Don’t “Screw Press” Around: Applying Screw Press Technology to WTP Residual Solids Dewatering

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Hana Litwin, Stantec
Agenda

1. Background
2. Screw Press Technology Overview
3. Sizing the Screw Press System
4. Design Alternatives
5. Detailed Design
Cleveland Water Department

Background
Cleveland Water Department (CWD)
Four plants established between 1925 and 1958

Only Crown has On-Site Sludge Dewatering

Remaining Three (3) Water Plants remove residuals from onsite sludge holding tanks to direct sewer connection
Current Crown Residuals Practices

• Crown Water
  o Avg flow through the plant: 42.1 MGD* (rated for 86.7 MGD)
  o Max flow through the plant: 63.6 MGD* (rated for 130 MGD)

• Four (4) Gravity Thickeners

• Since 1985, Crown has operated two (2) plate-and-frame presses

• Alum-polymer sludge with lime addition for dewatering

* Based on 2012-2013 data from the Residual Solids Production and Disposal Cost Report, July 2014, Stantec
Existing Residuals Process Schematic

- **Overflow to Lake Erie**
- **Gravity Thickener**
- **Lime**
- **Pressate to Sanitary Sewer**
- **Backwash Clarifiers**
- **Backwash Equalization Basin**
- **Plate and Frame Presses**
- **Pressate to Truck**
- **Anthracite Filters**
- **Existing Residuals Process Schematic**
Why Replace the Plate-and-Frame Presses

- Improve solids production
- Decrease maintenance requirements
- Reduce energy consumption
- Aging equipment
- Labor intensive system
Screw Press System

- Dewater solids to achieve 15-30% solids
- Slow screw speed: 0.5-1.5 rpm
**Screw Press & Ancillary Systems**

**Wash Water**
- To clean screw press, recommended every 2-3 hours of operation, 4-6 min

**Polymer**
- Added to Sludge Line at the Injection Ring for Dewatering

**Screw Conveyor**
- To evenly load trucks below the screw presses (multiple gates)

**Compressed Air**
- To pressurize the screw press

**Sludge Feed Pumps**
- Including flow and density meters
Sizing the Screw Press System
Residual Solids Production Rates

- Estimated and reported residual production rate for Crown Water Works were ~172 (dry lbs/MG)

- Production Rates:
  - Avg. day – 7,278 (dry lbs/day)
  - Max day – 51,221 (dry lbs/day)

- The peaking factor \( \frac{51,221}{7,278} \) is 7
  - Must be sized to handle maximum 7-day average with redundancy
Screw Press Sizing – Volume

Calculating Throughput Volume, V
- $W_s$ = Weight of Dry Solids (lbs)
- $\rho_\omega$ = Density of Water (lbs/gal)
- $S_{sl}$ = Specific Gravity of Sludge
- $P_s$ = Percent Solids, as a decimal

$$V = \frac{W_s}{\rho_\omega \times S_{sl} \times P_s}$$

Throughput Volumes
- Avg day = 21,284 gal/day
- Max day = 149,795 gal/day

Assumptions
- Specific Gravity = 1.025
- Solids Concentration from Thickeners = 4%
# Screw Press Sizing – Varying Safety Factors

<table>
<thead>
<tr>
<th>Ave-day¹</th>
<th>S.F.</th>
<th>0%</th>
<th>10%</th>
<th>15%</th>
<th>20%</th>
<th>25%</th>
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<tbody>
<tr>
<td>Ave-day Production (lbs/day)</td>
<td></td>
<td>7278</td>
<td>8006</td>
<td>8370</td>
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<td>Ave-day Production (lbs/week)</td>
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<td>Required Dry (lbs/hr)</td>
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<td>1698</td>
<td>1868</td>
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<td>Ave-day Volume (gal/day)</td>
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<td>21284</td>
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<td>Required Thruput (gpm)</td>
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<td>83</td>
<td>91</td>
<td>95</td>
<td>99</td>
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**Notes:**

1. Based on 30 hrs/week (6 hour days, 5 days a week)

Same method used for Max-day calculations
## Screw Press Sizing – Schwing

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<tr>
<th>Model</th>
<th>Capacity Aerobic 2.5% DS (dry lb/hr)</th>
<th>Capacity Anaerobic 3.5% DS (dry lb/hr)</th>
<th>Length (in)</th>
<th>Width (in)</th>
<th>Height (in)</th>
<th>Weight (lb)</th>
<th>Power (hp)</th>
<th>Reaction Tank</th>
<th>Washwater</th>
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<td>Model</td>
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<td>FSP 703</td>
<td>970</td>
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<td>255</td>
<td>57</td>
<td>72</td>
<td>11,640</td>
<td>5.0</td>
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<td>FSP 1102</td>
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<td>FSP 1202</td>
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<td>28,680</td>
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Alternative 1

Polymer Room (Lower Level)
Flocculation Tank (4)
Process Control Room
Contact Tank (2) (Lower Level)
Sludge Feed Pumps (5) (Lower Level)
Screw Press (4)

Alternative 2

Polymer Room (Lower Level)
Flocculation Tank (4)
Process Control Room
Contact Tank (2) (Lower Level)
Sludge Feed Pumps (5) (Lower Level)
Screw Press (4)
Process Control Room
Polymer Room (Lower Level)
Flocculation Tank (4)
Screw Press (4)
Sludge Feed Pumps (5) (Lower Level)
Contact Tank (2) (Lower Level)

Contact Tank (2) (Lower Level)
Sludge Feed Pumps (3) (Lower Level)

Alternative 3

Flocculation Tank (2)
Screw Press (2)
Polymer Room (Lower Level)

Alternative 4
## Pair-wise Comparison of Alternatives

<table>
<thead>
<tr>
<th>Pair-Wise Comparison</th>
<th>Alt 1 - 4 Screw Presses, 2 Conveyors, No Building Additions</th>
<th>Alt 2 - 4 Screw Presses, 4 Conveyors, No Building Additions</th>
<th>Alt 3 - 4 Screw Presses, 4 Conveyors, Building Addition</th>
<th>Alt 4 - 2 Screw Presses, 2 Conveyors, No Building Additions</th>
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<td><strong>12</strong></td>
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<td><strong>6</strong></td>
<td><strong>6</strong></td>
<td><strong>4</strong></td>
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<td>Maintenance</td>
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<td><strong>Score</strong></td>
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<td>Constructability</td>
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<td>Weight</td>
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<tr>
<td><strong>Score</strong></td>
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<td><strong>9</strong></td>
<td><strong>15</strong></td>
<td><strong>12</strong></td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>27</strong></td>
<td><strong>31</strong></td>
<td><strong>45</strong></td>
<td><strong>22</strong></td>
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</tbody>
</table>

Categories ranked on a score of 1-5, with 1 being the best score

*Total weight of all capital cost, operations, maintenance, and constructability adds up to 10, weight per category is the same for each alternative

Alternative 4 selected because the two trains are similar operationally to existing equipment and are lower cost
Cleveland Water Department

Detailed Design
Project Scope

• Replace two (2) Plate-and-Frame Presses with Screw Presses
• Replace three (3) Sludge Feed Pumps
• Install Ancillary Screw Press Systems
• Replace GST Sludge Transfer Pumps and Drives
• Demolish Lime System
• Contact Tanks: Replace Mixers, Add Baffles and Access Hatch
New Residuals Process Schematic

- SEDIMENTATION BASIN
- Polymer Overflow to Lake Erie
- BACKWASH EQUALIZATION BASIN
- BACKWASH CLARIFIERS
- ANTHRACITE FILTERS
- CONTACT TANK MODIFICATIONS AND NEW SLUDGE FEED PUMPS
- LIQUID HAULING CONNECTION
- NEW SLUDGE TRANSFER PUMPS AND GST DRIVES
- Shaftless Screw Conveyor
- Truck
- Liquid Hauling
- FLOCCULATION TANK
- Screws Presses
- Pressate to Sanitary Sewer
Sludge Dewatering System Schematic

- **Polymer Injection**: Potable Water for Batching
- **Flow Meter**: Screw Press
- **Density Meter**: Screw Press
- **Contact Tank**: Screw Press
- **Progressing Cavity Pumps**: Screw Press
- **Flocculation Tank**: Screw Press
- **Pressate**: Screw Press
- **Truck**: Screw Press
- **Feedback Loop for 4-6% Solids**: Screw Press
Sludge Dewatering Building Section

- Flocculation Tank raised to increase hydraulic head when draining
- Shaftless Screw Conveyor with three Knife Gate Valves
- Screw Presses will be installed through the existing floor openings
- Liquid Hauling Connection brought outside the building
Sludge Dewatering Building Plans (Lower Level)

- New Feed Pumps (Orange)
- New Duplex Air Compressor (Yellow)
- Polymer Room in NW corner, with three Polymer Blending Units. Spill containment pallets provided for 300 gal spill containment. (Green)
- New Washwater Booster Pump Skid (Blue)
- New Contact Tank Mixer (Purple)
Sludge Dewatering Building Plans (Intermediate)

- Lime System Removed
- Screw Press Drain lines to Rocky River WWTP (Red)
- Piping from Contact Tanks to Flocculation Tanks and Liquid Hauling (Orange)
- Air Compressor piping (Yellow)
- Polymer Piping (Green)
- Washwater Piping (Blue)
- Flocculation Tank Drain Lines (Purple)
Sludge Dewatering Building Plans (Upper Level)

- Two Screw Presses with Flocculation Tanks in place of existing Plate and Frame Presses
- Lime System Removed
- Platform to be built after Screw Press Delivery and Placement on 2nd Floor
- Break room removed and Control Room Rehabilitation
Sludge Dewatering Building Structural Modifications

- Additional intermediate beams added under 2nd Story
- Needed to support the screw presses, floc tanks, and screw conveyors
- Lightweight steel I-beams with simple installation
- Plate-and-Frame Presses spanned column lines 4 - 5 with no intermediate beams
Future Crown Residuals Operations

- Density meters and flow meters will determine contact tank batching and polymer dosing.

- Normal operation: 1 Screw Press, 4-6 hours/day, 5 days/week
  - Maximum operation: 1 Screw Press, 24 hours, 7 days/week or 2 Screw Presses, 12 hours/day, 7 days/week

Cleaning Cycle:
- Washwater booster pumps will be turned on for 4-6 min every 2-3 hours of operation.

- At the end of each day, the flocculation tank should be drained by gravity back to the Contact Tanks
Conclusion

• **Advantages to Screw Presses**
  - Completely Enclosed Machines
  - Less energy consumption and manpower
  - Entire system automated with centralized control through SCADA
  - Dewatered sludge can be used for beneficial re-use
Contact Information

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Questions?

Cleveland Water Department

Thank you