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Memorandum

TO: Dr. Daryl Dwyer

FROM: Chris Windnagle and Hugh Crowell, MS, PWS

DATE: September 24, 2008

RE: Subsurface Constructed Wetlands Engineering Initial Feasibility Analysis; UOT014.100.0005.DOC

In this memorandum, Hull & Associates, Inc. (Hull) summarizes the initial construction feasibility of a proposed subsurface constructed wetlands project at Maumee Bay State Park (MBSP) to capture and treat a portion of the flow in Berger Ditch, primarily to address observed problems with suspended sediment and sediment-associated pathogens. These problems have been documented by the US Geological Survey (USGS; Brady 2007), by USGS in partnership with the University of Toledo (Francy et al., 2005) and by State of Ohio health advisories issued through their ongoing beach testing programs at Maumee Bay State Park (MBSP). This memo provides background information and the calculations used to determine the initial construction and technical feasibility of a SSF approach as well as the land and soil volume requirements.

CONSTRUCTED WETLANDS

Constructed wetlands have successfully been used for wastewater treatment at various locations throughout the world. Engineered wetland systems can recreate many of the pollutant attenuation functions present in natural wetlands, including ion adsorption, UV exposure, nitrification and denitrification, pH buffering, and sediment filtering capacity. Constructed wetlands can also be used as water, stormwater, or wastewater treatment systems. In addition, constructed wetlands can be aesthetically pleasing and create wildlife habitat.

There are two general types of constructed wetlands: constructed surface flow (SF), and constructed subsurface flow (SSF) wetlands. Natural wetlands are not typically used for water treatment due to regulatory requirements, but do have the potential to be utilized under certain circumstances (Kadlec & Knight, 1996). SF wetlands are also referred to as free water surface (FWS) wetlands and SSF systems are also referred to as vegetated submerged beds (USEPA, 1999).

Constructed SF wetlands are often designed to include both open-water and vegetated areas, and tend to resemble natural emergent wetlands in appearance and functions. These systems are typically designed with different cells at different water depths to create multiple flow pathways and velocities, and maximize retention time. The major method of pathogen removal in these systems is through ultraviolet (UV) radiation. Constructed SSF wetlands are specifically designed to avoid surface flow, concentrating water flow where there is maximum contact with reactive substrate surfaces. In SSF wetland systems, flow is generally governed by Darcy's Law and analogous to groundwater flow as the water travels through porous media such as gravel or soil rather than across a free water surface (Kadlec & Knight, 1996). These systems are also typically designed with multiple cells to vary flow patterns and limit the required excavation. Pathogen removal in these systems is believed to be primarily by filtering and adsorption (Stevic, et.al, 2004). Occasionally, systems are designed to be a hybrid of constructed SF and SSF wetlands, with cells consisting of emergent marsh and open water and other cells with subsurface flow.

The specific purpose of this summary memorandum is to examine the initial technical feasibility of constructing a SSF wetland system at MBSP for studying the removal of sediments, pathogenic bacteria, and other pollutants from Berger Ditch.

MAUMEE BAY STATE PARK

Maumee Bay State Park Beach experiences annual beach health advisories due to high densities of *Eschericia coli*. (*E. coli*) (an indicator of fecal bacteria) (>235 cfu/ml per one time sample) following rainfall events, and advisories have also occurred occasionally during dry periods. Berger Ditch is the most likely primary source of the bacterial contamination, although other sources may contribute. The University of Toledo (UT) has proposed that an engineered wetland be built at Maumee Bay State Park to study the effectiveness of constructed wetlands for removing bacteria, sediment and other pollutants from Berger Ditch prior to discharging to Maumee Bay. Ideally, the constructed wetland would also re-establish wetland habitat in an area that historically was an estuarine coastal wetland complex, enhance aesthetics, create wildlife habitat, reduce the number of beach health advisories, and contribute to public education.

The precise size and location for the constructed wetland project has not yet been confirmed by the Ohio Department of Natural Resources (ODNR), but the area will likely be located on the left descending bank of Berger Ditch between Cedar Point Road and the MBSP road overpass approximately 1000 feet downstream. Once the final location and area that are available for the constructed wetland are known, it may necessary to adjust some aspects of this initial technical feasibility study to more closely match field conditions. Based on known siting criteria, Hull estimates that an area of 22.5 to 40 acres will be required for the project using the assumptions outlined in this memorandum.

FECAL COLIFORM BACTERIA

E. coli bacteria counts are used as an indicator organism for the potential presence of pathogenic bacterial contamination. Fecal coliform bacteria contamination has been shown to be reduced within constructed wetland systems (USEPA. 1999); however, additional research is needed to determine the effectiveness of their use as a treatment system. Various studies, including Watson, et. al. (1990), Gearheart et.al (1989) and Herskowitz (1986), have shown that SF wetland systems have resulted in fecal coliform most probable number MPN reductions of 86.2-99.9%

Most previous research on fecal coliform removal has focused on SF systems despite significant practical limitations on their use. Principally, SF wetlands have limited use in temperate areas that experience freezing in winter. Winter freezing conditions result in minimal or no treatment due to low biological activity and low flow. SSF systems have been shown to be capable of effectively treating water year round, especially when an appropriate mulching material is used to insulate the subsurface bed (Wallace, et. al, 2000). Selection of an appropriate mulching material is critical for the success of the system for operations during the winter.

This project will afford an opportunity to study the effectiveness of SSF wetland systems on water-borne pathogen removal, and to study and refine necessary design criteria to operate in a cold seasonal climate. In SF wetland systems, fecal coliforms are removed through ultraviolet (UV) radiation (sunlight), filtering and adsorption. In SSF systems, UV radiation is not a primary method of treatment, and removal is accomplished through filtering, adsorption, or another mechanism. Based on these mechanisms of removal, distance, media, flow, and biofilm accumulation rather than time appear to be the critical factors for effective treatment (Stevic, et.al, 2004, USEPA, 1993).

Grain size and substrate material are important factors in the effectiveness of pathogen removal via filtration and adsorption. In natural wetland systems the wetland media is often a fine grain (<0.062 mm) clay or silt soil, which provides an excellent media for adsorption and filtering of contaminants. The size of the pores associated with clayey and silty soils act as a filter to capture bacteria and sediments. These small grain sizes a have high overall porosity, but the pore size is extremely small, which restricts the available flow pathways resulting in very low hydraulic conductivity. Thus using clay or silt soils as a substrate in a SSF constructed wetland requires an extremely large area or would greatly restrict the amount of water that can be treated through the system. Grain size and porosity data referenced in the MBSP hydrogeological report, included in Attachment C, suggest that if a natural wetland still existed over much of this area, ideal conditions for adsorption and filtering of pathogens would be in place. However, from an initial feasibility standpoint, clayey and silty soils are not a practical substrate construction material, but a fine (pea) gravel should be utilized

While pea gravel does not have the same filtering capacity as a clay or silt medium, some filtering occurs initially and the growth of plant roots and biofilms increases the filtering capacity over time (Stevic, et.al 2004). Over time clay and silt particles will be settle in the SSF wetland system which will increase the effectiveness of the filtering capacity of the system. However, the settling of clay and silt particles along with, dense root growth can reduce the hydraulic conductivity of the substrate to the point of clogging over time (USEPA, 2004). Periodic draining and cleaning of the system can be completed to avoid these issues (USEPA, 2004).

WATER FLOW

Hull determined from available information that it is not practicable to capture the entire flow of Berger Ditch due to the limited amount of space available for this project. In order to determine a reasonable volume of water to capture from the Ditch, flow data obtained from the United

States Geological Survey (USGS) from 2006 and 2007 was examined to determine stream flows in the Ditch during the measuring period. Three separate flow capture scenarios were developed using actual storm/flow data to estimate the required area for a constructed wetland along with a retention basin to temporarily store water prior to discharge to the wetland.

The flow scenarios examined were to capture flow in the ditch when flow rates were between 10-20 cubic feet per second (CFS), 10-50 CFS, and 50-100 CFS. These flows were chose based on frequency of events and maintaining flow into the wetland system. These flow scenarios can be modified based on further analysis of flow data, clarification of project goals with respect to storm events, or other criteria as determined by the client or other interested parties. In order to capture flow at the desired rates, a weir would need to be constructed to temporarily hold the water so that it could be pumped or routed into a constructed pond where the flows would be directed either by pump or gravity into the constructed wetland. At low flows (flows below the desired capture volume) base flows in Berger Ditch would be maintained through a culvert constructed in the base of the weir. At high flows (i.e. flows greater than the desire capture volume water would overflow the weir back into Berger Ditch. Conceptual diagrams are located in Attachment A. Figure 1 shows the average daily flows in Berger Ditch during the 22006-2007 monitoring period. The graph is marked to indicate which would flows would be captured under the three scenarios examined for this report. The desired capture flows can be altered before a final design would be completed.

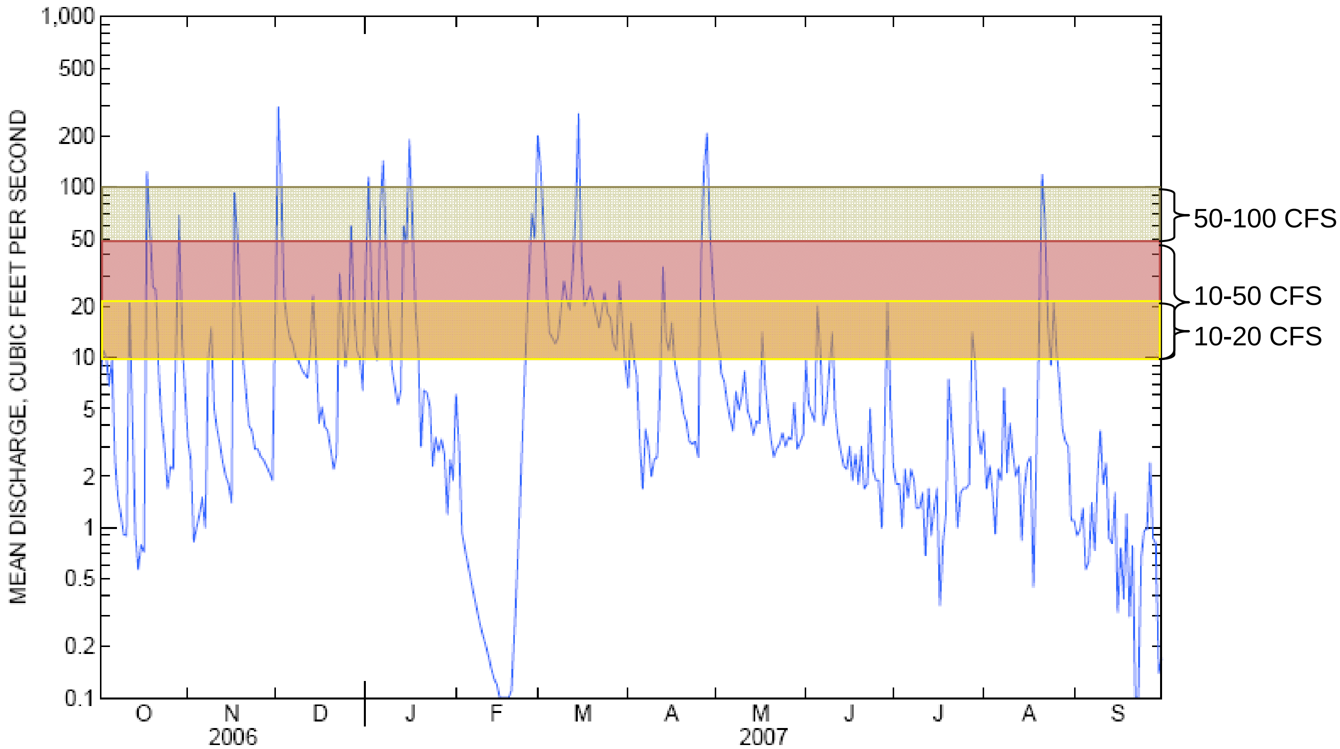

Figure 1. Average Daily Flows for Berger Ditch 2006-2007.

The duration of the peak flow period will determine the total volume of water that can be captured. The pond can be designed to capture a predetermined maximum flow of a given predicted storm event. However, a storm event resulting in a longer duration of peak flow will produce excess flow that will flow over the weir and into Maumee Bay. Actual flow event data was analyzed to determine the required volume for the pond and wetland.

Ohio EPA has expressed regulatory concern about weir installation on Berger Ditch. Placing a weir in the stream would require approvals under Sections 404 and 401 of the Clean Water Act. Given that the basic purpose of building the weir is to study and ultimately to improve water quality in Berger Ditch, obtaining permits is technically feasible. However, obtaining the permits would take a minimum of six to eight months and add additional costs.

Conceptual SSF Wetland Design Criteria

There are some fairly well-established criteria and range of parameters that are used for constructed wetland design. The criteria that were utilized during this feasibility analysis include substrate type, permeability, hydraulic conductivity, aspect ratio, depth of flow, and hydraulic gradient. A key component of SSF design and operation is to prevent water flowing through the system from surfacing. If water is allowed to surface, short-circuiting of the treatment system is likely to occur which diminishes effective treatment. Final design criteria as shown in the model depicted in Figure 2 will need to include considerations for retention time, concentration, flow, plant type, and project goals.

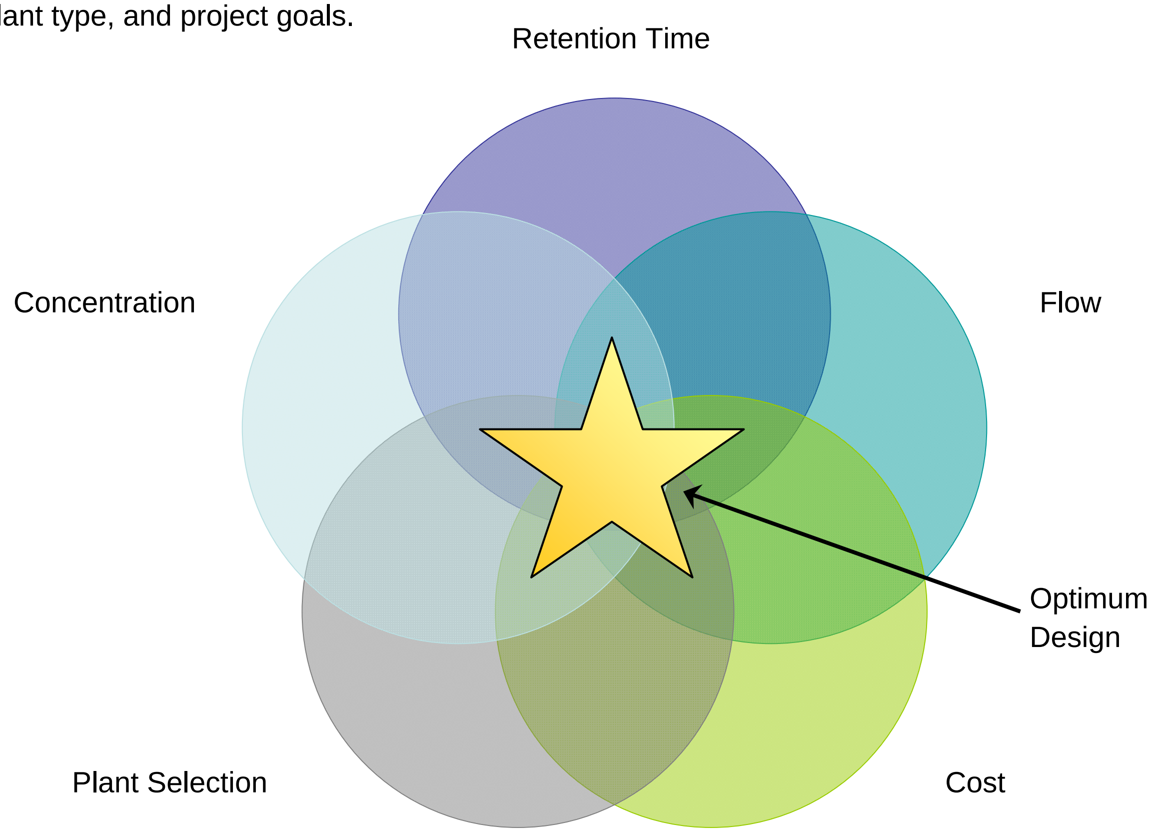

Figure 2. Final Design Decision Criteria

The most widely used and easiest-to-utilize constructed SSF wetland substrate material available is fine or pea gravel (4 to 8 mm). Pea gravel has porosity values that range from 32-40% and hydraulic conductivity in the range of 2.2 x 10^{-2} cm/sec to 20 cm/sec. The available information regarding the necessary hydraulic gradient for constructed wetlands ranges from construction of a flat, zero-gradient system to designs being utilized in Europe with as much as an 8% slope. Zero-gradient systems tend to have reduced flow and lower treatment potential (Rousseau, et. al., 2004). A hydraulic gradient can be established either through construction of the wetland base with the appropriate grade or by utilization of an outlet port that can be adjusted to increase or decrease the gradient based on flow or a combination of both grade and a hydraulic structure. Another important criterion of design is the aspect ratio or length to width (L:W) ratio of the system. The wider a system is designed the more flow can be treated through the system, while the length will dictate the hydraulic retention time (HRT). Typical depth of subsurface flow ranges from 1.6 to 2.6 feet.

Site conditions and local regulations will dictate whether or not a synthetic or recompacted clay liner needs to be constructed for any given project. The hydrogeological site investigation included in Attachment C discusses the results of that investigation.

SITE EVALUATION

Hull conducted a hydrogeological study of the potential wetland site at MBSP, and the results of that study are included as Attachment C. The study results indicate that the extremely flat MBSP site is underlain primarily by brown and grey clayey soils with uniformly low permeability (k=2.91 x 10^{-8} to 3.69 x 10^{-8} cm/sec). This indicates that a wetland constructed in this area likely may not need a synthetic or recompacted clay liner, as the permeability of the *in-situ* material (3.69 x 10^{-8} cm/sec) is low compared to the wetland substrate (8.68 cm/sec - estimated). The boring logs and grain size analysis data indicate the presence of some sand/silt lenses to some limited degree. Therefore the final design of the wetland will need to ultimately include a detailed analysis of liner system (synthetic, recompacted clay, *in-situ* soil, etc.) design,

CONCEPTUAL SCENARIO DESCRIPTIONS

The wetland and retention pond calculations discussed below are based on standard engineering hydrology principals and recommendations for constructed wetland design parameters from USEPA and various researchers, and on storm event data obtained from the USGS gauging station. The design parameter guidelines include the slope of the base of the wetland, substrate recommendations, length, and retention time recommendations. A retention pond that will maintain five feet of head was included in the volume calculations as a means to collect flows from Berger Ditch and redistribute them into the wetland for treatment. The retention pond would be used to control flow to the wetland to ensure adequate treatment time and to prevent water from surfacing within the SSF wetland.

To estimate the volumes that may be required, three conceptual scenarios were given consideration. The soil balance associated with each scenario was estimated. Based on the geotechnical data, topography and soil balance estimates, Hull concludes that the construction of SSF wetlands at Maumee Bay State Park is feasible from a constructability perspective. A conceptual drawing of the three scenarios is included in Attachment A, and the conceptual drawings of the wetland design are in Attachment B.

Scenario A utilizes pumps to move water from Berger Ditch to a pond that is constructed primarily above surrounding grades, and the wetland system is fed by gravity. The construction of the required berms should use the bulk of the soil that would need to be excavated for the wetlands below grade potions of the pond. Scenario B assumes the pond is constructed completely below grade, which allows the pond to be filled by gravity either through a siphon, culvert, pipes, or coarse granular material. However, a pump would need to be utilized to move water from the pond into the wetlands. In this scenario, the amount of soil that would need to be excavated increases significantly and there will be a positive soil balance to use as part of the project and other potential uses. Scenario C is a hybrid system consisting of a partially excavated pond and shallow excavated wetlands in an effort to avoid using any pumps. It appears that this scenario is not technically feasible due to the depth of Berger Ditch.

Table 1 provides the pond size required for the different flow scenarios examined. Based upon the analysis completed, the pond would need to have a storage capacity of 38 to 180 acre-feet depending upon the desired flow that is to be captured. This analysis assumes that the area available for the constructed wetland is 15 acres. If the available area increases so that the storage volumes of the pond could be decreased more flow from Berger Ditch could be captured and treated. Additional design calculations need to be conducted to refine the total area needed based upon additional storm durations, actual available acreage, and final design criteria.

Flow estimates through the wetland were based upon Darcy's Law and established criteria for depth, porosity, and hydraulic conductivity for constructed wetlands and porous media that are typically used for SSF systems.

TABLE 1
ESTIMATED VOLUME DESIGN SUMMARY

Flow Scenario	Pond Area/Depth	Wetland Area (Acres)	Depth of Wetland Substrate (pea gravel) (feet)	Soil Volumes Pond/Wetland (Acre-Feet)
10-20 CFS	5 Acres/11 feet	11.5	2	55/38
10-50 CFS	15 Acres/17 feet	11.5	3	215/50
50-100 CFS	15 Acres/13feet	11.5	3	150/50

CONCLUSIONS

Based upon an initial site investigation and review and application of design criteria available in the scientific literature, Hull concludes it is technically feasible to construct a SSF wetland system at Maumee Bay State Park for the purpose of capturing and treating flows from Berger Ditch and studying pollutant removal. The actual area available for use in this project has yet to be finalized by the Ohio Department of Natural Resources and this may affect the feasibility of utilizing this site for the project. Once the area available has been determined it will be possible to develop the final design as well as select the equipment necessary to operate the system.

A final engineering design will require that additional analysis be completed for retention time, land availability, plant selection, final design grades, flow, concentration, project goals, and a cost benefit analysis. While it is technically feasible to construct a SSF wetland from a constructability perspective the cost analysis of this scenario has not been completed. The additional treatment achieved utilizing this system may be disproportionately large relative the previous studies completed for the passive system recommended in the TMACOG report.

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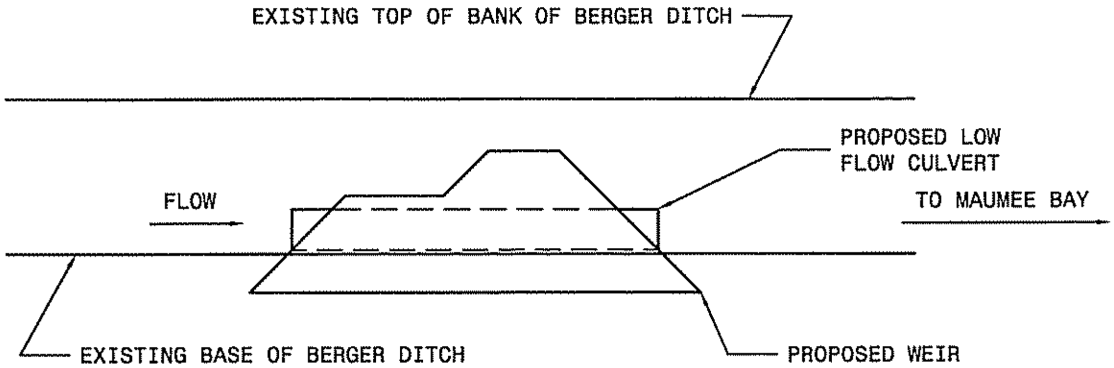
ATTACHMENT A

Ditch and Pond Cross Section Conceptual Drawings



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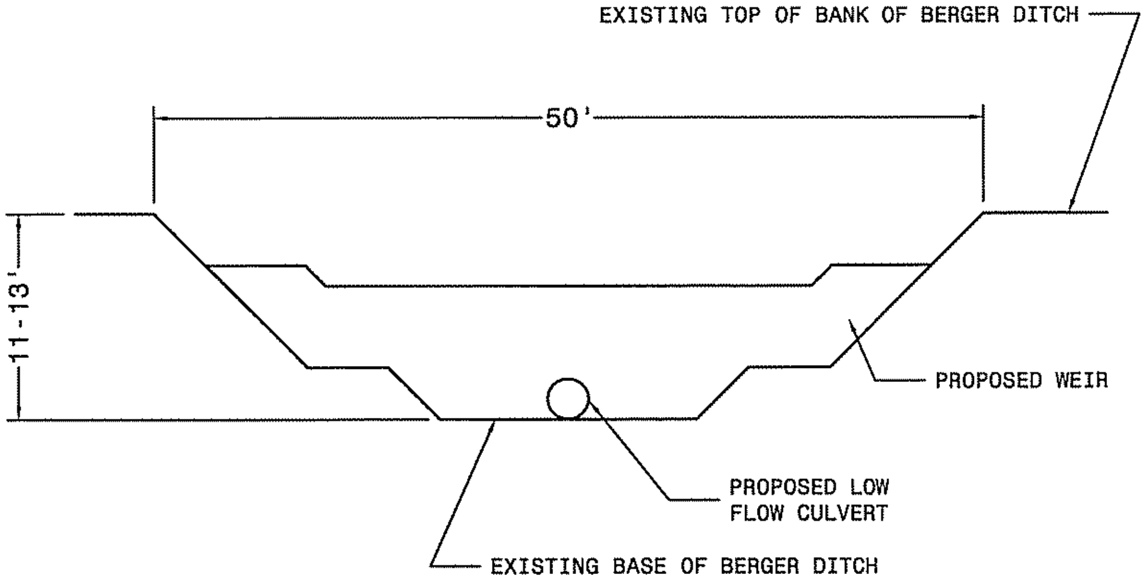

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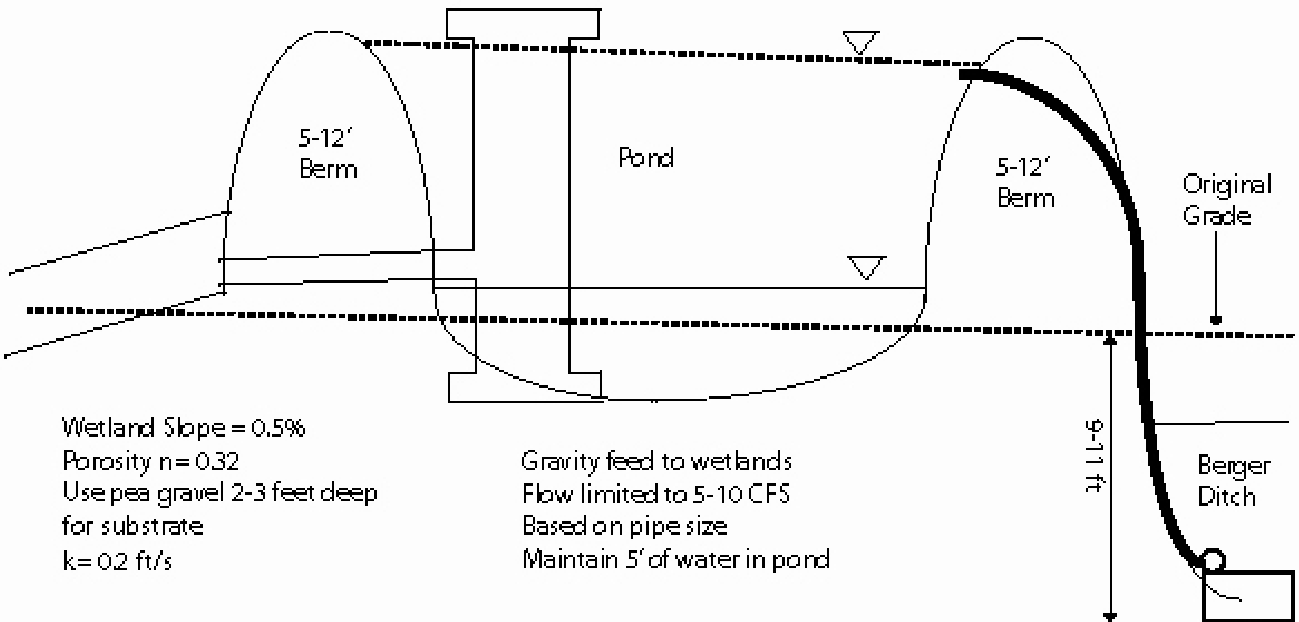
FIGURE 1
CONCEPTUAL WEIR DETAILS

CITY OF TOLEDO, LUCAS COUNTY, OHIO

PROJECT NO.: UOT014	SUBMITTAL DATE: JULY 2008
CAD DWG FILE: UOT014.100.0001 GAC	PLOT DATE: 7/29/08

Figure A-2
Scenario A - Construct Above-Grade Pond



Wetland Slope = 0.5%
Porosity n = 0.32
Use pea gravel 2-3 feet deep
for substrate
k = 0.2 ft/s

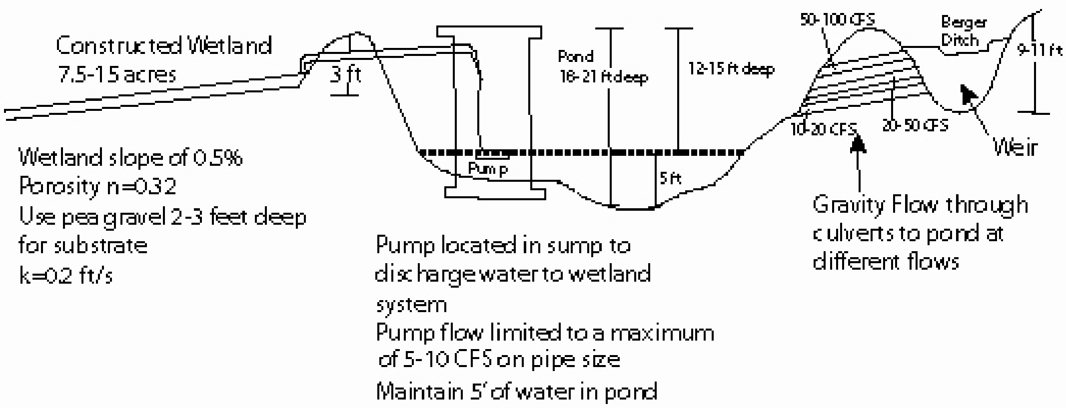
Gravity feed to wetlands
Flow limited to 5-10 CFS
Based on pipe size
Maintain 5' of water in pond

Pump ditch directly into
pond with pump at levels
based on flow.

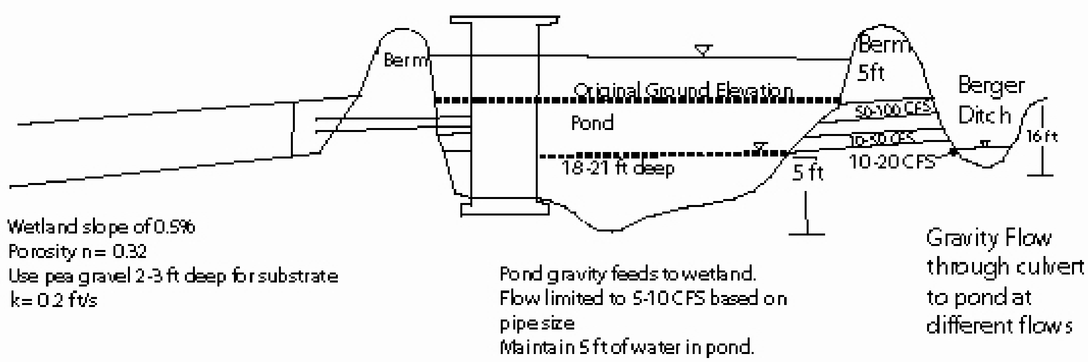
Berms constructed to maintain pond above grade.

Not to scale

Figure A-3
Scenario B - Construct Below Grad Pond



Scenario C - Construct Hybrid Above/ Below Grade Pond



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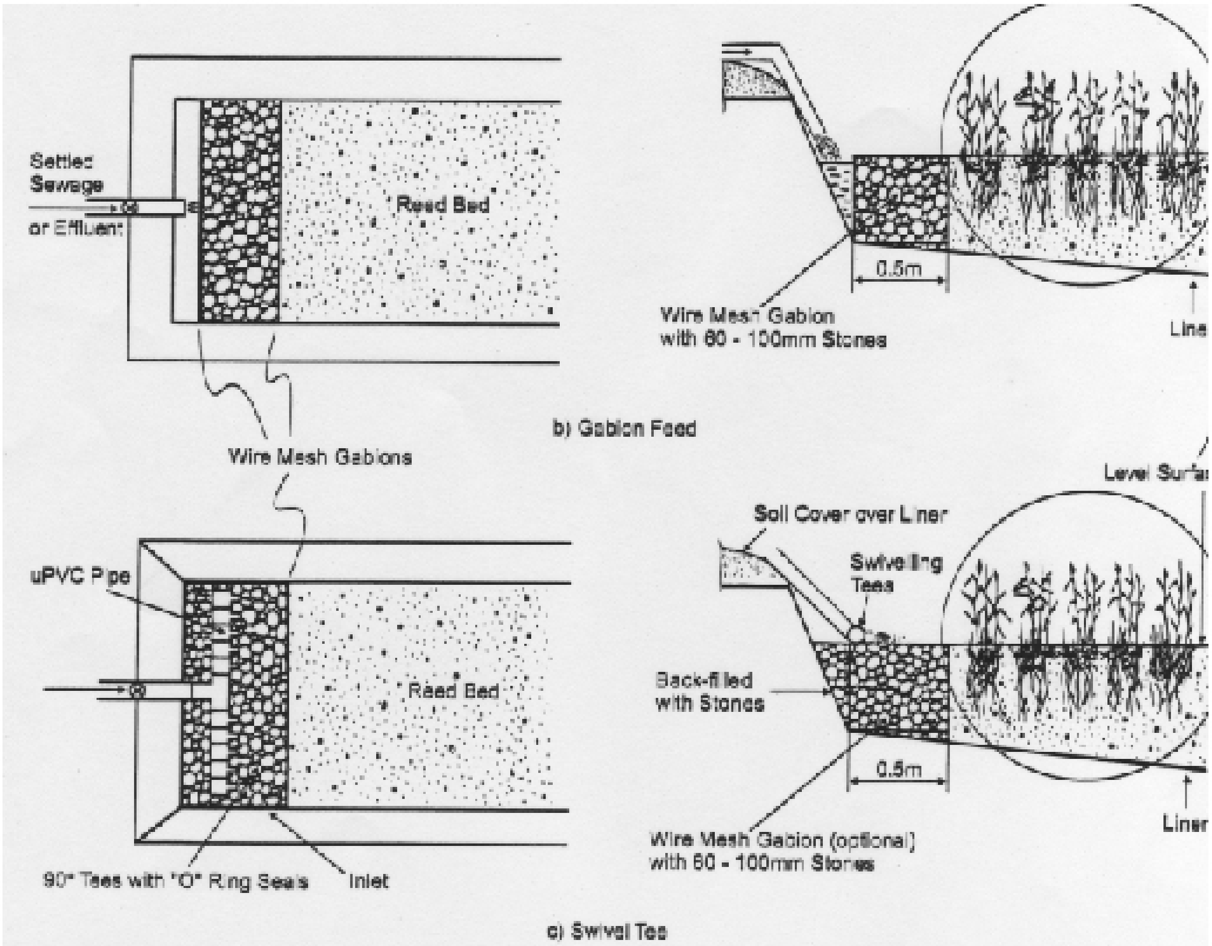
ATTACHMENT B

Conceptual Wetland Drawings

Figure B-1
Typical Inlets for SSF Wetland Systems



From: USEPA (1999) Not to scale

Figure B-2
Typical Outlet Structures for Constructed SSF Wetland Systems

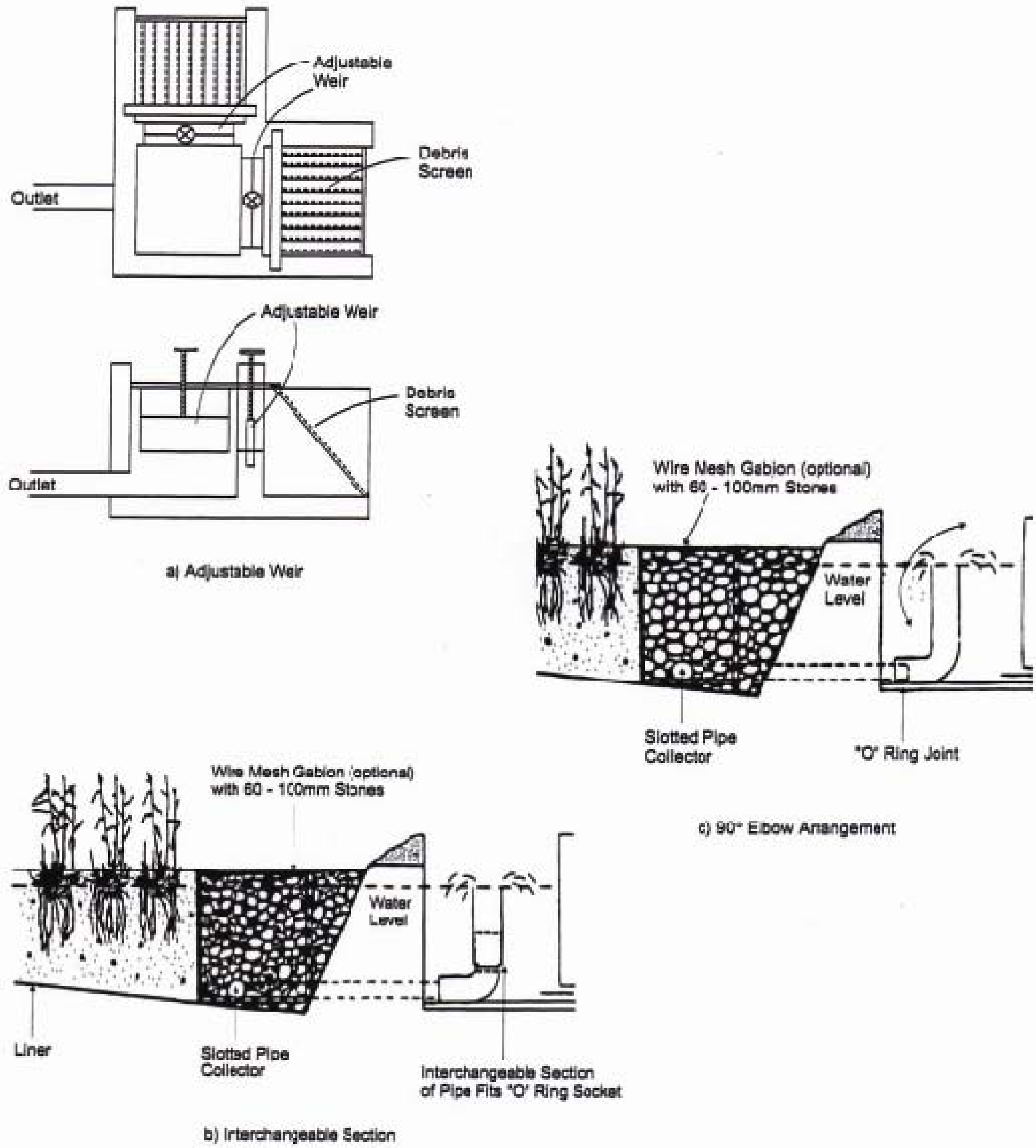


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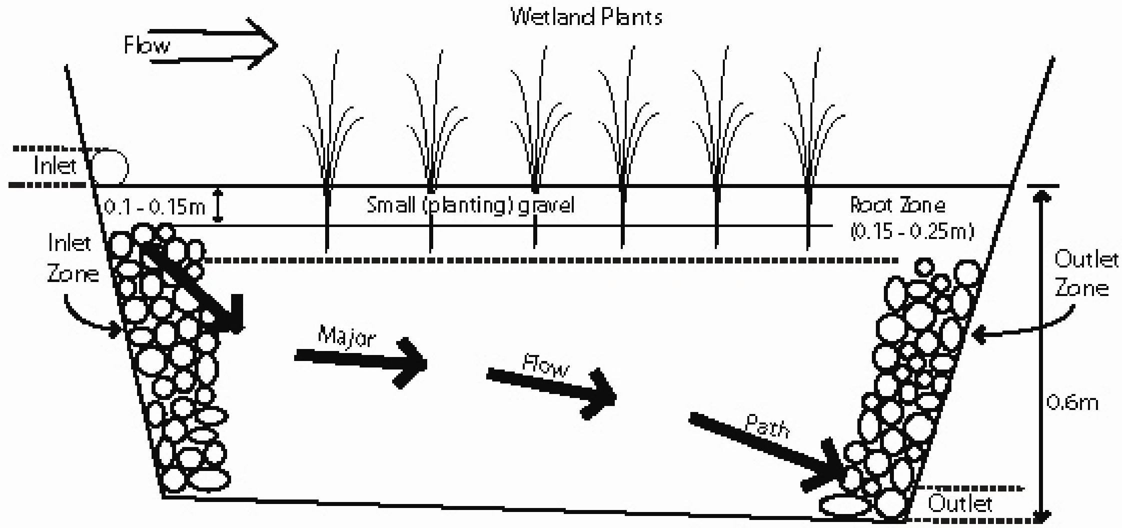
Figure B-3
Typical Subsurface Wetland Flow



From USEPA (1999)

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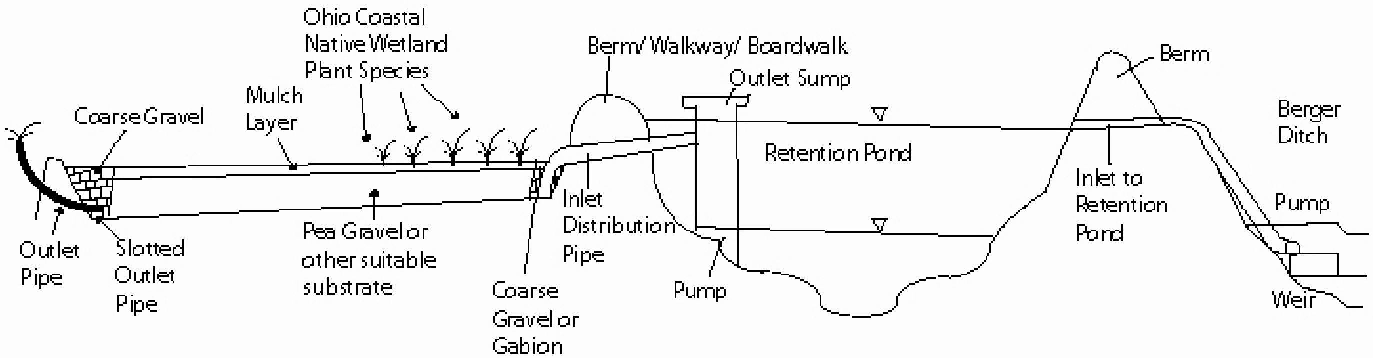
Figure B-4
Typical Cross Section Conceptual Drawing of Ditch/ Retention Pond/ Wetland System at Maumee Bay State Park



Conceptual Maumee Bay State Park/ Berger Ditch
Constructed Wetland/ Pond Cross Section

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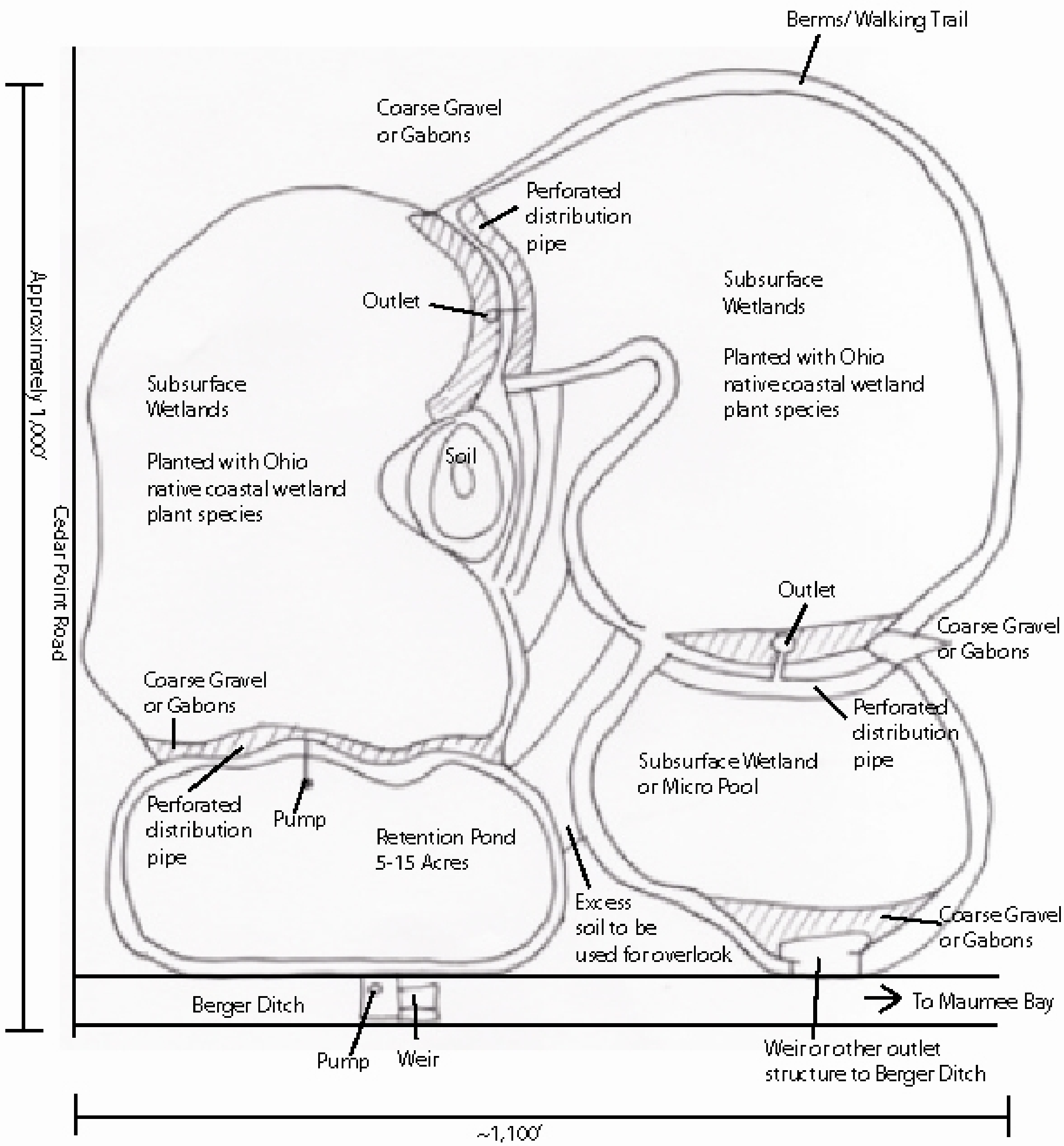
Figure B-5

Conceptual Maumee Bay State Park Berger Ditch Constructed Wetland

L:W Ratio Approximately 2:1



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ATTACHMENT C

Hydrogeological Investigation Report

Hull & associates, inc.

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Memorandum

TO: Dr. Daryl Dwyer

FROM: Hull & Associates, Inc.

DATE: June 26, 2008

RE: Investigative Soil Boring Installation, and Site Characterization at the Proposed Artificial Wetland, Maumee Bay State Park; UOT014.100.0004.DOC

INTRODUCTION

Hull & Associates, Inc. (Hull) has developed this memorandum to document the findings of investigative soil boring activities in conjunction with a geophysical survey conducted by Dr. Daryl Dwyer with the University of Toledo (UT), which were completed at the proposed subsurface wetland area (study site) located in Maumee Bay State Park. Investigative soil boring activities were completed to assist in optimizing the site characterization for the design phase of the proposed subsurface wetland. Soil boring activities and the interpretation of the site characterization is discussed in more detail below.

INVESTIGATIVE SOIL BORING ACTIVITIES

Hull completed three investigative soil borings (HSB-1 through HSB-3) at the site on June 10 and 11, 2008. The locations of the investigative soil borings were placed in strategic locations that enabled drill rig access and spatial variation in data. Soil boring locations are illustrated on Figure 1. North Coast drilling performed the soil boring activities, while Hull provided project coordination and documentation services associated with the soil boring activities. Investigative soil borings were completed by advancing 4.25-inch I.D. hollow stem augers and continuously sampled using 60-inch sampling barrel. All soil borings were advanced to a depth of 30-feet. UT requested that the HSB-3 boring be left open so that an investigative well could be installed at a later date. The boring logs for investigative soil borings HSB-1 through HSB-3 are included in Attachment A.

Select sample depth intervals from HSB-1 through HSB-3 were selected for USCS classification for grainsize and permeability analysis. Seven Shelby tubes were collected to enable accurate permeability testing at the lab. The selected sample depth intervals are illustrated on the soil boring logs included in Attachment A. USCS grainsize data and permeability data are also included in Attachment A.

SITE CHARACTERIZATION

According to investigative soil boring activities and the geophysical study, the general stratigraphy at the site is typical for northwest Ohio and includes:

- topsoil
- brown clay
- grey clay (within grey clay, HSB-2 (north) and HSB-3 (southwest) exhibited laterally discontinuous, wet interbedded sand seams and layers, while no such seams and layers were present in HSB-1 (east))
- carbonate bedrock

A generalized cross section is provided in Figure 2, and a discussion of the stratigraphic units illustrated on the cross section is discussed below in more detail.

Topsoil

Topsoil was observed to be laterally and vertically continuous and was generally observed from zero to one-foot below ground surface (bgs). It was described in the field as moist, medium to stiff grey lean clay, with some roots and organic debris.

USCS grain size classification or permeability tests were not necessary from this unit for site characterization or design of the subsurface wetland.

Brown Clay

The brown clay was laterally and vertically continuous and was generally observed from one to 10-feet bgs. This unit was described in the field as moist to wet, soft to very stiff brown lean clay with grey mottles, with sand and trace fines. Moist to wet vertical fractures was observed at some intervals of the brown clay. Also, a trace to some roots was observed in the brown clay unit at soil boring locations HSB-1 and HSB-2, respectively.

Grain size analysis data suggest the USCS classification for this unit ranges from CL (lean clay) in HSB-3 to CH (fat clay) in HSB-2, which suggests clay content increases from south to north. Permeability data collected from HSB-3 suggest the permeability for this unit is 3.34×10^{-8} cm/sec.

Grey Clay

The grey clay was laterally continuous and was generally observed from 10 to 30-feet bgs. This unit was described in the field as slightly moist to wet, soft to hard grey lean clay, trace fines, and non-plastic to highly plastic. Within the grey lean clay unit, laterally discontinuous, wet Interbedded sand seams were observed in investigative soil borings HSB-2 (north) and HSB-3 (southwest), at depths of 10 to 12-feet bgs and 12 to 12.8-feet bgs, respectively. In HSB-2, wet, small angular gravel seams were observed from 28.5 to 30-feet bgs. In HSB-3 a wet, fine to coarse sand layer was observed from 21.6 to 23.7-feet bgs. No granular zones were observed in HSB-1, which was located southeast in the study area.

Grain size analysis data suggest the USCS classification for this unit is CL in all soil borings. Permeability data collected suggest that permeability for this unit ranges from 2.91×10^{-8} to 4.98×10^{-8} cm/sec and is on average 3.73×10^{-8} cm/sec.

Carbonate Bedrock

Although Hull soil borings were terminated at a depth of 30-feet, communication with UT suggests compacted till observed at approximately 30 to 45-feet bgs is laterally and vertically continuous and overlies carbonate bedrock, which is encountered at approximately 100-feet bgs.

USCS grain size classification or permeability tests were not necessary or attainable from this unit for site characterization or design of the artificial wetland.

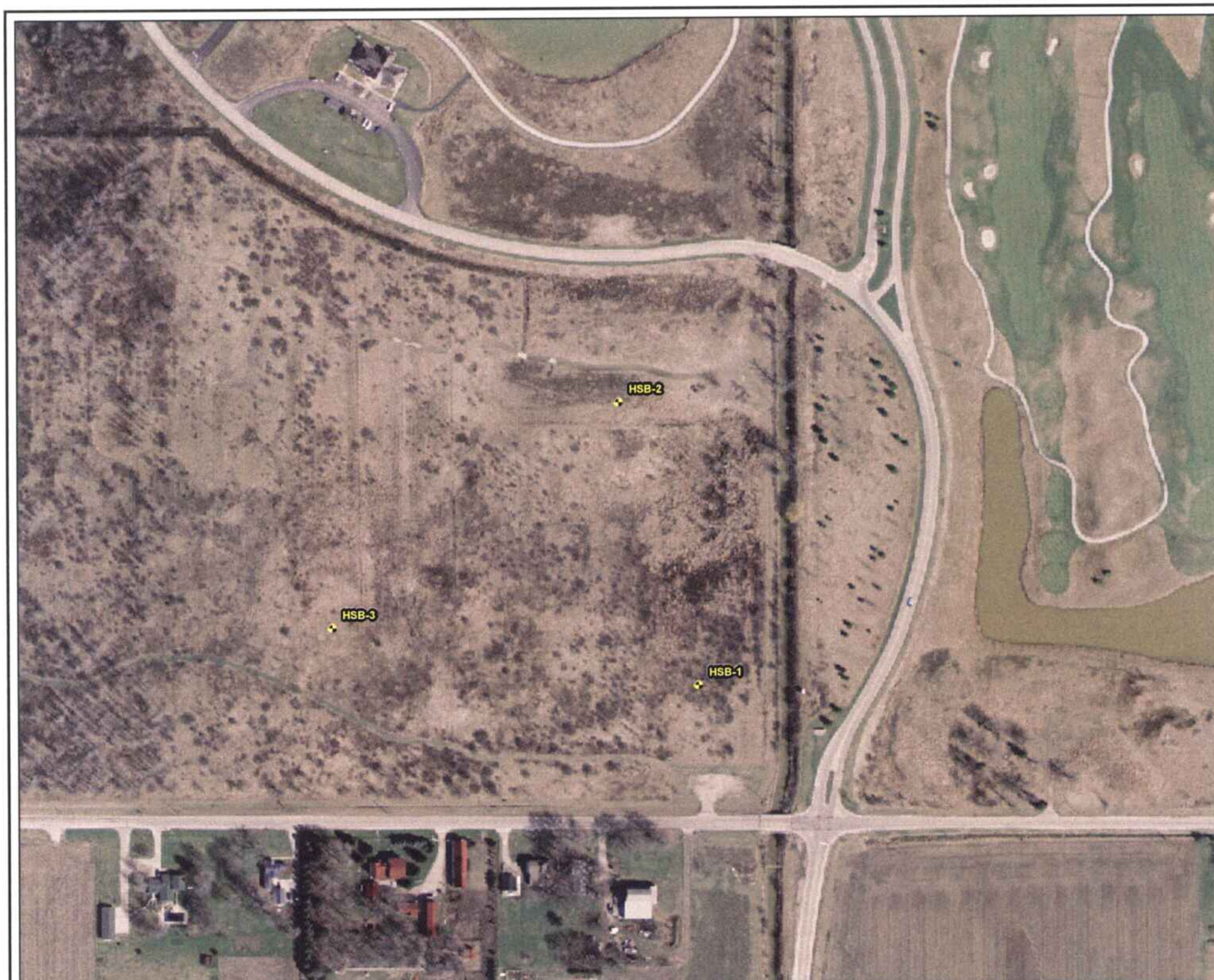
SUMMARY

Hull completed three investigative soil borings (HSB-1 through HSB-3) at the site on June 10 and 11, 2008 to assist in optimizing the site characterization for the design phase of the proposed artificial wetland to be located in Maumee Bay State Park. In addition to soil boring activities, several samples were submitted for grains size and permeability analysis, as discussed above. Investigative soil boring activities were completed in conjunction with a geophysical study conducted by UT.

Soil boring data collected by Hull suggest that the stratigraphy from bgs at the site consists of topsoil, brown clay, grey clay, and carbonate bedrock. As discussed in more detail above, within the grey clay, wet laterally discontinuous sand seams and layers were observed to be located north and south within the study area.

Grain size analysis data suggest the USCS classification for the brown clay unit ranges from CL (lean clay) in HSB-3 to CH (fat clay) in HSB-2, which suggest clay content increases from south to north. Permeability data suggests the brown clay unit has a low permeability (3.34×10^{-8} cm/sec). Grain size data for the grey clay unit suggest the USCS classification is CL. Permeability data suggest that the grey clay unit also has a low permeability (on average 3.73×10^{-8} cm/sec).

FIGURES



Hull & Associates, Inc.
6397 Emerald Parkway
Suite #200
Dublin, Ohio 43016
Phone (614) 793-8777
Fax (614) 793-9070
www.hullinc.com

Soil Borings

0 50 100 200 Feet
1:2,400

N

Maumee Bay State Park

Approximate Soil Boring Locations

Oregon, Lucas County, Ohio

Quadrangle Location

Date
June 2008

Project Number: UOT014
Geodatabase: UOT014.mdb
File Name: UOT014_01_Fig01_SoilBorings.mxd

Figure
1

Produced using ArcGIS 9.2

PROJECT
Sheet ______ of ______
Calc. by ______ Date ______
Checked by ______ Date ______

Hull & associates, inc.
3401 Glendale Avenue, Suite 300
Toledo, Ohio 43614
419.385.2018
fax: 419.385.5487
www.hullinc.com

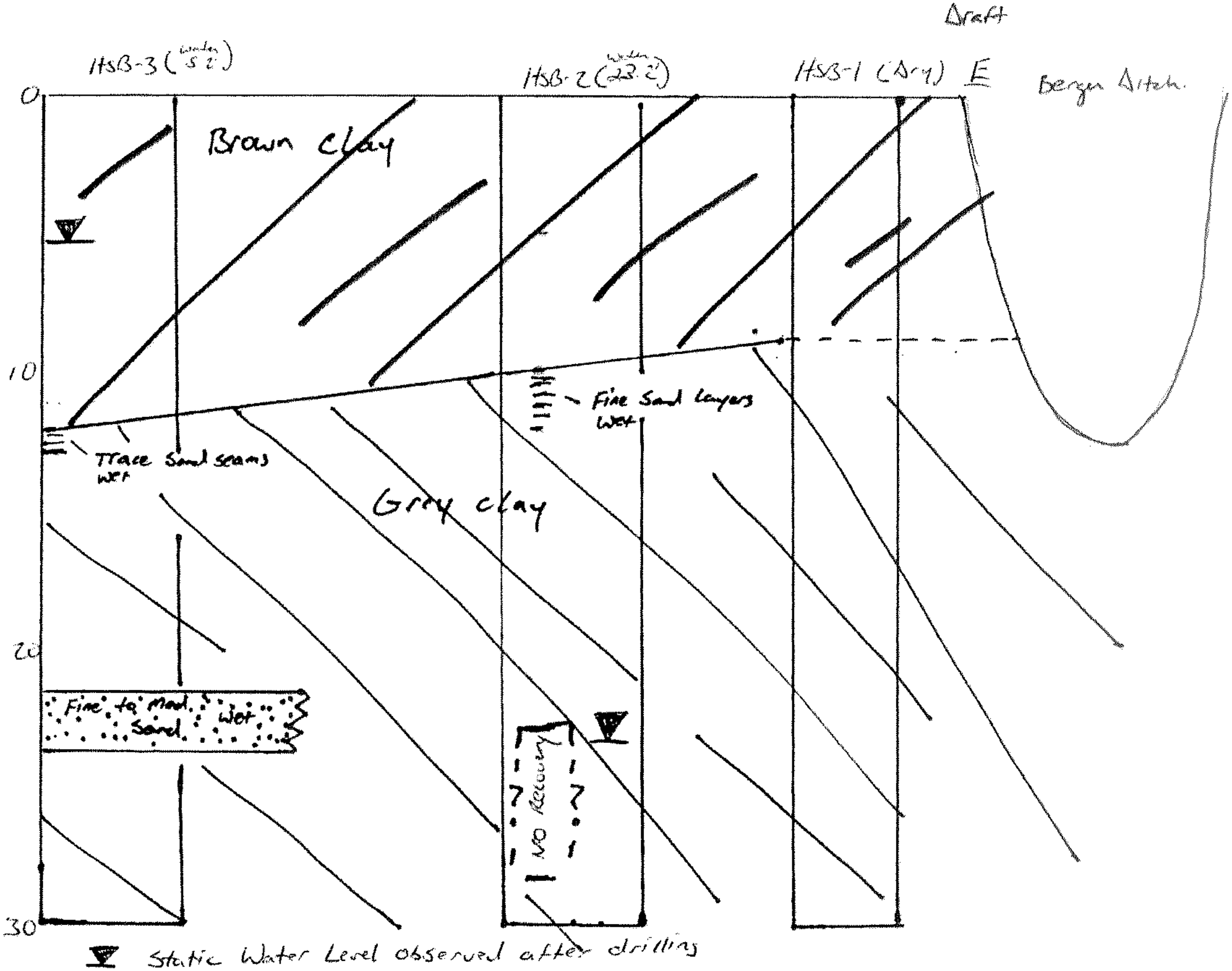


Figure 2
Generalized Cross section

ATTACHMENT A

Boring Logs and USCS Grain Size and Permeability Data

Hull & associates, inc.

University of Toledo
Geotech Investigation
Maumee Bay State Park
Oregon, Lucas County, Ohio
UOT014

Date Started	: 06-10-2008
Date Completed	: 06-10-2008
Logged By	: J. Carlson
Reviewed By	: J. Carlson
Drilling Contractor	: North Coast Drilling
Drilling Method	: 4.25 HSA
Sampling Method	: 5' Barrel Sampler
Total Depth	: 30'

LOG OF BORING HSB-1

Soil Samples
- Sample Interval
- Lab Sample

Water Levels
- Static
- During drilling

Depth in Feet	Length Drive/ Sample Recovery(ft.)	Sample Number/ Sample Interval	Sample	GRAPHIC	Water Level	DESCRIPTION
0	5/5	SB-1 0.0-5.0				Medium stiff grey lean CLAY, some roots and organics, moist.
1						Very stiff brown lean CLAY, trace roots, vertical fractures, grey mottled, non-plastic, moist.
5	5/5	SB-2 5.0-9.1				Medium stiff brown lean CLAY, grey mottles, trace roots, vertical fracture wet, low placticity, very moist to wet.
9		SB-3 9.1-10.0				Stiff grey lean CLAY, trace fines, medium plastic, very moist.
10	2/2	ST-1 10.0-12.0				Same as above, shelby tube.
12	3/3	SB-4 12.0-15.0				Very soft grey lean CLAY, trace fines, medium-high plasticity, very moist.
15	5/5	SB-5 15.0-20.0				Same as above, very soft, moist.
20						

Lab Samples:
UOT014:HSB-1:ST100120 - USCS & Perm
UOT014:HSB-1:S091100 - USCS

No measurable water during or after HSB-1 activities.

Hull & associates, inc.

University of Toledo
Geotech Investigation
Maumee Bay State Park
Oregon, Lucas County, Ohio
UOT014

Date Started	: 06-10-2008
Date Completed	: 06-10-2008
Logged By	: J. Carlson
Reviewed By	: J. Carlson
Drilling Contractor	: North Coast Drilling
Drilling Method	: 4.25 HSA
Sampling Method	: 5' Barrel Sampler
Total Depth	: 30'

LOG OF BORING HSB-1

Soil Samples
- Sample Interval
- Lab Sample

Water Levels
- Static
- During drilling

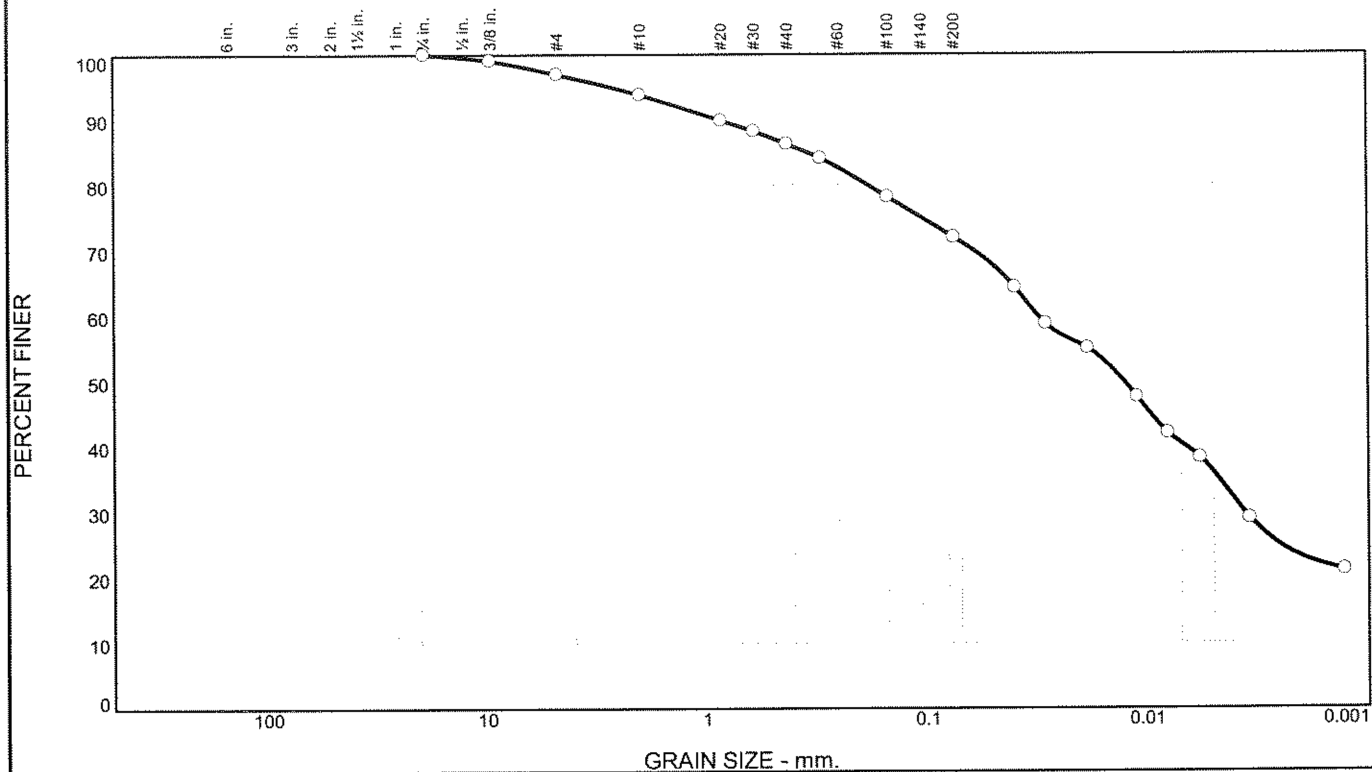
Depth in Feet	Length Drive/ Sample Recovery(ft.)	Sample Number/ Sample Interval	Sample	GRAPHIC	Water Level	DESCRIPTION
20	2/2	ST-2 20.0-22.0				Same as above, shelby tube.
22	3/3	SB-6 22.0-25.0				Stiff grey lean CLAY, some fines, medium to high plasticity, moist.
25	5/5	SB-7 25.0-30.0				Hard grey lean CLAY, some fines, non-cohesive silt, non-plastic, slightly moist.
30						EOB @ 30'

Lab Samples:
UOT014:HSB-1:ST100120 - USCS & Perm
UOT014:HSB-1:S091100 - USCS

No measurable water during or after HSB-1 activities.

06-17-2008 F:\CLIENTS\UOT\UOT013\logs\HSB-01.bor

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	3.0	3.2	7.5	14.3	35.9	36.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.375	99.0		
#4	97.0		
#10	93.8		
#20	89.9		
#30	88.2		
#40	86.3		
#50	84.1		
#100	78.2		
#200	72.0		

* (no specification provided)

Material Description

GREY LEAN CLAY WITH SAND

Atterberg Limits (ASTM D 4318)

PL= 14 LL= 26 PI= 12

Classification

USCS= CL AASHTO= A-6(6)

Coefficients

D_{85}= 0.3424 D_{60}= 0.0313 D_{50}= 0.0127
D_{30}= 0.0036 D_{15}= D_{10}=
C_u= C_c=

Date Tested: 6-18-08 **Tested By:** MG/CG

Remarks

NATURAL MOISTURE: 18.1%

Sample No.: E08-466 **Source of Sample:** **Date Sampled:** 6-10-08
Location: HSB-1 ST-1 **Elev./Depth:** 10.0-12.0'
Checked By: MIKE GERDEMAN **Title:** LAB SUPERVISOR

HULL & ASSOCIATES, INC.

Erie, MI

Client: UNIVERSITY OF TOLEDO
Project: MAUMEE BAY STATE PARK
Project No: UOT-014 **Figure**

PERMEABILITY TEST REPORT

TEST DATA:

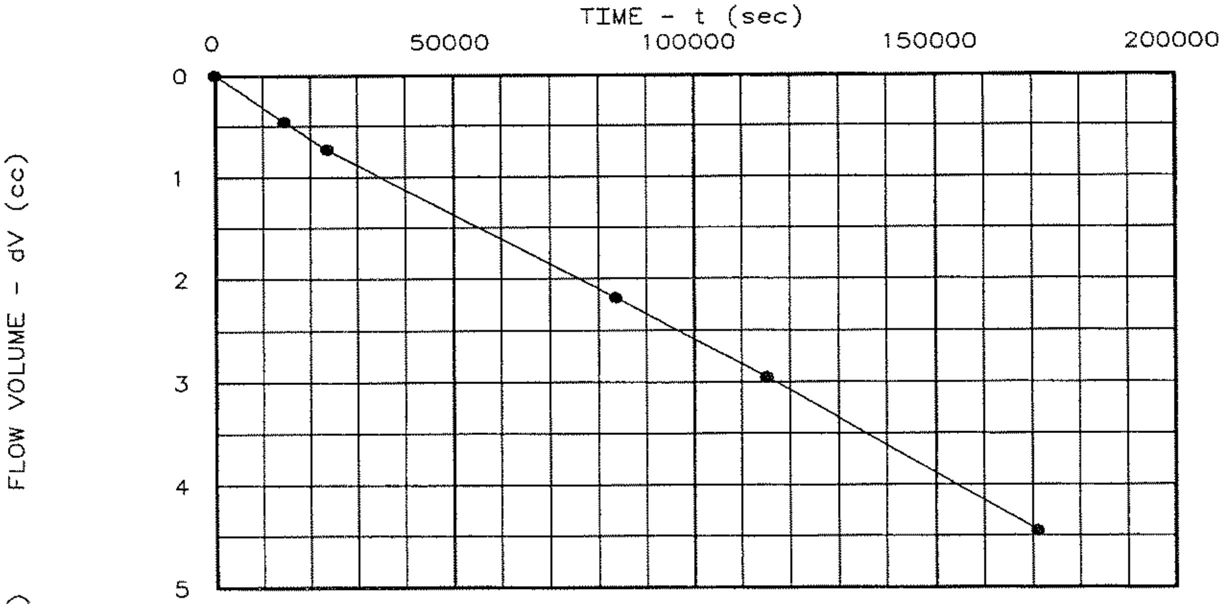
Specimen Height (cm): 7.87
Specimen Diameter (cm): 7.23
Dry Unit Weight (pcf): 115.1
Moisture Before Test (%): 17.1
Moisture After Test (%): 16.9
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 50.0
INFLUENT PSI(psi): 47.0
EFFLUENT PSI(psi): 44.7
Diff. Head (psi): 2.3
Flow Rate (cc/sec): 2.55 x 10^-5
Perm. (cm/sec): 2.91 x 10^-8

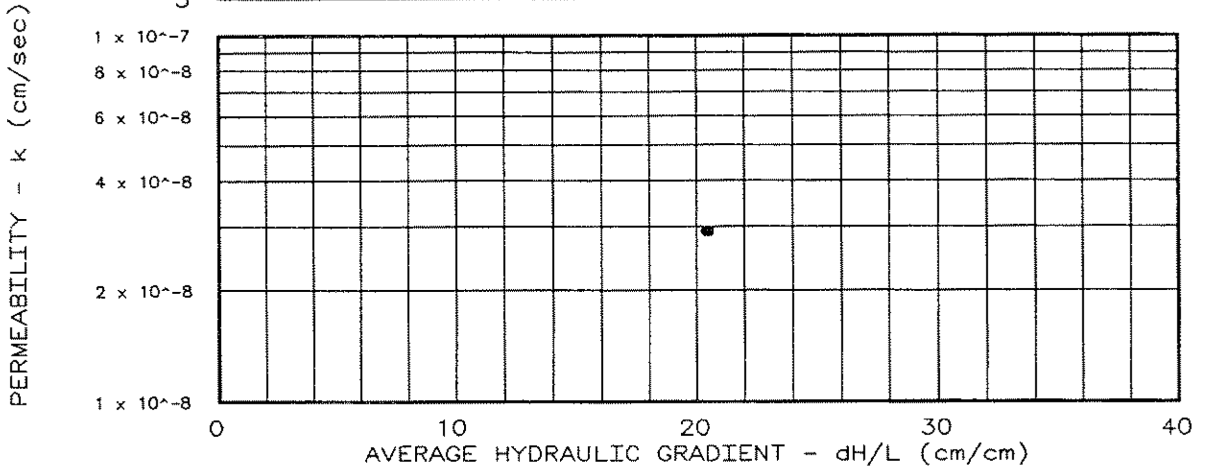
SAMPLE DATA:

Sample Identification: HSB-1 ST-1
DEPTH: 10.0-12.0'
Visual Description: GREY LEAN CLAY WITH SAND
Remarks: PERMEANT: DEAIRED WATER

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeameter type: Flex Wall
Sample type: UNDISTURBED





Project: UNIVERSITY OF TOLEDO
Location: MAUMEE BAY STATE PARK
Date: 6-16-08

PERMEABILITY TEST REPORT

HULL & ASSOCIATES, INC.

Project No.: UOT-014
File No.: 130
Lab No.: E08-466
Tested by: MG
Checked by: CG
Test: CH - Constant head

CONSTANT HEAD PERMEABILITY TEST RESULTS

PROJECT NAME: UNIVERSITY OF TOLEDO
PROJECT LOCATION: MAUMEE BAY STATE PARK
SAMPLE IDENTIFICATION: HSB-1 ST-1
DEPTH: 10.0-12.0'
DESCRIPTION: GREY LEAN CLAY
WITH SAND
MAX. DRY DENS.: OPT. WATER CONTENT:

FILE NO.: 130
PROJECT NO.: UOT-014
LAB NO.: E08-466

SAMPLE TYPE: UNDISTURBED

DATE: 6-16-08

SPECIMEN DATA

INITIAL PARAMETERS:	FINAL PARAMETERS:
HEIGHT: 7.87 cm	HEIGHT: 7.83 cm
DIAMETER: 7.23 cm	DIAMETER: 7.23 cm
WET WEIGHT: 697.5 g	WET WEIGHT: 696.3 g
MOISTURE CONTENT: 17.1 %	MOISTURE CONTENT: 16.9 %
DRY DENSITY: 115.1 pcf	DRY DENSITY: 115.7 pcf
PERCENT COMPACTION:	

TEST PARAMETERS

CELL NO.: 1 PANEL NO.: 1 POSITIONS:

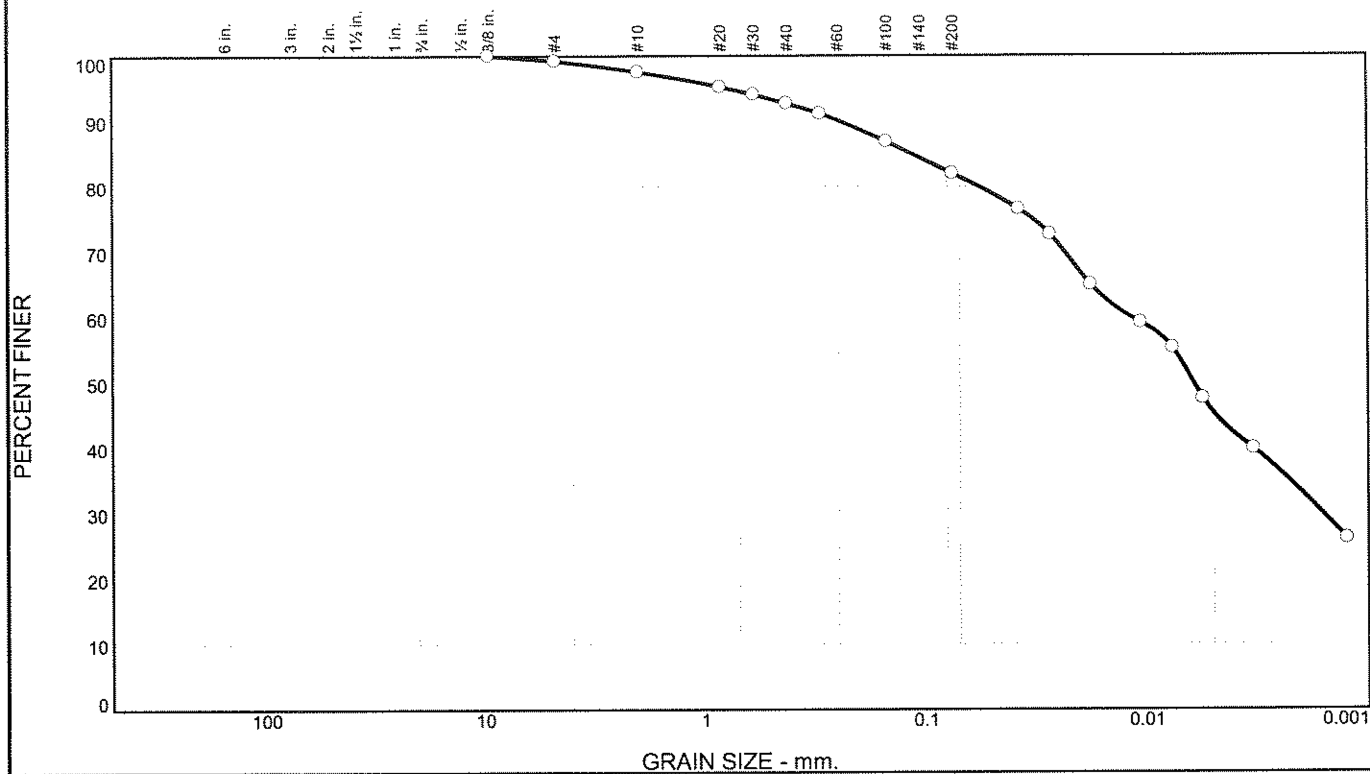
	RUN NO. 1	RUN NO. 2
CELL PRESSURE:	50.0 psi	
INFLUENT PSI:	47.0 psi	
EFFLUENT PSI:	44.7 psi /	
/ 0.0 psi		
DIFFERENTIAL HEAD:	2.3 psi	

PERMEABILITY DATA

	RUN NO. 1	RUN NO. 2
AVERAGE FLOW RATE:	2.55E-05 cc/sec	
COEFFICIENT OF CORRELATION:	0.99922	
AVERAGE GRADIENT:	20.4	
TEMPERATURE:	21.9 deg C	
PERMEABILITY, K, at 20 deg C:	2.91E-08 cm/sec	

========================= HULL & ASSOCIATES, INC. =========================

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.8	1.7	4.8	10.7	36.6	45.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0		
#4	99.2		
#10	97.5		
#20	95.2		
#30	94.0		
#40	92.7		
#50	91.1		
#100	86.8		
#200	82.0		

* (no specification provided)

Material Description

GREY FRAC BROWN LEAN CLAY WITH SAND

Atterberg Limits (ASTM D 4318)

PL= 16 LL= 31 PI= 15

Classification

USCS= CL AASHTO= A-6(11)

Coefficients

D_{85}= 0.1152 D_{60}= 0.0117 D_{50}= 0.0061
D_{30}= 0.0016 D_{15}= D_{10}=
C_u= C_c=

Date Tested: 6-17-08 **Tested By:** MG/CG

Remarks

NATURAL MOISTURE: 17.1%

Sample No.: E08-467 **Source of Sample:** **Date Sampled:** 6-10-08
Location: HSB-1 **Elev./Depth:** 9.1-10.0'
Checked By: MIKE GERDEMAN **Title:** LAB SUPERVISOR

HULL & ASSOCIATES, INC.

Erie, MI

Client: UNIVERSITY OF TOLEDO
Project: MAUMEE BAY STATE PARK
Project No: UOT-014 **Figure**

Hull & associates, inc.

University of Toledo
Geotech Investigation
Maumee Bay State Park
Oregon, Lucas County, Ohio
UOT014

Date Started	: 06-10-2008
Date Completed	: 06-10-2008
Logged By	: J. Carlson
Reviewed By	: J. Carlson
Drilling Contractor	: North Coast Drilling
Drilling Method	: 4.25 HSA
Sampling Method	: 5' Barrel Sampler
Total Depth	: 30'

LOG OF BORING HSB-2

Soil Samples
- Sample Interval
- Lab Sample

Water Levels
- Static
- During drilling

Depth in Feet	Length Drive/ Sample Recovery(ft.)	Sample Number/ Sample Interval	Sample	GRAPHIC	Water Level	DESCRIPTION
0	5/5	SB-1 0.0-5.0				Medium stiff grey lean CLAY, some roots and organics.
1						Stiff brown lean CLAY, some roots, vertical fractures, grey mottles, non-plastic, moist.
5	5/5	SB-2 5.0-10.0				Stiff becoming medium stiff brown lean CLAY, grey mottles, trace fine sand layers, trace vertical fractures at top, low plasticity, moist.
10	5/5	SB-3 10.0-12.0			▽	Very soft grey lean CLAY, some interbedded brown fill sand layers, low to medium plasticity, very moist to wet.
12		SB-4 12.0-15.0				Soft grey lean CLAY, medium to high plasticity, very moist to wet.
15	2/2	ST-1 15.0-17.0				Same as above, shelby tube.
17	3/3	SB-5 17.0-20.0				Medium stiff to stiff grey lean CLAY, medium to high plasticity, moist.
20						

Lab Samples:
UOT014:HSB-2:ST150170 - USCS & Perm.
UOT014:HSB-2:S050100 - USCS
UOT014:HSB-2:S100120 - USCS
Water measured at 23.2' bgs at the completion of HSB-2 activities.

06-17-2008 F:\CLIENTS\UOT\UOT013\logs\HSB-02.bor

Hull & associates, inc.

University of Toledo
Geotech Investigation
Maumee Bay State Park
Oregon, Lucas County, Ohio
UOT014

Date Started	: 06-10-2008
Date Completed	: 06-10-2008
Logged By	: J. Carlson
Reviewed By	: J. Carlson
Drilling Contractor	: North Coast Drilling
Drilling Method	: 4.25 HSA
Sampling Method	: 5' Barrel Sampler
Total Depth	: 30'

LOG OF BORING HSB-2

Soil Samples
- Sample Interval
- Lab Sample

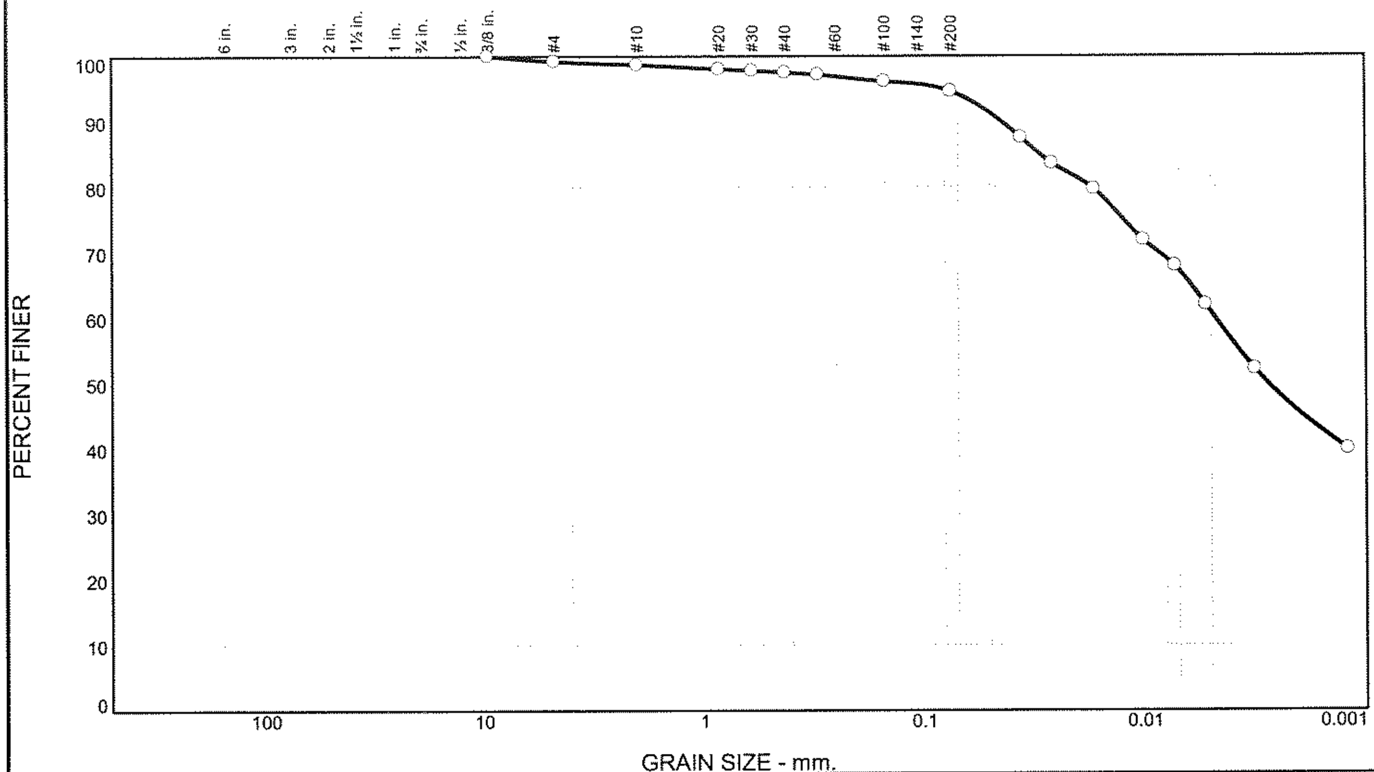
Water Levels
- Static
- During drilling

Depth in Feet	Length Drive/ Sample Recovery(ft.)	Sample Number/ Sample Interval	Sample	GRAPHIC	Water Level	DESCRIPTION
20	5/3	SB-6 20.0-25.0				Very stiff grey lean CLAY, trace fines, moist.
23					▼	No Recovery
25	2/0	ST-2 25.0-27.0				Shelby Tube, no recovery
27	2/0	ST-3 27.0-29.0				Shelby Tube, no recovery
28.5	1.5/1.4	SB-7 28.5-30.0				Hard grey lean CLAY, some small angular gravel, wet seams.
30						EOB @ 30'

Lab Samples:
UOT014:HSB-2:ST150170 - USCS & Perm.
UOT014:HSB-2:S050100 - USCS
UOT014:HSB-2:S100120 - USCS
Water measured at 23.2' bgs at the completion of HSB-2 activities.

06-17-2008 F:\CLIENTS\UOT\UOT013\logs\HSB-02.bor

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.8	0.5	1.2	2.9	33.6	61.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0		
#4	99.2		
#10	98.7		
#20	98.0		
#30	97.8		
#40	97.5		
#50	97.2		
#100	96.1		
#200	94.6		

* (no specification provided)

Material Description

GREY MTLD BROWN LEAN CLAY

Atterberg Limits (ASTM D 4318)

PL= 18 LL= 40 PI= 22

Classification

USCS= CL AASHTO= A-6(22)

Coefficients

D_{85}= 0.0295 D_{60}= 0.0048 D_{50}= 0.0028
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Date Tested: 6-18-08 **Tested By:** MG/CG

Remarks

NATURAL MOISTURE: 30.9%

Sample No.: E08-468 **Source of Sample:** **Date Sampled:** 6-10-08
Location: HSB-2 ST-1 **Elev./Depth:** 15.0-17.0'
Checked By: MIKE GERDEMAN **Title:** LAB SUPERVISOR

HULL & ASSOCIATES, INC.

Erie, MI

Client: UNIVERSITY OF TOLEDO
Project: MAUMEE BAY STATE PARK

Project No: UOT-014 **Figure**

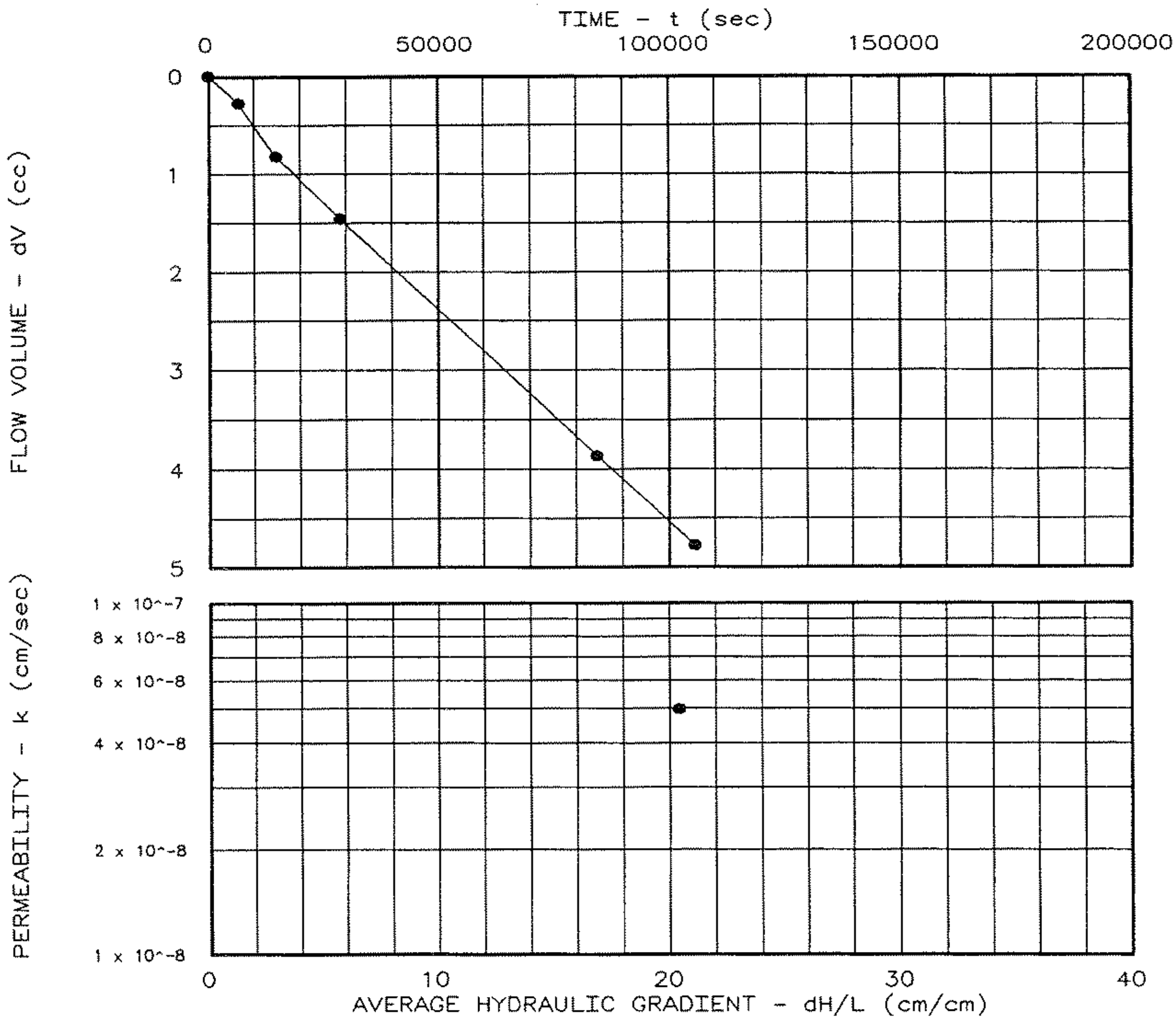
PERMEABILITY TEST REPORT

TEST DATA:
Specimen Height (cm): 7.94
Specimen Diameter (cm): 7.24
Dry Unit Weight (pcf): 92.6
Moisture Before Test (%): 30.3
Moisture After Test (%): 30.5
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 50.0
INFLUENT PSI(psi): 47.0
EFFLUENT PSI(psi): 44.7
Diff. Head (psi): 2.3
Flow Rate (cc/sec): 4.49 x 10^-5
Perm. (cm/sec): 4.98 x 10^-8

SAMPLE DATA:
Sample Identification: HSB-2 ST-1
DEPTH: 15.0-17.0'
Visual Description: GREY MTLD BROWN LEAN CLAY
Remarks: PERMEANT: DEAIRED WATER

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeameter type: Flex Wall
Sample type: UNDISTURBED



Project: UNIVERSITY OF TOLEDO
Location: MAUMEE BAY STATE PARK
Date: 6-16-08

PERMEABILITY TEST REPORT

HULL & ASSOCIATES, INC.

Project No.: UOT-014
File No.: 131
Lab No.: E08-468
Tested by: MG
Checked by: CG
Test: CH - Constant head

CONSTANT HEAD PERMEABILITY TEST RESULTS

PROJECT NAME: UNIVERSITY OF TOLEDO
PROJECT LOCATION: MAUMEE BAY STATE PARK
SAMPLE IDENTIFICATION: HSB-2 ST-1
DEPTH: 15.0-17.0'
DESCRIPTION: GREY MTLD BROWN LEAN CLAY
MAX. DRY DENS.: OPT. WATER CONTENT:

FILE NO.: 131
PROJECT NO.: UOT-014
LAB NO.: E08-468
SAMPLE TYPE: UNDISTURBED
DATE: 6-16-08

SPECIMEN DATA

INITIAL PARAMETERS:

HEIGHT: 7.94 cm
DIAMETER: 7.24 cm
WET WEIGHT: 632.1 g
MOISTURE CONTENT: 30.3 %
DRY DENSITY: 92.6 pcf
PERCENT COMPACTION:

FINAL PARAMETERS:

HEIGHT: 7.91 cm
DIAMETER: 7.25 cm
WET WEIGHT: 632.8 g
MOISTURE CONTENT: 30.5 %
DRY DENSITY: 92.7 pcf

TEST PARAMETERS

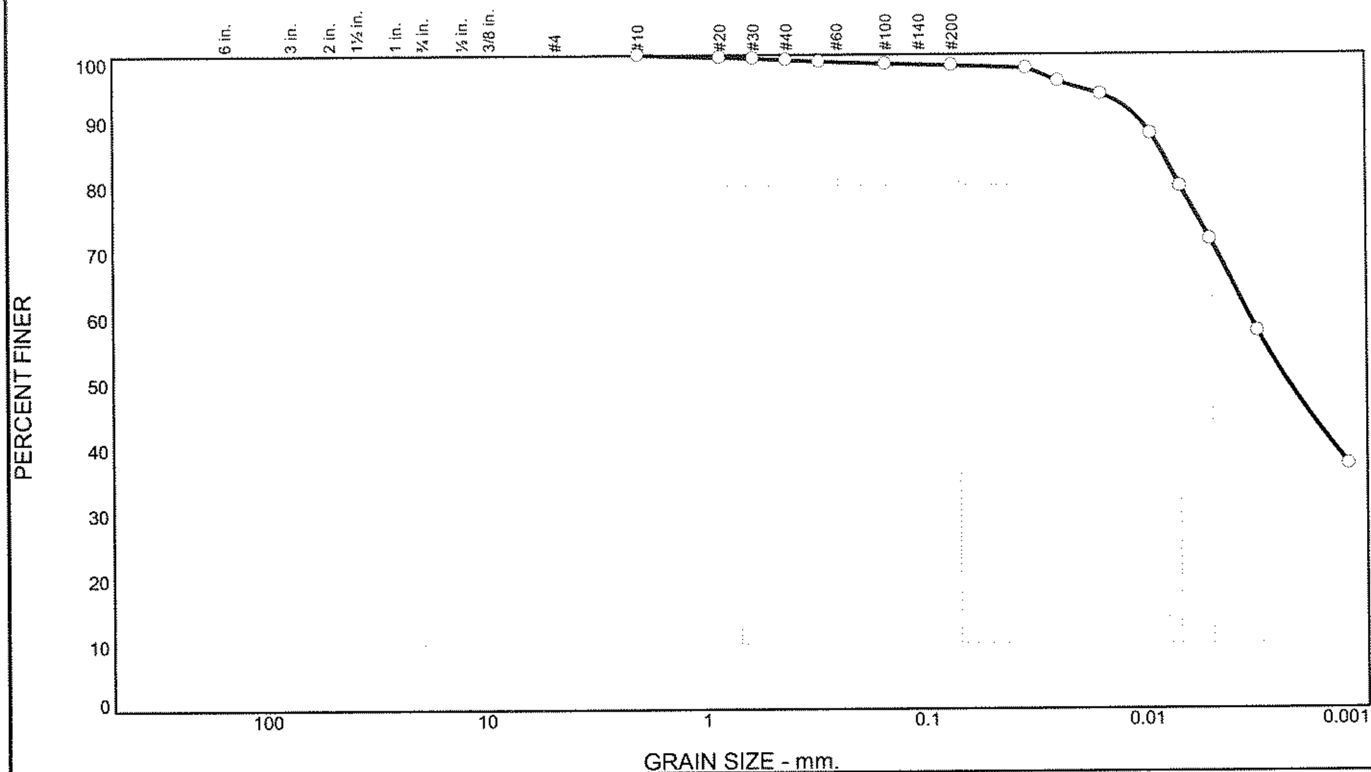
CELL NO.: 1 PANEL NO.: 6 POSITIONS:

	RUN NO. 1	RUN NO. 2
CELL PRESSURE:	50.0 psi	
INFLUENT PSI:	47.0 psi	
EFFLUENT PSI:	44.7 psi /	
/ 0.0 psi		
DIFFERENTIAL HEAD:	2.3 psi	

PERMEABILITY DATA

	RUN NO. 1	RUN NO. 2
AVERAGE FLOW RATE:	4.49E-05 cc/sec	
COEFFICIENT OF CORRELATION:	0.99835	
AVERAGE GRADIENT:	20.4	
TEMPERATURE:	23.0 deg C	
PERMEABILITY, K, at 20 deg C:	4.98E-08 cm/sec	

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.8	0.9	27.0	71.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.6		
#30	99.4		
#40	99.2		
#50	98.9		
#100	98.6		
#200	98.3		

* (no specification provided)

Material Description

GREY FRAC BROWN FAT CLAY

Atterberg Limits (ASTM D 4318)

PL= 21 LL= 51 PI= 30

Classification

USCS= CH AASHTO= A-7-6(33)

Coefficients

D_{85}= 0.0084 D_{60}= 0.0034 D_{50}= 0.0023
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Date Tested: 6-17-08 **Tested By:** MG/CG

Remarks

NATURAL MOISTURE: 29.9%

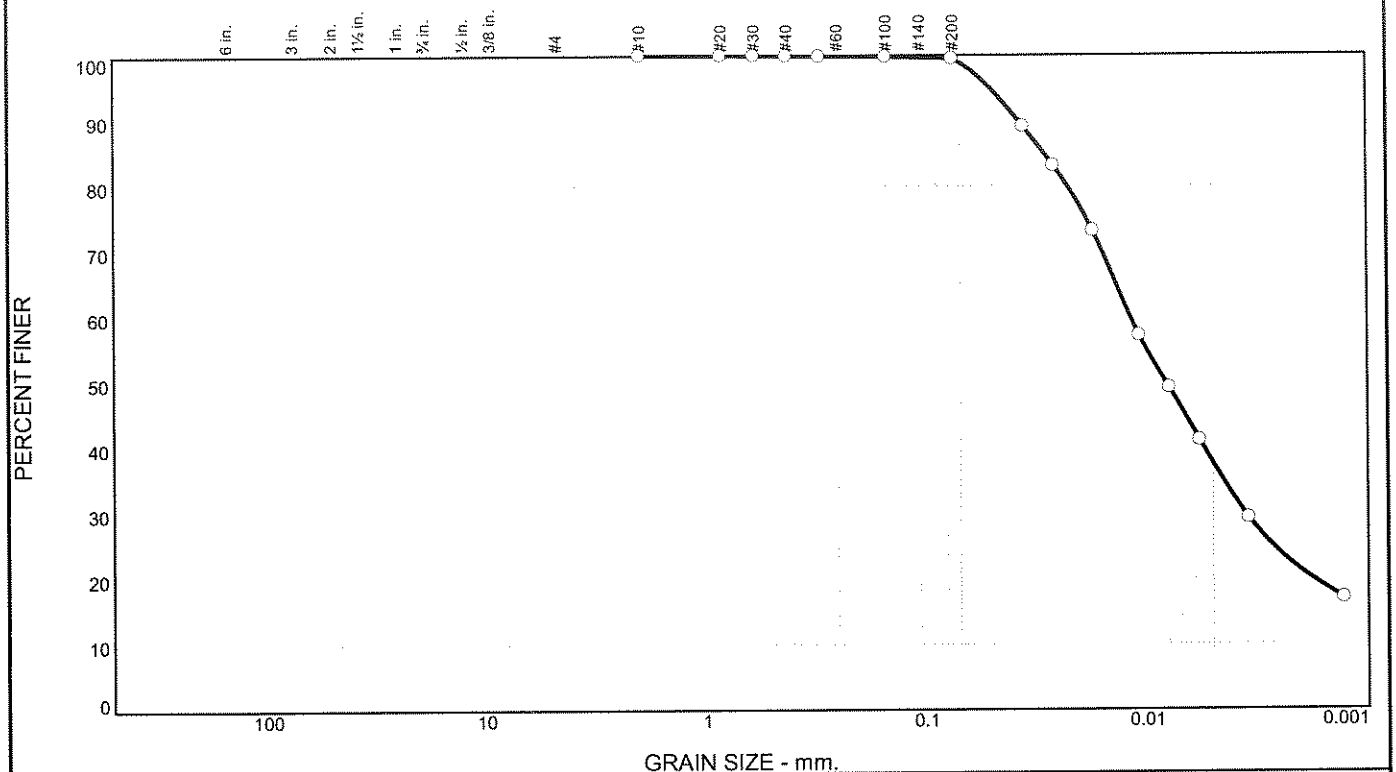
Sample No.: E08-469 **Source of Sample:** **Date Sampled:** 6-10-08
Location: HSB-2 **Elev./Depth:** 5.0-10.0'
Checked By: MIKE GERDEMAN **Title:** LAB SUPERVISOR

HULL & ASSOCIATES, INC.

Erie, MI

Client: UNIVERSITY OF TOLEDO
Project: MAUMEE BAY STATE PARK
Project No: UOT-014 **Figure**

Particle Size Distribution Report



% +3"	% Gravel Coarse	% Gravel Fine	% Sand Coarse	% Sand Medium	% Sand Fine	% Fines Silt	% Fines Clay
0.0	0.0	0.0	0.0	0.1	0.4	61.8	37.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#30	99.9		
#40	99.9		
#50	99.8		
#100	99.7		
#200	99.5		

* (no specification provided)

Material Description

GREY FRAC BROWN LEAN CLAY

Atterberg Limits (ASTM D 4318)

PL= 18 LL= 32 PI= 14

Classification

USCS= CL AASHTO= A-6(14)

Coefficients

D_{85}= 0.0288 D_{60}= 0.0118 D_{50}= 0.0081
D_{30}= 0.0036 D_{15}= D_{10}=
C_u= C_c=

Date Tested: 6-17-08 **Tested By:** MG/CG

Remarks

NATURAL MOISTURE: 28.1%

Sample No.: E08-470 **Source of Sample:** **Date Sampled:** 6-10-08
Location: HSB-2 **Elev./Depth:** 10.0-12.0'
Checked By: MIKE GERDEMAN **Title:** LAB SUPERVISOR

HULL & ASSOCIATES, INC.

Erie, MI

Client: UNIVERSITY OF TOLEDO
Project: MAUMEE BAY STATE PARK
Project No: UOT-014 **Figure**

Hull & associates, inc.

University of Toledo
Geotech Investigation
Maumee Bay State Park
Oregon, Lucas County, Ohio
UOT014

Date Started	: 06-11-2008
Date Completed	: 06-11-2008
Logged By	: J. Carlson
Reviewed By	: J. Carlson
Drilling Contractor	: North Coast Drilling
Drilling Method	: 4.25 HSA
Sampling Method	: 5' Barrel Sampler
Total Depth	: 30'

LOG OF BORING HSB-3

Soil Samples
- Sample Interval
- Lab Sample

Water Levels
- Static
- During drilling

Depth in Feet	Length Drive/ Sample Recovery(ft.)	Sample Number/ Sample Interval	Sample	GRAPHIC	Water Level	DESCRIPTION
0	5/3	SB-1 0.0-5.0	Sample Interval			Stiff grey lean CLAY, some rocks and organics, moist.
1						Stiff brown lean CLAY, grey mottles, non-plastic, moist.
5	5/5	SB-2 5.0-10.0	Sample Interval		Static	Soft to medium stiff brown lean CLAY, grey mottles, trace silt at bottom, trace wet seams, becoming more stiff with depth, low plasticity.
9						Stiff brown lean CLAY, some silt, non-plastic, moist.
10	2/2	ST-1 10.0-12.0	Lab Sample		During drilling	Shelby Tube, reddish grey lean CLAY, medium to high plasticity, wet.
12	3/3	SB-3 12.0-12.8	Sample Interval			Very soft grey lean CLAY, trace fines, trace red mottle, trace coarse sand seams, wet.
13		SB-4 12.8-15.0	Lab Sample			Soft grey lean CLAY, trace fines, moist to very moist.
15	3/3	SB-5 15.0-18.0	Sample Interval			Very soft grey lean CLAY, trace fines, medium to high plasticisty, wet.
18	2/2	ST-2 18.0-20.0	Lab Sample			Shelby tube, very soft grey lean CLAY, some fines, medium to high plasticity, wet.
20						

Lab Samples:
UOT014:HSB-3:ST100120 - USCS & Perm.
UOT014:HSB-3:ST180200 - USCS & Perm.
UOT014:HSB-3:S128150 - USCS
Water measured at 5.2' bgs one hour after completion of HSB-3 activities.

Univ. of Toledo requested the HSB-3 boring be left open, so they could set a well.

Hull & associates, inc.

University of Toledo
Geotech Investigation
Maumee Bay State Park
Oregon, Lucas County, Ohio
UOT014

Date Started	: 06-11-2008
Date Completed	: 06-11-2008
Logged By	: J. Carlson
Reviewed By	: J. Carlson
Drilling Contractor	: North Coast Drilling
Drilling Method	: 4.25 HSA
Sampling Method	: 5' Barrel Sampler
Total Depth	: 30'

LOG OF BORING HSB-3

Soil Samples
Sample Interval
Lab Sample

Water Levels
Static
During drilling

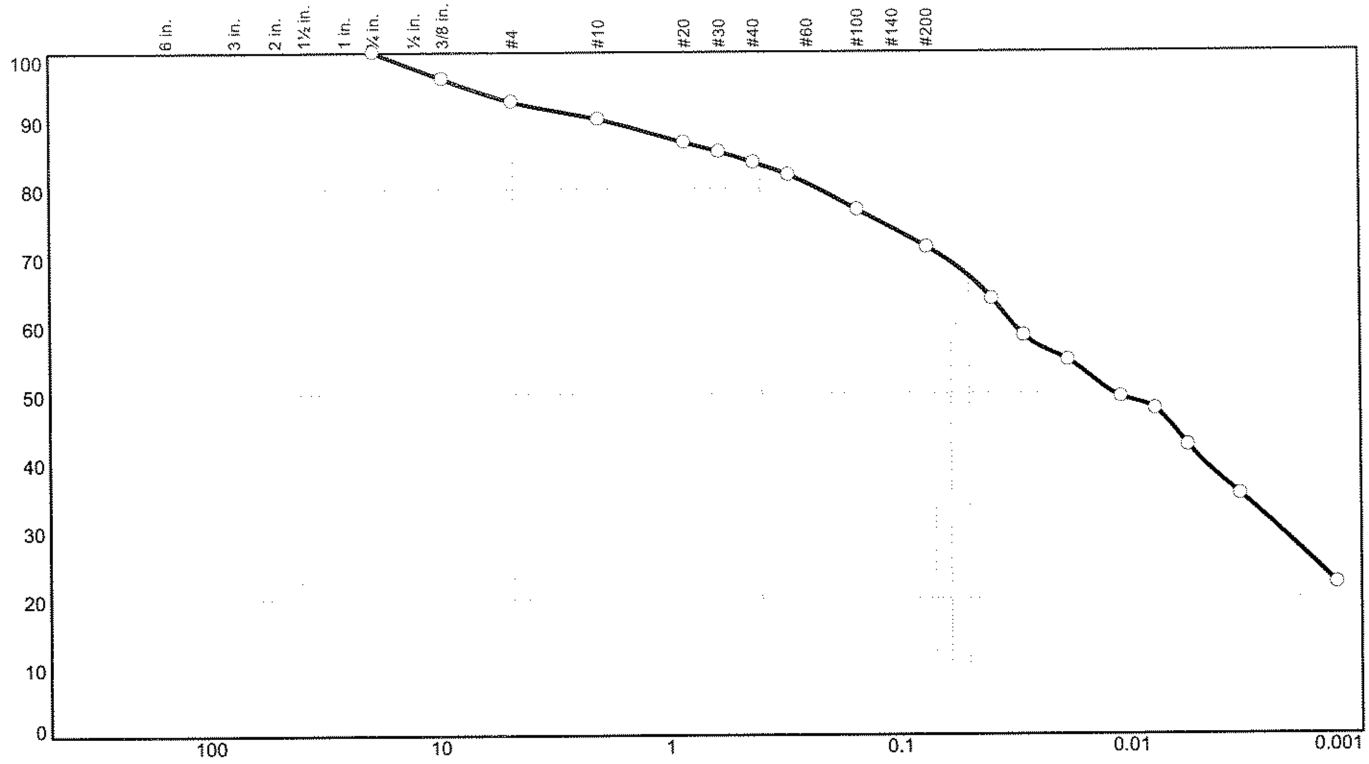
Depth in Feet	Length Drive/ Sample Recovery(ft.)	Sample Number/ Sample Interval	Sample	GRAPHIC	Water Level	DESCRIPTION
20	5/5	SB-6 20.0-22.0				Same as above, very soft, CLAY, wet around fines.
22		SB-7 21.6-23.7				Grey fine to coarse SAND, trace CLAY, wet.
24		SB-8 23.7-25.0				Stiff grey lean CLAY, some fines, low plasticity, moist.
25	5/5	SB-9 25.0-30.0				Stiff to very stiff grey lean CLAY, some fines, non-plastic, moist.
30						EOB @ 30'

Lab Samples:
UOT014:HSB-3:ST100120 - USCS & Perm.
UOT014:HSB-3:ST180200 - USCS & Perm.
UOT014:HSB-3:S128150 - USCS
Water measured at 5.2' bgs one hour after completion of HSB-3 activities.

Univ. of Toledo requested the HSB-3 boring be left open, so they could set a well.

06-17-2008 F:\CLIENTS\UOT\UOT013\logs\HSB-03.bor

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	7.2	2.6	6.4	12.5	30.9	40.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.375	96.1		
#4	92.8		
#10	90.2		
#20	86.8		
#30	85.4		
#40	83.8		
#50	82.0		
#100	76.8		
#200	71.3		

* (no specification provided)

Material Description

GREY FRAC BROWN LEAN CLAY WITH SAND

Atterberg Limits (ASTM D 4318)

PL= 15 LL= 30 PI= 15

Classification

USCS= CL AASHTO= A-6(8)

Coefficients

D_{85}= 0.5478 D_{60}= 0.0318 D_{50}= 0.0118
D_{30}= 0.0023 D_{15}= D_{10}=
C_u= C_c=

Date Tested: 6-18-08 **Tested By:** MG/CG

Remarks

NATURAL MOISTURE: 17.2%

Sample No.: E08-471 **Source of Sample:** **Date Sampled:** 6-10-08
Location: HSB-3 ST-1 **Elev./Depth:** 10.0-12.0'
Checked By: MIKE GERDEMAN **Title:** LAB SUPERVISOR

HULL & ASSOCIATES, INC.

Erie, MI

Client: UNIVERSITY OF TOLEDO
Project: MAUMEE BAY STATE PARK
Project No: UOT-014 **Figure**

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 8.11
Specimen Diameter (cm): 7.20
Dry Unit Weight (pcf): 115.9
Moisture Before Test (%): 16.5
Moisture After Test (%): 16.8

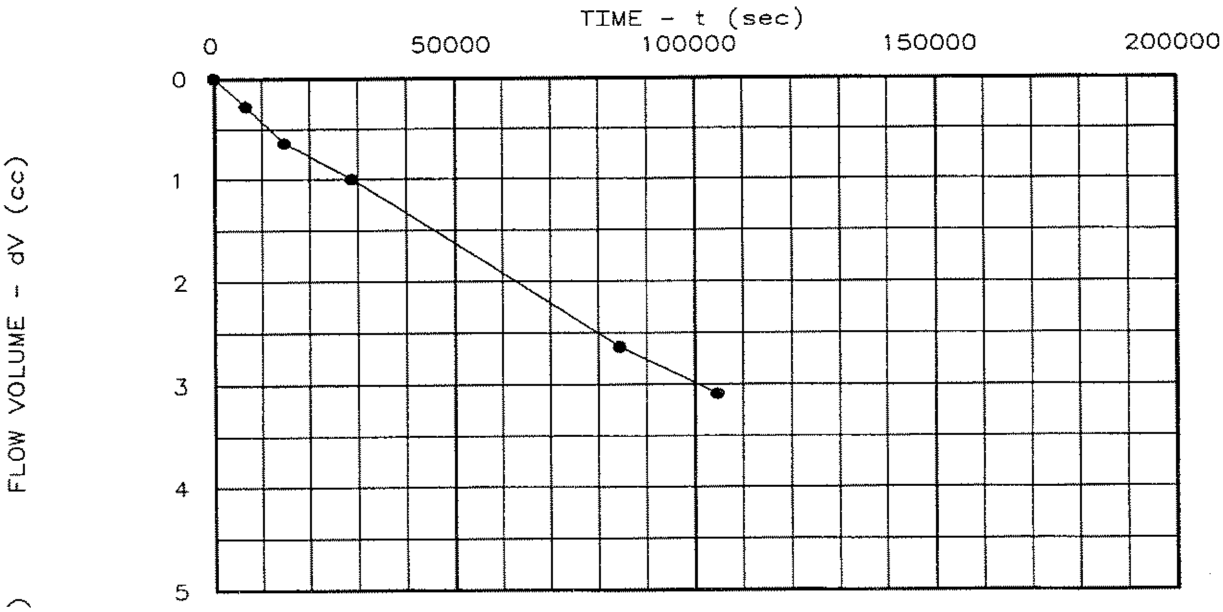
Run Number:	1 ●	2 ▲
Cell Pressure (psi):	50.0	
INFLUENT PSI(psi):	47.0	
EFFLUENT PSI(psi):	44.7	
Diff. Head (psi):	2.3	
Flow Rate (cc/sec):	2.92 x 10^-5	
Perm. (cm/sec):	3.34 x 10^-8	

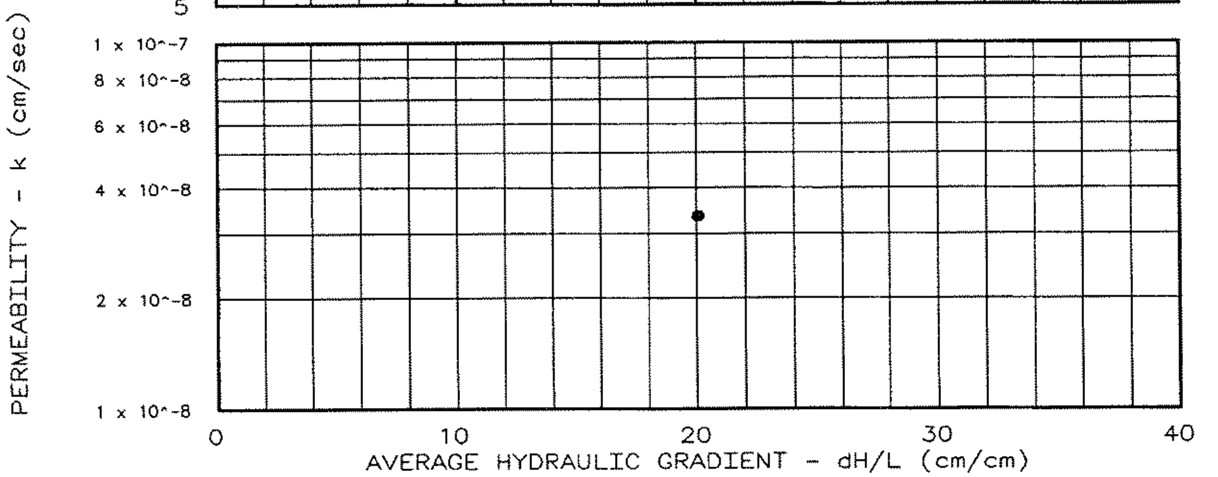
SAMPLE DATA:

Sample Identification: HSB-3 ST-1
DEPTH: 10.0-12.0'
Visual Description: GREY FRAC BROWN LEAN CLAY WITH SAND
Remarks: PERMEANT: DEAIRED WATER

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeameter type: Flex Wall
Sample type: UNDISTURBED





Project: UNIVERSITY OF TOLEDO
Location: MAUMEE BAY STATE PARK
Date: 6-16-08

PERMEABILITY TEST REPORT

HULL & ASSOCIATES, INC.

Project No.: UOT-014
File No.: 132
Lab No.: E08-471
Tested by: MG
Checked by: CG
Test: CH - Constant head

CONSTANT HEAD PERMEABILITY TEST RESULTS

PROJECT NAME: UNIVERSITY OF TOLEDO	FILE NO.: 132
PROJECT LOCATION: MAUMEE BAY STATE PARK	PROJECT NO.: UOT-014
SAMPLE IDENTIFICATION: HSB-3 ST-1 DEPTH: 10.0-12.0'	LAB NO.: E08-471
DESCRIPTION: GREY FRAC BROWN LEAN CLAY WITH SAND	SAMPLE TYPE: UNDISTURBED
MAX. DRY DENS.: OPT. WATER CONTENT:	DATE: 6-16-08

SPECIMEN DATA

INITIAL PARAMETERS:	FINAL PARAMETERS:
HEIGHT: 8.11 cm	HEIGHT: 8.08 cm
DIAMETER: 7.20 cm	DIAMETER: 7.20 cm
WET WEIGHT: 714.4 g	WET WEIGHT: 716.1 g
MOISTURE CONTENT: 16.5 %	MOISTURE CONTENT: 16.8 %
DRY DENSITY: 115.9 pcf	DRY DENSITY: 116.4 pcf
PERCENT COMPACTION:	

TEST PARAMETERS

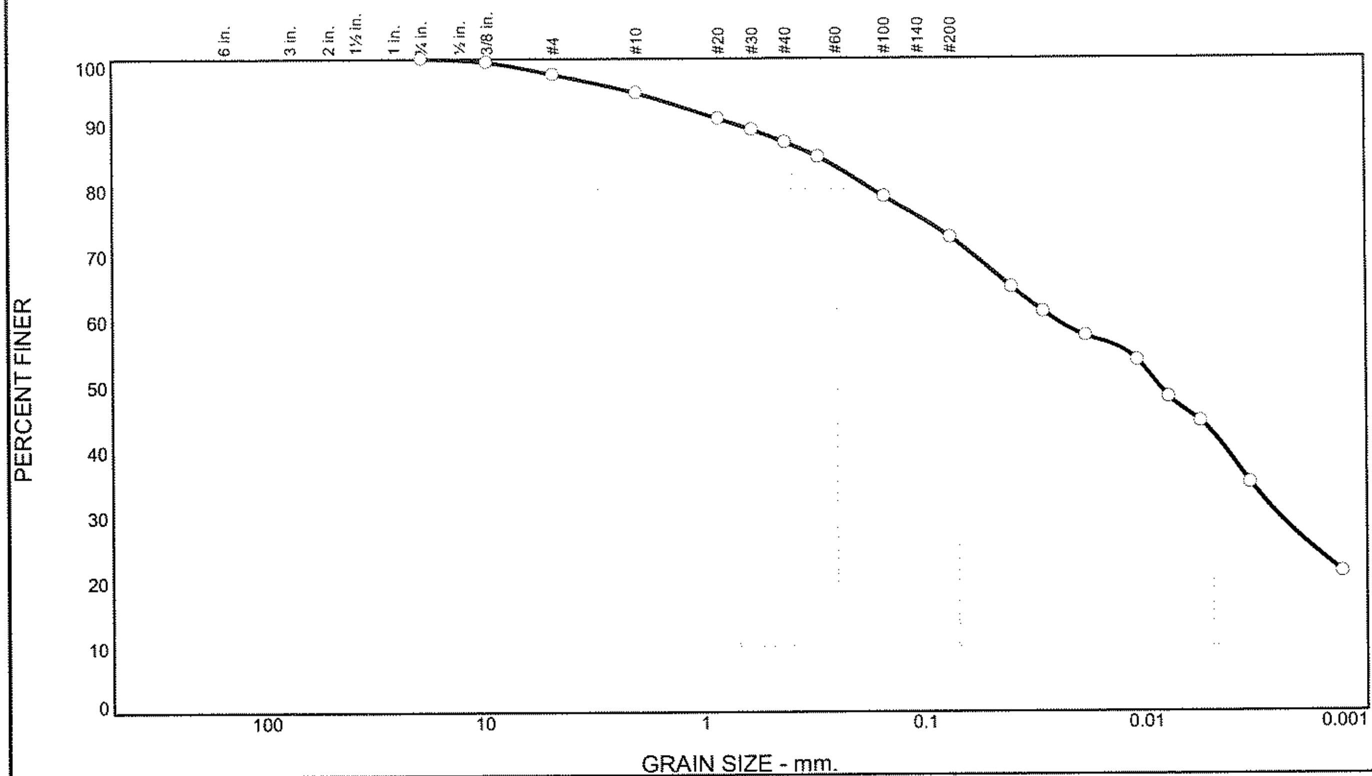
CELL NO.: 2 PANEL NO.: 5 POSITIONS:

	RUN NO. 1	RUN NO. 2
CELL PRESSURE:	50.0 psi	
INFLUENT PSI:	47.0 psi	
EFFLUENT PSI:	44.7 psi /	
/ 0.0 psi		
DIFFERENTIAL HEAD:	2.3 psi	

PERMEABILITY DATA

	RUN NO. 1	RUN NO. 2
AVERAGE FLOW RATE:	2.92E-05 cc/sec	
COEFFICIENT OF CORRELATION:	0.99581	
AVERAGE GRADIENT:	20.0	
TEMPERATURE:	22.9 deg C	
PERMEABILITY, K, at 20 deg C:	3.34E-08 cm/sec	

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.4	2.9	7.6	14.6	29.9	42.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.375	99.5		
#4	97.6		
#10	94.7		
#20	90.8		
#30	89.1		
#40	87.1		
#50	84.9		
#100	78.8		
#200	72.5		

* (no specification provided)

Material Description

GREY LEAN CLAY WITH SAND

Atterberg Limits (ASTM D 4318)

PL= 14 LL= 25 PI= 11

Classification

USCS= CL AASHTO= A-6(5)

Coefficients

D_{85}= 0.3052 D_{60}= 0.0256 D_{50}= 0.0088
D_{30}= 0.0025 D_{15}= D_{10}=
C_u= C_c=

Date Tested: 6-18-08 **Tested By:** MG/CG

Remarks

NATURAL MOISTURE: 17.4%

Sample No.: E08-472 **Source of Sample:** **Date Sampled:** 6-10-08
Location: HSB-3 ST-2 **Elev./Depth:** 18.0-20.0'
Checked By: MIKE GERDEMAN **Title:** LAB SUPERVISOR

HULL & ASSOCIATES, INC.

Erie, MI

Client: UNIVERSITY OF TOLEDO
Project: MAUMEE BAY STATE PARK
Project No: UOT-014 **Figure**

PERMEABILITY TEST REPORT

TEST DATA:

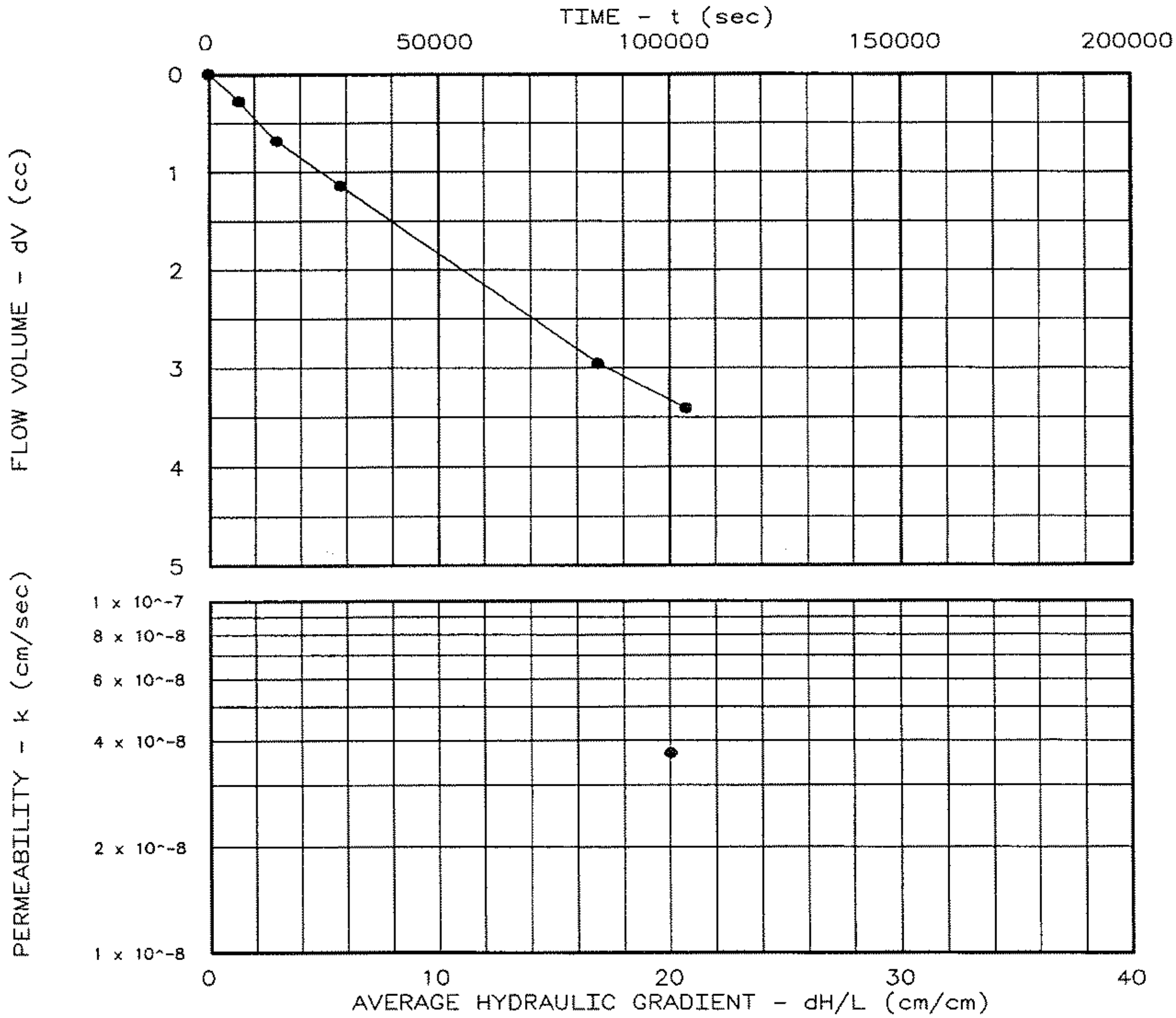
Specimen Height (cm): 8.12
Specimen Diameter (cm): 7.26
Dry Unit Weight (pcf): 115.4
Moisture Before Test (%): 17.0
Moisture After Test (%): 17.2
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 50.0
INFLUENT PSI(psi): 47.0
EFFLUENT PSI(psi): 44.7
Diff. Head (psi): 2.3
Flow Rate (cc/sec): 3.28×10^{-5}
Perm. (cm/sec): 3.69×10^{-8}

SAMPLE DATA:

Sample Identification: HSB-3 ST-2
DEPTH: 18.0-20.0'
Visual Description: GREY LEAN CLAY WITH SAND
Remarks: PERMEANT: DEAIRED WATER

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeameter type: Flex Wall
Sample type: UNDISTURBED



Project: UNIVERSITY OF TOLEDO Location: MAUMEE BAY STATE PARK Date: 6-16-08	Project No.: UOT-014 File No.: 133 Lab No.: E08-472
PERMEABILITY TEST REPORT HULL & ASSOCIATES, INC.	Tested by: MG Checked by: CG Test: CH - Constant head

CONSTANT HEAD PERMEABILITY TEST RESULTS

PROJECT NAME: UNIVERSITY OF TOLEDO
PROJECT LOCATION: MAUMEE BAY STATE PARK
SAMPLE IDENTIFICATION: HSB-3 ST-2
DEPTH: 18.0-20.0'
DESCRIPTION: GREY LEAN CLAY WITH SAND
MAX. DRY DENS.: OPT. WATER CONTENT:

FILE NO.: 133
PROJECT NO.: UOT-014
LAB NO.: E08-472
SAMPLE TYPE: UNDISTURBED
DATE: 6-16-08

SPECIMEN DATA

INITIAL PARAMETERS:

HEIGHT: 8.12 cm
DIAMETER: 7.26 cm
WET WEIGHT: 725.6 g
MOISTURE CONTENT: 17.0 %
DRY DENSITY: 115.4 pcf
PERCENT COMPACTION:

FINAL PARAMETERS:

HEIGHT: 8.10 cm
DIAMETER: 7.25 cm
WET WEIGHT: 726.9 g
MOISTURE CONTENT: 17.2 %
DRY DENSITY: 115.8 pcf

TEST PARAMETERS

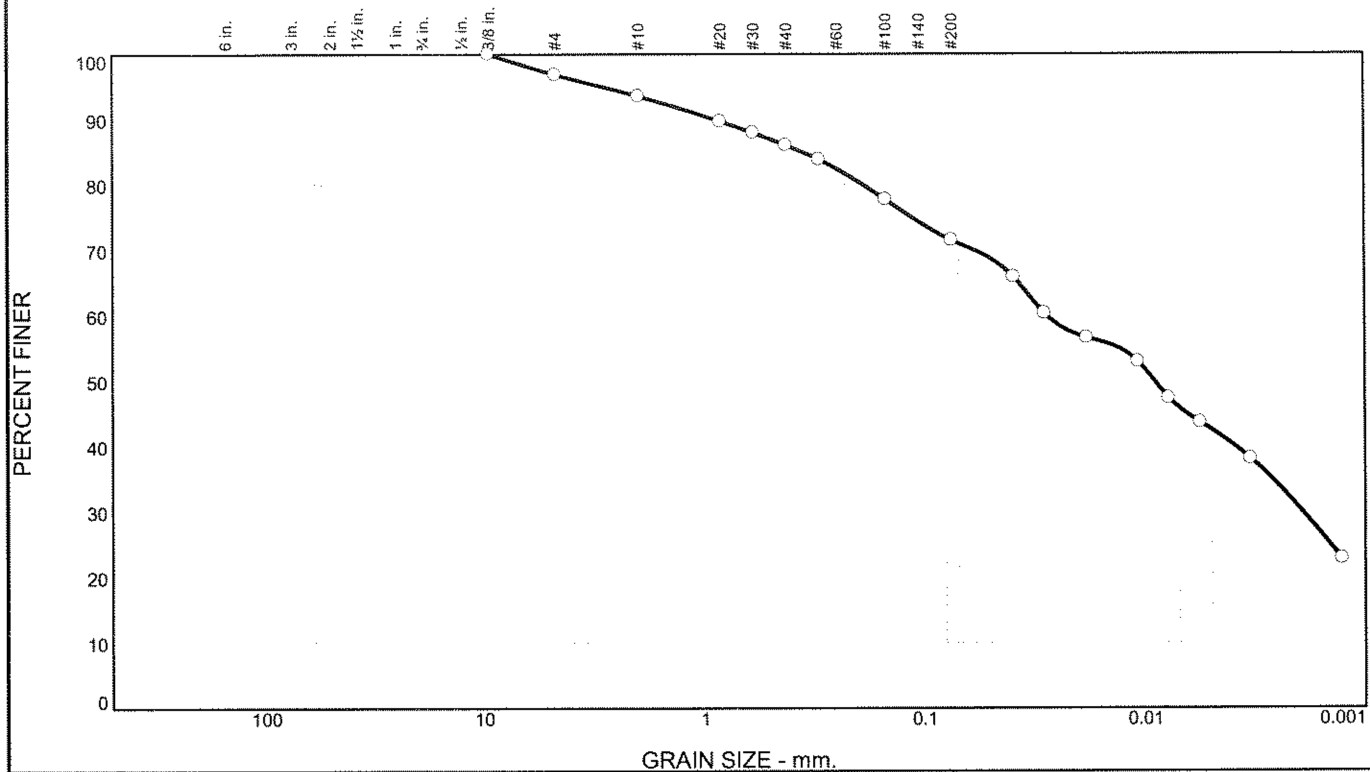
CELL NO.: 1 PANEL NO.: 4 POSITIONS:

	RUN NO. 1	RUN NO. 2
CELL PRESSURE:	50.0 psi	
INFLUENT PSI:	47.0 psi	
EFFLUENT PSI:	44.7 psi /	
/ 0.0 psi		
DIFFERENTIAL HEAD:	2.3 psi	

PERMEABILITY DATA

	RUN NO. 1	RUN NO. 2
AVERAGE FLOW RATE:	3.28E-05 cc/sec	
COEFFICIENT OF CORRELATION:	0.99560	
AVERAGE GRADIENT:	20.0	
TEMPERATURE:	23.0 deg C	
PERMEABILITY, K, at 20 deg C:	3.69E-08 cm/sec	

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	3.1	3.3	7.5	14.6	28.9	42.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0		
#4	96.9		
#10	93.6		
#20	89.7		
#30	88.0		
#40	86.1		
#50	83.9		
#100	77.8		
#200	71.5		

* (no specification provided)

Material Description

GREY LEAN CLAY WITH SAND

Atterberg Limits (ASTM D 4318)

PL= 14 LL= 26 PI= 12

Classification

USCS= CL AASHTO= A-6(6)

Coefficients

D_{85}= 0.3555 D_{60}= 0.0279 D_{50}= 0.0091
D_{30}= 0.0019 D_{15}= D_{10}=
C_u= C_c=

Date Tested: 6-18-08 **Tested By:** MG/CG

Remarks

NATURAL MOISTURE: 18.4%

Sample No.: E08-473 **Source of Sample:** **Date Sampled:** 6-10-08
Location: HSB-3 **Elev./Depth:** 12.8-15.0'
Checked By: MIKE GERDEMAN **Title:** LAB SUPERVISOR

HULL & ASSOCIATES, INC.

Erie, MI

Client: UNIVERSITY OF TOLEDO
Project: MAUMEE BAY STATE PARK
Project No: UOT-014 **Figure**