Creating A New Pressure Zone In A 100-Year Old System

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Outline

- Objectives
- Service area & existing conditions
- Components
- Planning
- Construction
- Commissioning
- Lessons learned

Objectives

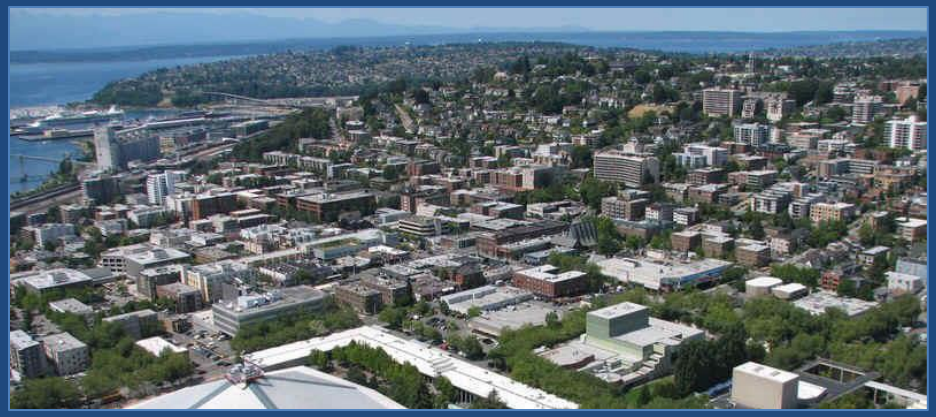
- Increase storage volume from 1.2 MG to 2.0 MG
- Solve low pressure & fire flow problems at highest elevations on Queen Anne Hill
- Maintain existing service levels and supply routes crossing through the project area

SPU Terminology

- District valves - DVs
  - Normally closed valves that create a pressure boundary
- Pressure Zones
  - 530, 580, etc. refer to the nominal hydraulic gradient in the zone
  - QA530 is the part of the 530z in Queen Anne

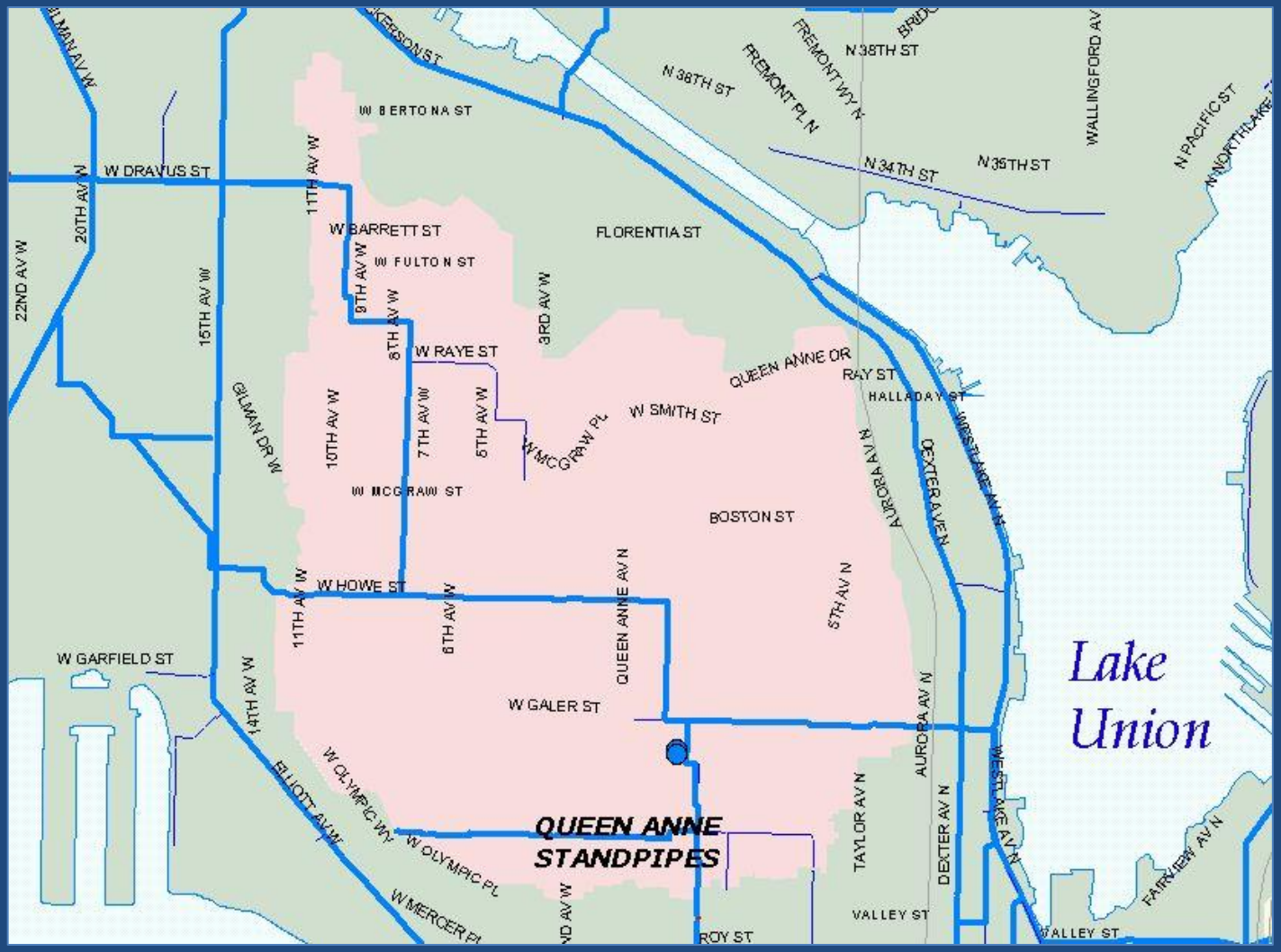
SERVICE AREA & EXISTING CONDITIONS

Queen Anne Neighborhood

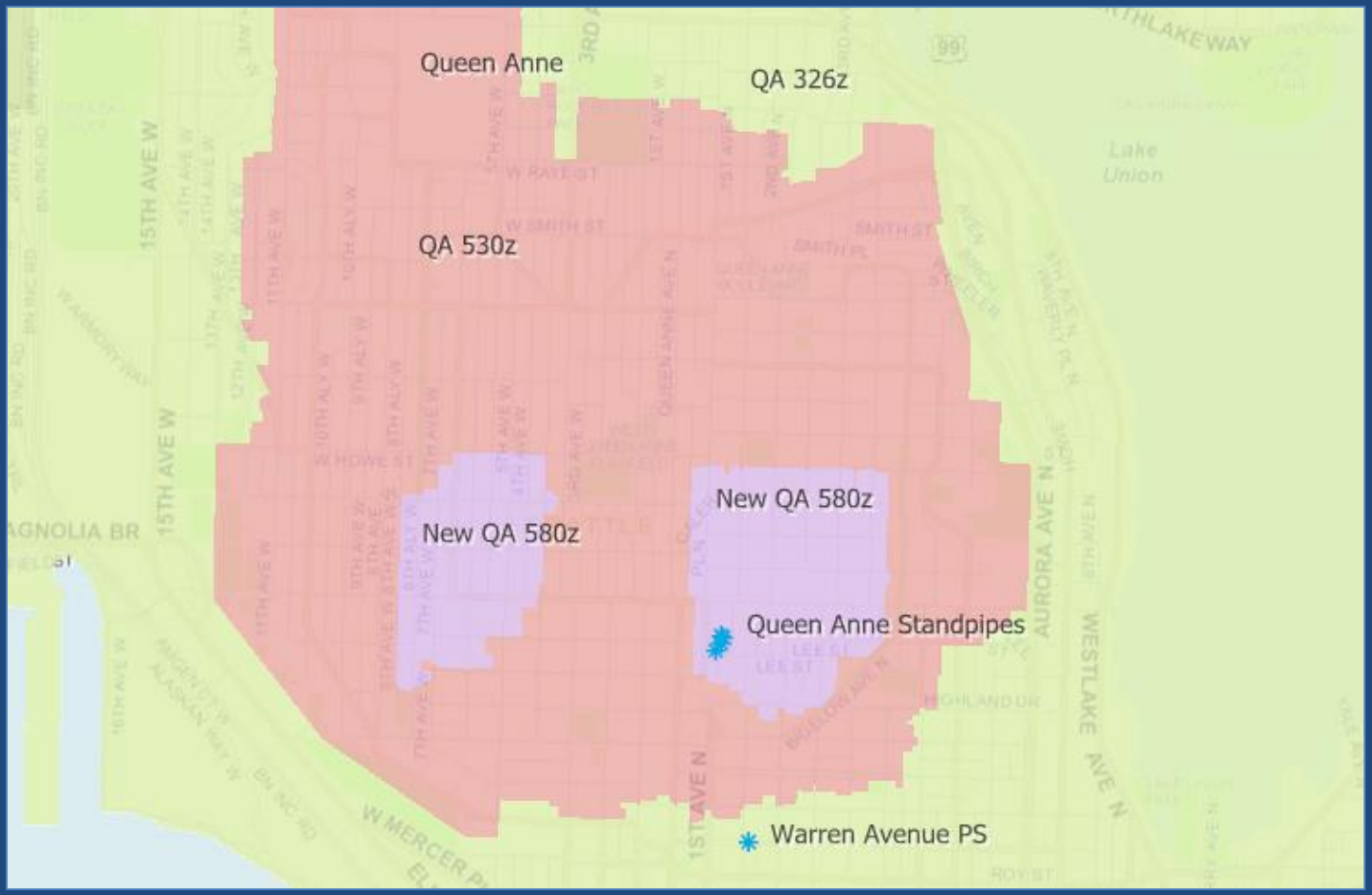


- High density residential
- Neighborhood businesses
- Narrow streets
- Not enough parking
- Infrastructure 1890-1920
- Undersized combined sewers
- Elementary schools
- Residents educated & well-informed

Queen Anne Hill Pressure Zone



New Queen Anne Booster Zone

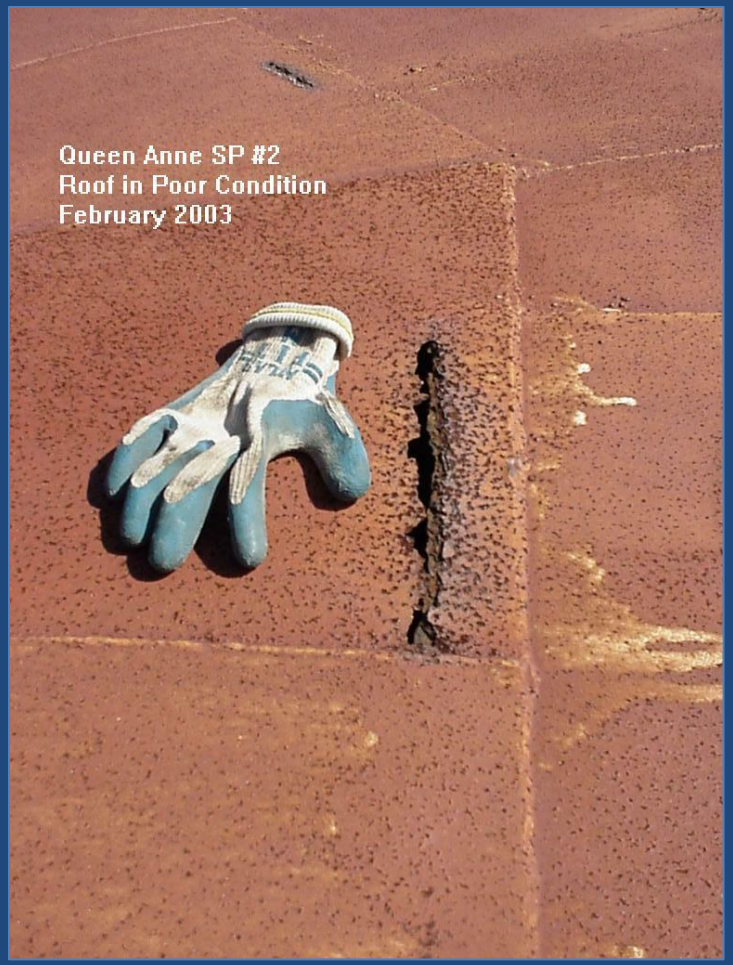


Century-Old Infrastructure

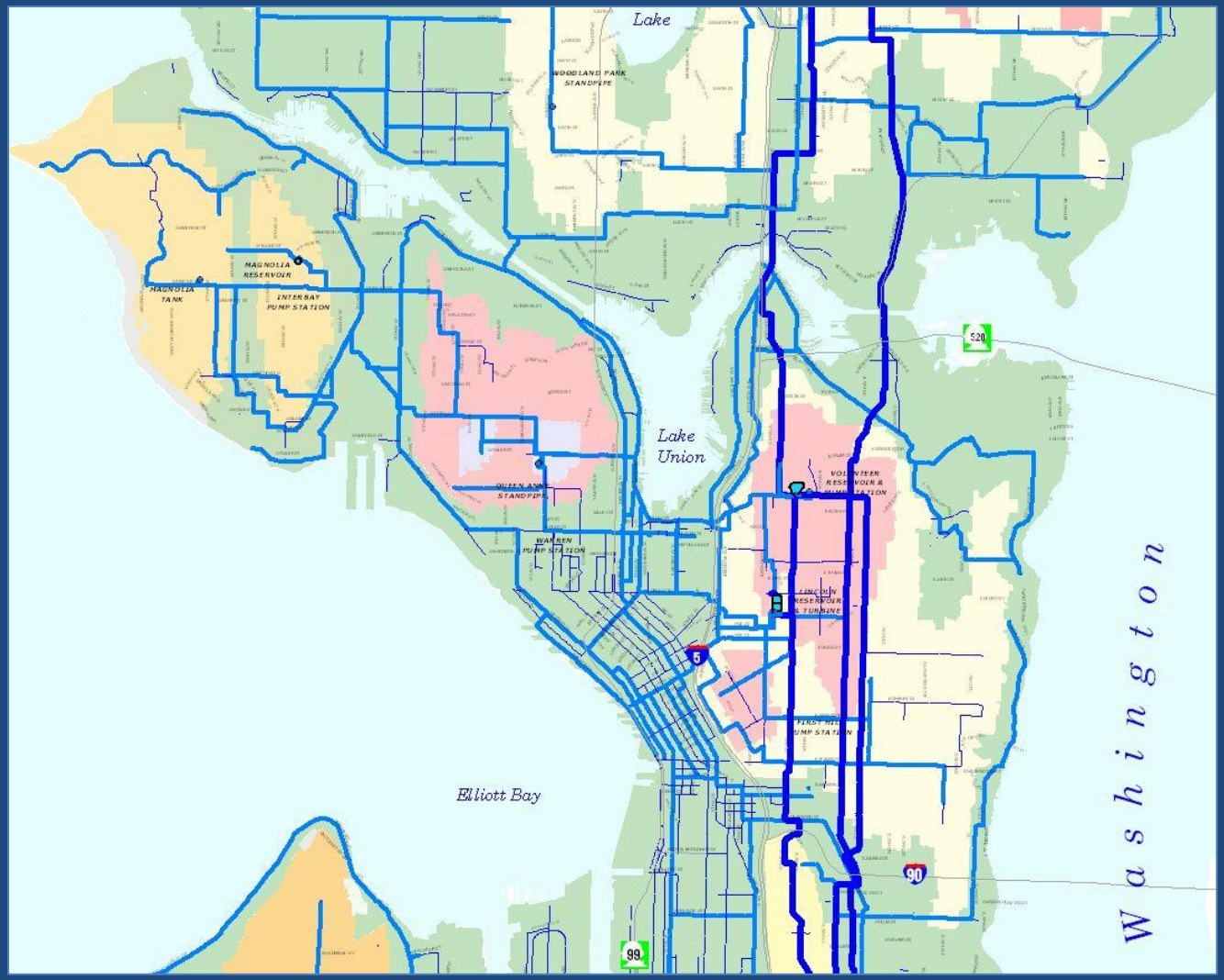
1.2 MG Storage

Unlined 4” – 12” CI pipe

Roof of Queen Anne SP #2



Wheeling Water Through Queen Anne



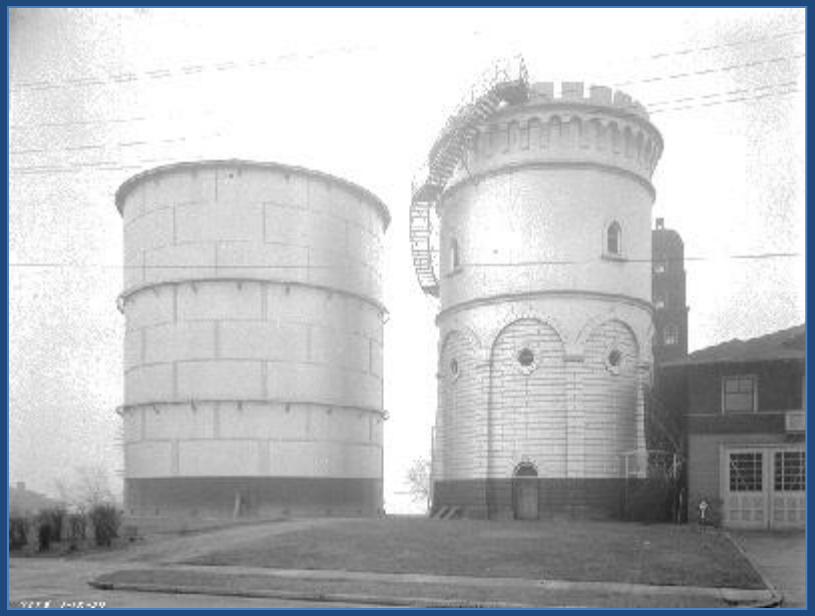
Other Conditions & Constraints

- Fire station operations & one-way traffic
  - Streets too narrow for trucks to easily turn & back in

Landmark Process

QUEEN ANNE WATER TANK NO. 1
(Queen Anne Standpipe No. 1)
HAER No. WA-177

Historic American Engineering Record
National Park Service
Department of the Interior
Seattle, Washington



Queen Anne Hill Standpipes. January 10, 1929. Historic Photo #3207. Seattle Municipal Archives, Photograph Collection.

Note that the fire station has moved from north of SP #1 to south of SP #2.

COMPONENTS

Sub-Projects

- Demolish existing standpipes
- Build new 2 MG standpipe
  - With tank mixing system
- Build new booster pump station

Sub Projects

- Watermain Work
  - Feeder from new pump station
  - Loop dead ends in new zone
  - Isolate 530 feeder from surrounding new 580 zone
  - Existing valves used as district valves
  - Check valve stations
    - No standby power for pump station
      - 580 zone to revert to original pressure

PLANNING

Operating Zone Without Storage

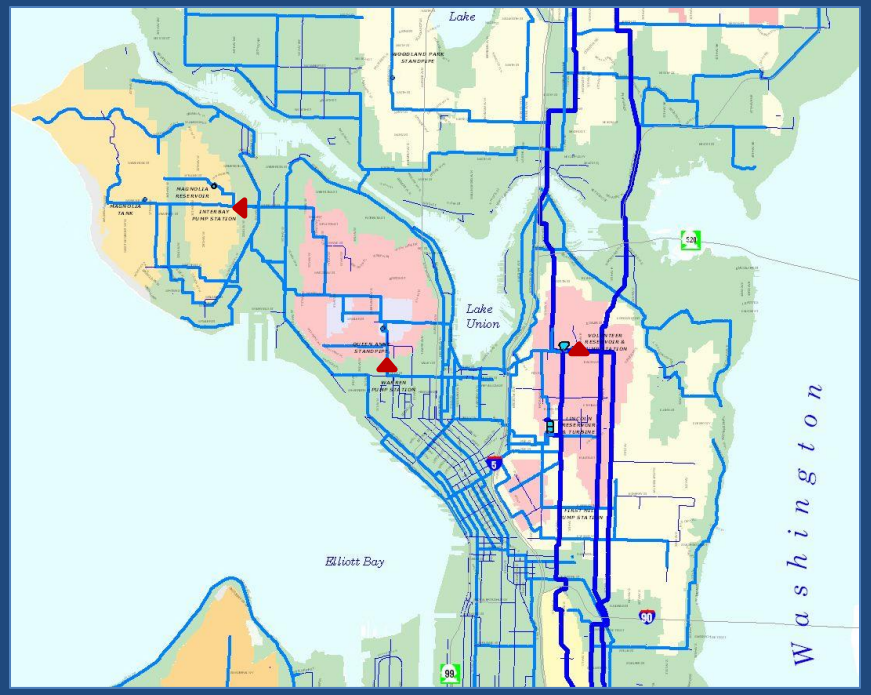
- Warren Avenue PS
  - Throttle flow on #1
  - Add new psi relief loop
- Interbay PS
  - Re-pilot PRV for 480z supply as 530z relief
  - Switch to 100% pump supply for Magnolia
  - Emergency pumping to QA530z

Test The Modifications

- Will these work like we think they will?
- Identify setpoints
  - Temporary relief valves under some conditions
- Night-time
  - Less impact on customers
  - Low flow conditions
- Day-time
  - Higher flows

Impacts on Wheeling Operations

- Disable altitude valve at Volunteer SP
- Gravity supply options to Magnolia converted to pressure relief only for 530z
- Volunteer PS & Warren Ave PS get top priority if they develop problems



Contingency Plans

- Normal configuration
  - What's in service & what's not
  - Valve crew to be in area whenever construction is parallel to or crossing a feeder
- Define unusual conditions and responses, such as:
  - Broken valves or feeder line leaks
  - 8 hr shutdown of feeder crosses
  - Power outages
  - 1-alarm fires

Unusual Conditions	Action Options
Fire – 1 alarm	Dispatch FRC to stand by as per normal SOP for 2 alarm & higher. to coordinate with Seattle Fire Department.
Broken valve in 24"	Suspend all construction parallel to feeder. Timing of further action dependent upon whether valve is broken open or closed.
8-hour shutdown Warren Av N; Galer & Warren Intersection	To be scheduled at night. Monitor other conditions, especially fire dispatches.
Scheduled single feeder shutdown	Monitor other conditions & status of supply facilities. Notify Water System Supervisor if any other status changes or another unusual/emergency condition develops.
Armory Way 530 leak	Schedule shutdown for repair. Suspend construction parallel to feeders.
Dravus 530 leak	Establish alternate relief if Galer is shutdown. Schedule shutdown for repair. line will be secondary relief via the 26th & Crockett RCBV.
Warren Av PS #1 trips off-line; delayed re-start; Galer Street line open.	Use Volunteer PS. If necessary, bleed excess water to Magnolia; avoid overflowing Volunteer SP. Use of P.S. assumes that Volunteer P.S. was either unavailable or insufficient to hold QA 530 zone or Warren and Volunteer were being used in conjunction. Start Warren P#2 and watch zone psi.

Contingency Plans

- Define emergency conditions, indications & responses, such as:
  - QA530 psi gage out of service
  - Unscheduled shutdowns
  - Multiple alarm fires
  - Sustained high or low pressure
  - Pumps trip off and won’t restart

Emergency	Action Options
530 psi gage out of service	Dispatch WSO or FRC to monitor psi gages on hydrants. Dispatch comm techs to restore gage to service.
Galer Street break	Indicated by no pressure at QA MW Bldg. psi monitor & Warren Av PS discharge pressure. Dispatch FRC, notify Fire via ORC that zone is dry. Isolate break, Water Supply staff to begin implementing refill & recovery.
Warren PS power outage	Indicated by pump off light, low zone psi alarm, no discharge flow. Start Volunteer PS, close 26 & Crockett if open. For long-term outage, transport generator & wire it up (4 hours minimum to wire generator.)
Unscheduled feeder shutdown	Suspend construction parallel to feeders. Dispatch crew to repair immediately.
Warren PS #1PRV outage	Use Volunteer PS. Monitor 530z psi, if necessary open valves to Magnolia. For long-term outage, set additional hydrant PRVs.
Fire – 2 alarm or greater	Dispatch FRC as per normal procedure. FRC to stay in close contact with WSCC as hydrants are opened & closed. Monitor very closely for pressure spikes with hydrant operations. SFD & WSCC to coordinate.
High pressure sustained	Verify correct pump size for demand. Attempt to bleed excess pressure without draining zone. Dispatch for stuck pump control valve. Based upon testing conducted by Water Supply, the failure of the PRV on the discharge of Warren P#1, i.e. PRV fails in the full open position allowing P#1 to pump at or near rated capacity of 4,000 gpm is not likely to cause an over-pressurization situation as long as the 8” PRV at Interbay is open.

Valve Inventory

- Inspect hundreds of valves
  - Which are needed for shut downs?
  - Which are to be district valves?
  - Do they still exist?
  - Are there valves out there that aren't mapped?
  - Does this valve need to be replaced?
    - Leaky DVs bleed water out of new zone

Valve Inventory

- Document location & condition
  - Tagged in field
  - Mapped
- Exercising schedule
  - Very old & crusty
- Repair
  - Or replace

Shutdowns

- Sequencing work
  - New mains, temporary cut & caps, connections
    - Usually short shutdowns
  - Replace in same location & temporary mains
    - More shutdowns
    - Temp mains require disinfection & bacti samples
  - Service transfers

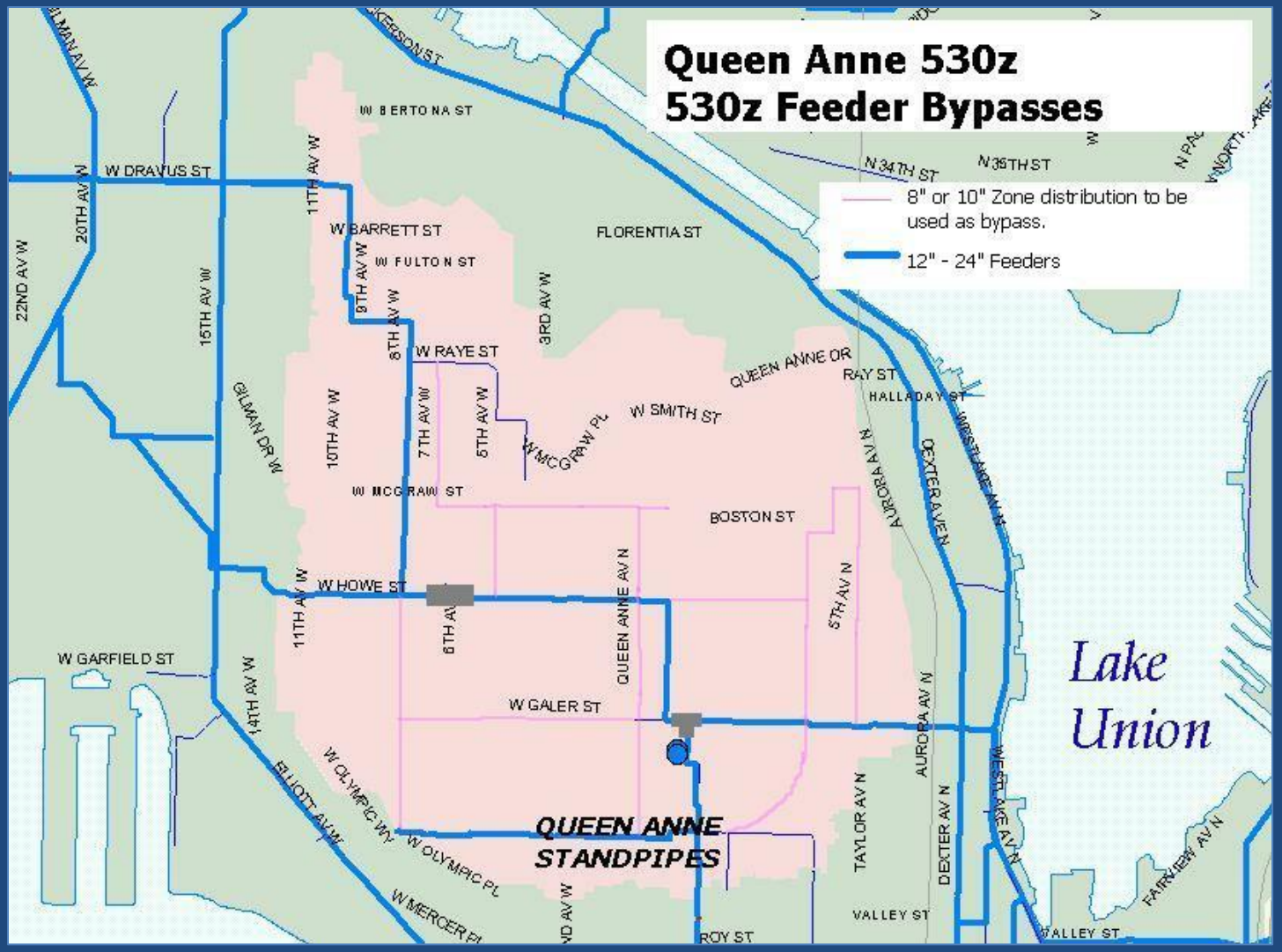
Key Sequencing Considerations

- How long mains will be out of service
  - Hours, weeks or months?
- Fire flow & access to working hydrants
  - Number of streets in a row off or on temporary
- Number of times customers will be shut off

Identify Conflicts & Constraints

- Go through maps & plans, identify
  - Alternate supply routes
    - Upstream & downstream impacts of outages
  - Likely extent & duration of outage
    - Will those be acceptable?
  - Distance by roadway to nearest working hydrants
    - In this area, keep under 800’
- Include this info in schedule review comments & approval

Alternate Supply Routes



Main Shutdown Spreadsheet

- Feeder shutdowns
  - Plan set page
  - SPU map page
  - Specific valves to be closed
  - Other lines required to be in service during shutdown

Watermain Plan Sheet	Segment & Mapbook Page	Valve	Other Lines Required to Be In Service
W7, W4	20" & 24" Warren Av N - Queen Anne SP to Galer (p35 & 35A)	20"V 20'W 100'N in Warren Av north of Lee (also shown as V#9 on page 35A)	24" Galer open from 5 Av N to EM of Warren Av
		16" V#3 (p 35A) on Queen Anne SP inlet line at base of tanks	8" Warren Av open from Galer to Howe
	Both feeds to western 530z are interrupted. Fire flow very bad.	24"V 20'S 1'W in Galer @ WM of Warren	8" Howe open from Warren Av N to 1 Av N
	Shutdowns must be as short as possible and at night whenever possible.	24"V 20' 6'W from S in Galer @ EM of Warren	12" Prospect open from 5 Av N to 8 Av W.
			8" 8 Av W open from Prospect to Howe.
			8" Bigelow Pl N open from Prospect to Galer.
			8" Queen Anne Av N open from Prospect to Galer, and from Galer to Howe.

QA Main Shutdown Spreadsheet

- Critical conflicts tab
  - Mains crossing under feeder backbones

Drawing	Feeder	Crossing
W1	24" 1 Av N	New 8" Howe
W2	24" 1 Av N	New 12" in Garfield
W5	24" Galer	New 8" at 2 Av N
W6	24" Galer	New 8" at 3 Av N

  - Water supply critical conflicts (next slide) – work may not proceed at the same time on any of these

Water Supply Critical Conflicts (work at these locations may not proceed simultaneously if one of these mains is shut down)	
Location	Projected Dates of WM Construction as of 12/19 Submittal
Location 1 East (24" 1 Av N)	Feb 20 to Apr 9
Location 4 East (24" Warren Av)	**Apr 17 to Jun 24**
Location 3 West (24" West Howe)	**Apr 19 to May 20**
Location 5 East (24" Galer)	Jul 6 to Sep 2
Location 6 East (20" Warren Av - parallel construction only - no crossings or connections)	Jun 7 to Jul 13
May be critical depending upon timing of C&C and connections	
Location 7 West (connect to 8" in 8 Av W)	Jun 20 to Jun 21
Location 10 West (7 Av W CV station)	Jul 20 to Jul 27
Location 6 West (connect 3 Av W to Galer)	25-Jun
Location 3 East (connect 4 Av N to Howe)	14-May

QA Main Shutdown Spreadsheet

- Cuts & caps tab

Plan Sheet	General Location	Cut & Cap Needed	Schedule (estimated based on 2/14 submittal)	completed as of 4/19
Sht (W7)	Warren Av N - Lee to Galer	1- 24" WM	Feb 20-21	yes
Sht (W10)	N Howe St - 2 Av N to 4 Av N	1- 8" WM	~ March 30	yes
Sht (W12)	W Blaine - 6 Av W to 8 av W	2- 6" WM	~ mid March	
Sht (W15)	W Garfield - 4 Av W to 6 Av W	2- 6" WM	~ early April	
Sht (W32)	3 Av W - Garfield to Galer	2 - 10" WM	first week of April	

QA Main Shutdown Spreadsheet

- Field verification tab

Location	Verify	Findings	Date & Name
1 Av N and Galer	Is there a 24" line valve 80'N of Galer? (p28 & 29)		
1 Av W & Galer	Is there a 6" valve on the SM of Galer?	yes	Muto
2 Av W & Galer	Is there a 6" valve on the SM of Galer?	yes	Muto
Intersection of 8 Av W & W Galer	Verify location of 2" line south of Galer is on east side of 8 Av W.		
24" West Howe - 2 Av W to 7 Av W	Do 24" valves have bypasses?		

Director's Briefings

- Construction
- Water supply operations during construction
- Water quality
- Communication plan
  - Contact
  - Description
  - Risks & risk management
  - Follow up & next steps

CONSTRUCTION


ELDER


DEERE
Genie

Tracking Watermain Progress

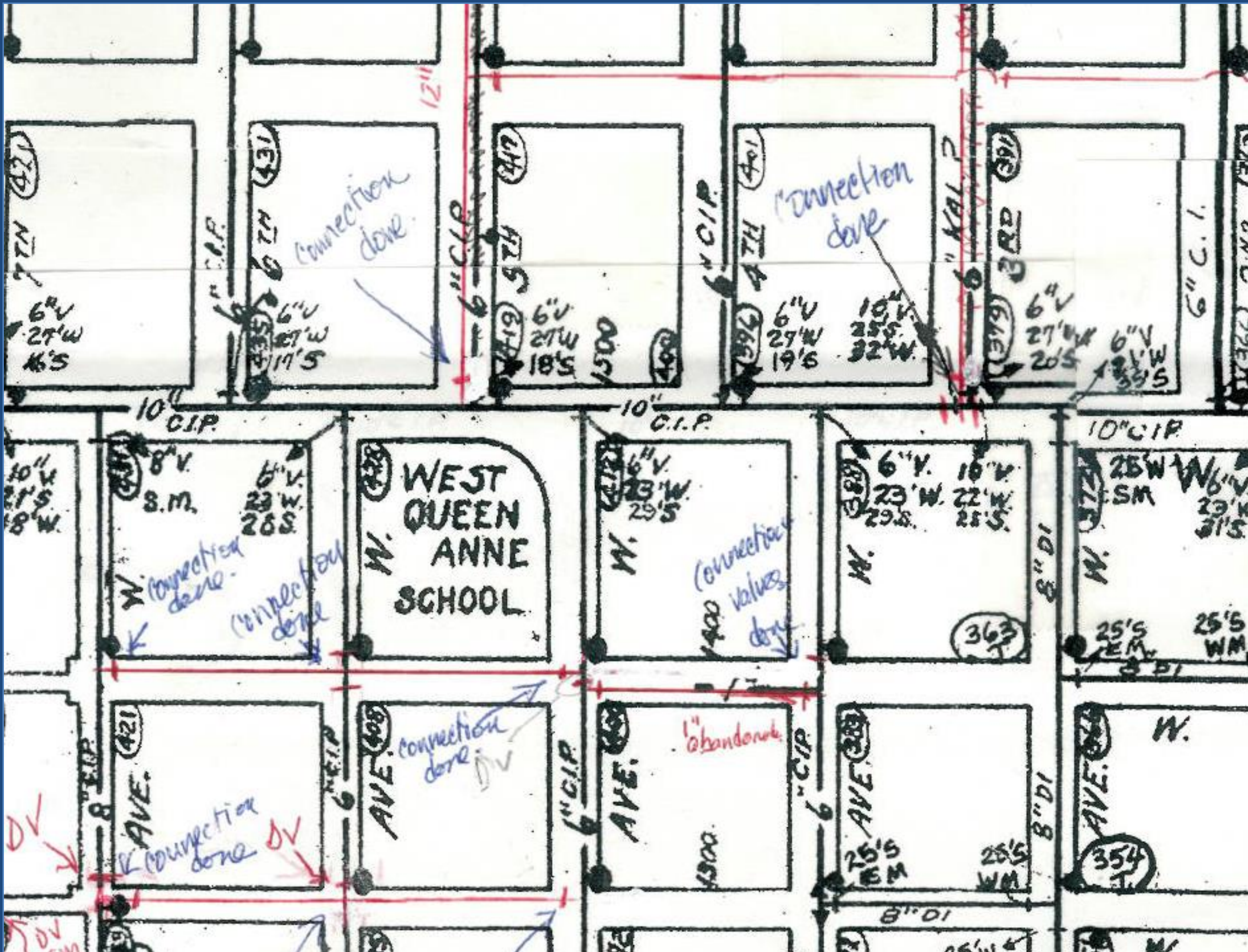
- Site meetings
  - Contractor
  - SPU pipe crew
  - SPU valve crew
- Changes to plan
  - Plans don’t always show what’s really there
- Review proposed shutdowns

Tracking Watermain Progress

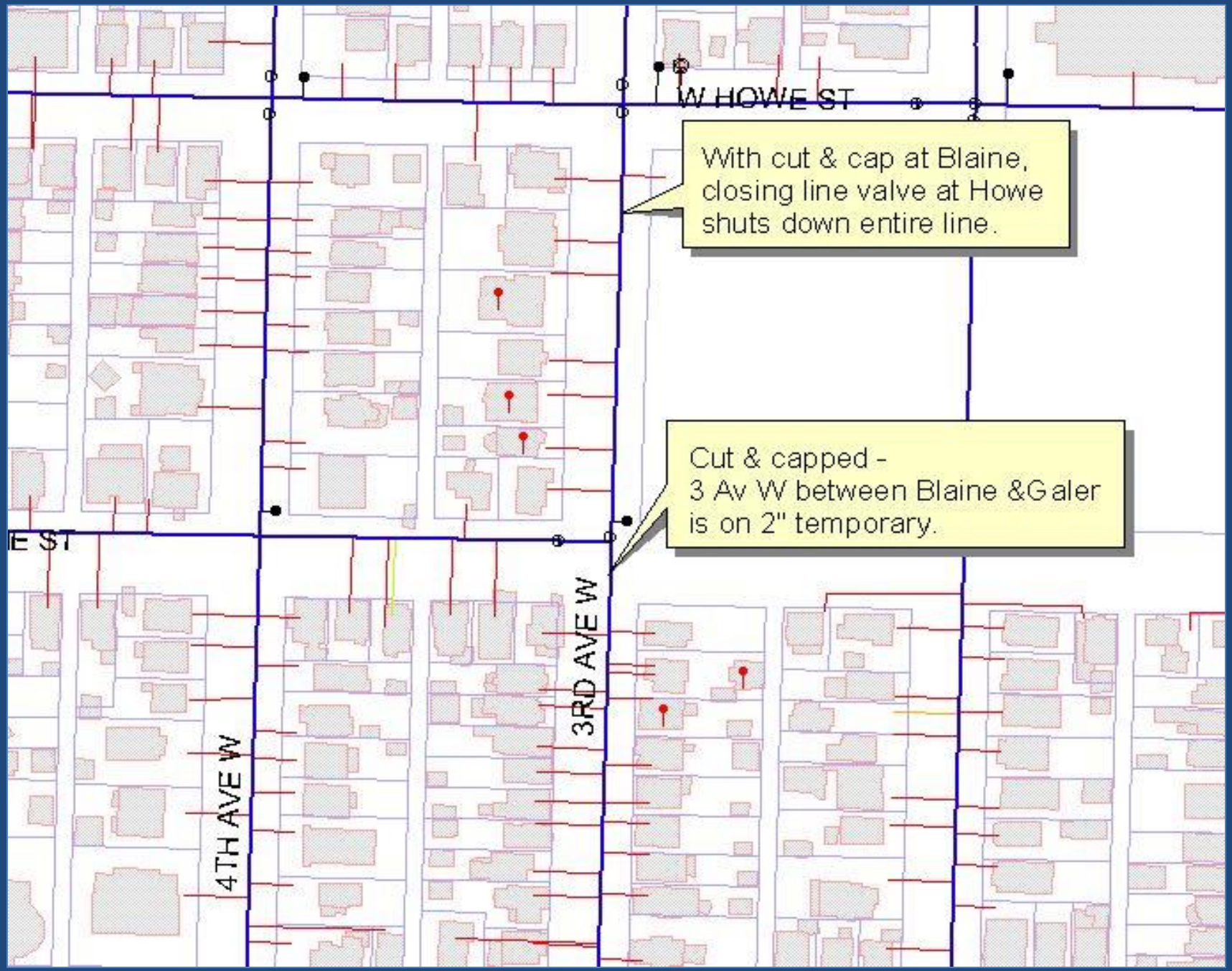
- Will this shutdown do exactly what we think it should?
  - Mock shutdown useful
    - All other necessary connections completed
    - Valves in correct position
    - Affected services accurately identified
    - Supply to remainder of area relatively unaffected
    - No surprise loss of monitoring or control

Tracking Watermain Progress

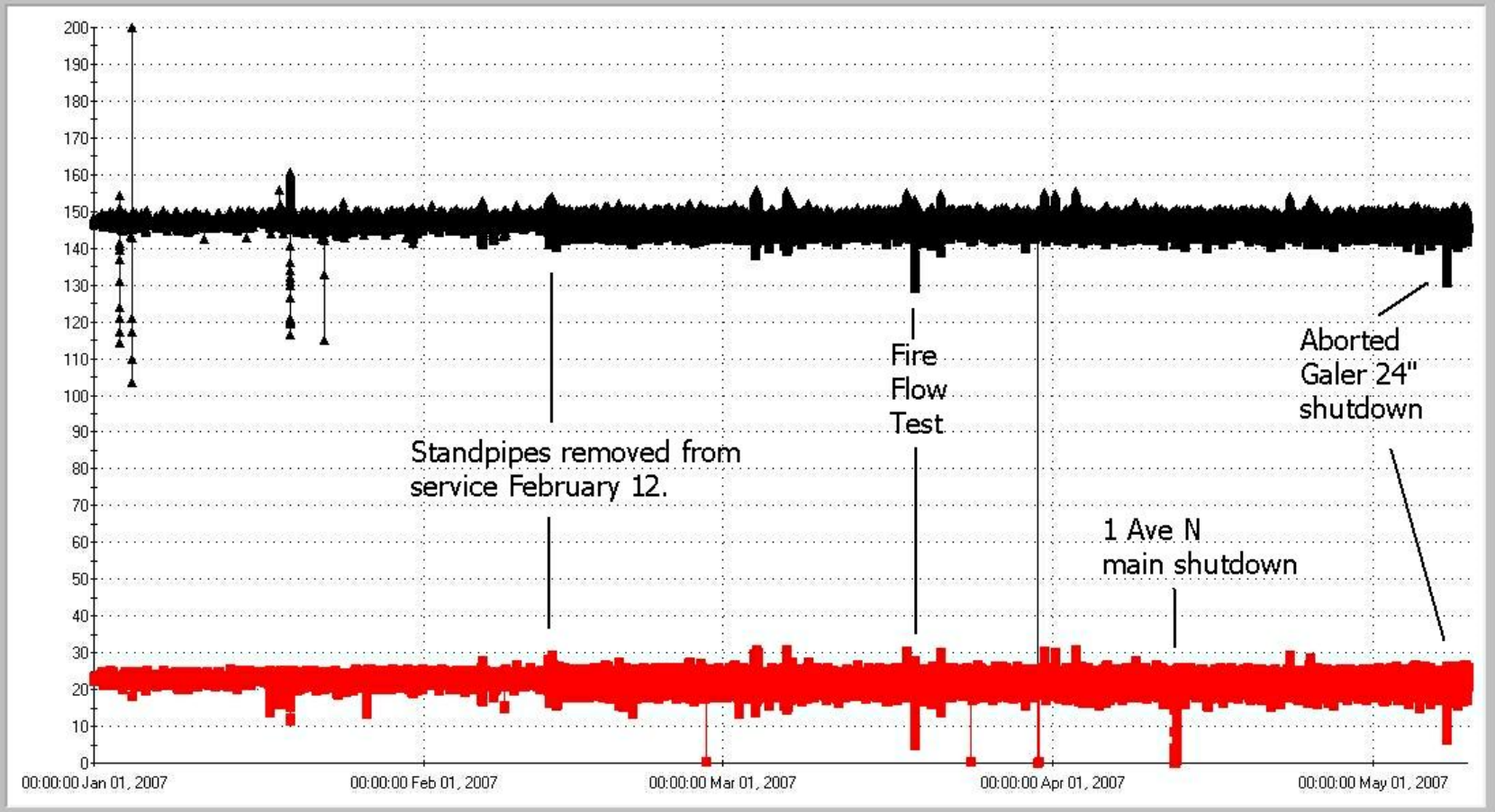
- Weekly meetings with contractor to confirm progress, update schedule, identify developing conflicts
- Monitor sequence of work to maintain supply & fire flow
- Update maps
- Evaluate impact of changed operating conditions on system



WEST QUEEN ANNE SCHOOL
Connection done
Connection done
connection done.
connection done
Connection valves done
connection done
connection done
1" abandoned
DV
DV
10" C.I.P.
10" C.I.P.
10"CIP
6TH
5TH
4TH
3RD
AVE.
AVE.
AVE.
AVE.
AVE.
W.
W.
W.
W.
W.
W.
6"V
27'W
18'S
6"V
27'W
19'S
363
354
8"DI
8"DI
8"DI
WEST
25'S
EM
25'S
WM


W HOWE ST
With cut & cap at Blaine, closing line valve at Howe shuts down entire line.
Cut & capped - 3 Av W between Blaine &Galer is on 2" temporary.
E ST
3RD AVE W
4TH AVE W

Queen Anne 530z Pressures



Tracking Watermain Progress

- Fire Department coordination
  - Access issues
    - Project wrapped around their station
  - Temporary protocols
    - SPU notified of all fire dispatches
    - SFD notified of fire flow issues
  - General updates
    - They can help with neighborhood outreach

Customer Service

- Traffic disruption, noise
- Water service interruption
- Anticipated water quality impacts due to flow reversals & flushing activities

Public Outreach

- Outside PR firm hired
  - Community meetings
  - Mailings
  - School field trips
  - Neighborhood newspapers
- Worked with SPU operations, engineering, PIO staff, & contractors to develop materials

Public Outreach

Standpipe

Standpipe

Booster Pump Station

- "Pump station in a can" was a first for SPU
- One lesson learned
  - Specified pumps were rated for irrigation duty, not for 24/7 water supply

SCADA

- Field work
  - New pressure, flow & level sensors
  - New pumps, controls & station data
  - Electrical, communications, RTUs / PLCs
- SCADA database
  - Delete old I/O points
  - Add new I/O points
  - Control schemes programmed according to concept of operation

COMMISSIONING

SCADA

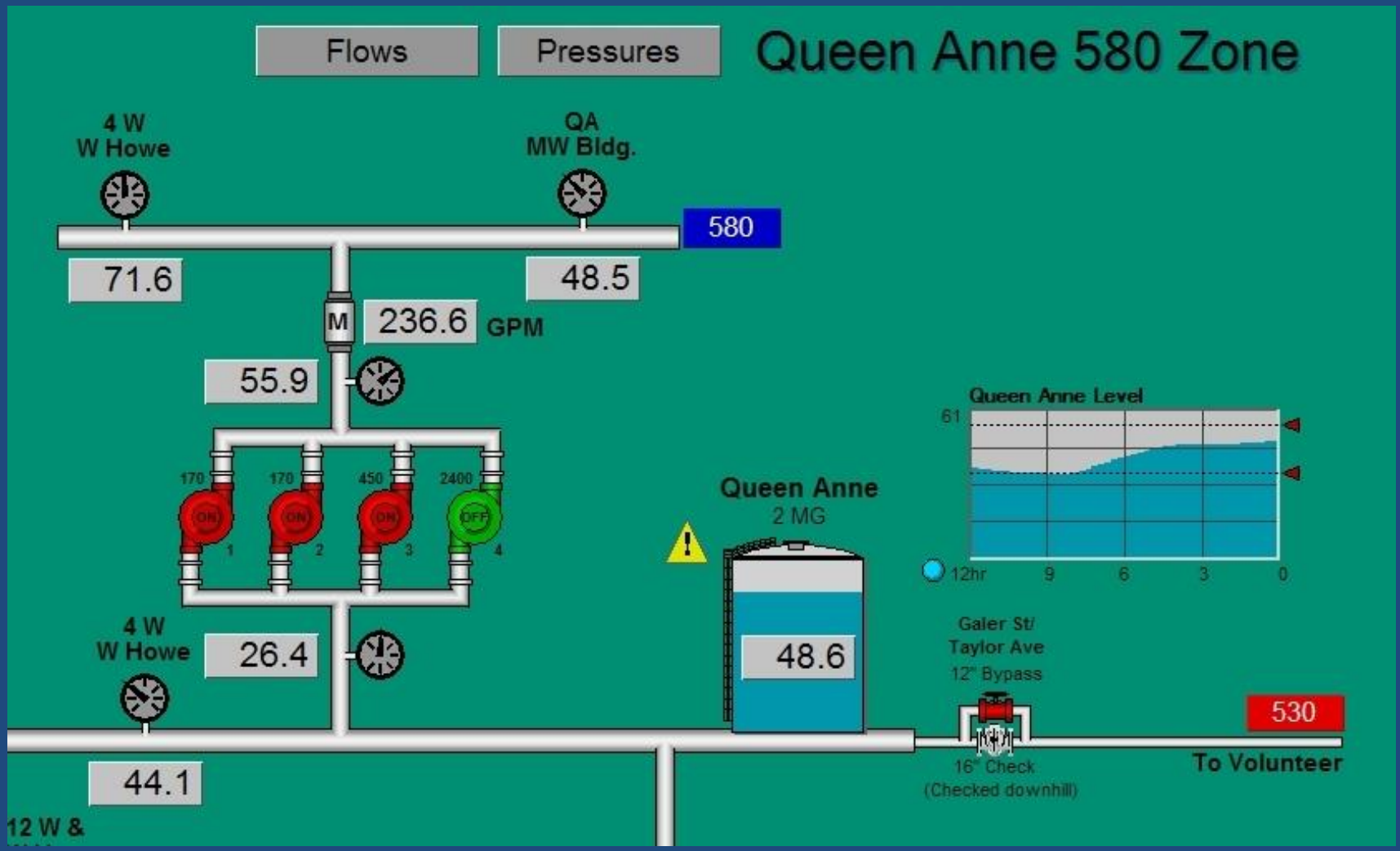
- Graphics/HMI
  - What data to display
  - I/O points directed correctly

- Needs to be done first
  - How do you know when to stop filling if you don't have level information?

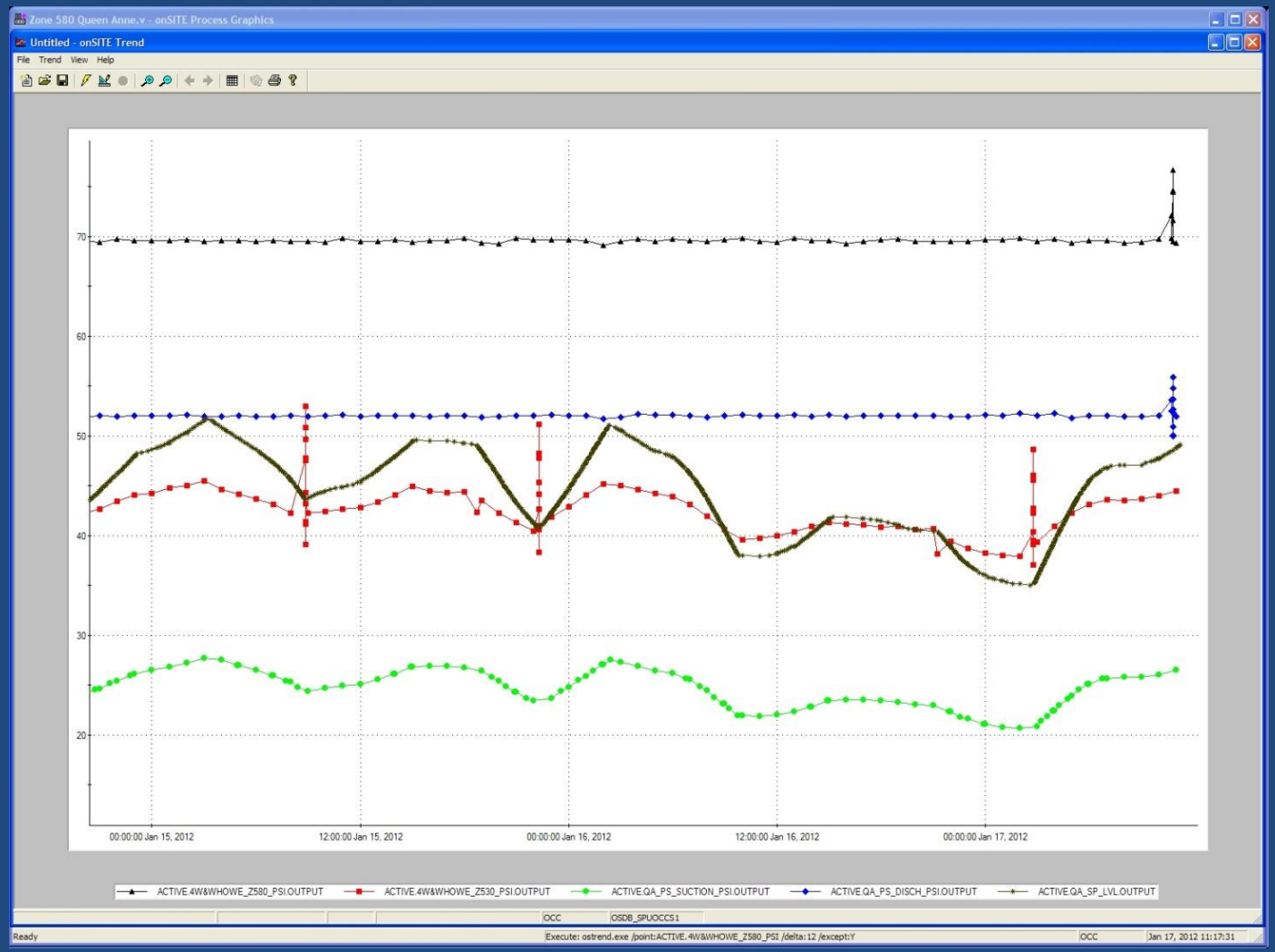
Tabular Data Display

	Tag	Description	Remote Tag	INPUT	Output	UNITS	State	Minimum	Maximum	ALARM	LABEL0	LABEL1
1	QA_PS_SUCTION_PSI	Queen Anne PS Suction Pressure			26.38	PSI		0.00	160.00			
2	QA_PS_DISCH_PSI	Queen Anne PS Discharge Pressure			52.63	PSI		0.00	160.00			
3	QA_PS_FLOW	Queen Anne PS Outlet Flow			199.20	GPM		0.00	5000.00			
4	QA_PS_P1_LOR_REMOTE	Queen Anne PS P1 LOR Switch			1.00		Remote				Not Remote	Remote
5	QA_PS_P1_RUN	Queen Anne PS P1 Variable Freq. Drv. Running			1.00		Running				Not Running	Running
6	QA_PS_P1_VFD_FAIL	Queen Anne PS P1 Variable Freq. Drv. Failed			0.00		Not Failed				Not Failed	Failed
7	QA_PS_P2_LOR_REMOTE	Queen Anne PS P2 LOR Switch			1.00		Remote				Not Remote	Remote
8	QA_PS_P2_RUN	Queen Anne PS P2 Variable Freq. Drv. Running			1.00		Running				Not Running	Running
9	QA_PS_P2_VFD_FAIL	Queen Anne PS P2 Variable Frequency Drive			0.00		Not Failed				Not Failed	Failed
10	QA_PS_P3_LOR_REMOTE	Queen Anne PS P3 LOR Switch			0.00		Not Remote				Not Remote	Remote
11	QA_PS_P3_RUN	Queen Anne PS P3 Variable Freq. Drv. Running			0.00		Not Running				Not Running	Running
12	QA_PS_P3_VFD_FAIL	Queen Anne PS P3 Variable Freq. Drv. Failed			0.00		Not Failed				Not Failed	Failed
13	QA_PS_P4_LOR_REMOTE	Queen Anne PS P4 LOR Switch			1.00		Remote				Not Remote	Remote
14	QA_PS_P4_RUN	Queen Anne PS P4 Reduced Voltage Starter Running			0.00		Not Running				Not Running	Running
15	QA_PS_P4_RVS_FAIL	Queen Anne PS P4 Reduced Voltage Starter Failed			0.00		Not Failed				Not Failed	Failed
16	QA_PS_RELIEF_V_CLOSED	Queen Anne PS Pressure Relief Valve			1.00		Closed				Not Closed	Closed
17	QA_PS_FLOOD_ALM	Queen Anne PS Flood Switch			1.00		No Flood				Flood	No Flood
18	QA_PS_SMOKE_ALM	Queen Anne PS Smoke Alarm			1.00		No Smoke				Smoke	No Smoke
19	QA_PS_TEMP_ALM	Queen Anne PS High Temperature Alarm			1.00		Normal				High Temp	Normal
20	QA_PS_VAULT_HATCH	Queen Anne PS Vault Hatch Switch			0.00		Open			Alarm	Open	Closed
21	QA_PS_INTRU_DET	Queen Anne PS Intrusion Switch			0.00		Enabled				Enabled	Disabled
22	QA_PS_PHASE_FAIL_ALM	Queen Anne PS Phase Fail Alarm			0.00		Normal				Normal	Fail
23	QA_PS_INTRU_ALM	Vault Security Status			1.00		Intrusion alarm			Alarm	Normal	Intrusion alarm
24	QA_PS_DISCH_PSI_H	QA PS Discharge pressure history		53	51.94							
25	QA_PS_FLOW_H	QA PS discharge flow rate history		199	206.04							
26	QA_PS_P1_CAPACITY	Pump #1 capacity			170.00	GPM		0.00	9000.00			
27	QA_PS_P2_CAPACITY	Pump #2 capacity			170.00	GPM		0.00	9000.00			
28	QA_PS_P3_CAPACITY	Pump #3 capacity			450.00	GPM		0.00	9000.00			
29	QA_PS_P4_CAPACITY	Pump #4 capacity			2400.00	GPM		0.00	9000.00			
30	QA_PS_SUCTION_PSI_H	QA PS Suction pressure history		26	26.38							

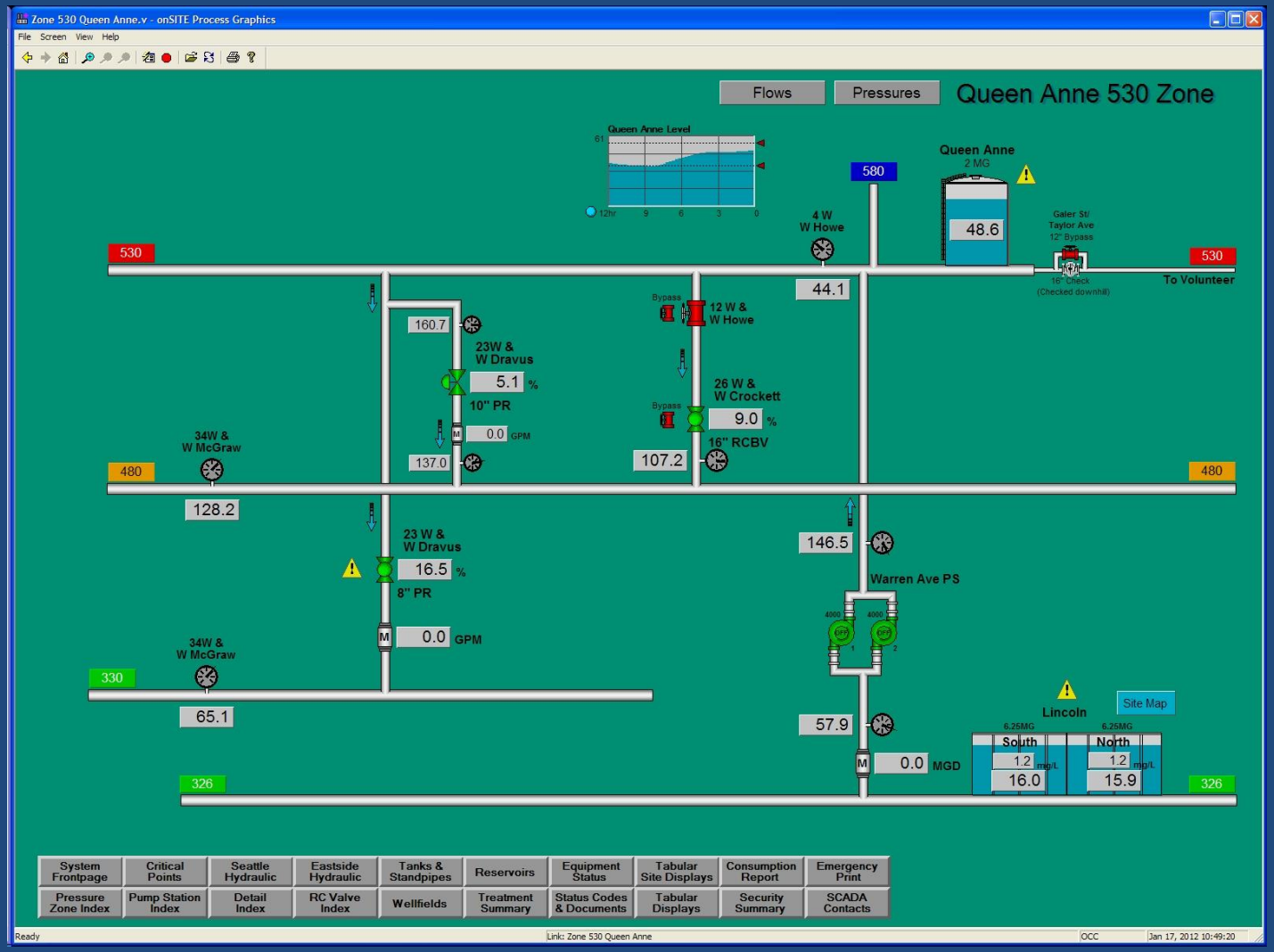
Graphic Display



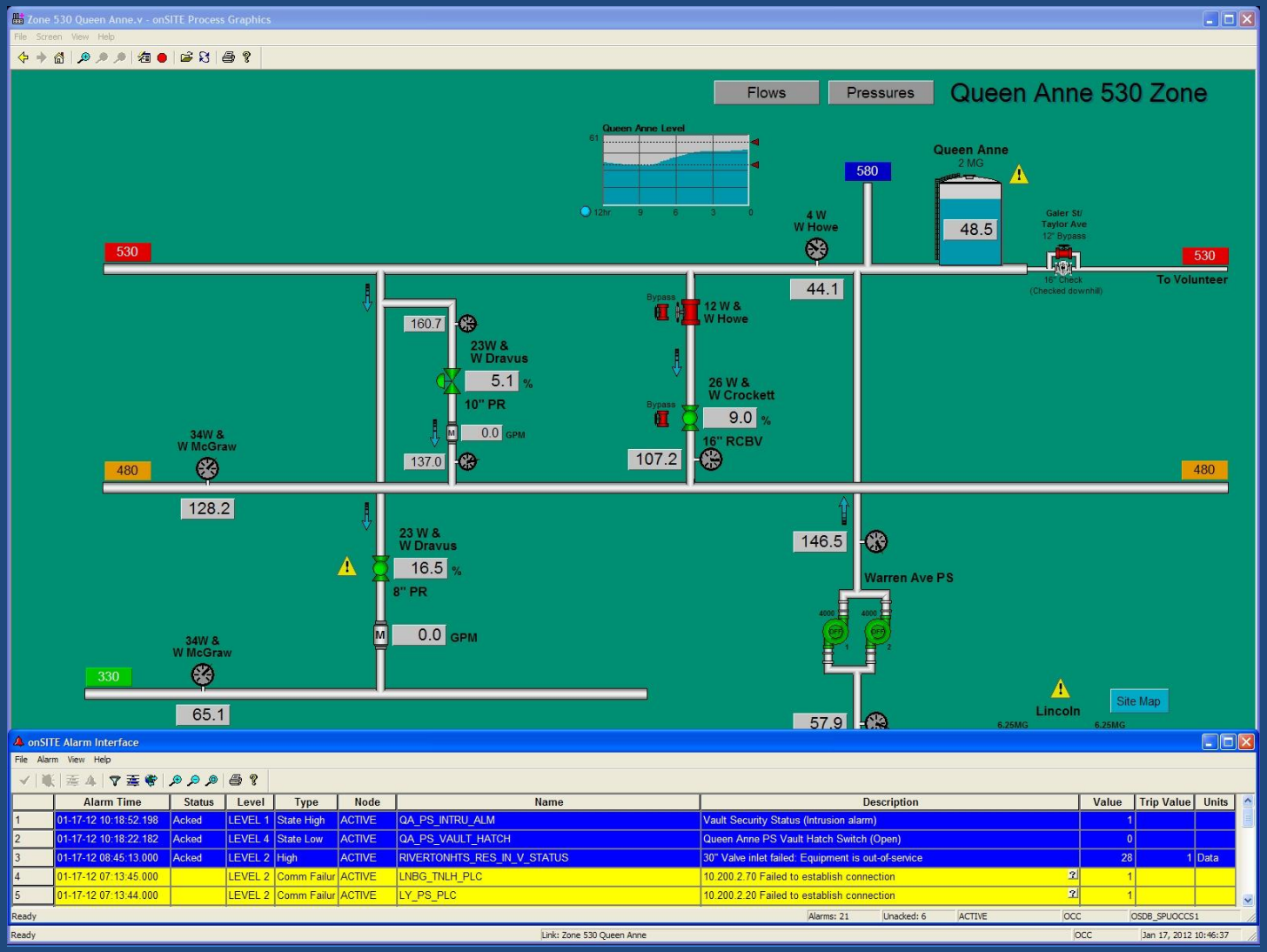
Pressure & Flow Trend Display



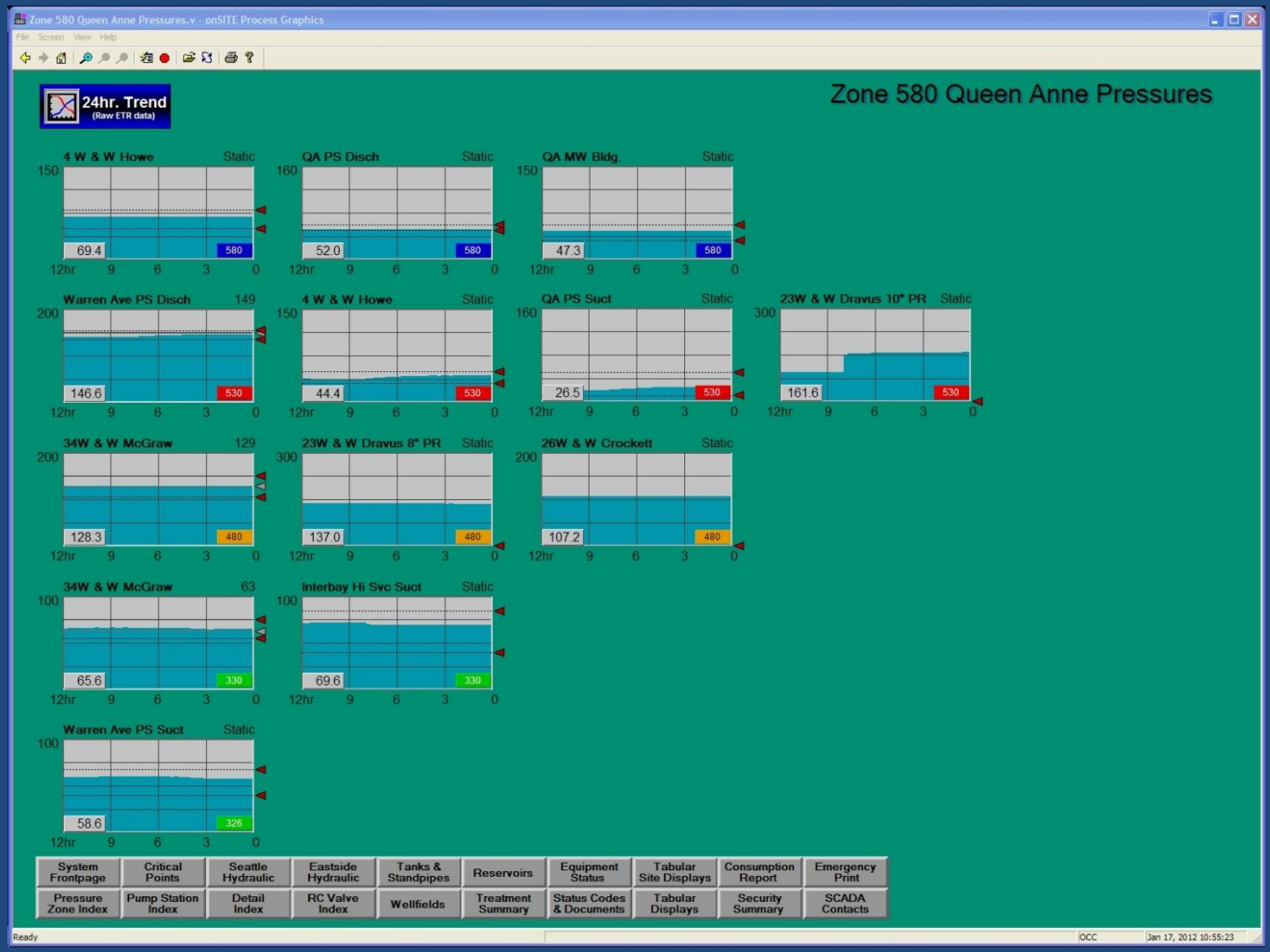
Queen Anne-Magnolia Overview



Same Screen With Alarm Display



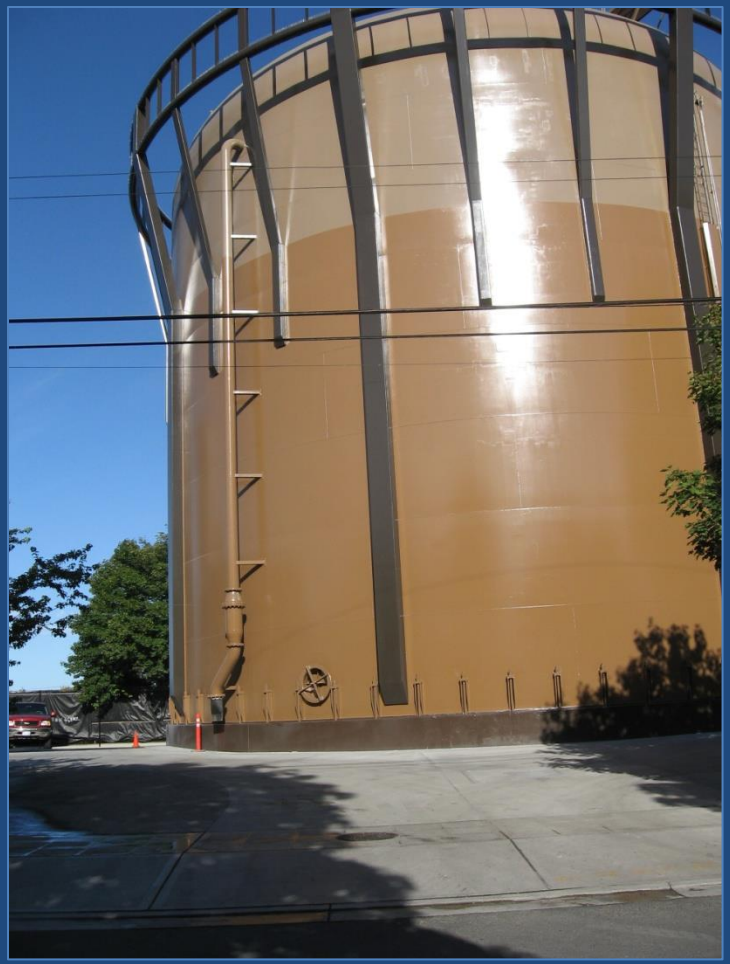
12-Hour Pressure Trends



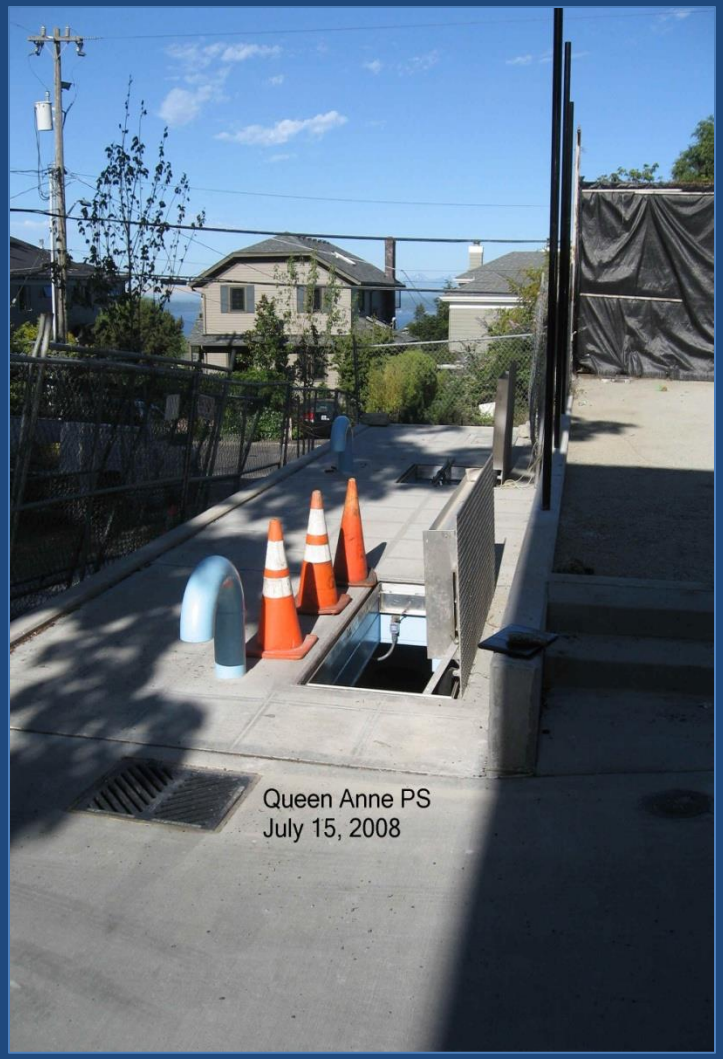
Watermains

- Pressure & bacti tests
- Valves & check valves tested
- All district valves left open

Standpipe



Pump Station

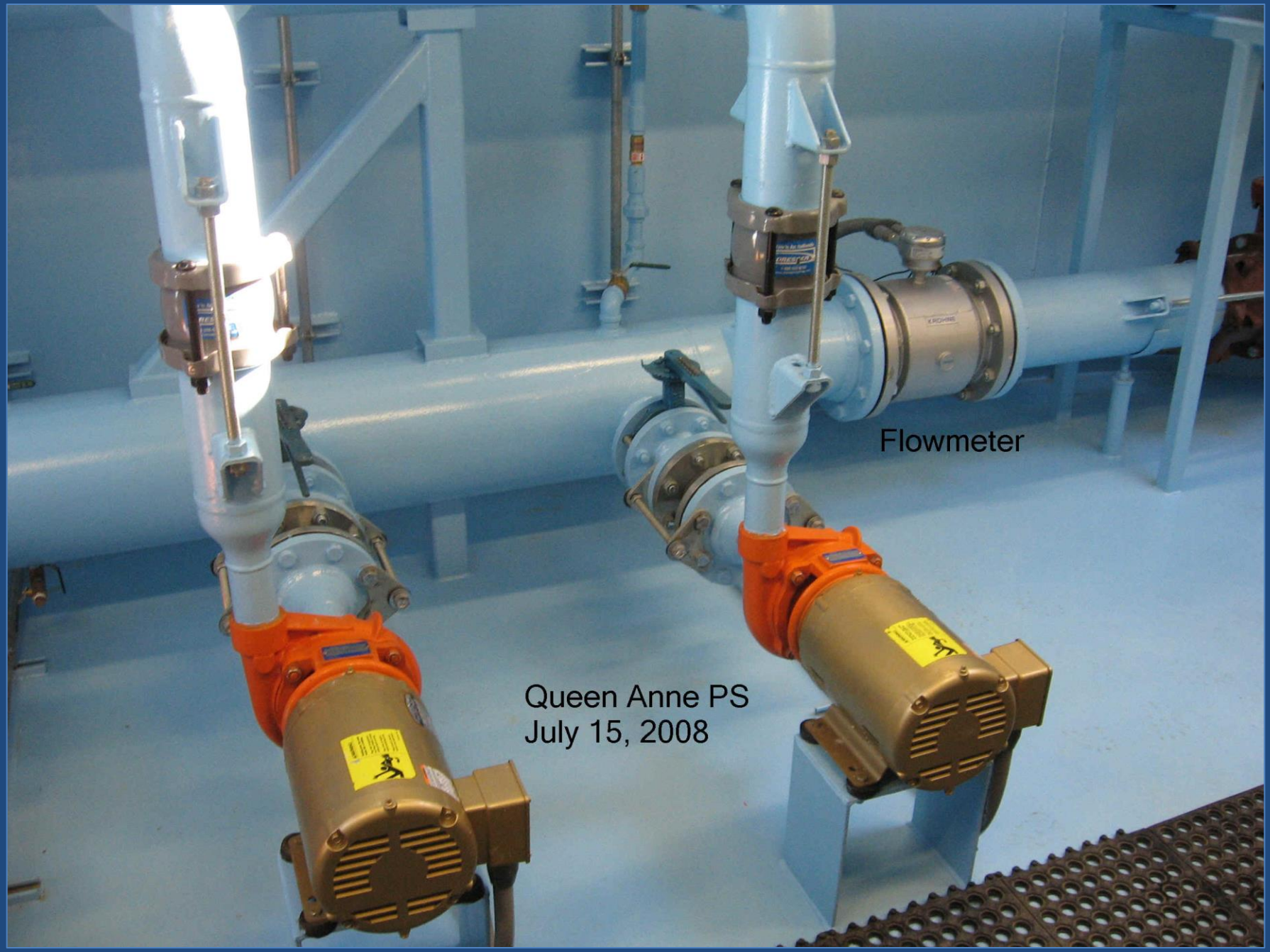


- System testing
- Acceptance testing
- Shut station down when testing completed
  - Need to coordinate when new zone will be activated

Queen Anne PS
July 15, 2008

7-Day System Testing

- Uses water or other process media to simulate actual conditions
- Manual & automatic modes
  - proper control sequences
  - interlocks
  - software logic & controllers
- Pumps fought each other, needed tweaking
- Tripped off line for unknown reasons

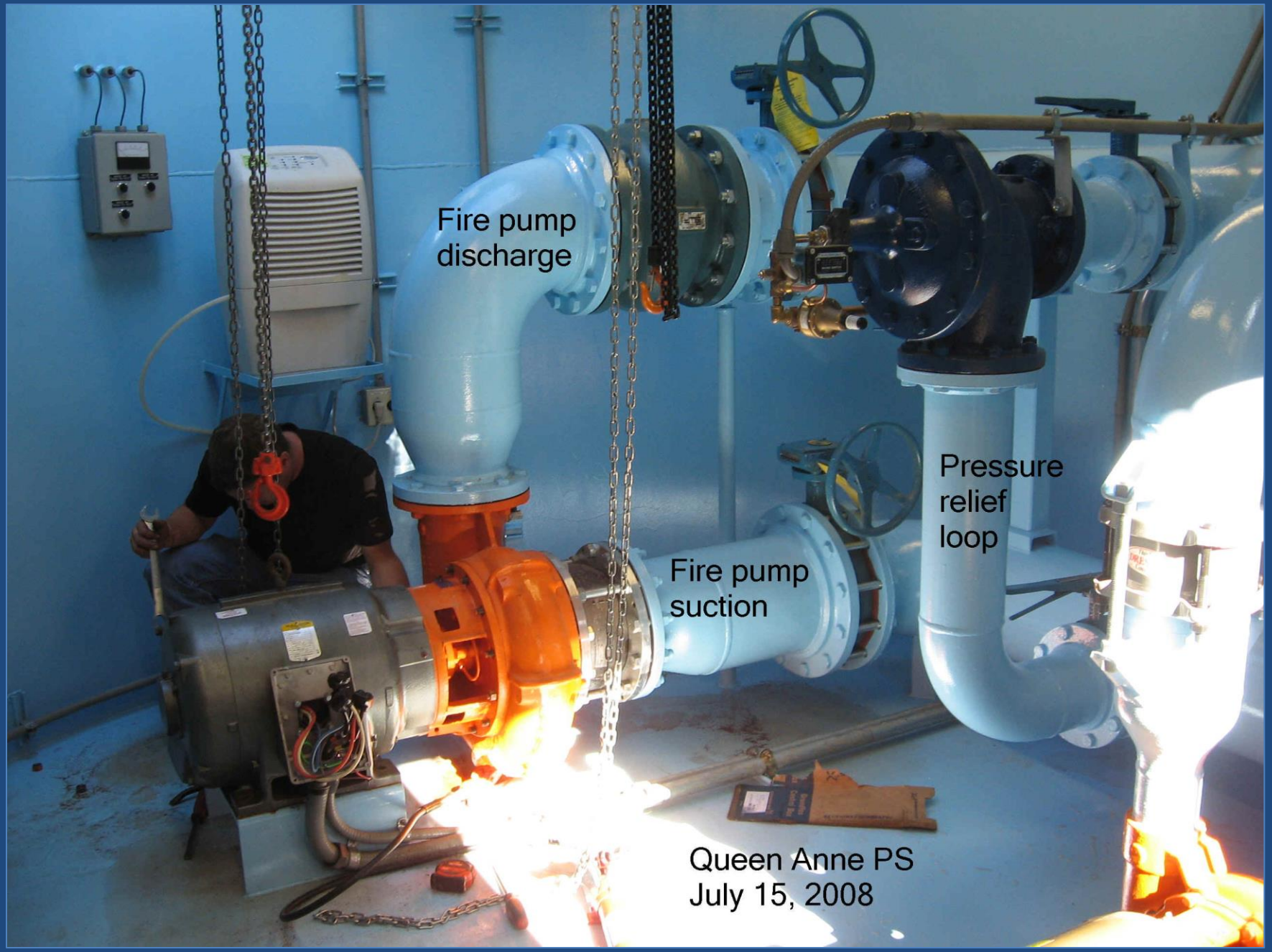

Flowmeter
Queen Anne PS
July 15, 2008

8-Day Acceptance Testing

- Continuous operation at rates directed by owner
- All other testing successfully completed
- Any malfunction resets the clock to zero
- Equipment lubed & maintained during test
- Strainers, filters, screens cleaned or replaced

8-Day Acceptance Testing

- Fire flow test required artificial demand
- Constraints
  - Tuberculated pipe
  - Poor combined sewers
  - Steep hills
- Needed the right combination of clean pipe & adequate drainage


Fire pump
discharge
Pressure
relief
loop
Fire pump
suction
Queen Anne PS
July 15, 2008

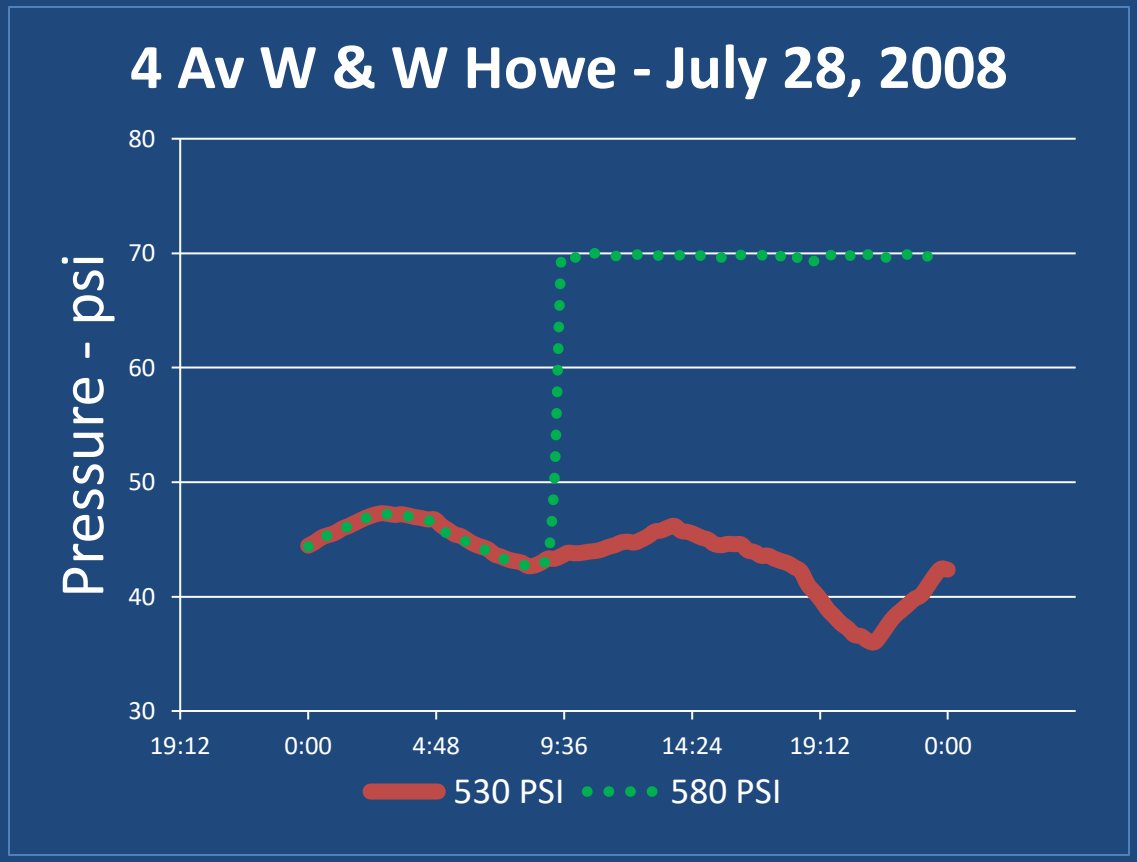
Plan To Isolate The New Zone

- District valves
  - Double-check against maps
    - Verify all the connections between zones are located; many weren't
  - Re-exercise valves
    - Tubercules re-formed in last 9 months
  - Close, verify no leak-by
    - They are 80-100 years old

Plan To Isolate The New Zone

- Valve verification is slow process
  - Can’t leave valves closed overnight
- Isolated in stages
  - Current maps critical
    - Fire flows change as valves are closed
    - Flow reversals generate WQ complaints
    - Did we get them all?

Start Up



- Notify customers
- Monitor flow & psi
  - Do they match model?

Lessons Learned

- Risks successfully managed by engineering, operations & management staff working together
  - Bring operating staff in very early in project
- Measure 3 or 4 times, cut once
- Stay on top of work
  - If you get behind, it can snowball

Lessons Learned

- Communications strategies are key
  - Contractors
  - Design engineers
  - Other agencies
  - Your own crews
  - Executives
  - Public

Acknowledging SPU Co-Workers

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- Dave Muto, Ops Planning & Control Mgr
- Tom Walker, System Control Supervisor
- Michael Langlois, Sr Water System Operator
- Don Shindle, Sr Water System Operator

He let me talk about this even though I'm retired
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Questions?

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