ONONDAGA LAKE

SEDIMENT CONSOLIDATION AREA (SCA) DEWATERING EVALUATION
Syracuse, New York

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EXECUTIVE SUMMARY

This report summarizes the activities and conclusions of a study conducted by Parsons to compare methods for dewatering up to 2.65 million cubic yards of dredged Onondaga Lake sediment. Settling basins and geotextile tubes were the methods considered, and the study included bench-scale testing, case study reviews, a comparative analysis of each technology's ability to meet established objectives, and a cost comparison.

Bench-scale testing for settling basins was performed during the Phase I and II Pre-Design Investigations (PDIs), and bench-scale tests for geotextile tubes were conducted during the Phase III PDI. Based on this testing, both settling basins and geotextile tubes were considered feasible methods for dewatering Onondaga Lake sediment. The following ten objectives were developed as a basis for the comparative analysis of the two dewatering methods:

- Protect the Public and Wildlife during SCA Operations;
- Facilitate Efficient Emissions and Odor Management;
- Protect Workers during SCA Operations;
- Maintain Geotechnical Stability and SCA Liner System Integrity;
- Meet Operations Requirements;
- Select a Method Acceptable to the Public;
- Meet Cell Closure Requirements;
- Minimize Dewatering Area;
- Enhance the Water Treatment Process; and
- Minimize Imported Material Quantities.

In addition, comparative cost estimates supported by conceptual designs for each method were prepared. This study indicated that, although higher in cost, geotextile tubes were considered to be more effective than settling basins at meeting project objectives, particularly in their ability to mitigate offsite odor potential. Based on these results, Honeywell selected geotextile tubes as the preferred dewatering method.

1.0 INTRODUCTION

This Report has been prepared on behalf of Honeywell International, Inc. (Honeywell) in accordance with the Draft Remedial Design Work Plan (RDWP) for the Onondaga Lake Bottom Subsite (Parsons, 2008a). The Draft RDWP presents the activities necessary to complete design of the remedy selected in the Record of Decision (ROD) issued by the New York State Department of Environmental Conservation (NYSDEC) and the United States Environmental Protection Agency (USEPA) Region 2 in 2005 (NYSDEC and USEPA, 2005), and as set forth in the Consent Decree (CD) (United States District Court, Northern District of New York, 2007) (89-CV-815). The purpose of this Report is to present the evaluation performed to select the method for dewatering the dredged sediment generated during the Onondaga Lake remedial action, consistent with the requirements and objectives of the ROD and CD, thus facilitating the advancement of the remedial design of the Sediment Consolidation Area (SCA). For both methods evaluated, the final location for the sediment is the SCA on Settling Basin 13.

The Report is organized as follows:

- Section 2 provides a general description of the potentially applicable dewatering methods (i.e., settling basins and geotextile tubes).
- Section 3 summarizes the technical feasibility evaluation for each method, including a review of bench-scale test results and case studies.
- Section 4 presents the conceptual design assumptions for each dewatering method.
- Section 5 presents a comparative evaluation of the effectiveness of the two dewatering methods using objectives that were developed for this purpose.
- Section 6 provides a summary of the evaluation and conclusions, including the selection of geotextile tubes as the preferred dewatering method.

2.0 DEWATERING METHOD ALTERNATIVES

General descriptions of the settling basin and geotextile tube dewatering methods and a discussion of how these methods could be incorporated into this project are provided in the subsections that follow. Both methods assume that Onondaga Lake sediments will be hydraulically transported as a slurry to the SCA.

2.1 Settling Basin Description

For the settling basin approach, the sediment slurry would be discharged continuously into a basin at the SCA that would be constructed using earthen berms. Figure 1 shows an aerial view of an active settling basin. The basin would be designed to provide the slurry adequate time for clarification, thus allowing the formation of a thickened slurry layer at the bottom of the basin and supernatant at the top. The thickened slurry layer would be left in place within the basin, and the supernatant would be decanted from the basin, treated, and returned to the lake. After allowing time for dewatering and consolidation, a final cover would be constructed over the dewatered sediment.

2.2 Geotextile Tubes Description

Geotextile tubes are fabricated in a variety of circumferences and lengths using high strength permeable geotextiles. For dewatering the Onondaga Lake sediment, it is anticipated that geotextile tubes 80 to 90 ft in circumference and 200 to 300 ft in length would be used. Slurry would be pumped into the tubes via ports along the top of the tubes, and the filtrate would drain through the openings of the geotextile. Solids would be retained within the geotextile tubes. The basic steps in the geotextile tube dewatering process are as follows:

- Step 1: A pre-conditioner (e.g., polymer) is added to the dredged slurry to enhance solids-liquid separation and dewatering. Single or multiple dosages of pre-conditioner may be used. Depending on the specific design, the slurry may be thickened in a clarifier.
- Step 2: The pre-conditioned slurry (underflow if a clarifier is used) is pumped into the tubes, which are located in a dewatering cell.
- Step 3: The filtrate is allowed to seep out of the tubes while the solids remain in the tube and consolidate. The filtrate would be collected, treated, and returned to the lake.

Once dewatering has occurred, the tubes (with the solids inside) would be left in place at the SCA and covered. Figure 2 shows geotextile tubes during operation.

3.0 TECHNICAL FEASIBILITY

To evaluate the technical feasibility of each method for dewatering Onondaga Lake sediment and to obtain sufficient data for a conceptual level design, bench-scale testing was performed. In addition, case studies were reviewed. The following assumptions were made for purposes of assessing technical feasibility:

- The sediments from Sediment Management Units (SMUs) 1 and 6 are representative of the majority of sediment to be dredged (i.e., they represent approximately 70% of the total dredge volume);
- The sediment slurry pumped from the lake will average approximately 10% solids by weight, but it may vary widely due to variability in dredge head, preprocessing, and transport operation conditions;
- The selected dewatering system will be capable of handling up to an estimated 2.65 million cubic yards of sediment over four years; and
- The entire area of Settling Basin 13 can be utilized, if necessary, for the SCA (approximately 160 acres).

3.1 Settling Basin

To evaluate the settling basin approach, column settling tests (CST) and column consolidation tests were performed by Geotesting Express in Boxborough, Massachusetts on multiple sediment samples. Details of these testing efforts are described in the Phase I Pre-Design Investigation (PDI) Work Plan (Parsons, 2005) and Phase II PDI Work Plan – Addendum 5 (Parsons and O'Brien & Gere, 2006). These tests were performed to evaluate the sedimentation and consolidation behaviors of the Onondaga Lake sediment slurry. The CST provides data on the sedimentation characteristics of the slurry. Using these data, a settling basin can be designed to meet effluent total suspended solids (TSS) concentration, clarification, and initial storage requirements. The column consolidation tests provide data to predict long-term volume reduction of settled solids due to consolidation. The test results are provided in the Phase I and Phase II Summary Reports (Parsons, 2007; Parsons, 2008b).

In most of the column settling tests, a distinct interface formed between the settled slurry and the supernatant water; thus, the sediments exhibited zone settling behavior in the column settling tests. In addition, the tests generally show relatively little change in total suspended solids or interface height after four days of testing. The test results also show differences between sedimentation and consolidation characteristics of the sediment from different SMUs; however, these differences can be quantified, and the full-scale design could account for them. Therefore, the CST and consolidation test results indicate that it is feasible to use a settling basin to retain and dewater the sediment from Onondaga Lake.

In addition to bench-scale testing that indicated the use of settling basins was feasible, case study reviews showed that settling basins have been effectively used at numerous contaminated sediment sites (e.g., Port of Tacoma Remediation in Washington, Indiana Harbor and Shipping Canal in Indiana), and the assumptions listed previously were compatible with an effective settling basin design.

3.2 Geotextile Tubes

Bench-scale tests were performed by Waste Stream Technology, Inc. (WST) in Buffalo, New York to evaluate the feasibility of using geotextile tubes to dewater the dredged sediment. The procedure used for the bench-scale hanging bag tests is described in the Phase III PDI Work Plan – Addendum 1 (Parsons, 2007). The detailed results of the bench-scale testing of samples collected from SMUs 1 and 6 are provided in the Phase III Summary Report (Parsons, 2008c).

For all the tests in this study, an approximately 10% solids by weight slurry was prepared from a SMU 1 or SMU 6 sediment sample that had been screened through a 1-inch sieve. After slurry preparation, half of the slurry samples were pumped directly into the hanging bag as prepared; whereas, the other half were mixed with a pre-conditioner (i.e., Hychem 824 polymer) prior to pumping into the hanging bag. The selection of Hychem 824 polymer was based on jar testing. After the hanging bags were filled, the slurry was allowed to dewater for approximately 24 hours. The results from this testing are summarized as follows:

- During sample preparation to replicate anticipated slurry conditioning (i.e., screening through a 1-inch sieve), significant oversize material was observed in the samples from SMU 1.
- The addition of Hychem 824 polymer to the slurry prior to pumping it into the hanging bag significantly increased the dewatering rate; however, the total filtrate volumes collected over the 24-hour test period were very similar whether or not polymer was used.
- In general, the turbidity and TSS of the filtrate from the hanging bag tests was significantly less (i.e., by at least a factor of two in most cases) when Hychem 824 polymer was added to the slurry prior to pumping it into the hanging bag as compared to the tests without polymer. One of the SMU 1 samples (i.e., one of the In-Lake Waste Deposit [ILWD] samples) was an exception to this because the filtrate from both with and without polymer hanging bag tests had similar TSS and turbidity.
- A comparison of the with and without polymer addition hanging bag tests for the SMU 6 samples indicates that the addition of Hychem 824 polymer to the slurry significantly increased the solids content of the material that was retained in the hanging bag after 24 hours of dewatering. However, this effect was not apparent for the SMU 1 hanging bag tests.
- In addition to increasing the dewatering rate, the Hychem 824 polymer addition to the slurry also affected the consistency of the material that was retained in the hanging bag after the 24-hour dewatering period. This was particularly the case for the SMU 1 samples. Specifically, the material strength after 24 hours of dewatering in the hanging bag was measurable in the polymer treated samples (i.e., it was approximately 50 psf); whereas, the untreated samples were too weak/soft for measurements to be taken with a mini-vane shear device. In addition, when polymer was not used on the SMU 1 tests, the material stuck to the sides of the bag and blinded the geotextile.

In general, the bench-scale test results indicate that the use of geotextile tubes is feasible for dewatering the Onondaga Lake sediment; however, polymer addition would likely be required. Based on this study, Hychem 824 is an effective polymer for the SMU 6 material, but additional polymer and bag testing is required to determine the most effective polymer(s) for all the anticipated dredged sediments.

As with the settling basin, case study reviews (e.g., Ashtabula River Site in Ohio) occurred as part of this technical feasibility evaluation. Site visits (e.g., Fox River in Wisconsin, confidential site in Alabama) were also a major component of this review. As with the settling basin, the development of an effective design given the previously listed assumptions was considered feasible. Therefore, based on the case study review and the bench-scale test results presented above, the use of geotextile tubes to dewater Onondaga Lake sediment was considered technically feasible.

4.0 CONCEPTUAL DESIGN ASSUMPTIONS

To more fully evaluate settling basins and geotextile tubes, a conceptual design was developed for each method. Assumptions for each method were established so that comparable conceptual designs could be developed. Therefore, the intent was to make parallel assumptions whenever possible. For both dewatering options, it was assumed that up to an estimated 2.65 million cubic yards of sediment would be dredged over a four year period. The assumptions for the conceptual designs are presented in the following subsections.

4.1 Settling Basin Assumptions

Multiple geometries were explored to optimize the settling basin layout that would be used for the conceptual design. The conceptual design developed for the settling basin layout is provided in Figure 3 and was based on the following assumptions:

- Two dewatering cells would be required with the possibility to subdivide into four cells to enhance operations, including potential odor mitigation.
- A minimum 500-ft buffer zone between the western edge of Settling Basin 13 and the settling basins for sediment dewatering is required based on a request from residents in the Town of Camillus.
- Two (2) ft minimum water depth would be required over settled solids to facilitate settling and to maintain a water blanket over the sediments.
- Two (2) ft minimum freeboard would be required between top of perimeter dikes and water surface to protect against overtopping due to precipitation and wave action.
- Based on capacity, water depth, and freeboard criteria, the settling basin footprint within Settling Basin 13 would be approximately 100 acres with constructed dike heights up to 33 ft.
- Particles sand-size and greater would be removed from the slurry prior to pumping into the settling basin to prevent mounding of sediments near the discharge.

4.2 Geotextile Tube Assumptions

The conceptual design developed for the geotextile tube dewatering area is provided in Figure 4, and the assumptions were as follows:

- Tubes would be stacked up to a height of 30 ft.
- Based on required capacity and stacked tube height constraints, the geotextile dewatering area would be approximately 100 acres.
- Constructed dikes would be 5-ft high.
- A minimum 500-ft buffer zone between the western edge of Settling Basin 13 and the geotextile tube dewatering area is required based on a request from residents in the Town of Camillus.

- Particles sand size and greater would be removed from the slurry prior to pumping into the geotextile tubes to prevent mounding near the filling ports of the tube.
- Slurry would require pre-conditioner addition and gravity thickening prior to pumping it into the geotextile tubes based on bench-scale test results.

5.0 DETAILED COMPARISON

For purposes of the comparative evaluation, ten objectives were developed by which the two dewatering methods could be compared. Those objectives are as follows:

- Objective 1: Protect the Public and Wildlife during SCA Operations
- Objective 2: Facilitate Efficient Emissions and Odor Management
- Objective 3: Protect Workers during SCA Operations
- Objective 4: Maintain Geotechnical Stability and SCA Liner System Integrity
- Objective 5: Meet Operations Requirements
- Objective 6: Select a Method Acceptable to the Public
- Objective 7: Meet Cell Closure Requirements
- Objective 8: Minimize Dewatering Area
- Objective 9: Enhance the Water Treatment Process
- Objective 10: Minimize Imported Material Quantities

Of these objectives, the first four were considered the most important, with decreasing importance from Objective 6 to Objective 10. In addition to the ten objectives listed above, cost effectiveness was also considered. Using the conceptual designs developed based on the assumptions presented in Section 4, the two methods were compared. A summary of those comparisons is provided in the following subsections.

5.1 Objective 1 – Public and Wildlife Protection During SCA Operations

Public and wildlife protection is considered to be of utmost importance. Whether settling basins or geotextile tubes are used, security will be in place around the entire perimeter to prevent the public from entering the project area. If the public and/or wildlife do enter the area, however, there is a drowning hazard for an open settling basin that does not exist for the geotextile tube dewatering area. Specifically, for geotextile tubes, the liquid generated from dewatering would be contained in the gravel drainage layer beneath the tubes; whereas, for the settling basin the liquid would accumulate on top of the dewatering sediment. In addition, the open settling basin has more potential than the tubes for attracting birds and other wildlife. The geotextile tubes, as compared to the basin, also provide additional containment of the sediment during operations. For these reasons, the geotextile tubes are considered to be more effective at protecting the public and wildlife.

5.2 Objective 2 – Emission and Odor Management

Minimizing volatile emissions and odors is also of utmost importance. Whether the slurry is discharged into a basin or a tube, the potential sources of odor and volatile emissions during operations are the water and the consolidating sediments. Based on the conceptual design, it was determined either method of dewatering could be utilized without offsite health impacts from emissions. Odor mitigation strategies for both methods were evaluated based on their effectiveness at meeting this important objective and their potential operational impacts.

Based on case studies, geotextile tubes have been shown to effectively control odors when used to dewater sludges (e.g., sludges from water treatment plants). In addition, minimizing the volume and movement of filtrate, minimizing the active dewatering area, and covering the tubes (if necessary) were considered to be effective and implementable odor mitigation strategies during tube operations.

For the settling basins, it was determined that floating covers could be needed to control odors. Floating covers would be more difficult and expensive to implement than the mitigation efforts for the tubes. In addition, the effectiveness of the floating covers may be impacted by the need to remove them due to operational requirements (e.g., moving the discharge). Therefore, the use of geotextile tubes was considered to be more effective at meeting the objective.

5.3 Objective 3 – Worker Protection During SCA Operations

As with the previous objectives, worker protection is also considered to be of utmost importance. In addition to the typical worker protection issues during construction, each dewatering method has unique risks to workers associated with it. Operating geotextile tubes requires workers to walk across the tubes to connect and disconnect hoses; therefore, trip and fall hazards are more significant than with the basins. For the basins, the risk of drowning is an example of a unique hazard as compared to the tubes. A hazard analysis for each dewatering method was performed to identify the worker risk mitigations that would be employed. Since the unique hazards for both methods can be adequately mitigated using the appropriate personal protective equipment (PPE) and/or operating procedures, both methods were considered to be similar with respect to worker protection.

5.4 Objective 4 – Geotechnical Stability and SCA Liner System Integrity

Maintaining geotechnical and SCA liner system integrity is also of utmost importance regardless of the dewatering method selected. Because the SCA will be built on compressible Solvay waste material for both methods, settlement (including total and differential settlement) and porewater pressures will be monitored during construction and operation; however, the geotextile tube method provides the flexibility to adjust the placement configuration if more or less settlement occurs in certain areas. If necessary, strategic tube placement could be used to maintain liner system integrity and/or positive grades to the areas for liquid removal. Conversely, once the berms for the settling basin are constructed and the slurry is discharged into the basin, it is difficult to monitor settlement or to adjust the loading to control settlement. In addition, the lower hydraulic head associated with the geotextile tubes as compared to the settling basin is considered preferable in terms of maintaining liner system integrity during operation. Because of the lower hydraulic head and the flexibility related to tube placement, geotextile tubes are considered more effective than a settling basin at meeting this objective.

5.5 Objective 5 – Operations

The operations objective includes consideration of sediment dewatering as it relates to the overall remedial process such that it enhances, or at a minimum does not impede, the implementation of the remedial action (i.e., schedule). This includes evaluating the option in regards to maintaining planned dredging rates, receiving and handling material, dewatering of sediment (during and following dredging), and managing water.

The results of the bench testing for the geotextile tubes indicate that varying or multiple pre-conditioners may be required for different sediment types. Operational controls will be required to properly dose the feed slurry with pre-conditioner so that it will dewater effectively and maintain the necessary dredge rate.

For the settling basin option, pre-conditioner is not required; therefore, the process of discharging the slurry into the basin is much simpler than discharging it into the tubes. However, discharge pipe movement will be required to control load distribution, which is more operationally challenging than adjusting tube placement, especially if a floating cover is required to control odors. In addition, access to liquid removal areas, which would be in the low spots of the SCA, would be more difficult for settling basins than tubes.

Since a similar level of operational challenges exists for both settling basins and geotextile tubes, especially when the challenges associate with odor control are taken into account, both methods were considered similarly effective at meeting this objective.

5.6 Objective 6 – Public Acceptance

Although the dewatering method selection process was not specifically discussed with the public, comments during previous phases of this project indicated that odor and security were the two major concerns. During the public comment period for the CD, the Town of Camillus, where the SCA is sited, formally requested a 500-ft buffer zone on the western boundary of the site to address these concerns. As indicated previously, both options provide positive odor control measures, security, and the requested buffer zone. However, the geotextile tubes have an advantage over the settling basins because the tubes provide additional containment of the dredged sediment during operations. In addition, they are more effective at mitigating odors, protecting the public and wildlife during operations, and maintaining geotechnical and SCA liner system integrity. Therefore, geotextile tubes are considered more effective at meeting this objective.

5.7 Objective 7 – Cell Closure

The cell closure objective includes consideration of potential reuse, consistency with the planned overall settling basin program, opportunities for closure enhancement, and time required for closure. Geotextile tubes provide reinforcement within the dredged sediment, which would allow for equipment to place a cover over the area relatively quickly after the tubes are filled; however, options are also available for the settling basin which could reduce time to closure. The conceptual design developed for the settling basin included a plan to slurry and place sand on the dredged sediment and/or use a reinforcement geotextile or geogrid to provide strength for cover placement. The geotextile tubes would also provide the ability to shape the area to facilitate drainage after filling; however, placement of dredge material within the settling basin could also be implemented in such a way as to facilitate drainage. For either option, designs could be developed that would address each of the cell closure issues (including reasonable time to closure); therefore, they were both considered similarly effective at achieving the final closure objective.

5.8 Objective 8 – Dewatering Area

Minimizing the dewatering area was included as an objective because reducing the footprint allows for greater buffer areas between local residents and the contained dredged materials. Although the goal of this objective was to minimize the required dewatering area for each method, the conceptual designs indicate that a similarly sized dewatering area is required for both the geotextile tubes and the settling basin for two reasons. First, because of the potential for large settlements and/or differential settlement, certain locations within Settling Basin 13 are preferred for berm construction and geotextile tube placement. Since the constraints are similar regardless of the selected dewatering method, the dewatering area size/configuration is assumed to be the same for both methods. Second, and as mentioned previously, the optimized size for the settling basin (approximately 100 acres including four cells) is fairly consistent with what would be required with a stacked geotextile tube arrangement. Since the same area is considered appropriate for both dewatering methods, they were both considered similarly effective at achieving this objective.

5.9 Objective 9 – Water Treatment

Since water treatment is an important component of the design, the potential for enhancing water treatment was a consideration in dewatering method selection. As discussed in the results of the bench-scale testing, the hanging bag tests indicate the filtrate has significantly less TSS, turbidity, and mercury concentrations as compared to the slurry; however, the CST results indicated that the slurries settled out quickly. Therefore, it was concluded that the same benefits could be accomplished using either method. Since the test results did not indicate there would be a significant advantage in terms of water treatment, both methods were considered relatively similar in terms of potential for enhancing water treatment.

5.10 Objective 10 – Imported Material Quantities

Minimizing imported material quantities is considered an objective because transporting materials to the site has the potential to disturb local residents, and the potential time period of disturbance increases with greater material quantities. Conceptual designs indicated that approximately 600,000 cubic yards less material would be required to construct the geotextile tube dewatering area as compared to the settling basin. Even though geotextile tubes and pre-conditioner would need to be delivered to the site, the geotextile tubes were judged to be more effective overall at minimizing the required imported material quantities; therefore, the geotextile tubes were considered slightly more effective at achieving this objective.

5.11 Cost Effectiveness

In addition to the ten objectives discussed previously, cost effectiveness was also considered in this evaluation. The cost comparisons were prepared based on the conceptual designs that were developed using the assumptions presented in Section 4. This comparison focused on evaluating the cost differentials between the two methods. When the cost implications and potential risks associated with achieving the project-specific requirements (e.g., odor management and soft subgrade) were evaluated for the entire process, the geotextile tube option was estimated to be more costly than the settling basin option.

5.12 Comparison Summary

As summarized in Table 1, the geotextile tubes were considered more effective than the settling basins at meeting the following objectives:

- Objectives 1 – Protect the Public and Wildlife during SCA Operations
- Objective 2 – Facilitate Efficient Emissions and Odor Management
- Objective 4 – Maintain Geotechnical Stability and SCA Liner System Integrity
- Objective 6 – Select a Method Acceptable to the Public
- Objective 10 – Minimize Imported Material Quantities

For the remaining objectives, the two methods were considered to be similarly effective.

6.0 CONCLUSION

The dewatering method selection process described in this Report includes bench-scale testing, case study reviews, a feasibility evaluation, a detailed cost comparison, and a comparative analysis of each technology's ability to meet established objectives. Using the bench-scale testing and preliminary design assumptions, conceptual-level designs were developed for the settling basin and geotextile tube options. Ten objectives by which the two methods could be compared were identified and evaluated for each method, and a cost comparison was prepared. Although geotextile tubes are considered to be more expensive than settling basins, they are the selected dewatering method for the Onondaga Lake remedial action because they are considered to be more effective at meeting project objectives, particularly with regard to their ability to mitigate offsite odor potential.

7.0 REFERENCES

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FIGURES

Figure 1 Example Site – Settling Basin

Figure 2 Example Site – Geotextile Tube Dewatering

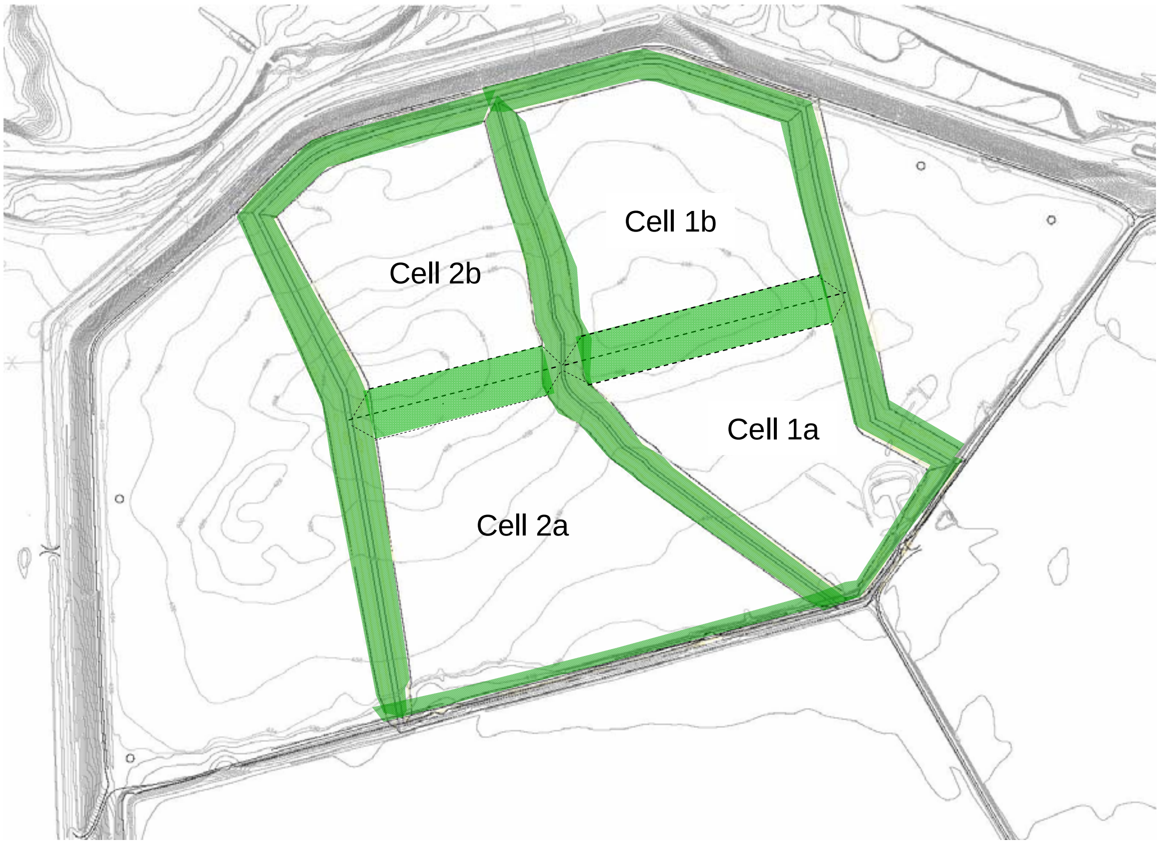

Figure 3 Settling Basin Conceptual Design

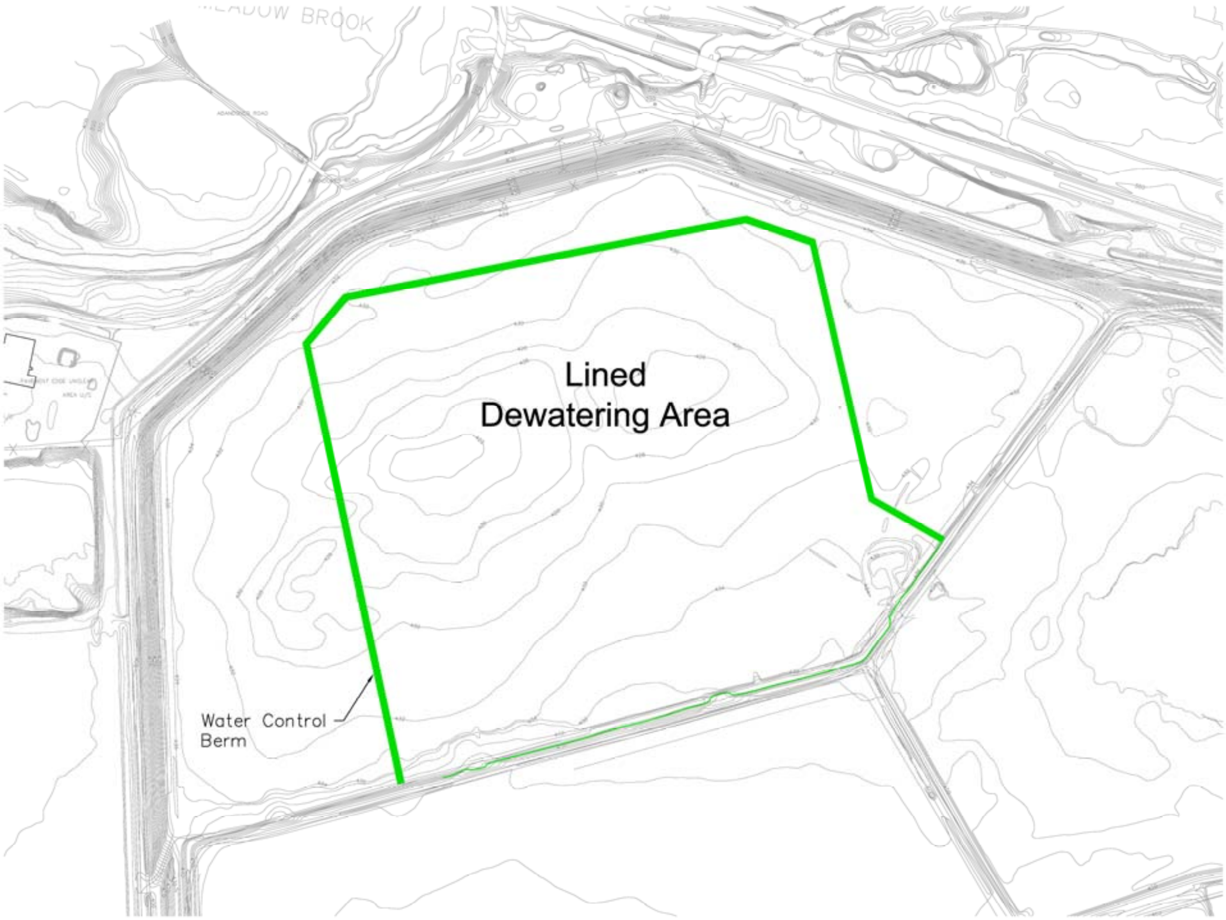

Figure 4 Geotextile Tubes Conceptual Design

TABLES

TABLE 1

SETTLING BASIN VERSUS GEOTEXTILE TUBES

Objectives	Settling Basin	Geotextile Tubes
1. Protect the Public and Wildlife during SCA Operations	--	+
2. Facilitate Efficient Emissions and Odor Management	--	+
3. Protect Workers during SCA Operations	o	o
4. Maintain Geotechnical Stability and SCA Liner System Integrity	--	+
5. Meet Operations Requirements	o	o
6. Select a Method Acceptable to the Public	--	+
7. Meet Cell Closure Requirements	o	o
8. Minimize Dewatering Area	o	o
9. Enhance the Water Treatment Process	o	o
10. Minimize Imported Material Quantities	--	+

Note: For a given objective, an "o" for both methods indicates that they are similarly effective at meeting the objective; whereas, a "+" for one method and a "--" for the other method indicates that the "+" method is considered to be more effective than the "--" method at meeting the objective.