City of Shasta Lake

Water Treatment Plant Residuals Dewatering Feasibility Study

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Background and Project Understanding

The City of Shasta Lake owns and operates a surface water treatment plant (WTP) south of the Shasta Lake dam. The facility is rated to treat up to 6.7 million gallons per day (mgd), but treats an average of approximately 2.5 million gallons per day. The treatment process consists of coarse screening followed by coagulation, flocculation and filtration in three packaged clarifier-filters (Microfloc, now owned by Siemens Corporation). The water is disinfected and then distributed.

Plant operations staff uses a polyaluminum chlorohydrate / organic polymer blend (Sterling Water Technologies SWT 9310A, abbreviated ACH hereafter). This coagulant/polymer blend is fed upstream of the clarifier-filter packages. ACH creates very little solids compared to many coagulants typically used for coagulation of surface water, but the solids that are formed, along with the ambient turbidity that is removed from the raw water, are trapped and removed in both the solids contact clarifiers (called forward-flush) and the filters (backwash). From these processes the solids are conveyed to a Solids Holding Basin located on the WTP site, where they settle and thicken. The supernatant (clear water left after settling) is recycled to the head of the WTP. The residual solids are periodically conveyed from the Solids Holding Basin to one of two ponds located at the former site of the Summit City WTP, on City of Shasta Lake property on Redbud Lane. This site is approximately 8,000 ft from the WTP.

At the Redbud Lane pond facility, solids are again settled and thickened, and clarified water overflows the ponds and discharges to an un-named tributary to Churn Creek. The City has a National Pollutant Discharge Elimination System (NPDES) waste discharge permit (ORDER NO. RS-2006-0102, NPDES NO. CA0004693) to discharge up to 175,000 gallons per day (gpd) from the ponds. The solids that are collected in the ponds are periodically dredged and hauled to the City’s Wastewater Treatment Plant (WWTP), located off Ashby Rd.

The current discharge permit for the ponds only contains limits for maximum flow, pH range, settleable solids and chlorine residual. The City routinely meets these limits. However, the Regional Water Quality Control Board (RWQCB) has informed the City that with the next permit, the City will be required to comply with water quality limits dictated by the California Toxics Rule (CTR) and the Water Quality Control Plan, Fourth Edition (5th is currently being finalized), for the Sacramento and San Joaquin River Basins (hereinafter referred to as the Basin Plan), for the protection of the beneficial uses for Churn Creek, which include cold freshwater habitat (COLD); warm and cold migration of aquatic organisms (MGR); and warm and cold spawning, reproduction, and/or early development. These designations bring with them stringent discharge limits for priority pollutants. In particular, the RWQCB has told the City that the discharge from the Redbud Lane pond facility will be unable to comply with receiving water hardness-based limits that will be established for the metals copper, zinc and aluminum.

Therefore, the City has decided to evaluate alternatives for a permanent solids dewatering facility that would eliminate the discharge from the Redbud Lane ponds. The purpose of this feasibility study is to evaluate the available options and to develop a budgetary cost estimate for the most cost-effective solution.

Alternatives to Eliminate Discharge

Project alternatives were discussed with the City during an initial site visit. Several alternatives were discussed with City of Shasta Lake staff, with some dismissed from further analysis. The alternatives discussed are listed in Table 1, along with the initial assessment of the alternatives’ merit or lack thereof, and the decision as to whether or not to include the alternative in a more detailed analysis.
Table 1. Initial Assessment of Project Alternatives

<table>
<thead>
<tr>
<th>Project Alternative</th>
<th>Initial Assessment</th>
<th>Alternative Selected for Further Analysis?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hauling or pumping of liquid and solid waste from Redbud Lane to the Wastewater Treatment Plant</td>
<td>• The 8,000 ft pipeline from the WTP to Redbud Lane is at the end of its service life. Replacement or slip-lining with 4-in pipe would cost minimum of $320,000, on top of high maintenance cost of hauling or pumping the waste from the Redbud Lane facility to the City’s WWTP</td>
<td>NO</td>
</tr>
<tr>
<td>Treat pond overflow to comply with future waste discharge requirements</td>
<td>• To insure compliance with future permit requirements, a chemical precipitation, nanofiltration or reverse osmosis membrane treatment system would be required. This would be a small but very costly, complex, and maintenance and energy intensive treatment system.</td>
<td>NO</td>
</tr>
</tbody>
</table>
| Land dispose of clarified water from the Redbud Lane Ponds at the site of the Ponds | • Groundwater monitoring and land application permit would be required.  
• Vegetation would require maintenance.  
• Agronomic application rates would likely require more storage volume to be constructed | NO                                        |
| Mechanical Dewatering Facility constructed at the WTP       | • Direct dewatering to greater than 20% total solids content is possible, greatly reducing sludge hauling cost  
• All liquid waste flows (decant, pressate, filtrate, etc.) will have to be recycled, minus some minimal blowdown volume. May have to meet 2 NTU or less in the combined recycle stream in order to recycle  
• WTP site is very limited in area  
• Cost of equipment approximately $300,000 | YES                                       |
| Filter Roll-Off Container Dewatering at the WTP             | • Passive dewatering, time and weather determine % solids results  
• Inexpensive relative to other alternatives (units cost approximately $40,000  
• All liquid waste flows (decant, pressate, filtrate, etc.) will have to be recycled, minus some minimal blowdown volume. May have to meet 2 NTU or less in the combined recycle stream in order to recycle  
• WTP site is very limited in area | YES                                       |
| Vacuum-assisted Drying Bed Dewatering at the WTP            | • Essentially a filter, with relatively high maintenance and surface area requirements relative to other Dewatering alternatives  
• “Filtrate” does is routinely less than 2 NTU, recycling filtrate will not require more equipment  
• Expensive and would require significant site work to locate two beds on the existing WTP property | NO                                        |
Based on this preliminary screening of alternatives, two alternatives were deemed worthy of further consideration:

1. **Construction of a mechanical dewatering facility** at the WTP site that would dewater the residuals that are currently settled in the Solids Holding Basin. The residuals would be dewatered to approximately 20% solids content, and then hauled to the City’s WWTP for further drying prior to eventual landfill disposal. Water removed from the solids (pressate) would be returned to the head of the WTP, but periodically (e.g. once every two weeks) this water would need to be hauled to the City’s WWTP for disposal, in order to remove contaminants that can accumulate in the recycle loop because they are not being removed in the water treatment process (this practice is commonly referred to as “blowdown”).

2. **Construction of a facility based around the use of filter roll-off containers.** Solids settled in the Solids Holding Basin would be pumped into one of two filter roll-off containers, which would dewater the solids to approximately 20% over approximately one month, depending on the season. The roll-offs would be hauled to the WWTP where the solids would be dumped, and then returned to the WTP. Filtrate that drains from the roll-offs would be returned to the head of the WTP, with periodic blowdown as described in item 2, above. Filter roll-off container dewatering is not typically considered practical for a WTP of this size. However, the City’s WTP raw water quality is so consistently good, and the necessary coagulant/polymer dose is so low that very little solids are generated by the facility relative to other WTPs of its size. This will be described in more detail in the following pages.

Either type of dewatering facility (mechanical or filter roll-off) would include a polymer feed system, provisions for future pressate or filtrate treatment system, and a metal building with an HVAC system. These ancillary systems will be described in further detail in subsequent sections.
WTP Residuals Production

Based on information gathered on the WTP, including flows, typical coagulant/polymer dose, and information on the coagulant that is used, a design criteria summary and estimates of residuals production were developed and are provided in Table 2.

### Table 2. City of Shasta Lake WTP Operations Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Units</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Demand</td>
<td>5.0</td>
<td>mgd</td>
<td></td>
</tr>
<tr>
<td>Average Demand</td>
<td>2.5</td>
<td>mgd</td>
<td></td>
</tr>
<tr>
<td>Average Raw Water Turbidity</td>
<td>1.0 to 10 NTU</td>
<td>NTU</td>
<td>Depends on withdrawal port in the dam – lower port pulls in ash from recent fire in watershed</td>
</tr>
<tr>
<td>Design Raw Water Turbidity</td>
<td>5.0</td>
<td>NTU</td>
<td></td>
</tr>
<tr>
<td>NTU:TSS Ratio</td>
<td>1.2</td>
<td></td>
<td>Correlation is generally unstable in very low (and high) NTU water, conservative ratio utilized</td>
</tr>
<tr>
<td>Estimated TSS in Raw Water</td>
<td>6.0</td>
<td>mg/L</td>
<td></td>
</tr>
<tr>
<td>Coagulant Dose (Feed Pump Setting)</td>
<td>800</td>
<td>mL/min</td>
<td>789 mL/min during site visit</td>
</tr>
<tr>
<td>Coagulant</td>
<td>Sterling Water Technologies SWT 9310 A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coagulant Type</td>
<td>Polyaluminum Chlorohydrate / Poly DADMAC Blend</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum Chlorohydrate Portion</td>
<td>48% Solids, 65% of total blend</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poly DADMAC Portion</td>
<td>40% Solids, 35% of total blend</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Calculated Solids Content of Product</td>
<td>45% Solids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solids Content of Dilution</td>
<td>8.64% Solids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polymer 9310 A Density</td>
<td>1200 g/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculated Coagulant/Polymer Mass Dose</td>
<td>83 g/min</td>
<td></td>
<td>Based on density and pump setting</td>
</tr>
<tr>
<td>Resulting Mass Dose to Raw Water</td>
<td>9.0 mg/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portion that produces an aluminum hydroxide</td>
<td>5.5 mg/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic Polymer (Poly DADMAC) Portion</td>
<td>3.0 mg/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated TSS Contribution from Coag/Poly Blend</td>
<td>2.4 mg/L</td>
<td>0.44 mg solids / mg fed product</td>
<td></td>
</tr>
<tr>
<td>Design Total Solids Load to the WTP</td>
<td>8.4 mg/L</td>
<td>Chemicals plus Raw Water Particles</td>
<td></td>
</tr>
<tr>
<td>Maximum Daily Solids Generation Rate</td>
<td>352 lb/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Daily Solids Generation Rate</td>
<td>176 lb/day</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Volumetric Sludge Production

The volume of sludge generated will depend on the solids content (dryness). The Backwash Holding Basin can be used to increase the solids content of the waste from the clarifier forward flush and the filter backwashes, which generate very “thin” (approximately 0.1% solids) waste streams. Thickening to 1% solids should be achievable in the basin with settling of the solids and decanting clarified water off the upper portion of the basin and recycling it to the head of the WTP.
The solids content of dewatered sludge will depend on the dewatering process selected. Table 3 below lists the volume of sludge produced in gallons per day and cubic yards per day, both on an average daily basis and on the maximum day basis, based on the percent solids content that could be achieved with a new dewatering system at the WTP.

### Table 3. City of Shasta Lake WTP Residuals Volume Generation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Units</th>
<th>Residuals Produced per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Daily Solids Generation Rate</td>
<td>352</td>
<td>lb/day</td>
<td></td>
</tr>
<tr>
<td>Volumetric Flow at 0.01% Solids</td>
<td>422,000</td>
<td>gpd</td>
<td></td>
</tr>
<tr>
<td>Volumetric Flow at 1% Solids</td>
<td>4,220</td>
<td>gpd</td>
<td>11.0 cu yds/day</td>
</tr>
<tr>
<td>Volumetric Flow at 10% Solids</td>
<td>422</td>
<td>gpd</td>
<td>2.1 cu yds/day</td>
</tr>
<tr>
<td>Volumetric Flow at 20% Solids</td>
<td>211</td>
<td>gpd</td>
<td>1.0 cu yds/day</td>
</tr>
<tr>
<td>Average Daily Solids Generation Rate</td>
<td>176</td>
<td>lb/day</td>
<td></td>
</tr>
<tr>
<td>Volumetric Flow at 0.01% Solids</td>
<td>211,000</td>
<td>gpd</td>
<td></td>
</tr>
<tr>
<td>Volumetric Flow at 1% Solids</td>
<td>2,110</td>
<td>gpd</td>
<td></td>
</tr>
<tr>
<td>Volumetric Flow at 10% Solids</td>
<td>211</td>
<td>gpd</td>
<td>1.0 cu yds/day</td>
</tr>
<tr>
<td>Volumetric Flow at 20% Solids</td>
<td>106</td>
<td>gpd</td>
<td>0.5 cu yds/day</td>
</tr>
</tbody>
</table>

### Mechanical Dewatering Alternative

Samples were collected of the City’s WTP residuals from the Backwash Holding Basin and sent to two manufacturers of mechanical dewatering equipment:

1) Andritz Separation Inc., manufacturer of both centrifuges and belt filter presses. Andritz tested the residuals to determine dewater-ability with both centrifuges and belt filter presses.
2) FKC Co., LTD, manufacturer of screw presses. FKC also tested the residuals to determine dewater-ability.

The two manufacturers tested the samples for general quality and the ease of dewatering, and then provided cost proposals for equipment sized for the City’s WTP, without redundancy (a single unit). A redundant dewatering unit is less necessary with some dewatering technologies (e.g. screw presses), and due to the low solids generation at the City’s WTP, it is possible to forego redundancy with any of the technologies if a Filter Roll-Off Container were used as the temporary storage and hauling equipment, rather than a typical un-lined container roll-off container. Therefore, it has been assumed that any of the three technologies evaluated would have a conveyor to move dewatered sludge to a filter roll-off container, and no redundant dewatering unit.

The complete results and equipment proposals from both manufacturers are attached in the Appendices (Andritz in Appendix A, FKC in Appendix B). A summary of the results and equipment proposals is provided in Table 4.
Table 4. Summary of Mechanical Dewatering Vendors Testing Results.

<table>
<thead>
<tr>
<th>Manufacturer and Equipment Type</th>
<th>Polymer and Dose</th>
<th>Ash Content %</th>
<th>Solids Content Achieved</th>
<th>Solids Capture Efficiency</th>
<th>Equipment Proposal</th>
<th>Equipment Capacity</th>
<th>Dewatering Equipment Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andritz Centrifuge</td>
<td>BASF E38 (anionic) 5.2 active lb/ton</td>
<td>83.9%</td>
<td>32±2%</td>
<td>95 to 97%</td>
<td>D2L High Solids Decanter Centrifuge</td>
<td>1600 gal/hr at 1% or higher feed solids concentration</td>
<td>$178,000 for Centrifuge Only, $225,000 for equipment package(^a)</td>
</tr>
<tr>
<td>Andritz Belt Filter Press</td>
<td>3.9 active lb/ton</td>
<td>21 ± 3% Solids</td>
<td>95 to 97%</td>
<td>0.5 meter, 3-Belt SMX–S12 Belt Filter Press Skid</td>
<td>1200 gal/hr at 1% or higher feed solids concentration</td>
<td>$166,000 for BFP Unit Only, $213,000 for equipment package(^a)</td>
<td></td>
</tr>
<tr>
<td>FKC Screw Press</td>
<td>Nalco 71300, 13.5 active lb/ton</td>
<td>76%</td>
<td>8.2% Gravity only, 17 - 22% with Press</td>
<td>90 to 95%</td>
<td>Model BHX-250 Dewatering Skid</td>
<td>25 lbs/hr, or 300 gal/hr @ 1% or higher feed solids concentration</td>
<td>$174,500 for manufacturer’s equipment package(^b)</td>
</tr>
</tbody>
</table>

\(^a\)Includes dewatering unit, local control panel, Seepex progressing cavity pump, Velodyne Polymer Feed System, 10 ft screw conveyor.

\(^b\)Proposal Included flocculation tank, progressing cavity feed pump, dewatering unit and local control panel. Did not include polymer feed system or conveyor.
It should be noted here that the BFP cost quote provided by Andritz and included in Appendix A was based on a belt filter press unit that was constructed for piloting purposes and then refurbished for sale. To account for the likelihood that this unit will not be available when the City implements this project, a 15% increase in the BFP was applied to account for newly fabricated equipment. Andritz reported that they typically only fabricate filter presses in this size range as a reaction to an order, because it is not very commonly used for such low solids generating plants.

**Mechanical Dewatering Equipment Evaluation**

**Advantages-Disadvantages Comparison**
The advantages and disadvantages of the three mechanical dewatering equipment types assessed are presented in Table 5, below.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrifuge</td>
<td>• Best Dewatering Performance</td>
<td>• Most complex</td>
</tr>
<tr>
<td></td>
<td>• Low Polymer Consumption</td>
<td>• Highest power consumption</td>
</tr>
<tr>
<td></td>
<td>• Smallest Footprint</td>
<td>• Most complex equipment, least reliable</td>
</tr>
<tr>
<td>Belt Filter Press</td>
<td>• Best solids capture efficiency</td>
<td>• Poor Dewatering Performance</td>
</tr>
<tr>
<td></td>
<td>• Lowest Polymer Consumption</td>
<td>• Largest Footprint</td>
</tr>
<tr>
<td></td>
<td>• Very low power consumption</td>
<td></td>
</tr>
<tr>
<td>Screw Press</td>
<td>• Least number of moving parts, generally the most reliable</td>
<td>• Poorest Dewatering Performance</td>
</tr>
<tr>
<td></td>
<td>• Small Footprint</td>
<td>• Highest Polymer Consumption</td>
</tr>
</tbody>
</table>

The centrifuge equipment produced the highest solids content, with the least amount of polymer. It also has a smaller footprint relative to the Belt Filter Press and the Screw Press, which is critical given the limited area available at the City’s WTP site.

The costs listed in Table 1 are for the dewatering equipment packages only, and are not uniform in scope. For example, the centrifuge and BFP proposals do not include a flocculation tank. The BFP proposal includes a flocculation tank but does not include a sludge feed pump or conveyor to move dewatered sludge into a container.

Even accounting for these differences, the equipment costs for the three dewatering technologies are still too close to effectively differentiate any one technology. However, it should be noted that there are two motors for the centrifuge (25 and 7.5 hp), and these would be driven with variable frequency drives. Belt Filter Presses and Screw Presses require relatively small horsepower (< 2 hp), constant speed motors. The O&M costs for a centrifuge will likely be higher than for a Screwpress or Belt Filter Press, although the difference will be somewhat offset by the reduced polymer consumption of the centrifuge. A centrifuge-based facility would have the smallest footprint, followed closely by a Screw Press and then the much larger footprint necessary for a Belt Filter Press. A centrifuge-based dewatering facility, minus a roll-off container for hauling, could occupy a shaded pad as small as approximately 22-ft wide by 22-ft in length. This, combined with the significantly higher solids content that could be achieved with the centrifuge, favors its selection as the mechanical dewatering technology should the City decide to pursue a mechanical dewatering facility. For the purposes of budgetary costing, the equipment cost for the mechanical dewatering alternative will be based on a centrifuge, at $225,000.
**Complete Mechanical Dewatering Facility**

The costs for the remaining components of a mechanical dewatering facility will be driven by the footprint of the facility, since the site is very tight, and the ancillary design of the facility. In addition to the dewatering equipment, a complete dewatering facility will have to have the following ancillary systems:

- Piping & valving – connection and yard piping
- Utility Water service
- Polymer Storage and Feed System (included with Andritz’s equipment package)
- Potentially a Recycle flow stream treatment system (see discussion below)
- Metal Building with HVAC
- Solids Conveyor (included with Andritz’s equipment packages)
- Motor Control Center and Power Distribution
- Control Panel (included with all equipment packages)
- Site Access Improvements

The footprint will have to be as small as possible in order to fit it on the WTP site while allowing as much access as possible. Other than building footprint and electrical, the cost of other systems necessary for a complete and operational dewatering facility (e.g. utility water connection, potential pressate treatment, lighting, roadway) have been assumed equal for each technology and will be omitted from this evaluation. Regardless of the type of dewatering technology, there are significant site access improvements that will be necessary at the site in order to accommodate truck access.

**Recycle Flow Stream Treatment**

The need for treatment of recycled flow streams is not entirely clear at this time. The Cryptosporidium Action Plan published by the California Department of Public Health (CDPH) in 1995 established a turbidity “goal” of 2 nephelometric turbidity units (NTU) or less for recycled flow streams at surface water treatment plants in California. Since that time, some district CDPH offices have begun writing this limit into some permits for surface water treatment plants. The approach has not been uniform. The City of Shasta Lake does not currently have a 2 NTU requirement for its recycle flows.

To consistently and reliably produce a recycle stream with turbidity less than 2, treatment would be required. The least maintenance intensive and most cost-effective approach to this treatment would be to collect the decant from the Backwash Equalization Basin and the liquid waste stream coming off the dewatering unit, and pump these flows through a small pressure filter to the head of the WTP. The approximate cost of this system, including ancillary systems and additional facility footprint, is $60,000.

Water Works Engineers recently discussed the issue of the potential requirement to treat recycle streams to a turbidity of below 2 NTU with the Redding CDPH office and requested clarification on the rule, because treating the recycled flow streams to achieve less than 2 NTU turbidity is costly, with a very poor economy of scale, and in our opinion pre-treating this flow stream prior to re-introduction into the main treatment plant is not clearly required by regulation and may in many cases make recycling of backwash water economically infeasible, unnecessarily marginalizing an important water resource.

Mike McNamara is the head of District 02, states that his office would review the City’s plans for the new dewatering system before commenting, but that in general he is amenable to not writing a 2 NTU recycle flow stream limit into the next permit if the City takes measures to optimize the quality of the recycle flow streams. This would be done, for example, by optimizing operation of the Backwash...
Equalization Basin so that good settling of solids results, and so that the decant from the upper portion of the tank is of the best quality attainable. At this time, this will be the approach to the issue. The Backwash Equalization Basin would be operated to maintain a water surface elevation that utilizes the entire basin, while decanting off the top, potentially with improved baffle design. An allowance has been reserved in the cost estimates for these purposes (and includes providing a means to withdraw settled residuals and pump them to the dewatering equipment).

Site Layout
A conceptual level site layout has been prepared based on a centrifuge dewatering facility at the City’s existing WTP, shown in Figure 1. The location of the facility was settled upon based on discussions with City of Shasta Lake staff. Truck access will likely require some moderate earthwork, including a small retaining wall at the toe of the slope leading up to the water storage tanks to the west of the Backwash Equalization Basin. To pick up a roll-off container (filter or otherwise), trucks will have to back into the area to the south of the facility and pull a roll-off container back out.

Mechanical Dewatering Facility Cost Estimate
The cost estimate for a centrifuge based dewatering facility is included in Appendix E. The total project cost is estimated at $760,000.
Filter Roll-Off Dewatering Evaluation

After the centrifuge and screw press manufacturers’ proposals were received and evaluated, and given the relatively high costs for treating a relatively low volume of solids, Water Works Engineers proceeded to further evaluate the use of filter roll-off containers. A sample was not sent to any filter roll-off container manufacturer, but both Andritz and FKC indicated that the sludge dewatered easily, and the residuals have a relatively high ash content, which is commonly used as a metric of sludge dewater-ability, so it is reasonable to expect that a filter roll-off container will produce a 15% solids product within a reasonable time frame (weeks).

Filter roll-off containers, pictured here, are roll-off containers that have been lined with reinforced filter fabric panels. Various “effective” fabric porosities are available. Units can be ordered with a cover rollover to block rainfall and reduce dust when hauling. A dewatering polymer, similar to those utilized with mechanical equipment, is injected into the inflowing sludge, and then the solids are distributed across the container and allowed to dewater by gravity and compression from the weight of additional solids inputs.

The feed schedule is intermittent, as this gravity-only dewatering method requires substantial time to achieve solids concentrations similar to those achieved with mechanical dewatering (≥ 15%).

A City of Shasta Lake – specific proposal was not requested for this TM, but Water Works Engineers has specified this equipment on numerous projects, so the vendors’ current pricing is known. A recent cost proposal provided by Flo Trend for two 40 cubic yard units listed the containers at $46,000 each. A shop drawing of the Flo Trend filter roll-offs is provided in Appendix C. Some agencies have opted to utilize disposable liners with the reinforced filter fabric walls, to simplify maintenance. The liner is simply dumped with the solids, and the filter cloth integral to the container is kept relatively clean.

The drawback to utilizing Filter Roll-Off containers is the time required to obtain good solids content, and the lack of control over the final solids content. With a polymer feed system, Filter Roll-Off containers can typically dewater solids to 10% within a few days. However, to get to 15% solids and above, weeks if not months are usually required to allow the additional water to either be compressed out by additional layers of solids loading, and via evaporation from solids in the upper layer. Allowing the containers to be exposed to sun and open air will decrease the time required to achieve a given solids content.

Photos of Filter Roll-Off containers at the Fallon, NV water treatment plant are shown below. Operations staff at the WTP has elected to use disposable liners within the units to simplify maintenance. The disposable liner is dumped with the solids, leaving the integral fabric cloth filters clean. This is a commonly reported practice, and operators familiar with filter roll-off containers report that without a disposable liner it is very difficult to get the solids to release from the container sidewalls if the solids content is higher than approximately 12%. City staff must consider this issue as retrieval and disposal of the liner can be problematic if it is first unloaded at the WWTP.
Assuming that the City can achieve minimum average solids content in the container of 15%, the average solids generation rate would fill a container in approximately 40 days. At maximum plant production, a container would be filled in approximately 20 days. At the end of this period the second roll-off container would be loaded and this “lead” container would be rested for a couple of weeks to obtain additional dewatering prior to hauling.

However, there is no way to definitively determine the time it will take to dewater the City’s WTP residuals other than to test a unit. However, even if the unit does not work (defined as achieving ≥ 15% solids) in an appropriate timeframe (≤ one month), the City could still use it to store and haul dewatered solids from a future mechanical dewatering facility. In this manner it would serve as a backup dewatering unit in the event that the mechanical dewatering unit is out of service, and it also may be used to increase the solids content of the mechanically dewatered solids (e.g., taking 20% solids from off the mechanical unit to 25%). The City would need to acquire a polymer feed system, and improve the site to enable storage and loading and unloading of a heavy filter roll-off container.

**Filter Roll-Off Facility Layout**

The ancillary equipment required for a filter roll-off based dewatering facility are a sludge pump, a polymer storage and feed system, and the same filtrate treatment equipment required for mechanical dewatering recycle flow streams. A conceptual-level site layout has been prepared for a filter roll-off based dewatering facility at the City’s existing WTP, shown in Figure 3. At this time, a two-container layout has been assumed. Potentially the City could use just one container, and store solids in the
Backwash Equalization Basin when the container is hauled away, or when it needs to be “rested” to allow the top sludge layers to dewater.

The Filter Roll-Off container(s) does not need to be indoors, further reducing the cost compared to a mechanical dewatering system. In addition, the containers require very little operator attention and no power, reducing O&M costs and the impact on plant staff.

**Filter Roll-Off Facility Cost Estimate**

The cost estimate for a filter roll-off based dewatering facility is included in Appendix D. The total project cost is estimated at $438,000, or approximately $220,000 less than a centrifuge based dewatering system.

![Figure 3. Site Layout for a Filter Roll-Off Container Based Dewatering Facility](image-url)

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**Figure 3. Site Layout for a Filter Roll-Off Container Based Dewatering Facility**
Conclusion and Recommendation

An assessment of the best means for the City of Shasta Lake to eliminate surface water discharge from their solids holding ponds on Redbud Lane yielded the following key findings:

- The most cost-effective solution to eliminating surface water discharge at the Redbud Lane facility is to construct a dewatering facility on the grounds of the City’s water treatment plant.

- The City generates very little residuals for a WTP of its size, due to the excellent raw water quality and the effectiveness of the coagulant it uses.

- Three mechanical dewatering technologies (centrifuge, belt filter press and screw press) were evaluated for their effectiveness and cost. All three technologies were similar in cost, and successfully dewatered the City’s residuals, although the centrifuge achieved a higher solids content and would have the smallest footprint. The centrifuge was used as the basis for developing a cost estimate for a mechanical dewatering facility. This facility would be the most direct, effective dewatering system for the City. The cost of mechanical dewatering facility would be approximately $760,000.

- Due to the relatively low residual solids generation at the City’s WTP, it may be feasible to utilize Filter Roll-Off Containers to dewater the sludge. The cost of a filter roll-off container based dewatering system would be approximately $545,000, saving the City approximately $215,000. However, predicting the time it takes to dewater the solids, and the dewatered solids content achievable in a reasonable timeframe is difficult.

- City staff has expressed a willingness to purchase or lease a filter roll-off container to determine its suitability to serve as the City’s primary dewatering process. If the City were to purchase a filter roll-off container and its dewatering performance proved insufficient for the City’s needs, the unit could be utilized as the storage and hauling container in a future, mechanical dewatering facility. This approach is justifiable given the low sludge production at the WTP, and the much lower O&M requirements and simpler facility design required for roll-off containers as compared to mechanical dewatering equipment.

Based on these results, it is recommended that the City purchase one filter roll-off container, a solids feed pump and a polymer feed system, setup a temporary piping (flexible hose) system, and improve the access to the southeast of the existing backwash equalization basin. The City could postpone the installation of more permanent ancillary systems, such as the building, until the long-term approach to residuals dewatering is settled. The cost of this “starter” dewatering facility would be approximately $160,000.
Addendum

The results of this feasibility study were presented to City of Shasta Lake engineering and operations staff on April 16th, 2012. The City expressed openness to proceeding with a mechanical dewatering facility. Filter roll-off containers were deemed less desirable due to 1) recent increases in raw water turbidity and subsequent higher solids generation at the WTP, 2) the City’s projection that in the long-term residuals will likely be hauled directly to the landfill, which increases the importance of achieving higher solids content so that hauling costs are minimized.

The City does not believe that any provisions need to be made to treat the recycle flow coming from the dewatering equipment. Based on the City’s experience with the quality of the decant water coming from the existing Backwash Storage Basin, it is felt that the recycle flow from the dewatering equipment can be simply returned to the basin and allowed to settle, and that will be adequate to comply with any future recycle turbidity limit of 2 NTU.

City staff did have two key comments that require additional evaluation prior to completion of the study: 1) Evaluate the feasibility and cost of utilizing a Rotary Drum Vacuum Filter for mechanical dewatering, and 2) Evaluate the Net Present Value (NPV) of mechanical dewatering versus Filter Roll-Off Containers, and 3) Provide a comparison of hauling directly to the landfill versus first hauling to the City’s WWTP for additional dewatering and then hauling to the landfill. Therefore, an addendum to the Draft Feasibility Study has been prepared and is provided in the following sections.

Rotary Drum Vacuum Filter

City of Shasta Lake WTP operations staff has previous experience using a Rotary Drum Vacuum Filter (RDVF) from Komline-Sanderson for dewatering cooling tower blowdown waste at the Pacific Gas & Electric (PG&E) plant in Burney, CA. Staff took a field trip to the plant in February of 2012 to evaluate the equipment, and were generally impressed with the equipment’s performance and operational simplicity.

An RDVF is a cylindrical filter screen that rotates in a bin and is connected to a vacuum pump. A schematic level process flow diagram of the equipment is shown below. The filter drum screen is placed under vacuum and a pre-coat of Diatomaceous Earth (DE) is fed onto the screen, approximately 4 inches in depth. The bin is then filled with the product (“slurry”) that is to be dewatered, and the vacuum pump pulls the product onto the DE coated surface. Liquid infiltrates the DE and the screen underneath, and is pulled from inside the drum to a vacuum receiver tank. The collected sludge, and a bit of the DE is continuously scraped from the surface (knife blade shown in diagram) and discharged from the equipment, typically into a roll-off container.
It must be noted that the use of this equipment for water treatment plant residuals dewatering is extremely rare. Komline Sanderson, manufacturer of the RDVF, reports that this is typically because it cannot compete with the other, more commonly utilized mechanical dewatering technologies on a first-cost basis. The unit is more commonly utilized in industrial applications, such as at the PG&E plant in Burney. The lack of a long track record with water treatment plant residuals is concerning, but can be mitigated with testing of the City’s residuals.

The relative advantages and disadvantages of RDVF technology are listed in Table A.6, below. The advantages and disadvantages of the other mechanical dewatering equipment evaluated herein are included again for reference convenience.

### Table 6. Advantages and Disadvantages of Mechanical Dewatering Equipment Alternatives.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| Rotary Drum Vacuum Filter | • Best Dewatering Performance  
• Does not require polymer  
• City WTP staff are familiar with equipment operation  
• Quality of the filtrate is likely good enough for continuous recycle to the head of the WTP without any additional treatment. | • Requires 15 hp vacuum pump  
• Requires Diatomaceous Earth  
• Not commonly utilized for Water Treatment Plant Residuals Dewatering  
• Most expensive of dewatering equipment evaluated  
• Most mechanically complex, with three drives and two pumps |
| Centrifuge            | • Best Dewatering Performance  
• Low Polymer Consumption  
• Smallest Footprint                                                                                                                      | • Highest power consumption  
• Most complex equipment, least reliable |
| Belt Filter Press      | • Best solids capture efficiency  
• Lowest Polymer Consumption  
• Very low power consumption                                                                                                                                                                | • Poor Dewatering Performance  
• Largest Footprint |
| Screw Press           | • Least number of moving parts, generally the most reliable  
• Small Footprint                                                                                                                        | • Poorest Dewatering Performance  
• Highest Polymer Consumption  
• Lower solids dewatering capacity compared to other equipment, will require larger unit or will have to be operated more often. |

### Rotary Drum Vacuum Filter Cost

A budgetary cost proposal was obtained from Komline-Sanderson, and is included in its entirety in Appendix D. Komline-Sanderson proposed a 3-ft diameter drum, 4-ft in width, complete with all ancillary and control equipment other than a Backwash Waste feed pump, for $215,000. The footprint of the equipment is 12.5 ft (length) by 7-ft width. This is marginally larger than the centrifuge or filter press dewatering equipment, but not substantial enough to significantly increase the cost of an RDVF based dewatering facility.
The need for DE storage would require additional building footprint. A solids conveyor is not included in the proposal. However, there is a small chute that is provided standard with the equipment that can be used to direct the scrapings from the drum into a roll-off container. The proposal also does not include a feed pump for the residuals. This differs from the other mechanical dewatering proposals received, so an adder must be included for the pump. The total project cost of an RDVF based dewatering facility should be comparable to the $780,000, comparable to the estimate of $760,000 for a centrifuge based dewatering facility, but significantly higher than a Filter Roll-Off Container based dewatering facility, estimated previously at $545,000.

**Net Present Value of Alternatives**

A Net Present Value (NPV) evaluation has been conducted using total project cost estimates for the alternatives evaluated, the estimated solids content of the dewatered residuals for each alternative, and associated hauling and disposal costs.

The only operations and maintenance (O&M) cost differences that were included were for loading, hauling, and un-loading of residuals, and tipping fees for disposal at the West Central Landfill. No O&M difference was assigned to the different mechanical dewatering facility alternatives (RVDF and centrifuge) because both systems require approximately equivalent levels of operator presence, electricity, and materials (DE for the RVDF, and polymer for the centrifuge), and without testing it is not clear that the percent solids achieved with RVDF would be substantially higher than with a centrifuge. An RDVF would likely achieve higher than 25% solids, but a significant amount of the bulk material would be DE rather than residuals. Without testing from Komline-Sanderson’s laboratory, estimating the cost-benefit of higher solids content but additional solids mass is not possible. A simplified approach would be to assume that the cost-benefit is similar to achieving 25% solids content with no additional mass, similar to the centrifuge. It was assumed that the average solids content of Filter Roll-Off Container dewatered residuals would be 15%. For a centrifuge, a solids content of 25% was utilized.

**Basis for the NPV evaluation:**

- 20-yr period, 6% Discount Rate
- 1% annual increase in WTP sludge production over the next 20 years.
- The estimate of $760,000 for a centrifuge-based dewatering facility was used for the capital cost of a Mechanical Dewatering Facility, and $545,000 was used for the capital cost of a Filter Roll-Off based dewatering facility.
- The solids content of residuals dried at the WWTP was assumed to be 70% on an average basis.
- The following unit costs were utilized:
  
<table>
<thead>
<tr>
<th>Cost Description</th>
<th>Unit Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loading at Water Treatment Plant</td>
<td>$100</td>
</tr>
<tr>
<td>Unloading at WWTP</td>
<td>$500</td>
</tr>
<tr>
<td>Reloading at WWTP</td>
<td>$1,000</td>
</tr>
<tr>
<td>Hauling from WWTP to West Central Landfill</td>
<td>$10.00</td>
</tr>
<tr>
<td>Tipping Fee at West Central Landfill</td>
<td>$40.00</td>
</tr>
</tbody>
</table>

The results of an NPV analysis comparing construction of a mechanical dewatering facility that generates 25% solids residuals, versus constructing a Filter Roll-Off Container dewatering facility that generates 15% solids residuals, is described below.

**Mechanical Dewatering vs. Filter Roll-Off Container Dewatering**

The 20-yr NPV of a Mechanical Dewatering Facility, generating 25% solids that would then be hauled to the West Central Landfill is approximately $815,000. This is based on an estimated capital cost of
$760,000 and an estimated annual residuals loading, hauling, and disposal cost of $7700 (in year 2013) to $9,400 (in year 2033).

The 20-yr NPV of a Filter Roll-Off Container Dewatering Facility, generating 15% solids that would be hauled to the West Central Landfill is approximately $844,000. This is based on an estimated capital cost of $545,000 and an estimated annual residuals loading, hauling, and disposal cost of $12,900 (in year 2013) to $15,700 (in year 2033).

The estimated difference in the NPV between the two alternatives is just 3.5%, which is not significant at this level of design and cost estimation. The City should view the two alternatives as virtually indistinguishable in terms of NPV, with the caveat that the level of uncertainty is higher for the Filter Roll-Off Container alternative, because its NPV is more sensitive to future cost predictions for labor, fuel and landfill tipping fees.

**Comparison of Hauling Directly to West Central Landfill vs. Drying at WWTP Prior to Hauling**

The City wished to evaluate the difference between hauling 15 or 25% solids to directly to the West Central Landfill versus hauling this sludge to the WWTP, where it would be dried to an approximate average of 70% solids (range of 40 to 80%, depending on the amount of time the sludge could be onsite and the season of delivery), and then re-loading it and hauling it to the landfill. The City realizes that drying the solids would greatly reduce the mass of sludge that is disposed of at the landfill, and therefore fuel and tipping fee costs, but also does not want to “double-handle” the solids unless it makes financial sense to do so.

In the near-future this additional drying would be accomplished in open earthen basins at the WWTP. In the longer term the City may install a drying bed facility at the WWTP for biosolids, and the WTP residuals could be incorporated with the biosolids. The cost of future drying facilities at the WWTP were not included in this evaluation, as the timing, design and cost of any future dewatering facility is uncertain at this time.

The comparison of the O&M for these two alternatives is shown in Table A.7., below, and indicates that there is essentially no benefit to the City of drying the residuals at the WWTP if the solids are mechanically dewatered to 25% solids content at the WTP. However, there is a minor cost savings ($45,000 over 20 years, or approximately 6% cost difference) in drying solids at the WWTP if they are only dewatered in a Filter Roll-Off container to 15% content at the WTP.

**Table 7. Net Present Value Evaluation of Drying Residuals at WWTP Prior to Landfill Disposal.**

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Net Present Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15% Solids Content</td>
</tr>
<tr>
<td></td>
<td>(Filter Roll-Off Container)</td>
</tr>
<tr>
<td>Dewater and Haul Direct to West Central Landfill</td>
<td>$844,000</td>
</tr>
<tr>
<td>Dewater, haul to WWTP for drying, then haul to West Central Landfill</td>
<td>$799,000</td>
</tr>
</tbody>
</table>
Final Conclusion and Recommendations

Based on the analysis described herein, there is very little cost difference on an 20-yr NPV basis for the City between installing a mechanical dewatering facility and installing a Filter Roll-Off Container dewatering facility. A mechanical dewatering facility will have a substantially higher capital cost (by approximately $215,000), but will reduce the mass of residual waste that has to be hauled away from the WTP.

Secondly, there is no benefit to the City of hauling residuals from the WTP to the WWTP for drying if the residuals are mechanically dewatered at the WTP, so if this is the City’s path forward, the residuals should be hauled directly to the landfill to free staff time for other responsibilites. If residuals are dewatered in Filter Roll-Off Containers at the WTP, then hauling to the WWTP for drying has a very marginal benefit, and the City should make the decision of direct hauling to the landfill versus drying at the WWTP prior to hauling to the landfill on the basis of staffing priorities.

The decision between mechanical dewatering and Filter Roll-Off Container dewatering should come down to risk and O&M requirements. Mechanical dewatering performance is more predictable, but the equipment will require more mechanical and electrical maintenance, and more operator attention to process function while in operation. Filter Roll-Off Container dewatering is much simpler, but performance is less predictable and it will require more management of containers (e.g., monitoring of solids content within the containers, rotating containers, higher hauling frequency, etc.). The City could mitigate some of the performance risk of the Filter Roll-Off container option by purchasing a unit now and evaluating its performance. If it does not achieve 15% solids content in a reasonable period of time (< 15 days), the City could keep it and use it as the roll-off container for a future mechanical dewatering facility, without losing its entire investment.

Finally, if the City decides to move forward with a mechanical dewatering facility, it is understood that operations staff strongly favor the Rotary Drum Vacuum Filter (RDVF) technology. This technology is rarely utilized in the municipal water treatment market, as it is typically not cost-competitive with centrifuge, belt filter press or screw press dewatering equipment. However, it does appear that the technology would work for this application, and due to the relatively low residuals generation rate at the City’s WTP, RDVF technology only appears marginally more expensive than these more common dewatering technologies. That said, the City should have a sample of its residuals sent to Komline Sanderson for testing before it moves forward with an RDVF based mechanical dewatering facility.