Sludge and Scum-Sucking Submersible Sewage Pump Station
(A Unique Approach to the Self-Cleaning Wet Well Design)

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Presentation Outline

• Historical Perspective on Wet Well Design
• The “Trench-Type Self-Cleaning Wet Well”
• Case Study
• Lessons Learned
• Planning Level Cost Estimates

Historical Perspective on Wet Wells

• Wet Well Design in the Late 1800’s
  – From www.sewerhistory.org:
    “…one large cistern of sufficient capacity to contain the accumulation of several days.”

“New Double Plunger Sewage Pump.” The Mechanic’s and Builder’s Volume 11, Issue 12
Historical Perspective on Wet Wells

- **Wet Well Design in the Early 1900’s**
  
  From www.sewerhistory.org:
  
  “In large works this great variation [in flow] can be met by having a large number of units, and in small works it can be minimised by having a reservoir accommodation for the night flow and making the pumps big enough to pump out the dry weather flow in a comparatively few hours….”


- **Wet Well Design in the 1950’s**
  
  “Suction and discharge piping are arranged to provide uniform change in velocity into and away from the pump without creating turbulence.”

  “Low velocity at the entrance to suction conduits permits the wet-well to be drawn down close to the top of the opening without creating vortices that would admit air and break the suction.”

  “Chapter 3 – Plant Pumping Stations,” WPCF Manual of Practice No. 8, ASCE Manual of Engineering Practice No. 36, A Joint Committee of the Water Pollution Control Federation and the American Society of Civil Engineers, 1959, p. 44.

- **Wet Well Design in the 1980’s**
  
  - Submersible Wastewater Pump Association

  ![Wet Well Plan](image1.png) ![Wet Well Section](image2.png)
Historical Perspective on Wet Wells

• Wet Well Design in the 1980’s
  – Baffle wall on inlet
    • Distribution of flow across wet well
    • Low parallel velocities - vortex reduction
    • Traps bubbles - reduction in air ingestion

• Wet Well Design in the 1980’s
  – Not made for solids-bearing water
    • Flow drops into wet well – release of odors
    • Scum gets trapped behind baffle wall
    • Deposition from slow velocities – odor problems

• Trench Type Wet Wells
  – Developed in the late 1950’s by Brown & Caldwell

• Recent Studies (starting in 1993)
  – Robert Sanks, Ph. D., P.E. - Montana State University
  – Garr Jones, P.E. - Brown & Caldwell
  – Charles Sweeney, P.E. - ENSR Laboratory
    • Large-scale (1:4) model testing
    – Fairbanks Morse
      • Full scale basin study
Historical Perspective on Wet Wells

- 1998 Pump Intake Design
  - ANSI/Hydraulics Institute
  - Study results developed into standards
  - Goals are to minimize:
    - Accumulation of solids in sewage wet wells
    - Odors and corrosion
    - Scum blanket formation
    - Vortex and eddy formation

Trench-Type Self-Cleaning Wet Wells

- Concept
  - Pumps in a linear trough ("trench")
  - Flow does not drop into wet well
  - Sized to keep velocities below 1 foot per second

Trench-Type Self-Cleaning Wet Wells

- Self Cleaning Wet Well Function
  - Sluice gate to throttle flow (optional)
  - Run pump farthest from inlet
  - Ogee ramp to promote super-critical flow across floor
  - Stop pump when it looses prime
Trench-Type Self-Cleaning Wet Wells

- Self Cleaning Wet Well Function
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- Model Demonstration

- Orientations for Differing Pump Types

Trench-Type Self-Cleaning Wet Wells

• General Design Criteria
  – Geometry of trench is based on suction bell diameter and Froude number
    • Width $\geq 2 \times D$ (or width needed for submersible pump volute)
    • Submergence $(1 + 2.3 \times F) \times D$
    • Radii on ogee ramp $= SF \times 2.33 \times v^2/2g$
    • Pump spacing $\geq 2.5 \times D$
    • Suction bell to floor height $= 0.5 \times D$
    • Suction bell to floor height (last pump) $= 0.25 \times D$
    • Angle of sloped surfaces $= 45^\circ$
  – Cross-sectional area sized to maintain a velocity in the channel of less than 1 ft/sec
  – Anti-rotation baffle and cone on last pump

Trench-Type Self-Cleaning Wet Wells

• Design Tools
  – Hydraulic Institute “Pump Intake Design” standard
  – Montana State University Civil Engineering spreadsheet
    • http://www.coe.montana.edu/ce/joelc/wetwell/
    • “Instructions 1-24-03.doc”
      – Instructions for the use of the spreadsheet
    • “Trench2.0.xls”
      – Spreadsheet calculates hydraulic and energy grade line profiles, Froude numbers, and sequent depths

Trench-Type Self-Cleaning Wet Wells

• Design Tools
  – MSU CE “Trench2.0.xls” spreadsheet

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Assumptions…Details…

N/A Calculation by:

Project Title: January 3, 2003

N/A Location:

Default Worksheet

Not Applicable

Cahoon

Save this worksheet unaltered to use as the default.

Wetted Perimeter =

Hydraulic Radius =

Program developed by Dr. Joel Cahoon, Montana State University.          Access: http://www.coe.montana.edu/ce/joelc/wetwell/

Section A - B

Section B - C

Ramp Height (ft) =

Flow Depth =

Manning’s n =

Diameter =

Slope =

Flow Area =

Velocity =

Trench-Type Self-Cleaning Wet Wells

- General Design Criteria
  - Geometry of incoming sewer pipe
  - Upstream gravity sewer
    - 200 feet of pipe at 2%
  - Connection to wet well
    - 5 to 10 pipe diameters of horizontal pipe
  - At deflection point upstream gravity sewer and connection to wet well
    - Bend pipe joint(s) – preferable
    - Manhole – less preferable

Case Study

- City of Harrisonville, Missouri
  - Located in Kansas City metropolitan area
  - Pump Station No. 2
    - Feeds flow to the wastewater treatment plant
Case Study

• Existing Pump Station
  – Underground factory-built steel pump station
    • Cast-in-place wet well
    • Two vertical centrifugal pumps
    • Existing 12" dia. force main
    • 3.6 MGD capacity
  – Modeled flow rates w/ 20-years growth
    • 2.2 MGD
  – Historical problems
    • Backups in collection system
    • Untreated sanitary sewer overflows
  – Storage basin at WWTP not at pump station

Case Study

• New Pump Station
  – City’s preferences
    • Basket screen
    • Submersible pumps
  – Decision to try TTSCWW design
    • Comments from value engineering of previous pump station
    • Discussion with Client

Case Study

• Initial Design Features

Case Study

• Modifications for Wet Weather Flows
  – 3 constant speed wet weather pumps
  – Weir wall
  – Sump pump

Case Study

• Unique Valve Vault Design
  – Electrical building above vault
    • Corbel for MCCs
    • Grating and stairs
  – Height of piping
  – Excessive lighting

Case Study

• Example of Combination Electrical Building over Valve Vault
Case Study

• **Pump Controls**
  - VFDs for dry weather pumps
  - Use of PLCs
    * Normal pump control
    * Control of “cleaning cycle”
      - Current monitors to turn off pump
  - Telemetry system alarms
    * High water level
    * Motor moisture, high temperature, loss of power, low current, low resistance
    * Generator running

• **Redundancies provided with the station**
  - Stand-by power
    * Generator to power entire station
    * 25% additional capacity for unknown future equipment
  - Interconnection between the parallel force mains
  - By-pass of PLCs (wet weather pumps only)
    * Separate pump controller with pressure transducer

• **Quality Control – Design**
  - Discussion with Pump Manufacturer
    * Overall station design
    * Vibrations caused by “cleaning cycle”
  - Discussion with Robert Sanks at WEFTEC 2002
    * Modifications to station design
      - Vanes in submersible pump intakes
      - Elimination of middle guide vanes
      - Questioned need for sluice gate
Case Study

• Quality Control – Construction
  – Meeting during shop drawing phase to coordinate equipment functions
    • Pump representative
    • Electrical sub-contractor
    • Motor control center vendor
    • Control panel vendor
  – Attendance at start-up
    • Pump manufacturer
    • Pump representative
    • Electrical sub-contractor
    • Controls vendor

• Construction Photos – Wet well

• Construction Photos – Wet well
Case Study

- Construction Photos – Wet well
Case Study

• Construction Photos – Wet well

Case Study


Case Study

Case Study


Case Study


Case Study

• Construction Photos – Pumps
Case Study

- Construction Photos – Pumps

Case Study

- Construction Photos – Pumps

Case Study

- Construction Photos – Pumps

Case Study

- Construction Photos – Pumps
Case Study

• Construction Photos – Basket Screen

Case Study

• Construction Photos – Completed Station

Case Study

• Pump Station in Operation
  – City’s reaction
    • Public Works director claimed the station as “his legacy”
    • City WWTP operators are currently using the cleaning cycle on a weekly basis
Case Study

• Pump Station in Operation

Lessons Learned

• Transition from Sluice Gate to Ogee Ramp
  – Must be the same width to prevent turbulence
• Need for Gate
  – Convenience of running self-cleaning cycle
• Baffle Plate
  – Provide detail on plans
• Submersible Pump Impellers (Ragging)
  – May need a single vane impeller
• Education of City Staff

Planning Level Cost Estimates

• Cost of Previous Design
  – Five previous designs
    • Capacity from 0.35 MGD to 3.6 MGD
• Cost of TTSCWW Design
  – Three pump stations in Kansas City metropolitan area
Planning Level Cost Estimates

Summary

- Unique Design
  - Promotes wet well cleaning
  - Potentially a less costly wet well
  - Simple design with PLC type controls
  - Fun to operate

Questions?