Paper K-25, in: G.S. Durell and E.A. Foote (Conference Chairs), *Remediation of Contaminated Sediments—2009.*
Fifth International Conference on Remediation of Contaminated Sediments (Jacksonville, Florida; February 2–5, 2009).
ISBN 978-0-9819730-0-5, publisher: Battelle Memorial Institute, Columbus, OH. **www.battelle.org/sedimentscon**

High-Speed Dewatering and Stabilization of Contaminated Sediments

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ABSTRACT: New, rapid dredged-sediment dewatering technology is leading to innovative disposal and re-use options for contaminated sediment. A high-speed dewatering process launched commercially in 2006 removes water from fine-grained sediment in real time, while separating and classifying coarse debris and sand. Many pollutants attach to fine-grained sediment particles, so the ability to dewater those at high speeds and on a small footprint has positive implications for many waterway restoration projects. Land prices and availability often make the use of traditional, confined disposal facilities too expensive or impractical. Short-term, on-site remediation facility costs have been historically expensive and time consuming. Rapid dewatering technology handles hydraulic dredge flows between 7,600 and 19,000 liters per minute (lpm) and results in 100-200 cubic meters per hour of dewatered solids, depending on the rate and percent solids of the dredge flow. The resulting sediment can be further dewatered to very low moisture content, resulting in stackable material for easier disposal. Alternatively, the primary floccules of dewatered sediment can be sheared and combined with cementatious/pozzolonic material for stabilization. Rapid dewatering removes the free-water phase of the flocculation process, resulting in a minimal amount of pozzolonic additions required to produce aggregate material.

INTRODUCTION

The primary goals for most dredge and dewatering operations are to minimize production downtime while maximizing operational process rates. It can be assumed that a hydraulic dredge can be sized for delivery rates of 7,600-16,000+ lpm. A wide and ever changing spectrum of these solids will be delivered from the dredge flow, ranging from 0% to 20% solids. The proposed system must be flexible enough to achieve an operational rhythm that is instantly responsive to the vagaries in flow and type of material being dredged (e.g., clam shells, beer cans, fibrous material, gravel sand, and clays, silts, and organics).

The numerous obstacles to these goals can, by themselves, be daunting. Multiplied, and without an absolute solution to the ultimate goal of high-speed removal of fine grain sediments as fine as 7-14 angstroms, results in dewatering operations that become extremely problematic and operationally compromised.

DREDGING AND COARSE-DEBRIS REMOVAL

Step one in meeting minimal downtime and maximum process goals is the removal of coarse debris and fibrous materials. One of the advantages of removing these types of debris is reduction in polymer demand. Typically, this removal equipment achieves only varying degrees of success with different types of coarse debris and becomes even less effective with fibrous material such as delaminated carpet or vegetation, which tends to clog and blind grizzlies and vibratory surfaces.

The recommended equipment for high speed dewatering of coarse debris utilizes a large 2.1x8.3 meter screen bed and a flexible synthetic screen surface. Consequently, the screen openings of the bed “breathe.” In other words, the apertures are regularly stretched open and then released to return to their original size. The benefit of this innovation is that the breathing screen dislodges irregularly shaped debris from the screen openings. The parabolic motion of the unit causes the liberated debris to tumble and bounce down the large screen surface, continually rolling and draining residual fluid from objects such as cans, shells, old shoes, plastic bags, etc. Furthermore, fibrous material from carpet or vegetation is tossed like spaghetti in a colander down the length of the screen for easy stockpiling. Consequently, the accumulated debris is relatively dry for final placement.

The self-clearing aspects of this system create very high screen efficiency, and the benefits to the dewatering operation become self-evident. The patented coarse screen operates at very low decibel levels, creating a quiet operating system of simple design, comprised of only one eccentric shaft, one motor, four bearings, and two adjustable flyweights.

High gravity forces of up to 50*g* are expressed upon the debris. Logically, the system generates high kinetic energy and impressive material liberation from the screen surface, which ultimately result in much lower downtime for the overall operation. While the bed is quite durable, abrasion from the debris will eventually take its toll. However, this unit has a sectional bed, so only the worn panels need to be replaced, rather than the entire bed. As part of the overall dewatering process, this reliable technology solves the various coarse debris dewatering problems. Maintaining un-obstructed valves, pumps, and instrumentation packages further enhances the operation.

Finally, the apertures in the bed can be sized to make a particle cut, so as to properly classify the solids in the flow for the next operation, which is de-sanding.

DE-SANDING OPERATION

The coarse screen makes a cut to 4.76 mm, which is necessary, so that no two objects can clog a single de-sanding cone. The de-sanding system then makes its cut to 0.149 mm (149 microns). Using hydro-cyclones and linear motion shakers, this tried-and-true method for removing medium grain particles represents the only traditional apparatus of this unorthodox technology train. The number, cut size, and flow capacity of the de-sanding system is adjusted for each project.

POLYMER DOSING SYSTEM

A state-of-the art polymer system has been designed to dose to flow rates up to 19,000 lpm. Liquid polymers and fresh water are used for easy polymer make-down. A benefit resides in being able to post-dilute and make up new polymer simultaneously. The system must automatically adjust to changing flow rates and densities, allowing very precise dosing to achieve the most durable floccule with minimal polymer residual. Recently developed, in-line, static polymer blending technologies and patented mixing and distribution chambers enable this system to induce flocculation without long contact time.

RAPID DEWATERING SYSTEM

In an effort to address the classic incompatibility of dredge flow rates relative to dewatering apparatus process rates, significant new advances have been achieved. A new technology has been developed and now patented that can dewater dredge flow in real time (Figure 1). This technology is a pragmatic option to belt press and thickeners, plate and frame presses, geo-tubes, or upland disposal sites.

FIGURE 1. Genesis Rapid Dewatering System.

The process begins when flocculated material is evenly distributed through a "V" shaped diffuser over a specially engineered grid surface. This distribution is facilitated by the introduction of compressed gas, which minimizes the hydrostatic pressure of the fluid column. The clear water phase of the flocculation process is then instantly drained away from the floccules. The grid screen is set at an angle of repose that allows the captured flocs to roll or slide down the length of the screen while constantly dewatering. The continually displacing flocs are then carefully transferred to a dispersion system which evenly stockpiles the floccule mass. Various apparatus is used to protect the integrity of the floc.

This mass, which is now a 1.0-1.5 meter high lift, is put under a mild vacuum resulting in a release of capillary water through the entire lift. These dewatering cells may be either shore or barge mounted and produce dry, stackable solids (60% to 70% solids). Two cells sit on either side of the Rapid Dewatering System and are sized to accommodate the daily production forecast for the project. Because the cells are alternately fed, the overall process is *not* a batch treatment and can continually be off-loaded by a long reach excavator.

The recovered water phases resulting from free water from the floc recovery and capillary water from the dewatering cell regularly report at very low turbidity levels of <20 mg/l total suspended solids (TSS). Added benefits include sharp reductions in most nutrients. The return water may also be oxygenated with microscopic bubbles to renew dead water zones in either fresh or salt-water applications.

Because there are few moving parts in the Rapid Dewatering System, there is very little downtime. The overall dewatering operation continually adapts to changing flow and density, operates on a small footprint, captures contaminates, and classifies materials by size and weight for easy disposal. The system has virtually unlimited scalability, since extra pods/screens can be added to increase production.

STABILIZATION VIA RAPID DEWATERING

The use of pozzolonic material as a stabilizing agent has been successfully tested. The aforementioned technology can dewater material to result in one of two conditions: (1) Material that is somewhat hydrophilic (less free water), or (2) dryer material that has undergone an additional secondary dewatering (less capillary water). Condition (1) has the advantage of simplicity of operation, whereby the technology simply removes the free water phase, thereby reducing the amount of pozzolonic material necessary for stabilization. In addition, the somewhat higher moisture content facilitates the blending of the substrate and the stabilization materials.

TESTING AND FIELD SIMULATION

Laboratory testing of sediment samples provides a field simulation of rapid dewatering and stabilization.

Flocculation Test. A sediment sample taken from a waterway first undergoes a laboratory test for flocculation and to determine the types and quantities of polymer needed. This test simulates the Rapid Dewatering System and produces dewatered material. A lab report describes the ability of the substrate to flocculate and recommends polymer options and dosage.

Solidification and Stabilization Treatability Study. The dewatered material then undergoes a separate laboratory test to evaluate the effectiveness of treating the material with various ratios of cementatious/pozzolonic material to improve the physical properties and handling characteristics of the waste. A lab report presents the test methods and protocols, the results for all analyses associated with solidification/stabilization treatment, and depending on the intended use of the material, can specifically test for an application of the aggregate.

Sample Lab Results: Ottawa River. In a study conducted by Weston Solutions for the U.S. Environmental Protection Agency, a sample was taken from the Ottawa River in Toledo, Ohio. The Ottawa River is a contaminated site, containing PCBs, polyaromatic hydrocarbons (PAHs), and lead. The sample was put through the both flocculation and stabilization studies with positive results.

At the outset of the flocculation and dewatering test, samples of “in situ” material extracted from the site were estimated to be as high as 56% solids. This corresponds to about 0.7 tons of dry solids per in-situ cubic yard (per 0.75 cubic meter). The +45 mesh fraction of these solids (+355 microns) was largely wood debris with shell chips interspersed. The -45 mesh fraction of these solids was predominantly sand, silt and/or clay with some lesser amount of organic material. A polymer program was identified that flocculated the simulated rapid dewatering screen feed prepared from the -45 mesh fraction of in-situ material.

The clarified water obtained from the rapid dewatering process was expected to represent between 74% and 89% of expected dredge flow volume and have turbidity of less than 30 NTU. Rapid dewatering technology would successfully concentrate and recover flocculated solids from projected dredge flow and convert them to a conveyable mass that could be dewatered further, if desired, using any of several means (Figure 2).

FIGURE 2. Dewatered sediment from Ottawa River and filtrate collected under the screen (at 15 NTU with "trace" suspended solids).

It is worthy to note that the "cake" solids (38%) recovered from the rapid dewatering screen test were appreciably denser than those recovered from the comparable bench scale dewatering test (23% to 29%). These results indicated the ease with which the substrate would continue to release secondary water after being initially dewatered with an appropriate polymer program.

The dewatered material then underwent the test for solidification and stabilization treatability. The primary objective of the solidification/stabilization treatability study was to evaluate the effectiveness of treating the material with various ratios of class C fly ash and type I/II Portland cement to improve the physical properties and handling characteristics of the waste. The ultimate disposition of the treated waste materials had not been finalized at this time. Therefore, mixtures were prepared which would allow the material to be disposed of in a landfill or utilized for other beneficial reuse, such as road base material.

The scope of work for the solidification/stabilization treatability study included homogenization of the pre-treated sediment, bench-scale solidification/stabilization treatment, physical properties testing of the treated material, evaluation of the results of testing and development of the report.

The findings from the treatability study determined that by varying the ratios of fly ash and Type I/II Portland cement, the waste material could be transformed into a monolithic material as shown in Figure 3.

This treated material could be landfilled and meet physical properties requirements of most subtitle D landfills. Alternatively, by reducing the amount of Type I/II Portland cement, an aggregate type product can be created, as shown in Figure 4.

It is important to note that additional testing would need to be completed to demonstrate that the treated materials could meet whatever leachability and physical properties requirements prescribed by regulatory agencies for the treated materials. The study confirmed that solidification/stabilization treatment of the dewatered waste from the Ottawa River site could improve its physical property characteristics. More bench and pilot scale studies were recommended once project specific goals are established.

FIGURE 3. Ottawa River sediment waste treated with class C fly ash/type I/II Portland cement to form a monolithic material.

FIGURE 4. Ottawa River sediment waste treated to create an aggregate material.

Improvements in analytical methodology and testing techniques may lead to more stringent regulations. As a result, acceptable environmental criteria for road base material may be subject to change. These factors need further evaluated before the ultimate disposition of any processed dredged material is determined.

CONCLUSION

All of the primary costs of a dredging and dewatering operation are reduced by the enhanced operational benefits of high speed dewatering. Less time spent on location and smaller staging areas create a more acceptable political solution and neighborhood-friendly approach. When dealing with contaminated sediment, rapid dewatering technology can also potentially greatly reduce the cost of pozzolonic material and time required to create a stabilized aggregate.

High Speed Dewatering and Stabilization of Contaminated Sediments

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4 February 2009

6-Step Rapid Dewatering and Stabilization Process

1. Lab Tests
2. Dredging
3. Coarse Debris Removal
4. De-sanding
5. Rapid Dewatering
6. Stabilization

Lab Results

- **Solids being dewatered on screen**
  - **Genesis "cake" solids: 38.5%**

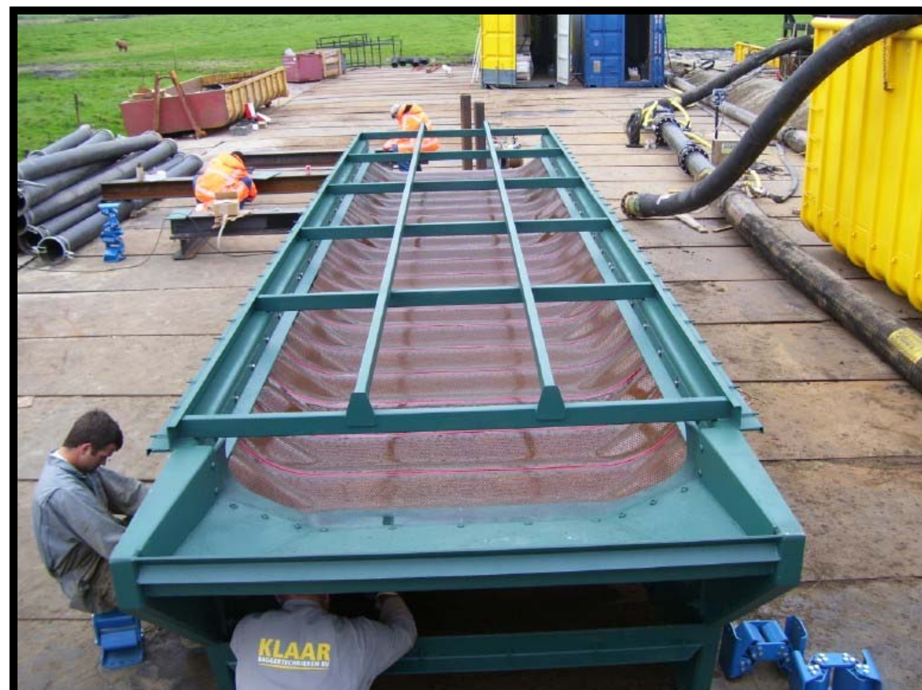
Filtrate Collected Under Screen

15 NTU with “trace” suspended solids

Hydraulic Dredge

Dredge Slurry

Coarse Debris Removal



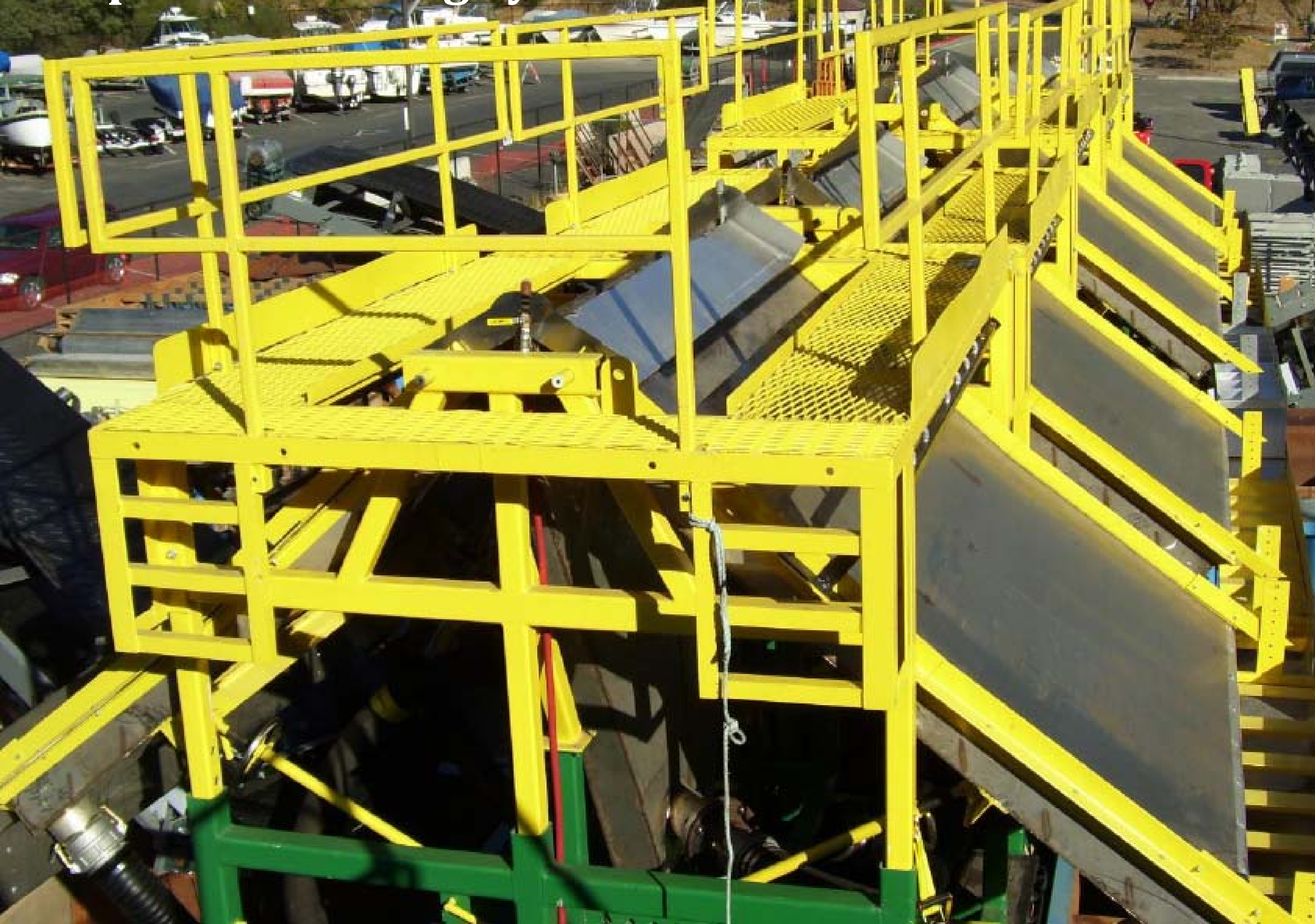
Debris

De-sanding Unit

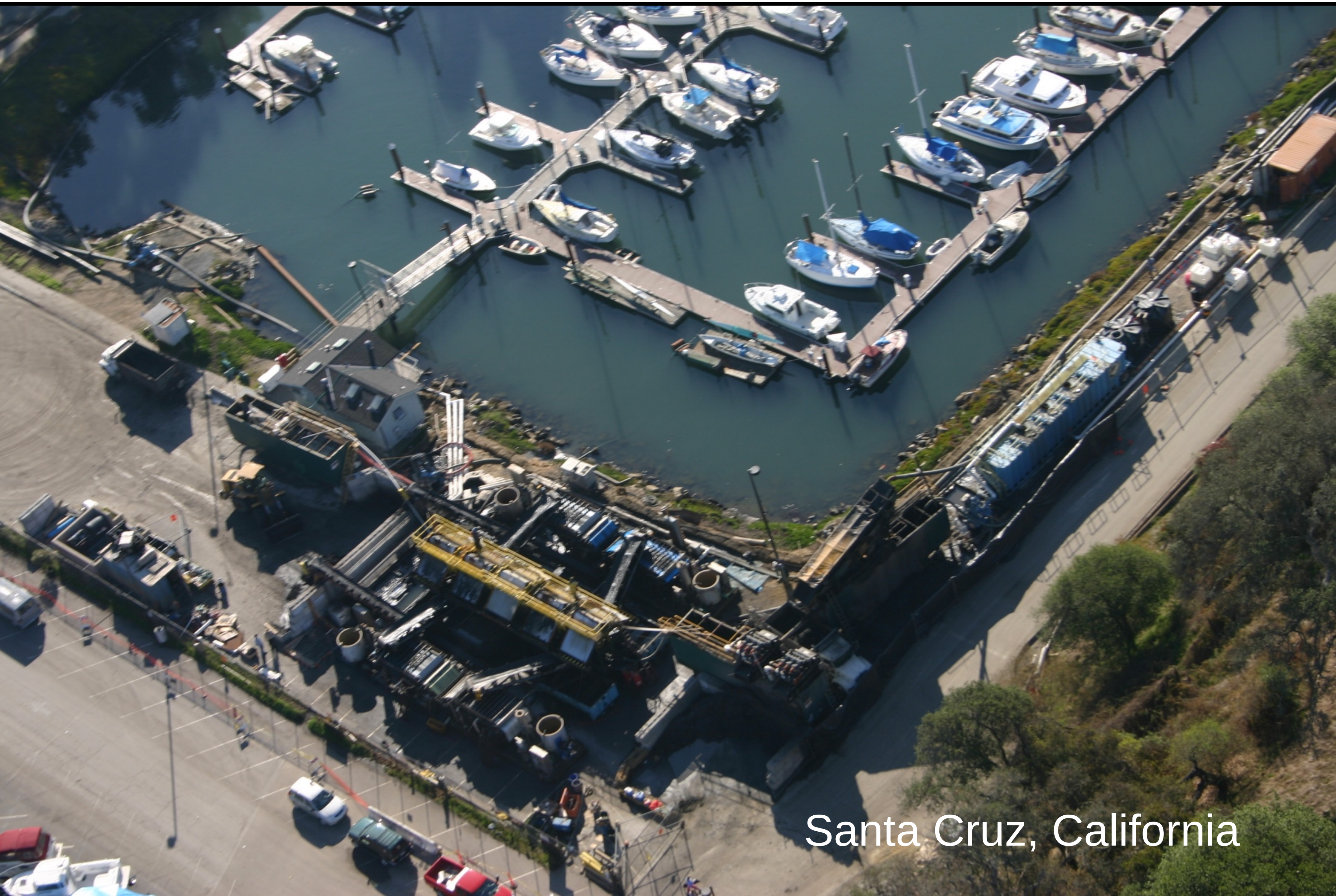
De-sanding Units and Rapid Dewatering System

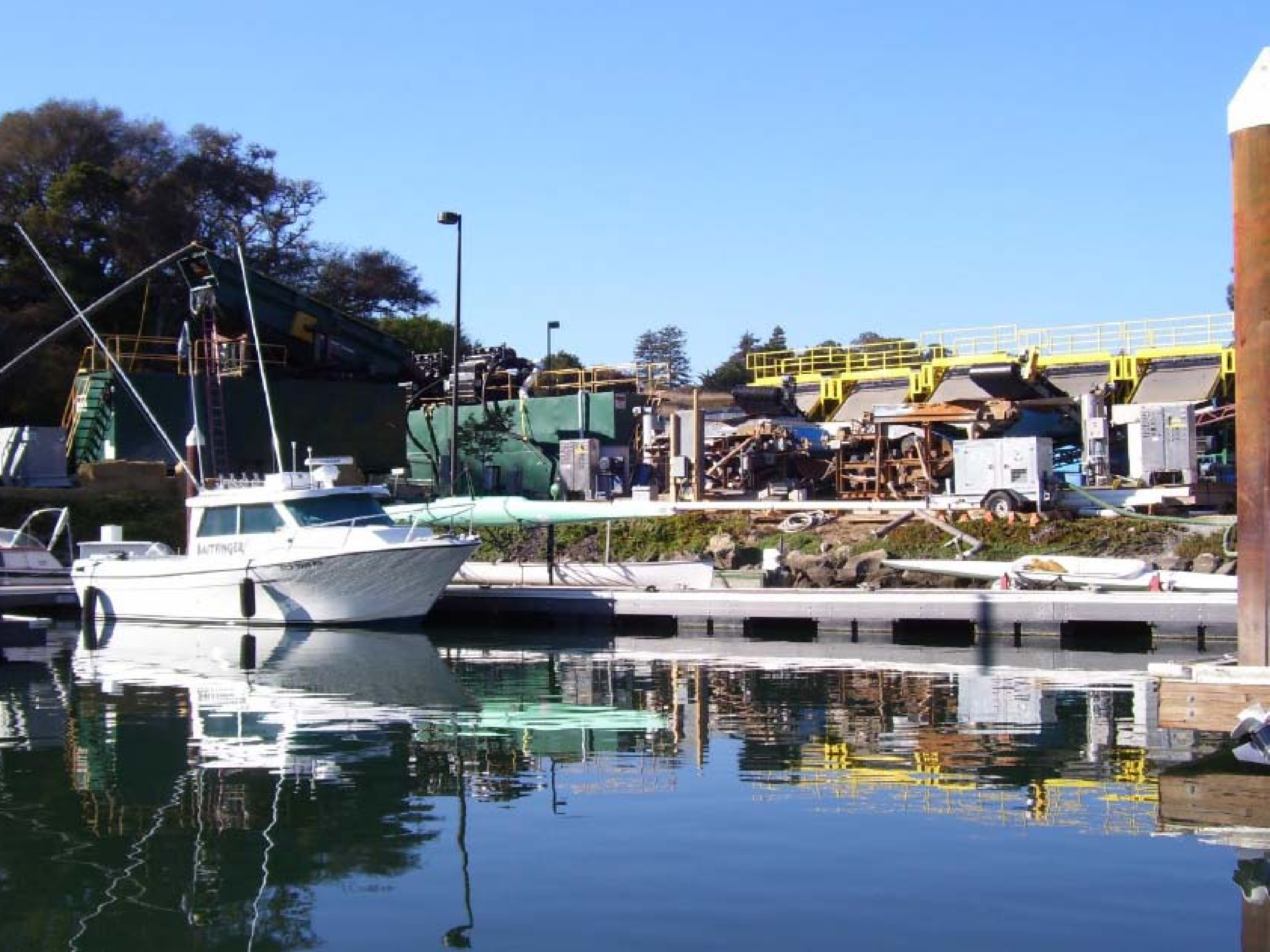
Rapid Dewatering System & Polymer System

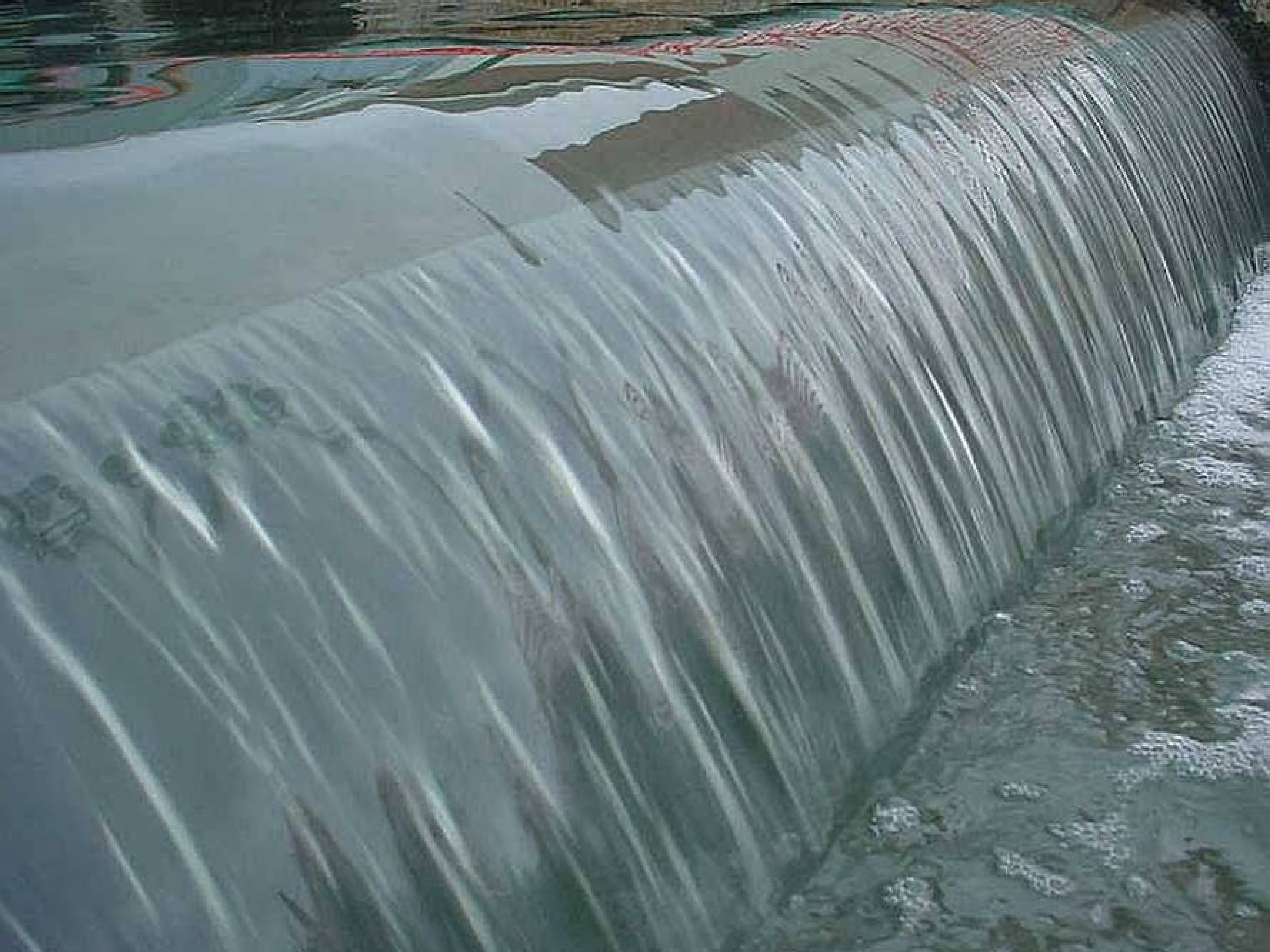
Rapid Dewatering System



Rapid Dewatering System - Footprint








CRAFTSMAN
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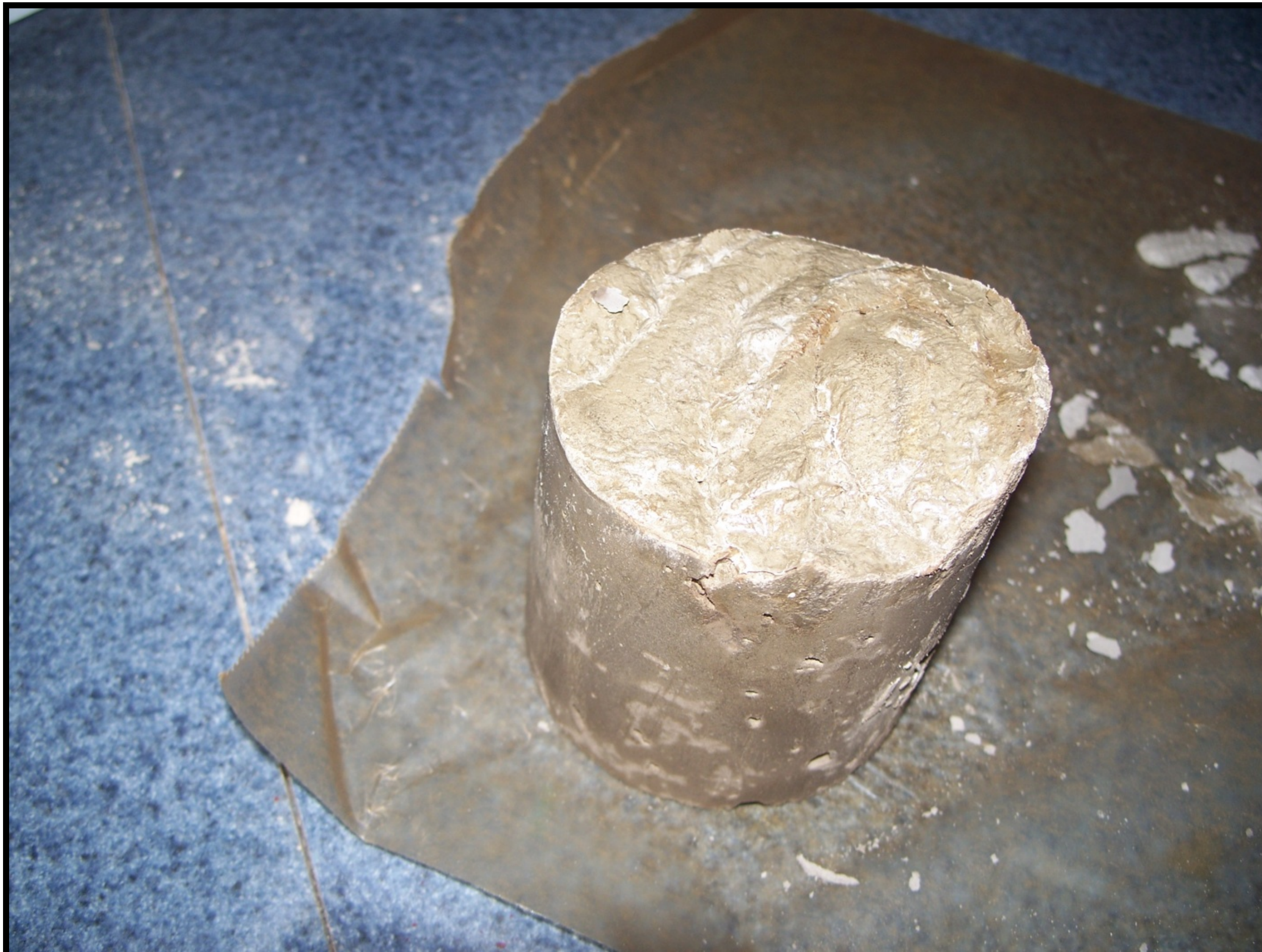
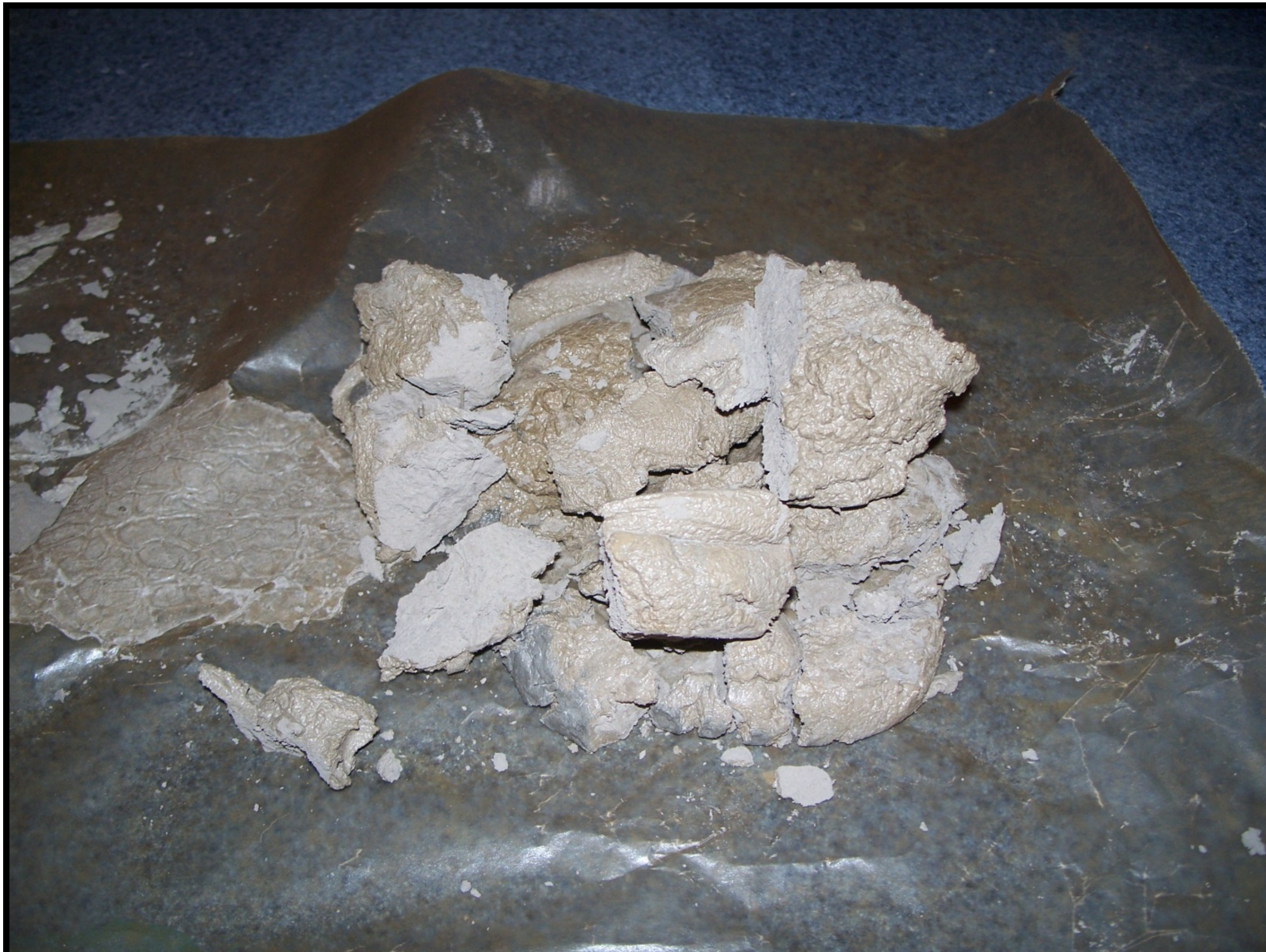
Stackable Solids

Untreated Waste Prior to Treatment

Waste Treated with Class C Fly Ash/Type I/II Portland Cement to Form a Monolithic Material



Waste Treated to Create an Aggregate Material



Summary

- Thousands of liters of sludge dewatered per minute
- Hundreds of cubic meters of sediment recovered hourly
- Cost and time on location greatly reduced
- Minimal pozzolonic material required
- Clear water discharged back to the waterway
- Very small operational footprint

Follow-up Questions

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