APPENDIX A – GEOTECHNICAL ENGINEERING APPENDIX

GENERAL REEVALUATION REPORT (GRR) AND SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (SEIS) FOR THE POPLAR ISLAND ENVIRONMENTAL RESTORATION PROJECT

CHESAPEAKE BAY, TALBOT COUNTY, MARYLAND

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1. EXISTING POPLAR ISLAND PROJECT

1.1. Existing Project Layout

The existing Poplar Island project consists of an 1,140-acre site with approximately 50 percent of the site devoted to upland habitat, and 50 percent of the site devoted to wetland habitat. The final upland surface elevation will be limited to an average of +20 ft MLLW, and the wetland surfaces will typically range from a low marsh elevation of +1.2 ft MLLW to an upper limit in the high marsh areas of +2.4 ft MLLW. The existing site has a total placement capacity of approximately 40 million cubic yards (mcy). Once filled, the temporarily overbuilt upland cell containment dikes will be graded down to the +20 ft MLLW elevation.

Table 1-1 Site Characteristics

Feature	Phase I	Phase II	Total Site
Length of perimeter dike	21,589 ft	18,279 ft	39,868 ft
Upland cells – No. cells & area	One – 326 ac	One – 243 ac	Two – 569 ac
Final upland elevation	+20 ft MLLW	+20 ft MLLW	+20 ft MLLW
Upland cells – capacity	15 mcy	17 mcy	32 mcy
Tidal wetlands – No. cells & area	Two – 312 ac	Two – 253 ac	Four- 565 ac
Tidal wetlands – low marsh elevation	+1.2 to 1.8 ft MLLW	+1.2 to 1.8 ft MLLW	+1.2 to 1.8 ft MLLW
Tidal wetlands – high marsh elevation	+1.8 to 2.4 ft MLLW	+1.8 to 2.4 ft MLLW	+1.8 to 2.4 ft MLLW
Tidal wetland cells – capacity	4.3 mcy	3.2 mcy	7.5 mcy
Total site capacity	19.3 mcy	20 2 mcy	39.5 mcy

1.2. Containment Dike Design and Construction

The original containment dikes were constructed using sand mined from the bay bottom and armored with large stone obtained from off-site sources. Approximately 5 mcy of sand was obtained mostly from within the project footprint. However, it was necessary to obtain some borrow sand immediately outside the southwest portion of the project on each side of the existing access channel. Prior to the initial construction contract, it had been anticipated that the dikes would be constructed using hydraulic placement methods similar to the approach used to construct the Hart-Miller Island project. However, the actual construction method for both phases consisted of dredging sand from subsurface borrow sources and creating a stockpile of material that was then mechanically excavated, trucked, and placed in the dike section using bulldozers for spreading and compaction. As a means of containing turbidity, the stone toe of the armor section was constructed before the sand dike section was placed. Nearly 800,000 tons of armor stone was obtained from quarries in West Virginia and Maryland to provide the exterior stone armor materials.

1.3. Wetland Habitat

To facilitate wetland cell filling and development, the original larger wetland cells (100 to 170 acres) have been temporarily subdivided into 30 to 40 acres cells. Dredged material will be placed into each wetland cell in four to six placement events of diminishing quantity until each cell is filled. The dredged material will be consolidated and a surface crust will be formed through an intensive crust management process. The final development phase will include excavation of a system of channels and mechanical grading of the dredged material surface to provide the required surface elevations related to the overall project goal of 80 percent low marsh and 20 percent high marsh surfaces. A temporary outlet structure will be constructed for each sub-cell to allow for full control of tidal flow into the cell while plants are established. After marsh stabilization, the outlet structures will be removed and tidal flow will enter the cell through an open channel breach of the original containment dike. After vegetation has been fully established within adjacent subcells, the temporary dike separating them will be removed to allow for tidal flow between subcells.

1.4. Upland Habitat

Upland habitat will be developed on the dredged material surfaces within the upland cells after they have been stabilized at approximately elevation +20 ft MLLW. The existing upland cells 2 and 6 are approximately 326 and 243 acres in size, respectively and are located along the western side of the Poplar Island site. Filling each cell will be accomplished so that a positive grade will be maintained toward the primary discharge spillway. In cell 2, a positive grade will be maintained from the south end toward spillway No. 1 at the extreme north end of the cell. In cell 6, the dredged material surface will naturally assume a grade from the highest surface elevation at the north end toward the spillway at the south end of the cell. When the dredged material approaches the top of the containment dike at the high end of the cell, it will be subdivided into several smaller subcells approximately 100 acres in size to facilitate final filling and grading. The final dredged material will be discharged from the western side of the cell to establish a surface gradient toward the wetlands to the east. After placement has been completed, the surface will be drained and a crust will be developed similar to the process used for development of wetland cells. However, in anticipation that the final grading pattern will require several feet of relief to achieve the desired drainage pattern, it may take several years of drainage, crust development, and grading to achieve the desired topography. Part of the final grading will include the removal of the perimeter dike overbuild above the nominal +20 ft MLLW elevation. The dike material will be incorporated into the final surface grading plan. If upland ponds are desired, they would be sited at locations that demonstrate a tendency for settlement. Planting would follow after the grading is completed.

1.5. Dredged Material Placement Capacity

Approximately 10 million cubic yards (mcy) of dredged material was placed into upland cell 2 during the first 3 years (2001 through 2004) of operation. That quantity significantly exceeded the 2.0 mcy per year that was originally anticipated. If the annual placement occurs at the historic average of 2.0 mcy per year through 2008, and 3.2 mcy per year thereafter, analysis has shown that the site would be filled by 2015, with 2014 being the last year able to accommodate the full 3.2 mcy quantity. Beginning in approximately 2010, the upland cells will be overloaded to accommodate an increase in average annual placement from approximately 2.0 mcy per year to 3.2 mcy per year. The analysis also indicates that the upland placement capacity will be exhausted at approximately the same time that the last wetland cell placement has been completed. A detailed discussion of the criteria and methods employed in the placement analysis is presented later is this report.

1.6. Future Dredged Material Placement Needs

Based on the current estimate of site capacity, it would be beneficial to develop additional placement capacity by approximately 2010 to avoid that point at which the site will have to be consistently overloaded to accommodate the average annual 3.2 mcy of dredged material. It is estimated that if overloading of the upland cells, especially cell 6, can be avoided, an additional 1 to 2 mcy of placement capacity might be realized. More efficient placement of dredged material into the upland cells will also promote more complete consolidation of the dredged material during the annual crust management process allowing for earlier development of the upland habitat. More complete consolidation will also decrease the risk of excessive localized settlement that could affect runoff patterns toward the wetland cells. A more detailed analysis of the remaining capacity of the existing project is presented in the next section of this report.

1.7. Future Placement Alternatives

Additional dredged material placement can be achieved by raising existing upland cells, by expanding the existing project footprint with the addition of new cells, or by constructing additional placement site(s) separate from the existing project. A Reconnaissance Study was completed that developed several alternative alignments for lateral expansion of the existing project. The current study will further evaluate the lateral expansion alternatives, and will also consider the potential for vertical raising of the existing cells either in place of lateral expansion, or in conjunction with it. The development of other project sites in the Chesapeake Bay is being addressed in separate studies.

2. EVALUATION OF EXISTING PROJECT

2.1 General

Before analyzing the expansion project, it was necessary to first analyze the existing project to determine the remaining dredged material placement capacity and remaining placement life consistent with the development of the desired upland and wetland habitat. Placement analyses were then performed for the various lateral and vertical expansion alternatives. The expansion placement acreage and capacity for each of those alternatives was then mathematically merged with the sequence of placement already established for the existing project to evaluate each alternative.

2.2 Analysis Input

The 1,140-acre existing project consists of 2 upland cells and 4 wetland cells. To control the initial dredged material surface elevation, it has been necessary to temporarily divide the original larger wetland cells into smaller subcells having individual areas typically 30 to 40 acres in size. Therefore, the existing project now has 2 upland cells and 15 wetland subcells as indicated on the spreadsheet presented as Figure 1. The nominal area, actual placement area, volume and placement capacity of each cell are shown in the initial columns of the placement spreadsheet. The actual dredged material placement quantities between 2001 and 2003 were entered to account for actual total dredged material placement for each of the first three years of the project life. Beginning with the year 2004, projected placement quantities for each cell were entered into the spreadsheet so that a total of 2 mcy will be placed from 2004 through 2008, and 3.2 mcy will be placed in the site from 2009 (reflecting closure of the Pooles Island placement site) until the site capacity was exhausted.

2.3 Analysis Results

As indicated on Figure 1, upland Cell 2 was heavily overloaded during the initial two years of placement when more than 6 mcy of dredged material was placed compared to the optimum placement quantity of approximately 2.88 mcy. The 1.8 mcy of dredged material placed into the wetland cells provided a placement ratio of approximately 4.6:1, close to the desired 5:1 ratio (i.e. approximately 80 percent of dredged material placed into the upland cells). However, the extremely thick initial placement thickness in the upland cell may result in a reduction in ultimate placement capacity.

The placement analysis has shown that, if the annual placement occurs at the historic average annual rate, the site will be filled by 2015 with 2014 being the last year able to accommodate the full 3.2 mcy quantity. (Freeboard limitations may prevent the cells from accepting the full theoretical annual capacity during the last year or two of placement.) Beginning in approximately 2010, the upland cells will be overloaded every year to accommodate an increase in average annual placement from approximately 2.0 mcy per year to 3.2 mcy per year. Optimum placement is associated with a lift thickness of approximately 3 feet. Overloading is defined as annual placement that would result in an upland cell lift thickness exceeding approximately 4 feet (or more than approximately 120 percent of the ideal annual placement volume for the cell). When the optimum lift thickness is significantly exceeded, the lower portion of the lift cannot be effectively consolidated by conventional crust management techniques. Therefore, the time required for consolidation of the dredged material increases to an extent that it becomes impractical to delay upland habitat development to realize the full theoretical cell capacity. The lost capacity must then be provided by another placement site.

The analysis also indicates that the upland placement capacity will be exhausted at approximately the same time that the last wetland cell placement has been completed. This leaves essentially no contingency for delayed or inefficient development of the wetland cells, or average annual placement that exceeds the estimated placement rate. This is a concern because the deep borrow excavations created in several of the wetland cells will result in thick dredged material layers that will require much more time to reach a state of full consolidation. The varying thickness of dredged material from as little as 5 feet to more than 20 feet within a cell will result in a wide variation of duration to reach a fully consolidated state. These complicating factors make the lack of contingency time a critical issue that could be partially mitigated by an adequately sized expansion project, particularly if additional upland placement capacity can be added by a vertical raising of the existing upland cells.

3. RECONNAISSANCE STUDY FOR POTENTIAL SITE EXPANSION.

3.1. General

In the Reconnaissance Study completed in 2002 (EA, 2003), six potential expansion alignments were developed. The alternative alignments included locations to the southeast, southwest and north of the existing project. Four of the alignments were approximately 750 acres in size, one was 313 acres, and the largest was 1,129 acres in size. All six alignments were attached to the existing project dikes and were arranged to provide additional upland and wetland cells in the proportion of 50 percent for each type of habitat. Following is a summary of the alignments and dike sections assumed in the Reconnaissance Study.

3.2. Alternate Alignments

Plans showing each of the original six alternative alignments and the added seventh alignment, are presented as Figures 2 and 3. (GBA, 2002). Table 3-1 presents a summary of the area, approximate capacity (for upland elevations at +20 ft MLLW), and project life for each alignment.

Table 3-1. Alternative Alignment Summary

Alternative Alignment	Area (acres)	Total Site Capacity (mcy)	Site Life (years)
1	753	32	13
2	754	30	13
3	754	29	13
4	1129	48	20
5	749	30	13
6	313	11	5
7	631	24	10

3.3. Dike Sections

The dikes will be constructed using sand excavated from the bay bottom borrow areas located within the footprint of the project, and from sand obtained from required access channel and turning basin excavations. The dikes are expected to have a cross section similar to the existing Poplar Island dikes with side slopes at 3 horizontal on 1 vertical (3H:1V). Upland dikes will be constructed to elevations typically about 5 feet higher than the final upland elevation. After all dredged material has been placed within the cell, the dikes will be cut down to the upland surface elevations. Wetland dikes will be constructed to approximately elevation +10.5 ft MLLW. Additional temporary dikes will sub-divide the wetlands into smaller 30 to 40 acres subcells to facilitate placement of dredged material for wetland development. The temporary internal dikes will later be removed and the smaller wetland subcells will be merged into larger cells.

3.4. Rock Armor

The external slopes of most of the outer containment dikes will be protected from erosion with multiple layers of rock armor overlying geotextile filter materials. Rock sizes are expected to be similar to the stone used on the existing project. Armor along the more protected eastern side of the project consisted of 250-lb stone on geotextile. The more exposed western side of the project required multiple layers of armor ranging from 3,000 to 4,000 lb. mean stone size overlying a double layer of 250-lb stone on a geotextile.

3.5. Subsurface Investigations

Approximately 70 new borings were completed to supplement original subsurface information accumulated from the previous Phase I and Phase II design investigations. These borings provided general information for each of the three expansion areas with respect to foundation conditions for potential dike alignments and sand borrow materials for dike construction. A plan of the subsurface investigations completed for the Reconnaissance Study is presented in Figure 4 (GBA, 2002). Laboratory testing was performed with a primary focus on grain size distribution of materials in the potential borrow areas.

3.6. Borrow Sources

Potential sand borrow sources were identified at four separate locations as shown on Figure 5 (GBA, 2002). The four areas have been designated as the Southeast, Southwest, Northeast, and Northwest Borrow areas. Each area was delineated to distinguish between those areas containing thicker deposits of sand up to 20 feet thick, and those deposits of sand approximately 10 feet thick. Table 3-2 presents a summary of the total area and total quantity of sand available at each site based on the reconnaissance subsurface investigations.

Table 3-2. Borrow Summary

Borrow Area	Area (acres)	Capacity (mcy)
Southeast	473	9.1
Southwest	211	4.2
Northeast	345	7.2
Northwest	170	4.6

The actual capacity of each borrow area would be reduced by that quantity of material lying within the footprint of the proposed dike alignment. In addition, it is desirable to limit borrow excavation to that portion of the borrow area that is located within the footprint of the proposed alignment to avoid disturbance of the bay bottom outside of the project limits. A detailed analysis of the borrow areas associated with each alternative alignment is presented Attachment A - *Borrow Analysis*. It should be noted that the borings providing the delineation and estimated borrow quantities are typically about 2,000 feet apart, thus representing up to 100 acres per boring. Therefore, until more detailed subsurface investigations are completed, there is significant uncertainty in the estimated borrow quantities shown above.

4. PLAN FORMULATION

4.1. Introduction

During the Plan Formulation stage, seven alternative alignments were evaluated. Six of these alignments were developed previously during the reconnaissance study performed for the Maryland Port Administration (EA, 2003). The alternative alignments consisted of extensions of the existing footprint including sites having 313, 630, 750 (four of the alternatives), and 1,129 acres. Each alternative included one to three segments, all of which were attached to the existing project. A seventh alignment, approximately 630 acres in size, was added during the early stages of Corps' plan formulation process. In addition, the Corps included consideration of raising the existing upland dikes to provide increased placement capacity within the existing project footprint.

Evaluation of the alternatives during the plan formulation process included environmental, cultural, real estate, engineering, agency comment, public comment, and other considerations. Early in the process, general indications were that the non-engineering considerations opposed alternatives located to the south and southwest of the existing project. Although the engineering analyses were still in progress, general engineering knowledge about site conditions at each of the alternative locations indicated that the southern and southwestern locations were also less favorable than the northern location. It was at this point that the seventh alternative, a 630-acre northern alternative was added to the original six alignments already being evaluated. Ultimately, the engineering screening process verified this early indication as described hereafter. The engineering process applied to the plan formulation phase included:

(a) Review of existing information. The majority of the existing information included the contents of the reconnaissance report prepared for the Maryland Port Administration for six potential expansion alignments.
(b) Screening the seven alternative expansion schemes (six Maryland Port Administration alternatives plus one additional developed by the Corps) to identify the preferred expansion location.
(c) Identification of the minimum expansion area required to satisfy typical annual dredged material placement needs.
(d) No additional subsurface investigations and laboratory testing of foundation soils and potential dike fill materials was performed prior to completing the formulation phase. Screening was based on the subsurface information acquired during the reconnaissance study.
(e) Conceptual design for potential raising of the upland dikes of the existing project.
(f) Recommended expansion alternative(s) from an engineering perspective to receive more detailed design analysis and evaluation.

The engineering evaluation consisted of an engineering screening process for the seven specific alternative alignments, supplemented by a series of generic placement analyses and analysis of the potential source of dike construction materials. These evaluation elements were the basis for defining the minimum expansion area and capacity that would be required to efficiently accommodate average annual dredged material placement needs, and to identify the optimum location for the expansion.

4.2 Description of Alternative Alignments

Following is a description of each alignment with an assessment of the foundation and borrow factors associated with each site.

4.2.1 Alignment 1. Alignment 1 is an extension to the southeast of existing Cells 5 and 6, and to the southwest of Cell 6. The alignment consists of 753 acres with the wetland habitat to the east, in line with existing wetland Cell 5, and two upland cells to the west, adjacent to existing upland Cell 6. Subsurface investigations have shown that significant portions of the proposed alignments are located in areas having soft clay and silt materials within the foundation. Significant portions of the adjacent Cell 6 dike required removal and replacement of very soft foundation soils beneath the dike alignment to assure satisfactory performance with respect to embankment slope stability and dike settlement. Portions of the Cell 5 and 6 dikes were also overbuilt to allow for additional long-term settlement. Surveys subsequent to the 2003 Isabel storm event have indicated that post-construction settlements did occur. Therefore, foundation conditions for Alignment 1 are considered marginal to poor for significant reaches of the primary dike system. The alignment incorporates approximately 160 of the 684 acres of the southeast and southwest borrow areas. The estimated borrow quantity available for dike construction within the proposed alignment footprint is approximately 4.8 mcy out of the 13.3 mcy associated with the two borrow areas. The available borrow quantity is significantly less than the 7.5 mcy required for dike construction.

4.2.2 Alignment 2. Alignment 2 has components of expansion to the southeast, southwest, and north of the project. The alignment consists of 754 acres with a wetland cell to the northeast adjacent to existing Cells 1 and 2, and two upland cells to the southeast and southwest, adjacent existing wetland Cell 5 and upland Cell 6. The foundation conditions for the southeastern and southwestern expansions are similar to the conditions described for Alignment 1 except that proportionally the southeastern alignment is associated with proportionally more unsuitable foundation conditions. The northern component of the expansion has more favorable foundation conditions. Overall, the foundation conditions are rated as marginal. The southeastern alignment incorporates none of the southeast borrow area, while the northeast component incorporates a significant portion of the northeast and northwest borrow areas. The estimated borrow quantity available for dike construction within the proposed alignment footprint is approximately 2.9 mcy out of the 25.1 mcy associated with the four borrow areas. The available borrow quantity is significantly less than the 7.1 mcy required for dike construction.

4.2.3 Alignment 3. Alignment 3 is very similar to Alignment 2 except that the southeastern component of the expansion is larger, and the northern component is smaller. The total area is virtually the same at 754 acres. The alternative has two wetland cells located at the southeast and northeast ends of the existing project adjacent to existing wetland Cells 1 and 5. Three proposed upland cells are located at the southeastern, southwestern and northern end of the project adjacent to existing upland Cells 2 and 6. The foundation conditions are very similar to those described for Alignment 2, and are therefore, rated as marginal. The borrow areas incorporated into the alignments will yield an estimated 3.5 mcy out of the total 25.1 mcy associated with the four borrow areas. The available borrow quantity is significantly less than the 9.6 mcy required for dike construction.

4.2.4 Alignment 4. Alignment 4 is similar to Alignments 2 and 3 except that the southeastern and northern expansion components are the largest potential expansion areas such that the total alternative area is 1129 acres. The alternative has two wetland cells located at the southeast and northeast ends of the existing project adjacent to existing wetland Cells 1 and 5. Three proposed upland cells are located at the southeastern, southwestern and northern end of the project adjacent to existing upland Cells 2 and 6. The foundation conditions are very similar to those described for Alignment 2, and are therefore, rated as marginal. The borrow areas incorporated into the alignments and the access channel will yield an estimated 5.9 mcy out of the total 25.1 mcy associated with the four borrow areas. The available borrow quantity is significantly less than the 12.3 mcy required for dike construction.

4.2.5 Alignment 5. Alignment 5 is similar to Alignment 4 except that the southwestern component has been eliminated reducing the total area to 749 acres. The alternative has two wetland cells located at the southeast and northeast ends of the existing project adjacent to existing wetland Cells 1 and 5. Two proposed upland cells are located at the southeastern and northern ends of the project adjacent to existing upland Cells 2 and 6. The foundation conditions are very similar to those described for Alignment 3, and are therefore, rated as marginal. The borrow areas incorporated into the alignments and the access channel will yield an estimated 5.8 mcy out of the total 20.9 mcy associated with the three borrow areas. The available borrow quantity is less than the 6.26 mcy required for dike construction.

4.2.6 Alignment 6. Alignment 6 is the smallest of the alternative alignments with only a northern expansion component totaling 313 acres. The alternative has one wetland and one upland cell adjacent to existing upland and wetland Cells 2 and 1. The foundation conditions, mostly sand with a limited zone of clay and silt, are more favorable than those alignments that include southern sites, and are rated as marginal to good. The borrow areas incorporated into the alignment and the access channel will yield an estimated 3.4 mcy out of the total 11.8 mcy associated with the two northern borrow areas. The available borrow quantity is more than the 2.8 mcy required for dike construction.

4.2.7 Alignment 7. Alignment 7 is similar to alignment 6 but expanded to the maximum limits that can be accommodated at the northern end of the project with a total area of 631 acres. The alternative has one wetland and one upland cell adjacent to existing upland wetland Cells 2 and 1. The foundation conditions, mostly sand with a limited zone of clay and silt, are slightly more favorable than alignment 6, and are rated as good. The borrow areas incorporated into the alignment and the access channel will yield an estimated 5.6 mcy out of the total 11.8 mcy associated with the two northern borrow areas. The available borrow quantity is more than the 4.8 mcy required for dike construction.

4.3. Preliminary Placement Analysis

Concurrent with the engineering screening process, preliminary analysis of dredged material placement was performed to determine whether the proposed alternatives could accommodate the anticipated average annual placement quantity of 3.2 mcy, and whether some sites could handle the quantity more efficiently than others. The results of this preliminary placement analysis were the basis for the input to the ranking for engineering screening factors **“a”** (**Potential Expansion Size**) and **“b”** (**Capacity of Expansion Components**).

The placement analysis included sites ranging in size from 300 to about 1,100 acres to include the range of actual alignments considered feasible from an engineering perspective. Initially, it was assumed that the sites would consist of 50 percent upland habitat, and 50 percent wetland habitat similar to the existing Poplar Island project. Subsequently, other placement analyses were performed for some of the alternatives at wetland proportions of 0 percent, 30 percent, 50 percent, 70 percent, and 100 percent. Later refinements added analyses of 40 percent upland and 60 percent wetland. The results of the analysis indicated that 60 percent wetland habitat is generally a practical upper limit that is consistent with efficient dredged material placement. Higher proportions of wetlands result in very inefficient placement of very small quantities of dredged material after the upland portion of placement site has been exhausted.

4.3.1 Purpose of Dredged Material Placement Analysis. During the initial years of placement of dredged material into the existing Poplar Island site, it has been generally understood that development of habitat, particularly wetland habitat, requires the carefully controlled placement of dredged material in a sequence that assures that the wetland cells will not be overfilled. This is to be accomplished by placing material into wetland cells in gradually diminishing increments over a period of years. It is also recognized that efficient use of upland capacity requires dredged material to be placed in relatively thin lifts so that the dredged material can be consolidated to a significant extent during the year or two before the surface is inundated by subsequent dredged material placement.

It had been anticipated that the average annual placement of dredged material at Poplar Island would be approximately 2 million cubic yards (mcy). During the initial year of placement, more than 6 mcy was placed into upland Cell 2 resulting in an extremely thick initial lift that was 3 to 4 times the desired lift thickness. This raised the concern that the upland placement capacity might be exhausted before placement of dredged material into wetland cells could be completed. Although the need to balance placement between upland and wetland cells was generally understood, it had not been formally or precisely quantified. Therefore, a placement analysis methodology was developed that could be applied to the exiting project over its remaining life, and the potential expansion projects under consideration. The primary purpose of the analyses was to determine:

- The remaining placement life of the existing Poplar Island project up to the maximum authorized upland elevation of +20 ft MLLW.
- A reasonable sequence of dredged material placement and cell development for the existing Poplar Island project employing efficient placement and site development methods.
- The minimum expansion project size that would support future dredged material placement requirements.
- The maximum percentage of wetlands that can be efficiently supported in the various expansion alternatives.
- The maximum potential vertical expansion of existing upland cells that can be achieved based on technical limitations such as containment dike stability.

- The maximum desirable vertical expansion of the existing upland cells that would expand the percentage of the expansion area devoted to wetlands.

4.3.2 Placement Criteria. The placement analysis consists of a mathematical model of the incremental placement of dredged material beginning with empty cells until the entire upland and wetland placement capacity has been exhausted. In order to complete the analysis, it was necessary to establish criteria by which all of the potential sites would be evaluated. These criteria focused primarily on dredged material placement needs and habitat development constraints that were developed during the initial 3 years of placement and site development at the existing Poplar island project. A detailed description of the criteria used to develop the placement analysis is presented in Attachment C – *Placement Analysis Criteria.*

4.3.3 Analysis of Expansion Alternatives: Dredged material placement analyses were conducted for potential expansion sites having areas of 313, 630, 750, and 1,129 acres representing all seven plan formulation alternative alignments. Although analyses were performed for a wide range of upland-wetland proportions, most of the analyses during the plan formulation phase focused on a 50 percent upland and 50 percent wetland split. Later, analyses were also performed for a generic 500-acre site, and schemes where the existing project upland cells would be raised by 5, 10, and 15 feet without a lateral expansion project. These analyses were used, along with the engineering screening process, ultimately identified the northern expansion location as the most desirable expansion site. A subsequent series of analyses were performed to identify the minimum expansion size, the upland/wetland ratio, and dike raising height that would support dredged material placement needs and habitat development in an efficient manner.

4.3.4 Plan Formulation Alternatives at 50 Percent Wetlands: As shown in Table 4-1 below, the placement analysis has shown that the potential alternatives could provide additional placement capacity ranging from approximately 12 to 40 mcy assuming an expansion area consisting of 50 percent wetlands and 50 percent uplands.

The 313-acre alternative was particularly deficient in that it provided only 3 additional years of placement life, and upland capacity would be exhausted at the same time that wetland placement was complete. That would provide no contingency to accommodate placement or wetland cell development problems. The placement analysis indicated that a 630-acre site would provide sufficient capacity to extend the project placement capacity for an additional 7 years, and would provide upland placement capacity extending at least a year beyond wetland placement. Consequently, another generic alternative having 500 acres was added to the placement evaluation suite to better define the minimum expansion area required to satisfy minimum placement requirements. The placement analysis generally showed that a site having a minimum area of approximately 500 acres will marginally satisfy placement requirements.

The analysis shows that the upland placement capacity of sites between about 500 and 1000 acres would be exhausted within 1 year of final wetland placement. Further, upland cell overloading is necessary over the last 5 to 8 years of placement to accommodate the required 3.2 mcy per year. Therefore, all of the alternatives between 500 and 1000 acres are considered marginally acceptable with respect to placement capacity. The primary means of increasing the duration of upland placement capacity include: (1) increase the percentage of upland placement area within the expansion scheme, or (2) raise the final placement elevation of the existing upland cells above the currently authorized +20 ft MLLW.

Table 4-1. Expansion Alternatives at 50 Percent Upland & 50 Percent Wetland

Alternative	Total Area (acres)	Wetland Area (acres)	Capacity (mcy)	Last Year at 3.2 mcy	Years of Cell Overload	Last Wetland Placement Year	Last Placement Year
Existing 1140-Acre Project	1140	570	40.4	2014	6	2014	2015
313 Acre Expansion	1453	727	52.0	2017	6	2018	2018
500 Acre Expansion	1640	820	58.8	2020	5	2020	2021
630 Acre Expansion	1770	885	63.6	2021	6	2021	2022
750 Acre Expansion	1890	945	67.2	2022	5	2022	2023
1,129 Acre Expansion	2269	1134	82.0	2027	8	2026	2028

4.3.5 Plan Formulation Alternatives that Include Dike Raising: Raising the existing upland dikes 5 feet would provide an additional 6 mcy of placement capacity. At an average annual placement rate of 3.2 mcy per annum, the additional capacity adds approximately 2 additional years to the upland placement capacity. This increase in placement duration is a function of the height of the dike raising and is independent of the size of the expansion alternative. The additional 2 years provides a significant additional contingency that might be needed to recover from extreme weather conditions that prevent cell grading, or a slower rate of consolidation of thicker dredged material layers within some of the proposed wetland cells. The maximum raising that can be accomplished is approximately 15 feet because of slope stability limitations. A 15-foot raising would provide 17 to 18 mcy, and about 5 to 6 additional years of placement life for the existing project. In theory, the additional upland capacity might allow an expansion area to be devoted to a higher percentage of wetland habitat while still satisfying efficient placement criteria. However, since extensive borrow materials cannot be obtained from wetland cells, there is a minimum percentage of each of the sites that must be designated as upland from which borrow materials can be obtained. That factor is addressed in more detail in paragraph 4.4 below.

Table 4-2 below shows the typical increase in site capacity and duration of placement for dike raisings ranging from 5 to 15 feet (final upland elevations +25 and +35 respectively) in conjunction with a typical 630-acre expansion site.

Table 4-2. 630-Acre Expansion Alternative at 50 Percent Upland & 50 Percent Wetland with Dike Raising

Expansion Alternative	**Upland Area (acres)**	**Wetland Area (acres)**	**Total Capacity (mcy)**	**Last Year at 3.2 mcy**	**Years of Cell 6 Overload**	**Last Wetland Placement Year**	**Last Upland Placement Year**
50% Upland & 50% Wetland with **Raising to +25** MLLW	885	885	69.6	2022	2	2021	2025
50% Upland & 50% Wetland with **Raising to +35** MLLW	885	885	81.7	2027	2	2021	2028

The table also shows that the number of years of overloading cell existing Cell 6 would be decreased significantly from 5 to 8 years without a raising, to 2 or 3 years with a raising. In this example, the placement life of the project increases to 10 or 13 years beyond the projected 2015 filling date for the existing project.

4.4 Preliminary Borrow Evaluation

The source of borrow material for containment dike construction is also a critical factor in the engineering screening process. To provide a basis for comparing alternatives, an evaluation of each potential borrow source was performed as it applied to each of the alignment alternatives. The borrow evaluation compared the quantity of borrow material available for construction that could be obtained from within the alignment footprint to the quantity required to construct the dikes for that alternative. Those alternatives requiring areas outside of the alignment limits to be disturbed to obtain sufficient borrow received a lower ranking. Generally, those alternatives located to the north of the existing project were most favorably ranked because of the location and quantity of available material in comparison to the proposed dike alignments. An assessment of the ratio of borrow available to borrow required is presented in each of the alternative evaluations in paragraph 4.2. A more detailed presentation of the borrow analysis is presented in Attachment A – *Borrow Analysis*.

4.5. Engineering Screening

A total of seven expansion alignments, including areas to the south, southwest and north of the existing project, were evaluated to determine the suitability of each alternative with respect to engineering considerations. Each site was subjected to a screening process that considered nine engineering factors, with the factors weighted according to their relative importance. The nine factors included:

1. Potential Expansion Size (area in acres)
2. Additional Placement Capacity (cubic yards)
3. Foundation Conditions that would affect dike construction cost
4. Borrow Material Quantity and Quality
5. Borrow Material Location
6. Depth of Water that would affect dike construction cost

7. Length of Access Channel that would affect construction & maintenance cost
8. Armor Stone Size that would affect initial construction cost
9. Dredged Material Haul Distance

The initial ranking was then adjusted by weighting the individual screening factors based on their relative importance. A detailed explanation of each of the screening criteria and weighting factors is presented in Attachment B – *Engineering Screening*.

4.6 Initial Engineering Ranking

Table 4-3 presents the initial non-weighted rankings for each of the seven alternative alignments for each of the nine engineering factors.

Table 4-3. Initial Engineering Ranking

CRITERIA	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7
Potential Expansion Size (ac)	*750 ac*	*750 ac*	*750 ac*	*1120 ac*	*750 ac*	*313 ac*	*630 ac*
Ranking	**3**	**3**	**3**	**4**	**3**	**2**	**3**
Additional Capacity (mcy)	*26.8 mcy*	*26.8 mcy*	*26.8 mcy*	*41.6 mcy*	*26.8 mcy*	*11.6 mcy*	*23.2 mcy*
Ranking	**3**	**3**	**3**	**4**	**3**	**1**	**3**
Foundation Material	*sandy silt & clay-fair to poor*	*sandy silt & clay -fair*	*sandy silt & clay -fair*	*sandy silt & clay -fair*	*sandy silt & clay -fair*	*silty sand & clay - fair to good*	*silty sand-good*
Ranking	**2**	**2.5**	**2.5**	**2.5**	**2.5**	**3.5**	**4**
Borrow Material Quantity & Quality	*fair/mixed*	*fair /mixed*	*fair/mixed*	*fair/mixed*	*fair/mixed*	*good*	*very good*
Ranking	**2.5**	**2**	**3**	**3**	**2.5**	**4**	**4.5**
Borrow Material Location	*64% inside*	*41% inside*	*36% inside*	*48% inside*	*92% inside*	*100% inside*	*100% inside*
Ranking	**3**	**2**	**2**	**2**	**4**	**5**	**5**
Depth of Water at Site (feet)	*0-10 (6)*	*0-10 (6)*	*0-10 (6)*	*0-10 (6)*	*0-10 (6)*	*0-10 (6)*	*0-10 (6)*
Ranking	**3**	**3**	**3**	**3**	**3**	**3**	**3**
Length of Access Channel (mi)	*0.5 to1 mi*	*0.5 to1 mi*	*0.5 to1 mi*	*0.5 to1 mi*	*0.5 to1 mi*	*<0.5 mi*	*<0.5 mi*
Ranking	**3**	**3**	**3**	**3**	**3**	**5**	**5**
Armor Stone Size (lbs)	*1500-3000 lbs*	*1500-4000 lbs*	*1500-4000 lbs*	*1500-4000 lbs*	*1500-4000 lbs*	*1500-4000 lbs*	*1500-4000 lbs*
Ranking	**3**	**2**	**2**	**2**	**2**	**2**	**2**
Dredged Material Haul Distance (mi)							
Ranking	**0**	**0**	**0**	**0**	**0**	**0**	**0**

4.7 Final Engineering Ranking

The engineering criteria do not all carry the same level of importance. Those factors associated with the source and quality of borrow materials for dike construction are critical with respect to initial construction cost and potential environmental impacts. Although the haul distance for dredged materials is not a significant factor in this evaluation since all of the alternatives are located approximately the same distance from the average dredging locations, it would potentially have a significant impact on cost and would be weighted more heavily than other engineering factors.

Table 4-4. Final Weighted Engineering Ranking

CRITERIA	Weight Factor	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7
Potential Expansion Size	***1***	3	3	3	4	3	2	3
Additional Capacity	***2***	6	6	6	8	6	2	6
Foundation Material	***2***	4	5	5	5	5	7	8
Borrow Material Quantity & Quality	***3***	7.5	6	9	9	7.5	12	13.5
Borrow Material Location	***3***	9	6	6	6	12	15	15
Depth of Water at Site	***2***	6	6	6	6	6	6	6
Length of Access Channel	***2***	6	6	6	6	6	10	10
Armor Stone Size	***1***	3	2	2	2	2	2	2
Dredged Material Haul Distance	***3***	0	0	0	0	0	0	0
Total Weighted Score	--	**44.5**	**40**	**43**	**46**	**47.5**	**56**	**63.5**
Ranking	--	**5**	**7**	**6**	**4**	**3**	**2**	**1**

4.8 Alternative Recommended by Engineering Screening Process

Based on the engineering screening process, alternatives 6 and 7, the two northern alternative alignments, received the highest ranking with respect to engineering considerations. These two sites have more favorable foundation conditions, better quality borrow sources, and incorporate more of the borrow areas within the footprint of the proposed alignments than is typical of the southeastern or southwestern expansion areas. It also appears that the required access channel for the northern alternatives 6 and 7 would be shorter than those required for the southern areas, and would generate a relatively high proportion of excavation material that could be used in the dike construction. Of the two alternatives, No. 7 is ranked the highest because it can accommodate the anticipated average annual dredged material placement quantity more efficiently than alternative No. 6.

It is recommended that the entire area north of the project, consisting of approximately 1,000 acres bounded by the existing oyster bars to the west, north, and east, be included for consideration of any expansion alignment. Additional engineering, environmental, and cultural investigations of the entire area should be conducted so that an optimum expansion alignment can be determined after that additional information has been collected. Based on the results of the preliminary placement analysis and borrow evaluation, a preliminary alignment consisting of not less than 500 acres should be developed and additional engineering investigations and analyses should be performed. These additional investigations will provide the basis for refinements of dike alignment, internal configuration of upland and wetland cells, dike sections, and other pertinent engineering features.

5. DEVELOPMENT OF RECOMMENDED EXPANSION ALTERNATIVE.

5.1 Introduction

5.1.1 Results of Plan Formulation. As a result of the plan formulation process, a 1,000-acre area located north of the existing project was identified as the preferred location for an expansion project. The engineering analyses concluded that the expansion alternative should be a minimum of 500 acres in size to accommodate average annual dredged material placement needs of approximately 3.2 million cubic yards (mcy), and that the expansion site should consist of a minimum 50 percent wetland habitat. At 50 percent wetlands, a 500 to 600 acre expansion site was determined to be *marginally* acceptable with respect to: (1) its capacity to accommodate required annual dredged material placement, and (2) its capacity to provide sufficient dike fill material for dike construction from borrow sources located within the footprint of the upland cells of the expansion footprint. This marginal status can be improved by either reducing the wetland component below 50 percent of the total area – an option that is not supported by various non-engineering factors – or by raising the existing upland dikes to increase the upland placement capacity. The later option has been addressed in more detail in the subsequent design analyses presented hereafter. It was recommended that additional engineering investigations and analyses be performed to optimize the recommended alignment for an expansion project, and to support the development of a detailed design of the various alignment features.

5.1.2 Additional Investigations and Design. The recommended additional engineering tasks include:

- Perform additional subsurface investigations and laboratory testing for both the expansion area and the existing upland cells subject to potential raising. These investigations will provide information on the foundation conditions that would affect dike and access channel alignment selection and dike raising limits, and provide better definition of borrow resources.
- Perform a series of detailed dredged material placement analyses to determine the appropriate total acreage for the final alignment, and the optimum internal distribution of upland and wetland habitat. This analysis will also determine the benefits of placement capacity added through dike raising, and help to define the optimum raising height.
- Apply the knowledge gained from recently raising the dikes of existing upland cell 2 to potential additional dike raising schemes.
- Perform slope stability analysis on the existing upland dikes to determine the upper limit, and appropriate construction staging that would be necessary.
- Develop a revised northern alignment based on the above investigations and analyses, and maintain coordination with other design team members to assure appropriate consideration of non-engineering issues.
- Incorporate coastal and hydraulic engineering considerations into design of such features as the dike section, stone armor protection, internal tidal gut and wetland channel systems.
- Provide updated cost estimate based on recommended expansion scheme.

5.2 Preliminary Alignment

Based on previous analysis and engineering judgement, a preliminary northern alignment containing approximately 550 acres was developed. Preliminary subsurface information suggested that very soft deep deposits of silt and clay located along the western limits of the study area should be avoided if possible. The information also indicated that the primary source of borrow sand was along the eastern side of the study area. Therefore, the upland portion of the expansion area was located on the eastern half of the preliminary alignment in contrast to the typical arrangement of the existing project. Because of the exposure of the expansion to high wave energy to the west, north, and northeast, it was considered unlikely that wetland cells would be opened directly to the Bay as they are in the existing Poplar Island project. Therefore, the preliminary expansion layout included a tidal gut feature that was intended to supply water needed for tidal flushing of wetland cells. Preliminary dike sections were based on the dike sections of the adjacent Phase I project where the top elevation of the armored dike section was approximately 10.5 ft MLLW. Stone armor sizes were also assumed to be the same as the adjacent Phase I armor.

5.3 Subsurface Investigations

5.3.1 Previous Investigations. During the design and construction of the original Poplar Island project (approximately 1994 through 2000), extensive subsurface investigations were performed. Most of the investigations were located within the footprint of the existing project, but some of the borings extended to the north, south, and southwest of the existing project. Those original investigations provided some useful subsurface information for each of the expansion alternatives, particularly where the expansion footprint connects to the existing project.

5.3.2 Reconnaissance Study Investigations. During November and December 2001, fifty six (56) borings were drilled to depths of 30 to 70 feet and samples were obtained to investigate six alternative alignments associated with the reconnaissance studies for the expansion of Poplar Island. Laboratory testing included grain size analyses for basic soil classification, and tests to determine shear strength and compressibility characteristics of the fine-grained (clay and silt) soils. Field-testing included cone penetrometer and vane shear tests at several locations. The grain size analyses on sandy soils provided information about the location, quantity, and quality of potential borrow materials for dike construction. Logs for all of the borings and results of laboratory testing are presented in the *Geotechnical Reconnaissance Study for Poplar Island Modifications, Chesapeake Bay, Maryland* (E2CR, 2002).

5.3.3 Expansion Study Investigations. The current expansion study considered the potential for expanding the existing project in a manner similar to the schemes presented in the reconnaissance study, and the potential for increasing placement capacity by raising the existing upland cells. Reconnaissance study investigations were considered sufficient to conduct the initial plan formulation screening.

Since raising the existing upland cells is necessarily fixed to the current location of the cells, subsurface investigations of the existing dike foundations were undertaken early in the study. During the early phases of the current expansion study, most of the potential lateral expansion alignments were dismissed from further consideration except for the alignments associated with the northern end of the existing project. Once that screening process had been completed, an additional phase of subsurface investigations was performed.

5.3.3.a Dike Raising Investigations. During April 2003, eleven (11) borings were completed to investigate subsurface conditions related to the potential raising of the existing upland cell dikes to elevations above +25 ft MLLW. Eight of the borings were located along the perimeter of Cell 2, and three borings were located at locations on the perimeter of Cell 6. The borings were typically drilled to a depth of 40 feet from a starting elevation of approximately +10 ft MLLW with the purpose of intercepting foundation clay materials that are critical to the analysis of the slope stability of the containment dikes. Twelve undisturbed samples of the clay were obtained and laboratory testing included undrained triaxial shear testing and consolidation testing of selected samples.

The primary goal of the dike raising investigations was to obtain samples of the weaker clay strata beneath the dike that were not removed and replaced during the original construction. These clays represent the weakest materials within the dike foundation and control the maximum height of dike raising. It is anticipated that these clays may have consolidated under the load of the dikes and gained additional strength compared to their original pre-dike strengths. Logs of the completed borings and results of laboratory testing are presented in Attachment E – *Subsurface Investigations and Laboratory Testing.*

5.3.3.b Northern Expansion Investigations. Thirty-four (34) borings were completed to investigate subsurface conditions for the northern expansion area supplementing approximately 30 borings that had previously been completed in the area. Those borings generally associated with the potential dike alignment were drilled 25 feet into the bay bottom deposits, and those borings associated with potential borrow materials sources were drilled up to 40 feet into the bay bottom deposits. Samples of the foundation soils were recovered for classification testing in the laboratory. Several undisturbed Shelby tube samples of the foundation clay deposits were also recovered. Logs of the completed borings and results of laboratory testing are presented in Attachment E – *Subsurface Investigations and Laboratory Testing*. Logs for previous borings are presented in previously published reports.

The additional drilling provided information needed to delineate two distinct subsurface conditions within the northern expansion area. The foundation within the western portion of the area, extending approximately 3,000 feet to the north of the existing project, consists of a deep deposit of medium to very soft clay. To the extent possible, the weakest and deepest of these clay deposits should be avoided for dike foundations. Where they are unavoidable, a portion of these clay materials may have to be removed and replaced with suitable sand backfill. Several undisturbed Shelby tube samples of the clay deposits were obtained for laboratory testing.

The remainder of the expansion area generally has a sandy bottom with the thickness of the sand deposit ranging from 10 to about 25 feet. Results of grain size analysis testing indicate that the fine sand (mean grain size equivalent to a No. 70 sieve) contains an average of approximately 14 percent fines (percent passing the No. 200 sieve) and would be suitable for dike construction. A detailed analysis of the quantity and quality of the sand borrow materials is addressed in Attachment A –Borrow Analysis.

5.4 Dike Raising

5.4.1 Slope Stability and Construction Methodology. The stability of potential raised dike sections was analyzed using the Corps of Engineers computer program UTEXAS4. A detailed summary of the analysis is presented in Attachment D – *Slope Stability Analysis.* The analysis determined that dike raisings to maximum elevation +40 ft MLLW can be accomplished following a controlled sequence of dike fill and dredged material placement that will assure the required balance of driving and resisting forces. A temporary +40 ft MLLW dike crest elevation would allow dredged material to be placed to approximately elevation +35 ft MLLW within the cell. The maximum dike elevation is controlled by the strength of clay deposits with the foundation beneath the dike and a desired minimum factor of safety of 1.3 for potential failure that would release dredged materials into the Chesapeake Bay.

The upland dikes surrounding Cell 2 are currently at elevation +23 ft MLLW, and Cell 6 dikes will be raised to the same elevation within the next two years. Raising to the next stage, elevation +30 ft MLLW, cannot be accomplished until the dredged material within the upland cells has been raised to approximately elevation +15 ft MLLW at all locations within the cell. A large portion of the dredged material placement during 2004 and 2005 will be directed toward the northern end of Cell 2 to initiate filling of the cell to accommodate future cell raising above elevation +23 ft MLLW if that proposal is adopted as part of the final expansion scheme. The existing dike section has been configured with a working bench along the interior of the cell to support crust management activities. The initial stage of dike raising would be founded on the existing sand bench surface. Raising to elevation +30 ft MLLW would be accomplished using sand stockpiled on site and mechanically placed and compacted with bulldozers to achieve desired engineering properties. Any raising above elevation +30 ft MLLW would be accomplished with sand placed on the crest of the existing dike and extending into the cell on a surface crust of dried dredged material built up to a thickness sufficient to support the raised dike section. It is anticipated that each increment of raising would be not more than 5 ft thick. A plan showing the limits of the anticipated dike raising is presented as Figure 6. A typical section of the anticipated dike raising is presented as Figure 7.

5.4.2 Preliminary Placement Analysis for Dike Raising. Raising the existing upland dikes 5, 10 or 15 feet would provide an additional 6, 12, or 18 mcy of placement capacity respectively. This scheme is a very cost-effective means of providing significant additional placement capacity, since the dike raising would be accomplished primarily with sand and little or no additional stone erosion protection. However, since the existing 1,140-acre site is undersized to accommodate 3.2 mcy annually efficiently, all of the additional placement would be accomplished by overloading the existing upland cells each additional placement year. Therefore, it is unlikely that all of the theoretical additional placement capacity would be fully realized before placement into the cell was terminated to permit development of the upland habitat. Table 5-1 shows a summary of the additional capacity and project life that results from raising the existing upland cells without consideration of lateral expansion of the existing project limits.

Table 5-1. Existing 1140-Acre Placement Site with Uplands Raised 5 to 15 feet

Expansion and/or Raising Alternative	Total Area (acres)	Upland Area (acres)	Wetland Area (acres)	Total Capacity (mcy)	Last Year at 3.2 mcy	Years of Cell 6 Overload	Last Wetland Placement	Last Upland Placement
Existing 1140-acre Project with **Upland Raised to +25**	1140	570	570	**46.4**	2016	8	2014	2017
Existing 1140-acre Project with **Upland Raised to +30**	1140	570	570	**52.4**	2018	10	2014	2019
Existing 1140-acre Project with **Upland Raised to +35**	1140	570	570	**58.4**	2020	12	2014	2020

5.4.3 Implications of Dike Raising. To realize the full upland capacity, the development of the upland habitat will be delayed significantly beyond the completion of the final dredged material placement. It is estimated that the delay would be in the range of 3 to 5 years. If the delay is not acceptable, a significant portion of the theoretical placement capacity will be lost because it is not practical to postpone habitat development until consolidation is complete.

It should also be recognized that without lateral expansion, all additional capacity is associated with upland placement, and there is no increase in wetland habitat area. However, if the existing upland capacity is increased in combination with a lateral expansion, the ability to accommodate placement difficulties (such as occasional cell overloading, extremely wet years that preclude wetland cell grading, etc.) is significantly enhanced. If the expansion project is designed to allow areas initially designated as upland to be shifted to wetland habitat during the development of the project, it may be possible to shift from 50 percent wetland habitat toward an upper limit of about 60 percent wetlands. The current configuration of the northern expansion alignment has designated a 40-acre upland cell within the northern expansion alignment might be re-designated as wetlands at some point after the completion of the initial containment dikes and the initial dredged material placement.

5.5 Borrow Area Evaluation

5.5.1 Borrow Area Limits. Additional investigations of the northern study area consisted of 34 new borings to supplement the approximately 30 borings completed in the northern study area during earlier phases of investigation. Based on the additional investigations, the delineation of the northern borrow area was refined and the estimated quantity of available sand borrow material was refined. Suitable sand for dike construction is located along the eastern and northern portions of the limits of the northern expansion area. The sand deposit ranges from less than 10 feet to slightly less than 25 feet in thickness, and is underlain by a clay stratum. The thickest sand deposit, between 20 and 25 feet in thickness, is located within approximately 80 acres of the southeastern portion of the northern expansion area. The sand deposit diminishes in thickness as it extends to the north where it is less than 10 feet thick.

5.5.2 Borrow Excavations. To the maximum extent practicable, borrow materials will be obtained from within the proposed upland cells of the expansion area, and from the required access channel and turning basin excavations. During the construction of the current Poplar island project, most of the required borrow materials were obtained from locations within wetland cells 3, 4, and 5. The deep depressions left in those cells significantly increased the thickness of dredged material and resulted in a wide variation in dredged material thickness within the cells. The consequent large differential in settlement of the dredged material consolidation will make it very difficult to achieve the extremely narrow range of target elevations (between elevation +1.2 and +1.8 ft MLLW) required for low marsh wetland habitat. Therefore, borrow sites will be excluded from wetland cells to the maximum extent possible. If unavoidable, borrow excavations will be completed to a uniform depth across the entire cell and the total depth will be kept to less than about 12 to 15 ft. However, such excavations would only be considered if all potential external borrow sources have been exhausted.

5.5.3 Borrow Quantity. Given that the proposed expansion site will contain approximately 550 acres of upland and wetland habitat, not more than 275 acres (50 percent) of that area will consist of upland habitat. After reducing the potential borrow area for the dike footprint and an appropriate setback from the toe of the dike, approximately 200 acres would remain for borrow excavation. That area would yield an estimated 5.7 million cubic yards (mcy) of sand for construction of the expansion project. That quantity is approximately 1.75 times the estimated quantity of material need for dike construction and is considered marginally sufficient to satisfy the project needs. While it has been considered preferable to identify borrow sources containing approximately twice the dike volume, the extremely high quality sand deposits in the northern study area should result in a decreased loss of fines during dredging, as well as superior engineering properties in place in the dike section. The reduction in loss of fines allows the borrow ratio of 1.75 to be considered acceptable provided dike construction is accomplished by stockpiling and mechanical placement methods (as used to construct Poplar Island Phase I and Phase II dikes) rather than direct hydraulic placement (as used to construct Hart-Miller Island dikes).

If the wetland area is expanded to 60 percent of the site, the upland proportion of the expansion area will be reduced to about 220 acres (40 percent of the area), and the potential borrow yield will be reduced to approximately 5.2 mcy. That quantity is approximately 1.6 times the estimated quantity of material need for dike construction of the expansion dikes. Therefore, it is likely that additional borrow materials would be required from borrow sources outside of the expansion footprint. A summary of available borrow quantities compared to required dike fill quantities is presented below in Table 5-2.

If the upland Cells 2 and 6 of the existing project are raised to allow the final upland elevations to be raised to elevation +25 ft MLLW, an additional 450,000 cy of borrow sands would be required (the in-situ borrow quantity should be approximately 800,000 to 900,000 cy to provide the required dike raising quantity). These materials would have to be obtained from other borrow sources outside of the expansion area. The two most likely sources include the borrow area to the southwest of existing cell 6, or sand obtained from required dredging of the shipping channels. The southwest borrow area is estimated to contain approximately 4.2 mcy (GBA, 2003) of suitable sand for dike construction. The southwest borrow area was partially utilized for the construction of the Phase II portion of the original project. That area, expanded to the south and southwest, will also be used as a source of materials for the completion of the Phase II construction. The remaining work consists of closure of the opening at the south end of Cell 6, and raising of the Cell 6 dikes to the height required to for placement of dredged material to elevation +20 ft MLLW requiring approximately 1.0 mcy of sand. Therefore, it appears that the southwest borrow area can accommodate the borrow requirements for both the completion of the existing project and the raising of the upland cells associated with the expansion project. A detailed evaluation of the potential use of all borrow areas and materials obtained from required access channel excavations is presented in Attachment A – *Borrow Analysis*.

Table 5-2. Analysis of Northern Borrow Area

	Site	Sub-Area (acres)	Avg. Sand Thickness (feet)	Borrow Volume (mcy)	Borrow Available (mcy)	Borrow Quantity Required
550 ACRES 50%wetland-50%upland	Borrow "A"	86.8	22.5	3.15	1.80	--
	Borrow "B"	47.2	12.5	0.95	0.54	--
	Borrow "C"	37.8	17.5	1.07	0.61	--
	Channel	10.2	15	0.25	0.14	--
	Basin	20.1	10	0.32	0.18	--
	Total	**202.0**	**--**	**5.7**	**3.3**	**3.3**
	Ratio of Total Borrow Volume to Borrow Required					**1.74**
550 ACRES 55%wetland-45%upland	Borrow "A"	86.8	22.5	3.15	1.80	--
	Borrow "B"	27.5	12.5	0.56	0.32	--
	Borrow "C"	37.8	17.5	1.07	0.61	--
	Channel	10.2	12.5	0.20	0.12	--
	Basin	20.1	12	0.39	0.22	--
	Total	**182.4**	**--**	**5.4**	**3.1**	**3.3**
	Ratio of Total Borrow Volume to Borrow Required					**1.63**
550 ACRES 60%wetland-40%upland	Borrow "A"	86.8	22.5	3.15	1.80	--
	Borrow "B"	23.0	12.5	0.46	0.26	--
	Borrow "C"	34.5	17.5	0.97	0.56	--
	Channel	10.2	12.5	0.20	0.12	--
	Basin	20.1	12	0.39	0.22	--
	Total	**174.4**	**--**	**5.2**	**3.0**	**3.3**
	Ratio of Total Borrow Volume to Borrow Required					**1.57**

5.5.4 Borrow Material Quality. A total of 71 gradation tests were performed on samples from the sand deposits in the northern study area. A summary of the gradation testing results is presented in Table 3-2 in Attachment A – *Borrow Analysis*. While not all of the sands tested will end up within the borrow limits, the tests are indicative of the quality of the materials that will be used for dike construction. The borrow materials in the northern borrow deposits contain an average of approximately 14.4 percent fines. The actual fines content ranged from a low of 2 to 3 percent to a high approaching 50 percent fines. More than 75 percent of the 71 samples tested contained 20 percent or less fines, and only 10 percent contained more than 30 percent fines.

Therefore, this sand deposit is an excellent source of materials with respect to quality of material required for dike construction.

The quality of the borrow material is primarily defined by the percentage of fines (percentage by weight passing a standard No. 200 sieve) within the sand. Fines are the silt and clay size portion of the borrow materials. A significant portion of these fine materials, and some of the fine sand fraction, will be washed away when the sand is dredged for use in dike construction. While that loss of fines improves the engineering properties of the sand, it reduces the quantity available for construction. It is generally estimated that 15 to 25 percent of the quantity excavated by dredging will be lost. As the percentage of fines at the borrow source increases, the percentage lost in the dredging process also increases. Since this deposit has a low average fines content, the percentage lost can be expected to remain near the low end of the typical 15 to 25 percent range.

A lower fines content at the borrow source will result in a lower fines content in the sand placed in the dike section. It is desirable to maintain the fines content in the dike fill below 30 percent to assure that the material properties are dominated by the sand fraction rather than the weaker and less permeable clay and silt materials. Because of the low average fines content in this deposit, the resulting fill properties can be expected to be excellent with limited pockets of marginal material.

5.6 Northern Dike Alignment

The subsurface exploration and borrow analysis generally confirmed the results of previous investigations. There were minor adjustments to the limits of the borrow areas and the estimated borrow quantities, but they did not require significant changes to the preliminary expansion alignment.

5.6.1 Layout. The alignment encompasses approximately 575 acres with 25 acres associated with a tidal gut that passes through the center of the site between the upland and wetland areas. The preliminary tidal gut is approximately 200 to 250 feet wide and has been modeled after the tidal gut separating the southern portion of the existing project and Coaches Island. Detailed hydraulic modeling could result in refinements of the tidal gut size and alignment as needed to accomplish the required tidal exchange with the wetland habitat. Parallel sand dikes will be constructed to define the tidal gut during the initial construction of the expansion. The bottom elevation of the channel will be raised to the desired level using clay excavated from the access channel. Under normal tidal conditions, the anticipated velocities in the channel are expected to be very low. The sides of the tidal gut sand dikes will be constructed with materials that will be resistant to erosion. This may be accomplished by using clay from required excavations, or by using a geosynthetic matting material that is incorporated into the root system of vegetation planted to stabilize the sand surfaces.

The upland cells remain on the eastern side of the site overlying the primary borrow sources and the wetlands are located to the north and west. Preliminary hydraulic modeling indicates that storm surge and wave action from hurricane events may pose a greater threat to the eastern side of the expansion. The western side is more exposed to wave activity associated with storm events from the west and north. Therefore, heavier stone armor will be provided on the western and northern sides of the expansion.

5.6.2 Foundation Issues. The subsurface exploration has further confirmed the presence of a deep deposit of very soft silt and clay along the western side of the site. The western dike alignment has been curved around the worst of the soft deposits to minimize the need to remove and replace these materials, and to minimize the risk of post-construction settlement of the containment dike. It is likely that not all of the very soft materials can be avoided and that some removal and replacement with suitable sand will be necessary. Final subsurface investigations will provide the data need to more precisely define the removal quantities. Based on the current subsurface data, it is estimated that approximately 50,000 cy of removal and replacement of unsuitable material will be necessary.

The remainder of the alignment foundation consists primarily of sand deposits, or sand overlying stiffer clays that should be able to support the dike without concern for slope stability or excessive settlement.

5.6.3 Borrow Issues. The borrow area analysis indicates that there is marginally sufficient material to support construction of the dikes for a project consisting of 50 percent uplands with a ratio of *borrow available to borrow required* of 1.75, slightly less than the desired 2.0. The ratio decreases to 1.63 and 1.57 for upland areas of 45 percent and 40 percent respectively as the project shifts toward a higher proportion of wetlands. Additional borrow can be obtained from the southwest borrow site where an estimated 4.2 mcy of sand is available to complete both the remaining dike construction work for the existing project, and to supplement the potential expansion and dike raising projects. The borrow deposit consists of very high quality sand averaging less than 15 percent fines, which should minimize losses during dredging and result in very favorable engineering properties as dike fill.

5.6.4 Tidal Gut. The 60 percent wetland, 40 percent upland and 50 percent wetland, 50 percent upland alternatives include a tidal gut passing through all of the wetland cell(s) with an opening at both the northern and southern end of the expansion footprint. This feature is the primary means of supplying tidal flow to the wetland habitat. The initial concept was to provide a channel similar in width to the 200 to 250 foot wide tidal gut between the southern portion of the existing project (i.e. cell 5) and Coaches Island. Preliminary modeling has indicated that a narrower channel, 100 to 150 feet wide, with only a single opening at the southern end of the channel, may provide satisfactory tidal flushing action. However, it may still be desirable to have a northern opening to allow increased flows through the channel, at least during the development stage when discharge associated with dredged material placement will occur. The current concept is that a control structure, consisting of ten large diameter pipes and stoplog closures would be constructed at the northern end of the tidal gut. The structure may remain closed under normal conditions, and only be opened if additional flow is need to address temporary water quality conditions. The final dimensions and alignment of the tidal gut and control features will be determined following more detailed hydraulic modeling.

Constructing unarmored containment dikes along both sides of the proposed alignment will create the tidal gut. These dikes will be composed primarily of sand with appropriate surface stabilization to minimize erosion and deposition that could affect the hydraulic efficiency of the gut during dredged material placement. The bottom elevation could be raised from the current -8 to -12 ft MLLW elevations to -4 to -6 ft MLLW using clays dredged from the access channel excavation. The containment dikes can be removed after development and stabilization of the wetlands, or can be left in place as dictated by the cell development design.

5.6.5 Upland Grading Issues. Final upland surfaces will be graded so that surface runoff will generally be directed toward wetlands. In the case of the existing Phase I and Phase II project, it is anticipated that the upland surfaces will be graded so that the runoff from approximately 30 to 40 acres will be collected and directed toward the wetland area immediately to the east. Achieving that runoff collection is expected to require several feet of elevation differential on the upland surface, and development of a system of shallow swales that will conduct water to the eastern side of the upland area. Collected runoff will then be transmitted from the +20 or +25 elevation to the +2.5 high marsh elevation over a distance of approximately 100 feet, and dispersed uniformly into the wetland areas. The exact methods of transporting flow across the 100-foot transition zone, and the means of dispersing the flow into the wetlands will be subject to extensive additional engineering analysis. The uplands associated with the expansion project will drain toward the wetland at the northern end of the area. As currently configured, most of the runoff will be directed from the upland surfaces toward the tidal gut that separates the upland and wetland areas. Therefore, the methods of transmitting collected flows from the +20 upland surfaces may differ somewhat from those required in the Phase I and Phase II areas.

5.6.6 Erosion of Dike Materials. The fine sand available for dike construction is highly erodible. Significant effort and expense has been required to repair and maintain the interior surfaces of the existing project dikes. Consideration will be given to providing a more erosion resistant surface. This may be accomplished by vegetation both with and without a geosynthetic reinforcement element, and mixing dredged materials with the sand used to form the interior surface of the dike slope.

5.7 Placement Analysis

5.7.1 Scope of Placement Analysis. Dredged material placement analyses were performed for six variations related to the 575-acre northern alignment (550 placement acres plus the 25-acre tidal gut). The six schemes included:

1. 50 percent wetlands without raising of existing uplands
2. 55 percent wetlands without raising of existing uplands
3. 60 percent wetland without raising of existing uplands
4. 50 percent wetlands with 5-foot raising of existing uplands
5. 55 percent wetlands with 5-foot raising of existing uplands
6. 60 percent wetland with 5-foot raising of existing uplands

In all cases, the final average elevation of the uplands associated with the lateral expansion is +20 ft MLLW, and the average final elevation of the raised uplands of the existing project is +25 ft MLLW. The analysis was performed in compliance with the detailed criteria presented in Attachment C – *Placement Analysis.*

5.7.2 Results of Analysis. The detailed results of the placement analyses are presented as a series of spreadsheets in Attachment C – *Placement Analysis.* A summary of the results are presented below in Table 5-3.

5.7.2.a Without Dike Raising: The analyses show that the lateral expansion can marginally support 50 percent and possibly 55 percent, wetlands without raising the existing upland cells, but cannot support 60 percent wetland habitat. At 50 percent wetlands, placement of dredged material within the expansion wetland cells requires approximately eleven years when following the prescribed placement sequence. Following the requirement that the site must accommodate 3.5 mcy of total dredged material placement annually, the upland cells are filled to capacity in 12 years, with the final year accommodating less than 600,000 cy. Therefore, the site only marginally satisfies the placement criteria that uplands should have additional placement capacity beyond the duration of wetland placement. At 55 percent wetlands, the upland capacity in the twelfth year decreases to only about 320,000 cy. At 60 percent wetlands, the upland capacity in the eleventh year, concurrent with the final year of wetland placement, is less than the minimum required 3.2 mcy per year. Therefore, development of 60 percent wetlands cannot be efficiently supported, and there is no contingency to deal with difficult placement or development of wetland cells.

5.7.2.b With Dike Raising. Raising the final average surface of the existing upland cells five feet from +20 to +25 ft MLLW increases the upland placement capacity by approximately 6 mcy – the equivalent of almost two additional years of placement. That additional two years significantly increases the probability of successfully completing the wetland placement and cell development. Not only can the placement be completed in accordance with efficient placement methods, the ability to accommodate difficulties during placement and cell development is enhanced. A single inflow significantly exceeding the average 3.2 mcy per year would create an unusually thick lift that would slow the consolidation process and extend the time to completely fill and grade a wetland cell. An unusually wet year, such as occurred in 2003, could prevent any surface grading activities planned for wetland cells, thereby extending wetland development. Either of these events could be accommodated with minimal impact if additional upland placement capacity was available. Therefore, both 50 percent and 55 percent wetland schemes are raised from marginally acceptable schemes to well supported schemes.

The 5-foot dike raising significantly increases that potential that the site could be developed with up to 60 percent wetland habitat. The primary difficulty in reaching the 60 percent goal is the limited availability of borrow materials for dike construction if the borrow must be obtained from within upland areas that area reduced to only 40 percent of the placement area. That limitation could be mitigated if additional borrow can be obtained from a second borrow source outside the expansion footprint. The source that has been identified is the borrow area located southwest of Cell 6 of the existing project. Whether or not the southwest borrow area is used to supplement lateral expansion construction, it would be necessary to provide approximately 450,000 cy of sand materials required to raise the existing upland surfaces to +25 ft MLLW.

Table 5-3. Summary of Placement Analysis - 575-Acre Site With and Without Dike Raising

	Upland/Wetland Distribution	Upland Expansion Area (acres)	Total Upland Area (acres)	Total Upland Capacity (mcy)	Wetland Expansion Area (acres)	Total Wetland Area (acres)	Total Wetland Capacity (mcy)	Upland Capacity / Wetland Capacity	Total Site Capacity (mcy)	Last Year @ 3.2 mcy Placed	Last Year Wetland Inflow	Last Year of Inflow into Site**
50% Upland 50% Wetland	Existing 1140-Acre Project	n/a	570.0	32.6	n/a	570.0	7.8	80.7%	40.4	2014	2014	2015
50% Upland 50% Wetland	Existing Project plus 50% Upland - 50% Wetland -Northern Alignment	275.0	844.0	49.0	275.0	832.0	15.5	75.9%	64.5	2021	2021	2022/2027
45% Upland - 55% Wetland	Existing Project plus 45% Upland - 55% Wetland -Northern Alignment	247.5	816.5	47.3	302.5	859.5	16.3	74.4%	63.6	2020	2021	2022/2027
40% Upland 60% Wetland	Existing Project plus 40% Upland - 60% Wetland -Northern Alignment	235.0	804.0	46.5	315.0	872.0	16.9	73.3%	63.4	2020	2021	2021/2026
50% Upland 50% Wetland with Raising	Existing Project plus 50% Wetland & 5' Raising -Northern Alignment	275.0	844.0	55.0	275.0	832.0	15.5	78.0%	70.5	2021	2021	2022/2027
45% Upland 55% Wetland with Raising	Existing Project plus 55% Wetland & 5' Raising -Northern Alignment	247.5	816.5	53.3	302.5	859.5	16.3	76.6%	69.6	2021	2021	2022/2027
40% Upland 60% Wetland with Raising	Existing Project plus 60% Wetland & 5' Raising -Northern Alignment	235.0	804.0	52.5	315.0	872.0	16.9	75.6%	69.4	2022	2021	2023/2027

** Note – The second year in the column for last year of inflow into the site is related to the potential development of the sheltered dredged material offloading facilities that may be recovered as a wetland cell, or may be left as an open cell.

5.8 Open-Water Embayment Concept and Alignment

Following the completion of the plan formulation process, a proposal from National Marine Fisheries Service (NMFS) and subsequent discussions with the Environmental Protection Agency (USEPA), Fish and Wildlife Service (USFWS), Maryland Department of Natural Resources (MDNR), and Maryland Department of the Environment (MDE) lead to the development and evaluation of an open-water embayment that could potentially be incorporated into a northern lateral alignment. The inclusion of an open-water embayment within the footprint of the lateral expansion would provide semi-protected fisheries habitat adjacent to wetland and upland cells, and would increase the trophic interaction between the wetland cells and the open-water embayment within the lateral expansion. The bottom habitat of the open-water embayment would remain essentially undisturbed, preserving the existing bathymetry and benthic habitat. In addition, the construction of small rock reefs within the open-water embayment would provide cover and enhance fish habitat.

Because the open-water embayment concept was introduced at the end of the plan formulation process after other alternatives had already been screened out, the details of the proposed design for the open-water embayment were compared only to the remaining alternatives: 1) 50 percent wetland, 50 percent upland plus 5-ft dike raising, and 2) 60 percent wetland, 40 percent upland plus 5-ft dike raising. Results of these analyses are summarized in the following sections, and the detailed engineering analysis for the open-water embayment is presented in Attachment G.

To incorporate the open-water embayment, the external footprint of the northern lateral alignment (which is the same for both the 50 percent wetland, 50 percent upland and 60 percent wetland, 40 percent upland scenarios) would not change. However, the tidal channel and approximately 115 acres of wetland habitat along the western side of the site would be replaced with an open-water embayment protected by a line of segmented breakwater structures (Figure 8). With the inclusion of an open-water embayment, the area within the perimeter footprint will contain 29 percent wetland habitat, 47 percent upland habitat, and 24 percent open water. The higher percentage of uplands is required to provide more efficient dredged material placement operations and to minimize sand borrow requirements outside of the lateral expansion footprint. The total dredged material placement capacity of the northern lateral alignment with the open-water embayment, would be approximately 27.8 mcy.

5.8.1 Alignment and Internal Configuration. The boundaries of the wetland area will be modified slightly to provide wetland habitat around a significant proportion of the shoreline of the 130-acre open-water embayment. The 10,600-foot embayment perimeter consists of approximately 3,400 feet of breakwater, 1,500 feet of upland shoreline, and 5,700 feet of wetland shoreline. The shoreline of the southern end of the open-water embayment was adjusted to provide a smoother alignment that should simultaneously improve hydraulic performance (by minimizing the potential for areas of poor circulation) and increase the proportion of marsh shoreline.

The tidal gut included in the 60 percent wetland, 40 percent upland alternative (Figure 9) was absorbed by the embayment except for a short segment at the southern end of the expansion footprint adjacent to existing wetland Cell 1 (Figure 8). This remaining portion of the tidal gut (approximately 10 acres) will provide necessary tidal access to Cell 1. Current engineering judgment indicates that circulation within the embayment will be adequate, and that connection of the tidal gut remnant at the southern end of the embayment will not be necessary. If hydraulic analysis indicates otherwise, or if environmental considerations make it desirable, the tidal gut can be connected to the embayment through the wetlands.

5.8.2 Capacity Analysis and Placement Efficiency. Analysis of dredged material placement was performed using the same mathematical placement model applied to each of the other expansion and dike raising alternatives (Appendix A, Attachment C). An analysis was performed for the inclusion of a 130-acre open-water embayment in the lateral expansion footprint, both with and without an associated 5-ft raising of the existing upland dikes. Results of the placement analysis for the open-water embayment (Table 5-4) indicate that the loss of wetland area associated with the open-water embayment reduces the dredged material placement capacity of the expansion by approximately 1.2 mcy. The capacity of the transformed wetland area alone is approximately three mcy. However, because the upland area is increased from approximately 40 percent to 47 percent to accommodate the open-water embayment, about 60 percent of the capacity associated with the lost wetland placement is recovered.

The last year that the site can accommodate the future average annual inflow of 3.2 mcy is unchanged with the inclusion of a 130-acre open-water embayment in the lateral expansion footprint, and the duration of upland and wetland placement is minimally affected (Table 5-4). The 60 percent wetland, 40 percent upland alternative and the open-water embayment alternative both require the additional capacity provided by a 5-ft raising of the existing upland cells for efficient placement of dredged material. That additional capacity can be held in reserve until the expansion site has been completely filled except for the wetland cell containing the protected offloading facility. As dredged material is placed into the final wetland cell, excess material can be directed to the raised upland cells. After the first year of placement, the quantity required in the wetland cell diminishes to a relatively small quantity, estimated to be less than 0.5 mcy out of the 3.2 mcy annual demand. The additional capacity associated with the raised upland cells provides the means to maintain a much more cost effective placement process compared to the scenario without the additional capacity associated with the raising.

Table 5-4. Comparison of 60 Percent Wetland and Open-Water Embayment Alternatives

Expansion and/or Raising Alternative	Total Expansion Area (acres)	Upland Area (acres)	Wetland Area (acres)	Water Area (acres)	Expansion Capacity (mcy)	Last Year at 3.2 mcy	Last Wetland Placement	Last Upland Placement
575-Acre Expansion with 60% Wetland & 40% Upland	575	235	315	25	**23.0**	2020	2021/2026	2021/2021
575-Acre Expansion with 60% Wetland & 40% Upland + 5' Raising	575	235	315	25	**29.0**	2022	2021/2027	2022/2025
575-Acre Expansion with 29% Wetland, 47% Upland, & 24% Open Water	575	270	165	140	**21.8**	2020	2019/2026	2021/2021
575-Acre Expansion with 29% Wetland, 47% Upland, & 24% Open Water + 5' Raising	575	270	165	140	**27.8**	2022	2019/2026	2021/2026

NOTE: The two dates shown in each cell of the last two columns for placement in wetland and upland cells reflect the additional 4 to 5 year period associated with recovery of the wetland cell used as a sheltered dredged material offloading site.

5.8.3 Borrow Analysis. The inclusion of an open-water embayment in the lateral expansion footprint has small, but generally favorable, impacts on the sand borrow excavation plan for the expansion construction. Because a significant portion of the western perimeter dike would be replaced by a stone breakwater structure and a portion of the interior dikes associated with the tidal gut are eliminated to accommodate the embayment, the required dike fill quantities decrease by 250,000, to a total of three mcy (Table 5-5). Therefore, the inclusion of the open-water embayment would decrease the total required fill quantity from 3.7 mcy to 3.4 mcy when raising the existing upland dikes is included.

Compared to the 60 percent wetland, 40 percent upland alternative, the proposed open-water embayment layout increases the upland proportions from 40 percent in to approximately 47 percent. As discussed previously, this mitigates a significant percentage of the placement capacity lost when 115 acres of wetlands are replaced with open-water habitat. This increase in upland area also increases the quantity of borrow material available for dike construction by nearly 15 percent, significantly reducing the projected area required from borrow sources outside the project limits. Only 19 acres of the southwest borrow area is anticipated for construction of the open-water embayment alignment.

Table 5-5. Borrow Requirements for the 60 Percent Wetland and Open-Water Embayment Alternatives

Alternative	Borrow Source	Borrow Volume (mcy)	Borrow Yield (mcy)	Borrow Area Disturbed (acres)
60% Wetland & 40% Upland	North Borrow	4.6	2.6	144
	Northern Access Channel/Turning Basin	0.5	0.3	30
(3.3 mcy sand required)	SW Borrow	0.7	0.4	42
	Subtotal		**3.3**	
60% Wetland & 40% Upland with 5-ft Raising	North Borrow	4.6	2.6	144
	Northern Access Channel/Turning Basin	0.5	0.3	30
(3.7 mcy sand required)	SW Borrow	1.5	0.8	91
	Subtotal		**3.7**	
With Open-Water Embayment	North Borrow	5.2	3.0	175
	Northern Access Channel/Turning Basin	0.5	0.3	30
(3.0 mcy sand required)	SW Borrow	0	0	0
	Subtotal		**3.3**	
With Open-Water Embayment and 5-ft Raising	North Borrow	5.2	3.0	175
	Northern Access Channel/Turning Basin	0.5	0.3	30
(3.4 mcy sand required)	SW Borrow	0.3	0.2	19
	Subtotal		**3.5**	

It should be noted that the reduction from a potential 91 acres of external borrow sources (for the 60 percent wetland, 40 percent upland alternative) to 19 acres (for the open-water embayment alternative) is very favorable, and significantly reduces the environmental impacts to the southwest borrow area. The actual dike placement quantity associated with the 19-acre excavation is less than 200,000 cy, and it is possible that the entire quantity may be obtained from within the expansion dike footprint if the final subsurface exploration indicates that the geologic variability of the borrow deposit within the expansion limits is less than was the case in the southern borrow sources used for the original Poplar Island construction.

5.9 Recommended Expansion Alternative

Selection of a final scheme for expanding the existing Poplar Island project includes consideration of environmental, cultural, real estate, political, public involvement, funding, and other factors in addition to engineering considerations. The following discussion focuses primarily on engineering considerations as developed within the generally established environmental and cultural limitations.

5.9.1 Preferred Engineering Alternative. From the perspective of efficient placement and high probability of success in wetland development, the recommended alternative based on the engineering analysis would consist of a 575 acre expansion site having 550 acres for placement split 50-50 between upland and wetland habitat in combination with a 5-foot raising of the existing upland cells. That alternative would provide nearly 30 mcy of additional dredged material placement capacity extending the life of the existing project by approximately seven years. Upland placement capacity would last at least two full years beyond anticipated wetland placement, and the quantity of fill required from the southwest borrow site would be less than 1.0 million of its estimated 4.2 million cubic yard capacity. A plan of the 50 percent wetland, 50 percent upland alignment, showing the proposed arrangement of upland and wetland cells, is presented as Figure 10.

5.9.2 Environmentally Preferred Alternative (Open-Water Embayment). Based on other analyses conducted by USACE-Baltimore District (Appendix H and Appendix I), inclusion of the open-water embayment in the northern lateral alignment is the environmentally preferred alternative. The open-water embayment alignment would consist of a 575-acre lateral northern expansion of the existing PIERP to the north and northeast, consisting nominally of 29 percent wetland habitat, 47 percent upland habitat, and 24 percent open water. The northern lateral expansion with the open-water embayment will provide approximately 27.8 mcy of placement capacity, and approximately 165 acres of wetland habitat; 270 acres of upland habitat; and 130 acres of open water habitat The total dredged material placement capacity of the northern lateral alignment with the open-water embayment, would be approximately 27.8 mcy. Construction of the open-water alignment would require only approximately 19 acres of sand borrow from external borrow sources, significantly reducing the environmental impacts to the southwest borrow area, as compared to the 50 percent wetland, 50 percent upland and 60 percent wetland, 40 percent upland alternatives.

5.9.2.a Expansion Dike Section. Figures 11 through 13 show the limits of each typical dike section for each of the alternatives considered - the open-water embayment, the 60 percent wetland, 40 percent upland, and the 50 percent wetland, 50 percent upland schemes, respectively. Sections of the heavily armored western and northern dike, the lightly armored eastern dike, the unarmored interior longitudinal dike and tidal gut, and the internal cross dikes are presented as Figures 14 through 17. The dike section for the proposed expansion will be similar to the section for the existing project. However, for the open-water embayment, a segmented stone breakwater structure (Figure 18) will replace a substantial portion of the armored western dike section, and light armor will be required along the interior perimeter of the embayment.

The dikes will be constructed using fine sand obtained from borrow sites located below water within the proposed upland cells. A geotextile will be placed on the sand surface of the external slope of the dike beneath the armor stone to act as a filter to retain the sand. A 12-inch layer of bedding material and a gravel-sized crushed stone material will be placed on the geotextile to protect it during armor stone placement. It has been necessary to specify a woven mono-filament geotextile to provide the required combination of tightly controlled filter capability while achieving the highest possible tensile and puncture strength needed to resist damage during placement of overlying armor stone layers.

Armor stone sections will be similar to the existing project with respect to dike slopes, geotextile filter and bedding, and stone placement methods. The external surfaces of the dike will be protected with several layers of armor stone obtained from commercial sources. Generally, the section will consist of two layers of armor stone placed on two layers of under layer having a mean weight of about 250 pounds. Preliminary hydraulic analysis indicates that the mean armor stone size will be approximately 2500 pounds, somewhat smaller than the 3,000 to 4,000 pound stone used on the existing project. The eastern and southern exposures will be more lightly armored with 350-pound stone. The 350-pound stone will be placed on a 6-inch bedding layer. The crest of the armored dike sections will be set at elevation 10.5 ft MLLW, with external armored slopes at 3 horizontal to 1 vertical (3H:1V), and internal sand slopes constructed to 3H:1V. Slopes of the upland dike sections above 10.5 ft MLLW will not require stone armor, but may receive lighter slope protection in the form of a reinforced vegetative matting. Further analyses will be required to finalize the upper dike slope protection features.

Breakwater structures associated with the open-water embayment will consist of two layers of 2500 pound armor stone overlaying a core of 250 pound stone founded on a high strength geotextile. Because of the relatively large fetch within the embayment, the interior dike slopes will require light armoring similar to the 350 pound stone section proposed for the eastern slopes of the perimeter dike.

During previous phases of this project, consideration was given to alternative means of providing slope protection that might be less costly than stone. However, locally available natural stone armor has proven to be more cost effective than other slope protection methods that would provide an equivalent level of protection.

5.9.2.b Submerged Rock Reefs. Three small subtidal artificial reefs were included within the open-water embayment (Figure 8). It is anticipated that the reefs will be constructed either entirely of rock with a cross section similar to the breakwater structures or may consist of a sand core with external armor, depending on the size of the reef. The initial location of the reefs placed them about 600 feet from the shoreline and the breakwater structures. It may be desirable to shift several of the reefs closer to the proposed 200-foot breakwater openings to reduce incoming wave energy and to provide protection to the interior eastern dikes. The location of the rock reefs will be determined based on the results of the hydrodynamic modeling conducted for the open-water embayment. However, if relocated, the reefs would be kept at least 200 feet away from the breakwater structures to provide adequate opening into the open-water embayment to provide for fish utilization.

5.9.2.c Perimeter Dike Breakwater Structures. To create the open-water embayment, segmented breakwaters following the same alignment as the armored sand dike in the 60 percent wetland, 40 percent upland alternative, would replace approximately 3,400 feet of the western leg of the perimeter dike. The breakwater segments are approximately 200 feet long and are separated by about 50 feet of open water except for one or two larger openings of approximately 200 feet (Figure 8). The breakwater structures will consist of a core of 250-lb underlayer stone and two layers of stone armor having a mean weight of approximately 2,500 lbs. The structure will have a width of 6.8 feet at crest elevation +6 ft MLLW, and 1.5 horizontal on 1 vertical (1.5H:1V) side slopes. A high-strength geotextile sheet will be placed on the Bay bottom to minimize loss of stone into soft or loose surface deposits. Hydraulic analyses will be performed to optimize the breakwater crest height, stone size, and dimension of openings between segments. Any proposed changes to the size of the openings will also be evaluated for potential impacts on fish passage.

5.9.2.d Internal Dikes. Internal containment dikes will be constructed with sand from borrow sources within the lateral expansion footprint. The interior dikes of the 60 percent wetland, 40 percent upland alternative are generally constructed to elevation +6.5 ft MLLW using sand, and have minimal slope protection provided by established vegetation. The dikes that form the perimeter of the proposed open-water embayment would be raised to a minimum crest elevation of +9 ft MLLW and would require slope protection to prevent erosion from the exposure along the embayment. The current design assumption is that adequate slope protection can be provided by a double layer of 350-lb stone placed on a bedding layer and a geotextile filter, similar to the protection proposed for the eastern slopes of the expansion dikes. Dike height and slope protection requirements will be refined as hydraulic analyses are completed.

5.9.2.e Discharge from Cells During and After Dredged Material Placement. During placement of dredged material into wetland cells decanted water will be discharged in accordance with water quality requirements into the open-water embayment through approximately three spillway structures (two associated with the northern wetland area, and one associated with the separate southern area). After placement of dredged material in wetland cells is complete, temporary interior dikes will be removed and channel systems will be established to assure hydraulic interconnection throughout the wetland areas. As part of the of the final wetland construction, the spillways will be replaced with temporary outlet control structures that will connect the wetland cells to the embayment to allow full tidal exchange while marsh plants are established and the dredged materials are stabilized to minimize erosion. After full stabilization has been achieved, the wetland control structures will be replaced with open breaches connecting to the embayment.

During placement into the upland cell, decanted water will be discharged to the Chesapeake Bay through one primary spillway located at the southern end of the cell. The spillway will be located a minimum of 1500 feet from the nearest oyster bar. A second spillway will be located along the western side of the cell to allow for occasional discharge into the open water embayment. It is anticipated that the second spillway will be used toward the latter stages of upland placement when it is necessary to even out the upland surface elevations. The upland spillway structures will remain in place until the upland cells are completely filled and graded. It is anticipated that the upland area will be graded to drain toward the adjacent wetland and open-water embayment areas rather than toward the Bay.

5.9.3 Dredged Material Offloading Facilities. Offloading of dredged materials will occur at the northern end of the site. A 40-acre sub-cell has been designated as the temporary offloading site. A segment of the cell external dike will be left open until all other cells have been filled. At that time, the cell could be left open and developed as a protected open-water environment with a fringe marsh habitat. The cell could be partially closed by constructing a submerged dike that would close the access channel and permit dredged material to be placed in the cell turning basin excavation to restore the bottom to near existing elevation of -10 ft MLLW. Another alternative would close the cell completely and provide a fully armored dike section that would allow the cell to be developed as a wetland cell with a combination of high marsh, low marsh, mudflats, and an open water pond overlying the thick dredged material deposit that would fill the turning basin excavation. The final disposition of this cell will be determined after consideration of both engineering and non-engineering factors.

5.10 Other Recommended Project Modifications

5.10.1 Raised Dike Section. To allow the upland cells to be raised to a final average elevation of +25 ft MLLW, it will be necessary to temporarily raise the existing upland dikes to an average elevation of +30 ft MLLW. To facilitate dredged material placement, it may be necessary to temporarily raise some localized sections of the dike in the vicinity of discharge locations slightly above +30 ft MLLW. After upland placement is complete, the containment dikes will be reduced to the average cell surface elevation of +25 ft MLLW.

The existing upland dikes were constructed entirely with the same fine sand materials that will be used to construct a dike raising. The current dikes have 2.5H:1V side slopes and a 25-foot wide crest at elevation +23.0 ft MLLW. The raised section will also have 2.5H:1V side slopes with a crest width of 10 to 15 feet at a nominal average elevation of +30 ft MLLW. The raising will be designed to accommodate spillway structures, access ramps, and other support features. It is estimated that approximately 450,000 cy of sand will be required to raise Cell 2 and 6 to an temporary average crest elevation of 30 ft MLLW. Sand to accomplish the raising will be obtained from the borrow area located immediately southwest of existing Cell 6.

5.10.2 Existing Upland Dike Slope Protection. Stone armor on the exterior slopes of the containment dikes currently stops at the elevation of the perimeter roadway, typically elevation +10 to +11 ft MLLW. The raised dikes consist entirely of sand with no slope protection other than vegetation above the roadway elevation. As a result of the experience gained from the Isabel storm event in 2003, consideration will be given to providing some form of slope protection along the lower elevations of the currently unarmored slope of the raised dike section of the upland cells. The required level of protection will likely vary dependent upon exposure to wave action and wave runup. It is anticipated that the southwestern and southern exposures may require light armoring such as a reinforced vegetative matrix using geosynthetic materials such as Pyramat or Miramat. Western and northern exposures were relatively unaffected by the Isabel event and may not require any additional slope protection.

5.10.3 Existing Upland Dike Crest Elevation. The perimeter dikes containing existing upland Cells 2 and 6 are restricted to maximum elevation +23.0 ft MLLW. In the original *Integrated Feasibility Report and Environmental Impact Statement* (USACE/MPA, 1996), the proposed project was to contain upland habitat to elevation +20 ft MLLW, with containment dikes constructed to elevation +23 ft MLLW. There was no rigorous analysis of the actual temporary dike elevation needed to achieve final upland elevations of +20, and the +23 elevation reflected a general recognition that some additional freeboard was needed above the desired final elevation. Experience has demonstrated that temporary dikes must be at least 5 feet higher than the final dredged material surface, and may even require several additional feet in the immediate vicinity of the inflow pipe discharge location. To date, the Corps has been restricted to +23 ft MLLW for maximum temporary dike elevations, which limits actual final upland elevations to about elevation +18 ft MLLW, thereby sacrificing more than 2 mcy of placement capacity. It is recommended that temporary dike elevations be permitted to extend to approximately elevation +25 ft MLLW to facilitate upland development to an average final elevation of +20 ft MLLW.

5.10.4 Existing Upland Surface Elevation. The original *Integrated Feasibility Report and Environmental Impact Statement* (USACE/MPA, 1996) identified the target upland surface elevation as +20 ft MLLW (reference page 6-1, paragraph 6.1). As a practical matter, it is necessary to understand that the target elevation represents an *average surface elevation* that will not be applied to the entire upland surface. It will be necessary to provide some topographic relief to assure that the surface drains adequately so that vegetation is not inundated by trapped surface water. There will likely be some ponds created as part of the upland habitat development plan, but the extent of these ponds will be controlled. The majority of the site will be graded to drain from west to east toward the wetland habitat. Surface runoff will be collected and conveyed to the wetland areas primarily through grading of upland surfaces and the transition zone between the +20 ft MLLW uplands and the +2.5 ft MLLW wetland high marsh areas.

5.10.5 Existing Wetland Cell Dikes. The existing external wetland dikes are lightly armored with 250 pound stone placed on geotextile, except for the reach parallel to Coaches Island that has a vegetated sand surface. The southern exposure of Cell 5 was overtopped during the Tropical Storm Isabel event and suffered extensive erosion of the internal portion of the sand dike including a complete breach of a 500-foot reach of the dike. Although the breach allowed full hydraulic communication between the Bay and the inside of the cell, the remnant dike section still had a sand zone extending above mean low water. Therefore, it is likely that the damaged dike may not have released any dredged material had the wetland habitat been completed at the time of the breach. Had the cell contained unconsolidated dredged material extending above elevation +2.5 ft MLLW, loss of some dredged materials would have been anticipated. During the same event, a smaller, 100-foot, breach occurred in wetland Cell 1 at a location where the armor consisted only of a double layer of 250-pound stone. After the sand dike had been eroded from the overtopping, the stone collapsed below the water surface. Although dredged material was present inside the cell to approximately elevation –1.0 ft MLLW, no obvious loss of material was detected.

To reduce the frequency of overtopping the southern dike segment of Cell 5, one approach would add a sand dike section several feet in height along the interior of the existing dike in a manner similar to the raising section used for upland cells. Approximately 20,000 cy of sand would be required to raise the dike crest 2 feet. The raised section would be located entirely within the footprint of the dike as originally constructed and would not reduce the originally proposed wetland habitat acreage. The raised section would be armored with a reinforced vegetative matrix as described previously. Consideration may be give to extending the vegetative reinforcement over the crest and interior slope of both the raised dike and other wetland dikes if further hydraulic analysis indicate that overtopping may be a significant risk for dike failure with loss of contained dredged material.

6. CELL DEVELOPMENT

6.1 Dredged Material Placement

Dredged material placed at Poplar Island will consist of clean, fine-grained silt and clay sediments obtained from the outer approach channels to the Port of Baltimore. Annual maintenance dredging of these channels will generate an average of 3.2 mcy per year. Dredged material placed into the existing project in 2003-2004 consisted of fine-grained silt and clay with 30 percent of the samples classified as silt (MH) and 70 percent classified as clay (CH) with average liquid limit and plasticity index values of 122 and 78 respectively.

These materials are generally mechanically dredged, loaded into barges, and hydraulically off-loaded into the containment cells at the site. The initial slurry has an average moisture content typically in excess of 300 percent corresponding to approximately 90 percent water and 10 percent solids by volume (void ratio = 8). The shear strength of the initial slurry is almost immeasurable. Dredged materials consolidate under their own weight for a period of years after placement in the containment site. The total duration of self-weight consolidation varies as a function of initial layer thickness and degree of surface drying and crust formation. The thicker the initial lift, the longer the pathway for drainage of water from within the dredged material layer. Any increase in the desiccated crust thickness resulting from mechanical crust management activities will accelerate the consolidation process. However, crust management can only effectively accelerate the surface drying and crust formation to a depth of 2 to 3 feet. After a year in place, the average moisture content will decline to approximately 150 percent corresponding to a void ratio of approximately 4, depending on the thickness of the initial lift and the proportion of crust that develops as a result of crust management activities. The shear strength of the dredged material under the surface crust typically ranges from 50 to 150 psf.

With continued crust management, the average moisture content can be reduced to approximately 100 percent corresponding to a void ratio under 3 and a shear strength of approximately 250 psf. However, placement of subsequent fresh dredged material lifts will retard consolidation until the new material has been drained and dessicated by solar exposure. In wetland cells, where the total thickness of dredged materials is less than ten feet, the surface crust of the dredged material can support equipment needed for channel excavation and surface grading within about four years after initial placement if drainage and crust development has been aggressively promoted. In upland cells where the total thickness of dredged material typically ranges from 25 to 30 feet (or up to 50 feet if the cell contained a mined borrow area extending the bottom to elevation -25 or -30 ft MLLW), consolidation will take much longer, and final grading of the dredged material surface will probably not be initiated until several years after the final placement of material within the cell.

6.2 Wetland Cell Development

Wetland cells will be graded to provide roughly 80 percent low marsh (includes open water and islands) habitat, and 20 percent high marsh habitat. The break between low marsh and high marsh is currently defined as the +1.8 ft MLLW contour. A successful wetland cell must be graded to satisfy the very tight vertical surface grading tolerances required for high marsh and low marsh plants, and must not be subject to any additional settlement after planting has been completed. Wetland cells will typically require at least four years of crust management and aggressive drainage before they are ready to be graded for planting.

Existing cell 3D (Figure 19) was the first wetland cell to be developed using dredged material. Dredged material was first placed into the cell in April 2001, and the surface grading was accomplished between April and December 2004. The initial inflow amounted to approximately 70 percent of the cell capacity, and these materials experienced self-weight consolidation for approximately one year before being subjected to a program of drainage and crust development. The drained upper 12 to 18 inches of the dredged material imposed a load on the underlying materials resulting in an over-consolidated state that would not have been achieved by self-weight consolidation alone. Once the cell has been flooded, and the upper dredged material have returned to a buoyant state, the load on the underlying materials will be arrested, and the risk of subsequent settlement will be minimized.

This process created a surface crust having sufficient strength to support the construction equipment needed to create the required channel system, and grade the surface to satisfy the topographic requirements. A variety of low-pressure excavators, bulldozers, and tracked dump trucks were used to move materials to their final locations within the cell. As channels extended in depth and drying conditions improved, the dredged materials continued to consolidate and gain strength, steadily improving conditions for operation of construction equipment. Because of the increased consolidation induced by this approach, the placement capacity of the cell was increased by approximately 35 percent over an approach that would accomplish dredged material placement entirely by hydraulic placement methods with minimal drainage and crust development.

Cell 3D was successfully configured in accordance with the proposed design using the development techniques described above. The cell will be monitored closely during the next several years after planting has been completed to document performance. These techniques will provide a basis for planning for future wetland cell development, although adjustments in the approach to improve efficiency are anticipated. In view of the complexity of the process and the variable conditions within each wetland cell, other placement and development techniques will be investigated to improve on cell development efficiency and adjust to needed changes in wetland design.

6.3 Upland Cell Development

Upland cells will be graded to provide a final surface at approximately elevation +20 ft MLLW (or +25 ft MLLW if a raising is included as a component of the expansion alternative). In general, the proportion of crust in comparison to the total thickness of the dredged material is considerably less than in wetland cells. Therefore, the underlying dredged materials are subjected to much lower consolidation loads than can be expected in upland cells. The maximum consolidation loading can be imposed if the individual placement lifts are maintained close to about three feet so that subsequent crust management can effectively reduce the moisture content of the new layer. Typically drainage trenches and dessication cracking extend only about 15 to 18 inches below the exposed dredged material surface.

The current development plan anticipates subdividing the larger upland cells as one portion of the cell approaches the final upland elevation. Using Cell 2 as an example, the southern 80 to 100 acres of the 326-acre cell will be separated by a temporary sand cross dike once the dredged material level at the south end of the cell approaches elevation +20 ft MLLW. Subsequent inflow will be located along the west side of the cell to develop a surface gradient toward the east side and toward the wetland cells. It will be desirable to overbuild the center of the cell to compensate for the larger magnitude of settlement that is anticipated in the center. It will also be desirable to create several feet of elevation difference across the upland surface to promote surface drainage from the final surface toward the wetland areas. Significant regrading of the transition area between the upland and wetland elevations will be necessary after placement has been completed and the upland surface has been graded and planted. It is anticipated that the surface grading techniques will be similar to those already used for wetland development.

7.0 REFERENCES

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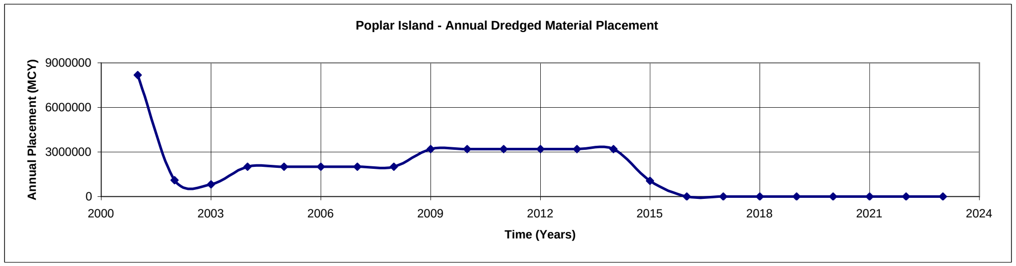
POPLAR ISLAND DREDGED MATERIAL PLACEMENT AND CELL DEVELOPMENT PLAN

FIGURE 1 EXISTING 1140 ACRE SITE AT 50% WETLAND AND 50% UPLAND

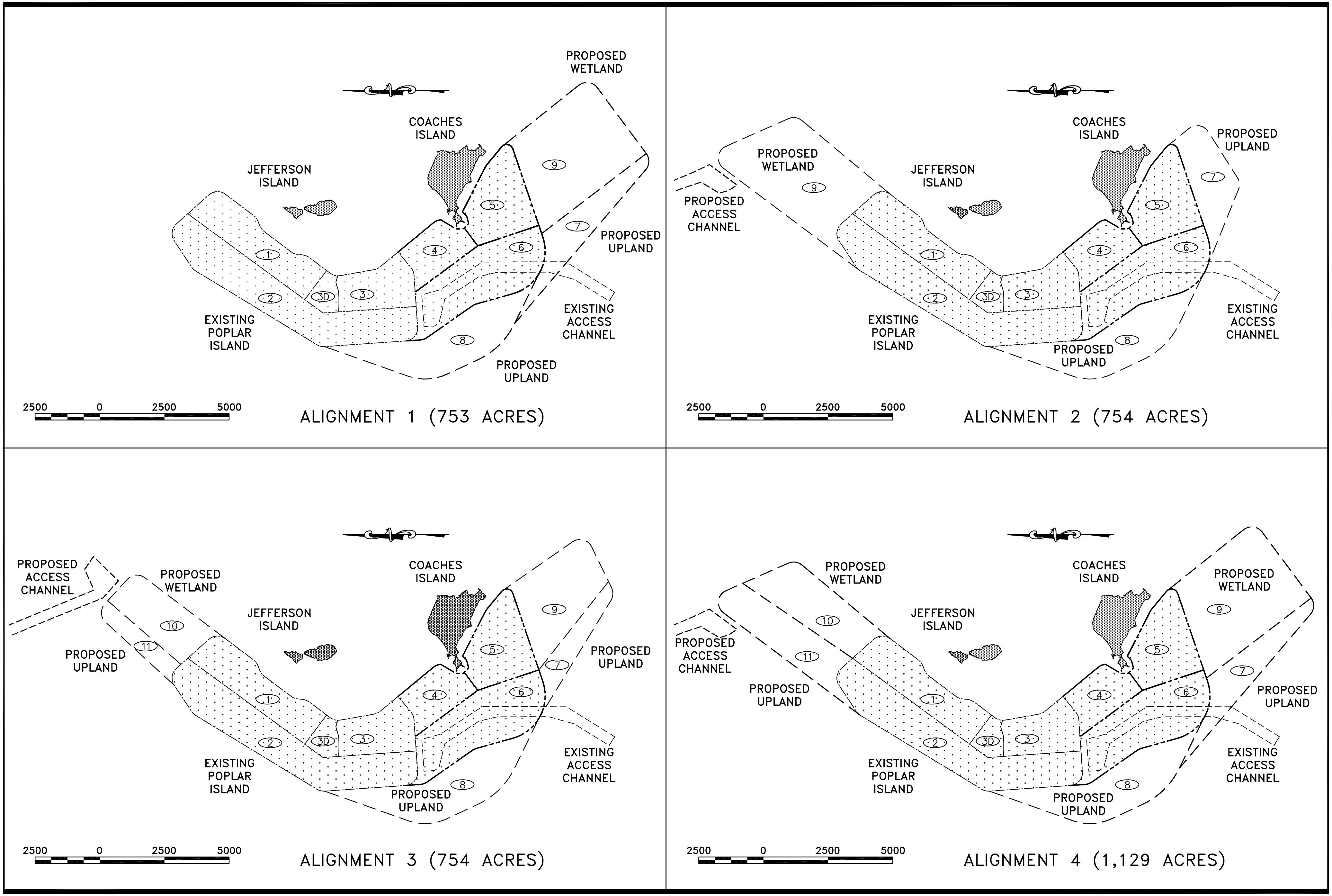
KEY:

- Red type represents dredged material placement quantity
- Red type in yellow cell indicates year cell will be overloaded
- Green type in green cell represents planting and habitat development.
- Orange type in orange cell represents final placement and grading.

Cell No.	Cell Acreage	Cell Acreage	Cell Volume	Cell Capacity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total Placed Quantity
	(Nominal)	(Actual)																										
EXISTING UPLAND CELLS									Cross-Dike Subcell 2A	Final fill 2A	Grade & Drain 2A	Plant 2A		Cross-Dike Subcell 2B	Final fill 2B	Grade & Drain 2B	Plant 2B		Final fill 2C		Grade & Drain 2C		Plant 2C	Plant 2C				
U-2	326	298	10,913,555	**15,590,792**	**6,399,848**	1,038,000	0	1,111,000	535,347	894,394	0	700,000	1,500,000	1,250,000	0	0	850,000	850,000	462,203	0	Grade	Grade	Plant	Plant				**15,590,792**
U-6	243	222	11,926,728	**17,038,183**	0	0	0	0	0	400,000	**1,700,000**	1,120,114	1,075,000	**1,480,028**	**3,050,000**	**2,994,429**	**2,244,714**	**2,322,609**	651,289	0	0	Grade	Grade	Plant	Plant			**17,038,183**
EXISTING WETLAND CELLS																												
W-1A	38	35	265,393	**379,133**	139,480	0	160,000	60,000	19,653	Grade	Plant																	**379,133**
W-1B	38	35	378,327	**540,467**	195,000	0	170,000	110,000	40,000	15,467	0	0	0	10,000	Grade	Plant												**540,467**
W-1C	44	40	367,840	**525,486**	195,000	0	200,000	80,000	40,000	10,486	Grade	Plant																**525,486**
W-1D	49	45	486,420	**694,886**	235,000	0	220,000	170,000	40,000	20,000	0	9,886	Grade	Plant														**694,886**
W-3A	35	32	366,549	**523,642**	220,000	0	0	210,000	55000	21,000	0	10,000	0	7,642	Grade	Plant												**523,642**
W-3B	30	28	275,557	**393,653**	290,000	0	0	75,000	20000	8,653	Grade	Plant																**393,653**
W-3C	39	35	400,913	**572,733**	225,403	0	66,000	184,000	50000	30,000	0	10,000	0	7,330	0	Grade	Plant											**572,733**
W-3D	31	26	251,680	**359,543**	284,500	62,000	12,000	Grade	Plant																			**358,500**
W-4A&B	34	31	150,040	**214,343**	0	0	0	0	0	0	0	0	0	0	0	130,000	65,000	19,343	Grade	Plant								**214,343**
W-4C	38	34	7,000	**10,000**	0	0	0	0	0	0	0	0	0	0	0	0	10,000	0	Grade	Plant								**10,000**
W-4DX	25	23	0	**0**	0	0	Plant																					**0**
W-5A	33	30	242,000	**345,714**	0	0	0	0	0	0	0	0	250,000	60000	25,000	10,714	Grade	Plant										**345,714**
W-5B	33	30	266,200	**380,286**	0	0	0	0	0	0	0	0	0	275,000	65000	30,000	10,286	Grade	Plant									**380,286**
W-5C	33	30	290,400	**414,857**	0	0	0	0	0	0	0	0	300,000	70000	30,000	14,857	Grade	Plant										**414,857**
W-5D	57	53	1,710,133	**2,443,048**	0	0	0	0	1,200,000	600,000	300,000	150,000	75,000	40,000	30,000	20,000	20,000	8,048	0	0	Grade	Plant						**2,443,048**
Annual Placement (mcy)				**40,426,766**	8,184,231	1,100,000	828,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	1,113,492	0	0	0	0	0	0	0	0	**40,425,723**



Total Upland Capacity	32,628,975
Total Wetland Capacity	7,797,790
Upland Placement Capacity Percentage	80.71%



ALIGNMENT 1 (753 ACRES)

ALIGNMENT 2 (754 ACRES)

ALIGNMENT 3 (754 ACRES)

ALIGNMENT 4 (1,129 ACRES)

Figure 2. Preliminary Alignments Considered during Scoping, Alignments 1 through 4

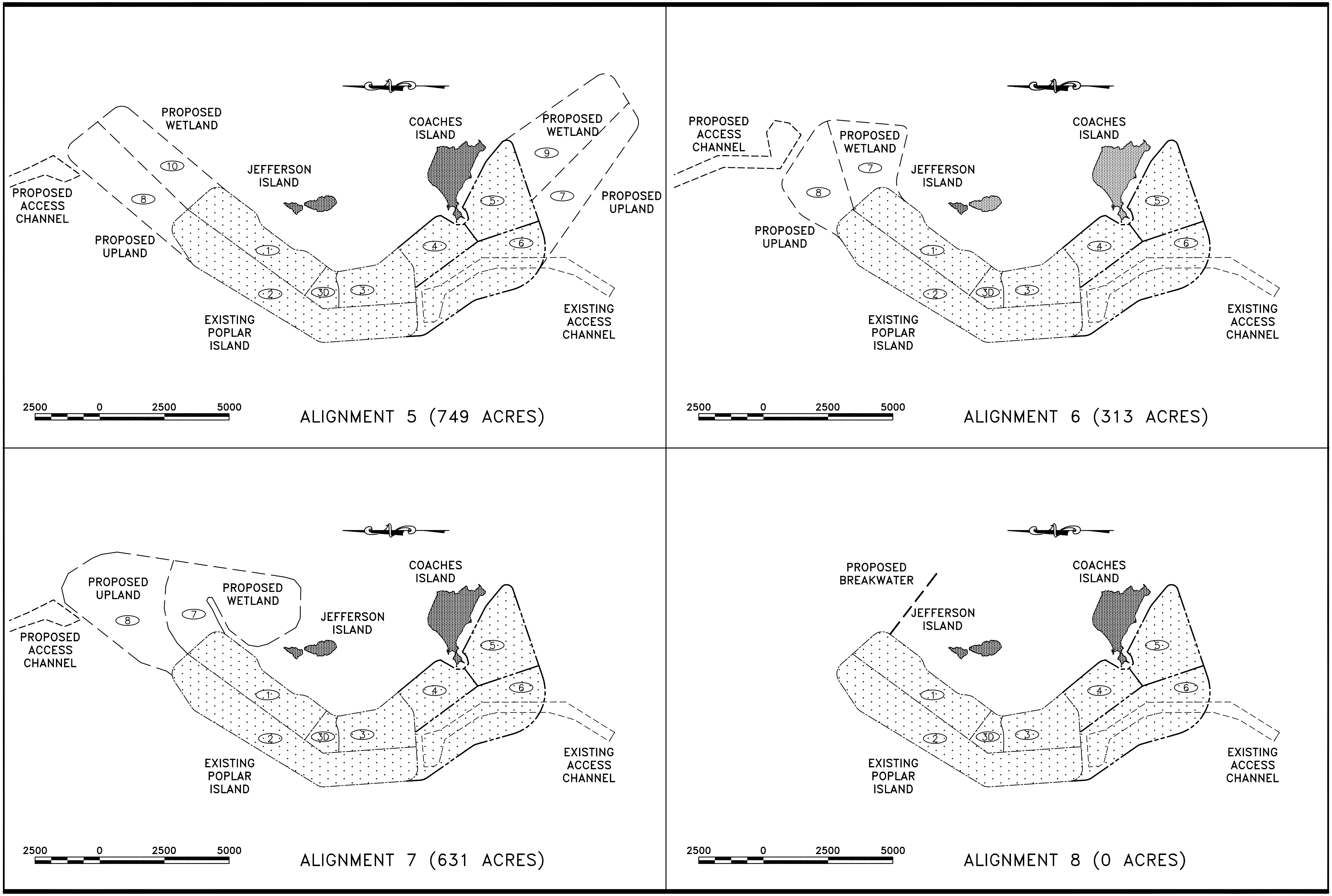


Figure 3. Preliminary Alignments Considered during Scoping, Alignments 5 through 8

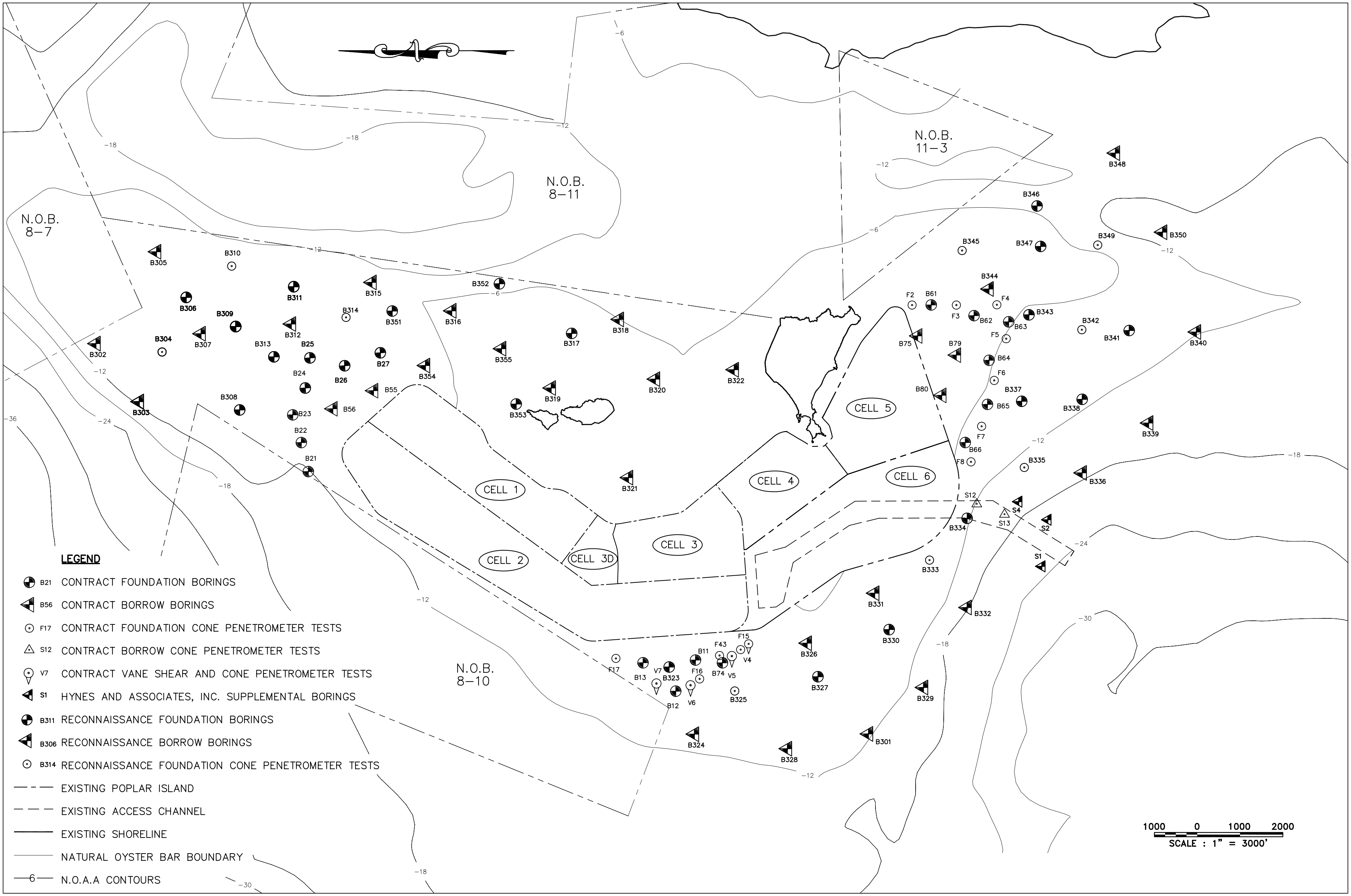


Figure 4. Maryland Port Administration Reconnaissance Report Subsurface Investigation Plan

Figure 5. Maryland Port Administration Reconnaissance Report Potential Sand Borrow Area Plan

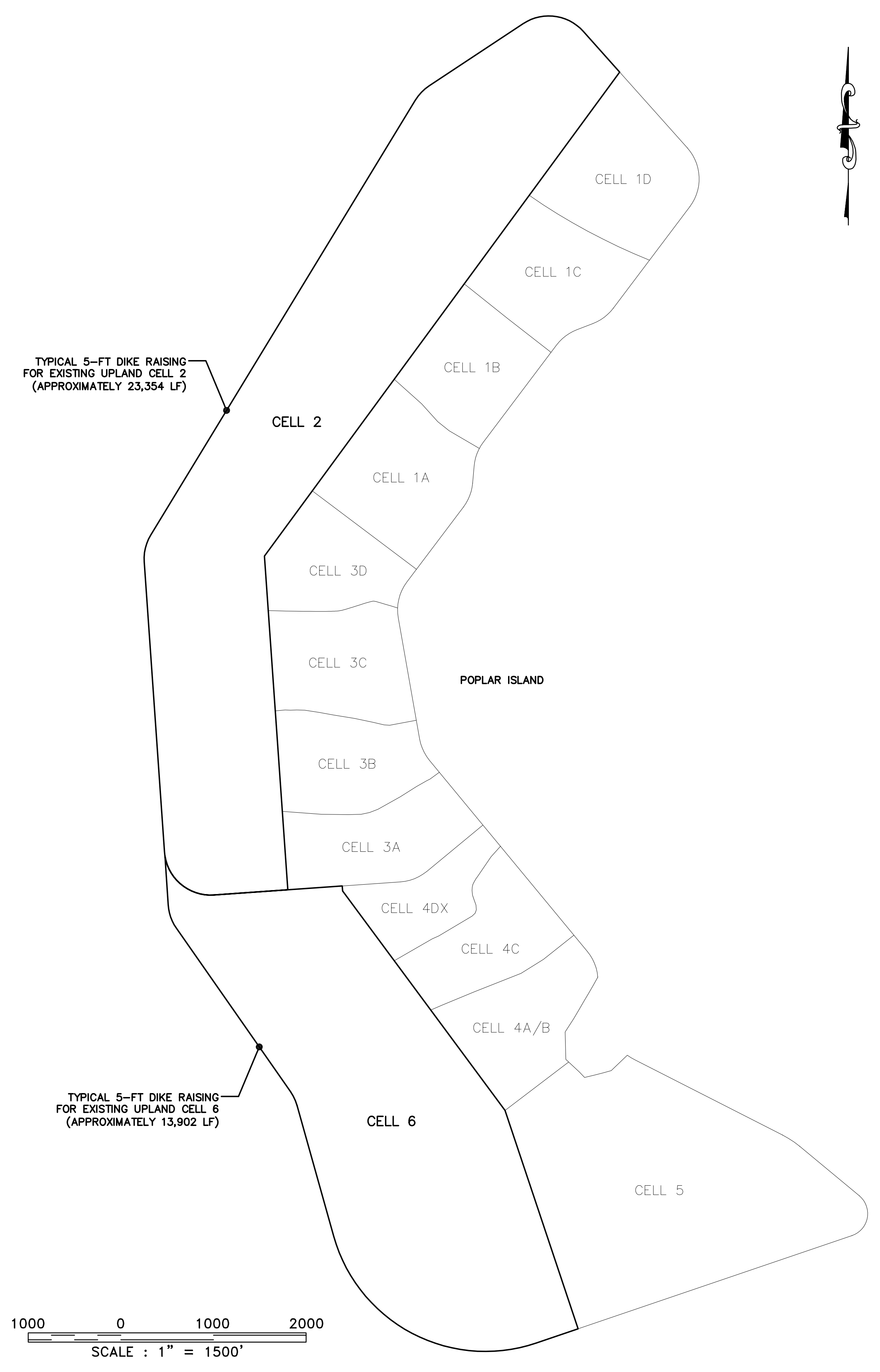


Figure 6. Layout of Typical Section for 5–ft. Dike Raising

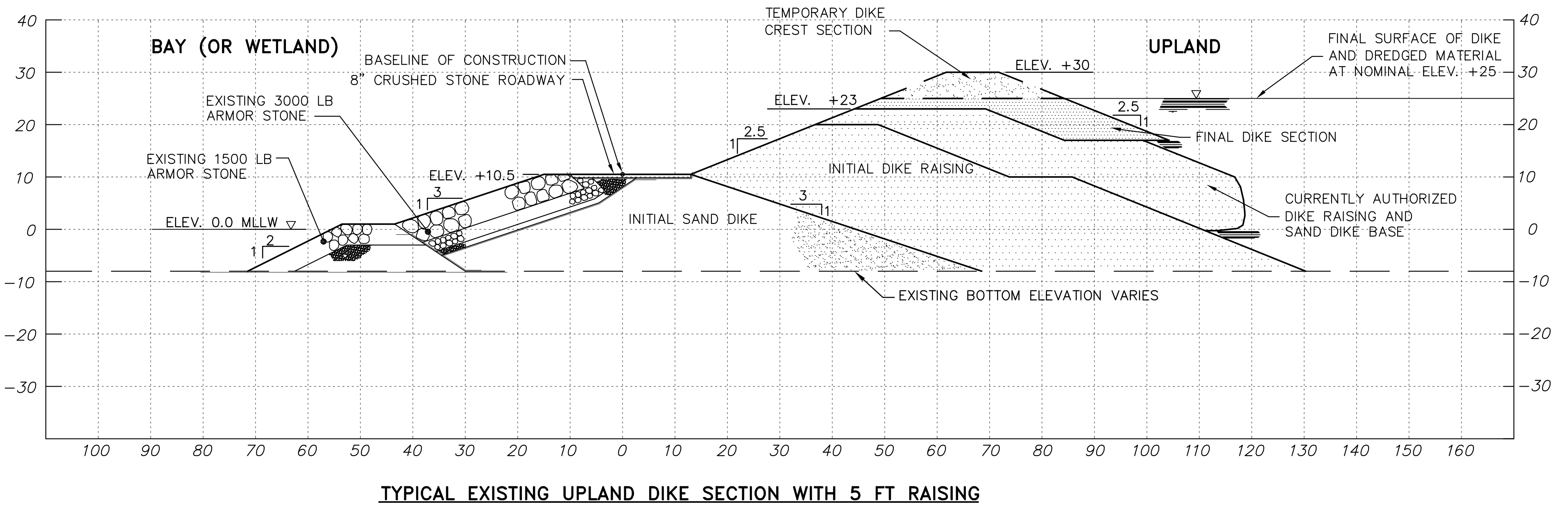


Figure 7. Typical 5 ft. Dike Raising Section for Existing Upland Cells 2 and 6

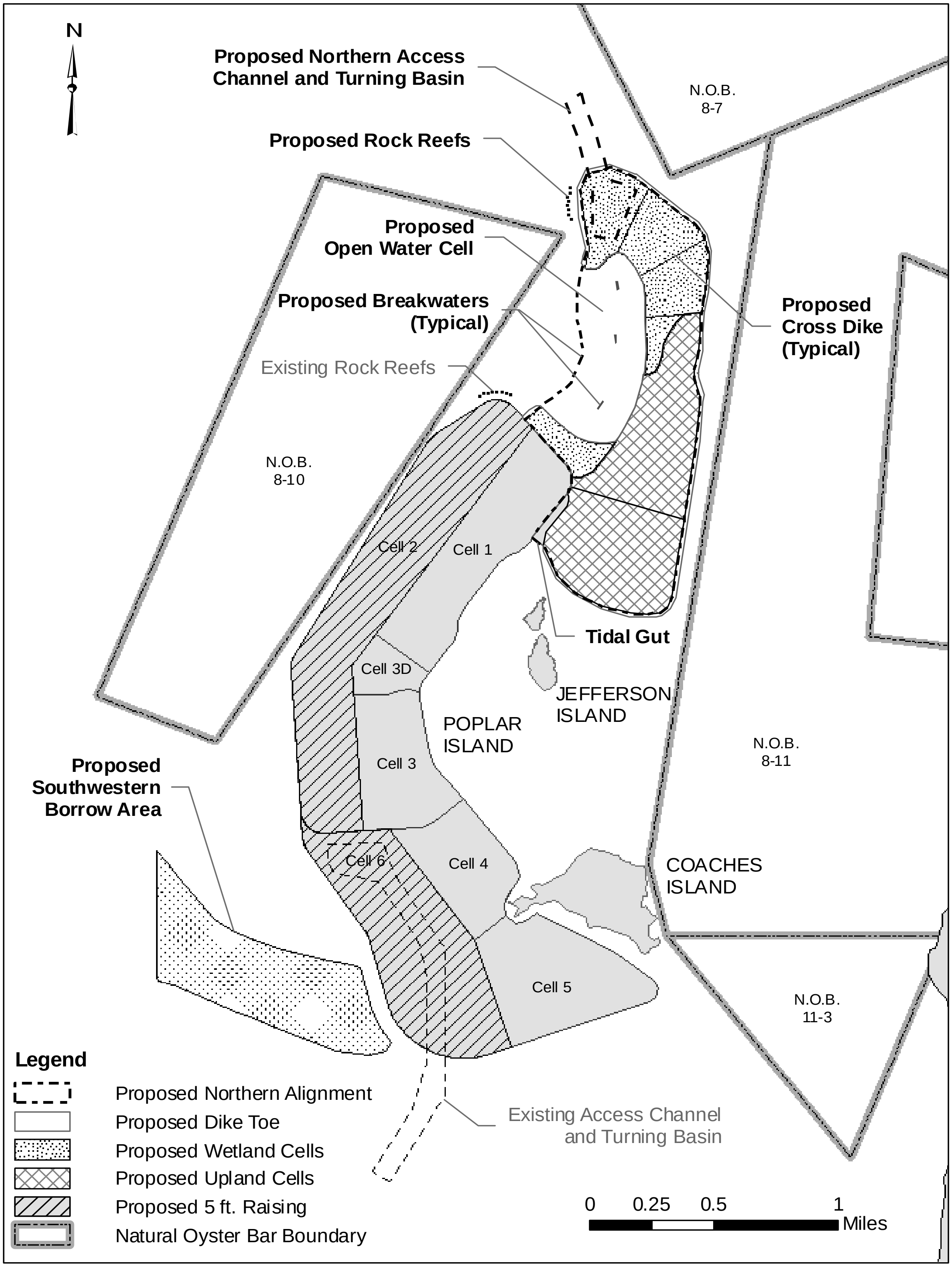


Figure 8. Open-Water Embayment Alignment (29% wetland, 47% upland, and 24% open water; plus a 5-ft raising of existing PIERP upland cells)

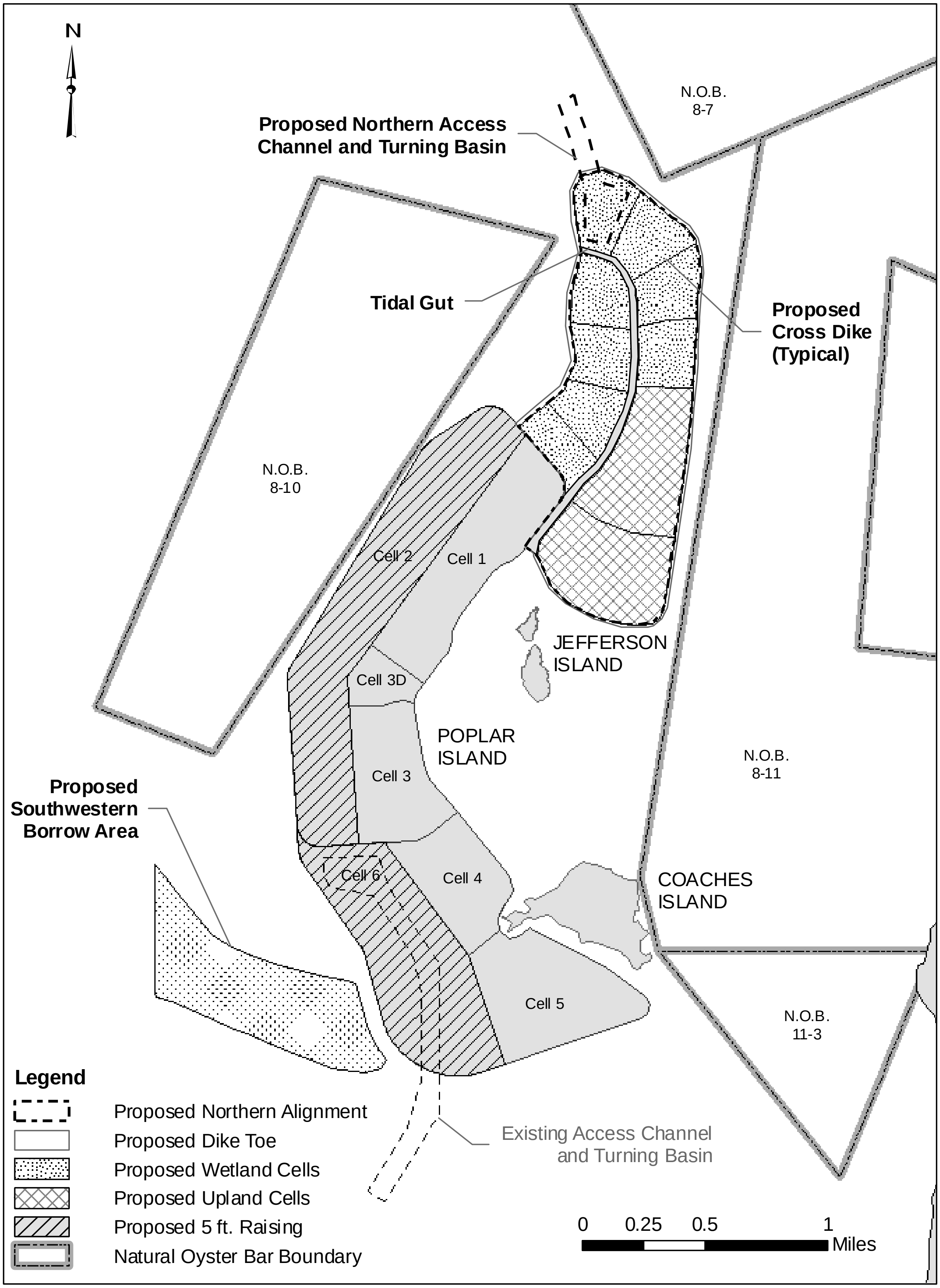


Figure 9. 60% Wetland to 40% Upland Ratio in the Lateral Alignment; plus a 5-ft Raising of Existing PIERP Upland Cells

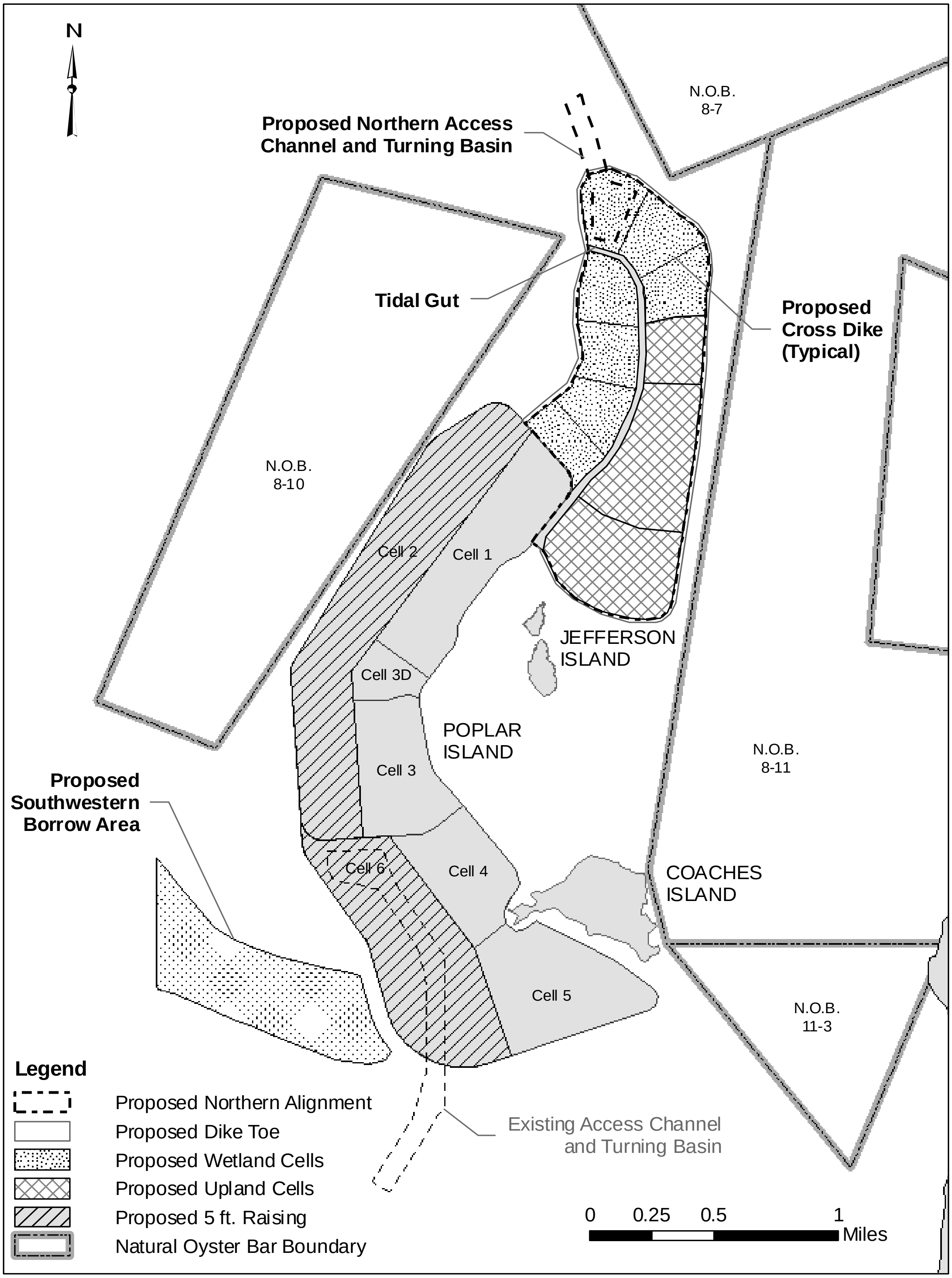


Figure 10. 50% Wetland to 50% Upland Ratio in the Lateral Alignment; plus a 5-ft Raising of Existing PIERP Upland Cells

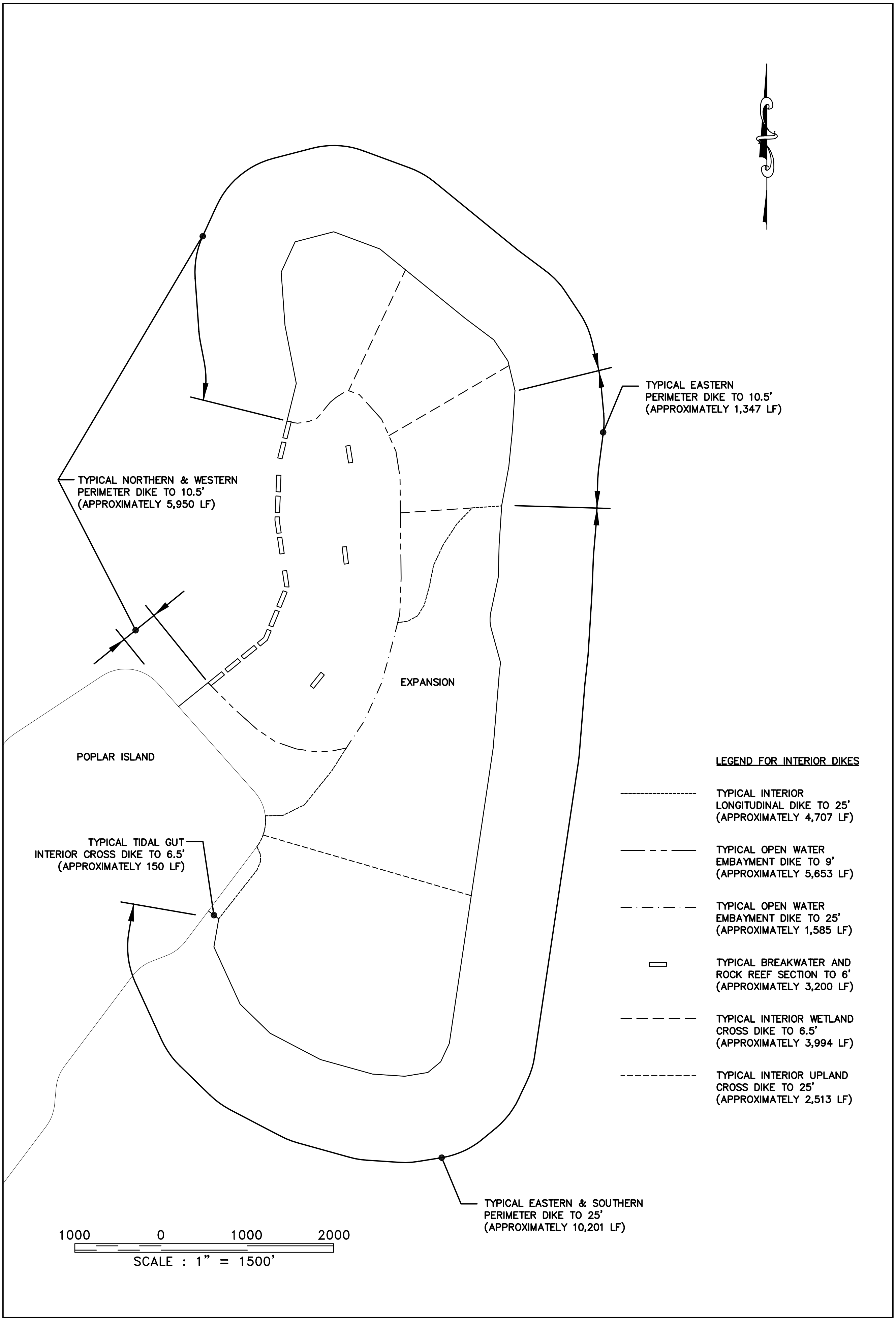


Figure 11. Layout of Typical Sections for Open Water Embayment Option

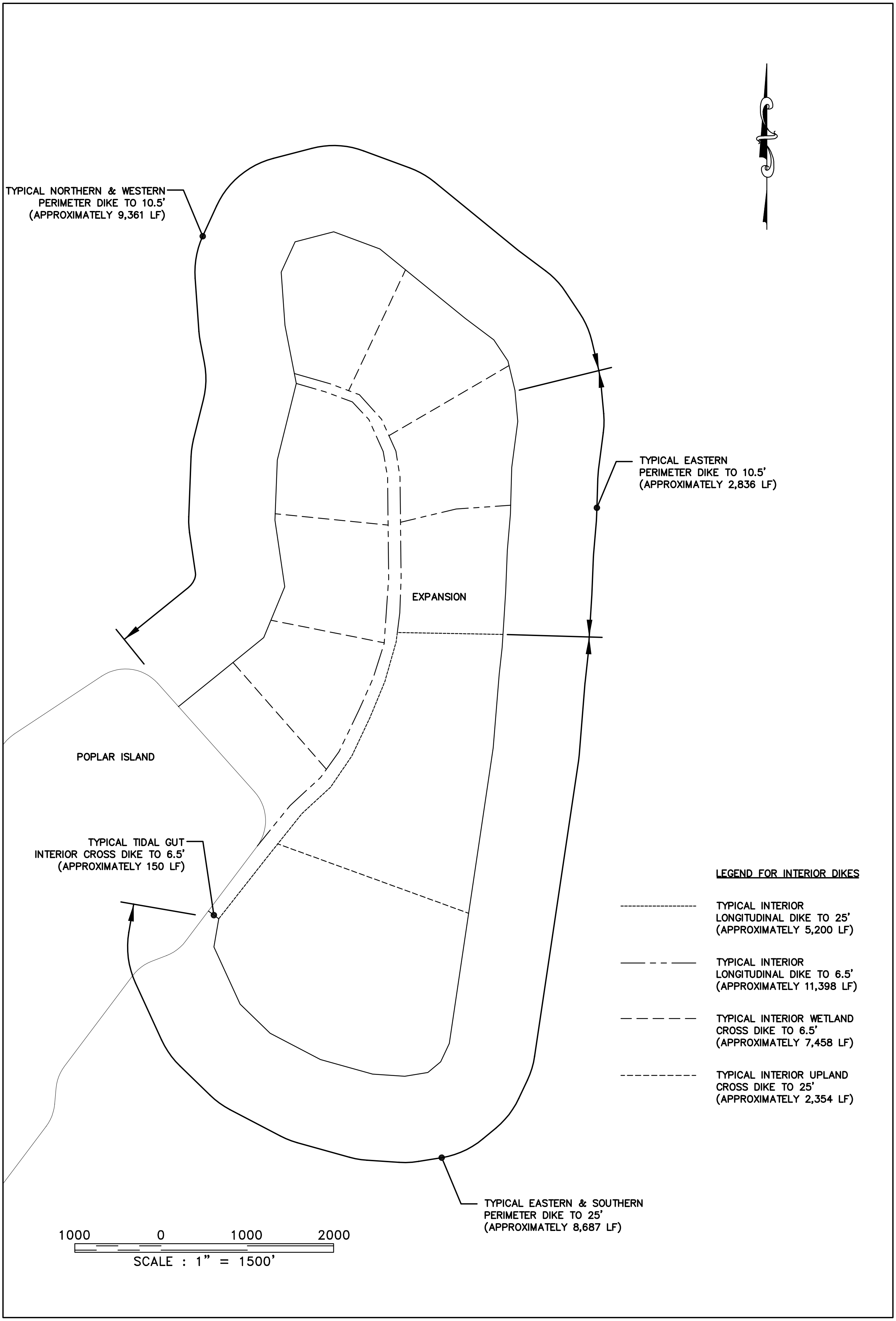


Figure 12. Layout of Typical Sections for 60% Wetlands/40% Uplands Option

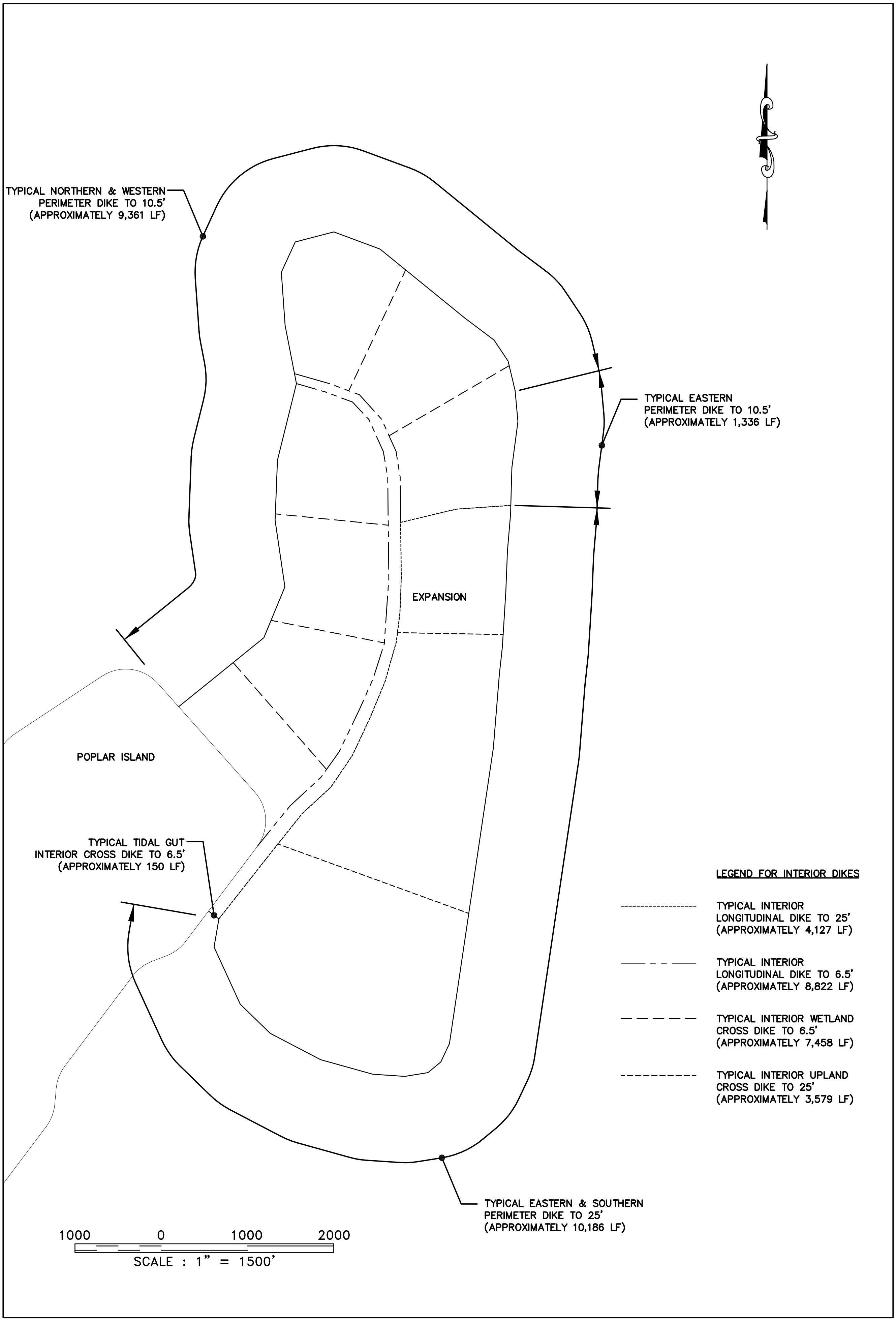
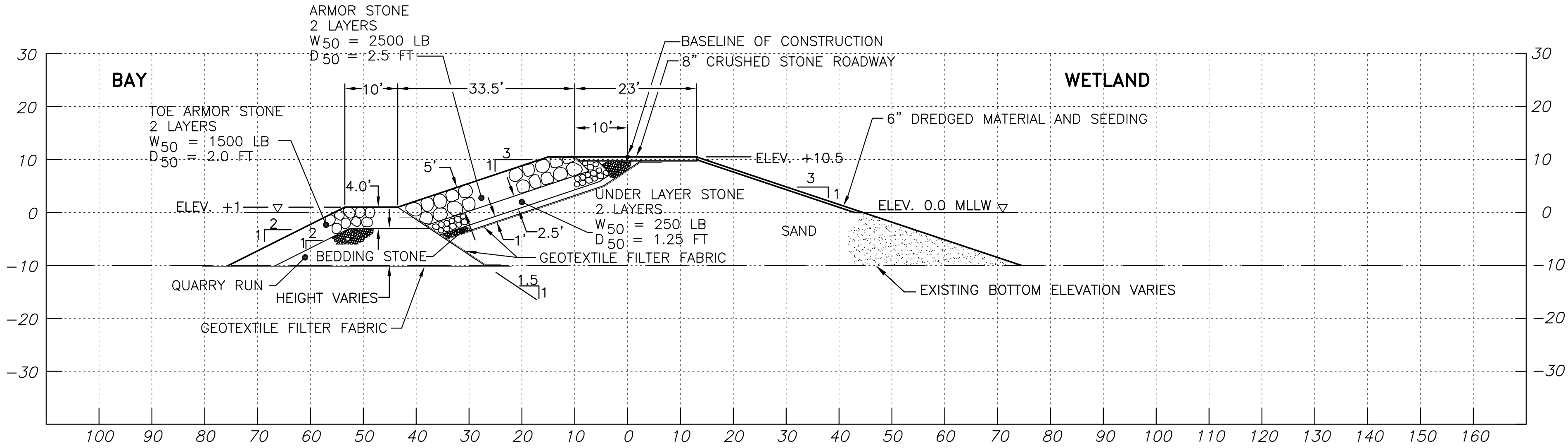
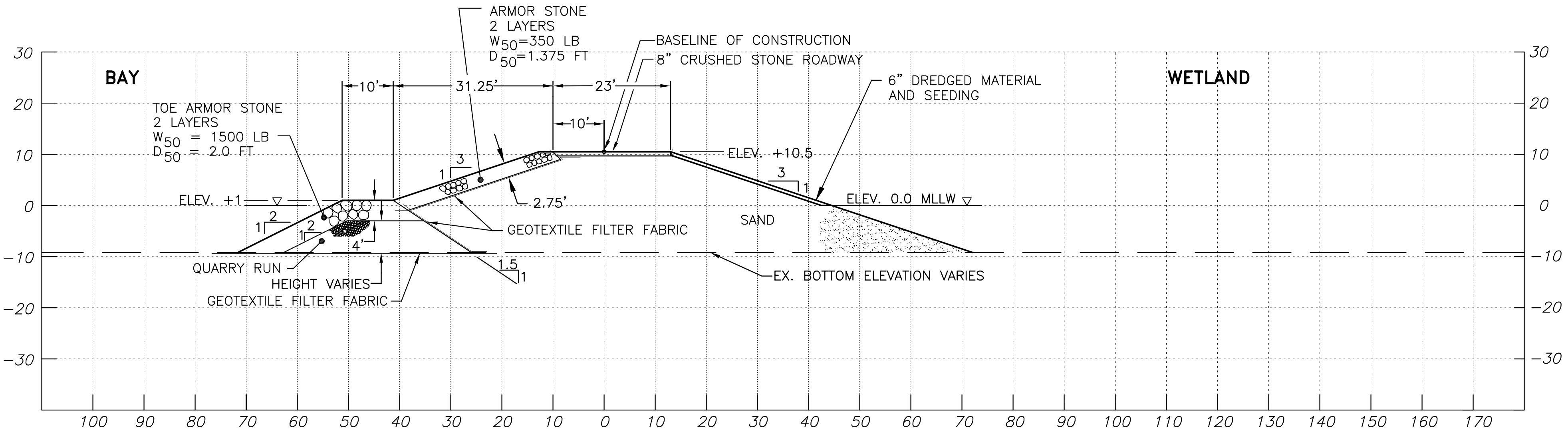


Figure 13. Layout of Typical Sections for 50% Wetlands/50% Uplands Option

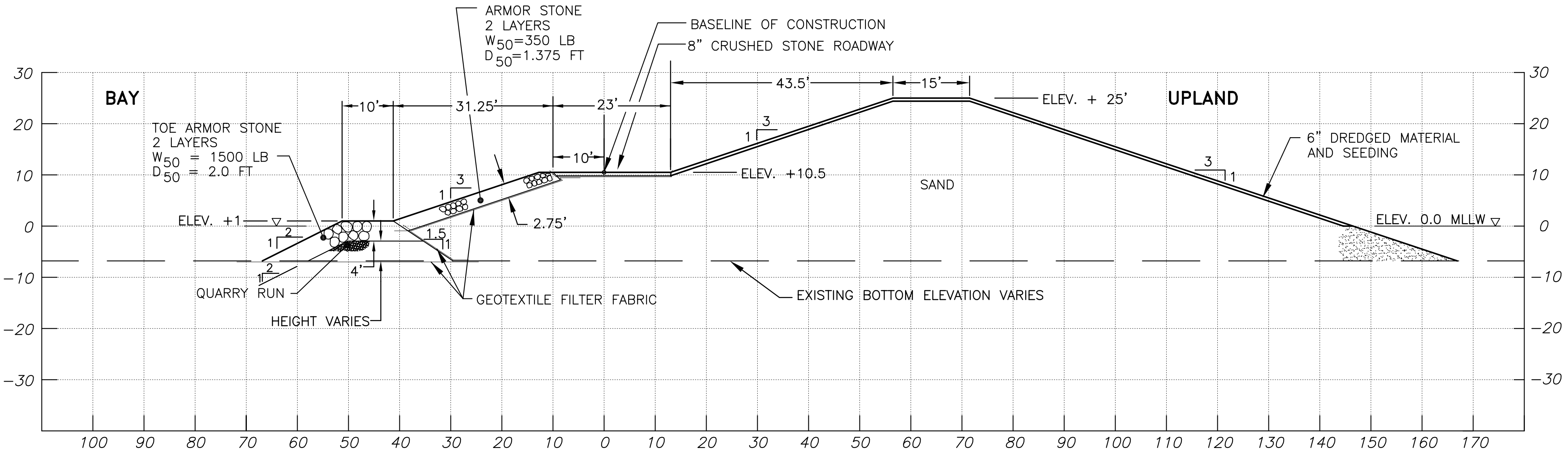


TYPICAL WESTERN AND NORTHERN PERIMETER DIKE SECTION TO 10.5 FEET

Figure 14. Typical Western and Northern Perimeter Dike Section



TYPICAL EASTERN PERIMETER DIKE SECTION TO 10.5 FEET



TYPICAL EASTERN AND SOUTHERN PERIMETER DIKE SECTION TO 25 FEET

Figure 15. Typical Eastern and Southern Perimeter Dike Sections

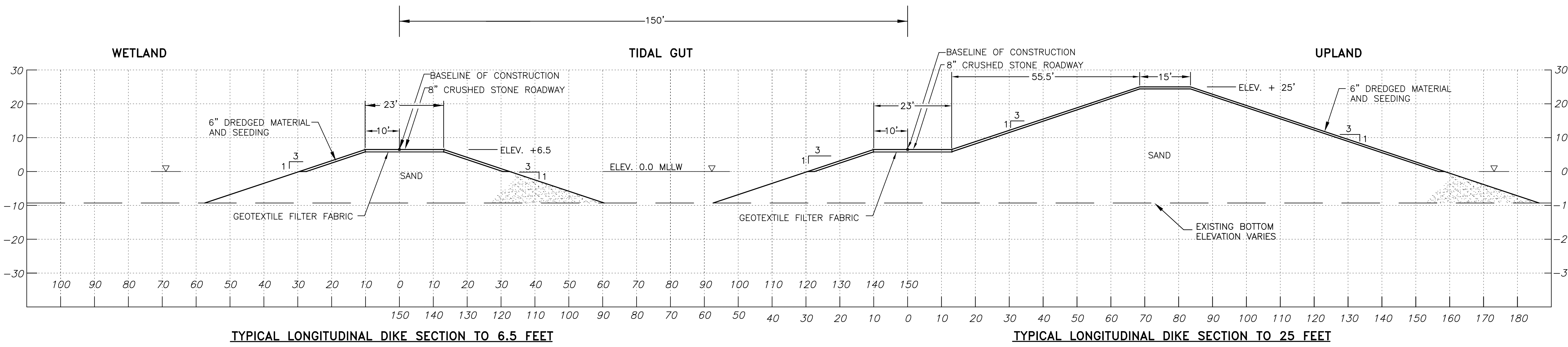
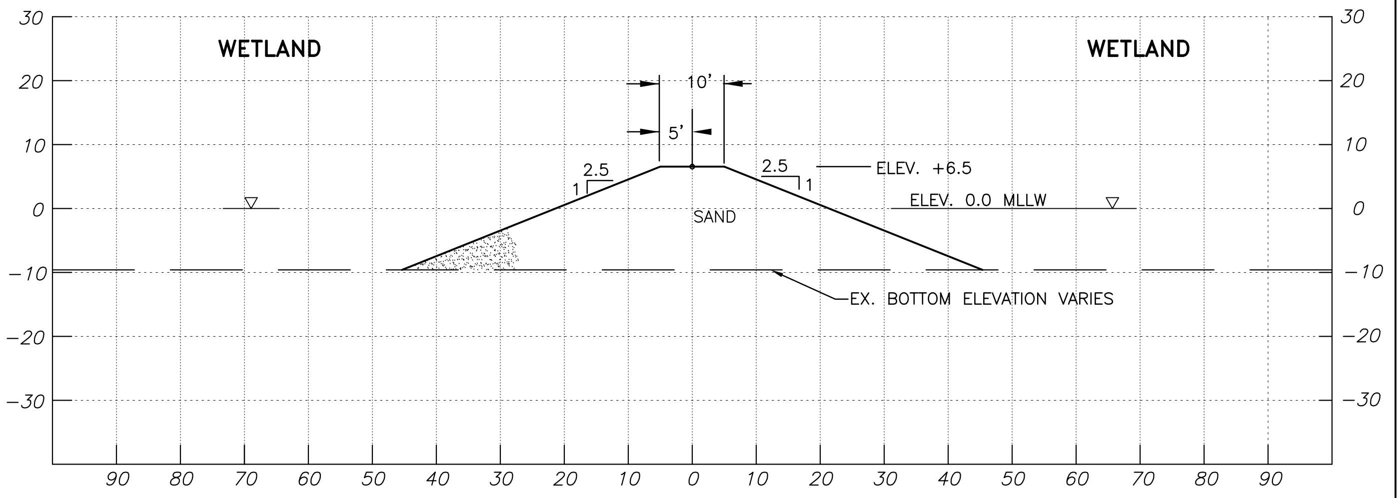
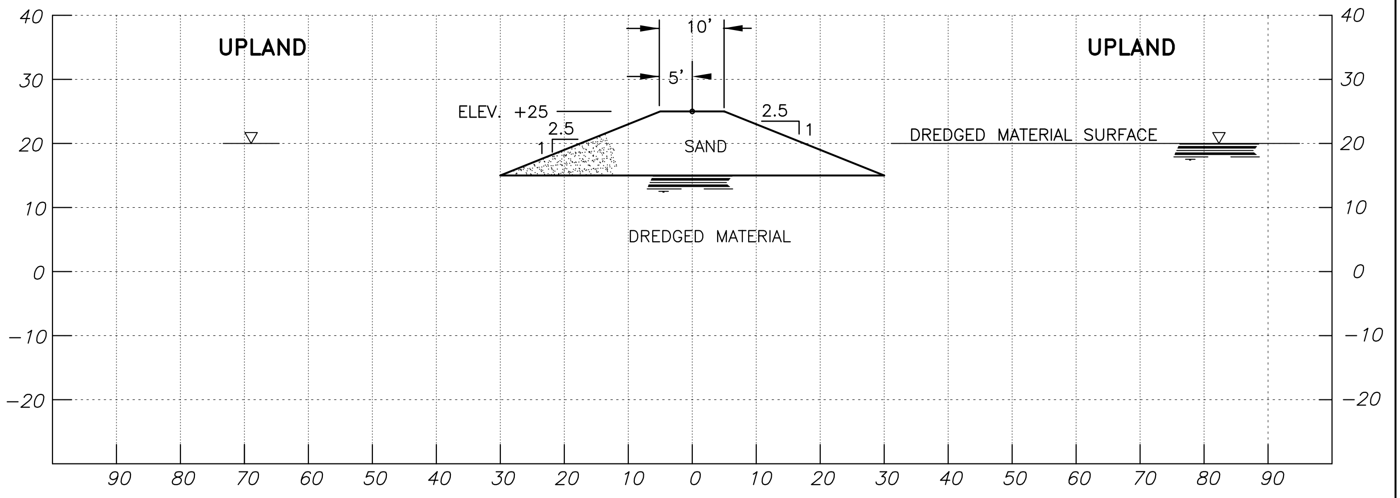


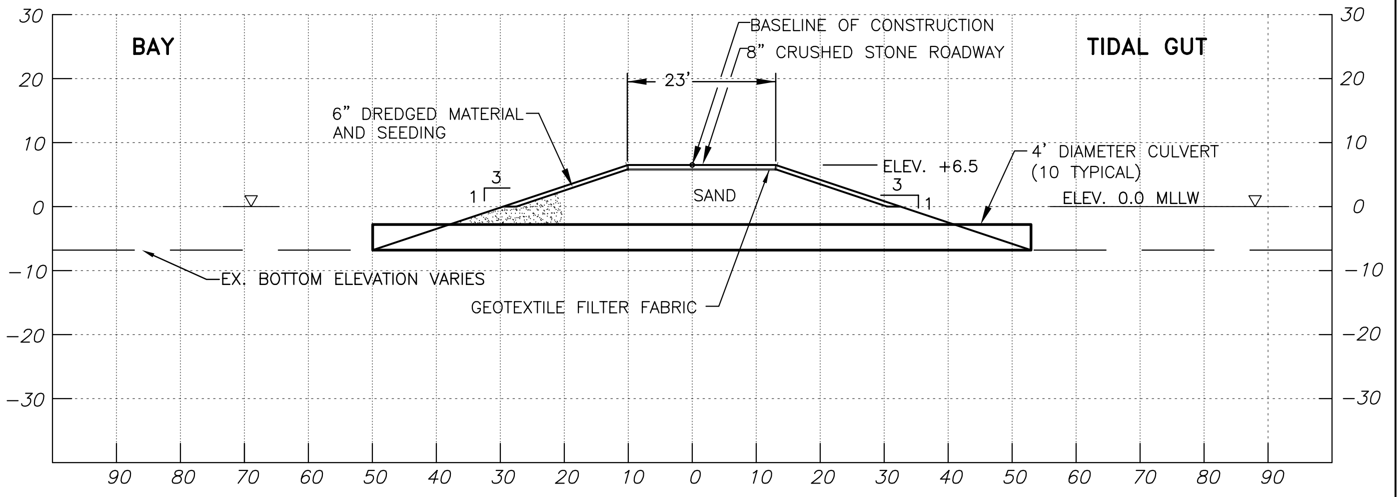
Figure 16. Typical Interior Longitudinal Dike and Tidal Gut Sections



TYPICAL DIKE SECTION FOR WETLAND CROSS DIKES TO 6.5 FEET

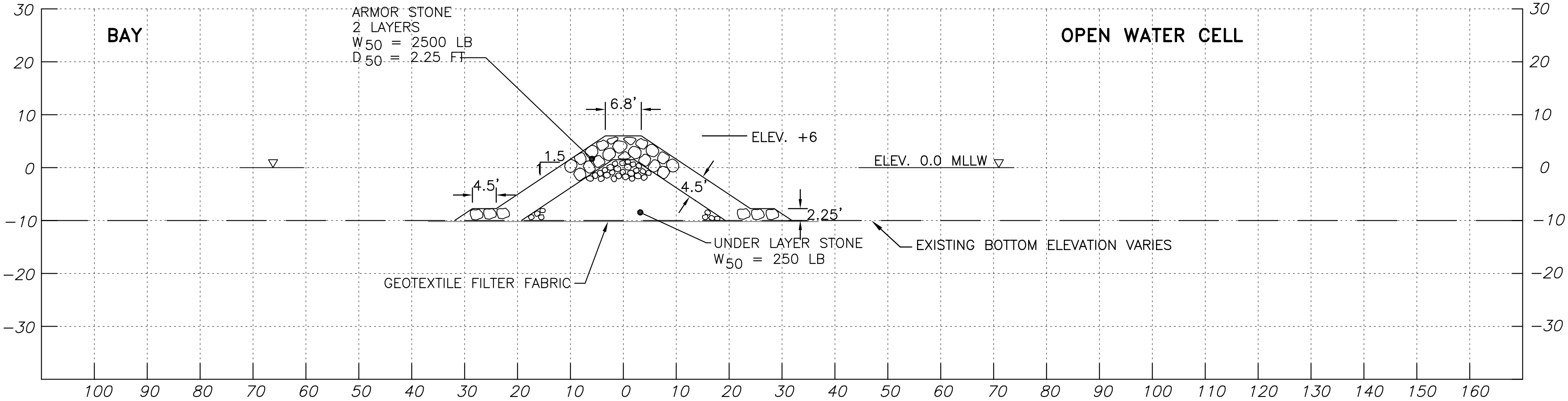


TYPICAL DIKE SECTION FOR UPLAND CROSS DIKE(S)



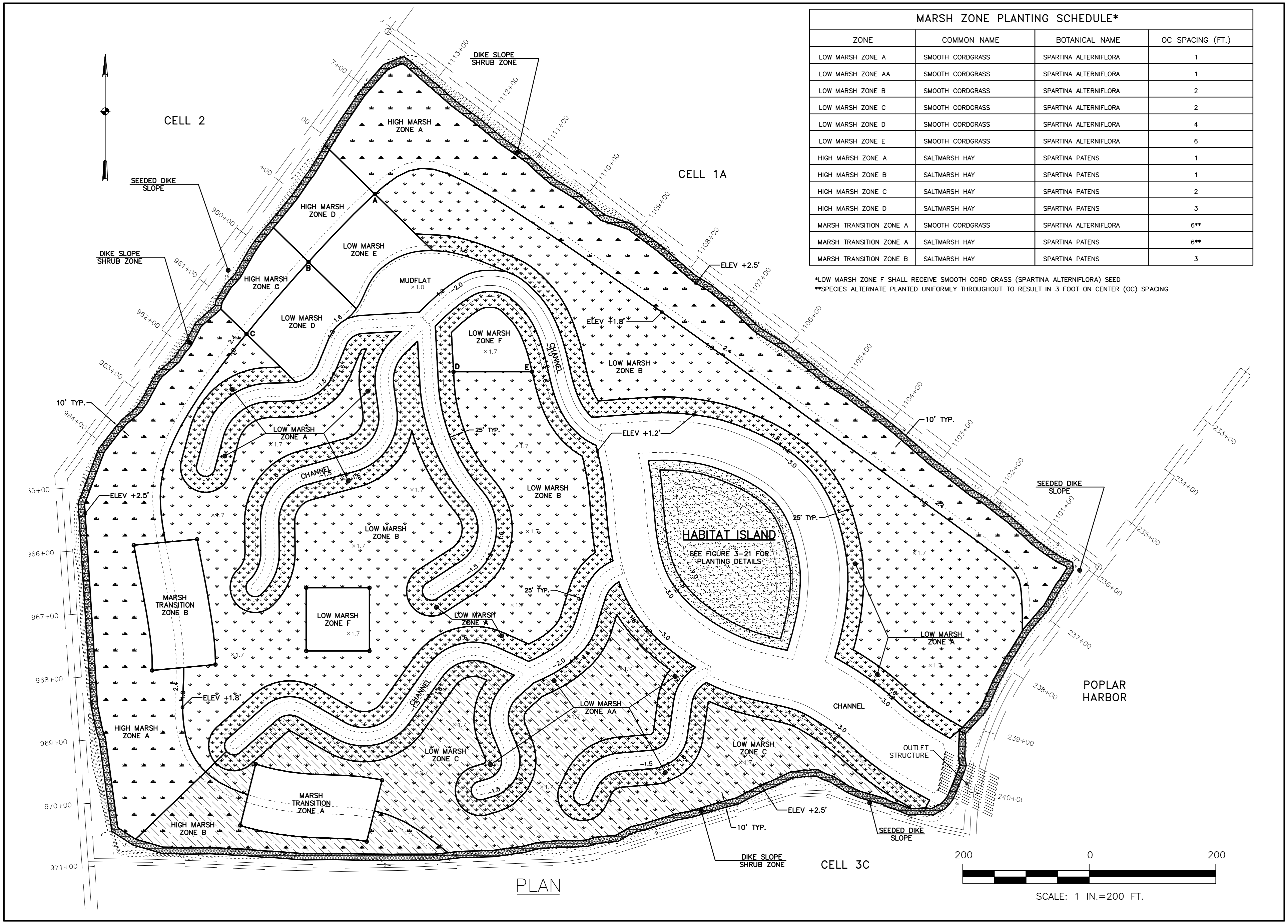
TYPICAL DIKE SECTION FOR TIDAL GUT CROSS DIKE

Figure 17. Typical Wetland, Upland, and Tidal Gut Interior Cross Dike Sections



TYPICAL BREAKWATER AND ROCK REEF SECTION TO 6 FEET

Figure 18. Typical Segmented Breakwater and Rock Reef Section



MARSH ZONE PLANTING SCHEDULE*			
ZONE	COMMON NAME	BOTANICAL NAME	OC SPACING (FT.)
LOW MARSH ZONE A	SMOOTH CORDGRASS	SPARTINA ALTERNIFLORA	1
LOW MARSH ZONE AA	SMOOTH CORDGRASS	SPARTINA ALTERNIFLORA	1
LOW MARSH ZONE B	SMOOTH CORDGRASS	SPARTINA ALTERNIFLORA	2
LOW MARSH ZONE C	SMOOTH CORDGRASS	SPARTINA ALTERNIFLORA	2
LOW MARSH ZONE D	SMOOTH CORDGRASS	SPARTINA ALTERNIFLORA	4
LOW MARSH ZONE E	SMOOTH CORDGRASS	SPARTINA ALTERNIFLORA	6
HIGH MARSH ZONE A	SALTMARSH HAY	SPARTINA PATENS	1
HIGH MARSH ZONE B	SALTMARSH HAY	SPARTINA PATENS	1
HIGH MARSH ZONE C	SALTMARSH HAY	SPARTINA PATENS	2
HIGH MARSH ZONE D	SALTMARSH HAY	SPARTINA PATENS	3
MARSH TRANSITION ZONE A	SMOOTH CORDGRASS	SPARTINA ALTERNIFLORA	6**
MARSH TRANSITION ZONE A	SALTMARSH HAY	SPARTINA PATENS	6**
MARSH TRANSITION ZONE B	SALTMARSH HAY	SPARTINA PATENS	3

*LOW MARSH ZONE F SHALL RECEIVE SMOOTH CORD GRASS (SPARTINA ALTERNIFLORA) SEED

**SPECIES ALTERNATE PLANTED UNIFORMLY THROUGHOUT TO RESULT IN 3 FOOT ON CENTER (OC) SPACING

Figure 19. Planting Plan Proposed for Cell 3D

ATTACHMENT A

BORROW ANALYSIS

POPLAR ISLAND EXPANSION STUDY
ENGINEERING APPENDIX

ATTACHMENT A

SECTION A
SUMMARY OF BORROW REQUIREMENTS FOR EXISTING AND EXPANSION PROJECTS

1. Borrow Sources

There are five potential borrow sources available to complete the construction of the existing project features and the northern expansion project. These sources include the partially exhausted borrow areas F and G, the southern access channel and turning basin, the southwestern borrow area, the northern borrow area, and the northern access channel and turning basin (Figure A-1). The total quantity of borrow material required will be dependent upon the selected expansion alternative. Sand quantities in the borrow areas are at least 1.75 times greater than the required fill. The necessity for this factor is discussed in Paragraph 5.5.3 of the main Engineering Appendix.

2. Project Features

2.1 Current Project. Construction of the existing 1,140-acre project has not yet been completed to its authorized configuration. Closure of the existing access channel opening at the southern end of Cell 6, raising the Cell 6 perimeter dike to elevation +25 ft MLLW, and construction of a new access channel and turning basin to replace the channel currently located inside of Cell 6 are the primary remaining construction activities. Other tasks include restoration of internal borrow sites within wetland cell 4 and construction of temporary cross dikes within wetland Cell 5. These activities will require approximately 1.5 mcy of sand. A small portion of the required sand (0.4 mcy) will be generated by the access channel and turning basin excavation, but the majority must be obtained from other borrow sources. During the Phase II construction of the existing Poplar Island, borrow areas F and G, located immediately south of Cells 5 and 6, were partially utilized as a borrow source for sand and are no longer in an undisturbed condition. Remaining materials within these areas may be used for the current project work, but are insufficient to satisfy quantity requirements. Therefore, after exhausting borrow areas F and G, additional borrow to complete the current project will be obtained from the southwestern borrow area delineated on Figure A-1.

2.2 Expansion Project. The expansion project has lateral and vertical expansion components. The lateral expansion consists of a 575-acre expansion to the north and northeast of the existing project. The vertical expansion component would be accomplished by raising existing upland Cells 2 and 6 to a temporary dike crest elevation of +30 ft MLLW to allow the creation of upland surfaces at approximately elevation +25 ft MLLW. The lateral expansion was aligned and configured so that borrow sources for the sand dike construction are obtained from within the footprint of the project, specifically from within the footprint of the upland cell(s), to the maximum extent possible. The preliminary estimates of available borrow and dike volume indicated that it might be possible to obtain all of the required borrow for a lateral expansion consisting of 50 percent wetlands from within the dike footprint and the required excavation for the access channel and turning basin. However, at wetland percentages of 55 percent or 60 percent, it may be necessary to obtain some borrow material from other sources. It is anticipated that all of the sand for the vertical expansion (i.e., the dike raising) will be obtained from the southwestern borrow area.

Table A-1. Borrow Requirements for Existing Project

Project Feature	Borrow Source	Borrow Yield (mcy)	Borrow Area Disturbed (acres)
Cell 6 Closure	South Access Channel & Basin	0.6	28
Cell 6 Dike Raising to +23	Southwest Borrow Area	0.9	54
Cell 4 Restoration	Southwest Borrow Area	0.6	38
Misc. Cell Development	Southwest Borrow Area	0.4	27
TOTAL REQUIREMENTS		**2.5**	**147**

Table A-2. Borrow Requirements for Expansion Project

Alternative	Borrow Source	Borrow Yield (mcy)	Borrow Area Disturbed (acres)
50% Upland – 50% Wetland	North Borrow (within upland cell limits)	5.2	172
	North Access Channel & Basin	0.5	30
	Southwest Borrow Area	0.0	0
45% Upland – 55% Wetland	North Borrow (within upland cell limits)	4.8	154
	North Access Channel & Basin	0.5	30
	Southwest Borrow Area	0.5	29
40% Upland – 60% Wetland	North Borrow (within upland cell limits)	4.6	144
	North Access Channel & Basin	0.5	30
	Southwest Borrow Area	0.7	42
5-foot Dike Raising	Southwest Borrow Area	0.8	49

3. Borrow Sources and Quantities

3.1 Southern Access Channel & Turning Basin. The southern access channel and turning basin will replace the existing channel and basin after Cell 6 has been closed in 2006 or 2007. This channel will extend from the end of the existing channel at the elevation –25 ft MLLW contour, and extend northeast to the southern end of the longitudinal dike of the existing project where a new turning basin will be excavated. The basin and about 20 percent of the new channel (30 acres) will be located within existing Borrow Area F that was used as a borrow source for the Phase II construction of Poplar Island. The remaining 80 percent of the channel (20 acres) will extend outside of the previously disturbed limits of Borrow Area F. The total area disturbed by the channel and basin excavation is approximately 55 acres. Approximately 1.2 mcy of excavation will be required for the new access channel and turning basin. Based on very preliminary subsurface excavations, about 50 percent of the excavated material will consist of sand suitable for dike fill and 50 percent will consist of clay or silt that will be spoiled within the existing project limits. It is anticipated that the sand portion of the excavation will provide most of the material needed to complete the closure of the existing gap in the Cell 6 dike alignment. The channel and basin will be excavated to elevation –25 ft MLLW with up to 2 feet of over-depth dredging allowed. The bottom width will be 400 feet and side slopes of the channel will be 3H:1V.

3.2 Borrow Areas F and G. Borrow Areas F and G encompass approximately 60 and 55 acres, respectively. The two sites were originally estimated to contain approximately 0.7 and 1.0 mcy of sand, respectively. It is estimated that Phase II construction extracted approximately 60 percent to 70 percent of the original estimated quantity of borrow material. The original bottom elevations varied from about elevation –5 to –13 ft MLLW. The current bottom elevations within the disturbed area range from –18 to –20 ft MLLW, corresponding to approximately 1.0 to 1.2 mcy of borrow excavation. The borrow area slopes parallel to the Cell 6 dikes were excavated to a slope of approximately 10H:1V to minimize the effect on the wave environment adjacent to the dikes. Additional subsurface investigations will be required to quantify the remaining borrow quantities within these areas. Based on the original borrow estimates, approximately 0.5 mcy would be expected to remain in this area. However, the depth of excavation in Borrow Area G was restricted to material above bottom elevation –20 ft MLLW. Therefore, some additional suitable borrow materials may be obtained from this site by excavating to a depth of –25 ft MLLW and extending the borrow area slightly to the south. At that final bottom elevation, both area F and G would daylight at the –25 ft MLLW existing Bay bottom contour and assure connection with the deeper bottom elevation of the existing Bay. Approximately 20 acres of Borrow Area G is located within the proposed southwestern borrow area.

3.3 Southwest Borrow Area. The southwest borrow area was investigated as part of the reconnaissance studies conducted by the Maryland Port Administration in 2002. Based on several recent borings, along with borings conducted for the original Poplar Island project, a 215-acre area was delineated immediately west of existing Cell 6. The bottom elevations of the area currently range from –8 ft MLLW near the outside toe of the Cell 6 dike, to approximately –16 ft MLLW at the southwestern corner of the area. The sand deposit ranges from approximately 10 to 22 ft in thickness, providing a total volume of suitable dike fill material of approximately 4.4 mcy. If the borrow site was completely exhausted, the final bottom elevations would range from approximately –16 ft MLLW near Cell 6 to approximately –34 ft MLLW at the extreme southwest corner. It is currently estimated that approximately 3.5 to 4.0 mcy of borrow material will be required to construct the currently authorized project plus the proposed expansion project. Therefore, it may be possible to limit the depth of borrow removal to approximately elevation –25 ft MLLW by restricting the borrow excavation to about 10 feet below the existing bottom elevations. It is also proposed that the borrow excavation begin at the western limits of existing Borrow Area G, and advance to the west as needed, always maintaining contact with the day lighted southern limits of Borrow Area G to assure adequate circulation with deeper water.

Upon completion, the borrow site would have a relatively flat bottom similar to existing bottom grades. Typical changes in grade are 1 vertical foot over 100 horizontal feet or flatter. At the lateral limits of the site, the excavation slopes would be limited to not steeper than approximately 5H:1V, although the actual side slopes tend to be much flatter as seen by the post-excavation results for borrow areas F and G. The total area disturbed by borrow activities would range from 120 acres (56 percent) to support the existing project plus an expansion at 50 percent wetlands, to 210 acres (98 percent) to support the existing project plus an expansion at 60 percent wetlands with a 5-foot dike raising.

Table A-3. Summary of Potential Southwestern Borrow Area Use

Project Alternative	SW Borrow Area Disturbed (acres)	Percentage of SW Borrow Area
50% Wetland + Existing Projects	119	56%
55% Wetland + Existing Projects	148	69%
60% Wetland + Existing Projects	161	75%
50% Wetland + 5’ Raising + Existing Projects	168	78%
55% Wetland + 5’ Raising + Existing Projects	197	92%
60% Wetland + 5’ Raising + Existing Projects	210	98%

3.4 Northern Access Channel & Turning Basin. The northern access channel and turning basin will provide access to the expansion cells for placement of dredged materials. This channel will extend from existing Bay bottom the elevation –25 ft MLLW contour northwest of the site, to the northern end of the placement site. The turning basin and about 20 percent of the new channel will be contained within the northern wetland cell. The remaining 80 percent of the channel will extend outside the expansion footprint**.** The total area disturbed by the channel and turning basin excavation is approximately 45 acres. Approximately 0.8 mcy of excavation will be required for the new access channel and turning basin. Based on preliminary subsurface excavations, about 60 percent of the excavated material will consist of sand suitable for dike fill and 40 percent will consist of clay or silt that will be spoiled within the existing project limits. The channel and basin will be excavated to elevation –25 ft MLLW with up to 2 feet of over-depth dredging allowed. The bottom width will be 400 feet and side slopes of the channel will be 3H:1V.

4. Northern Borrow Area

The northern borrow area was investigated as part of the reconnaissance studies conducted by the Maryland Port Administration in 2002. Based on those borings, along with borings conducted for the original Poplar Island project, two separate borrow areas were delineated to the north and northeast of the existing project. After the screening performed during the plan formulation phase of the study, a single northern study area was delineated with a single merged borrow source. An additional 34 borings were completed within the northern study area to further define subsurface conditions relevant to potential dike alignments and borrow sources.

The bottom elevations of the northern borrow area currently range from –5 ft MLLW at the southern end of the expansion footprint, to approximately –10 ft MLLW at the northern end of the area. The sand deposit ranges from approximately 10 to 23 ft in thickness, providing a total volume of suitable dike fill material of approximately 5.1 to 5.7 mcy. If the borrow site was completely exhausted, the final bottom elevations would range from approximately –20 ft MLLW at the northern end of the area to approximately –30 ft MLLW at the southern end. It is currently estimated that the dike construction for the expansion alternatives will require a borrow source containing between 5.7 and 5.8 mcy of suitable sand.

Since the northern borrow area is completely within the upland cell of the expansion alignment, it will be buried beneath the contained dredged material. To assure that the stability of the containment dikes is not compromised, the borrow excavation will be offset 50 to 100 ft from the interior toe of the dike, and side slopes of the borrow area will not be permitted to be steeper than 3H:1V. The total area disturbed by borrow excavation will vary from 144 to 172 acres depending upon the total area of the upland cell.

POPLAR ISLAND EXPANSION STUDY
ENGINEERING APPENDIX

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SECTION B
BORROW AREA ANALYSIS
(With Detailed Analysis of Northern Borrow Area)

1. Introduction
Analyses of potential borrow areas were performed in two stages. The first phase of analysis considered four potential borrow areas associated with the six expansion alternatives presented in the Reconnaissance Study conducted by the Maryland Port Administration in 2002. Information about these borrow areas was obtained from subsurface investigations and laboratory testing performed for the 2002 Reconnaissance Study as well as investigations from many previous investigations for the original Poplar Island project. Analysis of these borrow sources supported the engineering screening performed as part of the Plan Formulation process.

Plan Formulation identified a 1,000-acre area to the north of the existing project as the preferred location for an expansion alignment. The second phase of borrow analysis focused on the potential borrow sources located with the preferred northern location. This analysis considered all of the previous subsurface investigations and the information obtained from 34 new borings performed in the northern study area defined in the Plan Formulation phase of this study.

2. Phase I Borrow Analyses
Four potential borrow areas were identified to supply sand needed for construction of the containment dikes for the seven alternatives identified in the Reconnaissance Report (Figure A-2). The areas consist of a total of approximately 1,200 acres and contain silty fine sand materials that are similar to those materials used to construct the existing containment dikes. The areas include sand deposits ranging from a minimum of 10 to more than 20 ft in thickness. The deposits include some interbedded fine-grained silt and clay materials. Some portions of the sand borrow deposits may be overlain by a layer of fine-grained silt or clay that must be removed to expose the usable sand deposits.

3. Borrow Area Descriptions

3.1 Southeast Borrow Area. This borrow area is located approximately 4,000 feet southeast of the southern end of the existing Poplar Island project, and would be used for the construction of a portion of alternatives 1 through 5. The area encompasses approximately 473 acres with an estimated total volume of sand of approximately 9.1 million cubic yards (mcy). About 80 percent of the area contains sand between 10 and 20 ft thick, and the remaining 20 percent contains sand deposits exceeding 20 ft. The quantity of sand available for construction would be reduced by the quantity beneath the footprint of the proposed dikes. For each of the proposed alternatives that would use this site, only a portion of the total borrow area would be contained within the project footprint.

3.2 Southwest Borrow Area. This borrow area is located approximately 2,500 feet southwest of the southwestern side of the existing Poplar Island project, and would be used for the construction of a portion of alternatives 1 through 4. The area encompasses approximately 211 acres with an estimated total volume of sand of approximately 4.2 million cubic yards (mcy). About 80 percent of the area contains sand between 10 and 20 ft thick, and the remaining 20 percent contains sand deposits exceeding 20 ft. The quantity of sand available for construction would be reduced by the quantity beneath the footprint of the proposed dikes plus an additional offset between the inside toe of the dike and the edge of the borrow excavation. For each of the proposed alternatives that would use this site, only a portion of the total borrow area would be contained within the project footprint.

3.3 Northeast Borrow Area. This borrow area is located approximately 1,500 feet northeast of the northeastern corner of the existing Poplar Island project, and would be used for the construction of a portion of alternatives 6 and 7. The area encompasses approximately 345 acres with an estimated total volume of sand of approximately 7.2 million cubic yards (mcy). About 70 percent of the area contains sand between 10 and 20 ft thick, and the remaining 30 percent contains sand deposits exceeding 20 ft. The quantity of sand available for construction would be reduced by the quantity beneath the footprint of the proposed dikes. For each of the proposed alternatives that would use this site, only a portion of the total borrow area would be contained within the project footprint.

3.4 Northwest Borrow Area. This borrow area is located approximately 5,000 feet north of the northwestern corner of the existing Poplar Island project, and would be used for the construction of a portion of alternatives 6 and 7. The area encompasses approximately 170 acres with an estimated total volume of sand of approximately 4.6 million cubic yards (mcy). About 30 percent of the area contains sand between 10 and 20 ft thick, and the remaining 70 percent contains sand deposits exceeding 20 ft. The quantity of sand available for construction would be reduced by the quantity beneath the footprint of the proposed dikes. For each of the proposed alternatives that would use this site, only a small portion of the total borrow area would be contained within the project footprint. However, a substantial quantity of borrow material would be generated by the excavation of a channel required to provide access for dredged materials barges to the expansion site.

4. Borrow Quantity Evaluation. Table A-4 provides an analysis of the borrow materials available compared to the borrow quantities required to construct each of the seven expansion alternatives. The analysis identifies the portion of the borrow area within the footprint of the alternative alignment and the quantity associated with the enclosed area. The quantity of borrow material that would be obtained from the excavation of a required access channel is included in the estimate of available borrow material. The quantity available within the alignment limits and access channel is then compared to the required quantity, and any shortfall of borrow material is quantified. Where additional material is required, the approximate area of additional borrow outside the alignment footprint is identified.

Table A-4. Plan Formulation Alternatives Borrow Analysis

Alternative	Cell	Borrow Source	Borrow Area Size (acres)	Total Volume (mcy)	Volume Less Footprint (mcy)	Volume of Dike to +20 MLLW (mcy)	Volume Required for Construction (mcy)	Interior Borrow Area (acres)	Interior Borrow Volume (mcy)	Access Channel Volume (mcy)	Total Borrow Available (mcy)	Borrow Shortage (mcy)	External Borrow Req'd (acres)
1 753 ac	SE Cell	SE borrow	473	9.1	7.7	4.26	7.46	136	3.37	0.00	3.37	3.71	186
	SW Cell	SW borrow	211	4.2	4.1	--	--	25	0.38	0.00	0.38	--	--
2 754 ac	SE Cell	SE Borrow	473	9.1	8.8	4.35	7.61	0	0.00	0.00	0.00	4.77	239
	SW Cell	SW Borrow	211	4.2	3.6	--	--	25	0.38	0.00	0.38	--	--
	N Cell	NE Borrow	345	7.2	5.8	--	--	55	0.83	0.00	0.83	--	--
		NW Borrow	170	4.6	3.8	--	--	38	0.89	0.75	1.64	--	--
3 754 ac	SE Cell	SE Borrow	473	9.1	7.9	5.50	9.63	75	1.81	0.00	1.81	6.14	307
	SW Cell	SW Borrow	211	4.2	3.6	--	--	25	0.38	0.00	0.38	--	--
	N Cell	NE Borrow	345	7.2	6.1	--	--	20	0.30	0.00	0.30	--	--
		NW Borrow	170	4.6	4.6	--	--	0	0.00	1.00	1.00	--	--
4 1129 ac	SE Cell	SE Borrow	473	9.1	7.7	7.04	12.32	136	2.99	0.00	2.99	6.46	323
	SW Cell	SW Borrow	211	4.2	3.1	--	--	25	0.38	0.00	0.38	--	--
	N Cell	NE Borrow	345	7.2	5.8	--	--	55	0.83	0.00	0.83	--	--
		NW Borrow	170	4.6	3.7	--	--	38	0.92	0.75	1.67	--	--
5 749 ac	SE Cell	SE Borrow	473	9.1	7.7	3.58	6.26	170	3.74	0.00	3.74	0.53	26
	N Cell	NE Borrow	345	7.2	5.8	--	--	55	0.83	0.00	0.83	--	--
		NW Borrow	170	4.6	4.3	--	--	20	0.41	0.75	1.16	--	--
6 313 ac	N Cell	NE Borrow	345	7.2	5.4	1.63	2.84	110	2.42	0.00	2.42	-0.58	0
		NW Borrow	170	4.6	4.6	--	--	0	0.00	1.00	1.00	--	--
7 631 ac	N Cell	NE Borrow	345	7.2	4.5	2.71	4.75	200	4.12	0.00	4.12	-0.81	0
		NW Borrow	170	4.6	4.6	--	--	20	0.44	1.00	1.44	--	--

Total Borrow Quantities 1199 25.1

Alternatives 1 through 5 each require borrow materials in excess of the quantity available within the project footprint and the required access channel excavation. As shown on Table A-4, the additional external borrow areas required range from 26 acres for Alternative 5 to 323 acres for Alternative 4. All required borrow materials for Alternatives 6 and 7 can be obtained from within the project footprint and the required access channel excavation.

5. Phase II Borrow Analysis

The plan formulation screening of potential expansion alternatives determined that an expansion project within the northern site was the most desirable. Therefore, subsurface investigations focused only on the potential northern expansion area. Investigations consisted of 34 new borings to supplement the approximately 30 borings completed during various previous phases of investigation for the original Poplar Island project and the expansion studies. Based on the additional subsurface investigations, the delineation of the northern borrow area was refined and the available quantity of sand borrow material was estimated. The quality of the material was evaluated from laboratory testing results to determine the location of the best quality materials.

5.1 Revised Borrow Area Limits. The potential northern expansion area is bounded by oyster bars to the west, north, and east, and by the existing project to the south. Suitable sand for dike construction was located along the eastern and northern portions of the potential limits of the northern expansion area. The sand deposit ranges from less than 10 ft to slightly less than 25 ft in thickness, and is underlain by a clay stratum (Figure A-3). The thickest deposit, between 20 and 25 ft in thickness, is located within approximately 80 acres of the southeastern portion of the northern expansion area. The deposit diminishes in thickness as it extends to the north where it is less than 10 ft thick.

5.2 Borrow Excavations. Borrow materials obtained from within the expansion footprint will be limited (to the maximum extent practicable) to that quantity that can be excavated from within the proposed upland cells of the expansion area. During the construction of the current Poplar Island project, most of the required borrow materials were obtained from locations within wetland Cells 3, 4, and 5. The deep depressions left in those cells significantly increases the thickness of dredged material and results in a wide variation in dredged material thickness within the cells. Consequently, the large differential in settlement of the dredged material consolidation makes it extremely difficult to achieve the very narrow target elevations required for wetland plants. Therefore, borrow sites will be excluded from wetland cells to the maximum extent possible. If unavoidable, borrow excavations will be completed to a uniform depth across the entire cell and the total depth will be kept to less than about 12 to 15 ft.

5.3 Borrow Quantity. Given that the proposed expansion site will contain approximately 550 acres of upland and wetland habitat, not more than 275 acres (50 percent) of that area will consist of upland habitat. After reducing the potential borrow area for the dike footprint and an appropriate setback from the toe of the dike, approximately 200 acres would remain for borrow excavation. That area would yield an estimated 5.7 million cubic yards (mcy) of sand for construction of the expansion project. That quantity is approximately 1.75 times the estimated quantity of material need for dike construction and is considered marginally sufficient to satisfy the project needs.

If the wetland area is expanded to 60 percent of the site, the upland proportion of the expansion will be reduced to about 220 acres (40 percent of the area), and the potential borrow yield will be reduced to approximately 5.2 mcy. That quantity is approximately 1.6 times the estimated quantity of material need for dike construction of the expansion dikes. Therefore, it is likely that additional borrow materials would be required from borrow sources outside of the expansion footprint. A summary of available borrow quantities compared to required dike fill quantities is presented below in Table A-5.

If the upland Cells 2 and 6 of the existing project are raised to allow the final upland elevations to be raised to elevation +25 ft MLLW, an additional 450,000 cy of borrow sands would be required. These materials would have to be obtained from other borrow sources outside of the expansion area. The two most likely sources include the borrow area to the southwest of existing cell 6, or sand obtained from required dredging of the shipping channels. The southwest borrow area is estimated to contain approximately 4.2 mcy (GBA, 2003) of suitable sand for dike construction. The southwestern borrow area was partially utilized for the construction of the Phase II portion of the original project. That area, expanded to the south and southwest, will also be used as a source of materials for the completion of the Phase II construction. The remaining work consists of closure of the opening at the south end of cell 6, and raising of the cell 6 dikes to the height required to for placement of dredged material to elevation +20 ft MLLW requiring approximately 1.0 mcy of sand. Therefore, it appears that the southwestern borrow area can accommodate the borrow requirements for both the completion of the existing project and the raising of the upland cells associated with the expansion project.

5.4 Borrow Material Quality. A total of 71 gradation tests were performed on samples from the sand deposits in the northern study area. A summary of the gradation testing results is presented in Table A-6 below. While not all of the sands tested will end up within the borrow limits, the tests indicate of the quality of the materials that will be used for dike construction. The borrow materials in the northern borrow deposits contain an average of approximately 14.4 percent fines. The actual fines content ranged from a low of 2 to 3 percent to a high approaching 50 percent fines. More than 75 percent of the 71 samples tested contained 20 percent or less fines, and only 10 percent contained more than 30 percent fines. Therefore, this sand deposit is an excellent source of materials with respect to quality of material for dike construction.

The quality of the borrow material within the northern borrow site is primarily defined by the percentage of quantity of fines (percentage by weight passing a standard No. 200 sieve) within the sand. Fines are the silt and clay size portion of the borrow materials. A significant portion of these fine materials, and some of the fine sand fraction, will be washed away when the sand is dredged for use in dike construction. While that loss of fines improves the engineering properties of the sand, it reduces the quantity available for construction. It is generally estimated that 15 to 25 percent of the quantity excavated by dredging will be lost. As the percentage of fines at the borrow source increases, the percentage lost in the dredging process also increases. Since this deposit has a low average fines content, the percentage lost can be expected to remain near the low end of the typical 15 to 25 percent range.

A lower fines content at the borrow source will result in a lower fines content in the sand placed in the dike section. It is desirable to maintain the fines content in the dike fill below 30 percent to assure that the material properties are dominated by the sand fraction rather than the weaker and less permeable clay and silt materials. Because of the low average fines content in this deposit, the resulting fill properties can be expected to be excellent with limited pockets of marginal material.

Table A-5. Analysis of Northern Borrow Quantities

	Site	Sub-Area (acres)	Avg. Sand Thickness (feet)	Borrow Volume (mcy)	Borrow Available (mcy)	Borrow Quantity Required
550 ACRES 50%wetland-50%upland	Borrow "A"	86.8	22.5	3.15	1.80	--
	Borrow "B"	47.2	12.5	0.95	0.54	--
	Borrow "C"	37.8	17.5	1.07	0.61	--
	Channel	10.2	15	0.25	0.14	--
	Basin	20.1	10	0.32	0.18	--
	Total	**2,02.0**	**--**	**5.7**	**3.3**	**3.3**
	Ratio of Total Borrow Volume to Borrow Required					**1.74**
550 ACRES 55%wetland-45%upland	Borrow "A"	86.8	22.5	3.15	1.80	--
	Borrow "B"	27.5	12.5	0.56	0.32	--
	Borrow "C"	37.8	17.5	1.07	0.61	--
	Channel	10.2	12.5	0.20	0.12	--
	Basin	20.1	12	0.39	0.22	--
	Total	**1,82.4**	**--**	**5.4**	**3.1**	**3.3**
	Ratio of Total Borrow Volume to Borrow Required					**1.63**
550 ACRES 60%wetland-40%upland	Borrow "A"	86.8	22.5	3.15	1.80	--
	Borrow "B"	23.0	12.5	0.46	0.26	--
	Borrow "C"	34.5	17.5	0.97	0.56	--
	Channel	10.2	12.5	0.20	0.12	--
	Basin	20.1	12	0.39	0.22	--
	Total	**1,74.4**	**--**	**5.2**	**3.0**	**3.3**
	Ratio of Total Borrow Volume to Borrow Required					**1.57**

Table A-6. Analysis of Northern Borrow Quality

Drill Hole No.	Sample No.	Percent Fines		Drill Hole No.	Sample No.	Percent Fines		Drill Hole No..	Sample No.	Percent Fines
401	1	2		413	4	16		421	1	10
	4	4			7	9			4	26
	6	6			10	6		422	1	11
402	2	6		414	4	22			3	42
	4	8			7	11		428	4	30
403	1	47			10	6		429	6	23
	5	35		415	2	19		431	3	12
404	2	10			5	12			7	7
	4	18			7	3			11	4
405	3	14			9	2		432	5	19
	8	19			11	17			9	20
	3	13		416	3	20		433	3	10
406	1	3			6	5			7	4
407	4	4			8	3			10	3
	7	6		417	2	15		434	3	7
408	1	3			4	40			7	2
	3	6			7	25				
	6	16			10	5		**SUM**	**71**	**1016**
409	2	5		418	1	4		**AVG**		**14.3%**
	4	18			3	22				
	7	4			5	23		**% > 30%**	**=**	**9.9%**
410	1	37			7	43				
	6	15		419	2	7				
	9	4			5	12				
411	1	50		420	1	6				
412	3	30			3	13				
	6	30			4	37				
	9	15		--	--	--				

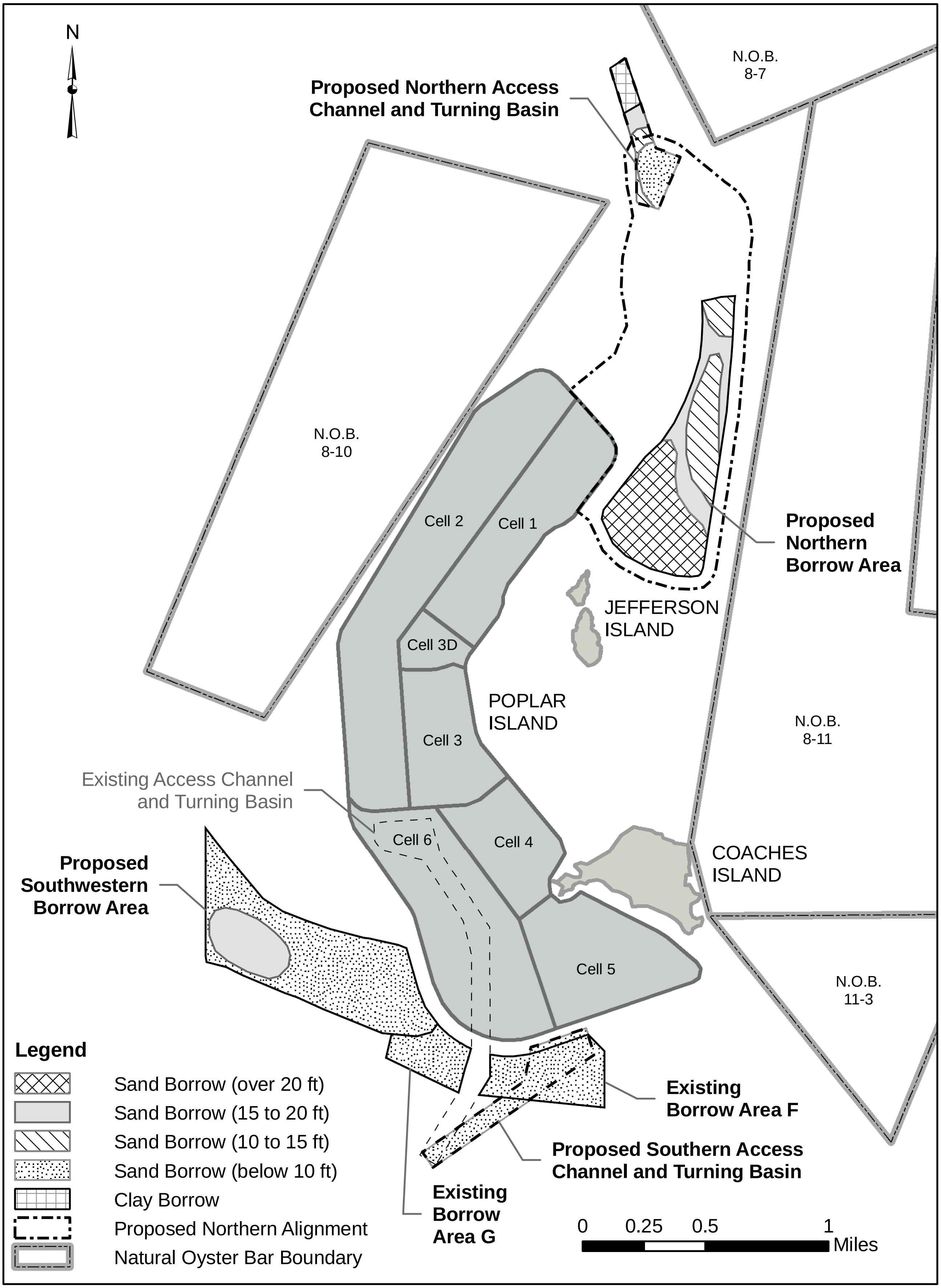


Figure A-1. Location of Existing and Proposed Sand Borrow Areas and Proposed Access Channels

Figure A–2. Maryland Port Administration Reconnaissance Report Potential Sand Borrow Area Plan

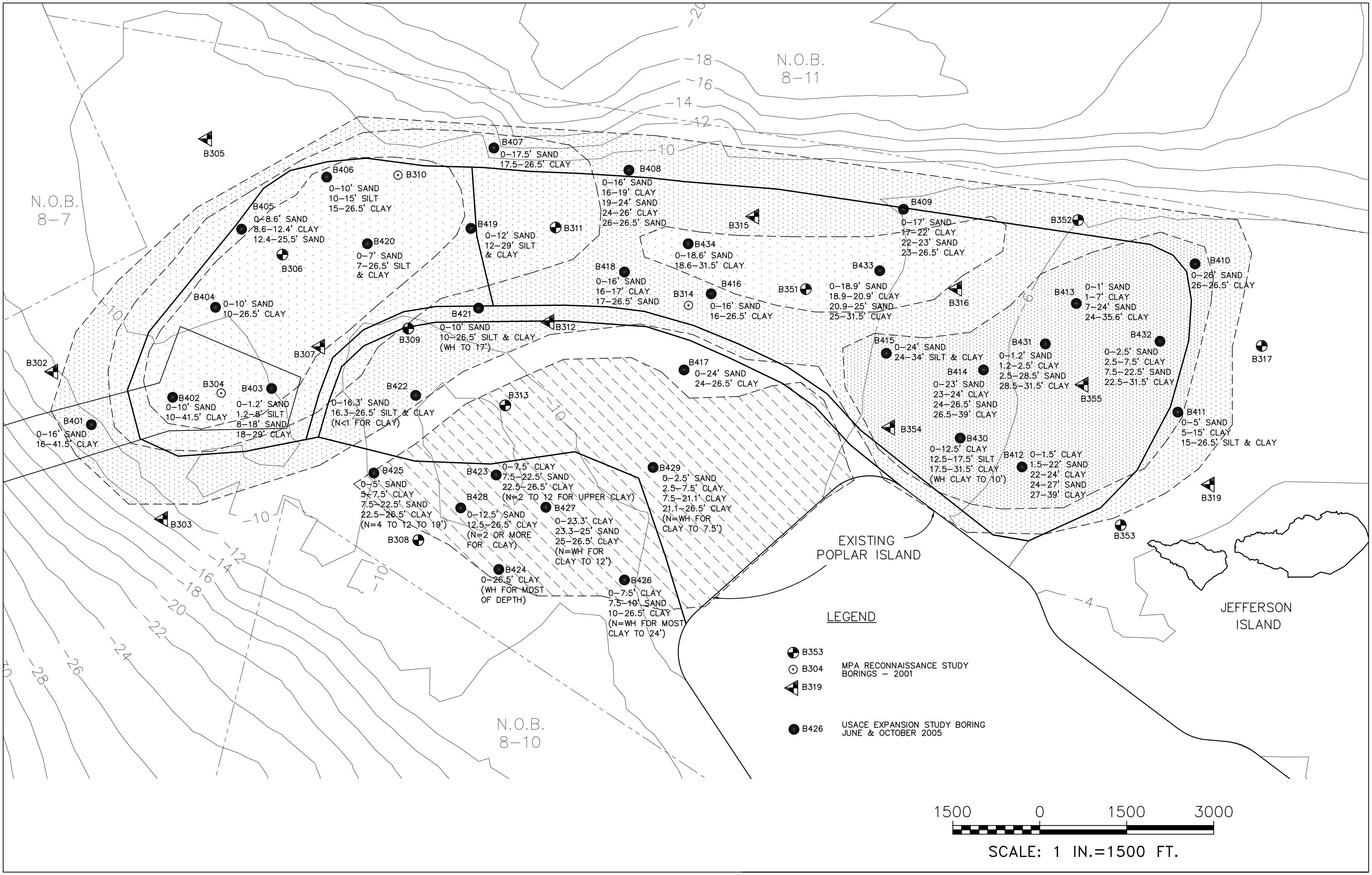


Figure A-3. Northern Expansion Borrow Plan with Boring Data

ATTACHMENT B

ENGINEERING SCREENING

POPLAR ISLAND EXPANSION STUDY
ENGINEERING APPENDIX

ATTACHMENT B - ENGINEERING SCREENING OF ALTERNATIVES

1. Introduction

The Reconnaissance study identified six alternative alignments for the expansion of the existing Poplar Island project. The alignments ranged from 313 to 1,129 acres in size, with 50 percent of the area designated as upland cells and 50 percent designated as wetland cells, consistent with the existing Poplar Island project. During the early stages of the current study, a seventh alignment was added that maximized the alignment limits to the north of the existing project.

2. Screening Process

Each of the seven alignments was subjected to a screening process that evaluated nine significant engineering factors. Each site was ranked with respect to each of the nine factors. The rankings were then weighted to adjust the relative importance of the nine engineering factors. The following nine engineering factors were evaluated in the screening process:

a. Potential Expansion Area
b. Additional Capacity of Expansion Components
c. Foundation Materials for the Containment Dikes
d. Borrow Material Location
e. Borrow Material Quantity and Quality
f. Depth of Water beneath the Site
g. Length of Access Channel
h. Armor Stone Size
i. Dredged Material Haul Distance

a. Potential Expansion Size: In general, project size is related to operational efficiency, allowing dredged materials to be spread out over a larger area in thinner lifts. Optimum lift thickness is limited to approximately 3 feet to allow for efficient dewatering of each dredge material lift prior to the placement of a subsequent lift. In the case of the lateral; expansion of Poplar Island, any project that adds 150 or more upland acres to the existing project would allow for reasonably efficient placement of the average annual dredged material placement quantity of 3.2 million cubic yards (mcy). Expansion areas under about 400 acres marginally satisfy this requirement, depending on the ratio of uplands to wetlands. Areas between 400 and 1,000 acres should fully satisfy the requirements and areas over 1,000 acres exceed the requirements.

Expansion Project Size	Ranking Factor
<300	0
300-400	2
400-1000	3
1000-1500	4

b. Capacity of Expansion Components: The capacity of the project components, either lateral expansion or vertical raising of the existing upland elevations, need to satisfy minimum annual placement needs and provide a project life that will alleviate cell overloading and extend the life of the existing Poplar Island project to a point that will exceed the anticipated availability of other placement sites. In general, it is anticipated that additional capacity in the range of 20 to 30 million cubic yards (mcy) will satisfy minimum capacity requirements. Capacity above or below this range has been rated relative to the minimum requirements.

Additional Capacity of Expansion Components	Ranking Factor
<10 mcy	0
10 to <15 mcy	1
15 to <20 mcy	2
20 to <30 mcy	3
30 to <50 mcy	4
>50 mcy	5

c. Foundation Material: The cost of the containment dikes for the potential lateral expansion alternatives will be affected by the foundation conditions. The most favorable foundation conditions consist of sands with minor silt or clay content. Good conditions include silty or clayey sand, or stiff clay materials with high shear strength and low compressibility characteristics. Poor foundations include very soft clay and silt materials where both shear strength and compressibility are unacceptable. These materials generally must be removed and replaced with suitable sand obtained from borrow sources at additional cost to the project.

Foundation Material	Ranking Factor
soft silt or clay	0
medium silt/sand	3
stiff clay or silty sand	4
sand	5

d. Borrow Material Location: The project containment dikes will be constructed using sand obtained from borrow sources on the bay bottom within or near the project site. It is desirable to obtain all materials required for construction of the containment dikes from borrow sites within the footprint of the project or from the access channel required to deliver dredged material to the completed project. Those alternative where it is anticipated that 100 percent of the required borrow material can be obtained from within the footprint receive the highest rating. Ratings are adjusted downward as the percentage of borrow material obtained from outside the project footprint increases.

Portion of Borrow within Footprint	**Ranking Factor**
100%	5
80 to 99%	4
60 to 79%	3
25 to 59%	2
10 to 24%	1

e. Borrow Material Quantity and Quality: In addition to the location of borrow materials, the project cost is affected by the quantity and quality of materials available for dike construction. Minimum cost is associated with borrow sources that consist of clean sand (less than 30 percent silt and clay fines), and provide at least twice the quantity required for the project dikes. Where sand sources are located beneath a layer of silt or clay materials, costs for recovery of those materials increases and the rating is adjusted downward accordingly.

Borrow Material Quality and Quantity	**Ranking Factor**
clay or silt	0
covered sand	3
sand	5

f. Depth of Water Beneath Site: The depth of water affects the construction cost for the containment dikes and the available placement capacity. Water depths between 8 and 10 feet below mean low low water (MLLW) are considered ideal. Water depths greater than 10 ft MLLW increase the cost of dike construction and armor stone placement, even though the overall site capacity increases. Water depths less than 5 feet also increase the cost of stone placement because of the need to dredge an access channel along the exterior toe of the dike to accommodate the draft of the loaded stone barges. In addition, water depths less than 5 feet significantly decrease the site placement capacity.

Depth of Water Beneath Site	**Ranking Factor**
<5	1
5-8	3
8-10	5
10-12	2
>12	0

g. Length of Access Channel: Placement of dredged material within the site requires an access channel between deeper water (elevation –25 ft MLLW) and the project. The costs of the initial construction and the maintenance of the channel are directly proportional to the channel length. Ratings have been assigned in proportion to channel lengths from less than ½ mile to greater than 2 miles.

Length of Required Access Channel	Ranking Factor
<0.5 mi	5
0.5-1 mi	3
1-2 mi	1
>2 mi	0

h. Armor Stone Size: The largest component of the initial construction cost is associated with armor stone. A larger stone size results in greater stone quantities associated with greater armor thickness. Because larger size stones are less abundant, the unit cost increases as the required stone size increases. The required stone size is determined based on the exposure to greater wave energy, which is governed by the depth of water, fetch, and orientation of the dike alignment relative to dominant wind directions. Because the proposed Poplar Island expansion alternatives all have similar levels of exposure, there is relatively little difference in the anticipated armor stone size. Those alternatives with proportionally less western and northwestern exposure would generally require smaller armor stone size.

Armor Stone Size	Ranking Factor
<1500 lbs	5
1500-3000 lbs	3
1500-4000 lbs	2

i. Dredged Material Haul Distance: A significant component of project cost is associated with the average haul distance between the dredging location and the placement site. While this was a significant factor in the screening for the Mid-Bay Island EIS, it is not significant for the Poplar Island expansion since each of the proposed alignments are essentially the same distance from the dredging locations. Therefore, this factor was not assigned a ranking in this screening.

3. Description of the Alternative Alignments

Following is a brief discussion of the proposed alignment for each alternative, with an assessment of the foundation and borrow factors.

3.1 Alignment 1. Alignment 1 is an extension of existing cells 5 and 6 to the southeast, and cell 6 to the southwest of the existing project. Alignment 1 is 753 acres with the wetland cell to the east, in line with existing wetland Cell 5, and two upland cells to the west, adjacent to existing upland Cell 6. Subsurface investigations have shown that significant portions Alignment 1 are located in areas having soft clay and silt materials within the foundation. Prior to construction, significant portions of the adjacent Cell 6 dike required removal and replacement of very soft foundation soils beneath the dike alignment to assure satisfactory performance with respect to embankment slope stability and dike settlement. Portions of the Cell 5 and 6 dikes were also overbuilt to allow for additional long-term settlement. Surveys subsequent to the 2003 Isabel storm event have indicated that post-construction settlements did occur. Therefore, foundation conditions for Alignment 1 are considered marginal to poor for significant reaches of the primary dike system. Alignment 1 incorporates approximately 160 of the 684 acres within the southeast and southwest borrow areas. The estimated borrow quantity available for dike construction within the proposed alignment footprint is approximately 4.8 mcy, out of the 13.3 mcy associated with the two borrow areas. The available borrow quantity is significantly less than the 7.5 mcy required for dike construction.

3.2 Alignment 2. Alignment 2 has components of expansion to the southeast, southwest, and north of the project. Alignment 2 consists of 754 acres, with a wetland cell to the northeast, adjacent to existing Cells 1 and 2, and two upland cells to the southeast and southwest, adjacent existing wetland Cell 5 and upland Cell 6. The foundation conditions for the southeastern and southwestern expansions are similar to the conditions described for Alignment 1, except that the southeastern alignment is associated with proportionally more unsuitable foundation conditions. The northern component of the expansion has more favorable foundation conditions. Overall, the foundation conditions for Alignment 2 are rated as marginal. The southeastern alignment incorporates none of the southeast borrow area, while the northeast component incorporates a significant portion of the northeast and northwest borrow areas. The estimated borrow quantity available for dike construction within the proposed alignment footprint is approximately 2.9 mcy, out of the 25.1 mcy associated with the four borrow areas. The available borrow quantity is significantly less than the 7.1 mcy required for dike construction.

3.3 Alignment 3. Alignment 3 is very similar to Alignment 2, except that the southeastern component of the expansion is larger, and the northern component is smaller. The total area of Alignment 3 is virtually the same - 754 acres. Alignment 3 has two wetland cells located at the southeast and northeast ends of the existing project, adjacent to existing wetland Cells 1 and 5. Three proposed upland cells are located at the southeastern, southwestern and northern end of the project, adjacent to existing upland Cells 2 and 6. The foundation conditions are very similar to those described for Alignment 2, and are rated as marginal. The borrow areas incorporated into the alignments will yield an estimated 3.5 mcy, out of the total 25.1 mcy associated with the four borrow areas. The available borrow quantity is significantly less than the 9.6 mcy required for dike construction.

3.4 Alignment 4. Alignment 4 is similar to Alignments 2 and 3, except that the southeastern and northern expansion components are the largest areas. Alignment 4 has a total area of 1,129 acres. Alignment 4 has two wetland cells located at the southeast and northeast ends of the existing project, adjacent to existing wetland Cells 1 and 5. Three proposed upland cells are located at the southeastern, southwestern and northern end of the project, adjacent to existing upland Cells 2 and 6. The foundation conditions are similar to those described for Alignment 2, and are rated as marginal. The borrow areas incorporated into the alignments and the access channel will yield an estimated 5.9 mcy, out of the total 25.1 mcy associated with the four borrow areas. The available borrow quantity is significantly less than the 12.3 mcy required for dike construction.

3.5 Alignment 5. Alignment 5 is similar to Alignment 4, except that the southwestern components are eliminated, reducing the total area of Alignment 5 to 749 acres. Alignment 5 has two wetland cells located at the southeast and northeast ends of the existing project, adjacent to existing wetland Cells 1 and 5. Two proposed upland cells are located at the southeastern and northern ends of the project, adjacent to existing upland Cells 2 and 6. The foundation conditions are similar to those described for Alignment 3, and are rated as marginal. The borrow areas incorporated into the alignments and the access channel will yield an estimated 5.8 mcy, out of the total 20.9 mcy associated with the three borrow areas. The available borrow quantity is less than the 6.26 mcy required for dike construction.

3.6 Alignment 6. Alignment 6 is the smallest of the alternative alignments, with only a northern expansion component totaling 313 acres. The alternative has one wetland and one upland cell adjacent to existing upland cells 2 and 1, respectively. The foundation conditions, mostly sand with a limited zone of clay and silt, are more favorable than those alignments that include southern sites, and are rated as marginal to good. The borrow areas incorporated into the alignment and the access channel will yield an estimated 3.4 mcy, out of the total 11.8 mcy associated with the two northern borrow areas. The available borrow quantity is more than the 2.8 mcy required for dike construction.

3.7 Alignment 7. Alignment 7 is similar to Alignment 6, but is expanded to the maximum limits that can be accommodated at the northern end of the project. Alignment 7 has a total area of 631 acres. The alternative has one wetland and one upland cell, adjacent to existing upland wetland cells 2 and 1, respectively. The foundation conditions, mostly sand with a limited zone of clay and silt, are slightly more favorable than Alignment 6, and are rated as good. The borrow areas incorporated into the alignment and the access channel will yield an estimated 5.6 mcy, out of the total 11.8 mcy associated with the two northern borrow areas. The available borrow quantity is more than the 4.8 mcy required for dike construction.

4. Initial Engineering Scoring

Table B-1 presents the initial non-weighted engineering scores for each of the seven alternative alignments for each of the nine engineering factors.

Table B-1. Initial Engineering Ranking

CRITERIA	Alternative 1	Alternative 2	Alternative3	Alternative 4	Alternative 5	Alternative 6	Alternative 7
Potential Expansion Size (ac)	*750 ac*	*750 ac*	*750 ac*	*1120 ac*	*750 ac*	*313 ac*	*630 ac*
Ranking	**3**	**3**	**3**	**4**	**3**	**2**	**3**
Additional Capacity (mcy)	*26.8 mcy*	*26.8 mcy*	*26.8 mcy*	*41.6 mcy*	*26.8 mcy*	*11.6 mcy*	*23.2 mcy*
Ranking	**3**	**3**	**3**	**4**	**3**	**1**	**3**
Foundation Material	*sandy silt & clay-fair to poor*	*sandy silt & clay -fair*	*sandy silt & clay -fair*	*sandy silt & clay -fair*	*sandy silt & clay - fair*	*silty sand & clay - fair to good*	*silty sand-good*
Ranking	**2**	**2.5**	**2.5**	**2.5**	**2.5**	**3.5**	**4**
Borrow Material Quantity & Quality	*fair/mixed*	*fair /mixed*	*fair/mixed*	*fair/mixed*	*fair/mixed*	*good*	*very good*
Ranking	**2.5**	**2**	**3**	**3**	**2.5**	**4**	**4.5**
Borrow Material Location	*64% inside*	*41% inside*	*36% inside*	*48% inside*	*92% inside*	*100% inside*	*100% inside*
Ranking	**3**	**2**	**2**	**2**	**4**	**5**	**5**
Depth of Water at Site (feet)	*0-10 (6)*	*0-10 (6)*	*0-10 (6)*	*0-10 (6)*	*0-10 (6)*	*0-10 (6)*	*0-10 (6)*
Ranking	**3**	**3**	**3**	**3**	**3**	**3**	**3**
Length of Access Channel (mi)	*0.5 to1 mi*	*0.5 to1 mi*	*0.5 to1 mi*	*0.5 to1 mi*	*0.5 to1 mi*	*<0.5 mi*	*<0.5 mi*
Ranking	**3**	**3**	**3**	**3**	**3**	**5**	**5**
Armor Stone Size (lbs)	*1500-3000 lbs*	*1500-4000 lbs*	*1500-4000 lbs*	*1500-4000 lbs*	*1500-4000 lbs*	*1500-4000 lbs*	*1500-4000 lbs*
Ranking	**3**	**2**	**2**	**2**	**2**	**2**	**2**
Dredged Material Haul Distance (mi)							
Ranking	**0**	**0**	**0**	**0**	**0**	**0**	**0**

5. Final Engineering Scoring and Ranking

The engineering criteria do not all carry the same level of importance. Those factors associated with the source and quality of borrow materials for dike construction are critical with respect to initial construction cost and potential environmental impacts. Although the haul distance for dredged materials is not a factor in this evaluation, it would potentially have a significant impact on cost and would be weighted more heavily than other engineering factors. Table B-2 presents the final weighted scoring and the ranking of the seven alternatives.

Table B-2. Final Weighted Engineering Scoring & Ranking

CRITERIA	Weight Factor	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7
Potential Expansion Size	***1***	3	3	3	4	3	2	3
Additional Capacity	***2***	6	6	6	8	6	2	6
Foundation Material	***2***	4	5	5	5	5	7	8
Borrow Material Quantity & Quality	***3***	7.5	6	9	9	7.5	12	13.5
Borrow Material Location	***3***	9	6	6	6	12	15	15
Depth of Water at Site	***2***	6	6	6	6	6	6	6
Length of Access Channel	***2***	6	6	6	6	6	10	10
Armor Stone Size	***1***	3	2	2	2	2	2	2
Dredged Material Haul Distance	***3***	0	0	0	0	0	0	0
Total Weighted Score	--	**44.5**	**40**	**43**	**46**	**47.5**	**56**	**63.5**
Ranking	--	**5**	**7**	**6**	**4**	**3**	**2**	**1**

6. Conclusion

Based on the above screening process, alternatives 6 and 7, the two northern alternative alignments, are the most favorable sites with respect to engineering considerations. These two sites have more favorable foundation conditions, better quality borrow sources, and incorporate more of the borrow areas within the footprint of the proposed alignments than is typical of the southeastern or southwestern expansion areas. It also appears that the required access channel for the northern alternatives 6 and 7 would be shorter than those required for the southern areas, and would generate a relatively high proportion of excavation material that could be used in the dike construction.

ATTACHMENT C

PLACEMENT ANALYSIS

POPLAR ISLAND EXPANSION STUDY
ENGINEERING APPENDIX

ATTACHMENT C - DREDGED MATERIAL PLACEMENT ANALYSIS

1. Introduction

The existing Poplar Island project consists of a 1,140-acre project with 50 percent of the area designated for upland habitat development and 50 percent designated for wetland habitat development. The actual acreage of each habitat zone is reduced by the area consumed by the footprint of the containment dikes, such that the actual placement area within the cells is reduced to about 90 percent of it's nominal area. The six alternatives developed in the reconnaissance study were all based on a continuation of the 50-50 split between upland and wetland areas, with the upland cells located to the west and the wetland cells located to the east consistent with the existing Poplar Island project.

During the formulation process, changing the upland-wetland ratio was considered to increase the wetland acreage where more environmental benefits are realized. Efficient use of the site requires that a balance between upland and wetland placement capacity be maintained such that the upland cells remain operational until all wetland cells are completely filled. However, that balance had not previously been formally quantified. Therefore a series of dredged material placement analyses were performed to determine the following:

- The remaining project life of the existing Poplar Island project up to the maximum authorized upland elevation of +20 ft MLLW.
- A reasonable sequence of dredged material placement and cell development for the existing Poplar Island project, employing efficient placement and site development methods.
- The minimum expansion project size that would support future dredged material placement requirements.
- The maximum percentage of wetlands that can be supported in the various expansion alternatives.
- The maximum potential vertical expansion of existing upland cells that could be achieved.
- The maximum desirable vertical expansion of the existing upland cells that would expand the percentage of the expansion area devoted to wetlands.

2. Criteria for Placement Analysis

2.1 General Assumptions.

- The site must be capable of accommodating annual dredged material placement of 3.2 mcy for most of the project life without overloading wetland cells and with minimal overloading of upland cells. The total site acreage required to satisfy this requirement will vary depending on the proportion of upland and wetland areas and the required project life.

- The project must be evaluated independent of other projects that may exist before or after the proposed project. Any reduction in annual placement quantities that might result from other projects is to be ignored.
- Placement of dredged material should be managed to minimize placement cost (i.e. placement in adjacent cells to maximize efficiency).
- Upland cell capacity must extend beyond the last year of dredged material placement in wetland cells to assure that the excess portion of each year placement quantity can be accommodated within the site. Where a larger proportion of wetland area is desired, uplands must be raised to higher elevations to provide the necessary upland placement capacity.
- Actual placement areas are typically about 91 percent of the nominal area for each cell after deduction for the dike footprint.
- The capacity of each cell is based on a volume occupied ratio of 0.7. (The volume of the dredged material ultimately occupied within the containment site compared to volume in-situ in the channels).
- The upland capacity calculations are based on a final upland elevation of +20 ft MLLW unless otherwise indicated.
- Because borrow areas cannot be located within wetland cells, it must be recognized that projects consisting of 100 percent wetlands must obtain materials for dike construction from the access channel required to deliver dredged materials to the site, or from other borrow sources outside the project footprint. Projects consisting of 70 percent wetlands and 30 percent uplands must have upland cells strategically located over the borrow deposits to maximize internal borrow sources. The quantity of borrow material within 30 percent of the site may not be sufficient to supply the required dike quantities without additional sources from outside the project footprint.

2.2 Wetland Cell Construction. Wetland cell construction requires a highly ordered and controlled sequence of dredged material placement that will assure that wetland cells are never overloaded beyond the quantities required to achieve the target wetland surface elevations. The existing project has targeted low marsh surfaces between elevation +1.2 and +1.8 ft MLLW, and high marsh surfaces between +1.8 and +2.4 ft MLLW.

- Borrow areas must be excluded from wetland cells to assure that the thickness of the dredged material within the cells is as uniform as possible. Large differences in dredged material thickness result in large differential settlements that exceed allowable tolerances for required final surface elevations. (The wetland cells within the existing Poplar Island site include significant areas that were used as borrow sources creating excavation depressions that extend to elevation of –15 to –20 ft MLLW. This will result in dredged material thicknesses within those cells exceeding 20 ft and will make stabilization of those wetland surfaces problematic.)

- The time allotted for wetland cell development (i.e. placement of dredged materials, final grading and initial planting) is based on dredged material thickness ranging from 6 to 12 ft. This range of thickness relates to typical cell bottom elevations ranging from –4.5 to –10.5 ft MLLW and a target surface elevation of +1.5 ft MLLW. Greater dredged material thickness will increase the time required to reach a stable surface ready for planting and will decrease the probability of achieving any particular target surface elevation.

- Wetland cells must be subdivided into smaller subcells having dimensions not exceeding approximately 1,200 to 1,400 feet, corresponding to cells in the 35 to 45 acre range.

    - Dredged materials will be offloaded from barges and deposited within subcells using hydraulic placement techniques. The resulting dredged material will typically consist of approximately 90 percent water and 10 percent solids. Maintenance dredged material can be expected to assume a slope of approximately 1 foot of vertical drop over 1000 feet of horizontal distance. The change in elevation of the surface of the dredged material between the discharge location and the far side of the wetland subcell cell must be limited to approximately 1 to 1.5 feet.
    - After completion of channel excavation and final grading of the de-water cell, an outlet control structure must be installed to allow the cell to be rehydrated prior to planting.
    - After completion of planting and satisfactory stabilization of adjacent subcells, temporary dividing dikes can be regraded or removed to allow tidal flooding between subcells.

- Wetland cells must never be overloaded such that the final surface elevation is higher than the maximum acceptable elevation. This is achieved by a tightly controlled sequence of dredged material placement with diminishing quantities of material placed within the cell each year until the final placement quantity is not more than about 20,000 cy.

    - Dredged materials immediately after decanting consist of approximately 90 percent water and 10 percent solids by volume. Ultimately, these dredged materials will consolidate to a degree that the water component occupies approximately 75 percent of the volume of the mass. The dredged material will ultimately consolidate to less than 1/2 of its initial thickness. Each layer must be closely monitored during the consolidation period to determine the actual rate and magnitude of consolidation corresponding to the specific properties of the dredged material placed in the cell each year.
    - Left to consolidate under its own weight in submerged conditions, the time to reach a stable (normally-consolidated) condition could require more than a decade, depending upon the total thickness of the dredged material. Dewatering the site as soon as possible after placement of each dredged material layer accelerates this process, so that the surface receives maximum solar exposure required to generate desiccation cracks. In addition, the site must be aggressively drained by a series of perimeter and interior drainage trenches using specialized construction equipment to result in the creation of a surface crust having sufficient

    strength and thickness to support the construction activities required for channel excavation and surface grading.
    - The crust development and site dewatering also allow the underlying dredged material deposits to be slightly over-consolidated to minimize the risk of subsequent settlement that could result in loss of plants.
    - Based on experience at the existing Poplar Island, it is estimated that the typical wetland cell development will limit the annual placement quantity to not more than 70 percent of the cell volume until the final increment of placement is less than about 20,000 cy. That sequence corresponds a typical dredged material placement duration of four years, assuming that free water from each inflow event can be discharged into an adjacent wetland cell before discharging to the Bay.
    - After the first 50 percent of the wetland subcells have been completed, it will not be possible to decant free water into adjacent cells. Therefore, dredged materials will have to be held within the placement cells for a longer period of time to allow for a slow discharge of water directly into the Bay once water quality criteria has been satisfied. This procedure will require dredged materials to be placed into the cells at a slower rate over a longer period of time. It has been estimated that the typical wetland cell development will limit the annual placement quantity to not more than 50 percent of the cell volume until the final increment of placement is less than about 20,000 cy. That sequence corresponds to a typical dredged material placement duration of six years.

- Wetland cells will typically have a system of channels with a range of width and depth dictated by hydraulic analyses and empirical information for existing wetlands. The materials excavated from these channels must be placed within the wetland cells in a manner that is consistent with the required final grades. Channels must remain stable (side slope stability and bottom elevations) to assure proper hydraulic functions. Graded areas must be stable with respect to surface elevation and erosion. It is estimated that required grading and outlet construction for each subcell will require approximately one year. It is estimated that two subcells can be graded in any single year. Occasionally three subcells might be prepared in an exceptional year; however, in extremely wet years it may be difficult to complete the grading for any subcells.

    - Excavation of channels will be accomplished using specialized hydraulic excavators designed to operate in extremely soft materials. Channels will be excavated gradually and drainage will be maintained to assure than channel surfaces gain the strength necessary to remain stable.
    - Excavated materials must be dried, broken down to acceptable particle size, and graded to achieve final surface elevations within approximately ± 0.2 feet.
    - Grades must account for anticipated additional settlement resulting from consolidation of subsurface materials and compaction of loose surface soils.
    - An outlet control structure will be constructed for each wetland subcell and tidal flooding will occur for several months after the completion of grading and prior to initial planting. The control structure will remain in place until the cell channel system has fully stabilized and plants are fully established.

- Excavation required to remove temporary subcell separation dikes should be as limited as possible to preserve the established wetland plants and the subcell drainage system.

2.3 Upland Cell Construction. Upland cell construction allows considerably more latitude with respect to final surface elevations than the wetland areas. However, the much greater thickness of dredged material (typically 20 to 30 feet above the existing Bay bottom, or 30 to 50 feet above the bottom of excavated borrow areas) will result in a very large magnitude and long duration of settlement. These factors will dictate the appropriate time frame for upland development and the final grading plan that will assure appropriate drainage of surface runoff into adjacent wetland areas. To maximize upland capacity, placement will be limited to optimum lift thickness whenever possible. Where overloading of upland cells is necessary, a corresponding reduction in placement capacity and/or increase in the time prior to development must be anticipated.

- Optimum placement is defined as the quantity of material that will result in a lift thickness not exceeding 3 ft. With proper drainage and crust management techniques applied following each placement event, a 3-foot lift will consolidate to less than half of the initial thickness. Solar exposure will desiccate the material further promoting drainage and consolidation, thereby increasing the capacity of the cell. Capacity calculations are based on the assumption that appropriate crust management techniques are applied annually.
- Overloading is defined as any annual placement quantity that exceeds the optimum by 20 percent. Such placement events have been highlighted on the spreadsheet (Figures C-1 through C-7). Occasional overload events not exceeding 50 percent are not likely have a significant impact on total cell capacity. However, extreme overloads of 200 percent or more, or a series of consecutive overloading events in the same cell are likely to have a significant impact on cell capacity.
- Upland cells will eventually be subdivided to allow for an incremental grading and planting scheme similar to the wetland development. It is anticipated that upland areas will be broken into segments approximately 80 to 125 acres in size. Placement to complete the subcell will typically require 2 to 4 years, followed by a 2 to 4 year period of grading and planting.
- Final grading will include the removal of the upper portion of the containment dikes exceeding the final upland surface elevations. Typically, containment dikes are constructed to a height approximately 5 ft higher than the desired upland elevation.
- An additional phase of site grading will include the area between the upland and wetland cells. These areas will be graded to remove or soften the initial construction haul roads and to assure proper conveyance of runoff from upland surfaces to the adjacent wetland cells.

3. Analysis of Existing Project

The existing project consists of two upland cells and four wetland cells. To control the initial dredged material surface elevation, it has been necessary to temporarily subdivide the original larger wetland cells into smaller cells having individual areas typically between 30 and 40 acres in size. Therefore, the existing project now has 15 wetland subcells. The nominal area, actual placement area, volume and placement capacity of each cell was entered into the placement spreadsheet. The actual dredged material placement quantities between 2001 and 2003 were entered into the spreadsheet to account for actual total dredged material placement for each of the first three years of the project life. Beginning with the year 2004, projected placement quantities for each cell were entered into the spreadsheet such that a total of 2 mcy was placed from 2004 through 2008, and 3.2 mcy was placed in the site from 2009 until the site capacity was exhausted.

The analysis has shown that, if the annual placement occurs at the historic average of 3.2 mcy per year, the site will be filled by 2015 with 2014 being the last year able to accommodate the full 3.2 mcy quantity. Beginning in approximately 2010, the upland cells will be overloaded to accommodate an increase in average annual placement from approximately 2.0 mcy per year to 3.2 mcy per year. Overloading is defined as annual placement that would result in an upland cell lift thickness exceeding approximately 4 ft. Optimum placement is associated with a lift thickness of approximately 3 ft. When the optimum lift thickness is significantly exceeded, the lower portion of the lift cannot be effectively consolidated by conventional crust management techniques. Therefore, the time required for consolidation of the dredged material increases to an extent that it becomes impractical to wait to realize the full theoretical cell capacity. The lost capacity must then be provided by another placement site. The analysis also indicates that the upland placement capacity will be exhausted at approximately the same time that the last wetland cell placement has been completed. This leaves essentially no margin for delayed or inefficient development of the wetland cells.

4. Analysis of Expansion Alternatives

The existing Poplar Island project was developed with approximately equal proportions of wetland and upland habitat. For the lateral expansion, a range of wetland components that theoretically could be developed was evaluated at the beginning of the plan formulation process. The range of wetland components evaluated for the lateral expansion included 0 percent, 30 percent, 50 percent, 70 percent, and 100 percent.

4.1 Experience at the Existing Project. Based on the placement experience at Poplar Island, it has become apparent that an efficient dredged material placement operation requires upland placement capacity to extend beyond the placement capacity in the wetlands. Wetland areas of the existing project will make up about 20 percent of the total site capacity. Each wetland cell must be filled with gradually diminishing quantities of dredged material so that the target low marsh surface elevation of 1.5 MLLW ± 0.3 ft can be achieved. As the last wetland cells are being completed, it is estimated that total dredged material placement quantities during the final wetland placement years will range from less than one hundred thousand cubic yards to, at most, several hundred thousand cubic yards - far less than the 3.2 mcy on average that must be accommodated each year. Therefore, the bulk of the annual placement volume during latter years of wetland development must be directed to upland cells within the existing placement site, or to other placement sites. If the upland cells of the existing project have been exhausted, it would be necessary to mobilize off-loading operations at a second placement site, and it would also be necessary to maintain crust management and cell development operations at more than one site. Operating multiple sites during the same year would significantly increase the cost of dredged material placement and cell development. The most obvious conclusion of the initial placement evaluation was that any expansion site consisting entirely of wetland habitat was not feasible because of the quantity limitations. However, to determine the upper limit of wetland habitat that would be consistent with efficient dredged material placement additional evaluation was needed.

4.2 Expansion Sites Consisting of 60 Percent to 100 Percent Wetlands.

4.2.1 Expansion Sites Consisting of 100 Percent Wetlands. Given the large number of variables that can affect dredged material placement and cell (habitat) development, it was difficult to determine the maximum proportion of wetland that could be developed. It was assumed that placement in the expansion area would begin in 2011, after the closing of both Hart-Miller Island and the Pooles Island open water placement site, and that the additional placement capacity within the lateral expansion would be used in combination with the partially filled existing site.

Initially, a generic 630-acre expansion site was analyzed for the full range of theoretically possible upland and wetland habitat proportions. For a 630-acre lateral expansion consisting of 100 percent wetland habitat where wetland cells are developed at the rate of two cells per year, placement in the wetland cells would continue until the year 2024, approximately seven years after the upland placement capacity would be exhausted. If wetland cells were developed at a rate of one cell per year, wetland placement would extend 17 years beyond the date when upland capacity would be exhausted. Clearly, this would result in an exceptionally inefficient and costly dredged material placement operation. A summary of the results of the analysis at 100 percent wetlands is shown in Table C-1 below.

Table C-1 - Placement Summary For 630-Acre Site with 100 Percent Wetland Habitat

Expansion and/or Raising Alternative	Total Area (acres)	Upland Area (acres)	Wetland Area (acres)	Total Capacity (mcy)	Last Year at 3.2 mcy	Years of Cell 6 Overload	Last Wetland Placement	Last Upland Placement	Placement Contingency (years)
Existing 1140-acre Project	1126	569	557	**40.4**	2014	7	2014	2015	**1**
Existing Site with 630 Acre Expansion at **100% Wetlands** and 2 wetland cells per year	1756	569	1187	**49.8**	2016	8	2024	2017	**-7**
Existing Site with 630 Acre Expansion at **100% Wetlands** and 1 wetland cell per year	1756	569	1187	**49.8**	2015	7	2033	2016	**-17**

4.2.2 Expansion Sites Consisting of 70 Percent Wetlands. The same generic 630-acre expansion site was next analyzed for a lateral expansion consisting of 30 percent upland and 70 percent wetland habitat, where wetland cells are developed at the rate of two cells per year. The analysis showed that placement in the wetland cells would continue until the year 2021, approximately one year after the upland placement capacity would be exhausted. Even if such a cell development pace could be maintained, there was no contingency for any placement difficulties such as adverse weather or excessive annual placement. Based on the observation that maintaining a wetland development pace of two cells per year would be extremely optimistic, the analysis was also performed assuming wetland cell development at the rate of one cell per year. The results of that analysis indicated that wetland placement would extend seven years beyond the date when upland capacity would be exhausted. Therefore, an expansion site consisting of 70 percent wetlands was also considered unfeasible. A summary of the results of the analysis at 70 percent wetlands is shown in Table C-2 below.

Table C-2 - Placement Summary For 630-Acre Site with 70 Percent Wetland Habitat

Expansion and/or Raising Alternative	Total Area (acres)	Upland Area (acres)	Wetland Area (acres)	Total Capacity (mcy)	Last Year at 3.2 mcy	Years of Cell 6 Overload	Last Wetland Placement	Last Upland Placement	Placement Contingency (years)
Existing 1140-acre Project	1126	569	557	**40.4**	2014	7	2014	2015	**1**
Existing Site with 630 Acre Expansion at **70% Wetlands** and 2 wetland cells per year	1756	758	998	**58.2**	2019	7	2021	2020	**-1**
Existing Site with 630 Acre Expansion at **70% Wetlands** and 1 wetland cells per year	1756	758	998	**58.2**	2019	11	2027	2020	**-7**

4.2.3 Expansion Sites Consisting of 60 Percent Wetlands. Although the initial plan formulation site proportions did not include an option consisting of 60 percent wetlands, placement analysis were performed identify the approximate upper limit of wetland habitat that could be developed applying criteria consistent with efficient placement.

The same generic 630-acre expansion site was evaluated for a lateral expansion consisting of 40 percent upland and 60 percent wetland habitat, where wetland cells are developed at the rate of two cells per year. The analysis showed that placement in the wetland cells would continue until the year 2020, approximately one year before the upland placement capacity would be exhausted. Again, based on the observation that maintaining a wetland development pace of two cells per year would be optimistic, the analysis was also performed assuming wetland cell development at the rate of one cell per year. The results of that analysis indicated that wetland placement would extend four years beyond the date when upland capacity would be exhausted. Therefore, an expansion site consisting of 60 percent wetlands was considered to represent the *upper limit* of wetland proportions that might be achieved. Achieving this upper limit of 60 percent wetland would be dependent on the realization of additional upland placement capacity by raising the existing upland cells or by efficient placement of borrow sites within upland cell limits. A summary of the results of the analysis at 60 percent wetlands is shown in Table C-3.

Table C-3 - Placement Summary For 630-Acre Site with 60 Percent Wetland Habitat

Expansion and/or Raising Alternative	Total Area (acres)	Upland Area (acres)	Wetland Area (acres)	Total Capacity (mcy)	Last Year at 3.2 mcy	Years of Cell 6 Overload	Last Wetland Placement	Last Upland Placement	Placement Contingency (years)
Existing 1140-acre Project	1126	569	557	**40.4**	2014	7	2014	2015	**1**
Existing Site with 630 Acre Expansion at **60% Wetlands** and 2 wetland cells per year	1756	821	935	**60.9**	2020	6	2020	2021	**+1**
Existing Site with 630 Acre Expansion at **60% Wetlands** and 1 wetland cells per year	1756	821	935	**60.9**	2020	10	2025	2021	**-4**

4.3 Expansion Alternatives from 313 to 1129 Acres. Preliminary dredged material placement analyses were conducted for potential expansion sites having areas of 313, 500, 630, 750, and 1129 acres representing all six of the alternative alignments presented in the reconnaissance report, plus a seventh alignment added during the plan formulation phase of the Corps' study.

The analysis has shown that the potential alternatives could provide additional placement capacity ranging from approximately 12 to 40 mcy, assuming a project consisting of 50 percent wetlands and 50 percent uplands. If the project shifts toward a higher percentage of wetlands and a corresponding lower percentage of uplands, the total site capacity would decrease accordingly. The capacity could be increased by up to an additional 17 mcy if the upland cells of the existing project were raised by 15 ft (slightly over one mcy for every foot the upland elevation is raised). The analysis also demonstrated that it is necessary to retain approximately 80 percent of the total site placement capacity within the upland cells to assure that upland placement capacity lasts until at least the completion of all wetland placement so that placement operations can be conducted in a reasonably efficient manner. Without concurrent placement of the bulk of the annual placement quantity in upland cells, placement of the very small quantities within the last several years of wetland cell placement would become an extremely expensive operation.

4.4 Summary of Initial Alternative Placement Analysis. Although all seven alternatives were subjected to preliminary placement analyses, the northern sites - alternatives 6 and 7 - were subjected to the most rigorous analysis based on their relatively high ranking in the engineering screening process. Table C-4 presents the results of the placement analyses performed for northern alignments, ranging from 313 to 1,129 acres.

Table C-4. Expansion Alternatives at 50 Percent Upland & 50 Percent Wetland

Alternative	Total Area (acres)	Wetland Area (acres)	Capacity (mcy)	Last Year at 3.2 mcy	Years of Cell Overload	Last Wetland Placement Year	Last Placement Year
Existing 1140-Acre Project	1140	570	40.4	2014	6	2014	2015
313 Acre Expansion	1453	727	52.0	2017	6	2018	2018
500 Acre Expansion	1640	820	58.8	2020	5	2020	2021
630 Acre Expansion	1770	885	63.6	2021	6	2021	2022
750 Acre Expansion	1890	945	67.2	2022	5	2022	2023
1129 Acre Expansion	2269	1134	82.0	2027	8	2026	2028

4.5 Summary of Placement Analysis for 630-Acre Site with Raising. Alternative 7, consisting of 630 acres, was further analyzed to determine the effects of including the capacity realized by raising the existing upland cells by 5 to 15 ft. Table C-5 presents the results of the placement analyses showing the increase in total site capacity and the extended period of placement within upland portions of the project. A raising of 5 ft will provide 6.3 mcy of additional capacity and extend upland placement by more than two years. A raising of 15 ft will provide 18.1 mcy of additional capacity and extend upland placement by approximately six years.

Table C-5. 630-Acre Expansion Alternative at 50 Percent Upland & 50 Percent Wetland with Dike Raising

Expansion Alternative	Upland Area (acres)	Wetland Area (acres)	Total Capacity (mcy)	Last Year at 3.2 mcy	Years of Cell 6 Overload	Last Wetland Placement Year	Last Upland Placement Year
50% Upland & 50% Wetland with **Raising to +25** ft MLLW	885	885	69.6	2022	2	2021	2025
50% Upland & 50% Wetland with **Raising to +35** ft MLLW	885	885	81.7	2027	2	2021	2028

4.6 Summary of Placement Analysis Upland Raising without Lateral Expansion. Early discussions among the design team identified a vertical raising of the existing uplands alone as an alternative that failed to provide any substantial additional environmental benefits in comparison to the existing project. The initial thought was that there might even be a reduction in environmental benefits since the development of the existing upland habitat would be substantially delayed while additional dredged material was placed into the raised cells, and consolidated to a state that would allow for surface grading.

The proposed vertical expansion alternative consisted of raising the final surface of the existing upland habitat between 5 feet and 15 ft. The upper limit was based on the results of slope stability analysis that indicated that temporary dike heights above +40 ft MLLW might not be stable. That limited the elevation of upland development to approximately elevation +35 ft MLLW. The results of a vertical raising-alone option are presented on in Table C-6 below.

Table C-6 - Placement Summary For Raising Existing Upland Cells 2 & 6

Expansion and/or Raising Alternative	Total Area (acres)	Upland Area (acres)	Wetland Area (acres)	Total Capacity (mcy)	Last Year at 3.2 mcy	Years of Cell 6 Overload	Last Wetland Placement	Last Upland Placement	Placement Contingency (years)
Existing 1140-acre Project	1126	569	557	**40.4**	2014	**7**	2014	2015	1
Existing Uplands Raised to +25 MLLW	1126	569	557	**46.4**	2016	**9**	2014	2017	3
Existing Uplands Raised to +30 MLLW	1126	569	557	**52.4**	2018	**11**	2014	2019	5
Existing Uplands Raised to +35 MLLW	1126	569	557	**58.4**	2019	**13**	2014	2020	6

Beneficially, the vertical raising provides from 6 to 18 mcy of additional dredged material placement capacity without taking up any additional Chesapeake Bay bottom. The expansion of upland placement capacity without any expansion of wetland habitat results in a significant increase in contingency to deal with the many uncertainties of wetland development. Therefore, the potential for successfully completing the wetland development while employing efficient (cost effective) dredged material placement methods, would be enhanced.

It should be noted that most, if not all, of the materials required for dike raising would be obtained from borrow sources outside of the limits of the existing project – most likely the borrow area to the southwest of Cell 6. As clearly shown in Table C-3, vertical expansion alone provides no relief to the cell overloading that will occur during the latter years of the existing project. Furthermore, every year of additional capacity results in an additional year of inefficient placement as the upland cells would have to be overloaded with placement lifts ranging from 5 to 9 ft, as opposed to the optimal 3-foot lift thickness. Therefore, the vertical expansion alternative alone was not considered a viable option to be carried through additional evaluation.

4.7 Summary of Placement Analysis for 550-Acre Site. As a result of the plan formulation process, a 1,000-acre area located north of the existing project was identified as the preferred location for an expansion project. The engineering analyses concluded that the expansion alternative should be a minimum of 500 acres in size to accommodate average annual dredged material placement needs of approximately 3.2 mcy, and that the expansion site should consist of a minimum 50 percent wetland habitat. At 50 percent wetlands, a 500 to 600 acre expansion site was determined to be *marginally* acceptable with respect to: (1) its capacity to accommodate required annual dredged material placement, and (2) its capacity to provide sufficient dike fill material for dike construction from borrow sources located within the footprint of the upland cells of the expansion footprint. This marginal status can be improved by either reducing the wetland component below 50 percent of the total area – an option that is not supported by various non-engineering factors – or by raising the existing upland dikes to increase the upland placement capacity. The later option has been addressed in more detail in the subsequent design analyses presented hereafter. It was recommended that additional engineering investigations and analyses be performed to optimize the recommended alignment for an expansion project, and to support the development of a detailed design of the various alignment features.

Based on previous analysis and engineering judgement, a preliminary northern alignment containing approximately 550 acres was developed. Dredged material placement analyses were performed for six variations related to the 575-acre northern alignment (550 placement acres plus the 25-acre tidal gut). The six schemes included:

1. 50 percent wetlands without raising of existing uplands
2. 55 percent wetlands without raising of existing uplands
3. 60 percent wetland without raising of existing uplands
4. 50 percent wetlands with 5-foot raising of existing uplands
5. 55 percent wetlands with 5-foot raising of existing uplands
6. 60 percent wetland with 5-foot raising of existing uplands

In all cases, the final average elevation of the uplands associated with the lateral expansion is +20 ft MLLW, and the average final elevation of the raised uplands of the existing project is +25 ft MLLW.

The detailed results of the placement analyses are presented as a series of spreadsheets (Figures C-1 through C-7) at the end of this section of the report. A summary of the results is presented below in Table C-7.

4.7.1 Without Dike Raising. The analyses show that the lateral expansion can marginally support 50 percent, and possibly 55 percent, wetlands without raising the existing upland cells, but cannot support 60 percent wetland habitat. At 50 percent wetlands, placement of dredged material within the expansion wetland cells requires approximately eleven years when following the prescribed placement sequence. Following the requirement that the site must accommodate 3.5 mcy of total dredged material placement annually, the upland cells are filled to capacity in 12 years, with the final year accommodating less than 600,000 cy. Therefore, the site only marginally satisfies the placement criteria that uplands should have additional placement capacity beyond the duration of wetland placement. At 55 percent wetlands, the upland capacity in the twelfth year decreases to only about 320,000 cy. At 60 percent wetlands, the upland capacity in the eleventh year, concurrent with the final year of wetland placement, is less than the minimum required 3.2 mcy per year. Therefore, development of 60 percent wetlands cannot be efficiently supported, and there is no contingency to deal with difficult placement or development of wetland cells.

4.7.2 With Dike Raising. Raising the final average surface of the existing upland cells five feet from +20 to +25 ft MLLW increases the upland placement capacity by approximately 6 mcy – the equivalent of almost two additional years of placement. That additional two years significantly increases the probability of successfully completing the wetland placement and cell development. Not only can the placement be completed in accordance with efficient placement methods, the ability to accommodate difficulties during placement and cell development is enhanced. A single inflow significantly exceeding the average 3.2 mcy per year would create an unusually thick lift that would slow the consolidation process and extend the time to completely fill and grade a wetland cell. An unusually wet year, such as occurred in 2003, could prevent any surface grading activities planed for wetland cells, thereby extending wetland development. Either of these events could be accommodated with minimal impact if additional upland placement capacity was available. Therefore, both 50 percent and 55 percent wetland schemes are raised from marginally acceptable schemes to well supported schemes.

The 5-foot dike raising significantly increases that potential that the site could be developed with up to 60 percent wetland habitat. The primary difficulty in reaching the 60 percent goal is the limited availability of borrow materials for dike construction if the borrow must be obtained from within upland areas that area reduced to only 40 percent of the placement area. That limitation could be mitigated if additional borrow can be obtained from a second borrow source outside the expansion footprint. The source that has been identified is the borrow area located southwest of cell 6 of the existing project. Whether or not the southwest borrow area is used to supplement lateral expansion construction, it would be necessary to provide approximately 450,000 cy of sand materials required to raise the existing upland surfaces to +25 ft MLLW.

Table C-7. Summary of Placement Analysis - 575-Acre Site With and Without Dike Raising

	Upland/Wetland Distribution	Upland Expansion Area (acres)	Total Upland Area (acres)	Total Upland Capacity (mcy)	Wetland Expansion Area (acres)	Total Wetland Area (acres)	Total Wetland Capacity (mcy)	Upland Capacity / Wetland Capacity	Total Site Capacity (mcy)	Last Year @ 3.2 mcy Placed	Last Year Wetland Inflow	Last Year of Inflow into Site**
50% Upland 50% Wetland	Existing 1140-Acre Project	n/a	570.0	32.6	n/a	570.0	7.8	80.7%	40.4	2014	2014	2015
50% Upland 50% Wetland	Existing Project plus 50% Upland - 50% Wetland -Northern Alignment	275.0	844.0	49.0	275.0	832.0	15.5	75.9%	64.5	2021	2021	2022/2027
45% Upland - 55% Wetland	Existing Project plus 45% Upland - 55% Wetland -Northern Alignment	247.5	816.5	47.3	302.5	859.5	16.3	74.4%	63.6	2020	2021	2022/2027
40% Upland 60% Wetland	Existing Project plus 40% Upland - 60% Wetland -Northern Alignment	235.0	804.0	46.5	315.0	872.0	16.9	73.3%	63.4	2020	2021	2021/2026
50% Upland 50% Wetland with Raising	Existing Project plus 50% Wetland & 5-ft Raising -Northern Alignment	275.0	844.0	55.0	275.0	832.0	15.5	78.0%	70.5	2021	2021	2022/2027
45% Upland 55% Wetland with Raising	Existing Project plus 55% Wetland & 5-ft Raising -Northern Alignment	247.5	816.5	53.3	302.5	859.5	16.3	76.6%	69.6	2021	2021	2022/2027
40% Upland 60% Wetland with Raising	Existing Project plus 60% Wetland & 5-ft Raising -Northern Alignment	235.0	804.0	52.5	315.0	872.0	16.9	75.6%	69.4	2022	2021	2023/2027

** Note – The second year in the column for last year of inflow into the site is related to the potential development of the sheltered dredged material offloading facilities that may be recovered as a wetland cell, or may be left as an open cell.

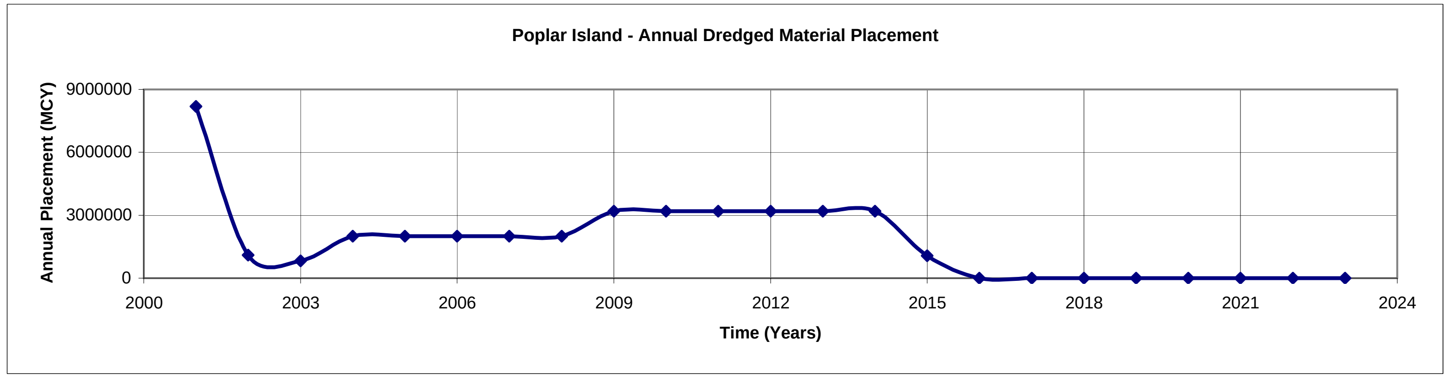
POPLAR ISLAND DREDGED MATERIAL PLACEMENT AND CELL DEVELOPMENT PLAN

FIGURE C-1 EXISTING 1140 ACRE SITE AT 50% WETLAND AND 50% UPLAND

KEY:

Red type represents dredged material placement quantity
Red type in yellow cell indicates year cell will be overloaded
Green type in green cell represents planting and habitat development.
Orange type in orange cell represents final placement and grading.

Cell No.	Cell Acreage (Nominal)	Cell Acreage (Actual)	Cell Volume	Cell Capacity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total Placed Quantity
EXISTING UPLAND CELLS									Cross-Dike Subcell 2A	Final fill 2A	Grade & Drain 2A	Plant 2A		Cross-Dike Subcell 2B	Final fill 2B	Grade & Drain 2B	Plant 2B		Final fill 2C		Grade & Drain 2C		Plant 2C	Plant 2C				
U-2	326	298	10,913,555	**15,590,792**	**6,399,848**	1,038,000	0	1,111,000	535,347	894,394	0	700,000	1,500,000	1,250,000	0	0	850,000	850,000	462,203	0	Grade	Grade	Plant	Plant				**15,590,792**
U-6	243	222	11,926,728	**17,038,183**	0	0	0	0	0	400,000	**1,700,000**	1,120,114	1,075,000	**1,480,028**	**3,050,000**	**2,994,429**	**2,244,714**	**2,322,609**	651,289	0	0	Grade	Grade	Plant	Plant			**17,038,183**
EXISTING WETLAND CELLS																												
W-1A	38	35	265,393	**379,133**	139,480	0	160,000	60,000	19,653	Grade	Plant																	**379,133**
W-1B	38	35	378,327	**540,467**	195,000	0	170,000	110,000	40,000	15,467	0	0	0	10,000	Grade	Plant												**540,467**
W-1C	44	40	367,840	**525,486**	195,000	0	200,000	80,000	40,000	10,486	Grade	Plant																**525,486**
W-1D	49	45	486,420	**694,886**	235,000	0	220,000	170,000	40,000	20,000	0	9,886	Grade	Plant														**694,886**
W-3A	35	32	366,549	**523,642**	220,000	0	0	210,000	55000	21,000	0	10,000	0	7,642	Grade	Plant												**523,642**
W-3B	30	28	275,557	**393,653**	290,000	0	0	75,000	20000	8,653	Grade	Plant																**393,653**
W-3C	39	35	400,913	**572,733**	225,403	0	66,000	184,000	50000	30,000	0	10,000	0	7,330	0	Grade	Plant											**572,733**
W-3D	31	26	251,680	**359,543**	284,500	62,000	12,000	Grade	Plant																			**358,500**
W-4A&B	34	31	150,040	**214,343**	0	0	0	0	0	0	0	0	0	0	0	130,000	65,000	19,343	Grade	Plant								**214,343**
W-4C	38	34	7,000	**10,000**	0	0	0	0	0	0	0	0	0	0	0	0	10,000	0	Grade	Plant								**10,000**
W-4DX	25	23	0	**0**	0	0	Plant																					**0**
W-5A	33	30	242,000	**345,714**	0	0	0	0	0	0	0	0	250,000	60000	25,000	10,714	Grade	Plant										**345,714**
W-5B	33	30	266,200	**380,286**	0	0	0	0	0	0	0	0	0	275,000	65000	30,000	10,286	Grade	Plant									**380,286**
W-5C	33	30	290,400	**414,857**	0	0	0	0	0	0	0	0	300,000	70000	30,000	14,857	Grade	Plant										**414,857**
W-5D	57	53	1,710,133	**2,443,048**	0	0	0	0	1,200,000	600,000	300,000	150,000	75,000	40,000	30,000	20,000	20,000	8,048	0	0	Grade	Plant						**2,443,048**
Annual Placement (mcy)				**40,426,766**	8,184,231	1,100,000	828,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	1,113,492	0	0	0	0	0	0	0	0	**40,425,723**



Total Upland Capacity	32,628,975
Total Wetland Capacity	7,797,790
Upland Placement Capacity Percentage	80.71%

POPLAR ISLAND DREDGED MATERIAL PLACEMENT AND CELL DEVELOPMENT PLAN

FIGURE C-2 EXISTING 1140-ACRE SITE WITH 550-ACRE EXPANSION WITH A NORTHERN ORIENTATION AT 50% WETLAND AND 50% UPLAND

(Expansion Cells Assumed to be Available in 2011)

KEY:

Red type represents dredged material placement quantity

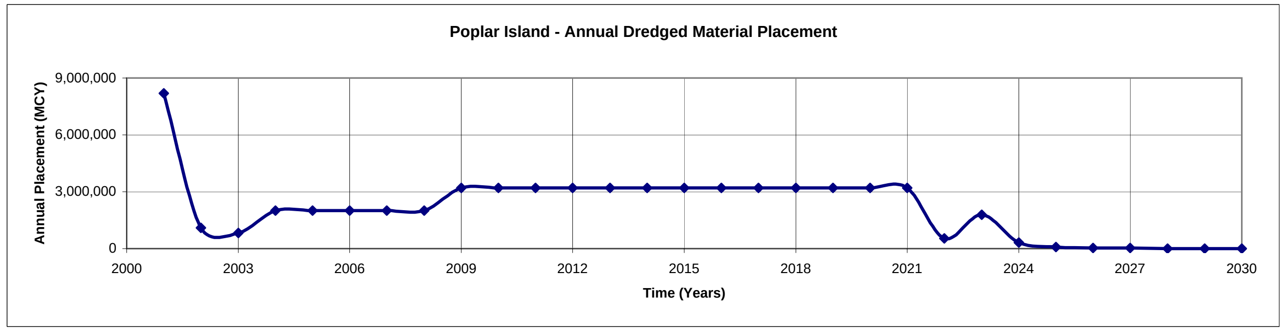
Red type in yellow cell indicates year cell will be overloaded

Green type in green cell represents planting and habitat development.

Orange type in orange cell represents final placement and grading.

Blue box denotes a year placement in occuring in expansion cell.

Cell No.	Cell Acreage	Cell Acreage	Cell Volume	Cell Capacity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total Placed Quantity
	(Nominal)	(Actual)																																	
EXPANSION UPLAND CELLS																																			
Up-8	40	36.6	1,712,392	2,446,274	0	0	0	0	0	0	0	0	0	0	177,144	177,144	177,144	177,144	177,144	177,144	177,144	177,144	177,144	177,144	**354,288**	**320,546**	0	0	Grade	Grade	Plant	Plant			**2,446,274**
Up-9	235	215.0	9,713,396	13,876,280											1,040,721	1,040,721	1,040,721	1,040,721	1,040,721	1,040,721	1,040,721	1,040,721	1,040,721	**1,457,417**	**2,827,485**	224,889	0	0	Grade	Grade	Plant	Plant			**13,876,280**
EXISTING UPLAND CELLS																																			
U-2	326	298	10,913,555	**15,590,792**	**6,399,848**	1,038,000	0	1,111,000	535,347	894,394	0	700,000	1,500,000	1,450,000	0	0	0	0	500,000	600,000	611268	250935	0	0	Grade	Grade	Plant	Plant							**15,590,792**
U-6	243	222	11,926,728	**17,038,183**	0	0	0	0	0	400,000	**1,700,000**	1,120,114	1,075,000	1,280,028	1,210,775	968,796	962,932	945,811	683,170	553,448	1,059,825	**1,621,841**	**1,927,455**	**1,528,986**	0	0	0	Grade	Grade	Plant	Plant				**17,038,182**
EXISTING WETLAND CELLS																																			
W-1A	38	35	265,393	**379,133**	139,480	0	160,000	60,000	19,653	Grade	Plant																								**379,133**
W-1B	38	35	378,327	**540,467**	195,000	0	170,000	110,000	40,000	15,467	0	0	0	10,000	Grade	Plant																			**540,467**
W-1C	44	40	367,840	**525,486**	195,000	0	200,000	80,000	40,000	10,486	Grade	Plant																							**525,486**
W-1D	49	45	486,420	**694,886**	235,000	0	220,000	170,000	40,000	20,000	0	9,886	Grade	Plant																					**694,886**
W-3A	35	32	366,549	**523,642**	220,000	0	0	210,000	55000	21,000	0	10,000	0	7,642	Grade	Plant																			**523,642**
W-3B	30	28	275,557	**393,653**	290,000	0	0	75,000	20000	8,653	Grade	Plant																							**393,653**
W-3C	39	35	400,913	**572,733**	225,403	0	66,000	184,000	50000	30,000	0	10,000	0	7,330	0	Grade	Plant																		**572,733**
W-3D	31	26	251,680	**359,543**	284,500	62,000	12,000	Grade	Plant																										**358,500**
W-4A&B	34	31	150,040	**214,343**	0	0	0	0	0	0	0	0	0	0	0	130,000	65,000	19,343	Grade	Plant															**214,343**
W-4C	38	34	7,000	**10,000**	0	0	0	0	0	0	0	0	0	0	0	0	10,000	0	Grade	Plant															**10,000**
W-4DX	25	23	0	**0**	0	0	Plant																												**0**
W-5A	33	30	242,000	**345,714**	0	0	0	0	0	0	0	0	250,000	60000	25,000	10,714	Grade	Plant																	**345,714**
W-5B	33	30	266,200	**380,286**	0	0	0	0	0	0	0	0	0	275,000	65000	30,000	10,286	Grade	Plant																**380,286**
W-5C	33	30	290,400	**414,857**	0	0	0	0	0	0	0	0	300,000	70000	30,000	14,857	Grade	Plant																	**414,857**
W-5D	57	53	1,710,133	**2,443,048**	0	0	0	0	1,200,000	600,000	300,000	150,000	75,000	40,000	30,000	20,000	20,000	8,048	0	0	Grade	Plant													**2,443,048**
EXPANSION WETLAND CELLS																																			
W-1	39.3	35.9	579,936	828,480	0	0	0	0	0	0	0	0	0	0	621,360	155,340	36,246	15,534	Grade	Plant															**828,480**
W-2	39.3	35.9	608,933	869,904	0	0	0	0	0	0	0	0	0	0	0	652,428	163,107	38,058	16,311	Grade	Plant														**869,904**
W-3	39.3	35.9	666,926	952,752	0	0	0	0	0	0	0	0	0	0	0	0	714,564	178,641	41,683	17,864	Grade	Plant													**952,752**
W-4	39.3	35.9	724,920	1,035,599	0	0	0	0	0	0	0	0	0	0	0	0	0	776,700	194,175	45,307	19,417	Grade	Plant												**1,035,599**
W-5	39.3	35.9	637,929	911,328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	546,797	218,719	72,906	36,453	18,227	18,227	Grade	Plant									**911,328**
W-6	39.3	35.9	637,929	911,328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	546,797	218,719	72,906	36,453	18,227	18,227	Grade	Plant								**911,328**
W-7	39.3	35.9	1,565,826	2,236,895	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,789,516	313,165	80,528	26,843	26,843	0	Grade	Plant	**2,236,895**
	1,676	**1,530**		**64,495,604**	8,184,231	1,100,000	828,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	545,435	1,789,516	313,165	80,528	26,843	26,843	0	0	0	**64,494,561**



Total Upland Capacity	48,951,530
Total Wetland Capacity	15,544,075
Upland Placement Capacity Percentage	75.90%

POPLAR ISLAND DREDGED MATERIAL PLACEMENT AND CELL DEVELOPMENT PLAN

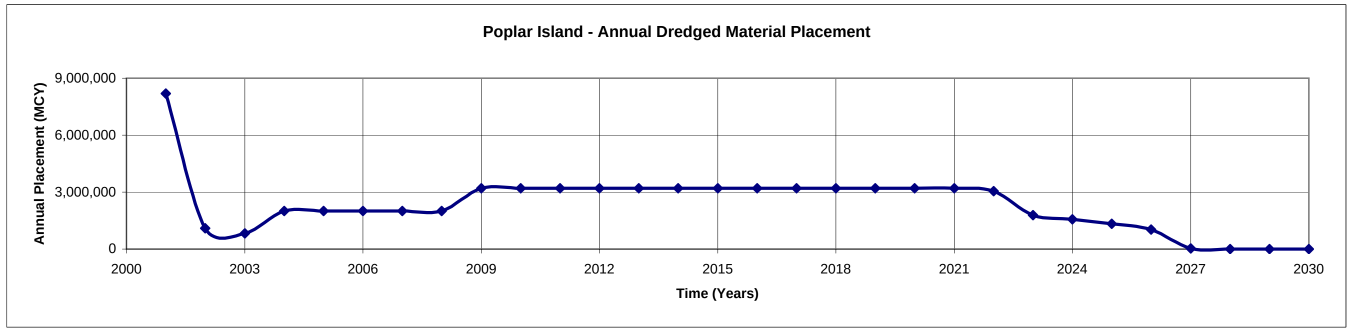
FIGURE C-3 EXISTING 1140-ACRE SITE WITH 550-ACRE EXPANSION WITH A NORTHERN ORIENTATION AT 50% WETLAND AND 50% UPLAND PLUS 5-FOOT RAISING OF EXISTING CELLS 2 & 6

(Expansion Cells Assumed to be Available in 2011)

KEY:

- Red type represents dredged material placement quantity
- Red type in yellow cell indicates year cell will be overloaded
- Green type in green cell represents planting and habitat development.
- Orange type in orange cell represents final placement and grading.
- Blue box denotes a year placement in occuring in expansion cell.

Cell No.	Cell Acreage	Cell Acreage	Cell Volume	Cell Capacity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total Placed Quantity
	(Nominal)	(Actual)																																	
RAISED EXISTING UPLAND CELLS																																			
U-2 Raised	326	298	2,406,206	3,437,437	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	750,000	750,000	0	750,000	750,000	437,437	Grade	Grade	Plant	Plant	**3,437,437**
U-6 Raised	243	222	1,793,583	2,562,261	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500,000	500,000	0	500,000	500,000	562,261	Grade	Grade	Plant	Plant	**2,562,261**
EXPANSION UPLAND CELLS																																			
Up-8 Exp	40	36.6	1,712,392	2,446,274	0	0	0	0	0	0	0	0	0	0	177,144	177,144	177,144	177,144	177,144	177,144	177,144	177,144	177,144	177,144	**354,288**	**320,546**	0	0	Grade	Grade	Plant	Plant			**2,446,274**
Up-9 Exp	235	215.0	9,713,396	13,876,280											1,040,721	1,040,721	1,040,721	1,040,721	1,040,721	1,040,721	1,040,721	1,040,721	1,040,721	**1,457,417**	**1,577,485**	**1,474,889**	0	0	Grade	Grade	Plant	Plant			**13,876,280**
EXISTING UPLAND CELLS																																			
U-2	326	298	10,913,555	**15,590,792**	**6,399,848**	1,038,000	0	1,111,000	535,347	894,394	0	700,000	1,500,000	1,450,000	0	0	0	0	500,000	600,000	611268	250935	0	0	0	0	0	0	0	0	DEFER TO GRADING AND PLANTING SHOWN ABOVE FOR RAISED CELLS 2 & 6				**15,590,792**
U-6	243	222	11,926,728	**17,038,183**	0	0	0	0	0	400,000	**1,700,000**	1,120,114	1,075,000	1,280,028	1,210,775	968,796	962,932	945,811	683,170	553,448	1,059,825	**1,621,841**	**1,927,455**	**1,528,986**	0	0	0	0	0	0					**17,038,182**
EXISTING WETLAND CELLS																																			
W-1A	38	35	265,393	**379,133**	139,480	0	160,000	60,000	19,653	Grade	Plant																								**379,133**
W-1B	38	35	378,327	**540,467**	195,000	0	170,000	110,000	40,000	15,467	0	0	0	10,000	Grade	Plant																			**540,467**
W-1C	44	40	367,840	**525,486**	195,000	0	200,000	80,000	40,000	10,486	Grade	Plant																							**525,486**
W-1D	49	45	486,420	**694,886**	235,000	0	220,000	170,000	40,000	20,000	0	9,886	Grade	Plant																					**694,886**
W-3A	35	32	366,549	**523,642**	220,000	0	0	210,000	55000	21,000	0	10,000	0	7,642	Grade	Plant																			**523,642**
W-3B	30	28	275,557	**393,653**	290,000	0	0	75,000	20000	8,653	Grade	Plant																							**393,653**
W-3C	39	35	400,913	**572,733**	225,403	0	66,000	184,000	50000	30,000	0	10,000	0	7,330	0	Grade	Plant																		**572,733**
W-3D	31	26	251,680	**359,543**	284,500	62,000	12,000	Grade	Plant																										**358,500**
W-4A&B	34	31	150,040	**214,343**	0	0	0	0	0	0	0	0	0	0	0	130,000	65,000	19,343	Grade	Plant															**214,343**
W-4C	38	34	7,000	**10,000**	0	0	0	0	0	0	0	0	0	0	0	0	10,000	0	Grade	Plant															**10,000**
W-4DX	25	23	0	**0**	0	0	Plant																												**0**
W-5A	33	30	242,000	**345,714**	0	0	0	0	0	0	0	0	250,000	60000	25,000	10,714	Grade	Plant																	**345,714**
W-5B	33	30	266,200	**380,286**	0	0	0	0	0	0	0	0	0	275,000	65000	30,000	10,286	Grade	Plant																**380,286**
W-5C	33	30	290,400	**414,857**	0	0	0	0	0	0	0	0	300,000	70000	30,000	14,857	Grade	Plant																	**414,857**
W-5D	57	53	1,710,133	**2,443,048**	0	0	0	0	1,200,000	600,000	300,000	150,000	75,000	40,000	30,000	20,000	20,000	8,048	0	0	Grade	Plant													**2,443,048**
EXPANSION WETLAND CELLS																																			
W-1	39.3	35.9	579,936	828,480	0	0	0	0	0	0	0	0	0	0	621,360	155,340	36,246	15,534	Grade	Plant															**828,480**
W-2	39.3	35.9	608,933	869,904	0	0	0	0	0	0	0	0	0	0	0	652,428	163,107	38,058	16,311	Grade	Plant														**869,904**
W-3	39.3	35.9	666,926	952,752	0	0	0	0	0	0	0	0	0	0	0	0	714,564	178,641	41,683	17,864	Grade	Plant													**952,752**
W-4	39.3	35.9	724,920	1,035,599	0	0	0	0	0	0	0	0	0	0	0	0	0	776,700	194,175	45,307	19,417	Grade	Plant												**1,035,599**
W-5	39.3	35.9	637,929	911,328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	546,797	218,719	72,906	36,453	18,227	18,227	Grade	Plant									**911,328**
W-6	39.3	35.9	637,929	911,328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	546,797	218,719	72,906	36,453	18,227	18,227	Grade	Plant								**911,328**
W-7	39.3	35.9	1,565,826	2,236,895	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,789,516	313,165	80,528	26,843	26,843	0	Grade	Plant	**2,236,895**
	1,676	**1,530**		**70,495,303**	8,184,231	1,100,000	828,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,045,435	1,789,516	1,563,165	1,330,528	1,026,541	26,843	0	0	0	**70,494,259**



Total Upland Capacity	54,951,228
Total Wetland Capacity	15,544,075
Upland Placement Capacity Percentage	77.95%

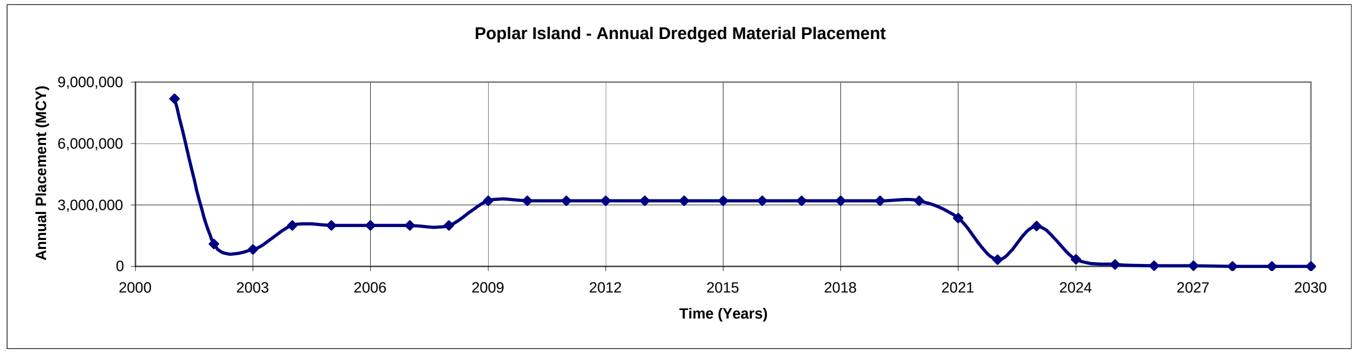
POPLAR ISLAND DREDGED MATERIAL PLACEMENT AND CELL DEVELOPMENT PLAN

FIGURE C-4 EXISTING 1140-ACRE SITE WITH 550-ACRE EXPANSION WITH A NORTHERN ORIENTATION AT 55% WETLAND AND 45% UPLAND

(Expansion Cells Assumed to be Available in 2011)

KEY:
- Red type represents dredged material placement quantity
- Red type in yellow cell indicates year cell will be overloaded
- Green type in green cell represents planting and habitat development.
- Orange type in orange cell represents final placement and grading.
- Blue box denotes a year placement in occuring in expansion cell.

Cell No.	Cell Acreage	Cell Volume	Cell Capacity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total Placed Quantity
	(Actual)																																	
EXPANSION UPLAND CELLS																																		
Up-8	36.6	1,712,392	2,446,274	0	0	0	0	0	0	0	0	0	0	177,144	177,144	177,144	177,144	177,144	177,144	177,144	177,144	177,144	177,144	**354,288**	**320,546**	0	0	Grade	Grade	Plant	Plant			**2,446,274**
Up-9	189.9	8,576,722	12,252,460											918,935	918,935	918,935	918,935	918,935	918,935	918,935	918,935	918,935	**2,004,379**	**1,977,671**		0	0	Grade	Grade	Plant	Plant			**12,252,460**
EXISTING UPLAND CELLS																																		
U-2	298	10,913,555	**15,590,792**	**6,399,848**	1,038,000	0	1,111,000	535,347	894,394	0	700,000	1,500,000	1,450,000	0	0	0	0	500,000	600,000	611268	250935	0	0	Grade	Grade	Plant	Plant							**15,590,792**
U-6	222	11,926,728	**17,038,183**	0	0	0	0	0	400,000	**1,700,000**	1,120,114	1,075,000	1,280,028	1,270,426	1,009,806	993,327	966,704	725,060	592,366	1,150,507	**1,732,691**	**2,043,774**	**978,379**	0	0	0	Grade	Grade	Plant	Plant				**17,038,183**
EXISTING WETLAND CELLS																																		
W-1A	35	265,393	**379,133**	139,480	0	160,000	60,000	19,653	Grade	Plant																								**379,133**
W-1B	35	378,327	**540,467**	195,000	0	170,000	110,000	40,000	15,467	0	0	0	10,000	Grade	Plant																			**540,467**
W-1C	40	367,840	**525,486**	195,000	0	200,000	80,000	40,000	10,486	Grade	Plant																							**525,486**
W-1D	45	486,420	**694,886**	235,000	0	220,000	170,000	40,000	20,000	0	9,886	Grade	Plant																					**694,886**
W-3A	32	366,549	**523,642**	220,000	0	0	210,000	55000	21,000	0	10,000	0	7,642	Grade	Plant																			**523,642**
W-3B	28	275,557	**393,653**	290,000	0	0	75,000	20000	8,653	Grade	Plant																							**393,653**
W-3C	35	400,913	**572,733**	225,403	0	66,000	184,000	50000	30,000	0	10,000	0	7,330	0	Grade	Plant																		**572,733**
W-3D	26	251,680	**359,543**	284,500	62,000	12,000	Grade	Plant																										**358,500**
W-4A&B	31	150,040	**214,343**	0	0	0	0	0	0	0	0	0	0	0	130,000	65,000	19,343	Grade	Plant															**214,343**
W-4C	34	7,000	**10,000**	0	0	0	0	0	0	0	0	0	0	0	0	10,000	0	Grade	Plant															**10,000**
W-4DX	23	0	**0**	0	0	Plant																												**0**
W-5A	30	242,000	**345,714**	0	0	0	0	0	0	0	0	250,000	60000	25,000	10,714	Grade	Plant																	**345,714**
W-5B	30	266,200	**380,286**	0	0	0	0	0	0	0	0	0	275,000	65000	30,000	10,286	Grade	Plant																**380,286**
W-5C	30	290,400	**414,857**	0	0	0	0	0	0	0	0	300,000	70000	30,000	14,857	Grade	Plant																	**414,857**
W-5D	53	1,710,133	**2,443,048**	0	0	0	0	1,200,000	600,000	300,000	150,000	75,000	40,000	30,000	20,000	20,000	8,048	0	0	Grade	Plant													**2,443,048**
EXPANSION WETLAND CELLS																																		
W-1	39.5	637,929	911,328	0	0	0	0	0	0	0	0	0	0	683,496	170,874	39,871	17,087	Grade	Plant															**911,328**
W-2	39.5	669,826	956,894	0	0	0	0	0	0	0	0	0	0	0	717,670	179,418	41,864	17,942	Grade	Plant														**956,894**
W-3	39.5	733,619	1,048,027	0	0	0	0	0	0	0	0	0	0	0	0	786,020	196,505	45,851	19,651	Grade	Plant													**1,048,027**
W-4	39.5	797,412	1,139,159	0	0	0	0	0	0	0	0	0	0	0	0	0	854,370	213,592	49,838	21,359	Grade	Plant												**1,139,159**
W-5	39.5	701,722	1,002,460	0	0	0	0	0	0	0	0	0	0	0	0	0	0	601,476	240,590	80,197	40,098	20,049	20,049	Grade	Plant									**1,002,460**
W-6	39.5	701,722	1,002,460	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	601,476	240,590	80,197	40,098	20,049	20,049	Grade	Plant								**1,002,460**
W-7	39.5	1,722,409	2,460,584	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,968,468	344,482	88,581	29,527	29,527	0	Grade	Plant	**2,460,584**
	1,530		**63,646,413**	8,184,231	1,100,000	828,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	2,352,008	320,546	1,968,468	344,482	88,581	29,527	29,527	0	0	0	**63,645,370**



Total Upland Capacity	47,327,710
Total Wetland Capacity	16,318,703
Upland Placement Capacity Percentage	74.36%

POPLAR ISLAND DREDGED MATERIAL PLACEMENT AND CELL DEVELOPMENT PLAN

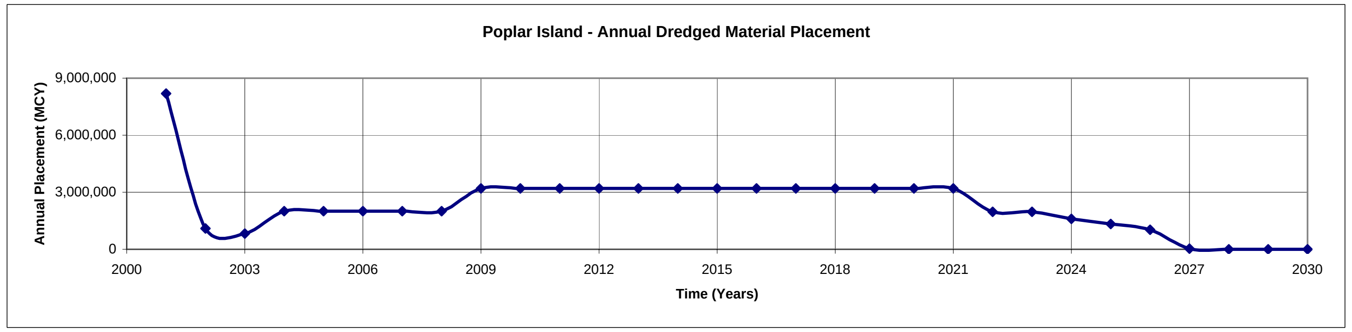
FIGURE C-5 EXISTING 1140-ACRE SITE WITH 550-ACRE EXPANSION WITH A NORTHERN ORIENTATION AT 55% WETLAND AND 45% UPLAND PLUS 5-FOOT RAISING OF EXISTING CELLS 2 & 6

(Expansion Cells Assumed to be Available in 2011)

KEY:

- Red type represents dredged material placement quantity
- Red type in yellow cell indicates year cell will be overloaded
- Green type in green cell represents planting and habitat development.
- Orange type in orange cell represents final placement and grading.
- Blue box denotes a year placement in occuring in expansion cell.

Cell No.	Cell Acreage	Cell Acreage	Cell Volume	Cell Capacity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total Placed Quantity
	(Nominal)	(Actual)																																	
RAISED EXISTING UPLAND CELLS																																			
U-2 Raised	326	298	2,406,206	3,437,437	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	750,000	750,000	0	750,000	750,000	437,437	Grade	Grade	Plant	Plant	3,437,437
U-6 Raised	243	222	1,793,583	2,562,261	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500,000	500,000	0	500,000	500,000	562,261	Grade	Grade	Plant	Plant	2,562,261
EXPANSION UPLAND CELLS																																			
Up-8 Exp	40	36.6	1,712,392	2,446,274	0	0	0	0	0	0	0	0	0	0	177,144	177,144	177,144	177,144	177,144	177,144	177,144	177,144	177,144	177,144	354,288	320,546	0	0	Grade	Grade	Plant	Plant			2,446,274
Up-9 Exp	207.5	189.9	8,576,722	12,252,460											918,935	918,935	918,935	918,935	918,935	918,935	918,935	918,935	918,935	2,004,379	1,575,663	402,008	0	0	Grade	Grade	Plant	Plant			12,252,460
EXISTING UPLAND CELLS																																			
U-2	326	298	10,913,555	**15,590,792**	6,399,848	1,038,000	0	1,111,000	535,347	894,394	0	700,000	1,500,000	1,450,000	0	0	0	0	500,000	600,000	611268	250935	0	0	0	0	0	0	0	0	DEFER TO GRADING AND PLANTING SHOWN ABOVE FOR RAISED CELLS 2 & 6				15,590,792
U-6	243	222	11,926,728	**17,038,183**	0	0	0	0	0	400,000	1,700,000	1,120,114	1,075,000	1,280,028	1,270,426	1,009,806	993,327	966,704	725,060	592,366	1,150,507	1,732,691	2,043,774	978,379	0	0	0	0	0	0					17,038,183
EXISTING WETLAND CELLS																																			
W-1A	38	35	265,393	**379,133**	139,480	0	160,000	60,000	19,653	Grade	Plant																								379,133
W-1B	38	35	378,327	**540,467**	195,000	0	170,000	110,000	40,000	15,467	0	0	0	10,000	Grade	Plant																			540,467
W-1C	44	40	367,840	**525,486**	195,000	0	200,000	80,000	40,000	10,486	Grade	Plant																							525,486
W-1D	49	45	486,420	**694,886**	235,000	0	220,000	170,000	40,000	20,000	0	9,886	Grade	Plant																					694,886
W-3A	35	32	366,549	**523,642**	220,000	0	0	210,000	55000	21,000	0	10,000	0	7,642	Grade	Plant																			523,642
W-3B	30	28	275,557	**393,653**	290,000	0	0	75,000	20000	8,653	Grade	Plant																							393,653
W-3C	39	35	400,913	**572,733**	225,403	0	66,000	184,000	50000	30,000	0	10,000	0	7,330	0	Grade	Plant																		572,733
W-3D	31	26	251,680	**359,543**	284,500	62,000	12,000	Grade	Plant																										358,500
W-4A&B	34	31	150,040	**214,343**	0	0	0	0	0	0	0	0	0	0	0	130,000	65,000	19,343	Grade	Plant															214,343
W-4C	38	34	7,000	**10,000**	0	0	0	0	0	0	0	0	0	0	0	0	10,000	0	Grade	Plant															10,000
W-4DX	25	23	0	**0**	0	0	Plant																												0
W-5A	33	30	242,000	**345,714**	0	0	0	0	0	0	0	0	250,000	60000	25,000	10,714	Grade	Plant																	345,714
W-5B	33	30	266,200	**380,286**	0	0	0	0	0	0	0	0	0	275,000	65000	30,000	10,286	Grade	Plant																380,286
W-5C	33	30	290,400	**414,857**	0	0	0	0	0	0	0	0	300,000	70000	30,000	14,857	Grade	Plant																	414,857
W-5D	57	53	1,710,133	**2,443,048**	0	0	0	0	1,200,000	600,000	300,000	150,000	75,000	40,000	30,000	20,000	20,000	8,048	0	0	Grade	Plant													2,443,048
EXPANSION WETLAND CELLS																																			
W-1	43.2	39.5	637,929	911,328	0	0	0	0	0	0	0	0	0	0	683,496	170,874	39,871	17,087	Grade	Plant															911,328
W-2	43.2	39.5	669,826	956,894	0	0	0	0	0	0	0	0	0	0	0	717,670	179,418	41,864	17,942	Grade	Plant														956,894
W-3	43.2	39.5	733,619	1,048,027	0	0	0	0	0	0	0	0	0	0	0	0	786,020	196,505	45,851	19,651	Grade	Plant													1,048,027
W-4	43.2	39.5	797,412	1,139,159	0	0	0	0	0	0	0	0	0	0	0	0	0	854,370	213,592	49,838	21,359	Grade	Plant												1,139,159
W-5	43.2	39.5	701,722	1,002,460	0	0	0	0	0	0	0	0	0	0	0	0	0	0	601,476	240,590	80,197	40,098	20,049	20,049	Grade	Plant									1,002,460
W-6	43.2	39.5	701,722	1,002,460	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	601,476	240,590	80,197	40,098	20,049	20,049	Grade	Plant								1,002,460
W-7	43.2	39.5	1,722,409	2,460,584	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,968,468	344,482	88,581	29,527	29,527	0	Grade	Plant	2,460,584
	1,676	**1,530**		**69,646,111**	8,184,231	1,100,000	828,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	1,972,554	1,968,468	1,594,482	1,338,581	1,029,225	29,527	0	0	0	**69,645,067**



Total Upland Capacity	53,327,408
Total Wetland Capacity	16,318,703
Upland Placement Capacity Percentage	76.57%

POPLAR ISLAND DREDGED MATERIAL PLACEMENT AND CELL DEVELOPMENT PLAN

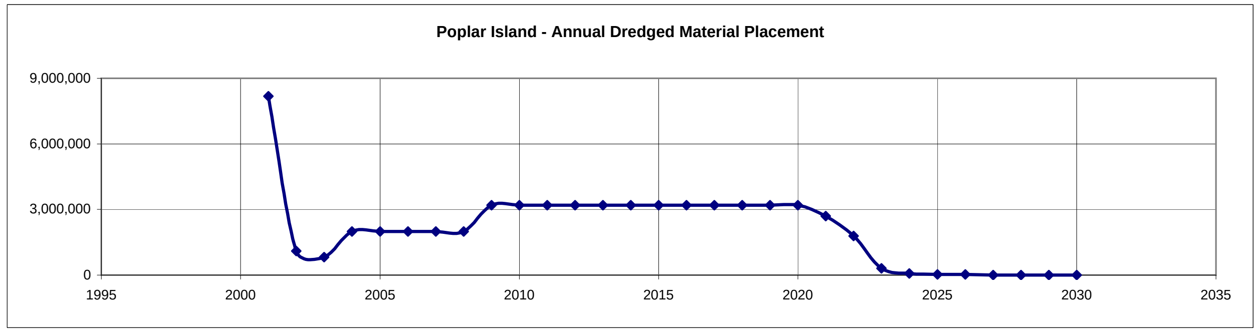
FIGURE C-6 EXISTING 1140-ACRE SITE WITH 550-ACRE EXPANSION WITH A NORTHERN ORIENTATION AT 60% WETLAND AND 40% UPLAND

(Expansion Cells Assumed to be Available in 2011)

KEY:

- Red type represents dredged material placement quantity
- Red type in yellow cell indicates year cell will be overloaded
- Green type in green cell represents planting and habitat development.
- Orange type in orange cell represents final placement and grading.
- Blue box denotes a year placement in occuring in expansion cell.

Cell No.	Cell Acreage	Cell Acreage	Cell Volume	Cell Capacity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total Placed Quantity
	(Nominal)	(Actual)																																	
EXPANSION WETLAND/UPLAND CELLS																																			
Wet-8	40	36.6	974,292	1,391,846	0	0	0	0	0	0	0	0	0	0	695,923	347,961	173,981	86,990	43,495	21,748	10,874	10,874	0	0	Grade	Grade	Plant	Plant							**1,391,846**
Up-9	235	215.0	9,713,396	13,876,280	0	0	0	0	0	0	0	0	0	0	1,040,721	1,040,721	1,040,721	1,040,721	1,040,721	1,040,721	1,040,721	1,040,721	1,040,721	**1,837,011**	**2,672,780**	0	0	0	Grade	Grade	Plant	Plant			**13,876,280**
EXISTING UPLAND CELLS																																			
U-2	326	298	10,913,555	**15,590,792**	**6,399,848**	1,038,000	0	1,111,000	535,347	894,394	0	700,000	1,500,000	1,450,000	0	0	0	0	500,000	600,000	611268	250935	0	0	Grade	Grade	Plant	Plant							**15,590,792**
U-6	243	222	11,926,728	**17,038,183**	0	0	0	0	0	400,000	**1,700,000**	1,120,114	1,075,000	1,280,028	691,996	797,979	966,096	1,035,965	816,819	708,845	1,226,095	**1,788,111**	**2,104,599**	**1,326,536**	0	0	0	Grade	Grade	Plant	Plant				**17,038,183**
EXISTING WETLAND CELLS																																			
W-1A	38	35	265,393	**379,133**	139,480	0	160,000	60,000	19,653	Grade	Plant																								**379,133**
W-1B	38	35	378,327	**540,467**	195,000	0	170,000	110,000	40,000	15,467	0	0	0	10,000	Grade	Plant																			**540,467**
W-1C	44	40	367,840	**525,486**	195,000	0	200,000	80,000	40,000	10,486	Grade	Plant																							**525,486**
W-1D	49	45	486,420	**694,886**	235,000	0	220,000	170,000	40,000	20,000	0	9,886	Grade	Plant																					**694,886**
W-3A	35	32	366,549	**523,642**	220,000	0	0	210,000	55000	21,000	0	10,000	0	7,642	Grade	Plant																			**523,642**
W-3B	30	28	275,557	**393,653**	290,000	0	0	75,000	20000	8,653	Grade	Plant																							**393,653**
W-3C	39	35	400,913	**572,733**	225,403	0	66,000	184,000	50000	30,000	0	10,000	0	7,330	0	Grade	Plant																		**572,733**
W-3D	31	26	251,680	**359,543**	284,500	62,000	12,000	Grade	Plant																										**358,500**
W-4A&B	34	31	150,040	**214,343**	0	0	0	0	0	0	0	0	0	0	0	130,000	65,000	19,343	Grade	Plant															**214,343**
W-4C	38	34	7,000	**10,000**	0	0	0	0	0	0	0	0	0	0	0	0	10,000	0	Grade	Plant															**10,000**
W-4DX	25	23	0	**0**	0	0	Plant																												**0**
W-5A	33	30	242,000	**345,714**	0	0	0	0	0	0	0	0	250,000	60000	25,000	10,714	Grade	Plant																	**345,714**
W-5B	33	30	266,200	**380,286**	0	0	0	0	0	0	0	0	0	275,000	65000	30,000	10,286	Grade	Plant																**380,286**
W-5C	33	30	290,400	**414,857**	0	0	0	0	0	0	0	0	300,000	70000	30,000	14,857	Grade	Plant																	**414,857**
W-5D	57	53	1,710,133	**2,443,048**	0	0	0	0	1,200,000	600,000	300,000	150,000	75,000	40,000	30,000	20,000	20,000	8,048	0	0	Grade	Plant													**2,443,048**
EXPANSION WETLAND CELLS																																			
W-1	39.3	35.9	579,936	828,480	0	0	0	0	0	0	0	0	0	0	621,360	155,340	36,246	15,534	Grade	Plant															**828,480**
W-2	39.3	35.9	608,933	869,904	0	0	0	0	0	0	0	0	0	0	0	652,428	163,107	38,058	16,311	Grade	Plant														**869,904**
W-3	39.3	35.9	666,926	952,752	0	0	0	0	0	0	0	0	0	0	0	0	714,564	178,641	41,683	17,864	Grade	Plant													**952,752**
W-4	39.3	35.9	724,920	1,035,599	0	0	0	0	0	0	0	0	0	0	0	0	0	776,700	194,175	45,307	19,417	Grade	Plant												**1,035,599**
W-5	39.3	35.9	637,929	911,328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	546,797	218,719	72,906	36,453	18,227	18,227	Grade	Plant									**911,328**
W-6	39.3	35.9	637,929	911,328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	546,797	218,719	72,906	36,453	18,227	18,227	Grade	Plant								**911,328**
W-7	39.3	35.9	1,565,826	2,236,895	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,789,516	313,165	80,528	26,843	26,843	0	Grade	Plant		**2,236,895**
	1,676	**1,530**		**63,441,176**	8,184,231	1,100,000	828,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	2,691,007	1,789,516	313,165	80,528	26,843	26,843	0	0	0	0	**63,440,132**



Total Upland Capacity	46,505,255	Expansion Upland Area	235	Total Upland Area	804
Total Wetland Capacity	16,935,920	Expansion Wetland Area	315	Total Wetland Area	872
Upland Placement Capacity Percentage	73.30%	Expansion wetland placement area percentage	57.3%	Project Wetland placement area percentage	52.0%
		Expansion Wetland Including Tidal Gut	343		
		Expansion Wetland area percentage	59.3%		

POPLAR ISLAND DREDGED MATERIAL PLACEMENT AND CELL DEVELOPMENT PLAN

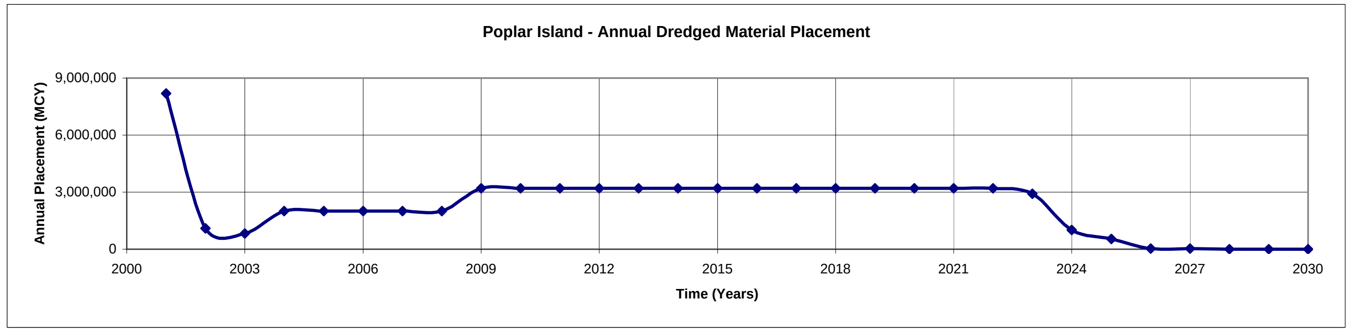
FIGURE C-7 EXISTING 1140-ACRE SITE PLUS 550-ACRE EXPANSION WITH A NORTHERN ORIENTATION AT 60% WETLAND AND 40% UPLAND WITH 5-FOOT RAISING OF EXISTING UPLAND CELLS 2 & 6

(Expansion Cells Assumed to be Available in 2011)

KEY:

- Red type represents dredged material placement quantity
- Red type in yellow cell indicates year cell will be overloaded
- Green type in green cell represents planting and habitat development.
- Orange type in orange cell represents final placement and grading.
- Blue box denotes a year placement in occuring in expansion cell.

Cell No.	Cell Acreage	Cell Acreage	Cell Volume	Cell Capacity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total Placed Quantity
	(Nominal)	(Actual)																																	
RAISED EXISTING UPLAND CELLS																																			
U-2 Raised	326	298	2,406,206	3,437,437	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,620,692	1,388,301	428,444			0	Grade	Grade	Plant	Plant	**3,437,437**
U-6 Raised	243	222	1,793,583	2,562,261	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	700,000	700,000	700,000	462,261		Grade	Grade	Plant	Plant	**2,562,261**
EXPANSION WETLAND/UPLAND CELLS																																			
Wet-8 Exp	40	36.6	974,292	1,391,846	0	0	0	0	0	0	0	0	0	0	695,923	347,961	173,981	86,990	43,495	21,748	10,874	10,874	0	0	Grade	Grade	Plant	Plant							**1,391,846**
Up-9 Exp	235	215.0	9,713,396	13,876,280	0	0	0	0	0	0	0	0	0	0	0	0	0	**1,561,082**	**1,561,082**	**1,561,082**	**1,561,082**	**1,561,082**	**1,561,082**	**1,837,011**	**1,561,082**	**1,111,699**	0	0	Grade	Grade	Plant	Plant	Plant		**13,876,280**
EXISTING UPLAND CELLS																																			
U-2	326	298	10,913,555	**15,590,792**	**6,399,848**	1,038,000	0	1,111,000	535,347	894,394	0	700,000	1,500,000	1,450,000	0	0	0	0	400,000	400,000	611268	550935	0	0	0	0	0	0	0	0	DEFER TO GRADING AND PLANTING SHOWN ABOVE FOR RAISED CELLS 2 & 6				**15,590,792**
U-6	243	222	11,926,728	**17,038,183**	0	0	0	0	0	400,000	**1,700,000**	1,120,114	1,075,000	1,280,028	1,732,717	1,838,700	2,006,817	515,604	396,458	388,484	705,734	967,750	1,584,239	1,326,536		0	0	0	0	0					**17,038,183**
EXISTING WETLAND CELLS																																			
W-1A	38	35	265,393	**379,133**	139,480	0	160,000	60,000	19,653	Grade	Plant																								**379,133**
W-1B	38	35	378,327	**540,467**	195,000	0	170,000	110,000	40,000	15,467	0	0	0	10,000	Grade	Plant																			**540,467**
W-1C	44	40	367,840	**525,486**	195,000	0	200,000	80,000	40,000	10,486	Grade	Plant																							**525,486**
W-1D	49	45	486,420	**694,886**	235,000	0	220,000	170,000	40,000	20,000	0	9,886	Grade	Plant																					**694,886**
W-3A	35	32	366,549	**523,642**	220,000	0	0	210,000	55000	21,000	0	10,000	0	7,642	Grade	Plant																			**523,642**
W-3B	30	28	275,557	**393,653**	290,000	0	0	75,000	20000	8,653	Grade	Plant																							**393,653**
W-3C	39	35	400,913	**572,733**	225,403	0	66,000	184,000	50000	30,000	0	10,000	0	7,330	0	Grade	Plant																		**572,733**
W-3D	31	26	251,680	**359,543**	284,500	62,000	12,000	Grade	Plant																										**358,500**
W-4A&B	34	31	150,040	**214,343**	0	0	0	0	0	0	0	0	0	0	0	130,000	65,000	19,343	Grade	Plant															**214,343**
W-4C	38	34	7,000	**10,000**	0	0	0	0	0	0	0	0	0	0	0	0	10,000	0	Grade	Plant															**10,000**
W-4DX	25	23	0	**0**	0	0	Plant																												**0**
W-5A	33	30	242,000	**345,714**	0	0	0	0	0	0	0	0	250,000	60000	25,000	10,714	Grade	Plant																	**345,714**
W-5B	33	30	266,200	**380,286**	0	0	0	0	0	0	0	0	0	275,000	65000	30,000	10,286	Grade	Plant																**380,286**
W-5C	33	30	290,400	**414,857**	0	0	0	0	0	0	0	0	300,000	70000	30,000	14,857	Grade	Plant																	**414,857**
W-5D	57	53	1,710,133	**2,443,048**	0	0	0	0	1,200,000	600,000	300,000	150,000	75,000	40,000	30,000	20,000	20,000	8,048	0	0	Grade	Plant													**2,443,048**
EXPANSION WETLAND CELLS																																			
W-1	39.3	35.9	579,936	828,480	0	0	0	0	0	0	0	0	0	0	621,360	155,340	36,246	15,534	Grade	Plant															**828,480**
W-2	39.3	35.9	608,933	869,904	0	0	0	0	0	0	0	0	0	0	0	652,428	163,107	38,058	16,311	Grade	Plant														**869,904**
W-3	39.3	35.9	666,926	952,752	0	0	0	0	0	0	0	0	0	0	0	0	714,564	178,641	41,683	17,864	Grade	Plant													**952,752**
W-4	39.3	35.9	724,920	1,035,599	0	0	0	0	0	0	0	0	0	0	0	0	0	776,700	194,175	45,307	19,417	Grade	Plant												**1,035,599**
W-5	39.3	35.9	637,929	911,328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	546,797	218,719	72,906	36,453	18,227	18,227	Grade	Plant									**911,328**
W-6	39.3	35.9	637,929	911,328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	546,797	218,719	72,906	36,453	18,227	18,227	Grade	Plant								**911,328**
W-7	39.3	35.9	1,565,826	2,236,895	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,789,516	313,165	80,528	26,843	26,843	0	Grade	Plant	**2,236,895**
	1,441			**69,440,874**	8,184,231	1,100,000	828,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	2,917,960	1,013,165	542,789	26,843	26,843	0	0	0	**69,439,831**



Total Upland Capacity	52,504,954	Expansion Upland Area	235	Total Upland Area	804
Total Wetland Capacity	16,935,920	Expansion Wetland Area	315	Total Wetland Area	872
Upland Placement capacity percentage	75.61%	Expansion wetland placement area percentage	57.3%	Total Project Wetland area percentage	52.0%
		Expansion Wetland Including Tidal Gut	343		
		Expansion Wetland area percentage	59.3%		

ATTACHMENT D

SLOPE STABILITY ANALYSIS

POPLAR ISLAND EXPANSION STUDY
ENGINEERING APPENDIX

ATTACHMENT D – SLOPE STABILITY ANALYSIS

1. General

The original Phase I dike section for Cell 2 was raised from elevation +20 to +23 ft MLLW between October 2003 and May 2004. Original slope stability analyses were performed for Phase I typical dike sections to elevation +10, +23 and +33 ft MLLW. The foundation conditions along Cell 2 have improved with respect to the strength and compressibility over time as a results of both constructed dike raisings (to +20 and to +23 ft MLLW). Also, prior to the construction of the Phase I dikes to +10 ft MLLW, soft, compressible silty clay foundation soils (characterized by Standard Penetration Test (SPT) N-values of 1 blow per foot or less) were removed and replaced with suitable sand backfill materials. Wherever possible, the limits of removal were reduced to only the portion of the dike outboard of the baseline where the armorstone would be placed. This reduction in removal limits was applied to soft zones having SPT N-values between 1 and 2 blows per foot. Areas having extremely soft materials with predominate N-values less than 1 (i.e. weight-of-hammer (WH) or weight-of-rod (WR) penetration resistance) were removed from beneath the entire dike cross section and replaced with Zone B quality sand (i.e., 20 to 30 percent fines). Even though the foundation materials are improving with time and additional surcharge, it was warranted that additional analyses be performed based on predicted dredge material inflow elevations and raised dike sections. Guidelines, such as minimum elevation of dredge material within the cell relative to the proposed raised dike height for future dike raising, were established based on these analyses.

2. Method of Analysis

Circular “arc” analyses were performed using the Corps of Engineers slope stability computer program UTEXAS4. This computer program analyzed a floating grid using the Spencer’s factor of safety method. Results of all of the analyses and representative computer printout graphics are presented following this section.

3. Strength of Dike Materials

The strength of the sand materials comprising the dike section was based on engineering judgement and the use of strength correlations presented in Bowles, Foundation Analysis and Design, 4th Edition. The correlated strength values from Bowles are for granular soils based on SPT N-values. The upper sand dike section up to +20 ft MLLW, placed above water and subjected to some compactive effort, was assigned a Phi value of 32 degrees. This corresponds to a medium dense sand [relative density = 50 percent (approximately)]. Sand placed below water was assigned a Phi value of 28 degrees. This corresponds to a loose to very loose density sand [relative density = 15 percent (approximately)]. The raised dike section (to +23 ft MLLW) and future raising sections were assigned a Phi value of 30 degrees. This corresponds to a medium to loose sand [relative density = 35 percent (approximately)]. To accommodate raised dike sections, dike bases were used in the analyses. The dike base fill materials were assigned a Phi value of 26 degrees, which corresponds to an undrained shear strength of 200 psf. These low strength values were selected based on the assumption that the dike base materials consist of very loose sand or very soft sandy clay materials.

4. Strength of Foundation Materials

For the current conditions and for the analyzed dike-raising scenarios (+30, +35 and +40 ft MLLW), the foundation material strengths were adequate to provide a minimal factor of safety against slope failure of 1.3 for exterior slopes to the wetlands and the Chesapeake Bay. Cell 2 consisted of layered foundation materials. Generally, the upper foundation layer consisted of silty sand materials of varying relative density. Based on blow counts, correlated Phi values of 26 to 28 degrees were used. Below the silty sand were varying strength cohesive materials with occasional layers of sandy material. The foundation materials increased in strength with depth. The upper cohesive foundation materials were very soft, with undrained shear strength values of 700 psf, as determined by lab testing. Conservatively, some clay layers were analyzed using undrained shear strength values as low as 500 psf. With increasing depth, the undrained shear strength values increased to 1000 psf and higher. The strength determination of the foundation clays were based on the results of unconfined compression tests, consolidated-undrained triaxial shear tests, and testing performed during Phase I design.

5. Strength of Dredged Materials

The strength determination of the dredge material within the cells was based on engineering judgement and the use of a vane shear testing device. Lower dredge materials that have been in-place the longest were assigned an undrained shear strength value of 200 psf. The upper-most portion of the dredge material (newest) was assigned an undrained shear strength value of 50 psf. Based on vane shear testing performed in the wetland cells, an undrained shear strength value of 150 psf was assigned to the dredge material in the wetland cells. Because of the normally very soft consolidated state of the dredge materials, the interior slope failure planes (into Cell 2) governed the stability analyses. Based on the results of the interior slope stability analyses, recommendations and guidelines for future raising(s) were established, such as minimum dredge material elevations within Cell 2 relative to the proposed raised dike height.

6. Guidelines for Future Raisings

Based on the slope stability analyses performed for this report, it has been determined that a future dike raising to +30 ft MLLW cannot be performed until the in-place dredge material in Cell 2 reaches a minimum in-place elevation of +15 ft MLLW. This in-place dredge material elevation of +15 ft MLLW would be achieved after decanting and initial crust development has begun. Future raisings beyond +30 ft MLLW will be limited to a difference in elevations (existing dredge material elevation verses proposed dike raised elevation) of 10 feet. For example, to raise Cell 2 dikes to a proposed +35 ft MLLW, the dredge material shall achieve an elevation of +25 ft MLLW prior to the raising. This recommendation is based on slope stability analyses that show a factor of safety just above 1.0 for interior slope failures into Cell 2.

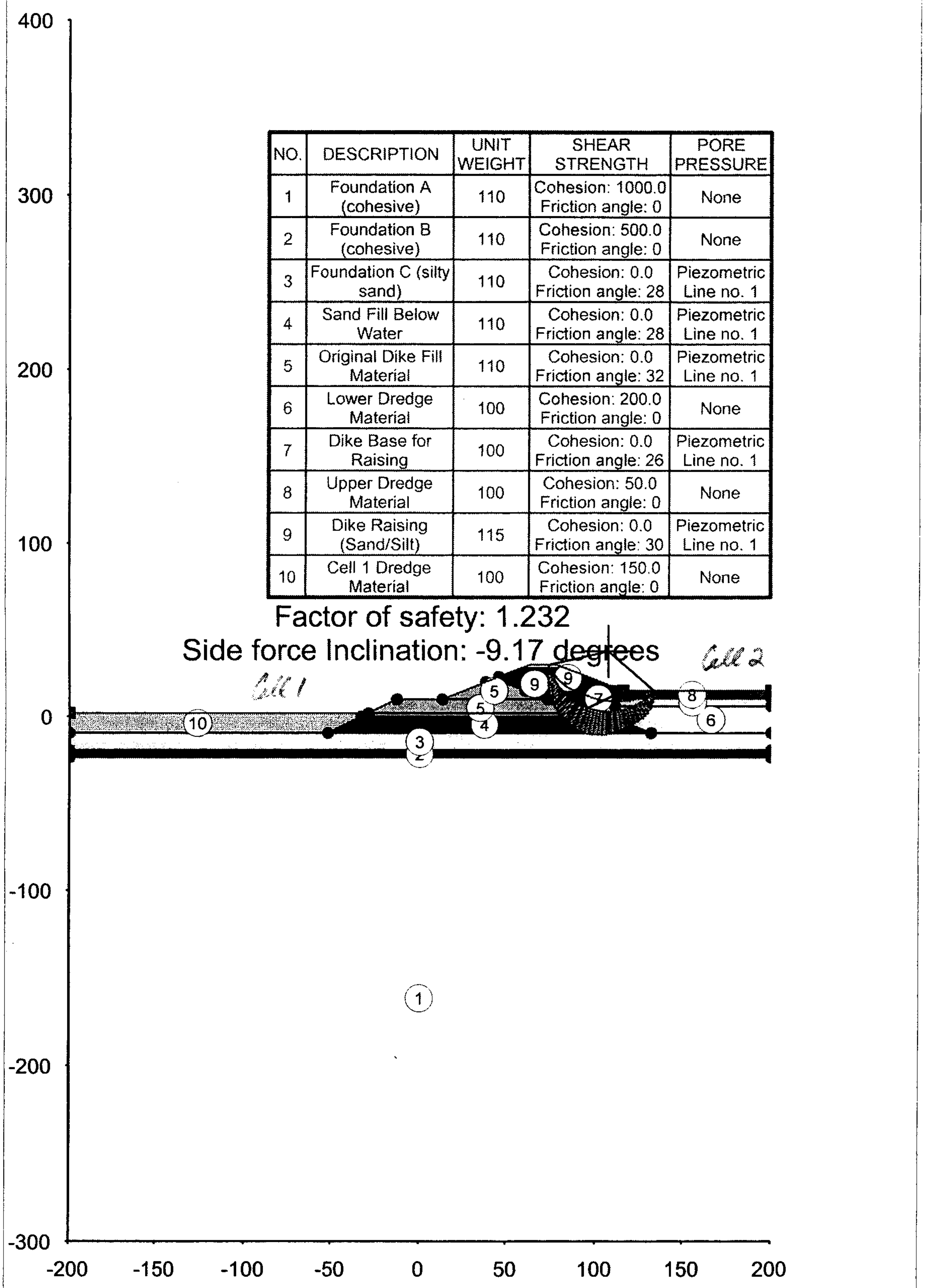
If the dredged material is approximately 5 feet below the existing dike crest when a raising increment is constructed, the risk of initiating a failure that would release dredged material is very small. It is anticipated that any failure would begin as minor sloughing in a localized area that could be stabilized by placing additional fill to displace an extremely soft dredged material zones, and replaced with stiffer dredged materials or sand. Therefore, a safety factor of 1.0 is an acceptable approach for gradual dike raising construction.

SUMMARY OF STABILITY ANALYSIS
UTEXAS 4 COMPUTER PROGRAM - SPENCER METHOD

Station Number	Foundation discription	Failure Surface	Minimum Dredge Material Elev (ft)	Proposed Dike Height (ft)	Critical Factor of Safety
904+00	upper sand material, Phi = 28 degrees upper clay layer, c = 500 psf lower clay material, c = 1000 psf	arc plane, interior failure	+15	+30	1.23
		arc plane, exterior failure	+15	+30	1.48
		arc plane, interior failure	+25	+35	1.03
		arc plane, exterior failure	+25	+35	1.51
		arc plane, interior failure	+30	+40	1.12
		arc plane, exterior failure	+30	+40	1.33
930+00	upper sand material, Phi = 26 degrees upper clay layer, c = 500-700 psf lower sand material, Phi = 28 degrees	arc plane, interior failure	+15	+30	1.06
		arc plane, exterior failure	+15	+30	1.37
		arc plane, interior failure	+25	+35	1.03
		arc plane, exterior failure	+25	+35	1.32
		arc plane, interior failure	+30	+40	1.12
		arc plane, exterior failure	+30	+40	1.32
975+00	upper sand material, Phi = 28 degrees upper clay material, c = 750 psf thin sand layer, Phi = 30 degrees thin clay layer, c = 1000 psf thin sand layer, Phi = 28 degrees lower clay material, c = 1500 psf	arc plane, interior failure	+15	+30	1.03
		arc plane, exterior failure	+15	+30	1.45
		arc plane, interior failure	+25	+35	1.06
		arc plane, exterior failure	+25	+35	1.56
		arc plane, interior failure	+30	+40	1.11
		arc plane, exterior failure	+30	+40	1.34

Note: An "interior" failure surface plane is one in which the slope failure is inward toward Cell 2. These are slightly less critical than the "exterior" failure surface planes which are slope failures toward the wetland cells or the bay.

Poplar Island Dike Raising



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (cohesive)	110	Cohesion: 1000.0 Friction angle: 0	None
2	Foundation B (cohesive)	110	Cohesion: 500.0 Friction angle: 0	None
3	Foundation C (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
4	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
5	Original Dike Fill Material	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
6	Lower Dredge Material	100	Cohesion: 200.0 Friction angle: 0	None
7	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
8	Upper Dredge Material	100	Cohesion: 50.0 Friction angle: 0	None
9	Dike Raising (Sand/Silt)	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
10	Cell 1 Dredge Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.232

Side force Inclination: -9.17 degrees

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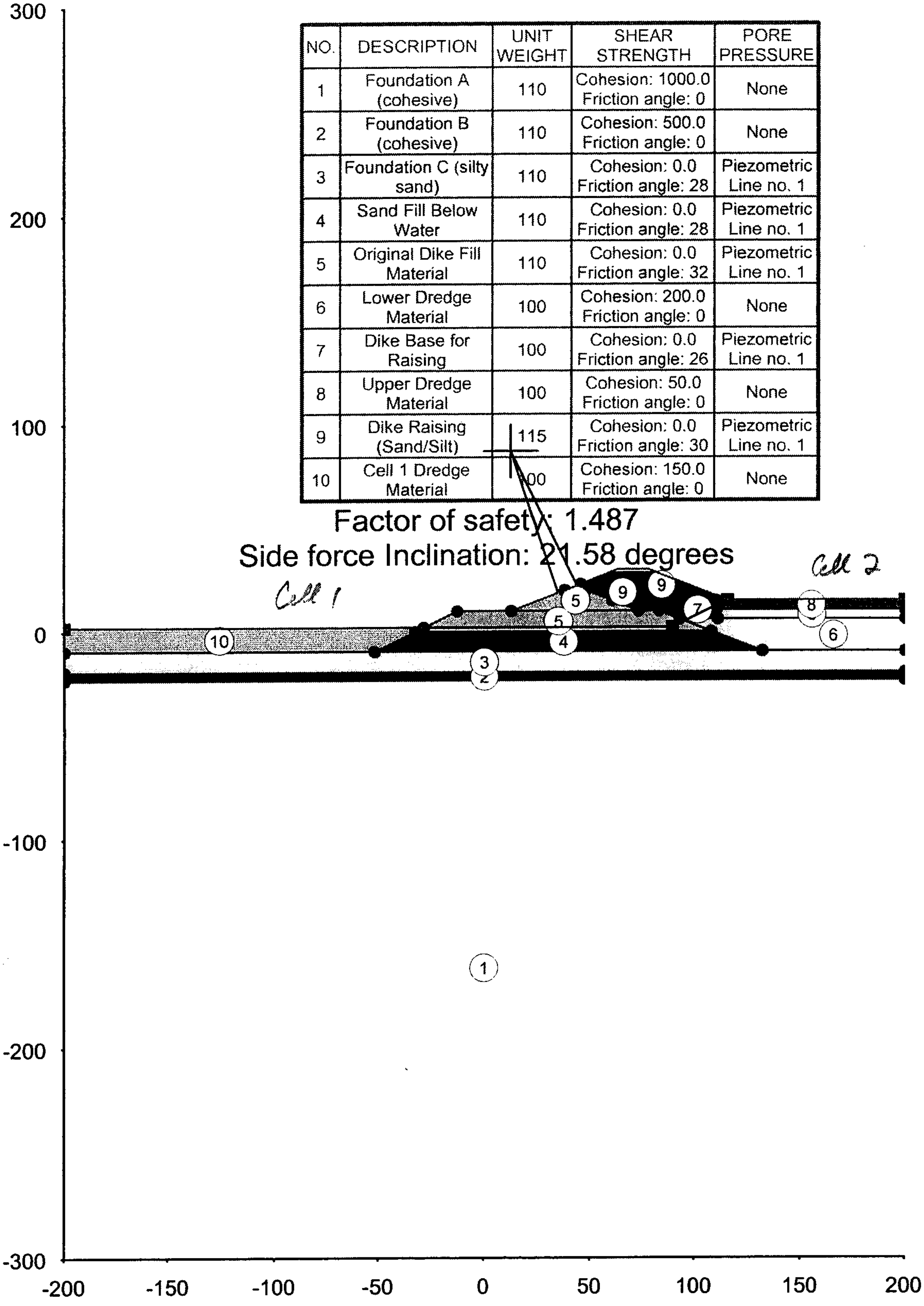
Sta. 904+00
+30 Dike Raising

Poplar Island Dike Raising



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (cohesive)	110	Cohesion: 1000.0 Friction angle: 0	None
2	Foundation B (cohesive)	110	Cohesion: 500.0 Friction angle: 0	None
3	Foundation C (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
4	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
5	Original Dike Fill Material	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
6	Lower Dredge Material	100	Cohesion: 200.0 Friction angle: 0	None
7	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
8	Upper Dredge Material	100	Cohesion: 50.0 Friction angle: 0	None
9	Dike Raising (Sand/Silt)	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
10	Cell 1 Dredge Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.487

Side force Inclination: 21.58 degrees

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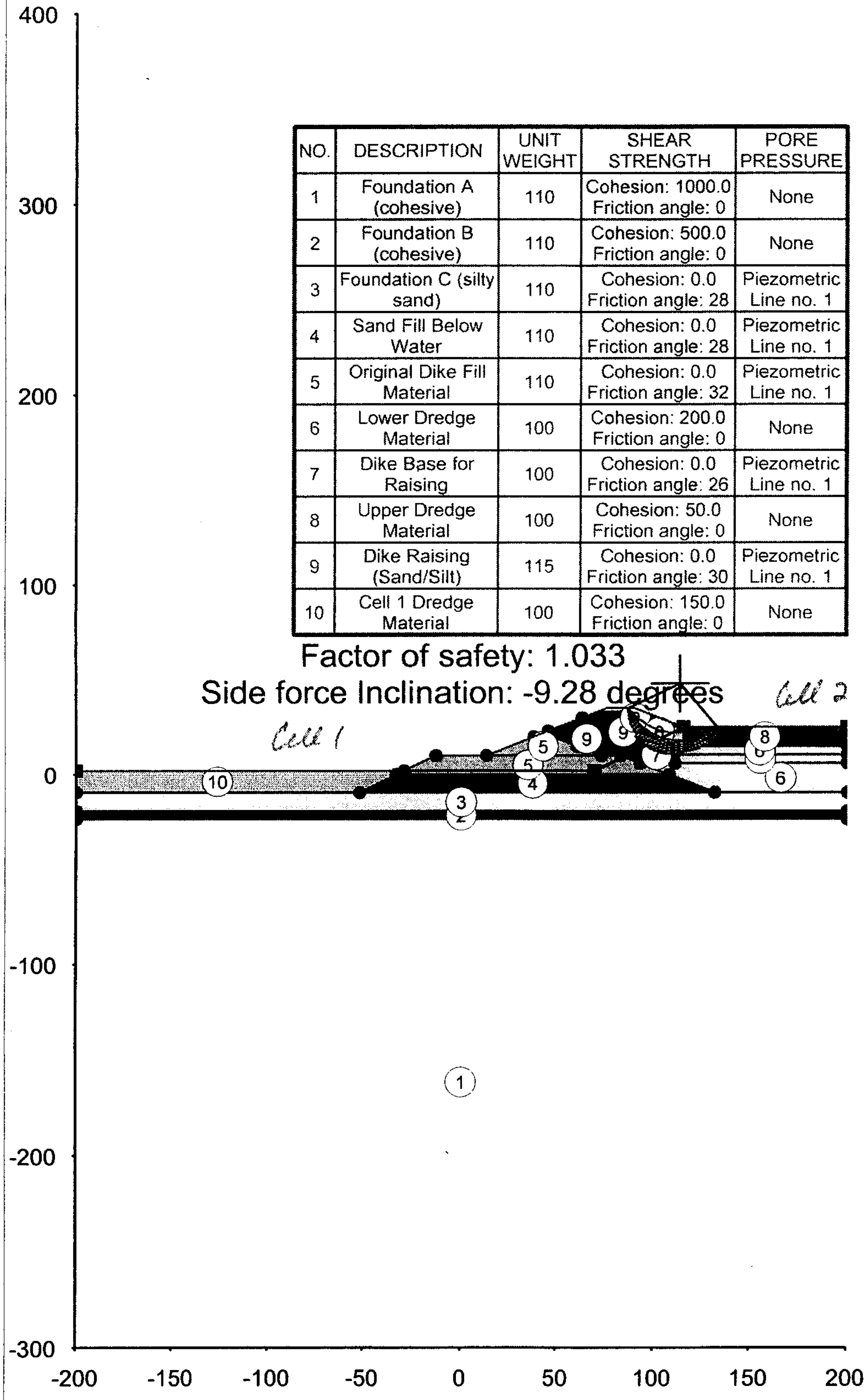
Sta. 904+00
+ 30 Dike Raising

Poplar Island Dike Raising



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (cohesive)	110	Cohesion: 1000.0 Friction angle: 0	None
2	Foundation B (cohesive)	110	Cohesion: 500.0 Friction angle: 0	None
3	Foundation C (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
4	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
5	Original Dike Fill Material	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
6	Lower Dredge Material	100	Cohesion: 200.0 Friction angle: 0	None
7	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
8	Upper Dredge Material	100	Cohesion: 50.0 Friction angle: 0	None
9	Dike Raising (Sand/Silt)	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
10	Cell 1 Dredge Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.033

Side force Inclination: -9.28 degrees

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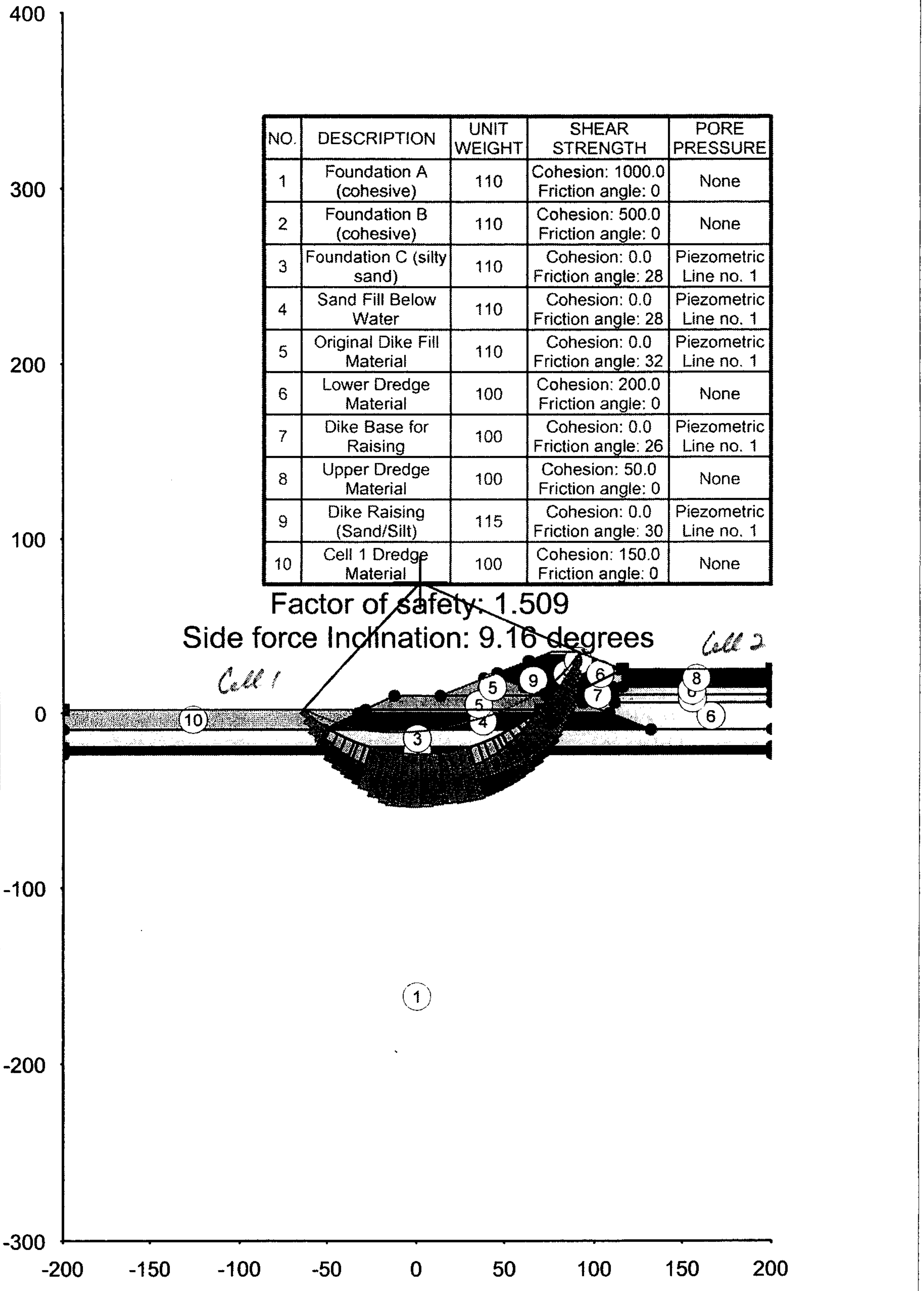
Sta. 904+00
+ 35 Dike Raising

Poplar Island Dike Raising



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (cohesive)	110	Cohesion: 1000.0 Friction angle: 0	None
2	Foundation B (cohesive)	110	Cohesion: 500.0 Friction angle: 0	None
3	Foundation C (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
4	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
5	Original Dike Fill Material	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
6	Lower Dredge Material	100	Cohesion: 200.0 Friction angle: 0	None
7	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
8	Upper Dredge Material	100	Cohesion: 50.0 Friction angle: 0	None
9	Dike Raising (Sand/Silt)	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
10	Cell 1 Dredge Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.509
Side force Inclination: 9.16 degrees

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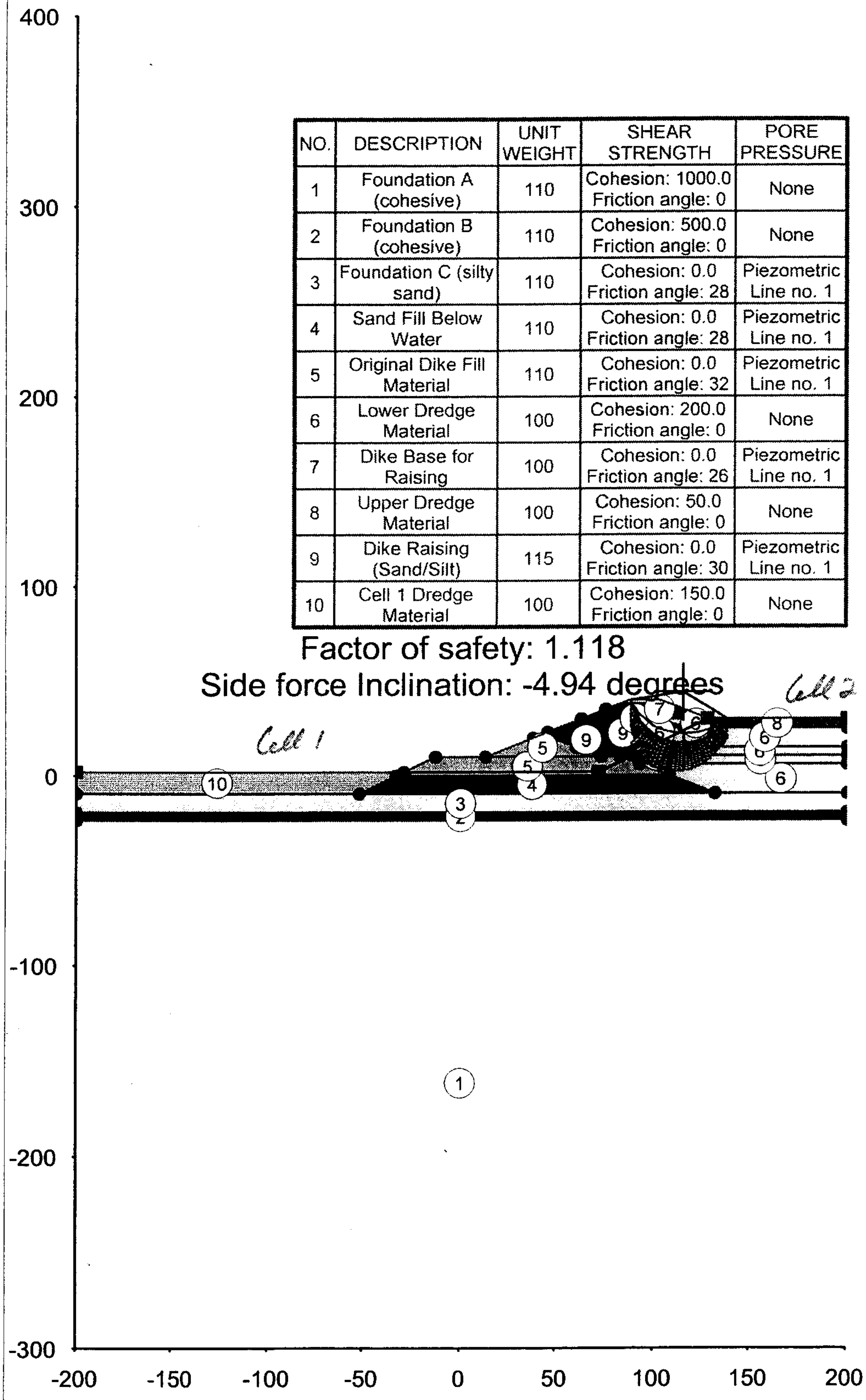
Sta. 904+00
+35 Dike Raising

Poplar Island Dike Raising



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (cohesive)	110	Cohesion: 1000.0 Friction angle: 0	None
2	Foundation B (cohesive)	110	Cohesion: 500.0 Friction angle: 0	None
3	Foundation C (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
4	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
5	Original Dike Fill Material	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
6	Lower Dredge Material	100	Cohesion: 200.0 Friction angle: 0	None
7	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
8	Upper Dredge Material	100	Cohesion: 50.0 Friction angle: 0	None
9	Dike Raising (Sand/Silt)	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
10	Cell 1 Dredge Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.118

Side force Inclination: -4.94 degrees

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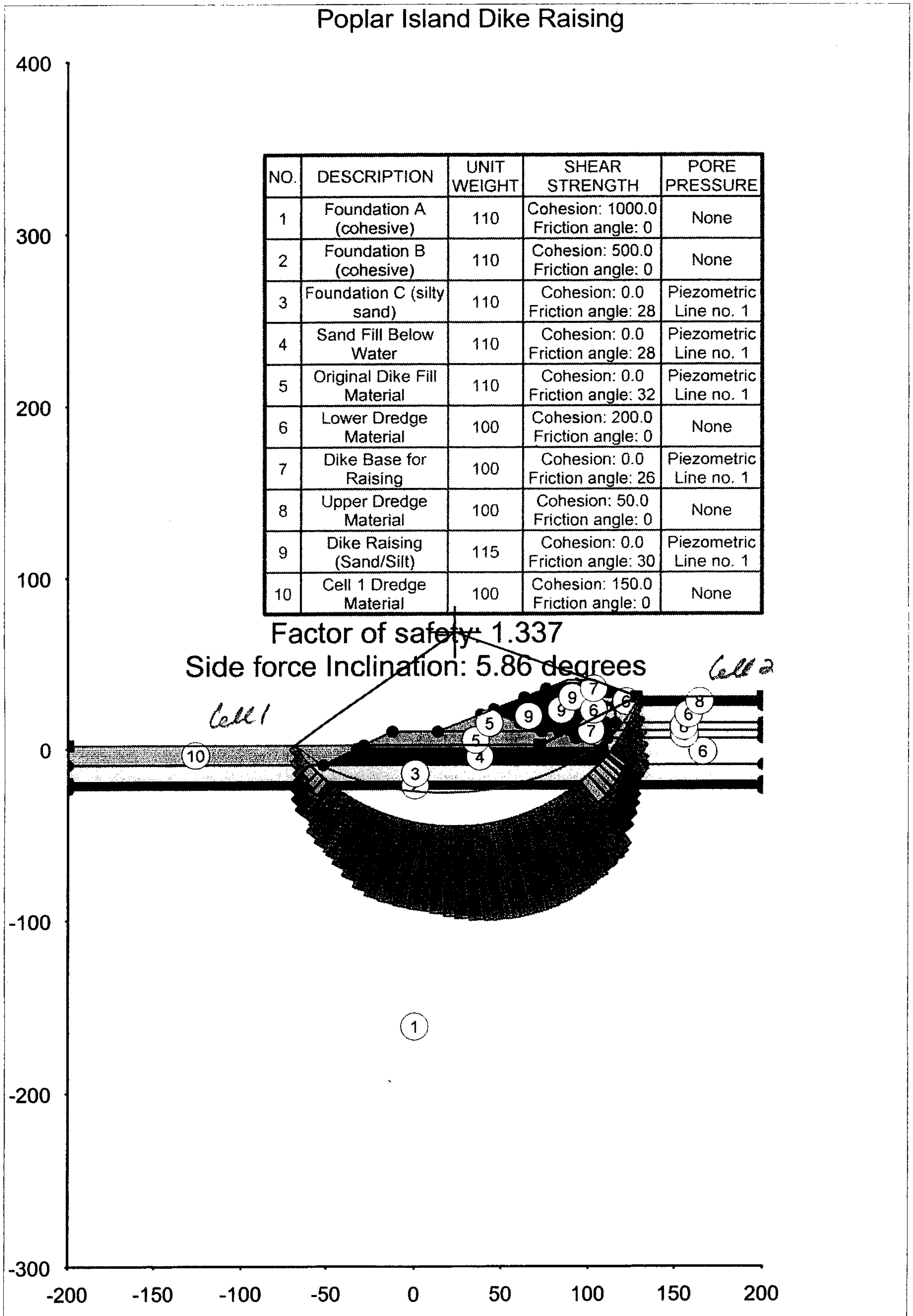
Sta. 904+00
+40 Dike Raising

Poplar Island Dike Raising

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (cohesive)	110	Cohesion: 1000.0 Friction angle: 0	None
2	Foundation B (cohesive)	110	Cohesion: 500.0 Friction angle: 0	None
3	Foundation C (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
4	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
5	Original Dike Fill Material	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
6	Lower Dredge Material	100	Cohesion: 200.0 Friction angle: 0	None
7	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
8	Upper Dredge Material	100	Cohesion: 50.0 Friction angle: 0	None
9	Dike Raising (Sand/Silt)	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
10	Cell 1 Dredge Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.337
Side force Inclination: 5.86 degrees



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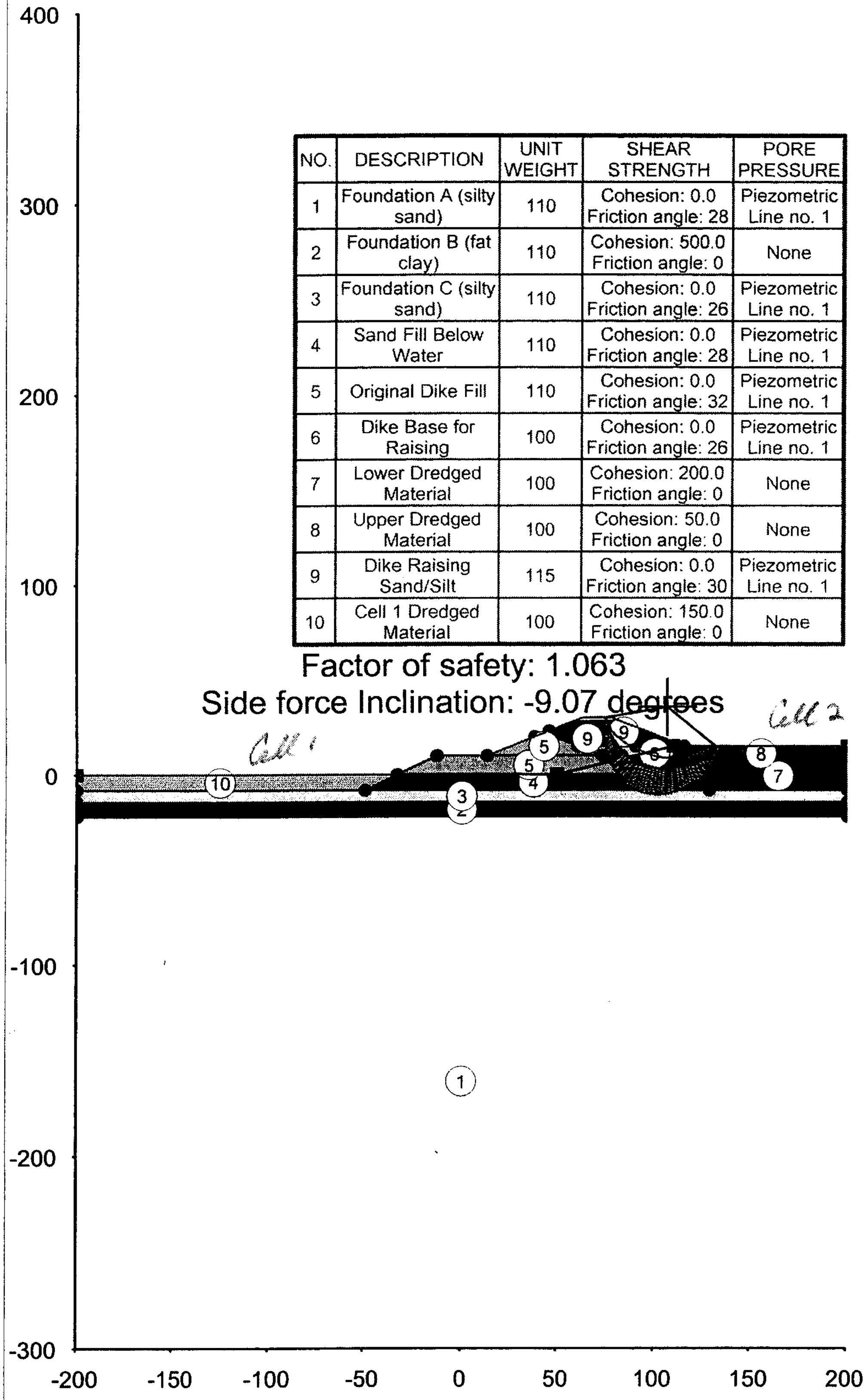
Sta 904+00
+40 Dike Raising

Poplar Island Dike Raising



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
2	Foundation B (fat clay)	110	Cohesion: 500.0 Friction angle: 0	None
3	Foundation C (silty sand)	110	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
4	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
5	Original Dike Fill	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
6	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
7	Lower Dredged Material	100	Cohesion: 200.0 Friction angle: 0	None
8	Upper Dredged Material	100	Cohesion: 50.0 Friction angle: 0	None
9	Dike Raising Sand/Silt	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
10	Cell 1 Dredged Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.063

Side force Inclination: -9.07 degrees

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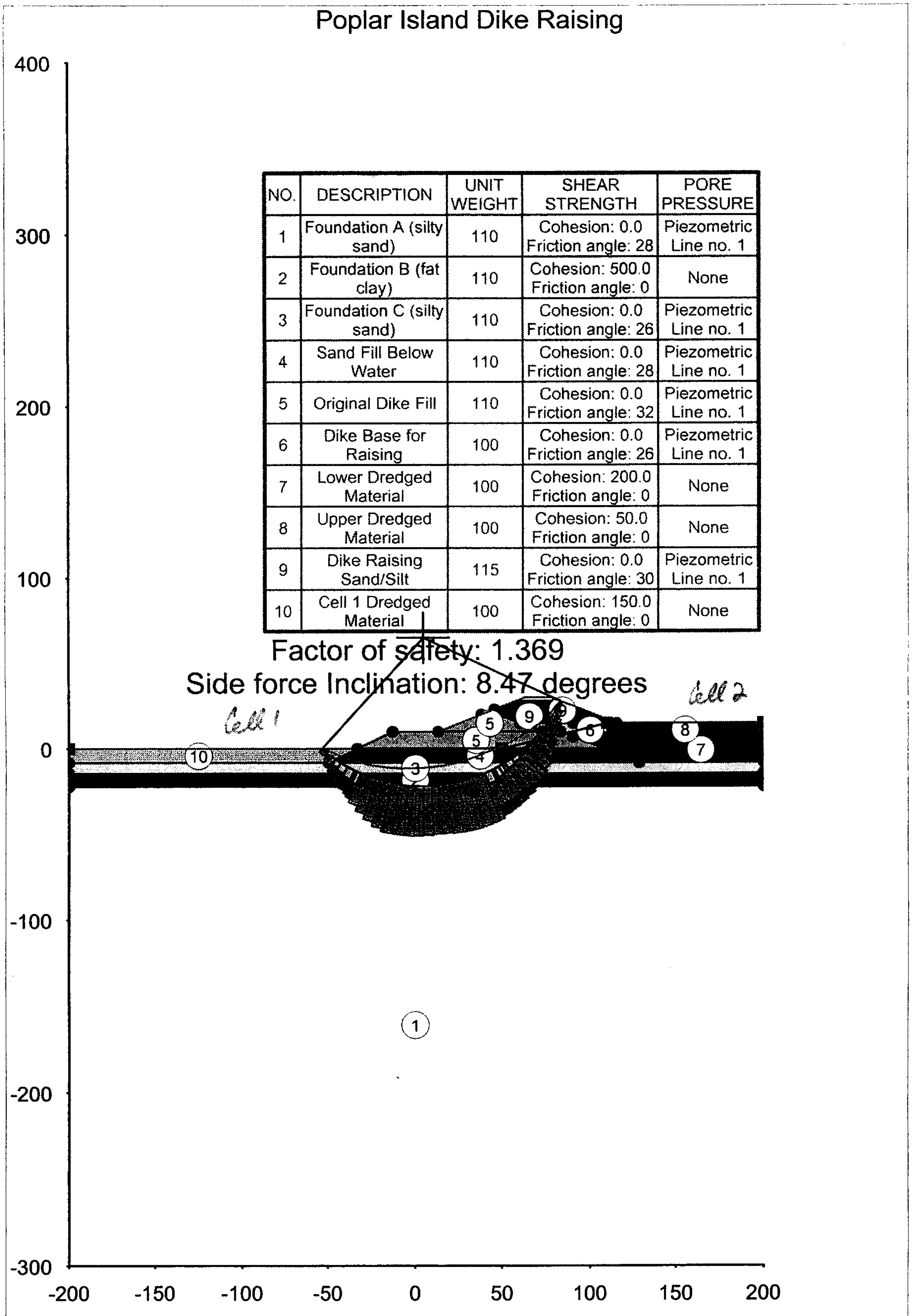
Sta. 930+00
+30 Dike Raising



Poplar Island Dike Raising

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
2	Foundation B (fat clay)	110	Cohesion: 500.0 Friction angle: 0	None
3	Foundation C (silty sand)	110	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
4	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
5	Original Dike Fill	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
6	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
7	Lower Dredged Material	100	Cohesion: 200.0 Friction angle: 0	None
8	Upper Dredged Material	100	Cohesion: 50.0 Friction angle: 0	None
9	Dike Raising Sand/Silt	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
10	Cell 1 Dredged Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.369

Side force Inclination: 8.47 degrees

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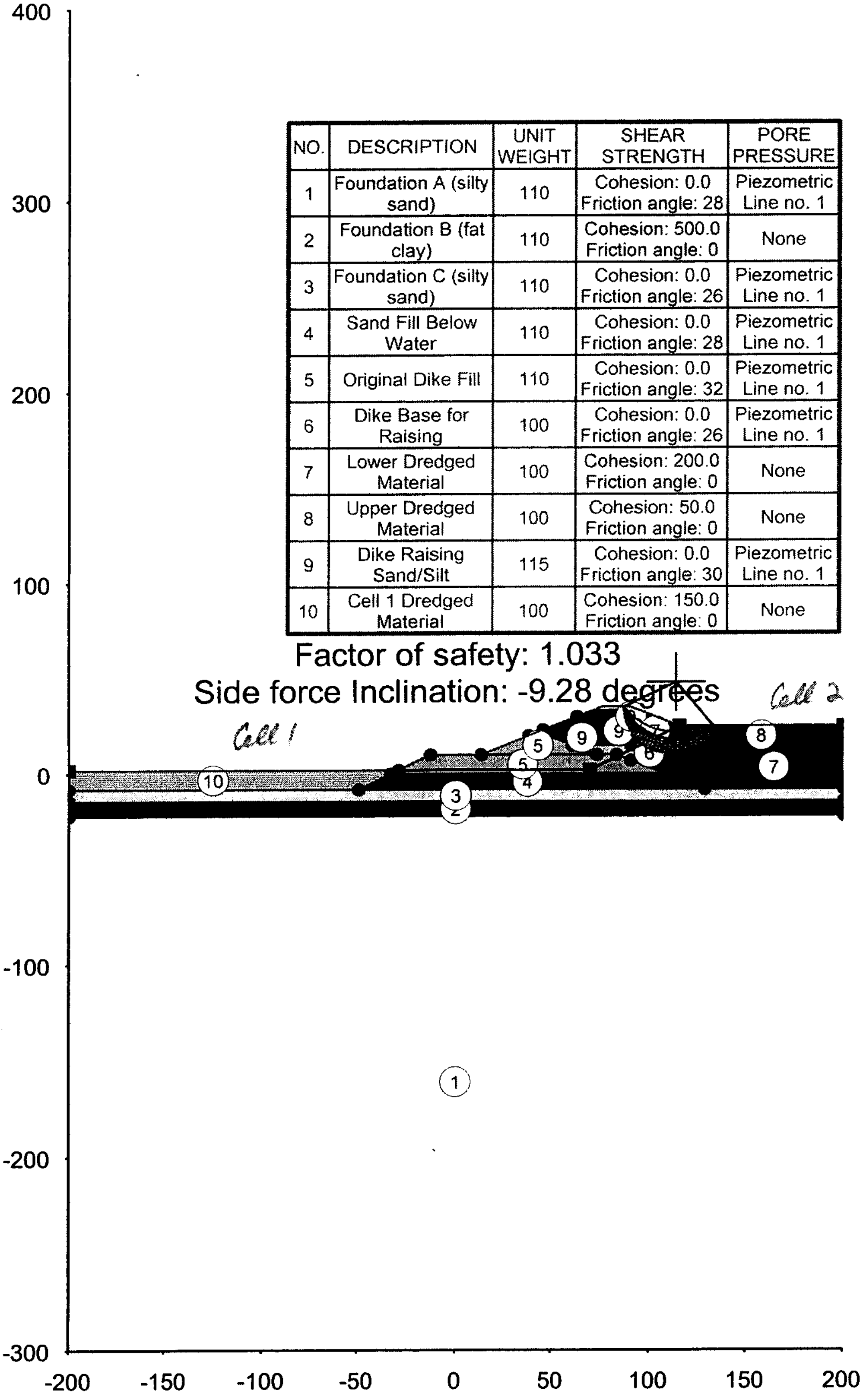
Sta. 930+00
+30 Dike Raising

Poplar Island Dike Raising



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
2	Foundation B (fat clay)	110	Cohesion: 500.0 Friction angle: 0	None
3	Foundation C (silty sand)	110	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
4	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
5	Original Dike Fill	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
6	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
7	Lower Dredged Material	100	Cohesion: 200.0 Friction angle: 0	None
8	Upper Dredged Material	100	Cohesion: 50.0 Friction angle: 0	None
9	Dike Raising Sand/Silt	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
10	Cell 1 Dredged Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.033

Side force Inclination: -9.28 degrees

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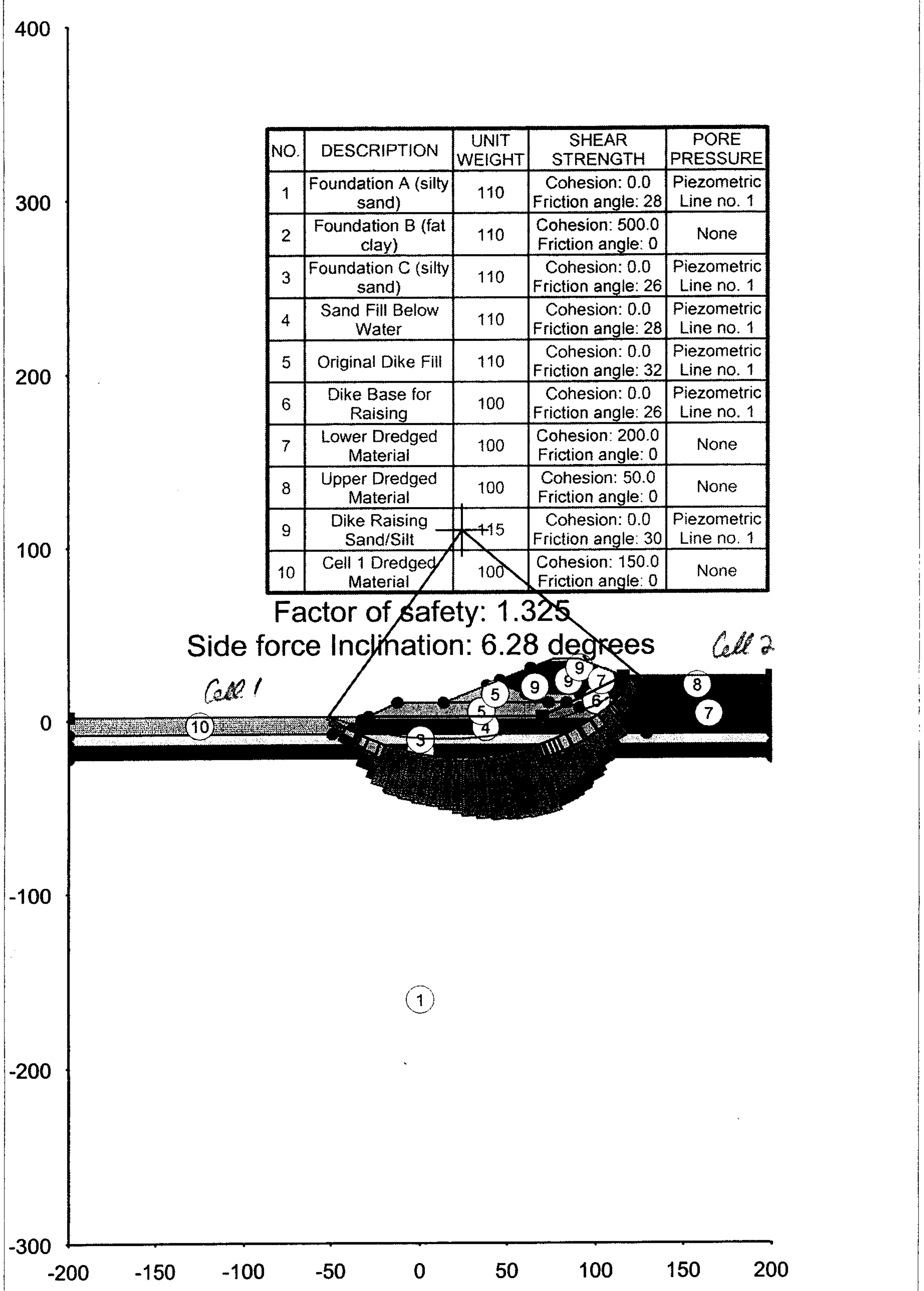
Sta 930+00
+35 Dike Raising

Poplar Island Dike Raising



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
2	Foundation B (fat clay)	110	Cohesion: 500.0 Friction angle: 0	None
3	Foundation C (silty sand)	110	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
4	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
5	Original Dike Fill	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
6	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
7	Lower Dredged Material	100	Cohesion: 200.0 Friction angle: 0	None
8	Upper Dredged Material	100	Cohesion: 50.0 Friction angle: 0	None
9	Dike Raising Sand/Silt	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
10	Cell 1 Dredged Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.325

Side force Inclination: 6.28 degrees

Cell 1

Cell 2

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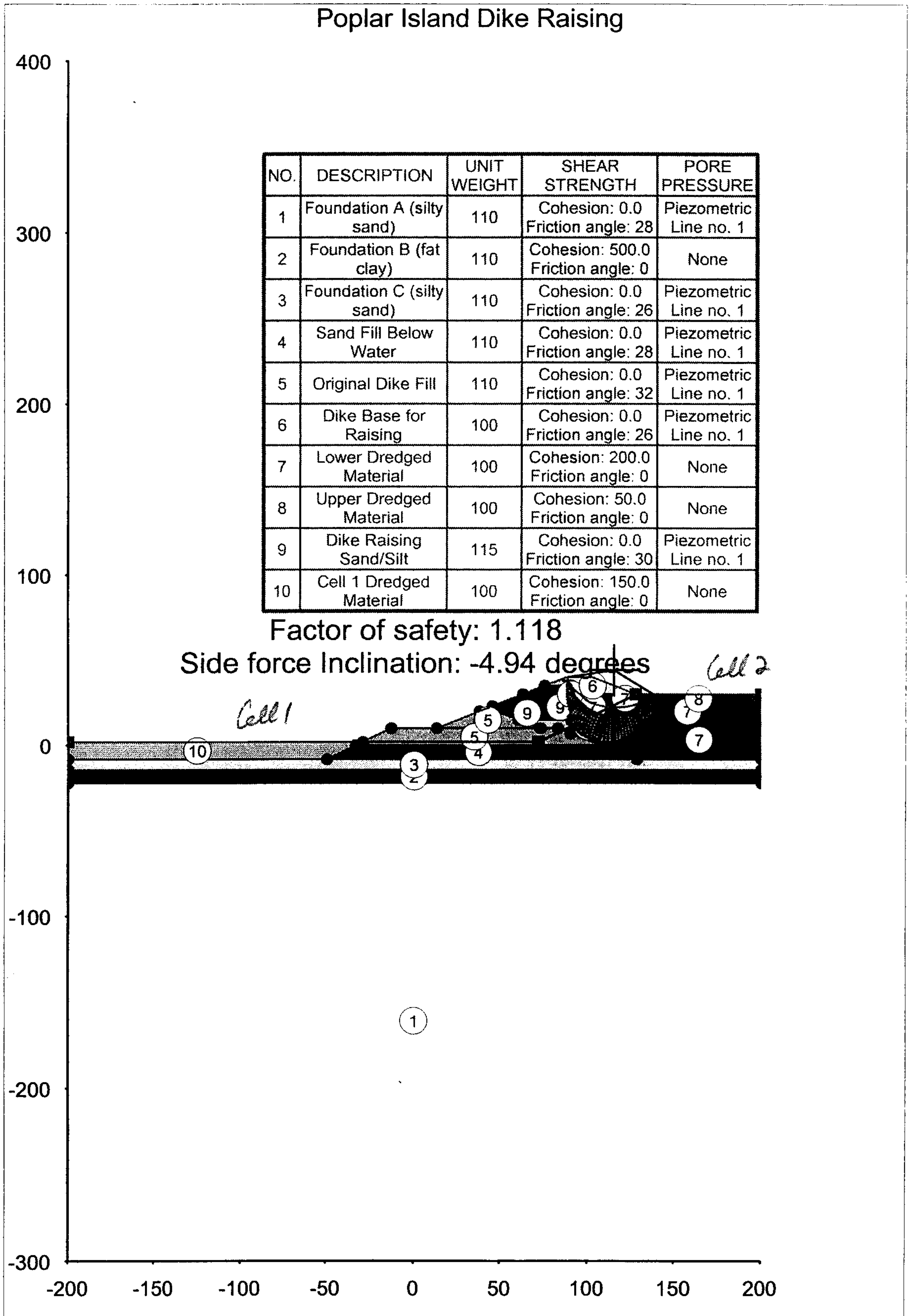
Sta 930+00
+35 Dike Raising



Poplar Island Dike Raising

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
2	Foundation B (fat clay)	110	Cohesion: 500.0 Friction angle: 0	None
3	Foundation C (silty sand)	110	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
4	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
5	Original Dike Fill	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
6	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
7	Lower Dredged Material	100	Cohesion: 200.0 Friction angle: 0	None
8	Upper Dredged Material	100	Cohesion: 50.0 Friction angle: 0	None
9	Dike Raising Sand/Silt	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
10	Cell 1 Dredged Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.118

Side force Inclination: -4.94 degrees

Cell 1

Cell 2

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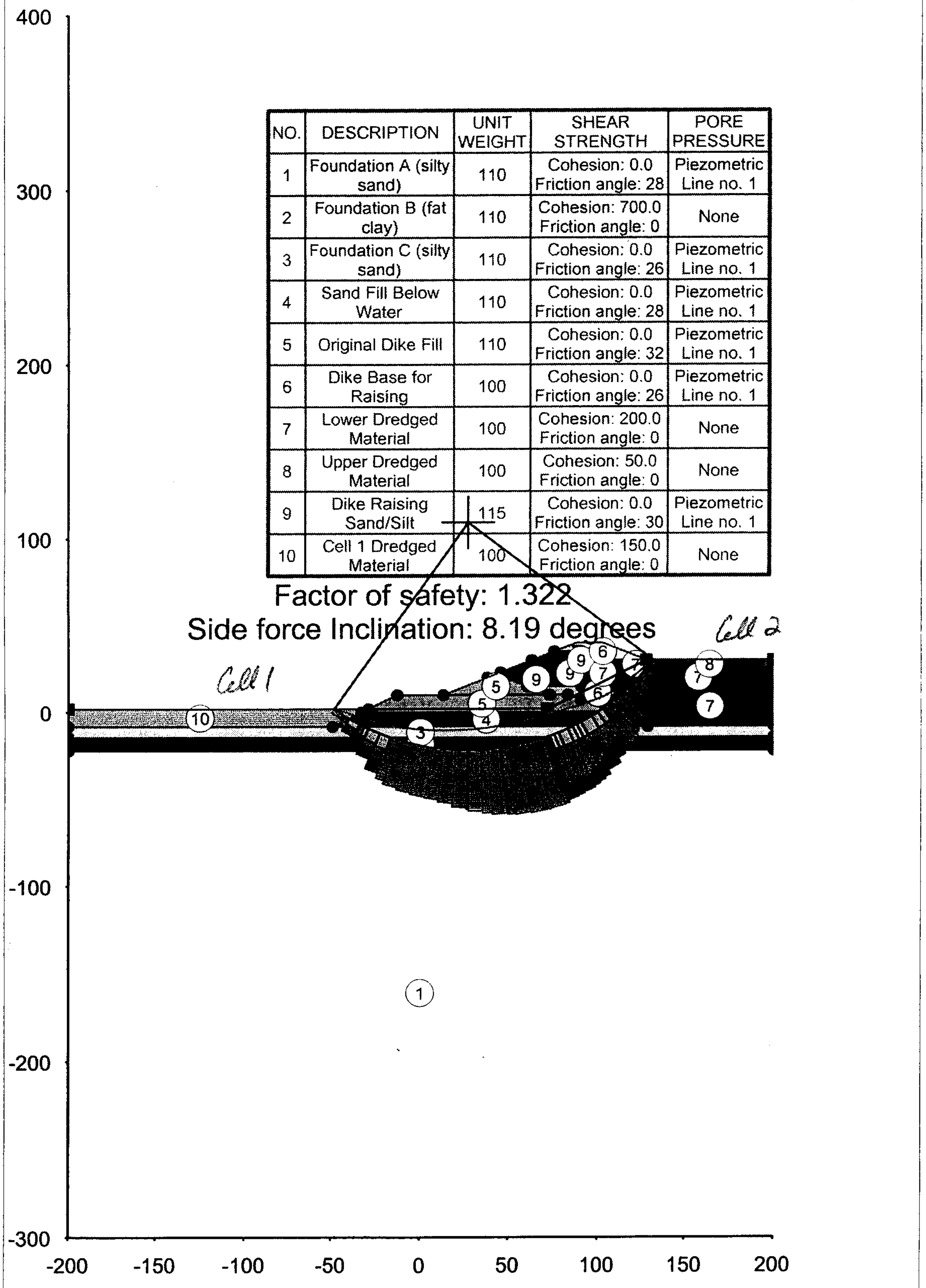
Sta 930+00
+40 Dike Raising

Poplar Island Dike Raising



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
2	Foundation B (fat clay)	110	Cohesion: 700.0 Friction angle: 0	None
3	Foundation C (silty sand)	110	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
4	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
5	Original Dike Fill	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
6	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
7	Lower Dredged Material	100	Cohesion: 200.0 Friction angle: 0	None
8	Upper Dredged Material	100	Cohesion: 50.0 Friction angle: 0	None
9	Dike Raising Sand/Silt	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
10	Cell 1 Dredged Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.322
Side force Inclination: 8.19 degrees

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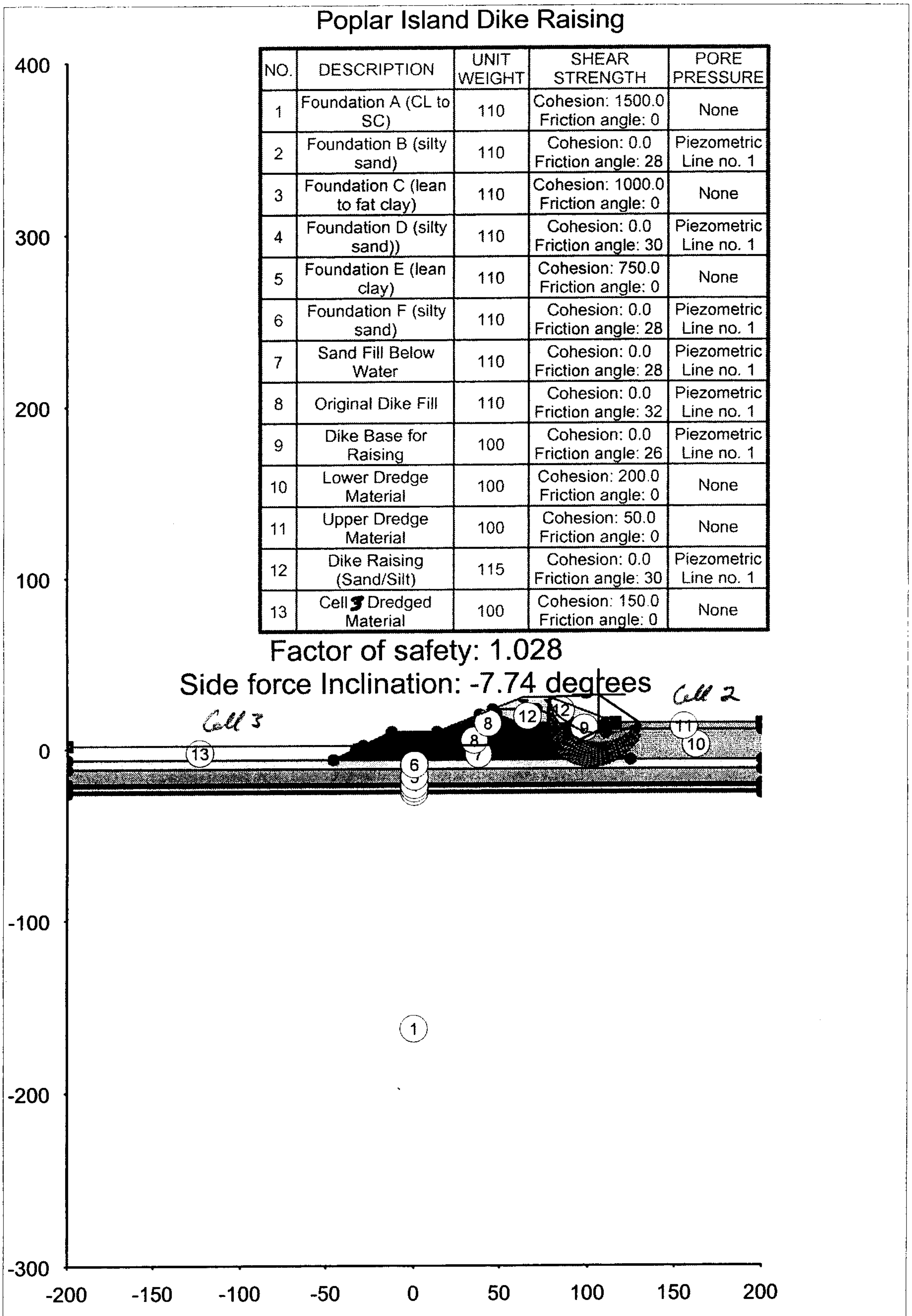
Sta. 930+00
+40 Dike Raising



Poplar Island Dike Raising

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (CL to SC)	110	Cohesion: 1500.0 Friction angle: 0	None
2	Foundation B (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
3	Foundation C (lean to fat clay)	110	Cohesion: 1000.0 Friction angle: 0	None
4	Foundation D (silty sand))	110	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
5	Foundation E (lean clay)	110	Cohesion: 750.0 Friction angle: 0	None
6	Foundation F (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
7	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
8	Original Dike Fill	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
9	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
10	Lower Dredge Material	100	Cohesion: 200.0 Friction angle: 0	None
11	Upper Dredge Material	100	Cohesion: 50.0 Friction angle: 0	None
12	Dike Raising (Sand/Silt)	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
13	Cell 3 Dredged Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.028

Side force Inclination: -7.74 degrees

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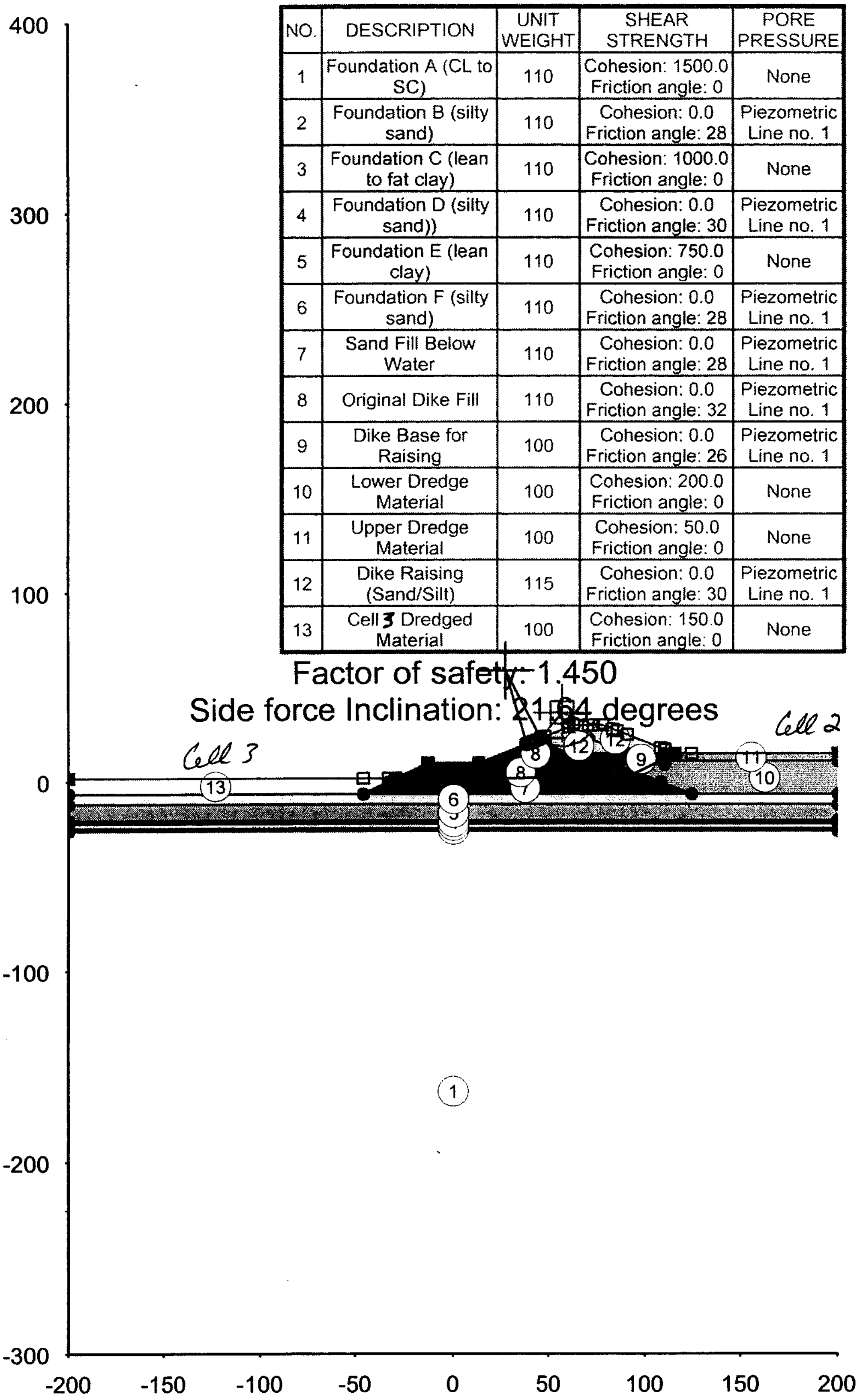
Sta 975+00

+30 Dike Raising

Poplar Island Dike Raising



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (CL to SC)	110	Cohesion: 1500.0 Friction angle: 0	None
2	Foundation B (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
3	Foundation C (lean to fat clay)	110	Cohesion: 1000.0 Friction angle: 0	None
4	Foundation D (silty sand))	110	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
5	Foundation E (lean clay)	110	Cohesion: 750.0 Friction angle: 0	None
6	Foundation F (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
7	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
8	Original Dike Fill	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
9	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
10	Lower Dredge Material	100	Cohesion: 200.0 Friction angle: 0	None
11	Upper Dredge Material	100	Cohesion: 50.0 Friction angle: 0	None
12	Dike Raising (Sand/Silt)	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
13	Cell 3 Dredged Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.450

Side force Inclination: 21.64 degrees

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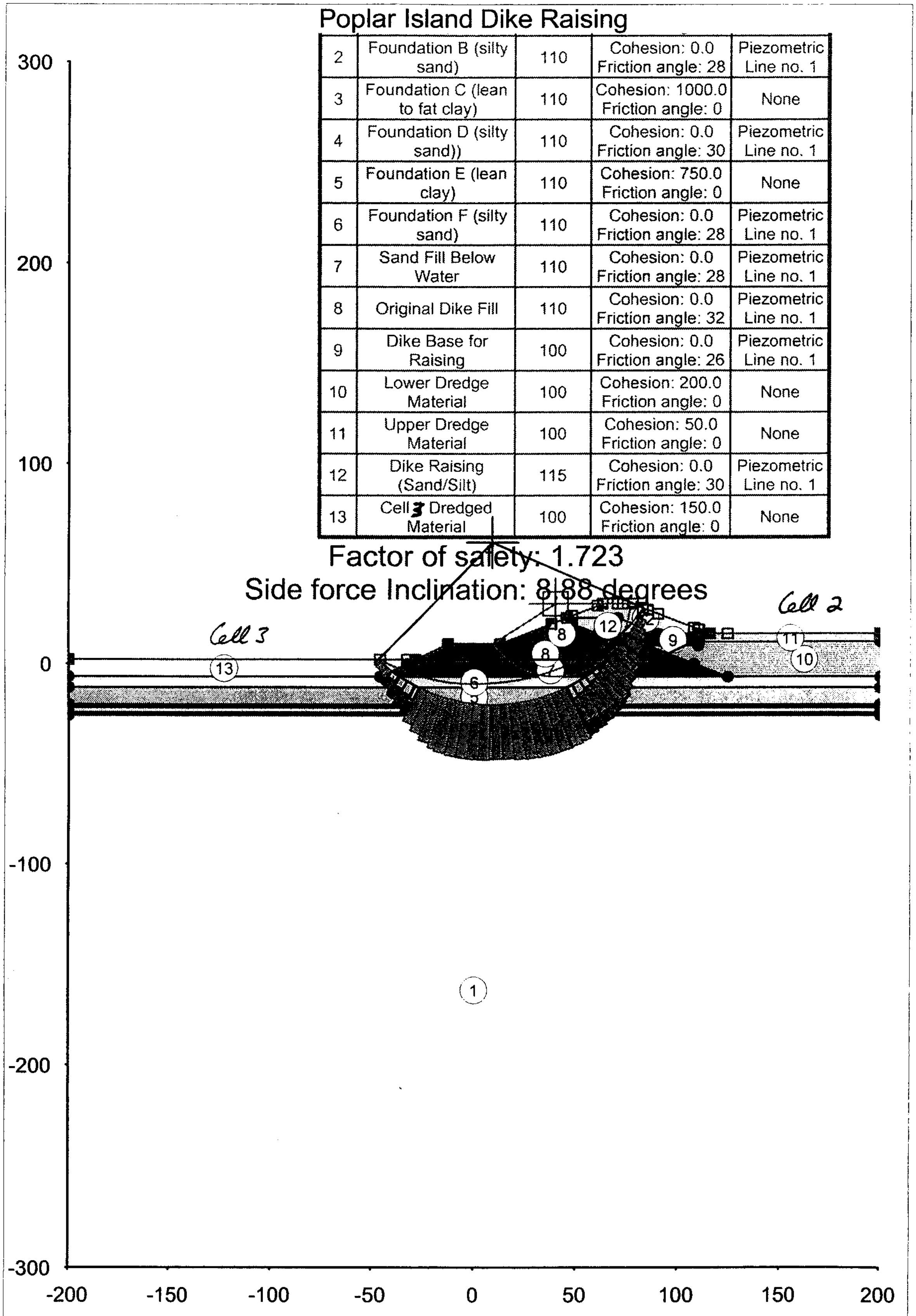
Sta. 975+00
+30 Dike Raising



Poplar Island Dike Raising

2	Foundation B (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
3	Foundation C (lean to fat clay)	110	Cohesion: 1000.0 Friction angle: 0	None
4	Foundation D (silty sand))	110	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
5	Foundation E (lean clay)	110	Cohesion: 750.0 Friction angle: 0	None
6	Foundation F (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
7	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
8	Original Dike Fill	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
9	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
10	Lower Dredge Material	100	Cohesion: 200.0 Friction angle: 0	None
11	Upper Dredge Material	100	Cohesion: 50.0 Friction angle: 0	None
12	Dike Raising (Sand/Silt)	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
13	Cell 3 Dredged Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.723

Side force Inclination: 8.88 degrees

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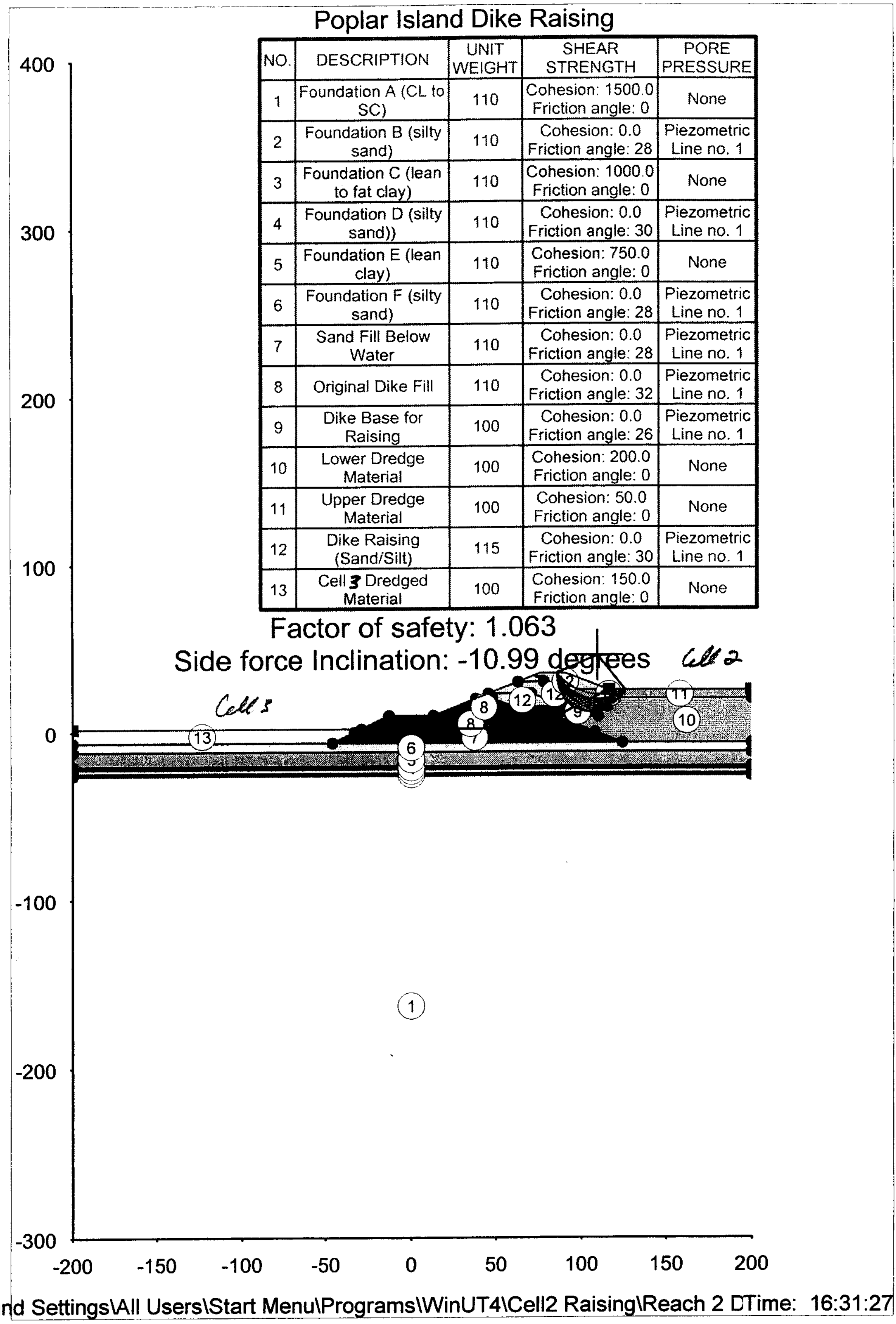
Sta. 975+00

+ 30 Dike Raising



Poplar Island Dike Raising

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (CL to SC)	110	Cohesion: 1500.0 Friction angle: 0	None
2	Foundation B (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
3	Foundation C (lean to fat clay)	110	Cohesion: 1000.0 Friction angle: 0	None
4	Foundation D (silty sand))	110	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
5	Foundation E (lean clay)	110	Cohesion: 750.0 Friction angle: 0	None
6	Foundation F (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
7	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
8	Original Dike Fill	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
9	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
10	Lower Dredge Material	100	Cohesion: 200.0 Friction angle: 0	None
11	Upper Dredge Material	100	Cohesion: 50.0 Friction angle: 0	None
12	Dike Raising (Sand/Silt)	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
13	Cell 3 Dredged Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.063

Side force Inclination: -10.99 degrees

Cell 2

Cell 3

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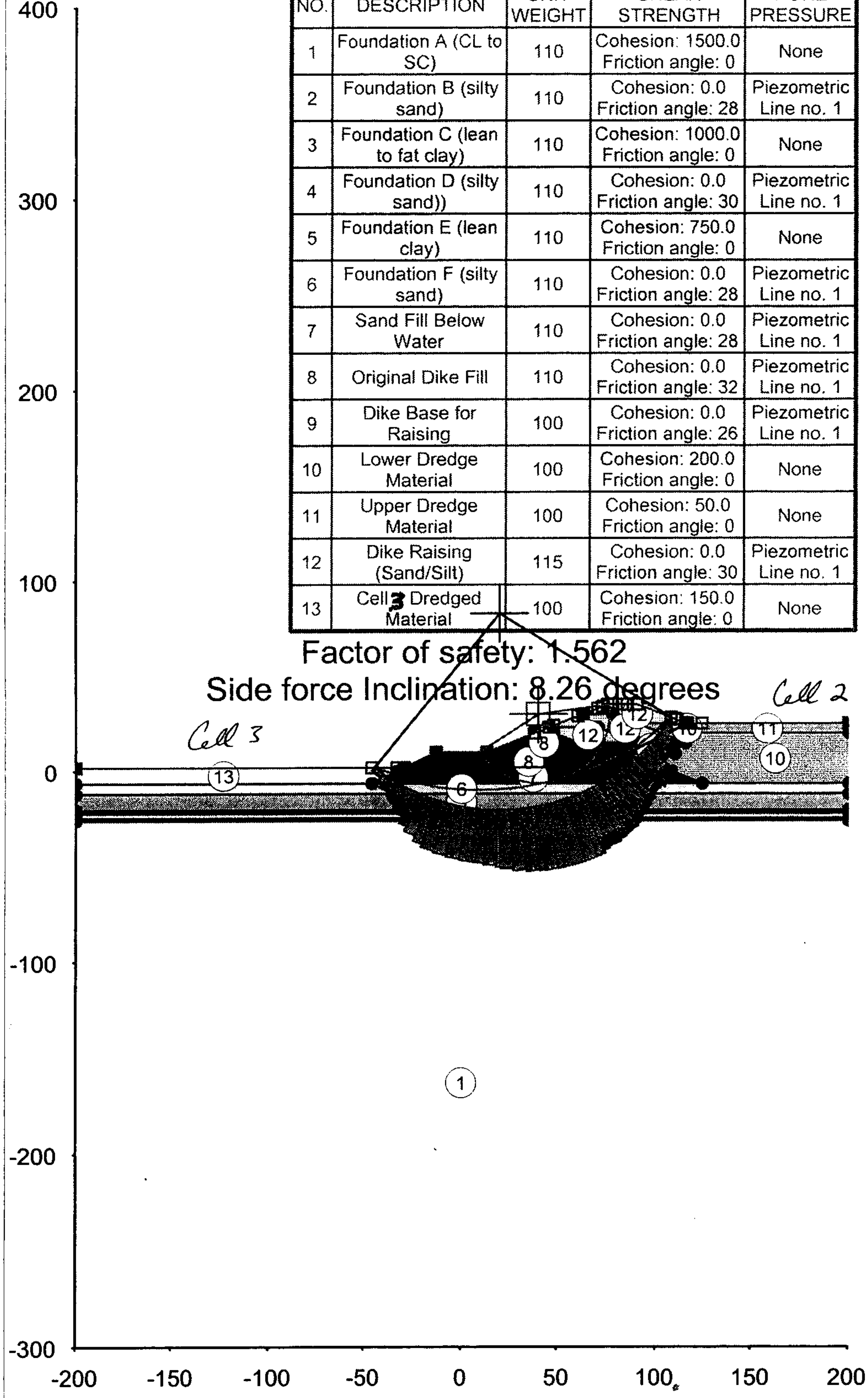
Sta. 975+00
+35 Dike Raising

Poplar Island Dike Raising



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (CL to SC)	110	Cohesion: 1500.0 Friction angle: 0	None
2	Foundation B (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
3	Foundation C (lean to fat clay)	110	Cohesion: 1000.0 Friction angle: 0	None
4	Foundation D (silty sand))	110	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
5	Foundation E (lean clay)	110	Cohesion: 750.0 Friction angle: 0	None
6	Foundation F (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
7	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
8	Original Dike Fill	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
9	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
10	Lower Dredge Material	100	Cohesion: 200.0 Friction angle: 0	None
11	Upper Dredge Material	100	Cohesion: 50.0 Friction angle: 0	None
12	Dike Raising (Sand/Silt)	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
13	Cell 3 Dredged Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.562

Side force Inclination: 8.26 degrees

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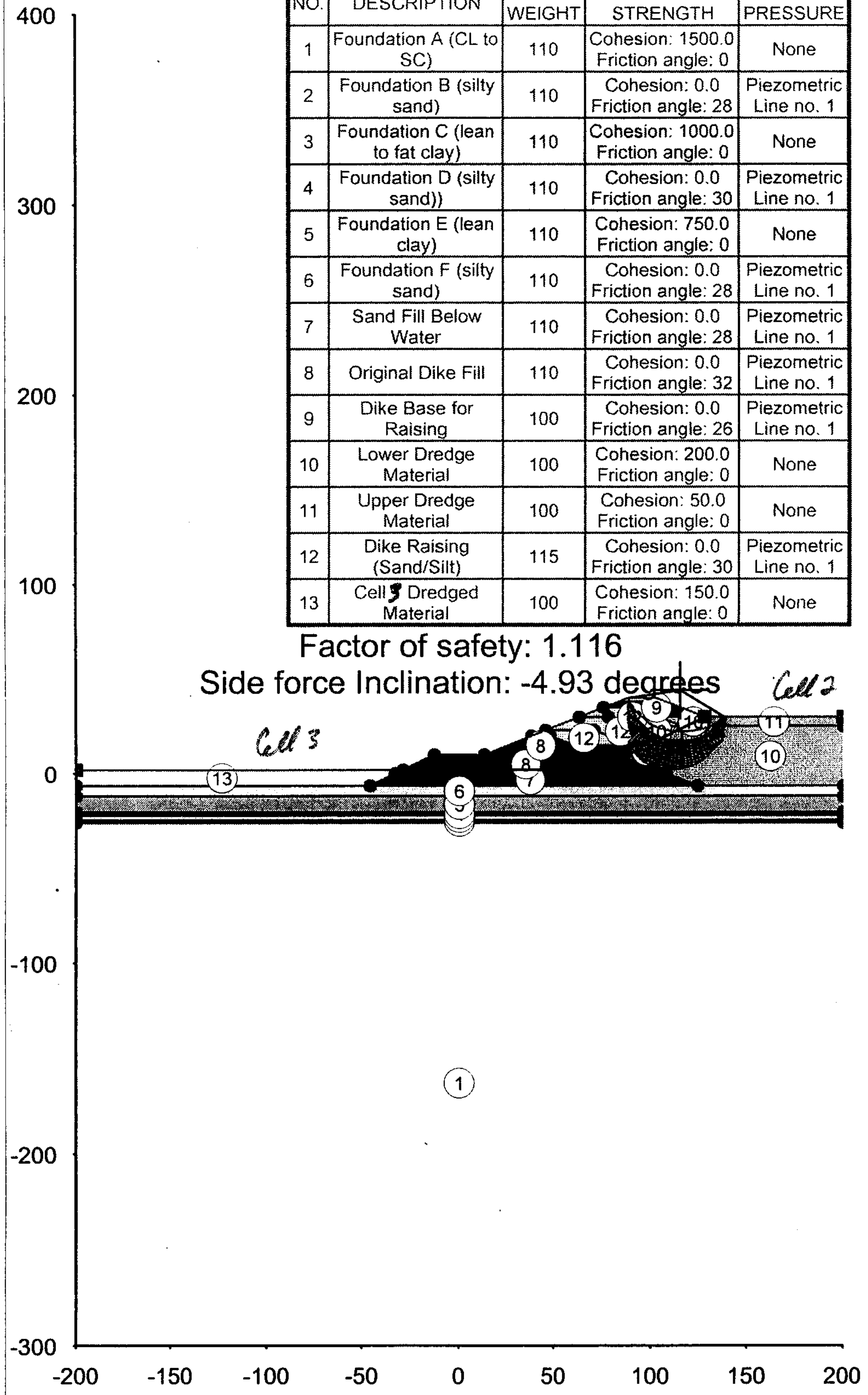
Sta. 975+00
+35 Dike Raising

Poplar Island Dike Raising



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (CL to SC)	110	Cohesion: 1500.0 Friction angle: 0	None
2	Foundation B (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
3	Foundation C (lean to fat clay)	110	Cohesion: 1000.0 Friction angle: 0	None
4	Foundation D (silty sand))	110	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
5	Foundation E (lean clay)	110	Cohesion: 750.0 Friction angle: 0	None
6	Foundation F (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
7	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
8	Original Dike Fill	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
9	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
10	Lower Dredge Material	100	Cohesion: 200.0 Friction angle: 0	None
11	Upper Dredge Material	100	Cohesion: 50.0 Friction angle: 0	None
12	Dike Raising (Sand/Silt)	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
13	Cell 3 Dredged Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.116

Side force Inclination: -4.93 degrees

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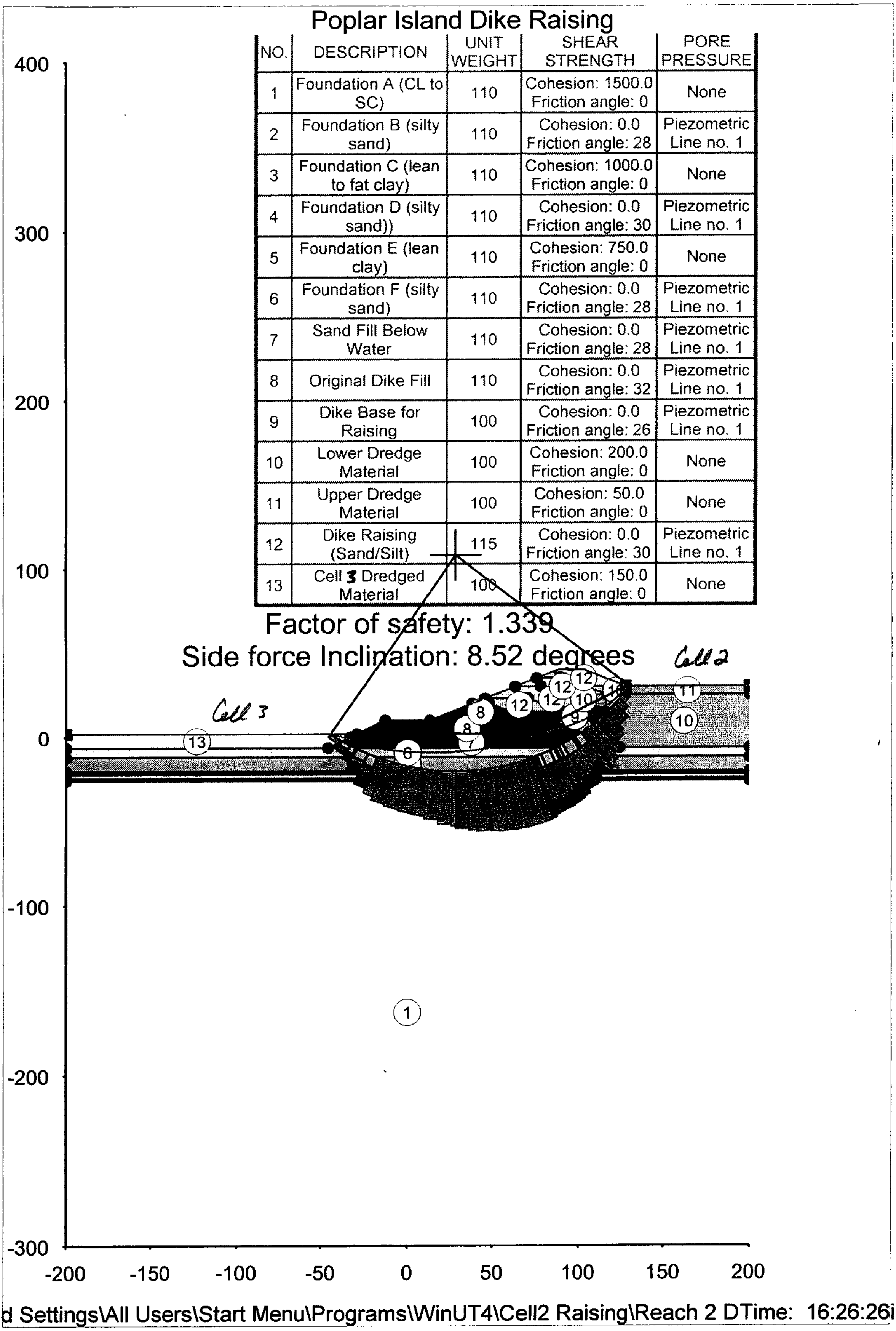
Sta. 975+00
+40 Dike Raising

Poplar Island Dike Raising

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation A (CL to SC)	110	Cohesion: 1500.0 Friction angle: 0	None
2	Foundation B (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
3	Foundation C (lean to fat clay)	110	Cohesion: 1000.0 Friction angle: 0	None
4	Foundation D (silty sand))	110	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
5	Foundation E (lean clay)	110	Cohesion: 750.0 Friction angle: 0	None
6	Foundation F (silty sand)	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
7	Sand Fill Below Water	110	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
8	Original Dike Fill	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
9	Dike Base for Raising	100	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
10	Lower Dredge Material	100	Cohesion: 200.0 Friction angle: 0	None
11	Upper Dredge Material	100	Cohesion: 50.0 Friction angle: 0	None
12	Dike Raising (Sand/Silt)	115	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
13	Cell 3 Dredged Material	100	Cohesion: 150.0 Friction angle: 0	None

Factor of safety: 1.339

Side force Inclination: 8.52 degrees



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Sta. 975+00
+40 Dike Raising

ATTACHMENT E

SUBSURFACE INVESTIGATIONS

AND

LABORATORY TESTING

POPLAR ISLAND EXPANSION STUDY
ENGINEERING APPENDIX

ATTACHMENT E – SUBSURFACE INVESTIGATIONS and LABORATORY TESTING

1. Previous Investigations

During the design and construction of the original Poplar Island project (PIERP) (approximately 1994 through 2000), extensive subsurface investigations were performed. Most of the subsurface investigations were located within the footprint of the existing project, but some of the borings extended to the north, south, and southwest of the existing project. Those original investigations provide useful subsurface information for each of the expansion alternatives, particularly where the expansion footprint connects to the existing project. The majority of the results for the original design investigations are presented in Volumes 1 through 4 of the *E2Si Subsurface Investigations Report* (December 1995). The most comprehensive record of subsurface investigations and laboratory testing performed during the Phase I construction (approximately 252 borings) and the Phase II design (approximately 150 borings) for the existing PIERP are presented in *Poplar Island Phase II Design Report*, Appendix H (January 2000). Numerous additional borings were completed subsequent to the Phase II design, were mainly focused on borrow areas A, D and H within the Phase II footprint.

2. Reconnaissance Study Investigations

During November and December 2001, fifty-six (56) borings were drilled to depths of 30 to 70 ft, and samples were obtained to investigate the six alternative alignments for the reconnaissance studies for the expansion of Poplar Island. Laboratory testing of soil samples included grain size analyses for basic soil classification, and tests to determine shear strength and compressibility characteristics of the fine-grained (clay and silt) soils. Field testing of soil samples included cone penetrometer and vane shear tests at several locations. The grain size analyses on the sandy soils was used to determine the location, quantity, and quality of potential borrow materials for dike construction. Logs for the borings and results of laboratory testing are presented in the *Geotechnical Reconnaissance Study for Poplar Island Modifications* (E2CR, 2000).

3. General Re-Evaluation Study Investigations

The current reevaluation study considered the potential for expanding the existing project in a manner similar to the schemes presented in the reconnaissance study, and the potential for increasing placement capacity by raising the existing upland cells. Since the existing upland cells are already in place, subsurface investigations of the existing dike foundations were conducted early in the expansion study.

During the plan formulation for the current study, most of the potential expansion alignments were eliminated from further consideration, with the exception of alignments associated with the northern end of the existing project. Once the initial screening process was completed, a supplemental phase of subsurface investigations was performed in the area north of the existing project.

3.1 Dike Raising Investigations. During April 2003, a total of eleven (11) borings (Table E-1 and Figure E-1), were completed to investigate subsurface conditions related to the potential raising of the existing upland cell dikes to elevations above +25 ft MLLW. Eight of the borings were located along the perimeter of cell 2, and three borings were located at locations on the perimeter of cell 6 (Figure E-1). The borings were drilled to a depth of 40 ft from a starting elevation of approximately +10 ft MLLW, with the purpose of intercepting foundation clay materials that are critical to the analysis of the slope stability of the containment dikes. Twelve undisturbed Shelby tube samples of the clay were obtained, and laboratory testing included undrained triaxial shear testing and consolidation testing of selected samples. Logs of the completed borings and results of laboratory testing are presented at the end of this section.

Table E-1. Summary of Drilling Results for the Dike Raising

Boring Number	Location	Top Elevation (MLLW)	Depth (feet)	Description of Materials (Depth)	
				Sand	Clay
1	Sta. 150+00, 10 right	10.0	44.0	0-29.5 ft	29.5-44 ft
2	Sta. 138+00, 10’ right	10.0	41.5	0-22 ft 34.5-41.5 ft	22-34.5 ft
3	Sta. 118+00, 11’ right	10.0	41.5	0-18.25 ft	18.25-32 ft
4	Sta. 118+00, 80’ right	20.0	41.5	0-18.25 ft	18.25-32 ft
5	84+00, 50’ right	20.0	41.5	0-34.5 ft 38.3-41.5 ft	34.5-38.3 ft
6	69+00, 10’ right	10.5	41.5	0-13.25 ft 15.6-27 ft 32.9-41.5 ft	13.25-15.6 ft 27-32.9 ft
7	58+00, 10’ right	10.5	41.5	0-22 ft 24.5-26 ft 32-39.5 ft	22-24.5 ft 26-32 ft 39.5-41.5 ft
8	449+00, 15’ right	10.0	41.5	0-41.5 ft	34.5 – 37 ft
9	400+00, 15’ right	10.0	41.5	0-24.5 ft	24.5-41.5 ft
10	975+00, 10’ right	10.0	41.5	0-22 ft 30.6-32 ft 37.3- 41.5 ft	22-30.6 ft 32-37.3 ft
11	930+00, 10’ right	10.0	41.5	0-21.1 ft 32-41.5 ft	21.1-32 ft

3.2 Results of Dike Raising Investigations. The primary goal of the dike raising investigations was to obtain samples of the weaker clay strata beneath the dike that were not removed and replaced during the original construction. These clays represent the weakest materials within the dike foundation and control the maximum height of dike raising. It was anticipated that these clays may have consolidated under the load of the existing dikes and gained additional strength compared to their original strengths (pre-dike construction). To adequately characterize the nature of these clay materials, additional undisturbed samples for laboratory analysis were collected adjacent to the logged borings (as indicated by the 'A').

Triaxial shear strength testing of foundation clay samples was performed by GeoSystems Consultants, Inc. Unconfined compression tests were performed on a sample from DH-3A (depth = 27 to 29 ft) and DH-4A (depth = 23 to 25 ft) (Table E-2). Isotropically Consolidated Undrained Triaxial Shear Tests were performed on samples from DH-3A (depth = 27 to 29 ft), DH-9A (depth = 26 to 28 ft), and DH-11A (depth = 25 to 27 ft) (Table E-3). A consolidation test was performed on a sample of the clay from DH-6A (depth = 28 to 30 ft) (Table E-4).

Table E-2. Dike Raising Unconfined Compression Tests

Boring Number	Depth of Sample (ft)	Classification*	Liquid Limit & Plasticity Index (LL & PI)	Water Content (w_c)	Dry Density (pcf)	Initial Void Ratio (e_0)	Undrained Shear Strength (psf)
4A	23-25	CL	40 / 21	31.4 %	90.1	0.891	S_u = 850
3A	27-29	CL	44 / 26	31.8 %	90.2	0.875	S_u = 210
AVERAGE	**--**	**--**	**42 / 23**	**31.6 %**	**90.1**	**0.88**	**600**

** CL = inorganic clay of low to medium plasticity (Source = ASTM 2487)*

Table E-3. Dike Raising Consolidated Undrained Triaxial Tests

Boring Number	Depth of Sample (ft)	Classification*	Liquid Limit & Plasticity Index (LL & PI)	Dry Density (pcf)**	Percentage Passing No.200 Sieve	Shear Strength Envelope (ϕ deg. & c=psf)
3A	27-29	CL	37 / 18	90.4	59.8	ϕ_u=22.6°, C_u=220 psf
9A	26-28	CH	71 / 26	91.7	96.2	ϕ_u=22.4°, C_u=170psf
11A	25-27	CH	69 / 21	90.9	69.6	ϕ_u=19.5°, C_u=200 psf
AVERAGE	**--**	**--**	**59 / 22**	**91.0**	**75.2**	**21.5°, 197 psf**

** CL = inorganic clay of low to medium plasticity; CH = inorganic clay of high plasticity (Source = ASTM 2487)*

** Dry density is average of 3 shear test specimens

Table E-4. Dike Raising Consolidation Tests

Boring Number	Depth of Sample (ft)	Classification*	Dry Density (pcf)	Water Content (w_c)	Initial Void Ratio (e_0)	Liquid Limit & Plasticity Index (LL & PI)	Compression Index (C_c)
6A	28-30 ft	CH	72.6	49.4	1.362	65 / 43	C_C = 0.688

** CH = inorganic clay of high plasticity (Source = ASTM 2487)*

3.3 Northern Expansion Investigations. A total of thirty-four (34) borings (Figure E-2) were completed to investigate subsurface conditions for the northern expansion area, supplementing approximately 30 borings that were previously completed during the reconnaissance phase. Those borings associated with the potential dike alignment were drilled 25 feet into the bay bottom deposits, and those borings associated with potential borrow materials sources were drilled up to 40 feet into the bay bottom deposits. Samples of the foundation soils were recovered for classification testing in the laboratory. Several undisturbed Shelby tube samples of the foundation clay deposits were also recovered. Logs of the 34 borings completed for this study and results of laboratory testing are presented at the end of this section. Logs for boring completed in for the reconnaissance study are in previously published reports (E2CR, 2000).

3.4 Results of Northern Expansion Investigations. The additional drilling delineated two distinct subsurface conditions within the northern expansion area. The foundation comprising the western portion of the area, extending approximately 3000 ft to the north of the existing project, consists of a deep deposit of medium to very soft clay. To the extent possible, the weakest and deepest of these clay deposits will be avoided for dike foundations. Where they are unavoidable, a portion of these clay materials may have to be removed and replaced with suitable backfill. Several undisturbed Shelby tube samples of the clay deposits were obtained for potential laboratory testing.

The foundation of the remainder of the expansion area consists of a sand bottom, with the thickness of the deposit ranging from 10 to about 25 ft. Results of grain size analysis testing indicated that the fine sand (mean grain size equivalent to a No. 70 sieve) would be suitable for dike construction. A detailed analysis of the quantity and quality of the borrow materials is addressed in Attachment A (*Borrow Analysis*) of this Appendix.

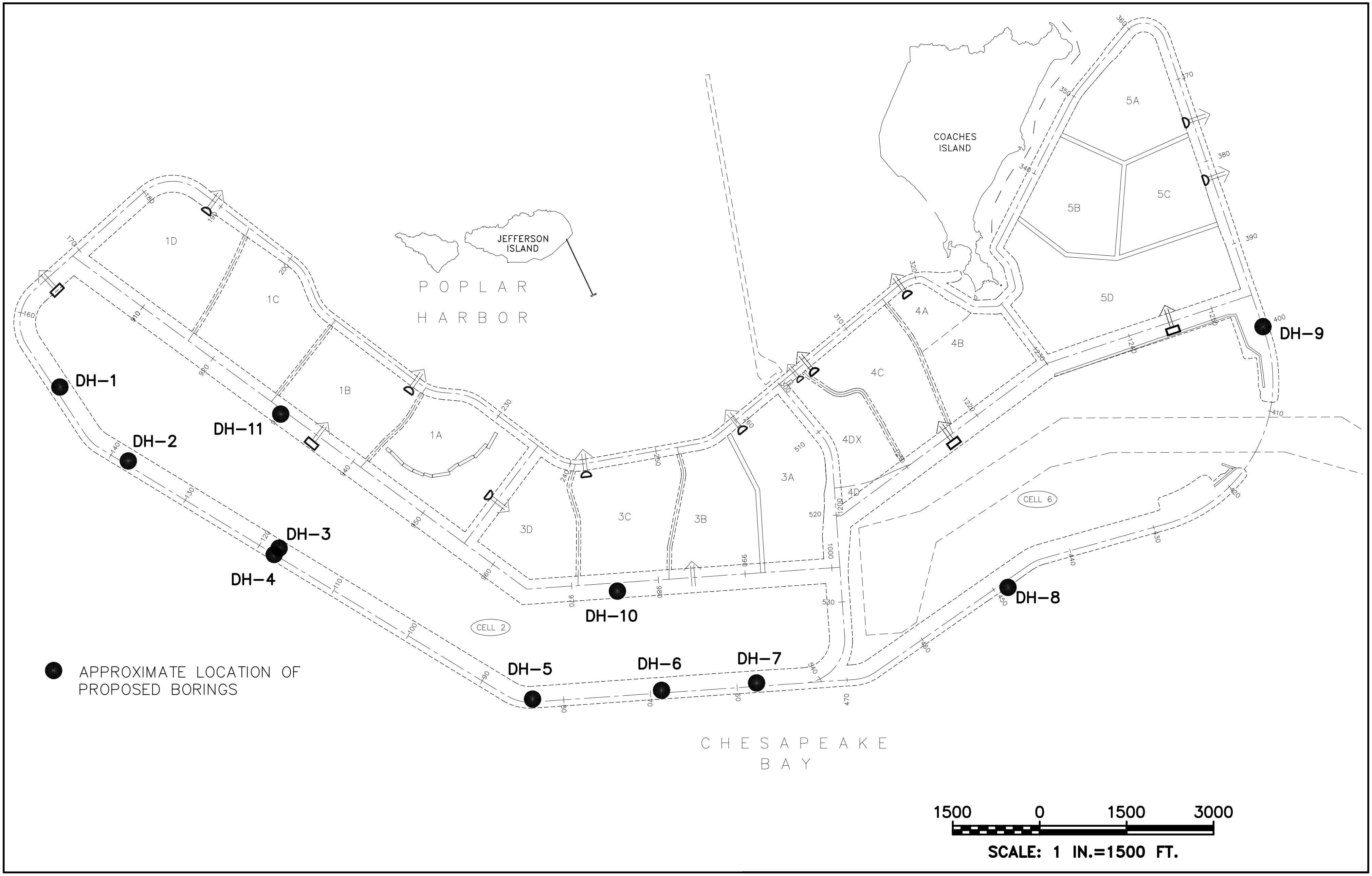


Figure E-1. Subsurface Exploration Plan for Dike Raising Investigations

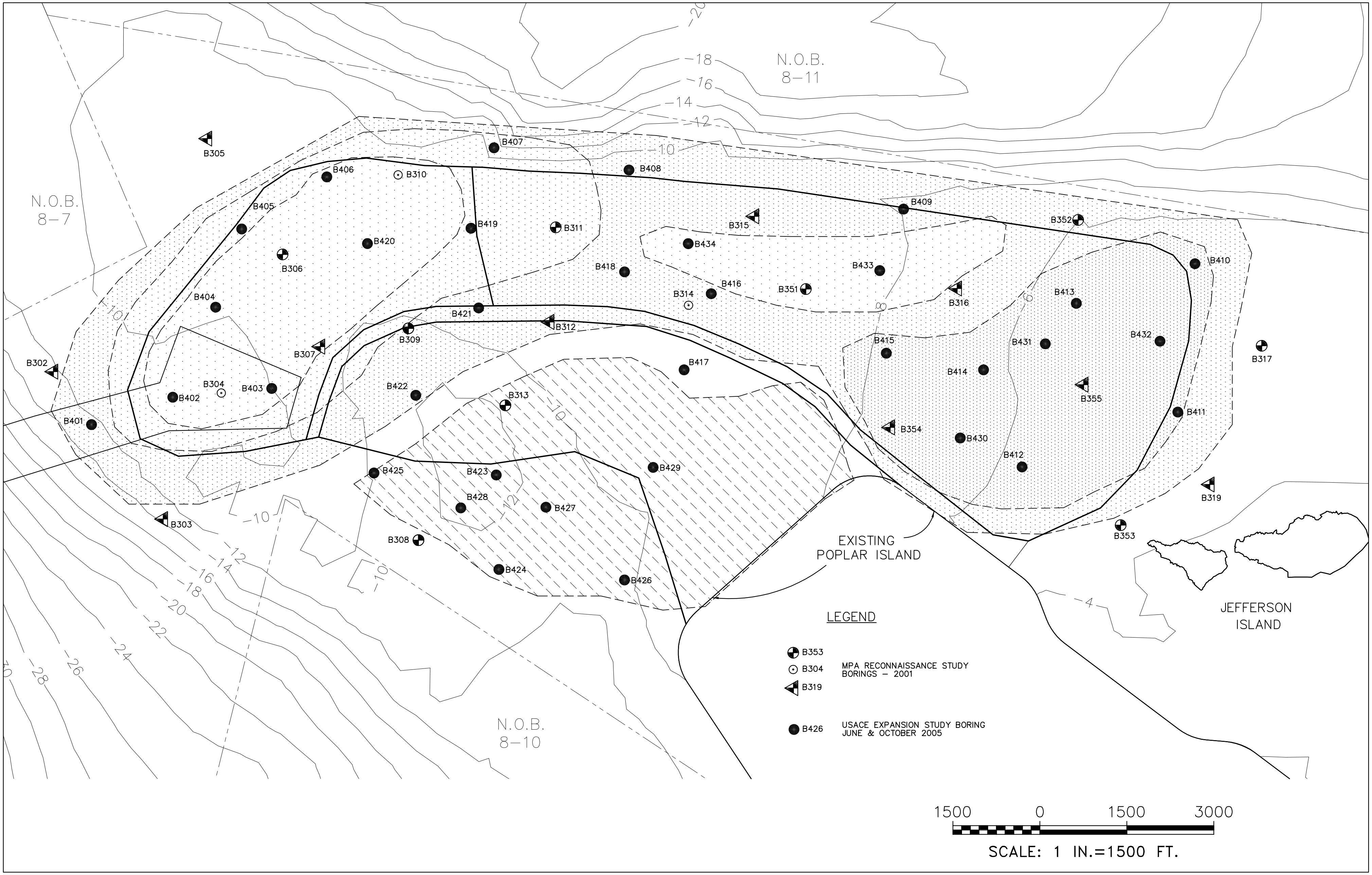


Figure E-2. Subsurface Exploration Plan for Lateral Expansion Investigations

DRILLING AND TESTING FOR

RAISING EXISTING UPLAND CELLS

APRIL through JUNE 2003

DIKE RAISING
POPLAR ISLAND, MD.

SUBSURFACE EXPLORATION NOTES

1. EXPLORATION WAS PERFORMED DURING APRIL 2003.

2. DRILL HOLES (DH) WERE ACCOMPLISHED BY STANDARD PENETRATION TEST PROCEDURE **(SPT, ASTM - 1586)** USING A 1-3/8"ID SPLIT SPOON SAMPLER. SAMPLE SPOONS WERE ADVANCED BY A 140# HAMMER FALLING 30". THESE HOLES WERE POWER AUGERED BETWEEN SAMPLES UNLESS OTHERWISE INDICATED. BLOW COUNTS SHOWN ARE FOR 0.5' OF DRIVE, UNLESS OTHERWISE INDICATED.

   ALL BORINGS WERE DRILLED BY A CME 750 SWAMP BUGGY DRILL RIG.

   P - INDICATED LOCATION OF PRESSED SHELBY TUBE SAMPLE

   RB - HOLE WAS ADVANCED BY ROLLER BIT

   WH - DENOTES WEIGHT OF HAMMER

3. BLOW COUNTS REQUIRED TO ADVANCE SAMPLE SPOON ARE SHOWN IN COLUMN (a).

4. COLUMN (b) SHOWS THE NATURAL WATER CONTENTS IN PERCENT OF DRY WEIGHT OF THOSE SAMPLES TESTED.

5. SOIL DESCRIPTIONS ARE SHOWN IN COLUMN (c).

   ALSO SHOWN IN THIS COLUMN ARE:

   PPR - UNCONFINED COMPRESSION STRENGTH (tsf) READINGS FROM POCKET PENETROMETER TESTS. DASHES ARE SHOWN WHEN PART OF A SAMPLE DRIVE IS NOT SUITABLE FOR POCKET PENETROMETER TESTS. NOTHING IS SHOWN IF THE ENTIRE SAMPLE IS NOT SUITABLE FOR PPR TESTS.

   TOR - UNDRAINED SHEAR TEST (tsf) READINGS FROM TORVANE SHEAR TESTS.

6. SOIL DESCRIPTIONS ARE LABORATORY CLASSIFICATIONS BASED ON THE UNIFIED SOIL CLASSIFICATION SYSTEM (**ASTM D2487/2488**), EXCEPT THOSE INDICATED THUS (**), WHICH ARE FIELD INSPECTOR'S CLASSIFICATIONS.

7. GROUNDWATER DEPTHS ARE INDICATED ON THE LOGS AS ▽, ▼ & ▼ ARE SHOWN IN COLUMN (d). PERTINENT DATA FOR THESE READINGS ARE SHOWN AT THE BOTTOM OF LOG UNDER GROUNDWATER DATA OR ADDITIONAL GROUNDWATER DATA. THESE READINGS MAY VARY DEPENDING UPON SEASONS AND AMOUNT OF RAINFALL.

   NE - INDICATES GROUNDWATER NOT ENCOUNTERED

   NT - INDICATES GROUNDWATER READING NOT TAKEN

8. ELEVATIONS SHOWN ON THE BORING LOGS ARE GROUND SURFACE ELEVATIONS AT THE TIME OF EXPLORATION. THEY WERE DETERMINED BY ESTIMATION FROM TOPOGRAPHIC CONTOUR MAPS AND ARE DESIGNATED (±).

   HORIZONTAL DATUM: NORTH AMERICAN 1983 DATUM, MARYLAND STATE PLANE COORDINATE SYSTEM.

   FOR ALL BORINGS, STATION OFFSET IS FROM CENTERLINE OF PERIMETER ROAD.

9. FOR LOCATIONS OF SUBSURFACE EXPLORATIONS, SEE BORING LOCATION PLAN.

STA. 150+00 (Cell 2)
OFFSET: 10' Inward
TOP ELEV: 11.5±

DIKE RAISING
POPLAR ISLAND, MD.

N 406591.0
E 1489831.0
COMPLETED: April 15, 2003

DH-1

1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
1.50	Very moist, lt. olive brown, poorly graded SAND w/ silt & roots (SP-SM) w/ grass		1-3-7	
7.50	RIPRAP (**)			
9.10	Very moist, lt. olive brown, poorly graded SAND w/ silt & tr. of gravel (SP-SM)		43-28/0.2	
13.25	Wet, dk. yellowish brown, poorly graded SAND w/ tr. of shells (SP)	▽	6-9-8	
18.25	Wet, lt. olive brown, poorly graded SAND w/ clay lense (SP) w/ tr. of shells		2-1-2	
22.00	Wet, lt. olive brown, poorly graded SAND w/ tr. of shells (SP)		2-1-4	
24.50	Wet, olive brown, sandy SILT w/ shells & clay lense (ML)		2-3-3	
26.00	Wet, olive brown, poorly graded SAND w/ silt (SP-SM)		4-2-1	
27.00	Wet, dk. gray, soft, sandy lean CLAY (CL)			
29.50	Wet, dk. gray, very fine silty SAND (SM) w/ tr. of shells		2-1-2	
32.00	Wet, dk. gray, soft lean CLAY (CL) PPR 30.0'-31.5': 0.25, 0.25, 0.25 TOR @ 30.0': 0.44	▼	WH/1.5	
33.50 P	Wet, dk. gray, soft sandy lean CLAY (CL)		WH/1.5	
	Wet, dk. gray, soft lean CLAY (CL) PPR 32.5'-34.0': ---, 0.5, 0.5 PPR 35.0'-36.5': 1.0, 1.0, 1.0 TOR @ 35.0': 0.83 PPR 37.5'-39.0': 1.0, 1.0, 1.0 PPR 40.0'-41.5': 1.0, 1.0, 1.0 TOR @ 40.0': 0.55	▼	WH/1.5 WH/1.0-1	

DH-1
GROUNDWATER DATA
▽ WHILE DRILLING: 11.0
▼ ON COMPLETION: 37.5
▼ 24 Hr. READING: 29.5

DH-1A(4/24/03)
GROUNDWATER DATA
WHILE DRILLING: NT
ON COMPLETION: NT
24 Hr. READING: NT

P - indicates pressed shelby tube sample obtained from an additional boring.

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. 150+00 (Cell 2)
OFFSET: 10' Inward
TOP ELEV: 11.5±

DIKE RAISING
POPLAR ISLAND, MD.

N 406591.0
E 1489831.0
COMPLETED: April 15, 2003

DH-1
2 of 2

DEPTH(ft)		**(c)**	**(d)**		**(a)**	**(b)**
41.50		Wet, dk. gray, soft lean CLAY (CL)*(continued from the previous page)*			WH/0.5-1-2	
42.00		Not Sampled - Cleaned out w/ rock bit				
44.00	P	Not Classified				
		BOTTOM OF HOLE		45		
				50		
				55		
				60		
				65		
				70		
				75		
				80		

STA. 138+00 (Cell 2)   DIKE RAISING   N 405730.0   **DH-2**
OFFSET: 10' Inward   POPLAR ISLAND, MD.   E 1488890.0   **1 of 2**
TOP ELEV: 11.5±   COMPLETED: April 16, 2003

DEPTH(ft)	(c)	(d)
0.30	Moist, lt. olive brown, silty SAND w/ grass & roots (SM)	
3.35	Moist, olive brown, silty SAND w/ tr. of gravel (SM)	
8.25	Moist, lt. olive brown, poorly graded SAND w/ silt & shells (SP-SM)	
13.25	Moist, lt. olive brown, poorly graded SAND w/ silt, tr. of gravel & shells (SP-SM)	
18.25	Wet, olive brown, poorly graded SAND w/ silt & tr. of shells (SP-SM)	▽ ▼
21.00	Wet, black & dk. gray, silty SAND (SM)	
22.00	Wet, lt. olive brown, silty SAND (SM)	
24.50	Very moist, grayish brown, soft, lean CLAY (CL) PPR 22.5'-24.0': 1.0, 0.5, 0.5	
27.00	Wet, dk. grayish brown, silty SAND w/ tr. of shells (SM)	
28.70	Very moist, grayish brown, soft, sandy lean CLAY (CL) PPR 27.5'-29.0': 0.5, 1.0, 1.0 TOR @ 29.0': 1.27	
29.50 P	Moist, dk. gray, firm, lean CLAY (CL)	
32.00	Very moist, dk. gray, soft fat CLAY w/ tr. of sand (CH) PPR 30.0'-31.5': 0.5, 0.5, 0.5	
34.50	Moist, dk. gray, soft, sandy lean CLAY (CL) PPR 32.5'-34.0': 1.0, 2.0, 2.0 TOR @ 34.0': 0.99	
37.00	Moist, dk. gray, silty SAND (SM)	
	Wet, very dk. gray, poorly graded SAND w/ silt (SP-SM)	

	(a)	(b)
	2-5-6	
5	7-10-18	
10	13-14-20	
15	2-2-3	
20	3-4-4	
	WH/1.3-1/.2	
25	WH/.5-2-1	
	WH/1.5	
30	WH/1.2-1/.3	42.1
	1-3-3	
35	2-9-20	
	3-4-8	

DH-2
GROUNDWATER DATA
▽ WHILE DRILLING: 15.0
▼ ON COMPLETION: 17.3
24 Hr. READING: NT

DH-2A(4/24/03)
GROUNDWATER DATA
WHILE DRILLING: NT
ON COMPLETION: NT
24 Hr. READING: NT

P - indicates pressed shelby tube sample obtained from an additional boring.

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. 138+00 (Cell 2)
OFFSET: 10' Inward
TOP ELEV: 11.5±

DIKE RAISING
POPLAR ISLAND, MD.

N 405730.0
E 1488890.0
COMPLETED: April 16, 2003

DH-2
2 of 2

DEPTH(ft)	**(c)**	**(d)**		**(a)**	**(b)**
41.50	Wet, very dk. gray, poorly graded SAND w/ silt (SP-SM) *(continued from previous page)*			5-7-13	
	BOTTOM OF HOLE				
			45		
			50		
			55		
			60		
			65		
			70		
			75		
			80		

STA. 118+00 (Cell 2)	DIKE RAISING	N 403684.0	**DH-3**
OFFSET: 10' Inward	POPLAR ISLAND, MD.	E 1487653.0	**1 of 2**
TOP ELEV: 11.0±		COMPLETED: April 16, 2003	

DEPTH(ft)		(c)	(d)	(a)	(b)
3.25		Moist, yellowish brown, poorly graded medium to fine SAND w/ silt, tr. of roots & gravel (SP/SP-SM) w/ tr. of shells		2-9-11	
8.25		Moist, lt. yellowish brown, poorly graded medium to fine SAND w/ silt (SP/SP-SM)		11-17-27	
18.25		Wet, pale brown, poorly graded medium SAND (SP)	∇	4-4-5 1-1-2	
22.00		Moist, lt. brownish gray, sandy lean CLAY (CL) PPR 20.0'-21.5': 1.0, 2.0, 2.0 TOR @ 21.5': 0.55		2-2-2	
24.50		Wet, lt. brownish gray, silty SAND (SM) PPR 22.5'-24.0': 1.0, 2.0, 2.0		WH/1.5	
29.50	P	Moist, lt. gray, gravelly lean CLAY w/ sand (CL) PPR 25.0'-26.5': 1.0, 0.5, 0.25 TOR @ 26.8': 0.83		WH/1.5 WH/1.5	31.8
32.00		Moist, gray, gravelly lean CLAY w/ sand (CL) PPR 30.0'-31.5': 0.25, 0.25, 0.25		WH/1.2-2/.3	
32.90		Very moist, grayish brown, silty coarse to fine SAND w/ tr. of gravel (SM)			
	P	Moist, olive gray, sandy fat CLAY (CH) PPR 32.5'-34.0': >4.5, >4.5, >4.5 TOR @ 34.3': +4.12 PPR 35.0'-36.5': 4.5, 4.0, 4.0 PPR 37.5'-39.0': 4.5, 4.5, 4.0 TOR @ 36.8': +4.12 PPR 40.0'-41.5': 4.0, 4.0, 4.0 TOR @ 41.8': +4.12	▼	2-6-9 4-8-9 3-4-13	55.0

DH-3
GROUNDWATER DATA
∇ WHILE DRILLING: 10.0
▼ ON COMPLETION: 33.8
24 Hr. READING: NT

DH-3A (4/29/03)
GROUNDWATER DATA
WHILE DRILLING: NT
ON COMPLETION: NT
24 Hr. READING: NT

P - indicates pressed shelby tube sample obtained from an additional boring.

Fill	**Auger**	☒ **SPT**	**RB**
Cored	**300 lb**	**Tubex**	**Hand**
Fish Tail	**Vibra Core**	**Water Jet**	**Odex**

STA. 118+00 (Cell 2)
OFFSET: 10' Inward
TOP ELEV: 11.0±

DIKE RAISING
POPLAR ISLAND, MD.

N 403684.0
E 1487653.0
COMPLETED: April 16, 2003

DH-3

2 of 2

	DEPTH(ft)		**(c)**	**(d)**		**(a)**	**(b)**
☒	41.50	▨	Moist, olive gray, fat CLAY w/ sand (CH)*(continued from previous page)*			6-9-11	
			BOTTOM OF HOLE				
					45		
					50		
					55		
					60		
					65		
					70		
					75		
					80		

STA. 118+00 (Cell 2)
OFFSET: 80' Inward
TOP ELEV: 10.0±

DIKE RAISING
POPLAR ISLAND, MD.

N 403684.0
E 1487653.0
COMPLETED: April 16, 2003

DH-4

1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
3.25	Moist, grayish brown, sandy lean CLAY (CL)		1-4-10	
8.25	Moist, grayish brown, silty medium to fine SAND (SM)		3-5-19	
13.25	Very moist, lt. yellowish brown, poorly graded coarse to fine SAND (SP)		5-6-6	
18.25	Wet, lt. brownish gray, poorly graded coarse to fine SAND (SP)	⊻	1-2-2	
22.00	Moist, lt. brownish gray, lean CLAY w/ sand (CL) PPR 20.0'-21.5': 4.5, 4.0, 4.0 TOR @ 20.0': 0.39		2-4-1	
24.50 P	Moist, lt. gray, lean CLAY w/ sand (CL) PPR 22.5'-24.0': 0.5, 0.25, 0.75		WH/1.5	31.4
27.00	Moist, lt. brownish gray, lean CLAY w/ sand (CL) PPR 25.0'-26.5': 0.5, 0.5, 0.5 TOR @ 25.0': 0.55		WH/1.5	36.5
29.50	Moist, lt. brownish gray, sandy lean CLAY w/ tr. of gravel (CL) PPR 27.5'-29.0': 0.25, 0.25, 0.25		WH/1.5	
32.00	Moist, gray, lean CLAY w/ sand & tr. of gravel (CL) PPR 30.0'-31.5': 0.25, 0.25, 0.25 TOR @ 30.0': 0.55		WH/1.1-2/.4	
	Moist, olive gray, fat CLAY w/ sand (CH) PPR 32.5'-34.0': 4.5, 4.5, 4.5 PPR 35.0'-36.5': 4.5, 4.5, 4.5 PPR 37.5'-39.0': >4.5, >4.5, >4.5 PPR 40.0'-41.5': >4.5, >4.5, >4.5		5-7-11 5-7-9 15-18-23	

DH-4
GROUNDWATER DATA
⊻ WHILE DRILLING: 15.0
ON COMPLETION: NT
24 Hr. READING: NT

DH-4A (4/29/03)
GROUNDWATER DATA
WHILE DRILLING: NT
ON COMPLETION: NT
24 Hr. READING: NT

P - indicates pressed shelby tube sample obtained from an additional boring.

Fill
Auger
SPT
RB
Cored
300 lb
Tubex
Hand
Fish Tail
Vibra Core
Water Jet
Odex

STA. 118+00 (Cell 2)
OFFSET: 80' Inward
TOP ELEV: 10.0±

DIKE RAISING
POPLAR ISLAND, MD.

N 403684.0
E 1487653.0
COMPLETED: April 16, 2003

DH-4

2 of 2

DEPTH(ft)		**(c)**	**(d)**		**(a)**	**(b)**
41.50	▨	Moist, olive gray, fat CLAY w/ sand (CH)*(continued from previous page)*			7-12-18	
		BOTTOM OF HOLE ADDITIONAL GROUNDWATER DATA: At completion reading, augers were filled with mud.				
				45		
				50		
				55		
				60		
				65		
				70		
				75		
				80		

STA. 84+00 (Cell 2) DIKE RAISING N 401011.0 **DH-5**
OFFSET: 50' Inward POPLAR ISLAND, MD. E 1486111.0 **1 of 2**
TOP ELEV: 20.0± COMPLETED: April 18, 2003

DEPTH(ft)	(c)	(d)
3.25	Moist, lt. yellowish brown, poorly graded medium to fine SAND w/ silt, tr. of roots & gravel (SP/SP-SM)	
8.25	Moist, lt. yellowish brown, poorly graded medium to fine SAND (SP)	
13.25	Moist, grayish brown, silty medium to fine SAND (SM)	∇ (10.0)
18.25	Moist, brownish yellow, poorly graded medium to fine SAND (SP)	
24.50	Wet, lt. yellowish brown, silty coarse to fine SAND (SM)	
27.00	Wet, pale brown, silty coarse to fine SAND (SM)	▼ (26.0)
30.15	Wet, lt. yellowish brown, coarse to fine SAND (SM)	
32.00	Moist, lt. yellowish brown, sandy SILT (ML)	
34.50	Wet, lt. yellowish brown, poorly graded coarse to fine SAND w/ tr. of gravel (SP)	
37.00	P Moist, lt. brownish gray, sandy lean CLAY (CL) PPR 35.0'-36.5': 1.0, 0.5, 0.5	
38.30	Moist, lt. brownish gray, sandy lean CLAY w/ tr. of gravel (CL) PPR 37.5'-39.0': 1.0, 1.0, 0.5 TOR @ 38.0': 0.72	
39.50	Moist, lt. yellowish brown, clayey medium to fine SAND w/ tr. of	

Depth	(a)	(b)
0	1-2-2	
5	4-4-5	
10	8-18-21	
15	8-18-21	
20	8-18-21	
	3-4-5	
25	2-2-2	
	WH-1-1	
30	4-6-5	
	WH/1.5	
35	WH/1.0-3	
	3-2-2	

DH-5
GROUNDWATER DATA
∇ WHILE DRILLING: 10.0
▼ ON COMPLETION: 26.0
24 Hr. READING: NT

DH-5A (4/30/03
GROUNDWATER DATA
WHILE DRILLING: NT
ON COMPLETION: NT
24 Hr. READING: NT

P - indicates pressed shelby tube sample obtained from an additional boring.

Fill	**Auger**	**SPT**	**RB**
Cored	**300 lb**	**Tubex**	**Hand**
Fish Tail	**Vibra Core**	**Water Jet**	**Odex**

STA. 84+00 (Cell 2)
OFFSET: 50' Inward
TOP ELEV: 20.0±

DIKE RAISING
POPLAR ISLAND, MD.

N 401011.0
E 1486111.0
COMPLETED: April 18, 2003

DH-5

2 of 2

DEPTH(ft)	**(c)**	**(d)**		**(a)**	**(b)**
	gravel (SC) *(continued from previous page)*			WH/.9-1/.1-2	
41.20	Moist, grayish brown, lean CLAY w/ tr. of sand (CL) *(continued from previous page)*				
41.50	Very moist, brown, clayey medium to fine SAND w/ tr. of gravel (SC) PPR 40.0'-41.5': 0.5, 1.0, 1.0				
	BOTTOM OF HOLE				
			45		
			50		
			55		
			60		
			65		
			70		
			75		
			80		

STA. 69+00 (Cell 2)
OFFSET: 10' Inward
TOP ELEV: 10.5±

DIKE RAISING
POPLAR ISLAND, MD.

N 399489.0
E 1486237.0
COMPLETED: April 17, 2003

DH-6

1 of 2

DEPTH(ft)	(c)	(d)
0.50	Moist, yellowish brown, poorly graded coarse to fine SAND w/ silt & gravel (SP-SM)	
3.25	Moist gray, poorly graded coarse to fine SAND w/ silt, gravel & pieces of filter cloth (SP-SM)	
8.25	Moist, lt. yellowish brown, silty medium to fine SAND w/ tr. of gravel & pieces of filter cloth (SM)	
13.25	Wet, lt. yellowish brown, poorly graded coarse to fine SAND w/ pieces of filter cloth (SP)	∇
15.60	Moist, gray, sandy lean CLAY (CL)	
18.25	Wet, lt. brownish gray, poorly graded coarse to fine SAND w/ pieces of filter cloth (SP) PPR 15.0'-16.5': 0.5, 0.5, 0.25	▼
22.00	Wet, lt. brownish gray, silty coarse to fine SAND w/ pieces of filter cloth (SM)	
23.50	Wet, brown, poorly graded SAND w/ silt (SM/SP-SM)	
24.50	Wet, lt. brownish gray, clayey medium to fine SAND (SC)	
27.00	Wet, grayish brown, poorly graded medium to fine SAND (SP-SM/SP)	
30.00	P Very moist, lt. yellowish brown, fat CLAY w/ tr. of sand & gravel & w/ pieces of filter cloth (CH) w/ shells PPR 27.5'-29.0': 0.5, 0.25, <0.25	
32.00	Moist, dk. grayish brown, fat CLAY w/ tr. of sand & gravel & w/ pieces of filter cloth (CH) PPR 30.0'-31.5': 0.25, 0.25, 0.25 TOR @ 31.0': 1.27	
32.90	Moist, grayish brown, sandy lean CLAY (CL)	
34.50	Wet, dk. grayish brown, poorly graded coarse to fine SAND w/ tr. of gravel (SP) PPR 32.5'-34.0': <0.25, <0.25, <0.25	
37.50	Wet, dk. grayish brown, poorly graded medium to fine SAND (SP-SM/SP)	
39.50	Wet, gray, poorly graded coarse to fine SAND w/ gravel (SP)	

	(a)	(b)
	3-11-8	
5	7-11-11	
10	4-4-4	
15	6-6-8	
20	2-1-2	
	1/.6-1/.9	
25	WH/1.5	
	WH/1.5	49.4
30	WH/1.3-2/.2	44.1
	2-2-3	
35	1-1-3	
	4-11-24	

DH-6
GROUNDWATER DATA
∇ WHILE DRILLING: 10.0
▼ ON COMPLETION: 17.8
24 Hr. READING: NT

DH-6A (4/30/03)
GROUNDWATER DATA
WHILE DRILLING: NT
ON COMPLETION: NT
24 Hr. READING: NT

P - indicates pressed shelby tube sample obtained from an additional boring.

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. 69+00 (Cell 2)
OFFSET: 10' Inward
TOP ELEV: 10.5±

DIKE RAISING
POPLAR ISLAND, MD.

N 399489.0
E 1486237.0
COMPLETED: April 17, 2003

DH-6

DEPTH(ft)	(c)	(d)	(a)	(b)
41.50	Wet, grayish brown, poorly graded coarse to fine SAND w/ tr. of silt & gravel (SP-SM)*(continued from previous page)*		12-22-19	
	BOTTOM OF HOLE			

45
50
55
60
65
70
75
80

STA. 58+00 (Cell 2)
OFFSET: 10' Inward
TOP ELEV: 10.5±

DIKE RAISING
POPLAR ISLAND, MD.

N 397873.0
E 1486363.0
COMPLETED: April 16, 2003

DH-7
1 of 2

DEPTH(ft)	(c)	(d)
1.00	Moist, olive gray, silty GRAVEL w/ pieces of filter cloth (GM)	
8.23	Moist, lt. olive brown, poorly graded SAND w/ silt, tr. of gravel & pieces of filter cloth (SP-SM) w/ tr. of shells	
13.25	Wet, lt. olive brown, poorly graded SAND (SP) w/ tr. of gravel	∇ (10)
22.00	Wet, lt. olive brown, poorly graded SAND w/ silt & filter cloth fibers (SP-SM) w/ tr. of gravel, shells & organics	
24.50	Very moist, grayish brown, soft, lean CLAY w/ sand (CL) w/ tr. of shells PPR 22.5'-24.0' 0.5, 0.5, 0.25	▼ (24)
26.00	Wet, grayish brown, clayey SAND (SC) w/ tr. of shells PPR 25.0'-26.5': 0.5, 0.5, 0.25	
27.00	Wet, olive, soft, sandy CLAY (CL)	
28.50	Wet, olive, soft, sandy CLAY (CL) w/ tr. of shells	
29.50	Wet, olive gray & yellowish brown, clayey SAND w/ tr. of shells (SC) PPR 27.5'-29.0': <0.25, <0.25, <0.25	
30.50	Very moist, dk. gray, sandy lean CLAY (CL)	
32.00	Very moist, dk. gray, soft, lean CLAY w/ sand (CL) w/ tr. of shells PPR 30.0'-31.5': 0.5, 0.5, 0.5	
34.50	Wet, dk. grayish brown, poorly graded SAND (SP) w/ tr of shells	
37.00	Wet, dk. grayish brown, poorly graded GRAVEL w/ silt & sand (GP-GM)	
39.50	Wet, dk. grayish brown, poorly graded SAND w/ silt (SP-SM)	

	(a)	(b)
	5-7-6	
5	7-11-13	
10	4-6-4	
15	7-2-5	
20	2-1-1	
	1-WH/1.0	
25	WH/1.5	
	WH/1.0-2	
30	WH/1.0-3	
	WH-1-2	
35	6-18-14	
	WH/1.0-2	

DH-7
GROUNDWATER DATA
∇ WHILE DRILLING: 10.0
▼ ON COMPLETION: 24.0
24 Hr. READING: NT

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. 58+00 (Cell 2)
OFFSET: 10' Inward
TOP ELEV: 10.5±

DIKE RAISING
POPLAR ISLAND, MD.

N 397873.0
E 1486363.0
COMPLETED: April 16, 2003

DH-7
2 of 2

DEPTH(ft)		**(c)**	**(d)**		**(a)**	**(b)**
41.50	▨	Very moist, dk. gray, firm, leanto fat CLAY (CL/CH) PPR 40.0'-41.5': 1.0, 1.0, 1.0 TOR @ 41.8': 0.83 *(continued from previous page)*			WH-2-2	
		BOTTOM OF HOLE				
				45		
				50		
				55		
				60		
				65		
				70		
				75		
				80		

STA. 449+00 (Cell 6)
OFFSET: 15' Inward
TOP ELEV: 10.0±

DIKE RAISING
POPLAR ISLAND, MD.

N 395658.0
E 1487539.0
COMPLETED: April 22, 2003

DH-8
1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
0.10	Moist, yellowish brown, poorly graded medium to fine SAND w/ silt & tr. of roots (SP-SM) w/ grass		5-6-9	
3.25	Moist, yellowish brown, silty medium to fine SAND w/ clay lens (SM)			
8.25	Slightly moist, yellowish brown, clayey medium to fine SAND (SC) w/ rock fragments		4-9-12	
13.25	Wet, grayish brown, poorly graded coarse to fine SAND (SP)	⊻	5-9-8	
15.50	Wet, grayish brown, poorly graded coarse to fine SAND (SP) w/ tr. of shells			
18.25	Wet, lt. yellowish brown, clayey coarse to fine SAND (SC) PPR 15.0'-16.5': 0.5, 0.5, ---	▼	WH/.3-1/.7-1	
22.00	Wet, grayish brown, poorly graded coarse to fine SAND w/ silt & tr. of gravel (SP-SM) w/ tr. of shells		1-2-2	
24.50	Wet, grayish brown, poorly graded coarse to fine SAND (SP-SM/SP) w/ tr. of shells		1-1-2	
27.00	Wet, lt. brownish gray poorly graded coarse to fine SAND (SP) w/ tr. of shells		1-2-2	
29.50	Wet, grayish brown, poorly graded coarse to fine SAND w/ silt (SP-SM) w/ tr. of shells		3-2-2	
32.00	Wet, grayish brown, poorly graded coarse to fine SAND w/ silt (SP/SP-SM) w/ tr. of shells		WH/.3-1/.7-1	
33.80	Wet, grayish brown, poorly graded coarse to fine SAND w/ silt (SP-SM) w/ tr. of shells		2-1-1	
34.50	Wet, dk. gray, silty medium to fine SAND (SM)			
37.00	Moist, dk. gray, fat CLAY w/ tr. of sand (CH) PPR 35.0'-36.5': 0.5, 0.5, 0.5		WH/1.5	48.6
	Wet, grayish brown, poorly graded coarse to fine SAND (SP) TOR @ 37.5': 0.83		WH/1.5	

DH-8
GROUNDWATER DATA
⊻ WHILE DRILLING: 10.0
▼ ON COMPLETION: 16.8
24 Hr. READING: NT

DH-8A (4/30/03)
GROUNDWATER DATA
WHILE DRILLING: NT
ON COMPLETION: NT
24 Hr. READING: NT

P - indicates pressed shelby tube sample obtained from an additional boring.

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. 449+00 (Cell 6) DIKE RAISING N 395658.0 **DH-8**
OFFSET: 15' Inward POPLAR ISLAND, MD. E 1487539.0 **2 of 2**
TOP ELEV: 10.0± COMPLETED: April 22, 2003

DEPTH(ft)		**(c)**	**(d)**		**(a)**	**(b)**
☒	41.50	Wet, grayish brown, poorly graded coarse to fine SAND (SP) *(continued from the previous page)*			WH/1.5	
		BOTTOM OF HOLE				
				45		
				50		
				55		
				60		
				65		
				70		
				75		
				80		

STA. 400+00 (Cell 6) DIKE RAISING N 392720.0 **DH-9**
OFFSET: 15' Inward POPLAR ISLAND, MD. E 1490407.0 **1 of 2**
TOP ELEV: 10.0± COMPLETED: April 23, 2003

DEPTH(ft)		(c)	(d)
3.25		Moist, lt. yellowish brown, poorly graded medium to fine SAND w/ silt (SP-SM)	
8.25		Moist, lt. yellowish brown, silty medium to fine SAND (SP-SM/SM)	
15.00		Moist, grayish brown, silty medium to fine SAND (SM)	▽
18.25		Moist, grayish brown, silty medium to fine SAND (SP-SM/SM) w/ shells	
24.50	P	Wet, grayish brown, poorly graded medium to fine SAND w/ silt (SP-SM) w/ tr. of shells	
		Moist, gray, fat CLAY (CH) PPR 25.0'-26.5': <0.25, <0.25, <0.25	
27.00	P	Wet, dk. gray fat CLAY (CH) PPR 27.5'-29.0': 0.25, 0.25, 0.25 TOR @ 29.0':	
29.50		Moist, dk. gray, sandy lean CLAY w/ tr. of shell fragments (CL) PPR 30.0'-31.5': 0.25, 0.25, 0.25	
32.00	P	Moist, gray, lean CLAY w/ tr. of sand (CL) w/ wood PPR 32.5'-34.0': 0.5, 0.5, 0.5 PPR 35.0'-36.5': 0.5, 0.5, 1.0 TOR @ 34.0': 0.55	▼
37.00	P	Moist, grayish brown lean CLAY w/ tr. of sand (CL) PPR 37.5'-39.0': 0.5, 0.75, 0.5 PPR 40.0'-41.5': 1.0, 0.75, 1.0 TOR @ 40.3': 0.77	

	(a)	(b)
	2-4-5	
5	5-5-9	
10	8-10-8	
15	2-4-4	
20	WH/1.5	
	WH/1.5	
25	WH/1.5	
		59.7(av)
	WH/1.5	
30	WH/1.5	
	WH/1.5	29.9
35	WH/1.2-2/.3	
	WH/1.3-1/.2	

DH-9
GROUNDWATER DATA
▽ WHILE DRILLING: 10.5
▼ ON COMPLETION: 34.9
24 Hr. READING: NT

DH-9A (5/7/03)
GROUNDWATER DATA
WHILE DRILLING: NT
ON COMPLETION: NT
24 Hr. READING: NT

P - indicates pressed shelby tube sample obtained from an additional boring.

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. 400+00 (Cell 6) DIKE RAISING N 392720.0 **DH-9**
OFFSET: 15' Inward POPLAR ISLAND, MD. E 1490407.0 **2 of 2**
TOP ELEV: 10.0± COMPLETED: April 23, 2003

	DEPTH(ft)			**(c)**	**(d)**		**(a)**	**(b)**
☒	41.50		▨	Moist, grayish brown lean to fat CLAY w/ sand (CL/CH) *(continued from the previous page)*			WH/1.5	

BOTTOM OF HOLE

Note:
Water contents followed by (av) were determined by averaging the three tests performed on the tube sample.

45
50
55
60
65
70
75
80

STA. 975+00 (Cell 2) | DIKE RAISING | N 399671.0 | **DH-10**
OFFSET: 10' Inward | POPLAR ISLAND, MD. | E 1487427.0 | **1 of 2**
TOP ELEV: 10.0± | COMPLETED: April 23, 2003

DEPTH(ft)	(c)	(d)
3.25	Moist, yellowish brown, poorly graded medium to fine SAND w/ silt & gravel (SP-SM)	
5.20	Moist, grayish brown, sandy lean CLAY w/ tr. of gravel (CL)	
8.25	Moist, yellowish brown, silty medium to fine SAND (SP-SM/SM)	
13.25	Very moist, yellowish brown, silty medium to fine SAND w/ tr. of gravel (SP-SM/SM)	▽
18.25	Wet, grayish brown, silty medium to fine SAND (SP-SM/SM)	
22.00	Wet, dk. grayish brown, silty fine SAND w/ tr. of gravel (SM)	▼
24.50	Moist, lt. brownish gray, sandy lean CLAY w/ tr. of gravel (CL) PPR 22.5'-24.0': 0.25, 0.25, 0.25	
27.00	Very moist, lt. yellowish brown, sandy lean CLAY w/ tr. of gravel (CL) PPR 25.0'-26.5': 1.5, 1.0, 0.5 TOR @ 25.0': 0.50	
29.50 P	Moist, grayish brown, lean CLAY w/ sand (CL) w/ rock fragments PPR 27.5'-29.0': 0.5, 0.75, 0.5	
30.60	Moist, dk. grayish brown, sandy lean CLAY (CL) w/ rock fragments	
32.00	Very moist, dk. grayish brown, silty medium to fine SAND w/ tr. of gravel (SM) PPR 30.0'-31.5': 0.5, 0.25, 0.25	
34.50	Moist, greenish gray, lean to fat CLAY w/ sand (CL/CH) PPR 32.5'-34.0': 2.5, 1.5, 2.5	
35.80	Very moist, grayish brown, silty medium to fine SAND (SM)	
37.30	Moist, olive gray, sandy lean CLAY (CL) PPR 35.0'-36.5': 2.0, 1.5, 1.5 TOR @ 37.0: 0.83	
39.50	Moist, olive gray, clayey medium to fine SAND w/ gravel (SC) w/ shell fragments PPR 37.5'-39.0': 1.0, 1.0, 1.0	

	(a)	(b)
	3-5-7	
5	30-12-22	
10	5-7-8	
15	9-12-12	
20	1-1-2	
	WH/1.3-1/.2	
25	WH/1.2-1/.3	29.8
	WH/1.5	
30	2-10-10	
	2-2-3	
35	2-3-3	
	9-8-6	

DH-10
GROUNDWATER DATA
▽ WHILE DRILLING: 10.0
▼ ON COMPLETION: 21.1
24 Hr. READING: NT

DH-10A (5/6/03)
GROUNDWATER DATA
WHILE DRILLING: NT
ON COMPLETION: NT
24 Hr. READING: NT

P - indicates pressed shelby tube sample obtained from an additional boring.

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. 975+00 (Cell 2)
OFFSET: 10' Inward
TOP ELEV: 10.0±

DIKE RAISING
POPLAR ISLAND, MD.

N 399671.0
E 1487427.0
COMPLETED: April 23, 2003

DH-10
2 of 2

DEPTH(ft)	**(c)**	**(d)**		**(a)**	**(b)**
41.50	Wet, dk. gray, clayey medium to fine SAND w/ gravel (SC) PPR 40.0'-41.5': <0.25, <0.25, <0.25*(continued from previous page)*			6-7-7	
	BOTTOM OF HOLE				
			45		
			50		
			55		
			60		
			65		
			70		
			75		
			80		

STA. 930+00 (Cell 2)
OFFSET: 10' Inward
TOP ELEV: 10.0±

DIKE RAISING
POPLAR ISLAND, MD.

N 403738.0
E 1489239.0
COMPLETED: April 22, 2003

DH-11

1 of 2

DEPTH(ft)	(c)	(d)
0.60	Moist, grayish brown, poorly graded medium to fine SAND w/ silt, gravel & tr. of roots (SP-SM)	
3.25	Moist, yellowish brown, silty medium to fine SAND (SM)	
8.25	Moist, yellowish brown, poorly graded medium to fine SAND (SM/SP-SM) w/ tr. of shells	
18.25	Wet, grayish brown, poorly graded medium to fine SAND (SM/SP-SM) w/ tr. of shells	▽ ▼
21.10	Wet, grayish brown, silty medium to fine SAND (SM) w/ tr. of shells PPR 20.0'-21.5': 0.5, 0.5, 0.5	
22.00	Moist, grayish brown, sandy lean CLAY (CL)	
24.50	Wet, grayish brown, silty medium to fine SAND w/ tr. of gravel (SM)	
P 27.00	Moist, gray, sandy fat CLAY (CH) PPR 25.0'-26.5': 0.5, 0.5, 0.5	
29.50	Moist, grayish brown sandy fat CLAY (CH) PPR 27.5'-29.0': 0.5, 0.5, 0.5 TOR @ 28.0': 0.55	
P 32.00	Moist, grayish brown, lean CLAY w/ sand (CL)	
34.50	Wet, lt. olive brown, silty medium to fine SAND (SM)	
37.00	Wet, dk. gray, silty medium to fine SAND (SM)	
39.50	Wet, dk. grayish brown, silty medium to fine SAND (SM)	

	(a)	(b)
	9-8-11	
5	8-21-36	
10	5-8-10	
15	1-1-2	
20	WH/1.3-1/.2	
	WH/1.5	
25	WH/1.5	39.0 49.3(av)
	WH/1.5	
30	WH/1.5	
	4-5-7	
35	1-2-3	
	1-2-3	

DH-11
GROUNDWATER DATA
▽ WHILE DRILLING: 10.5
▼ ON COMPLETION: 17.1
24 Hr. READING: NT

DH-11A (5/2/03)
GROUNDWATER DATA
WHILE DRILLING: NT
ON COMPLETION: NT
24 Hr. READING: NT

P - indicates pressed shelby tube sample obtained from an additional boring.

Fill	**Auger**	**SPT**	**RB**
Cored	**300 lb**	**Tubex**	**Hand**
Fish Tail	**Vibra Core**	**Water Jet**	**Odex**

STA. 930+00 (Cell 2)
OFFSET: 10' Inward
TOP ELEV: 10.0±

DIKE RAISING
POPLAR ISLAND, MD.

N 403738.0
E 1489239.0
COMPLETED: April 22, 2003

DH-11

2 of 2

DEPTH(ft)	**(c)**	**(d)**	**(a)**	**(b)**
41.50	Wet, dk. gray, silty medium to fine SAND (SM) *(continued from previous page)*		WH-1-1	

BOTTOM OF HOLE

Note:
Water contents followed by (av) were determined by averaging the three tests performed on the tube sample.

45
50
55
60
65
70
75
80

STA. 929+90
OFFSET:
TOP ELEV: 10.0±

DIKE RAISING
POPLAR ISLAND, MD.

N
E
COMPLETED: April 14, 2004

DH-12
1 of 1

DEPTH(ft)		(c)	(d)	(a)	(b)
20.00		Not Sampled			
21.50		Moist, lt. brownish gray, sandy fat CLAY (CH)		1-2-2	
23.00		Moist, lt. brownish gray, sandy fat CLAY w/tr. of gravel (CH)		1-2-2	
24.30		Moist, lt. brownish gray, sandy fat CLAY (CH)		2-3-2	
26.00		Moist, gray, fat CLAY w/tr. of sand (CH)		1-2-2	
27.50	P	V. moist, dk. gray, soft fat CLAY w/sand (CH)		1-3-2	42.8
30.50	P	V. moist, dk. gray, soft to firm lean CLAY (CL)		2-2-2 2-2-9	38.8
32.00		V. moist, dk. grayish brown, silty med. to fine SAND (SM)		6-7-9	
		BOTTOM OF HOLE			

DH-12
GROUNDWATER DATA
WHILE DRILLING: NT
ON COMPLETION: NT
24 Hr. READING: NT

DH-12A (4/14/04)
GROUNDWATER DATA
WHILE DRILLING: NT
ON COMPLETION: NT
24 Hr. READING: NT

P - indicates pressed shelby tube sample obtained from an additional boring.

Fill	**Auger**	**SPT**	**RB**
Cored	**300 lb**	**Tubex**	**Hand**
Fish Tail	**Vibra Core**	**Water Jet**	**Odex**

STA. 930+25 DIKE RAISING N **DH-13**
OFFSET: POPLAR ISLAND, MD. E **1 of 1**
TOP ELEV: 10.0± COMPLETED: April 15, 2004

DEPTH(ft)		(c)	(d)	(a)	(b)
23.00		Not Sampled			
	P	Moist, lt. brownish gray, sandy fat CLAY w/tr. of gravel (CH)		WR/1.0-WH	
26.00				WR-1-1	
	P	Moist, lt. gray, fine to med. sandy lean CLAY (CL)		1-2-1	35.9 37.7
29.00				1-2-2	
30.50		Moist, gray, fat CLAY w/sand (CH)		1-2-2	
32.00		V. moist, dk. gray, clayey med. to fine SAND w/tr. of gravel (SC)		11-5-13	
		BOTTOM OF HOLE			

DH-13
GROUNDWATER DATA
WHILE DRILLING: NT
ON COMPLETION: NT
24 Hr. READING: NT

DH-13A (4/15/04)
GROUNDWATER DATA
WHILE DRILLING: NT
ON COMPLETION: NT
24 Hr. READING: NT

P - indicates pressed shelby tube sample obtained from an additional boring.

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

VISUAL CLASSIFICATION

PROJECT: Poplar Island
Dike Raising

AREA: Talbot County, MD

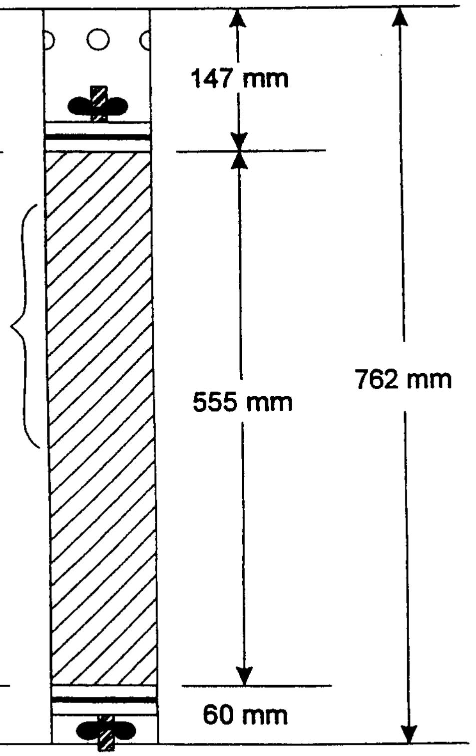
DATE: June 2003

Hole No.	Sample No.	Depth (ft)
DH-4A	Shelby-1	23.0-25.0

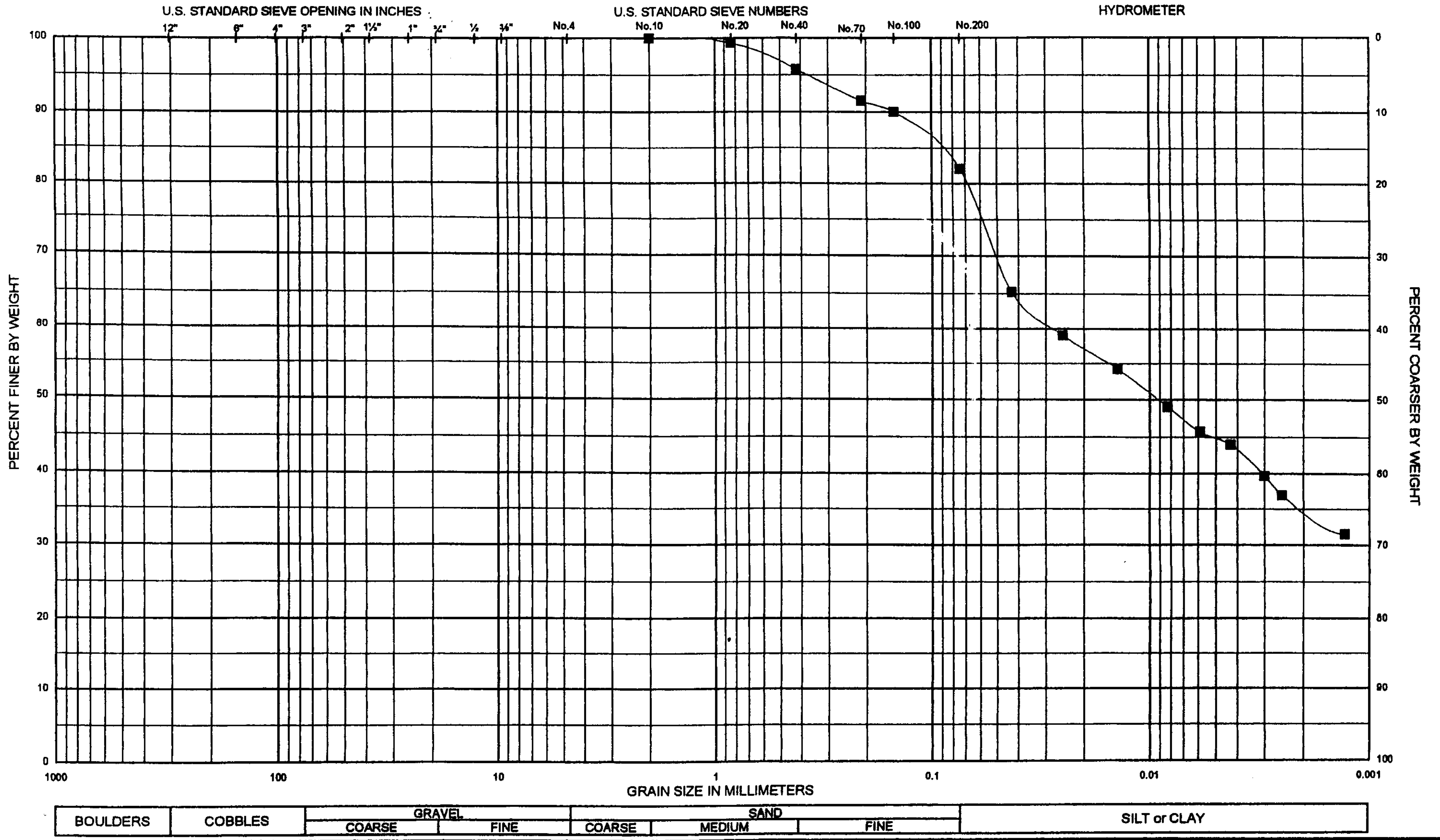
Tube plug & void.

Moist, gray, lean clay. (CL)

Tube plug & void.



Unconfined Compression Test taken.



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Shelby-1	23.0-25.0	Lean clay with sand (CL)	31.4	40	18	22

PROJECT: Poplar Island
Dike Raising

AREA: Talbot County, MD

Boring No.: DH-4A

DATE: Jul 2003

ENG FORM 2087

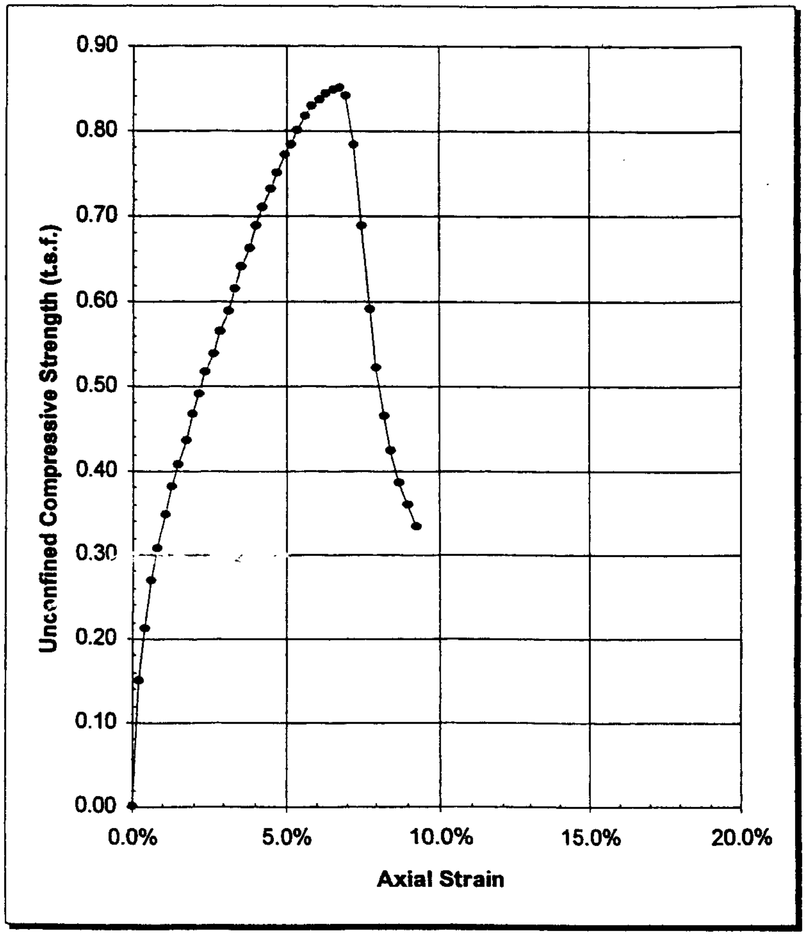
GRADATION CURVES

(Sieve Analysis: ASTM D422)

UNCONFINED COMPRESSION TEST

FAILURE SKETCHES

CONTROLLED STRAIN



TEST NO.		1	2	3	4
TYPE OF SPECIMEN		Undisturbed			
WATER CONTENT, %	w_o	31.4			
VOID RATIO	e_o	0.891			
SATURATION, %	S_o	96.3			
DRY UNIT WEIGHT, LB./CU.FT.	γ_d	90.1			
TIME TO FAILURE, MIN.	t_f	7.50			
UNCONFINED COMPRESSIVE STRENGTH, TSF	q_u	0.85			
UNDRAINED SHEAR STRENGTH, TSF	s_u	0.43			
SENSITIVTY RATIO	S_t	——			
INITIAL SPECIMEN DIAMETER, IN.	D_o	2.87			
INITIAL SPECIMEN HEIGHT, IN.	H_o	7.01			

CLASSIFICATION: Moist, gray with dark yellowish brown, lean clay with sand. (CL)

LL= 40	PL= 18	PI= 22	G_S= 2.73

REMARKS:	**PROJECT:**	Poplar Island		
		Dike Raising		
	AREA:	Talbot County, MD		
	Hole No.:	DH-4A	**Sample No.:**	Shelby-1
	Depth (ft.):	23.0-25.0	**Date:**	Jul.2003

ENG FORM 3659 (Test method: ASTM D2166) **UNCONFINED COMPRESSION TEST REPORT**

VISUAL CLASSIFICATION

PROJECT: Poplar Island
Dike Raising

AREA: Talbot County, MD

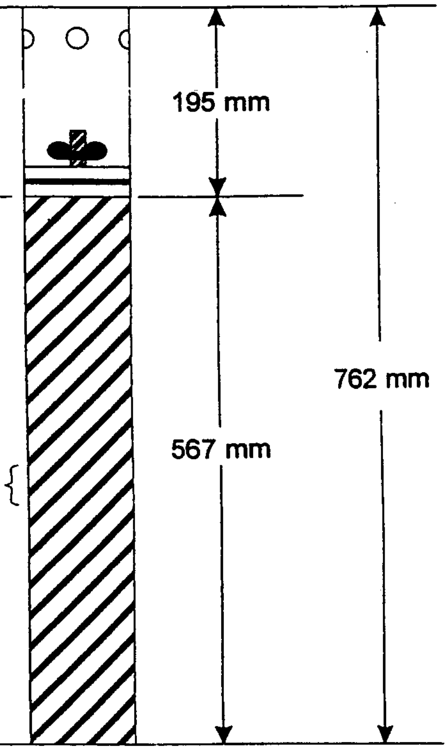
DATE: June 2003

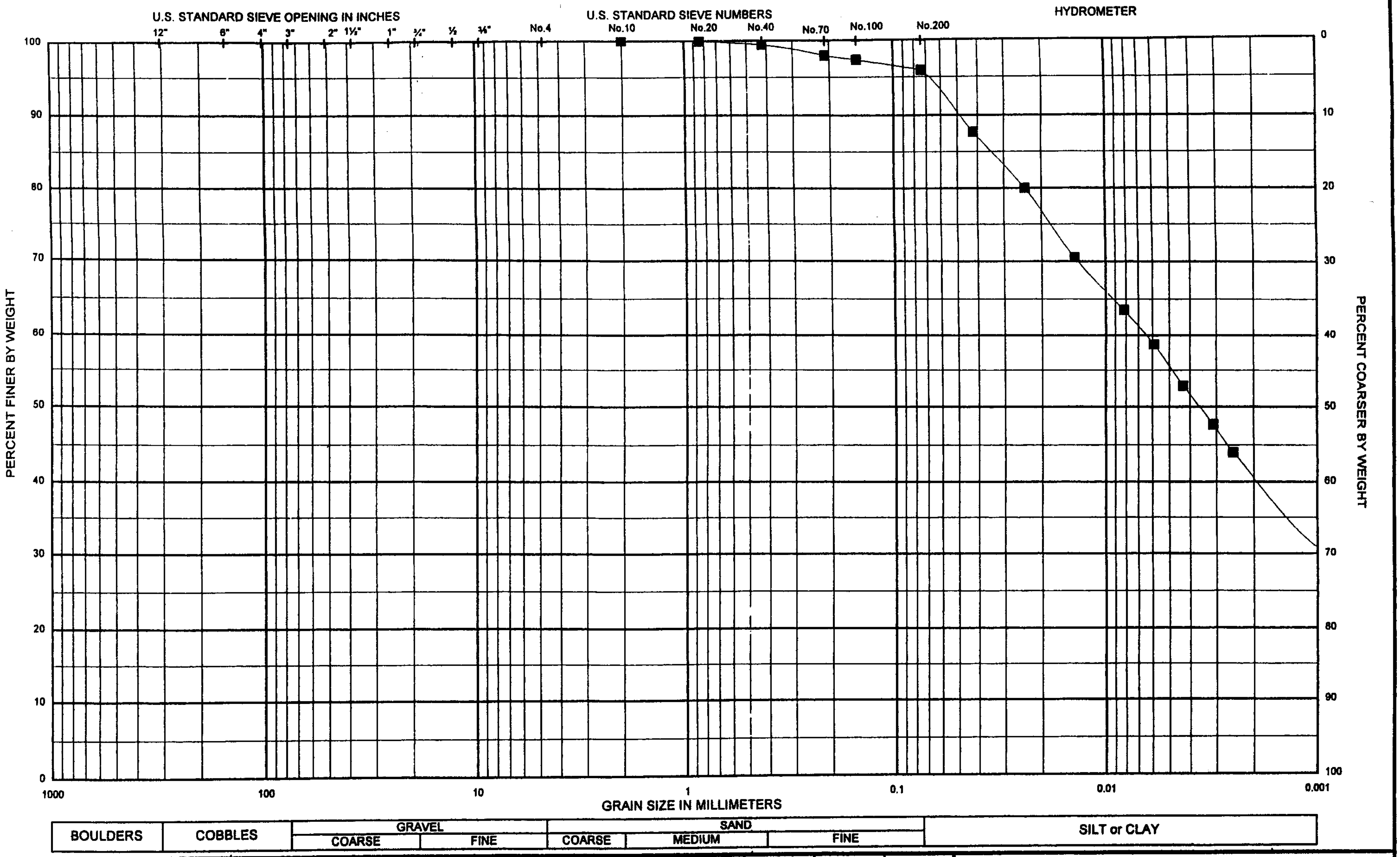
Hole No.	Sample No.	Depth (ft)
DH-6A	Shelby-1	28.0-30.0

Tube plug & void.

Moist, dark gray, fat clay. (CH)
(trace of sand)

Consolidation
Test taken.





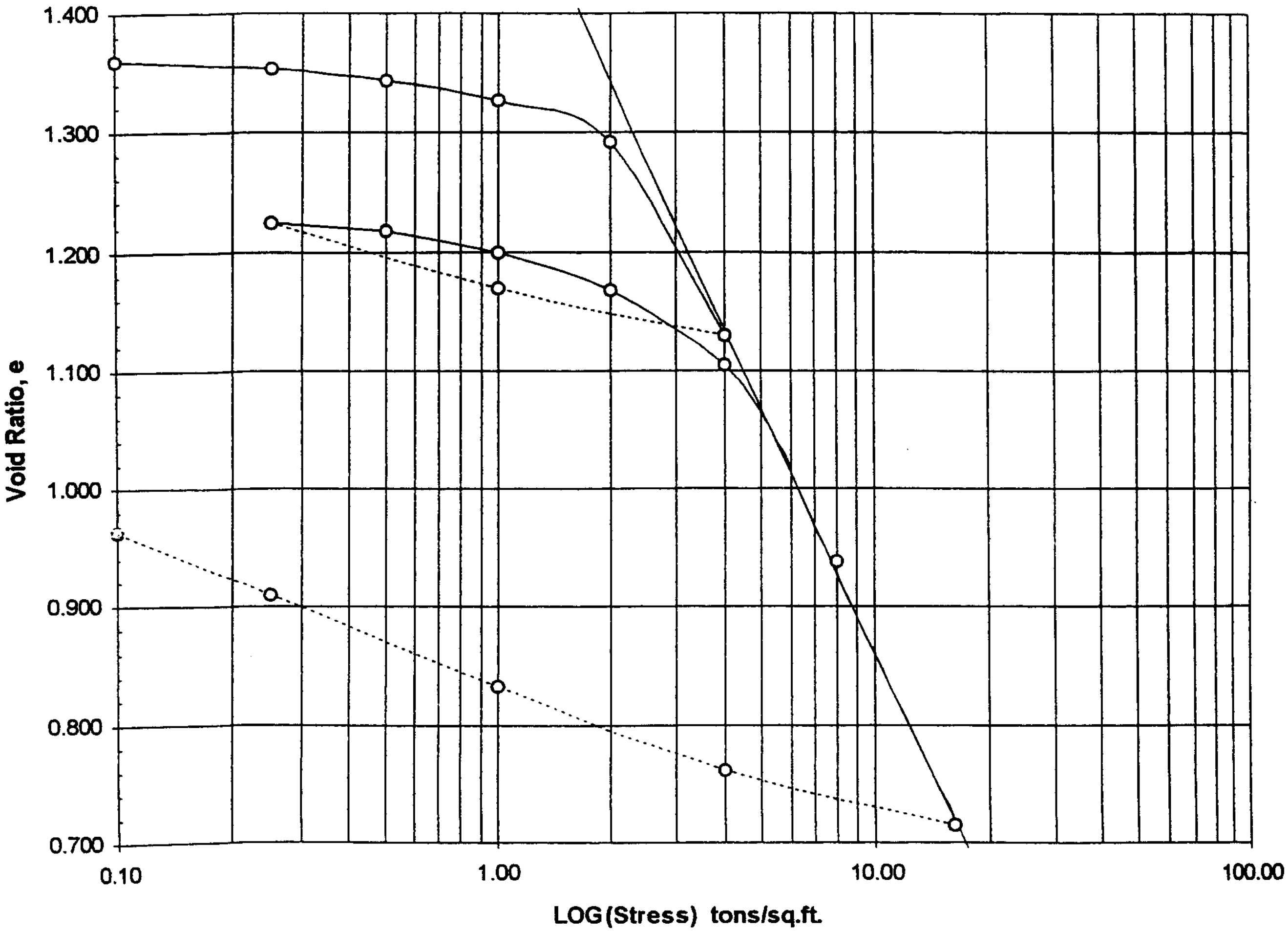
Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Shelby-1	28.0-30.0	Fat clay (tr. sand)	(CH)	49.4	65	22	43

PROJECT: Poplar Island
Dike Raising
AREA: Talbot County, MD
Boring No.: DH-6A
DATE: Jul 2003

ENG FORM 2087

GRADATION CURVES

(Sieve Analysis: ASTM D422)



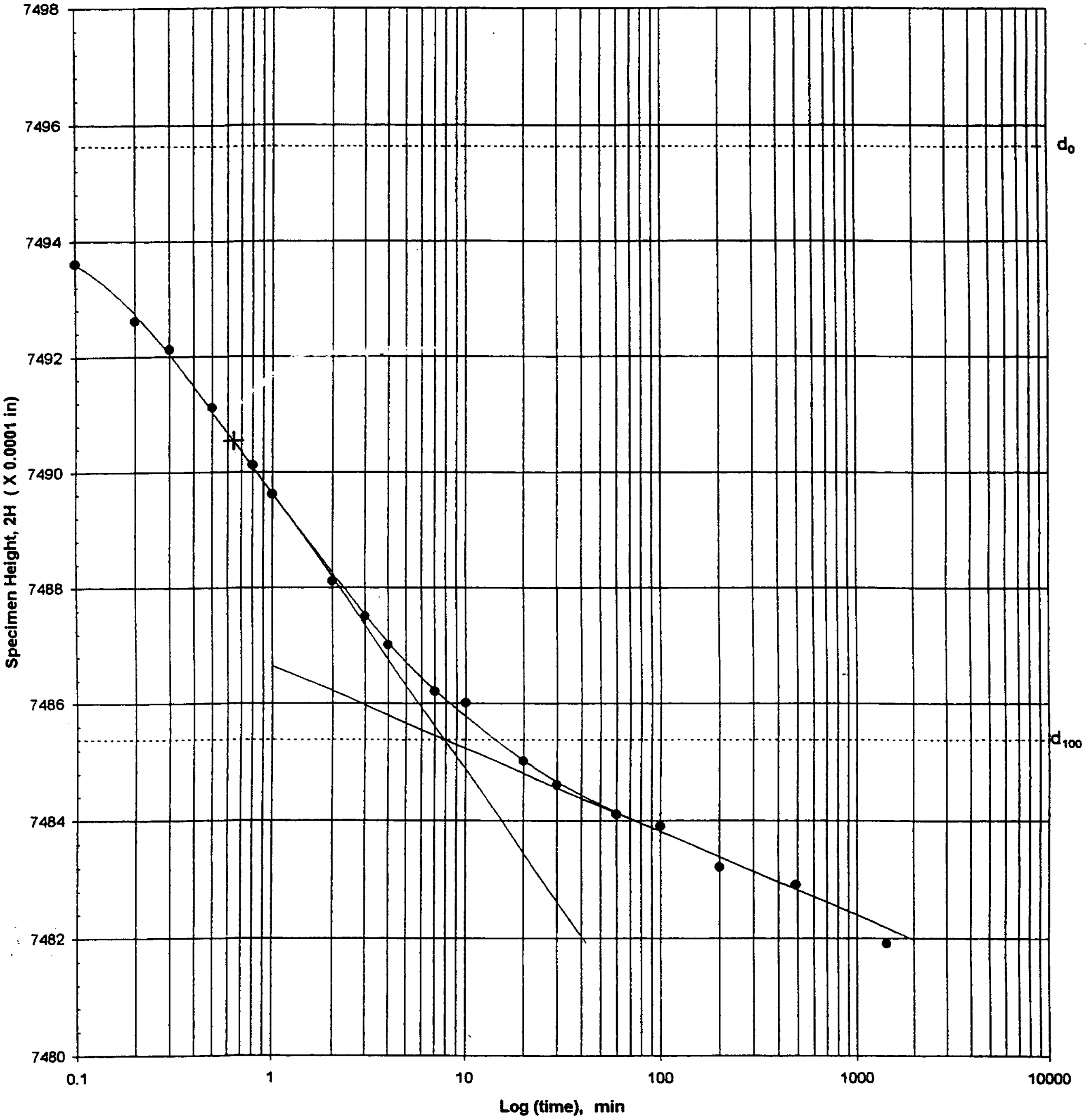
Type of Specimen:	**Undisturbed**			Before Test		After Test
Diameter= **2.50** in.	Height= **0.75** in.	Water Content, %	w_o	49.4	w_f	36.6
Overburden Pressure, p_o = tons/sq.ft.		Void Ratio	e_o	1.362	e_f	1.006
Preconsol. Pressure, p_c = tons/sq.ft.		Saturation, %	S_o	99.7	S_f	100.1
Compression Index, C_c =	0.688	Dry Density	γ_d	72.6	lbs./cu.ft.	

Classification: Moist, dark gray, fat clay. (CH)
(trace of sand)

LL = 65	PL = 22	PI= 43	G_s = 2.75

Remarks:	**PROJECT:**	Poplar Island	
		Dike Raising	
	AREA:	Talbot County, MD	
	Hole No.: DH-6A	**Sample No.:** Shelby-1	
	Depth (ft.): 28.0-30.0	**Date:** Jul.2003	
ENG FORM 2090 (Test method: ASTM D2435)	**CONSOLIDATION TEST REPORT**		

t_{50} TIME CURVE



U.S.Army Corps of Engineers
Materials & Instrumentation Section
Baltimore, Maryland 21230

PROJECT: Poplar Island
Dike Raising
AREA: Talbot County, MD

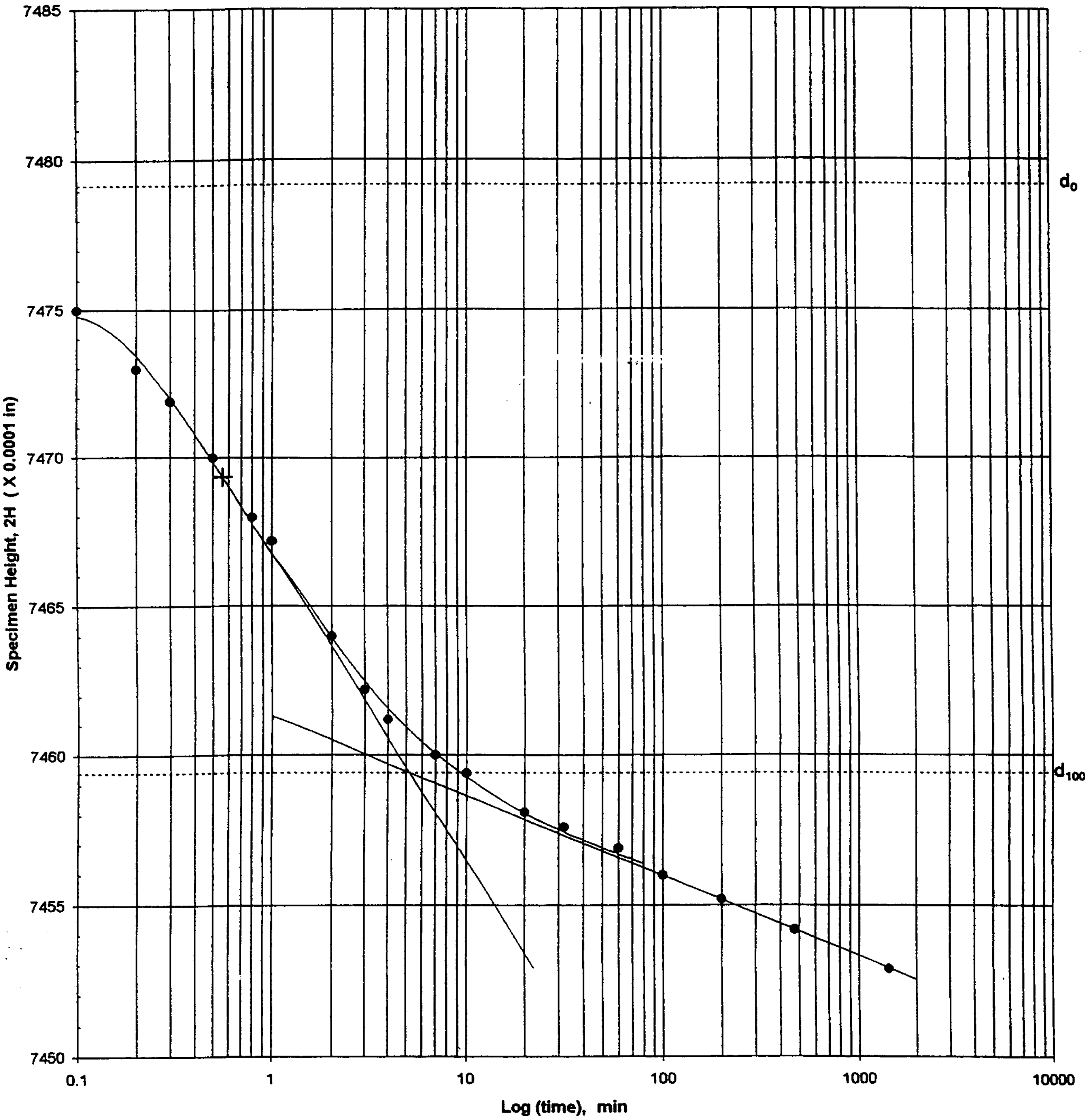
Normal Stess =	**0.25**	tons/ft²
t_{50} =	0.64	min
H =	0.3745	in
c_v =	7.16 X 10^{-4}	in²/sec

Hole No.:	**Sample No.:**	**Depth (ft):**
DH-6A	Shelby-1	28.0-30.0 ft

ENG Form 2088

CONSOLIDATION TEST - TIME CURVE

t_{50} TIME CURVE



U.S.Army Corps of Engineers
Materials & Instrumentation Section
Baltimore, Maryland 21230

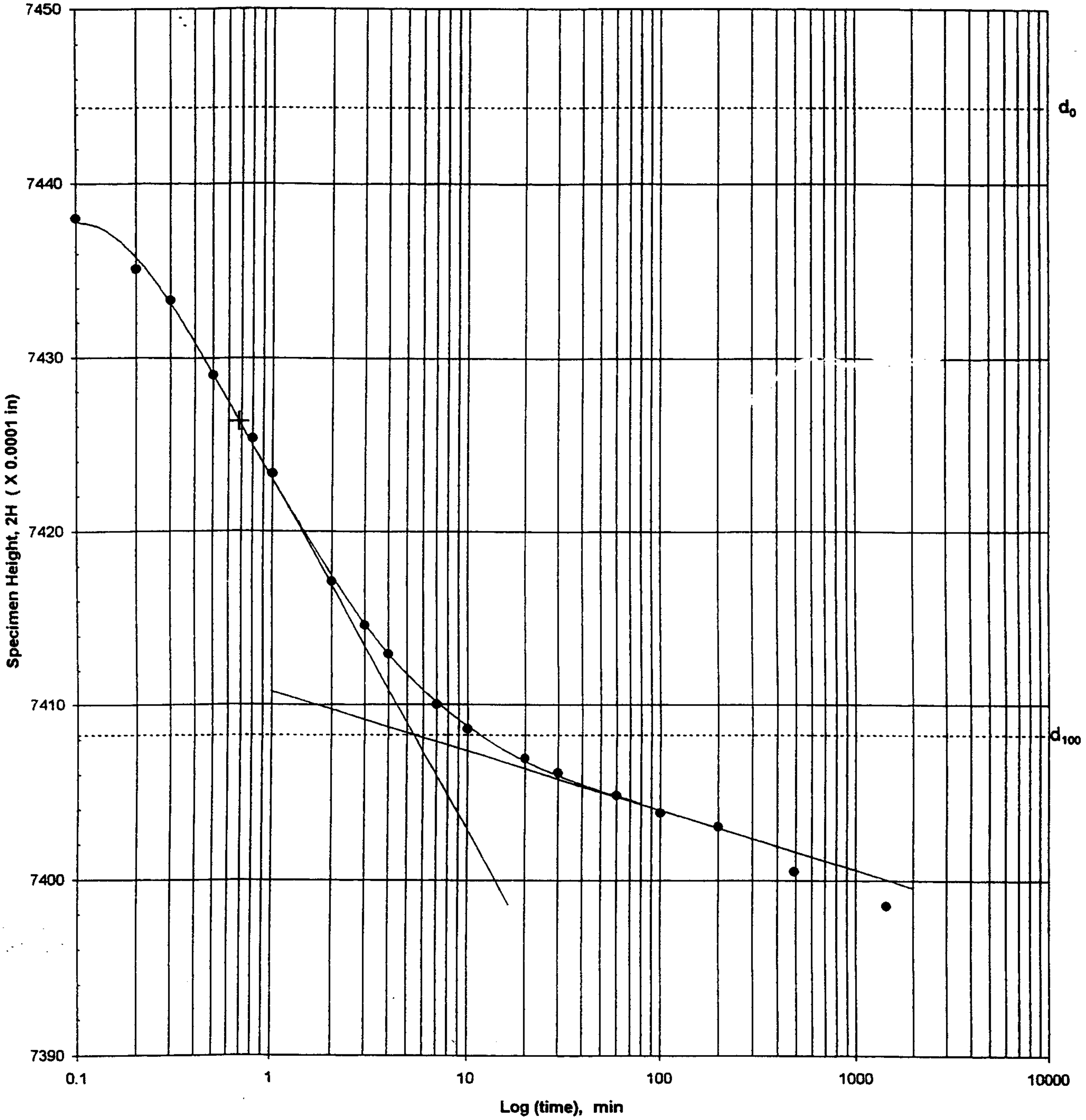
PROJECT: Poplar Island
Dike Raising
AREA: Talbot County, MD

Normal Stess = **0.50** tons/ft²
t_{50} = 0.56 min
H = 0.3735 in
c_v = 8.14 X 10^{-4} in²/sec

Hole No.:	**Sample No.:**	**Depth (ft):**
DH-6A	Shelby-1	28.0-30.0 ft

ENG Form 2088 **CONSOLIDATION TEST - TIME CURVE**

t_{50} TIME CURVE



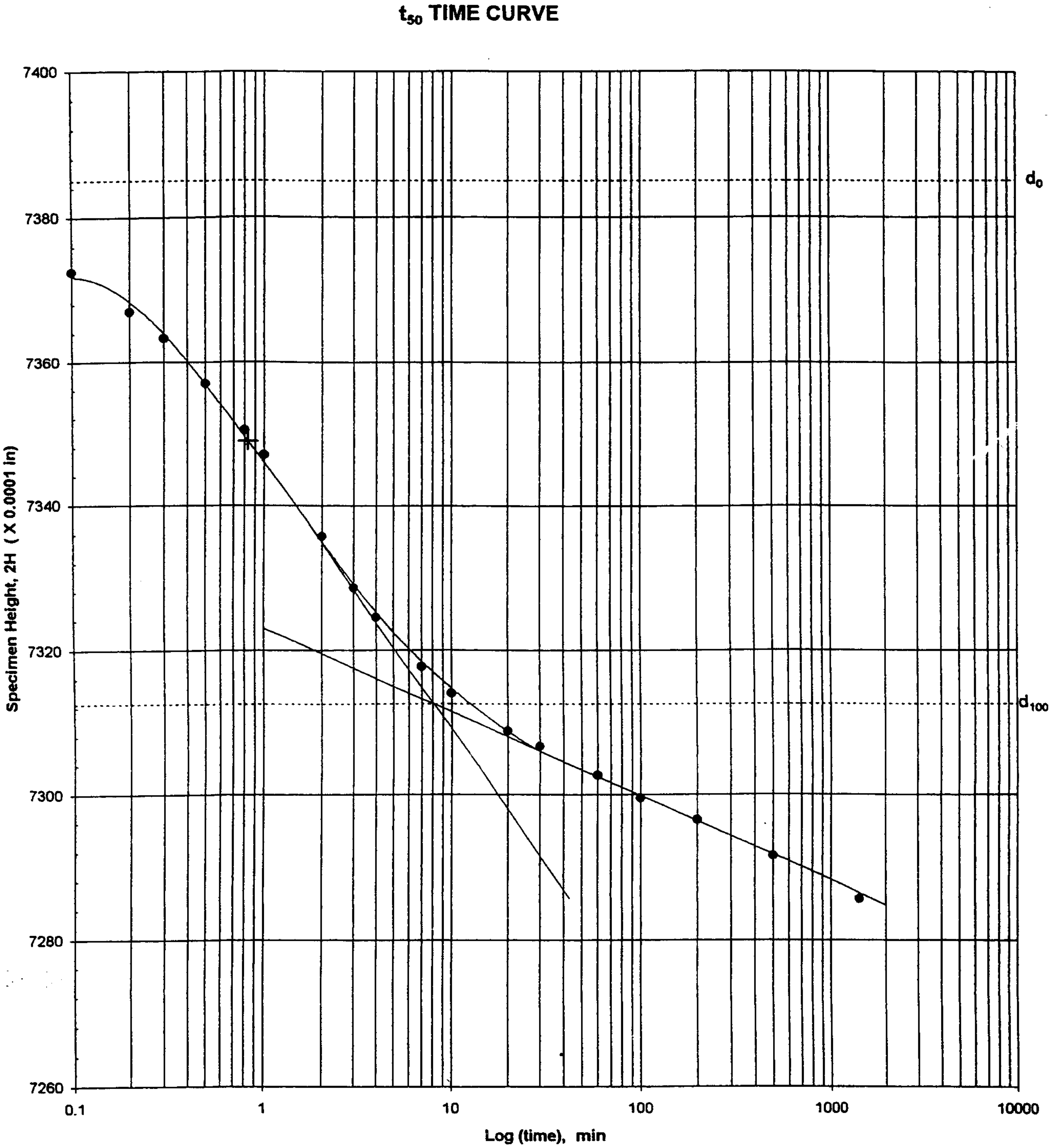
U.S.Army Corps of Engineers
Materials & Instrumentation Section
Baltimore, Maryland 21230

PROJECT: Poplar Island
Dike Raising
AREA: Talbot County, MD

Normal Stess = **1.0** tons/ft²
t_{50} = 0.68 min
H = 0.3713 in
c_v = 6.62 X 10^{-4} in²/sec

Hole No.:	**Sample No.:**	**Depth (ft):**
DH-6A	Shelby-1	28.0-30.0 ft

ENG Form 2088 **CONSOLIDATION TEST - TIME CURVE**



U.S.Army Corps of Engineers
Materials & Instrumentation Section
Baltimore, Maryland 21230

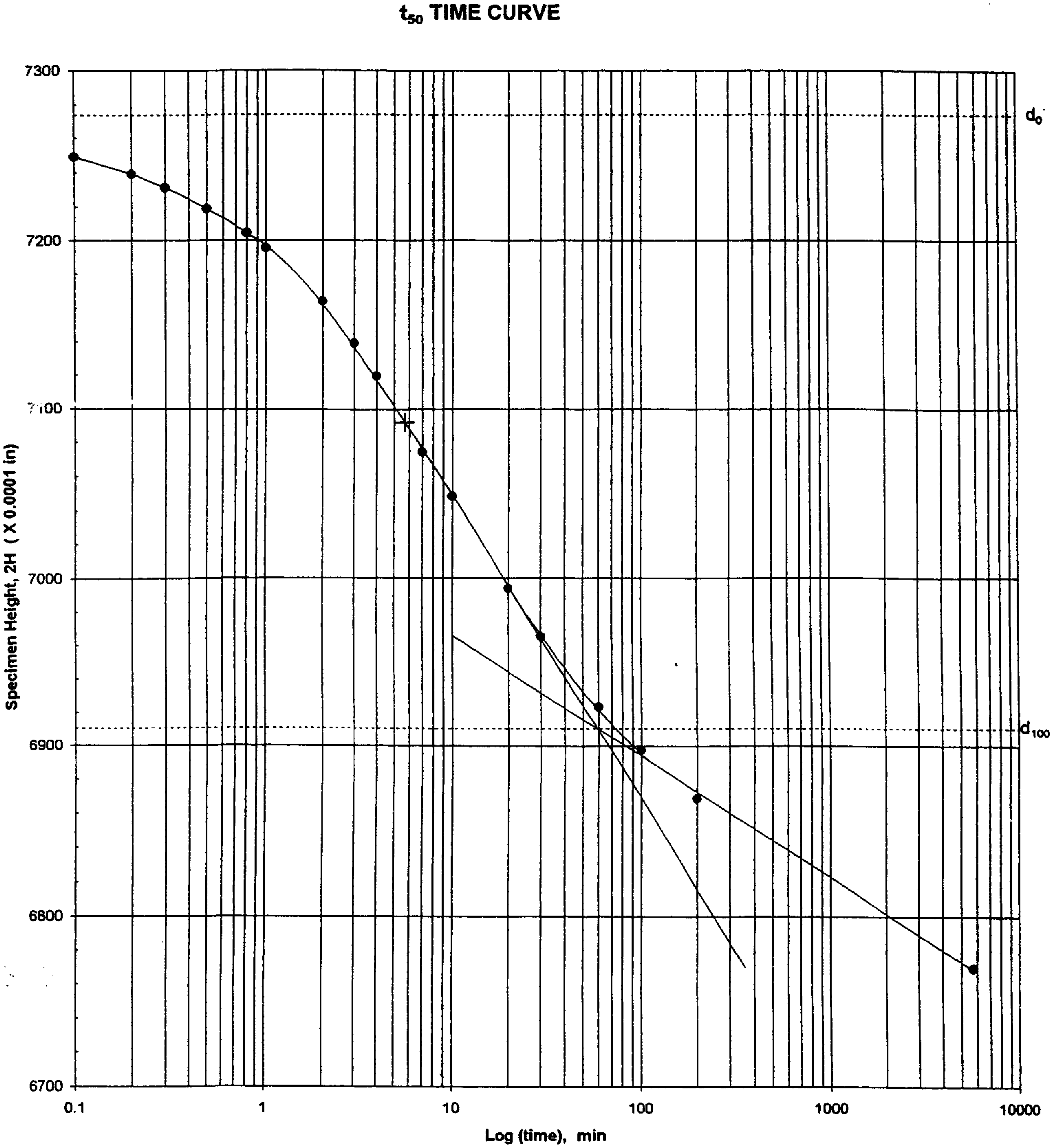
PROJECT: Poplar Island
Dike Raising
AREA: Talbot County, MD

Normal Stess = **2.0** tons/ft²
t_{50} = 0.83 min
H = 0.3674 in
c_v = 5.31 X 10^{-4} in²/sec

Hole No.:	**Sample No.:**	**Depth (ft):**
DH-6A	Shelby-1	28.0-30.0 ft

ENG Form 2088

CONSOLIDATION TEST - TIME CURVE



U.S.Army Corps of Engineers
Materials & Instrumentation Section
Baltimore, Maryland 21230

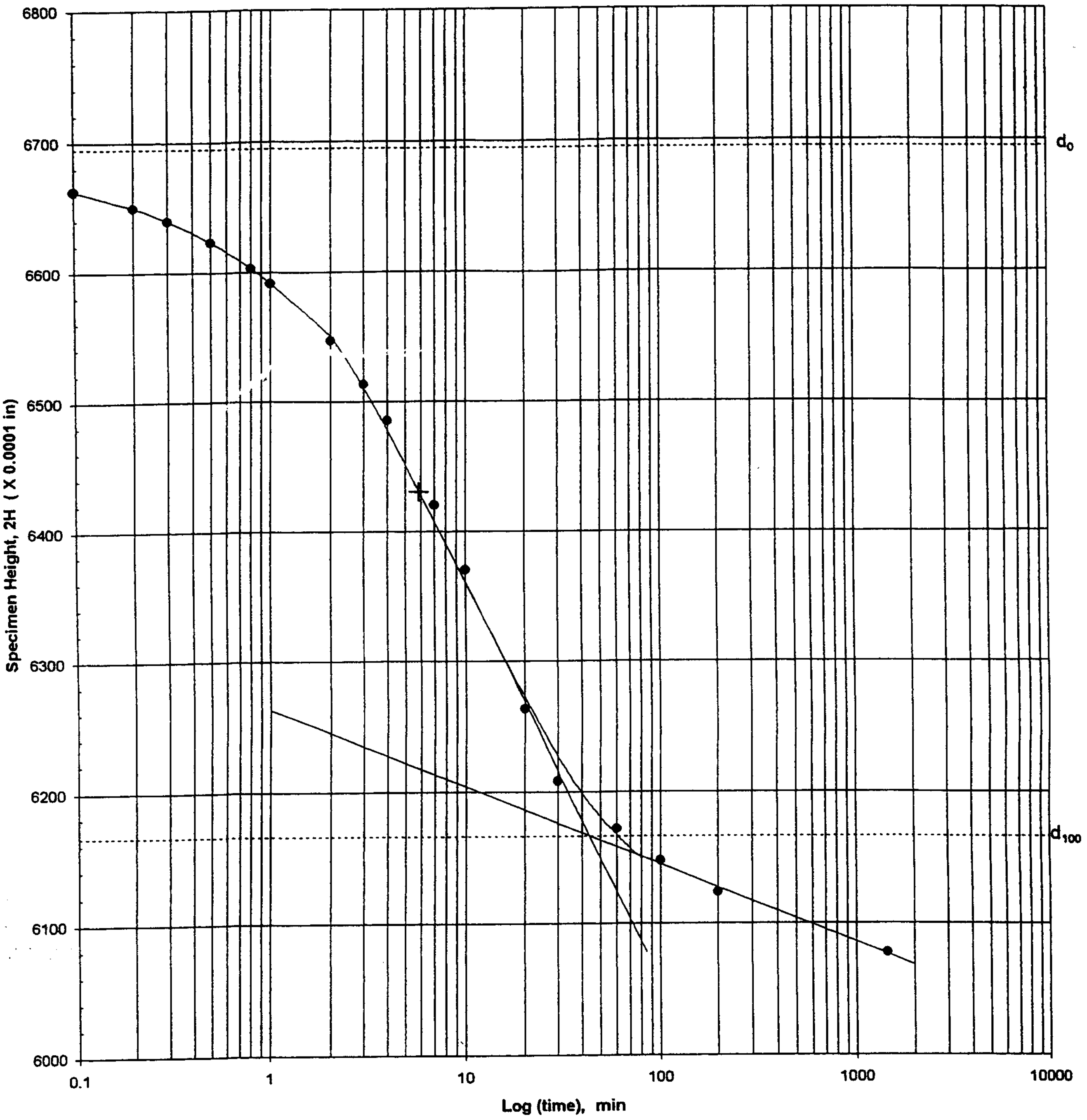
PROJECT: Poplar Island
Dike Raising
AREA: Talbot County, MD

Normal Stess =	**4.0**	tons/ft²
t_{50} =	5.68	min
H =	0.3546	in
c_v =	7.23 X 10^{-5}	in²/sec

Hole No.:	**Sample No.:**	**Depth (ft):**
DH-6A	Shelby-1	28.0-30.0 ft

ENG Form 2088 **CONSOLIDATION TEST - TIME CURVE**

t_{50} TIME CURVE



U.S.Army Corps of Engineers
Materials & Instrumentation Section
Baltimore, Maryland 21230

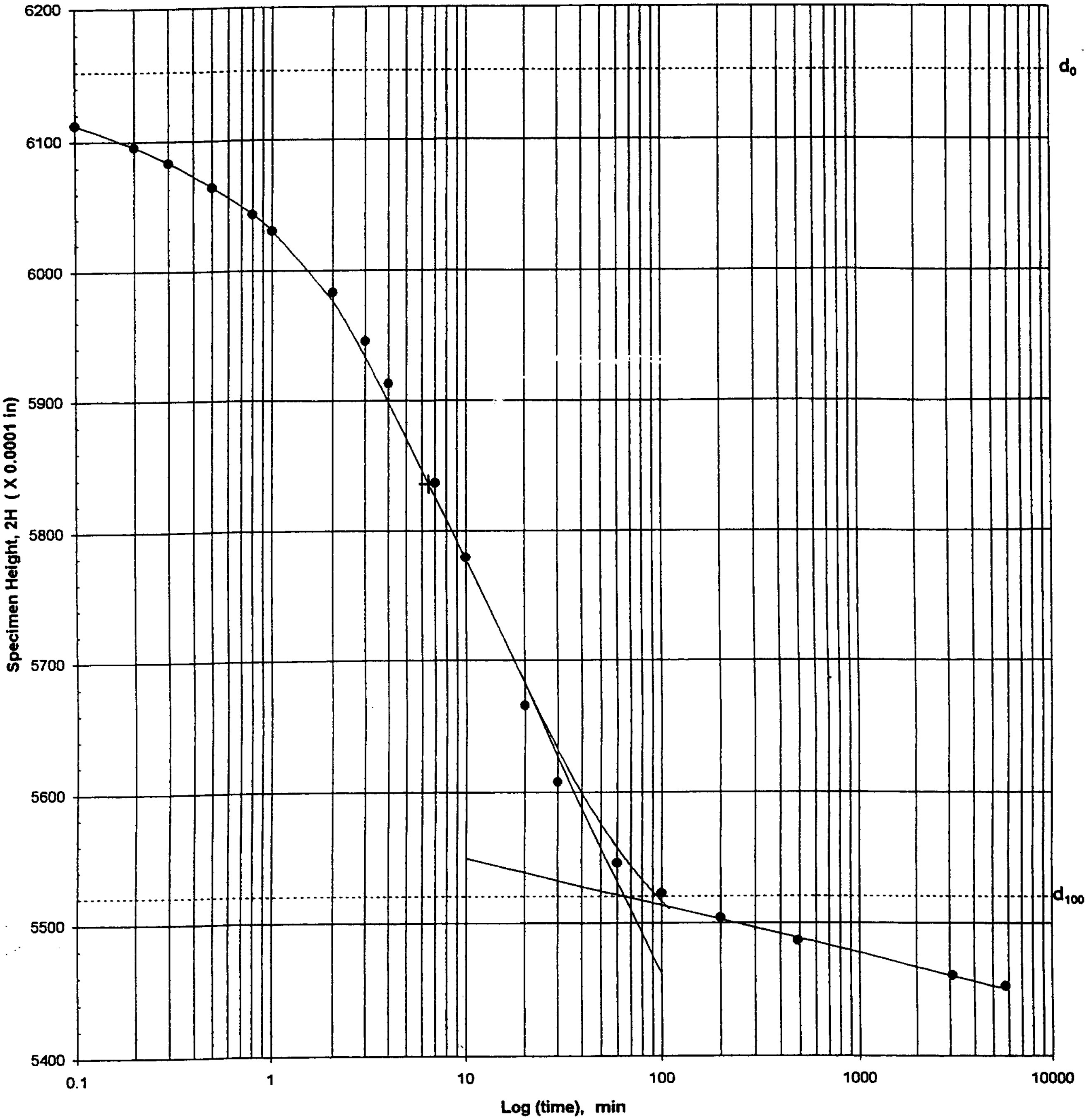
PROJECT: Poplar Island
Dike Raising
AREA: Talbot County, MD

Normal Stess = **8.0** tons/ft²
t_{50} = 5.88 min
H = 0.3215 in
c_v = 5.74 X 10^{-5} in²/sec

Hole No.: DH-6A	**Sample No.:** Shelby-1	**Depth (ft):** 28.0-30.0 ft

ENG Form 2088 **CONSOLIDATION TEST - TIME CURVE**

t_{50} TIME CURVE



U.S.Army Corps of Engineers
Materials & Instrumentation Section
Baltimore, Maryland 21230

PROJECT: Poplar Island
Dike Raising
AREA: Talbot County, MD

Normal Stess = **16.0** tons/ft²
t_{50} = 6.5 min
H = 0.2918 in
c_v = 4.28 X 10^{-5} in²/sec

Hole No.: DH-6A	**Sample No.:** Shelby-1	**Depth (ft):** 28.0-30.0 ft

ENG Form 2088 **CONSOLIDATION TEST - TIME CURVE**

GeoSystems Consultants, Inc.

Fort Washington, Pa 19034

Laboratory Testing Assignment & Billing Summary Sheet

Proj No: 2003G384 Project Name: Poplar Island Dike Raising Client: Baltimore USACOE

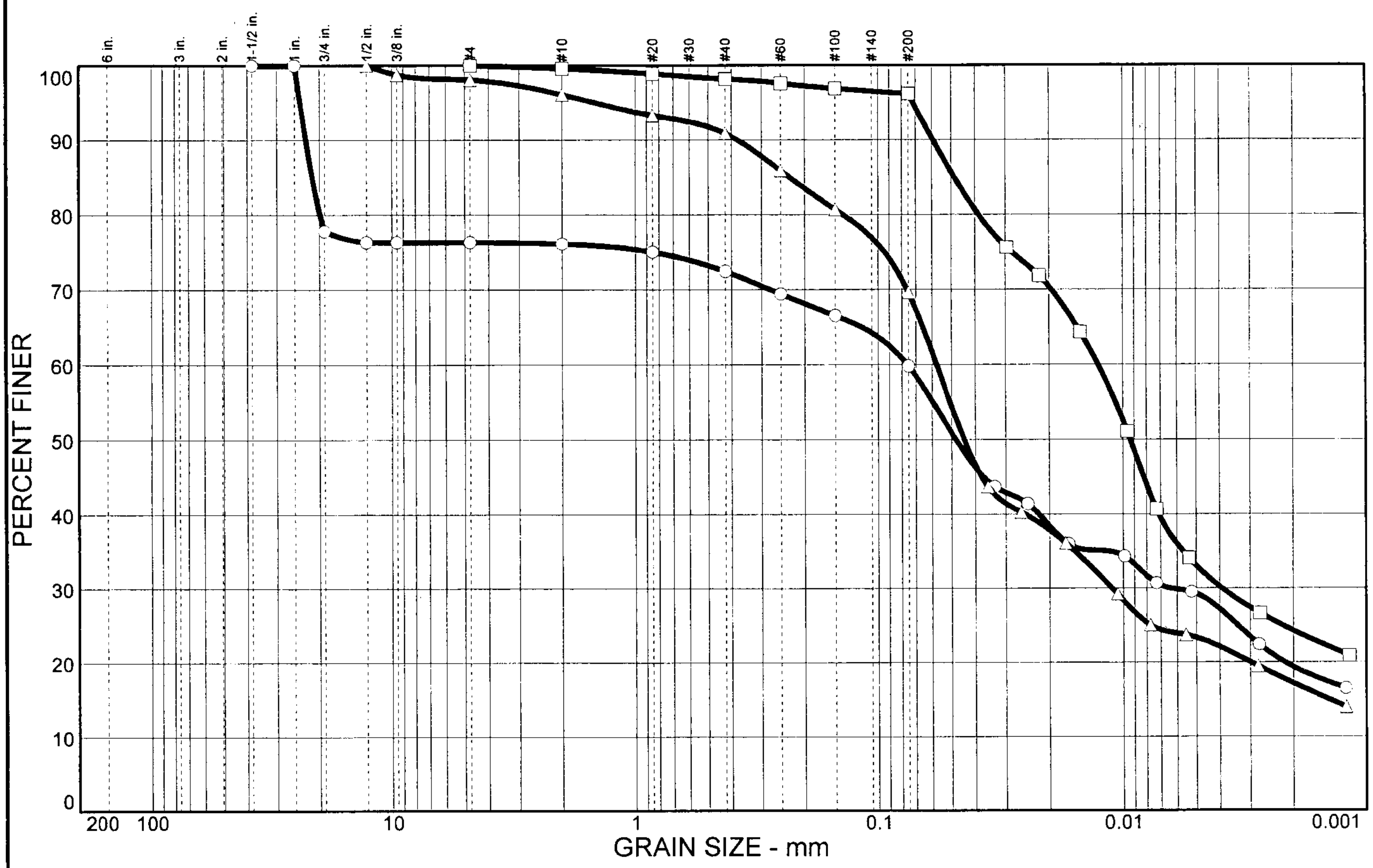
Date: June 12 2003 Reviewed By: CRC Proj Eng: CRC

File No. 2003G384 LS-1 Page No. 1

Date	Boring No.	Sample No.	Depth (ft)	Water Content (%) ASTM D 2216	Atterberg Limits liquid/plastic ASTM D 4318	Specific Gravity ASTM D 854	Sieve / Hydrometer ASTM D 422		% Finer Than # 200 ASTM D 1140	Carbonate ASTM D 3042	Perme-ability Test ASTM D 5084	Perme-ability Test ASTM D 2434	Consoli-dation Test ASTM D 2435	Uc Test ASTM D 2166	CIU Test ASTM D 4767	Compac-tion Test ASTM D 698 1557	Direct Shear ASTM D 3080
GSC Test No.				1.02	1.03	1.15	1.06	1.10	1.07	1.16	3.01	3.04	5.03	4.01	4.04a	2.01	4.03
12-Jun-03	**DH - 03A**	Shelby -1	27-29	*	37/18	2.71	*	*						*	*		
12-Jun-03	**DH - 09A**	Shelby -2	26-28	*	71/26	2.76	*	*							*		
12-Jun-03	**DH - 11A**	Shelby -1	25-27	*	69/21	2.69	*	*							*		

M:\Projects\2003\2003G384 USACOE Poplar Is\[2003G384 LS-1.xls]Lab SummaryJune 2003

Particle Size Distribution Report



	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		23.7	16.5	30.5	29.3	CL	A-6(9)	18	37
□			3.8	63.1	33.1	CH	A-7-6(50)	26	71
△		1.9	28.5	46.3	23.3	CH	A-7-6(33)	21	69

SIEVE inches size	PERCENT FINER ○	PERCENT FINER □	PERCENT FINER △
1.5	100.0		
1	100.0		
3/4	77.8		
1/2	76.3		100.0
3/8	76.3		98.8
	GRAIN SIZE		
D60	0.0759	0.0126	0.0575
D30	0.0064	0.0039	0.0111
D10			
	COEFFICIENTS		
Cc			
Cu			

SIEVE number size	PERCENT FINER ○	PERCENT FINER □	PERCENT FINER △
#4	76.3	100.0	98.1
#10	76.1	99.6	96.1
#20	75.0	98.9	93.3
#40	72.4	98.2	90.9
#60	69.4	97.6	85.9
#100	66.5	96.9	80.7
#200	59.8	96.2	69.6

SOIL DESCRIPTION

○ Light gray gravelly lean clay with sand

□ Light gray fat clay.

△ Gray sandy fat clay

REMARKS:

○ ASTMD 422

□ ASTMD 422

△ ASTMD 422

○ Source: DH-3A Sample No.: ST-1 Elev./Depth: 27.0-29.0
□ Source: DH-09A Sample No.: ST-2 Elev./Depth: 26.0-28.0
△ Source: DH-11A Sample No.: ST-1 Elev./Depth: 25.0-27.0

GeoSystems Consultants, Inc.

Client: U.S Army Corps of Engineers
Project: Poplar Island Dike Raising
Project No.: 2003G384 File # 01

GeoSystems Consultants

Project No.	2003g384	Date	6/23/2003
Project Name:	Poplar Island Dike Raising		
Boring No.	DH-03A	Depth	27.0-29.0
Sample No.	ST-1	File No	2003384tl-2

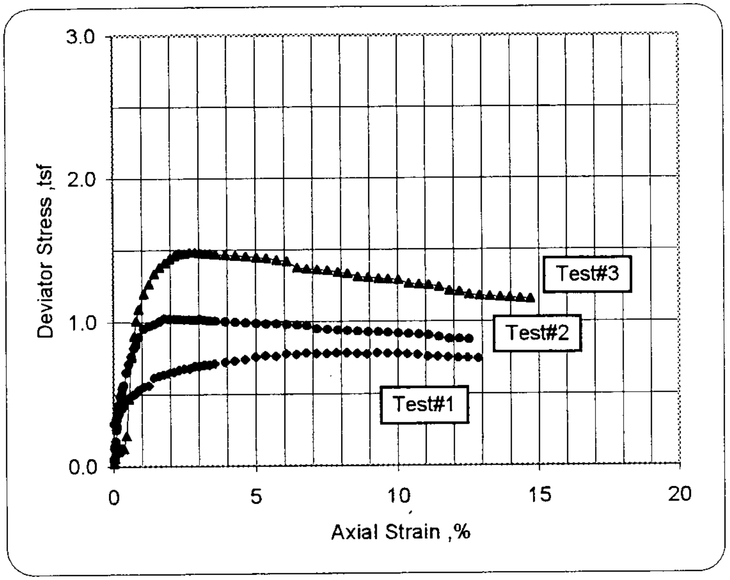
Tube Log

Type of Tube	Steel
Diameter of Tube	3"
Length of Tube	30"
Weight of tube and Soil	
Weight of tube and Soil	
Weight of Soil	
Total Recovery	24"
Remark	

Top Of Soil		Soil Description and Remarks
0, Inch.		
1		
2	UC Test	
3		Gray and gets firm with depth, silty clay
4		Scattered mottled pyrite or coarse grain Nodules
5		
6		
7		
8	CIU-1	
9		
10		
11		
12		
13		
14	CIU-2	
15		
16		
17		
18		
19		
20	CIU-3	
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		

File No. GSC-3 Tested By TV/ENM

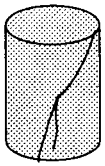
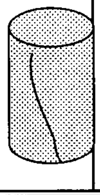
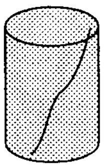
GeoSystems Consultants, Inc.

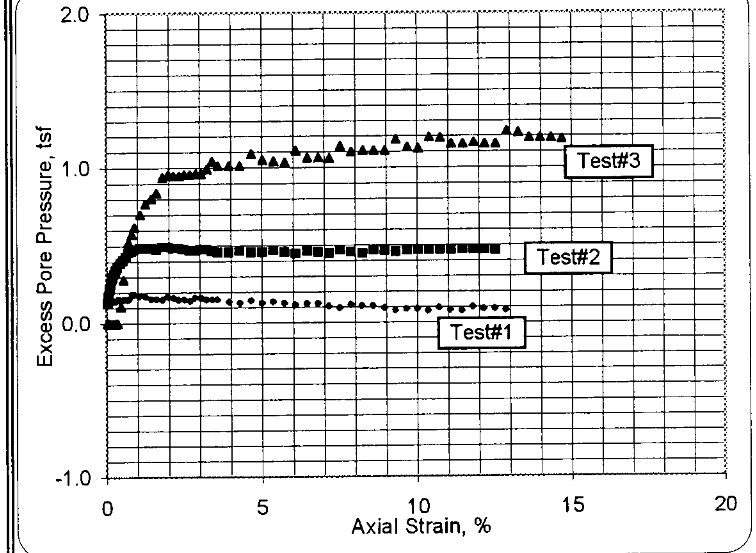


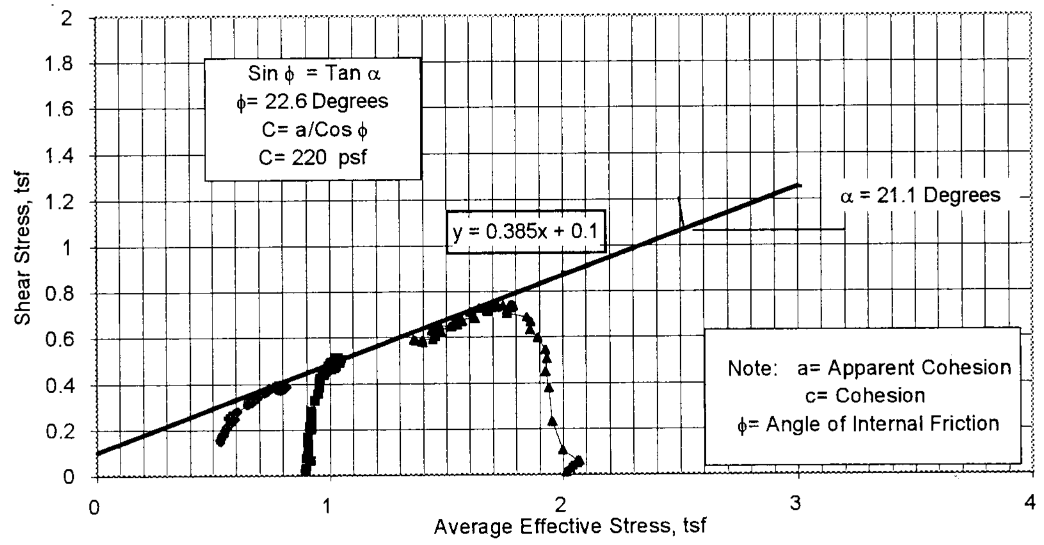
Test Sample Summary

Test No.	Boring No.	Sample No.	Depth Ft.	Water Content, %	Dry Density, pcf	Init.Void Ratio	Initial Saturation, %	$\bar{\sigma}$ tsf
1	DH-O3A	ST	27.0-29.0	30.5	89.7	0.887	93.2	0.50
2	DH-O3A	ST	27.0-29.0	29.9	91.9	0.841	96.4	1.00
3	DH-O3A	ST	27.0-29.0	31.2	89.7	0.885	95.6	2.00
4								
5								

Test Series Summary

Test No.	Max. Deviator Stress, tsf	Value at Maximum Shear Stress			Test# 1	Test#2	Test#3	
		Axial Strain, %	Obliquity	A- Factor				
1	0.79	7.86	3.041	0.147				
2	1.02	1.79	3.005	0.479				
3	1.48	2.33	2.408	0.643				
4								
5								





Sin ϕ = Tan α
ϕ= 22.6 Degrees
C= a/Cos ϕ
C= 220 psf

Note: a= Apparent Cohesion
c= Cohesion
ϕ= Angle of Internal Friction

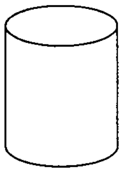
Isotropically Consolidated Undrained Triaxial Test Series (With Pore Pressure Measurements) ASTMD 4767

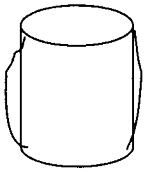
Project No.	2003G384	**File No**	2003G384ciu-1	**Figure No**	
Project Name	Poplar Island Dike Raising			**Date**	6/27/2003

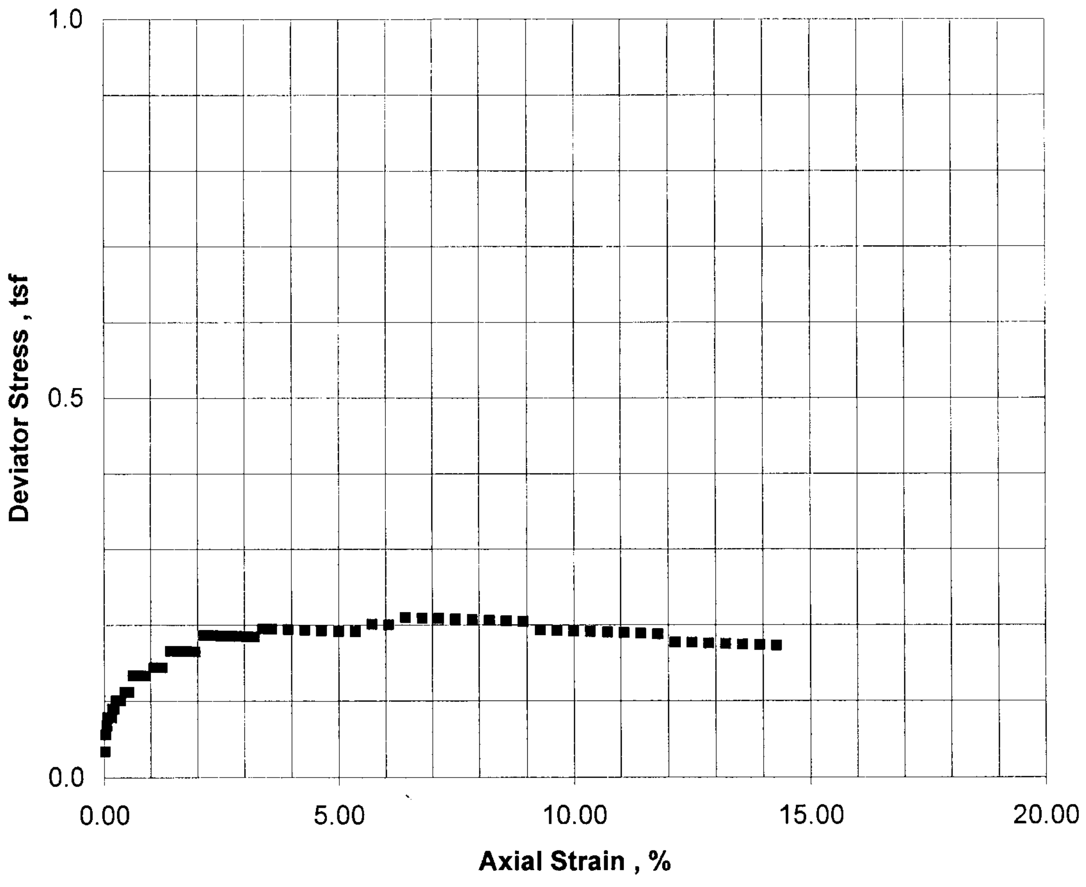
GeoSystems Consultants , Inc.

Fort Washington , Pa.

Project Name:	Poplar Island Dike Raising			Project No.	2003g384
Boring No.	DH-3A	Sample No.	ST-1	Depth,ft.	27.0-29.0
Description	Gray soft silty clay			File No.	2003384uc-1
Moisture Cont.,%	31.83	Dry Density , pcf	90.2	Void Ratio	0.875
Strain @ Fail.,%	6.43	Maximum Deviator Stress, tsf	0.21	Init. Saturation	98.58


Before


After


Unconfined Compression Test
ASTMD 2166

GeoSystems Consultants

Project No.	2003g384	Date	6/24/2003
Project Name:	Poplar Island Dike Raising		
Boring No.	DH-09A	Depth	26.0-28.0
Sample No.	ST-2	File No	2003384tl-1

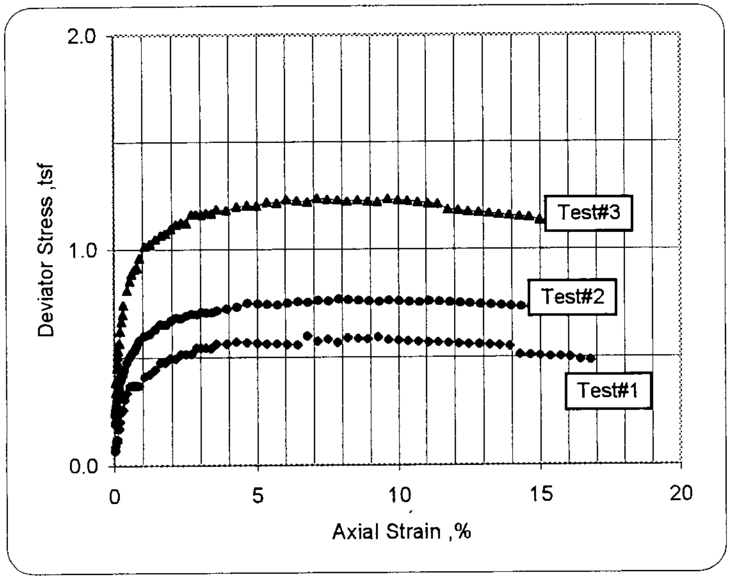
Tube Log

Type of Tube	Steel
Diameter of Tube	3"
Length of Tube	30"
Weight of tube and Soil	
Weight of tube and Soil	
Weight of Soil	
Total Recovery	24"
Remark	

Top Of Soil	Soil Description and Remarks			
0, Inch.				
1		Top 3" looks disturbed		
2				
3		Gray and gets firm with depth, silty clay		
4				
5	CIU-1			
6				
7				
8				
9				
10				
11	CIU-2			
12				
13				
14				
15				
16				
17				
18	CIU-3			
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

File No. GSC-3 Tested By TV/ENM

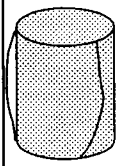
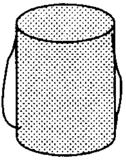
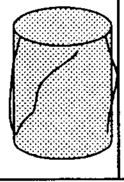
GeoSystems Consultants, Inc.

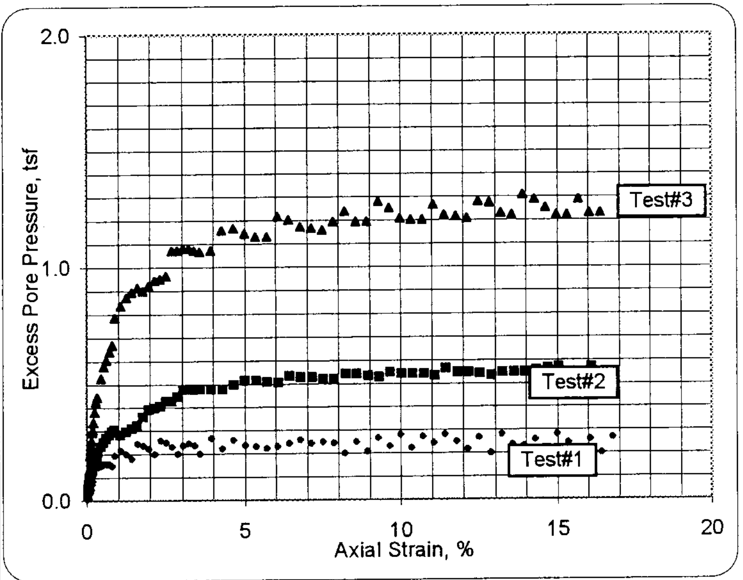


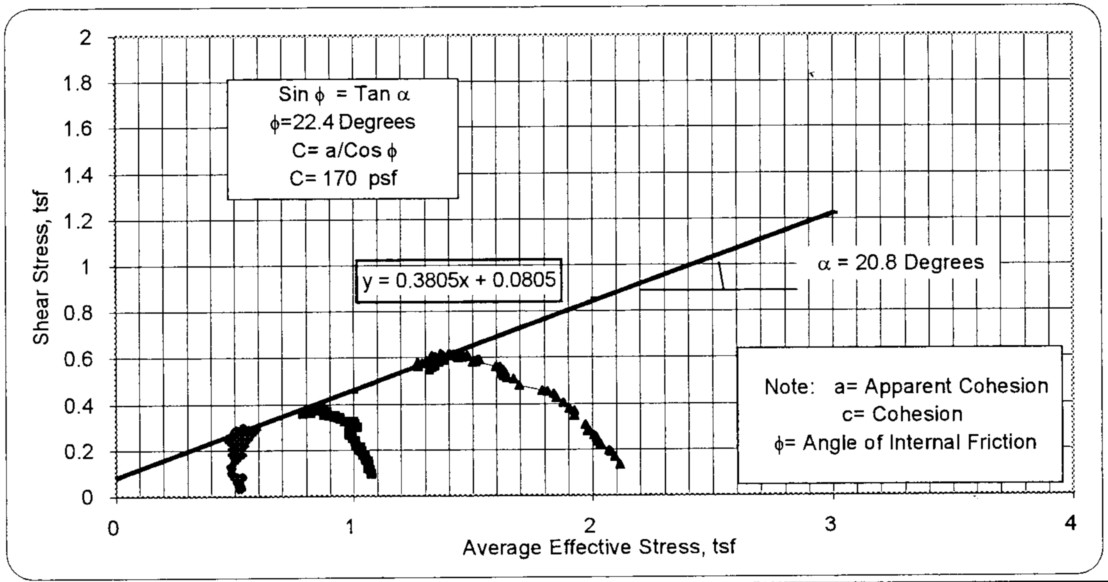
Test Sample Summary

Test No.	Boring No.	Sample No.	Depth Ft.	Water Content, %	Dry Density, pcf	Void Ratio	Init. Saturation	$\bar{\sigma}$ tsf
1	DH-09A	ST-2	26.0-28.0	56.7	65.8	1.550	98.4	0.50
2	DH-09A	ST-2	26.0-28.0	59.3	64.9	1.654	98.9	1.00
3	DH-09A	ST-2	26.0-28.0	63.2	63.3	1.741	100.9	2.00
4								
5								

Test Series Summary

Test No.	Max. Deviator Stress, tsf	Value at Maximum Shear Stress			Test# 1	Test#2	Test#3	
		Axial Strain, %	Obliquity	A- Factor				
1	0.60	6.79	3.473	0.435				
2	0.76	7.17	2.389	0.798				
3	1.24	7.17	2.484	0.943				
4								
5								





Isotropically Consolidated Undrained Triaxial Test Series (With Pore Pressure Measurements)ASTMD 4767

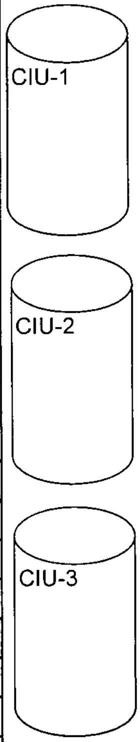
Project No. 2003G384 **File No** 2003G384ciu-3 **Figure No**
Project Name Poplar Island Dike Raising **Date** 6/27/2003

GeoSystems Consultants

Project No.	2003g384	Date	6/26/2003
Project Name:	Poplar Island Dike Raising		
Boring No.	DH-11A	Depth	25.0-27.0
Sample No.	ST-1	File No	2003384tl-3

Tube Log

Type of Tube	Steel
Diameter of Tube	3"
Length of Tube	30"
Weight of tube and Soil	
Weight of tube and Soil	
Weight of Soil	
Total Recovery	22"
Remark	



Top Of Soil	Soil Description and Remarks
0, Inch.	
1	
2	
3	Gray and gets firm with depth, silty clay
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
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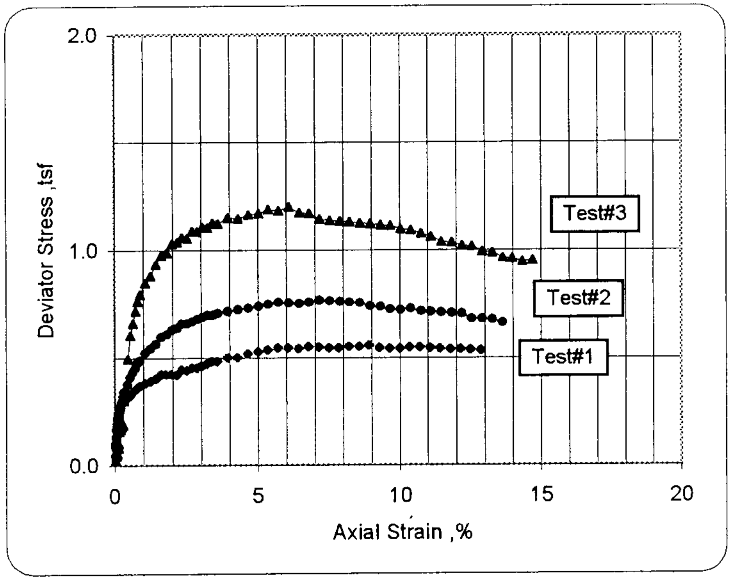
30	

File No. GSC-3 Tested By TV/ENM

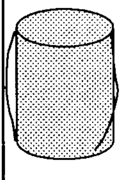
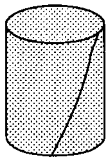
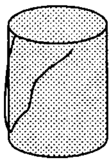
GeoSystems Consultants, Inc.

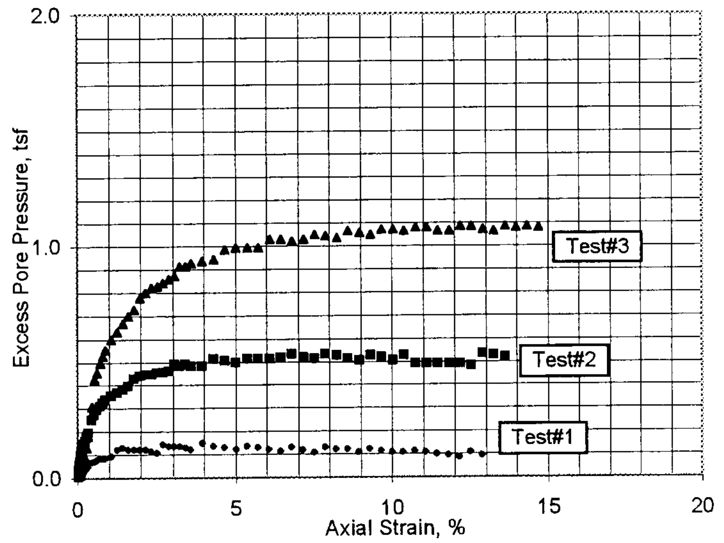


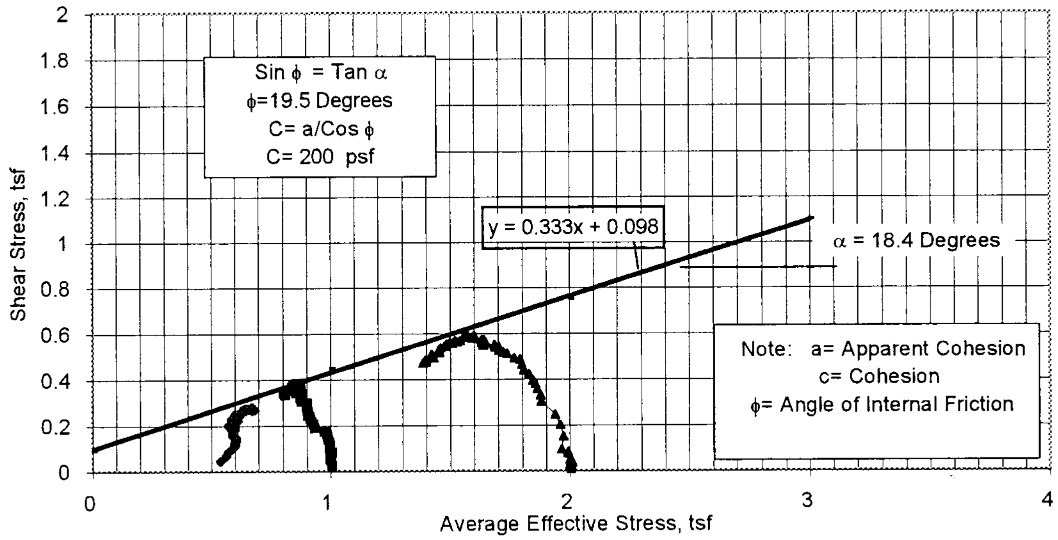
Test Sample Summary

Test No.	Boring No.	Sample No.	Depth Ft.	Water Content, %	Dry Density, pcf	Void Ratio	Init. Saturation	$\bar{\sigma}$ tsf
1	DH-11A	ST	25.0-27.0	38.4	83.6	1.060	100.0	0.50
2	DH-11A	ST	25.0-27.0	50.1	72.4	1.380	100.3	1.00
3	DH-11A	ST	25.0-27.0	59.4	64.5	1.671	98.1	2.00
4								
5								

Test Series Summary

Test No.	Max. Deviator Stress, tsf	Value at Maximum Shear Stress			Test# 1	Test#2	Test#3	
		Axial Strain, %	Obliquity	A- Factor				
1	0.56	8.93	2.426	0.193				
2	0.77	7.17	2.589	0.677				
3	1.20	6.09	2.235	0.859				
4								
5								





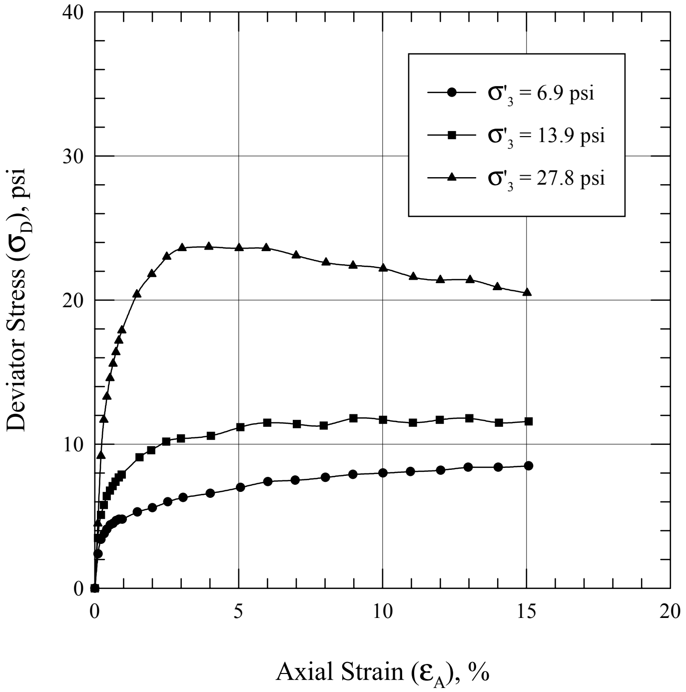
Sin ϕ = Tan α
ϕ=19.5 Degrees
C= a/Cos ϕ
C= 200 psf

Note: a= Apparent Cohesion
c= Cohesion
ϕ= Angle of Internal Friction

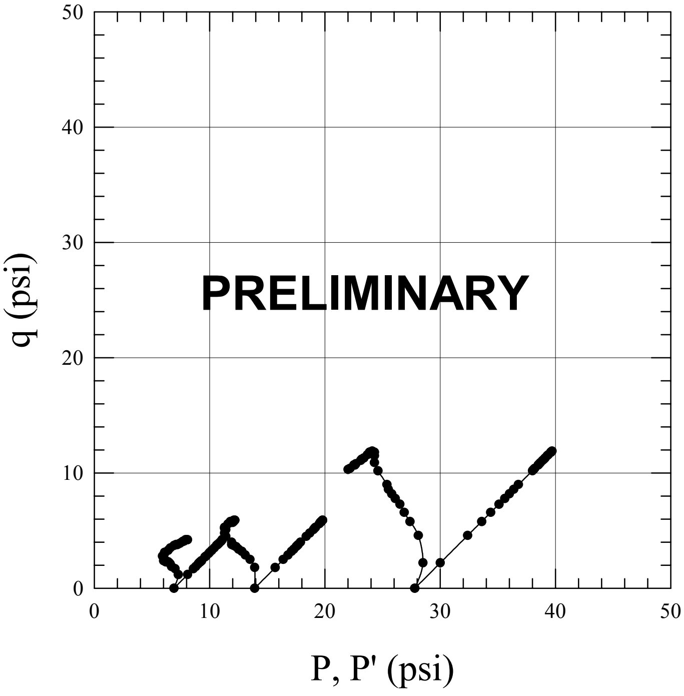
Isotropically Consolidated Undrained Triaxial Test Series (With Pore Pressure Measurements) ASTMD 4767

Project No. 2003G384 **File No** 2003G384ciu-2 **Figure No**
Project Name Poplar Island Dike Raising **Date** 6/27/2003

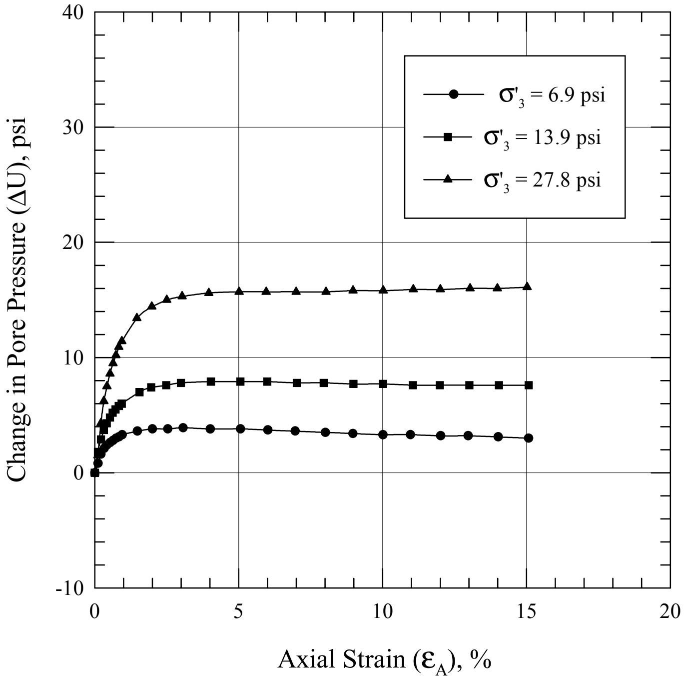
Deviator Stress vs. Axial Strain



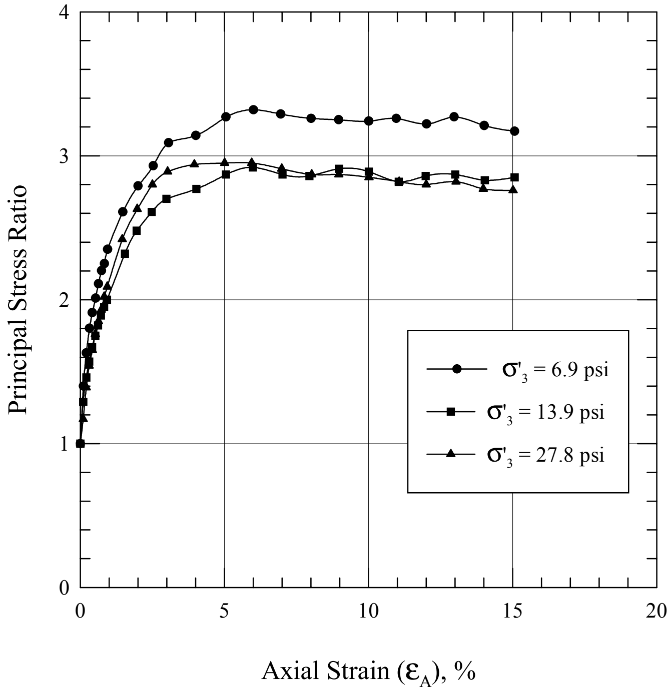
Stress Paths



Change in Pore Pressure vs. Axial Strain



Principal Stress Ratio vs. Axial Strain



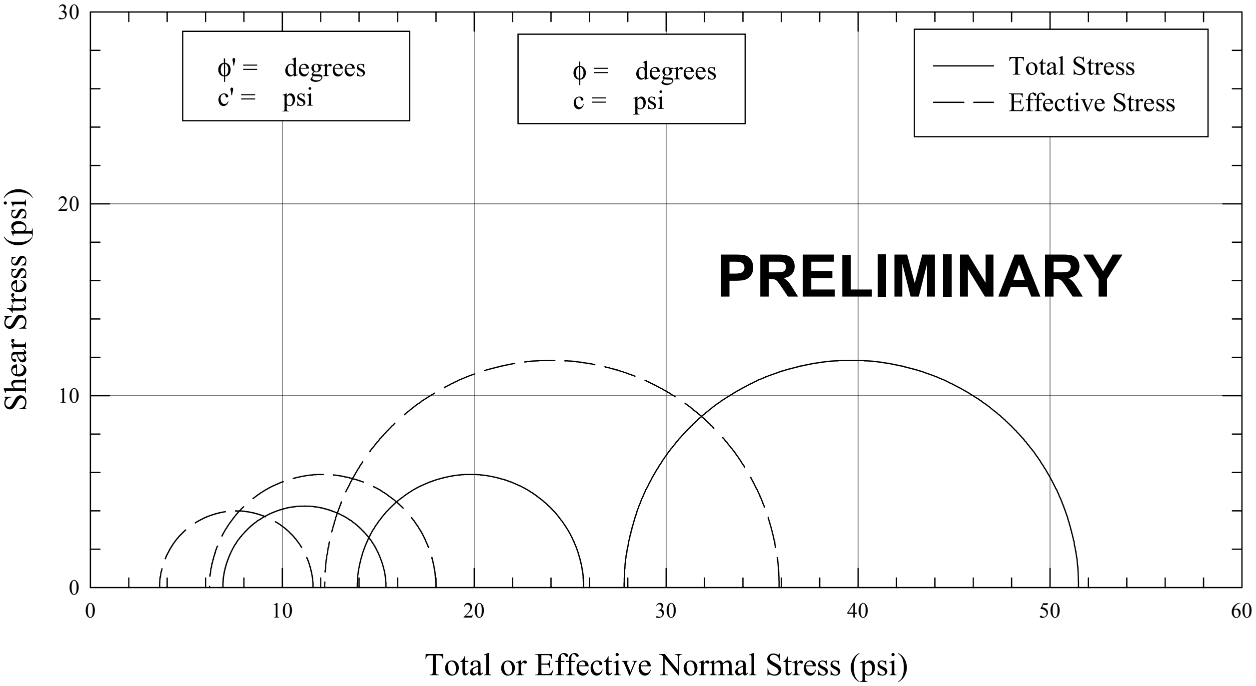
Boring No.: *BH-13A* Depth: *26.5-28.5 ft* SEI Contract: *04141015* Date:
Sample Description: *LEAN CLAY - light gray* Reviewed By:
Specimen Type: *Tube Sample* Specific Gravity: *2.72* LL: PI: %<200:

Schnabel
Schnabel Engineering

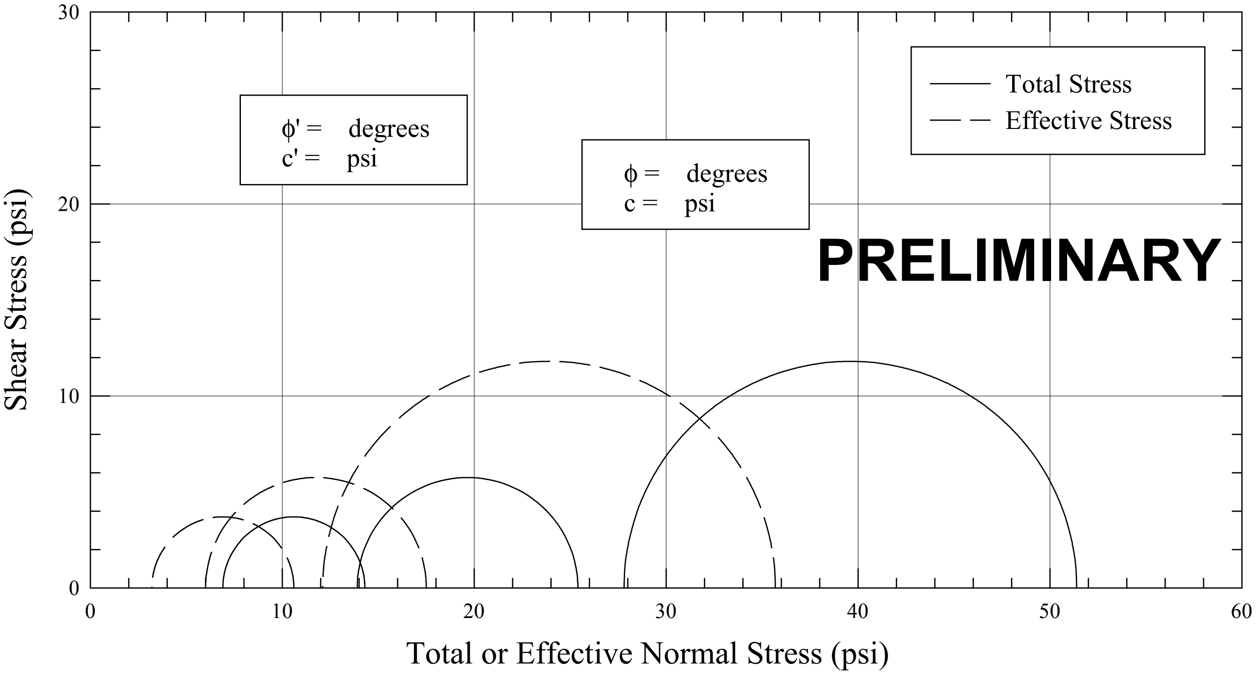
Poplar Island Dike Raising
Talbot County, Maryland

Consolidated Undrained (CU) Triaxial Shear (ASTM D4767)

Mohr Stress Circles at Maximum Deviator Stress Criterion



Mohr Stress Circles at Maximum Principal Stress Ratio Criterion



Boring No.: *BH-13A* Depth: *26.5-28.5 ft* SEI Contract: *04141015* Date:
Sample Description: *LEAN CLAY - light gray* Reviewed By:
Specimen Type: *Tube Sample* Specific Gravity: *2.72* LL: PI: %<200:

Schnabel Engineering

Poplar Island Dike Raising
Talbot County, Maryland

Consolidated Undrained Triaxial Compression Test

ASTM D4767

Schnabel Contract: *04141015*
Date:
Project: *Poplar Island Dike Raising*
Boring No.: *DH-13A*
Depth: *26.5-28.5 ft.*
Location: *Talbot County, MD*
Confining Stress (psi): *6.9*
Reviewed by: *0*

	Specimen Conditions	
	Initial	Consolidated
Diameter (in)	2.883	2.83
Height (in)	5.796	5.69
Area (in^2)	6.53	6.28
Moisture (%)	35.9	▨
W_{solids} (lbs)	1.89	▨
ρ_{wet} (pcf)	117.2	▨
ρ_{dry} (pcf)	86.2	91.2
Void Ratio	0.96	0.85
Saturation, %	100	96

Shear Testing Conditions	
Cell Pressure (psi):	21.9
Back Pressure (psi):	15.0
Eff. Confining Stress (psi):	6.9
Final B check	0.95
t_{50} (min.):	19.4
Rate of Strain (%/min):	0.021

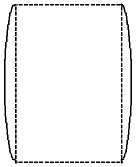
Soil Description: *LEAN CLAY - light gray*

Liquid Limit: *36*
Plasticity Index: *22*
% finer that No. 200: *0.0*

Specimen Type: *Tube Sample*

Remarks: *PRELIMINARY RESULTS*

Failure Sketch



Reading No.	Deviator Load (lbs)	Corrected[1] Dev. Load (lbs.)	Axial Deformation (in.)	Axial Strain (%)	Pore Pressure (psi)	Change in Pore Press. (psi)	Corrected Area[2] (in^2)	σ_1 (psi)	σ_3 (psi)	σ'_1 (psi)	σ'_3 (psi)	Deviator Stress (psi)	Principal Stress Ratio	A bar	P (psi)	P' (psi)	q (psi)
Zero	0.0	0.0	0.000	0.00	15.0	0.0	6.28	6.9	6.9	6.9	6.9	0.0	1.00	0.00	6.9	6.9	0.0
1	15.4	15.2	0.006	0.11	15.8	0.8	6.29	9.3	6.9	8.5	6.1	2.4	1.40	0.33	8.1	7.3	1.2
2	21.6	21.1	0.012	0.21	16.6	1.6	6.29	10.3	6.9	8.7	5.3	3.4	1.63	0.48	8.6	7.0	1.7
3	24.8	24.1	0.018	0.32	17.1	2.1	6.30	10.7	6.9	8.6	4.8	3.8	1.80	0.55	8.8	6.7	1.9
4	26.9	25.9	0.024	0.42	17.4	2.4	6.31	11.0	6.9	8.6	4.5	4.1	1.91	0.58	9.0	6.6	2.1
5	28.7	27.5	0.030	0.53	17.6	2.6	6.31	11.3	6.9	8.7	4.3	4.4	2.01	0.60	9.1	6.5	2.2
6	30.1	28.6	0.036	0.63	17.8	2.8	6.32	11.4	6.9	8.6	4.1	4.5	2.11	0.62	9.2	6.4	2.3
7	31.2	29.5	0.042	0.74	18.0	3.0	6.33	11.6	6.9	8.6	3.9	4.7	2.20	0.64	9.2	6.2	2.3
8	32.1	30.2	0.048	0.84	18.1	3.1	6.33	11.7	6.9	8.6	3.8	4.8	2.25	0.65	9.3	6.2	2.4
9	32.9	30.7	0.054	0.95	18.3	3.3	6.34	11.7	6.9	8.4	3.6	4.8	2.35	0.68	9.3	6.0	2.4
10	37.2	33.8	0.084	1.48	18.6	3.6	6.38	12.2	6.9	8.6	3.3	5.3	2.61	0.68	9.6	6.0	2.7
11	40.2	35.6	0.114	2.00	18.8	3.8	6.41	12.5	6.9	8.7	3.1	5.6	2.79	0.68	9.7	5.9	2.8
12	43.2	38.5	0.144	2.53	18.8	3.8	6.44	12.9	6.9	9.1	3.1	6.0	2.93	0.64	9.9	6.1	3.0
13	45.4	40.6	0.174	3.06	18.9	3.9	6.48	13.2	6.9	9.3	3.0	6.3	3.09	0.62	10.0	6.1	3.1
14	48.4	43.4	0.228	4.01	18.8	3.8	6.54	13.5	6.9	9.7	3.1	6.6	3.14	0.57	10.2	6.4	3.3
15	51.8	46.5	0.288	5.06	18.8	3.8	6.62	13.9	6.9	10.1	3.1	7.0	3.27	0.54	10.4	6.6	3.5
16	55.0	49.5	0.342	6.01	18.7	3.7	6.68	14.3	6.9	10.6	3.2	7.4	3.32	0.50	10.6	6.9	3.7
17	56.6	50.9	0.396	6.96	18.6	3.6	6.75	14.4	6.9	10.8	3.3	7.5	3.29	0.48	10.7	7.1	3.8
18	58.4	52.5	0.456	8.01	18.5	3.5	6.83	14.6	6.9	11.1	3.4	7.7	3.26	0.46	10.7	7.2	3.8
19	60.5	54.4	0.510	8.96	18.4	3.4	6.90	14.8	6.9	11.4	3.5	7.9	3.25	0.43	10.8	7.4	3.9
20	62.5	56.2	0.570	10.01	18.3	3.3	6.98	14.9	6.9	11.6	3.6	8.0	3.24	0.41	10.9	7.6	4.0
21	63.9	57.4	0.624	10.96	18.3	3.3	7.05	15.0	6.9	11.7	3.6	8.1	3.26	0.41	11.0	7.7	4.1
22	65.5	58.8	0.684	12.02	18.2	3.2	7.14	15.1	6.9	11.9	3.7	8.2	3.22	0.39	11.0	7.8	4.1
23	67.5	60.6	0.738	12.97	18.2	3.2	7.22	15.3	6.9	12.1	3.7	8.4	3.27	0.38	11.1	7.9	4.2
24	68.4	61.2	0.798	14.02	18.1	3.1	7.31	15.3	6.9	12.2	3.8	8.4	3.21	0.37	11.1	8.0	4.2
25	70.0	62.6	0.858	15.07	18.0	3.0	7.40	15.4	6.9	12.4	3.9	8.5	3.17	0.35	11.1	8.1	4.2

Notes:
1. Deviator load corrected for membrane and filter cage (if applicable) effects.
2. Right Cylinder Correction Method

Consolidated Undrained Triaxial Compression Test

ASTM D4767

Schnabel Contract: *04141015*

Date:

Project: *Poplar Island Dike Raising*

Boring No.: *DH-13A*

Depth: *26.5-28.5 ft.*

Location: *Talbot County, MD*

Confining Stress (psi): *13.9*

Reviewed by: *0*

	Specimen Conditions	
	Initial	Consolidated
Diameter (in)	2.881	2.82
Height (in)	5.924	5.81
Area (in^2)	6.52	6.26
Moisture (%)	40.7	
W_{solids} (lbs)	1.86	
ρ_{wet} (pcf)	116.8	
ρ_{dry} (pcf)	83.0	88.2
Void Ratio	1.04	0.92
Saturation, %	100	86

Shear Testing Conditions	
Cell Pressure (psi):	28.9
Back Pressure (psi):	15.0
Eff. Confining Stress (psi):	13.9
Final B check	0.95
t_{50} (min.):	16.7
Rate of Strain (%/min):	0.021

Soil Description: *LEAN CLAY trace sand - light gray*

Liquid Limit: *36*

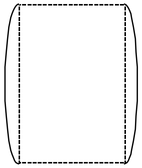
Plasticity Index: *22*

% finer that No. 200: *0.0*

Specimen Type: *Tube Sample*

Remarks: *PRELIMINARY RESULTS*

Failure Sketch



Reading No.	Deviator Load (lbs)	Corrected[1] Dev. Load (lbs.)	Axial Deformation (in.)	Axial Strain (%)	Pore Pressure (psi)	Change in Pore Press. (psi)	Corrected Area[2] (in^2)	σ_1 (psi)	σ_3 (psi)	σ'_1 (psi)	σ'_3 (psi)	Deviator Stress (psi)	Principal Stress Ratio	A_{bar}	P (psi)	P' (psi)	q (psi)
Zero	0.0	0.0	0.000	0.00	15.0	0.0	6.26	13.9	13.9	13.9	13.9	0.0	1.00	0.00	13.9	13.9	0.0
1	22.4	22.2	0.006	0.10	16.8	1.8	6.27	17.4	13.9	15.6	12.1	3.5	1.29	0.51	15.7	13.9	1.8
2	32.2	31.7	0.012	0.21	17.9	2.9	6.27	19.0	13.9	16.1	11.0	5.1	1.46	0.57	16.4	13.5	2.5
3	37.3	36.6	0.018	0.31	18.7	3.7	6.28	19.7	13.9	16.0	10.2	5.8	1.57	0.64	16.8	13.1	2.9
4	41.1	40.1	0.024	0.41	19.3	4.3	6.29	20.3	13.9	16.0	9.6	6.4	1.67	0.67	17.1	12.8	3.2
5	44.0	42.8	0.030	0.52	19.8	4.8	6.29	20.7	13.9	15.9	9.1	6.8	1.75	0.71	17.3	12.5	3.4
6	46.4	45.0	0.036	0.62	20.2	5.2	6.30	21.0	13.9	15.8	8.7	7.1	1.82	0.73	17.5	12.3	3.6
7	48.6	46.9	0.042	0.72	20.5	5.5	6.31	21.3	13.9	15.8	8.4	7.4	1.89	0.74	17.6	12.1	3.7
8	50.4	48.5	0.048	0.83	20.8	5.8	6.31	21.6	13.9	15.8	8.1	7.7	1.95	0.75	17.7	11.9	3.8
9	52.2	50.1	0.054	0.93	21.0	6.0	6.32	21.8	13.9	15.8	7.9	7.9	2.00	0.76	17.9	11.9	4.0
10	61.4	57.8	0.090	1.55	22.0	7.0	6.36	23.0	13.9	16.0	6.9	9.1	2.32	0.77	18.4	11.4	4.5
11	65.9	61.4	0.114	1.96	22.4	7.4	6.39	23.5	13.9	16.1	6.5	9.6	2.48	0.77	18.7	11.3	4.8
12	70.0	65.3	0.144	2.48	22.6	7.6	6.42	24.1	13.9	16.5	6.3	10.2	2.61	0.75	19.0	11.4	5.1
13	71.8	67.0	0.174	2.99	22.8	7.8	6.45	24.3	13.9	16.5	6.1	10.4	2.70	0.75	19.1	11.3	5.2
14	74.3	69.3	0.234	4.03	22.9	7.9	6.52	24.5	13.9	16.6	6.0	10.6	2.77	0.74	19.2	11.3	5.3
15	79.1	73.8	0.294	5.06	22.9	7.9	6.59	25.1	13.9	17.2	6.0	11.2	2.87	0.71	19.5	11.6	5.6
16	82.3	76.8	0.348	5.99	22.9	7.9	6.66	25.4	13.9	17.5	6.0	11.5	2.92	0.68	19.7	11.8	5.8
17	82.3	76.6	0.408	7.02	22.8	7.8	6.73	25.3	13.9	17.5	6.1	11.4	2.87	0.69	19.6	11.8	5.7
18	83.0	77.1	0.462	7.95	22.8	7.8	6.80	25.2	13.9	17.4	6.1	11.3	2.86	0.69	19.6	11.8	5.7
19	87.5	81.4	0.522	8.98	22.7	7.7	6.88	25.7	13.9	18.0	6.2	11.8	2.91	0.65	19.8	12.1	5.9
20	87.7	81.4	0.582	10.01	22.7	7.7	6.96	25.6	13.9	17.9	6.2	11.7	2.89	0.66	19.7	12.0	5.8
21	87.3	80.8	0.642	11.05	22.6	7.6	7.04	25.4	13.9	17.8	6.3	11.5	2.82	0.66	19.6	12.0	5.7
22	90.0	83.3	0.696	11.98	22.6	7.6	7.11	25.6	13.9	18.0	6.3	11.7	2.86	0.65	19.8	12.2	5.9
23	91.9	85.0	0.756	13.01	22.6	7.6	7.20	25.7	13.9	18.1	6.3	11.8	2.87	0.64	19.8	12.2	5.9
24	91.2	84.0	0.816	14.04	22.6	7.6	7.28	25.4	13.9	17.8	6.3	11.5	2.83	0.66	19.7	12.1	5.8
25	93.2	85.8	0.876	15.07	22.6	7.6	7.37	25.5	13.9	17.9	6.3	11.6	2.85	0.65	19.7	12.1	5.8

Notes:

1. Deviator load corrected for membrane and filter cage (if applicable) effects.
2. Right Cylinder Correction Method

Schnabel Engineering

Consolidated Undrained Triaxial Compression Test

ASTM D4767

Schnabel Contract: *04141015*

Date:

Project: *Poplar Island Dike Raising*

Boring No.: *DH-13A*

Depth: *24-26 ft.*

Location: *Talbot County, MD*

Confining Stress (psi): *27.8*

Reviewed by: *0*

	Specimen Conditions	
	Initial	Consolidated
Diameter (in)	2.875	2.79
Height (in)	5.918	5.75
Area (in^2)	6.49	6.10
Moisture (%)	41.4	
W_{solids} (lbs)	1.78	
ρ_{wet} (pcf)	113.4	
ρ_{dry} (pcf)	80.2	87.8
Void Ratio	1.11	0.93
Saturation, %	100	97

Shear Testing Conditions	
Cell Pressure (psi):	37.8
Back Pressure (psi):	10.0
Eff. Confining Stress (psi):	27.8
Final B check	0.96
t_{50} (min.):	19.4
Rate of Strain (%/min):	0.021

Soil Description: *LEAN CLAY trace sand - light gray*

Liquid Limit: *36*

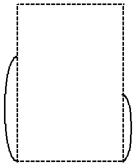
Plasticity Index: *22*

% finer that No. 200: *0.0*

Specimen Type: *Tube Sample*

Remarks: *PRELIMINARY RESULTS*

Failure Sketch



Reading No.	Deviator Load (lbs)	Corrected[1] Dev. Load (lbs.)	Axial Deformation (in.)	Axial Strain (%)	Pore Pressure (psi)	Change in Pore Press. (psi)	Corrected Area[2] (in^2)	σ_1 (psi)	σ_3 (psi)	σ'_1 (psi)	σ'_3 (psi)	Deviator Stress (psi)	Principal Stress Ratio	A bar	P (psi)	P' (psi)	q (psi)
Zero	0.0	0.0	0.000	0.00	10.0	0.0	6.10	27.8	27.8	27.8	27.8	0.0	1.00	0.00	27.8	27.8	0.0
1	27.6	27.4	0.006	0.10	11.5	1.5	6.11	32.3	27.8	30.8	26.3	4.5	1.17	0.33	30.0	28.5	2.2
2	57.0	56.5	0.012	0.21	14.3	4.3	6.12	37.0	27.8	32.7	23.5	9.2	1.39	0.47	32.4	28.1	4.6
3	72.2	71.5	0.018	0.31	16.2	6.2	6.12	39.5	27.8	33.3	21.6	11.7	1.54	0.53	33.6	27.4	5.8
4	82.4	81.4	0.024	0.42	17.5	7.5	6.13	41.1	27.8	33.6	20.3	13.3	1.65	0.56	34.4	26.9	6.6
5	90.6	89.4	0.030	0.52	18.6	8.6	6.13	42.4	27.8	33.8	19.2	14.6	1.76	0.59	35.1	26.5	7.3
6	97.2	95.8	0.036	0.63	19.5	9.5	6.14	43.4	27.8	33.9	18.3	15.6	1.85	0.61	35.6	26.1	7.8
7	102.7	101.0	0.042	0.73	20.2	10.2	6.15	44.2	27.8	34.0	17.6	16.4	1.93	0.62	36.0	25.8	8.2
8	107.6	105.7	0.048	0.83	20.9	10.9	6.15	45.0	27.8	34.1	16.9	17.2	2.02	0.63	36.4	25.5	8.6
9	112.5	110.3	0.054	0.94	21.4	11.4	6.16	45.7	27.8	34.3	16.4	17.9	2.09	0.64	36.8	25.4	9.0
10	129.7	126.3	0.084	1.46	23.4	13.4	6.19	48.2	27.8	34.8	14.4	20.4	2.42	0.66	38.0	24.6	10.2
11	140.4	135.8	0.114	1.98	24.4	14.4	6.23	49.6	27.8	35.2	13.4	21.8	2.63	0.66	38.7	24.3	10.9
12	148.8	144.1	0.144	2.50	25.0	15.0	6.26	50.8	27.8	35.8	12.8	23.0	2.80	0.65	39.3	24.3	11.5
13	153.1	148.3	0.174	3.03	25.3	15.3	6.29	51.4	27.8	36.1	12.5	23.6	2.89	0.65	39.6	24.3	11.8
14	155.8	150.8	0.228	3.96	25.6	15.6	6.35	51.5	27.8	35.9	12.2	23.7	2.94	0.66	39.7	24.1	11.9
15	156.7	151.5	0.288	5.01	25.7	15.7	6.42	51.4	27.8	35.7	12.1	23.6	2.95	0.67	39.6	23.9	11.8
16	158.6	153.2	0.342	5.95	25.7	15.7	6.49	51.4	27.8	35.7	12.1	23.6	2.95	0.67	39.6	23.9	11.8
17	157.5	151.9	0.402	6.99	25.7	15.7	6.56	50.9	27.8	35.2	12.1	23.1	2.91	0.68	39.4	23.7	11.6
18	155.8	149.9	0.462	8.03	25.7	15.7	6.64	50.4	27.8	34.7	12.1	22.6	2.87	0.69	39.1	23.4	11.3
19	156.3	150.2	0.516	8.97	25.8	15.8	6.70	50.2	27.8	34.4	12.0	22.4	2.87	0.71	39.0	23.2	11.2
20	156.7	150.4	0.576	10.02	25.8	15.8	6.78	50.0	27.8	34.2	12.0	22.2	2.85	0.71	38.9	23.1	11.1
21	154.9	148.4	0.636	11.06	25.9	15.9	6.86	49.4	27.8	33.5	11.9	21.6	2.82	0.74	38.6	22.7	10.8
22	155.4	148.7	0.690	12.00	25.9	15.9	6.93	49.2	27.8	33.3	11.9	21.4	2.80	0.74	38.5	22.6	10.7
23	157.3	150.4	0.750	13.04	26.0	16.0	7.02	49.2	27.8	33.2	11.8	21.4	2.82	0.75	38.5	22.5	10.7
24	155.2	148.1	0.804	13.98	26.0	16.0	7.09	48.7	27.8	32.7	11.8	20.9	2.77	0.77	38.2	22.2	10.4
25	154.9	147.6	0.864	15.02	26.1	16.1	7.18	48.3	27.8	32.2	11.7	20.5	2.76	0.78	38.1	22.0	10.3

Notes:

1. Deviator load corrected for membrane and filter cage (if applicable) effects.
2. Right Cylinder Correction Method

DRILLING AND TESTING FOR

LATERAL EXPANSION

JULY through OCTOBER 2004

POPLAR ISLAND EXPANSION STUDY
TALBOT COUNTY, MD.

SUBSURFACE EXPLORATION NOTES

1. EXPLORATION WAS PERFORMED DURING JULY 2004.

2. DRILL HOLES (DH) WERE ACCOMPLISHED BY STANDARD PENETRATION TEST PROCEDURE (SPT, ASTM - 1586) USING A 1-3/8"ID SPLIT SPOON SAMPLER. SAMPLE SPOONS WERE ADVANCED BY A 140# HAMMER FALLING 30". THESE HOLES WERE POWER AUGERED BETWEEN SAMPLES UNLESS OTHERWISE INDICATED. BLOW COUNTS SHOWN ARE FOR 0.5' OF DRIVE, UNLESS OTHERWISE INDICATED.

   ALL BORINGS WERE DRILLED BY A CME 45-RIG MOUNTED ON A BARGE IN THE BAY.

   WH - DENOTES WEIGHT OF HAMMER

   WR - DENOTES WEIGHT OF ROD

3. BLOW COUNTS REQUIRED TO ADVANCE SAMPLE SPOON ARE SHOWN IN COLUMN (a).

4. COLUMN (b) SHOWS THE NATURAL WATER CONTENTS IN PERCENT OF DRY WEIGHT OF THOSE SAMPLES TESTED.

5. SOIL DESCRIPTIONS ARE SHOWN IN COLUMN (c).

   ALSO SHOWN IN THIS COLUMN ARE:

   PPR - UNCONFINED COMPRESSION STRENGTH (tsf) READINGS FROM POCKET PENETROMETER TESTS. DASHES ARE SHOWN WHEN PART OF A SAMPLE DRIVE IS NOT SUITABLE FOR POCKET PENETROMETER TESTS. NOTHING IS SHOWN IF THE ENTIRE SAMPLE IS NOT SUITABLE FOR PPR TESTS.

6. SOIL DESCRIPTIONS ARE LABORATORY CLASSIFICATIONS BASED ON THE UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487/2488), EXCEPT THOSE INDICATED THUS (**), WHICH ARE FIELD INSPECTOR'S CLASSIFICATIONS.

7. NO GROUNDWATER READINGS WERE TAKEN SINCE EXPLORATION WAS LOCATED IN BAY.

8. START OF BORING (0.0), REPRESENTS THE BOTTOM OF BAY.

9. DEPTH OF BAY WATER SHOWN ON EACH BORING LOG WAS DETERMINED BY SOUNDING WITH WEIGHTED TAPE MEASURE TO TOP OF SEDIMENT PRIOR TO SAMPLING.

   VERTICAL DATUM: M.L.L.W., FOR THE '60 TO '78 TIDAL EPOCH.

10. FOR LOCATIONS OF SUBSURFACE EXPLORATIONS, SEE BORING LOCATION PLAN.

STA. POPLAR ISLAND EXPANSION STUDY N **DH-401**
OFFSET: POPLAR ISLAND, MD E **1 of 2**
TOP ELEV: COMPLETED: July 21, 2004

DEPTH(ft)	(c)	(d)	(a)	(b)
2.00	Wet, dk. gray, poorly graded fine SAND w/shells (SP)		WH-1.0-3	
4.50	Wet, dk. grayish brown, poorly graded fine-med. SAND w/silt (SP)		9-10-10	
7.00	Wet, grayish brown, poorly graded fine-med. SAND w/silt (SP-SM)		7-7-7	
9.50	Wet, dk. grayish brown, poorly graded fine-med. SAND w/silt (SP)		1-1-2	
16.05	Wet, lt. olive brown, poorly graded fine SAND w/silt (SP-SM) PPR 15.0'-16.5': 0.25, 0.25, 0.25		3-3-5 2-4-3 WH/1.5	
19.50	Wet, dk. gray, soft lean CLAY w/sand (CH)		WH/1.5	45.3
22.00	Wet, dk. greenish gray, soft fat CLAY w/sand (CH)		WH/1.0-1	
24.50	V. moist, dk. greenish gray, soft lean CLAY w/sand (CL) PPR 22.5'-24.0': 0.25, 0.25, 0.25		WH/1.0-1	47.6

DH-401
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. POPLAR ISLAND EXPANSION STUDY N **DH-401**
OFFSET: POPLAR ISLAND, MD E **2 of 2**
TOP ELEV: COMPLETED: July 21, 2004

DEPTH(ft)	**(c)**	**(d)**	**(a)**	**(b)**
29.50	V. moist, dk. gray, soft fat CLAY (CH) *(continued from previous page)* PPR 25.0'-26.5': 0.25, 0.25, 0.25 PPR 27.5'-29.0': 0.25, 0.0, 0.25		WH/1.5 WH/1.0-1	
34.50	V. moist, v. dk. greenish gray, soft fat CLAY (CH) PPR 30.0'-31.5': 0.0, 0.0, 0.5		WH/1.5 WH/1.0-1	
37.00	V. moist, dk. gray, soft SILT (ML) PPR 35.0'-36.5': 1.0, 0.0, 0.5		WH-1-2	
41.50	V. moist, v. dk. greenish gray, soft fat CLAY w/silt lense (CH) PPR 37.5'-39.0': 0.0, 1.0, 1.0		1/1.0-1 WH-1-2	

BOTTOM OF HOLE

Depth of bay water @ start of boring 11.4' @ 0840 Hrs.

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: July 21, 2004

DH-402

1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
2.00	Wet, grayish brown, poorly graded med. SAND w/silt & shells (SP-SM)		WH-1.0-2	
4.50	Wet, dk. gray, poorly graded fine SAND w/silt & trace of shells (SP-SM)		2-2-2	
9.50	Wet, dk. gray, poorly graded fine SAND w/silt (SP-SM)		WH/1.5 WR/1.0-WH	
14.50	Wet, dk. gray, v. soft lean CLAY w/sand (CL)		WH/1.5 WH/1.0-2	51.9
17.00	V. moist, greenish gray, soft fat CLAY w/sand (CH) PPR 15.0'-16.5': 1.0, 0.5, 0.0		1-3-2	
19.50	Wet, olive, soft clayey v. fine SAND (SC)		WH/1.5	
22.00	V. moist, gray & olive brown, firm fat CLAY w/sand (CH) PPR 20.0'-21.5': 1.0, 2.0, 1.0		1-1-2	
27.00	V. moist, gray & olive brown, firm lean CLAY w/sand (CL) PPR 22.5'-24.0': 2.0, 1.5, 1.0 PPR 25.0'-26.5': 1.5, 0.5, 0.5		1-2-3 WH-3-3	28.6
	V. moist, dk. gray, soft fat CLAY (CH) PPR 27.5'-29.0': 0.0, 0.0, 0.5		WH-1-1	

Depth scale: 5, 10, 15, 20, 25

DH-402
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill	Auger	SPT	RB
Cored	300 lb	Tubex	Hand
Fish Tail	Vibra Core	Water Jet	Odex

STA. POPLAR ISLAND EXPANSION STUDY N **DH-402**

OFFSET: POPLAR ISLAND, MD E **2 of 2**

TOP ELEV: COMPLETED: July 21, 2004

DEPTH(ft)	**(c)**	**(d)**	**(a)**	**(b)**
34.50	V. moist, dk. gray, soft fat CLAY (CH) *(continued from previous page)*		WH/1.5 WH/1.5	
39.50	V. moist, v. dk. gray, soft fat CLAY (CH) PPR 37.5'-39.0': 0.25, 0.25, 0.25		WH/1.5 WH-2-2	
41.50	Wet, v. dk. gray, sandy SILT (ML) PPR 40.0'-41.5': 0.5, 0.5, 0.5		2-2-3	

BOTTOM OF HOLE

Depth of bay water @ start of boring 10.0' @ 1307 Hrs.

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: July 31, 2004

DH-403

1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
2.00	Wet, dk. gray, silty fine SAND w/shells & silt lense (SM)		1-1-2	
4.50	V. moist, olive gray, soft lean CLAY w/sand & shell lense (CL) PPR 2.5'-4.0': 1.0, 2.0, 2.0		1-3-5	
7.00	Moist, olive gray, firm silty lean CLAY (CL-ML) PPR 5.0'-6.5': 2.5, 3.25, 3.25		4-6-8	20.7
9.50	Wet, lt. olive brown, soft sandy lean CLAY (CL) PPR 7.5'-9.0': 0.5, 0.0, 0.0		1-1-2	
12.00	Wet, lt. olive brown, silty v. fine SAND (SM)		1-2-1	
17.00	Wet, olive gray, silty v. fine SAND (SM)		1-2-2 2-4-5	
19.50	V. moist, v. dk. greenish gray, soft sandy lean CLAY (CL) PPR 17.5'-19.0': 1.0, 0.5, 1.0		2-2-2	30.6
	V. moist, dk. greenish gray, soft fat CLAY (CH)			

DH-403
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: July 31, 2004

DH-403

2 of 2

DEPTH(ft)	**(c)**	**(d)**	**(a)**	**(b)**
	V. moist, dk. greenish gray, soft fat CLAY (CH) *(continued from previous page)*			
	PPR 20.0'-21.5': 0.0, 0.0, 0.5		1-1-2	
	PPR 22.5'-24.0': 0.5, 0.5, 0.5		WH-1-2	
	PPR 25.0'-26.5': 0.25, 0.25, 0.5	25	2-1-1	
29.00	PPR 27.5'-29.0': 0.5, 0.0, 0.0		1-1-1	
	BOTTOM OF HOLE	30		
	Depth of bay water @ start of boring 11.0' @ 0831 Hrs.			
		35		
		40		

STA. POPLAR ISLAND EXPANSION STUDY N **DH-404**
OFFSET: POPLAR ISLAND, MD E **1 of 1**
TOP ELEV: COMPLETED: July 21, 2004

DEPTH(ft)	**(c)**	**(d)**		**(a)**	**(b)**
	Wet, dk. gray, poorly graded fine SAND w/silt & shells (SP-SM)			WH/1.5	
2.00					
	Wet, dk. gray, poorly graded fine SAND w/silt (SP-SM)				
				WH-1-1	
			5		
				WH/1.5	
7.00					
	Wet, dk. gray, poorly graded silty fine SAND (SM)				
				WH/1.5	
9.50					
	Wet, dk. gray, soft fat CLAY (CH)				
			10		
				WH/1.5	
12.00					
	V. moist, v. dk. greenish gray, SILT (ML)				
				WH/1.5	39.3
			15		
				WH/1.5	
17.00					
	V. moist, v. dk. greenish gray, soft fat CLAY w/shells (CH)				
				WH/1.5	
19.50					
	V. moist, v. dk. greenish gray, sandy SILT w/shells (ML)				
			20		
				1/1.0-1	
22.00					
	V. moist, v. dk. gray, silty v. fine SAND w/trace of shells (SM)				
				WH/1.5	
24.50					
	V. moist, v. dk. gray, clayey v. fine SAND w/trace of shells (SC)				
			25		
				WH/1.5	
26.50					

BOTTOM OF HOLE

Depth of bay water @ start of boring 10.0' @ 1604 Hrs.

DH-404
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

▨ **Fill**	▮ **Auger**	☒ **SPT**	▨ **RB**
▯ **Cored**	⧓ **300 lb**	⌐ **Tubex**	▯ **Hand**
↓ **Fish Tail**	▯ **Vibra Core**	⁘ **Water Jet**	▯ **Odex**

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: July 31, 2004

DH-405

1 of 1

DEPTH(ft)	(c)
	Wet, dk. gray, poorly graded silty fine SAND w/shells (SM)
2.00	Wet, dk. gray, poorly graded silty fine SAND (SM)
7.00	Wet, dk. gray, silty fine SAND w/shells (SM)
9.50	Wet, dk. gray, soft sandy SILT (ML)
12.00	Wet, greenish gray, sandy SILT (ML)
14.50	Wet, dk. yellowish brown, silty fine SAND w/silt lense (SM)
19.50	EMPTY JAR
22.00	Wet, olive, silty fine SAND (SM)
26.50	BOTTOM OF HOLE Depth of bay water @ start of boring 10.0' @ 1040 Hrs.

(d)	(a)	(b)
	WH/1.5	
	1-1-1	
5	WH/1.5	
	WR/1.5	
10	WH/1.5	
	1-1-1	
15	1-1-3	
	4-2-2	
20	WH/1.5	
	WH/1.0-1	
25	2-2-2	

DH-405
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

GEO-2 POPISL EXPANSION.GPJ 1/24/05 09:04

STA.　　POPLAR ISLAND EXPANSION STUDY　　N　　**DH-406**
OFFSET:　　POPLAR ISLAND, MD　　E　　**1 of 1**
TOP ELEV:　　COMPLETED: July 26, 2004

DEPTH(ft)	(c)	(d)	(a)	(b)
2.00	Wet, dk. gray, poorly graded fine SAND w/silt & shells (SP-SM)		WH/1.5	
4.50	Wet, dk. gray, silty fine SAND w/shells (SM)		1-1-1	
7.00	Wet, dk. gray, poorly graded silty fine SAND (SM)		WH/1.5	
9.50	Wet, dk. gray, poorly graded fine SAND (SP-SM)		WH/1.5	
17.00	V. moist, dk. gray, soft SILT w/sand (ML)		WH/1.5 WH/1.5 WH/1.5	41.6
22.00	V. moist, dk. gray, soft fat CLAY w/trace of shells (CH) PPR 17.5'-19.0': 0.25, 0.25, 0.25		WH/1.5 WH/1.5	58.4
24.50	V. moist, dk. gray, soft SILT w/sand (ML) PPR 22.5'-24.0': 0.25, 0.25, 0.25		WH/1.5	
26.50	V. moist, dk. gray, soft SILT w/sand & trace of shells (ML)		WH/1.5	

BOTTOM OF HOLE

Depth of bay water @ start of boring 10.5' @ 1140 Hrs.

DH-406
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill	**Auger**	**SPT**	**RB**
Cored	**300 lb**	**Tubex**	**Hand**
Fish Tail	**Vibra Core**	**Water Jet**	**Odex**

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: July 30, 2004

DH-407

1 of 1

DEPTH(ft)	(c)	(d)	(a)	(b)
2.00	Wet, dk. gray, poorly graded fine SAND w/silt & shells (SP)		1-1-1	
7.00	Wet, dk. gray poorly graded fine SAND w/shells (SP)		1-WH/1.0 WH-1-1	
9.50	Wet, dk. gray poorly graded fine SAND w/trace of shells (SP)		WH-1-1	
12.00	V. moist, dk. gray, poorly graded fine SAND w/silt (SP-SM)		WH-1/1.0	
14.50	V. moist, dk. gray, poorly graded fine SAND w/silt & trace of shells (SP-SM)		1-2-1	
17.00	Wet, dk. gray, poorly graded med. SAND w/silt & shells (SP-SM)		WH-1/1.0	
19.50	V. moist, dk. gray, soft fat CLAY w/sand (CH)		WH/1.5	52.0
22.00	V. moist, dk. gray, silty fine SAND w/shells (SM)		WH/1.5	
26.50	V. moist, dk. gray, soft fat CLAY (CH) PPR 25.0'-26.5': 0.25, 0.25, 0.25		WH/1.5 WH/1.5	

BOTTOM OF HOLE

Depth of bay water @ start of boring 9.5' @ 1451 Hrs.

DH-407
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

GEO-2 POPISL EXPANSION.GPJ 1/24/05 09:05

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: July 26, 2004

DH-408

1 of 1

DEPTH(ft)	(c)	(d)	(a)	(b)
2.00	Wet, dk. gray, poorly graded fine SAND w/silt & shells (SP)		WH/1.0-1	
4.50	Wet, dk. gray, poorly graded fine SAND w/trace of shells (SP)		WH-1-1	
9.50	Wet, dk. gray, poorly graded fine SAND (SP)		1-1-1 1-1-2	
12.00	Wet, dk. gray, poorly graded fine SAND w/shells (SP)		WH/1.5	
14.50	Wet, dk. gray, poorly graded silty fine SAND w/shells (SM)		1-1-1	
17.00	V. moist, dk. gray, sandy SILT (ML) PPR 15.0'-16.5': 3.0, 3.0, 3.0		1-4-5	
19.50	V. moist, dk. gray, soft silty CLAY w/sand (CL-ML)		2-5-7	21.3
22.00	Wet, grayish brown, poorly graded fine SAND w/silt (SP-SM)		1-2-3	
24.50	Wet, lt. olive brown, poorly graded fine SAND (SP-SM)		WH/1.5	
26.50	V. moist, dk. greenish gray, soft fat CLAY (CH)		WH/1.5	

BOTTOM OF HOLE

Depth of bay water @ start of boring 8.9' @ 1435 Hrs.

DH-408
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: July 22, 2004

DH-409

1 of 1

DEPTH(ft)	(c)	(d)
	EMPTY JAR	
2.00	Wet, black & dk. gray, poorly graded fine SAND w/silt (SP-SM)	
4.50	Wet, dk. gray, poorly graded fine SAND (SP-SM)	
7.00	Wet, black, poorly graded silty fine SAND (SM)	
9.50	Wet, dk. gray, silty fine SAND (SM)	
12.00	Wet, olive brown, poorly graded fine SAND (SP)	
17.00	V. moist, dk. greenish gray, soft sandy lean CLAY (CL)	
22.00	V. moist, dk. greenish gray, soft fat CLAY w/sand lense (CH)	
24.50	V. moist, dk. greenish gray, soft fat CLAY w/sand (CH) PPR 25.0'-26.5': 0.5, 0.5, 0.5	
26.50	BOTTOM OF HOLE Depth of bay water @ start of boring 8.1' @ 1342 Hrs.	

	(a)	(b)
	WH/1.5	
	1-2-1	
5	WH/1.5	
	WH-1-1	
10	2-2-3	
	4-2-5	
15	2-3-2	
	1-1-1	
20	WH/1.0-1	53.8
	WH/1.0-1	
25	WH/1.5	

DH-409
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. POPLAR ISLAND EXPANSION STUDY N **DH-410**
OFFSET: POPLAR ISLAND, MD E **1 of 1**
TOP ELEV: COMPLETED: July 22, 2004

DEPTH(ft)	(c)	(d)	(a)	(b)
2.00	Wet, dk. gray, clayey, fine SAND w/shells (SC)		2-1-1	
4.50	Wet, dk. gray, silty fine SAND w/shells (SM)		WH/1.0-1	
7.00	Wet, yellowish & grayish brown, sandy SILT (ML)		3-3-3	
14.50	Wet, grayish brown, silty fine SAND (SM)		1-3-2 3-3-4 2-2-4	
17.00	Moist, yellowish brown, poorly graded med. SAND w/silt (SP-SM)		3-4-8	
19.50	Moist, yellowish brown, poorly graded med. SAND (SP-SM)		5-6-8	
24.50	Moist, yellowish brown, poorly graded med. SAND (SP)		2-1-1 4-1-1	
24.87	Moist, grayish brown, poorly graded med. SAND (SP)			
26.50	Moist, dk. gray, soft fat CLAY (CH)		3-2-1	

BOTTOM OF HOLE

Depth of bay water @ start of boring 5.8' @ 1040 Hrs.

DH-410
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: July 31, 2004

DH-411

1 of 1

DEPTH(ft)	(c)	(d)	(a)	(b)
2.00	10 grams of silty SAND (SM)		WH/1.5	
4.50	25 grams of SILT & SAND		WH/1.5	
12.00	V. moist, dk. gray, soft fat CLAY w/sand & trace of shells (CH)		WH/1.5	
			WH/1.5	61.3
			WH/1.5	
14.50	V. moist, dk. gray, soft lean CLAY w/trace of sand & shells (CH)		WH/1.5	
17.00	V. moist, dk. gray, soft sandy lean CLAY w/trace of shells (CL)		WH/1.5	36.7
19.50	Wet, dk. gray, sandy lean CLAY w/trace of shells (CL)		WH/1.5	
22.00	Moist, greenish gray & grayish brown, sandy firm fat CLAY (CH) PPR 20.0'-21.5': 2.0, 2.0, 2.0		WH-1-1	
26.50	Moist, greenish gray, firm fat CLAY w/sand (CH) PPR 22.5'-24.0': 0.5, 0.5, 0.5		1-1-2	37.6
	PPR 25.0'-26.5': 0.5, 0.5, 0.5		1-2-1	

BOTTOM OF HOLE

Depth of bay water @ start of boring 6.8' @ 1421 Hrs.

DH-411
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill
Auger
SPT
RB
Cored
300 lb
Tubex
Hand
Fish Tail
Vibra Core
Water Jet
Odex

STA. POPLAR ISLAND EXPANSION STUDY N **DH-412**
OFFSET: POPLAR ISLAND, MD E **1 of 2**
TOP ELEV: COMPLETED: July 22, 2004

DEPTH(ft)	(c)	(d)		(a)	(b)
	Moist, lt. olive brown, firm lean CLAY w/trace of shells (CL) PPR 0.0'-1.5': 2.0, 1.5, 3.0			2-3-5	23.1
2.00	Wet, grayish brown, silty fine SAND (SM)			3-3-4	
			5	2-3-4	
				1-1-1	
			10	1-2-3	
				1-2-3	
			15	3-4-7	
17.00	Wet, grayish brown, poorly graded silty fine SAND (SM)			2-5-7	
			20	1-2-3	
22.00	Moist, dk. gray, soft fat CLAY w/sand (CH)			WH/1.5	
24.50					

DH-412
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. POPLAR ISLAND EXPANSION STUDY N **DH-412**
OFFSET: POPLAR ISLAND, MD E **2 of 2**
TOP ELEV: COMPLETED: July 22, 2004

DEPTH(ft)	**(c)**	**(d)**		**(a)**	**(b)**
27.00	Moist, grayish brown, poorly graded fine SAND w/silt (SP-SM) *(continued from previous page)*			WH/1.0-1	
34.50	Moist, greenish gray, soft fat CLAY w/trace of sand (CH) PPR 27.5'-29.0': 0.5, 0.5, 0.5		30	WH/1.0-1 WH-1-1 2-2-1	 41.8
39.00	Moist, dk. gray, soft lean CLAY w/sand (CL)		35	WH/1.5 WH/1.5	
	BOTTOM OF HOLE Depth of bay water @ start of boring 6.9' @ 0810 Hrs.		40 45 50		

STA.	POPLAR ISLAND EXPANSION STUDY	N	**DH-413**
OFFSET:	POPLAR ISLAND, MD	E	**1 of 2**
TOP ELEV:		COMPLETED: July 26, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
2.00	Wet, dk. gray, poorly graded fine SAND w/silt lense & shells (SP-SM)		1-2-WH	
4.50	V. moist, dk. gray, soft to firm lean CLAY (CL) PPR 2.5'-4.0': 1.0, 0.5, 0.5		1-1-1	24.4
7.00	V. moist, olive gray, firm fat CLAY (CH) PPR 5.0'-6.5': 2.5, 3.0, 3.5		6-10-11	
9.50	Wet, lt. olive brown, poorly graded silty fine SAND (SM)		2-5-7	
12.00	V. moist, lt. olive brown, poorly graded fine SAND w/silt (SP-SM)		2-3-5	
17.00	Wet, lt. olive brown, poorly graded fine SAND w/silt (SP-SM)		1-2-1 1-2-4	
19.50	V. moist, yellowish brown, poorly graded fine SAND (SP)		2-3-5	
	Wet, lt. olive brown, poorly graded fine SAND w/silt (SP-SM)			

DH-413
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. POPLAR ISLAND EXPANSION STUDY N **DH-413**
OFFSET: POPLAR ISLAND, MD E **2 of 2**
TOP ELEV: COMPLETED: July 26, 2004

DEPTH(ft)	(c)	(d)	(a)	(b)
	Wet, lt. olive brown, poorly graded fine SAND w/silt (SP-SM) *(continued from previous page)*		2-2-3	
			1-1-1	
24.50	V. moist, dk. greenish gray, soft sandy lean CLAY (CL)			
		25	WH-1/1.0	
			WH-1/1.0	40.6
	PPR 30.0'-31.5': 0.5, 0.5, 0.5	30	1-1-1	
	PPR 32.5'-34.0': 0.0, 0.5, 0.0		1-1-1	
34.50	V. moist, dk. gray, soft to firm fat CLAY (CH)		WR-1-1	
35.50	BOTTOM OF HOLE	35		
	Depth of bay water @ start of boring 5.9' @ 1620 Hrs.			
		40		

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: July 27, 2004

DH-414

1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
2.00	V. moist, yellowish brown, firm lean CLAY w/trace of sand (CL) PPR 0.0'-1.5': 3.5, 3.5, 3.0		2-5-6	22.6
4.50	Wet, yellowish brown, poorly graded fine SAND w/silt & clay lense (SP-SM) PPR 2.5'-4.0': 3.0, 3.0, 3.0		4-5-6	
9.50	Wet, yellowish brown, silty fine SAND (SM)		4-4-3 1-2-2	
12.00	V. moist, yellowish brown, poorly graded fine SAND w/silt (SP-SM)		2-4-4	
27.00	Wet, yellowish brown, poorly graded fine SAND w/silt (SP-SM)		2-2-3 2-3-3 3-3-4 1-2-2 1-3-1 WH/1.5	
29.50	V. moist, dk. greenish gray, soft fat CLAY w/sand(CH) PPR 27.5'-29.0': 0.5, 0.5, 0.5		WH/1.0-1	47.1

DH-414
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill	**Auger**	**SPT**	**RB**
Cored	**300 lb**	**Tubex**	**Hand**
Fish Tail	**Vibra Core**	**Water Jet**	**Odex**

STA. POPLAR ISLAND EXPANSION STUDY N **DH-414**
OFFSET: POPLAR ISLAND, MD E **2 of 2**
TOP ELEV: COMPLETED: July 27, 2004

DEPTH(ft)	(c)	(d)	(a)	(b)
32.00	Wet, dk. greenish gray, soft sandy fat CLAY (CH) *(continued from previous page)*		WR/1.5	
37.00	V. moist, dk. greenish gray, soft fat CLAY (CH) PPR 32.5'-34.0': 0.5, 0.5, 0.25		WR-1-1 WH/1.0-1	
39.00	V. moist, dk. gray, soft lean CLAY (CL) PPR 37.5'-39.0': 0.5, 0.5, 0.5		WH-1-1	36.4

BOTTOM OF HOLE

Depth of bay water @ start of boring 7.5' @ 0905 Hrs.

STA. POPLAR ISLAND EXPANSION STUDY N **DH-415**
OFFSET: POPLAR ISLAND, MD E **1 of 2**
TOP ELEV: COMPLETED: July 27, 2004

DEPTH(ft)	(c)
	Wet, dk. grayish brown, silty fine SAND w/shells (SM)
2.00	Wet, dk. grayish brown, silty fine SAND (SM)
4.50	Wet, dk. yellowish brown, poorly graded fine SAND w/silt (SP-SM)
7.00	Wet, brown, poorly graded fine SAND w/silt (SP-SM)
12.00	Wet, yellowish brown, poorly graded fine SAND w/silt (SP-SM)
14.50	Wet, yellowish brown, poorly graded fine SAND (SP)

(d)	(a)	(b)
	WH/1.0-1	
	1-1-2	
5	1-2-2	
	1-5-4	
10	1-2-3	
	2-3-5	
15	2-6-8	
	1-1-2	

DH-415
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill	**Auger**	**SPT**	**RB**
Cored	**300 lb**	**Tubex**	**Hand**
Fish Tail	**Vibra Core**	**Water Jet**	**Odex**

DEPTH(ft)	**(c)**	**(d)**		**(a)**	**(b)**
22.00	Wet, yellowish brown, poorly graded fine SAND (SP) *(continued from previous page)*			2-2-2	
24.50	Wet, yellowish brown, poorly graded fine SAND w/silt (SP)			1/1.0-1	
27.00	Wet, dk. gray, silty clayey fine SAND w/trace of gravel (SC-SM)		25	WH/1.5	25.6
29.50	V. moist, dk. greenish gray, soft fat CLAY (CH) PPR 27.5'-29.0': 2.0, 2.0, 2.0			WR-WH-2	
32.00	V. moist, dk. greenish gray, soft sandy fat CLAY (CH)		30	1/1.0-1	
34.00	Wet, dk. gray, soft fat CLAY w/sand (CH)			1-1-1	
	BOTTOM OF HOLE Depth of bay water @ start of boring 9.3' @ 1235 Hrs.		35		
			40		

STA. POPLAR ISLAND EXPANSION STUDY N **DH-416**
OFFSET: POPLAR ISLAND, MD E **1 of 1**
TOP ELEV: COMPLETED: July 31, 2004

DEPTH(ft)	(c)	(d)	(a)	(b)
	15 grams of silty SAND & shell fragments		WH/1.5	
2.00	Wet, dk. gray, silty fine SAND w/trace of shell frags. (SM)		WH/1.5	
4.50	Wet, dk. gray, silty fine SAND w/shell frags. (SM)		1/1.0-2	
7.00	Wet, grayish brown, poorly graded SAND w/silt (SP-SM)		1-1-1	
9.50	Wet, grayish brown, poorly graded SAND (SP-SM)		2-1-2	
12.00	Wet, yellowish brown, poorly graded SAND (SP)		4-2-2	
14.50	V. moist, yellowish brown, poorly graded SAND w/silt & clay lense (SP-SM)		1/1.0-1	
17.00	V. moist, yellowish brown, poorly graded SAND (SP)		WH/1.5	24.5
19.50	V. moist, greenish gray, soft lean CLAY w/sand (CL)			43.7
26.50	BOTTOM OF HOLE			

Depth of bay water @ start of boring 9.8' @ 1239 Hrs.

DH-416
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: July 28, 2004

DH-417
1 of 1

DEPTH(ft)	(c)	(d)	(a)	(b)
2.00	EMPTY JAR		WH/1.5	
7.00	Wet, dk. gray, silty fine SAND w/trace of shell frags. (SM)		1-1-1 1/1.0-1	
9.50	Wet, olive gray, silty fine SAND (SM)		1-3-2	24.8
12.00	Wet, olive gray, poorly graded SAND with silt (SP-SM)		1-4-4	
14.50	Wet, olive gray, poorly graded SAND (SP-SM)		4-6-6	
17.00	Wet, dk. gray, silty fine SAND w/trace of shell frags. (SM)		1-1-2	
24.50	Wet, grayish brown, poorly graded SAND w/silt (SP-SM)		3-2-2 1-3-1 1/1.0-1	
26.50	Moist, dk. gray, soft fat CLAY w/sand (CH) PPR 25.0'-26.5': 0.50, 0.5, 0.5		WH/1.5	

BOTTOM OF HOLE

Day 1: Depth of bay water @ start of boring 10.0' @ 1544 Hrs.

Day 2: Depth of bay water @ start of boring 10.3' @ 0834 Hrs.

DH-417
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: July 28, 2004

DH-418

1 of 1

DEPTH(ft)	(c)	(d)	(a)	(b)
4.50	Wet, grayish brown, poorly graded SAND w/trace of shells (SP)		WH/1.5 1-1-WH	
14.50	Wet, grayish brown, poorly graded silty SAND (SM)		WH/1.5 3-7-3 1-1-1 1-4-1	
17.00	Moist, grayish brown, poorly graded clayey SAND (SC) PPR 15.0'-16.5': 0.0, 0.5, 0.0		WH/1.5	35.7
19.50	Moist, grayish brown, poorly graded SAND (SP)		WR/1.5	
22.00	(Approx. 15 grams) Moist, grayish brown, poorly graded SAND (SP)		WH/1.0-1	
26.50	Moist, greenish gray, soft sandy lean CLAY (CL) PPR 22.5'-24.0': 0.5, 0.5, 0.5 PPR 25.0'-26.5': 1.0, 0.5, 0.5		WH/1.5 1-1/1.0	41.2

BOTTOM OF HOLE

Depth of bay water @ start of boring 8.8' @ 0956 Hrs.

DH-418
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill	Auger	SPT	RB
Cored	300 lb	Tubex	Hand
Fish Tail	Vibra Core	Water Jet	Odex

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: July 28, 2004

DH-419
1 of 2

DEPTH(ft)	(c)	(d)		(a)	(b)
	Less than 5 grams of SAND			WH/1.5	
2.00	Wet, dk. gray, poorly graded SAND w/silt & trace of shells (SP-SM)			1/1.5	
4.50	Wet, dk. gray, poorly graded SAND w/trace of shells (SP-SM)		5	WH/1.5	
7.00	Wet, dk. gray, poorly graded SAND (SP)			WR/1.5	
9.50	Wet, grayish brown, poorly graded silty SAND (SM)		10	WH/1.5	
12.00	V. moist, dk. gray, soft lean CLAY w/sand & shells (CL) PPR 12.5'-14.0': 2.0, 2.0, 2.0			WH/1.0-1	
14.50	Moist, greenish gray, silty CLAY w/trace of sand (CL-ML) PPR 15.0'-16.5': 1.5, 3.0, 3.0		15	1-5-11	22.5
17.00	Wet, olive brown, poorly graded SAND w/silt & shells (SP-SM)			1-1-1	
19.50	Wet, olive brown, clayey SAND w/trace of shells (SC)				

DH-419
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. POPLAR ISLAND EXPANSION STUDY N **DH-419**
OFFSET: POPLAR ISLAND, MD E **2 of 2**
TOP ELEV: COMPLETED: July 28, 2004

DEPTH(ft)	**(c)**	**(d)**		**(a)**	**(b)**
	Wet, olive brown, clayey SAND w/trace of shells (SC) *(continued from previous page)*			1/1.0-1	24.6
22.00	Wet, olive gray, sandy CLAY w/trace of shells (CL)			WH/1.5	
24.50	Moist, gray, sandy lean CLAY (CL)		25	1-2-2	
				WH/1.5	
29.00	BOTTOM OF HOLE Depth of bay water @ start of boring 9.5' @ 1257 Hrs.		30		
			35		
			40		

STA. POPLAR ISLAND EXPANSION STUDY N **DH-420**
OFFSET: POPLAR ISLAND, MD E **1 of 1**
TOP ELEV: COMPLETED: July 28, 2004

DEPTH(ft)	(c)	(d)	(a)	(b)
4.50	Wet, dk. gray, poorly graded med-fine SAND w/silt & shells (SP-SM)		WH/1.0-1 WH-1-1	
7.00	Wet, gray, silty fine SAND (SM)		WH/1.5	
9.50	Wet, dk. gray, silty fine SAND w/trace of shells (SM)		WH/1.5	38.0
12.00	V. moist, dk. gray, fine sandy SILT w/trace of shells (ML/SM) PPR 10.0'-11.5': 0.5, 0.0, 0.0		WH/1.5	
14.50	V. moist, dk. gray, fine sandy lean CLAY w/trace of shells (CL)		WH/1.5	
19.50	Moist, dk. gray, fine sandy lean CLAY w/trace of shells (CL)		WH/1.5 WH/1.5	46.5
26.50	Moist, dk. gray, soft fat CLAY w/trace of shells (CH) PPR 20.0'-21.5': 0.0, 0.25, 0.25 PPR 22.5'-24.0': 0.25, 0.25, 0.25		WH/1.5 WH/1.5 WH/1.5	64.6

BOTTOM OF HOLE

Depth of bay water @ start of boring 9.7' @ 1513 Hrs.

5
10
15
20
25

DH-420
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: July 29, 2004

DH-421

1 of 1

DEPTH(ft)	(c)
4.50	Wet, dk. gray, poorly graded med-fine SAND w/silt & shells (SP-SM)
9.50	Wet, dk. gray, poorly graded silty SAND w/shells (SM)
12.00	V. moist, dk. gray, fine sandy SILT (ML)
17.00	Moist, dk. gray, fine sandy soft fat CLAY w/trace of shells (CH)
19.50	Wet, dk. gray, v. soft fat CLAY w/shells & sand (CH)
22.00	Wet, dk. gray, sandy fat CLAY w/shells (CH)
26.50	V. moist, greenish gray, sandy firm lean CLAY w/shells (CL)

BOTTOM OF HOLE

Depth of bay water @ start of boring 10.0' @ 1456 Hrs.

(a)	(b)
WH/1.5	
WH/1.5	
WH/1.5	
WH/1.5	
WH/1.5	
WH/1.5	55.1
WH/1.5	
WH/1.0-2	
WH/1.5	
WH-2-1	27.7
1-2-2	

(d)

5
10
15
20
25

DH-421
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill	**Auger**	**SPT**	**RB**
Cored	**300 lb**	**Tubex**	**Hand**
Fish Tail	**Vibra Core**	**Water Jet**	**Odex**

STA.	POPLAR ISLAND EXPANSION STUDY	N	**DH-422**
OFFSET:	POPLAR ISLAND, MD	E	**1 of 1**
TOP ELEV:		COMPLETED: July 29, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
2.00	Wet, dk. gray, poorly graded SAND w/silt & shells (SP-SM)		WR/1.5	
4.50	V. moist, dk. gray, fine sandy lean CLAY w/shells (CL)		WH/1.0-1	
7.00	Wet, dk. gray, silty fine SAND w/shells (SM)		1-4-2	
12.00	Wet, lt. olive brown, silty med-fine SAND (SM)		WH-1-2 WH-1-1	
14.50	Wet, yellowish brown, sandy SILT (ML)		2-5-6	
17.00	Moist, yellowish brown, poorly graded SAND (SP-SM)		1-5-3	
19.50	Moist, dk. gray, soft fat CLAY w/sand (CH)		WH/1.0-1	
22.00	EMPTY JAR		WR/1.5	
26.50	Moist, dk. greenish gray, soft sandy lean CLAY (CL) PPR 22.5'-24.0': 0.5, 0.5, 0.5 PPR 25.0'-26.5': 0.5, 0.0, 0.0		WH/1.0-1 1/1.0-1	38.4
	BOTTOM OF HOLE Depth of bay water @ start of boring 12.5' @ 1626 Hrs.			

DH-422
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill	**Auger**	**SPT**	**RB**
Cored	**300 lb**	**Tubex**	**Hand**
Fish Tail	**Vibra Core**	**Water Jet**	**Odex**

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: July 30, 2004

DH-423

1 of 1

DEPTH(ft)	(c)
2.00	Moist, grayish brown, firm lean CLAY w/trace of shells & sand (CL/ML) PPR 0.0'-1.5': 2.5, 3.0, 2.5
4.50	Moist, grayish brown, sandy lean CLAY (CL) PPR 2.5'-4.0': 2.0, 1.0, 2.0
7.00	Moist, grayish brown, fine sandy lean CLAY (CL/SC) PPR 5.0'-6.5': 1.5, 1.25, 1.25
9.50	Wet, grayish brown, fine sandy SILT (ML)
17.00	Wet, lt. olive brown, silty fine SAND (SM)
19.50	Moist, dk. gray, fat CLAY w/sand (CH) PPR 17.5'-19.0': 0.0, 0.0, 0.25
26.50	Moist, dk. greenish gray, sandy fat CLAY w/sand (CH) PPR 20.0'-21.5': 0.5, 0.5, 0.25 PPR 22.5'-24.0': 0.0, 0.5, 0.5 PPR 25.0'-26.5': 0.5, 0.5, 0.5
	BOTTOM OF HOLE Depth of bay water @ start of boring 12.7' @ 0816 Hrs.

(d)	(a)	(b)
	WH-3-3	
	1-3-3	
5	2-3-3	
	4-2-3	
10	3-2-2	
	4-5-5	26.7
15	1-2-2	
	WH/1.0-1	
20	WH-1-1	43.7
	WH-1-1	
25	WH-1-1	

DH-423
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. POPLAR ISLAND EXPANSION STUDY N **DH-424**
OFFSET: POPLAR ISLAND, MD E **1 of 1**
TOP ELEV: COMPLETED: July 30, 2004

DEPTH(ft)	(c)	(d)	(a)	(b)
	EMPTY JAR		WH/1.5	
2.00	Wet, dk. gray, lean CLAY w/sand & shells (CL/ML)		WH/1.0-1	
4.50	Wet, dk. gray, sandy lean CLAY (CL)		WH/1.5	
7.00	V. moist, dk. gray, fat CLAY w/shells & sand (CH)		WH/1.5	57.4
9.50	Moist, olive gray, soft fat CLAY w/shells & sand (CH)		WH/1.5	
12.00	Moist, olive gray, soft lean CLAY w/sand & shells (CL) PPR 12.5'-14.0': 0.5, 1.0, 0.5		WH-1-2	27.2
14.50	Moist, olive gray, firm fat CLAY w/sand (CH) PPR 15.0'-16.5': 1.5, 1.0, 1.5		WH-1-2	
17.00	Moist, lt. olive gray, firm lean CLAY w/sand (CL) PPR 17.5'-19.0': 1.0, 0.5, 1.0		WH/1.0-1	
	PPR 20.0'-21.5': 0.5, 0.5, 0.5		WH/1.5	
			WH/1.5	28.0
			WH/1.5	
26.50	BOTTOM OF HOLE Depth of bay water @ start of boring 11.5' @ 0945 Hrs.			

DH-424
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. POPLAR ISLAND EXPANSION STUDY N **DH-425**
OFFSET: POPLAR ISLAND, MD E **1 of 1**
TOP ELEV: COMPLETED: July 30, 2004

DEPTH(ft)	(c)	(d)		(a)	(b)
	Moist, brown, firm lean CLAY w/trace of sand (CL/ML) PPR 0.0'-1.5': 2.0, 2.5, 1.0			WH-1-1	
4.50	PPR 2.5'-4.0': 2.5, 1.0, 2.0			3-5-7	
7.00	Wet, lt. olive brown, clayey fine SAND (SC)		5	1-3-5	
9.50	Wet, lt. olive brown, silty fine SAND (SM)			1-4-4	
12.00	Wet, lt. olive brown, poorly graded SAND w/silt (SP-SM)		10	WH-2-4	
	Wet, lt. olive brown, poorly graded silty SAND (SM)			6-4-5	
			15	1-1-3	
19.50				3-2-2	
22.00	Wet, lt. olive brown, silty med-fine SAND (SM)		20	WH/1.0-1	
	Moist, dk. greenish gray, soft fat CLAY w/sand (CH) PPR 22.5'-24.0': 0.5, 0.5, 0.5			WH/1.0-1	52.3
26.50	PPR 25.0'-26.5': 0.5, 0.0, 0.0		25	WH-1-1	

BOTTOM OF HOLE

Depth of bay water @ start of boring 10.0' @ 1142 Hrs.

DH-425
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. POPLAR ISLAND EXPANSION STUDY N **B-426**
OFFSET: POPLAR ISLAND, MD E **1 of 1**
TOP ELEV: COMPLETED: October 6, 2004

DEPTH(ft)	(c)	(d)	(a)	(b)
2.00	Wet, dk. gray, silty v. fine SAND w/tr. of shells & wood (SM/ML)		WH-1-1	
4.50	Wet, dk. gray, silty fine SAND w/tr. of shells (SM)		WH/1.5	
7.00	Wet, dk. gray, v. fine sandy SILT w/tr. of shells (ML)		WH-1-3	25.7
9.50	Wet, dk. gray, silty v. fine SAND (SM/ML)		1-3-2	
12.00	V. moist, greenish gray, soft fat CLAY w/sand lense (CH) PPR 10.0'-11.5': 0.25, 0.25, 0.25		WH/1.0-2	
14.50	P V. moist, greenish gray, soft sandy lean CLAY (CL) w/tr. of sand		WH/1.5	36.2
22.00	V. moist, greenish gray, soft sandy lean CLAY (CL) PPR 17.5'-19.0': 0.25, 0.25, 0.25		WH/1.5 WH/1.5 WH/1.5	
26.50	V. moist, dk. gray, soft fat CLAY (CH)		WH/1.5 1-1-1	

BOTTOM OF HOLE

Depth of bay water @ start of boring 12.9' @ 0840 Hrs.

B-426
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

B-426A
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

P - indicates pressed shelby tube sample obtained from an additional boring.

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: October 6, 2004

B-427

1 of 1

DEPTH(ft)		(c)	(d)	(a)	(b)
2.00		Wet, dk. gray, SILT w/sand & shells (ML)		WH/1.5	
4.50		Wet, dk. gray, soft lean CLAY (CL)		WH/1.5	46.7
7.00		Wet, dk. gray, soft SILT (ML)	5	WH/1.5	
9.50	P	V. moist, dk. gray, soft lean CLAY (CL)		WH/1.5	52.2
14.50		Wet, dk. gray, soft fat CLAY (CH)	10	WH/1.5 1/1.0-1	
17.00		V. moist, greenish gray, soft fat CLAY w/sand lense (CH) PPR 15.0'-16.5': 0.5, 0.0, 0.0	15	WH-1-2	
19.50		V. moist, greenish gray soft to firm fat CLAY (CH) PPR 17.5'-19.0': 0.5, 0.5, 1.0		WH/1.0-1	
22.00		V. moist, olive & gray, soft to form fat CLAY w/sand (CH) PPR 20.0'-21.5': 1.0, 0.0, 1.0	20	WH-2-1	
24.50		V. moist, olive & gray, soft to firm fat CLAY (CH) PPR 22.5'-24.0': 0.5, 0.5, 0.5		1-1-1	
26.50		V. moist, olive & gray, soft to firm fat CLAY w/tr. of sand (CH)	25	WH/1.0-1	

BOTTOM OF HOLE

Depth of bay water @ start of boring 12.6' @ 1202 Hrs.

B-427
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

B-427A
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

P - indicates pressed shelby tube sample obtained from an additional boring.

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: October 6, 2004

B-428

1 of 1

DEPTH(ft)	(c)	(d)	(a)	(b)
2.00	Wet, olive gray, v. soft lean CLAY w/sand & shells (CL)		1-1-2	
4.50	Wet, olive, poorly graded fine SAND w/silt & clay lense (SP-SM)		1-3-4	
7.00	Wet, olive gray, poorly graded v. fine SAND w/silt (SP-SM)		1-3-2	
12.00	Wet, olive gray, poorly graded silty v. fine SAND (SM)		4-4-3 2-3-2	
14.50	Wet, olive brown, silty v. fine SAND (SM)		3-3-4	
17.00	V. moist, dk. gray, soft sandy lean CLAY (CL)		1-1-1	
24.50	V. moist, dk. greenish gray, soft fat CLAY (CH) PPR 17.5'-19.0': 0.5, 0.25, 0.25 PPR 20.0'-21.5': 0.5, 0.25, 0.5 PPR 22.5'-24.0': 0.5, 0.5, 0.5		1-1-1 1/1.0-2 1-1-1	
26.50	V. moist, dk. gray, soft lean CLAY (CL) PPR 25.0'-26.5': 0.25, 0.25, 0.25		WH/1.0-1	

BOTTOM OF HOLE

Depth of bay water @ start of boring 13.6' @ 1410 Hrs.

B-428
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: October 6, 2004

B-429
1 of 1

DEPTH(ft)		(c)
2.00		Wet, dk. gray, poorly graded fine SAND w/silt & shells (SP-SM)
4.50		Wet, dk. gray, soft lean CLAY w/tr. of shells (CL)
7.00	P	V. moist, dk. greenish gray, soft sandy SILT (ML)
9.50		Wet, dk. gray, silty v. fine SAND (SM)
12.00		Wet, dk. gray, poorly graded silty fine SAND (SP-SM)
14.50		Wet, dk. gray, poorly graded silty fine SAND (SM)
17.00		Wet, lt. olive brown, poorly graded silty fine SAND (SM)
22.00		Wet, lt. olive brown, poorly graded fine SAND (SP)
24.50		Wet, dk. greenish gray, soft sandy fat CLAY (CH)
26.50		V. moist, dk. greenish gray, soft fat CLAY (CH)

BOTTOM OF HOLE

Depth of bay water @ start of boring 9.7' @ 1545 Hrs.

	(a)	(b)
	WH/1.5	
	WH/1.5	
5	WH/1.5	22.5
	1-3-3	
10	1-2-4	
	1-1-2	
15	1/1.0-3	
	2-1-1	
20	WH/0.5-1/1.0	
	WR-1/1.0	
25	1-1-1	

B-429
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

B-429A
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

P - indicates pressed shelby tube sample obtained from an additional boring.

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA.
OFFSET:
TOP ELEV:

POPLAR ISLAND EXPANSION STUDY
POPLAR ISLAND, MD

N
E
COMPLETED: October 7, 2004

B-430
1 of 1

DEPTH(ft)	(c)	(d)		(a)	(b)
	Wet, dk. gray, clayey fine SAND w/tr. of shells (SC)			WH/1.5	
2.00	EMPTY JAR			WH/1.5	
4.50	V. moist, dk. gray, soft lean CLAY w/tr. of sand (CL)		5	WH/1.5	53.4
7.00	V. moist, dk. gray, soft lean CLAY (CL)			WH/1.5	
9.50	V. moist, gray, fine sandy soft lean CLAY w/tr. of decaying organic material (CL)		10	WH/1.0-2	
12.00	Moist, gray, silty CLAY w/sand (CL-ML) PPR 12.5'-14.0': 1.0, 0.5, 0.0			1-1-3	26.1
			15	WH/1.5	
17.00	Moist, dk. greenish gray, sandy soft fat CLAY (CH)			WH/1.5	
	PPR 20.0'-21.5': 0.25, 0.0, 0.0		20	WH/1.0-1	
	PPR 22.5'-24.0': 0.25, 0.25, 0.25			WH-1-1	
24.50	Moist, dk. gray, fine sandy soft fat CLAY (CH)		25	WH/1.0-1	
				WH/1.0-1	
			30	WH-1-1	
31.50	BOTTOM OF HOLE Depth of bay water @ start of boring 4.7' @ 0953 Hrs.				

B-430
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. POPLAR ISLAND EXPANSION STUDY N **B-431**
OFFSET: POPLAR ISLAND, MD E **1 of 1**
TOP ELEV: COMPLETED: October 6, 2004

DEPTH(ft)	**(c)**	**(d)**
2.00	Wet, grayish brown, silty med. SAND w/clay & tr. of shells (SM) PPR 0.0'-1.5': 2.0, 2.5, 2.0	
4.50	Wet, yellowish brown, silty med. SAND w/clay & tr. of shells (SM)	
7.00	Wet, yellowish brown, silty med. SAND w/tr. of shells (SM)	
9.50	Wet, yellowish brown, poorly graded med. SAND w/silt & shells (SP-SM)	
19.50	Wet, yellowish brown, poorly graded med. SAND w/silt (SP-SM)	
27.00	Wet, brown, poorly graded med. SAND (SP)	
28.25	Moist, brown, poorly graded med. SAND (SP)	
29.50	Moist, dk. greenish gray, soft fat CLAY (CH)	
31.50	V. moist, dk. greenish gray, soft fat CLAY w/tr. of sand (CH)	

BOTTOM OF HOLE

Depth of bay water @ start of boring 6.0' @ 1751 Hrs.

(a)	**(b)**
5-5-5	
1-2-4	
2-5-5	
2-2-4	
2-3-5	
1-1-3	
2-1-2	
1-2-2	
2-3-3	
1/1.0-1	
WR/1.0-WH	
WH/0.5-1/1.0	
WR/1.0-1	

B-431
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill	**Auger**	**SPT**	**RB**
Cored	**300 lb**	**Tubex**	**Hand**
Fish Tail	**Vibra Core**	**Water Jet**	**Odex**

STA. POPLAR ISLAND EXPANSION STUDY N **B-432**
OFFSET: POPLAR ISLAND, MD E **1 of 1**
TOP ELEV: COMPLETED: October 7, 2004

DEPTH(ft)	(c)	(d)	(a)	(b)
2.00	Wet, dk. gray, silty med-fine SAND w/tr. of shells (SM)		WH-1-1	
4.50	Moist, lt. yellowish brown, fine sandy lean CLAY (CL/ML) PPR 2.5'-4.0': 2.5, 2.5, 2.0		3-4-6	
7.00	Moist, lt. yellowish brown & gray, fine sandy lean CLAY (CL/ML) PPR 5.0'-6.5': 3.0, 0.5, 0.5		2-3-4	
12.00	Wet, lt. olive brown, silty fine SAND (SM)		1-2-4 2-5-5	
19.50	Wet, brown, silty fine SAND (SM)		1-2-4 1-2-2 1-1-3	
22.00	Wet, dk. gray, silty fine SAND (SM)		1-1-5	
29.50	Moist, dk. greenish gray, sandy soft fat CLAY (CH) PPR 27.5'-29.0': 0.25, 0.25, 0.25		1-1/1.0 WH/1.5 WH/1.0-1	
31.50	Moist, dk. greenish gray, fine sandy soft fat CLAY (CH) PPR 30.0'-31.5': 0.5, 0.25, 0.0		WH-1-4	

BOTTOM OF HOLE

Depth of bay water @ start of boring 5.6' @ 0756 Hrs.

B-432
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. POPLAR ISLAND EXPANSION STUDY N **B-433**
OFFSET: POPLAR ISLAND, MD E **1 of 1**
TOP ELEV: COMPLETED: October 7, 2004

DEPTH(ft)	(c)
4.50	Wet, dk. gray, silty fine SAND w/tr. of shells (SM)
7.00	Wet, dk. gray, poorly graded med. SAND w/silt (SP-SM)
9.50	Wet, dk. gray, poorly graded med. SAND (SP-SM)
12.00	Wet, dk. grayish brown, poorly graded med. SAND w/silt (SP-SM)
19.50	Wet, brown, poorly graded med. SAND (SP)
22.00	Wet, dk. gray, clayey med. SAND (SC)
24.50	Wet, brown, poorly graded med. SAND (SP)
29.50	V. moist, dk. greenish gray, soft fat CLAY w/sand (CH) PPR 25.0'-26.5': 0.0, 0.0, 0.5 PPR 27.5'-29.0': 0.25, 0.0, 0.0
31.50	V. moist, dk. greenish gray, clayey SAND (SC-H)

BOTTOM OF HOLE

Depth of bay water @ start of boring 9.4' @ 1144 Hrs.

(a)
WH/1.5
WH/1.5
WH-2-1
2-2-2
1-1-2
WH-1-2
1-3-3
WH/1.0-1
9-6-2
WH/1.0-1
WH/1.0-1
WH/1.0-1
WH/1.0-1

(d) (b)

5 10 15 20 25 30

B-433
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**

STA. POPLAR ISLAND EXPANSION STUDY N **B-434**
OFFSET: POPLAR ISLAND, MD E **1 of 1**
TOP ELEV: COMPLETED: October 7, 2004

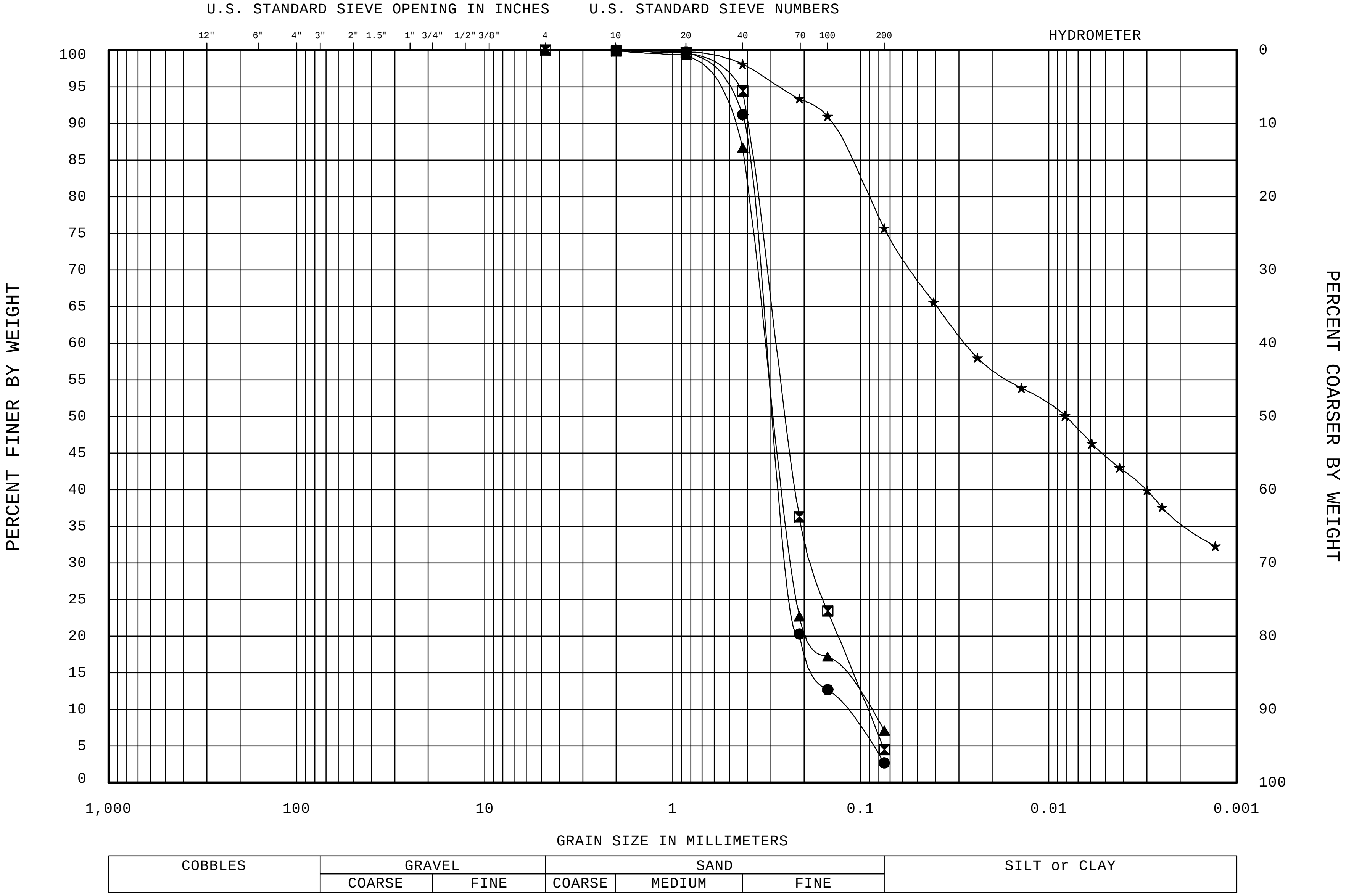
DEPTH(ft)	(c)	(d)	(a)	(b)
9.50	Wet, dk. gray, poorly graded fine SAND w/silt & tr. of shells (SP-SM)		WH/1.0-1 WH/1.0-1 WH-2-2 2-2-3	
12.00	Wet, dk. gray, poorly graded med-fine SAND w/silt (SP-SM) PPR 10.0'-11.5': 0.5, 0.5, 0.5		1-2-3	
14.50	V. moist, grayish brown, poorly graded med. SAND (SP)		10-3-3	
17.00	Wet, grayish brown, poorly graded med. SAND (SP)		WH/1.5	
19.50	Wet, lt. olive brown, poorly graded med. SAND (SP)		WR/1.0-1	
22.00	Moist, dk. greenish gray, soft fat CLAY w/sand (CH) PPR 20.0'-21.5': 0.0, 0.25, 0.25		WH/1.0-1	
29.50	Moist, dk. greenish gray, sandy soft fat CLAY (CH) PPR 22.5'-24.0': 0.0, 0.25, 0.25		WH/1.5 WH/1.5 WH/1.5	
31.50	Moist, dk. gray, sandy soft fat CLAY (CH)		WH/1.0-1	

BOTTOM OF HOLE

Depth of bay water @ start of boring 8.5' @ 1606 Hrs.

B-434
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill **Auger** **SPT** **RB**
Cored **300 lb** **Tubex** **Hand**
Fish Tail **Vibra Core** **Water Jet** **Odex**



Legend	Sample No.	Depth (ft)	Classification	(ASTM D 2487)	Nat wc%	LL	PL	PI
—●—	Jar-2	2.5-4.0	POORLY GRADED SAND	SP				
—⊠—	Jar-4	7.5-9.0	POORLY GRADED SAND	SP				
—▲—	Jar-6	12.5-14.0	POORLY GRADED SAND with SILT	SP-SM				
—★—	Jar-8	17.5-19.0	LEAN CLAY with SAND	CL	45.3	48	19	29

Remarks:

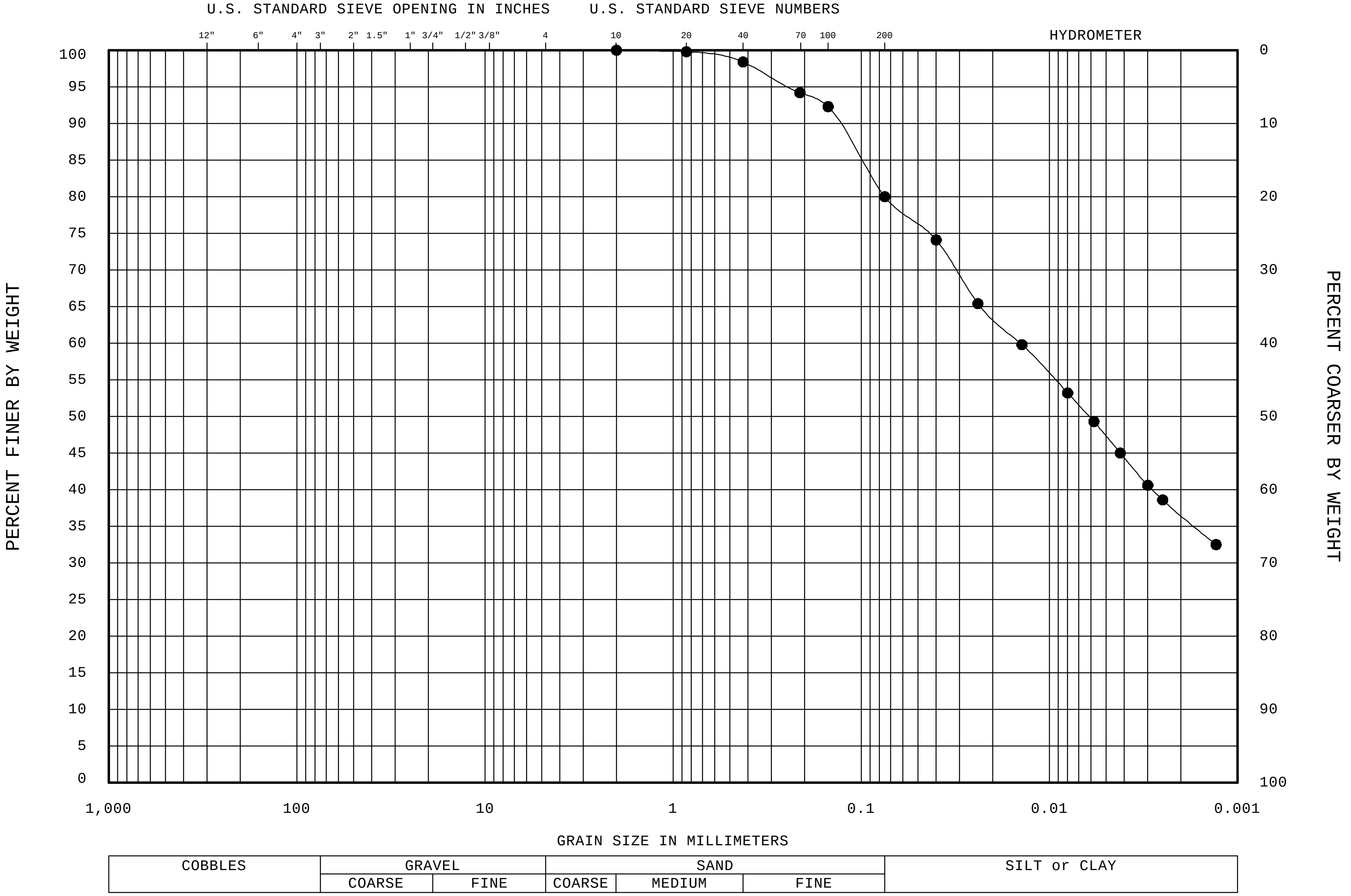
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-401*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
—●—	Jar-10	22.5-24.0	LEAN CLAY with SAND CL	47.6	45	19	26
—— ——							
—— ——							
—— ——							

Remarks:

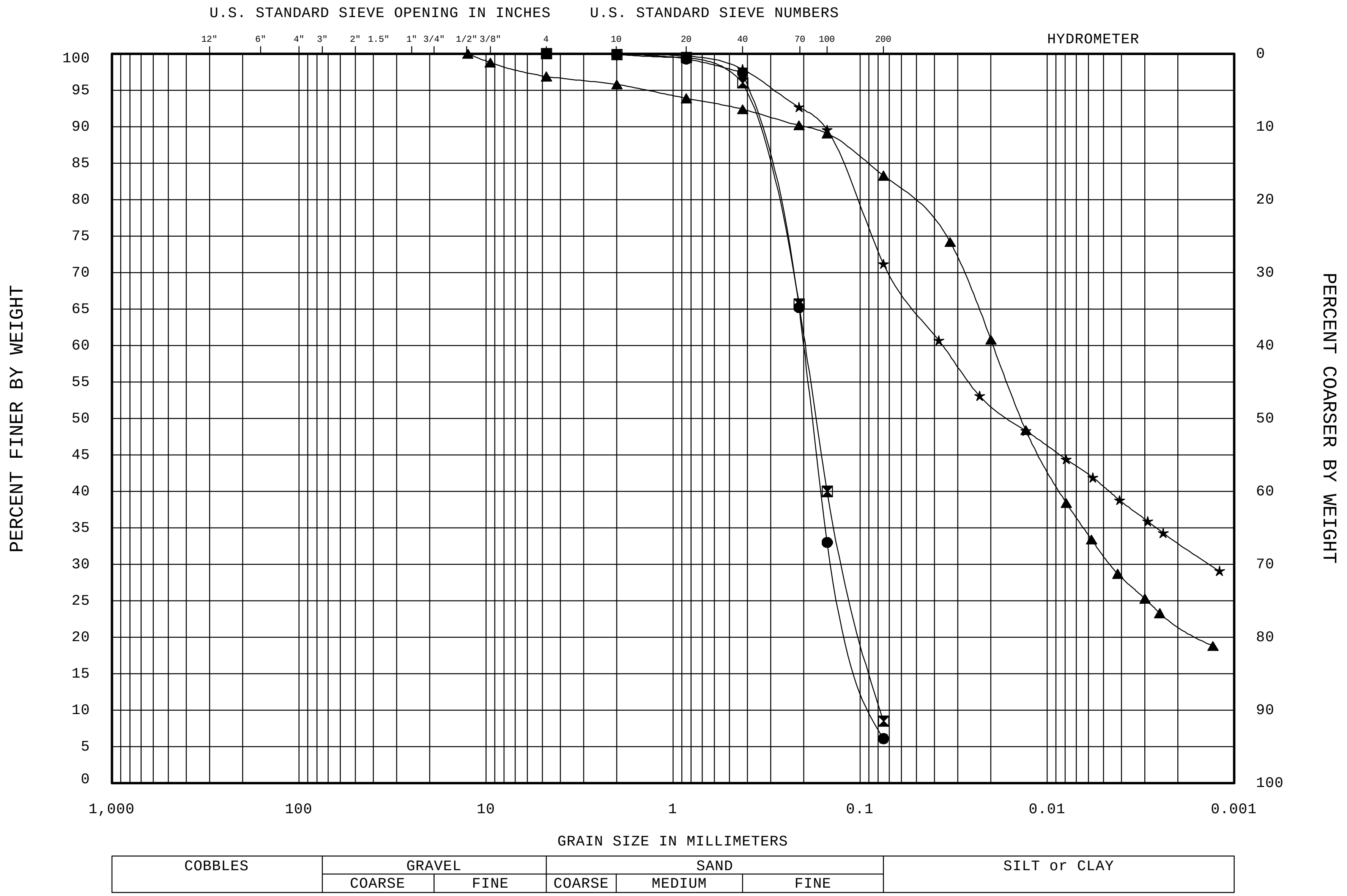
ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-401*

DATE: *Oct 2004*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
—●—	Jar-2	2.5-4.0	POORLY GRADED SAND with SILT SP-SM				
—⊠—	Jar-4	7.5-9.0	POORLY GRADED SAND with SILT SP-SM				
—▲—	Jar-6	12.5-14.0	LEAN CLAY with SAND CL	51.9	43	24	19
—★—	Jar-10	22.5-24.0	LEAN CLAY with SAND CL	28.6	34	16	18

Remarks:

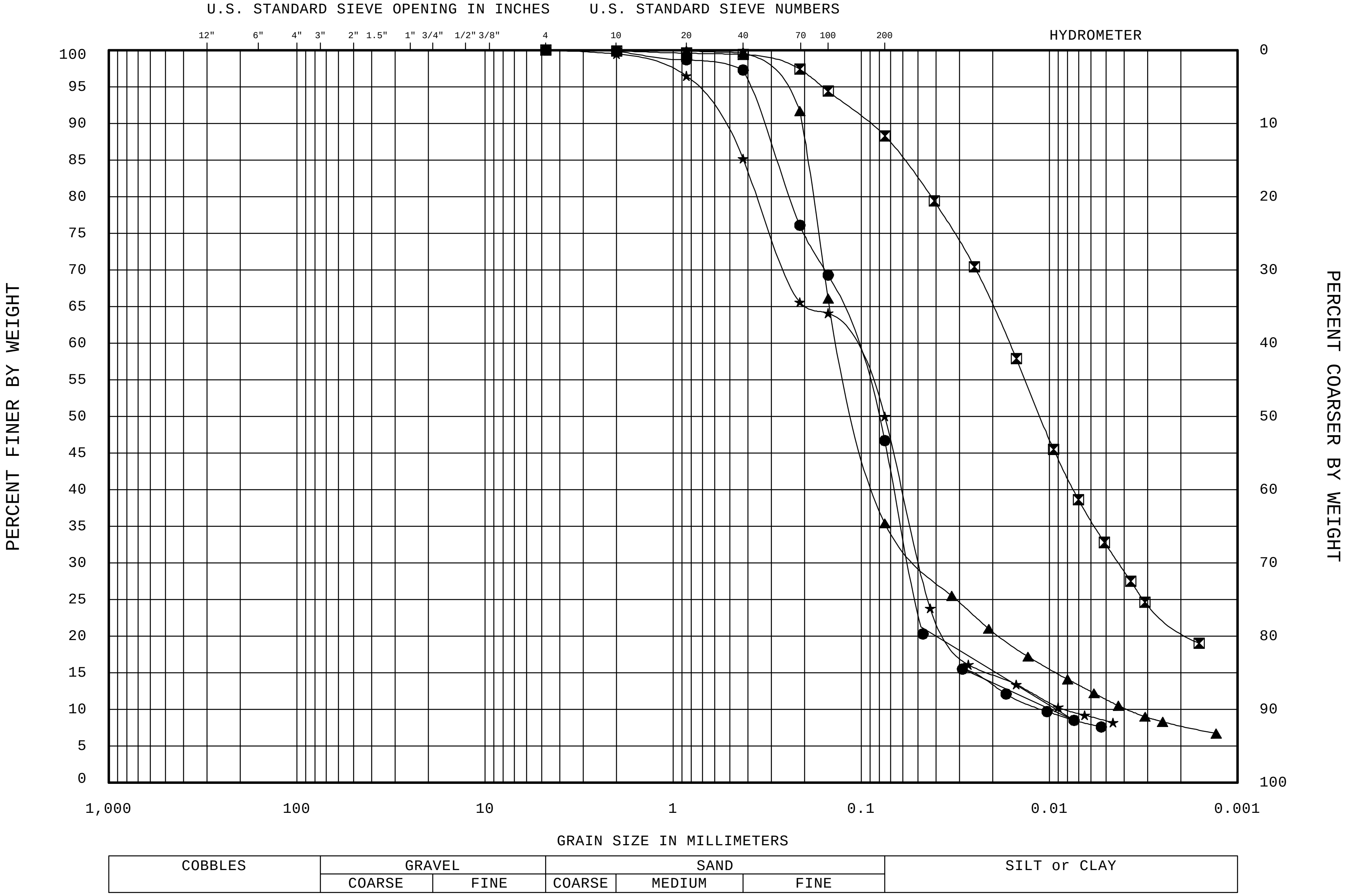
ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-402*

DATE: *Oct 2004*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-1	0.0-1.5	SILTY SAND	SM				
—⊠—	Jar-3	5.0-6.5	SILTY CLAY	CL-ML	20.7	25	18	7
—▲—	Jar-5	10.0-11.5	SILTY SAND	SM				
—★—	Jar-8	17.5-19.0	SANDY LEAN CLAY	CL	30.6	37	17	20

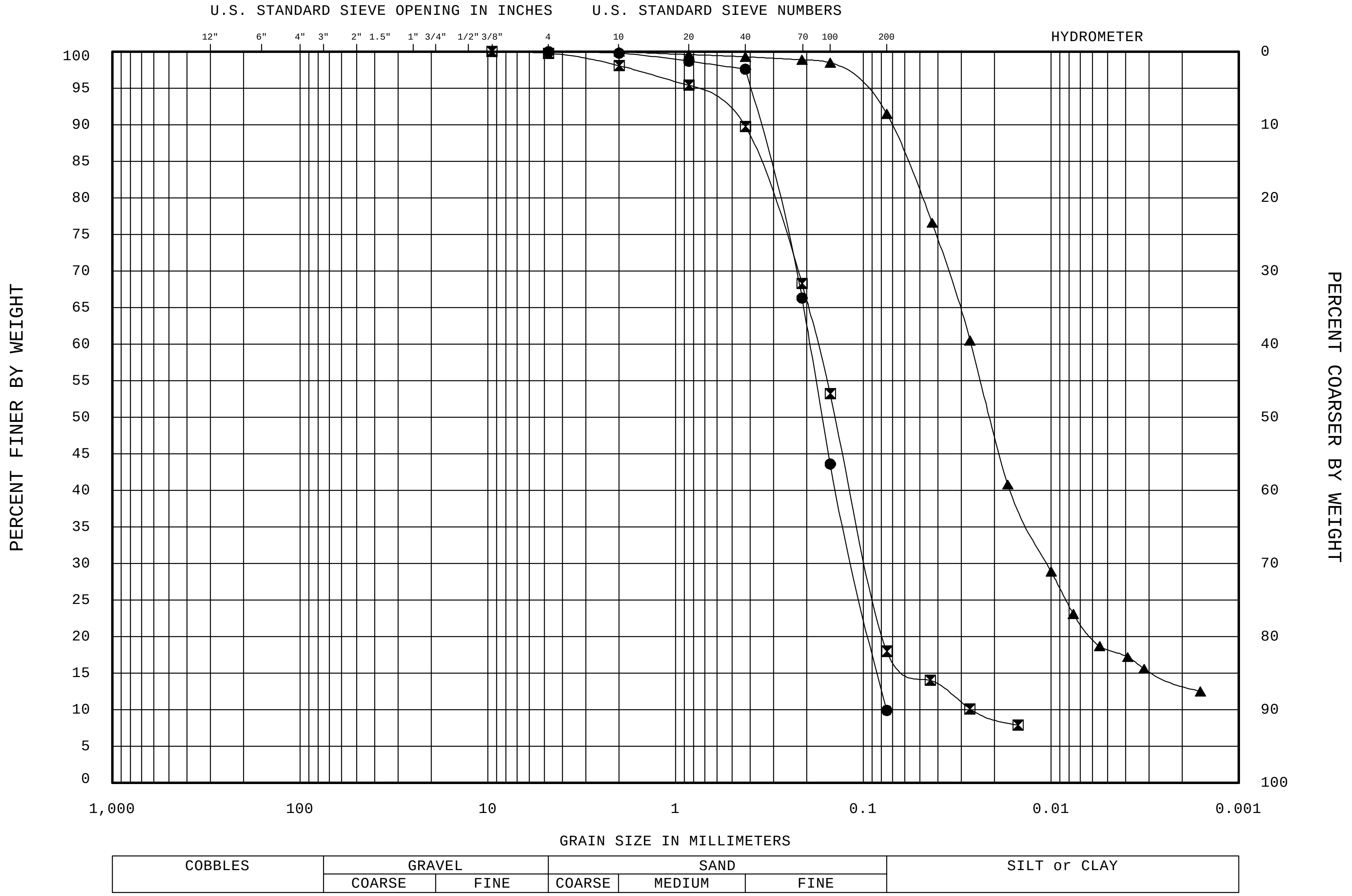
Remarks:

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-403*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-2	2.5-4.0	POORLY GRADED SAND with SILT	SP-SM				
—☒—	Jar-4	7.5-9.0	SILTY SAND	SM				
—▲—	Jar-6	12.5-14.0	SILT	ML	39.3	34	24	10
— —								

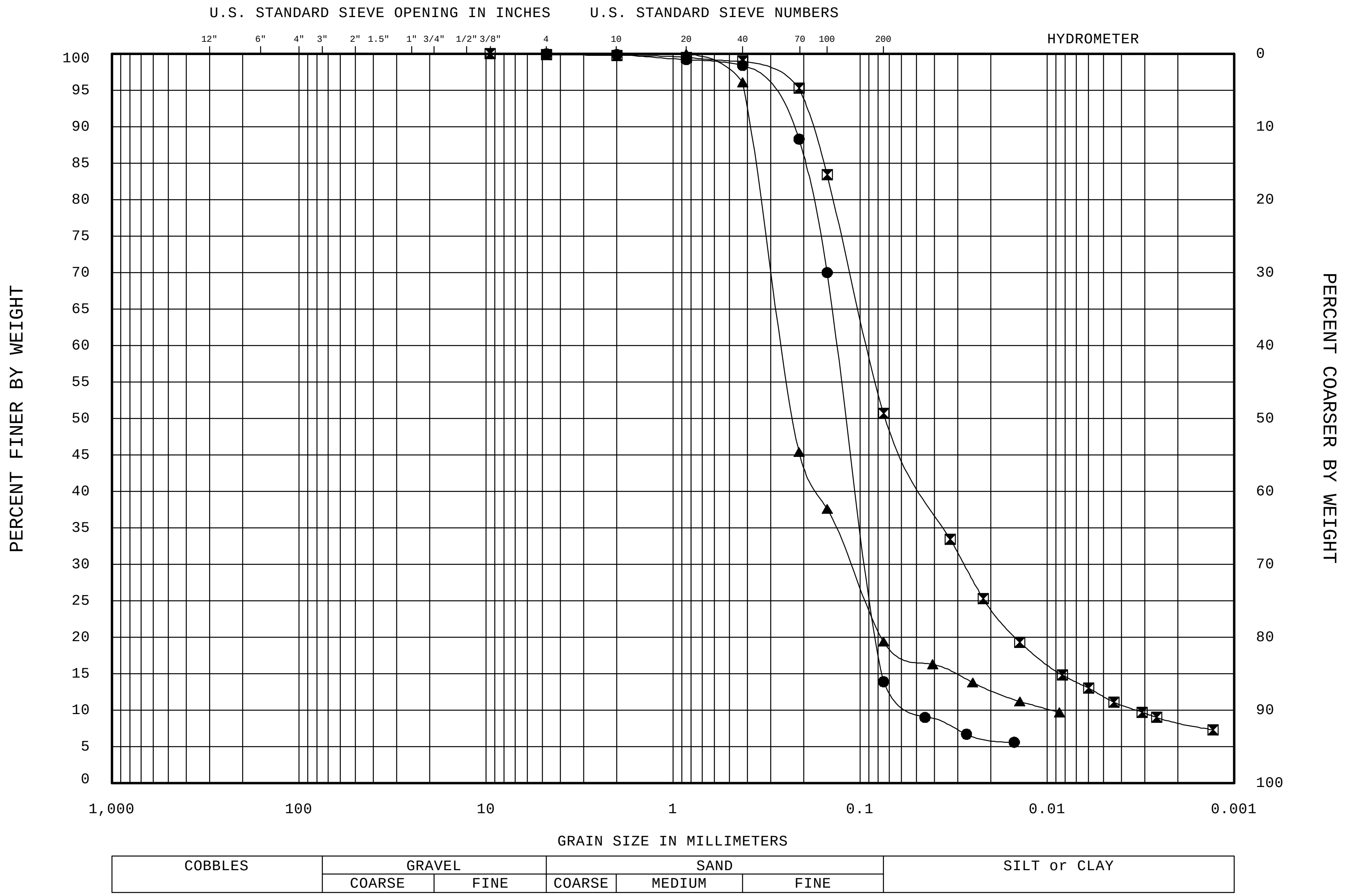
Remarks:

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-404*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-3	5.0-6.5	SILTY SAND	SM				
—☒—	Jar-6	12.5-14.0	SANDY SILT	ML				
—▲—	Jar-8	17.5-19.0	SILTY SAND	SM				
—— ——								

Remarks:

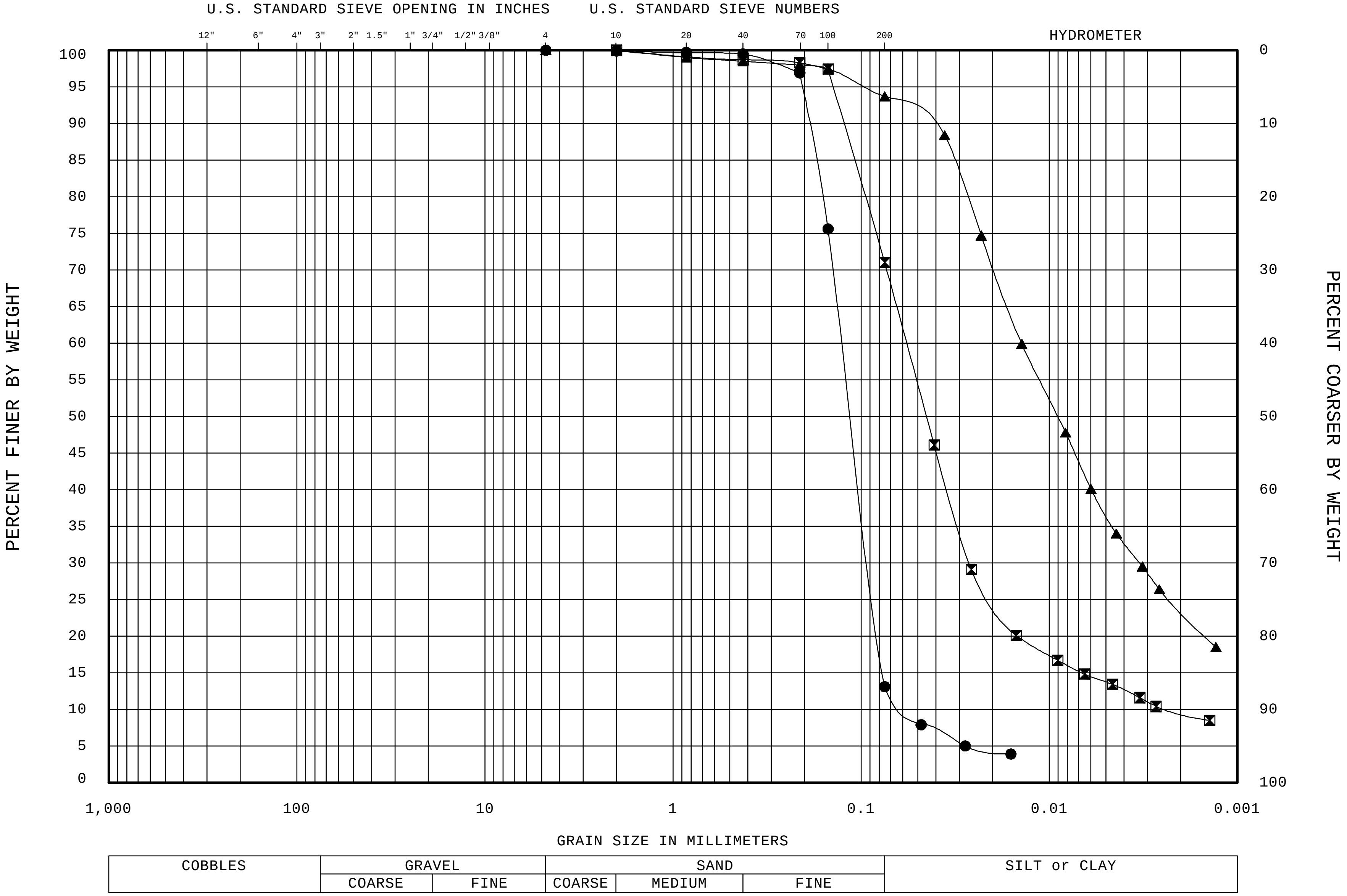
ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-405*

DATE: *Oct 2004*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-3	5.0-6.5	SILTY SAND	SM				
—☒—	Jar-5	10.0-11.5	SILT with SAND	ML	41.6	37	27	10
—▲—	Jar-8	17.5-19.0	FAT CLAY	CH	58.4	75	31	44
— —								

Remarks:

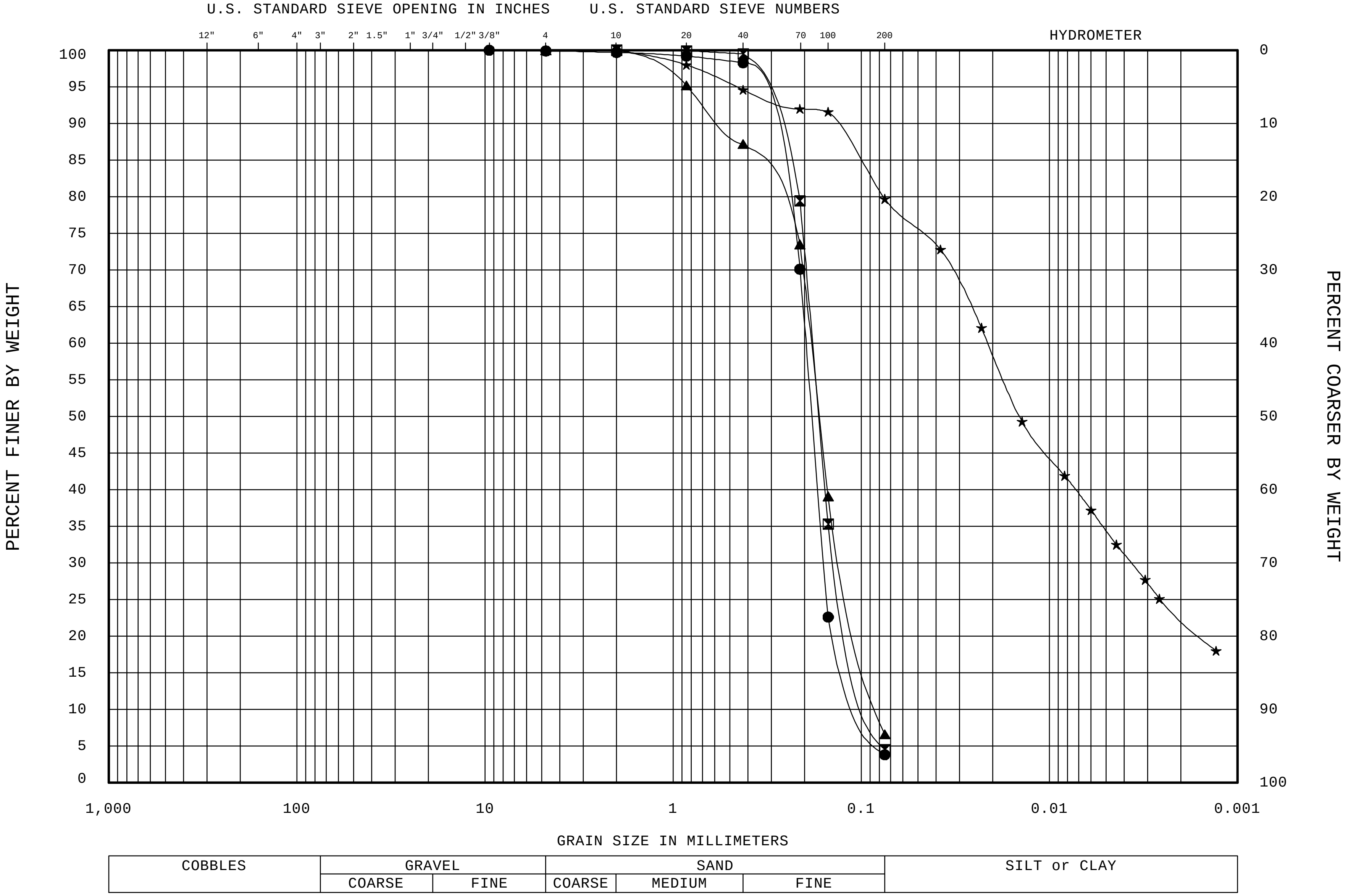
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-406*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-1	0.0-1.5	POORLY GRADED SAND	SP				
⊠	Jar-4	7.5-9.0	POORLY GRADED SAND	SP				
▲	Jar-7	15.0-16.5	POORLY GRADED SAND with SILT	SP-SM				
★	Jar-8	17.5-19.0	FAT CLAY with SAND	CH	52.0	65	28	37

Remarks:

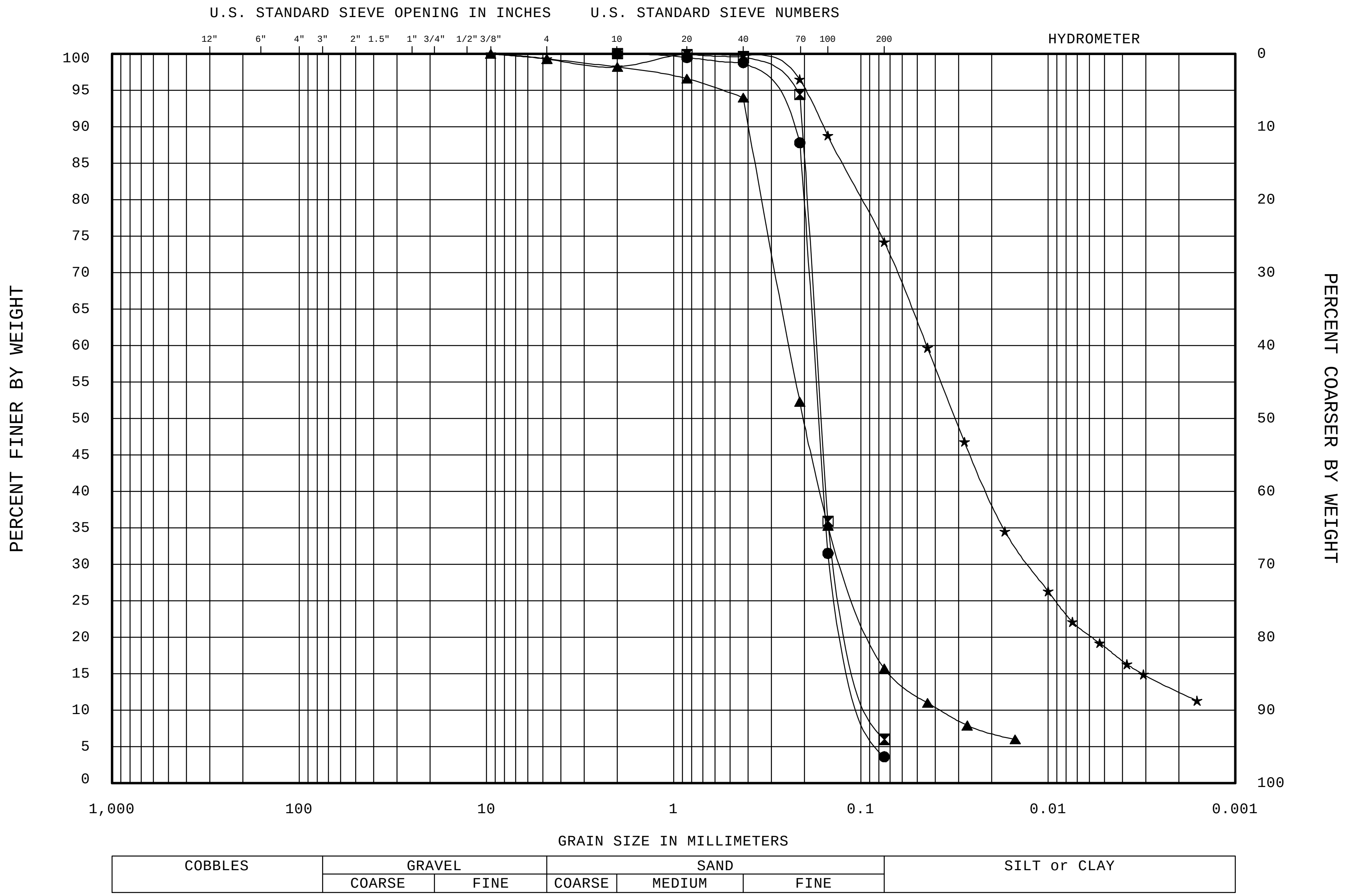
ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-407*

DATE: *Oct 2004*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-1	0.0-1.5	POORLY GRADED SAND	SP				
☒	Jar-3	5.0-6.5	POORLY GRADED SAND with SILT	SP-SM				
▲	Jar-6	12.5-14.0	SILTY SAND	SM				
★	Jar-8	17.5-19.0	SILTY CLAY with SAND	CL-ML	21.3	20	16	4

Remarks:

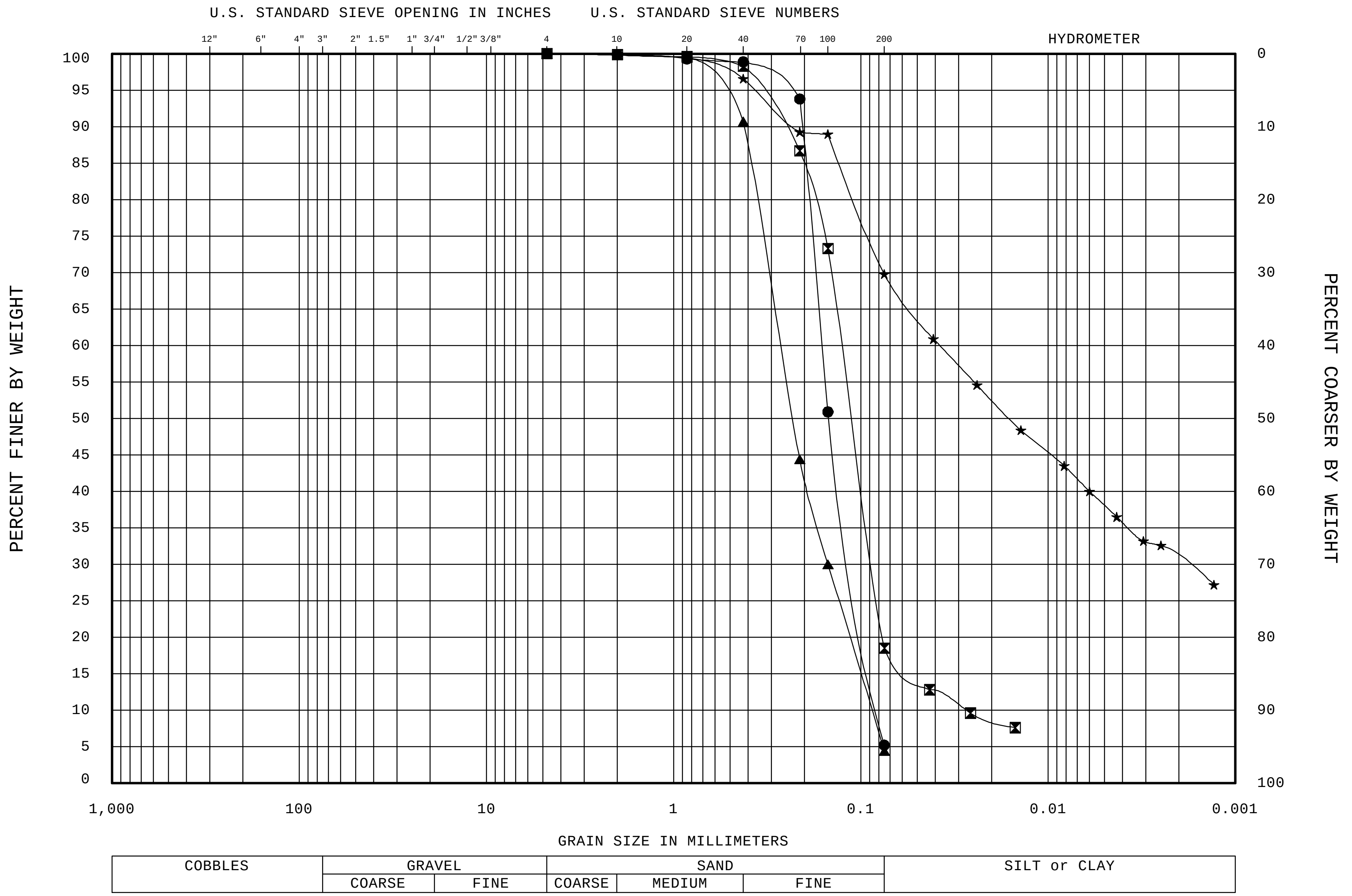
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-408*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-2	2.5-4.0	POORLY GRADED SAND with SILT	SP-SM				
—⊠—	Jar-4	7.5-9.0	SILTY SAND	SM				
—▲—	Jar-7	15.0-16.5	POORLY GRADED SAND	SP				
—★—	Jar-9	20.0-21.0	SANDY LEAN CLAY	CL	53.8	42	19	23

Remarks:

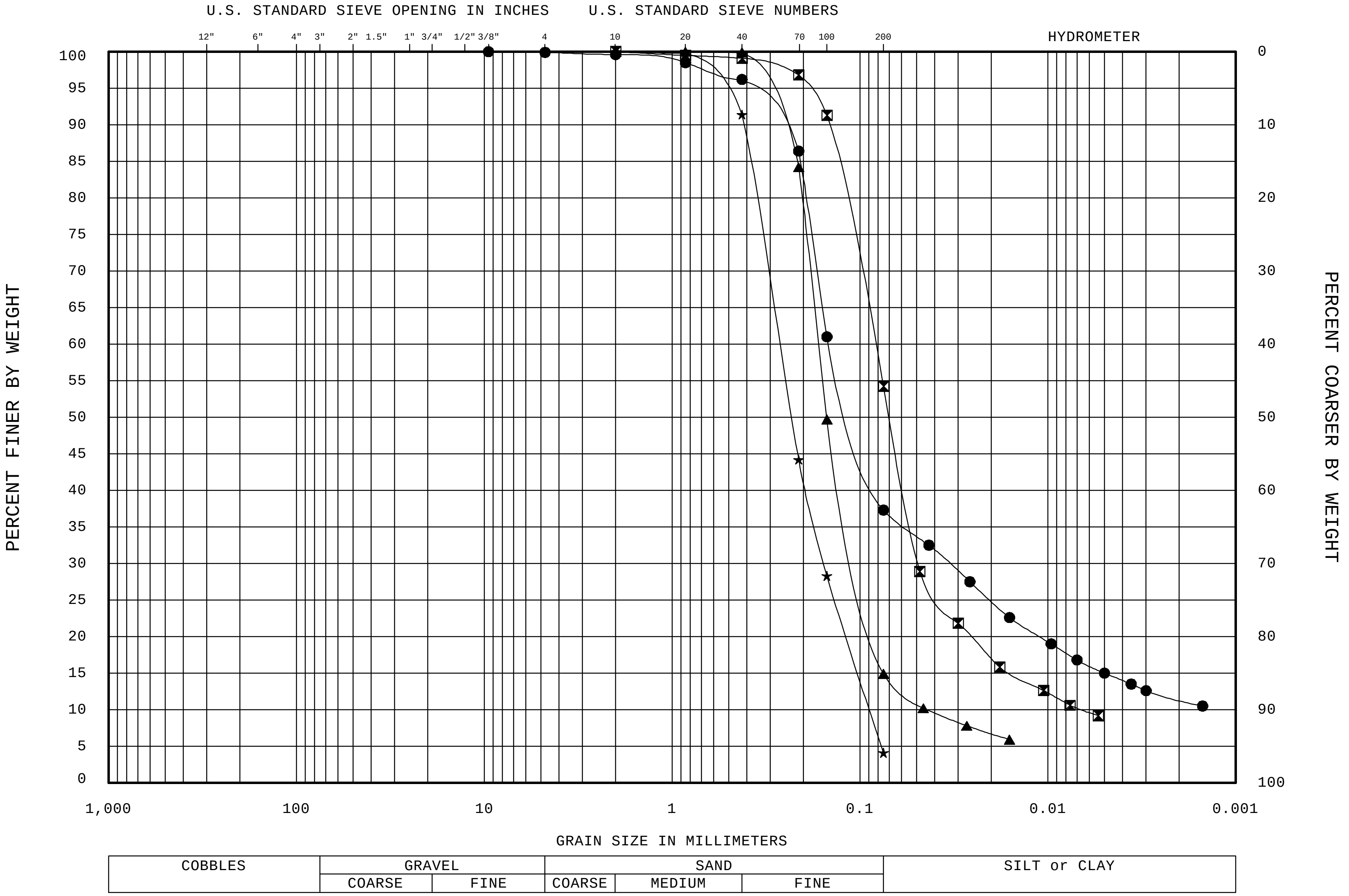
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-409*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-1	0.0-1.5	CLAYEY SAND	SC				
⊠	Jar-3	5.0-6.5	SANDY SILT	ML				
▲	Jar-6	12.5-14.0	SILTY SAND	SM				
★	Jar-9	20.0-21.5	POORLY GRADED SAND	SP				

Remarks:

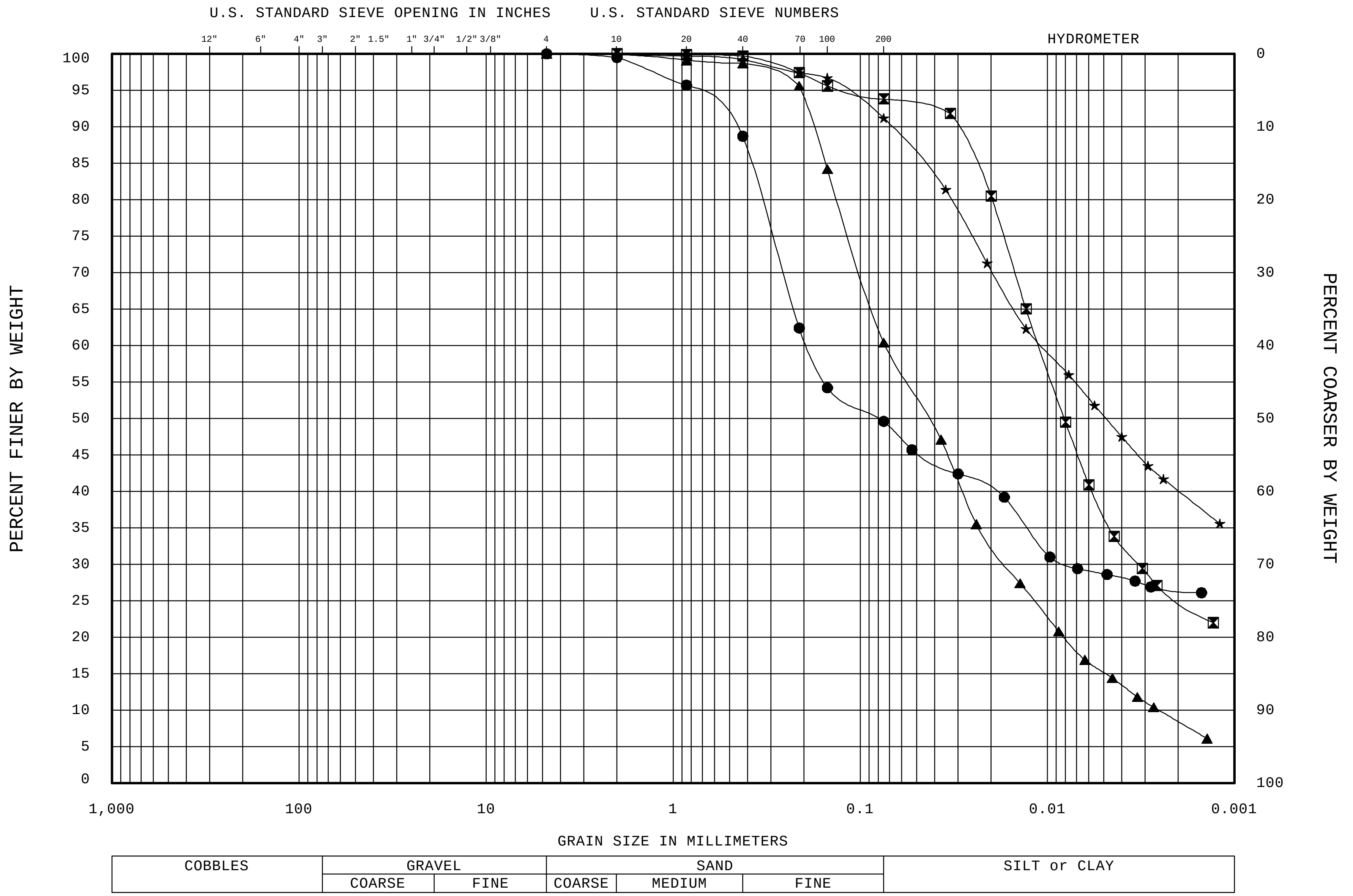
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-410*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-1	0.0-1.5	SILTY SAND	SM				
—☒—	Jar-4	7.5-9.0	FAT CLAY	CH	61.3	59	26	33
—▲—	Jar-7	15.0-16.5	SANDY LEAN CLAY	CL	36.7	35	22	13
—★—	Jar-10	22.5-24.0	FAT CLAY	CH	37.6	61	21	40

Remarks:

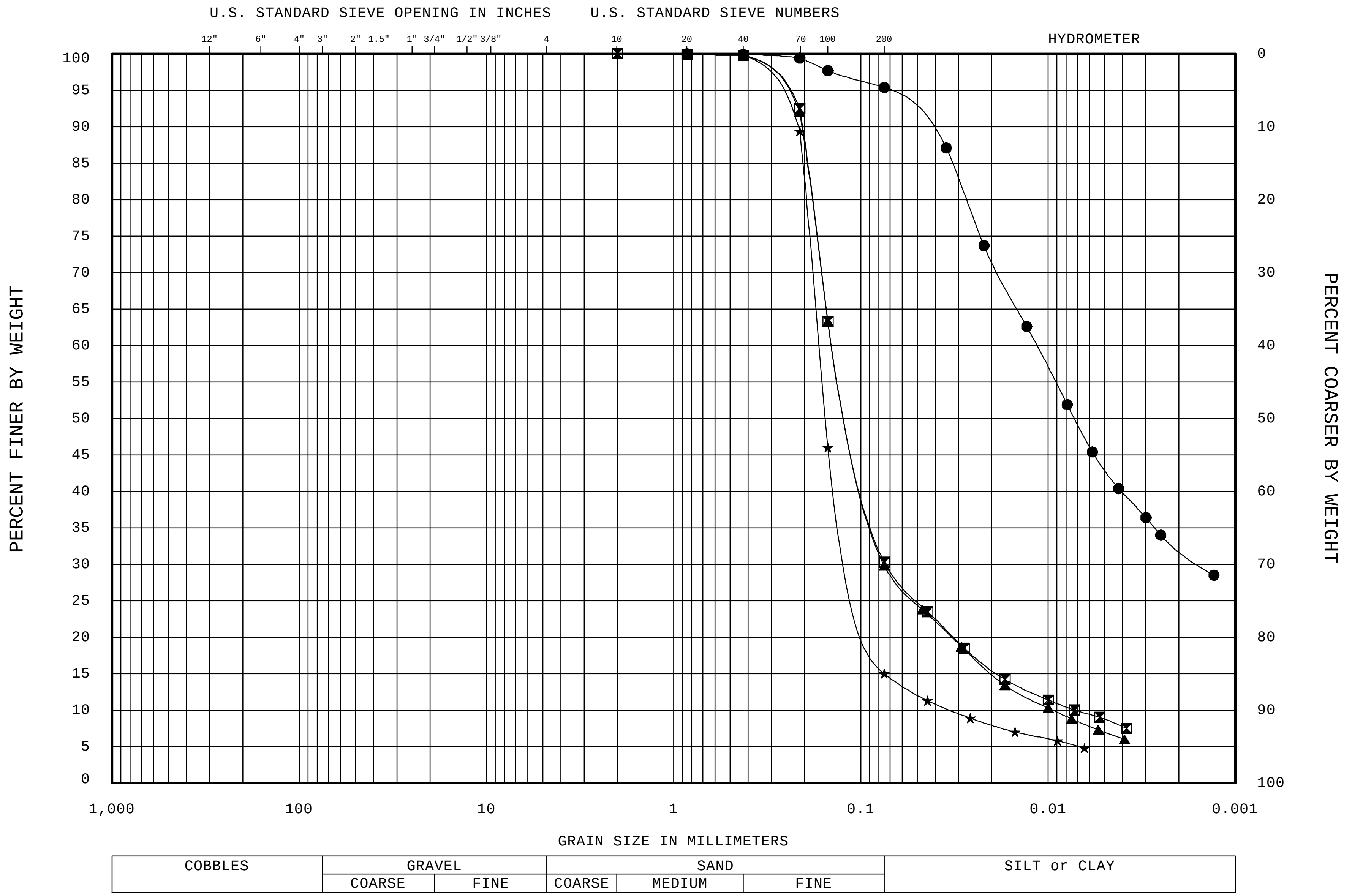
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-411*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-1	0.0-1.5	LEAN CLAY	CL	23.1	29	19	10
—☒—	Jar-3	5.0-6.5	SILTY SAND	SM				
—▲—	Jar-6	12.5-14.0	SILTY SAND	SM				
—★—	Jar-9	20.0-21.5	SILTY SAND	SM				

Remarks:

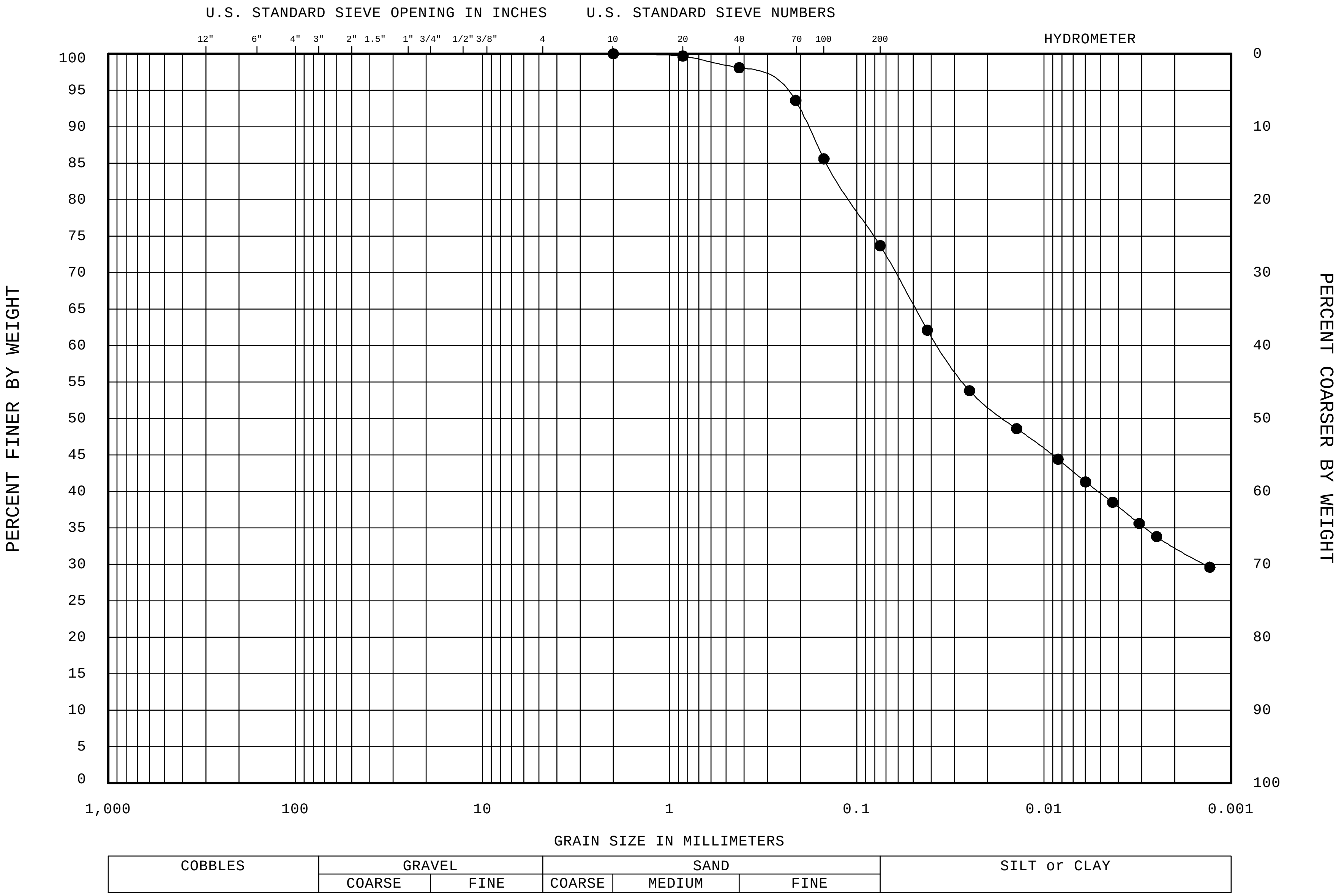
ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-412*

DATE: *Oct 2004*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-13	30.0-31.5	LEAN CLAY with SAND	CL	41.8	46	18	28
—— ——								
—— ——								
—— ——								

Remarks:

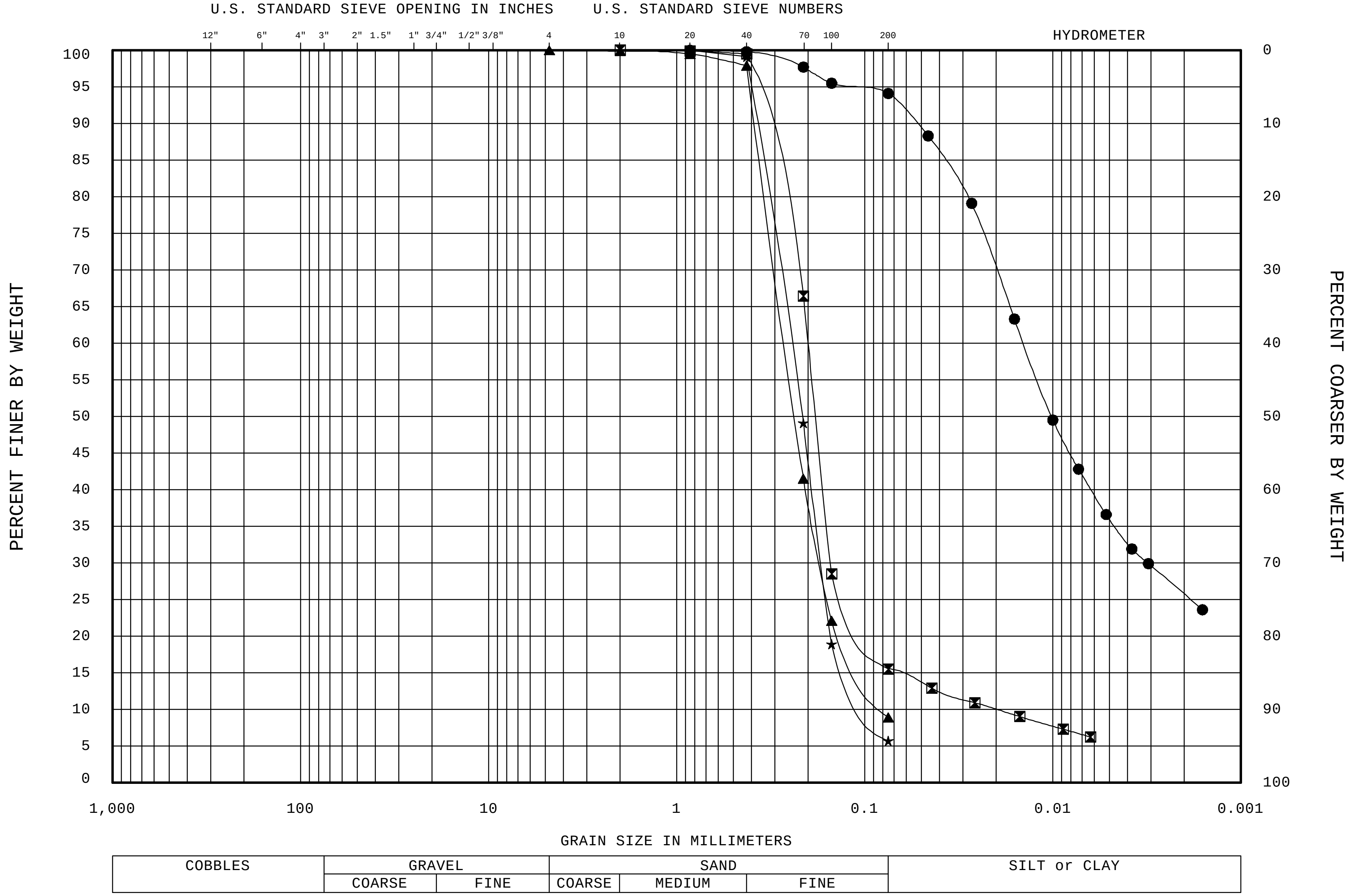
ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-412*

DATE: *Oct 2004*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-2	2.5-4.0	LEAN CLAY	CL	24.4	31	18	13
☒	Jar-4	7.5-9.0	SILTY SAND	SM				
▲	Jar-7	15.0-16.5	POORLY GRADED SAND with SILT	SP-SM				
★	Jar-10	22.5-24.0	POORLY GRADED SAND with SILT	SP-SM				

Remarks:

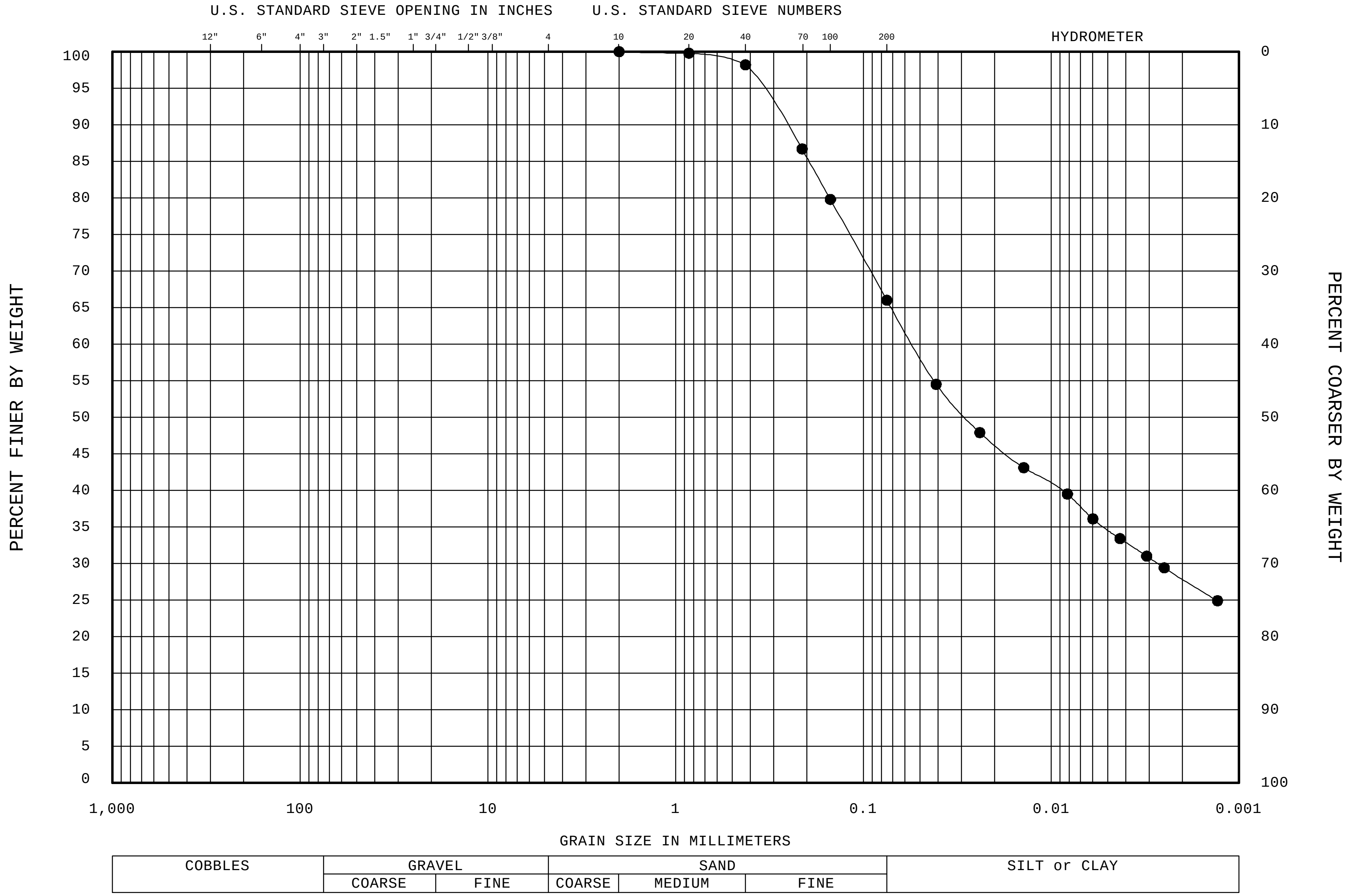
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-413*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-12	27.5-29.0	SANDY LEAN CLAY	CL	40.6	46	18	28
—— ——								
—— ——								
—— ——								

Remarks:

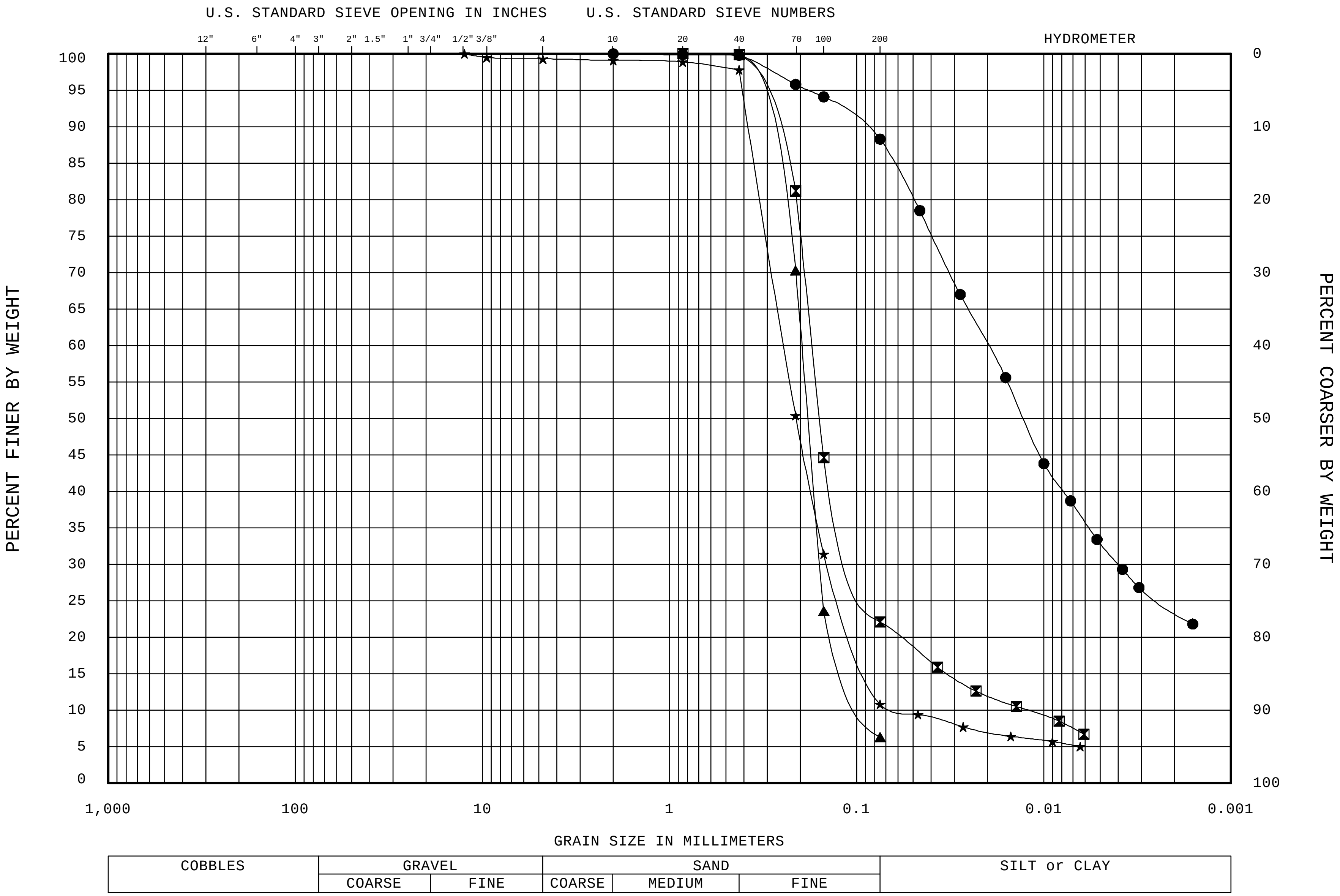
ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-413*

DATE: *Oct 2004*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-1	0.0-1.5	LEAN CLAY	CL	22.6	33	22	11
—⊠—	Jar-4	7.5-9.0	SILTY SAND	SM				
—▲—	Jar-7	15.0-16.5	POORLY GRADED SAND with SILT	SP-SM				
—★—	Jar-10	22.5-24.0	POORLY GRADED SAND with SILT	SP-SM				

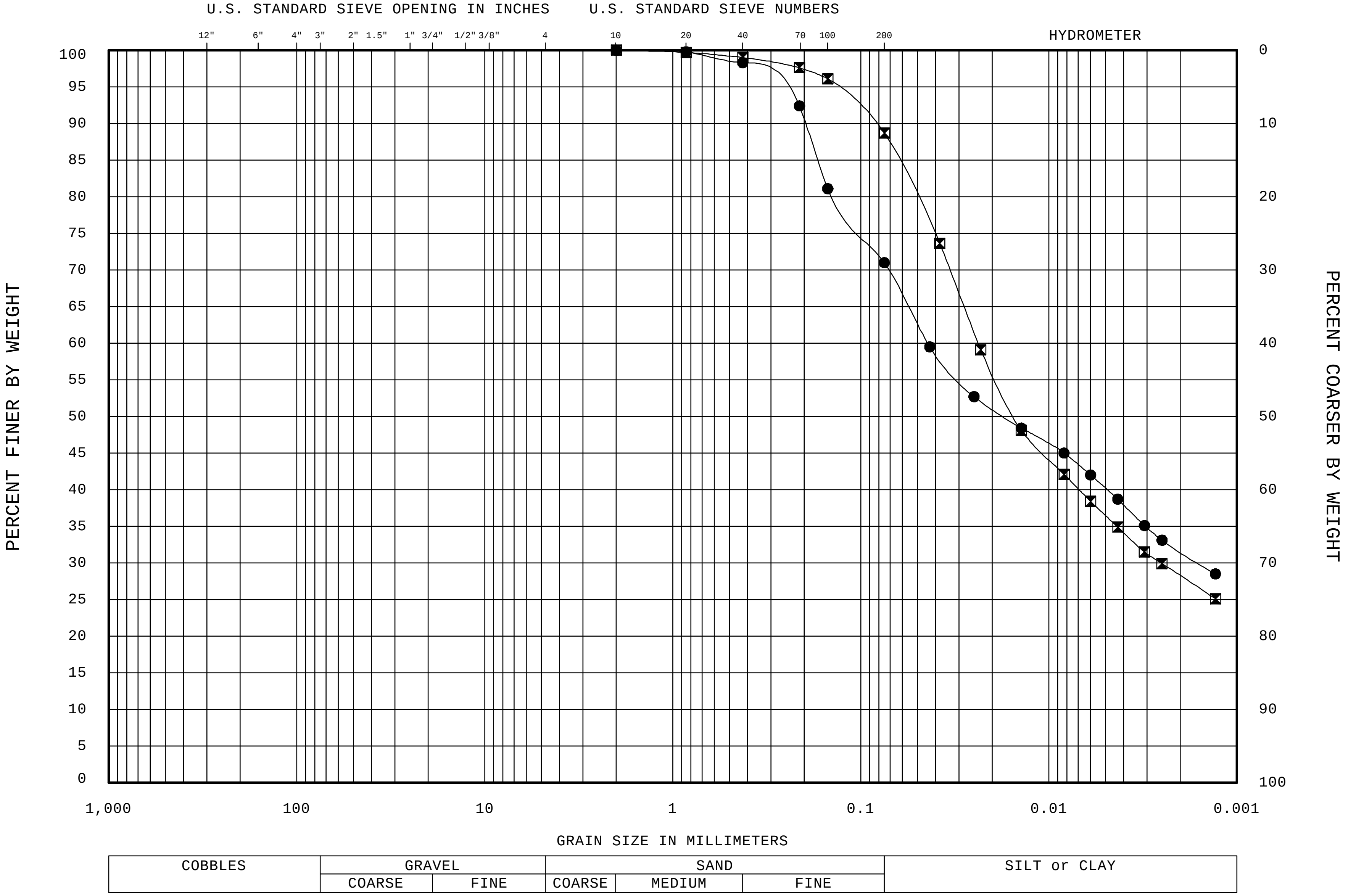
Remarks:

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-414*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-12	27.5-29.0	FAT CLAY with SAND	CH	47.1	51	20	31
⊠	Jar-16	37.5-39.5	LEAN CLAY	CL	36.4	37	19	18

Remarks:

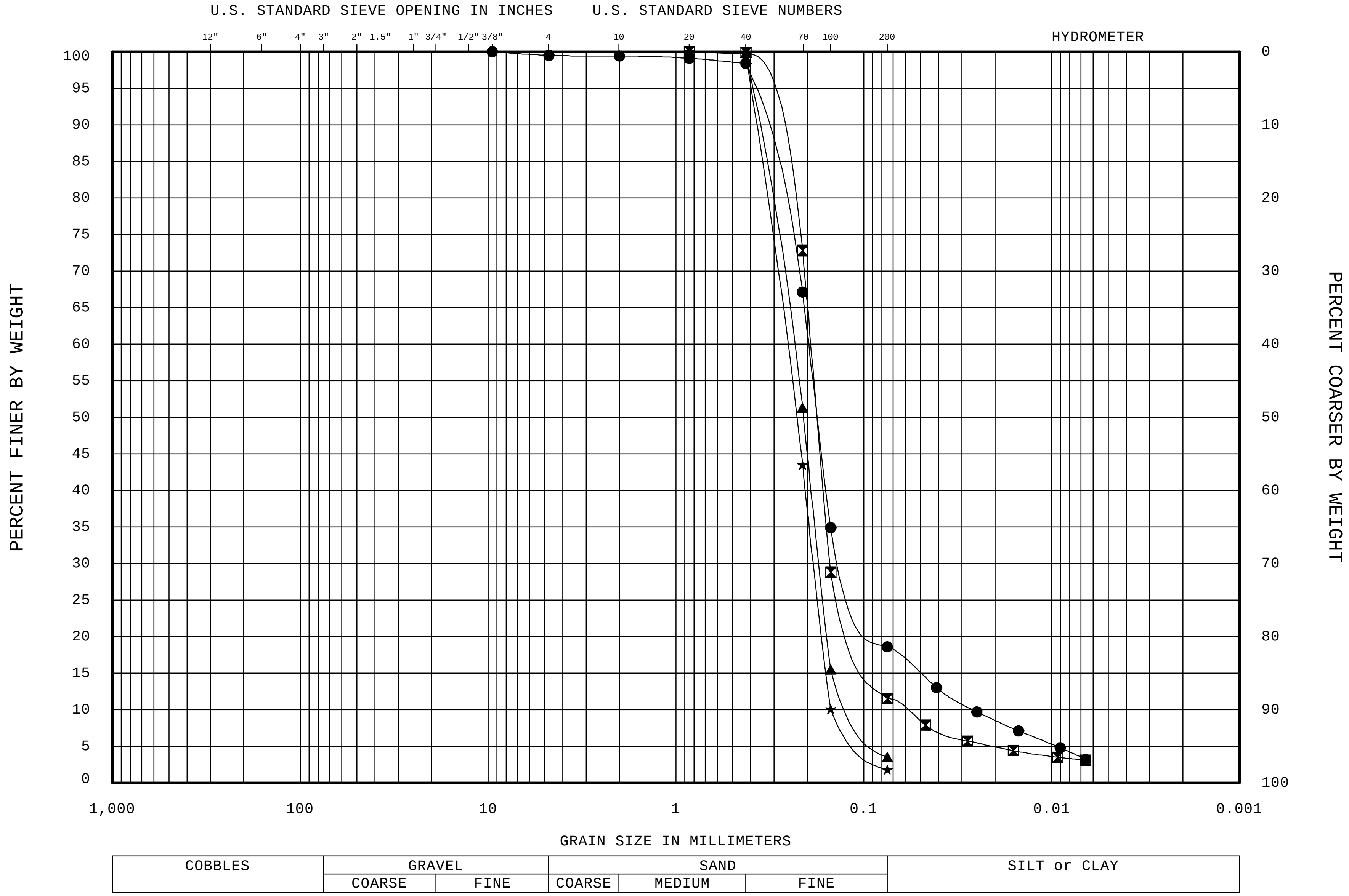
ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-414*

DATE: *Oct 2004*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-2	2.5-4.0	SILTY SAND	SM				
⊠	Jar-5	10.0-11.5	POORLY GRADED SAND with SILT	SP-SM				
▲	Jar-7	15.0-16.5	POORLY GRADED SAND	SP				
★	Jar-9	20.0-21.5	POORLY GRADED SAND	SP				

Remarks:

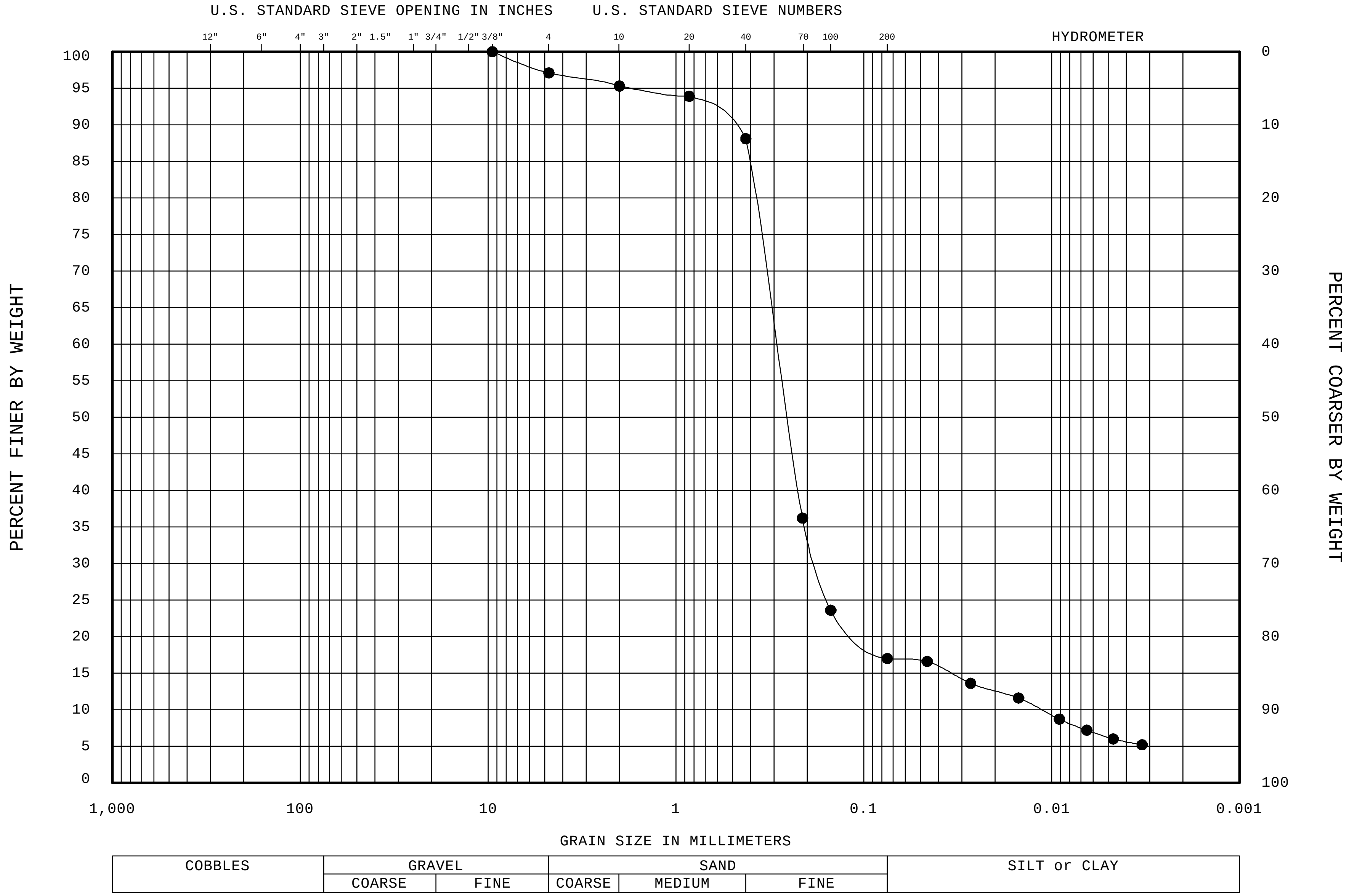
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-415*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
——●——	Jar-11	25.0-26.5	SILTY, CLAYEY SAND	SC-SM	25.6	22	16	6
—— ——								
—— ——								
—— ——								

Remarks:

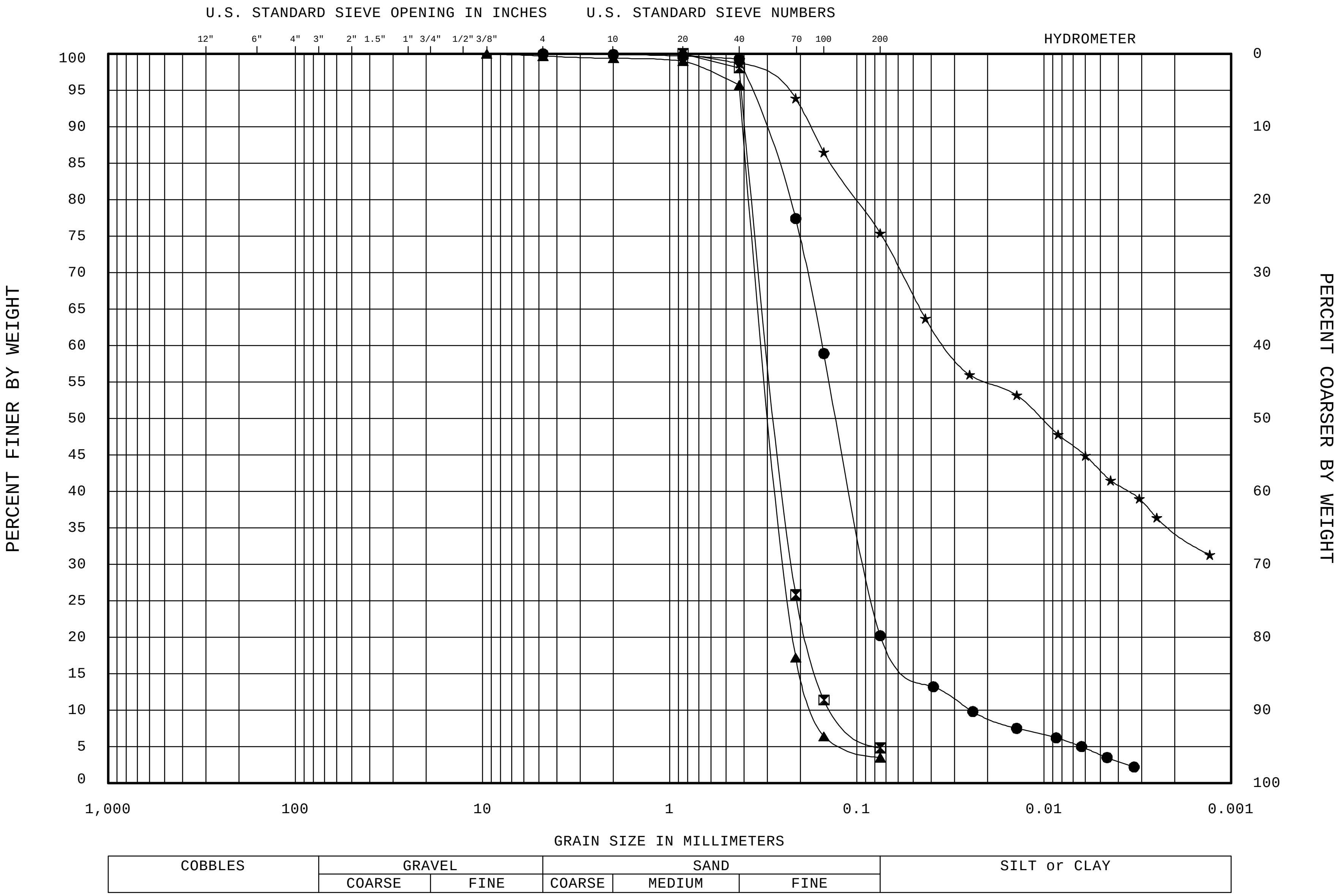
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-415*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-3	5.0-6.5	SILTY SAND	SM				
—⊠—	Jar-6	12.5-14.0	POORLY GRADED SAND	SP				
—▲—	Jar-8	17.5-19.0	POORLY GRADED SAND	SP	24.5	NP	NP	NP
—★—	Jar-10	22.5-24.0	LEAN CLAY with SAND	CL	43.7	43	18	25

Remarks:

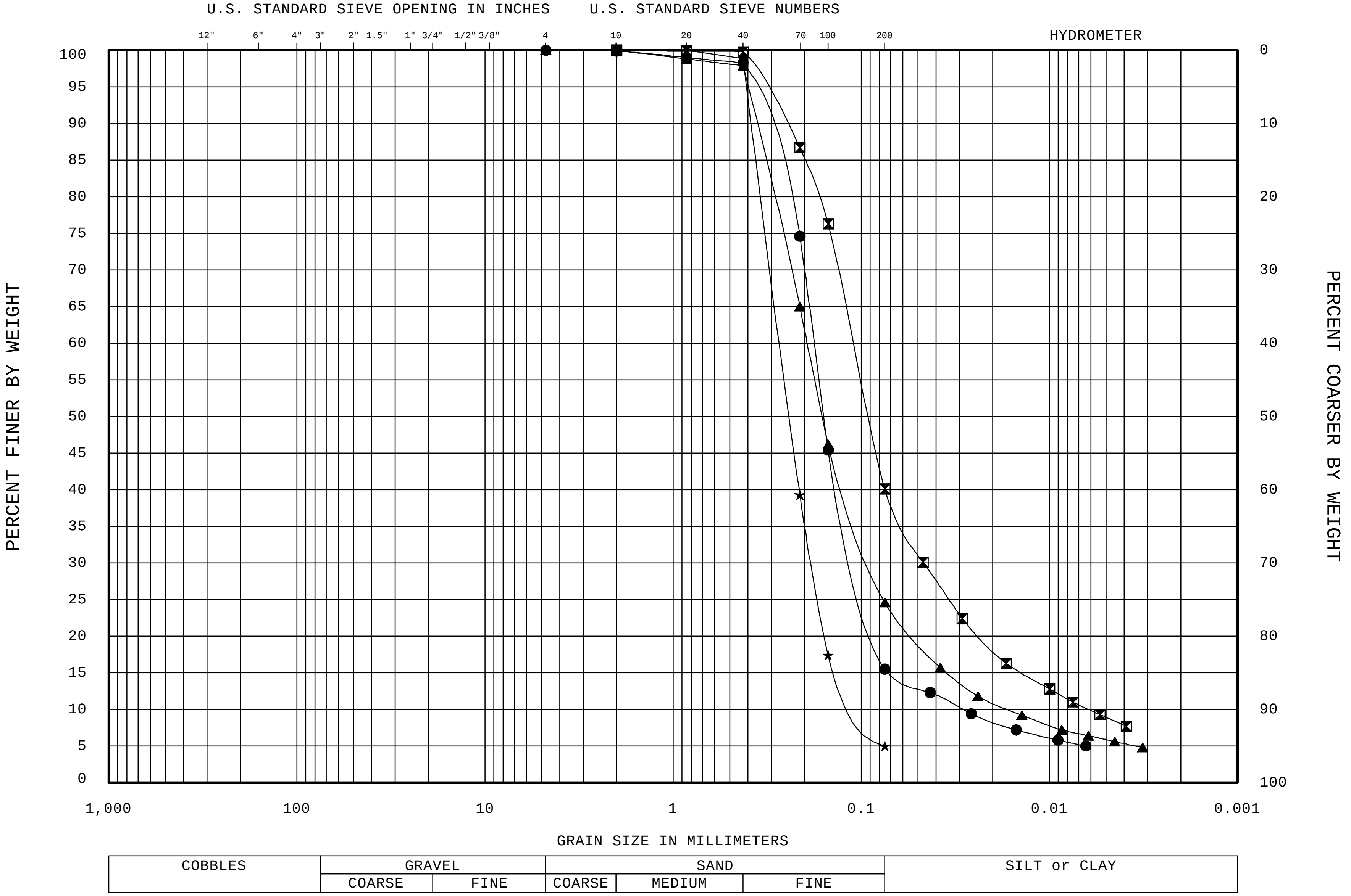
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-416*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-2	2.5-4.0	SILTY SAND	SM				
—⊠—	Jar-4	7.5-9.0	SILTY SAND	SM	24.8	NP	NP	NP
—▲—	Jar-7	15.0-16.5	SILTY SAND	SM				
—★—	Jar-10	22.5-24.0	POORLY GRADED SAND with SILT	SP-SM				

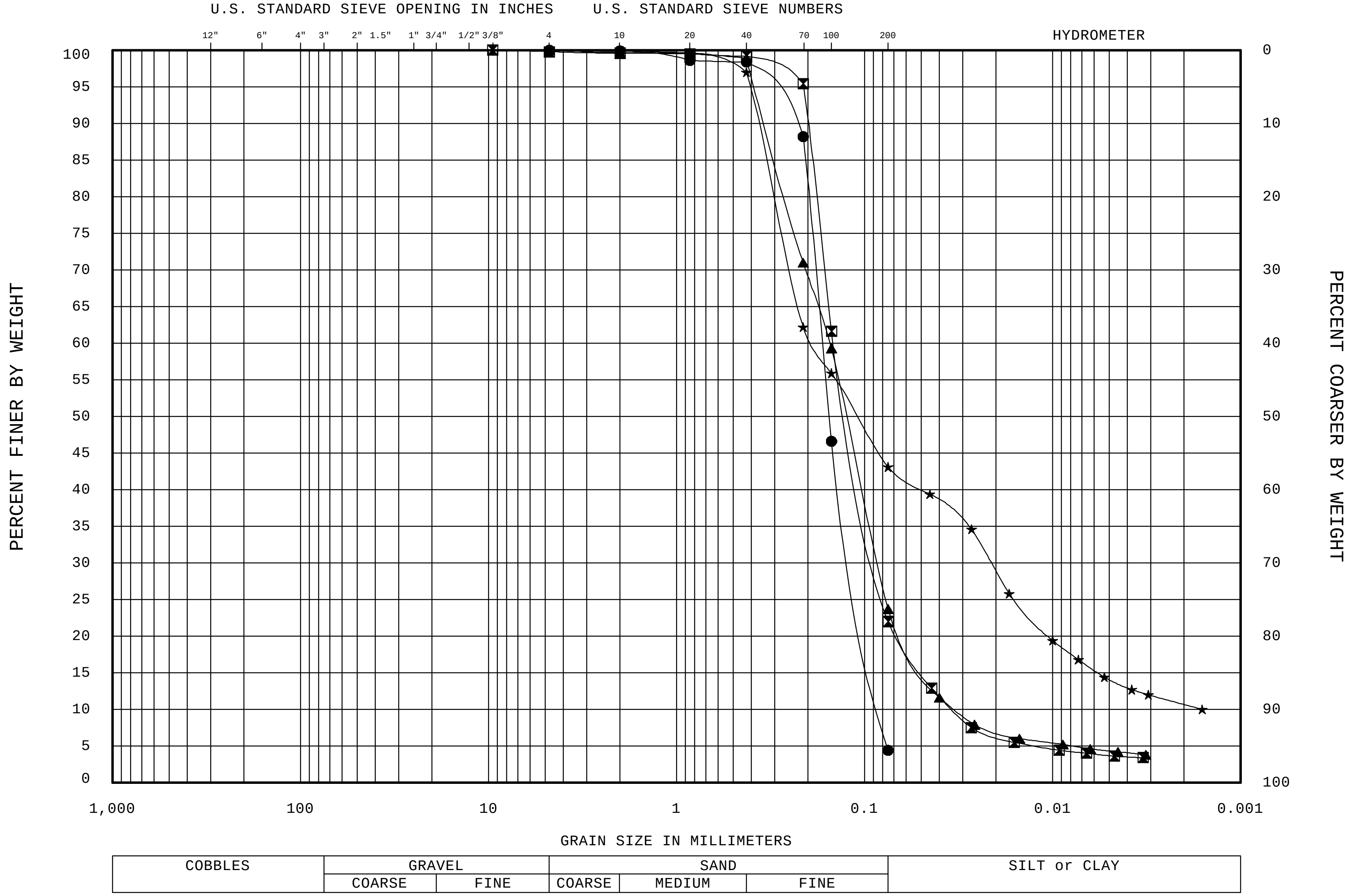
Remarks:

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-417*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-1	0.0-1.5	POORLY GRADED SAND	SP				
☒	Jar-3	5.0-6.5	SILTY SAND	SM				
▲	Jar-5	10.0-11.5	SILTY SAND	SM				
★	Jar-7	15.0-16.5	CLAYEY SAND	SC	35.7	27	16	11

Remarks:

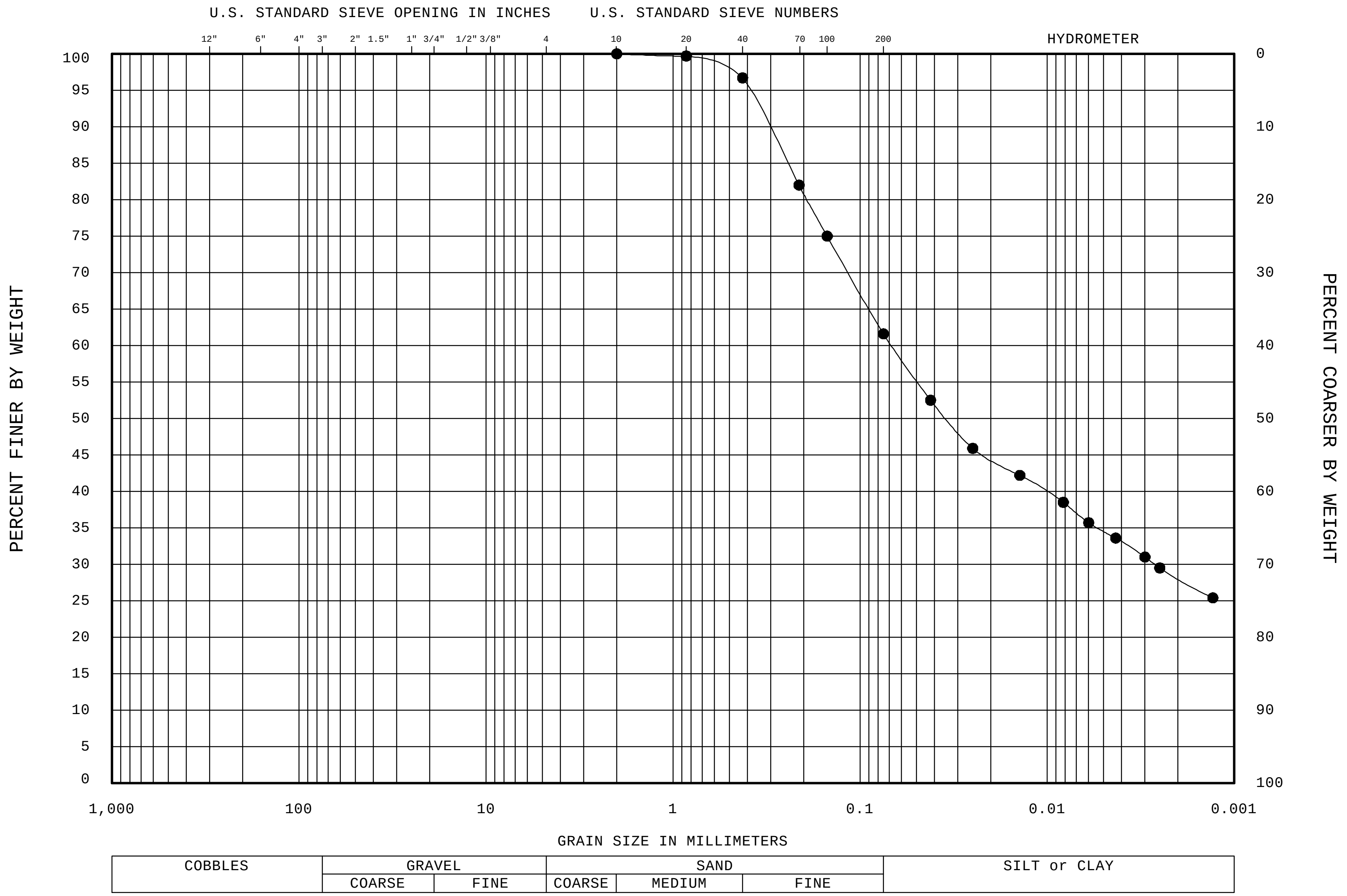
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-418*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-10	22.5-24.0	SANDY LEAN CLAY	CL	41.2	42	17	25
—— ——								
—— ——								
—— ——								

Remarks:

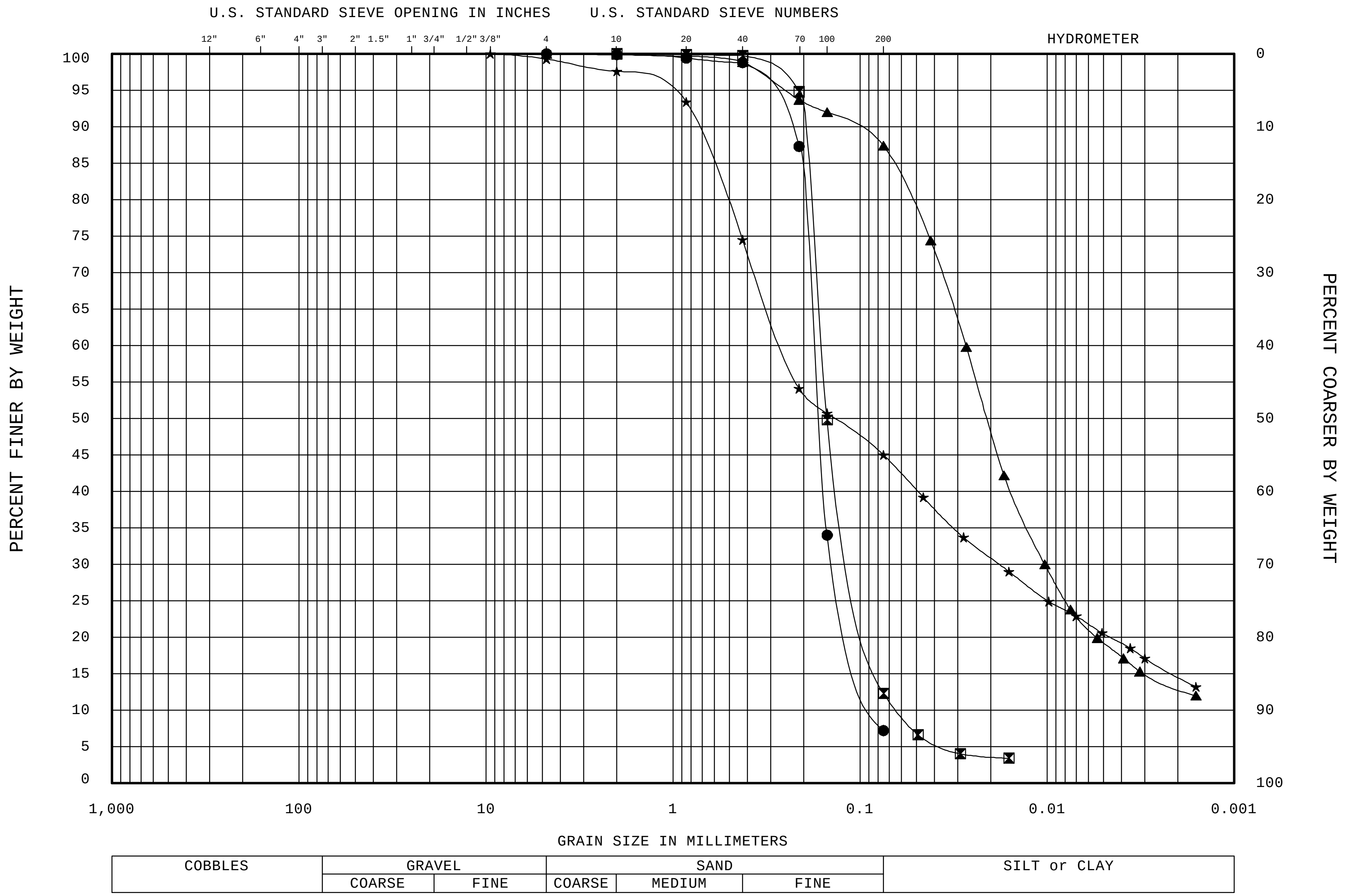
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-418*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-2	2.5-4.0	POORLY GRADED SAND with SILT	SP-SM				
⊠	Jar-5	10.0-11.5	SILTY SAND	SM				
▲	Jar-7	15.0-16.5	SILTY CLAY	CL-ML	22.5	23	19	4
★	Jar-9	20.0-21.5	CLAYEY SAND	SC	24.6	30	17	13

Remarks:

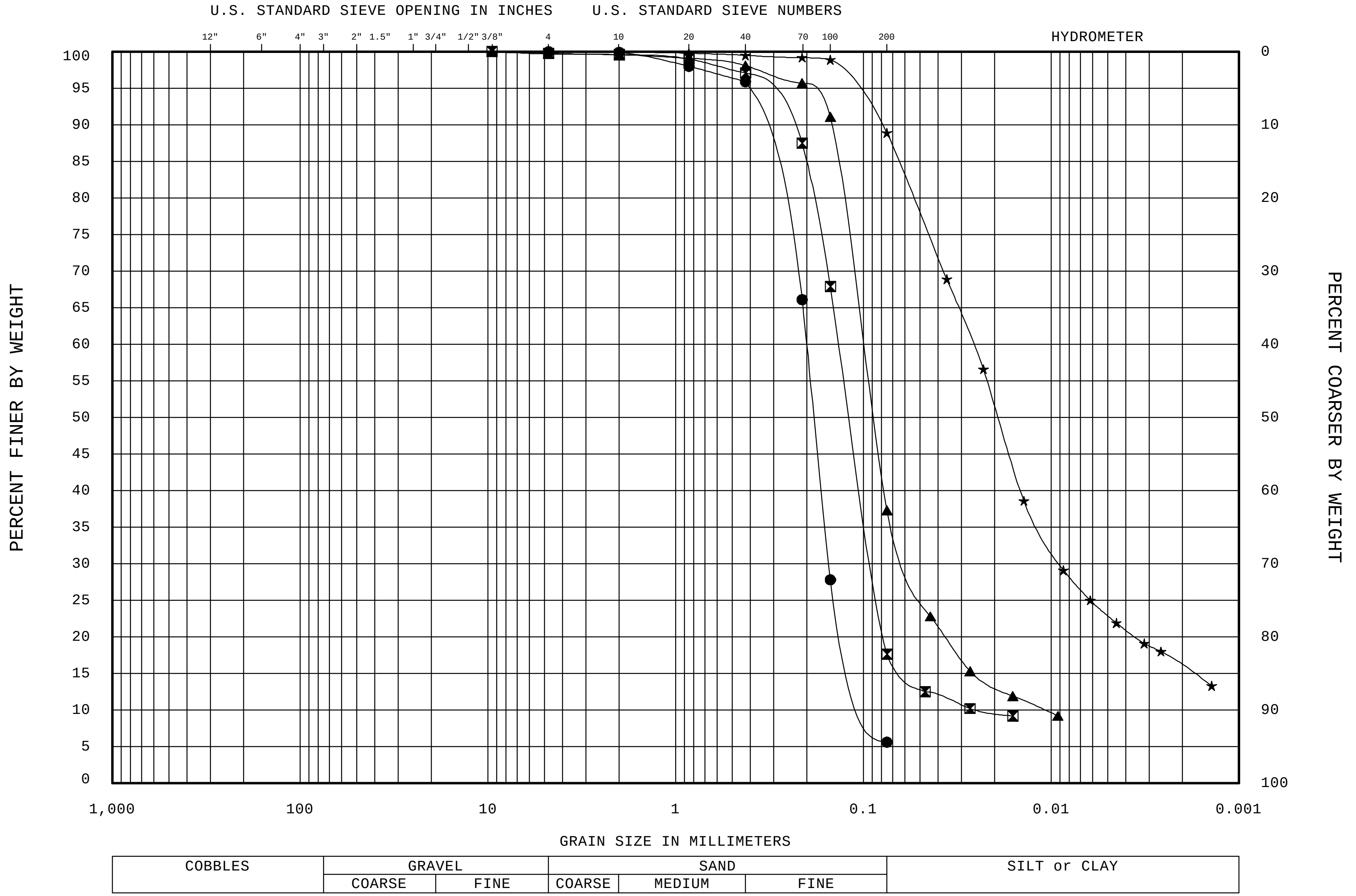
ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-419*

DATE: *Oct 2004*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-1	0.0-1.5	POORLY GRADED SAND with SILT	SP-SM				
—⊠—	Jar-3	5.0-6.5	SILTY SAND	SM				
—▲—	Jar-4	7.5-9.0	SILTY SAND	SM	38.0	NP	NP	NP
—★—	Jar-7	15.0-16.5	LEAN CLAY	CL	46.5	44	24	20

Remarks:

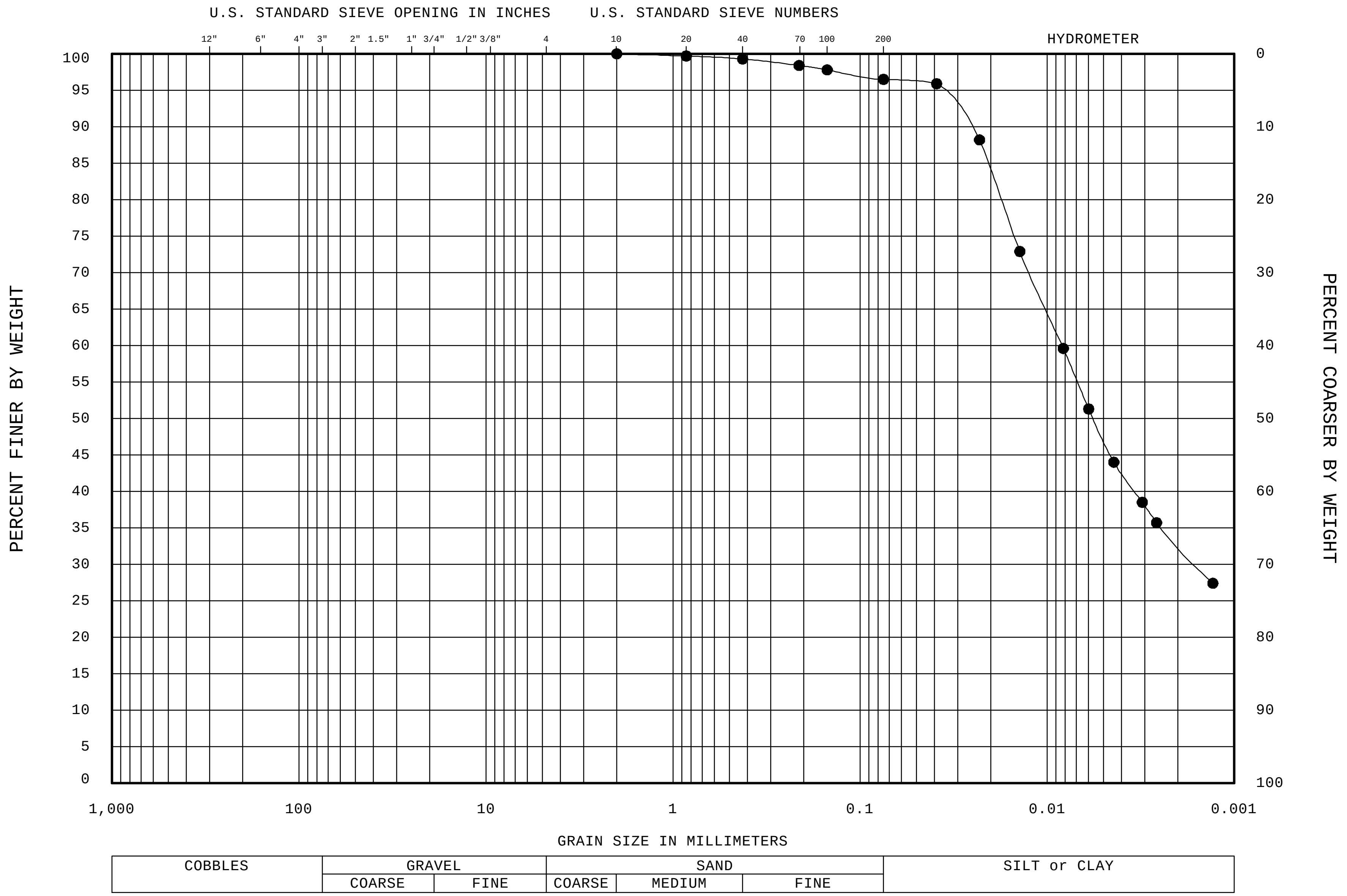
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-420*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-11	25.0-26.5	FAT CLAY	CH	64.6	73	30	43
— —								
— —								
— —								

Remarks:

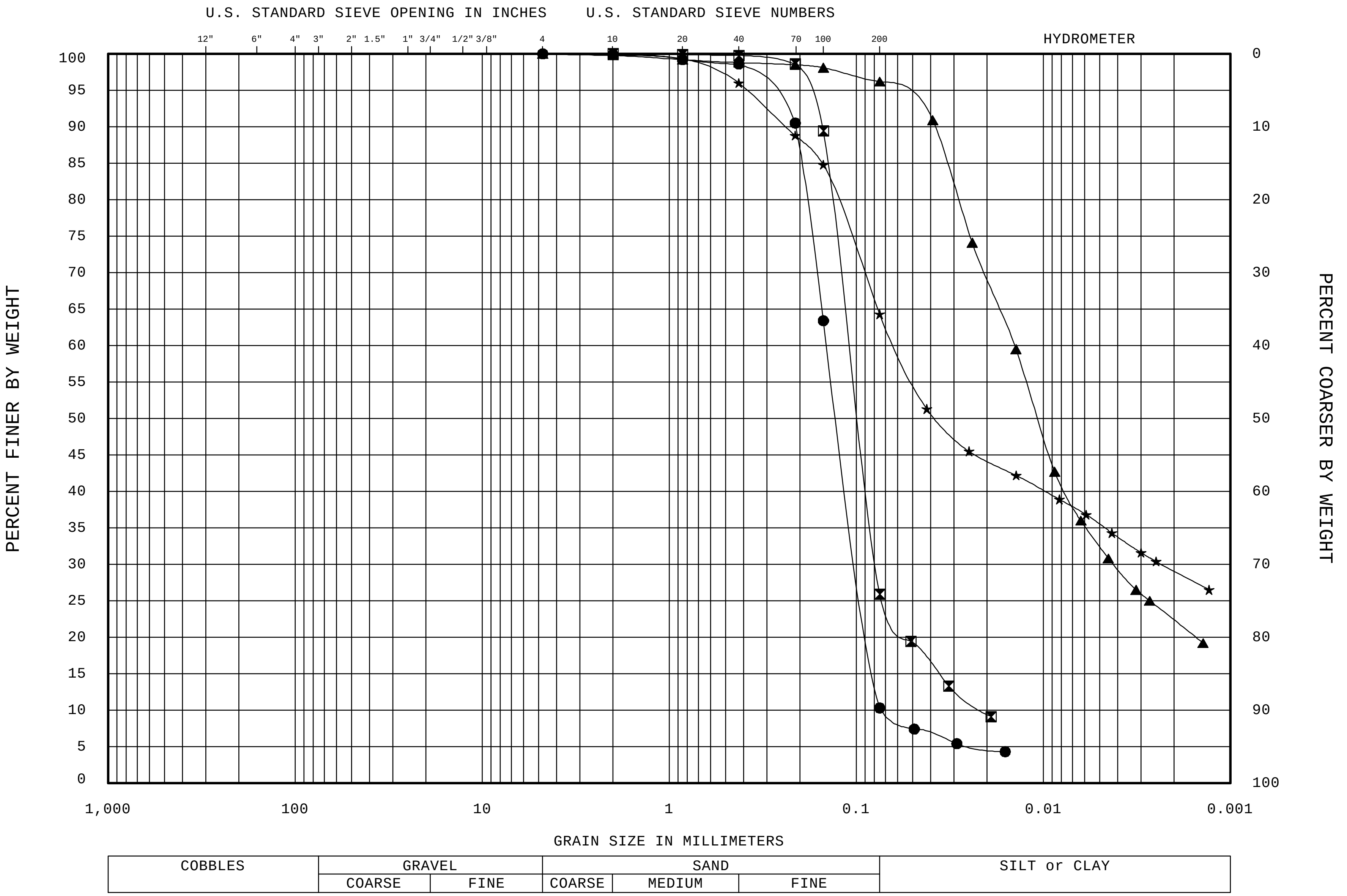
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-420*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-1	0.0-1.5	POORLY GRADED SAND with SILT	SP-SM				
⊠	Jar-4	7.5-9.0	SILTY SAND	SM				
▲	Jar-6	12.5-14.0	FAT CLAY	CH	55.1	61	28	33
★	Jar-10	22.5-24.0	SANDY LEAN CLAY	CL	27.7	31	15	16

Remarks:

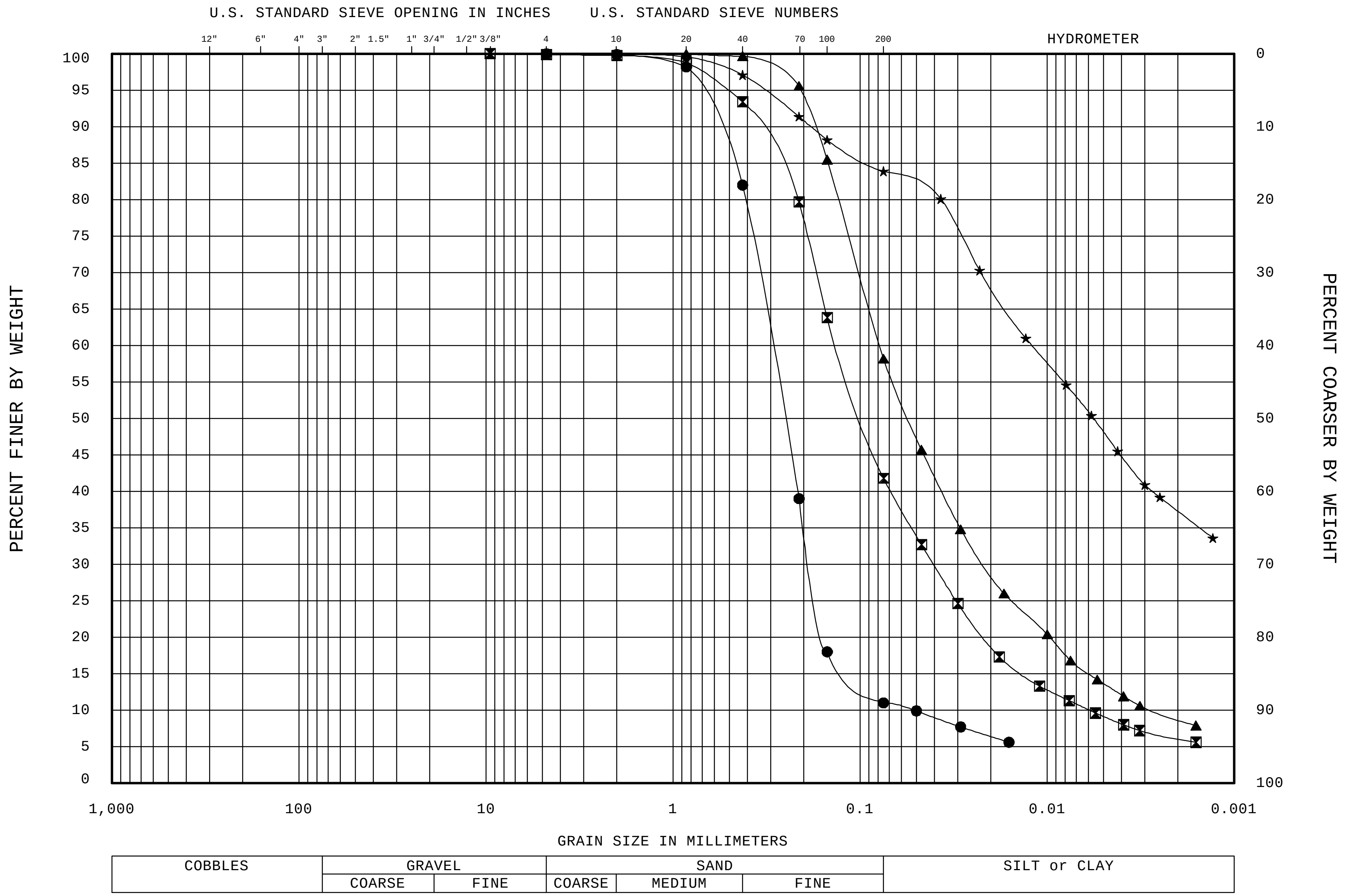
ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-421*

DATE: *Oct 2004*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
——●——	Jar-1	0.0-1.5	POORLY GRADED SAND with SILT	SP-SM				
——☒——	Jar-3	5.0-6.5	SILTY SAND	SM				
——▲——	Jar-6	12.5-14.0	SANDY SILT	ML				
——★——	Jar-8	17.5-19.0	CLAY with SAND	CH/CL				

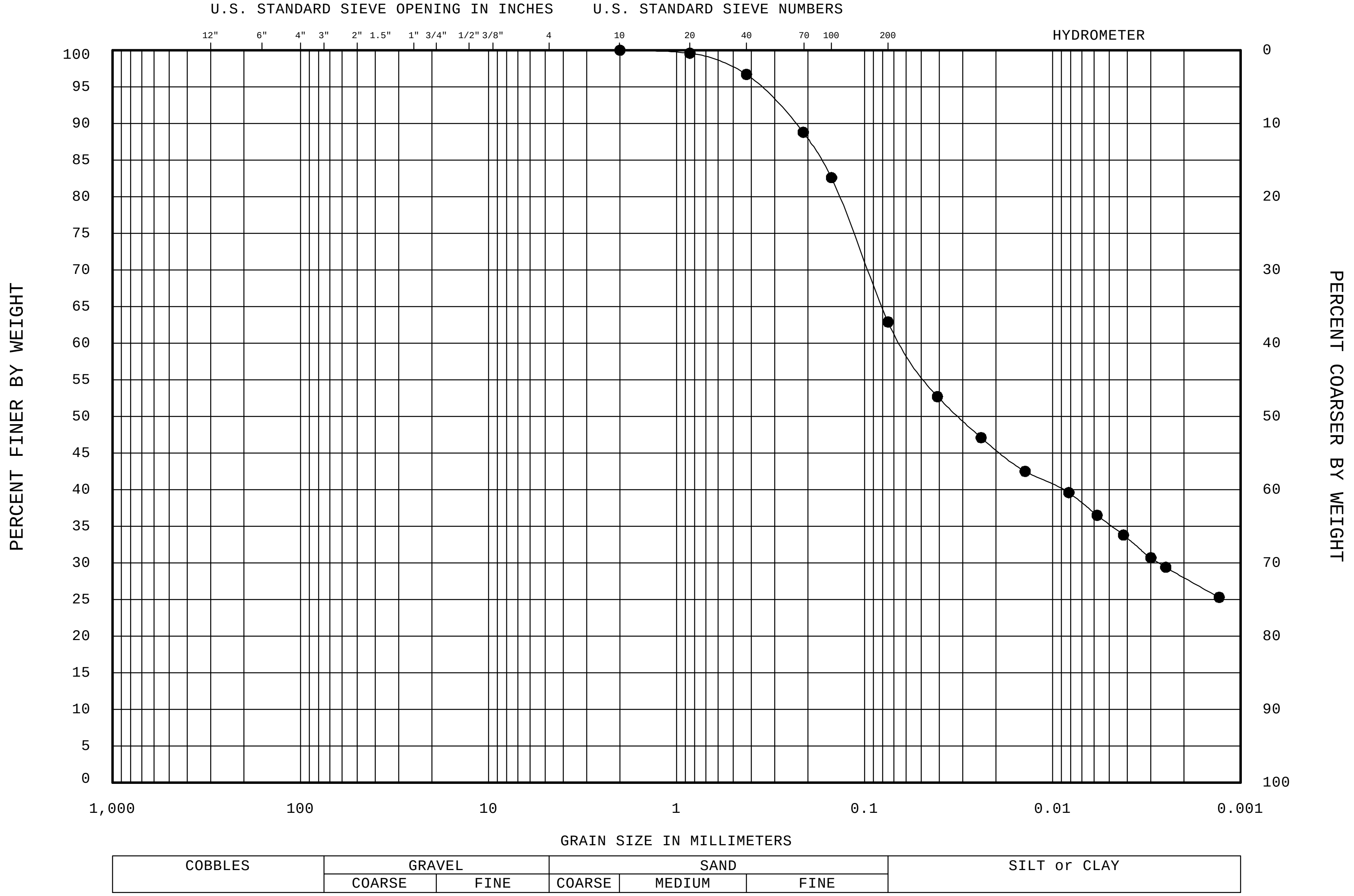
Remarks:

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-422*

DATE: *Oct 2004*

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-10	22.5-24.0	SANDY LEAN CLAY	CL	38.4	40	17	23
— —								
— —								
— —								

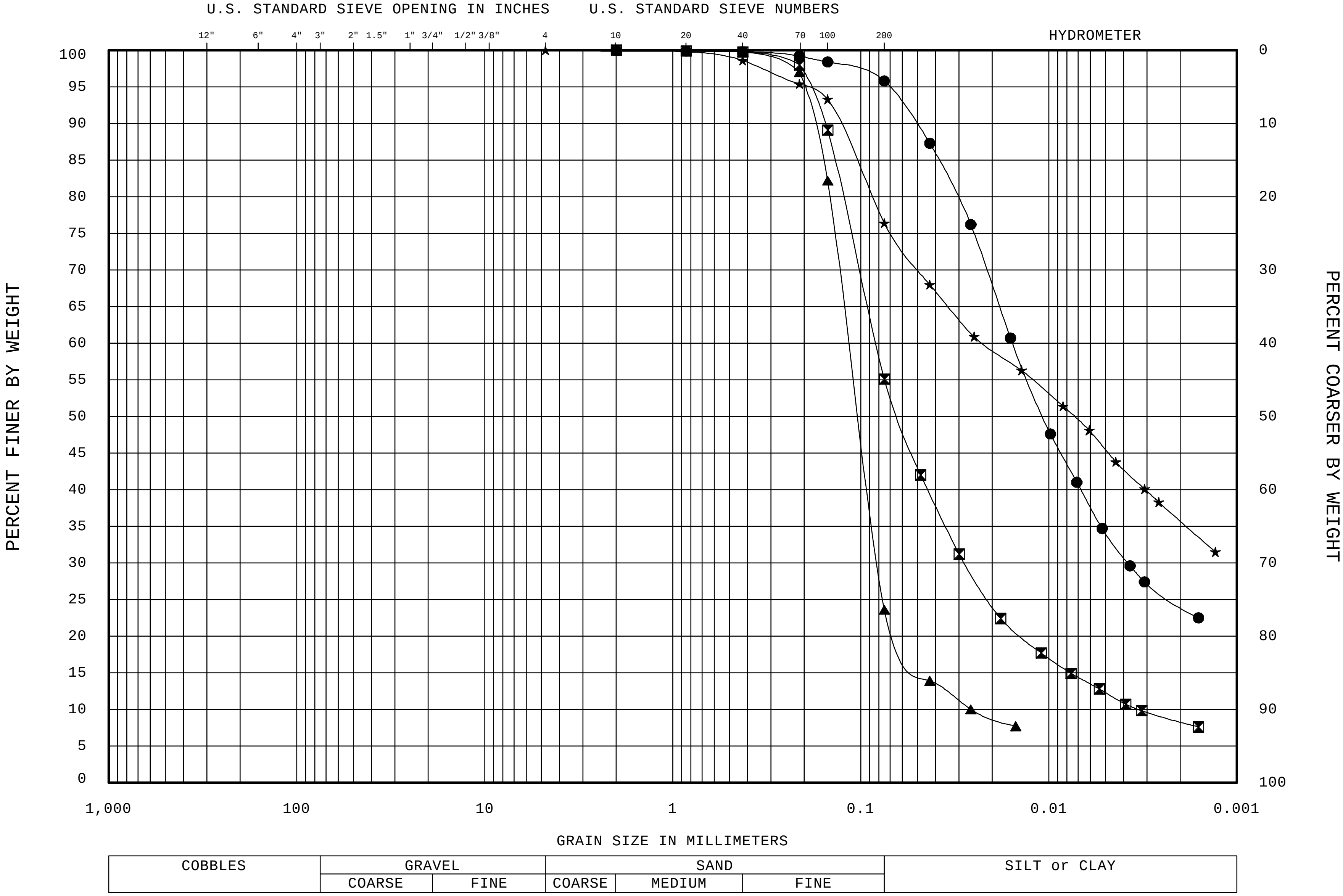
Remarks:

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-422*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-1	0.0-1.5	CLAY	CL/ML				
—⊠—	Jar-4	7.5-9.0	SANDY SILT	ML				
—▲—	Jar-6	12.5-14.0	SILTY SAND	SM	26.7	NP	NP	NP
—★—	Jar-9	20.0-21.5	FAT CLAY with SAND	CH	43.7	52	21	31

Remarks:

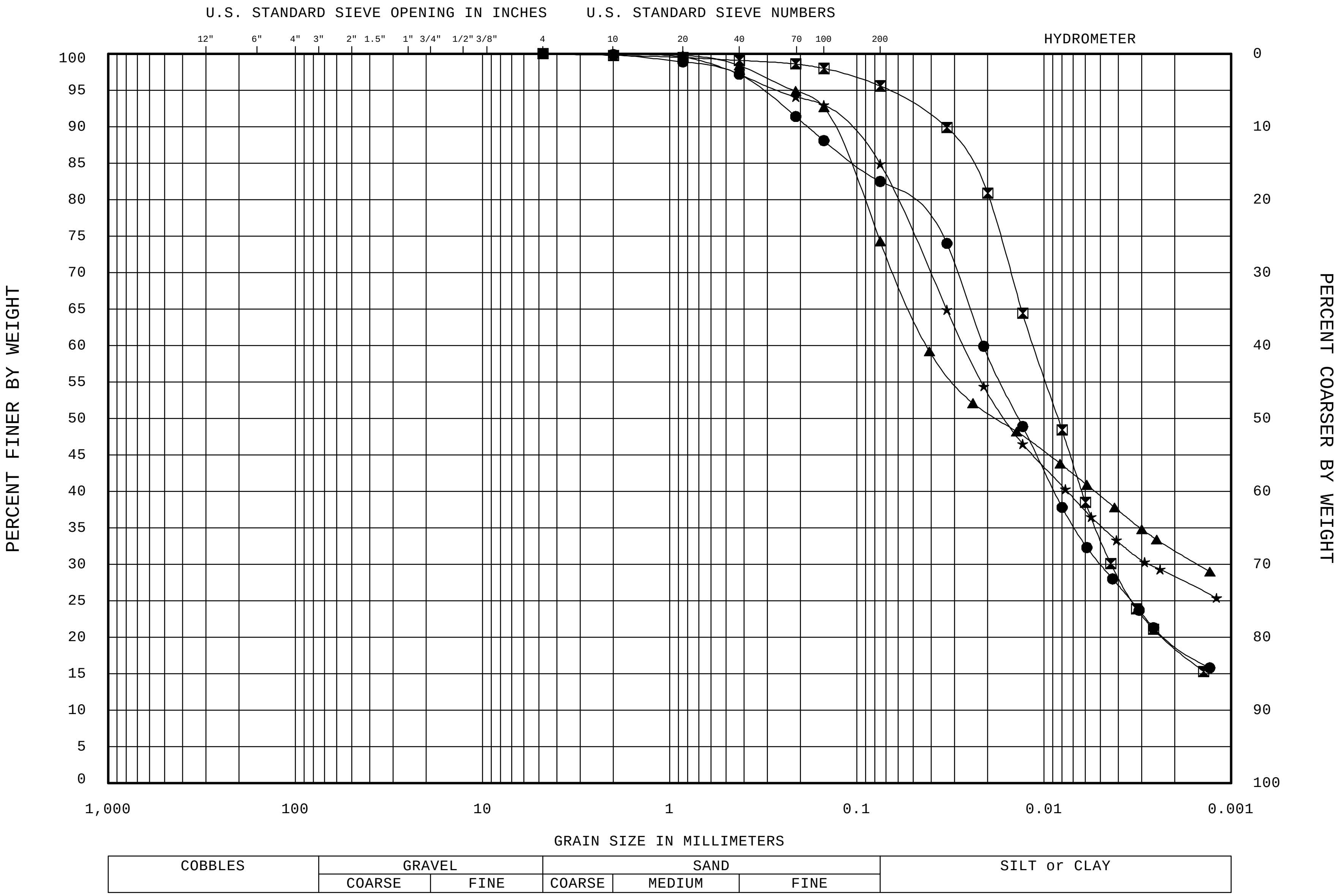
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-423*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-2	2.5-4.0	CLAY with SAND	CL/ML				
☒	Jar-4	7.5-9.0	FAT CLAY	CH	57.4	63	26	37
▲	Jar-6	12.5-14.0	LEAN CLAY with SAND	CL	27.2	31	15	16
★	Jar-10	22.5-24.0	LEAN CLAY with SAND	CL	28.0	30	17	13

Remarks:

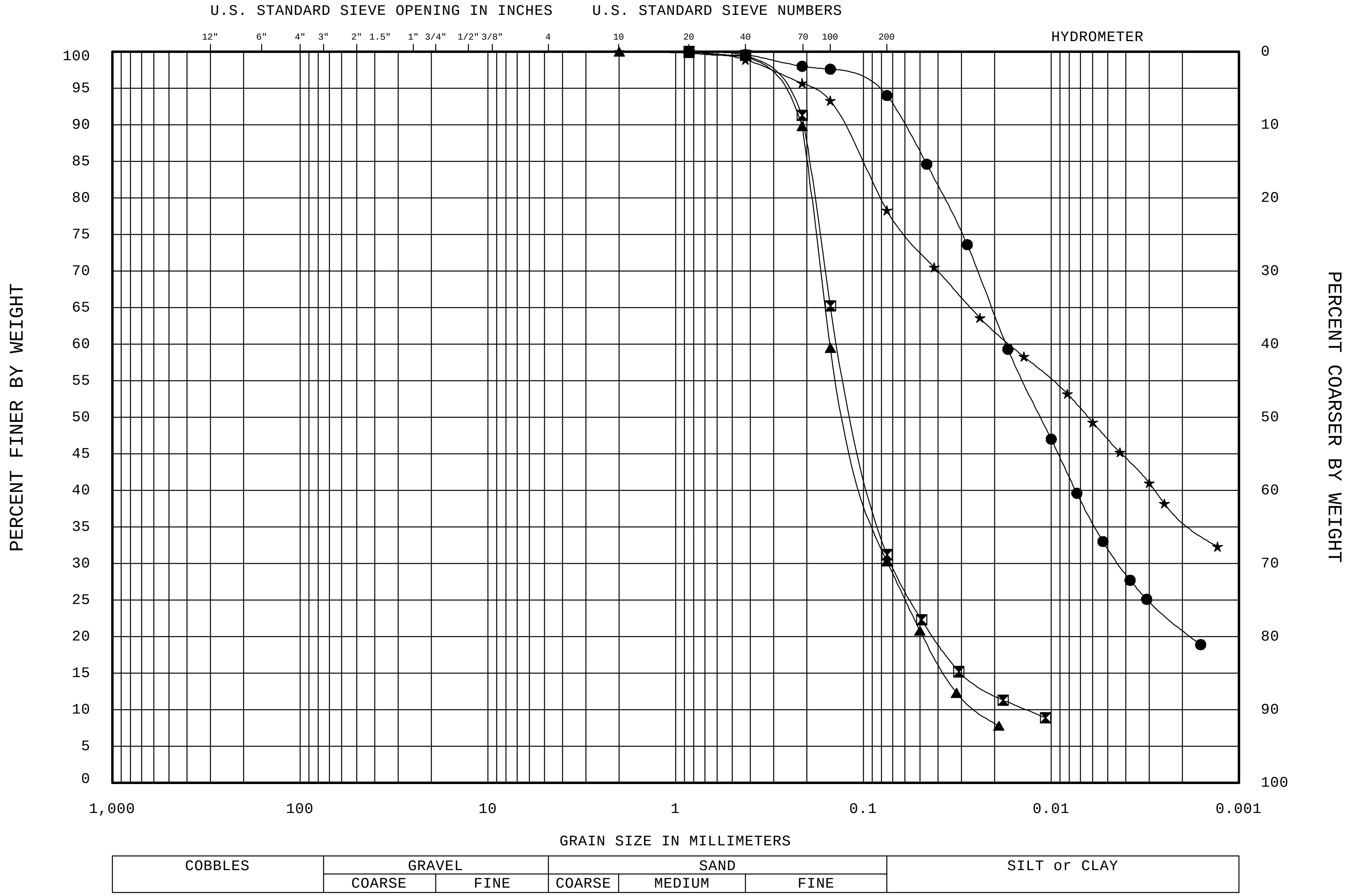
ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-424*

DATE: *Oct 2004*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-1	0.0-1.5	CLAY	CL/ML				
☒	Jar-4	7.5-9.0	SILTY SAND	SM				
▲	Jar-8	17.5-19.0	SILTY SAND	SM				
★	Jar-10	22.5-24.0	FAT CLAY with SAND	CH	52.3	58	22	36

Remarks:

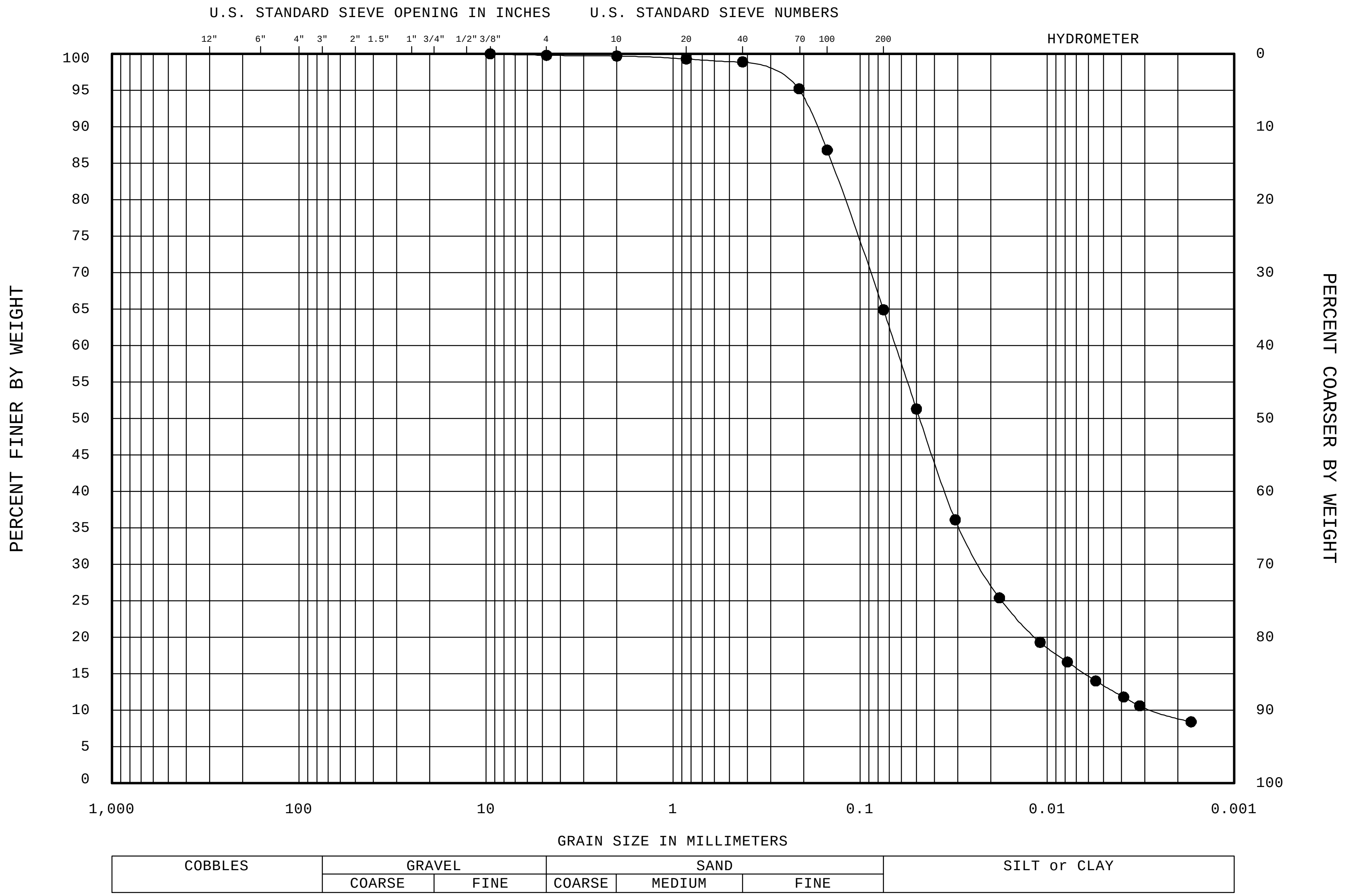
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-425*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
—●—	Jar-3	5.0-6.5	SANDY SILT ML	25.7	22	19	3
— —							
— —							
— —							

ORGANIC CONTENT (%) :

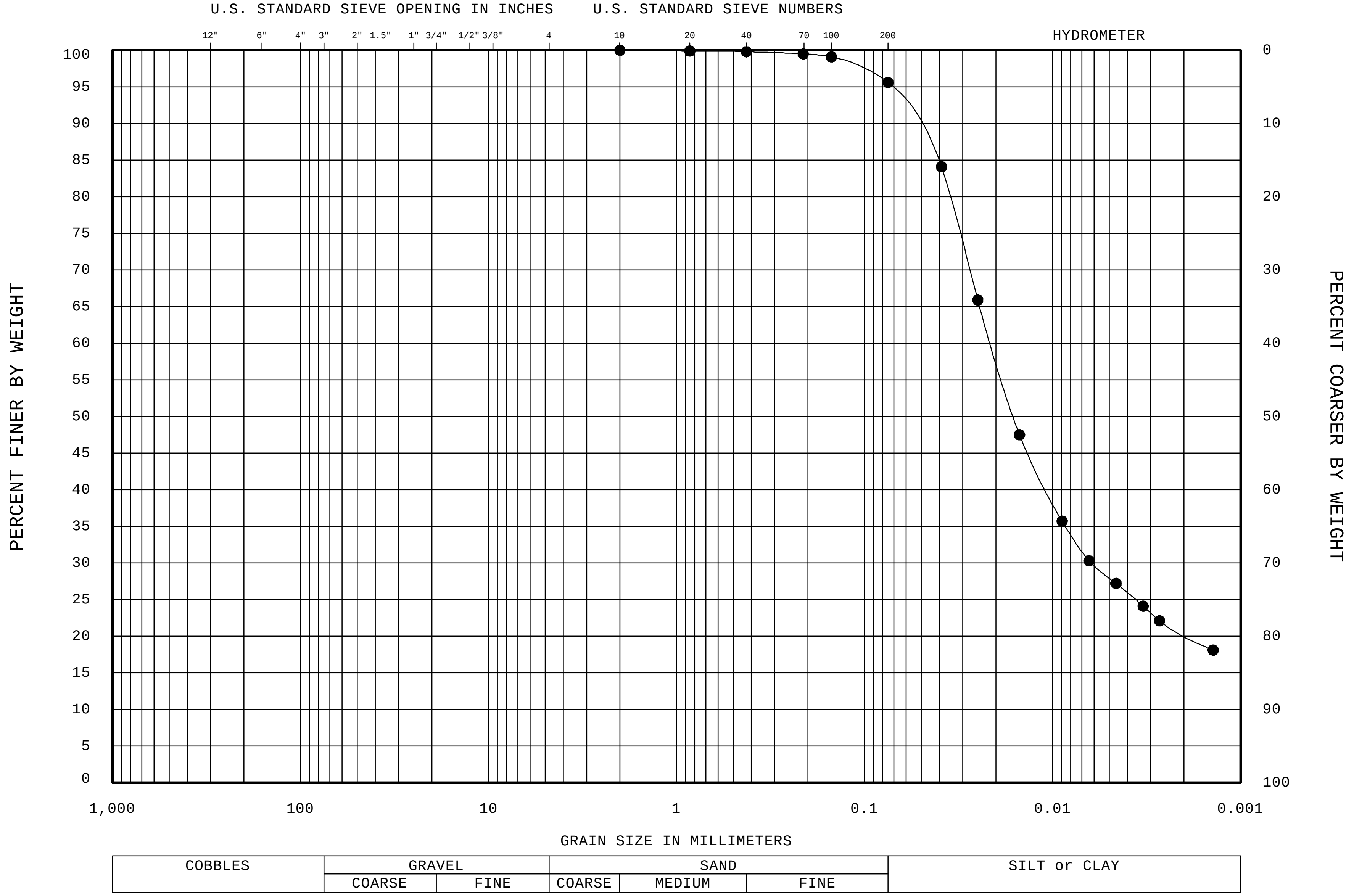
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-426*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-2	2.5-4.0	LEAN CLAY	CL	46.7	37	23	14
— —								
— —								
— —								

ORGANIC CONTENT (%) :

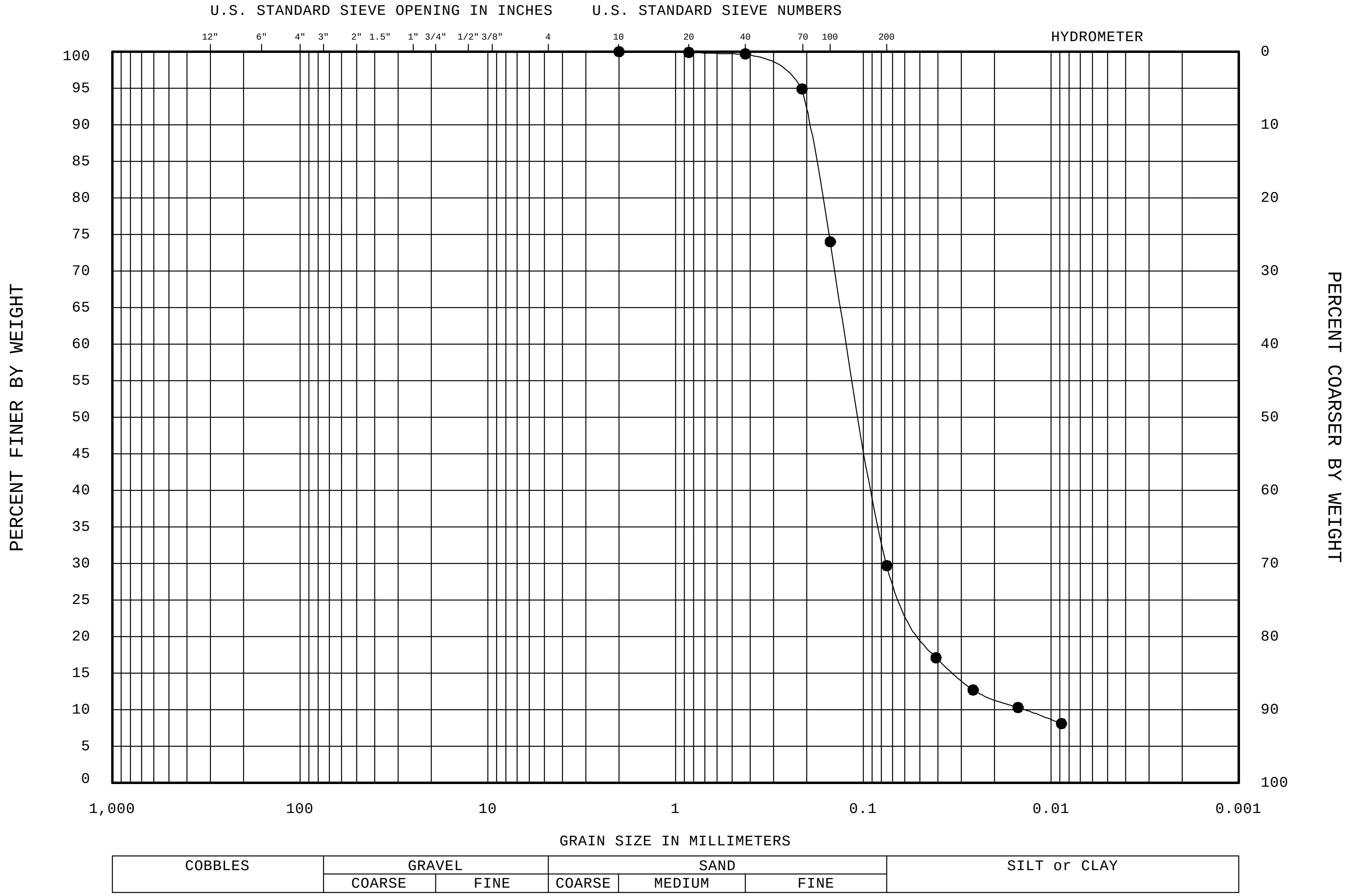
ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-427*

DATE: *Oct 2004*



Legend	Sample No.	Depth (ft)	Classification	(ASTM D 2487)	Nat wc%	LL	PL	PI
●	Jar-4	7.5-9.0	SILTY SAND	SM				

ORGANIC CONTENT (%) :

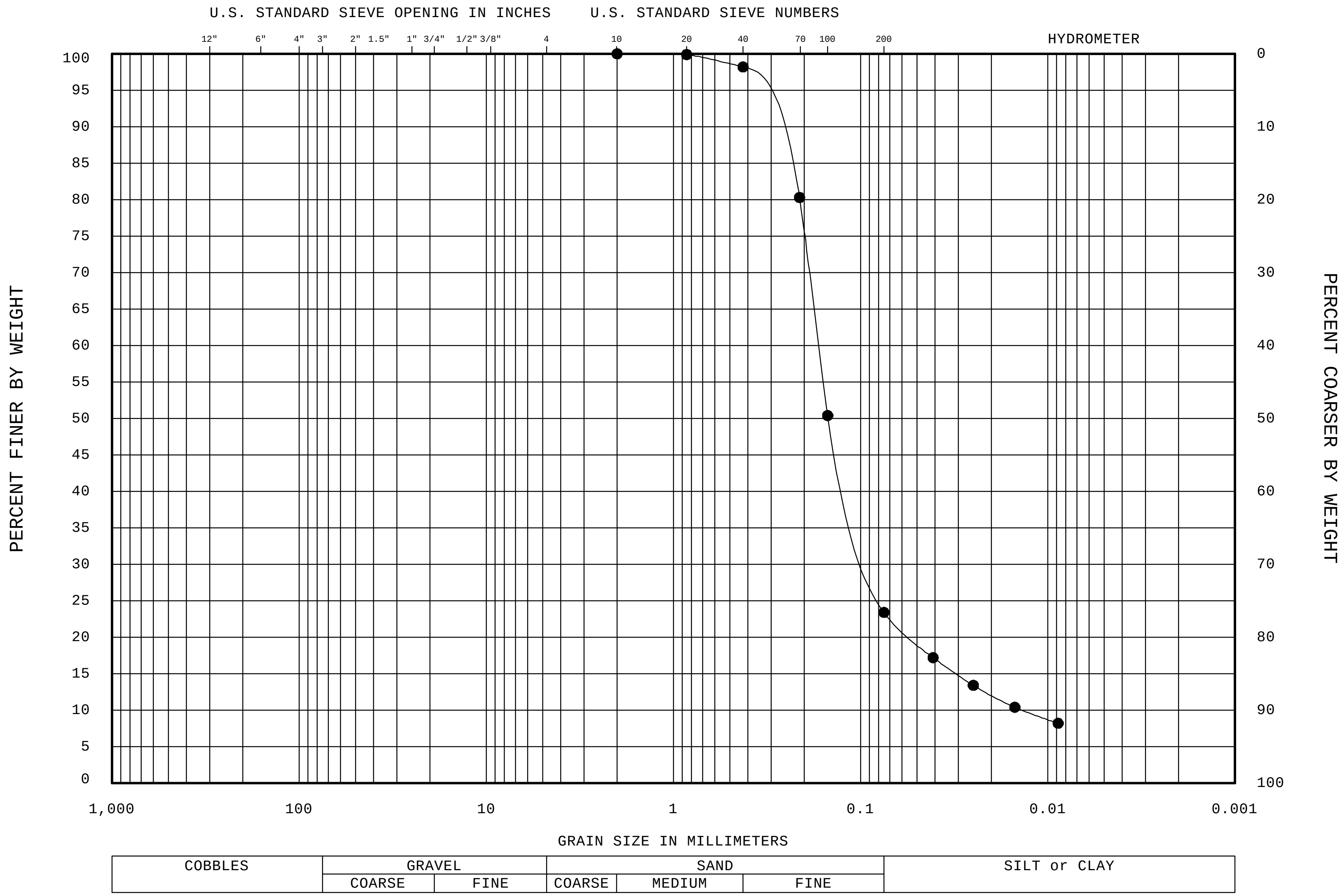
ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-428*

DATE: *Oct 2004*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-6	12.5-14.0	SILTY SAND	SM				
— —								
— —								
— —								

ORGANIC CONTENT (%) :

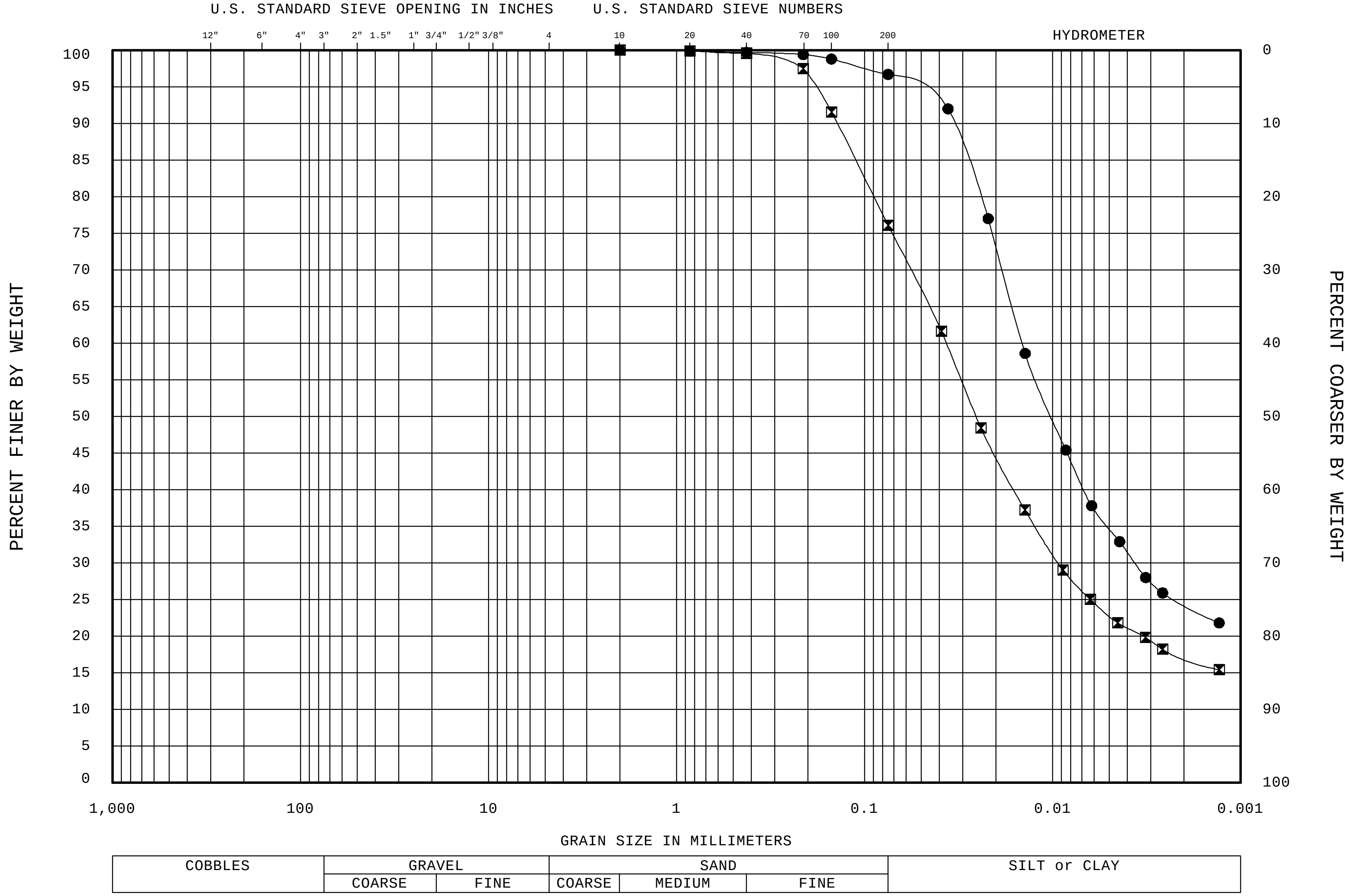
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-429*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-3	5.0-6.5	LEAN CLAY	CL	53.4	40	22	18
—☒—	Jar-6	12.5-14.0	SILTY CLAY with SAND	CL-ML	26.1	23	17	6
— —								
— —								

ORGANIC CONTENT (%) :

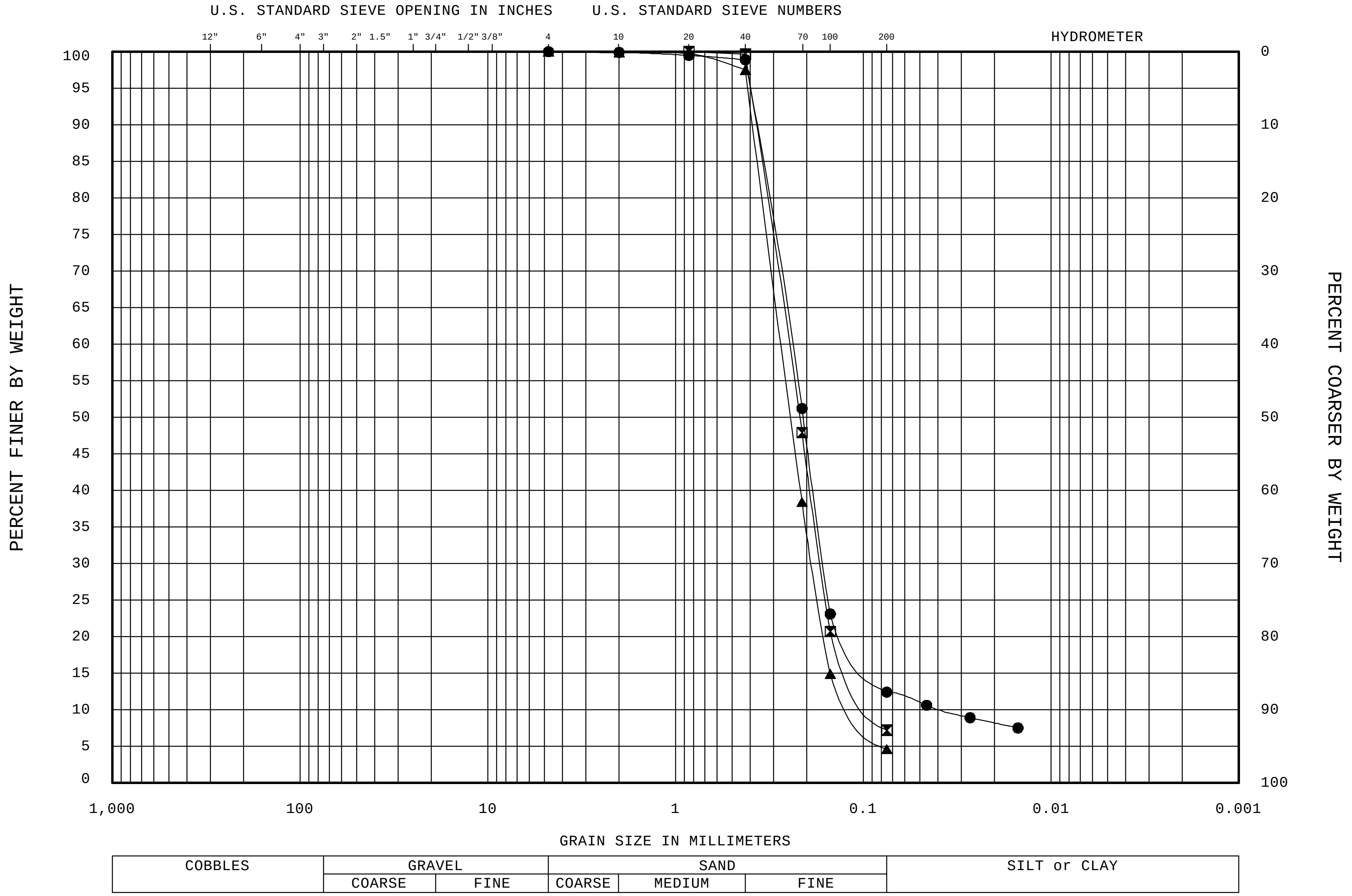
ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-430*

DATE: *Oct 2004*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-3	5.0-6.5	SILTY SAND	SM				
—⊠—	Jar-7	15.0-16.5	POORLY GRADED SAND with SILT	SP-SM				
—▲—	Jar-11	25.0-26.5	POORLY GRADED SAND	SP				
— —								

ORGANIC CONTENT (%) :

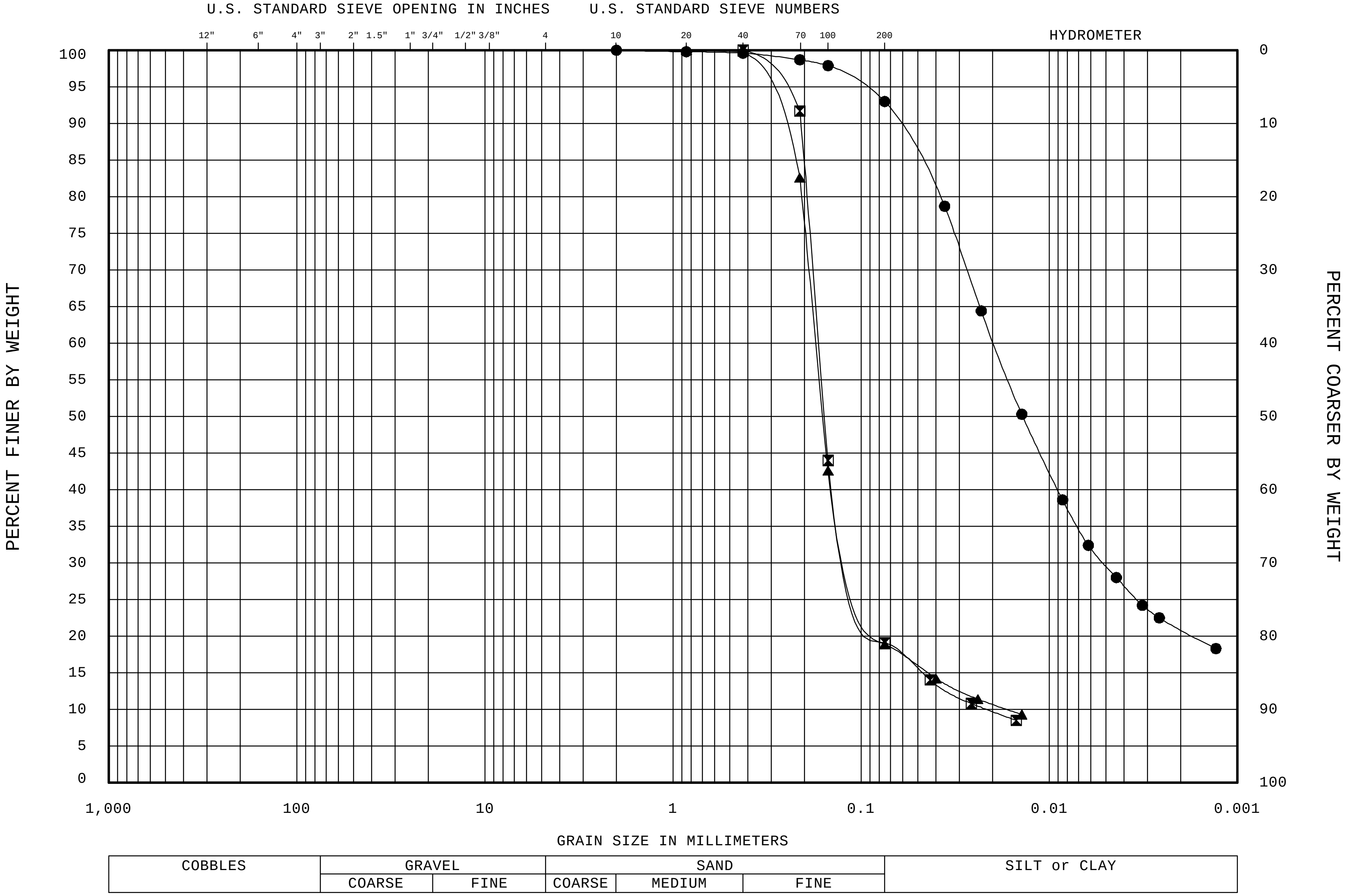
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-431*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
—●—	Jar-2	2.5-4.0	LEAN CLAY CL/ML				
—☒—	Jar-5	10.0-11.5	SILTY SAND SM				
—▲—	Jar-9	20.0-21.5	SILTY SAND SM				
— —							

ORGANIC CONTENT (%) :

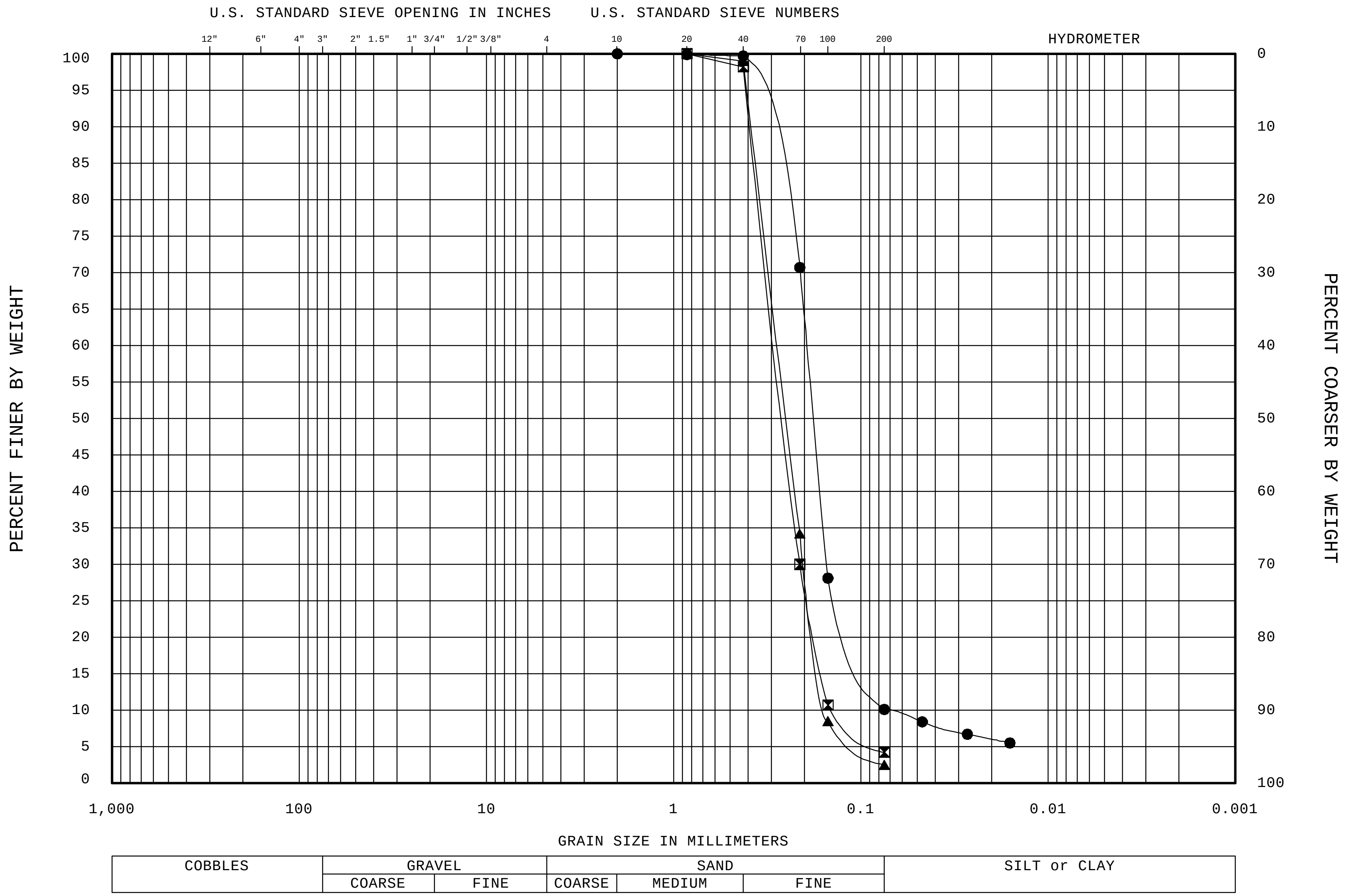
ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-432*

DATE: *Oct 2004*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-3	5.0-6.5	POORLY GRADED SAND with SILT	SP-SM				
⊠	Jar-7	15.0-16.5	POORLY GRADED SAND	SP				
▲	Jar-10	22.5-24.0	POORLY GRADED SAND	SP				
— —								

ORGANIC CONTENT (%) :

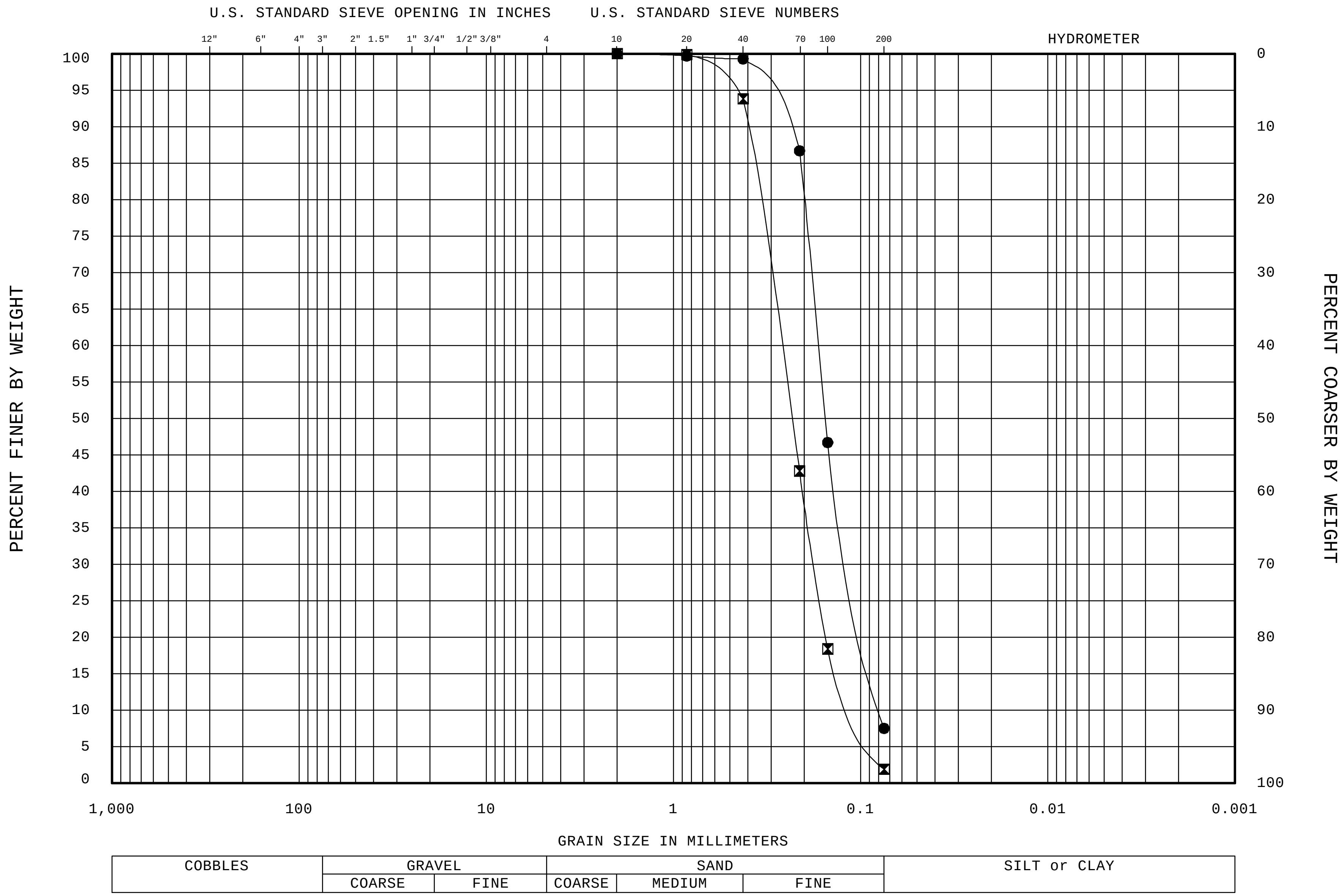
PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-433*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-3	5.0-6.5	POORLY GRADED SAND with SILT	SP-SM				
☒	Jar-7	15.0-16.5	POORLY GRADED SAND	SP				
— —								
— —								

ORGANIC CONTENT (%) :

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-434*

DATE: *Oct 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

TUBE CLASSIFICATION

ASTM D2487

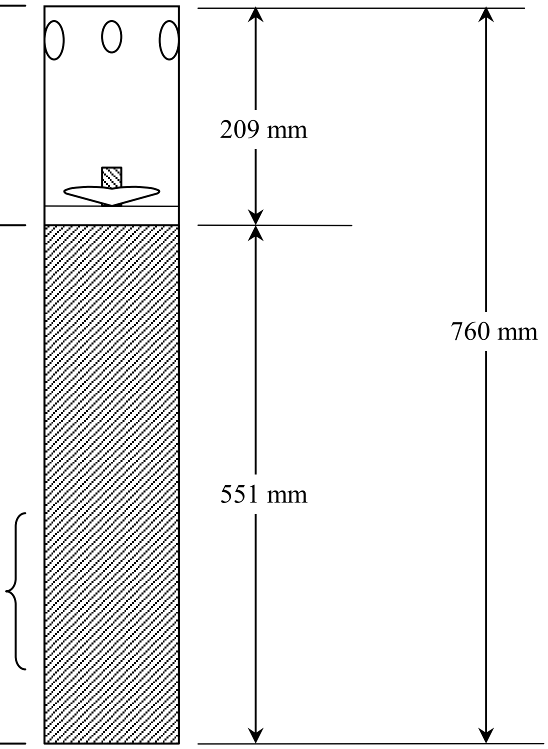
PROJECT: Expansion Study
Poplar Island
AREA: Talbot County, MD

DATE: Nov 2004

Hole No.	Sample No.	Depth (ft)
DH-426A	Shelby-1	13.0-15.0

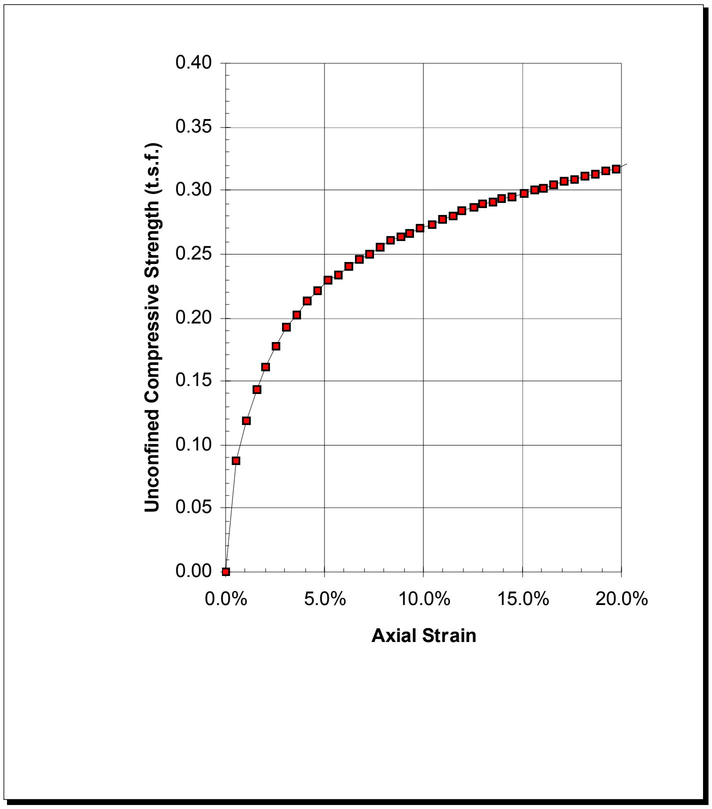
Tube plug & void

Very moist, greenish gray, soft, sandy, LEAN CLAY (CL) Unconfined Compression



UNCONFINED COMPRESSION TEST

FAILURE SKETCHES



CONTROLLED STRAIN

TEST NO.		1	2	3	4
TYPE OF SPECIMEN		Undisturbed			
WATER CONTENT, %	w_o	36.2			
VOID RATIO	e_o	0.855			
SATURATION, %	S_o	100+			
DRY UNIT WEIGHT, LB./CU.FT.	γ_d	86.9			
TIME TO FAILURE, MIN.	t_f	9.5			
UNCONFINED COMPRESSIVE STRENGTH, TSF	q_u	0.32			
UNDRAINED SHEAR STRENGTH, TSF	s_u	0.16			
SENSITIVTY RATIO	S_t	------			
INITIAL SPECIMEN DIAMETER, IN.	D_o	2.88			
INITIAL SPECIMEN HEIGHT, IN.	H_o	6.04			

CLASSIFICATION: (ASTM D2487)

V. moist, greenish gray, soft, sandy LEAN CLAY (CL)

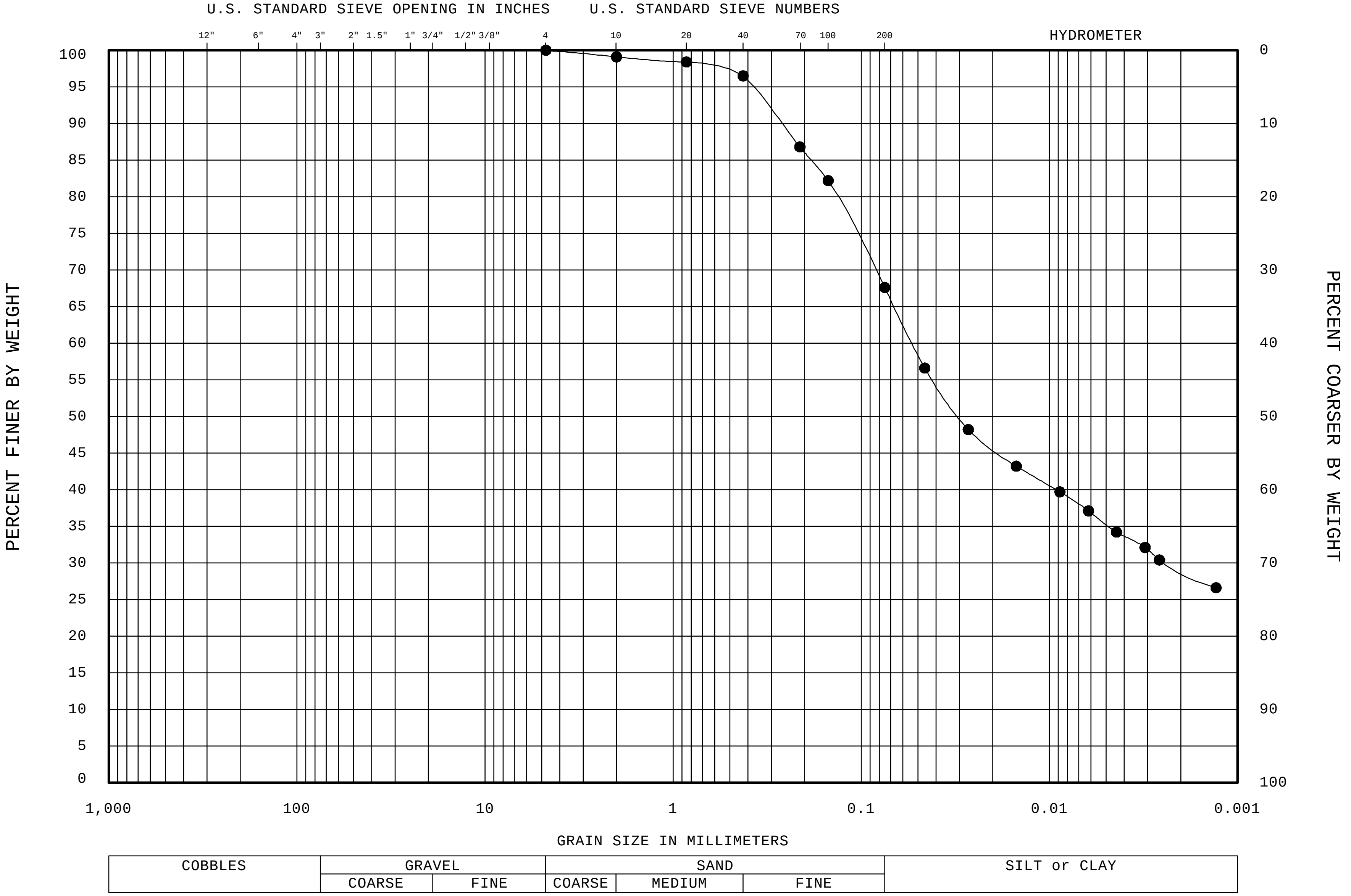
LL=	34	PL=	16	PI=	18 (ASTM D4318)	G_S=	2.53 (ASTM D854)

REMARKS:

PROJECT: Poplar Island
Expansion Study
AREA: Talbot County, MD
Hole No.: DH-426A
Sample No.: Shelby-1
Depth (ft.): 13.0-15.0
Date: Feb.2005

ENG FORM 3659 (Test method: ASTM D2166)

UNCONFINED COMPRESSION TEST REPORT



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
—●—	Shelby-1	13.0-15.0	SANDY LEAN CLAY CL	36.2	34	16	18
—— ——							
—— ——							
—— ——							

REMARKS :

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-426A*

DATE: *Nov 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

TUBE CLASSIFICATION

ASTM D2487

PROJECT: Expansion Study
Poplar Island
AREA: Talbot County, MD

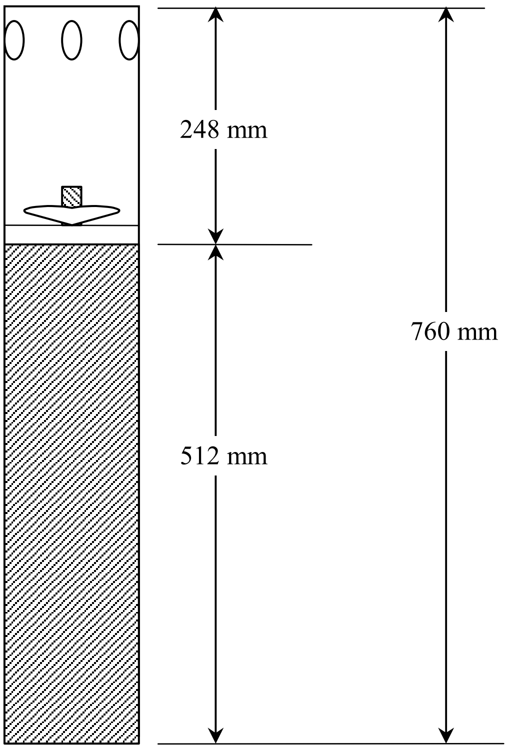
DATE: Nov 2004

Hole No.	Sample No.	Depth (ft)
DH-427A	Shelby-1	7.0-9.0

Tube plug & void

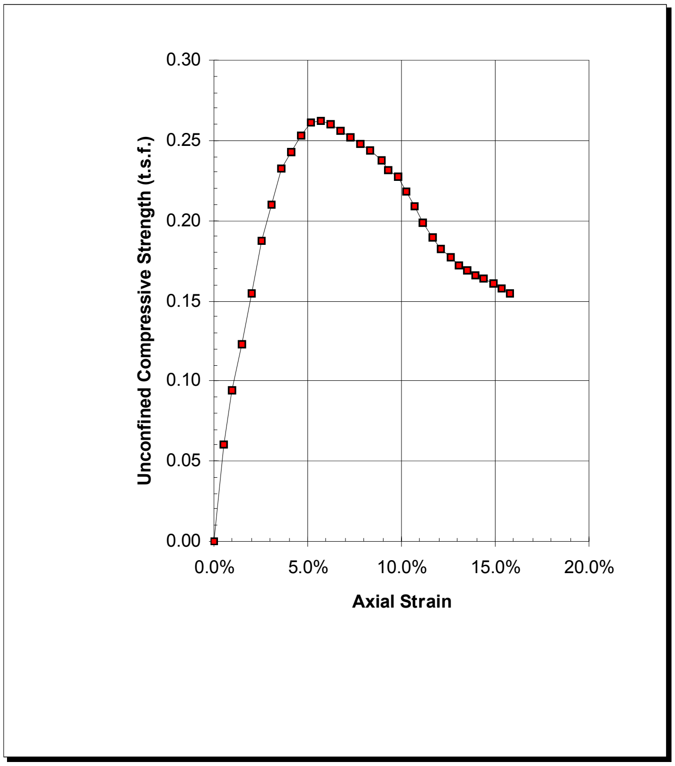
Very moist, dark gray, soft, LEAN CLAY (CL)

Unconfined Compression



UNCONFINED COMPRESSION TEST

FAILURE SKETCHES



CONTROLLED STRAIN

TEST NO.		1	2	3	4
TYPE OF SPECIMEN		Undisturbed			
WATER CONTENT, %	w_o	52.2			
VOID RATIO	e_o	1.219			
SATURATION, %	S_o	100+			
DRY UNIT WEIGHT, LB./CU.FT.	γ_d	70.0			
TIME TO FAILURE, MIN.	t_f	2.8			
UNCONFINED COMPRESSIVE STRENGTH, TSF	q_u	0.26			
UNDRAINED SHEAR STRENGTH, TSF	s_u	0.13			
SENSITIVTY RATIO	S_t	------			
INITIAL SPECIMEN DIAMETER, IN.	D_o	2.85			
INITIAL SPECIMEN HEIGHT, IN.	H_o	6.03			

CLASSIFICATION: (ASTM D2487)

V. moist, dark gray, soft, LEAN CLAY (CL)

LL= 38 | PL= 23 | PI= 15 (ASTM D4318) | G_S= 2.49 (ASTM D854)

REMARKS:

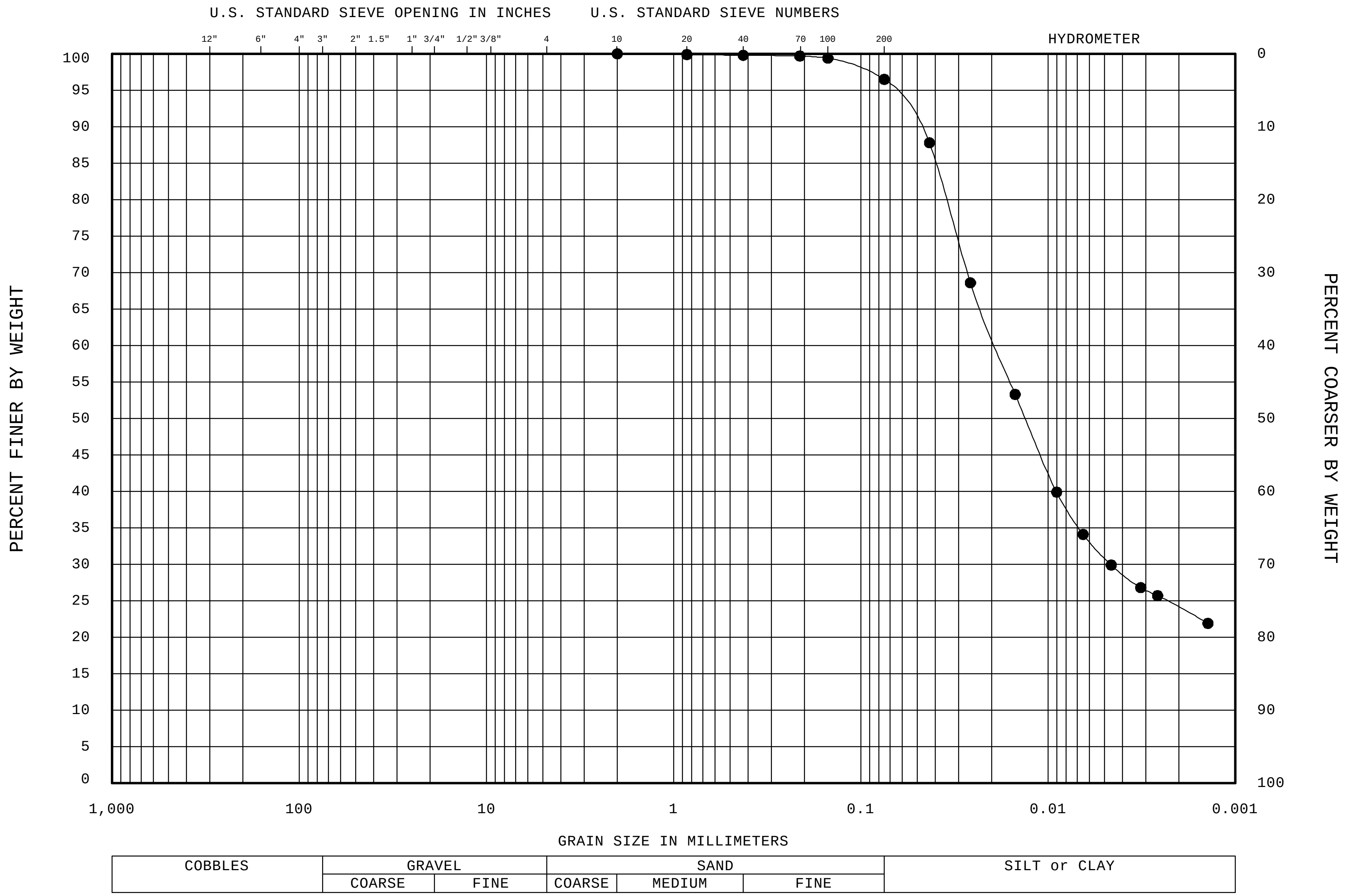
PROJECT: Poplar Island
Expansion Study

AREA: Talbot County, MD

Hole No.: DH-427A **Sample No.:** Shelby-1

Depth (ft): 7.0-9.0 **Date:** Feb.2005

ENG FORM 3659 (Test method: ASTM D2166) **UNCONFINED COMPRESSION TEST REPORT**



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Shelby-1	7.0-9.0	LEAN CLAY	CL	52.2	38	23	15
— —								
— —								
— —								

REMARKS :

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-427A*

DATE: *Nov 2004*

TUBE CLASSIFICATION

ASTM D2487

PROJECT: Expansion Study
Poplar Island
AREA: Talbot County, MD

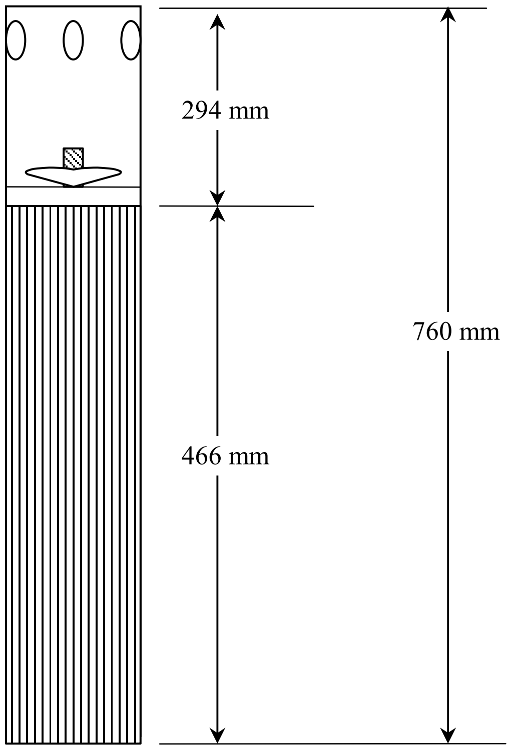
DATE: Nov 2004

Hole No.	Sample No.	Depth (ft)
DH-429A	Shelby-1	4.0-6.0

Tube plug & void

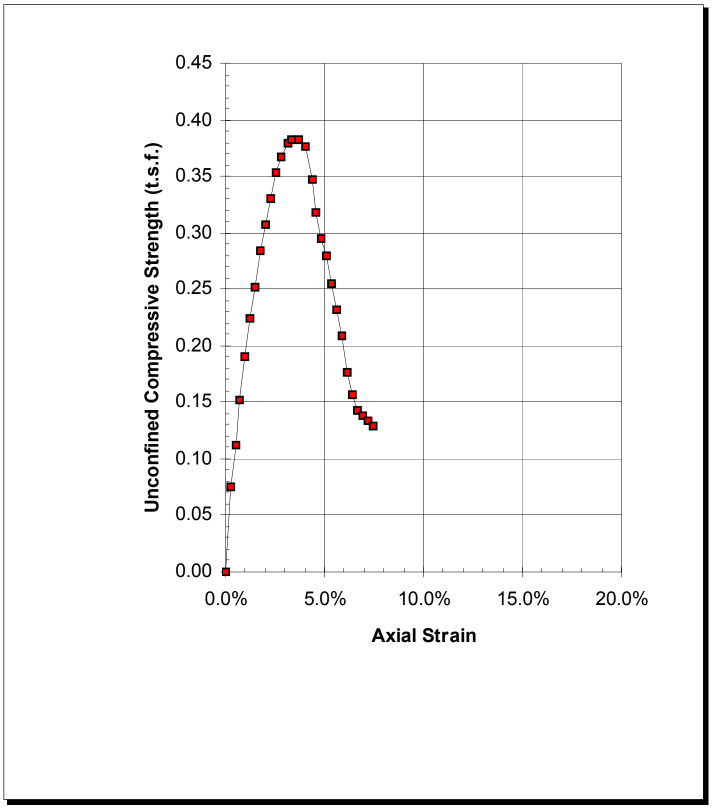
Very moist, dark greenish gray, sandy SILT (ML)

Unconfined Compression



UNCONFINED COMPRESSION TEST

FAILURE SKETCHES



CONTROLLED STRAIN

TEST NO.		1	2	3	4
TYPE OF SPECIMEN		Undisturbed			
WATER CONTENT, %	w_o	22.5			
VOID RATIO	e_o	0.538			
SATURATION, %	S_o	100+			
DRY UNIT WEIGHT, LB./CU.FT.	γ_d	103.4			
TIME TO FAILURE, MIN.	t_f	3.25			
UNCONFINED COMPRESSIVE STRENGTH, TSF	q_u	0.38			
UNDRAINED SHEAR STRENGTH, TSF	s_u	0.19			
SENSITIVTY RATIO	S_t	------			
INITIAL SPECIMEN DIAMETER, IN.	D_o	2.85			
INITIAL SPECIMEN HEIGHT, IN.	H_o	6.07			

CLASSIFICATION: (ASTM D2487)

V. moist, dark greenish gray, soft, sandy SILT (ML)

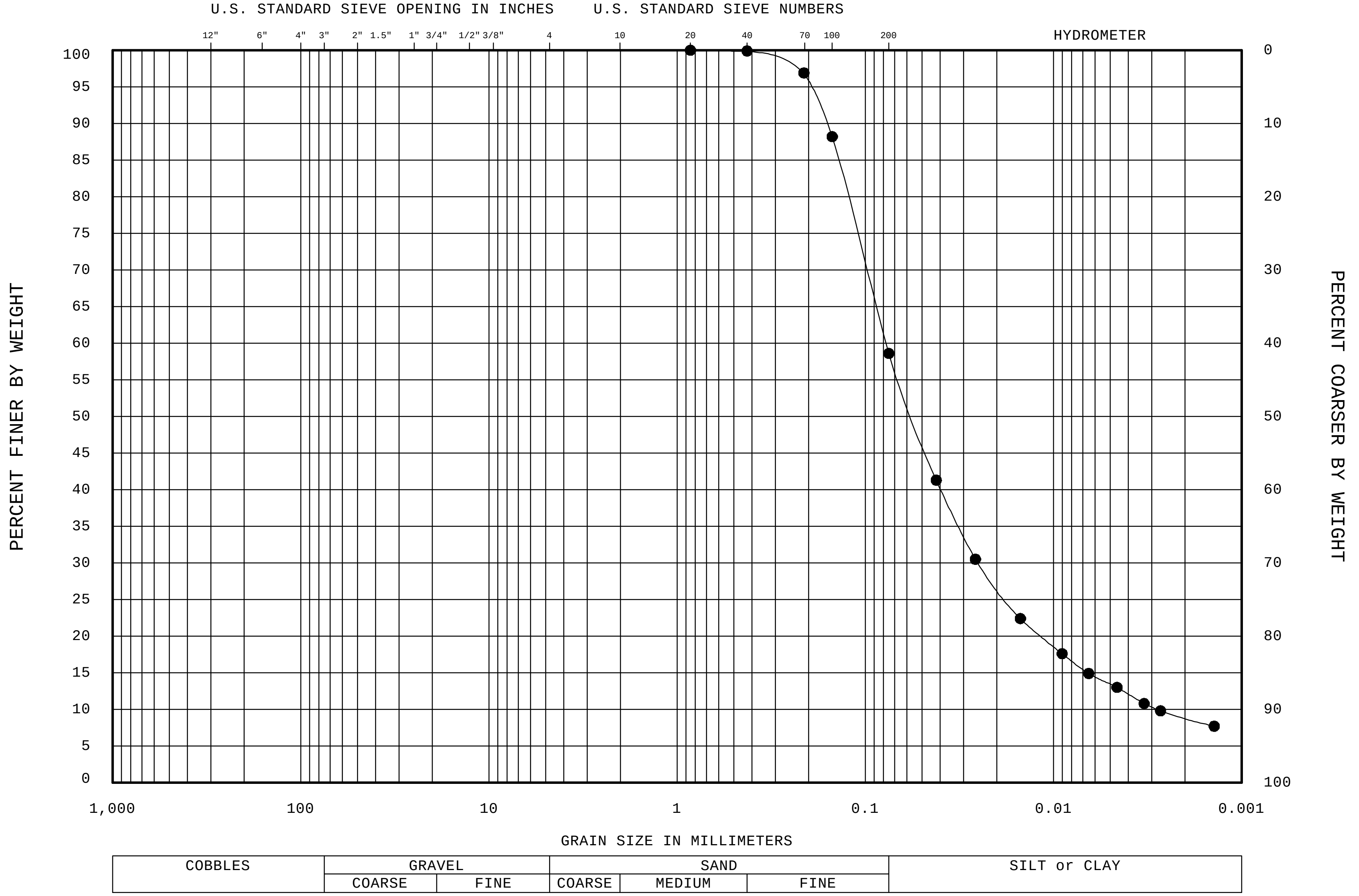
LL= 18	PL= 17	PI= 1 (ASTM D4318)	G_S= 2.55 (ASTM D854)

REMARKS:

PROJECT: Poplar Island
Expansion Study
AREA: Talbot County, MD
Hole No.: DH-429A **Sample No.:** Shelby-1
Depth (ft): 4.0-6.0 **Date:** Feb.2005

ENG FORM 3659 (Test method: ASTM D2166)

UNCONFINED COMPRESSION TEST REPORT



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Shelby-1	4.0-6.0	SANDY SILT	ML	22.5	18	17	1
— —								
— —								
— —								

REMARKS :

PROJECT: *Poplar Island*
AREA: *Expansion Study*
Talbot County, MD

BORING NO.: *DH-429A*

DATE: *Nov 2004*

ENG FORM ENG2087POPLAR IS EXPANSION STUDY.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

ATTACHMENT F

CELL DEVELOPMENT

POPLAR ISLAND EXPANSION STUDY
ENGINEERING APPENDIX

ATTACHMENT F – CELL DEVELOPMENT

1. Dredged Material Placement

1.1 Maintenance Dredged Material Characteristics. Dredged material placed at Poplar Island will consist of fine-grained silt and clay sediments obtained from the Upper Chesapeake Bay Approach Channels to the Port of Baltimore. Annual maintenance dredging of these channels will generate an average of 2.0 mcy per year through approximately 2009, and will increase to approximately 3.2 mcy per year thereafter. Nine (9) samples of maintenance materials obtained from the Craighill and Brewerton Extension channels prior to the initial 2001 dredged material placement were tested and consisted of fined grained silt and clay (classified as CH), with average liquid limit and plasticity index values of 127 and 84, respectively. These materials had average moisture content, void ratio and density values of 230 percent, 5.9, and 77.7 pcf, respectively (GBA, 2000). Dredged material placed into the existing project in 2003-2004 consisted of fine-grained silts (MH) (30 percent) and clays (CH) (70 percent), with average liquid limit and plasticity index values of 122 and 78, respectively.

1.2 Placement in Cells. The channel maintenance dredged materials are generally mechanically dredged using a clamshell, loaded into barges (scows), towed to the Poplar Island site, and hydraulically off-loaded into the containment cells at the site. The hydraulic unloader mixes additional water with the dredged material in the scows to create a slurry that is then pumped through a pipe line into the cells.

The maintenance material in place in the channels begins with a typical moisture content of about 220 percent which increases to an estimated 260 percent in the barge as some additional water is added by the clamshell dredging process. The hydraulic unloader adds additional water to create a slurry with an estimated to have a moisture content in excess of 500 percent. Much of the initial water is decanted from the cell within the first several days and weeks, so that the moisture content of the dredged material soon after placement reaches approximately 300 to 400 percent, corresponding to void ratios between 8 and 10. At that point, the material in the cell consists of approximately 90 percent water and 10 percent solids by volume, and a shear strength that is almost too low to be measurable.

1.3 Stabilization of Initial Dredged Materials. Dredged materials consolidate under their own weight for a period of years after placement. The total duration of self-weight consolidation varies as a function of initial layer thickness, the permeability of the stratum beneath the dredged material, and the degree of surface drying and crust formation. The thicker the initial lift, the longer the pathway for drainage of water from within the dredged material layer. Most of the existing Poplar Island cell bottom surfaces consisted of sand, which has had a significant effect in reducing the time required for consolidation. The foundation beneath about half of the proposed expansion wetlands will consist of low-permeability clay and silt, significantly increasing the time required to reach a normally-consolidated state. Any increase in the desiccated crust thickness resulting from mechanical crust management activities will also accelerate the consolidation process. However, crust management can only effectively accelerate the surface drying and crust formation to a depth of 2 to 3 feet.

After a year in place in wetland cell 3D, the average moisture content of the initial 6-foot thick dredged material layer declined to approximately 150 percent, corresponding to a void ratio of approximately 4. A surface crust was observed to begin forming within about 4 months after (October 2001) the initial placement (April & May 2001) was completed.

At a point in time when the surface crust had shear strengths from 300 to 600 psf and could easily support foot traffic, the shear strength of the dredged material under the surface crust typically ranged from 50 to 150 psf. With continued crust management, the average moisture content can be reduced to approximately 100 percent, corresponding to a void ratio less than 3 and an average shear strength of approximately 250 psf. However, placement of subsequent fresh dredged material lifts will inhibit consolidation until the new material has been drained and dessicated by solar exposure. In wetland cells where the total thickness of dredged materials is less than ten feet, the surface crust of the dredged material can support equipment needed for channel excavation and surface grading within about four years after initial placement if drainage and crust development has been aggressively promoted, and sandy bottom deposits permit drainage at both the top and bottom of the dredged material. In upland cells where the total thickness of dredged material typically ranges from 25 to 30 feet (or up to 50 feet if the cell contained a mined borrow area extending the bottom to elevation -25 or -30 ft MLLW), consolidation will take much longer and final grading of the dredged material surface will probably not be initiated until several years after the final placement of material within the cell.

2. Wetland Cell Development

2.1 General Development Goals. The goal for development of the wetland cells in the existing Poplar Island project has been to achieve approximately 80 percent low marsh and 20 percent high marsh habitat. These proportions will continue to be used for the development of the wetland habitat within the lateral expansion. By definition, low marsh includes low-marsh planting surfaces; all open water in channels, moats, and ponds; and islands, regardless of elevation. High marsh includes surfaces graded between approximately elevation +1.8 and +2.5 ft MLLW. The containment dike surfaces above elevation +2.5 ft MLLW to the baseline of the containment dikes are above actual high marsh elevations and are only included to compute the total nominal wetland acreage.

Wetland cells will continue to be graded to provide roughly 80 percent low marsh habitat and 20 percent high marsh habitat. The break between low marsh and high marsh is currently defined as the +1.8 ft MLLW contour. A successful wetland cell must be graded to satisfy the very tight vertical surface grading tolerances required for high marsh and low marsh plants, and must not be subject to any additional settlement after planting has been completed. Wetland cells will typically require at least four years of crust management and aggressive drainage before they are ready to be graded for planting.

2.2 Existing Wetland Cell Development. Following is a summary of the development of existing cell 3D, which was the first wetland cell to be developed using dredged material. At this time, all dredged material has been placed, the channel system has been excavated, the marsh surfaces have been graded, and the temporary inlet control structure has been completed. Flooding and initial tidal exchange will occur between February and April 2005, with planting scheduled to begin in approximately April or May 2005. The sequence of development for cell 3D is expected to be typical of many of the wetland cells during the next several years, although some refinements and alternate development techniques will likely be attempted.

Dredged material was first placed into cell 3D in April 2001, and the surface grading was completed between April and December 2004. The initial inflow amounted to approximately 70 percent of the total cell capacity and resulted in an initial layer thickness of about 8.5 feet (-4.5 ft MLLW to +4 ft MLLW). These materials experienced self-weight consolidation for approximately one year before being subjected to a program of drainage and crust development. At that point (April 2002), the dredged material had an average moisture content, void ratio, and shear strength of approximately 153 percent, 4.0, and 150 psf, respectively, and testing results showed that the upper 6 to 12 inches of the material was forming a drained crust layer (Table F-1).

As drainage trenches were excavated around the perimeter of the cell and connected to a series of shallow trenches crossing the surface of the site, drainage was promoted in the upper 12 to 18 inches of the dredged material, and the material shifted from a buoyant state with unit weight of about 25 pcf, to a saturated unit weight of about 85 pcf. The drained surface layer exerted a load on the underlying materials that would not have been achieved by self-weight consolidation alone, eventually resulting in an over-consolidated state. By the end of 2003, the average moisture content had reduced to about 110 percent, estimated to be slightly well below the normally consolidated state predicted in PSDDF computer models. This computer modeling approach was the basis for initial estimates of dredged material quantities that would be required to achieve target marsh elevations in each of the wetland cells.

Table F-1. Summary of Void Ratio & Moisture Content for Cell 3D from April 2001 through December 2004
(Detailed void ratio data for each of nine monitoring points within Cell 3D)

Location	1st Inflow April 13-18 180,000 Cy	Apr-01	2nd Inflow May 16-22 71,000 Cy	Jun-01	3rd Inflow July 15 44,000 Cy	Oct-01	Dec-01	Apr-02	Aug-02	Oct-02	4th Inflow November 19-21 42,000 Cy	Dec-02	Apr-03	Jul-03	Sep-03	5th Inflow November 3-4 12,000 Cy	Nov-03	Mar-04	Jul-04	Dec-04
1		10.12		7.37		5.42	4.90	4.34	3.22	2.74		3.24	2.42	2.33	2.48		3.16	2.52	2.54	2.32
2		8.75		7.53		5.69	4.57	4.90	3.67	3.68		4.02	3.06	3.36	2.54		3.34	2.93	2.73	1.82
3		8.02		7.30		5.34	5.00	4.54	3.43	3.24		4.11	3.42	3.38	3.22		3.00	2.93	2.74	2.57
4		7.56		6.87		5.00	4.33	4.52	3.36	3.30		4.86	3.32	2.95	3.13		2.59	2.38	2.81	2.04
5		8.17		7.28		5.18	4.67	4.67	3.81	3.50		4.39	3.34	3.12	3.41		3.20	3.06	3.07	2.36
6		8.19		7.27		5.48	5.16	No Sample	3.99	3.25		4.69	3.27	3.33	3.09		2.82	2.81	2.88	2.86
7		9.24		6.97		4.68	4.23	4.15	2.89	3.00		4.63	3.06	2.90	2.59		2.74	2.71	2.61	2.34
8		9.19		7.08		5.02	4.74	4.36	3.39	3.39		3.65	3.16	3.16	2.73		3.15	2.91	2.07	1.54
9		8.46		7.57		5.71	5.03	4.66	3.48	3.55		4.22	3.28	3.38	3.73		3.18	2.84	2.58	2.63
Average		**8.76**		**7.23**		**5.25**	**4.72**	**4.01**	**3.43**	**3.24**		**4.14**	**3.09**	**3.04**	**2.91**		**3.01**	**2.76**	**2.64**	**2.24**
Moisture (%)		**334.5**		**275.9**		**200.5**	**180.1**	**153.1**	**130.8**	**123.8**		**158.2**	**118.0**	**115.9**	**110.9**		**114.8**	**105.2**	**100.7**	**85.6**

2.2.1 Computer Modeling. The computer model Primary Consolidation Secondary Compression and Dessication of Dredged Fill (PSDDF) was used to predict bulking and shrinkage characteristics of the dredged material placed into Cell 3D to predict the final elevation of the dredged material surface. The model computes the total settlement of a dredged material layer based on consolidation characteristics of the soils above and below the layer, the consolidation characteristics of the dredged material, local climatological data, and surface water management techniques within the containment facility (GBA, 2002).

The model predicted that a *steady state* condition would be achieved when the dredged material reached an average void ratio of approximately 4.0, and would occur about 4 years after initial filling (i.e. around late 2004 or early 2005). An average void ratio of 4 corresponds to a moisture content of approximately 150 percent. The quantity of dredged material required to achieve this condition was estimated to be 293,000 cy, occupying a cell volume of 246,242 cy. The resulting volume occupied ratio would be 0.84 (241,242 / 293,000 = 0.84).

2.2.2 Revised Development Approach. One of the primary concerns with the approach modeled by the PSDDF analysis was that the extremely narrow low marsh elevations would not be achieved. The initial target was to create an average surface elevation of +1.5 ft MLLW across the cell, with the range between the highest and lowest elevations being only about ± 0.6 feet (i.e. +1.2 to +1.8 ft MLLW). The surveys during the initial two years showed that the dredged material surface had a slope of approximately 1000H:1V, or more than a 1-foot change across the cell. It was the Corps' opinion that it would be necessary to perform mechanical grading of the surface to achieve the desired surface elevations. Further, there was significant concern that it would be difficult to know whether or not the dredged material had reached a "steady state" condition where no additional settlement was anticipated. Given the very tight tolerances, there is little margin for error in estimating post-planting settlement potential.

Therefore, a revised cell development approach was pursued that called for aggressive drainage of the dredged material and development of the maximum possible crust layer so that mechanical grading could be performed using low-pressure construction equipment. It was also recognized that to create the required channel system with bottom elevation at -3 ft MLLW or greater and widths up to 50 feet at the channel bottom, development of a stable dredged material surface would be necessary.

By the end of 2003, the average moisture content of the dredged material had been reduced to about 110 percent, and the crust layer was 12 to 15 inches thick with an average shear strength of about 500 psf. Adversely, lack of proper trenching and drainage during 2003 left the 65,000 cy dredged material inflow from the fall of 2002 in a partially drained state, with a very soft saturated zone trapped between the initial crust surface and the new crust surface. This trapped zone was quickly drained by a series of lateral trenches cut through the upper 1-foot lift late in 2003. Nevertheless, the lack of 2003 crust management delayed the consolidation of the underlying materials and contributed to under-estimation of the appropriate placement quantity for the final fall 2003 inflow.

2.2.3 Cell 3D Development. Site development was initiated in early 2004 by excavating first passes of the third order channels and moat surrounding the island. The moat had a bottom elevation of -3 ft MLLW and a bottom width of 50 feet. Third order channels were excavated to elevation -2 ft MLLW with a bottom width of 20 feet. Second order channels had a bottom elevation of -1.5 ft MLLW and a bottom width of 15 feet. The estimated 23,000 cy of excavated materials were to be spread across the site to accomplish the final grading to achieve +1.5 average low marsh and +2.4 average high marsh elevations. The surface crust was able to support a low ground pressure D-6 bulldozer, but had to avoid soft spots initially.

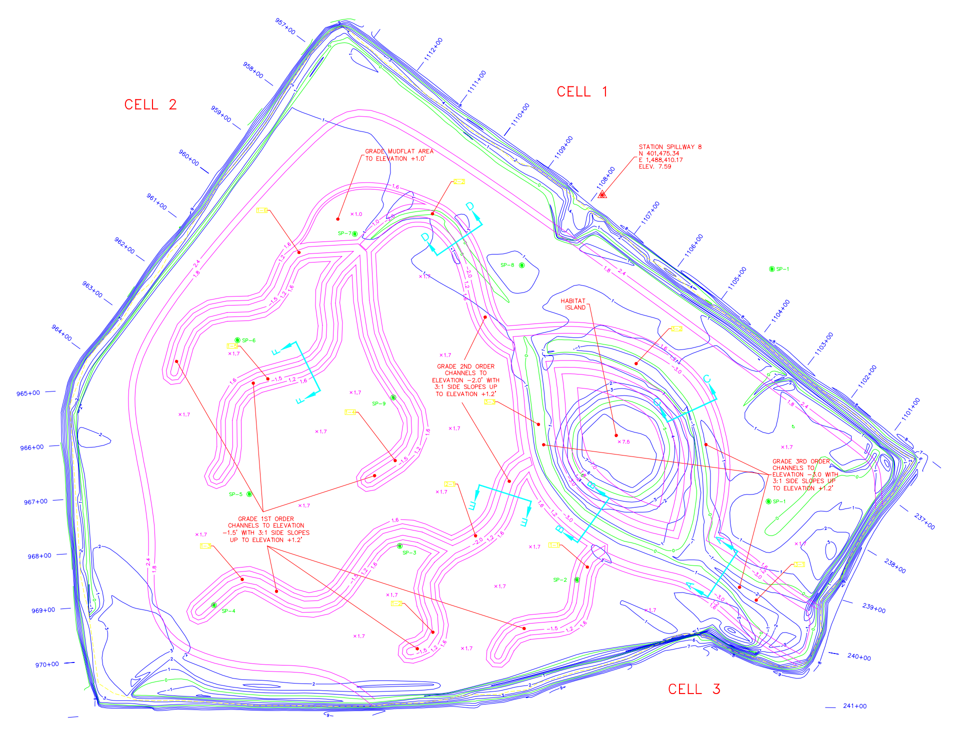


Figure F-1. Poplar Island Cell 3D Channel & Grading Plan

As the channels were deepened to promote general dewatering of the dredged materials and surface drying was enhanced (May and June 2004), the surface became very stable, and consolidation exceeded estimates. By August, it was apparent that additional material would have to be brought into the cell. Between the difficulty of performing precise surveys and quantities within an active and continually changing site and the continuation of consolidation with drainage and equipment vibration, it was difficult to estimate the additional quantity that would be required. The final additional quantity was estimated to have exceeded 30,000 cy (the equivalent dredged material placement quantity would have been at least 60,000 cy). At a final moisture content and void ratio of 86 percent and 2.24, respectively, it is estimated that the quantity of dredged material actually placed in the cell was the equivalent of more than 400,000 cy, or more than 35 percent greater than the quantity estimated by the PSDDF model.

2.2.4 Results of Revised Development Approach. In addition to the substantial increase in wetland cell placement, the revised development approach created a crust surface that was capable of easily supporting low pressure excavation, grading, and hauling equipment, providing sufficient flexibility to create any channel dimensions and surface grading configuration desired. In addition, the final moisture content of 85 percent indicates that the dredged material within the cell was consolidated significantly beyond a normally-consolidated state, and should have minimal risk of additional settlement after the dredged material is returned to a buoyant state and planting has been completed. Monitoring during the initial year after completion of grading will provide verification and will also reveal whether there is any tendency for these materials to swell after re-hydration. The monitoring data will be important in making adjustments in future cell development work.

2.3 Future Wetland Development. Cell 3D was successfully configured in accordance with the proposed design using the development techniques described above. The cell will be monitored closely during the next several years after planting has been completed to document performance. These techniques will provide a basis for planning for future wetland cell development, although adjustments in the approach to improve efficiency are anticipated. In view of the complexity of the process and the variable conditions within each wetland cell, other placement and development techniques will be investigated to improve on cell development efficiency and adjust to needed changes in wetland design.

3. Upland Cell Development

Upland cells will be graded to provide a final surface at approximately elevation +20 ft MLLW (or +25 ft MLLW if a raising is included as a component of the expansion alternative). In general, the proportion of over-consolidated crust in comparison to the total thickness of the dredged material is considerably less than in wetland cells. Therefore, the degree of consolidation that can be accomplished under the load of the drained crust layer in the upland dredged materials will be less than can be accomplished in the wetland dredged materials. Maximum consolidation loading can be imposed if the individual placement lifts are maintained close to about 3 feet so that subsequent crust management can effectively reduce the moisture content of each new layer. Typically drainage trenches and dessication cracking extend only about 15 to 18 inches below the exposed dredged material surface.

By late 2003, Cell 2 had received more than seven mcy of dredged material from inflows in 2001 and 2002. The cell contained dredged material having an average thickness of about 16 feet, with an average moisture content and void ratio of 122 percent and 3.2, respectively. Therefore, the dredged material had already passed the normally-consolidated state predicted by PSDDF modeling for the wetland cells. Although the upland elevations are not very sensitive to actual final elevations, it will be important to have a reasonably accurate understanding of the moisture content that will indicate that most or all of the anticipated settlement has been achieved before final grading is initiated.

The current development plan anticipates subdividing the larger upland cells as an initial portion of the cell approaches the final upland elevation. Using Cell 2 as an example, the southern 80 to

100 acres of the 326-acre cell will be separated by a temporary sand cross dike once the dredged material level at the south end of the cell approaches elevation +20 ft MLLW. Subsequent inflow will be located along the west side of the cell to develop a surface gradient toward the wetland cells on east side. It will be desirable to overbuild the center of the cell to compensate for the larger magnitude of settlement that is anticipated in the center. It will also be desirable to create several feet of elevation change across the upland surface to promote surface drainage from the final upland surface toward the wetland areas. Neither of these overbuilding goals is easy to achieve by hydraulic placement alone, because the new dredged materials assume a flat initial grade.

Once the optimum surface elevations have been achieved by hydraulic placement and several years of crust development, drainage, and monitoring indicate that settlement has been largely completed, the subcell will be graded to achieve the desired topography. If small ponds are desired, they will be sited at locations that tend to settle (based on monitoring results). It is anticipated that the surface grading techniques will be similar to those already used for wetland development. Significant regrading of the transition area between the upland and wetland elevations will also be necessary after placement has been completed and the upland surface has been graded and planted. To accomplish final grading plans, it may be necessary to excavate portions of the eastern containment dike below elevation +20 ft MLLW and stabilize the dredged materials exposed within the excavation limits.

ATTACHMENT G

EVALUATION OF AN OPEN-WATER EMBAYMENT WITHIN THE LATERAL EXPANSION FOOTPRINT

POPLAR ISLAND EXPANSION STUDY
ENGINEERING APPENDIX

ATTACHMENT G –
EVALUATION OF AN OPEN WATER EMBAYMENT WITHIN THE FOOTPRINT OF THE NORTHERN LATERAL EXPANSION

Following the completion of the plan formulation process, a proposal from National Marine Fisheries Service (NMFS) and subsequent discussions with the Environmental Protection Agency (USEPA), Fish and Wildlife Service (USFWS), Maryland Department of Natural Resources (MDNR), and Maryland Department of the Environment (MDE) lead to the development and evaluation of an open-water embayment that could potentially be incorporated into a northern lateral alignment. The inclusion of an open-water embayment within the footprint of the lateral expansion would provide semi-protected fisheries habitat adjacent to wetland and upland cells, and would increase the trophic interaction between the wetland cells and the open-water embayment within the lateral expansion. The bottom habitat of the open-water embayment would remain essentially undisturbed, preserving the existing bathymetry and benthic habitat. In addition, the construction of small rock reefs within the open-water embayment would provide cover and enhance fish habitat.

USACE-Baltimore conducted an evaluation of the inclusion of an open-water embayment within the footprint of the recommended northern lateral expansion, including placement analysis to determine site life and capacity and engineering design and feasibility. Because the open-water embayment concept was introduced at the end of the plan formulation process after other alternatives had already been screened out, the details of the proposed design for the open-water embayment were compared only to the remaining alternatives: 1) 60 percent wetland, 40 percent upland, and 2) 60 percent wetland, 40 percent upland plus 5-ft dike raising. Detailed results and discussion of these analyses are summarized in the following sections.

1. BACKGROUND

A description of the essential environmental design features of the NMFS proposed modification to the northern lateral alignment was presented in a letter dated April 15, 2005 (Appendix F). The following paragraph presents an excerpt from that letter providing key details:

> "In summary, NMFS recommends modification of the preferred alternative for lateral expansion (i.e., Alternative 2, 600-acre lateral expansion with northern alignment, and raising of dikes on existing upland Cells 2 and 6 of Poplar Island); i.e., to construct a 130-acre open water cell in lieu of 3 proposed wetland cells on the west side of the expansion footprint, to protect the cell with stone breakwater across its mouth, to provide 4,000 to 6,000 linear feet of marsh shoreline around the cell, and to construct 3 small subtidal artificial reefs within the cell."

The proposal was presented by a concept drawing (Figure G-1) that delineated the features described in the excerpt above. The initial concept presented by NMFS drawing was modified slightly by USACE-Baltimore District (Figure G-2) to enhance the hydraulic characteristics of the proposal and minimize the impact on dredged material placement capacity. Those adjustments made by USACE-Baltimore District were informally reviewed by NMFS before proceeding with the analysis presented below.

2. DESCRIPTION OF THE OPEN-WATER EMBAYMENT ALIGNMENT

The open-water embayment alignment consists of a 575-acre (nominal area contained within the project footprint) lateral expansion to the north and northeast of the existing project, and raising the existing upland cells (Cells 2 and 6) an additional five feet in elevation. As proposed, the northern lateral expansion would include an open-water embayment that would be between 80-140 acres in size. The final size of the open-water embayment will be evaluation further in the next design phase of the project based on additional consultation with each resource agency (USFWS, NMFS, USEPA, MDNR, and MDE) and Maryland Port Administration (MPA) (the non-Federal sponsor); results of additional hydrodynamic modeling studies; and additional design considerations. However, for the evaluation conducted in this document, the size of the open-water embayment within the northern lateral expansion was estimated to be 130 acres in size.

For comparison, the proposed open-water embayment alignment was evaluated with regard to the 60 percent wetland, 40 percent upland alternative (Figure G-3). Approximately 40 percent of the expansion site would consist of upland habitat, and the remaining 60 percent would consist of wetland habitat, with a tidal channel (open water) occupying approximately 25 acres of the area within the center of the lateral expansion to provide necessary tidal flushing to the wetland habitat. The total dredged material placement capacity of the 60 percent wetland, 40 percent upland plus 5-ft dike raising alternative would be approximately 29 million cubic yards (mcy).

To construct a northern lateral alignment with the open-water embayment, the primary change to the 60 percent wetland, 40 percent upland alternative would be the replacement of the tidal channel and approximately 115 acres of wetland habitat along the western side of the site with an open-water embayment protected by a line of segmented breakwater structures (Figure G-2). The external footprint of the site would not change. With the inclusion of an open-water embayment, the area within the perimeter footprint will contain 29 percent wetland habitat, 47 percent upland habitat, and 24 percent open water. The higher percentage of uplands is required to provide more efficient dredged material placement operations and to minimize sand borrow requirements outside of the lateral expansion footprint. The total dredged material placement capacity of the northern lateral alignment with the open-water embayment, would be approximately 27.8 mcy.

2.1 Alignment and Internal Configuration

The external footprint of a northern lateral alignment with an open-water embayment would be identical to the footprint of the 60 percent wetland, 40 percent upland alternative. A minor adjustment to the eastern portion of the footprint is currently under consideration in response to comments by local watermen and to avoid a primary cultural site identified during this study. Other minor adjustments are anticipated and will be incorporated as necessary as the design process continues.

The boundaries of the wetland area will be modified slightly to provide wetland habitat around a significant proportion of the shoreline of the 130-acre open-water embayment. The 10,600-foot embayment perimeter consists of approximately 3,400 feet of breakwater, 1,500 feet of upland shoreline, and 5,700 feet of wetland shoreline, consistent with the initial proposal requesting "4,000 to 6,000 linear feet of marsh shoreline" (agency coordination dated April 15, 2005; Appendix F). The shoreline of the southern end of the embayment was adjusted to provide a smoother alignment that should simultaneously improve hydraulic performance (by minimizing the potential for areas of poor circulation) and increase the proportion of marsh shoreline.

The tidal gut included in the 60 percent wetland, 40 percent upland alternative (Figure G-3) was absorbed by the embayment except for a short segment at the southern end of the expansion footprint adjacent to existing wetland Cell 1 (Figure G-2). This remaining portion of the tidal gut (approximately 10 acres) will provide necessary tidal access to Cell 1. Current engineering judgment indicates that circulation within the embayment will be adequate, and that connection of the tidal gut remnant at the southern end of the embayment will not be necessary. If hydraulic analysis indicates otherwise, or if environmental considerations make it desirable, the tidal gut can be connected to the embayment through the wetlands.

2.2 Submerged Rock Reefs

Three small subtidal artificial reefs were included within the open-water embayment (Figure G-2). It is anticipated that the reefs will be constructed either entirely of rock with a cross section similar to the breakwater structures (Figure G-4) or may consist of a sand core with external armor, depending on the size of the reef. The initial location of the reefs placed them about 600 feet from the shoreline and the breakwater structures. It may be desirable to shift several of the reefs closer to the proposed 200-foot breakwater openings to reduce incoming wave energy and to provide protection to the interior eastern dikes. The location of the rock reefs will be determined based on the results of the hydrodynamic modeling conducted for the open-water embayment. However, if relocated, the reefs would be kept at least 200 feet away from the breakwater structures to provide adequate opening into the open-water embayment to provide for fish utilization.

2.3 Perimeter Dike

The 60 percent wetland, 40 percent upland alternative is bounded by an armored sand dike similar in cross section to the dikes of the existing project. To create the open-water embayment, segmented breakwaters following the same alignment as the armored sand dike in the 60 percent wetland, 40 percent upland alternative would replace approximately 3,400 feet of the western leg of the perimeter dike. The breakwater segments are approximately 200 feet long and are separated by about 50 feet of open water except for one or two larger openings of approximately 200 feet (Figure G-2). As shown on Figure G-4, the breakwater structures will consist of a core of 250-lb underlayer stone and two layers of stone armor having a mean weight of approximately 2,500 lbs. The structure will have a width of 6.8 feet at crest elevation +6 ft MLLW, and 1.5 horizontal on 1 vertical (1.5H:1V) side slopes. A high-strength geotextile sheet will be placed on the Bay bottom to minimize loss of stone into soft or loose surface deposits. Hydraulic analyses will be performed to optimize the breakwater crest height, stone size, and dimension of openings between segments. Any proposed changes to the size of the openings will also be evaluated for potential impacts on fish passage.

2.4 Internal Dikes

Internal containment dikes will be constructed with sand from borrow sources within the lateral expansion footprint. The interior dikes of the 60 percent wetland, 40 percent upland alternative are generally constructed to elevation +6.5 ft MLLW using sand, and have minimal slope protection provided by established vegetation. The dikes that form the perimeter of the proposed open-water embayment would be raised to a minimum crest elevation of +9 ft MLLW and would require slope protection to prevent erosion from the exposure along the embayment (Figure G-5). The current design assumption is that adequate slope protection can be provided by a double layer of 350-lb stone placed on a bedding layer and a geotextile filter, similar to the protection proposed for the eastern slopes of the expansion dikes. Dike height and slope protection requirements will be refined as hydraulic analyses are completed.

3. ENGINEERING SCREENING

If the open-water embayment alignment had been evaluated as an alternative during plan formulation in the original engineering screening process (See Section 4.5.2.b and Appendix A, Attachment B), it would have received the same weighted score as Alternative 7. Alternative 7 consisted of a northern lateral of 630-acres, and had the number one ranking. Therefore, the open-water embayment alignment would have been carried forward for a more detailed engineering evaluation.

4. DREDGED MATERIAL PLACEMENT ANALYSIS

4.1 Capacity Analysis

Analysis of dredged material placement was performed using the same mathematical placement model applied to each of the other expansion and dike raising alternatives (Appendix A, Attachment C). An analysis was performed for the inclusion of a 130-acre open-water embayment in the lateral expansion footprint, both with and without an associated 5-ft raising of the existing upland dikes. A summary of the results of the placement analysis is presented in Table G-1, along with the results of the analyses previously performed on the 60 percent wetland, 40 percent upland alternative (both with and without an associated 5-ft raising of the existing upland dikes). The analyses indicate that the loss of wetland area associated with the open-water embayment reduces the dredged material placement capacity of the expansion by approximately 1.2 mcy. The capacity of the transformed wetland area alone is approximately three mcy. However, because the upland area is increased from approximately 40 percent to 47 percent to accommodate the open-water embayment, about 60 percent of the capacity associated with the lost wetland placement is recovered.

4.2 Placement Efficiency

As shown in Table G-1, the last year that the site can accommodate the future average annual inflow of 3.2 mcy is unchanged with the inclusion of a 130-acre open-water embayment in the lateral expansion footprint, and the duration of upland and wetland placement is minimally affected. The 60 percent wetland, 40 percent upland alternative and the open-water embayment alternative both require the additional capacity provided by a 5-ft raising of the existing upland cells for efficient placement of dredged material. That additional capacity can be held in reserve until the expansion site has been completely filled except for the wetland cell containing the protected offloading facility. As dredged material is placed into the final wetland cell, excess material can be directed to the raised upland cells. After the first year of placement, the quantity required in the wetland cell diminishes to a relatively small quantity, estimated to be less than 0.5 mcy out of the 3.2 mcy annual demand. The additional capacity associated with the raised upland cells provides the means to maintain a much more cost effective placement process compared to the scenario without the additional capacity associated with the raising. The detailed placement analysis for the open-water embayment including a 5-ft dike raising is presented in Figure G-6.

Table G-1. Comparison of 60 Percent Wetland and Open-Water Embayment Alternatives

Expansion and/or Raising Alternative	Total Expansion Area (acres)	Upland Area (acres)	Wetland Area (acres)	Water Area (acres)	Expansion Capacity (mcy)	Last Year at 3.2 mcy	Last Wetland Placement	Last Upland Placement
575-Acre Expansion with 60% Wetland & 40% Upland	575	235	315	25	**23.0**	2020	2021/2026	2021/2021
575-Acre Expansion with 60% Wetland & 40% Upland + 5’ Raising	575	235	315	25	**29.0**	2022	2021/2027	2022/2025
575-Acre Expansion with 29% Wetland, 47% Upland, & 24% Open Water	575	270	165	140	**21.8**	2020	2019/2026	2021/2021
575-Acre Expansion with 29% Wetland, 47% Upland, & 24% Open Water + 5’ Raising	575	270	165	140	**27.8**	2022	2019/2026	2021/2026

NOTE: The two dates shown in each cell of the last two columns for placement in wetland and upland cells reflect the additional 4 to 5 year period associated with recovery of the wetland cell used as a sheltered dredged material offloading site.

4.3 Placement Conclusions

The impact of the inclusion of an open-water embayment in the lateral expansion footprint on dredged material placement is minor as compared to the 60 percent wetland, 40 percent upland alternative. From the perspective of placement efficiency, the additional six mcy of placement capacity realized by raising the existing upland dikes 5 feet is very beneficial to the lateral expansion with or without the open-water embayment. The time and cost impact associated with developing wetland habitat within the offloading cell is mitigated by including a 5-ft dike raising.

5. BORROW ANALYSIS

After the original seven alternatives were screened and a northern expansion study area was defined (See Section 4.5.2.c), additional subsurface investigations and analyses of potential sand borrow sources were performed. To the maximum extent possible, it is desirable to obtain all sand borrow for the construction of the containment dikes from sand obtained from within the footprint of the project (North Borrow area) (Figure G-7), and from the excavation required for the new access channel and turning basin (Attachment A, Figure A-1). Because of the significant adverse impact that deep holes have on wetland cell development, borrow excavations within wetland areas will be avoided in all but the most extreme cases. One such case is the temporary dredged material off-loading basin that will be constructed in the wetland cell at the northwest corner of the expansion site. Otherwise, borrow within the expansion footprint will be limited to the upland cells as shown on Figure G-7.

The inclusion of an open-water embayment in the lateral expansion footprint has small, but generally favorable, impacts on the sand borrow excavation plan for the expansion construction. A summary of the borrow sources needed for both the 60 percent wetland, 40 percent upland alternative and the inclusion of the open-water embayment is presented in Table G-2. The data in the first two sections of the table present the fill quantities required and the borrow sources proposed for the 575-acre northern lateral alignment at 60 percent wetland and 40 percent upland, both with and without a 5-ft raising of the existing upland dikes. The data in the last two sections of the table present the fill quantities required and the borrow sources proposed for the 575-acre northern alignment with the inclusion of an open-water embayment. Because a significant portion of the western perimeter dike would be replaced by a stone breakwater structure and a portion of the interior dikes associated with the tidal gut are eliminated to accommodate the embayment, the required dike fill quantities decrease by 250,000, to a total of 300,000 cy. Therefore, the inclusion of the open-water embayment would decrease the total required fill quantity from 3.7 mcy to 3.4 mcy when raising the existing upland dikes is included.

Compared to the 60 percent wetland, 40 percent upland alternative, the proposed open-water embayment layout increases the upland proportions from 40 percent in to approximately 47 percent. As discussed previously, this mitigates a significant percentage of the placement capacity lost when 115 acres of wetlands are replaced with open-water habitat. This increase in upland area also increases the quantity of borrow material available for dike construction by nearly 15 percent, significantly reducing the projected area required from borrow sources outside the project limits. The 91 acres of the southwest borrow area anticipated for construction of the 60 percent wetland, 40 percent upland alternative is reduced to 19 acres. Both of these calculations are based on an assumed factor of safety of 1.75 applied to the computed borrow volumes. This safety factor is required because experience in the construction of Phase II of the existing project showed that the actual yield from the designated borrow areas was approximately 75 percent less than the theoretical volume in the borrow areas. A portion of the losses were attributed to fine-grained soils being lost during the dredging process and portions of the stockpiled materials not being fully recovered during construction. The larger factor, however, was the variability of the borrow deposit which had significantly higher proportions of clay and silt deposits than the geotechnical borings indicated. The final borrow excavations in nearly all cases varied significantly from the borrow limits anticipated in the original contract documents.

Table G-2. Borrow Requirements for the 60 Percent Wetland and Open-Water Embayment Alternatives

Alternative	Borrow Source	Borrow Volume (mcy)	Borrow Yield (mcy)	Borrow Area Disturbed (acres)
60% Wetland & 40% Upland	North Borrow	4.6	2.6	144
	Northern Access Channel/Turning Basin	0.5	0.3	30
(3.3 mcy sand required)	SW Borrow	0.7	0.4	49
	Subtotal		**3.3**	
60% Wetland & 40% Upland with 5-ft Raising	North Borrow	4.6	2.6	144
	Northern Access Channel/Turning Basin	0.5	0.3	30
(3.7 mcy sand required)	SW Borrow	1.5	0.8	91
	Subtotal		**3.7**	
With Open-Water Embayment	North Borrow	5.2	3.0	175
	Northern Access Channel/Turning Basin	0.5	0.3	30
(3.0 mcy sand required)	SW Borrow	0	0	0
	Subtotal		**3.3**	
With Open-Water Embayment and 5-ft Raising	North Borrow	5.2	3.0	175
	Northern Access Channel/Turning Basin	0.5	0.3	30
(3.4 mcy sand required)	SW Borrow	0.3	0.2	19
	Subtotal		**3.5**	

It should be noted that the reduction from a potential 91 acres of external borrow sources (for the 60 percent wetland, 40 percent upland alternative) to 19 acres (for the open-water embayment alternative) is very favorable, and significantly reduces the environmental impacts to the southwest borrow area. The actual dike placement quantity associated with the 19-acre excavation is less than 200,000 cy, and it is possible that the entire quantity may be obtained from within the expansion dike footprint if the final subsurface exploration indicates that the geologic variability of the borrow deposit within the expansion limits is less than was the case in the southern borrow sources used for the original Poplar Island construction.

6. IMPACTS OF THE INCLUSION OF THE OPEN-WATER EMBAYMENT ON CELL DEVELOPMENT

6.1 Dredged Material Placement

Other than the small reduction in total placement quantity and minor impacts on the placement sequence, placement of dredged material would be as described in Appendix A, Section 6.1. It is anticipated that excess water from the wetland cells would be discharged into the open-water embayment during the dredged material placement process. Discharge standards will be the same as those applicable for discharge directly to the Bay.

6.2 Open-Water Embayment

No dredged material would be placed within the 130-acre embayment, and the construction process would be controlled to minimize disturbance to all but those areas immediately adjacent to the dikes, reefs, and breakwater structures. Sand dike fill materials stockpiled for dike construction will be limited to the area designated as the southern wetland cell, and the southwestern edge of the upland cell immediately east of existing wetland Cell 1, or might be temporarily placed within the northern end of existing wetland Cell 1.

6.3 Wetland Cell Development

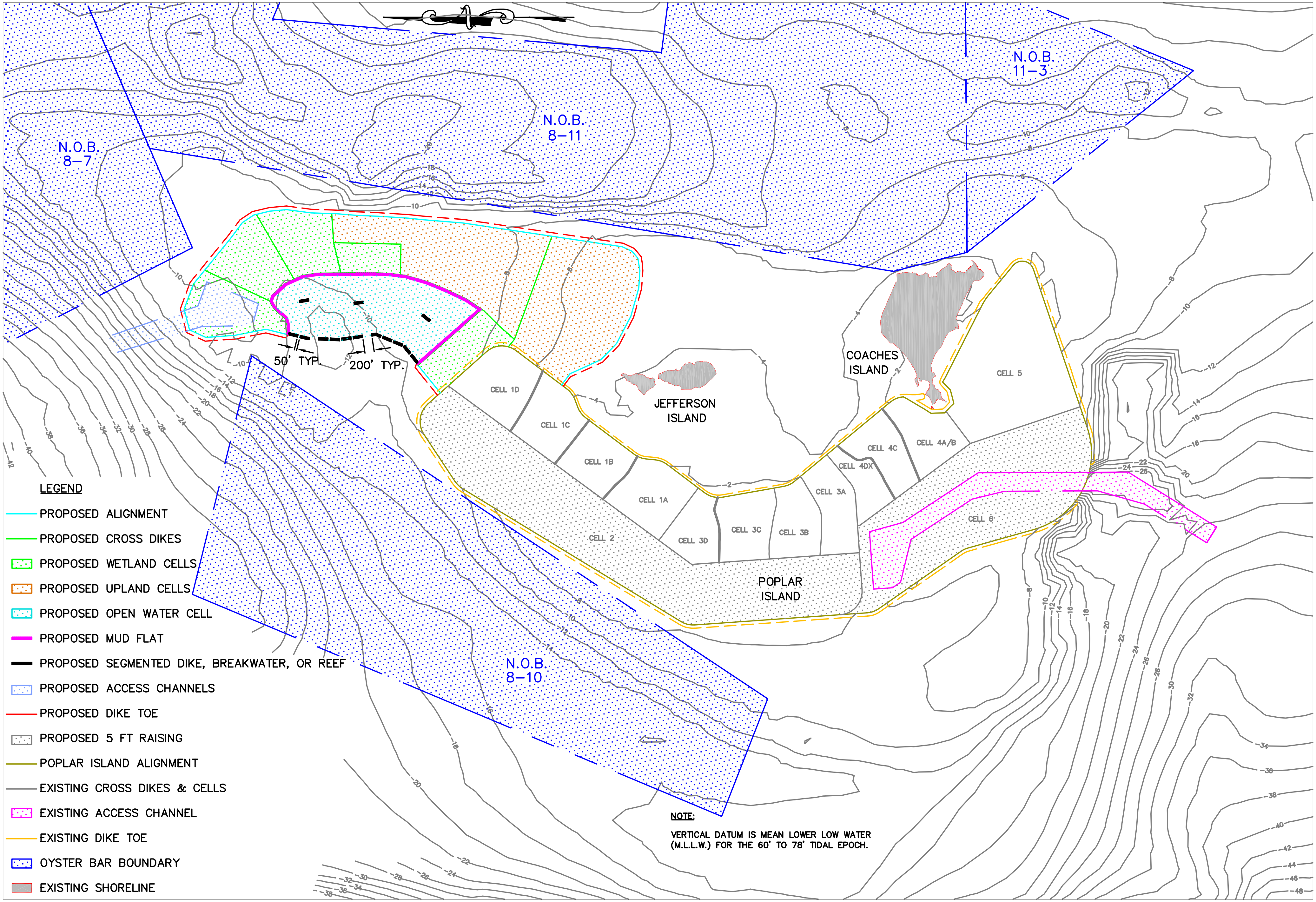
With the inclusion of the open-water embayment, the design and functionality of the remaining wetland cells will be essentially unchanged. Therefore, the proposed cell development approach will be the same as the presented in Appendix A, Section 6.2.

6.4 Upland Cell Development

With the inclusion of the open-water embayment, the design and functionality of the remaining upland cells will also be essentially unchanged. Therefore, the proposed cell development approach will be the same as the presented in Appendix A, Section 6.3.

6.5 Existing Upland Cell Dike Raising and Development

Since there are essentially no changes to the plan for raising the existing upland cell dikes, the proposed cell development approach will be as presented in Appendix A, Section 5.9.1.



NOTE:

VERTICAL DATUM IS MEAN LOWER LOW WATER (M.L.L.W.) FOR THE 60' TO 78' TIDAL EPOCH.

Figure G–1. Original Open Water Embayment Concept Proposed by National Marine Fisheries Service

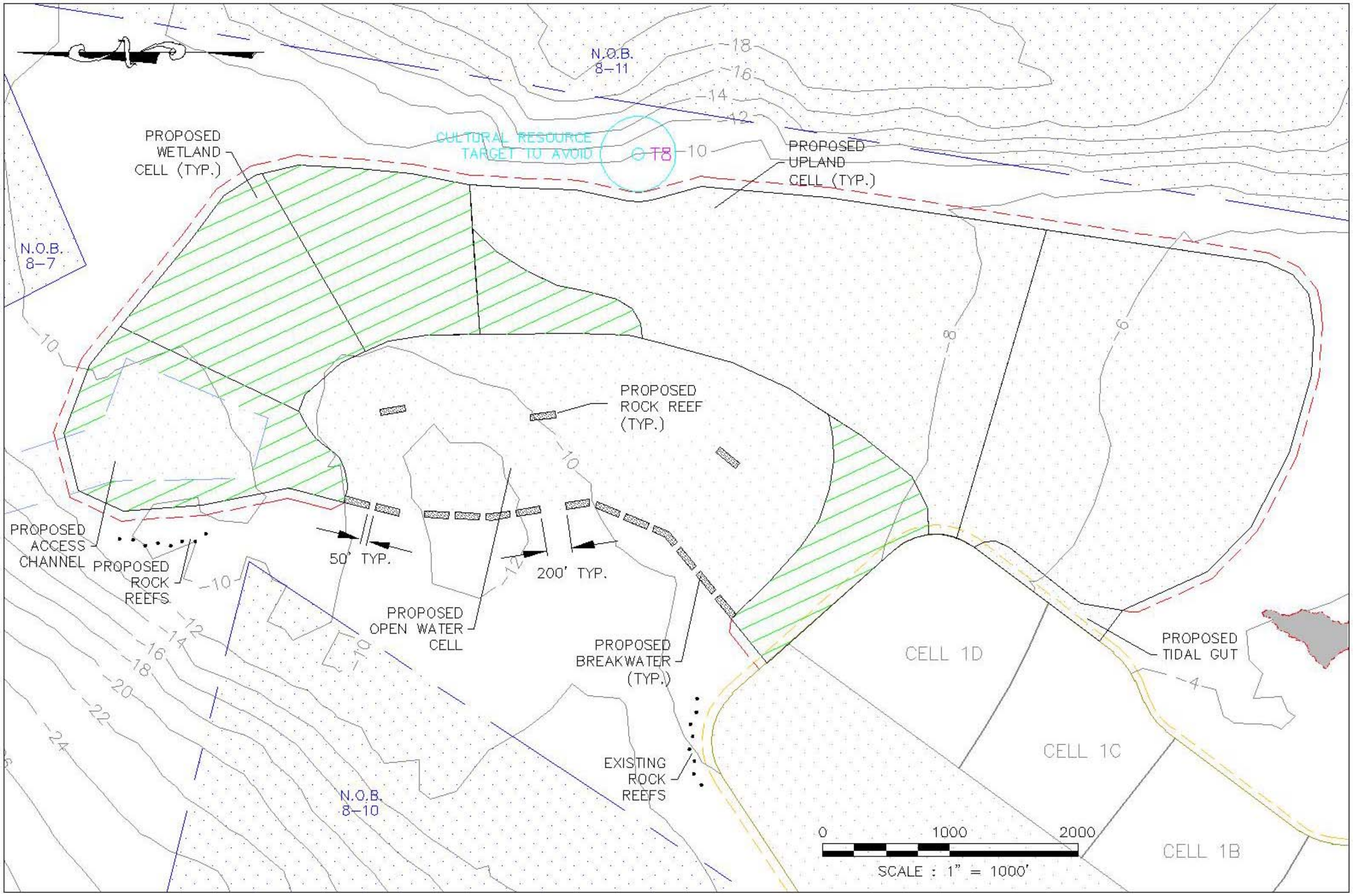


Figure G-2. Northern Lateral Alignment with 130-Acre Open Water Embayment, as modified by USACE-Baltimore District

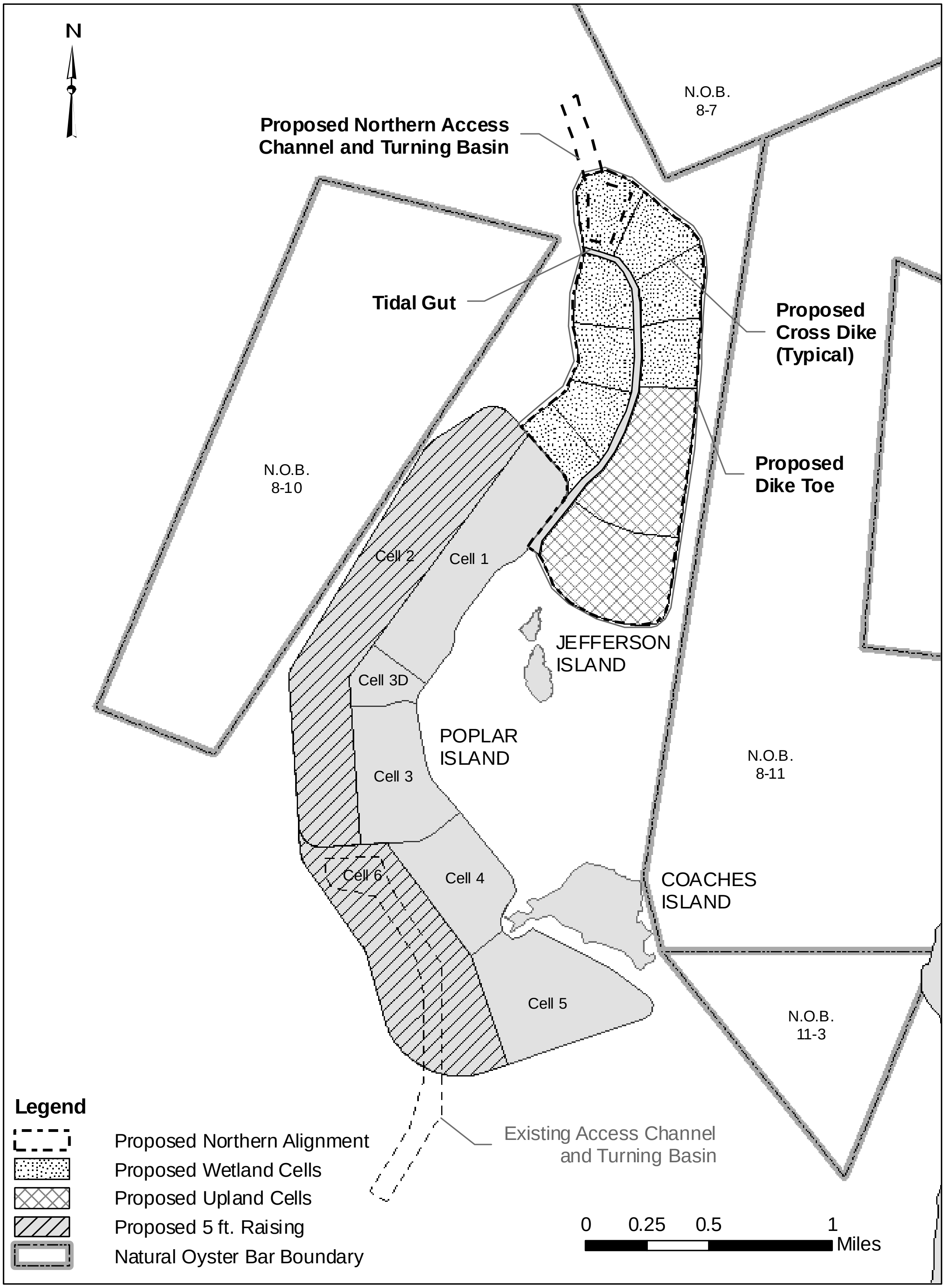


Figure G-3. Alternative for the Northern Lateral Alignment - 60% Wetland to 40% Upland Ratio and 5-ft Raising of PIERP Upland Cells

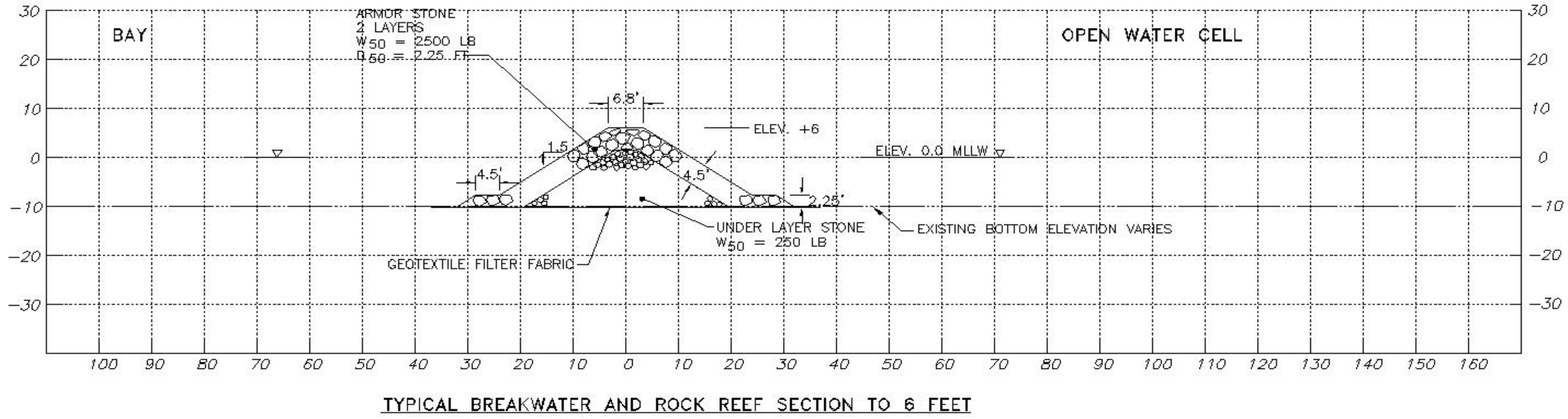
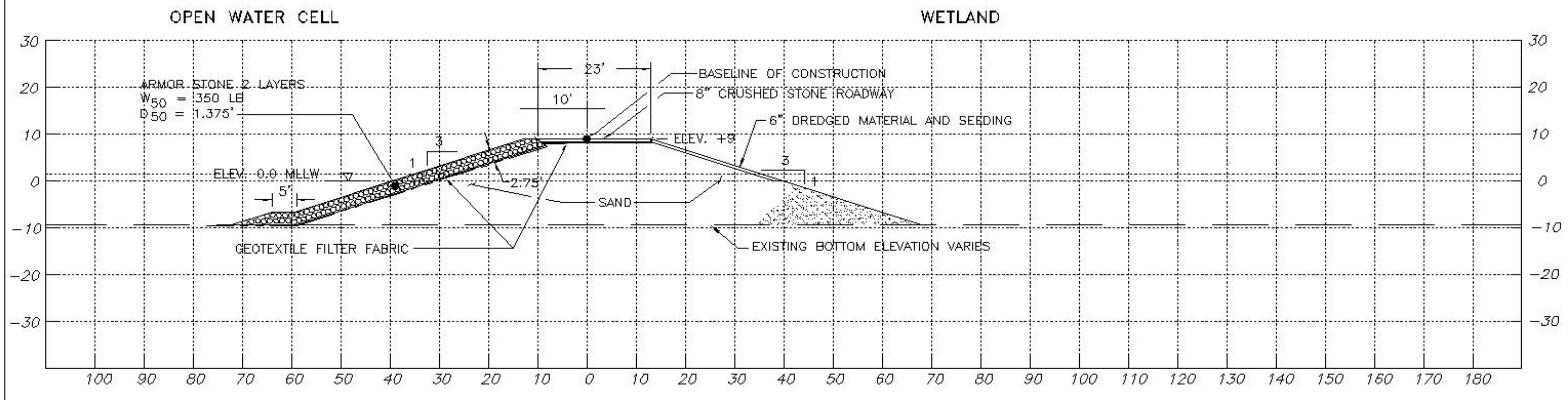
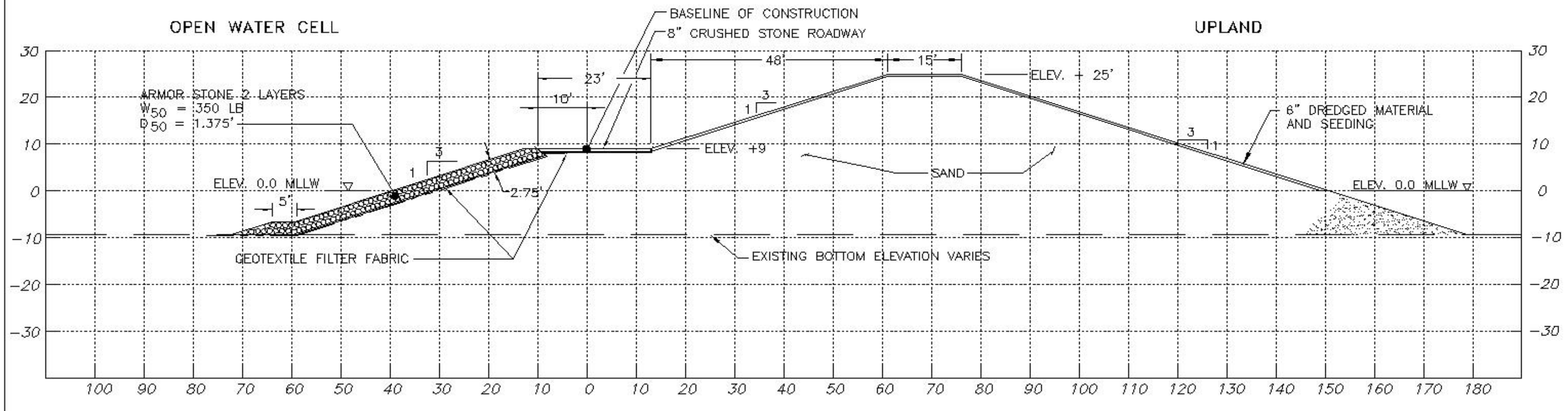


Figure G-4. Typical Segmented Breakwater and Rock Reef Section



TYPICAL OPEN WATER EMBAYMENT PERIMETER DIKE SECTION TO 9 FEET



TYPICAL OPEN WATER EMBAYMENT PERIMETER DIKE SECTION TO 25 FEET

Figure G-5. Typical Open Water Embayment Perimeter Dike Sections

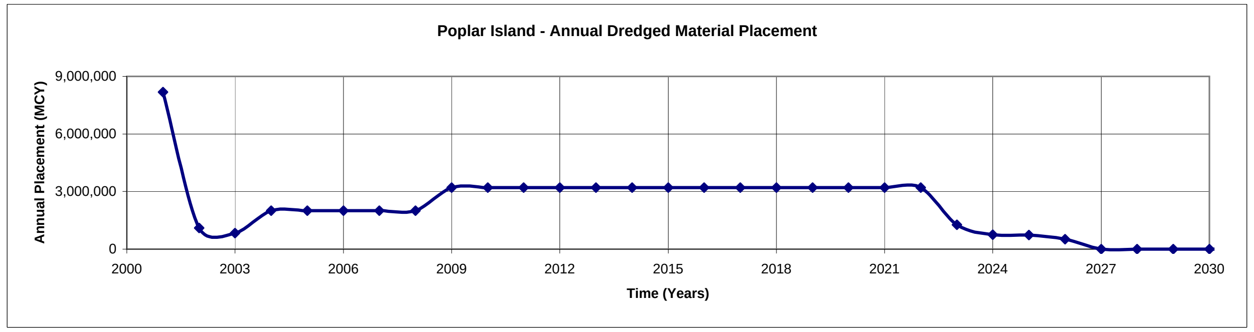
POPLAR ISLAND DREDGED MATERIAL PLACEMENT AND CELL DEVELOPMENT PLAN

FIGURE G-6. EXISTING 1140-ACRE SITE PLUS 575-ACRE NORTHERN EXPANSION WITH AN 130-ACRE OPEN WATER EMBAYMENT PLUS 5-FOOT RAISING OF EXISTING UPLAND CELLS

(Expansion Cells Assumed to be Available in 2011)

Cell No.	Cell Acreage	Cell Acreage	Cell Volume	Cell Capacity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Total Placed Quantity
	(Nominal)	(Actual)																																			
EXPANSION UPLAND CELLS																																					
U-2	326	298	2,406,206	3,437,437	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,490,265	631,332	500,000	300,000	400,000	115,840	0	Grade	Grade	Plant	Plant		**3,437,437**
U-6	243	222	1,793,583	2,562,261	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,000,000	200,000	350,000	350,000	300,000	362,261	0	Grade	Grade	Plant	Plant		**2,562,261**
																																					0
Up-10	270	247.1	11,359,359	16,227,656	0	0	0	0	0	0	0	0	0	0	1,434,866	1,434,866	1,434,866	1,434,866	1,434,866	1,434,866	1,434,866	1,434,866	1,434,866	**2,604,123**	709,735	0	0	Grade	Grade	Plant	Plant						**16,227,656**
EXISTING UPLAND CELLS																																					
U-2	326	298	10,913,555	**15,590,792**	**6,399,848**	1,038,000	0	1,111,000	535,347	894,394	0	700,000	1,500,000	1,450,000	0	0	0	0	500,000	600,000	611268	250935	0	0	Grade	Grade	Plant	Plant									**15,590,792**
U-6	243	222	11,926,728	**17,038,183**	0	0	0	0	0	400,000	**1,700,000**	1,120,114	1,075,000	1,280,028	1,219,723	1,460,710	982,614	895,534	949,649	1,045,435	1,094,016	**1,473,371**	**1,746,112**	595,877	0	0	Grade	Grade	Plant	Plant							**17,038,182**
EXISTING WETLAND CELLS																																					
W-1A	38	35	265,393	**379,133**	139,480	0	160,000	60,000	19,653	Grade	Plant																										**379,133**
W-1B	38	35	378,327	**540,467**	195,000	0	170,000	110,000	40,000	15,467	0	0	0	10,000	Grade	Plant																					**540,467**
W-1C	44	40	367,840	**525,486**	195,000	0	200,000	80,000	40,000	10,486	Grade	Plant																									**525,486**
W-1D	49	45	486,420	**694,886**	235,000	0	220,000	170,000	40,000	20,000	0	9,886	Grade	Plant																							**694,886**
W-3A	35	32	366,549	**523,642**	220,000	0	0	210,000	55000	21,000	0	10,000	0	7,642	Grade	Plant																					**523,642**
W-3B	30	28	275,557	**393,653**	290,000	0	0	75,000	20000	8,653	Grade	Plant																									**393,653**
W-3C	39	35	400,913	**572,733**	225,403	0	66,000	184,000	50000	30,000	0	10,000	0	7,330	0	Grade	Plant																				**572,733**
W-3D	31	26	251,680	**359,543**	284,500	62,000	12,000	Grade	Plant																												**358,500**
W-4A&B	34	31	150,040	**214,343**	0	0	0	0	0	0	0	0	0	0	0	130,000	65,000	19,343	Grade	Plant																	**214,343**
W-4C	38	34	7,000	**10,000**	0	0	0	0	0	0	0	0	0	0	0	0	10,000	0	Grade	Plant																	**10,000**
W-4DX	25	23	0	**0**	0	0	Plant																														**0**
W-5A	33	30	242,000	**345,714**	0	0	0	0	0	0	0	0	250,000	60000	25,000	10,714	Grade	Plant																			**345,714**
W-5B	33	30	266,200	**380,286**	0	0	0	0	0	0	0	0	0	275,000	65000	30,000	10,286	Grade	Plant																		**380,286**
W-5C	33	30	290,400	**414,857**	0	0	0	0	0	0	0	0	300,000	70000	30,000	14,857	Grade	Plant																			**414,857**
W-5D	57	53	1,710,133	**2,443,048**	0	0	0	0	1,200,000	600,000	300,000	150,000	75,000	40,000	30,000	20,000	20,000	8,048	0	0	Grade	Plant															**2,443,048**
EXPANSION WETLAND CELLS																																					
W-1	25.0	22.9	369,050	527,214	0	0	0	0	0	0	0	0	0	0	395,411	98,853	23,066	9,885	Grade	Plant																	**527,214**
W-2	43.3	39.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																		**0**
W-3	43.3	39.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																	**0**
W-4	43.3	39.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																**0**
W-5	47.0	43.0	763,195	1,090,279	0	0	0	0	0	0	0	0	0	0	0	0	654,167	261,667	87,222	43,611	21,806	21,806	Grade	Plant													**1,090,279**
W-6	41.0	37.5	665,766	951,095	0	0	0	0	0	0	0	0	0	0	0	0	0	570,657	228,263	76,088	38,044	19,022	19,022	Grade	Plant												**951,095**
W-7	52.0	47.6	2,072,585	2,960,835	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		2,368,668	414,517	106,590	35,530	35,530	0	0	Grade	Grade	Plant		**2,960,835**
W-8	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Grade	Plant																**0**
Water	130.0	130.0	0	0											Embayment completed as part of initial expansion construction with no subsequent placement of materials																						
	1,691	**1,544**		**68,183,543**	8,184,231	1,100,000	828,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	1,264,517	756,590	735,530	513,631	0	0	0	0	0	0	**68,182,499**

			EXPANSION AREA	w/o Raising	with Raising
	Area	% Area	Capacity	% Capacity	% Capacity
wetland	165.0	29.21%	5,529,423	25.41%	19.92%
water	129.9	23.00%	0	0.00%	
upland	270	47.80%	16,227,656	74.59%	80.08%
raising	569		5,999,699		



Total Upland Capacity	54,856,330
Total Wetland Capacity	13,327,214
Upland Placement Capacity Percentage	80.45%
Total Expansion Capacity	27,756,778

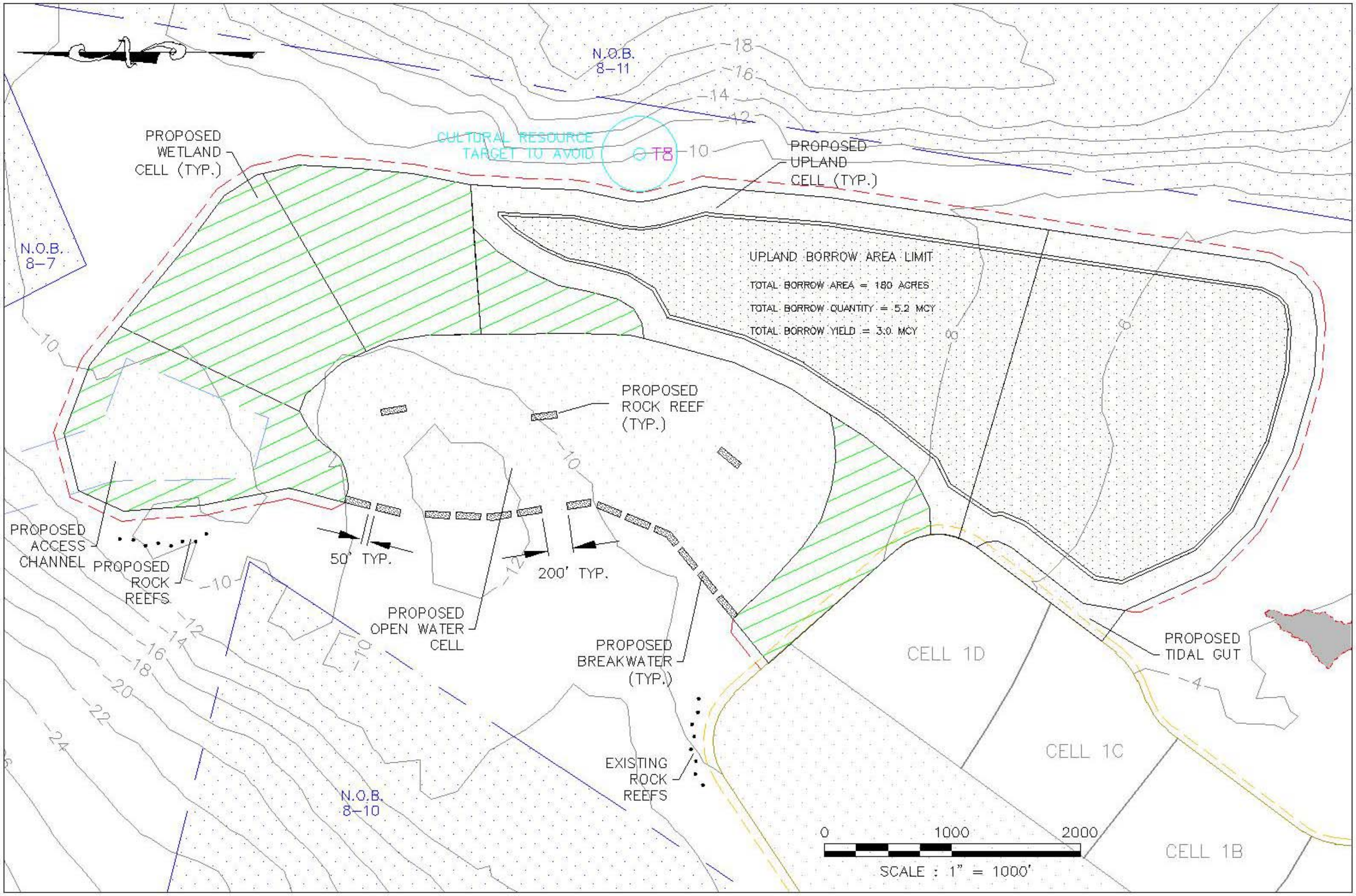


Figure G-7. Sand Borrow Limits for the Northern Lateral Alignment with an Open Water Embayment