Easterly CSO Tunnel Dewatering Pump Station Enhancement Improvements

HARRY SHAPOSKA, P.E. | MAY 9, 2024

Northeast Ohio Regional Sewer District

Thank you for the introduction. Good Afternoon, I'm glad to be here.

How many people have seen the movie Apollo 13? Great! In the movie there is a scene where there is an oxygen tank explosion and Tom Hanks says "Houston we have a problem". And for this pump station we had a similar experience where our sewer system maintenance staff informed engineering that there was hard settlement/gravel that filled the grit trap in the tunnel shaft and they believed it was building up in the pump suction header pipe. They also said that several pumps were pumping below their design capacity.

This presentation is about making a good pump station better.

Agenda

- Pump Station Background
- Pump Station O&M Issues
- Enhancement Evaluations
- Why Enhancements Are Needed
- Questions

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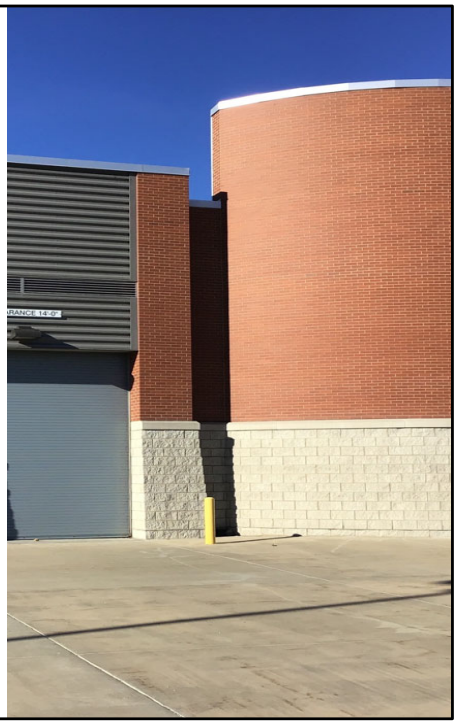
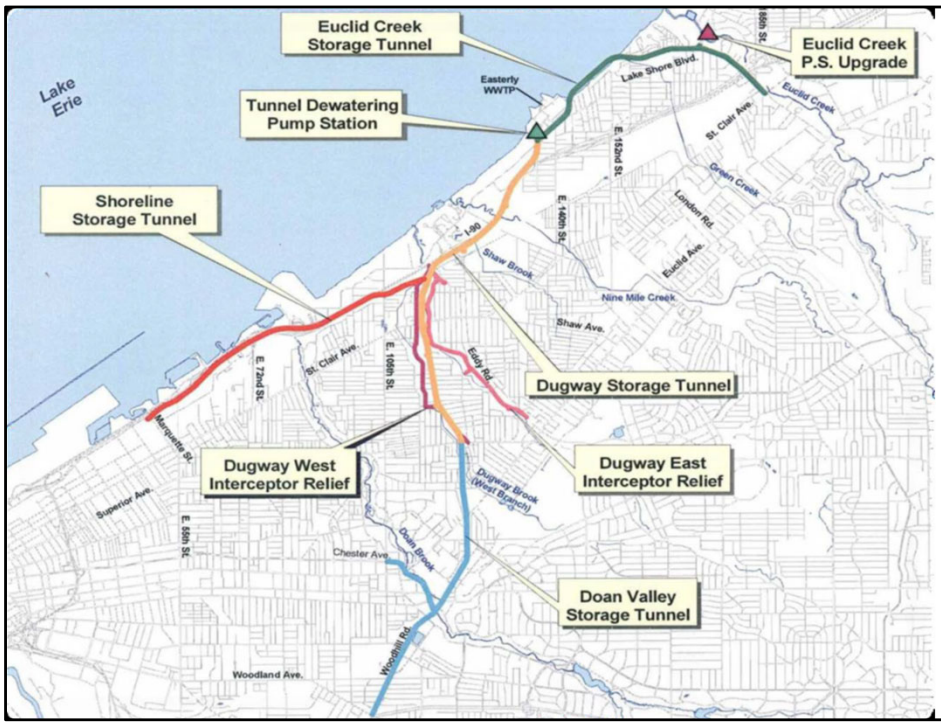


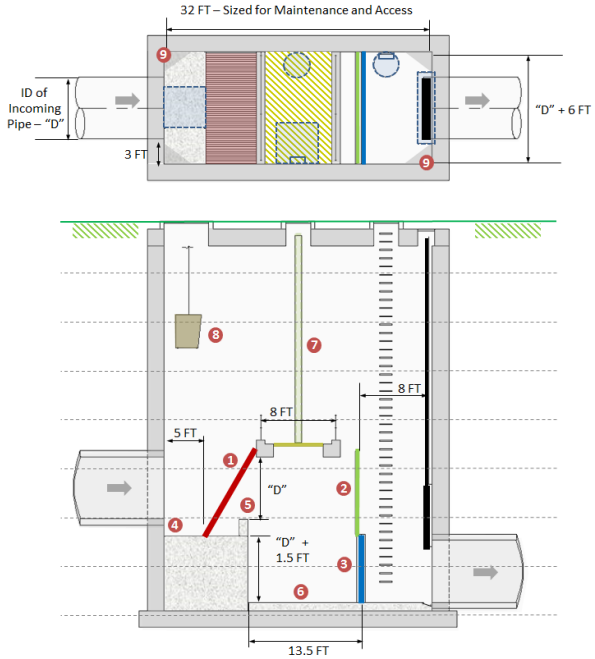
This afternoon I'll provide a brief background on the pump station and CSO tunnel assets and then talk about the pump station O&M issues, then talk about engineering enhancement alternative evaluations that were the outcome from a Preliminary design condition assessment. The detailed design phase is next. I'll finish up with why the enhancements are needed. Lastly, answer any questions you may have.



ETDPS is designed to drain up to 160 MG of CSO stored flow.

Easterly CSO Tunnel Site Map

•This slide shows the Easterly CSO tunnels than can store up to 160 MGs, and the green triangle is the pump station location. EWWTP is shown here. Two tunnels, Euclid Creek in green and Dugway light brown discharge to a shaft called ECT-1 that connects to the pump station.



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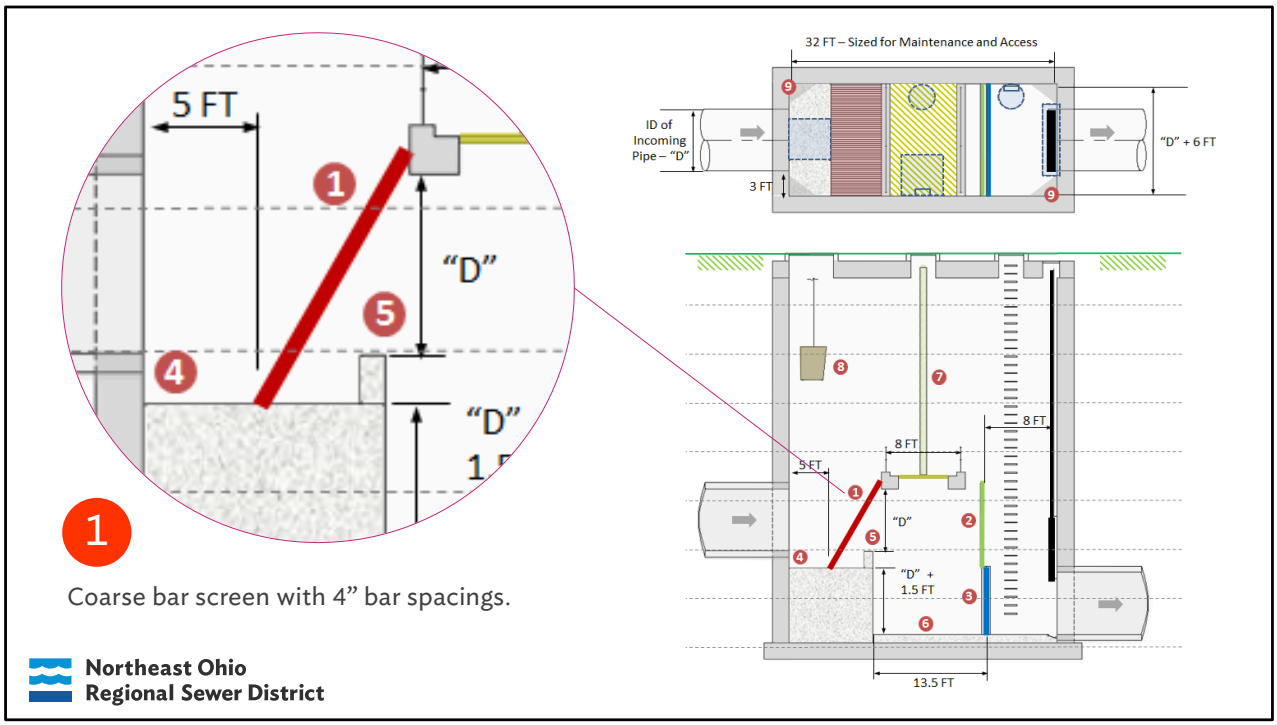
All CSO sewers that discharge to a tunnel have screening and grit trap structures as shown in this slide.
Flow is left to right.
Item 1 is a coarse bar screen with 4" bar spacings.
Item 2 is a floatable bar rack.
Item 3 is a wedge wire screen with 1" bar spacings.
Item 6 is a grit trap.
After storm events, our SSMO staff visits each CSO screening structure to assess cleaning requirements.
Note: if the screening structure surcharges, floatables objects can overtop Item 2 and get into the tunnel.



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Coarse bar screen with 4" bar spacings.

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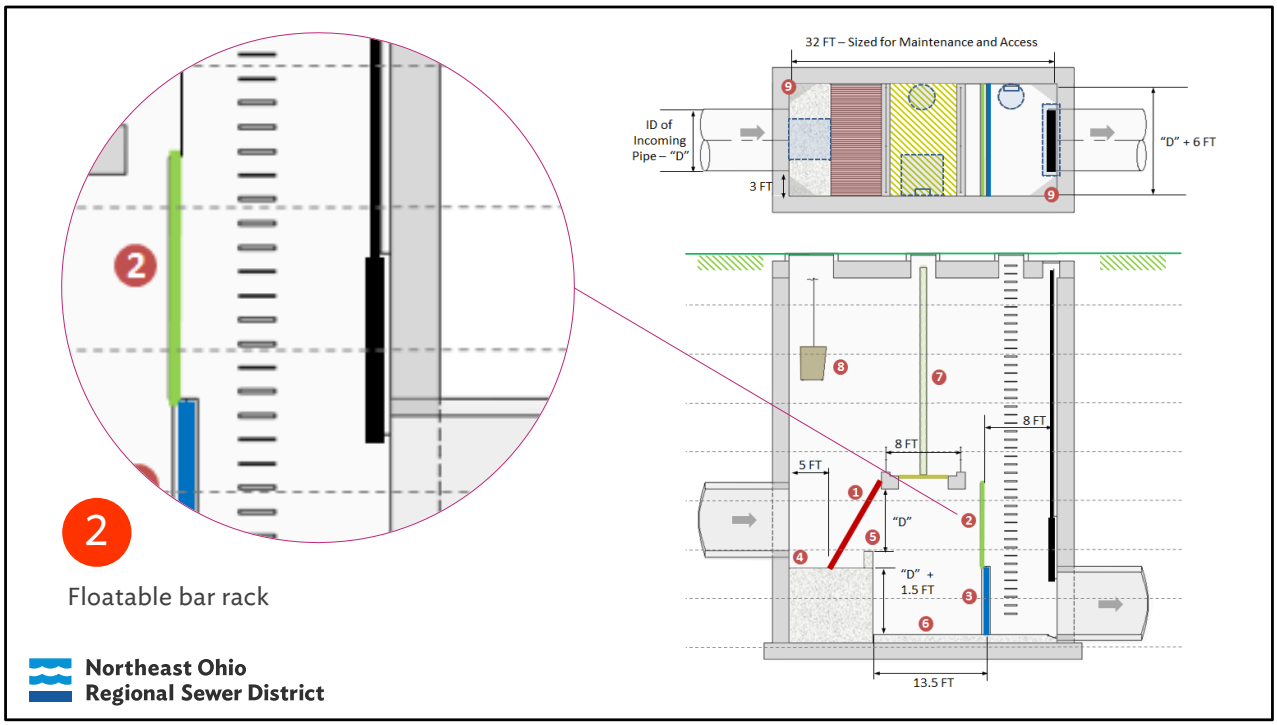

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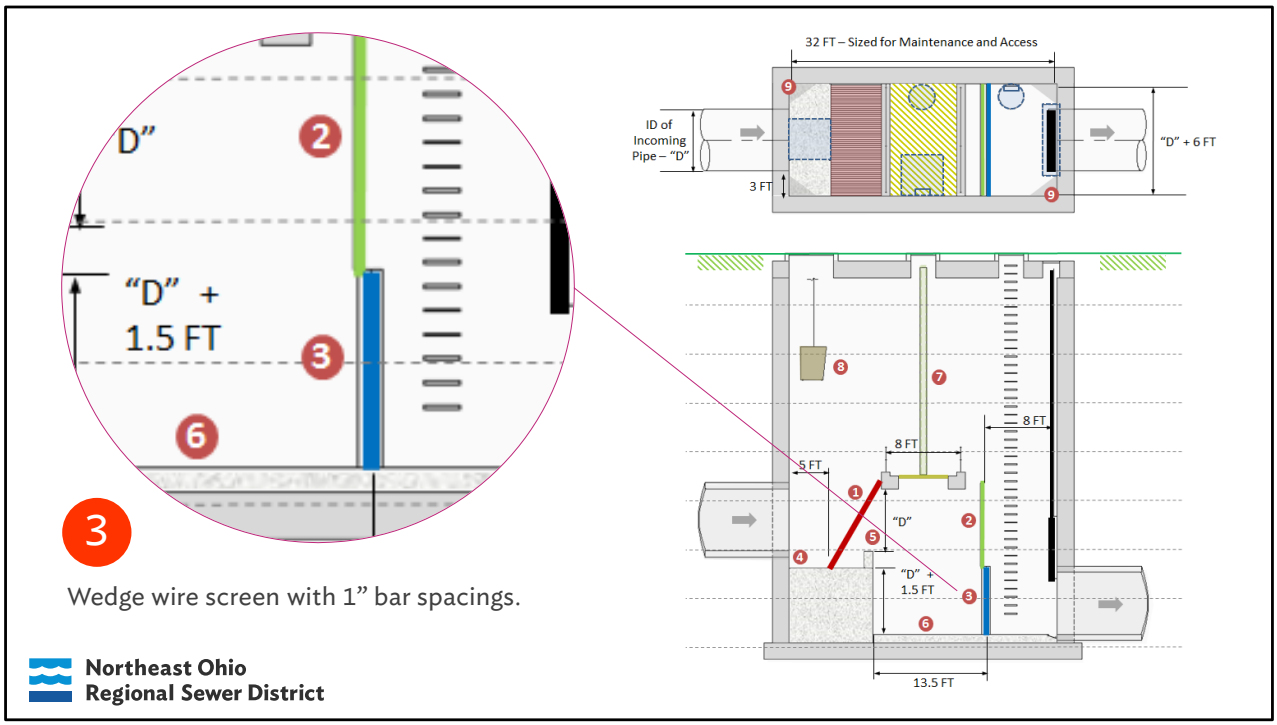

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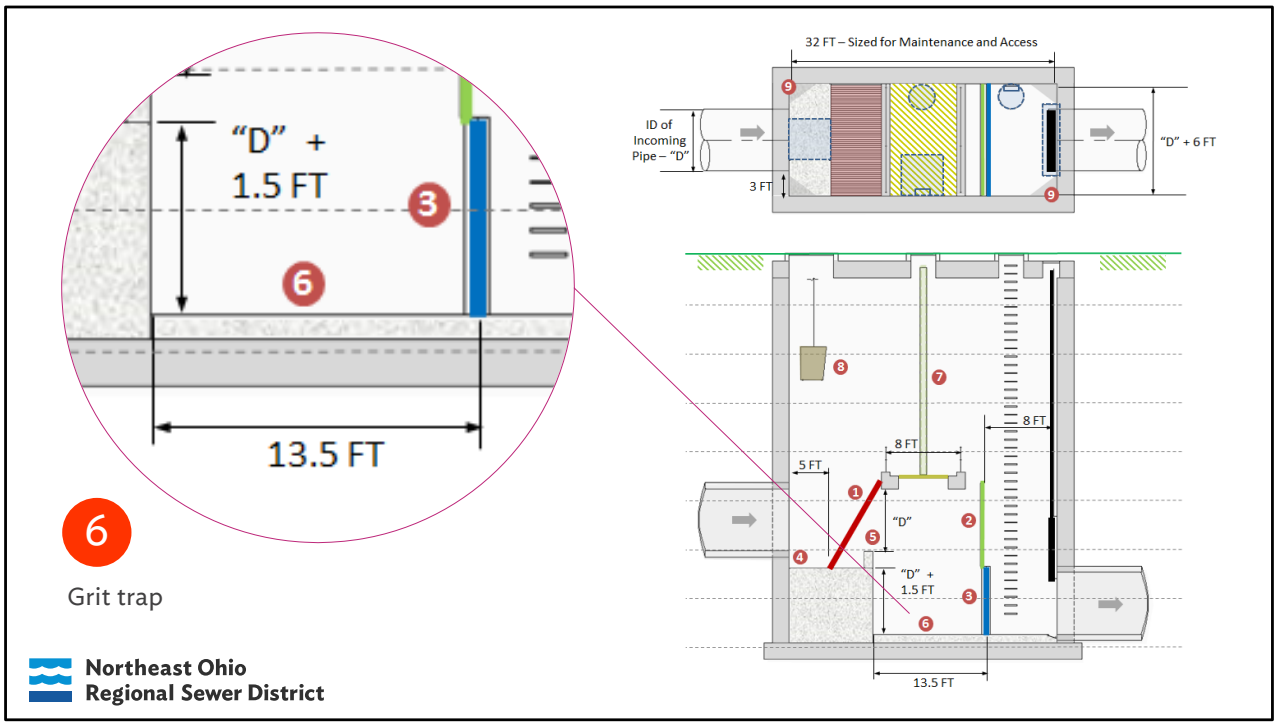

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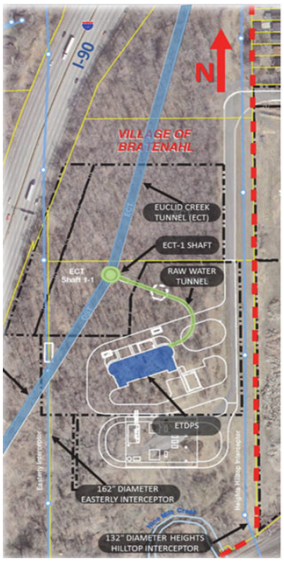
Easterly Tunnel Dewatering Pump Station



ECT-1 Shaft and ETDPS Location

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•This slide shows the easterly tunnel dewatering pump station. The photo on the right shows the raw water tunnel in green that connects the ECT-1 shaft to the pump station. The dewatering pumps discharge to the easterly interceptor sewer chamber shown. Easterly operators manage the pump station operation and control the discharge flow rates based on plant capacity.

•The cavern style pump station has a firm pumping capacity of 160 million gallons per day and the cavern pump room is approximately 230 feet below the surface.

ETDPS: Pump Station Features

- Euclid Creek CSO Storage Tunnel
  - 24’ Diameter
- Dugway CSO Storage Tunnel
  - 24’ Diameter
- ECT-1 Shaft
  - 40’ Diameter
  - 205’ deep including grit trap
- Raw Water Tunnel
  - 8.5’ Diameter
- Cavern style pump station
- 7 dewatering pumps
- Firm pumping capacity, 160 MGD

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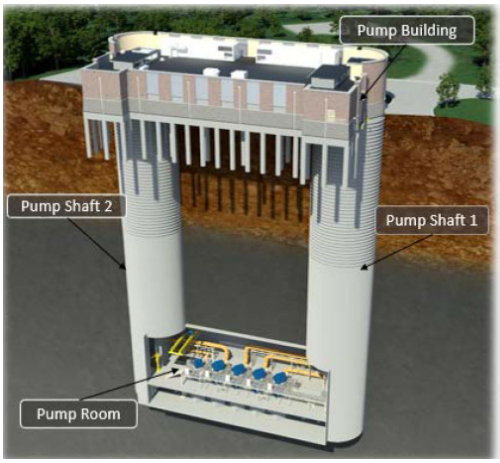
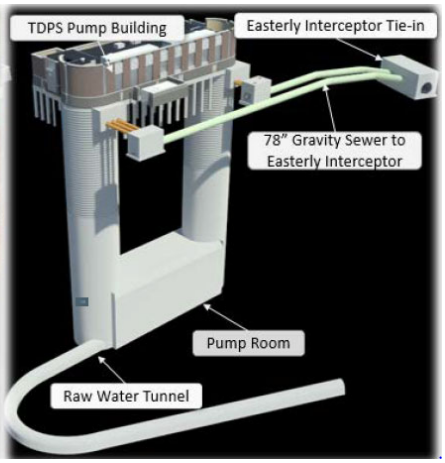
•The Euclid Creek and Dugway Tunnels are shown in blue with purple flow arrows.
•ECT-1 shaft is shown in green along with the raw water tunnel.
•The pump station is shown in blue.

Easterly Tunnel Dewatering Pump Station

CAVERN STYLE PUMP STATION WITH TWO SHAFTS



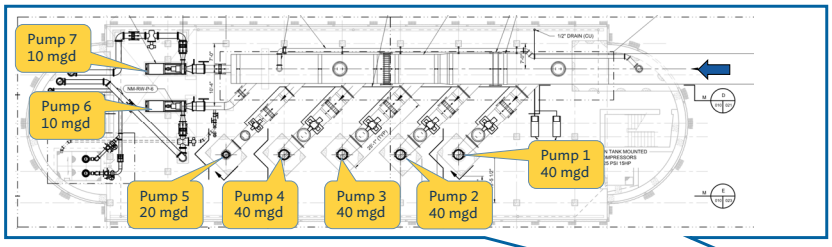
Looking North

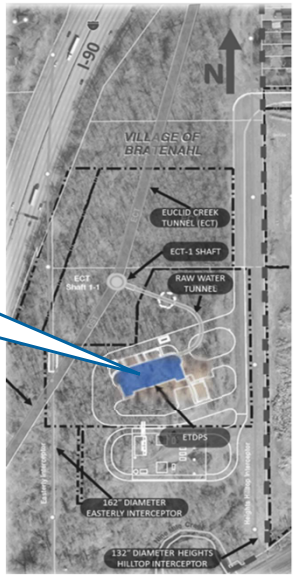


Looking South

•This slide shows a three-dimensional view looking N on the left and looking S on the right. The raw water tunnel is shown in the right picture, and it curves into the pump suction header inside the cavern pump station shown on the left. There are two shafts that the pump discharge piping goes up to ground level and then discharge into two chambers that allows gravity flow to the easterly interceptor sewer junction chamber shown in the right.

Pump Numbering and Flow Capacities





Pump #	Rated Capacity (mgd)	Description
1 thru 4	40	Main dewatering pump
5	20	Main dewatering pump
6 and 7	10	Final dewatering pump

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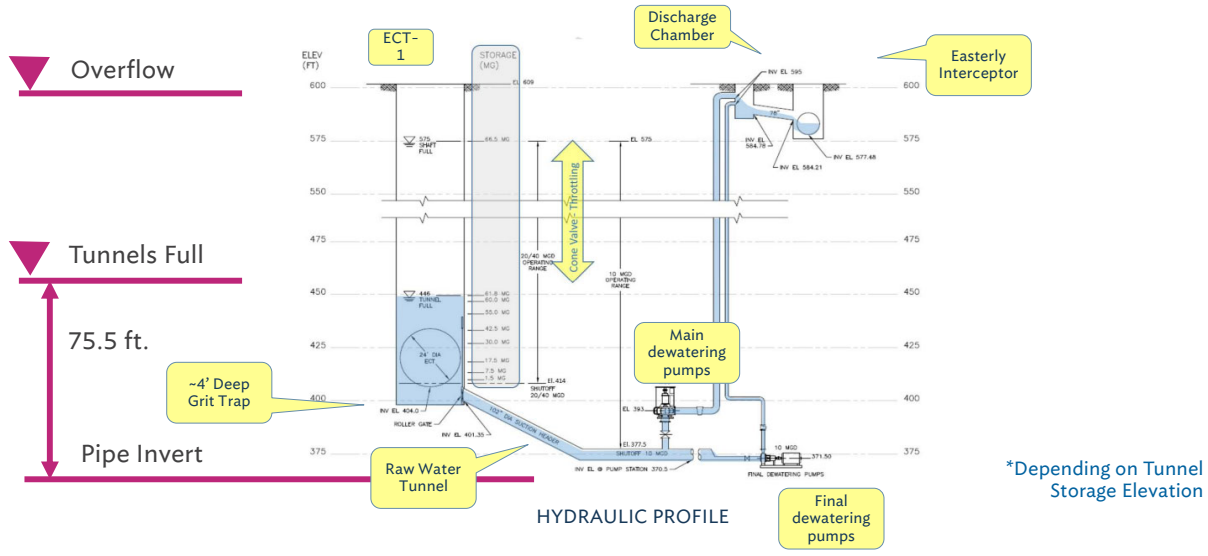
•The five main dewatering pump locations, numbering and capacities are shown. .

Static Lift Varies from 20 feet to 220 feet*



•This slide shows the ECT-1 shaft, raw water tunnel, pump suction header, pumps, and discharge chamber and gravity sewer to tie into the Easterly Interceptor. Note the pump operating range levels.

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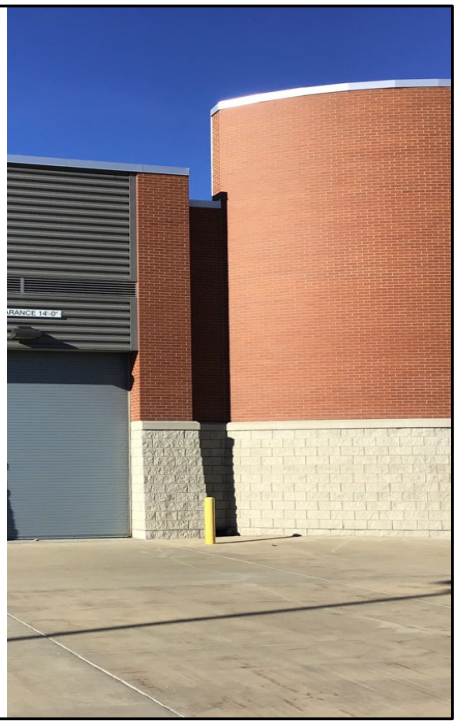

Timeline of events

Jan 2012	Aug 2018	Aug 2022	Dec 2022	May 2023
Construction Notice to Proceed	Commissioning and Startup	O&M reported issues	Diver inspection • ECT-1 shaft • Raw water tunnel • pump suction header pipe	Study, evaluation • Gate slamming • Evaluated, presented solutions for pumping issues, sediment • Proposed miscellaneous improvements

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Major timeline of events are shown. Aug. 2022 is when engineering was notified of the grit/hard sediment issues, or this is the Apollo 13 moment of “Engineering we have a problem”. The study and evaluation phase ended in Dec. 2023. Next phase is to begin the detailed design and then construction.

O&M Related Issues

Area	Reported Issue(s)
ECT-1 Shaft	**1. ECT 1-Shaft Isolation gate slams upon closure**
Pump Suction Header	**2. Grit accumulation** 3. Constraints on suction pipe manhole access 4. Lack of flushing connection to 6” drain line 5. Lack of pressure trending data at each pump inlet

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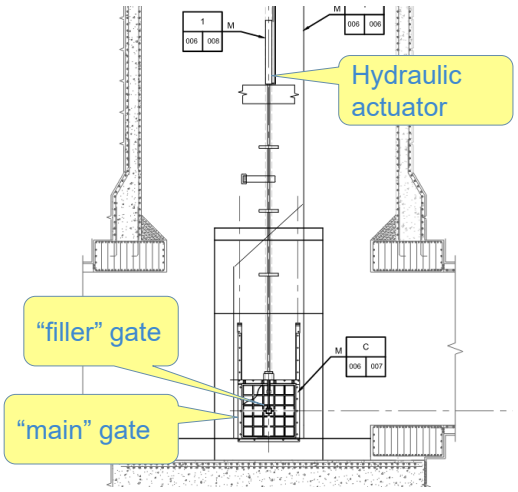
Five O&M related issues. Items bolded are main issues.

O&M Related Issue #1 - ECT-1 Gate Slamming

- Adequate operation from Close to Open position
- Restriction in operation Open to Close
  - At ~50% closed, main gate stops moving filler gate begins to close.
  - 50%-90%, both gates close simultaneously
  - At ~90% closed, both gates become stuck.
  - Hydraulic pressure builds up in actuator.
  - Main gate "slams" shut to fully closed position.
- Actions taken to address issue
  - Shaft coupling replacement.
  - Gate typically left in Open position unless Raw Water Tunnel isolation is required.



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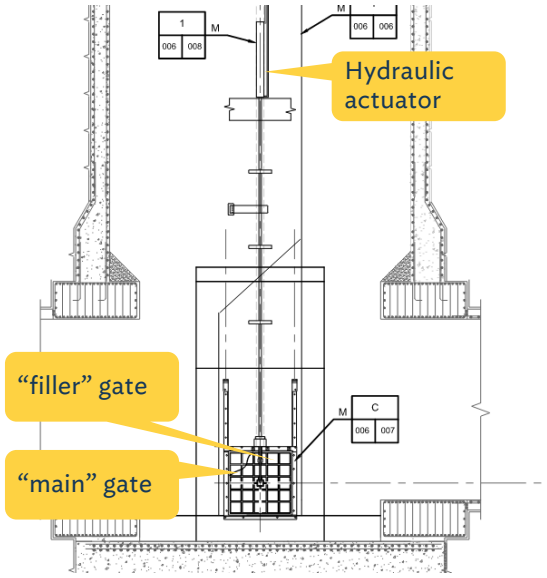
The gate elevation view is shown to the right. The gate is operated by hydraulic oil fluid pressure. The gate slams shut at about the 90% closed position. Hydraulic fluid pressure builds up in the actuator. The gate weighs about 5 tons, so longevity of the gate is a concern. The gate is needed to dewater the tunnels and protect the pump station from flooding.

Issue #1: ECT-1 Gate Slamming



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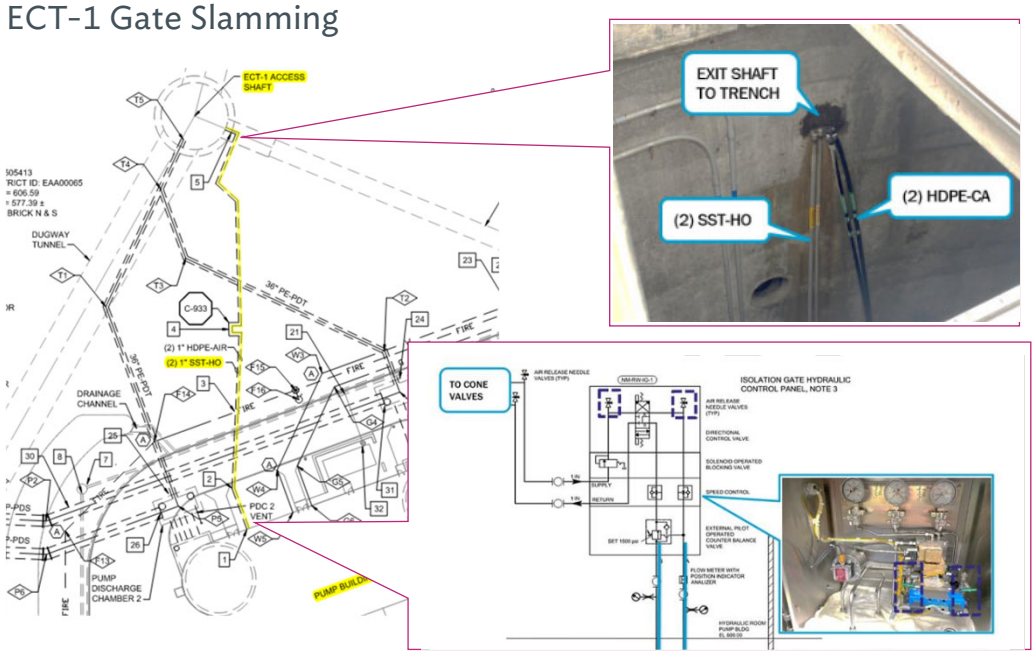

The hydraulic line may have an air pocket in the line that is causing the gate to slam.
Current air release valves are in the control panel inside the pump station has not vented air.
If there is a low spot in the yard, air could be trapped at the entrance to the ECT-1 shaft.

- Potential for air build-up in hydraulic line H.P. in shaft
- Lack of means to release within ECT-1 shaft or yard
- Current air release is located at Pump Building in the Isolation Gate Hydraulic Control Panel

Issue #2: Sedimentation Accumulation

- When called to run, pumps experience:
  - Vibration
  - Loss of capacity
  - Failure/automatic shutdown

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Pumps 1 and 2 choke during pump startup.
Pumps 6 and 7 struggle at low flows approximately 8 MGD.
Pump 7 is being tested for vibration issues.

Issue #2: Sedimentation Accumulation

- Upon failure at startup, the next pump in sequence will attempt to start.
- Large and heavy sediment noted in ECT-1 trap from O&M staff

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Pumps 1 and 2 choke during pump startup.
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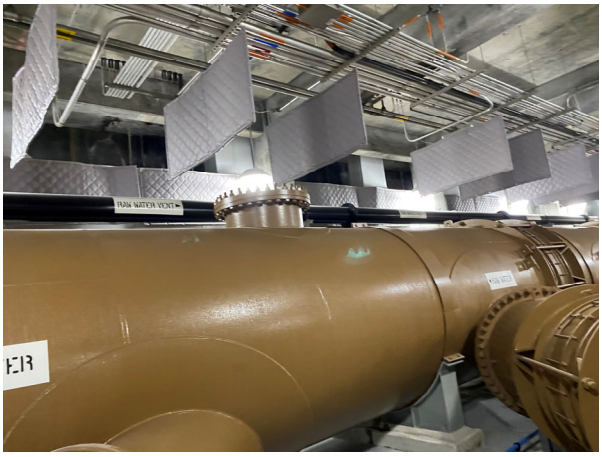
Issue #3: Suction Header Access Constraints



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Existing suction pipe layout is not conducive to inspect and clean the inside of the pipe.

Existing layout is not conducive for routine maintenance

- Lack of means to remove 36” blind flanges
- Temporary ladder is required to access manhole
- Overhead HVAC restrictions

Issue #4: Flushing at 6” Drain

- Permissives prevent pump operation if 6” plug valves are not completely closed.
- O&M staff reported concerns with ragging and obstructions at drain valves preventing full closure and pump operation.
- Historically, valves have not shown signs of closure.
- Objective is to provide a means to flush plug valves if full closure of plug valves is not achieved.

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The pump suction header has a manual 6” drain shown in blue that drains to a sump pit. Photo on the right shows two 6” plug valves in series with a spool pipe in between. Both valves need to close to protect the pump station from flooding.
Also, The concern is that the pumps have a permissive that does not allow any pumps to run unless both of the drain valves are in the fully-closed position. If a valve closed on a piece of debris, that could potentially take down the pump station.

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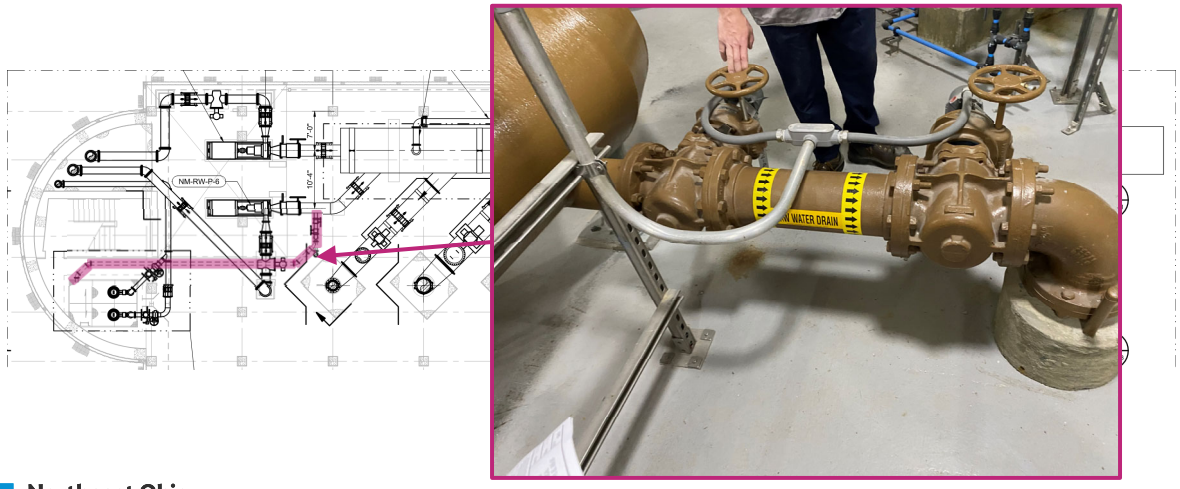

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Issue #5: Pump Inlet Pressure Transmitter

- Pumps 1 through 5 have inlet pressure gauges with local readouts at seal water panels. No trending data back to SCADA
- Pumps 6 and 7 have inlet pressure gauges with data back to SCADA. Pumps have low pressure interlock to turn pumps off.

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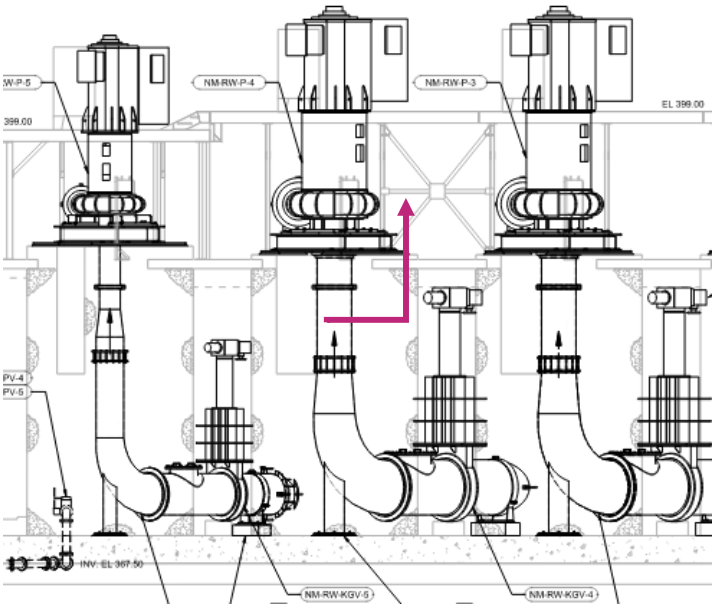
Pumps 1-5 did not include SCADA data outputs for the pump suction pressure.
Pumps 6-7 had both inlet and discharge pressure sensors that reported back to SCADA.



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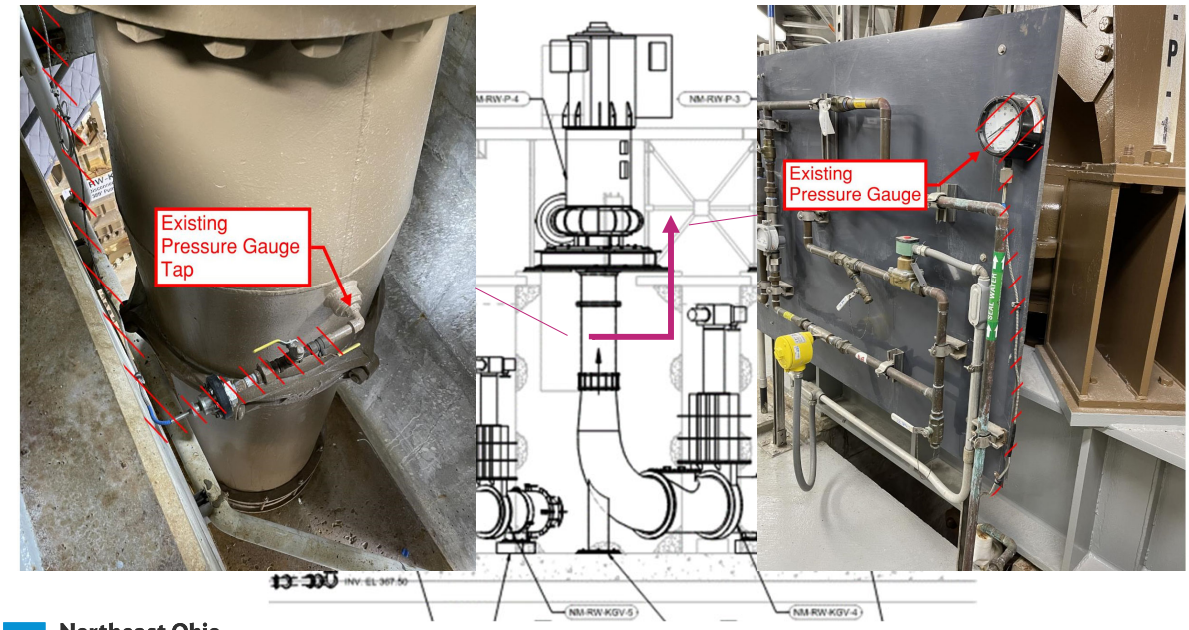

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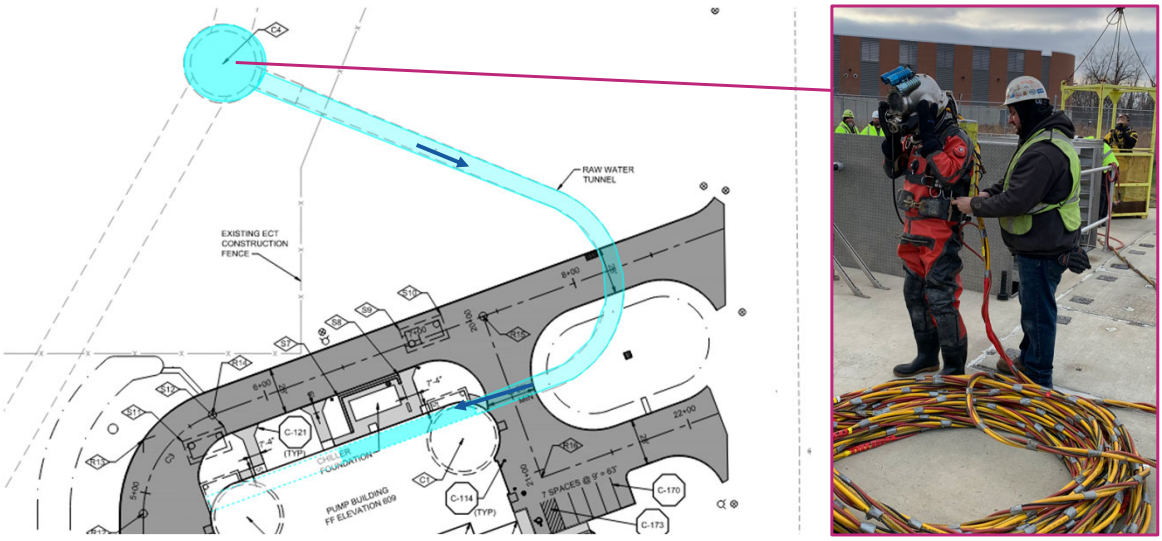
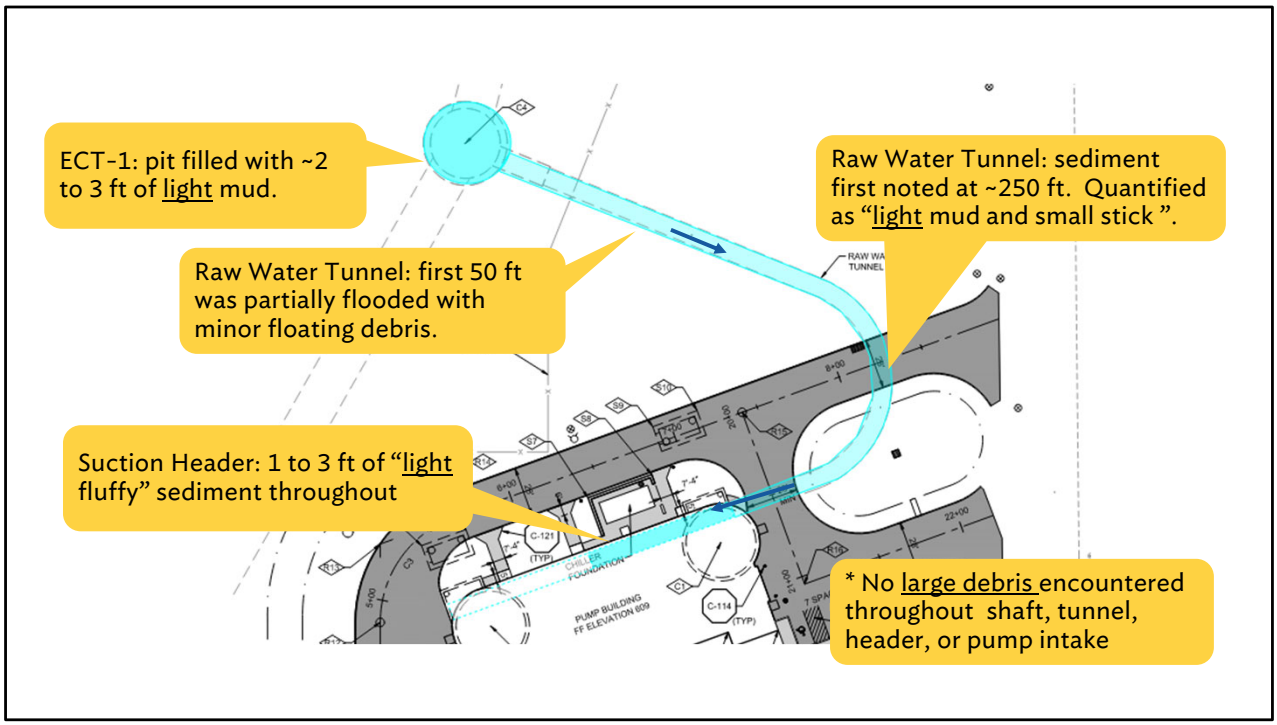
Diver inspection workplan and scope



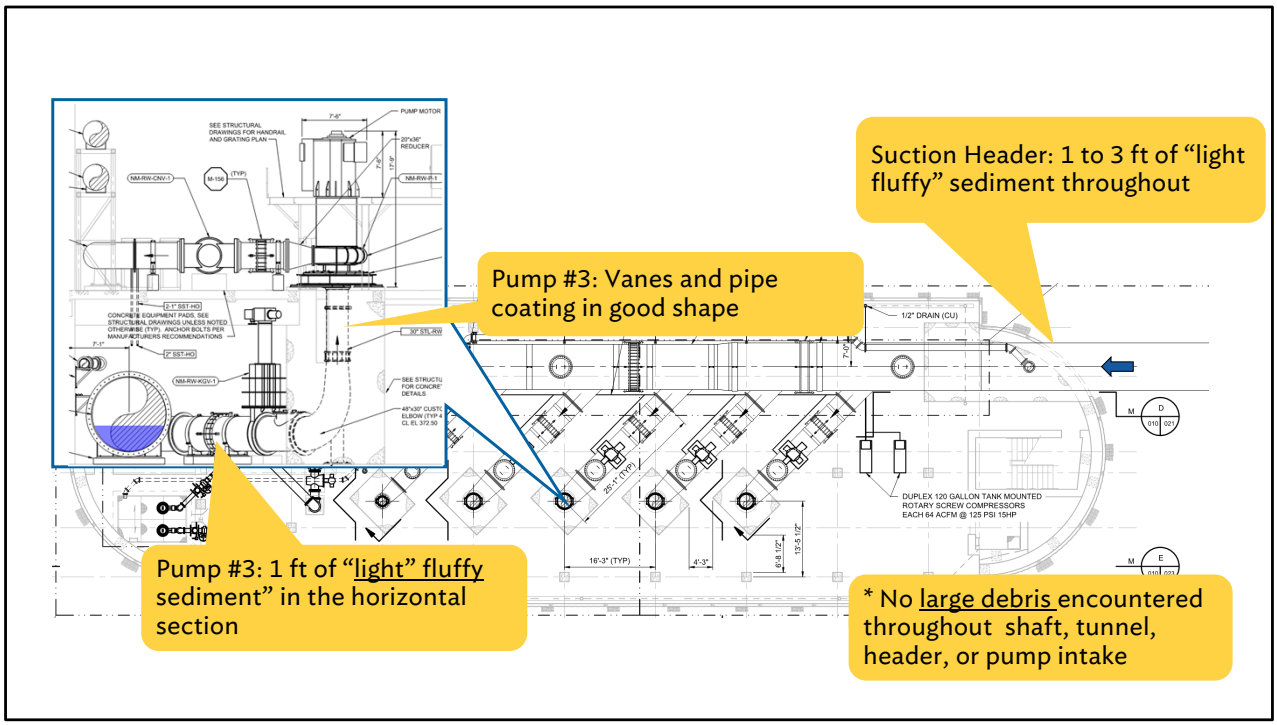
•December 2022 Underwater Marine Contractors was hired to inspect the raw water tunnel and pump suction header.

•Inspected ECT-1 Shaft Grit Trap, 102” Raw Water Concrete Intake Tunnel and 102” and 96” Steel Pump Suction Piping in ETDPS.

•Inspection continued through suction header to Pump 3 intake and vane



•Findings from the dive inspection are shown in yellow highlights.



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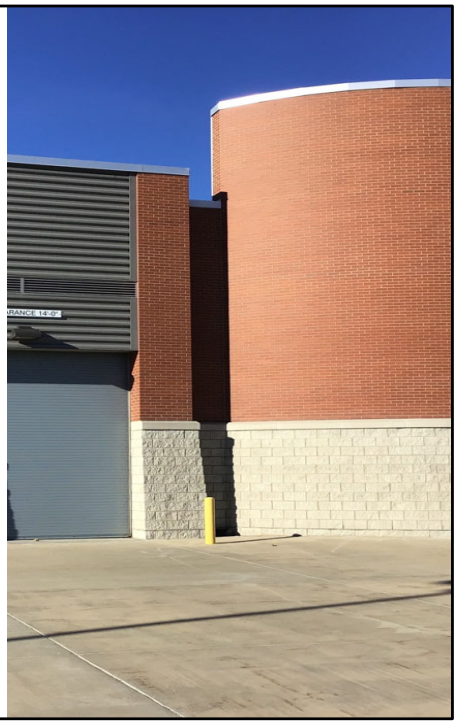

Evaluation: Sedimentation Accumulation Prescreening

Alt. No.	Description	Detailed Eval (Y/N)
1	Suction Header Backflush	N
2	Sequence Number of Pumps in Operation	Y
3	Jet Nozzle Mixing Header	Y
4	Tow-Bro Suction Header	N
5	Reduction in Suction Header Effective Area	N
6	Flushing Reservoir in ECT-1 Shaft	N
7	Install Final Drain Pump	Y

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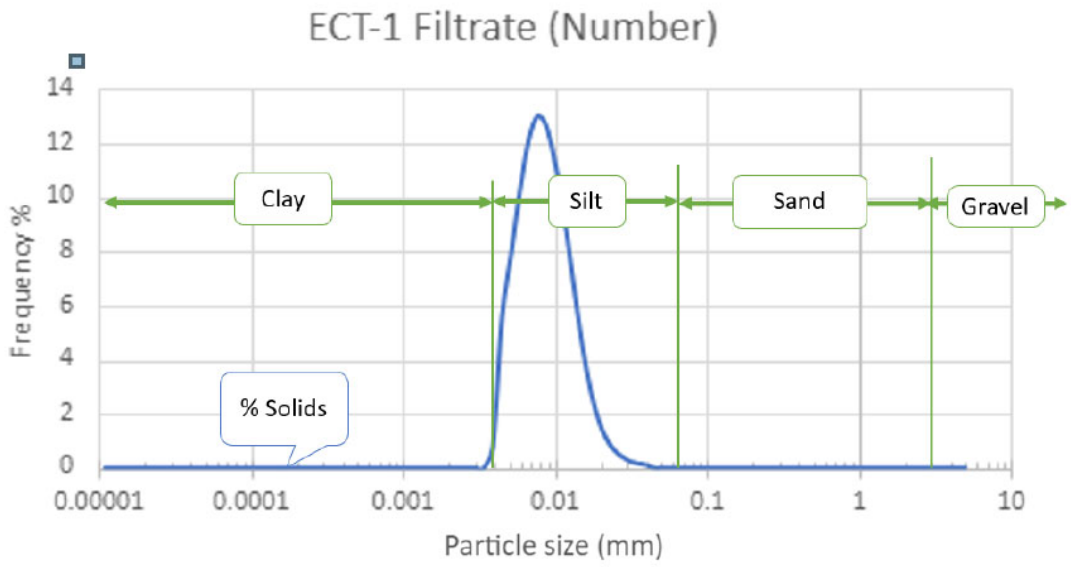
We brainstormed and came up with seven alternatives to move the sediment in the pump inlet bottom. Alternatives 2, 3 and 7 were chosen to be considered for possible improvements.

Note:

- 7 alternatives were evaluated to address grit accumulation.
- Alternatives 2 and 3 were modeled with computation fluid dynamics (CFD).
- Suction Header physical modifications noted in Alternatives 3 through 6 would require physical modeling



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Particle Distribution Graph

•The purpose of the screening of particles greater than 5 mm diameter was to represent what was observed by the diver. If large grit is deposited in the ECT-1 shaft grit trap, then mainly silt size particles will flow into the pump suction header as shown in the graph. Thus, light mud as described by the diver.

Grit Sampling Analysis

Sampled Solids

Filtered Solids >5 mm

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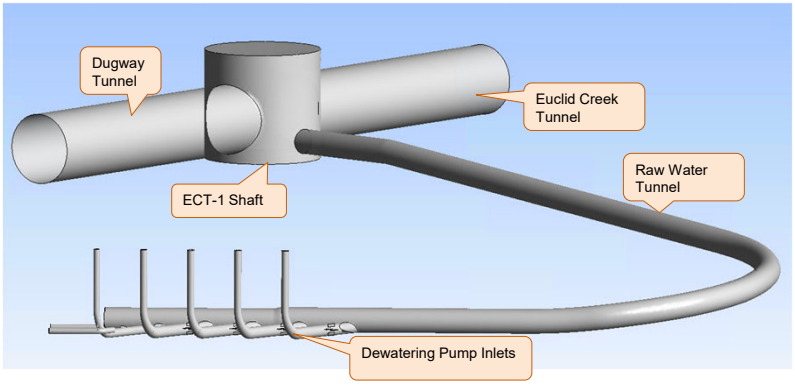
Evaluation - CFD Modeling Raw Water Tunnel & Piping Goals

Target Velocities

Velocity (fps)	Description
≤1	Solids settle
2	Min. to transport smaller solids
3	Min. to suspend smaller solids and transport grit
3.5 – 4+	Target to suspend grit



Assumptions:
- Raw Water Tunnel and suction header full

CFD modeling was performed to determine velocities in raw water tunnel and pump suction header pipe. Target velocity is 3 fps as shown in red highlight.

CFD Modeling was performed to better understand flushing velocities – Pump 1 Operating (Current SOP)

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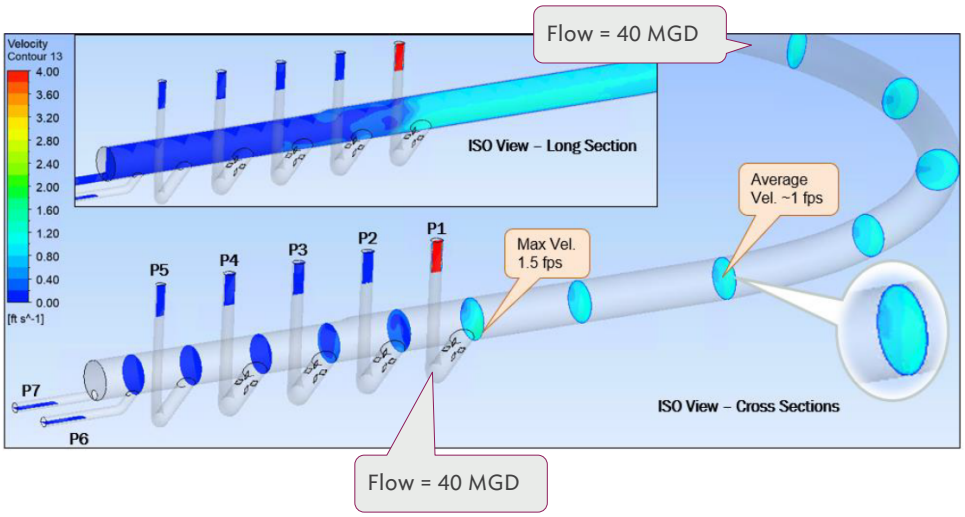
3.5 – 4+	Target to suspend grit



•With one pump operating the velocity is less that 1 fps that is too low to move solids.

CFD Model Results
Pumps 2 and 4 Operating (Modified SOP)

Velocity (fps)	Description
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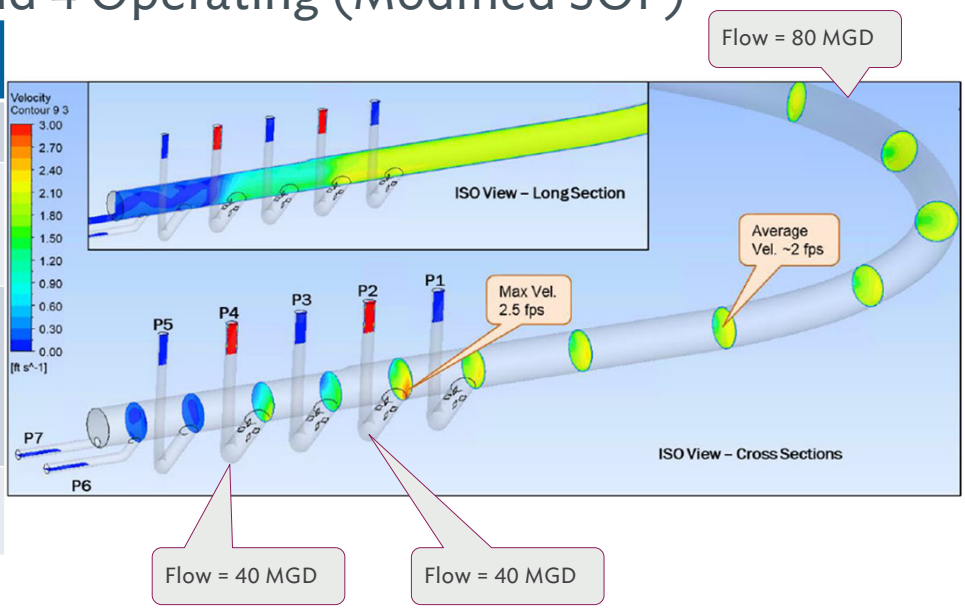
2	Min. to transport smaller solids
3	Min. to suspend smaller solids and transport grit
3.5 – 4+	Target to suspend grit



•Two pumps in operation improves the velocity to 2 fps but still too low.

CFD Model Results
Pumps 3, 4, 5 and 7 Operating (Modified SOP)

Velocity (fps)	Description
≤1	Solids settle
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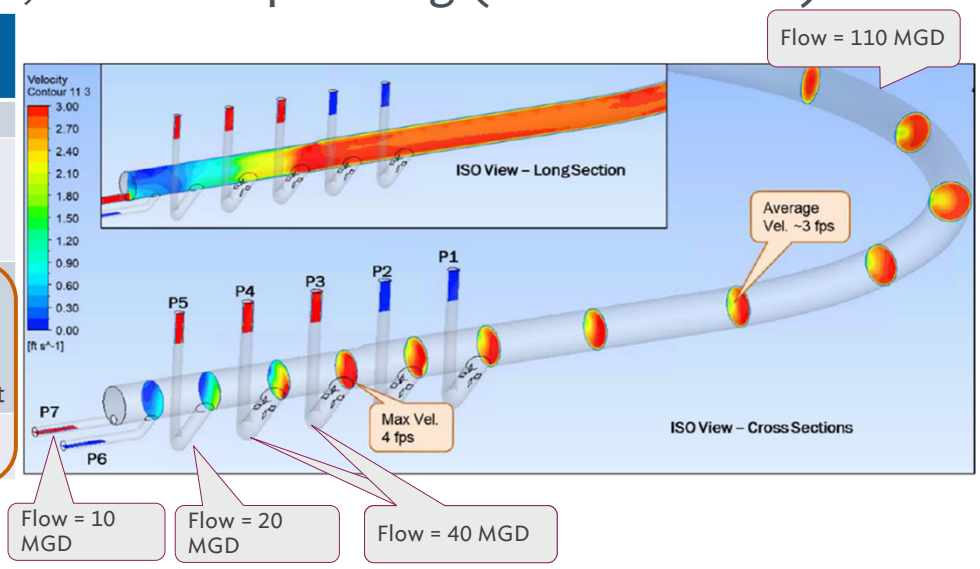
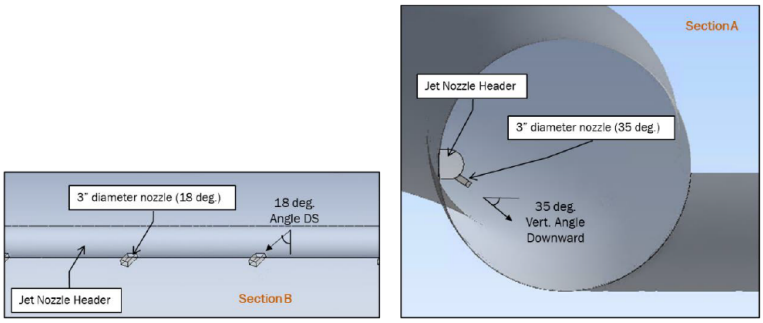
3	Min. to suspend smaller solids and transport grit
3.5 – 4+	Target to suspend grit

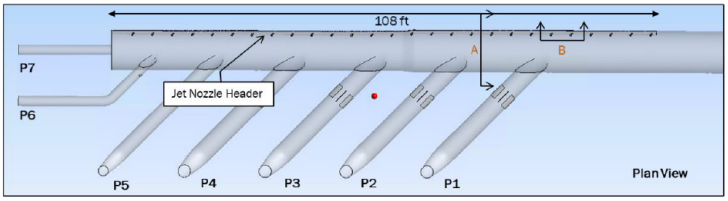


•Four pumps in operation achieves the desired 3 fps but may impact Easterly WWTP operation.

Modeled Nozzle System within Suction Header

- 108 ft long diffuser header
- 27 jet nozzles | 4’ spacing
- 3” dia. nozzles.
- Angled down 35° from horizontal
- Angled downstream 18°
- Recirculated Raw Water from pumps 6 and 7
- Target jet nozzle velocity of 18 fps
- Water will be motive force

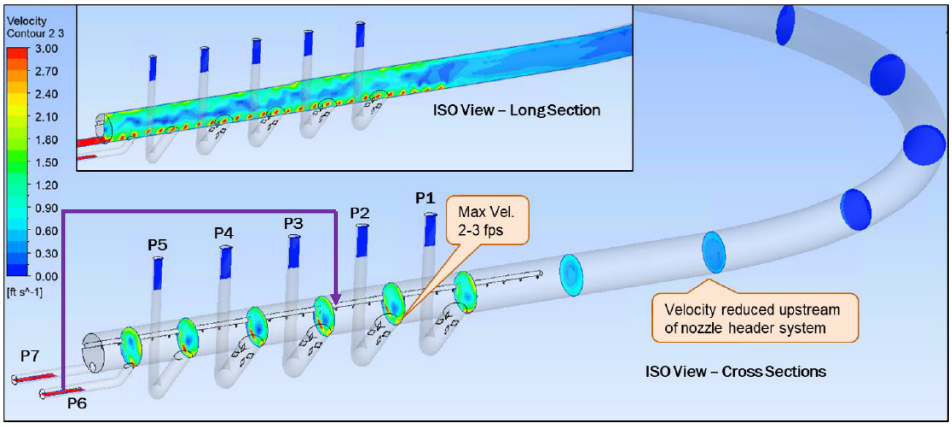




•A nozzle system was evaluated with design data shown on the left.

Modeled Nozzle System with only Recirculation and no Dewatering

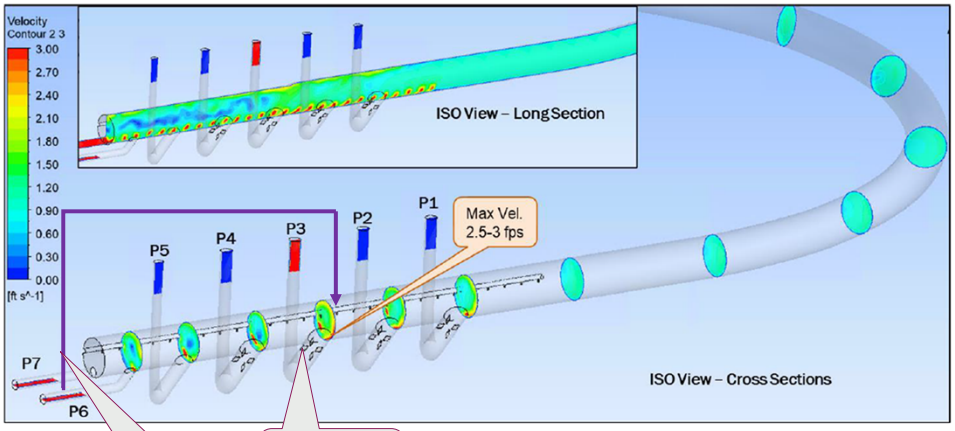
Velocity (fps)	Description
≤1	Solids settle
2	Min. to transport smaller solids
3	Min. to suspend smaller solids and transport grit
3.5 – 4+	Target to suspend grit



•Pumps 6 and 7 provide 20 mgd of recirculation water without discharging to Easterly.

Modeled Nozzle System with Recirculation and 1 Dewatering Pump

Velocity (fps)	Description
<1	Solids settle
2	Min. to transport smaller solids
3	Min. to suspend smaller solids and transport grit
3.5 – 4+	Target to suspend grit



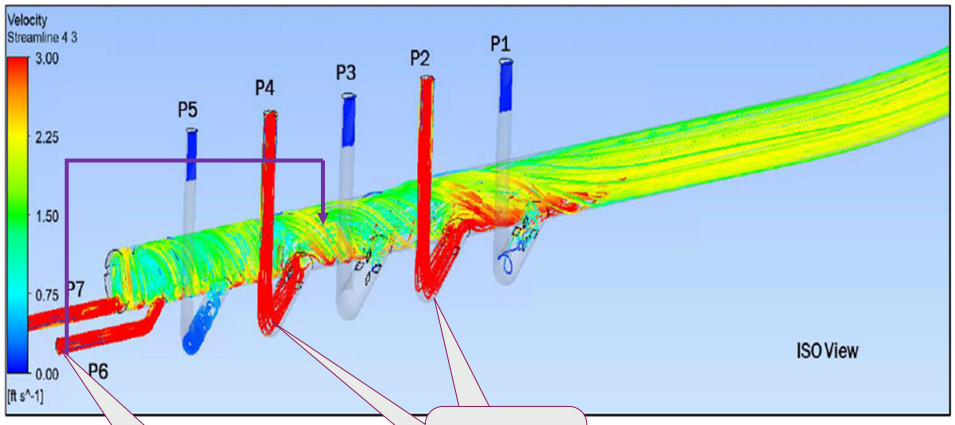
20 MGD recirculated

40 MGD to Easterly Interceptor

- One main 40 mgd dewatering pump on with mixing system improves the velocity.

Modeled Nozzle System with Recirculation and 2 Dewatering Pumps

Velocity (fps)	Description
≤1	Solids settle
2	Min. to transport smaller solids
3	Min. to suspend smaller solids and transport grit
3.5 – 4+	Target to suspend grit



20 MGD recirculated

80 MGD to Easterly Interceptor

- Two main dewater pumps on increases pipe velocities.

Evaluation: Sedimentation Accumulation Prescreening

Alt. No.	Description	Detailed Eval (Y/N)
1	Suction Header Backflush	N
2	Sequence Number of Pumps in Operation	Y
3	Jet Nozzle Mixing Header	Y
4	Tow-Bro Suction Header	N
5	Reduction in Suction Header Effective Area	N
6	Flushing Reservoir in ECT-1 Shaft	N
7	Install Final Drain Pump	Y

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•Decision was made not to advance the mixing system into the design phase based on the risks

Note:

- 7 alternatives were evaluated to address grit accumulation.
- Alternatives 2 and 3 were modeled with computation fluid dynamics (CFD).
- Suction Header physical modifications noted in Alternatives 3 through 6 would require physical modeling

Modeled Nozzle System Conclusions

- Jet Nozzle Risks:
  - Imbalanced loading could be imparted on pumps due to suction header flow patterns
  - Nozzles could plug or detach, damaging pumps
  - Pump intake hydraulics not favorable
- Modifications to pumping operation showed favorable results

•Decision was made not to advance the mixing system into the design phase based on the risks.

Modeled Nozzle System Conclusions

- Decision:
  - Alterative 3 not advanced for design
  - Multiple pump sequence incorporated into SOP
  - Install self-priming final drain pump to completely dewater following each event

•The number of pumps operating was advanced into a standard operating procedure.
•Decision was made to install a chopper drain pump to completely dewater the pump suction header pipe.

Condition Assessment Recommends 5 Specific Improvements

- Correct ECT-1 Shaft Gate Slamming Issue
- Install Access Platform, Manway Cover Lifting System
- Install NPW Flushing Pipe
- Address Final Header Pipe Drain Pump Concept
- Add Pressure-Indicating Transmitters to Pump Inlets

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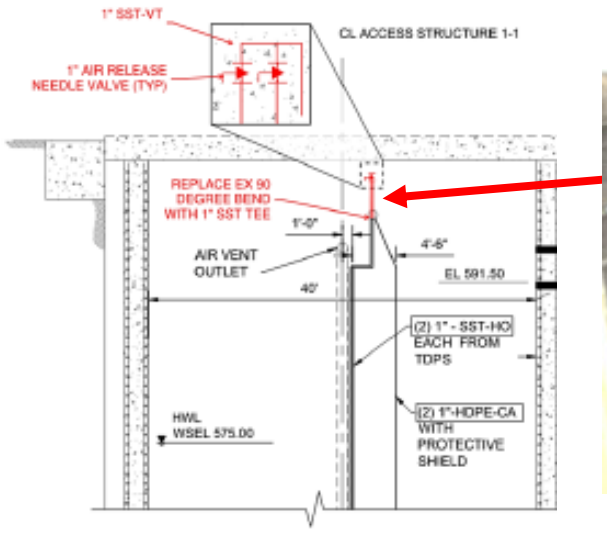
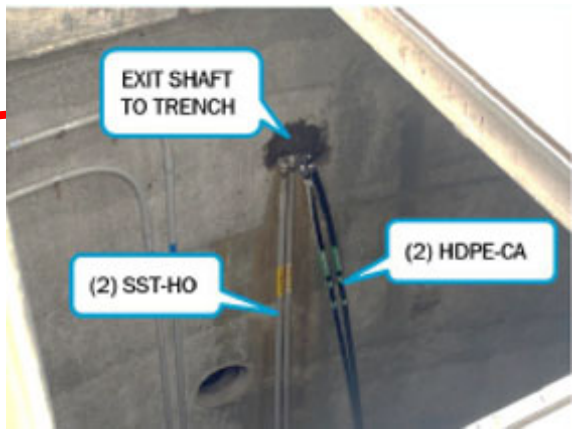
ECT-1 Shaft Correct Gate Slamming Issue #1





- Have gate manufacturer inspect gate and frame inside ECT-1 shaft.
- Install air release valves at top of ECT-1 shaft where oil lines turn down.

Condition Assessment Recommends 5 Specific Improvements

- Correct ECT-1 Shaft Gate Slamming Issue
- Install Access Platform, Manway Cover Lifting System
- Install NPW Flushing Pipe
- Address Final Header Pipe Drain Pump Concept
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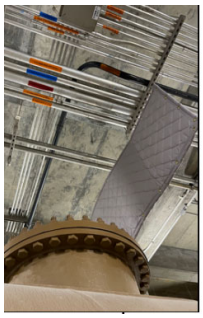
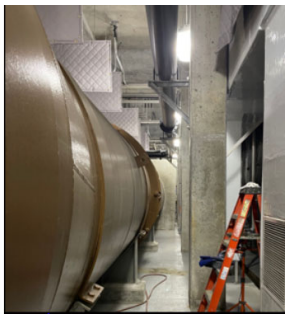
Suction Header: Install Manway Access Issue #2





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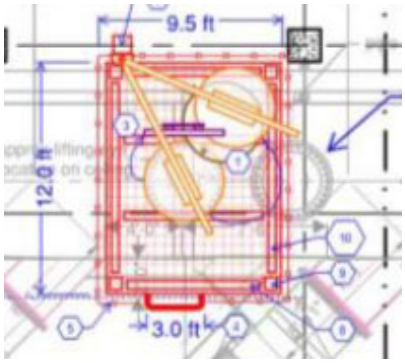
East access manway location chosen as location for platform and jib crane.

Access Platform and Jib Crane Will Allow Maintenance to Safely Remove 1,200 lb. Cover



Plan View
Platform & Jib Crane

Proposed Jib Crane

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- Access Platform and jib crane shown.

Condition Assessment Recommends 5 Specific Improvements

- Correct ECT-1 Shaft Gate Slamming Issue
- Install Access Platform, Manway Cover Lifting System
- Install NPW Flushing Pipe
- Address Final Header Pipe Drain Pump Concept
- Add Pressure-Indicating Transmitters to Pump Inlets

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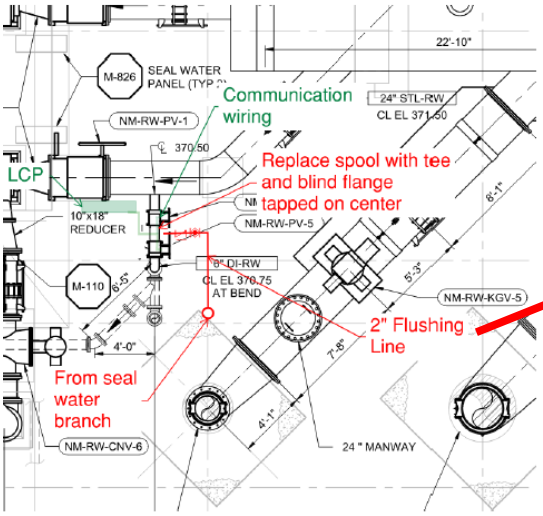
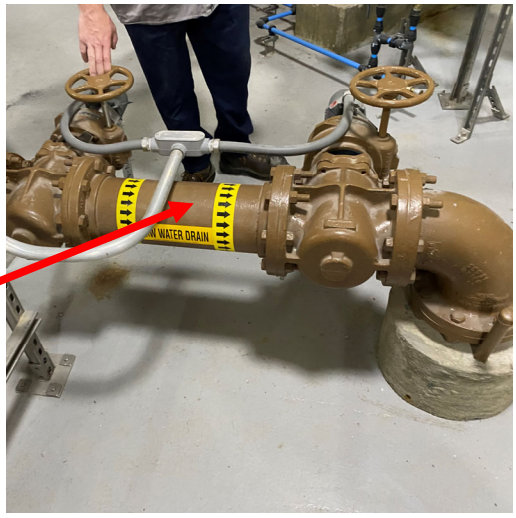
Install NPW Flushing Pipe Issue #3





•Install 2” NPW tap to the spool piece between the two plug valves is recommended. NPW can be used to flush solids back into the pump suction header or towards the sump pit.

Condition Assessment Recommends 5 Specific Improvements

- Correct ECT-1 Shaft Gate Slamming Issue
- Install Access Platform, Manway Cover Lifting System
- Install NPW Flushing Pipe
- Address Final Header Pipe Drain Pump Concept
- Add Pressure-Indicating Transmitters to Pump Inlets

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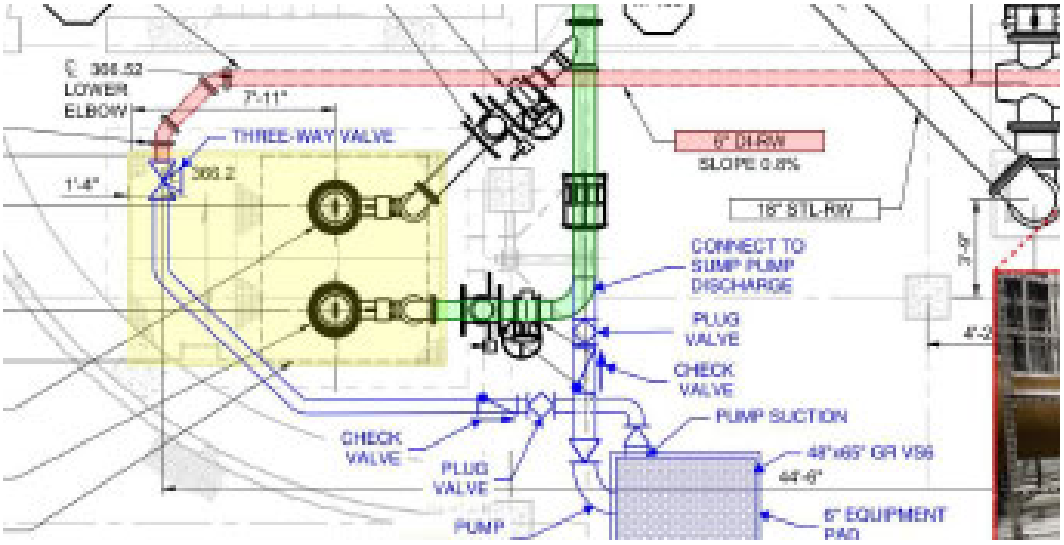
Install Final Drain Pump Issue #4



•The two submersible pumps shown in the yellow rectangle are emergency suction header backup drain pumps that are designed to pump cavern groundwater. Pumps 6 and 7 shutoff with about 3 ft. of water remaining in the suction header. The new self-priming trash pump is designed to dewater the header pipe.

Condition Assessment Recommends 5 Specific Improvements

- Correct ECT-1 Shaft Gate Slamming Issue
- Install Access Platform, Manway Cover Lifting System
- Install NPW Flushing Pipe
- Address Final Header Pipe Drain Pump Concept
- Add Pressure-Indicating Transmitters to Pump Inlets

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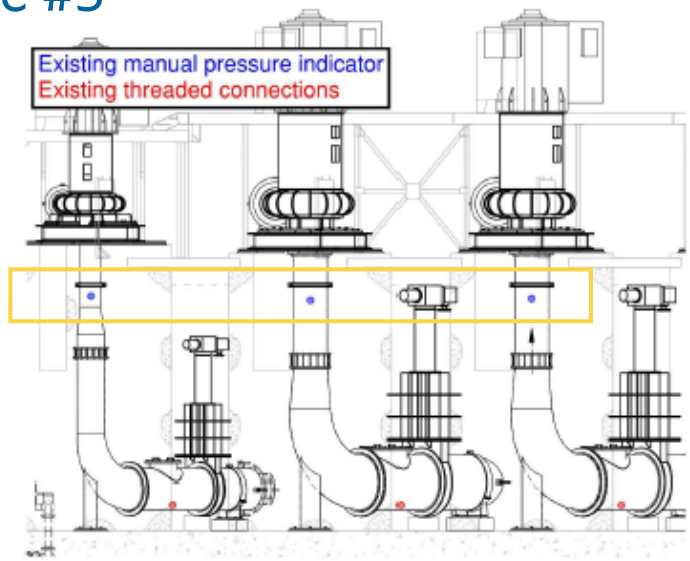
Add Inlet Pressure Sensors at Pumps 1-5 Issue #5



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•Pump 1-5 manual pump suction gauges replaced with pressure sensors that report back to SCADA.

Add Inlet Pressure Sensors at Pumps 1-5 Issue #5

Pumps 1-5 Manual Suction Gauges

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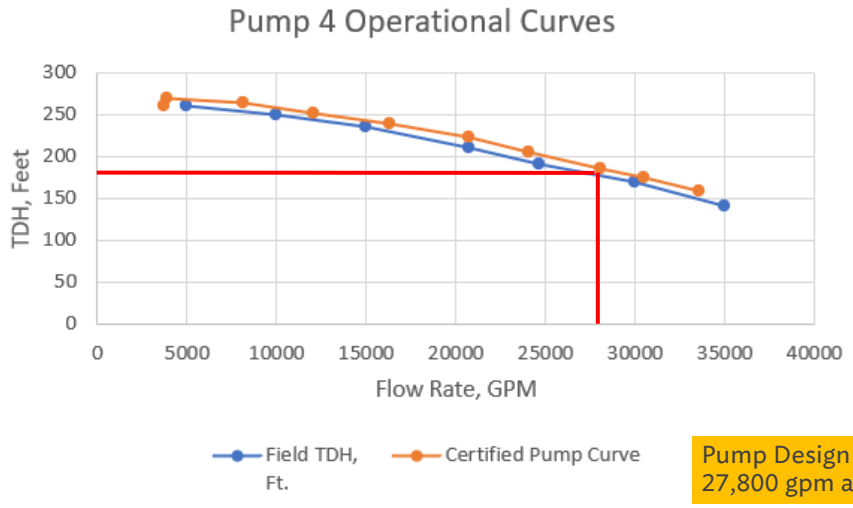
•Pump 1-5 manual pump suction gauges replaced with pressure sensors that report back to SCADA.

Pumps 1-5 Inlet Pressure-Indicating Transmitters



Example

Pump Design Point: 27,800 gpm at 179 ft.

- Pump suction pressure transmitter allows engineering to verify impeller condition.
- Use Bernoulli's equation to determine pump curve operating points.
- Compare pump curve operating points to original pump certified pump curve operating points.

Agenda

- Pump Station Background
- Pump Station O&M Issues
- Enhancement Evaluations
- Why Enhancements Are Needed
- Questions

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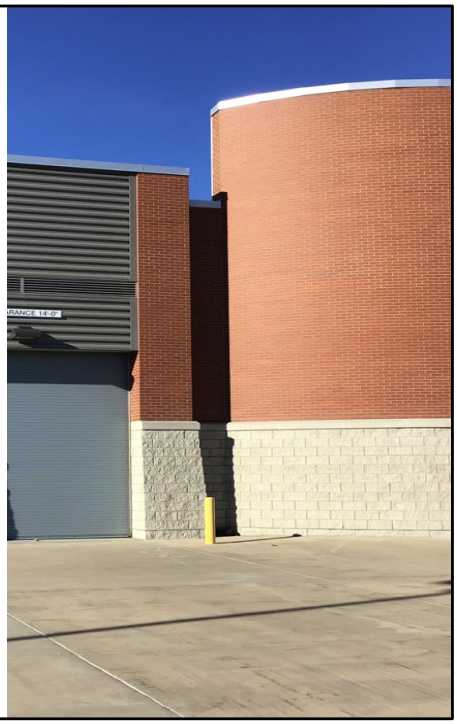

Why Enhancements Are Needed:

- ECT-1 Shaft
  - Fix cause of gate slamming to protect pump station.

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Why Enhancements Are Needed:

- Pump Suction Header
  - Suction header ladder, platform, and jib crane improves manway access for inspections, cleaning work and safety.
  - 6-inch drain line flushing system prevents clogging
  - Final drain pump completely dewaters suction header pipe.

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Why Enhancements Are Needed:

- Pump Suction Header
  - Pressure indicating transmitters (PITs) allows monitoring of dewatering pump suction pressure and pump impeller performance.
  - Sequencing multiple dewatering pump startup to increases suction header velocity and moves settled solids to pump inlets.

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Next Steps

- Detail Design
  - Begin detailed design 4th Quarter 2024
  - Advertise/Bid 3rd Quarter 2025
- Construction
  - Issue NTP 4th Quarter 2025
  - Complete Construction 4th Quarter 2026

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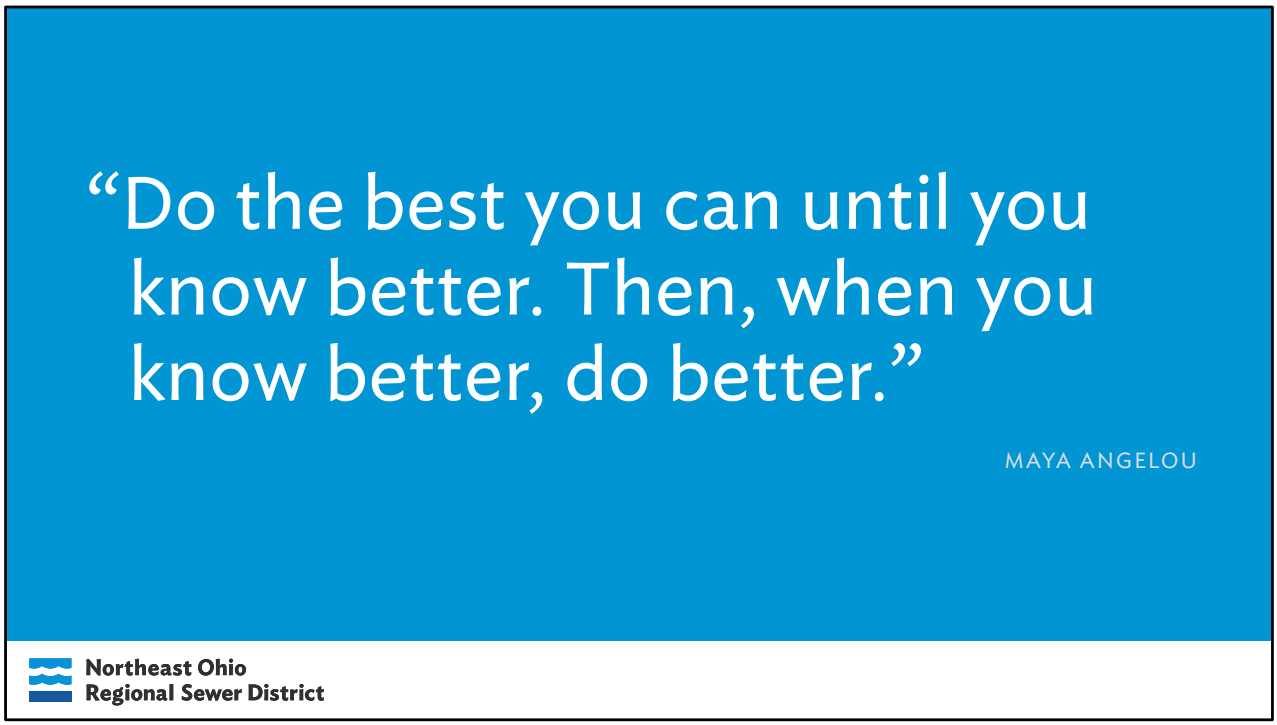

•I like to finish the presentation with a quote from Maya Angelou.

Agenda

- Pump Station Background
- Pump Station O&M Issues
- Enhancement Evaluations
- Why Enhancements Are Needed
- Questions

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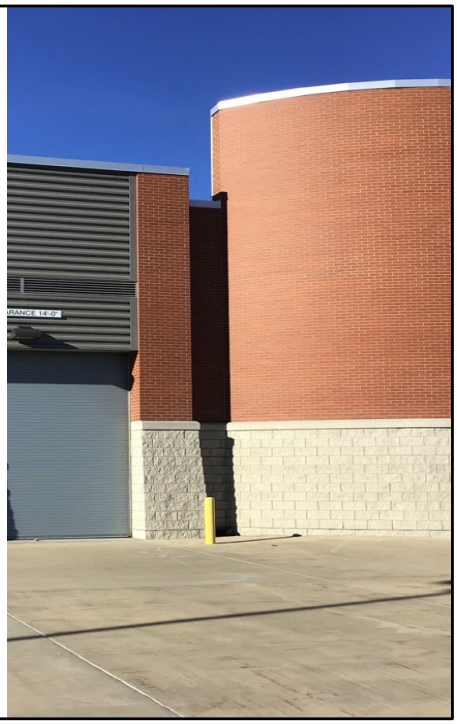

Easterly CSO Tunnel Dewatering Pump Station Enhancement Improvements

HARRY SHAPOSKA, P.E.

Northeast Ohio Regional Sewer District

Questions?