Columbus Collection and Treatment System Real Time Wet Weather Operational Implementation

Presenters

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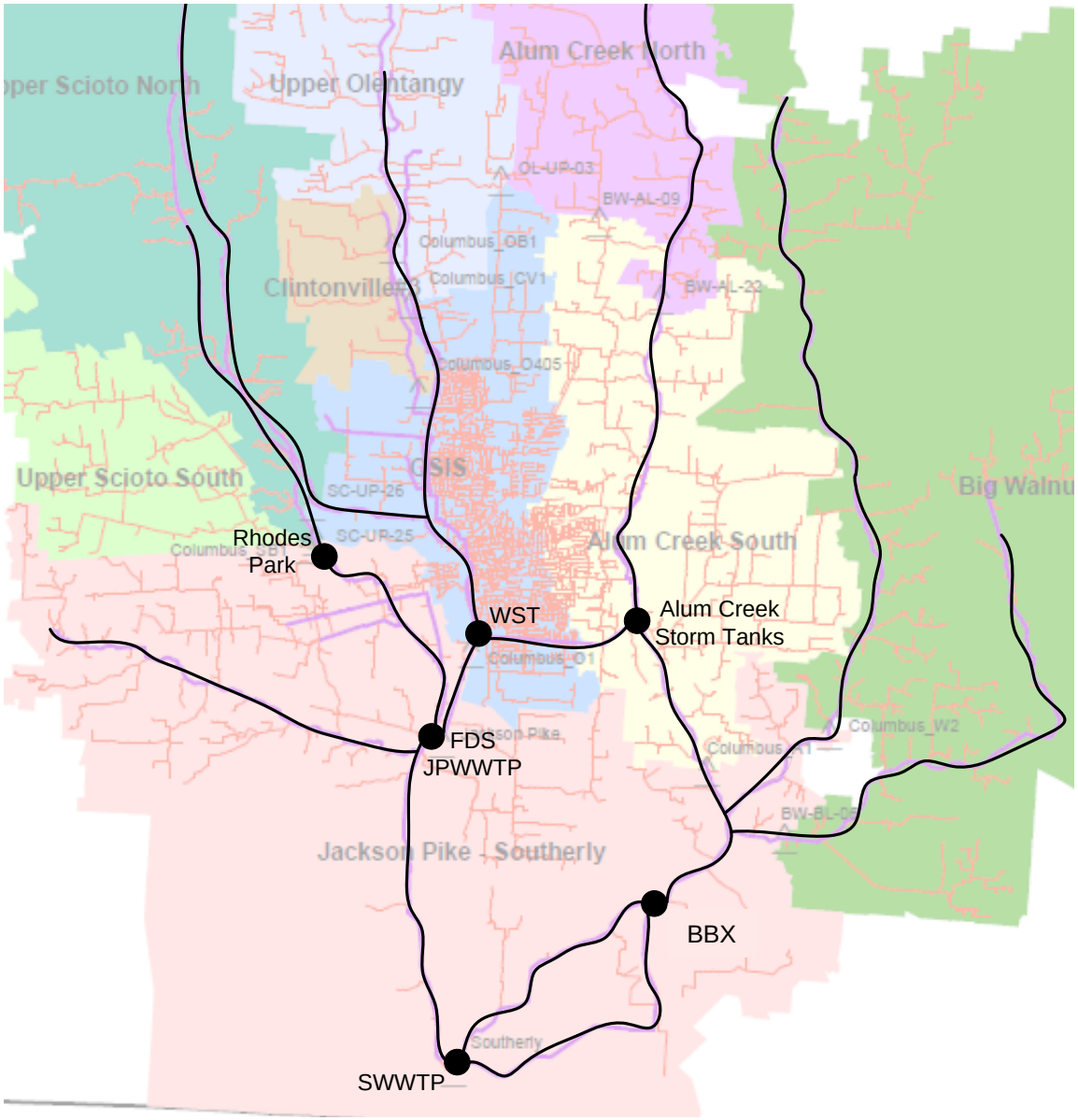
THE CITY OF COLUMBUS

CDM Smith

Existing Collection System



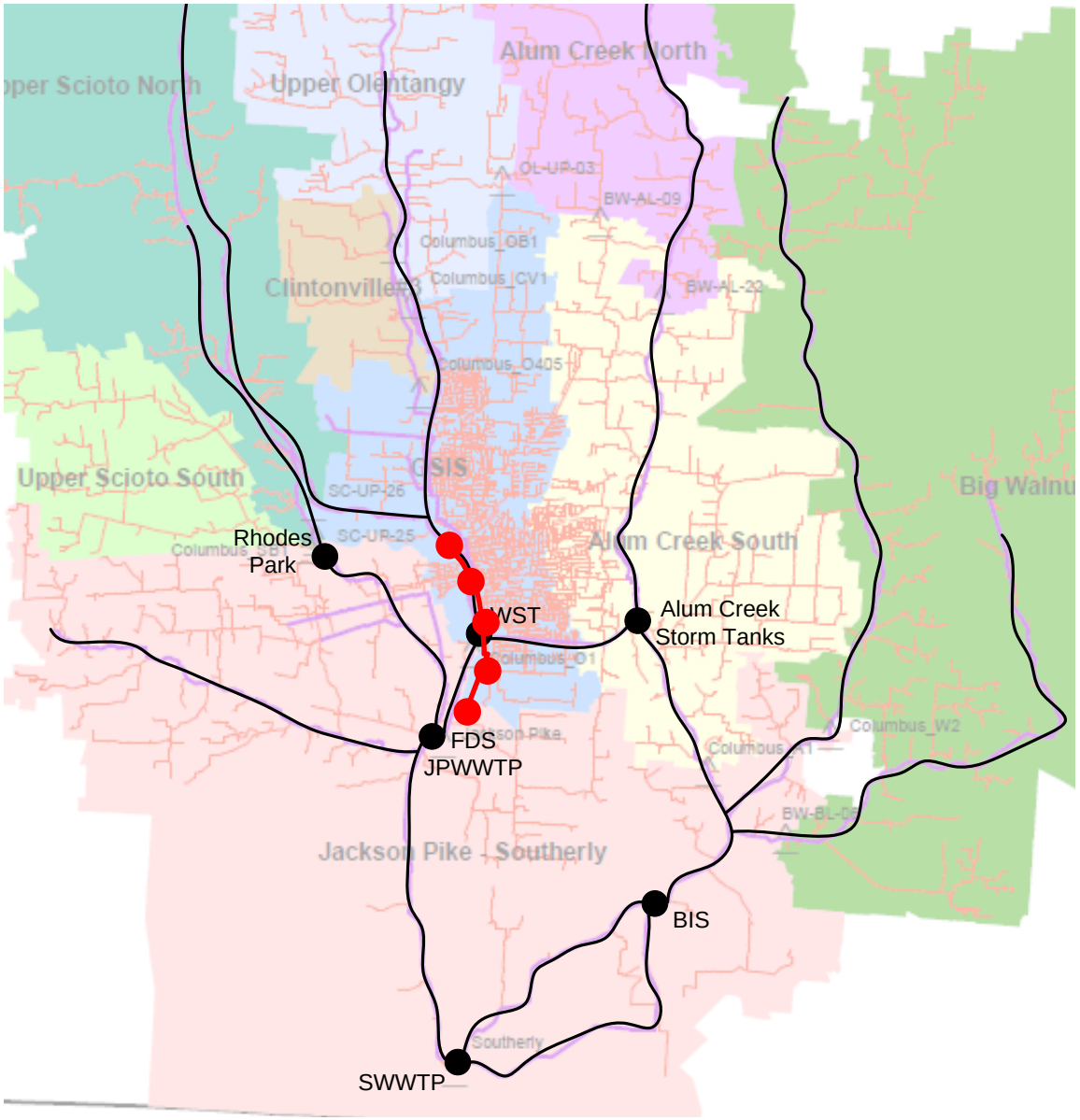
OARS Tunnel Addition

OARS Tunnel

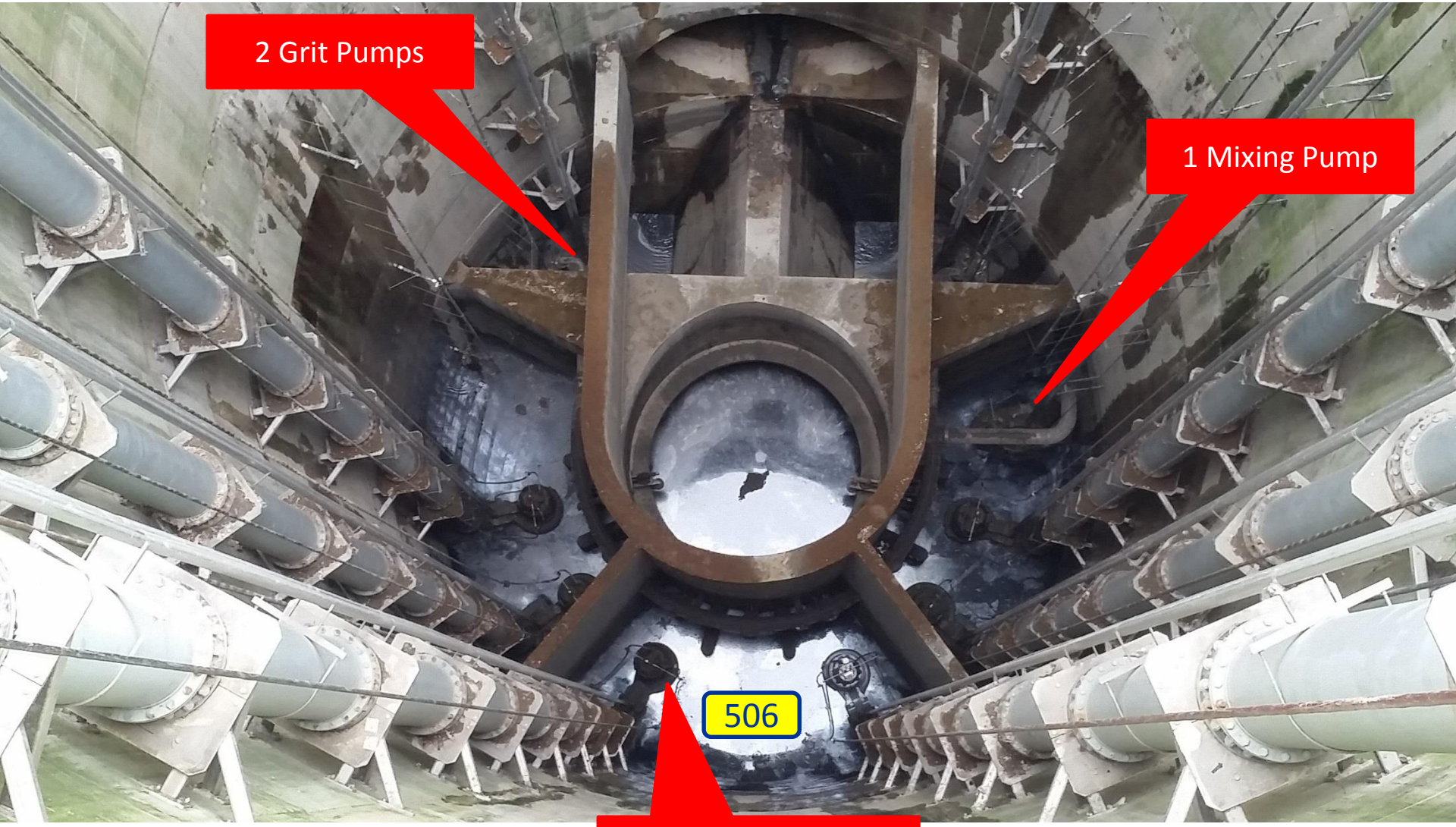
- 23,000 feet long
- 20 ft diameter
- ~180 ft deep
- Four drop shafts
- 63MG storage

OARS Dewatering Pump Station

- Tunnel must be pumped empty to be ready for next wet weather event
- 9 pumps
- 4 level sensors
- Complex control circuits



OARS Dewatering Pump Station



715 – Elevation picture taken from

OARS Dewatering Pumps

Dewatering Pumps

- Two pumping zones to deal with depth of tunnel
- Zone 2 – 2 pumps, 4160V, 450HP, 20MGD each
- Zone 1 – 4 pumps, 4160V, 800HP, 15MGD each
- Grit Pumps – 2 pumps, 480V, 105HP, 1MGD each
- Mixing Pump – 1 pump, 480V

Many Items in Control Circuit

Adjustable Frequency Drive

Pump Monitor

Local Control Panel

Programmable Logic Controller

Area Operator Touch Panel

Plant Wide HMI System

Many Different Providers

Pump vendor

Pump vendor AFD provider

Adjustable Frequency Drive

Pump Monitor

Pump vendor panel provider

Local Control Panel

CDM Smith

Programmable Logic Controller

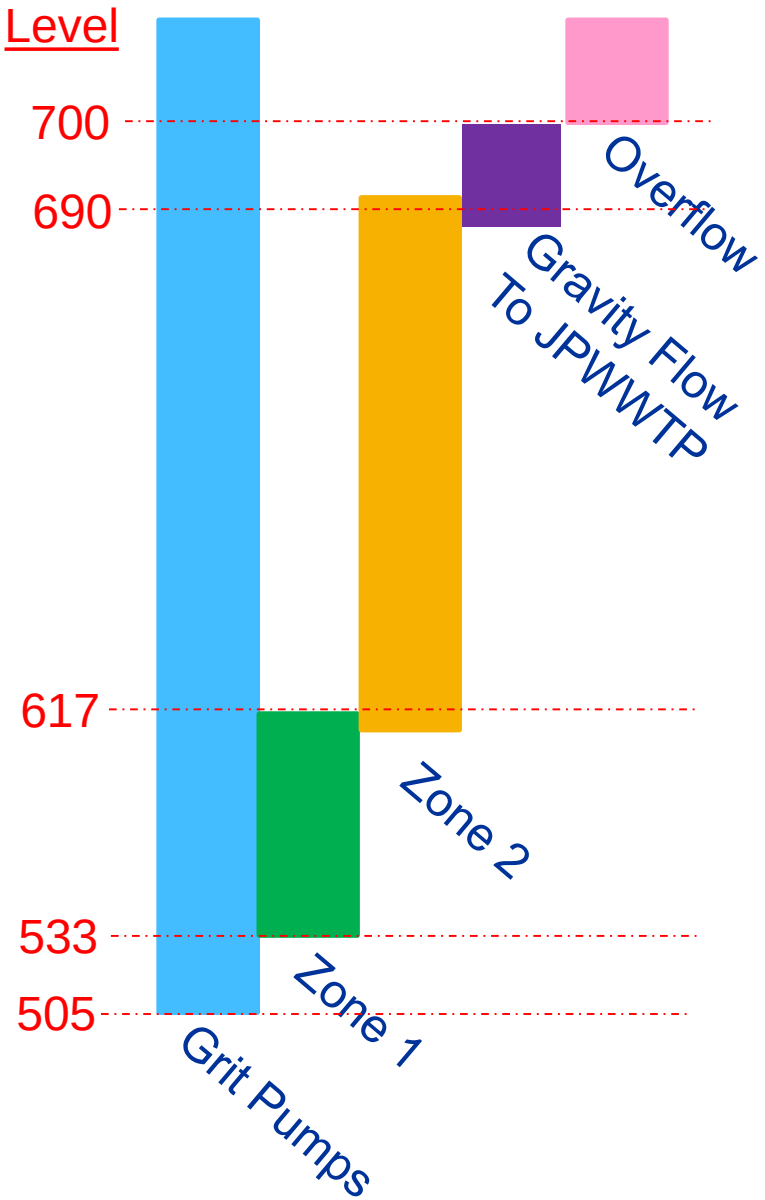
System Integrator

Area Operator Touch Panel

Plant Wide HMI System

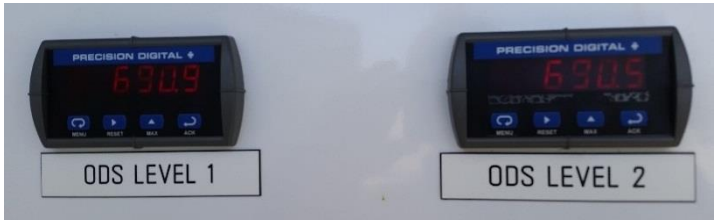
Electrical sub responsible for all wires between them

Complex Control Strategy



- Each pump has an operating depth range
- Tunnel can be completely filled and flow by gravity to JPWWTP which requires throttling of gates to control the flow
- Speed of pumps must be varied with depth to maintain operation on favorable pump curve
- Many pump protective interlocks

Level Measurement Complexities



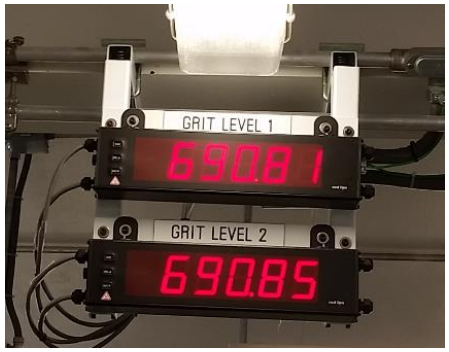
Local Control Panel

Display in AFD Room

- 4 Hydrostatic level sensors
- 1 each grit sump
- 2 for dewatering pumps
  - Automatic failover
- Multiple local displays
- Must be correct to compare to other plant influent levels
- 0.25% accuracy is about ½ foot error

11885	ODS LEVEL 1	506.19	to 721.19	FT	690.83
11886	ODS LEVEL 2	506.23	to 721.23	FT	690.83
11887	OARS GRIT SUMP 1 LEVEL	501.21	to 721.21	FT	690.85
11888	OARS GRIT SUMP 2 LEVEL	501.18	to 721.18	FT	690.84

Plant Wide HMI System



Display in AFD Room

Equipment Values

Equipment	Value
Zone 1 Pump, AFD, Rails & Brackets	~$600,000 Each (4 total)
Zone 2 Pump, AFD, Rails & Brackets	~$500,000 Each (2 total)
Grit Pump, AFD, Rails & Brackets	~$170,000 Each (2 total)
Mixing Pump, Starter, Nozzles	~$500,000

Testing must reduce risks due to equipment values.

"Press & Pray" is not a good method to manage risks

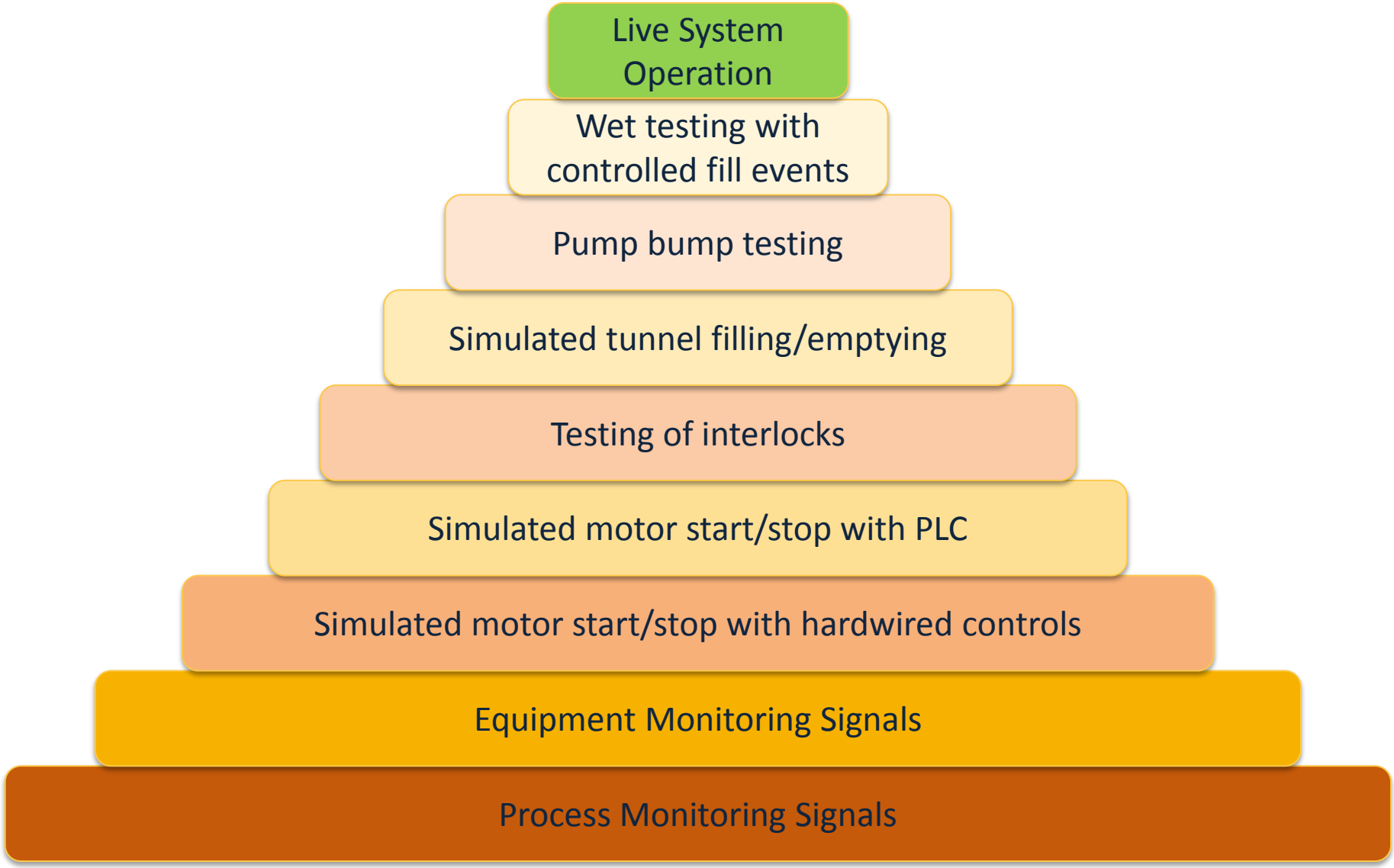
Something this complex doesn't get "turned on" one day

40 people here and no one will stand next to the person who hits the start button the first time. Why?

The first pump start with sewage

Answer:
It worked the first time, they didn't have time to walk over

Testing and Validation



Process Monitoring Signals

Hydrostatic inside guide pipes Grit 1

Hydrostatic inside guide pipes Grit 2

Hydrostatic inside guide pipes ODS 1

Hydrostatic inside guide pipes ODS 2

Tested by using smart instrument interface to force simulation.

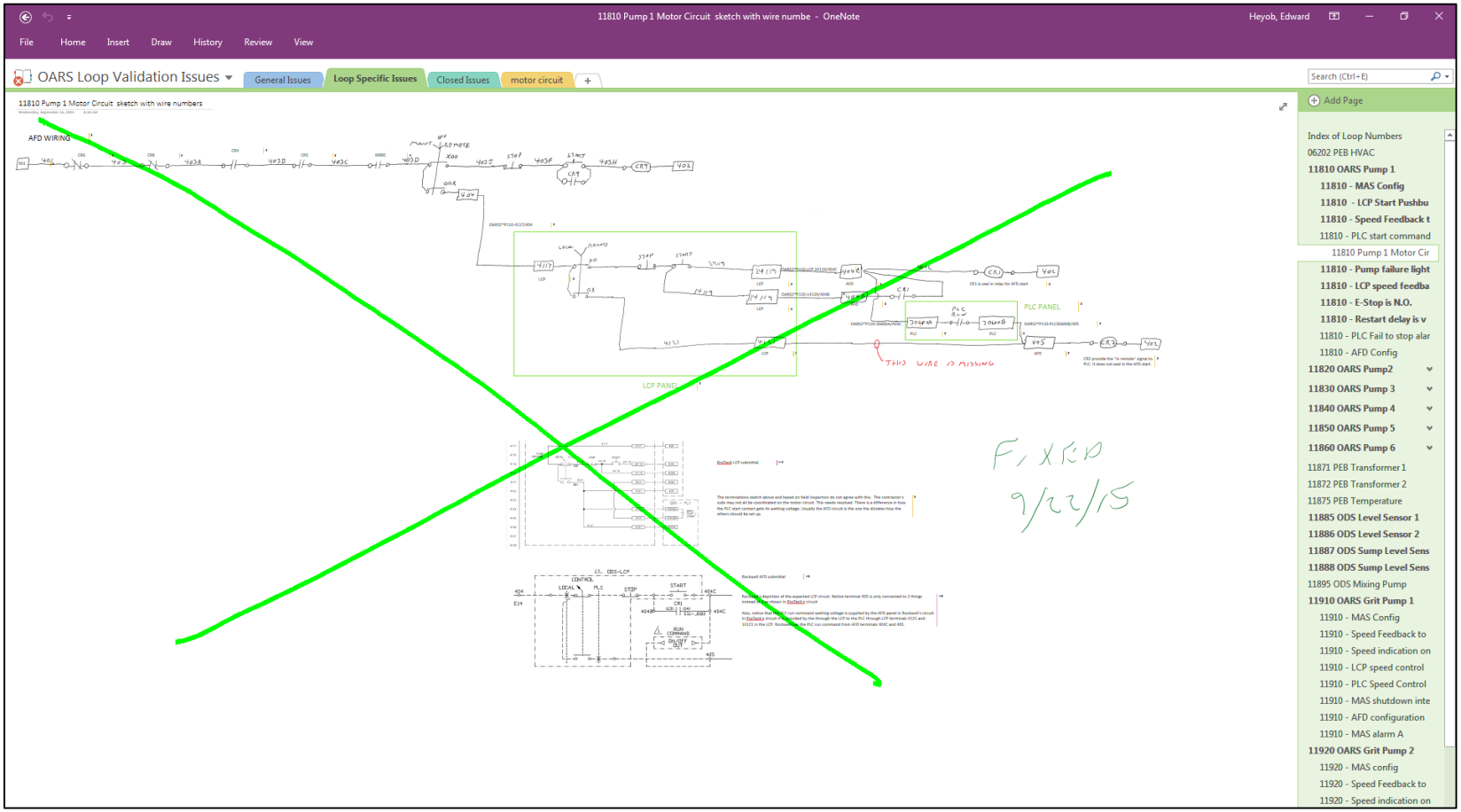
Filling the tunnel just to test level sensors isn't feasible

Pump Operation Simulation

Medium Voltage
Adjustable Frequency Drive

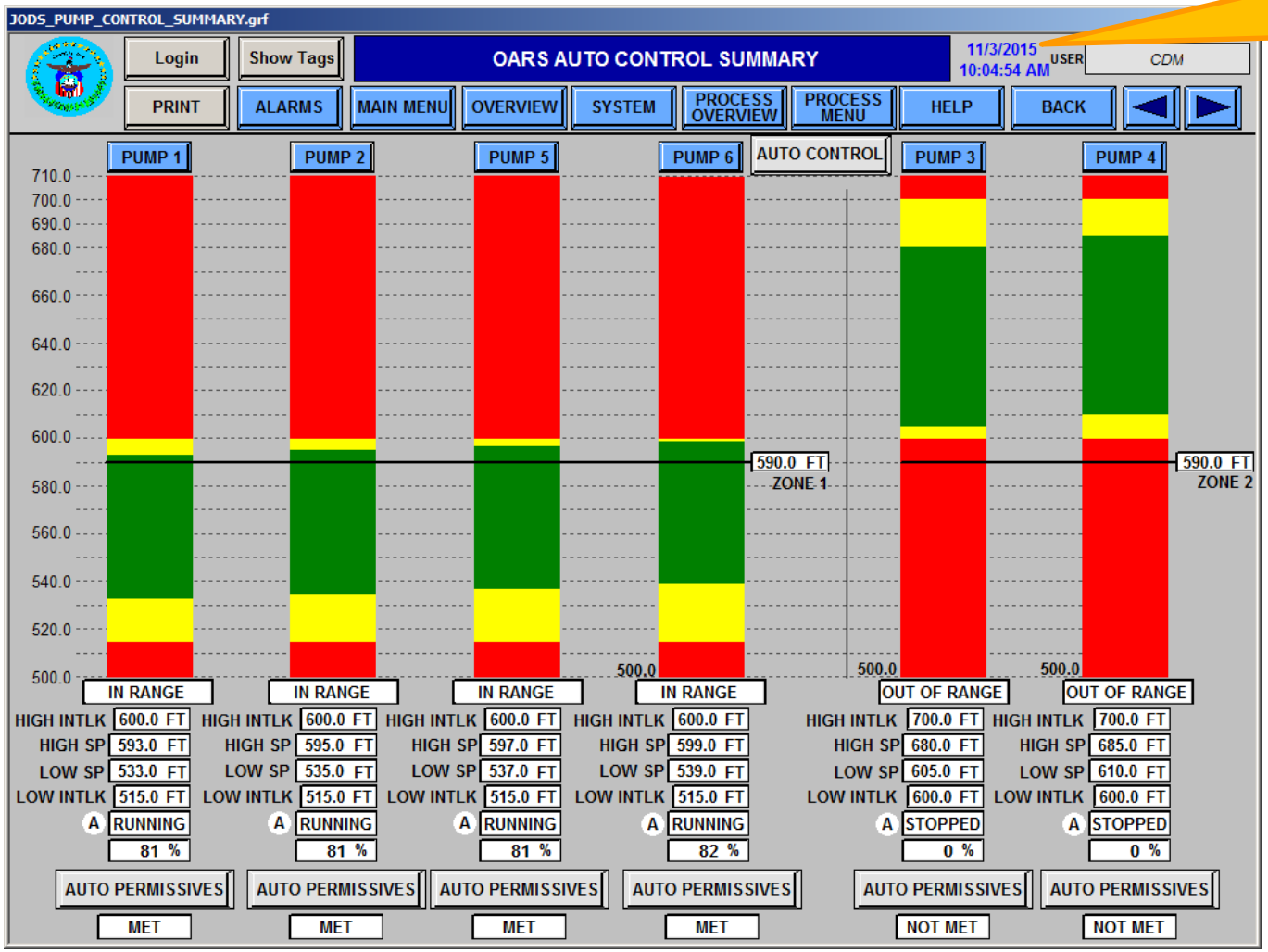
- Cannot operate pumps without sewage
- Medium voltage AFD has a motor simulation mode
- Allows for full testing of local and PLC circuits without starting the pump
- Testing without even having the pump attached was possible with a jumper to bypass the pump protection devices
- Many wiring issues fixed between the multiple vendor panels and electrical contractor. Several failed lights & indicators replaced.
- 480VAC pumps were simulated tested by removing motor leads from AFD

Tracking and Coordinating Circuit Issues



Every circuit issues was tracking individually. Microsoft Surface with OneNote was used as it could capture pictures, drawings and hold markups. Allowed for detailed notes in field with quick conversion to PDF to coordinate with Contractor, Construction Manager and Design Professional.

Simulated Tunnel Filling/Emptying



Simulated testing occurred many months before pumps were installed in shaft

AFD Simulation Mode allowed for initial testing of automatic logic against the actual control circuits.

This uncovered some additional circuit issues on pump shutdown with restart delay timer effecting the “remote” status signal to the PLC.

Pump Bump Testing

First time medium voltage applied to pumps in field

Video of each pump spinning the correct direction. Pumps tested on surface before being lowered in. Allowed for easier inspection and troubleshooting.

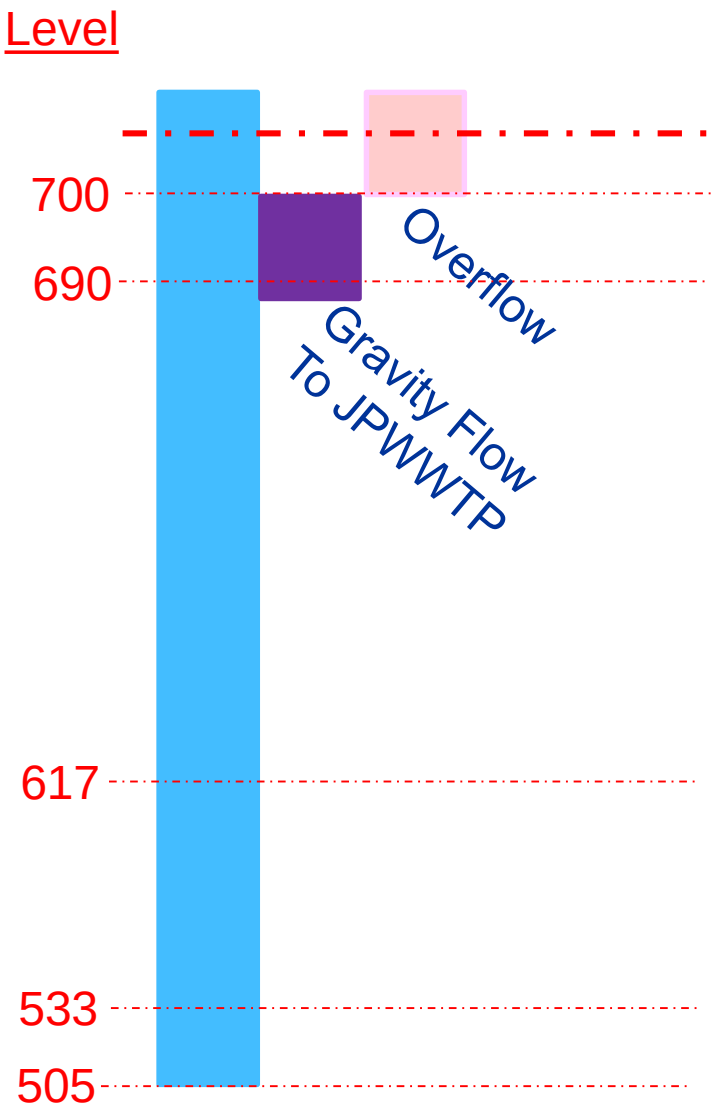
Special submersible cables with plug terminations. One of them was not terminated correctly. Found during bump testing and fixed.

Wet Test with Controlled Tunnel Filling

- Test each pump by doing a volume draw down test over its operating range
- Tunnel holds ~60MG
- Utilize surface sewer to fill tunnel for pump testing
- Fill tunnel during dry weather ideally
- Repeat multiple times to test each pump

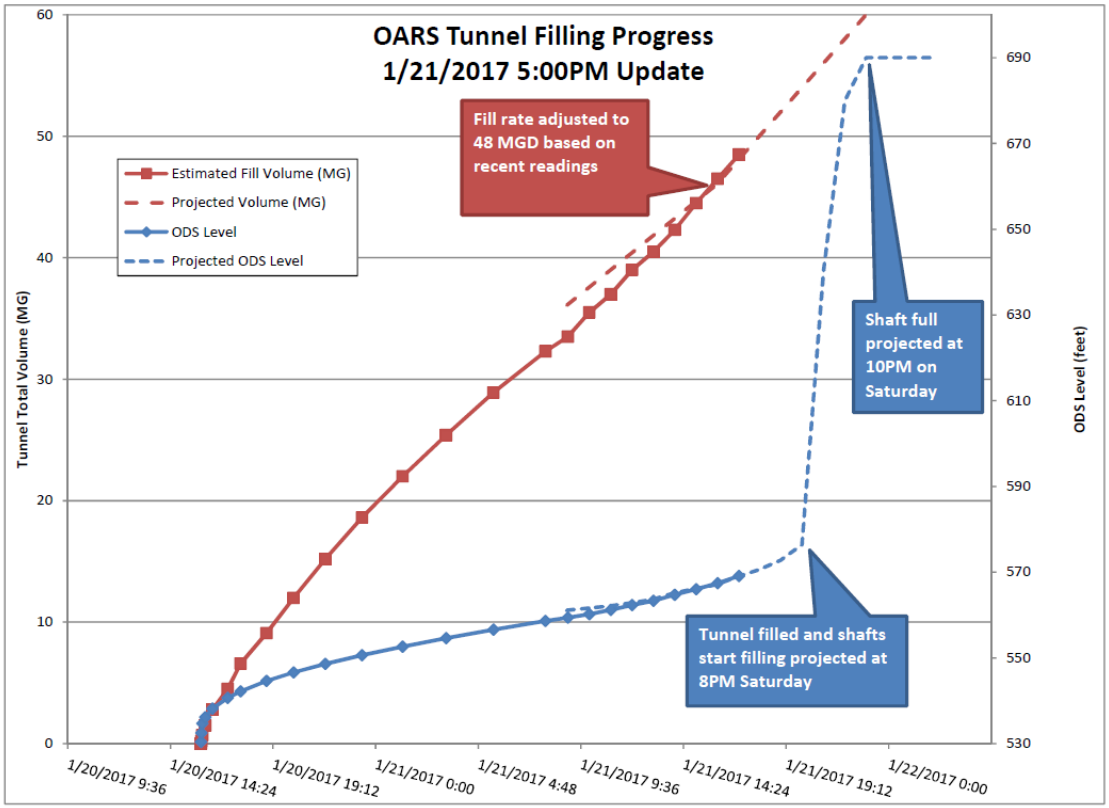
First tunnel filling test
Flow enters the dewatering pumps station

Wet Test with Controlled Tunnel Filling



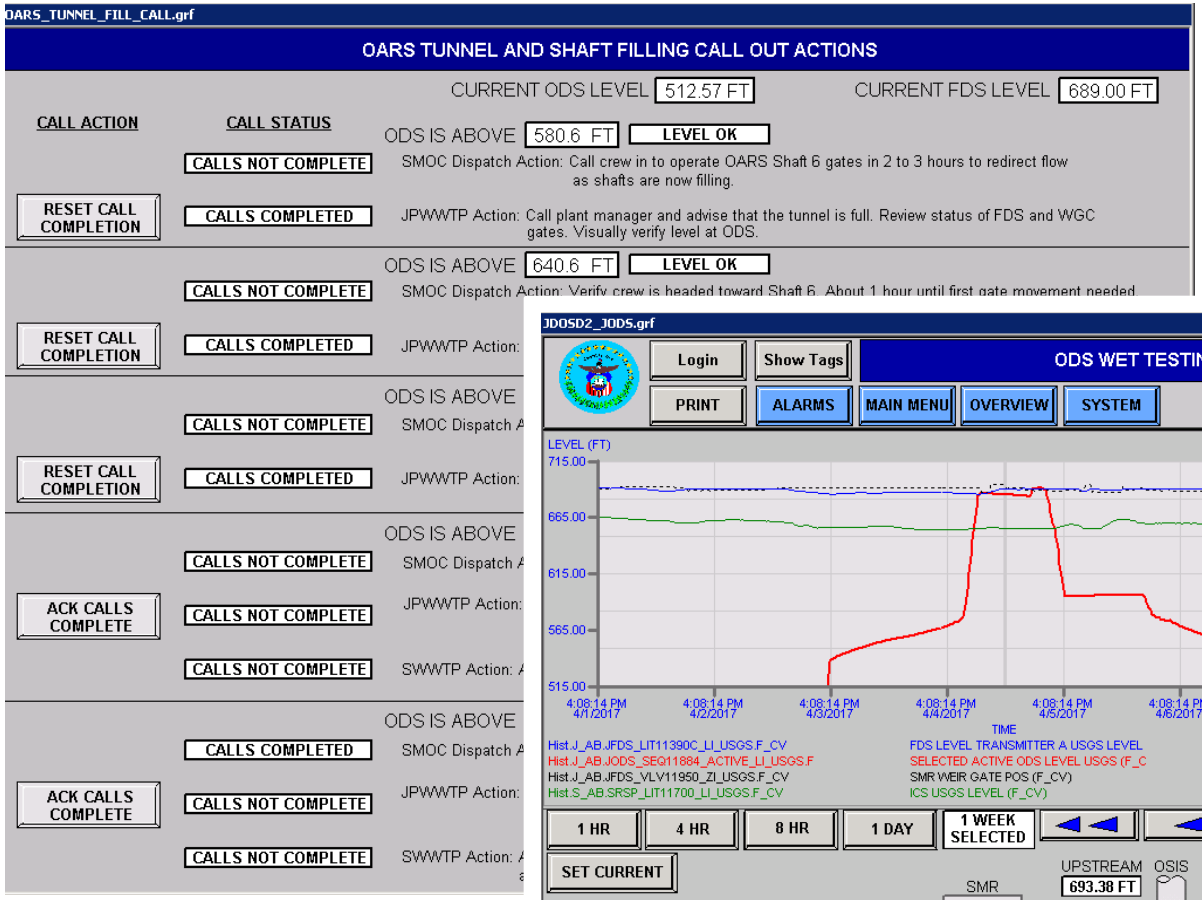
- Invert of filling sewer is higher than overflow at end of tunnel
- Must manage the filling process with crews called in to stop the filling process
- Surface sewer flow is variable adding uncertainty to the procedure
- Pumps not tested yet so they can't be used during first fill to slow the rate of filling
- Flow must be stopped or sent by gravity to Jackson Pike WWTP. Capacity must be available to receive it.

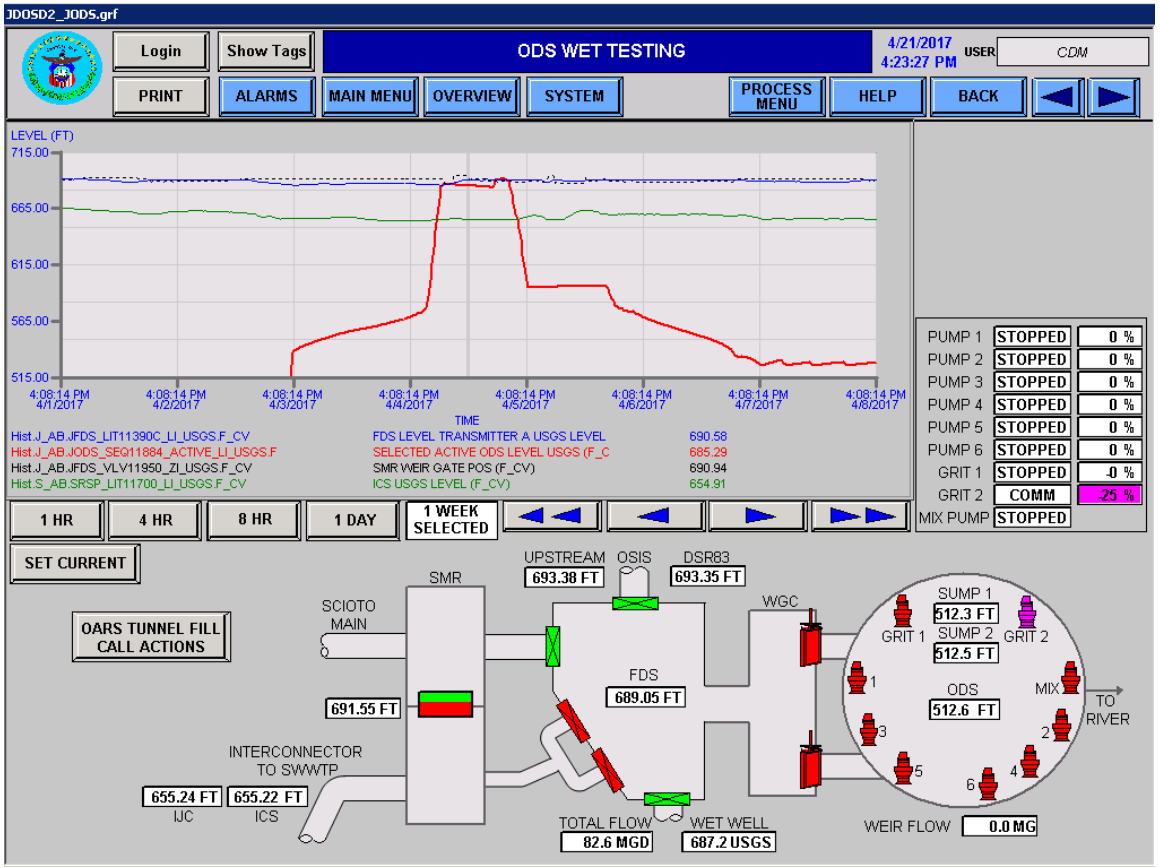
Wet Test with Controlled Tunnel Filling



- Filling projections done to aid the team in responding
- Flow calculated based on the volume change in the tunnel
- Far majority of tunnel volume is in the tunnel, not in the shafts. Notice rapid rise at end as shafts are filling
- Shafts can fill in 1 to 2 hours
- One fill test was filling shafts at 1ft/min

Wet Test with Controlled Tunnel Filling

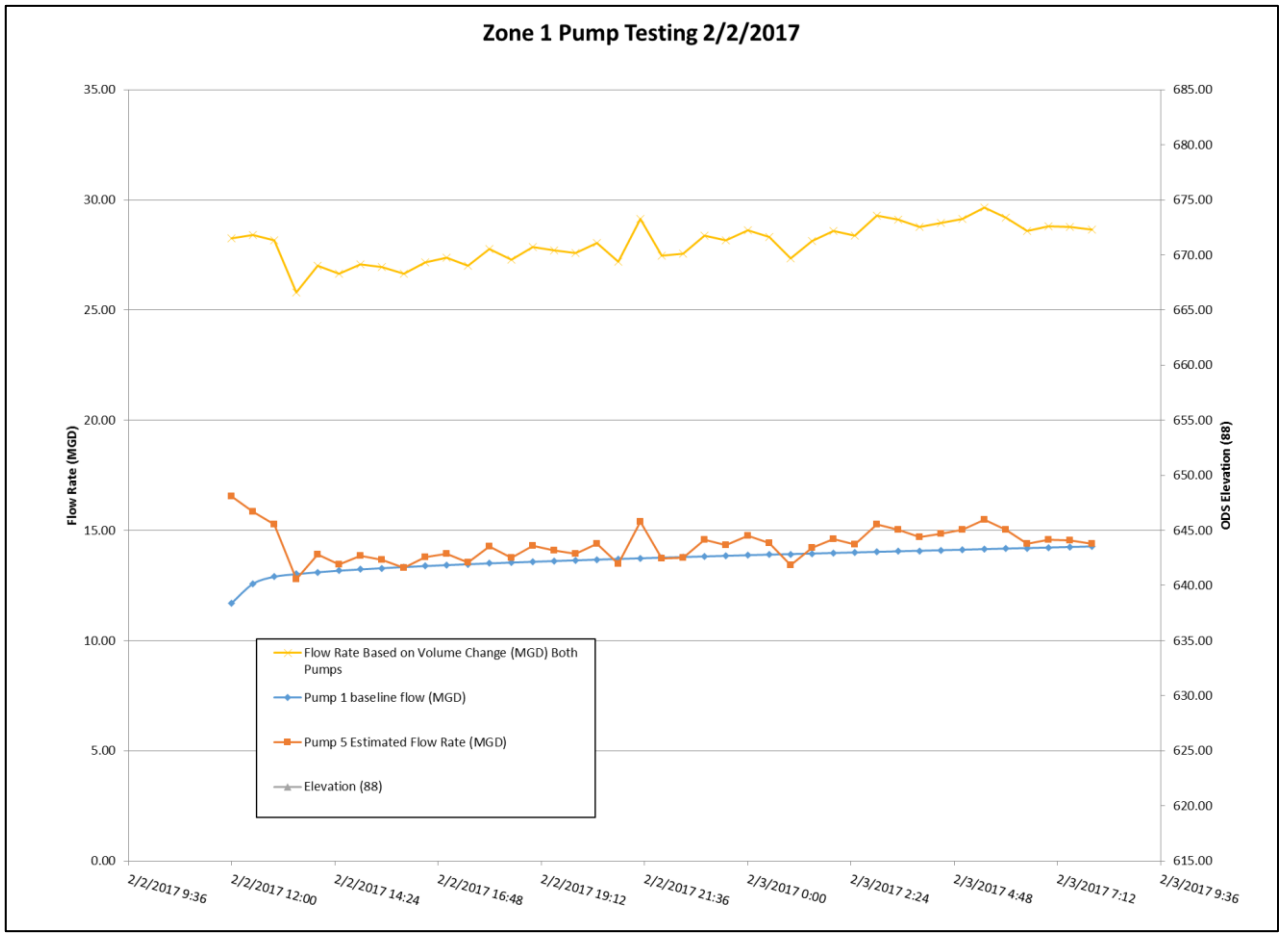




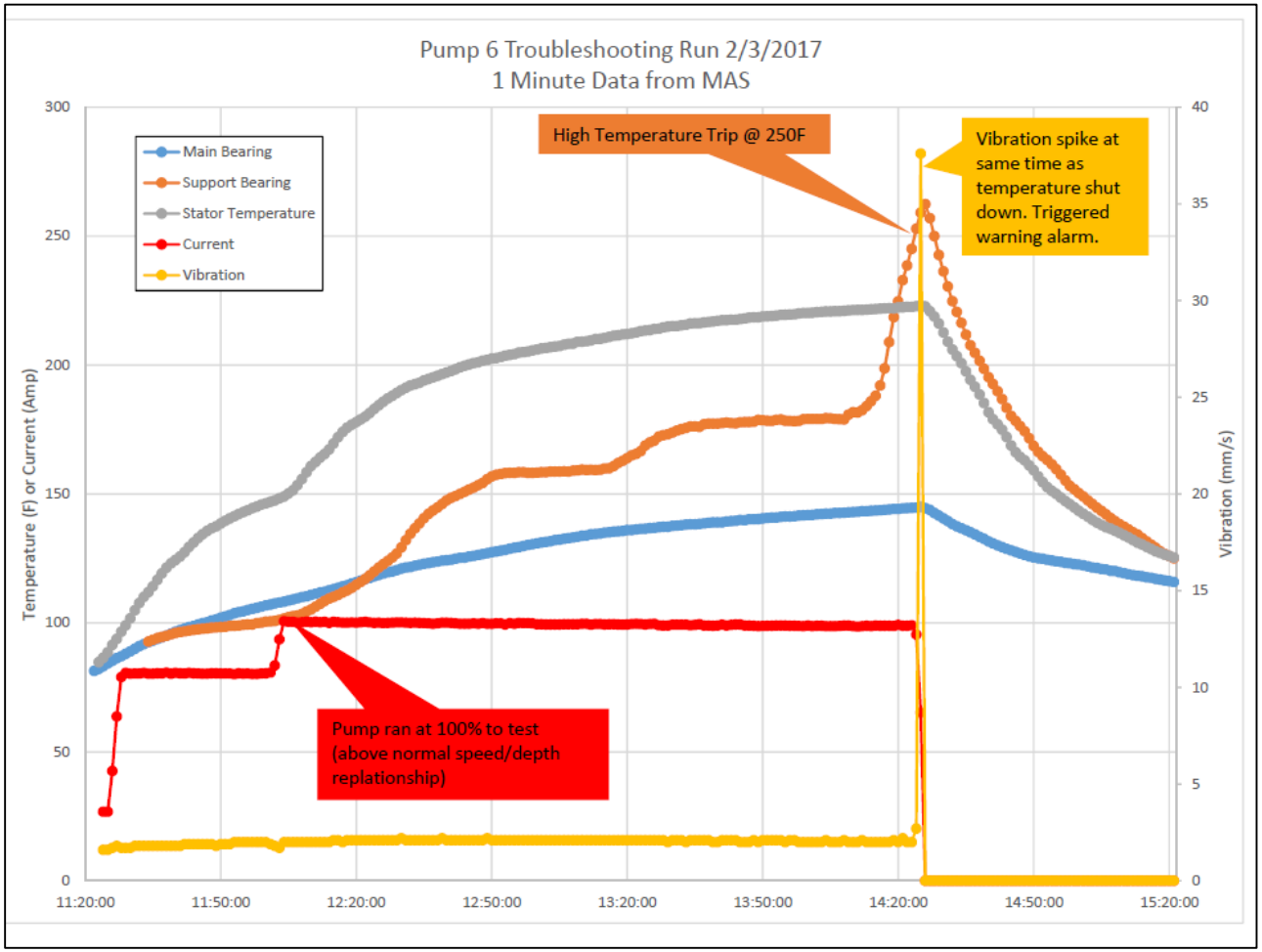
Common graphics at JPWWTP, SWWTP and SMOC to coordinate actions

Pump Wet Testing Progressive Testing

- Pump flow rate estimated by drop in tunnel level and calculated tunnel volume
- Subsequent testing runs built on data from previous runs for each pumps baseline performance
- Due to testing of circuits before, equipment ran without control system issues.

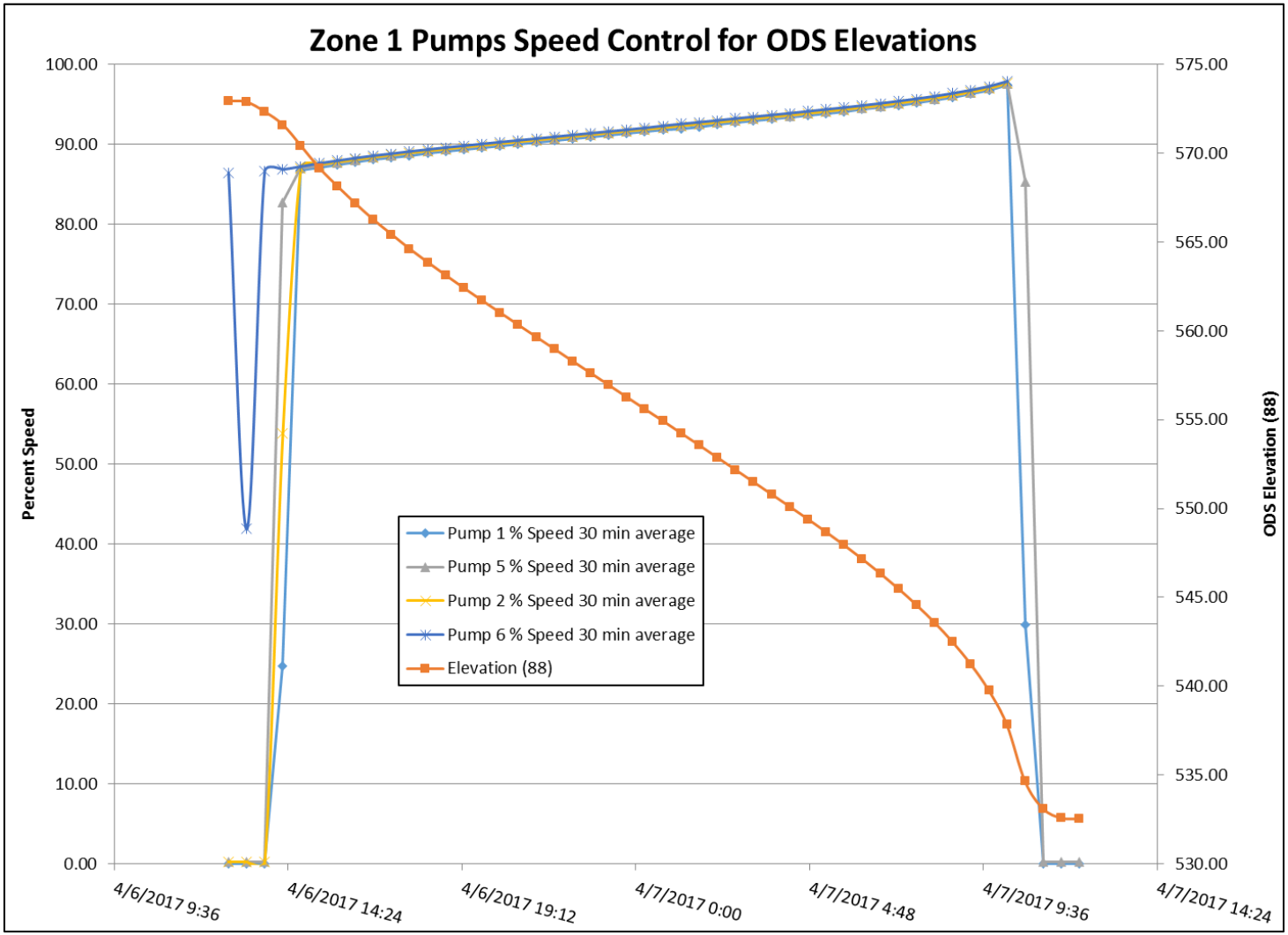


Wet Testing Issues



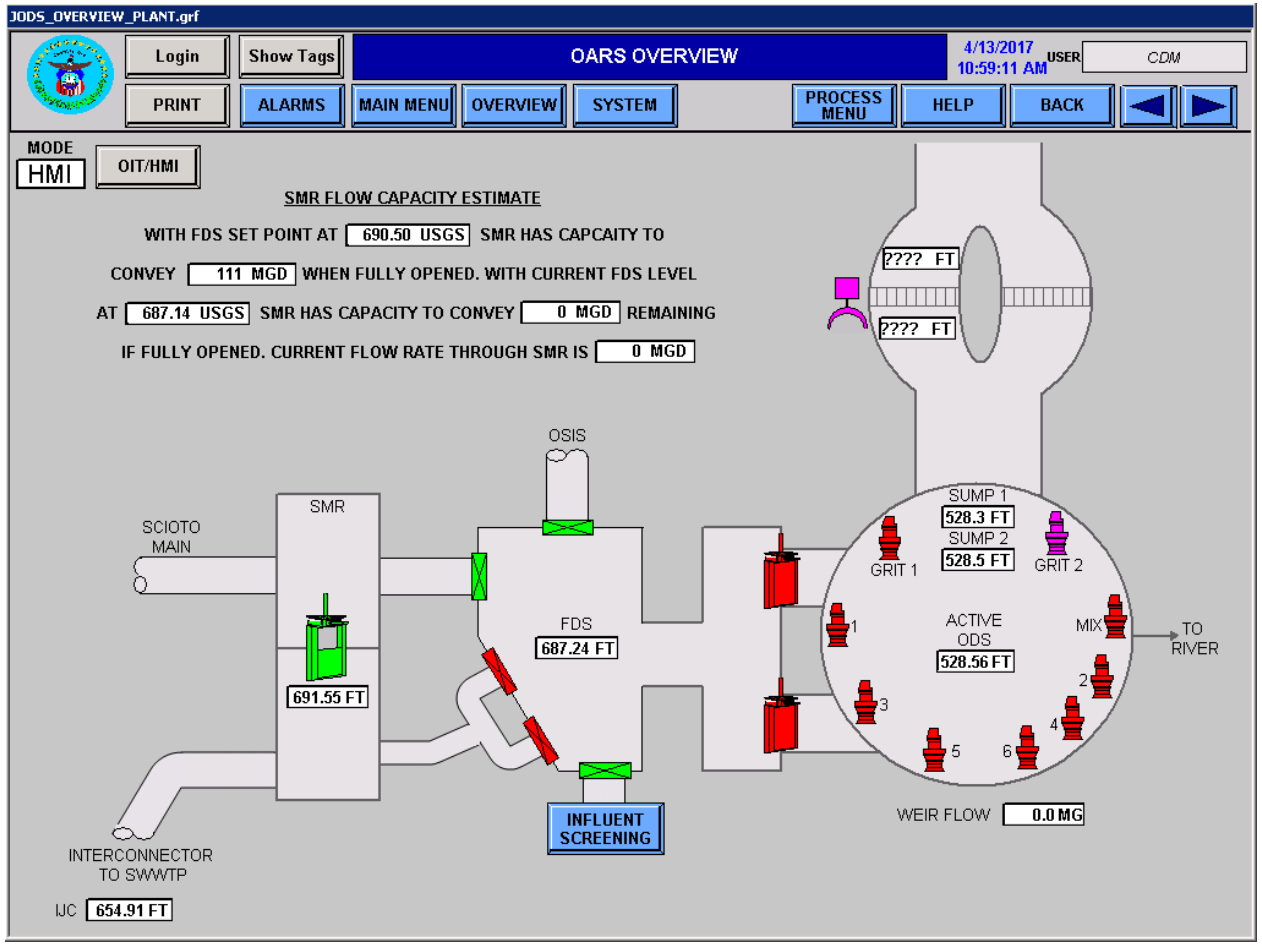
- Pump 6 had a manufacturing issue that resulted in high bearing temperature shut down after several hours of operation
- Manufacturer pulled pump and repaired it
- Internal pump monitoring only way to know what is going on under 100+ feet of sewage

Wet Testing Success



All four Zone 1 pumps operation run including Pump 6.
Notice change of speed with depth

Preparing for Live Operation



- Wet testing helped establish interactions between tunnel pump station and surface sewers at JPWWTP
- Many graphic and automatic programming adjustments being made
- SOP being prepared with lessons learned from testing
- Final construction items being completed

Thank You to everyone who helped with all of the testing and issue resolutions

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