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RAPID DEWATERING TECHNIQUES FOR DREDGED LAKE SEDIMENTS LITERATURE REVIEW AND SUMMARY REPORT

RAPID DEWATERING TECHNIQUES
FOR DREDGED LAKE SEDIMENTS
LITERATURE REVIEW AND SUMMARY
REPORT

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

PREFACE

The following report has been prepared for the St. Johns River Water Management District. The report provides a review of recent advances in the rapid dewatering of dredged sediments. Information presented in this report was obtained through the review of published literature, “gray” literature, technical association proceedings, interviews with vendors and service providers and the experience of BCI Engineers & Scientists, Inc. (BCI). The search for information was as complete as possible, however it is always possible that other techniques exist and that no omission is intentional and that no inclusion is an endorsement of any method over another for commercial purposes.

1.0 INTRODUCTION

Sediment removal from lakes and other waterbodies has proven to be an effective method for removing contaminants and limiting the internal recycling of nutrients (Cook et al). There are many methods for dredging sediments, and in each case, the disposal of the dredge material presents the greatest challenge in project design. The disposal of dredge materials is often complicated by the lack of land around a waterbody that is available for disposal. The use of rapid dewatering technologies can mitigate the lack of available land for disposal and facilitate lake dredging projects primarily in urban areas. Rapid dewatering is defined as any process that accelerates the separation of solid and water fractions in dredge slurries, and the use of rapid dewatering techniques often reduces the amount of land needed for disposal.

In Florida, most lakes have experienced some level of development around the shoreline. The value of lakefront property is often significantly greater than that in the remaining watershed. Many lakes in need of restoration have been degraded as the result of extensive development in the watershed and associated stormwater runoff and habitat loss. Vacant land may be non-existent or zoning may be such that sitting a dredging disposal area in the vicinity of the lake may not be practical. As a result, the location of final disposal sites for dredging projects in urban lakes may be many miles from the waterbody and the area available for dewatering and temporary storage may be limited to a few acres or less.

The design of lake dredging projects is driven by the physical characteristics of the dredged sediment and the availability of suitable disposal areas. Consideration must also be given to the type of dredging most practical for a specific application. The two primary dredging types are mechanical and hydraulic. Mechanical dredges use a clamshell, shovel, backhoe, or other such device that scoops material from the lake bottom. This may be a land based or barge mounted crane. Barges may be used to move the material from the dredging site to a disposal site, or to trucks for haulage to a suitable site. Since the nature of mechanical dredging is such that lake bottom material is removed with the other sediments, the mixed material (slurry) is often mud-like and thick enough to transport and store without further dewatering **(Figure 1)**.

Hydraulic dredges use water and a pumping system to remove and transport sediments. Dredged material moves through a pipeline, often thousands of feet, assisted by a booster pump (or series of pumps) if necessary when the distance warrants. Due to the very dilute nature of the hydraulically dredged sediment discharge, subsequent mechanical or chemical dewatering and thickening is often necessary.

In cases where land is readily available, sediment disposal areas can be designed that will provide sufficient sediment retention/detention time to allow gravity settling and drying without the use of mechanical or chemical dewatering technologies (BCI, 1989). In many cases, dredge slurries must be rapidly dewatered to facilitate storage in relatively small areas or where the sediment must be transported to a distant disposal site. Rapid dewatering of hydraulically dredged lake sediments has been tested and successfully used in Florida and Ohio by BCI and others.

Figure 1
Dredge Slurry

Another advantage of rapid dewatering is the enhancement of the quality of water returned to the waterbody (or watershed) following the separation of water and solids. For example, the use of flocculants and coagulants can bind metals, nutrients and other pollutants to the settled solids, resulting in improved water quality of the return water.

Advances in rapid dewatering technologies has evolved in recent years as more water resource managers have incorporated dredging and sediment removal into their comprehensive watershed management programs. In Florida, this approach was first tested in large scale at Lake Hollingsworth in Polk County in 1996. Lake Hollingsworth was a 354-acre lake with over 3 million cubic yards of organic sediments on the lake bottom. A new process had been developed for the phosphate mining industry by the Florida Institute for Phosphate Research. The process mixed waste paper with polyacrilamide polymers to form flocs that were passed across a static screen. The water passed through the screen openings while the flocs traveled down the screen to a collection area. This process was tested at a pilot scale prior to the final design for the Hollingsworth dredging project and a new process was developed that did not use paper pulp but used two stage polymer injection to achieve suitable flocculation. During the final design, modifications to the process were made which, when combined with the changes that accompanied full-scale operations, resulted in poor flocculation and sediment thickening performance. Many modifications to the dewatering process were made during the four-year term of the project. (**Figures 2 and 3**) including the construction of an in-ground clarifier for sediment thickening following polymer addition.

Figure 2
Lake Hollingsworth Dewatering Facility

Figure 3
Lake Hollingsworth Drying/Disposal Site

2.0 RECENT DEWATERING TECHNOLOGIES

The information in this report is organized as both generic technologies and as proprietary or patented processes provided to us by the service providers. In many cases, the proprietary technologies may reflect a specific series of generic processes. The following list of rapid dewatering technologies was the result of an extensive on-line and electronic library literature search. Additional equipment types were noted during the search, but were not included, as they were generally derivatives of those described in this list. The list is divided into five classifications. These are:

- Passive, which refers to reliance on natural evaporation and drainage to remove moisture;
- Chemical aids, including polymers and coagulants which aggregate smaller particles together to form larger composite particles using various physical and chemical interactions;
- Physical, in which two or more components of a system are separated based on physical properties or characteristics of the materials;
- Mechanical, which requires the input of energy to squeeze, press, or draw water from the hydrated material; and,
- Integrated systems, which use combinations of chemical, physical and mechanical methods to achieve rapid segregation and dewatering of dredged sediments.

Table 1 includes the list of dewatering technologies with examples of each included.

Details on the mechanisms associated with each technology, along with information on the dewatering properties are included in the discussion. A general process description is given, followed by known operational advantages and disadvantages of the various rapid dewatering methods in the context of shallow, subtropical lakes in urban watersheds. Nutrient dynamics in each process are discussed. Cost information is included where data was available, and a vendor is listed with each technology.

Table 1
Dewatering Technologies

Classification	Vendor	Type	Description
PASSIVE	Miratech	Geo-textile Tubes	Geotextile tubes are comprised of high-strength polypropylene fabric and are fabricated to the project's requirements. The tube is filled by a system pumping sludge material. The tube retains fine-grain fill material while allowing effluent water to exit through the tube wall.
CHEMICAL AIDS	NALCO Ciba SNF	Polymers	Chemical formulations used to coagulate and flocculate dredged slurries. Polyacrylamide polymers are currently most widely used for this purpose. Chemicals may be used in conjunction with confined settling/dewatering areas, or they may be used as conditioning agents for integrated systems such as the Phoenix or Genesis systems.
PHYSICAL	Veolia Environmental Services	Centrifuge	Flocculated sludge is pumped into the feed port of the centrifuge where it is immediately subjected to high centrifugal forces (in excess of 2800 G's). The high "g" force takes advantage of the difference in specific gravity and thus separates the solids from the liquids.
PHYSICAL	Linatex Tennessee	Hydrocyclone	A hydrocyclone is a high-throughput, particle-size classifier that can accurately separate sediments into coarse and fine-grained portions.
PHYSICAL	Waste Technologies of Australia Environmental Biotechnology CRC Pty Ltd	Electrodewatering	A direct current voltage is applied to the biosolids mixture. The application of current in the initial stages of dewatering causes particles to migrate to the electrode of opposite charge (i.e., electrophoresis). Once a cake is formed, electroosmosis occurs as ions migrate to the appropriate electrode to compensate for particle charges.

Table 1
Dewatering Technologies

Classification	Vendor	Type	Description
PHYSICAL	Dorr-Oliver Eimco USA Inc.	Conventional Thickener	The conventional thickener (clarifier) is a rotary raked vessel designed to accept dilute slurry and provide a pre-thickening step in the dewatering process. Thickened sludge typically ranges 12 – 15 % solids and may be pumped to a disposal area for final settling and drying. Thickener capacities range from small to tens of thousands of gallons per minute.
PHYSICAL	Mitchell Dryers Ltd Denton Holme, Carlisle, Cumbria CA2 5DU England	Thermal Dryer	Thermal drying removes water from sludge to a significantly higher degree than all other dewatering processes. Solids reaching 90% are attainable, but the sludge is typically dewatered to a minimum of 18-20% solids before it is directed to the drying facility.
MECHANICAL	TEFSA-USA	Filter Press	Sludge is pumped into the filter press via a feed connection. As multiple chambers fill with sludge, liquid passes through a cloth medium, across a drain field, through drain ports and exits through the corner of each plate. As solids build in the press, a pressure differential develops between the feed and the filtrate discharge headers. The pressure differential across the media causes the filtration process to occur.
		Belt Press	Flocculated sludge is pumped onto the gravity drain section of the belt press where it is slowly rolled and spread across the belt by a series of “rakes” & “plows”. This causes the flocculated sludge to release most of its liquid, which is then gravity drained through the cloth and into a liquid drain pan. The sludge is then compressed between porous belt cloths as it passes through a series of rollers that steadily decrease in diameter.

Table 1
Dewatering Technologies

Classification	Vendor	Type	Description
MECHANICAL	Ascension Industries	Plate and Frame Press	A plate and frame press consists of a series of frame supported plates that contain facing recessed sections. This forms a void into which liquid sludge can be transferred for dewatering.
MECHANICAL	Atkins Water	Bucher Hydrulic Press	The Bucher press is a hydraulic de-juicing press consisting of a cylinder and a moving piston that squeezes the sludge allowing the water to pass through several filter elements made of porous cloth material. The sludge cake is retained inside the cylindrical shell. After the sludge enters the cylinder, it is continuously squeezed by the piston, thereby achieving a high degree of mechanical dewatering.
INTEGRATED SYSTEMS	Phoenix Brennen Genesis Eagle North America	Integrated Systems	These technologies represent a combination of methods that may include any of the technologies described above in series. The combination of technologies is intended to produce a stackable, truckable product within a small footprint.

2.1 Passive

2.1.1 Equipment Type – Geotextile Tubes

Geotextile tubes **(Figure 4)** are comprised of high-strength polypropylene fabric and are fabricated to the project's requirements. Each tube is filled with dredged material. The tube retains fine-grain fill material while allowing effluent water to exit through the tube wall. With the addition of a polymer flocculation agent, excess water drains from the container through the geotextile resulting in effluent that is suitable for reuse. Volume reduction within the container typically allows for repeated filling. Slurry to the tube may be as dilute as that discharging directly from the dredge, or pre-thickened to 12 – 15 % solids. Following the final cycle of filling and dewatering, the solids may be removed from the tube when dryness goals are met.

Geotubes are custom made and supplied in various sizes and lengths to suit design and installation requirements. They are suitable for installations on dry land or in water depths to 15 feet. The containment capacity ranges from about 1 to over 3 cubic yards per linear foot.

Figure 4
Geotube

2.1.2 Confined Disposal Area (CDA)

Dredged lake sediments are pumped in dilute slurry (as low as 4% by weight) to a confined disposal area of varying acreage. The disposal area is typically surrounded by earthen dams with wall height dependent on available acreage. The area may be sectioned to facilitate filling and decanting of the released water.

The dredged slurry is typically treated with a polymer to enhance and expedite solids settling in the disposal area, and the supernatant, decanted from the disposal area, is treated prior to return with aluminum sulfate to remove dissolved phosphates. Return water may flow by gravity through a ditch system, or be pumped through a pipeline back to the lake.

Sediments may be removed by truck for reuse as drying occurs, followed by reclamation of the disposal area.

2.2 Chemical

2.2.1 Process Type – Polymer

The use of polymers for the rapid dewatering of lake dredge sediments has been successfully demonstrated in recent years. Polymers are used in dredging projects to improve solids capture, increase cake solids and enhance the dewatering characteristics of the solids.

Thickening with polymers concentrates suspended solids by flocculation and improves the capture in all thickening equipment including gravity, mechanical and passive dewatering systems. Additionally, enhanced solids thickening increases the efficiency of any downstream equipment. Polymers can improve the settling rate of solids in both conventional settling basins and up-flow solids clarifiers.

Typical Applications include:

- Thickening of dredged sediments by polymer injected directly in hopper dredgers to obtain a clear overflow.
- In settlement ponds, the addition of polymers decreases the settlement time, reducing the number of ponds necessary. The overflow is typically clear after the first pond.
- Dewatering of thickened sludge with either geo-textile tubes, centrifuges, belt filter presses or screw presses. Polymers have been proven to be very efficient in the dewatering of sludge from municipal and industrial lagoons, ponds, and lake clean-out projects.
- In the case of contaminated sediment, polymers are able to enhance the attachment of the contaminants to the large flocculated sediment particles, thus leaving cleaner sediment behind. Therefore reducing the amount of contaminated sediment that will need to be properly disposed or contained.

Laboratory jar testing is used to establish the correct product and dosage which will optimize performance to achieve the highest solids concentration and greatest solids capture.

2.3 Physical

2.3.1 Equipment Type - Solid Bowl Centrifuge

Flocculated sludge is pumped into the feed port of the centrifuge where it is immediately subjected to high centrifugal forces (in excess of 2800 G's). The high "g" force takes advantage of the difference in specific gravity and thus separates the solids from the liquids. The solids collect and dry out on the elongated area of the bowl until they are augured to the solids discharge port. The liquids collect close to the interior of the unit (in effect "on top" of the solids) and are discharged from the liquid port. Dry centrifuge cake (solid phase) and clear centrate (liquid phase) can be achieved on almost any type of sludge by expert operation of quality equipment.

Centrifuge dewatering units **(Figure 5)** are available in capacities of approximately 800 gallons per minute of a pre-thickened sludge.

Figure 5
Solid Bowl Centrifuge

2.3.2 Equipment Type – Hydrocyclone

A hydrocyclone **(Figure 6)** is a high-throughput, particle-size classifier that can accurately separate sediments into coarse and fine-grained portions. The typical hydrocyclone is a cone-shaped vessel with a cylindrical section containing a tangential feed entry port and axial overflow port on top and an open apex at the bottom (the underflow). A slurry of the particles to be separated enters at high velocity and pressure through the feed port and swirls downward toward the apex. Near the apex, the flow reverses into an upward direction and leaves the hydrocyclone through the overflow. Coarse particles settle rapidly toward the walls and exit at the apex through a nozzle. Fine particles are carried with the fluid flow to the axial overflow port.

Hydrocyclones are best suited for removing sand particles greater than 150 mesh. In this application, cyclones are used to remove dredge over-cut from the sediment prior to dewatering. Sand is discharged from the cyclone at around 65 % solids and is suitable for immediate reuse.

Sediments are retained in the cyclone overflow which is typically directed to a dewatering process.

Typical hydrocyclone capacity ranges from 1,000 to 2,000 gallons per minute of a 30 – 35 % solids feed.

Figure 6
Hydrocyclone

2.3.3 Equipment Type – Electrodewatering

A direct current voltage is applied to the biosolids mixture. The application of current in the initial stages of dewatering causes particles to migrate to the electrode of opposite charge (i.e., electrophoresis). Once a cake is formed, electroosmosis occurs as ions migrate to the appropriate electrode to compensate for particle charges. Electrodewatering can also be combined with conventional filter presses. A cost benefit of electrodewatering is likely greatest for sludge that does not respond well to traditional pressure filtration. Studies have demonstrated that the novel electrodewatering technique is applicable to a wide range of sludges and indicated that performance might be limited for sludges with high conductivities.

Electrodewatering is considered an 'emerging' technology with little full-scale information available.

2.3.4 Equipment Type – Conventional Thickener

Thickeners **(Figure 7)** accept dilute slurry directly from the dredge, or in the event hydrocyclones are used to remove over-cut sand; sediment laden cyclone overflow may be directed to the thickener. This dilute feed is pre-treated upstream of the clarifier either in-line or in coagulation tanks, and flocculent is added to the feed line prior to the stilling well. Mixing of the flocculent occurs gently in the feed pipe and stilling well which agglomerates the fine particles, quickly forming large sediment flocs that readily settle.

The flow is directed vertically downward towards the base of the clarifier. The solids and flocs continue to settle towards the base of the clarifier forming a sludge blanket. A sludge level detector may be used to monitor the sludge blanket depth. A slowly rotating rake assembly directs the sludge into the center outlet cone. Thickened sludge typically ranges from 12 – 15 % solids and may be pumped to a disposal area for final settling and drying. The clarified water flows over a peripheral weir to a discharge point.

Thickener capacities are specific to the application ranging from small to tens of thousands of gallons per minute.

Figure 7
Thickener/Clarifier

2.3.5 Equipment Type- Thermal Dryer

Thermal drying **(Figure 8)** removes water from sludge to a significantly higher degree than all other dewatering processes. Solids reaching 90% are attainable, but the sludge is typically dewatered to a minimum of 18-20% solids before it is directed to the drying facility.

Sludge drying occurs in a three-step process. The first is preliminary drying, during which the temperature of the sludge is increasing to a prescribed, constant value. The second phase is called essential drying and is period during which moisture evaporates from the surface of the sludge particles with a constant speed. The sludge particle surface is covered with water, which constantly evaporates and is replaced by water from inside the particle. The temperature of sludge during drying the phase is constant and is the same as the temperature of the surrounding water, typically 50-85oC. The last phase of sludge drying is final drying. Water from the surface of sludge evaporates quicker than it is replaced from the inside of the particle. The speed of drying in the last phase is decreasing until balanced hydration is achieved.

Since thermal drying, in this application, is intended to increase the solids content of pre-thickened sludge to a level beyond that necessary for transport and storage, this alternative is not seen as a practical option.

Figure 8
Drying Plant

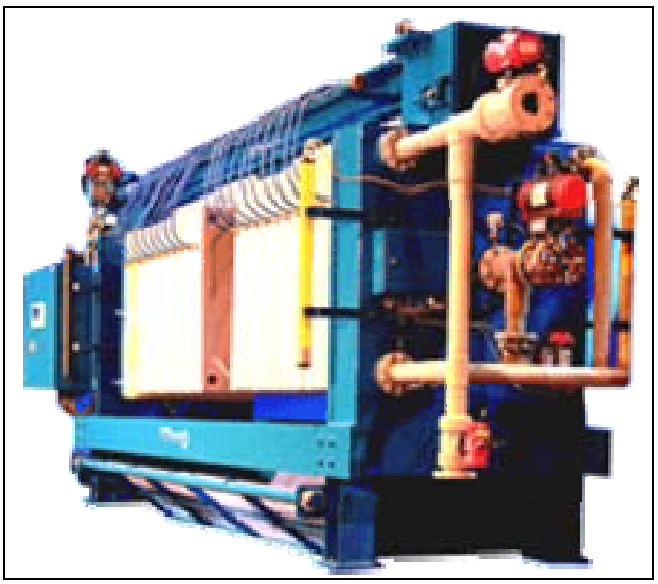
2.4 Mechanical

2.4.1 Equipment Type- Filter Press

Sludge is pumped into the filter press **(Figure 9)** via a feed connection. As multiple chambers fill with sludge, liquid passes through a cloth medium, across a drain field, through drain ports and exits through the corner of each plate. As solids build in the press, a pressure differential develops between the feed and the filtrate discharge headers. The pressure differential across the media causes the filtration process to occur. Solids build in each chamber until full and the path for liquid to flow out of the chamber is obstructed. At that point, feed is suspended and the filter plates are shifted to drop the solids from each chamber formed by adjacent plates/cloths. The filter cake (solids) is dropped onto a conveyor beneath the filter plates and is transferred to an appropriate disposal means.

Typical batch filtration rates are 150 to 350 gallons per minute of a pre-thickened sludge (10 – 15 %) with cycle times averaging 1 to 3 hours, with cake solids reaching 30 – 40 % by weight.

Figure 9
Filter Press



2.4.2 Equipment Type- Belt Filter Press

Flocculated sludge is pumped onto the gravity drain section of the belt press **(Figure 10)** where it is slowly rolled and spread across the belt by a series of “rakes” and “plows”. This causes the flocculated sludge to release most of its liquid, which is then gravity drained through the cloth and into a liquid drain pan. The sludge is then compressed between porous belt cloths as it passes through a series of rollers that steadily decrease in diameter. The net affect is a steady increase in pressure applied to the sludge in order to “squeeze” water out of the flocculated solids. The dewatered belt press cake is scraped off the belts and drops into a containment pan.

Generally, a belt filter press receives pre-thickened sludge ranging from a very low 4 % to a more typical 15 % solids and produces a final product of 12 - 35 % cake solids; performance depending on the nature of the solids being processed. Filtration rates for the largest units are approximately 450 gallons per minute treating about 15 tons of solids per hour.

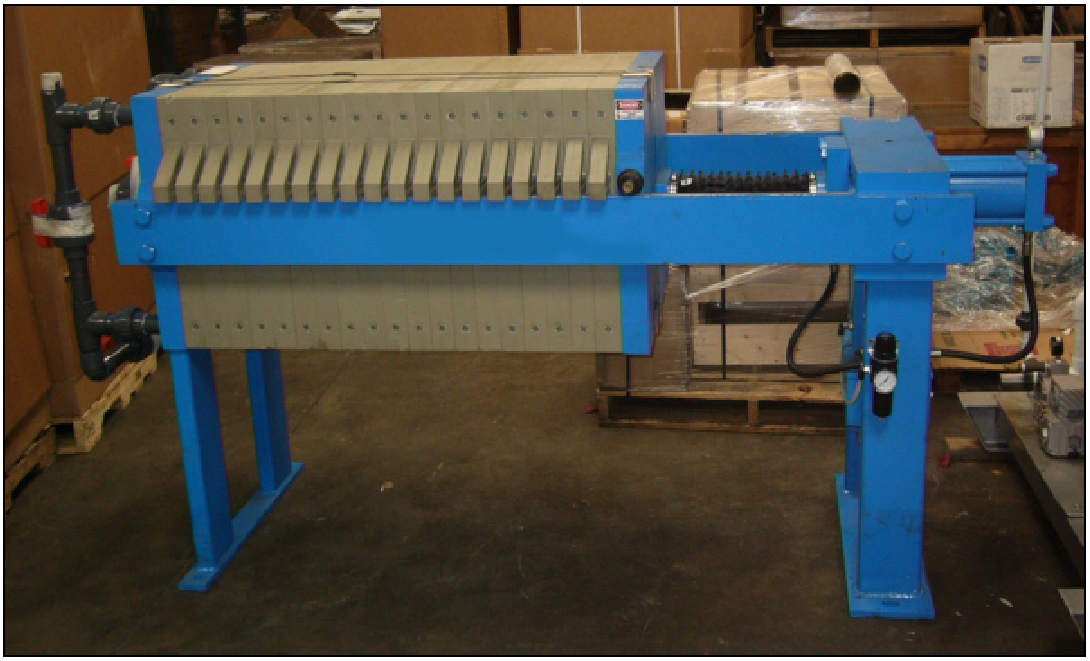
Figure 10
Belt Filter Press

2.4.3 Equipment Type- Plate and Frame Press

A plate and frame press **(Figure 11)** consists of a series of frame supported plates that contain facing recessed sections. This forms a void into which liquid sludge can be transferred for dewatering. The plates that form the recessed chambers are filter media lined to retain sludge solids while discharging filtrate. During the filtration cycle, sludge is pumped under pressure into the volume formed between the plates. As the filtration process progresses, filtrate passes through the solid cake and filter media. This process continues until a maximum pressure or minimum flow rate is achieved. This maximum design pressure is then maintained until the desired cake solids content is achieved. The filtration cycle is ended when a practical low feed rate is achieved. The sludge feed pumping is stopped, the individual plates are separated, and the sludge cake is discharged.

Plate and frame units are a cost-effective dewatering solution for batch operations with liquids containing high solids concentrations or slurries containing 3 - 30 % solids. Typical capacities for a plate and frame filter will depend on the solids being dewatered, but will range around 1/2 gallon per minute of feed for low solids content slurries (1/2 – 1 % solids) to over 1 gallon per minute of slurry per square foot of surface area on the plates.

Figure 11
Plate and Frame Press

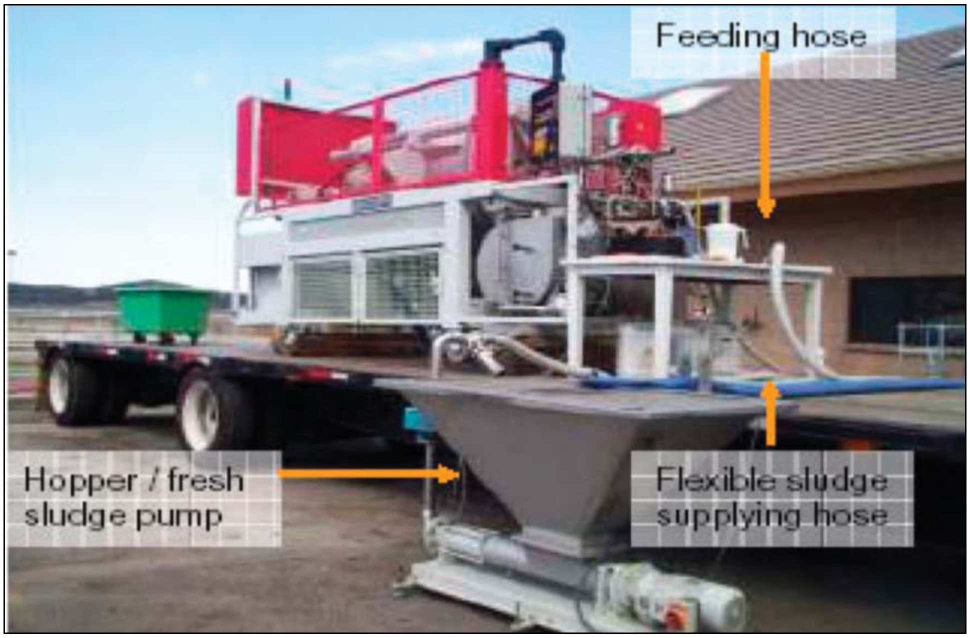


2.4.4 Equipment Type – Bucher Press

The Bucher press **(Figure 12)** is a hydraulic de-juicing press consisting of a cylinder and a moving piston that squeezes the sludge allowing the water to pass through several filter elements made of porous cloth material. The sludge cake is retained inside the cylindrical shell. After the sludge enters the cylinder, it is continuously squeezed by the piston, thereby achieving a high degree of mechanical dewatering. Filtrate can be collected and discharged to the wastewater system.

The bucher press is considered developing technology in the United States and little full-scale operation information is available.

Figure 12
Bucher Press



2.5 Integrated Systems

2.5.1 Equipment Type – Genesis Rapid Dewatering System

The Genesis Rapid Dewatering System is a complete process for lake and waterway clean up and restoration. Each Genesis dewatering unit can continually process and recover sediments at dredge operating rates of approximately 2500-5000 gallons per minute, and 150-250 cubic yards per hour. Multiple units may operate in unison to increase processing rates. Recovered sediments include coarse debris to gravel to sand and fine sediments (clays, silts, and organics). The system includes a group of conditioning and settling equipment and processes that work in series. The series includes a vibrating screen for coarse debris removal **(Figure 13)**; a sand separator and polymer injection followed by an inclined static screen.

The Genesis Rapid Dewatering System produces a reusable stackable solid (40-45%) that is truckable for easy disposal. Consolidated material is usually 50%-65% solids by volume. Return water is clear and turbidity levels are less than 30 ppm total suspended solids, which meet or exceed typical discharge standards. Coupled with a state-of-the-art solids monitoring system and polymer instrumentation package, the Genesis RDS integrated technology adapts to a dredge flow of 2-18% solids by volume. All Genesis RDS equipment can be located on an operational footprint of 150 x 150 feet enabling the mobile dewatering unit to be set up in areas with limited space; of if necessary, on barges.

Figure 13
Coarse Screen/Fluid Bed Technology

2.5.2 Equipment Type- ID&D® - Integrated Dredging & Dewatering

Integrated Dredging & Dewatering – ID&D® was developed by JF Brennan Co. Inc., under an alliance with Phoenix Process Equipment Co. to provide an integrated process of dredging and dewatering. Included is the added benefit of being able to re-utilize dredged sediments, which required a system capable of segregating and dewatering sediments as well as the ability to remove any intrained debris. Further, many clients had insufficient space to passively dewater dredged slurries. The ID&D®/PHOENIX system uses a combination of chemical and mechanical methods to achieve high-speed segregation and dewatering of the dredged sediments **(Figure 14)**. Processing rate information is currently unavailable. This system includes a group of conditioning and settling equipment and processes that work in series. The series includes a scalping screen for large debris removal; a hydrocyclone for sand removal; a polymer injection unit; a clarifier/thickener; second polymer injection unit; and belt filter press.

The PHOENIX **HiFlo™ Thickener** combines water clarification and solids separation and thickening in one step, greatly reducing the volume going to a slurry pond by thickening solids from 4-10% by weight to 40%, or more. If complete elimination of a confined disposal area is desired, the thickener underflow is sent to a PHOENIX belt filter press, where the sludge may be thickened to as high as 75% solids. This results in a dry cake that is easy to convey, store, stack, or handle.

Figure 14
Lake Maggiore Dewatering Facility

2.5.3 Equipment Type- Eagle North America Extended Contracting Service

The majority of Eagle North America's dewatering services are performed using belt press technology. Eagle North America's portable dewatering units are skid mounted to allow for easy transport and configuration. All skids feature new equipment rather than reconditioned equipment. Eagle North America's engineers customize each project to include a variety of other processes including screening, thickening, sand removal, washing, drying, and thermal treatment processes. As a part off their initial project planning, Eagle North America performs a preliminary site investigation, as well as a bench scale treatability study.

Some of the methods in use by Eagle North America for dewatering are:

- High pressure belt press
- Centrifuge
- Plate and frame filter press
- Screw press
- Grinders, screens, hydrocyclones, tanks
- Geotube technology

3.0 COMPARISON OF TECHNOLOGIES

Rapid dewatering techniques can range from singular elements such as chemical addition to complex combinations of chemical and mechanical elements in series. The utilization of rapid dewatering technology may increase or decrease the unit cost of dredging a project depending on the site specific factors including dredge material characteristics, disposal area location and size, pumping rates, etc.. In certain instances, the use of these methods could prove to be less expensive than purchasing large disposal areas. Rapid dewatering technology can produce dewatered solids that are capable being trucked to remote disposal sites and have the potential for immediate beneficial reuse in a variety of applications.

For the purpose of this report, rapid dewatering techniques are grouped into four general categories – mechanical, physical, passive and chemical. In most of the recent lake dredging projects that utilize rapid dewatering, chemical flocculants have been used to enhance the dewatering and settling characteristics of the solids. There are a number of manufacturers of chemicals used for this purpose, and several are included in the vendor list in Section 5. These companies will receive and analyze sediments from a candidate lake to determine the most effective chemical(s) for the project. The classes of chemicals used for dredge material dewatering include a wide variety of polyacrylamides, as well as ferric chloride, lime, and others. In recent years, polyacrylamide polymers seem to be the chemical of choice for the rapid dewatering of lake sediments.

As noted above chemical flocculants may be used as a stand alone rapid dewatering technique. In this case, polymers are injected into a dredge slurry, and the slurry is then placed in shallow drying beds. Solids content following the polymer addition may range from 10 to 15% solids (dry weight). Care must be taken handling the slurry following polymer addition to prevent the destruction of the flocs during pumping to the drying beds. Water naturally drains from the solids and the material is left in the beds for additional drying. Examples of this approach include Lake Hollingsworth in Polk County, Sippo Lake in Ohio and the C-51 Canal in Palm Beach County.

Other rapid dewatering techniques utilize some combination of dewatering chemicals and mechanical, physical or passive technologies. The selection of equipment and processes is often tailored to the project. For example, J.F. Brennan Co. offers an Integrated Dredging & Dewatering (ID&D) process that may include the use of drying beds or geotextile tubes depending on the material and drying area. Other contractors, such as Genesis, offer a more fixed process train for rapidly dewatering dredged sediments, and are able to appropriately size the operation by adding or removing the number of processing units.

Table 2, presents a comparison of the different processes methods. Additionally, a standardized set of dredging conditions is identified to provide for a basis of comparison. Properties such as, drying effectiveness, processing area requirements, disposal area requirements, equipment needs and unit costs are included in the comparison of methods. Where complete data was not available, performance numbers were assumed based on data given for similar equipment.

Comparisons were based on a sediment in situ volume of 1,000,000 cubic yards at 45% organic content and 0.1 grams/cm^3. Storage requirements in acres are based on processed solids shown in Table 2. Disposal site area was based on a final fill height of 5 feet.

Post process solids ranged from an estimated low of 15% using confined area disposal placement to a high of 40% when using one of the integrated process systems. Based on this range of solids and the selected stack height, storage area requirements ranged from 70 to 200 acres for the one million yards of lake sediments removed.

Column six of **Table 2** is labeled 'Processing Rates to Truckable Solids (+25%)'. To clarify; these rates are reflective of the tons per hour (tph) of cake solids, on a dry basis, produced by each process. However, while dry-basis tons are shown in the table, final solids content varies with the process type. Two process parameters were looked at for each rapid dewatering option, which were rate (tph) and process continuity (batch/continuous). Dredging rates and discharge solids were held constant for all investigations.

Since the dewatering process output must match the dredging process input, all rapid dewatering options have effectively the same capacity, and all recover a calculated $\pm$ 40 tph of sediment (with the +200 mesh fraction removed). Once each system of dewatering alternatives is charged with slurry and has reached operational equilibrium, the sole difference becomes the final sediment solids. The second fundamental difference among the various dewatering alternatives involves the nature of feed slurry entry and removal from the system component(s). The two types in this investigation are classified as batch and continuous. A batch system must halt periodically to discharge the thickened cake and reload with feed slurry, creating an interruption in the process flow. This potentially leads to the need for a temporary storage, or 'dump' area, for process feeds somewhere in the system. A continuous system discharges product at the same rate as feed is introduced; thus, no interruptions occur and the process runs steady-state.

Each of the rapid dewatering alternatives is preceded by cycloning to remove associated sand. Using cyclones, however, to directly fill a confined disposal area results in effectively the same thickening timing as pumping directly to the disposal area. As previously noted, **Table 2** differentiates between the two process types for each rapid dewatering alternative.

Table 2
Comparison Table

Processing 1 M yds @ 45% organics; 0.1 g/cm3 bulk density							
Vendor	Process	**Cost/yd	Area (acre) Requirements for 5' Ht. Max	Product Solids Assumed at End of Process	*Processing Rates to Truckable Solids (+25%)	Return Water Characteristics	Truckable (Y/N)
Genesis	Integrated System	$7-10	70	40%	± 40 tph Continuous	Slurry to Dewatering Process Treat and Return to Lake	Y
Phoenix	Integrated System	$7-10	70	40%	± 40 tph Continuous	Slurry to Dewatering Process Treat and Return to Lake	Y
Eagle NA	Filter Press	None provided	80	35%	± 40 tph Batch	Slurry to Dewatering Process Treat and Return to Lake	Y
TEFSA-USA	Filter Press	None provided	120	25%	± 40 tph Batch	Slurry to Dewatering Process Treat and Return to Lake	Y
TEFSA- USA	Belt Filter Press	None provided	120	25%	± 40 tph Continuous	Slurry to Dewatering Process Treat and Return to Lake	Y
Ascension Industries	Plate & Frame Press	None provided	120	25%	± 40 tph Batch	Slurry to Dewatering Process Treat and Return to Lake	Y
Atkins Water	Bucher Hydraulic Press	None provided	120	25%	± 40 tph Batch	Slurry to Dewatering Process Treat and Return to Lake	Y
Veolia Environmental Services	Solid Bowl Centrifuge	$20-2,000	100	30%	± 40 tph Batch	Slurry to Dewatering Process Treat and Return to Lake	Y
Dorr-Oliver Eimco USA Inc.	Deep Cone Thickener	None provided	80	35%	± 40 tph Continuous	Slurry to Dewatering Process Treat and Return to Lake	Y
Linatex Tennessee	Hydrocyclone overflow to CDA Disposal	None provided	200	15%	193 days filling plus drying period	Slurry to Dewatering Process Treat and Return to Lake	N
Waste Technologies of Austrlia	Electroosmotic Filter Press	None provided	120	25%	± 40 tph Batch	Slurry to Dewatering Process Treat and Return to Lake	Y
Miratech	Geotextile Tubes	$6-8	100	30%	1-2 days per tube	Slurry to Dewatering Process Treat and Return to Lake	N/A
Ciba Nalco SNF	Polymers	$2-7	200	15%*	193 days filling plus drying period	Slurry to Dewatering Process Treat and Return to Lake	N

*Estimated average solids during filling of containment area. Drying/desiccation to truckable solids may be several months
**The costs for the mechanical process vary by equipment type, size and vendor. The individual pieces of equipment are not to be used alone. They are used in part of a process depending on the Integrated System designed for the specific sediment that is being dewatered. Individual vendors rental price is based on the type of equipment and duration needed. Most vendors requested project specifications in order to quote a price.

4.0 RAPID DEWATERING TECHNOLOGY ADVANTAGES AND DISADVANTAGES

The following section presents information on the advantages and disadvantages associated with the different rapid dewatering technologies. One advantage that is shared by the various methods discussed in this report is the ability to dewater dredged slurries in a limited amount of space. The space needed varies with each technique, but it is generally significantly less that is needed for passive dewatering. The reduced time required for the consolidation of solids is also a primary advantage of these methods.

Disadvantages center around the complex nature of the processes and the operation and maintenance of the equipment needed in most of the techniques. Another disadvantage is the sensitivity of the processes to temporal variation in the quality of the dredge material delivered to the processing facilities. As dredges move both vertically and horizontally in a lake, large differences in solids content and sediment characteristics can affect the dewatering efficiency of the rapid dewatering process. For this reason, some methods will include a mixing/storage tank at the process headworks to provide a more uniform feed of dredge material to the processing unit.

Table 3 provides a summary of the advantages and disadvantages of each process. A more detailed discussion of these features is providing the subsequent narrative.

4.1 Passive

4.1.1 Geotextile Tubes

Advantages:

Geotextile tubes are comprised of high-strength polypropylene fabric and are fabricated to the project’s requirements. With the addition of a polymer flocculation agent, excess water drains from the container through the geotextile resulting in effluent that is suitable for reuse, and volume reduction within the container typically allows for repeated filling. Following the final cycle of filling and dewatering, the solids may be removed from the tube when dryness goals are met.

Geotextile tubes require much less dewatering equipment, less labor and operator effort, and provide effective containment. The tubes are a basic low tech operation requiring less labor and operator effort than more conventional approaches. Geotextile tubes are noted as typically the least expensive dewatering approach and provide effective containment.

Disadvantages:

Geotextile tubes typically require expensive polymer addition to pre-condition sludge. Tube solids are not as dry as filter press, belt press or centrifuge cake; therefore, much less waste volume reduction is gained. It is noted also that geotextile tubes do not meet the required PFT and/or dryness and compaction specs on many sludge streams.

Geotextile tubes are susceptible to cloth blinding by many sludge streams (oil and/or high biological content are most difficult), and require a large area. Additionally, tubes require a long period of time to dewater and can be adversely impacted by local climate conditions (high humidity/rain). Finally, the geotextile tubes are not feasible for hazardous sludge streams and require extensive preparation and construction of tube lay-down and drainage systems.

4.1.2 Confined Disposal Area

Advantages

Placement of sediments in a confined disposal area offers several advantages. Foremost is the elimination of mechanical dewatering equipment necessitated by an accelerated process approach. Sediments are pumped directly from the dredge to a disposal area and are allowed to passively dewater while supernatant is decanted and returned to the lake. Maintenance requirements and operator expertise are minimal as the approach is basic with limited technology.

Disadvantages:

Confined disposal areas can require vast acreages to provide sufficient storage. In addition, engineered dams may be required, with the associated construction costs. Pumping logistics are to be considered with the generally increased distance, and as with most dewatering technologies, chemical treatment is necessary to enhance settlement. Consideration must also be given to sludge reuse timing as drying cannot occur until compartment filling is complete and the supernatant is removed.

4.2 Chemical Aids

4.2.1 Polymer

Advantages:

Polymer technology, as an approach to enhanced settling of suspended sediments, is in continual development with tailoring to specific industries; including dredging and dewatering applications. The polymer (coagulant and flocculent) market is expanding due to shrinking disposal sites and an increase in dredging projects.

Studies confirm that tailor-made products enhance the efficiency of the dredging application and reduce overall costs for the contractor. Polymers applied in both thickening and de-watering processes improve the speed and efficiency of water separation thus saving time and disposal costs.

Polymers are typically used as pre-treatment aids in dewatering sludge when using geo-textile tubes, centrifuges, belt filter presses, screw presses, and thickeners.

Specific advantages include:

- Increasing the concentration of solids in the sludge blanket

- Increasing the settling rate of solids
- Reducing sensitivity to temperature & flow fluctuations
- Efficient use of disposal areas due to improved thickening and dewatering
- Substantially increased clarity of recovered water

Disadvantages:

The cost of Polymer application must be considered in the choice of a dewatering system. Additionally, the disposition of released water must be considered. For water returning to a lake or stream environment, polymers should be investigated for wildlife toxicity.

4.3 Physical

4.3.1 Solid Bowl Centrifuge

Advantages:

The solid bowl centrifuge is a continuous feed operation typically requiring reduced labor and operator effort. This technology is also noted as being the best technology for most oil, water, and latex sludge streams. Filter cake is produced at sufficiently high solids content to truck or convey to a reuse or final disposal site.

As with most mechanical dewatering systems, the need for settling basins, return water systems, and containment area restoration, as well as the piping and pumps to the settling area is eliminated.

Disadvantages:

The solid bowl centrifuge cake is not as dry as a more conventional filter press cake. The result is less waste volume reduction. Operation of a centrifuge requires a higher skill level and a more experienced operator, as well as a greater amount of electric power compared to filter press and belt press technology.

The solid bowl centrifuge functions as a secondary dewatering step, necessitating a pre-thickening step; usually accomplished by a conventional thickener or clarifier. This technology must be considered a step in a more complex process and is not applicable as a stand-alone dewatering system. Additionally, return water will likely need treatment to remove dissolved phosphates prior to reintroduction to the lake

4.3.2 Hydrocyclone

Advantages:

A hydrocyclone is a high-throughput, particle-size classifier that can accurately separate sediments into coarse and fine-grained portions and is particularly effective at removing the sand sized fraction. As such, this device would be used primarily to remove large amounts of coarse sand from dredge over-cut. A hydrocyclone contains no moving parts within the unit, and requires no power consumption, other than delivery of feed slurry to the equipment.

Disadvantages:

Feed slurry to a hydrocyclone must first be screened for debris and oversize material prior to introduction. The coarse fraction underflow from a hydrocyclone typically retains a large amount of light organic solids that must be either considered in the return water. Additionally, hydrocyclones are somewhat capacity limited, thus multiple units are typically required.

Sediment laden cyclone overflow must be moved to either a disposal area or to a pre-thickening device. Pre-thickening (thickener or clarifier) will produce a pumpable solids in range of 10 – 15 %, which must then be placed in a confined disposal area. This technology must be considered a step in a more complex process and is not applicable as a stand-alone dewatering system.

4.3.3 Electrodewatering

Advantages:

A cost benefit of electrodewatering is likely greatest for sludge that does not respond well to traditional pressure filtration. Electrodewatering can also be combined with conventional filter presses. Studies have demonstrated that the novel electrodewatering technique is applicable to a wide range of sludges but indicated that performance might be limited for sludges with high conductivities.

Disadvantages:

Current costs for electrodewatering are higher than costs for standard belt filter presses. With continued improvements, however, costs should be comparable to belt filter presses as the process is a slight modification of the press. Increases in operating cost over conventional belt filter presses due to higher electricity use should be offset by the reduction in tipping fees associated with disposing of a drier and less voluminous product.

It should be noted that electrodewatering is considered an ‘emerging’ technology with little-to-no plant scale use or information available. As an unknown quantity, electrodewatering should be dismissed as a process step in this effort.

4.3.4 Conventional Thickener

Advantages:

Thickeners are used primarily to reduce the volume of sludge to be treated downstream, but provide good process variation mitigation as well (in the case of dredge discharge reporting directly to the thickener). Thickeners can concentrate sludges from a variety of in-plant sources and will produce concentrations ranging from 12 – 15 % solids, depending on the type of sludge.

Thickener discharge may further thickened by means of mechanical dewatering device, or pumped to a containment for passive dewatering and drying.

Thickener capacities are specific to the application, ranging from small to tens of thousands of gallons per minute. Clarified water flows over a peripheral weir to a discharge point.

As with most mechanical dewatering systems, the need for settling basins, return water systems, and containment area restoration, as well as the piping and pumps to the settling area is eliminated.

Disadvantages:

Thickeners are large processing devices easily exceeding 100 feet in diameter, and multiple units may be required to accommodate typical dredge rates.

Thickener sludge pumped to a confined disposal area can require vast acreages of storage. In addition, engineered dams may be required, with the associated construction costs. Pumping logistics are to be considered with the generally increased distance, and as with most dewatering technologies, chemical treatment is necessary to enhance settlement. Consideration must also be given to sludge reuse timing as drying cannot occur until compartment filling is complete and the supernatant is removed.

4.3.5 Thermal Dryer

Advantages:

Thermal sludge drying eliminates water and diminishes the volume of the sludge by a factor of 4-5. This also lowers the transportation cost and facilitates storage. Thermal treatment may also increase sludge calorific value, allowing incineration without the need for additional fuel. Stability is achieved by drying sludge to a dry mass above 90%, which improves sludge structure for spreading by agricultural equipment.

Disadvantages:

Thermal drying is noted for its high-energy demand. An appropriate energy source, the best method of drying (drier type) for a particular type of sludge, and the organization of the sludge drying process so that it is efficient and safe for the environment are all problems impacting the quality of product obtained after sludge drying.

4.4 Mechanical

4.4.1 Filter Press

Advantages:

As with most mechanical dewatering technologies a filter press produces a relatively dry filter cake; as high as 35% solids by weight. This reduces the initial waste volume compared to a dilute dredge discharge pumping directly to a confined disposal area. This is sufficient solids content to truck or convey to a reuse or final disposal site.

A filter press is capable of dewatering a wide variety of sludge streams, and offers basic and durable operation. In addition, as with most mechanical dewatering systems, the need for settling basins, return water systems, and containment area restoration, as well as the piping and pumps to the settling area is eliminated.

Disadvantages:

A filter press typically uses a batch process that requires significant labor and operator effort. Lower process and production rates result compared to belt press technology. Filter presses are also susceptible to cloth blinding on most oily or "tacky" sludge streams.

The filter press functions as a secondary dewatering step, necessitating a pre-thickening step; usually accomplished by a conventional thickener or clarifier. This technology must be considered a step in a more complex process and is not applicable as a stand-alone dewatering system. Additionally, return water will likely need treatment to remove dissolved phosphates prior to reintroduction to the lake.

4.4.2 Belt Filter Press

Advantages:

The belt filter press is a continuous feed process typically requiring less labor and operator effort than a batch process. Additionally, higher sludge processing and production rates are noted when compared to filter press and centrifuge technologies. The filter press is thought to be the best technology for bio-solids and primary and secondary digested sludge, and offers basic and durable operation.

Filter cake is produced at sufficiently high solids content to truck or convey to a reuse or final disposal site. As with most mechanical dewatering systems the need for settling basins, return water systems, and containment area restoration, as well as the piping and pumps to the settling area is eliminated

Disadvantages:

The belt filter press cake is not as "dry" as filter press cake; therefore, waste volume reduction is somewhat less than other technologies.

The belt filter press functions as a secondary dewatering step, necessitating a pre-thickening step; usually accomplished by a conventional thickener or clarifier. This technology must be considered a step in a more complex process and is not applicable as a stand-alone dewatering system. Additionally, return water will likely need treatment to remove dissolved phosphates prior to reintroduction to the lake.

4.4.3 Plate and Frame Press

Advantages:

Due to the nature of the plate and frame press, sludges typically difficult to dewater respond well and reach solids as high as 30% by weight. In some applications, the plate and frame press has a very high solids capture rate and is one of the few mechanical devices capable of producing a cake dry enough to meet landfill requirements in some locations.

As with most mechanical dewatering systems, the need for settling basins, return water systems, and containment area restoration, as well as the piping and pumps to the settling area is eliminated.

Disadvantages:

Plate and frame presses have a high capital cost, especially for variable-volume filter presses. Large quantities of conditioning chemicals are commonly used, and if the sludge is poorly conditioned or if the press is not automated, labor cost may be high as well.

Additional disadvantages include replacement filter media that is both expensive and time consuming, and noise levels caused by feed pumps can be excessive. Batch discharge after each cycle also requires consideration of receiving and storage.

The plate and frame press functions as a secondary dewatering step, necessitating a pre-thickening step; usually accomplished by a conventional thickener or clarifier. This technology must be considered a step in a more complex process and is not applicable as a stand-alone dewatering system. Additionally, return water will likely need treatment to remove dissolved phosphates prior to reintroduction to the lake.

4.4.4 Bucher Hydraulic Press

Advantages:

The Bucher hydraulic press is fitted with a strong, hard wearing filter cloth (similar to recessed-plate filter cloth) which holds back the sludge solids. The Bucher HP hydraulic press system is fully automated, and operating status, yield and performance values, as well as alarms are continuously and automatically logged by an internal data acquisition system.

The Bucher hydraulic press system produces filter cake solids in the range of 30 – 40%. A side-by-side comparison with a belt filter press indicated that a hydraulic press can improve cake solids content by more than 25% compared to a belt filter press. Higher solids contents could be achieved by extending the batch time but this gives a significant reduction in throughput.

As with most mechanical dewatering systems, the need for settling basins, return water systems, and containment area restoration, as well as the piping and pumps to the settling area is eliminated.

Disadvantages:

The Bucher hydraulic press functions as a secondary dewatering step, necessitating a pre-thickening step; usually accomplished by a conventional thickener or clarifier. This technology must be considered a step in a more complex process and is not applicable as a stand-alone dewatering system. Additionally, return water will likely need treatment to remove dissolved phosphates prior to reintroduction to the lake.

4.5 Integrated Systems

4.5.1 Genesis Rapid Dewatering System

Advantages:

The Genesis Rapid Dewatering System is a continuous process providing dredging through dewatering in one integrated system. In comparison to more conventional dewatering devices, cake solids from the Genesis Rapid Dewatering System are much higher, generally in the range of 40-45% by weight, vs. about 25% for a press alone, and 50%-65% solids by volume. Return water is clear and turbidity levels are less than 30 ppm total suspended solids, which meet or exceed typical discharge standards. This is coupled with a state-of-the-art solids monitoring system and polymer instrumentation package. As with all technologies investigated, the Genesis RDS integrated technology accepts a dredge flow as low as 2% solids by volume.

The operational cost of the Genesis RDS integrated technology typically runs 30-50% less than more common dewatering techniques, including confined disposal areas and various pressure dewatering presses. The required operational site, or footprint, is only about 150 by 150 feet, enabling the mobile Genesis dewatering unit to set up in small parking lots, on golf courses, or on barges. No pits, ponds, or return channels are needed. Each mobile system is discrete in operation, emitting little noise or odor, and can be set-up and operational in 24-48 hours.

Disadvantages:

Return water will likely need treatment to remove dissolved phosphates prior to reintroduction to the lake.

4.5.2 ID&D® - Integrated Dredging & Dewatering

Advantages:

Brennan's Integrated Dredging & Dewatering – ID&D®, created in alliance with Phoenix Process Equipment Co., is an integrated system providing dredging through dewatering as a continuous process. As with most mechanical dewatering systems the need for settling basins, return water systems, and containment area restoration, as well as the piping and pumps to the settling area is eliminated. The required operational site, or footprint, is generally small, enabling the mobile ID&D® dewatering unit to set up in small parking lots, on golf courses, or on barges.

The system handles a variety of sediment types, grain sizes and debris, and is well automated reducing the operating staff to two. Computer controlled polymer addition is integrated with real-time dredge slurry solids measurement, optimizing polymer use. Because a pre-thickening step can be used prior to final dewatering, solids of 40-45% may be achieved providing material, which may be trucked or conveyed to a disposal area.

Disadvantages:

Return water will likely need treatment to remove dissolved phosphates prior to reintroduction to the lake.

4.5.3 Eagle North America – Extended Contracting Service

Advantages:

Each project developed by EAGLE NORTH AMERICA may be customized to include all required processes such as screening, thickening, sand removal, washing, and drying. Most of Eagle North America's dewatering services are performed using belt press technology, but dewatering is customized for the client using the most suitable technologies including:

- High pressure belt press
- Centrifuge
- Plate and frame filter press
- Screw press
- Grinders, screens, hydrocyclones, tanks
- Geotube technology

Eagle North America's portable units are skid mounted to allow for easy transport and quick configuration, and all skids feature new equipment rather than reconditioned equipment.

As an integrated dewatering system the need for settling basins, return water systems, and containment area restoration, as well as the piping and pumps to the settling area is eliminated. The required operational site, or footprint, is generally small, enabling the mobile dewatering unit to set up in limited area.

Eagle North America's process cost is said to be comparatively lower than the alternate processes, and the product solids is sufficiently high for transport by truck or conveyor.

Disadvantages:

Return water will likely need treatment to remove dissolved phosphates prior to reintroduction to the lake.

Table 3
Dewatering Technologies Advantages and Disadvantages

Classification	Vendor	Type	Advantages	Disadvantages
PASSIVE	Miratech A Division of Ten Cate Nicolon	Geo-textile Tubes	1) Requires much less dewatering equipment 2) Requires less labor/operator effort 3) Very basic, low-tech operation 4) Usually the most inexpensive dewatering approach 5) Effective containment	1) Typically requires expensive polymer addition to pre-condition sludge 2) Geo-tube solids are not as "dry" as filter press, belt press or centrifuge "cake", therefore, much less waste volume reduction 3) Does not meet the required PFT and/or dryness/compaction specs on many sludge streams 4) Susceptible to cloth blinding by many sludge streams (oil and/or high biological content are most difficult) 5) Requires a large amount of real-estate 6) Requires a long period of time to dewater 7) Can be adversely impacted by local climate conditions (high humidity/rain) 8) Relatively "sloppy" and not feasible on hazardous sludge streams 9) Requires extensive preparation/construction of tube lay-down and drainage area/system
PASSIVE	N/A	Confined Disposal Area	Placement of sediments in a confined disposal area offers several advantages. Foremost is the elimination of mechanical dewatering equipment necessitated by an accelerated process approach. Sediments are pumped directly from the dredge to a disposal area and are allowed to passively dewater while supernatant is decanted and returned to the lake. Maintenance requirements and operator expertise are minimal as the approach is basic with limited technology.	Confined disposal areas can require vast acreages to provide sufficient storage. In addition engineered dams may be required, with the associated construction costs. Pumping logistics are to be considered with the generally increased distance, and as with most dewatering technologies chemical treatment is necessary to enhance settlement. Consideration must also be given to sludge reuse timing as drying cannot occur until compartment filling is complete and the supernatant is removed.
CHEMICAL AIDS	Ciba Specialty Chemicals SNF Nalco Company	Polymer	1) Increasing the concentration of solids in the sludge blanket 2) Increasing the settling rate of solids 3) Reducing sensitivity to temperature & flow fluctuations 4) Efficient use of disposal areas due to improved thickening and dewatering 5) Substantially increased clarity of recovered water	The cost of Polymer application must be considered in the choice of a dewatering system. Additionally, the disposition of released water must be considered. For water returning to a lake or stream environment, polymers should be investigated for wildlife toxicity.

Table 3 Continued
Dewatering Technologies Advantages and Disadvantages

Classification	Vendor	Type	Advantages	Disadvantages
PHYSICAL	Veolia Environmental Services Separations	Solid BowlCentrifuge	1) Continuous feed process typically requiring less labor/operator effort 2) Best technology for most oil/water/solid and latex sludge streams 3) Thickened sludge is truckable	1) Typically requires polymer/chemical addition to pre-condition sludge 2) Centrifuge cake is not as "dry" as filter press cake, therefore, less waste volume reduction 3) Operation requires higher skill level and more experience 4) Operation requires greater amount of electric power compared to filter press and belt press technology
PHYSICAL	Dorr-Oliver Eimco USA Inc. Sales	Deep Cone Thickener	1) Maximum water recovery for recycling 2) Disposal by stacking not ponding 3) Minimum installed thickener area 4) Minimum disposal volume 5) Sludge transportable by pumps 6) Minimum liquid discharge after deposition	No disadvantages listed
PHYSICAL	Linatex Tennessee	Hydrocyclone	1) Effective at removing sand sized fraction 2) No moving parts within the cyclone 3) No power consumption, other than delivery of slurry	1) Coarse fraction typically retains a large amount of light organic solids. 2) Limited capacity, multiple units required 3) Sediment laden cyclone overflow must be moved to a disposal area 4) Feed slurry must first be screened for debris and oversize material
PHYSICAL	Waste Technologies of Australia Environmental Biotechnology CRC Pty Ltd	Electrodewatering	1) Current costs for electrodewatering are higher than costs for standard belt filter presses. With continued improvements, however, costs should be comparable to belt filter presses as the process is a slight modification of the press. 2) Increases in operating cost over conventional belt filter presses due to higher electricity use should be offset by the reduction in tipping fees associated with disposing of a drier and less voluminous product.	1) Current costs for electrodewatering are currently higher than costs for standard belt filter presses. 2) Increases in operating cost over conventional belt filter presses due to higher electricity use

Table 3 Continued
Dewatering Technologies Advantages and Disadvantages

Classification	Vendor	Type	Advantages	Disadvantages
PHYSICAL	Mitchell Dryers Ltd Denton Holme, Carlisle, Cumbria CA2 5DU England	Thermal Drying	1) Sludge drying process diminishes volume of sludge making the transportation cost lower and storage easier. 2) Drying increases sludge calorific value; makes it hygienic, stabilizes it and improves its structure. 3) The comparison of the total costs of different sludge utilization options often indicates sludge drying as the best option.	1) Not all drying facilities are able to dry sludge only partially. 2) Moist air collected from a dryer should undergo certain processes before it is released to the atmosphere. 3) The process of sludge thermal drying is not a cheap solution mainly because of its high energy demand. 4) As thermal drying of sludge inquires significant amount of energy it is advised to use biogas, energy from sludge or waste incineration or other "waste" energy for diminishing the amounts of fossil fuels.
INTEGRATED SYSTEMS	TEFSA-USA	Filter Press	1) Dryer filter cake, therefore, greater waste volume reduction 2) Capable of effectively dewatering a wide variety of sludge streams 3) Chemical and filter aids are generally less expensive 4) Basic and durable operation	1) Batch process that typically requires more labor/operator effort 2) Lower process/production rates compared to belt press technology 3) Susceptible to cloth blinding on most oily or "tacky" sludge streams
MECHANICAL	TEFSA-USA	Belt Filter Press	1) Continuous feed process typically requiring less labor/operator effort 2) Higher sludge processing/production rates compared to filter press and centrifuge technologies 3) Fairly basic and durable operation 4) Best technology for bio-solids and primary/ secondary digested sludge	1) Typically requires more expensive polymer addition to pre-condition sludge 2) Belt press cake is not as "dry" as filter press cake, therefore, less waste volume reduction 3) Susceptible to cloth blinding by most oily or "tacky" sludge streams

Table 3 Continued
Dewatering Technologies Advantages and Disadvantages

Classification	Vendor	Type	Advantages	Disadvantages
MECHANICAL	Ascension Industries	Plate and Frame Press	1) High solids content cake 2) Can dewater hard-to-dewater sludge 3) Very high solids capture 4) Only mechanical device capable of producing a cake dry enough to meet landfill requirements in some locations	1) Large quantities of conditioning chemicals are commonly used 2) High capital cost, especially for variable-volume filter presses 3) Labor cost may be high if sludge is poorly conditioned and if press is not automated 4) Media replacement is both expensive and time consuming 5) Noise levels caused by feed pumps can be excessive 6) Batch discharge after each cycle requires consideration of receiving and storing cake
MECHANICAL	Atkins Water	Bucher Hydraulic Press	Side-by-side testing results with a belt filter press indicated that a hydraulic press can improve the biosolids and cake solids content by more than 25% compared to a belt filter press. The chemical conditioning requirements for a hydraulic press were similar to the belt filter press.	Batch process - low production rate
INTEGRATED SYSTEMS	Genesis Fluid Solutions	GENESIS Rapid Dewatering System	1) The operational cost of this technology typically runs 30-50% less than more common dewatering techniques 2) The required operational site, or footprint, is only about 150 by 150 feet, enabling the mobile Genesis dewatering unit to set up in small parking lots, on golf courses, or on barges. 3) No pits, ponds, or return channels are needed. Each mobile system is discrete in operation, emitting little noise or odor.	1) Unit costed and processed material is substantially higher than other less technically intensive options. 2) Potential mechanical breakdowns due to many unit processes

Table 3 Continued
Dewatering Technologies Advantages and Disadvantages

Classification	Vendor	Type	Advantages	Disadvantages
INTEGRATED SYSTEMS	J.F. Brennan Co., Inc. PHOENIX Process Equipment Co.	ID&D® – Integrated Dredging & Dewatering	1) Continuous process - Dredging through dewatering is one integrated system 2) No need for settling basins - Eliminates berm, return water systems and containment area restoration 3) Eliminates long pipelines and boosters 4) Processes a variety of materials - Handles a wide variety of sediment types, grain sizes and debris 5) Highly automated - Due to computerization, only two people are needed to operate dewatering system 6) Optimizes polymer consumption - Computer controlled polymer addition is integrated with real-time measurement of solids content of the dredge slurry 7) Low turbidity of return water, water returned directly to waterway or used as process water 8) Environmentally sensitive - All equipment, systems, and materials are designed to be environmentally sensitive. 9) Dewatered material is stackable & available immediately - Ready for beneficial use, recycling, treatment, packaging, transport and/or disposal 10) Streamlines agency permitting - Eliminates groundwater mounding and return water issues	1) Unit costed and processed material is substantially higher than other less technically intensive options. 2) Potential mechanical breakdowns due to many unit processes
INTEGRATED SYSTEMS	Eagle North America	EAGLE NORTH AMERICA Extended Contracting Service	Most of Eagle North America's dewatering services are performed using belt press technology, but dewatering is customized for the client using the most suitable technologies including: • High pressure belt press • Centrifuge • Plate and frame filter press • Screw press • Grinders, screens, hydrocyclones, tanks • Geotube technology Each project may also be customized to include required processes such as screening, thickening, sand removal, washing, and drying. Eagle North America's portable units are skid mounted to allow for easy transport and quick configuration, and all skids feature new equipment rather than reconditioned equipment.	1) Unit costed and processed material is substantially higher than other less technically intensive options. 2) Potential mechanical breakdowns due to many unit processes

5.0 VENDORS

A list of vendors is provided in Table 4. Contact information for each vendor is provided along with information on their past experience in Florida, and/or their willingness or ability to work on projects in the state. Appendix A includes detailed information on each of the vendors dewatering technology processes.

Table 4
Vendor List

Vendor	Method	Address	Phone Fax	Email/Web Page	Work In Florida
American Earth Mover	Integrated System	821 Ne 79th St. Miami Shores, FL 33138-4713	(305) 865-6952 (305) 861-6329 Fax #: (305) 867-5050	dredger@bellsouth.net www.marinedredging.com	
Ascension Industries	Plate & Filter Press	1254 Erie Avenue North Tonawanda, NY 14120	716-693-9381 716-693-9882	Sales@asmfab.com www.asmfab.com	Yes
Atkins Water	Bucher Press	3020 Old Ranch Parkway, Suite 180 Seal Beach, CA 90740	562-314-4231	rupert.kruger@atkinsglobal.com www.atkinsglobal.com	Yes
Ciba	Polymer	2301 Wilroy Road P.O. Box 820 Suffolk 23439 - 0820 Virginia	757-538-3700 757-538-3989	Customerservice.USWP@cibasc.com www.cibasc.com	Yes
DEL TANK & FILTRATION SYSTEMS	Mechanical	436 Highway 93 North Scott, LA 70583	337-237-8400 ext. 7732 337-266-7800	duke@deltank.com www.deltank.com	Yes
Dredge America	Integrated System	9555 NW Highway N Kansas City, MO 64153	1-800-464-5597 863-330-3103	info@dredgeamerica.som www.dredgeamerica.com	Yes
Dredging Specialists	Integrated System	43 Dewitt Ave. Mattoon, IL 61938	217-259-2229 (217) 234-3347	dredgesp@consolidated.net www.dredgingspecialists.com	Yes
Dorr-Oliver Eimco USA Inc.	Conventional Thickener	2850 So. Decker Lake Drive Salt Lake City, UT 84119-2300	801-526-2000 801-526-2001	www.dorrolivereimco.com	Yes
Eagle North America	Integrated System	503 Blackburn Drive Augusta, GA 30907	864-224-0940 877-407-6098	darrell_turner@eaglenorthamerica.com www.eaglenorthamerica.com	Yes
Ellicott a Division of Baltimore Dredges, LLC	Integrated System	1425 Wicomico Street Baltimore, MD 21230	888-870-3005 or 410-625-0808 410-545-0200	rmanning@dredge.com www.dredge.com	Yes
Genesis Fluid Solutions	Integrated System	6660 Delmonico Drive Suite 242-D Colorado Springs, CO 80919	719-761-7952	dlohrmeyer@genesisfluidsolutions.com www.genesisfluidsolutions.com	Yes
Infrastructure Alternatives	Integrated System	960 W River Center Dr. Suite B, Comstock Park, MI 49321	616-647-3300	www.infralt.com	Yes

Table 4
Vendor List

Vendor	Method	Address	Phone Fax	Email/Web Page	Work In Florida
J.F. Brennan Co., Inc.	Integrated System	820 Bainbridge Street La Crosse, WI 54603	608-784-7173 608-785-2090	ggreen@jfbrennan.com www.jfbrennan.com	
Linatex Tennessee	Hydrocyclone	1550 Airport Road Gallatin, TN 37066	615-230-2100 615-230-2109	www.linatex.com	Yes
Mitchell Dryers Ltd.	Thermal Dryer	Denton Holme, Carlisle, Cumbria CA2 5DU England	44(0)1228 534433 44(0)1228 33555	info@mitchell-dryers.co.uk www.mitchell-dryers.co.uk/sludge.htm	Unknown
Miratech a Division of Ten Cate Nicolon	Geo-textile tubes	3680 Mount Olive Road Commerce, GA 30529	706-693-1897 706-693-1896	www.geotubes.com	Yes
Nalco Company	Polymer	1601 West Diehl Road Naperville, IL 60563-11198	630-305-1732 630-305-2879	mstrominger@nalco.com www.nalco.com	Yes
PHOENIX Process Equipment Co.	Integrated System	2402 Watterson Trail Louisville, KY 40299	502-499-6198 502-499-1079	phoenix@dewater.com	Yes
RHMoore & Associates Distribution Group	Geo-textile tubes	Building D & E 8917 Maislin Drive Tampa, FL 33637	813-988-0200	larry@rhmooreassociates.com www.rhmooreassociates.com	Yes
SNF	Polymer	1 Chemical Plant Rd. P.O. Box 250 Riceboro, GA 31323	(912) 884-3366 Ext. 286		Yes
TEFSA-USA	Filter Press & Belt Press	15207 N. 75th Street Suite 101, Scottsdale, AZ 85260	800-269-4098 480-951-8434	www.beltfilterpress.com	Yes
Tencate	Geo-textile tubes	3680 Mount Oliva Road Commerce, GA 30529	706-693-1852 888-795-0808 Fax: 706-693-1896	e.trainer@tencate.com www.geotube.com	Yes
Veolia Environmental Services	Centrifuge	Separations Main Office 806 Hoods Creek Pike Ashland, KY 41101	877-758-3431 606-327-0596	www.veoliaenvironmental.com	Yes
Waste Technologies of Australia	Electrodewatering	Environmental Biotechnology CRC Pty Ltd Suite G01 Bay 3 Locomotive Workshop Australian Technology Park Everleigh NSW 1430	+61 (0) 2 9209 4963	www.wastetechnologies.com	Unknown

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