Bull Run TREATMENT PROJECTS

Our water: Safe and abundant for generations to come

PORTLAND WATER BUREAU

Bull Run Filtration Pipelines Project

Dual Challenges:

Minimizing Head Loss and Optimizing Flow Control

May 3, 2023

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Jacobs
Challenging today.
Reinventing tomorrow.

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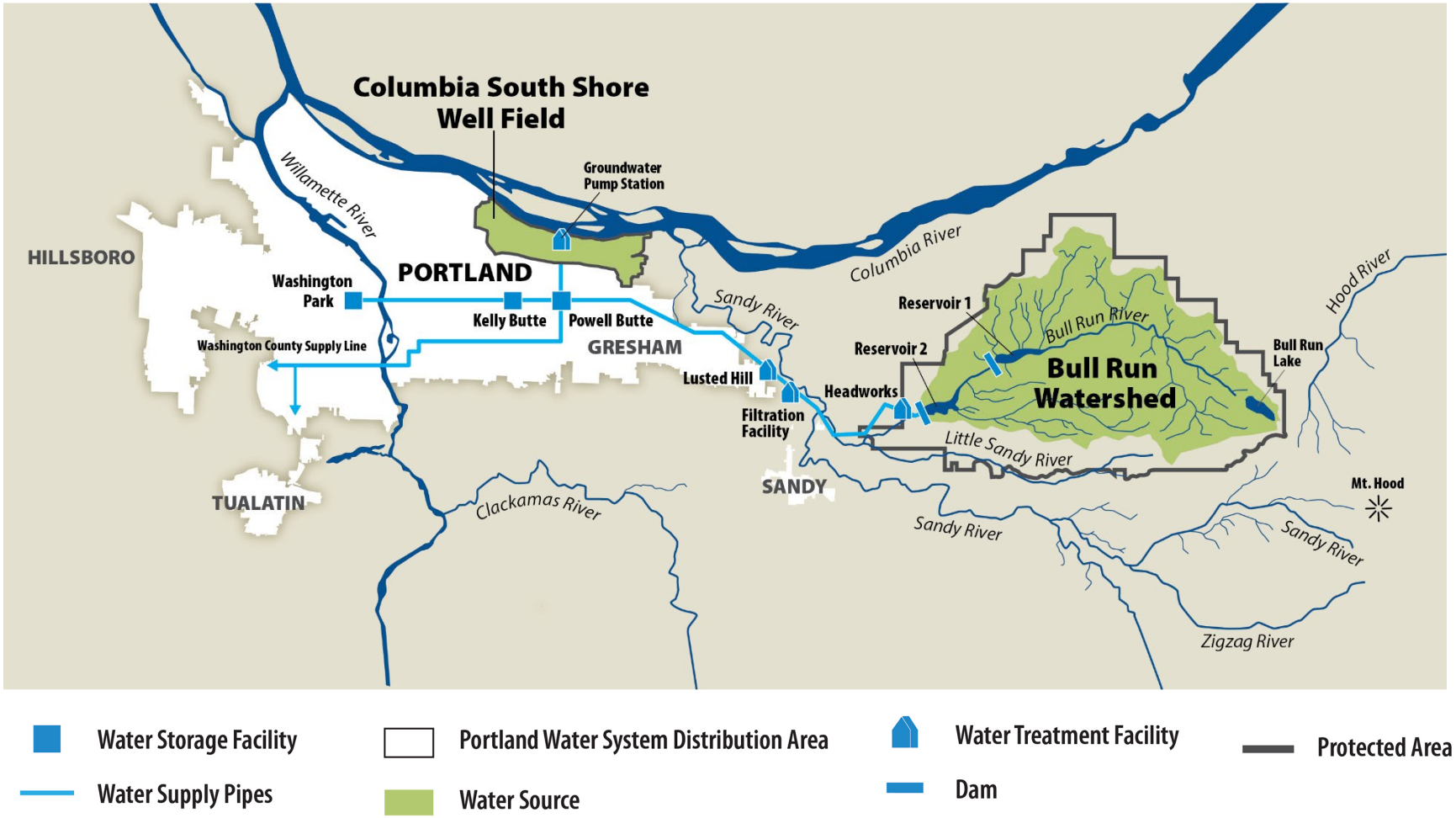
Program Overview

Thanks to thoughtful planning, Bull Run has been a source of **excellent water since 1895**



- Serves almost 1 million people
- Serves the City of Portland and 19 wholesale customers
- Uses 100 million gallons of water on an average day

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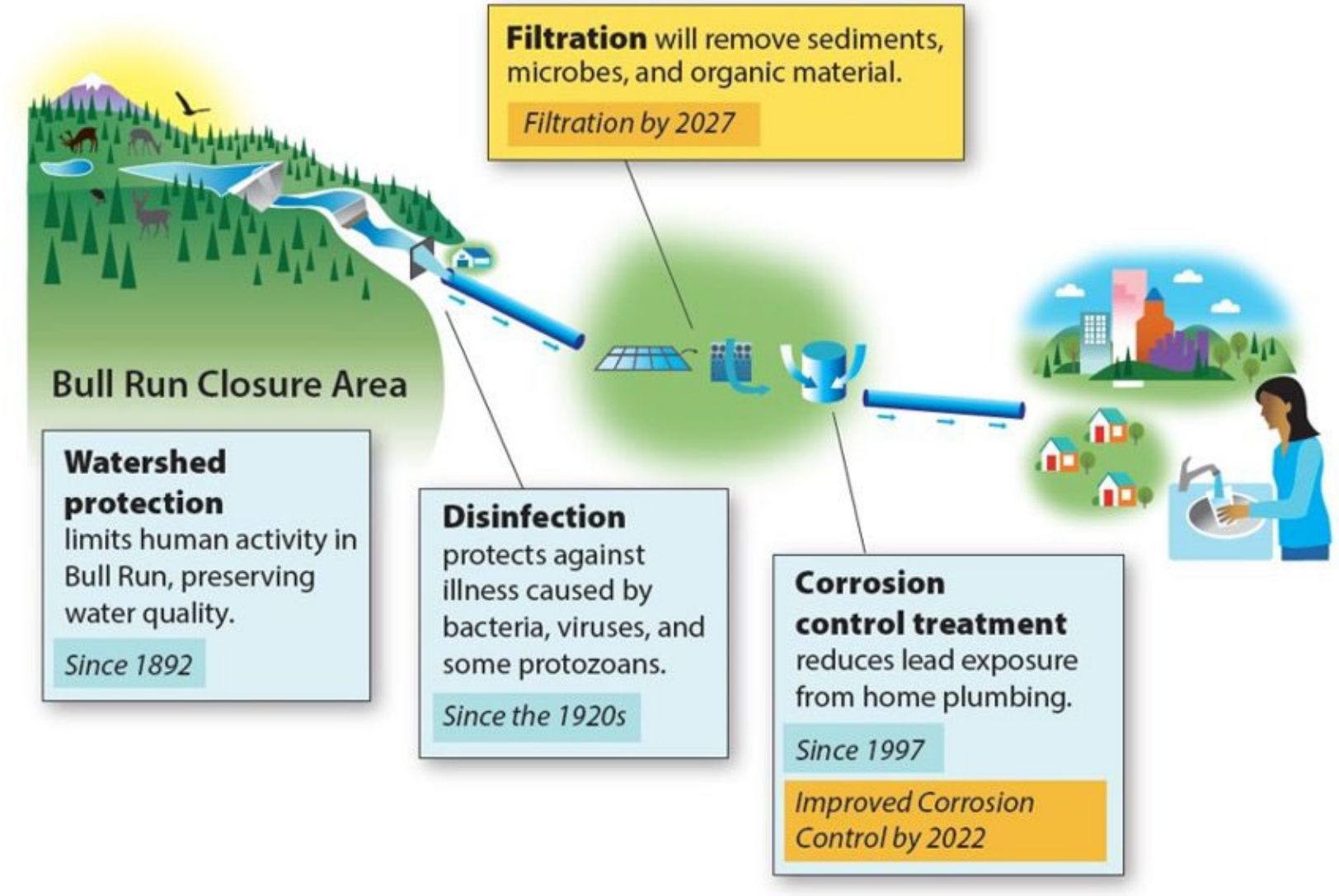
Improvements to our system are needed to meet national drinking water standards



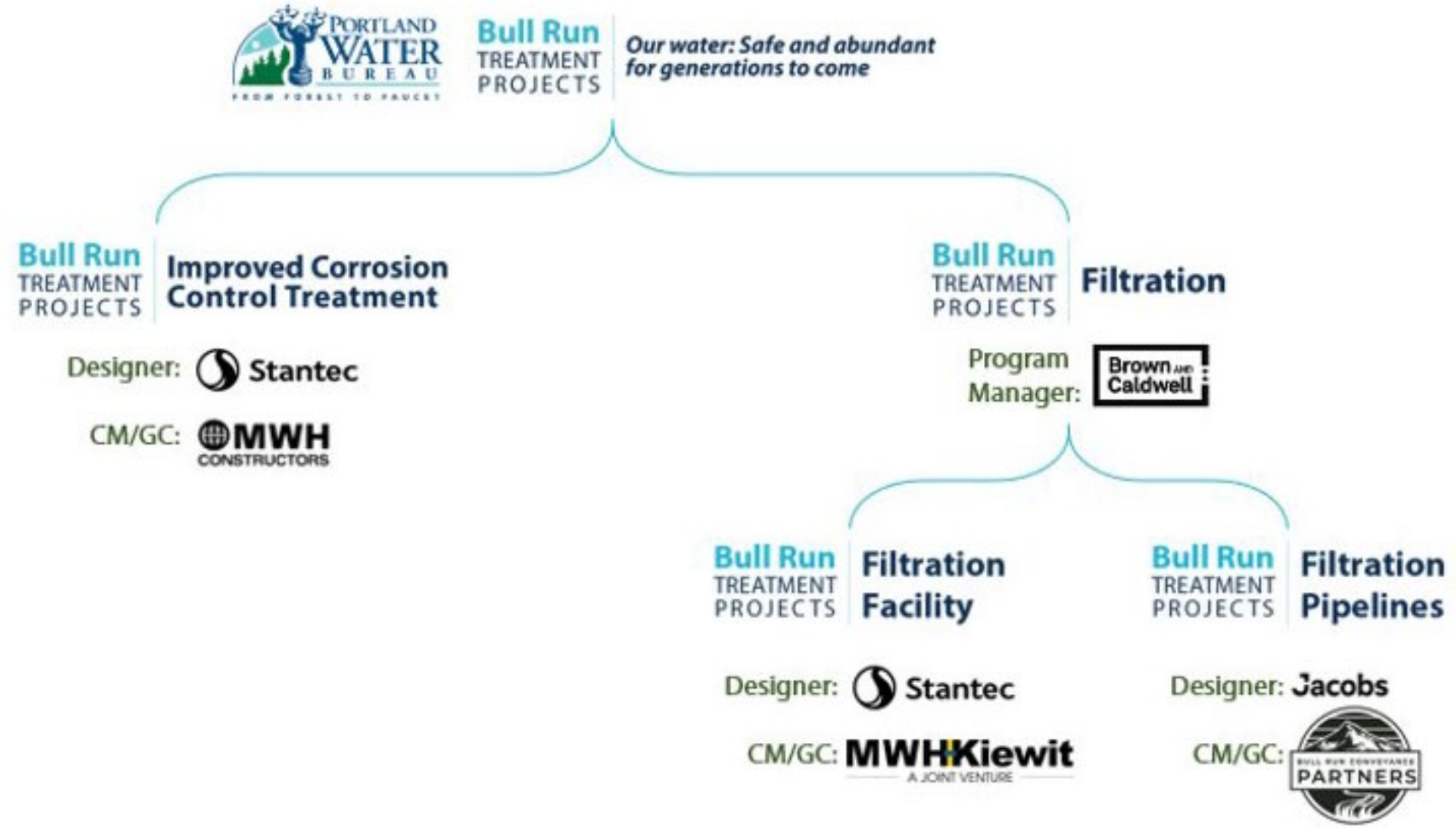
On-track to deliver filtered Bull Run water to customers beginning September 2027

Planning Completed
2018-2020

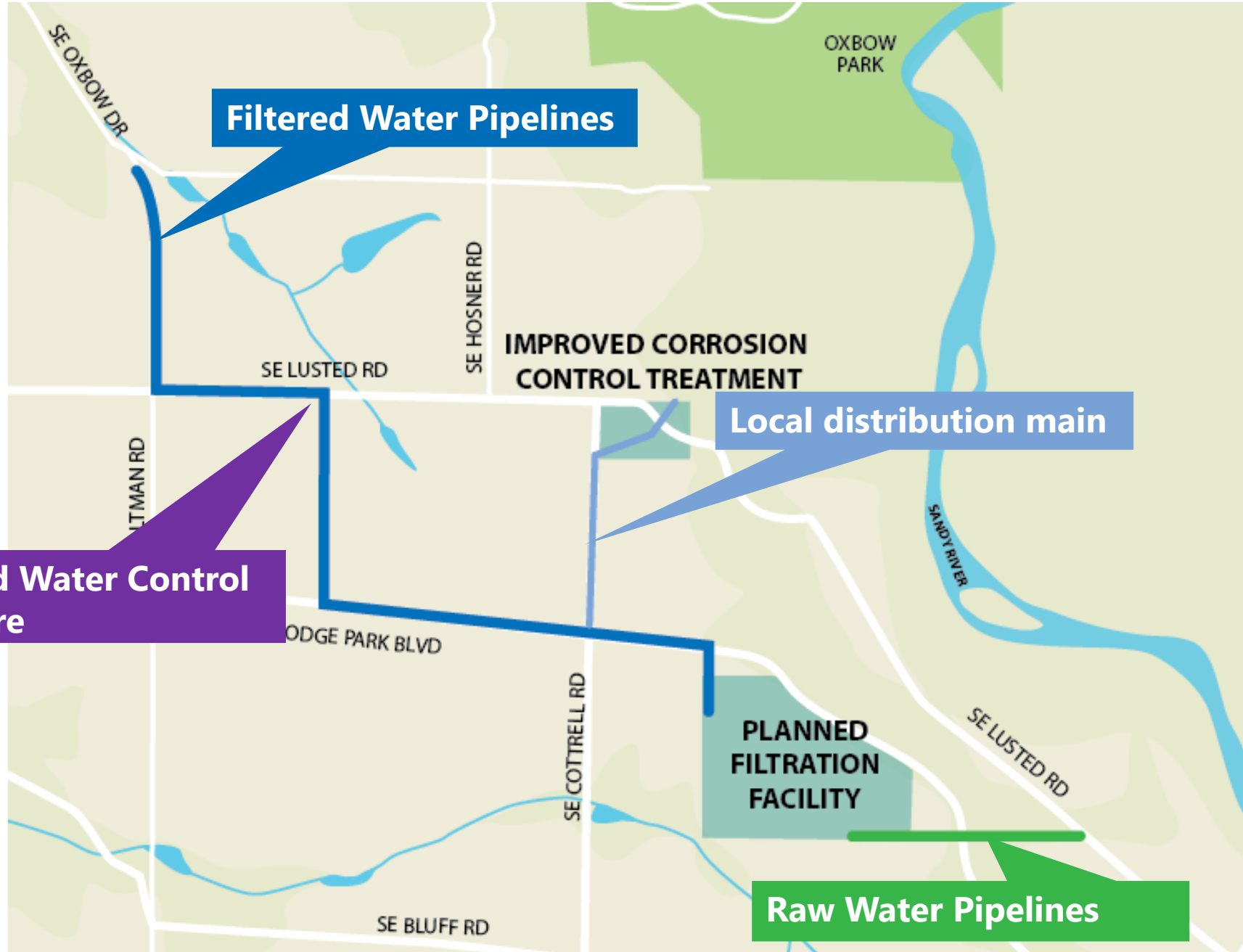
Design Underway
2020-2023

Construction Expected
2023-2027

Bull Run Treatment Projects - Team



New pipelines will tie the water filtration facility into the existing transmission system



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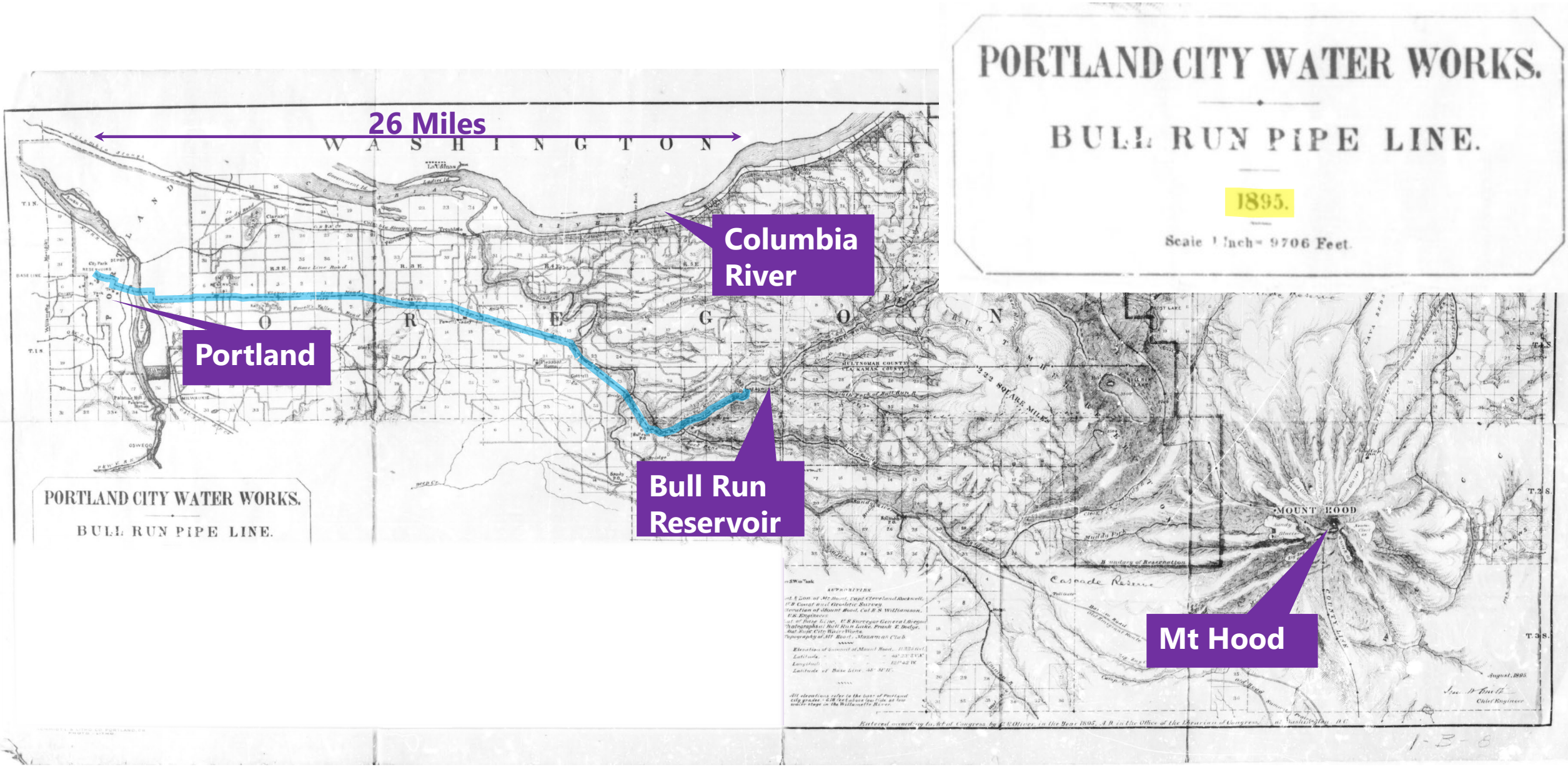
Pipeline Hydraulics & Flow Control Structure

BULL RUN PIPE LINE HYDRAULICS



Existing System Components

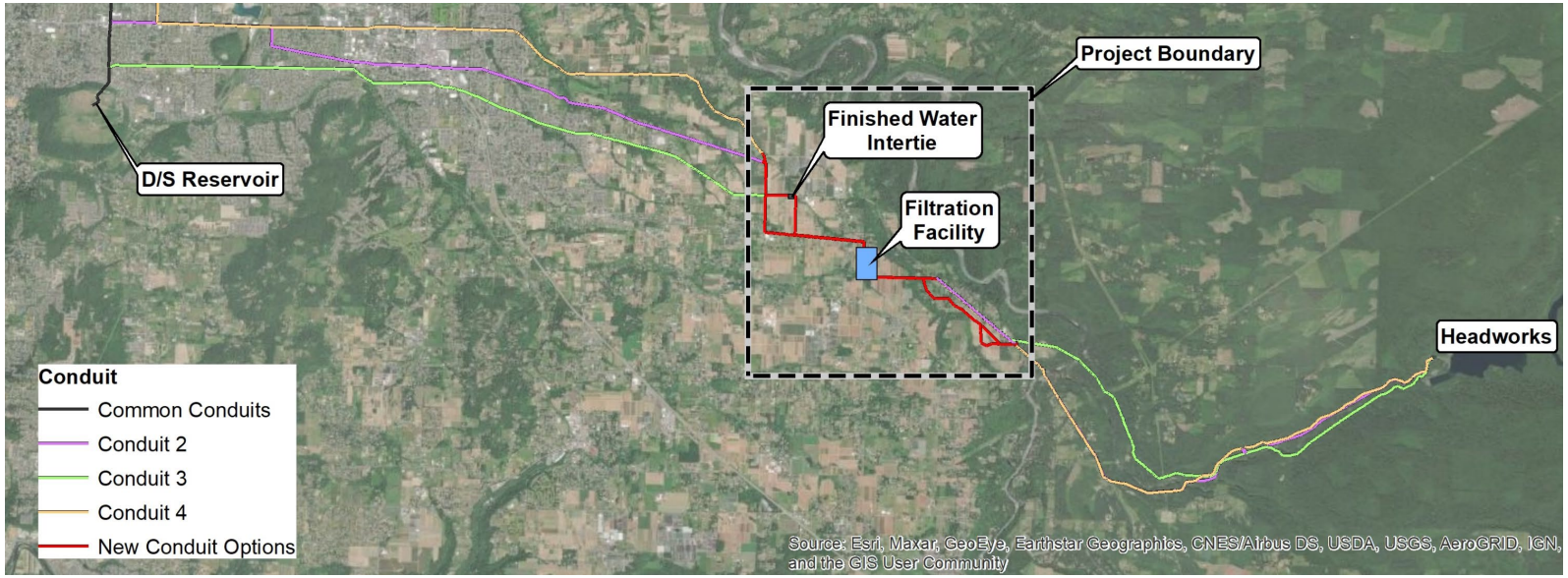
- 3 large conduits (Conduits 1/2/3) from Upstream Headworks to Terminal Reservoirs (~20 miles)
- Consisting of 42 to 72-inch Diameter
- Built between 1910s and 1950s
- Welded Steel, Lockbar Steel, and Riveted Steel

Conduit 1 Construction
1890's

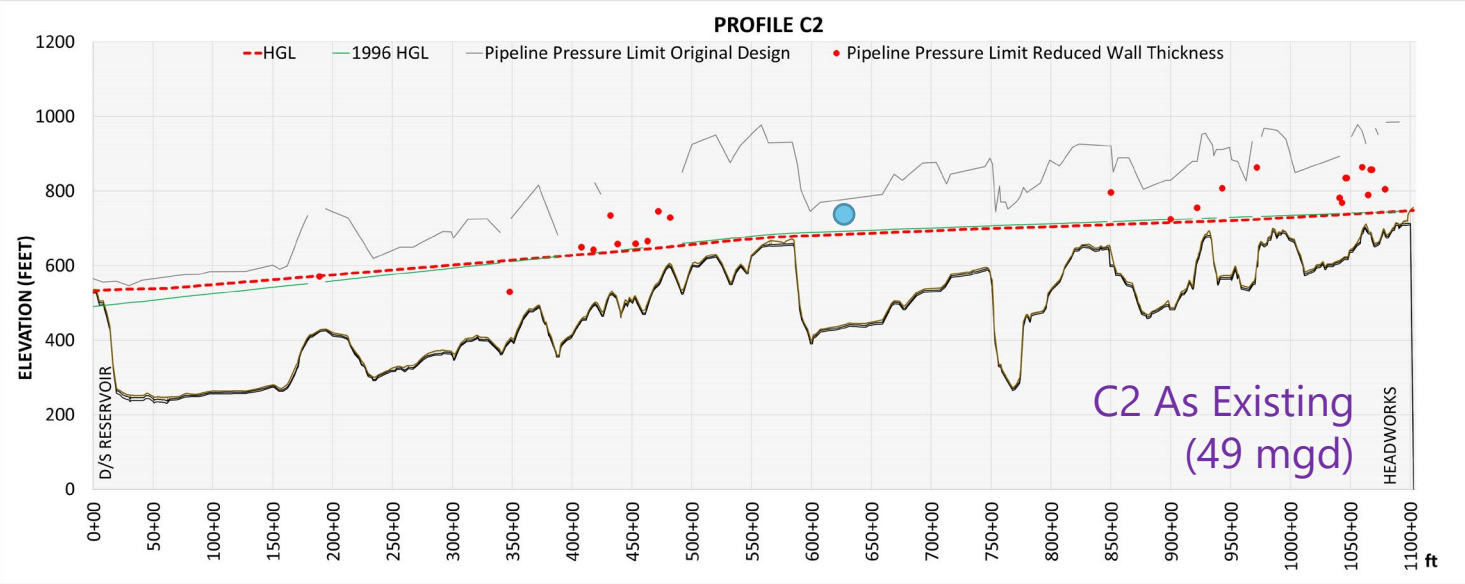
Hydraulics – System Constraints of a Gravity Fed Transmission System

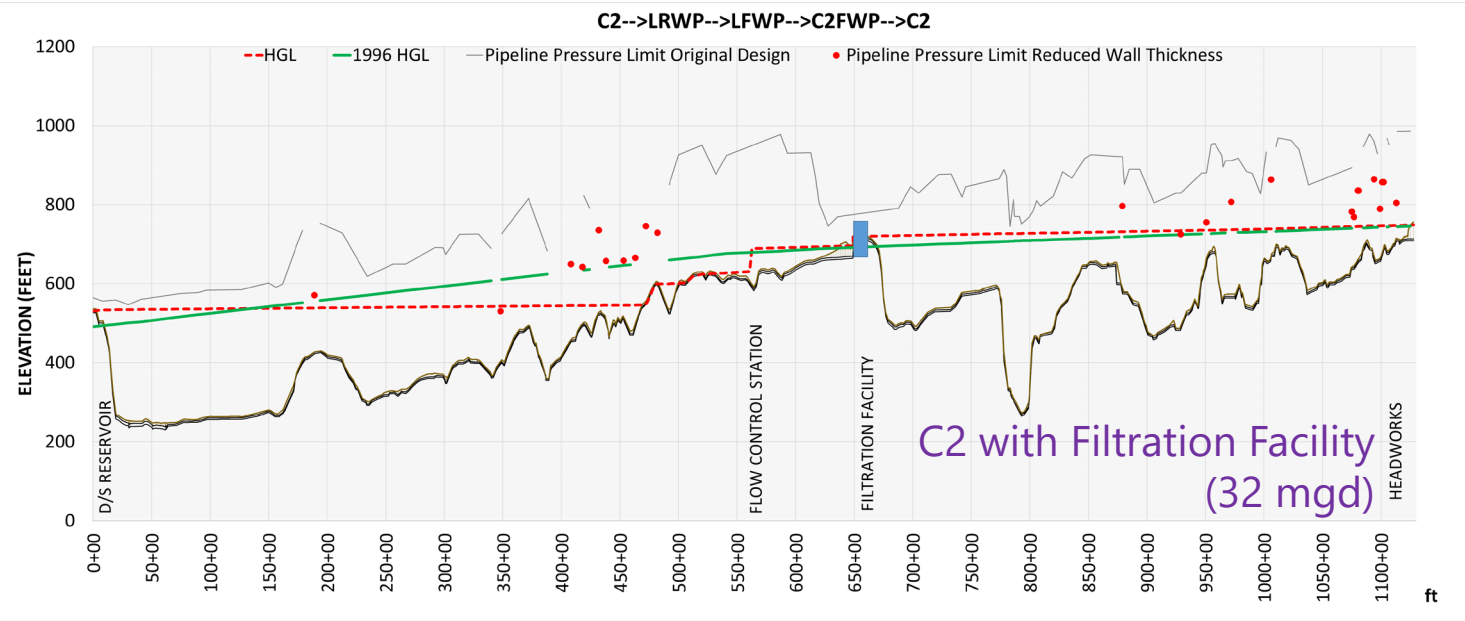
With New Filtration Facility Added

- Headworks Inlet Elevation
  - Existing: 747 to 749 feet
  - Future: 830 to 860 feet
- System Demand
  - Near-Term: 135 MGD
  - Future: 220 MGD
- Existing conduits vulnerable to excessive pressure
- New Filtration Facility changes operating HGL for existing conduits



Effects of Flow on Conduit 2 from Existing Conditions to Adding Facility

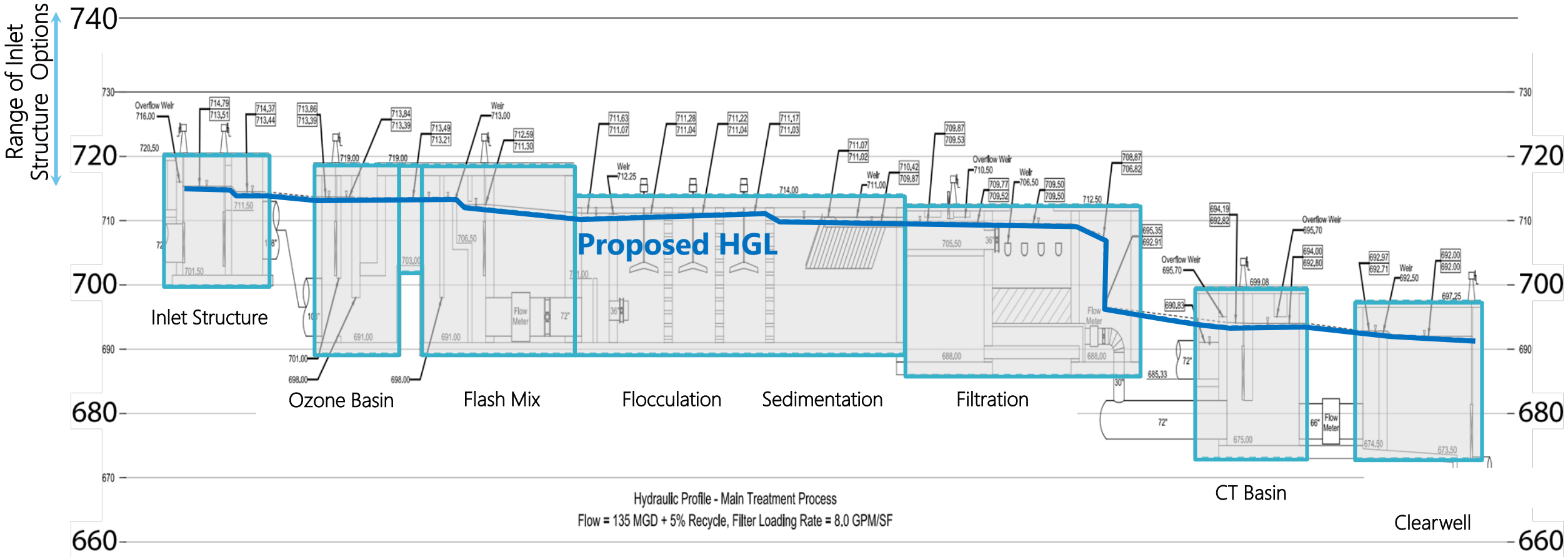




- Over Ten Miles of Transmission Pipeline from Headworks to Terminal Reservoirs
- Existing Conduit Pressure Constraints defined from Recent Testing
- New Filtration Facility changes operating HGL for existing conduits

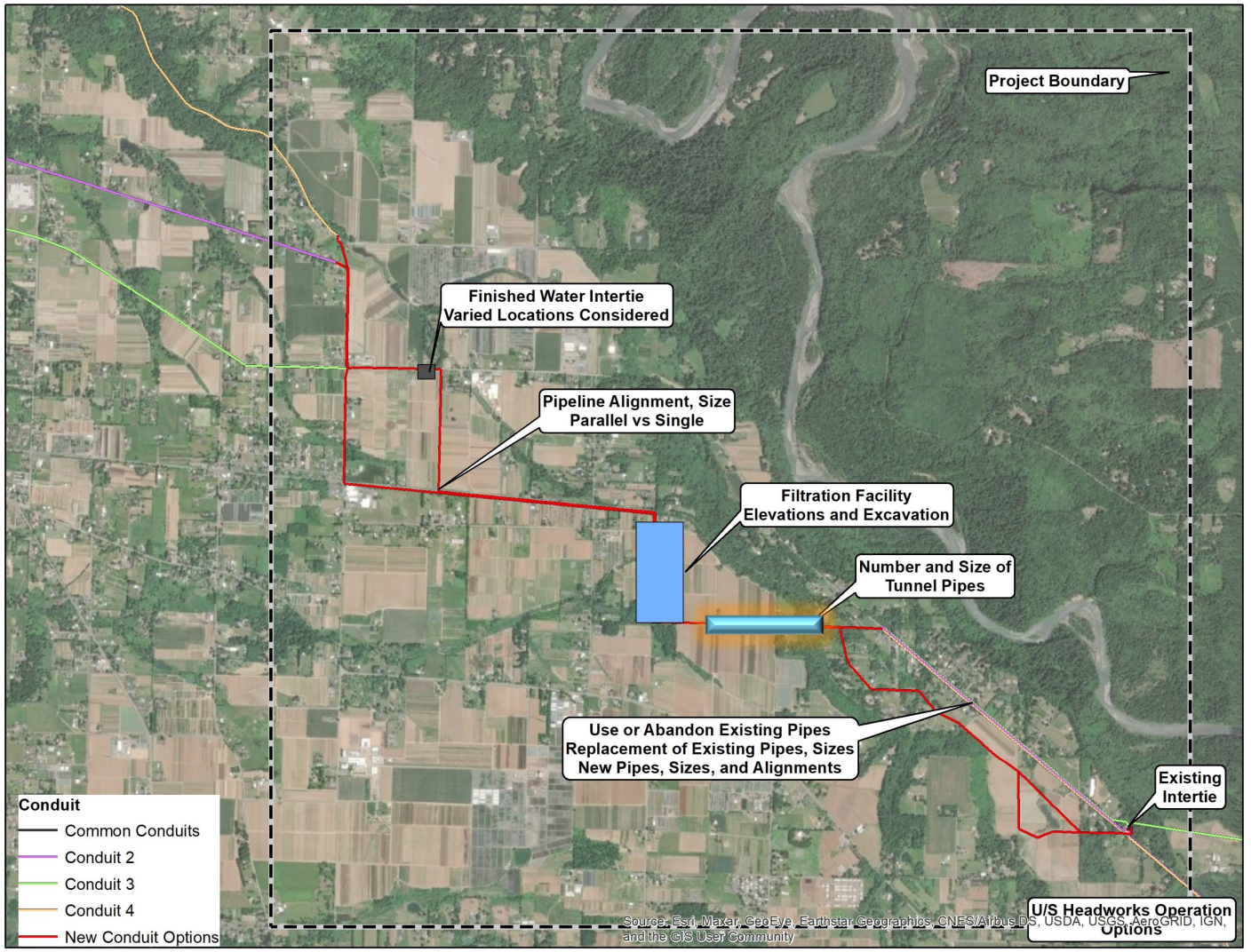
Hydraulics Analysis Determined Optimal Revised Facility Elevation and Flow Capacity

- Process basin elevations set to allow gravity flow
- Elevation of non-process structures set to minimize excavation and imported fill
- Initial Facility Design was Set at El 715 Inlet Structure
- Required Approx. ***26'*** excavation for process basins
- Alternatives of Pipelines Capacity vs Plant Inlet Elevations drove further hydraulics analysis



Improvement Options – Focused on Raw Water

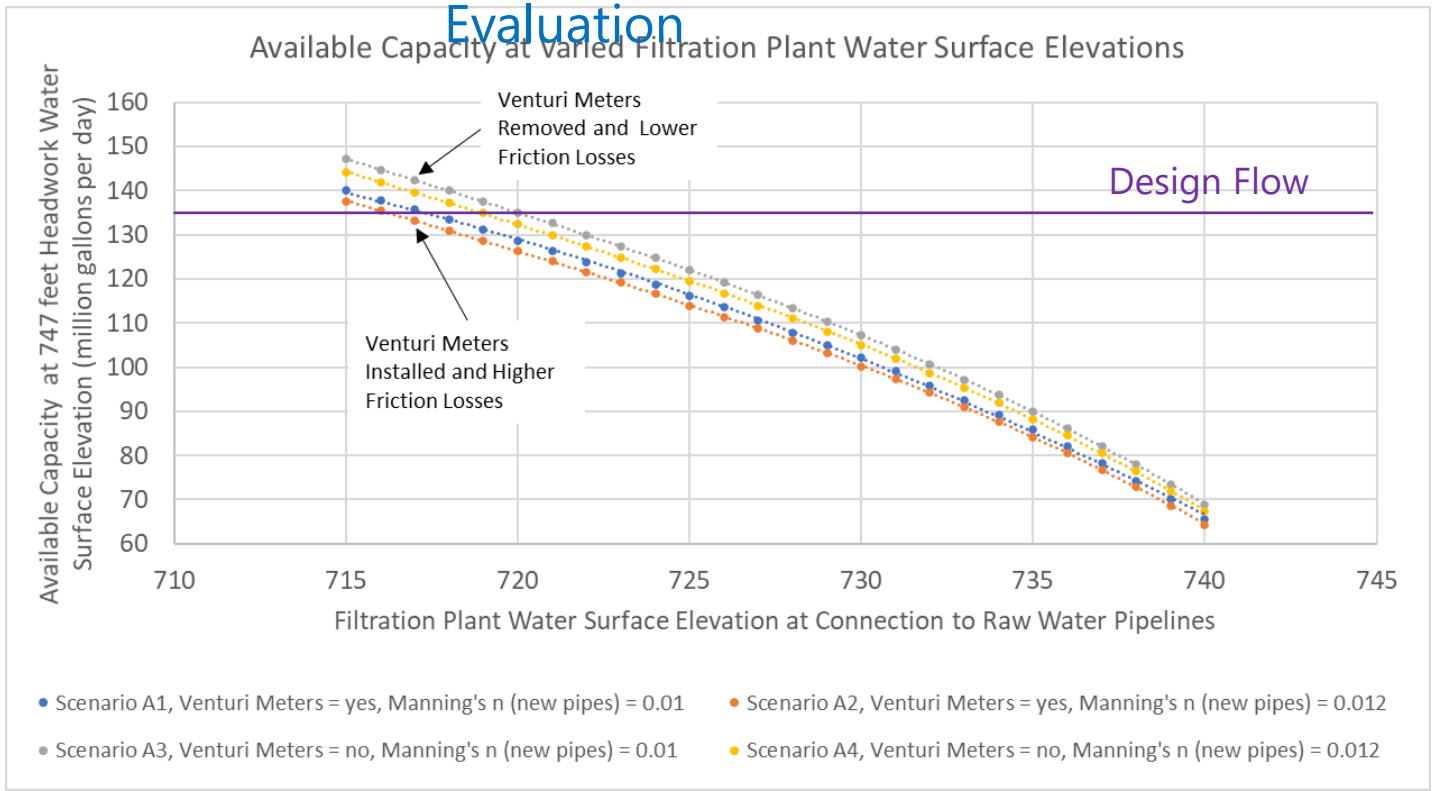
- Remove Venturi System near headworks
- Tunnel Pipes
  - Parallel Tunnel Pipes
  - Single Tunnel Pipe with Larger Sizing
- Conduit Replacement Upstream (2+ miles)
  - New Alignment Upstream (replace existing with 72-inch)
  - Replace Existing Bridge Crossings
- Use Groundwater Supply to Supplement Surface Water Supply
- Filtration Facility Elevation (excavation cost)
- Variable Headworks Elevation Operation



Hydraulics – System Analysis

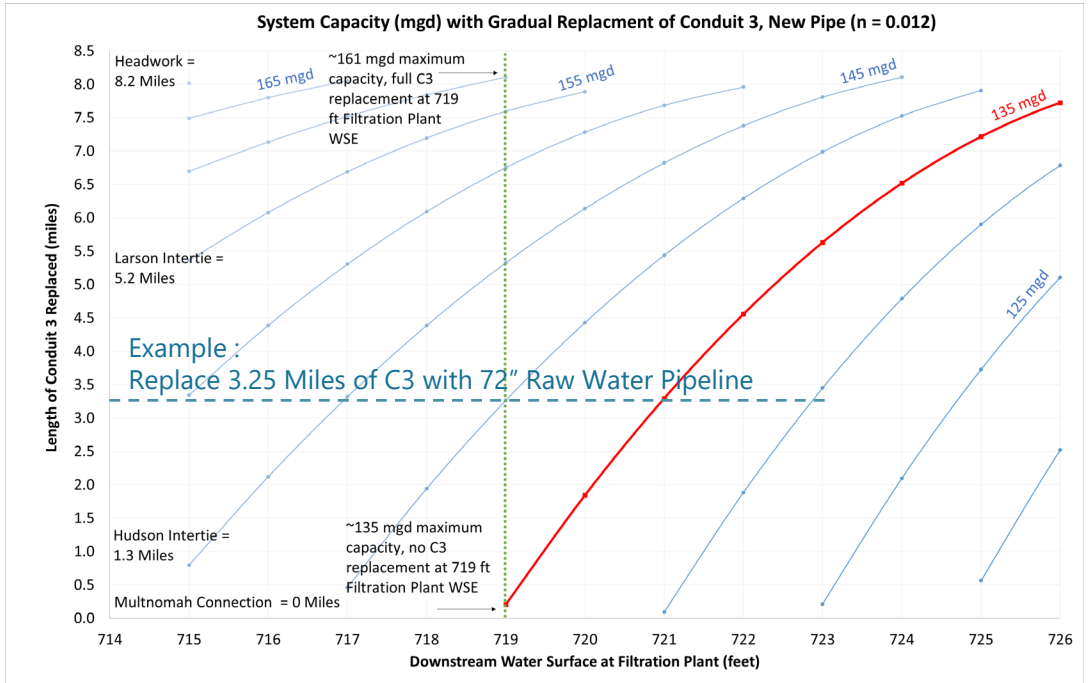
- Optimize preliminary design phase
- Assess Pipeline Modifications and Improvements as Compared to Facility Excavation Cost
- Filtration Facility considered at elevations between 715 – 740 feet with varied pipe sizing and replacement lengths upstream
- Consider specific minor losses (old venturi meters) and safety factor for frictional losses or unknowns

Minor Loss Evaluation

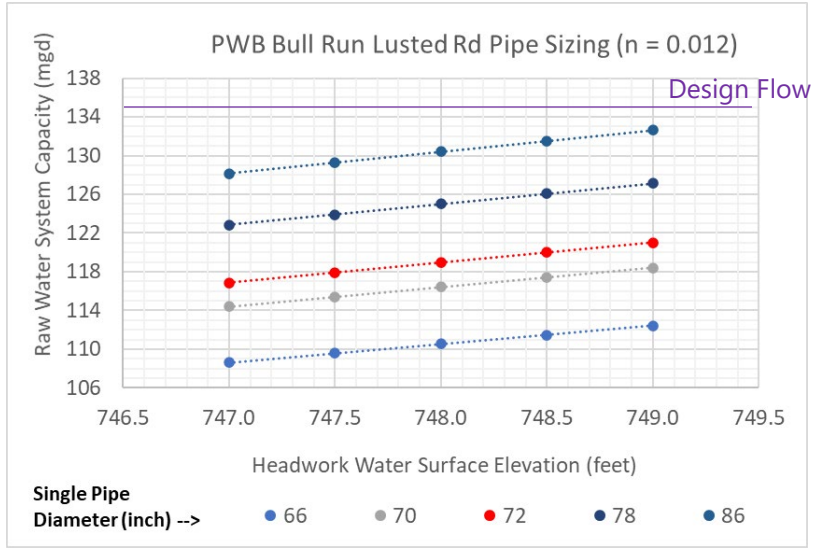


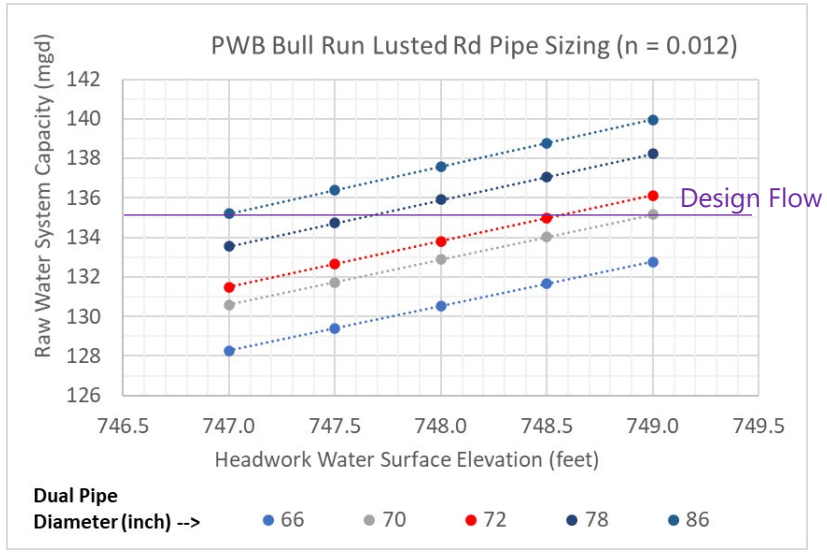
Optimization Analysis

- Automated thousands of simulations with combination of options or trade-off variables
- Selected options that provided adequate capacity for cost review and risk discussions
- Iterative approach to respond to questions



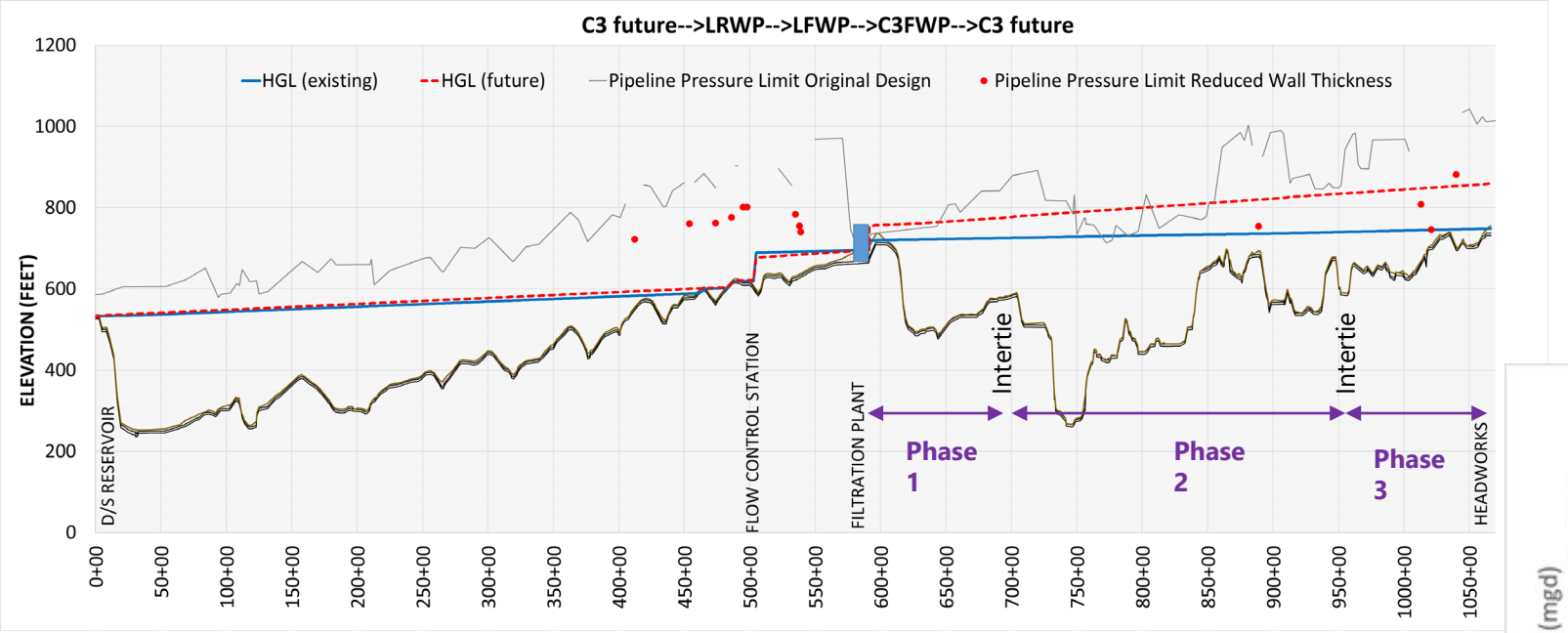
Trade-off between Upstream Conduit Replacement and Facility Excavation Depth (operating water





Tunnel Pipes Size Trade-offs
Number of Tunnel pipes vs Headworks Operation Levels

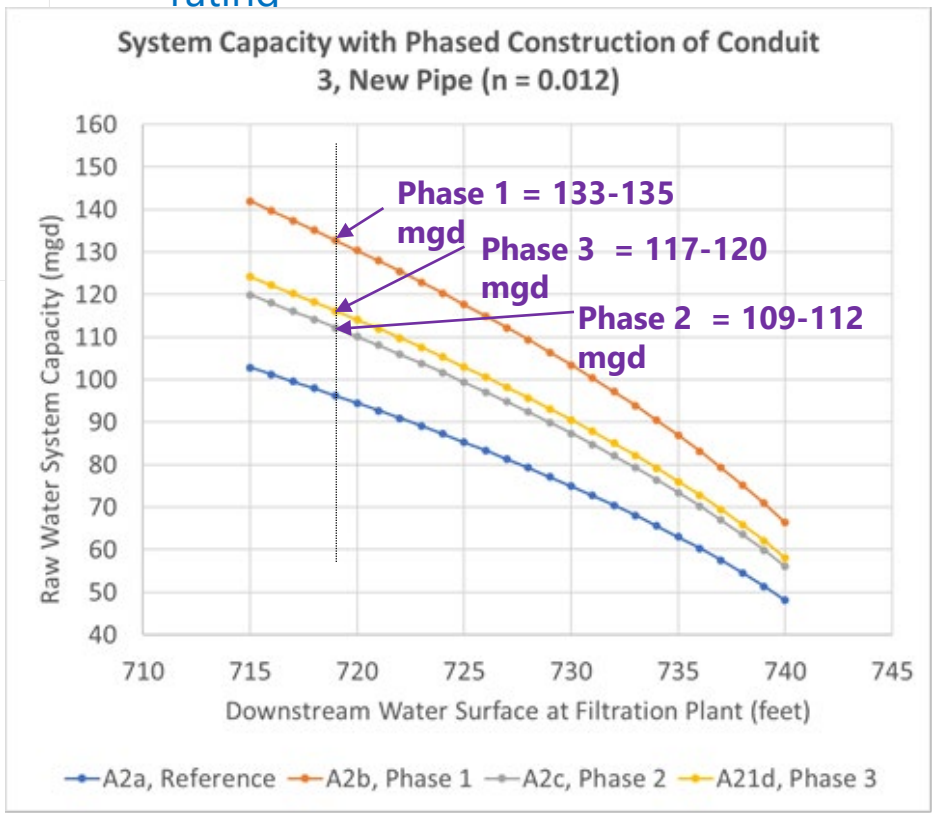
Effect of Raw Water Flow Capacity during C3 Replacement and Phasing of Construction



Replace Conduit 3 (42 mgd capacity to 110 mgd capacity)

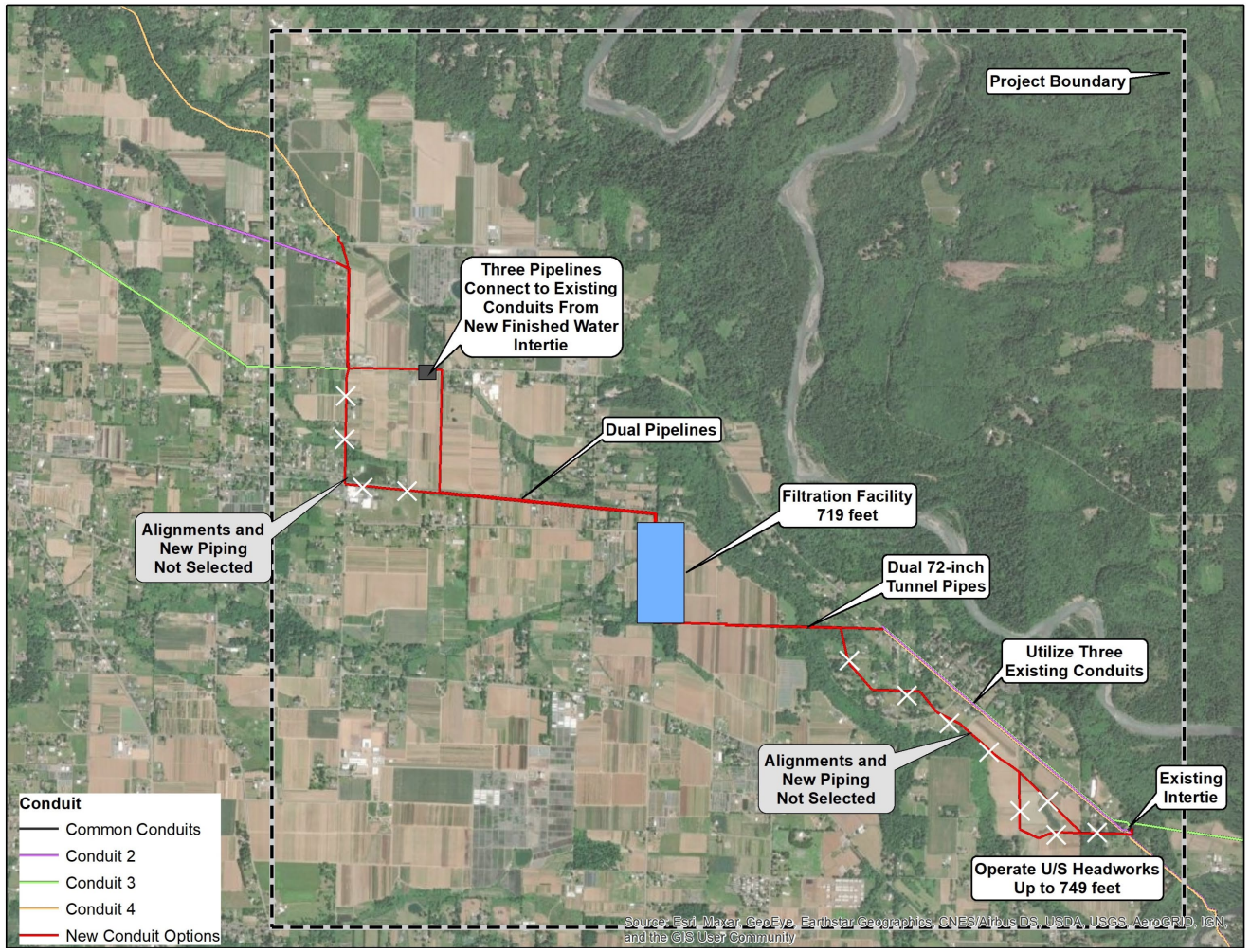
- Careful planning of system requires understanding of impacts to operations for installing replacement pipelines
- Phasing of conduit replacement needs to work between available interties
- Considered varied filtration facility elevations and isolation of existing conduits and replacement conduit sections

- Future headworks at 830 -860 feet will expand capacity of the system (downstream flow control)
- Operating pressures will increase above existing conduits pressure rating



Selected Improvements

- Flow Capacity – 135 MGD
- Remove old venturi meter systems near headworks (~7MGD Increase – 5%)
- Filtration Facility Inlet Structure at 719 feet
  - (4 feet less excavation than original concept)
- Headworks Operation 747 – 749 feet
- Tunnel Pipes
  - Parallel Tunnel Pipes (72-inch)
- Use of Existing Infrastructure
  - No Immediate Pipe Replacement or New Alignments in Raw Water System Upstream of Facility
- Limit Demand to 135 MGD from Surface Water Supply



> $40 million dollars in initial capital cost savings

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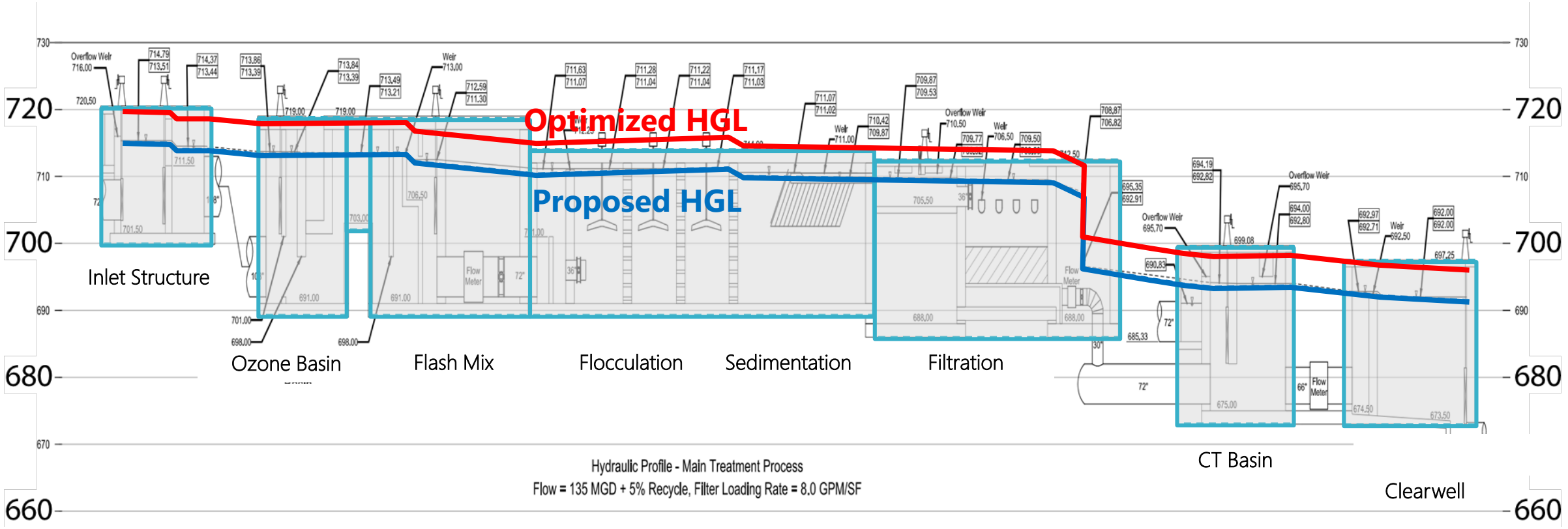
- Required Approx. ***26'*** excavation for process basins
- Alternatives of Pipelines Capacity vs Plant Inlet Elevations drove further hydraulics analysis
- Raise Facility 4 Vertical Feet



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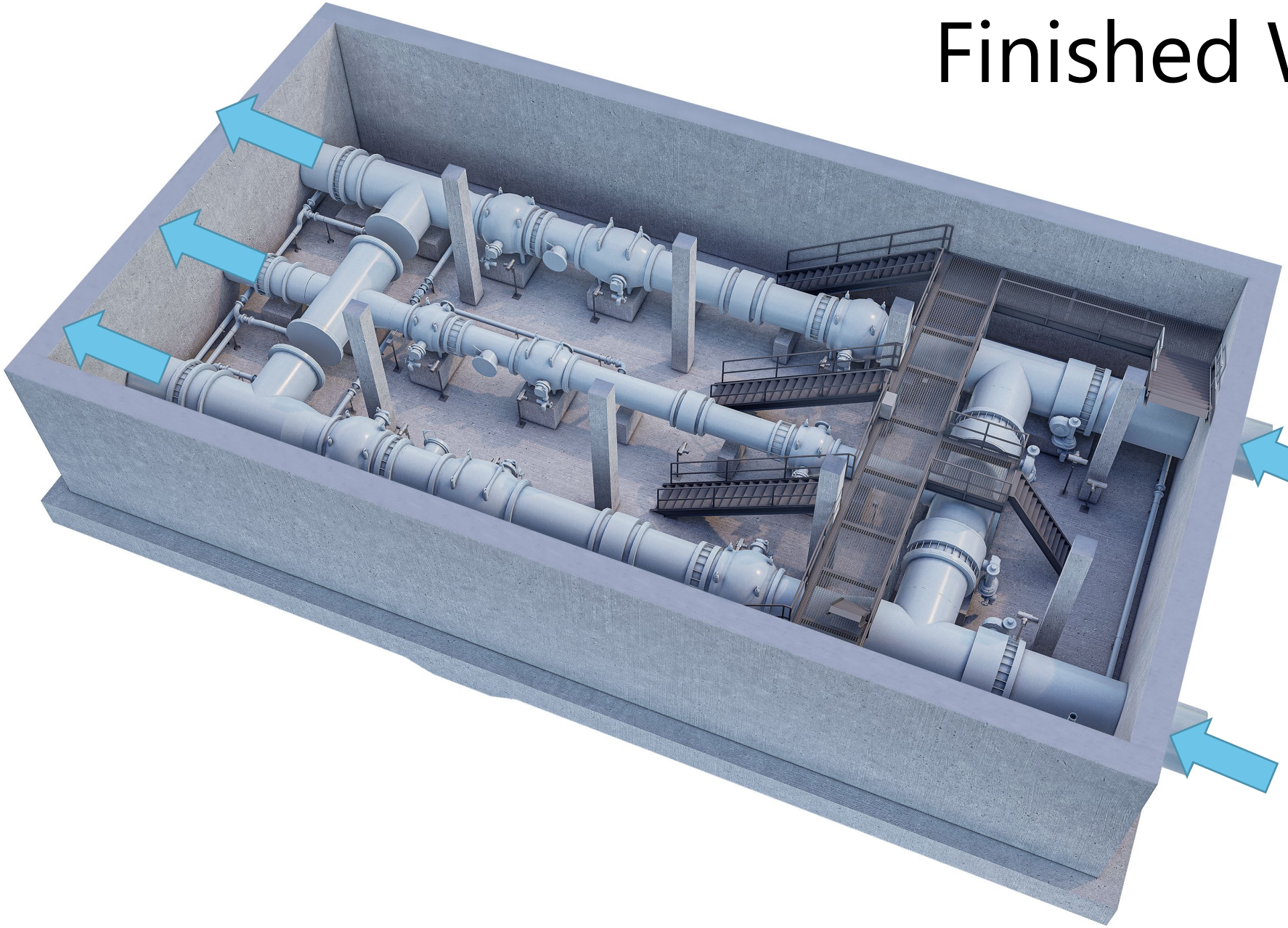
Flow Control Downstream of Facility

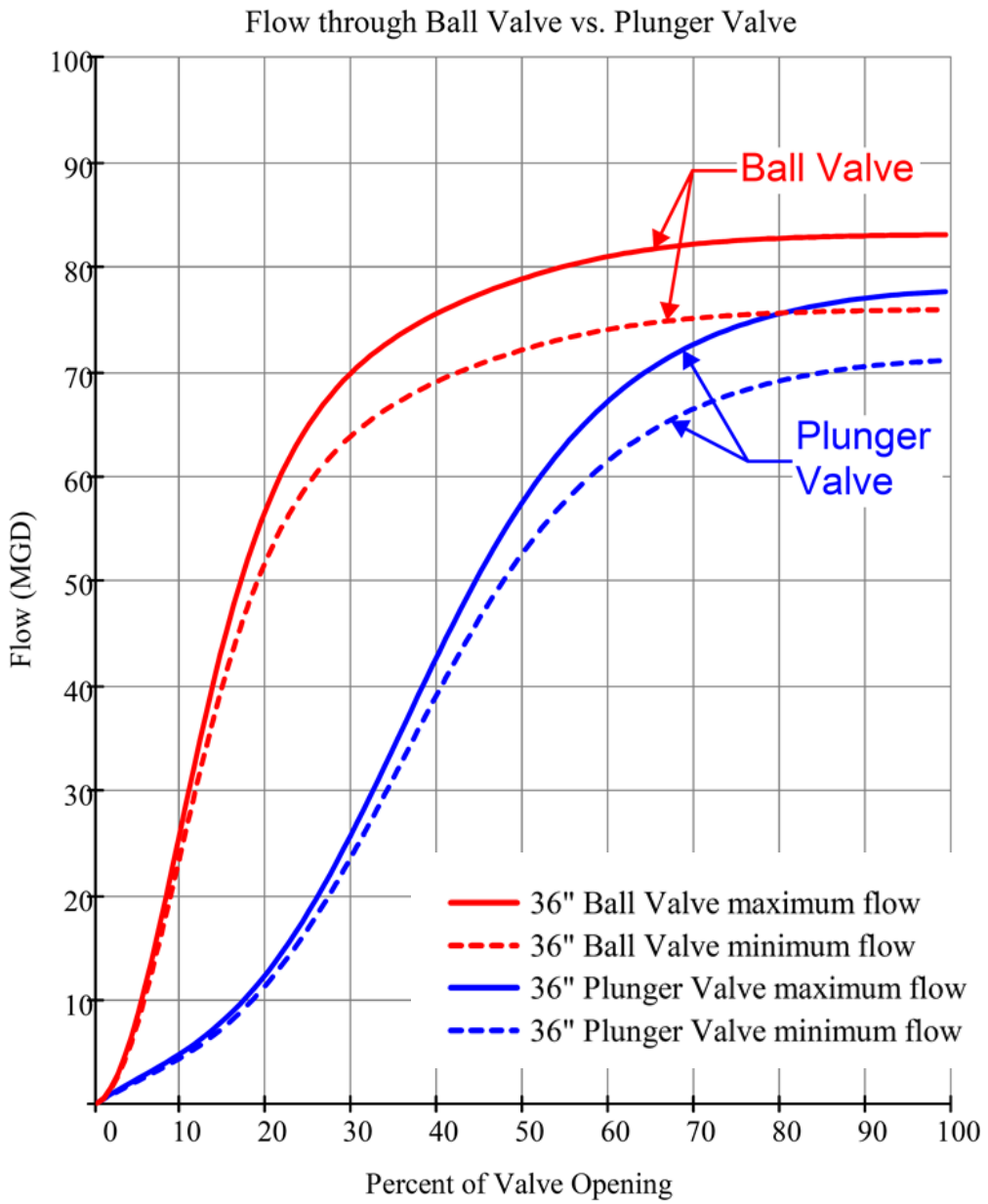
Finished Water Intertie



- Intertie Located D/S of Facility to Manage Flow Rate to Portland through the 3 Conduits
- Mezzanine Access
- Isolation Valves
- Flow Meters
- Plunger Valves (Flow Control)
- Allocation for Future Downstream Intertie
- Pipeline Drains

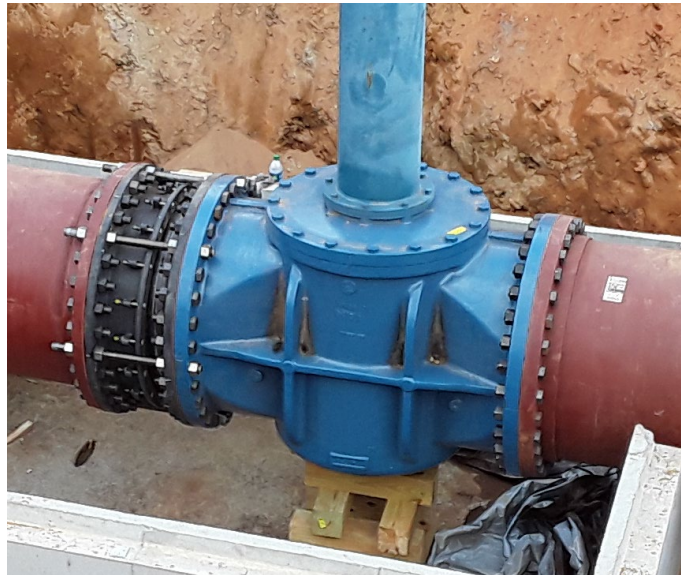
Selection of Flow Control Valves

- Provide a Flow Range of 20 to 220 MG
- Hydraulics
  - Range of Flowrates
  - Allowable Headloss
  - Cavitation Potential
- Operations and Maintenance
  - Performance
- Constructability
  - Layout
- Capital and Operating Costs



Valve Options

- Quarter Turn Valves
  - Butterfly Valves
  - Ball Valves
  - Plug Valves
  - Cone Valves
- Globe Valves
- Specialty Valves
  - Sleeve Valves
  - Plunger Valves

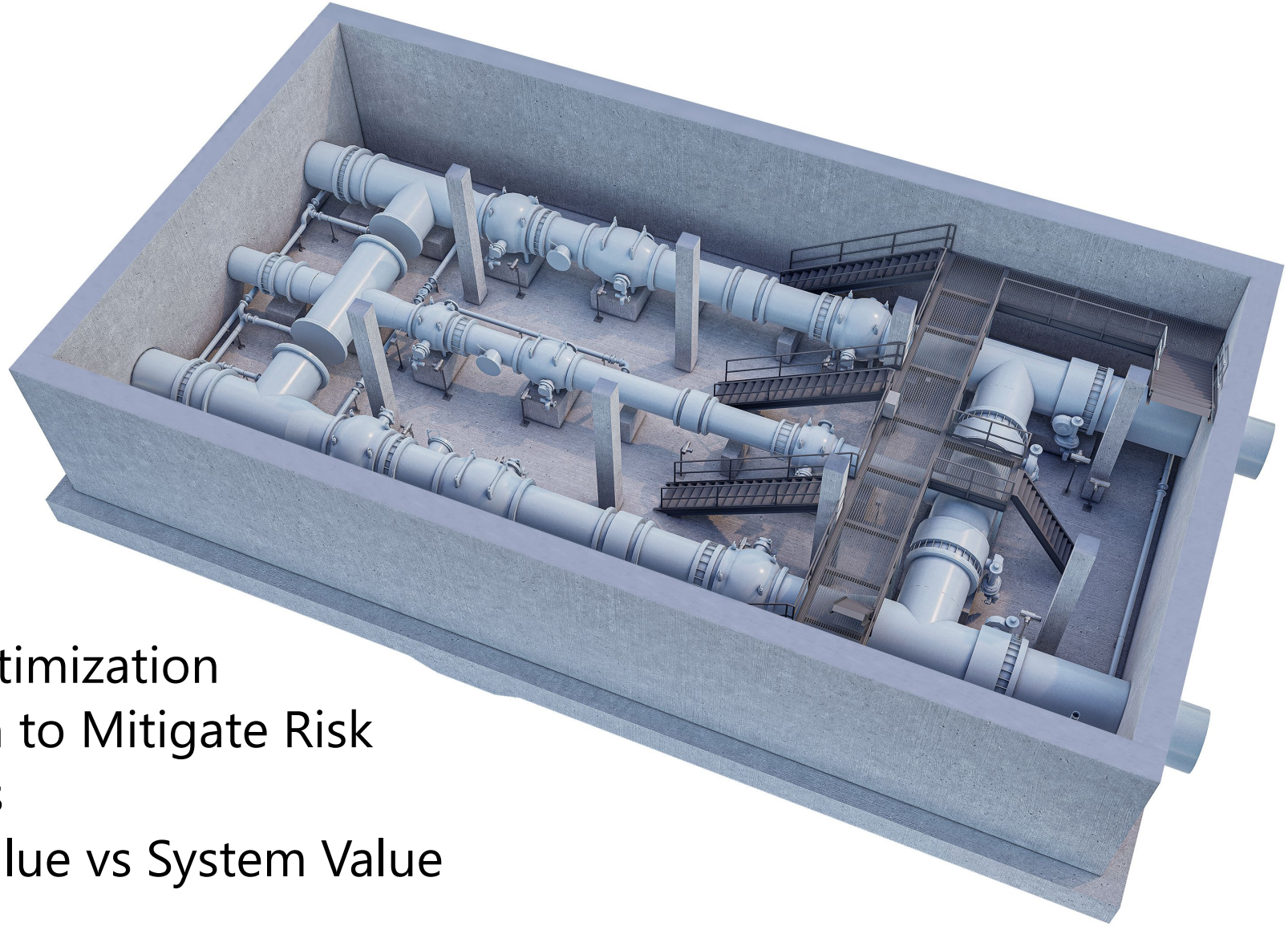


Final Design

- Wide Range of Flowrates
- Limited Allowable Headloss
- Low Downstream Head
- Valve Selected: Plunger Valve

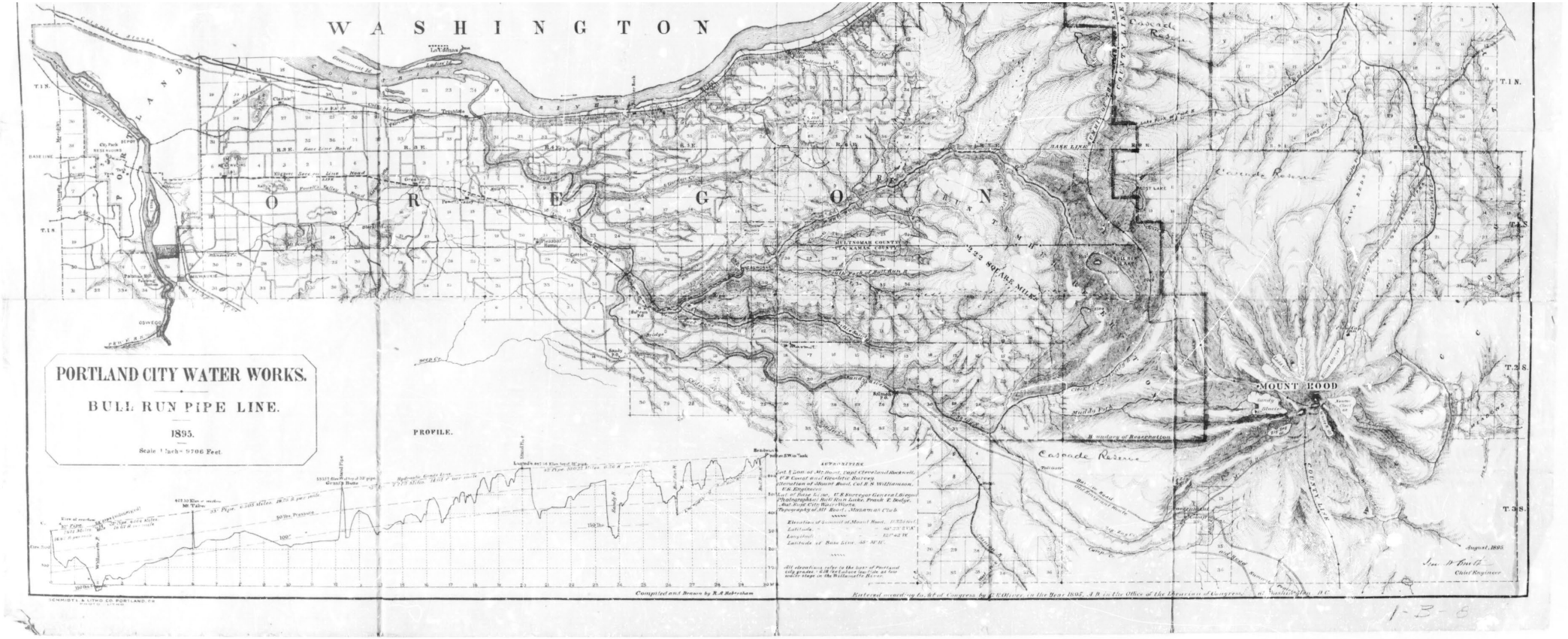
Pipeline ID	Proposed Valve Size	Near-Term Capacity*
Conduit 2	36 inch	46 MGD
Conduit 3	48 inch	65 MGD
Conduit 4	48 inch	87 MGD
Total		**135 MGD**

Take Aways



- Cost Savings through Optimization
- Operational Optimization to Mitigate Risk
- Cover the Range of Flows
- Pick the Best-Fit: Valve Value vs System Value

References: Murdock, Adam; Nathaniel Jones; Daryl Devey; Fitting Flow Control for Your Aqueduct, June 2013, ASCE Pipelines Conference, Fort Worth, TX



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Thank you!

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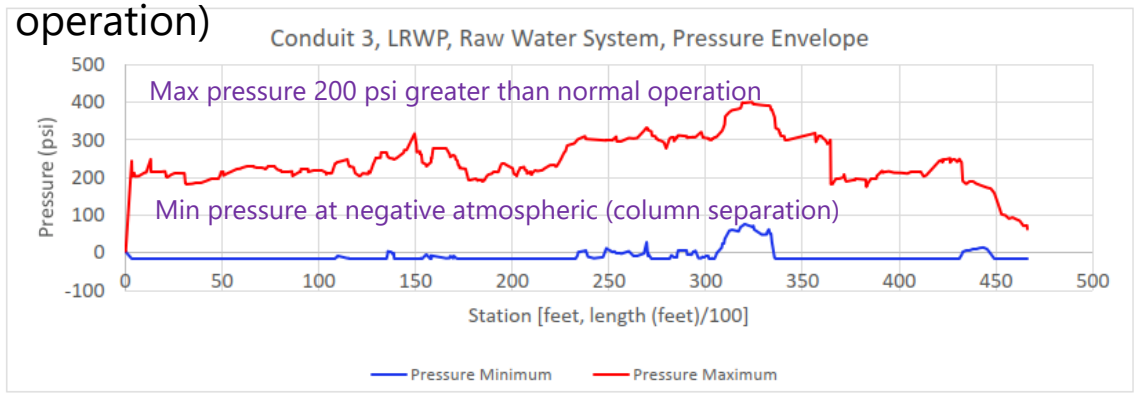
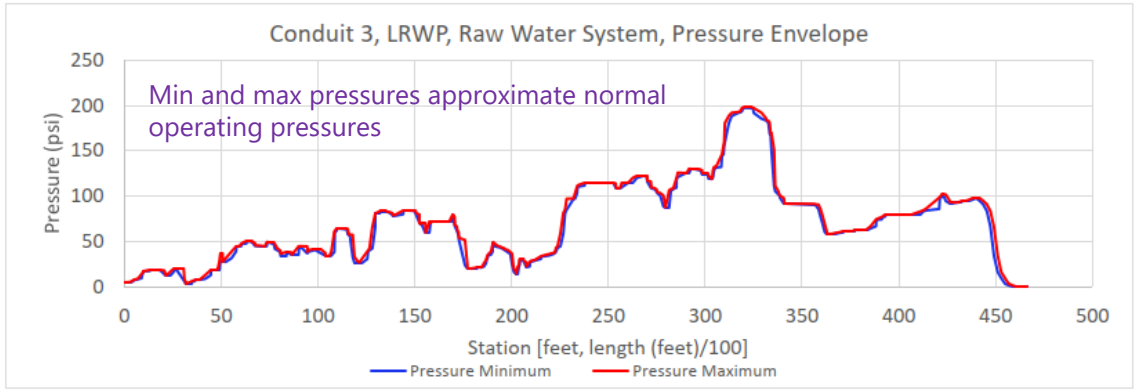
Operational Analysis – Pressure Transients

- Pressure transients (water hammer or pressure surges): rapid shift in velocity causing a pressure wave that results in significant increase in pressure and subsequent vacuum pressure
- Causes: valve or gate operation, pump start up or shutdown, pipe break or rupture
- Risks: damage to pipelines and pipe joints; potential pipe collapse
- Mitigation: long operational times to open and close valves or gates; combination valves (air inlet and air release functions); surge tanks or chambers

Raw Water System Example (pressure envelopes, valve operation)



Valve Closure at 2-minutes

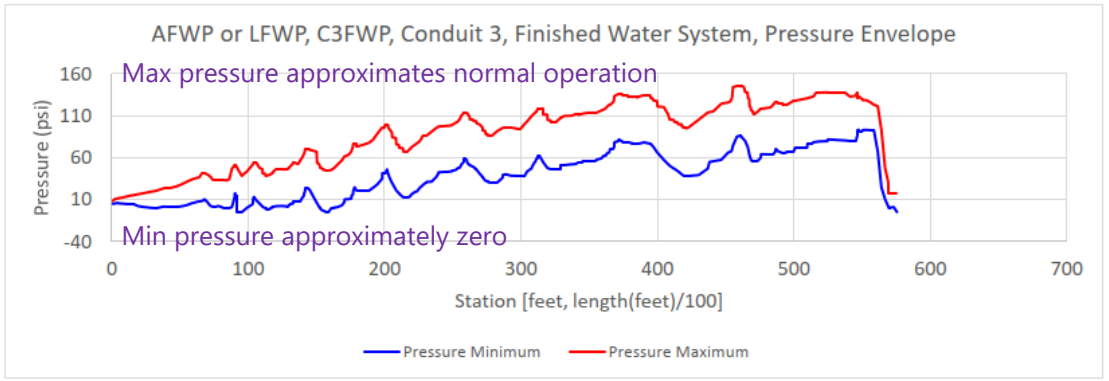


Valve Closure at 7-minutes

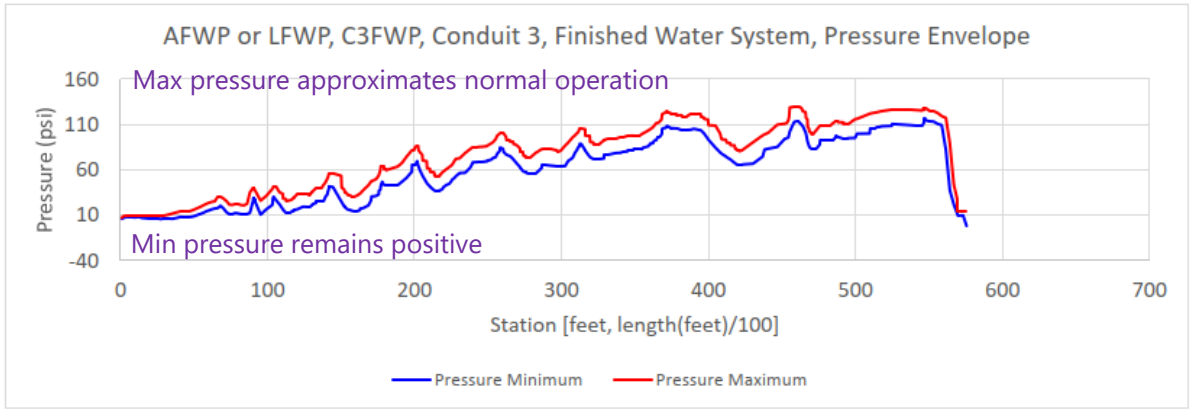
- Transient Evaluation
  - 17 scenarios in raw water system, 29 scenarios in finished water system, 1 scenario emergency
    - gate and valve operations at varied speeds
    - pipe breaks resulting in rapid system draining at varied times
    - emergency power failure and back feed pump shutdown

  - Analysis used to size and place combination air valves, recommend maximum valve open/closure timing with new system hydraulics

Finished Water System Example (pipe break, mitigated with combo valves)



Break (30-inch size) and 1-minute drain time



Break (30-inch size) with mitigation