Denver Water

Colorado’s oldest and largest water utility.

Established in 1918

Serves 1.4 Million people

Denver and Suburbs

Collection, storage, and distribution of Drinking water

Operating revenue $284 Million (2016)
Denver Water System

- Supply by 3 treatment plants
- 3,100 miles of pipelines
- 33,000 Hydrants
- 144 pressure zones
- 150 major control valves
- 520 PRVs
- 58 storage tanks
- 200 pump units in 51 stations
- Over 50 distributors

Innovation, strategic planning, advanced technologies are a chosen path for Denver Water
Denver Water Drivers and Motivation

- Population growth
- Climate change
- Periodic drought
- Competition for water resources
- Changing water usage
- Changing regulatory and political environment.
- Maximize water efficiency

![Population vs. Year Graph]

Dynamic and Adaptive Master Planning

Beyond documents
Dynamic Adaptive Master Plan Using an Optimization Approach

Why?

Optimization
Provides unbiased and transparent cost-effective solutions.

Software

Treated Water Planning Study and Integrated Resource Plan In Progress
Guide decisions over the next 50 years.

Recently updated Innovyze InfoWater Hydraulic Model
Evaluates the hydraulic performance of various alternatives.
Software: Optimizer WDS
A Step by Step Journey

Data Collection
Set-up Hydraulic Design Criteria
Identify Operating Alternatives
Interim and Final Optimization Runs

Great Benefits
- Cloud Computing
- Multi-Objective Optimization
- Customized Scripts for DW needs
- Evaluate thousands of alternatives
- Basis for Future Optimization Efforts
- Easy to integrate within DW processes
- Transparency
- Confidence

Select Best Option for Today Needs

4-5 Months Journey

2/12/2018
Dynamic Adaptive Master Plan

Evaluate thousands of alternatives and select the best

Every dot represents a different alternative.

Best operating alternative to while maintaining good hydraulic performance at the minimum cost

OPTIMIZE

Operating Conditions

Hydraulic Performance

Operating Cost

Evaluate system performance and needs

Plan

Changes

Select

Implement

2/12/2018
Optimization Software Data Needs

- Calibrated hydraulic model
- Improvement options
  - Pump off/on level controls
  - Control valve settings and status
- Cost information

- InfoWater model
- Hydraulic model skeletonized to 60,000 pipes, original model had 350,000
- Extended period simulation (24hr) of 2016 Maximum Day Conditions.

2/12/2018
Optimization Goals

Which set of operating conditions will have the least energy cost while meeting service level goals for pressure, tank turnover, and tank recovery.

- Energy Cost
- Pressure Criteria
- Tank Turnover
- Tank Recovery

Operating Conditions
Pumps, valve settings
Optimization Decisions

Pump Unit
- On and Off control levels
- Status (open/close)

Control Valves
- On and Off control levels
- Setting
- Status (open or close)

WTP
- Supply flow

The Optimization software evaluates the potential combinations of the decisions for each pump unit, control valve and treatment plant.
Pareto Optimal Front – Multi-Objective

- Inflection points - good alternatives with different operating cost and different levels of hydraulic performance

Each dot represents an alternative to operate the pumps and valves

The Pareto plot useful to identify the best alternative of operation for our budget
Optimization Results
Project Outcomes

- Storage analysis matched views of O&M
- Interesting operations on max day
- Ideas for future analysis and optimization
Hidden Issues – Water Optimization is More Complex than Sewer or Flooding

• Sewer / River / Combined Optimization
  – Cost
  – Minimize Flooding

• Water Optimization
  – Source Availability
  – Conduit Outages
  – WTP Outages
  – Fireflow
  – One Side Out Analysis
  – Demand Variations
Future Potential Optimization Projects at Denver Water

**Downtown Area Pipe Replacement Project**

**Shoulder Month Operations**

**Plant Outage Planning**

**Source Water Management Optimization**

**Continue Optimization of Operation Alternatives - 200-300 MGD and Raw Water**

**Major Improvements of Transmission System C25**

**Optimization for Risk Reduction and Resilience Enhancement**

**Real-Time Modeling**

2/12/2018
Future Goals

- Optimize Optimization
- Real-Time Modeling
- Raw Water Side
- CIP Optimization
- Finalize GIS Integration
Partnerships

WaterPlans  HDR  Innovyze  Optimatics
Thank You!