Mechanical Dewatering of Navigation Sediments: Equipment, Bench-Scale Testing, and Fact Sheets

PURPOSE: This technical note provides an overview and technical guidance for evaluating mechanical dewatering at dredged material placement sites. This document introduces the basic pieces of equipment that make up a dewatering circuit or train, some advantages and disadvantages of different equipment options, the state of the practice in bench-scale testing, discussions of performance specifications and cost, and several fact sheets on various process technologies and their applications.

BACKGROUND: The fundamental objective of the Innovative Dredging Technology Focus Area of the Dredging Operations and Environmental Research (DOER) Program is to identify and catalog innovative dredging operations, processes, or equipment and techniques developed by domestic and international dredging entities. A number of technologies developed within the U.S. Army Corps of Engineers (USACE) are currently undergoing evaluation for potential demonstration under the DOER Program. Among these is the mechanical dewatering of dredged material at confined disposal facilities (CDFs).

INTRODUCTION: The solids content of a typical dredge discharge slurry ranges from roughly 100 to 200 g/l, as compared to the in situ solids content, which may range from 250 to 1800 g/l, depending upon the grain size distribution of the in situ sediment. Conventional upland placement of dredged material involves discharge of the slurry into a CDF, where clarification and settling take place. Clarified water is normally returned to the originating water body. Large areas are required for upland placement of hydraulically dredged sediments, and CDFs must be in relatively close proximity to the shore in order to economically manage return flows. Over time, the material placed in the CDF continues to dewater and consolidate, making room for additional "lifts" from subsequent dredging cycles. Surface trenching and weir management are typically the only active dewatering efforts that take place.

Mechanical dewatering uses special equipment to reduce the water content of the dredge slurry at the time of placement. There are a number of possible motivations for considering mechanical dewatering, including:

- Remaining storage capacity in the CDF is insufficient for clarification and water management.
- Sediments are very contaminated and must be transported to a permitted landfill for disposal.
- Conditioning of the material is needed to facilitate handling and transport and to reduce transport costs.
- Water content must be reduced to meet disposal or beneficial use specifications.

Mechanical dewatering is not presently used as a standard operating procedure in dredged material management. However, as the available capacity in existing CDFs has diminished, there has been greater interest in beneficial use of dredged material to reclaim or preserve disposal area capacity. Given the time required for materials to consolidate sufficiently so that they can be excavated and recovered from a CDF, mechanical dewatering may offer a viable means of continuing to operate in a CDF that is nearing the end of its design life. It is envisioned that with proper management these facilities would become "rehandling" stations, and dredged material would be treated as a resource rather than a long-term storage problem. Where sediments are too contaminated for either beneficial use or CDF disposal, savings in transportation costs to a permitted disposal facility may justify the dewatering processing cost. Whatever the motivation, mechanical dewatering is being considered more frequently in dredged material management evaluations.

TREATMENT TRAINS: There is a variety of equipment from which to choose in developing a dewatering treatment train. Equipment selection will be based on such variables as sediment characteristics (e.g. grain size distribution, organic content, plasticity), available staging area, capacity requirements, and ultimate disposition of the dewatered dredged material. Available transportation, disposal, and beneficial use alternatives will determine the specifications for the dewatered cake and the importance of volume and weight reduction. A typical treatment train will incorporate the following three primary stages: 1) sand and oversize removal, 2) thickening, and 3) dewatering. Each of these stages may require one or more different pieces of equipment, depending upon the specific requirements of the application and the characteristics of the sediment.

Sand and Oversize Removal. Removal of sand, trash, and oversize materials is typically the first operation in a dewatering circuit, as for any physical separation treatment train. Physical separation and dewatering treatment trains may, in fact, be almost identical, with the only difference being the principal processing objective. Sand may be removed first, using a sand screw with sump and conveyor, followed by light trash removal (bark, grass, and plastic) on a scalping screen. Alternatively, oversize materials (e.g. coarse gravel, rocks, debris, and light trash) may be removed first on a grizzly or a vibrating wet screen, followed by sand removal downstream using a hydrocyclone. Advantages of the first approach are:

- The sump on the sand screw provides some surge capacity, which is important in coupling the dewatering treatment train to a dredging process.
- The sand is separated at a point in the system where this will occur without additional energy input, and where energy would otherwise be required to prevent its settling during process stoppages.
- The overflow passes from the sump of the sand screw with sufficient energy to be passed onto the scalping screen for removal of light, floatable trash, and collection of the fine slurry in a mixing tank. Conversely, when the trash and oversize material are separated first on a wet screen, the underflow (sand and fines slurry) must be pumped to the next stage. The presence of coarse organics in the sand, however, may necessitate the use of a hydrocyclone to achieve effective removal of the organics. Also, the fine slurry leaving the mixing tank

must also be pumped to the next stage, so a pump will either precede or follow the sand separation unit operation. Although the bulk of the water reports with the fines, the solids flow rate will be lower for a pump to transfer the fine slurry from the mixing tank to the thickener, than for a pump to transfer the wet screen underflow (sand and fines) to the hydrocyclone. Pump abrasion will also be decreased with removal of the sand.

- The sand coming off the screw is essentially self stacking, and can be periodically removed with a front-end loader. Additional dewatering might be required for the underflow from a hydrocyclone (sand fraction), and a sand screw might be used for this purpose, as well as to convey material from beneath the hydrocyclone. The sand screw followed by the scalping screen therefore requires less equipment overall when additional washing of the sand is not required to remove coarse organics and agglomerated fines.

Thickening. Fine-grain slurries normally require the addition of polymer to coagulate the solids and facilitate dewatering. Polymer may be added to the slurry in a tank and agitated to encourage flocculation, but it is often added in-line, between the sand separation unit and the dewatering stage. At this point, a thickener may be used to settle solids to optimum solids content for the dewatering equipment. The thickener also acts as a clarifier, recovering the free water from this initial dewatering step, and reducing the suspended solids in filtrate returned from the dewatering equipment. The clarifier overflow may be recycled through the system for necessary process dilutions, or returned to the receiving water body. Alternatively, thickening and initial dewatering of fines can be done with an inclined wedge wire screen. However, the inclined screen is sensitive to changes in grain size of the feed, resulting in process upsets and variability in the solids content of materials leaving the screen. Sandy materials may fall through the screen entirely, rather than flowing down the face of the screen to the next stage.

Dewatering. Once sand and oversize materials have been removed, and the material thickened if necessary, the fine slurry can be dewatered using a centrifuge or filter press, each of which are available in a variety of configurations. Selection of the best equipment and configuration for the application will depend upon the degree of water removal and volume reduction required, the ability of the equipment to handle the type and volume of material being processed, and the rate of production. Bench and pilot scale testing are typically used to make this determination and to size the equipment. Depending upon the dewatering equipment used downstream of the thickener, additional polymer may be required to further coagulate the solids for the final dewatering step. Insufficiently coagulated or low-solids-content slurry may result in poor solids capture in the dewatering step. Overtreating with polymer can be equally undesirable with respect to processing cost and wastewater quality.

DEWATERING EQUIPMENT:

Sand Screw. A sand screw typically consists of a sump equipped with a flat or angled auger to transport settled sand from the sump, and a conveyer to feed the sand from the auger (Figure 1). Alternatively, sand may simply be allowed to stack at the base of the sand screw and be handled with conventional earth-moving equipment. Slurry is fed into the top of the sump, and the coarse materials settle onto the auger. Fine and organic materials are carried out in the overflow. The sump may be equipped with counter-current flow capability, to improve the removal of the fines and organics from the sand fraction. The sand fraction can be coarsened by increasing the throughput, causing the fine sand to report with the fines. This will improve the permeability of the cake produced in the follow-on dewatering processes, but may also decrease compressibility. The sump on the sand screw provides some surge capacity for the system and takes advantage of the fact that coarse materials are difficult to maintain in suspension, even with high-energy mixing. The relative efficiency of fines removal for different materials and varying operating conditions is an area that requires further study for environmental applications.

Scalping Screen. A scalping screen removes oversize materials, such as rocks, gravel, bark, plastic, grass, shells, and other debris. Besides being destructive to equipment and filter fabrics, debris constitutes unnecessary treatment and storage volume when carried through the process. A scalping screen may be fixed or rotate in a belt configuration (Figure 2). The belt configuration permits additional capacity in a smaller footprint, and prevents the blinding of the screen with grass and similar materials because they are dropped off the end of the belt as it rotates.

Figure 1. Sand screw

Figure 2. Scalping screen

Hydrocyclones. A hydrocyclone is a cone-shaped piece of equipment with no moving parts, constructed of metal or plastic (Figure 3). Hydrocyclones may be lined for improved wear resistance. Slurry is fed into the hydrocyclone tangentially, and flows in a spiral direction down the cone. Finer and lighter materials migrate toward the center of the cone (vortex) and are carried out in the overflow. Coarser and heavier materials leave the cyclone through the apex, as the underflow. The bulk of the water reports with the fines, and the underflow may be relatively well dewatered if the material is coarse (sandy). Hydrocyclones are often used to recover sand, but may be sized for finer separations as well. There may be several advantages to removing sand in a dewatering circuit:

- Materials loading to the presses and equipment abrasion are reduced.
- Polymer costs may be reduced. Dosage of polymers added for the purpose of coagulating fine materials is determined by the solids concentration in the slurry, and is expressed in terms of grams polymer per gram solids. Chemical demand can be reduced by removing the sand, which competes with the fine materials for the polymer.
- Long-term storage capacity requirements may be reduced if alternative uses are available for the sand. Sand removal as a volume reduction measure and beneficial use of dredged materials are topics extensively discussed in a number of other publications (Olin-Estes et al. 2002; Olin-Estes and Palermo 2000a, b; Olin-Estes 2000; Great Lakes Commission 2004a, b).

Figure 3. Hydrocyclone

Figure 4. Wet screen

Wet Screen. A wet screen may be used to achieve preliminary size separation of material. Material may be fed onto the screen dry, and washed through the screen by water jets mounted on the top of the screen (Figure 4). The screens are usually mechanically vibrated to facilitate separation. Vibrating wet screens can be useful in breaking up agglomerated clay containing material. Decks are wire or polymer with square or rectangular openings. The openings may blind when presented with grasses or similar debris, thus necessitating the scalping screen.

Surge Tanks/Mixers. One of the principal challenges in incorporating a dewatering circuit as part of a dredging process is the interface between the dredge and the dewatering circuit. Typical dredge sizes used in large-scale maintenance dredging projects are too large to interface well with a dewatering circuit unless significant buffering capacity and system redundancy are incorporated in the dewatering circuit. Because of this, smaller dredges (6- or 8-in. dredges) are typically used. The comparative cost compromise between reduced production at the dredge versus increased capacity of the dewatering circuit, must be balanced in the cost/benefit evaluation.

Clarifiers/Thickeners. High rate, circular clarifiers/thickeners are appropriate for a wide variety of dredged sediment slurries. Typically, suspended solids are increased from 10 to 20 percent dry solids in the influent, to approximately 30 percent solids in the underflow, greatly reducing the slurry volume in the process with this equipment. At the same time, clarified water overflows a weir and is available as process water or is returned to the receiving water body (Figure 5). Polymers are required to accelerate sedimentation and optimize clarified water quality. Features include the ability to process a high volume of solids without fouling, minimum space requirement, rugged construction, and low SS in the overflow (15-30 mg/l).

Figure 5. Circular clarifier

When used to thicken feed for a belt filter press, additional polymers may be added to the underflow, or the solids may need some dilution to meet optimum feed concentrations to the press. Solids can be continuously stirred to maintain pumpability during system shutdown, a significant advantage over lamellar clarifiers. Lamellar, plate-type clarifiers are frequently used for lower concentrations of suspended solids, emphasizing the need for clarification of the overflow water, rather than for the thickening of the underflow. Polymers are required, and the plates are sometimes subject to solids build-up and plugging, especially when applied to heavy concentrations of sticky solids.

As a processing alternative, the clarifier may be used as the principal dewatering component. Operated for maximum thickening, a circular clarifier can produce a pumpable underflow of up to 40 percent solids. These partially dewatered materials can then be placed in a containment area for further consolidation. Although a temporary dewatering area would be required, this might be a more cost-effective alternative than mechanical dewatering. Clarifier capacity can be increased at less cost than press capacity, enabling the use of larger dredges for which labor costs are comparable to smaller dredges. Additionally, the dredge can operate more continuously if the capacity of the rate limiting components is increased. This reduces the length of time the dredge must be on-site, resulting in further cost savings.[1]

Polymer Mixing and Injection Systems. Dry or liquid polymers (nonionic, anionic or cationic) are available for thickening and/or dewatering dredged sediment slurries. To economically justify more capital-intensive dry systems, the polymer requirements must be very substantial because of the solids throughput in the system or because of the large size of the processing system. Small, packaged systems blending neat polymer with water and then

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[1] Personal communication. May 13, 2004, Vic Buhr, Division Manager of Hydraulic Dredging and Dewatering, J.F. Brennon Co., 820 Bain Bridge, LaCrosse, WI 54602-2557.

injecting the diluted polymer through an in-line mixer are economical for smaller systems. However, the cost/pound of liquid polymer is usually higher than for dry polymers. Equipment configuration and high flow rates sometimes dictate the use of flocculant mixing tanks in lieu of in-line mixers. Polymers may be introduced at several points within the treatment train, preceding the thickener for example, and again preceding the principal dewatering equipment. Polymer dosage prior to a belt filter press may be as much as three times higher than the dosage preceding the thickener, which is one of the reasons slurry is not generally fed directly to the press (slurry volume is reduced at the thickener, thus reducing polymer consumption).

Various means of controlling the injection rate of mixed or blended polymer into the slurry are commercially available. The degree of automation that is desired depends on a number of factors, including the variability of the feed solids characteristics during the dredging process and/or the change in the percent solids in the slurry. Because many factors affect the amount of polymer that is required and because conditions can change so quickly, automatically adjusted injection can sometimes be difficult to justify from a capital cost perspective.

Slurry Density Instrumentation. To achieve optimal system performance, including maximum dewatering effectiveness and minimum polymer consumption, the percent solids in the slurry feeding the dewatering equipment should be continuously monitored and adjusted to a preset level. This is frequently accomplished with a densometer and dilution water from the thickener/clarifier overflow. A controlled proportional valve can be used to introduce the required water flow into the clarifier/thickener underflow.

Belt Filter Presses. Belt filter presses have historically been used in the paper industry and for dewatering of sewage sludge, and are well-proven for dewatering dredged material. They offer continuous operation, low operator labor, reasonable capital cost, ease and simplicity of maintenance, high solids throughput, moderate footprint, high solids capture rate (i.e., low solids in filtrate), low power consumption, reasonable polymer consumption rate, high reliability and availability, and adaptability to changing process conditions. However, solids content of the cake may be lower than that produced by a plate and frame press. Typically, a belt filter press will produce a cake of approximately 40 to 50 percent solids by weight, as compared to 50 to 65 percent solids achievable with plate and frame presses. These values are a function of the density of the solids in the material as well as the dryness and compression achieved by the equipment. Solids content for very low-density materials may be more in the range of 30-40 percent solids. Solids content may be a pivotal factor where the final weight or volume of the processed material factors significantly into management economics, as it does when transport or off-site disposal costs must be considered.

A belt press has three dewatering zones: gravity, wedge, and high pressure. Free water drains from the conditioned sludge in the gravity zone. The press is equipped with rakes to distribute the material and encourage drainage (Figure 6). In the wedge zone, the sludge is captured between two moving belts where additional water is squeezed out under low pressure as the belts converge. The belts sandwich the now more-compressed sludge and pass over a series of rollers of decreasing size and increasing pressure to further reduce the water content (Figure 7). The number of rollers employed can be varied according to product specifications and requirements of the material being processed.

Figure 6. Belt filter press rakes in gravity drainage zone

Figure 7. Belt filter press

If the conditioned sludge is insufficiently flocculated, an excessive amount of solids may be lost through the belt. In other cases, a well-flocculated sludge will fail to drain properly in the gravity zone. When the sludge enters the low-pressure zone, it may then migrate off the edge of the belts (i.e. soft migration), resulting in low solids capture, high filtrate solids, and a fouled processing area. A similar phenomenon occurs with cake that is insufficiently dewatered upon reaching the high-pressure zones, and is termed “hard migration” (Neogen Corporation 1992). If the cake becomes extruded into the belt, it may fail to release. A dirty belt subsequently leads to failure in the gravity zone, further compounding the problem that was initiated due to inadequate gravity drainage.

Plate and Frame Presses. Also known as recessed chamber filter presses, these machines process slurry in batches, although multiple compartments or parallel installations may be employed to achieve continuous operation (Figure 8). Slurry is fed into each compartment (frame) of the press, where the solids are retained on a membrane and the water passes through as filtrate. Flow is stopped at a specified pressure differential, the filter plates are opened, and dewatered cake is discharged. In order to avoid interruptions to the dredging operation, adequate storage or surge capacity must be available upstream of the press, with sufficient system redundancy to permit continuous operation. This type of operation may have higher operator labor requirements, a larger footprint, and a higher capital cost than the belt filter press. However, the solids capture rate is very high, as is the percent solids in the filter cake. Savings in trucking or offsite disposal costs for the dryer, more condensed cake may justify the differences in capital and operating costs relative to belt filter presses. This should be evaluated in the cost/benefit analysis. As for all dewatering processes, polymer cost varies with the physical characteristics of the solids. Power cost can be high as a result of a high pressure drop as the filter becomes loaded with solids.

Fixed volume filters require a specific volume of solids in order to produce the driest possible cake. Addition of a diaphragm or membrane plate produces a variable volume filter. The bladder or diaphragm may be inflated to physically press additional liquid from the filter cake, reducing cycle time and producing dryer cakes when solids capture is low relative to the filter capacity

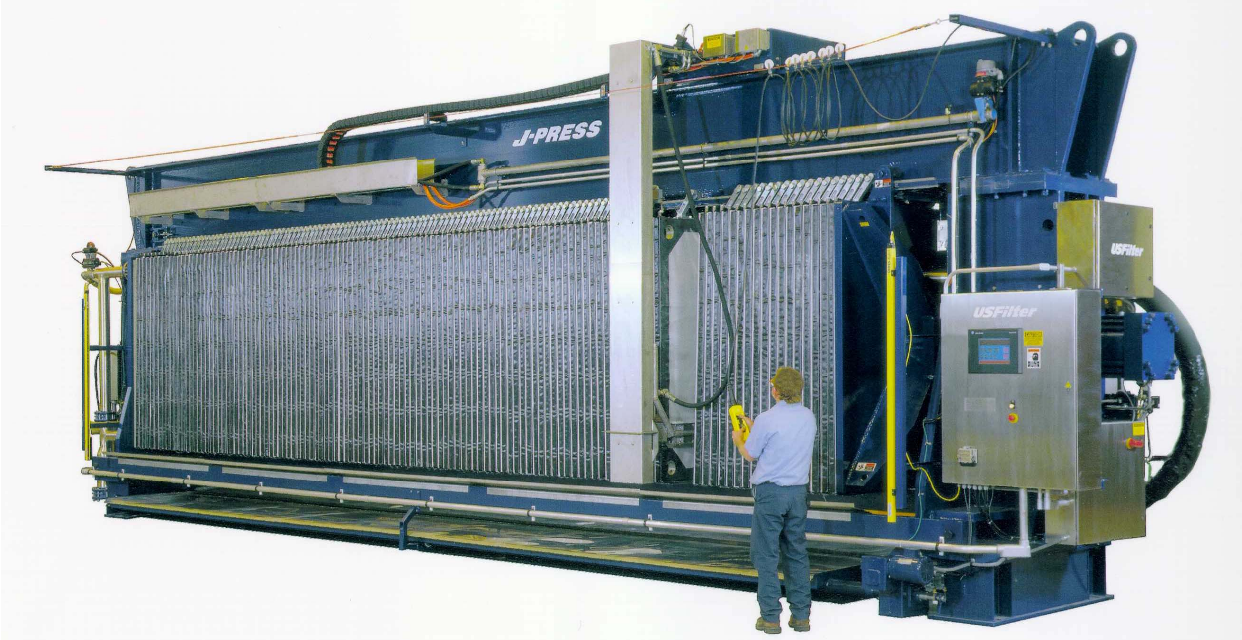

Figure 8. Plate and frame press (photograph provided courtesy of U.S. Filter Dewatering Systems, Holland, MI)

(U.S. Filter 2004). Pumping costs associated with high pressure differentials necessary to fill the filter to capacity may also be reduced with the use of a bladder press.

Centrifuges. Centrifuges operate continuously, and they feature low operator labor costs. Capital cost varies, depending on the design and resulting dewatering effectiveness of the machine. As for the other dewatering equipment, polymer consumption varies with solids characteristics. Power requirements are high and abrasion on internal parts can be problematic. Maintenance is very sophisticated; reliability and availability can be problematic on abrasive materials. The solids capture rate tends to be lower (resulting in more solids in the centrate) than for either belt or plate and frame presses, but centrifuges can be very effective for some materials (Figure 9). Centrifuges are very compact and can be accommodated in a relatively small footprint (Figure 10).

BENCH AND PILOT SCALE TESTING: Full-scale operations should be preceded by adequate material characterization, and appropriate bench- and pilot-scale testing. Bench-scale testing is employed to identify suitable polymers and dosages, and evaluate the expected processing requirements of the material to meet project objectives. Initial equipment selection should be based on bench-scale testing. This is followed by pilot-scale testing to ascertain process response to the variability of the material that can be expected on a larger scale. Pilot-scale testing allows adjustments to be made to the equipment or process at a point where cost impacts would be less than would be incurred after full-scale processing begins. Information obtained from bench- and pilot-scale testing may also be valuable in developing performance specifications.

Figure 9. Flocculated slurry, supernatant and cake (Photo provided courtesy Centrisys)

Figure 10. Decanting centrifuge (Photo provided courtesy Centrisys)

Physical and chemical characterization of the in situ material should include grain size distribution, water content, percent solids, bulk specific gravity and specific gravity of the solids, organic content, Atterburg limits, and chemical analysis of expected processing streams. If contaminant concentrations are of concern, and size separations are to be done prior to the principal dewatering step, chemical concentrations should be measured in the resulting solid and aqueous process streams. Estimates of filtrate suspended solids and total and dissolved contaminants will typically be of interest. Control of volatile emissions may also be a permit requirement. Process flow diagrams with material mass balances will normally be needed.

Polymer Testing. Conditioners (flocculants) are used to produce optimum slurry suspended solids in the feed to the dewatering equipment. Equipment performance is dependent upon selection of an appropriate conditioner. The floc must have enough shear strength to minimize solids losses in the dewatering equipment, but must be permeable enough to permit free drainage. Chemical conditioners often constitute a major operating cost of a dewatering circuit, so this step is very important with respect to process economics. Typically multiple conditioners will be evaluated at bench scale to identify those that produce the best sludge for the least cost. The best conditioners identified in bench tests will then be evaluated with the bench- and pilot-scale dewatering equipment. Bench-scale testing may consist of a fairly simple funnel and filter apparatus to evaluate gravity drainage characteristics of the flocculated material. It is common to test a large number of polymers in order to identify the optimum conditioner and dosage. Toxicity of conditioners may become an issue if filtrate and process water are to be discharged to a water body without further treatment.

Crown Press. The Crown Press$_{\text{TM}}$ is a bench-scale piece of equipment intended to model the belt filter press (Figure 11). The press facilitates evaluation of conditioners and belt materials, and the action of multiple rollers can be simulated to achieve a specific cake dryness and density. Migration of sludge on the belt can be measured. The belt tension applied on the bench press translates to the units of force per inch. This information is used in adjusting the belts on a full-scale press. Process variables of interest are: solids throughput rate, filtrate quality and suspended solids, cake dryness or density, and polymer requirements. The bench press facilitates the correlation between performance of the compression zones of the press and changes in one or more of these variables. A gravity test drainage kit is also included to simulate drainage of the sludge in the gravity zone of the belt press (Figure 12). The actual sludge sample volume required for testing must be calculated, but typically ranges from 100 ml to 400 ml. More complete information regarding the equipment and recommended testing procedures can be found in the Crown Press$_{TM}$ Owners Manual (Neogen Corporation 1992), which is also available on-line, and in Severin et al. (1998).

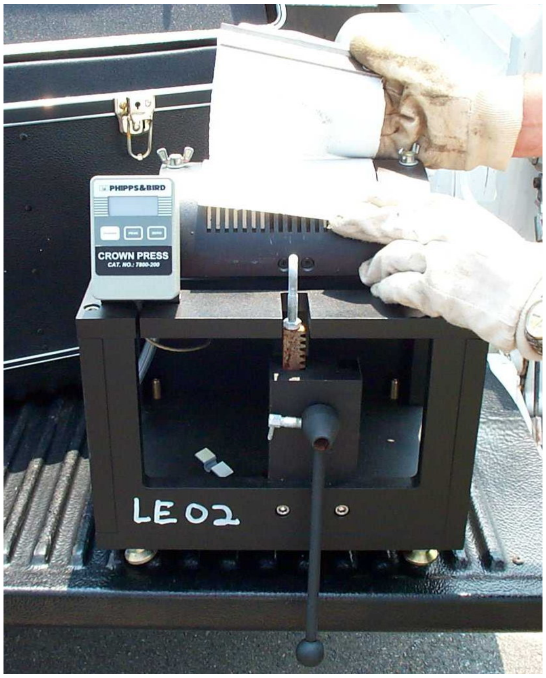

Figure 11. Crown Press$_{TM}$

Figure 12. Crown Press$_{TM}$ gravity test kit

Chamber Filter Press. This bench-top unit models the plate and frame press (Figure 13). Approximately 1 L of slurry is fed into the top of the unit and is compressed to about the size of a hockey puck. The properties of the compressed cake can be measured and utilized in scaling up the process. Testing units like this are made by a number of manufacturers. The unit pictured is made by U.S. Filter.[1]

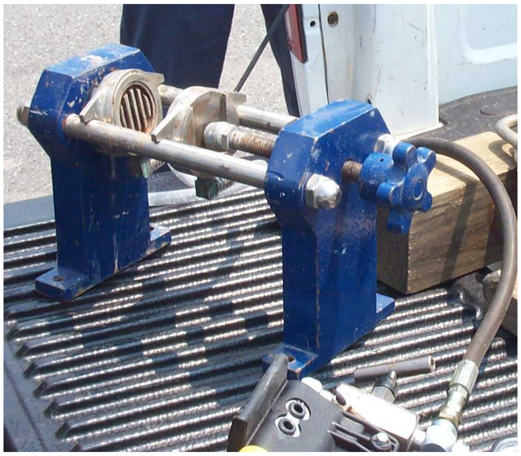

Figure 13. Chamber filter press

Plate and Frame Press. This unit is a lab-scale version of the full-scale plate and frame press. The unit may be equipped with single or multiple chambers, with a filter volume ranging from approximately 1.0 ft^3 to 2.6 ft^3, and maximum

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[1] Personal communication. March 24, 2004, Robert Hamm, Lab Director/Process Development Mgr. U.S. Filter/JWI Inc., Holland, MI 49414.

operating pressures of 225 psig (Figure 14). Specifications will vary with manufacturer. Presses may be equipped for counter-current operation to facilitate cake washing. Presses may be trailer-mounted for mobility (Figure 15). A press with multiple leaves is typically quite heavy (up to 1,500 lb).

Figure 14. Single frame plate and frame press

Figure 15. Trailer-mounted plate and frame press

Estimating Volume Reduction. A simple method of estimating the volume reduction that can be achieved based on bench-scale testing requires measurement of the initial and final water content, sand removal efficiency (if applicable), mass sand and fines in the in situ or unseparated sediment, and the initial and final total density. From these parameters, a bulking factor can be calculated (which would be less than one for dewatering). The relationship is as follows (Olin-Estes et al. 2002):

$$b = \frac{\left(1+w_f\right)\left[\left(1-x_m\right)M_{S_i}+M_{F_i}\right]\rho_{t_i}}{\left(1+w_i\right)\left(M_{S_i}+M_{F_i}\right)\rho_{t_f}} \tag{1}$$

where:

w_i and w_f = initial or in situ and final water content, as a decimal

x_m = sand removal efficiency by mass, as a decimal

M_{Si} = mass sand, initial

M_{Fi} = mass fines, initial

ρ_{ti} = total or wet density, initial or in situ

ρ_{tf} = total or wet density, final

The relative initial and final material volumes are then given by:

$$V_{T_f} = bV_{T_i} \tag{2}$$

PERFORMANCE SPECIFICATIONS: Developing suitable performance specifications is critical to the success of a dewatering project. There is a balance that must be achieved in order to take into account project goals, the variability of the material being processed, and the impact of processing variations on operating and disposal costs. Performance specifications must take into account the risk tolerance of all parties in order to achieve project goals and minimize costs as well as establishing the basis for contract payment.

Performance Goals and Objectives. Processing goals and objectives must be clearly articulated and the manner in which performance will be evaluated explicitly specified. A careful cost/benefit analysis will help to identify the chief operating objectives. For example, in cases where volume and weight of material must be minimized in order to reduce transportation and offsite disposal costs, the performance specification might be based on a minimum cake density and maximum water content that would be acceptable. However, a processing cost incurred to achieve a tight specification may offset the potential savings in transportation and disposal costs. A slightly less efficient and less expensive treatment train might yield the lowest overall project costs.

Risk Tolerance. Performance specifications written with a tight material specification increase the risk to the contractor, who must base his ability to process a heterogeneous material to specifications on limited bench and pilot testing. Higher risk generally results in higher contract bids. Conversely, a contract specifying only the processing method, which might be considered desirable based on results of preliminary bench scale testing, would be easier for the contractor to estimate, but may not sufficiently motivate the contractor to operate in a manner that optimizes material properties or results in the least cost for the sponsor.

Processing interruptions in the dewatering circuit may impact the dredging operation. Because both dredging and dewatering are relatively specialized functions, however, contracts may be let to separate companies who may then find themselves in an adversarial position. The dewatering plant must have adequate capacity to minimize disruptions to the dredging. Similarly, the dredge must be operated in a manner that provides the greatest possible uniformity in the influent to the dewatering circuit. Highly variable slurry solids or flow rates may result in processing upsets and down time on both ends. Instrumentation linking the dredging plant and the dewatering circuit can minimize problems and reduce overall costs due to greater operating efficiency. This approach has been demonstrated in the field and is described in the Clinton, Iowa, fact sheet in Appendix A.

Material Properties. Performance specifications based upon material properties must consider the possibility of material variability on both sides of the treatment train and specify remedies and responsibilities arising from that. Off-spec materials may result from processing operations that are not sufficiently robust or from poor process design. However, off-spec materials may also result from unanticipated variability in the feed. If the material obtained for bench-scale testing and process design is not representative of the full range of materials to be processed, substantial additional costs may be incurred in order to make necessary modifications to the process.

Plant design is based on the measurable properties of representative samples, taking into account an appropriate level of variability and uncertainty. This could be taken to constitute a feed “spec.” The processing modifications required to handle feed outside these parameters should be anticipated, however, and costed along with the mainstream processing activities. For example, if sand content was less than 2 percent in the pre-design sampling, and no sand removal operations were included in the plant design, what are the impacts if 25-percent sand is encountered? What costs would be anticipated in connection with this, including equipment changes and dredging or processing interruptions? These are the uncertainties that drive costs of remediation activities up. Defining the necessary actions and remedies in advance, to the extent possible, allows better definition of the risk to all parties. It is to be hoped that this will have the ultimate effect of reducing the cost of processing for mainstream materials treatment.

Sampling and testing to determine compliance with materials specifications should also be carefully developed. The scale of material heterogeneity should be considered. Sampling volume, location, frequency, and sampling and analytical methods must be explicitly specified. Uncertainty associated with the sampling and analysis should be estimated and factored into considerations. Material variations resulting from changes in operating conditions should also be considered in specifying performance testing. For example, percent solids of the cake is a commonly tested parameter for process comparison. However, percent solids in the cake is a function of the compaction and dryness of the materials (% solids = mass solids/total mass), and the specific gravity of the materials in the sample tested. Percent solids may be increased in organic sediment by coarsening the cut at the front of the treatment train and allowing more sand to report with the fines. The density of the cake would be higher, and permeability may be improved, but the volume may also increase due to the higher mass reporting with the fines and decreased material compressibility. Higher percent solids for materials of the same specific gravity would indicate greater volume reduction. Testing of the cake should therefore also include not only percent solids, but bulk density of the cake, specific gravity of the solids, grain size distribution, and water content in order to fully determine the fate of materials and the effectiveness of the process. Use of these factors in evaluating overall volume reduction was discussed earlier in this document. Weight reduction can be estimated using the same parameters.

Basis of Payment. Payment is typically specified in terms of cost per unit volume dredged. Alternatively, payment might be specified in terms of cost per unit volume processed, or cost per unit volume cake produced. The obvious disadvantage of the latter specification is that the contractor will profit from maximizing the cake volume, which will likely be contradictory to processing and cost reduction objectives. Chemical costs, however, should be correlated and charged based on the volume or mass of fines processed, rather than the total volume of sediment processed. For example, if sand content is higher than expected, chemical demand will be lower. Chemical costs based on total sediment volume would not reflect this.

Process water normally requires treatment prior to discharge. If the dewatering contractor is responsible for water treatment costs, this may motivate conservative water use and minimize the volume of water to be treated. Emissions control, decontamination, and other site management considerations will normally be encompassed in the agreement as well. Payment basis is therefore an area which should be given careful consideration when developing performance specifications.

COST: Unit treatment costs are a function of character and volume of the material to be processed. Mobilization and demobilization costs are relatively insensitive to treatment volume; small projects will therefore have a higher associated unit cost. Mechanical dewatering is dependent upon chemical addition to flocculate the material. Under unfavorable conditions (in which the slurry requires high dosages of flocculants) chemical costs can outweigh equipment costs.

The fact sheets in Appendix A give a range of costs for the processes described, reflecting the impact of less-than-optimum operating conditions. When comparing cost estimates from different vendors, care should be taken to do so on an equivalent-cost basis. If one estimate includes wastewater treatment and another does not, for example, it may be impossible to extract these cost differentials and establish a uniform basis for comparison. Requests for proposals should attempt to address this issue by specifying all cost items that are to be included or itemized.

APPLICATION TO USACE DREDGING PROJECTS: With decreasing storage capacity available, managers in many areas of the country are considering efforts to recover and put to beneficial use previously dredged materials. Often transport and placement specifications require that the material be dewatered. While this can be effectively accomplished with passive dewatering methods, area requirements are large and time to achieve sufficient dewatering for the materials to be workable may be lengthy. Additionally, construction costs for new CDFs are high. Dewatering technology has matured in recent years, making material processing more cost-competitive than in the past. Where existing upland storage is available and adequate, mechanical dewatering will typically not be the least-cost alternative. Where storage is limited or must be constructed, or where offsite disposal options are being considered, mechanical dewatering may offer a reasonable alternative for some projects.

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POINTS OF CONTACT: For additional information contact Ms. Trudy Estes (601-634-2125, Trudy.J.Estes@erdc.usace.army.mil), or the manager of the Dredging Operations and Environmental Research Program, Dr. Robert M. Engler (601-634-6324, Robert.M.Engler@erdc.usace.army.mil). This technical note should be cited as follows:

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APPENDIX A: INNOVATIVE TECHNOLOGY FACT SHEETS

Dredging Operations and Environmental Research Program

Focus Area – Innovative Technology

Wilds Polander Demonstration[1]

BACKGROUND

This project involved the excavation of 200,000 yd^3 of sandy material from an existing disposal area coupled with dredging of 27,000 yd^3 of fine sediment from Polander Lake as topsoil cover, for use in the construction of a 6,000-ft island complex within the lake.

TECHNOLOGY

All process equipment was mounted on two 120-ft barges. The high speed dewatering system was composed of:

- **Feed tank.** Dredged slurry was delivered to a trash screen (0.5 in. to 65 mesh, 1500 gpm capacity) at the inlet of a Flo-Line Scalper positioned on top of a 15,000-gal rectangular frac tank. The scalper removed coarse solids of +10 mesh or greater. Water and smaller particles discharged to the feed tank. The scalped sand was discharged on the barge deck for land placement. The tank was equipped with three 5HP mixers to maintain the <10 mesh particles in suspension. The slurry was then to be pumped into the control module via the slurry delivery line. The feed tank was intended to serve two functions: 1) remove coarse material prior to the dewatering circuit, and 2) even out flow and material variations. However, there was a greater-than-expected sand content between 200 mesh and 10 mesh, and the mixers were insufficient to keep these particles suspended.

- **Control module.** The control module was a sea container, 20 ft x 8 ft x 8 ft high, housing the polymer dilution and delivery sub-systems, instrumentation to monitor pulp density (in-line coriolis meter), a slurry distribution system to the primary dewatering modules, a Doppler measurement system to monitor volumetric flow rate in the slurry delivery lines, and the power system.

- **Primary dewatering modules.** Two modules consisting of first- and second-stage inclined stainless steel wedge wire dewatering screens (64 ft^2 each) were employed. Slurry was conditioned and delivered to the first stage dewatering screen, then discharged onto the second stage screen. From there dewatered solids were discharged onto a gathering screw and delivered to the gravity zone of a belt filter press. By preceding the filter press with dewatering screens, it was projected that the belt

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[1] Wilds Polander was a project of the St. Paul District. Site visit and technology evaluation was conducted under the auspices of the DOER Innovative Technology Program.

Wilds Polander Demonstration (Continued)

press could be operated at speeds over 120 ft/min. Volumetric capacity was estimated at 800 gpm of primary slurry feed per meter of belt width, as compared to 100 gpm for conventional belt presses without preliminary feed treatment. A 2-m belt press was specified to handle the output of the two primary dewatering modules. The belt press discharged to a screw auger for stacking and placement. Pressate water was collected and delivered to a holding tank for filtration before discharge to the waterway. The higher-than-expected fine sand content was problematic to the operation of the inclined screens, tending to fall through the screens rather than being carried over to the belt filter press. More containment area was needed for the belt filter press to handle overflow. Blinding of the belt occurred after approximately 10 minutes of operation. Different belt fabric did not resolve the problem.

The inclined screens and belt filter press were removed from the treatment train. Discharge from the hydraulic dredge was delivered to the hopper of a sand screw (Figure 1) with flocculent added upstream of the sump. Settled sands and flocculated fines were recovered from the sump via the sand screw and transported by conveyor (Figure 2) to the island base where they were placed and graded with conventional earthmoving equipment. Additional flocculated fines were recovered by pumping from the sump of the sand screw; solids content of these fines were reportedly 30-35 percent by weight. The overflow of the hopper was discharged to a small holding basin at the foot of the conveyor to permit remaining suspended solids to settle before the water was returned to the river. Effluent suspended solids were in the range of 30-40 mg/l after a short period of settling. Additional fine materials were dredged from the river using specially equipped, barge-mounted trackhoes to excavate the highly cohesive material (Figure 3).

Figure 1. Sand screw preceding conveyor

Wilds Polander Demonstration (Continued)

Figure 2. Sand placement and fines settling basin

Figure 3. Trackhoe dredging bucket

CURRENT USE This project demonstrates the need to take into account the possible range of material characteristics in process design and costing. It appears that the fine sand content of the river sediments was higher than expected, and the clay present was possibly too cohesive for the equipment originally specified. Perhaps this could have been determined with additional testing on the preliminary samples, such as clay content and plasticity. It would appear that the full grain size distribution of the in situ materials was not completely captured in the characterization that was done, resulting in a need to significantly modify the process in the field. The screw conveyor used to transport the flocculated material from the inclined screens to the belt filter

Wilds Polander Demonstration (Continued)

press was also identified as a problem. Apparently, although operated at a very low speed, the screw conveyor sheared the flocs formed on the inclined screens, contributing to the clogging of the belts on the belt press.[1] Although this particular equipment did not perform well in this application, the system has reportedly been used very successfully with very fine, low-specific-gravity bio-solids. Additionally, the system reportedly performs best with the use of a mix-tank on the front end of the treatment train to minimize variability of the pump density entering the system.

Maximum capacity as designed: approximately 300 yd^3/hr (in situ) with belt press. Capacity after modification: 50 yd^3 (in situ) /hr with sand screw. The limiting factor was the sump capacity in the sand screw and detention time requirements for sand settling and fines thickening.

POTENTIAL APPLICATION The demonstrated process is applicable to dredging projects with similar volume and operating depth requirements. Plant capacity as modified was adequate for an 8-in. hydraulic dredge. Scale up would be required to accommodate projects utilizing larger dredges. This could potentially be addressed by adding units in parallel.

COST Projected costs for the project were in the range of $20/yd3 (in situ), including mobilization, dredging, and dewatering processes. Costs for the pictured application with modifications were approximately $15/yd3 (in situ).[2] Costs may be converted to dry tons, but the contractor is typically paid on in situ production and the conversion is subject to site-specific variations (material bulk density). Materials processed here were uncontaminated. Cost to dredge and process contaminated material are typically higher, reflecting higher wage rates and additional requirements for personal protective equipment, containment, and cleanup.

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[1] Personal communication. April 08, 2004. Bob Braddock, owner, Operations Service Corp.

[2] Personal communication, June 25, 2004. Glenn Green, Director of Mobility and Business Development, and Vic Buhr, Division Manager of Hydraulic Dredging and Dewatering, J.F. Brennon Co.

Dredging Operations and Environmental Research Program

Focus Area – Innovative Technology

Clinton, Iowa, Demonstration[1]

BACKGROUND

This project demonstrated the Integrated Dredging and Dewatering system (ID&D®). The project involved dredging of 101,000 yd^3 of predominantly fine silty sediment from a boat harbor in Clinton, Iowa. The dredge utilized was an 8-in. swinging ladder dredge equipped with instrumentation for monitoring of slurry solids content and flow to the plant, and with slurry dilution capabilities. Similarly, the plant was instrumented to monitor slurry density at various points in the process, in order to optimize operation and chemical additions.

TECHNOLOGY

Influent from the dredge is delivered to the hopper of a sand screw. Sand feeds off the end of the screw and stacks in piles for relocation with a front-end loader. Fines pass out the overflow of the hopper over a trash screen, a rotating belt which removes light, floating trash such as grass and plastic. The fine particulates passing the screen flow to a surge/mixing tank and from there to a thickener (circular clarifier). Solids concentration in the thickener influent is approximately 10-15 percent by weight. Polymer is added to encourage flocculation. Settled solids are picked up by the rake and discharged at approximately 30 percent solids by weight. Clarified water passes over the weir and flows into the freshwater tank where it is either discharged or recirculated within the system. Slurry density leaving the thickener is monitored in-line. Dilution water or additional polymer may be fed to the slurry at this point to improve the characteristics of the material feeding to the belt filter presses. Two six-roller belt filter presses were used. Cake discharging from the belt filter presses (Figure 1) was relocated and stacked using a front-end loader (Figure 2). Percent solids in the cake were reported to be in the range of 60-65 percent, reflective of the mineral character of the sediments.

CURRENT USE

The configuration of this plant reflects modifications based on lessons learned in the Wilds Polander demonstration. Other unit operations could be added to meet more stringent processing objectives. For example, additional fines removal from the sand could be accomplished with hydrocyclones.

As configured, the dredge was producing approximately 1100 gpm at 10-12 percent solids by weight from in situ sediments of 20 percent solids, predominantly fine silt. Cake production averaged 30-40 tons per hour dry

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[1] Clinton, Iowa, was a non-federal dredging project. Site visit and technology evaluation was conducted under the auspices of the DOER Innovative Technology Program.

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Clinton, Iowa Demonstration (Continued)

Figure 1. Dewatered cake from belt filter presses

Figure 2. Stockpiled dewatered sand and fines

weight. Weight production for organic sediment would be less due to the differences in solids density. Three polymers were used, two for coagulation and settling and one to further condition for dewatering.

As for any belt filter press operation, unflocculated or poorly flocculated solids may pass through the screens and the belt filter press fabric with the filtrate. Belt filter presses in general tend to present some housekeeping problems, as cake may periodically migrate off the belts and spill out the sides. This is normally captured with the filtrate (Figure 3). Depending upon site-specific criteria and unit operations employed within the plant, additional treatment may be required to remove suspended solids from this process stream. In this case, filtrate is sent to the thickener where solids are recovered and recycled to the belt filter presses. Overflow is either discharged or recycled through the plant.

Clinton, Iowa, Demonstration (Continued)

Figure 3. Filtrate capture at belt filter presses

POTENTIAL APPLICATION The plant as configured is suitable for small dredging jobs for which an 8-in. dredge is sufficient to reach project depths and accommodate the dredging schedule. Most commercial dredging operations utilize much larger dredges, however, so scale up would be required to directly couple this process to a large-scale navigational dredging operation. Process upsets, which are to be expected periodically due to equipment failure or varying influent characteristics, could present problems if dredging and dewatering are interdependent. This should be less a problem with an integrated system as was demonstrated here, than for separately operated and contracted dredging and processing operations, but may still present significant challenges. As for any belt filter press dewatering circuit, percent solids in the cake is a function of conditioner and sediment characteristics. Solids contents of 45-65 percent for freshwater and marine sediments are reportedly achievable, with 45-50 percent solids representative for most sediment. The 65 percent solids content reported for this application is therefore higher than has been demonstrated in other applications. This may be attributable to the predominantly mineral character of the sediments, but data were not available for verification.

The process would also be a suitable end stage treatment to complement dredged material recovery processes employing physical separation. The process would facilitate re-use of makeup water and reduce the volume of fine residuals.

COST A minimal cost, assuming all factors are optimum, would be in the range of \$15/in-situ yd^3 ton. Costs for the pictured application were approximately \$18/ in-situ yd^3.

Dredging Operations and Environmental Research Program

Focus Area – Innovative Technology

METHA Plant, Hamburg, Germany[1]

BACKGROUND The METHA Plant is a permanent installation constructed in 1993 to address disposal of contaminated sediments dredged from Hamburg Harbor. The plant handles approximately 1M tons of dredged material every year.

TECHNOLOGY Sand and fines in the incoming dredge slurry are separated in two steps (63 µm and 20 µm) at the front end of the plant. Fine materials are processed through the dewatering circuits (Figures 1-4), then the two materials are combined in a disposal area, layering 1.5 m of dewatered silt over 0.3 m of sand, to facilitate further dewatering. Material is stacked up to 38 m above the surrounding area.

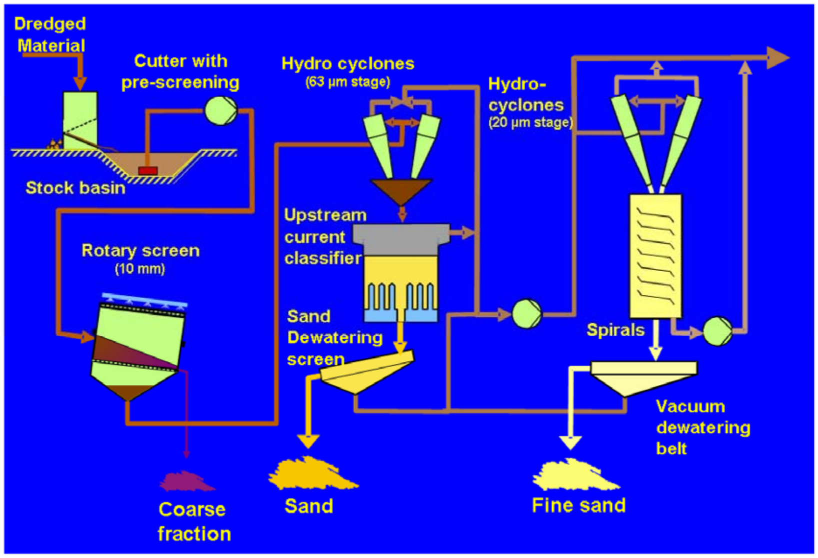

Figure 1. Process schematic – separation (Detzner 2004)

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[1] The METHA Plant is a municipal facility located in Hamburg, Germany. The technology summary was assembled under the auspices of the DOER Innovative Technology Program, with the assistance of Mr. Heinz-Dieter Detzner, Department of Port and River Engineering, State Ministry for Economic and Labour Affairs, Hamburg, Germany.

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METHA Plant, Hamburg, Germany (Continued)

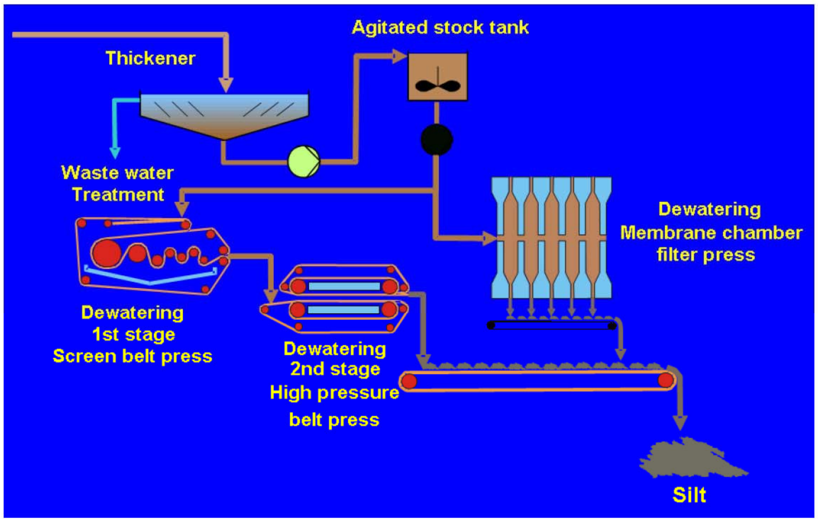

Figure 2. Process schematic - Dewatering (Detzner 2004)

Figure 3. Cyclone banks

Figure 4. Parallel press installation and cake discharge

METHA Plant, Hamburg, Germany (Continued)

The principal dewatering equipment in the METHA plant consists of conventional belt filter presses followed by high-pressure belt (HIP) presses. There are six 3.5-m-wide screen belt presses in series with six 2.2-m-wide HIP presses. More recently, two large membrane filter presses (recessed chamber or plate and frame presses (2 x 2 m) with an inflatable bladder) have been added to the plant to increase capacity, reduce water content of the cake, and improve process economics. Demonstrated operating parameters were obtained from Mr. Heinz-Dieter Detzner[1,2] (Table 1). Wastewater treatment is handled in a two-stage treatment plant (for removal of suspended solids and ammonia) with a capacity of approximately 2600 gpm.

Table 1
Operating Parameters

Equipment	Throughput (tons/hr)	Energy Usage (kWh)	Flocculant Demand (kg/ton)	Water Content (%)	Noise
Filter press/high pressure press	8.0	77.0	1.2	50-54/45	Moderate
Membrane	13.0	35.0	0.9	<45	Low

CURRENT APPLICATION The current application is for management of sediments dredged for maintenance of navigation.

POTENTIAL APPLICATION The METHA plant represents a large-scale operation from which representative costs and operating parameters can be extrapolated. There are no comparable facilities in the United States, where mechanical dewatering has been used primarily for remediation dredging, and the need for the equipment was finite. Consistent demand is a critical factor to the economics of a permanent facility; sufficient production in accessible locations would be required to justify this type of facility. The capital investment for METHA was reportedly 70 million Euro (over $86 million U.S.). The plant has a staff of 96 employees. Annual operating expenses are reported in the range of 6.5 million Euro ($8 million U.S.).[3]

COST Unit cost for processing, including capital and operating costs, is approximately 15-20 Euro ($19.-$25. U.S.)/m^3 in situ.[3]

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[1] Personal communication. January 2004. Heinz-Dieter Detzner, Department of Port and River Engineering, State Ministry for Economic and Labour Affairs, Hamburg, Germany.

[2] Detzner, D., Kitschen, L., and Weimerskirch, W. (1993). "METHA – The first large-scale plant for treatment of harbour sediments," Aufbereitungs-Technik 34: 235-242.

[3] Netzband, Hakstege, and Hamer. (2002). "Dutch-German exchange on dredged material - Part 2 - Treatment and Confined Disposal of Dredged Material September 2002," Coordinated by: A. Netzband / Strom- und Hafenbau, Hamburg, A.L. Hakstege / AKWA/WAU, Utrecht, K. Hamer / Universität Bremen.

METHA Plant, Hamburg, Germany (Continued)

CONTACT INFORMATION

Heinz-Dieter Detzner
Freie und Hansestadt Hamburg (Free and Hanseatic City of Hamburg)
Behörde für Wirtschaft und Arbeit (State Ministry for Economic and Labour Affairs)
Strom- und Hafenbau (Department of Port and River Engineering) - 2224-2 -
Dalmannstrasse 1
D 20457 Hamburg
Tel.: +49 (0)40 428 47 2387
Fax: +49 (0)40 428 47 2794
e-mail: Heinz-Dieter.Detzner@ht.hamburg.de

Dredging Operations and Environmental Research Program

Focus Area – Innovative Technology

Albany, Oregon, Dewatering Project[1]

BACKGROUND This project involved dredging of a primary settling pond at a paper plant for the purpose of recovering the capacity of the lagoon. The settled material differs from dredged material, having a lower specific gravity, with no coarse fraction. Performance of this system for dewatering of freshwater sediments dredged from the Mississippi River was tested at another dredging site (see Wilds Polander Demonstration fact sheet). The system was also tested on sediments from the Port of New Jersey (see New Jersey Sediment Dewatering Demonstration fact sheet).

TECHNOLOGY The Solomon Dewatering Process (U.S. Patent Number 5,656,174) consists of both proprietary and commercially available equipment, augmented by customized process controls. In situ sediments are dredged with a portable hydraulic dredge (Ellicott Mudcat or similar) and fed to a sump tank. Slurry is pumped from the tank to the dewatering module. Dredging is on demand, rather than continuous, due to transfer pump limitations and the relative size and capacity of the dredge. Oversize material is scalped from slurry feed, which is then flocculated and passed over multiple wedge-wire inclined screens in the initial dewatering step. An agglomerated, saturated material passes off the screens onto a conveyor (Figure 1), then through a belt filter press for the final dewatering step. A final solids content of 45-50 percent can be achieved (Figure 2), depending upon the nature of the feed stream. Flocculant feed is self-adjusting, regulated to the incoming pulp density (solids concentration).

Figure 1. Flocculated material passing off wedge wire screen

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[1] The Albany, Oregon, project was a private dredging project. Site visit and technology assessment were conducted under the auspices of the DOER Innovative Technology Program.

Albany, Oregon, Dewatering Project (Continued)

Figure 2. Wedge wire screens in parallel discharging to conveyor

CURRENT USE This technology was initially developed for processing freshwater sediments dredged from lakes and ponds to restore and maintain adequate water depth. The process is marketed as an alternative to excavating the sediments and trucking to a disposal area; this process produces a dry solid product and recycles expressed water to the water body. The process has also been demonstrated for dewatering of paper plant sludge dredged from primary settling basins (Figure 3). This sludge contains materials of varying specific gravity (SG), ranging from approximately 0.7 to 2.0, predominantly passing a #200 sieve. The relative proportion of these components varies in the influent stream, affecting the rheology of the processed material. Significant compositional changes can upset the process, but the system appears to recover quickly and with minimal operator intervention. In the pictured configuration, only two of three screens were utilized, operating at approximately 700 GPM (70-75 dry tons/8 hr day). In this case, the process was limited by the capacity of the slurry supply pump. A maximum of 1200 GPM is projected for this unit at full capacity.

Figure 3. Dewatered solids at 45-50 percent solids content

Unflocculated or poorly flocculated solids may pass through the screens and the belt filter press fabric with the filtrate. Depending upon site-specific criteria, additional treatment may be required to remove suspended solids from this process stream. Principal project objectives, feed stream characteristics, downstream treatment processes, and effluent requirements will be determining factors. For the pictured application, filtrate was returned to the sedimentation basin without additional treatment.

Albany, Oregon, Dewatering Project (Continued)

POTENTIAL APPLICATION Scale-up would be required to directly couple this process to a large-scale navigational dredging operation. Process upsets, which are to be expected periodically due to equipment failure or varying influent characteristics, could present problems if dredging and dewatering are interdependent. A possible configuration would consist of dredging to a holding basin, then resuspending to feed the dewatering plant independently, as was done for the pictured application.

Subject to favorable cost/benefit analysis, the process would also be a suitable end stage treatment to complement dredged material recovery processes employing physical separation. The process would facilitate re-use of makeup water and reduce the volume of fine residuals. This would enhance process efficiency overall and reduce process residual storage volume requirements.

COST The process is dependent upon chemical addition to flocculate the material. For the paper plant sludge pictured, chemical requirements are relatively low because small paper fibers are present in the pulp and act as nuclei for flocculation of other particles. Under unfavorable conditions, chemical costs can outweigh equipment costs.

A minimal cost, assuming all factors are optimum, would be in the range of $25/dry ton. Costs for the pictured application were approximately $80/dry ton, including dredging and polymer. Because the specific gravity of a significant fraction of the material is low, however, this represents a higher volume than for natural sediments

Dredging Operations and Environmental Research Program

Focus Area – Innovative Technology

New Jersey Sediment Dewatering Demonstration

BACKGROUND

The dewatering demonstration was a pre-treatment step integral to treatability studies reported in JCI/Upcycle Associates, LLC (2002)[1] and conducted on behalf of the New Jersey Department of Transportation and the United States Environmental Protection Agency – Region 2 (JCI/Upcycle 2002). The equipment utilized was essentially the Solomon Dewatering Process used at the paper plant in Albany, OR (see previous fact sheet), with the primary dewatering components consisting of inclined wedge wire screens and a belt filter press. Total volume of material treatment was approximately 2000 yd^3 in situ, less debris and oversize material. The sediments were mechanically dredged and then slurried to feed the dewatering circuit. The in situ sediments were predominantly fine silts and clays. Treatment process description and test results were obtained from JCI/Upcycle Associates, LLC (2002)[1] report. No site visit of this demonstration was conducted.

TECHNOLOGY

The pilot capacity was specified at 300 gpm slurry influent. A grizzly was used to remove debris greater than 3/8 in. in diameter.[2] Dilution water was added to the less than 3/8 inch material and the slurry was collected in a 20,000-gal tank and agitated to maintain the solids in suspension. The feed slurry was passed through a flo-line scalper to separate less than 35 mesh (.0196-in.) materials. The -1/2 in. +35 mesh material constituted the feed to the dewatering circuit. Polymer was added and the flocculated slurry fed to the inclined, wedgewire screens, the first stage of dewatering. From here the partially dewatered material was fed to a belt filter press. Material coming off the belt filter press was transported to the next treatment stage using a feed screw.

Target slurry solids concentrations in the feed were 10-15 percent by weight. Initial concentrations delivered to the dewatering circuit ranged between 20 and 25 percent solids. Pressate recycle was employed to dilute the incoming slurry to optimum pulp density. The press reportedly produced a thin cake, approximately 3/8-in. thick, which broke apart under its own weight coming off the belt. After passing through the feed screw, however, the material formed a sticky, paste-like mass. Dewatered cake was subsequently stockpiled and

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[1] JCI/Upcycle Associates, LLC. (2002) "Sediment decontamination and beneficial use pilot project," Final Summary Report, May 2002, Prepared for New Jersey Department of Transportation, Office of Maritime Resources, and United States Environmental Protection Agency, Region 2, through Brookhaven National Laboratory. www.bnl.gov/wrdadcon/publications/reports/report.htm.

[2] Personal Communication. March 29, 2004. Lee Schwartz.

New Jersey Sediment Dewatering Demonstration (Continued)

allowed to sit for 72 hr to evaluate water content. No free water was observed to drain from the stockpiles during this period. Results of physical testing of the cake are summarized in Table 1.

Table 1
Physical Rest Results on Dewatered Cake

Parameter	Sample 1	Sample 2
Moisture content	61.1%	63.7%
Solids content (by weight)	38.9%	36.3%
Grain size (%/by weight)		
+#4	0%	0.04%
-#4 +200 mesh	1.04%	1.12%
-200 mesh	98.96%	98.84%
TOC (dry weight basis)	83000 mg/kg	82600 mg/kg

The process was not tested sufficiently to optimize the dewatering circuit, according to JCI/Upcycle Associates, LLC (2002). In their conclusions, they state that optimization of the feed solids to the dewatering circuit is fundamental to obtaining the desired cake quality, and that this may present additional challenges at scale-up. It was noted that the primary and secondary dewatering units have slightly different optimum feed solids requirements, which could be problematic at scale-up. Based on the results of the pilot, an influent slurry feed of 8-10 percent solids is projected to produce a dewatered cake closest to project specifications. Flocculant usage was reported to be only 55-60 percent that estimated based on bench scale testing, and was relatively consistent throughout the test. The primary dewatering units (inclined screens) reportedly performed well. Capacity at scale up was projected to be 375 gpm per 30 ft^2 screen area, for a feed slurry of 10 percent solids. The secondary dewatering unit (belt filter press) was oversized for the test, and therefore did not experience any capacity problems. It was recommended that the unit be sized similarly at scale-up to prevent any subsequent processing delays resulting from insufficient capacity at this point in the treatment train. Capacity can be modified somewhat by varying the belt speed as well. Increased feed slurry surge capacity was recommended for scale-up.

POTENTIAL APPLICATION

Scale-up would be required to directly couple this process to a large-scale navigational dredging operation. This was evaluated and a treatment train proposed (JCI/Upcycle Associates, LLC 2002).

COST

Projected cost estimates provided in JCI/Upcycle Associates, LLC (2002) for the dewatering phase of the treatment were approximately \$19/cu yd^3, including the following items: material analysis/characterization, hydraulic offloading from barges, solids/liquid separation and dewatering, treatment/ disposal of effluent liquid, debris disposal, material handling/storage/loading, indirect costs and tankage for intermediate storage. Transportation to

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follow-on processes, on-site supervision, engineering, administrative and lab personnel, and other expenses would be added to this, but the amount attributable to the dewatering portion was difficult to separate from the other processes costed. A stand-alone dewatering circuit would therefore have a higher unit cost. Additionally, costs were based on an annual volume of 500,000 cu yd^3 in situ. One-time, smaller-volume projects would have less favorable economy of scale.