will reduce energy consumption and also remove excess nutrients such as nitrogen and phosphorus, which can lead to algae blooms in the Cumberland River and other water bodies downstream.

PASSIVE FLOW SPLIT

BACKGROUND:

Existing aeration tank influent piping relies on mechanical equipment and instrumentation to distribute flows, which has proven to be maintenance intensive, unreliable, and can limit treatment capacity.

SOLUTION:

Provide new means to passively and equally split flow among the aeration tanks.

AERATION BLOWERS AND CONTROLS

BACKGROUND:

The existing blowers are not compatible with the new fine bubble diffusers in the deep aeration tanks, and air flow control is manually adjusted based on demand.

SOLUTION:

New higher pressure blowers will be installed in the existing blower building. The new aeration system will use state-of-the-art instrumentation-based air flow control that optimizes aeration efficiency, reducing energy consumption.

benefits

Water Quality | Reliability | Sustainability

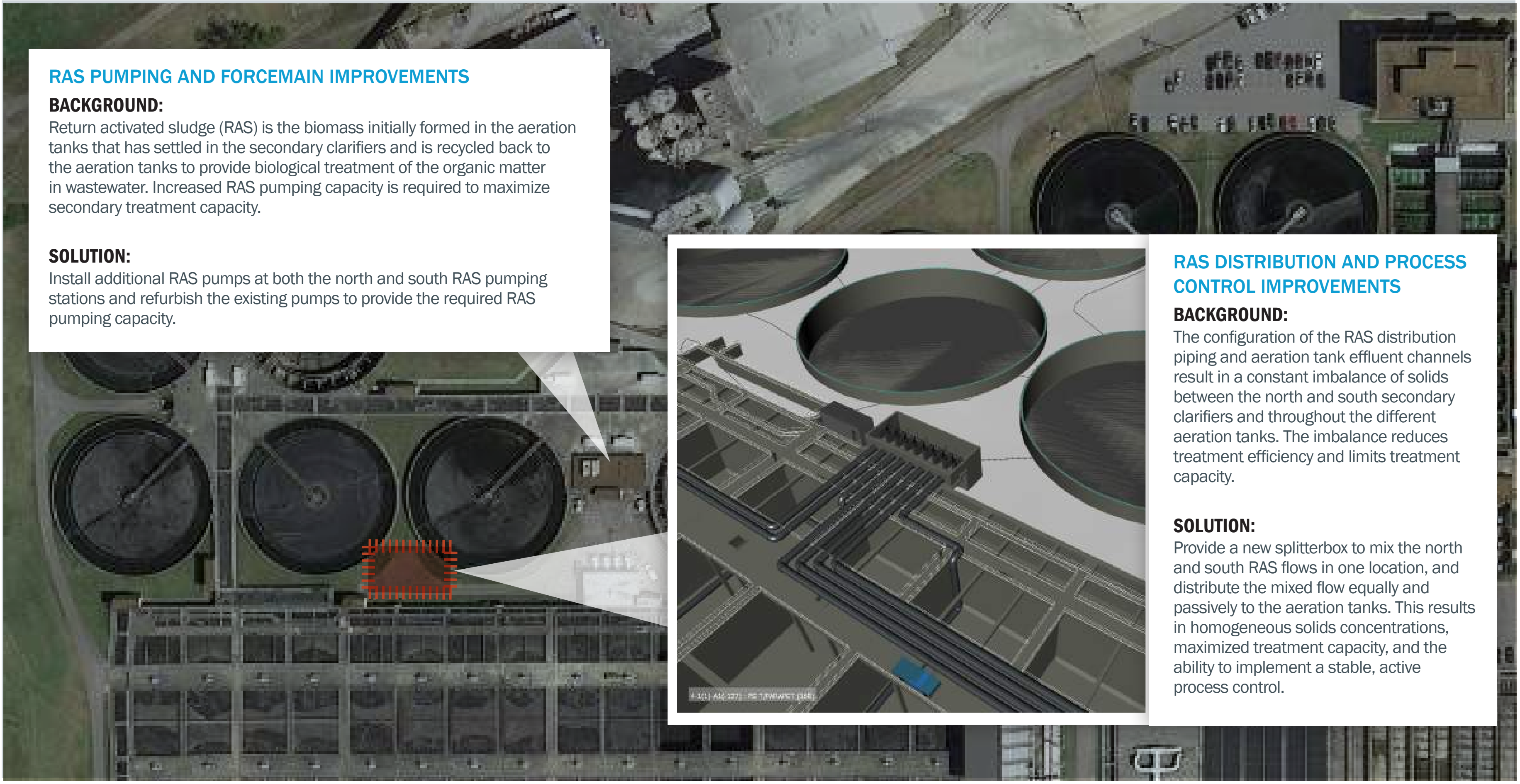
- **Water Quality:** Increases treatment capacity and provides for nutrient removal
- **Reliability:** Replaces aging equipment with latest technology
- **Sustainability:** Reduces energy consumption

see more:

Aeration System TM // Process Flow Diagram

BODR Level Cost: $34M

Return Activated Sludge System



RAS PUMPING AND FORCEMAIN IMPROVEMENTS

BACKGROUND:

Return activated sludge (RAS) is the biomass initially formed in the aeration tanks that has settled in the secondary clarifiers and is recycled back to the aeration tanks to provide biological treatment of the organic matter in wastewater. Increased RAS pumping capacity is required to maximize secondary treatment capacity.

SOLUTION:

Install additional RAS pumps at both the north and south RAS pumping stations and refurbish the existing pumps to provide the required RAS pumping capacity.

RAS DISTRIBUTION AND PROCESS CONTROL IMPROVEMENTS

BACKGROUND:

The configuration of the RAS distribution piping and aeration tank effluent channels result in a constant imbalance of solids between the north and south secondary clarifiers and throughout the different aeration tanks. The imbalance reduces treatment efficiency and limits treatment capacity.

SOLUTION:

Provide a new splitterbox to mix the north and south RAS flows in one location, and distribute the mixed flow equally and passively to the aeration tanks. This results in homogeneous solids concentrations, maximized treatment capacity, and the ability to implement a stable, active process control.

benefits

Water Quality | Reliability | Sustainability

- **Water Quality:** Equal solids distribution maximizes treatment capacity
- **Reliability:** Minimizes operator attention for managing high flows
- **Sustainability:** Hydraulic flow splitting does not rely on mechanical and electrical equipment

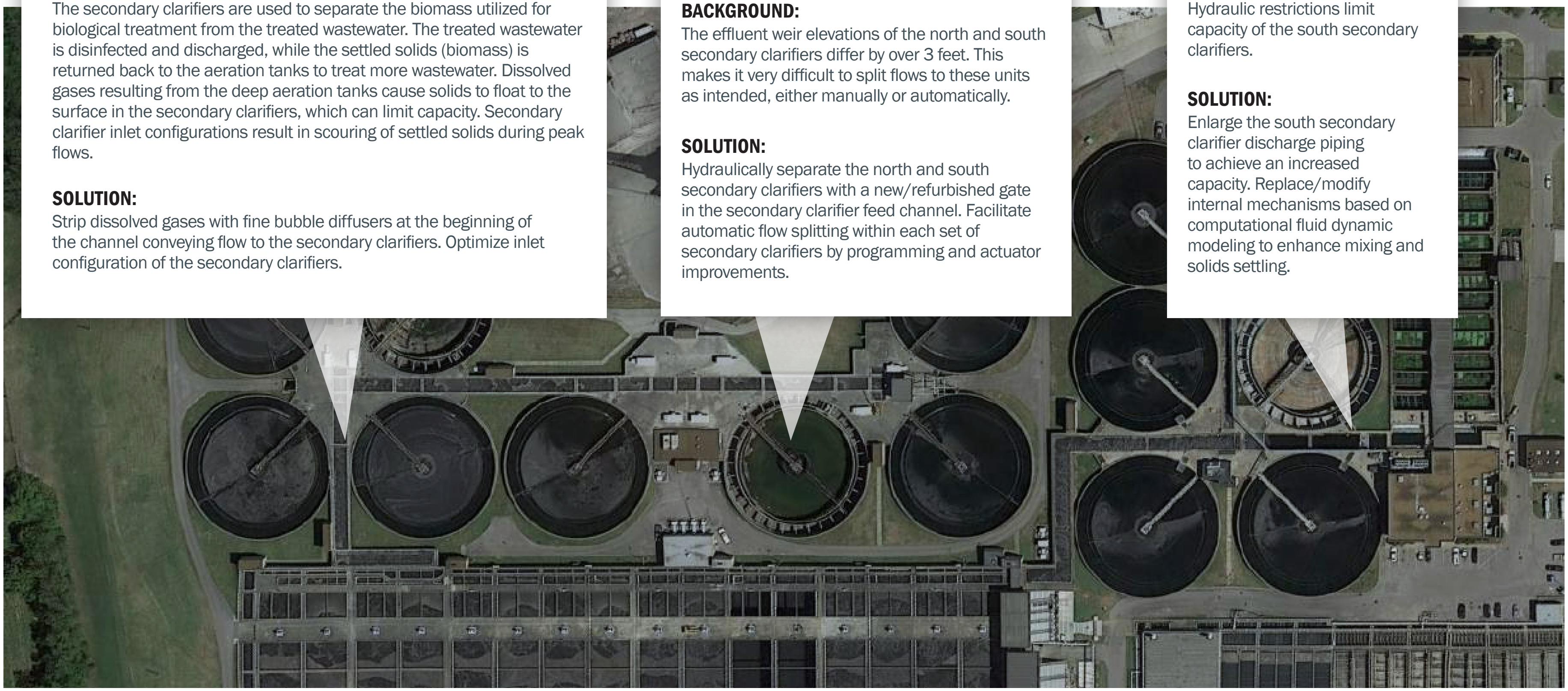
see more:

Return Activated Sludge System TM //

Process Flow Diagram

BODR Level Cost: $12.5M

Secondary Clarifiers



PROCESS OPTIMIZATION

BACKGROUND:
The secondary clarifiers are used to separate the biomass utilized for biological treatment from the treated wastewater. The treated wastewater is disinfected and discharged, while the settled solids (biomass) is returned back to the aeration tanks to treat more wastewater. Dissolved gases resulting from the deep aeration tanks cause solids to float to the surface in the secondary clarifiers, which can limit capacity. Secondary clarifier inlet configurations result in scouring of settled solids during peak flows.

SOLUTION:
Strip dissolved gases with fine bubble diffusers at the beginning of the channel conveying flow to the secondary clarifiers. Optimize inlet configuration of the secondary clarifiers.

IMPROVED OPERABILITY AND FLOW SPLITTING

BACKGROUND:
The effluent weir elevations of the north and south secondary clarifiers differ by over 3 feet. This makes it very difficult to split flows to these units as intended, either manually or automatically.

SOLUTION:
Hydraulically separate the north and south secondary clarifiers with a new/refurbished gate in the secondary clarifier feed channel. Facilitate automatic flow splitting within each set of secondary clarifiers by programming and actuator improvements.

INCREASED CAPACITY

BACKGROUND:
Hydraulic restrictions limit capacity of the south secondary clarifiers.

SOLUTION:
Enlarge the south secondary clarifier discharge piping to achieve an increased capacity. Replace/modify internal mechanisms based on computational fluid dynamic modeling to enhance mixing and solids settling.

benefits

Water Quality | Reliability | Sustainability

- **Water Quality:** Minimize effluent solids concentration and maximize secondary treatment capacity
- **Reliability:** Improve flow splitting to secondary clarifiers
- **Sustainability:** Refurbish existing infrastructure with new, efficient equipment

see more:

Secondary Clarifiers TM // Process Flow Diagram

BODR Level Cost: $17M

Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Secondary Effluent Conveyance

ROUTE ALL SECONDARY EFFLUENT TO ONE DISINFECTION LOCATION

BACKGROUND:

Disinfection of the treated wastewater is required prior to discharge into the Cumberland River to reduce the potential for harmful pathogenic organisms to impact water quality or adversely affect public health. There are currently two separate secondary effluent outfall structures at the Central treatment plant which requires disinfection systems at two separate locations.

SOLUTION:

Repurpose an existing pipe chase structure to convey south secondary effluent flow to one common disinfection facility at the north disinfection area.

benefits

Reliability

Sustainability

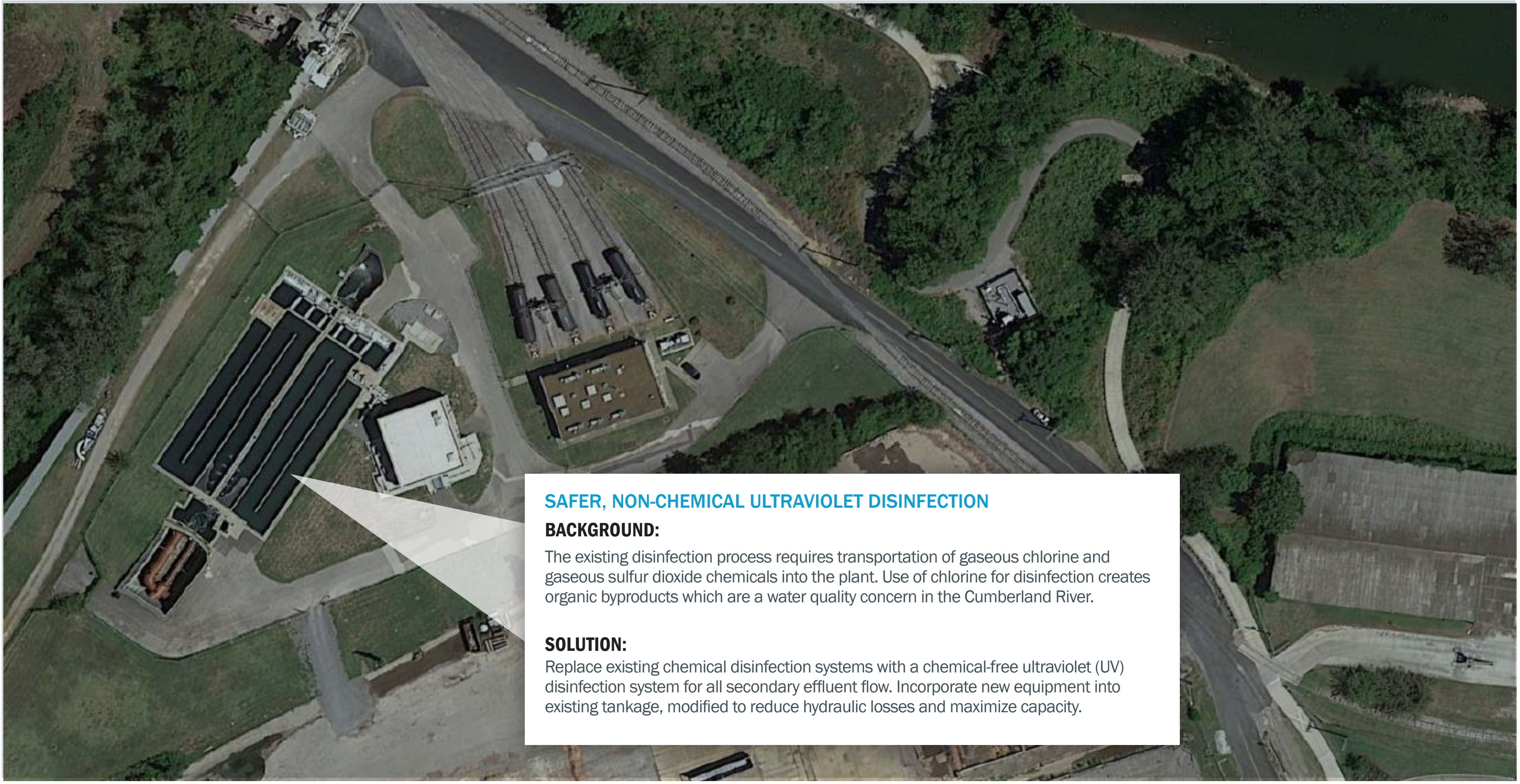
- **Reliability:** Allows for use of one common disinfection location
- **Sustainability:** Repurposing existing infrastructure for beneficial use

see more:

Secondary Effluent Conveyance TM

BODR Level Cost: $3M

Ultraviolet Disinfection Facility



SAFER, NON-CHEMICAL ULTRAVIOLET DISINFECTION

BACKGROUND:

The existing disinfection process requires transportation of gaseous chlorine and gaseous sulfur dioxide chemicals into the plant. Use of chlorine for disinfection creates organic byproducts which are a water quality concern in the Cumberland River.

SOLUTION:

Replace existing chemical disinfection systems with a chemical-free ultraviolet (UV) disinfection system for all secondary effluent flow. Incorporate new equipment into existing tankage, modified to reduce hydraulic losses and maximize capacity.

benefits

Water Quality

Sustainability

- **Water Quality:** Improve effluent water quality (no disinfection by-products)
- **Sustainability:** Eliminate the need to produce and transport disinfection chemicals

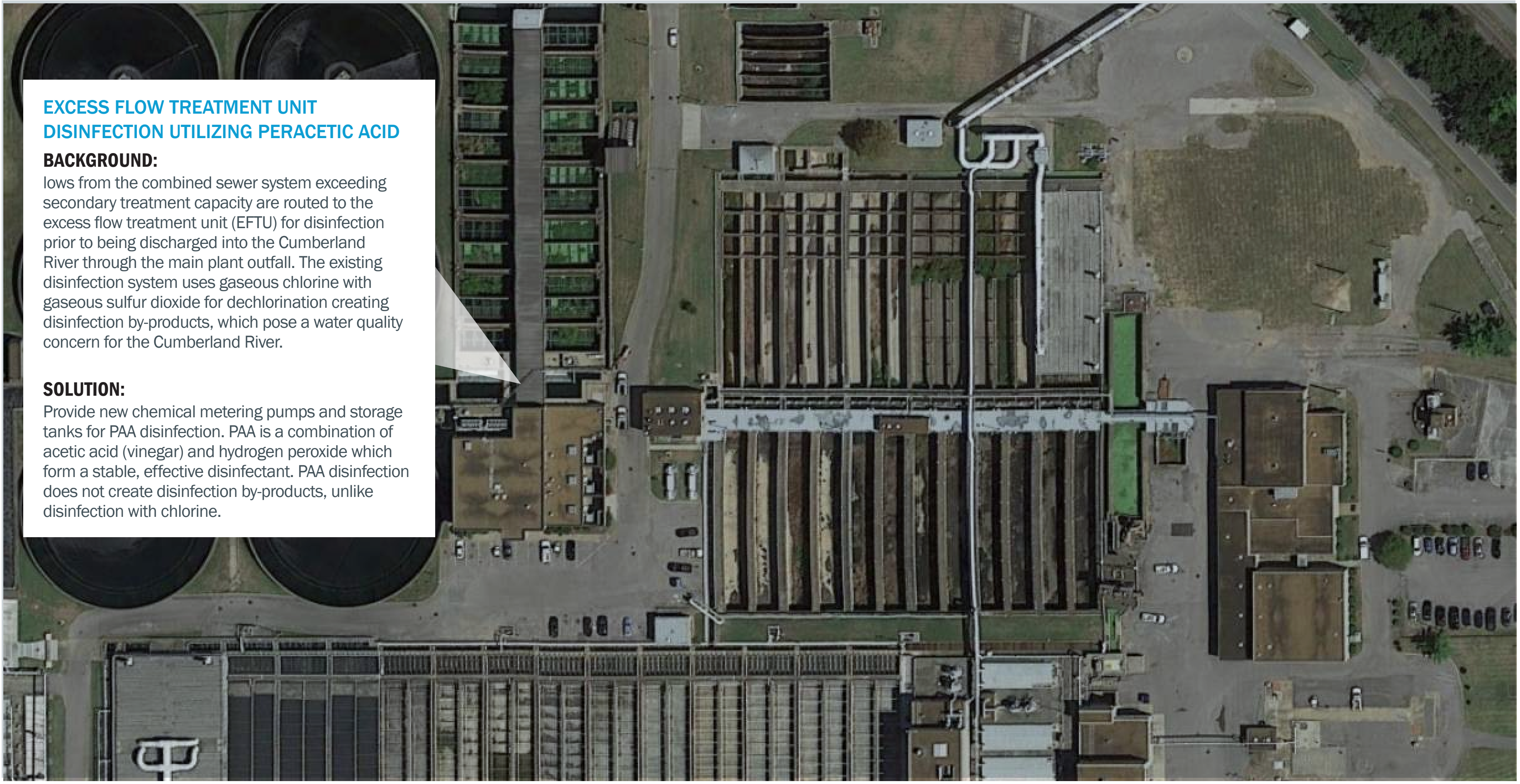
see more:

UV Disinfection TM // Process Flow Diagram

BODR Level Cost: $26M

Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Excess Flow Treatment Unit and Flow Equalization



EXCESS FLOW TREATMENT UNIT DISINFECTION UTILIZING PERACETIC ACID

BACKGROUND:
lows from the combined sewer system exceeding secondary treatment capacity are routed to the excess flow treatment unit (EFTU) for disinfection prior to being discharged into the Cumberland River through the main plant outfall. The existing disinfection system uses gaseous chlorine with gaseous sulfur dioxide for dechlorination creating disinfection by-products, which pose a water quality concern for the Cumberland River.

SOLUTION:
Provide new chemical metering pumps and storage tanks for PAA disinfection. PAA is a combination of acetic acid (vinegar) and hydrogen peroxide which form a stable, effective disinfectant. PAA disinfection does not create disinfection by-products, unlike disinfection with chlorine.

benefits

Water Quality

Sustainability

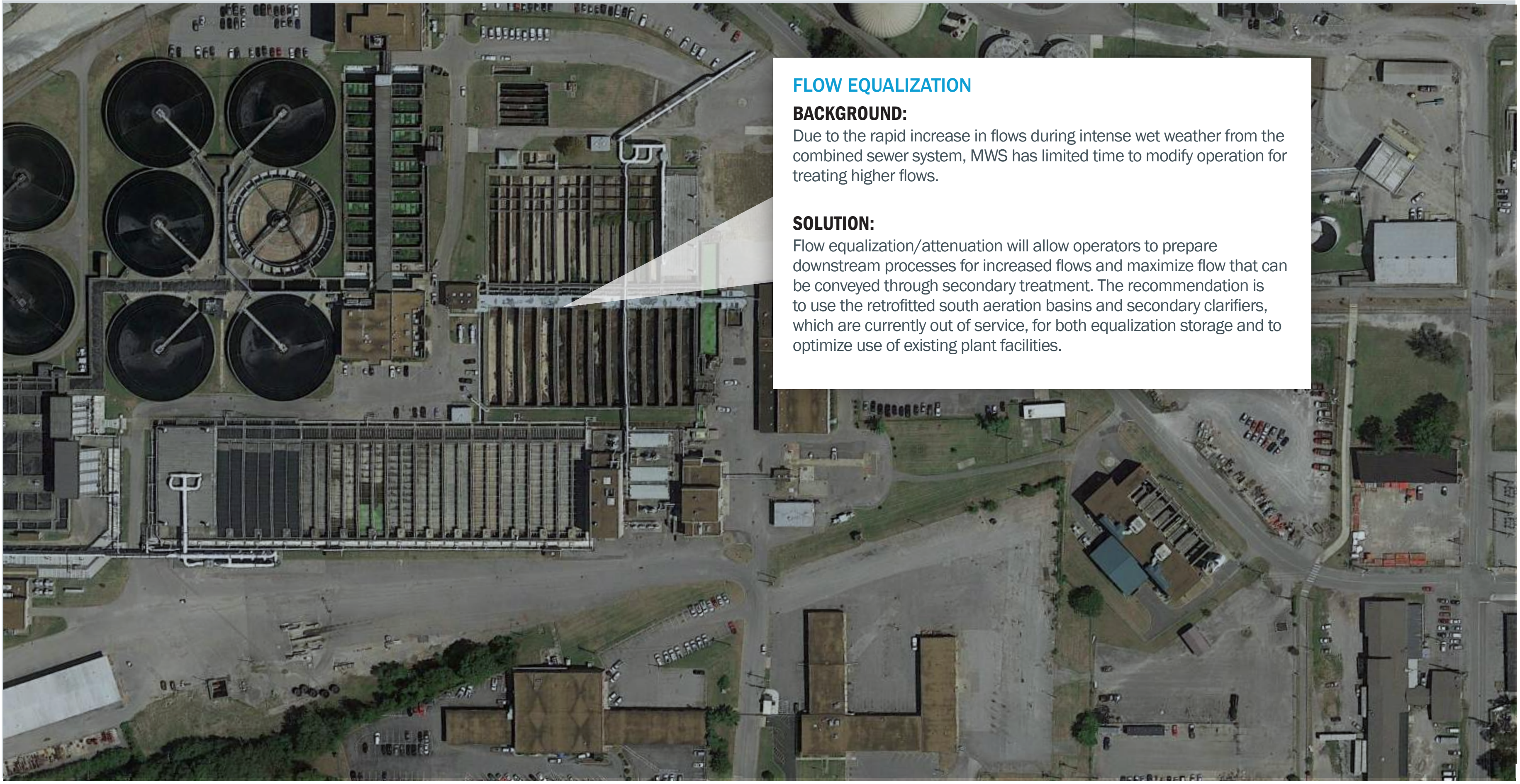
- **Water Quality:** Improve water quality for wet weather flows
- **Sustainability:** Repurpose old tankage

see more:

Excess Flow Treatment Unit TM // Process Flow Diagram

BODR Level Cost: $1.5M

Flow Equalization



benefits

Water Quality

Reliability

- **Water Quality:** Increases treatment capacity and reduces collection system overflows from the combined sewer system
- **Reliability:** Increases wet weather treatment reliabilty

see more:

Equalization TM

BODR Level Cost: $18 M

Biosolids Facility

ENHANCED SOLIDS CAPTURE

BACKGROUND:
The liquid sidestreams resulting from the biosolids dewatering and drying processes are recycled back to the Central plant for treatment. Higher concentrations of solids in the sidestreams adversely impact the capacity of the treatment plant.

SOLUTION:
Repurpose an existing thickening facility to remove the solids from the recycle flow.

DIGESTER OPTIMIZATION

BACKGROUND:
Digestion of the organic solids removed from the treatment process stabilizes the material into biosolids and produces methane biogas as a by-product. The methane biogas is utilized as a heat source for drying the biosolids into pellets, which are then beneficially used as fertilizer. The existing configuration of the digester feed, the mixing systems, and the biogas systems results in unstable digestion.

SOLUTION:
Install dedicated digester feed pumps, replace the digester mixing system, and install a more appropriately sized waste gas flare to optimize the digestion process.

FLOOD MITIGATION

BACKGROUND:
The Biosolids facility was inundated with 3 feet of floodwater during the May 2010 flood that damaged equipment and electrical gear and prevented the facility from operating for several months.

SOLUTION:
Install a perimeter flood wall around the Biosolids facility with a new stormwater drainage system to protect the site from future flooding.

benefits

Water Quality | Reliability | Community Partnership | Sustainability

- **Water Quality:** Reducing recycle solids loading will maximize secondary treatment capacity
- **Reliability:** Promote more stable digester operation
- **Community Partnership:** Improve resiliency of critical infrastructure
- **Sustainability:** Enhancing digester gas production reduces natural gas energy consumption

see more:

Biosolids Facility TM Summary // Process Flow Diagrams

BODR Level Cost: $3.8M

Regulatory Design Criteria

Section 1: Introduction

This section of the Basis of Design Report (BODR) provides an overview/summary of the proposed upgrades and improvements to the Central Wastewater Treatment Plant (CWWTP) necessary to achieve capacity requirements and improve the operational reliability of both the liquid and solids treatment processes. This document is not intended to provide all design information, but it does include key design criteria to give the reader a high-level basis of the proposed improvements. References for additional information are included in the subsequent tables to guide the reader to the appropriate location within the BODR or within the Central Optimization Study (COPT Study), which provides the basis for most of the BODR's recommended improvements.

Additionally, this document provides design criteria listed in the Tennessee Department of Environment and Conservation (TDEC) Design Criteria for Sewage Works as relevant to the COPT improvements, and a comparison of design criteria used in the CWWTP Capacity Improvements and CSO Reduction Project (COPT Project). Where the COPT Project design criteria differs from the TDEC design criteria, a variance is provided to give basis for how the final design will address that specific design criteria. The information presented in this section is expanded upon in the BODR Technical Memoranda, and additional backup/supporting material can be found in the Appendix.

1.1 General Engineering Requirements

The following design criteria apply to the general development, design, and submission of engineering documents, as described in Section 1 of the TDEC Design Criteria.

Documentation of design criteria used for the proposed improvements has been presented in various documents developed throughout the COPT Study and COPT Project, and are referenced throughout this section. However, some design information will continue to be developed through final design. The following bullets present a status of design criteria that will be updated during detailed design:

- Process flow diagrams (PFDs) of the existing facility and proposed improvements are included in this BODR, and will be updated throughout design.
- Solids handling processes were constructed within the last 10 years as part of the CWWTP Biosolids Facility project. As such, they have sufficient capacity to meet treatment requirements of the optimized CWWTP. COPT Project improvements will improve the reliability of this facility, but major improvements are not required as part of this project.
- Previous geotechnical evaluations and information will be supplemented by additional geotechnical investigations during detailed design to support the detailed design efforts.
- An overall plant mass balance was performed during the COPT Study (Refer to TM 5.4). This mass balance will be updated based on most recent data during detailed design.
- A 20-year basis for cost estimate and design criteria was used for design of improvements.

The Long Term Control Plan for Metro Nashville Combined Sewer Overflows (LTCP) and Corrective Action Plan/Engineering Report for Sanitary Sewer Overflows (CAP/ER) that were developed by MWS include recommendations to reduce overflows into the Cumberland River and achieve the requirements of the Consent Decree. These documents provide relevant information that was used during BODR evaluations and will continue to be used in detailed design, including:

- Present and design population
- Nature and extent of the service area (including immediate and probable future development)

- Description of existing collection and/or treatment system, including its condition and problems, renovation and rehabilitation or replacement requirements

Improvements will be designed based on the flood mitigation level of protection that was developed in response to Nashville's May 2010 flood. The flood elevation used for basis of design is 2 feet above flood of record, which is greater than the 500-year flood elevation.

1.2 Reliability of Design

CWWTP falls into Reliability Class II as listed in Section 1.3.11.2 of the TDEC Design Criteria. However, the existing CWWTP and proposed improvements will meet or exceed the requirements for Reliability Class I with the design.

Section 2: Plant Influent Flows and Loading Design Criteria

The following section provides a description of the wastewater flows and influent pollutant loading characteristics developed for the COPT project. The overall plant process flow diagrams (PFDs) for the existing and recommended plant configuration can be found in the BODR. These PFDs provide flows to each process area for reference.

The basis of design used for influent flows were based on information provided in the LTCP and CAP/ER, as well as detailed plant historical flow data. Plant loadings were developed using plant historical sampling and flow data and a detailed wastewater characterization study completed as part of the COPT Study. A detailed description of how the flows and loads were developed can be found in COPT Study TM #1.

The following list defines what flow values are used throughout this document for various flow scenarios:

- Total Facility Capacity: Total rated capacity for each process area assuming all process units are in service
- Firm Capacity: Capacity for each process area assuming largest process unit out of service
- Average Flow Conditions: 125 mgd with largest unit of each process area out of service

Historical data was analyzed to estimate the projected future combined influent flows as presented in the LTCP and associated pollutant loadings to be used as a basis of design for the COPT Project. Table 1 presents a summary for the design influent criteria from this analysis to be used for detailed design of facility improvements. These values will be updated as updated sampling and process modeling are performed in detailed design.

Figure 1 shows the peak flow routing throughout the CWWTP. All sanitary sewer flow will receive secondary treatment. Combined sewer system (CSS) flow will also receive secondary treatment up to the available secondary capacity, at which point the remaining CSS flows will be routed to the excess flow treatment unit (EFTU) for primary treatment and disinfection.

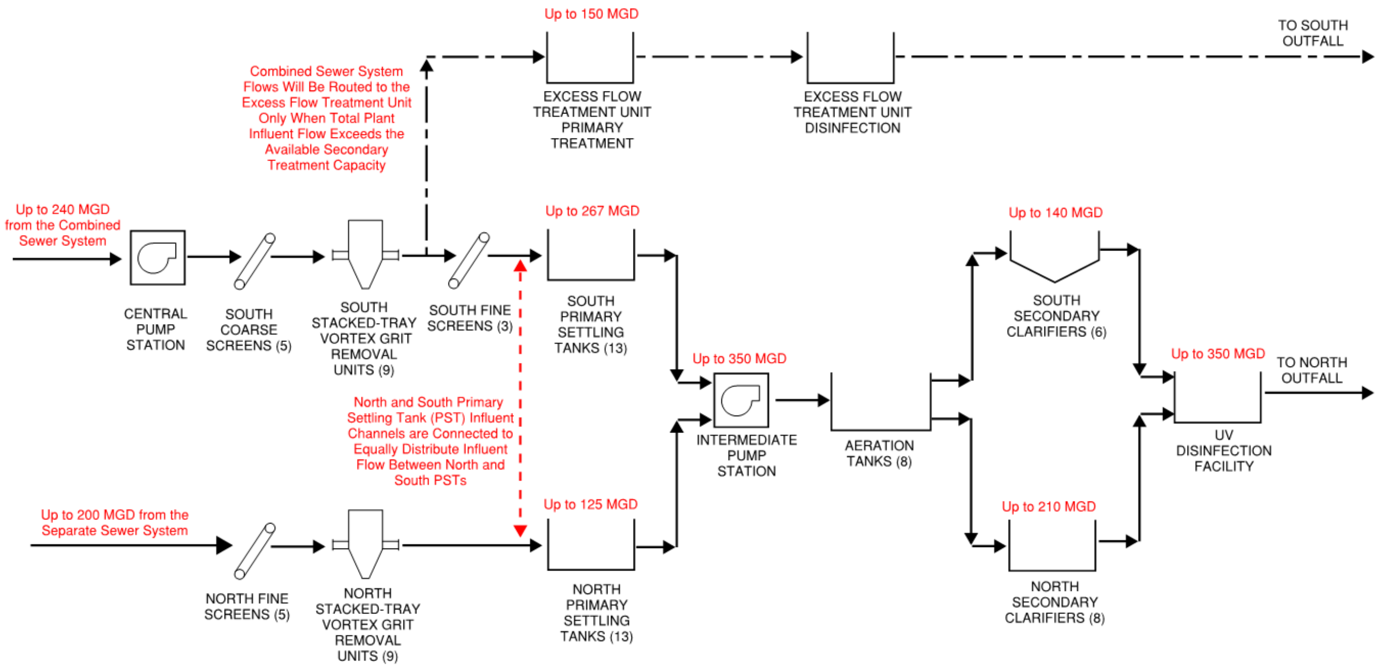


Figure 1 –Peak Flows Routing per Process Area Throughout the CWWTP

Table 1-1: Plant Influent Flows and Loading Design Criteria		
Parameter	**Condition**	**Design Values**
Flow (mgd)	Annual Average	125
	Maximum Month	193
	Maximum Day	328
	Peak Hour	440
$CBOD_5$ (lb/day)	Annual Average	114,680
	Maximum 30-day Avg.	158,140
	Maximum Day	428,370
TSS (lb/day)	Annual Average	152,900
	Maximum 30-day Avg.	210,850
	Maximum Day	571,160
NH_3-N (lb/day)	Annual Average	11,470
	Maximum 30-day Avg.	15,810
	Maximum Day	42,840
TKN (lb/day)	Annual Average	23,850
	Maximum Month	32,920
	Maximum Day	61,390

Table 1-1: Plant Influent Flows and Loading Design Criteria		
Parameter	**Condition**	**Design Values**
TP (lb/day)	Annual Average	2,680
	Maximum Month	3,700
	Maximum Day	6,900

Section 3: Coarse Screening Design Criteria

The following section provides a summary of the necessary design criteria that impact the design and implementation of coarse screening facility improvements at the CWWTP south treatment train. Table 3-1 presents general design criteria, and Table 3-2 summarizes specific TDEC design criteria related to this process area and briefly states how this design will address these requirements. Further detailed information is presented in corresponding TM's as referenced in Table 3-2.

Table 3-1. South Coarse Screening Design Criteria	
Parameter	**Value**
Firm Facility Capacity (mgd)	240
Total Facility Capacity (mgd)	300
Capacity per Screen (mgd)	60
Channel Width (ft)	6
Channel Depth (ft)	9
Number of Channels	5
Number of Screens	5
Type of Screen	Multi-rake or catenary multi-rake
Bar spacing (inches)	½
Type of Screening Conveyance	Belt conveyor
Number of Screening Conveyors	2

Table 3-2. South Coarse Screening Regulatory Design Criteria				
TDEC Design Criteria	**TDEC Design Criteria Reference**	**MWS COPT Design**	**MWS COPT TM Reference**	**Variance**
Clear openings no less than 5/8-inch	4.1.3.2	½-inch openings	TM #2	Smaller openings provided to minimize clogging potential of downstream grit system.
Protection from freezing conditions should be considered	4.1.3.2	South coarse screens will be installed inside building	TM #2	-

Table 3-2. South Coarse Screening Regulatory Design Criteria				
TDEC Design Criteria	TDEC Design Criteria Reference	MWS COPT Design	MWS COPT TM Reference	Variance
Other than the rakes, no moving parts shall be below the water line	4.1.3.2	Multi-rake or catenary multi-rake screens are proposed.	TM #2	Other than climber type bar screens that are not desirable for this application, all screens also have chain and some have sprockets that move and below the water surface. All electrical components are above water surface elevation line (WSEL).
Approach velocities should be no less than 1.25 ft/sec nor greater than 3.0 ft/sec through the bar screen	4.1.3.3	Approach velocity design criteria will be considered during detailed design.	TM #2	-

Section 4: Fine Screening Design Criteria

The following section provides a summary of the necessary design criteria that impact the design and implementation of fine screening facility improvements at the CWWTP north and south treatment trains. Table 4-1 presents general design criteria, and Table 4-2 summarizes specific TDEC design criteria related to this process area and briefly states how this design will address these requirements. Further detailed information is presented in corresponding TM's as referenced in Table 4-2.

Note that the combined firm capacity of the north and south fine screening facilities is less than the total peak hour influent flow to the CWWTP. The new north fine screening facility will be able to handle peak flows from the separate sewer system. The south fine screens will be retrofit into an existing structure, which limits its ability to provide fine screening to peak combined sewer system (CSS) influent flows. Based on a combination of factors, the project team determined that the limited fine screening capacity was acceptable. These factors include:

- All CSS influent flow will receive coarse screening (½-inch openings as noted above) and grit removal prior to entering the south fine screening facility.
- Firm capacities represent conservative blinded operating condition.
- An existing screen bypass channel can be utilized to divert flows exceeding the available fine screen capacity to downstream processes.
- Firm capacity is more than double the peak diurnal dry weather flow from the CSS and wet weather events that result in CSS flow exceeding the facilities firm capacity are relatively infrequent. Annually, the facility is estimated to be capable of handling more than 80% of all CWWTP influent flow from the CSS.
- During major wet weather events where available secondary treatment capacity is exceeded, CSS influent flow that has received coarse screening and grit removal will be diverted to the excess flow treatment unit primary settling tanks upstream of the south fine screening facility, limiting the amount of flow that is potentially diverted around the fine screens.

Table 4-1. Fine Screening Design Criteria		
Parameter	South Fine Screening Facility	North Fine Screening Facility
Firm Facility Capacity (mgd)	107	200
Total Facility Capacity (mgd)	160	250
Capacity per Screen (mgd)	53	50
Channel Width (ft)	6	6
Channel Depth (ft)	16.25	12
Number of Screens	3	5
Number of Channels	3	5
Type of Screen	Perforated plate	Perforated plate
Screen Aperture Size (inches)	¼	¼
Type of Screenings Conveyance	Sluiceway	Sluiceway
Number of Sluiceways	2	2
Number of Screening Washer/Compactors	2	2

Table 4-2. Fine Screen Regulatory Design Criteria				
TDEC Design Criteria	TDEC Design Criteria Reference	MWS COPT Design	MWS COPT TM Reference	Variance
Must be preceded by coarse bar screen	4.1.4.1	North fine screening facility has coarse screens upstream at Browns Creek and 28th Ave pump stations. South fine screening facility will have new coarse screens upstream.	TM #3A	-
Minimum of 2 fine screens	4.1.4.1	South fine screenings facility will have 3 screens installed. North fine screenings facility will have 5 screens installed.	TM #3A	-
Each fine screen must be capable of independent operation at peak design flow	4.1.4.1	Each screen and associated equipment will include a local control panel capable of independent operation. Local control panels will interface with the plant SCADA system for coordinated facility operation.	TM #3A	-

Section 5: Grit System Design Criteria

The following section provides a summary of the necessary design criteria that impact the design and implementation of grit facility improvements at the CWWTP north and south treatment trains. Table 5-1 presents general design criteria, and Table 5-2 summarizes specific TDEC design criteria related to this process area and briefly states how this design will address these requirements. Further detailed information is presented in corresponding TM's as referenced in Table 5-2.

Table 5-1. Headworks – Grit Removal Design Criteria

Parameter	South Grit Facility		North Grit Facility
	Alternative 2 (Retrofit)	Alternative 3 (New)	
Firm Capacity (mgd)	240	240	212
Total Facility Capacity (mgd)	270	275	230
Capacity per Unit (mgd)	30	35	19
Type of Grit Unit	Stacked tray vortex	Stacked tray vortex	Stacked tray vortex
Number of Units	9 (8 duty, 1 standby)	8 (7 duty, 1 standby)	12 (11 duty, 1 standby)
Removal performance	95% Removal ≥150 microns @ 240 mgd (peak) 95% Removal ≥75 microns @ 80 mgd	95% Removal ≥150 microns @ 240 mgd (peak) 95% Removal ≥75 microns @ 80 mgd	95% Removal ≥106 microns @ 212 mgd (peak) 95% Removal ≥75 microns @ 75 mgd
Type of Grit Pumps	Recessed Impeller	Recessed Impeller	Recessed Impeller
Number of Grit Pumps	10 (1 per unit + shelf spare)	9 (1 per unit + shelf spare)	13 (1 per unit + shelf spare)
Type of Grit Washer/Concentrator	Forced vortex/cyclone	Forced vortex/cyclone	Forced vortex/cyclone
Number of Grit Washer/Concentrators	9	8	12
Type of Grit Dewatering Unit	Belt escalator	Belt escalator	Belt escalator
Number of Grit Dewatering Units	5	4	6

Table 5-2. Headworks – Grit System Regulatory Design Criteria

TDEC Design Criteria	TDEC Design Criteria Reference	MWS COPT Design Criteria	MWS COPT TM Reference	Variance
Complete treatment analysis to be submitted for approval for cyclone or swirl-type grit removal	4.2.3.4	The use of a stacked tray, vortex-type grit removal system is proposed and has similar successful installations throughout TN. Treatment analysis has been provided based on grit sampling and analysis provided in this BODR.	TMs #2 and 3B	-
Storage containers shall be provided for grit holding and disposal	4.2.4	Dumpsters and/or trucks will be used for grit holding and disposal (to be determined in detailed design).	TMs #2 and 3B	-
Run-off control shall be provided	4.2.4	Dumpsters and/or trucks will be located inside a building with containment and floor drains.	TMs #2 and 3B	-
Grit washing/disposal is required	4.2.4	Grit washing and concentration will be part of the grit system design package, and dewatered grit will be designed to meet requirements for direct landfill disposal.	TMs #2 and 3B	-

Section 6: Primary Settling Tanks Design Criteria

The following section provides a summary of the necessary design criteria that impact the design and implementation of improvements to the primary settling tanks (PSTs) at the CWWTP north and south treatment trains. Table 6-1 presents general design criteria, and Table 6-2 summarizes specific TDEC design criteria related to this process area and briefly states how this design will address these requirements. Further detailed information is presented in corresponding TM's as referenced in Table 6-2.

Additional information on the design of improvements to the PSTs:

- This project will include modifications to the existing PSTs that were previously approved by TDEC when constructed.
- Based on field stress testing and hydrodynamic modeling, PST average surface overflow rate (SOR) values between 800-1200 gpd/ft^2 would result in 62-68% total suspended solids (TSS) removal efficiency; which is considered adequate for this type of application.
- During average conditions, one north PST and two south PSTs can be taken out of service without affecting the performance of the plant. During high, wet weather conditions, it is assumed that all the PSTs would be online.
- Throughout this document and the BODR, what is referred to in the TDEC design criteria as "primary clarifier" is referred to as "primary settling tanks."

Table 6-1. Primary Settling Tanks Design Criteria

Parameter	South Primary Settling Tanks	North Primary Settling Tanks
Firm Facility Capacity (mgd)	246	102
Total Facility Capacity (mgd)	267	123
Capacity per Tank (mgd)	20.5	20.5
Tank Length (ft)	166	166
Tank Width (ft)	41.5	41.5
Tank Depth (ft)	8	14.7
Number of Tanks	13	6
Weir Length per Tank (ft)	380	635
Surface Overflow Rate @ Ave Flow (gpd/ft^2)[1]	1,070	1,070
Surface Overflow Rate @ Peak flow (gpd/ft^2)	2,980	2,975

1. Average flow assumed to be 125 mgd with one PST out of service each train (12 south PSTs & 5 north PSTs in service)

Table 6-2. Primary Settling Tanks Regulatory Design Criteria

TDEC Design Criteria	TDEC Design Criteria Reference	MWS COPT Design Criteria	MWS COPT TM Reference	Variance
SOR of 800-1,200 gpd/ft^2 for average design flow	5.2.1	Average flow conditions are unchanged from original design except for the elimination of 2 PSTs	TM #4	-

Table 6-2. Primary Settling Tanks Regulatory Design Criteria				
TDEC Design Criteria	TDEC Design Criteria Reference	MWS COPT Design Criteria	MWS COPT TM Reference	Variance
SOR of 2,000-3,000 gpd/ft^2 for peak design flow	5.2.1	SOR for peak design flow is 2,975 gpd/ft^2	TM #4	-
A properly designed primary clarifier should remove 30 to 35% of the influent BOD	5.2.1	Except for updates to influent baffles, tanks are unchanged from original design. Historical data for CWWTP provides basis that the PSTs have achieved this removal percentage historically.	-	-
Weir troughs shall be designed to prevent submergence at maximum design flow and to maintain velocity of at least 1 ft/sec at one-half design flow	5.3.3	There are no weir trough modifications proposed as part of this project. The existing weir troughs meet both of these criteria under all anticipated operating conditions.	-	-
12-inches of freeboard	5.3.4	Approximately 18-inches of freeboard	TM #4	-
Weir loadings should not exceed 15,000 gallons per day per linear feet (gpd/LF)	5.2.4	South PSTs ~51,000 gpd/LF North PSTs ~ 30,500 gpd/LF	COPT Study TM #5.4	Proposed design capacity is based on computational fluid dynamic (CFD) modeling. Metcalf & Eddy's *Wastewater Treatment Engineering* lists design range of 10,000 – 40,000 gpd/LF. Decreased removal efficiency at high flows will be accommodated by biological treatment design
The hydraulic detention time in primary clarifiers is not recommended to be greater than 2.5 hours as a function of the surface overflow rate and side water depth (SWD)	5.2.5	The hydraulic detention time meets this criterion under all anticipated operating conditions.	TM #4	-
Minimum SWD = 8-feet	Table 5-2, 5.2.5	Both sets of PSTs meet these requirements with SWDs of 14.7 feet for the north and 8 feet for the south.	TM #4	-
Inlets should be designed to dissipate the influent velocity, to distribute the flow equally in both the horizontal and vertical vectors, and to prevent short-circuiting.	5.3.1	The upgraded inlet perforated and/or canopy baffles, which will be installed in both sets of PSTs will allow for these requirements to be met	TM #4	-

Table 6-2. Primary Settling Tanks Regulatory Design Criteria				
TDEC Design Criteria	TDEC Design Criteria Reference	MWS COPT Design Criteria	MWS COPT TM Reference	Variance
Channels should be designed to maintain an inlet velocity of at least 1 ft/sec at one-half the design flow.	5.3.1	There are no PST inlet modifications proposed as part of this project. The existing PST inlets meet both of these criteria under all anticipated operating conditions.	TM #4	-

Section 7: Activated Sludge/Aeration System Design Criteria

The following section provides a summary of the necessary design criteria that impact the design and implementation of improvements to the activated sludge/aeration system at the CWWTP. Table 7-1 presents general design criteria, and Table 7-2 summarizes specific TDEC design criteria related to this process area and briefly states how this design will address these requirements. Further detailed information is presented in corresponding TM's as referenced in Table 7-2.

Table 7-1. Activated Sludge/Aeration System Design Criteria	
Parameter	Value
Design DO (mg/L)	2.0
Average AOR[1] (kg O_2/d)	67,365
Peak Hour AOR[2] (kg O_2/d)	130,909
Alpha	0.5
Beta	0.95
Theta	1.02
Standard Oxygen Transfer Efficiency (SOTE) avg. (%)	48%
SOTE Peak Hour (%)	45%
Average Airflow Rate (scfm)	32,500
Peak Airflow Rate (scfm)	71,500
Blowers[2]	
Number of Blowers (Duty + Standby)	4 (3 + 1)
Type of Blowers	Single-Stage Integrally Geared Centrifugal
Capacity of Each Blower (scfm)	21,000
Operating Pressure (psi)	14-17.5

kg O_2/d = kilograms of oxygen per day

[1] AOR values were estimated by BioWin modeling assuming average removal efficiency in the PSTs of 65% TSS and 25% BOD.

[2] To be finalized during detailed design

Table 7-2. Activated Sludge/Aeration Tanks Regulatory Design Criteria				
TDEC Design Criteria	TDEC Design Criteria Reference	MWS COPT Design Criteria	MWS COPT TM Reference	Variance
Aeration tank sizing based on food to microorganism (F/M) ratio	7.3.1, Appendix 7A	Existing tanks will be utilized for improvements. BioWin and sampled wastewater influent characteristics will be utilized for design of optimized aeration tanks. Design will meet typical sizing criteria in respect to F/M ratio and SRT conditions.	COPT Study TM #5.4	-
Liquid depths of aeration tanks should not be less than 10 feet or more than 30 feet	7.3.1	Design utilizes existing tankage. Minimum liquid level = 30.8 feet Maximum liquid level = 32.3 feet	TM #6	BioWin and aeration off gas testing will be utilized to ensure effective treatment. At this depth of tank, nitrogen gas will form in solution, so degassing will occur in the mixed liquor (ML) channels to prevent floating material to accumulate in channels and secondary clarifiers.
Inlets/outlets for each aeration tank should be equipped to permit control of flow and maintain reasonably constant liquid level. They should also permit max instantaneous hydraulic load to be carried with any single aeration tank unit out of service	7.3.4.1	New influent cutthroat flumes will split flow evenly between all aeration tanks that are online and will be designed to accommodate max instantaneous hydraulic loading with one aeration tank out of service. Aeration tank liquid levels will be controlled based on secondary clarifier flow distribution.	TM #6	-
Inlet/effluent channels should be designed to keep solids in suspension	7.3.4.2	Existing coarse bubble channel mixing will be replaced with a new high efficiency channel mixing system designed to keep solids in suspension.	TMs #6 & 6B	-
Where multiple aeration tanks and secondary clarifiers are used, flow should be divided evenly to all aeration tanks (ATs) in service and then recombined and divided evenly to secondary clarifiers (SCs) in service and then recombine. Treatment plants using more than 4 ATs and SCs may divide the activated sludge systems into two or more process trains consisting of not less than two ATs and SCs per train.	7.3.4.3	Aeration influent flow and return activated sludge (RAS) flow will each be split evenly into all ATs in service using cutthroat flumes. Flow is then recombined and split among two sets of SCs using control valves/gates and flow meters.	TMs #6, #7, & #8	-

Table 7-2. Activated Sludge/Aeration Tanks Regulatory Design Criteria				
TDEC Design Criteria	TDEC Design Criteria Reference	MWS COPT Design Criteria	MWS COPT TM Reference	Variance
For plants >250,000 gallons per day (gpd), devices shall be installed for totalizing, indicating, and recording influent sewage and returned sludge to each aeration tank.	7.3.5	Individual flow meters will not be necessary. RAS forcemains have flow meters to totalize RAS flow and then RAS will be mixed and distributed equally among aeration tanks in service using cutthroat flumes.	TBD	Design eliminates the need for active flow control and measurement to each aeration tank by utilizing passive flow splitting devices during all flows up to 250 mgd.
Minimum 18-inches freeboard	7.3.6	A minimum of 18-inches of freeboard will be met under all anticipated operating conditions.	TM #6	-
1,500 cubic feet of air available per pound of BOD load applied	7.4.2.1	Design BOD loading and associated aeration requirements were determined based on a detailed wastewater characterization and BioWin modeling, respectively. Approximately 600 cubic feet of air will be applied per pound of BOD.	COPT TM #5.4	Fine bubble aeration installed in deep aeration tanks requires less air per pound of BOD load applied than other, less efficient aeration systems. It should be noted this information will be revised during final design by conducting on-site off-gas testing.
Design of aeration system shall always maintain minimum mixing levels	7.4.4	Design of aeration system will maintain mixing in the aeration tanks during all design flow conditions.	TM #6	-
Nitrification	Chapter 8	The design will utilize BioWin and anticipates meeting all the requirements in Chapter 8. Specific design criteria will be documented during detailed design.	-	-
At least two blowers available for service	1.3.11.2; 9.3.3.5	Potential blower configurations will utilize a minimum of 4 blowers.	TM #6A	-
Blower motor horsepower shall be sufficient to handle min and max ambient temperatures on record	7.4.2.2	Blower design will use minimum and maximum temperature and relative humidity in design criteria.	TM #6A, Table 3-3	-
Blowers provided in multiple units and meet max air demand with single largest unit out of service	7.4.2.2	Potential blower configurations are capable of meeting max air demand with single largest unit out of service.	TM #6A	-

Section 8: Secondary Clarifiers Design Criteria

The following section provides a summary of the necessary design criteria that impact the design and implementation of improvements to the secondary clarifiers at the CWWTP north and south treatment trains. Table 8-1 presents general design criteria, and Table 8-2 summarizes specific TDEC design criteria related to this process area and briefly states how this design will address these requirements. Further detailed information is presented in corresponding TM’s as referenced in Table 8-2.

Table 8-1. Secondary Clarifiers Design Criteria		
Parameter	South Secondary Clarifiers	North Secondary Clarifiers
Firm Facility Capacity (mgd)	117	182
Total Facility Capacity (mgd)	140	210
Number of Tanks	6	8
Capacity per Tank (mgd)	23	26
Diameter (ft)	160	160
Sidewater Depth (ft)	14	16
Flocculator Center Well Diameter (ft)	53	55
Flocculator Center Well Depth (ft)	9	8
Sludge Collection Mechanism	Scraper Type	Tow-Bro Type
Type of Launders	Inboard	Inboard
Maximum RAS Drawoff Capacity (mgd)	53	87
Average RAS Drawoff Capacity (mgd)	20	32.5
Maximum ML Concentration (mg/L) @ Dry Weather	3,200	3,200
Maximum ML Concentration (mg/L) @ Wet Weather	2,500	2,500
Surface Overflow Rate (gpd/ft^2) @ Ave Flow[1]	500	500
Surface Overflow Rate (gpd/ft^2) @ Peak Flow	1,160	1,300
Solids Loading Rate (lb/day-ft^2) @ Ave Flow	20	20
Solids Loading Rate (lb/day-ft^2) @ Peak Flow	30	30
Weir Loading Rate (gpd/LF)	28,560	31,900

1. Average flow assumed to be 125 mgd with one SC out of service each train (5 south PSTs & 7 north PSTs in service)

Table 8-2. Secondary Clarifiers Regulatory Design Criteria				
TDEC Design Criteria	TDEC Design Criteria Reference	MWS COPT Design Criteria	MWS COPT TM Reference	Variance
Minimum SWD of 15 ft. required for clarifier diameter greater than 140 ft.	Table 5-2 (5.2.4)	South secondary clarifiers (6 tanks) - depth of 14 ft. with diameter of 160 ft. North secondary clarifiers (8 tanks) – depth of 16 ft. with a diameter of 160 ft.	COPT Study TM #5.4	6 existing 14-ft clarifiers were modeled using combination of BioWin and CFD modeling to determine achievable capacities
Maximum surface overflow rate of 800 gpd/ft^2 for average design flow	Table 5-1 (5.2.3)	Average flows for proposed improvements do not change from original design values	-	-

Table 8-2. Secondary Clarifiers Regulatory Design Criteria				
TDEC Design Criteria	TDEC Design Criteria Reference	MWS COPT Design Criteria	MWS COPT TM Reference	Variance
Maximum surface overflow rate of 1,200 gpd/ft² for peak design flow	Table 5-1 (5.2.3)	The maximum SOR to the north SCs would be approximately 1,300 gpd/ft² which was determined through stress testing and hydrodynamic modeling. The maximum SOR to the south SCs is 1,160 gpd/ft² which is lower than the recommended value by TDEC	TM #6	The maximum SOR for the north SCs is expected to be slightly higher than TDEC's recommendation. However, the design value was determined through field testing and detailed modeling.
Solids loading rate of 30 lb/day – ft² for average design flow	Table 5-1 (5.2.3)	South SCs = 15 lb/day – ft² North SCs = 15 lb/day – ft²		-
Solids loading rate of 50 lb/day – ft² for peak design flow	Table 5-1 (5.2.3)	South SCs ~ 25 lb/day – ft² North SCs ~28 lb/day – ft²	-	-
Weir loadings should not exceed 15,000 gallons per day per linear feet (gpd/LF)	5.2.4	South SCs ~28,560 gpd/LF North SCs ~ 32,000 gpd/LF	-	Proposed design capacity is based on CFD modeling. M&E design criteria for weir loading rate suggests a maximum of 30,000 gpd/LF
Weir troughs shall be designed to prevent submergence at maximum design flow and to maintain velocity of at least 1 ft/sec at one-half design flow	5.3.3	There are no weir trough modifications proposed as part of this project. The existing weir troughs meet both of these criteria under all anticipated operating conditions.	-	-
12-inches of freeboard	5.3.4	North and south SCs: > 24-inches freeboard		-
Channels should be designed to maintain an inlet velocity of at least one 1 ft/sec at one-half the design flow.	5.3.1	There are no modifications proposed that affect channel velocity as part of this project. The existing channel hydraulics meet both of these criteria under all anticipated operating conditions.	-	-

Section 9: UV Disinfection Design Criteria

The following section provides a summary of the necessary design criteria that impact the design and implementation of improvements to the UV disinfection facility at the CWWTP. Table 9-1 presents general design criteria, and Table 9-2 summarizes specific TDEC design criteria related to this process area and briefly states how this design will address these requirements. Further detailed information is presented in corresponding TM's as referenced in Table 9-2.

Table 9-1. UV Disinfection Design Criteria	
Parameter	Value
Type of UV Disinfection System	Channel type
Number of UV Channels	6
Firm Capacity (mgd)	350
Total Facility Capacity (mgd)	420
Average Flow (mgd)	125
Capacity per Channel (mgd)	70
UV Transmittance – Design (%)	55
Suspended Solids – Ave (mg/L)	5
Suspended Solids – Max (mg/L)	30
UV Dose Minimum at Peak Flow (mJ/cm²)	15
Number of Banks per Channel	2

Table 9-2. UV Disinfection Regulatory Design Criteria				
TDEC Design Criteria	TDEC Design Criteria Reference	MWS COPT Design Criteria	MWS COPT TM Reference	Variance
Reactor hydraulics	10.3.2	Static effluent weirs will be installed to maintain acceptable levels within the UV channels such that all flow is treated. Additionally, CFD modeling will be performed during detailed design to determine whether inlet baffling or other means of flow straightening is required to achieve uniform flow in the upstream portion of each UV channel.	TM #10	-
Properties of wastewater being disinfected and factors affecting transmission of UV light to the microorganisms	10.3.2	Algae protection will be further evaluated during detailed design.	TM #10	-
UV disinfection is considered as Developmental Technology and all design criteria shall be submitted upon request to justify the basis of the UV disinfection system. The detailed design requirements will be determined on a case-by-case basis.	10.3.2	Design will utilize design criteria from 10-state standards including: • Units can be removed from the flow • At least two banks in series provided for reliability and uninterrupted service during maintenance • The hydraulic properties of the system shall be designed to simulate plug flow conditions without short circuiting under the full operating flow range • Water level control shall be provided to achieve the necessary exposure. • At least 65% UV radiation transmittance at 254 nanometers wave length	TM #10	-

Table 9-2. UV Disinfection Regulatory Design Criteria				
TDEC Design Criteria	TDEC Design Criteria Reference	MWS COPT Design Criteria	MWS COPT TM Reference	Variance
		• BOD_5 and suspended solids concentrations no greater than 30 mg/L at any time. • UV dosage shall be based on the design peak hourly flow. Collimated beam testing will be performed to confirm design UV dosage		

Section 10: Excess Flow Treatment

The following section provides a summary of the necessary design criteria that impact the design and implementation of improvements to the excess flow treatment unit (EFTU) at the CWWTP.

10.1 Disinfection Design Criteria for EFTU

EFTU disinfection will be achieved in existing south CCTs which have been utilized for chemical disinfection since they were constructed in the 1970's. The serpentine configuration of these existing tanks is appropriate for a chemical disinfectant such as PAA. TDEC Design Criteria for Sewage Works requires that wastewater receives a minimum contact time of 15 minutes during peak flow conditions. Based on the volume of the existing south CCTs, flows up to 160 mgd can be treated while meeting the 15-minute requirement. It should be noted that literature suggests that PAA requires substantially less contact time to meet disinfection requirements compared to chlorine-based chemicals, which adds a degree of conservatism to the design. It is anticipated that quenching of PAA residual will not be required and that disinfection limits can be reliably met while maintaining residual PAA concentrations below 1 mg/L. Table 10-1 presents disinfection-specific design criteria for the EFTU.

Table 10-1. Disinfection Design Criteria for EFTU		
Criteria	Value	Notes
Peak Flow (mgd)	150	Average condition not applicable
Contact time (minutes)	15	Minimum value, HRT is greater than 16 min at 150 MGD
PAA Dosage (mg/L)	5	TBD by jar test
PAA Residual (mg/L)	<1	TBD by jar test
Minimum Storage	TBD	Based on 5 mg/L dose
Mixing	Gravity hydraulic mixing	Will evaluate need for mechanical mixing during detail design
pH	6 – 9	PAA will not appreciably affect the pH

Table 10-1. Disinfection Design Criteria for EFTU		
Criteria	**Value**	**Notes**
Suspended Solids	TBD	Jar testing will determine the effect of suspended solids on dose
Organics	TBD	Jar testing will determine the effect of organics on dose

10.1.1 Primary Treatment Criteria for EFTU

TDEC Design Criteria for Sewage Works states that PSTs are designed primarily based on SOR and suggests a peak rate range of 2,000-3,000 gpd/ft^2. Assuming the high end of this range, the surface area available within the old south aeration tanks (45,000 ft^2 can achieve up to 135 mgd of primary settling capacity. If the old south secondary clarifiers are also used for primary treatment, flows up to 150 mgd can be accommodated. This assumes that the available volume will be effectively utilized to facilitate discrete particle settling. Weir loading rate will be a secondary design parameter. Effluent weir length will be maximized as feasible, but it will not limit the proposed capacity.

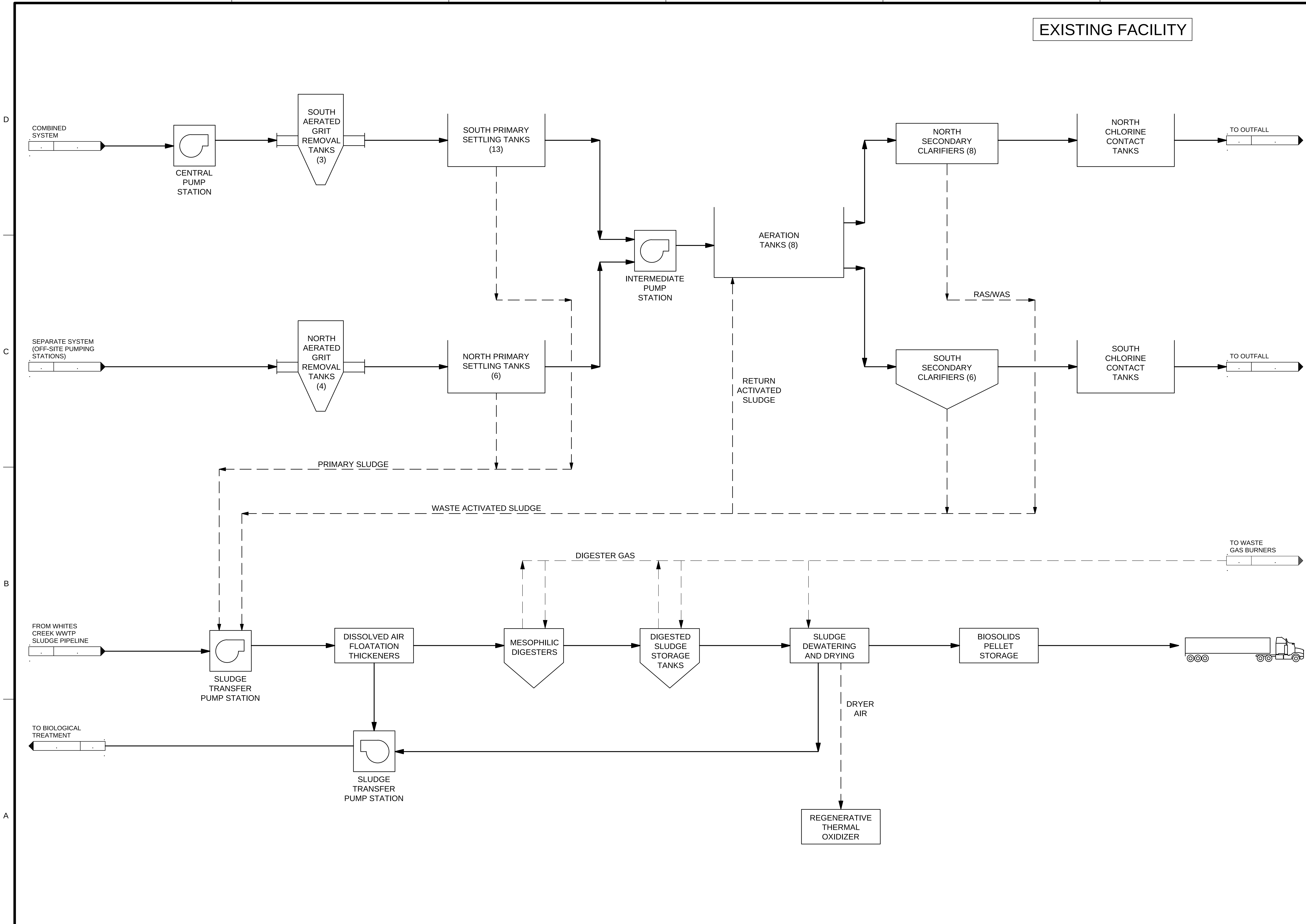
Table 10-2 presents design criteria specific to the primary treatment component of EFTU, and Table 9C summarizes specific TDEC design criteria related to this process area and briefly states how this design will address these requirements. Further detailed information is presented in corresponding TM's as referenced in Table 10-3.

Table 10-2. Excess Flow Treatment Primary Settling Tanks Design Criteria		
Parameter	**PSTs in Old South Aeration Tank Footprint**	**PSTs in Old South Secondary Clarifier Footprint**
Total Facility Capacity (mgd)	Up to 135	TBD
Capacity per Tank (mgd)	TBD	TBD
Tank Length (ft)	TBD	TBD
Tank Width (ft)	TBD	TBD
Tank Depth (ft)	15	12
Number of Tanks	TBD	TBD
Weir Length per Tank (ft)	TBD	TBD
Surface Overflow Rate @ Ave Flow (gpd/ft^2)	NA	NA
Surface Overflow Rate @ Peak flow (gpd/ft^2)	Up to 3,000	Up to 3,000

Table 10-3. Excess Flow Treatment Regulatory Design Criteria				
TDEC Design Criteria	TDEC Design Criteria Reference	MWS COPT Design Criteria	MWS COPT TM Reference	Variance
Sufficient number of units for disinfectant contact basins such that, with the largest flow capacity unit out of service, the remaining units should have a design flow capacity of at least 50 percent of the total design flow to that unit operation.	1.3.11.3	The two existing tertiary filter CCTs provide sufficient contact time with both tanks in service. Additionally, the existing EFTU CCT will serve as a redundant CCT.	-	-
Surface overflow rate of 800-1,200 gpd/sp. ft. for average design flow	5.2.1	EFTU PSTs will only operate during major wet weather events.	TM #11	-
Surface overflow rate of 2,000-3,000 gpd/sp. ft. peak design flow	5.2.1	The recommended configuration of the EFTU PSTs has not been finalized, but utilizing the area available within the old south aeration tank footprint, 135 mgd can be treated based on a peak surface overflow rate of 3,000 gpd/ft^2	TM #11	-
A properly designed primary clarifier should remove 30 to 35% of the influent BOD	5.2.1	The EFTU PSTs will receive dilute wastewater from the combined sewer system. Due to a high amount of inert solids and a low BOD concentration, 30-35% removal of influent BOD is unlikely.	-	-
Weir troughs shall be designed to prevent submergence at maximum design flow and to maintain velocity of at least 1 ft/sec at one-half design flow	5.3.3	This design criterion will be incorporated during detailed design once the EFTU PST configuration is finalized.	-	-
12-inches of freeboard	5.3.4	This design criterion will be incorporated during detailed design once the EFTU PST configuration is finalized.	-	-
Weir loadings should not exceed 15,000 gallons per day per linear feet (gpd/li ft)	5.2.4	This design criterion will be incorporated during detailed design once the EFTU PST configuration is finalized. Similar to the existing PSTs, it is likely that this criterion will not be met. Weir loading rates will be minimized as practical.	-	Metcalf & Eddy's *Wastewater Treatment Engineering* lists design range of 10,000 – 40,000 gpd/LF.

Table 10-3. Excess Flow Treatment Regulatory Design Criteria				
TDEC Design Criteria	TDEC Design Criteria Reference	MWS COPT Design Criteria	MWS COPT TM Reference	Variance
The hydraulic detention time in primary clarifiers is not recommended to be greater than 2.5 hours as a function of the surface overflow rate and SWD	5.2.5	This design criterion will be incorporated during detailed design once the EFTU PST configuration is finalized. It is anticipated that this design criterion will be met.	-	-
Minimum side water depth = 8-feet	Table 5-2, 5.2.5	Old south aeration tanks = 15 Old south secondary clarifiers = 12	-	-
Inlets should be designed to dissipate the influent velocity, to distribute the flow equally in both the horizontal and vertical vectors, and to prevent short-circuiting.	5.3.1	This design criterion will be incorporated during detailed design once the EFTU PST configuration is finalized.	-	-

Process Flow Diagrams



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GENERAL

CWWTP AND BIOSOLIDS FACILITY PROCESS FLOW DIAGRAM

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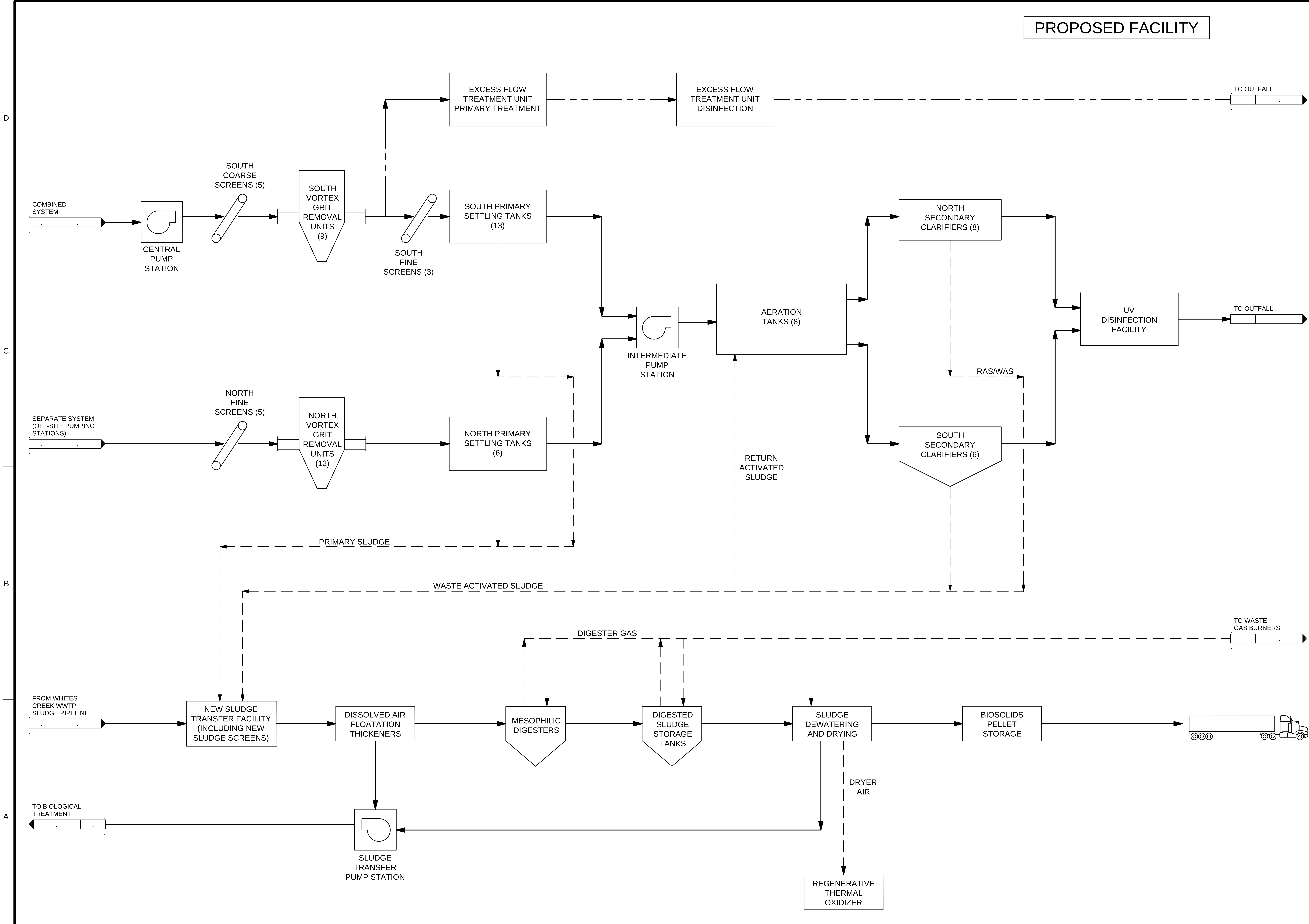

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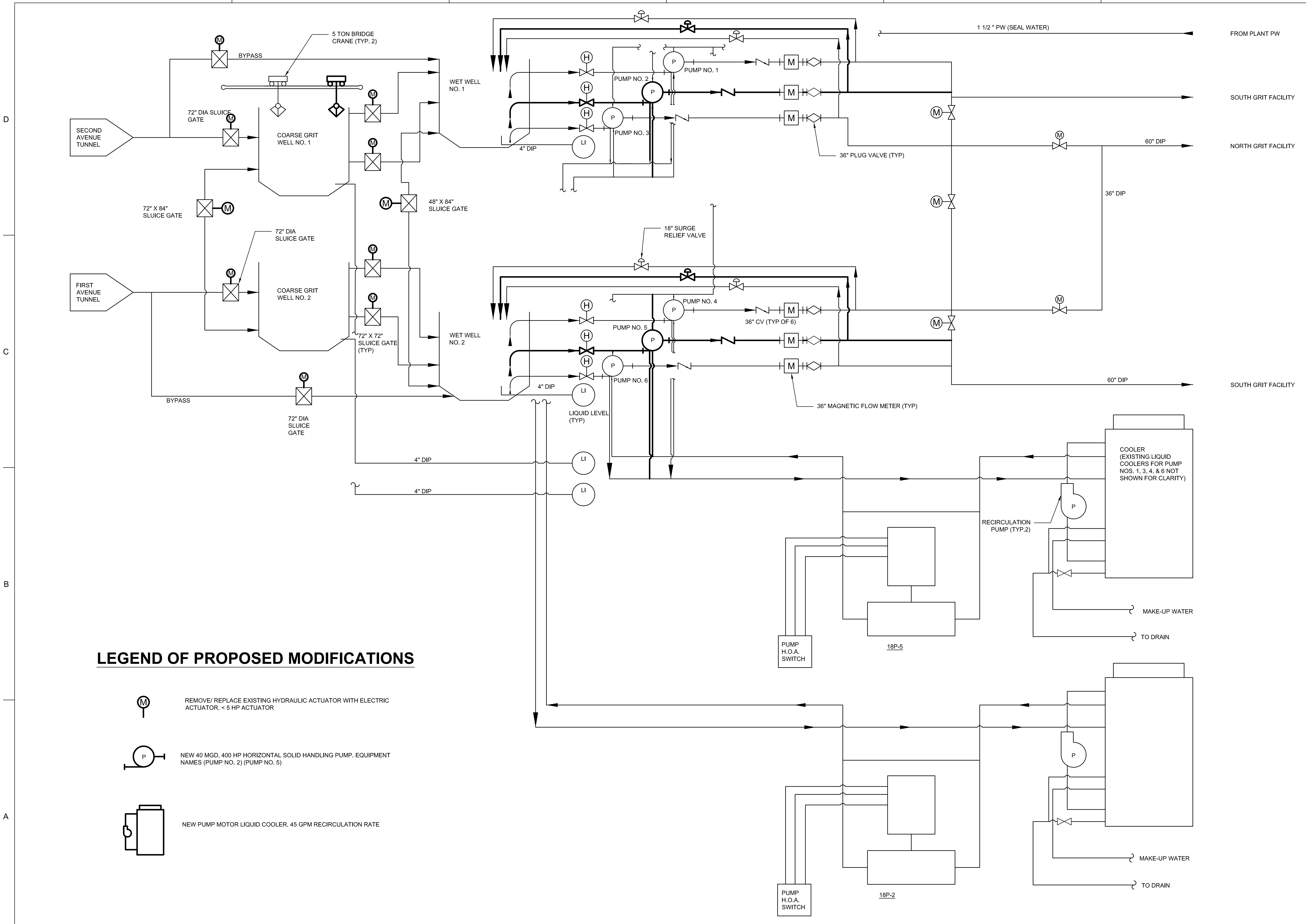

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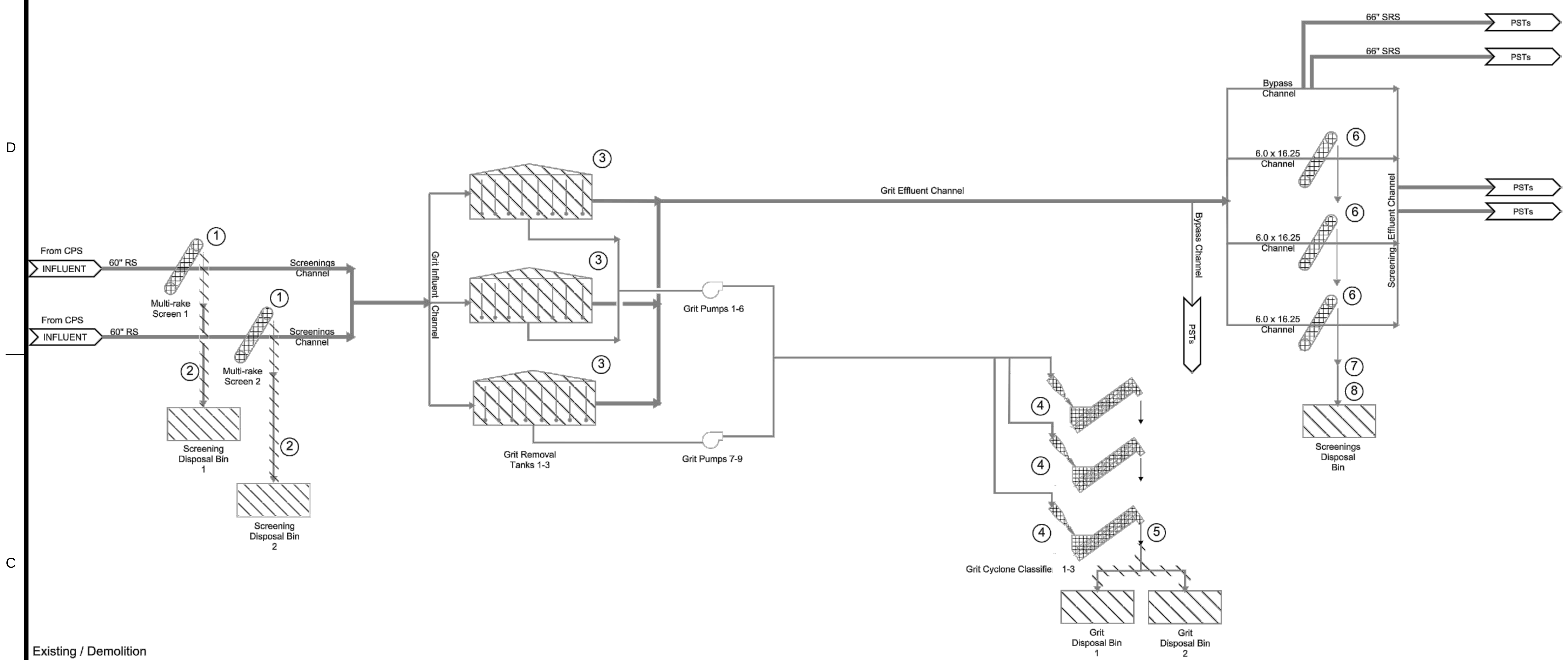
Existing / Demolition

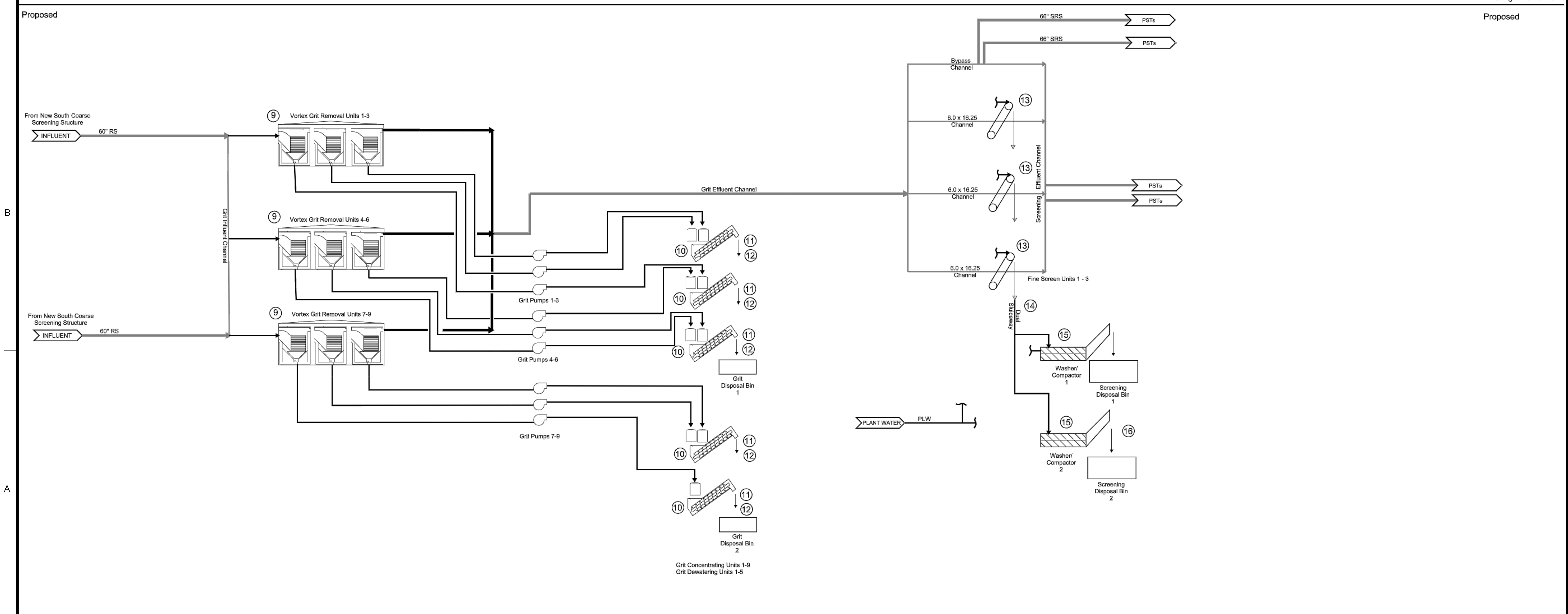


KEY NOTES:

1. TAKE EXISTING COARSE BAR SCREENS OUT OF SERVICE.
2. TAKE EXISTING BELT CONVEYOR OUT OF SERVICE.
3. DEMOLISH EXISTING GRIT TANK FLOOR AND ASSOCIATED AERATION DIFFUSERS.
4. DEMOLISH EXISTING GRIT CLASSIFIERS AND ASSOCIATED PIPING.
5. DEMOLISH EXISTING BELT CONVEYOR AND GRIT DISCHARGE CHUTES.
6. DEMOLISH EXISTING COARSE CLIMBER BAR SCREENS.
7. DEMOLISH EXISTING SCREENINGS DISCHARGE CHUTE.
8. DEMOLISH EXISTING SCREENING CONVEYANCE SYSTEM.
9. INSTALL NINE (9) VORTEX GRIT REMOVAL UNITS AND ASSOCIATED PIPING.
10. INSTALL NINE (9) GRIT CONCENTRATING AND FIVE (5) GRIT DEWATERING UNITS WITH ASSOCIATED PIPING.
11. INSTALL THREE (3) SCREENINGS DISCHARGE CHUTES.
12. INSTALL BELT CONVEYANCE SYSTEM.
13. INSTALL THREE (3) FINE SCREENS AND ASSOCIATED APPURTENANCES.
14. INSTALL DUAL SLUICEWAY CONVEYANCE SYSTEM.
15. INSTALL TWO (2) WASHER/COMPACTOR UNITS AND ASSOCIATED PIPING.
16. INSTALL TWO (2) WASHER/COMPACTOR UNITS AND ASSOCIATED PIPING.

Existing / Demolition

Proposed



Proposed

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SOUTH HEADWORKS PROCESS FLOW DIAGRAM

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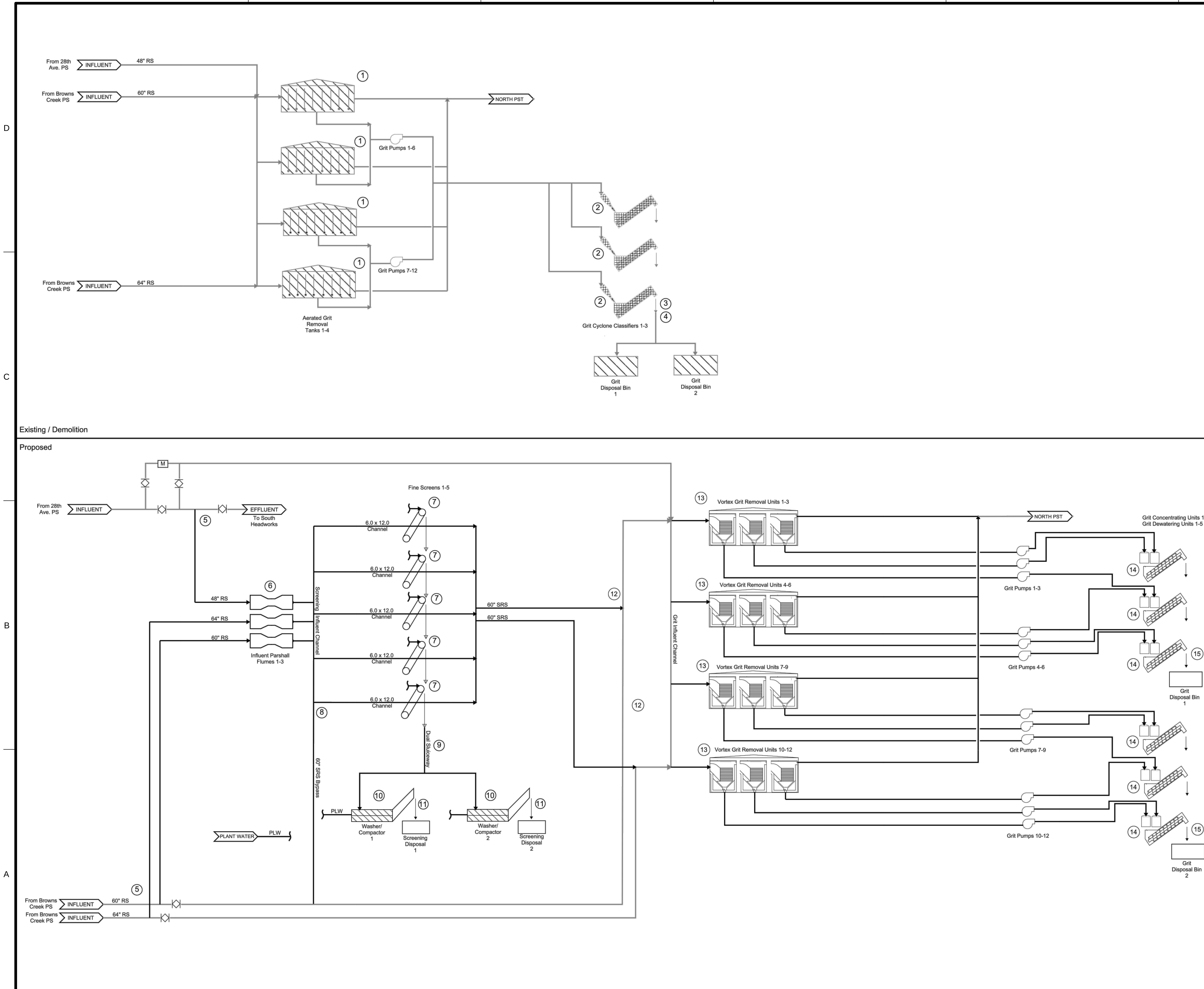

KEY NOTES:

1. DEMOLISH EXISTING GRIT TANK FLOOR AND ASSOCIATED AERATION DIFFUSERS.
2. DEMOLISH EXISTING GRIT CLASSIFIERS AND ASSOCIATED PIPING.
3. DEMOLISH EXISTING GRIT CONVEYANCE SYSTEM.
4. DEMOLISH EXISTING GRIT DISCHARGE CHUTES.
5. CONNECT TO EXISTING FORCE MAINS AND DIRECT FLOW TO INFLUENT PARSHALL FLUMES.
6. INSTALL THREE (3) INFLUENT PARSHALL FLUMES.
7. INSTALL FIVE (5) FINE SCREENS.
8. INSTALL 60" BYPASS PIPING AND CONNECT TO EXISTING FORCE MAINS.
9. INSTALL DUAL SLUICEWAY CONVEYANCE SYSTEM.
10. INSTALL TWO (2) WASHER/COMPACTOR UNITS AND ASSOCIATED PIPING.
11. INSTALL TWO (2) SCREENINGS DISCHARGE CHUTES.
12. CONNECT TO EXISTING FORCE MAINS.
13. INSTALL TWELVE (12) VORTEX GRIT REMOVAL UNITS AND ASSOCIATED PIPING.
14. INSTALL TWELVE (12) GRIT CONCENTRATING AND SIX (6) DEWATERING UNITS AND ASSOCIATED PIPING.
15. INSTALL TWO (2) BELT CONVEYORS AND FOUR (4) GRIT DISCHARGE CHUTES.

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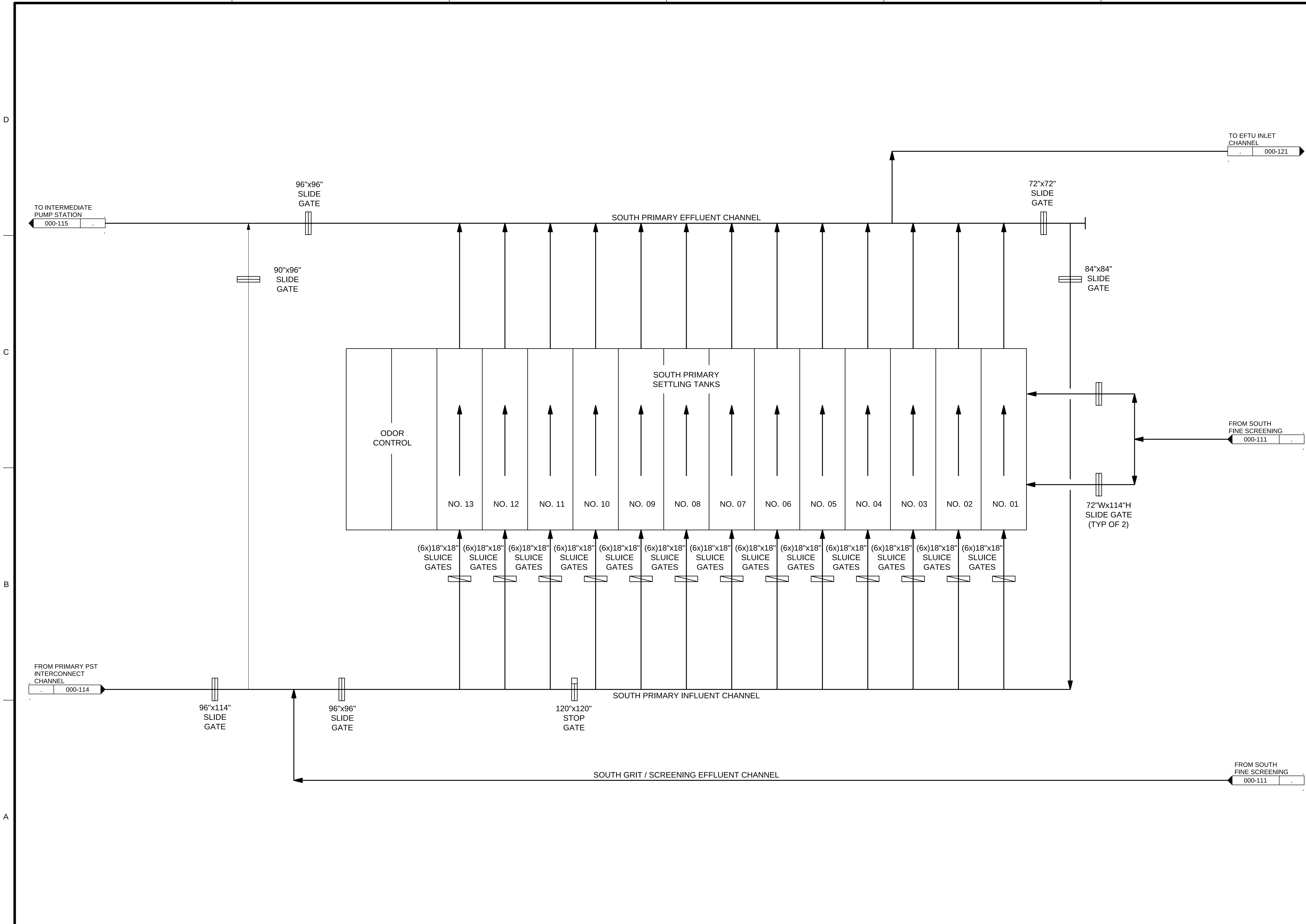

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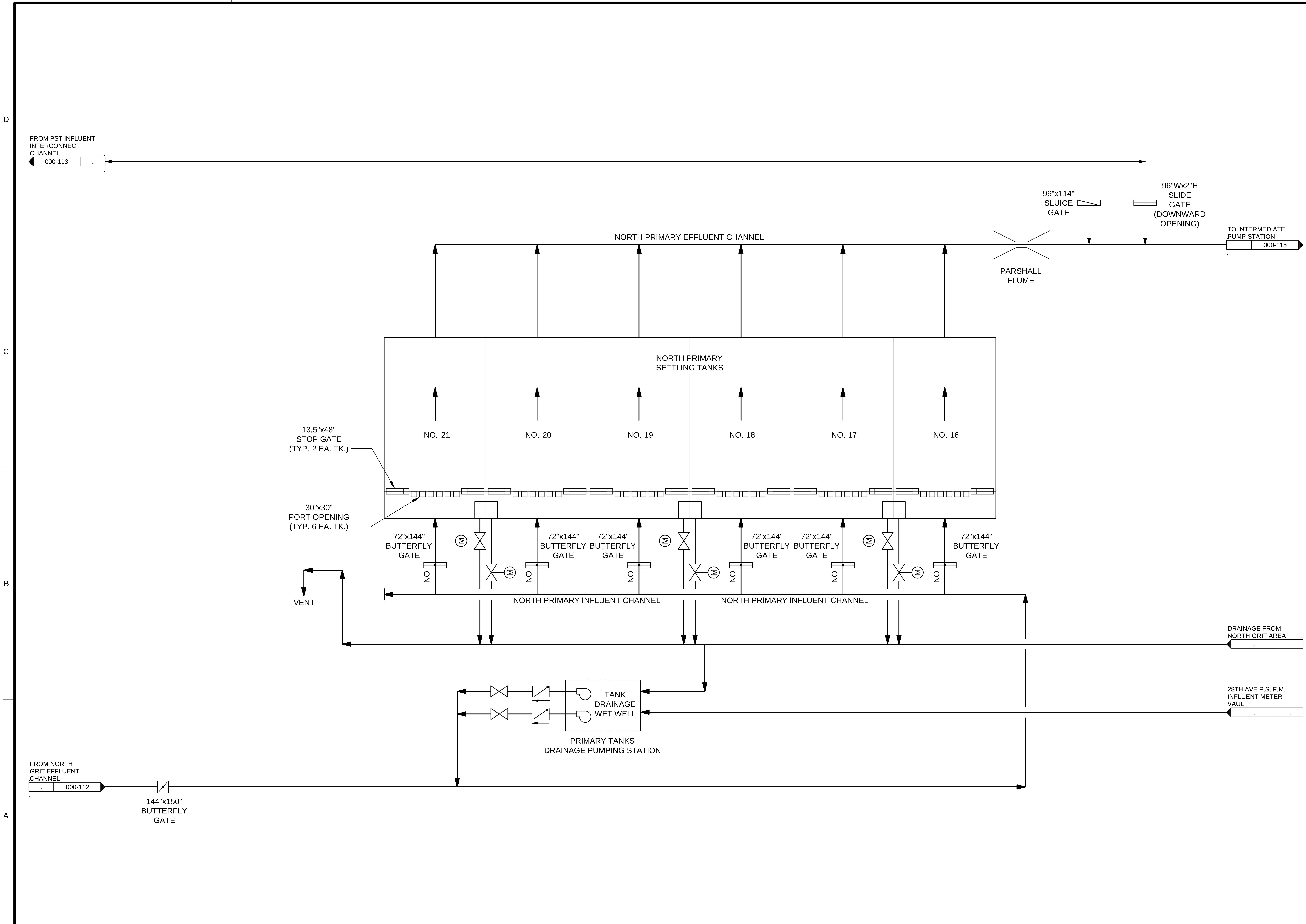

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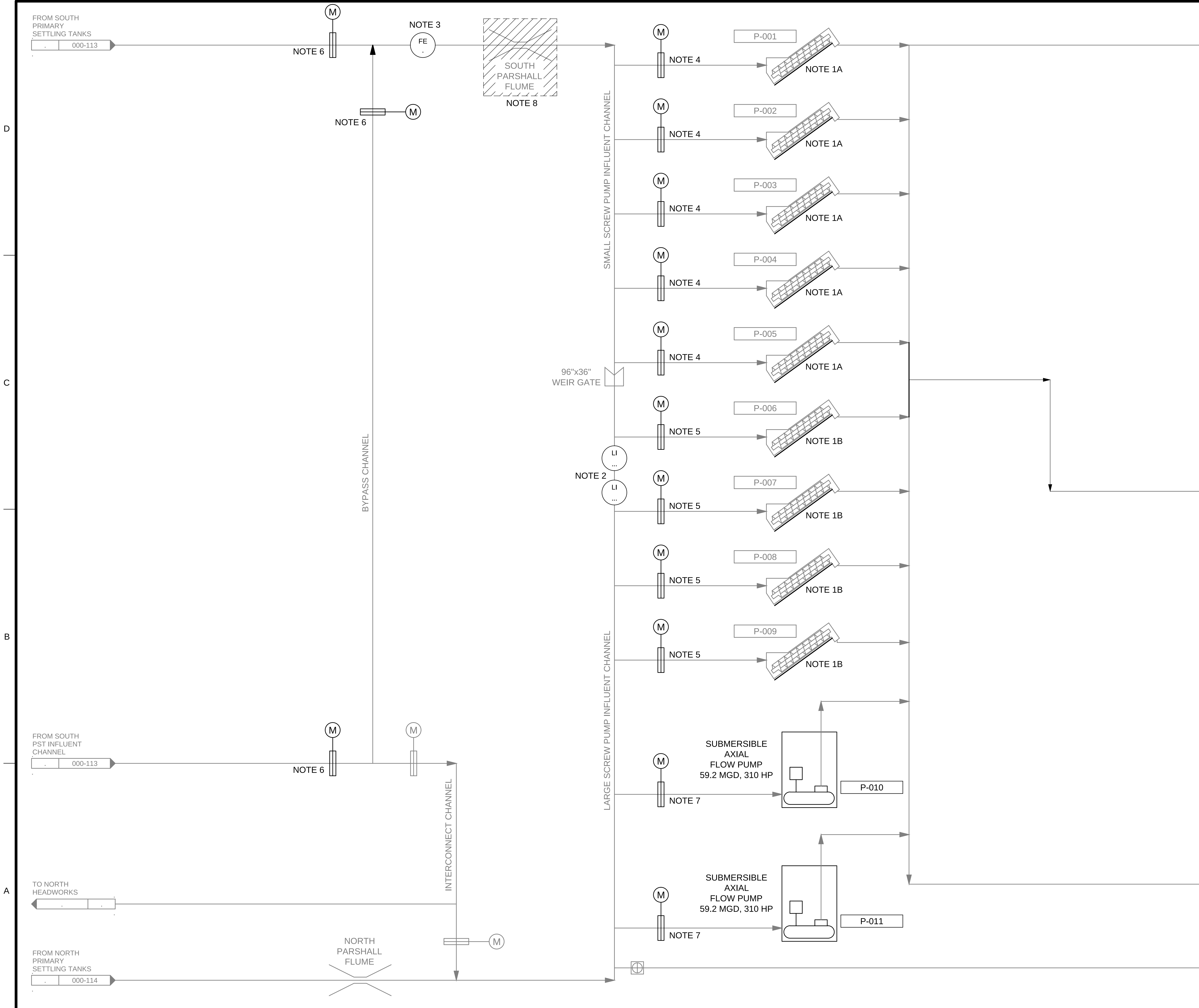

NOTES:

1. REHABILITATE AND UPDATE BEARINGS AND GREASE PUMPS ON EXISTING SCREW PUMPS (1A - 84" & 1B - 114").
2. INSTALL NEW LEVEL INDICATORS IN THE COMBINED INFLUENT CHANNEL.
3. FLO-DAR FLOW METER REPLACES FLUME.
4. REPLACE EXISTING 84"x72" (5 PLACES) BUTTERFLY GATES AND ACTUATORS WITH MOTOR ACTUATED SLIDE GATES.
5. REPLACE EXISTING 114"x108" (4 PLACES) BUTTERFLY GATES AND ACTUATORS WITH MOTOR ACTUATED SLIDE GATES.
6. REPLACE EXISTING 96"x96" (3 PLACES) BUTTERFLY GATES AND ACTUATORS WITH MOTOR ACTUATED SLIDE GATES.
7. NEW MOTOR ACTUATED SLIDE GATES (2 PLACES).
8. SOUTH PARSHALL FLUME TO BE DEMOLISHED.

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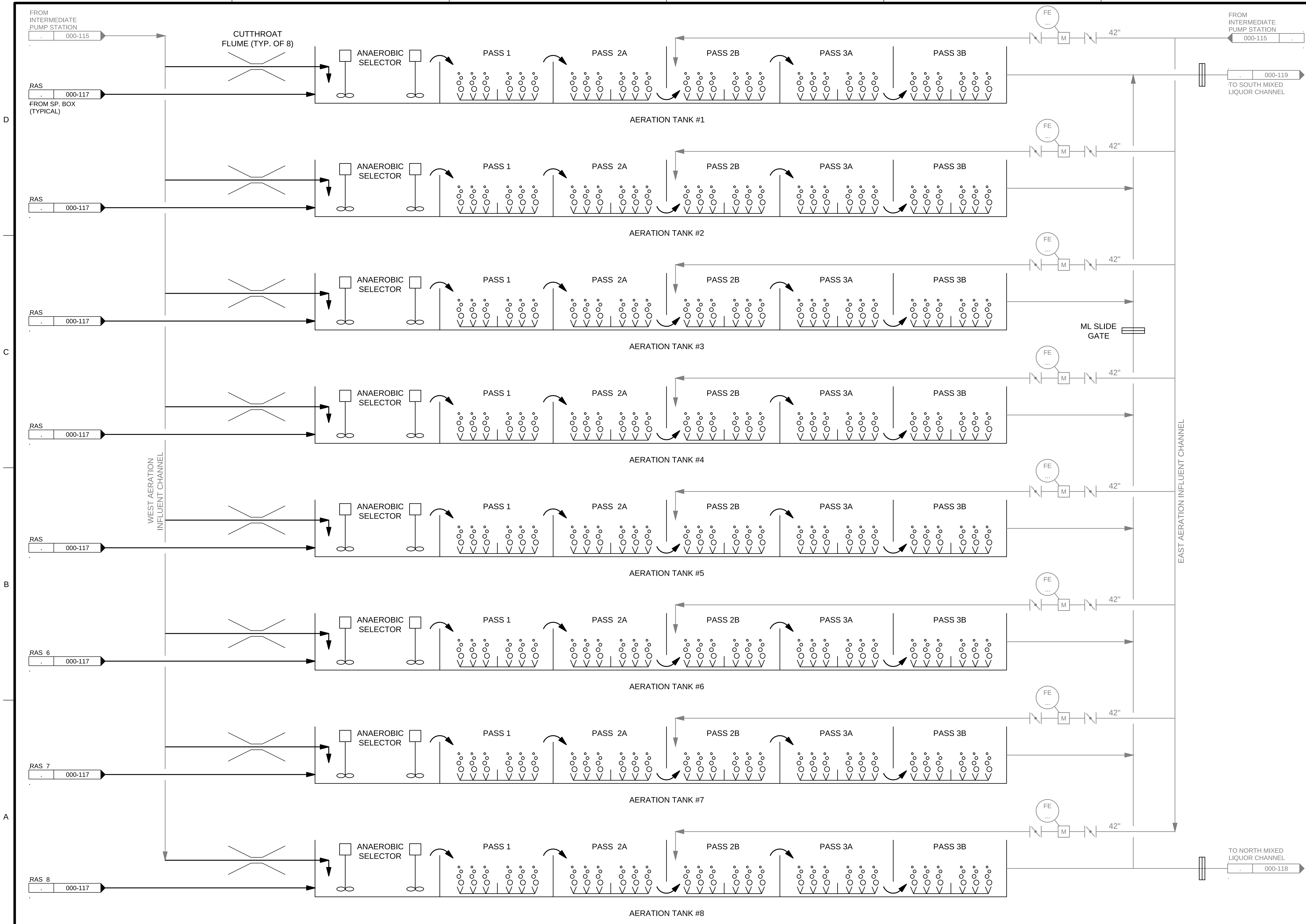

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AERATION SYSTEM PROCESS FLOW DIAGRAM

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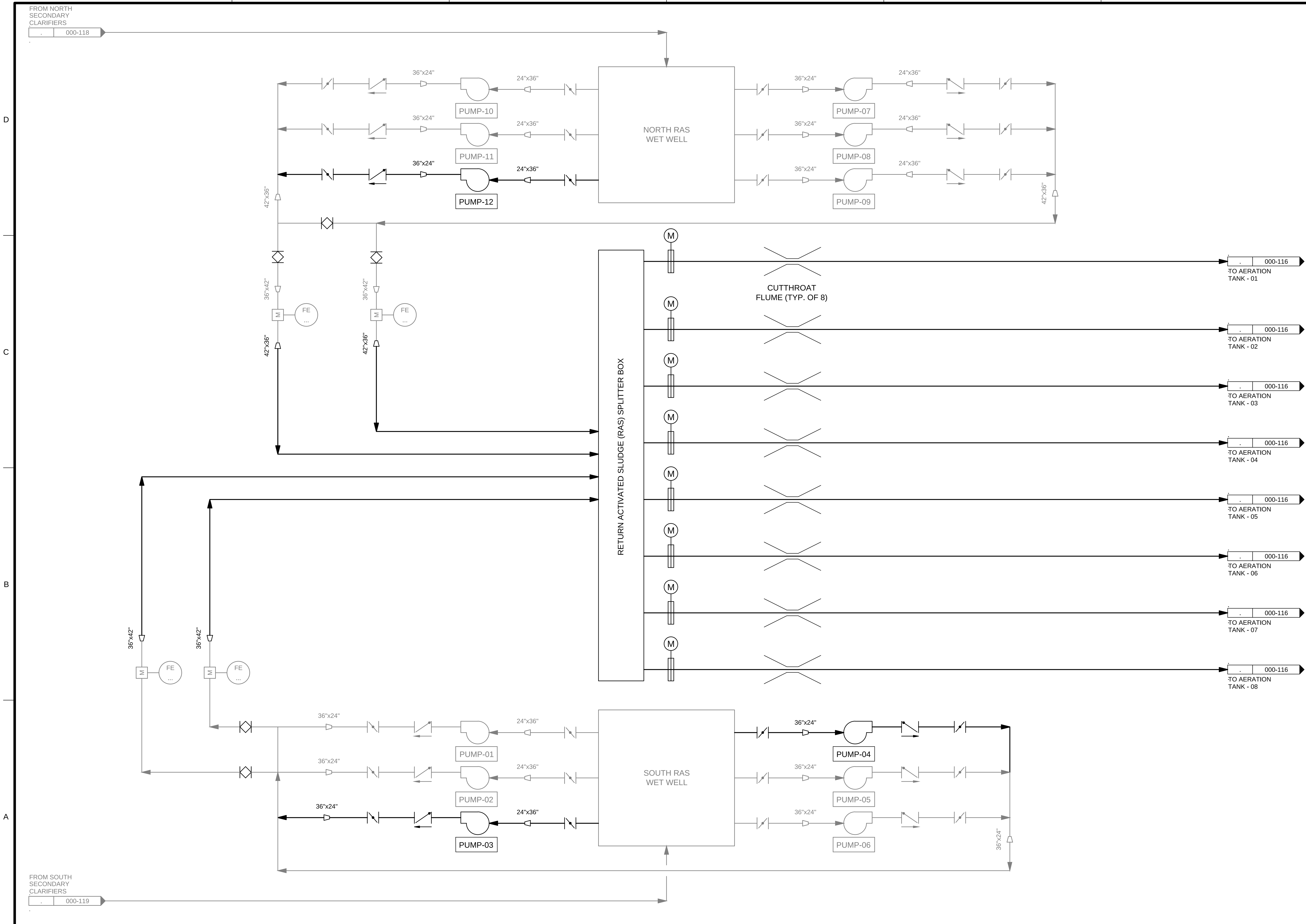

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CENTRAL WWTP CAPACITY IMPROVEMENTS AND CSO REDUCTION

REVISIONS

REV	DATE	DESCRIPTION

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FILENAME
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BC PROJECT NUMBER
148388.00
CLIENT PROJECT NUMBER

GENERAL

RETURN ACTIVATED SLUDGE SYSTEM PROCESS FLOW DIAGRAM

DRAWING NUMBER
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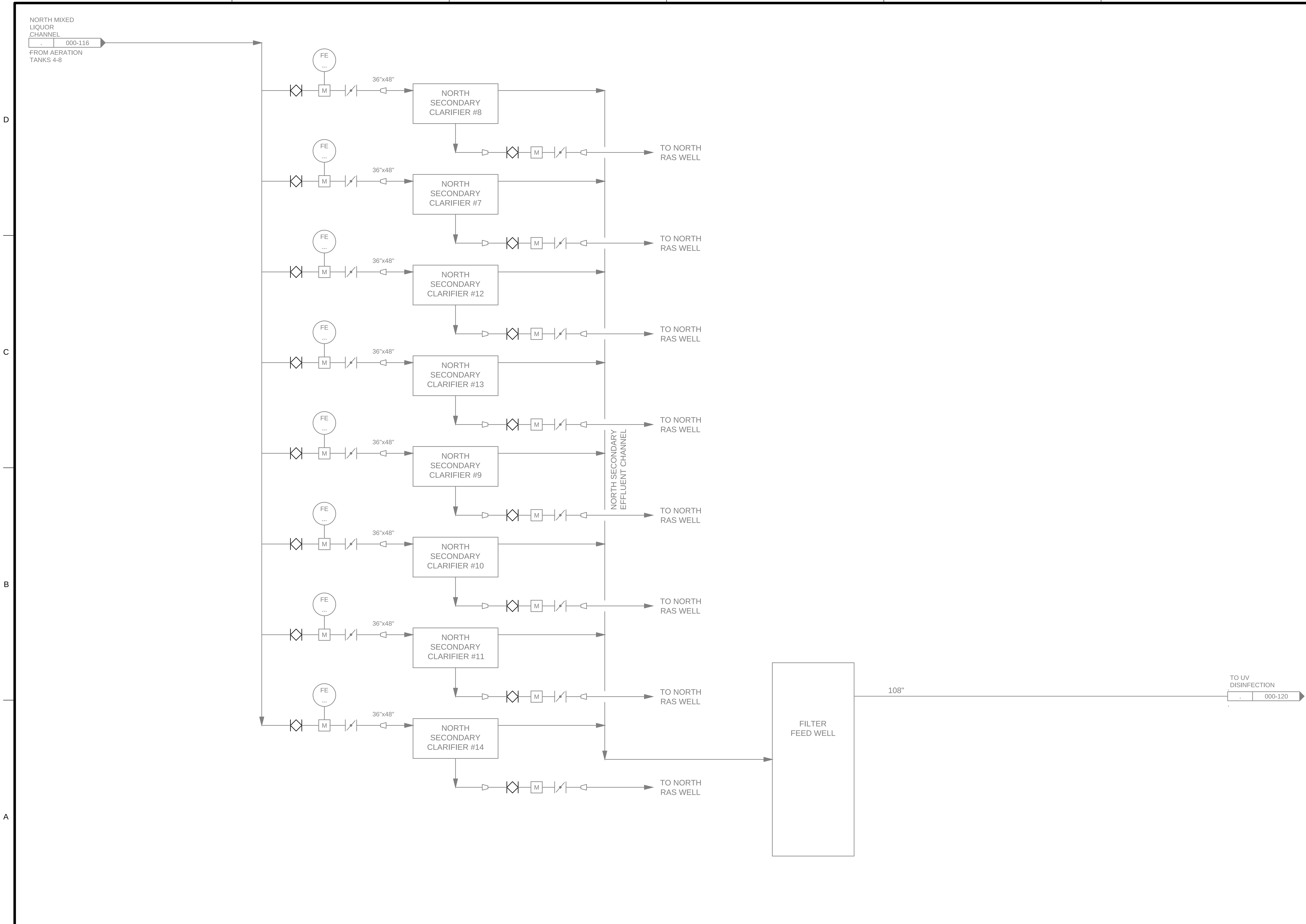

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CENTRAL WWTP CAPACITY IMPROVEMENTS AND CSO REDUCTION

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NORTH SECONDARY CLARIFIERS - PFD

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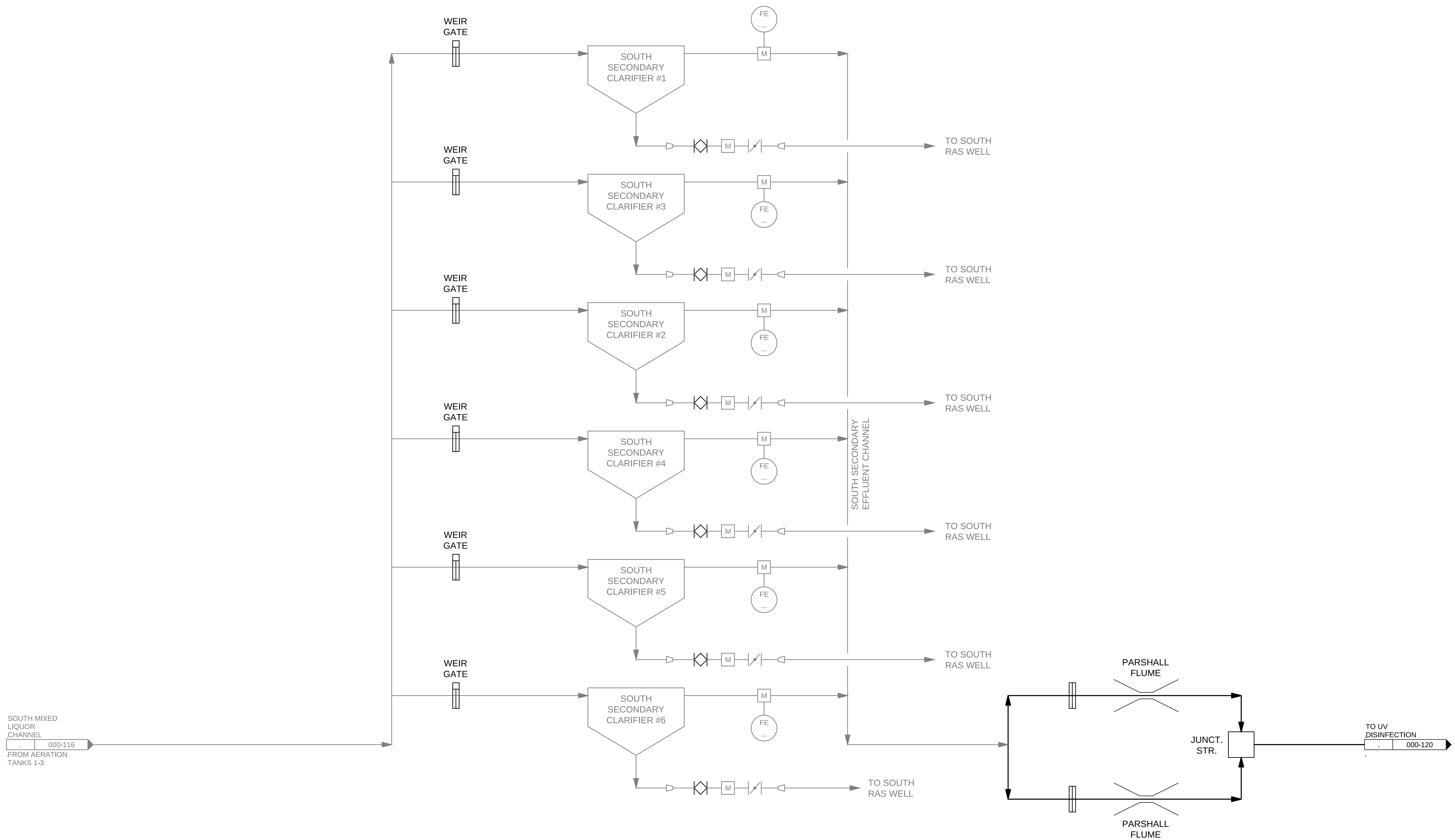

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NOT FOR CONSTRUCTION

METRO WATER SERVICES

CENTRAL WWTP CAPACITY IMPROVEMENTS AND CSO REDUCTION

REVISIONS

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FILENAME
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BC PROJECT NUMBER
148388.00
CLIENT PROJECT NUMBER

GENERAL

SOUTH SECONDARY CLARIFIERS - PFD

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SHEET NUMBER
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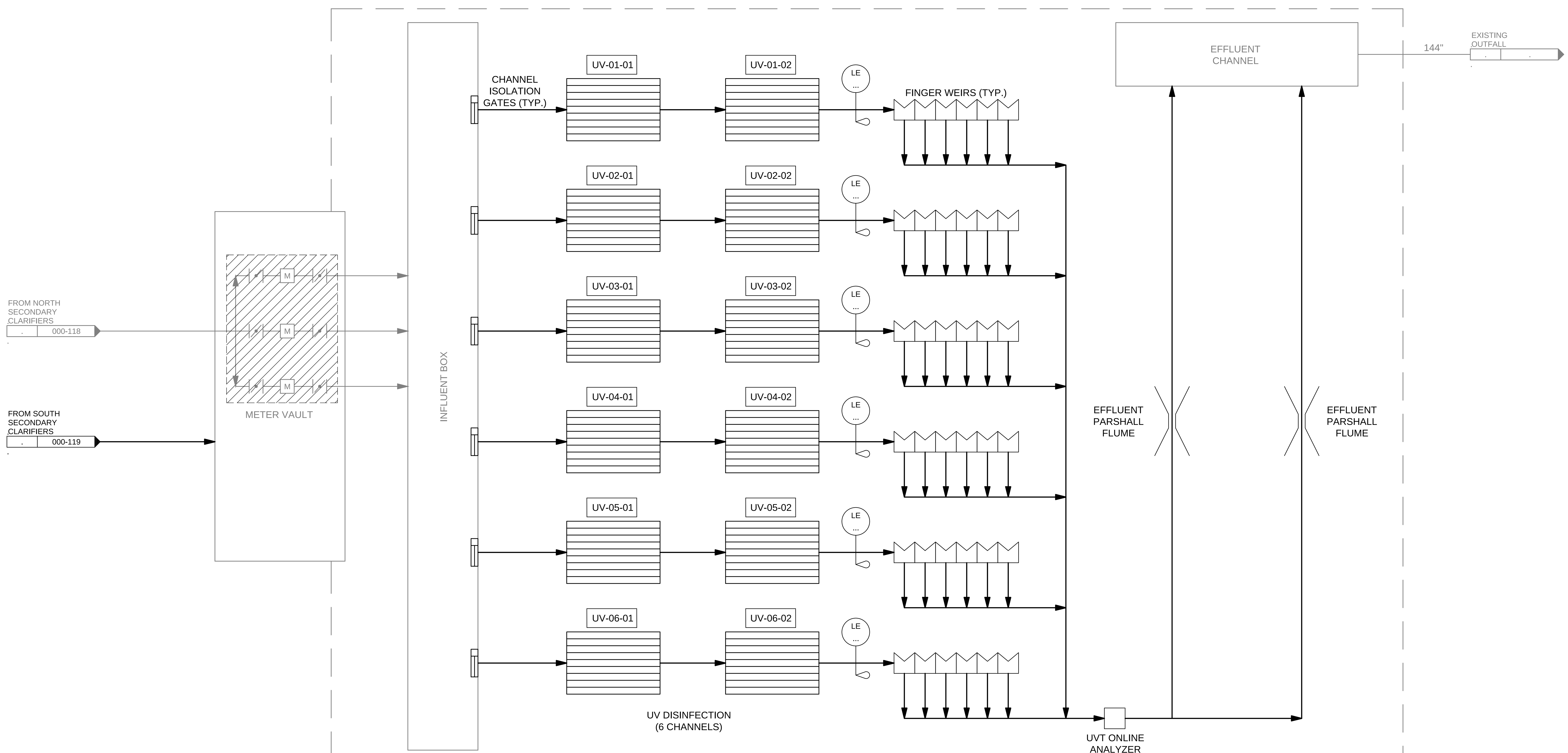

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Brown AND Caldwell

Nashville, TN.

PRELIMINARY
NOT FOR CONSTRUCTION

METRO WATER SERVICES

CENTRAL WWTP CAPACITY IMPROVEMENTS AND CSO REDUCTION

REVISIONS

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BC PROJECT NUMBER
148388.00
CLIENT PROJECT NUMBER

GENERAL

UV DISINFECTION PROCESS FLOW DIAGRAM

DRAWING NUMBER
000-120

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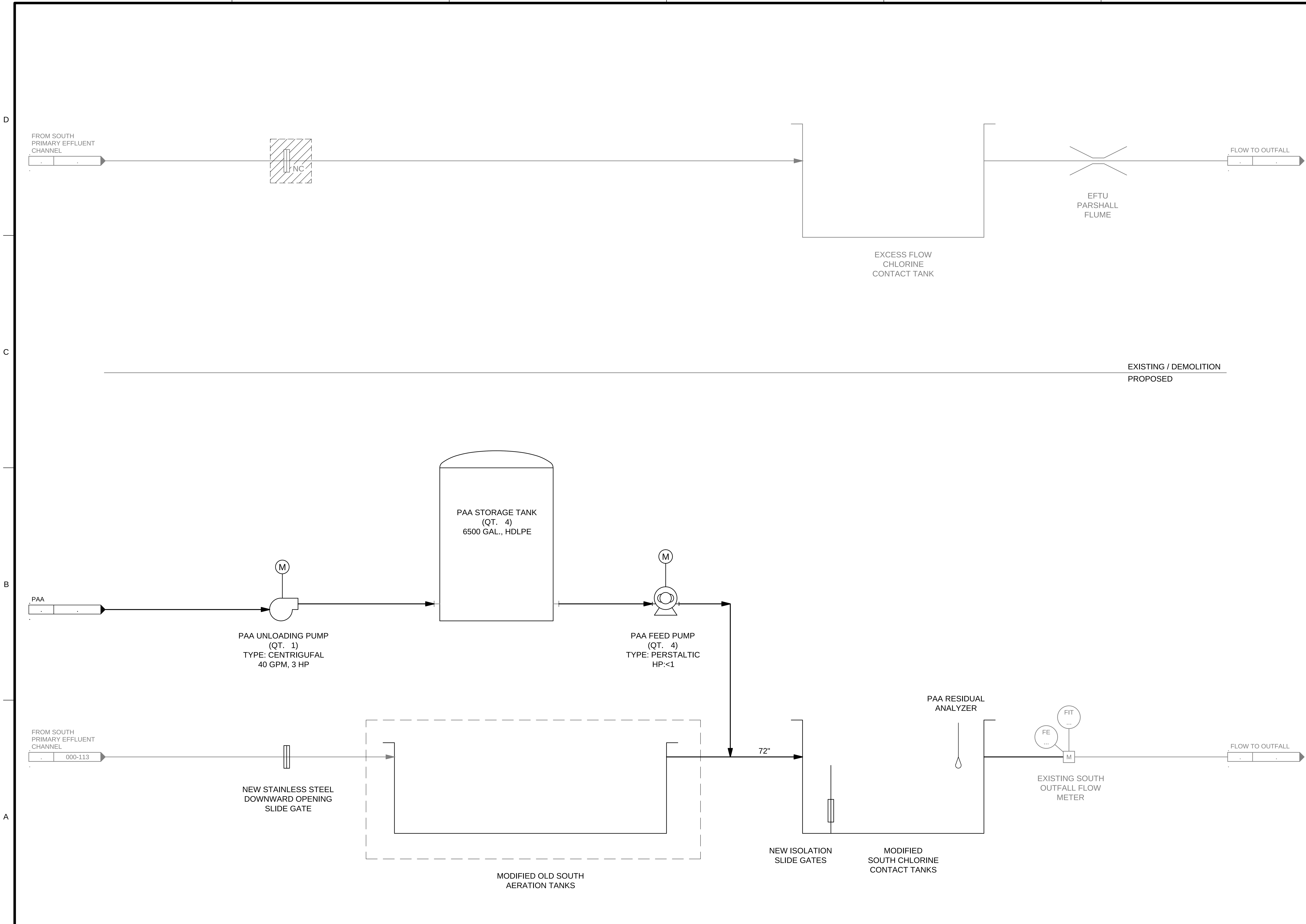

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Brown AND Caldwell

Nashville, TN.

PRELIMINARY
NOT FOR CONSTRUCTION

METRO WATER SERVICES

CENTRAL WWTP CAPACITY IMPROVEMENTS AND CSO REDUCTION

REVISIONS

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BC PROJECT NUMBER
148388.00
CLIENT PROJECT NUMBER

GENERAL

EXCESS FLOW TREATMENT UNIT (EFTU) - PFD

DRAWING NUMBER
000-121

SHEET NUMBER
OF

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Technical Memoranda

Technical Memorandum

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Prepared for: Metro Water Services

Project Title: Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Project No.: 148388

Technical Memorandum No. 1

Subject: Central Pump Station

Date: December 21, 2016

To: Trey Cavin, Metro Water Services

From: Tazio Qubeck, Project Manager

Copy to: Ron Taylor, Metro Water Services

Prepared by: ______________________
Patrick Stephens, P.E.,(TN, TX)

Reviewed by: ______________________
William P Hamilton, P.E., (AL, TN)

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Executive Summary

The objective of this Technical Memorandum (TM) is to present the basis of design for the proposed improvements to the Central Pump Station (CPS) at the Central Wastewater Treatment Plant (CWWTP) for the CWWTP Improvements & CSO Reduction Project (COPT Project). The CPS is an influent pumping station that receives flows from Nashville's combined sewer system (CSS) via the First Avenue Tunnel (FAT) and the Second Avenue Tunnel (SAT). Influent flows are then pumped to the CWWTP south headworks facilities. The proposed improvements for the CPS are listed below:

A. Proposed Improvement – Installation of New Traveling Bridge Crane and Clamshell

   The CPS contains two coarse wells to capture and prevent large debris from entering the pump wet wells. Currently, Metro Water Services (MWS) staff operates a clamshell suspended from a traveling bridge crane to remove debris from the coarse wells.

   The bridge crane and clamshell are subject to mechanical issues. MWS has a maintenance contract with an external contractor who provides service for the existing bridge crane and clamshell. Historically, if the bridge crane or clamshell encounters a problem and is in need of service, the maintenance contractor requires long lead times to complete the repairs, thus preventing debris removal operations while repairs are pending.

   Replacing the existing bridge crane and clamshell with new, more reliable equipment was found to be the preferred alternative for maintaining continuous reliable debris removal from the coarse wells. A manufacturer's warranty with local service capable of completing any necessary repairs in a timely manner is a critical component of this alternative.

B. Proposed Improvement – Gate Actuator Replacement and Relocation

   The CPS contains ten sluice gates with electro-hydraulic actuators that isolate the coarse wells and wet wells. The actuators are located below the upper level of the coarse wells and wetwells in covered vaults that are currently not ventilated.

   The lack of ventilation and confined nature of the actuator location limits access for inspection and maintenance. Additionally, the actuators are over 20 years old and nearing their life expectancy.

   The existing electro-hydraulic actuators will be replaced with standard electric actuators. The new actuators will be relocated from the odor control chambers to finished floor level, providing better maintenance access and eliminating confined space concerns.

   According to MWS staff, all CPS sluice gates are functional, however some of the gates do not seat completely because of debris in the frame and seating surfaces. MWS is planning on performing the replacement and relocation of the sluice gate actuators in-house. As part of this work, MWS will also be cleaning and inspecting the coarse wells and wet wells. Additional work that will be performed concurrently with the actuator replacement is discussed throughout this TM.

C. Proposed Improvement – Installation of Two New Influent Pumps and Associated Equipment

   The CPS currently consists of four 40 million gallons per day (MGD), variable speed pumps (Nos. 1, 3, 4, and 6) for a total capacity of 160 MGD. Each pump has a dedicated seal water system and a dedicated motor cooling loop. Provisions were made in the original CPS design to accommodate two future pumps of equal capacity to the four existing pumps.

   Based on recommendations from the Long Term Control Plan (LTCP), two additional pumps will be added to increase the capacity of the station to 240 MGD. MWS is planning to install the suction bell fittings, dry well suction isolation valves, and any other piping associated with the two new influent pumps that require wet well shut downs for installation in coordination with the wet well cleaning and gate actuator work.

Two new pumps to be designated Nos. 2 and 5 with a minimum capacity of 40 MGD. Each proposed pump will be of the same type and capacity of Pump Nos 1, 3, 4, and 6. Pumps Nos. 2 and 5 will each be provided with a variable frequency drive (VFD), motor cooling water loop, and seal water stations.

D. Proposed Improvement – Cleaning and Inspection of Existing Coarse Wells and Wet Wells

The CPS contains two coarse wells and two wet wells that are approximately 92-feet (ft) deep. The coarse wells are uncovered and the majority of the debris removal can be accomplished with the existing clamshell. The wet wells are covered and rarely taken out of service for repair or inspection.

During a site inspection, one of the wet well covers was removed and a large amount of debris was observed in the wet well.

Each coarse well and wet well will be dewatered and cleaned of all debris by MWS. Inspection of the existing concrete, equipment, piping, and baffles should be performed once MWS has cleaned and dewatered the coarse wells and wet wells during the actuator replacement work.

E. Proposed Improvement – Pump Automatic Control System Reliability

Currently, only the lead pump is operated in automatic mode. Lag pumps are brought online via remote manual mode at the discretion of the operations staff based on available CWWTP capacity and levels associated with the 2nd Avenue diversion structure, Kerrigan regulator, Cumberland River, and CPS wet wells.

An automatic, level-based control strategy will be implemented that varies the output of the CPS proportionally based on the level in the CPS wet well, but also utilizes levels at the 2nd Avenue diversion structure, Kerrigan regulator, and Cumberland River within the automated control strategy. CWWTP improvements downstream of the CPS will facilitate conveyance, treatment, and overall management of quickly rising CPS flows. The design team will work closely with MWS staff to develop automatic control parameters that meet the needs of the operations staff.

Section 1: Process Area Description

The CPS is the plant influent pump station for flows from Nashville's CSS. The pump station (Figure 1) is composed of two parallel trains. Each train consists of three areas: a coarse well to capture large debris, a wet well for pump intake, and a dry well which houses the pumps. Sluice gates are installed for isolation of each train or individual wells such that one coarse well can be out of service while both wet wells are still in service and full pumping capacity is maintained. The station originally contained an odor control system, but this system is in need of repair and is currently disabled.

Accumulated debris in the coarse wells is removed with a one cubic yard clamshell attached to an overhead bridge crane. Under normal operation, flow passes from the coarse wells to the wet wells through gated openings that are 72-inches wide by 72-inches tall. If necessary, sluice gates are used to bypass the coarse wells and divert flow directly to the wet wells. Flow is then pumped from the wet wells to the plant headworks for preliminary treatment. Figure 1 shows a schematic view of the CPS process.

There are four existing 40 MGD pumps used to convey raw wastewater into the CWWTP. Flow from the CPS was designed to normally pump to the south headworks, but it can also be routed to the north headworks via a connection to one of the Browns Creek PS forcemains located adjacent to the CPS. The pump suction pipes extend from the dry wells into the wet wells and on each pump suction pipe there is a flared 90-degree elbow. Each wet well contains baffles to reduce turbulence at the pump intakes. Each pump is connected to a VFD. Due to the depth of the pumps and concerns about adequate ventilation for cooling, each pump motor has a dedicated external motor cooling system. Lastly, each pump also contains a seal water supply station.

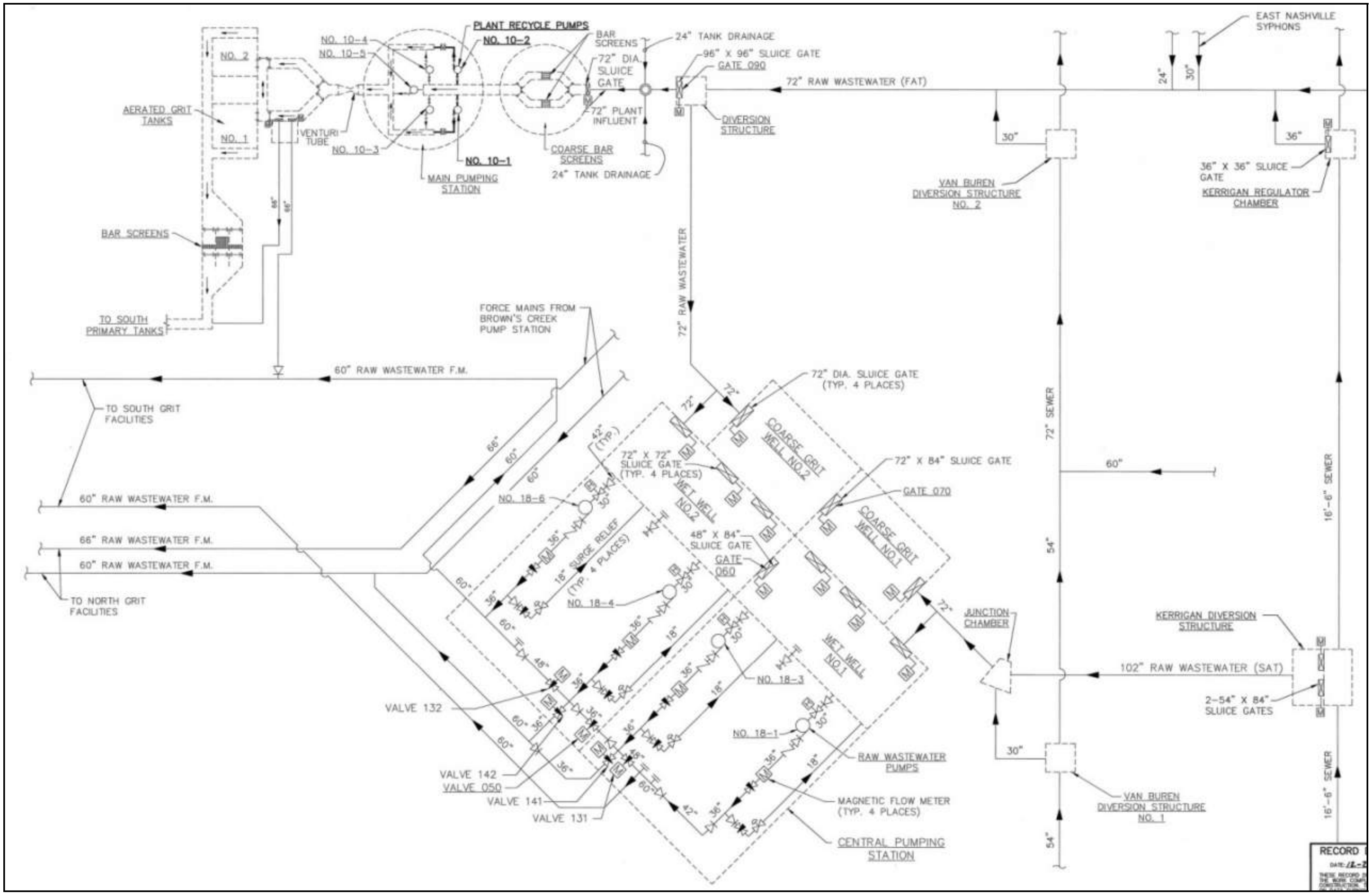

Figure 1 – Overall Flow Schematic for CPS Process

Section 2: Design Intent

CPS improvements are focused on increasing pumping capacity to accommodate future wet weather flows and improving operational reliability.

The following list represents the overall design intent for improvements to the CPS:

- A new bridge crane and clamshell will be installed to replace the existing equipment. The new equipment will include a manufacturer's warranty with local service capable of completing any necessary repairs in a timely manner which will significantly reduce debris removal downtime due to maintenance and repair of the existing bridge crane or clamshell.
- Ten existing hydro-electric actuators for the existing sluice gates will be replaced with electric actuators and elevated above the finished floor to improve inspection and maintenance of these actuators. The condition of the existing sluice gates will be examined while the coarse wells and wet wells are empty. MWS is planning on self-performing this work. An allowance will be included in the cost estimate for assumed repairs.
- Sluice gate seating frame flushing connections are being considered for the ten sluice gates. Determination of whether flushing is required and preferred method of providing flushing to be discussed with MWS. An allowance will be included in the cost estimate for sluice gate flushing.
- Two new 40 MGD pumps and associated VFDs, suction and discharge piping, plug valves, gate valves, surge relief valves, flow meters, motor cooling systems, and seal water stations will be installed. The pumps will be installed to achieve the 240 MGD capacity proposed in the LTCP and modified head conditions associated with discharging to the new south headworks structure. Connection of suction and discharge piping to the existing pipe network will utilize provisions included during the original CPS design to accommodate new pump installation. MWS is planning on self-performing portions of this work.
- Because the wet wells will be drained for new pump suction pipe installation, the wet wells will be cleaned and inspected. Existing concrete, baffling, and equipment within the wet well will also be inspected and repaired if required in coordination with the Construction Manager at Risk (CMAR). MWS is planning on performing this cleaning and inspection concurrently with the actuator replacement.
- The CWWTP Distributed Control System (DCS) will be updated to include the new pumps, flow monitoring, and automated level control. Pumps at CPS are currently operated in manual mode due to both capacity concerns in downstream processes and available collection system storage indicated based on the liquid level at the Kerrigan regulator and the Cumberland River. With improvements made in the overall COPT Project, the pumps will be able to operate in a reliable, level-based automatic mode by accommodating downstream capacity concerns and incorporating level readings at the CPS coarse and wet wells, 2nd Avenue diversion structure, Kerrigan regulator, and the Cumberland River.
- Incorporate any additional improvements required for the upgraded CPS to pump to its new discharge location at the new south headworks structure. See TM #2 – South Headworks for additional details.
- The 240 MGD capacity will be achieved using a total of six influent pumps, each rated to convey 40 MGD with the wet wells at levels that are typical of normal dry weather conditions. This capacity is nearly 5 times the current peak diurnal dry weather flow rate from the CSS. During wet weather conditions and corresponding moderately surcharged wet well levels, the CPS is able to meet the required 240 MGD pumping rate with only five of the six influent pumps in service and can exceed 240 MGD with all six pumps in service. As such, the firm wet weather pumping capacity is based on a surcharged wet well level. Firm and total capacities and wet well level ranges will be verified during

detailed design when new force main routings, new south headworks configurations, and automatic level-based pump control strategies are finalized.

Section 3: Constraints

3.1 Design Criteria

This section describes the constraints associated with this process area for meeting the design intent.

3.1.1 Bridge Crane and Clamshell Design Criteria

Table 1 provides a list of design criteria for the new replacement bridge crane and clamshell.

Table 1. Bridge Crane and Clamshell Design Criteria

Item	Design Criteria
Removal Method	Bridge Crane with Clamshell
Bridge Crane Capacity	5 Ton
Clamshell Capacity	1 Cubic Yard
Lift Depth	115 ft
Electrical Requirements	480V/60Hz/3 phase
Operation	From Cab on Bridge Crane or Remote with Handheld Pendant or Local Manual
Bridge Crane Mobility	Motorized bridge, trolley, and hoist

3.1.2 Influent Pump Design Criteria

Table 2 provides a list of design criteria for proposed influent pumps. Note that the discharge head condition will be marginally higher due to the relocated discharge location at the proposed south headworks structure. The revised pumping design conditions are estimated below, and will be updated during detailed design.

Table 2. Influent Pump Design Criteria

Item	Design Criteria
2014/2015 Average Daily Flow	31 MGD
2014/2015 Diurnal Minimum Flow	17 MGD
2014/2015 Daily Average Maximum Flow	50 MGD
Current Total Pumping Capacity	160 MGD
Proposed Firm Pumping Capacity (Surcharged Wet Well Level)	240 MGD (Based on preliminary evaluation, to be confirmed in detailed design)
Proposed Total Pumping Capacity (Surcharged Wet Well Level)	> 240 MGD (Based on preliminary evaluation, to be confirmed in detailed design)
Pump Type	Horizontal Centrifugal
Number of New/Total Units	2/6
Individual Pump Rated Duty Point	40 MGD at 97 ft Total Dynamic Head (To be updated during detailed design)

Table 2. Influent Pump Design Criteria	
Item	**Design Criteria**
Suction Flange	30 inches
Discharge Flange	24 inches
Electrical Requirement	4160V/60hz/3phase, 900 HP motor rating
Drive Type	Variable Frequency
Motor Cooling	External Water Recirculation with Pump and Fluid Cooler
Seal Water	Non-Potable Seal Water Station with Backup Plant Water

3.1.3 Gate Actuator Replacement Design Criteria

Table 3 provides a list of design criteria for the gate actuator replacement.

Table 3. Gate Actuator Replacement Design Criteria	
Item	**Design Criteria**
Actuator Type	Electric, Explosion Proof
Number of Units	10
	Four (4) – 72-inch circular
	Four (4) – 72-inch x 72-inch rectangular
	One (1) – 72-inch x 84-inch rectangular
Existing Gate Sizes	One (1) – 48-inch x 84-inch rectangular
Mounting Style	Pedestal Mounted, Above Grade
Valve Type	Sluice Gate

3.2 Code Considerations (Partial List)

- 2011 National Electrical Code with Local Amendments
- 2012 International Fire Code (NFPA 820) Fire Protection in Wastewater Treatment and Collection Facilities
- OSHA Regulations

A complete list of all codes used for design will be included in the Code Classification Summary, which will be completed during preliminary design.

3.3 Regulatory Drivers

3.3.1 Tennessee Department of Environment & Conservation (TDEC)

Continuous influent flow monitoring is required under NPDES permit.

Design will adhere to requirements of the TDEC Design Criteria for Sewage Works, as applicable. Adherence and/or justification for deviation to specific TDEC design criteria is documented in the Regulatory Design Criteria section of the Basis of Design Report (BODR).

3.3.2 Environmental Protection Agency (EPA) Consent Decree

The LTCP documents MWS's evaluations and recommended improvements associated with the consent decree. This document, which is currently under review, outlines MWS's strategy for controlling the frequency and volume of discharges from the Kerrigan CSO. The level of control proposed in the LTCP for the Kerrigan CSO forms the basis for the increased CPS pumping included in the COPT Project. A complete list of regulatory drivers and impacts to the design based on regulatory requirements will be included in an overall regulatory TM.

3.4 Sequencing and Constructability

The following subsections provide a list of sequencing considerations and constructability items that will impact design and implementation of improvements in this process area. This sequencing and constructability section will be updated based on coordination with the CMAR in development of overall sequencing plan.

3.4.1 Sequencing and Constructability - General

- Prior to performing work in the wet wells, functionality of existing sluice gates must be confirmed to isolate individual basins. MWS has taken responsibility for testing the existing gates and has determined that all gates required for isolation are functional. Therefore, no bypass pumping is anticipated at this time. This will be re-evaluated during Phase 2 detailed design once MWS has inspected the existing gates and their condition is known.
- Wet well basins will be taken out of service by MWS for debris removal and cleaning. Based on discussions with MWS, this work will be performed during the dry season and construction will be a continuous, 24–hour operation until work is complete. Only one wet well shall be removed from service at any time.
- There shall be no interruption in FAT or SAT influent sewer flows during construction.
- The wet wells and odor control chambers are confined spaces. All work in these areas shall follow confined space procedures.

3.4.2 Sequencing and Constructability - Pump Installation

- Two openings exist between the wet well and dry well to accommodate the connection of Pump Nos. 2 and 5. Currently the openings are plugged on each side as shown in Figure 2.

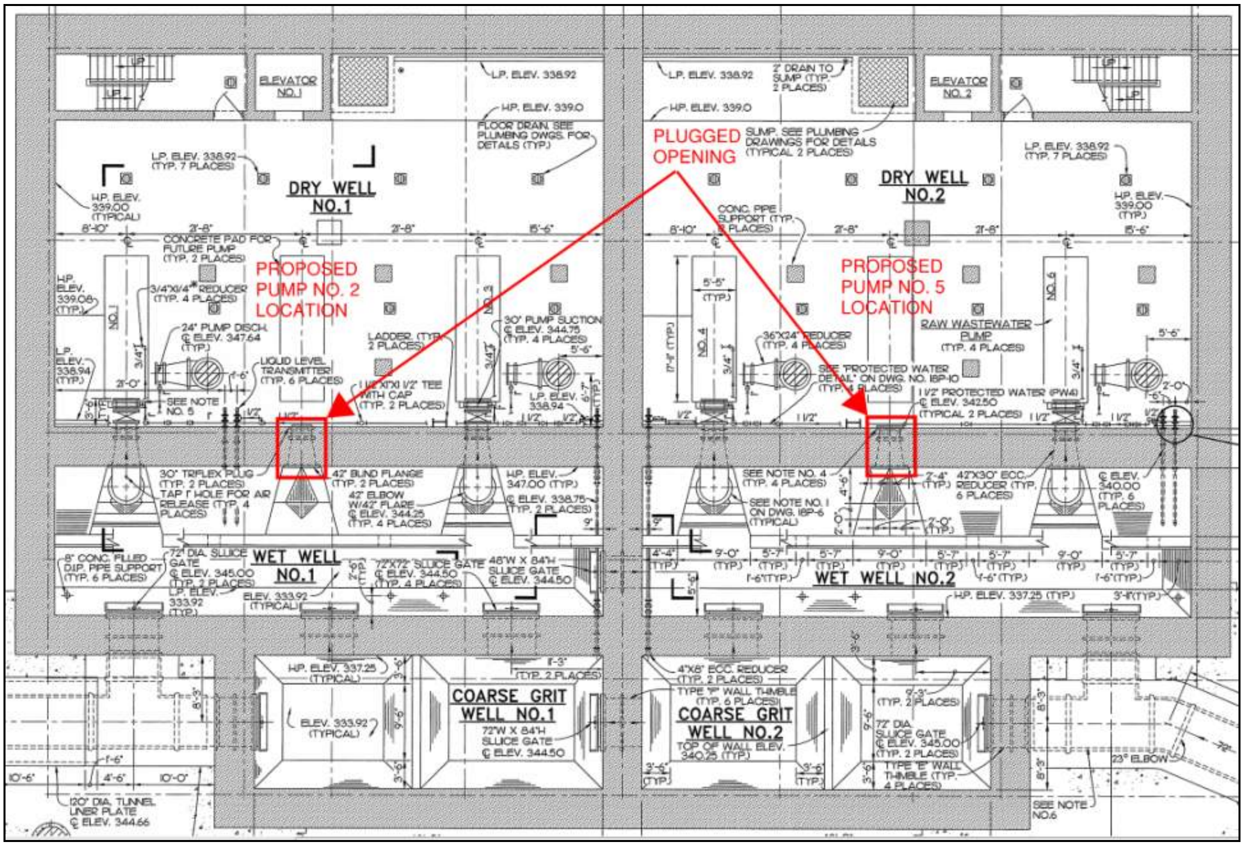

Figure 2 – Existing Basin Configuration

- Proposed Sequencing for Installing Pumps and Discharge Piping:
    1. Set Pump No. 2 and Pump No. 5.
    2. Isolate a portion of the discharge header by closing of valves similar to that depicted in Figure 3. Depending on which valve(s) are closed, flow can only be conveyed to one side of the South Grit Facility or to the North Grit Facility.
    3. Drain discharge header.
        a. Draining of the discharge header between the CPS and the south screen of the south grit facility will be required to accommodate the discharge piping connection of Pump No. 5. Similarly, draining of the discharge header to the west screen of the South Grit Facility will be required to accommodate the discharge piping connection of Pump No. 2 18-2.
        b. Further investigation and discussion with MWS operations staff and CMAR will be required to determine the best method for emptying the discharge headers.
    4. With discharge header emptied, make up connection of discharge piping from Pump No. 2 or Pump No. 5 to header, including a check valve, plug valve, surge relief valve and piping and magnetic flow meter.

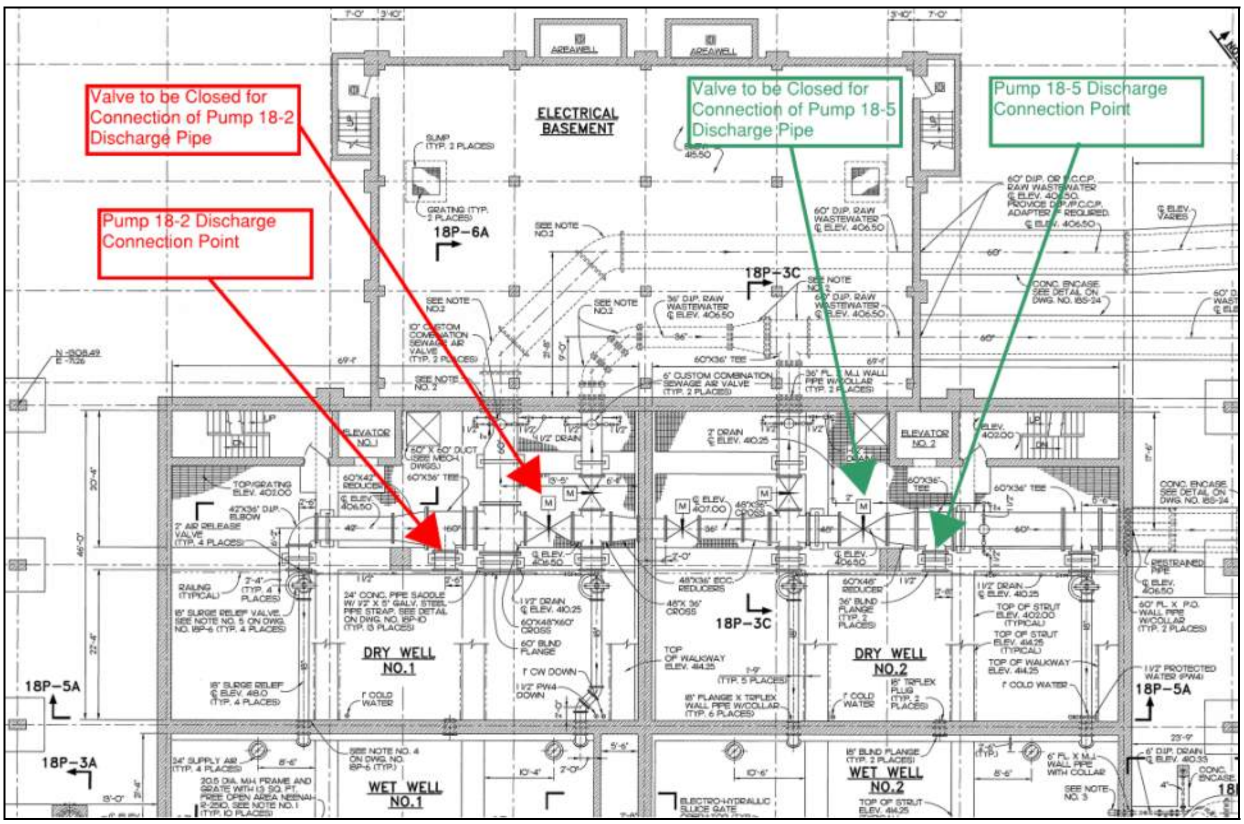

Figure 3 – Pump Discharge Connection and Valve Orientation

Proposed Sequencing for Installing Suction Piping (to be self-performed by MWS concurrent with the gate actuator replacement):

1. Isolate and dewater Wet Well No. 1 for installation of Pump No. 2 suction piping. Isolate and dewater Wet Well No. 2 for installation of Pump No. 5 suction piping.
    a. Wet well dewatering is a constructability concern that will need to be discussed with the CMAR. The existing pumps will be able to evacuate the basin to an extent, but the wet well is approximately 93-ft deep so pumping options will need to be evaluated for complete dewatering. An allowance will be included in the cost estimate for dewatering and disposal of debris removed from the wet wells.
    b. Figure 4 depicts required sequencing of sluice gates for isolation of Wet Well No. 2. Similarly, Gate Nos. 2 and 3 would be closed and Gate Nos. 5 and 6 would be opened to isolate Wet Well No. 1.
2. Install suction piping.
    a. To match the suction piping of the existing CPS pumps, a new 42-inch 90-degree elbow, extension pipe, and flare section will be installed on the wet well side.
    b. A new electrically operated gate valve, equipment connection fitting, and make up piping will be installed on the dry well side.

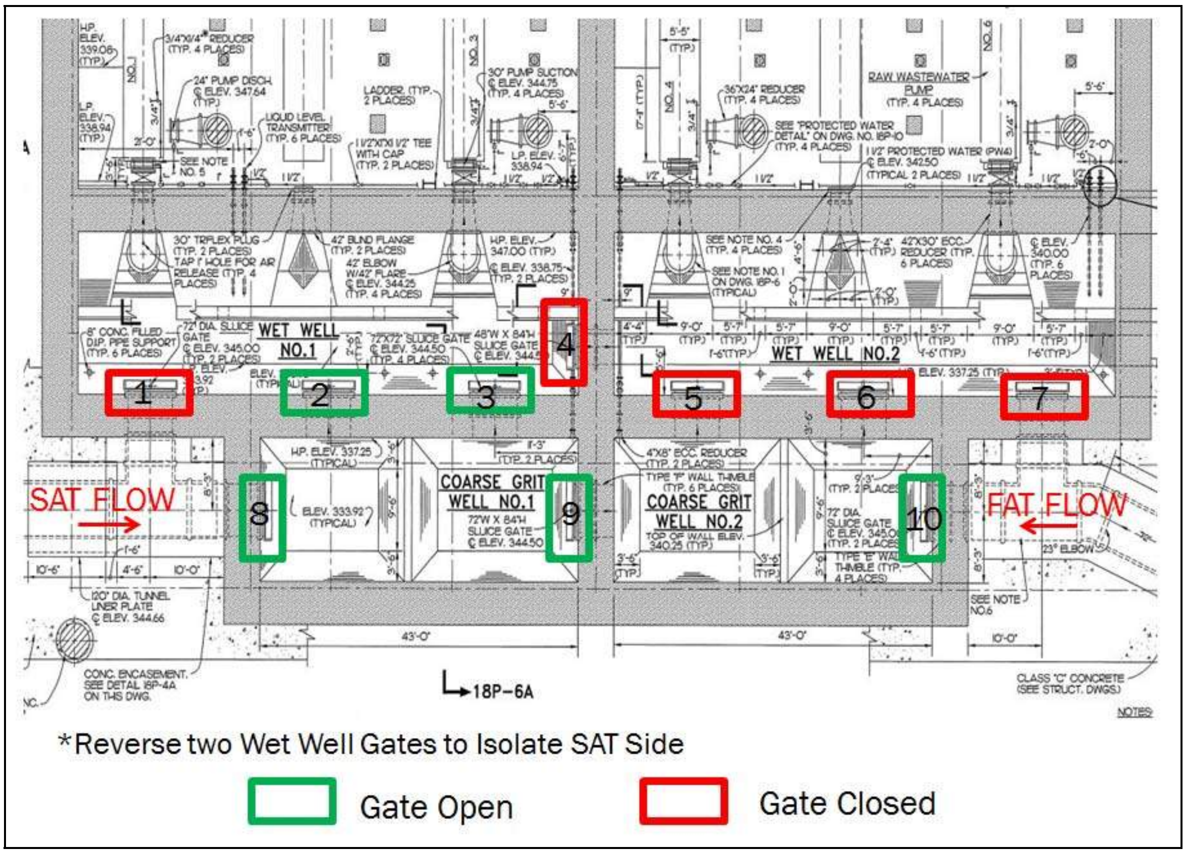

Figure 4 – Gate Control for Isolation of Wet Well No. 2

3.5 Operational Considerations

- Temporary interruption in clam shelling operations will be required to complete the proposed improvements.
- Only two of the four existing CPS pumps will be available while the initial wet well is out of service for cleaning and new pump installation. It is recommended to perform the work during the dry season.

Section 4: Description of Improvements

4.1 Process Area Designation

4.1.1 Detailed Design Considerations and Assumptions

A. Design considerations and assumptions for replacement of the existing bridge crane and clamshell include the following:

- The existing runway beams will require strengthening to support new bridge crane. Further evaluation of existing runway system will be required based on selection of new bridge crane and clamshell.

B. Design considerations and assumptions for the installation of Pump Nos. 2 and 5 include the following:

- It is assumed that the proposed pumps and associated motors shall be of the same type as the existing CPS pumps. Existing infrastructure has been provided in the original design to accommodate installation of these new pumps and associated equipment.
- It is assumed that all existing sluice gates are operable in the coarse and wet wells. No bypass pumping will be required for FAT or SAT flows to isolate the wet wells. However, an allowance has been included for bypass pumping if further inspection discovers that gates are in need of replacement.
- It is assumed that all existing valves are operable on the existing CPS pumps suction and discharge piping.

4.1.2 Process Mechanical

4.1.2.1 Process

A. Coarse Well Debris Removal

- A new bridge crane and clamshell will be installed to replace the existing equipment.

B. Gate Actuator Replacement

- The existing electro-pneumatic actuators will be replaced with electric actuators and relocated from within the existing odor control chamber to above the finished floor slab.

C. Raw Wastewater Pumps

- Two new 40 MGD pumps will be installed in the CPS dry wells.
- The proposed pumps are intended to match the existing pumps unless modifications are required (impeller trim) based on the proposed discharge location at the new south headworks. If modifications are required, it is assumed that these modifications will be implemented on all six pumps.

- New suction and discharge piping and associated valves will be installed. Provisions were made in the original design to accommodate suction and discharge connections. Figure 5 depicts the proposed pump and piping arrangement.

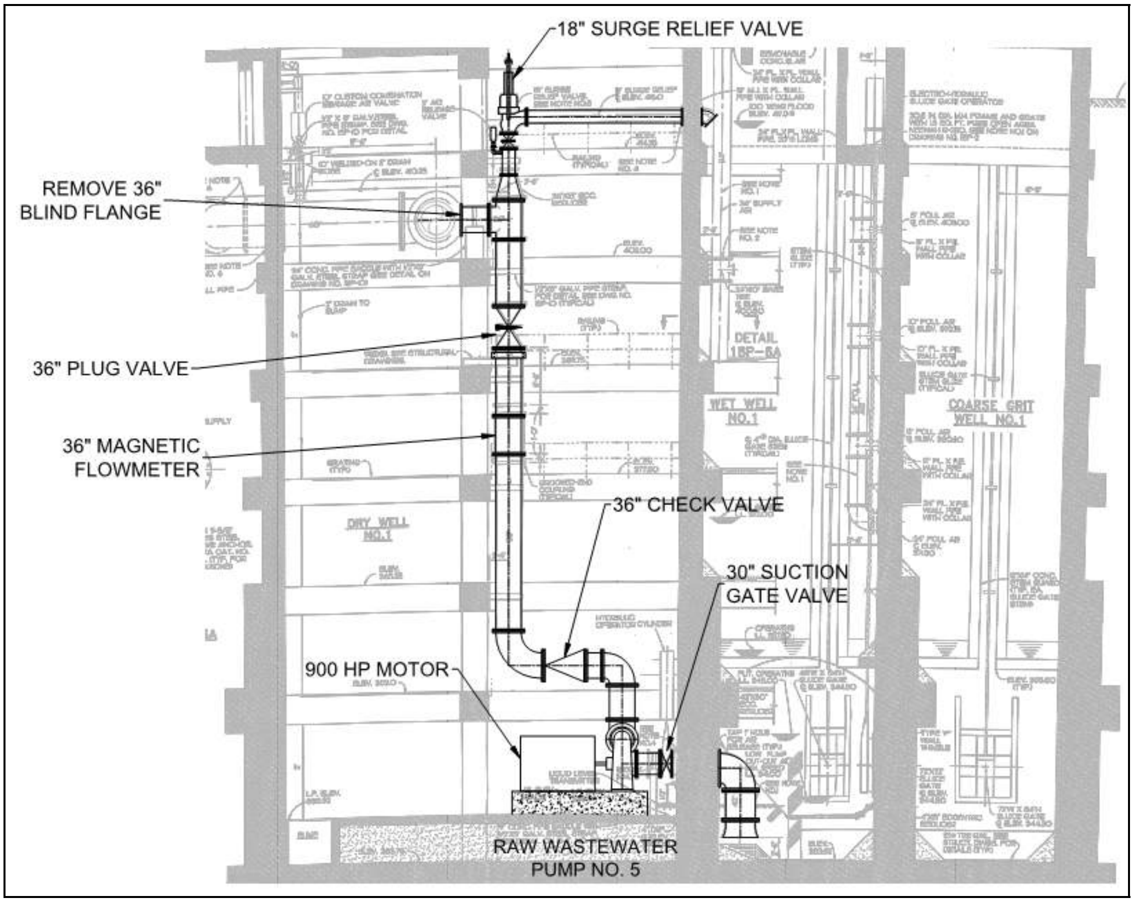

Figure 5 – Proposed Pump Piping Orientation

4.1.2.2 Odor Control

Provisions for future odor control will be included but rehabilitation of the existing system or installation of a new system are not anticipated at this time. A plant-wide odor control evaluation including the CPS will be performed during detailed design.

4.1.2.3 Heating, Ventilation, and Air Conditioning (HVAC)

- Cooling supply and exhaust fans and associated ductwork will be provided for the new pump VFDs. Space was allocated in the original pump station design to support installation of cooling equipment in existing mechanical and electrical rooms.
- All existing HVAC systems in the CPS will be assessed during detailed design.

4.1.2.4 Plumbing

- Two dedicated cooling water loop systems will be installed for each proposed pump motor. Each cooling loop will consist of a new recirculation pump and fluid cooler. Existing piping is already in place to accept required connections from the pump motors, recirculation pumps, and fluid coolers. Improvements to the existing cooling water loop systems will be assessed during detailed design.

- Two dedicated seal water stations will be supplied for each proposed pump. Existing non-potable and plant water piping is already in place to supply the seal water stations.

4.1.3 Instrumentation and Controls

A. Bridge Crane and Clamshell

- The new bridge crane and clamshell will be operated in a similar manner as the equipment that will be replaced; either from the cab attached to the bridge crane or with a remote hand-held unit.

B. Gate and Valve Actuators

- The new actuators associated with the existing sluice gates and pump suction gate valves will be opened and closed via the dedicated local control panels. Gate and valve position will be monitored from the existing CWWTP DCS.

C. Raw Wastewater Pumps

- The proposed pumps and associated flow meters will be integrated into the existing CWWTP DCS for monitoring and control which will be similar to that of the existing pumps and associated equipment.
- The proposed pumps may be operated locally or remotely in manual or automatic mode.
  - Local Hand Mode – When in Local Hand, operator starts/stops and sets % speed of the pump at the associated VFD, but pump also has run permissive based on level in the wet well.
  - Remote Manual Mode – When in Remote Manual Mode, operator starts/stops and sets % speed of the pump via the plant DCS. This is the same as the current Remote Manual Mode.
  - Remote Automatic Mode:
    - Current Operation: When in Remote Automatic Mode, the speed of the lead pump is varied to maintain a wet well level set point. Control is via the DCS and the level setpoint is input by the operator. Lag pumps are brought online via Remote Manual Mode at the discretion of the operations staff based on available CWWTP capacity and levels associated with the Kerrigan regulator, as indicated via MWS system-wide SCADA computer located in the control room.
    - Proposed Normal Operation: When in Remote Automatic Mode, a level-based control strategy will be implemented that varies the output of the CPS proportionally based on the level in the CPS wet well. During this project, CWWTP improvements downstream of the CPS will facilitate conveyance, treatment, and overall management of quickly rising CPS flows. The design team will work closely with MWS staff to develop automatic control parameters that meet the needs of the operations staff.
    - Proposed Alternate Operation: Level signals from the 2nd Avenue diversion structure, Kerrigan regulator, and Cumberland River will be input to the DCS to facilitate Alternate Remote Automatic Mode that can be initiated manually by the operations staff to limit CPS discharge flow and utilize available collection system storage volume. A combination of several key parameters (TBD) would have to be within acceptable ranges to enable manual initiation of this alternate mode and the control scheme would automatically revert back to normal

operation and activate an alarm if any of these parameters exceeded the acceptable range. During this alternate mode, the discharge flow from the CPS will be limited to on operator settable flow and/or number of pumps. Further details of the Alternate Remote Automatic Mode control strategy will be developed during detailed design. At this time, based on preliminary discussions:

- Level signals would be input from the 2nd Avenue diversion structure to indicate level in the Kerrigan sewer upstream of Kerrigan regulator, at the Kerrigan regulator to indicate the level downstream of the diversion structure weir, and of the Cumberland River.
- At least one key parameter to be utilized in the control strategy would be the difference between the Cumberland River elevation and water surface elevation in the 2nd Avenue diversion structure. This provides the operations staff with an indication of available storage capacity in the upstream sewer.
- Anticipated near-term rainfall amounts within the combined sewer catchment area.
- It is anticipated that this mode would be utilized during minor rain events, towards the end of major wet weather events, and other specific circumstances.

4.1.4 Electrical

A. Bridge Crane and Clamshell

B. 460V/3PH/60Hz power will be provided to the new bridge crane and clamshell. It is intended to re-use existing electrical infrastructure feeding the current unit. Suitability of existing electrical system will be evaluated based on selection of new bridge crane and clamshell system. Sluice Gate Actuators

- 460V/3PH/60Hz power will be provided to the 10 new sluice gate actuators.

C. Influent Pumps

- Two new VFDs will be installed in the existing electrical room for the proposed pumps.
- 4160V/3PH/60Hz power will be provided to two new 900 Hp Motors.
- Existing infrastructure is already in place to support electrical requirements of the new pumps.
- Power will be provided for the pump motor cooling system recirculation pumps and fluid coolers.
- Power will be provided to the pump suction valve actuators and solenoid valves on pump seal water system.

4.1.5 Structural

A. Bridge Crane and Clamshell

- All existing runway beam connections will be strengthened to withstand assumed loading of new bridge crane. Additional ¾ - inch plates will be welded to the existing runway beam and secured to the existing concrete beam as shown in workshop presentation and meeting minutes.

- Existing runway beams shall be cleaned and recoated as required to repair rust damage.

B. Wet Well Sluice Gate Actuators

- The floor slab will be repaired and reinforced to accommodate new sluice gate actuators.

C. Raw Wastewater Pumps

- Modifications to the existing guardrail will be required to accommodate the new discharge piping.

- Pipe supports will be required for new discharge piping.

D. Wet Well Cleaning and Inspection

- The structural condition of the wet wells is unknown and will be further evaluated while dewatered. MWS will coordinate this inspection with the design team. An allowance has been included to account for potential structural repairs.

4.1.6 Geotechnical

Not Applicable

4.1.7 Architectural

Not Applicable

4.1.8 Site Civil Scope of Improvements

Not Applicable

References

Brown and Caldwell., *Central Wastewater Treatment Plant Optimization Study*

Consoer Townsend & Associates., *Central Pumping Station Operation and Maintenance Instructions*, Volume No. 1.

AECOM, *Long Term Control Plan for Metro Nashville Combined Sewer Overflows*

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METRO WATER SERVICES

Central WWTP Capacity Improvements and CSO Reduction

Final Basis of Design Report
Technical Memorandum No. 2: South Headworks Facility
Hazen No. 50045-004
December 28, 2016

SCOTT WOODARD
REGISTERED ENGINEER
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12-28-2016

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1. Executive Summary

The south side of the Nashville Metro Water Services (MWS) Central Waste Water Treatment Plant (CWWTP) receives flow from the south collection system, which includes combined sewers and, accordingly, has a strong influence from stormwater flows. The existing headworks (screening and grit removal) facilities in the south are inadequate for future design flows and will be replaced as part of the Capacity Improvements and CSO Reduction Project. This Technical Memorandum (TM) presents alternatives for the proposed new south headworks and provides the basis for detailed design of the recommended alternative.

The 2013 CWWTP Optimization Study proposed several improvements to retrofit existing infrastructure with new equipment, and improve reliability of the south screening and grit removal[1]. However, some of those retrofit improvements (in particular, coarse screening) had intrinsic flow capacity limitations that restricted benefits for future peak flows. Since that report was completed, greater importance has been placed on providing headworks facilities sized to handle future peak flows. Accordingly, new facilities are proposed in this report to provide complete coarse screening and grit removal for peak design flows, either as standalone facilities or to supplement retrofit facilities.

Over the course of four workshops with the MWS project team from November 2015 to April 2016, six alternatives were developed and presented for the south headworks facility. In Workshop Nos. 3 and 4, the alternatives were narrowed to two options that were to be considered further with construction manager at risk (CMAR) input. Alternative No. 2 – new coarse screening facility includes new coarse screens and Alternative No. 3 – new coarse screening and grit removal facility includes new coarse screens and grit removal. Both facilities include capacity to provide preliminary treatment for anticipated central pump station (CPS) peak flows of 240 MGD, with ability to expand to 300 MGD.

The scope of the south area improvements is divided into two groups: new facilities and retrofit facilities. This TM includes design criteria for south headworks in general, and a summary of conceptual designs for the proposed new facilities; the basis of design for the retrofit facilities is included in separate TMs (see TM 3A – North and South Fine Screening and TM 3B – North and South Grit).

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[1] Brown and Caldwell, April 12, 2013. *Technical Memorandum No. 5-2: Potential Improvements at South Grit Facility*. Central Wastewater Treatment Plant Optimization Study.

2. Design Criteria

2.1 Flows

The south area of the CWWTP receives flows from combined sewers via the 1st and 2nd Avenue Tunnels. Influent flow from these tunnels is lifted into the existing headworks by the CPS. As part of the Long Term Control Plan (LCTP) to reduce overflows at the Kerrigan CSO, the capacity of the CPS is being increased to 240 MGD from its current 160 MGD. The design criteria for peak flow to the proposed south headworks are based on the increased capacity of the CPS:

- Average Dry Weather Flow (ADWF): 30 MGD
- Peak Sustained Flow: 240 MGD

Based on the above flows, the south headworks facility alternatives were developed to provide 240 MGD firm capacity. Higher flows may be possible from CPS under surcharged conditions. Final design criteria and expected operating conditions will be evaluated during detailed design. The ability to expand the treatment capacity to a future peak flow of 300 MGD firm capacity was also included in each alternative. An additional screen channel with a manually-cleaned screen is included in the alternatives. This channel is sized to accommodate a self-cleaning screen in the future.

2.2 Process and Operations

2.2.1 Rapid, Heavy Storm Flows

There is limited data available to determine the effects of heavy storm flows. CWWTP staff have provided anecdotal information regarding high peaking factors (PFs) and quickly rising flows observed at the existing east/west coarse screens at the existing south grit facility. Generally flows can increase from average to peak in the matter of one to two hours, depending on the intensity, duration, and aerial influence of the storm. Overflows of the upstream screen channels have been observed on multiple occasions during storm events, especially when the existing screens cannot keep up with the heavy load of debris, or when the rakes are disabled by an obstruction. These overflows have occurred within minutes of the first high flows arriving at the plant.

2.2.2 First Flush Conditions and Heavy Grit Loads

Due to the rapid increase in flow during wet weather, the CWWTP commonly experiences a high debris and grit load at the beginning of a storm event. This “first flush” condition results from high flows suspending larger and heavier debris (e.g. bricks, rocks) that have collected in the sewer system during dry weather, and subsequent scour during a storm event. This debris and grit ends up at the CWWTP, and those items that make it through the CPS have resulted in the need for significant tank and channel cleaning and maintenance issues in plant process areas. At times, plant staff have observed significant loads of stone and other debris that is not typical of combined sewers. During conversations with staff, examples were provided of significant No. 57 stone at the existing screens; this loading was suspected to have been caused by upstream construction in the incoming sewers.

The May 2011 *Grit Removal Assessment Technical Memorandum* (Gresham Smith and Partners) includes data for grit characterization at the south plant conducted over two consecutive wet weather days (April 12-13, 2011). Testing showed high concentrations of influent grit (approximately 94 lb/Mgal and 26 lb/Mgal during the second day). It is suspected that the first day was "first flush" conditions.

2.2.3 Seasonal Leaf Loads

A common challenge during the fall season is leaves which rapidly blind influent screens, overwhelm the screenings conveyor system, and cause maintenance issues downstream (see Figure 2-1). Equipment selections and recommendations include ability to handle the excessive leaf load and rapid screen blinding potential. Screens will also be capable of multiple operational speeds, with a faster cleaning mode for wet weather.

Figure 2-1: Leaves Causing Overflow at Existing West Screen Compactor

2.2.4 Large Debris

The CPS pumps can pass up to a 9-inch solid. Large debris, such as bricks, car batteries, two liter bottles, long pieces of pipe, etc. cause issues downstream of the existing coarse screens. The recommended screens will remove this large debris at the front of the plant and keep it from causing greater damage downstream.

The existing CPS features a coarse grit well upstream of the pumps designed to capture these large debris for removal by a clamshell, which is operated from a manned bridge crane (see **Figure 2-2**). Historically the depth of the coarse grit well (nearly 100 ft) made operation of the clamshell difficult, and frequency of cleaning of the coarse grit well was historically low. The buildup of grit during these periods allowed for the passage of larger solids through the CPS pumps to the rest of the treatment process.

Figure 2-2. Existing CPS Coarse Grit Well Clamshell

Operations staff have begun regular and frequent clam-shelling of the coarse grit wells at the CPS and have noted a reduction in debris and grit in the existing coarse screen channels and aerated grit tanks. The recommended south headworks facility alternatives assume the existing CPS coarse grit well will continue to be cleaned on a regular basis to minimize pass through of large debris. Provisions for a future rock trap are incorporated into the alternatives to provide additional debris removal and protection of downstream equipment should this be necessary in the future.

2.3 Operational Flexibility

The ability for MWS operational staff to efficiently manipulate the south headworks facilities based on operational conditions is a critical feature of the proposed improvements. Because the facilities are on the influent end of the CWWTP, their ability to automatically adjust to different operational and influent conditions is important to prevent hydraulic backups and maximize the volume of treated flow.

2.3.1 Automatic Flow Control

The recommended south headworks facilities will automatically route flow and bring standby units in and out of service as flows increase and decrease based on operations entered setpoints. For example, during wet weather events, influent gates will automatically open on standby units to ensure optimal treatment as flows increase. The control system will open the gates at operator-adjustable water level setpoints, which have been calculated based on flow conditions that ensure optimal screening and grit removal.

2.3.2 Passive Hydraulic Bypass

Passive hydraulic flow splitting is included in the alternatives to automatically bypass treatment units and send flow to equalization (EQ) or the excess flow treatment unit (EFTU) as appropriate. Passive flow splitting reduces dependency on valves, actuators, and flow meters (and the associated electrical and controls functionality) to split flows, thus increasing reliability and reducing operational complexity. CPS discharge flow will be able to bypass screening and grit removal and flow directly to EQ or EFTU.

2.3.3 Discharge to Flow Equalization

There are several alternatives for EQ, as described briefly in the following paragraphs and discussed in detail in a separate TM. The implemented alternative will include ability to passively discharge to EQ upstream or downstream of screening and grit removal. This will minimize the potential for overflow in the event of excessive blinding/clogging or other operational difficulties with the equipment. Normal operations will include ability to send flow to EQ downstream of screening and grit removal to minimize debris and grit in the EQ tanks.

Alternatives for flow EQ, including conversion of the existing south aeration tanks (SATs) and final settling tanks (FSTs) are discussed in a separate TM. Both passive and automatic discharge to the recommended EQ facilities are included in the headworks alternatives.

2.3.4 Ability to Transfer Flow Between North and South Areas of Plant

Plant staff currently have the ability to divert south influent flows to the North and vice versa as needed for plant operations and maintenance. It is recommended that Metro operate these two facilities separately based on the following:

- Capital cost difference – the capital cost for constructing a junction chamber and/or effluent diversion from the proposed south headworks is significant.
- Regulatory considerations – during wet weather, it will be important to keep North and South flows separate (i.e. north flow is primarily separate system, south side is primarily combined system).
- Equipment reliability – the proposed equipment in both areas of the plant will be much more reliable than existing systems and will have necessary redundancy for operations and maintenance.

3. Existing Conditions

3.1 Existing South Headworks Facilities

The existing east and west screens do not have adequate peak flow design capacity of 240 MGD, nor do they have adequate bypassing capability to convey the peak flow to downstream treatment units. The existing aerated grit chambers could pass 240 MGD hydraulically, but would provide very low grit removal during high flows (see TM 3B).

3.1.1 East and West Screens

The existing east and west screens were installed in the south grit facility in 2006. Photos are shown in **Figure 3-1** and a plan drawing is shown in **Figure 3-2**. They are bar screens with 1-inch openings and rated capacities of 80 MGD each.

Figure 3-1: East (left photo) and West (right photo) Screens at South Grit Facility

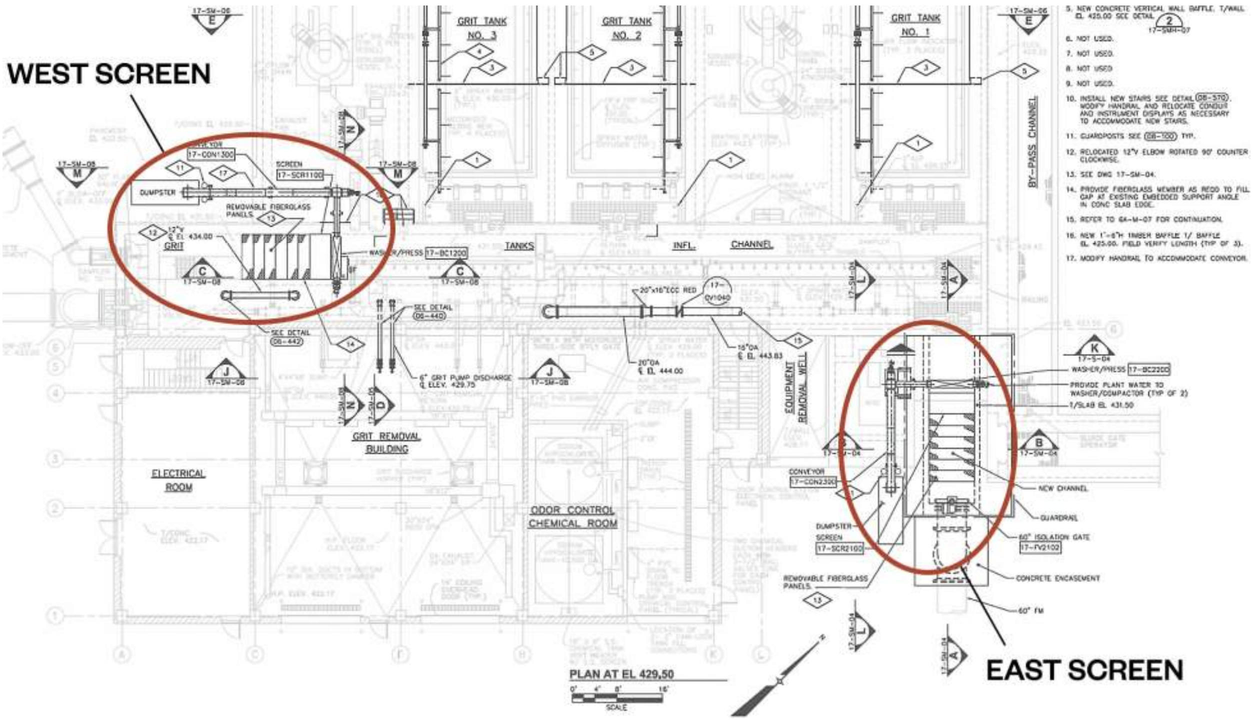

Figure 3-2. Plan Drawing of East and West Screens

The east and west screens have difficulty keeping up with seasonal leaf loads, especially at the entrance to the compactor unit, where bridging occurs due to the leaves. Other debris also causes equipment failure at these screens somewhat frequently, particularly because the CPS pumps are able to pass relatively large solids. Because there is no capability to bypass these screens, a failure or excessive blinding can quickly cause a hydraulic bottleneck in the system and a significant operational concern. In addition, the 1-inch openings are too large to adequately protect the proposed downstream grit removal equipment. New coarse screens with ½ inch openings in a new screening facility are recommended.

3.1.2 Aerated Grit Chambers

There are three aerated grit chambers immediately downstream of the east and west screens in the existing south grit facility. The existing chambers were retrofitted in place of old gravity grit tanks and sludge storage tanks as the focus of a 1998 project. Plan drawings from this project are shown in **Figure 3-3**.

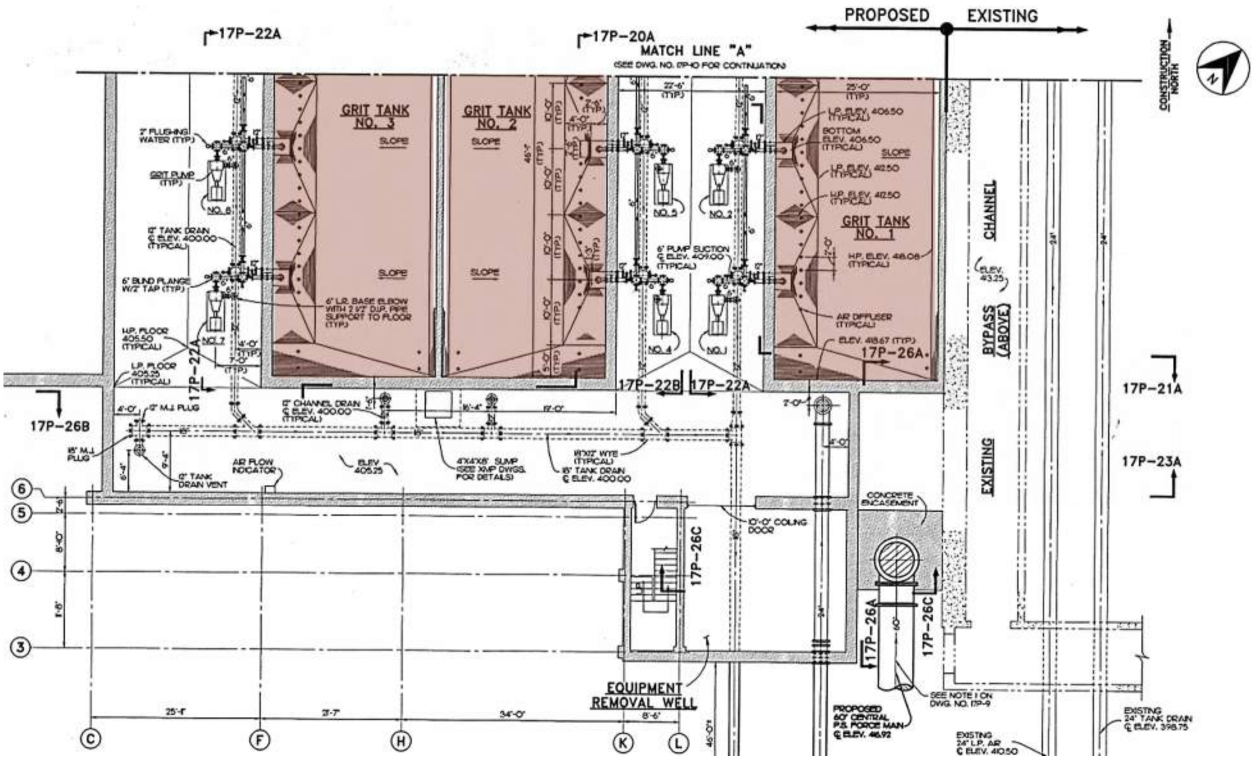

Figure 3-3. Plan Drawing of Existing Aerated Grit Chambers

Aerated grit chambers typically have lower removal performance than modern grit technologies, particularly at peak flows. Proposed upgrades will replace the existing aerated grit tanks with newer technology and higher removal efficiencies. Two alternatives are recommended for additional evaluation by the construction manager at risk (CMAR):

- Stacked tray grit removal in south coarse screening facility
- Retrofit of existing aerated grit tanks with stacked tray grit removal equipment (the alternative incorporating this option was developed by Brown and Caldwell (BC) and is covered in a separate TM).

Additional details are presented in **Section 5**.

3.1.3 Abandoned Climber Screens

Three climber screens with 1-inch openings (see photo in **Figure 3-4** and the plan drawing in **Figure 3-5)** were installed in 1998 in a separate building. These screens have been abandoned in place for several years, and will be replaced with fine screens (1/4-inch openings). The replacement of the existing screens was evaluated by BC and is covered in a separate TM.

Figure 3-4. Photo of Abandoned Climber Screens at South Grit Facility

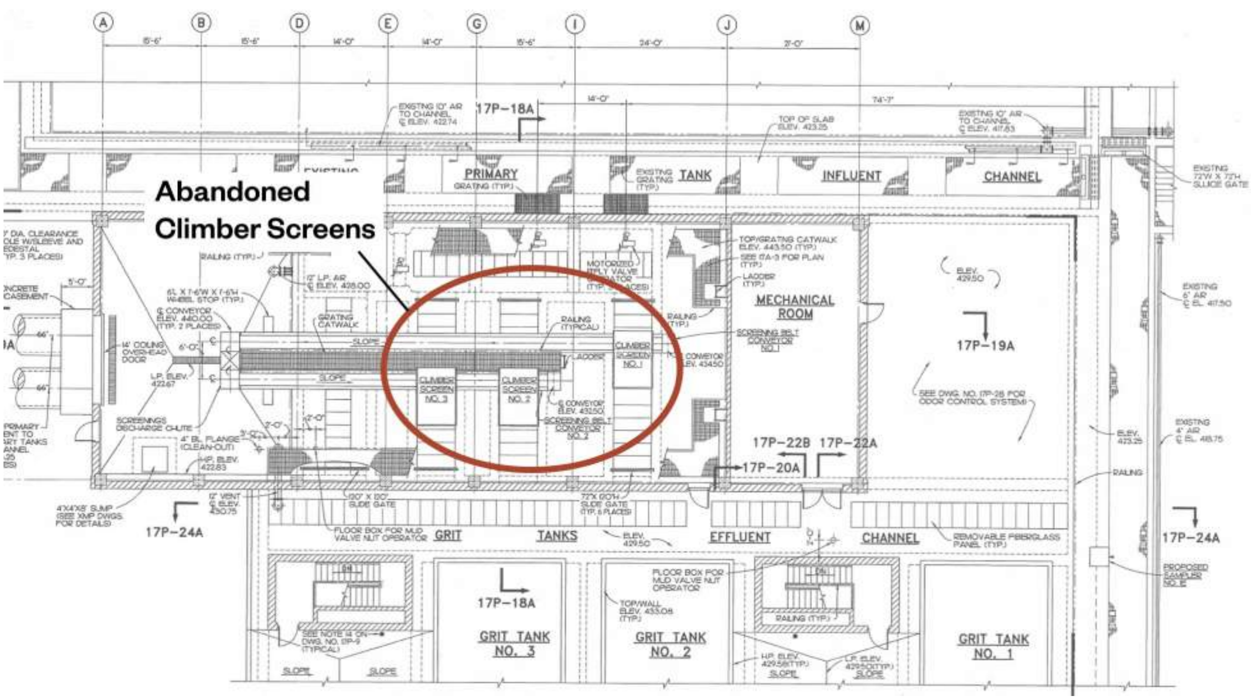

Figure 3-5. Plan Drawing of Abandoned Climber Screens at South Grit Facility

3.2 South Headworks Facility Site Selection

3.2.1 Headworks Facility Location Alternative No. 1 - Near Maintenance Center

Site constraints were taken into consideration while identifying potential locations of the south headworks. Critical electrical and water feeds as well as large diameter sewer and force mains (FMs) are adjacent to the CPS. These constraints limit the areas available for new structures onsite. Two location alternatives were considered for the new south headworks.

Alternative No. 1 included locating a new headworks facility adjacent to the existing Maintenance Center. There are significant conflicts with existing major utilities including sludge lines and electrical duct banks (see Figure 3-6). This location also conflicts with future plans for sludge transfer facility improvements and significantly impacts employee parking areas and access to plant operations facilities in the south of the Maintenance Center.

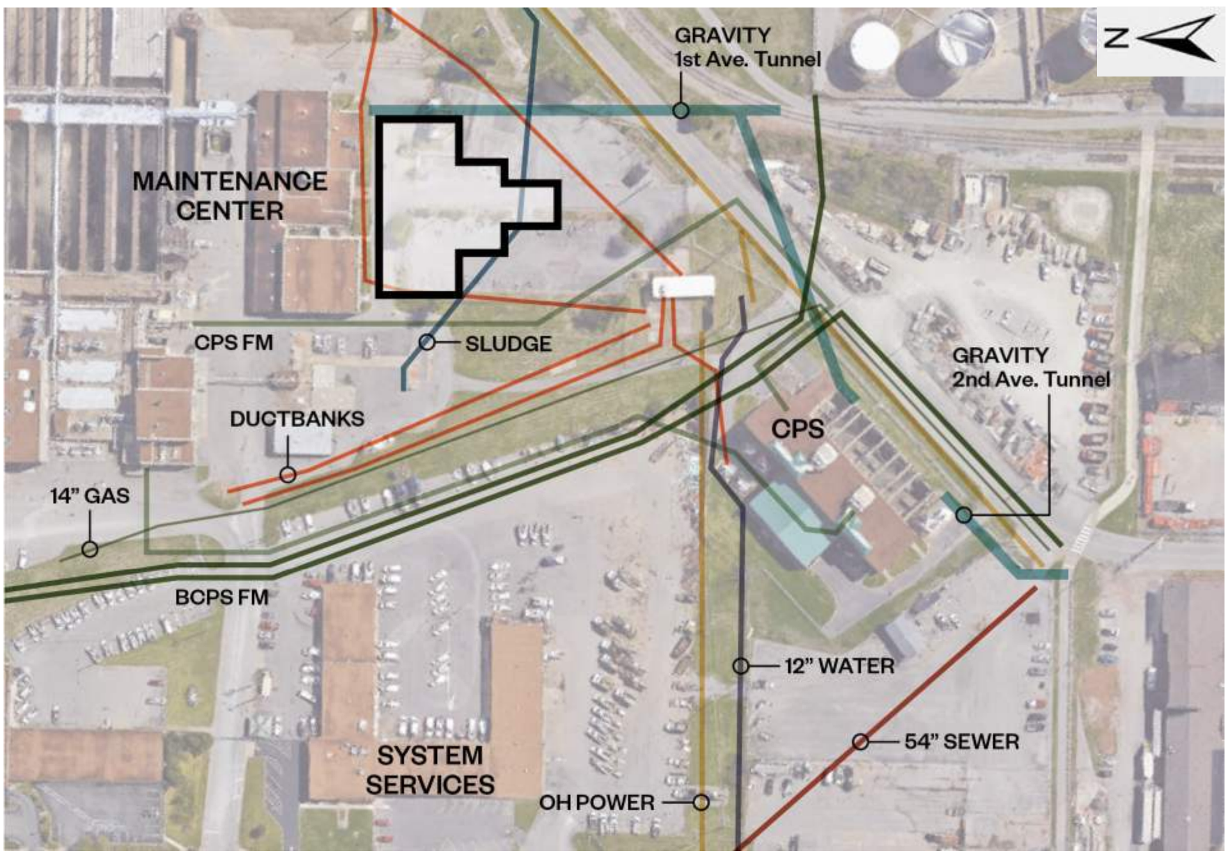

Figure 3-6: Site Layout for Headworks Location Alternative No. 1

3.2.2 Headworks Facility Location Alternative No. 2 – System Services Building

Alternative No. 2 - constructing a new facility next to the system services building has the least amount of conflicts with existing piping and future connections (see Figure 3-7). Location of the new headworks in this location would require demolishing at least the southern portion of the system services building. This area of the building is not in compliance with current building codes and would require significant capital investment if used in the future. This area is also at a higher elevation than Alternative No. 1, facilitating gravity conveyance to downstream treatment and/or EQ. Location No. 2 was recommended and was incorporated into development of the headworks alternatives discussed later in this report.

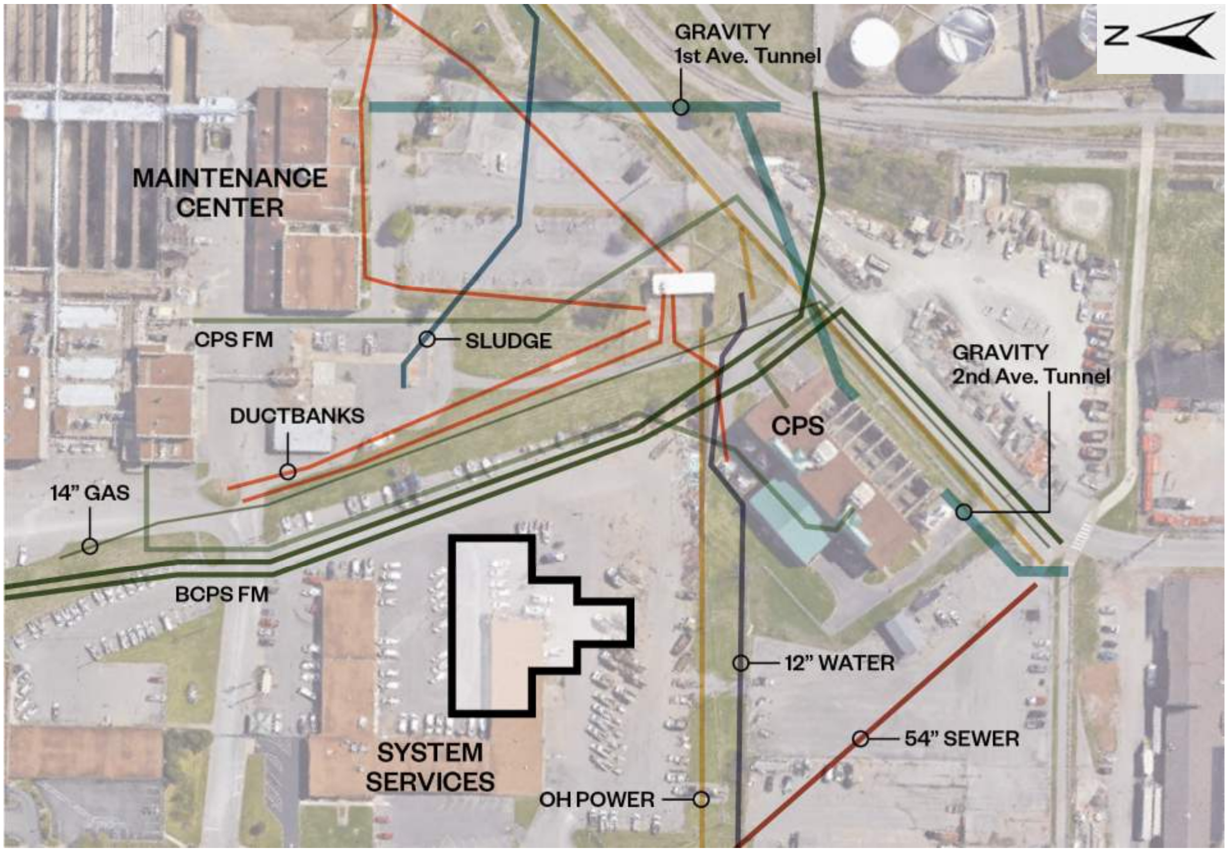

Figure 3-7: Site Layout for Headworks Location Alternative No. 2

3.3 Hydraulic Constraints

The downstream controlling water surface for the proposed south headworks facilities is the primary settling tanks (PSTs) influent channel. The peak water surface elevation (WSE) in the PSTs influent channel was calculated to be 422 ft, assuming unsubmerged effluent weirs on the downstream side of the PSTs. The elevations in the WWTP record drawings were used as the basis for the hydraulic calculations.

Since the physical locations of fine screening and grit removal could be either in a new or existing facility, and because fine screening may be partially bypassed during peak flows, a detailed hydraulic profile was not developed for every alternative (and every flow condition) at this phase of design. WSE for each of the alternatives presented in this report were calculated assuming discharge from the new south headworks facility directly to the PSTs influent channel. Once final facility alternatives are selected a more detailed hydraulic conditions and final elevations will be optimized to preserve existing CPS hydraulics, but to provide favorable hydraulics through the proposed facilities.

Upstream of the south headworks facility, the peak flow elevation will have a significant impact on the capacity of the CPS. During normal operating conditions, the CPS pumps will discharge directly upstream of the coarse screens; the hydraulic conditions within the south headworks facility will dictate the downstream controlling WSE (i.e. the head conditions) of the CPS. Because of the importance of the CPS capacity evaluation, the hydraulic conditions of south headworks will be determined as soon as possible after an alternative is selected.

4. Headworks Unit Processes and Equipment

The discussion in the following sections focuses on preferred / selected equipment types for major headworks unit processes. Significant discussions were held with the project team to discuss and identify the most viable unit process equipment. Further detail is provided in meeting summaries.

4.1 Rock Trap

The CPS currently has coarse grit wells that function as rock traps when regularly clam-shelled, providing a quiescent zone in the wet well to allow heavier debris to settle. The existing CPS coarse grit well is cleaned from a manned bridge crane (see **Section 2.2.4**), which is difficult to operate, but is having positive results relative to decreasing debris loading to the existing downstream screens and grit removal. Hazen developed another rock trap design for consideration as an alternative to the existing coarse grit well cleaning and for potential future provisions for debris removal, should it become necessary.

The rock trap was conceptually designed as a concrete tank (covered for odor control) that slows the flow velocity to less than 1 foot per second, at peak flows (see **Figure 4-1 and 4-2**). Large access doors are included for entry of equipment such as a small bulldozer to move debris around inside for removal. A bypass channel is also included to ensure continuous flow if the rock trap is taken out of service for maintenance.

The section view (Figure 4-2) shows a concept for the cleaning mechanism (clamshell on a bridge crane, similar to current operation at CPS) and debris removal via truck. An alternative feature on the rock trap exit to the south headworks influent channel would be a submerged port to trap floating material. Conceptual level costs were much higher than the current manual clam-shelling at CPS (including proposed retrofits / rehab / improvements at CPS). It is recommended that Metro continue manual clam-shelling operations at CPS on a regular basis and that they make upgrades to make the system more reliable. Further information on CPS is contained in a separate TM.

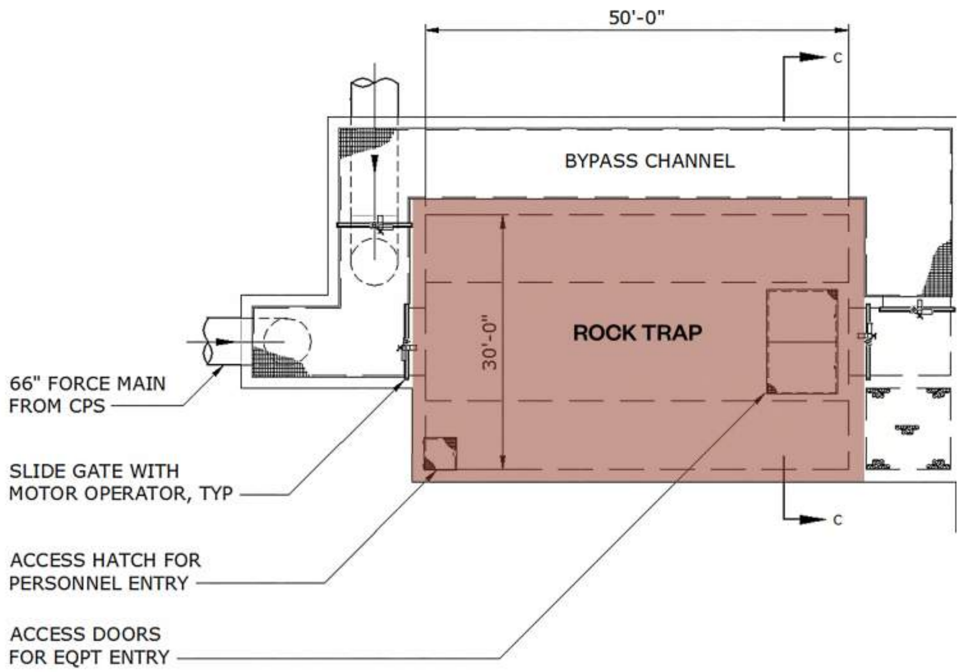

Figure 4-1. Plan of Optional Future Rock Trap

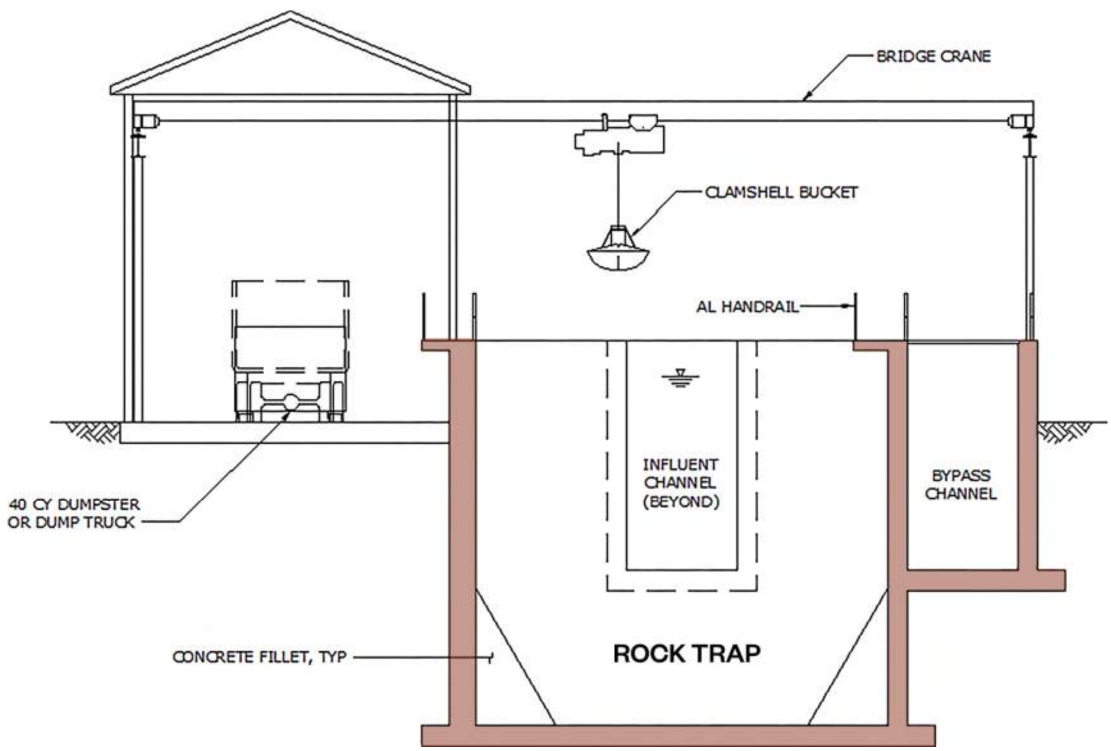

Figure 4-2. Section of Optional Future Rock Trap

4.2 Screening Equipment

4.2.1 Coarse Screens

Multi-rake bar screens are recommended for the coarse screens. Their design consists of three basic components: a drive head, raking device, and bar screen. The rakes are mounted to chains or links and move the debris up the screen and discharge the screenings on the back side, then return to the bottom of the screen, staying entirely on the influent side of the bars. Two types of multi-rake screens, catenary and conventional are recommended for further consideration.

Catenary multi-rake screens have no fixed lower bearing or sprocket at the bottom of the screen (i.e. in the flow path) that requires maintenance. Catenary multi-rake screens are manufactured by Duperon, and are designed to resist jamming due to large debris. Instead of a fixed rotation point at the bottom, the rakes (see **Figure 4-3**) are designed to pull debris up the bars under the power of their own weight. The links to which the rakes are attached also act like a lever arm to work around large debris and prevent equipment stoppage even with a partial blockage of flow.

Figure 4-3: Duperon FlexLink Elements

Conventional multi-rake bar screens have essentially the same design elements as catenary multi-rake screens except that they have a submerged, lower sprocket at the bottom of the screen in the channel (see **Figure 4-4**). Conventional multi-rake screens are manufactured by Headworks, Vulcan, Huber, and others. The advantage of the lower sprocket is that it provides more rigidity in the rakes, increasing their pressure on the front side of the screen and providing additional force to carry screened solids up to the discharge point. This additional pressure improves the overall capture efficiency of the screens. MWS staff has had issues with jamming of the lower sprocket on the existing headworks bar screens at CWWTP. Many utilities also have concerns about the need for maintenance of the lower sprocket, although manufacturers provide a full sealed and lubricated design and have numerous installations that have been operating for over ten years without operational issues.

Figure 4-4: Conventional Multi-Rake Bar Screen Lower Sprocket (courtesy Huber)

Fine screens are also recommended in the south area of the plant, and will be installed downstream of grit removal. Fine screens were evaluated by BC for installation in the existing screening building. A summary of this evaluation is included in a separate TM.

4.2.2 Coarse Screen Channel Design

Table 4-1 summarizes required screening channel widths for Duperon, Headworks, and Huber multi-rake bar screens at 60 MGD per screen and varying blinding percentages.

Table 4-1: Screen Channel Widths at 60 MGD per Screen

% Blinding	Duperon[1]	Headworks[2]	Huber[3]
25	5.0	6.5	5.4
30	5.4	7.0	5.8
35	5.8	7.5	6.3
40	6.3	8.1	6.8
45	6.8	8.9	7.4
50	7.5	9.8	8.2

1. Duperon bar thickness = 0.25 inches
2. Headworks bar thickness = 0.472 inches
3. Huber bar thickness = 0.313 inches
4. Screen Widths calculated at 60 MGD per screen, 4 fps slot velocity, and 9 ft downstream depth

Based on the information provided by the manufacturers, we recommend a screen channel width of 6.5 ft. This size allows for blinding percentage at typical design levels (at a minimum) to account for heavy leaf loads, while maintaining flexibility in screen manufacturers. Further optimization of screen channel depth and sizing will be performed during detailed design.

4.2.3 Screenings Conveyance and Handling

Several options for conveyance and compaction / dewatering of screenings were considered for the south headworks. Since the flow in the south area is primary combined flow, large debris is anticipated at the coarse screens. Large debris often causes issue with compaction equipment and can lead to frequent jams / shutdowns of this equipment. Therefore, it is recommended that screenings be conveyed directly to the dumpsters, with provisions for drainage from the dumpsters to meet the required paint filter test for landfill. A belt conveyor is recommended for transport of material because other conveyance methods, including sluicing channels and screw conveyors are susceptible to failure or clogging with large volumes of leaves, coarse grit, and trash. Equipment options will be further evaluated during detailed design.

Figure 4-5: Cleated Belt Conveyor (courtesy Serpentix)

Conveyance of screenings is a critical link in effective screening and debris removal. If only one conveyor were installed and it happened to fail, multiple screens would have to be shut down. To ensure continuous screening removal, it is essential that conveyance has redundancy. For the south headworks facility, a single belt conveyor with diversion of screenings to adjacent small dumpsters is recommended, as shown in **Figure 4-6**. The small dumpster option also provides the advantage of clearing away large and rapidly discharged volumes of screenings during storm events while optimizing capital spent in the facility (versus having two duplicate conveyors).

Figure 4-6: Screenings Diverter to Dumpsters

A 20 cubic yard (CY) dumpster is proposed to hold screenings in the south headworks facility and allow the material to drain before removal. The dumpster would be a dewatering type in order to allow drainage of excess water from the coarse screenings prior removal.

4.3 Grit Removal Equipment

Two primary alternatives for grit removal were considered in the south headworks facility: vortex, and stacked tray. Based on installation cost and performance under peak flows, it is recommended that stacked tray grit removal be included for grit removal in the south.

4.3.1 Grit Separation

Stacked tray grit removal equipment uses a series of stacked trays within the conical tank to assist with settling of finer grit particles. These units have shown superior performance in removal of fine grit, even at peak flows. Hazen and Sawyer performed a detailed "potential failure" analysis on stacked tray systems. Some of the major considerations for installation and successful operation during wet weather are shown in **Figure 4-7**.

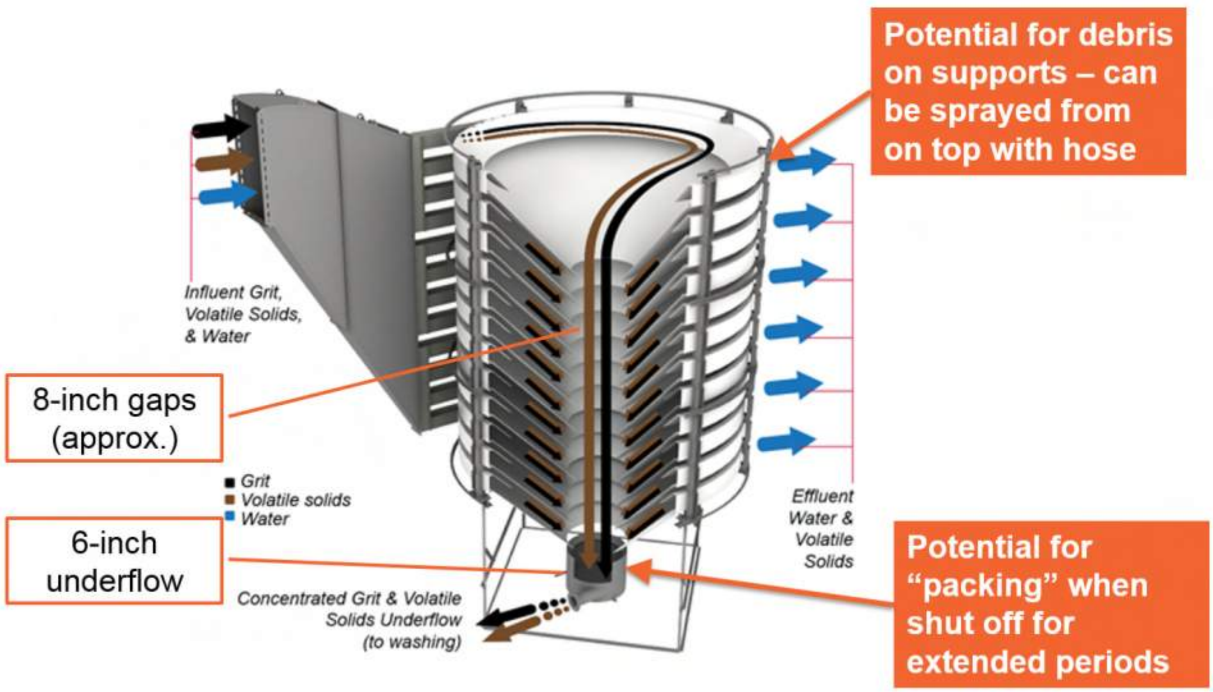

Figure 4-7: Example Stacked Tray Grit Removal System (Courtesy Hydro International)

The number of stacked tray units for varying performance (measured by minimum particle size target, or "cut point") was calculated to meet the peak flow design criteria of firm capacity at 240 MGD, as shown in **Table 4-2.**

Table 4-2: Quantity of 12-ft Diameter Stacked Tray Units to Treat 240 MGD*

	No. of Units for Particle Size Cut Point (95% Removal at 240 MGD)		
No. of Trays/Unit	106 micron	150 micron	212 micron
9	16	10	9
10	14	9	8
11	13	9	7
12	12	8	7

* 240 MGD firm capacity (quantities include one standby)

There is a large increase in the number of units required to meet the 106 micron cut point versus 150 micron. The number of units required is directly proportional to the cost of the facility. Because of the significant increase in number of units required when comparing 106 micron and 150 micron particle size cut points, the 150 micron cut point design standard at peak flow is recommended for implementation. Metro will achieve optimal return for this investment, achieving removal and lower size cutpoints during normal flow and maintaining grit removal of 150 micron particles during infrequent peak flow events.

4.3.2 Grit Washing and Classifying

Several well established alternatives are available for grit washer/classifier systems, all of which generally use a cyclonic flow pattern and screw conveyors for transport of the grit to a dumpster. Hydro International offers the SlurryCup washer/classifier system (see **Figure 4-8**), which is often coupled with their stacked tray grit removal systems. Wemco offers a washer/classifier system (see **Figure 4-9**) that can be coupled with any grit removal equipment.

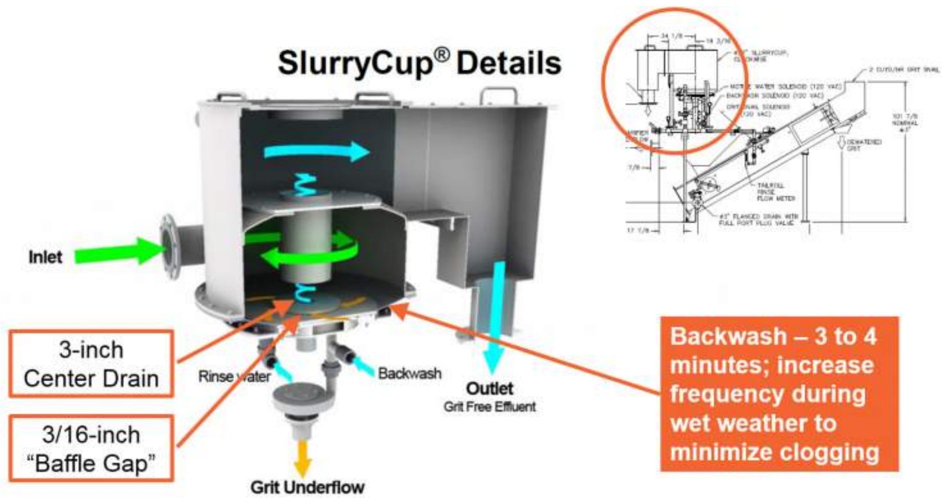

Figure 4-8: Hydro International Washer/Classifier Systems

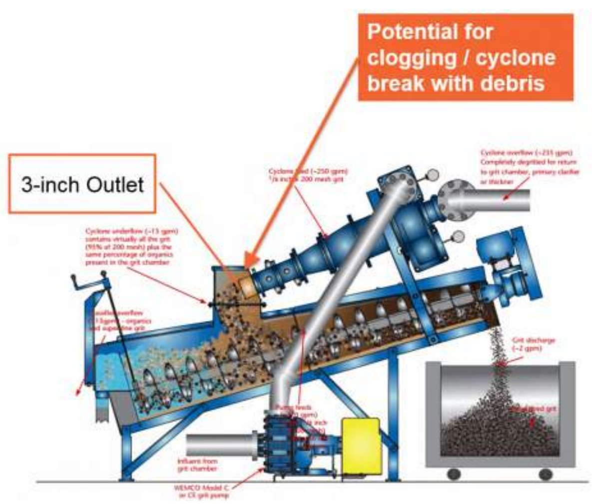

Figure 4-9: Wemco Washer/Classifier System

Because grit removal efficiencies depend on grit recovery in the entire grit treatment train, delinking manufacturer offerings makes performance requirements in grit removal systems difficult to enforce. Use of the Slurry Cup / Grit Snail is recommended to maintain removal efficiencies across the entire grit removal and handling system.

4.4 Odor Control

Because of the proximity of residential properties and other establishments near the CWWTP, odor control for exhaust foul air from the south headworks will be necessary. Metro has contracted with others to perform a plant-wide evaluation of odor control needs, including the south headworks and the other planned improvements. The recommended facilities will include ventilation for both code requirements and personnel health and safety for each facility area. Coordination of final odor control system requirements and associated connections will be coordinated during detailed design.

5. Alternatives

5.1 Overview

A total of six alternatives were evaluated in the south headworks workshops, and four alternatives were eliminated from detailed consideration in a series of workshops prior to the BODR. Alternative Nos. 2, 3 which include coarse screening (Alternatives Nos. 2 and 3) and grit removal (Alternative No. 3) in a new facility were selected for further evaluation and are presented below in further detail. Information on alternatives 1, 4, 5, and 6 are contained in project meeting minutes and related correspondence. Input from the CMAR on potential costs and feasibility of these options will be used by Metro to determine the final selected alternative for implementation.

5.2 Alternative No. 2 – New Coarse Screening Facility

Alternative No. 2 includes construction of a new coarse screen facility upstream of the existing south grit facility. A list of major equipment is presented in **Table 5-1**, a process schematic of this Alternative is shown in **Figure 5-1**Error! Reference source not found., and a conceptual site layout is shown in **Figure 5-2**. The CPS FMs will discharge to the coarse screen influent channel. Provisions will be included for discharge to a future rock trap upstream of the coarse screens. Bypass of the existing screening channels will be possible under emergency situations to the proposed EQ in the existing SATs and FSTs.

Screened influent will be conveyed to new grit removal at the existing south grit facility. The existing east/west screens upstream of the existing grit chambers will be removed, and the existing three aerated grit chambers will be retrofitted with stacked tray grit removal units. Downstream of grit removal, the abandoned climber screens will be replaced with fine screens (1/4-inch openings). Modifications to the existing grit facility and the retrofit of the existing screening facility with fine screens are covered in TM 3A.

Normal operation will include coarse screening and grit removal for all south plant flow, and fine screening for all flows during dry weather and a portion of the flow under peak flow conditions.

Table 5-1: Alternative No. 2 List of Major Equipment

Equipment	Quantity
Multi-rake Coarse Bar Screens with 1/2-inch Openings (with one channel with manual bar rack)	5
Cleated Belt Conveyor (individual small dumpsters for backup)	1
Bridge Crane	1
Stacked Tray Grit Removal (Placed in existing aerated grit channels)	9*
Fine Screens with 1/4-inch Openings (Installed in existing screening facility)	3*

*Details presented in TM 3A and 3B

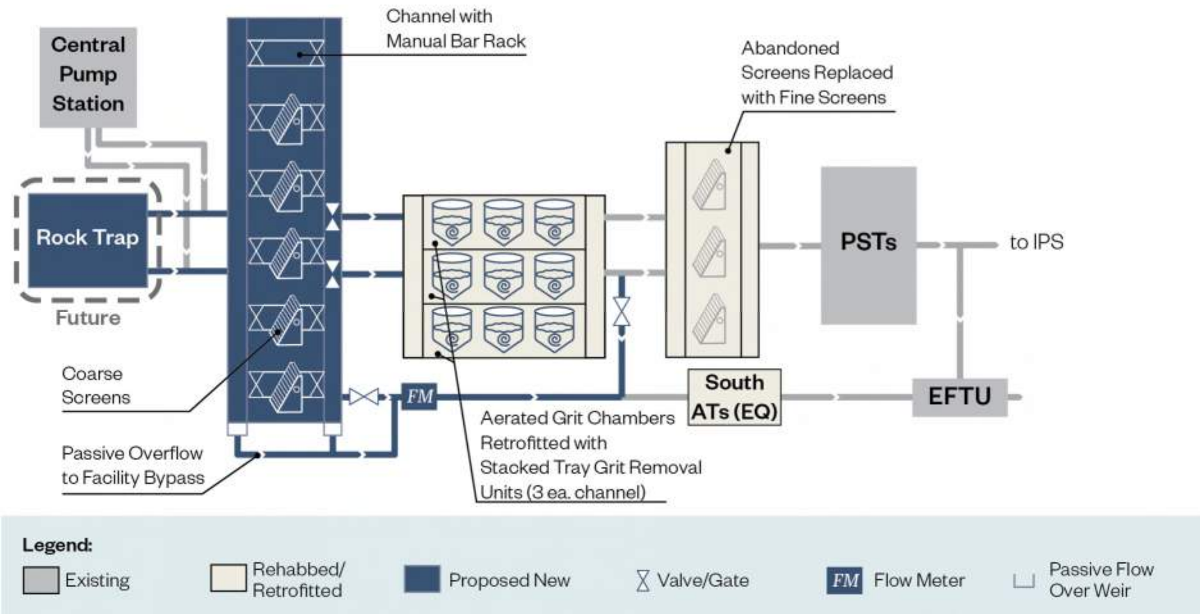

Figure 5-1: Alternative No. 2 Schematic

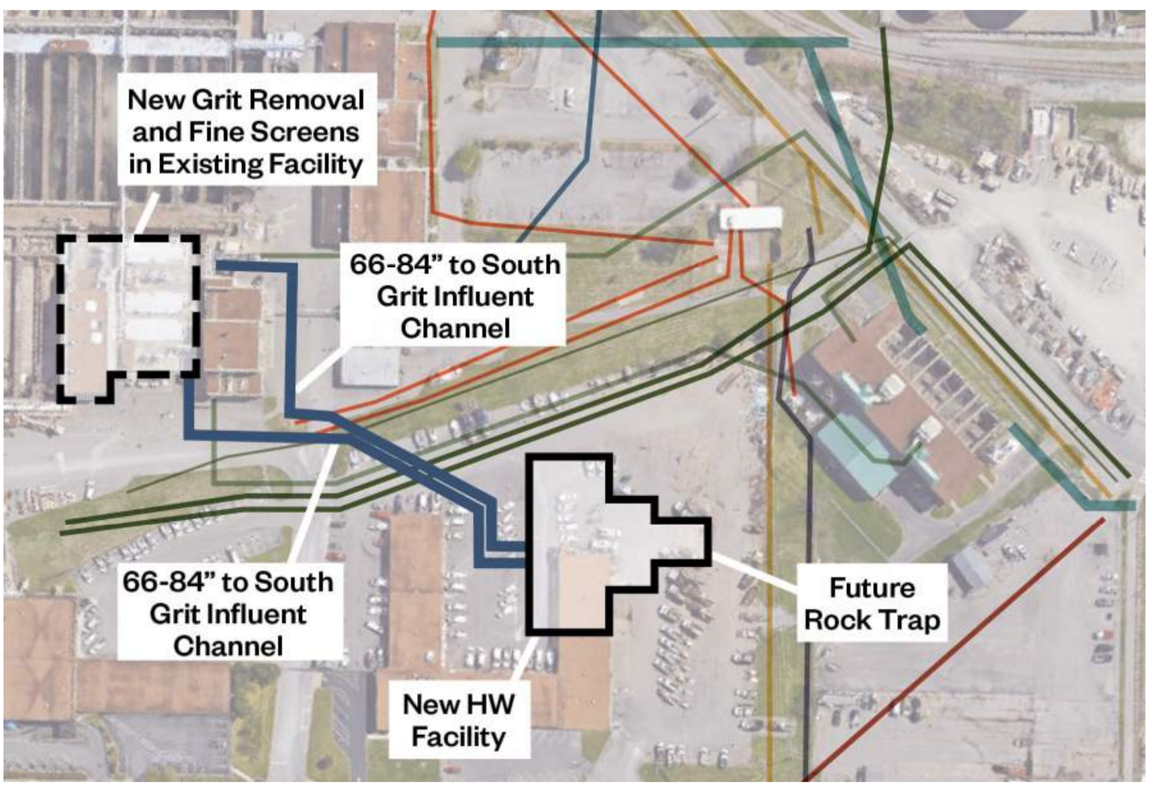

Figure 5-2: Alternative No. 2 Conceptual Site Layout

5.2.1 Process and Operation

The proposed facility includes five multi-rake bar screens with 1/2-inch openings and a rated capacity of 60 MGD each with a bypass channel sized to accommodate a future screen. This bypass channel will include a manually-cleaned coarser bar rack to prevent large debris from continuing to downstream processes when in use.

Flow to the five multi-rake bar screens will be automatically controlled with electrically-actuated open/close sluice gates. In addition to isolation gates, each channel will also be provided with stop log grooves to allow isolation for maintenance. During typical dry weather flows (approximately 30 MGD), only one screen will likely be in operation. The SCADA system will be programmed to alternate which screen is in “lead” operation on a time basis, to allow for even wear among the equipment. The screens will be provided with differential level sensors that can be used to control frequency/speed of the cleaning rakes and call additional screens to operate (by opening the appropriate sluice gates) as flows increase.

5.2.2 Facility Layout

A layout of the proposed facility is included in **Figure 5-3**. The layout will include space for the rock trap to allow its construction in the future.

The bypass channels/pipes will have adjustable weirs to allow passive overflow during a backup or high flow event. Each screen channel is sized to handle up to 60 MGD without exceeding the specified velocity between the bars, allowing for a firm coarse screening capacity (with one multi-rake bar screen out of service) of 240 MGD.

Truck access is shown on the west side of the facility to allow removal and replacement of the screenings dumpster. This side of the facility will be accessed for removal of the material via one of the 3rd Avenue gates. Further analysis of vehicle access and site traffic will be conducted during detailed design; sufficient space is provided for vehicle access to the remove screenings on either the east or west side of the facility.

The electrical room will be provided with a separate exterior entrance and exit doors to maintain a physical separation from the Class 1, Division 1 explosion hazard screening area. If sufficient wall space is available, a viewing window to the screening area will be provided for visual communication between personnel in the screen room and the electrical room. Ventilation of the screening area to Class 1, Division 2 will be further evaluated during detailed design.

Solid non-slip tread plates will cover the screen channels to allow safe personnel access throughout the facility while maintaining a separate headspace for reduced odor control volumes. Monorails and davit cranes, or a bridge crane will be included to move portable screenings containers (in the event of a conveyor outage or overload), stop logs, and other equipment.

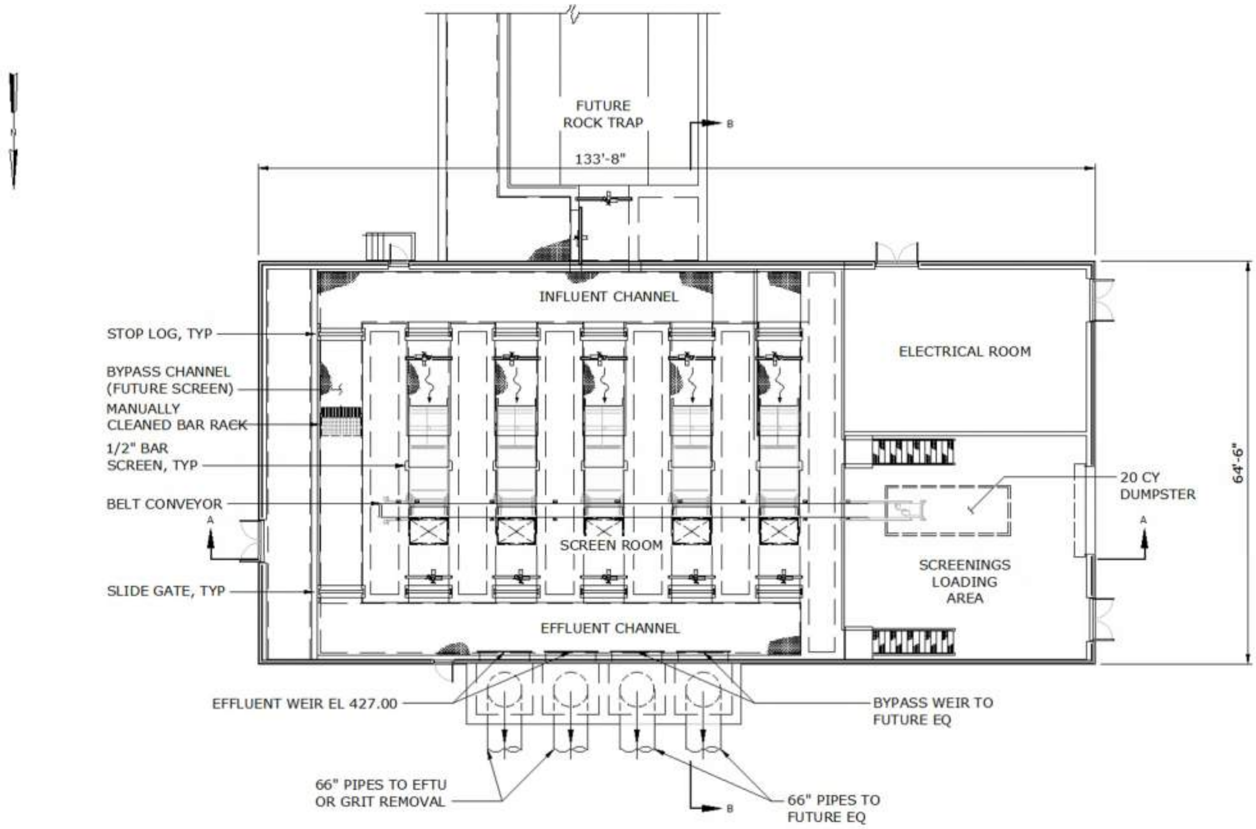

Figure 5-3. Alternative No. 2 Facility Layout

5.2.3 Hydraulics

During typical dry weather flows, one screen will be in service to maintain minimum velocities greater than 1 foot per second (FPS) and excessive settling of material. The facility layout includes dual 66-inch diameter pipes conveying flow downstream. If excessive conflicts with existing utilities will preclude construction of two large diameter pipes from the headworks facility, a single larger pipe (likely 84-inch diameter) will be considered. Due to low minimum velocities in a single pipe, cleaning on a periodic basis may be required. The downstream piping alignment and sizing will be further evaluated during design.

The hydraulic elevations shown in **Figure 5-4** were calculated based on the dual 66-inch pipes with approximate alignments as shown in **Figure 5-2**, assuming a downstream WSE of 422 ft, (see Section 3.3).

The influent and effluent channels both have widths of 8 ft, and fillets have been shown as a measure to prevent settling of material during low flows. Mixing and/or aeration will be evaluated during detailed design to keep material in suspension.

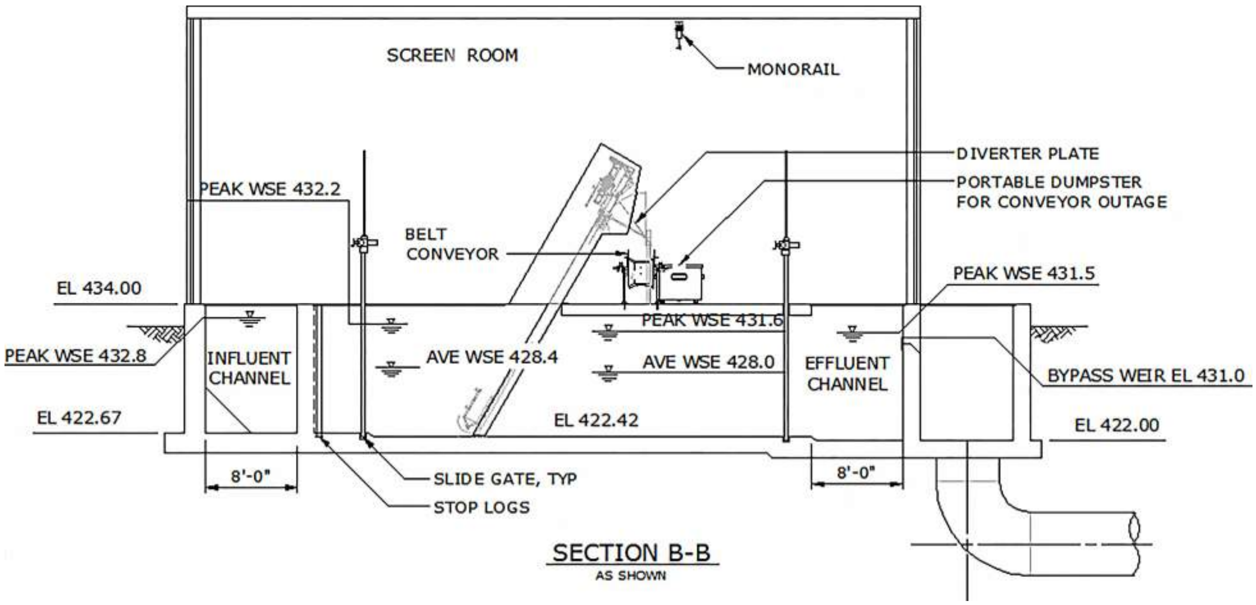

Figure 5-4. Alternative 2 Facility Section with Initial Hydraulic Elevations

5.2.4 Constructability

The proposed headworks with coarse screening can be constructed while existing facilities remain on line at the recommended location. The south wing of the existing system services building will require demolition prior to construction. The current uses for the remainder of the building and its impacts on accessibility for construction and operation of the headworks facility will be further evaluated during detailed design.

Constructability of installation of the stacked tray grit units and fine screens is more complicated than construction of the new facility. Input on constructability will be obtained from the CMAR contractor prior to final decision on implementation. The retrofits of both the existing aerated grit facility and the existing screening building are described in TM 3A and 3B.

Installation of the downstream piping to the south grit facility will be challenging due required crossing of the large Brown's Creek FMs and electrical duct banks (see **Figure 3-7)**, as well as smaller utilities that will likely be rerouted. Key pipe crossings and tie-ins may require shutdowns of existing facilities. These shutdowns, and coordination of construction to maintain plant operations will be further evaluated during detailed design.

5.3 Alternative No. 3 – New Coarse Screening and Grit Removal Facility

Alternative No. 3 includes construction of a new coarse screening (1/2-inch openings) facility with stacked tray grit removal. A list of major equipment is presented in **Table 5-2**, a process schematic of this alternative is shown in **Figure 5-5**, and a site layout is shown in **Figure 5-6**. The CPS FMs will discharge to the coarse screen influent channel. Provisions will be included for discharge to a future rock trap upstream of the coarse screens.

The existing east/west screens upstream of the existing grit chambers will be removed, and the existing three aerated grit chambers will be converted to flow-through channels to fine screening. Downstream of grit removal, the abandoned climber screens will be replaced with fine screens (1/4-inch openings). Modifications to the existing screening facility are covered in TM 3A.

Normal operation will include coarse screening and grit removal for all south plant flow, and fine screening for all flows during dry weather and a portion of the flow under peak flow conditions.

Table 5-2: Alternative No. 3 List of Major Equipment

Equipment	Quantity
Multi-rake Coarse Bar Screens with 1/2-inch Openings (with one channel with manual bar rack)	5
Cleated Belt Conveyor (individual small dumpsters for backup)	1
Bridge Crane	1
Stacked Tray Grit Removal (Placed in existing aerated grit channels)	8
Fine Screens with 1/4-inch Openings (Installed in existing screening facility)	3*

*Details presented in TM 3A

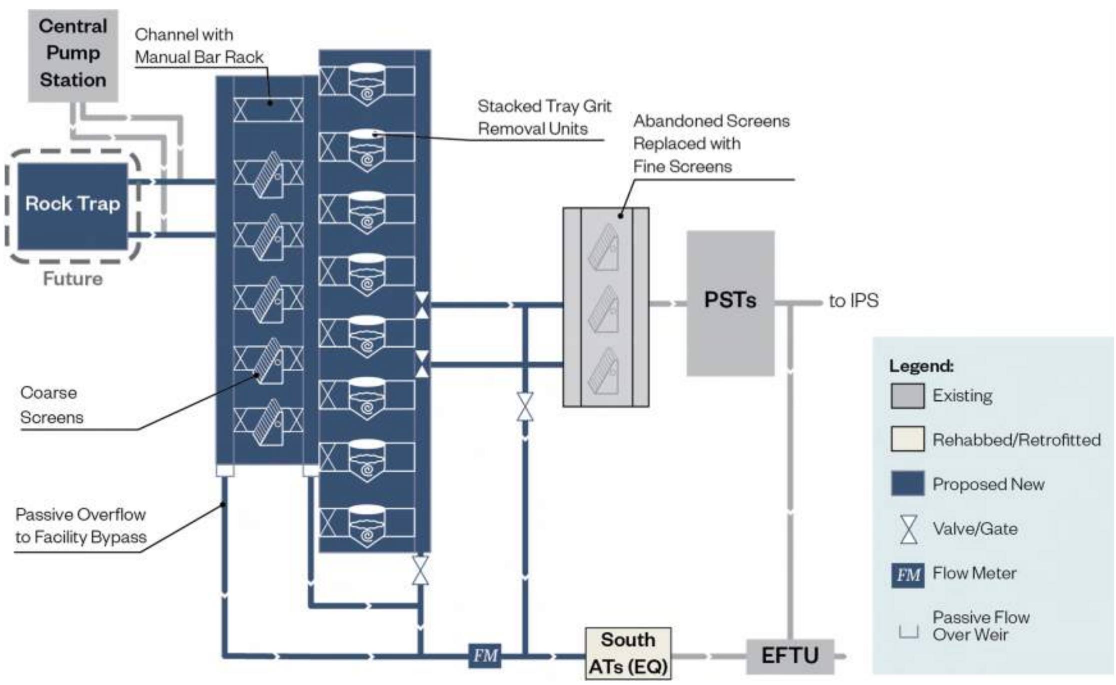

Figure 5-5: Alternative 3 Schematic

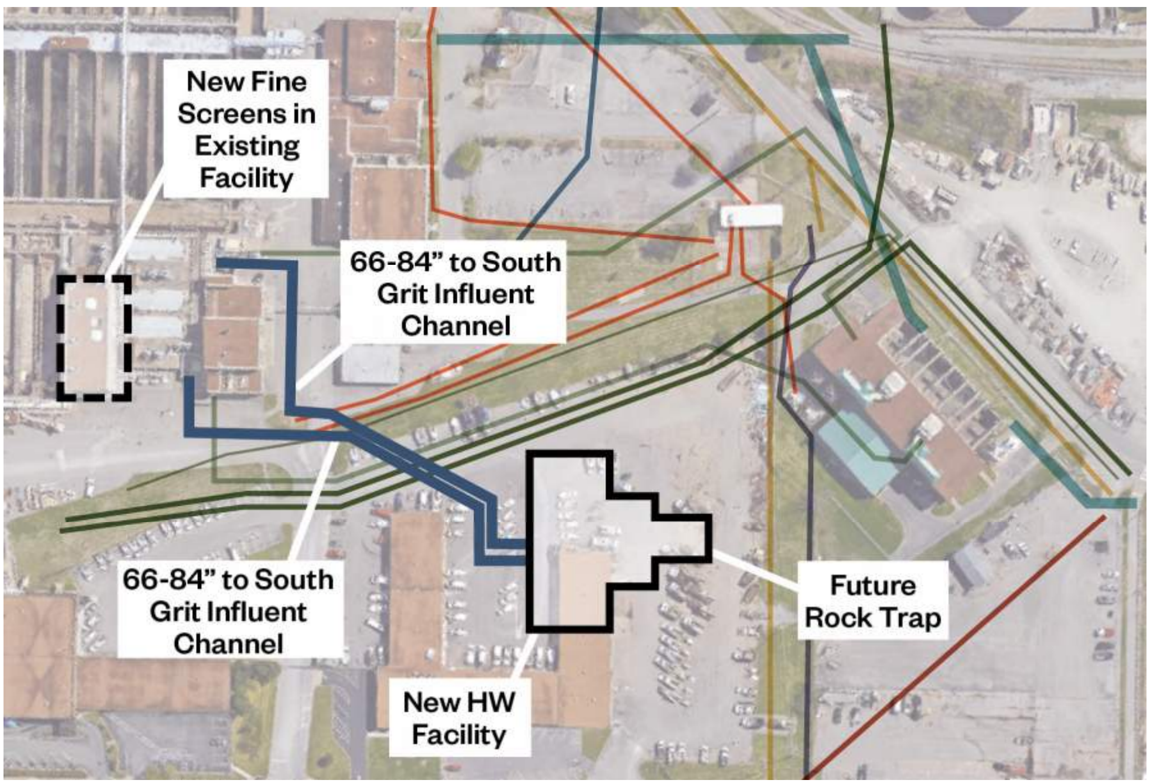

Figure 5-6: Alternative No. 3 Site Layout

5.3.1 Process and Operation

The proposed coarse screening facility includes five multi-rake bar screens with 1/2-inch openings and a rated capacity of 60 MGD each with a bypass channel sized to accommodate a future screen. This bypass channel will include a manually-cleaned coarse bar rack to prevent large debris from continuing to downstream processes when in use. The coarse screening facility will be designed to operate as described for Alternative 2.

Alternative 3 also includes eight stacked tray grit removal systems. Each stacked tray grit system will include a dedicated grit pump in the lower level of the facility to convey the settled grit slurry to four dedicated grit concentration / washing units. The grit concentrators will be mounted in 2-to-1 arrangement on the four grit washing dewatering screws, which will discharge washed and dewatered grit to two 20 CY dumpsters.

Flow to these units will be controlled automatically based on level in the intermediate channel upstream of grit removal, similar to the screen flow control. During typical dry weather flows (approximately 30 MGD), only one or two grit removal systems will likely be in operation. The SCADA system will be programmed to alternate which system is in "lead" operation on a time basis, to allow for even usage among the equipment. As flow increases and the channel level rises, additional grit units will be called into operation by opening the upstream slide gates. As flow decreases, units will be isolated and drained with their respective grit pumps. Occasional maintenance will be needed after draining the units to keep rags and debris from building up between the trays and generating odors. In particular, the support rungs around the outside of the trays tend to collect rags over time and will require cleaning.

5.3.2 Facility Layout

A layout of the proposed facility is included in **Figure 5-7**. The layout will include space for a rock trap to allow its construction in the future.

The bypass channels and pipes will have upstream adjustable weirs to allow passive overflow during a backup or high flow event. Each screen channel is sized to handle up to 60 MGD without exceeding the specified velocity between the bars (as discussed in Section 4.2.2), allowing for a firm coarse screening capacity (with one multi-rake bar screen out of service) of 240 MGD. Similarly, each grit system is designed to handle up to approximately 35 MGD with 150 micron removal for a firm capacity of 240 MGD.

Truck access is shown on the west and north sides of the facility to allow removal replacement of the screenings and grit dumpsters. Facility access for removal of the material is anticipated to be via one of the 2nd Avenue gates. Further analysis of vehicle access and site traffic will be conducted during detailed design; sufficient space is provided for vehicle access to the remove screenings on either the east or west side of the facility.

The electrical room will be provided with a separate exterior entrance and exit doors to maintain a physical separation from the Class 1, Division 1 explosion hazard screening area. If sufficient wall space is available, a viewing window to the grit removal area will be provided for visual communication between personnel in the screening and grit room and the electrical room. Ventilation of the screening area to Class 1, Division 2 will be further evaluated during detailed design.

Solid non-slip tread plates will cover the screen channels to allow safe personnel access throughout the facility while maintaining a separate headspace for reduced odor control volumes. A bridge crane will be included to move portable screenings containers (in the event of a conveyor outage or overload), stop logs, cover plates, and other equipment.

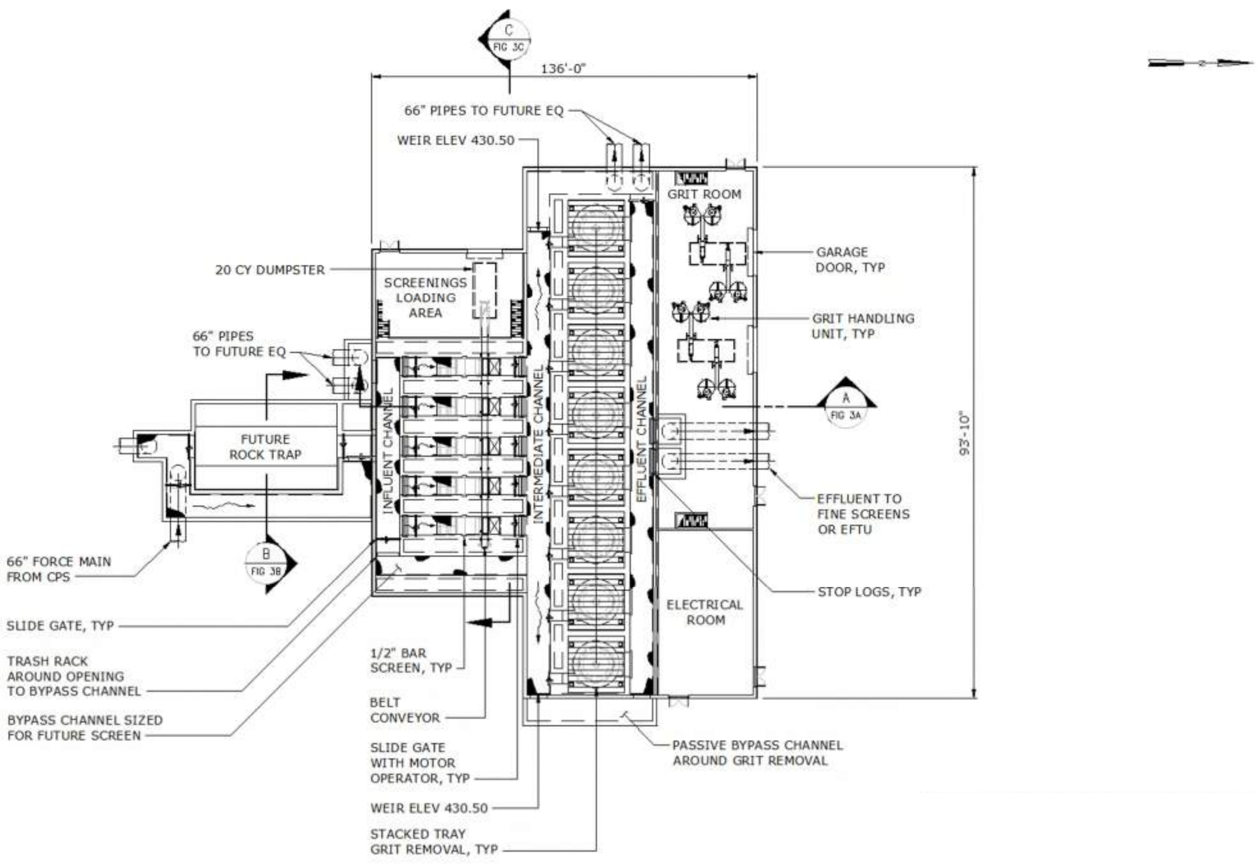

Figure 5-7. Alternative 3 Facility Layout

5.3.3 Hydraulics

During typical dry weather flows, only one screen will be in operation to prevent velocities of less than 1 FPS and excessive settling of material. WSEs are critical to proper operation of the stacked tray grit systems. In order to accommodate the required capacities without compromising performance, the peak

WSE should be no more than twelve inches above the top of the grit tank. Downstream weirs will be used to maintain this evaluation. However, these weirs also impart a significant hydraulic head loss through the grit removal systems, so the units must be lowered significantly from the upstream channels, which requires a deeper excavation than Alternative 2 as shown in **Figure 5-8**.

The hydraulic elevations shown in **Figure 5-8** were calculated based on dual 66-inch pipes with approximate alignments as shown in Error! Reference source not found.**6**, assuming a downstream WSE of 422 ft. (see Section 3.3)

The influent and effluent channels both have widths of 8 ft, and fillets have been shown as a measure to prevent settling of material during low flows. Mixing and/or aeration will be evaluated during detailed design to keep material in suspension.

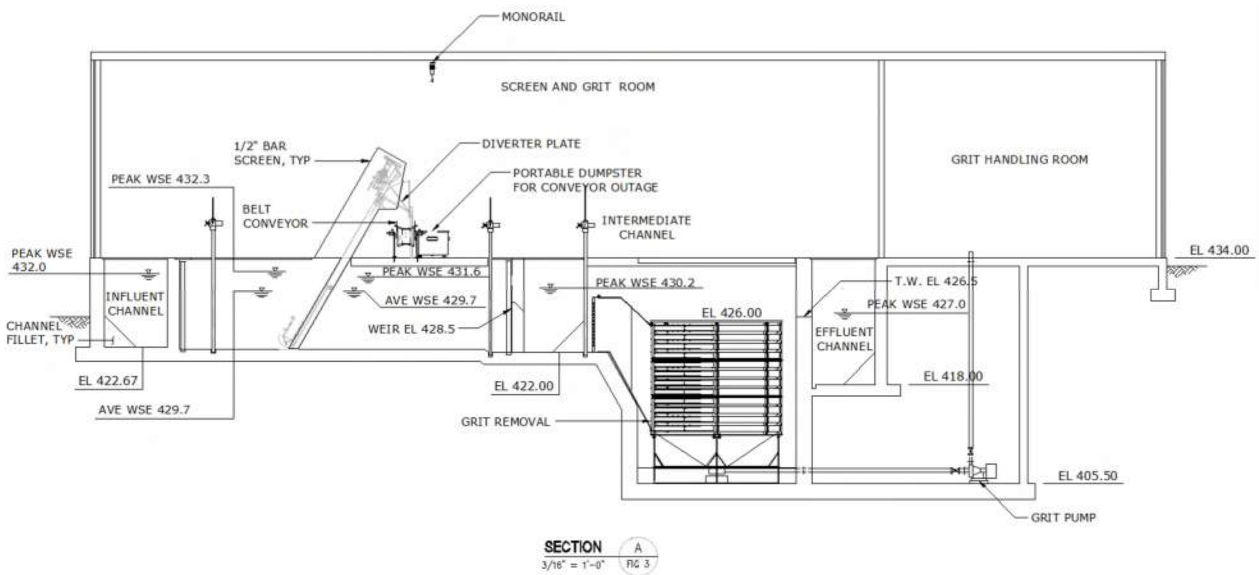

Figure 5-8. Alternative 3 Facility Section with Initial Hydraulic Elevations

5.3.4 Constructability

The proposed headworks with coarse screening and grit removal can be constructed while existing facilities remain on line at the recommended location. The south wing of the existing system services building will require demolition prior to construction. The current uses for the remainder of the building and its impacts on accessibility for construction and operation of the headworks facility will be further evaluated during detailed design.

The constructability of retrofitting the existing facilities with fine screens is more complicated than construction of the new facility. The retrofit portions of the existing screening building is described in another TM.

Installation of the downstream piping to the south grit facility will be challenging due required crossing of the large Brown's Creek FMs and electrical duct banks, as well as smaller utilities that will likely be rerouted. Key pipe crossings and tie-ins may require shutdowns of existing facilities. These shutdowns, and coordination of construction to maintain plant operations will be further evaluated during detailed design.

5.4 Consideration of Non-Cost Factors

The Project Team assessed Alternatives 2 and 3 using the Envision Rating System framework. This rating system divides the spectrum of sustainable practices into readily quantifiable metrics and is comprised of sixty discrete credits, classified within the following five broad categories:

- **Quality of Life:** Purpose, Community, Wellbeing
- **Leadership**: Collaboration, Management, Planning
- **Resource Allocation**: Materials, Energy, Water
- **Natural World**: Siting, Land and Water, Biodiversity
- **Climate and Risk**: Emissions, Resilience

Each alternative was ranked in terms of sustainability (with 1 being less sustainable and 2 being more sustainable) and then weighted based on the maximum score available for each Envision credit. This evaluation included only those credits within each category that were applicable and did not include credits where each alternative was considered to be equivalent in terms of sustainability. Since the two alternatives represent a small portion of the overall project, a limited number of credits were considered.

Quantitative factors, such as estimated materials of construction and pumping requirements were used to estimate greenhouse gas emissions from each alternative. Qualitative factors, such as configuration, accessibility and flexibility were used to assess safety, reliability and resiliency. Alternative 2 received a weighted score of 153 while Alternative 3 received a weighted score of 158. Alternative 2 was estimated to use less raw materials, more effectively integrate infrastructure and have lower potential for noise beyond the plant perimeter. Alternative 3 was estimated to have lower greenhouse gas emissions due to lower pumping requirements and to provide more flexibility for future expansion. A summary table of this evaluation is included in Appendix A.

6. Recommendations

6.1 Recommended Alternatives

A recommended alternative will be selected and identified in the final BODR. For comparison, **Table 6-1** presents a summary of Alternatives No. 2 and 3.

Table 6-1. Summary of South Headworks Alternatives No. 2 and 3

	Alternative No. 2	Alternative No. 3
Description	New Coarse Screen Facility	New Coarse Screen and Grit Facility
Unit Processes in New Facility (240 MGD Firm Capacity throughout)	**Coarse Screens** • 5 units with 1/2-inch openings	**Coarse Screens** • 5 units with 1/2-inch openings **Stacked Tray Grit Removal** • 8 units with 150 micron particle size cutpoint
Unit Processes in Existing Facilities (Costs presented in separate TM)	**Stacked Tray Grit Removal** • 8 units with 150 micron particle size cutpoint **Fine Screens** • 3 units with 1/4-inch openings	**Fine Screens** • 3 units with 1/4-inch openings
Advantages	Reuse of existing facilities	Reuse of existing facilities (fine screening facility only) One location for coarse screenings and grit collection
Disadvantages	Multiple locations for screenings and grit collection No grit removal prior to future CPS EQ	Multiple locations for screenings and grit collection

*NOTE: Opinions of probable construction cost are shown in the cost summary section.

6.2 Key Issues and Decisions

The following key issues need to be resolved or confirmed in order for the project team to provide a recommendation for an alternative to be the basis of design:

1. South headworks facility Alternative Nos. 2 and 3: Although cost is a major factor, constructability and operability of both new and retrofit facilities should be considered. The CMAR is expected to provide input regarding construction complexity and maintenance of plant operations (MOPO) during construction for the alternatives.

2. Type and sizing of odor control system: An odor control "master plan" for the CWWTP is expected to incorporate the design criteria for the new south headworks facility. The foul air from south headworks could either be routed to a centralized odor control facility, or the south headworks facility could have its own dedicated system.

3. Routing of traffic to and from the south headworks facility, particularly for removal of screenings and grit: Coordination with other facilities on the CWWTP site is needed to ensure that the configuration of the new facilities is optimized for plant traffic flow.

4. Ability to demolish the south wing of the systems services building: confirmation is needed to (at a minimum) define the design constraints for Alternative No. 2, and determine the viability of Alternative No. 3.

5. CPS hydraulic capacity: Because the south headworks has a direct impact on the operating conditions of the CPS pumps, confirmation of the pumping capacity must be confirmed to ensure that any new facility isn't imposing an unexpectedly high head condition. The selection of a south headworks alternative will also impact this issue.

Appendix A: Non-Cost Evaluation Factors

Potential Envision Credits for Comparison

Credit	Intent	Project Specific	Max Points Available	Fraction Multiplier	Comparison Within Credit	Relative Ranking		Envision Score	
						Alternative 2	Alternative 3	Alternative 2	Alternative 3
QL2.1 Enhance public health and safety	*Take into account the health and safety implications of using new materials, technologies or methodologies*	*Assess potential safety risks to workers for each configuration during construction and operation.*	16	0.5	any operator safety issues would likely be reduced with a new coarse screening and grit facility as opposed retrofitting the existing grit removal facility.	1	2	8	16
QL2.2 Minimize noise and vibration	*Minimize noise and vibration generated during construction and in the operation of the constructed works*	*Identify potential sources of vibration and noise during construction and operation for each alternative*	11	0.5	A3 would result in more equipment being located near the perimeter of the plant site.	2	1	11	5.5
QL2.6 Improve site accessibility, safety and wayfinding	*Improve user accessibility, safety, and wayfinding of the site*	*Identify access routes during construction and operation. Assess potential configuration and pedestrian/worker conflicts*	15	0.5	Contractor access for A2 must avoid existing channels, transformers and piping. During operation A2 will require two access points for residuals removal.	1	2	7.5	15
LD2.2 Improve infrastructure integration	*The project accounts for the operational relationships among other elements of infrastructure to improve efficiency and effectiveness*	*Consider level of existing infrastructure reused/restored. Consider impacts to other adjacent infrastructure*	16	0.5	A2 includes retrofitting the existing grit facilities so it has an efficiency in materials usage	2	1	16	8
LD3.1 Plan for long-term monitoring and maintenance	*Project elements that ensure that the design performance will be maintained throughout the design life of the project*	*Identify maintenance requirements and potential opportunities for backsliding.*	10	0.5	Maintenance requirements for both alternatives would be similar. However a the grit pumps would be more accessible with A3 since it is new construction	1	2	5	10
LD3.3 Extend useful life	*The project is designed to be more durable, flexible and resilient*	*Assess the flexibility to enable refurbishment and reconfiguration.*	12	0.5	A3 has more flexibility for future refurbishment and reconfiguration	1	2	6	12
RA1.1 Reduce Net Embodied Energy	*reducing the net embodied energy of project materials over the project life*	*Estimate the LCA of the major components of each alternative.*	18	0.5	A2 estimated to use less materials & have approximately 73 % lower CO_2eq than A3.	2	1	18	9
RA1.3 Use Recycled Materials	*The project includes materials that are reused or recycled*	*Estimate the amount of recycled, reused including existing structures on site.*	14	0.5	A2 will reuse piping and existing structure.	2	1	14	7
RA1.6 Reduce Excavated Materials Taken off Site	*Minimize the movement of soils and other excavated materials off site to reduce transportation and environmental impacts*	*Estimate the amount of demolition materials generated and transported off site*	6	0.5	A2 demolish exisiting grit tanks and structure for retrofit, all of grit handling equipment in existing building to make room for slurry cup/grit snails; only reuse soil - 20% of total ; A3 demolishes part of existing grit tanks to create a bypass channel & existing grit handling equipment; assume 40 % of soil/rock will be reused on-site; assume no other construction debris to be reused	1	2	3	6
RA2.1 Reduce energy consumption	*Conserve energy by reducing overall operation and maintenance energy consumption throughout the project life cycle*	*Estimate the energy used throughout the useful life of the project.*	18	0.5	A2 will use 33 % less energy for pumping that A3	2	1	18	9
NW1.4 Avoid adverse geology	*Avoid development in adverse geologic formations and safeguard aquifers to reduce natural hazards risk and preserve high quality groundwater resources*	*Based on the geotechnical evaluation, identify level of mitigation (if any) needed to implement the project.*	5	0.5	A2 requires more extensive structural support due to depth of tanks.	1	2	2.5	5
NW2.1 Manage stormwater	*impact of infrastructure on stormwater runoff quantity and quality*	*Identify opportunities to reduce stormwater runoff. Note any estimated increase in impervious area*	21	0.5	Don't expect any additional impervious area. However, the area of disturbance during construction will be greater with A3	2	1	21	10.5
CR1.1 Reduce Greenhouse Gas Emissions	*life-cycle carbon analysis to calculate the anticipated amount of net greenhouse gas emissions during the life cycle of the project*	*Use estimates from RA1.1 and RA2.1 plus any other potential GHG sources and sinks.*	25	0.5	Over 20 years , A3 is estimated to have approximately 27 % less GHG emissions than A2	1	2	12.5	25
CR2.2 Avoid traps and vulnerabilities	*Avoid traps and vulnerabilities that could create high, long-term costs and risks for the affected communities.*	*Identify potential design condition changes and the impact to project configuration.*	20	0.5	Should expansion of the headworks be necessary in the future, A3 would be considered more flexible.	1	2	10	20
			Total Envision Score					**152.5**	**158**

Technical Memorandum

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Prepared for: Metro Water Services

Project Title: Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Project No.: 148388

Technical Memorandum No. 3A

Subject: North and South Fine Screening

Date: December 21, 2016

To: Trey Cavin, Metro Water Services

From: Tazio Qubeck, Brown and Caldwell

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Executive Summary

The objective of this Technical Memorandum (TM) is to present the basis of design for the north and south fine screening at the Central Wastewater Treatment Plant (CWWTP) for the CWWTP Improvements & CSO Reduction project (COPT Project).

Supplemental to this TM are the previous TMs that were performed by Brown and Caldwell (BC) as a part of the Central Optimization Study Project (COPT Study). These TMs form an integral part of the basis of design report (BODR) and are referenced throughout this document. The basis of design for each screening area (north and south) includes screening system improvements which are discussed independently within this summary TM.

The major proposed improvements for the north and south screening are generally as follows:

North Fine Screening Facility Proposed Improvements:

- Construct a new 200 million gallons per day (MGD) north fine screening facility that will include fine screening, compaction and screenings removal for flows entering CWWTP from Browns Creek Pump Station (PS) and 28th Avenue PS.
    - Six, ¼-inch perforated plate or multi-rake screens with an inclination angle of 70 degrees
    - Dual sluiceway screenings conveyance system
    - Three medium size washer/compactor units
- Provide long-term reliable flow measurement for flows entering the north headworks with influent Parshall flumes.
- Re-route Browns Creek PS and 28th Avenue PS forcemains (FMs) to discharge into influent of new screenings influent channel.
- Re-use existing portions of Browns Creek PS dual FMs to route gravity discharge the screened effluent to the upgraded north grit facility with stacked-tray vortex grit removal system.
- Provide means for passive fine screen bypass and separate full fine screening facility bypass to facilitate maintenance.
- Equally distribute homogenous screened influent wastewater to the north grit removal system.

South Screening Facility Proposed Improvements:

- Construct a new 160 MGD screening system in the abandoned screening structure downstream of the aerated grit removal tanks:
    - Three, ¼-inch perforated plate or multi-rake fine screens with inclination angle of 70 degrees;
    - Dual sluiceway screenings conveyance system; and,
    - Two medium size washer/compactor units.
- Provide means for passive screen bypass if required for maintenance or screen capacity exceedance.

These improvements are recommended to increase solids capture, protect downstream equipment and processes from damage and debris collection, and minimize equipment and system maintenance. Additional information about the evaluations performed to determine the recommended improvements can be found in supplemental design information.

Section 1: Process Area Description

Figure 1-1 portrays an aerial site plan of the CWWTP with the existing and proposed north and south screening facilities highlighted to illustrate the area evaluated in this TM.

Figure 1-1. Location of North and South Fine Screening Facilities at CWWTP

Existing North Screening

Wastewater flow enters each end of the existing CWWTP north headworks influent channel from the Browns Creek PS and the 28th Avenue PS. The north treatment train does not process flow from the combined sewer unless flow is diverted from the south to the north during dry weather or system maintenance. No screening currently exists at the north headworks. However, each of the PSs transporting wastewater to the north treatment train have 1-inch coarse screens. A gate located at the midpoint of the influent channel separates the channel into two sections with access to aerated grit removal tank numbers 1 and 2 or 3 and 4. The gate allows control of flow from each end of the channel to allow flow modulation or isolation. Flow from the influent channel proceeds into four aerated grit removal tanks.

Existing South Screening

Wastewater flow from a combined sewer collection system enters the CWWTP south headworks via the central pump station (CPS). The flow passes through two 1-inch multi-rake screens located at the east and west ends of the aerated grit removal tank influent channel. The aerated grit removal tank influent channel leads to three aerated grit removal tanks with dimensions and layout identical to those at the north headworks with the exception of some internal baffling. Effluent from the aerated grit removal tanks flows into a common discharge channel and then passes through an abandoned screening structure equipped with three climber bar screens that are out of service and non-operational. The flow is routed through a parallel bypass channel within the abandoned screening structure. The abandoned screening structure contains 3, 6-feet (ft) wide, 16.25-ft deep screening channels, a bypass channel, skylight hatches for screen removal, and manually operated channel isolation gates. The abandoned screening structure is fully enclosed and has an odor control system in place.

Section 2: Design Intent

Improvements to the north and south screening facilities are focused on installing an efficient and reliable screening system, while meeting the requirements of the COPT Study to maximize wet weather capacity. Modifications to the existing facilities will be critical to the success of minimizing maintenance issues in downstream process areas. Existing structures should be reused whenever feasible.

The following list represents the overall design intent for the recommended improvements associated with installation of the north fine screening facility:

- Influent Parshall flumes will be constructed ahead of new fine screens in order to provide reliable flow measurement and equally split influent flow to the new screening channels.
- Fine screening facility will be installed to provide greater solids capture efficiency and protect the rehabilitated downstream grit removal system.
- Screening conveyance, washer/compactor units and disposal systems will be installed to properly wash and dispose of raw screenings.

The following list represents the overall design intent for the recommended improvements to the south screening system:

- Demolish existing 1-inch multi-rake screens and conveyors installed upstream of the existing aerated grit tanks. Coarse screens with 1/2-inch maximum openings will be constructed in the new south headworks structure, upstream of the grit removal system. See TM 2 – South Headworks.
- Demolish abandoned 1-inch climber screens and conveyors in abandoned coarse screening building located downstream of the existing aerated grit tanks.
- Retrofit new fine screens into existing abandoned screening channels to provide greater capture efficiency and protect downstream processes. A cursory review of potentially retrofitting the existing screening bypass channel to serve as a 4th fine screening channel was performed as part of the BODR evaluations. Due to hydraulic and space constraints and the relatively infrequent need for the additional capacity, modifications required to include a 4th fine screen channel were not recommended, but will be considered if necessary during Phase 2 detailed design.
- Screening conveyance, washer/compactor units and disposal systems will be installed to properly wash and dispose of raw screenings.

Section 3: Constraints

This section describes the constraints associated with implementing the proposed improvements to the north and south screening facilities at the CWWTP as described in this TM.

3.1 Design Criteria

The following section provides a summary of the necessary design criteria that impact the design and implementation of screening facility improvements at the CWWTP north and south treatment trains. COPT Study TM 5.1 - Hydraulic Capacity Assessment and COPT Study TM 5.4 – Process Capacity Assessment and

Alternatives Analysis include a complete design basis for the process design of the proposed fine screening facilities.

3.1.1 Screen Technologies

The type of screen chosen for a particular application will vary depending upon the plant specific objective. Screens chosen to satisfy head loss constraints may differ from those where capture rate alone is the priority. As stated in Section 1, it is the MWS' desire to improve solids capture efficiency utilizing fine screens without adversely affecting downstream process operation. The capture rate, or more appropriately the amount of solids allowed to pass through the screens, impacts the operation of all downstream processes at the CWWTP. Because the screens at the north and south facilities are to be installed within the boundaries of the existing CWWTP system both space limitations and hydraulic constraints play a significant role in the screen technology and aperture size selection, number of screening units, and channel configuration.

Evaluations associated with this BODR resulted in the determination that 1/4-inch perforated plate and multi-rake fine screens would provide a robust system with a high capture rate and reliability. The final screen selection will be made by the project team during Phase 2 detailed design. It is important to note that during Phase 2 detailed design, it may be determined that a different type screening system is more suitable for the south combined sewer system (CSS) than the north system due to the existing wastewater characteristics. Even if this decision is made, installing the same type screens for ease of maintenance will also play an important role in the final selection process. Screen technology evaluations and recommendations can be found in supplemental design information.

3.1.2 Screening Ancillary Equipment

Conveyance System

Screening conveyance systems at the north and south fine screening facilities will be required to transfer raw screenings from the proposed screen discharge points to the proposed washer/compactor units. Operational requirements include redundancy and means of readily cleaning large debris from the system without shutting it down.

It was determined during this evaluation that dual sluiceways capable of receiving screenings from multiple input points would be the preferred method of transferring raw screenings from the screen discharge points to the washer/compactor units at the proposed north and south fine screening facilities. A dual sluiceway in conjunction with diverter gates on screen discharge chutes will provide screening conveyance redundancy and flexibility while minimizing maintenance.

Washer/Compactor Equipment

Washing and compacting the screenings is necessary to provide a product that can be properly and cost effectively disposed within a landfill by removing as much of the organics and water as possible from the screenings before discharging into collection bins for transport to the final disposal location. The final product must have enough water removed to pass a paint filter test for landfill disposal and generally are required to be at least 50 percent solids. Organics and water removed during this process are returned to the sewage flow stream. Operational requirements include redundancy, flexibility, and the desire to minimize maintenance.

The evaluations of potential washer/compactor equipment led to the recommendation that three washer/compactor units be installed within the proposed north screening facility and two washer/compactor units be installed within the existing south screening facility. These proposed washer/compactor units will provide the required capacity, redundancy, and flexibility. Phase 2 detailed design is to include the goal of providing a layout within the existing site constraints, which is particularly an issue at the existing south facility and will minimize and provide efficient access for system maintenance.

Disposal System

Disposal bins containing washed and dewatered screenings discharged from the washer/compactor units are recommended to be of sufficient capacity to minimize hauls to the final disposal location yet be maneuverable within the space constraints of the site. The number and size of disposal bins depends on the selected screening system configuration. The location of the disposal bins should be in a facility designed to control odors, minimize vector attraction, and prevent blowing of screenings from the bin.

Based on preliminary evaluation, it is recommended that three, 20 cubic yard (CY) disposal bins be utilized at the north screening facility and two, 20 CY disposal bins be utilized at the south screening facility. Additionally, it is recommended that a tipping trough be installed on the discharge tube of each washer/compactor unit to equally distribute the washed and compacted screenings the length of the disposal bins.

3.2 Code Considerations

A complete list of all codes used for design will be included in the Code Classification Summary, which will be completed during preliminary design.

3.3 Regulatory Drivers

There are no direct regulatory drivers for the improvements at the north and south screening facilities. Indirectly, the improvements are deemed necessary for continued reliable operation of the CWWTP necessary to meet National Pollutant Discharge Elimination System (NPDES) permit requirements at proposed wastewater flows and loads. Less efficient screening would lead to operations and maintenance issues caused by excessive debris in downstream treatment processes. Additionally, the grit removal technology proposed in TM 3B requires installation of a screen upstream with a maximum opening of 1/2 inch.

3.4 Sequencing and Constructability Issues Affecting Design

The following provides a list of specific sequencing issues and constructability items that will impact the design scope of improvements in this process area. Other COPT project components that affect and require coordination with this process area are included. The overall sequencing plan for this process area is discussed in Section 5 of this TM. These sections will be coordinated with the Construction Manager at Risk (CMAR) during development of the overall site construction sequencing plan.

- It is recommended by the grit system manufacturer that screens with a maximum opening of 1/2-inch should be installed upstream of the proposed grit removal equipment prior to its installation.
- It is recommended that coarse screens be installed upstream of the proposed south fine screening facility to reduce the potential for fine screen blinding with debris from the CSS during wet weather events.

Section 4: Description of Improvements

The following basic improvements are proposed for construction as part of the north and south fine screening improvements scope:

- Construct a new north fine screening facility.
- Install fine screens in the existing abandoned south screening facility.

4.1 Detail Design Considerations and Assumptions

The following sections provide more detailed information on process selections for the general improvements listed above including listing of decision points which need to be addressed prior to moving to the preliminary design phase.

4.1.1 Screen Type and Aperture

Perforated plate screens and multi-rake screens are being considered as screening technologies for the proposed north and south headworks facilities improvements. The aperture size for the screens is proposed to be 1/4-inch (6mm). It is recommended that prior to final selection of screen type and aperture, the team conduct plant site visits and interviews with operations staff.

4.1.2 Screening Facility Washer/Compactor Layout

The proposed north and south screening facilities have the capability to accommodate two large or three medium washer/compactor units given the proposed/existing footprints and required capacities. The selection of the two larger units will allow for a smaller footprint; but, less redundancy. Further evaluation and process layout during preliminary design will affect the decision as to which layout is preferred.

4.1.3 Finalization of Hydraulics

Assumptions made pertaining to downstream water elevations for the north headworks should be revisited during preliminary design. All preliminary hydraulic calculations for the north and south headworks will need to be finalized to confirm potential layouts.

4.2 Process Mechanical

This section summarizes the process mechanical improvements required in junction with the north and south fine screening facility improvements.

4.2.1 Process

North Fine Screening Facility

There is currently no screening facility at the CWWTP for the north treatment train. A new facility will be constructed to install fine screens and associated appurtenances. The screening facility receives flow from the 28th Avenue and Browns Creek PS FMs. The north screening facility will have the capacity to process peak flows of 200 MGD with the proposed improvements depicted below:

- 3 influent Parshall flumes to record and control flow.
- 5 covered fine screens capable of processing 50 MGD each and an overflow bypass.
- Screening channel dimensions to be (L x W x D): 30 ft. x 6 ft. x 12 ft.
- 10 influent and effluent screening channel gates with actuators.
- Aluminum channel covers to contain gasses to minimize odors and maintenance issues related to facility exposure.
- Raw screening dual sluiceway conveyance system.
- 2 screenings washer/compactor units.
- Enclosed building to capture odors and minimize maintenance issues related to weather and pests.
- Odor control system for containment, collection, and delivery to main odor control system provided at plant for multiple processes.

- Electrical and control components.

Table 4-1 summarizes the key design data for the proposed north fine screening facility.

Table 4-1. North Fine Screening Facility – Key Design Data	
Element	**Design**
Capacity	200 MGD Firm, 50 MGD per channel
Influent Parshall Flumes	2 – 8 ft. wide and 1 – 6 ft. wide
Screening Channel Dimensions	30 ft. x 6 ft. x 12 ft. (L x W x D)
Screen Aperture Size	1/4 inch (6mm)
Overflow Bypassing	60-inch Bypass piping
Screen Channel Isolation Gates	2 per channel, plus bypass and effluent channels, 10 total

South Fine Screening Facility

The abandoned south coarse screening facility is to be retrofitted with proposed fine screens. The proposed fine screens shall be installed in the existing screening channels and the retrofitted facility will be capable of screening a peak flow of 160 MGD (firm capacity of 107 MGD). The existing screen bypass channel will remain in place to facilitate routing flows around the fine screens when the available screening capacity is exceeded. The proposed south screening facility improvements will include the following:

- Retrofit of three fine screens with 53 MGD capacity each into existing channels and reuse of existing bypass channel.
- Existing screening channel dimensions (L x W x D): 27 ft. x 6 ft. x 16.25 ft.
- Six influent and effluent screening channel gates with actuators.
- Aluminum channel covers to contain gasses to minimize odors and maintenance issues related to facility exposure.
- Raw screening dual sluiceway conveyance system.
- Two washer/compactor units.
- Odor control system for containment, collection, and delivery to main odor control system provided at plant for multiple processes. Reuse existing ductwork where possible.
- Electrical and control components.

Table 4-2 summarizes the key design data for the south fine screening facility.

Table 4-2. South Fine Screening Facility– Key Design Data	
Element	**Design**
Total Capacity	160 MGD Plus Bypass
Firm Capacity	107 MGD
Existing 10-foot Bypass Channel (to PSTs) Capacity	160+ MGD
Screening Channels	27 ft. x 6 ft. x 16.25 ft. (L x W x D)
Screen Aperture Size	1/4 inch (6mm)
Screen Channel Isolation Gates	2 per channel, 6 total
EFTU Diversion Bypassing	Location and capacity TBD during detailed design

4.2.2 Odor Control

Odor control improvements to be performed as part of the north and south fine screening facility improvements scope are as follows:

- All channels shall be covered for containment with ductwork to odor control treatment unit.
- All equipment installed including screens, sluiceways, and screenings washers/compactors shall be covered for odor containment and include connection for ductwork with negative pressure pulling air to odor control treatment unit.
- All existing and proposed structures shall include ventilation systems, which shall either evacuate air to exterior of structure per NFPA code or ductwork to deliver air to odor control system if it is determined it will be nuisance odor. At this point in design, if all equipment and channels are covered and sent to odor control system as indicated above then ventilation to exterior will suffice. This shall be revisited as the next design phase continues.
- An overall odor control plan for the CWWTP improvements project will be developed to determine if additional odor control capacity is required, where any new units would be constructed, and which units are dedicated to each process area.

4.2.3 HVAC

HVAC improvements to be performed as part of the north and south headworks improvements scope are as follows:

- The proposed north screening facility will require air conditioning in the proposed MCC room to protect the electrical and control equipment. Two air conditioning units will be required to provide redundancy.
- Screening process areas will need to be ventilated per NFPA 820 code requirements for coarse and fine screenings and to provide conditions acceptable for operations and maintenance staff. Existing ventilation systems will need to be reviewed for capacity and condition and the proposed north fine screening facility will need to provide appropriately sized new ventilation systems.

4.2.4 Plumbing

Plumbing improvements to be performed as a part of the north and south fine screening facility improvements scope are as follows:

- Install plumbing including water piping and drains required for proposed fine screens, sluiceways, washer/compactor units, sinks, hose bibs for equipment wash down, and grit classifier and dewatering units.
- It can be assumed that each screening facility will require potable and plant water supplies.

4.3 Instrumentation and Controls

This section presents the equipment instrumentation and control strategies for the north and south fine screening facility improvements. The controls required for the proposed equipment and associated appurtenances will be integrated into the plant's existing SCADA system. These controls will consist of new field instrumentation, control panels, local process graphic screen/database, data collection/trending and reporting as required for a complete system.

New field instrumentation will be provided to measure typical process variables such as level, pressure, flow and miscellaneous analytical measurements as required. Instrumentation with screens located outdoors will include a sun/rain shield and surge protection. Proposed control panels will be vendor control panels (VCPs). The VCPs are supplied as part of the vendor package for the new screening systems, washer/compactor systems, and concentrating and dewatering systems.

Instrumentation requirements for specific process areas and equipment within the proposed north and south fine screening facilities are as depicted in the following sections.

4.3.1 North Fine Screening Facility

- Provide a 4-20 mA control for proposed flume channel isolation gates. Normal operation will be open/close, but 4-20 mA control will allow operations staff to partially open gates and see the gate position from the distributed control system (DCS).
- All normal process-related equipment will be designed to facilitate monitoring and control from the plant DCS. The need to monitor and control infrequently used equipment such as influent channel, screening channel and bypass isolation gates from the DCS will be determined based on discussions with the operations staff during the design phase of the project.
- Influent flow will be measured by level indicators at the Parshall flumes. Flow will be split equally among the screening channels.
- Level indication will be supplied in the common influent channel prior to the Parshall flumes and shall be used to monitor bypass status and serve as back-up flow measurement to indicate need for engaging screening channels as influent flow changes.
- Channel level indicators upstream and downstream of screens will be required by screen manufacturer's. Level shall be transmitted to VCPs and the DCS.

4.3.2 South Fine Screening Facility

- Provide a 4-20 mA control for channel isolation gates. Normal operation will be open/close, but 4-20 mA control will allow operations staff to partially open gates and see the gate position from the DCS.
- All normal process-related equipment will be designed to facilitate monitoring and control from the plant DCS. The need to monitor and control infrequently used equipment such as influent channel, screening channel and bypass isolation gates from the DCS will be determined based on discussions with the operations staff during preliminary design phase of this project.
- Level indication for the common influent channel provided to monitor bypass status and serve as back-up level measurement to engage screening channels.

4.3.3 North and South Fine Screen Control Strategies

As part of Phase 2 detailed design, a life-cycle cost analysis will be performed to determine the most beneficial screening control strategy that balances capacity, efficiency, and operational complexity. The headworks refresh workshop that was led by BC and included MWS on April 12, 2016 presented the description of the proposed north screening control philosophy.

- A level sensor on the inlet and discharge side of the fine screens will be provided to allow the screen to cycle on or off based on differential level. Additional controls for the fine screens will be determined based on discussions with the operations staff during Phase 2 detailed design of this project.
- A timer will be provided in the control panels to serve as a backup to the differential level indicator.
- A high level float switch will be provided in each screening channel that will indicate for the screens to start at high speed.

4.3.4 Sluiceways and Washers/Compactors

The sluiceways and washer/compactor units will be furnished with local control panels provided by the vendor as part of the equipment packages. The DCS system will serve as the master control panel to coordinate required operations.

4.4 Electrical

This section depicts the required electrical work for the north and south fine screening facility improvements:

- Provide power and control wiring to proposed equipment as listed in previous sections. Existing facilities to be reused shall be powered from existing MCCs as appropriate.
- Coordinate with overall plant power evaluation to confirm power source for proposed north fine screening facility. The proposed MCC will house electrical and control equipment.
- Site lighting shall be provided around proposed facilities and where there is insufficient lighting around existing facilities. This shall be coordinated with proposed overall plant site lighting plan.
- Interior lighting improvements for proposed facilities and where upgrades are necessary around existing facilities to be reused.
- Video monitoring of existing and proposed facilities including disposal bins for viewing by DCS.
- Provide power to proposed and existing HVAC equipment.

4.5 Geotechnical

This section presents the required geotechnical scope for the north and south fine screening facility improvements.

- Perform geotechnical investigation at the site proposed for the north fine screening facility in order to provide structural engineer data for foundation design.

4.6 Structural

This section depicts the required structural scope for the proposed north and south fine screening facility improvements.

- Provide design for proposed north fine screening facility with associated influent Parshall flume structure
- Provide foundation design including piles, as needed, for the new fine screening facility.
- Miscellaneous equipment and piping supports.
- Install elevated slab over existing bypass channel opening in existing south screening facility.

4.7 Architectural

This section depicts the required architectural scope for the proposed north and south fine screening facility improvements.

- Provide design for the proposed north fine screening facility
- Final architectural improvements for the proposed upgrades to the existing south screening facility will be determined after inspection by the team architect to insure code compliance and recommended upgrades as necessary for deteriorated finishes. Specific areas to be evaluated include:
  - General aesthetics for facility exterior
  - Building doors
  - Building windows
  - Building louvers
  - Building roof

4.8 Site Civil

The section depicts the required site civil scope for the proposed north and south fine screening facility improvements. No significant site civil improvements will be required for the proposed south fine screen facility improvements because existing facilities will be utilized. The improvements listed below are related to work proposed for the north fine screening facility.

- Demolition of existing structures, pavements and utilities at the proposed north fine screening facility site including, but not limited to:
  - Southern half of the existing warehouse.
  - Concrete storage pad located to the west of the existing warehouse.
  - Asphalt pavement sufficient to locate proposed north fine screening facility and connecting piping.
  - 6-inch potable water line that connects to the southwest corner of the existing warehouse.
  - 3-inch gas line connecting to the south side of the existing warehouse.
  - 4-inch sanitary line that connects to the southeast corner of the existing warehouse.
- Relocation of existing piping at proposed north fine screening facility:
  - 2-inch potable water line at south side of existing warehouse.
  - 6-inch gas line at south side of existing warehouse.
- Possible conflict with existing utilities at proposed north fine screening facility:
  - 2-inch vacuum chlorine gas line and effluent to Browns Creek FMs.
  - 8-inch sludge line and effluent to Browns Creek FMs.
  - 2-inch potable water line and influent from 28th Avenue FM
- Open-cut pipeline installation will be required for the following pipe segments at the proposed north fine screening facility:
  - Facility influent from 28th Avenue PS FM.
  - Facility influent from two Browns Creek PS FMs.
  - Facility bypass pipeline to Browns Creek PS 60-inch FM.
  - Facility effluent to two Browns Creek PS FM.
  - Rerouting of existing septage receiving station discharge pipeline from north aerated grit removal influent channel to proposed north fine screening facility influent.
- Erosion and sediment control as necessary
- Required storm water permitting

Section 5: Sequencing and Constructability

The following subsections provide a list of sequencing issues and constructability items that will impact design and implementation of improvements in this process area. This section will be coordinated with the project CMAR during development of the overall site construction sequencing plan.

5.1 Maintenance of Plant Operations (MOPO)

The intent of the MOPO is to mitigate interruptions to plant operation and maintain permit compliance throughout construction and startup of the optimization improvements.

- Prior to work beginning for the north grit removal system modifications, it is recommended that construction of the new fine screening structure be completed to prevent high levels of debris from entering the grit removal facility and causing maintenance issues.
- The proposed screening system improvements at the north and the south facilities can be completely installed prior to being placed online since work is primarily being performed outside of the existing treatment trains.
- New fine screens should be brought online one channel at a time as influent flow increases through the screening facility.

5.2 Potential Sequencing Issues

- Demolition of all or a part of an existing storage building located on the west side of the existing north grit removal facility will need to occur prior to beginning construction to make room for the proposed north fine screening facility.
- New yard piping shall be laid and contain stub outs for new tie-in connections to existing FMs before the new fine screening facility is placed into service.
- Influent pipeline connections at the north fine screening facility should be made sequentially. Influent and effluent connections to the existing 60-inch Browns Creek FM should be made while still routing influent flow through the existing 64-inch Browns Creek PS FM to the existing grit removal facility. After the connection is made to the 60-inch Browns Creek FM its flow will be routed through the north fine screening facility while the tie-in connections are made for the existing 64-inch Browns Creek PS FM. Upon completion of connections to the existing Browns Creek PS FM's, an additional influent connection to the existing 48-inch 28th Avenue PS FM can be completed. A final bypass effluent connection can be made to the existing 60-inch Browns Creek FM while routing flow through the new screening structure.
- The south headworks fine screens can be installed in existing facility channels at any time since the channels already have isolation gates and are being bypassed.

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Technical Memorandum No. 3B

Subject: North and South Grit Removal

Date: December 21, 2016

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Executive Summary

The objective of this Technical Memorandum (TM) is to present the basis of design for the north and south grit removal facility improvements at the Central Wastewater Treatment Plant (CWWTP) for the CWWTP Improvements & CSO Reduction project (COPT Project). The improvements are recommended to increase grit capture efficiency, protect downstream equipment and processes from damage and grit accumulation, and minimize equipment and system maintenance. In addition to the specific system improvement goals for grit removal, a goal set for the entire project design team was to reuse existing facilities wherever feasible.

Supplemental to this TM are the previous TMs that were completed as a part of the Central Optimization Study Project (COPT Study) and the CWWTP Grit and Primary Clarifier Improvements-Condition Assessment TM performed by Gresham Smith and Partners (GS&P TM). The GS&P TM included grit characterization studies at the existing north and south aerated grit removal systems as well as pilot studies for the proposed stacked tray, vortex grit removal system. These TMs form an integral part of the basis of design report (BODR) and are referenced throughout this document. The presentations and minutes from the developmental workshops provide additional decision making background and supplemental information for this BODR.

The major proposed improvements for the north and south grit removal systems are generally as follows:

North Grit Removal Facility Proposed Improvements

- Rehabilitate and reconfigure existing grit removal system influent channels to minimize solids settling and distribute a more homogenous wastewater to the rehabilitated grit removal system.
- Install stacked tray, vortex-type grit removal systems in the existing aerated grit removal tanks including required structural and pumping modifications to significantly increase grit removal capabilities.
- Install new grit concentrating/dewatering and conveying equipment capable of processing projected increased grit removal loads in the existing grit processing area.

South Grit Removal Facility Proposed Improvements

Proposed improvements for the south grit removal facility were evaluated and narrowed to two potential options by the design team consisting of engineering groups from Brown and Caldwell (BC) and Hazen and Sawyer. It was determined by the design team that the costs and constructability of each option were to be evaluated further by the Construction Manager at Risk (CMAR) prior to making the final decision on options to pursue for this area; thus, the two basic options are presented below for reference pending final selection.

<u>Option No. 1 (Presented by Brown and Caldwell Design Team)</u>

- Rehabilitate existing grit removal system influent channels to minimize solids settling and distribute a more homogenous wastewater to the rehabilitated grit removal system.
- Install stacked tray, vortex-type grit removal systems in the existing aerated grit removal tanks including required structural and pumping modifications to significantly increase grit removal capabilities.
- Install new grit concentrating/dewatering and conveying equipment capable of processing projected increased grit removal loads in the existing grit processing area.

<u>Option No. 2 (Presented by Hazen and Sawyer Design Team)</u>

Construct a new stacked tray, vortex-type grit removal system in a common structure with the proposed south coarse screening facility. The proposed structure would be located between the central pump station (CPS) and the south grit facility, and the grit removal capabilities would match those proposed for Option No. 1. This option was evaluated by Hazen and Sawyer and details are presented in TM 2 – South Headworks.

Section 1: Process Area Description

Figure 1-1 below portrays an aerial site plan of the CWWTP with the existing north and south grit removal facilities highlighted to illustrate the area evaluated in this TM.

Figure 1-1. Location of North and South Grit Removal Facilities at the CWWTP

<u>North Grit Removal Facility</u>

Wastewater flow currently enters each end of the existing CWWTP north grit removal facility influent channel from the Browns Creek PS and the 28th Ave. PS. The design intent for the north treatment train was not to normally process flow from the south combined sewer system (CSS); however, currently the north does treat the majority of the dry weather flow from the CSS. This is due to multiple unfavorable treatment configurations and other factors that will be addressed as part of this project. It is anticipated that combined sewer flows will not be routed to the north headworks during normal operation once the CWWTP has been optimized. No screening currently exists at the north headworks; however, each of the pumping stations transporting wastewater to the north treatment train has 1-in coarse screens. A gate located at the midpoint of the grit tank influent channel separates the channel into two sections allowing half of the influent channel to be isolated and taken out of service. Flow from the influent channel proceeds into the existing aerated grit removal tanks as depicted in Table 1-1. The CWWTP operations and maintenance (O&M) manual depicts the maximum treatment capacity of each tank as 62 million gallons per day (MGD). All of the aerated grit tanks are covered for odor control and each tank has sloped floors which directs settled grit to three individual grit hoppers. Each hopper has a dedicated recessed impeller centrifugal pump which transports collected grit to one of six cyclone separators. Each pair of cyclone separators discharges into one of three grit classifiers which deposits dewatered grit directly into dump trucks for disposal. The center grit classifier deposits dewatered grit onto a conveyor belt which is used to direct the grit into either dump truck location for transport to the final disposal location. Effluent from the aerated grit removal tanks flows into common primary settling tank (PST) influent channel.

The removal percentage for an aged aerated grit removal system such as the ones located at the CWWTP is typically 50-60 percent. As part of the GS&P CWWTP Grit and Primary Clarifier Improvements evaluation, a grit characterization study was performed to assess the removal capabilities of the existing systems. This study indicated that the north aerated grit removal system was showing a negative capture rate.

South Grit Removal Facility

Wastewater flow from the combined sewer collection system enters the CWWTP south headworks via the CPS. The flow passes through two 1-inch multi-rake bar screens located at the east and west ends of the south aerated grit removal tank influent channel. The south aerated grit removal tank influent channel leads to three aerated grit removal tanks with dimensions and layout identical to those at the north headworks with the exception of some internal baffling and coarse bubble diffuser improvements completed as part of the 2009 Central Wastewater Treatment Plant Biosolids Facility project. As in the north treatment train, all of the south aerated grit removal tanks are covered for odor control and each tank has sloped floors, which directs the grit slurry to three individual grit hoppers. Each hopper has a dedicated recessed impeller centrifugal pump which transports collected grit to one of six cyclone separators. The cyclone separators are grouped together three pairs with each pair discharging into one of three grit classifiers which deposit dewatered grit into dump trucks for final transport to final disposal location. The end two grit classifiers deposit dewatered grit directly into the dump trucks while the middle grit classifier deposits the dewatered grit onto a conveyor where it can be directed to either dump truck.

Effluent from the aerated grit removal tanks flows into a common discharge channel and then passes through the bypass channel of an abandoned coarse screening structure equipped with three 1-inch climber bar screens that are currently out of service and non-operational.

As mentioned above, the removal percentage for an aged aerated grit removal system such as the ones located at the CWWTP is typically 50-60 percent. As part of the GS&P CWWTP Grit and Primary Clarifier Improvements evaluation, a grit characterization study was performed to assess the removal capabilities of the existing systems. It was determined during this study that the south aerated grit tanks were getting about 50 percent capture which is in line with anticipated removal for the facility.

Table 1 depicts a summary of the existing north and south grit removal systems, along with physical descriptions and associated data.

Table 1. Summary of Existing North and South Grit Removal Systems at the CWWTP

	Parameter	Unit	Value	Notes
Existing North Grit Removal Facility				
Aerated Grit Removal Tanks	Number of tanks	No.	4	Rectangular
	Dimensions (L x W x D[1])	ft.	65 x 25 x 11	Per tank
	Aeration System	--	Single Drop Point Diffusers	
	Total Tank Volume	MG	0.13 / 0.52	Per tank / Total
Grit Removal Tank Aeration Supply	Blower Building Channel Blower	-	-	Plant Channel Air Supply
Grit Pumps	Recessed Impeller Centrifugal Pumps	No.	3/12	Per Tank / Total

Table 1. Summary of Existing North and South Grit Removal Systems at the CWWTP				
	Parameter	Unit	Value	Notes
Grit Concentrating and De-watering	Grit Cyclone Separators / Grit Classifiers	No.	6/3	Wemco Hydrogritters
Existing South Grit Removal Facility				
Aerated Grit Removal Tanks	Number of Tanks	No.	3	Rectangular
	Dimensions (L x W x D[1])	Ft.	65 x 25 x 11	Per tank
	Aeration System	--	Single Drop Wide-Band Dif-fusers	
	Total Tank Volume	MG	0.13 / 0.39	Per tank / Total
Grit Removal Tank Aeration Supply	Blower Building Channel Blower	-	-	Plant Channel Air Supply
Grit Pumps	Recessed Impeller Centrifugal Pumps	No.	3/9	Per tank / Total
Grit Concentrating and De-watering	Grit Classifiers	No.	6/3	Wemco Hydrogritters

Depths depicted for aerated grit removal tanks are average operating depths. Actual tank depth varies due to slope; but, is approximately 20-feet.
Ft - feet

Section 2: Design Intent

Improvements to the north and south grit removal facilities are focused on installing a more efficient and reliable system while meeting the requirements of the COPT Study to maximize wet weather capacity. Modifications to the existing grit removal facility will be critical to the success of minimizing maintenance issues in downstream process areas. Existing structures should be reused whenever feasible. The COPT Study, as well as the GS&P TM, indicated adding baffling and making changes to the aeration supply and pumping system could potential increase the capture rate for the aerated grit removal facility. However, both TMs also indicated adding vortex grit removal systems in lieu of the aerated system should significantly increase the grit capture rate from an average of 50-60 percent to approximately 95 percent. These removal rates are highly dependent upon flow and grit size so pilot studies were performed at the north and south grit systems during the previously referenced GS&P evaluation. The vortex grit removal system vendor utilized the data collected during their pilot studies as well as the data from the grit characterization studies to determine the number of units required for each site and their associated guaranteed removal rates. It is important to note that the vortex grit removal unit manufacturer requires a screen with a maximum opening size of ½-inch upstream of their proposed equipment; thus, the proposed fine screening facility for the north described in TM# 3A and the coarse screening system proposed by Hazen and Sawyer for the south is recommended to be installed prior to installation of the proposed vortex grit removal facilities at the north and south by the grit manufacturer. The referenced Hazen and Sawyer TM should also be consulted for review of an alternative location presented for the proposed south vortex grit removal facility.

The following list represents the overall design intent for the recommended improvements to the north grit removal facility:

- The existing aerated grit removal system shall be demolished and new more efficient vortex grit removal units shall be retrofitted into the existing tanks as depicted in concept drawings provided to MWS.

- Upgrades to the existing common grit influent channel to minimize solids settling in the channel and facilitate equal flow/grit loading to the new grit removal system
- Refurbishment of the existing grit pumps and piping modifications such that each grit pump has its own discharge forcemain (FM) and concentrating unit.
- Upgrades to the existing grit removal system shall include associated odor control system improvements.
- The existing concentrating and dewatering units will be removed and replaced with new hydraulic vortex concentrating and dewatering equipment capable of processing the higher grit loads from the upgraded system as depicted in concept drawings. The concentrating and dewatering units are recommended to be upgraded along with the addition of the vortex grit removal units for the vendor to guarantee system performance.

The following list represents the overall design intent for the recommended improvements to the south grit removal facility:

- Demolish existing 1-inch multi-rake screens and conveyors (it is recommended by the grit system manufacturer that coarse screens with a maximum screen opening size of 1/2-inch be installed upstream of the grit removal system as depicted by Hazen and Sawyer).
- The existing aerated grit removal system shall be demolished and new more efficient vortex grit removal units shall be retrofitted into the existing tanks as depicted in concept drawings.
- Upgrades to the existing common grit influent channel to minimize solids settling in the channel and facilitate equal flow/grit loading to the new grit removal system

  Refurbishment of the existing grit pumps and piping modifications such that each grit pump has its own discharge FM and concentrating unit.
- Upgrades to the existing odor control system improvements.
- The existing concentrating and dewatering units will be removed and replaced with new hydraulic vortex concentrating and dewatering equipment capable of processing the higher grit loads from the upgraded system as depicted in concept drawings. It is recommended that the concentrating and dewatering units be upgraded along with the addition of the vortex grit removal units for the vendor to guarantee system performance.

Section 3: Constraints

This section describes the constraints associated with implementing the proposed improvements to the north and south grit removal facilities at the CWWTP as described in this TM.

3.1 Design Criteria

The following section provides a summary of the necessary design criteria that impact the design and implementation of improvements at the CWWTP north and south grit removal facilities. COPT Study TM 5.1 - Hydraulic Capacity Assessment and COPT Study TM 5.4 – Process Capacity Assessment and Alternatives Analysis include a complete design basis for the process design of the proposed grit removal systems.

3.1.1 Site Limitations

One of the main goals of the COPT Project is to reuse as much of the existing facilities as possible. The existing aerated grit removal tanks at the north and south are located in existing structures within the

CWWTP headworks which may be difficult to access during construction. The proposed construction for retrofitting the existing tanks with vortex grit removal systems has been reviewed with the structural engineer and estimated costs include those to access site. Concurrent with this evaluation, the Hazen and Sawyer design team developed alternatives for installing the same grit removal system as part of the proposed coarse screening facility at a remote location within the boundary of the CWWTP site. Design parameters were coordinated between the two teams so equipment sizing would be consistent. Cost estimates were developed for each installation option by the two design teams; however, because the two estimates were developed using different formats and assumptions, a clear cost comparison was never agreed upon. The final process location was postponed until the alternatives could be reviewed by the CMAR to determine comparative costs and constructability. The option to locate the grit removal facility with the coarse screening facility is discussed as applicable within this document; however, the assumption carried forth herein is that the south vortex grit removal facility will be retrofitted into the existing aerated grit removal tanks.

3.1.2 Hydraulics

The proposed vortex grit removal systems shall be installed within the existing hydraulic grade of the CWWTP headworks so no additional pumping of influent wastewater would be required. All influent flow to the north and south headworks is pumped via FM pipelines and enters influent channels before being split amongst existing grit removal tanks. Flow is discharged from the girt removal facilities into common channels leading to either the proposed fine screening facility (south headworks) or the PSTs influent (north headworks). Preliminary hydraulic calculations indicate the headloss though the proposed vortex grit removal facility is comparable to that of the existing aerated grit removal facility; however, in order to allow gravity flow through the proposed systems the vortex grit removal systems will need to be installed at an elevation which will require the bottom of the existing aerated grit removal tanks to be removed and replaced at a lower elevation.

3.1.3 Grit Removal System Technology

The existing aerated grit removal tank's removal efficiencies are limited and the system requires a significant amount of energy for air production. The improvements proposed for the north and south grit removal systems would be implemented to improve the grit removal efficiency and minimize the process electrical consumption. Operational requirements include redundancy, flexibility, and the desire to minimize maintenance.

Options for upgrading the grit removal facilities ranged from pumping and piping improvements only to constructing new facilities. After evaluations were complete, the recommended grit removal system improvements to meet the system technology requirements consisted of installation of twelve, hydraulically driven, stacked tray, vortex grit removal units at the north headworks and nine units at the south headworks. These units will be retrofitted inside of each existing aerated grit removal tanks. The retrofit will include upgrades to the associated pumps, piping, and influent and effluent channels. As noted in section 2, the vortex grit removal unit manufacturer requires a screen with a maximum opening size of 1/2-inch upstream of their proposed equipment; thus, the proposed fine screening facility for the north described in TM 3A and the coarse screening system proposed by Hazen and Sawyer for the south is recommended to be installed prior to installation of the proposed vortex grit removal facilities at the north and south. The recommended improvements will provide the required capacity, redundancy, flexibility, and energy conservation.

The anticipated grit removal at peak flow for the proposed south grit removal facility is 95 percent, as shown in Table 2. The system is actually capable of processing more than the anticipated north train peak flow of 200 MGD, as indicated in the table.

Table 2. Proposed North Grit Removal Facility Performance (11 of 12 Units Operating)	
Flow (MGD)	**Performance**
212 (peak)	95% Removal ≥106 microns
75	95% Removal ≥75 microns

Note: Data provided in table assumes 12 units (12-ft diameter, 10 trays each) installed and 11 in operation.

The anticipated grit removal at peak flow for the proposed south grit removal facility is 95% as shown in Table 3.

Table 3. Proposed South Grit Removal Facility Performance	
Flow (MGD)	**Performance**
240 (peak)	95% Removal ≥150 microns
160	95% Removal ≥125 microns
80	95% Removal ≥75 microns

Note: Data provided in table assumes 9 units (12-ft diameter, 10 trays each) installed and 8 in operation.

The stacked tray, vortex grit removal system has no internal moving parts; thus, is expected to require less maintenance. Phase 2 detailed design should include interviews with existing vortex grit removal system operators and site visits by MWS operations staff to determine installed system O&M needs. Figure 3.1 depicts the proposed vortex grit removal equipment.

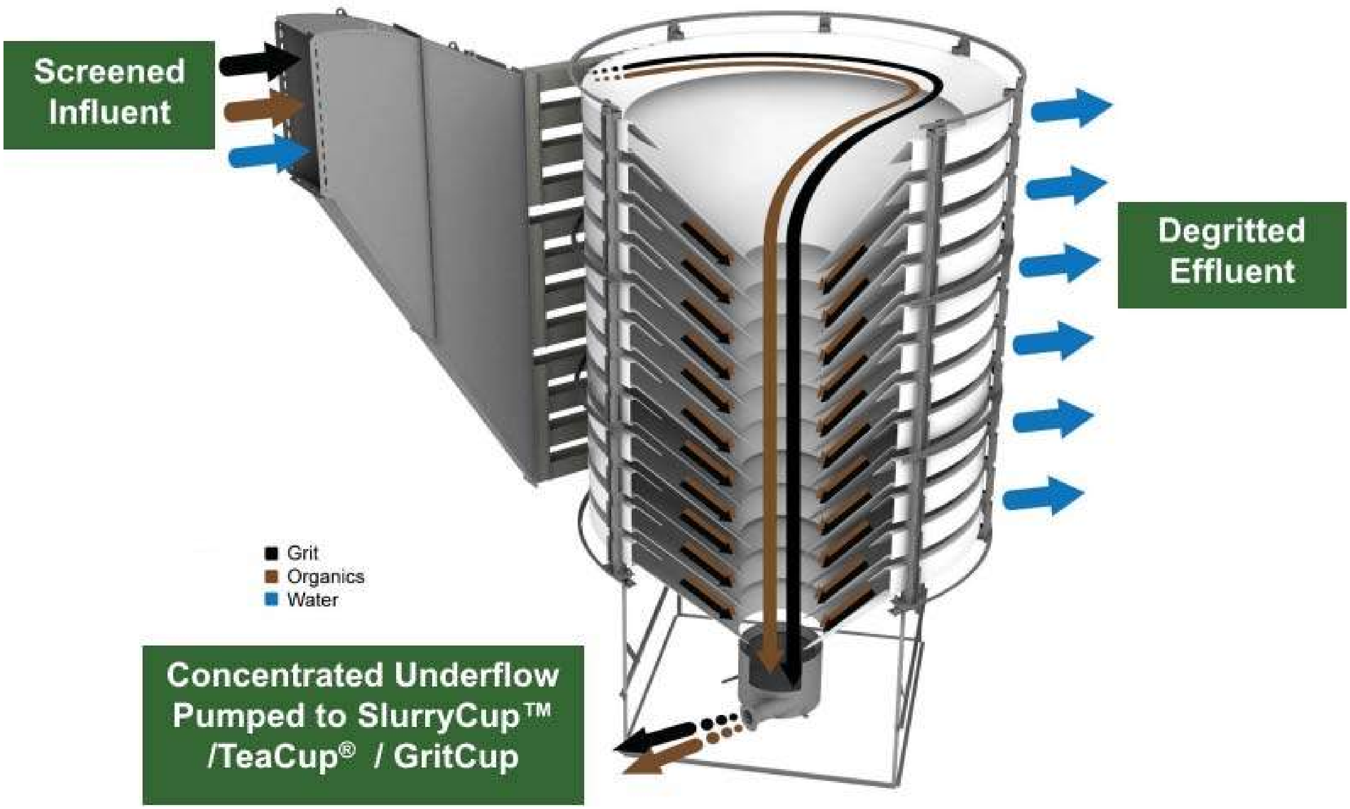

Figure 3.1 Vortex Grit Removal System

3.1.4 Concentrating/Dewatering/Conveying Equipment

The projected grit load to the concentrating and dewatering equipment after installation of the proposed grit removal equipment will be significantly higher than the existing load; thus, the existing equipment would be incapable of processing it and is recommended to be upgraded. Additionally, removal efficiencies for the proposed grit removal equipment will only be guaranteed by the manufacturer if they supplied the entire system including concentrating and dewatering equipment. It is recommended that the concentrating and dewatering equipment be installed in the existing facilities to provide the required redundancy, flexibility, and minimized maintenance.

The improvements proposed for the north and south grit concentrating and dewatering system include installation of 12 concentrators and 6 dewatering units at the north headworks along with 9 concentrators and 5 dewatering units at the south headworks. The dewatered grit will be discharged on to two new belt conveyors at each location for moving to one of two disposal bins prior to hauling to the final disposal location. In each location the elevated slabs currently supporting the concentrating and dewatering equipment must be extended to provide room for installation of the new units as depicted in concept drawings. This proposed system provides capacity with one fully redundant unit at each location at peak flow. The system will be designed with the flexibility to utilize any combination of units based upon flow rates. Phase 2 detailed design will include layout goals promoting ease of system maintenance. Figure 3.2 depicts the vortex grit removal unit with proposed classifiers and dewatering systems.

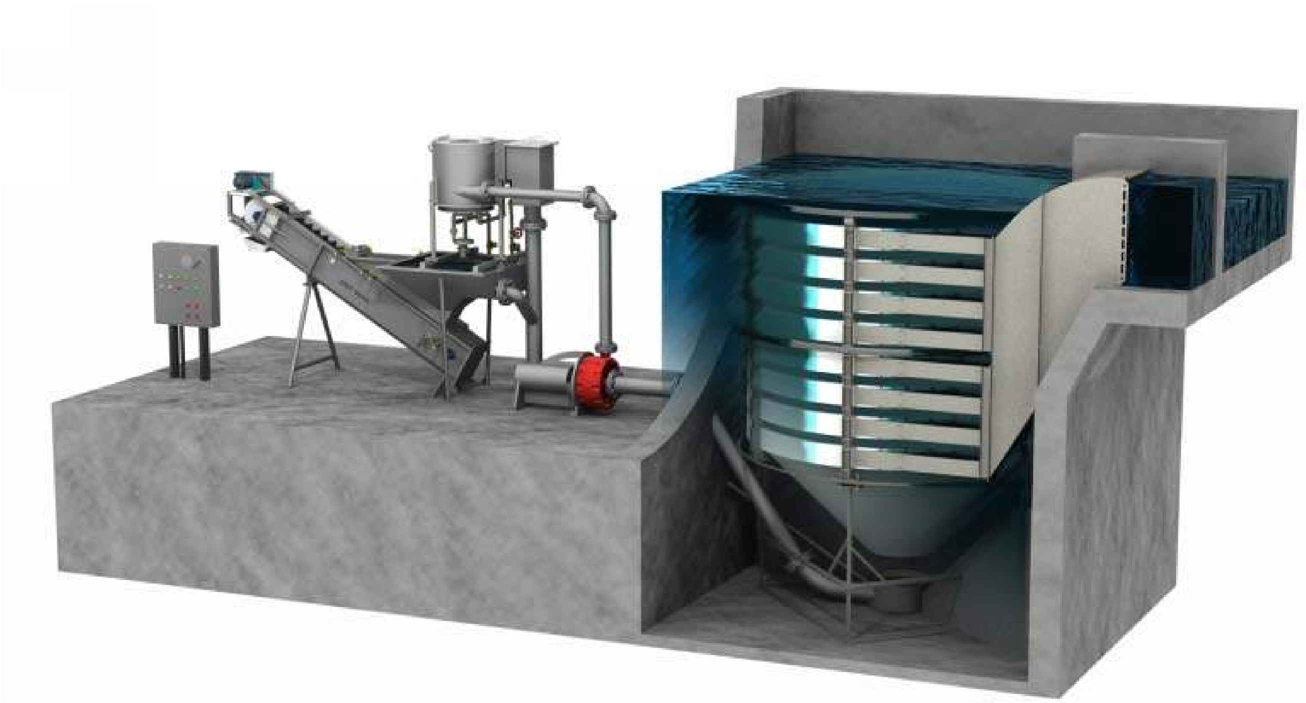

Figure 3.2 Vortex Grit Removal System Including Classifiers and Dewatering Units

3.2 Code Considerations

A complete list of all codes used for design will be included in the Code Classification Summary. This section will be filled in later once the code classification summary is updated.

3.3 Regulatory Drivers

There are no direct regulatory drivers for the improvements at the north and south grit removal facilities. Indirectly, the improvements are deemed necessary for continued reliable operation of the CWWTP necessary to meet NPDES permit requirements at proposed wastewater flows and loads. Less efficient grit removal systems would lead to operations and maintenance issues caused by excessive debris in downstream treatment processes. Grit removal prior to the Excess Flow Treatment Unit (EFTU) is not required; however, it would decrease the amount of solids depositing in the EFTU tanks or discharging from the EFTU.

3.4 Sequencing and Constructability

The following text provides a preliminary list of specific sequencing issues and constructability items that impact the design scope of improvements in this process area. Other COPT Project components that affect and require coordination with this process area are included. The overall sequencing plan for this process area is discussed in Section 5 of this TM. These sections will be coordinated with the project CMAR in development of the overall sequencing plan.

3.4.1 Potential Sequencing Issues

- Prior to work beginning for the north grit removal system modifications construction of the new fine screening structure should be completed; thus, flows routed to the retrofitted grit removal facility will have a higher level of debris removal prior to entering the facility.
- Modifications to the existing grit removal influent channel may be completed at the north utilizing the existing isolation gate to work on either side of the channel with the other remaining in service. If the isolation gate is inoperable bypass pumping may be required while the gate is being repaired or replaced.

3.4.2 Potential Constructability Issues

- Retrofit of the proposed grit removal equipment into the existing aerated grit removal tanks presents structural challenges. To accommodate the proposed retrofit, the bottom of the existing aerated grit removal tanks would be removed and existing piles be demolished down to the proposed elevation required to support the new structure. Additional piles would be constructed within these existing tanks and exterior walls be temporarily supported while construction is underway.
- Construction of the influent channel to each retrofitted grit tank will also pose potential construction issues because the channel will be constructed in the pump gallery while equipment is in service.

Section 4: Description of Improvements

The basic improvements proposed for construction as part of the north and south grit removal facility improvements include installation of vortex grit removal units and associated grit concentrating and dewatering equipment. Workshop presentations and meeting minutes include proposed alternatives discussed, process flow diagrams, proposed equipment layouts and selected alternatives. Additionally, the concept drawings depict the proposed layouts for the north and south grit removal facilities.

4.1 Detail Design Considerations and Assumptions

The following sections provide more detailed information on process selections for the general improvements listed above including listing of decision points which need to be addressed prior to moving to Phase 2 detailed design.

4.1.1 Vortex Grit Removal Facility

Retrofit of the existing aerated grit removal tanks with a stacked tray, vortex grit removal system is proposed for this project at the north and south headworks because of its superior grit removal capabilities. Further evaluation of the south headworks layout is to be performed by the team, with the CMAR, to determine if it would be more cost effective and/or feasible to include installation of the proposed equipment at the proposed south coarse screen facility.

4.1.2 Finalization of Hydraulics

Assumptions made pertaining to downstream water elevations for the north headworks should be revisited during preliminary design. All preliminary hydraulic calculations for the north and south headworks will need to be finalized to confirm potential layouts.

4.2 Process Mechanical

This section summarizes the process mechanical improvements required at the north and south grit removal facilities.

4.2.1 Process

North Grit Removal System

The existing north aerated grit removal system is to be retrofitted with a proposed stacked tray, vortex type grit removal system. Flow from the 28th Avenue and Browns Creek PS FMs is received from both the north and south side of the existing grit removal influent channel. The proposed north grit facility will be capable of processing 212 MGD with a removal cut point of 106 microns.

The north grit removal facility improvements scope includes the following:

- 12 stacked tray, vortex grit removal units (11 duty, 1 redundant).
- 12 influent slide gates controlling flow to the proposed grit removal units.
- 12 grit concentrating and 6 dewatering units with two belt conveyance systems to disposal bins.
- Dedicated pumps and piping from each vortex grit removal unit to grit concentrating units.
- Channel modifications to prevent solids settling and accommodate vortex grit removal unit layout.
- Odor control system for the containment, collection, and delivery areas of grit removal system will be required. The modified grit removal system odor control systems will be re-connected to the main plant odor control system.
- Demolition of existing aerated grit removal system and appurtenances.
- Electrical and control components.

Concept drawings with proposed layouts were provided as supplemental information to MWS.

Table 4 summarizes the key design data for the proposed north headworks facility.

Table 4. North Grit Removal Facility – Key Design Data

Element	Design
Capacity	212 MGD, 95% Removal ≥106 micron
Stacked Tray, Vortex Grit Removal Systems	12 units each with,10 trays
Grit Concentrating Units	12
Grit Dewatering Units	6
Influent Slide Gates	12

South Grit Removal

The existing south aerated grit removal system is to be retrofitted with a proposed stacked tray, vortex type grit removal systems. Flow from the CPS is received from both the east and west side of the existing grit removal influent channel after passing through coarse screens which are to be demolished. The proposed south grit facility will be capable of processing 240 MGD with a removal cut point of 150 microns.

The south grit removal facility improvements scope includes the following:

- 9 stacked tray, vortex grit removal units (8 duty, 1 redundant).

- 9 influent slide gates controlling flow to the proposed grit removal units.
- 9 grit concentrating and 5 dewatering units with two belt conveyance systems to disposal bins.
- Dedicated pumps and piping from each vortex grit removal unit to grit concentrating units.
- Channel modifications to prevent solids settling and accommodate vortex grit removal unit layout.
- Odor control system for the containment, collection, and delivery areas of the grit removal systems will be required. The modified grit removal system odor control systems will be re-connected to the plant odor control system that serves the Central Biosolids Facility. Reuse existing system where possible.
- Demolition of existing aerated grit removal system and appurtenances.
- Electrical and control components.

Concept drawings with proposed layouts were provided in as supplemental information to MWS.

Table 5 summarizes the key design data for the south headworks.

Table 5. South Headworks– Key Design Data

Element	Design
South Grit Facility	
Capacity	240 MGD, 95% Removal ≥150 microns
Stacked Tray, Vortex Grit Removal Systems	9 units each with10 trays
Grit Concentrating Units	9
Grit Dewatering Units	5
Influent Slide Gates	9

4.2.2 Odor Control

Channel and tank covers are currently located at the existing north and south grit removal facilities for odor containment. There is also ductwork in place at the existing south grit facilities for the capture and transport of foul air to the existing odor control system located adjacent to the existing south PSTs next to the excess flow treatment tank. At the north grit facilities there is existing ductwork in place for the capture and transport of foul air to the existing odor control system located at the south PSTs. It is anticipated that the proposed vortex grit removal systems will produce a significantly less odor load to the odor control systems than the existing aerated grit removal units.

Odor control improvements to be performed as part of the north and south grit removal system improvements scope are as follows:

- All channels shall be covered for containment with ductwork to odor control treatment units.
- All equipment installed including grit removal units, and classifiers and dewatering units shall be covered for odor containment and include connection for ductwork with negative pressure pulling air to odor control treatment units.
- All existing and proposed structures shall include ventilation systems which shall either evacuate air to exterior of structure per National Fire Protection Association (NFPA) code or ductwork to deliver air to odor control system if it is determined it will be nuisance odor. At this point in design, if all equipment and channels are covered and sent to odor control system as indicated above then ventilation to exterior will suffice. This shall be revisited as the next design phase continues.

- An overall odor control plan for the CWWTP improvements project will be developed to determine if additional odor control capacity is required, where any new units would be constructed, and which units are dedicated to each process area.

4.2.3 Heating, Ventilation, and Air Conditioning (HVAC)

HVAC improvements to be performed as part of the north and south grit removal facilities improvements scope are as follows:

- The existing HVAC systems for the north and south grit removal facilities motor control center (MCC) rooms should be reviewed for capacity and condition to determine if any upgrades will be required to protect electrical equipment.
- The existing heating hot water supply and return piping and system will need to be checked to see what is still in service and functioning. This system will be either repaired or replaced whichever is cost efficient.
- Grit, pumping areas, dewatering areas and truck loading areas will need to be ventilated per NFPA 820 code requirements for coarse and fine screenings and to provide conditions acceptable for operations and maintenance staff. Existing ventilation systems will need to be reviewed for capacity and condition.

4.2.4 Plumbing

Plumbing improvements to be performed as a part of the north and south grit removal facilities improvements scope are as follows:

- Provide inspection and testing for plumbing drain systems within the existing grit removal facilities to confirm pipes are not corroded or plugged. Flush lines as necessary. An allowance should be provided in the preliminary cost estimate for drainage pipe rehabilitation or additional of trench drains.
- Replace hot water lines inside existing facility.
- Replace existing sump pumps.
- Install plumbing including water piping and drains required for proposed sinks, hose bibs for equipment wash down, and grit classifier and dewatering units. It can be assumed that each facility will require potable and plant water supplies.

4.3 Instrumentation and Controls

This section presents the equipment instrumentation and control strategies for the north and south grit removal facilities improvements. The controls required for the proposed grit removal facilities equipment and associated appurtenances will be integrated into the plant's existing SCADA system. These controls will consist of new field instrumentation, control panels, local process graphic screen/database, data collection/trending and reporting as required for a complete system.

New field instrumentation will be provided to measure typical process variables such as level, pressure, flow and miscellaneous analytical measurements as required. Instrumentation with screens located outdoors will include a sun/rain shield and surge protection. Proposed control panels will be Vendor Control Panels (VCPs). The VCPs are supplied as part of the vendor package for the new concentrating and dewatering systems.

Instrumentation requirements for specific process areas and equipment within the proposed north and south grit removal facilities are as depicted in the following sections.

4.3.1 Vortex Grit Removal Units

The vortex grit removal units will be placed into service and taken out of service either manually by plant operators or automatically based upon influent flows and influent channel elevations which will be monitored from distributed control system (DCS). Influent gates to each of the vortex grit removal units shall be actuated and capable of opening/closing by the DCS. Depending upon the type of gate and the speed at which the influent gates will need to open at incremental steps so the vortex grit units do not become damaged. Channel level indicators shall be mounted in the main influent channel and at each of the vortex grit removal influents.

The vortex grit removal units do not have internal mechanical equipment needing control.

4.3.2 Grit Pumps

Each vortex grit removal unit shall have a dedicated grit removal pump that shall operate on a timed or continuous basis when the associated grit removal unit is in service or manually from the DCS by operations staff. The timer utilized for pump run cycles shall be resettable by operations staff depending upon detected influent flows and loads. All pump monitoring signals and alarms shall be sent to the DCS and in the event a pump is called for and not running an alarm shall be sent to the DCS for operators to shut down the associated grit removal unit to prevent clogging.

4.3.3 Grit Concentrating and Dewatering Units

Grit concentrating and dewatering units will be furnished with local control panels provided by the vendor as part of the equipment packages. The DCS system will serve as the master control panel to coordinate required operations.

4.4 Electrical

This section depicts the required electrical work for the north and south grit removal facilities improvements:

- Existing facility exposed wiring, corroded conduit routed along floor, and corroded junction and pull boxes need replacing.
- Provide power and control wiring to proposed equipment listed in previous sections. Existing facilities to be reused shall be powered from existing MCC’s as appropriate.
- Determine electrical demand for existing grit removal tank aeration system that will be removed and replaced with the vortex grit removal units. The exiting blower supplying air for the existing grit removal tanks also provides air to other processes at the CWWTP. If enough load is removed by taking the aerated grit tanks out of service along with other improvements depicted in this BODR, the blowers could potentially be removed from service or replaced with smaller units to reduce energy consumption.
- Site lighting shall be provided around proposed facilities and where there is insufficient lighting around existing facilities. This shall be coordinated with proposed overall plant site lighting plan.
- Interior lighting improvements for proposed facilities and where upgrades are necessary around existing facilities to be reused.
- Video monitoring of existing and proposed facilities including disposal bins for viewing by DCS.
- Provide power to proposed and existing HVAC equipment.

4.5 Geotechnical

This section presents the required geotechnical scope for the north and south grit removal facilities improvements.

- Review existing information on piles and structures at the existing aerated grit tank facilities to be reused for vortex grit removal unit installation.
- Coordinate with structural and process engineers to determine testing required to confirm existing structural foundation capacity and proposed foundation requirements for installation of vortex grit removal units.

4.6 Structural

This section depicts the required structural scope for the proposed north and south grit removal facilities improvements.

- Grit removal unit influent channel modifications as required by process engineer to inhibit solids settling.
- Modify existing aerated grit removal tanks for installation of vortex grit removal units including influent channels and isolation gates for proposed units and tank structural modifications required for unit installation. Modifications shall include demolition of existing floor and piles to proposed elevation required for installation of vortex grit removal systems and installation of new piles, tank floor, and sidewalls as required.
- Modify existing grit effluent channel to accommodate grit tank discharge channel connections and fine screening influent channel weir wall construction for passive bypass.
- Extend elevated slab to adjacent walls in north and south grit concentrating and dewatering facilities to accommodate new concentrating and dewatering units and belt conveyors.
- Provide walkway between grit concentrating and dewatering units for maintenance access.
- Miscellaneous equipment and piping supports.

4.7 Architectural

This section depicts the required architectural scope for the proposed north and south grit removal facilities improvements.

- Final architectural improvements for the proposed upgrades to the existing north grit and south grit facility will be determined after inspection by the team architect to ensure code compliance and recommended upgrades as necessary for deteriorated finishes. Specific areas to be evaluated include:
  - General aesthetics for facility exterior
  - Building doors
  - Building windows
  - Building louvers
  - Building roof

4.8 Site Civil

The section depicts the required site civil scope for the proposed north and south grit removal facility improvements.

No significant site civil improvements will be required for the proposed north or south grit removal facility improvements because existing facilities will be utilized.

Section 5: Sequencing and Constructability

The following text provide a preliminary list of sequencing issues and constructability items that will impact design and implementation of improvements in this process area. This section will be coordinated with the CMAR in development of the overall sequencing plan.

5.1 Potential Sequencing Issues

- It is recommended that the proposed screens be installed at the north and south headworks prior to installation of the proposed grit removal facility.
- Installation of proposed grit removal equipment in the existing aerated grit removal tanks at the north and the south headworks shall be made with only one tank at a time out of service. All associated improvements including pumping, piping, and concentrating and dewatering equipment shall be constructed concurrently with the associated tank out of service. Bypass pumping is not anticipated while work is under construction in the north grit removal tanks unless one of the other tanks is removed from service at the same time for unforeseen maintenance. The south headworks grit removal facility also has means of bypass during dry weather which would allow construction on more than one tank simultaneously.

5.2 Potential Constructability Issues

- Retrofit of the proposed grit removal equipment into the existing aerated grit removal tanks presents structural challenges. In order to accommodate the proposed retrofit, the bottom of the existing aerated grit removal tanks would be removed and existing piles be demolished down to the proposed elevation required to support the new structure. Additional piles would also be constructed within these existing tanks and exterior walls be temporarily supported while construction is underway.
- Construction of the influent channel to each retrofitted grit tank will also pose potential construction issues because the channel will be constructed in the pump gallery while equipment is in service.
- Accessibility for cranes and equipment to the north aerated grit tanks will be a challenge since the structure is surrounded by buildings and tankage.
- Access to the existing grit removal tanks with the equipment necessary to construct tank modifications required for installation of proposed grit removal equipment will present a challenge and needs to be coordinated with the CMAR before Phase 2 detailed design commences.

5.3 Operational Issues

- During construction while the modifications to the existing aerated grit is proceeding the remaining grit tanks will need to remain in service to provide adequate grit removal for the CWWTP influent flows. Routine maintenance and system checks may need to be performed more frequently to keep systems in top operating condition.
- Operators must be completely apprised of the re-direction of flows so they can be carefully monitored to ensure a mistake does not occur that could fill the pipe gallery.
- Once in service disposal bins throughout headworks will need to be monitored to prevent solids from overfilling before removal.

Section 6: Operations and Maintenance

The section describes the operations plan for the proposed north and south grit removal facility improvements.

6.1 North Vortex Grit Removal Facility

The design capacity of the proposed north vortex grit removal facility is 212 MGD. This capacity is obtainable with 11 of the 12 proposed vortex grit removal systems in operation. In the event the flow exceeds the capacity of the vortex grit removal system the flows will still pass through the system; but, the removal efficiencies will decrease allowing more grit to pass through the system to the downstream processes.

Equipment associated with the proposed north vortex grit removal facility will include local control panels provided by the system manufacturers. The facility operation including these panels and the actuated influent gates will also be connected to the CWWTP DCS for remote monitoring and control.

- Normal Operation - During diurnal low flows of 30 MGD and average daily flows of 60 MGD a minimum of three vortex grit removal units shall remain in operation. Grit removal cut points will rise and fall between 75 microns and 106 microns based upon influent flows. Grit removal units can be placed into service and removed from service manually or automatically by opening and closing the unit's influent slide gate. Operation shall be based upon influent flow and influent channel levels. If a vortex grit removal unit's dedicated grit removal pump fails to operate the associated vortex grit removal unit shall be taken out of service to prevent clogging.
- Wet Weather Operation – As the influent flows continue to rise additional grit removal units shall be automatically placed in service in the same manner as above until all units available are placed into service.
- Associated equipment such as classifiers, dewatering systems, and belt conveyors shall operate automatically when receiving flow from the grit removal pumps. The grit pumps and grit classifiers will automatically start after a time delay after the grit tank influent gate is 100 percent open.

6.2 South Vortex Grit Removal Facility

The design capacity of the proposed north vortex grit removal facility is 240 MGD. This capacity is obtainable with 8 of the 9 proposed vortex grit removal systems in operation. In the event the flow exceeds the capacity of the vortex grit removal system the flows will still pass through the system; but, the removal efficiencies will decrease allowing more grit to pass through the system to the downstream processes.

Equipment associated with the proposed south vortex grit removal facility will include local control panels provided by the system manufacturers. The facility operation including these panels and the actuated influent gates will also be connected to the CWWTP DCS for remote monitoring and control.

- Normal Operation - During diurnal low flows of 20 MGD and average daily flows of 30 MGD a minimum of two vortex grit removal units shall remain in operation. Grit removal cut points will rise and fall between 75 microns and 150 microns based upon influent flows. Grit removal units can be placed into service and removed from service manually or automatically by opening and closing the unit's influent slide gate. Operation shall be based upon influent flow and influent channel levels. If a vortex grit removal unit's dedicated grit removal pump fails to operate the associated vortex grit removal unit shall be taken out of service to prevent clogging.

- Wet Weather Operation – As the influent flows continue to rise additional grit removal units shall be automatically placed in service in the same manner as above until all units available are placed into service.
- Associated equipment such as classifiers, dewatering systems, and belt conveyors shall operate automatically when receiving flow from the grit removal pumps. The grit pumps and grit classifiers will automatically start after a time delay after the grit tank influent gate is 100 percent open.

References

Books

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Technical Memorandum

Prepared for: Metro Water Services

Project Title: Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Project No.: 148388

Technical Memorandum No. 4

Subject: North and South Primary Settling Tanks

Date: December 21, 2016

To: Trey Cavin, Metro Water Services

From: Tazio Qubeck, Project Manager

Copy to: Ron Taylor, Metro Water Services

Prepared by: Kim K. Hargett
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Executive Summary

The objective of this Technical Memorandum (TM) is to present the basis of design for the north and south primary settling tank (PST) improvements at the Central Wastewater Treatment Plant (CWWTP) for the Central WWTP Improvements & CSO Reduction project (COPT Project). The improvements are recommended to increase solids capture efficiency, increase hydraulic capacity, replace deteriorated equipment to improve system reliability, and decrease energy consumption.

Supplemental to this TM are the previous TMs that were performed by Brown and Caldwell (BC) as a part of the Central Optimization Study Report (COPT Study) and by Gresham Smith and Partners (GS&P) as part of the CWWTP Grit and Primary Clarifier Improvements-Condition Assessment Project (GS&P TM). These TMs form an integral part of the basis of design report (BODR) and are referenced throughout this document. Also provided within this document are a series of attachments. The presentations and minutes from the developmental workshops provide additional decision making background and supplemental information for this BODR.

The major proposed improvements for the north and south PST systems are generally as follows:

- Modify north and south PST inlet baffling by installing canopy baffles and/or perforated baffles to prevent scouring of sludge blankets in PSTs. Because of larger operating depth in north PSTs, computational fluid dynamics (CFD) model should be used to confirm baffling needs in north tanks at start of Phase 2 detailed design.
- Replace north PST effluent channel aeration mixing system with more reliable and efficient channel mixing system.
- Inspect south influent and effluent and north influent channel aeration systems while PSTs are out of service for improvements to determine if repairs need to be made.
- Install electric actuators on PST drain lines and inspect drain system for potential pump and piping rehabilitation.
- Install channel covers and ductwork for odor control at south PST launders and effluent channel.
- Install passive overflow weir in vicinity of the existing Gate 200 to prevent the primary influent channel from overflowing during wet weather events.

Section 1: Process Area Description

Figure 1-1 below portrays an aerial site plan of the CWWTP with the existing north and south PST improvement areas highlighted to illustrate locations evaluated as part of this TM.

Figure 1-1. Location of North and South Primary Settling Tank Facilities at the CWWTP

Flow enters the PSTs from a common channel flowing from the existing north and south grit removal facilities. There are a total of 19 rectangular PSTs for the removal of settleable solids at the CWWTP. The PSTs use typical chain and flight collectors to move settled solids along its horizontal axis to the sludge hopper located at the influent end of the PST. Cross collectors, also chain and flight, are located in the hopper to continue moving the sludge toward the sludge pump inlet located at the bottom of the hopper. The settled primary sludge captured in the hopper is pumped to the solids transfer pump station where it is to be screened then conveyed to the Biosolids Facility for further treatment. The flight collectors also move floating material such as scum commonly found on the surface of the PSTs to a tipping trough located at the effluent end of the clarifiers.

There are 6 PSTs in the north system with dimensions depicted in Table 1. Each north PST has a motorized butterfly gate at the inlet. Flow passes from the north primary influent channel through the dedicated PST butterfly gate and into a primary tank influent channel with diffusers to distribute low pressure air to keep the channel mixed. Once in the influent channel, the flow has to pass through six evenly spaced, submerged 30-inch square ports to enter the PST. The north PSTs are drained into an existing tank drainage well located near the influent end of PST Nos. 17 and 18. Two submersible pumps transport wastewater from the 50-foot (ft) deep tank drainage well to the north grit tank effluent channel near north grit tank number 4 when the tanks are taken out of service.

There are 13 PSTs in the south system with dimensions depicted in Table 1. The south PST drains transport flow back to the main pump station in the maintenance building when the tanks are taken out of service.

Historical data analyzed as part of the COPT Study indicated a high variability, ranging from 5 to over 80 percent, in TSS removal due to the variable conditions under which the PSTs operate. Based upon historical data review, design calculations, stress tests, and CFD modeling performed during the COPT Study, the total combined existing capacity of the PSTs is 300 MGD, assuming sludge blankets are maintained at manageable levels. However, the total combined achievable optimized capacity developed during the COPT Study is 390 MGD (125 MGD to north PSTs and 265 MGD to south PSTs). While not included in this TM, Phase 2 detailed design should include an assessment to determine if two additional PSTs at the north should be added to scope to treat excess flows as opposed to bypassing the PSTs or sending flow to the south PSTs if capacity is available.

Flow is discharged from the PSTs by passing over effluent weirs then through effluent launders to effluent channels. The effluent channels direct flow from the north and south PSTs to the intermediate pump station (IPS). Parshall flumes are located within each of the north and south primary effluent channels for flow measurement upstream of the IPS. The Parshall flume in the south primary effluent channel was determined to be the primary hydraulic restriction that limits the amount of south primary effluent flow that can be conveyed to secondary treatment. In addition to the south primary effluent Parshall flume, the COPT Study states that the effluent launder geometry of the south PSTs was also a hydraulic restriction. The south effluent launders were replaced in 2014 as part of project #90-SC-0055, South Grit and Primary Clarifier Improvements. Demolition of the south primary effluent Parshall flume and associated channel improvements is discussed in TM 5 – Intermediate Pump Station.

The north PST effluent launders, north PST influent and effluent channels, and south PST influent channels were covered with foul air routed to biofilters as part of project #99-SG-8B, Odor Control Improvements; however, the south PST launders and effluent channels are not covered and can be a significant source of odor at the CWWTP. As a result, these tanks are only used during wet weather to minimize the release of odors to the community.

Table 1 depicts a summary of the existing north and south PSTs, along with physical descriptions and associated data.

Table 1. Summary of Existing North and South Primary Settling Tanks at the CWWTP

	Parameter	Unit	Value	Notes
Existing North Primary Settling Tanks				
Primary Settling Tanks	Number of tanks	No.	6	Rectangular
	Dimensions (L x W x D[1])	Ft.	166 x 41.5 x 14.7	Per tank
	Aeration System	--	Single Drop Diffusers Supply from Plant Air System	Influent and Effluent Channel PST Dedicated Inlet Channel
	Surface Area	Ft^2	6,889 / 41,334	Per tank / Total
Primary Sludge Pumps	Torque Flow Centrifugal Pumps	No.	3	Each Pump Serves Two Tanks
Tank Drainage Well	Submersible Pumps	No.	2	Duty/Standby
Scum Pump Stations	Submersible Chopper Pumps	No.	2 Pump Stations	2 Pumps in Each Station (4 pumps total)
Existing South Primary Settling Tanks				
Primary Settling Tanks	Number of Tanks	No.	13	Rectangular
	Dimensions (L x W x D[1])	Ft.	166 x 41.5 x 8	Per tank
	Aeration System	--	Single Drop Diffusers Supply from Plant Air System	Influent and Effluent Channel

Table 1. Summary of Existing North and South Primary Settling Tanks at the CWWTP				
	Parameter	Unit	Value	Notes
	Surface Area	Ft^2	6,889 / 89,557	Per tank / Total
Primary Sludge Pumps	Torque Flow Centrifugal Pumps	No.	7	Each Pump Serves Two Tanks Except Pump #7 Which Only Serves PST #13
Scum Pump Stations	Submersible Chopper Pumps	No.	3 Pump Stations	2 Pumps in Each Station (6 pumps total)

(1) Depths depicted for PSTs are average operating depths.

Section 2: Design Intent

Improvements to the north and south PSTs are focused on making the system more efficient and reliable by maximizing solids capture efficiency while meeting the requirements of the COPT Study to maximize wet weather capacity. Upstream headworks screening and grit removal improvements will greatly improve the reliability of primary treatment. These improvements are outlined in TMs 3A and 3B –North and South Fine Screening and North and South Grit Removal.

The COPT Study, as well as the GS&P TM, recommended several PST improvements to meet the design intent and increase the total combined capacity to approximately 390 MGD. Many of the recommended improvements have already been completed or are in the process of completion by MWS.

The following list represents the recommended improvements which have either been completed or are in the process of being completed by MWS at the north and south PSTs.

- South PST weir and effluent launder replacement to match north PSTs completed in 2014 (Project #90-SC-0055).
- South PST influent and effluent channel aeration system rehabilitation completed in 2014 (Project #90-SC-0055).
- North PST influent channel aeration system currently being rehabilitated by MWS.
- North PST internal equipment including flights, chains, and drives currently being replaced by MWS.
- North PST influent slide gates currently being installed by MWS to replace deteriorated influent butterfly gates (1 per tank inlet).
- North PST pressure reducing valves are being replaced as needed by MWS.
- Stop logs are being installed by MWS in north PST channels for isolation.

The following list represents the overall design intent for the recommended improvements to the north and south PSTs to be completed during the COPT Project.

- Modifications shall be made to the north and south PST influent baffling to prevent scouring of solids blanket by influent flow during elevated flows.
- Replacement of the north PST effluent channel aeration system with a more efficient compressed air mixing system.
- Install actuators on PST drain lines.
- Installation of covers and foul air ducts for odor control at south PST effluent launders and effluent channel.
- Installation of a passive overflow weir and flow measuring device near existing Gate 200 to prevent overflows during peak weather events.

While unlikely, there is a potential for the PST influent flow to exceed the existing system's hydraulic capacity based upon the PSTs in operation at that time. Gate 200 provides PST bypass capability; however, it is bottom opening and lacks the ability to control the amount of flow bypassed. It also has the potential to be left open without operator's knowledge. The proposed passive overflow weir would allow high flows to pass over a weir wall from the PST influent channel to the PST effluent channel to prevent the influent channel from overflowing.

Section 3: Constraints

This section describes the constraints associated with implementing the proposed improvements to the north and south PSTs at the CWWTP as described in this TM.

3.1 Design Criteria

The following section provides a summary of the necessary design criteria that impact the design and implementation of improvements at the CWWTP north and south PSTs. COPT Study TM 5.1 - Hydraulic Capacity Assessment and COPT Study TM 5.4 – Process Capacity Assessment and Alternatives Analysis include the conceptual design basis for the process design of the proposed PST improvements.

3.1.1 PST Inlet Baffling Improvements

The existing PST capacities are limited by poor solids capture efficiency at high flows attributed to the inlet configuration which directs high velocity inlet flows downward toward the solids blanket; thus, scouring the blanket. The proposed inlet baffle improvements, which were recommended based on CFD modeling, are limited by the dimensions of the existing PST structure and the location of solids removal equipment. Improvements made to the inlet baffling will need to achieve the goal protecting the sludge blanket from being scoured by flow entering the tank while maintaining the core function of the PST and minimizing maintenance requirements.

3.1.2 PST Channel Mixing Improvements

The existing PST influent and effluent channel mixing system consists of wide band diffusers with air supplied from the channel blower located in the blower building. The south PST influent and effluent channel aeration system was rehabilitated in 2014 and is in good condition. The north PST influent channel aeration diffusers, piping, and valves are currently being replaced by MWS. The north PST effluent channel aeration system will need to be replaced during the COPT Project. A more efficient compressed air channel aeration system is proposed for installation in the north PST effluent channel. The channel aeration equipment must be installed in the existing facilities while providing the required redundancy, flexibility, and minimized maintenance.

3.2 Code Considerations

A complete list of all codes used for design will be included in the Code Classification Summary, which will be completed during preliminary design.

3.3 Regulatory Drivers

The proposed improvements to the north and south PSTs are required to increase the capacity and meet the requirements set forth in the COPT Study. Additionally, the improvements are deemed necessary for continued reliable operation of the CWWTP necessary to meet NPDES permit requirements at proposed wastewater flows and loads.

3.4 Sequencing and Constructability Issues Affecting Design

The following subsections provide a list of sequencing issues and constructability items that impact the design scope of improvements in this process area. Other project components that affect and require coordination with this process are included. The overall sequencing plan for this process area is discussed in Section 5 of this TM. These sections will be coordinated with the project Construction Manager at Risk (CMAR) in development of the overall sequencing plan.

- Proposed inlet baffling improvements will need to be designed around the existing PST solids removal equipment to prevent conflicts. The cross collectors may need to be reworked if baffles cannot be installed with them in current location.
- A structural assessment will need to be made to determine the exact location of the proposed passive bypass near the existing Gate 200. The size and number of passive bypass locations may need to be adjusted if the current layout does not work with existing structural constraints.

Section 4: Description of Improvements

The basic improvements proposed at the north and south PSTs include installation of inlet baffling and a more efficient channel aeration system.

4.1 Detail Design Considerations and Assumptions

The following sections provide more detailed information for the general improvements listed above including listing of decision points which need to be addressed prior to moving to Phase 2 detailed design.

4.1.1 PST Inlet Baffling Improvements

The inlet baffling at the north and south PSTs is proposed for rehabilitation including installation of canopy baffles in the north and south PSTs, installation of perforated baffles in the north PSTs, and addition of perforations in existing baffles at the south PSTs. The inlet baffling improvements will redirect high velocity flow currently directed downward by the existing solids target baffle. The redirection of the flow will prevent scouring of the sludge blanket at higher flows. Figure 4.1 depicts the existing inlet baffling at the CWWTP.

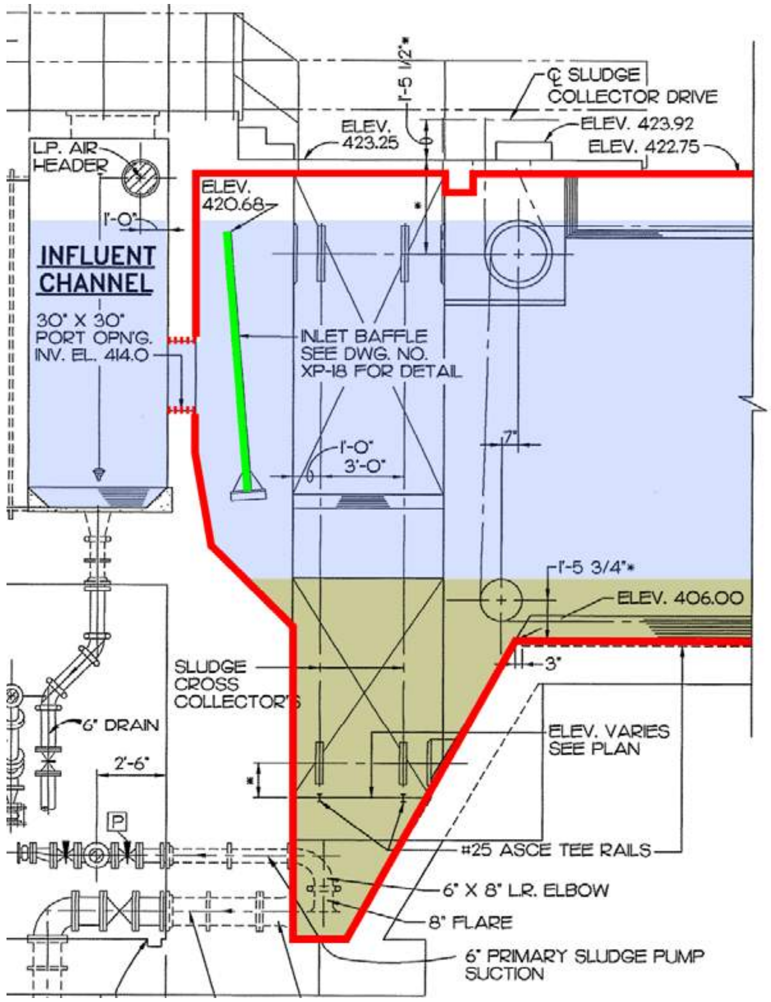

Figure 4.1 Existing PST Inlet Baffling

4.1.2 North PST Effluent Channel Aeration Improvements

The existing inefficient north PST effluent channel aeration system shall be replaced with a more efficient compressed air channel aeration/mixing system. The proposed aeration/mixing system utilizes large compressed air volumes to mix the wastewater as they expand and move upward in the channel. The expanding bubbles provide controlled turbulence, fluid currents and mixing in the channels. The system utilizes rotary screw compressors and releases compressed air intermittently; thus, requiring less energy than the traditional coarse bubble mixing. Figures 4.2 and 4.3 depict the proposed compressed gas channel aeration/mixing system. Note that tank mixing is shown, but the same equipment is used for channel mixing.

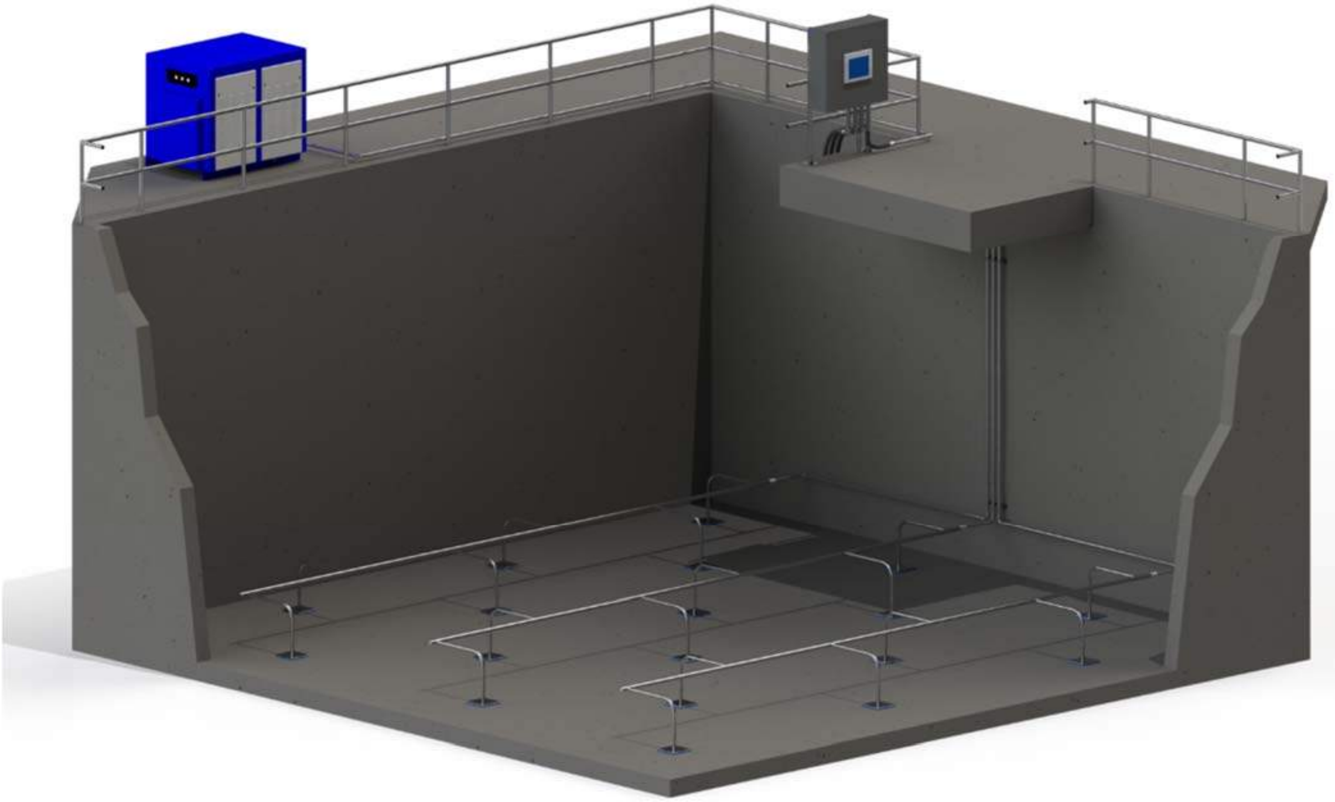

Figure 4.2 Typical Compressed Gas Aeration/Mixing System

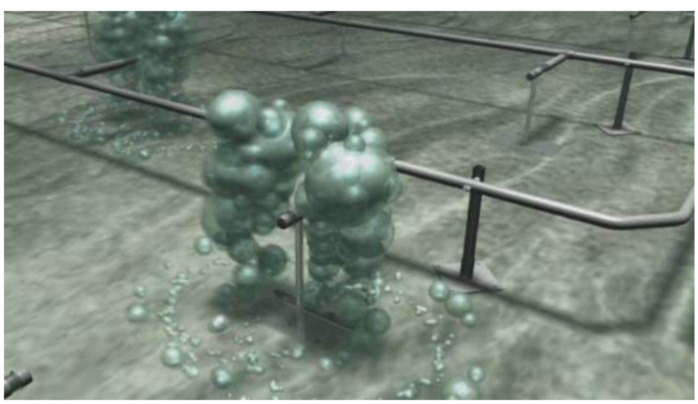

Figure 4.3 Typical Compressed Gas Discharge from Proposed Aeration/Mixing System

4.1.3 Actuators

Electric actuators shall be installed on all PST drain pipeline valves.

4.1.4 Passive Overflow

A passive overflow weir shall be installed near existing Gate 200 to prevent overflows into parking lot in the event the PST influent exceeds the capacity of the PST tanks in service. The passive overflow weir shall allow flow to spill from the PST influent channel into the PST effluent channel only in the event the influent channel elevation has reached a level indicating an eminent overflow. The approximate location for the passive overflow weir is depicted in Figure 4.4.

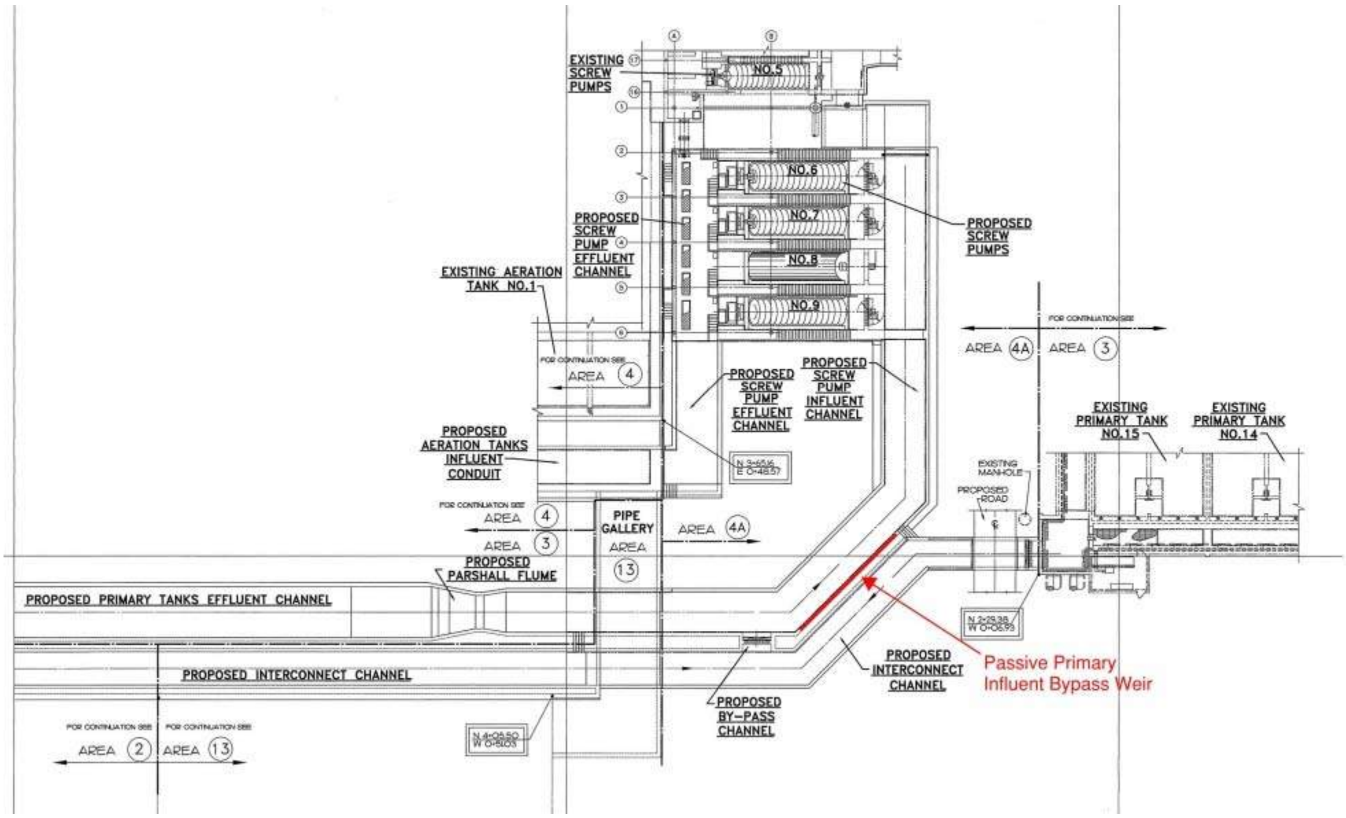

Figure 4.4 Passive Overflow Weir at Gate 200

4.2 Process Mechanical

This section summarizes the process mechanical improvements required at the north and south PSTs. The CFD model should be checked prior to making improvements at the north PST to confirm necessary baffling given the larger depth in the north PSTs.

4.2.1 Process

In order to achieve the optimized capacity for the PSTs the following improvements are recommended:

- Influent canopy baffle installation at the north and south PSTs.
- Influent perforated baffle installation at the north PSTs.
- Rehabilitation of existing influent target baffles at the south PSTs to provide required perforations.
- Demolition of existing north PST effluent channel aeration system.
- Installation of compressed air channel aeration/mixing in north PST effluent channel.

- Electric actuators shall be installed on all PST drain pipeline valves.
- Installation of passive bypass at Gate 200.

4.2.2 Odor Control

Covers shall be installed over the south PST effluent launders and the effluent channel for odor containment. In addition, ductwork shall be installed to capture and transport the collected air to the existing odor control system located adjacent to the existing south primary settling tanks.

An overall odor control master plan for the CWWTP improvements project will be developed to determine if additional odor control capacity is required, where any new units would be constructed, and which units are dedicated to each process area. The odor control master plan is will be developed in an Odor Control Master Plan.

4.2.3 Heating, Ventilation, and Air Conditioning (HVAC)

No HVAC improvements are to be performed as part of the north and south PST improvements scope.

4.2.4 Plumbing

No plumbing improvements to be performed as a part of the north and south PST improvements scope.

4.3 Instrumentation and Controls

Instrumentation and controls changes included in the PST improvements scope include the following.

- The proposed north PST effluent channel compressed gas mixing system shall be supplied with a vendor control panel (VCP). The VCP shall allow both local control and shall be connected to the DCS for remote monitoring and control.
- Addition of actuators to all tank drain pipeline valves. The actuators shall be locally operated; however, a 4-20 mA control signal shall be sent to the DCS to allow remote control and monitoring including indication of open/closed status as well as intermediate position indication.

4.4 Electrical

Electrical improvements included in the PST scope are as follows.

- Provide power to the proposed north PST effluent channel compressed air mixing system.
- Provide connection of proposed north PST effluent channel compressed air mixing system VCP to the DCS for monitoring.
- Provide power to the proposed tank drain pipeline valve electric actuators.

4.5 Geotechnical

No geotechnical work is required as part of the north and south PST improvements scope.

4.6 Structural

This section depicts the required structural scope for the proposed north and south PST improvements.

- Supports required for the proposed PST inlet baffling improvements.
- Supports for south PST odor control covers.
- Structural design and details for passive overflow weir at Gate 200.

4.7 Architectural

No architectural work is required as part of the north and south PST improvements scope.

4.8 Site Civil

No site civil work is required as part of the north and south PST improvements scope.

Section 5: Sequencing and Constructability

The following subsections provide a list of sequencing issues and constructability items that will impact design and implementation of improvements in this process area. This section will be coordinated with the project CMAR during development of the overall site construction sequencing plan.

5.1 Maintenance of Plant Operations (MOPO)

The intent of the MOPO is to mitigate interruptions to plant operation and maintain permit compliance throughout construction and startup of the optimization improvements.

- Installation of proposed PST improvements will need to be performed during dry weather or low rainfall periods when flows are at levels which allow isolated groups of tanks to be out of service at the same time. During construction in the existing PSTs and north PST effluent channel a sufficient number of PSTs must remain in service to provide adequate solids removal capacity for the CWWTP influent flows.
- When the proposed north PST effluent channel mixing/aeration system is being replaced flow will need to be diverted to the south PSTs.

5.2 Preliminary Sequencing Plan

Inlet baffling improvements and north PST effluent channel mixing/aeration system improvements will need to be performed in stages with groups of tanks out of service. Isolation gates and stop logs are in place to allow isolation during improvements without disrupting the remaining system operation. All other proposed improvements can be made without disruption to the system operation.

References

Books

Water Environment Federation, *Design of Municipal Wastewater Treatment Plants*, 5th Ed.,

Reports

Central Wastewater Treatment Plant Grit and Primary Clarifier Improvements, Condition Assessment Technical Memorandum, Gresham, Smith and Partners, 2011

Brown and Caldwell, *Central Optimization Study Report,* 2014

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Technical Memorandum

Prepared for: Metro Water Services

Project Title: Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Project No.: 148388

Technical Memorandum No. 5

Subject: Intermediate Pump Station

Date: December 21, 2016

To: Trey Cavin, Metro Water Services

From: Tazio Qubeck, Project Manager

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Executive Summary

The Intermediate Pump Station (IPS) at the Central Wastewater Treatment Plant (CWWTP) is to be rehabilitated and expanded from its current firm capacity of 242 million gallons per day (MGD) to a minimum firm capacity of 350 MGD. This Technical Memorandum (TM) outlines the proposed improvements.

Additional information, which presents recommendations for improving the reliability of the existing screw pumps in service at the IPS and the findings of an alternatives analysis to select the type of pump to be utilized, is provided in supplemental design information. The alternatives analysis compared screw pumps to submersible pump options. The result of this analysis is a recommendation to rehabilitate a number of the existing screw pumps, supplemented by a number of submersible axial flow pumps to reach the new target capacity. Submersible pumps clearly represent the least initial capital expenditure and are the more efficient pumps from an operations and maintenance standpoint. Less clear is the final configuration of how many new submersible pumps should be constructed. A clear economic advantage between two submersible pump options under consideration could not be determined by the high level present worth analysis performed. The consensus of the design team is that the Construction Management at Risk (CMAR) partner will be able to provide valuable input regarding the means and methods of construction, sequencing, bypass pumping, and demolition, all of which can greatly impact cost. Final selection of the recommended option to be advanced in Phase 2 detailed design should be deferred until the CMAR is selected.

The following design considerations are addressed in this TM:

- Reliability issues associated with the bearings and belt drives of the existing screw pumps.
- Hydraulic improvements on both the suction and discharge sides of the station.
- Hydraulic restrictions in the supply channels.
- Improved flow distribution among the pump suction intakes.

Given the size of the station and complexity of the inlet conditions, a scale model of the proposed improvements is recommended. The physical model allows observation of flow patterns over the full range of anticipated operation, facilitates identification of any hydraulic issues, and can be used to optimize the wet well geometry, add baffles, or incorporate hydraulic improvements such as formed suction intakes, as necessary to minimize inlet disturbances and promote efficient station operation.

Existing butterfly gates influent which feed the pumps will be replaced with stainless steel slide gates. The ability to remotely open, close, or achieve a specific gate position will be provided.

The aeration tank (AT) inlet channels on the discharge side of each of the two IPS structures are to be connected. This will provide operational flexibility in feeding the ATs as described in TM 6 – Aeration System.

Monitoring and control of the IPS will be improved to provide the operators with reliable feedback on wet well levels, influent flow trends, and which pumps are operating. Operators will retain local and remote manual control and the option of full automated control of the pump station (PS).

Section 1: Process Area Description

The IPS consists of two sets of Archimedes screw pumps. The small pumps numbered one through five are rated at 21.6 MGD each and the larger pumps numbered six through nine are rated at 44.5 MGD each resulting in a current firm capacity of 242 MGD. The pumps are located adjacent to the south end of the ATs as shown in Figure 1 below. The pumps lift effluent from the north and south primary settling tanks (PSTs) effluent channels approximately 20 feet (ft) and discharge into two separate AT influent channels. These channels in turn feed the ATs along the east and west side of the ATs. The two AT influent channels will be connected at the discharge area of the IPS. Once connected the dry weather flow will be routed to the west aeration influent channel. Only during large wet weather events will a portion of the influent flow be routed to the east channel. Aeration influent channel improvements are presented in TM 6 – Aeration System.

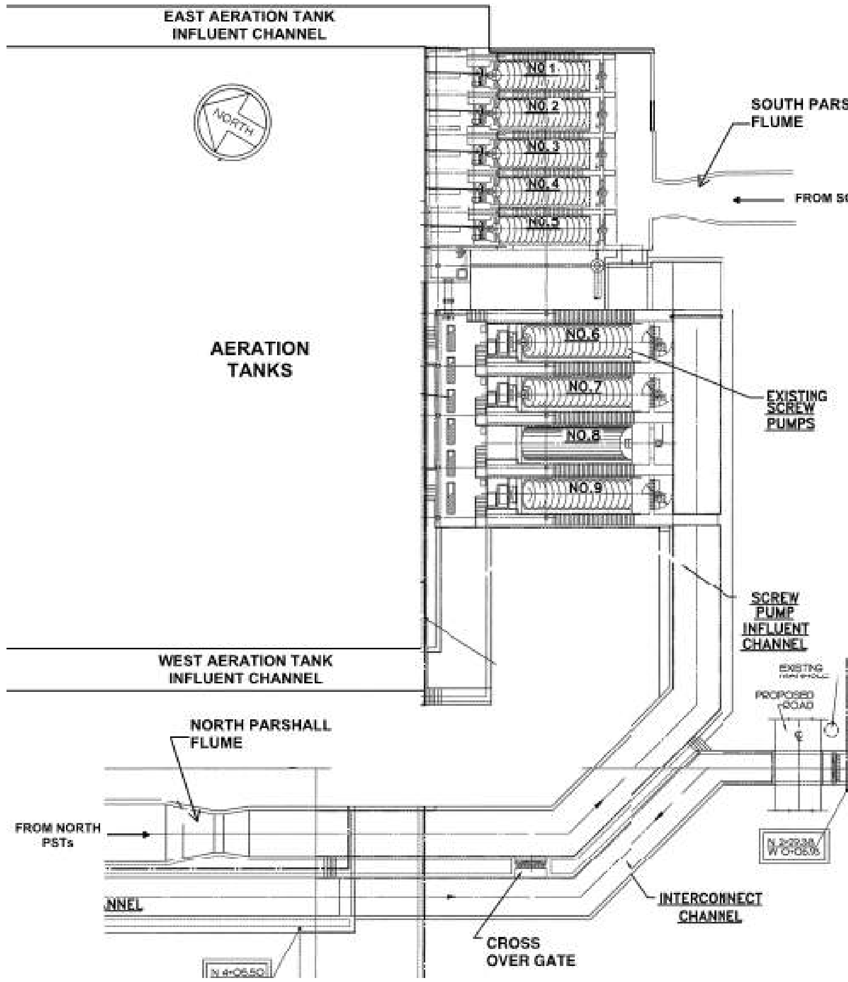

Figure 1 - Intermediate Pump Station

Section 2: Design Intent

The design goals of the project are:

- Increase the firm capacity of the IPS from 242 MGD to a minimum of 350 MGD.
- Utilize a combination of existing and new pumps that results in the greatest overall long-term benefit, including energy efficiency.
- Rehabilitate and resolve reliability issues with the existing screw pumps that are to remain.
- Improve monitoring and control of the PS.

- Replace all existing rectangular butterfly gates with slide gates capable of remote open, close, and intermediate positioning via the distributed control system (DCS).
- Optimize the configuration of the PST effluent channels and their connection to the IPS to eliminate existing hydraulic restrictions such that all PST effluent flow can be routed to any of the IPS pumps.
- Connect the two AT influent channels where the IPS discharges for operational flexibility feeding the ATs.

Section 3: Constraints

3.1 Design Criteria

Table 1. Design Criteria

Item	Design Criteria
Total Firm Pumping Capacity	350 MGD
Existing Firm Pump Capacity	242 MGD
Minimum New Pump Capacity Added	108 MGD
Total Dynamic Head (TDH)	20 ft
Pump Design Type	Submersible Axial Flow
Pump Drive	Variable Frequency

3.2 Code Considerations

- 2013 ANSI/HI 2.3.Rotodynamic Vertical Pumps of Radial, Mixed and Axial Flow Types
- 2012 ANSI/HI 9.8 Intake Design for Rotodynamic Pumps
- 2012 International Building Code with Local Amendments
- 2012 International Energy Conservation Code
- 2009 ICC/ANSI A-117.1 Accessible and Usable Buildings and Facilities
- 2012 International Mechanical Code with Local Amendments
- 2011 National Electrical Code with Local Amendments
- 2012 International Fire Code with Local Amendments
- 2012 Life Safety Code (NFPA 101) with Local Amendments
- 2012 International Fire Code (NFPA 820) Fire Protection in Wastewater Treatment and Collection Facilities

3.3 Regulatory Drivers

An increase in pumping capacity is required to achieve the proposed optimized secondary treatment capacity. All options provide firm capacity in excess of the 350 MGD minimum capacity required with one of the largest pumping units out of service

3.4 Sequencing and Constructability Issues

The following subsections provide a list of sequencing issues and constructability items that will impact design and implementation of improvements in this process area. Means and methods for addressing these issues and others identified during design will be further developed in conjunction with the CMAR partner resulting in an overall project construction sequencing plan.

- Sequencing:
  - Initial construction should be scheduled to coincide with the dry season flows to minimize bypass pumping.
  - The maximum number of existing pumps must remain in service during initial construction.
  - Once one or more of the new larger capacity pumps are online the firm capacity of the PS should not be impacted during construction.
- Constructability:
  - Safely demolish equipment and portions of existing structures and construct new work while other portions of the facility remain in service.
  - Install pile foundations to support the new work without disturbing existing structures and utilities
  - Provide reliable bypass pumping as necessary.

3.5 Operational Issues

Below is a list of operational issues that have been identified:

- Existing screw pumps are maintenance intensive and unreliable.
- Lack of reliable monitoring and control of the IPS forces manual operation. Lack of equal distribution of flow among all pumps.
- Restriction of flow through the Parshall flume in the channel connecting the IPS to the South PST.
- Operation and Maintenance of the existing butterfly valves.

Specific operation and maintenance issues of the screw pumps are enumerated in supplemental design information. A recommended plan of action to address these issues is outlined in the TM along with recommendations for monitoring and control to improve reliability.

Standard operating procedure for the CWWTP is to direct the influent to the maximum extent possible through the North PSTs which are equipped with odor control. Currently, flow approaching the IPS' large screws from only one direction creates a hydraulic gradient resulting in uneven distribution among the screw pumps. The depth of flow tapers as it passes each screw pump, therefore screw pump nine pumps more flow than the remaining pumps downstream. The pump isolation gates have been adjusted manually to help equalize the flow. Manual adjustment of these gates is not a permanent solution to this problem. The proposed pumping improvements should be modeled during design to determine the optimum geometry of the new pump wet wells and intakes as well as the approach channels. However, MWS has indicated that they would like the ability to partially open the new isolation side gates remotely, if necessary.

Planned odor control improvements to the South PSTs and channel modifications to route flow from the South PSTs to the screw pumps will likely result in a better distribution of flow to the pump intakes. More PSTs on line will also provide some buffering capacity of rapidly changing flows. The Parshall flume which measures the effluent from the South PSTs restricts the flow to the pumps. It is recommended that the flume should be removed and replaced with a channel with an invert elevation an estimated two feet lower than the flume invert to eliminate this restriction.

- The existing butterfly gates in the supply channels and pump wet well areas are difficult to operate and maintain. MWS has requested all the butterfly gates be removed and replaced with slide gates capable of remote open, close, and intermediate positioning via the DCS.

Section 4: Description of Improvements

4.1 Process Area Designation

4.1.1 Detailed Design Considerations and Assumptions

- Firm capacity must be increased to a minimum of 350 MGD.
- The IPS must react quickly to increased flows during rainfall events.
- Standby power will be provided
- Vehicular access to the drop points for each of the cranes must be maintained.
- Permanent changes to site surface drainage are not anticipated.

4.1.2 Process Mechanical

4.1.2.1 Process

Portions of the existing IPS will be rehabilitated, and a number of new submersible axial flow pumps will be added to reach the new target capacity.

The existing screw pumps have experienced high rates of failure of the lower bearing and failure of the belt drive systems in the past. These reliability issues are discussed in detail in supplemental design information. Steps have been taken to improve the grease lubrication system in an attempt to extend the lower bearing life. Alternatives to the grease lubricated bearing have also been investigated. The existing bearing can be retrofitted with a water lubricated “Vesconite” liner. The screw pump manufacturer also offers a permanently lubricated enclosed bearing. If the grease lubrication system cannot be improved to an acceptable level of service, the alternate bearing designs should be installed on a trial basis and each should be evaluated to determine the best approach to bearing replacement. The screw pumps that are to remain will be rehabilitated to a condition as close as possible to their original condition. All screw pumps shall be checked to ensure the shafts are rotating concentrically about the center shaft. Troughs will be re-screeded and defects in concrete shall be repaired.

The V-Belt drive systems have been evaluated and found to be properly designed. The belts slip when the pumps are started in a submerged condition or the screw is physically blocked by a foreign object. This slippage causes wear of both the belts and the sheaves. Lack of proper contact between worn belts and rounded grooves of the sheaves leads to slippage across a wider range of operating conditions. Improvements in monitoring and control should reduce submerged starts. Headworks improvements will reduce the amount of debris that can potentially block screw pump operation damaging the belts.

Axial flow submersible pumps were identified as the most effective pump for the high head low flow conditions at the IPS. A 310 HP axial flow pump manufactured by Flygt which supplies 59.2 MGD at 20 ft Total Dynamic Head (TDH) was selected as a basis of comparison to screw pumps. More detail regarding the pump selection is provided in the supplemental design information

A clear economic advantage between the two submersible pump options described below and illustrated in Figure 2 could not be established. The consensus of the design team is the CMAR partner will be able to provide valuable input regarding the means and methods of construction, sequencing, bypass pumping, and demolition, all of which can greatly impact cost. Final selection of the option to be advanced in the final design should be deferred until the CMAR is selected.

- New Submersible Pumps West (Option 2)
  - Rehabilitate and retain the existing small and large screw pumps.
  - Add new capacity with two (2) submersible pumps supplying 59.2 MGD each.
- New Submersible Pumps East (Option 3):
  - Rehabilitate and retain the existing large screw pumps.
  - Demolish the small screw pumps and replace with four (4) submersible pumps supplying 59.2 MGD each.
- Hybrid Option
  - Rehabilitate and retain the existing large screw pumps (178 MGD).
  - Add new capacity with two (2) submersible pumps supplying 59.2 MGD each (118.4 MGD)
  - Demolish the existing small screw pumps and replace with two (2) submersible pumps supplying 59.2 MGD each (118.4 MGD)

All options supply the minimum required capacity of 350 MGD with one of the largest pumps out of operation. Option 2 represents the option with the highest degree of uncertainty since it involves complete rehabilitation of the oldest structure, which is in poor condition. Option 3 and the hybrid option would reduce the level of uncertainty since it includes demolition and replacement of the critical portions of this structure which support the pump loads. The portions of this structure to remain would only serve as pipe supports and provide access to the pumps. These functions do not represent any significant structural loads.

The hybrid option involves work in both the existing screw PSs, plus construction of a new submersible station. This worst case, highest construction cost option was used in the project cost estimate.

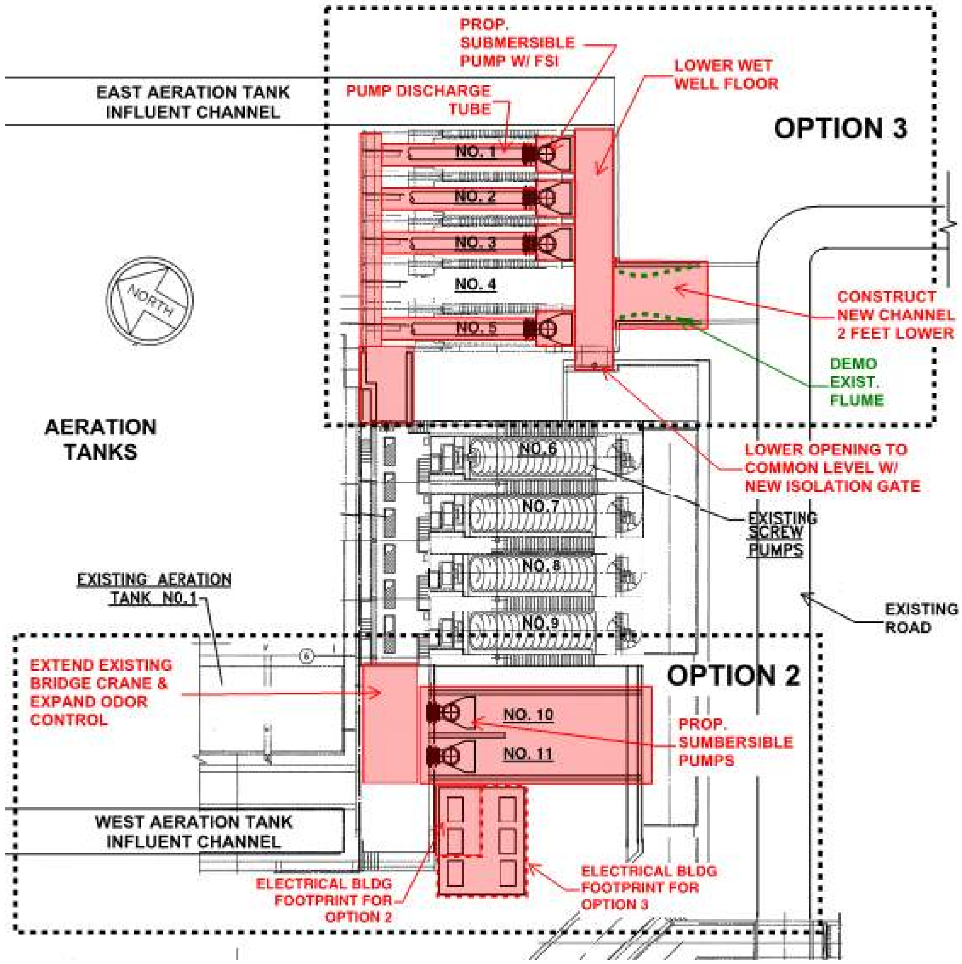

Figure 2 – IPS Upgrade Options

A major portion of the cost associated with the above concepts depends upon the contractor's means and methods, as well as the timing and scheduling of the work which determines the volume and duration of bypass pumping required. These items will be discussed further with all parties including the selected CMAR partner prior to final design.

Parshall Flume Modifications

To alleviate hydraulic restrictions from the South PSTs, the existing Parshall flume will need to be eliminated and replaced with a new channel section with an invert a minimum of two feet below the current flume invert to avoid surcharging the South PST effluent launders.

Figure 3 is a photograph taken during construction, with the utilities in the area underneath the channel exposed. The photograph indicates that the pipelines in the area, with the exception of the 14-inch south waste activated sludge (WAS), were all installed below the bottom of the channel. In the absence of any unknown utility conflicts, it should be possible to lower this section of the channel. The 14-inch south WAS line can be lowered as necessary. The Parshall flume measurement can be replaced with an open channel flow measurement device. Open channel flow measurement can be accomplished by devices which use a combination of Doppler Radar to measure velocity and an ultrasonic device to measure level in the channel. Laser Flow™ by Teledyne ISCO or Flo-Dar™

manufactured by Hach are two examples of open channel measurement devices available. The flume replacement work could be sequenced during dry period flow when the plant influent is routed through the north PSTs. Air used to maintain solids in suspension would be extended through the newly constructed section of channel.

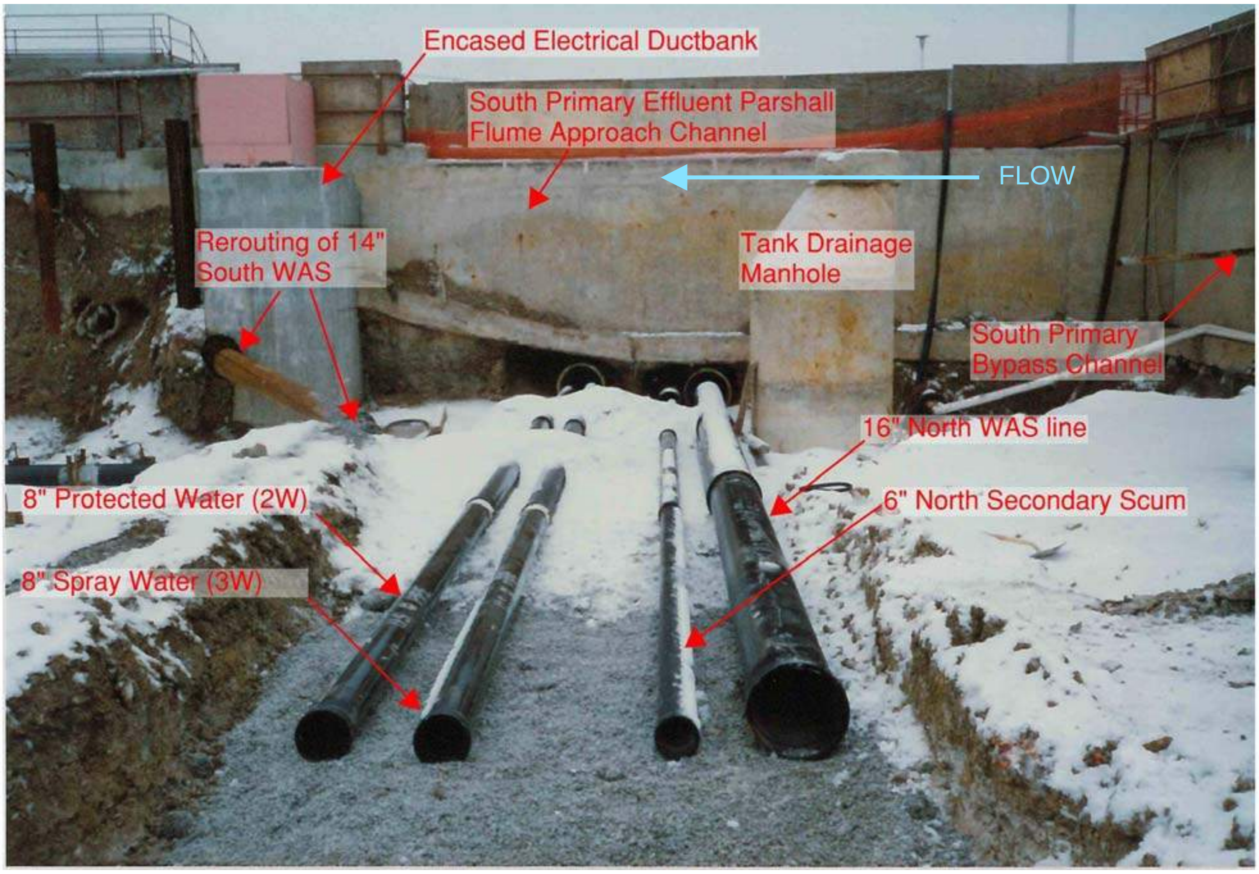

Figure 3 – Existing Utilities under East Parshall Flume

Aeration Basin Influent Channel

Currently, the two sets of screw pumps discharge into separate aeration basin influent channels. Figure 4 below illustrates an elevation view through the existing channels looking south. The intent is to cast concrete walls and floor sections in the space between to connect the two channels. The existing walls currently spanning north-south that create the separation will be demolished. Removable stop logs can be built into the new connecting channel section to allow for isolation of channels in the future. The current butterfly gate used for isolation will be demolished and removed.

Slide Gate Thirteen (13) existing butterfly gates described below will be will be demolished and replaced with new stainless steel slide gates

- Five 84-inch x 72-inch gates at the screw pumps which are to remain shall be replaced. All butterfly gates located on influent the channels of Screw Pump Nos. 1 through 5.
- Four 114-inch x 108-inch gates located on influent channels of Screw Pump Nos. 6 through 9.

- Two 96-inch x 96-inch gates located on the South between the IPS and the Primary Clarifier Influent /Effluent Channels.
- One 90-inch x 96-inch gate located on the South Primary Clarifier Bypass Channel.
- One 114" x 150-inch gate located on the North Primary Clarifier Bypass Channel.

New stainless steel slide gates will be installed on the new submersible pump intake channels. Each slide gate will be equipped with an electric actuator capable of remote monitoring and open, close, and intermediate positioning via the DCS.

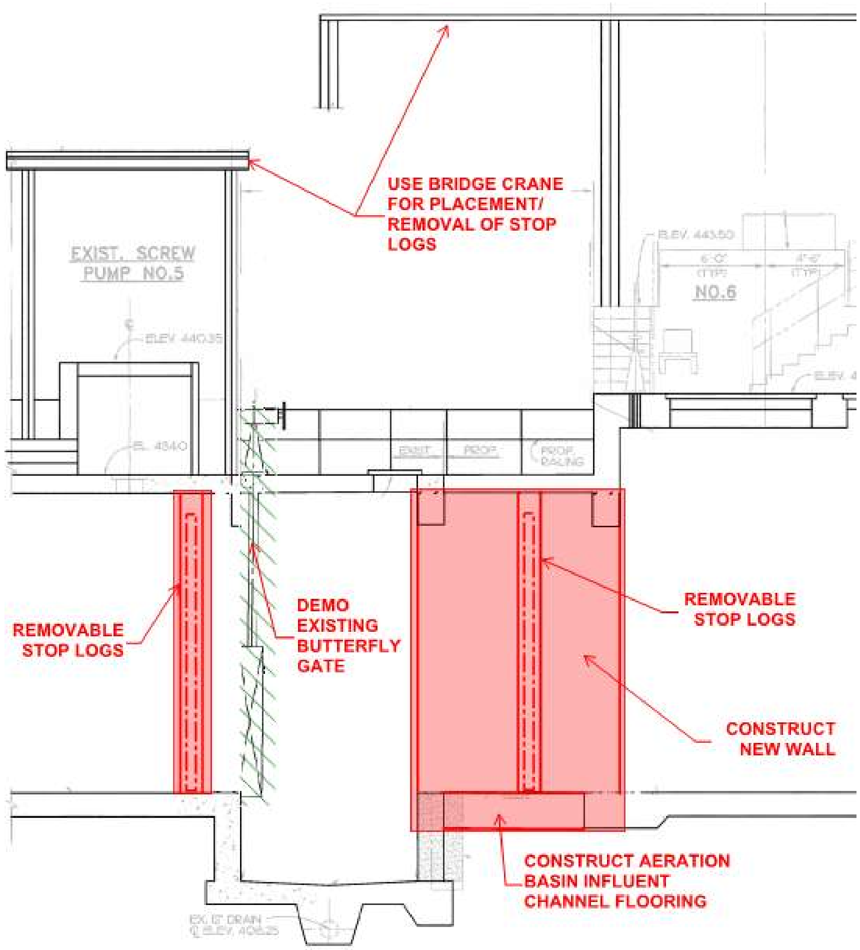

Figure 4 – Aeration Basin Influent Channel Section

4.1.2.2 Odor Control

The wet well along with the inlet and outlet channels of the existing screw pumps are covered by solid aluminum grating. Negative pressure is maintained inside the headspace by withdrawal of air through odor control ducts. Individual ducts with balancing valves withdraw air from each compartment. Similar odor control measures shall be provided to cover the expansion. The impact on the odor control system should be minimal. The submersible pump options should require less volume under cover requiring odor control and the reduced turbulence should minimize the amount of odor compounds that are volatilized during pumping.

4.1.2.3 HVAC

The IPS pump area is not heated or ventilated. Electrical buildings for the new electrical equipment will be prefabricated with air-conditioning specified to support the Variable Frequency Drives (VFDs) environmental limits.

4.1.2.4 Plumbing

Not Applicable

4.1.2.5 Instrumentation and Controls

The instrumentation modifications and additions will be similar for all pump options under consideration, with only the quantities of pumps being affected. Existing screw pumps shall retain local controls. Modifications to the “auto” operations sequences will be necessary to coordinate operation of screw pumps with submersible pumps as described in Section 5 of this TM. Monitoring and control of the IPS will be developed via detailed design workshops with MWS as the design progresses.

- Additional monitoring of screw pumps rotation:
  - Current sensors will be added to each screw pump motor branch circuit current and set to alarm in the plant control system to indicate when a motor is commanded to run, but running current level is not detected.
- New submersible pumps:
  - Local Hand/Off/Remote selector switch with remote monitoring at each pump.
  - Each submersible pump will have a pump monitor module for thermal and moisture detection. Interlocks will be hard wired into the drive enable circuit and the manufacturers units will be networked and mapped to the plant monitoring system.
  - VFDs on new pumps will include Ethernet communication to allow full monitoring of pump status and remote control as noted in the remote monitoring and control section below.
- Level monitoring
  - Existing ultrasonic level transmitters in the wet well level will be changed to submerged membrane transmitters per MWS instrumentation standards.
  - Hardwired low level float switches will be interlocked to stop pumps on low level in wet well.
  - Hardwired high level float switch will alarm and start pumps on high level in wet well.
- Isolation gates
  - Local/Off/Remote control on the drive actuator
  - Local Mode – When in Local, operator opens/closes/stops gate with push buttons at gate actuator.
  - Remote Mode – When in Remote, operator opens/closes or inputs desired valve position from the plant DCS.
  - Actuators will be specified with Ethernet or RS485 communications compatible with the system for remote monitoring and control.

- Remote monitoring and control
  - Manufacturer supplied pump protection device and VFD monitored via Ethernet.
  - Wet Well Level Indication
  - Wet Well Low Level Alarm
  - Wet Well High Level Alarm
  - Pump on/off operation and speed control
  - Gate Status – by RS-485 or Ethernet as determined during design.

4.1.3 Electrical

4.1.3.1 New Submersible Pumps West (Option 2 – Alternatives Analysis)

Review of record documents indicates the Motor Control Centers (MCCs) for the large screw pumps (MCC-P131, and -P132MCC-) located in the blower building each have a spare reduced voltage autotransformer starter (RVAT) for a 250 HP future screw pump. The capacity of these MCCs would indicate that they each would accommodate the increase from the planned future 250 HP screw pump future slots to the proposed 310 HP submersible pump. A further investigation should be performed to record the actual operating demand loads on each of these MCCs to confirm that capacity availability. This capacity may be diminished by the odor control equipment added in 2005.

If capacity is available, then spare RVAT starter units would need to be replaced with 800A adjustable trip feeder breaker units to serve new 500A minimum output VFDs, one for each new submersible pump.

The design will need to consider drives with near unity power factor and harmonic mitigation in order to utilize these existing sources for the increased horsepower. This solution maintains diversity and redundancy in the pump electrical supply and is powered by the existing plant dual source redundancy in the main 13.8kV distribution system.

If spare capacity is not available, another secondary tap from T13-1 and T13-2 would be considered or 4160V feeds from MV-H131MCC- and MV-H132MCC- could serve the new drives via 4160 to 480V stepdown transformers.

Records indicate spare feeder breakers in the noted MCCs that would be used to serve the new motor actuated slide gates. The design should contemplate gates being fed from the same MCC as the respective pump.

Space in existing electrical rooms is not available for new drives of this size. It is recommended that a new outdoor, air-conditioned, prefabricated electrical enclosure be added to house the drives and the new PLC Input and Output (IO). The proposed location of the new electrical enclosure is shown in Figure 2 above. For Option 2 the structure footprint would be approximately 8 ft. by 12 ft. housing two VFDs. The electrical enclosure would increase to approximately 10 ft. by 18 ft. for Option 3.

4.1.3.2 New Submersible Pumps East (Option 3- Alternative Analysis):

Review of record documents indicate -P131MCC- and -P132 MCC-would not have adequate capacity (1600A limitation) to accommodate all four proposed 310 HP submersible pumps. Preliminary calculations based upon record documents indicate that -P133MCC- and -P134MCC- have ampacity available for two of the pumps, but no spaces or spares. If the five 100 HP screw pumps are removed, one of 100 HP new submersible pumps could be serviced from a full capacity tap off of MCC P47 after three of the screw pumps were removed. This would result in a net addition of 10 HP to that circuit. From calculations, it would appear that another pump could be fed from a tap off of MCCP48 when two of the 100 HP screw pumps have been removed. This would need to be verified by actual load recordings. The net addition would be 110 HP to that circuit. The remaining two new pumps could be fed as described in Option 2 above.

The design will need to consider drives with near unity power factor and harmonic mitigation in order to utilize these existing sources for the increased horsepower. This solution maintains diversity and redundancy in the pump electrical supply and is powered by the existing plant dual source redundancy in the main 13.8kV distribution system.

Records indicate spare feeder breakers in the noted MCCs that would be used to serve the new motor actuated gates. The design should contemplate gates being fed from the same MCC as the respective pump.

Space in existing electrical rooms is not available for new drives of this size, nor will the sequencing of construction allow for demolition to make space available prior to new VFDs needing to be in service. It is recommended that a new outdoor, air-conditioned, prefabricated electrical enclosure be added to house the drives and the new PLC IO.

Demolition of circuits and sparing of starters for screw pump auxiliary components such as lube pumps will be included in the design. Starters will be “spared;” wire will be removed; and exposed conduits will be removed and capped where they become inaccessible.

4.1.4 Structural

- General-
  - Due to the site restrictions, it should be anticipated that any new construction will require shoring of the excavated area and potential temporary support and bracing during construction for the existing structures in the immediate vicinity.
  - All options will include constructing a new 20-ft long channel to connect the two existing aeration basin influent channels.
  - All new construction will require micropiles to support the structural foundation. It may be possible to reuse some of the existing piles depending upon the option that is selected, the load requirements, and the condition of the existing piles.
  - It is anticipated that all options will include the construction of a new electrical building. The size of the building will be determined based upon the requirements for the option that is selected.
- Submersible Pumps West (Option 2)
  - Construct new wet well to the west of the existing large screw PS in order to house two new submersible pumps.
  - The new PS will be connected into the existing primary effluent and aeration basin influent channels.
  - New submersible PS canopy and bridge crane will be extended to the existing canopy and bridge crane at the existing large screw PS.
  - Odor control covers will be provided over the existing aeration basin influent channel at the submersible PS discharge location.
  - Continued use of the existing small screw PS will require extensive rehab, including re-screeding around screws, rehab of concrete stairs, rehab of motor support pads, rehab of roof slabs at channels, and replacement of existing canopy and crane.

- Existing Parshall flume will be removed and replaced with a new channel that matches the existing influent channel elevation.

- Submersible Pumps East (Option 3)
  - The screw pump foot well, and a portion of the screw channels at the small screw PS will be demolished to make room for the new deeper submersible pumps wet well.
  - The existing aeration basin influent channel will be rehabilitated as required and serve as the aeration basin influent channel for the new submersible station.
  - The existing canopy and bridge crane at the small screw PS will be demolished along with the pump motor support pads. A new canopy and traveling bridge crane will be constructed along the centerline of the new submersible pumps.
  - The inclined portions of the screw channels will be utilized as support for the discharge piping from the submersible pumps. Minimal concrete work is expected in order for these channels to function as piping supports.
- Hybrid option
  - The hybrid option combines the new submersible pumps described under Option 2 above and the replacement of the old screw pumps with a number of submersible pumps of equal capacity in the same footprint.

4.1.5 Geotechnical

Due to the large quantity of debris and fill material at the site, it is anticipated that micropiles will be required to support the foundation for the retaining wall. Micropiles are preferable due to limited site access, anticipation of obstructions below grade, and in order to protect the existing structures against vibration damage. Geotechnical services will be required to provide recommendations for design. A number of the existing piles should be tested for capacity and supplemented with micropiles as necessary to support the anticipated loads.

4.1.6 Architectural

Architectural work is limited to the canopies covering the traveling bridge cranes which service the pumps. The crane servicing the existing screw pumps number one through five is in poor condition and will be replaced along with a new canopy if the screw pumps are retained. The canopy covering the existing screw pumps number six through nine is in serviceable condition and will be extended depending on the pump option selected. All new construction will incorporate a means of passive ventilation to avoid trapping any moisture or condensation released from the channels underneath the canopy.

4.1.7 Site Civil

Grading in the vicinity of the IPS is not anticipated to be affected. Stormwater runoff is not anticipated to increase appreciably due to the proposed construction. Access to the IPS will remain unchanged.

References

AECOM, *Long Term Control Plan for Metro Nashville Combined Sewer Overflows*

Central Wastewater Treatment Plant Optimization Study TM No. 3 – Plant Hydraulic Evaluation, Brown & Caldwell, October, 2012.

Consoer Townsend and Associates Central Wastewater Treatment Plant Expansion; *Equipment Operation and Maintenance Manual*; Project No. 90-SC-05; Volume 6; Spec Section 11314; 1992

Lakeside Equipment Corporation, *Screw Pump Installation and Operating Instructions for Nashville, Tennessee S.O 80-299*, 10/5/1980

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Technical Memorandum

Prepared for: Metro Water Services

Project Title: Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Project No.: 148388

Technical Memorandum No. 6

Subject: Aeration System

Date: December 21, 2016

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Limitations:

This document was prepared solely for Metro Water Services in accordance with professional standards at the time the services were performed and in accordance with the contract between Metro Water Services and Brown and Caldwell dated September 15, 2015. This document is governed by the specific scope of work authorized by Metro Water Services; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by Metro Water Services and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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Executive Summary

The objective of this Technical Memorandum (TM) is to present the basis of design for the proposed improvements to the aeration tanks (ATs) and associated areas at Central Wastewater Treatment Plant (CWWTP) for the CWWTP Improvements & CSO Reduction project (COPT Project).

Supplemental to this TM are the previous TMs that were developed by Brown and Caldwell (BC) as part of the Central Optimization Study Project (COPT Study). These TMs form an integral part of the basis of design report (BODR) and are referenced throughout this document. The presentations and minutes from the developmental workshops provide additional decision making background and supplemental information for this BODR.

The major modifications proposed for the ATs are highlighted below:

- Replace existing draft tube aerators within each of the ATs with a new fine bubble diffuser aeration system.
- Provide new influent cutthroat flumes and gates to passively and equally split flow for the existing ATs, and provide means to isolate tanks in/out of service.
- Reconfigure the existing AT layout to include an anaerobic selector and anoxic/aerobic zones to provide the most beneficial capacity, efficiency, future nutrient removal and operational configuration.
- Provide a more energy-efficient and effective mixing system within the aeration influent channels.
- Upgrade the existing blower system to achieve the increased operating pressure and air requirements from implementing fine bubble aeration in the deep ATs.

The improvements and modifications are recommended primarily to increase the secondary treatment capacity of the CWWTP and maximize peak flow capacity within the existing tankage. These improvements also are recommended to improve operations, reliability, and process control, and to reduce energy and operating costs within the aeration system.

Improvements being recommended for the return activated sludge (RAS) system including the new RAS splitter box, RAS pumping and forcemain (FM) improvements, and new RAS gravity piping to each AT are provided in TM 7 – Return Activated Sludge. Additional improvements to the secondary clarifiers (SCs) and mixed liquor (ML) channel including design of efficient mixing in the ML channel to reduce degassing issues created by the deep ATs are provided in TM 8 – Secondary Clarifiers.

Section 1: Process Area Description

The following presents a review of the existing aeration system, including the ATs, blowers, aeration influent channels, and any new proposed improvements which are part of the overall AT design.

1.1 Description of Existing Facilities

Figure 1 below portrays an aerial site plan of CWWTP with the aeration system highlighted to show process areas that are covered in this TM. Table 1 below lists a summary of the aeration process units at CWWTP, along with physical descriptions and data for the existing system.

Figure 1. Location of ATs and Aeration Influent Channel at CWWTP

Table 1. Summary of Existing Aeration Process Units at the CWWTP

Parameter	Unit	Value	Notes
Aeration Tanks			
Number of tanks/passes	--	8/2	2 passes per tank
Dimensions (length x width x depth)	Feet (Ft)	175- x 50 x 30	Per tank
Total Reactor Volume	MG	3.9 / 31.4	Per tank / Total
Aeration System	--	Mechanical Aerators (Draft-tube)	
No. of Aerators	--	4/32	Per tank / Total
Aerator Capacity, each	lb O_2 per hour	950	
West Aeration Influent Channel			
Dimensions (length x width x depth)	Ft	900 x 15 x 18.17	
Air provided for mixing	Scfm	2,700	Assuming 3 cfm/LF[1]
North Aeration Influent Channel			
Dimensions (length x width x depth)	Ft	230 x 15 x 18.17	
Air provided for mixing	Scfm	690	Assuming 3 cfm/LF[1]
East Aeration Influent Channel			
Dimensions (length x width x depth)	Ft	850 x 6 x 18.17	
Air provided for mixing	Scfm	2,550	Assuming 3 cfm/LF[1]

Table 1. Summary of Existing Aeration Process Units at the CWWTP			
Parameter	Unit	Value	Notes
Blowers			
Number of blowers	--	7	Four in North Blower Building. Three in Process Center Building.
Design Flow	cfm	23,700	
Discharge Pressure	psig	9.0	
Motor Size	hp	1000	
Motor Voltage	V	4160	

[1] *3 cfm/LF is assumed based on values presented in Central WWTP O&M manual for design criteria*

Section 2: Design Intent

Improvements to the ATs are focused on installing a more efficient aeration system and meeting the process requirements of the COPT Study recommendations to improve biological performance and maximize wet weather capacity. Modifications to the blower system will be necessary to achieve the increased operating pressure for the deep ATs. Other major improvements include passive influent flow split and AT arrangements to facilitate consistent distribution of influent loading, wet weather treatment, anaerobic selector, and anoxic/aerobic zones for nutrient removal.

The following list represents the overall design intent for the recommended improvements to the ATs.

- The existing draft tube aerators will be removed and replaced with fine bubble diffusers in order to provide adequate process treatment for the current and future aeration demands.
- The AT layout will be reconfigured to provide the most beneficial AT configuration that balances capacity, efficiency, future nutrient removal, and operational configuration.
- Anaerobic selectors and anoxic/aerobic zones are included in each AT to achieve a system for future biological nutrient removal.
- Modifications to the existing aeration influent flow will be implemented to route all dry-weather flow to feed the ATs from the west aeration influent channel, utilize the large channel as a “zero-loss” channel. This will allow flow to be passively and evenly split to the ATs and accommodating the updated AT configuration.
- Cutthroat flumes will be constructed between the west aeration influent channel and each AT in order to provide passive and even flow split of mixed aeration influent flow to the ATs.
- A new blower system is sized in order to meet the design criteria and air flows rates associated with implementation of fine bubble diffusers in the ATs (described in Section 3), and to meet the increased operating pressure from installing the diffusers at the floors of the deep ATs.
- Biological contact mode will be implemented in order to minimize mixed liquor suspended solids (MLSS) concentration sent to the SCs and provide optimum level of treatment during wet weather flow conditions.
- Existing coarse bubble diffusers in the aeration influent channel will be removed and replaced with other mixing alternatives in order to optimize energy usage for the channels while still providing adequate mixing.
- Currently, primary effluent from both north and south is not adequately mixed prior to entry into ATs, and flow is not automatically split evenly to each of the 8 ATs – operators rely on butterfly valves that are

unreliable and some of which are not able to be closed completely. Aeration influent will be completely mixed and passive and evenly split to the ATs along with RAS flow to limit migration of solids in mixed liquor channels to the SCs.

Section 3: Constraints

This section describes the constraints associated with this process area for meeting the design intent.

3.1 Design Criteria

The following section provides a summary of the necessary design criteria that impact the design and implementation of improvements for the aeration system at CWWTP. COPT Study TM 5.1 – Hydraulic Capacity Assessment & COPT Study TM 5.4 – Process Capacity Assessment and Alternatives Analysis of the CWWTP include a complete process design basis for the aeration system.

3.1.1 Influent/Effluent Flow and Loading Criteria

Table 2 presents a summary of the plant influent design parameters used for the evaluation. Table 3 presents a summary of the design influent criteria used for the process modeling and recommendations for process upgrades.

Table 2. Summary of Existing Plant Influent Design Data for Liquid Process Units at the CWWTP

Description	Capacity
Average Daily Flow (MGD)	104 (Summer) – 125 (Winter)
Peak Hour Flow (MGD)	270 (Summer) – 330 (Winter)
$CBOD_5$ (mg/L)	200 (Summer) – 170 (Winter)
TSS (mg/L)	260 (Summer) – 220 (Winter)
NH_3-N (mg/L)	20 (Summer) – 14 (Winter)
TKN (mg/L)	35 (Summer) – 25 (Winter)

Table 3. Summary of Future Influent Flows and Pollutant Loadings for the Central Plant

Parameter	Condition	Value 2030
Flow (MGD)	Annual Average	125
	Maximum Month	193
	Maximum Day	328
	Peak Hour	430
Temperature (^oF)	Annual Average	68
	Winter Average	54
	Summer Average	72

Table 3. Summary of Future Influent Flows and Pollutant Loadings for the Central Plant		
Parameter	**Condition**	**Value 2030**
$CBOD_5$ (lb/d)	Annual Average	114,675
	Maximum Month	158,141
	Maximum Day	428,367
TSS (lb/d)	Annual Average	152,900
	Maximum Month	210,854
	Maximum Day	571,156
TKN (lb/d)	Annual Average	23,852
	Maximum Month	32,916
	Maximum Day	61.392
NH_3-N (lb/d)	Annual Average	11,468
	Maximum Month	15,814
	Maximum Day	42,837
TP (lb/d)	Annual Average	2,683
	Maximum Month	3,703
	Maximum Day	6,907

3.1.2 Effluent Permit Requirements

Table 4 summarizes the effluent requirements for the CWWTP based on the National Pollutant Discharge Elimination System (NPDES) Permit No. TN0020575 (included in Appendix A of COPT Study TM 1- Flows and Loading Analysis). In the case of the CWWTP, three sets of current effluent requirements are established as follow:

1. Advanced secondary activated sludge treatment: this applies to dry weather conditions for flows in the range of 0 to 100 million gallons per day (MGD). It includes seasonal effluent requirements for $CBOD_5$, total suspended solids (TSS) and ammonia concentrations;
2. Conventional activated sludge treatment: in cases where flows are in excess of 100 MGD but lower than 220 MGD (wet weather conditions), weekly and maximum day average requirements are established;
3. Primary treatment and disinfection: for flows in excess of 220 MGD, secondary treatment is not required for the excess flow. Hence, this fraction of flow is diverted to the excess flow treatment unit for disinfection only after primary treatment. During these conditions, the CWWTP is only required to report effluent concentrations, except for disinfection-related parameters.

Table 4. Summary of Current NPDES Requirements for the CWWTP						
Effluent Characteristics	Effluent Limitations (advanced secondary activated sludge treatment – Dry weather flows in the range of 0 to100 MGD)					
	Monthly Average Conc. (mg/L)	Monthly Average Mass (lb/d)	Weekly Average Conc. (mg/L)	Weekly Average Mass (lb/d)	Daily Average Conc. (mg/L)	Daily Average Mass (lb/d)
$CBOD_5$ (May 1- October 31)	10	8,340	15	12,510	25	20,850
$CBOD_5$ (November 1-April 30)	20	16,680	30	25,020	40	33,360
Ammonia-N (May 1- October 31)	5	4,170	7.5	6,225	10	8,340
Ammonia-N (November 1-April 30)	10	8,340	15	12,510	20	16,680
Total Suspended Solids	30	25,020	40	33,360	45	37,530
Effluent Characteristics	Effluent Limitations (conventional-level activated sludge treatment – wet weather flows in the range of 100 to 220 MGD)					
$CBOD_5$	NA	NA	35	64,218	40	73,392
Ammonia-N	NA	NA	15	27,522	20	36,696
Total Suspended Solids	NA	NA	40	73,392	45	82,566

3.1.3 Aeration Criteria

This section presents a summary of aeration requirements for the CWWTP to be used for the design of process improvements for the ATs and blower system. Three separate aeration control methods are provided in Table 5 to show parameters based on what is brought forward through Phase 2 detailed design. Both near-term and future design parameters are included to provide design setpoints for the updated aeration system. A detailed alternatives evaluation of the aeration system including blower selection that is based on the following aeration requirements is included in supplemental design information. The following lists a brief description of the three types of instrumentation-based aeration control used for developing a range of aeration requirements.

- Dissolved Oxygen (DO)-Based Aeration Control – DO probes are installed in different aerated zones, and aeration in each zone is controlled through modulation of air based on DO setpoints within the distributed control system (DCS).
- Ammonia-Based Aeration Control – Aeration is controlled to meet effluent ammonia concentration; aeration demand is lowered during low ammonia loading conditions which enhances denitrification
- Ammonia vs. NO_2-N + NO_3-N (AvN) Aeration Control - Ammonia and nitrate (NO_2-N) + nitrite (NO_3-N) concentrations are maintained equal in the effluent at all times

Table 5 presents a summary of the aeration requirements based on type of aeration control.

Table 5. Summary of Aeration Requirements for the CWWTP			
Parameter	DO-Based Aeration Control	Ammonia-Based Aeration Control	AvN Aeration Control
Design DO (mg/L)	2.0	--	--
Average AOR[1] (kg O_2/d)	68,400	60,900	54,500

Table 5. Summary of Aeration Requirements for the CWWTP			
Parameter	DO-Based Aeration Control	Ammonia-Based Aeration Control	AvN Aeration Control
Max AOR (kg O_2/d)	132,400	121,800	109,000
SOTE[2] avg, %	48%	48%	48%
SOTE max, %	45%	45%	45%
Average Airflow Rate (scfm)	33,100	26,200	23,400
Maximum Airflow Rate (scfm)	68,200	55,700	49,900

[1]*AOR = Actual Oxygen Requirement*

[2]*SOTE = Standard Oxygen Transfer Efficiency*

3.1.4 Aeration Influent Channel Mixing Requirements

Table 6 presents a summary of the existing aeration influent channel dimensions provided for mixing aeration influent flow. Channel mixing design will include means for complete mixing of the entire aeration influent channel length while preventing sedimentation. All influent flow up to 250 MGD will be sent to the west aeration influent channel and the north and east aeration influent channels will be offline. The remaining flows over 250 MGD will be routed to the east aeration influent channel. A detailed alternatives evaluation of the channel mixing system that is based on the following channel dimensions and additional mixing criteria is included in the supplemental design information.

Table 6. Summary of Existing Aeration Influent Channel Dimensions at CWWTP			
Channel/Tank Description	Length (ft)	Width (ft)	Depth (ft)
West Aeration Influent	900	15	18.17
North Aeration Influent	220	15	18.17
East Aeration Influent	800	Varies from 6' to 11'-10"	18.17

3.2 Code Considerations

A complete list of all codes used for design will be included in the Code Classification Summary, which will be completed during preliminary design.

3.3 Regulatory Drivers

The following includes a list of regulatory drivers that impact the design and implementation of improvements for the ATs as part of this project.

3.3.1 Future Effluent Permit Requirements

Design considerations in Phase 2 detailed design will include discussions with the Clean Water Nashville Overflow Abatement Program (CWNOAP) regarding implications on the effluent permit based on the optimized design and future effluent capacity of CWWTP.

The current permitted limit for total pounds of TSS per day may need to be increased to accommodate the increased maximum daily loading to the Cumberland River in order to maintain the current maximum permit concentration of 40 mg/L with higher flows. Otherwise, the maximum permitted TSS concentration will have to be reduced to accommodate an increase in flows.

3.3.2 Air Permit

CWWTP has an air permit for emission limits that is currently issued on the existing plant configuration. It is assumed that the existing air permit emission limits will remain the same through the full implementation of COPT improvements. The permit limits will be used as design constraints for proposed improvements, and the existing air model will be updated throughout the design and construction to ensure permit limits are met. If any modifications to the existing air permit are required, the permitting timeline for a new air permit will become a time-sensitive component of the design process due to the long lead time of permit application and review process before reissuance.

The updated air permit will not change the design of the aeration system; however, it could impact the overall project schedule based on the time constraints of the application and permit reissuance process.

3.3.3 Future Nutrient Limits

The CWWTP currently does not have total nitrogen or total phosphorous effluent requirements. However, it is anticipated that limits on these parameters may be added to the CWWTP NPDES permit in as soon as 5 years, but more likely 10 or more years based on discussion with MWS and Tennessee Department of Environment & Conservation (TDEC). Effluent total nitrogen and total phosphorous requirements are expected to be specific to the Cumberland River in lieu of statewide numerical criteria. Based on information recently presented by TDEC, future total nitrogen and total phosphorus limits are currently anticipated to be approximately 10 mg/L and 1 mg/L, respectively. During Phase 2 detailed design, anticipated nutrient limits should be updated based on the most recent guidance from TDEC.

3.3.4 Environmental Protection Agency (EPA) Consent Decree

A major constraint of the design and implementations of the COPT improvements project includes how much flow MWS will be required to treat through secondary treatment based on the Consent Decree from EPA, as part of the Long Term Control Plan Corrective Action Plan/Engineering Report (LTCP CAP/ER). It is currently undetermined when the Consent Decree will be finalized.

3.4 Sequencing and Constructability Affecting Design

The following text provides a preliminary list of specific sequencing issues and constructability items that impact the design scope of improvements in this process area. Other COPT Project components that affect and require coordination with this process area are included. The overall sequencing plan for this process area is discussed in Section 5 of this TM, and overall construction sequencing plan will be included in an overall sequencing plan, and will be referenced when completed. These sections will be coordinated with the project Construction Manager at Risk (CMAR) in development of the overall sequencing plan.

- The structural condition of the existing aeration tank walkways and walls between the west aeration influent channel and aeration tanks must be assessed to determine the structural feasibility of installing the new influent cutthroat flume channels and chimney-type influent structure.

- The structural condition of the aeration tank floors and interior walls must be assessed to determine the structural capacity for the additional load of baffle walls, the gravity RAS piping within the tanks, and other modifications to the tank walls and structure.

Section 4: Description of Improvements and Scope of Work

The following describes the key development information, features, design data and operations and control narrative for the secondary treatment system.

4.1 Detailed Design Considerations and Assumptions

The following list includes assumptions and considerations used for this BODR evaluation, and are to be confirmed during Phase 2 detailed design. BODR evaluations are based on the AT configuration proposed in the COPT Study and illustrated in Figure 2.

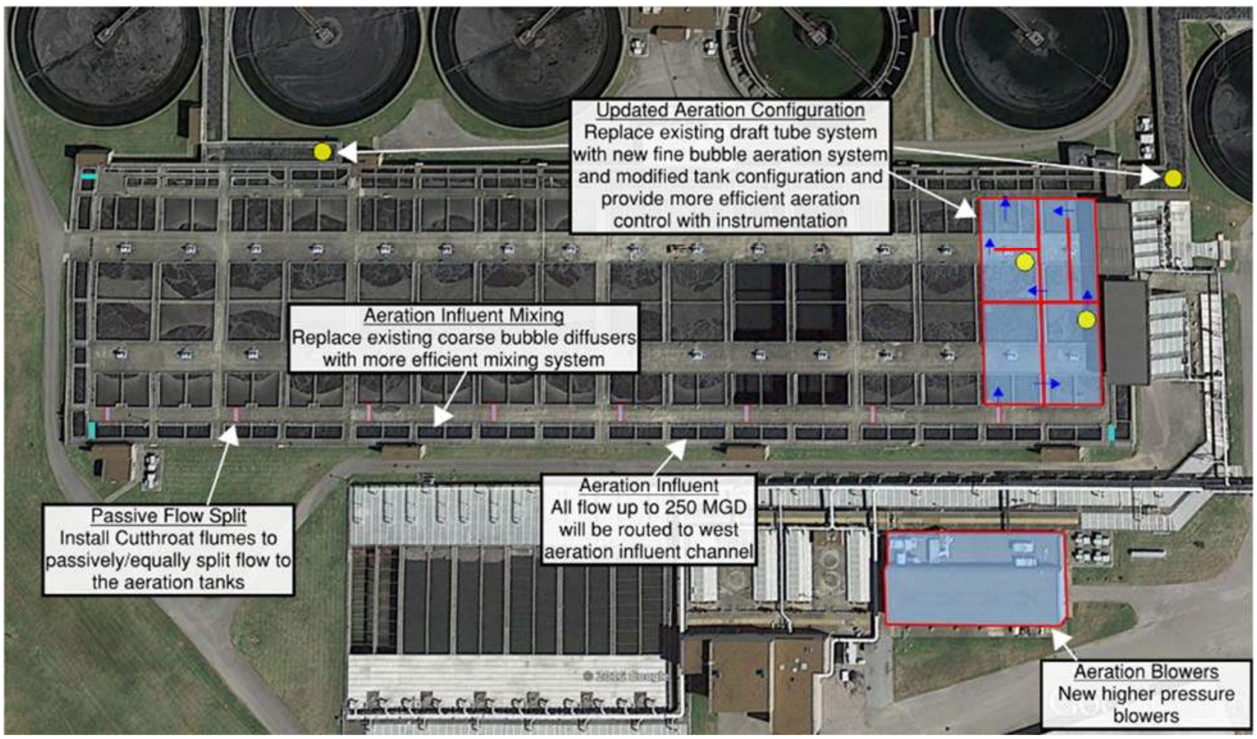

Figure 2. Proposed Aeration System Modifications

The final AT configuration will be determined during Phase 2 detailed design and is assumed to include the following general features:

- The maximum water surface elevation in the ATs was assumed to be 432.0 ft (total depth of 33 ft). COPT Study TM 5.1- Plant Hydraulic Capacity Assessment and Alternatives Evaluation provides a detailed hydraulic evaluation of the existing plant.
- Approximately 25 percent of the total AT volume will function as an anaerobic selector.

- The remaining 75 percent of the tank volume will consist of aerated zones with fine bubble diffusers. Plug flow characteristics will be achieved using a combination of existing tank walls and new baffle walls.
- New baffle walls are anticipated to be constructed of fiberglass reinforced plastic (FRP) and/or concrete.
- Both aeration influent flow and RAS will enter the anaerobic selectors at or near the bottom of the tank to promote mixing of these flows and minimize short-circuiting across the surface of the tank.
- Improvements are intended to minimize accumulation of surface foam/scum and promote its continuous removal from the tank.
- 6-in of headloss is assumed within the ATs, mostly associated with the baffle walls.
- The BioWin model will be updated during Phase 2 detailed design based on the final AT configuration and results of oxygen efficiency transfer testing.
- For the evaluation of aeration influent channel tank mixing alternatives and the passive and even flow split of aeration influent flow into the ATs, it was assumed that north and south primary effluent will be completely mixed prior to the inlet of AT #1 and that all flow up to 250 MGD will be routed to the west aeration influent channel. Primary effluent flow exceeding 250 MGD will be routed to the east aeration influent channel. Refer to TM 5, Intermediate Pump Station, and TM 4, Primary Settling Tanks, for specific details on how the north and south primary effluent flow is proposed to be mixed.
- Elevations and distances were determined using record drawings from 1976 and 1990 Major Plant Expansion sets.

4.1.1 Hydraulics

- As described in COPT Study TM 5.1- Plant Hydraulic Capacity Assessment and Alternatives Evaluation, the ATs and influent/effluent channels were modeled as part of the overall hydraulic model for the CWWTP. This evaluation determined that the west aeration influent channel could accommodate all aeration influent flow up to 250 MGD and operate as a “zero-loss” hydraulic channel, allowing flow to be passively split into each AT. As part of phase 2 detailed design, the hydraulic model will be calibrated to confirm assumption of this channel being a “zero-loss” channel.
- The aeration influent cutthroat flumes shall be designed to equally split flow among the ATs over the entire range of design flow rates and downstream hydraulic conditions. Two design approaches were evaluated to assess the free flow at both the peak condition and a low flow, partially-submerged condition. The following assumed flow rates and elevations were used for the preliminary design:
  - Maximum aeration influent flow = 350 MGD.
    - Max flow through influent flumes = 250 MGD
    - Flow exceeding 250 MGD will enter biological contact influent piping
  - Minimum aeration influent flow = 80 MGD.
  - Maximum AT water surface elevation = 431.8 ft.
  - Minimum AT water surface elevation = 430.3 ft.
  - Aeration influent channel invert elevation = 415.8 ft.
  - Maximum allowable aeration influent channel water surface elevation = 432.0 ft.
  - Minimum energy loss to achieve flow split = 1.2 ft.
- To prevent short-circuiting in zone 1 and to achieve required nitrogen removal, a chimney-type inlet will be constructed to disperse the influent into each AT. The chimney-type inlet will convey the influent to the bottom of the tank and this would be released there to avoid short-circuiting. Figure 3 below shows

a conceptual schematic of how a chimney-type inlet will direct flow from the aeration influent channel to the anaerobic selector zones of each AT.

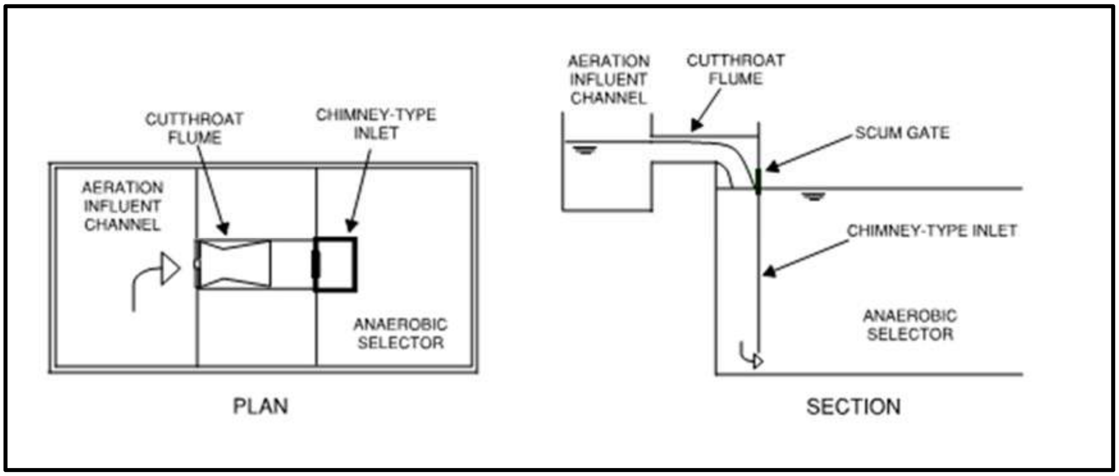

Figure 3. Chimney-type Inlet Plan and Section Schematic

- Existing aeration inlet piping that is currently used from the east aeration influent channel into the aeration basins will be left in place and used for biological contact mode. The existing butterfly valves on the inlet piping are currently being replaced by MWS and will be used to open/close pipelines during wet weather flows.

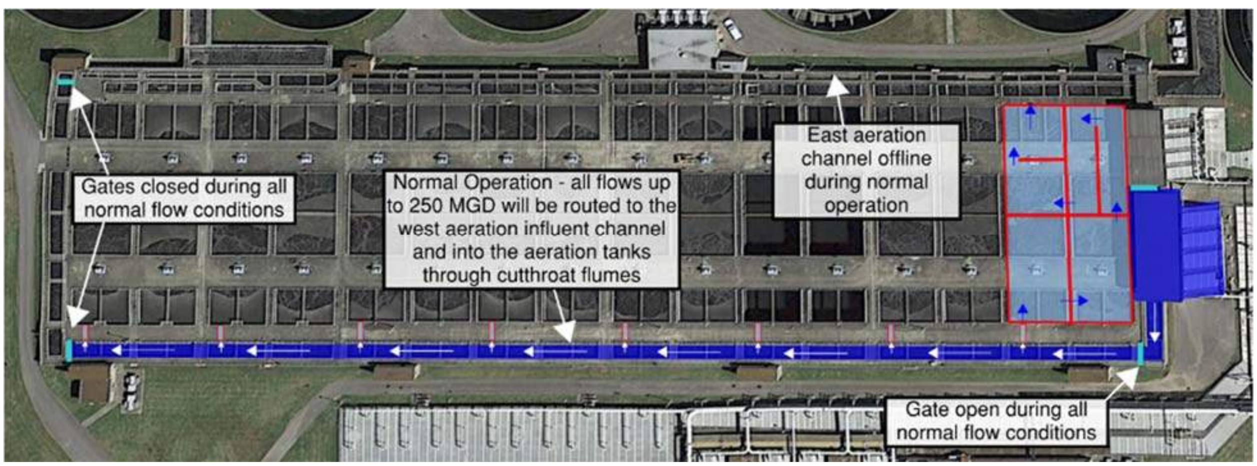

Figure 4. Normal Operation for Aeration Tanks with Proposed Improvements

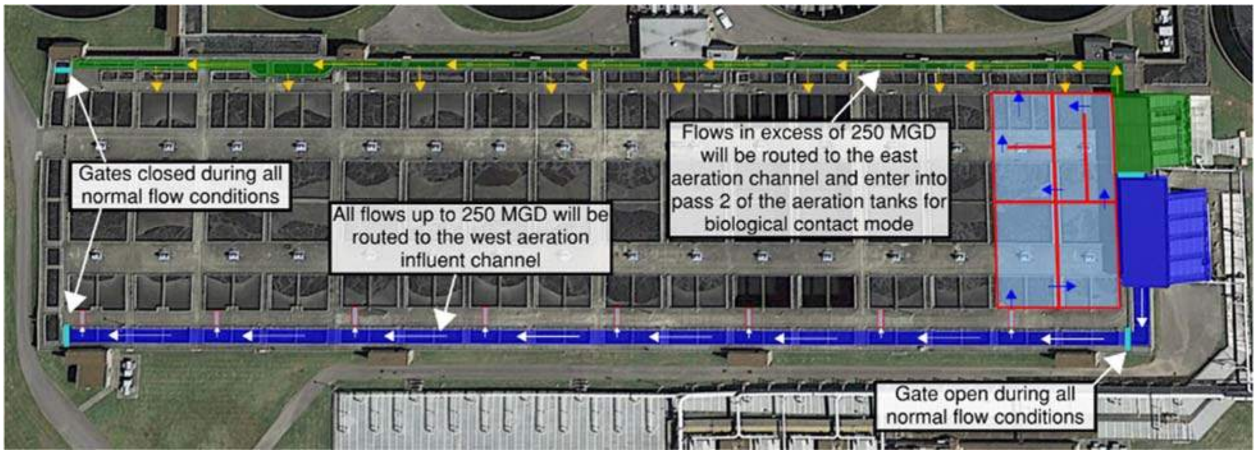

Figure 5. Biological Contact Mode Operation for Aeration Tanks with Proposed Improvements

4.2 Process Mechanical

4.2.1 Aeration Influent Channel

With the implementation of the proposed AT configuration (shown in Figure 2), the east and north aeration influent channels will only be online and accepting influent flow at flows above 250 MGD. The existing aeration influent channels currently do not have the ability to be completely isolated, so the following scope items provide the ability to utilize only the west aeration influent channel for aeration influent flow up to 250 MGD:

- Provide slides gates and/or stop logs in the aeration influent channels at locations marked in Figures 5 and 6 to provide MWS the ability to isolate/drain the north and east aeration influent channels when not in use. Also utilize existing stop log gates if required. Coordinate channel isolation for energy savings with overall sequencing for the aeration improvements and overall COPT improvements. Assume 3 slide gates will be installed in the aeration influent channel.
- Slide gates on the upstream end of the 8 cutthroat flume channels will be provided to allow for isolation of individual ATs.
- Replace aeration influent butterfly valves with full-port plug valves. Assume 8 butterfly valves will be replaced with plug valves.

4.2.2 Aeration Influent Mixing

As discussed previously and in COPT Study TM 5.5– Low Pressure Aeration System Upgrades, the existing coarse bubble air mixing system in the aeration influent channels provides excess air from what is required for mixing, resulting in energy costs that could be saved by MWS. Additionally, the existing coarse bubble diffusers are damaged and are ineffective in mixing the channels, and need to be replaced with a new channel mixing system. The alternatives evaluation, originally completed in COPT Study TM 5.5, was updated and is included in supplemental design information that includes new long band type diffusers (as were installed in south primary effluent channel in recent upgrades project), top-mounted hyperboloid mixers, and compressed gas mixing. The selected mixing alternative will be finalized in Phase 2 detailed design of this project, but costs for the compressed gas mixing alternative are shown in the cost estimate of this BODR.

The following scope items will provide an energy-efficient mixing system within the aeration influent channels while meeting channel mixing requirements:

- Demolish existing point-type coarse bubble diffusers, and associated air piping within the aeration influent channel (as applicable).
- Replace existing damaged air piping as necessary (full replacement assumed for cost estimate).
- Finalize selection of aeration influent channel mixing alternative to provide adequate mixing to the aeration influent channels while providing energy efficiency.
- If a mixing alternative that utilizes air is used within the aeration influent channels, improvements to the air piping should be included to provide the ability to shut off air to channels not in service.

4.2.3 AT Configuration

Biological process modeling (BioWin) that was performed in COPT Study TM 5.4- Process Capacity Assessment and Alternatives Analysis indicates that the existing ATs can be reconfigured and upgraded to achieve the required treatment under the proposed design conditions.

The following lists scope items to be included with the design of the AT configuration upgrades:

- Demolish existing mixers, draft tube aerators, and associated air piping within each AT
- Provide top-mounted hyperbolic mixers to completely mix the anaerobic selectors
- Provide fine bubble diffused aeration system:
  - Diffusers mounted at or near tank floor bottoms in each of the aerated zones
  - Urethane-strip diffusers and EPDM disc diffusers will be evaluated during Phase 2 detailed design.
  - In-tank manifold piping is assumed to be polyvinyl chloride (PVC)
- Above tank aeration air manifolds and drop legs to each aeration zone will be 316SS
- Provide ability to vary the amount of air applied to different zones using control valves and instrumentation. The number of control valves and the degree/resolution of control will be determined during Phase 2 detailed design.
- During Phase 2 detailed design the option of having non-aerated mixing in passes 3A and 3B will be evaluated as a means to save energy during minimum loading periods.

4.2.4 Blowers

Various blower types and size combinations were considered for their ability to provide the high head conditions required for this project, as well as the wide range of flow under current and future plant loading conditions. Based on the analysis, the following three blower alternatives are viable and should be considered further during Phase 2 detailed design:

- Four equally sized single stage integrally geared blowers
- Two large and two small single stage integrally geared blowers
- Two multistage centrifugal blowers and four pairs of screw blowers

4.2.5 Aeration Piping

The aeration piping will be exposed to higher temperatures. The insulation, expansion joint, and support systems will need to be reviewed during Phase 2 detailed design to for any issues that would need to be addressed. In addition, the piping will need to be inspected and cleaned to ensure that debris does not foul the new fine bubble diffusers.

4.3 Odor Control (NOT USED)

4.4 Heating, Ventilation, and Air Conditioning (HVAC)

- Update/replace existing HVAC in aeration tunnels and in the blower building as necessary.
- Update/evaluate existing HVAC for blower electrical room based on updated blower selection and associated electrical equipment upgrades.

4.5 Plumbing

- Provide inspection and testing for plumbing system in tunnels to confirm pipes are not corroded or plugged. An allowance is provided in the cost estimate for overall scope of work.
- Install plumbing and water piping required for proposed heat exchangers.

4.6 Instrumentation and Controls

4.6.1 AT Influent Flow

- Provide 4-20 mA control for cutthroat flume channel isolation gates. Normal operation will be open/close, but 4-20 mA control will allow operations staff to partially open gate and see the gate position from the DCS.
- All normal process-related equipment will be designed to facilitate monitoring and control from the plant DCS. The need to monitor and control infrequently used equipment such as channel isolation gates from the DCS will be determined based on discussions with operations staff during Phase 2 detailed design.
- It is assumed that individual AT influent flow will not be measured by the cutthroat flumes as the flumes will split flow equally among online ATs.
- Biological contact influent flow from the east aeration influent channel will be measured by the existing magnetic flow meters.
- Coordinate with replacement of aeration influent butterfly valves with full-port plug valves to provide control of new valves via DCS.

4.6.2 Aeration Control Strategies

As part of Phase 2 detailed design, a life-cycle cost analysis will be performed to determine the most beneficial aeration control strategy that balances capacity, efficiency, future nutrient removal, and operational complexity. The aeration/activated sludge system workshop that was led by BC and included MWS on December 1, 2015 presented the description of different aeration control strategies and approximate locations of probes. Figure 6 below shows approximate location of mixers, DO probes and ammonia probes for the updated AT configuration.

- New local control stations (manual on/off control) for mixers for each tank with local disconnect and on/off control for each mixer in anaerobic selectors (16 total). Facilitate monitoring and control from DCS.
- Install new DO probes at the ATs (16 total) with local readout. Facilitate control via DCS.
- Install new ammonia probes in ML channel to facilitate ammonia-based aeration control (assume 2 total)

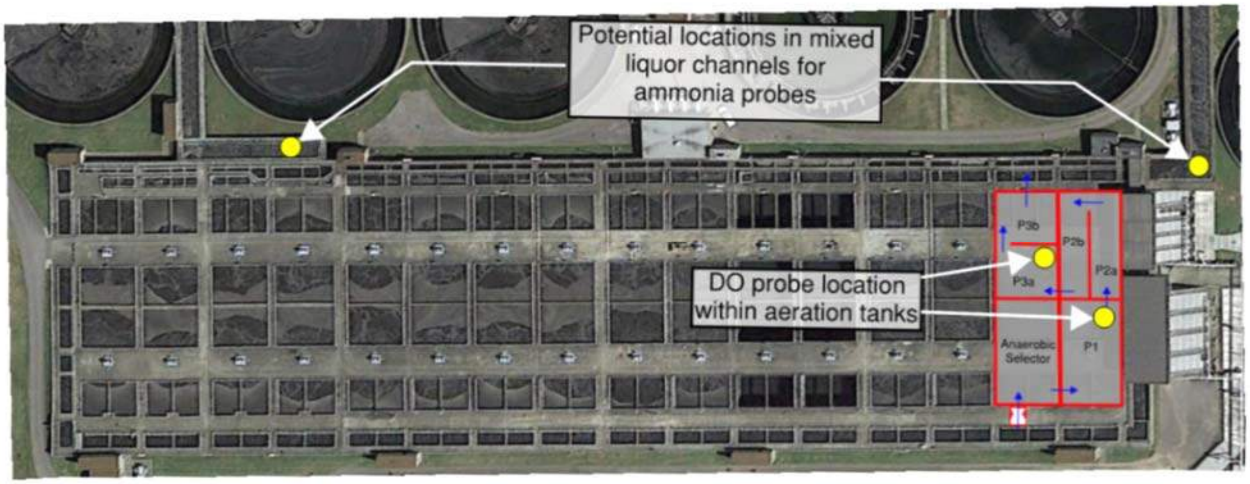

Figure 6. Location of Mixers and Instrumentation in Aeration System

4.6.3 Blowers

A detailed alternatives evaluation of blower options was developed and is included supplemental design information. The aeration blowers will each be furnished with a local control panel. The DCS system will serve as the master control panel to coordinate blower operations.

The blower air flow will modulate to maintain the header discharge set point. As the air demand reduces, the zone air control valves will close. The blower will react by reducing its output to reduce the discharge header pressure set point. Energy use can be further optimized through automatic pressure setpoint adjustment to periodically adjust the pressure setpoint for the system as required to maintain the aeration valves within their controllable range, and the blower system at its optimum efficiency. For example, if none of the valves are at or near the maximum position setpoint, then the system pressure is too high. Producing the same quantity of air at a lower pressure will result in more efficient operation of the blowers, and will keep the valves in their most controllable range. Detection of this scenario will result in the system pressure automatically being decreased.

4.7 Electrical

4.7.1 AT Influent Flow

- Provide new conduit and cable to new equipment being installed with power needs
- Coordinate with overall plant power evaluation to confirm where power will be fed to proposed aeration improvements
  - Potential use of aeration electrical room at northwest corner of ATs (T4-1, T4-2) to power some or all of the new equipment
  - Confirm location of new 480V power for actuators, either in MCC or 480V power panel
  - Confirm if the starter will be located in the actuator or in the MCC
- Determine the electrical demand for existing coarse bubble diffusers in aeration influent channels that will be removed with demolition of existing coarse bubble aeration system in channels (if selected)

4.7.2 AT Configuration and Aeration Control

- Coordinate with overall plant power evaluation as part of an electrical condition assessment to confirm where power will be fed to proposed aeration improvements
- Determine the electrical demand for existing draft tube aerators in ATs that will be removed with demolition of existing coarse bubble aeration system in channels (if selected)
- Confirm that adequate electrical power is available for the proposed aeration mixing system and new fine bubble diffuser demands/blower power requirements
- Provide new conduit and cable to new equipment being installed with power needs

4.7.3 Blowers

- The smaller of the two existing medium voltage transformers serving the blower building will be replaced with a new 5000 kVa transformer. This will require installing two additional conduits from one of the existing transformers to the new medium voltage MCC.
- A new medium voltage MCC will be installed to supply the required increased amperage to the new blowers.
- The existing conduit serving the blowers will be reused for the new blowers, but a larger power cable will be required.

4.8 Geotechnical (NOT USED)

4.9 Structural

4.9.1 ATs

- Modify existing aeration influent channel and AT structure to incorporate new influent cutthroat flumes and chimney-type inlets
  - Identify and eliminate expansion joints and/or pipe penetrations that currently allow aeration influent channel contents to leak into the tunnel below
  - Install aluminum grating over new cutthroat flume channel
- Modify existing aeration influent channels at 3 locations as indicated on Figures 5 and 6 to accommodate installation of isolation slide gates
- Install supports required for proposed mixing system in the anaerobic selector zone of each AT to support the top-mounted hyperbolic mixers
- Install supports required for proposed mixing system over the aeration influent channels to support top-mounted mixers if selected alternative for channel aeration. See Appendix F, Aeration Channel Mixing Alternatives, for details.
- Design AT baffle walls to reduce the possibility of differential hydrostatic pressure within each tank by adding notches to the bottom of the water to prevent differential filling or draining
- Modify existing tank pass walls by sealing off the existing bottom openings and adding top openings to accommodate the proposed flow pattern

4.9.2 Blowers

The layout of the blower building has five 10 ft x 12 ft blower pedestals that are supported by columns and piles. This configuration limits the potential blower configurations to blower units that fit within the pedestal footprint because the pedestal configuration would be very difficult to modify. As a result, the existing blower building is more suitable for four to five large blowers than numerous small blowers.

4.10 Architectural (NOT USED)

4.11 Site Civil

There are no specific civil-related improvements associated with this portion of the project. However, cranes and other equipment may be required to be on site between the existing north primary settling tanks and ATs. Coordination with overall site civil improvements and a grading and paving plan to repair or potentially replace damaged areas from construction work will be required.

Section 5: Sequencing and Constructability

5.1 Maintenance of Plant Operations (MOPO)

The intent of the MOPO is to mitigate interruptions to plant operation and maintain permit compliance throughout construction and startup of the optimization improvements. This section discusses procedures and action items to maintain plant operations during the construction and modification of the aeration tank improvements.

5.1.1 Overall Project Specific

The construction sequencing of the aeration system will require several tie-ins and shutdowns. The following list describes a general list of sequencing and constructability items that will impact installation of improvements for the ATs.

- Preliminary analysis suggests that a new transformer will be required for the new blowers. This upgrade will need to occur prior to the installation of a new blower system. In addition, the MCCs for the existing blowers will be replaced. There are two MCC units, each serving two blowers. The MCC replacement is expected to take approximately two days, so the updates would need to be sequenced to maintain aeration service.
- Although on different plant circuits, the electrical load that will be added to the D Circuit (blower building) should be coordinated with the reduction in load on the C Circuit (draft tube mixers) such that overall primary power capacity is not exceeded at any point.
- Prior to work beginning on the ATs and aeration influent channels, the construction of connecting the channels between both sets of the intermediate screw pumps should be completed. This will allow flow to be routed either all to the west or all to the east aeration influent channels to tank ATs and sections of the west aeration influent channel offline for construction, and will provide flexibility during construction.
- Slide gates and stop logs should be installed within the aeration influent channel ahead of constructing the aeration influent cutthroat flumes and AT upgrades to allow for tanks and influent channel areas to be completely offline during construction.
- For the installation of new intermediate pumps, portions of the aeration influent channel will have to be taken out of service.
- Construction of the new RAS splitter box, tie-in of RAS forcemains to the splitter box, and construction of new RAS gravity distribution piping should be online before the AT upgrades (fine bubble diffusers, baffle walls, etc.) are completed.

5.1.2 Maintenance of Plant Operations (MOPO)

- During construction of the proposed improvements for the AT system, only two ATs can be taken out of service at one time. The remaining ATs are required to be in service in order to meet current dry-weather process demands and not compromise secondary treatment. It is necessary to keep an adequate number ATs online to ensure that the plant is kept within compliance of the effluent discharge permit at all times.
- When upgrading tanks, there will be two pressure zones for the tanks in terms of some having fine bubble and some still with the existing draft tubes. The new blowers in the north blower building should be installed in a sequential order to meet the higher discharge pressures of the fine-bubble diffusers while still meeting air demands of existing draft tubes. Air can be provided to ATs 1-6 using the blowers in the process center. Some in tank temporary air piping modifications will be required so all four tank draft tube aerators can be supplied air from process center blowers.
- During periods of time when ATs are being taking offline, it will be important to preserve the biomass within the ATs to ensure adequate treatment is being met. To physically accomplish the construction of baffle walls in the ATs, by-pass routing will need to be incorporated into the construction phase so that each AT can be drained, modified and the walls constructed to create the anaerobic selector and aeration zones of the treatment process.
- Bypass pumping/routing may be required for various construction components between the aeration influent channel improvements and AT configuration upgrades.
- Sequencing of taking ATs and channels offline should be coordinated such that tank/channel cleaning can take place at the same time the tank/channel is out of service.

5.1.3 Preliminary Sequencing Plan of Aeration System

The following is a preliminary sequencing plan for the aeration related improvements. Figure 7 portrays a graphical depiction of how sequencing for aeration system upgrades could take place as described below:

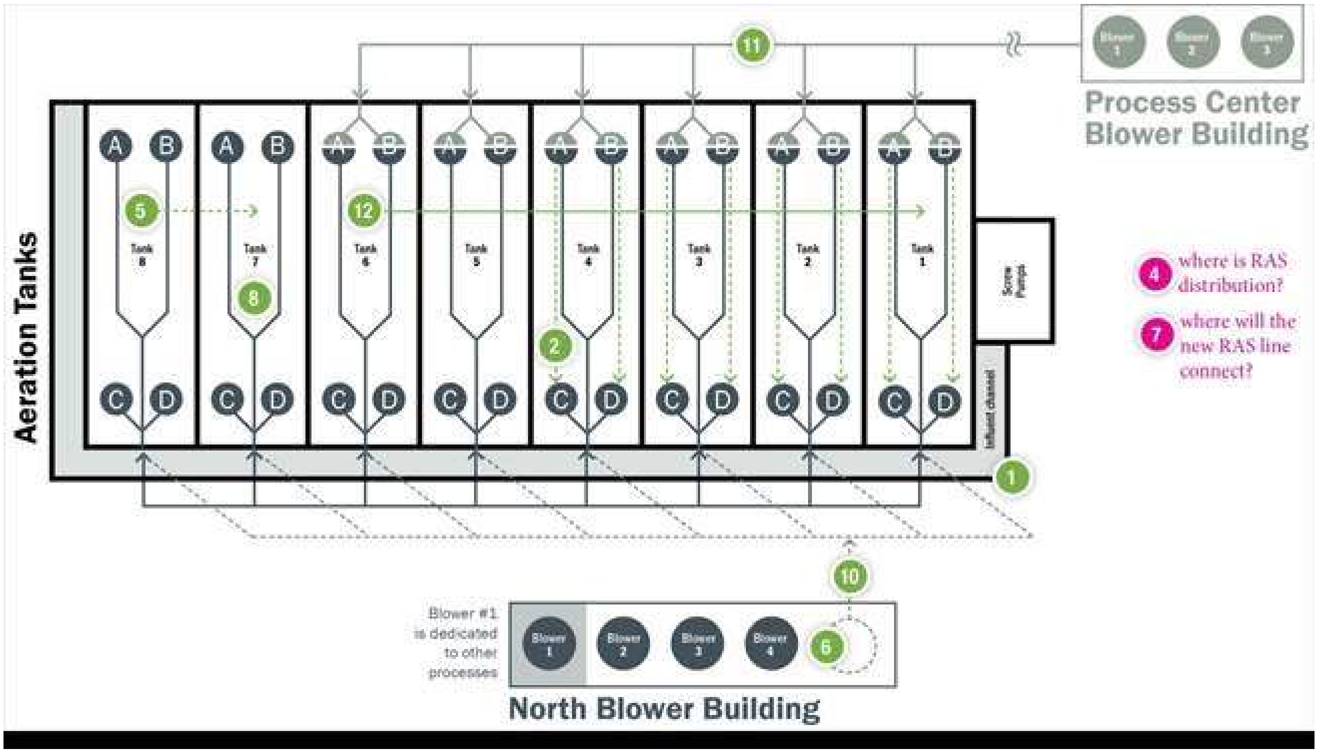

Figure 7. Aeration Tank Sequencing

1. Provide ability for channel isolation in the AT influent channel so sections of the channel can be taken out of service while work is performed.
2. Blowers in the north blower building supply air to all of the aerators (A-D) in all eight ATs while the process center building blowers only supply air to 2 of the aerators (A-B) in ATs 1-6. Temporary piping connections will be required so the process center blowers can feed all of the aerators in at least 4 of the ATs.
3. Prepare emergency contingency plans that the Contractor and/or Operators can follow if plant flow increases or there are unexpected equipment failures.
4. Start work on the RAS splitter box and associated piping.
5. Install the tank modifications and install the fine bubble diffusers in AT 8. If possible, complete AT 7 at the same time (dependent on time of year and operational decisions with MWS staff).
6. Install the first new, larger blower in the north blower building by replacing an existing unit.
7. Connect the new RAS line to the tank.
8. Next install fine bubble diffusers and complete the tank modifications on AT 7 (if not being done at the same time as AT 8).
9. Start-up ATs 7 and 8.
10. Use the excess air from the new blower to supply air to draft tube aerators C and D in ATs 1-6 (Due to the pressure differential between the fine bubble diffusers and draft tube aerators some air balancing will be required).
11. As AT modifications are completed, aeration control can be switched over to be provided by process control center blowers for the unfinished tanks based on piping modifications described previously.

12. The tank and blower modifications would then progress down to ATs 6, 5, 4, 3, 2 and 1 during which time the new blowers will be installed based on blower capacity and air requirements for the ATs.

5.2 General Description

All primary effluent flow up to 250 MGD will be routed to the west aeration influent channel. Primary effluent flow exceeding 250 MGD will be routed to the east aeration influent channel in biological contact mode. Figures 5 & 6 above show both normal and biological contact mode operation through the ATs. The BODR includes BODR-level process & instrumentation diagrams (P&IDs) for the ATs and blower aeration piping.

5.2.1 Aeration Influent

- Normal Operation - Cutthroat flumes from the west aeration influent channel will equally and passively split flow into the ATs. Each flume will have an inlet isolation gate. When tanks are taken out of service the cutthroat flumes will evenly and passively split flow to all tanks that are online.
- Wet Weather Operation (Biological Contact Mode) – At a flow of 250 MGD or greater the gates/stop logs in the aeration influent channel will be opened up to allow aeration influent flow to be conveyed to the east influent channel. Existing influent piping from east channel to the ATs will be reused to send wet weather flows into pass 2b.
- Influent Channel Mixing – Aeration influent flow in online channels will be completely mixed by means described supplemental design information. Mixing systems will be provided with means for isolation and shutdown so that mixing can be taken out of service in channels offline during normal flow conditions, and can be ramped online quickly during wet weather flows.

5.2.2 Anaerobic Selector Mixing

- Hyperbolic mixers will be installed to keep anaerobic selector solids in suspension and to prevent the formation of stagnant pockets

5.2.3 Blower control

The blower flow will modulate to maintain the header discharge set point. As the air demand reduces, the zone air control valves will close and the header pressure. The blower will react by reducing its output to reduce the discharge header pressure set point.

Energy use can be further optimized through automatic pressure setpoint adjustment to periodically adjust the pressure setpoint for the system as required to maintain the aeration valves within their controllable range, and the blower system at its optimum efficiency. For example, if none of the valves are at or near the maximum position setpoint, then the system pressure is too high. Producing the same quantity of air at a lower pressure will result in more efficient operation of the blowers, and will keep the valves in their most controllable range. Detection of this scenario will result in the system pressure automatically being decreased.

5.3 Sampling/Data Recommendations

As part of the COPT Study, an evaluation of the overall solids stream at CWWTP and the Biosolids Facility was performed and was presented in COPT Study TM 17- Biosolids Facility Assessment. Part of the evaluation included special sampling at both the CWWTP and Biosolids Facility to develop a mass balance to track solids throughout the plant.

Section 2.2.2 of COPT Study TM 17 presents updated data and sampling recommendations for both CWWTP and the Biosolids Facility to provide MWS with operational plant data to increase efficiency and better track flow streams throughout the plant. In order to accurately determine aeration requirements based on plant flows, updated data tracking and sampling will be discussed early in Phase 2 detailed design in order to collect as much new data as possible for detailed design.

Additionally, updated sampling and data tracking will be implemented as proposed COPT improvements are brought online to help sequence new process units.

5.4 Process Control

With the proposed improvements to the aeration system, additional operational and maintenance will be required for new process equipment. The following list highlights on important aspects of the COPT improvements that will be focused on operationally throughout implementation and life of the improvements:

- Maintaining DO and ammonia (if applicable) probes to ensure proper readings
- Fine bubble diffuser cleaning
- Passive flow split and even loading to ATs
- Compressor and associated instrumentation maintenance for gas-induced mixing (if applicable)

Technical Memorandum

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Prepared for: Metro Water Services

Project Title: Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Project No.: 148388

Technical Memorandum No. 7

Subject: Return Activated Sludge System Basis of Design

Date: December 21, 2016

To: Trey Cavin, Metro Water Services

From: Tazio Qubeck, Project Manager

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Executive Summary

The objective of this Technical Memorandum (TM) is to present the basis of design for the proposed improvements to the return activated sludge (RAS) system and other related systems at Central Wastewater Treatment Plant (CWWTP) for the CWWTP Improvements & CSO Reduction project (COPT Project).

Supplemental to this TM are the previous TMs that were performed by Brown and Caldwell (BC) as part of the Central Optimization Study Project (COPT Study). These TMs form an integral part of the basis of design report (BODR) and are referenced throughout this document. The presentations and minutes from the developmental workshops provide additional decision-making background and supplemental information for this BODR.

The modifications proposed for the RAS system are highlighted below:

- Construct new RAS mixing and flow splitter box with an influent mixing chamber and cutthroat flumes to passively and equally distribute north and south RAS flow to each of the eight aeration tanks (ATs).
- Install new gravity piping from the new RAS splitter box to each AT anaerobic selector zone
- Provide upgrades to RAS forcemains (FMs) to tie both north and south RAS pumped flow to the new splitter box including coordination with piping condition assessment for repair/replacement of RAS piping as necessary.
- Provide reliable, long-term, and efficient RAS draw-off and pumping capacity to achieve optimized flows for the north and south RAS systems

Improvements being recommended for the ATs including passive flow split of aeration influent, optimized AT configuration, new fine bubble aeration system, and associated blower upgrades are presented in TM 6 - Aeration System. Improvements to the secondary clarifiers and mixed liquor channels including new fine bubble degassing and efficient mixing in the mixed liquor channel are presented in TM 8 – Secondary Clarifiers.

Section 1: Process Area Description

The following presents a review of the existing RAS system, including RAS wetwell sizes, existing pump sizes and capacities, and any new proposed improvements which are part of the overall design.

1.1 Description of Existing Facilities

Figure 1 below portrays an aerial site plan of CWWTP with the RAS system highlighted to show process areas that are covered in this TM. Table 1 below lists a summary of the RAS system process units at CWWTP, along with physical descriptions and data for the existing system.

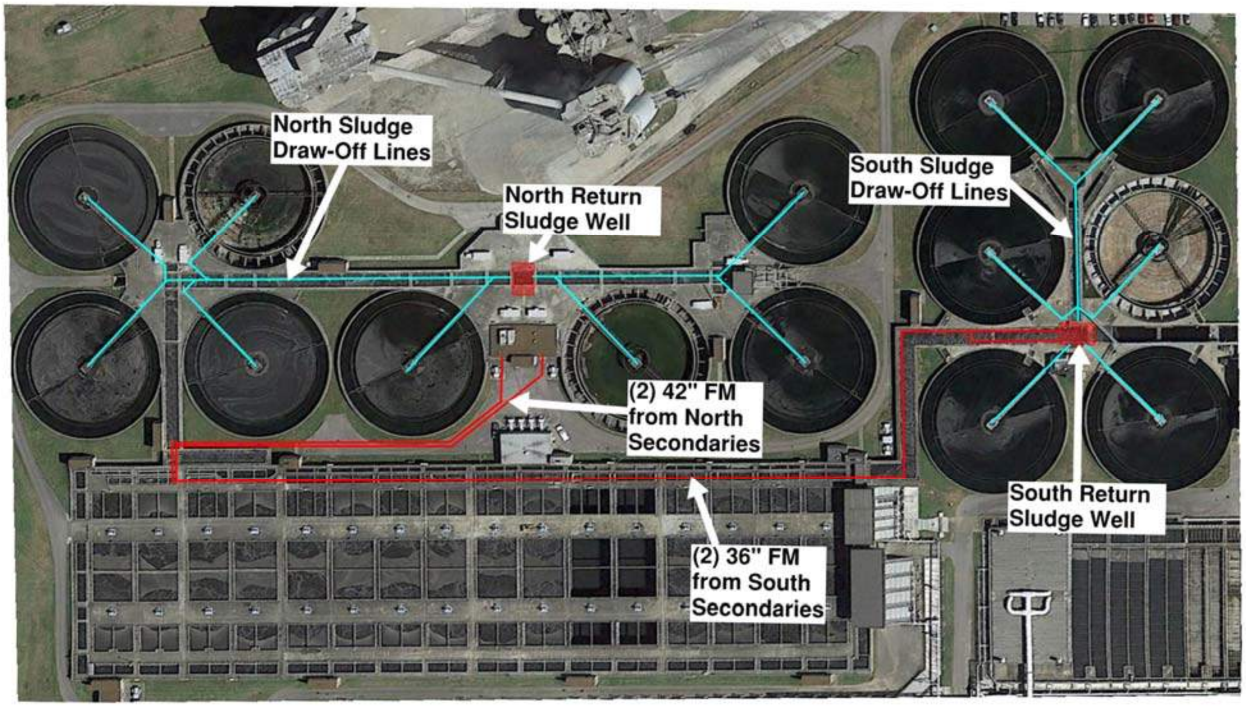

Figure 1. Existing Activated Sludge System at CWWTP

Table 1. Summary of Existing RAS Process Units at the CWWTP		
Parameter	Unit	Value
North RAS Sludge Draw-Off		
Draw-off mechanism	--	Suction manifold
Pipe Size	in	36
South RAS Sludge Draw-Off		
Draw-off mechanism	--	Scraper
Pipe Size	in	36
North RAS Pumps		
Number of Pumps	--	5
Pump Type	--	Non-clog centrifugal
Capacity per pump	gpm	13,425
Total Dynamic Head	ft	38.5
Motor Size	hp	500
Motor Voltage	V	460
FM Size	in	42 (2 FMs)
South RAS Pumps		
Number of Pumps	--	4
Pump Type	--	Non-clog centrifugal

Table 1. Summary of Existing RAS Process Units at the CWWTP		
Parameter	**Unit**	**Value**
Capacity per pump	Gpm	11,300
Total Dynamic Head	ft	35
Motor Size	hp	125
Motor Voltage	V	460
Forcemain size	in	36 (2 FMs)

Ft- feet

Gpm- gallons per minute

Hp- horsepower

In- inches

V- volts

Section 2: Design Intent

Based on the optimized wet weather capacity of the secondary treatment system, modifications are necessary to increase the RAS pumping capacity. A new means of redistributing return solids to the ATs is proposed that utilizes a new RAS splitter box. RAS flow from the north and south secondary clarifiers (SCs) will be routed to the influent chamber of a new RAS splitter box, where the flow will be mixed and evenly distributed using cutthroat flumes and conveyed to the ATs by gravity.

The following list represents the overall design intent for the recommended improvements to the RAS system:

- A new RAS splitter box will be constructed in order to combine and evenly mix north and south RAS flow and passively distribute it to the ATs.
  - Portions of the existing RAS FMs from both north and south RAS wet wells will be repurposed to reroute flow to a new RAS splitter box where flow will be mixed into a homogeneous RAS concentration prior to discharge into the ATs. The existing south RAS header will be configured to convey south RAS through the aeration gallery and unite with the north RAS FMs at the new splitter box location.
  - The RAS splitter box will include dedicated cutthroat flumes to passively and equally distribute north and south RAS flow to each AT, which will reduce solids migration and improve secondary treatment.
- New gravity piping will be constructed to convey the homogeneous mixed RAS flow from the new splitter box to the anaerobic selector zone in each reconfigured AT.
- The influent chamber of the RAS splitter box will be designed to completely mix RAS flow from the north and south SCs.
- The existing RAS pumps will be refurbished and additional pumps will be added to provide reliable, energy-efficient pumping capacity based on new pumping conditions to the RAS splitter box.
- For all hydraulic improvements, the intent is to optimize energy usage by minimizing the long-term total dynamic head on the RAS pumps.

Section 3: Constraints

This section describes the constraints associated with this process area for meeting the design intent.

3.1 Design Criteria

The following section provides a summary of the necessary design criteria that impact the design and implementation of improvements for the RAS system at CWWTP. Technical Memoranda 5.1 – Plant Hydraulic Capacity Analysis and 5.4 – Process Capacity Assessment and Alternatives Analysis of the CWWTP from the COPT Study present the conceptual design basis for the hydraulic and process design of the RAS system, respectively.

3.1.1 RAS Gravity Draw-Off Piping

The existing conditions of the RAS gravity draw-off piping were used to develop a conceptual hydraulic model of the RAS gravity draw-off piping to the north and south RAS wet wells assuming the following:

- Maximum RAS flow from each clarifier – 10.5 million gallons per day (MGD)
- Invert elevation of north RAS well – 399.50 ft
- Maximum level in north RAS well –18.9 ft (418.4 ft water surface elevation (WSE))
- Minimum level in north RAS well – 6.5 ft (406.0 ft WSE)
- Invert elevation of south RAS well – 406 ft
- Maximum level in south RAS well – 14 ft (420 ft WSE)
- Minimum level in south RAS well – 9 ft (415 ft WSE)
- Pipe sizes – 36-inch (north) and 30-inch (south)

As discussed in Section 4 below, further hydraulic analysis will be required during Phase 2 detailed design.

3.1.2 Return Activated Sludge Pumping/Conveyance Design Criteria

Table 2 presents the design flow and head conditions for the north and south RAS pumps based on the optimized configuration of rerouting the RAS FMs to a new RAS splitter box, and total RAS draw-off flows based on optimized peak flow values. Refer to COPT Study TM 5.1- Plant Hydraulic Capacity Assessment and Alternatives Evaluation and Section 4 below for discussion of how these values were calculated. Return rates of 40 percent forward flow were assumed to calculate optimized return capacity for peak flows, and return rates of 50 percent forward flow were assumed for average flows.

Table 2. Return Sludge Pumping/Conveyance Capacity

Description	Optimized Return Capacity		Head Conditions (ft)
	Peak (MGD)	Minimum (MGD)	
North	87	32.5	38-43
South	53	20	25-30
Total	**140[1]**	**52.5[2]**	--

[1] *Peak RAS flows were calculated based on 40 percent RAS rate at peak forward flow conditions at 350 MGD.*

[2] *Minimum RAS flows were calculated based on 50 percent RAS rate at current average forward flow conditions at 105 MGD.*

3.1.3 Siting Criteria for Splitter Box

The RAS splitter box location on site will be constructed such that it:

- Minimizes complexity/cost required to receive north and south return flow at opposite ends of the two existing 42-inch return FMs at the splitter box location.
- Minimizes or avoids rerouting of existing above-grade and buried structures/utilities to facilitate construction.
- Minimizes the length of gravity piping from the RAS splitter box to the individual ATs.
- Allows proper access to the new structure and does not block existing vehicle access to plant areas.
- Maximizes utilization of existing structures.

3.2 Code Considerations

A complete list of all codes used for design will be included in the Code Classification Summary, which will be completed during preliminary design.

3.3 Regulatory Drivers

The following includes a list of permitting/regulatory drivers that impact the design and implementation of improvements for the RAS system as part of this project. Overall design considerations based on regulatory requirements for the secondary treatment system are listed TM 6 – Aeration System. Refer to TM 6 for further regulatory drivers to consider for design of the RAS system. These drivers are in addition to those required by the Consent Decree and other current and future state and federal regulations.

- Air Permit – CWWTP has an air permit for emission limits that is currently issued on the existing plant configuration. The emission limits are calculated based on total square footage of open tanks/channels at the plant. It is assumed that the existing air permit emission limits will remain the same through the full implementation of COPT improvements. However, the addition of the RAS splitter box will increase the overall square footage of open tanks/channels at CWWTP, and the existing air model will be required to be updated during design.

3.4 Sequencing and Constructability Affecting Design

The following subsections provide a list of sequencing issues and constructability items that will impact design and implementation of improvements in this process area. The sequencing plan for this area is discussed in Section 5 of this TM, and the overall construction sequencing plan will be developed. This sequencing and constructability section will be updated based on coordination with the Construction Manager at Risk (CMAR) in development of overall sequencing plan.

- The two north RAS pipes will require some preparation work before they can be tied into the influent chamber of the splitter box. Temporary valves may need to be installed into the piping depending upon the construction sequence.
- The structural condition of the existing AT walkways must be assessed to determine the structural capacity for the additional load of RAS distribution piping along length of channel being routed to each anaerobic selector of the ATs.
- The structural condition of the tunnel floors and walls where the existing RAS FMs are located must be assessed prior to installing supports for additional RAS FMs and to determine if a new penetration in the tunnel wall between ATs 6 and 7 can be made to allow a new 36-in FM to pass through.

Section 4: Description of Improvements

The following describes the key development information, features, design data and operations and control narrative for the RAS system.

4.1 Detailed Design Considerations and Assumptions

The following list includes assumptions and considerations used for this BODR evaluation of the RAS splitter box and distribution piping, and are to be confirmed during Phase 2 detailed design.

- The maximum water surface in the ATs was assumed to be 432.0 ft (total depth of 33 ft). COPT Study TM 5.1 provides a detailed hydraulic evaluation of the existing plant.
- For peak flow conditions, it was assumed that all eight ATs were online and in service.
- RAS flow to each tank was assumed to be 18.5 MGD for peak flow conditions. This was calculated as one eighth of the assumed 40 percent return flow at the secondary treatment maximum of 350 MGD. Gravity pipes from the RAS splitter box to each AT will be sized for 20 MGD capacity to provide a factor of safety to design.
- RAS flow to each tank was assumed to be 6.6 MGD for average/minimum flow conditions. This was calculated as one eighth of the assumed 50 percent return flow at the secondary treatment average/minimum of 105 MGD. It should be noted that during average flow periods, the return rate is often higher, but 50 percent represents a conservative minimum speed condition for the RAS pumps.
- It was noted by Metro Water Services (MWS) staff that the pipe thickness in numerous locations of the RAS FMs has been eroded from grit and debris within the flow, and holes in the pipe walls have been forming that require periodic patching to keep these lines in service. It was assumed that the existing RAS FMs would be re-used for this conceptual design. A detailed condition assessment for piping will be performed in Phase 2 detailed design of this project.
- It was assumed that existing RAS pump variable frequency drives (VFDs) could be reused with the optimized system.
- VFDs – how old are they and do they need to be replaced?
- Spots in existing motor control centers (MCCs) for new RAS pumps?
- How old are existing MCCs and are they in good condition/need to be replaced?
- It was assumed that existing RAS gravity draw-off lines will be reused. A detailed condition assessment will be completed in Phase 2 detailed design.
- Elevations and distances were determined using record drawings from the 1976 and 1990 major plant upgrades as well as well as other miscellaneous improvements.

4.1.1 Hydraulics

Hydraulic-specific components of this area include the sizing and design of the RAS splitter box and distribution piping to provide for means to fully mix north and south RAS flows together and passively and evenly distribute to pass 1 of all online ATs. Figures 2 and 3 provide a conceptual design of the RAS splitter box plan and section view. Note that exact dimensions will be confirmed during Phase 2 detailed design.

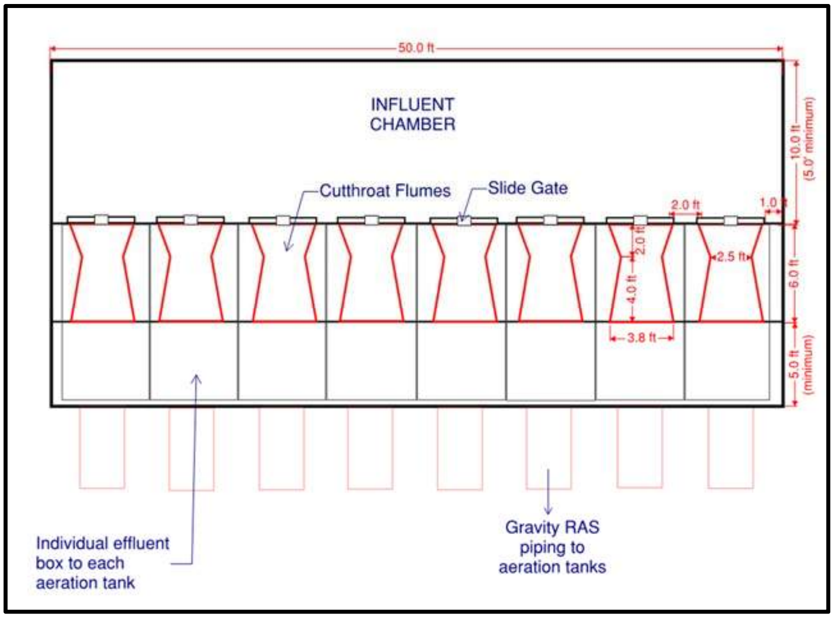

Figure 2. Plan View of Proposed RAS Splitter Box

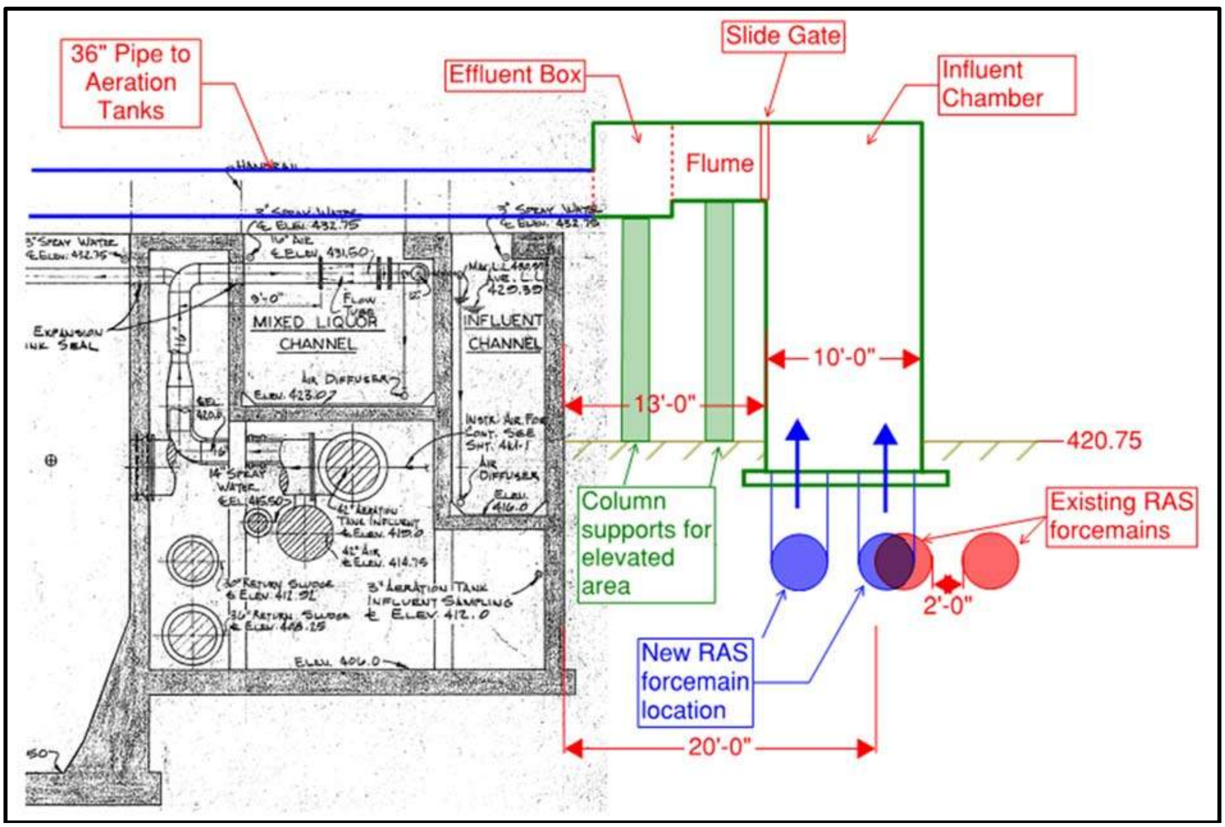

Figure 3. Section View of Proposed RAS Splitter Box

Specific scope items for detailed design include:

- RAS splitter box influent chamber should be designed and sized such that combined RAS flow has a maximum upward velocity of <1 ft/sec. during all flow conditions to prevent short-circuiting of RAS flow, and allow even flow splitting to occur. If possible, with space for splitter box, the design shall allow for 5D (hydraulic depth) length in the influent chamber for flow to develop prior to flow split.

- The gravity RAS piping from the splitter box to the individual ATs was modeled using *Visual Hydraulics* to size the piping and determine preliminary key elevations for the splitter box. 36-inch piping is assumed for cost purposes, but 30-inch piping to the ATs closer to the new splitter box may be adequate. During Phase 2 detailed design, further evaluation will occur to determine optimized sizing of the RAS drop piping.
- The cutthroat flumes in the RAS splitter box will be designed to equally split the combined north and south RAS flow among the ATs over the entire range of design flow rates and downstream hydraulic conditions. The effectiveness of the equal flow split was evaluated at free flow and partially submerged (energy efficient) conditions during both peak and low flow scenarios. The following assumed flow rates and elevations were used for the preliminary design and are illustrated by Figure 4:
  - Maximum RAS flow = 140 MGD.
  - Minimum RAS flow = 52.5 MGD.
  - Maximum effluent box water surface elevation = 437.5 ft.
  - Minimum effluent box water surface elevation = 435.0 ft.
  - Gravity RAS piping invert elevation = 434.5 ft.
  - Cutthroat flume invert elevation = 436.14 ft.
  - Maximum allowable RAS splitter box influent chamber water surface elevation = 438.5 ft

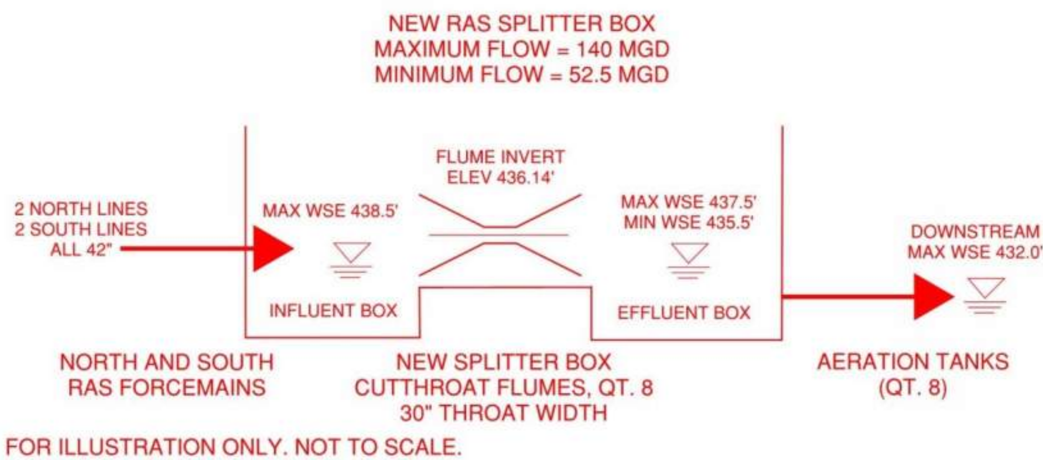

Figure 4. Preliminary Hydraulic Model of Key Elements in RAS Splitter Box

4.1.2 Geotechnical Assumptions

Figure 5 provides a highlight of geotechnical borings in the vicinity of the proposed splitter box location performed during the last major plant expansion in the early 1990's. The elevations shown on the figure indicate that the borings showed auger refusal at approximately 45-50 ft below the existing grade on site. It is assumed that piles will be required to be driven approximately 45 ft below grade to support the new RAS splitter box structure. For cost estimating purposes, steel piling (HP 12x53) was assumed at 4 ft on center (OC).

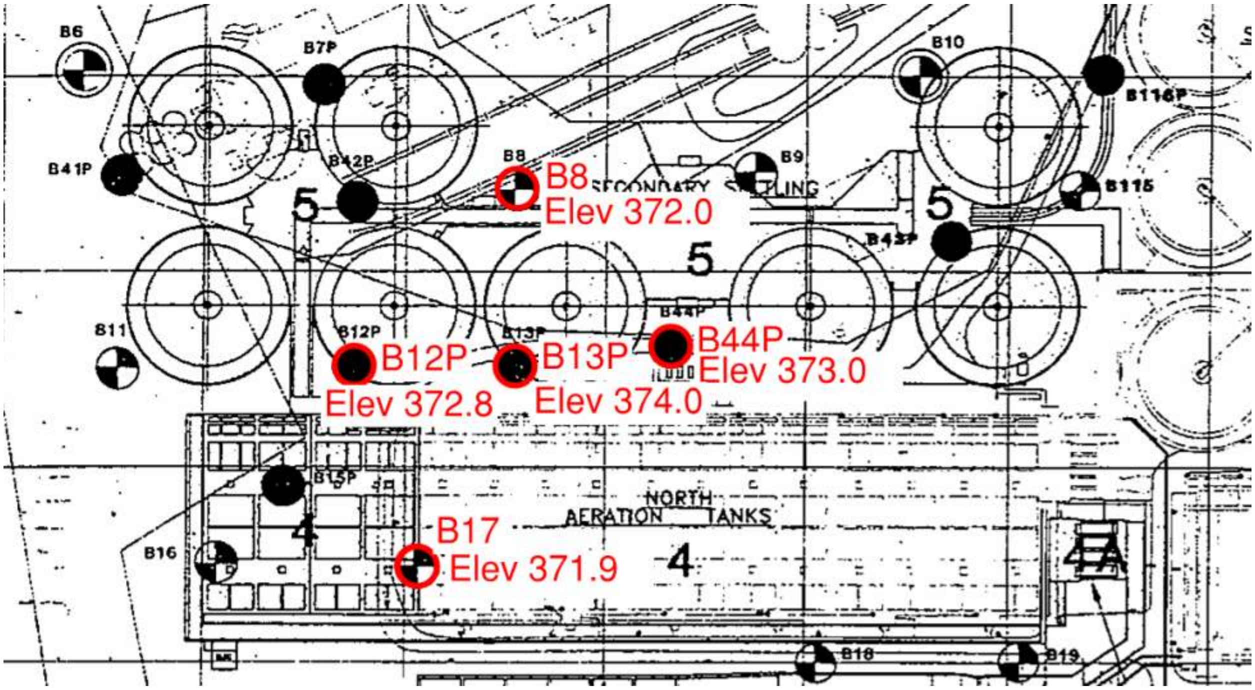

Figure 5. Geotechnical Borings Available Near Proposed RAS Splitter Box

4.2 Process Mechanical

The following section summarizes the overall process mechanical improvements required to complete the necessary improvements associated with the construction of the RAS splitter box and associated piping and components.

4.2.1 RAS Splitter Box

- Design the influent chamber of the RAS splitter box to provide complete mixing of north and south RAS flow. Computational fluid dynamics (CFD) modeling will be performed in Phase 2 detailed design for the influent chamber of the RAS splitter box to ensure adequate mixing is developed in the design. Potential outcomes of CFD modeling include modification of inlet piping configuration to ensure effective mixing, adding baffles within the RAS splitter box influent chamber, installation of coarse fine bubble diffusers, or installation of mechanical mixing equipment. Costs are included for mechanical mixing within the influent chamber, and will be updated as CFD modeling is completed.
- Slide gates on the upstream end of the cutthroat flume channels should be provided to allow for isolation of individual ATs. Figure 2 above shows location of slide gates for each cutthroat flume channel.
- Provide means for foam/scum removal in the RAS splitter box. Design may include options for foam/scum removal in the influent chamber or effluent drop boxes, and will be finalized in Phase 2 detailed design.
- Provide means to drain RAS splitter box when portions are out of service.

4.2.2 RAS Pumping and FMs

Currently, RAS flow is pumped from both the north and south SCs to opposite ends of a common manifold in the east aeration gallery, where individual pipes with valves and flow meters are routed from the manifold to each AT. The proposed site location of the RAS splitter box will require piping modifications to be performed on both north and south RAS FMs to combine flow at the influent chamber of the RAS splitter box. Figure 6 below shows the modified routes for the RAS FMs from the north and south sludge wells.

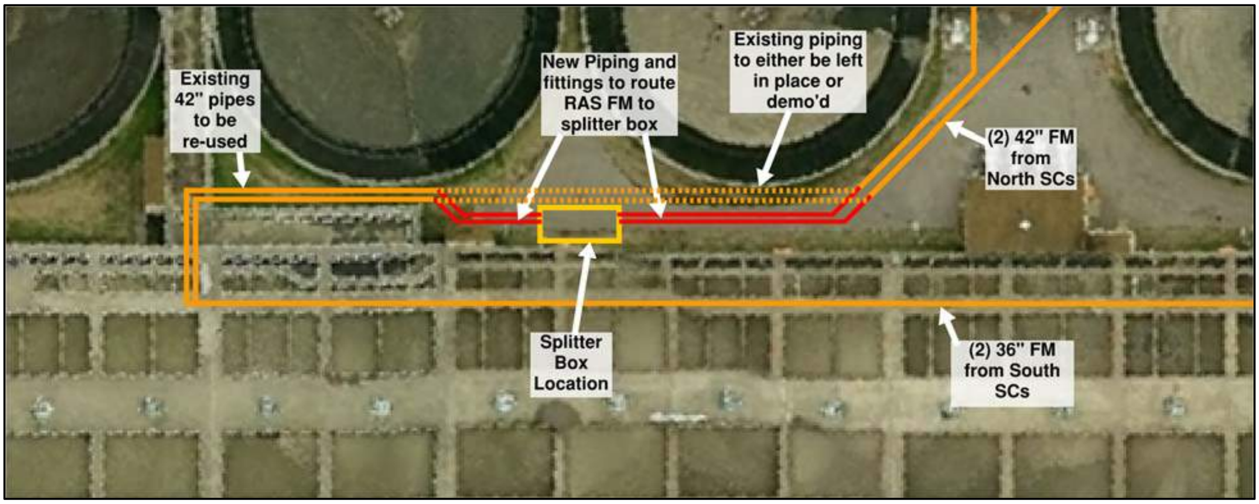

Figure 6. RAS Splitter Box Location and FM Modifications

New piping and fittings will be installed to route RAS flow from the existing FMs to the RAS splitter box. The following items are detailed scope items identified for the recommended improvements to RAS pumping and FMs.

- North RAS FMs
  - Connect and re-use existing 42-inch FMs from north RAS pumps to new splitter box
  - Extend FMs further towards ATs and install new fittings and piping to route north RAS to influent chamber of RAS splitter box (refer to Figure 6).
- South RAS Forcemains
  - Re-use existing 36-inch FMs in tunnels from south RAS wet well to where they are combined between ATs 3 and 4.
  - Enlarge existing portions of RAS manifold from AT 4 to AT 7 to be 36-inch diameter throughout entire FM run.
  - Construct new 36-inch FM that routes beneath the proposed enlarged RAS manifold such that functionally, there are two 36-inch FMs between the south RAS pumps and their connection to the two existing 42-inch north RAS FMs.
  - Connect converted south RAS 42-inch FMs to new piping and fittings as shown in Figure 6 to route south RAS to influent chamber of RAS splitter box.
- Provide means to seal off abandoned RAS FMs in the yard after new tie-ins are made to the RAS splitter box. It is assumed that the existing FMs will be cut and sections of pipe removed to make room for installation of new fittings (as shown in Figure 6), and short sections of both ends of pipes will be filled with flowable fill and then capped and abandoned in place.
- Install new RAS pump at both north and south RAS wells to account for additional peak flows (2 pumps total). Pump design and selection will be performed in Phase 2 detailed design, and costs assumed installation of similar size pump as is existing for each area.

4.2.3 RAS Gravity Draw-Off Piping

RAS draw-off piping routes RAS flow from each SC to both the north and south RAS wells, as shown in Figure 1. Currently, RAS draw-off for each of the SCs is controlled via butterfly valves and flow meters on the draw-off piping. Provisions will be included in Phase 2 detailed design to replace all 14 butterfly isolation valves with plug valves.

4.2.4 RAS Gravity Piping

RAS flow will be routed from the discharge of the RAS splitter box and into the anaerobic selector zones of each AT via new gravity piping. Figure 7 shows a conceptual schematic overview of where the new RAS gravity piping will be located along the top of the ATs and within each tank.

Figure 7. RAS Gravity Piping Concept

The following detailed scope items associated with the gravity RAS piping are recommended:

- New piping and fittings will be installed to route RAS flow from the RAS splitter box to the anaerobic selector zone of each AT. The following length of pipe and fittings for the gravity pipelines are assumed:
  - 3,000 ft of 36-inch pipe
  - 32 – 3-inch 90-deg bends (4 per tank)

4.3 Odor Control (NOT USED)

4.4 Heating, Ventilation, and Air Conditioning (HVAC)

- Update/replace existing HVAC in aeration tunnels as necessary. Assumptions will be added here to document what is used for basis of cost estimate.

4.5 Plumbing

- Perform repairs/modifications as necessary for seal water system including piping and connections for existing north and south RAS pumps.
- Perform repairs/modification as necessary for drains in north and south RAS wetwell tunnel area.

4.6 Instrumentation and Controls

- Provide 4-20 mA control for flume channel isolation gates. Normal operation will be open/close, but 4-20 mA control will allow operations staff to partially open gate and see the gate position from the distributed control system (DCS).
- All normal process-related equipment will be designed to facilitate monitoring and control from the plant DCS. The need to monitor and control infrequently used equipment such as channel isolation gates from the DCS will be determined based on discussions with operations staff during Phase 2 detailed design.
- It is assumed that RAS flow to individual ATs will not be measured by the cutthroat flumes as the flumes will split flow equally among online ATs.
- Existing RAS pumps and flow meters will be used for RAS flow control from RAS wetwells to new RAS splitter box. A new level float will be provided in the influent chamber of the RAS splitter box to provide further control for the existing RAS pumps based on new pumping location.
- Work with MWS staff to update programming within DCS to achieve more accurate flow split of RAS draw off from SCs to each the north and south RAS wells through the use of automatic valves and flow meters.

4.7 Electrical

This section presents the electrical design criteria for the proposed process area. Any existing electrical equipment that is intended to be repurposed shall be tested prior to any modifications.

4.7.1 RAS Splitter Box

- Provide new conduit/cable to new equipment being installed with power needs.
- Coordinate with overall plant power evaluation to confirm where power will be fed to proposed RAS splitter box improvements.
  - Provide 480V power for actuators at splitter box via MCC or new 480V power panel
- If mechanical mixing is required for the influent chamber of the RAS splitter box based on CFD modeling that will be performed in Phase 2 detailed design, confirm that adequate electrical power is available.
- Provide new lighting around the RAS splitter box structure

4.8 Geotechnical

- Perform new geotechnical borings in area of the proposed RAS splitter box to determine depth of piles required to support RAS splitter box.
- Install new piles for foundation support of proposed splitter box.
  - Steel H-piles (HP12x53) at 40-ft length and 4-ft OC throughout area of splitter box assumed for cost estimate
- Construct foundation for splitter box based on geotechnical boring findings and requirements, including footer for concrete influent chamber of splitter box and above-grade columns to support cutthroat flume channels and effluent box area of splitter box (refer to Figures 2 and 3 for graphical depiction of supports)

4.9 Structural/Architectural

The structural design for the RAS splitter box and associated piping will be developed in accordance with the design criteria below.

- Construct splitter box structure based on foundation requirements.
- Coordinate design with re-routing of RAS FMs to intercept north and south RAS flow and allow for pipe penetrations in RAS influent box for mixing.
- Provide design for construction and support of cutthroat flume channels including forms to create cutthroat flume within new concrete channels. Provide evaluation and design of material to be used for column supports of cutthroat flume channels and effluent boxes. Assumed concrete columns to be used for basis of cost estimate.
- Construct crossover walkways over RAS distribution piping to maintain access across the top of the ATs.
- Provide supports for proposed RAS distribution piping going across the top of and in the ATs. Coordinate with design of proposed baffle walls and fine bubble diffuser system as discussed in TM 6 – Aeration System.
- Reconfigure pipe supports on existing 36-inch FM from south RAS wet well such that a new 36-inch FM can run directly beneath existing pipe
- Installation of handrail and stairs for RAS splitter box

4.10 Site Civil

The following provides the necessary site civil improvements including stormwater and flood mitigation items for the RAS system improvements.

- Relocate two 42-inch FMs around proposed splitter box
- Re-grade area as necessary to maintain existing site drainage patterns
- Replace disturbed pavement
- Erosion prevention and sediment control (EPSC) components

Section 5: Sequencing and Constructability

5.1 Maintenance of Plant Operations (MOPO)

The intent of the MOPO is to mitigate interruptions to plant operation and maintain permit compliance throughout construction and startup of the optimization improvements. This section discusses procedures and action items to maintain plant operations during the construction and modification of the RAS system improvements.

5.1.1 Overall Project Specific

The construction sequencing of the new RAS system will require several tie-ins and shutdowns. The following list describes a general list of sequencing and constructability items that will impact construction of improvements for the RAS system.

- The construction of the RAS splitter box, tie-in of RAS FMs to the splitter box, and construction of new RAS gravity discharge piping should be online prior to installation of the fine bubble aeration system and any improvements implemented within the ATs to accommodate the updated tank configuration and provide RAS flows to the new anaerobic selector zones.

- Improvements to the north and south SC internal mechanisms will need to be completed in order to achieve the optimized peak RAS flow rates. This includes full replacement of mechanisms for the south SCs (scraper-type sludge draw-off), and rehab and potential replacement of Tow-Bro suction manifold sludge draw-off for the north SCs. Refer to TM 8 – Secondary Clarifiers for discussion on these improvements.

5.1.2 Maintenance of Plant Operations

- During construction of the proposed improvements for the RAS splitter box and conveyance piping to the ATs, only two ATs can be taken out of service at one time. The remaining ATs are required to be in service in order to meet current dry-weather process demands and ensure that the plant is kept within compliance of the effluent discharge permit at all times.
- To maintain operation of the RAS system throughout construction, the RAS splitter box must be constructed first and the new gravity distribution pipes to each AT installed prior to tying into the existing RAS FMs to the splitter box.
  - The south RAS header valve will be closed so the south RAS FM can be tied into the influent chamber of the splitter box. The header valve will allow some ATs to remain in service while others are being modified.
  - Additional new piping will be required at bends to facilitate construction of splitter box while keeping the current system in service
- Bypass pumping/routing will be required while modifications to the existing RAS FMs are completed.
- Coordinate tie-ins of relocated FM in order to maintain plant operations
- Tunnels must remain passable for people and equipment during and after construction. Coordinate with all other work to ensure access is maintained.

5.1.3 Constructability

- Access to galleries is through a below grade garage door on north side of north SCs. Confirm that new 36-inch FM pipe can be loaded through this entrance.
- Mitigate impact to other existing underground piping in area
- Verify access for heavy construction equipment (including cranes)

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Technical Memorandum

Prepared for: Metro Water Services

Project Title: Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Project No.: 148388

Technical Memorandum No. 08

Subject: Secondary Clarifiers Basis of Design

Date: December 21, 2016

To: Trey Cavin, Metro Water Services

From: Tazio Qubeck, Project Manager

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Limitations:

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Executive Summary

The objective of this Technical Memorandum (TM) is to present the basis of design for the proposed improvements to the secondary clarifiers (SCs) and associated areas for the Central WWTP Improvements & Combined Sewer Overflow (CSO) Reduction project (COPT Project).

Supplemental to this TM are the previous TMs that were performed by Brown and Caldwell (BC) as part of the Central Optimization Study Project (COPT Study). These TMs form an integral part of the basis of design report (BODR) and are referenced throughout this document. The presentations and minutes from the developmental workshops provide additional decision making background and supplemental information for this BODR.

The major modifications proposed for the aeration tanks (ATs) are highlighted below:

- Hydraulically separate mixed liquor (ML) channel from north and south SCs
- Increase process and hydraulic capacity of SCs by replacing various equipment, valves, and modifying existing hydraulics
- Route secondary effluent from south SCs to new Parshall flumes in existing filter bay
- Strip dissolved gasses in ML channel for improved settleability
- Evaluate new mixing system to maximize efficiency of ML channel performance

The improvements and modifications are recommended for implementation primarily in order to increase the secondary treatment capacity of the CWWTP via enhanced settling and maximize peak flow capacity within the existing tankage. These improvements are also recommended to improve operations, reliability, and process control, and to reduce energy and operating costs within the secondary treatment system.

Section 1: Process Area Description

1.1 Description of Existing Facilities

Figure 1 below portrays an aerial site plan of CWWTP with the SCs highlighted to show process areas that are covered in this TM. Table 1 below lists a summary of the SC units at CWWTP, along with physical descriptions and data for the existing system.

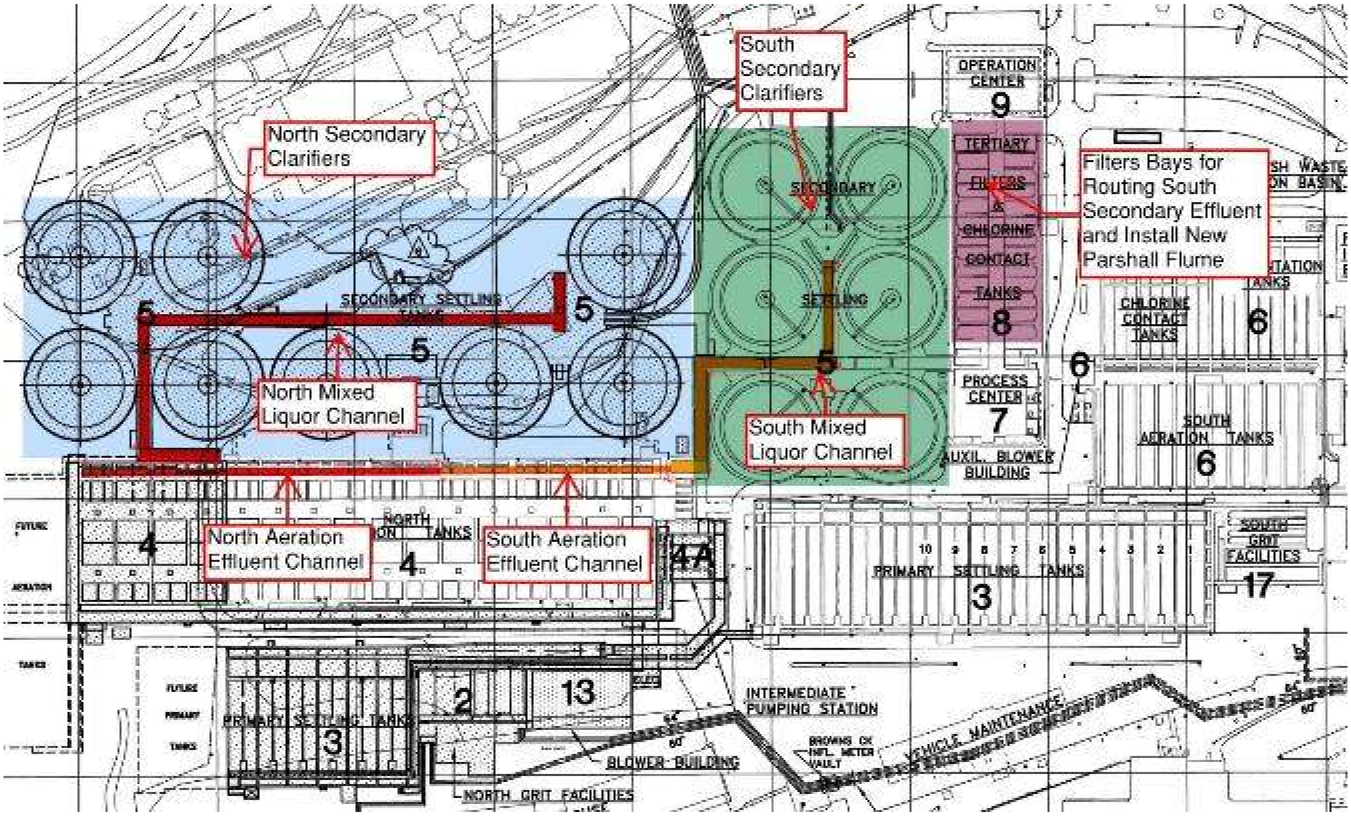

Figure 1. Secondary Treatment Overview

Table 1. Summary of Current Secondary Treatment Parameters					
SECONDARY CLARIFIERS					
	Number of Tanks	Individual Hydraulic Capacity (MGD)	Total Hydraulic Capacity (MGD)	Diameter (ft)	Depth (ft)
North SCs	8	28.75	230	160	16
South SCs	6	15	90	160	14
Total SCs	14	-	320	-	-

Table 1. Summary of Current Secondary Treatment Parameters						
ML CHANNELS						
	Length (ft)	Width (ft)	Coarse Bubble Diffuser Depth (ft)	Air Flow Rate (scfm/LF)	Air Flow Rate (scfm)	Line Pressure (psig)
North ML Channel (at ATs)	520	12	11	3	1,560	9
North ML	975	15	11	3	2,925	9
South ML Channel (at aeration effluent)	330	12	11	3	990	9
South ML	530	18	11	3	1,590	9
Total	2,355	-	-	-	7,065	-

Section 2: Design Intent

Improvements to the SCs are focused on installing more efficient internal mechanisms to improve flow splitting and sludge settleability in the SCs to maximize secondary treatment capacity. Modifications within the ML channels will strip dissolved gasses from the ML prior to entry into the SCs and provide more efficient mixing to improve settleability and optimize energy usage. Other major improvements include routing of south secondary effluent through new Parshall flumes to facilitate combining all secondary effluent flow at the north disinfection area, and improving maintenance access within channels to better isolate sections and SCs.

The following list represents the overall design intent for the recommended improvements to the ML channels, SCs, and secondary effluent routing within the existing plant structures.

ML Channels

- Refurbish and close existing ML channel gate between ATs 3 and 4 to hydraulically isolate ML channels feeding each set of SCs
- Install fine bubble diffusers in ML channels and associated new high-speed channel blower(s) to strip dissolved gases from the ML prior to SC inlets
- Install more efficient mixing in ML channels downstream of fine bubble stripping to optimize energy usage of mixing in channels
- Install curbing at upstream portions of ML channels to provide adequate freeboard during peak flow events and maximize capacity of existing channels
- Install gates or other means of isolating channels to facilitate fine bubble diffuser and ML channel maintenance in general, while minimizing reductions in available capacity during maintenance activities
- Install foam wasting station(s) and guide baffles to remove foam from the ML channel surface

SCs

- Replace existing internal mechanisms in the existing south SCs with new equipment that will provide better inlet distribution and flocculation conditions and improve performance of the existing SC's
- Replace existing north SC influent butterfly valves with full-port plug valves to reduce headloss, provide more robust means of isolation, and minimize potential for ragging
- Provide maintenance-friendly means of accessing inside of SC influent piping, valves, and flow meter downstream of new full-port plug valve
- Modify SCADA programming and utilize existing actuated valves and flow meters to provide equal flow split within sets of SCs
- Replace existing south SC butterfly inlet gates to facilitate flow splitting and provide a better means of isolation
- Install larger diameter south SC effluent piping and flow meters to increase hydraulic capacity
- Construct two new Parshall flumes in existing filter bays to accurately measure south secondary effluent flow and transition flow to new south secondary effluent conveyance pipe to north disinfection area.
- Install new south secondary scum pump station (PS) and abandon existing scum well in return activated sludge (RAS) PS gallery to provide better means of scum removal

Section 3: Constraints

This section describes the constraints associated with this process area for meeting the design intent.

3.1 Design Criteria

The following section provides a summary of the necessary design criteria that impact the design and implementation of improvements for the ML channels and SCs at the CWWTP. COPT Study TM 5.4 – Process Capacity Assessment and Alternatives Analysis of the CWWTP presents the conceptual design basis for the process design of these project components. COPT Study TM 5.1 – Hydraulic Capacity Assessment presents the conceptual design basis of the hydraulic improvements to the ML channels and SCs.

3.1.1 SC Process Design Criteria

Tables 2 and 3 present a summary of SC loadings and design parameters used for the evaluation.

Table 2. Summary of Design Parameters for SCs				
Parameter	Condition	Value		
		North	South	Total
Forward Flow (MGD)	Maximum	217.5	132.5	350
	Average	65	40	105
RAS Drawoff (MGD)	Maximum	87	53	140[1]
	Average	32.5	20	52.5[2]
Maximum ML Concentration (mg/L)	Wet Weather	2,500	2,500	-
	Dry Weather	3,500	3,500	-
Maximum SVI (mL/g)	-	140	140	-

[1] *Peak RAS flows were calculated based on 40 percent RAS rate at peak forward flow conditions*

[2] *Average RAS flows were calculated based on 50 percent RAS rate at current average forward flow conditions*

Table 3. Summary of Current NPDES Requirements for the CWWTP						
Effluent Characteristics	Effluent Limitations (advanced secondary activated sludge treatment – Dry weather flows in the range of 0 to100 MGD)					
	Monthly Average Conc. (mg/L)	Monthly Average Mass (lb/d)	Weekly Average Conc. (mg/L)	Weekly Average Mass (lb/d)	Daily Average Conc. (mg/L)	Daily Average Mass (lb/d)
Total Suspended Solids	30	25,020	40	33,360	45	37,530
Effluent Characteristics	Effluent Limitations (conventional-level activated sludge treatment – wet weather flows in the range of 100 to 220 MGD)					
Total Suspended Solids	NA	NA	40	73,392	45	82,566

Overall design considerations based on regulatory requirements for the secondary treatment system are listed in TM 6 – Aeration System. Refer to TM 6 for further regulatory drivers to consider for design of the secondary treatment system.

3.1.2 ML Channel

Table 4 presents a summary of the physical characteristics and design criteria for adequate mixing and off-gassing of the ML channels. Figure 2 shows the delineation of areas for the north and south ML channels between where fine bubble diffusers will be installed and where other means of channel mixing will be installed.

Table 4. Summary of Design Parameters for ML Channels		
Parameter	North ML Channel	South ML Channel
Total Length (ft)	1,495	860
Length of Fine Bubble (ft)	862	575
Mixed Length (ft)	633	285
Width (ft)	12, 15	17.67
Depth (ft)	11, 12	11, 8
Current Total Air Supply (3 cfm/LF)	3,150	2,925
Proposed Fine Bubble Air Supply (0.27 and 0.22 cfm/sq ft for north and south respectively)[1,2]	3,500 cfm	2,250 cfm

[1] *Proposed air supply is for fine bubble portion of channel only, remaining channel will be mixed as discussed in section 4.2.1*

[2] *Refer to COPT Study TM 5.4 –Process Capacity Assessment and COPT Study TM 5.5 – Low Pressure Air System Upgrades for discussion on how proposed air rates were determined based on process design*

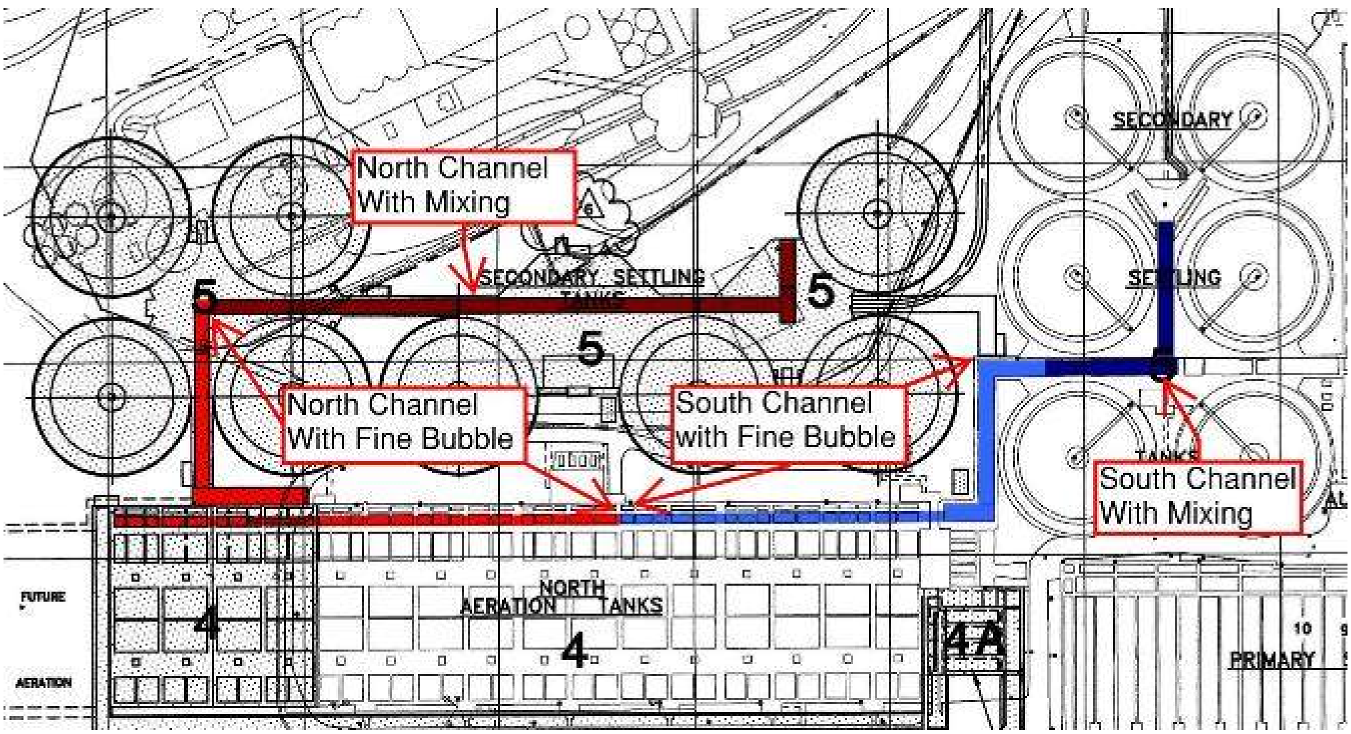

Figure 2. ML Channel Fine Bubble/Mixing Overview

3.1.3 South Secondary Effluent Routing

The following list presents design parameters for the design of two new Parshall flumes located in existing abandoned filter bays that will accept effluent from south SCs and route to new UV disinfection facility.

- Downstream water surface elevations (WSE) in secondary effluent combination box = 418.25 feet (ft)
- Total headloss in new south secondary effluent conveyance line at max flows = 4.25 ft
- Top of south SC flow meter pipe = 426.00 ft
- Anticipated flume invert = 423.50 ft (in order to keep SC flow meter pipe full at 140 MGD south secondary effluent flow)
- Minimum south secondary effluent flow = 40 MGD
- Maximum south secondary effluent flow = 140 MGD
- Parshall flume throat width = 8 ft

3.2 Code Considerations

A complete list of all codes used for design will be included in the Code Classification Summary. This section will be filled in later once the code classification summary is updated.

3.3 Regulatory Drivers

Design considerations in Phase 2 detailed design will include discussions with the Clean Water Nashville Overflow Abatement Program (CWNOAP) regarding implications on the effluent permit based on the optimized design and future effluent capacity of CWWTP.

3.3.1 Future Effluent Permit Considerations

The current permitted limit for total pounds of total suspended solids (TSS) per day may need to be increased to accommodate the increased maximum daily loading to the Cumberland River in order to maintain the current maximum permit concentration of 40 mg/L with higher flows. Otherwise, maximum permitted TSS concentration will have to be reduced to accommodate an increase in flows. Overall wet weather wastewater-based TSS loading to the Cumberland River will be reduced as a result of this project and the CSO reductions at the Kerrigan CSO outfall. As such, modifying the total maximum daily effluent TSS loading during wet weather is justified.

3.3.2 Air Permit

The CWWTP also has an air permit for emission limits that is currently issued on the existing plant configuration. It is assumed that the requirements of the current air permit will remain the same through the full implementation of COPT improvements. The current permit limits will be used as design constraints for proposed improvements, and the existing air model will be updated throughout the design and construction to ensure permit limits are met. If any modifications to the current air permit are required, the timeline for a new air permit will become a time-sensitive component of the design process due to the long lead time of the application process.

3.4 Sequencing and Constructability Affecting Design

The following text provides a preliminary list of specific sequencing issues and constructability items that impact the design scope of improvements in this process area. Other COPT Project components that affect and require coordination with this process area are included. The overall sequencing plan for this process area is discussed in Section 5 of this TM, and overall construction sequencing plan will be included in an overall sequencing plan. These sections will be coordinated with the project Construction Manager at Risk (CMAR) in development of the overall sequencing plan.

- The number and location of ML channel isolation gates may be affected by the number of SC that must remain in service during construction. The number of units within each set of SCs that must remain in service may depend on the sequencing of other plant improvements. A conservative number of ML isolation locations are included during Phase 1 to accommodate for this uncertainty. This will be revisited during Phase 2 detailed design once more information is available.

Section 4: Description of Improvements

The following describes the key development information, features, design data and operations, and control narrative for the secondary treatment system.

4.1 Detailed Design Considerations and Assumptions

The following list includes assumptions and considerations used for this BODR evaluation. These are to be confirmed during Phase 2 detailed design.

4.1.1 ML Channels

As referenced in COPT Study TM 5.4, the optimization improvements include the stripping of dissolved gases from the ML prior to SC inlets. The dissolved gasses are a result of the deep ATs and currently contribute to floating solids and decreased effluent quality. It is assumed that adequate gas stripping will occur if fine bubble diffusers are installed in each ML channel (north and south) from the ATs to the first SC inlet within each side. Refer to previous Figure 2 for a depiction of where channels will have fine bubble diffusers installed.

4.1.2 North and South SCs

MWS has indicated that work needed to implement recommendations for improvements made in the COPT Study for the south SCs could be performed as part of an early action project, prior to the completion of detailed design for the entire plant. This work could be performed by the CMAR or by a separate mechanical contractor to be solicited by MWS. In either case, BC will develop procurement documents that align with the overall scope of work. Improvements and costs will be included in this scope of work in the event that MWS decides to have work performed by the CMAR. Description of work that will be completed on the south SCs includes:

- Complete inner mechanism replacement including centerwell/skirt, RAS sludge scraper mechanisms, scum baffles, and other associated mechanism replacement.
- Re-balancing effluent v-notch weir plates on all south SCs

Recommended upgrades to the north SC mechanisms will be included in this scope of work and associated estimated costs of upgrades will be included in the overall cost estimate.

4.1.3 Hydraulics

As described in TM 5.1 (Hydraulic Analysis) of the COPT Study, secondary effluent from both north and south SCs will be routed to a new UV disinfection facility located at the north disinfection area. North secondary effluent is currently routed via a 108-in pipe to the north secondary effluent meter vault where it is split into two 66-in pipes and one 30-in pipe for flow measurement prior to discharge into the north disinfection area. South secondary effluent is currently routed to an existing south chlorine contact tank and discharged through a separate effluent pipe to the Cumberland River. Proposed improvements will provide means for south secondary effluent to be routed through two new Parshall flumes that will be constructed within existing tertiary filter bays to accurately measure south secondary effluent flow and transition flow to new south secondary effluent conveyance pipe to north disinfection area. Design approaches were evaluated to assess the free flow at both the peak hydraulic condition and a low flow condition. Figure 3 highlights the existing and proposed routing of both north and south secondary effluent.

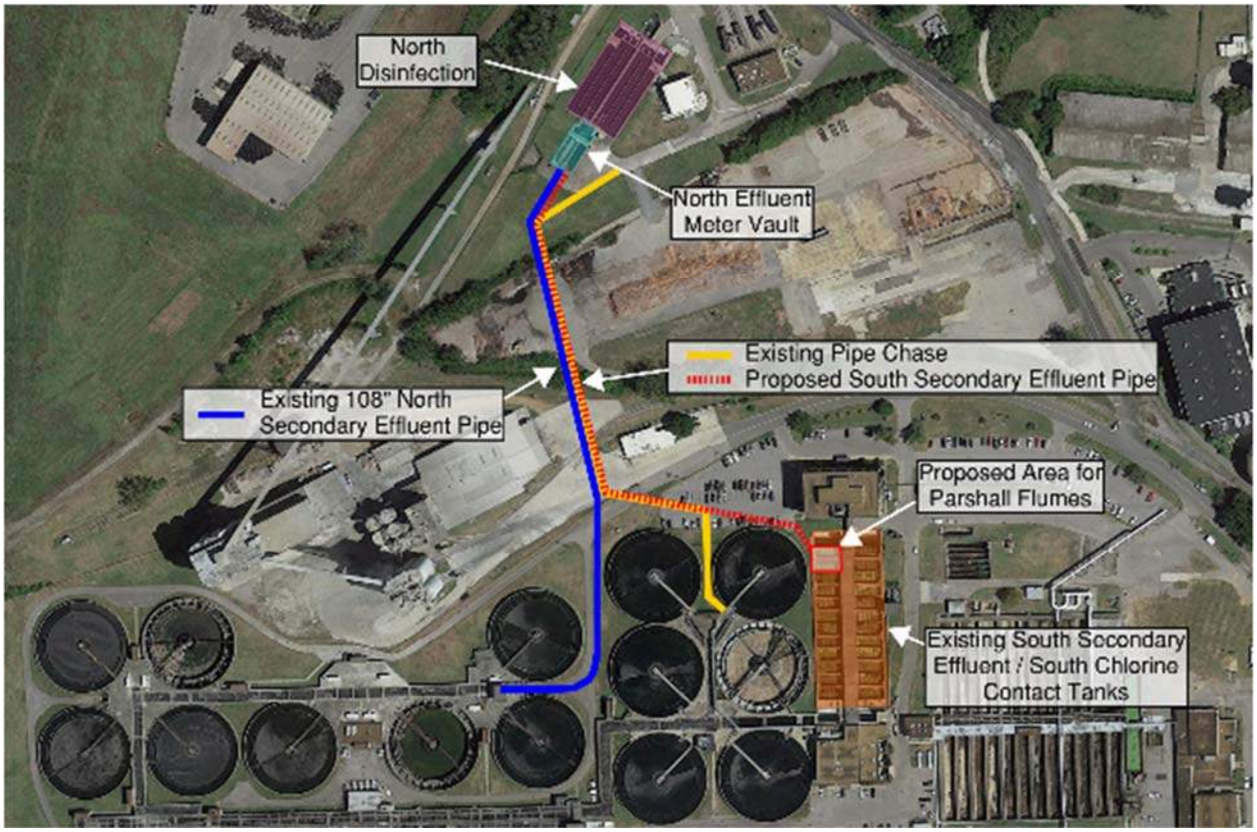

Figure 3. Existing and Proposed North and South Secondary Effluent

Parshall flumes will be installed in the existing filter bay and will be designed to accurately measure south secondary effluent prior to being routed to the north disinfection area, and to maintain head conditions upstream in order to keep south SC effluent flow meter pipes full at all flow conditions. The following assumed flow rates and hydraulic elevations/considerations were used for the preliminary design of the Parshall flumes:

- Downstream WSE in secondary effluent combination box = 418.25 ft
- Total headloss in new south secondary effluent conveyance line at max flows = 4.25 ft
- Top of south SC flow meter pipe = 426.00 ft
- Anticipated flume invert = 423.50 ft (in order to keep SC flow meter pipe full at 140 MGD south secondary effluent flow)
- Minimum south secondary effluent flow = 40 MGD
- Maximum south secondary effluent flow = 140 MGD
- Parshall flume throat width = 8 ft

4.2 Process Mechanical

4.2.1 ML Channel Improvements

The existing north and south ML channels will continue to be utilized to convey flow to the SCs. In order to maximize hydraulic capacity, improve performance, allow for fine bubble diffuser maintenance, and provide for operational flexibility; the following scope items are provided. See Figure 4 below for locations of scope items.

- Provide slide gates or other means of channel isolation that allow for sections of ML channel to be taken off-line for diffuser maintenance while still maintaining operation of all SCs.
- Install a curb around section of north ML channel to raise freeboard and increase hydraulic capacity of north SCs.
- Rehab or replace existing slide gate in ML channel between ATs 3 and 4, replace the existing electric actuator, and connect to distributed control system (DCS) to facilitate remote monitoring/control.

4.2.2 ML Channel Mixing

As discussed previously, the existing coarse bubble air mixing system in the ML channels will not provide de-gassing required based on the improved AT configuration. Fine bubble diffusers will be installed in the ML channel prior to entry into each set of SCs to provide adequate stripping of gases. Additionally, the existing coarse bubble diffusers provide excess air from what is needed for mixing in the remainder of the ML channels, and are damaged and are ineffective in mixing the channels, and need to be replaced with a new channel mixing system. An alternatives evaluation was completed in supplemental design information that includes new long band type diffusers (as were installed in south primary effluent channel in recent upgrades project), top-mounted hyperboloid mixers, and compressed gas mixing. The selected mixing alternative will be finalized in Phase 2 detailed design of this project, but costs for the compressed gas mixing alternative are shown in the cost estimate

- Demolish existing point-type coarse bubble diffusers, and associated air piping within the ML channels (as applicable)
- Replace existing damaged air piping as necessary (full replacement assumed for cost estimate).
- Install fine bubble diffusers in ML channels along ATs and from ATs to first SC inlets. Total approximate length of channels that fine bubble diffusers will be installed in is 1,450-ft.
- Provide for adequate mixing in ML channels downstream of first SCs through the use of a compressed gas mixing system that utilizes a new compressor and control valves to introduce short bursts of air into the channel.

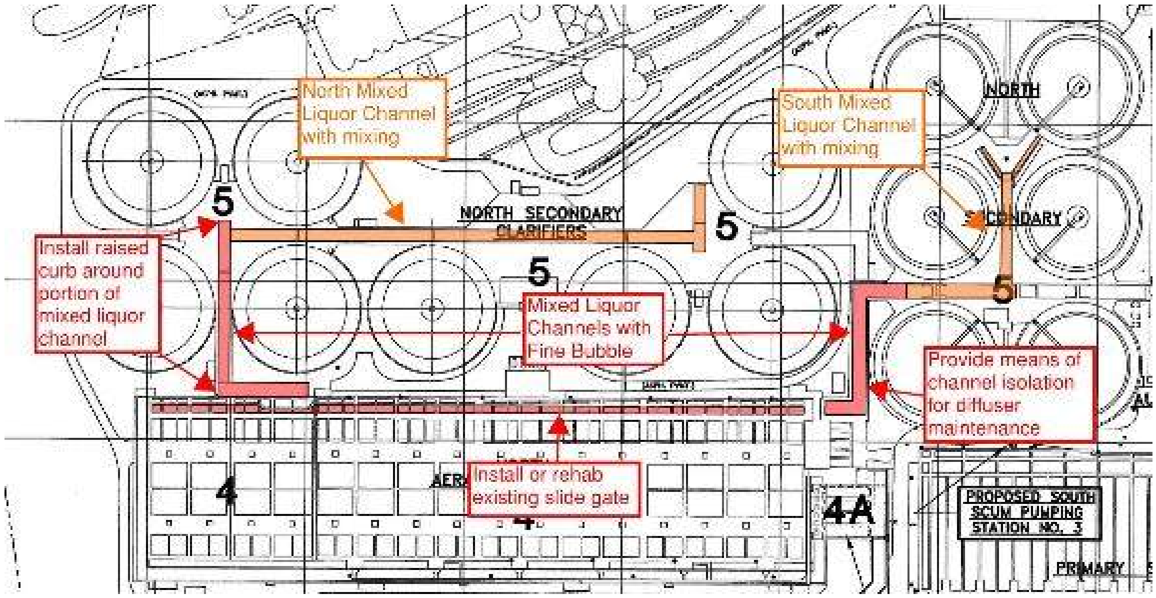

Figure 4. Modifications to ML Channels

4.2.3 Secondary Clarifiers

- Inspect the suction header mechanisms on north SCs to evaluate seal/gasket condition and effect on performance
- Increase depth of north SC 28-ft diameter centerwell/flocculation well by 1.6-ft to improve hydraulics
- Demolish existing internal mechanisms within the south SCs including centerwell/skirt, RAS sludge scraper mechanisms, and other associated mechanism equipment.
- Complete inner mechanism replacement for the south SCs.
- Replace existing north SC influent 36-inch butterfly isolation valves upstream of flow meters with 36-inch full port plug valves (8 total)
- Replace existing south SC butterfly inlet gates with weir gates to facilitate flow splitting and provide a better means of isolation.
- Replace south SC effluent 24-inch flow meters and associated piping with 36-inch flow meters and piping (6 flow meters total)

4.2.4 South Secondary Scum Well and PS

The existing south secondary scum is routed by gravity from each of the six south SCs to a 30-inch diameter watertight manhole (wet well) located in the south secondary pipe gallery adjacent to SC 3 (refer to Figure 5 for location). Chopper pumps send scum from this location to connect with the south waste activated sludge (WAS) line that eventually ties into the Whites Creek sludge forcemain (FM) to route all flow to the sludge holding tanks. At times when WAS is being pumped through this combined FM, the south secondary scum pumps cannot overcome the additional pressure in the line, so secondary scum is routed through a pipe connected to the tank drainage system. This sends south secondary scum back into the front of the plant instead of being routed to the Biosolids Facility.

Recent modifications to the south secondary scum system by MWS have re-routed the pipeline to be connected to the north secondary scum piping system, where it connects to the north secondary scum system. This pipeline is isolated to secondary scum flow only, so provisions were made to the north and south secondary scum PSs to operate each side intermittently so that only one set of pumps can operate at a time.

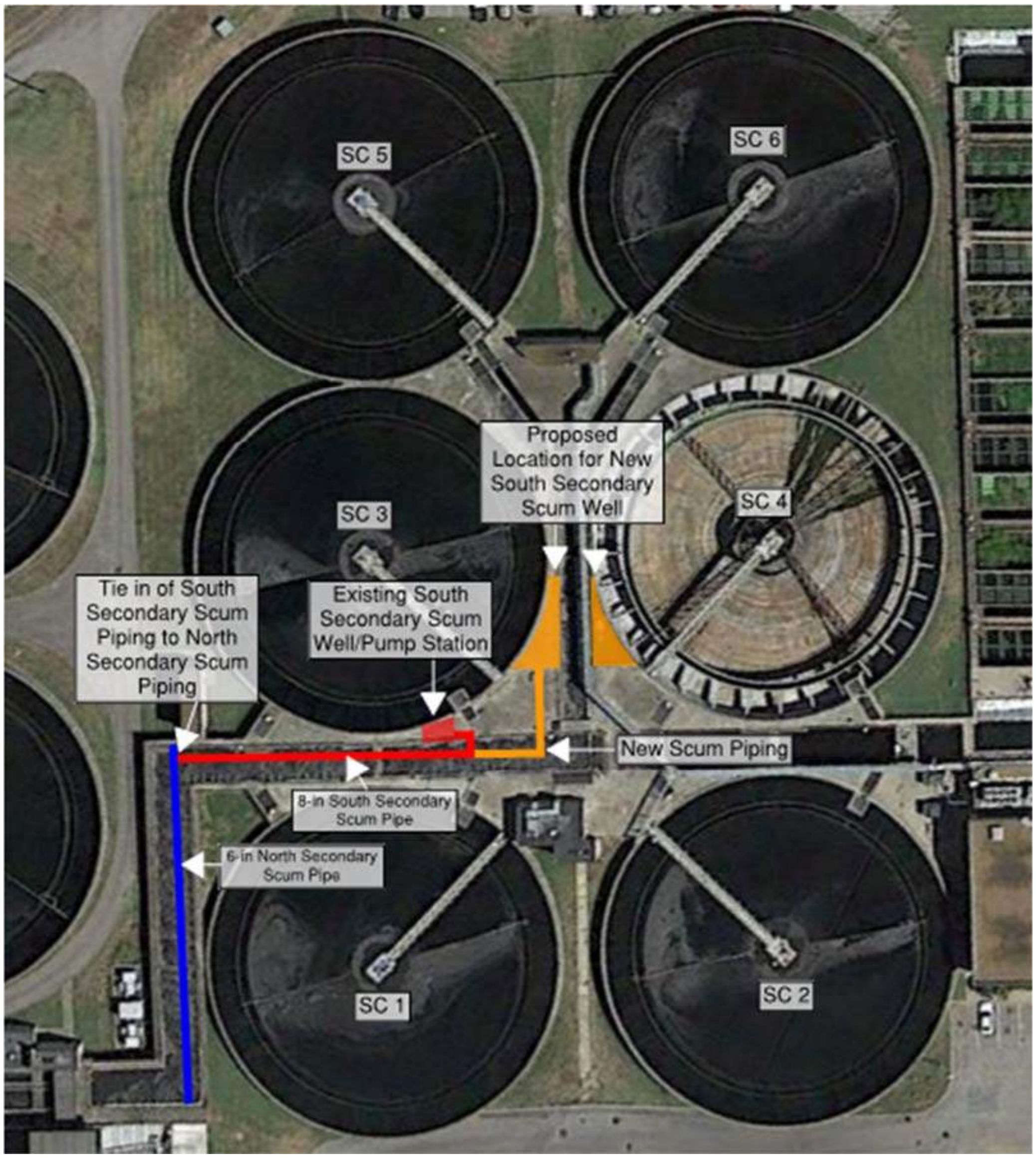

Figure 5. South Secondary Scum Well Enhancements

Additional upgrades can be made to the south secondary scum well to increase reliability of the pumping system, as illustrated in Figure 5. The following presents proposed modifications to the south secondary scum system:

- Demolish existing scum well and PS components, including existing pumps and piping that will not be reused with new location
- Design the size of new scum wells as shown in Figure 5 to allow for adequate sizing based on capacity/flow of scum required.
- Provide means for south secondary scum to be routed to new well/PS location
- Design new scum pumps to be sized to account for required capacity
- Install new discharge piping from scum pumps to tie into existing system

4.2.5 South Secondary Effluent

Secondary effluent from the south SCs will be routed through a new conveyance line (see TM 9 – South Secondary Effluent Conveyance) and combined with the north secondary effluent at the existing north secondary effluent meter vault to facilitate disinfection of all secondary effluent in a new UV disinfection facility (see TM 10 – UV). The following improvements to the existing tertiary filter structure are necessary to route south secondary effluent to the proposed conveyance line and measure flow rate. Refer to Figure 6 below for locations of scope items within existing filter bays.

- Demolish existing filter equipment within filter bays No. 21 and 23 to provide for installation of new Parshall flumes and upstream flume inlet channel.
- Provide two new 8 ft throat width Parshall flumes within existing filter bays No. 21 and 23 to provide flow measurement for south secondary flows.
- Demolish walls between south secondary effluent channel and tertiary filter bays No. 21 and 23 to allow for flow to be routed through two new 8 ft Parshall flumes with minimal headloss.
- Provide slide gates and/or stop logs on the upstream end of the two Parshall flume channels to allow for channel isolation.

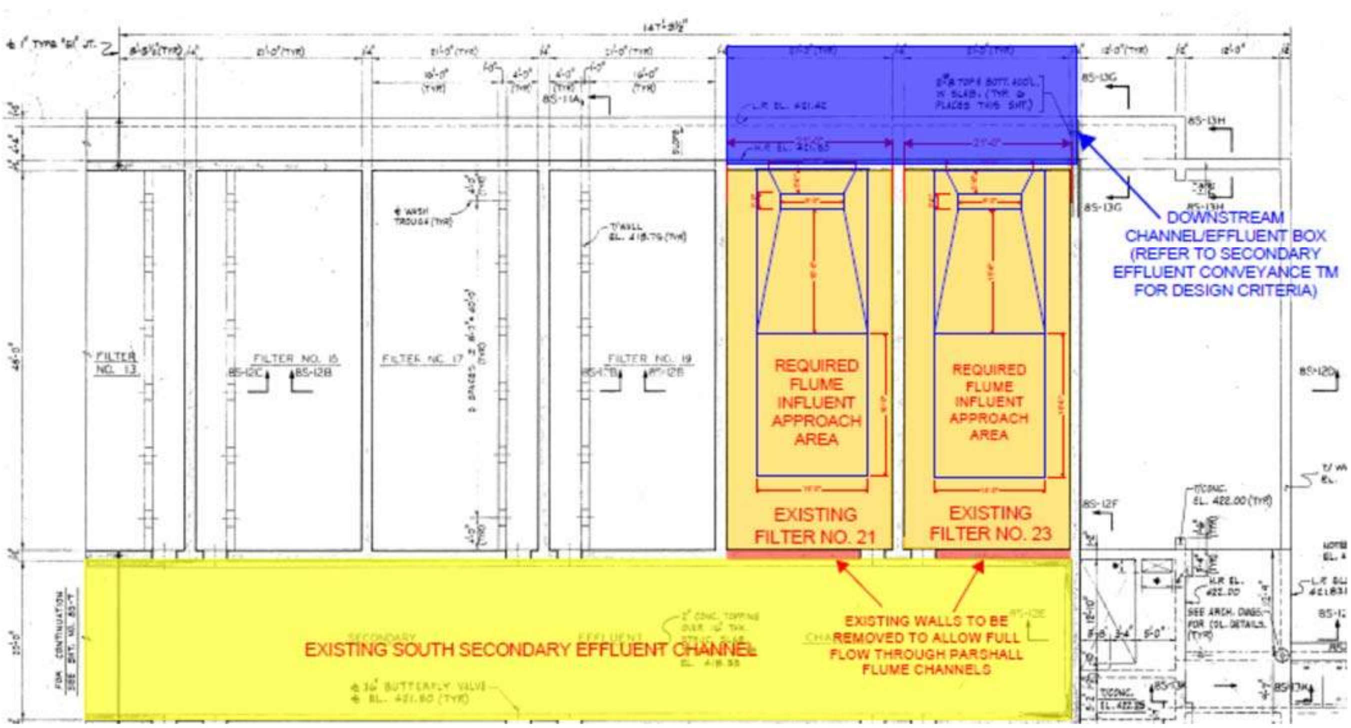

Figure 6. South Secondary Effluent Parshall Flume Location in Existing Filter Bays

4.3 Odor Control (NOT USED)

4.4 HVAC

- Evaluate and potentially update/replace existing HVAC in tunnels below north and south ML channels and secondary effluent channels. A comprehensive HVAC evaluation will be performed during Phase 2 detailed design.

4.5 Plumbing

- Provide inspection and testing for plumbing system in tunnels to confirm pipes are not corroded or plugged. Provide allowance in cost estimate for overall scope of work.
- Coordinate plumbing system for north and south SCs with internal mechanism replacement.
- A comprehensive plumbing evaluation will be performed during Phase 2 detailed design.

4.6 Instrumentation and Controls

4.6.1 ML Channels

- Provide means to monitor and control all mixing and aeration equipment installed in ML channels from the plant DCS.

4.6.2 North and South SCs

- Provide means to monitor and control all normal process equipment, such as automatic valves, such that it can be monitored from the plant DCS. All infrequently used equipment such as slide gates can be incorporated into DCS based on discussions with operations staff during Phase 2 detailed design.
- Work with MWS staff to update programming within DCS to achieve more accurate flow split to SCs through the use of automatic valves and flow meters.

4.6.3 Secondary Effluent

- Provide 4-20 mA control for Parshall flume channel isolation gates. Normal operation will be open/close, but 4-20 mA control will allow operations staff to partially open gate and see the gate position from the DCS.
- All normal process-related equipment will be designed to facilitate monitoring and control from the plant DCS. The need to monitor and control infrequently used equipment such as channel isolation gates from the DCS will be determined based on discussions with operations staff during Phase 2 detailed design.
- Provide flow meter at each Parshall flume throat to accurately measure flow of secondary effluent. Provide 4-20 mA control for flow meters to allow operations staff to see flow measurement from the plant DCS.

4.7 Electrical

- Provide new conduit and cable to new equipment being installed with power needs.
- Coordinate with overall plant power evaluation to confirm where power will be fed to proposed SC and secondary effluent improvements.
  - Confirm location of new 480V power for actuators for Parshall flume channels, either in MCC or 480V power panel

4.8 Structural

4.8.1 ML Channels

The following scope items describe structural considerations for design within the ML channels. Refer to Figure 4 for location of where improvements will be located.

- Construct a raised curb around section of north ML channel from ATs to first set of SCs as indicated on Figure 4
- Modify existing ML channels as indicated on Figure 4 to accommodate installation of slide gates and/or baffle walls to provide for channel isolation

4.8.2 SCs

The following scope items describe structural considerations for design within the SCs.

- Evaluate condition of north SC mechanisms and consider complete replacement

4.8.3 Secondary Effluent

The following scope items describe structural considerations for design with the construction of new Parshall flumes in the existing filter tank structure.

- Modify existing south secondary effluent channel and filter tank structure to incorporate new Parshall flumes as shown in Figure 6.
- Install aluminum grating over new Parshall flume channels
- Modify existing filter tank walls to allow for south secondary effluent flow to pass from Parshall flumes to proposed channel prior to south secondary effluent conveyance pipeline.
- Design handrails around new Parshall flume channels

4.8.4 South Secondary Scum Well and PS

The following scope describes structural considerations for design with the construction of a new south secondary scum well and PS. Refer to Figure 1 above for a depiction of the area of work and specifics.

- Demolish concrete between walkways and existing SCs as shown on Figure 1 and remove fill material in areas
- Modify existing concrete/construct new scum wells as required.

4.9 Geotechnical (NOT USED)

4.10 Architectural (NOT USED)

4.11 Site Civil Scope of Improvements

There are no specific civil-related improvements associated with this portion of the project. However, cranes and other equipment may be required to be on site between the existing south SCs and filter tanks. Coordination with overall site civil improvements and a grading and paving plan to repair or replace damaged areas from construction work will be required.

Section 5: Sequencing and Constructability

The following text provides a preliminary list of sequencing issues and constructability items that will impact design and implementation of improvements in this process area. This section will be coordinated with the project CMAR in development of the overall sequencing plan.

5.1 Maintenance of Plant Operations (MOPO)

The intent of the MOPO is to mitigate interruptions to plant operation and maintain permit compliance throughout construction and startup of the optimization improvements.

5.1.1 Discipline specific

- Electrical – If it is determined that a new electrical substation will be needed for a new high speed blower, this work will need to take place prior to replacement of existing channel blower. Channel air will need to remain in service during all work.
- Structural – modifications to ML channel including separating north and south clarifiers will require taking clarifiers offline and reducing overall capacity of the plant. This work needs to be coordinated so that the plant is kept within compliance of the effluent discharge permit at all times.

5.1.2 Overall Project Specific

- Prior to any work, the north and south clarifiers need to be hydraulically separated in the ML channel between ATs 3 and 4 either by reusing an existing slide gate within the channel, or by installing a means of channel isolation. This will allow both sets of clarifiers to be taken offline independently.
- South clarifier mechanisms may be replaced as a part of an early action item project
- Prior to routing south secondary effluent flow through the new Parshall flumes in the filter bay, the new UV disinfection facility and secondary effluent conveyance tunnel need to be completed.

5.1.3 Maintenance of Plant Operations

- During construction of the proposed improvements for the SCs, it is necessary to keep an adequate number of tanks online to ensure that the plant is kept within compliance of the effluent discharge permit at all times.
- Bypass pumping/routing may be required for various construction components between the ML channel improvements and SC upgrades.
- Sequencing of taking ATs and channels offline should be coordinated such that tank/channel cleaning can take place at the same time the tank/channel is out of service.

Technical Memorandum

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Prepared for: Metro Water Services

Project Title: Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Project No.: 148388

Technical Memorandum No. 9

Subject: South Secondary Effluent Conveyance

Date: December 21, 2016

To: Trey Cavin, Metro Water Services

From: Tazio Qubeck, Project Manager

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Executive Summary

The objective of this Technical Memorandum (TM) is to present the basis of design for the proposed improvements to the effluent conveyance from the south secondary clarifiers to route all secondary effluent flow to the north disinfection area to facilitate one disinfection location for the north and south secondary clarifiers.

Supplemental to this TM are the previous TMs that were completed by Brown and Caldwell (BC) as part of the Central Optimization Study Project (COPT Study). These TMs form an integral part of the basis of design report (BODR) and are referenced throughout this document.

The modifications proposed for the effluent conveyance from the south secondary clarifiers include:

- Construct a new conduit on site at the Central Wastewater Treatment Plant (CWWTP) and underneath an existing railroad crossing to transport all south secondary effluent flow from the existing south filter bay to the north disinfection area.
    - Convert portions of the existing pipe chase with a suitable pipe rehabilitation method that will be determined during the design phase to provide a conduit with an adequate cross-sectional area to convey the effluent flow.
    - Construct sections of open-cut 72-inch reinforced fiberglass pipe to connect the pipe chase to the existing filter bay to transport south secondary effluent flow to the existing pipe chase, and to connect the pipe chase to the north disinfection facility.
- Construct a cast-in-place junction structure to collect flow from the two flumes that will be installed in existing tertiary filters No. 21 and No. 23.
- Construct cast-in-place junction structures at horizontal bends of the existing pipe chase and at all connection points between the pipe chase and 72-inch reinforced fiberglass pipe.
- Construct sluice gates at the connection point to the north secondary effluent meter vaults to isolate south secondary effluent flow.

Improvements being recommended for the north disinfection area, including the conversion of the north secondary effluent meter vault into a water bearing structure to mix north and south secondary effluent flow and the conversion of the existing north chlorine facility to ultraviolet (UV) disinfection, are described in TM 10 – UV Disinfection. Improvements recommended for the construction of Parshall flumes in the existing tertiary filters to route south secondary effluent flow to the junction structure and pipe chase are provided in TM 8 – Secondary Clarifiers.

Section 1: Process Area Description

The following presents a review of the existing secondary effluent conveyance system and any new proposed improvements that are part of the overall south secondary effluent conveyance design.

1.1 Description of Existing Facilities

The secondary effluent system is currently divided into two independent processes: north and south. North secondary effluent is currently collected via a 108-inch pipe and conveyed to the north secondary effluent meter vault. In the vault, flows are split into two 66-inch pipes and one 30-inch pipe for flow measurement prior to entering the north chlorine contact tanks (CCTs) and discharge into the Cumberland River. South secondary effluent is currently collected and conveyed to the south CCTs and discharged through a separate effluent pipe into the Cumberland River.

To reach the north disinfection facility, north effluent is conveyed under 2nd Avenue North and two CSX railroad spur lines servicing the Lone Star Industries Ready Mix plant. The spur line splits roughly 150 feet (ft) NW of the 2nd street CWWTP entrance. Figure 1 shows 2nd Avenue and the spur line prior to splitting. The existing crossing is approximately 250 linear ft from the east boundary of the plant site and the west boundary of the composting facilities.

Figure 1- Existing CSX Spur line

An existing 6-ft by 8-ft pipe chase that parallels the 108-inch north effluent pipe was constructed during the 1990's major plant expansion project to route chlorine and sulfur dioxide gas piping (among others) from the north disinfection area to the main plant. These chemicals are used for disinfection at the south chlorine facility and north and south secondary effluent channels. An 8-inch tank drain line is also present in the pipe chase. Figure 2 shows construction and inspection photos of the existing pipe chase as it was being constructed during the mid-1990's plant upgrade project and as it was inspected during 2012.

Figure 2- Pipe Chase Construction and Inspection Photos

1.2 Description of Proposed Facilities

As described in COPT Study TM 5.1 (Hydraulic Analysis), secondary effluent from both north and south SCs will be routed to a new UV disinfection facility located at the north disinfection area. Proposed improvements will provide means for south secondary effluent to be routed through two new Parshall flumes that will be constructed within existing tertiary filter bays to accurately measure south secondary effluent flow and transition flow to new south secondary effluent conveyance pipe to the north disinfection area. To minimize utility conflicts, permitting and trenchless construction under the railroad, the current design proposes to use the existing 6-ft by 8-ft pipe chase that parallels the 108-inch north effluent pipe. Figure 3 below portrays an aerial site plan showing north and south effluent conveyance (existing and proposed), highlighted to show the areas covered in this TM.

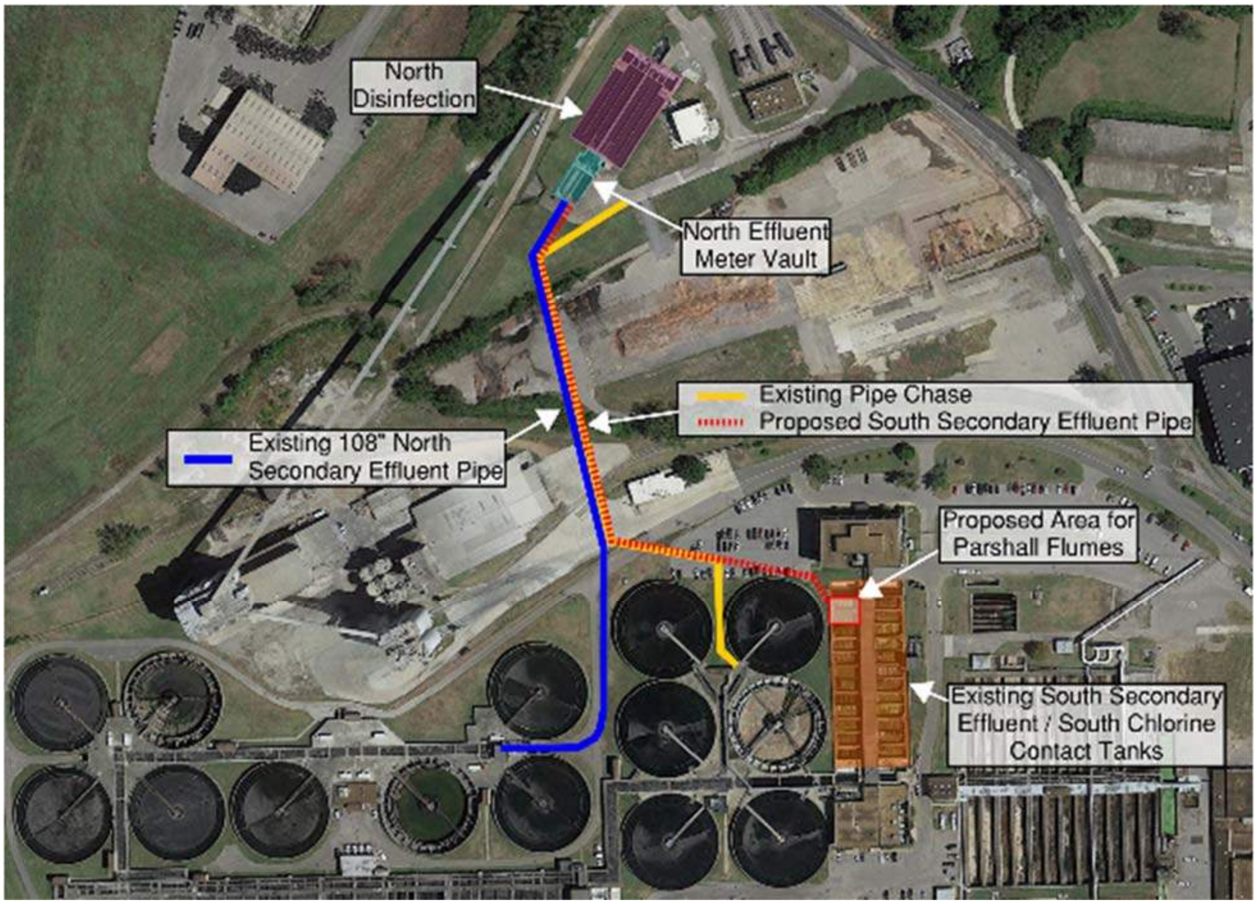

Figure 3- Secondary Effluent Conveyance Routes

Use of the pipe chase is the preferred option to minimizing access coordination, permitting and construction requirements and trenchless construction to cross the existing CSX railroad tracks to the north disinfection Area. A condition assessment and structural review of the existing pipe chase must be performed to determine the feasibility and construction requirements to utilize the unreinforced concrete structure. A preliminary review has been performed and is discussed in Section 3.1.2 below. Coincident with the structural review, changed service loads must also be reviewed to determine the support and stability of the subsurface material

Section 2: Design Intent

Improvements to the secondary effluent conveyance system are focused on providing means to convey both north and south effluent flow to one disinfection and outfall location at the CWWTP.

The following list represents the overall design intent for the recommended improvements to the south secondary effluent conveyance system:

- Utilize an existing 6-ft x 8-ft chlorine pipe chase as conduit to the maximum extent practical and construct new piping as necessary in order to convey the maximum flow of secondary effluent from the south secondary clarifier area to the north disinfection area (future UV disinfection area)

- A new junction structure will be designed to collect south secondary effluent from two Parshall flumes to be installed in the existing tertiary filter structure and convey flow to existing pipe chase without adding excessive headloss to the system.
- Existing junction structures at bends will be utilized if practical along the existing pipe chase as part of the new conveyance system to reduce new construction to the project.
- The design will minimize conflicts with and impact on existing utilities, and mitigate obtaining any new permits or easements from CSX railroad or private property owners if possible.
- The design of the conveyance system within the existing pipe chase will maintain service of the 8-inch tank drain line.

Section 3: Constraints

This section describes the constraints associated with this process area for meeting the design intent.

3.1 Design Criteria

The following section provides a summary of the necessary design criteria that impact the design and implementation of improvements for the south secondary effluent conveyance system at CWWTP.

3.1.1 Hydraulic Design Conditions

The following Table 1 lists hydraulic design parameters for the conveyance lines. TM 5.1 – Plant Hydraulic Capacity from the COPT Study present the conceptual design basis for the hydraulic design of the south secondary effluent conveyance system.

Table 1. Hydraulic Design Criteria

Item	Units	Design Criteria
South Secondary Effluent Flow	Min	40 MGD
	Max	140 MGD
Hydraulic Head in Conveyance Line	Max	25 ft
Velocity Range in Conveyance Line	--	2 ft/sec – 7 ft/sec

3.1.2 Structural Design Considerations

Based on a preliminary structural evaluation of the existing pipe chase, there is concern that use of the existing 6-ft x 8-ft chlorine pipe chase as a water-bearing structure will be feasible. Original design criteria for the pipe chase and existing 108-inch north secondary effluent pipe (constructed adjacent to the pipe chase as seen in Figure 1) used a water head pressure of 25-ft for design.

The existing pipe chase or culvert was constructed with precast concrete culvert sections for the main run and cast-in-place sections at the bends in the chase. Based on initial review of drawings and construction photos, it does not appear that the precast culvert sections have adequate reinforcing to withstand the water pressure. With the assumption that the pipe chase would have 25-ft of water head pressure when south secondary effluent would be flowing through, this pressure would likely increase tension in the culvert walls past the point it was originally designed for.

Initial evaluation has determined that the pipe chase will not be able to be used as a support structure for a non-restrained pipe lining alternative. A full finite element analysis (FEA) of the pipe chase will be performed during phase 2 detailed design, and further information (as listed below) will be used for analysis:

- Shop drawings of precast culvert indicating concrete strength, culvert wall thickness, and reinforcing (if any). If shop drawings are not available, conservative assumptions will be made.
- Available information on subgrade preparation for culvert construction. If no information is available on the subgrade preparation for culvert construction, conservative assumptions will be used.
- Verification of structure condition of culvert. If condition assessment cannot be performed, the culvert will be assumed to be in good condition.

3.1.3 Pipe Chase Conversion Design Considerations

The following Table 2 provides design criteria and considerations for the selection, design and constructability for converting the existing pipe chase to a water-bearing conveyance line. Watertight liner options considered include flexible coatings, cured liners, and fiberglass channels such as non-circular fiberglass pipe or preformed fiberglass channels. Final selection of the liner will be made during future design efforts in coordination with the structural and geotechnical assessments.

Table 2. Pipe Chase Design Considerations

Item	Design Criteria/Effort
Structural Assessment	Condition assessment of the existing pipe chase.
Repurposing Assessment	Structural assessment of service conditions and existing pipe chase. (See Section 3.1.2)
Material Selection: Cost and Availability	Coordination with Liner Manufacturers
Material Selection: Hydraulic	Hydraulic review and review of low head gravity flow performance
Material Selection: Loading	Review of changes to the in service loading on the existing pipe chase based on the construction requirements.
Water tightness and design life	Review of joint type and service for water tightness over the design life.
Pipe Chase Modification Requirements	Review of constructability, operational maintenance and overall cost to provide a watertight conveyance

3.1.4 Pipe Design Considerations

Two pipe materials were reviewed and considered suitable for the pipeline conveyance; concrete pressure pipe and glass-reinforced resin mortar pressure pipe (fiberglass pipe). Other materials such as welded steel pipe, ductile iron pipe (DIP), high-density polyethylene, polyvinyl chloride (PVC), and fusible PVC are also suitable materials but were not considered based on longevity, constructability or the capacity required.

The following Table 3 provides design criteria and considerations for the final selection, design and construction of an open cut pipe conveyance:

Table 3. Pipe Design Considerations	
Item	**Design Criteria/Effort**
Material Cost and Availability	Coordination with Pipe Manufacturers
Material Properties – Hydraulic	Hydraulic review and review of low head gravity flow performance
Material Properties – Corrosion Protection	Lining and Coating requirements for service conditions. Product and Geotechnical Review
Joint Design – low head gravity	Joint selection and service review
Construction Risks and Requirements including Subsidence and Settlement Review	Characterization of subsurface materials and water quality, pipe trench and support design per Geotechnical Evaluation
Pipe configuration	Constructability, cost and configuration requirements based on the final alignment corridor.
Operations and Maintenance	Operator familiarity and present use

Based on a preliminary review, fiberglass pipe, as manufactured by Hobas or FlowTite, is recommended for the open cut sections of the conveyance system. These materials are recommended due to their inherent corrosion resistance, flexibility for alignment changes and access, and constructability for the anticipated site conditions on the site and potential use in the pipe chase modifications.

3.2 Code Considerations

A complete list of all codes used for design will be included in the Code Classification Summary, which will be completed during preliminary design.

3.3 Regulatory Drivers

The following includes a list of major permitting/regulatory drivers that impact the design and implementation of improvements for the secondary effluent conveyance system as part of this project. These drivers are in addition to those required by the Consent Decree and other current and future state and federal regulations.

- Discharge Permit – The current discharge permit for the CWWTP will be modified during Phase 2 detailed design. This TM does not address the permit modification in regards to discharge locations changing with routing south secondary effluent to the north.
- Pipe Chase and Pipeline Easement – the access and easement requirements for work in the existing 108-inch and pipe chase corridor will be reviewed as part of Phase 2 detailed design.
- Coordination with CSX Transportation– A section of the proposed south secondary effluent conveyance conduit travels under an existing railway owned by CSX, and a permit may be required for this project.
- Colonial Gas Pipeline - regulations as they relate to placement of adjacent pipelines and construction limits and easements.

3.4 Sequencing and Constructability Issues Affecting Design

The following text provides a preliminary list of specific sequencing issues and constructability items that impact the design scope of improvements in this process area. Other COPT Project components that affect and require coordination with this process area are included. The overall sequencing plan for this process area is discussed in Section 5 of this TM. These sections will be coordinated with the project Construction Manager at Risk (CMAR) in development of the overall sequencing plan.

- Perform an assessment of the existing pipe chase. The structural condition of the existing pipe chase and associated junction structures and subsurface conditions must be assessed to determine if structural capacity will allow for the pipe chase to be utilized as part of the new conveyance system.
- Perform geotechnical investigations to determine subsurface conditions for strength and stability of the pipe chase, pipe design and to characterize material disposal and dewatering requirements during construction.
- Review access and easement requirements for work in the existing 108-inch and pipe chase corridor.
- Coordinate permit requirements for work within the CSX ROW for modification of the existing pipe chase or for construction of a new pipe crossing if the chase is not feasible to determine impact to schedule and Bid price. CSX permits will be obtained by the Contractor at the time of construction. Trenchless design is not included in the current scope of work.
- Coordinate improvements for the new conveyance with the north disinfection area UV improvements and north secondary effluent meter vault modifications. The existing chlorine and sulfur dioxide piping in the pipe chase will no longer be utilized once UV is implemented and will be removed from service as part of the construction sequencing. Since these lines will be removed, either the final UV disinfection system or a temporary disinfection system for the north secondary effluent flow must be installed, tested, and put into service prior to removal of the lines within the pipe chase.
- Coordinate improvements for the new conveyance with the south chlorine contact tanks and tertiary filters to maintain operations.

Section 4: Description of Improvements

The following describes the key development information, features, design data and operations and control narrative for the south secondary effluent conveyance system.

4.1 Detailed Design Considerations and Assumptions

The following list includes assumptions and considerations used for this BODR evaluation. These are to be confirmed during Phase 2 detailed design.

- The conveyance system will utilize a portion of the existing pipe chase that extends from the existing secondary settling tanks to the existing north disinfection area.
- Identify any coordination required with CSX railroad if all proposed work is inside pipe chase within their right-of-way
- Determine status of potential new plant effluent line from north disinfection area to main plant campus as a non-potable plant water supply
- Determine amount of time the existing 8-inch tank drainage line in the pipe chase can be out of service during construction of new conveyance system and relocated tank drainage line
- Determine location of tie-in to north disinfection structure
- Determine method of connecting new conveyance line to existing north disinfection structure
- Determine type, size, and installation method for flow control device at connection to existing north disinfection structure

- Field verify utility locations (vertical and horizontal) that may impact design
- Evaluate existing subsurface conditions at flume effluent collection channel location
- Verify available space for construction of flume effluent collection channel (horizontal and vertical)

4.1.1 Hydraulics

Proposed improvements will provide means for south secondary effluent to be routed through a new south secondary effluent conveyance conduit to the north disinfection area. Design approaches were evaluated to assess the free flow at both the peak hydraulic condition and a low flow condition and include the following:

- Based on flow data developed through the hydraulic modeling effort (COPT Study TM 5.1), a conduit with an equivalent cross-sectional area of at least 72-inch diameter pipe is required. Further hydraulic modeling will be performed in detailed design to determine the hydraulic capacity requirements of the conveyance system, final alignment and specified materials.
- Downstream water surface elevations (WSE) in secondary effluent combination box (existing north secondary effluent meter vault) = 418.25 ft
- Anticipated flume invert = 423.50 ft (in order to keep SC flow meter pipe full at 140 MGD south secondary effluent flow)
- Minimum south secondary effluent flow = 40 MGD
- Maximum south secondary effluent flow = 140 MGD
- Maximum hydraulic head in conveyance line = 25 ft
- Velocity range in conveyance line = 2 ft/sec – 7 ft/sec
- Review of hydraulic design if a railroad crossing is required.

4.1.2 Geotechnical Assumptions

As discussed previously, the water pressure head that will be experienced with routing south secondary effluent flow through the pipe chase will increase tension in the culvert walls and add an increased load onto the soil surrounding. Based on initial analysis, the internal pressure within the pipe chase would be greater than the soil pressure, which could cause the culvert walls to fail if not reinforced. Geotechnical evaluation will also be required to identify the presence and characteristics of unsuitable materials in the open-cut pipeline alignment to determine pipe stability and support, mitigation requirements, and impacts to pipe and trench design. determine soil strength for pipe design, potential settlement and support requirements in unsuitable materials.

The following summarizes a list of assumptions and design considerations that will be in included in phase 2 detailed design:

- Existing geotechnical borings relative to proposed pipelines, structures and footings will be reviewed
- Additional geotechnical borings may be necessary based on review of existing borings
- It is possible that a significant amount of unknown debris or, unsuitable subgrade material may be encountered during excavation of the open-cut segments of the conveyance system. Materials and water quality should be characterized for design and handling requirements during construction.
- It is possible that unsuitable material may be encountered during excavation for the flume effluent channel at the repurposed existing tertiary filters. Composition of backfill materials during past construction operations is unknown.
- Additional geotechnical subsurface investigation to determine limits and characteristics of subsurface materials, potential settlement and support requirements in unsuitable materials may be necessary.

4.2 Process Mechanical

The following section summarizes the overall process mechanical design components required to complete the necessary improvements associated with the south secondary effluent conveyance improvements. Figure 2 below shows the proposed sections of the existing pipe chase that are to be re-used with the recommended improvements along with the areas where new open cut pipe will be constructed and locations of junction structures.

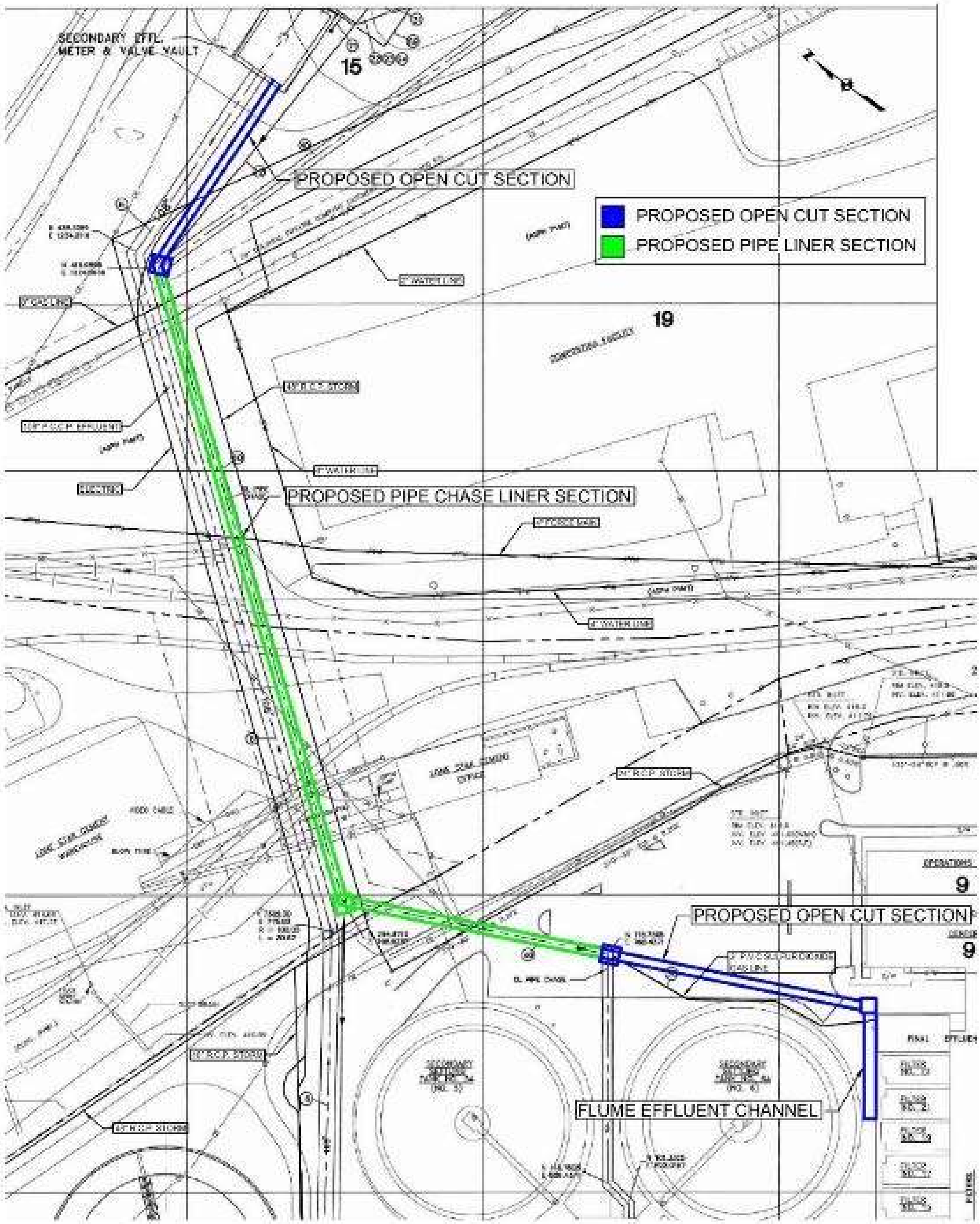

Figure 4- South Secondary Effluent Conveyance Components

4.2.1 Conversion of Existing Pipe Chase

As described previously, the conveyance system will utilize a portion of the existing pipe chase to convert it to a water-bearing conduit to transport all south secondary effluent flow from the existing secondary clarifiers to the existing north disinfection area. The pipe chase was initially installed to route the chlorine and sulfur dioxide lines and a tank drainage pipe between the north and south plant areas.

An alternatives evaluation was performed to determine the recommended method of converting the pipe chase to a water-bearing conduit. The alternatives evaluation was provided as supplemental information to MWS and describes the process used to determine the recommended alternative for the conveyance system. The selected alternative will be finalized in detailed design for this project, but costs for the cured in place pipe (CIPP) alternative are shown in the cost estimate of this BODR, and scope items for this alternative are shown below:

- Demolish small diameter chlorine and sulfur dioxide piping within the pipe chase (assume 635 ft of 3/4-inch to 4-inch piping for both chlorine and sulfur dioxide piping)
- Slip line pipe chase with CIPP. (Assume 635 ft of 72-inch CIPP)
- The existing 8-inch tank drainage line in the pipe chase must remain in service and will be relocated to the bottom of the chase and encased by grout or concrete (assume 635 ft of 8-inch DIP)

4.2.2 Open Cut Pipe Sections

As described previously, the conveyance system will also require sections of pipeline to be constructed by open cut. An alternatives evaluation was performed to determine the recommended alignment and pipe materials for the open cut portion. The alternatives evaluation was provided as supplemental information. The recommended pipe is fiberglass and was assumed for the preliminary cost estimate.

Scope items for confirmation of this pipe material and to develop the contract documents are shown below:

- Plan and profile drawings will be developed based on the recommended alignment. Development will include review of yard piping, utility conflicts and recommended potholing to be completed to verify the alignment prior to construction.
- Pipe and trench designs will be developed based on service loading (dead load, live load including H-20 and E-80 as applicable) and subsurface conditions
- Pipe joint review to maintain watertight connections at structures, access points, and under hydraulic head.
- Pipe settlement potential review and design of pipe support requirements, including geogrid reinforced base layers to pipe supports.
- CSX permit coordination and design of trenchless crossings if required. Design will assume a two pass, casing.

4.2.3 Sluice Gate

- Install 72-inch sluice gate with 72-inch wall thimble for isolation of the conveyance system at connection to disinfection facility (assume stainless steel pipe)
- Cut hole for 72-inch pipe penetration at north secondary effluent meter vault to allow for installation of 72-inch pipe connection. Assume grouted wall pipe or LinkSeal connection.

4.3 Odor Control (NOT USED)

4.4 Heating, Ventilation, and Air Conditioning (HVAC) (NOT USED)

4.5 Plumbing (NOT USED)

4.6 Instrumentation and Controls

- Provide 4-20 mA control for 72-in isolation sluice gates. Normal operation will be open/close, but 4-20 mA control will allow operations staff to partially open gate and see the gate position from the DCS.
- All normal process-related equipment will be designed to facilitate monitoring and control from the plant DCS. The need to monitor and control infrequently used equipment from the DCS will be determined based on discussions with operations staff during Phase 2 detailed design.

4.7 Electrical

- Provide new conduit and cable to new equipment being installed with power needs.
- Coordinate with overall plant power evaluation to confirm where power will be fed to proposed sluice gates.
- Provide 480V power for actuators at north secondary effluent meter vault via MCC or new 480V power panel

4.8 Geotechnical

- Review existing geotechnical borings relative to proposed structures and footings
- Confirm structural integrity of existing piles.
- Foundation design for new junction structures.

4.9 Structural

The structural design for the south secondary effluent conveyance improvements will be developed in accordance with the design criteria below.

- Develop FEA model of culvert section using RISA-3D software version 12.0
- Engage geotechnical engineer to confirm equivalent lateral soil pressure, allowable bearing pressure and soil modulus of subgrade reaction based on review of existing geotechnical reports and available information on subgrade preparation for culvert construction
- Compare calculated stresses from FEA to allowable stresses on concrete to determine if culvert can support the internal pressure associated with a max WSEL 423.0
- Calculate estimated settlement of culvert from FEA and discuss potential impacts to nearby structures, utilities and surface features
- Structural design and construction of new structures utilized for access and at directional changes
- Structural design and construction of connection points with existing structures
- Structural design and construction of flume effluent channel including foundation, walls, access steps/ walkways
- Design and construction of anchoring system for existing cast-in-place structures in the pipe chase system, if required

4.10 Architectural (NOT USED)

4.11 Site Civil

- Evaluation and selection of lining system along portions of the existing pipe chase
- Relocation of existing 8-inch tank drainage line, temporarily during demo of existing line and installation in its permanent location within the pipe chase
- Open-cut conveyance pipe segments including connections to the portion of the existing pipe chase to be repurposed, isolation and access at directional changes,
- Relocation of existing utilities, if required. Existing utility locations to be field verified during Phase 2 detailed design.
- Protection of existing high-pressure Colonial gas line
- Protection of existing electrical duct bank. Duct bank location and dimensions to be field verified during Phase 2 detailed design.
- Abandonment of unused portions of existing pipe chase. Collapse chase and backfill voids with crushed stone, fill chase with flowable fill, or seal ends at points where chase is abandoned.
- Design and construction of concrete “anchors” or “kickers” at existing cast-in-place structures where directional changes in the pipe chase occur.
- Erosion and sediment control design will be determined based on location as necessary, particularly where open cut pipe segments are to be installed.
- Preparation of required permit documents (Metro Stormwater and TDEC plans review)
- Assistance to MWS in coordination with CSX Railroad easement access

Section 5: Sequencing and Constructability

The following text provides a preliminary list of sequencing issues and constructability items that will impact design and implementation of improvements in this process area. This section will be coordinated with the project CMAR in development of the overall sequencing plan.

5.1 Maintenance of Plant Operations (MOPO)

The intent of the MOPO is to mitigate interruptions to plant operation and maintain permit compliance throughout construction and startup of the optimization improvements.

- Existing 8-inch tank drainage line must be taken out of service with temporary alternative provided
- Coordination of tie-ins at existing tertiary filter structure and north disinfection area
- Existing utilities in area (electrical duct bank, storm sewers, high pressure Colonial gas line, force main, water line)
- Proximity to existing 108-inch secondary effluent line
- Structural integrity of existing pipe chase and structures at bends in pipe chase
- Sluice gate to be installed at connection to north disinfection structure for use during construction and future isolation of the effluent conveyance system, if necessary
- Access to conveyance line – access structures at changes of direction
- Provide adequate free flow for flume discharge in flume effluent channel at existing tertiary filter structure

- Conveyance system must be capable of transporting the design flow without overflows or flow restrictions
- Due to plant disinfection procedures, the temporary PAA system must be installed, tested, and put into service prior to removal of the lines within the pipe chase.

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Technical Memorandum

Prepared for: Metro Water Services

Project Title: Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Project No.: 148388

Technical Memorandum No 10

Subject: UV Disinfection Facility Basis of Design

Date: December 21, 2016

To: Trey Cavin, Metro Water Services

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Executive Summary

The objective of this Technical Memorandum (TM) is to present the basis of design for the proposed improvements to the final effluent disinfection at the north disinfection tanks and associated areas at Central Wastewater Treatment Plant (CWWTP) for the Central WWTP Improvements & CSO Reduction Project (COPT Project).

Supplemental to this TM are the previous TMs that were performed by Brown and Caldwell (BC) as part of the Central Optimization Study Report (COPT Study). These TMs form an integral part of the basis of design report (BODR) and are referenced throughout this document. Presentations and meeting minutes from the development workshops provide additional decision-making background and supplemental information for this BODR.

The major modifications proposed for the north disinfection area are highlighted below:

- Discontinue the use of chlorine and sulfur dioxide gas as disinfection chemicals
- Provide a new ultraviolet (UV) disinfection system for secondary effluent, including tank conversion, new UV building enclosure, and all additional structures or facilities required for the new disinfection system
- Upgrade and reconfigure the north chlorine contact tanks (CCTs) to accommodate the UV equipment and receive all secondary effluent flow from the north and south
- Provide new electrical buildings to house electrical equipment necessary for the UV equipment
- Provide new Parshall flumes for flow measurement coordinated with the new UV system

The improvements and modifications are recommended for implementation in order to improve the safety and operability of the facility by replacing the gaseous chlorine and sulfur dioxide with non-chemical disinfection treatment. These improvements are also recommended to simplify disinfection operations and to accommodate optimized plant secondary effluent flows in a single disinfection location.

Section 1: Process Area Description

The following presents a review of the existing north disinfection area, including the CCTs and gaseous chlorine disinfection.

1.1 Description of Existing Facilities

The existing north disinfection area at CWWTP currently treats secondary effluent from the eight north secondary clarifiers (Clarifier No. 7-14) using gaseous chlorine for disinfection and gaseous sulfur dioxide for dechlorination. Figure 1-1 below portrays an aerial site plan of the north disinfection area highlighted to show process areas covered in this TM. Table 1 below lists a summary of the north disinfection process units, along with physical descriptions and data for the existing system.

Figure 1-1: North Chlorine Contact Tank Area

Table 1. Summary of Existing North Secondary Effluent Chlorine Contact Tanks at the CWWTP

	Parameter	Unit	Value	Notes
North Secondary Effluent Chlorine Contact Tanks				
	Number of tanks/passes	--	2/3	Assumes both tanks in service
	Dimensions of pass	Ft	151.5-ft x 15.25-ft x 19-ft (L x W x D, per pass)	
	Dimensions of weir trough	Ft	47.75-ft x 12-ft x 19-ft (L x W x D, one per tank)	
	Total Reactor Volume	MG	1.07 / 2.13	Per tank / Total
	Detention Time @ 205 MGD	--	15 minutes	
	Chlorine Disinfection	--	4 Chlorinators, 3 Chlorine Induction Unit	
	Sulfur Dioxide Dechlorination	--	2 Sulfonators, 2 Sulfur Dioxide Induction Unit	
	North Secondary Effluent Meter Vault	--	2 66-inch magnetic flowmeters; 1 30-inch magnetic flow meter	

FT- feet

MG- million gallons

1.2 Selected Disinfection Technologies

CWWTP currently uses gaseous chlorine for disinfection and sulfur dioxide for dechlorination for both plant effluent and excess flow. Due to the safety concerns for transporting, storing, and handling these chemicals, as well as possible future effluent requirements concerning disinfection byproducts, alternative disinfection technologies were evaluated as part of the COPT Study. The alternatives considered for final plant effluent were bulk sodium hypochlorite, on-site generation of sodium hypochlorite, UV, ozone, and peracetic acid (PAA). A combination of cost and non-cost factors led to the recommendation of UV for disinfection at the north disinfection facility that will treat the entire plant flow. Refer to COPT Study TM 7 – Central WWTP Disinfection Feasibility Study for additional detail.

Section 2: Design Intent

The recommended improvements to the north disinfection area are intended to reduce risk through removal of hazardous chemicals and maximize the achievable flow capacity for final effluent disinfection.

The following list represents the overall design intent for the recommended improvements to the north disinfection area:

- The existing gaseous chlorine disinfection and sulfur dioxide dechlorination systems will be removed and replaced with an UV disinfection system to eliminate the safety concern of having these hazardous gases on site.
- The north chlorine contact tank layout will be reconfigured to most beneficially accommodate the system hydraulics and increase capacity of the north disinfection area.
- The UV equipment will be protected from algae to maximize effectiveness of the UV dose without causing undue hydraulic losses.
- Two new Parshall flumes will be installed in the downstream portion of the reconfigured north CCTs to provide passive flow measurement.
- A new enclosed building will be constructed over the existing north CCTs to provide shelter for operators and UV equipment from exposure to extreme weather, as well as improved isolation from birds, bugs, and other pests.
- A new electrical building or buildings will be provided to house the new electrical and control equipment associated with the new UV system and protect this equipment from flooding.

Section 3: Constraints

This section describes the constraints associated with this process area for meeting the design intent.

3.1 Design Criteria

The following section provides a summary of the necessary design criteria that impact the design and implementation of improvements for the UV Disinfection Facility at Central WWTP. COPT Study TM 7– Central WWTP Optimization Disinfection Feasibility Study includes the conceptual process design for the CWWTP disinfection technology recommended during the COPT Study.

3.1.1 Influent Flow and Loading Characteristics

The characteristics of the plant secondary effluent are provided in Table 2.

Table 2. Influent Characteristics of Plant Secondary Effluent

Parameter	Average	Peak
Flow	125 MGD average	350 MGD
TSS	5 mg/L	30 mg/L
UVT	55% assumed	
Required UV dose	15 mJ/cm^2 (assumes T1 indicator phage)	

Units: MGD = million gallons per day; mg/L = milligrams per liter; mJ/cm^2 = millijoules per square centimeter

3.1.2 Disinfection Criteria

The north disinfection facility will treat secondary effluent from both the north and south secondary clarifiers. Thus the new UV facility must be designed to treat the maximum secondary treatment capacity of 350 MGD. Disinfection criteria based on the Tennessee Department of Environment and Conservation (TDEC) Sewage Works Disinfection Criteria and design considerations for this installation specific to UV disinfection are:

- Reactor hydraulics – The contact time of the UV light with the wastewater will be optimized using several approaches. The UV equipment manufacturer is responsible for optimizing the hydraulics and UV light contact within the UV bank. Static effluent weirs will be installed to maintain acceptable levels within the UV channels such that all flow is treated. Additionally, CFD modeling will be performed during phase 2 detailed design to determine whether inlet baffling or other means of flow straightening is required to achieve uniform flow in the upstream portion of each UV channel.
- Properties of the wastewater being disinfected and factors affecting transmission of UV light to the microorganisms – Constituents such as suspended or dissolved solids and organics can impact the effectiveness of UV. An online UV transmittance (UVT) meter will be installed to measure the UVT of the secondary effluent to obtain continuous data of the wastewater's receptiveness to UV treatment. Additionally, algae that grows in upstream tanks and channels can affect UV transmittance. The selected UV equipment will be protected from algae either by preventing the growth of algae by covering the secondary clarifier launders and in other tanks/channels upstream of the UV equipment or by installing algae screens at the upstream end of the UV facility. Algae protection will be further evaluated during phase 2 detailed design.

In the COPT Study, a UVT value of 70 percent was assumed in the life-cycle cost analysis based on limited daily grab samples over a 7-week period in May-July 2012. These UVT values ranged from 60 to 86 percent, and the 70 percent value was chosen based on anticipated long-term improvements to final effluent quality. For the 15 percent design, presented in this TM, a reasonably conservative UVT value of 55 percent was assumed due to the limited UVT data available. BC believes the conservatism is warranted because the CWWTP is a large plant that receives flow from a combined sewer system and seasonal impacts such as decaying leaves can negatively affect UVT. Additionally, the CWWTP receives very fine residuals from both of MWS's water treatment plants, which may also negatively impact UVT. A continuous UVT meter will be installed and the assumed 55 percent UVT value will either be confirmed or updated during Phase 2 detailed design. Capital costs associated with the more conservative 55 percent UVT have been included in this BODR.

3.1.3 Structural Design Conditions

A preliminary structural evaluation of the existing north chlorine contact tanks determined that existing pile loads vary based on pile spacing and location. Under existing conditions, the pile loads range from approximately 75 to 85 percent of pile capacity. It is assumed that geo-foam will be used as fill material under a new slab to raise the channel floors to install the new UV equipment. By reducing the depth of water load and adding the weight of a building superstructure plus associated roof and floor live loads, pile loads are expected to increase by approximately 5 percent, resulting in piles loaded up to approximately 90 percent of capacity. During Phase 2 detailed design, further evaluations will consider lighter building materials in an effort to maintain pile loads closer to existing conditions.

3.2 Code Considerations

A complete list of all codes used for design will be included in the Code Classification Summary. This section will be amended once the code classification summary is updated.

3.3 Regulatory Drivers

The following includes a list of regulatory drivers that impact the design and implementation of improvements in the north disinfection facility process area as part of this project.

3.3.1 National Pollutant Discharge Elimination System (NPDES) Permit Requirements

Table 3 summarizes the effluent requirements for the CWWTP based on the current NPDES Permit (TN0020575) (included in Appendix A of TM 1 in the COPT Study). In the case of the CWWTP, three conditions of current effluent requirements are established as follows:

1. Advanced secondary activated sludge treatment: this applies to dry weather conditions for flows in the range of 0 to 100 MGD. It includes seasonal effluent requirements for carbonaceous biochemical oxygen demand ($CBOD_5$), total suspended solids (TSS), and ammonia concentrations.
2. Conventional-level activated sludge treatment: in cases where flows are in excess of 100 MGD but lower than 200 MGD (wet weather conditions), weekly and maximum day average requirements are established.
3. Primary treatment and disinfection: for flows in excess of 220 MGD, secondary treatment is not required for the excess flow. Hence, this fraction of flow is diverted to the excess flow treatment unit (EFTU) for disinfection after only primary treatment. During these conditions, MWS is only required to report EFTU flow and effluent concentrations except for *E. coli*, chlorine residual, and pH, which are required to fall under stated limits in the permit.

Table 3. Summary of Current NPDES Requirements for the CWWTP

Effluent Characteristics	Effluent Limitations (advanced secondary activated sludge treatment – Dry weather flows in the range of 0 to100 MGD)					
	Monthly Average Conc. (mg/L)	Monthly Average Mass (lb./d)	Weekly Average Conc. (mg/L)	Weekly Average Mass (lb./d)	Daily Average Conc. (mg/L)	Daily Average Mass (lb./d)
$CBOD_5$ (May 1- October 31)	10	8,340	15	12,510	25	20,850
$CBOD_5$ (November 1-April 30)	20	16,680	30	25,020	40	33,360
Ammonia-N (May 1- October 31)	5	4,170	7.5	6,225	10	8,340
Ammonia-N (November 1-April 30)	10	8,340	15	12,510	20	16,680
Total Suspended Solids	30	25,020	40	33,360	45	37,530
Effluent Characteristics	**Effluent Limitations (conventional-level activated sludge treatment – wet weather flows in the range of 100 to 220 MGD)**					
$CBOD_5$	NA	NA	35	64,218	40	73,392
Ammonia-N	NA	NA	15	27,522	20	36,696
Total Suspended Solids	NA	NA	40	73,392	45	82,566

3.3.2 Environmental Protection Agency (EPA) Consent Decree

A major constraint of the design and implementation of the COPT improvements project includes how much flow will be required to treat through secondary treatment based on the consent decree from EPA. It is currently undetermined when the consent decree will be finalized.

3.3.3 Future Regulatory Requirements

Design considerations in Phase 2 detailed design will include discussions with the Clean Water Nashville Overflow Abatement Program (CWNOAP) regarding implications on the effluent permit based on the optimized design and future effluent capacity of CWWTP.

The current permit does not restrict chlorinated disinfection by-products (DBP) in the effluent from CWWTP. However, future regulatory requirements may place limitations on DBP, and anticipation of this limitation provided an additional factor in the selection of UV as the recommended disinfection technology for the CWWTP effluent. As discussed in the COPT Study, UV is a non-chemical disinfection technology (germicidal wavelengths which inactivate pathogens through destruction of their proteins and nucleic acids), and thus UV disinfection produces no DBP.

3.3.4 Risk Management Plan (RMP)

The CWWTP currently has an RMP for the gaseous chlorine used for disinfection of both secondary effluent and EFTU flows due to the volume of chemical stored on site. It is anticipated that the gaseous chlorine will be completely removed from the site and an ongoing RMP for the plant effluent disinfection will not be required, since UV is a non-chemical disinfection technology. As discussed in TM 11 – Excess Flow Treatment Unit, an abbreviated RMP may be required for the reduced chemical storage of PAA for the EFTU process area.

3.3.5 Stormwater Permit

Site grading and civil work will be required around the new ancillary electrical building(s) associated with the UV equipment. Supplemental design information includes additional detail regarding the requirements of the plant-wide stormwater permit based on the optimization improvements across the facility.

3.4 Sequencing and Constructability Issues Affecting Design

The following text provides a preliminary list of specific sequencing issues and constructability items that will impact the design scope of improvements in this process area. Other COPT project components that affect and require coordination with this process area are included here. The overall sequencing plan for this process area is discussed in Section 5 of this TM. These sections will be coordinated with the project Construction Manager at Risk (CMAR) in development of the overall sequencing plan.

- Improvements to the north disinfection area must be coordinated with the south secondary effluent conveyance improvements. It is anticipated that the UV equipment will be installed and be online before decommissioning of the south CCTs. The existing north secondary effluent meter vault must also be modified as a water-bearing structure prior to the tie-in with the new south secondary effluent conveyance line. To minimize bypassing to construct the new UV disinfection facilities, a portion of the flow will temporarily be diverted to the south plant.
- Temporary disinfection may be required during portions of the construction work on the existing north CCTs. Further evaluation is required to determine the preferred means of temporary disinfection – whether gaseous chlorine will continue to be used on site until the UV equipment is fully operational, or whether another disinfection chemical will be used.

- The structural condition of the existing tanks, channels, and surrounding site associated with the north disinfection facility must be assessed to determine available structural capacity for construction of the new UV Disinfection Facility. This assessment will determine the weight limitations for new structures, including the building or canopy structure.
- It is anticipated that PAA will be used for temporary disinfection of south secondary effluent through the south CCTs while modifications are being made to facilitate the south secondary effluent conveyance to the new north UV facility. The design parameters for the PAA dose and adequate chemical storage will be determined by pilot testing to be performed during Phase 2 detailed design. It is anticipated that PAA unloading and dosing equipment will be co-located with the EFTU PAA disinfection system.
- Modifications to the north contact tanks will have hydraulic implications on the existing tie-in with the Biosolids Effluent Pumping Station. During Phase 2 detailed design, a new tie-in location point will be determined based on the head requirements of the existing pumps.
- Chlorinated secondary effluent (prior to dechlorination) is currently utilized for non-potable plant water (PW) and distributed from the north disinfection area and the process center. Once the UV disinfection system is operational, PW distributed from these areas will no longer have a disinfection residual without installing a smaller supplemental chemical feed system (likely sodium hypochlorite). It should be noted that PW from the north secondary clarifiers (filter feed area) is currently distributed both without a chemical residual, but also without being disinfected. Based on recent discussions with the operations staff, they haven't noticed issues with north secondary PW specifically attributed to the lack of disinfection. Drivers for disinfection of PW with a chemical residual include health and safety considerations and potential operational issues due to system fouling/clogging due to growth in the lines. The need for disinfection of PW will be investigated as part of the comprehensive PW evaluation performed during phase 2 detailed design.

Section 4: Description of Improvements

The following describes the key development information, features, design data and operations and control narrative for the EFTU improvements.

4.1 Detailed Design Considerations and Assumptions

The following list includes assumptions and considerations used for this BODR and are to be confirmed during Phase 2 detailed design.

- The north CCTs are proposed to be refurbished as the new plant UV disinfection facility and treat secondary effluent from all CWWTP secondary clarifiers. A structural condition assessment of the existing chlorine contact tanks will be included in a Structural Condition Assessment.
- Combined secondary effluent is assumed to achieve 55 percent UVT or greater. As noted above, the design UVT value may be modified based on continuous UVT data, which could substantially change the design of the UV equipment.
- It is assumed that there will be adequate capacity on electrical Circuit E for all power needs associated with the UV equipment once the loads associated with the draft tube aerators are removed at the aeration tanks, as well as the feeds for the existing gaseous disinfection system.
- Due to the hydraulic or electric raising mechanisms of the UV equipment, it is anticipated that no monorail or other ceiling-mounted hoisting mechanism will be required in the new UV disinfection facility.
- It is assumed that the existing tank drainage pump station can continue to be used to serve this process area. This existing forcemain is routed from the north disinfection area to the aeration influent channel

via a precast concrete pipe chase, which is proposed to be used to convey south secondary effluent to the new UV disinfection facility. Proposed modifications to this forcemain are presented in TM 9 – South Secondary Effluent Conveyance.

4.1.1 UV Disinfection

As supported in the TM 7– CWWTP Optimization Disinfection Feasibility Study, UV is recommended to be implemented as the disinfection technology at the north disinfection process area. The advantages of a chemical-free disinfection technology include operator safety, no dechlorination requirements, and no disinfection by-product (DBP) formation. Prior to implementation of UV at the Central WWTP, continuous UVT readings should be obtained using an online analyzer installed to measure the secondary effluent under a variety of conditions and seasonal variation. Further decisions determining design criteria may be made in conclusion of existing plant site visits/interviews. For this evaluation, it is assumed that the UVT of combined plant secondary effluent achieves a minimum of 55 percent UVT.

4.1.2 Preliminary Hydraulics

A preliminary hydraulic model was created to trace the proposed flow routing through the new UV Disinfection Facility layout at the anticipated maximum flow of 350 MGD in this process area. Key assumptions and maximum water surface elevations are presented in Figure 4-1 and supporting discussion below.

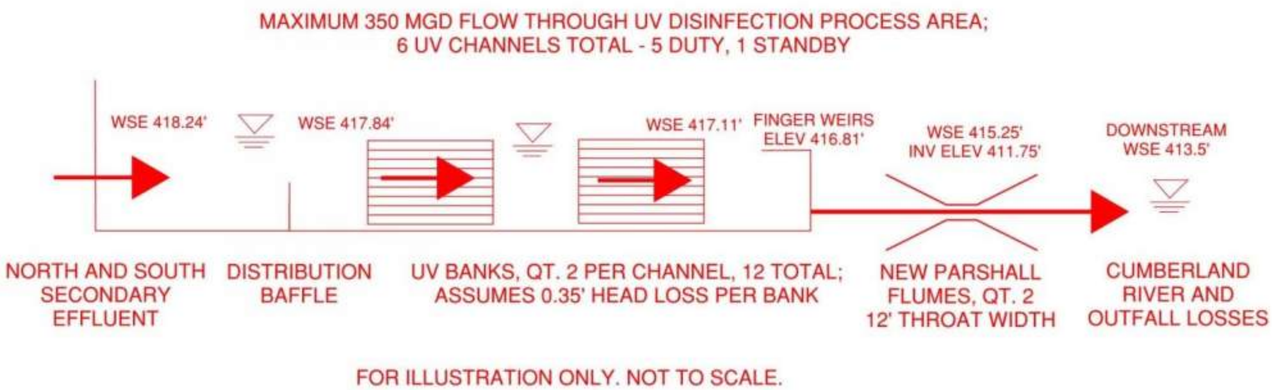

Figure 4-1. Preliminary Hydraulic Profile for UV Disinfection Facility

- A maximum of 5 channels will be in operation at 350 MGD, or 70 MGD each, with 1 additional channel for redundancy.
- The channel influent gates will be either fully open or fully closed for channel isolation only, and will not be used for flow modulation.
- The total head loss through the UV banks at 70 MGD per channel is 8.4 inches (0.7 ft) as reported by the equipment manufacturers.
- The water surface elevation (WSE) in each channel may vary by no more than 15 inches (difference between max WSE and min WSE) to maintain optimal UV treatment. To minimize WSE changes, finger weirs (multiple parallel openings with weir plates), with a total weir length that minimizes the range of water surface elevation over a wide range of flows, will be installed around the periphery of each opening with sufficient length to limit this variation in WSE. For each UV channel, a minimum of 200 ft of weir length will be provided. Currently, we anticipated that 4 double-sided finger weirs, 30 ft long, will be installed. The finger weirs hydraulic and structural features will be refined during Phase 2 detailed design and will be considered in collaboration with the UV manufacturer.

- Two Parshall flumes will be installed in the downstream channel area, each with the following physical characteristics:
  - Throat width = 12 ft
  - Anticipated flume invert = 411.75 ft
  - Unobstructed straight approach length = 43 ft
- The existing chlorine contact tank weir wall and sulfur dioxide weir wall shall be demolished/removed.
- The need for a flow straightening baffle wall at the upstream end of the UV channels shall be determined by CFD modeling to be performed during detailed design. Flow straightening baffles should not be used for algae removal.
- The head loss of algae screens and flow straightening baffle wall (if necessary) can be accommodated based on conservative assumptions in downstream elements or by hydraulic modifications at the upstream north SC process. It is also assumed that if an algae screen is deemed necessary, it will be designed with a passive overflow and scum baffle for high flow conditions.

Additional hydraulic modeling and CFD modeling should be performed during Phase 2 detailed design. This will include further evaluation of the need for algae screening to protect equipment without causing undue headloss.

4.2 Process Mechanical

This section summarizes the overall improvements to the process area.

4.2.1 UV Disinfection

As previously stated, the recommendation from the COPT Study is to convert from the existing gaseous chlorine disinfection and sulfur dioxide dechlorination system to a new UV disinfection system. The UV disinfection system will be sized to treat a peak flow of 350 MGD with five duty channels and one spare channel at an assumed minimum UVT of 55 percent.

The UV disinfection facility is anticipated to include the following features:

- UV equipment consisting of low pressure, high output lamps in inclined banks
- Motorized influent gates for channel isolation
- Flow straightening baffle wall, as determined by CFD modeling
- Automatic hydraulic or electric lifting mechanisms as part of the UV banks to raise banks out of the flow without the use of a crane or monorail
- Finger weirs to provide a minimum of 200 ft of weir length per channel
- UV channel drains and other process drains routed to existing tank drainage pump station
- Two Parshall flumes for flow measurement
- On-line UVT monitoring sensor
- Other instrumentation and controls components
- Electrical components
- Algae mitigation screens would likely be mechanically cleaned, perforated plate screens with high pressure spray cleaning (if required)

4.3 Odor Control

Since the secondary effluent contains little to no organic content and odors are anticipated to be minimal, no odor control measures are anticipated for this process area.

4.4 Heating, Ventilation, and Air Conditioning (HVAC

This section summarizes the design criteria for the HVAC systems for the proposed process area.

The UV disinfection building (if completely enclosed) and the two accompanying electrical buildings will be air conditioned and will include air purifying units. The indoor design criteria will be reviewed during Phase 2 detailed design of this project.

4.5 Plumbing

This section presents the plumbing design criteria for the proposed process area.

- Provide inspection and testing for the plumbing system within the existing north CCTs to confirm pipes are not corroded or plugged. Provide allowance in cost estimate for overall scope of work.
- Install plumbing and water piping required for UV disinfection system.
- Maintain continuous supply of disinfected non-potable plant water.

4.6 Instrumentation and Controls

This section presents the equipment instrumentation and control strategies for the UV disinfection facility.

The controls required for the UV equipment and associated control system will be integrated into the plant's existing SCADA system. These controls will consist of new field instruments, control panels, and local process graphic screen/database, historical data collection/trending, and reporting as required for a complete system.

New field instruments will be provided to measure typical process variables such as level, pressure, flow, and any necessary analytical measurement including UVT. Instruments located outdoors will include a sun/rain shield and surge protection. The control panels will be Vendor Control Panels (VCPs). The VCPs are supplied as part of the vendor package for the new UV system.

- Provide accurate flow signal for UV dose pacing (4-20 mA from the new Parshall flumes).
- Provide a 4-20 mA control for UV channel isolation gates. Normal operation will be open/close, but a 4-20 mA control will allow operations staff to partially open gates and see the gate position from the DCS.
- All normal process-related equipment will be designed to facilitate monitoring and control from the plant DCS. The need to monitor and control infrequently used equipment will be determined based on discussions with the operations staff during Phase 2 detailed design of this project.
- The secondary effluent flow will be split equally among the active UV channels by the finger weirs and the final effluent flow will be measured by the Parshall flumes.
- Level indication will be provided to monitor status and serve as back-up flow measurement to engage UV channels.

4.6.1 UV Control Strategies

As part of Phase 2 detailed design, a life-cycle cost analysis will be performed to determine the most beneficial UV control strategy that balances capacity, efficiency, and operational complexity at varying anticipated flow rates.

- The UV lamps will be capable of greater than 50 percent turndown, and that each bank per channel can be operated independently to provide full coverage for expected flow conditions. Each channel is expected to be capable of treating between 15 MGD and 70 MGD.
- Control and monitoring of the UV system and UVT online analyzer will be accessible through the plant DCS in addition to the local vendor panel.

4.7 Electrical

This section presents the electrical design criteria for the proposed process area. Any existing electrical equipment that is intended to be repurposed shall be tested prior to any modifications. Electrical equipment associated with the existing chlorine system that cannot be repurposed to serve the UV electrical system will be removed or abandoned in place.

- The proposed UV system will require approximately 1150 kW for the 5 duty channels to be distributed by 12 vendor provided 480V power distribution centers. The equipment will be powered with 1200A rated switchboard equipment. Due to the type loads required for the UV equipment, MCCs are not required. The switchboard equipment is more compact, less expensive, and a smaller footprint. The switchboards will be installed in the new UV electrical building/room and feed the UV equipment located in the process area.
- Circuit E transformers 15-1 and 15-2 near north disinfection area were installed as part of the Last Plant Expansion (1990s) and will need to be increased in size to 1000 kVA (1200A) each to accommodate the increase in load created by the UV equipment. Each will be able to support the total UV load. Due to the increase in transformer size and weight, new transformer pads will need to be built with elevation set to accommodate the flood level.
- Two switchboards will be installed to provide redundancy. Each switchboard will be sized to feed the total UV equipment load. They will be connected via a main-tie-main configuration with Kirk key interlocking capability allowing for each switchboard to be able to power all UV loads if needed. Normal configuration will allow each switchboard to power half the loads at any time. UV loads will be distributed between the two switchboards based on vendor equipment and process redundancy requirements.
- Provide new conduit/cable to new equipment being installed with power needs:
  - New conduit and feeders from upsized transformers (T15-1 and T15-2) to the two new switchboards in the UV electrical building
  - Existing Circuits E1 and E2 are adequately sized for the increased loads for UV and will not need to be replaced
- Electrical demand for ancillaries and building loads will be fed from the new switchboard equipment via a 480V and 120V power distribution panel to be located in the UV electrical building.
  - Hydraulic System Equipment – 6 units @ 480V, 3A each
  - Control Panel – 1 control panel @ 120V, 15A
  - Additional building loads to be determined during Phase 2 detailed design

4.8 Geotechnical

This section presents the geotechnical design criteria for the proposed process area.

- Confirm structural integrity of existing piles.
- Foundation design for new electrical buildings

4.9 Structural

The structural design for the UV disinfection facility will be developed in accordance with the design criteria below.

- Verify load conditions for existing piles.
- Refine analysis of building loads and design of building or covered enclosed space. Investigate lighter building materials. This may include a steel bar joist roof with metal deck and, if the building is

unheated, single Wythe masonry wall construction or a galvanized metal framed wall using FRP inner panel and metal exterior siding.

- Design supporting slab and geo-foam fill to install UV equipment in existing channels.
- Design finger weirs and accommodate process openings in existing tank walls to allow flow in channel underneath finger weirs slab.
- Design concrete and aluminum grating walking surfaces within and around UV building.
- Retrofit existing concrete tank structures to best accommodate new UV disinfection, finger weirs, and Parshall flume flow measurement.
- Construct new building / canopy structure as determined by load analysis and MWS preferences.
- Design new electrical buildings adjacent to the main UV disinfection building, with finished floor elevation of 2 feet above the flood of record.
- Provide handrails as needed
- Provide installation details and related modifications.

4.10 Architectural

This section presents the architectural design criteria for the proposed UV disinfection facility. The footprint of the anticipated new building over the UV equipment is approximately 105 ft L x 55 ft W. The footprint of each new electrical building is anticipated to be approximately 50 ft L x 20 ft W.

- General aesthetics
  - Exterior finish to match new Biosolids Effluent Pump Station, contingent upon the structural capacity and MWS preferences
- Building doors, windows, louvers, roof, etc.

4.11 Site / Civil

The following presents the scope of improvements for the site work at the UV disinfection facility.

- Partial demolition of existing structures, pavements, and utilities.
  - Existing final north secondary effluent meter vault
  - Chlorine lines
  - Portion of pipe chase between chlorine building and tie-in point – refer to the South Secondary Effluent Conveyance
- Relocation of existing piping:
  - Tie-in with new south secondary effluent line
  - Possible conflict with existing utilities
- Grading around new UV Disinfection building and new electrical buildings
- Erosion and sediment control as necessary

Section 5: Sequencing and Constructability

The following text provides a preliminary list of sequencing issues and constructability items that will impact design and implementation of improvements in this process area. This section will be coordinated with the project CMAR in development of the overall sequencing plan.

5.1 Maintenance of Plant Operations (MOPO)

The intent of the MOPO is to mitigate interruptions to plant operation and maintain permit compliance throughout construction and startup of the optimization improvements. This section discusses procedures and action items to maintain plant operations during the construction and modification of the north chlorine contact tanks into the new UV disinfection facility to provide disinfection for both the north and south secondary effluent in a single location.

5.1.1 Discipline Specific

- Process – Temporary disinfection may be required during portions of the construction work on the existing north chlorine contact tanks. Further evaluation is required to determine the preferred means of disinfection – whether gaseous chlorine will continue to be used on site until the UV equipment is fully operational, or whether another disinfection chemical will be utilized.
- Electrical – This process area must be coordinated with the overall Primary Power evaluation.
- Civil / Site – Existing yard piping and utilities located near the proposed tank modifications will be located and marked prior to beginning construction.

5.1.2 Overall Project Specific

- Since chlorine gas is currently piped through the south secondary effluent conveyance line to reach the south CCTs, an alternative means of disinfection will be necessary to disinfect south secondary effluent while the conveyance line is being modified and constructed. The UV facility and other modifications to the north disinfection area must be complete and online prior to the tie-in with the new south secondary effluent conveyance line. The south CCTs will continue to treat south secondary effluent until those modifications are complete, precluding those tanks from being used as the new EFTU disinfection tanks.

5.1.3 Maintenance of Plant Operations

- Bypass pumping/routing may be required while modifications to the existing layout of the north CCTs are being performed.

5.1.4 Preliminary Sequencing Plan

The following presents a preliminary sequencing plan for the UV disinfection facility and associated areas. Modifications regarding the south secondary effluent conveyance line are not included here but are assumed to be occurring concurrently.

1. Prepare emergency contingency plans that the Contractor and/or Operations can follow if plant flow increases or facility experiences any unexpected equipment failures.
2. Install alternative chemical disinfection and bypass pumping as needed.
3. Begin construction of channel modifications in one of the two channels (referred to as channel 1).
4. Install UV disinfection equipment and ancillaries in channel 1.
5. Demo and convert north secondary effluent meter vault into water bearing structure.

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Technical Memorandum

Prepared for: Metro Water Services

Project Title: Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Project No.: 148388

Technical Memorandum No. 11

Subject: Excess Flow Treatment Unit

Date: December 21, 2016

To: Trey Cavin, Metro Water Services

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Limitations:

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Executive Summary

The objective of this Technical Memorandum (TM) is to present the basis of design for the proposed improvements to the excess flow treatment unit (EFTU) and associated areas at Central Wastewater Treatment Plant (CWWTP) for the Central WWTP Improvements & CSO Reduction Project (COPT).

Supplemental to this TM are the previous TMs that were prepared by Brown and Caldwell (BC) as part of the Central Optimization Study (COPT Study). These TMs form an integral part of the basis of design report (BODR) and are referenced throughout this document. The presentations and meeting minutes from the developmental workshops provide additional decision-making background and supplemental information for this Basis of Design Report (BODR).

The major modifications proposed for the EFTU are highlighted below:

- Eliminate the existing gaseous chlorination disinfection system.
- Provide a new peracetic acid (PAA) disinfection system for the EFTU, including tank conversion and all new structures or facilities required for the new disinfection system to meet the necessary water quality criteria through adequate contact time and chemical dosage.
- Reconfigure existing tank structures, which may include the old south aeration tanks, currently abandoned old south secondary clarifiers, EFTU chlorine contact tank (CCT), and the current south secondary effluent CCTs to provide primary treatment and disinfection. The EFTU will also be utilized as equalization storage to attenuate quickly rising flows during peak wet weather events and as storage to facilitate plant shutdowns required during plant maintenance and construction activities. Inspection, evaluation, refurbishment, and reconfiguration of the old south tankage are discussed in TM 12, which was developed by Hazen and Sawyer with input from the BC team.
- Upgrade and reconfigure the existing EFTU influent conveyance from primary treatment with a weir gate or fixed weir to provide a passive bypass to the EFTU.

With these improvements, the modified EFTU will be capable of treating combined sewer system (CSS) influent flows that exceed the available secondary treatment capacity. The intent is to maximize the throughput of secondary treatment utilizing all process units that are available at the time. Assuming a minimum firm secondary treatment capacity, the peak flow to the EFTU is currently estimated to be in the 135-150 million gallons per day (MGD) range. The peak flow rate will be finalized during phase 2 detailed design.

The improvements and modifications are recommended for implementation in order to improve the safety of the facility and to maximize peak capacity within the existing tankage. These improvements are also recommended to improve operations and reliability during peak wet weather events.

Section 1: Process Area Description

The following presents a review of the existing excess flow treatment system, including three cells of the old south secondary clarifiers, primary effluent channel bypass, and gaseous chlorine disinfection.

1.1 Description of Existing Facilities

The EFTU is CWWTP's CSO treatment train. It can be manually activated if the total plant influent flow exceeds the available secondary treatment capacity, but only when plant influent flow exceeds 220 MGD as required by the permit. These wet weather events can last several days with the total plant influent flow currently peaking at 330 MGD. Flow entering the EFTU must originate from the CSS and receive primary treatment, which is currently achieved in the south primary settling tanks (PST). After primary settling, flow is diverted to the EFTU from the south primary effluent channel via a butterfly gate and then conveyed through the EFTU CCT where it is disinfected via chlorine injection and sulfur dioxide dechlorination prior to being discharged to the Cumberland River. Figure 1-1 below portrays an aerial site plan of CWWTP with the EFTU highlighted to show process areas that are covered in this technical memorandum. Table 1-1 below lists a summary of the EFTU process units at CWWTP, along with physical descriptions and data for the existing system.

Figure 1-1: Location of EFTU CCTs, Primary Effluent Bypass, and Old South Tanks at CWWTP

Table 1-1. Summary of Existing Process Units at the CWWTP Pertaining to the EFTU				
	Parameter	Unit	Value	Notes
Excess Flow Treatment CCT				
	Number of tanks/passes	--	1 / 9	
	Dimensions	Ft	180-ft x 16.33-ft x 10.5-ft (L x W x D, per pass)	
	Total Reactor Volume	MG	0.23 / 2.1	Per pass / Total
	Detention Time @ 80 MGD	--	38 minutes	
	Chlorine Disinfection	--	2 Chlorinators, 1 Chlorine Induction Unit	
	Sulfur Dioxide Dechlorination	--	2 Sulfonators, 1 Sulfur Dioxide Induction Unit	
	Parshall Flume	--	10-ft throat, 125 MGD peak capacity	
Excess Flow Treatment (Tertiary Filter) CCTs				
	Number of tanks/passes	--	2 / 13	
	Dimensions	Ft	48-ft x 21-ft x 9-ft (L x W x D, per pass)	

Table 1-1. Summary of Existing Process Units at the CWWTP Pertaining to the EFTU				
	Parameter	Unit	Value	Notes
	Total Reactor Volume	MG	0.88 / 1.75	Per tank / Total
	Detention Time @ 100 MGD	--	25 minutes	
	Chlorine Disinfection	--	2 Chlorinators, 2 Chlorine Induction Unit	
	Sulfur Dioxide Dechlorination	--	1 Sulfonators, 2 Sulfur Dioxide Induction Unit	
	South (Tertiary) Effluent Flowmeter	--	42-inch diameter magnetic flow meter	
Old South Aeration Tanks (currently abandoned)				
	Number of tanks/passes	--	6 / 2	
	Dimensions	Ft	150-ft x 25-ft x 15-ft (L x W x D, per pass)	
	Total Volume	MG	0.84 / 5.05	Per tank / Total
Old South Secondary Clarifiers (currently abandoned)				
	Number of tanks	--	2	
	Dimensions	Ft	180-ft x 51-ft x 12-ft (L x W x D, per pass)	Depth and volume based on SC operation
	Total Volume	MG	0.82 / 1.64	Per tank / Total

Ft- feet

1.2 Selected Disinfection Technologies

CWWTP currently uses gaseous chlorine for disinfection and sulfur dioxide for dechlorination for both plant effluent and excess flow. Due to the safety concerns for transporting, storing, and handling these chemicals, as well as possible future effluent requirements concerning disinfection by-products, alternatives disinfection technologies were evaluated as part of the COPT Study. The alternatives considered for EFTU were bulk sodium hypochlorite, on-site generation of sodium hypochlorite, and PAA. A combination of cost and non-cost factors led to the recommendation of PAA for disinfection at the EFTU. Refer to TM COPT Study 7 – CWWTP Disinfection Feasibility Study for additional detail.

Section 2: Design Intent

The recommended improvements to the EFTU are intended to reduce risk through removal of hazardous gaseous disinfection chemicals, maximize the available storage volume to accommodate plant shutdowns, and achieve primary treatment and disinfection of peak CSS influent flows during wet weather events.

The following list represents the overall design intent for the recommended improvements to the EFTU:

- Treat peak flows from the CSS that exceed the CWWTP secondary treatment capacity available during each wet weather event. The intent is to maximize the flow through secondary treatment utilizing redundant process units (if available).
- Provide a safer and more operator friendly disinfection system. The existing gaseous chlorine disinfection and sulfur dioxide dechlorination systems will be removed and replaced with a PAA disinfection system to eliminate the safety concern of having these hazardous gases on site.

- Reserve the south PSTs to provide consistent and more reliable primary treatment for flow that will be routed to secondary treatment. In lieu of utilizing the south PSTs to achieve primary treatment for EFTU flow, primary treatment will be achieved via settling in the old south aeration tanks. South PSTs will be dedicated to flow that will receive secondary treatment. EFTU influent flow will be routed directly from the new south headworks structure or from the South Grit Facility's grit tank effluent channel.
- Provide wet weather flow attenuation to allow more time for operator response. In addition to providing primary treatment, the old south aeration tanks will also provide EQ storage volume during plant shutdowns, small wet weather events, and potentially at the beginning of major wet weather events.
- Make use of existing structures to save capital and meet treatment objectives. The EFTU tank layout will be reconfigured to provide the most beneficial combination of primary treatment, EQ storage via flow attenuation, and disinfection contact time for the combined sewer influent flow during wet weather events. For this evaluation, it is assumed that the south CCTs underneath the decommissioned tertiary filter structure will be repurposed as the new PAA disinfection tanks for excess flow treatment.
- A new weir gate will be installed at the upstream end of the existing EFTU influent channel such that south primary effluent flow can be passively routed to the EFTU to protect the south PSTs effluent weirs from being submerged.
- A new tank cleaning system will be provided in the reconfigured old south plant tanks (aeration and clarification tanks) to improve operations and minimize odors after a wet weather event. Additionally, all tanks that are being beneficially reused as part of this process area will be refurbished by repairing cracks in the tank walls and floors, repair expansion joints, fill void spaces under the floor slab, cap piping, seal off openings and or repairs where necessary to adequately contain flow and protect the process tunnels and also protect the Biofilters that are occupying the southernmost old south secondary clarifier.

Inspection, evaluation, refurbishment, and reconfiguration of the old south aeration tanks, old south secondary clarifiers, and the current EFTU CCT to meet the design are discussed in TM #12, which was developed by Hazen and Sawyer, with input from the BC team.

Section 3: Constraints

This section identifies the constraints associated with this process area for meeting the design intent.

3.1 Design Criteria

The following section provides a summary of the criteria that impact the design and implementation of improvements for the EFTU at CWWTP. COPT Study TM #6.1 – Wet Weather Treatment Alternatives Analysis includes the original conceptual design basis for the hydraulic modifications of the EFTU. COPT Study TM #7.1 – CWWTP Disinfection Feasibility Study includes the process design basis for the EFTU disinfection technology recommended during the COPT Study.

3.1.1 Primary Treatment

Tennessee Department of Environment and Conservation (TDEC) Design Criteria for Sewage Works states that primary settling tanks are designed primarily based on surface overflow rate (SOR) and suggests a peak rate range of 2,000-3,000 gallons per day per square foot (gpd/sq. ft.) Assuming the high end of this range, the surface area available within the old south aeration tanks (45,000 sq. ft.) can achieve up to 135 MGD of primary settling capacity. If the old south secondary clarifiers are also used for primary treatment, flows up to 150 MGD can be accommodated. This assumes that the available volume will be effectively utilized to facilitate discrete particle settling. Weir loading rate will be a secondary design parameter. Effluent weir length will be maximized as feasible, but it will not limit the proposed capacity.

While the EFTU's current permit does not include numerical water quality parameters, using SOR as the basis of design demonstrates that primary treatment can be achieved in the old south tankage for flows up to 150 MGD.

3.1.2 Influent Flow and Loading Characteristics

The maximum anticipated flow rate to the EFTU is determined based on peak CWWTP influent flow rates, optimized secondary treatment capacity, the rate at which combined sewer system flows increase during major wet weather events, and the existing tankage available to achieve the required treatment. The current permit does not limit the influent flow rate to the EFTU.

As noted above, the peak anticipated EFTU influent flow rate is currently estimated to be in the 135-150 MGD but this value may evolve as detailed design progresses and design parameters are finalized.

Historical EFTU influent loading characteristics from reports submitted by MWS to TDEC are presented in Table 3-1. This data corresponds to south primary effluent that was sent to existing EFTU disinfection over calendar year 2015 through first quarter 2016, during which there were 14 separate occurrences of EFTU discharge resulting from wet weather events. There were 41 days during this period when flow was discharged from the EFTU as many of these occurrences lasted multiple days.

Table 3-1. Wet Weather Flows to EFTU Disinfection

Parameter	Wet Weather Flow, MGD	Total suspended solids (TSS), mg/L
Maximum	81.9	154
Minimum	3.7	4
Average	41	45

Peaking of flows does not coincide with peaking of TSS concentrations.

Typically, as CSO flows increase during wet weather events, stormwater inflow and groundwater infiltration results in increased hydraulic loading with minimal increase to the organic load to the plant. As discussed in COPT Study TM 6.1 – Wet Weather Treatment Alternative Analysis, historical data demonstrates that influent $CBOD_5$, TSS, and ammonia (NH_3-N) concentrations drop during peak wet weather events due to the dilution effect of the dry weather influent with groundwater infiltration and stormwater flow.

3.1.3 PAA Disinfection Criteria for EFTU

Table 3-2 presents a summary of disinfection requirements for the EFTU to be used for the design of process improvements and tank configuration.

Table 3-2. Disinfection Criteria for EFTU

Criteria	Value	Notes
Peak Flow	150 MGD	Average condition not applicable
Contact time (HRT)	15 minutes	Minimum value, HRT is greater than 16 min at 150 MGD
PAA Dosage	5 mg/L	TBD by jar test
PAA residual	<1 mg/L	TBD by jar test
Minimum Storage	TBD	Based on 5 mg/L dose
Mixing	Gravity hydraulic mixing	Will evaluate need for mechanical mixing during detail design

Table 3-2. Disinfection Criteria for EFTU		
Criteria	**Value**	**Notes**
pH	6 – 9	PAA will not appreciably affect the pH
Suspended solids	TBD	Jar testing will determine the effect of suspended solids on dose
Organics	TBD	Jar testing will determine the effect of organics on dose

EFTU disinfection will be achieved in existing south CCTs which have been utilized for chemical disinfection since they were constructed in the 1970's. The serpentine configuration of these existing tanks is appropriate for a chemical disinfectant such as PAA. TDEC Design Criteria for Sewage Works requires that wastewater receives a minimum contact time of 15 minutes during peak flow conditions. Based on the volume of the existing south CCTs, flows up to 160 MGD can be treated while meeting the 15-minute requirement. It should be noted that literature suggests that PAA requires substantially less contact time to meet disinfection requirements compared to chlorine-based chemicals, which adds a degree of conservatism to the design. It is anticipated that quenching of PAA residual will not be required and that disinfection limits can be reliably met while maintaining residual PAA concentrations below 1 mg/L.

As with any chemical disinfectant, effectiveness of application will depend on the suspended and dissolved solids, effluent oxidant demand, color, and other constituents that survive the treatment process. During Phase 2 detailed design, extensive jar testing on combined sewer system influent will be performed to determine the PAA dose needed to meet the permitted pathogen reduction requirements. The results of the jar test and the design PAA dose/concentration will be incorporated into this TM once available. Until the test results are available, it is assumed that a dose of 5 mg/L will be required.

3.1.4 Temporary PAA Disinfection of South Secondary Effluent

It is assumed that PAA will be used to provide temporary disinfection of south secondary effluent flow when gaseous disinfectants are no longer available during the construction of the south secondary effluent conveyance improvements. It is anticipated that unloading, storage, and feed equipment will be co-located with the EFTU PAA disinfection system and potentially share storage volume to minimize the amount of installed equipment required for the temporary system. A secondary effluent PAA pilot study is planned to determine dosing requirements needed to design the facility. However, until the pilot study is completed, a maximum dose of 3 mg/L is assumed for the south secondary effluent to facilitate coordination with the conceptual design of the long-term EFTU PAA system design. Additional detail and discussion regarding the need for the temporary south secondary effluent PAA disinfection system are included in TM 10 – UV Disinfection.

3.2 Code Considerations

A complete list of all codes used for design will be included in the Code Classification Summary. This section will be amended once the code classification summary is updated.

3.3 Regulatory Drivers

The following includes a list of regulatory drivers that impact the design and implementation of improvements in the excess flow treatment process area as part of this project.

3.3.1 National Pollutant Discharge Elimination System (NPDES) Permit Requirements

The EFTU is currently regulated under the NPDES Permit (TN0020575) for the CWWTP. Three conditions of effluent requirements are established for CWWTP under the existing permit, with the third condition applicable when the EFTU is online:

1. Advanced secondary activated sludge treatment: this applies to dry weather conditions for flows in the range of 0 to 100 MGD. It includes seasonal effluent requirements for $CBOD_5$, TSS, and ammonia concentrations.
2. Conventional-level activated sludge treatment: in cases where flows are in excess of 100 MGD but lower than 200 MGD (wet weather conditions), weekly and maximum day average requirements are established.
3. Primary treatment and disinfection: for flows in excess of 220 MGD, secondary treatment is not required for the excess flow. Hence, this fraction of flow is diverted to the EFTU for disinfection after primary treatment. During these conditions, MWS is only required to report EFTU flow and effluent concentrations except for *E. coli*, chlorine residual, and pH, which are required to fall under stated limits in the permit.

Table 3-3 below provides the existing CWWTP NPDES permit requirements for effluent discharge into the Cumberland River as specifically pertaining to flow levels when the EFTU is operating. It is anticipated that the NPDES permit will be updated based on COPT Project improvements.

Table 3-3 Summary of Current NPDES Requirements for the CWWTP EFTU

Effluent Characteristics	Effluent Limitations Primary Treatment and Disinfection – Wet weather flows greater than 220 MGD					
	Monthly Average Conc. (mg/L)	Monthly Average Mass (lb/d)	Weekly Average Conc. (mg/L)	Weekly Average Mass (lb/d)	Daily Average Conc. (mg/L)	Daily Average Mass (lb/d)
$CBOD_5$	Report	Report	Report	Report	Report	Report
Total Suspended Solids	Report	Report	Report	Report	Report	Report
Flow (MGD)	Report (MGD)					
E. coli (in cfu)	126/100 mL				487/100 mL	
Chlorine Residual (Total)					2.0	
pH	6.0 to 9.0					
Days of Discharge		Report Quantity				

3.3.2 Long-Term Control Plan Currently Under Review

COPT Project improvements presented in this BODR are designed to achieve the level of control proposed for the Kerrigan CSO outfall as outlined in the Long-Term Control Plan (LTCP). This LTCP proposes that the capacity of the Central pumping station (CPS) is increased from 160 MGD to 240 MGD. The CPS capacity upgrade and CWWTP improvements required to accommodate the increased flow are included in the COPT Project. The LTCP is currently under review by TDEC and the Environment Protection Agency (EPA). Any changes to the required level of CSO control at the Kerrigan outfall or the treatment requirements of the CSO influent flow would likely change the design criteria for portions of the COPT Project.

3.3.3 Primary Treatment for EFTU

As detailed in the findings of the COPT Study, peak influent flow to the CWWTP exceeds the achievable optimized secondary clarifier and PST capacity. Due to site constraints and cost considerations, in lieu of constructing additional PSTs, it is proposed that primary treatment can be achieved within the footprint of the currently abandoned old south aeration tanks. Instead of routing excess flow through the existing south PSTs, flow would be routed to the EFTU upstream of the PSTs, but downstream of screening and grit removal. It was determined during preliminary design workshops that reserving the existing PST capacity for flow receiving secondary treatment would result in superior solids capture for secondary treatment and EFTU flows while improving secondary treatment process efficiency and simplifying wet weather operations.

Since the EFTU is utilized infrequently, is online for relatively short durations, and the wet weather CSS influent TSS is substantially lower than for PSTs receiving typical dry weather flows, we do not anticipate the need to provide sludge collection and pumping systems. In lieu of sludge collectors and sludge pumps, settled solids would be scoured utilizing water cannons or an automated tank cleaning system once the wet weather event has ended and the tanks are drained. The solids laden flow from the scouring/cleaning operation would be routed to the PST influent channel for further treatment.

It is anticipated that operation of the EFTU as proposed will be allowed by TDEC and will be included in future CWWTP NPDES permit renewals. If future regulatory requirements for the CWWTP include additional water quality limits for the EFTU (such as TSS, BOD, ammonia, or nutrient limits), additional modifications to achieve enhanced treatment will be required.

3.3.4 Residual PAA Concentration

Based on other recent PAA disinfection applications in TN, we anticipate that a maximum residual PAA concentration of 1 or 2 mg/L will be included in the CWWTP NPDES permit. It is assumed that pathogen requirements can be met while maintaining a residual PAA concentration well below the anticipated permit limit without using a chemical such as sodium bisulfite for quenching. However, if more stringent residual PAA concentrations are imposed, quenching may be required, which could potentially justify further evaluation into alternative EFTU disinfectants.

3.3.5 Risk Management Plan (RMP)

The CWWTP currently has an RMP for the gaseous chlorine and sulfur dioxide used for disinfection of both treated secondary effluent and EFTU flows. Updating the current RMP is a time consuming and tedious task due to the extent and severity of the risks associated with the existing system. It is anticipated that due to the relatively lower risks associated with PAA, an abbreviated RMP would be required. Depending on the volume of PAA that would be stored on site for disinfection of EFTU flows, it is possible an RMP would not be required at all.

3.4 Sequencing and Constructability Issues Affecting Design

This paragraph provides a preliminary list of specific sequencing issues and constructability items that impact the design scope of improvements in this process area. Other COPT project components that affect and require coordination with this process area are included. The overall sequencing plan for this process area is discussed in Section 5 of this TM. These sections will be coordinated with the project Construction Manager at Risk (CMAR) in development of the overall sequencing plan.

- As noted above, the installed storage and feed capacity for PAA chemical disinfection will be designed to accommodate treatment of both EFTU and temporary south secondary effluent. This requires four tanks and four feed pumps compared to two tanks and two feed pumps required solely for the EFTU.

Section 4: Description of Improvements

The following describes the key development information, features, assumptions, design data and discipline-specific information for the EFTU improvements.

4.1 Detailed Design Considerations and Assumptions

The following list includes assumptions and considerations used for this BODR evaluation and are to be confirmed during detail design.

- Old south plant tankage is proposed to be used as both EQ storage and flow attenuation (Hazen) and excess flow treatment (BC). BODR evaluations associated with refurbishment of the old south plant tankage for these purposes are presented in TM 12, which was developed by Hazen and Sawyer with input from the BC team.
- The information presented in this TM is based on EFTU concepts currently being discussed with MWS and Hazen and Sawyer. The development of these concepts is ongoing and this TM will be updated as new information becomes available.
- CSS influent will receive preliminary treatment (screenings and grit removal) prior to being routed to the old south aeration tanks. The old south aeration tanks will be utilized to achieve primary treatment.

4.1.1 PAA Disinfection

As recommended in the COPT Study disinfection technical memorandum, PAA should be implemented as the disinfection technology at the EFTU. Its advantages over sodium hypochlorite include operator safety, longer shelf life, no dechlorination requirements, and minimal disinfection byproduct (DBP) formation. Prior to implementation of PAA at the EFTU, jar testing will be performed in order to determine the effectiveness of PAA and required dosage to disinfect wet weather flows under a variety of conditions and durations. The results of this jar testing will refine the recommended chemical storage quantities and other equipment requirements. Further decisions determining design criteria may be made in conclusion of existing plant site visits/interviews. For this evaluation, it is assumed that the required PAA dose for treating EFTU flows is 5 mg/L for the duration of the wet weather event while the EFTU is in operation.

4.1.2 Preliminary Hydraulics

The hydraulic design for the EFTU will impact the design of upstream processes, including the new south headworks structure, and will be finalized during the detailed design. A preliminary hydraulic model was created to determine water surface elevations for the proposed flow routing through the south CCTs at a conservative maximum flow of 150 MGD in this process area.

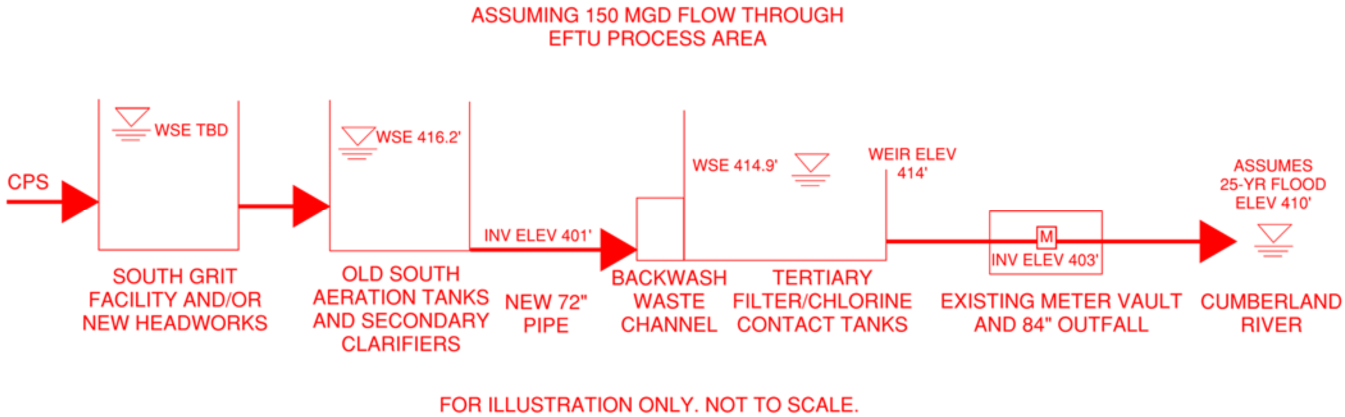

Figure 4-1. Illustrative Hydraulic Profile/Process Flow Diagram for EFTU Process Area

There is approximately 3.8 ft of available head for modifications to achieve primary treatment in the old south plant tankage. Additional hydraulic modeling will be performed during phase 2 detailed design.

4.2 Process Mechanical

This section summarizes the overall improvements to the process area.

4.2.1 EFTU Disinfection

As previously stated, the recommendation from the COPT Study is to convert from the existing gaseous chlorine disinfection and sulfur dioxide dechlorination system to a new PAA disinfection system. The PAA disinfection system will be sized to treat continuously peak flows of up to 150 MGD and will achieve a minimum of 15 minutes of chemical contact time in the proposed tank layout.

4.2.1.1 Key Development Information, Features, and Design Data

The EFTU disinfection facility includes the following features:

- One centrifugal unloading pump to pump chemical from supply tanker truck
- Four PAA storage tanks, cross-linked polyethylene, approximate capacity 6500 gallons each
- Four PAA feed pumps, approximate capacity 100 gph each, 2 duty/2 standby configuration
- Nitric acid passivated stainless steel piping for delivery of neat PAA to designated dosing point
- PAA residual analyzer
- Eye wash and safety shower
- Instrumentation and controls components
- Electrical components

4.2.2 Primary Bypass Channel Gate

A weir gate will be installed at the primary bypass channel to achieve the following:

- 6'-0" W stainless steel downward opening slide gate. Depth to be determined during phase 2 detailed design.
- Prevent dry weather flows from entering the channel and requiring additional aeration

4.3 Odor Control

Since the CSO flows are dilute when diverted to the EFTU process area, no odor control measures are anticipated for this process area.

4.4 Heating, Ventilation, and Air Conditioning (HVAC)

Since the PAA equipment will be installed outdoors on an open concrete pad, no HVAC additions or modifications are anticipated for this process area.

4.5 Plumbing

This section presents the plumbing design criteria for the proposed process area.

- Provide inspection and testing for plumbing system within the existing south CCTs to confirm pipes are not corroded or plugged. Provide allowance in cost estimate for overall scope of work.
- Install plumbing and water piping required for wash water (non-potable plant water) used for cleaning tanks at the conclusion of a wet weather event.

4.6 Instrumentation and Controls

This section presents the equipment instrumentation and control strategies for the EFTU.

4.6.1 Flow Diversion and Primary Equivalent Treatment

Anticipated equipment pertaining to flow diversion, flow isolation, and primary equivalent treatment as part of the EFTU process area includes level meters, diversion gates, and flushing gates, and flow diversion to the EFTU is assumed to be manually activated.

4.6.2 PAA Disinfection

The controls required for operation of the PAA disinfection equipment and flow isolation gates/valves will be integrated into the plant's existing SCADA system. These controls will consist of new field instruments, control panels, and local process graphic screen/database, historical data collection/trending and reporting as required for a complete system.

New field instruments will be provided to measure typical process variables such as level, pressure, flow, and any necessary analytical measurement such as PAA residual. Instruments located outdoors will include a sun/rain shield and surge protection. The control panel will be supplied as art of the PAA vendor package.

- All normal process-related equipment will be designed to facilitate monitoring and control from the plant DCS. The need to monitor and control infrequently used equipment will be determined based on discussions with the operations staff during detailed design.
- Level indication for the influent channel to the EFTU will be provided.

As part of phase 2 detailed design, a life-cycle cost analysis will be performed to determine the most beneficial chemical dosing control strategy that balances capacity, efficiency, and operational complexity. The PAA feed rate is assumed to be based upon one of the following:

1. EFTU flow
2. EFTU flow + fine tuning by PAA residual
3. EFTU flow + fine tuning by PAA demand as determined by other wastewater characteristics

4.7 Electrical

This section presents the electrical design criteria for the proposed process area.

- Provide new conduit/cable to new equipment being installed with power needs.
- Coordinate with overall plant power evaluation to confirm where power will originate from to supply proposed PAA disinfection equipment and other flow control/isolation equipment. Small 480V and 120V power supplies are anticipated. It is anticipated that power feeds can be repurposed from the existing chlorine equipment at the tertiary filter CCTs or that new power feeds may be provided from other nearby equipment.
- Evaluate South CCTs under filters and coordinate with structural.

4.8 Geotechnical

This section presents the geotechnical design criteria for the proposed process area.

- Determine whether additional geotechnical information is needed to design and construct the proposed slab on grade for the PAA storage tanks and equipment.
- Refer to the TM 12 provided by Hazen and Sawyer for discussion of old south plant tankage refurbishment and geotechnical considerations.

4.9 Structural

The structural design for the facility will be developed in accordance with the design criteria below.

- Conduct a structural condition assessment of the existing tanks and channels.
  - Tertiary filter/CCT structure
  - Old south plant tankage
- Construct concrete junction structures at upstream and downstream ends of the new 72-inch pipe between the old south plant and the backwash waste channel.
- Modify the existing tertiary filter CCTs to facilitate conveying the flow through the existing backwash waste channel on the southeast side of the existing tertiary filter/chlorine contact structure and then through the CCTs.
- Construct new epoxy coated concrete pad of approximate dimensions 80ft L x 20ft W to support PAA chemical storage tanks.
- Modify existing backwash waste channel adjacent to the south CCTs to route flow from the EFTU tanks.

4.10 Architectural

No architectural additions or modifications are anticipated for this process area. Improvements mainly utilize existing tankage and other structures. Additionally, the PAA equipment will be installed outdoors on an open concrete pad,

4.11 Site/Civil

This section presents the scope of improvements for the site/civil work at the proposed process area.

- Locate and mark existing yard piping and utilities near the proposed tank modifications prior to beginning construction.
- Demolish asphalt pavement sufficient to install new 72-inch diameter pipe between south CCTs and existing EFTU tanks

- Construct new 72-inch diameter pipe underneath road between south CCTs and existing EFTU tanks.
- Modify grading around new PAA disinfection equipment pad to appropriate direct flow from potential PAA equipment washdown to tank drainage.
- Install erosion and sediment control as necessary
- Required permitting – Metro Stormwater and TDEC plans review

Section 5: Sequencing and Constructability

This section provides a preliminary list of sequencing issues and constructability items that will impact design and implementation of improvements in this process area. This section will be coordinated with the project CMAR in development of the overall sequencing plan.

5.1 Maintenance of Plant Operations (MOPO)

The intent of the MOPO is to mitigate interruptions to plant operation and maintain permit compliance throughout construction and startup of the optimization improvements.

- The south CCTs will no longer be used to treat effluent from the south secondary clarifiers once the south secondary effluent conveyance line to the north contact tanks is complete. All plant effluent during normal flow conditions will be conveyed to the new UV facility at the north CCTs (refer to TM 10 – UV Disinfection for further discussion). Since chlorine gas is currently piped through that conveyance line to reach the south CCTs, an alternative means of disinfection will be necessary to disinfect south secondary effluent while the conveyance line is being modified and constructed. Thus, the south CCTs may continue to treat south secondary effluent until the UV facility and south secondary effluent conveyance line are complete, precluding those tanks from being used as the new EFTU disinfection tanks. Once south secondary effluent is permanently routed to the new UV facility at the north disinfection area, the south CCTs can be modified to function as EFTU disinfection.
- Since the existing EFTU is only operated during wet weather, there is relatively more flexibility for improvements in this area since it is not always in operation. Where possible, construction should be scheduled to occur during dry weather or low rainfall conditions when the EFTU will not be in operation.
- Alternate flow routing may be needed to convey EFTU effluent flow to the outfall if wet weather events requiring the EFTU occur while modifications to the existing and future EFTU tanks are being performed.

5.2 Preliminary Sequencing Plan

The following presents a preliminary sequencing plan for the excess flow treatment area. Modifications regarding the new UV disinfection facility at the north CCTs are not included here but are assumed to be occurring concurrently:

1. Install and bring online PAA disinfection equipment.
2. Demo chlorine line in south secondary effluent conveyance route.
3. Start construction of the south secondary effluent conveyance.
4. Complete construction of south secondary effluent conveyance and bring online.
5. Construct new pipe from existing EFTU disinfection tanks to south CCTs.
6. Perform influent channel modifications to route EFTU flow through south CCTs.
7. Bring disinfection equipment and south CCTs online as flow increases as needed during wet weather events.

8. Prepare emergency contingency plans that the Contractor and/or Operators can follow if plant flow increases or facility experiences any unexpected equipment failures.

References

AECOM, *Long Term Control Plan for Metro Nashville Combined Sewer Overflows*

Brown and Caldwell., *Central Wastewater Treatment Plant Optimization Study*

Central Wastewater Treatment Plant Expansion; Equipment Operation and Maintenance Manual; Project No. 90-SC-05; Volume 6; Spec Section 11314; Consoer Townsend and Associates; 1992

Tennessee Department of Environment and Conservation (TDEC) Design Criteria for Sewage Works, Chapter 5 "Clarifiers, Chapter 10 "Disinfection", March 2016

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METRO WATER SERVICES

Central WWTP Capacity Improvements and CSO Reduction

Final Basis of Design Report
Technical Memorandum No. 12: South Equalization
Hazen No. 50045-004
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1. Executive Summary

This technical memorandum (TM) includes the evaluation of alternatives for equalization (EQ) storage, either new or within existing tanks, and potential use of storage as both EQ and excess flow treatment units (EFTU) during wet weather events. Design criteria and design features are summarized for detailed design. Key issues to be evaluated further prior to selection of the final alternative are also described.

Influent flow to the Nashville Metro Water Services (MWS) Central Wastewater Treatment Plant (CWWTP) comes from two distinct service areas. Separate sewer flow is pumped to the north plant's primary treatment facilities from the Browns Creek, 28th Avenue, Cowan Street, and Shelby Park pumping stations. Combined sewer system (CSS) flow is pumped to the south plant's primary treatment facilities from the central pumping station (CPS). Nashville's long term control plan (LTCP) recommended increasing CPS capacity from 160 MGD to 240 MGD and adding flow EQ at the CWWTP to reduce combined sewer overflows (CSOs) at the Kerrigan CSO facility. The south plant's existing headworks (screening and grit removal) facilities are inadequate to accommodate the increased flows from the CPS and will be upgraded as part of the capacity improvements and CSO reduction project (Project).

Proposed improvements in the south plant influent area include increasing CPS capacity from 160 to 240 MGD, new/retrofitted south headworks facilities and flow EQ facilities. The scope of improvements included in the 2013 Central Optimization Study (COPT Study) included 18 MG of EQ storage[1], as included in the LTCP.

Over the course of four workshops with the MWS project team from December 2015 to June 2016, multiple alternatives were developed for EQ in the south plant. In Workshop Nos. 3 and 4, the list was narrowed down to three viable alternatives. This TM includes a summary of all alternatives presented and a detailed discussion of the three viable EQ/EFTU alternatives.

Of the short listed alternatives, the option believed to be the most advantageous to carry forward includes rehabilitation of the old south aeration basins (SABs) and old south settling tanks (SSTs). This alternative could provide storage of approximately 8.9 MG and meet the needs of MWS by providing flow equalization/attenuation to allow operators to prepare downstream processes for increased flows and maximize flow that can be conveyed through secondary treatment.

[1] Brown and Caldwell, April 12, 2013. *Technical Memorandum No. 5-2: Potential Improvements at South Grit Facility*. Central Optimization Study Project.

2. Design Criteria

2.1 Design Storm Analysis

The Project will increase CPS capacity from 160 MGD to 240 MGD and will thus increase the peak flow potential from the combined sewer area by 80 MGD to the south plant. Hazen utilized predicted future flows provided by the MWS Clean Water Nashville Program Manager, CDM Smith (Program Manager) to evaluate the impact of increased flows on the south plant. These predicted flows were generated by using a typical year analysis. The Program Manager utilized an existing calibrated MIKE SWMM hydraulic model to generate the predicted future flow conditions.

Analysis of the data determined that EQ would be utilized between 30-60 times during a typical year once the CPS is expanded. This represents no less than ½ of measurable rainfall events in Nashville. While the volume utilized during each event will vary based on event size, the analysis demonstrates the benefit EQ will provide, no matter the total volume of EQ provided.

2.2 Process / Operations

2.2.1 Use for Wet Weather Operations

To minimize cost and operational complexity, a gravity in / gravity out approach to filling and dewatering was included in the conceptual design where possible. Also, passive flow splitting and automatic routing is featured in the conceptual approaches to wet weather operation. Each EQ alternative provides a significant amount of flow attenuation, thus giving plant staff time to prepare downstream processes for increases in flow.

2.2.2 Cleaning / Draining

It is assumed that draining of EQ will occur within 24 hours after a rain event. Small pump stations (PSs) are only proposed to facilitate cleaning and provide additional capacity for dewatering in the existing south plant tankage and may not be required if preliminary engineering determines available gravity drainage is sufficient. Various levels of functionality for cleaning operations are offered in the different alternatives and are discussed in detail in the sections describing the alternatives.

2.2.3 Covered / Uncovered

The EQ basins located near the CPS would be covered to minimize odors. The tanks would remain uncovered if the existing south tanks are utilized for EQ. However, a separate site-wide odor study is underway, which will further evaluate odor control measures.

3. Existing Conditions

The CWWTP has been constructed through numerous phases over its operating history. As a result, there are a significant number of existing facilities as well as major process piping that must be considered in the evaluation. Discussion on existing conditions related to specific alternatives considered for this evaluation are discussed in the individual alternative sections. Operations-related criteria is discussed in the previous section.

3.1 Geotechnical Investigation

3.1.1 Boring Summary

KS Ware reviewed available geotechnical information for the CWWTP, including older borings performed on previous capacity / facility upgrades.

Figure 3-1 shows recently completed borings, as well as boring information from previous projects and geotechnical reports at the CWWTP listed below:

- 1956 Original plant construction
- 1966 First plant expansion-improvements and additions to central sewage treatment plant
- 1976 Major plant expansion-additions and modifications to existing CWWTP
- 1990 Last major expansion-Nashville overflow abatement program
- 1990 Central CSO PS-Nashville overflow abatement program
- 1990 South grit facilities-Nashville overflow abatement program
- 1990 Plant submerged outfall-Nashville overflow abatement program
- 1998 Central biosolids improvements-biosolids facility
- Geotechnical Reports
  - 1994 Site settlement evaluation
  - Report of geotechnical exploration – south grit facility
  - Report of geotechnical exploration CWWTP 1990's expansion
  - Report of geotechnical exploration proposed browns creek force mains (FM)
  - Report of geotechnical exploration proposed sludge loading hopper
  - 2016 preliminary geotechnical exploration for CPS EQ tankage

The approximate bedrock elevations across the CWWTP site are shown in **Figure 3-2**.

As part of the current evaluation, new borings were taken around the CPS to determine the refusal depth rock elevation for potential siting of an EQ tank. These findings are shown in **Figure 3-3**. Based on these boring reports, fill ranges from 2 feet on the southeast side of the site to up to 42 feet on the northwest side of the site underlying surface material. Beneath the fill, alluvial soils consisting of sandy silt, silty sand, and a silty sandy gravel are present. With exception of the southwest side of the site, average refusal depth ranged from approximately 45 to 55 feet below ground surface with an approximate average elevation of 370 feet.

In general, most of the subgrade at the CWWTP site has either been disturbed by previous construction projects (100 % fill material) or consists of alluvial, sandy, clay, and gravel. These types of soil conditions typically require piles for structure foundations. Piles for foundation support are included in all alternatives for costing.

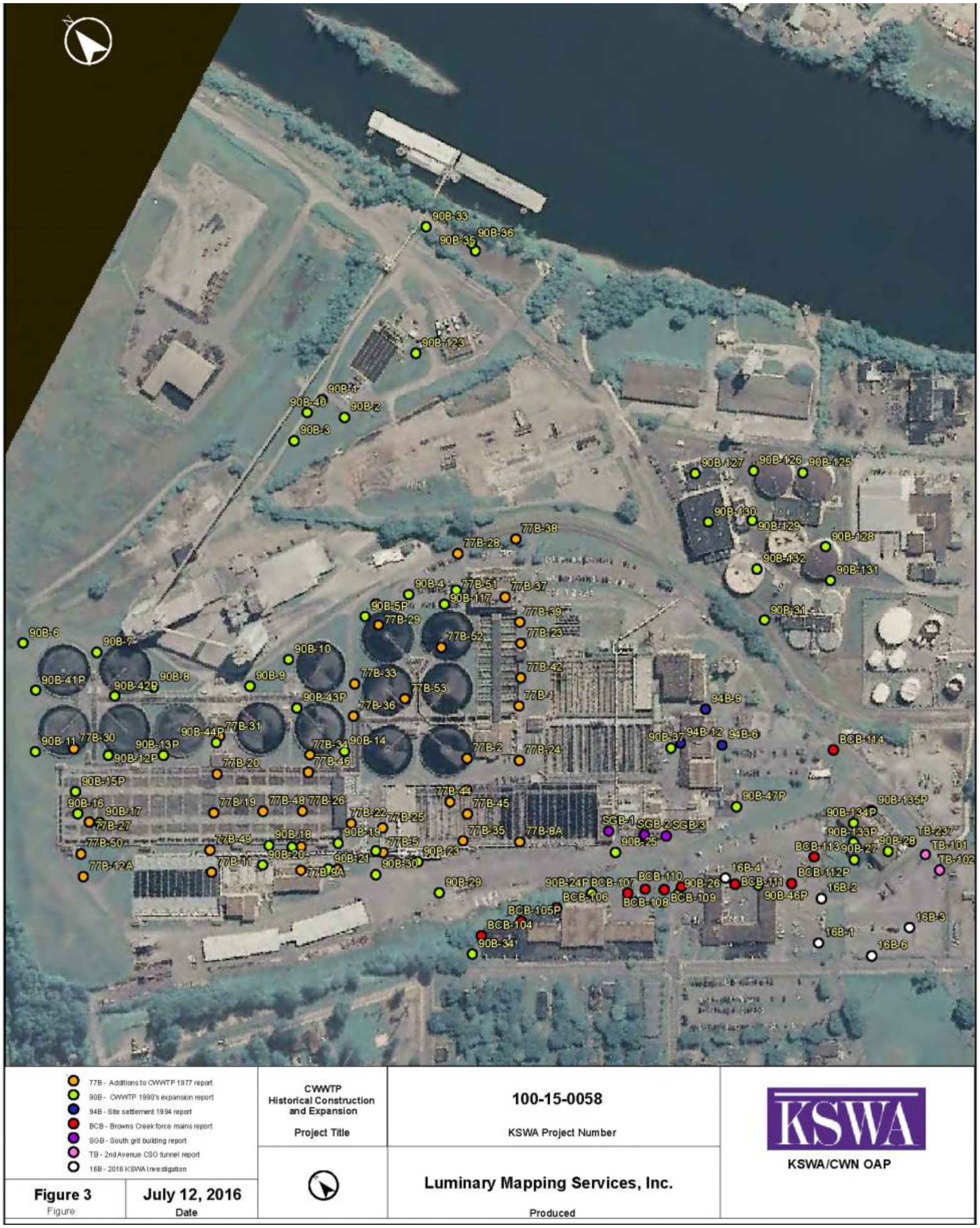

Figure 3-1: Borings from Geotechnical Reports

Figure 3-2: Top of Rock Contour Site Map

Figure 3-3: Top of Rock Contour Map Near CPS

3.2 South Plant Tank Structural Evaluation

3.2.1 Overview

The Hazen team conducted a subsurface investigation using ground penetrating radar (GPR) at the south aeration basins (SABs) and south final settling tanks (FSTs). The objective of this evaluation was to identify subsurface issues that should be addressed as part of the implementation of recommended alternatives involving the use of these tanks. Additional structural evaluation of the structure was also conducted – findings of this evaluation are summarized in later sections dealing with Alternative No. 1.

GPR is a geophysical method that uses radar pulses to image the subsurface. GPR can help an evaluation by investigating the subsurface without coring through existing concrete slabs. Concrete characteristics of the tank floors including thickness and arrangement of the reinforcing steel can be discovered, along with the thickness of the subgrade and potential presence of voids or piles beneath the tanks.

A full GPR survey was conducted for SAB Tank A and SST Tank A (**Figure 3-4**). This implemented a 3D survey with a 900 MHz antenna, 2D survey with a 100 MHz antenna, and a 2 GHz scan. An abbreviated survey was conducted for the remaining tanks with only 2D surveys.

Figure 3-4: GPR Survey Area

3.2.2 Exterior / Structure Findings

Concrete analysis based on the GPR survey concluded that rebar spacing is approximately 6 inches on center (OC) within 5 feet of existing walls. In the remaining areas, reinforcement spacing is 12 inches OC. Cover thickness over a top mat of rebar ranged from 3 to 10 inches. Lower mat of rebar has a spacing of approximately 12 inches at an average 6 inches above the base. The base of concrete ranges from approximately 14 to 16 inches.

Void detection indicated isolated areas of high amplitude reflections within interior of tank which may be interpreted as the presence of voids. Signs of piles were not observed; however, high amplitude reflections indicate 9 to 12 feet of crushed rock/broken stone beneath the base of the tanks.

Figure 3-5: Possible Void beneath Old South Aeration Basin

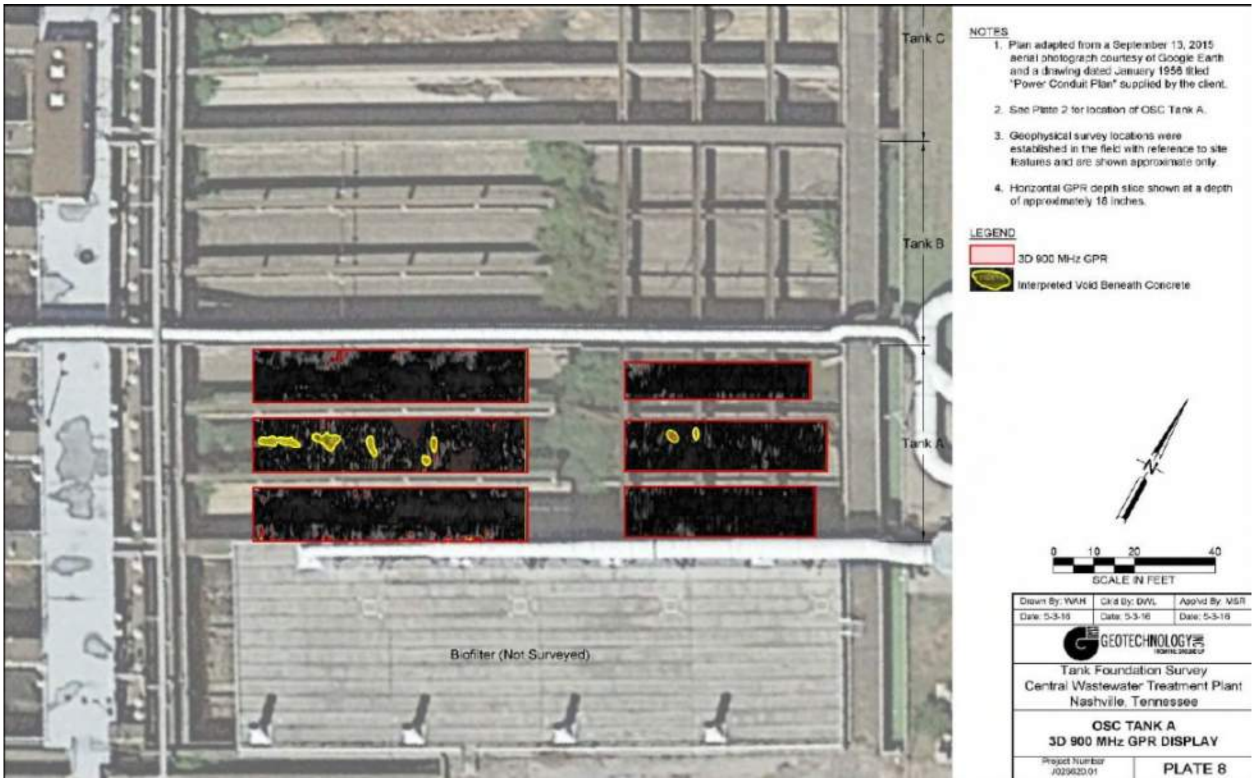

Figure 3-6: Possible Void beneath Old South Settling Tanks

3.3 Facility Hydraulic Constraints

At the existing south tankage, the maximum hydraulic grade line (HGL) upstream of fine screens is 422.12, based on a flow of 150 MGD through three screens in service with 50% blinding assumed. Additional discussion of the flow split and control of the HGL in the south grit facility is discussed in the section detailing alternatives at south grit building and EQ at the existing south plant tankage.

The basis of design for the EQ tank near CPS assumes that flows into the tank will be gravity flows from a new headworks facility with a maximum HCL of 430.00 and minimum floor elevation of 365.00 for gravity drainage to CPS. This allows for up to 65 feet of storage volume.

3.4 Existing EFTU Operations

In the existing EFTU operation, primary effluent from the south primary clarifiers enters the settled sewage channel on the north side of the SABs. Flow leaves the settled sewage channel and enters the northwest corner of the SSTs immediately after chlorine injection in the settled sewage channel downstream of the last butterfly gate upstream of the SSTs. The EFTU flow makes nine passes in three of the existing SSTs with modified CMU baffle walls before exiting over the effluent weir into the effluent channel through the Parshall Flume for discharge to the Cumberland River.

4. Alternatives

4.1 Overview

Three major alternatives and several sub-alternatives were considered for EQ at the CWWTP:

- Alternative No. 1 – Rehabilitation of Existing South Plant Tanks for EQ/EFTU
- Alternative No. 2 – Construction of New Tanks Within Existing South Plant Tank Footprint
- Alternative No. 3 – Construction of New Tank near CPS

Alternatives 1 and 2 are proposed improvements at the SABs and SSTs and include provisions for accepting flow that is diverted upstream of the fine screens in the south grit facility into the south aeration basins. The SABs and SSTs would be configured to provide primary treatment before discharge to the proposed peracetic acid (PAA) contact basin underneath the existing tertiary filters. The alternatives in this section assume all EQ and EFTU functions will be accomplished in the SABs and SSTs. Further discussion of considerations for use of the tankage for EFTU function is included in the Regulatory Considerations TM. Alternatives for rehabilitating the existing tankage will be discussed in detail in this section.

Alternative 3 proposes EQ storage adjacent to the CPS. At this location, flows would be diverted to the flow EQ tank upstream of the proposed new headworks by gravity. Emergency diversion would also be possible at this location (i.e. failure of major equipment in proposed headworks). The tank would drain by gravity back to the CPS after the storm event is over.

The firm capacity for fine screening installed in the south grit building is approximately 107 MGD. The peak instantaneous flow of the CPS is 240 MGD. In Alternatives 1 and 2, the influent flow that is not able to pass fine screens with CPS discharging at 240 MGD will be passively diverted through a gated passage into the existing bypass channel to the east of the south grit facility. When fine screens are operating at the firm capacity of 107 MGD, the diversion to EQ/EFTU will be controlled by the elevation of a weir at the SABs.

The firm capacity for coarse screening installed in the new south headworks building is 240 MGD to match the peak instantaneous flow of the CPS. In Alternative 3, the influent flow that is not able to pass coarse screens when the CPS is discharging at 240 MGD may be passively diverted to EQ through a bypass channel in the headworks. In all of the south plant headworks alternatives (refer to south headworks TM), there will be a bypass around the associated equipment to divert flow to EQ. The tank will be constructed to allow for gravity fill and drainage with a maximum HGL of 430 in the EQ tank.

4.2 Alternative 1 – Rehabilitation of Existing South Plant Tanks

4.2.1 Available Volume

The approximate capacity of the rehabilitated SABs and SSTs together in Alternative 1 and its variants will is approximately 8.9 MG, based on tanks filled to a maximum water surface elevation (WSE) of 419.00 and existing basin slab top elevation of 420.50 at the SSTs (lowest top slab, SSTs top slab elevation is 421.35). This volume assumes that no major changes in thickness of walls is necessary for rehabilitation and use of the existing tanks. Additional volume of approximately 1.7 MG is also available downstream in the PAA contact basin downstream below the effluent weir elevation and is not included in the 8.9MG volume estimate for the SABs and SSTs approximate capacity.

4.2.2 Alternative 1A – Rehab with Complete Functionality

4.2.2.1 Process / Operation

The diversion to EFTU can be automated to divert flow to EFTU when maximum HGL is reached upstream of the fine screens by opening a gate, thus ensuring the maximum amount of flow is being fine screened. Bypass around the fine screens before maximum HGL is reached can be a manual operation and initiated before maximum HGL at the fine screen is reached. Bypass around fine screens while flowing to EFTU (after maximum HGL is reached) can be automated to protect screens in extreme conditions. After tanks completely fill and begin to top the overflow weir, the tankage will overflow downstream to PAA disinfection.

4.2.2.1.1 Hydraulics

Maximum HGL will be controlled by a fixed weir at the southwest corner of the SABs so that the HGL does not exceed 422.12, the max upstream HGL allowed at the fines screens. Final design flows can be accommodated with adjustments to weir length and elevation. Also, a modulating gate, capable of chasing a flow set point to EFTU can also be considered for additional operational flexibility.

The proximity of the SABs and the SSTs to the tertiary filter complex and outfall greatly simplifies integration of the EQ and EFTU operations into a single location. EQ overflow will flow by gravity through PAA disinfection underneath the tertiary filters in the existing chlorine contact basin and continue to the outfall via existing piping downstream of the existing chlorine contact basin effluent weir. Some minor modifications to the existing tertiary filter complex and existing chlorine contact basin are required to accept and convey this flow as well as the addition of a pipe connecting the existing SSTs to the existing tertiary filters backwash channels to convey flow from the south EQ facility. The modifications downstream of the south EQ facility and large diameter piping to the tertiary filter complex (including connection to the existing backwash channel) are included in the cost estimate, but modifications beyond the connection of the large diameter piping connection are outside Hazen's scope and are not discussed in detail in this report, but have been coordinated with Brown & Caldwell (BC) to verify viability of approach.

4.2.2.1.2 Dewatering / Washdown Flow Schematic

The approach for dewatering the south flow EQ facility, which is similar for Alternatives 1 and 2, will be refined during preliminary design. It is anticipated that a PS in the SABs and another in the SSTs will be required to dewater the EQ volume in a timely manner. These PSs will discharge upstream of the fine screens in the south grit facility and additional discharge locations may be considered to provide flexibility in dewatering operations. Additional methods of drainage can be considered in addition to the PSs to reduce the pump sizing or in lieu of a PSs. These additional methods may include partial gravity drainage to PAA disinfection, use of existing RAS pumps, and use of existing drains to the plant drain system.

It is anticipated that the flow entering the south flow EQ facility will have passed coarse screening and grit removal prior to entering the EQ volume during typical operation. Therefore, it is anticipated that this will greatly reduce accumulation of material in the floor of the SABs and SSTs. The basic provision for cleaning includes high pressure water cannons installed at key locations around the tankage for pushing material to grit wells, drains, and PS wet wells. The Alternative 1A variant includes flushing equipment and sloped floors. An illustration of the cleaning and dewatering operations and features is shown in **Figure 4-1**Error! Reference source not found..

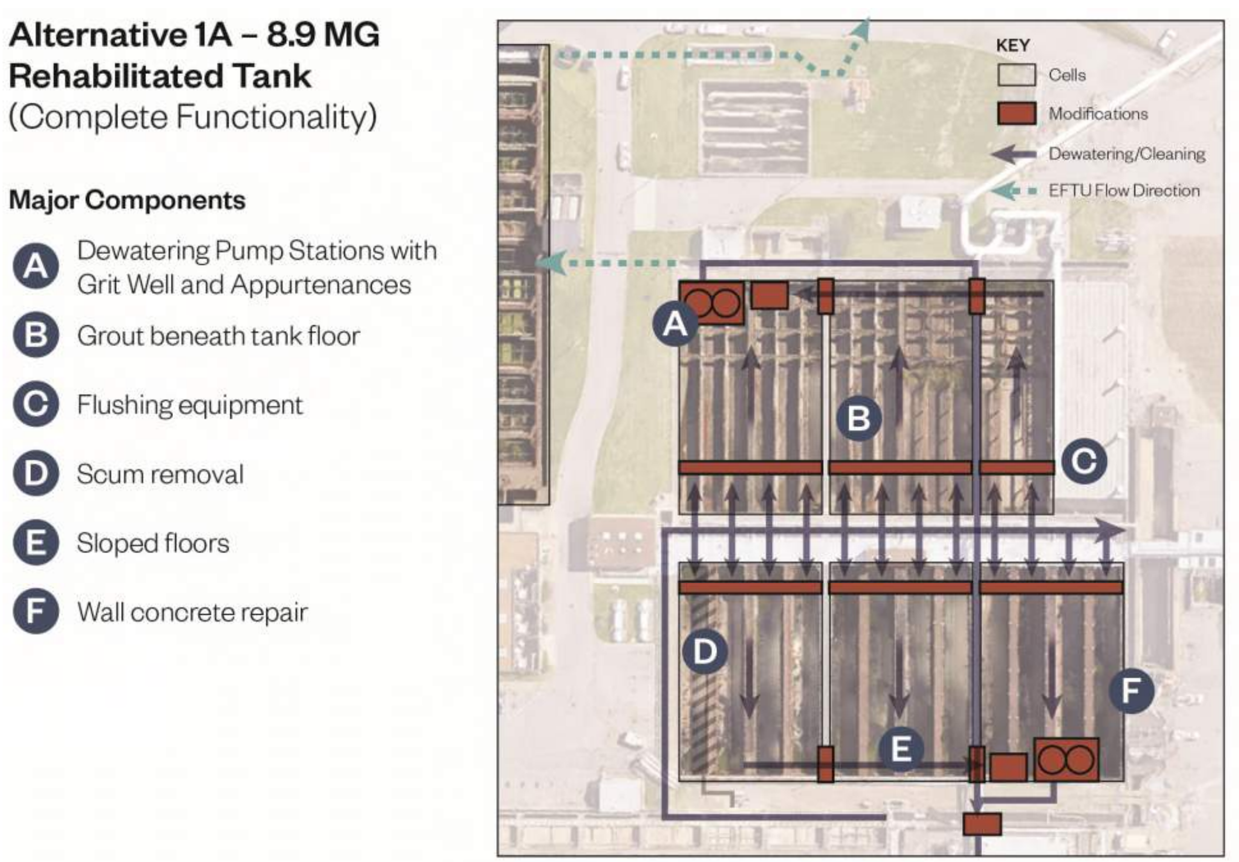

Figure 4-1: EQ Dewatering and Cleaning Operations Overview (Alt. 1, Full Functionality, shown)

4.2.3 Alternative 1B – Reduced Functionality

4.2.3.1 Reductions from 1A

The Alternative 1B variant is a lower cost alternative created by removing features that facilitate cleaning and using a different approach and assumptions regarding structural rehabilitation of the existing structure. It is anticipated that since the flow entering the south flow EQ facility has already been screened and passed through grit removal, removal of optimized cleaning could be a viable alternative. However, costs associated with manual cleaning should be considered further to contrast with the full functionality options. An illustration highlighting the difference in features between full functionality and reduced functionality variants of Alternative 1 is shown in **Figure 4-2**.

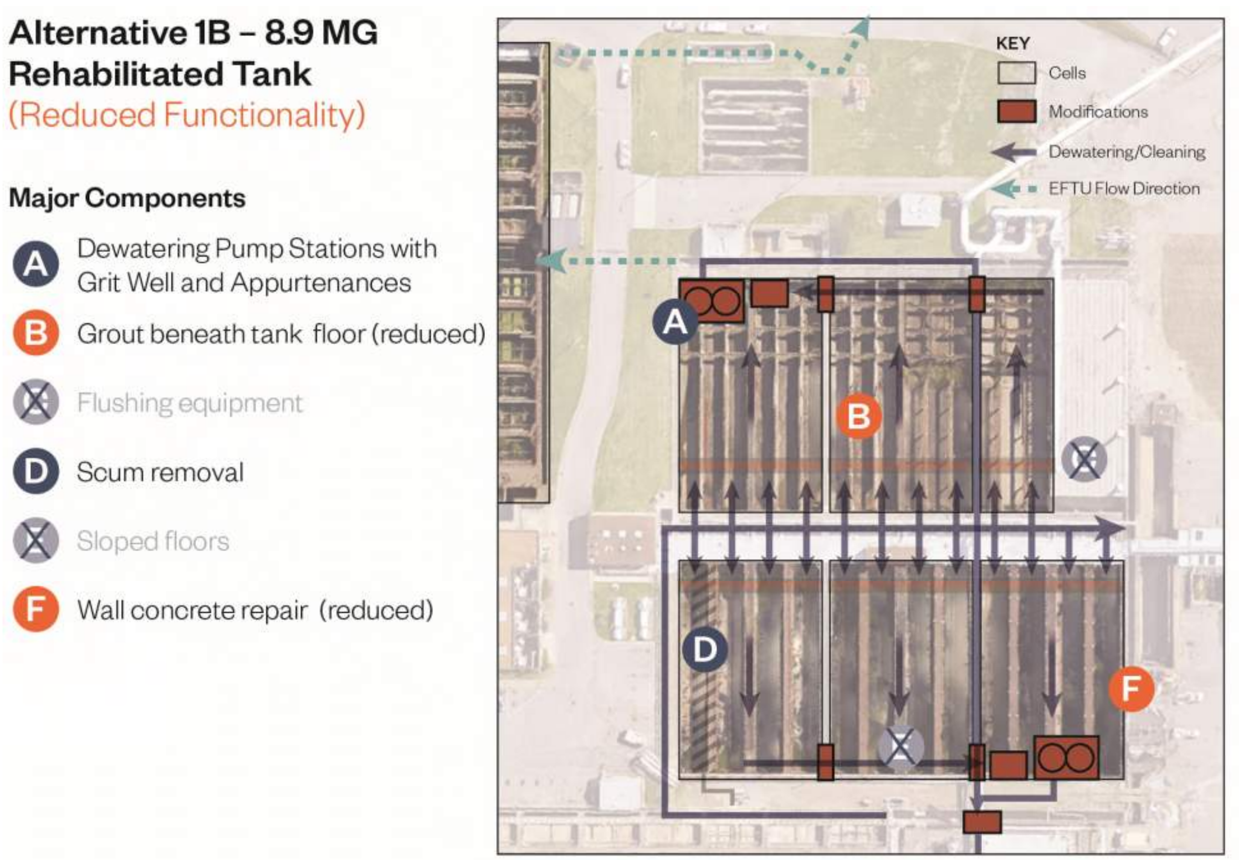

Figure 4-2: Alternative 1B – Existing Tank Rehab, Reduced Functionality

As shown in **Figure 4-2**, sloped floors and flushing equipment have been removed to save costs. Additional cost saving differences include changes in assumptions and approaches to structural repair of the existing tankage.

4.2.4 Structural Rehabilitation and Geotechnical Considerations

4.2.4.1 Geotechnical and Structural Concerns

In addition to the GPR subsurface evaluation that was conducted, a field structural review was conducted to characterize the needs for rehabilitation of the south aeration tanks. The following are significant concerns based on review of available construction documents and the site investigation.

- The existing tankage was built to 1950 standards and does not meet current code requirements for water tight tanks which require an additional 30% additional reinforcing to accommodate flexure and mitigate cracking. There is not a practical way to mitigate this issue and it is not anticipated to be a major issue if the walls are intact and the rebar is not compromised by corrosion.
- The original structure was intended for consistent long-term loads associated with operation while filled nearly all the time. The cyclical loading of the structure when in service as EQ raises concerns regarding differential settlement between structures.
- GPR investigations indicated what may be voids underneath the bottom slab, possibly requiring grout injection to resolve and introducing significant uncertainty in cost of rehabilitation due to the uncertainty in the amount of grout injection that may be required.
- Buoyancy of the structure is also a concern, as variations in the water table in the area can create uplift forces which cannot be countered by the existing foundation system.
- The existing structure is approximately 60 years old and the typical design life of concrete structure is typically estimated to be about 50 years.

Additional investigations were pursued and are summarized in the following sections.

4.2.4.2 Geotechnical and Structural Investigations

Further consideration of repurposing the SABs and SSTs required verification of the existing condition of the structures and any relevant subsurface conditions. To supplement the review of construction drawing from the projects during which the SABs and SSTs were built or modified, visual and GPR surveys were performed on the tanks and surrounding area. In addition to this, existing geotechnical information from other projects at the CWWTP were compiled and reviewed to determine subsurface conditions at the SABs and SSTs.

The visual survey was performed from the top of the tank walls and adjacent walkways and piping gallery between the SABs and SSTs. The objective of the visual survey was to estimate the nature and extent of structural repairs necessary.

The GPR survey of the existing SABs and SSTs was performed to accomplish several objectives:

- Investigate the subsurface without coring through the slab of the SABs and SSTs tanks
- Determine concrete characteristics of the tank floors including thickness and arrangement of reinforcing steel
- Detect potential presence of voids or piles beneath the tanks

- Verify thickness of the subgrade

The compilation of geotechnical data included information from projects at the CWWTP from 1956-1998. There was no geotechnical information from previous projects within in the existing SABs and SSTs footprint, but information from adjacent projects was available and useful for insight into the subsurface conditions in the area.

4.2.4.3 Geotechnical and Structural Investigations Findings

The GPR analysis largely confirmed that the structure was built as reflected in the construction drawings and a summary of findings is as follows:

Table 4-1: Summary of Geotechnical and Structural Investigation Findings

Item of Interest	Finding
Concrete Analysis	
Reinforcement Spacing	12 inches except within approximately 5 feet of the walls where spaced approximately 6 inches
Cover over top mat of reinforcement	3-10 inches
Cover below bottom mat of reinforcement	6 inches above base
Concrete Bottom Slab Thickness	14-16 inches
Void Detection	
Presence of voids	Isolated areas of high amplitude reflections within interior of tank which may be interpreted as the presence of void
Existence of Piles	No piles detected.
Subgrade Characteristics	
Thickness	9 - 12 feet
Type	crushed rock/broken stone

When considering the GPR survey findings, the largest cost impacts would be a determination that voids were present underneath the tanks and a confirmation of the design of the existing foundation system. The GPR survey did find areas that may possibly be voids, but similar GPR reflections could be generated due to the presence of variable amounts of materials such as clay or moisture within subgrade materials. For the purpose of estimating the cost impact of this finding, it is assumed that the potential voids in the SABs and SSTs were distributed similarly in the other tanks and would require filling with grout injection. The presence of voids should be confirmed and additional survey is recommended to verify if any voids are present under other portions of the SABs and SSTs. Location of the potential voids in the SABs and SSTs are shown in **Figure 4-3** and **Figure 4-4**, respectively.

Figure 4-3: Alternative 1 – Potential Voids in SABs

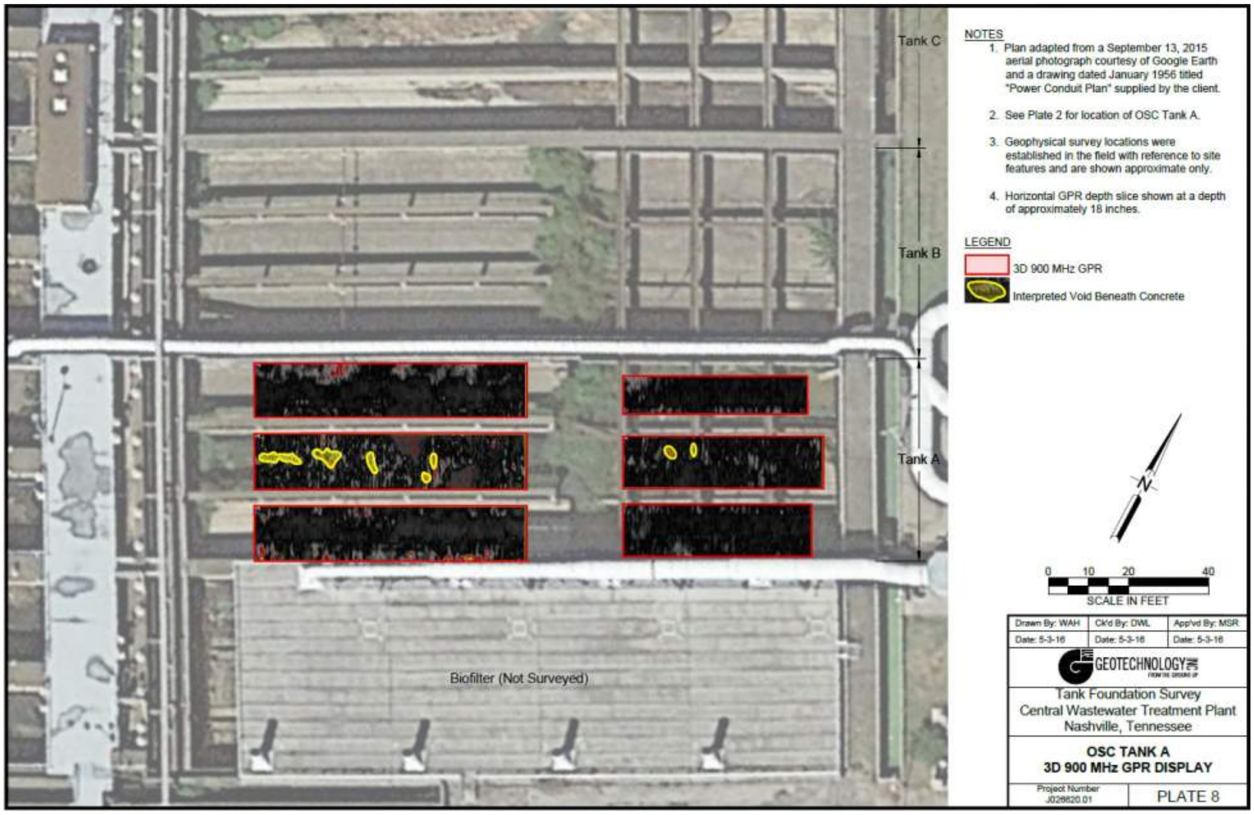

Figure 4-4: Alternative 1 – Potential Voids in SSTs

It is also significant that no signs of a pile foundation system was detected by the GPR Survey which confirms that concerns regarding differential settlement and buoyancy will need to be considered.

4.2.4.4 Mitigation of Risks Associated with Rehabilitation of Existing Tanks

The repair methods for rehabilitation of the existing SABs and SSTs and related risks are discussed in this section.

4.2.4.4.1 Cracking/Spalling Concrete

Cracking or spalling of concrete can be a sign that excessive flexure had taken place or freeze/thaw mechanism resulting from water penetrating the concrete surface. Reinforcing steel may be exposed or have corroded because of cracking allowing moisture to get to the steel depending on extent or age of the defect. Since the tank is designed to outdated standards and will be subjected to cyclical loading in the future, concrete may continue to crack and spall over the remaining service life.

Potential repair methods include a combination of epoxy injection, non-sag mortar and corrosion inhibiting agents. Composite strengthening systems may be required for extreme degradation.

Figure 4-5: Concrete Cracking at SABs

Figure 4-6: Concrete Spalling at SABs

Figure 4-7: Example of concrete spalling resulting in exposure of reinforcing steel (Example photo, not from Central WWTP)

The risks associated with cracking and spalling are primarily cost concerns derived from the iterative nature of the repair process. Some defects may affect water tightness of the tanks and the associated leakage may not be addressed on the first attempt at repair. Also, without detailed investigation of the structure to be repaired, it is difficult to be certain of the extent of the repairs required. Material quantities required for repairs are not known in advance of the repair effort.

4.2.4.4.2 Settlement

As previously discussed, the existing tank does not bear on a deep foundation system. Excessive or differential settlement in the structure may cause existing cracks to widen or cause additional cracking. This concern is exacerbated by the cyclical nature of the loading associated with EQ storage. The concerns related localized voids are similar in that an area of floor with inadequate support from the subgrade would result in excess localized flexure and cracking. Pressure grouting below the existing structure is the most common method of improving foundation conditions and minimizing the potential for future settlement.

Potential risks associated with pressure grouting include that grout may find a way into all voids and openings, including cracks in pipes, conduit, etc. and end up deposited in unintended locations causing either damage or the need to inject significant amounts of material beyond pre-injection estimates.

4.2.4.4.3 Buoyancy

The existing drawings do not show measures to counteract buoyancy, nor did the GPR Survey. High water events that would cause concern include fluctuations in water table that would remain below finished grade elevation yet not necessarily be apparent. A potential repair method is to retrofit pressure relief valves (PRVs) into the existing tankage floor. A concern regarding the of PRVs in this application is the reliability of the PRV seal preventing contained liquid from leaking out of the tank.

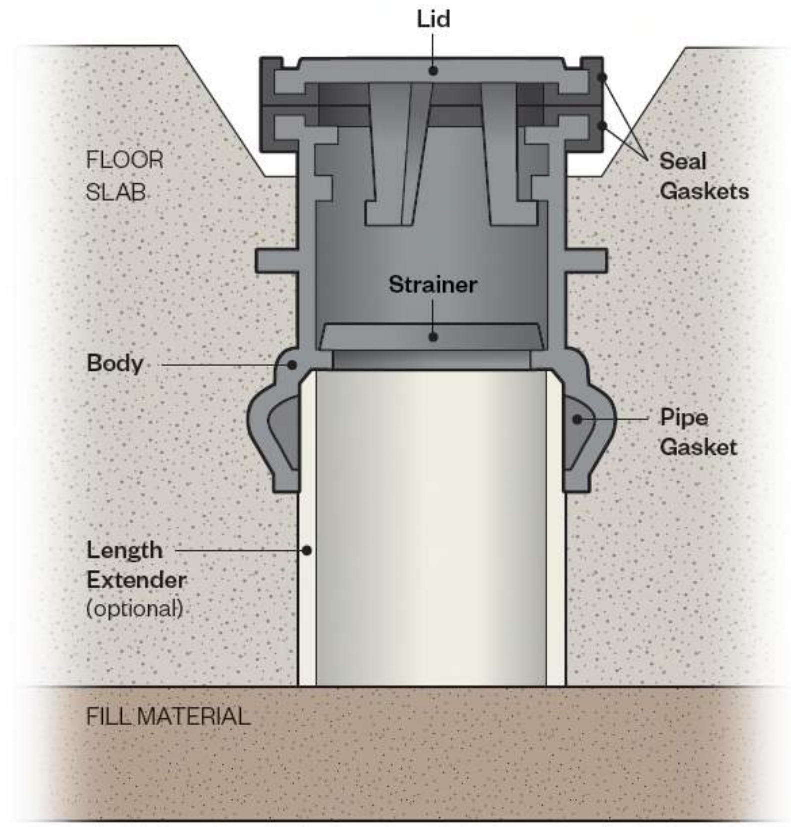

Figure 4-8: Typical Floor-Type Tank Pressure Relief Valve (PRV)

4.2.4.4.4 Differential Settlement between Structures

Since the structures are not equally founded, settlement may occur and cause damage to process piping between structures.

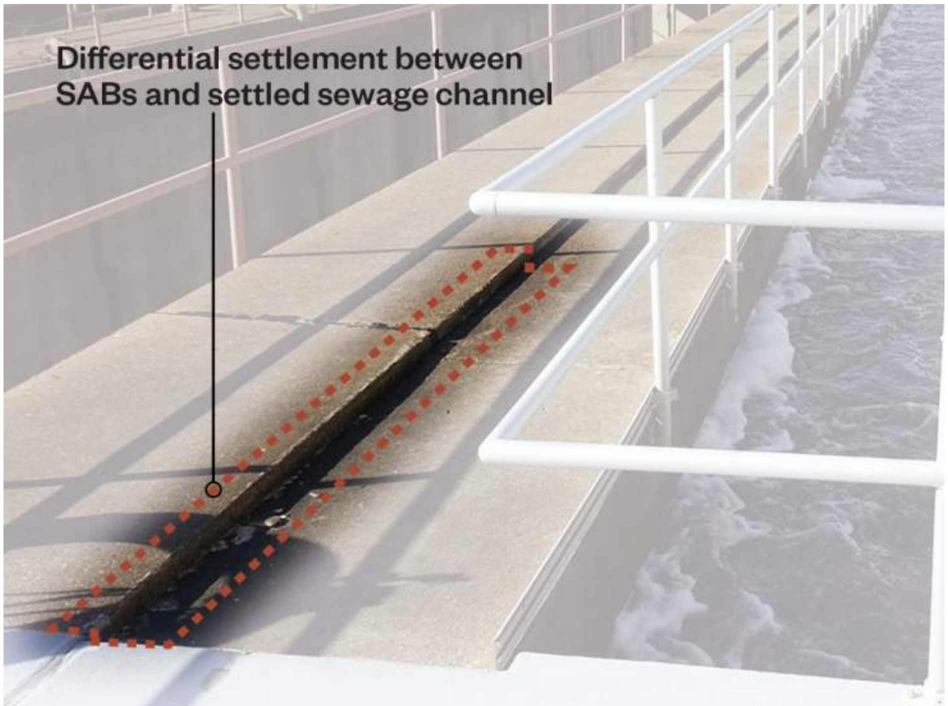

Figure 4-9: Differential Settlement at SABs

Potential repair methods vary depending on the extent of differential settlement as determined by the geotechnical engineer.

Potential risks associated with differential settlement include leakage between structures and possible impact on connecting process piping. There may also be hazards associated with repair methods to mitigate this risk. For example, if pressure grout is recommended by the Geotechnical Engineer, then the risks associated with the repair would be the same as those previously mentioned for pressure grout mitigation of settlement.

4.2.4.4.5 Cost Uncertainty

The extent of the required repairs to address all or some of these risks may be fully understood until the construction phase. The extent of repair work will also be determined during the construction phase.

Risks related to costs include the uncertainty regarding problematic issues that may actually exist and the time and materials required to complete the necessary remediation. As a result, it would be difficult to estimate final repair costs.

A summary of findings and mitigating techniques is summarized below in **Table 4-2**.

Table 4-2: Summary of Geotechnical and Structural Issues, Impacts, and Mitigating Techniques

Item Requiring Mitigation	Potential Negative Impact of Item	Mitigating Technique	Mitigation Technique Outcome and Issues
Inadequate reinforcement spacing and excess cover.	Excess concrete cracking	Repair existing cracks	Concerns regarding cyclical loading remain
Voids (potential, to be confirmed)	Floor cracking leading to tank leakage and additional subsurface compromise	Localized Grout Injection	Grout can travel to unintended areas, costly. Should address voids where they exist.
Piles	Differential settlement and uplift issues	More extensive grout injection (for settlement) and Pressure Relief Valves (PRVs) to address buoyancy (uplift)	Grout can travel to unintended areas, costly. PRVs can be unreliable.

4.2.5 Constructability

The nature of the rehabilitation and the uncertainty regarding extent of repairs makes it difficult to know the magnitude of impact on construction schedule and costs. It is believed that the tanks are repairable and that the repair process could be iterative and time consuming.

4.3 Alternative 2 – New Tankage in Existing Footprint of SABs and SSTs

Alternative 2 and its variants entail the construction of new tankage within the footprint of the existing SABs and SSTs. This approach addresses the risks associated with the extensive concrete repair and foundation augmentation that will be required to repurpose the existing circa 1950s tankage in Alternative 1. This alternative also includes large diameter piping to convey flow to the PAA contact facility underneath the existing tertiary filter complex.

4.3.1 Available Volume

The approximate capacity of the repaired SABs and SSTs together in Alternative 2 and its variants will be approximately 7.4MG.

4.3.2 Alternative 2A – Complete Functionality

4.3.2.1 Process / Operation

The process and operation of all variants of Alternative 2A is the same as the variants of Alternative 1.

4.3.2.1.1 Hydraulics

The hydraulics of all variants of Alternative 2A are the same as the variants of Alternative 1.

4.3.2.1.2 Fill / Flow Schematic

The Fill / Flow Schematic for all variants of Alternative 2A is the same as the variants of Alternative 1 as shown in Error! Reference source not found..

4.3.2.2 Dewatering / Washdown Flow Schematic

Alternative 2 variants differ in the provisions for cleaning and maintenance. Other differences between the variants includes difference in EQ compartments. Alternative 2A is a “complete functionality” alternative, offering features that facilitate cleaning of the storage volume floor with minimum labor. The major features of Alternative 2A are illustrated in **Figure 4-10**.

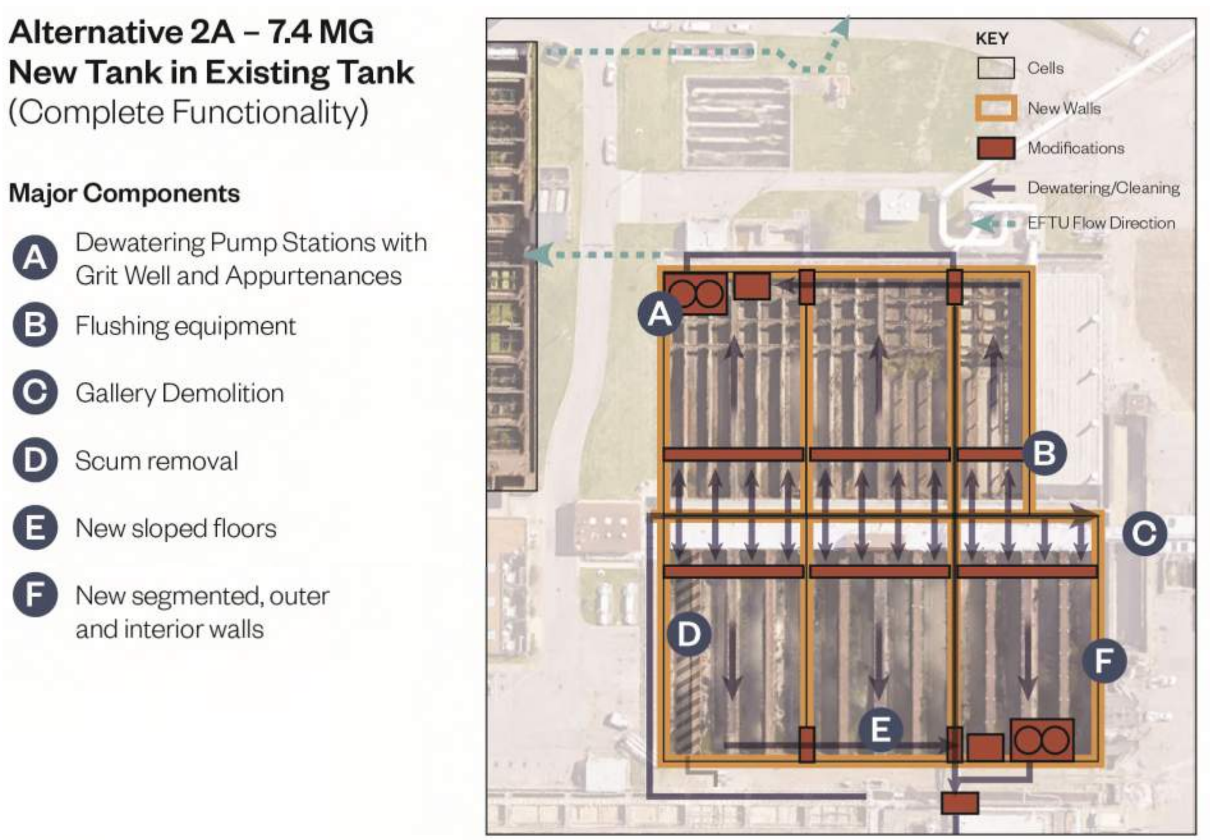

Figure 4-10: Alternative 2A – New Tankage, Full Functionality

4.3.3 Alternative 2B – Reduced Functionality

4.3.3.1 Reductions from 2A

Reductions made to Alternative 2A to create Alternative 2B shown in **Figure 4-11**, include reduction in number of, divider walls (reduced number of segments from 6 to 4) and flushing equipment.

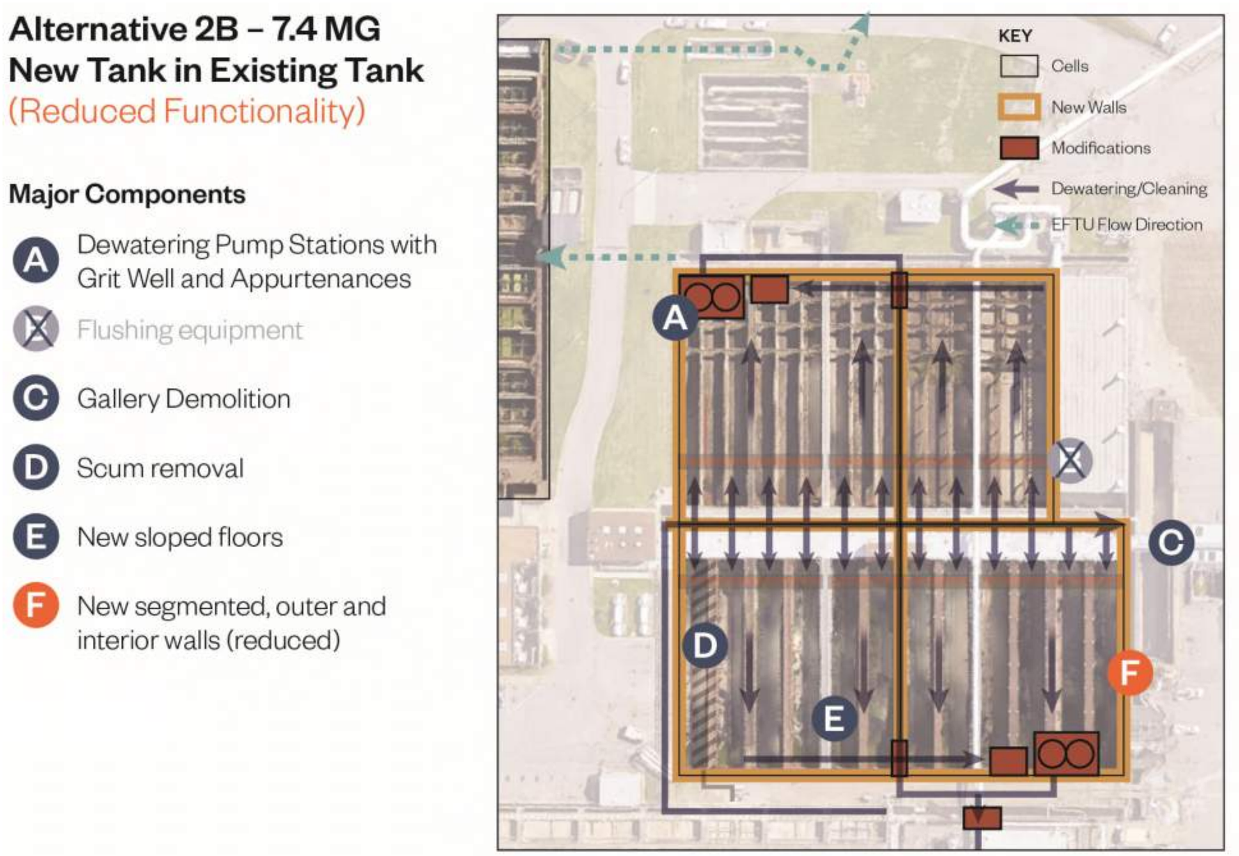

Figure 4-11: Alternative 2B – New Tankage, Reduced Functionality

4.3.4 Structural Rehabilitation and Geotechnical Considerations

4.3.4.1 Geotechnical and Structural Concerns

The construction of a new tank within the existing tankage addresses the issues and risks associated with reusing the existing tankage:

- New Design
  - Structure will be built to current building code (IBC 2012)
- New Structure does not need retrofits
  - Will be designed for its intended cyclic operation with highly variable loading conditions
- Negligible Settlement or Buoyancy
  - Structure will be supported by a new deep foundation system
- Cost and Schedule
  - Less risk (cost and schedule uncertainty) associated with new construction

4.3.5 Constructability

Due to the nature of construction of the new tankage within the existing tankage, and designing the new tankage to mitigate the issues associated with the geotechnical conditions at the site, Alternative 2 and its variants provide the highest degree of constructability as compared with Alternative 1 and its variants.

4.4 Alternative 3 – New Tanks near CPS

New EQ storage would be constructed in the large parking area in the southwest corner of the property. This site is directly adjacent to the CPS thus easily accommodating a gravity drain system from the EQ tank with very short dewatering piping runs. This location is also adjacent to the proposed screening and headworks Facility. Because the desired mode of operation is to have the EQ tank fill by gravity with flows from the proposed screening facility, the EQ tank influent piping runs will also be very short, optimizing the hydraulic grade line from the screening facility to the proposed EQ tank. Another advantage of this location is that few existing utilities will require removal and relocation. The only major utility is a relatively shallow, 54-inch-diameter sanitary sewer that crosses the site. This site is bordered by the CPS to the east, Magdeburg Greenway to the south, Third Avenue to the west and the primary power lines to the north.

4.4.1 Existing Site Constraints

Several major utilities will need to be addressed at the parking lot sites in the southwest corner of the property and directly north of this site as shown in **Figure 4-12.** A 54-inch sanitary sewer that crosses the southern site is relatively shallow but cuts diagonally across the center of the site. This sewer would need to be relocated, likely by routing a new sewer to the south along Third Avenue, then constructing a structure and routing the sewer to the east along Magdeburg Greenway.

One of the primary electrical feeds to the WWTP is located between the parking lot site on the south and the parking lot site directly adjacent to system services. If the EQ tank is constructed in this location, the electrical utility would need to be relocated to the north or south. Because this is a major electrical feed, the relocation could be quite costly and temporary plant shutdowns may be required. A 12-inch water line buried along this same alignment would be relatively easy to relocate if the EQ tank is built in this location but considerations should be taken as it is the main feed to the WWTP.

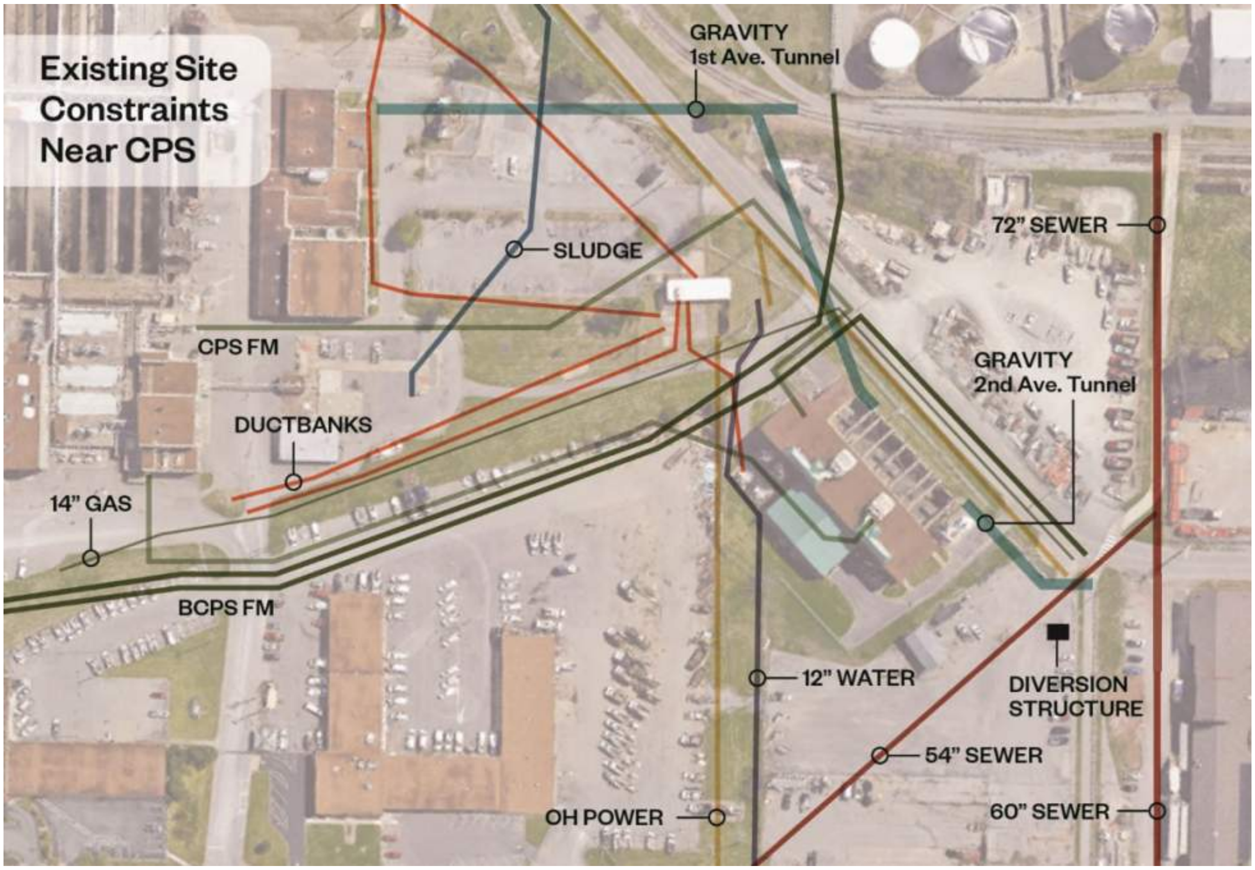

Figure 4-12: Existing Site Constraints near CPS

One of the main site parameters that impacts construction of a below-ground EQ facility is the varying subsurface conditions. The rock profile in this area varies considerably with relatively deep rock to the north and west near the system services building and shallow rock toward the southeast near the CPS. Major construction cost impacts related to depth of rock include the need to provide temporary earth retention in the overburden soils above the rock and the method and cost associated with rock excavation and removal below. There are two feasible means of earth retention for the proposed facilities. For circular structures the earth retention would likely consist of a ring wall of steel sheeting driven to rock. The sheeting would be braced by circular concrete ring wales (**Figure 4-13**). For rectangular structures the earth retention would likely consist of a steel sheet pile wall driven to rock. The sheeting would be braced by several rows of steel wales and rock anchors, anchored into the bedrock (**Figure 4-14**).

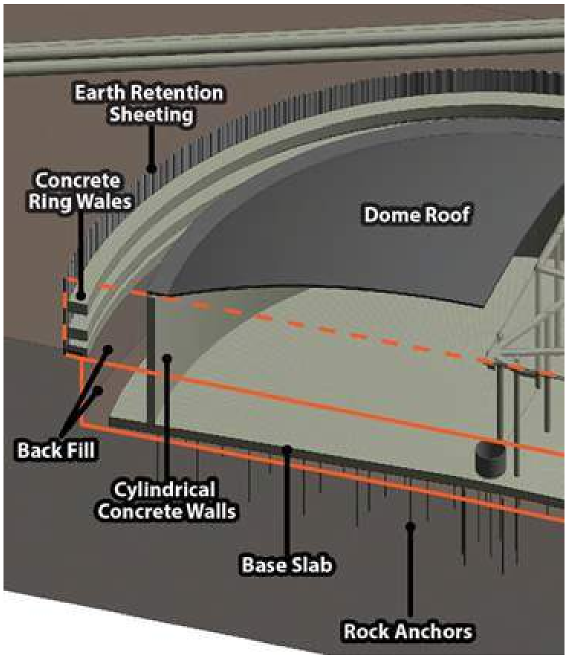

Figure 4-13: Earth Retention for Circular Structures

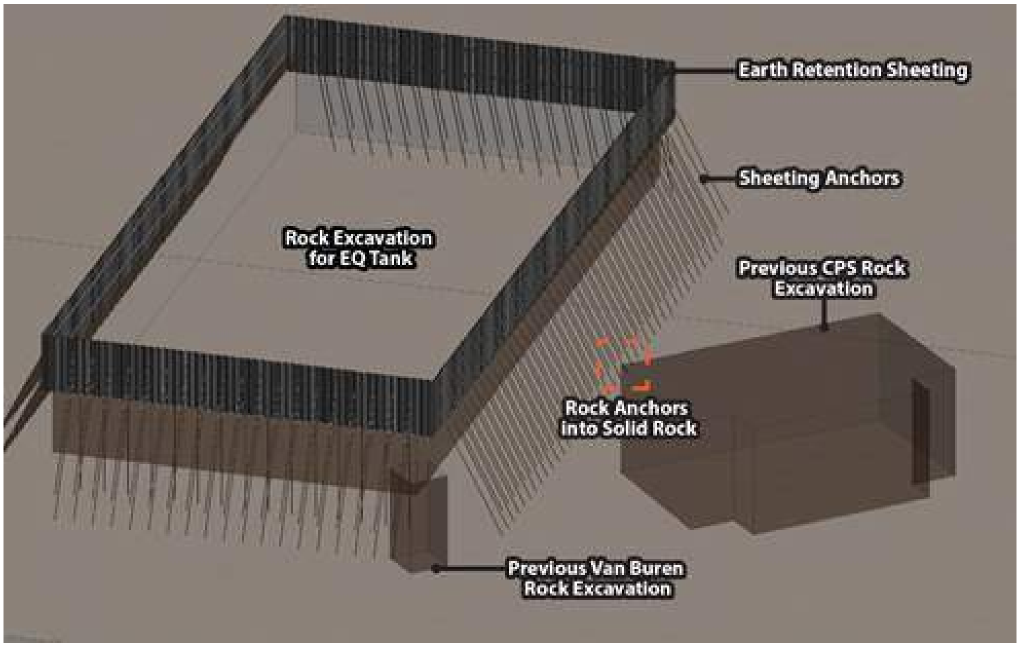

Figure 4-14: Earth Retention for Rectangular Structures

4.4.2 Hydraulics / Profile on Site

A maximum HGL of 430.00 must be maintained and is, therefore, the upper storage volume elevation for the proposed EQ tank. The location of the EQ adjacent to the CPS would be the most visual aspect of the project as it sits on the edge of Third Avenue and is adjacent to the Magdeburg Greenway, which connects to Morgan Park. Currently, the neighborhood surrounding the WWTP is rapidly redeveloping with mixed-use residential and commercial properties. Therefore, aesthetics and odor control are very important considerations for these EQ alternatives. To accommodate the maximum HGL of the tank, the side wall would rise about 10 feet above grade in this location. Architectural design to match the CPS could be incorporated to improve the aesthetics of the structure. Improvements to the greenway could be included with educational material about the plant to inform the public about the work MWS is doing to keep Nashville safer, cleaner, and greener.

The tanks will be covered to reduce odors and could be connected to the south headworks odor control system if desired. A rectangular tank would have a flat roof while the most economical circular tank would have about a 20 foot tall domed roof.

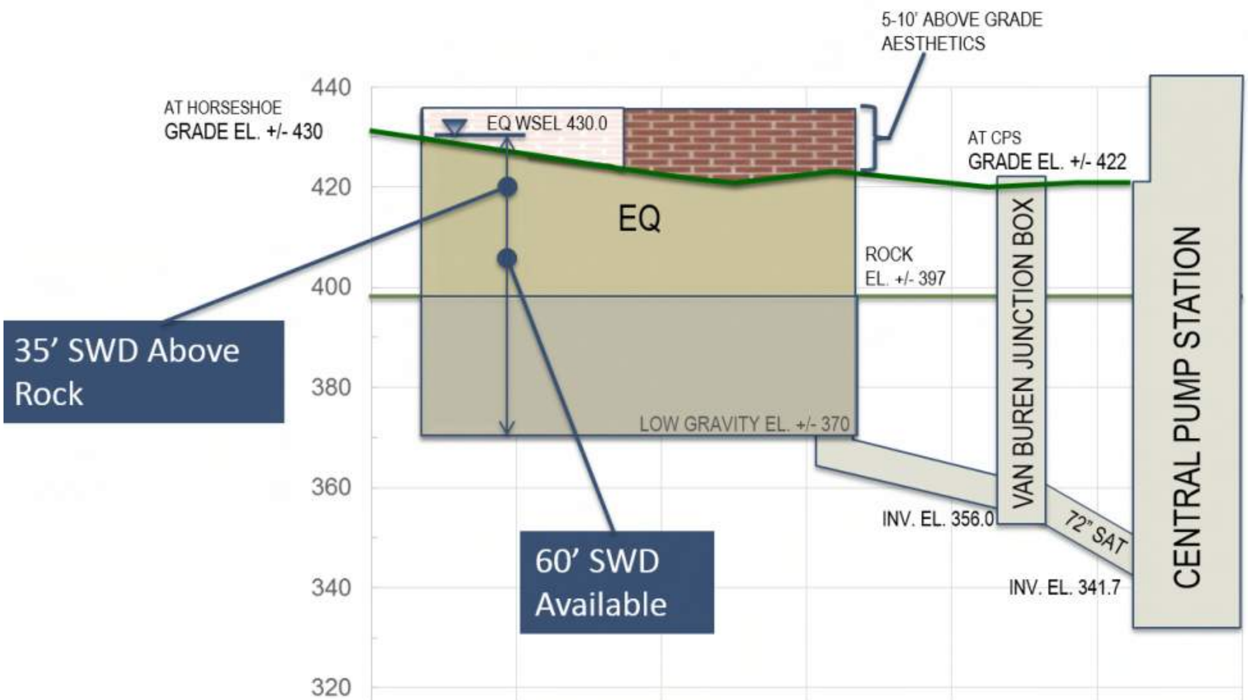

Figure 4-15: Existing Site Constraints near CPS

4.4.3 Volume

Prestressed circular tanks and cast-in-place rectangular tanks were considered. In the earliest workshops, the maximum amount of onsite storage, up to 30 MG of storage, was evaluated. These alternatives were not considered further as they would require new PSs or were in conflict with construction of a new south headworks facility. To accommodate the new headworks and existing site constraints, the recommended capacity of the EQ at CPS varies from 7 MG to 12 MG of storage, depending on the tank design selected. The tank configurations were optimized to provide the most storage with a single tank located south of the existing major overhead power supply, based on site constraints and cost of rock excavation. Additional EQ volume of approximately 2.5 MG to 4 MG is available if a second tank were to be constructed on the site but major utilities would need to be relocated.

The sub-alternatives for Alternative will be discussed in detail in this section but the volumes are summarized below:

- 3A – 12 MG Prestressed Circular Tank
- 3B – 7 MG Prestressed Circular Tank
- 3C – 10 MG Rectangular Tank

4.4.4 Fill / Drain

The proposed EQ tank will receive flows from the proposed screening and headworks facility when operators want to divert flows away from the plant. The proximity of the EQ tank to the CPS simplifies fill operations. For all alternatives, EQ fill will flow from the south headworks facility by gravity to fill the tank. For prestressed circular tanks, it is recommended that fill lines enter through the bottom slab of the tank which will require the piping to be deeper than if a rectangular tank were utilized.

The tank is intended to dewater by gravity back to the CPS. Located directly west of the CPS is the Van Buren junction box which directs the Second Avenue Tunnel (SAT) sewer into the CPS. The drain line from the proposed EQ tank will be tied into this chamber to allow flows to dewater back to the CPS. The invert of this chamber is at elevation 352.00, which sets the lower extent of the proposed storage volume. For the layout of alternatives, the lower limit for the tank drain was set at elevation 365.00.

The approach for dewatering EQ at CPS is similar for all alternatives and will be refined during preliminary design. The drain line will be sized to dewater the EQ volume in a timely manner. Some minor modifications to the existing Van Buren diversion chamber and relocation of the 54” gravity sewer are required to accept and convey this drainage flow to the CPS.

4.4.5 Alternative 3A

4.4.5.1 Configuration

For this alternative, the proposed EQ tank would be a prestressed circular tank. Constraints for Alternative 3A are the requirements to:

- Maintain a minimum 35-foot setback from Third Avenue to keep the earth retention sheeting and ring wales out of the Third Avenue right-of-way. This sets the western most edge of the EQ tank.
- Maintain a minimum setback of 35 feet between the proposed EQ tank and greenway to keep the earth retention sheeting and ring wales out of the right-of-way. This sets the southern limit for construction of the EQ tank.
- Maintain a minimum separation of 35 feet between the proposed EQ tank and the existing CPS to allow for installation of the sheeting and ring wale earth retention system. This sets the eastern limit for construction of the EQ tank.

- Limit the northern extents to allow construction of a circular EQ tank without relocating the existing electrical and water utilities.

Using these parameters, a 12 MG EQ tank with an inside diameter of 185 feet and a side water depth of 60 feet can fit on the site to maximize the amount of storage with a single circular tank and still allow for gravity drainage.

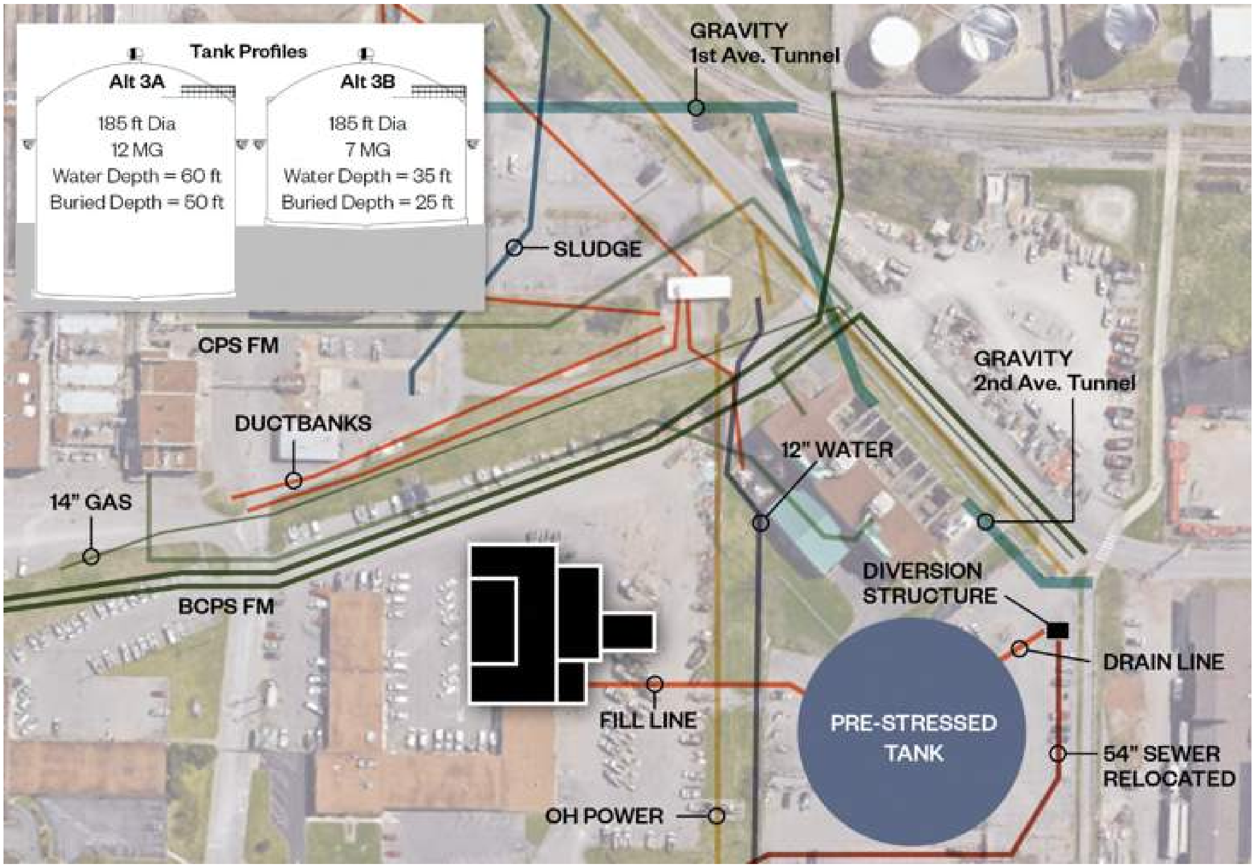

Figure 4-16: Alternatives 3A and 3B Tank Layout

An earth retention system consisting of steel sheet piling and concrete ring wales would be installed in the overburden soils to allow for excavation adjacent to Third Avenue and the CPS.

4.4.5.2 Process / Operation

4.4.5.2.1 Hydraulics

As stated before, a maximum hydraulic grade line of 430.00 was set as the upper storage volume elevation for the proposed EQ tank. The invert of the Van Burn junction box set the lower extent of the proposed storage volume. A side water depth of 60 feet would provide the maximum storage of 12 MG and still allow for gravity drainage into the CPS.

4.4.5.2.2 Flow Schematic

The Fill / Flow Schematic for Alternative 3A is shown in Figure 4-16.

4.4.5.3 Washdown

It is anticipated that the flow entering the EQ at CPS will have passed coarse screening at a minimum and potentially grit removal prior to entering the EQ volume during typical operation. Therefore, it is anticipated that this will greatly reduce accumulation of material in the floor of the EQ tank. As in Alternatives 1 and 2, the basic provision for cleaning includes high pressure water cannons installed at key locations around the tankage for pushing material to drains. It is anticipated that a prestressed circular tank will not require flushing equipment due to the sloped floor of 3% minimum.

4.4.6 Alternative 3B

Alternative 3B has all of the same conditions, configurations and operations as Alternative 3A except for the tank water depth. Alternative 3B limits excavation down to the bedrock elevation of +/- 397 with a side water depth of 35 feet to provide 7 MG of storage. This alternative reduces excavation and tank construction cost but an additional tank would need to be constructed to achieve 18 MG of storage onsite.

4.4.7 Alternative 3C

4.4.7.1 Configuration

Alternative 3C attempts to maximize potential storage volume by constructing a rectangular cast-in-place concrete tank. The site layout is shown in **Figure 5-17**. Constraints on this alternative are the requirements to:

- Maintain a minimum 45-foot setback from Third Avenue to keep the earth retention rock anchors out of the road right-of-way. This represents the western most edge of the EQ tank.
- Maintain a minimum separation of 50 feet between the proposed EQ tank and the Van Buren junction box to avoid interference between the earth retention rock anchors and the existing concrete chamber. This represents the southern limit for construction of the EQ tank.
- Maintain a minimum separation of 50 feet between the proposed EQ tank and the existing CPS to avoid interference with the earth retention rock anchors and the existing CPS Substructure. This represents the western limit for construction of the EQ tank.
- Limit the northern extents of the EQ tank to allow for construction of the tank without demolishing any of the existing electrical and water utilities.

Using these parameters, a 10 MG EQ tank that is 225 feet long x 200 feet wide x 30 feet deep fits on the proposed site. The more shallow structure allows the perimeter walls to reduce in thickness, thereby reducing the unit cost of the facility. The roof of the tank is a flat concrete roof consisting of a concrete slab spanning between concrete beams supported by concrete columns spaced 25 feet along the flushing bay divider walls. The floor would slope to the east to a collection channel and then drain to the adjacent Van Buren junction box.

An earth retention system consisting of steel sheet piling, wales and rock anchors would be installed in the overburden soils to allow for excavation adjacent to Third Avenue and the CPS.

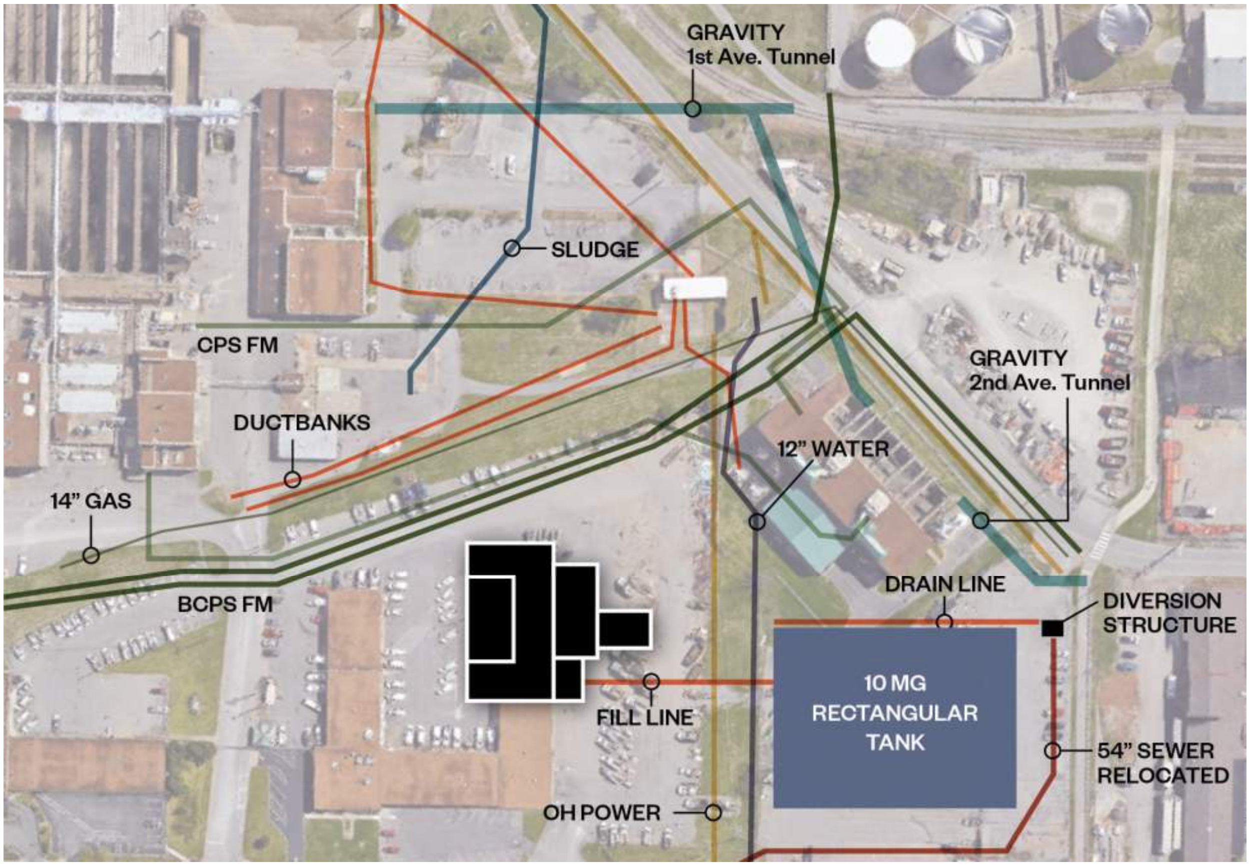

Figure 4-17: Alternative 3C Tank Layout

4.4.7.1.1 Hydraulics

Hydraulics would be dictated by the same upper and lower limits as Alternatives 3A and 3B.

4.4.7.1.2 Flow Schematic

The Fill / Flow Schematic for Alternative 3C is shown in **Figure 4-17**.

4.4.7.2 Washdown

The 200-foot dimension of the tank allows for a single pass flush bay utilizing either tipping buckets or flushing gates. The tank could be constructed with bays to only fill sections of the tank during lower flow EQ events to reduce cleaning and maintenance.

5. Key Issues

Utilizing the existing south plant tankage for EQ/EFTU (Alternative 1) is the preferred alternative since the alternative includes reuse of existing infrastructure and also provides the added benefit of EFTU functionality improvements. However, Alternative 1 also includes outstanding risks associated with undefined rehabilitation costs and other unknowns associated with modifying existing 60-year-old infrastructure. In advance of a final selected alternative, more information is needed to provide MWS with sufficient information to select the preferred alternative. The outstanding issues include:

1. Additional structural evaluation by the Hazen team structural engineer
2. Additional detailed sub-surface exploration using GPR and possible excavation of the tank floor in suspect areas
3. Coordination with the selected CMAR contractor once the CMAR contract is in place to receive contractor input on perceived risks and rehabilitation cost implications

Assuming these issues can be addressed and risks are deemed reasonable, Alternative 1 will be recommended. If risks or anticipated costs are too high, one of the Alternative 3 variants will likely be recommended.

Technical Memorandum

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Prepared for: Metro Water Services

Project Title: Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Project No.: 148388

Technical Memorandum No.13A

Subject: Biosolids Centrate and Condensate Treatment

Date: December 21, 2016

To: Trey Cavin, Metro Water Services

From: BWSC

Copy to: Ron Taylor, Metro Water Services

Prepared by: Bill Hamilton
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Limitations:

This document was prepared solely for Metro Water Services in accordance with professional standards at the time the services were performed and in accordance with the contract between Metro Water Services and Brown and Caldwell dated September 15, 2015. This document is governed by the specific scope of work authorized by Metro Water Services; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by Metro Water Services and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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Executive Summary

The following technical memorandum (TM) summarizes improvements and modifications to the centrate and condensate (C/C) collection system to provide additional solids removal prior to the return of the C/C liquid flow and infrequent digester overflows to the Central Wastewater Treatment Plant (CWWTP) or digesters. The C/C flow is currently recycled to the central pump station (CPS) of the CWWTP and represents a substantial (~15-20 dry ton/day) solids load. This TM summarizes an approach, utilizing a new pump station (PS) and existing equipment, to improving the solids recovery from this stream prior to recycle and reducing the solids loading on the liquid stream processes.

An existing dissolved air floatation thickener (DAFT) will be designated as a dedicated treatment unit to provide additional treatment of C/C flow from the new pump station, assuming all DAFTs are operational and there is excess DAFT capacity available. Should a DAFT be off-line or excess capacity not be available, the system can be modified to distribute the C/C flow from the new pump station among the remaining DAFTs in service. If the DAFTs are unable to treat the C/C, then the plant will have the operational flexibility to return to the current operation of sending all flow back to CWWTP. In order to provide this treatment and flexibility, a new forcemain (FM) connection from the existing DAFTs to the digested sludge storage tank, modifications to the influent splitter box, and modifications to the thickened sludge pump discharge piping will be required, in addition to the new C/C pump station. An emergency overflow will also be installed between the new PS wet well and the existing recycle PS wet well to route solids-laden C/C flow to the CWWTP.

Section 1: Process Area Description

This TM documents the basis of design and conceptual layout for additional treatment of C/C flows discharging from the dryer building (from centrifuges, dryer condenser, and Venturi scrubber operations) at the Metro Water Services (MWS) Biosolids Facility. Centrate from the dewatering of digested solids and condensate from the drying of dewatered cake is currently collected and conveyed by gravity to the recycle PS via an 18-inch line, where it is currently pumped (recycled) to a sanitary sewer manhole and then flows by gravity to the CPS, the head of the CWWTP. This routing is temporary and will be modified by MWS to discharge to the south primary bypass channel via the process center tank drainage PS. This combined flow contains colloidal and dissolved solids with average total solids (TS) content of 0.20-0.25 percent solids. Due to the volume of the combined C/C flow, recycling this flow results in a considerable solids load (estimated at 15-20 dry ton per day) to the CWWTP and results in retreatment of solids that have already been fully processed by the CWWTP and biosolids facilities. The methods outlined below will not increase the overall solids loading to the DAFTs since these solids would eventually be pumped back to the Biosolids Facility; however, it will increase the hydraulic loading to the DAFTs. In essence, the solids recirculation will be shortened so that solids remain on the Biosolids Facility site and will not be retreated at CWWTP.

In order to reduce this side stream loading to the CWWTP and minimize recirculation of solids at the CWWTP and Biosolids Facility, additional solids removal from this side stream has been proposed [Biosolids Assessment TM-17, 2015]. One proposed approach (Alternative 1) consists of converting one of the four existing DAFTs currently used to thicken sludge from the CWWTP and Whites Creek WWTP and modifying it to serve as a dedicated DAFT for C/C flows. By intercepting the combined C/C flow and redirecting it via a new dedicated pump station to the modified C/C DAFT, additional solids could be removed before recycling the treated subnatant to the CWWTP, thus reducing the solids loading on the CWWTP. The float and settled solids from this dedicated C/C DAFT would be discharged directly to the digested sludge storage tank (DSST), thus reducing the volume of solids that would ultimately find their way back to the digesters.

This proposed operating scenario has many merits, including the use of existing infrastructure; however, the existing DAFTs have experienced operational and mechanical issues, which have impacted the ability to operate the full complement of DAFTs on a consistent basis. This may limit the use of one of the existing DAFTs for dedicated side stream treatment.

Alternatively, it was proposed (Alternative 2) to redirect the C/C flows (again with a new, dedicated pump station) back to the DAFT splitter box and mix C/C flows with raw sludge prior to thickening in the DAFTs. While this approach would reduce the solids load at CWWTP, the continued retreatment of previously digested solids represents wasted energy, and the solids load would continue to consume some of the digester capacity.

As an alternative to the first approach (Alternative 1), the construction of a new, dedicated DAFT for side stream treatment was considered (Alternative 3). While the dedicated system would provide additional reliability to the primary operation of the facility (treatment of solids produced at the CWWTP) and make side stream treatment independent from the operational reliability of the existing DAFTs, this alternative was found to be considerably more expensive and would add an additional maintenance burden to the Biosolids Facility. A hybrid solution capitalizing on the benefits of Alternatives 1 and 2 has been proposed which allows an existing DAFT to be used to treat C/C flows when excess DAFT capacity is available and online; when an excess DAFT is unavailable, C/C flows would be directed to the DAFT splitter box for distribution to the remaining DAFT units online. This alternative provides the flexibility to respond to the reliability of the existing DAFTs; reduces solids loads to the CWWTP; and, during periods when excess DAFT capacity is available, minimizes the retreatment of previously digested solids.

Figure 1 identifies the location of the existing DAFTs, the recycle PS, and the relevant piping associated with this process modification at the Biosolids Facility.

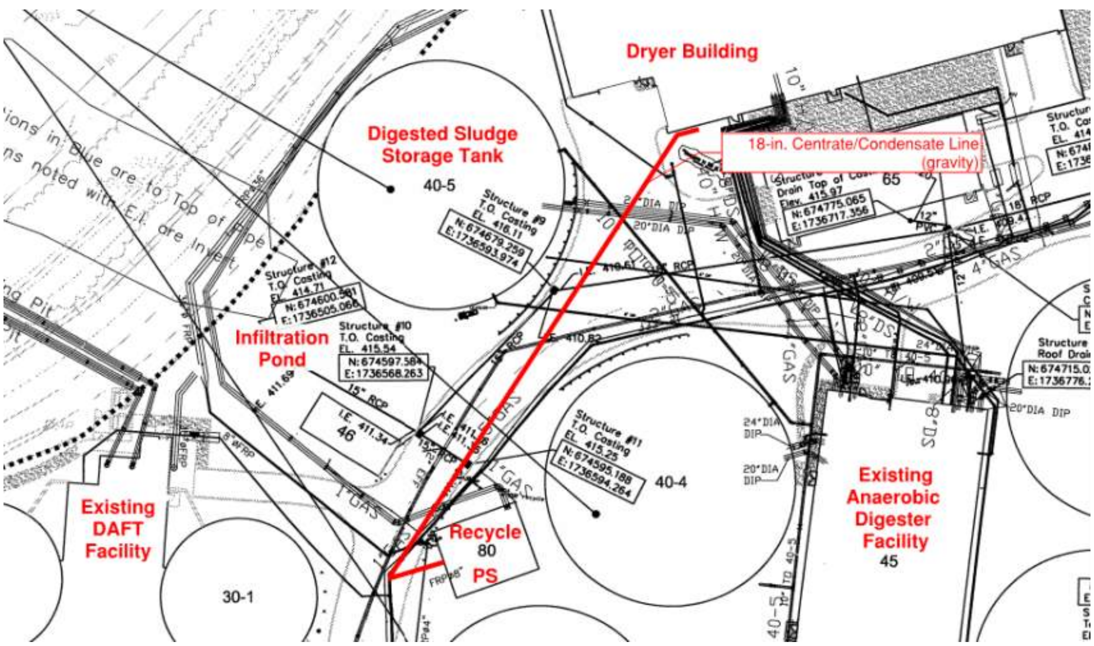

Figure 1: Existing DAFTs, the Recycle Pump Station, and the Relevant Piping Associated with Centrate/Condensate Treatment at the Biosolids Facility.

Section 2: Design Intent

The modifications to this process area are proposed in order to:

- Modify existing piping, install a new pump station, and design new piping to divert the C/C flow for additional treatment;
- Provide additional treatment to the combined C/C waste stream using existing treatment units (DAFTs) to significantly reduce the solids loading to the CWWTP;
- Provide treatment and operational flexibility that maximizes the capture of digested solids in the C/C waste stream in a dedicated system that bypasses digestion (Alternative 1), while also providing a means of solids treatment when the dedicated system is unavailable (Alternative 2).

Section 3: Constraints

3.1 Design Criteria

The following general criteria are used to design the C/C pump station and FM:

- Polymer type and dose to be determined with jar testing/pilot testing prior to modifications
- Maintain 2 to 3 feet per second (fps) in FM

Table 1 summarizes the ranges in flows and concentrations that are typical for the combined C/C waste stream: Note that the values for flows and concentrations found in Table 2 are considerably lower than the flows and concentrations used as a basis of design for the existing DAFT units (BODR, 2006).

Table 1. Characteristics of Influent Flows

Criterion	Minimum	Design	Maximum
Influent Flow[a], MGD	0	1.4	2.0
Influent Flow[a], gpm		970	1,400
Centrate Flow[a], MGD		0.29	
Condensate Flow[a], MGD		1.11	
Influent TSS[a] Concentration, mg/L	--	2,300	4,000
Temperature, °C	10	40	60
Effluent TSS Concentration, mg/L	0	200	400
Polymer Dose[b], #/DT	0		10

[a]Polymer dose based on bench scale testing by Brown and Caldwell (TM-17).

Table 2 summarizes the criteria used to design the existing DAFTs. Note that the existing DAFTs were designed to treat higher flows (2 MGD) at higher solids concentrations (5,575 mg/L). Additionally, the existing DAFTs were designed assuming one unit was redundant (3 units required to treat the design flows and loads.)

Table 2. Design Criteria for Existing DAFTs			
Criterion	Minimum	Design	Maximum
DAFT capture, %		>90	
Surface Overflow Rate (SOR), gpd/ft^2		620	930
Solids Loading Rate (SLR), lbs./d/ft^2		28.8	53.5
Air/Solids ratio		0.03	

Table 3 summarizes the operating conditions used to size the C/C pumps. For consistency, Flygt centrifugal submersible pumps were assumed.

Table 3. Assumed Pump Operating Conditions[a]					
Pump	Type	No.	Flow (gpm)	Head (ft.)	Power, each (HP)
New C/C PS	Submersible Centrifugal	3	1,400	40	10

[a] *Assume 70% efficiency for pumps*

Concrete:

- Wet well: 12-ft. x 12-ft. x 15-ft.; 18-in wall and slab thickness

3.2 Code Considerations

- 2012 International Building Code with Local Amendments
- 2012 International Energy Conservation Code
- 2012 International Plumbing Code with Local Amendments
- 2012 International Mechanical Code with Local Amendments
- 2012 International Fuel Gas Code with Local Amendments
- 2011 National Electrical Code with Local Amendments
- 2012 International Fire Code with Local Amendments
- 2012 Life Safety Code (NFPA 101) with Local Amendments
- 2012 International Fire Code (NFPA 820) Fire Protection in Wastewater Treatment and Collection Facilities
- American Society for Testing Materials (ASTM)
- 2015 Hydraulic Institute Standards (HI)
- National Electrical Manufacturers Association (NEMA)
- Standards of the Occupational Safety & Health Administration (OSHA)
- 2016 State of Tennessee, Department of Environment and Conservation, Division of Water, Design Criteria for Sewage Works

Pavement:

- AASHTO Guide to Design of Pavement Structures, 4th Ed., 1998

3.3 Regulatory Drivers

Reduction of solids stream recycled to CWWTP will potentially enhance secondary clarification capacity and permit compliance at the plant.

3.4 Sequencing and Constructability Issues

Pumping facilities and new piping will be constructed off line to minimize impact on existing treatment processes until the systems are switched over.

Piping modifications should be coordinated to minimize the disruption to the Biosolids facility operation:

- New piping connections to the combined C/C line around the recycle pump station will require excavation of the manhole and large diameter pipe in the road through the facility. This will effectively close the internal facility road between the digesters and the DAFT building (1st Avenue N.). A temporary detour using the service road to the east of the facility will be required.
- Piping modifications to the influent piping to the DSST may cause a temporary interruption to the DSST influent piping.
- Piping modifications should be coordinated with the current design build project to either tie into 8-inch tee and valve to the sludge transfer manifold, or discharge piping directly to DSST and tie into 10-inch sludge transfer line.
- New pipe connections between the existing C/C line and the new C/C PS may require temporary bypass pumping of DAFT subnatant and C/C flows unless coordinated with a shutdown.
- New pipe connections between the new C/C FM and the influent piping to DAFT 1 will require DAFT 1 to be taken off-line.
- Modifications to the DAFT splitter box, including the modification of the existing splitter box overflow, will cause a temporary interruption in DAFT operation.
- An overflow/passive bypass from the C/C PS to the existing recycle PS will be required, which may result in temporary interruption of pumping.
- Overflow elevations in the DAFT splitter box should be hydraulically modeled, and overflow elevation should be modified, if necessary, to prevent excessive bypasses of DAFT influent flows under the modified flow regime.
- Maintain facility operations to the greatest extent possible during construction
- Minimize disruption to the greenway and roadways during construction

3.5 Operational Issues

For the alternative outlined in this TM to be feasible, existing DAFTs will need to be more reliably operational for a dedicated DAFT to be used. Additionally, it may be necessary to modify current operations to manage the additional solids directed to the existing DAFT units.

Additional Jar Testing and on-site piloting are recommended to determine the appropriate polymer dose for the C/C feed and for the combined sludge – C/C feed. The site piloting will likely involve the use of a trailer mounted unit which can be brought to the site. When switching between modes of operation, set points for polymer feed may require adjustment to achieve adequate solids removal.

The operating scheme outlined in this TM assumes that valve adjustments are all made manually. Alternatively, these changes could be automated with valve adjustments made on the SCADA system and after additional actuators on the critical valves and gates are added.

Section 4: Description of Improvements

4.1 Centrate and Condensate Capture Improvements

4.1.1 Detailed Design Considerations and Assumptions

The content of this TM summarizes a conservative approach to solids removal from the C/C line at the Biosolids Facility. Prior to execution of this plan, it is recommended that a pilot study be conducted to evaluate the use of an existing DAFT for treatment of this waste stream. This pilot study would utilize a trailer-mounted pilot unit and temporary pumping and piping, contingent on manufacturers'' recommendations, and it would evaluate the treatability of the waste stream to optimize polymer doses and capture rates over the solids loading rates likely to be encountered.

4.1.2 Process Mechanical

4.1.2.1 Process

- Provide additional treatment to the combined C/C waste stream to reduce the solids loading to the CWWTP (See Figure 2.);

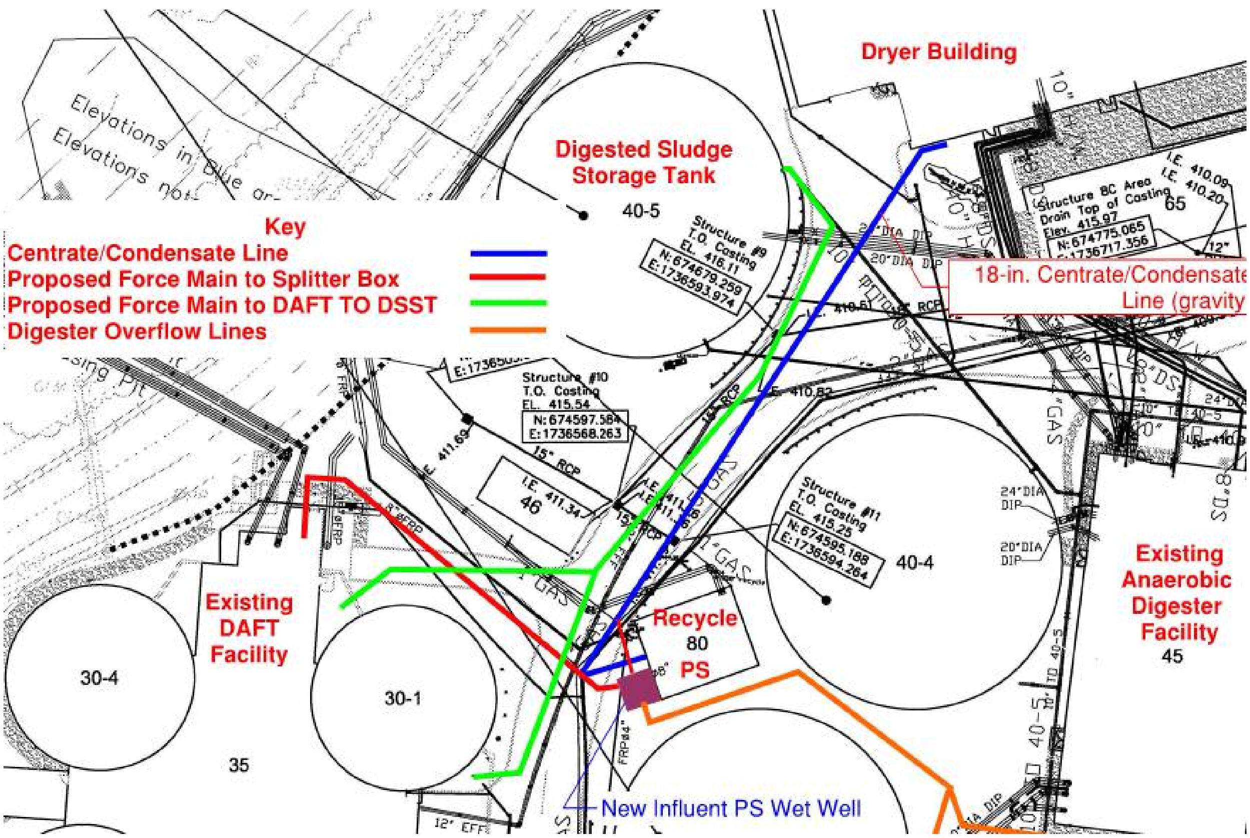

Figure 2: Treatment of Centrate/Condensate Flow Using Existing Equipment

- Intercept the C/C waste line prior to its discharge into the manhole southwest of the recycle PS wet well;

- Construct a new, dedicated pump station (C/C PS) to capture the C/C flow before it enters the recycle PS;
  - Station shall be constructed adjacent to the existing recycle PS;
  - Station shall be approximately 12 ft. x 12 ft. x 15 ft. and formed from cast-in-place reinforced concrete;
  - Station will be a triplex system (2 duty/1 standby) with 10-HP submersible pumps with variable frequency drives to adjust to changing flow conditions;
  - Each pump discharge will include a 12-inch check valve and a 12-inch plug valve for isolation;
  - Pump speed will be controlled by a local level indicator in the new wet well;
  - Station will be designed to convey the peak design flow at the total dynamic head between the new pump station wet well and the DAFT 1 influent line or DAFT splitter box;
  - Station will include a bypass to revert to pumping untreated C/C flow to the CWWTP via the recycle PS when the new C/C PS is out of service.
  - Pump operation and wet well level will be connected to plant SCADA system.
- Construct a new, 12-inch DIP FM to reroute the C/C flow to the influent line to DAFT 1 or to the influent to the DAFT splitter box.
  - A new 150 ft. FM between the existing DAFT building and the C/C PS should have two options for discharge (Figure 3):
    - The primary discharge point will be a direct connection into the existing 12-inch DAFT 1 influent line to allow DAFT 1 to provide dedicated treatment of the C/C flow;
    - The secondary discharge point will be a direct connection into the 14-inch influent line of the DAFT splitter box to allow the C/C flow to be distributed to all DAFTs in service;
  - The forcemain will include two 12-inch manually operated plug valves to direct flow to either discharge point.
  - A 12-inch wall penetration will be required to connect the new FM to the splitter box piping gallery through the existing exterior wall;
  - During design, the hydraulics of the splitter box will be evaluated to determine the impact of increased flow on the required overflow structure elevation. The structure may need to be extended to accommodate the additional flows;
- Allow the discharge of thickened sludge (float solids) from DAFT 1 to be pumped directly into the DSST to avoid retreatment of processed solids at the Biosolids Facility:
  - Modify the discharge piping from the thickened sludge pumps associated with DAFT 1 to allow the transfer of thickened sludge either to the existing thickened sludge storage tank or the DSST:
    - Install 6-inch plug valves and fittings to facilitate pumping thickened sludge from DAFT 1 directly to the DSST and to the thickened sludge storage tank, it’s current discharge location;
    - Install a 6-inch DIP FM connecting each of the two thickened sludge pumps associated with DAFT 1 to the DSST;
    - Modify the influent piping to the DSST to allow direct discharge of thickened sludge from DAFT 1 into the DSST.
    - Install Approximately 400 ft. of 6-inch glass-lined DIP.

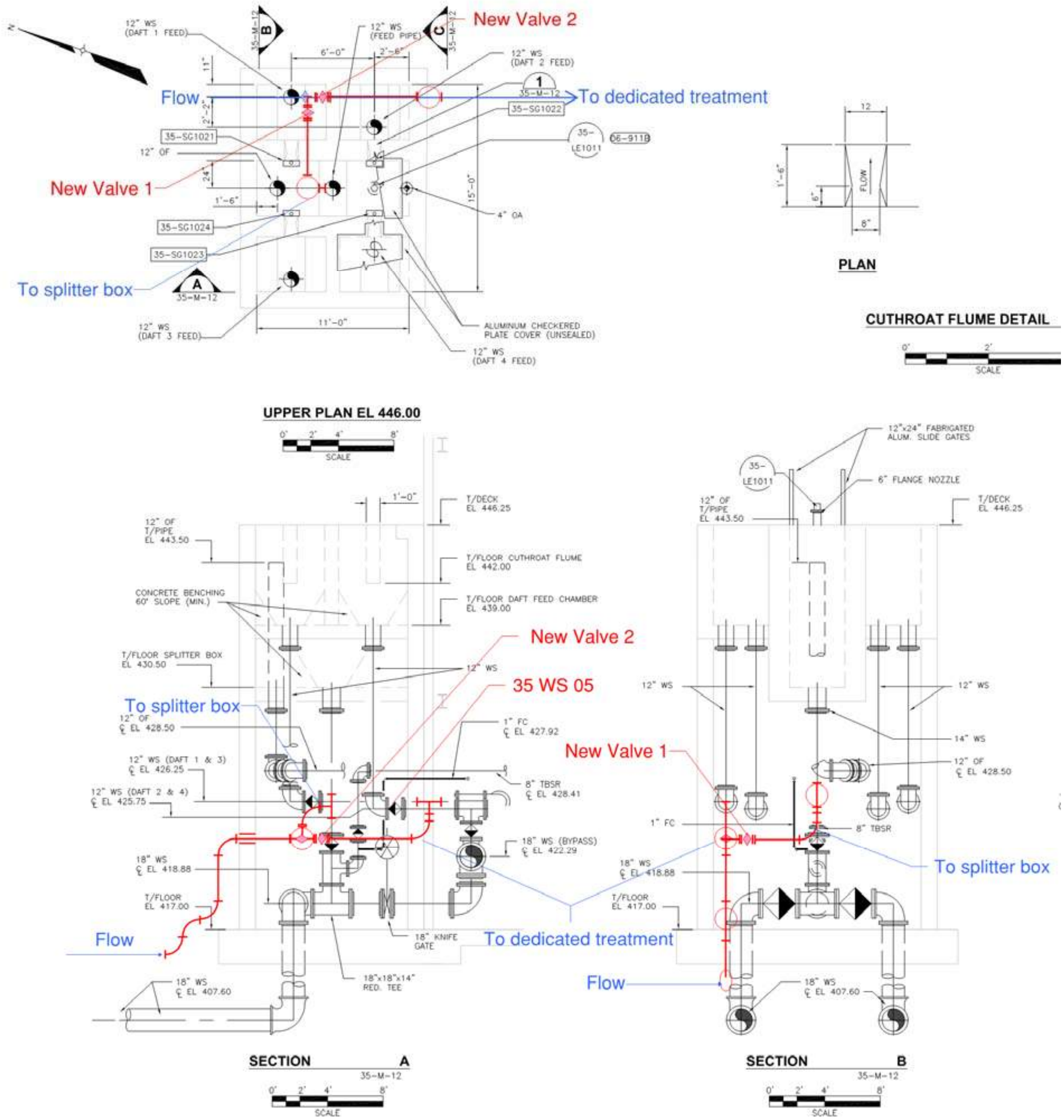

Figure 3: DAFT Splitter Box Piping Modifications

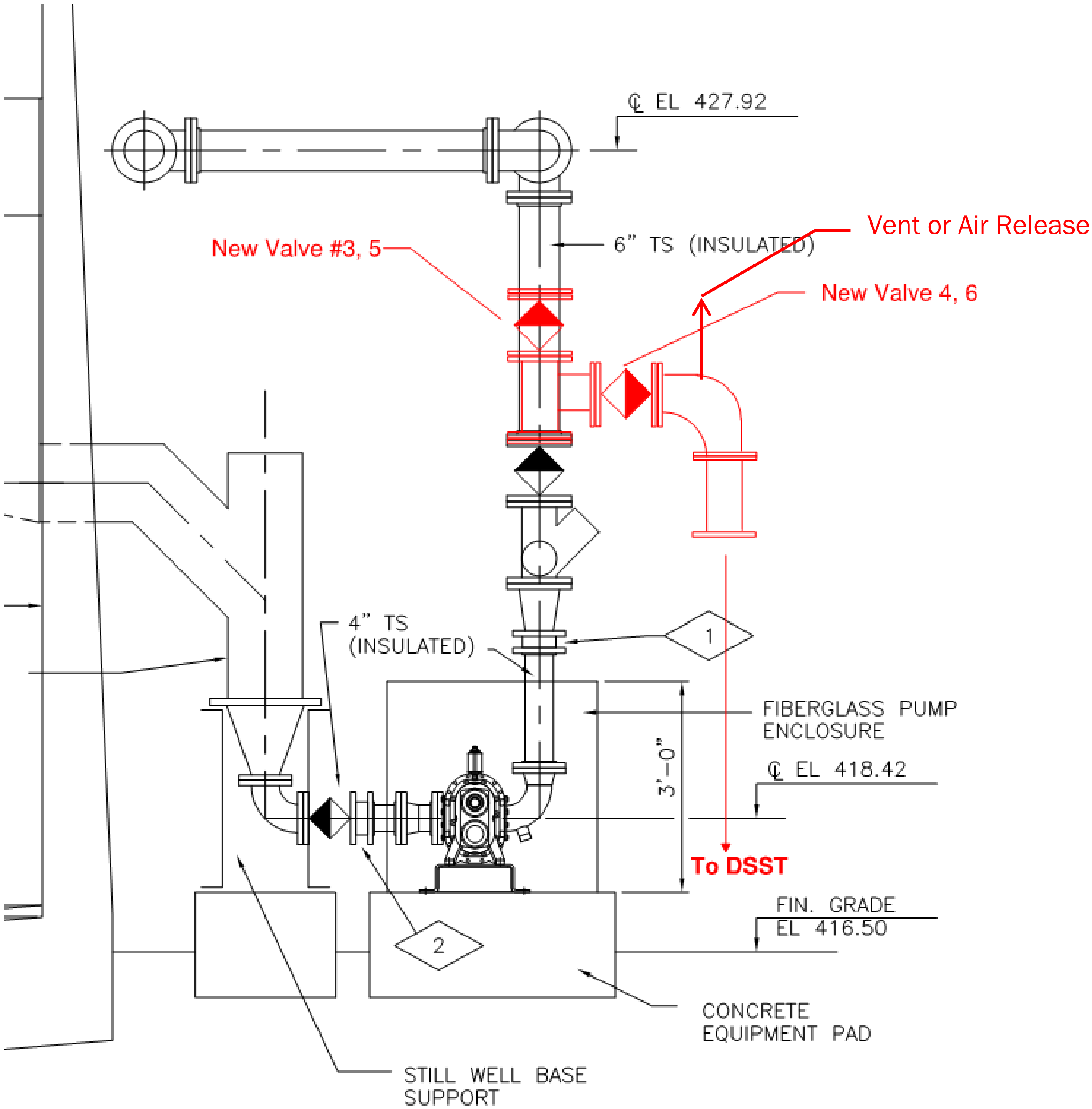

Figure 4: Thickened Sludge Pump Discharge Modifications

4.1.2.2 Odor Control

NA

4.1.2.3 HVAC

NA

4.1.2.4 Plumbing

NA

4.1.3 Instrumentation and Controls

New C/C PS:

- The new influent PS pump motors will include variable frequency drives (VFDs) for speed control.
- Monitoring and status unit will include typical submersible pump alarms/monitoring (vibration, motor bearing, temperature, etc.)
- VFDs will be controlled locally with an analog signal from a level indicator in the wet well. Pump operation, pump settings, and pump speed will be monitored and adjusted on the Plant SCADA system in the Biosolids Facility control room.
- Valve switch over will be manual.

4.1.4 Electrical

- Power to each 10-HP pump will be fed from a new motor control center (MCC) in the new electrical building that is being constructed as part of the digester design-build project. The new electrical building will be located between digester 3 and the fats, oils, and grease (FOG) receiving station.
- Coordination with design build project will be required.
- Each pump will be driven by a dedicated VFD.
- The programmable logic controller panel that is being installed in the new building 47 as part of the ongoing digester cover and mixing improvements project will run all three pumps.
- Conduit will be run from the new electrical building to the C/C PS. Pump control panels and VFDs will be installed along the wall in the new electrical building associated with the design-build project.

4.1.5 Structural

- A new 12-ft. x 12-ft. by 15-ft. (deep) wet well will be installed adjacent to the existing recycle PS.
- The exterior wall of the recycle PS will form one of the walls of the wet well.
- Individual aluminum hatches will cover the pumps to provide maintenance access to the pumps.
- A passive bypass will be cored into the existing wetwell wall to provide emergency relief to the recycle PS in case of C/C PS failure.

4.1.6 Geotechnical

- See Geotechnical Report (dated September 29, 2005) for details of subsurface conditions.

4.1.7 Architectural

N/A

4.1.8 Site Civil

- Site work for the following installations will need to be performed (sizes, quantities, and locations have been described previously):
  - New C/C pump station
  - New FM between DAFT building and splitter box and DAFT 1
  - New FM between DAFT 1 and DSST
  - New electrical conduit between new pump station and new electrical building being constructed during design-build project.

- Pavement will be repaired to meet AASHTO Guide for Design of Pavement Structures, including a 1.5-inch asphalt surface, a 2-inch binder layer, a 4-inch asphalt base, and a 10-inch stone base.

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Technical Memorandum

Prepared for: Metro Water Services

Project Title: COPT - BODR

Project No.: 148388

Technical Memorandum No. 13B

Subject: Waste Gas Flare and Appurtenances and Biogas Compressors

Date: December 21, 2016

To: Trey Cavin, Metro Water Services

From: BWSC

Copy to: Ron Taylor, Metro Water Services

Prepared by: ______________________
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Executive Summary

The biogas management system at the Metro Water Services (MWS) Biosolids Facility is currently subject to wide swings in biogas production and pressure, resulting in unstable and inefficient operation, due in part to semi-batch digester feeding, flare sizing, and gas production. These factors result in considerable header pressure variations throughout the day. When the pressure in the gas system triggers the valve at the existing flare to open there is a rush of gas that passes to the flare which results in a quick reduction in gas pressure in the system. This rush of gas to the flare is caused by the high minimum biogas flow requirement needed for the existing biogas flares (~400 SCFM). The activation of these flares results in large pressure swings as biogas is rapidly evacuated from the digester headspace. These pressure swings lead to cycling of biogas management equipment (the Dystor fans, biogas compressors) along with cycling in the operation of the flares. This cycling also leads to excess gas being routed to the flares instead of its beneficial use as a fuel for boiler heating and dryer operations.

In order to respond to the variable gas production and pressure conditions of the gas management system, a smaller capacity flare with wider turndown is required. A smaller capacity flare will be able to respond to the variations in pressure without consuming excess gas, thereby leaving additional gas available for beneficial use. As part of this modification, a permanent structure will be constructed to provide freeze protection for the appurtenances for the new and existing waste gas flares. Combined with improvements to the digester feeding operation, this should improve the stability of the gas management system and facilitate more efficient biogas usage on site.

In addition to the waste gas flare improvements, new blowers will be added, in place of the existing liquid ring compressors, to the digester gas dryer train to better match the dryer pressure requirements and to provide variable speed operation to improve efficiency and better respond to variations in gas demands.

Section 1: Process Area Description

This Technical Memorandum (TM) documents the basis of design and conceptual layout for modifications to the existing digester gas management and utilization system at the MWS Biosolids Facility. The purpose of this system is to safely collect, convey, and beneficially utilize available digester gas in the dryers and boilers at the Biosolids Facility. The gas undergoes limited treatment (moisture removal and pressurization) prior to utilization in the dryers. As designed, a portion of the digester gas that is currently produced must be flared as only approximately 60 percent of the gas can be utilized by the dryers and boilers. MWS has recently added improvements to the dryer gas trains to increase the utilization of digester gas.

The existing waste gas flares are sized for a maximum flow of 2,100 SCFM each. At an allowable 5:1 turndown, the existing flares have a minimum operating flow rate of 420 SCFM. The minimum flow rate is required to meet emissions requirements during flaring.

Currently, average gas production in the anaerobic digesters has been estimated at 550 SCFM [Energy Management Program TM 3, 2014]; future improvements in the digestion process (draft tube mixers, continuous feed) could increase average gas production to 725 SCFM (Energy Management Program TM 3, 2014). The gas system pressure set point is anticipated to continue to be 8-10 inches (inch) water column (w.c).

Because of the current method of feeding the digesters and the minimum allowable flow rate of the flares, the gas management system experiences large swings in system pressure and digester gas production. Gas production and digester gas system pressure increase during intermittent (batch) digester feeding, eventually activating the flares. The high minimum flow rate of the flares quickly evacuates the digester headspace leading to a rapid pressure drop in the gas management system. These large swings in biogas pressure cause instability in the gas management system and lead to inefficient use of biogas in boilers and dryers.

These large pressure swings in the gas management system also have a negative impact on other components of the biogas management system. Cycling the waste gas flares on and off can cause a premature breakdown of the refractory insulating blanket within the enclosure. The Dystor gas storage system inflation fans, and the liquid ring compressors used to pressurize digester gas for use in sludge dryers, experience these wide pressure swings and must attempt to compensate.

In addition to the supply-side pressure variations, the existing liquid ring compressors are constant speed machines that utilize pressure-based gas return valves (pressure regulating valves) to accommodate variable demand for digester gas. These valves automatically recirculate digester gas back to the suction side (low pressure side) of the compressors when the compressor capacity exceeds the digester gas demand of the dryers and the discharge pressure exceeds the valve setpoint. The end result is that the compressors typically operate at a higher rate and use more electricity than is necessary. In fact, when a dryer train is taken off-line, the compressors continue to operate at 100 percent recycle until the units are manually shut down.

The existing appurtenances for the waste gas flares are subject to freezing, which can result in valve blockage and pipe breakage. Currently, plant staff has constructed a temporary shelter over the appurtenances made from heavy gauge aluminum sheeting. Explosion-proof heaters have been installed inside the structure to prevent freezing. As part of the waste gas flare construction, a permanent structure will be installed over the existing and new gas appurtenances to prevent freezing. The structure will include heaters and proper ventilation for a classified environment.

Figure 1 identifies the location of the existing gas flares and liquid ring compressors at the Biosolids Facility.

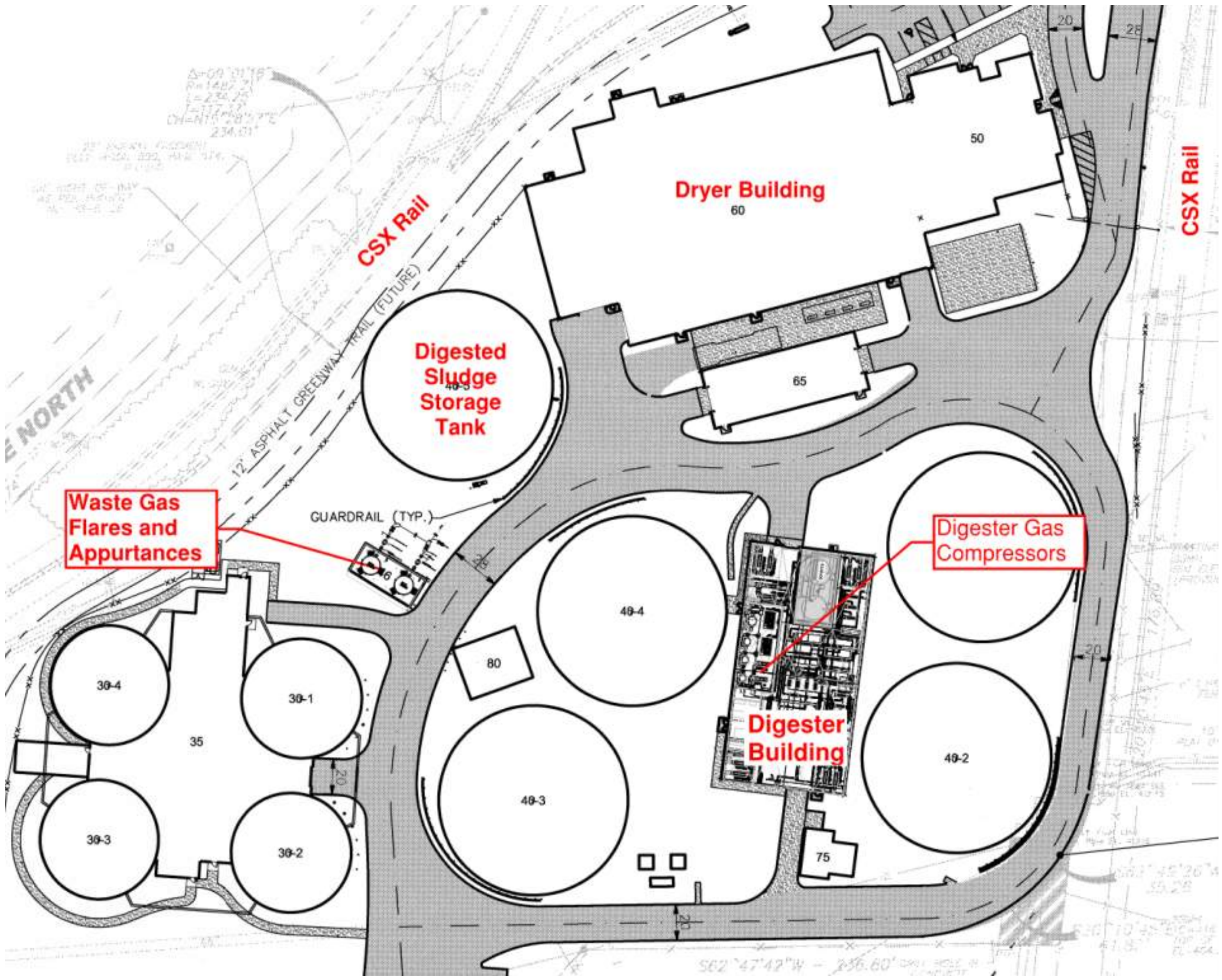

Figure 1: Biosolids Facility with Location of Flares and Compressors.

Section 2: Design Intent

The design intent for this process area is:

- Provide a new gas flare that can operate at gas flow rates lower than the sustained minimum gas flow rate required to be flared to minimize pressure swings and increase the efficient use of digester gas in the boilers and dryers. This minimum gas flow rate is substantially lower than the minimum flow rates that can be efficiently flared by the currently installed flares. The new gas flare will be an enclosed, low-emission type, similar to the current flares but with much better turndown and control capabilities.
- Provide properly sized piping, fittings, valving, and appurtenances to safely and effectively convey waste gas to the new flare.
- Enclose appurtenances in a permanent weather-proof enclosure to prevent the negative effects of condensate freezing.
- Replace existing liquid ring compressors with hermetically sealed centrifugal blowers and variable frequency drives to provide a more efficient operation and better meet the pressure needs of the biosolids dryers.

Section 3: Constraints

3.1 Design Criteria

Table 1 summarizes current gas production and consumption and associated peaking factors (PFs) for the digester gas handling system.

Table 1. Current (2015) Gas Production and Consumption (Energy Management Program TM 3, 2014)

Flow Duration	Production (SCFM)	Consumption (SCFM)	Flared (SCFM)
Average Day	488	306	182
Maximum Day	835	565	270
Average Month	555	303	252
Maximum Month	640	408	232

Gas Consumption (Dryers, assumes both units online):

- Theoretical maximum: 767 CFM (560 BTU/cf, 70 percent digester gas, 44 MBTU/hr) [Energy Management Program TM 3, 2014]
- Historical maximum: 666 SCFM (20,000 cf/hr per dryer) [Energy Management Program TM 3, 2014]

Table 2 summarizes projected gas production by 2021 and the basis of design for the existing flares at the Biosolids Facility.

Table 2. Projected Gas Production, 2021 (BODR. 2006)

Subhead	Production (SCFM)	Production PF
Average Annual	593	--
Maximum Month	784	1.32
Peak Day	1,238	2.09
2xMaximum Month	1,569	2.65
BODR, 2006	1,830	3.09

Velocity and Headloss in Biogas Piping:

- Maximum velocity in gas piping: 2,700 feet (ft)/min (14 m/s)

Ventilation Requirements for New Building over the Waste Gas Piping:

- Air turnover or refresh rate for the new enclosure over the existing gas valves will be 12 per hour for Class 1, Division 1.

Future Expansion

Gas Flares: The proposed three-flare arrangement provides for a wider range of gas flows that will accommodate more efficient biogas use at the facility (lower flaring rates) as well as greater gas production with no biogas usage (higher flaring rates). With the new flare, the minimum biogas flare rate will be 75 SCFM and the maximum biogas flare rate of 750 SCFM and the firm flare capacity (maximum flaring capacity with the largest flare out of service) will be 2,850 SCFM.

- New piping is sized for the maximum flow condition to the new smaller flare.
- Existing piping is large enough to accommodate future flows.
- Blowers will be sized to meet both current low flows and anticipated future high flows.
- Minimum pressure at the flare: 9 in w.c.

3.2 Code Considerations

- 2012 International Building Code with Local Amendments
- 2012 International Energy Conservation Code
- 2012 International Plumbing Code with Local Amendments
- 2012 International Mechanical Code with Local Amendments
- 2012 International Fuel Gas Code with Local Amendments
- 2011 National Electrical Code with Local Amendments
- 2012 International Fire Code with Local Amendments
- 2012 Life Safety Code (NFPA 101) with Local Amendments
- 2012 International Fire Code (NFPA 820) Fire Protection in Wastewater Treatment and Collection Facilities
- National Electrical Manufacturers Association (NEMA)
- Standards of the Occupational Safety & Health Administration (OSHA)
- 2016 State of Tennessee, Department of Environment and Conservation, Division of Water, Design Criteria for Sewage Works

3.3 Regulatory Drivers

Part of this design requires that a slab for the new waste gas flare be constructed within the extent of the existing stormwater infiltration pond adjacent to Area 46. The implications of altering the existing stormwater infiltration pond will be determined based on discussions with Metro Stormwater. Additional volume may need to be excavated in the area to compensate for the volume occupied by the new slab.

3.4 Sequencing and Constructability Issues

Gas Flares and Appurtenances:

1. The design will minimize the duration and quantity of methane discharge to the atmosphere, as practical. A detailed MOPO will be developed in collaboration with MWS and the CMAR to facilitate construction while minimizing methane emissions and promoting safe work practices. It is anticipated that the smaller flare and piping will be constructed and in place up to the tie-in location. Location of the new digester gas piping tie-ins to the existing piping will be considered in phase 2 detailed design to minimize and potentially eliminate discharge of methane gas.
2. Working on or around biogas systems carries an increased risk of asphyxiation and fire or explosion. Proper lock out/tag out procedures must be followed along with a safety plan by the contractor to safely evacuate the gas from the piping and provide proper safety procedures during construction activities. In

addition, gas sensors will be employed to monitor for unsafe biogas levels. Personal protective equipment should be used consistent with OSHA recommendations.

3. Installation of the new flare should be coordinated with flood mitigation activities. The new flare and new appurtenances should be installed with at least 6 inches of freeboard above the flood elevations.
4. After installation, the existing flares should be inspected by a qualified service technician to determine the state of the refractory lining in each of the existing flares. Repairs to existing flares can be made once the new flare is on line.

Blowers:

1. The existing liquid ring compressors will be replaced with hermetically sealed centrifugal blowers. During demolition and installation, no more than one compressor will be off-line at a time.
2. Electrical disruptions to the compressor control panel may be likely during installation of the blower control panel/variable frequency drive (VFD).

3.5 Operational Issues

The new flare can burn up to 750 SCFM of digester gas at 9–12 inch of w.c. When the flare is burning at the maximum rate and pressures continue to rise, flaring operations will need to switch to a larger existing flare.

- The existing control scheme will need to be modified to monitor both supply pressure and gas flare flow rate.
- During design, the gas flare system pressures will be determined for the most robust approach to manage the switching between flares.
- Blowers will operate on VFDs that will adjust speed based on blower discharge pressure.

Section 4: Description of Improvements

4.1 Waste Gas Flares

4.1.1 Detailed Design Considerations and Assumptions

Still to be decided/verified

- Gas headloss from the furthest digester to the waste gas flares (20-inch pipe) is less than 4 inch of w.c.
- Required turn down of the blowers is approximately 50 percent.
- The required discharge pressure for the blowers will be determined during phase 2 detailed design.
- Indoor air temperature 100°F max, 70°F min.
- Minimum daily mean outdoor air temperature of -5°F.

4.1.2 Process Mechanical

4.1.2.1 Process

Flares

A new enclosed-type gas flare with a maximum capacity of 750 SCFM at a minimum 9-inch w.c. (725 SCFM at 8-in w.c.) will be installed on a new concrete slab adjacent to (west of) the existing gas flares in Area 46 of the Biosolids Facility (Figure 2).

- The existing 20-inch digester gas header will be modified by adding a new digester gas supply train that will connect the new flare to the existing gas distribution system.
  - The existing stainless steel 20-inch 90° bend will be replaced with a 20x20x20-inch stainless steel tee, and the tee will be connected to the existing 20-inch isolation valve.
  - A new 20-inch stainless steel supply line will be constructed to supply the new flare. The supply line will include a 20-inch manual isolation valve suitable for gas service, a new combined flame arrester with thermocouple and explosion relief assembly, and a backpressure regulator valve. The back-pressure regulator will maintain the upstream system pressure at 9-12-inch of w.c.
  - New actuators will be installed on the isolation valves to each flare to allow for automated switchover between the low-flow and high-flow flares.
- The existing 1-inch natural gas supply for flare pilots will be extended to the new flare. A third pilot gas train with isolation valve and pressure regulating valve will be included.
- The new flare should have a minimum turndown of 10:1 and achieve this turndown by routing digester gas to different burner zones based on flow. Automatically actuated open/close solenoid valves associated with the different burner zones will be utilized to achieve the required turndown.
- Existing and/or required maintenance clearances will be provided for the new flare.
- Long-term maintenance needs associated with the infrequently used large flares will be identified and accommodated during phase 2 detailed design.

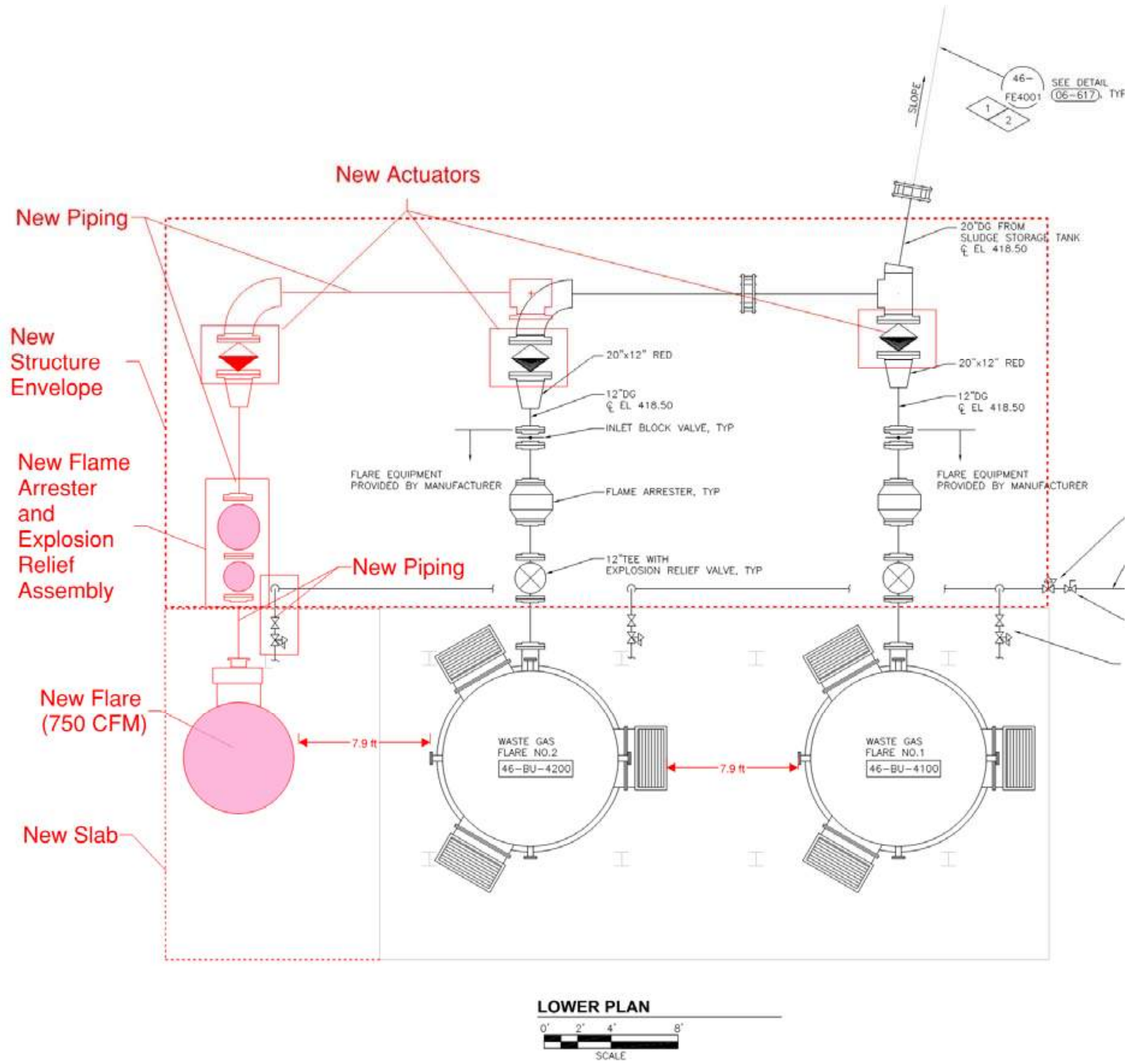

Figure 2: Addition of a New, Low-flow, Digester Gas Flare with Appurtenances and Shelter

Compressors

The existing liquid ring gas compressors will be removed and new multistage centrifugal blowers will be installed in the digester building.

- Blowers shall be sized for current and future gas production.
  - Current average gas consumption is approximately 300 SCFM (Table 1).
  - Required maximum flow rate is 750 SCFM for each blower;
  - The required discharge pressure for the blowers will be determined during phase 2 detailed design.
- Indoor Air Temperature
  - 100°F max

  - 70°F min
- Gas quality for blower and flares (60 percent CH_4, 40 percent CO_2, saturated in H_2O)
- VFDs should provide adequate turn down to accommodate historical lows (approximately 50 percent). VFDs can be installed in the electrical room adjacent to the existing compressors.
- Existing maintenance clearances will be provided.

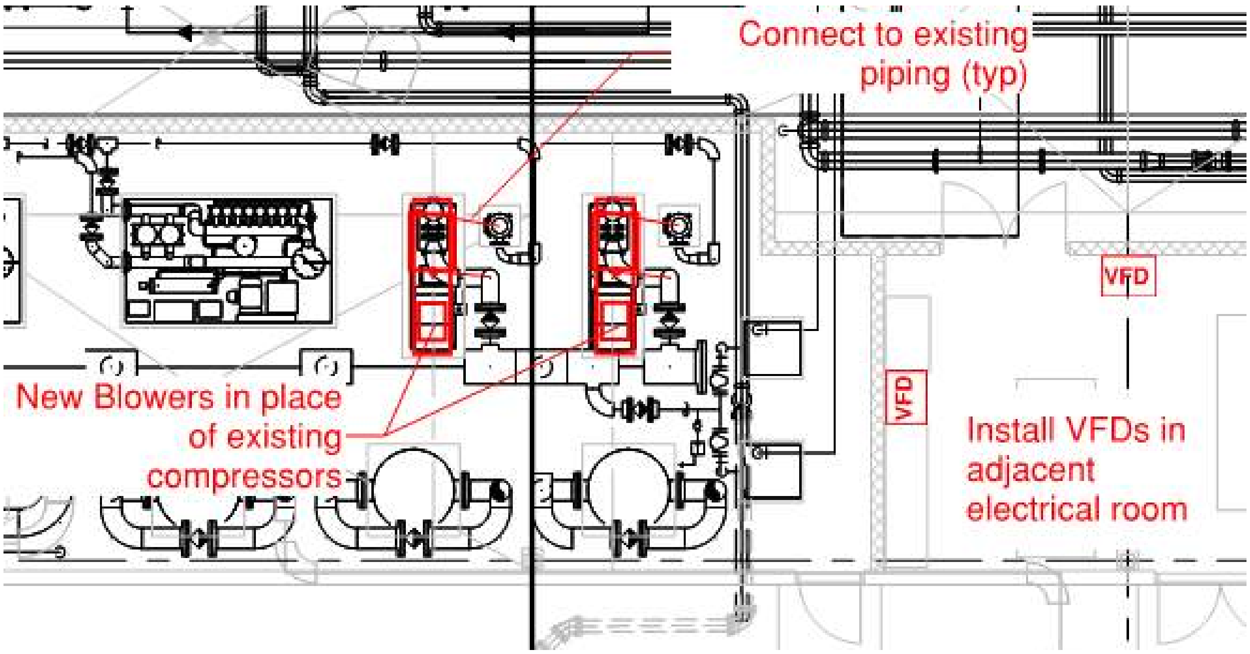

Figure 3: Location of New Hermetically Sealed Multi-Stage Centrifugal Blowers.

4.1.2.2 Odor Control

N/A

4.1.2.3 HVAC

A new enclosure will be built over the existing and new appurtenances feeding the gas flares. This enclosure will replace the existing temporary structure.

- The new enclosure will require air changes consistent with NFPA 820 for classified space.
  - The enclosure will require an air turnover of 12 times per hour since it is a Class 1, Division 1 space.
- The new enclosure will require permanent space heaters that meet the requirements of NFPA 820 for classified space. Per MWS, the existing heaters meet the requirements of NFPA 820 for the existing space, but the heaters will be evaluated for the new enclosure to ensure compliance is maintained.
- Space heaters should maintain ambient air temperature above freezing for a minimum daily mean outdoor air temperature of -5°F.

4.1.2.4 Plumbing

N/A

4.1.3 Instrumentation and Controls

- The initial control concept for the waste gas flares is to utilize the new flare as the duty flare and maintain the existing flares for occasions when both boilers and dryers are simultaneously out of service. The new flare shall operate in the range of 75 to 750 SCFM.
- In order to allow automatic switchover from the duty flare (the new flare) to the existing flare, both waste gas flow rates and system pressure shall be monitored.
- The waste gas flow rate signal will transmit from the existing flow indicating transmitter.
- If the duty flare is operating at maximum flow and system pressures continue to rise above a set point, one of the existing waste gas flares shall be activated. The initial concept for this switchover would be to turn down the duty flare to approximately 45 percent (330 SCFM) of its rated capacity and activate the existing flare at maximum turndown (420 SCFM). The duty flare could then be used to modulate gas flows between 495 SCFM (75 SCFM + 420 SCFM) and 1,170 SCFM (750 SCFM + 420 SCFM). For gas flows above 1,170 SCFM, the existing flares would be ramped up to manage flows.
- When system pressures recede and/or flow rates decrease to <495 SCFM, the existing flare shall shut down and the duty flare will operate alone.

4.1.4 Electrical

- The Control Panel and VFDs for the blowers will be supplied by the blower manufacturer and will be installed in the adjacent Electrical Room to ensure adequate cooling and to avoid the need for any equipment upgrades required in a classified environment.
- There may be challenges associated with locating the blower panels and drives in the adjacent Electrical Room, as there is not a lot of open wall space for new equipment. Existing equipment will be removed from the existing MCCs and space may be available. There are additional options, such as elevating transformers (suspending them from the ceiling), separate installation on opposite sides of the room where open space permits, or reclaiming one door of a double door to provide additional wall space for installation. These options will be evaluated during design.

4.1.5 Structural

The new flare will be installed on a new structural concrete slab, which will be supported on a deep foundation system.

The entire enclosure and everything inside will be classified.

The enclosure will have multiple entrances so that maintenance and operations crews have easy access without having to climb over piping.

New piping and appurtenances will be supported on concrete saddles or Stainless UniStrut supports as appropriate.

A new enclosure will be built over the existing and new appurtenances feeding the gas flares. This structure will replace the existing temporary enclosure.

- The enclosure will be a pre-engineered metal building with approximate dimensions of 23 ft wide by 53 ft long by 10 ft high.
- The enclosure will be constructed over the existing and new structural concrete slabs.
- The enclosure will be ventilated, heated, and lighted consistent with NFPA 820.
- The enclosure will include doors or removable panels that allow for maintenance and/or removal of any of the valves or appurtenances inside the enclosure.

4.1.6 Geotechnical

- Due to the large quantity of debris and fill material at the site, it is anticipated that micropiles will be required to support the foundation.
- Micropiles are preferable due to limited site access, anticipation of obstructions below grade, and in order to protect the existing structures against vibration damage.
- Geotechnical services will be required to provide recommendations for design.

4.1.7 Architectural

The exterior of the enclosure built over the slab for the flare appurtenances will be designed in such a way as to blend in to the existing facility architectural scheme.

The interior of the enclosure will be unfinished; however, electrical conduit and any other process piping will be painted in a manner that is consistent with the existing facility paint schedule.

4.1.8 Site Civil Scope of Improvements

Existing detention pond shall be regraded to accommodate volume lost to new flare slab.

The new flare slab will be constructed at an elevation to protect the flare from the 500-yr flood.

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Prepared for: Metro Water Services

Project Title: Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Project No.: 148388

Technical Memorandum No. 13C

Subject: Biosolids DAFT Modifications

Date: December 21, 2016

To: Trey Cavin, Metro Water Services

From: BWSC

Copy to: Ron Taylor, Metro Water Services

Prepared by: Bill Hamilton

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Executive Summary

The following Technical Memorandum (TM) summarizes improvements and modifications to the Dissolved Air Flotation Thickeners (DAFTs) and associated systems. Based on discussions and several site visits with operations staff, the following items were targeted in Areas 30 and 35 to improve biosolids operations and improve system reliability with the overall goal of maximizing system performance and up time to allow excess capacity to be used to reduce solids loading to the Central Wastewater Treatment Plant (CWWTP):

- Measurement of polymer flow to the individual DAFTs;
- Sampling of DAFT underflow and centrate/concentrate (C/C) to determine the solids load being returned to the CWWTP;
- Containment structures for the thickened sludge pumps to prevent thickened solids from being released to the environment.

Section 1: Process Area Description

This TM documents the basis of design and conceptual layout for modifications to the existing DAFTs at the Metro Water Services (MWS) Biosolids Facility. The purpose of this thickening system is to increase the solids concentration of the sludge from the CWWTP and Whites Creek WWTP (WCWWTP) by mixing it with polymer and compressed air. Destabilized and flocculated sludge is concentrated (thickened) at the surface of the DAFT and discharged via the thickened sludge pumps to the thickened sludge storage tanks prior to anaerobic digestion. Underflow (subnatant) is recycled from the Recycle Pump Station to the Central Pump Station (CPS).

Polymer usage in each DAFT is not currently metered and only the turbidity of the underflow is monitored so the total solids concentrations are unknown. In order to better monitor process performance and reduce the amount of solids returned in the subnatant to the CWWTP, the modifications to the existing thickening process included in this TM are recommended.

Figure 1 identifies the location of the polymer feed system, the DAFT underflow lines, and the thickened sludge pumps at the DAFT building in the Biosolids Facility.

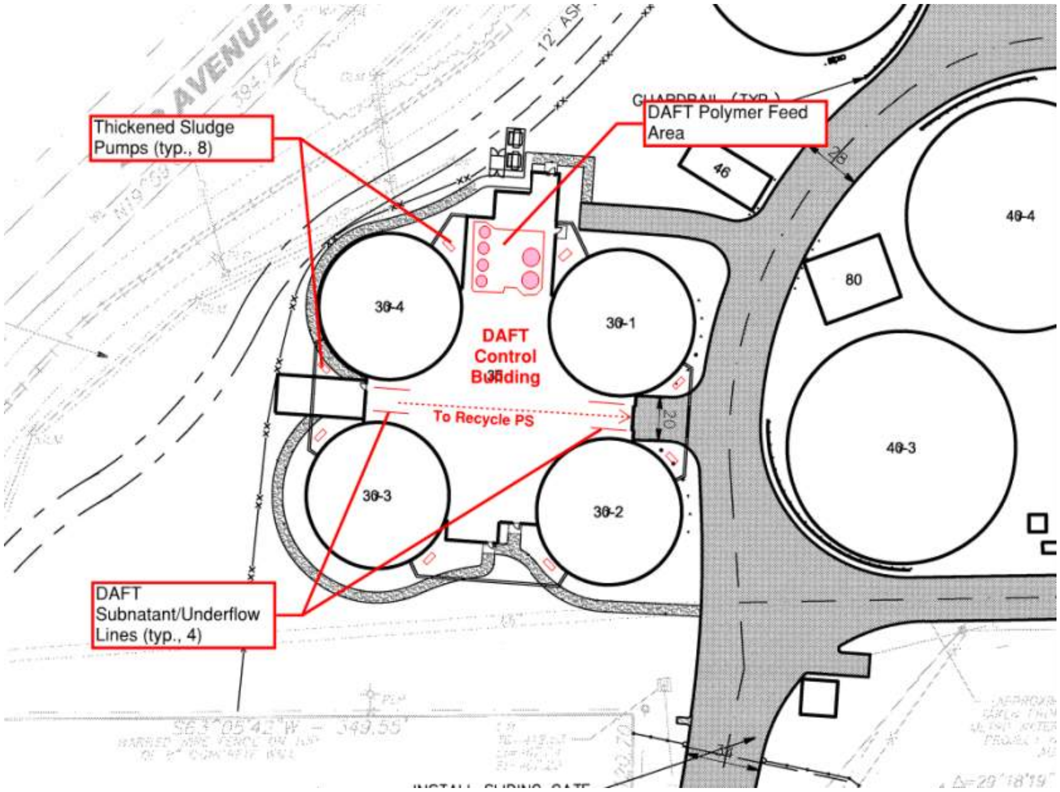

Figure 1: DAFT Building, including Polymer System and Thickened Sludge Pumps at the Biosolids Facility.

Section 2: Design Intent

The design intent for this process area is to:

- Identify a means to measure polymer flow to the individual DAFTs, and provide recommendations for installation
- Conceptually design a scheme for sampling the underflow of each DAFT, and the underflow from the proposed combined C/C DAFT, to determine the potential subnatant/underflow solids load being returned to the WWTP and underflow from the dedicated C/C DAFT, in addition to the current flow and turbidity readings
- Conceptually design containment structures for the thickened sludge pumps to prevent solids from being released to the environment. Provide a portable pump which can convey the solids captured in the containment structures that will have the flexibility to be pumped into the adjacent DAFT tank. The sump area will have a canopy to minimize precipitation that can accumulate but will be open on the sides for ease in maintenance.

Section 3: Constraints

- Minimize disruption to plant operation
- Only one DAFT train can be taken off line at a time

- Sumps in containment areas around thickened sludge pumps will be pumped out using a portable submersible pump

3.1 Design Criteria

Flow Meters for Polymer Feed:

- Polymer feed pumps are progressing cavity type with variable speed 1.5 horsepower (HP) motors and have a maximum mass flow rate of 50 lbs. per hour, a dosage range of 8 to 10 lbs. per ton of dried solids, and a maximum flow rate of 3,000 gallons per hour (gph) at 33 pounds per square inch gage (psig). The pumps are designed to operate 24 hours per day, seven days per week. (BODR, 2006).
- Flow meters shall be sized so that velocities through the meters average 3–5 feet per second (fps). Current flows and the maximum discharge flow from the individual polymer feed pumps at full capacity should be considered.
- Flow meters should be installed with a straight run of at least 5 pipe diameters (minimum) upstream of the meter and a straight run of 2 pipe diameters (minimum) downstream.
- Meters should provide 0.5 percent accuracy across the measured flow range.

Auto Samplers for Underflow:

- The maximum pressure in the underflow line from a DAFT unit is less than 11 ft (4.75 psig, BODR, 2006); therefore, the automatic valve and pressure regulator valve (PRV) on each sampling line is not necessary except to provide spill mitigation.
- The maximum design underflow rate for each DAFT is 2 MGD.

Containment for Thickened Sludge Pumps and Sump Pumps

- Canopy structure will have a roof slope of 12:1
- Concrete slope inside sump area: 8:1
- Design Point for the portable sump pump: 15 GPM at 20 ft of head. Assume pumped fluid is diluted with plant/wash down water, such that it has the characteristics of water at 68°F.
  - Portable pump can be brought to all locations and connected to hard piping connection to DAFT.
  - Sludge that collects in sump area will be watered down to make the fluid less percent solids so it can be pumped.
- Dynamic headloss in the discharge piping including friction, minor loss: 1.5 ft
- Existing thickened sludge pumps have a rated capacity of 120 GPM at 25 psig. Each pump is driven by a 5 HP variable speed motor, with speed control based on level in the float collection trough.
- Elevation of pump pads for existing thickened sludge pumps will dictate the maximum curb elevation so that the sump cannot flood the motor.
- Addition of new hose stations around the DAFTs for wash down inside the sump area.

3.2 Code Considerations

- 2012 International Building Code with Local Amendments
- 2012 International Energy Conservation Code
- 2012 International Plumbing Code with Local Amendments
- 2012 International Mechanical Code with Local Amendments

- 2012 International Fuel Gas Code with Local Amendments
- 2011 National Electrical Code with Local Amendments
- 2012 International Fire Code with Local Amendments
- 2012 Life Safety Code (NFPA 101) with Local Amendments
- 2012 International Fire Code (NFPA 820) Fire Protection in Wastewater Treatment and Collection Facilities
- 2015 Hydraulic Institute Standards
- 2016 State of Tennessee, Department of Environment and Conservation, Division of Water, Design Criteria for Sewage Works

Regulatory Drivers

By containing the spills from the thickened sludge pumps we are eliminating sanitary sewer overflows (SSOs) points on site.

3.3 Sequencing and Constructability Issues

Coordinate installation of meters, samplers, and containment to minimize disruption to operations.

Only one treatment train can be taken out of service at a time, and then only with advanced coordination to operations staff.

3.4 Operational Issues

- Installation of flow meters will require one polymer feed line to be off line
- Construction of containment areas may result in limited and brief loss of thickened sludge pumping capability. Coordinate sump installation with other DAFT modifications to limit/eliminate system down-time.
- Existing plant water will be used at each containment area for wash down and to supplement flow to the sump pump.

Section 4: Description of Improvements

4.1 DAFT Area Improvements

4.1.1 Detailed Design Considerations and Assumptions

The following issues or information remain outstanding at this point in the design and will be determined during phase 2 detailed design:

- DAFT Underflow Sampling
  - Assumed that sample will be 24-hr composite; if multiple individual samples taken at fixed intervals are desired, slight changes will need to be made to the specifications to provide this capability.
  - Assumed that the existing flow meter signal can be used to flow pace the sampler.
- Thickened Sludge Pump Containment

— Thickened sludge pump sump will accommodate a sump pump with the following approximate dimensions: 7-inch by 10-inch by 8-inch(H)

4.1.2 Process Mechanical

4.1.2.1 Process

The following process mechanical improvements are proposed for this process area:

Polymer flow for individual polymer feed pumps will be measured using in-line magnetic flow meters suitable for industrial service (Figure 2).

- Flow meters will be sized so that the operating velocity through each meter will range from 3 -5 fps;
- Flow meters will have 150 lb. ANSI flanges.
- Flow meters will be installed with a minimum run of straight pipe equal to 5 pipe diameters upstream and a minimum of 2 pipe diameters downstream;
- Isolation valves and couplings will be installed upstream and downstream of the straight pipe runs to facilitate maintenance and repair;
- Flow meters will be provided with an integral signal indicator/transmitter to allow integration into the existing plant SCADA system. (See Section 4.1.3.)

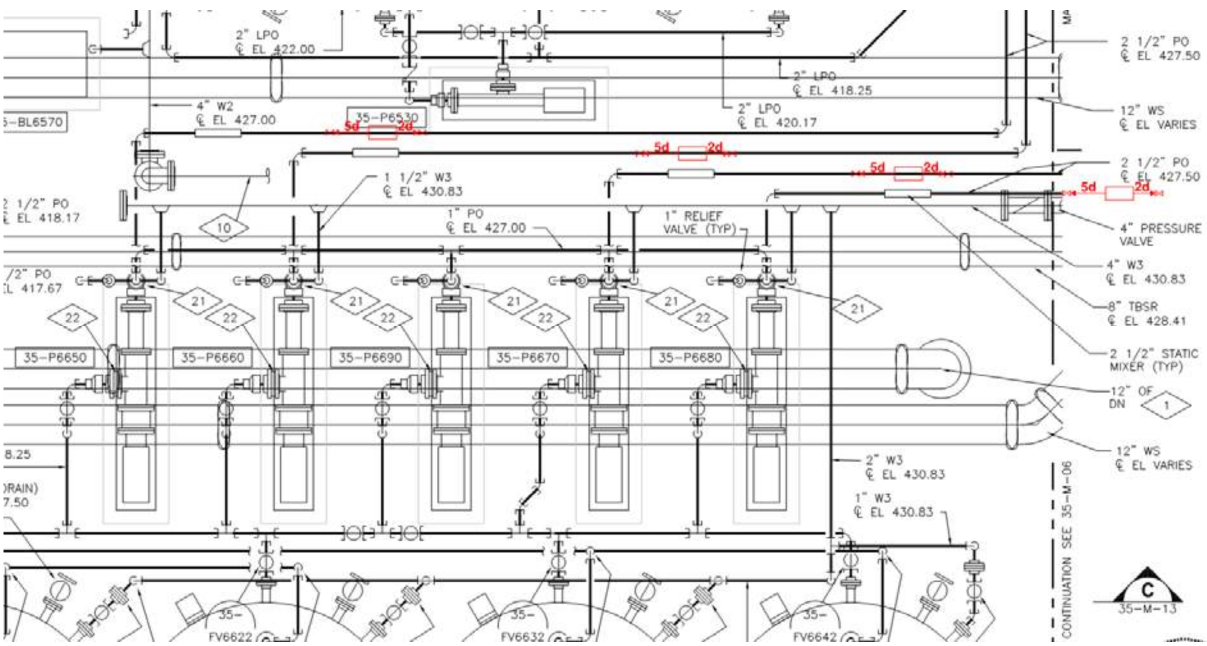

Figure 2: Installation of Flow Meters on Polymer Feed Lines

A sampler will be installed adjacent to each DAFT underflow/subnatant line (for a total of four (4) samplers) to collect flow weighted, flow proportional, or timed underflow samples and provide an accurate estimate of the DAFT capture efficiency (Figure 3).

A fifth sampler will be installed at the recycle pump station adjacent to the existing recycle flow sampler to collect samples from the combined C/C line.

- Samplers will be portable-type models, similar to ISCO Avalanche.
- Samplers will be refrigerated.
- A 3/8-inch sample port will be installed in each underflow line. (Four (4) total taps.)
- Samplers will be connected to the tap at each underflow line with 3/8-inch tubing.
- Samples from each tap will be collected by a dedicated peristaltic pump integral to each sampler.
- Each sampler will have an integral sample controller to control pumping, valve actuation, sample line purge, and flow weighting/pacing. Each unit will have data logging capabilities for subsequent download of data.

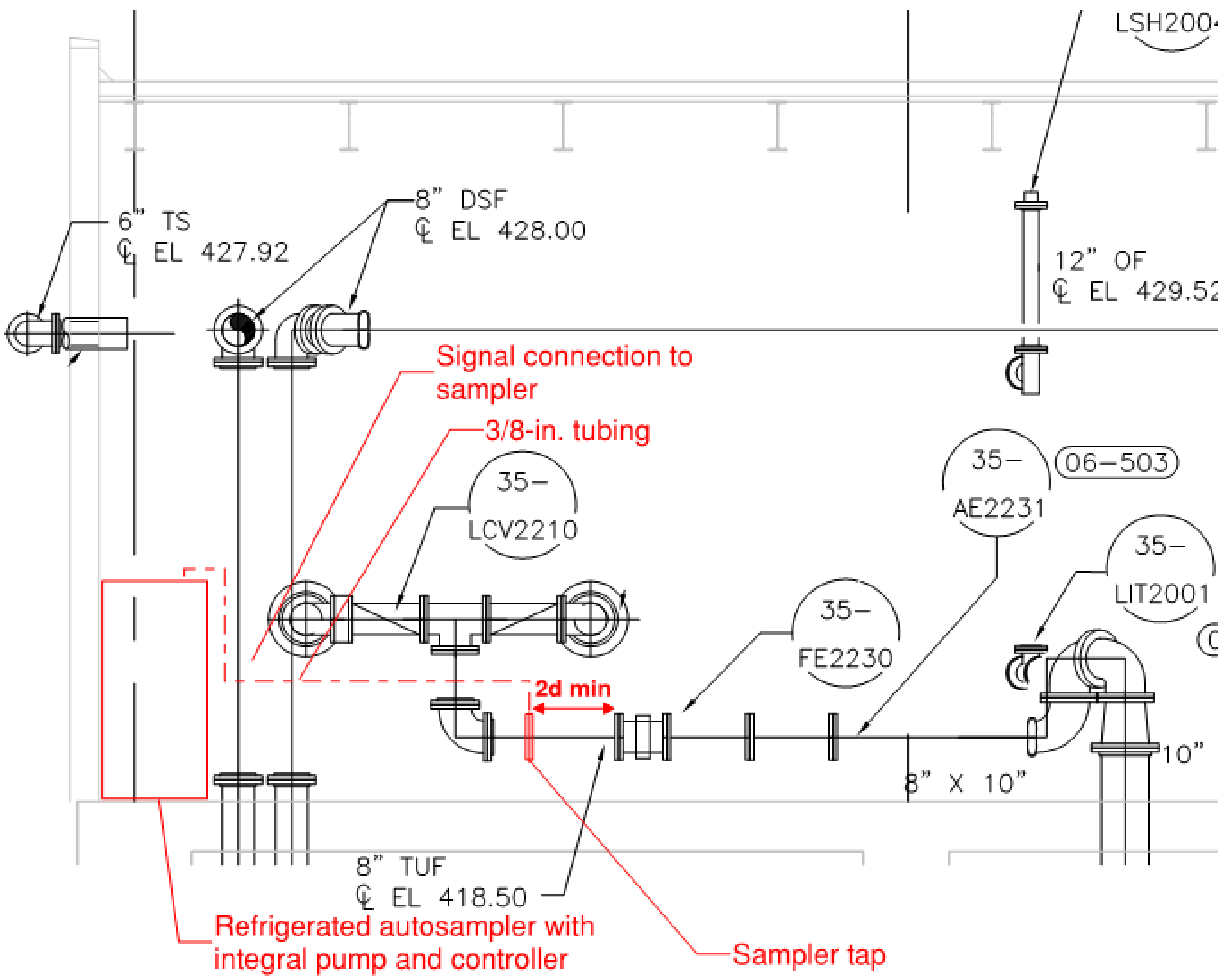

Figure 3: Typical Installation of Autosamplers on DAFT Underflow Line

Samplers will take a flow signal from the existing flow meters installed in the underflow/subnatant line for flow pacing

- Containment areas will be constructed around each thickened sludge pump to prevent accidental discharge of thickened sludge (Figure 5).

- Containment areas will be constructed from concrete and include a poured slab base and reinforced curb;
  - Curb elevations will be less than the elevation of the particular pump pad to prevent flooding of the pump motor;
  - All containment slabs will be poured on a slope (8:1) to encourage drainage to a pump sump;
  - Containment slabs will include a shallow sump with dimensions that permit the placement of a portable submersible pump;
  - All containment areas will include a sensor installed in the containment area sump to alert staff of the presence of accumulated material in the sump;
  - All containment areas will be covered to prevent precipitation from accumulating in the containment sump;
- Electrical outlets will be installed in the vicinity of the containment areas.
- A portable submersible sump pump suitable for drainage applications on industrial sites will be specified.
  - Pump should operate on 110 VAC, 1 phase, 60 Hz power and include a standard grounded US plug;
  - Pump should have an integral strainer over the impeller;
  - Pump should have a top discharge with a 2-in. quick connect coupling.
  - The design point for the sump pump is approximately 15 GPM at 20 feet of head. The performance curve is shown below in Figure 4.

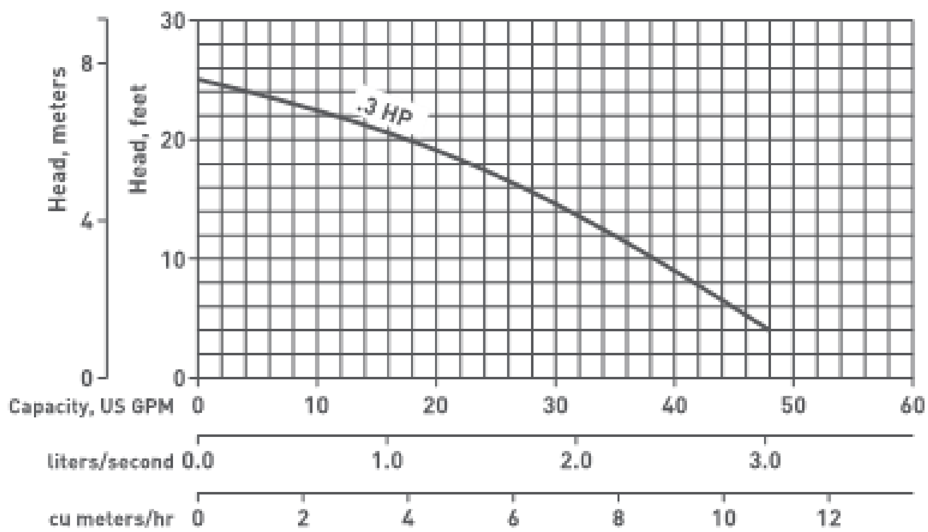

Figure 4: Sump Pump Performance Curve

- Each containment area should include dedicated piping that will allow the contents of the containment area to be pumped to the discharge piping of the thickened sludge transfer pump.

- A 6-inch x 2-inch tee should be installed in each of the 6-inch discharge pipes of the thickened sludge transfer pumps to accept the discharge from the containment sump pump;
- For each containment area, 2-inch threaded stainless steel piping should be permanently installed between the sump and the discharge piping of the thickened sludge transfer pumps;
- A 2-inch quick connect coupling with integral check valve should be installed at the end of the piping near the containment sump;
- A 2-inch swing-style check valve should be installed at the opposite end of the piping at the connection to the discharge line of the sludge transfer pump;
- A stainless steel ball valve will be installed between the existing thickened sludge pipe and the new check valve to be able to isolate the line to allow for the check valve to be inspected for clogs;
- A tee with a normally closed stainless steel ball valve should be installed adjacent to the quick connect coupling to allow the sump pump piping to be dewatered, or to allow plant staff to maintain the containment area without discharging the wash down water to the thickened sludge transfer pumps.

- The entire containment area should be covered with a canopy to prevent rainwater from accumulating in the containment area/sump. Vinyl strips will be added to prevent rainwater and leaves from collecting in the sump.
  - Canopy should cover the entire containment area and overhang the perimeter of the containment area by at least 6 inch.
  - Canopy should slope (12:1) away from the DAFTs.
  - Canopy should be high enough to permit routine maintenance on the pumps and containment area, but low enough to minimize exposure to precipitation.
  - Canopy should be secured to supports with fasteners that allow for temporary disassembly of the structure for maintenance or repair of pumps or piping.

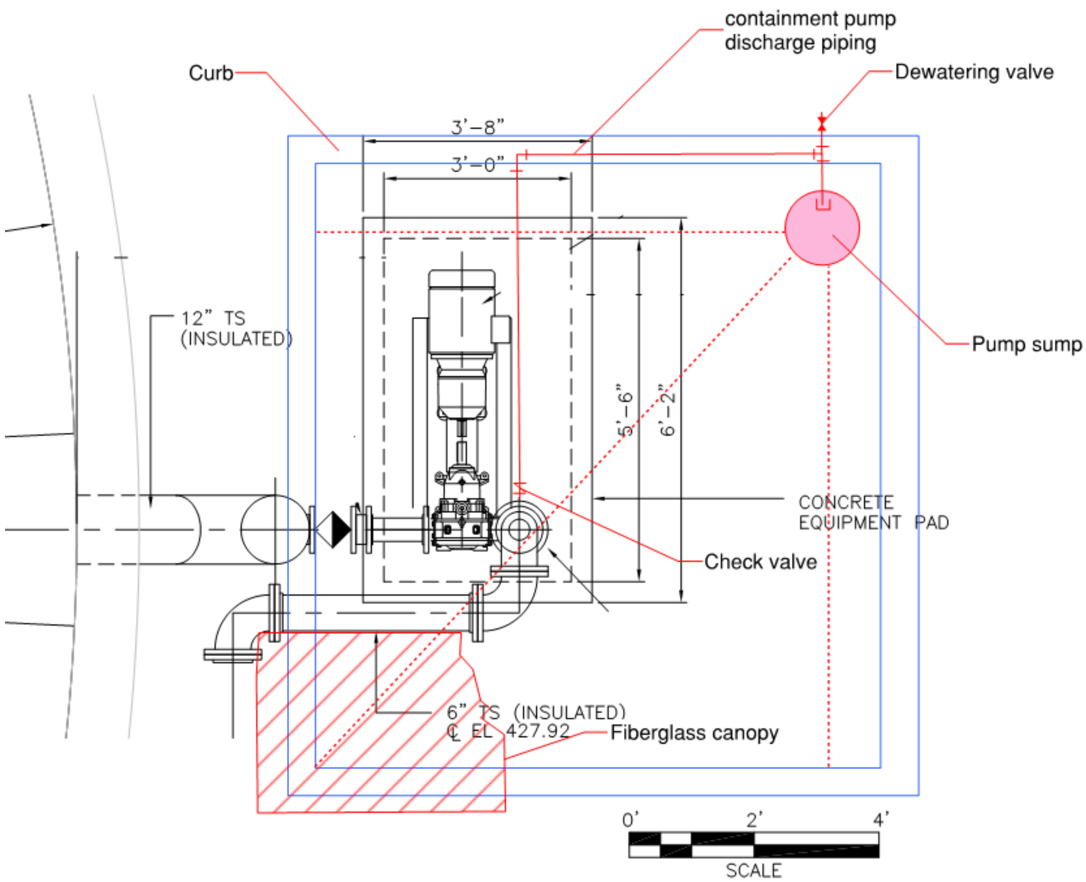

Figure 5: Typical Installation of Thickened Sludge Pump Containment

4.1.2.2 Odor Control

N/A

4.1.2.3 HVAC

N/A

4.1.2.4 Plumbing

Adjacent 3/4-inch plant water (W3) yard hydrants will be used to wash down containment areas and to provide supplemental water for pumping.

4.1.3 Instrumentation and Controls

Flow Meters on Polymer System

- Flow meters will send an analog signal (4-20 mA) from the integral transmitter to the SCADA system. The signal will be proportional to flow. Signals less than 4 mA represent a fault or alarm condition.

Samplers on DAFT Underflow Line

- All controls for the underflow samplers will be local and controlled by the controller integral to the sampler unit. A signal from the existing flow meter will be sent to the integral controller on the sampler to trigger sampling events.

Float Switch in Containment Areas

- Containment area sumps will be monitored for the collection of liquid.

4.1.4 Electrical

Electrical service will be required for the polymer flow meters, the auto samplers, the portable sump pump and the sump sensors. All of these applications will require 110 VAC, 1 HP, 60 Hz power.

4.1.5 Structural

See Section 4.1.2 for description of containment area for sludge pumps

4.1.6 Geotechnical

N/A

4.1.7 Architectural

N/A

4.1.8 Site Civil

N/A

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Technical Memorandum

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Prepared for: Metro Water Services

Project Title: Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Project No.: 148388

Technical Memorandum No. 13D

Subject: Biosolids Continuous Digester Feeding

Date: December 21, 2016

To: Trey Cavin, Metro Water Services

From: BWSC

Copy to: Ron Taylor

Prepared by: ______________________
Clayton Foster, P.E., (TN)

Reviewed by: ______________________
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Executive Summary

The existing digester feed system requires an upgrade to provide continuous feeding of the digesters. Currently, the digesters are fed in a batch mode, which contributes to rapid rise events, inconsistent gas production, and reduced process stability in general. The system is comprised of two digester feed tanks and three digester feed pumps which pump through two separate forcemains (FMs) which connect to the four digesters. The FM piping has been modified to allow for two digesters to be feed at once and magnetic flow meters were added to measure flow into each digester.

A rapid rise event can occur when a large supply of degradable material is sent to the digester. The material will breakdown and create a rapid increase in gas production. The resulting increase in the gas concentration and gas holdup can contribute to a sudden increase in digester volume (Chapman, 2014). The rapid rise events can cause sludge to overflow the digesters via an overflow pipe in the effluent structure to the Recycle Pump Station (PS), which sends flow back to the Central Wastewater Treatment Plant (CWWTP) to be retreated. This limits overall plant capacity and is inefficient due to processing costs to pump and retreat the same solids. The rapid rise events have also resulted in damage to the fixed digester covers.

The batch feeding of the digesters causes problems with the gas production system resulting in fluctuating gas supply which forces the system to have dramatic pressure changes as the gas flares turn on and off. These issues have a cascading effect on other gas production equipment such as the Dystor fans.

This technical memorandum (TM) documents decisions made and communicates the improvements required to provide continuous feeding to all four digesters simultaneously to help minimize the potential for rapid rise events and help stabilize the digester gas management system (in combination with the smaller flare), which will improve digester performance. The improvements described herein will be designed in Phase 2 detailed design of this project. The digester feeding system improvements will include:

- The installation of two new positive displacement lobe pumps;
  - One pump for redundancy in case of failure of one of the duty pumps;
  - Reuse of existing three digester feed pumps to feed individual digesters;
- Two new FMs from the digester feed pumps to the digesters; and
- Interconnecting piping so pumps are interchangeable.

Section 1: Process Area Description

The existing digester feed system utilizes two 20,000-gallon digester feed tanks and three Vogelsang positive displacement rotary lobe pumps. The digester feed tanks were designed with pumped mixing using chopper pumps that take suction from the digester feed pump suction header. The digester feed tanks are located west of the dissolved air flotation thickener (DAFT) Control Building and the three digester feed pumps are located in the western section of the building. Two 10-inch lines from the digester storage tanks reduce down to 8-inch to form the suction lines to the three digester feed pumps. From the pumps, the two FMs wind through the DAFT building before going below grade on the eastern side, going through the southern part of the yard. The two lines enter and emerge in the southern part of the Digester Control Building. The two FMs manifold into the 24-inch digested sludge mixing pipes on the discharge side of each mixing pump.

Currently each digester is being fed intermittently. Because of limitations in piping and pumping, the original feeding scheme only allowed for one digester to be fed at any given time; the three digesters not being fed would continue to be mixed. Thus for every 8 minutes of feeding, a given digester is mixed, but not fed, for 24 minutes, assuming all digesters are in service. Recently Metro Water Services (MWS) has modified the facility with additional interconnecting piping and control valves in the Digester Control Building in an attempt at continuous feeding. These improvements have allowed for two digesters to be fed simultaneously. Therefore, for every 8 minutes of feeding a given digester is mixed, but not fed, for 8 minutes, resulting in a better approximation of continuous feeding.

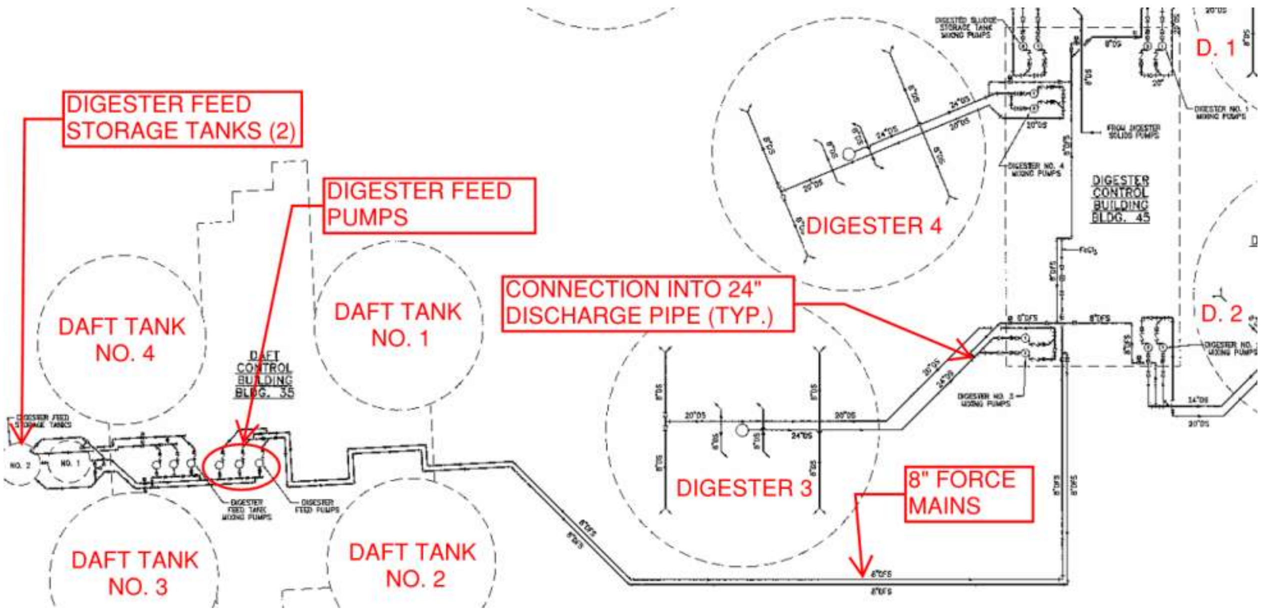

Figure 1: Existing Digester Feed System

Section 2: Design Intent

The design intent of the project is to simultaneously and continuously feed all four digesters.

- By providing continuous feeding to all digesters, the overall process will improve due to the digesters becoming more stable which will allow the loading rate to increase and result in more gas production while maintaining process reliability.
- The three existing pumps will be reused and paired with two new pumps to provide feeding to the digesters. One pump will be for redundancy.
  - The pumps will operate based on the storage level in the digester feed tanks.

Section 3: Constraints

This section describes the constraints associated with this process area for meeting the design intent.

3.1 Design Criteria

Table 1. Existing Pump Design Criteria	
Item	**Design Criteria**
Pump Type	Vogelsang Positive Displacement Lobe Pump
Quantity	3 pumps (2 duty, 1 standby)
Capacity	325 gpm
Discharge Pressure	55 psig
Motor	Inverter Duty
Drive	Variable Frequency
Horsepower	40HP
Electrical Requirements	460 Volts / 60 Hz / 3 Phase
Pump Redundancy	Yes
Piping Interconnection	Yes

GPM- gallons per minute

PSIG- pounds per square inch gage

The new operating point for the digester feed pumps when continuous feeding operation commences will be between 100 GPM and 200 GPM.

- When operation switches to continuous feeding, the total volume sent currently was assumed to be split between the 4 digesters, approximately 110 GPM.
- The existing pumps have the ability to turn down and operate within this range.
- Two new rotary lobe pumps with similar characteristics to those presented above will be installed resulting in a total five pumps (4 duty, 1 standby)

3.2 Code Considerations

- 2012 International Building Code with Local Amendments
- 2012 International Energy Conservation Code
- 2012 International Plumbing Code with Local Amendments
- 2012 International Mechanical Code with Local Amendments
- 2012 International Fuel Gas Code with Local Amendments
- 2011 National Electrical Code with Local Amendments
- 2012 International Fire Code with Local Amendments
- 2012 Life Safety Code (NFPA 101) with Local Amendments
- 2012 International Fire Code (NFPA 820) Fire Protection in Wastewater Treatment and Collection Facilities
- 2016 International Fire Code (NFPA 820) Fire Protection in Wastewater Treatment and Collection Facilities
- 2015 Hydraulic Institute Standards (HI)

- 2016 State of Tennessee, Department of Environment and Conservation, Division of Water, Design Criteria for Sewage Works

3.3 Regulatory Drivers

- N/A

3.4 Sequencing and Constructability Issues

- Sequencing
  - There shall be limited interruption in biosolids operation during construction to connect to existing piping.
- Constructability
  - Piping interconnection shall be coordinated with existing digester feed piping.
  - Construction space is limited inside DAFT control building.
  - Construction space is limited in yard due to existing piping and need to keep access road open for truck traffic.
    - Potential piping conflicts in the yard are Browns Creek FM, Lion Oil pipes, storm sewers, and sanitary sewers.

3.5 Operational Issues

- Current truck access and regress shall not be obstructed during construction of the new digester feed lines.
  - One lane of traffic must be maintained for vehicular access to allow for trucks to exit following the normal route on First Avenue.
- Piping interconnection with existing system should not hinder normal digester feeding.

Section 4: Description of Improvements

4.1 Continuous Digester Feeding

4.1.1 Detailed Design Considerations and Assumptions

- Considerations
  - Investigate digester feed pump suction pipe sizing.
- Assumptions
  - New pumps should match existing digester feeding pumps in manufacture and sizing for ease in maintenance and operation. A spare or redundant pump shall be provided.
  - The new operating range for the digester feed pumps will be between 200-300 GPM.
  - The new digester feed pumps can be located in the space vacated by the removal of the digester feed tank mixing pumps.

    - Existing mixing pumps have already been removed by MWS.
  - Site disturbance is acceptable to install FMs.
    - Excavation will be required through the site to install forcemains.
  - New pumps will have the same instrumentation and controls as existing.

4.1.2 Process Mechanical

4.1.2.1 Process

- Addition of two new Vogelsang positive displacement lobe pumps with characteristics described above
  - This will provide four duty pumps and one stand-by pump, three existing pumps and two new pumps.
  - Pumps will be situated in western wing of the DAFT control building in place of the existing digester feed storage tank mixing pumps, as shown in Figure 2.
  - Pumps will be located in the same orientation as the existing digester feed pumps.
  - Manifold into the existing suction pipes from the digester feed storage tanks to the new pumps.
  - The digester feed storage tanks will serve as equalization for the digester feed pumps.
    - Variable Frequency Drives (VFDs) will control speed of pump to account for varying levels in storage tanks.
    - VFDs are already in place on existing pumps and new VFDs will be installed with new pumps
  - Pumps will be sized to handle low flow from the storage tanks and to maintain minimum velocity to keep the discharge line flushed; both of which will be determined during Phase 2 detailed design.

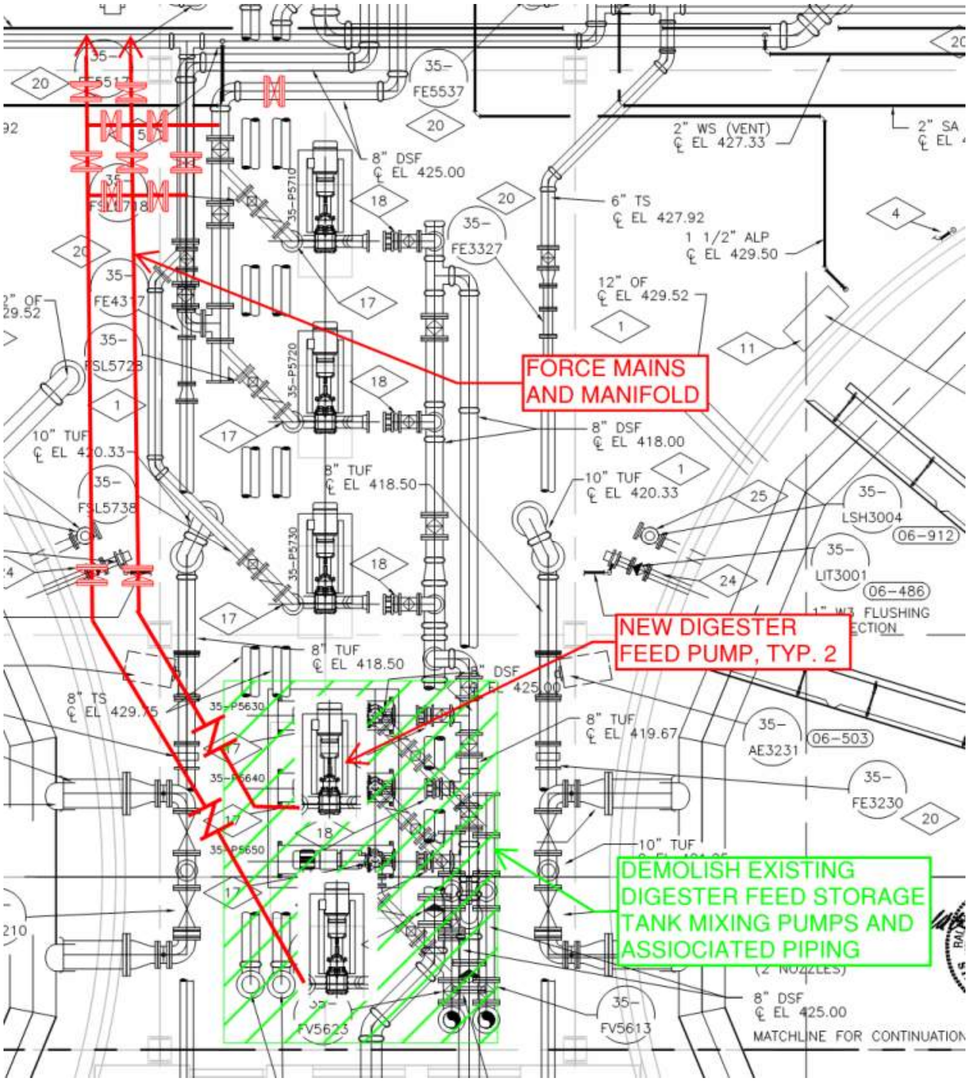

Figure 2: New Digester Feed Pumps

- Two new 8-inch glass lined ductile iron discharge pipes and associated valving to interconnect system to each individual digester and the existing piping system, as shown in Figure 3.
  - The two new discharge lines will interconnect with existing pump discharges using 8-inch plug valves to allow for flow to use any of the four discharge pipes (two existing and two new)
  - Piping Manifold
    - Inside the DAFT Control Building the pipes will be valved to interconnect the system so that each pump has the ability to pump to different digester tanks
  - A microwave-type total solids meter will be installed on each line to better quantify the loading to each digester.
  - Two new lines will go through the DAFT building, through the yard, and into the Digester Control Building following a similar path to the existing digester feed lines.

- The lines go below grade before exiting the DAFT building and emerge inside the Digester Control Building.
- The portion of these lines from inside digester control building to the southern access road will be installed as part of the Central Biosolids Facility – Digester 4 Fixed Cover and Digester Mixing Upgrades project. The ends of these lines will be capped and located and the lines from that location to the DAFT building will be installed as part of the COPT Project. This is depicted in Figure 3 below.

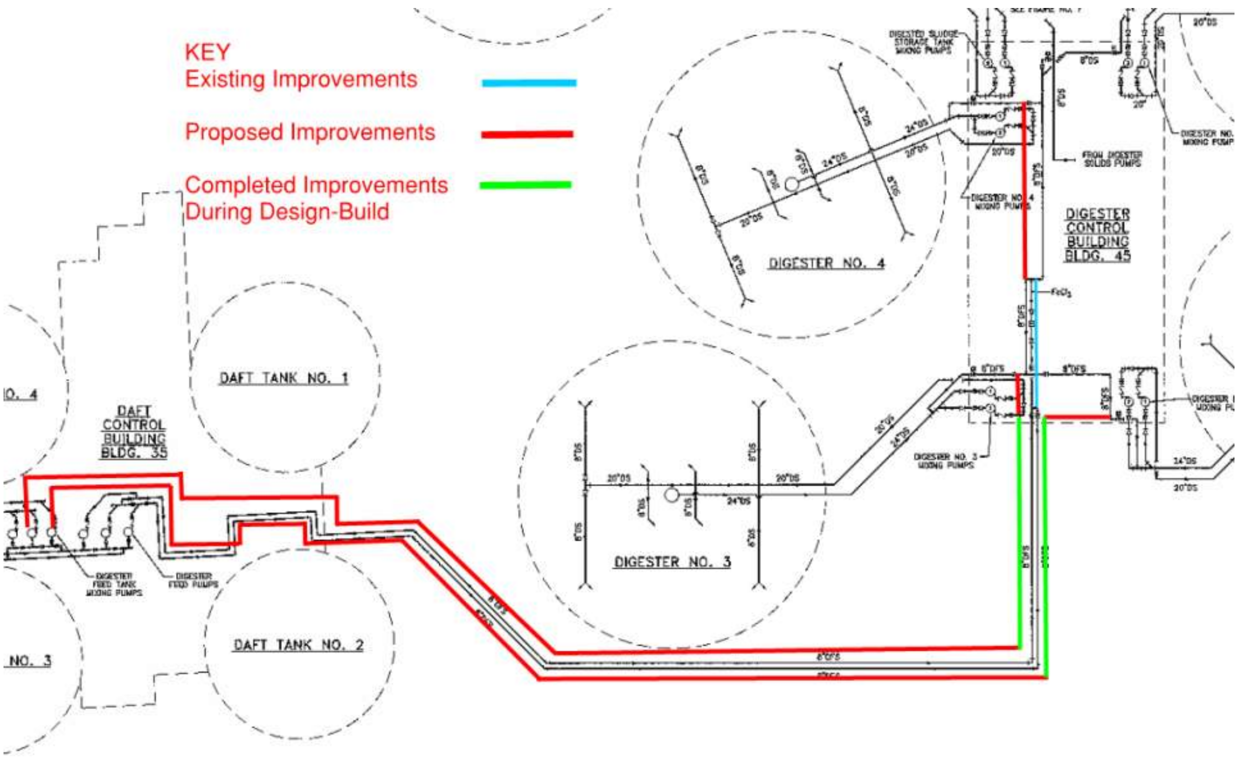

Figure 3: Proposed Improvements to Digester Feeding System

4.1.2.2 Odor Control

N/A

4.1.2.3 HVAC

N/A

4.1.2.4 Plumbing

N/A

4.1.3 Instrumentation and Controls

- Pumps

- Digester Feed Pumps
  - Local Hand/Off/Automatic control panel with remote monitoring
  - Hand Mode – When in Hand, operator starts/stops pumps at local control panel.
  - Automatic Mode – When in Auto, pumps are controlled by SCADA as follows:
    - Operators will type in GPM required to maintain target lbs/kft.
    - Control logic will split flow between available digesters.
    - Control logic will control pump speed to maintain individual GPM split to each digester.
    - Logic will include low level shutoff from digester feed storage tanks.
    - DAFT rake speed will be controlled to maintain level in digester feed storage tanks.
  - Pump monitoring units provided for protection of pumps.

- Level Sensors
  - Digester Feed Storage Tanks
    - Existing level instruments in the digester feed storage tanks to remain
    - Hardwired low level float switch interlock to stop pumps on low level in the digester feed storage tanks.
    - Hardwired high level float switch will alarm on high level in the digester feed storage tanks.
- Remote Monitoring and Control
  - Pump Status – Running/Stopped/Alarm
  - Pump speed
  - Voltage
  - Total solids concentration
  - Existing Alarms that will be used in new system:
    - Storage tank Level Indication
    - Storage tank Low Level Alarm
    - Storage tank High Level Alarm
  - Remote monitoring capabilities will be consistent with the remote monitoring and control capabilities of the existing digester feed pumps.

4.1.4 Electrical

- Remove existing starters for mixing pumps (35P5630, 35P5640, and 35P5650) from 35MCC1, 35MCC2, and 35MCC3.
- Add 100 A circuit breakers to feed from 35MCC1 and 35MCC2.
  - One breaker will be installed in each MCC to accommodate the two new pumps.
- Connect VFDs and pumps to 35MCC1 and 35MCC2.

4.1.5 Structural

- Demolition of existing digester feed storage tank mixing pumps concrete pads.

- New concrete pads for two new digester feed pumps.
- Piping penetrations through the structural slab will require saw cutting and repair of the slab.
- Pipe supports for new digester feed lines throughout buildings.

4.1.6 Geotechnical

N/A

4.1.7 Architectural

N/A

4.1.8 Site Civil

As shown in Figure 3, two new 8-inch FMs will be installed in the southern part of the Biosolids Facility yard.

- The new FMs will closely follow the existing digester sludge feed FMs through the yard.
  - Due to existing utilities running through the site, the new FMs may have to change alignment from the existing FMs to avoid conflicts.
- The FMs will remain at least 3 feet below the ground surface.
  - Due to existing utilities running through the site, the new forcemains may have to change depth to avoid conflicts.

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Technical Memorandum

Prepared for: Metro Water Services

Project Title: Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Project No.: 148388

Technical Memorandum No. 13E

Subject: Biosolids Truck Loading Area

Date: December 21, 2016

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From: BWSC

Copy to: Ron Taylor, Metro Water Services

Prepared by: ______________________
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Limitations:

This document was prepared solely for Metro Water Services in accordance with professional standards at the time the services were performed and in accordance with the contract between Metro Water Services and Brown and Caldwell dated September 15, 2015. This document is governed by the specific scope of work authorized by Metro Water Services; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by Metro Water Services and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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This Technical Memorandum (TM) documents the basis of design and conceptual layout for modifications in the truck loading area including:

- Installation of a new smaller biosolids silo for storage of off-specification product;
- Installation of a new remote pellet loading control panel in a new elevated enclosed control room on the 2nd floor access stairs to allow operations staff to observe loading;
- Reworking the air intakes of the existing air compressors to provide a cleaner source of air.
- Install float switches on all the final product chutes so the chutes will rise automatically to keep chute on top of the pile in the truck bed.

The improvements described herein will be designed in Phase 2 detailed design of this project. The system improvements onsite will help to improve overall facility performance by:

- Installing a new smaller pellet storage silo for off specification product which frees up an existing storage silo and increases finished product storage compared to current operation;
- Providing the operators with direct line-of-site observations of truck loading activities;
- Improving air compressor operation by ducting in outside make-up air to the compressors which minimizes the potential for filter fouling, overheating, and subsequent failure.

Section 1: Process Area Description

The Truck Loading Building, Building 65, (Figure 1 and Figure 2) is a 90 foot (ft) x 34 ft structure with two 18,000 cubic feet dry product storage silos and one wet cake hopper. The process area receives a dried pellet intended for agricultural reuse which is intended to be stored in the two large existing silos. The silos are able to interchangeably feed trailer dump trucks using conveyors and three separate drop chutes. Currently one of the large storage silos is being utilized for finished product storage and one is being used for storage of off-specification product. This practice severely limits the finished product storage capacity of the plant because one silo must remain empty to store off-specification product. This is because in the rare event that off-specification product is produced it can be stored separately from the in-spec product.

The wet cake storage hopper drops directly into the truck bed utilizing two separate drop chutes. Wet cake is occasionally diverted from the process area to a storage hopper when both dryers are out of service. When the wet cake is loaded, it splatters from the truck bed and results in spray on nearby equipment and structures.

The truck loading system is controlled from an operations platform located on the second level of Building 65. However, the current location of the control panel results in inefficient truck loading operation. Observation of the truck loading operation is obstructed due to the location of the control panel on the second level. The operator must manually raise and lower the telescoping chute in order to minimize dust generation; however, without the ability to directly observe operations, this is difficult to do. Additionally, the truck loading operator does not have the ability to communicate with the driver of the truck to reposition the truck for an even loading of finished product in the bed of the truck.

Two air compressors located inside the truck loading area feed the pneumatic pellet conveyance system and other dryer pneumatic controls. Each compressor is dedicated to a dryer train; however, the two systems are interconnected to allow for redundancy if one of the compressors is down so that it can operate with either dryer if needed. This arrangement does not allow for system redundancy if both dryers are operational, but one of the air compressors is out of service. The air compressors can often become covered in sludge if trucks are being loaded with wet cake, or filters can foul with dust generated from pellet loading operation, which causes the compressors to overheat.

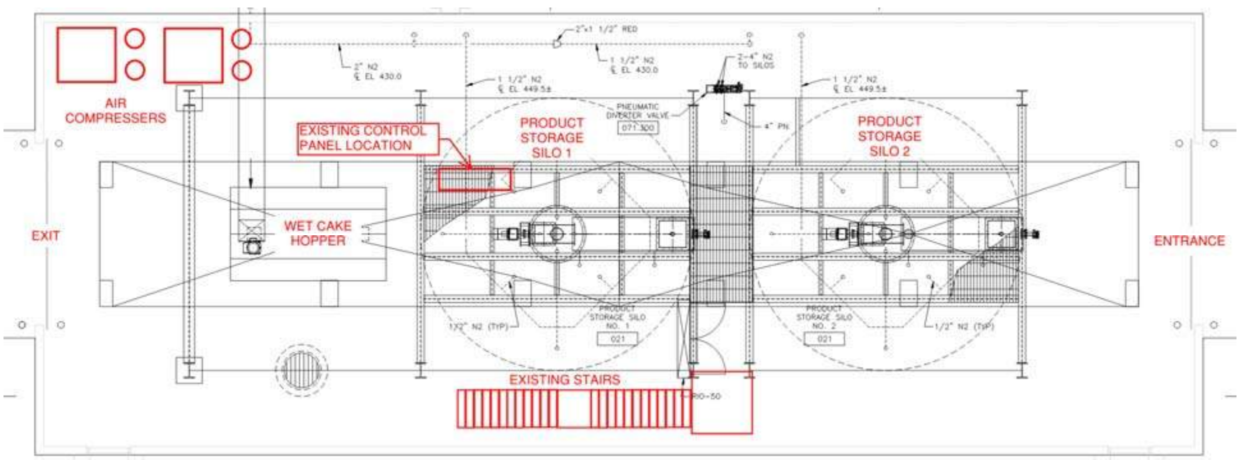

Figure 1: Plan of Truck Loading Building, Building 65

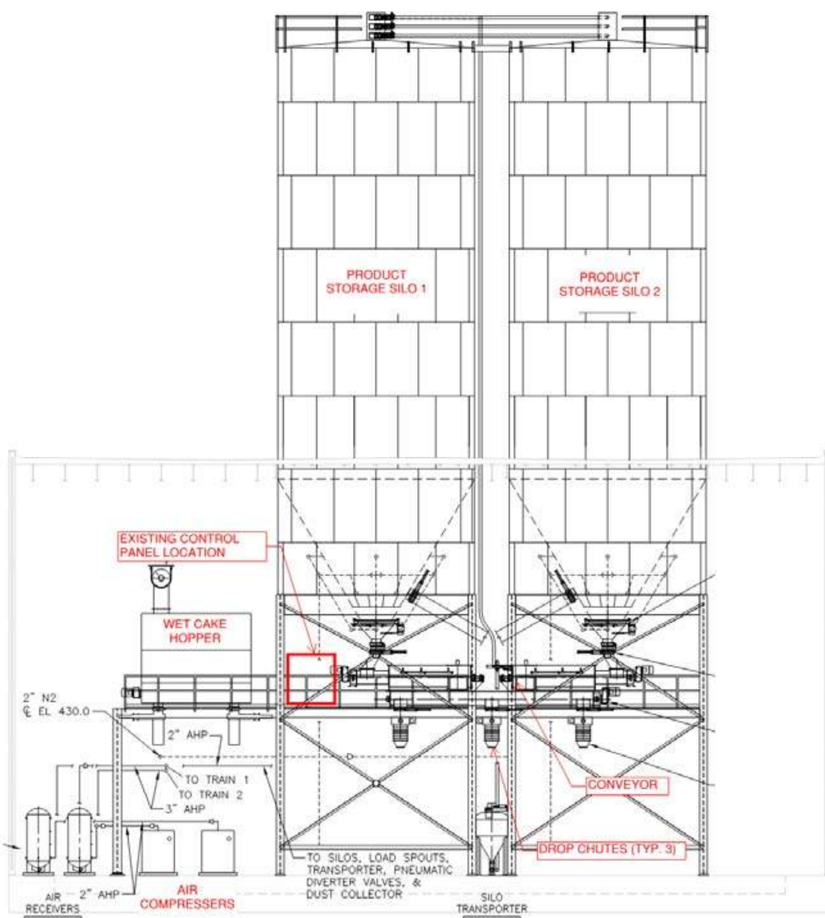

Figure 2: Section of Truck Loading Building, Building 65

Section 2: Design Intent

The design intent for this process area is:

- Provide a new smaller silo to store off-specification product. Re-route off-specification product from the existing pneumatic line which connects to the existing pneumatic conveyor system from the Biosolids Processing Building and which is sized for the maximum off-specification product production;
  - Installing a new smaller pellet storage silo for off-specification product will free up an existing storage silo and increases finished product storage compared to current operation;
- Provide a new operator station location for truck loading personnel which allows operators to perform truck loading with an unobstructed view of the operation and which offers needed functionality;
  - Providing the operators with direct line-of-sight observations of truck loading activities will allow the operators easier and more effective loading operation into the truck;
  - Provide a means of effective communication between the new pellet loading control station and the truck driver to assist in more effective loading;
- Provide a new air compressor arrangement which provides improved reliability by having outside air available to the system and adding moveable protective vinyl curtains, which will shield the compressors from wet cake splatter during loading;
  - Improving air compressor operation by ducting in outside make-up air to the compressors will minimizes the potential for filter fouling, overheating, and subsequent failure.
- Provide float switches on the off-loading chutes so they will raise the chutes automatically off the pile during truck loading.

Section 3: Constraints

3.1 Design Criteria

- New off-specification silo
  - Provide a new off-specification silo with 30 cubic yard (c.y.) capacity
    - Each dryer train can convey a maximum of 150 cubic feet (cf)./hr. (Basis of Design Report, 2006);
    - (150 cf./hr.)x(2 hrs. of production)x(2 dryer trains)/27cf./cy. = 22.22 yds. =~30 yds.
      - Pellets are checked every two hours to ensure product is within specifications per MWS.
- Remote pellet loading control panel and control room
  - Provide an unobstructed view of product filling operation with necessary local controls provided to load pellets.
  - Provide an effective way to communicate with driver of truck from the new control room.
- Air compressors
  - Provide compressors with 1300 ACFM at 130 psi of make-up air.
- There are electrical boxes and transformers on the south side of the garage door where the off-specification silo is to be located so the steel support structure must avoid these conflicts.

3.2 Code Considerations

- 2012 International Building Code with Local Amendments
- 2012 International Energy Conservation Code
- 2012 International Plumbing Code with Local Amendments
- 2012 International Mechanical Code with Local Amendments
- 2012 International Fuel Gas Code with Local Amendments
- 2011 National Electrical Code with Local Amendments
- 2012 International Fire Code with Local Amendments
- 2012 Life Safety Code (NFPA 101) with Local Amendments
- 2012 International Fire Code (NFPA 820) Fire Protection in Wastewater Treatment and Collection Facilities
- 2016 State of Tennessee, Department of Environment and Conservation, Division of Water, Design Criteria for Sewage Works
- 2016 International Fire Code (NFPA 820) Fire Protection in Wastewater Treatment and Collection Facilities
- American Concrete Institute (ACI)
- American Institute of Steel Construction (AISC)
- American National Standards Association (ANSI)
- American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
- American Society of Mechanical Engineers (ASME)
- American Welding Society (AWS)
- Air Movement and Control Association (AMCA)
- Conveyor Equipment Manufacturers Association (CEMA)
- Institute of Electrical and Electronics Engineers (IEEE)
- Instrument Society of America (ISA)
- National Electrical Manufacturers Association (NEMA)
- Standards of the Occupational Safety & Health Administration (OSHA)
- Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

3.3 Regulatory Drivers

N/A

3.4 Sequencing and Constructability Issues

- Coordinate all installations to minimize disruption in truck loading operations.
  - Tight space; may require work during weekends or evening to accommodate existing operation.
- New off-specification silo
  - Requires coordination to ensure truck loading is not impeded by new silo construction over entrance to existing building.
- Remote pellet loading control panel and control room

  - Requires new temporary means of access during expansion of staircase to accommodate the new remote pellet loading control room so that second level can be accessed.
- Temporary access must meet code requirements.
  - Installation shall be completed on weekends when no pellets are unloaded from the silos.
- Installation of floats onto the off-loading chutes will be installed during the weekend or when no trucks are scheduled for a particular day.
- The design needs to avoid the existing electrical components that are in the location where the off-specification silo is to be located.

3.5 Operational Issues

The improvements presented in this TM are meant to help resolve several operational issues throughout the truck loading building area. The operation of the facility is limited because one silo must remain empty in case an off-specification product is produced which limits the silo storage volume by half. The location of pellet loading control panel causes inefficient loading of pellets into the trucks because of an obstructed view of the truck bed. The air compressor's filters fouling due to the dusty environment can cause the compressor's to overheat and limit the facility to one pneumatic system to move pellets from the dryer building to the silos. The manual chutes result in a large quantity of dust causing the operator difficulty in seeing the pellet loading operation and the excess dust is a safety issue.

Section 4: Description of Improvements

4.1 Truck Loading Area

4.1.1 Detailed Design Considerations and Assumptions

- Considerations
  - New off-specification silo will:
    - Be suitable for outdoor use;
    - Be supported on a superstructure to allow for truck passage below;
    - Include temperature monitoring using thermocouple ropes;
    - Be connected into new odor control system or bag house;
    - Have nitrogen padding;
    - Have dust containment with collection and return to fugitive dust collector; and
    - Connect into existing SCADA for local and remote control and to interface with Andritz system.
- Assumptions
  - New off-specification silo:
    - Metro does not wish to send off specification product back to the recycled bin.
    - Metro will not require a "viewing platform" for loading of the off-specification silo into the trucks.
    - Plant will only send off-specification product to the off-specification silo for a limited time (~2 hours).
    - The nitrogen system, existing exhaust handling system have capacity to handle the new silo.

- This will be confirmed during Phase 2 detailed design.
  - Pellet oil will not be required by Metro for the off-specification product.
  - Remote pellet loading control panel location MWS personnel only require limited functionality at new remote control panel and not all operation capabilities that main control panel offers.
  - Insulation of the silo to prevent rust and condensation.

4.1.2 Process Mechanical

4.1.2.1 Process

A new silo with a capacity of 30 cubic yards will be installed on the entrance of the truck loading building, Figure 3, to store off-specification product.

- The existing pneumatic conveyors that move product from the biosolids processing building to the two existing silos will be connected to existing system using pneumatic diverter valves so that product can be moved into new silo
  - The new pellet conveyance ducting will be 4-in stainless steel to match existing system.
- A slide gate and extension tube will be used to load the pellets from the silo into the bed of the truck.
- A float switch will be attached to the end of the extension tubing. The float will automatically raise the extension tubing so that dust creation is minimized during loading.
- Stainless steel piping will be required to connect to the existing nitrogen system to provide nitrogen padding to the new smaller silo.
  - Piping will be sized in design for smaller silo.
- Stainless steel piping will be installed on top of the new silo with air filter to provide make-up air.
- A thermocouple rope will be installed inside the silo for safety monitoring.

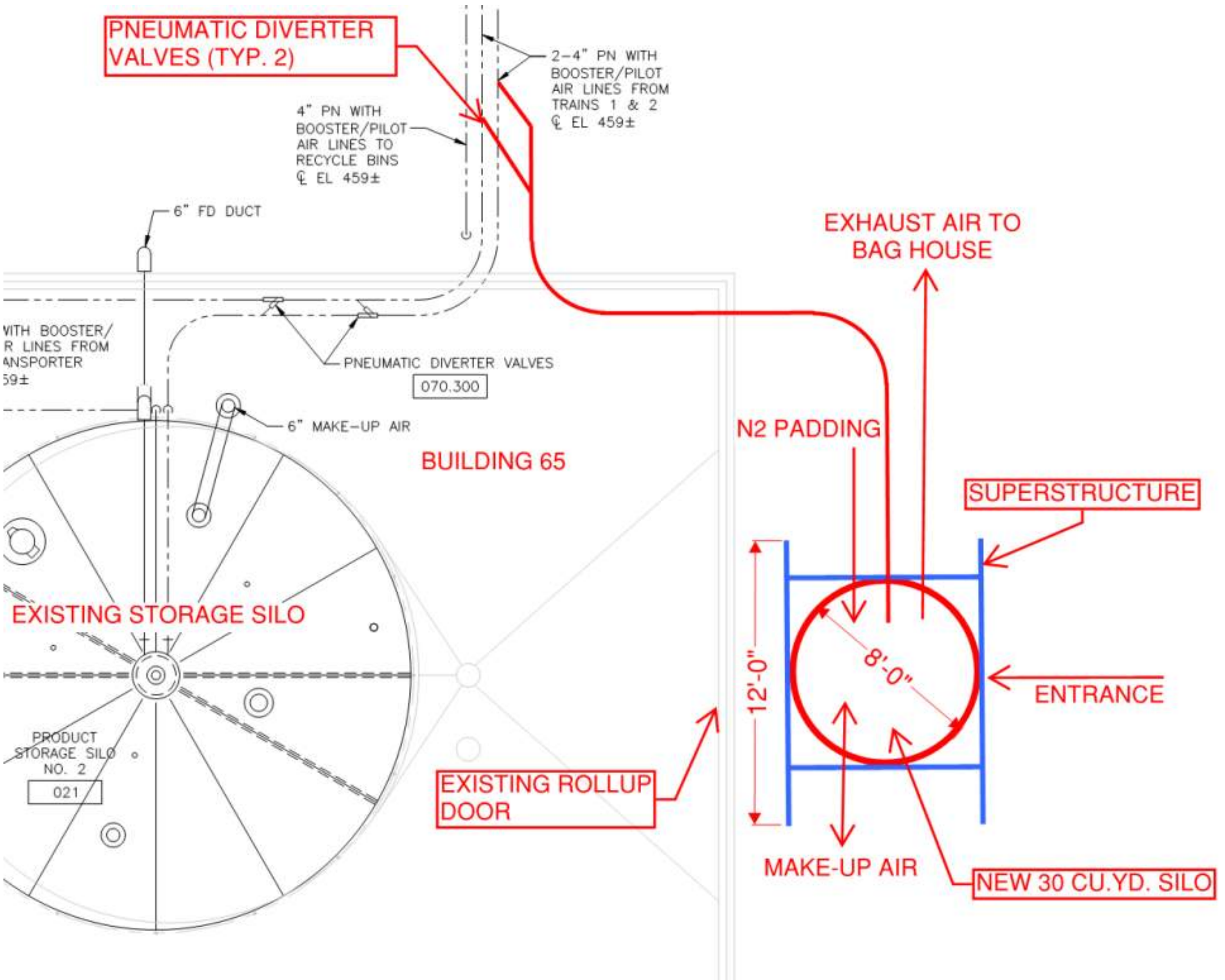

Figure 3: Pneumatic Modifications for Off-Specification Silo

- Air compressors
  - To improve the air compressor operation, the air intakes are to be ducted from the outside rather than directly from the truck loading building.
  - The intent is to provide a new wall mounted intake louver installed above the top of the compressors to allow for ductwork to be routed down to each compressor.
  - Each unit will be modified with a new opening in the top for intake. The existing unit opening will be blanked off.
  - The airflow requirements for each unit are as follows:
    - 7,200 CFM of cooling air.
    - 450 CFM for compressed air demand.
  - The compressor manufacturer indicated the maximum allowable external static pressure drop is 0.25 inch w.g.

4.1.2.2 Odor Control

- New off-specification silo:
  - Stainless steel piping for exhaust air from the new silo will be installed and connected to a new bag houses.
    - Piping will be sized in design for the smaller silo.

4.1.2.3 heating, ventilation, and air conditioning (HVAC

- New off-specification silo
  - Considerations will be given to control dust by directing collected dirty air to the fugitive dust collector.
- New Pellet Loading Control Room
  - Remote pellet loading control panel and control room Mechanical cooling and heating inside the new enclosed remote pellet loading control room will be achieved with a split system heat pump. The unit is to be sized for the internal loads generated by the electrical equipment to maintain a space temperature of 78 degrees F (maximum). Ventilation air will be provided to the new enclosed control room from an outside air intake louver to meet the minimum ventilation rates specified in the International Mechanical Code.
  - Air compressors
  - Ductwork design for the modified outside air intake is required to achieve the operational improvements described above.
  - During design, the system capacity will be reviewed to determine the existing and future demand. The plant will be modified as needed to meet the process demand.

4.1.2.4 Plumbing

N/A

4.1.3 Instrumentation and Controls

- New off-specification silo:
  - New silo will include SCADA for local and remote control
  - System will tie into the existing SCADA system (Plant and Andritz SCADA systems have recently been combined into one system)
  - New silo SCADA controls will be added to existing SCADA screen for SILOs.
  - The instrumentation system and controls will be designed and installed in collaboration with Andritz.
  - A local control panel will control the loading of the pellets from the new silo. This will be finalized in phase 2 detailed design.
- Remote pellet loading control panel
  - No new controls will be added to the system but a subset of the existing controls will be provided at the new remote pellet loading control panel
    - New subset will be those required to perform daily operations.

4.1.4 Electrical

- New off-specification silo:
  - Electrical for valve actuation, monitors, and chute control
  - Remote pellet loading control panel Wiring interconnection will be required from new remote pellet loading control panel to the existing master control panel.
  - Wiring for electrical power will be required for the new pellet loading control panel.
  - Electrical for lighting and HVAC wall mounted system inside the new pellet loading control room.
  - Electrical lighting will be provided outside at the off-specification silo to assist the operators during night unloading.
  - The design must avoid the existing electrical components located next to the proposed off-specification silo location.
- Communication system for driver to operator interface
  - Communication system will consist of a push button intercom system controlled from inside the control room
    - Intercom will be placed out of the truck drive through but in a convenient place where the truck cab generally stops.
  - Additionally, a light system similar to a traffic light or a car wash system will be used as a visual aid to help the driver move the truck forward.
    - The light will be positioned near the truck door exit so it is easily seen through the truck windshield.

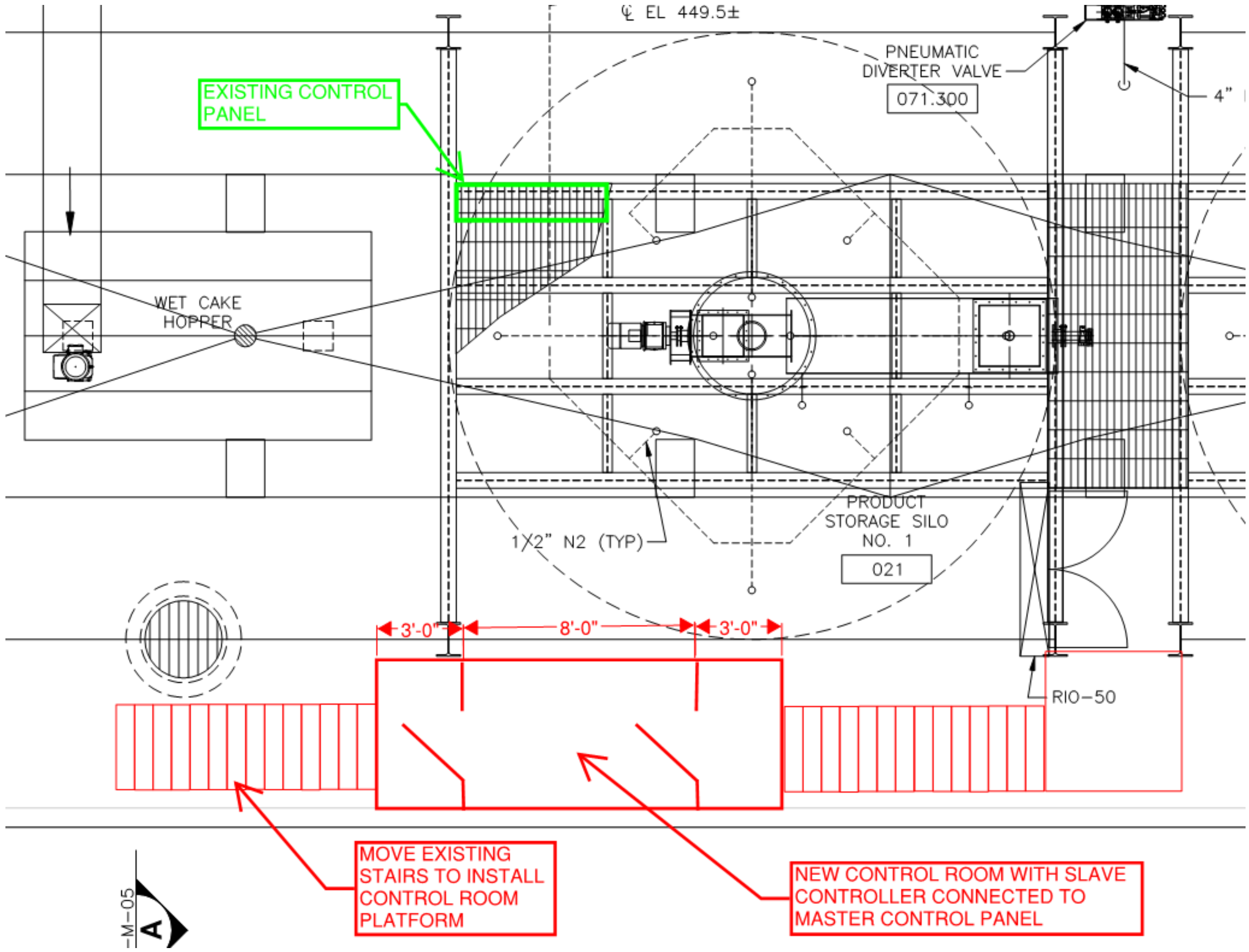

Figure 4: Control Room for Truck Loading

4.1.5 Structural

- New 8-ft diameter by 22-ft tall storage silo
  - Installed outside of the existing building on an approximate 12-ft square by 20-ft tall metal frame.
  - Frame required to elevate the silo to allow trucks to drive underneath for loading.
  - Two new concrete strip footings will be required.
    - Strip footings will be utilized, instead of a mat foundation, in order to limit the disruption to the normal operation of the building.
    - Each of the concrete strip footings will be approximately 4-ft wide by 15-ft long by 2-ft thick with 2-ft tall pedestals at each of the frame's columns.
    - Each strip footing will also bear on top of eight 8-in diameter concrete micropiles. See geotechnical section for additional detail on the micropiles.
    - Clearances will be verified for support columns during Phase 2 detailed design
- Remote pellet loading control panel and control room
  - The stairs along the south wall of the building will need to be removed and replaced.

- The new staircase will include a 5-ft wide by 14-ft long landing
- The landing will include an 8-ft long aluminum or fiberglass reinforced plastic enclosure with viewing windows.
- All new aluminum framing, grating, and guardrail will be required.
- Space between existing support beams will be verified during the design phase to ensure control room will provide adequate space for egress requirements.
  - Need at least 36-inch doors with 36-inch open space through booth with doors opening in down stair direction for quick regress, have 36-inch landing on each side for door access

- Air compressors
  - If a third compressor is determined to be needed during phase 2 detailed design, then support pad and micro piles will need to be installed and an overhead cover will need to be constructed.
    - The third air compressor will most likely have to be placed between the building and the access road.
    - Ducting route will be determined in design.

4.1.6 Geotechnical

- Due to the large quantity of debris and fill material at the site, it is anticipated that micropiles will be required to support the foundation for the retaining wall.
- Micropiles are preferable due to limited site access, anticipation of obstructions below grade, and in order to protect the existing structures against vibration damage.
- Geotechnical services will be required to provide recommendations for design.

4.1.7 Architectural

- New off-specification silo
  - Blend in new silo with existing silos.

4.1.8 Site Civil Scope of Improvements

N/A

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Technical Memorandum

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Prepared for: Metro Water Services

Project Title: Central Wastewater Treatment Plant Capacity Improvements and CSO Reduction Project

Project No.: 148388

Technical Memorandum No. 13F

Subject: Biosolids Miscellaneous Modifications

Date: December 21, 2016

To: Trey Cavin, Metro Water Services

From: BWSC

Copy to: Ron Taylor, Metro Water Services

Prepared by: ______________________
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Table of Contents

List of Figures

Executive Summary

This Technical Memorandum (TM) documents the basis of design and conceptual layout for installation of a number of miscellaneous items, including:

- Additional walkways throughout the Biosolids Processing Building (Building 60);
- An access staircase to the Recycle Pump Station (PS) dry pit;
- An emergency source of potable water to the Biosolids Processing Building for dryer operations when plant water quality or quantity is insufficient;
- A scheme for isolating the Biosolids Facility stormwater drainage system to prevent accidental spills within the facility from reaching surface water;
- A modification of the Thermal Drum Dryer Induced Draft (ID) Fans in the Biosolids Processing Building to allow the fans to operate using variable speed drives rather than modulating inlet dampers.

The modifications and installations of new walkways will allow Metro Water Services (MWS) personnel easier and quicker access to needed areas in the Biosolids Processing Building to perform daily maintenance and operational tasks. Current walkways and access points do not function as effectively as needed causing personnel to have a difficult time getting between process areas to complete duties.

The access stairway for the Recycle PS dry pit will allow for maintenance access to the pump floor when there are technical difficulties using the existing man lift. Currently, if the man lift is out of service, the operators must use an extension ladder placed in one of the equipment hatches and have tools lowered into the pit. The access staircase will allow for personnel to have a physical means of access to the pump floor.

While the addition of the new Central Biosolids Facility Effluent PS has improved the availability of water to the Biosolids Processing Building, occasionally the strainers become fouled and flow or pressure are reduced. An emergency connection to the potable water system will provide a backup supply if flow or pressure from the plant water system is insufficient.

In the event of a large spill into the stormwater collection system, plant staff can insert a manual stop gate into the storm sewer to prevent the spill from migrating beyond the plant boundary. The Biosolids Flood Mitigation TM called for the installation of an electrically actuated isolation valve at the end of the plant stormwater collection system to prevent flood waters from backing up into the Biosolids Facility (along with a floodwall to isolate the facility from flooding). This isolation valve could also be used to prevent spills within the Biosolids Facility from moving off-site and discharging into surface waters.

Finally, the ID Fans on each thermal drum dryer system have suffered from excessive wear which has impacted performance. The adjustable inlet dampers on each ID fan are subjected to continuous abrasion due to pellet fragments from the drying process. Removing the inlet dampers and converting the ID Fans from constant speed to variable speed should reduce wear and improve performance.

Figure 1 identifies the location of the various miscellaneous items discussed in this TM.

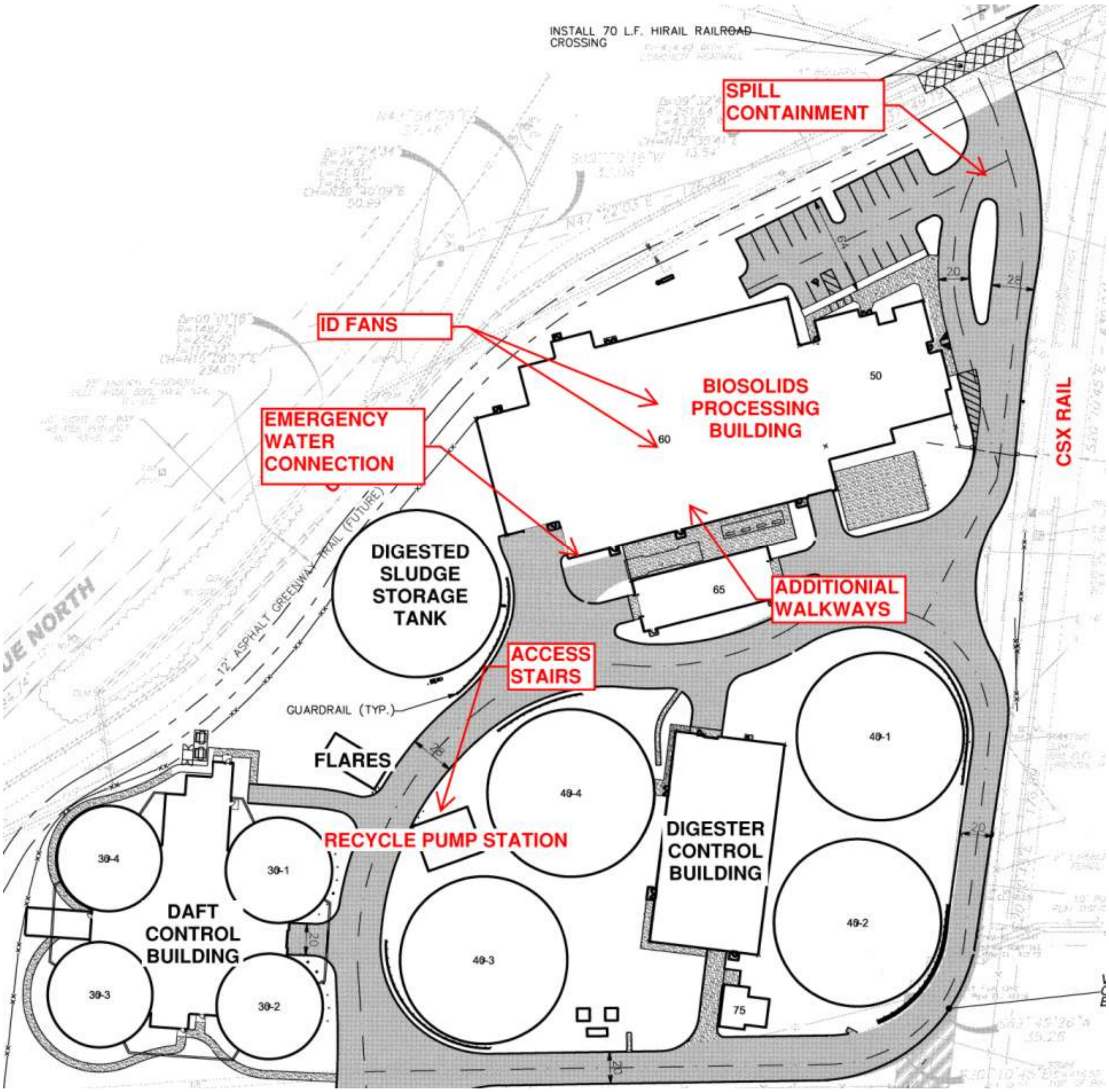

Figure 1: Biosolids Facility with Location of Miscellaneous Modifications

Section 1: Process Area Description

1.1 Biosolids Processing Building:

The Biosolids Processing Building, Building 60, processes the digested sludge and is the final processing treatment center to remove liquid from the solids utilizing centrifuges and dryers. The dewatered material is then processed to create a beneficially reusable Class A excellent quality pelletized biosolids product which is sent to the truck loading silos by pneumatic conveyors.

The existing walkway arrangement limits operator mobility between different control areas as shown in Figure 2. Currently the two dryer train operations levels are not connected to one another and the dryer trains do not have direct access to the conveyors and control room. Additionally, the top level of the polycyclones does not have an access across to allow for rapid adjustments to both systems. The Venturi scrubbers and condensers do not have platforms to perform maintenance.

MWS would like to improve operations and maintenance by installing additional access platforms and walkways.

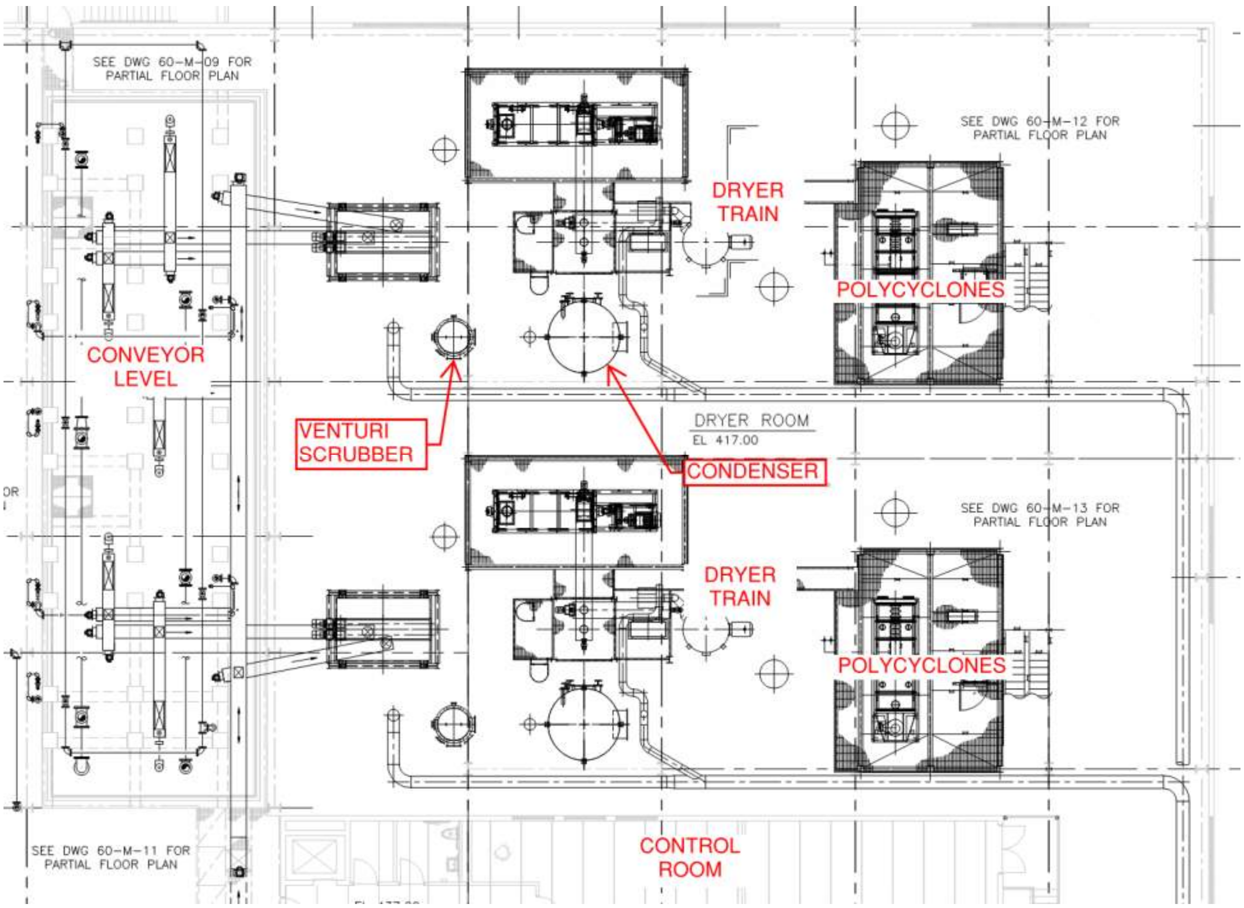

Figure 2: Dryer Building

Plant water from a new Biosolids Effluent PS at the CWWTP's North Chlorine Contact Tanks is pumped via a 16-inch FM to the Biosolids Facility. A 10-inch line supplies the Biosolids Processing Building with plant effluent water (W3), which is required for the drying process. Occasionally, the existing strainers, located in new PS, become blinded and pressure and flow are reduced, requiring the dryers to be shut down.

MWS would like to eliminate these shutdowns by providing a potable water connection to the dryers as a back-up water supply.

There are two ID fans (one per dryer train) in the Dryer System in the Biosolids Processing Building. Flow through the dryer drum is modulated using adjustable inlet dampers on the fans. Due to the abrasive environment, the fans have suffered excessive wear. To improve the performance of the ID air system, the vendor (Andritz) recommends converting the fans from constant speed to variable speed operation and remove the modulating inlet dampers. This modification will require the installation of two 300-HP variable frequency drives (VFDs) in the electrical room adjacent to Dryer Train 2. Figure 3 identifies the location of ID Fan 2 and the electrical room.

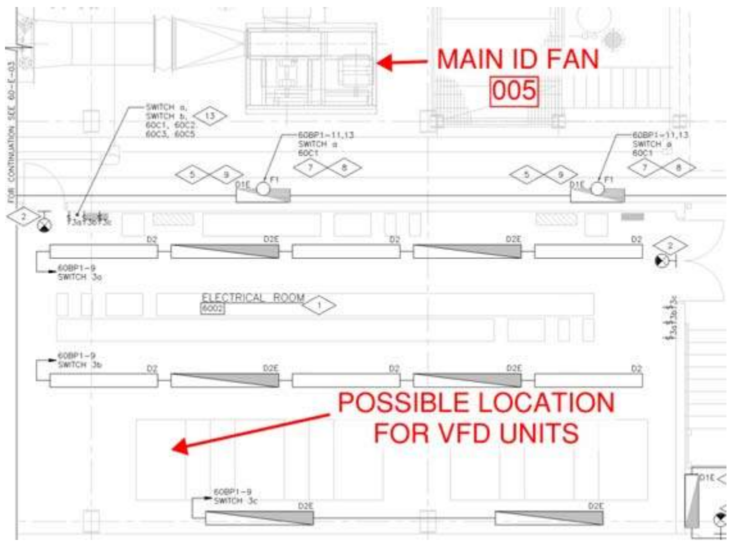

Figure 3: Existing ID Fan and Potential Location of VFDs in Electrical Room.

1.2 Recycle PS:

The existing Recycle PS, Building 80, receives flow from the DAFTs, digesters, dryers, and centrifuges in a 10 feet (ft) x 27 ft wet well through a 36-inch diameter inlet as shown in Figure 4. Three 100-HP, 5,200 GPM horizontally driven centrifugal recycle pumps operating on VFDs convey the flow to the CWWTP in a 24-inch ductile iron pipe. The operating floor of the station is accessed by utilizing a one-person man lift located in the west corner of the PS dry pit. When the man lift is out of service, extension ladders are placed through the equipment removal hatches to access the operating floor.

MWS would like to add a stairway to the recycle PS to have a better way to access the pump floor so that the pump floor can be accessed regardless of man lift functionality.

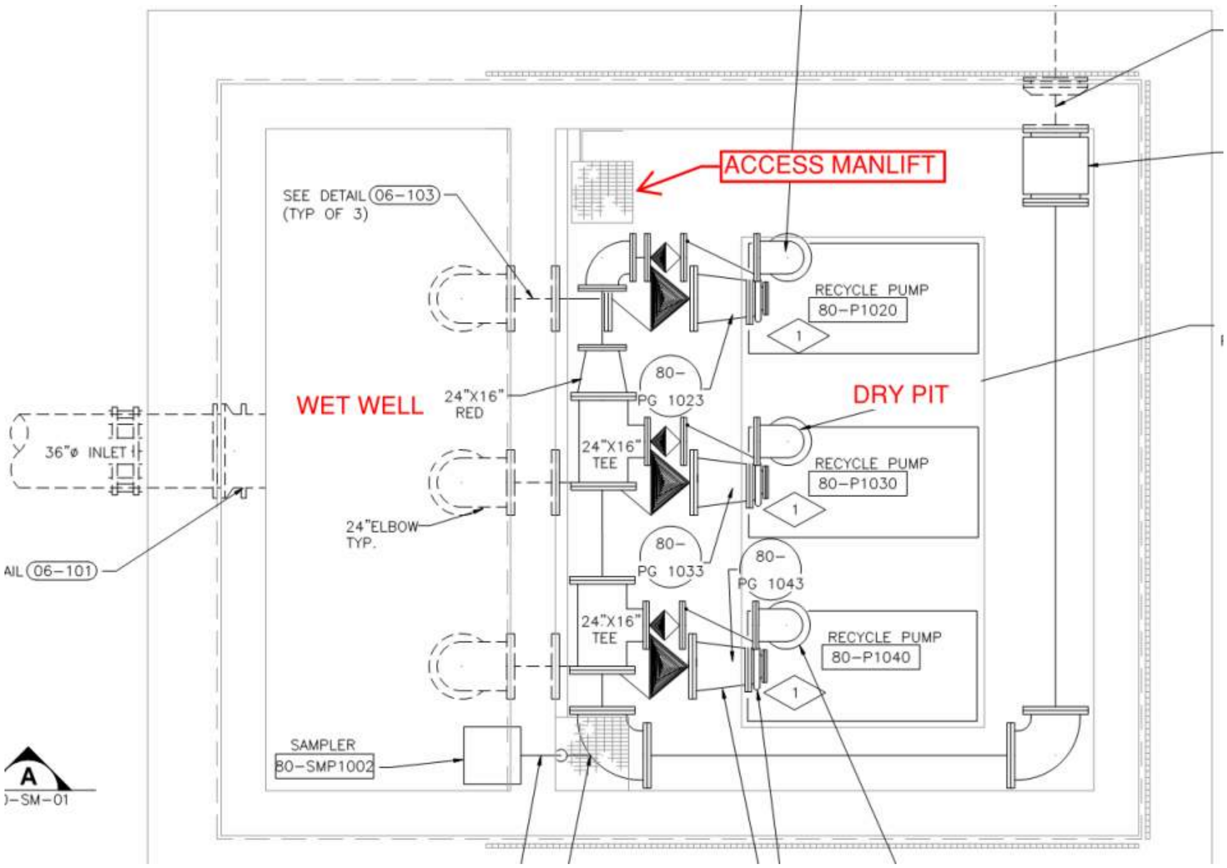

Figure 4: Recycle PS

1.3 Plant Stormwater Drainage Containment:

The Biosolids Flood Mitigation TM proposes the installation of a floodwall, actuated valve, and PS to protect the Biosolids Facility from flooding. During a flood event, an automatic gate valve would be closed to prevent floodwaters from backing up in the stormwater piping and flooding the facility. Due to the closed valve, any stormwater collected within the floodwall would be diverted to a stormwater PS and pumped out of the protected area. The proposed system is illustrated in Figure 5. This system will also help isolate the plant stormwater drainage system so that spills that occur on site will be captured in the stormwater drainage system and not reach surface water.

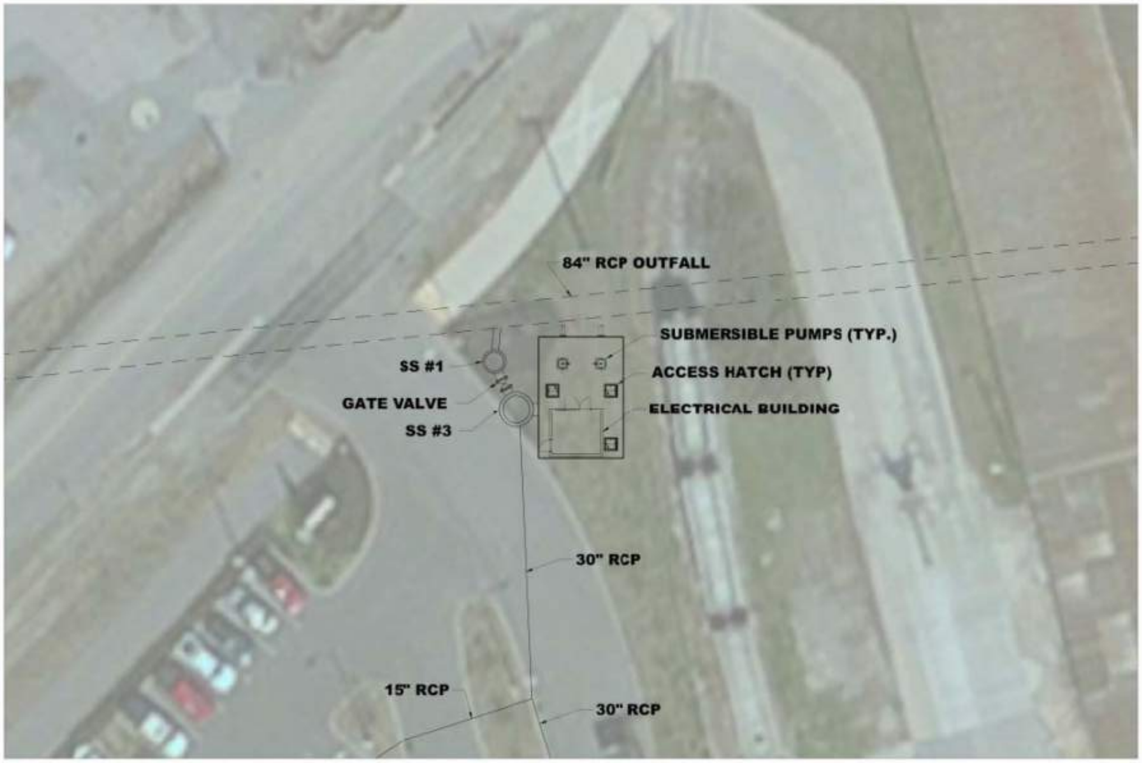

Figure 5: Proposed Biosolids Stormwater Piping Modifications and PS

Section 2: Design Intent

The design intent for this process area is:

- Provide new walkways throughout the Biosolids Processing Building to increase operational accessibility between the electrical room, dryer trains, and centrifuges and between the top of polycyclone towers.
- Provide new access from the second level platforms and provide new platforms above the equipment top to allow for maintenance on Venturi scrubbers and condensers for the two dryer trains.
- Provide new stair access to recycle PS dry pit floor.
- Provide an emergency source of potable water to the Biosolids Processing Building for dryer operations when plant water quality or quantity is insufficient;
- Provide a scheme for isolating the plant stormwater drainage system to prevent accidental spills within the facility from reaching surface water;
- Modify the dryer ID fans in the Biosolids Processing Building to allow the fans to operate at variable speed.

Section 3: Constraints

- The existing piping and structures on site and in building will limit location and alignment of new walkways and stairs.
- Equipment clearances will need to be maintained for equipment removal through Biosolids Processing Facility.
- The recycle PS is located in a congested area which will limit where stairs can be placed.

3.1 Design Criteria

- Recycle PS stairwell shall meet all access and egress code requirements.
- Walkways shall meet code requirements.
  - Verify maintenance and safety clearances are suitable.
- Maintenance platforms provide adequate space for all maintenance required on Venturi scrubbers and condensers.
- Potable water connections to the Dryer System should pass through a MWS-approved backflow preventer and water meter before connecting to the Plant Water (W3) system.
- Velocity in the water supply piping should be less than 8 fps.
- Supply a minimum of 1000 GPM at 50 psi to the dryer systems.

3.2 Code Considerations

- 2012 International Building Code with Local Amendments
- 2012 International Energy Conservation Code
- 2009 ICC/ANSI A-117.1 Accessible and Usable Buildings and Facilities
- 2012 International Plumbing Code with Local Amendments
- 2012 International Mechanical Code with Local Amendments
- 2011 National Electrical Code with Local Amendments
- 2012 International Fire Code with Local Amendments
- 2012 Life Safety Code (NFPA 101) with Local Amendments
- 2016 International Fire Code (NFPA 820) Fire Protection in Wastewater Treatment and Collection Facilities

3.3 Regulatory Drivers

N/A

3.4 Sequencing and Constructability Issues

- Sequencing
  - There shall be no interruption in Biosolids operation during installation of the walkways or emergency piping connections.
  - Installation of the VFDs and modifications to the ID Fans shall be coordinated with the operations staff to minimize the downtime to the dryer operation. Only one dryer can be

taken out of service at a time for no longer than five consecutive days. Downtime must be coordinated to begin at lowest operational level in DSST.

- The stormwater work can be completed with minimal interruptions to the operation of the Biosolids Facility. The roadway into the Biosolids Facility must be left open to allow final pellet tractor trailers and MWS equipment onto the site.
- It is not anticipated that the recycle well will be taken down for any extended period of time for the installation of the stairway.
- Some work will be required to be completed on weekends.

- Constructability
  - Construction space is limited inside Biosolids Processing Building and on the site.
  - Shoring will be required for building of the access stairwell for the Recycle PS and the stormwater pumping station.
  - Wall and foundation penetrations in the Biosolids Processing Building will be required for the connection to the potable water system.

3.5 Operational Issues

N/A

Section 4: Description of Improvements

4.1 Miscellaneous Facility Improvements

4.1.1 Detailed Design Considerations and Assumptions

N/A

4.1.2 Process Mechanical

4.1.2.1 Process

- All modifications to the ID Fans, including connections to the Dryer System SCADA, will be coordinated with Andritz.

4.1.2.2 Odor Control

N/A

4.1.2.3 Heating, Ventilation, and Air Conditioning (HVAC)

- Heat load in the electrical room will be evaluated due to the addition of two 300-hp VFDs. Initial calculations suggest an additional 50 kW of heat rejection will be realized due to the drives.
- An additional roof top unit may be required to accommodate heat from VFDs.

4.1.2.4 Plumbing

- Piping from the potable water main to the Biosolids Processing Building should be upsized to 10-inch ductile iron pipe (DIP) to accommodate the required flows to the Dryer System.

- An approved backflow preventer should be installed onsite in the Biosolids Processing Building in a location approved by Metro Water Services. Isolation valves should be included to allow the device to be serviced.
- A meter should be installed with appropriate straight run of pipe and isolation valves to allow the meter to be removed for service.
- The emergency line should be connected to the existing W3 line by replacing an existing 10-inch bend with a 10-inch 3-way gate valve.
- Figure 6 illustrates the recommended modifications.

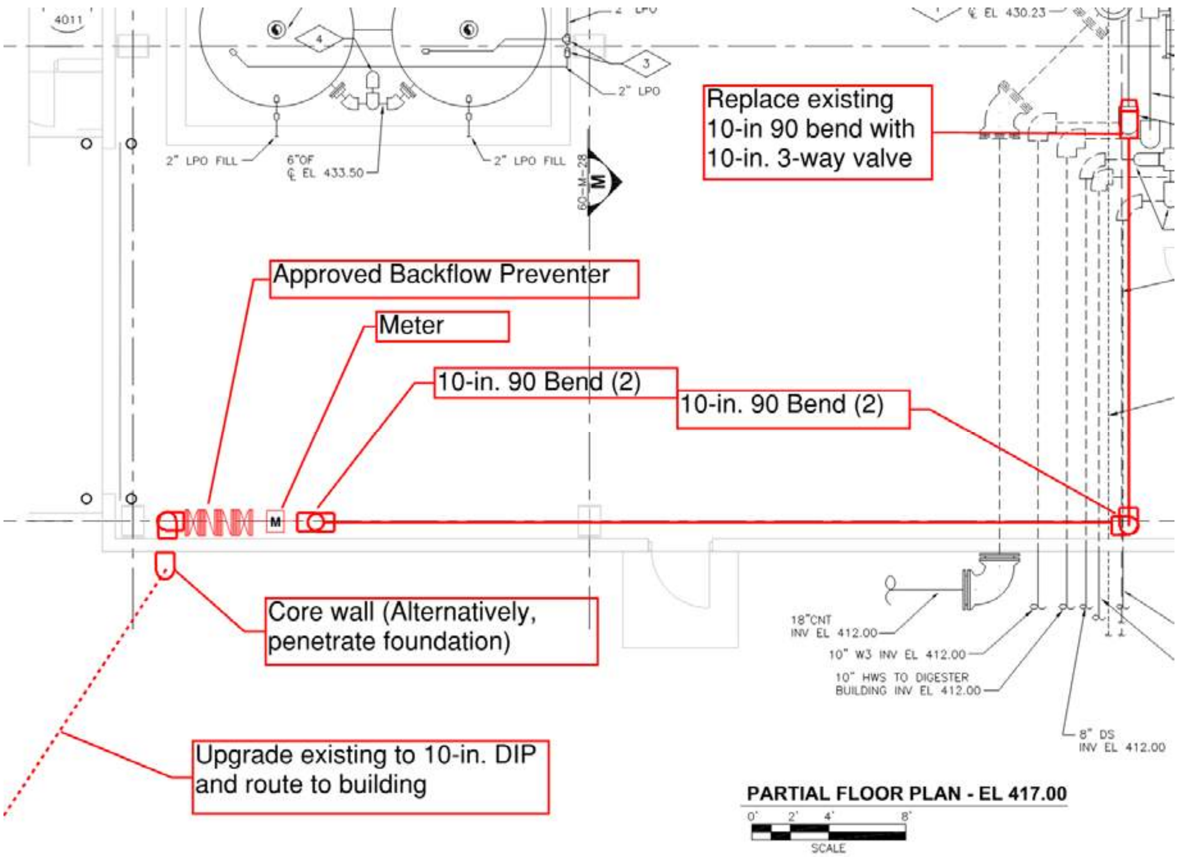

Figure 6: Connections to the Potable Water System for Emergency Service

4.1.3 Instrumentation and Controls

- I/O and logic will need to be modified in existing Andritz PLC to allow VFDs to vary speed of ID Fans to control system air flow.

4.1.4 Electrical

- Recycle PS access
  - Electrical wiring for lighting in stairwell
  - Potentially a need to relocate electrical panels in Recycle PS west wall for stair access door opening into pump floor.

- ID Fans
  - Locate VFDs in adjacent electrical room or second floor electrical room

4.1.5 Structural

- Dryer Walkways
  - The new walkway framing for the proposed walkways shown in Figure 7 will be attached to the existing structural framing or to new structural framing, as required.
  - The new walkways will be constructed of galvanized steel and will have a 30-inch minimum clear width between the guardrails.
  - The walkway guardrails will be a two-rail system with a toe plate and all materials will be galvanized steel to match the existing walkways. The top rail of all guardrails will be 42-inch above the walking surface to comply with International Building Code (IBC) requirements.
  - The new walkways must not impede the removal of equipment when it is being removed by the bridge crane.

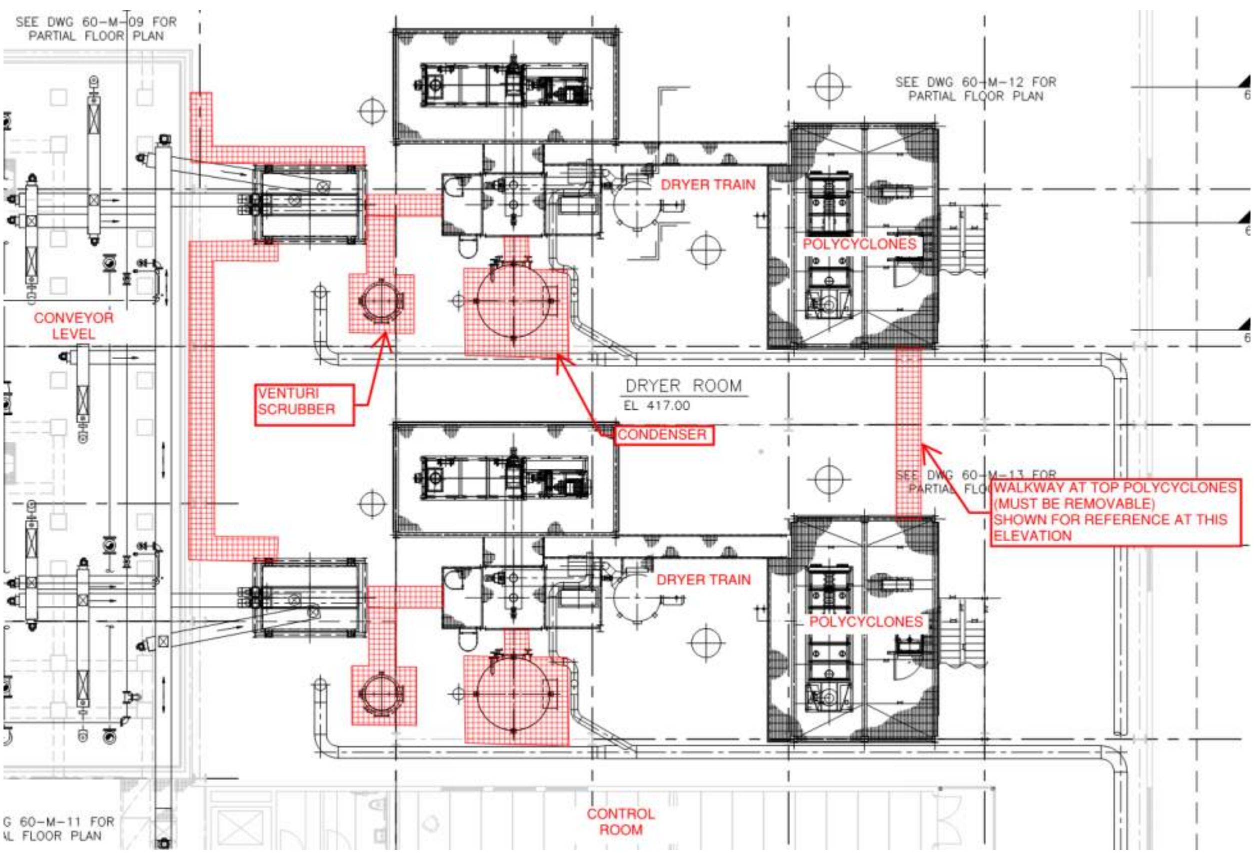

Figure 7: New Dryer Building Walkways

- Recycle PS access
  - Access will be provided to the PS dry pit by means of a new 3-ft wide external concrete staircase. (Figure 8)
  - New stair will provide safe, code-compliant egress, which will also be more operator-friendly. A handrail will also be provided along one side of the stair.
  - The stairwell will be enclosed to keep precipitation from entering the structure.
  - Temporary shoring and bracing will be required for excavating the new staircase.
  - Existing PS will have a 3-ft by 7-ft door opening saw cut into the wall at the top of the foundation.
  - A new concrete retaining wall will be required on the exterior of the staircase.
  - Retaining wall foundation will bear on a deep foundation system, similar to micropiles.
  - The stair will be enclosed and therefore require a drain at the bottom landing. The drain will be tied into the existing sump drainage system in the dry well.

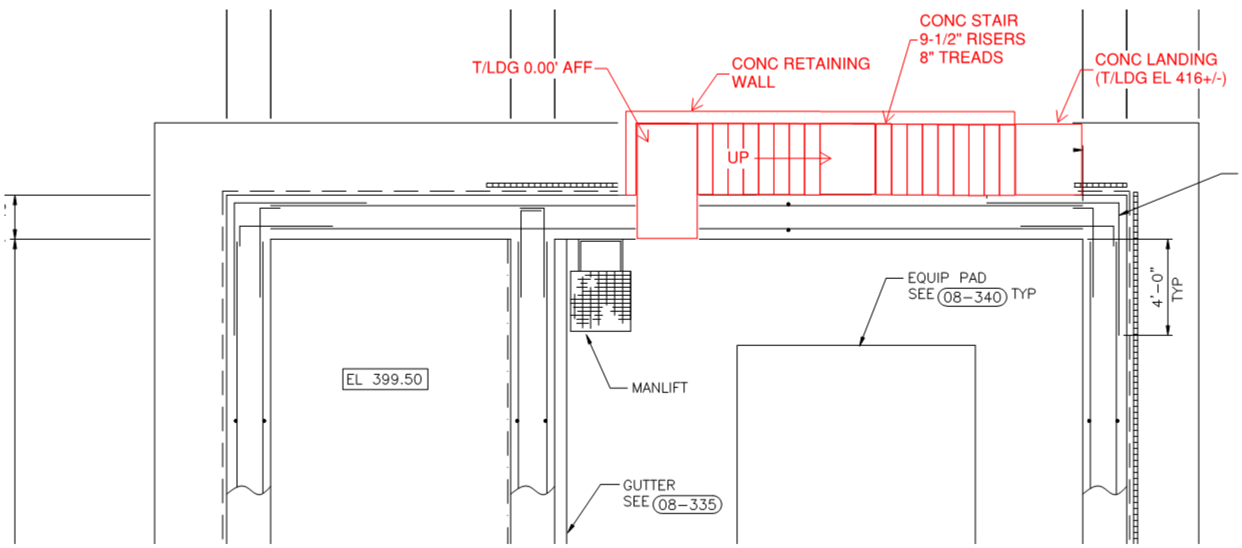

Figure 8: Exterior Recycle PS Access Stairs

4.1.6 Geotechnical

- Due to the large quantity of debris and fill material at the site, it is anticipated that micropiles will be required to support the foundation for the retaining wall.
  - The retaining wall is around the access stairway.
- Micropiles are preferable due to limited site access, anticipation of obstructions below grade, and in order to protect the existing structures against vibration damage.
- Geotechnical services will be required to provide recommendations for design.

4.1.7 Architectural

- Recycle PS Access
  - An above ground metal structure will be provided for access to the stairwell.
  - The structure will match the existing structures in the area in appearance.
  - The structure will be large enough so that required head clearances are maintained going down the stairs.

4.1.8 Site Civil

- Potable Water for Dryer System
  - Site work will be required to install 10-in potable water line.
    - The line will be approximately 50 ft at a 3 ft depth.
    - The concrete cut for installation of the new water line will need to be replaced to match existing.
- Recycle PS Access
  - Site work will be required for excavation of the access stairway and retaining wall.
    - Facility access road will be disturbed and, therefore, will need to be cut and repaved.
- Stormwater Modifications
  - Site work will be required throughout the biosolids site to accommodate the construction of the flood wall, stormwater pumping station and other stormwater improvements.

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