



CITY OF FLAGSTAFF
WILDCAT HILL WASTEWATER TREATMENT PLANT

CONCEPTUAL COMPARISON AND PRELIMINARY
RECOMMENDATION

TEMPORARY DEWATERING SYSTEM

DRAFT
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City of Flagstaff Wildcat Hill Wastewater Treatment Plant
TEMPORARY DEWATERING SYSTEM

1.0 INTRODUCTION

The objective of this technical memorandum is to evaluate geotextile containers (Geotubes[®]) as a temporary wastewater solids dewatering option including cost effectiveness, ease of operation, labor intensiveness, solids retention, solids handling time, flow and volume rates, and seasonality. The City of Flagstaff, Arizona (City) has asked Carollo Engineers (Carollo) to compare Geotube[®] containers against two traditional solids dewatering options (dredging existing basins and belt filter press) and make an initial recommendation for the installation of a temporary dewatering process at the City's Wildcat Hill Wastewater Treatment Plant (WWTP). Geotube[®] containers, with the aid of dewatering polymers, have been implemented on several dewatering projects into which wastewater solids were pumped directly from digesters, storage basins or lagoons.

Thickening and dewatering sludge from wastewater treatment provides the following benefits:

- Reduces the sludge mass and volume, thus reducing storage and transportation costs
- Eliminating free liquids before landfill disposal
- Produces a material which will have sufficient void space and volatile solids for composting when blended with a bulking agent
- Avoids the potential for biosolids pooling and runoff associated with liquid land application
- Reduced fuel requirements if residuals are to be incinerated or dried
- Optimizes the subsequent process such as thermal drying

Geotube[®] containers are typically implemented on environmental dredging projects generally in remote locations requiring extensive site preparation time, lacking utilities, and are considered temporary construction sites. The Geotube[®] containers have begun to see an increased use in solids dewatering applications as contractual budgets for dewatering decrease and engineers search for innovative residuals management options without high associated costs.

2.0 BACKGROUND

The City of Flagstaff Wildcat Hill WWTP has no mechanical dewatering of digested sludge. Sludge is pumped from the anaerobic digesters to solids settling basins (SSBs or lagoons) that are located southeast of the WWTP for storage. At appropriate times (seasonal, or when ponds are full) the solids from SSBs are disposed of using on-site land application in an approximately 40-acre "Dedicated Land Disposal" (DLD) area. The sludge is disked, or knifed, into the earth on the DLD when frost or saturation conditions allow. When the DLD is shut down due to seasonality/weather, the digested solids are hauled to a landfill for

disposal. The hauling of the sludge without dewatering is costly and the City would like to move away from this practice.

The City contacted Carollo to discuss the feasibility of designing and installing a temporary solids dewatering system on-site. Currently the WWTP is sending approximately 70,000 gallons per day (gpd) of digested sludge at 2-2.5% solids to the SSBs. The SSBs are experiencing operational issues. The SSBs and DLD (during rainfall/snowmelt events) are not functioning to drop the solids out of the dewatering system. Some of the digested sludge solids (and high nitrogen loads) are being returned to the WWTP in the centrate sidestream. The sidestream flow comes back into the WWTP downstream of the primary clarifiers. The digested sludge solids that are returned to the WWTP float (do not settle out), so they are not removed the secondary clarifiers, causing bulking and solids overflow to the tertiary filters, which causes additional problems with filtration and disinfection. The solids and nitrogen loads that are being returned are thought to be causing issues with the Integrated Fixed-Film Activated sludge (IFAS) process. Some of the issues the City would like to address with the temporary dewatering system are: dewater the solids; reduce the amount of solids returning to the plant; reduce the amount of ammonia being returned to the plant; reduce the amount of hauling and hauling costs; reduce the disposal fee being paid at the landfill; and install a temporary system that will function during cold weather months.



Figure 1 Wildcat Hill WWTP SSBs and DLD

3.0 COMPARISON

The comparison of the Geotube[®] containers is to result in the recommendation of a temporary dewatering process at the Wildcat Hill WWTP. **The final selection of a permanent dewatering process and dewatering equipment should be based on the results of a site specific biosolids management plan which identifies both processing and end-use alternatives and cost estimates.** Smaller facilities like the Wildcat Hill WWTP should evaluate mechanical (centrifuge or belt filter press) and non-mechanical (sludge drying beds) dewatering methods as part of an overall dewatering process alternative evaluation. An effective biosolids management plan will include the above alternative evaluation and long-term planning information. Odor complaints at WWTPs and biosolids end-use sites can interfere with implementation of the most cost-effective biosolids management options. Regardless of the final recommended dewatering method, it is important to note that even the temporary system has to be designed for excess capacity so that the anticipated amount of incoming solids can be easily dewatered during operating hours. Allowing for excess capacity also ensures that the plant will not experience a build-up of solids if a unit (part of a process) is out of service. If only one unit is required, the plant should have an alternate program to remove solids in liquid form.

The City has asked Carollo to compare the following three options for the temporary dewatering of digested solids at their Wildcat Hill WWTP. The comparison will result in the recommendation of a temporary dewatering process, and a preliminary design concept, which will be developed and implemented at the project site.

4.0 SOLIDS SETTLING BASINS (SSB) CLEANING

The City initially considered hiring a contractor to clean their Solids Settling Basins (SSBs) to allow access to enough storage capacity to allow operation over the next year. The SSBs would be used to dewater the digested sludge in the same manner that the WWTP currently operates. The centrate would return to the plant by gravity, upstream of the IFAS basin, and the settled solids would be hauled to a landfill for disposal (\$40 per load disposal fee). The quoted cost for the SSB cleaning was \$500,000 and the contractor estimated it would take more than two (2) months to perform the work. The SSB cleaning option would not necessarily solve/mitigate five (5) of the main issues the City wanted to address with their temporary solids dewatering system. The five issues that would not be addressed would be:

- Return of a high solids content to the plant in the SSB centrate
- Return of a high nitrogen load to the plant in the SSB centrate
- Relatively inexpensive capital cost to implement
- Reduction of hauling/disposal costs
- Expedited installation or implementation schedule

The City decided the SSB cleaning option did not meet the preliminary goals of the project and removed it from further consideration.

5.0 BELT FILTER PRESS

Belt filter presses (BFPs) are a common mechanical dewatering technique used to remove water from liquid residuals and produce a non-liquid material or “cake”. A BFP dewateres by applying pressure to the biosolids to squeeze out the water. Biosolids are sandwiched between two tensioned porous belts and passed over and under rollers of various diameters. Increased pressure is created as the BFP passes over rollers which decrease in diameter. All BFPs utilize a polymer conditioning zone, gravity drainage zones, low pressure squeezing zone, and high pressure squeezing zone.

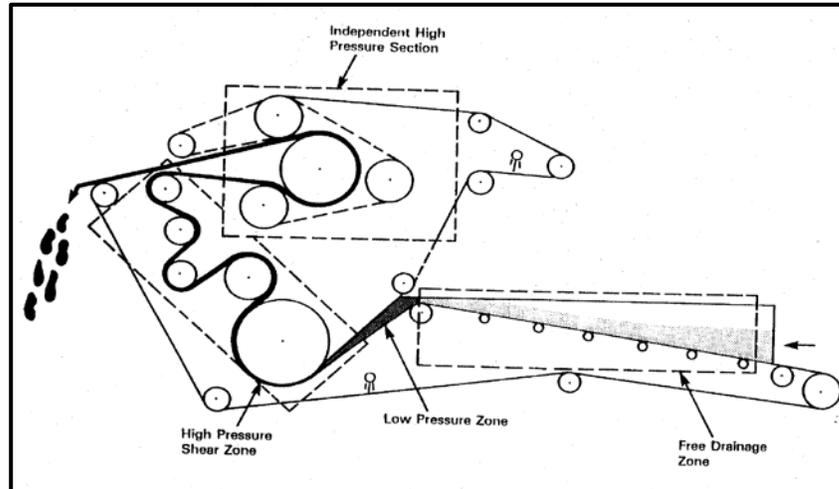


Figure 2 Cross-Section of a Belt Filter Press

BFPs are a common type of mechanical dewatering equipment, but may not be the most cost effective alternative for dewatering at WWTPs operating at less than about 4 mgd. The City is considering renting a used BFP and temporarily installing it to dewater solids at the Wildcat Hill WWTP.

Advantages of a BFP are generally considered to be:

- Staffing requirements are low, especially if the equipment is large enough to process the solids in one shift.
- Maintenance is relatively simple and can usually be completed by a wastewater treatment plant maintenance crew.
- Replacing the belt is the major maintenance cost.
- BFPs can be started and shut down quickly compared to centrifuges.
- Less noise associated with BFPs compared to centrifuges.

Disadvantages of a BFP are generally considered to be:

- Mechanical techniques may include excessive noise
- High energy requirements
- Blinding and short-circuiting due to a lack of optimal flocculation

- High daily maintenance time
- Expensive spare parts and major repair work that may take several days to weeks to complete.
- Odors may be a problem, but can be controlled with good ventilation systems and chemicals (some manufacturers offer fully enclosed equipment to minimize odors and reduce vapors in the operating room air)
- More operator attention if the feed solids vary in their solids concentration or organic matter.
- Solids with higher concentrations of oil and grease can result in blinding the belt filter and lower solids content cake.
- Solids must be screened and/or ground to minimize the risk of sharp objects damaging the belt.
- Belt washing at the end of each shift, or more frequently, can be time consuming and require large amounts of water.

5.1 Design Criteria

Belt presses are sized on the basis of weight or volume of solids to be dewatered rather than the wastewater flow to the plant. To determine the size (or how many presses are) needed, the wastewater treatment plant must:

- Determine the amount of primary solids that will flow through the plant per day
- Determine the amount of waste-activated solids produced per day
- Determine the volume of thickened solids to be dewatered per day
- Estimate the range of dry solids concentration in the feed
- Estimate future increases in solids production
- Anticipate changes in sewer discharges or operation that could change solids quality or organic matter content.

The BFP polymer conditioning zone is usually a tank located in close proximity to the press, a rotating drum attached to the top of the press, or an in-line injector. The gravity drainage zone is a flat or slightly inclined belt unique to each model. Solids are dewatered by the gravity drainage of the free water. A 5-10 percent increase in solids concentration from the original biosolids should occur in this zone. The free water drainage is a function of wastewater solids type, quality, conditioning, screen mesh, and design of the drainage zone. The low-pressure zone is the area where the upper and lower belts come together with the wastewater solids in between. The low-pressure zone prepares the biosolids by forming a firm cake that can withstand the forces of the high-pressure zone. In the high-pressure zone, forces are exerted on the solids by the movement of the upper and lower belts as they move over and under a series of rollers of decreasing diameter. It is estimated that a typical BFP operation will dewater digested sludge like the type found at the Wildcat Hill WWTP to 10 to 15 percent solids concentration.

An additional design feature is a self-enclosed facility to reduce odors and protect worker health. Workers in the belt press areas are exposed to aerosols from wash spray nozzles and pathogens and hazardous gasses such as hydrogen sulfide. Enclosing the press reduces visibility to the operators and produces a corrosive environment for the rollers and bearings. The choice of dewatering technique and chemical polymer or salts impacts dewaterability as well as the potential for odor during further processing or recycling to land. Ancillary equipment for efficient operation of a belt press includes: polymer, mixing, aging, feed, liquid feed day tank, liquid residuals feed pump, odor control and ventilation, conveyor and/or pump to move dewatered cake, and an enclosed area to load trucks or containers.

5.2 Performance

Manufacturers should be consulted for design and performance data early in the planning stage. Data should be confirmed with other operating installations and/or pilot testing. Evaluation of equipment should consider capital and operating costs (including polymer), electricity, wash water, solids capture, and ventilation and odor control during dewatering. Since solids characteristics and quantity vary from plant to plant, it is important to evaluate different weaves, permeability, and solids retention abilities of dewatering belts to ensure optimum performance. Surveys of similar plants or testing of wastewater solids can be helpful in the decision-making process. Table 1 displays the range of performance of a high pressure BFP on various types of wastewater solids.

Table 1 Typical Data For Various Types of Sludges Dewatered on Belt Filter Presses (Source: U.S. EPA, 1987) Temporary Dewatering System City of Flagstaff Wildcat Hill Wastewater Treatment Plant			
Type of Wastewater Sludge	Total Feed Solids (%)	Polymer (g/kg)	Total Cake Solids (%)
Raw Primary	3 - 10	1 - 5	28 - 44
Raw WAS	0.5 - 4	1 - 10	20 - 35
Raw Primary + WAS	3 - 6	1 - 10	20 - 35
Anaerobically Digested Primary	3 - 10	1 - 5	25 - 36
Anaerobically Digested WAS	3 - 4	2 - 10	12 - 22
Anaerobically Digested Primary + WAS	3 - 9	2 - 8	18 - 44
Aerobically Digested Primary + WAS	1 - 3	2 - 8	12 - 20
Oxygen Activated WAS	1 - 3	4 - 10	15 - 23

5.3 Operation and Maintenance

It is important to understand that with a BFP the City staff will be required to monitor operating parameters to achieve performance, ensure that solids are properly conditioned and that good gravity drainage occurs. The manufacturer (rental company) should provide operation and maintenance training after installation. Dewatering belts should be designed

for easy replacement with minimum downtime. Belt washing should occur daily after the cake is removed. Replacement of filter belts is a common maintenance requirement. Historical information indicates that belt life averages about 2,000 running hours. In general, a BFP operator is responsible for polymer mixing, dosing and monitoring usage, observing the feed and cake several times per day, and making adjustments as necessary. Rollers and bearings require frequent lubrication. It is important for the operator to keep records of all press performance parameters, including the volume of biosolids fed to the press, polymer dosage, and chemical usage. A sample of the biosolids to the press, cake discharge, and filtrate should be taken at least once per shift and analyzed for total solids. At the end of each shift, the belt should be cleaned with high-pressure wash water. As with any mechanical WWTP process, labor is relative to plant size. The Town of Gilbert Santan Water Treatment Plant operated a rental BFP for solids dewatering in 2011. Their lead operator estimated it would take approximately six to eight staff hours per day (including lab testing) to operate that same BFP at a WWTP experiencing the flow/loading of Wildcat Hill.

5.4 Cost

Capital costs to purchase a BFP vary with the size of the equipment. Vendor estimates vary from \$60,000 (approximate capacity of 500 dry pounds per hour) to \$150,000 (approximate capacity of 1,600 dry pounds per hour). These estimates are based on a feed material which is 5 percent solids – twice that of the Wildcat Hill WWTP. These prices do not include the cost of installation, shipping, or ancillary equipment, such as flow control and centrate management. The rental of a BFP in a size that would dewater the solids at the Wildcat Hill WWTP (See Figure 3) costs approximately \$5,000 per week (excluding set-up, piping, polymer, mobilization/demobilization, \$10,000 security deposit, and a 60 hour a week limit on usage).



Figure 3 Rental Belt Filter Press

Neither of these costs (capital or rental) includes the construction of a building, conveyor, truck loading area, polymer cost; polymer feed system, power and fuel requirements, operations, maintenance, hauling, or disposal.

Anaerobically digested sludge solids from a BFP are typically dewatered to 10 percent moisture and hauled to the landfill the same processing day. Although the dewatered solids pass the required tests and were transportable, disposal fees could be reduced significantly by allowing the dewatered solids to dry to even 20 – 25 percent solids (such as in Geotube[®] containers). Overall operation and maintenance costs range from \$80 per dry ton of solids (DTS) in a large treatment plant to \$200 per DTS in plants in the 4 mgd size range. Typical polymer conditioning costs for BFP dewatering range from \$5 per million gallons to \$100 and average \$25 per million gallons. Polymer costs increase sharply for residuals that are difficult to dewater. Permanganate adds about \$1 per million gallons to the cost of dewatering the biosolids. These costs vary widely, depending on the source of the residuals.

6.0 GEOTEXTILE TUBES (GEOTUBES[®])

Large-diameter geotextile tubes have been used to contain and dewater dredge materials from river channels and harbors for decades. In these applications, coarse-grain sediments pumped into the geotextile tube settle rapidly and slurry water is discharged through ports in the top of the tube. Use of geotextile tubes to thicken and dewater fine-grained sediments is a developing field and has had limited application in the municipal, industrial, and environmental excavation markets. Technological advances in the use and application of polymers and other chemical conditioning agents for the expedient separation of solids from water have facilitated the use of geotextile tubes for containment, dewatering, and consolidation municipal wastewater residuals. An alternative method for dewatering of wastewater residuals was sought by engineers to not only reduced costs associated with solids processing but required less facility resources to operate. Geotube[®] containment and dewatering technology was recommended as a cost effective, safe, and efficient method for handling biosolids in the shortest amount of processing time. The objective of this comparison was to evaluate Geotube[®] containers as a dewatering option for solids dewatering including cost effectiveness, ease of operation, solids retention, solids handling time, flow and volume rates, seasonality, and footprint required for process operations.

Geotube[®] containers are constructed of woven polypropylene material, which is extremely efficient at retaining solids and producing a clear effluent. The Geotube[®] units sit upon a constructed lay down area, which is designed to direct the filtrate to wherever the application demands. As sludge is pumped to the containers, it is chemically conditioned with a polymer to allow the Geotube[®] container to dewater at its maximum efficiency. Once pumping is complete, the Geotube[®] units are left to dewater until such time that the odorless, retained solids are land applied. The lay down area for the Wildcat Hill WWTP site will allow filtrate to be directed back to the treatment plant.

The lay down construction process generally consists of the following steps:

- Level the lay down area (dewatering pad) by creating a sand/aggregate subgrade
- Install a waterproof geo-synthetic membrane over the subgrade to allow the filtrate to drain
- For temporary laydown areas, use an impermeable liner and berms to create the dewatering cell.
- Install filtration media under the Geotube[®] units to promote dewatering from the bottom of the containers.
- Install a polymer mixing chamber, to inject a pre-determined amount of polymer solution into the sludge prior to dewatering and containment by the Geotube[®] unit.
- Keep the laydown area level and properly graded – you do not want the bags shifting.
- Orientate the Geotube[®] containers so that your collection basin is at the narrow end of the unit.
- Plan for a method to supply heat to the Geotube[®] containers if extended periods of below freezing temperatures are anticipated.

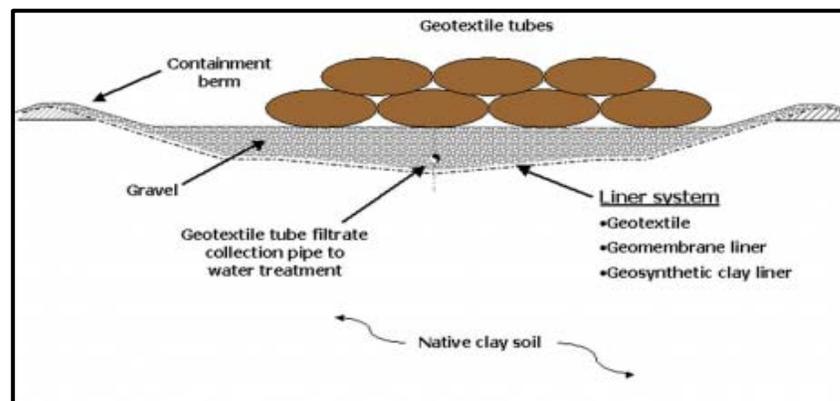


Figure 4 Geotube[®] Stacked Installation Cross-Section

Geotube[®] containers offer plant staff a non-mechanical dewatering system based on simplicity, affordability, versatility, environmentally friendly, and the standard Geoport plumbing fittings make connections for pumping simple. The Geotube[®] dewatering process for anaerobically digested sludge is essentially comprised of three distinct stages:

Containment Stage: The Geotube[®] container is filled with digested sludge that is treated with an environmentally safe polymer to make the sludge particles bind together. The containers unique fabric confines the fine grains of the sludge material.

Dewatering Stage: Excess liquid simply drains from the Geotube[®] container. The decanted liquid is often of a quality that it can easily be returned for processing without additional treatment.

Consolidation Stage: Solids continue to densify due to desiccation as residual liquid vapor escapes through the fabric. Volume reduction can be as high as 25 percent. In river dredging operations where a more sandy material is encountered, volume reduction can be as high as 95 percent.



Figure 5 Three Stages of Geotube Dewatering Process

The Geotube[®] system is available for purchase as Mobile Dewatering System (MDS). The Geotube[®] container units in the MDS set-up are sized to fit in a roll-off dumpster. As the solids in the MDS unit reach moisture content where the City decides to transport them for disposal, the entire dumpster container is transported with the MDS unit inside it. Although this system does make transport significantly easier, the amount of flow/solids at the Wildcat Hill WWTP would make the number of units/dumpsters required unfeasible.

6.1 Design Criteria

For Geotube[®] container sizing the day-to-day operational objectives and overall project goals must be considered. Geotube[®] container sizing is important in order to design an appropriate lay-down area for Geotube filling and contain the volume and mass pumped to the Geotubes[®]. In order to estimate the total operational and project containment capacity within the Geotube[®] containers, project engineers will require:

- Volume of liquid to be sent for dewatering
- Percent dry weight solids of the digested sludge
- Specific gravity of the digested sludge
- Daily sludge production rates and objectives
- Hourly/Peak/Minimum sludge flow rates to the Geotube[®] containers
- Space available for lay-down and dewatering of Geotubes[®]
- Timeline for project completion
- Chemical conditioning and/or hanging bag results
- Project objectives for percent dry weight solids for dewatered solids in the Geotubes[®].



Figure 6 Geotube® Container on Lay Down Area

To help meet dewatering goals, the project team will perform a series of “chemical conditioning” tests (performance trials) on the digested sludge from the WWTP. The objective of the dewatering performance trials is to develop a chemical conditioning program for each potential Geotube® dewatering application. Polymers will be evaluated based on water release rate, water clarity, flocculent appearance, and water volume after passing through a Geotube® geotextile filter. In addition, dosing rate(s) will be determined during these bench-top dewatering experiments and recommendations will be provided as a part of these trials. Geotube® hanging bag performance evaluations should be performed with the recommended chemical conditioning program to evaluate filtrate quality and time to attain desired cake solids within the Geotube® container. Once a recommended chemical conditioning program is identified in the hanging bag test, other chemical application variables can be evaluated for potential full-scale operations.

6.2 Performance

In typical sludge dewatering applications, solids concentrations greater than, or equal to, 25 percent are routinely accomplished within the Geotube® containers. As pumping of solids is initiated to a new container, a layer of solids covers the inside of the geotextile and decreases the loss of solids due to surface tension. This process typically occurs within one to five minutes of solids flow to the new Geotube® container and clear filtrate is normally observed for the rest of the dewatering operation.



Raw digester sludge (left),
treated with polymer (middle),
and effluent from Geotube (right)

Figure 7 Geotube® Filtrate

With respect to solids handling time, each system and application will behave differently. An advantage of using Geotube® technology is that the system is a closed loop and solids are only handled one time, during the excavation of the full containers. A closed loop system eliminates odors, potential for spills, and solids handling, as well as decreases risk(s) of operator(s) exposure to pathogens and other solids contaminants. With a BFP system, solids are open to the atmosphere, potentially release volatiles and associated odors, are excessively noisy, can spill off the belt onto the ground if blinding occurs due to insufficient flocculation, and increases potential risk(s) of operator exposure to solids contaminants.

The flow and volume rates (100 to 2,000 gpm) to Geotube® containers are dependent on the equipment available on site. Typically, solids from the case study projects were pumped to the Geotube® containers at 100 to 300 cubic yards per hour (700 to 2,000 gpm). In comparison, a 0.5-m belt press (a typical belt size for a truck mounted rental unit) has a maximum solids flow rate of 150 gpm. There are very few reasons to stop the flow of solids to a Geotube® system except potentially changing an empty polymer drum/tote, or shifting solids flow from a full container to a new container. In comparison, BFP operations are typically considered efficient at greater than 75 percent working operations.

Flagstaff has a notable change in climate between seasons. The pumping of solids to a new Geotube® container can occur during any time of the year as long as the polymer feed lines and solids lines are freeze protected. The pumping of solids to a partially filled container with frozen solids is not recommended due to inefficient dewatering and filling and the potential for overfilling. However, allowing a full or partially full Geotube® container to sit outside during a freeze/thaw cycle typically releases additional free water and will not harm the container. For the temporary dewatering application at the Wildcat Hill WWTP, measures should be implemented to keep the Geotube® containers from freezing. A BFP is capable of operating through all seasons, as long as the polymer feed lines and solids lines are freeze protected. A belt press requires constant operator supervision, regardless of the weather. In comparison, a Geotube® system is hands off after daily start-up and calibration

and an operator may not have to revisit the system during his/her shift, depending on the variability of the solids feed rate.

The Wildcat Hill WWTP has ample area for a Geotube[®] container lay-down area. The existing dedicated land disposal (DLD) area is approximately 40 acres in size. The footprint required for six 120-foot circumference x 100-foot long Geotube[®] containers should be approximately 140-feet by 360-feet, sufficient to collect filtrate from the Geotube[®] containers and channel it back to the facility. Geotube[®] containers can be site-specific manufactured to fit the facility's available footprint. For solids dewatering, containers are manufactured in 30-foot to 120-foot circumferences in 5-foot increments with lengths of 50-feet to 400-feet. Standard Geotube[®] sizes designed for containment of solids can hold between 20 and 1,750 cubic yards of material.

In comparison, a mechanical dewatering technique may be better suited for sites with a large volume of solids or sites that have limited space for an appropriately sized Geotube[®] lay-down area. A difficulty of using Geotube[®] containers in these situations is the large footprint required to contain the solids. Facilities in urban settings typically do not have the space available for a Geotube[®] dewatering systems and would have to make some capital improvements to accommodate these systems.

6.3 Operations And Maintenance

An added benefit to the use of the Geotube[®] containers for solids dewatering is their ease of operation. Start-up of these projects has typically required low man hours, including installation of the Geotube[®] containers and manifold system, set up of the polymer injection unit, time to initiate solids pumping, and calibration of the inline polymer feed rate. Once the system is calibrated to an optimal solids flow rate and sufficient inline flocculation is observed, the system will be monitored and adjustments made to the polymer feed rate. Throughout the start-up process, the solids flow rate to the Geotube[®] containers is neither reduced nor stopped. Geotube[®] containers continue to dewater and solids consolidate even as the percent solids of the sludge and strength of flocculation fluctuate during pumping. In comparison to belt press operations, the Geotube[®] dewatering system required little to no operation and maintenance time. Operation of a belt press requires nearly full-time monitoring and constant adjusting, particularly with an influent that fluctuates in percent solids and/or organic matter concentration. In order to complete the initial set-up, start-up and convey, and process approximately one week worth of solids at Wildcat Hill WWTP (500,000 gallons) with a BFP (maximum flow rate of 150 gpm), it is estimated that over 100 total man hours will be required by plant personnel.



Figure 8 Geotube® Dewatering

6.4 Cost

In order to try to determine a level of “cost effectiveness” for any dewatering system, some assumptions, or initial criteria, need to be developed. Initial discussions with the City established that their main concern was the digested sludge material and nitrogen load that return to the plant from the SSBs and DLD filtrate. At Wildcat Hill, there is no mechanical dewatering of digested sludge. Sludge disposal is on-site land application. Sludge is first sent to the SSBs for storage. At appropriate times (seasonal, or when ponds are full) the sludge is disked into the earth on the 40-acre DLD site adjacent to the plant. The solids/nitrogen return is at its worst during heavy rain or snowmelts that occur in the spring or late fall. The DLD is not normally used in the winter due to frost.

For the Wildcat Hill WWTP dewatering system, Carollo will begin with the initial assumption that the system will remain in place for one calendar year. Our initial assumption, for cost estimating purposes, will be to design the installation of 6-months worth of dewatering/storage capacity using Geotube® containers. The units will be planned for removal and replacement at the six month (halfway point) of the project duration. By planning for 6-months of storage, we can cut the size of the lay down area in half, saving money on excavation, piping, impermeable membrane, aggregate, and filter fabric.

Items included in the cost to initiate this Geotube[®] project would include:

- Design of the dewatering program
- Determine the required Geotube[®] container capacity
- Develop a polymer injection system
- Chemical conditioning program
- Bench testing
- Mobilization/demobilization
- Excavation, subgrade preparation, membrane and liner installation
- Piping and ancillary equipment installation
- Manufacturer technical assistance during start-up

Over the one-year project duration, the container system would dewater approximately 15,707 cubic yards (13,333 tons) of digested sludge material (25.5 million gallons of liquid). The initial six-month portion of the project would incur the majority of the capital costs. The second six-month portion of project will basically only incur costs to replace the container units (\$30,000) and polymer. Transportation and disposal of dried solids were not included in list of costs to initiate the project, as these costs would fluctuate depending on the percent solids in the containers and final mass disposed of at the landfills.

For the Wildcat Hill WWTP projects, there is sufficient time for solids to dry to 25 percent solids and take advantage of the added savings of excavation and disposal of significantly less residuals mass. Many project sites and facilities do not have the luxury of waiting for further drying beyond 15 to 20 percent solids and must remove solids from their facilities immediately upon processing. In these instances, a mechanical dewatering technique may be more appropriate for efficient and timely results.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on literature review, case studies, end-user input, and historical information, the Geotube container dewatering methodology reduced the volume and mass of residual solids and costs associated with hauling and disposal while allowing continual operation of treatment facilities. In instances where time and space were available for Geotube[®] operations, like at the Wildcat Hill WWTP, Geotube[®] applications were significantly less capital intensive compared to BFP onsite dewatering techniques. For this comparison technical memorandum, Geotube[®] containers were evaluated as a solids dewatering option and compared to a BFP operation, including cost effectiveness, ease of operation, solids retention, solids handling time, flow and volume rates, seasonality, and footprint required to operate. The Geotube[®] dewatering methodology's ability to reduce the volume and mass of residual solids can result in saving the City as much as 50 percent of the costs associated with hauling and disposal while allowing continual operation at the project site. Geotube[®] containers also allow the City to save money by dewatering and containing the sludge in one process. Mechanical dewatering requires the City to incur the cost of removal (dewatering) and disposal at the same time. In addition, the City will not be disposing of a

material that is over 97 percent liquid, they will be disposing of a material that could reach up to 25 percent solids content, greatly reducing the volume to be hauled off site, transportation costs, and disposal fees. Table 2 presents a preliminary cost estimate for comparison purposes of the design concepts. This “level of magnitude” cost estimating is to allow the City to make an initial comparison of three alternatives being studied.

Table 2 Conceptual Cost Comparison of Solids Dewatering Technologies for Wildcat Hill WWTP Temporary Dewatering System City of Flagstaff Wildcat Hill Wastewater Treatment Plant			
Description	Geotube® - 120' Circumference X 9' Height	Belt Filter Press - 1.7 meter, 300 gpm	SSB Cleaning
Cost to Buy/Rent (52 weeks)	\$60,000 (\$5,000/bag)	\$820,000 (\$0.032/gal)	\$500,000
Mobilization/Demobilization	\$10,000	\$25,000	-
Security Deposit	\$0	\$10,000	-
Excavation	\$20,000	\$10,000	-
Set-Up	\$10,000	\$25,000	-
Membrane/Filter Fabric	\$100,000	-	-
Dewatering Polymer	\$30,000	\$330,000 (\$0.013/gal)	-
Odor Control Chemical	-	\$1000	-
Hauling	\$75,000	\$150,000	\$150,000
Disposal (\$40/LD Tipping Fee)	\$25,000	\$50,000	\$50,000
Miscellaneous	\$25,000	\$25,000	\$25,000
Total	\$355,000	\$1,446,000	\$725,000

Based on the initial evaluation of the use of Geotube® containers compared to a BFP operation as a temporary solids dewatering option including; cost effectiveness, ease of operation, solids retention, solids handling time, flow and volume rates, seasonality, and footprint required to operate, ***the Geotube® containers, with the aid of dewatering polymers, were preferential to the BFP for the application required at the Wildcat Hill WWTP.***

8.0 DESIGN CONCEPT

The preliminary recommendation for the temporary solids dewatering system at the Wildcat Hill WWTP is the use of Geotube® containers within an engineered dewatering cell. The design concept must be reviewed and approved by the City prior to moving into detailed design of the facilities. The detailed design effort will address the principal objectives and goals as developed collaboratively between the City and Carollo. The detailed design effort will develop plans and specifications (contract documents) that address the technical issues

for the project and will allow a contractor sufficient information to construct the temporary dewatering system. For the Wildcat Hill WWTP temporary solids dewatering system using the Geotube[®] containers, the general design concept will consist of the following principal steps:

- Locate the site utilities, including the piping in the DLD, specifically any utility that may be present within the area or limits of the dewatering cell.
- Excavate the lay down area (dewatering pad) to the required dimensions, while windrowing the excavated material to the outer perimeter of the dewatering cell to create a containment berm.
- Grade and compact the in-situ material within the dewatering cell, if the material appears to be soft or unstable, place and compact sand/aggregate to establish a stabilized subgrade.
- Install a waterproof (impermeable) geo-synthetic membrane over the subgrade and up to the top of the perimeter berm, to allow the filtrate to drain.
- Place, grade, and compact filtration media (gravel) on top of the impermeable membrane to act as a driving surface. Install a geotextile filtration fabric (if necessary) under the Geotube[®] units to promote dewatering from the bottom of the containers.
- Bench test the flagstaff digested sludge to determine the optimal polymer type and polymer dosage rate to chemically condition the sludge. Bench testing will also determine how many, and what size, Geotubes[®] will be required to complete the project.
- Install a polymer injection system (determine if mixing required), to inject a pre-determined amount of polymer solution into the sludge prior to dewatering and containment by the Geotube[®] unit.
- Design a contingency method to supply heat to the Geotube[®] containers if extended periods of below freezing temperatures are anticipated. Design the piping, pumping, and drainage systems to be insulated from the cold weather to mitigate freezing.

See conceptual design drawings FIGURE-1 and FIGURE-2 for preliminary information on the temporary dewatering system location and plan and section drawings showing the design concept.

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Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo Std Pen_v0905.pen PlotScale: 2:1

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SEE FIGURE 2 FOR SITE LAYOUT AND SECTIONS

- NOTE:
1. PLACE 1'-6" DEPTH SOIL IN A LOOSE CONDITION FOR AREA I.
 2. FOR AREA II, EXTEND THE FILL FROM AREA I AND GRADE IT TO MATCH THE EXISTING GRADE FROM AREA II.

SCALE: 1" = 100'-0"

REV	DATE	BY	DESCRIPTION

DESIGNED
MLH
DRAWN
MLH
CHECKED
BJB
DATE
OCTOBER 2012

CITY OF FLAGSTAFF
WILDCAT HILL WWTP
TEMPORARY SOLIDS
DEWATERING SYSTEM



DEWATERING LAY DOWN AREA
CIVIL
LOCATION PLAN

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

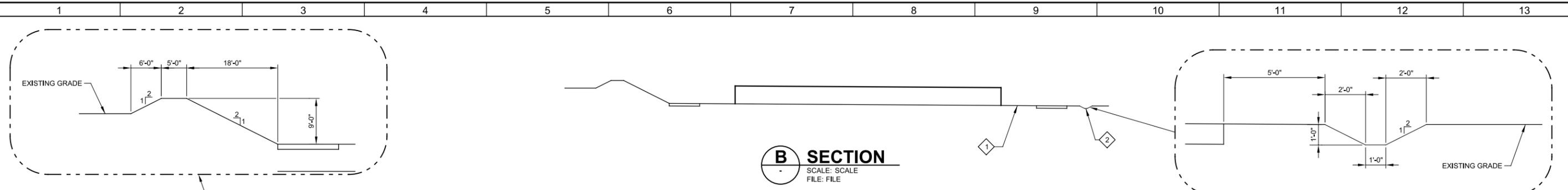
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FIGURE-1
SHEET NO.
OF XX

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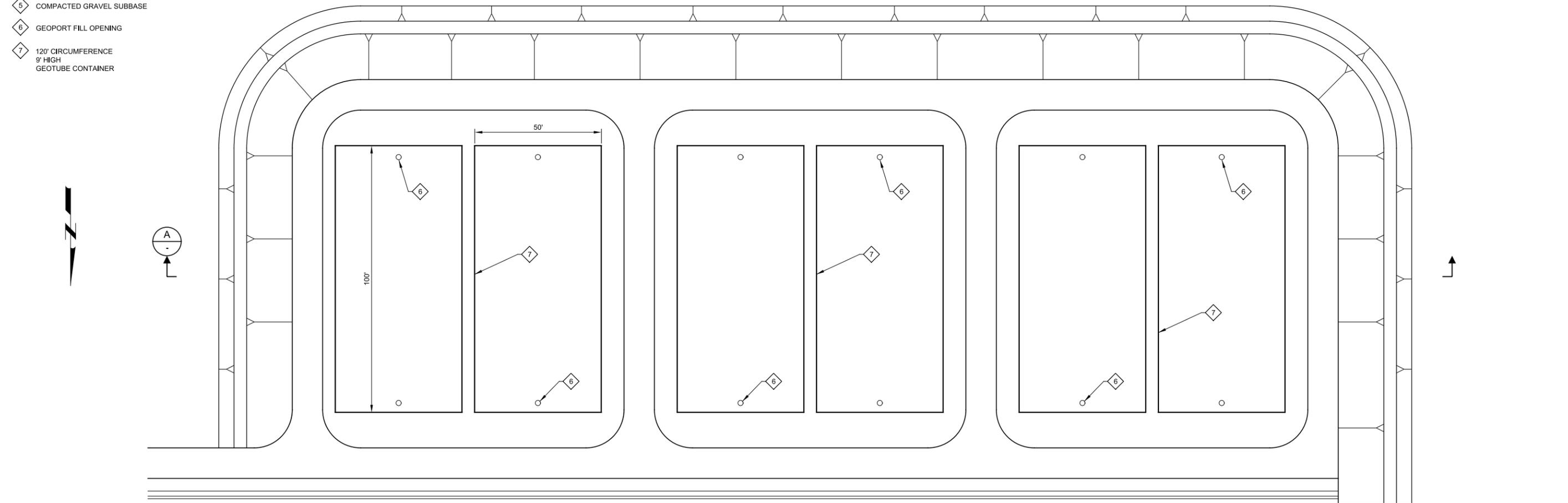
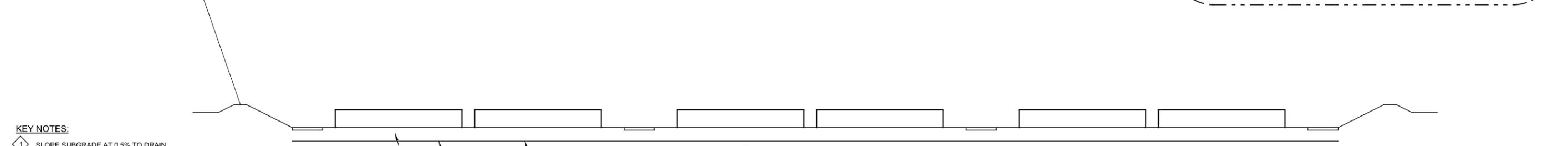
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- KEY NOTES:**
- 1 SLOPE SUBGRADE AT 0.5% TO DRAIN
 - 2 SLOPE DRAINAGE DITCH AT 0.5% TO DRAIN FROM WEST TO EAST
 - 3 EXCAVATE EXISTING MATERIAL TO STABLE SURFACE - WINDOW MATERIAL TO FORM PERIMETER BERM
 - 4 HIGH DENSITY SYNTHETIC LINER - GEOMEMBRANE LINER
 - 5 COMPACTED GRAVEL SUBBASE
 - 6 GEOPORT FILL OPENING
 - 7 120" CIRCUMFERENCE 9' HIGH GEOTUBE CONTAINER



REV	DATE	BY	DESCRIPTION

DESIGNED MLH
DRAWN MLH
CHECKED BJB
DATE OCTOBER 2012

**CITY OF FLAGSTAFF
WILDCAT HILL WWTP
TEMPORARY SOLIDS
DEWATERING SYSTEM**



DEWATERING LAY DOWN AREA

CIVIL

PLAN AND SECTIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO.
9034A.40

DRAWING NO.
FIGURE-2

SHEET NO.
OF XX