May 3, 2023

consor

Leveraging Hydraulic Modeling Tools for Pump Selection in Closed Water Systems

Case Study: Whatcom PUD No. 1 Water Treatment Plant 1

PNWS-AWWA 2023

Chadwick Johnson

Agenda

01 Open vs. closed pressure zones

02 Hydraulic Modeling 101

03 Case study: Whatcom PUD No. 1 WTP1

04 Key Takeaways

KEY POINTS

Question #1

What are the added complexities of designing and modeling pumps in a closed network?

Question #2

How can developing a hydraulic model assist with pump design?

Question #3

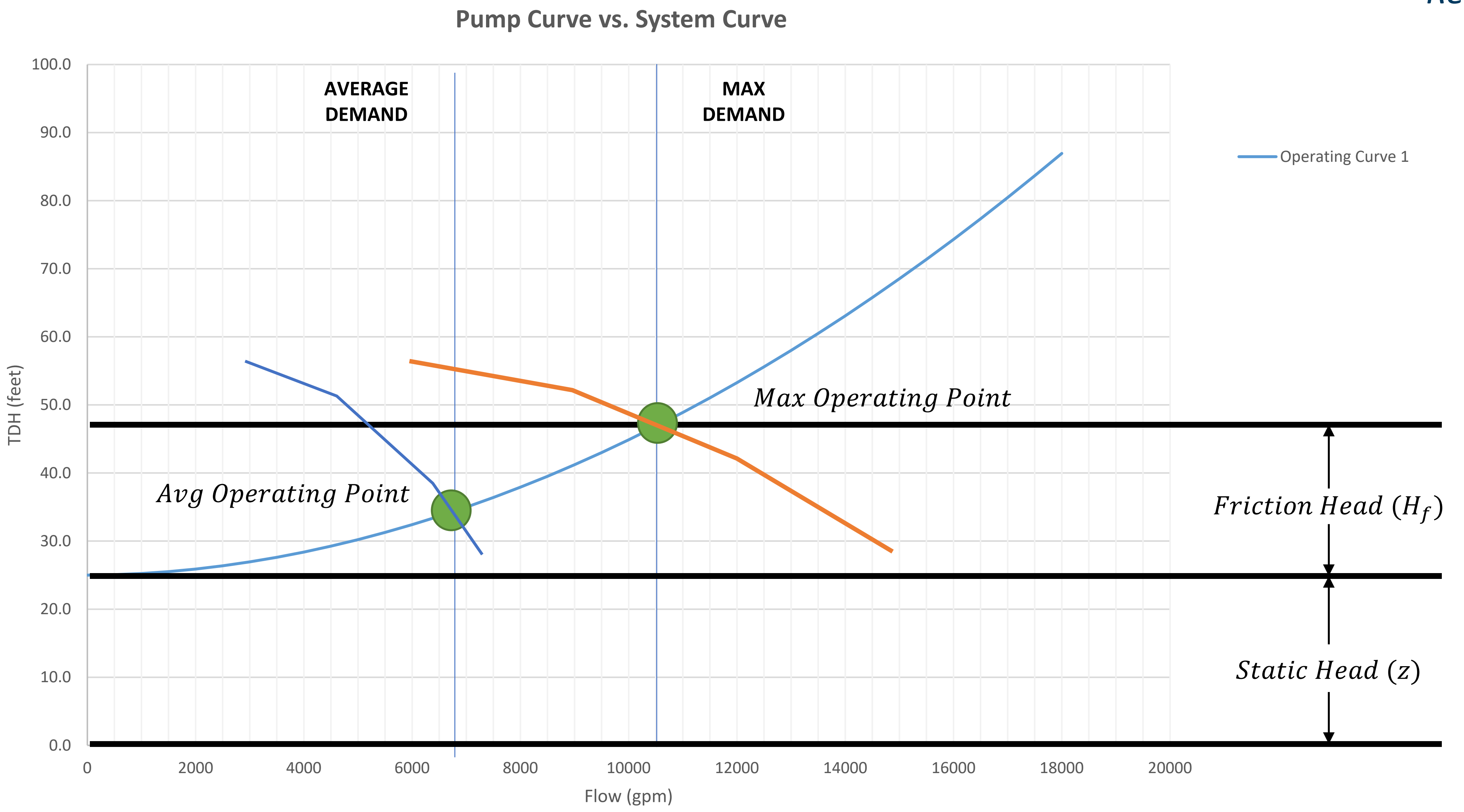
How can the hydraulic model inform operating constraints?

01

Background

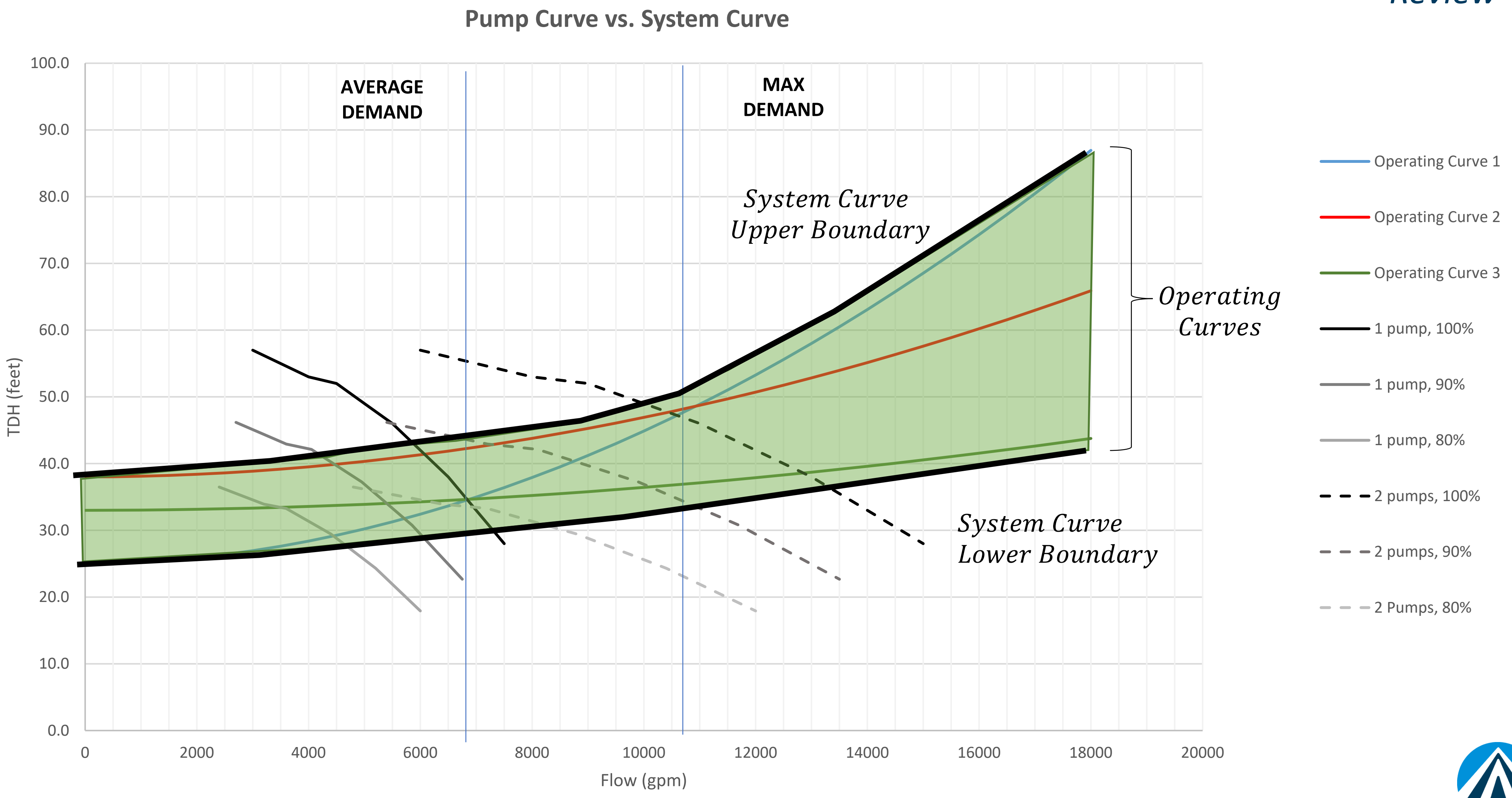
Closed vs Open Pressure Zones

Review



Closed vs Open Pressure Zones

Review

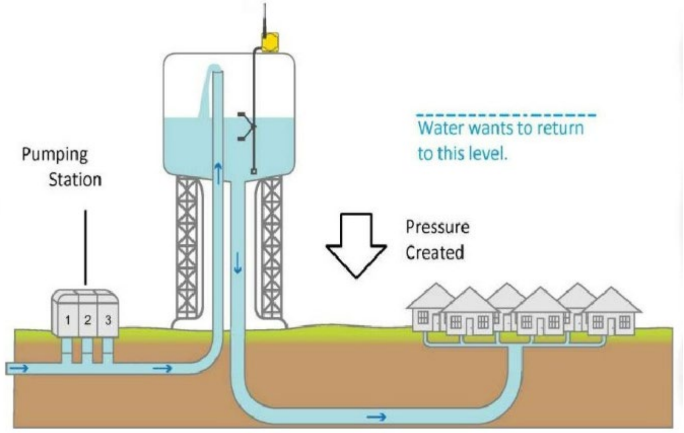


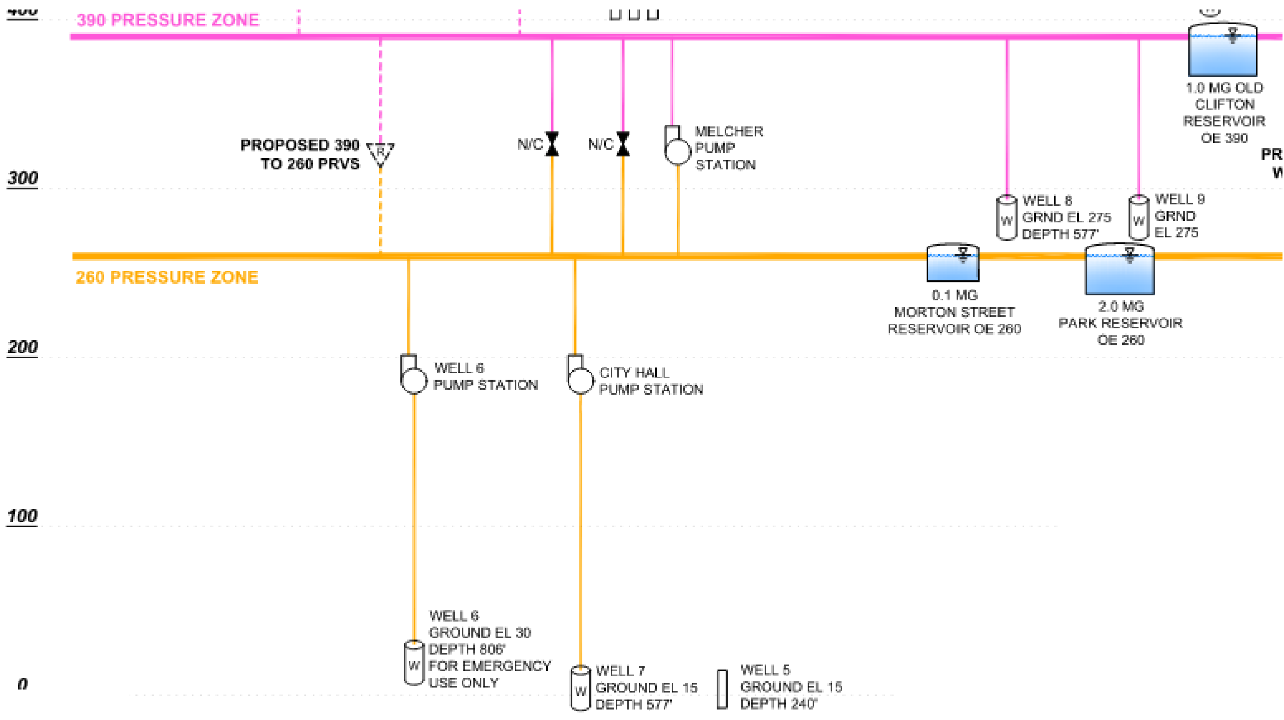
Closed vs Open Pressure Zones

Review

OPEN PRESSURE ZONES

- Tanks set the system pressure
- Storage provides supply during high demand
- Supply pumps, booster pumps, and PRVs operate based on pressure settings



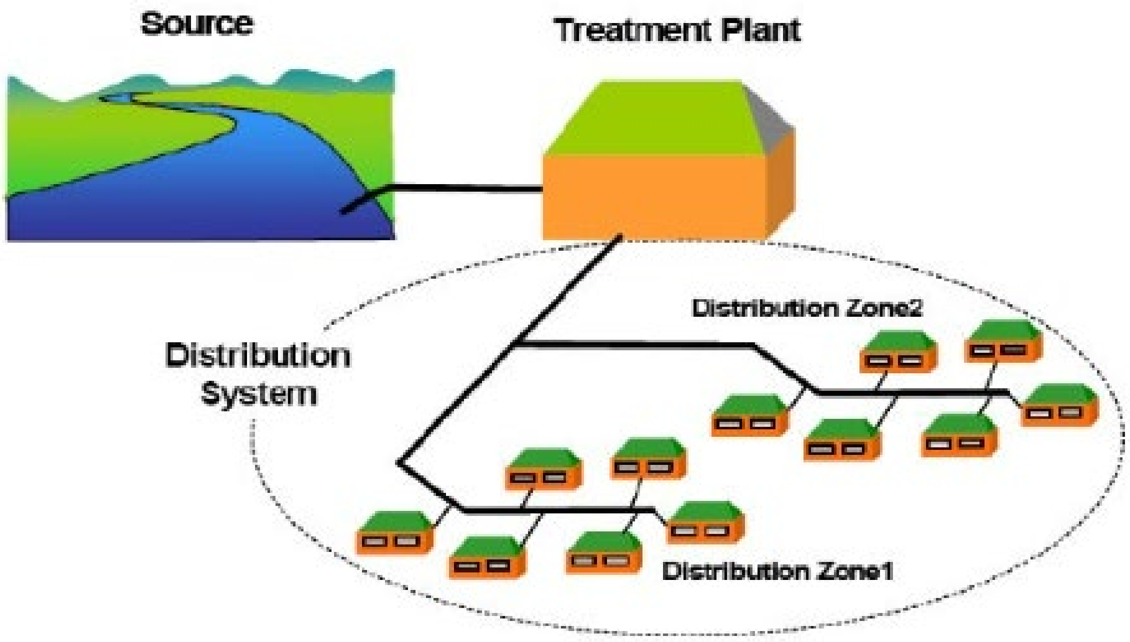


Closed vs Open Pressure Zones

Review

CLOSED PRESSURE ZONES

- No elevated storage
- Pumps maintain pressure and react to changes
  - Hydropneumatics zones
  - Variable frequency drives (VFDs)
- Pumps must cover wider range of flow and pressure conditions
- Risk of no supply is greater
  - No/limited storage if pump fails
  - Pump redundancy

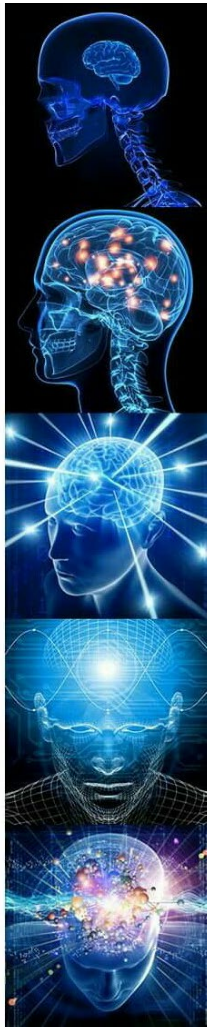


02

Hydraulic Modeling 101

Hydraulic Modeling

Review



COMMON APPLICATIONS

- Fire flow assessment for new developments
- **System curve development and pump selection**

Focus for today

- System-wide capacity analysis
- 20-year Water System and Capital Improvement Planning (CIP)

Hydraulic Modeling

Review

KEY CHALLENGES

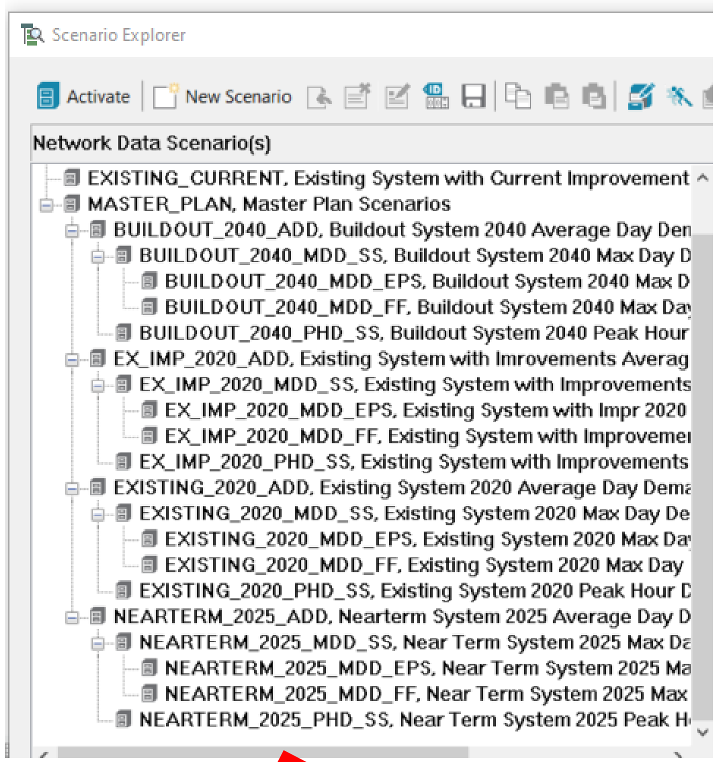
- Initial investment in developing
- Learning new software and troubleshooting
- Collecting/processing data
  - Geospatial
  - SCADA
- User documentation ("Read me" file)
- Calibration and verification

Hydraulic Modeling

Review

WHEN TO USE A MODEL?

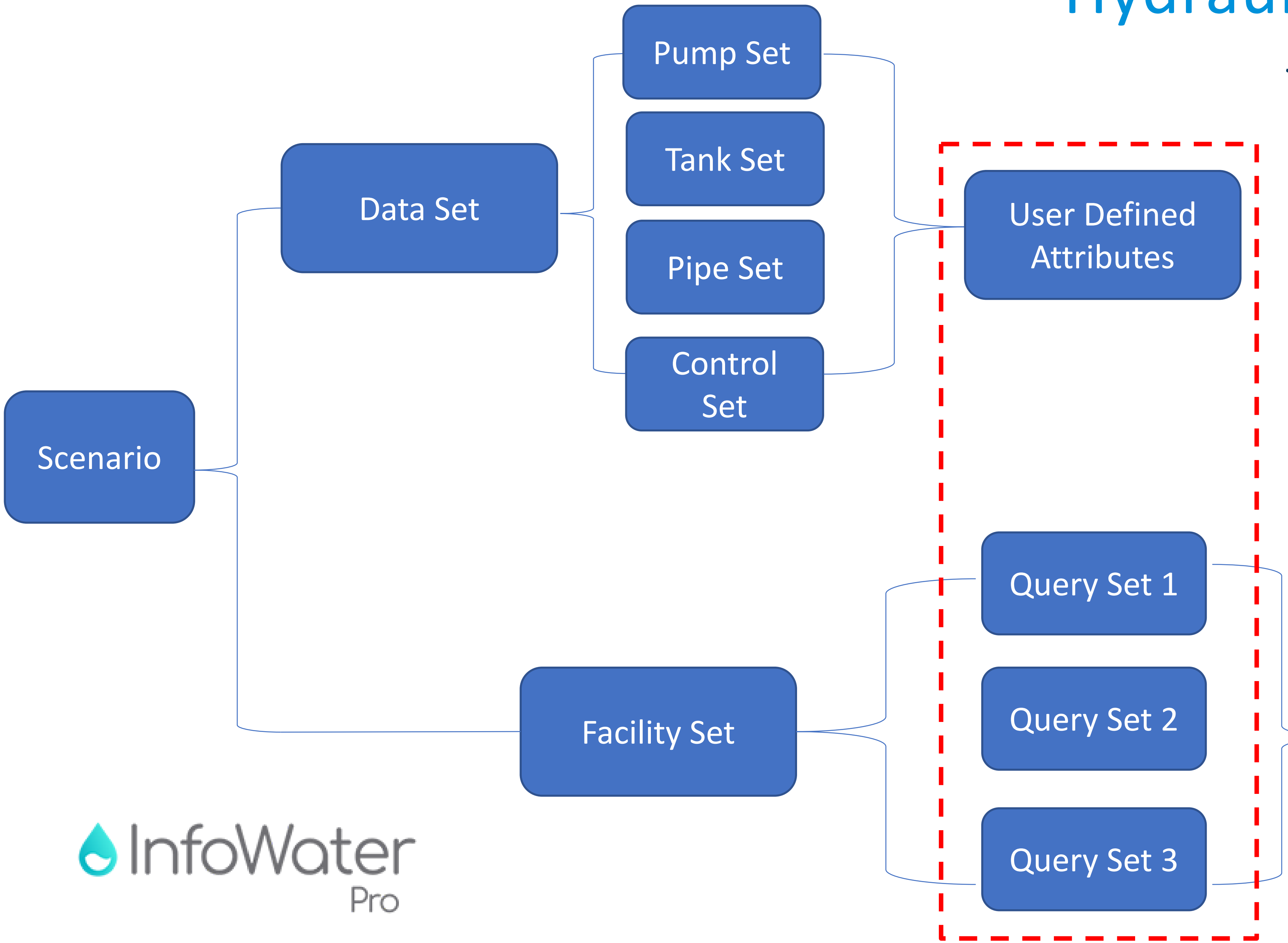
- Already have an existing model
- Multiple operating scenarios
    - Easily change parameters to meet design requirements with data sets
- Complex system operations with multiple components



InfoWater Pro

Hydraulic Modeling

Scenario Management



User can query attributes to toggle facilities on and off

InfoWater Pro

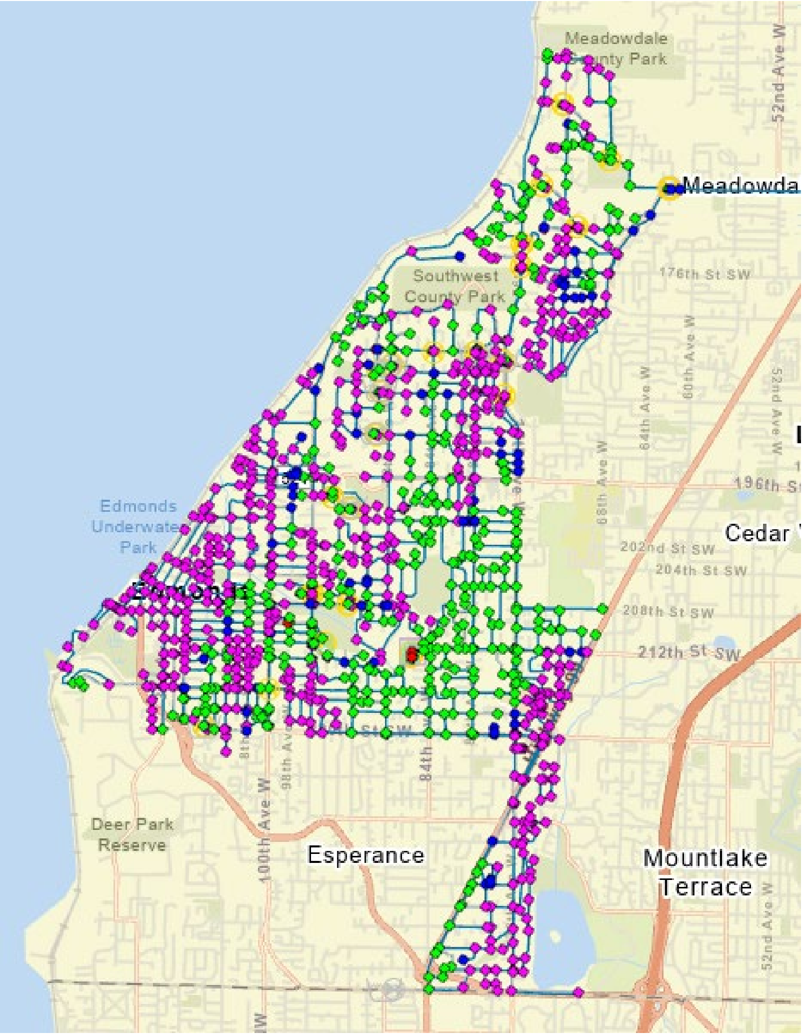
Hydraulic Modeling

Considerations

OTHER BENEFITS

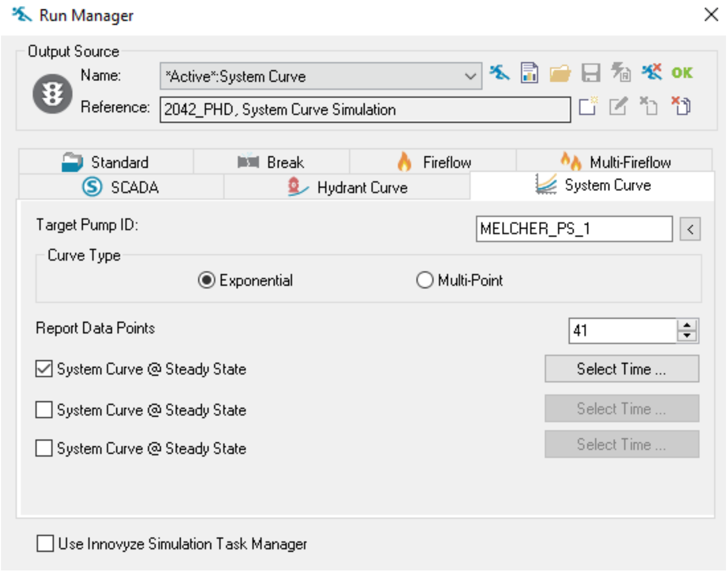
- Mapping pipe flow, pressure, and velocity
- Can be exported and used in other modeling platforms
- Utility can fine tune operations to improve efficiency
    - Pumps
    - Reservoirs
    - PRVs

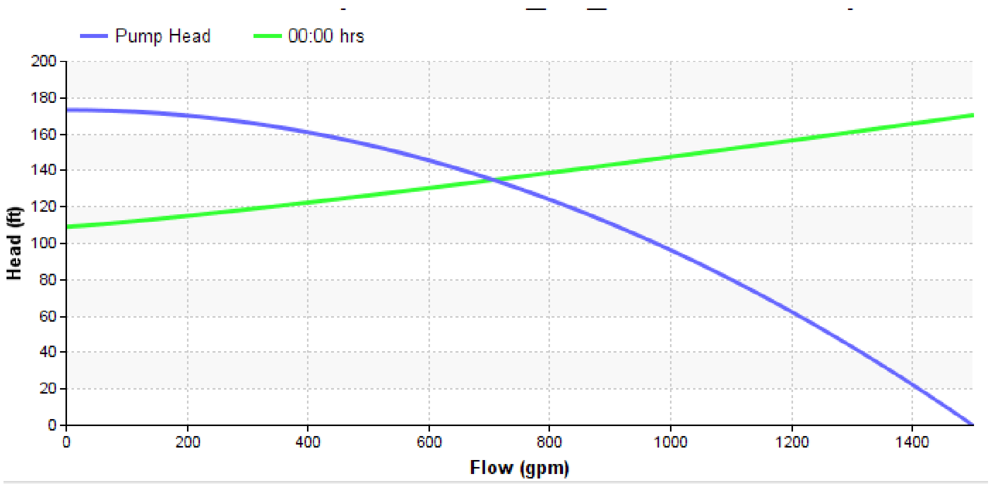
EPANET



SYSTEM CURVE TOOL

- System Curve tool
  - Easy way of checking system curve at pumps in open zones
  - Added complexity in closed zones with an elevated tank to set the hydraulic grade line





03

Case Study

Case Study

WPUD1 WTP1: High Head Pump Station

Ferndale, WA

Whatcom County PUD No. 1 (WPUD1)

Water Treatment Plant 1 (WTP1)

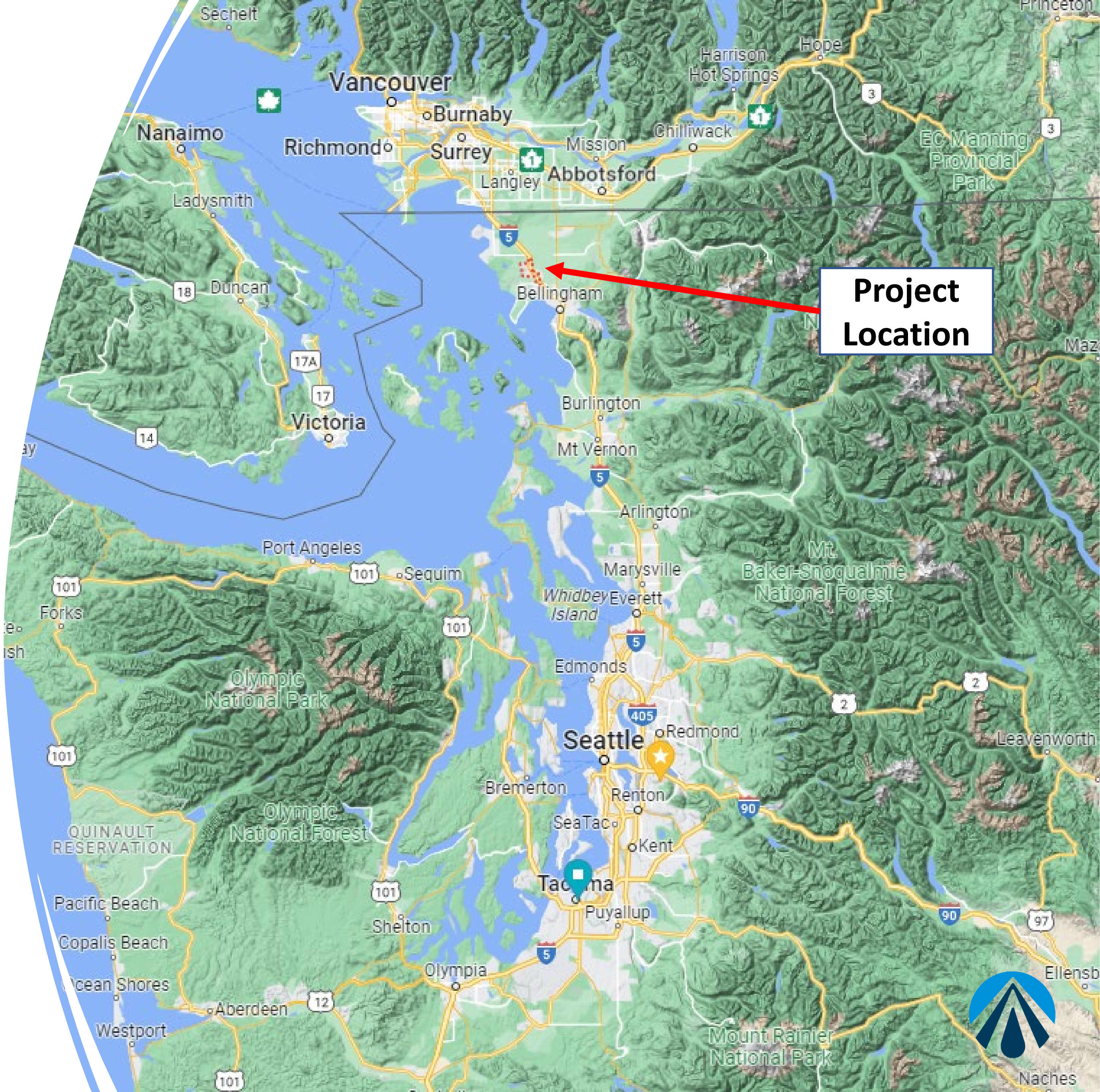
High Head Pump Station (HHPS)

Preliminary design of a 21 MGD pump station in a closed water system

WPUD1 WTP1 HHPS

Background

- Location: Ferndale, WA
- Non-potable water (industrial and irrigation customers)

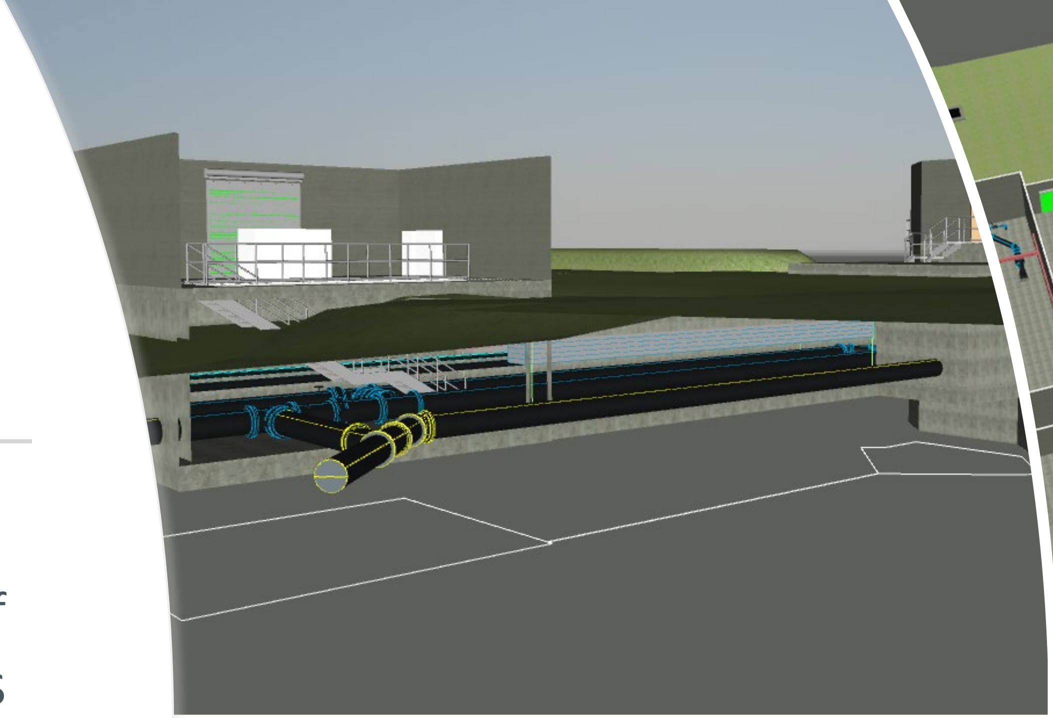


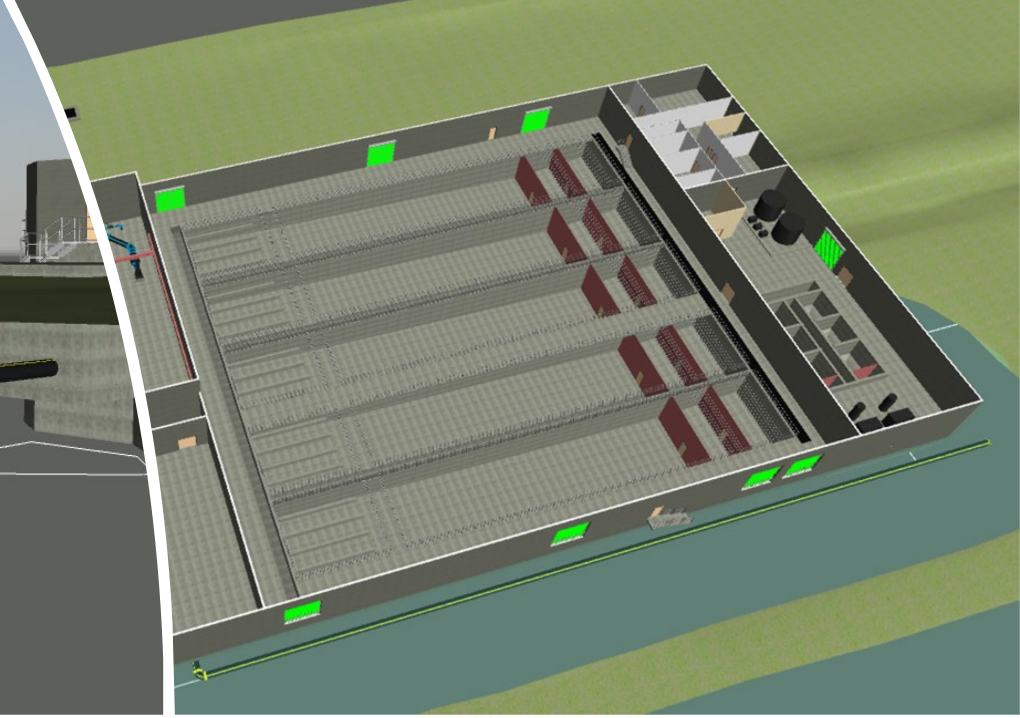
WPUD1 WTP1 HHPS

Case Study

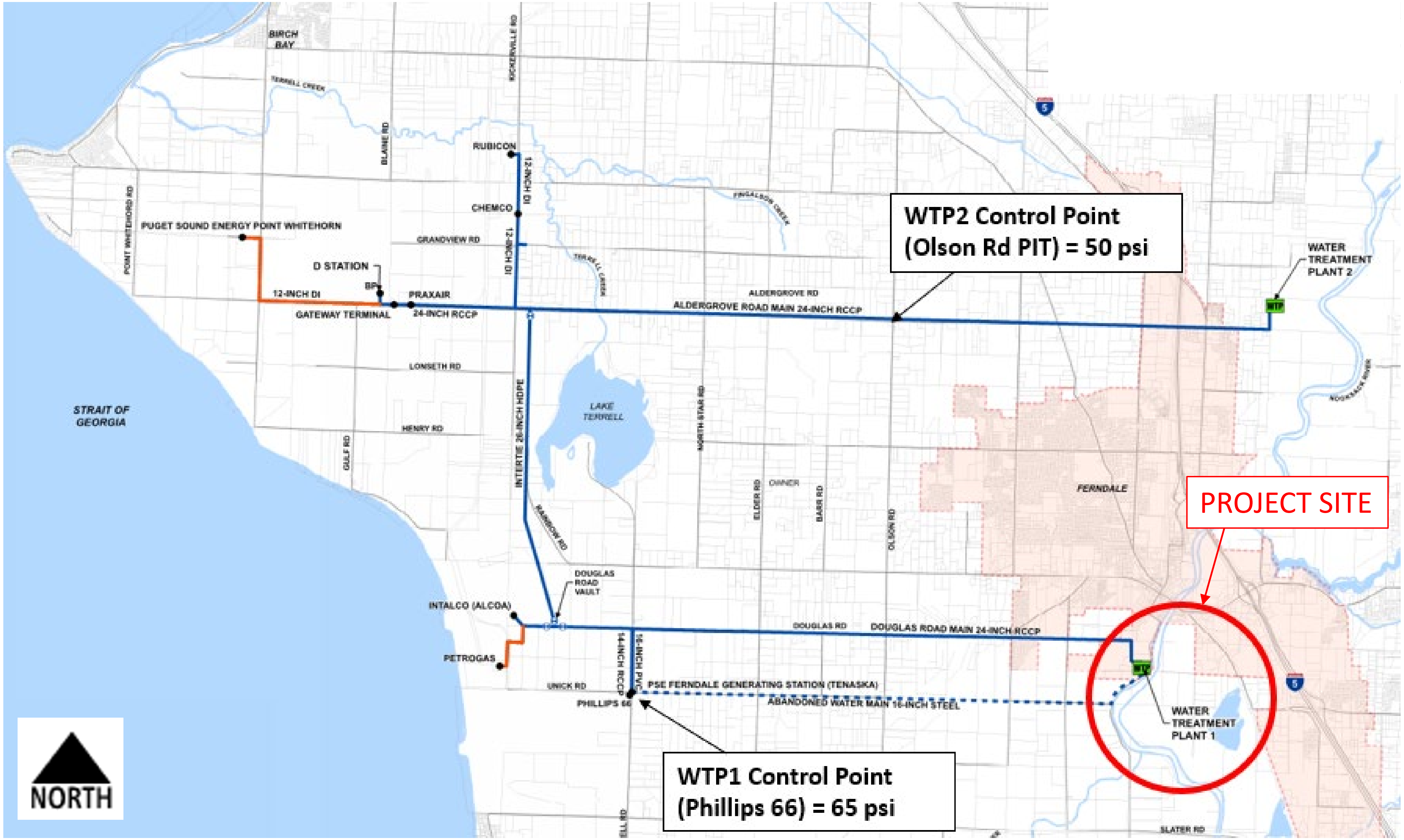
PROPOSED IMPROVEMENTS

- Complete replacement of WTP1 including the HHPS
- Increase capacity of WTP1 to 21 mgd
- Full redundancy
- Transmission main improvements (from CIP)



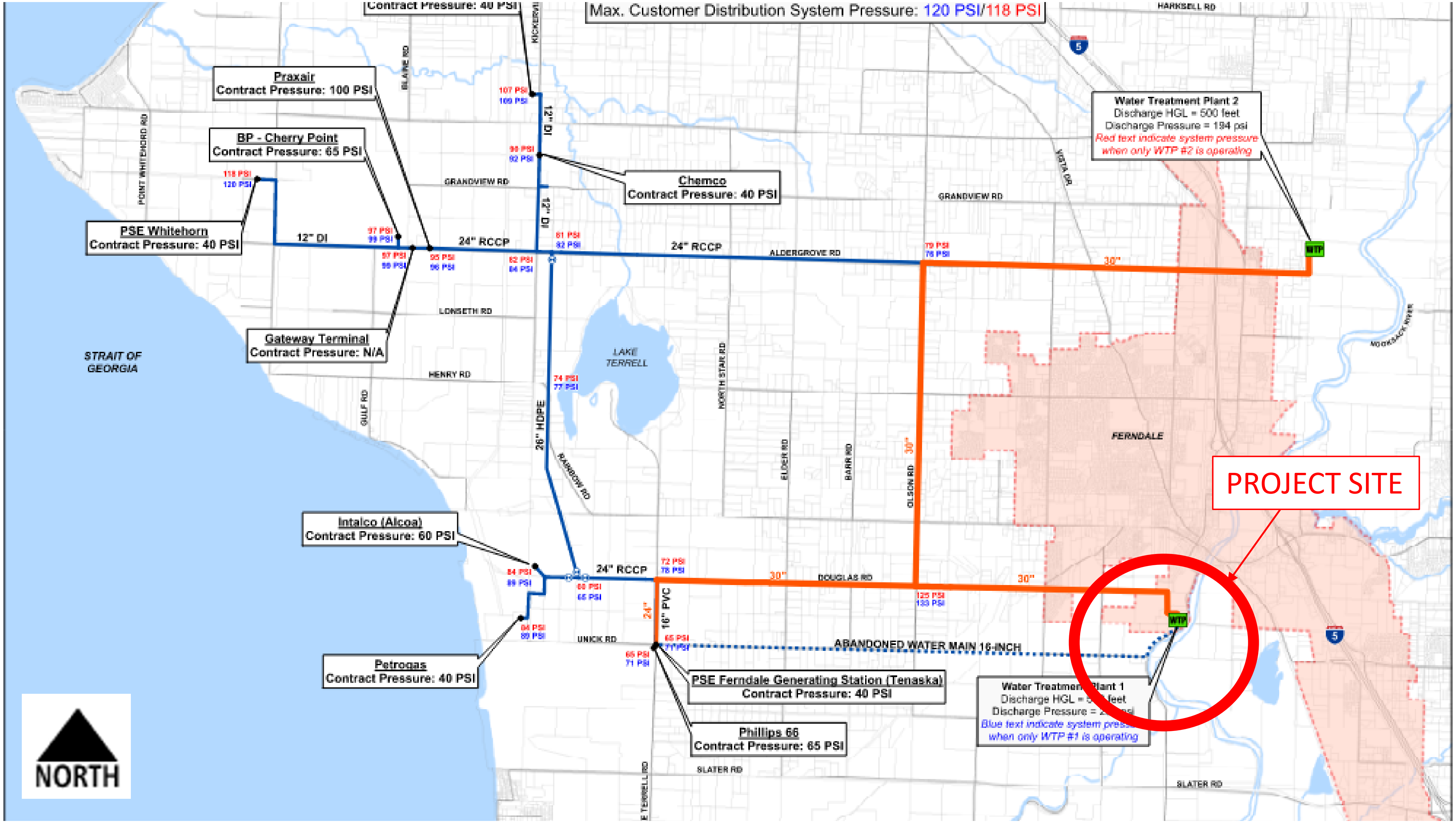


Existing



WTP2 Control Point
(Olson Rd PIT) = 50 psi
WTP1 Control Point
(Phillips 66) = 65 psi
PROJECT SITE
NORTH
WATER TREATMENT PLANT 2
WATER TREATMENT PLANT 1
STRAIT OF GEORGIA
LAKE TERRELL
FERNDALE
BIRCH BAY
PUGET SOUND ENERGY POINT WHITEHORN
D STATION
BP
PRAXAIR
GATEWAY TERMINAL
12-INCH DI
24-INCH RCCP
RUBICON
CHEMCO
GRANDVIEW RD
ALDERGROVE RD
ALDERGROVE ROAD MAIN 24-INCH RCCP
LONSETH RD
HENRY RD
INTERTIE 26-INCH HDPE
DOUGLAS ROAD VAULT
INTALCO (ALCOA)
PETROGAS
DOUGLAS RD
DOUGLAS ROAD MAIN 24-INCH RCCP
UNICK RD
PHILLIPS 66
PSE FERNDALE GENERATING STATION (TENASKA)
ABANDONED WATER MAIN 16-INCH STEEL
14-INCH RCCP
16-INCH PVC
SLATER RD

Proposed



Max. Customer Distribution System Pressure: 120 PSI/118 PSI
Praxair
Contract Pressure: 100 PSI
BP - Cherry Point
Contract Pressure: 65 PSI
PSE Whitehorn
Contract Pressure: 40 PSI
Chemco
Contract Pressure: 40 PSI
Gateway Terminal
Contract Pressure: N/A
Intalco (Alcoa)
Contract Pressure: 60 PSI
Petrogas
Contract Pressure: 40 PSI
PSE Ferndale Generating Station (Tenaska)
Contract Pressure: 40 PSI
Phillips 66
Contract Pressure: 65 PSI
Water Treatment Plant 2
Discharge HGL = 500 feet
Discharge Pressure = 194 psi
Red text indicate system pressure when only WTP #2 is operating
Blue text indicate system pressure when only WTP #1 is operating
PROJECT SITE
ABANDONED WATER MAIN 16-INCH
24" RCCP
12" DI
36" HDPE
16" PVC
30"
STRAIT OF GEORGIA
LAKE TERRELL
FERNDALE
GRANDVIEW RD
ALDERGROVE RD
LONSETH RD
HENRY RD
DOUGLAS RD
UNICK RD
SLATER RD
NORTH

Case Study

Objectives

Design Tasks

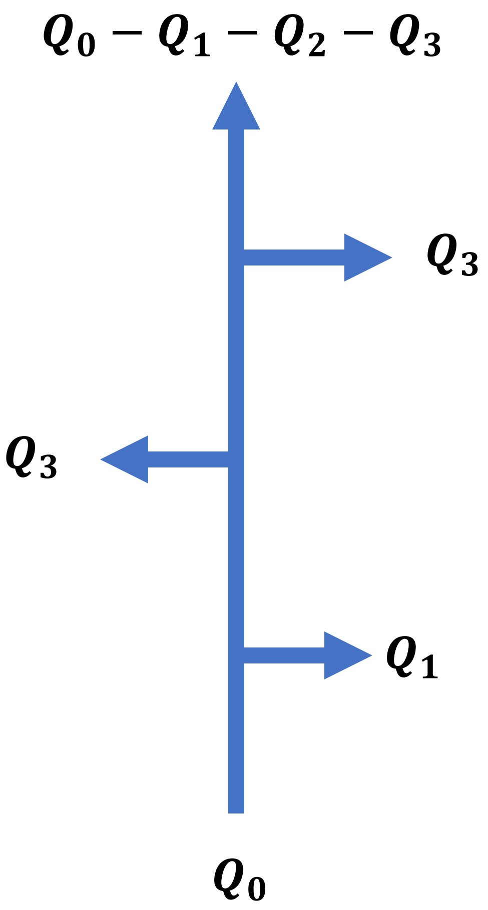
1. Develop system curve for existing and future operating scenarios (based on CIP)
2. Use system curve to select type and number of pumps to cover full operating range
3. Verify pressure in pipe does not exceed pipe rating
4. Advise client on pump operating constraints

Case Study

Objectives

Why use a model?

1. Pumps will have massive power requirement (~1000 hp), don’t want to oversize
2. The model will provide more dynamic platform for testing multiple scenarios:
    a) Multiple supply sources
    b) Existing vs. future
    c) Flow loss along the transmission main

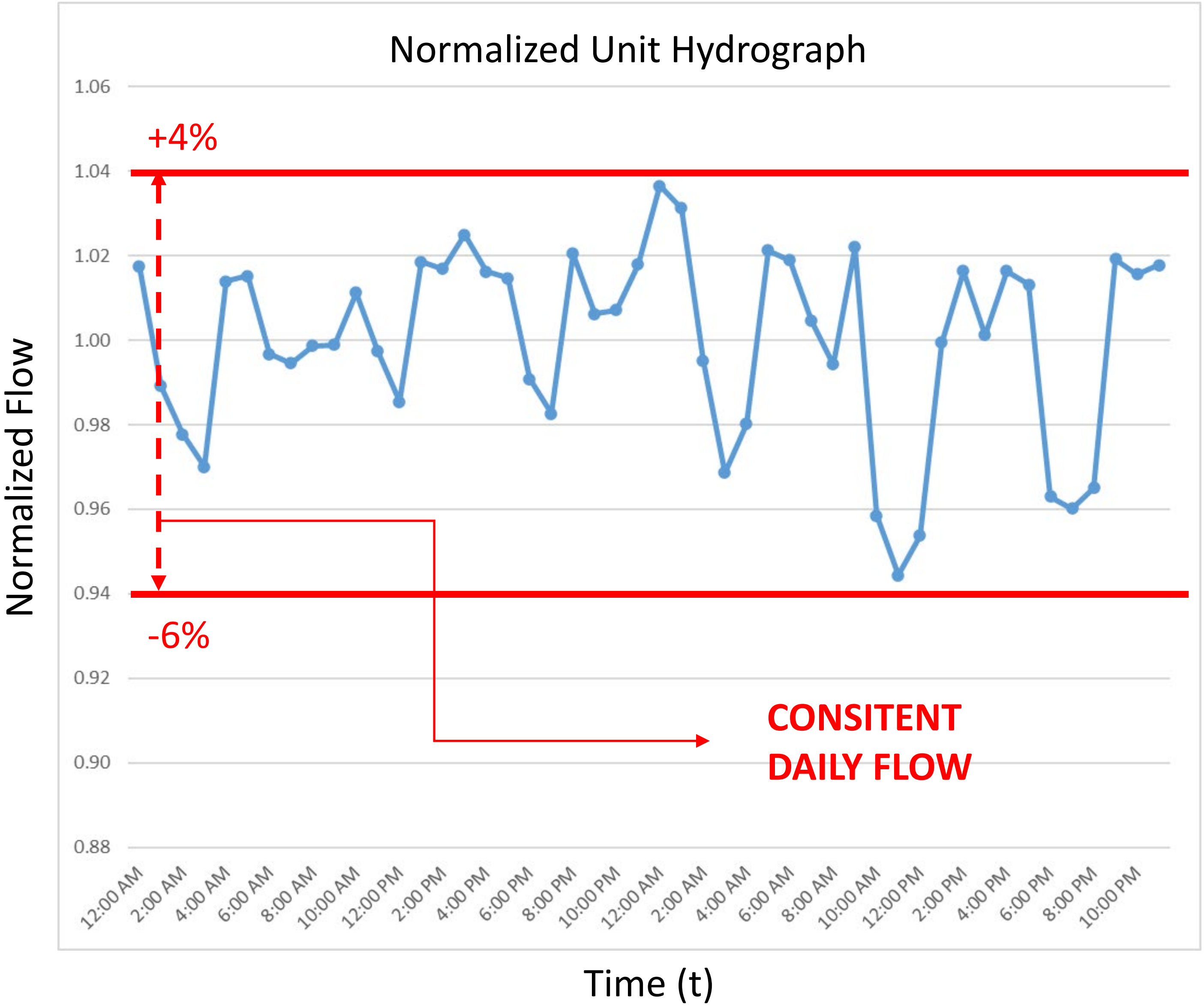


Modeling Steps

1. Data analysis
2. Model set up
3. Scenario management
4. Verification of model results
5. System curve development
6. Pump selection

Case Study

Data Analysis

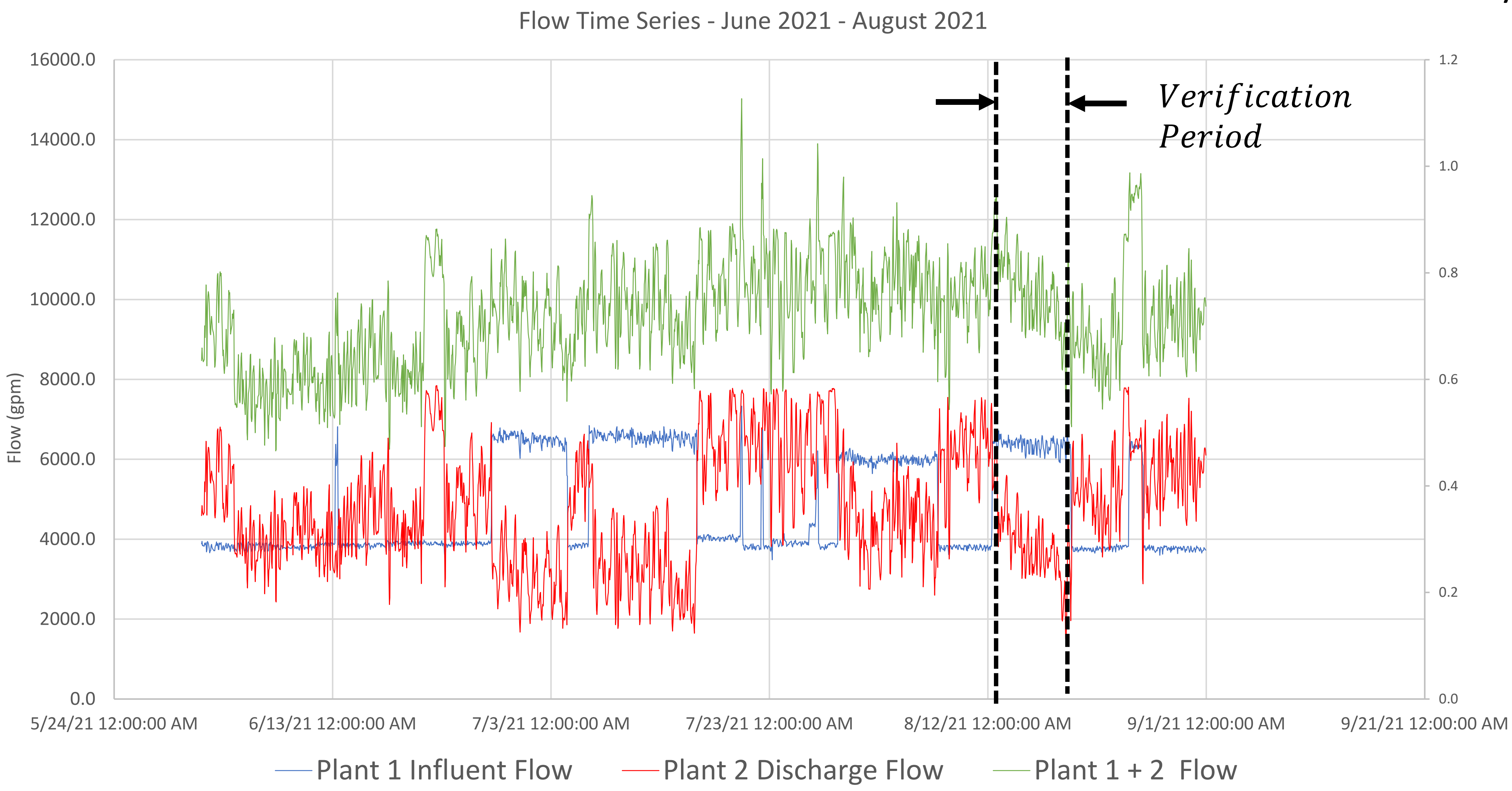


FLOW PATTERNS

- Daily demand fluctuations
- Peaking factors
- Industrial customers operate more **consistently** than residential
- Water balance

Case Study

Data Analysis

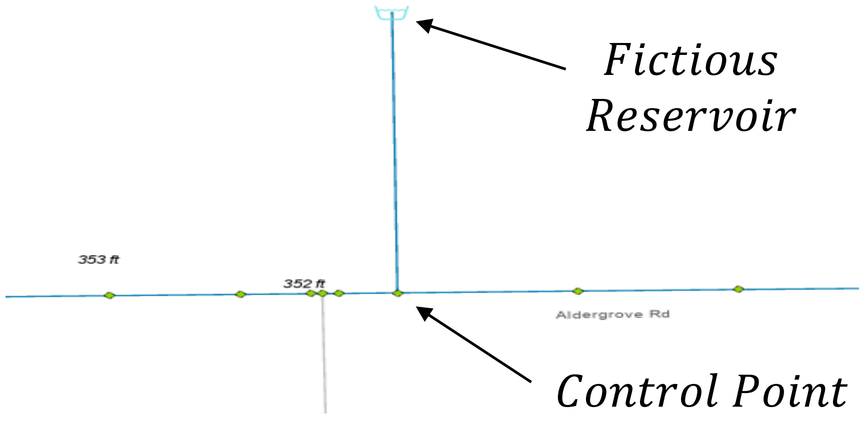


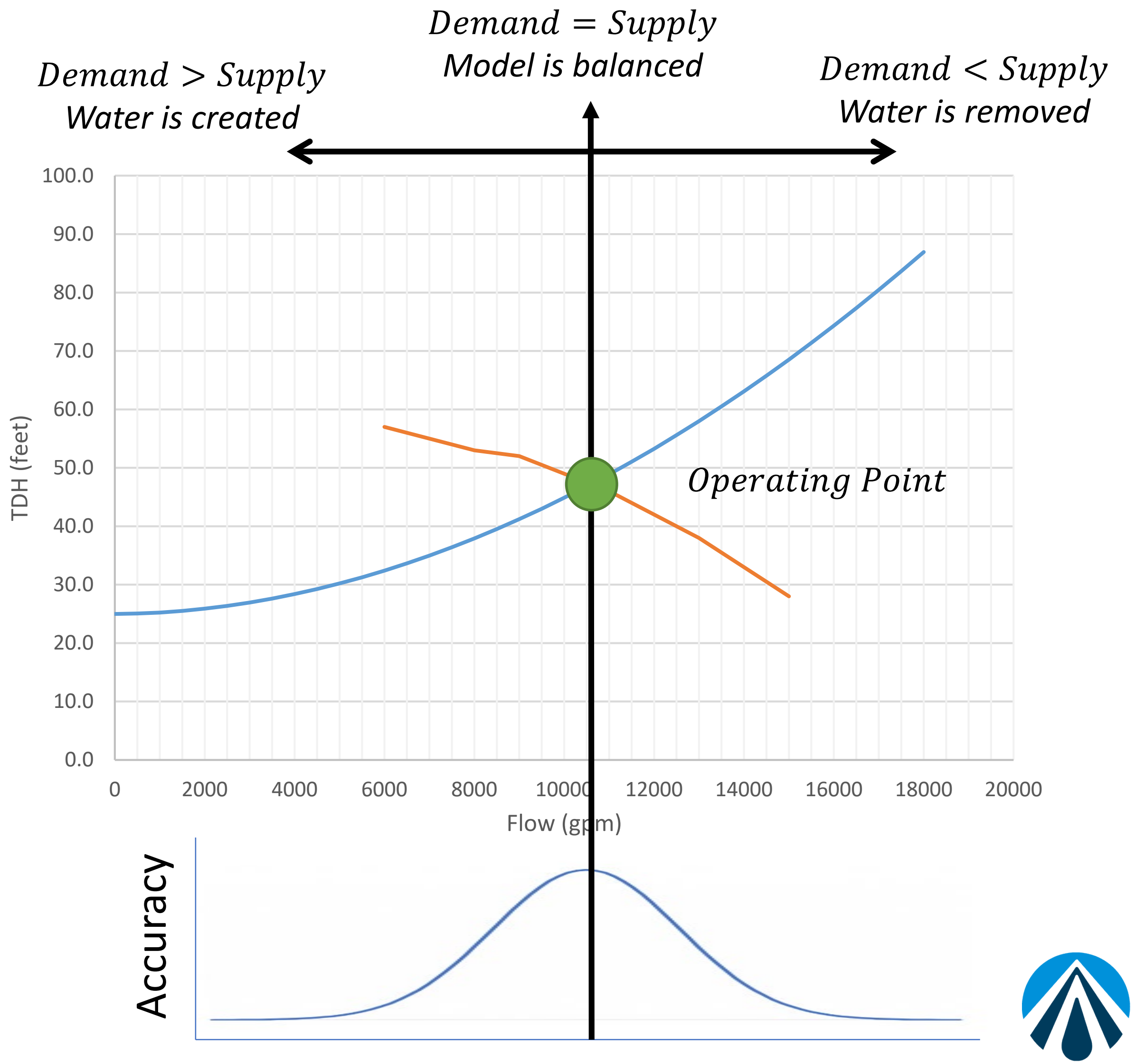
Case Study

Model Set Up

CONTROL POINTS

- Fictious reservoirs:
  - Set HGL at control points
  - Balance supply / demand
- (Pro) Know we're hitting the correct pressure at the control point
- (Con) Accuracy decreases the further away from exact demand





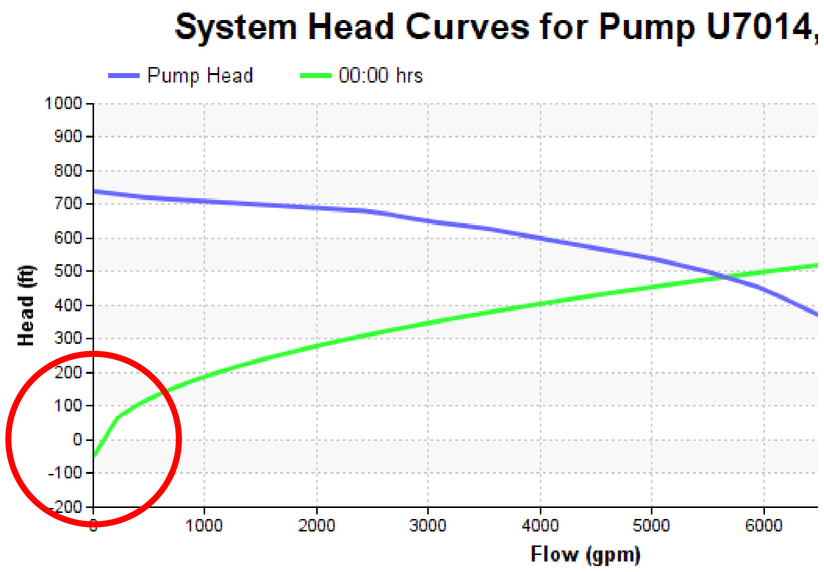
Case Study

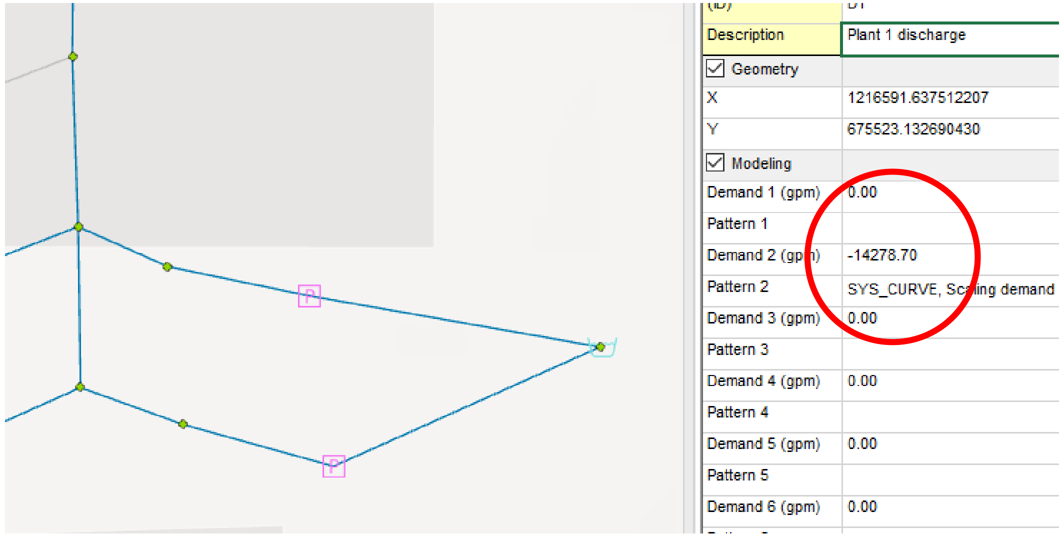
Model Set Up

INJECTIONS

- Check system curve by plotting a series of injections at different flow rates
- If negative pressures are shown, something is probably wrong
  - Indication that the results at those flow conditions are inaccurate

Always ask: Does the system curve make sense???





Case Study

Scenario Management

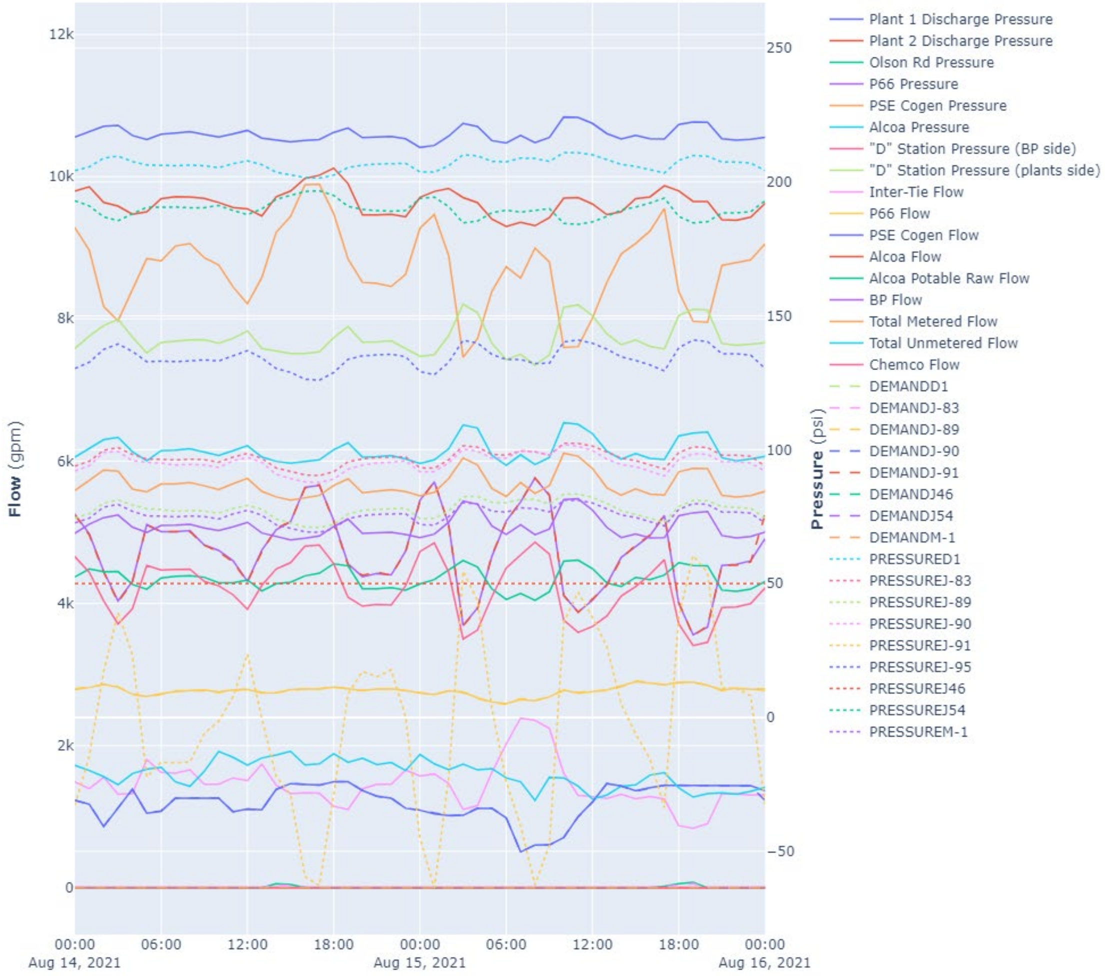
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
WTP	WTP1 online WTP2 offline	WTP1+2 online (normal operating condition)	WTP 1 online	WTP2 online WTP 1 offline
Demands	Operating Demand (21 MGD)	Each WTP splitting operating demand (10.25 MGD each)	Southern customers only at operating demand (7.8 MGD)	Operating Demand (21 MGD)
Intertie	Open	Open	Closed	Open
Piping	Existing/Future	Existing/Future	Existing/Future	Existing/Future

Case Study

Model Verification

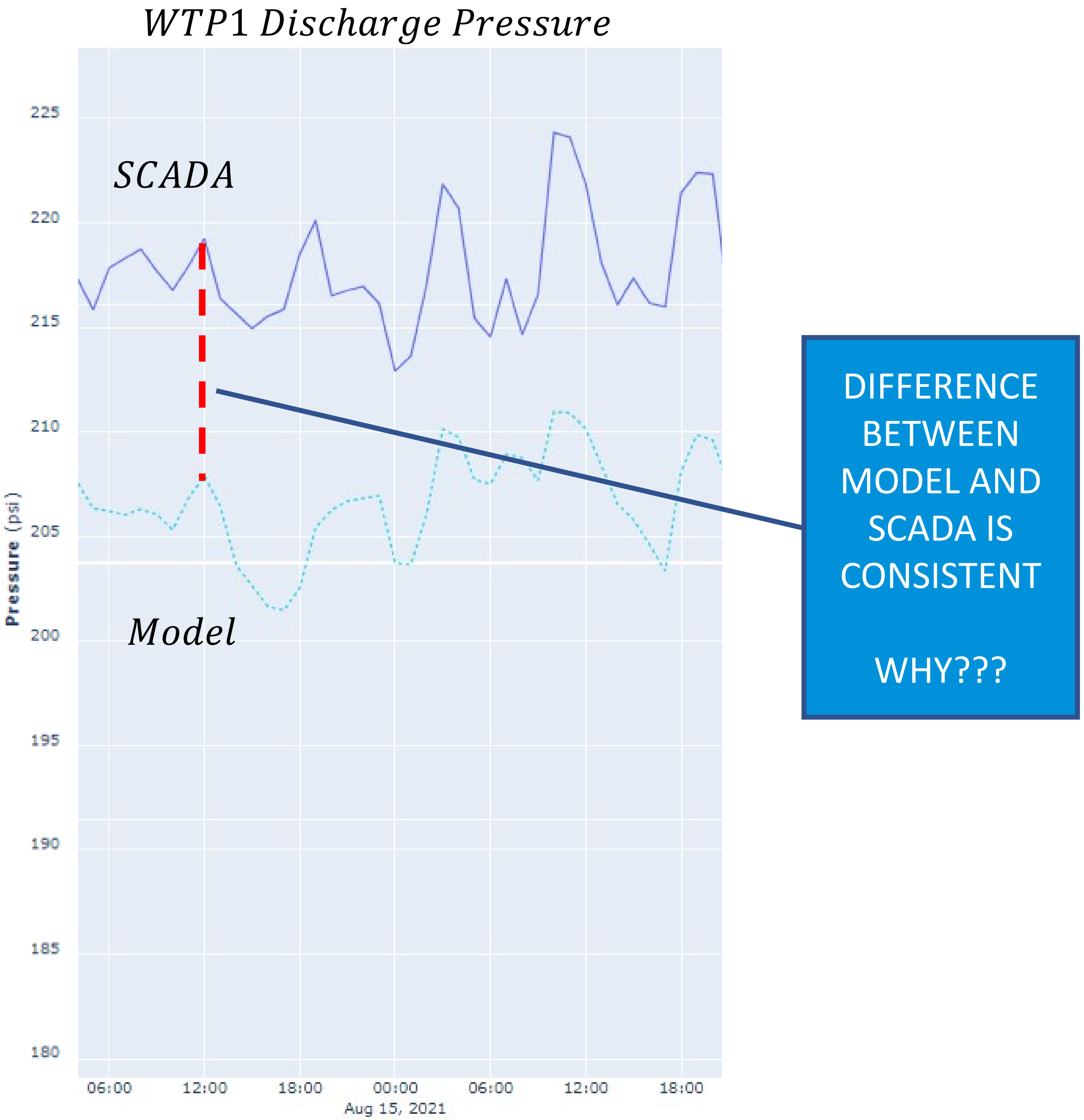
Pump Flows

All Demands and Pressures

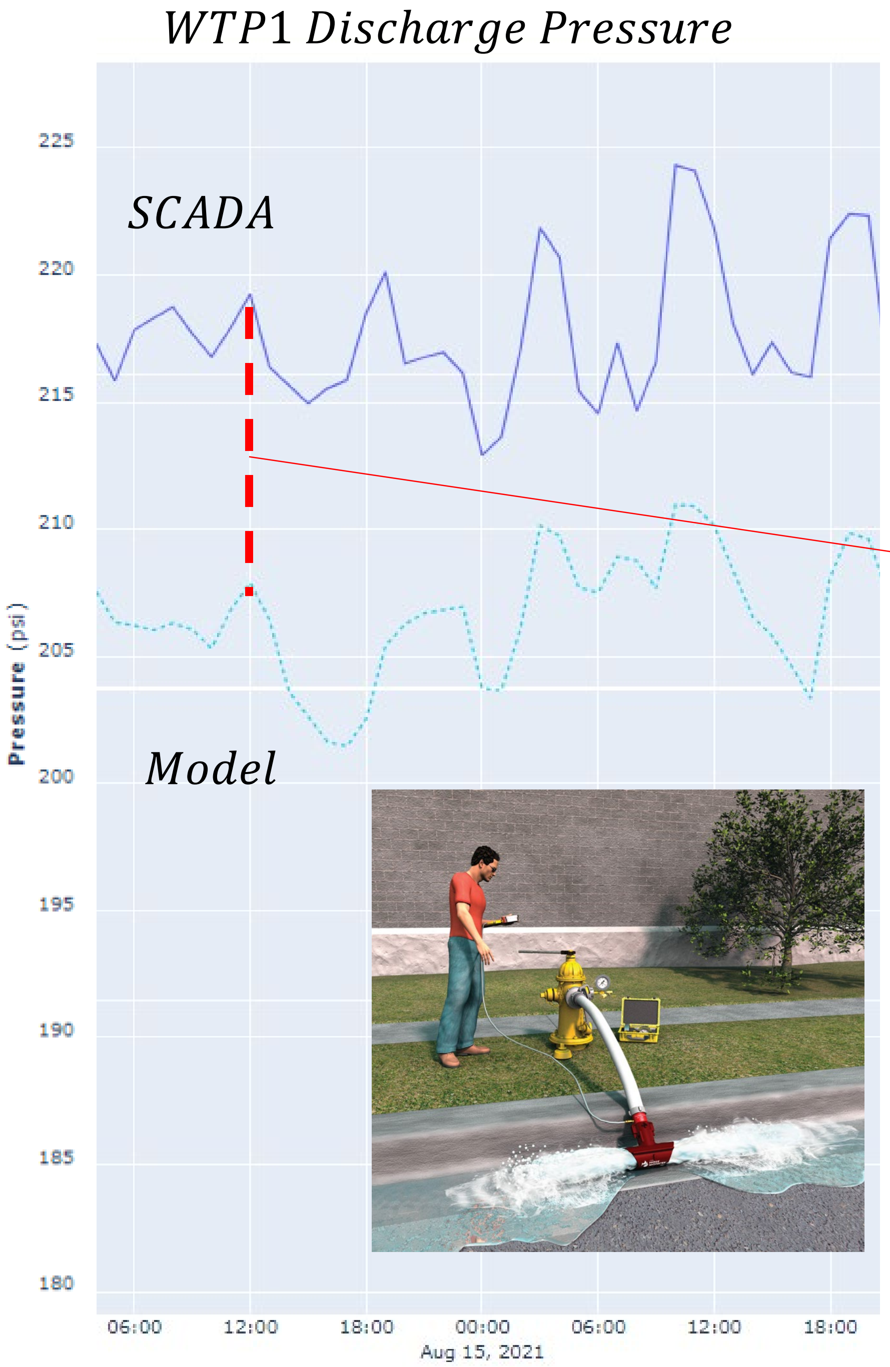


Case Study

Model Verification



- Compare SCADA readings to model output with scripting
- Used Root-Mean-Square analysis to understand if model results are acceptable
- Target < 5%



Case Study

Model Verification

SCADA > MODEL

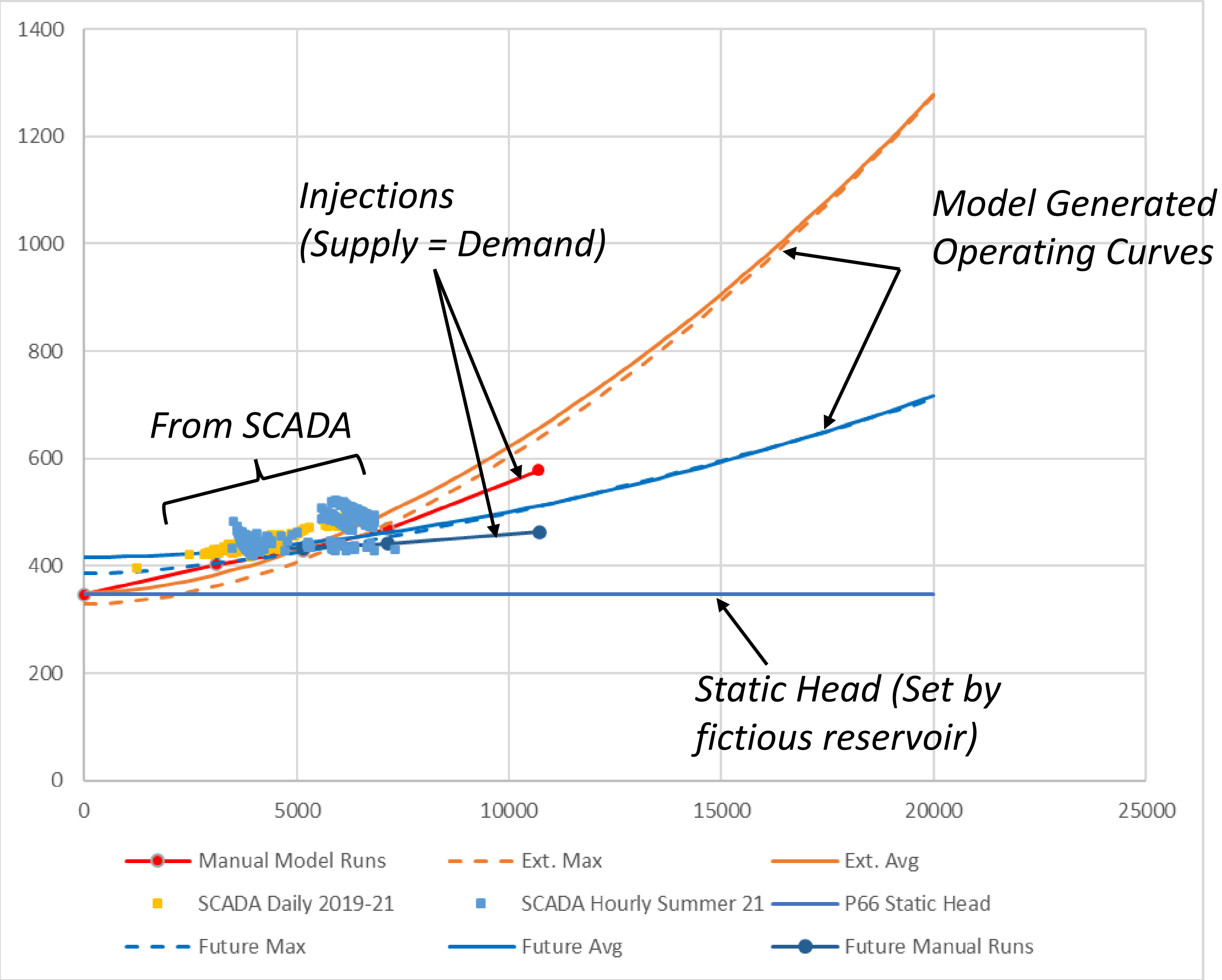
- Aging existing pumps no longer operating on their original pump curve
- Different number of pumps operating than expected
- Manual operation / throttling
- Inaccurate elevations at pump stations or service connections

SCADA < MODEL

- Not enough losses in the pipeline (Partially closed valves, Hazen “C” value)
- Additional field tests may be required

Case Study

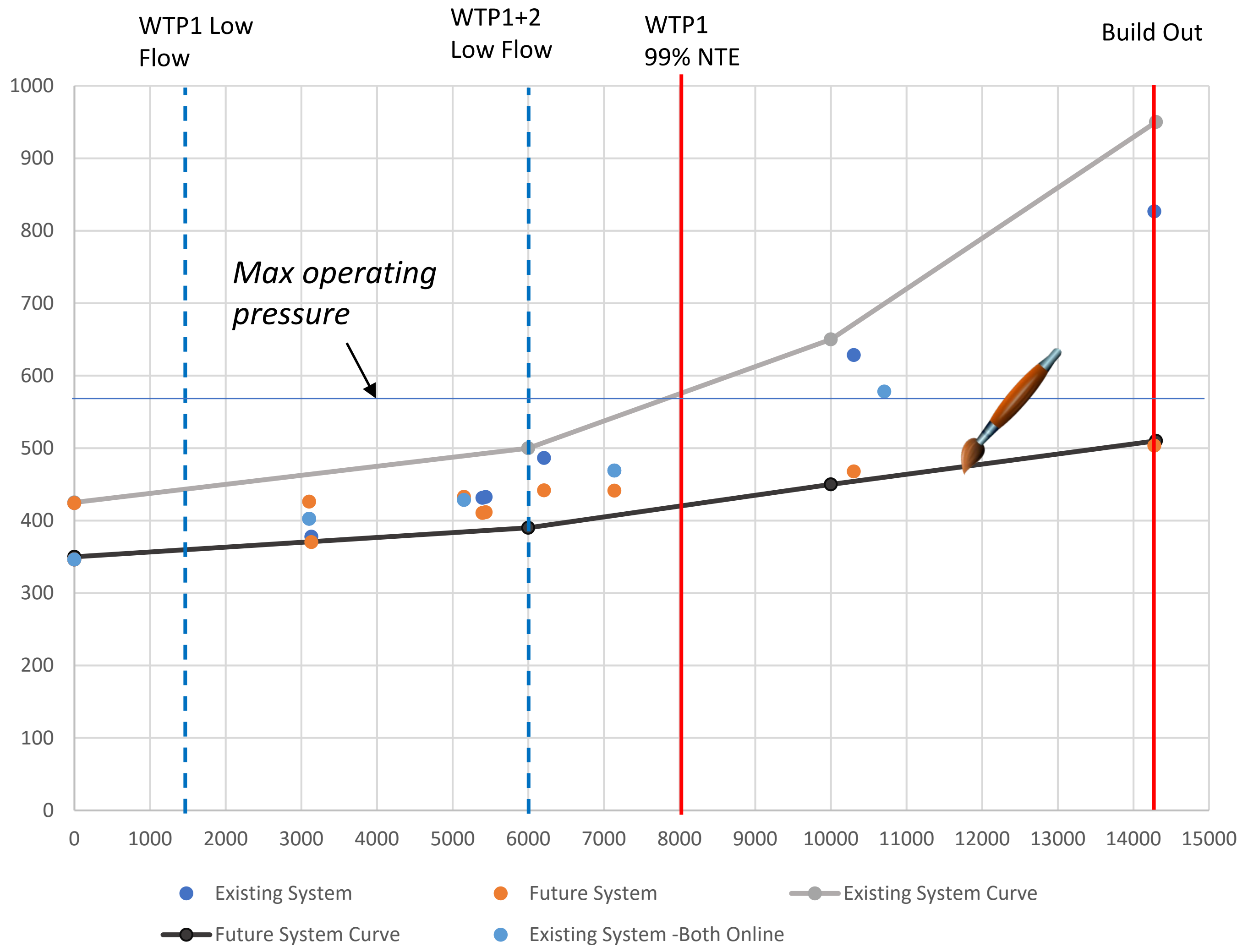
System Curve Development



- At this point, our injections, model generated operating curves, and SCADA data is lining up
- Now we need to define boundary conditions (high and low curve)

Case Study

System Curve Development



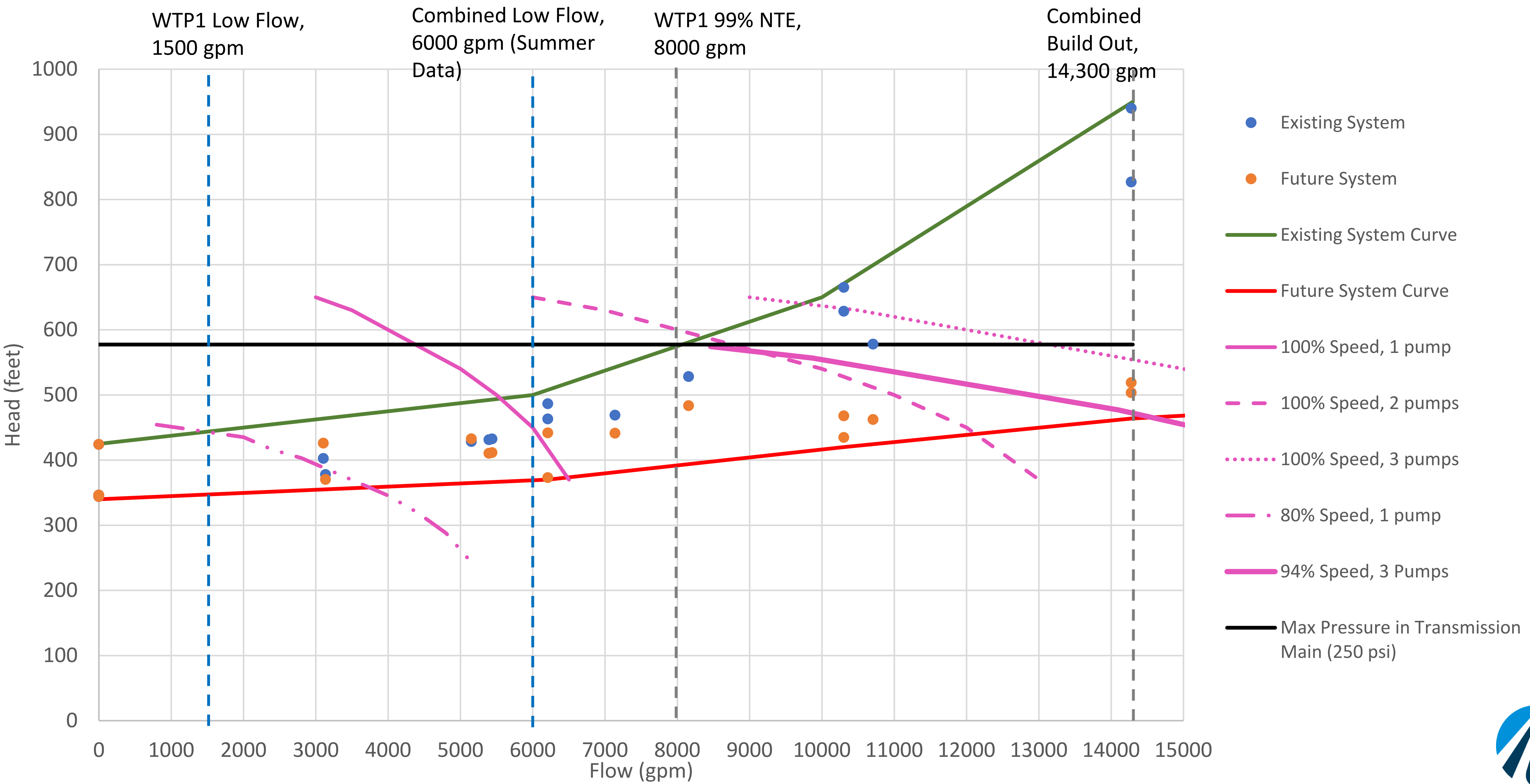
- Channel your inner artist!

PUMP SELECTION

- Choosing pump style
    - Split-case horizontal
    - Vertical turbine
- Determine number of pumps (firm capacity)
- Variable frequency drives (VFDs)
- Understand power limitations
- Phasing of pump installation
- Plan for build out

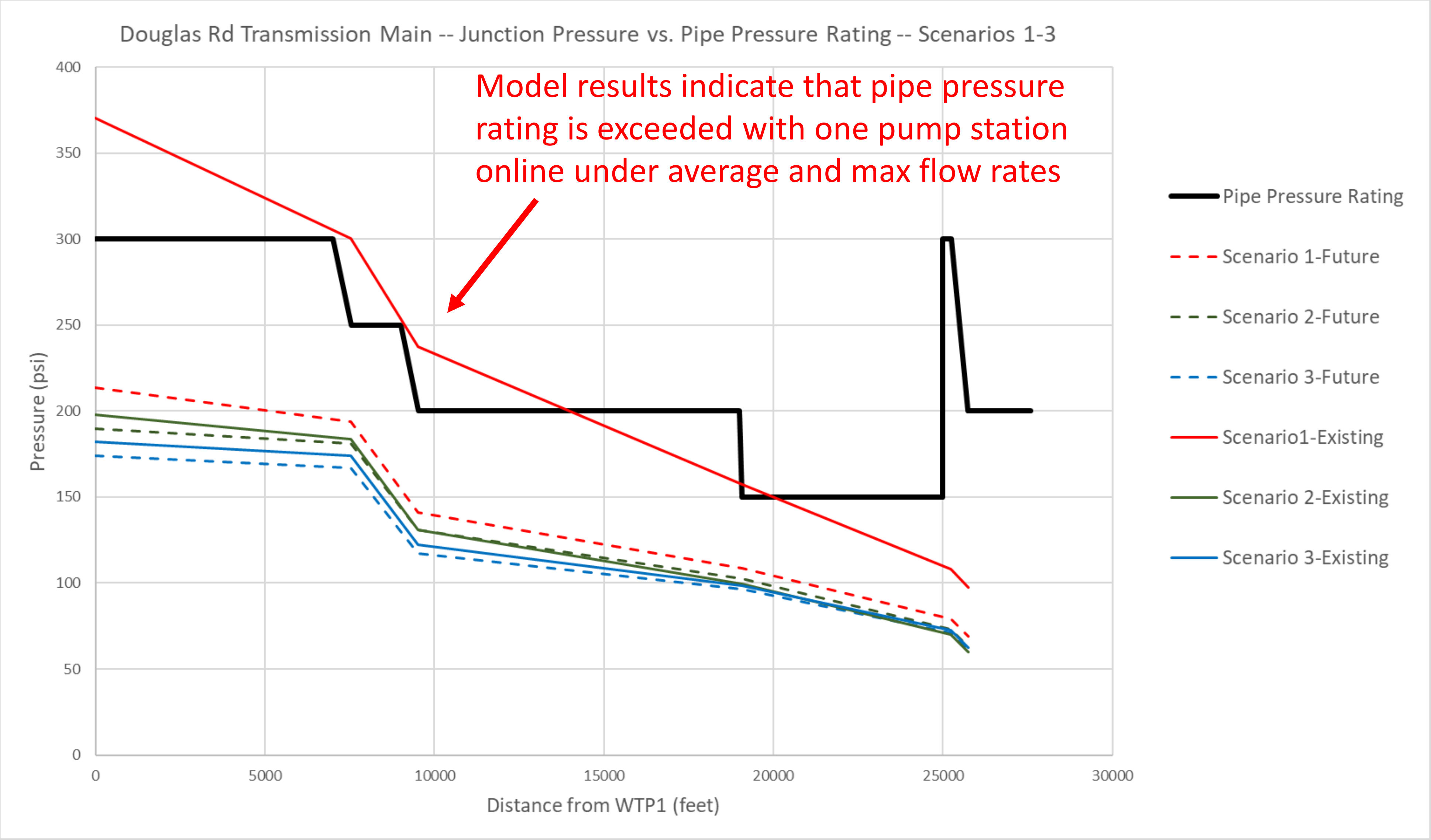
Case Study

Pump Selection



Case Study

Operating Constraints

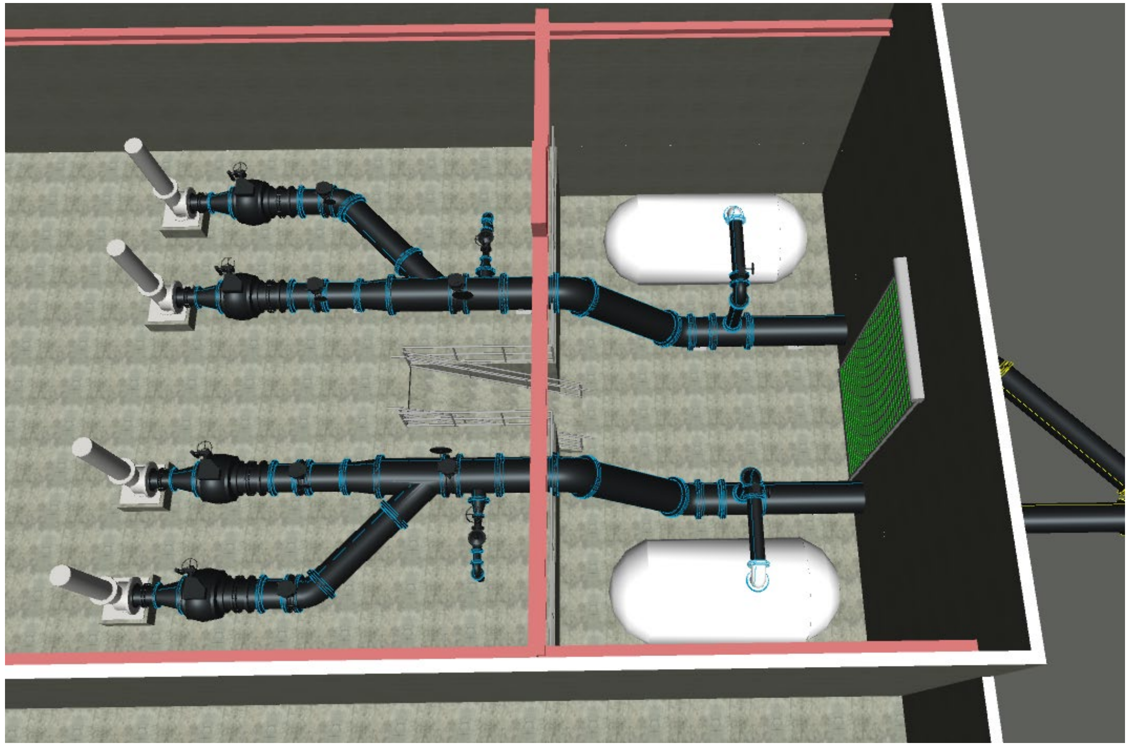


Case Study

Operating Constraints

Summary of Analysis

- Pipe limitations
  - PUD cannot supply 21 mgd until transmission main is upgraded
  - PUD cannot meet south targets with intertie closed and existing piping
- Pump vs. System Curve
  - Three (3) 1000 HP vertical turbine pumps to meet existing conditions (firm)
  - Four (4) pumps to meet future conditions (firm)

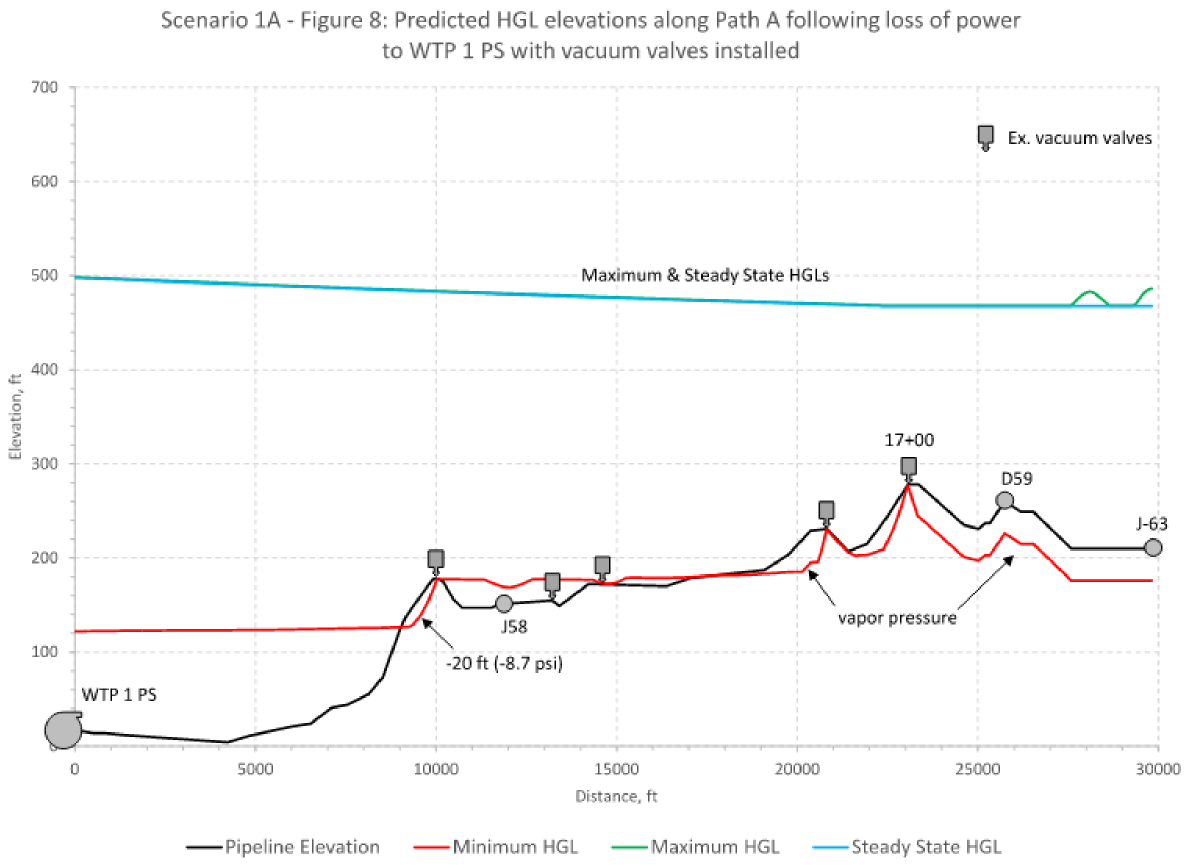


WPUD1 WTP1 HHPS

Case Study

CONTINUED BENEFITS

- Model can be used by the client for futu planning work
    - CIP tracking and updating
    - Development capacity
    - Fine tuning operations
- Can exported to other platforms



04

Key Takeaways

Summary

- Pumps dictate pressure
- Wide range of flow and pressures
- Reacting to system changes
- Setting control points
- Inaccurate results using built in system curve tools

Question #1

- What are the added complexities of designing and modeling pumps in a closed network?

Summary

- Develop operating curves
- Understand boundary conditions
- Scenario management
- Account for network complexities

Question #2

- How can developing a hydraulic model assist with pump design?

Summary

- Maximum operating point
- Number of pumps operating
- Pipe upgrade requirements
- Reservoir, VFD, PRV settings

Question #3

- How can the hydraulic model inform operating constraints?

Thank you!