Dynamic Hydraulic Modeling of a Wastewater Treatment Plant

City of Fort Worth Case Study

2011 Technical Sessions
AGENDA

• Drivers for a Dynamic Integrated Large WWTP Hydraulic Model
• Model Development
• Modeling Conduits and Bends
• Modeling Primary Clarifiers
• Modeling Filters and Chlorine Contact Basins
• Integrating Collection System Hydraulics with WWTP Hydraulics
DRIVERS FOR A DYNAMIC INTEGRATED LARGE WWTP HYDRAULIC MODEL

• Fastest Growing WWTP Service Area in the USA
  – 5 MGD to 166 MGD over the last 50 years with significant future growth still expected

• Need to evaluate capacity of treatment facilities with aging infrastructure and budget constraints

• Need to Integrate Collection System and Treatment Improvements to Minimize Overall CIP Needs

• Recognition that WWTP Facility is facing substantial regulatory changes over the next 10 year planning horizon
History of Fort Worth

• City of Fort Worth was first incorporated in 1873 with a population of 500.
• Over the past 130 + years, Fort Worth has grown to 736,000 people.
• City of Fort Worth is now the 16th largest City in the nation.
• City of Fort Worth provides Wastewater service to over 1,000,000 people.
• City of Fort Worth has 24 wastewater wholesale customers.

Fort Worth's first City Hall at 2nd and Rusk (now Commerce) streets housed all municipal offices, including Police and Fire departments from 1877 to 1893.
Village Creek Reclamation Facility Service Area

CITY SERVICE AREA POPULATION GROWTH HAS AVERAGED 25,000 PEOPLE PER YEAR OVER THE LAST DECADE
Village Creek Wastewater Treatment Facility History

1958
5 mgd

1972
45 mgd

1980
96 mgd

1988
129 mgd

1999
166 mgd

2005
HRC & Screening Facility
Award Winning Village Creek Reclamation Facility

126 state certified operators, mechanics and administrative staff

NACWA Platinum Award
20 consecutive years of 100% permit compliance
EXISTING HYDRAULIC MODEL

- Excel based
- Sound engineering model
- Limitations:
  - Non-dynamic simulation
  - Difficult to complete "what-if" analysis
  - Dynamic connection to collection system model not possible
DYNAMIC HYDRAULIC MODEL

• Advantages
  – Dynamic, varying flow input
  – Total data management
  – Collection system model tied directly to treatment facility model
  – “what-if” analysis is more feasible
  – Improved graphic outputs
  – Functional model for city after master plan
  – Ability to evaluate Peak Flow capacity needs as well as Permitting capacity needs
MODEL DEVELOPMENT

• Digitized Sewer Lines, Junction Boxes, Facilities in GIS
• GeoReferenced Plant Layout into InfoWorks CS
• Worked with Plant Staff to verify alignments and flow splits
• Attributed pipe diameters, lengths, inverts, manhole rim elevations, etc.
• Surveyed Junction Boxes and Researched Record Drawings
FIELD DATA AND CALIBRATION

- Need three pieces of Field Data:
  - Water Surface Elevations
  - Flow Rates
  - Plant Controls (Gate Settings, Overflow Settings, etc.)

- A Surveyor can shoot the water surface elevations (WSE) relatively easy

- Surveyor must record the time each WSE is shot so it can be tied back to a flow

- Most larger WWTPs have flow meters placed throughout the plant and can provide flow data
HYDRAULIC MODELING: CONDUITS AND BENDS

<table>
<thead>
<tr>
<th>Headloss Type</th>
<th>K value</th>
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<tr>
<td>Exit Loss</td>
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<tr>
<td>45° Bend (x2)</td>
<td>.4</td>
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<tr>
<td>Sharp Edged Entry Loss</td>
<td>.5</td>
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</tbody>
</table>

**Exit Loss**

**2 45° Bends**

**Sharp Edged Entry Loss**
HYDRAULIC MODELING: PRIMARY CLARIFIERS

• Used Series of Weirs Method
  – Storage node used to model the primary clarifier with dimensions found in As Built plans
  – V-Notch Weir links used to model the Primary Clarifier Weir
    • Equally divided Primary Clarifier weir length and number of notches
      – 10 weir links for the 160 ft Primary Clarifiers
      – 1 weir link for the 80 ft Primary Clarifiers
  – Open Channel Shape conduit used to model the Primary Clarifier Effluent Channel with the dimensions found in As Built plans
  – V-Notch Weir link connects Storage node to Open Channel Shape conduit
HYDRAULIC MODELING: PRIMARY CLARIFIERS
PRIMARY CLARIFIERS

Storage Node

V-Notch Weirs

Primary Effluent Channel

Primary Influent Piping

PE PS #2 Wet Well Outfall
PRIMARY CLARIFIERS
HYDRAULIC MODELING: FILTERS

- Use the User Control Link to model the Filter Media.
  - Need the Filter Media Headloss vs Flow
- Doesn’t account for the gradual increase in headloss as the filter binds
HYDRAULIC MODELING: FILTERS

- Chlorine Contact Basins
- Influent Box
- Filter Backwash Pump Station
- Bypass Channel
- Final Clarifier #18 Effluent Box
- Deep Bed Media Filter
HYDRAULIC MODELING: FILTERS

Alternative #1

96"/72" conduit

Alternative #2

15’/20’ channel
HYDRAULIC MODELING: CHLORINE CONTACT BASINS
INTEGRATING COLLECTION SYSTEM HYDRAULICS WITH WWTP HYDRAULICS

Strategic Planning

Wastewater Model Development

Flow Monitoring & Model Calibration

GIS Coordination

Population Data Review & Wastewater Flow Projections

Wastewater Collection Planning

Wastewater Treatment Planning

Risk Based Assessment

COMPREHENSIVE CAPITAL IMPROVEMENT PLAN

Funding and Cost Recovery Options

WASTEWATER MASTER PLAN PROCESS
INTEGRATING COLLECTION SYSTEM HYDRAULICS WITH WWTP HYDRAULICS

• Advantages of Integrated Model
  – Dynamic Modeling
    • Extended Period Simulations
    • Alternative modeling for future improvements
    • Flow splits and WSE projections were determined in the model
    • Near Term improvements developed and phased
  – Model Results
    • Influent piping can handle near term peak wet weather flows
    • Recommended improvements at the plant reduce collection system improvements (lowers HGL)
  – Comprehensive CIP
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