Hydraulic Analysis Comparing Efficiency of One and Two-Zone Pressure Water Systems

Agenda:
- Background
- Objectives
- Water Distribution System Overview
- GIS and Hydraulic Modeling Relationship
- Hydraulic Modeling Concepts
- Project Approach and Methodology
- Project Timeline
- References

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# Background

- **Overview of City of Downey**
  - Location – 12 Miles SE of Downtown Los Angeles
  - Area - 12.8 Sq. Miles
  - Population - 113,000
  - Topography, Elevations 140 ft. to 85 ft.
  - Primary Drinking Water Purveyor
  - Five Emergency Connection with Other Water Agencies
Background

- Overview of Downey’s Water Distribution Network
  - No of Customers 23,500
  - No. of Active Groundwater Wells 20
  - Average Daily Demand 10.2 MGD
  - Total Pipe Length in Mile – 260 miles
  - No. of Valves - 3800
  - No. of Fire Hydrants – 1,450
  - Elevation Difference Between North (140 ft.) and South (85 ft.) Boundaries – 55 ft.
  - System Pressure Varies From North (48 psi) to South (98 psi)
  - Water System Pressure Controlled by SCADA at Single Location for 65 psi.
**Background**

- **Problem**
  - High Costs of Pumping Energy Rates. Annual Energy Cost for Operating 20 Wells is about $1.4 Million
  - There is about 50 psi difference between North and South portion of the City
  - Existing Water Network System consists of Single Pressure Zone
  - Pumps Run more Frequently to keep the Required Pressure of 65 psi at the Water Yard Location.
Objectives

- The factors that could help in maximizing the efficiency of the system
  - Energy Cost Savings
  - Water Distribution Network Pressures Improvement
  - Implementation Payback Analysis

**Existing Condition**

**Project Goal**
Water Distribution System Concept (GIS and Hydraulic Model)

- **Major Components of the City of Downey’s Water Distribution System**
  - Groundwater Wells
  - Pumps
  - Pipes
  - Nodes
  - Deep Aquifer Layers

- **Hydraulic Model Representation**
GIS and Hydraulic Modeling

- Feature Classes, GIS vs Hydraulic Model

**GIS Feature Classes**

- Mains
- Laterals (Service Lines)
- Main Nodes
- Lateral Nodes

**Hydraulic Model Elements**

- Pipes
- Valves
- Junctions
- Reservoirs
- Pumps

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Water Mains in GIS

Water Mains
- TYPE
  - DISTRIBUTION
  - LATERAL
  - RECYCLE WATER
  - STEEL CASING
  - TRANSMISSION
  - VAULT

Model Schematics
GIS and Hydraulic Modeling

- Feature Classes, GIS vs Hydraulic Model

**GIS Feature Classes**

**Hydraulic Model Elements**

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(Walski, 2003)
GIS and Hydraulic Modeling

- Feature Class Attributes, GIS vs Hydraulic Model
  - Model (Pipes, Nodes), Pipe Material, Elevations, Demand Consumption, Water Depth, Pump Parameters and Other Attributes.
  - GIS (Lines, Points), Offset Distance, Size, Ownership, Source linkages, etc.

<table>
<thead>
<tr>
<th>GIS VS HYDRAULIC MODEL ATTRIBUTE COMPARISON</th>
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<tbody>
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<td><strong>GIS</strong></td>
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<tr>
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<td>FLOW DICTION</td>
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<td>VELOCITY (FPS)</td>
<td>WATER AGE (HHS)</td>
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<td>HEADLOSS (FT)</td>
<td>ELEVATION (FT)</td>
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<td>STATUS (open/close)</td>
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Hydraulic Modeling Concepts

- Methodology for Building a Hydraulic Model from GIS Data
  - Step 1: Extract and COGO Water Infrastructure Data from CAD Asbuilts
  - Step 2: Review GIS Data
  - Step 3: Integrate and Develop Network Topology from GIS Features Classes (Skelotonization)
  - Step 4: Collect Meter Data (Water Demands / Node Consumption)
  - Step 5: Input/Import Facilities
  - Step 6: Determine Node Elevations
  - Step 7: Assign Pipe Roughness / Material Coefficients Based on Pipe Material
  - Step 8: Allocate Node Demands /Demand Projection Factor Based on Land Use Zoning Criteria
  - Step 9: Integrate Pump Control Curves, Diurnal Curve, and Pump Sequencing Logics, Reservoirs / Wells Configuration (Ground Levels etc.)
  - Step 10: Import Fire Flow Demands
  - Step 11: Build Hydraulic Model
  - Step 12: Calibrate Model with Fire Hydrant Flow Tests
Hydraulic Modeling Concepts

- Summarization of Major Steps Involved in Building a Hydraulic Model using GIS Data
  - Extract, COGO, and Build GIS Feature Class From CAD and As-Built Paper Maps
Hydraulic Modeling Concepts

- Review, Import and GIS Data and Develop Network Topology (Skeletonization)

- Pipes and Junction Review
Hydraulic Modeling Concepts

- Node Elevations and Water Meter Consumption Data Association and Aggregation
  - Elevation Extraction from a Digital Elevation Model (DEM) Model

- Allocate Water Consumption Demands

(Walski, 2003)
Hydraulic Modeling Concepts

- Pump Data And Operating Curves
- Well Water Levels
- Pump Turn On /Off Logic Sequencing
- Water Consumption Diurnal Curves

Groundwater Well Representation (Walski, 2003)
Hydraulic Modeling Concepts

- GIS and Hydraulic Model Integration

**Hazen-Williams**

\[ K_p = \frac{C_f L}{C^2 D^{4/3}} \]

- where  
  - \( K_p \) = pipe resistance coefficient (s/ft, s/m)  
  - \( L \) = length of pipe (ft, m)  
  - \( C \) = C-factor with velocity adjustment  
  - \( C_f = \) unit conversion factor (4.73 English, 10.7 SI)  
  - \( D \) = pipe diameter (ft, m)  

\[ H = h_i + \sum K_p Q^2 + \sum K_M Q^2 \]

- where  
  - \( H \) = total head (L)  
  - \( h_i \) = static lift (L)  
  - \( K_p \) = pipe resistance coefficient (T/L s^1)  
  - \( Q \) = pipe discharge (L/T)  
  - \( z \) = coefficient  
  - \( K_M \) = minor loss resistance coefficient (T/L)  

(Walski, 2003)
Hydraulic Modeling Concepts

- Hydraulic Model Calibration

(Walski, 2003)
Hydraulic Modeling Software

- InfoWater Software from Innovyze Company (Create, Edit, Run, Analyze, Design, and Optimize the Water Distribution Network)
Hydraulic Modeling Capabilities

- Steady State / Extended Period Simulation
- Water Quality Evaluation (Chemicals / Water Age / Trace)
- Fire Flow Analysis (Residual Pressure / Available)
- Master Planning
- Energy Management
- Development Assessment (Helps in System Reliability, Modeling Wells and Pumps Analysis)
- System Operational Studies
Project Approach and Methodology

What will it take to accomplish this?

- Use City’s Existing One Pressure Zone System
- Dividing the Pipe Network into Two Zones

- Use existing City of Downey’s water distribution system hydraulic model, one pressure zone
- Configure and prepare hydraulic model for simulation studies. Run and analyze model for two pressure zone system
- Divide and create two zone system, create new well sequencing logic, balance water well flows, and collect pump energy consumption meter data from billing cycles to be used for analyses
- Present findings of one and two pressure zone simulated hydraulic model systems with observed values about zone pressures differences and Energy efficiencies

- Collect Pump Meter Billing Data
- Update Node Demands to Current Usage
- Create Two Zones in the System
- Assign Pressure Control Points
- Add / Remove Valves and Other Appurtenances
- Add Pumping Sequence
- Balance Flow / Recodify Boundary for Zone
- Run Model to Assess Pump Flow Times
- Evaluate One Zone and Two Zone Pump Flows / Duration to Evaluate Energy Use in Comparing map patterns of pressure
- Generate Comparison Excel Document
- Generate Map of Two Zone Distribution System
Anticipated Results

- Water Distribution Network Local Pressures will Improve
- Two Pressure Zone System will optimize the Distribution System and doing so It will help in Saving Energy Costs
- Implementation Costs are Estimated to be Recovered in 3 – 4 Years
## Project Timeline

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<th>JUNE 2015</th>
<th>JULY 2015</th>
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<td>WEEK 3</td>
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<td>Collect water consumption data from billing meter read</td>
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<td>Collect pump energy use data</td>
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<td>Create two pressure zone model from existing model</td>
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<td>Update model with current consumption data</td>
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<td>Create pump sequencing logic</td>
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<td>Update model with pumping electrical usage data</td>
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<td>7</td>
<td>Test and trials of balancing flow in two pressure zone</td>
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<td>8</td>
<td>Run hydraulic model and extract results</td>
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<td>Presentation at ESRI UC San Diego</td>
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References

Acknowledgements

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Questions?