

# OARS – the Massive Tunnel to Protect Downtown Columbus

## PART 2



THE CITY OF  
**COLUMBUS**

ANDREW J. GINTHER, MAYOR

DEPARTMENT OF  
PUBLIC UTILITIES



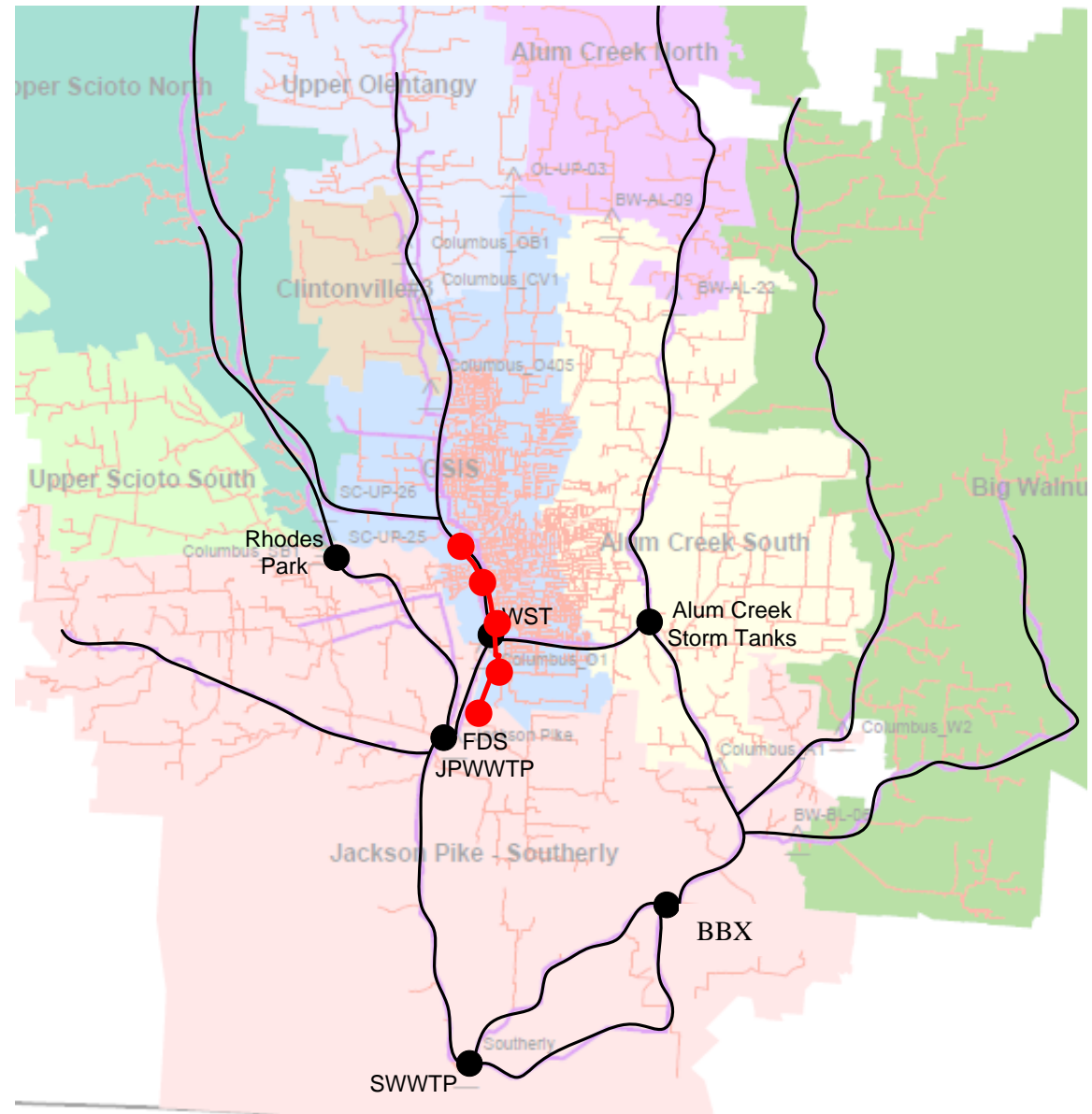
# OARS Tunnel Addition

## OARS Tunnel

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

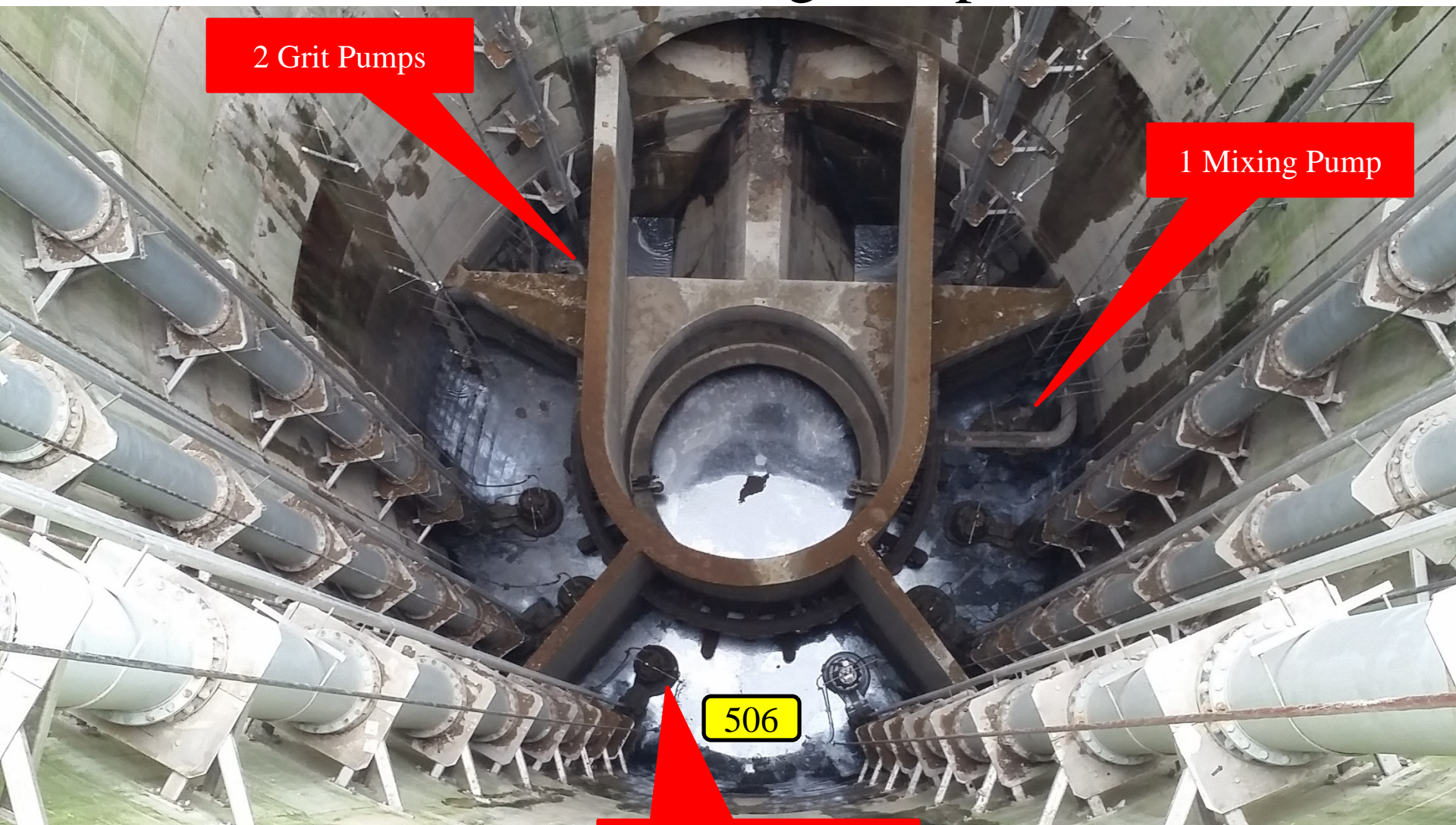
## OARS Dewatering Pump Station

- 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



2 Grit Pumps

1 Mixing Pump

506

6 Dewatering Pumps

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



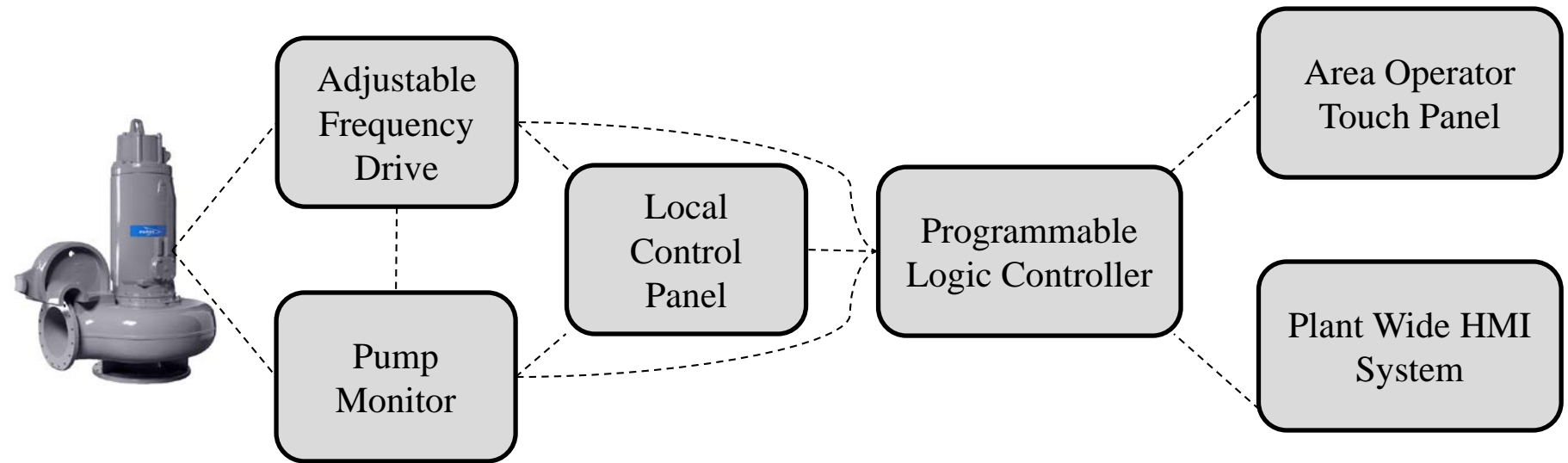
So how good was your checkout?  
Are you really ready on day 1?



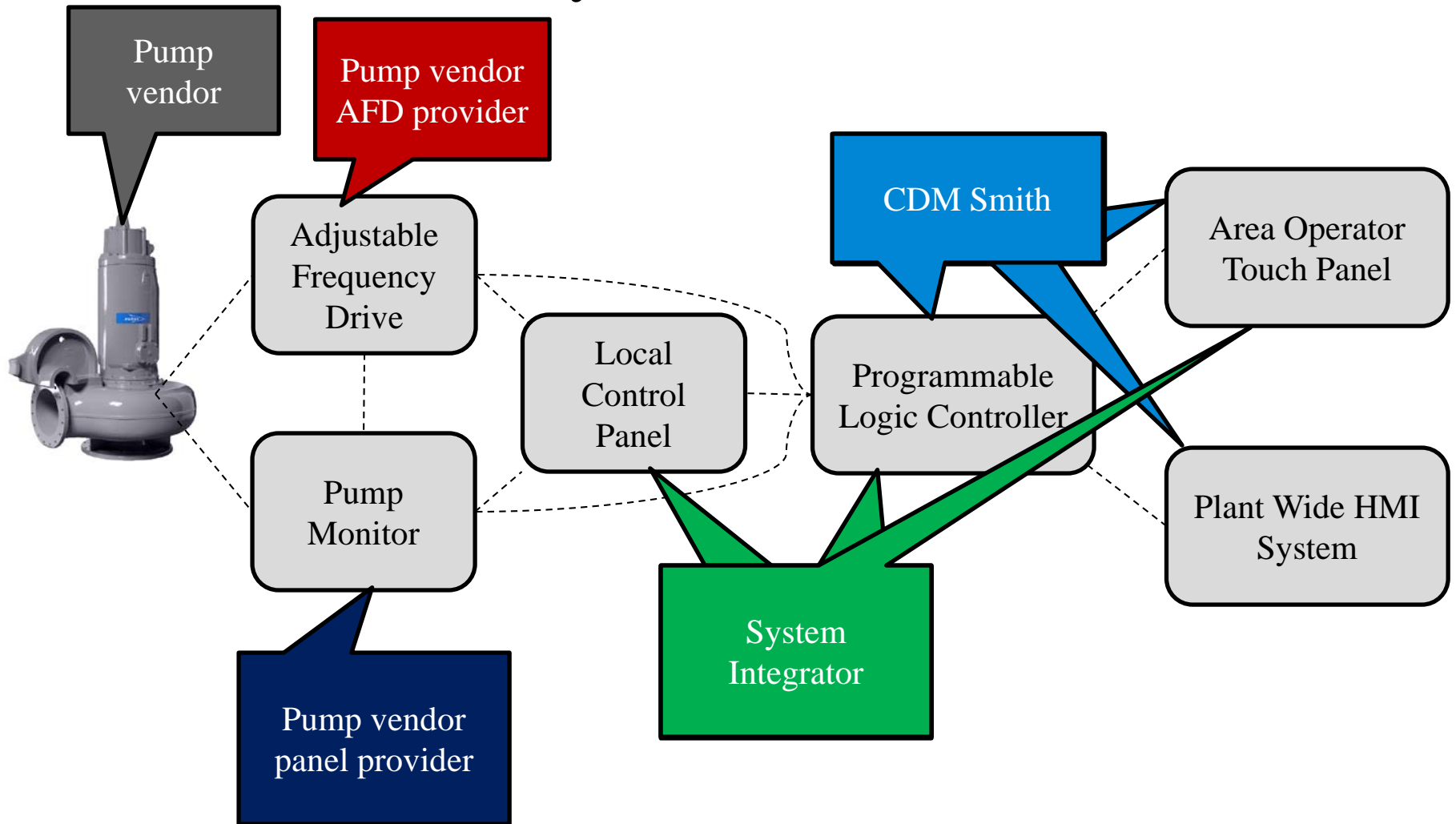
Standing at  
JPWWTP



# Many Items in Control Circuit

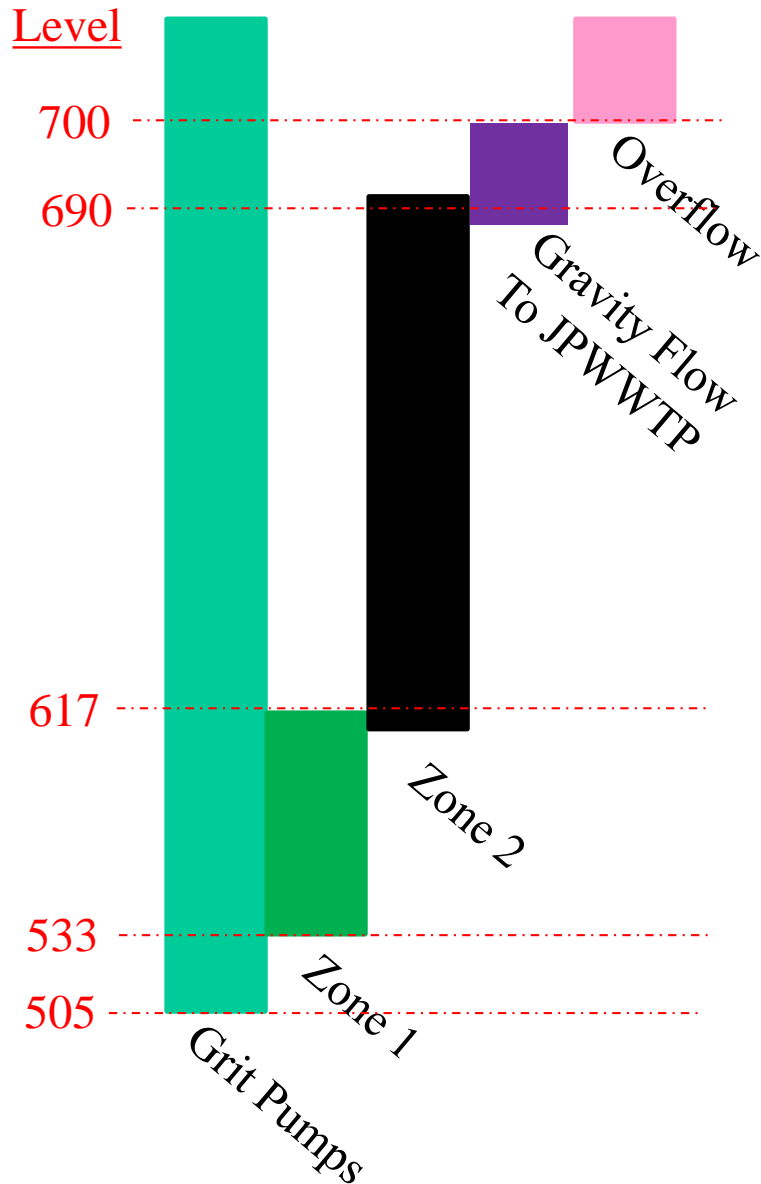


# Many Different Providers



Electrical sub responsible for all wires between them

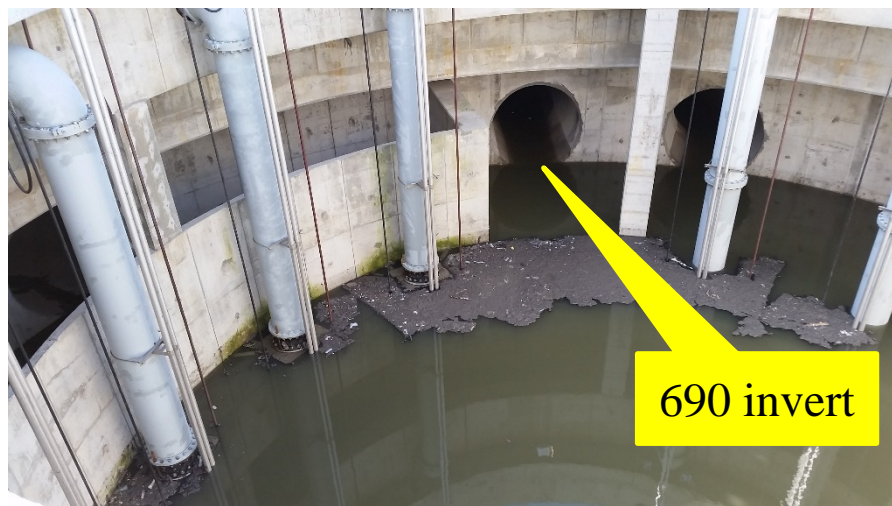
# Complex Control Strategy



- 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



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 1/2 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

# 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?

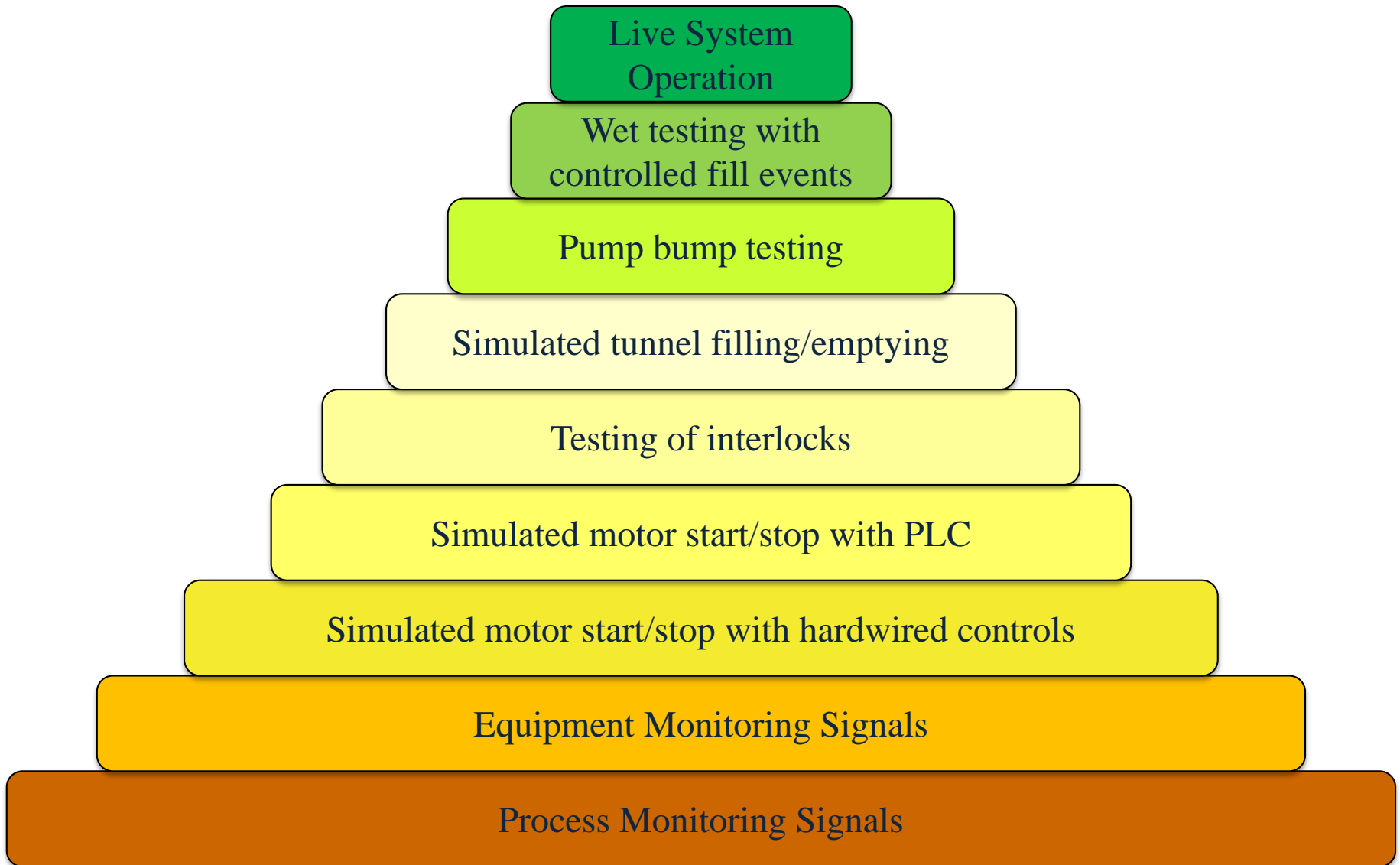
Answer:

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



The first pump start with sewage

# Testing and Validation





# Process Monitoring Signals

Hydrostatic  
inside  
guide pipes  
Grit 1

Hydrostatic  
inside  
guide pipes  
ODS 1

Hydrostatic  
inside  
guide pipes  
Grit 2

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

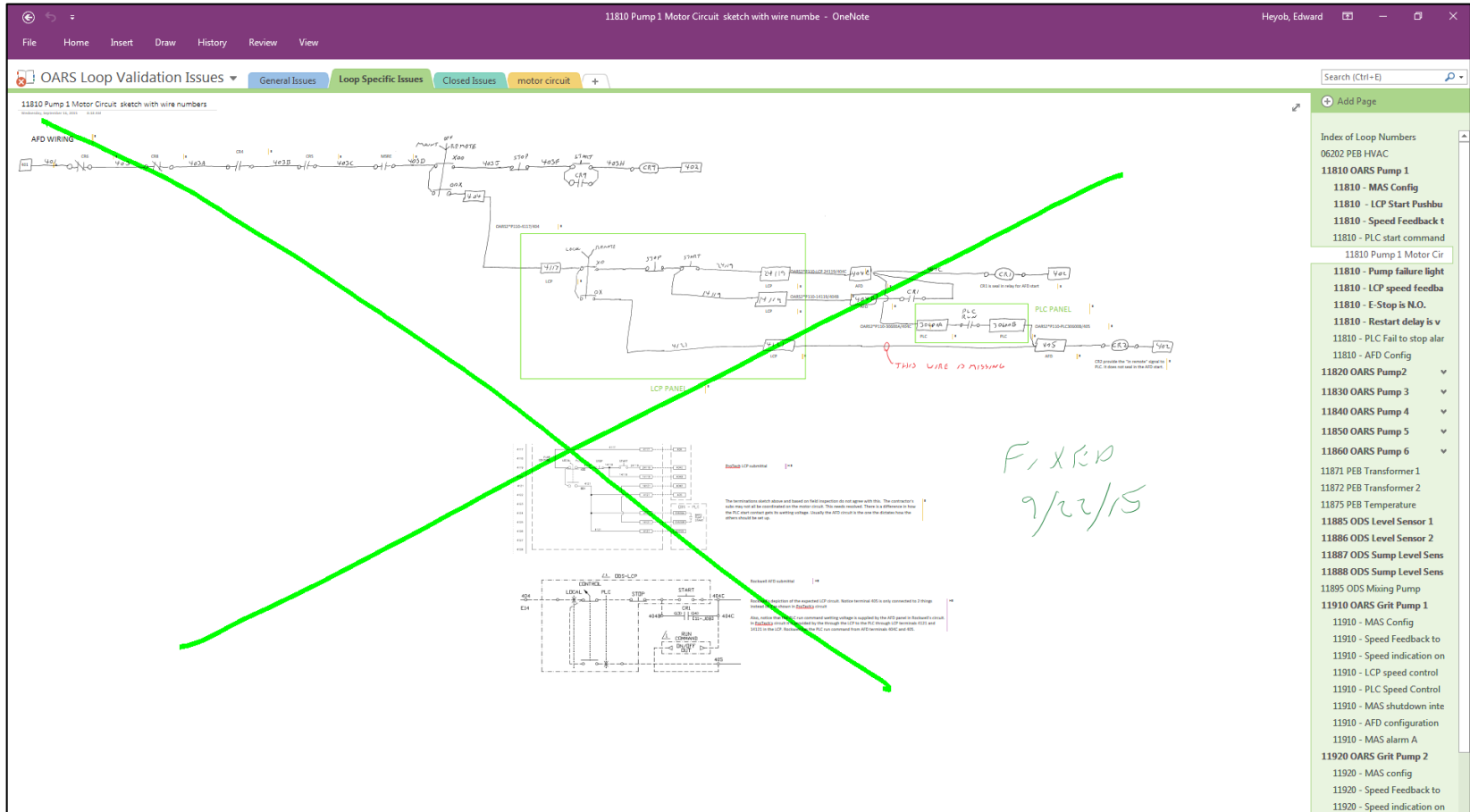


Medium Voltage  
Adjustable Frequency Drive

- 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



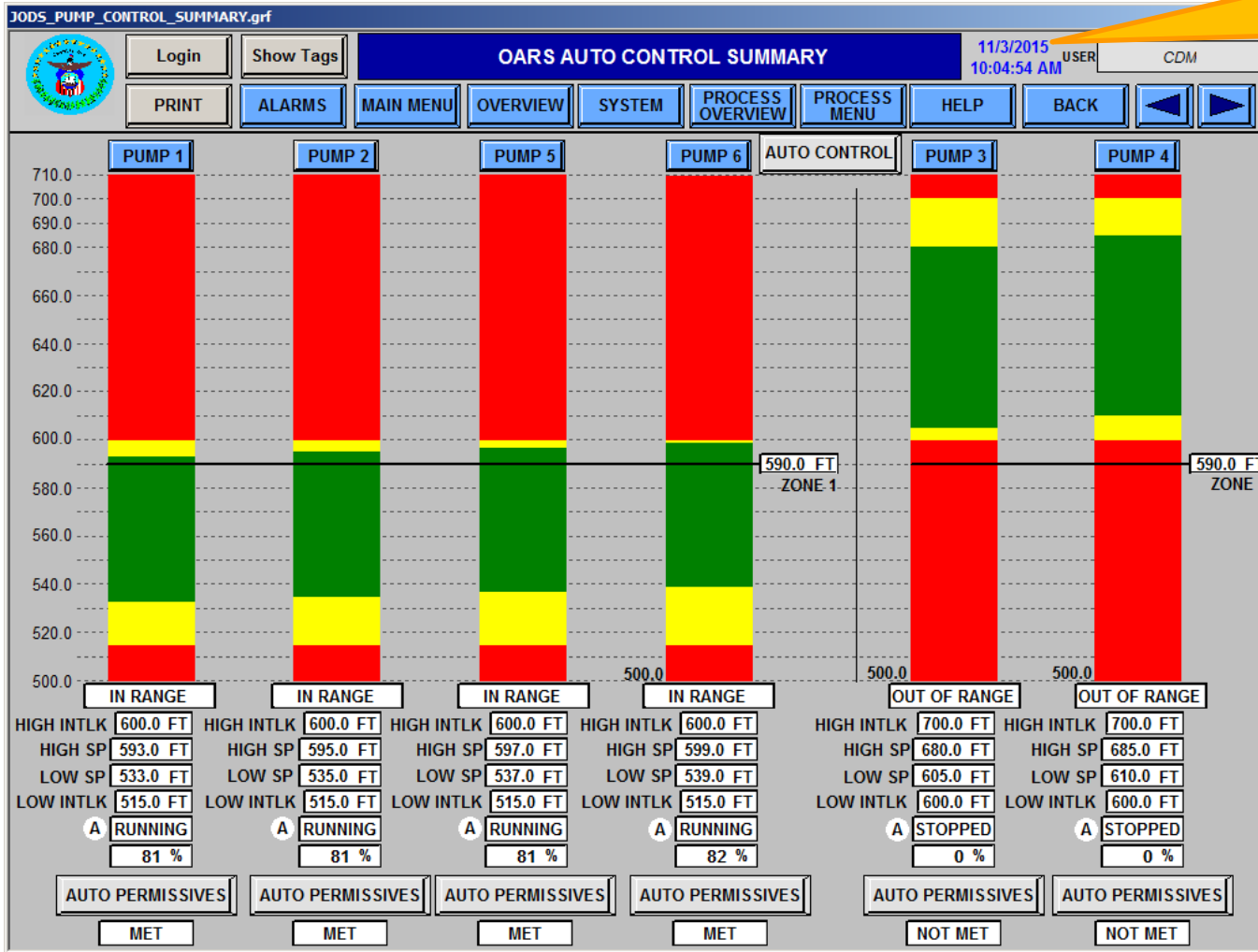
# Tracking and Coordinating Circuit Issues



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

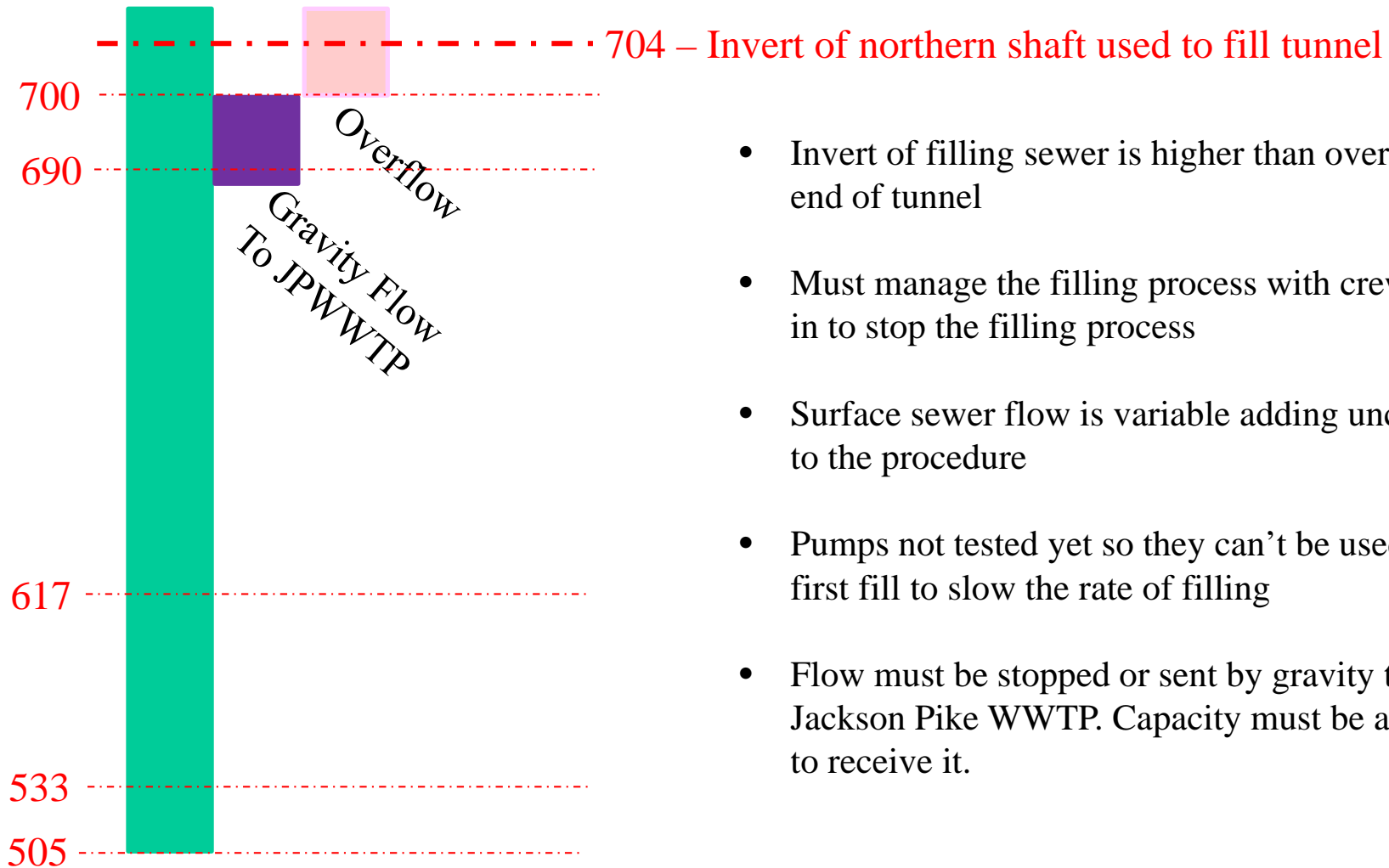


*First tunnel filling test*

*Flow enters the dewatering pumps station*

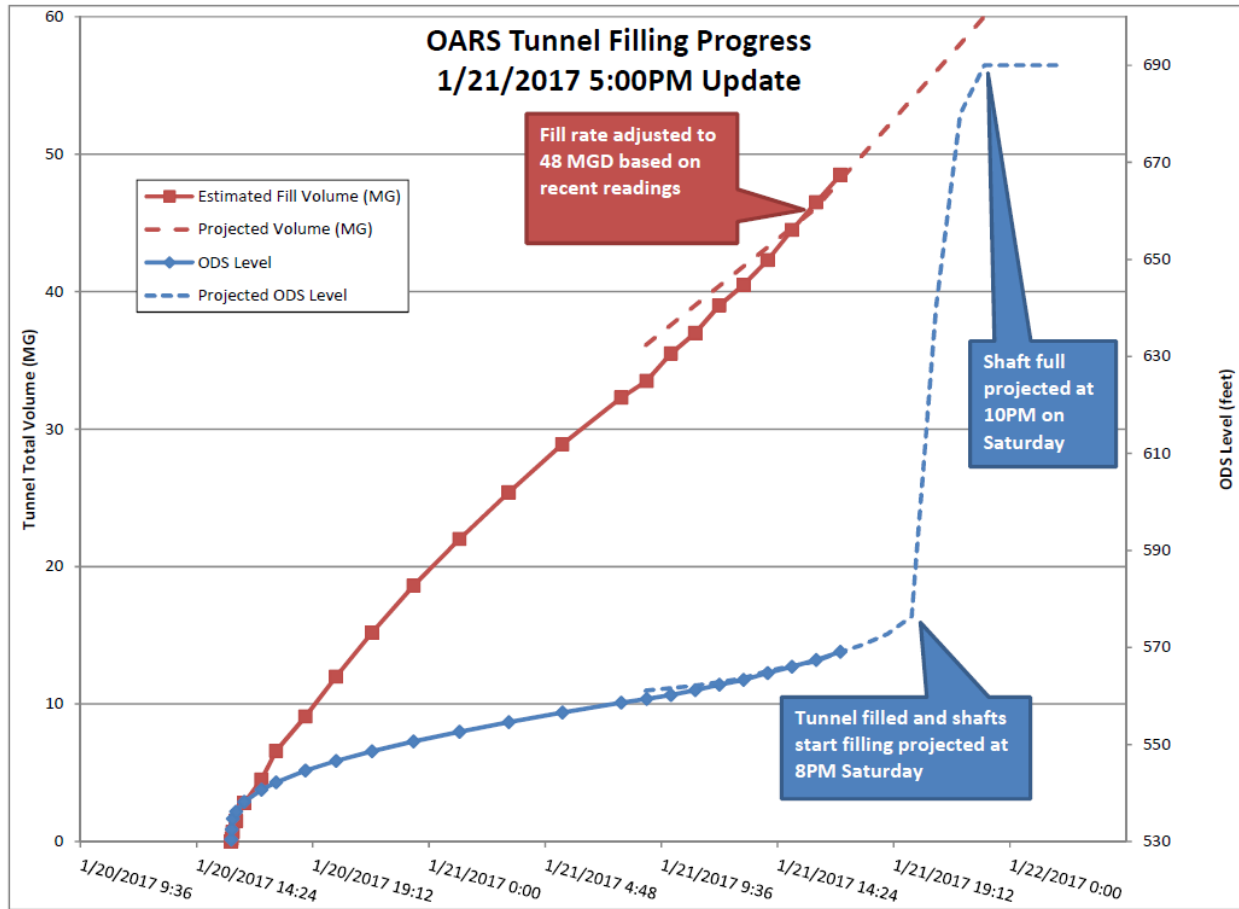
# Wet Test with Controlled Tunnel Filling

Level



- 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

OARS\_TUNNEL\_FILL\_CALL.grf

### OARS TUNNEL AND SHAFT FILLING CALL OUT ACTIONS

CURRENT ODS LEVEL **512.57 FT**      CURRENT FDS LEVEL **689.00 FT**

<b>CALL ACTION</b>	<b>CALL STATUS</b>	ODS IS ABOVE <b>580.6 FT</b> <b>LEVEL OK</b>
<b>RESET CALL COMPLETION</b>	<b>CALLS NOT COMPLETE</b>	SMOC Dispatch Action: Call crew in to operate OARS Shaft 6 gates in 2 to 3 hours to redirect flow as shafts are now filling.
<b>RESET CALL COMPLETION</b>	<b>CALLS COMPLETED</b>	JPWWTP Action: Call plant manager and advise that the tunnel is full. Review status of FDS and WGC gates. Visually verify level at ODS.
<b>RESET CALL COMPLETION</b>	<b>CALLS NOT COMPLETE</b>	ODS IS ABOVE <b>640.6 FT</b> <b>LEVEL OK</b>
<b>RESET CALL COMPLETION</b>	<b>CALLS NOT COMPLETE</b>	SMOC Dispatch Action: Verify crew is headed toward Shaft 6. About 1 hour until first gate movement needed.
<b>RESET CALL COMPLETION</b>	<b>CALLS COMPLETED</b>	JPWWTP Action:
<b>RESET CALL COMPLETION</b>	<b>CALLS NOT COMPLETE</b>	SMOC Dispatch A
<b>RESET CALL COMPLETION</b>	<b>CALLS COMPLETED</b>	JPWWTP Action:
<b>ACK CALLS COMPLETE</b>	<b>CALLS NOT COMPLETE</b>	ODS IS ABOVE
<b>ACK CALLS COMPLETE</b>	<b>CALLS NOT COMPLETE</b>	SMOC Dispatch A
<b>ACK CALLS COMPLETE</b>	<b>CALLS NOT COMPLETE</b>	JPWWTP Action:
<b>ACK CALLS COMPLETE</b>	<b>CALLS NOT COMPLETE</b>	SWWTP Action: A
<b>ACK CALLS COMPLETE</b>	<b>CALLS COMPLETED</b>	ODS IS ABOVE
<b>ACK CALLS COMPLETE</b>	<b>CALLS NOT COMPLETE</b>	SMOC Dispatch A
<b>ACK CALLS COMPLETE</b>	<b>CALLS NOT COMPLETE</b>	JPWWTP Action:
<b>ACK CALLS COMPLETE</b>	<b>CALLS NOT COMPLETE</b>	SWWTP Action: A

Common graphics at JPWWTP, SWWTP and SMOC to coordinate actions

JD0SD2\_J0DS.grf

### ODS WET TESTING

4/21/2017 4:23:27 PM      USER: CDM

Login    Show Tags    PRINT    ALARMS    MAIN MENU    OVERVIEW    SYSTEM    PROCESS MENU    HELP    BACK

PUMP 1	STOPPED	0 %
PUMP 2	STOPPED	0 %
PUMP 3	STOPPED	0 %
PUMP 4	STOPPED	0 %
PUMP 5	STOPPED	0 %
PUMP 6	STOPPED	0 %
GRIT 1	STOPPED	0 %
GRIT 2	COMM	-25 %
MIX PUMP	STOPPED	

1 HR    4 HR    8 HR    1 DAY    1 WEEK SELECTED

SET CURRENT

**OARS TUNNEL FILL CALL ACTIONS**

SCIOTO MAIN: 691.55 FT

INTERCONNECTOR TO SWWTP: 655.24 FT (IJC), 655.22 FT (ICS)

SMR: 693.38 FT (UPSTREAM), 693.35 FT (OSIS), 689.05 FT (FDS)

WGC: 687.2 USGS (WET WELL)

ODS: 512.6 FT

SUMP 1: 512.3 FT, SUMP 2: 512.5 FT

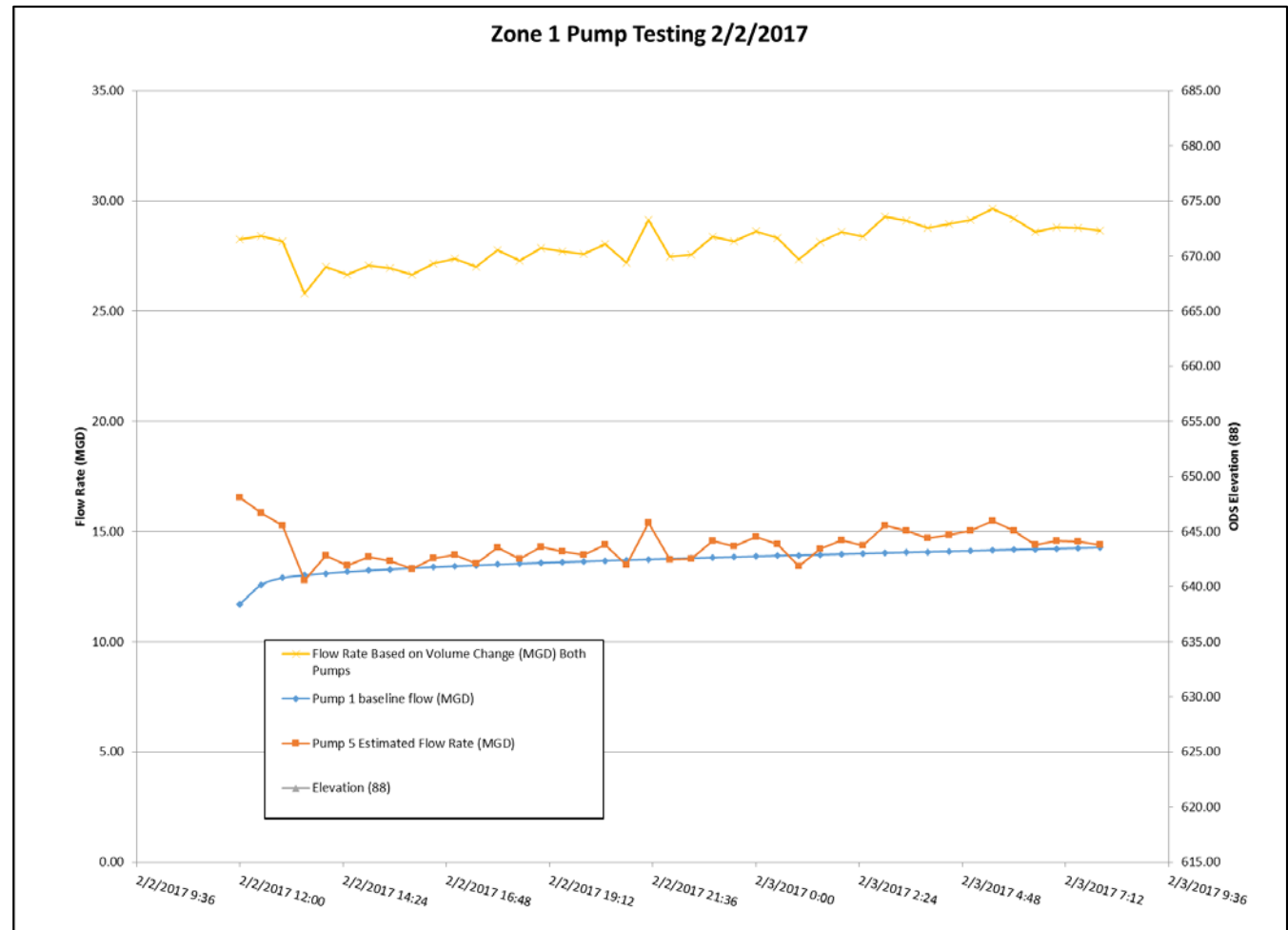
GRIT 1, GRIT 2, MIX, TO RIVER

TOTAL FLOW: 82.6 MGD      WEIR FLOW: 0.0 MG

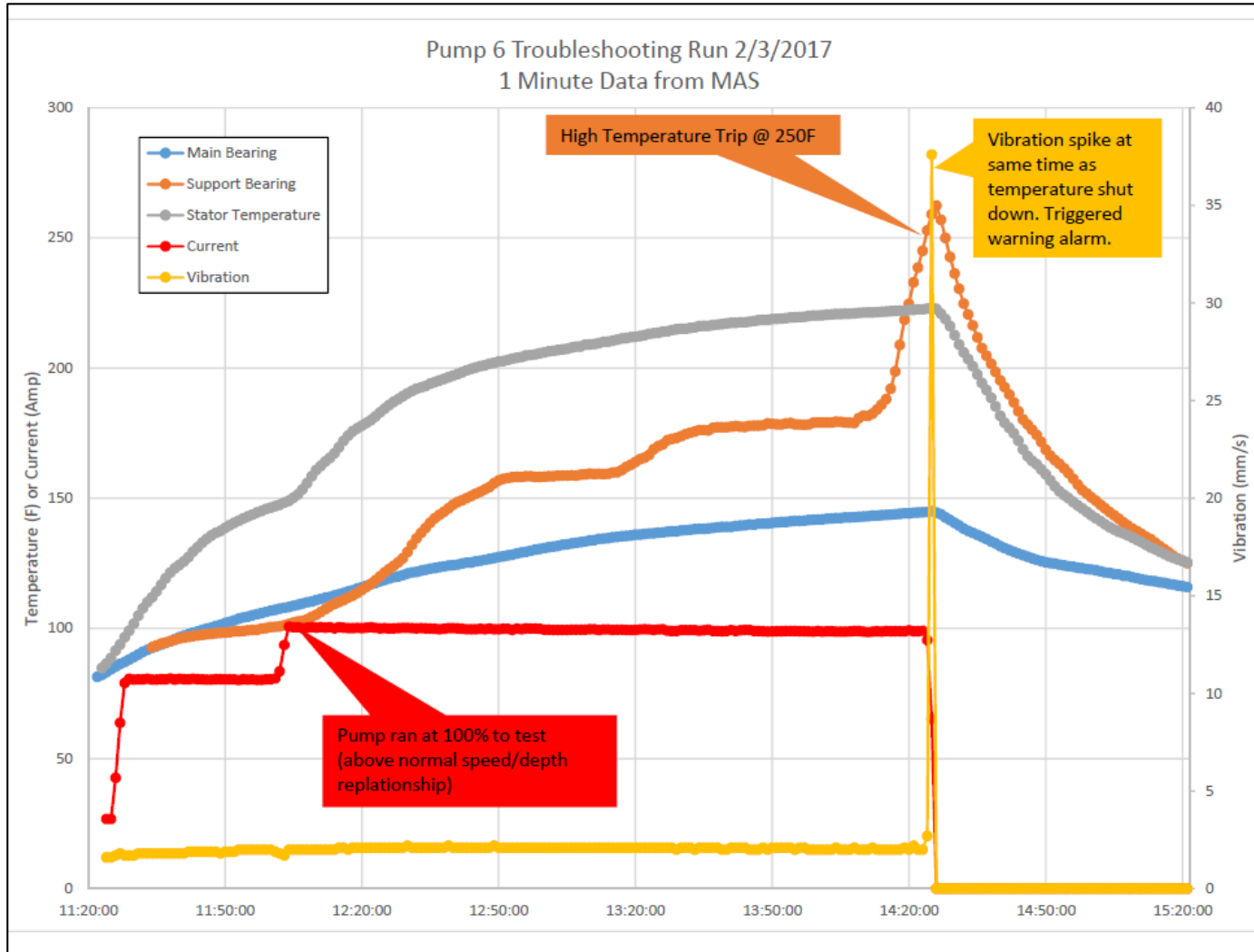
Legend:  
 Hist\_J\_AB.JFDS\_LIT11390C\_LI\_USGS.F\_CV      FDS LEVEL TRANSMITTER A USGS LEVEL      690.58  
 Hist\_J\_AB.J0DS\_SEQ11884\_ACTIVE\_LI\_USGS.F      SELECTED ACTIVE ODS LEVEL USGS (F\_CV)      685.29  
 Hist\_J\_AB.JFDS\_VLV11950\_ZI\_USGS.F\_CV      SMR WEIR GATE POS (F\_CV)      690.94  
 Hist\_S\_AB.SRSP\_LIT11700\_LI\_USGS.F\_CV      ICS USGS LEVEL (F\_CV)      654.91

# 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.



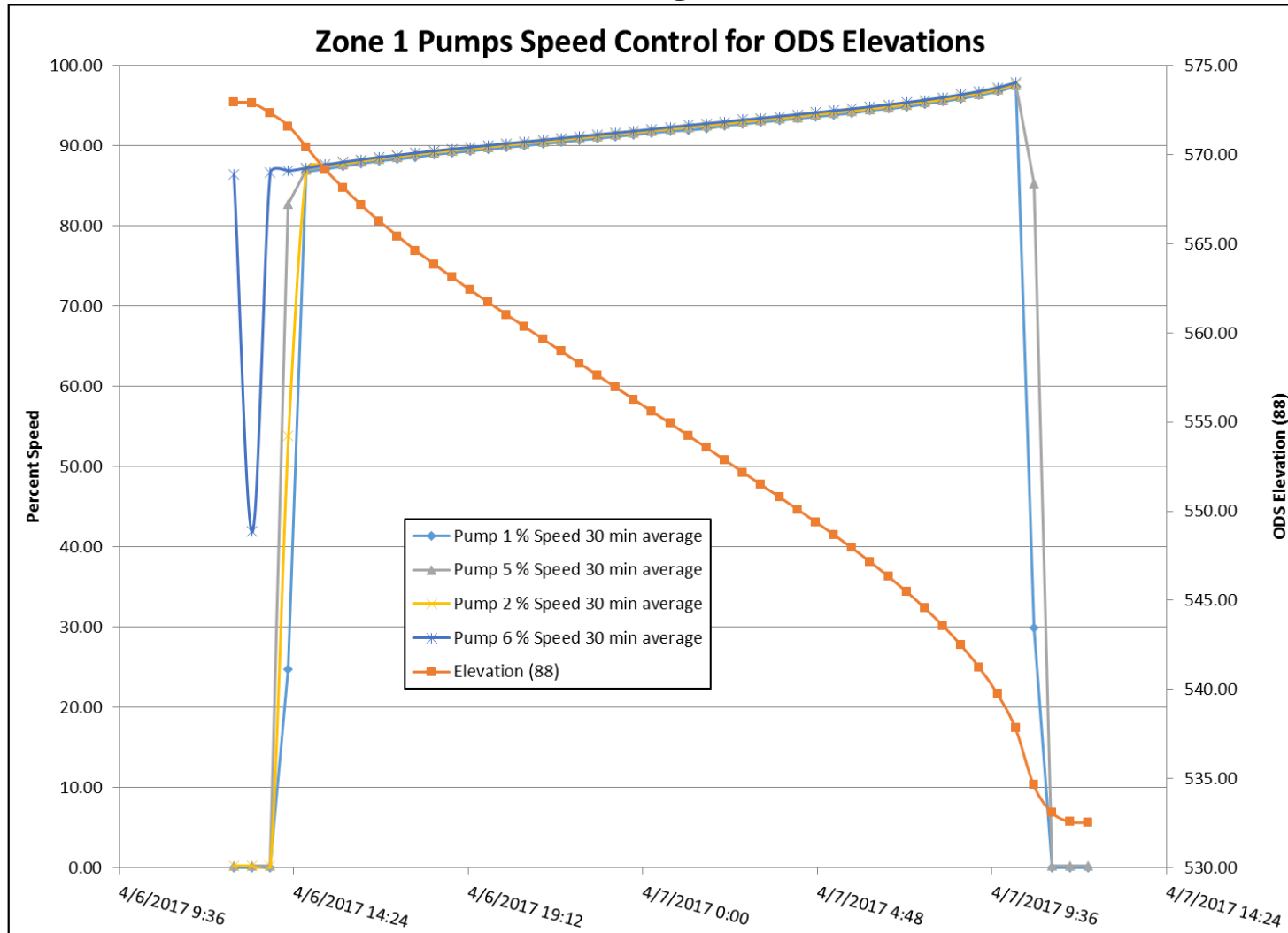
# Wet Testing Issues



- 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

# Live Operation



Drop shaft 4 weir gates just after being set.  
7/10/2017 12:30PM

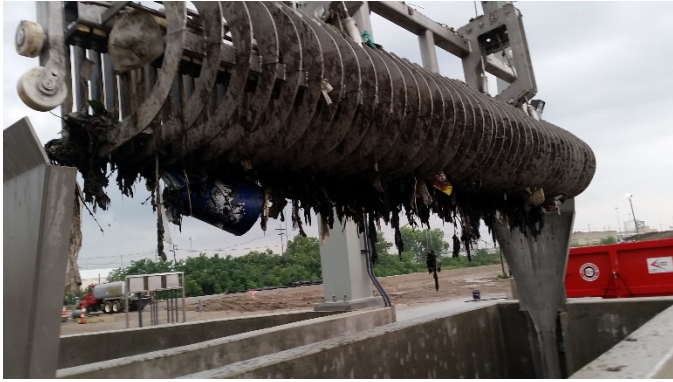
Dry weather conditions. First day of live tunnel operation as stop logs pulled and weir gates set.



Shaft 1 OARS Dewatering Pump Station, Overflowing.

7/10/2017 3:50PM

# OARS Screening

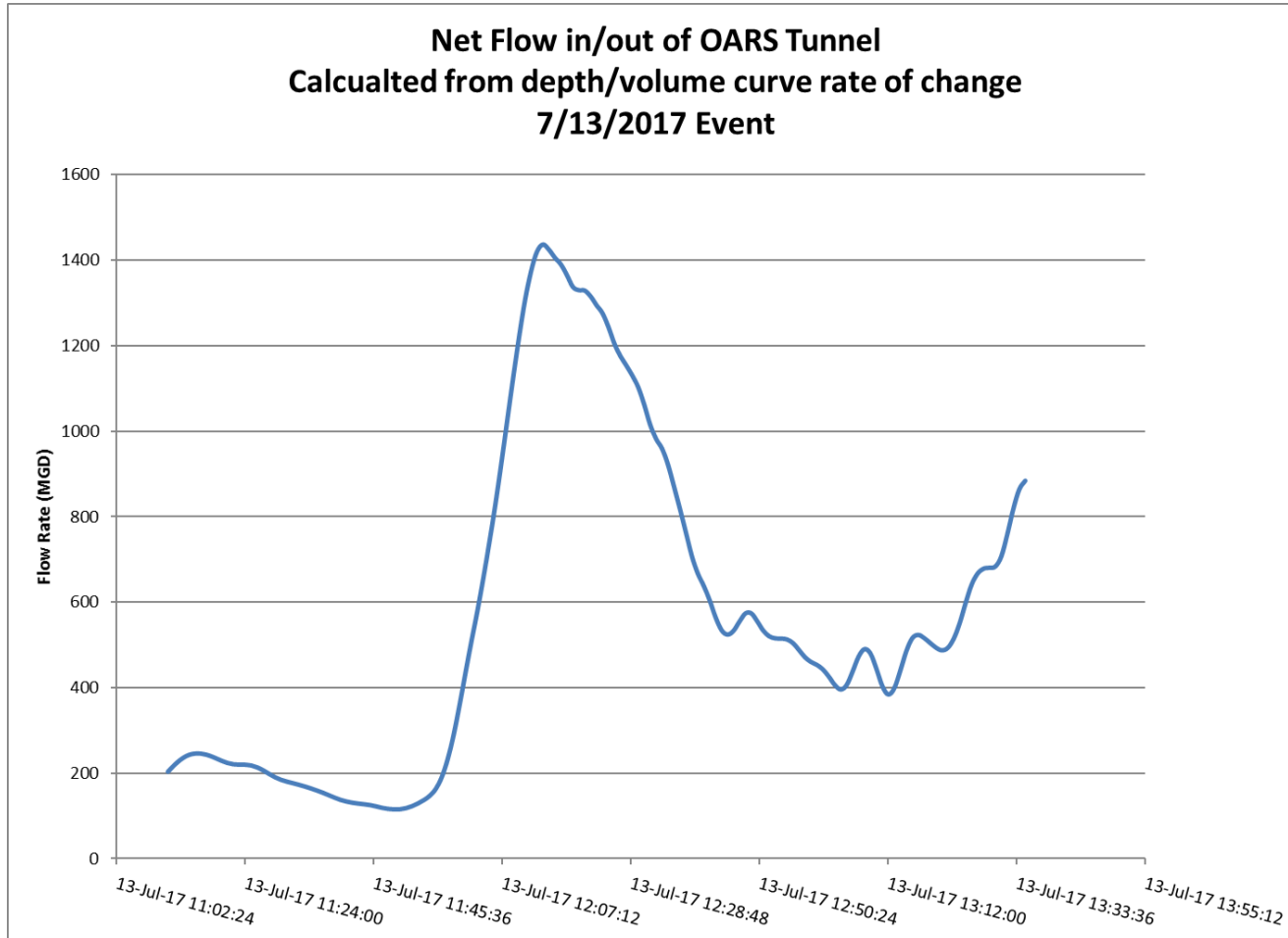


Screen cleaning in action after 7/10 event was pumped down. Just in time to be ready for 7/13 event.





# First Week had Multiple Events

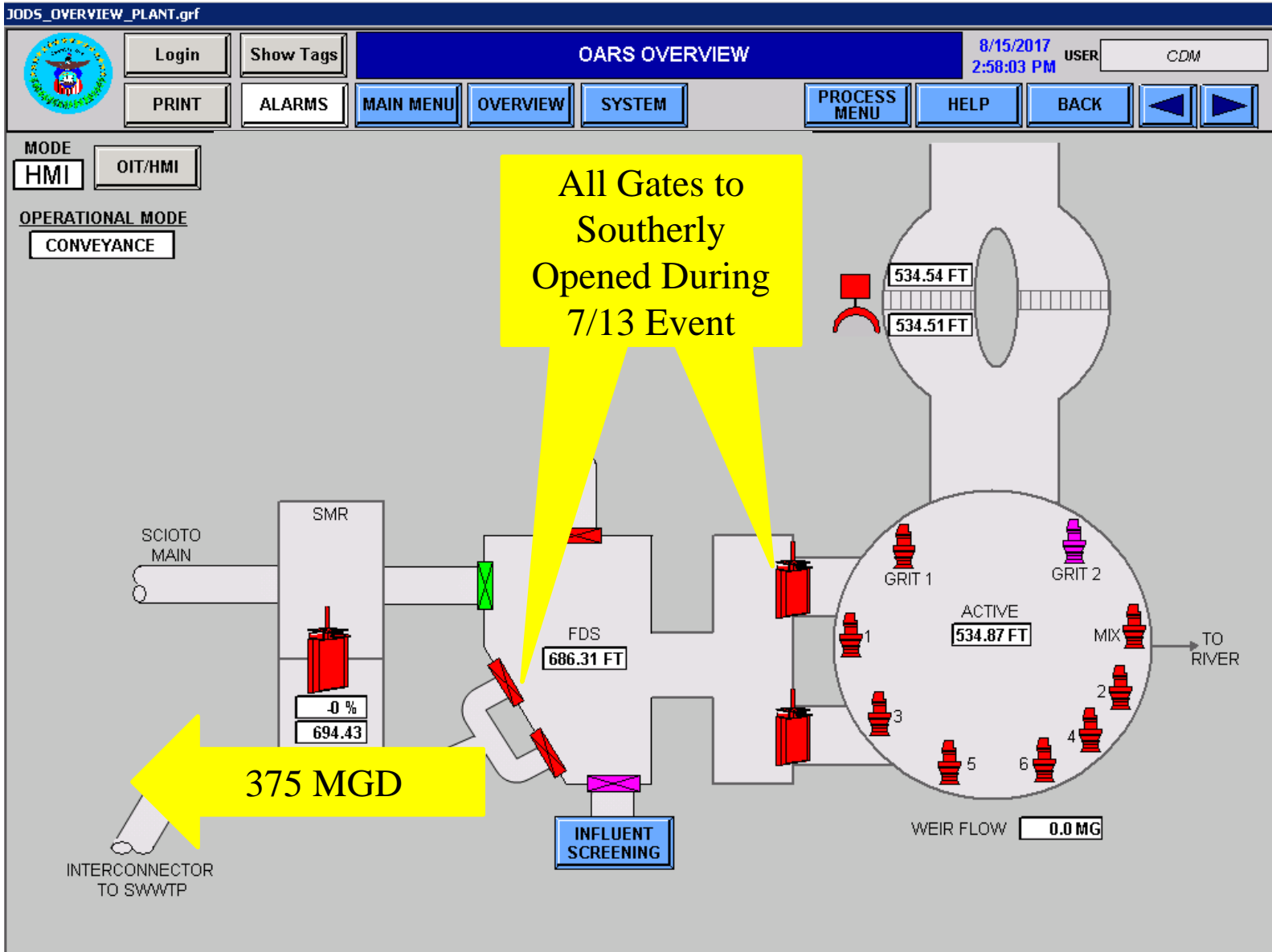


7/13 event was even larger.

580MGD Average net influent rate while tunnel was filling. Peak of 1,400MGD or more.

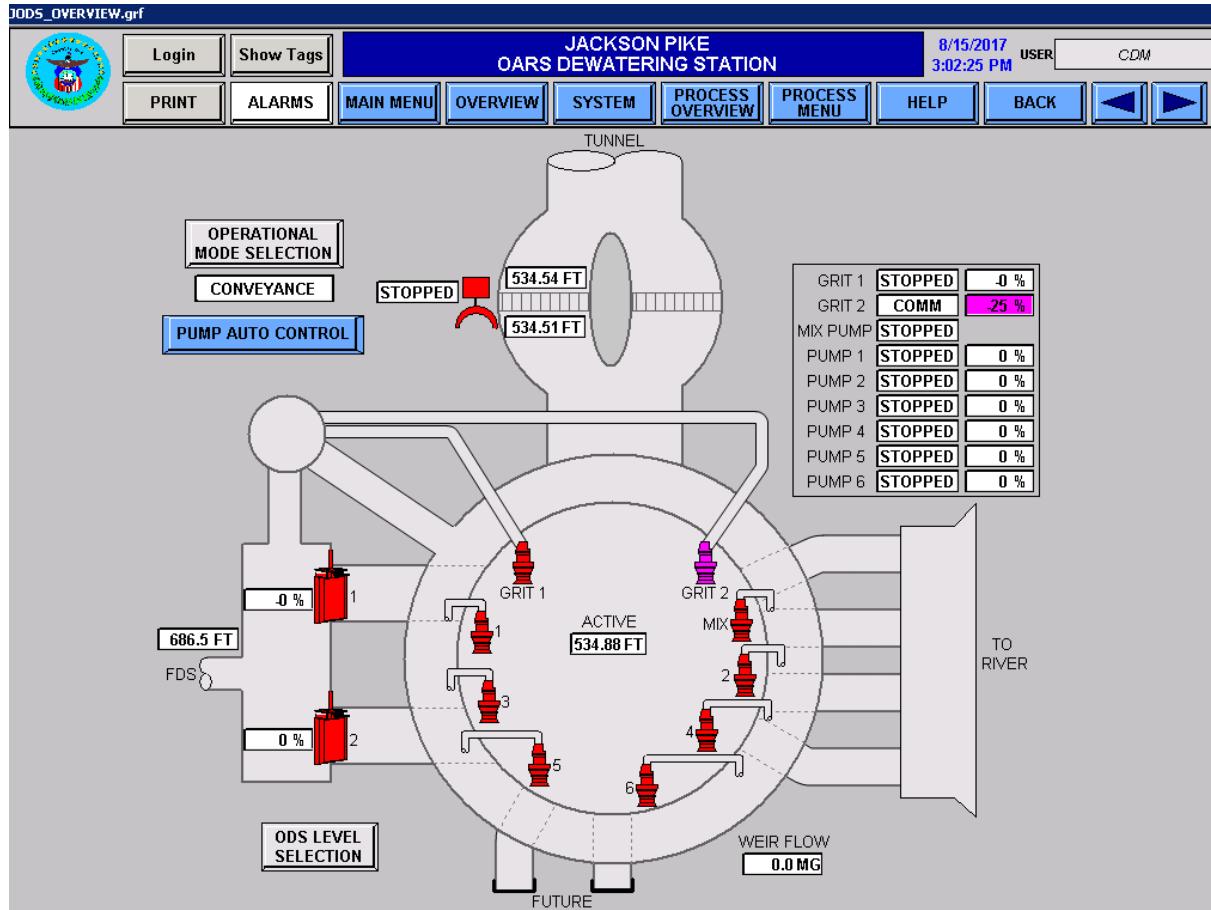
About 2.5 hours to fill tunnel even with pumping on leading edge of filling.

Tunnel shafts filled in 7 minutes (580' to 700')



7/13 found the maximum hydraulic conveyance of the Interconnector Sewer

# Prepared for the Next Wet Weather Building on Lessons Learned



- OARS pumping interlock with surface sewer improved
- Shaft 6 level sensor ready
- Plant operational review
- Several small events since that first week, but they barely fill the tunnel
- Contractor punch list items
- Refine graphics to aid operations with decisions



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

And especially to JPWWTP staff during start up!





Will it be this nice out  
when its put on-line?



Ed Heyob  
CDM Smith Automation Engineer  
heyobes@cdmsmith.com

You knew better....  
Any other questions?



Kim Brown  
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