WATER TREATMENT PLANT
RESIDUALS MANAGEMENT
CASE STUDIES

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Residuals Management Case Studies:

• Two Recent CDM Smith Design Projects -

• **Residuals Facility Design** – New 20 mgd Conventional Treatment Plant (Loudoun, VA)

• **Rehabilitation Project** – Misc. plant modifications including replacement of Trac-Vac Sludge Collectors at Moore’s Bridges WTP (Norfolk, VA)
TRAP ROCK WTP RESIDUALS CASE STUDY
Loudoun, VA
New WTP Design Case Study:

- Recently completed planning and design for a new “greenfield” water treatment plant
  - Trap Rock WTP in Loudoun, Virginia (*under construction*)
- 20 mgd Conventional WTP design (Expandable to 42 mgd)
- Surface water source (Potomac River)

- Desired - “Zero Discharge Facility Design” for residuals
Residuals Facility Design Challenges:

- **Zero Discharge Facility:**
  - Recycle 100% of treated residuals streams to the head of the WTP
  - No normal discharges of residuals to stream (VPDES)
  - No normal discharges to the sanitary sewer system

- **Limited space for residuals facilities**

- **No historical operations data to use for residuals facility sizing, must be projected**

- **DEQ $\rightarrow$ SFBW and SB residuals must be treated prior to recycle (no direct recycle)**

- **Residuals facility layout to allow for future plant expansion**
Residuals Facility Design Steps:

2. Identify Fed/State Regulatory Requirements
3. Facility Planning Process
4. Residuals Facility Design
5. Residuals Facility Operations
STEP 1

Solids Production Calculations / Residuals Streams Generated
1. WTP Process Design:

- Raw Water
- Rapid Mix
- Flocculation
- Sedimentation
- Intermediate Ozone
- GAC Biological Filters
- Clearwell
- High Service Pumps
- Potable Water
- Chlorine
- Caustic
- Ammonia
- Coagulant
- Ozone Preoxidation
- Pumped Injection Mixing
- Ozone Flash Reactor
- Future Plate Settlers
- UV Disinfection

**Process Enhancement**

**Equipment Alternative**
1. Solids Production Calculations

- Obtained Potomac River raw water turbidity data from 2007-2009 (3 yrs) from Leesburg, VA area

- Used Fairfax Water’s Corbalis WTP flow and chemical feed data:
  - Coagulant: PACL (used chem feed data from Corbalis WTP) – DelPAC 2500 Aluminum Chloride Hydroxide Sulfate
  - Coagulant Aid: polymer

- Quarry Pre-sedimentation: Reduced raw turbidity peaks > 50 ntu to avg. daily turbidity value.
1. Solids Production Calculations

- **Empirical Calculation: (b value=1.0)**

<table>
<thead>
<tr>
<th>Formula</th>
<th>( S = 8.34 \times Q \times (0.32 \times \text{PACL} + (b \times \text{Tu}) + \text{A}) )</th>
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</thead>
<tbody>
<tr>
<td>PACl</td>
<td>DelPAC Aluminum Chloride Hydroxide Sulfate (12.5% Al(_2)O(_3), 6.6 % Al)</td>
</tr>
<tr>
<td>( S )</td>
<td>Sludge produced (dry lb/day)</td>
</tr>
<tr>
<td>( Q )</td>
<td>Raw water flow (Corbalis WTP)</td>
</tr>
<tr>
<td>( \text{Tu} )</td>
<td>Turbidity (ntu) – Potomac River Leesburg, VA</td>
</tr>
<tr>
<td>( \text{A} )</td>
<td>Polymer, mg/L as dry product (Corbalis WTP)</td>
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- **Solids production rate = 161 dry lb/MG (avg)**

- **Develop percent of time curve to determine the solids design basis – 95\(^{th}\) percentile value was selected:**
  - 7,000 dry lb/day @ 21 mgd (95\(^{th}\) percentile)
1. Identify Residuals Assumptions:

- **Filter Backwash**
  - 6 washes /day max at 300,000 gpw, frequency 1 BW/ 2 hrs.
  - 15,000 gpm rate

- **Sedimentation basin blowdown**
  - 95th percentile production = 7,000 dry lb/d @ 21 mgd
  - Avg. concentration 0.3%, 280,000 gpd (200 gpm max)

- **Filter to Waste**
  - 6 washes /day max at 44,000 gpw, frequency 1 BW/ 2 hrs
  - 3,000 gpm rate

- **Process Overflows** – Unpredictable flows?

- **Basin Cleanings / Draining** – Predictable but infrequent
STEP 2

Federal and State Residuals Regulatory Requirements
2. Regulatory Permitting (Virginia)

- **VPDES Permit** (VA Pollutant Discharge Elimination System):
  - Required by DEQ for residuals “direct discharges” to surface waters

- **VPA Permit** (VA Pollutant Abatement Permit):
  - Direct land application to farm land or monofill. DEQ has a specific VPA application forms / approval process.

- **Sewer Discharge** (POTW quality / quantity limits)

- **Recycle** (Filter Backwash Recycle Rule, VA DEQ)
2. Regulatory Permitting (Virginia)

- EPA “Filter Backwash Recycle Rule” – Administered by VA DEQ
  - Contaminants of concern: Fe-Mn, TOC, DBPs, *Giradia* and *Cryptosporidium*, TSS
  - To minimize risk - recycle flows are typically limited to 10% instantaneous rate (per EPA guidance)

- Our recent experience – VA DEQ requires treatment of residuals streams prior to recycle (solid/liquid separation)

- Dewatering streams – required to discharge to the sanitary sewer
2. Regulatory Permitting (Virginia)

- **Residuals Facility Design** – All liquid residuals generated are to be clarified and recycled.
  - DEQ required treatment prior to recycle (engineered solid/liquid separation process)
  - BUT...Allowed for instantaneous recycle rate up to 20% *(recycle flow to be returned prior to pre-ozone)*

- **VPDES Permit** – limited discharge of treated residuals to Goose Creek
  - TSS: 30 mg/L (mo. avg) - 60 mg/L (max)
  - Flow 4.0 mgd max, 0.33 mgd avg daily
  - pH 6-9, TR chlorine < 0.004 mg/L
2. Regulatory Permitting (Solids)

- VA DEQ considers WTP solids to be an non-hazardous “industrial waste” – beneficial use permitted on “case-by-case” basis:
  - “Beneficial” Reuse – No Federal guidelines, States assume primacy. Some use Biosolids regs 503 metals, TCLP test, other.
    - Composting
    - Soil blending
    - Land application
    - Other...

Landfill/Landfill Cover – RCRA Subtitle C&D, Non-hazardous based on TCLP, no free liquids
STEP 3

Facility Planning
3. Facility Planning

- **Key Residuals Design Decisions:**
  - Treat backwash and sed basin residuals separately, 100% recycle
  - Equalization of SFBW
  - Plate settlers for clarification of SFBW
  - Gravity thickening of sed basin residuals
  - Direct recycle of FTW
  - Treated SFBW, thickener effluent and FTW combined for recycle
  - Initial Solids Disposal Practice - Liquid hauling of 2-3% thickened solids (until mech. dewatering required)
3. Facility Planning

[Flowchart image with details on water treatment processes, including recycling, filtration, treatment of plant overflows, sedimentation, and storage.]

NOTE: VALUES SHOWN ARE PRELIMINARY DESIGN PARAMETERS. ACTUAL FLOWS AND % SOLIDS WILL VARY IN OPERATION.
3. Site Layout:
3. WTP Rendering:
3. WTP Architecture:
STEP 4

Residuals Facility Design
4. Residuals Facility Design (Site Plan)

- EQ Basin
- Plate settlers
- Recycle Basin
- Thickener PS
- Thickened Solids Storage
- Emergency Basin and PS
4. Facility Design (EQ)

**Equalization Assumptions:**

- 6 filter washes/day (worst case) @ 21 mgd
- Frequency: 1 BW every 2 hrs
- **EQ In:** SFBW - 15,000 gpm for 20 min = 300,000 gal
- **EQ In:** Thickener effluent = 200-400 gpm
- **EQ Out:** To Plate Settlers (2,500 gpm)

**EQ 24 hr. Fill and Draw Analysis:**

- Calc. Storage Required = 300,000 gallons
- Added 25% capacity → 400,000 gal (with mixing)
4. Facility Design (EQ)
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4. Facility Design (Plate Settlers)

- **Plate Settlers:** *(engineered system)*
  - MRI Package System – flocc mixing, baffle wall, plates, sludge collectors, overflow trough (2 basins)
  - Need to wash 1 filter /2hrs = 300,000/120 min = 2,500 gpm
  - 1,250 gpm per basin (VFD control pumps)
  - Design loading rate = 0.35 gpm/ft²

- **Quality:** *(meet VPDES limits)*
  - Influent: Approx. 200 – 600 mg/L
  - Effluent: < 30 mg/L TSS
4. Facility Design (Plate Settlers)
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4. Facility Design (Plate Settler)
4. Facility Design (Recycle)

- **Recycle Basin and Pump Station:**
  - DEQ allowed up to 20% inst. recycle rate
  - Influent Plate Settler effluent and Filter to Waste:
    - P.S. effluent = 2,500 gpm
    - FTW = 44,000 gwp (2,900 gpm for 15 min and 6 washes/day max)
  - Storage Basin Vol. = 210,000 gallons (extra EQ capacity for FTW)
  - Submersible pumps w/ VFD control to pace recycle flow
4. Facility Design (Recycle)
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4. Facility Design (Recycle)
• Recycle Issues for “Zero Discharge Facility”
  – Maintain flow balance to meet inst. recycle limits
  – Problems when operating at low plant flow, backwashing can be limited
  – Example:
    • WTP operating at 5 mgd (3,500 gpm)
    • Max recycle rate (20%)= 1 mgd (694 gpm)
    • Only recycle the treated washwater for 2 filters per day + Thick eff. residuals (= approx. 970,000 gpd)
  – Backup Plan:
    • Emergency Storage Basin
    • VPDES – 4.0 mgd (max), 0.33 mgd (avg day)
4. Facility Design (Thickening)

- **Thickeners:**
  - 7,000 dry lb/day @ 21 mgd (95<sup>th</sup> Percentile)
  - Solids flux rate = 3.5 dry lb/day/ft<sup>2</sup>
  - Solids Conc. (in/out) = 0.3% / 3.0%
  - No. Thickeners (@21 mgd) = 2 (continuous flow)
  - Calculations required a 36 ft thickener design

→ **Selected 45 ft thickener design (some extra solids capacity + only one more 45 ft thickener required in the future for 42 mgd)**
4. Facility Design (Thickening)
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4. Facility Design (Thickened Solids Storage)

- **Thickened Solids Storage:**
  - Progressive cavity pumps – from Thickener at 2-4% solids
  - Density meter
  - Used 36,000 gal storage capacity w/ mixing
  - 6 days of storage at 11 mgd (at avg. solids production)
  - Truck connection and pump to load tanker trucks for Contractor disposal

Backup plan - Can dump TS tank to Emergency Basin
4. Facility Design (Thickened Solids Storage)
4. Facility Design (Thickened Solids Storage)
4. Facility Design (Emergency Basin)

- **Emergency Storage Basin:**
  - Critical basin for plant operations: approx. 400,000 gallons
  - Process and Residuals drains/overflows, cooling water flow
  - Direct discharge of SFBW, FTW, SB blowdown
  - Can dump thickener and Thickened Solids Storage tanks
    - HDPE liner w/ geocomposite underdrain
    - Pump station to return EB residuals to EQ basin or to sewer
    - Underdrain pump station – pumps water under liner to storm system
4. Facility Design (Emergency Basin)
4. Facility Design (Emergency Basin)
STEP 5

Future Expansion
5. Facility Design (Future Expansion)

- **Future Residuals Facility Expansion:**
  - Mechanical dewatering facility (timing depends on production flow increases)
    - @ 11 mgd → 1-2 tanker trucks / day (avg. production)
  - New 45 ft thickener (42 mgd)
  - New EQ/ Plate Settler/ Recycle basin (42 mgd) – *mirror image*
  - New Thickened solids storage tank (42 mgd)
  - Upsize recycle pumps and add thickened solids pumps
  - **Phase III** - Room for 4th 45 ft thickener (60 mgd)
5. Facility Design (Future Expansion)
PART 6

Residuals Facility Operations
6. Residuals Facility Operations

- **Residuals Facility Operations:**
  - SCADA monitoring and remote control, w/ level, flow monitoring
  - *Variable speed pumping* gives operational flexibility for flow balance and recycle
  - Polymer feed – from central chemical building (outside of residuals area)
  - Ability to discharge to the Emergency Basin for when necessary due to flow imbalance or for facility maintenance, process redundancy
  - Other disposal outlets: Limited sewer discharge availability and VPDES
6. Residuals Facility Operations (Solids Disposal)

- Liquid Hauling and Land Application (by Contractor):
  - Thickened Solids 2 to 4%
  - Hauled from WTP in 6,000 gal tanker truck
  - Cost ($/gallon) = $0.06 to $0.10 / gallon ($0.08/gal used for planning)
  - Plant startup flows $\rightarrow$ 5-8 mgd

**Short term solution**
**Liquid Hauling only practical for < 11 mgd**
6. WTP Construction Status

- Construction is on-going: civil site work, yard piping, building and tank foundations
- Startup expected in summer 2017
MOORE’S BRIDGES SLUDGE COLLECTOR REPLACEMENT DESIGN

Norfolk, VA
Water System Upgrades 2012
(Photo compliment of City of Norfolk Pictometry)

- Multiphase design and construction
- Rehabilitate finished water tanks, filters, and other miscellaneous improvements
- Rehabilitate sedimentation basin’s 2 – 6
Rehabilitate Sedimentation Basin’s 2 - 6

- Rehabilitate and repair concrete
- Repair existing water mains
- Rehabilitate sluice gates
- Rehabilitate flocc paddles
- Replace existing trac-vac system
Typical Existing Sludge Removal System for Basins 2-6
(graphic excerpt from City of Norfolk record drawing)
Why Replace the Sludge Removal System?

- Repetitive maintenance issues
- Pneumatic drive system, w/ air compressor
- Concerns of unavailable repair parts
- Pump clogging
Why Replace the Sludge Removal System?

- Outdated controls technology
- Beneficial use of components near end of life
Replacement Option 1 – Hoseless Cable Vac

(Graphic excerpt taken from Meurer Research)
Replacement Option 2 – MRI Cable Driven Trac-Vac Retrofit

- Use existing tracks
- Use existing wall penetration
Replacement Option 2 – Pumps/Piping Improvements

- Interior mechanical piping in sound condition
- Pump replacement to positive displacement or open face impellor would change HP
- Pumps to remain
Improvements to system
(Graphic excerpt taken from Meurer Research)

- Simpler cable driven trolley with speed control
- Improved solids removal using new intake pipe
- Replace hoses
Pre-final Design

- Typical replacement
- Cost savings pays for other modifications

Moores Bridges WTP Improvements
Pre-final Design

- Typical replacement
- Motor and drive with easy access
Summary

- Replace pneumatic trac-vac with hybrid cable driven system
- Pumps, interior piping, track, and hardware to remain
- Performance will exceed existing system
- Cost savings pays for other improvements
Q&A Session

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Questions??