SEVEN YEARS OF SEDIMENT PROCESSING COMPARED TO BASIS OF DESIGN ON THE OPERABLE UNITS 2-5 LOWER FOX RIVER SEDIMENT REMEDIATION PROJECT

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ABSTRACT

The Lower Fox River sediment remediation project in Wisconsin includes dredging, capping and covering of PCB–impacted sediment at specified locations over a 21.4 kilometer (13.3 mile) stretch of the river comprising Operable Units (OUs) 2-5. One key objective of the sediment processing facility is to minimize waste disposed at the landfill by beneficial reuse of the separated sand and by dewatering the fine (contaminated) fraction of the dredged sediments. This paper will provide a comparison of major performance parameters from the past seven operating seasons (2009-2015) to the original basis of design.

The project team is comprised of Tetra Tech EC, Inc. (Tetra Tech) as general contractor responsible for the engineering design, construction, and operation of the wastewater treatment plant; J.F. Brennan Company, Inc. (Brennan) as dredging & capping subcontractor; and Stuyvesant Projects Realization Inc. (SPRI) as desanding & dewatering subcontractor.

Development of the design parameters traces back to before the initial proposal in 2007 and continued after project award during the fast-tracked design performed simultaneously with construction of the sediment processing facility from 2008-2009. The sediment characterization and desanding/dewatering treatability studies were used to establish the mass balance that helped define the project team's approach to the remediation, including equipment sizing and production capacity.

A significant basis of design issue was the feasibility of beneficial reuse offsite of recovered sand from the sediment processing operations. As predicted, our team has been able to successfully separate sand meeting the regulatory criteria for reuse in local infrastructure projects. This achievement is the first such application on a full scale sediment remediation project in the US.

The project approach also had to address technical challenges from the single stream process where dredged sediments from Brennan's multiple hydraulic dredges are directly piped to the land-based processing facility. Another key design issue was the use of membrane filter presses to achieve consistently higher dry solids in the filter cake over a variety of sediment feed characteristics as predicted by the pilot treatability testing. This paper will also provide lessons learned with respect to particle size distribution test methods and process optimizations during operations.

Keywords: Membrane Filter Press (MFP) dewatering, sand separation, beneficial reuse, Particle Size Distribution (PSD) test methods.

INTRODUCTION

The Lower Fox River remediation project is designed as a combination remedy to reduce risk to human health and the environment caused by the presence of PCBs in the river sediment. The scope of work includes the remediation

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of PCB-impacted sediments from a 21.4-kilometer (13.3-mile) stretch of the Lower Fox River between Little Rapids Dam and the mouth of the river at Green Bay. It is a multi-year effort that includes dredging, capping with coarse sand, gravel and quarry stone, sand separation, sediment dewatering, water treatment, transportation and disposal. This project remains one of the largest environmental remediations of its kind in the world.

The client is the Lower Fox River Remediation LLC. The regulatory agencies include representatives from the United States Environmental Protection Agency (USEPA) and the Wisconsin Department of Natural Resources (WDNR), along with their consultants, collectively known as the Agencies/Oversight Team (A/OT).

Tetra Tech EC, Inc. (Tetra Tech) is the general contractor responsible for the design, construction, and operation of the wastewater treatment plant. Tetra Tech subcontracted J.F. Brennan Company, Inc. (Brennan) for the dredging, capping and sand covering required as part of the remediation; and also subcontracted Stuyvesant Projects Realization Inc. (SPRI) for the sediment desanding and dewatering plant (SPRI is one of the US operating companies of Boskalis Environmental). Engineering and equipment support for SPRI is provided by its Dutch sister company, Boskalis Dolman bv; together these companies have more than 30 years of directly relevant experience in the management of 13.6 million metric tons (15 million short tons) of contaminated sediments/soils in the US, Canada, The Netherlands and other European countries.

The “Integrated Approach” used to perform this sediment remediation project emphasizes the seamless integration of all aspects of the work by each of the performing partners. This includes the client, the A/OT, local stakeholders, and all of the contractors performing the various aspects of the work (e.g., dredging, desanding, dewatering, water treatment, beneficial reuse, and T&D). Local stakeholders include municipalities nearby the project operations and haul route and numerous private and commercial property owners along the river (Feeney et al. 2011).

Communication and cooperation amongst the general contractor, the marine contractor and the sediment processing contractor have proven critical in achieving the level of success on this sediment mega-project. The basis for this success, amongst other things, is the mutual understanding of the need for this collaborative approach, memorialized in a signed Memorandum of Understanding (MOU) among Tetra Tech, SPRI and Brennan. The MOU clearly defines each contractor’s scope and “ownership” of their respective operations, and the agreed upon method to resolving issues in the various interactions among each contractor that focuses on meeting the overall project objectives. Regularly scheduled and frequent MOU meetings, at both the technical/operational and executive levels, facilitate these interactions. This approach has fostered a seamless project execution strategy that achieves end-results faster. Having an MOU among the major contractors ensures a process for smooth collaboration and conflict prevention and resolution. When properly implemented and maintained, this MOU process fosters internal team problem solving and risk sharing instead of adverse impacts resulting from internal disagreement.

DESIGN OF SEDIMENT DESANDING AND DEWATERING PLANT (SDDP)

The design of the Sediment Desanding and Dewatering Plant (SDDP) for the Lower Fox River sediment remediation project included four major unit operations:

1. feed system
2. sand separation
3. chemical addition
4. dewatering

Feed System

The project approach presented certain technical challenges since it was comprised of a single stream process where dredged sediments from Brennan’s multiple (typically three) hydraulic dredges are directly piped to the land-based processing facility. An approximate flow of 20,800 to 22,700 liters per minute (5,500 – 6,000 gallons per minute) enters the processing plant by two separate lines, 24 hours a day, 5 days per week. One line is directly connected to the 25.4-centimeter (10-inch) dredge and the other line is connected to the two/three 20.3-centimeter (8-inch) dredges; the feed lines from the 20.3 centimeters (8 inches) are merged before entering the plant. Typical dry solids content pumped to the processing facility is about 5%-10% by weight; this number changes depending on the dredge cut (layer thickness) and the sediment characteristics.

Since dredges pumping 22,700 liters per minute (6,000 gallons per minute) cannot be instantly stopped in the event of a plant power outage, our design incorporated an overflow basin which can store approximately 20 minutes of dredge flow. In the event of a problem at the plant, the incoming dredge flow is immediately diverted to this basin.

Our design also addressed the continuously changing density in the incoming dredge flow. Although both dredge lines enter the plant in the same feedbox (on top of the shaker screen) which begins to equalize the density, a special tank was designed to significantly modulate/flatten the fluctuations. This so called thickener tank is equipped with two high capacity hydrocyclones, and it pumps the sediment slurry around in the tank in a closed loop. The overflow of the cyclones (lighter particles/fines) is directly fed to the preconditioning step for dewatering. Due to this recirculation and removal of a significant amount of water with fines/organics, the slurry in the tank concentrates and the density modulates. The underflow of this thickener tank is the feed for the sand separation unit. The thickener tank is presented in Figure 1.

Figure 1. Thickener tank

Sand Separation

The start of the desanding process is the scalping screen that separates the fine debris entrained with the dredge slurry from the incoming flow. Both incoming dredge flows enter into a feedbox before running over the 6-mm (1/4”) shaker screen. Our design basis assumed at least 40% sand content in the feed sediment. In this feedbox the flows are blended and therewith spikes in dredge flow concentrations are minimized. The scalping/shaker screen has a flat screening surface enhanced by a shaking motion that prevents clogging while maximizing throughput. The screened slurry is then collected in a slurry tank, situated under the shaker screen, and then pumped via the thickener tank (which modulates the fluctuations in density and sand content), to the hydrocyclones of the desanding unit. The fine screenings (scalping material) drop onto a conveyor belt and are conveyed into a roll-off box outside the process building. In the roll-off, the scalping material (majority is organic material) can drain so that the amount of water transported to the final reuse or disposal destination is minimized (cost aspect).

The sand separation at the Lower Fox River Project separates sand at two cut-points, 150µm (0.00591 inch) and 63 µm (0.00248 inch) (Sieve mesh No.100 and No. 230). This approach was implemented based on our extensive experience, the aim for beneficially reusing the sand, and the history of the contaminants. PCBs typically adhere to organic particles, which are highly present in the sediments (ranging12-20% by weight). Introducing an extra cut point in the sand separation (150µm [0.00591 inch]) was designed to further enhance our separation capacity and efficiency using upflow technology thereby increasing the possibility to meet the reuse criteria. With an additional processing step for the 63µm (0.00248 inch) separation, this portion of the sand will likely also be suitable for reuse.

Our advanced sand separation unit in the Lower Fox River processing facility is shown in Figure 2.

Figure 2. Advanced sand separation unit

The sand separation unit uses hydrocyclones to separate the fraction greater than 150µm (0.00591 inch) into a separate stream that passes through an upflow device and then falls onto a dewatering shaker screen which dewaters it to a condition where it can be stockpiled. The sand solids content is approximately 80% coming from the screen. The dewatered sand drops onto the storage pad where it is sampled and chemically tested. The 63µm (0.00248 inch) sand separation also uses hydrocyclones for separation; however the underflow of the cyclones slides into the additional (advanced) processing step. In this step the 63µm (0.00248 inch) sand will create a higher quality sand product since organic particles will be removed. The 63µm (0.00248 inch) sand falls onto a dewatering shaker screen and is dewatered so that it can be stockpiled. The sand solids content is approximately 80% coming from the screen. The dewatered sand drops onto the storage pad where it is also sampled and chemically tested. After both sand flows are tested and approved they are blended together and stockpiled in an onsite storage area awaiting transportation to the reuse site.

Chemical Addition

After the desanding operation, the remainder of the slurry (fraction 0 – 63µm) is led into a so called residue tank. From this tank the flow is distributed over 4 large clarifiers (pre-thickeners). The necessary coagulant is added in the residue tank where the high velocity, the agitator, and the turbulence will mix the coagulant with the fine particles. The slurry will then be pumped to the pre-thickener while the flocculant is added in the pipeline. The bends in the pipeline, the inline mixers, and the length of the pipeline all help to provide the mixing energy for the slurry flowing into the pre-thickener. Due to the large surface area, the relatively light flocks will settle and the supernatant runs over a weir towards the wastewater treatment plant operated by Tetra Tech. Each pre-thickener is equipped with a flocculant dosing station as shown in Figure 3.

Figure 3. Flocculant dosing station

The settled slurry is pumped into one of the four holding tanks. Due to the flexibility built into the design, it is possible during a press shutdown that the slurry can be pumped to any of these four tanks. This feature has proved very useful during operations. In the holding tank the slurry is kept in suspension using agitators, and each holding tank serves two Membrane Filter Presses (MFPs). From the holding tank two feed pumps fill the MFPs, with some additional flocculant being dosed during this pumping through inline mixers. Each MFP is equipped with a flocculant dosing station.

Dewatering

From the sludge holding tanks the slurry is pumped to the MFPs for dewatering. The MFPs designed for the Lower Fox River project are sized to process approximately10.7 cubic meters (14 cubic yards) of solids per hour per press, with a compression factor of 1.3 and a cycle time of 75 minutes.

MFPs were selected for this project since they are:

1. More flexible in consistently dewatering a wide variation in feed sludge composition, thereby avoiding time-consuming shutdowns and recalibrations;
2. Able to provide additional dewatering by inflating the membrane system (“membraning”) to further “squeeze” the sediments at pressures up to 15 bar (220 psi). This additional squeezing provides significant performance advantages in terms of increased dry solids content (typically up to 5%, depending on the sediment characteristics) in the filter cake when compared to standard plate and frame presses; and,
3. Able to operate at a relatively consistent cycle time.

The number of presses needed was calculated based on the mass balance including an anticipated range of flow rates through the dewatering system, an assumed uptime for the presses, and the hourly production rate for each press. From this information it was determined that eight MFPs will be sufficient for the dredge production rates, assuming the incoming sediment is within the anticipated range of geotechnical properties (e.g., sediment density, percent solids). However, as contingency, space was allocated in the building layout for two additional presses, should actual feed characteristics vary beyond the expected range.

Our design basis assumed that the MFPs would produce an annual average of no less than 52.5% dry solids in the filter cake. One of the 8 MFPs are presented in Figure 4.

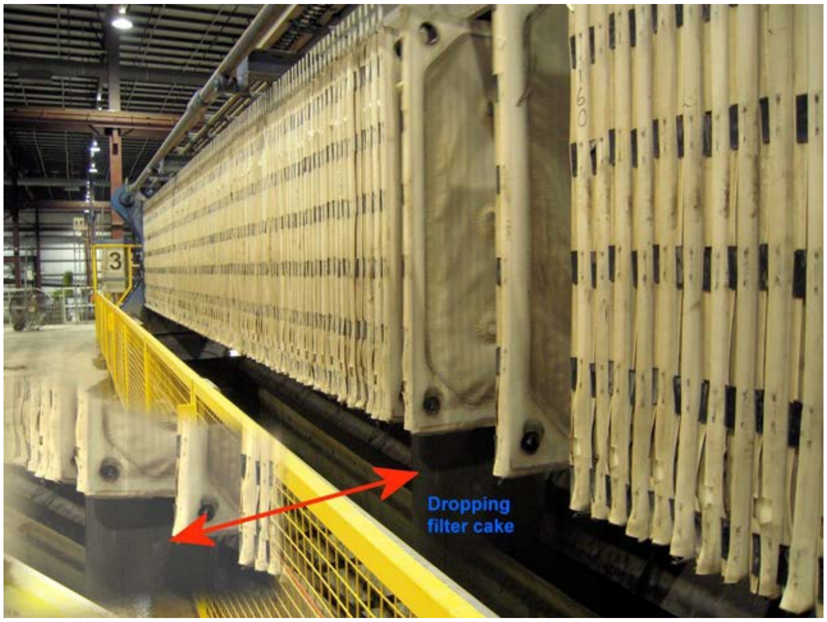


Figure 4. Membrane Filter Presses (MFPs)

LESSONS LEARNED

Lower Fox River Sediment Sampling and Testing

Our team believes in the added value of early contractor involvement on such remediation projects. The Lower Fox River project used a fast track design-build approach and during the pre-proposal phase in 2007, we performed sediment sampling and bench-scale testing to develop a first insight on the river conditions and what to expect when processing the sediments. The results were used to establish the mass balance that helped define the team's proposed approach to the remediation. From the mass balance we were able to select and size the appropriate sediment processing approach and equipment. Disposal costs and beneficial use options were considered during the selection process, while the estimated dredge production rate was critical when sizing the processing equipment.

After award of the project, initial conclusions were verified by performing an additional site investigation to address the various sediment types. Boskalis Environmental also performed both lab-scale and onsite pilot desanding and dewatering tests to establish the size, number and type of filter presses and most suitable filter cloths. The following equipment was used for these various tests conducted in collaboration with local laboratories, filter press manufacturers, and polymer vendors:

- Jar test equipment at a local lab facility;
- Lab-scale dewatering using bench top plate and frame filter press to simulate mechanical forces on the sediment; and,
- Plate and frame membrane filter press simulator for the onsite pilot-scale dewatering tests.

Our pilot-scale dewatering test equipment is shown in Figure 5.

Figure 5. Plate and frame membrane filter press simulator for onsite pilot testing

Several important findings resulted from the pilot testing. There were relatively large differences in sediment dewatering characteristics. The selected polymer was effective for all the samples tested (which represented a large stretch of the river), however dosages varied significantly. The fine material organic matter content was proven to be an especially important parameter defining sediment dewaterability and filter cake dry solids content. We determined that a coagulant was needed in addition to the polymer to achieve the best dewatering performance.

Particle Size Distribution (PSD) Test Methods: ASTM vs British Standard

We also determined that the ASTM 422D method for Particle Size Distribution (PSD) was not the appropriate test method. Using the ASTM method results in larger amounts of sand being reported due to the presence of organic material and clay balls. In contrast, the British Standard (BS) 1377-2 ("Methods of test for soil for civil engineering purposes" 1990; British Standard Institute) appeared to be more accurate, presenting lower (i.e., conservative) amounts of sand. Therefore, in collaboration with the general contractor and the client's representative, a Technical Memorandum - Standard Operating Procedures (SOPs) for Grain Size Analysis, which included a combination of both methods, was developed and approved for the Lower Fox River dewatered sediments (Tetra Tech EC, Stuyvesant Dredging Inc. and AECOM 2009).

During the proposal phase of the Lower Fox River OU2-5 project a significant amount of geotechnical data was reviewed. Sand content in the sediment was estimated to be an average of 35 to 40 percent, based on grain size analysis testing performed during the earlier remedial design efforts from 2004 through 2007, and during subsequent investigations performed in 2008 and 2009. However, during the 2009 dredge season, the percent of sand separated from the sediment plus the sand observed in the filter cake was significantly lower than expected.

Early grain size analyses performed using the ASTM D422 Method resulted in sand that clearly contained small clods of silt/clay particles as well as organics that were in the sand-size particle range. When these silt/clay clods were soaked overnight in water to soften them, they could easily be crushed and smeared; producing orange streaks on white paper suggesting silt/clay fines rather than sand. Also, the organic particles were visible in the sand removed from the filter cake. The silt/clay clods and organics were present in sufficient quantity to produce a very misleading percentage for sand in the filter cake as determined using the ASTM method.

The standard approach for PSD is often evaluation of the most relevant fraction; 75 μm (0.0030 inch) and greater. The ASTM D422 method in general describes a dry sieve test procedure. The British Standard 1377 however makes the distinction between samples with and without organic material. In the event of relatively high percentages of organic material, a pretreatment step should be performed on the sample before any further testing. Then after the pretreatment the remaining (mineral) portion of the sample will be washed over the smallest sieve size (63μm or 75μm) (0.00248 or 0.0030 inch) to eliminate the fines. Thereafter the remaining material on the sieve can be either dry or wet sieved for the PSD greater than 63 or 75 µm (0.00248 or 0.0030 inch). This last step can conform to either protocol, ASTM or British Standard.

The applicable standards for the grain size analysis are as follows (Tetra Tech EC, Stuyvesant Dredging Inc. and AECOM 2009):

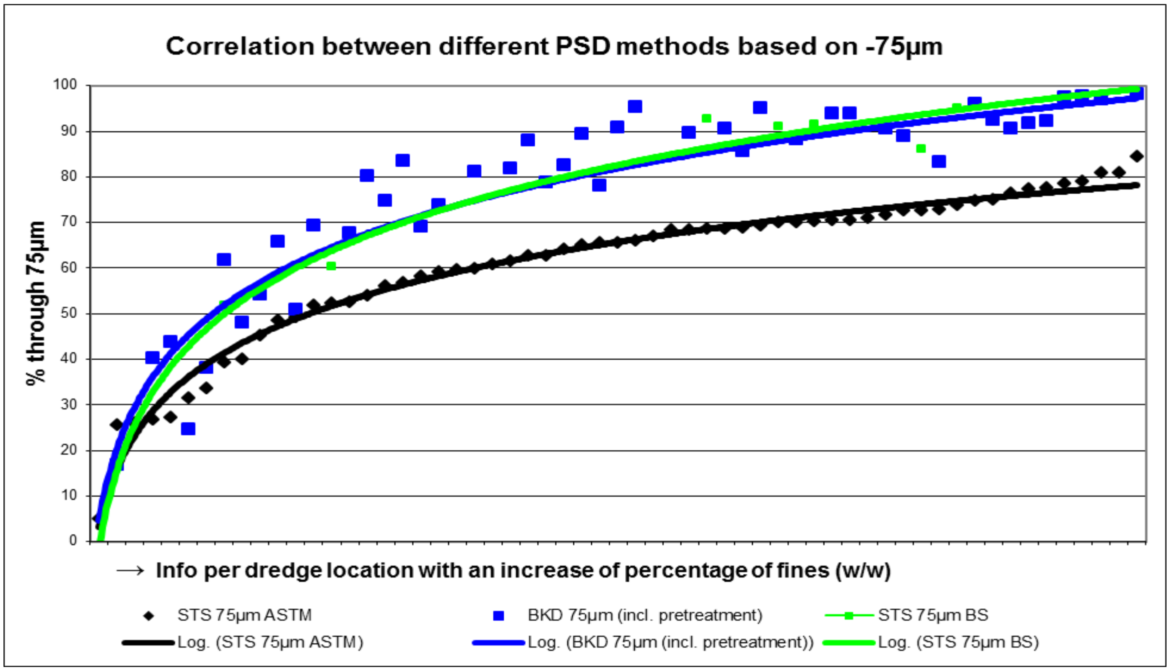
American Society for Testing and Materials ASTM D422 – Standard Test Method for Particle-Size Analysis of Soils: This test method covers the quantitative determination of particle sizes in soils. The distribution of particle sizes greater than 75 µm (0.0030 inch) is determined by sieving while the distribution of particles sizes smaller than 75 µm (0.0030 inch) is determined by a sedimentation process, using a hydrometer to secure the necessary data.

British Standard Institution BS 1377-2:1990 – Methods of Test for Soils for Civil Engineering Purposes, Part 2: Classification Tests, Chapter 9 Determination of Particle Size Distribution: Combined sieving and sedimentation procedure enables a continuous particle size distribution curve of a soil to be plotted from the size of the coarsest particles down to the clay size. The distribution of particle sizes greater than 63 µm (0.00248 inch) is determined by sieving while the particle size distribution less than 63 µm (0.00248 inch) is determined by sedimentation procedures.

Sediments from the Lower Fox River can have a significant fraction of organic matter which can interfere with the particle size determination of the mineral fraction of the sediments. Pretreatment of the sample may be required to accurately determine the particle size distribution of the mineral fraction. A series of parallel tests should be carried out on identical specimens with and without pretreatment to ascertain whether pretreatment is necessary.

Since the separation system utilizes density differences to achieve separation of particles, it would be more useful to determine the content of mineral sand in the sediment than the percentage of sand-size particles. It is likely that the same sand-size particles that are silt/clay clods and organics, and not mineral sand, are causing the sand content in the sediment to be over-estimated.

In the following graph the differences between both PSD methods are shown on Figure 6.



BKD = Boskalis Dolman In-house Geotech Lab.
STS = Local Green Bay Geotech Lab, later AECOM Lab.

Figure 6. Comparison between two PSD methods

The blue and green lines represent the result from samples that have been pretreated and processed according to the British Standard method; the black line shows the results without pretreatment and according to the ASTM method. From the graph it can be concluded that the more fines/organics in the sediments, the greater the resulting difference in sand/fine percentage. In general the difference between these two methods is in a range of 10% – 20% for those samples containing 35% or more fines/organics based on the ASTM method.

Sand Separation

Over the past seven seasons on the Lower Fox River project we have observed a wide variety in the composition of the sediments. The sand content in the sediments range from 10% – 80% (all on weight/weight basis), with an average of 24%, where the amount of fines varied from 35% - 95% with an average of 74%. The remaining 2% represents the fraction larger than 6 mm (0.24 inch) (scalping material) which showed a fluctuation between 0% - 15% (Geevers et al. 2016).

The primary reasons for separating sand include: 1) avoiding unnecessary transportation & disposal (T&D) cost; 2) producing a product that can possibly be beneficially reused and thereby conserving valuable landfill space; and, 3) preventing additional wear and tear on downstream processing equipment.

Performing a thorough evaluation of sediment characteristics upfront proved to be a worthwhile investment on this project since it confirmed the potential for beneficial reuse of separated sand which was then incorporated into the design. While such a testing program is a critical first step towards beneficial reuse, the reuse concept can only be implemented if the project team is able to collaborate with the regulatory agencies and other stakeholders. Fortunately, on the Lower Fox River project such collaboration exists and it all began with following the regulatory procedures while establishing trust amongst all parties.

The 2007 Record of Decision (ROD) Amendment for the Lower Fox River and Green Bay Site (USEPA 2007) contemplated the beneficial reuse of sand processed at the Site. In 2010, Tetra Tech prepared and submitted to WDNR the project's first Low Hazard Exemption Request. The overall procedure for obtaining WDNR approval requires that each request must be for a specific offsite project or projects. Details that need to be provided for each project include proposed location, use, tons shipped, schedule, analytical and geotechnical data. Tetra Tech addressed WDNR's comments on the request, conducted a public hearing to address questions from the local community and then on October 18, 2010 WDNR issued Tetra Tech a "Conditional Grant of Low Hazard Exemption for the Beneficial Reuse of Separate Sand" from dredging non-TSCA sediment from the Lower Fox River remediation project. In accordance with this conditional grant, our team began shipping sand from the project in 2011. Later in 2012 WDNR modified the original exemption to extend the expiration date, expand the uses of the material, and relax notification requirements.

Following demonstration of concept with sand separated from dredging non-TSCA sediment, Tetra Tech obtained approval to beneficially reuse sand separated from dredging in situ TSCA sediment, subject to complying with the same analytical parameters. In 2013 USEPA confirmed that based on input from their Region 5 TSCA program, they had no objection to the proposed beneficial reuses described by our team provided that the PCB concentration of the sand is less than 1 mg/kg (1 ppm), however the WDNR amended the PCB limit to coincide with that for sand separated from dredging non-TSCA sediment, a maximum 0.49 mg/kg (0.49 ppm) PCB concentration. In response to Tetra Tech's request to allow reuse of sand from dredging of in situ TSCA designated material, USEPA further clarified that their 2013 approval includes all sand material generated by the Fox River remediation regardless of in situ TSCA or non-TSCA designation.

For the past seven years of operation (2009-2015) recovered sand from the sediment processing plant has been beneficially reused at several locations within a major local infrastructure project; the first such application on a full scale sediment remediation project in the US. To date, an estimated 319,000 metric tons (352,000 short tons) of sand have been separated. Approximately 90% of the total tonnage of separated sand or 286,000 metric tons (315,000 short tons), has been hauled offsite and beneficially reused at several project locations including the ongoing Wisconsin Department of Transportation (WisDOT) major highway expansion project near Green Bay. Of the portion not sent offsite for beneficial reuse (about 33,500 metric tons [37,000 short tons]), a significant volume was used onsite for grading purposes or disposed. The remainder was disposed at an offsite landfill due to not meeting the Beneficial Reuse Material (BRM) criteria.

Separated sand produced during one season was hauled to the approved WisDOT project located at 2059 Shawano Avenue near the US Highway 41/State Highway 29 Interchange; an aerial photo is presented in Figure 7.

Figure 7. Aerial photo of US Highway 41/State Highway 29 Interchange showing WisDOT construction using approved sand from Lower Fox River project

Process Optimizations

Most of the equipment was designed and installed based on previous project experience along with the available sediment data. The overall performance of the Sediment Desanding and Dewatering Plant (SDDP) went very well from the beginning of operations in 2009, experiencing no significant start-up issues and even exceeding the estimated production volume for the first season. Nevertheless, there is a responsibility to look for available opportunities to improve/optimize the system. The first few months of operations in 2009 provided actual field data to enhance the team's knowledge and understanding of the Lower Fox River sediments. Based on this knowledge, enhancements were introduced to the system for even better performance. Two such examples of system performance optimization are described below.

Chemical Addition

In the dewatering process flocculants are commonly used to settle the sediments. During the pilot studies it became clear that flocculants alone would not be enough to settle all particles. The free water still contained a significant amount of suspended solids. The design goal was to discharge only a limited amount of suspended solids from the SDDP to the onsite wastewater treatment system. Therefore a coagulant was introduced, in this particular case an ACH (Aluminum Chloro-Hydrate). During the first two months this coagulant was dosed in a relatively small tank. Since the retention time in this tank was relatively short (due to high flow, small tank), the original idea was that this setup should provide enough mixing force for the coagulant. However, despite the high velocity (turbulence) in this tank it was clear that mixing was not optimal. The four installed clarifiers (pre-thickeners) showed different settling results when compared to each other. During the second half of the season, four individual dosing pumps were installed and the feed pumps for the clarifiers served as mixing devices. The relative improvement in settling characteristics is presented on Figure 8.

Figure 8. Settling improvement from Coagulant addition

Each of the four clarifiers has its own polymer station capable of preparing “high” concentrations of polymer solutions (up to 1%). The advantage of such a system is the ability to handle high capacities while only needing a very small foot print. Although the performance of these units was good, the difference in viscosity between the polymer and the slurry flow impacted the mixing of both streams. The dosing of the chemicals is regulated by a mass/flow device; when density increases the chemical dosing rate increases and vice versa.

The result was that this higher concentration polymer did not blend well with the high flow sediment slurry. To improve this setup a dilution system was installed during the off-season to enable dilution of the higher concentration polymer to a lower working concentration of 0.15% or 0.20%. The viscosity of the diluted polymer solution is now more in the range of the sediment slurry, and therefore easier to blend/mix.

Dewatering Equipment

The installed Membrane Filter Presses (MFPs) came with pre-installed software in the PLC (Programmable Logic Controller) supplied by the manufacturer. Enhancements to the basic software program were made prior to start up based on the results from pilot scale tests conducted on sediment samples from the Lower Fox River. In the first couple of months of operations several observations were made regarding filter cake thickness, pump behavior and the working of the tiltable frames. Press deck operators noted that the filter cake dropping out of the presses showed significant differences in cake thickness per plate. After several test sessions in collaboration with the manufacturer, we came to the conclusion that the preprogrammed pump filling speed was too high. Due to the resulting high shear, the fairly light flocks were breaking down which reduced their dewaterability. We therefore lowered the pump filling speed by roughly a third to ensure optimum performance.

It is important to note that performing these tests must take place while in full production mode. To minimize possible impact to the production, the software was therefore adjusted for only two of the eight MFPs. By decreasing the initial pump filling speed the cake thickness became consistent throughout the entire press. After a few trials the software was also adjusted for the other six presses, and this problem was resolved.

CONCLUSIONS

For seven years the operational results of our processing plant have met or exceeded the performance criteria established in the basis of design.

Development of the design parameters traces back to before the initial proposal in 2007 and continued after project award during the fast-tracked design performed simultaneously with construction of the sediment processing facility from 2008-2009. Although there is always a significant amount of historical information available regarding the chemical composition of the sediments, often there are less geotechnical data. Also, these geotechnical data often represent certain layers in the sediment and not the entire depth. For this project, the team conducted additional sediment characterization along with bench-scale and pilot-scale desanding/dewatering treatability studies to establish the mass balance that helped define the remediation approach, including equipment sizing and production capacity.

A significant basis of design issue was the feasibility of beneficial reuse offsite of recovered sand from the sediment processing operations. Sand content in the feed sediments has averaged between 13% - 32% over the seven years compared to the initial design average of at least 40%; however, this fits within the difference of the two particle size distribution methods discussed in this paper. As predicted, our team has been able to successfully separate sand meeting the regulatory criteria for reuse in local infrastructure projects. This achievement is the first such application on a full scale sediment remediation project in the US.

Achieving the required approvals to ship separated sand from the Lower Fox River remediation project to the approved WisDOT reuse sites resulted in a "Win-Win" for these 2 major projects. The LLC (client) saved substantial cost by not having to transport the sand for landfill disposal and WisDot benefitted from getting local sand for reuse at no cost instead of purchasing from commercial sources.

The project approach also had to address technical challenges from the single stream process where dredged sediments from Brennan's multiple hydraulic dredges are directly piped to the land-based processing facility. Another key design issue was the use of membrane filter presses to achieve consistently higher dry solids in the filter cake over a variety of sediment feed characteristics as predicted by the pilot treatability testing.

Dry solids in the filter cake have averaged between 53% - 62% over the seven years, better than the design average of 52.5%. Other parameters (e.g. filter press cycle time, dredge flow) were all within the design ranges.

The success achieved over the past seven years of operations can be attributed to several reasons:

- Early contractor involvement, including upfront sediment & dewaterability testing;
- Good communication between the lead operators for the three major elements of this project - dredging, processing, and water treatment;
- Establishing a culture that allows the plant people "on the floor" to control the day to day discussions instead of waiting for direction to come down from management; and,
- Collaboration and maintaining effective working relationships with regulatory agencies and other stakeholders.

Our team will continue to apply its lessons learned as this project continues with the eighth season of sediment remediation expected to start in spring of 2016.

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CITATION

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