



2022 Fall Conference at OC Fontainebleau Resort

**SOIL CONSOLIDATION & PREPARATION TO INSTALL 800 MGD PUMPING
STATION ON A THIN CLAY LAYER AND UNUSABLE SOIL**

Paul Deardorff and Alex Adu-Osei

September 30, 2022

2:30 to 3:30 PM

BIOGRAPHY

- Paul Deardorff

- Project Manager at JMT
- 17 Years of experience in water infrastructure
- Project Engineer on Back River WWTP Headworks Contract



- Alex Adu-Osei, Ph.D., P.E.

- Project Manager at E2CR, Inc.
- 30 Years of experience in Geotechnical Engineering
- Geotechnical Engineer on Back River WWTP Headworks Contract



OBJECTIVES AND AGENDA

SOIL CONSOLIDATION & PREPARATION TO INSTALL 800 MGD PUMP STATION ON A THIN CLAY LAYER AND UNUSABLE SOIL

- Understand Background and Project Drivers
- Discussion of Project Delivery Method – CMAR
- Discussion of Site Conditions and Investigations
- Approach to Foundation Design and Site Preparation
- Summary of Construction Activities
- 1.0 PDH

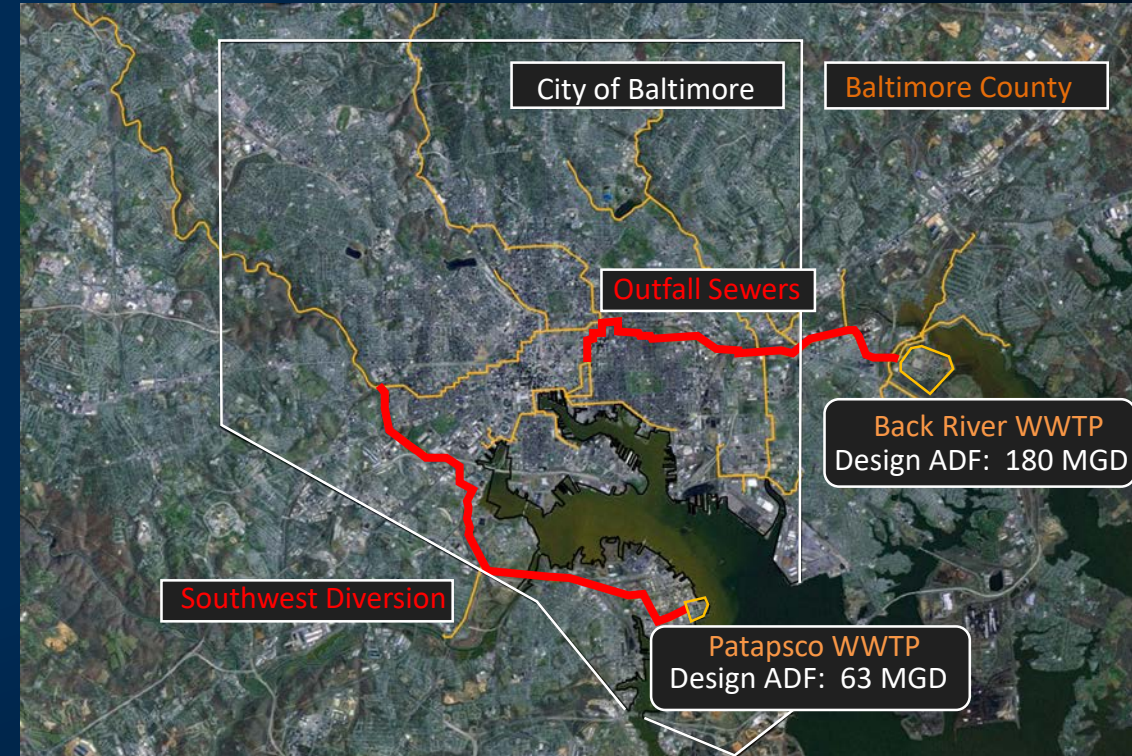


WET WEATHER CONSENT DECREE PROGRAM

In 2002, City of Baltimore entered a Consent Decree with state and federal regulators

Consent Decree required upgrades to the wastewater collection system including:

- Elimination of existing sanitary sewer overflows
- Comprehensive sewer evaluation program including development of a dynamic hydraulic model and infiltration/inflow (“I/I”) analysis



WET WEATHER CONSENT DECREE PROGRAM

The City/Wet Weather Program Consultant develop a system wide hydraulic model which predicts wastewater collection system flows

Model predicted flows consider:

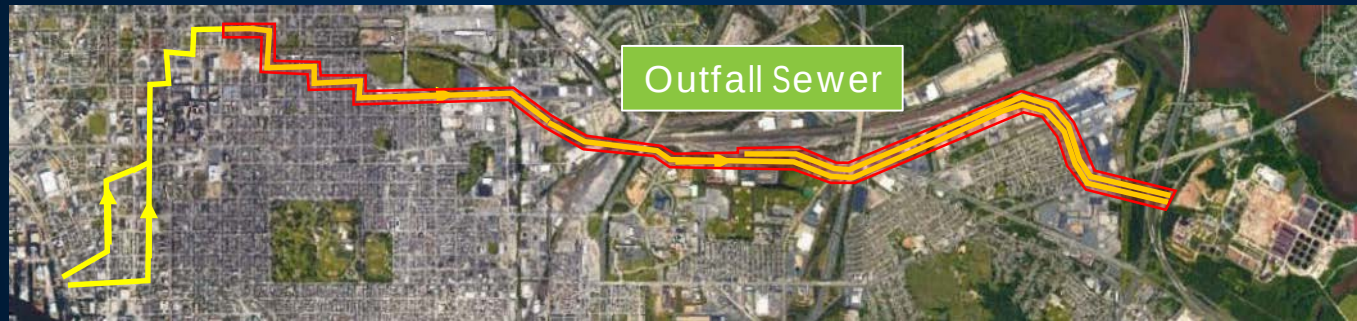
- Future growth
- System aging
- Proposed improvements in the collection system to increase hydraulic capacity and reduce I/I influence



PROJECT BACKGROUND

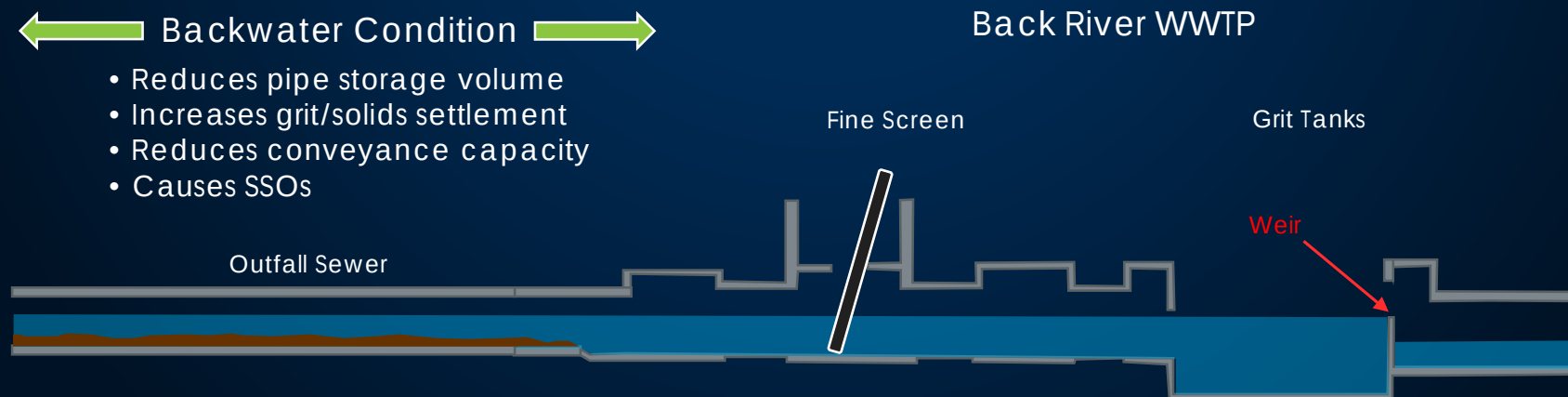
HYDRAULIC RESTRICTIONS

- City Wet Weather Program identifies hydraulic restriction at Back River WWTP
- Creates more than 7-mile backwater condition in Outfall Sewer



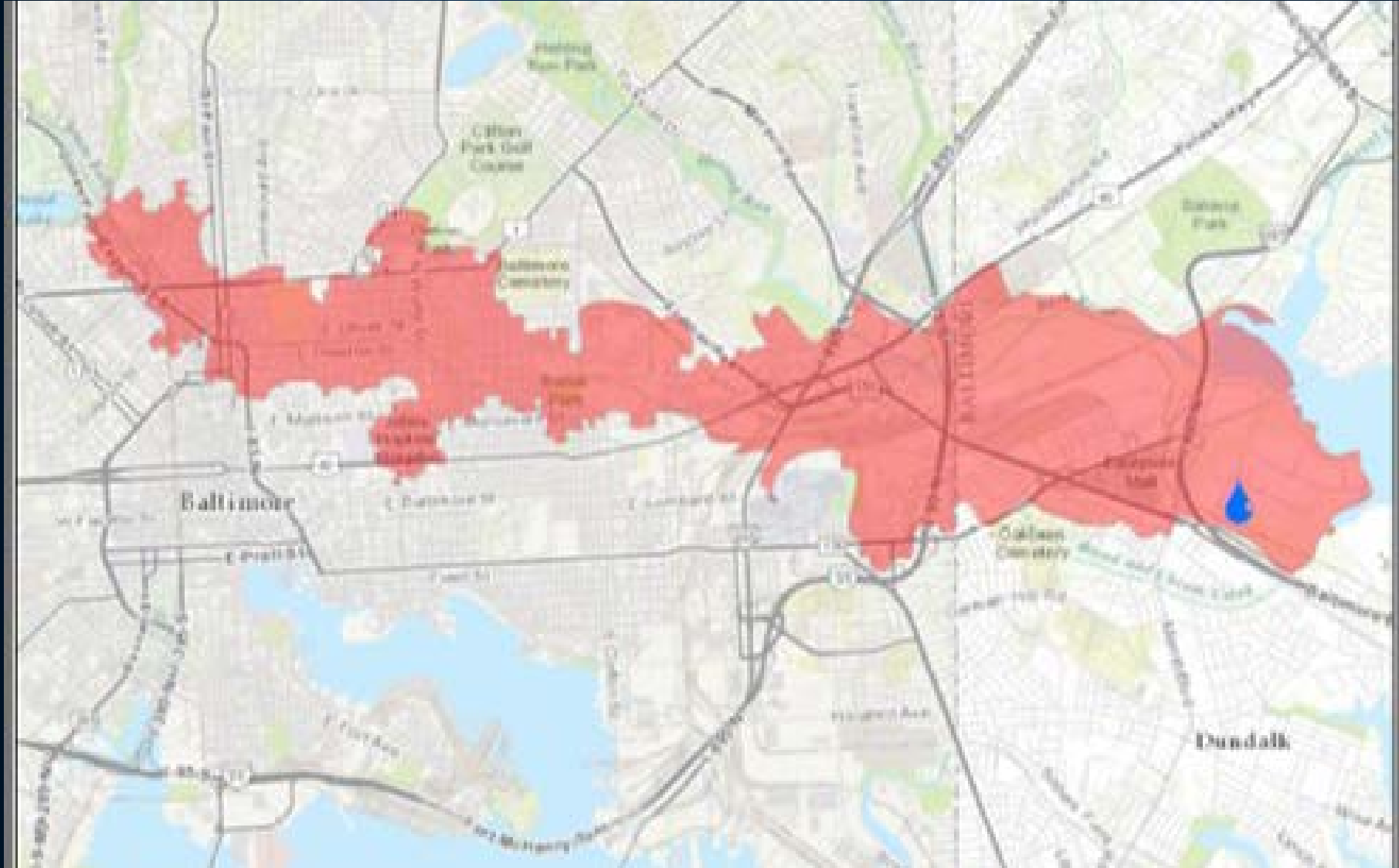
← Backwater Condition →

- Reduces pipe storage volume
- Increases grit/solids settlement
- Reduces conveyance capacity
- Causes SSOs



PROJECT BACKGROUND

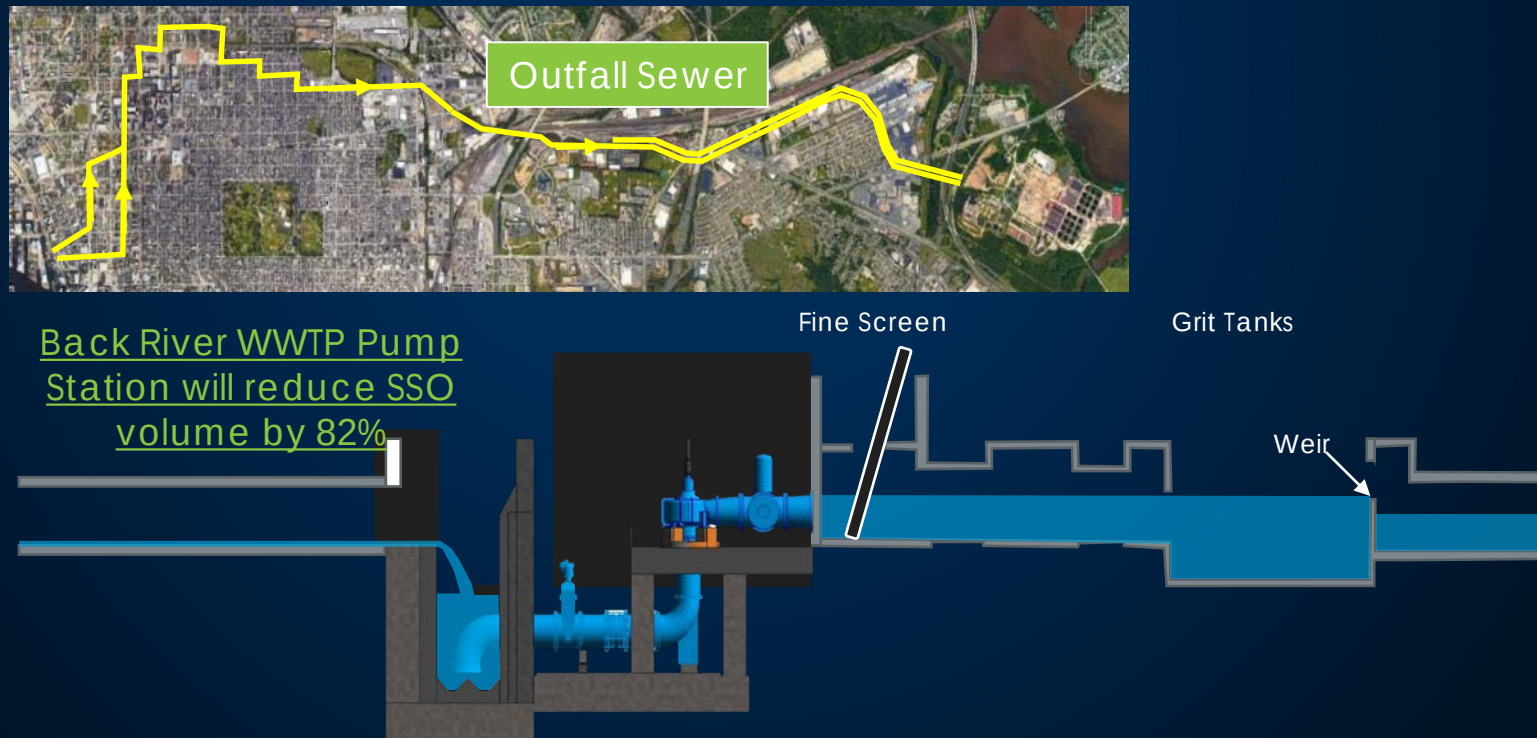
HYDRAULIC RESTRICTIONS



PROJECT BACKGROUND

FREE DISCHARGE

- Create a free discharge for Outfall Sewer by **January 1, 2021**
- Removes backwater condition in Outfall Sewer

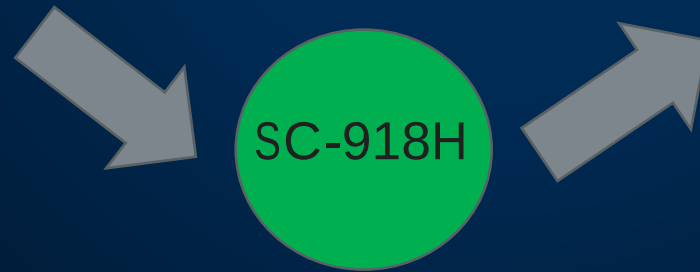


BACK RIVER WWTP HEADWORKS DESIGN

- Influent flows to Back River WWTP projected to increase by greater than 50%
 - Require wet weather storage

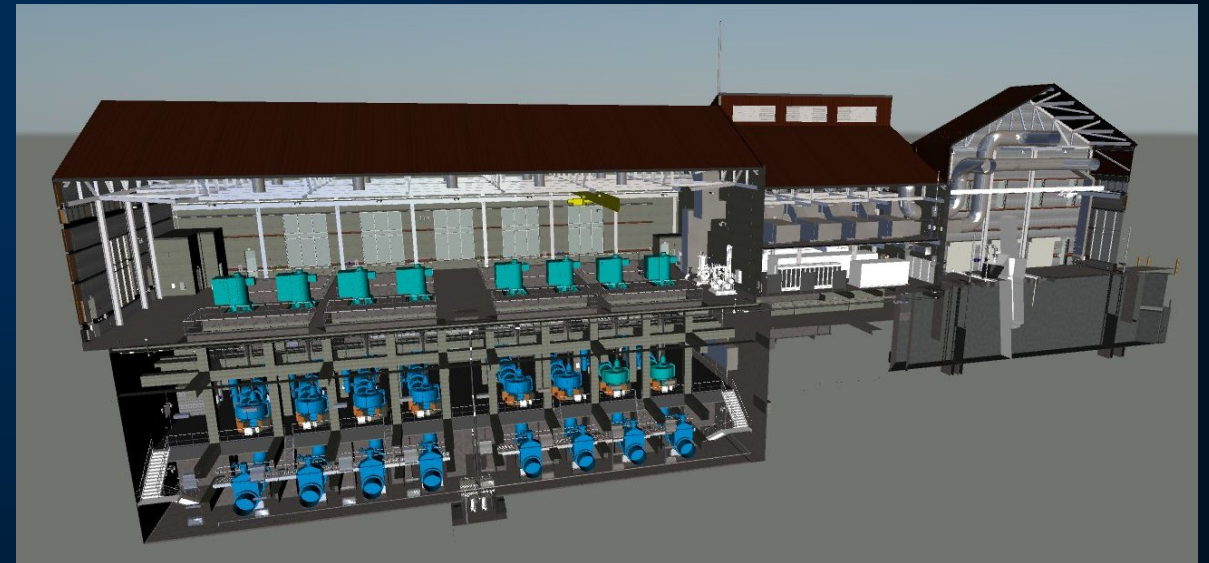
Collection System
Flow > 750 MGD

Back River WWTP
Capacity < 450MGD



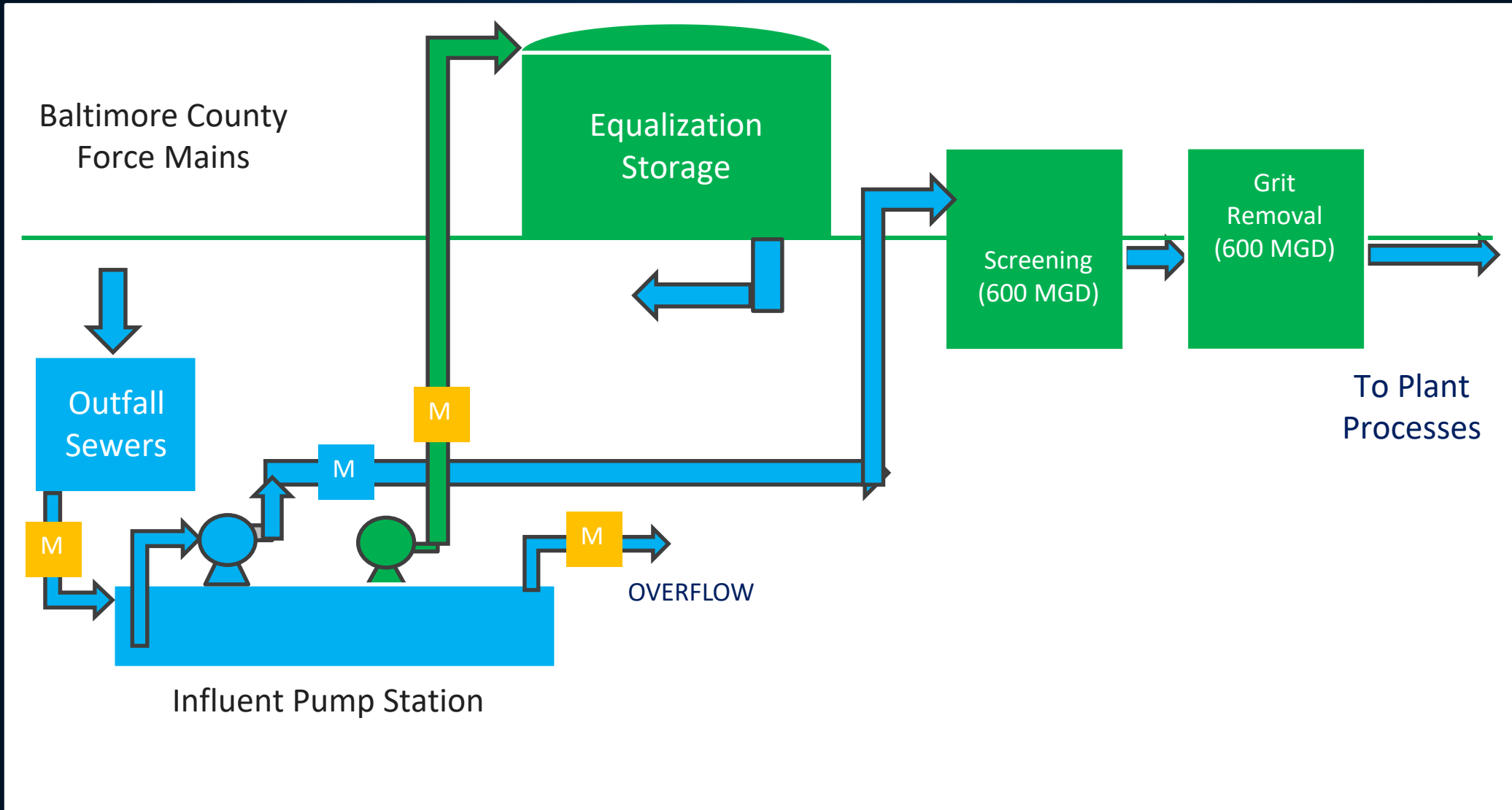
BACK RIVER WWTP HEADWORKS DESIGN

- 15-Month Design Phase (2,400 Drawings)
- Weekly Coordination Meetings with 9 Subconsultant Team
- Monthly Meetings with City Operations/Engineering
- 3D Design with REVIT Modeling Software
- HI Physical Model of Influent Pump Station
- Site Visits to Washington D.C., Chicago and Dallas for Equipment Evaluation



BACK RIVER WWTP HEADWORKS

PROPOSED PROCESS FLOW



BACK RIVER WWTP HEADWORKS

NEW FACILITIES

Influent Pumping Station

Coarse Screen Facility

Wet Weather Storage Tanks

Grit Removal Facility

Fine Screen Facility

Influent Junction Chamber

Odor Control Facilities
Power Supply Systems
Roadway and Grading
Site Utilities



BACK RIVER WWTP HEADWORKS

BIDDING AND CMAR

- Project Advertised and Bid in June 2015
 - Bids ~30% over budget
 - Aggressive schedule, skilled labor shortages, soils disposal identified as bidding risks
- City, Design Team and Third-Party Consultant Evaluate Paths Forward
- Re-Procurement via Construction Manager at Risk (CMAR) Model
- Advanced Contracts to Maintain Schedule
 - Soil Surcharge
 - Force Main Relocation



BACK RIVER WWTP HEADWORKS

CMAR APPROACH

- City Design-Build Committee Approves CMAR Approach
- Best Value Selection of CMAR Team
 - Technical Proposal
 - Cost Proposal
- City Selects Clark/Ulliman Schutte CMAR Team for Back River Headworks Contract
- Pre-Construction Phase Begins July 2016
 - Initial Construction Estimate from CMAR
 - Value Engineering Workshops
 - Scope Agreement
 - Develop Guaranteed Maximum Price (GMP)
 - Bid Package Development & Procurement
- Advance GMP for IPS Excavation and Foundation Concrete

SCOPE CHANGES & VALUE ENGINEERING

Combine Influent and EQ Pump Stations

Coordinate City Projects for Emergency Power Redundancy

Reduction in Fine Screen and Grit Removal Facility Capacity

Materials Selection Alternatives

Controls System Provider

BACK RIVER WWTP HEADWORKS

CMAR APPROACH

Why CMAR?



- **Selection based on qualifications and best value**
- **Traditional Design-Bid-Build has not yielded desired outcome**
- **Best method to leverage investment already made in project**
- **Flexible, collaborative approach**
- **Costs transparency leading to better financial control**
- **CMAR oversees all construction phases to reduce risks**

BACK RIVER WWTP HEADWORKS

CMAR GMP AND SCHEDULE

PROJECT COST

CM Staff, Facilities, Equip.
GCs, Fixed Fee

Bid Packages, Future VE

Construction Contingency

Owner's Allowance



Total GMP = \$429 M

SCHEDULE

Notice to Proceed

June 29, 2017

Technical Compliance*

December 31, 2020

Substantial Completion

October 31, 2021

Technical Compliance

- Free Discharge Condition
- 400 MGD Pumping Capacity
- Coarse Screens and Fine Screens Operational

BACK RIVER WWTP HEADWORKS

NEW FACILITIES

Influent Pumping Station

Coarse Screen Facility

Wet Weather Storage Tanks

Grit Removal Facility

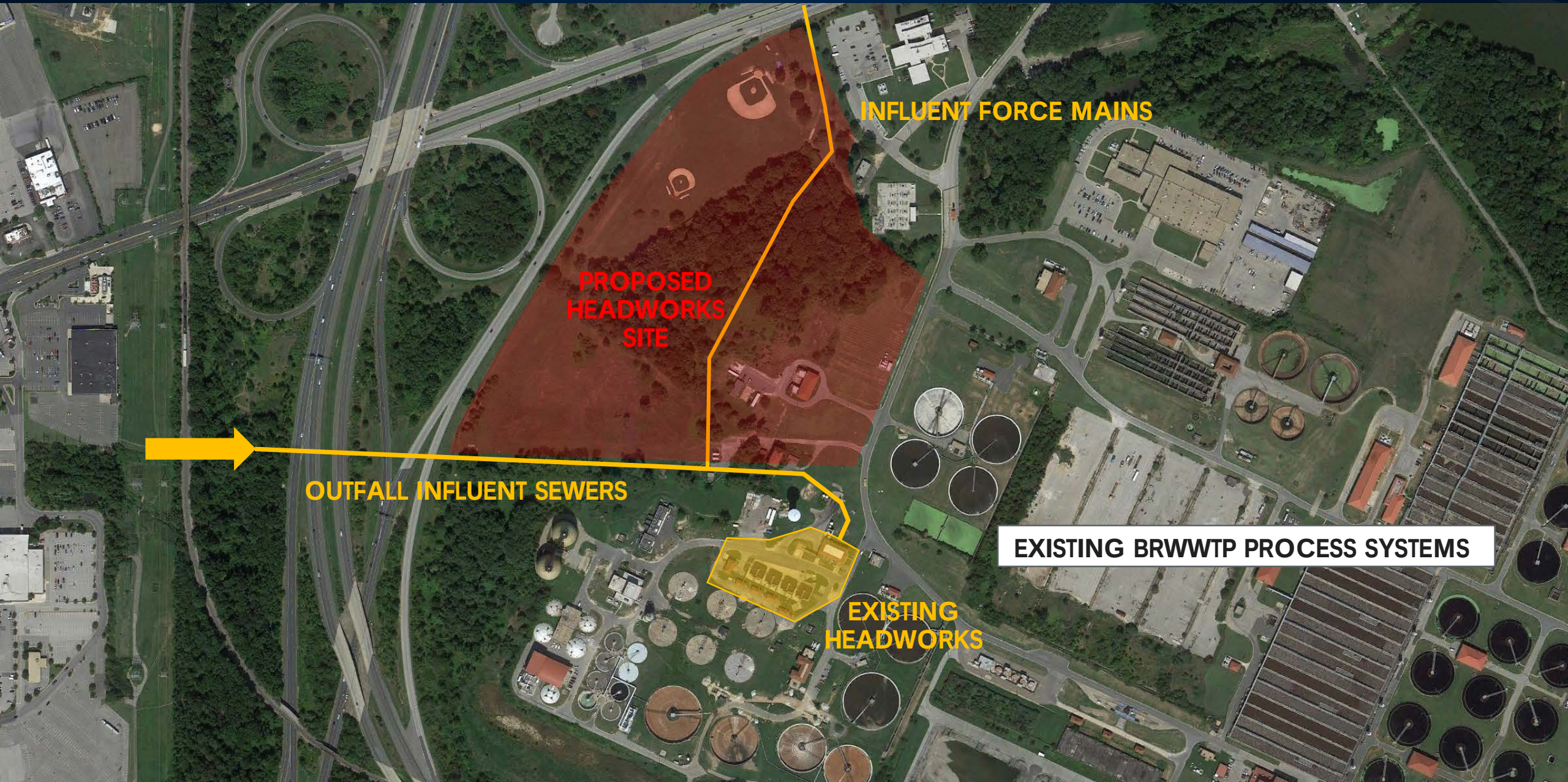
Fine Screen Facility

Influent Junction Chamber

Odor Control Facilities
Power Supply Systems
Roadway and Grading
Site Utilities



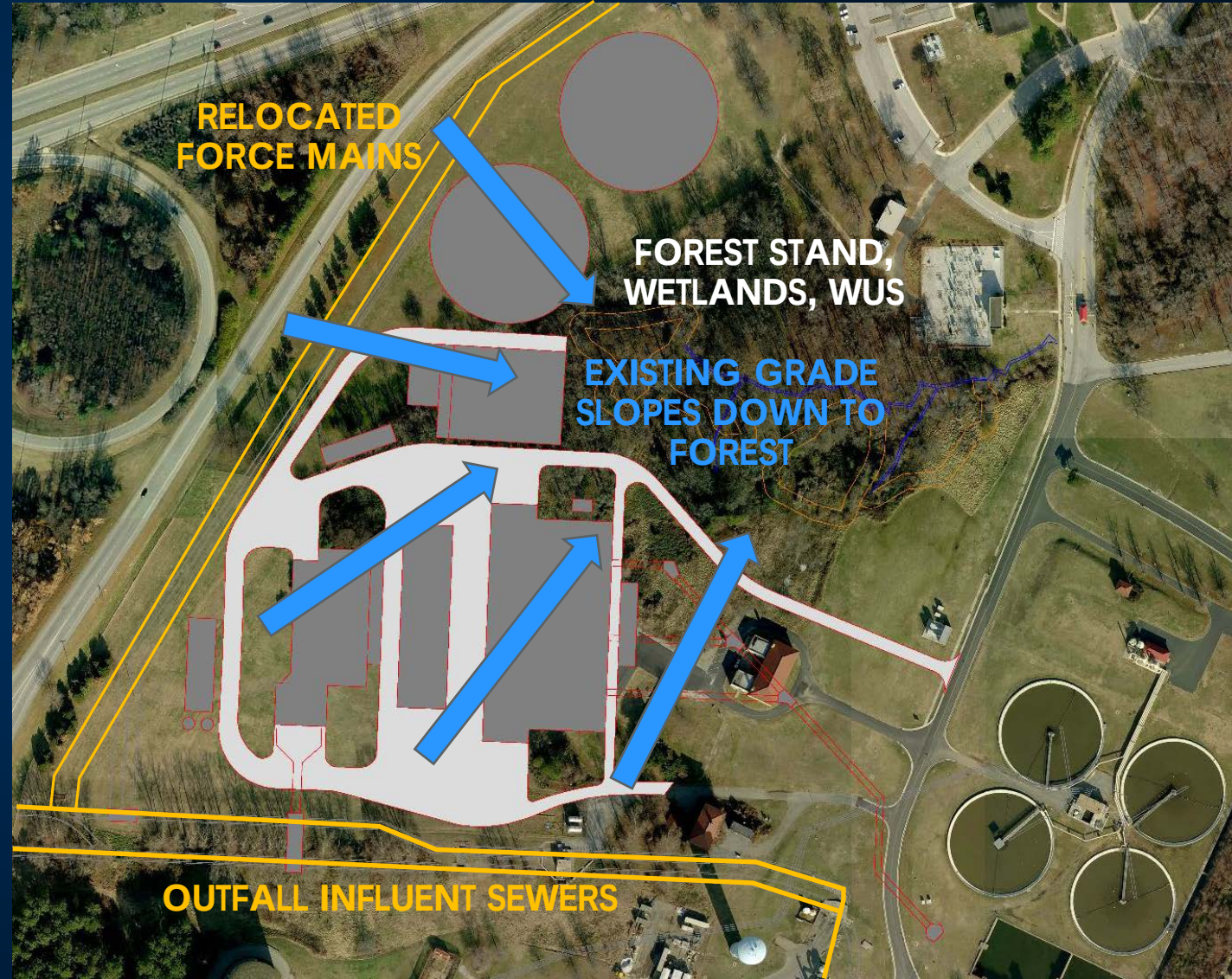
BACK RIVER WWTP SITE PLAN - 2013



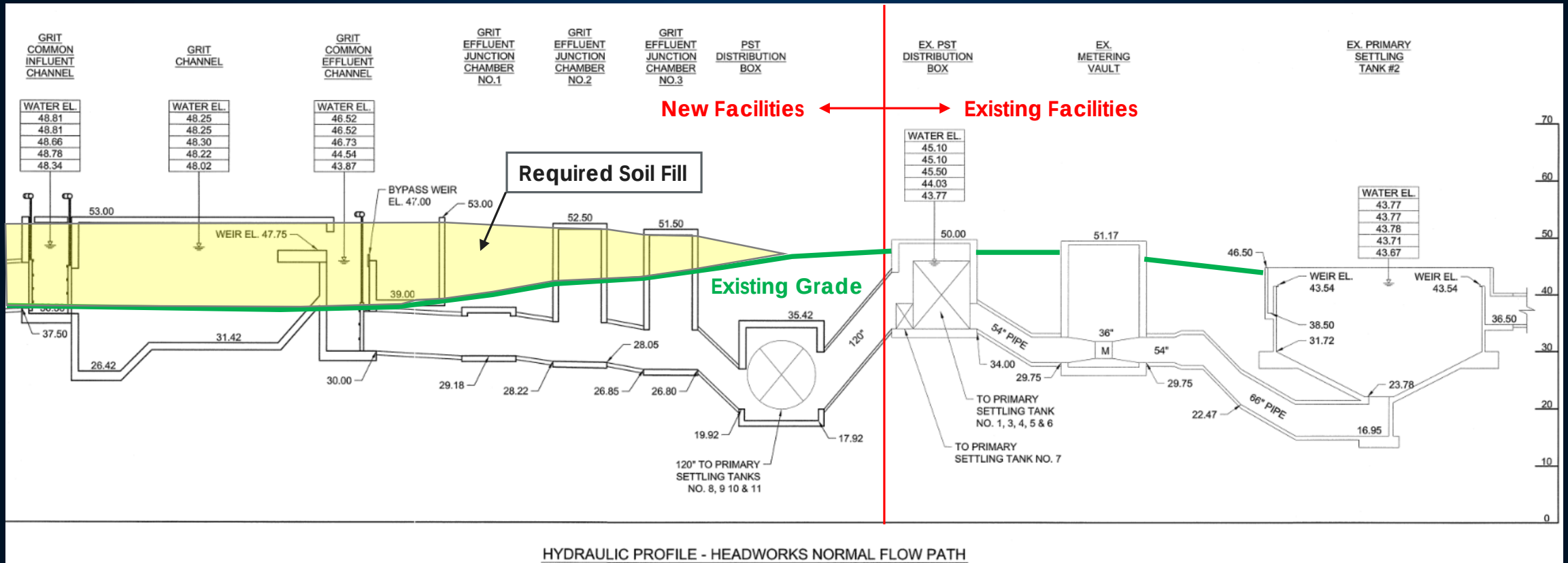
BACK RIVER WWTP HEADWORKS

CONCEPT SITE PLAN

- Environmental Site Features
 - Forest, wetlands, WUS
- Relocate force mains
- Demolition existing buildings
- Existing grade slopes ~15 ft



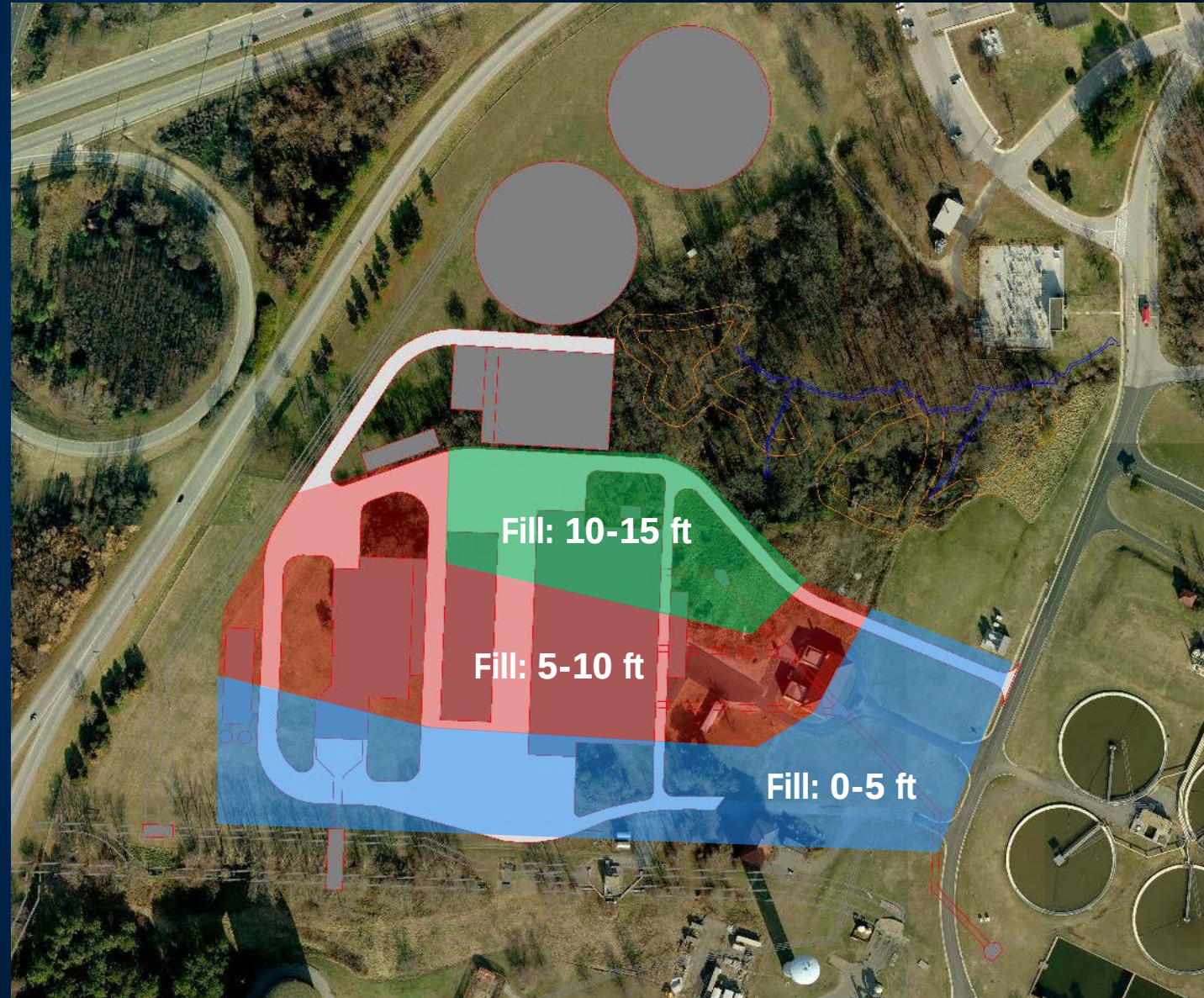
BACK RIVER WWTP HEADWORKS HYDRAULIC GRADELINE



BACK RIVER WWTP HEADWORKS

SITE FILL GRADING

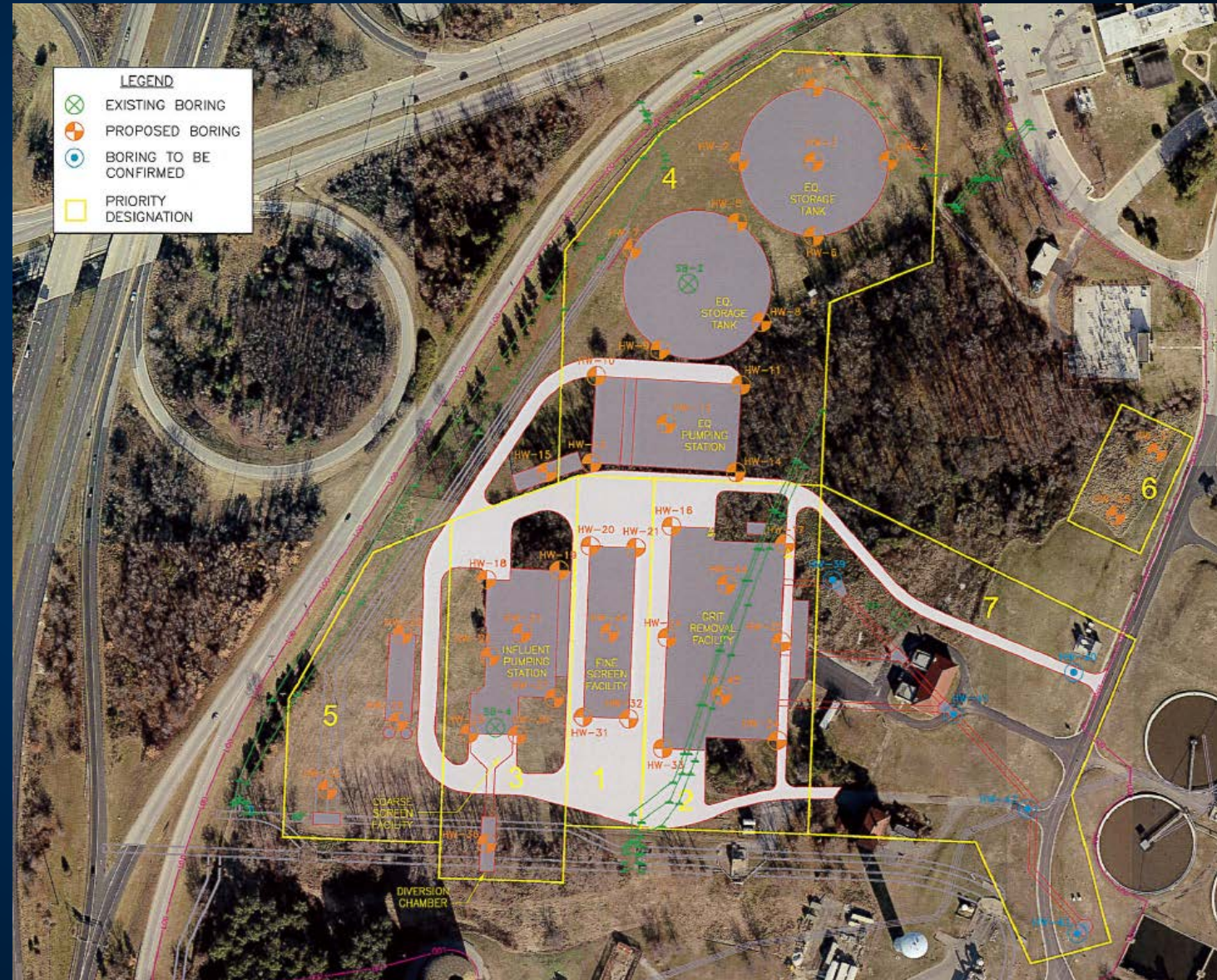
- Process hydraulics driven
- Required to add fill above existing grade
- Up to 15 feet of fill required



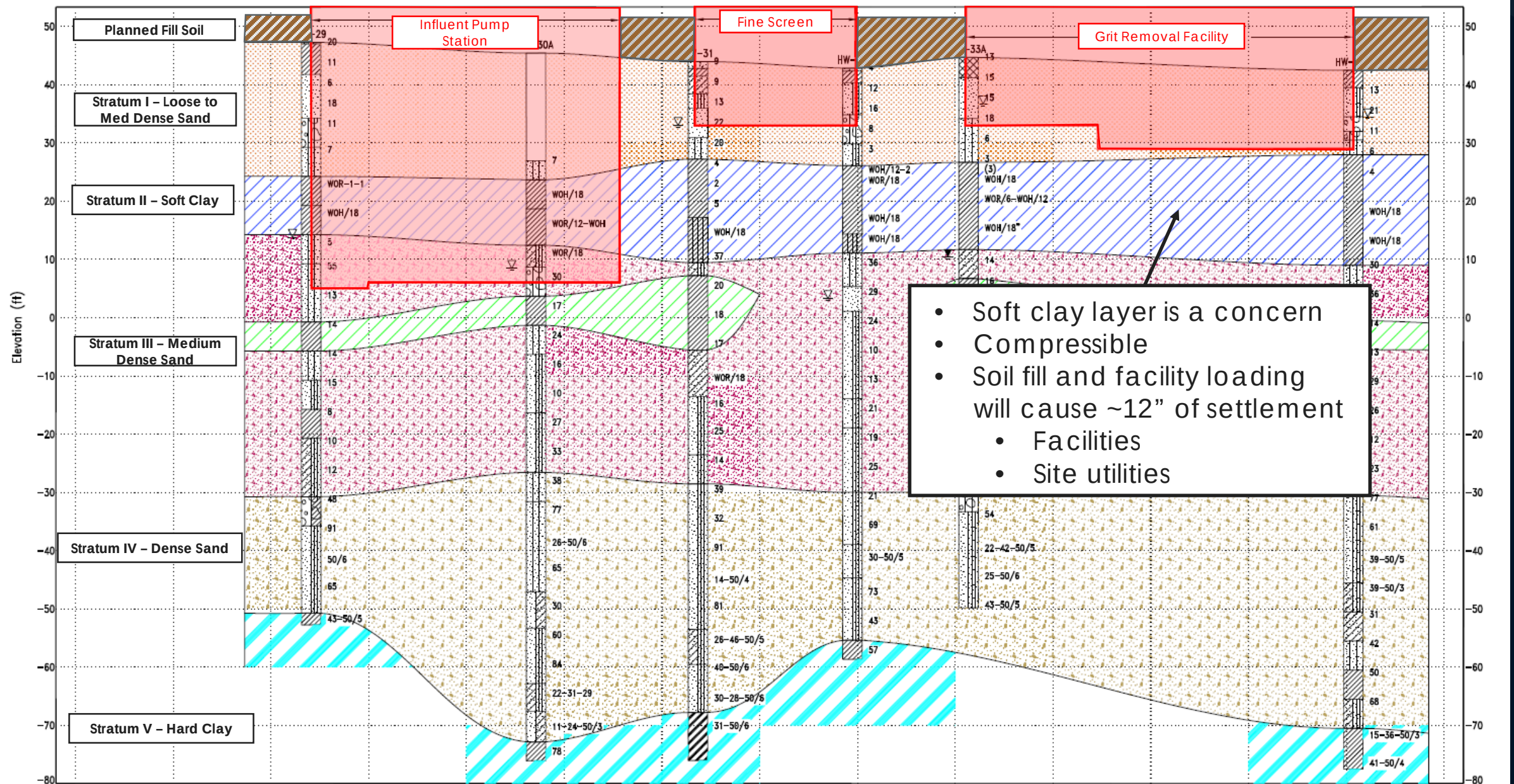
BACK RIVER WWTP HEADWORKS

BORING PLAN

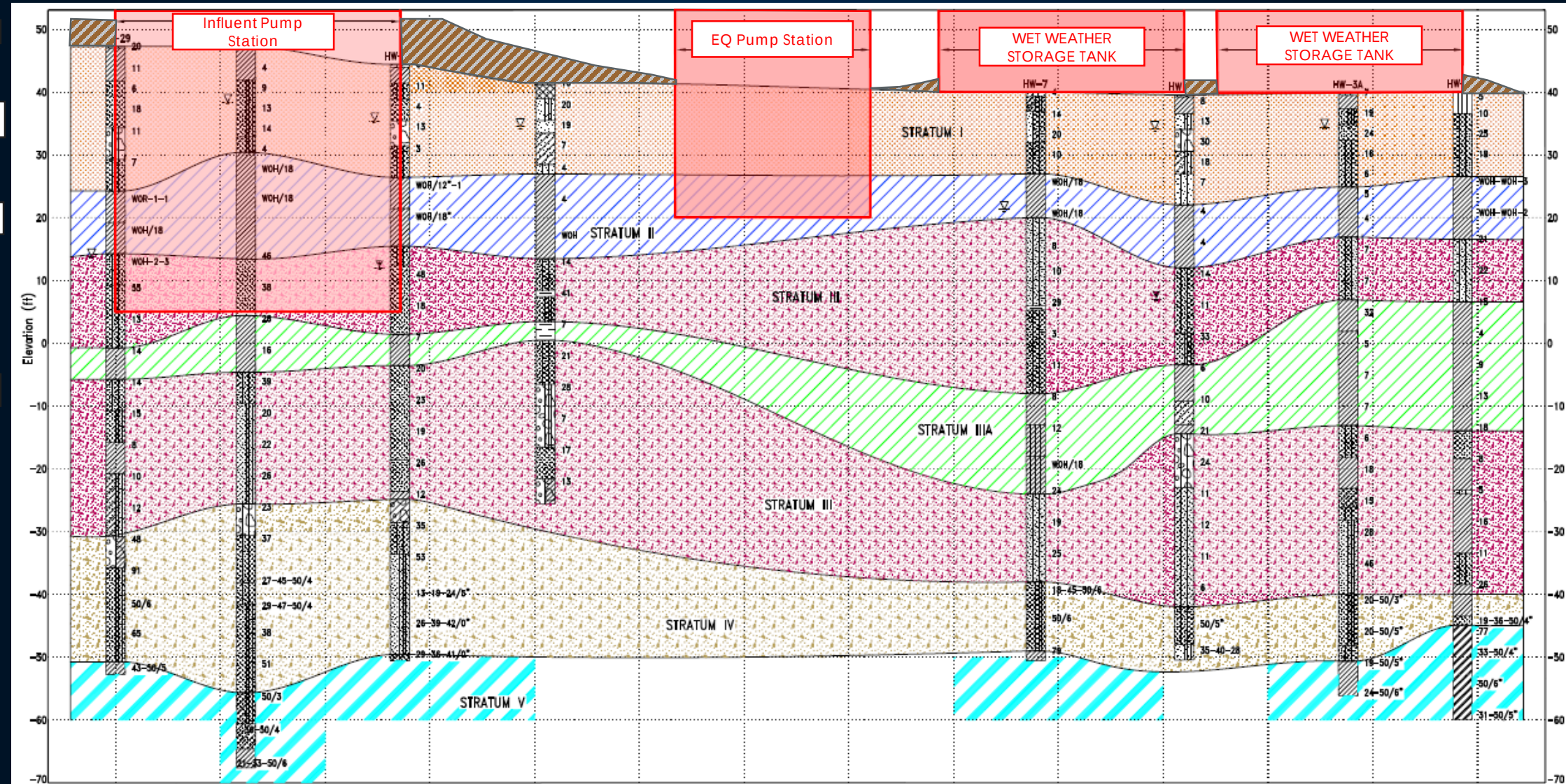
- Site plan and building/channel depth established
- Borings at building corners/middle
- Approximately 46 borings
- Facilitate foundation design recommendations



BORING LOG AND SOIL CONDITIONS



BORING LOG AND SOIL CONDITIONS



ANTICIPATED SOIL SETTLEMENT CONSTRUCTION ALTERNATIVES

- Construction requires existing grade to be raised up to 15 feet by fill (40,000 to 80,000 CY)
 - Fill and proposed facilities will cause ~12" of settlement of soft clay layer
- Options to address potential settlement
 - Construct facilities on piles and surcharge areas between buildings after foundation construction
 - Surcharge entire site prior to construction of facilities
- Adjacent contract on site has ~220,000 CY of excavated soil (~130,000 CY to be hauled off-site)

ANTICIPATED SOIL SETTLEMENT CONSTRUCTION ALTERNATIVES

- Piles + Surcharge Option
 - Estimated ~4,500 piles
 - 70-75 ft pile depth
 - Subsequent surcharge between facilities
 - Estimated \$34M in piles and surcharge cost
- Full Site Pre-Surcharge Option
 - ~200,000 CY soil
 - Stone drainage layer
 - Limited sheet piling in select areas
 - Beneficial use of excess soil from adjacent project (\$ savings)
 - Estimated \$10M in surcharge cost

Recommended Pre-Surcharge Option

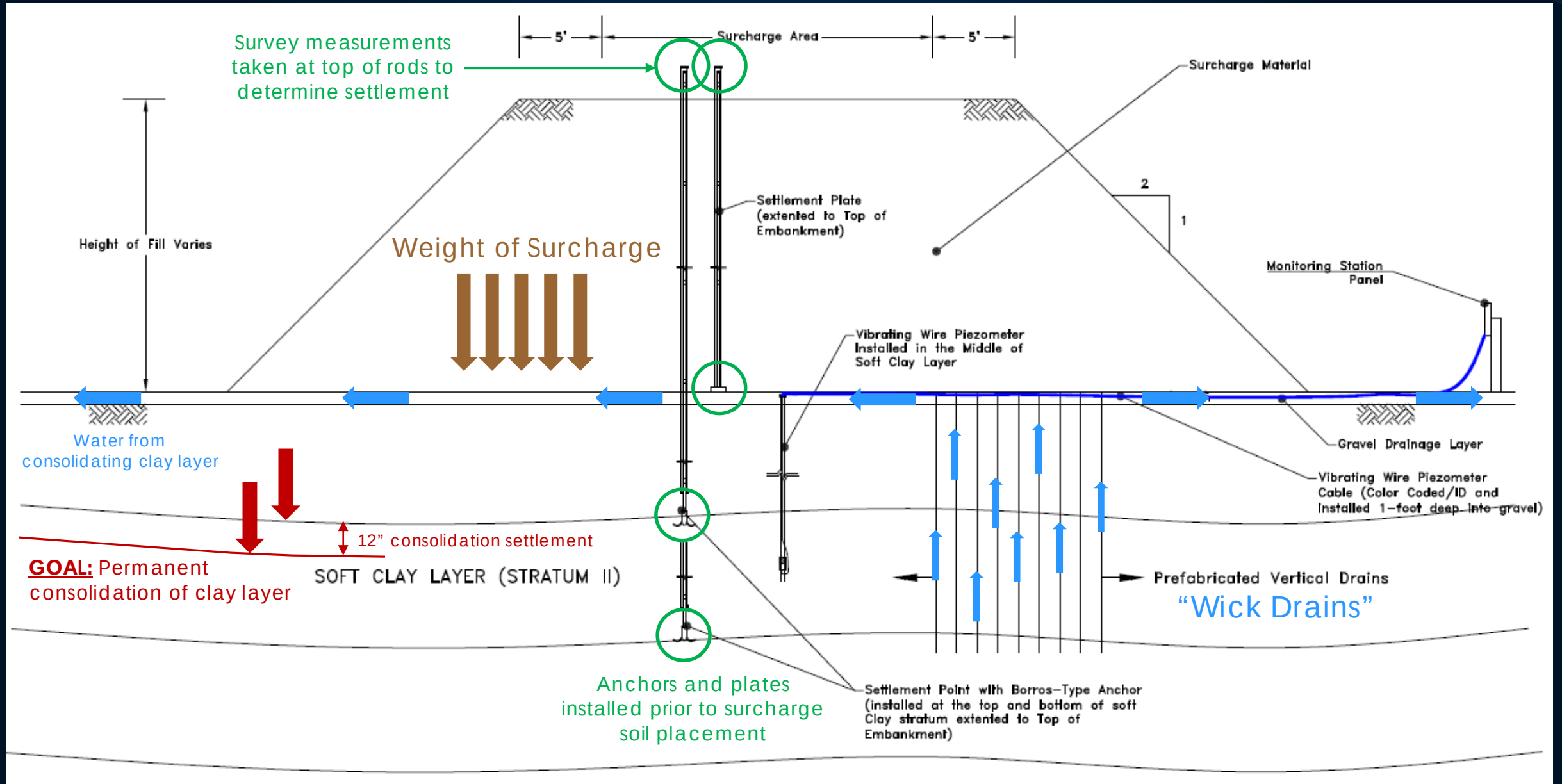
- Option for early start to complete surcharge contract
- Significant cost benefit

SOIL SURCHARGE PHASING

- Divided into phases for efficient sequencing
- Surcharge Area A (SC-877 Contractor)
- Surcharge Area B (SC-877 Contractor)
- Relocate Existing Forcemains (SC-918S Contractor)
- Surcharge Area C (SC-918S Contractor)
- Building and Utilities Construction (SC-918H Contractor)



SOIL SURCHARGE FIGURE



SOIL SURCHARGE PLACEMENT



Wick Drain Installation



Surcharge Soil Placement



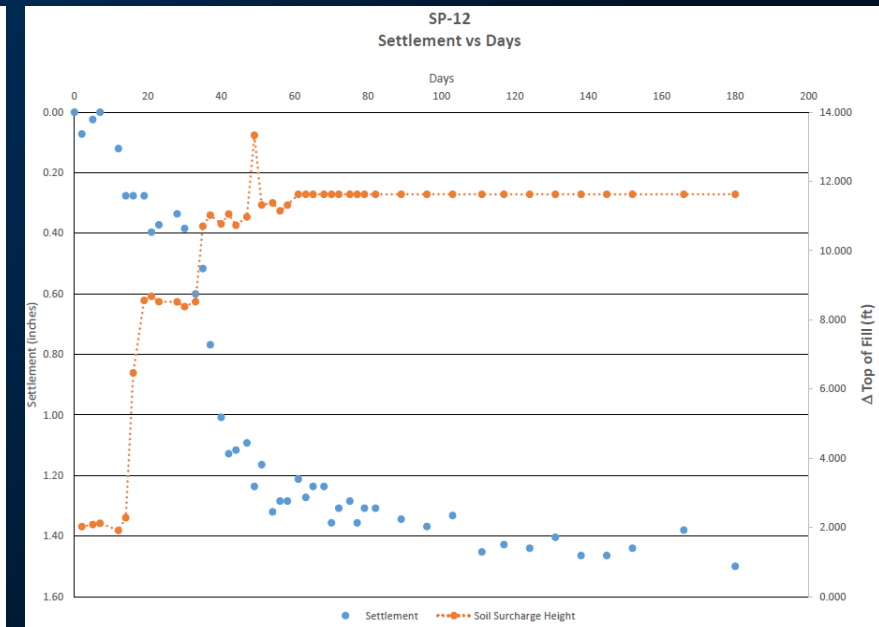
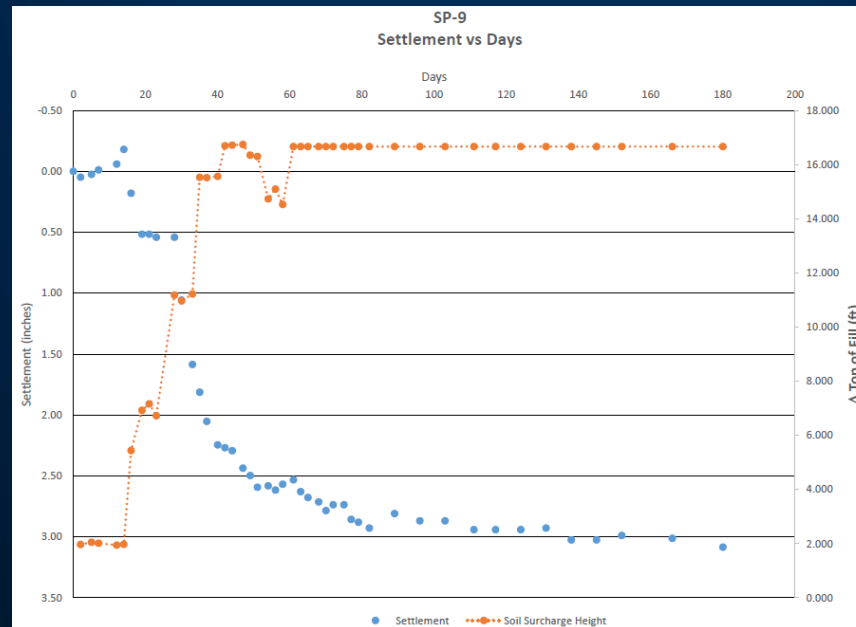
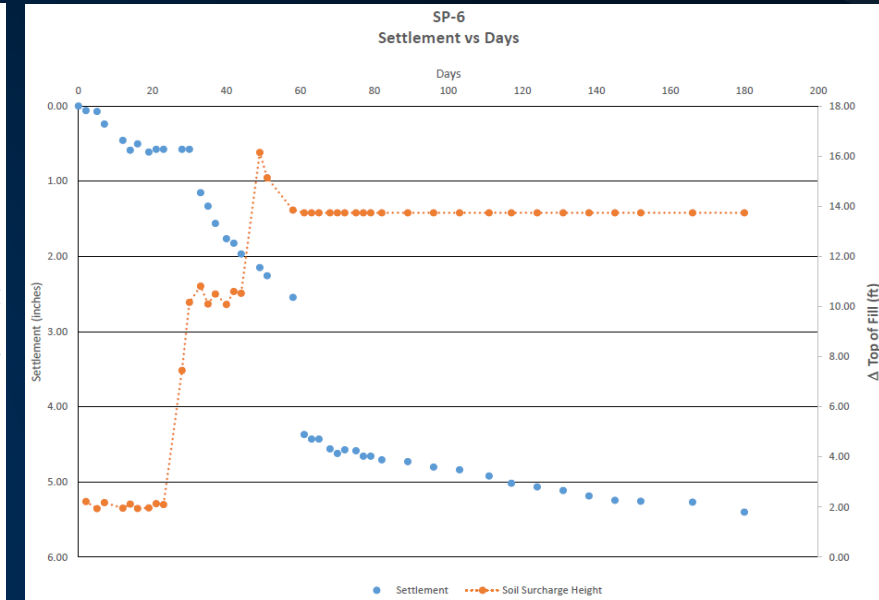
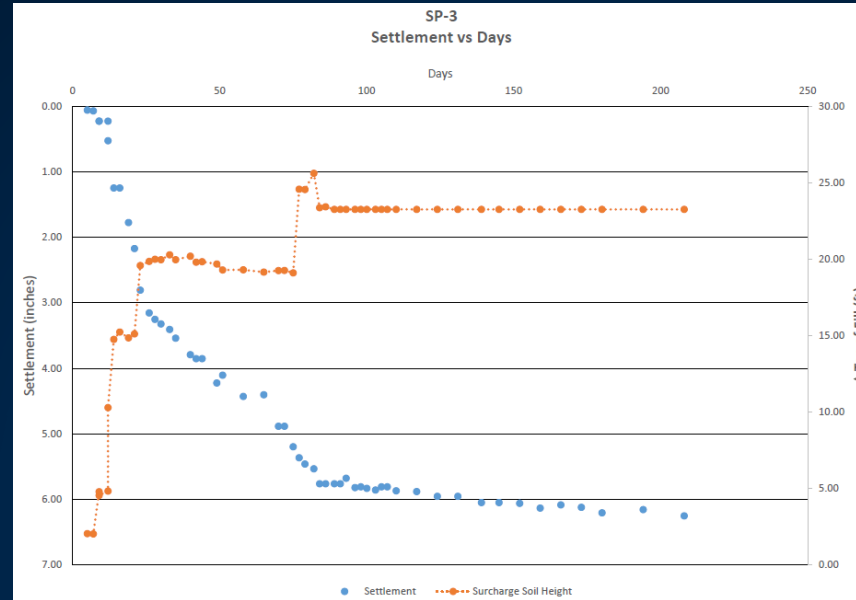
Stone Layer and Wick Drains



Surcharge Monitoring Instrumentation

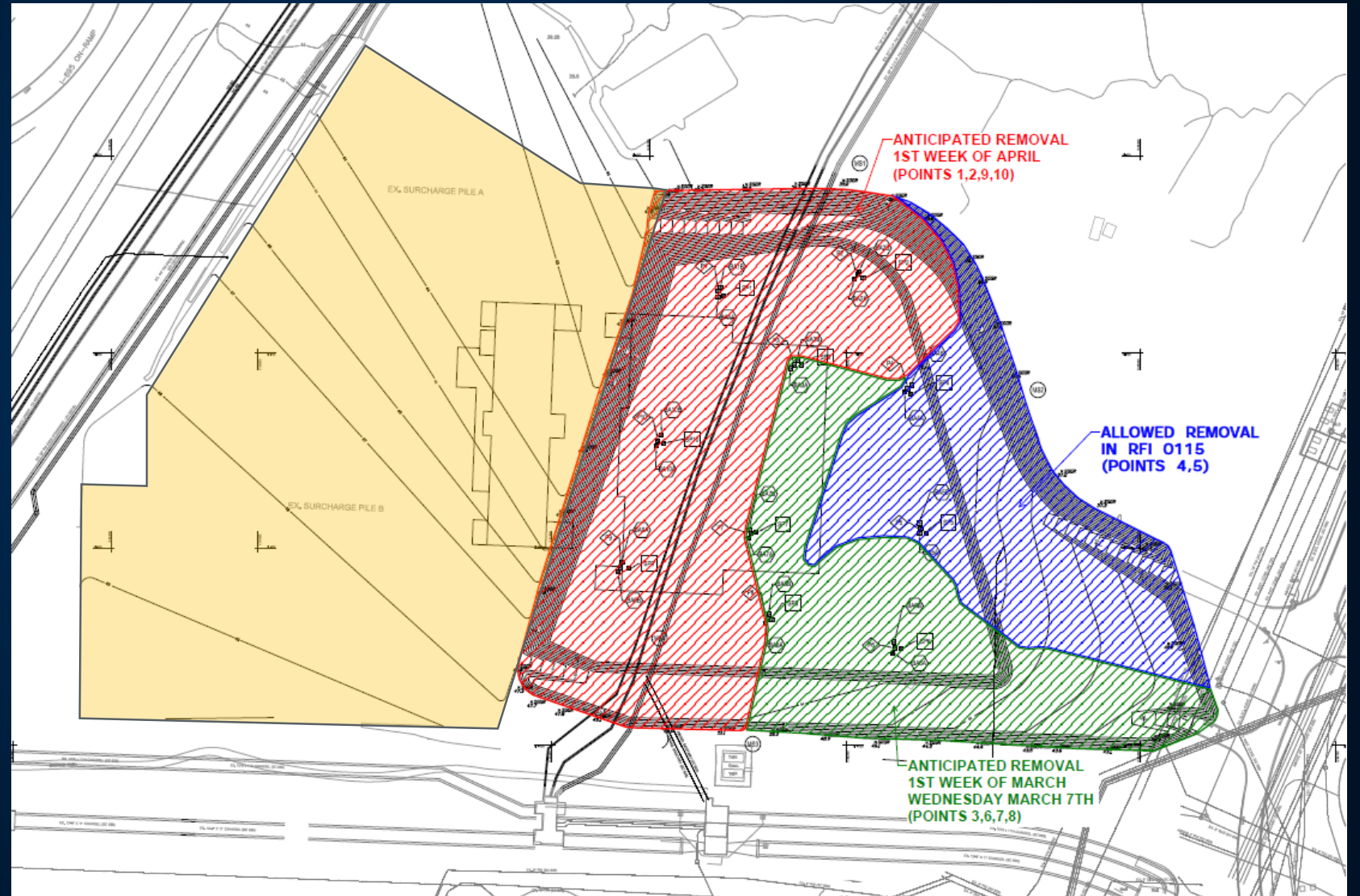
SOIL SURCHARGE MONITORING

- 2-3 readings per week
- Survey settlement plate and boros anchor elevations
- Piezometer readings → surcharge height
- Monitoring for primary consolidation achievement



SOIL SURCHARGE REMOVAL

- Phased removal
- Surcharge A and B removal
- IPS foundation begins
- Surcharge C removal



EXCAVATION BEGINS INFLUENT PUMP STATION

September 2017



EXCAVATION INFLUENT PUMP STATION

November 2017



EXCAVATION INFLUENT PUMP STATION

December 2017



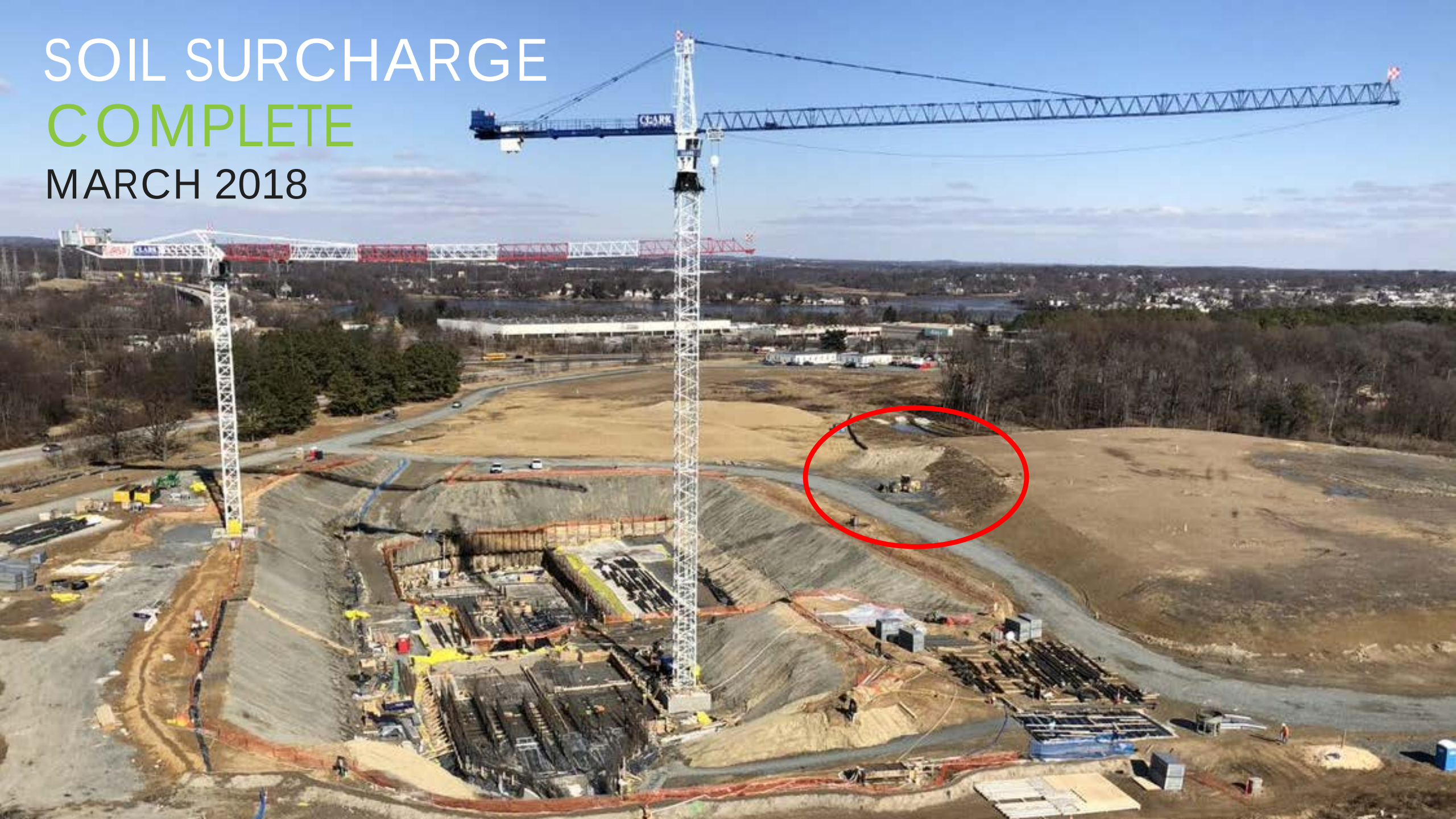
EXCAVATION INFLUENT PUMP STATION

January 2018



SOIL SURCHARGE COMPLETE

MARCH 2018



FOUNDATION PREP FINE SCREEN FACILITY

APRIL 2018 – PROOF ROLL



FOUNDATION PREP FINE SCREEN FACILITY

APRIL 2018 – GEOTEXTILE FABRIC AND STONE



FOUNDATION PREP GRIT REMOVAL FACILITY

MAY 2018 – GEOTEXTILE FABRIC AND STONE



FOUNDATION PREP GRIT REMOVAL FACILITY

JUNE 2018 – MUD MAT FOR GRF



An aerial photograph of a large-scale construction project. A tall white lattice crane stands prominently on the left side of the frame. The ground is mostly excavated, showing dark soil and some areas covered with yellow plastic sheeting. In the background, there are green trees and some industrial buildings. The sky is overcast.

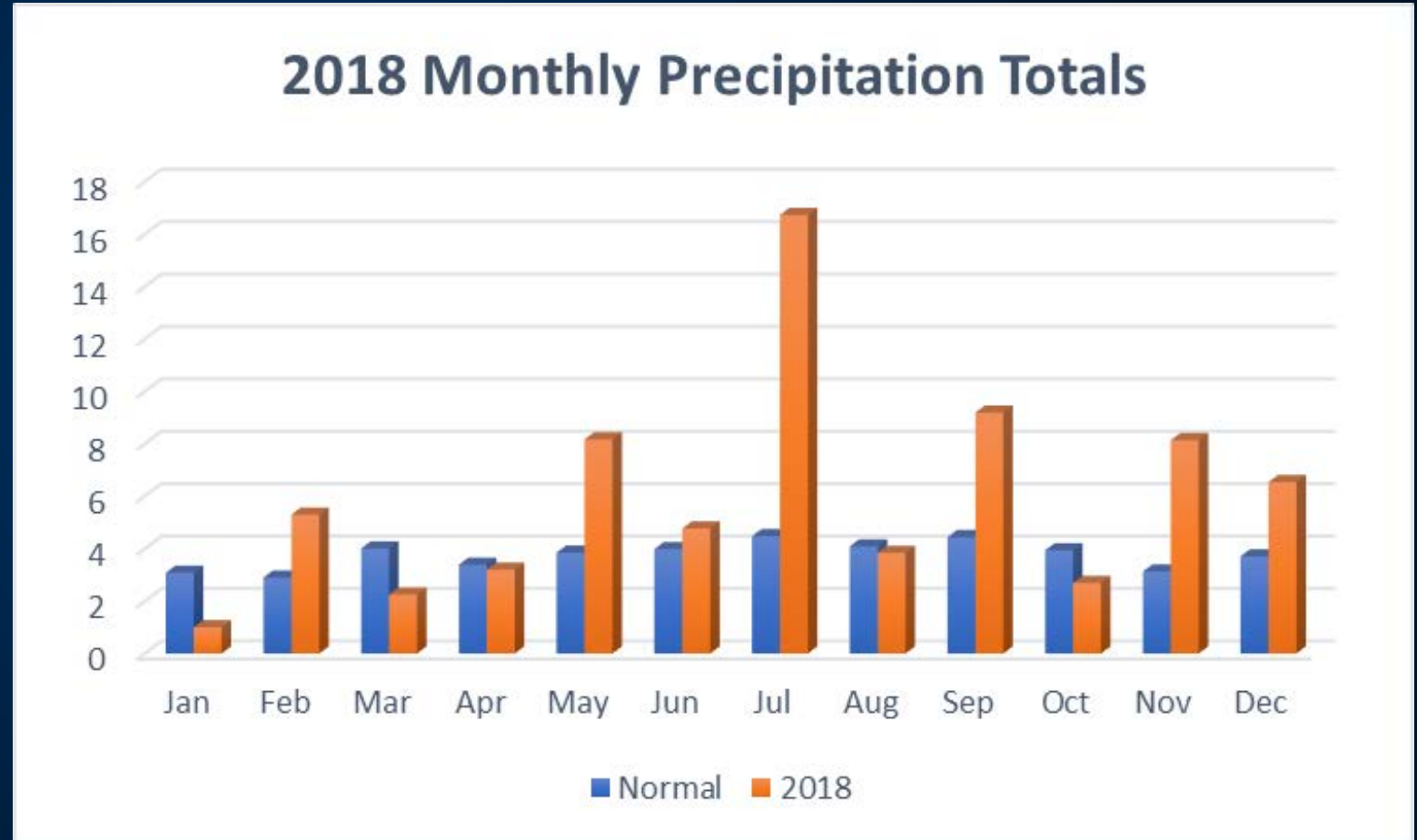
IPS, FSF, GRF EXCAVATION

MAY 2018

PROJECT CHALLENGES

2018 – BALTIMORE WETTEST YEAR ON RECORD

- BWI Annual Total – 71.8 Inches
 - Previous Record – 62.7 Inches
- Six Daily Rainfall Records
- Two Monthly Rainfall Records



WET WEATHER CHALLENGES

JULY 2018



PROGRESS CONTINUES

FEBRUARY 2019



Large Steel Pipe Install

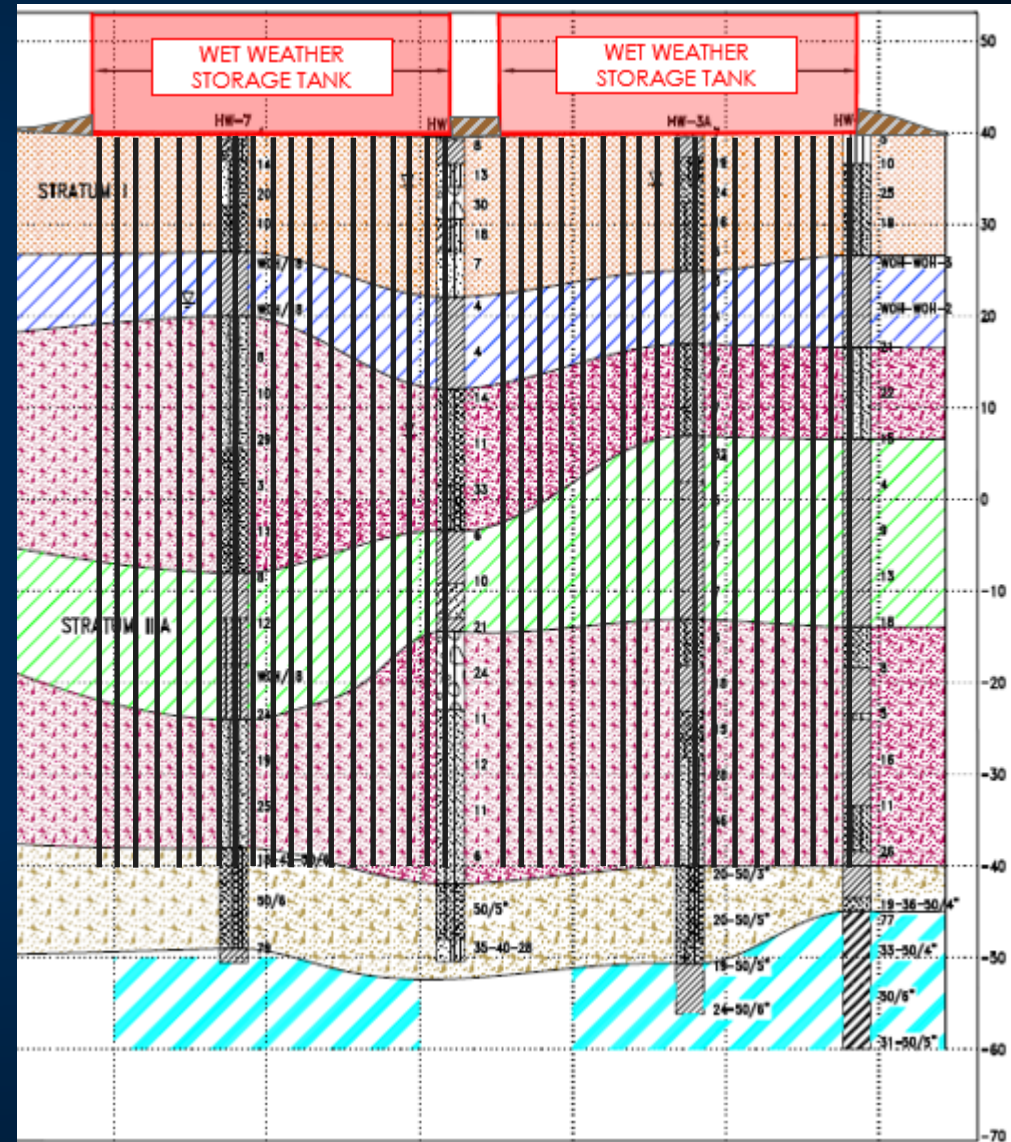
EQ Tank Slab Pour

Foundation Concrete Coming to Grade

Outfall Conduit Repair

WET WEATHER TANK FOUNDATION PILES

- Limited soil fill in tank area
- Settlement from utilities not a concern
- Settlement of clay due to tank load
- Decision: Tanks to be founded on piles
- Auger Cast-in-Place Piles
 - Delegated design
 - 16-inch diameter, 125-ton capacity
 - Minimum tip El. = -40 ft
 - ~1,000 piles per tank
- Pile Test Specifications
 - Indicator Piles – Establish installation procedures and grout take
 - Static Load Test Piles
 - Dynamic Load Test Piles



WET WEATHER TANK FOUNDATION PILES

- Auger Cast-in-Place Piles
 - Rotating hollow-shaft auger drilled
 - High-strength grout pumped in
 - Auger is withdrawn
 - Grout fills auger hole and penetrates ground voids laterally
- Quality Control Activities
 - Grout strength monitoring – breaks and batch tickets
 - Installation logs – pile depth, timing, grout take (pump strokes)
 - Delegated design review
 - Pile test program review



PROGRESS CONTINUES

Wet Weather Tank Construction



Tank 1 Pile Installation



Tank 1 Stone Installation

PROGRESS CONTINUES

Wet Weather Tank Construction



Tank 1 Slab Pours – Tank 2 Pile Install



Tank 1 Slab Complete+Wall Panels – Tank 2 Slab

PROGRESS CONTINUES

Wet Weather Tank Construction



Tank 1 Wall Panel Erection



Tank 1 Wall Panels Up – Tank 2 Slab

PROGRESS CONTINUES

STRUCTURAL STEEL AND MASONRY

JUNE 2019

Roof System Installation

Coarse Screen Facility Masonry



PROGRESS CONTINUES BUILDING SYSTEMS

OCTOBER 2019

EQ Tank Panels and Shotcrete

Grit Removal Facility Steel

Electrical Systems Install



PROGRESS CONTINUES

SITE WORK

MARCH 2020



PROGRESS CONTINUES TECHNICAL COMPLIANCE MILESTONE

APRIL 2020 → DECEMBER 31, 2020



Flow Path to New Headworks

Flow Path to Plant to be Abandoned

Influent Junction Chamber

Outfall Sewer

Outfall Conduit

APRIL TO OCTOBER 2020





PROGRESS CONTINUES

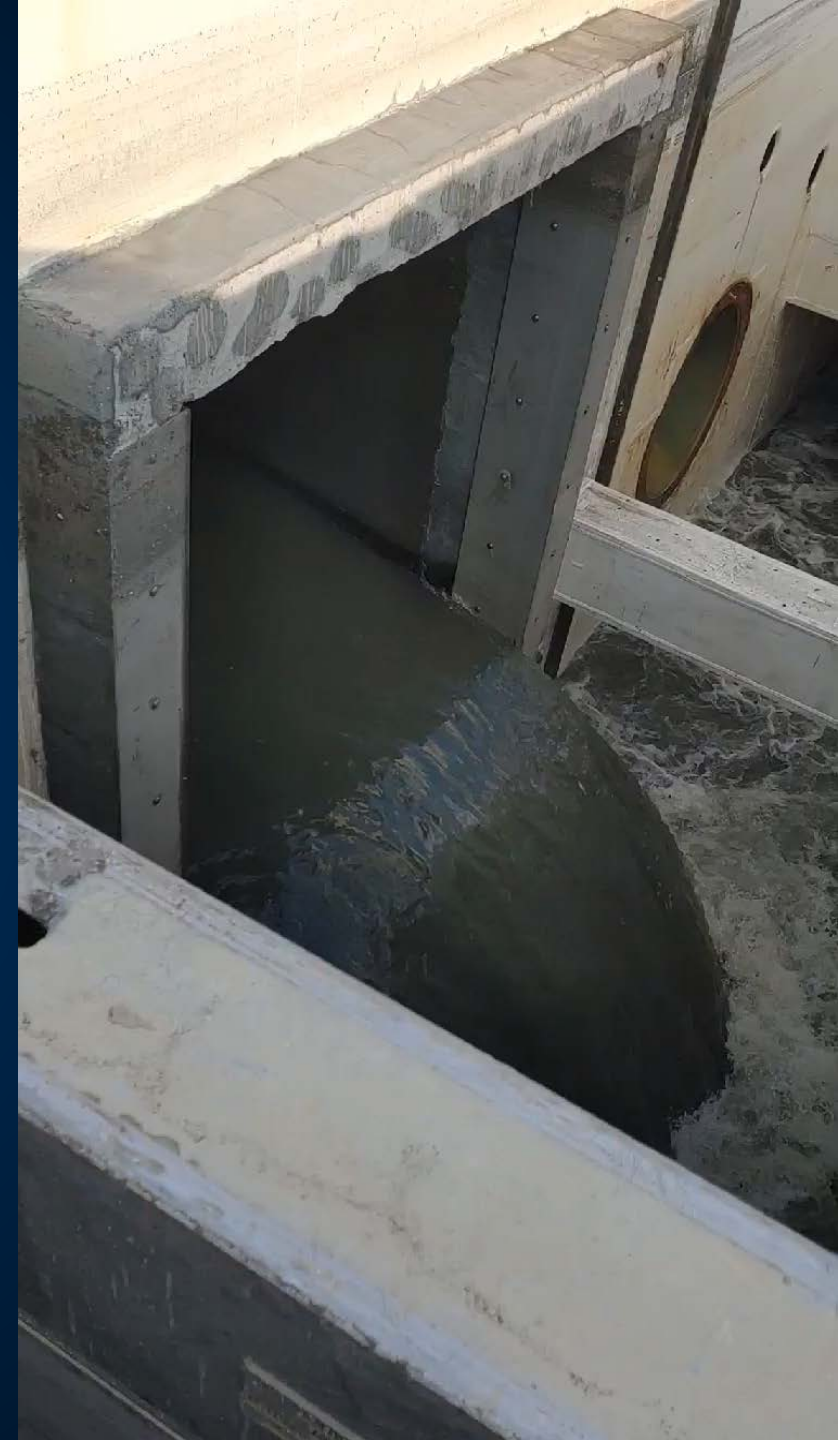
TECHNICAL COMPLIANCE APPROACHING

NOVEMBER 2020

FREE DISCHARGE!

PHASE II START-UP

- November 16, 2020
- Flow from Outfall Sewer to Headworks
- Process Equipment On-line



FREE DISCHARGE HYDRAULIC IMPACTS



COARSE SCREEN FACILITY

- Four (4) 200 MGD Coarse Screens
- Solids Handling
- Odor Control





INFLUENT PUMP STATION

- Eight (8) 100 MGD Pumps and Motors
- Variable Frequency Drives
- Discharge Piping, Valves and Meters



FINE SCREEN FACILITY

- Six (6) 100 MGD Fine Screens
- Sluice Trough Screenings Conveyance

The image shows a large industrial facility, likely a wastewater treatment plant, with a high ceiling and red structural beams. Several large, grey, cylindrical traveling bridges are visible, each equipped with a blue motor at the top. These bridges are positioned over a series of conveyor belts. The conveyor belts are supported by a metal frame and feature red rollers. The floor is a light-colored concrete. The overall scene is well-lit by overhead industrial lights.

GRIT REMOVAL FACILITY

- Eight (8) 75 MGD Traveling Bridges
- Eight (8) Grit Collection and Removal Pumps
- Eight (8) Grit Classifiers
- Two (2) Belt Conveyors



EQ STORAGE TANKS

- Two (2) 18 MG Tanks
- Twelve (12) Flushing Gates per Tank

SUMMARY OF WORK

PROJECT STATISTICS

- June 2017 Construction Notice to Proceed
- 1.56 Million Construction Personnel Hours
- Peak 450 Construction Personnel On Site
- Average \$10M in Monthly Invoices
- 43,000 Cubic Yards of Concrete (IPS, FS, GRF)
- 3,600 Submittals
- 1,300 RFIs
- December 31, 2020 Technical Compliance





BACK RIVER WWTP HEADWORKS

- 250,000 Design Hours
- City's First CMAR
- DPW's largest construction Project
- Technical Compliance Achieved on Schedule!
- ENR Mid-Atlantic Project of the Year
- ASCE Outstanding Civil Engineering Achievement

ACKNOWLEDGEMENTS

- City of Baltimore Office of Engineering and Construction
- Back River WWTP Operations and Maintenance
- Clark/Ulliman Schutte Team
- WSP Team
- Electronic Documentation and File Sharing
- Design Team
 - JMT
 - HDR
 - Dhillon Engineering, Inc.
 - Hope Furrer Associates
 - Constellation Design Group
 - Transviron
 - Sidhu (CCJM)
 - Min Engineering
 - AS Architects
 - SP ARCH
 - Phoenix Engineering



QUESTIONS?

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