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Appendix C – Design

For the Feasibility Study of Rebuild by Design Meadowlands Flood Protection Project

June 2018

Boroughs of Little Ferry, Moonachie, Carlstadt, and Teterboro and the Township of South Hackensack, Bergen County, New Jersey

REBUILD BY DESIGN MEADOWLANDS

Prepared by AECOM for the State of New Jersey Department of Environmental Protection

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Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AISC	American Institute of Steel Construction, Inc.
ASD	Allowable Strength Design
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
AWI	American Welding Society
CDBG-DR	Community Development Block Grant – Disaster Recovery
CFR	Code of Federal Regulations
cfs	Cubic feet per second
DM	Design Manual
EIS	Environmental Impact Statement
EM	Engineer Manual
ETL	Engineer Technical Letter
FEMA	Federal Emergency Management Agency
HEC-HMS	Hydrologic Engineering Center - Hydrologic Modeling System
HUD	US Department of Housing and Urban Development
ICC	International Code Council
LOP	Line of Protection
LRFD	Load and Resistance Factor Design
NAVD 88	North American Vertical Datum of 1988
NAVFAC	Naval Facilities Engineering Command
NJDCA	New Jersey Department of Community Affairs
NJDEP	New Jersey Department of Environmental Protection
NAVD 88	North American Vertical Datum of 1988
pcf	Per cubic foot
RBDM	Rebuild by Design Meadowlands
RBD	Rebuild by Design
UNS	Unified Numbering System
USACE	United States Army Corps of Engineers

1.0 Introduction

This Design Appendix presents the supporting technical information used in the feasibility analysis of the Rebuild by Design Meadowlands (RBDM) Flood Protection Project (the Proposed Project). This appendix (Appendix C) provides the geotechnical and structural detailed analyses for the line of protection (LOP) and the design of the surge barrier and pump station near the Paterson Plank Road Bridge over Berry's Creek associated with Alternatives 1 and 3.

A general location map of the RBDM Project Area is provided in **Figure C-1**, (i.e., the Phase 1 Pilot Area).

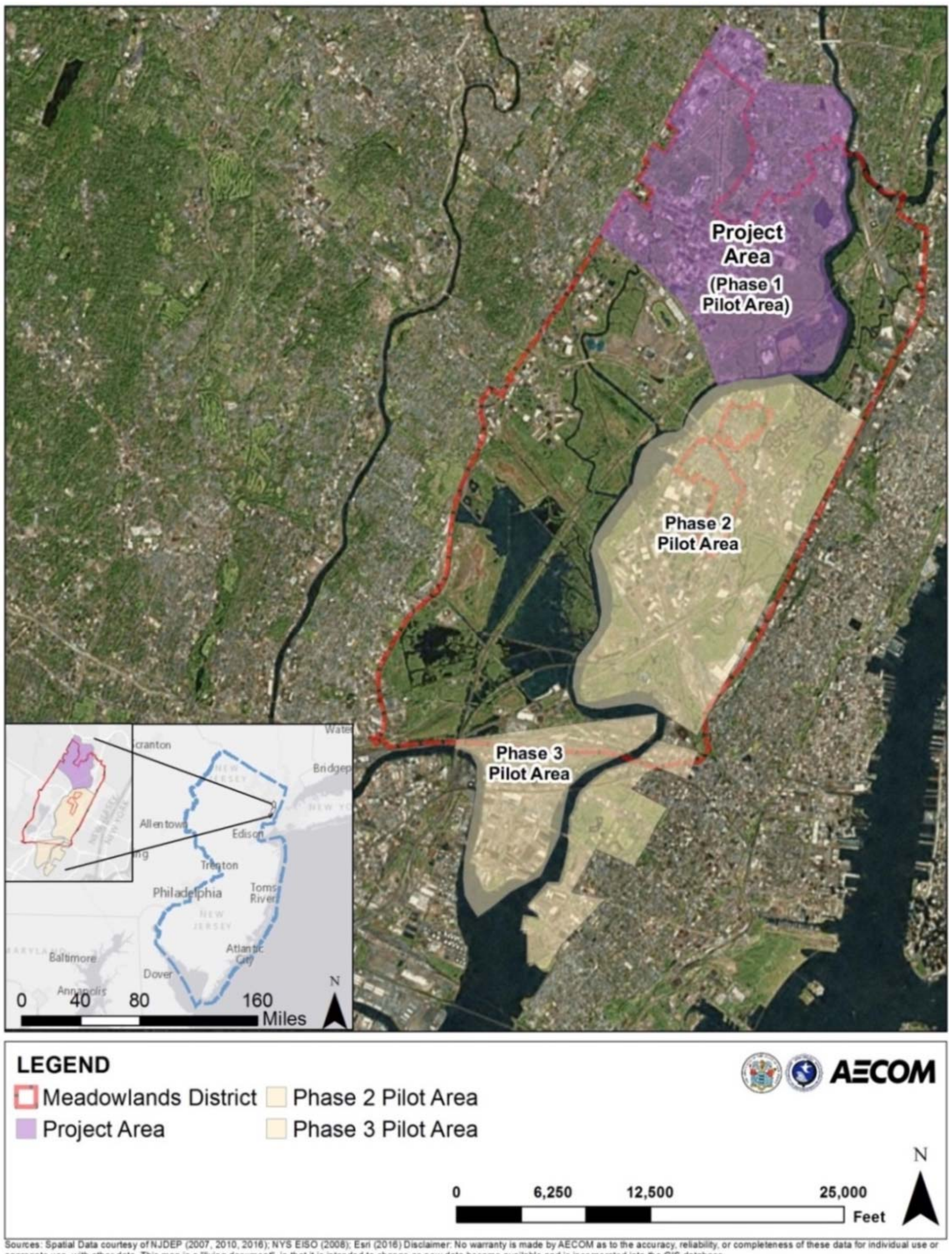

Figure C-1: RBDM Project Area

2.0 Project Purpose

The Proposed Project includes the construction of flood risk reduction measures designed to address the impacts of coastal and systemic inland flooding on the quality of the physical, natural, cultural, and socioeconomic environment due to both storm hazards and sea level rise within the Project Area. The purpose of the Proposed Project is to reduce flood risks and increase the resiliency of the communities and ecosystems in the Project Area, thereby protecting infrastructure, facilities, residences, businesses, and ecological resources from the more frequent and intense flood events anticipated to occur in the future.

3.0 Proposed Project Alternatives

Three alternatives were proposed to reduce the flood risk within the Project Area. The alternatives vary by the type of infrastructure that is proposed. Alternative 1 includes various infrastructure-based solutions intended to provide protection against coastal storm surges. Alternative 2 includes various grey and green infrastructure-based solutions, as well as new parks and improved open spaces, intended to improve stormwater management in key locations throughout the Project Area. Alternative 3 would consist of a hybrid of coastal flood protection and stormwater drainage improvements. .

- **Alternative 1**, the **Structural Flood Reduction Alternative**, to the extent practical, would evaluate a Federal Emergency Management Agency (FEMA) certifiable level of flood protection to a portion of the Project Area. Under Alternative 1, a LOP would be constructed using of a range of grey infrastructure, including floodwalls, levees, berms, a tide gate and eight closure gates, and a surge barrier and pump station, designed to provide flood protection up to an elevation of 7.0 feet (North American Vertical Datum of 1988 (NAVD 88)). In addition to flood reduction infrastructure, this alternative would integrate open space features and green infrastructure into the design.
- **Alternative 2**, the **Storm Water Drainage Improvement Alternative**, would improve stormwater management through the installation of 41 green infrastructure systems (bioswales, storage/tree trenches, and rain gardens) along roadways, five new parks, improvements to five existing open spaces/public amenities, three new pump stations, two new force mains, and dredging of the lower reach of East Riser Ditch.
- **Alternative 3**, the **Hybrid Alternative**, would combine components of Alternatives 1 and 2 to provide an integrated, hybrid solution that employs a combination of appropriate levees, berms, drainage structures, pump stations, and/or floodgates, coupled with local drainage improvement projects, to achieve the maximum amount of flood protection within the boundaries of the Project Area. However, due to funding and construction constraints associated with a project of this magnitude, the Alternative 3 features would be separated into two stages: a *Build Plan*, which includes all features to be constructed as part of the Proposed Project, and a *Future Plan*, which includes the remaining features that could be constructed over time by others as funding sources become available and construction feasibility permits. The Alternative 3 *Build Plan* would consist of all of the Alternative 2 components, with the exceptions of two new parks and a pump station force main in Losen Slote. Additionally, the proposed improvements proposed for one of the parks under Alternative 2 would be altered under the Alternative 3 *Build Plan.* The Alternative 3 *Future Plan* would consist of all of the remaining features from Alternative 2, as well as all of the features from Alternative 1.

4.0 Summary of Geotechnical Analysis (Subappendix C1)

For the geotechnical analysis, the following flood protection alternatives were analyzed: earth levees, double sheet pile walls, flood walls (T, I, and L-sections), cantilever sheet pile walls, and an anchored sheet pile wall. In addition, deep foundation alternatives were analyzed for the proposed East Riser Ditch pump station and forebay.

Based on historical soil borings, the Project Area along the proposed line of protection was divided into seven Soil Areas. The boring data indicated a soft organic clay/peat layer in Soil Areas 4 to 7 compared to Soil Areas 1 to 3, where this layer was not encountered. The geotechnical analyses were performed for various flood heights for each flood protection alternative. The flood elevation was assumed to be +8 feet (referenced to the North American Vertical Datum of 1988, or NAVD88). Based on the results of the geotechnical analyses, the levee alternative is feasible for flood heights of 2-feet, 4-feet, 6-feet, and 8-feet for Soil Areas 1 to 3, and for flood heights 2-feet and 4-feet for Soil Areas 4 to 7. Levees with 6-feet and 8-feet flood height for soil areas 4 to 7 will require sheet piles on both the riverside and the landside.

A double sheet pile wall is a feasible alternative to 6-feet and 8-feet high levees with sheet piles for Soil Areas 4 to 7. A double sheet pile wall structure consists of two parallel steel sheet piles whose exposed upper segments are connected by welded steel struts and backfilled with ballast material (sand, suitable excavation spoils, etc.), thereby forming a wall.

The floodwall alternative was considered for all Soil Areas. T-walls, without deep foundations, are recommended from a seepage standpoint for all flood heights for Soil Areas 1 to 3. I-Walls, without deep foundations, are recommended for 2 feet and 5 feet flood height within Soil Areas 4 to 7. T-Walls and L-Walls on deep foundations are recommended for 6-feet and 8-feet flood height within Soil Areas 4 to 7. A combination of sheet piles with either driven battered steel piles or battered micro piles is recommended as the deep foundation alternatives to T- and L- walls in Soil Areas 4 to 7.

The cantilever sheet pile wall alternative is feasible for flood heights of 6 feet and 8 feet for the Soil Areas 1 to 3. The cantilever wall with 15 feet flood height in Soil Area 2 is only feasible when flood overtopping criteria is not governing the design. In the event flood overtops the walls beyond the design basis, additional deflection at the top of the sheet piles could be expected, but would remain within serviceability limits. The anchored sheet pile alternative is recommended for a 15-foot flood height in Soil Area 2, where the bedrock is higher than elevation -27 feet.

At locations where dense soils are encountered, sheet piles would be installed in a pre-augured trench and would be fully-grouted. Grouting could be performed in one of two ways: 1. non-shink grout would be injected through tremie pipes attached to both sides of the sheet pile; or 2. the trench would be filled with a slurry mixture until a 2-foot width had been achieved.

Due to the presence of the organic clay/peat layer in Soil Area 6, deep foundations are the only feasible option. A proposed deep foundation option (a group of H-Piles with 212 HP 16×141 steel piles with lengths of 65 feet and a center-to-center spacing of 6 feet) for the pump station is adequate in terms of the axial capacity of a single pile. In addition, a proposed deep foundation option (40 HP 16×141 steel piles with lengths of 75 feet and a center-to-center spacing of 9 feet) is also adequate for the forebay of East Riser Ditch pump station in Soil Area 6.

Considering that the exit gradient and flow rate for the I-wall and T-wall alternatives with much shorter sheet piles were within acceptable limits, seepage is not a concern for double sheet pile walls, cantilever sheet pile walls, and anchored sheet pile wall. However, it is highly recommended to perform global stability analyses for each flood protection alternative and a pile group analysis for each foundation system using the computer program GROUP as part of the design phase of the project.

The above recommendations are based on preliminary analyses and the feasibility of these structural design alternatives may change should accuracy of subsurface information and additional analysis be performed during the design phase.

5.0 Summary of Structural Analysis (Subappendix C2)

The structural protection measures evaluated in the RBDM project includes Concrete Floodwall (T-wall) and Walkway. These structures are subdivided based on their forms of foundation, widths, and locations.

Structural analyses included designs of shallow foundation concrete floodwall (T-wall), cantilever walkway and its relevant sections, and fluvial park elevated walkway. The top elevation of each section is designed to be 8 feet (NAVD 88), including 1 foot of freeboard. Microsoft Excel Spreadsheet and hand calculations were used for calculating equations and SAP 2000 was used for structural modeling. The analysis of the cross sections not covered in Subappendix C2 (Structural) can be found in Subappendix C1 (Geotechnical), such as the single and double sheet pile wall and cantilever sheet pile walkway.

Subappendix C2 covers concrete structures such as a slab and columns of cantilever walkway, which are proposed along the line of protection, while Subappendix C3 covers hydraulic concrete structures such as a surge barrier at Berry's Creek. Because two subappendices cover different types of concrete structures at different locations, different design criteria were used. The only hydraulic concrete structure Subappendix C2 covers is the shallow foundation concrete floodwall (T-wall), and only stability check was performed with service load combination in this phase of design. Reinforced concrete design for the shallow foundation concrete floodwall (T-wall) would be performed in the next phase of design with the same load combination with Subappendix C3. The design criteria used in designs of the shallow foundation concrete floodwall (T-wall), cantilever walkway and its relevant sections, and fluvial park elevated walkway could be found in Subappendix C2.

Nine shallow foundation concrete floodwall sections were designed at heights from 2-feet to 10-feet with an increment of one foot. Every section has been checked for its sliding and overturning stability and soil bearing capacity in accordance with COE EM 1110-2-2502 with service load combination. The load case I2 was used, which is an inland flood wall case of water to top of wall. The stability criteria used in the design of the shallow foundation concrete flood wall is listed in **Table C-1** based on analyses performed and documented in Subappendix C2.

Table C-1: Inland Flood Wall Stability Criteria Load Case

Criteria	Minimum Required
Sliding Factor of Safety	1.33
Minimum Base Area in Compression in Soil Foundation (Overturning Criteria)	75%
Bearing Capacity Safety Factor	2.0

*I2: Water to Top of Wall

The smallest actual sliding safety factor was 1.40 for 9-feet to 10-feet high floodwalls, and all floodwall sections had 100 percent minimum base area in compression. The smallest actual bearing capacity safety factor was 2.01 for 1 foot to 2 feet high floodwalls.

Sliding and overturning stability has been checked for the retaining wall on the protected side of the 25-feet wide cantilever walkway. The minimum required safety factor for both sliding and overturning stability is 1.5 while the analyses showed a safety factor of 2.51 for sliding and 3.49 for overturning.

Structural members of cantilever walkway section near the existing pump station were designed and their design efficiencies were summarized. The analysis showed a design efficiency of 95.44 percent for the walkway slab, 14.04 percent for the column at the flood side of the walkway, 2.13 percent bearing efficiency, and 3.48 percent axial compression efficiency for the wall at the protected side of the walkway.

Concrete frame of the elevated walkway section at Fluvial Park was designed and a design efficiency of each member was summarized. The analysis showed a design efficiency of 61.82 percent for the center beams, 43.11 percent for the girder, 4.83 percent for the column, and 58.02 percent bending efficiency and 92.79 percent torsion efficiency for the side beams. See Sheet S-409 for required foundation dimensions.

6.0 Summary of Berry's Creek Surge Barrier (Subappendix C3)

6.1 General

A Recon Study of Berry's Creek Option 1, surge barrier (floodgate) and pump station, was prepared to a level needed to develop a cost estimate for comparison purposes. Drawings of gates and pump stations with similar load conditions along with a stability analyses were used for preparing the Recon Plans. The stability analysis consisted of a pile foundation design and only load cases that typically govern design were considered. A more detailed design would be required if a future re-evaluation led to the selection of the Surge Barrier option.

The water stage of elevation 7.0 feet (NAVD 88) was used as the design stage for the Alternative 1, Berry's Creek Option 1 system. This stage does not meet the 1 percent storm event criteria mandated for FEMA Certification. Elevation 7.0 feet (NAVD 88) was selected largely for economic reasons. In holding elevation 7.0 feet (NAVD 88), the Patterson Plank Road (Route 120) embankment and adjacent higher natural ground would provide a shorter line of protection, thus reducing the overall cost of the Proposed Project. The floodgate and pump stations were considered critical structures and were designed adding 3 feet of freeboard above the system design stage. This adjustment in elevation satisfied the 2.6 feet future sea level rise and complies with the 3 feet increase over the Base Flood Elevation as specified in 33 Coed of Federal Regulations (CFR) 65.10. The floodgate width of 100 feet (two 50 feet gates) matched the existing width of Berry's Creek channel immediately south of the Patterson Plank Road Bridge. The 1,000 cubic feet per second (cfs) pump capacity was estimated based on Hydrologic Engineering Center - Hydrologic Modeling System (HEC-HMS) modeling of Berry's Creek drainage area under the design events (10-year fluvial along with a 2-year tide). A detailed drainage study is required if this option is advanced. The pumps are only used when the floodgates are closed. The pumps prevent the protected side stage from increasing due to impounded water. There are no navigation demands. Approach guide walls and fenders were not required.

6.2 Codes and Standards

The following is a list of general United States Army Corps of Engineers (USACE) references and industry codes and standards which are applicable to structural design. Local codes will govern in case of conflicting requirements. The general codes and standards listed below apply to design elements such as the pump station, operations/ control buildings and bridge, but are not necessarily limited to, the following:

- American Association of State Highway and Transportation Officials (AASHTO), Load and Resistance Factor Design (LRFD) 3rd Edition, 2004 with Interim Revisions excluding Section 6 of 2006
- American Concrete Institute (ACI) 318-14, Building Code Requirements for Structural Concrete
- ACI 350--06, Concrete Sanitary Engineering Structures

- American Institute of Steel Construction, Inc. (AISC), Manual of Steel Construction, 14th Edition
- American Society of Civil Engineers (ASCE) 7-10 , Minimum Design Loads for Buildings and Other Structures
- International Code Council (ICC), International Building Code New Jersey Edition: 2015
- American Society for Testing and Materials (ASTM)
- American Welding Society (AWS) D1.1-10, Structural Welding Code, or latest edition
- AWS D1.6-10, Stainless Steel Welding Code, or latest edition
- USACE Engineer Manual (EM) 1110-2-2000 Standard Practice for Concrete for Civil Works Structures
- USACE EM 1110-2-2102, Water Stops and Other Preformed Joint Material for civil Works Structures
- USACE EM 1110-2-2104, Strength Design for Reinforced Concrete Hydraulic Structures
- USACE EM 1110-2-2100, Stability Analysis of Concrete Structures
- USACE EM 1110-2-2502, Retaining and Flood Walls
- USACE EM 1110-2-2906, Design of Pile Foundations
- USACE EM 1110-2-3104, Structural and Architectural Design of Pumping Stations
- USACE Engineer Technical Letter (ETL) 1110-2-584, Design of Hydraulic Steel Structures
- 44 CFR 65.10, FEMA Levee Mapping and Certification

6.3 General Design Load Parameters

6.3.1 Load Combinations

Structures, components, and foundations shall be designed so that their design strength equals or exceeds the effects of the factored loads in USACE EM1110-2-2104 or ASCE 7-10. Load combinations per EM 1110-2-2104 will be applicable to Berry's Creek and are listed in Error! Reference source not found..

Table C-2: Strength Load Combinations and Strength Design Parameters

Load Combinations		Strength Design									
		Reduction Factor (Rf)	Hydraulic Factor (Hf)	Dead (D)	Live (L)	Hydro-Static (H)	Uplift (U)	Wind (W)	Soil (S)	Settle-ment (ST)	Impact (I)
Construction											
Construction Condition	A1	0.86	1.3	1.7	-	-	-	1.7	-	1.7	-
Operation											
Normal Operation Condition	B1	1	1.3	1.7	1.7	1.7	1.7	-	1.7	-	1.7
Start-up Condition	B2	1	1.3	1.7	1.7	1.7	1.7	-	1.7	-	1.7
High Head Condition	B3	1	1.3	1.7	1.7	1.7	1.7	-	1.7	-	1.7

Load Combinations		Reduction Factor (Rf)	Hydraulic Factor (Hf)	Dead (D)	Live (L)	Hydro-Static (H)	Uplift (U)	Wind (W)	Soil (S)	Settle-ment (ST)	Impact (I)
		Strength Design									
Reverse Head	B4	0.86	1.3	1.7	1.7	1.7	1.7		1.7	-	1.7
Hurricane											
Storm Surge Condition	C1	0.75	1.3	1.7	1.7	1.7	1.7	1.7	1.7	-	1.7
Maintenance											
Maintenance Conditions	D1	0.86	1.3	1.7	1.7	1.7	1.7	-	1.7	-	1.7

6.3.2 Hydraulic Stages

Water and ground surface elevations for the structural analysis are shown in **Table C-3**.

Table C-3: Hydraulic Stages and Design Water Surface Elevations

Stage	Flood Side (elevation in feet NAVD 88)	Protected Side (elevation in feet NAVD 88)
Normal	1.0	1.0
Maximum Direct Water*	7.0	0.0
Maximum Reverse Water	0.0	5.0

* Stages do not meet the 100-year levels required for FEMA Certification

6.4 Load Cases

6.4.1 Dead Loads

Dead loads shall be determined in accordance with applicable engineering manuals and ASCE 7-10, and shall include the self-weight of all permanent construction components including foundations, slabs, walls, roofs, actual weights of equipment, overburden pressures, and all permanent non-removable stationary construction. Typical unit weights (in per cubic foot (pcf)) are shown in **Table C-4**.

Table C-4: Unit Weights

Item	Weight [pcf]
Water (Fresh)	62.4
Semi-compacted Fill	110
Fully Compacted Granular Fill, wet	120
Fully Compacted Granular Fill, Effective	58
Fully Compacted Clay Fill, wet	110
Fully Compacted Clay Fill, Effective	48
Riprap	130
Silt	94
Reinforced Concrete (Normal weight)	150
Steel	490

6.4.2 Live Loads

Live loads for building structures shall be determined in accordance with applicable engineering manuals and ASCE 7-10. Additional details are provided in **Subappendix C3**.

6.4.3 Soil Pressures (S)

Structures are designed for lateral and vertical soil pressures. Lateral pressures are determined using the at-rest coefficients, K_0 obtained from the Geotechnical Report:

- Lateral Soils at-rest Pressure Coefficients:
  - K0 = 0.8 for Clay; and
  - K0 = 0.48 for Granular Material.

Per Naval Facilities Engineering Command (NAVFAC) Design Manual (DM) 7.2, the following coefficients of friction are recommended:

- Mass Concrete on Rock: tan(35) = 0.70;
- Mass Concrete on Medium Clays: tan(18) = 0.32; and
- Mass Concrete on Medium Sands: tan(26) = 0.48.

Per the values of K_0 provided above, Active and Passive Earth Pressure Coefficients have been determined as follows:

- Clays:
  - K_0=0.8, the corresponding friction angle is Ø =11.54° (K_0=1-sin(Ø))
  - Assume level backfill, and use Rankine Theory
  - $K_a=\tan^2(45-Ø/2) = \tan^2(45-11.54/2) = 0.667$
  - $K_p=\tan^2(45+Ø/2) = \tan^2(45+11.54/2) = 1.500$
- Granular Material:
  - K_0=0.48, the corresponding friction angle is Ø =31.6° (K_0=1-sin(Ø))
  - Assume level backfill, and use Rankine Theory
  - $K_a=\tan^2(45-Ø/2) = \tan^2(45-31.6/2) = 0.316$
  - $K_p=\tan^2(45+Ø/2) = \tan^2(45+31.6/2) = 3.170$.

6.4.4 Hydrostatic Loads (H)

Hydrostatic loads for which structures will be designed refer to the vertical and horizontal loads induced by a static water head and buoyant pressures, excluding uplift pressures. Dynamic Wave Load is neglected in this RECON Design but must be considered in advanced design. The inland location would preclude a wind driven wave.

6.4.5 Uplift Loads (U)

Uplift loads for which structures will be designed are defined by two uplift conditions: Uplift Condition A assumes the sheet pile cutoff wall is fully effective, and Uplift Condition B, assumes the sheet pile cutoff wall is ineffective (pressure assumed to be vary linearly across the base). The dewatered construction case may govern; however, a reduced load factor should be considered for the short-term loading.

6.4.6 Wind Loads (W)

Structures are designed for wind loads established by ASCE No. 7, “Minimum Design Loads for Buildings and Other Structures.”

6.4.7 Impact Loads (I)

For elements supporting reciprocating or rotating equipment and cranes proper allowance, or as determined by analysis, shall be made for impact in addition to other loads. The following minimum impact loads shall be used:

- Traveling cranes and hoists: 25 percent of the lifted loads;
- Rotating equipment: 20 percent of the total machine weight;
- Reciprocating equipment: 50 percent of the total machine weight (consideration will be given to the deflection of beams supporting reciprocating and rotating machines); and
- The use of isolators can be considered in reducing the effects of machinery impact (the reduction shall be based on manufacturers' recommendations).

6.4.8 Access Bridge

Access bridge shall be designed per AASHTO for highway truck railing loadings.

6.4.9 Settlement Loads (ST)

Structures are designed for forces generated by settlement (downdrag) in coordination with the Geotechnical Design. Downdrag forces are applied to sustained load cases (i.e., construction). The downdrag force exerted by settling soil adjacent to the pump station and floodgate is applied to the perimeter of the structure. Downdrag forces are also included in the structural check of the piles. Downdrag loads are obtained from the geotechnical engineer on a case-by-case basis as applicable. How downdrag forces on piles are computed is explained in the geotechnical report.

6.5 Concrete Design Criteria

Concrete Structures permanently exposed to water and the splash zone shall be designed in accordance with EM 1110-2-2104 or the ACI 350R Concrete Sanitary Engineering Structures and will comply with the ACI 318 latest edition strength design method, unless otherwise required. Concrete structures not exposed to water, nor harsh environment shall be designed in accordance with ACI-318-14. Typical design materials are as follows unless otherwise noted:

- Structural concrete: 5,000 psi @ 28 days with a maximum water/cement ratio = 0.40; and
- Steel reinforcement: 60,000 psi (ASTM A615).

6.6 Steel Design Criteria

Steel design shall utilize the ETL 1110-2-584 and the AISC Steel Construction Manual, 15th edition. Either Allowable Strength Design (ASD) or LRFD design methods are permissible. Typical design materials are as follows unless otherwise noted:

- Structural steel rolled shapes: ASTM 572, Grade 50 or ASTM A992, Grade 50
- Plates: ASTM A36, Grade 36
- Bolts and nuts: ASTM A325, min. ¾" or ASTM A490
- Anchor Bolts: ASTM F1554, (¾" diameter or greater)
- Corrosion stainless steel: ASTM A240 (freshwater) or ASTM A316 (saltwater)
- Sheet Piles: ASTM A572, Grade 50

- Stainless Steel Embedded Anchors: ASTM A276, Type 316 or Unified Numbering System (UNS) S21800

6.7 Pile Foundation Design Criteria

All forces applied to the primary concrete structures are resisted by the pile foundation. The pump station and floodgate are supported independently and are not designed to transmit load to any adjoining structure. Pile designs are based on a soil structure interactive analysis, with the pile supports input as springs in accordance with EM 1110-2-2906. Group effects will be applied as required.

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Subappendix C1 – Geotechnical Analysis

For the Feasibility Study of Rebuild by Design Meadowlands Flood Protection Project

June 2018

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This Page has been Intentionally Left Blank.

Table of Contents

List of Figures

List of Tables

Attachments

Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
EM	Engineer Manual
FOS	Factor of safety
HP	H-Pile
LiDAR	Light Detection and Ranging
LOP	Line of protection
NAVD 88	North American Vertical Datum of 1988
SPT	Standard penetration test
USACE	US Army Corps of Engineers

1.0 Introduction

This subappendix presents the findings of the feasibility assessment for Rebuild by Design Meadowlands Flood Protection Project (the Proposed Project) in Bergen County, New Jersey. The following five flood protection concepts evaluated under Alternative 1 included: (1) earth levee; (2) double sheet pile wall; (3) flood wall (T-, I- and L-wall); (4) cantilever sheet pile wall; and (5) anchored sheet pile wall. The feasibility of a deep foundation alternative for the pump station and forebay at the Berry's Creek Surge Barrier was also assessed.

The Project Area along the proposed line of protection (LOP) was divided into seven Soil Areas based on the subsurface conditions and the bedrock elevations. Based on the existing borings, no organic soil layer was identified in Soil Areas 1 to 3, while an organic clay or peat layer was found in Soil Areas 4 to 7.

The flood protection alternatives were analyzed for flood heights of 2-feet, 4-feet, 6-feet and 8-feet. The flood elevation was assumed to be +8 feet (referenced to the North American Vertical Datum of 1988 [NAVD 88]), and groundwater table elevation was assumed to be +1 foot (NAVD 88). The earth levee alternative was considered for all Soil Areas. The 6 feet and 8 feet levees in Soil Areas 4 to 7 will require a significantly large volume of existing soils to be replaced by structural fill; therefore, levees with sheet piles on both landside and riverside were considered for these cases. In addition, a double sheet pile wall was considered for the 6 feet and 8 feet flood height for Soil Areas 4 to 7.

The flood wall alternative was considered for all Soil Areas. T-walls on shallow foundations are recommended for all flood heights for Soil Areas 1 to 3. I-walls are recommended for 2-foot and 4-foot flood height in Soil Areas 4 to 7. T-walls and L-walls on deep foundations are recommended for 6-foot and 8-foot flood heights in Soil Areas 4 to 7. A combination of sheet piles with either driven battered steel piles or battered micropiles is recommended as the deep foundation for the T-walls and L-walls in Soil Areas 4 to 7.

The cantilever sheet pile wall alternative for flood heights of 6-feet and 8-feet was considered for Soil Areas 1 to 3, and a 15-foot flood height was considered for Soil Area 2, where top of bedrock is elevation -27 feet or lower. The cantilever wall with 15 feet flood height in Soil Area 2 is only feasible, if there is no overtopping from storm surge unless the backfill is quickly drained. Consequently, an anchored sheet pile wall is recommended for the 15-foot flood height in Soil Area 2, where bedrock elevation is higher than -27 feet.

Due to the presence of the organic clay/peat layer in Soil Area 6, driven piles or micropiles are recommended as deep foundation alternative for the proposed pump station and forebay at Patterson Plank Road. The proposed pile groups for the pump station and forebay are adequate based on the estimated total axial capacities using a group reduction factor and axial capacity of a single H-pile (HP) 16×141 steel pile.

2.0 Generalized Subsurface Profiles

Figure C1-1 presents the location of existing soil borings and the contours of bedrock elevation below the sea level on the project area map. The existing soil borings include borings with standard penetration test (SPT) N-values from the New Jersey Department of Transportation Soil Borings Database and borings without SPT N-values from Joseph S. Ward, Inc. (NJDOT 2016; USACE 1962; Scott 1993; The Louis Berger Group 2010; USACE 2010). The bedrock elevation contours are from the New Jersey Department of Transportation's Soil Borings Database (NJDOT 2016).

Based on the subsurface conditions and the bedrock elevations, the project area along the proposed line of flood protection (LOP) was divided into seven soil areas. In order to characterize the subsurface conditions at each soil area, soil profiles were prepared using the boring logs and results of geophysical investigations from Earthworks LLC (2007). All boring logs used in this study are included as **Attachment C1-A**. Ground surface elevations were estimated from the ground elevation (NAVD 88) contour maps based on the Light Detection and Ranging (LiDAR) survey data obtained from State of New Jersey. Likewise, bedrock elevations were estimated from the bedrock elevation contours where no data were available from the boring logs (Ward 1962).

A representative stratification and set of material properties were assigned to each Soil Area after carefully examining the soil profiles. No organic soil layer was identified in Soil Areas 1 to 3, while an organic clay or peat layer was found in Soil Areas 4 to 7. The material properties were carefully selected based on engineering judgement, material descriptions and the limited SPT N-values available from the existing boring logs and results of laboratory tests performed on similar soils from a nearby project site (AECOM 2016).

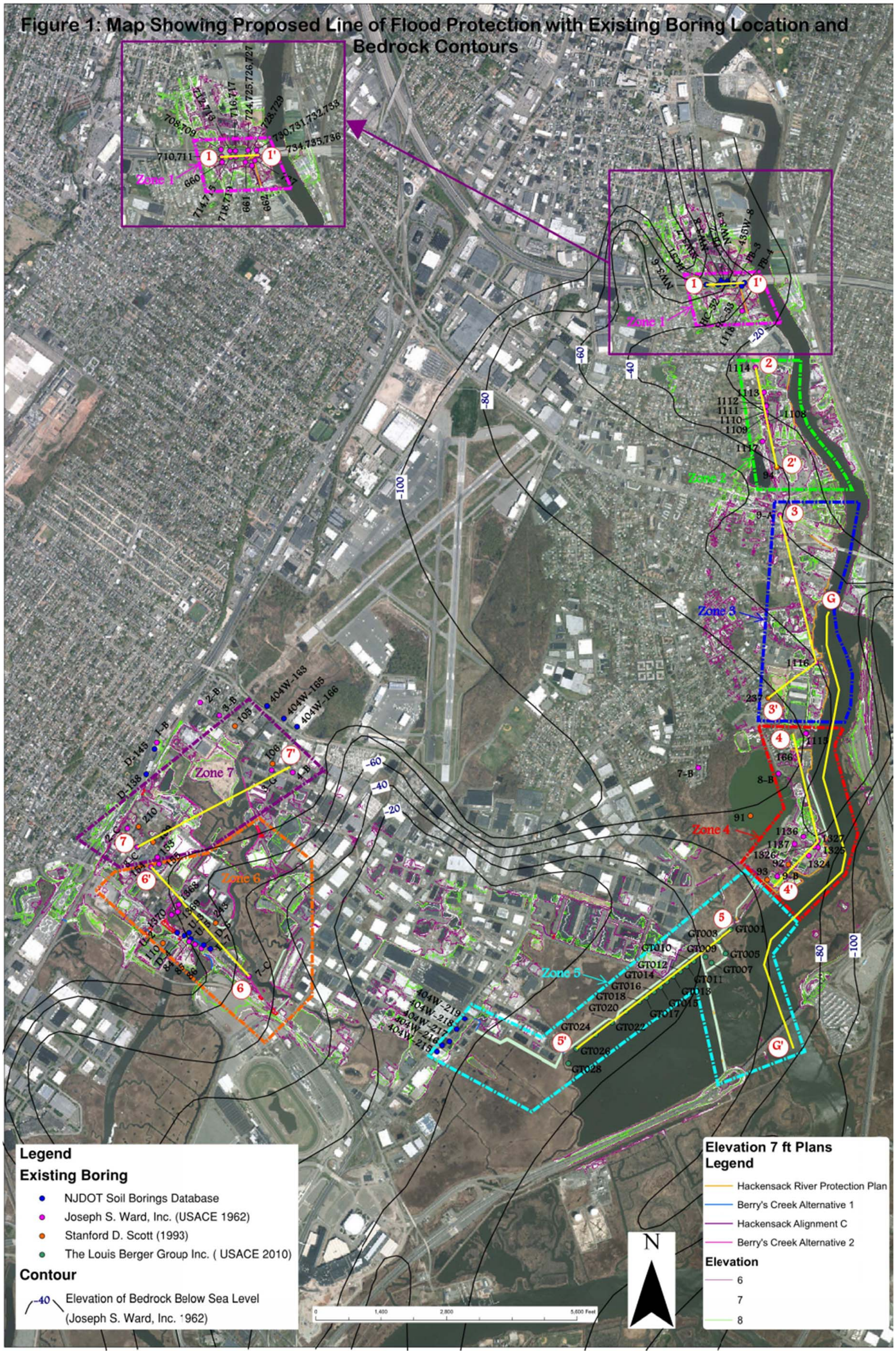


Figure C1-1: Map Showing Proposed Line of Flood Protection with Existing Boring Location and Bedrock Contours

2.1 Soil Area 1

Soil profile represented by Section 1-1’, shown in **Figure C1-2**, was used to prepare the representative stratification and recommended material properties for Soil Area 1, which are presented in **Table C1-1**. The properties materials were selected based on historical boring with SPT N-values and correlations with shear strength.

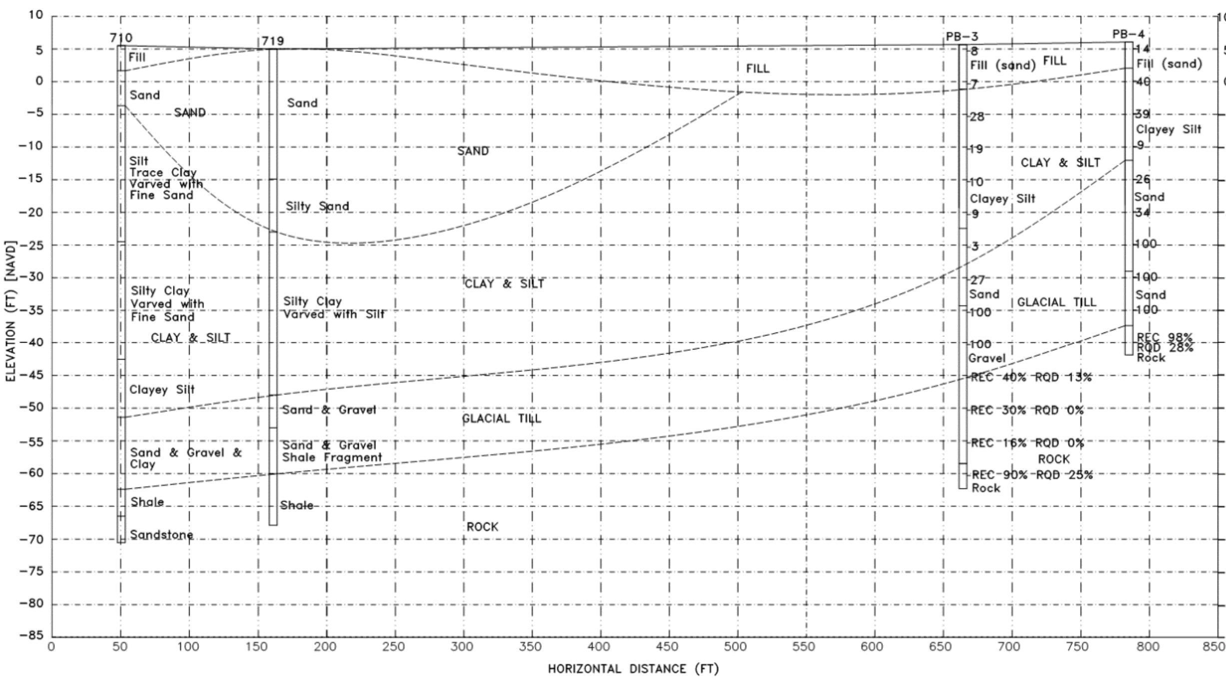


Figure C1-2: Generalized Subsurface Profile at Section 1 – 1’

Table C1-1: Representative Stratification and Recommended Material Properties for Soil Area 1

Stratum No.	Top Elevation (ft)	Bottom Elevation (ft)	Mat-erial	Unit Weight, γ (lb/ft^3)	Friction Angle, ϕ (degree)		Cohesion, c (lb/ft^2)	k=Hydraulic Conductivity kh=kv (cm/sec)
1	Ground Surface Elevation	0	Fill	110	32		0	1.0×10^{-3} to 1.0×10^{-4}
2	0	-40	Clay and silt	110	Short term	0	1,000	2.01×10^{-4} to 2.01×10^{-5}
					Long term	25	100	
3	-40	-55	Glacial till	130	36		0	5.02×10^{-4} to 5.02×10^{-5}
4	-40 to -60	N/A	Bedrock	N/A	N/A	N/A	N/A	N/A

2.2 Soil Area 2

Soil profile represented by Section 2-2’, shown in **Figure C1-3**: , was used to prepare the representative stratification and recommended material properties for Soil Area 2, which are presented in **Table C1-2**. As shown in **Figure C1-3**: , Section 2-2’ is located significantly inland from the riverbank and the LOP. Thus, the top fill layer was ignored in the stratification for Soil Area 2. The properties material were selected based on historical borings classification, engineering judgment, and existing laboratory test performed on similar soils from a nearby project site.

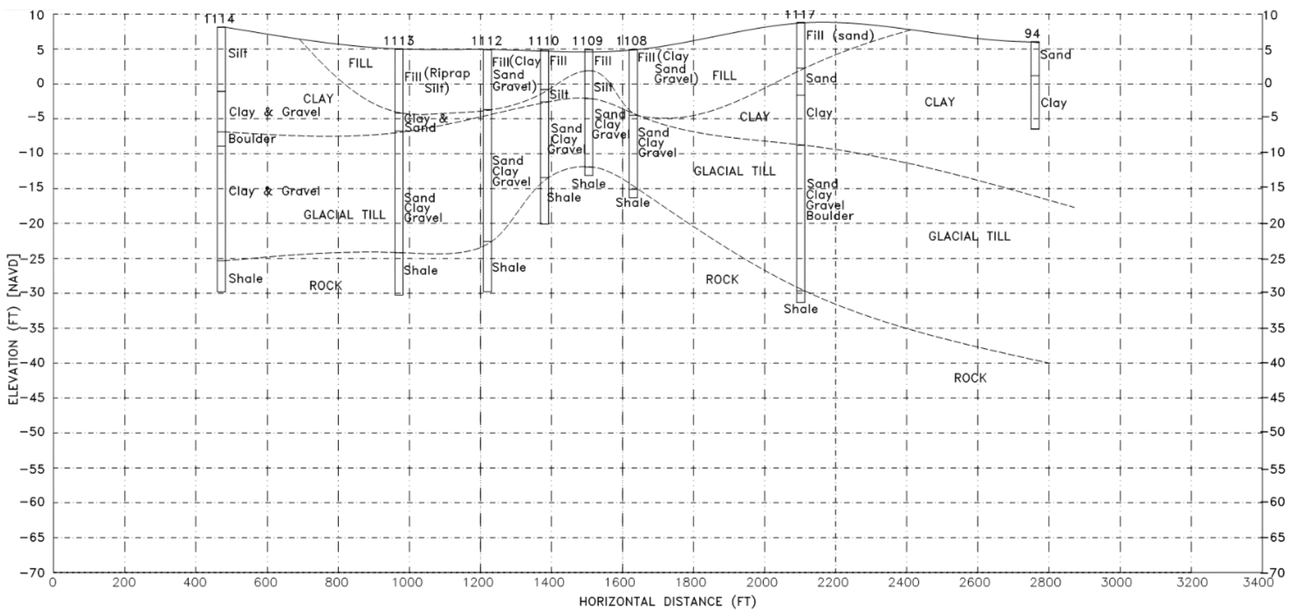


Figure C1-3: Generalized Subsurface Profile at Section 2 – 2’

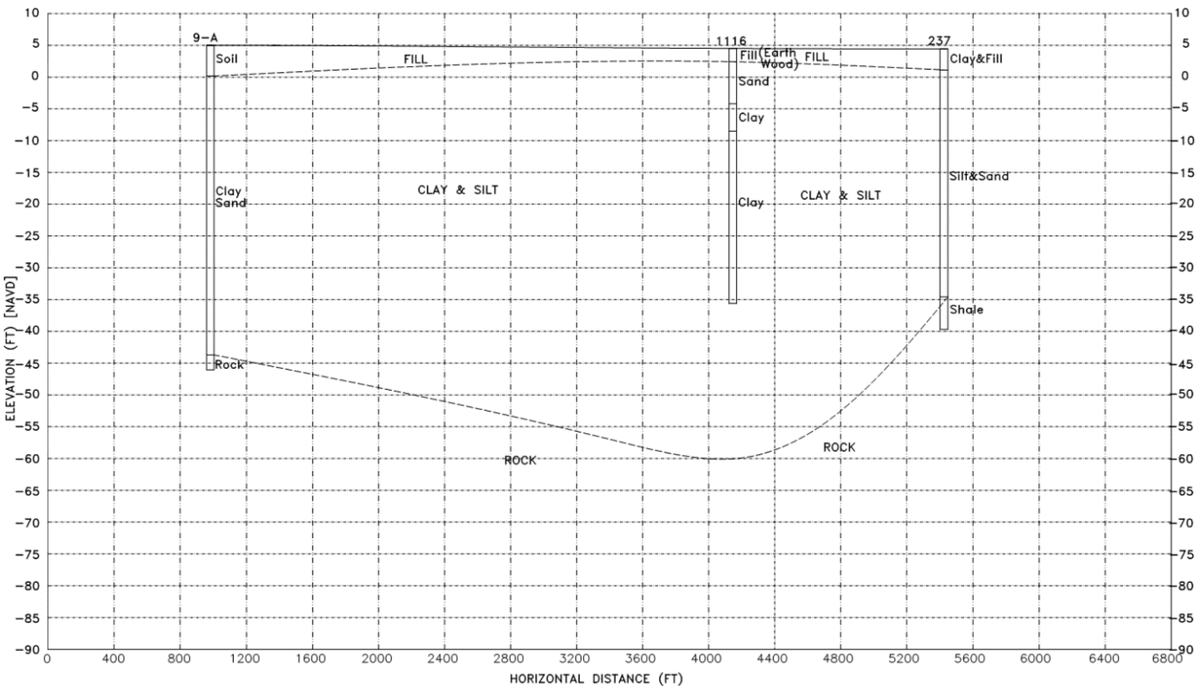
Table C1-2: Representative Stratification and Recommended Material Properties for Soil Area 2

Stratum No.	Top Elevation (ft)	Bottom Elevation (ft)	Mat-erial	Unit Weight, γ (lb/ft³)	Friction Angle, ϕ (degree)		Cohesion, c (lb/ft²)	k=Hydraulic Conductivity kh=kv (cm/sec)
1	Ground Surface Elevation	-10	Clay	110	Short term	0	500	1.0×10^{-4} to 1.0×10^{-5}
					Long term	22	50	
2	-10	-35	Glacial till	130	36		0	5.02×10^{-4} to 5.02×10^{-5}
3	-15 to -40	N/A	Bedrock	N/A	N/A	N/A	N/A	N/A

N/A = not applicable.

2.3 Soil Area 3

Soil profile represented by Section 3-3’, shown in **Figure C1-4:**, was used to prepare the representative stratification and recommended material properties for Soil Area 3, which are presented in **Table C1-3**. As shown in **Figure C1-4:**, Section 3-3’ is located significantly inland from the riverbank and the LOP. Thus, the top fill layer was ignored in the stratification for Soil Area 3. The properties material were



selected based on historical borings classification, engineering judgment and existing laboratory test performed on similar soils from a nearby project site. **Figure C1-5**: presents soil profile at Section G-G’ obtained from the US Army Corps of Engineers (USACE) (Earthworks, 2007). As shown in **Figure C1-5**: , a portion of Section G-G’ is located in Soil Area 3 and in general, shows similar stratification as Section 3-3’.

Figure C1-4: Generalized Subsurface Profile at Section 3 – 3’

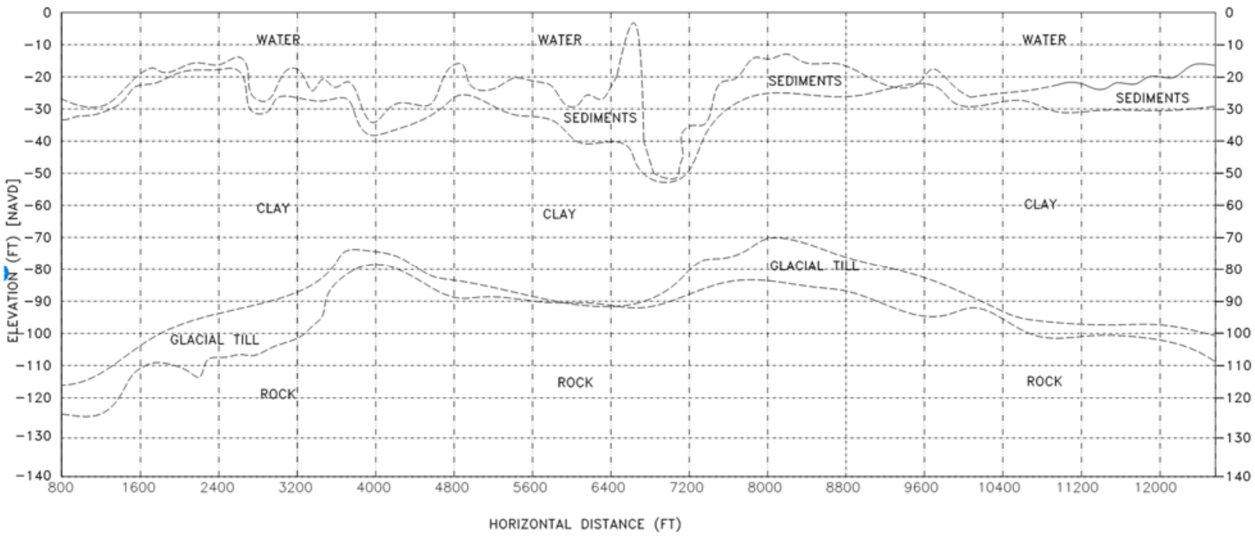


Figure C1-5: Generalized Subsurface Profile at Section G – G'

Table C1-3: Representative Stratification and Recommended Material Properties for Soil Area 3

Stratum No.	Top Elevation (ft)	Bottom Elevation (ft)	Mat-erial	Unit Weight, γ (lb/ft³)	Friction Angle, ϕ (degree)		Cohesion, c (lb/ft²)	k=Hydraulic Conductivity kh=kv (cm/sec)
1	Ground Surface Elevation	-70	Clay and silt	110	Short term	0	500	2.01×10^{-4} to 2.01×10^{-5}
					Long term	25	0	
2	-45 to -70	N/A	Bedrock	N/A	N/A	N/A	N/A	N/A

N/A = not applicable.

2.4 Soil Area 4

Soil profile represented by Section 4-4', shown in **Figure C1-6**: , was used to prepare the representative stratification and recommended material properties for Soil Area 4, which are presented in

Table C1-4: . As shown in **Figure C1-6**: , Section 4-4' is located significantly inland from the riverbank and the LOP. Thus, the top fill layer was ignored in the stratification for Soil Area 4. The properties material were selected based on historical borings classification, engineering judgment and existing laboratory test performed on similar soils from a nearby project site.

As shown in **Figure C1-5**: , a portion of Section G-G' is located in Soil Area 4 and in general, shows similar stratification as Section 4-4'.

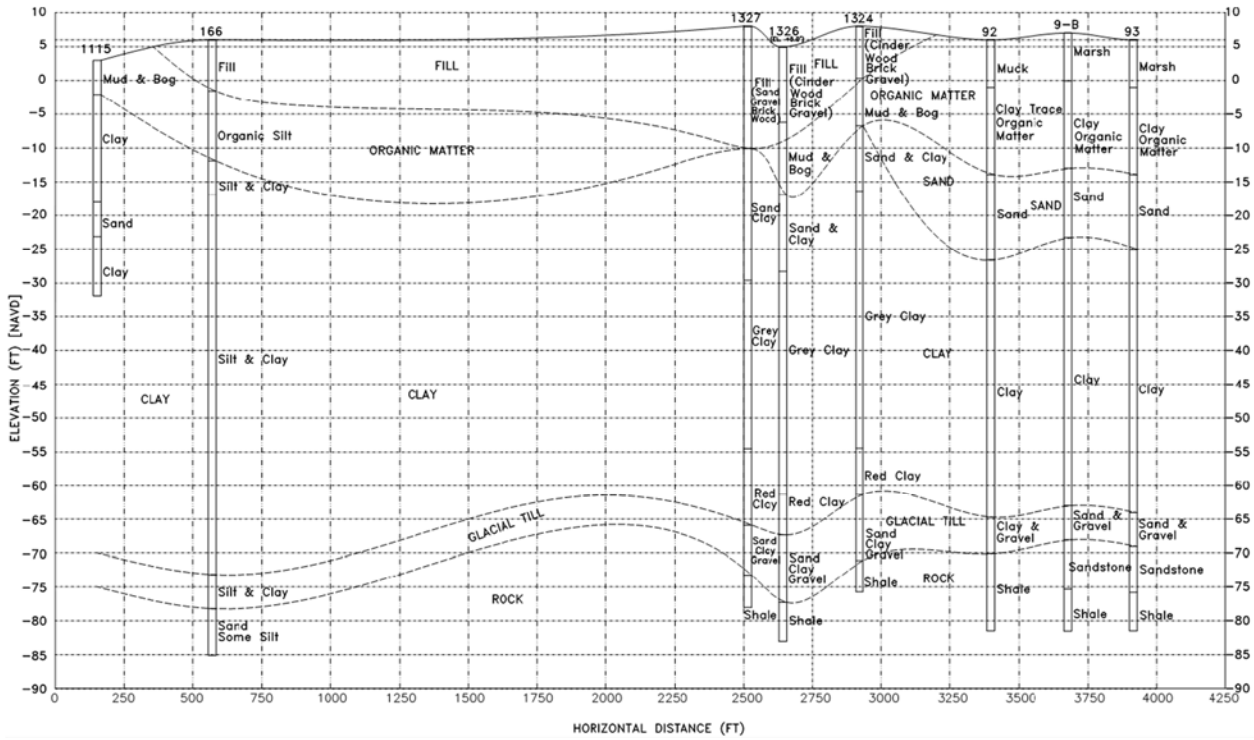


Figure C1-6: Generalized Subsurface Profile at Section 4 – 4’

Table C1-4: Representative Stratification and Recommended Material Properties for Soil Area 4

Stratum No.	Top Elevation (ft)	Bottom Elevation (ft)	Mat-erial	Unit Weight, γ (lb/ft³)	Friction Angle, ϕ (degree)		Cohesion, c (lb/ft³)	k=Hydraulic Conductivity kh=kv (cm/sec)
1	Ground Surface Elevation	-12	Organic clay	85	Short term	0	200	1.0×10^{-4} to 1.0×10^{-5}
					Long term	20	0	
2	-12	-65	Clay	110	Short term	0	300	1.0×10^{-4} to 1.0×10^{-5}
					Long term	22	0	
3	-65	-70	Glacial till	130	36		0	5.02×10^{-4} to 5.02×10^{-5}
4	-60 to -75	N/A	Bedrock	N/A	N/A	N/A	N/A	N/A

N/A = not applicable.

2.5 Soil Area 5

Soil profile represented by Section 5-5’, shown in **Figure C1-7**: , was used to prepare the representative stratification and recommended material properties for Soil Area 5, which are presented in **Table C1-5.**

The properties material were selected based on historical borings classification, engineering judgment and existing laboratory test performed on similar soils from a nearby project site.

As shown in **Figure C1-5**: , a portion of Section G-G' is located in Soil Area 5 and in general, shows similar stratification as Section 5-5'.

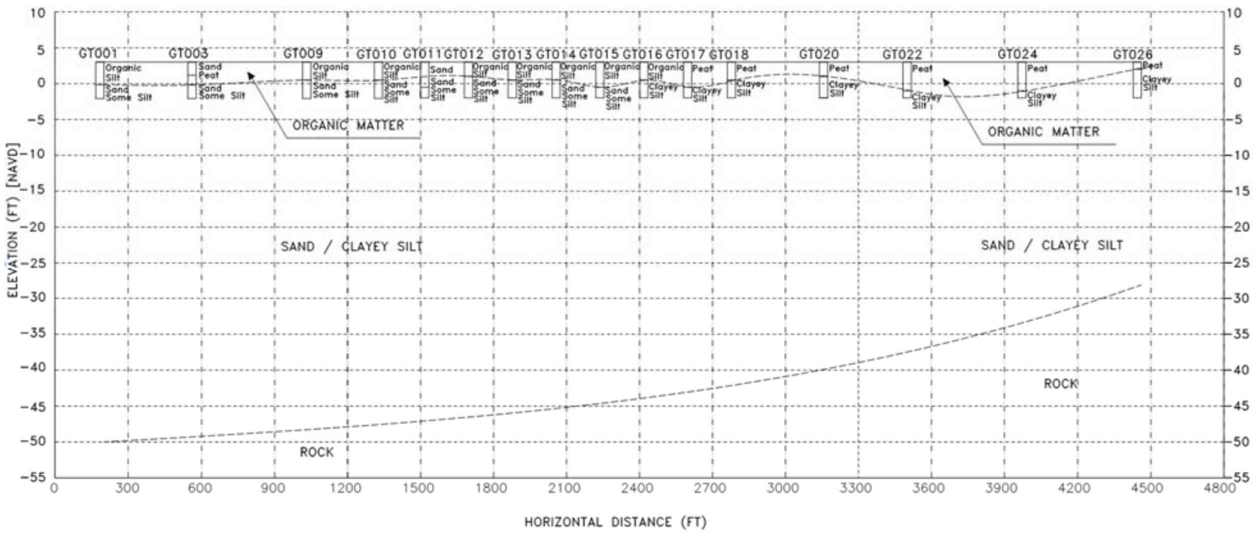


Figure C1-7: Generalized Subsurface Profile at Section 5 – 5'

Table C1-5: Representative Stratification and Recommended Material Properties for Soil Area 5

Stratum No.	Top Elevation (ft)	Bottom Elevation (ft)	Mat-erial	Unit Weight, γ (lb/ft³)	Friction Angle, ϕ (degree)		Cohesion, c (lb/ft²)	k=Hydraulic Conductivity kh=kv (cm/sec)
1	Ground Surface Elevation	0	Peat	65	0		200	1.0×10^{-3} to 1.0×10^{-4}
2	0	-40	Clayey silt	110	Short term	0	300	2.01×10^{-4} to 2.01×10^{-5}
					Long term	22	0	
3	-20 to -45	N/A	Bedrock	N/A	N/A	N/A	N/A	N/A

N/A = not applicable.

2.6 Soil Area 6

Soil profile represented by Section 6-6', shown in **Figure C1-8**: , was used to prepare the representative stratification and recommended material properties for Soil Area 6, which are presented in **Table C1-6**. The properties materials were selected based on historical boring with SPT N-values, engineering judgment and correlations with shear strength.

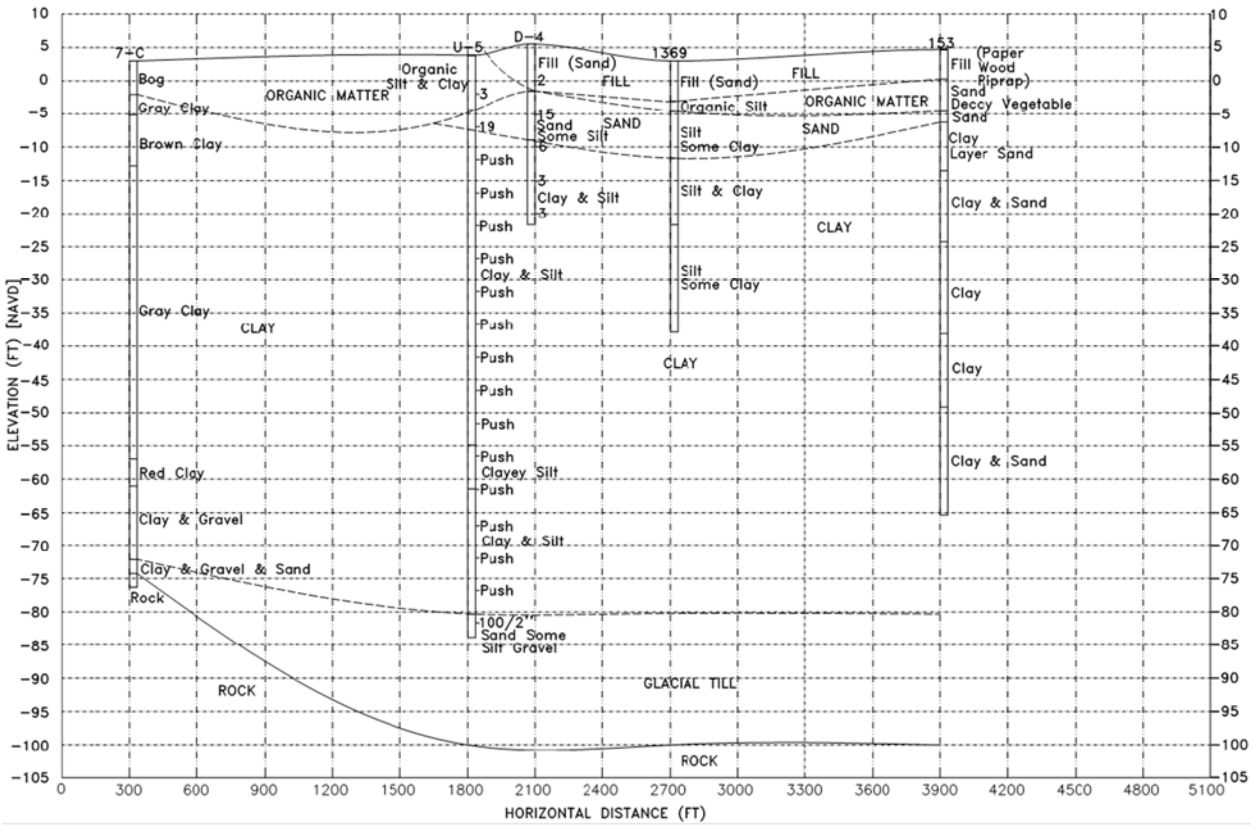


Figure C1-8: Generalized Subsurface Profile at Section 6 – 6'

Table C1-6: Representative Stratification and Recommended Material Properties for Soil Area 6

Stratum No.	Top Elevation (ft)	Bottom Elevation (ft)	Mat-erial	Unit Weight, γ (lb/ft^3)	Friction Angle, ϕ (degree)		Cohesion, c (lb/ft^2)	k=Hydraulic Conductivity kh=kv (cm/sec)
1	Ground Surface Elevation	-7	Organic clay	85	Short term	0	200	1.0×10^{-4} to 1.0×10^{-5}
					Long term	20	0	
2	-7	-75	Clay	110	Short term	0	300	1.0×10^{-4} to 1.0×10^{-5}
					Long term	22	0	
3	-75	-85	Glacial till	130	36		0	5.02×10^{-4} to 5.02×10^{-5}
4	-75 to -100	N/A	Bedrock	N/A	N/A	N/A	N/A	N/A

N/A = not applicable.

2.7 Soil Area 7

Soil profile at Section 7-7’, shown in **Figure C1-9**: , was used to prepare the representative stratification and recommended material properties for Soil Area 7, which are presented in **Table C1-7**: . The properties material were selected based on historical borings classification, engineering judgment and existing laboratory test performed on similar soils from a nearby project site.

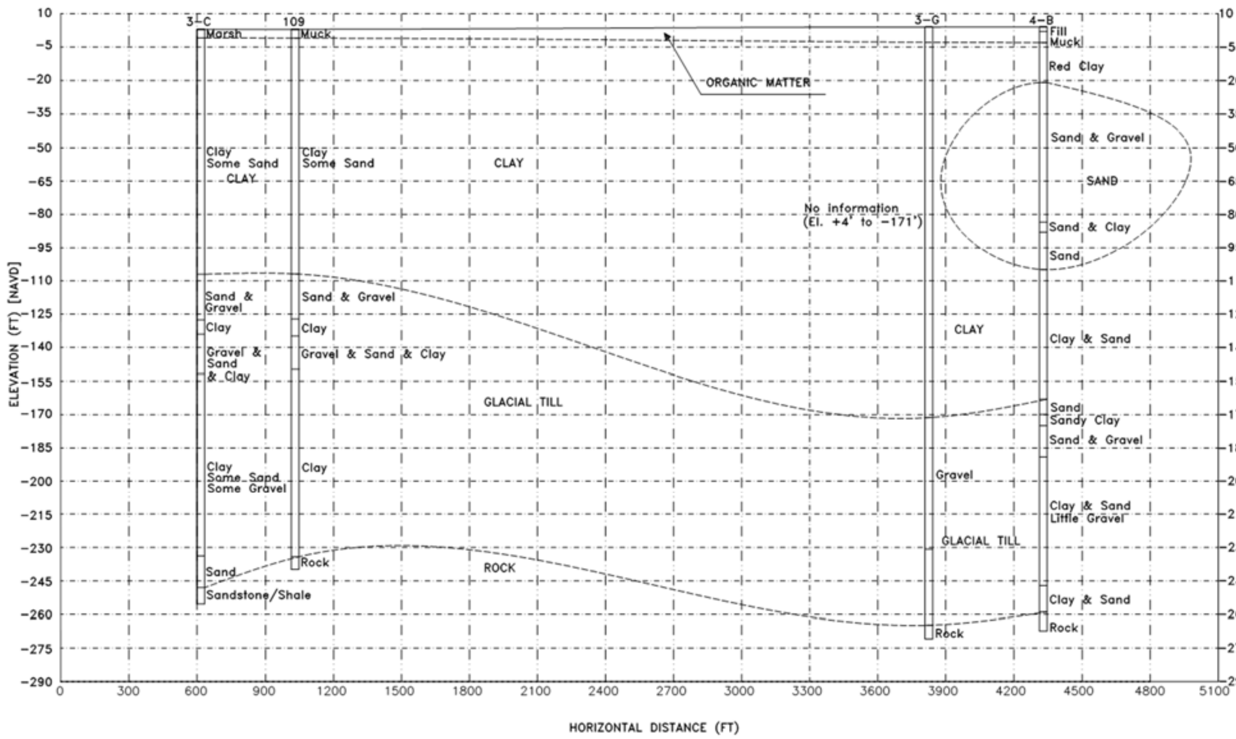


Figure C1-9: Generalized Subsurface Profile at Section 7 – 7’

Table C1-7: Representative Stratification and Recommended Material Properties for Soil Area 7

Stratum No.	Top Elevation (ft)	Bottom Elevation (ft)	Mat-erial	Unit Weight, γ (lb/ft³)	Friction Angle, ϕ’ (degree)		Cohesion, c’ (lb/ft²)	k=Hydraulic Conductivity kh=kv (cm/sec)
1	Ground Surface Elevation	-4	Organic clay	85	Short term	0	200	1.0 × 10⁻⁴ to 1.0 × 10⁻⁵
					Long term	20	0	
2	-4	-140	Clay	110	Short term	0	300	1.0 × 10⁻⁴ to 1.0 × 10⁻⁵
					Long term	22	0	
3	-140	-245	Glacial till	130	36		0	5.02 × 10⁻⁴ to 5.02 × 10⁻⁵

4	- 230 to - 260	N/A	Bedrock	N/A	N/A	N/A	N/A	N/A

N/A = not applicable.

3.0 Earth Levee

The earth levee alternative was initially considered for all Soil Areas. Prior to the construction of levees, the upper soil must be inspected down to 6-foot depth by excavating trenches. If the existing material is not suitable for construction, it must be replaced by proper structural fill. Slope stability, seepage, and settlement analysis were performed for the levees.

3.1 Slope Stability and Seepage Analysis

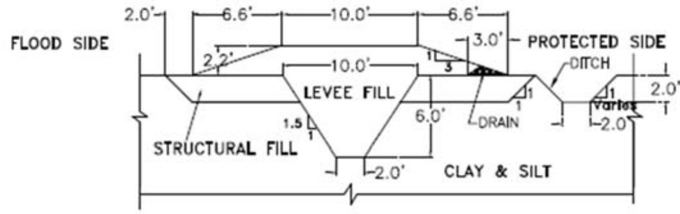
The slope stability and seepage analyses were performed following the guidelines in USACE, *Design and Construction of Levees*, Engineer Manual (EM) 1110-2-1913 (USACE 2000). The analyses were performed for levees with 2.2 feet, 4.4 feet, 6.6 feet and 8.8 feet height (2 feet, 4 feet, 6 feet and 8 feet plus settlement) in Soil Areas 1 to 3, and levees with 2.6 feet, 4.9 feet, 7.2 feet and 9.8 feet height (2 feet, 4 feet, 6 feet and 8 feet plus settlement) in Soil Areas 4 to 7 (see **Section 3.2** for settlement estimates).

Construction of levees with 7.2 feet (6 feet plus settlement) and 9.8 feet (8 feet plus settlement) height in Soil Areas 4 to 7 will require an excessive volume of existing soils to be replaced by structural fill due to the presence of soft/organic material at these Soil Areas based on the historical data. In order to avoid this problem, installation of sheet piles on both sides of the levees is recommended. Details of sheet pile analyses for lateral load for the 7.2 feet and 9.8 feet levees are presented in **Section 3.3**.

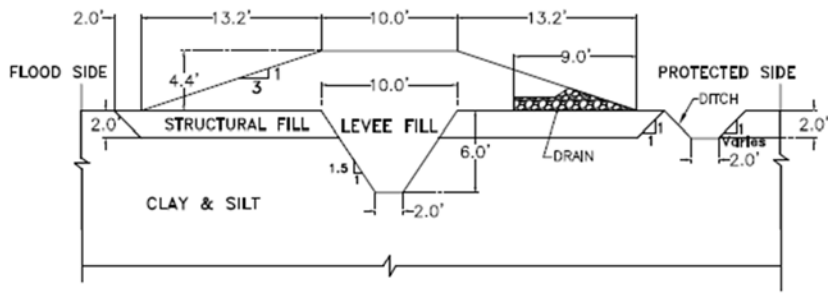
Cross-sections of the levees in Soil Areas 1 to 3 and Soil Areas 4 to 7 are presented in **Figures C1-10** and **C1-11**, respectively. Underlying soils properties were selected based on material description, engineering judgement, SPT N –values from historical boring logs and results of laboratory tests performed on similar soils from a nearby project site. A summary of properties of the proposed levee materials and underlying soils used in the stability and seepage analyses is presented in **Table C1-8**.

Table C1-8: Properties of Levee Materials and Subsurface Soils

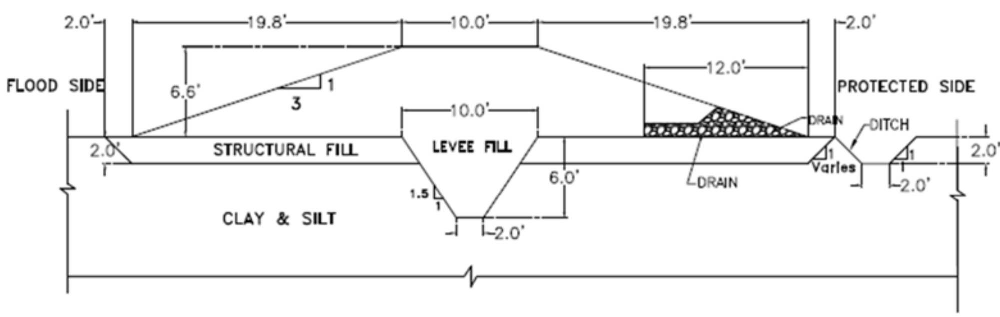
Material	Unit Weight, γ (lb/ft^3)	Friction Angle, ϕ (deg.)		Cohesion, c (lb/ft^2)	Hydraulic Conductivity, k kh=kv(cm/sec)
Soil Areas 1 to 7					
Levee Fill	120	Short Term	15	200	2.01×10^{-5}
		Long Term	25	50	
Structural Fill	120	N/A	32	0	5.02×10^{-4}
Drain	120	N/A	32	0	1.0×10^{-2}
Soil Areas 1 to 3					
Clay and Silt	110	Short Term	0	500	2.01×10^{-4}
		Long Term	25	0	
Soil Areas 4 to 7					
Organic Clay	85	Short Term	0	200	1.0×10^{-4}
		Long Term	20	0	
Clay	110	Short Term	0	300	1.0×10^{-4}
		Long Term	22	0	



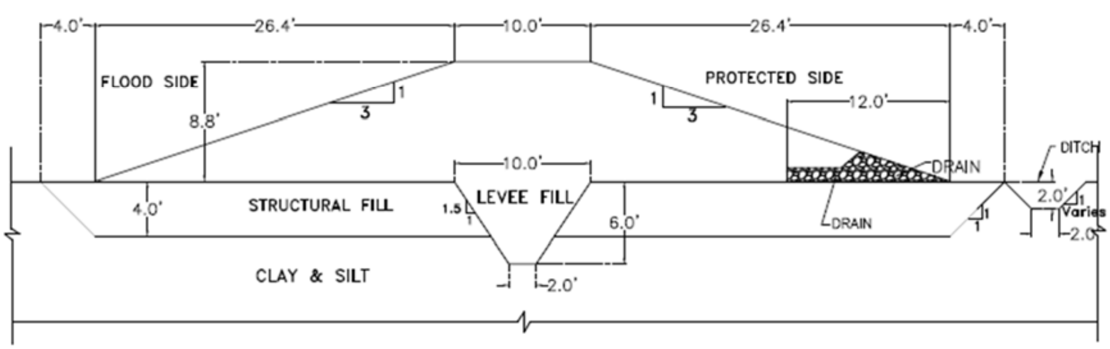
2.2 FT (2 FT + 0.2 FT SETTLEMENT) LEVEE SECTION FOR SOIL AREAS 1 TO 3



4.4 FT (4 FT + 0.4 FT SETTLEMENT) LEVEE SECTION FOR SOIL AREAS 1 TO 3



6.6 FT (6 FT + 0.6 FT SETTLEMENT) LEVEE SECTION FOR SOIL AREAS 1 TO 3



8.8 FT (8 FT + 0.8 FT SETTLEMENT) LEVEE SECTION FOR SOIL AREAS 1 TO 3

Figure C1-10: Cross-Section of Levees for Soil Areas 1 to 3

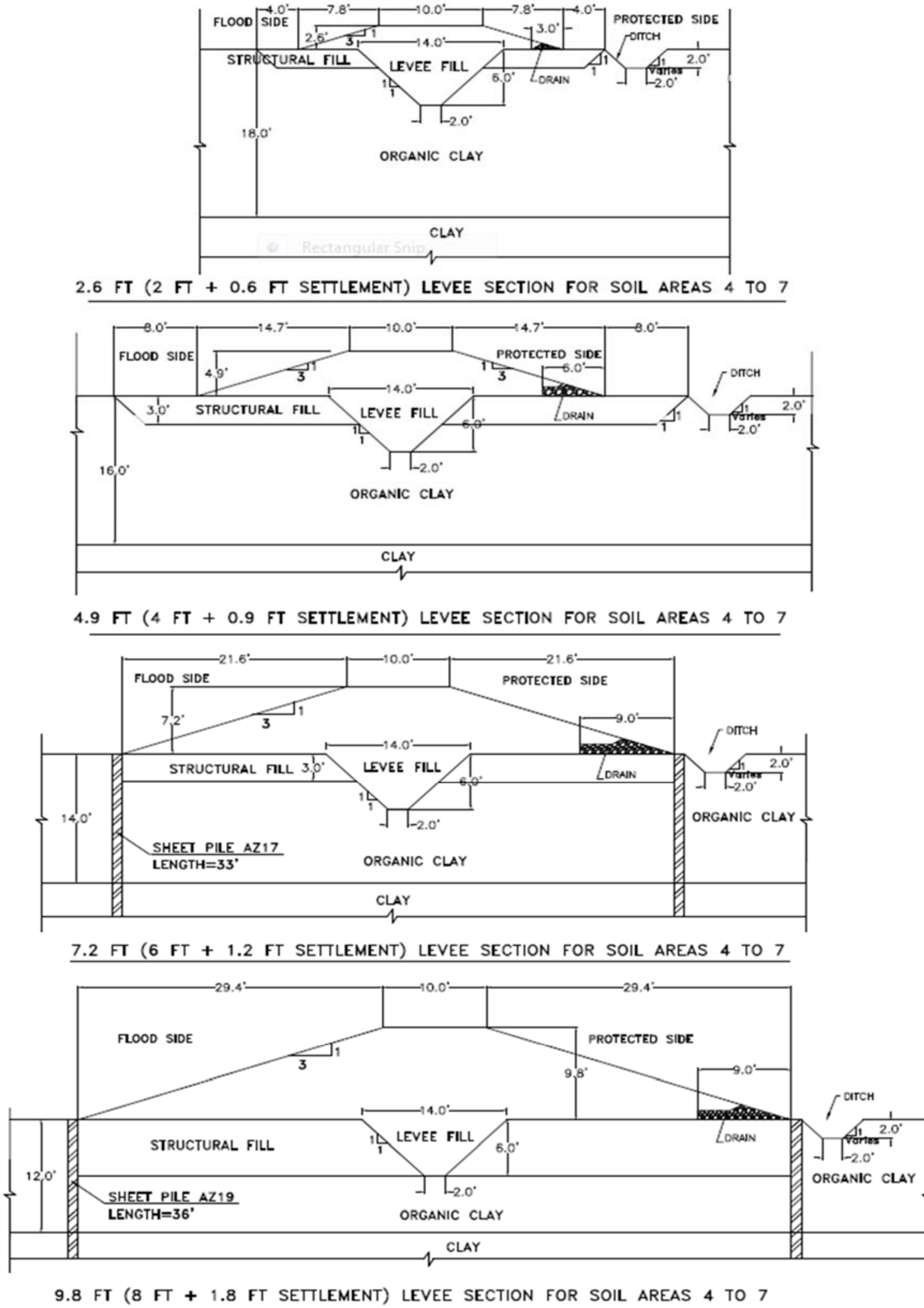


Figure C1-111: Cross-Section of Levees for Soil Areas 4 to 7

The analyses were performed using the commercially available software GeoStudio 2007 SEEP/W© and SLOPE/W© by Geoslope International, Ltd. Based on the requirements in the USACE guidance for the design and construction of levees, the following four loading cases were considered in the analyses (USACE, 2000):

- Case I: End of Construction;
- Case II: Steady Seepage from Full Flood Stage, fully developed phreatic surface;
- Case III: Rapid Drawdown from Full Flood Stage; and,
- Case IV: Seismic Loading, no flood conditions.

Spencer's procedure for the method of slices was used to determine the minimum factor of safety (FOS) values and the controlling/critical slip surface associated with the FOS values for all four loading cases.

For Case I stability analysis, groundwater was modeled at elevation +1.0 feet (NAVD 88). Considering that Case I is a short-term scenario, undrained strength parameters were used for cohesive soil layers.

Case II was analyzed at flood level elevation of +8.0 feet (NAVD 88) to estimate the conditions at a full flood stage. Seepage analysis was performed for this case to estimate flow and exit gradient characteristics and to develop the phreatic surface for use in the stability analyses.

Case III was performed to estimate the conditions when the water level adjacent to the riverside slope lowers rapidly. This case generally has a greater influence on soils with lower permeability since the dissipation of pore pressure is slower in these materials. For this case, the phreatic surface was conservatively modeled as in Case II while keeping the flood level lowered along the riverside slope to the toe.

Case IV utilizes the pseudo-static slope stability analysis. The piezometric line was modeled the same as in Case I. It is standard practice to consider the pseudo-static coefficient as 2/3 of PGA/g. Accordingly, a pseudo-static coefficient of 0.16 (2/3×0.25g/g) was estimated based on the national ground motion maps from the American Association of State Highway and Transportation Officials (AASHTO) (2014), *LRFD Bridge Design Specifications* for approximate return period of 1,000 years and used in the analysis (AASHTO 2014).

A summary of the calculated FOS and the corresponding required minimum FOS values are listed in **Table C1-9**, which indicates that the calculated FOS values fulfil the minimum requirements. The details of all stability and seepage analysis results from GeoStudio are included as **Attachment C1-B**.

Table C1-9: Results of the Slope Stability Analysis for Levees

Soil Areas	Analysis Case	Required Minimum Factor of Safety	Calculated Factor of Safety			
			2.2 ft Levee	4.4 ft Levee	6.6 ft Levee	8.8 ft Levee
1 to 3	Case I: End of Construction	1.3	4.1	3.2	2.8	2.0
	Case II: Steady State - Full Flood Stage	1.4	2.1	1.7	1.6	1.5
	Case III: Rapid Drawdown	1.2	2.3	1.6	1.4	1.2
	Case IV: Seismic Load	1.0	1.8	1.5	1.2	1.0
			2.6 ft Levee	4.9 ft Levee	7.2 ft Levee *	9.8 ft Levee *
4 to 7	Case I: End of Construction	1.3	3.1	1.8	1.8	1.4
	Case II: Steady State - Full Flood Stage	1.4	1.4	1.4	1.7	1.5
	Case III: Rapid Drawdown	1.2	1.5	1.5	1.5	1.3
	Case IV: Seismic Load	1.0	1.5	1.3	1.0	1.0

*Without considering sheet piles (factor of safety will increase if sheet piles are considered)

The maximum exit gradient and flow rate for the steady state seepage at full flood stage, are presented in **Table C1-10**. The estimated maximum exit gradients are lower than the allowable critical gradients, typically 0.5 to 0.8, according to the USACE guidance for the design and construction of levees (USACE 2000).

Table C1-10: Results of the Steady State Seepage Analysis for Levees

Soil Areas	Criteria	2.2 ft Levee	4.4 ft Levee	6.6 ft Levee	8.8 ft Levee
1 to 3	Maximum Exit Gradient	0.06	0.12	0.16	0.20
	Flow Rate (gal/day/ft)	8.7	15.5	20.4	26.5
		2.6 ft Levee	4.9 ft Levee	7.2 ft Levee*	9.8 ft Levee*
4 to 7	Maximum Exit Gradient	0.04	0.08	0.11	0.12
	Flow Rate (gal/day/ft)	4.8	9.3	12.7	14.3

*Without considering sheet piles (exit gradient and flow rate will decrease if sheet piles are considered)

3.2 Consolidation Settlement

The primary and secondary consolidation settlement of the cohesive (clayey) soil layers below the structural fill were calculated according to the general guidelines in the USACE guidance for the design and construction of levees (USACE 2000). Details of the primary and secondary consolidation settlement calculations for levees are provided in **Attachment C1-C**. A summary of the settlement estimates is presented in **Table C1-11**.

In the settlement analysis, the compressible soil layers were divided into sub-layers of 2 feet thicknesses for obtaining better accuracy of calculations. Increase in vertical stresses at the mid depth of each sub-layer due to the weight of levee was calculated using the elastic stress distribution methods outlined in the *Principles of Geotechnical Engineering* (Das 2006).

Table C1C1-11: Results of the Consolidation Settlement Analysis for Levees

Soil Areas	Criteria	Settlement (ft=feet)			
		2.2 ft Levee	**4.4 ft Levee**	**6.6 ft Levee**	**8.8 ft Levee**
1 to 3	Primary Consolidation	0.083	0.250	0.50	0.583
	Secondary Consolidation	0.166	0.166	0.166	0.166
	Total	0.25	0.416	0.666	0.750
		2.6 ft Levee	**4.9 ft Levee**	**7.2 ft Levee**	**9.8 ft Levee**
4 to 7	Primary Consolidation	0.416	0.750	1.00	1.66
	Secondary Consolidation	0.166	0.166	0.166	0.166
	Total	0.583	0.916	1.166	1.833

The primary consolidation parameters (e.g., initial void ratio and compression index for the clay and silt layer and the clay layer) were assumed from the results of consolidation tests performed on similar soils from a nearby sites (AECOM 2016). The primary consolidation parameters for the organic clay layer were assumed from the results of consolidation test performed on organic soil from a nearby site reported in the USACE General Design Memorandum (1995), Passaic River Flood Damage Reduction (USACE 1995). All three clayey soil layers were assumed to be normally consolidated.

Secondary consolidation parameters for the organic clay, clay and silt, and clay layers were assumed from the results of consolidation tests performed on similar soils from the nearby sites (AECOM 2016). Secondary consolidation settlement was calculated for a 50-year period after the construction of the levees.

3.3 Sheet Pile Analysis

Lateral loads on the sheet piles for the 7.2 and 9.8 feet levees in Soil Areas 4 to 7 were analyzed using the commercially available software Shoring Suite V8 by CivilTech Software. Wedge analysis (Culmann) method was used to estimate the active and passive earth pressures acting on the sheet piles. For each levee, the horizontal line force acting on the sheet pile was determined from the critical slice information from the slope stability analysis described in **Section 3.1**. Output from Shoring Suite is included as **Attachment C1-D**. A summary of the results of the sheet pile analysis are presented in **Table C1-12**.

Table C1-12: Results of the Sheet Pile Analysis for 7.2 and 9.8 feet Levees in Soil Areas 4 to 7

Levee Height (ft)	Sheet Pile Type	Required Minimum Pile Length (ft)	Required Minimum Section Modulus (in^3/ft)	Pile Section Modulus (in^3/ft)	Pile Top Deflection (in)
7.2	AZ17	33	27.0	31.0	1.46
9.8	AZ19	36	34.0	36.1	2.23

4.0 Double Sheet Pile Wall

As an alternative to the levee or floodwall with sheet piles for 6 and 8 feet flood height in Soil Areas 4 to 7, a double sheet pile wall was considered. A double sheet pile wall structure consists of two steel sheet piles with tops connected by struts and the space between the sheet piles filled with sand. No surcharge load was considered for the design; therefore, there will be not vehicle access to the top of wall. Cross-sections of the 6 feet and 8 feet double sheet pile walls with maximum 10 feet spacing are presented in **Figures C1-12** and **C1-13**, respectively.

The double sheet pile walls were analyzed using the commercially available software PYWall by Ensoft, Inc. Long-term (drained) soil properties of the organic clay and clay layers were conservatively (higher active pressure on wall) used for the analysis. The following four loading cases were considered: 1) no flood condition; 2) full flood stage; 3) rapid drawdown from full flood stage; and 4) seismic loading.

A summary of the results of the PYWall analysis is presented in **Table C1-13**. The analysis indicates that minimum section sizes of AZ19 and AZ26 are required for 6 feet and 8 feet double sheet pile walls, respectively. Plots of lateral defection, bending moment and shear force with depths of sheet piles are included as **Attachment C1-E**. As shown in **Attachment C1-E**, lateral deflection at the bottom of the sheet piles is almost zero for all cases. Output from PYWall analysis for 8 feet double sheet pile wall in Soil Area 4 is included as **Attachment C1-F**.

Considering that the exit gradient and flow rate for the I-wall and T-wall alternatives with much shorter sheet piles (see **Sections 5.2.2** and **5.2.3**) were within acceptable limits, seepage is not a likely concern for the double sheet pile walls.

Table C1-13: Results of the Double Sheet Pile Wall Analysis for Soil Areas 4 to 7

Analysis Case	Wall Height (ft)	Sheet Pile Section	Sheet Pile Length	Allowable Moment Capacity (kip-	Maximum Deflection (in)	Maximum Moment (kip-in)
No Flood Condition	6	AZ19	30	3,996	0.03	265
Full Flood Stage					0.28	312
Rapid Drawdown					0.03	124
Seismic Load					0.40	345
No Flood Condition	8	AZ26	35	5,558	0.08	428
Full Flood Stage					0.52	648
Rapid Drawdown					0.04	200
Seismic Load					0.77	620

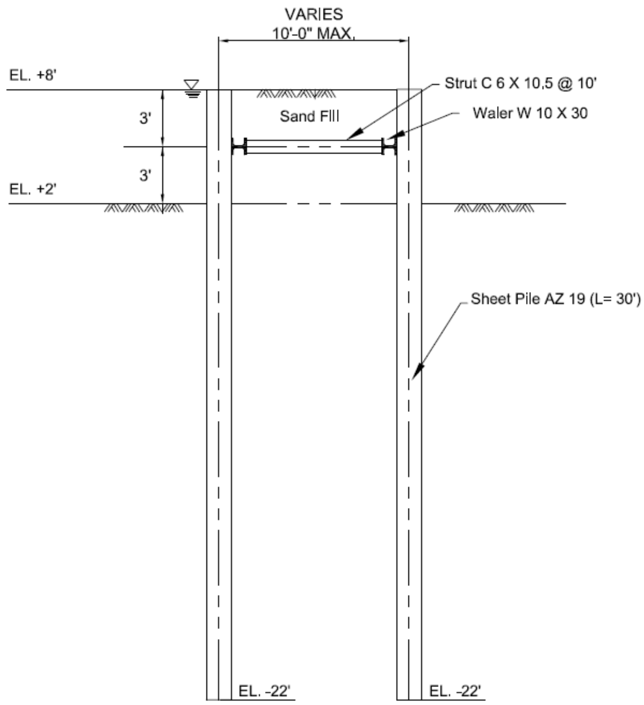


Figure C1-12: Cross-section of 6 ft Double Sheet Pile Wall for Soil Areas 4 to 7

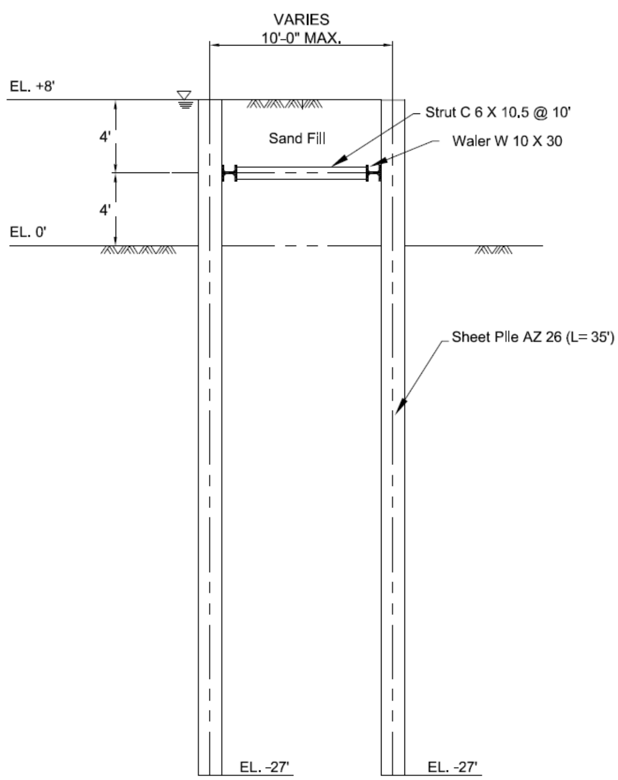


Figure C1-23: Cross-section of 8 ft Double Sheet Pile Wall for Soil Areas 4 to 7

5.0 Flood Wall

The floodwall alternative was considered for all Soil Areas. For Soil Areas 1 to 3 the shallow foundations were considered due to present of suitable material based on the historical borings. However, the upper 6 feet of soil must be inspected prior to construction. For Soil Areas 4-7 deep foundations were considered due to the presence of unsuitable material such as organics and peats. Therefore, a floodwall with deep foundation system is required for these areas.

5.1 Soil Areas 1 to 3

T-walls on shallow foundations were considered for all wall heights for Soil Areas 1 to 3. Prior to the construction of the T-walls on shallow foundations, the upper soil layer must be inspected down to 6 feet depth by excavating trenches. If the existing material is not suitable for construction, it must be replaced by proper structural fill. Bearing capacity, consolidation settlement and seepage analysis were performed for the T-walls. Further analysis for sliding, overturning and global stability of the T-walls is performed in the structural calculations.

5.1.1 Bearing Capacity

Bearing capacities were calculated following guidelines in the USACE, Retaining the Flood Walls, EM 1110-2-250 (USACE 1989). A factor of safety of 3 was used to calculate the allowable bearing capacities. For all cases, the depth from the soil surface to the base of floodwall was assumed to be 3.5 feet or 4 feet. Cross sections of the T-walls are presented in **Figures C1-14** to **C1-17**.

Details of bearing capacity calculations for floodwalls are included as **Attachment C1-G**. A plot of allowable bearing capacities versus base width is presented in **Figure C1-18**. As shown in **Figure C1-18**,bearing capacities vary from 1.0 vary from 1.0 to 1.2 kip per feet squared in Soil Area 1, and from 0.5 to 0.6 kip per feet squared in Soil Areas 2 and 3.

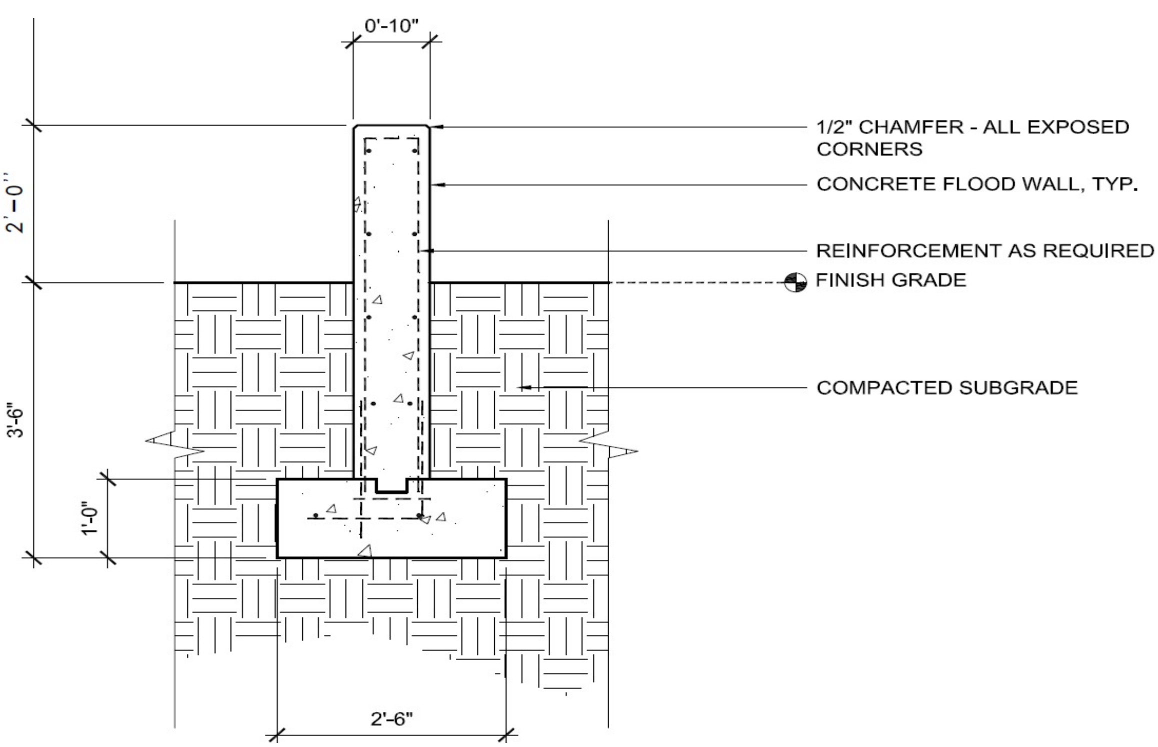


Figure C1-14: Cross-Section of 2 ft Flood Wall for Soil Areas 1 to 3

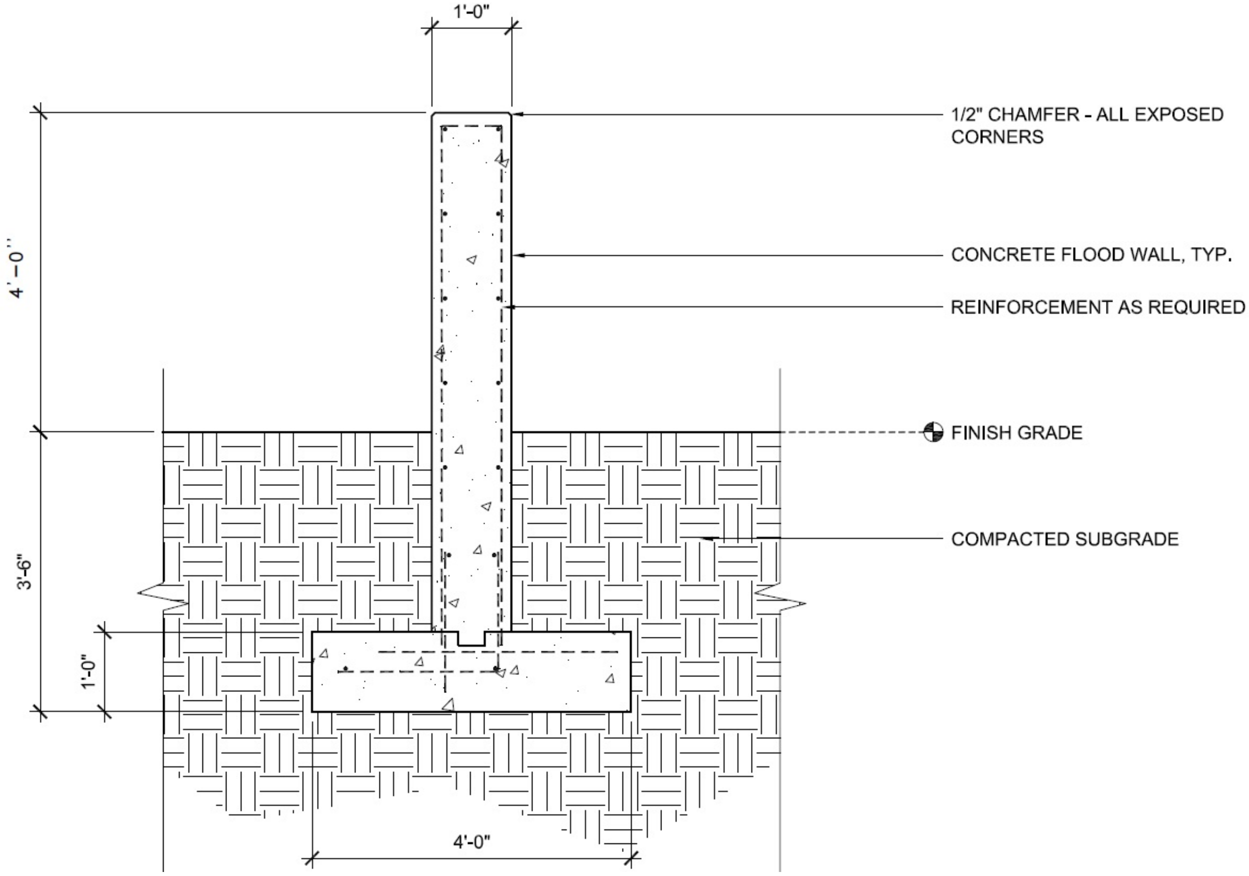


Figure C1-25: Cross-Section of 2 ft Flood Wall for Soil Areas 1 to 3

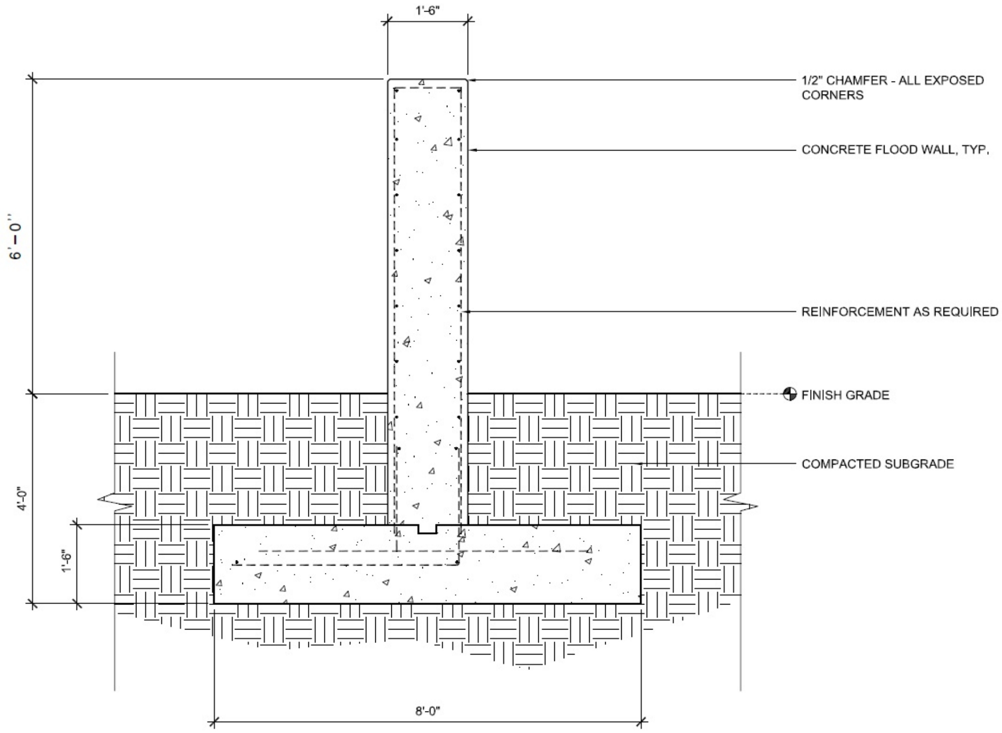


Figure C1-36: Cross-Section of 6 ft Flood Wall for Soil Areas 1 to 3

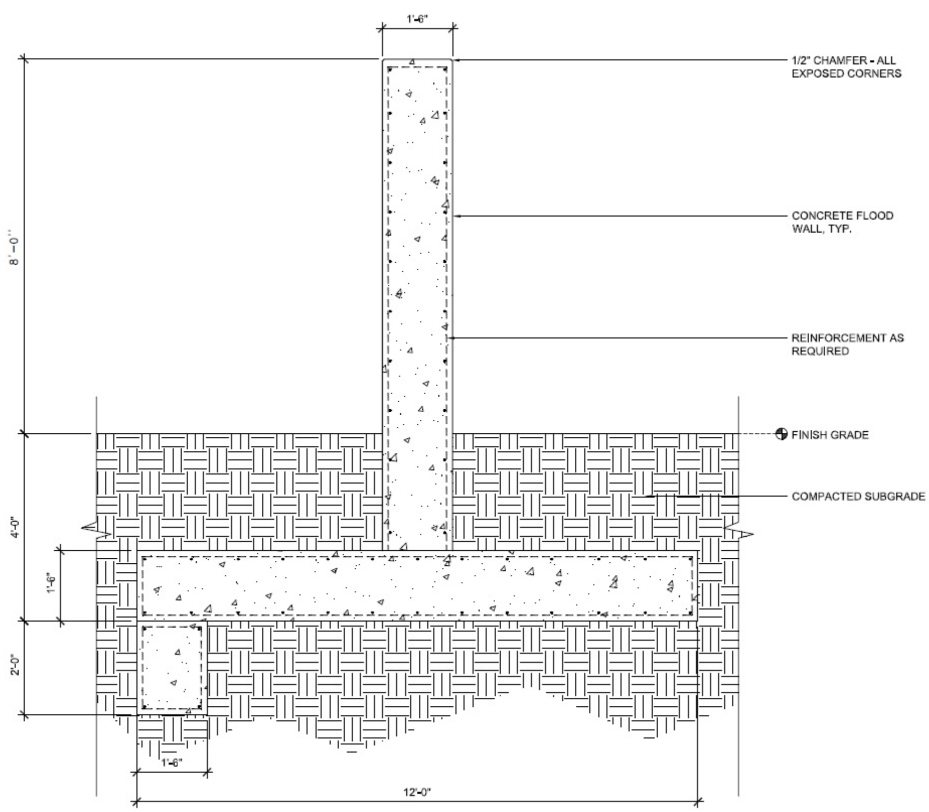
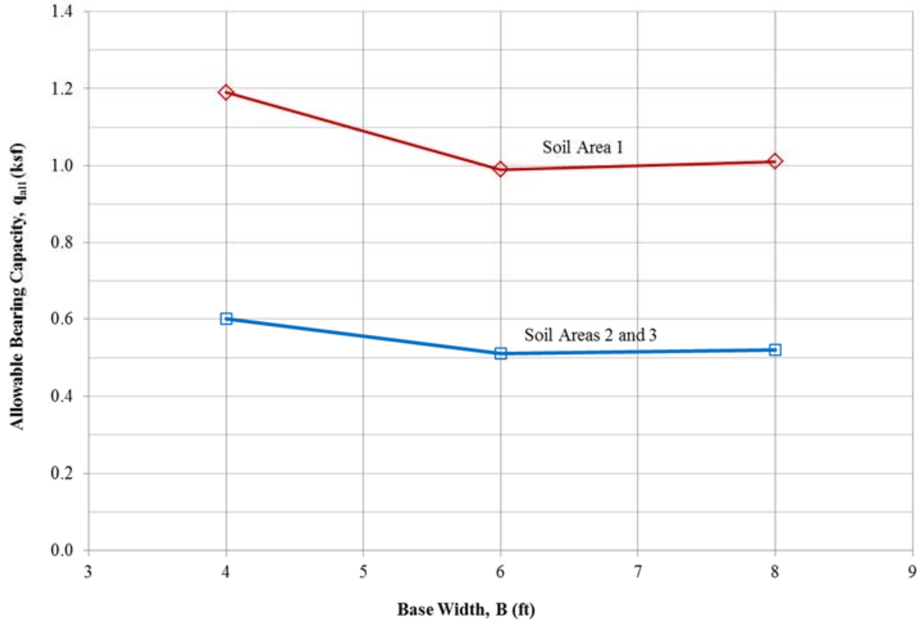


Figure C1-47: Cross-Section of 8 ft Flood Wall for Soil Areas 1 to 3



5.1.2 Figure C1-58: Variation of Allowable Bearing Capacities with Base Width of Flood Walls for Soil Areas 1 to 3Consolidation Settlement

The primary and secondary consolidation settlement of the cohesive (clayey) soil layers below the T-walls were calculated following the guidelines in USACE, Settlement Analysis, EM 1110-1-1904 (USACE 1990). The elevations of wall top and groundwater table were assumed +8 feet and +1feet, respectively. Based on the generalized subsurface profiles described in **Section 2.0**, thickness of the clayey layer in Soil Area 3 is 70 feet, which is greater than 40 feet in Soil Area 1 and 10 feet in Soil Area 2. Therefore, Soil Area 3 was conservatively selected for the settlement calculations. Details of the primary consolidation settlement calculations for flood walls are provided in **Attachment C1-H**.

The primary consolidation parameters (e.g., the initial void ratio and compression index) for the clay and silt layer were assumed from the results of consolidation tests on similar soils from a nearby site (AECOM 2016). The compressible soil layers were divided into sub-layers of 2 feet thicknesses for obtaining better accuracy of calculations. Stress distribution below the footing for uniform strip load was calculated using the method outlined in Naval Facilities Engineering Command, *Soil Mechanics Design Manual*, DM 7.01 (NAVFAC 1986). A summary of the settlement estimates are presented in **Table C1-14**.

Table C1-14: Results of the Primary Consolidation Settlement Analysis for T-walls in Soil Areas 1 to 3

Wall Height (ft)	Base Width of Wall (ft)	Settlement (in)
2	2.5	1.1
4	4.0	1.7
6	8.0	2.6
8	12.0	3.0

5.1.3 Seepage Analysis

Steady state seepage analysis at full flood stage was performed for T-walls with 2, 4, 6 and 8 ft flood height in Soil Areas 1 to 3 using GeoStudio SEEP/W© and following the guidelines in the USACE guidance on designs for retaining and flood walls (USACE, 1995). As indicated in **Section 2.0**, hydraulic conductivity of the top layer in Soil Area 3 is higher than the top layers in Soil Areas 2 and 3. Thus, Soil Area 3 was conservatively selected for the seepage analysis. Results of the seepage analysis are included as **Attachment C1-I**. The maximum exit gradient and flow rate for the T-walls at full flood stage are presented in **Table C1-15**. The estimated maximum exit gradients are lower than the allowable critical gradients, typically 0.5 to 0.8 (USACE 1989).

Table C1-15: Results of the Steady State Seepage Analysis for T-walls in Soil Areas 1 to 3

Flood Height (ft)	Maximum Exit Gradient	Flow Rate (gal/day/ft)
2	0.12	8
4	0.23	19
6	0.25	23
8	0.28	27

5.2 Soil Areas 4 to 7

I-walls were considered for 2 and 4 feet flood height for Soil Areas 4 to 7. T- and L-walls with sheet piles and driven battered steel piles or battered micropiles were considered for 6 and 8 feet flood height for Soil Areas 4 to 7.

5.2.1 I-wall

Lateral load and seepage analysis were performed for the I-walls.

5.2.1.1 Sheet Pile Analysis

I-walls were analyzed using PYWall. Long-term (drained) soil properties of the organic clay and clay layers were conservatively (higher active pressure on wall) used for the analysis. Since I-walls can have a maximum free height of 5 feet, only 2 and 5 feet high I-walls were considered (USACE 1989). A summary of I-wall analysis results for Soil Areas 4 to 7 are presented in **Table C1-16**: .

Considering a maximum allowable lateral deflection of 1 in at the top and approximately zero inches of deflection at the tip of the wall, AZ12 is recommended for the sheet piles. A minimum sheet pile length of the free height of the wall plus 10 feet is recommended. Plots of lateral defection, bending moment and shear force with depths of sheet piles are included as **Attachment C1-J**. Output from PYWall analysis for the 2 feet I-wall in Soil Area 4 is provided in **Attachment C1-K**.

Table C1-16: Results of the Sheet Pile Analysis for I-walls in Soil Areas 4 to 7

Soil Area	Sheet Pile Section	Allowable Moment Capacity (kip-in)	2 ft Wall			5 ft Wall		
			Sheet Pile Length (ft)	Maximum Deflection (in)	Maximu m Moment (kip-in)	Sheet Pile Length (ft)	Maximum Deflection (in)	Maximum Moment (kip-in)
4	AZ12	1,934	14	0.039	33	20	0.25	256
5	AZ12	1,934	14	0.035	32.5	20	0.22	248
6	AZ12	1,934	14	0.036	34	20	0.24	264
7	AZ12	1,934	14	0.038	34	20	0.24	256

5.2.1.2 Seepage Analysis

Steady state seepage analysis at full flood stage was performed for 2 and 4 feet I-walls in Soil Areas 4 to 7 using GeoStudio SEEP/W© and following the guidelines in USACE guidance on retaining and flood walls (USACE 1989). Results of the seepage analysis are in **Attachment C1-L**.

The maximum exit gradient and flow rate for the I-walls at full flood stage are presented in **Table C1-17**. The estimated maximum exit gradients are lower than the allowable critical gradients, typically 0.5 to 0.8 (USACE 1989).

Table C1-17: Results of the Steady State Seepage Analysis for I-walls in Soil Areas 4 to 7

Parameter	Soil Area	2 ft I-wall	4 ft I-wall
Maximum Exit Gradient	4	0.07	0.11
	5	0.05	0.10
	6	0.07	0.11
	7	0.07	0.12
Flow Rate (gal/day/ft)	4	2.7	4.8
	5	2.8	5.2
	6	2.6	4.8
	7	2.6	5.1

5.2.2 T-wall

Seepage and pile load analysis were performed for the T-walls with sheet piles and deep foundations. Unlike the I-walls, sheet piles in T-walls were used only for seepage control. Thus, no load analysis for the sheet piles is necessary.

5.2.2.1 Seepage Analysis

Steady state seepage analysis at full flood stage was performed for 6 and 8 feet T-walls in Soil Areas 4 to 7 following the same procedure used for I-walls. Cross sections of the 6 and 8 feet T-walls are presented in **Figures C1-19** and **C1-20**, respectively.

The seepage analysis results are provided as **Attachment C1-M**. The required minimum sheet pile lengths for T-walls based on the seepage analysis are presented in **Table C1-18**. To avoid any possible drivability issues, a minimum section size of AZ12 is recommended for the sheet piles.

Table C1-18: Required Minimum Sheet Pile Lengths for T-walls in Soil Areas 4 to 7

Soil Area	Sheet Pile Section	Sheet Pile Length (ft)	
		6-ft Wall	8-ft Wall
4	AZ12	12	10
5	AZ12	10	10
6	AZ12	10	10
7	AZ12	10	10

The maximum exit gradient and flow rate for the T-walls with sheet piles at full flood stage are presented in **Table C1-19**. The estimated maximum exit gradients are lower than the allowable critical gradients of 0.5 to 0.8 (USACE 1989).

Table C1-19: Results of the Steady State Seepage Analysis for T-walls in Soil Areas 4 to 7

Parameter	Soil Area	T-wall	
		6 ft I-wall	8 ft I-wall
Maximum Exit Gradient	4	0.12	0.18
	5	0.19	0.18
	6	0.13	0.18
	7	0.13	0.18
Flow Rate (gal/day/ft)	4	6.1	8.8
	5	9.6	13.4
	6	6.6	8.8
	7	6.6	8.8

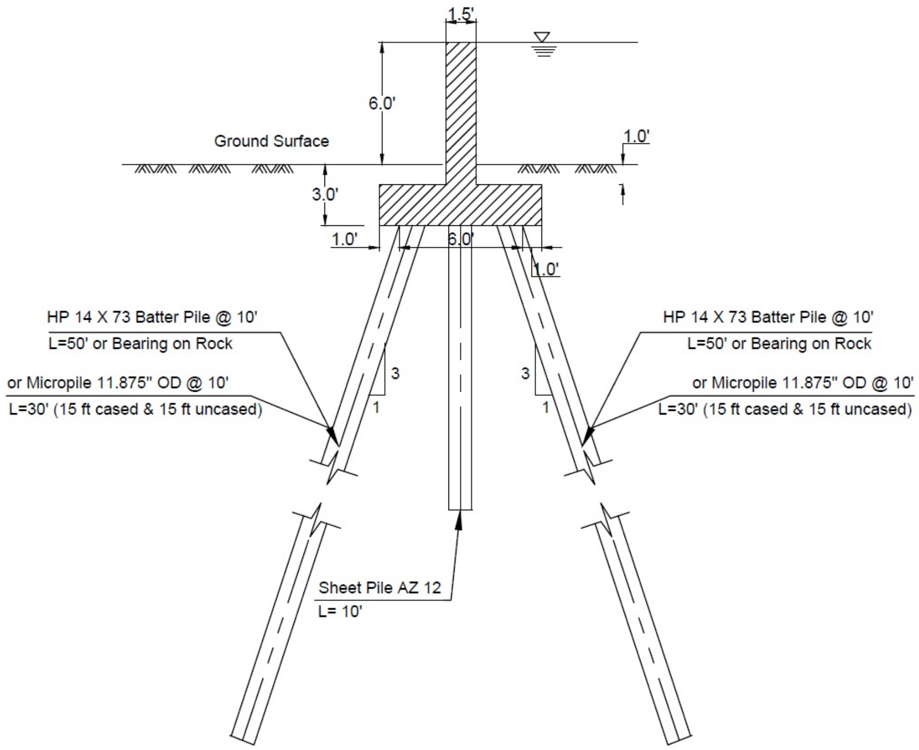


Figure C1-69: Cross-section of 6 feet T-wall for Soil Areas 4 to 7

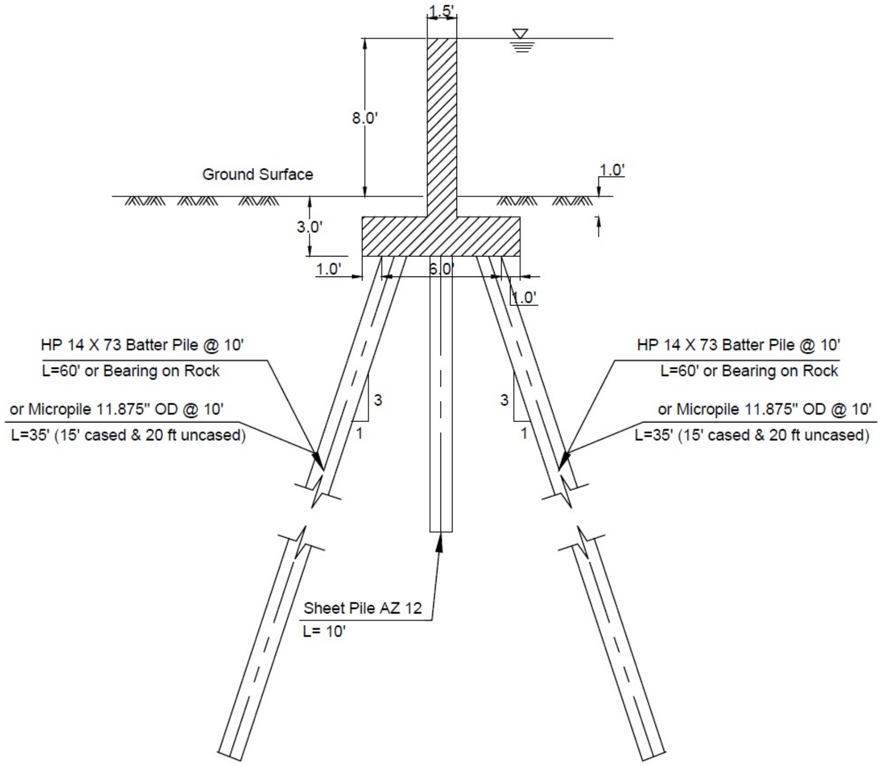


Figure C1-7: Cross-section of 8 feet T-wall for Soil Areas 4 to 7

5.2.2.2 Pile Group Analysis

Pile group analyses were performed for the driven battered steel piles and the battered micropiles for 6 and 8 feet T-walls in Soil Areas 4 to 7 using the commercially available software GROUP v2016 by Ensoft, Inc. A batter slope corresponding to three vertical units to one horizontal unit (3V:1H) was used for both the driven piles and the micropiles. Pile spacing was assumed to be 10 feet in the longitudinal direction of the T-walls. A 6 feet by 10 feet and an 8 feet by 10 feet pile cap with 2 batter piles (one on the landside and another on the riverside of the T-wall) were considered for the 6 and 8 feet T-walls, respectively. Pile size and length were selected based on the results of the pile axial capacity analysis (see **Section 5.2.4**).

The vertical loads on the pile cap consisted of weight of the concrete wall, weight of the compacted soil, water weight and buoyancy. The lateral load consisted of horizontal water pressure from the flood side. Moment was caused by water pressure from the flood side and buoyancy. Horizontal water pressure from the landside was conservatively ignored in the lateral load and moment calculation. The results from the GROUP analysis for T-walls are presented in

Table C1-20. Output from GROUP analysis for the 8 feet T-wall in Soil Areas 4 to 7 is included as **Attachment C1-N**.

Table C1-20: Results of the Pile Group Analysis for the Driven Battered Steel Piles and Battered Micropiles for T-walls in Soil Areas 4 to 7

Pile Type	Flood Height (ft)	Pile Length (ft)	Pile No.	Compression (kip)	Tension (kip)	Moment (kip-in)	Shear (kip-in)	Deflection (in)
HP 14 × 73 Steel Pile	6	50	1*	22	-	870	9	0.16
			2*	-	1.1	882	9	0.16
	8	60	1	31	-	1,455	14	0.30
			2	-	6	1,468	14	0.31
11.875 in OD Micropile	6	30	1	21	-	834	10	0.32
			2	-	0.6	853	10	0.34
	8	35	1	30	-	1,417	14	0.61
			2	-	5	1,436	14	0.63

*Piles No. 1 and 2 are on the riverside and landside of the T-wall, respectively.

5.2.3 L-wall

L-walls with sheet piles supported by driven battered (5V:2H) steel piles or battered (5V:2H) micropiles for 6 and 8 ft flood height were analyzed using PYWall. Cross sections of the 6 and 8 ft L-walls are presented in **Figures C1-21** and **C1-22**, respectively.

Long-term (drained) soil properties of the organic clay and clay layers were conservatively (higher active pressure on wall) used for the analysis. The supporting piles were modeled as lateral springs in PYWall to estimate the compression in piles.

A summary of the results of the L-wall analysis are presented in

Table C1-21. Size and length of the supporting piles were selected based on the results of the pile axial capacity analysis (see **Section 5.2.4**). Plots of lateral defection, bending moment and shear force with depths of sheet piles are provided as **Attachment C1-O**. As shown in **Attachment C1-O**, lateral deflection at the bottom of the sheet piles is approximately zero for all cases. Output from PYWall analysis for 6 feet L-wall is shown in **Attachment C1-P**.

Considering a maximum lateral deflection of 1 in at the top and approximately zero deflection at the tip of the wall, AZ14 section with minimum sheet pile length of 30 and 35 feet are recommended for the 6 and 8 feet walls, respectively. Seepage analysis for L-walls is not necessary considering that the exit gradient and flow rate for the I- and T-wall alternatives with much shorter sheet piles are within acceptable limits.

Table C1-21: Results of the Analysis for L-walls in Soil Areas 4 to 7

Flood Height (ft)	Sheet Pile Section	Sheet Pile Length (ft)	Allowable Moment Capacity of Sheet Pile (kip-in)	Supporting Batter (5V:2H) Pile Type	Supporting Pile Length (ft)	Compression in Supporting Pile (kip)	Maximum Deflection in Sheet Pile (in)	Maximum Moment in Sheet Pile (kip-in)
6	AZ14	30	3,183	HP14×73 Steel Pile	50	26	0.10	306
				11.875 in OD Micropile	40	25	0.10	306
8	AZ14	35	3,183	HP16×141 Steel Pile	67	45	0.22	578
				11.875 in OD Micropile	55	43	0.24	577

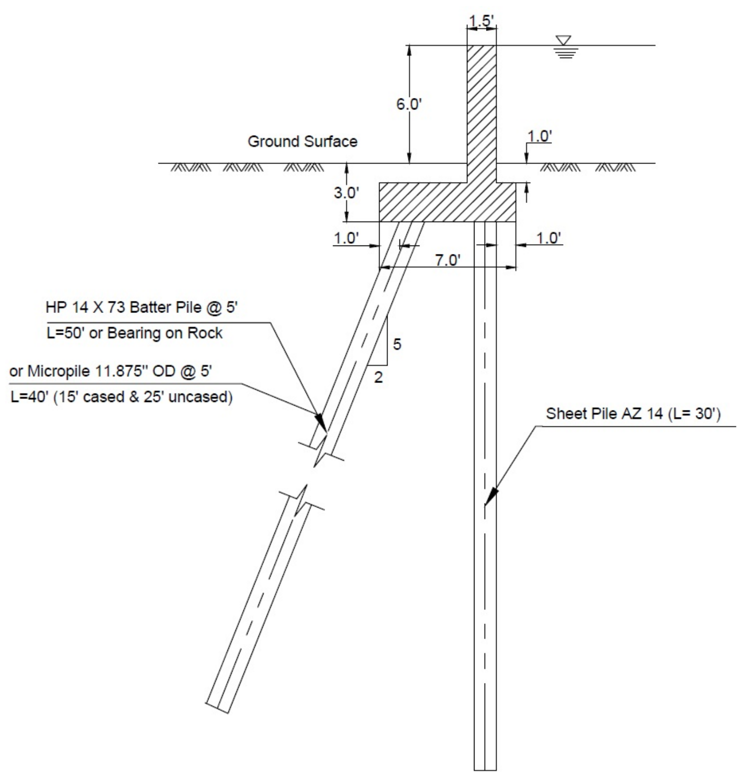


Figure C1-21: Cross-section of 6 feet L-wall for Soil Areas 4 to 7

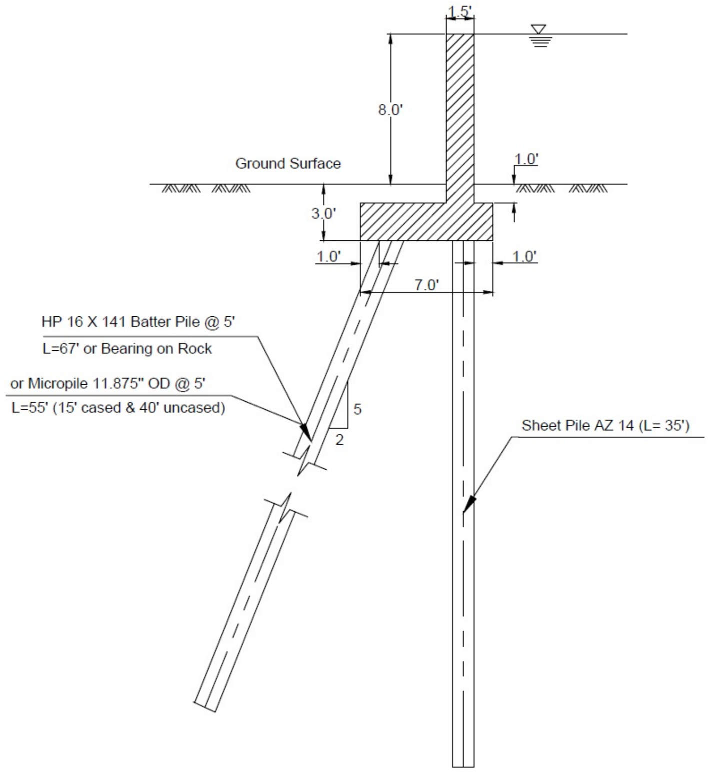


Figure C1-22: Cross-section of 8 feet L-wall for Soil Areas 4 to 7

5.2.4 Pile Axial Capacity

Axial capacity analyses were performed for driven friction piles and end bearing piles on rock, and micropiles. As mentioned in **Sections 5.2.2** and **5.2.3**, the required minimum lengths of driven piles for T- and L-walls in Soil Areas 4 to 7 vary from 50 to 67 feet. Thus, friction piles will be applicable in Soil Areas 4, 6 and 7, where the average depth to bedrock is greater than the required minimum pile lengths. However, the average depth to bedrock in Soil Area 5 is approximately 45 feet and hence, friction piles are not feasible. Instead, end bearing pile on rock will likely be applicable for Soil Area 5.

For all piles, the estimated structural capacities of the steel piles are significantly higher than the geotechnical capacities. Thus, the geotechnical capacities will govern for all cases.

5.2.4.1 Friction Piles

The geotechnical compression and tension capacities of battered HP14×73 and HP16×141 steel friction piles in Soil Areas 4, 6 and 7 were estimated using APILE according to the procedures outlined in the USACE, *Design of Pile Foundations*, EM 1110-2-2906 (USACE 1991). Soil Area 4 was conservatively (greater thickness of clayey layer than other Soil Areas) selected as the representative subsurface profile for the analysis.

Any skin friction from the organic clay layer was ignored. Self-weight of the pile was considered in the tension capacity estimate. A minimum factor of safety of 2.0 for compression and 3.0 for tension were used, assuming that the compression capacity will be verified by pile load test. Plots of the ultimate axial compression and tension capacities versus length of friction piles are provided as **Attachment C1-Q**. An APILE output file is provided in **Attachment C1-R**. The compression and tension capacities of various lengths of friction piles are presented in **Table C1-22**.

Table C1-22: Summary of Axial Capacities of Battered Friction Piles in Soil Areas 4, 6 and 7

Pile Type	Pile Length (ft)	Skin Friction (kip)	End Bearing (kip)	Ultimate Compression Capacity (kip)	Allowable Compression Capacity (kip)	Self-Weight (kip)	Ultimate Tension Capacity (kip)	Allowable Tension Capacity (kip)
HP14×73	50	47	4	51	26	3	50	17
HP14×73	60	61	4	65	32	4	65	22
HP16×141	67	85	5	90	45	5	90	31

5.2.4.2 End Bearing Piles on Rock

The geotechnical compression capacity of battered HP14×73 and HP16×141 steel end bearing piles on rock in Soil Area 5 was estimated according to the method outlined in Braja M. Das (2007), *Principles of Foundation Engineering* (Das 2006). For the compression capacity estimates, full contact between the pile tip and bedrock was assumed and skin friction was ignored. The geotechnical tension capacity of the end bearing pile was estimated using the same procedure used for the friction pile.

The unconfined compression strength (q_u) and the drained friction angle (ϕ') of rock were obtained from the results of a laboratory unconfined compression test performed on a sample of similar bedrock (siltstone/shale) from a nearby site reported in the AECOM Geotechnical Report (2007), *Route 120 SB Flyover over Route 3 and South Service Road Roadways and Structures* (AECOM 2006). A minimum factor of safety of 2.0 for compression and 3.0 for tension were used, assuming that the compression capacity will be verified by a pile load test.

Details of the compression capacity calculation are provided in **Attachment C1-S**. Allowable compression capacity of 200 kip for the end bearing pile on rock is recommended. The compression and tension capacities of the end bearing piles in Soil Area 5 are presented in **Table C1-23**.

Table C1-23: Summary of Axial Capacities of Battered Steel End Bearing Piles on Rock in Soil Area 5

Pile Type	Pile Length (ft)	Ultimate Compression Capacity (kip)	Allowable Compression Capacity (kip)	Skin Friction (kip)	Self-Weight (kip)	Ultimate Tension Capacity (kip)	Allowable Tension Capacity (kip)
HP14×73	44	400	200	48	3	51	17
HP16×141	44	400	200	48	3	51	17

5.2.4.3 Micropiles

The compression and tension capacities of battered micropiles in Soil Areas 4 to 7 were estimated based on the methods and specifications outlined in the 2015 International Building Code, New Jersey Edition (International Code Council, 2015).

Piles were assumed to have an 11.875 inch outside diameter (OD) steel casing and one #10 reinforcing bar. The minimum length of steel casing is assumed 15 feet, matching the average thickness of the organic clay layer in Soil Areas 4 to 7. Bond zone diameter of the micropile was assumed to be 11.5 inches. An allowable grout-to-soil bond strength of 5 and 3 psi were assumed for compression and tension, respectively.

Details of the micropile axial capacity calculations are provided in **Attachment C1-T**. The allowable compression and tension capacities are presented in **Table C1-24**.

Table C1-24: Summary of Axial Capacities of Battered Micropiles with 11.875 inch OD Casing and 1 - #10 Rebar for Soil Areas 4 to 7

Wall Type	Cased Length (ft)	Batter Slope	Bond Length (ft)	Total Length (ft)	Allowable Compression Capacity (kip)	Allowable Tensile Capacity (kip)
T-wall	15	3V:1H	15	30	32	19
			20	35	44	26
L-wall	15	5V:2H	25	40	54	32
			40	55	86	44

6.0 Cantilever Sheet Pile Wall

Cantilever sheet pile wall was considered as an additional alternative for 6 feet and 8 feet flood heights for Soil Areas 1 to 3 and 15 feet flood height in Soil Area 2, where the bedrock elevation is at -27.0 feet (NAVD 88) or lower. Cross sections of the 6 feet, 8 feet, and 15 feet cantilever sheet pile walls are presented in **Figures C1-23** to **C1-25**, respectively.

The cantilever sheet pile walls were analyzed using the commercially available software PYWall by Ensoft, Inc. For these analyses it was assumed that no overtopping from the flood and the water in the backfill is drained due to presence of drainage pipe in the fill layer. Therefore, analyses were performed for two cases - 1) no flood/drained condition, and 2) no flood and seismic loading, with assumed water levels at flood and backfill side at elevation 0.00 feet. Long-term (drained) soil properties of the clay layer were conservatively (higher active pressure on wall) used for the analysis. In addition, a 250 pound per square foot (psf) surcharge load was applied on the backfill side to account for vehicular traffic. For the 15 feet cantilever sheet pile wall, the grouted portion was considered in the analyses with assuming 24 inch thick, covering entire width of the sheet piles.

A summary of the results of the PYWall analyses is presented in **Tables C1-25** and **C1-26**. Plots of lateral defection, bending moment and shear force with respect to depth of sheet piles are provided in **Attachment C1-U**. As shown in **Attachment C1-U**, lateral deflection at the bottom of the sheet piles is almost zero for all cases. Output from PYWall analysis for 15 feet cantilever sheet pile walls in Soil Area 2 is provided in **Attachment C1-V**.

Considering that the exit gradient and flow rate for the I-wall and T-wall alternatives with much shorter sheet piles (see **Sections 5.2.2** and **5.2.3**) were within acceptable limits, seepage is not a concern for the cantilever sheet pile walls.

The grouting will be performed by pre auguring procedure and tremie pipes will be attached to the sheet piles on both sides that pressure non shrink grout will be injected through. Or a slurry method will be used to form a trench 2 feet wide filled with concrete/grout around the sheet piles.

Table C1-25: Results of the Cantilever Sheet Pile Wall Analysis for Soil Areas 1 to 3

Analysis Case	Wall height (ft)	Sheet Pile Section	Sheet Pile Length (ft)	Allowable Moment Capacity (kip-	Maximum Deflection (in)	Maximum Moment (kip-in)
No Flood or Drained	6	AZ12	37	1,934	0.41	400
No Flood and Seismic	6	AZ12	37	1,934	0.44	440
No Flood or Drained	8	AZ12	39	1,934	1.1	900
No Flood and Seismic	8	AZ12	39	1,934	1.2	1020

Table C1-26: Results of the Cantilever Sheet Pile Wall Analysis for Soil Area 2

Analysis Case	Grouted	Sheet Pile Section	Sheet Pile Length (ft)	Allowable Moment Capacity (kip-in)	Maximum Deflection (in)	Maximum Moment (kip-in)
No Flood or Drained	No	AZ25	35	4,028	1.78	3333
No Flood and Seismic	No	AZ25	35	4,028	2.2	3700
No Flood or Drained	Yes	AZ25	35	4,028	0.79	3320
No Flood and Seismic	Yes	AZ25	35	4,028	0.96	3920

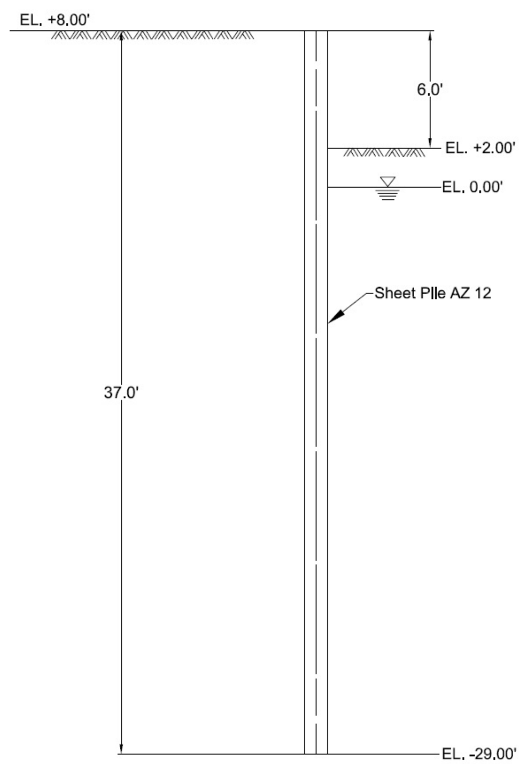


Figure C1-23: Cross-section of 6 feet Cantilever Sheet Pile Wall for Soil Areas 1 to 3

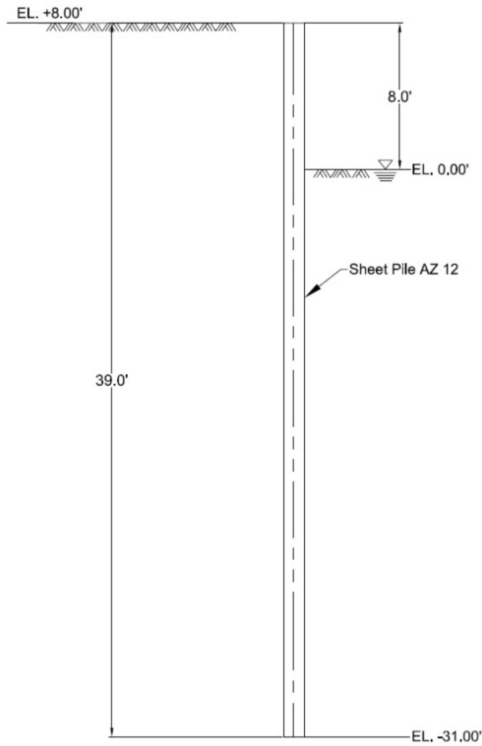


Figure C1-24: Cross-section of 8 feet Cantilever Sheet Pile Wall for Soil Areas 1 to 3

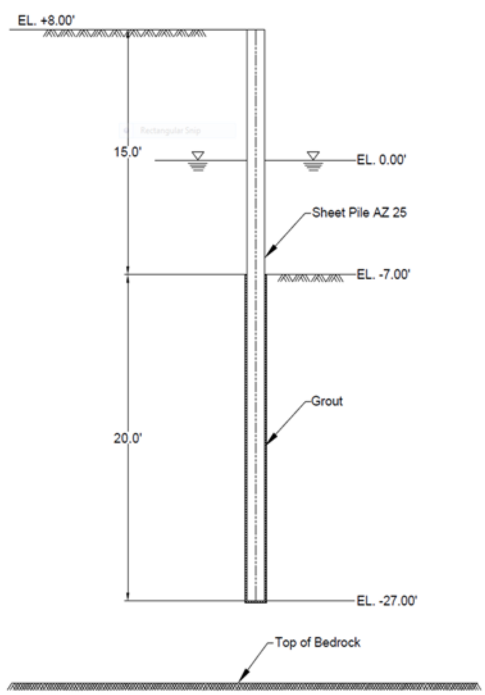


Figure C1-25: Cross-section of 15 feet Cantilever Sheet Pile Wall for Soil Area 2

7.0 Anchored Sheet Pile Wall

Anchored sheet pile wall was considered as an alternative to 15 feet flood height in Soil Area 2, where the bedrock is higher than elevation -27.0 feet (NAVD 88). A cross section of the 15 feet anchored sheet pile wall is presented in **Figure C1C1-26**.

The anchored sheet pile wall structure consists of a steel sheet pile wall supported by 25 foot long grouted steel anchors, located 5 feet below the top of the wall spaced at 10 feet intervals. This wall was analyzed using the commercially available software PYWall by Ensoft, Inc. It was assumed that no flood overtopping occurs and water in the backfill is drained due to the presence of drainage pipes in the fill layer. Therefore, analyses were performed for two cases - 1) no flood/drained condition, and 2) no flood and seismic loading, with water levels at flood and backfill side at elevation 0.00 feet. Long-term (drained) soil properties of the clay layer were conservatively (higher active pressure on wall) used for the analysis. In addition, 250 psf surcharge load was applied on the backfill side to account for vehicular traffic.

A summary of the results of the PYWall analysis is presented in **Table C1-27**. Plots of lateral defection, bending moment and shear force with depths of sheet piles are provided in **Attachment C1-W**. As shown in **Attachment C1-W**, lateral deflection at the bottom of the sheet piles is almost zero for all cases. Output from PYWall analysis is provided in **Attachment C1-X**.

Considering that the exit gradient and flow rate for the I-wall and T-wall alternatives with much shorter sheet piles (see **Sections 5.2.2** and **5.2.3**) were within acceptable limits, seepage is not a concern for the anchored sheet pile wall.

Table C1-27: Results of the Anchored Sheet Pile Wall Analysis for Soil Areas 1 to 3

Analysis Case	Sheet Pile Section	Sheet Pile Length (ft)	Allowable Moment Capacity (kip-	Maximum Deflection (in)	Maximum Moment (kip-in)
No Flood or Drained	AZ25	40	4,028	0.13	410
No Flood and Seismic	AZ25	40	4,028	0.15	400

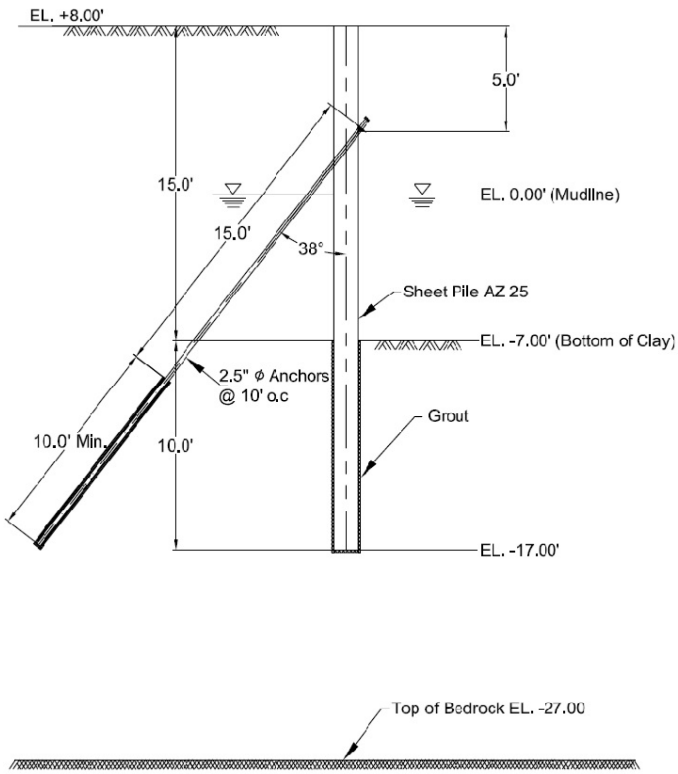


Figure C1C1-26: Cross-section of 15 feet Anchored Sheet Pile Wall for Soil Area 2

8.0 Foundation Systems

A deep foundation alternative (such as driven piles and micropiles) was considered for the East River Ditch pump station and forebay in Soil Area 6. The details of the proposed deep foundation system are discussed in the following sections.

8.1 Pile Foundation for Pump Station

A conceptual design of a deep foundation system for the proposed pump station in Soil Area 6 was performed by HDR based on the results of pile capacity analyses presented in the Geotechnical Engineering Memorandum dated February, 2017 (Geotechnical Engineering Memo 2017). The total axial load on the pile cap was estimated as the weight of the pump station plus an additional 15 percent axial load to account for any lateral forces on the pile cap due to the pumping operation. The weight of the pump station was determined based on the sum of weights of the following: the screw pump, water in the screw pump, the building, the concrete intake, the concrete pump base slab, and the discharge channel/spillway.

The conceptual deep foundation layout consists of 212 HP 16×141 steel piles with lengths of 65 feet and a center-to-center spacing of 6 feet. As recommended in the 2017 Geotechnical Memorandum [18], the allowable compression capacity of a single HP 16×141 pile is 45 kips. Since the spacing to diameter ratio is 4.5 (6 feet / 16 inch), a group reduction factor of 0.85 was applied to the single pile capacity. Therefore, the total allowable capacity of the 212 piles is 8,109 kip (0.85×212×45), which is greater than the estimated load of 8,100 kip. Assuming the total axial load will be uniformly distributed on the pile cap, the pile capacities are adequate. However, we recommend that a pile group analysis be performed using the computer program GROUP for the design phase of the project to verify the uniform loading assumption. Note that, any potential lateral load and/or moment on the pile cap will cause uneven distribution of axial loads on the piles.

8.2 Pile Foundation for Forebay

A conceptual design of the pile foundation system for the forebay in Soil Area 6 was also performed by HDR based on the results of pile capacity analyses presented in the 2017 Geotechnical Memorandum. The conceptual pile layout consists of 40 HP 16×141 steel piles bearing on rock with lengths of 75 feet and a center-to-center spacing of 9 feet. The pile capacities are adequate with respect to the estimated axial load. However, we recommend a pile group analysis using the computer program GROUP as part of the design phase of the project. Details of the conceptual design calculations by HDR are included in **Attachment C1-Y**.

9.0 Conclusions and Recommendations

Following are the conclusions and recommendations based on the findings of this feasibility study level geotechnical analysis:

- The levee alternative is feasible for flood height of 2 feet, 4 feet, 6 feet and 8 feet for Soil Areas 1 to 3 where no organic soil was identified in the soil profiles.
- The levee alternative is feasible for flood height of 2 and 4 feet for Soil Areas 4 to 7 where peat or organic clay was identified in the soil profiles. Levees with 6 and 8 feet flood height for Soil Areas 4 to 7 will require installing sheet piles on both the riverside and landside of the levee.
- A more reasonable alternative to 6 and 8 feet levees with sheet piles for Soil Areas 4 to 7 may be a double sheet pile wall.
- T-walls supported on shallow foundation are feasible from seepage standpoint for all flood heights in Soil Areas 1 to 3. Further analysis for calculating the factor of safety for bearing capacity, sliding and overturning of the T-walls is expected to be performed by the Marine Engineering Group of AECOM during the design phase.
- I-walls are feasible for 2 feet and 5 feet flood heights for Soil Areas 4 to 7.
- T- and L-walls with sheet piles and pile foundations are recommended for 6 and 8 feet flood heights for Soil Areas 4 to 7.
- Cantilever sheet pile walls are feasible for 6 and 8 feet flood heights for Soil Areas 1 to 3 and for 15 feet flood height for Soil Area 2, where bedrock is at elevation -27 feet or lower. Drained back fill conditions were assumed for the 15 feet cantilever sheet pile wall.
- Anchored sheet pile walls are feasible for 15 feet flood height for Soil Area 2, where bedrock elevation is higher than -27 feet. Drained back fill conditions were assumed for anchored sheet pile wall.
- Considering that the exit gradient and flow rate for the I-wall and T-wall alternatives with much shorter sheet piles were within acceptable limits, seepage is not a concern for double sheet pile walls, cantilever sheet pile walls, and anchored sheet pile wall.
- Analysis for global stability of the I-, T- and L-walls for full flood and reverse flood conditions in all soil areas must be performed as part of the design phase of this project.
- The upper soil must be inspected down to 6 feet depth by excavating trenches prior to the construction of levees and T-walls on shallow foundations. If the existing material is not suitable for construction, it must be replaced by proper structural fill.
- For the cantilever sheet pile wall and anchored sheet pile wall alternatives, the grouting will be performed by pre auguring procedure and tremie pipes will be attached to the sheet piles on both sides that pressure non shrink grout will be injected through or a slurry method will be used to form a trench 2 feet wide filled with concrete/grout around the sheet piles.
- The driven pile deep foundation alternative for the proposed East River Ditch pump station and forebay is adequate based on the capacity of a single pile. However, it is recommended that a pile group analysis be performed for each group of piles using the computer program GROUP as part of the design phase of the project.

It should be noted that this feasibility study level geotechnical analysis is based on limited subsurface soil information from borings near the project site. For example, most of the existing boring logs used in this study do not have SPT blow count data. A more comprehensive geotechnical evaluation of the flood protection measures will require extensive geotechnical investigations along the line of protection including soil borings with SPTs, field permeability tests, cone penetration tests, laboratory testing on soil and rock samples collected from the borings including sieve analysis, Atterberg limits, consolidation and triaxial tests. Also note that transient seepage analysis was not performed as the flood stage condition data were not available at the time of this Feasibility Study.

10.0 References

NJDOT. New Jersey Department of Transportation Soil Borings Database. October 2016. https://njgin.state.nj.us/DOT_GDMS.

Joseph S. Ward, Inc. Foundation Reconnaissance Investigation, Hackensack Meadows, New Jersey. New York District: United States Army Corps of Engineer, Joseph S. Ward, Inc., Caldwell, NJ, 1962.

Stanford D., Scott. Surficial Geologic Map of the Weehawken and Central Park Quadrangles, Bergen, Hudson, and Passaic Counties. Open-File Map OFM 13, Scale 1:24,000, New Jersey Geological Survey, 1993.

The Louis Berger Group, Inc. Revised Geotechnical Investigation Report for Kane Wetland Mitigation Bank. United States Army Corps of Engineer, New York District, The Louis Berger Group, Inc., Morristown, NJ., 2010.

Earthworks, LLC. Geophysical Investigation as part of the Design of the Hackensack River Enhancement Project. Sandy Hook, CT: United States Army Corps of Engineer, New York District, Earthworks LLC, 2007.

AECOM. USPS – Network Distribution Center, New Jersey Site Repairs. Clifton, NJ: 2016.

USACE. Engineering and Design: Design and Construction of Levees. EM 1110-2-1913, Washington, DC: USACE, 2000.

AASHTO. LRFD Bridge Design Specifications. Seventh Edition, Washington, DC: AASHTO, 2014.

Das, B. M. "Principles of Geotechnical Engineering." 686. Ontario, Canada: Nelson, 2006.

USACE. Passaic River Flood Damage Reduction Project . General Design Memorandum, New York District: USACE, 1995.

USACE. Engineering and Design: Retaining and Flood Walls. EM 1110-2-2502 , Washington, DC: USACE, 1989.

USACE. Engineering and Design: Settlement Analysis. EM 1110-1-1904, Washington, DC: USACE, 1990.

NAVFAC. Soil Mechanics Design Manual. DM 7.01, Alexandria, VA: NAVFAC, 1986.

USACE. Engineering and Design: Design of Pile Foundations. EM 1110-2-2906, Washington, DC.: USACE, 1991.

Das, B. M. "Principles of Foundation Engineering, Sixth Edition." 750. Stamford, CT: Cengage Learinig, 2006.

AECOM. Route 120 SB Flyover over Route 3 and South Service Road Roadways and Structures. Geotechnical Report, Iselin, NJ: AECOM , 2007.

International Code Council, Inc. International Building Code, New Jersey Edition. 2015.

Geotechnical Engineering Memorandum Dated February 3rd, 2017 Feasibility Assessment of Earth Levee, Double Sheet Pile Wall and Flood Wall, New Meadowlands Flood Protection Bergen County, New Jersey

ATTACHMENTS

Appendix C1-A

Soil Boring Logs Used to Prepare Generalized Subsurface Profiles for Soil Areas 1 to 7

Boring Logs from Soil Area 1

Parsons Brinckerhoff -FG, Inc.

BORING LOG

BORING NUMBER: PB-2
SHEET NUMBER: 1 OF 4
PROJECT NUMBER: 6122T

PROJECT: Route 80 bridge over Hackensack River.
LOCATION: Hackensack, New Jersey.
CLIENT: New Jersey Department of Transportation.
CONTRACTOR: Warren George, Inc.
DRILLER: J. and T. Kurznowski
INSPECTOR: E. Vierno
DRILLING METHOD: Mud Rotary
RIG TYPE: Truck mounted

LOCATION: Rt-80E 100 ft W of Exit 67 sign
COORD. N: E:
STN. NO.: 936+42 OFFSET: 94 rt
SURFACE ELEV.: 37.10 ft
Baseline : CENTERLINE OF ROUTE 80
START DATE: 6-8-93 TIME: 11:30 am
FINISH DATE: 6-9-93 TIME: 2:00 pm

	Casing	Split Spoon	Shelby Tube	Piston	Pitcher	Core Barrel
Type/Symbol		S	U	P	L	C
I.D.	4	1.375				2
O.D.	4.25	2				2.25
Length		24				
Hammer Wt.	300	140	Drill Rod Size			
Hammer Fall	24	30	I.D. (O.D.)			

GROUNDWATER DATA

Date	Time	Water Depth	Casing Depth	Hole Depth

DEPTH (FT)	CASING (BLOWS/FT) CORING (MIN./FT)	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE DEPTH (FT)	SOIL (BLOWS/6 in.) 0/6 / CORING RUN (in.)	6/12 / REC. (in.)	12/18 / REC. (%)	18/24 / L>4" (in.)	REC. (in.) / RQD (%)	Depth Elev.	FIELD CLASSIFICATION AND REMARKS
0		S	1	1-3	19	23	30	38	15		Brown coarse to fine SAND, little(+) Silt, trace(+) fine Gravel (Fill).
5		S	2	5-7	38	30	62	28	14	5.0 / 32.1	Gray - brown medium to fine GRAVEL, some coarse to fine Sand, trace(+) Silt (Fill).
10		S	3	10-12	23	31	40	27	9		Same.
15		S	4	15-17	21	33	36	29	13	15.0 / 22.1	Gray medium to fine GRAVEL, some coarse to fine Sand, trace(-) Silt (Fill).
20		S	5	20-22	22	27	19	37	12		Same.
25											

Parsons Brinckerhoff -FG, Inc.

BORING LOG

(continued)

BORING NUMBER: **PB-2**

SHEET NUMBER: 2 OF 4

PROJECT NUMBER: **6122T**

PROJECT: **Route 80 bridge over Hackensack River.**

LOCATION: **Hackensack, New Jersey.**

DRILLER: **J. and T. Kurznowski**

INSPECTOR: **E. Vierno**

DEPTH (FT)	GRAPHIC LOG	CASING (BLOWS/FT) CORING (MIN./FT)	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE SYMBOL	SAMPLE DEPTH (FT)	SOIL (BLOWS/6 in.) 0/6 / CORING RUN (in.)	6/12 / REC. (in.)	12/18 / REC. (%)	18/24 / L>4" (in.)	REC. (in.) / RQD (%)	Depth Elev.	FIELD CLASSIFICATION AND REMARKS
25			S	6		25-27	19	21	26	28	11		Gray medium to fine GRAVEL, some coarse to fine Sand, trace(-) Silt (Fill).
30			S	7		30-32	26	31	27	24	14	30.0 / 7.1	Gray medium to fine GRAVEL, some coarse to fine Sand, trace(+) Silt (Fill).
35			S	8		35-37	17	21	16	6	6	35.0 / 2.1	Brown medium to fine GRAVEL, some(+) coarse to fine Sand, little(-) Silt (Fill). Loss of water.
40			S	9		40-42	3	4	5	5	3	40.0 / -2.9	Dark gray medium to fine GRAVEL, little(+) coarse to fine Sand, trace(-) Silt.
45			S	10		45-47	7	7	9	8	6	45.0 / -7.9	Gray - brown varved clayey SILT. PP = 1.75 tsf
50			S	11		50-52	6	6	7	8	16		Same. PP = 1.0 tsf
55			S	12		55-57	1	1	2	2	18		Same. PP = 0.75 tsf
60													

Parsons Brinckerhoff -FG, Inc.

BORING LOG
(continued)

BORING NUMBER: PB-2
SHEET NUMBER: 3 OF 4
PROJECT NUMBER: 6122T

PROJECT: Route 80 bridge over Hackensack River.
LOCATION: Hackensack, New Jersey.
DRILLER: J. and T. Kurznowski
INSPECTOR: E. Vierno

DEPTH (FT)	GRAPHIC LOG	CASING (BLOWS/FT) CORING (MIN./FT)	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE SYMBOL	SAMPLE DEPTH (FT)	0/6 / RUN (in.)	6/12 / REC. (in.)	12/18 / REC. (%)	18/24 / L>4" (in.)	REC. (in.) / RQD (%)	Depth / Elev.	FIELD CLASSIFICATION AND REMARKS
60			S	13		60-62	2	5	5	7	24		Gray - brown varved clayey SILT. PP = 0.5 tsf
65			S	14		65-67	WOR	WOR	6	8	24		Same. PP = 0.70 tsf
70			S	15		70-72	WOR	WOR	WOR	WOR	24		Red - brown clayey SILT. PP = 0.25 tsf
75			S	16		75-77	WOR	WOR	24	20	24		Red - brown SILT, little coarse to fine Sand, trace fine Gravel.
												79.0 / -41.9	
80			S	17		80-80.5	100	-	-	-	4		Red - brown coarse to fine SAND, some Silt, trace(+) fine Gravel.
85			S	18		85-85.4167	100/5"	-	-	-	4		Same.
90			S	19		90-90.5	100	-	-	-	2	90.0 / -52.9	Red - brown medium to fine GRAVEL, some coarse to fine Sand, little(-) Silt.
95												95.0 / -57.9	

Parsons Brinckerhoff -FG, Inc.

BORING LOG

(continued)

BORING NUMBER: **PB-2**
SHEET NUMBER: 4 OF 4
PROJECT NUMBER: **6122T**

PROJECT: **Route 80 bridge over Hackensack River.**
LOCATION: **Hackensack, New Jersey.**
DRILLER: **J. and T. Kurznowski**
INSPECTOR: **E. Vierno**

DEPTH (FT)	GRAPHIC LOG	CASING (BLOWS/FT) CORING (MIN./FT)	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE SYMBOL	SAMPLE DEPTH (FT)	SOIL (BLOWS/6 in.) 0/6 / CORING RUN (in.)	6/12 / REC. (in.)	12/18 / REC. (%)	18/24 / L>4" (in.)	REC. (in.) / RQD (%)	Depth Elev.	FIELD CLASSIFICATION AND REMARKS
95			S	20		95-95.5	100	–	–	–	6		Red - brown coarse to fine SAND, little(+) Silt, trace(+) fine Gravel (Till)
												99.0 -61.9	Approximate top of rock. Red - brown interbedded SANDSTONE / SILTSTONE / MUDSTONE, slightly to moderately weathered, weak to medium strong , slightly to moderately fractured, thin bedded.
100			C	1		100-105	60	51	85	24	40%		
105												105.0 -67.9	**Boring terminated at 105 feet.**
110													
115													
120													
125													
130													

Note 1: Field classifcation is based on Burmister Soil Identifcation System.

2. The subsurface information shown hereon was obtained for State design and estimate purposes. It is made available to authorized users only that they may have access to the same information available to the State. It is presented in good faith, but is not intended as a substitute for investigations, interpretation or judgment of such authorized users.

3. WOR = Weight Of Rod
PP = Unconfined compression strength from Pocket Penetrometer.

Parsons Brinckerhoff -FG, Inc.	BORING LOG	BORING NUMBER: PB-3
		SHEET NUMBER: 1 OF 3
		PROJECT NUMBER: 6122T

PROJECT: Route 80 bridge over Hackensack River.
LOCATION: Hackensack, New Jersey.
CLIENT: New Jersey Department of Transportation.
CONTRACTOR: Warren George, Inc.
DRILLER: S. Dimico / G. Kutshera
INSPECTOR: E. Vierno
DRILLING METHOD: Mud Rotary
RIG TYPE: Truck mounted

LOCATION: River road near Pier 1-D
COORD. N: E:
STN. NO.: 938+55 OFFSET: 90' rt
SURFACE ELEV.: 6.39 ft
Baseline : CENTERLINE OF ROUTE 80
START DATE: 6-7-93 TIME: 8:45 am
FINISH DATE: 6-8-93 TIME: 3:00 pm

	Casing	Split Spoon	Shelby Tube	Piston	Pitcher	Core Barrel
Type/Symbol		S	U	P	L	C
I.D.	4	1.375				2
O.D.	4.25	2				2.25
Length		24				
Hammer Wt.	300	140	Drill Rod Size			
Hammer Fall	24	30	I.D. (O.D.)			

GROUNDWATER DATA

Date	Time	Water Depth	Casing Depth	Hole Depth
6-11-93	1:00 pm	6.0 ft		
6-18-93	7:30 am	5.8 ft		

DEPTH (FT)	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE DEPTH (FT)	0/6	6/12	12/18	18/24	REC. (in.)	Depth Elev.	FIELD CLASSIFICATION AND REMARKS
0	S	1	0-2	3	4	4	4	14		Brown coarse to fine SAND, little Silt, with red Brick, concrete (Fill).
5	S	2	5-7	3	3	4	7	20	6.5	Brown coarse to fine SAND, some Silt.
									-0.1	Brown SILT. PID = 4.0 ppm PP = 4.5 tsf
										Brown varved clayey SILT.
10	S	3	10-12	7	12	16	19	20		Same. PID = 2.0 ppm PP = 3.25 tsf
15	S	4	15-17	6	9	10	10	16		Brown clayey SILT. PP = 1.0 tsf
20	S	5	20-22	3	5	5	5	20		Same. PP = 1.5 tsf
25										

Parsons Brinckerhoff -FG, Inc.

BORING LOG
(continued)

BORING NUMBER: PB-3
SHEET NUMBER: 2 OF 3
PROJECT NUMBER: 6122T

PROJECT: **Route 80 bridge over Hackensack River.**
LOCATION: **Hackensack, New Jersey.**

DRILLER: **S. Dimico / G. Kutshera**
INSPECTOR: **E. Vierno**

DEPTH (FT)	TYPE	NUMBER	DEPTH (FT)	0/6 (RUN in.)	6/12 (REC. in.)	12/18 (REC. %)	18/24 (L>4" in.)	REC. in. (RQD %)	Depth / Elev.	FIELD CLASSIFICATION AND REMARKS
25	S	6	25-27	4	4	5	5	16		Brown clayey SILT PP = 1.0 tsf
									28.0 / -21.6	
30	S	7	30-32	1	1	2	2	11		Red - brown coarse to fine SAND, some(+) Silt, trace fine Gravel.
35	S	8	35-37	9	14	13	14	10		Same.
40	S	9	40-41	35	100	-	-	8	40.0 / -33.6	Red - brown medium to fine GRAVEL, some coarse to fine Sand, little Silt.
45	S	10	45-45.5	100	-	-	-	3		Same.
50	C	1	49-54	60	24	40	8	13%		Red - brown SANDSTONE BOULDER, slightly weathered, medium strong. (BOULDER IN TILL) Attempted Spoon at 48' with 100/1"
55	C	2	54-59	60	18	30	0	0%		Red - brown MUDSTONE & SANDSTONE COBBLES AND BOULDERS, slightly to highly weathered, v. weak to medium strong (COBBLES AND BOULDER IN TILL)
60										

Parsons Brinckerhoff -FG, Inc.

BORING LOG

(continued)

BORING NUMBER: **PB-3**

SHEET NUMBER: 3 OF 3

PROJECT NUMBER: **6122T**

PROJECT: **Route 80 bridge over Hackensack River.**

LOCATION: **Hackensack, New Jersey.**

DRILLER: **S. Dimico / G. Kutshera**

INSPECTOR: **E. Vierno**

DEPTH (FT)	GRAPHIC LOG	CASING (BLOWS/FT) CORING (MIN./FT)	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE SYMBOL	SAMPLE DEPTH (FT)	0/6 / RUN (in.)	6/12 / REC. (in.)	12/18 / REC. (%)	18/24 / L>4" (in.)	REC. (in.) / RQD (%)	Depth Elev.	FIELD CLASSIFICATION AND REMARKS
60			C	3		59-64	60	9.5	16	0	0%	64.0	1.5" diameter piece of GNEISS COBBLE, pieces of GNEISS in Sand matrix (Till).
65			C	4		64-69	60	54	90	15	25%	-57.6 / 69.0	Approximate top of rock. Red - brown fine grained SANDSTONE / SILTSTONE with some MUDSTONE, slightly weathered, medium strong, slightly fractured, thin to medium bedded.
70												-62.6	**Boring terminated at 69 feet.**
75													
80													
85													
90													
95													

Note 1: Field classification is based on Burmister Soil Identification System.

2:The subsurface information shown hereon was obtained for State design and estimate purposes. It is made available to authorized user only that they may have access to the same information available to the State. It is presented in good faith, but is not intended as a substitute for investigations, interpretation or judgment of such authorized users.

3. PP = Unconfined compression strength from Pocket Penetrometer.
PID = Photonionization Detector reading.

Parsons Brinckerhoff -FG, Inc.

BORING LOG

BORING NUMBER: **PB-4**
SHEET NUMBER: 1 OF 2
PROJECT NUMBER: **6122T**

PROJECT: **Route 80 bridge over Hackensack River.**
LOCATION: **Hackensack, New Jersey.**
CLIENT: **New Jersey Department of Transportation.**
CONTRACTOR: **Warren George, Inc.**
DRILLER: **S. Dimico / G. Kutshera**
INSPECTOR: **E. Vierno**
DRILLING METHOD: **Mud Rotary**
RIG TYPE: **Truck mounted**

LOCATION: **Opposite Pier 3-D**
COORD. N: E:
STN. NO.: **940+00** OFFSET: **90' rt**
SURFACE ELEV.: **7.1 ft**
Baseline : CENTERLINE OF ROUTE 80
START DATE: **6-1-93** TIME: **11:10 am**
FINISH DATE: **6-2-93** TIME: **11:30 am**

	Casing	Split Spoon	Shelby Tube	Piston	Pitcher	Core Barrel
Type/Symbol		S	U	P	L	C
I.D.	4	1.375				2
O.D.	4.25	2				2.25
Length		24				
Hammer Wt.	300	140	Drill Rod Size			
Hammer Fall	24	30	I.D. (O.D.)			

GROUNDWATER DATA

Date	Time	Water Depth	Casing Depth	Hole Depth
6-2-93	7:30 am	4.5 ft		

DEPTH (FT)	TYPE	NUMBER	SAMPLE DEPTH (FT)	0/6 (RUN in.)	6/12 (REC. in.)	12/18 (REC. %)	18/24 (L>4" in.)	REC. in. (RQD %)	Depth / Elev.	FIELD CLASSIFICATION AND REMARKS
0	S	1	0-2	3	5	9	12	15		Brown coarse to fine SAND, some Silt, trace(+) fine Gravel with red Brick, concrete (Fill).
									4.0 / 3.1	
5	S	2	5-7	6	15	25	40	15		Brown - gray SILT. PP = 4.5 tsf
10	S	3	10-12	13	16	23	26	20		Red - brown clayey SILT, trace coarse to fine Sand. PP = 0.75 tsf
15	S	4	15-17	4	5	4	6	15		Red - brown clayey SILT. PP = 0.75 tsf
									18.0 / -10.9	
20	S	5	20-22	6	13	13	14	16		Red - brown coarse to fine SAND, some(+) Silt, little(-) fine Gravel.
25										

Parsons Brinckerhoff -FG, Inc.

BORING LOG

(continued)

BORING NUMBER: **PB-4**

SHEET NUMBER: 2 OF 2

PROJECT NUMBER: **6122T**

PROJECT: **Route 80 bridge over Hackensack River.**

LOCATION: **Hackensack, New Jersey.**

DRILLER: **S. Dimico / G. Kutshera**

INSPECTOR: **E. Vierno**

DEPTH (FT)	GRAPHIC LOG	CASING (BLOWS/FT) CORING (MIN./FT)	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE SYMBOL	SAMPLE DEPTH (FT)	SOIL (BLOWS/6 in.) 0/6 / CORING RUN (in.)	6/12 / REC. (in.)	12/18 / REC. (%)	18/24 / L>4" (in.)	REC. (in.) / RQD (%)	Depth / Elev.	FIELD CLASSIFICATION AND REMARKS
25			S	6		25-27	50	16	18	23	9		Red - brown coarse to fine SAND, some(+) Silt, little(-) fine Gravel.
30			S	7		30-31	45	125	-	-	12		Red - brown medium to fine SAND, some(+) Silt.
35			S	8		35-35.5	115	-	-	-	3	35.0 / -27.9	Red - brown coarse to fine SAND, little(+) fine Gravel, trace Silt, with red shale fragments.
40			S	9		40-40.9	40	130/5"	-	-	9		Same.
45			C	1		43-48	60	58.5	98	17	28%	43.0 / -35.9	Approximate top of rock. Attempted Spoon at 43' with 100/0". Red - brown MUDSTONE / SANDSTONE, slightly weathered, weak to medium strong , moderately fractured.
50												48.0 / -40.9	**Boring terminated at 48 feet.**
55													
60													

Note 1: Field classification is based on Burmister Soil Identification System.

2: The subsurface information shown hereon was obtained for State design and estimate purposes. It is made available to authorized users only that they may have access to the same information available to the State. It is presented in good faith, but is not intended as a substitute for investigations, interpretation or judgment of such authorized users.

3. PP = Unconfined compression strength from Pocket Penetrometer.

A.G. LICHTENSTEIN & ASSOCIATES, INC.

ROUTE: 80	LOCAL NAME:	NJDOT BORING NO.:
SECTION 20		FIELD BORING NO.: NW3-6
STATION: 28+428	OFFSET: 31 m Rt. / REFERENCE: CL ROUTE 80 BL	GROUND ELEVATION: 6.76
DRILLER: JEFF CRAIG	DATE STARTED: 10/25/99	Ground Water Elevation
INSPECTOR: L.J. ESPINOZA	DATE COMPLETED: 10/25/99	0 Hr. NOT RECORDED Date:
BORING CONTRACTOR: CRAIG TEST BORING CO., INC.		24 Hr. Date:
		P.P. Installed Date:

DEPTH (m)	CASING	SAMPLE	SAMPLE DEPTH		Blows on Spoon 150mm	300mm	450mm	REC (mm)	SOIL DESCRIPTION & STRATIGRAPHY	
		S-1	0.3	0.76	24	24	21	203	bn-gy cmf SAND, sm Gravel, tr Silt	FILL
1.5		S-2	1.5	1.95	22	23	22	229	same	FILL
3.0		S-3	3	3.45	19	18	12	229	gy cmf SAND & GRAVEL, tr Silt	FILL
4.5		S-4	4.5	4.95	15	23	30	254	bn cmf SAND & mf GRAVEL	FILL
6.0		S-5	6	6.45	32	47	40	229	same	FILL
7.5		S-6	7.5	7.95	31	24	23	203	bn mf SAND, tr Silt	FILL
9.0		S-7	9	9.45	12	16	18	305	bn SILT, sm Clay, tr f Sand	
									BOTTOM OF HOLE 9.45 m	
10.5										
12.0										

Nominal I.D. of Drive Pile	85 mm 100 mm
Nominal I.D. of Split Barrel Sampler	35 mm
Weight of Hammer on Drive Pipe	140 kg
Weight of Hammer on Split Barrel Sampler	63.5 kg
Drop of Hammer on Drive Pipe	600 mm
Drop of Hammer on Split Barrel Sampler	760 mm

Soil descriptions represent a field identification after D.M. Burmister unless otherwise noted.

NOTE: HOLE MOVED APPROXIMATELY 6' NORTH INTO SHOULDER
HOLLOW STEM AUGER USED

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A.G. LICHTENSTEIN & ASSOCIATES, INC.

Approximate Change in Strata: ________

Inferred Change in Strata: - - - - - - - -

A.G. LICHTENSTEIN & ASSOCIATES, INC.

ROUTE: 80	LOCAL NAME:		NJDOT BORING NO.:
SECTION 20			FIELD BORING NO.: NW3-7
STATION: 28+485	OFFSET: 30 m Rt.	REFERENCE: CL ROUTE 80 BL	GROUND ELEVATION: 8.81
DRILLER: JEFF CRAIG		DATE STARTED: 10/25/99	Ground Water Elevation
INSPECTOR: TONY DROZDOWSKI		DATE COMPLETED: 10/25/99	0 Hr. NOT RECORDED Date:
BORING CONTRACTOR: CRAIG TEST BORING CO., INC.			24 Hr. Date:
			P.P. Installed Date:

DEPTH (m)	CASING	SAMPLE	SAMPLE DEPTH		Blows on Spoon 150mm	300mm	450mm	REC (mm)	SOIL DESCRIPTION & STRATIGRAPHY	
									0.15m Asphalt	
		S-1	0.15	0.61	62	42	23	300	bn fmc SAND, sm fc Gravel	FILL
1.5		S-2	1.5	1.95	13	19	25	250	gy-bl fc GRAVEL, sm mc Sand, tr Silt	FILL
3.0		S-3	3	3.45	11	13	21	200	gy-bl fc GRAVEL, lt c Sand (note: lost mud)	FILL
4.5		S-4	4.5	4.95	12	8	10	150	same (lg 3/4" dia. Stones) (note: lost mud)	FILL
6.0		S-5	6	6.45	21	20	23	300	same, sm f Sand	FILL
7.5		S-6	7.5	7.95	16	19	21	300	bn mc SAND, sm f Gravel, tr Silt	FILL
9.0		S-7	9	9.45	20	16	23	200	bn fmc SAND, tr f Gravel, tr Silt	FILL
									BOTTOM OF HOLE 9.45 m	
10.5										
12.0										

Nominal I.D. of Drive Pile	85 mm 100 mm
Nominal I.D. of Split Barrel Sampler	35 mm
Weight of Hammer on Drive Pipe	140 kg
Weight of Hammer on Split Barrel Sampler	63.5 kg
Drop of Hammer on Drive Pipe	600 mm
Drop of Hammer on Split Barrel Sampler	760 mm

Soil descriptions represent a field identification after D.M. Burmister unless otherwise noted.

NOTE: DRILLER'S MUD USED.

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A.G. LICHTENSTEIN & ASSOCIATES, INC.

Approximate Change in Strata: ________________________

Inferred Change in Strata: -

A.G. LICHTENSTEIN & ASSOCIATES, INC.

ROUTE: 80	LOCAL NAME:		NJDOT BORING NO.:
SECTION 20			FIELD BORING NO.: NW3-8
STATION: 28+530	OFFSET: 28 m Rt.	REFERENCE: CL ROUTE 80 BL	GROUND ELEVATION: 10.49
DRILLER: JEFF CRAIG		DATE STARTED: 10/26/99	Ground Water Elevation
INSPECTOR: L.J. ESPINOZA		DATE COMPLETED: 10/26/99	0 Hr. +6.22 MUD LEVEL — Date: 10/26
BORING CONTRACTOR: CRAIG TEST BORING CO., INC.			24 Hr. WATER LEVEL WAS NOT REACHED — Date: 10/27
			P.P. Installed — Date:

DEPTH (m)	CASING	SAMPLE	SAMPLE DEPTH		Blows on Spoon 150mm	300mm	450mm	REC (mm)	SOIL DESCRIPTION & STRATIGRAPHY	
									0.20 m Asphalt	
		S-1	0.3	0.76	6	8	7	127	gy cf GRAVEL & cf SAND	FILL
1.5		S-2	1.5	1.95	5	9	8	127	same	FILL
3.0		S-3	3	3.45	21	23	19	203	gy cf GRAVEL & cmf SAND	FILL
4.5		S-4	4.5	4.95	11	19	12	229	same	FILL
6.0		S-5	6	6.45	13	20	12	279	same	FILL
7.5		S-6	7.5	7.95	14	14	16	254	same	FILL
9.0		S-7	9	9.45	18	14	9	254	blk-gy cmf SAND, sm cf Gravel, sm Silt	FILL
									BOTTOM OF HOLE 9.45 m	
10.5										
12.0										

Nominal I.D. of Drive Pile	85 mm 100 mm
Nominal I.D. of Split Barrel Sampler	35 mm
Weight of Hammer on Drive Pipe	140 kg
Weight of Hammer on Split Barrel Sampler	63.5 kg
Drop of Hammer on Drive Pipe	600 mm
Drop of Hammer on Split Barrel Sampler	760 mm

Soil descriptions represent a field identification after D.M. Burmister unless otherwise noted.

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A.G. LICHTENSTEIN & ASSOCIATES, INC.

Approximate Change in Strata: ________

Inferred Change in Strata: - - - - - - - -

A.G. LICHTENSTEIN & ASSOCIATES, INC.

ROUTE: 80	LOCAL NAME:		NJDOT BORING NO.
SECTION 20			FIELD BORING NO.: NW3-9
STATION: 28+578	OFFSET: 23 m Rt.	REFERENCE: CL ROUTE 80 BL	GROUND ELEVATION: 11.53
DRILLER: JEFF CRAIG		DATE STARTED: 10/26/99	Ground Water Elevation
INSPECTOR: L.J. ESPINOZA		DATE COMPLETED: 10/26/99	0 Hr. +6.04 MUD LEVEL Date: 10/26
BORING CONTRACTOR: CRAIG TEST BORING CO., INC.			24 Hr. WATER LEVEL WAS NOT REACHED Date: 10/27
			P.P. Installed Date:

DEPTH (m)	CASING	SAMPLE	SAMPLE DEPTH		Blows on Spoon 150mm	300mm	450mm	REC (mm)	SOIL DESCRIPTION & STRATIGRAPHY	
									0.25 m Asphalt	
		S-1	0.3	0.76	7	15	22	229	gy cmf SAND, sm cf Gravel, tr Silt	FILL
1.5		S-2	1.5	1.95	7	12	7	254	same	FILL
3.0		S-3	3	3.45	26	14	13	178	gy cf GRAVEL & cmf SAND	FILL
4.5		S-4	4.5	4.95	17	18	16	178	same	FILL
6.0		S-5	6	6.45	11	12	13	152	same	FILL
7.5		S-6	7.5	7.95	16	14	15	203	same	FILL
9.0		S-7	9	9.45	13	11	14	203	same	FILL
									BOTTOM OF HOLE 9.45 m	
10.5										
12.0										

Nominal I.D. of Drive Pile	85 mm 100 mm
Nominal I.D. of Split Barrel Sampler	35 mm
Weight of Hammer on Drive Pipe	140 kg
Weight of Hammer on Split Barrel Sampler	63.5 kg
Drop of Hammer on Drive Pipe	600 mm
Drop of Hammer on Split Barrel Sampler	760 mm

Soil descriptions represent a field identification after D.M. Burmister unless otherwise noted.

The subsurface information shown hereon was obtained for State design and estimate purposes. It is made available to authorized users only that they may have access to the same information available to the State. It is presented in good faith, but is not intended as substitute for investigations, interpretation or judgement of such authorized users.

A.G. LICHTENSTEIN & ASSOCIATES, INC.

Approximate Change in Strata: ____________

Inferred Change in Strata: - - - - - - - - - - - -

Form SO-2 7/74

NEW JERSEY DEPARTMENT OF TRANSPORTATION

ROUTE: 80 **LOCAL NAME:** Sign Structure **TEST HOLE NO.** 435W - 8

SECTION: Route 17 to Teaneck Road

STATION: 937+40 **OFFSET:** 92' Rt. **REFERENCE LINE:** BL - Route 80 - E.B. **GROUND LINE ELEVATION:** +39.5'

BORINGS MADE BY: Bronston **DATE STARTED:** 6/6/77

INSPECTOR: Henry **DATE COMPLETED:** 6/7/77

Elevation G.W.T.		Date
0 Hr.	+27.5' Caved in & Dry	6/7/77
24 Hr.	+29.1' Caved in & Dry	6/8/77
ft. P.P. Installed		

Depth	Casing Blows	Sample No.	Depth from	Depth to	Blows on Spoon 0-6	Blows on Spoon 6-12	Blows on Spoon 12-18	Rec.	Sample ID and Profile Change
	5	S-1	0.0'	1.5'	1	7	11	2"	Brown SILT some, CF Sand, trace (+) CF Gravel.
	17								
	30								
	31								
	58								
5	169	S-2	5.0'	6.5'	22	39	57	12"	Grey CF SAND, little Silt, some CF Gravel.
	89	S-3	6.5'	8.0'	58	49	20	10"	Brown CF SAND, some Silt, little CF Gravel.
	60								
	35	S-4	8.0'	9.5'	17	18	21	12"	Brown CF Sand, some Silt, some CF Gravel.
	62								
10	51	S-5	10.0'	11.5'	13	25	24	14"	Grey CF Sand, little (+) Silt, some (+) CF Gravel.
	75								
	83								
	65								
	63								
15		S-6	15.0'	16.5'	15	14	23	6"	Brown CF SAND little (+) Silt, little MF Gravel

16.5'

BOTTOM OF HOLE

G.W.T.

Date	Elevation
6/13/77	+28.7' Caved in and Dry

Nominal I.D. of Drive Pipe	2½" XXX
Nominal I.D. of Split Barrel Sampler	1½"
Weight of hammer on Drive Pipe	300 lbs.
Weight of hammer on Split Barrel Sampler	140 lbs.
Drop of hammer on Drive Pipe	24"
Drop of hammer on Split Barrel Sampler	30"

Core Dia. ____________

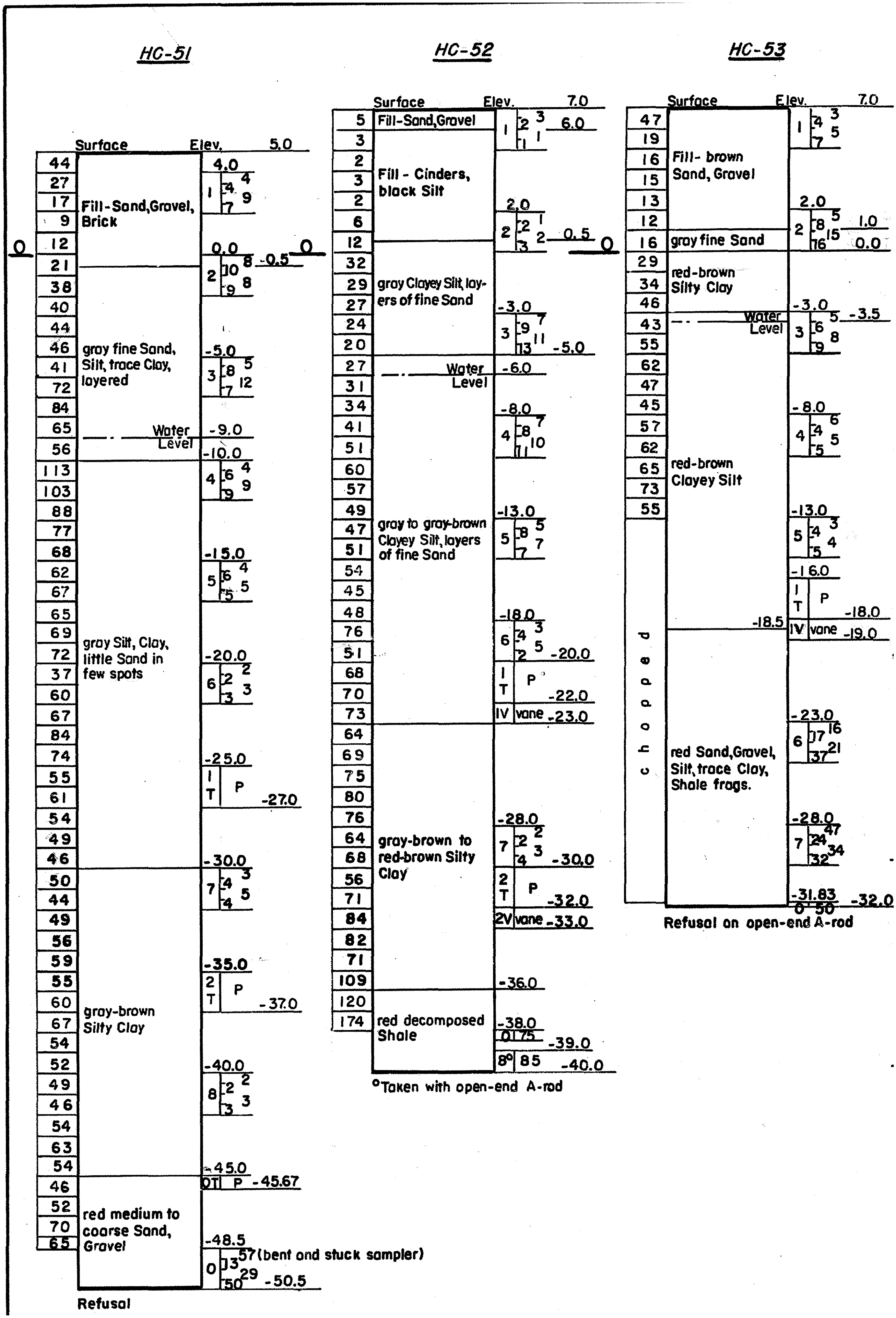
Soil descriptions represent a field identification after D.M. Burmister unless otherwise noted.

The Contractor shall make his own subsurface investigations in order to satisfy himself of the actual subsurface conditions. The information contained on this log is not warranted to show the actual subsurface conditions. The Contractor agrees that he will make no claims against the State if he finds that the actual conditions do not conform to those indicated by this log.

New Jersey Department of Transportation
Soils Bureau

Approximate Change in Strata ____________

Inferred Change in Strata – – – – – – – –


HC-51
Surface Elev. 5.0
Fill-Sand, Gravel, Brick
gray fine Sand, Silt, trace Clay, layered
Water Level
gray Silt, Clay, little Sand in few spots
gray-brown Silty Clay
red medium to coarse Sand, Gravel
57 (bent and stuck sampler)
Refusal
HC-52
Surface Elev. 7.0
Fill-Sand, Gravel
Fill - Cinders, black Silt
gray Clayey Silt, layers of fine Sand
Water Level
gray to gray-brown Clayey Silt, layers of fine Sand
gray-brown to red-brown Silty Clay
red decomposed Shale
°Taken with open-end A-rod
HC-53
Surface Elev. 7.0
Fill- brown Sand, Gravel
gray fine Sand
red-brown Silty Clay
Water Level
red-brown Clayey Silt
chopped
red Sand, Gravel, Silt, trace Clay, Shale frags.
Refusal on open-end A-rod

No. 660	Elev. +5.0'	
	0'0"-5'6"	Fill-Sand, Gravel, Brick
	5'6"-15'0"	Gray Fine Sand, Silt, Trace Clay, Layered
	15'0"-35'0"	Gray Silt, Clay, Little Sand in Few Spots
	35'0"-50'0"	Gray-Brown Silty Clay
	50'0"-55'6"	Red Medium to Coarse Sand, Gravel
	W.L. 14'0"	
No. 661	Elev. +7.0'	
	0'0"-1'0"	Fill-Sand, Gravel
	1'0"-6'6"	Fill-Cinders, Black Silt
	6'6"-12'0"	Gray Clayey Silt, Layers of Fine Sand
	12'0"-30'0"	Gray to Gray-Brown Clayey Silt, Layers of Fine Sand
	30'0"-43'0"	Gray-Brown to Red-Brown Silty Clay
	43'0"-47'0"	Red Decomposed Shale
	W.L. 13'0"	
No. 662	Elev. +7.0'	
	0'0"-6'0"	Fill-Brown Sand, Gravel
	6'0"-7'0"	Gray Fine Sand
	7'0"-10'0"	Red-Brown Silty Clay
	10'0"-25'6"	Red-Brown Clayey Silt
	25'6"-39'0"	Red Sand, Gravel, Silt, Trace Clay, Shale Fragments
	W.L. 10'6"	

No. 708	Elev. +6.2	
	0'0"-3'6"	Fill-Gravel, Silt, Sand
	3'6"-8'0"	Gray-Brown Medium Sand
	8'0"-12'0"	Gray Clayey Silt, Varved With Fine Sand
	12'0"-18'0"	Gray Silt, Trace Clay, Sand
	18'0"-25'0"	Gray Silty Clay, Varved With Fine Sand
	25'0"-33'0"	Gray-Brown Clayey Silt
	33'0"-52'0"	Gray-Brown Clayey Silt to Silty Clay, Varved With Fine Sand
	52'0"-58'0"	Red-Brown Silty Clay, Trace Sand
	58'0"-65'0"	Red-Brown Silty Clay, Varved With Fine Sand
	65'0"-73'0"	Red Sand, Gravel, Silt
	73'0"-81'0"	Red Shale
	W.L. 4'0"	
No. 709	Elev. +6.4	
	0'0"-9'0"	Fill-Gravel, Cinders
	9'0"-18'0"	Gray Silt, Little Fine Sand
	18'0"-27'0"	Gray Silty Clay, Varved With Fine Sand
	27'0"-45'0"	Gray Clayey Silt to Silty Clay, Layers of Fine Sa
	45'0"-57'0"	Red-Brown Clay, Few Sand Partings
	57'0"-65'0"	Red Silty Clay, Trace Sand
	65'0"-67'0"	Red Decomposed Shale
	67'0"-75'0"	Red Shale
	W.L. 4'0"	

No. 710	Elev. +6.2	
	0'0"-1'0"	Topsoil
	1'0"-4'0"	Fill
	4'0"-9'0"	Brown Medium Sand
	9'0"-30'0"	Gray Silt, Trace to Little Clay, Varved With Fine Sand
	30'0"-48'0"	Red-Brown Silty Clay, Varved With Fine Sand
	48'0"-57'0"	Red-Brown Clayey Silt, Closely Spaced Partings
	57'0"-68'0"	Red Medium Sand, Gravel, Clay
	68'0"-72'0"	Red Shale
	72'0"-76'0"	Red Sandstone
	W.L. 6'0"	
No. 711	Elev. +6.1	
	0'0"-6'0"	Fill-Sand, Gravel
	6'0"-9'0"	Brown Fine Sand
	9'0"-18'0"	Gray Silt, Little Clay, Trace Fine Sand
	18'0"-24'0"	Gray-Brown Clayey Silt
	24'0"-52'6"	Red-Brown Silty Clay Varved With Fine Sand
	52'6"-65'6"	Red Sand, Silt, Gravel, Shale Fragments
	65'6"-73'6"	Red Sandy Shale
	W.L. 4'0"	
No. 712	Elev. +6.1	
	0'0"-4'0"	Fill
	4'0"-8'0"	Brown Fine to Medium Sand
	8'0"-12'0"	Gray Fine Silty Sand
	12'0"-18'0"	Gray-Brown Silty Clay, Varved With Fine Sand
	18'0"-25'0"	Gray Fine Silty Sand, Trace Clay
	25'0"-30'0"	Gray Silty Clay Varved With Fine Sand
	30'0"-40'0"	Gray Silty Clay
	40'0"-58'0"	Red-Brown Silty Clay, Varved With Fine Sand
	58'0"-81'0"	Red Fine to Medium Silty Sand, Trace Clay, Fine Gravel
	81'0"-87'0"	Red Shale
	W.L. 4'0"	
No. 713	Elev. +5.9	
	0'0"-7'0"	Brown Sand, Clay (Fill-Driller)
	7'0"-18'0"	Gray Clayey Silt, Layers of Fine Sand
	18'0"-40'0"	Gray Silty Clay, Varved With Fine Sand
	40'0"-53'0"	Red-Brown Silty Clay, Varved With Fine Sand
	53'0"-75'0"	Red Silty Sand, Gravel
	75'0"-77'0"	Soft Red Shale
	77'0'-83'0"	Red Sandy Shale
	W.L. 2'0"	
No. 714	Elev. +5.1	
	0'0"-1'0"	Cobblestone
	1'0"-6'0"	Brown Medium Sand (Fill-Driller)
	6'0"-12'0"	Gray Fine to Medium Sand
	12'0"-22'0"	Gray-Brown Silt, Varved With Fine Sand

No. 714 Cont'd.	22'0"-47'0"	Red-Brown Silty Clay, Varved with Fine Sand
	47'0"-58'0"	Red Silty Clay, Few Layers of Sand
	58'0"-70'0"	Red Fine Sand, Silt, Gravel,
	70'0"-78'0"	Red Sandstone and Shale
	W. L. 2'6"	
No. 715	Elev. +5.4	
	0'0"-0'4"	Macadam
	0'4"-7'0"	Fill-Brown Sand Cinders
	7'0"-17'0"	Gray Clayey Silt
	17'0"-40'0"	Gray Silty Clay, Partings to 1/16th of an Inch Varves of Silt or Silt to Fine Sand
	40'0"-55'0"	Red-Brown Silty Clay, Irregular Layers Fine Sand and Fine Silty Sand
	55'0"-71'0"	Red Fine to Medium Sand, Gravel, Boulder Fragments, Shale Fragments at Bottom
	71'0"-79'0"	Red Sandy Shale
	W. L. 5'0"	
No. 716	Elev. +6.0	
	0'0"-14'0"	Brown Medium Sand
	14'0"-26'6"	Gray Clayey Silt, Varved with Silt to Fine Sand
	26'6"-38'0"	Gray Silty Clay, Varved with Clayey Silt
	38'0"-59'0"	Red-Brown Clay, Trace Silt
	59'0"-70'0"	Red Fine to Medium Sand, Gravel
	70'0"-82'6"	Red Fine to Medium Sand, Gravel, Shale Fragments
	82'6"-88'6"	Red Sandy Shale
	W. L. 2'0"	
No. 717	Elev. -	
	0'0"-1'6"	Fill-Dark Sand
	1'6"-3'0"	Gravel, Fibers
	3'0"-11'0"	Brown Fine to Medium Sand
	11'0"- 21'6"	Gray Clayey Silt Trace Sand
	21'6"-32'0"	Gray Silty Clay, Partings of Fine Sand, Silt
	32'0"-45'0"	Gray and Red-Brown Silty Clay, Varved with Clayey Silt
	45'0"-53'0"	Red Sand, Silt, Gravel, Shale Fragments
	53'0"-59'0"	Red Sandy Shale
	W. L. 2'0"	
No. 718	Elev.+5.4	
	0'0"-1'0"	Soil, Roots
	1'0"-2'6"	Fill-Cinders
	2'6"-18'0"	Brown Fine to Medium Sand
	18'0"-23'0"	Gray-Brown Silty Clay, Varved with Silt, Very Fine Sand, Trace Clay
	23'0"-35'0"	Red-Brown Silty Clay, Varved with Silt, Very Fine Sand, Trace Clay

No. 718 Cont'd.	35'0"-42'6"	Red Silty Clay Varved with Silt
	42'6"-50'6"	Red Sand, Fine Gravel, Trace Silt
	50'6"-54'0"	Red Sand, Cobbles, Trace Clay
	54'0"-60'6"	Red Sandy Shale
	W. L. 1'0"	
No. 719	Elev. +5.2	
	0'0"-15'0"	Yellow and Brown Fine to Medium Sand
	15'0"-28'0"	Brown, Gray-Brown and Gray Fine Saturated Silty Sand
	28'0"-53'0"	Gray to Red-Brown Silty Clay, Varved with Silt
	53'0"-58'0"	Red Silty Sand, Fine Gravel
	58'0"-65'0"	Red Fine to Medium Sand, Gravel, Shale Fragments
	65'0"-73'0"	Red Sandy Shale
	W. L. 2'0"	

No. 724	Elev. +6.6	
	0'0"-4'0"	Fill-Cinders, Sand, Gravel
	4'0"-7'0"	Gray-Brown Fine Sand
	7'0"-11'0"	Dark Organic Silt
	11'0"-20'0"	Gray Clay, Silt, Fine Sand-Alternating in Thin Varves and Partings
	20'0"-49'0"	Gray to Red-Brown Silty Clay, Partings of Silt to Fine Sand
	49'0"-70'0"	Red-Brown Silty Sand, Gravel, Cobbles, Rock Fragments
	70'0"-78'0"	Red Sandy Shale
	W. L. 5'6"	
No. 725	Elev. +6.5	
	0'0"-5'0"	Fill-Cinders, Sand, Clay, Gravel, etc.
	5'0"-20'0"	Gray Fine to Medium Sand
	20'0"-25'0"	Gray Fine to Medium Sand, Trace Silt
	25'0"-40'0"	Gray-Brown Clay and Silt, Varved with Silt to Fine Sand
	40'0"-49'0"	Red-Brown Silty Clay, Varved with Silt to Fine Sand
	49'0"-52'0"	Red Sand, Gravel, Cobbles
	52'0"-54'0"	Brown Sand-Stone Boulders
	54'0"-62'0"	Red Sand, Gravel, Boulders, Clay
	62'0"-68'0"	Red Sandstone
	68'0"-70'0"	Red Shale and Sandstone
	70'0"-73'0"	Red Sandy Shale
	W. L. 4'0"	
No. 726	Elev. +7.3	
	0'0"-4'0"	Fill-Gravel, Sand, Boulders, Miscellaneous
	4'0"-7'0"	Yellow-Brown Fine Sand, Silt, Fibers
	7'0"-47'0"	Gray to Red-Brown Clay, Varved with Silt, Some Seams of Fine Sand
	47'0"-69'6"	Red Fine Silty Sand, Gravel, Cobbles
	69'6"-77'6"	Red Sandstone, Streaks of Sandy Shale
	W. L. 6'0"	

No. 727	Elev. +6.1	
	0'0"-5'0"	Fill-Gray and Brown Sand, Gravel
	5'0"-9'0"	Brown Sandy Silt
	9'0"-24'0"	Gray Clay, Little Silt, Varved with Silt, Little Clay; Silt to Fine Sand Partings
	24'0"-41'0"	Red-Brown Silty Clay, Partings of Silt to Fine Sand
	41'0"-50'0"	Red Fine Sand Gravel
	50'0"-68'0"	Red Fine to Medium Sand, Gravel, Cobbles
	68'0"-76'0"	Red Sandstone
	76'0"-78'6"	Red Sandy Shale to Sandstone
	W. L. 7'6"	
No. 728	Elev. +6.9	
	0'0"-1'0"	Fill-Cinders Sand Gravel Silt
	1'0"-10'6"	Brown Fine Sand, Trace Silt
	10'6"-23'6"	Gray Clay, Varved with Silt, Partings of Fine Sand
	23'6"-34'6"	Red-Brown Silty Clay, Partings of Silt to Fine Sand
	34'6"-45'0"	Red Silty Clay, Seams of Fine Sand
	45'0"-65'0"	Red Sand, Gravel, Cobbles
	65'0"-67'0"	Red Sandy Shale
	67'0"-75'0"	Shale
	W. L. 5'0"	
No. 729	Elev. +6.4	
	0'0"-9'0"	Fill-Dark Sand, Ashes, Organic Matter, Gravel
	9'0"-16'0"	Gray Sand, Trace Silt
	16'0"-24'0"	Gray Clayey Silt, Trace Silty Sand
	24'0"-40'0"	Gray Silty Clay, Varved with Clayey Silt
	40'0"-60'0"	Red Fine to Coarse Sand, Gravel
	60'0"-65'0"	Red Sandstone
	65'0"-68'0"	Red Sandy Shale
	W. L. 4'0"	
No. 730	Elev. +5.7	
	0'0"-3'0"	Fill-Broken Rock, Sand, Gravel
	3'0"-9'0"	Red-Brown Fine to Coarse Sand, Gravel, Trace Silt
	9'0"-14'0"	Gray Fine Sand, Trace Silt, Plant Remains
	14'0"-19'6"	Gray Silty Clay, Varved with Silt to Fine Sand
	19'6"-24'0"	Gray and Red Silty Clay, Varved with Silt to Sand
	24'0"-35'0"	Red-Brown Silty Clay, Varved with Silt to Fine Sand
	35'0"-40'0"	Dark Red Silty Clay, Varved with Silt to Fine Sand
	40'0"-50'0"	Red-Brown Fine Sand, Fine Gravel, Little Silt
	50'0"-64'0"	Red-Brown Fine to Medium Sand, Gravel, Trace Silt, Sandstone Fragments
	64'0"-68'0"	Red Sandstone
	68'0"-72' 0"	Red Sandy Shale
	W. L. 2'0"	

No. 731	Elev. +8.1	
	0'0"-5'0"	Fill-Broken Rock
	5'0"-9'0"	Brown and Gray Sand, Gravel, Trace Silt
	9'0"-11'0"	Brown Fine Sand, Trace Silt
	11'0"-15'0"	Gray Fine Sand, Little Silt, Few Fibers
	15'0"-25'0"	Red-Gray Silty Clay, Partings of Silt to Fine Sand
	25'0"-36'6"	Red-Brown Silty Clay, Partings to Varves of Silt to Fine Sand
	36'6"-50'0"	Red-Brown Fine Sand, Silt, Gravel
	50'0"-64'0"	Red Fine Sand, Silt, Gravel, Boulders
	64'0"-72'0"	Red Sandy Shale
	W. L. 7'0"	
No. 732	Elev. +6.3	
	0'0"-6'6"	Fill-Brown Sand, Gravel
	6'6"-17'0"	Gray Silt, Trace Clay, Fine Sand, Layers of Peaty Plant Remains
	17'0"-29'0"	Gray Fine to Medium Sand
	29'0"-37'0"	Gray and Red-Brown Silty Clay, Partings to Varves of Silt to Fine Sand
	37'0"-59'6"	Red-Brown Fine Sand, Little Silt, Gravel, Few Rock Fragments
	59'6"-67'6"	Red Sandy Shale
	W. L. 5'6"	
No. 733	Elev. +6.2	
	0'0"-7'0"	Fill-Brown Sand, Little Gravel
	7'0"-23'0"	Gray Silt, Peaty Plant Remains
	23'0"-25'0"	Gray Fine to Medium Sand
	25'0"-34'0"	Gray to Red-Brown Silty Clay, Varved with Silt to Fine Sand
	34'0"-58'0"	Red-Brown Fine Sand, Gravel, Little Silt, Sandstone Fragments Bottom
	58'0"-66'0"	Red Shaley Sandstone to Red Sandy Shale
	W. L. 5'0"	
No. 734	Elev. +6.1	
	0'0"-2'0"	Macadam
	2'0"-4'0"	Brown Sand, Gravel (Fill?)
	4'0"-10'0"	Gray Silt, Peaty Plant Remains, Trace Brown Sand
	10'0"-24'0"	Gray Silt, Trace Fine Sand Increasing to Partings of Silt to Fine Sand
	24'0"-35'0"	Red-Brown Silty Clay, Partings of Silt to Fine Sand
	35'0"-39'0"	Red-Brown Silt, Fine Sand, Gravel, Trace Clay
	39'0"-45'0"	Red-Brown Fine Sand, Silt, Gravel
	45'0"-60'0"	Red-Brown Fine Sand, Little Silt, Gravel, Boulders
	60'0"-65'0"	Red Decomposed Shale
	65'0"-73'0"	Red Shaley Sandstone, and Red Sandy Shale
	W. L. 3'0"	

No. 735	Elev. +6.3	
	0'0"-6'0"	Fill-Red-Brown Sand, Gravel, Crushed Rock
	6'0"-9'0"	Dark Silt, Plant Remains, Trace Clay, Fine Sand
	9'0"-17'0"	Gray Fine to Medium Sand
	17'0"-30'0"	Gray and Red-Brown Silty Clay, Partings of Silt to Fine Sand
	30'0"-51'0"	Red-Brown Sand, Gravel, Little Silt
	51'0"-54'0"	Red Shaley Sandstone
	54'0"-59'0"	Red Sandy Shale
	W. L. 4'6"	
No. 736	Elev. +5.1	
	0'0"-4'0"	Fill-Crushed Rock, Sand, Gravel, etc.
	4'0"-8'0"	Gray and Yellow-Brown Fine Sand
	8'0"-15'0"	Gray Clayey Silt
	15'0"-26'0"	Red-Brown Silty Clay, Partings of Silt to Fine Sand
	26'0"-41'0"	Red-Brown Sand, Silt, Gravel, Cobbles
	41'0"-45'6"	Red Soft Sandstone
	45'6"-48'6"	Red Shaley Sandstone
	48'6"-53'6"	Red Sandy Shale
	W. L. 3'8"	
No. 737	Elev. +6.4	
	0'0"-7'0"	Fill-Red-Brown Silty Sand, Cine Cinders, Gravel, Miscellaneous
	7'0"-10'6"	Gray Fine Sand, Trace Silt
	10'6"-13'0"	Gray Clayey Silt
	13'0"-20'0"	Gray and Red-Brown Silty Clay
	20'0"-28'0"	Red-Brown Silty Clay, Partings of Silt to Fine Sa
	28'0"-50'0"	Red-Brown Silty Sand, Gravel
	50'0"-58'0"	Red Sandy Shale
	W. L. 6'0"	

Boring Logs from Soil Area 2

No. 1108	Elev. -	
	0'0"-9'0"	Black Silt Clay, Sand Gravel Riprap Fill
	9'0"-20'0"	Red Sand Clay and Gravel
	20'0"-21'0"	Soft Shale
	W. L. 0'6"	
No. 1109	Elev. -	
	0'0"-3'0"	Black Silt, Clay, Sand Gravel, Riprap Fill
	3'0"-7'0"	Black Silt
	7'0'-17'0"	Red Sand Clay and Gravel
	17'0"-18'0"	Soft Shale
	W. L. 0'0"	
No. 1110	Elev. -	
	0'0"-6'0"	Black Silt, Sand, Clay Gravel, Riprap Fill
	6'0"-7'6"	Black Silt
	7'6"-18'6"	Red Sand Clay and Gravel
	18'6"-20'0"	Soft Shale
	20'0"-25'0"	Shale
	W. L. 0'0"	
No. 1111	Elev. -	
	0'0"-10'0"	Black Silt Clay Gravel and Riprap Fill
	W. L. 0'0"	
No. 1112	Elev. -	
	0'0"-9'0"	Black Silt Sand Clay Gravel Riprap Fill
	9'0"-27'5"	Red Sand Clay and Gravel
	27'5"-29'11"	Soft Shale
	29'11"-34'11"	Shale (Drilled)
	W. L. 0'0"	
No. 1113	Elev.-	
	0'0"-9'6"	Riprap Fill Black Silt
	9'6"-12'0"	Brown Clay Layer of Brown Sand
	12'0"-29'4"	Red Sand Clay and Gravel
	29'4"-30'4"	Soft Shale
	30'4"-35'4"	Shale (Drilled)
	W. L. 0'0"	

No. 1114	Elev. -	
	0'0"-9'6"	Black Silt
	9'6"-15'0"	Red Sand Clay and Gravel
	15'0"-17'0"	Boulder (Drilled)
	17'0"-33'0"	Red Sand Clay and Gravel
	33'0"-38'0"	Shale (Drilled)
	W. L. 2'0"	
No. 1115	Elev. +3.0	
	0'0"-5'0"	Mud and Bog
	5'0"-21'0"	Soft Gray Clay
	21'0"-26'0"	Fine Silty Gray Sand
	26'0"-35'0"	Gray Clay
	W. L. 0'0"	
No. 1117	Elev. +8.75	
	0'0"-6'6"	Earth Sand Gravel Brick Fill
	6'6"-10'3"	Fine Brown Sand
	10'3"-17'5"	Red Clay
	17'6"-38'6"	Compact Red Sand Clay Gravel and Boulders
	38'6"-40'0"	Red Shale
	W. L. -	
No. 1118	Elev. +6.0	
	0'0"-5'0"	Earth Sand and Gravel Fill
	5'0"-8'6"	Fine Red Sand
	8'6"-10'0"	Red Clay
	10'0"-24'0"	Red Sand and Gravel
	24'0"-28'0"	Shale
	W. L. 3'0"	

94	N 26-3-939	former clay pit exposed 3 to 7 feet of yellow-brown sand (Qmt) overlying 10 feet of horizontally-bedded light-gray- brown fat clay (Qhkl)

Boring Logs from Soil Area 3

9-A. Mauraydi (well).

0 - 5	soil
5 - 48	red clay and sand
48 -	red shale

No. 1116	Elev. +4.5	
	0'0"-2'0"	Earth and Wood Fill
	2'0"-8'8"	Silty Red and Gray Sand
	8'8"-13'0"	Gray Clay Thin Layers of Sand
	13'0"-40'0"	Gray Clay
	W. L. 3'8"	

237	26-5190	0-3	clay and fill
		3-37	fine silt, sand (Qmt over Qhkl)
		37-300	red shale

Boring Logs from Soil Area 4

7-B. Bergen County Sewage Plant boring.

90 feet to rock

8-B. Morhoff Brick Company Well.

85 feet to rock

9-B. Bergen County Sewage Plant boring.

0 -	7	marsh
7 -	20	gray clay and organic matter
20 -	31	fine sand
31 -	70	clay
70 -	75	sand and gravel
75 -	82	gray sandstone
82 -	87	red shale

No. 166 Elev. -

0'0"-7'6"	Fill
7'6"-18'0"	Gray Organic Silt
18'0"-23'0"	Light Gray Silt & Clay
23'0"-79'0"	Light Gray & Light Brown Varved Silt & Clay
79'0"-84'0"	Red Brown Silt & Clay
84'0"-91'6"	Red Brown Coarse to Fine + Sand, Some - Silt, Trace Fine Gravel

W. L. -

No. 1115 Elev. +3.0

0'0"-5'0"	Mud and Bog
5'0"-21'0"	Soft Gray Clay
21'0"-26'0"	Fine Silty Gray Sand
26'0"-35'0"	Gray Clay

W. L. 0'0"

No. 1136 Elev. +4.15

0'0"-21'0"	Organic Silt
21'0"-71'0"	Gray and Reddish Brown Clay
71'0"-78'0"	Red Brown Clay and Gravel

W. L. -

No. 1137 Elev. +6.80

0'0"- 7'0"	Organic Silt
7'0"-21'0"	Gray Clay Trace of Organic Silt
21'0"-36'0"	Medium to Fine Sand and Clay
36'0"-72'0"	Grayish Brown and Reddish Brown Clay
72'0"-82'4"	Red Clay and Gravel

W. L. -

1324 to 1327 The Bergen County Sewer Authority, Clinton Bogert, Engrs.

No. 1324	Elev. +8.0'	
	0'0"-7'5"	Cinders, Wood, Brick, Sand and Gravel Fill
	7'5"-14'8"	Mud and bog
	14'8"-24'0"	Gray Sand and Clay
	24'0"-62'4"	Gray Clay
	62'4"-69'0"	Red Clay
	69'0"-79'0"	Red Sand, Clay and Gravel
	79'0"-84'0"	Shale
	W.L. 6'0"	

No.1325	Elev. +5.0'	
	0'0"-9'0"	Cinders, Brick, Wood, Sand and Gravel Fill
	W.L. 8'1"	

No. 1326	Elev. +5.0'	
	0'0"-11'3"	Cinders, Wood, Brick, Sand, Gravel and Clay Fill
	11'3"-22'0"	Mud and Bog
	22'0"-33'5"	Gray Clay and Sand
	33'5"-66'4"	Gray Clay
	66'4"-72'0"	Red Clay
	72'0"-82'6"	Red Clay, Sand and Gravel
	82'6"-87'6"	Shale
	W.L. 6'3"	

No. 1327	Elev. +8.0'	
	0'0"-18'3"	Brown Sand, Gravel, Brick and Wood Fill
	18'3"-37'5"	Gray Clay and Sand
	37'5"-62'0"	Gray Clay
	62'0"-73'8"	Red Clay
	73'8"-81'0"	Red Clay, Sand and Gravel
	81'0"-86'0"	Shale
	W.L. 11'2"	

18'3"-37'5" Gray Clay and Sand
37'5"-62'0" Gray Clay
62'0"-73'8" Red Clay
73'8"-81'0" Red Clay, Sand and Gravel
81'0"-86'0" Shale
W.L. 11'2"

91	Salisbury, 1902, p. 617	0-85	clay (Qhkl)
		at 85	bedrock
93	Parillo, 1959 well 9B	0-7	marsh (Qm)
		7-20	gray clay and organic matter (Qm)
		20-31	fine sand (Qal)
		31-70	clay (Qhkl)
		70-75	sand and gravel (Qhkf)
		75-82	gray sandstone
		82-87	red shale

Boring Logs from Soil Area 5

The Louis Berger Group, Inc. 412 Mt Kemble Ave Morristown, NJ 07960	**Drilling Log** Page 1 of 1	**BORING NO.:** GT001 **WELL NO.:** N/A

CLIENT: EarthMark Mitigation Services	**PROJECT NO:** KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank	**DATE STARTED:** 2/18/2009
DRILLING CONTRACTOR: N/A	**DATE FINISHED:** 2/18/2009
DRILLING METHOD: Hand Auger	**DRILLER:** N/A

BOREHOLE DATA	**WELL DATA**	
		INSPECTOR: K. Schuch
Diameter (in): 3	**Completion:** N/A	**NORTHING:** N/A
Total Depth (ft): 5.00	**Total Depth (ft):** N/A	**EASTING:** N/A
Sampler: Hand Auger	**Screen Length (ft) /Slot (in):** N/A	**GROUND ELEVATION (ft):** N/A
Depth to Water (ft): At Surface	**Depth to Water (ft):** N/A	**TOC ELEVATION (ft):** N/A
Depth to Rock (ft): N/A	**Permit No.:** N/A	

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0 – 3.5		OL					Dark greenish gray (5GY4/1) Organic SILT; saturated.	**Organic Silt (collected sample GT001A at 0.0 to 3.5 ft bgs)**
	3.5 – 5		SM					Olive black (5Y2/1) fine SAND, some Silt; saturated .	**Silty Sand (collected sample GT001B at 3.5 to 5.0 ft bgs) End of Boring at 5 ft. bgs.**

The Louis Berger Group, Inc. 412 Mt Kemble Ave Morristown, NJ 07960	**Drilling Log** Page 1 of 1	**BORING NO.:** GT003 **WELL NO.:** N/A

CLIENT: EarthMark Mitigation Services	**PROJECT NO:** KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank	**DATE STARTED:** 2/18/2009
DRILLING CONTRACTOR: N/A	**DATE FINISHED:** 2/18/2009
DRILLING METHOD: Hand Auger	**DRILLER:** N/A

BOREHOLE DATA	**WELL DATA**	
		INSPECTOR: K. Schuch
Diameter (in): 3	**Completion:** N/A	**NORTHING:** N/A
Total Depth (ft): 5.00	**Total Depth (ft):** N/A	**EASTING:** N/A
Sampler: Hand Auger	**Screen Length (ft) /Slot (in):** N/A	**GROUND ELEVATION (ft):** N/A
Depth to Water (ft): At Surface	**Depth to Water (ft):** N/A	**TOC ELEVATION (ft):** N/A
Depth to Rock (ft): N/A	**Permit No.:** N/A	

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0 – 2		SP-SM					Dark greenish gray (5GY4/1) fine SAND, lttle Silt; saturated.	**Sand (collected sample GT003A at 0.0 to 2.0 ft bgs)**
	2 – 3.5		PEAT					Brownish black (5YR2/1) PEAT, little fine Sand; saturated.	**Peat (collected sample GT003B at 2.0 to 3.5 ft bgs)**
	3.5 – 5		SM					Dark greenish gray (5GY4/1) fine SAND, some Silt; saturated.	**Silty Sand (collected sample GT003C at 3.5 to 5.0 ft bgs)** **End of Boring at 5 ft. bgs.**

The Louis Berger Group, Inc. 412 Mt Kemble Ave Morristown, NJ 07960	**Drilling Log** Page 1 of 1	**BORING NO.:** GT005 **WELL NO.:** N/A

CLIENT: EarthMark Mitigation Services	**PROJECT NO:** KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank	**DATE STARTED:** 2/18/2009
DRILLING CONTRACTOR: N/A	**DATE FINISHED:** 2/18/2009
DRILLING METHOD: Hand Auger	**DRILLER:** N/A

BOREHOLE DATA	**WELL DATA**	
		INSPECTOR: K. Schuch
Diameter (in): 3	**Completion:** N/A	**NORTHING:** N/A
Total Depth (ft): 5.00	**Total Depth (ft):** N/A	**EASTING:** N/A
Sampler: Hand Auger	**Screen Length (ft) /Slot (in):** N/A	**GROUND ELEVATION (ft):** N/A
Depth to Water (ft): At Surface	**Depth to Water (ft):** N/A	**TOC ELEVATION (ft):** N/A
Depth to Rock (ft): N/A	**Permit No.:** N/A	

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0		SP-SM					Dark greenish gray (5GY4/1) fine SAND, little Silt; saturated.	**Sand (collected sample GT005A at 0.0 to 3.5 ft bgs)**
	1								
	2								
	3		SP-SM					Greenish black (5GY2/1) fine SAND, little Silt, trace Peat; saturated.	**Collected sample GT005B at 3.5 to 5.0 ft bgs**
	4								**End of Boring at 5 ft bgs.**
	5								

The Louis Berger Group, Inc. 412 Mt Kemble Ave Morristown, NJ 07960	**Drilling Log** Page 1 of 1	**BORING NO.:** GT007 **WELL NO.:** N/A

CLIENT: EarthMark Mitigation Services	**PROJECT NO:** KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank	**DATE STARTED:** 2/18/2009
DRILLING CONTRACTOR: N/A	**DATE FINISHED:** 2/18/2009
DRILLING METHOD: Hand Auger	**DRILLER:** N/A

BOREHOLE DATA	WELL DATA	
Diameter (in): 3	**Completion:** N/A	**INSPECTOR:** K. Schuch
Total Depth (ft): 5.00	**Total Depth (ft):** N/A	**NORTHING:** N/A
Sampler: Hand Auger	**Screen Length (ft) /Slot (in):** N/A	**EASTING:** N/A
Depth to Water (ft): At Surface	**Depth to Water (ft):** N/A	**GROUND ELEVATION (ft):** N/A
Depth to Rock (ft): N/A	**Permit No.:** N/A	**TOC ELEVATION (ft):** N/A

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0		SP-SM					Dark greenish gray (5GY4/1) fine SAND, little Silt; saturated.	**Sand (collected sample GT007A at 0.0 to 3.5 ft bgs)**
	1								
	2								
	3								
			SP-SM					Greenish black (5GY2/1) fine SAND, little Silt, trace Peat; saturated.	**Collected sample GT007B at 3.5 to 5.0 ft bgs**
	4								
	5								**End of Boring at 5 ft. bgs.**

The Louis Berger Group, Inc.
412 Mt Kemble Ave
Morristown, NJ 07960

Drilling Log

BORING NO.:	GT009
WELL NO.:	N/A

CLIENT: EarthMark Mitigation Services		**PROJECT NO:**	KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank		**DATE STARTED:**	2/16/2009
DRILLING CONTRACTOR:	N/A	**DATE FINISHED:**	2/16/2009
DRILLING METHOD:	Hand Auger	**DRILLER:**	N/A

BOREHOLE DATA		**WELL DATA**			
				INSPECTOR:	K. Schuch
Diameter (in):	3	**Completion:**	N/A	**NORTHING:**	N/A
Total Depth (ft):	5.00	**Total Depth (ft):**	N/A	**EASTING:**	N/A
Sampler:	Hand Auger	**Screen Length (ft) /Slot (in):**	N/A	**GROUND ELEVATION (ft):**	N/A
Depth to Water (ft):	At Surface	**Depth to Water (ft):**	N/A	**TOC ELEVATION (ft):**	N/A
Depth to Rock (ft):	N/A	**Permit No.:**	N/A		

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0–2.5		PEAT					Grayish black (N2) PEAT; saturated.	**Peat (collected sample GT009A at 0.0 to 2.5 ft bgs)**
	2.5–5		SP-SM					Medium gray (N5) fine SAND, little Silt; saturated.	**Sand (collected sample GT009B at 2.5 to 5.0 ft bgs)** **End of Boring at 5 ft. bgs.**

Depth scale: 0, 1, 2, 3, 4, 5

The Louis Berger Group, Inc.
412 Mt Kemble Ave
Morristown, NJ 07960

Drilling Log

BORING NO.:	GT010
WELL NO.:	N/A
CLIENT:	EarthMark Mitigation Services
PROJECT:	Richard P. Kane Wetland Mitigation Bank
DRILLING CONTRACTOR:	N/A
DRILLING METHOD:	Hand Auger
PROJECT NO:	KT500F4
DATE STARTED:	2/16/2009
DATE FINISHED:	2/16/2009
DRILLER:	N/A
INSPECTOR:	K. Schuch
NORTHING:	N/A
EASTING:	N/A
GROUND ELEVATION (ft):	N/A
TOC ELEVATION (ft):	N/A

BOREHOLE DATA		WELL DATA	
Diameter (in):	3	**Completion:**	N/A
Total Depth (ft):	5.00	**Total Depth (ft):**	N/A
Sampler:	Hand Auger	**Screen Length (ft) /Slot (in):**	N/A
Depth to Water (ft):	At Surface	**Depth to Water (ft):**	N/A
Depth to Rock (ft):	N/A	**Permit No.:**	N/A

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0–2.5		OL					Brownish black (5YR2/1) Organic SILT; saturated.	**Organic Silt (collected sample GT010A at 0.0 to 2.5 ft bgs)**
	2.5–5		SP-SM					Dark greenish gray (5G4/1) fine SAND, little Silt; saturated.	**Sand (collected sample GT010B at 2.5 to 5.0 ft bgs)** **End of Boring at 5 ft. bgs.**

Depth scale: 0, 1, 2, 3, 4, 5

The Louis Berger Group, Inc. 412 Mt Kemble Ave Morristown, NJ 07960	**Drilling Log** Page 1 of 1	**BORING NO.:** GT011 **WELL NO.:** N/A

CLIENT: EarthMark Mitigation Services		**PROJECT NO:** KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank		**DATE STARTED:** 2/16/2009
DRILLING CONTRACTOR: N/A		**DATE FINISHED:** 2/16/2009
DRILLING METHOD: Hand Auger		**DRILLER:** N/A
BOREHOLE DATA	**WELL DATA**	**INSPECTOR:** K. Schuch
Diameter (in): 3	**Completion:** N/A	**NORTHING:** N/A
Total Depth (ft): 5.00	**Total Depth (ft):** N/A	**EASTING:** N/A
Sampler: Hand Auger	**Screen Length (ft) /Slot (in):** N/A	**GROUND ELEVATION (ft):** N/A
Depth to Water (ft): At Surface	**Depth to Water (ft):** N/A	**TOC ELEVATION (ft):** N/A
Depth to Rock (ft): N/A	**Permit No.:** N/A	

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0–3.5		SM					Olive black (5Y2/1) fine SAND, and Silt; saturated.	**Silty Sand (collected sample GT011A at 0.0 to 3.5 ft bgs)**
	3.5–5		SM					Medium dark gray (N4) fine SAND, some Silt; saturated.	**Collected sample GT011B at 3.5 to 5.0 ft bgs** **End of Boring at 5 f.t bgs.**

The Louis Berger Group, Inc. 412 Mt Kemble Ave Morristown, NJ 07960	**Drilling Log** Page 1 of 1	**BORING NO.:** GT012 **WELL NO.:** N/A

CLIENT: EarthMark Mitigation Services	**PROJECT NO:** KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank	**DATE STARTED:** 2/16/2009
DRILLING CONTRACTOR: N/A	**DATE FINISHED:** 2/16/2009
DRILLING METHOD: Hand Auger	**DRILLER:** N/A

BOREHOLE DATA	**WELL DATA**	
		INSPECTOR: K. Schuch
Diameter (in): 3	**Completion:** N/A	**NORTHING:** N/A
Total Depth (ft): 5.00	**Total Depth (ft):** N/A	**EASTING:** N/A
Sampler: Hand Auger	**Screen Length (ft) /Slot (in):** N/A	**GROUND ELEVATION (ft):** N/A
Depth to Water (ft): At Surface	**Depth to Water (ft):** N/A	**TOC ELEVATION (ft):** N/A
Depth to Rock (ft): N/A	**Permit No.:** N/A	

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0–2		OL					Olive black (5Y2/1) Organic SILT; saturated.	**Organic Silt (collected sample GT012A at 0.0 to 2.0 ft bgs)**
	2–5		SM					Pale yellowish brown (10YR6/2) fine SAND, some Silt; saturated.	**Silty Sand (collected sample GT012B at 2.0 to 5.0 ft bgs)** **End of Boring at 5 ft. bgs.**

The Louis Berger Group, Inc.
412 Mt Kemble Ave
Morristown, NJ 07960

Drilling Log

BORING NO.:	GT013	**WELL NO.:**	N/A
CLIENT:	EarthMark Mitigation Services	**PROJECT NO:**	KT500F4
PROJECT:	Richard P. Kane Wetland Mitigation Bank	**DATE STARTED:**	2/16/2009
DRILLING CONTRACTOR:	N/A	**DATE FINISHED:**	2/16/2009
DRILLING METHOD:	Hand Auger	**DRILLER:**	N/A

BOREHOLE DATA		**WELL DATA**			
Diameter (in):	3	**Completion:**	N/A	**INSPECTOR:**	K. Schuch
Total Depth (ft):	5.00	**Total Depth (ft):**	N/A	**NORTHING:**	N/A
Sampler:	Hand Auger	**Screen Length (ft) /Slot (in):**	N/A	**EASTING:**	N/A
Depth to Water (ft):	At Surface	**Depth to Water (ft):**	N/A	**GROUND ELEVATION (ft):**	N/A
Depth to Rock (ft):	N/A	**Permit No.:**	N/A	**TOC ELEVATION (ft):**	N/A

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0–2.5		OL					Olive black (5Y2/1) Organic SILT; saturated.	**Organic Silt (collected sample GT013A at 0.0 to 2.5 ft bgs)**
	2.5–5		SM					Pale yellowish brown (10YR6/2) to moderate yellowish brown (10YR5/4) fine SAND, some Silt; saturated.	**Silty Sand (collected sample GT013B at 2.5 to 5.0 ft bgs)** **End of Boring at 5 ft. bgs.**

The Louis Berger Group, Inc.
412 Mt Kemble Ave
Morristown, NJ 07960

Drilling Log

BORING NO.:	GT014
WELL NO.:	N/A

CLIENT:	EarthMark Mitigation Services	**PROJECT NO:**	KT500F4
PROJECT:	Richard P. Kane Wetland Mitigation Bank	**DATE STARTED:**	2/16/2009
DRILLING CONTRACTOR:	N/A	**DATE FINISHED:**	2/16/2009
DRILLING METHOD:	Hand Auger	**DRILLER:**	N/A

BOREHOLE DATA		**WELL DATA**			
Diameter (in):	3	**Completion:**	N/A	**INSPECTOR:**	K. Schuch
Total Depth (ft):	5.00	**Total Depth (ft):**	N/A	**NORTHING:**	N/A
Sampler:	Hand Auger	**Screen Length (ft) /Slot (in):**	N/A	**EASTING:**	N/A
Depth to Water (ft):	At Surface	**Depth to Water (ft):**	N/A	**GROUND ELEVATION (ft):**	N/A
Depth to Rock (ft):	N/A	**Permit No.:**	N/A	**TOC ELEVATION (ft):**	N/A

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0 1 2		OL					Olive black (5Y2/1) Organic SILT; saturated.	**Organic Silt (collected sample GT014A at 0.0 to 2.5 ft bgs)**
	3 4 5		SM					Pale yellowish brown (10YR6/2) to moderate yellowish brown (10YR5/4) fine SAND, some Silt; saturated.	**Silty Sand (collected sample GT014B at 2.5 to 5.0 ft bgs)** **End of Borjng at 5 ft. bgs.**

The Louis Berger Group, Inc. 412 Mt Kemble Ave Morristown, NJ 07960	**Drilling Log** Page 1 of 1	**BORING NO.:** GT015 **WELL NO.:** N/A

CLIENT: EarthMark Mitigation Services	**PROJECT NO:** KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank	**DATE STARTED:** 2/16/2009
DRILLING CONTRACTOR: N/A	**DATE FINISHED:** 2/16/2009
DRILLING METHOD: Hand Auger	**DRILLER:** N/A

BOREHOLE DATA	WELL DATA	
		INSPECTOR: K. Schuch
Diameter (in): 3	**Completion:** N/A	**NORTHING:** N/A
Total Depth (ft): 5.00	**Total Depth (ft):** N/A	**EASTING:** N/A
Sampler: Hand Auger	**Screen Length (ft) /Slot (in):** N/A	**GROUND ELEVATION (ft):** N/A
Depth to Water (ft): At Surface	**Depth to Water (ft):** N/A	**TOC ELEVATION (ft):** N/A
Depth to Rock (ft): N/A	**Permit No.:** N/A	

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0–3		OL					Olive black (5Y2/1) Organic SILT, trace fine Sand; saturated.	**Organic Silt (collected sample GT015A at 0.0 to 3.0 ft bgs)**
	3–5		SM					Pale yellowish brown (10YR6/2) to moderate yellowish brown (10YR5/4) fine SAND, some Silt; saturated.	**Silty Sand (collected sample GT015B at 3.0 to 5.0 ft bgs)** **End of Boring at 5 ft. bgs.**

The Louis Berger Group, Inc. 412 Mt Kemble Ave Morristown, NJ 07960	**Drilling Log** Page 1 of 1	**BORING NO.:** GT016 **WELL NO.:** N/A
CLIENT: EarthMark Mitigation Services		**PROJECT NO:** KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank		**DATE STARTED:** 2/16/2009
DRILLING CONTRACTOR: N/A		**DATE FINISHED:** 2/16/2009
DRILLING METHOD: Hand Auger		**DRILLER:** N/A
BOREHOLE DATA	**WELL DATA**	**INSPECTOR:** K. Schuch
Diameter (in): 3	**Completion:** N/A	**NORTHING:** N/A
Total Depth (ft): 5.00	**Total Depth (ft):** N/A	**EASTING:** N/A
Sampler: Hand Auger	**Screen Length (ft) /Slot (in):** N/A	**GROUND ELEVATION (ft):** N/A
Depth to Water (ft): At Surface	**Depth to Water (ft):** N/A	**TOC ELEVATION (ft):** N/A
Depth to Rock (ft): N/A	**Permit No.:** N/A	

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0 1 2		OL					Olive black (5Y2/1) Organic SILT, trace fine Sand; saturated.	**Organic Silt (collected sample GT016A at 0.0 to 2.5 ft bgs)**
	3 4 5		ML					Medium dark gray (N4) Clayey SILT, trace fine Sand; saturated.	**Clayey Silt (collected sample GT016B at 2.5 to 5.0 ft bgs)** **End of Boring at 5 ft. bgs.**

The Louis Berger Group, Inc. 412 Mt Kemble Ave Morristown, NJ 07960	**Drilling Log** Page 1 of 1	**BORING NO.:** GT017 **WELL NO.:** N/A

CLIENT: EarthMark Mitigation Services		**PROJECT NO:** KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank		**DATE STARTED:** 2/16/2009
DRILLING CONTRACTOR: N/A		**DATE FINISHED:** 2/16/2009
DRILLING METHOD: Hand Auger		**DRILLER:** N/A
BOREHOLE DATA	**WELL DATA**	**INSPECTOR:** K. Schuch
Diameter (in): 3	**Completion:** N/A	**NORTHING:** N/A
Total Depth (ft): 5.00	**Total Depth (ft):** N/A	**EASTING:** N/A
Sampler: Hand Auger	**Screen Length (ft) /Slot (in):** N/A	**GROUND ELEVATION (ft):** N/A
Depth to Water (ft): At Surface	**Depth to Water (ft):** N/A	**TOC ELEVATION (ft):** N/A
Depth to Rock (ft): N/A	**Permit No.:** N/A	

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0–3.5 (0, 1, 2, 3)		PEAT					Olive black (5Y2/1) PEAT; saturated.	**Peat (collected sample GT017A at 0.0 to 3.5 ft bgs)**
	3.5–5 (4, 5)		ML					Medium dark gray (N4) Clayey SILT, trace fine Sand; saturated.	**Clayey Silt (collected sample GT017B at 3.5 to 5.0 ft bgs)** **End of Boring at 5 ft. bgs.**

The Louis Berger Group, Inc. 412 Mt Kemble Ave Morristown, NJ 07960	**Drilling Log** Page 1 of 1	**BORING NO.:** GT018 **WELL NO.:** N/A

CLIENT: EarthMark Mitigation Services	**PROJECT NO:** KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank	**DATE STARTED:** 2/16/2009
DRILLING CONTRACTOR: N/A	**DATE FINISHED:** 2/16/2009
DRILLING METHOD: Hand Auger	**DRILLER:** N/A

BOREHOLE DATA	**WELL DATA**	**INSPECTOR:** K. Schuch
Diameter (in): 3	**Completion:** N/A	**NORTHING:** N/A
Total Depth (ft): 5.00	**Total Depth (ft):** N/A	**EASTING:** N/A
Sampler: Hand Auger	**Screen Length (ft) /Slot (in):** N/A	**GROUND ELEVATION (ft):** N/A
Depth to Water (ft): At Surface	**Depth to Water (ft):** N/A	**TOC ELEVATION (ft):** N/A
Depth to Rock (ft): N/A	**Permit No.:** N/A	

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0–2.5		PEAT					Olive black (5Y2/1) PEAT; saturated.	**Peat (collected sample GT018A at 0.0 to 2.5 ft bgs)** **Collected sample GT018B at 2.5 to 3.0 ft bgs**
	2.5–3		OL					Olive black (5Y2/1) Organic SILT; saturated.	**Organic Silt**
	3–5		ML					Medium dark gray (N4) Clayey SILT, trace fine Sand; saturated.	**Clayey Silt (collected sample GT018C at 3.0 to 5.0 ft bgs)** **End of Boring at 5 ft. bgs.**

The Louis Berger Group, Inc. 412 Mt Kemble Ave Morristown, NJ 07960	**Drilling Log** Page 1 of 1	**BORING NO.:** GT020 **WELL NO.:** N/A
CLIENT: EarthMark Mitigation Services		**PROJECT NO:** KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank		**DATE STARTED:** 2/17/2009
DRILLING CONTRACTOR: N/A		**DATE FINISHED:** 2/17/2009
DRILLING METHOD: Hand Auger		**DRILLER:** N/A
BOREHOLE DATA	**WELL DATA**	**INSPECTOR:** K. Schuch
Diameter (in): 3	**Completion:** N/A	**NORTHING:** N/A
Total Depth (ft): 5.00	**Total Depth (ft):** N/A	**EASTING:** N/A
Sampler: Hand Auger	**Screen Length (ft) /Slot (in):** N/A	**GROUND ELEVATION (ft):** N/A
Depth to Water (ft): At Surface	**Depth to Water (ft):** N/A	**TOC ELEVATION (ft):** N/A
Depth to Rock (ft): N/A	**Permit No.:** N/A	

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0 – 2		PEAT					Brownish black (5YR2/1) PEAT; saturated.	**Peat (collected sample GT020A at 0.0 to 2.0 ft bgs)**
	2 – 5		ML					Medium dark gray (N4) Clayey SILT; saturated.	**Clayey Silt (collected sample GT020B at 2.0 to 5.0 ft bgs)** **End of Boring at 5 ft. bgs.**

The Louis Berger Group, Inc. 412 Mt Kemble Ave Morristown, NJ 07960	**Drilling Log** Page 1 of 1	**BORING NO.:** GT022 **WELL NO.:** N/A

CLIENT: EarthMark Mitigation Services	**PROJECT NO:** KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank	**DATE STARTED:** 2/17/2009
DRILLING CONTRACTOR: N/A	**DATE FINISHED:** 2/17/2009
DRILLING METHOD: Hand Auger	**DRILLER:** N/A

BOREHOLE DATA		**WELL DATA**			
Diameter (in):	3	**Completion:**	N/A	**INSPECTOR:**	K. Schuch
Total Depth (ft):	5.00	**Total Depth (ft):**	N/A	**NORTHING:**	N/A
Sampler:	Hand Auger	**Screen Length (ft) /Slot (in):**	N/A	**EASTING:**	N/A
Depth to Water (ft):	At Surface	**Depth to Water (ft):**	N/A	**GROUND ELEVATION (ft):**	N/A
Depth to Rock (ft):	N/A	**Permit No.:**	N/A	**TOC ELEVATION (ft):**	N/A

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0–4		PEAT					Brownish black (5YR2/1) PEAT; saturated.	**Peat (collected sample GT022A at 0.0 to 4.0 ft bgs)** **Collected sample GT022B at 4.0 to 5.0 ft bgs**
	4–5		ML					Medium dark gray (N4) Clayey SILT, trace fine Sand; saturated.	**Clayey Silt** **End of Boring at 5 ft. bgs.**

The Louis Berger Group, Inc. 412 Mt Kemble Ave Morristown, NJ 07960	**Drilling Log** Page 1 of 1	**BORING NO.:** GT024 **WELL NO.:** N/A

CLIENT: EarthMark Mitigation Services		**PROJECT NO:** KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank		**DATE STARTED:** 2/17/2009
DRILLING CONTRACTOR: N/A		**DATE FINISHED:** 2/17/2009
DRILLING METHOD: Hand Auger		**DRILLER:** N/A
BOREHOLE DATA	**WELL DATA**	**INSPECTOR:** K. Schuch
Diameter (in): 3	**Completion:** N/A	**NORTHING:** N/A
Total Depth (ft): 5.00	**Total Depth (ft):** N/A	**EASTING:** N/A
Sampler: Hand Auger	**Screen Length (ft) /Slot (in):** N/A	**GROUND ELEVATION (ft):** N/A
Depth to Water (ft): At Surface	**Depth to Water (ft):** N/A	**TOC ELEVATION (ft):** N/A
Depth to Rock (ft): N/A	**Permit No.:** N/A	

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0 – 4		PEAT					Dusky brown (5YR2/2) PEAT; saturated.	**Peat (collected sample GT024A at 0.0 to 4.0 ft bgs)** **Collected sample GT024B at 4.0 to 5.0 ft bgs**
	4 – 5		ML					Medium dark gray (N4) Clayey SILT, trace fine Sand; saturated.	**Clayey Silt** **End of Boring at 5 ft. bgs.**

The Louis Berger Group, Inc. 412 Mt Kemble Ave Morristown, NJ 07960	# Drilling Log Page 1 of 1	**BORING NO.:** GT026 **WELL NO.:** N/A

CLIENT: EarthMark Mitigation Services	**PROJECT NO:** KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank	**DATE STARTED:** 2/17/2009
DRILLING CONTRACTOR: N/A	**DATE FINISHED:** 2/17/2009
DRILLING METHOD: Hand Auger	**DRILLER:** N/A

BOREHOLE DATA		WELL DATA			
Diameter (in):	3	**Completion:**	N/A	**INSPECTOR:**	K. Schuch
Total Depth (ft):	5.00	**Total Depth (ft):**	N/A	**NORTHING:**	N/A
Sampler:	Hand Auger	**Screen Length (ft) /Slot (in):**	N/A	**EASTING:**	N/A
Depth to Water (ft):	At Surface	**Depth to Water (ft):**	N/A	**GROUND ELEVATION (ft):**	N/A
Depth to Rock (ft):	N/A	**Permit No.:**	N/A	**TOC ELEVATION (ft):**	N/A

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0		PEAT					Brownish black (5YR2/1) PEAT, little Silt; saturated.	**Peat (collected sample GT026A at 0.0 to 1.0 ft bgs)**
	1		ML					Medium dark gray Clayey SILT, trace fine Sand; saturated.	**Clayey Silt (collected sample GT026B at 1.0 to 5.0 ft bgs)**
	2								
	3								
	4								**End of Boring at 5 ft. bgs.**
	5								

The Louis Berger Group, Inc. 412 Mt Kemble Ave Morristown, NJ 07960	# Drilling Log Page 1 of 1	**BORING NO.:** GT028 **WELL NO.:** N/A

CLIENT: EarthMark Mitigation Services	**PROJECT NO:** KT500F4
PROJECT: Richard P. Kane Wetland Mitigation Bank	**DATE STARTED:** 3/6/2009
DRILLING CONTRACTOR: N/A	**DATE FINISHED:** 3/6/2009
DRILLING METHOD: Hand Auger	**DRILLER:** N/A

BOREHOLE DATA		**WELL DATA**			
Diameter (in):	3	**Completion:**	N/A	**INSPECTOR:**	K. Schuch
Total Depth (ft):	5.00	**Total Depth (ft):**	N/A	**NORTHING:**	N/A
Sampler:	Hand Auger	**Screen Length (ft) /Slot (in):**	N/A	**EASTING:**	N/A
Depth to Water (ft):	At Surface	**Depth to Water (ft):**	N/A	**GROUND ELEVATION (ft):**	N/A
Depth to Rock (ft):	N/A	**Permit No.:**	N/A	**TOC ELEVATION (ft):**	N/A

NOTES:

Well Construction	Depth	Lithology	USCS	Sample Interval	Sample Recovery	Blows/6 in	PID (ppm)	Description	Remarks
	0		ML-CL					Olive gray (5Y4/1) Silty CLAY, trace fine Sand; saturated.	**Silty Clay (collected sample GT028A at 0.0 to 5.0 ft bgs)**
	1								
	2								
	3								
	4								
	5								**End of Boring at 5 ft. bgs.**

Form SO-2 2/79

NEW JERSEY DEPARTMENT OF TRANSPORTATION

Filed #B-25

ROUTE: LOCAL NAME: Retaining Wall Boring TEST HOLE NO. 404W-215

SECTION: Washington Ave., FAUS #M-8298(102)

STATION: 127 + 25 OFFSET: 15' Rt. REFERENCE LINE: Washington Ave. S BL GROUND LINE ELEVATION: 19.7'

BORINGS MADE BY: Rubino DATE STARTED: 11-30-82

INSPECTOR: Henry DATE COMPLETED: 11-30-82

Elevation G.W.T.

0 Hr. +14.7' Date: 11-30-82

24 Hr. +15.7' Filled in Dry Date: 12-01-82

_____ ft. P.P. Installed Date:

Depth	CASING BLOWS	SAMPLE NO.	DEPTH		Blows on Spoon 0/6	6/12	12/18	REC.	Sample ID and Profile Change	
	4	S-1	0.0'	1.5'	1	5	8	0.9'	Brown/Red Brown CF Sand, and Silt, little	
	11								MF Gravel	
	19									
	48									
5	20									
	37	S-2	5.0'	6.3'	20	40	125/	0.8'	Red Brown CF Sand, some Silt, some CF Gravel	
	300/						0.3'			6.5'
	0.5'									
		C-1	6.5'	11.5'	CORE			1.8'	Red Brown interbedded SANDSTONE & SHALE	
10						REC		36%		
						RQD		0%		
									Bottom of Hole	11.5'
15										
20										
25										
30										
35										
40										

Nominal I.D. of Drive Pipe	2½"	XXX
Nominal I.D. of Split Barrel Sampler	1½"	
Weight of hammer on Drive Pipe	300 lbs.	
Weight of hammer on Split Barrel Sampler	140 lbs.	
Drop of hammer on Drive Pipe	24"	
Drop of hammer on Split Barrel Sampler	30"	

Core Dia. 1 1/8"

Soil descriptions represent a field identification after D.M. Burmister unless otherwise noted.

The Contractor shall make his own subsurface investigations in order to satisfy himself of the actual subsurface conditions. The Information contained on this log is not warranted to show the actual subsurface conditions. The Contractor agrees that he will make no claims against the State if he finds that the actual conditions do not conform to those indicated by this log.

New Jersey Department of Transportation

Bureau of Geotechnical Engineering

Approximate Change in Strata ________

Inferred Change in Strata — — — — — —

Form SO-2 2/79 — NEW JERSEY DEPARTMENT OF TRANSPORTATION — Field #B-26

ROUTE: LOCAL NAME: Retaining Wall TEST HOLE NO. 404W - 216

SECTION: Washington Ave. Improvements FAUS #M-8298(102)

STATION: 127 + 95 OFFSET: 15' Rt. REFERENCE LINE: Washington Ave. S BL GROUND LINE ELEVATION: +21.5'

BORINGS MADE BY: Rubino DATE STARTED: 11-23-82

INSPECTOR: Henry DATE COMPLETED: 11-29-82

Elevation G.W.T.

0 Hr. +16.5' Date: 11-29-82

24 Hr. +13.5' Caved in & Dry Date: 11-30-82

_______ ft. P.P. Installed Date:

Depth	CASING BLOWS	SAMPLE NO.	DEPTH		Blows on Spoon 0/6	6/12	12/18	REC.	Sample ID and Profile Change	Strata
	6	S-1	0.0'	1.5'	2	6	11	0.8'	Red Brown CF Sand, some Silt, some CF Gravel	
	30									
	41									
	45									
5	28									
	91	S-2	5.0'	5.5'	125	-	-	0.3'	Same	
	140									
	357/0.5'	S-3	6.5'	7.5'	36	125	-	0.5'	Same	7.5'
10		C-1	7.5'	12.5'	CORE			1.1'	Red Brown Soft SHALE	
					REC			22%		
					RQD			0%		12.5'
									Bottom of Hole	
15										
20										
25										
30										
35										
40										

Nominal I.D. of Drive Pipe	2½" XXXX
Nominal I.D. of Split Barrel Sampler	1½"
Weight of hammer on Drive Pipe	300 lbs.
Weight of hammer on Split Barrel Sampler	140 lbs.
Drop of hammer on Drive Pipe	24"
Drop of hammer on Split Barrel Sampler	30"

Core Dia. AX

Soil descriptions represent a field identification after D.M. Burmister unless otherwise noted.

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New Jersey Department of Transportation

Bureau of Geotechnical Engineering

Approximate Change in Strata ________

Inferred Change in Strata — — — — —

Form SO-2 2/79 NEW JERSEY DEPARTMENT OF TRANSPORTATION Field #B-27

ROUTE: LOCAL NAME: Retaining Wall TEST HOLE NO. 404W - 217

SECTION: Washington Ave. Improvements FAUS #M-8298(102)

STATION: 128 + 60 OFFSET: 40' Rt. REFERENCE LINE: Washington Ave. SBL GROUND LINE ELEVATION: +21.3

BORINGS MADE BY: Rubino DATE STARTED: 11-22-82

INSPECTOR: Henry DATE COMPLETED: 11-23-82

Elevation G.W.T.
0 Hr. +16.3' Date: 11-23-82
24 Hr. +16.3' Caved in & Wet Date: 11-24-82
______ ft. P.P. Installed Date:

CASING BLOWS	SAMPLE NO.	DEPTH		Blows on Spoon 0/6	6/12	12/18	REC.	Sample ID and Profile Change	
2	S-1	0.0'	1.5'	1	1	2	0.3'	Red Brown CF Sand, and Silt, little MF Gravel	
15									
29									
30									
44									
34	S-2	5.0'	6.5'	20	16	20	0.8'	Red Brown CF Sand, some (+) Silt, some CF Gravel	
47									
93	S-3	6.5'	8.0'	42	42	125	1.5'	Same	
216									
500/ 0.8'	S-4	8.0'	8.8'	65	125/ 0.3'	-	0.2'	Same	9.8'
	C-1	9.8'	14.8'	CORE			2.4'	Red Brown Soft SHALE	
				REC			48%		
				RQD			0%		
									14.8'
								Bottom of Hole	

Nominal I.D. of Drive Pipe	2½" XXX
Nominal I.D. of Split Barrel Sampler	1½"
Weight of hammer on Drive Pipe	300 lbs.
Weight of hammer on Split Barrel Sampler	140 lbs.
Drop of hammer on Drive Pipe	24"
Drop of hammer on Split Barrel Sampler	30"

Core Dia. AX

Soil descriptions represent a field identification after D.M. Burmister unless otherwise noted.

The Contractor shall make his own subsurface investigations in order to satisfy himself of the actual subsurface conditions. The Information contained on this log is not warranted to show the actual subsurface conditions. The Contractor agrees that he will make no claims against the State if he finds that the actual conditions do not conform to those indicated by this log.

New Jersey Department of Transportation

Bureau of Geotechnical Engineering

Approximate Change in Strata ______

Inferred Change in Strata - - - - - -

Form SO-2 2/79 **NEW JERSEY DEPARTMENT OF TRANSPORTATION** Field #B-28

ROUTE: LOCAL NAME: Roadway Boring TEST HOLE NO. 404W-218

SECTION: Washington Ave. Improvement FAUS #M-8298(102)

STATION: 130 + 05 OFFSET: 2' Lt. REFERENCE LINE: Washington Ave. SBL GROUND LINE ELEVATION: +28.0'

BORINGS MADE BY: Augustine DATE STARTED: 12-22-82

INSPECTOR: Henry DATE COMPLETED: 12-22-82

Elevation G.W.T.

0 Hr. Filled in Dry +22.4' Date: 12-22-82

24 Hr. Same Date: 12-23-82

ft. P.P. Installed Date:

Depth	CASING BLOWS	SAMPLE NO.	DEPTH		Blows on Spoon 0/6	6/12	12/18	REC.	Sample ID and Profile Change	
	1760								8" BLACKTOP	0.8'
	52	S-1	1.0'	2.5'	15	26	24	1.5'	Brown CF SAND, little Silt, little (-) F Gravel	
	17									
	10									
5	9									
		S-2	5.0'	6.5'	4	7	4	0.5'	Brown CF SAND, little Silt, some CF Gravel	
		S-3	6.5'	8.0'	3	4	11	1.2'	Red Brown CF Sand, and (-) Silt, little (+) CF Gravel	
		S-4	8.0'	9.5'	19	19	26	1.0'	Red Brown CF Sand, some Silt, some (+) CF Gravel	
10										
		S-5	9.5'	11.0'	37	36	40	1.5'	Brown CF Sand, some (+) Silt, some (+) CF Gravel	
		S-6	11.0'	12.0'	51	118	-	1.0'	Red Brown CF Sand, and (+) Silt, little MF Gravel	12.0'
									Bottom of Hole	
15										
20										
25										
30										
35										
40										

Nominal I.D. of Drive Pipe	2½" XX
Nominal I.D. of Split Barrel Sampler	1½"
Weight of hammer on Drive Pipe	300 lbs.
Weight of hammer on Split Barrel Sampler	140 lbs.
Drop of hammer on Drive Pipe	24"
Drop of hammer on Split Barrel Sampler	30"

Core Dia.

Soil descriptions represent a field identification after D.M. Burmister unless otherwise noted.

The Contractor shall make his own subsurface investigations in order to satisfy himself of the actual subsurface conditions. The Information contained on this log is not warranted to show the actual subsurface conditions. The Contractor agrees that he will make no claims against the State if he finds that the actual conditions do not conform to those indicated by this log.

New Jersey Department of Transportation

Bureau of Geotechnical Engineering

Approximate Change in Strata

Inferred Change in Strata

Form SO-2 2/79 NEW JERSEY DEPARTMENT OF TRANSPORTATION FIELD # B-29

ROUTE: LOCAL NAME: Wall Boring TEST HOLE NO. 404W-219

SECTION: Washington Ave., Improvements, ,FAUS # M-8298(102)

STATION: 131 + 03 OFFSET: 11' Rt. REFERENCE LINE: Washington Ave. S BL GROUND LINE ELEVATION: +24.6'

BORINGS MADE BY: Rubino DATE STARTED: 12-09-82

INSPECTOR: Henry DATE COMPLETED: 12-10-82

Elevation G.W.T.
0 Hr. +23.6' Date: 12-10-82
24 Hr. Same Date: 12-13-82
______ ft. P.P. Installed Date:

Depth	CASING BLOWS	SAMPLE NO.	DEPTH		Blows on Spoon 0/6	6/12	12/18	REC.	Sample ID and Profile Change	
	4	S-1	0.0'	1.5'	2	22	14	0.5'	Brown CF SAND, some Silt, little (-) CF Gravel	
	19									
	21	S-2	1.5'	3.0'	10	12	14	0.7'	Brown CF Sand, and Silt, little (-) MF Gravel	
	31									
5	37									
	40	S-3	5.0'	6.5'	32	38	49	1.0'	Reddish Brown CF Sand, and Silt, little MF	
	45								Gravel	
	73	S-4	6.5'	8.0'	31	51	125	1.5'	Same	
	300	S-5	8.0'	9.0'	63	125	-	0.7'	Same	9.0'
10										
		C-1	9.0'	14.0'	CORE			1.8'	Red Brown SANDSTONE and SHALE	
					REC			36%		
					RQD			0%		14.0'
15									Bottom of Hole	
20										
25										
30										
35										
40										

Nominal I.D. of Drive Pipe	2½" XXX
Nominal I.D. of Split Barrel Sampler	1½"
Weight of hammer on Drive Pipe	300 lbs.
Weight of hammer on Split Barrel Sampler	140 lbs.
Drop of hammer on Drive Pipe	24"
Drop of hammer on Split Barrel Sampler	30"

Core Dia. AX

Soil descriptions represent a field identification after D.M. Burmister unless otherwise noted.

The Contractor shall make his own subsurface investigations in order to satisfy himself of the actual subsurface conditions. The Information contained on this log is not warranted to show the actual subsurface conditions. The Contractor agrees that he will make no claims against the State if he finds that the actual conditions do not conform to those indicated by this log.

New Jersey Department of Transportation

Bureau of Geotechnical Engineering

Approximate Change in Strata ______

Inferred Change in Strata - - - - - -

Boring Logs from Soil Area 6

HOWARD, NEEDLES, TAMMEN & BERGENDOFF
CONSULTING ENGINEERS

Boring No. U-2
Sheet No. 1 of 2

BORINGS FOR

Berry's Creek Bridge
(PROJECT)

Giles Drilling Corp.
(CONTRACTOR)

CONTRACT NO. ______ PURPOSE ______ STRUCTURE NO. ______

LOCATION ______ RDWY. Rt.20B STA. 17+20 OFF. 14' LT

RIG NO. 1	TYPE Jeep		DRILLER C.Antonazio		HELPER(S) H. Kingsten	
DATE	7-11-69					
TIME STARTED	8:00 A.M.					
TIME FINISHED	4:20 P.M.					
WEATHER	Cloudy					
DEPTH REACHED	13.0'					

GROUND ELEVATION +5.9 M.L.W. ELEVATION ______

ZERO OF BORING LOG +5.9 ELEVATION GROUND WATER ______

PAY QUANTITIES										
LINEAL FEET OF BORING					SAMPLES			LIN. FT. OF ROCK CORE		
2-½"	3"	4"			ORDINARY DRY	UNDIST. DRY		1-⅜"	1-⅝"	
ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM
		13.0'			2	2				

	UNIT WEIGHT	SIZE	WEIGHT OF HAMMER	AV. FALL
CASING		4"	300#	18"
ORDINARY DRY SAMPLES		O.D. 2" I.D. 1-1/2"	140#	30"

UNDISTURBED SAMPLES TYPE Shelby LENGTH 24" O.D. 3-1/2" I.D. 3-1/4"

GROUND WATER READINGS

DATE ______

TIME ______

DEPTH No Checks

GENERAL REMARKS ______

INSPECTOR C. N. Garmaldi RESIDENT ENGINEER ______

FORM N21-A

HOWARD, NEEDLES, TAMMEN & BERGENDOFF
CONSULTING ENGINEERS

Boring No. U-2
Sheet No. 2 of 2

BORINGS FOR
Berry's Creek Bridge

CONTRACT NO. ______ PURPOSE ______

ELEV.	BLOWS ON CASING	BLOWS ON SPOON FOR 6" PENETRATION		SAMPLE NO.	SAMPLE DEPTH	LOG	MATERIAL & REMARKS
±5.9							
	63						
	42						Misc. Fill
	13						
	14						
	23						
-0.1	10	Push		U-1	5.0 -	6.0'	15"/24"
	21				7.0'		Brown PEAT & Organic SILT.
	8	Push		U-2	7.0 -		
-3.1	24				9.0'	9.0'	-do-
	16	Push		S-1	9.0 -		Shelby-insufficient recovery
	27				11.0'		Varved Brown-Clayey SILT; Silty CLAY.
		12	11	5.2	11.0'-		-same-
-7.1		14	15		13.0'		
							Bottom of Hole @ 13.0'

HOWARD, NEEDLES, TAMMEN & BERGENDOFF
CONSULTING ENGINEERS

Boring No. U-3
Sheet No. 1 of 2

BORINGS FOR

Berry's Creek Bridge
(PROJECT)

Giles Drilling Corp.
(CONTRACTOR)

CONTRACT NO. ______ PURPOSE ______ STRUCTURE NO. ______
LOCATION ______ RDWY. Rt.20 ℄ STA. 18+42 OFF. 56' LT

RIG NO.	1	TYPE Jeep	DRILLER C.Antonazio	HELPER(S)	H. Kingsten	
DATE	7-10-69					
TIME STARTED	12:30 P.M.					
TIME FINISHED	4:30 P.M.					
WEATHER	Cloudy					
DEPTH REACHED	12.0'					

GROUND ELEVATION +4.9 M.L.W. ELEVATION ______
ZERO OF BORING LOG +4.9 ELEVATION GROUND WATER ______

PAY QUANTITIES

LINEAL FEET OF BORING					SAMPLES			LIN. FT. OF ROCK CORE		
2-½"	3"	4"			ORDINARY DRY	UNDIST. DRY		1-⅜"	1-⅝"	
ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM
		12.0'			2	1				

	UNIT WEIGHT	SIZE	WEIGHT OF HAMMER	AV. FALL
CASING		4"	300#	18"
ORDINARY DRY SAMPLES		O.D. 2" I.D. 1-1/2"	140#	30"

UNDISTURBED SAMPLES TYPE Shelby LENGTH 24" O.D. 3-1/2" I.D. 3-1/4"

GROUND WATER READINGS

DATE								
TIME								
DEPTH	no check							

GENERAL REMARKS ______

INSPECTOR C. N. Garmaldi RESIDENT ENGINEER ______

FORM H21-A

HOWARD, NEEDLES, TAMMEN & BERGENDOFF
CONSULTING ENGINEERS

Boring No. U-3
Sheet No. 2 of 2

BORINGS FOR

Berry's Creek Bridge

CONTRACT NO. ______ PURPOSE ______

ELEV. +4.9	BLOWS ON CASING	BLOWS ON SPOON FOR 6" PENETRATION		SAMPLE NO.	SAMPLE DEPTH	LOG	MATERIAL & REMARKS	
	36							
	58							
	19	7	7	S1	2.0 -		Fill. Br. c-f + SAND and Silt,	20/24
	13	9	7		4.0'			
	10	Push		U	4.0 -		No Recovery	0/24
-1.1	14				6.0'	6.0'		
	19	3	3	S-2	6.0-		Gr. Br. Varved Clayey SILT; Silty CLAY,	24/24
	24	6	8		8.0'			
	25							
	23							
		Push		U-1	10.0-		-same-	19/24
-7.1					12.0'			
							Bottom of Hole @ 12.0'	

FORM N 20-B

HOWARD, NEEDLES, TAMMEN & BERGENDOFF

CONSULTING ENGINEERS

Boring No. U-5

Sheet No. 1 of 3

BORINGS FOR

Berry's Creek Bridge
(PROJECT)

Giles Drilling Corp.
(CONTRACTOR)

CONTRACT NO. ________ PURPOSE ________ STRUCTURE NO. ________

LOCATION ________ RDWY. Rt. 20 E STA. 18 + 90 OFF. 18' LT

RIG NO. 1 TYPE Jeep DRILLER C. Antanazio HELPER(S) H. Kingsten

DATE	7-7-69	7-8-69	7-9-69	7-10-69		
TIME STARTED	8:00 A.M.	8:00 A.M.	8:00 A.M.	8:00 A.M.		
TIME FINISHED	4:30 P.M.	4:30 P.M.	4:30 P.M.	4:30 P.M.		
WEATHER	Rain	Clear	Clear	Cloudy		
DEPTH REACHED	10.0'	34.0'	80.0'	87.5'		

GROUND ELEVATION +3.8 M.L.W. ELEVATION ________

ZERO OF BORING LOG +3.8 ELEVATION GROUND WATER ________

PAY QUANTITIES

LINEAL FEET OF BORING					SAMPLES			LIN. FT. OF ROCK CORE		
2-½"	3"	4"			ORDINARY DRY	UNDIST. DRY		1-⅜"	1-⅝"	
ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM
5.5'		82.0'			3	11				

	UNIT WEIGHT	SIZE	WEIGHT OF HAMMER	AV. FALL
CASING		4"	300#	24"
ORDINARY DRY SAMPLES		O.D. 2" I.D. 1-1/2"	140#	30"

UNDISTURBED SAMPLES TYPE Shelby LENGTH 24" O.D. 3-1/2" I.D. 3-1/4"

GROUND WATER READINGS

DATE								
TIME								
DEPTH								

GENERAL REMARKS At 82.0' switched to 2-1/2" casing

INSPECTOR C. N. Garmaldi RESIDENT ENGINEER ________

FORM N21-A

HOWARD, NEEDLES, TAMMEN & BERGENDOFF
CONSULTING ENGINEERS

Boring No. U-5
Sheet No. 2 of 3

BORINGS FOR

Berry's Creek Bridge

CONTRACT NO. ____ PURPOSE ____

ELEV.	BLOWS ON CASING	BLOWS ON SPOON FOR 6" PENETRATION		SAMPLE NO.	SAMPLE DEPTH	LOG	MATERIAL & REMARKS	
+ 3.8								
	12							
	17							
	19							
	17							
	15							
	9	1	1	S1	5.0 -		Gray Organic SILT & CLAY, trace roots.	
	10	2	2		7.0'			
- 4.2	17					8.0'		
	32							
	35							
	53	7	9	S2	10.0-		Varved Brown Silty CLAY; Clayey SILT	
	66	10	12		12.0'			
	60							
	41							
	31	Push		U1	15.0-		-same-	
					17.0'			
		Push		U2	20.0-		Varved Gray Silty CLAY; Clayey SILT	18"/
					22.0'			
		Push			25.0'-		no recovery	
					27.0'			
		Push		U3	27.0'-		-same-	23"/2
					29.0'			
		Push		U4	34.0'-		-same-	21"/2
					36.0'			
		Push		U5	40.0-		Varved Gray Silty CLAY; Clayey Silt	21"/24
					42.0'			
		Push		U6	45.0-		-same-	24"/24
					47.0'			

HOWARD, NEEDLES, TAMMEN & BERGENDOFF

CONSULTING ENGINEERS

Boring No. U-5

Sheet No. 3 of 3

BORINGS FOR

Berry's Creek Bridge

CONTRACT NO. ______ PURPOSE ______

ELEV.	BLOWS ON CASING	BLOWS ON SPOON FOR 6" PENETRATION		SAMPLE NO.	SAMPLE DEPTH	LOG	MATERIAL & REMARKS	
-46.2								
		Push			50.0'-		no recovery	
					52.0'		-same-	
		Push		U7	52.0'-			24"/24"
					54.0'			
-54.2						58.0'		
		Push		U8	60.0'-		Red Brown Clayey SILT	12"/24"
					61.0'			
-61.2						65.0'		
		Push			65.0'-		no recovery	
					67.0'			
		Push		U9	67.0'-		Varved Red Br.Silty CLAY; Clayey Silt, trace	24"/24"
					69.0'		f Gravel.	
		Push		U10	75.0'-		-same-	24"/24"
					77.0'			
	23	Push		U11	80.0'-		Red Br. Silty CLAY; Clayey Silt, trace	24"/24"
	24				82.0'		f Gravel.	
	24							
-80.2	16					84.0'		
	87							
	53	46	12X	S3	85.0'-		Red Br. c-f SAND, some Clayey Silt, some	
	96	12X	14X		87.0'		c-f Gravel (Shale fragments) - Till	
-83.9	250/6"				87.5'-		Drove Open end rod. 300# hammer, 100 blows	
					87.7'		for 2"	
							Bottom of hole @ 87.7'	
							X used 300# hammer from 85.5' to 87.0'	

FORM N20-B

HOWARD, NEEDLES, TAMMEN & BERGENDOFF
CONSULTING ENGINEERS

Boring No. D-4
Sheet No. 1 of 2

BORINGS FOR

Berry's Creek Bridge
(PROJECT)

Giles Drilling Corp.
(CONTRACTOR)

CONTRACT NO. ____ PURPOSE ____ STRUCTURE NO. ____

LOCATION ____ RDWY. Rt. 20 ℄ STA. 18 + 04 OFF. 25' LT

RIG NO. 1	TYPE Skid	DRILLER J. Fowler	HELPER(S) A. Kingsten			
DATE	7-2-69					
TIME STARTED	8:00 A.M.					
TIME FINISHED	4:30 P.M.					
WEATHER	Clear					
DEPTH REACHED	27.0'					

GROUND ELEVATION +5.4 M.L.W. ELEVATION ____

ZERO OF BORING LOG +5.4 ELEVATION GROUND WATER ____

PAY QUANTITIES

LINEAL FEET OF BORING					SAMPLES			LIN. FT. OF ROCK CORE		
2-½"	3"	4"			ORDINARY DRY	UNDIST. DRY		1-⅜"	1-⅝"	
ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM
27.0'					5					

	UNIT WEIGHT	SIZE	WEIGHT OF HAMMER	AV. FALL
CASING		~~2-1/2"~~	~~300#~~	~~18"~~
ORDINARY DRY SAMPLES		O.D. 2" I.D. 1-1/2"	180#	30"

UNDISTURBED SAMPLES TYPE ____ LENGTH ____ O.D. ____ I.D. ____

GROUND WATER READINGS

DATE								
TIME								
DEPTH	~~no check~~							

GENERAL REMARKS ____

INSPECTOR C. N. Garmaldi RESIDENT ENGINEER ____

FORM H21-A

HOWARD, NEEDLES, TAMMEN & BERGENDOFF
CONSULTING ENGINEERS

Boring No. D-4
Sheet No. 2 of 2

BORINGS FOR

Berry's Creek Bridge

CONTRACT NO. ______ PURPOSE ______

ELEV. +5.4	BLOWS ON CASING	BLOWS ON SPOON FOR 6" PENETRATION		SAMPLE NO.	SAMPLE DEPTH	LOG	MATERIAL & REMARKS
	60						
	100						
	98						
	41						
	6						
	5	6	1	1	5.0'-		Fill: Black c+-f SAND, trace+ Silt, little m-f
-1.6	11	1	1		7.0'	7.0'	Gravel.
	17						
	17						
	14						
	15	11	6	2	10.0' -		Layers: Br. f SAND, some Clayey SILT; Br.
	17	9	14		12.0'		CLAY & SILT, 1/16" - 1/4" layers.
	31						
-8.6	17					14.0'	
	14						
	19	2	3	3	15.0'-		Varved Gray Clayey SILT; Silty CLAY.
	21	3	3		17.0'		1/16" - 1/8" layers
	31						
	29						
	30						
	22	1	2	4	20.0'-		-same-
	40	1	2		22.0'		
	27						
	31						
	33						
		1	2	5	25.0'-		-same-
-21.6		1	1		27.0'		
							Bottom of Hole @ 27.0'

FORM N 20-B

HOWARD, NEEDLES, TAMMEN & BERGENDOFF

CONSULTING ENGINEERS

Boring No. D-7

Sheet No. 1 of 2

BORINGS FOR

Berry's Creek Bridge
(PROJECT)

Giles Drilling Corp.
(CONTRACTOR)

CONTRACT NO. ________ PURPOSE ________ STRUCTURE NO. ________

LOCATION ________ RDWY. Rt.20B STA. 22 + 27 OFF. 32'LT

RIG NO. 2 TYPE Jeep DRILLER Beckwith HELPER(S) Hunter

DATE	7-3-69					
TIME STARTED	8:00 A.M.					
TIME FINISHED	4:30 P.M.					
WEATHER	Clear					
DEPTH REACHED	77.0'					

GROUND ELEVATION +7.1 M.L.W. ELEVATION ________

ZERO OF BORING LOG +7.1 ELEVATION GROUND WATER ________

PAY QUANTITIES

LINEAL FEET OF BORING					SAMPLES			LIN. FT. OF ROCK CORE		
2-½"	3"	4"			ORDINARY DRY	UNDIST. DRY		1-⅜"	1-⅝"	
ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM
27.0'					6					

	UNIT WEIGHT	SIZE	WEIGHT OF HAMMER	AV. FALL
CASING		2-1/2"	300#	18"
ORDINARY DRY SAMPLES		O.D. 2" I.D. 1-1/2"	180#	24"

UNDISTURBED SAMPLES TYPE ________ LENGTH ____ O.D. ____ I.D. ____

GROUND WATER READINGS

DATE								
TIME								
DEPTH	no check							

GENERAL REMARKS ________

INSPECTOR C. N. Garmaldi RESIDENT ENGINEER ________

FORM N21-A

HOWARD, NEEDLES, TAMMEN & BERGENDOFF
CONSULTING ENGINEERS

Boring No. D-7
Sheet No. 2 of 2

BORINGS FOR

Berry's Creek Bridge

CONTRACT NO. ____ PURPOSE ____

ELEV. +7.1	BLOWS ON CASING	BLOWS ON SPOON FOR 6" PENETRATION		SAMPLE NO.	SAMPLE DEPTH	LOG	MATERIAL & REMARKS
	24	10	21	1	0-2.0'		3" Asphalt
	31	9	8				Fill: Red Brown c-f SAND, some Silt, some m-f
	25						Gravel (shale fragments).
	7						
	10						
	14	7	8	2	5.0-		-same-
	22	11	10		7.0'		
-0.9	31					8.0'	
	5						
	5						
	7	1	2	3	10.0-		Black Organic SILT & CLAY.
	9	2	1		12.0'		
	7						
	8						
	6						
-8.9	7	2	2	4A	15.0-	16.0'	Gray f SAND, some c Silt.
	8	3	2	4B	17.0'		Varved Brown Clayey SILT; Silty CLAY.
	10						1/16" - 1/8" varves.
	15						
	14						
	15	2	2	5	20.0-		Varved Gray Clayey SILT; Silty CLAY.
	21	2	2		22.0'		1/16" - 1/8" varves.
	12						
	17						
	18						
		1	1	6	25.0-		-same-
-19.9		1	1		27.0'		
							Bottom of Hole @ 27.0'

FORM N20-B

HOWARD, NEEDLES, TAMMEN & BERGENDOFF
CONSULTING ENGINEERS

Boring No. D-6
Sheet No. 1 of 2

BORINGS FOR

Berry's Creek Bridge
(PROJECT)

Giles Drilling Corp.
(CONTRACTOR)

CONTRACT NO. ______ PURPOSE ______ STRUCTURE NO. ______

LOCATION ______ RDWY Rt. 20B L STA. 21 + 26 OFF. 25'LT

RIG NO. 2	TYPE Jeep		DRILLER Beckwith	HELPER(S) Hunter		
DATE	7-2-69					
TIME STARTED	8:00 A.M.					
TIME FINISHED	4:30 P.M.					
WEATHER	Clear					
DEPTH REACHED	27.0'					

GROUND ELEVATION +4.7 M.L.W. ELEVATION ______
ZERO OF BORING LOG +4.7 ELEVATION GROUND WATER ______

PAY QUANTITIES

LINEAL FEET OF BORING					SAMPLES			LIN. FT. OF ROCK CORE		
2-½"	3"	4"			ORDINARY DRY	UNDIST. DRY		1-3/8"	1-5/8"	
ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM
27.0'					6					

	UNIT WEIGHT	SIZE	WEIGHT OF HAMMER	AV. FALL
CASING		2-1/2"	300#	18"
ORDINARY DRY SAMPLES		O.D. 2" I.D. 1-1/2"	180#	30"

UNDISTURBED SAMPLES TYPE ______ LENGTH ______ O.D. ______ I.D. ______

GROUND WATER READINGS

DATE								
TIME								
DEPTH	no checks							

GENERAL REMARKS ______

INSPECTOR C. N. Garmaldi RESIDENT ENGINEER ______

FORM N21-A

HOWARD, NEEDLES, TAMMEN & BERGENDOFF
CONSULTING ENGINEERS

Boring No. D-6
Sheet No. 2 of 2

BORINGS FOR

Berry's Creek Bridge

CONTRACT NO. ______ PURPOSE ______

ELEV.	BLOWS ON CASING	BLOWS ON SPOON FOR 6" PENETRATION		SAMPLE NO.	SAMPLE DEPTH	LOG	MATERIAL & REMARKS
+4.7							
	1	1	1	1	0.0-2.0'		Black Organic SILT & CLAY.
	1	1	1				
	2						
	2						
	1						
	1	1	P	2	5.0 -		Black Organic SILT & CLAY, trace roots.
	1	P	P		7.0'		
	1						
	2						
- 5.3	2					10.0'	
	4	1	1	3	10.0-		Black Organic SILT & CLAY, with layer Gr. f Sand.
	5	2	2		12.0'		
	5						
- 9.3	6					14.0'	
	7						
	10	2	3	4	15.0'-		Varved Brown Clayey SILT; Silty CLAY.
	11	3	4		17.0'		
	14						
	14						
	10						
	9	1	1	5	20.0-		Varved Gray Clayey SILT; Silty CLAY.
	13	1	2		22.0'		
	10						
	11						
	12						
		1	2	6	25.0'-		-same-
-22.3		2	2		27.0'		
							Bottom of Hole @ 27.0'

FORM N20-8

7-C. WNEW Radio Station borings.

0 - 5	bog
5 - 8	gray clay
8 - 16	brown clay
16 - 60	gray clay
60 - 64	red clay
64 - 75	clay and gravol
75 - 78	clay gravel and sand
78 -	rock - other borings had 72 and 84 feet to bedrock

No. 84	Elev. -	
	0'0"-15'0"	Water
	15'0"-19'0"	Wood Piling & Timbers
	19'0"-21'0"	River Mud Fill
	21'0"-24'0"	Grey Silt
	24'0"-42'0"	Grey Silty Clay
	42'0"-68'5"	Brown Silty Clay (Varved)
	W. L. -	
No. 85	Elev. -	
	0'0"-27'0"	Water
	27'0"-29'0"	River Mud Fill
	29'0"-47'0"	Grey Silty Clay
	47'0"-68'6"	Greyish Brown Silty Clay (Varved)
	W. L. -	

No. 86	Elev. -	
	0'0"-14'0"	Water
	14'0"-18'0"	River Mud Fill
	18'0"-40'0"	Grey Silty Clay
	40'0"-56'0"	Greyish Brown Silty Clay (Varved)
	56'0"-78'0"	Brown Silt Traces of Clay & Fine Sand
	78'0"-81'0"	Brown Silt Some Sand & Gravel
	81'0"-84'0"	Brown Silt Sand & Gravel
	84'0"-96'6"	Brown Silt & Clay Sand, Gravel & Sandstone Fragments
	W. L. -	

No. 154	Elev. +6.60	
	0'0"-5'0"	Miscellaneous Fill
	5'0"-9'5"	Silty Sand, Trace Decayed Vegetation
	9'5"-11'8"	Medium Sand
	11'8"-34'0"	Clay; Layers of Fine Brown Sand
	34'0"-50'0"	Red Clay, Trace of Gray Clay
	W. L. 1'5"	
No. 155	Elev. +5.64	
	0'0"-4'5"	Miscellaneous Fill
	4'5"-5'5"	Peat; Silt
	5'5"-7'5"	Silty Sand, Decayed Vegetation
	7'5"-12'5"	Medium Gray Sand
	12'5"-16'0"	Clay; Some Brown Red Clay
	16'0"-23'0"	Red Clay; Gray Clay
	23'0"-37'0"	Clay; Layers of Fine Sand; Trace of Red Clay
	37'0"-53'0"	Red Clay, Trace of Gray Clay
	W. L. -	

1368 to 1370 Turner Warehouse and Shop, Carlstadt, New Jersey

No. 1368	Elev. –	
	0'0"-2'0"	Sand and Gravel, Fill
	2'0"-6'0"	Sand, Some Silt, Trace of Gravel Trace of Clay. Miscellaneous Fill
	6'0"-8'6"	Organic Silt Little Clay
	8'6"-9'0"	Fine Sand
	9'0"-18'0"	Silt, Some Clay, Trace of Fine Sand
	18'0"-21'0"	Silt and Clay, Trace of Fine Sand (Varved)
	W. L. 2'4"	
No. 1369	Elev. –	
	0'0"-2'6"	Sand and Gravel, Fill
	2'6"-6'6"	Sand, Some Silt, Trace of Gravel Trace of Clay. Miscellaneous Fill
	6'6"-7'6"	Organic Silt Little Clay
	7'6"-14'0"	Silt, Some Clay, Trace of Fine Sand
	14'0"-24'0"	Silt and Clay, Trace of Fine Sand (Varved)
	24'0"-41'0"	Silt, Some Clay, Trace of Fine Sand
	W. L. 2'4"	
No. 1370	Elev. –	
	0'0"-2'0"	Sand, Gravel, Boulders Fill
	2'0"-8'6"	Sand, Some Silt, Trace of Gravel Trace of Clay. Miscellaneous Fill
	8'6"-17'0"	Silt, Some Clay, Trace of Fine Sand
	17'0"-21'0"	Silt, Little Clay, Trace of Fine Sand
	W. L. 2'6"	

110	Parillo, 1959 well 5G	0-7	marsh mud (Qm)
		7-27	clay (Qhkl)
		27-109	sand and gravel (Qbnf)
		109-150	clay (Qbnl)
		150-192	sand and gravel (Qbnf)
		192-263	clay, sand, and gravel (Qbnl and Qbnf)
		263-271	sandstone

243	26-4817	0-6	black muck (Qm)
		6-56	gray clay (Qhkl)
		56-150	red clay (Qbnl)
		150-162	red sand with some gravel (Qbnf or Qt)
		162-330	red shale

Boring Logs from Soil Area 7

HOWARD, NEEDLES, TAMMEN & BERGENDOFF
CONSULTING ENGINEERS

Boring No. D-138
Sheet No. 1 of 2

BORINGS FOR

Route 17 Widening
(PROJECT)

Warren George, Inc.
(CONTRACTOR)

CONTRACT NO. A PURPOSE Embankment Culvert STRUCTURE NO. ______

LOCATION Route 17 (Buff's Diner) RDWY. NB STA. 138+25 OFF. 87'Rt.

RIG NO. 3	TYPE Acker-Skid	DRILLER J. Cochran	HELPER(S) V. Larance			
DATE	6-17-65					
TIME STARTED	0915					
TIME FINISHED	1130					
WEATHER	Clear					
DEPTH REACHED	27'					

GROUND ELEVATION + 5.0 M.L.W. ELEVATION ______

ZERO OF BORING LOG IS ELEV. + 5.0 ELEVATION GROUND WATER -9.6

PAY QUANTITIES										
LINEAL FEET OF BORING					SAMPLES			LIN. FT. OF ROCK CORE		
2½"	3"	4"			ORDINARY DRY	UNDIST. DRY		1⅜"	1⅝"	
ITEM #	ITEM #	ITEM #	ITEM #	ITEM #	ITEM #	ITEM #	ITEM #	ITEM #	ITEM #	ITEM #
27					6					

	UNIT WEIGHT	SIZE	WEIGHT OF HAMMER	AV. FALL
CASING		$2\frac{1}{2}$"	300#	24"
ORDINARY DRY SAMPLES		2"OD, 1-3/8"ID	140#	30"

UNDISTURBED SAMPLES TYPE ______ DIMENSIONS ______

GENERAL REMARKS G.W. Level 6-17-65 @1130, -9.6'; covered because it was dangerous uncovered.

INSPECTOR J. W. Kopas RESIDENT ENGINEER George Sable

FORM N21

HOWARD, NEEDLES, TAMMEN & BERGENDOFF
CONSULTING ENGINEERS

Boring No. D-138
Sheet No. 2 of 2

BORINGS FOR

Route 17 Widening

CONTRACT NO. A PURPOSE Embankment Culvert

ELEV.	BLOWS ON CASING	BLOWS ON SPOON FOR 6" PENETRAT'N.		SAMPLE NO.	SAMPLE DEPTH	LOG	MATERIAL & REMARKS
5.0							
	10	13	9	1	0-2		Rd.Br. fine SAND, some medium to/ coarse
	8	5	4				Gravel trace Silt 12/24
	6						
	4						
	3						
	3	4	2	2	5-7		Rd.Br.&Br.Gr. fine to/ medium SAND, some
	17	2	11				medium to fine Gravel, trace Silt 18/24
	28						
	38						
	44						
	11	13	11	3a	10-11.5		Br.&Rd. fine SAND, little Silt 7/24
-6.5	21	15	16	3b	11.5-12.0		Rd.Br. SHALE Gravel, tr. fine SAND. (possibili
	35						ty of Boulders) 6/24
-8.5	64					13.5	
	67						
	22	17	38	4	15-17		Rd.Br. medium to fine SAND, some Rd.Br. Sand-
	152	41	49				stone (Boulders), little medium to fine
	77						Gravel, tr. Silt 14/24
	40						
	41						
	43	37	94	5	20-22		(Driller said that boulders were evident)
	27	15	27				Rd.Br. coarse to medium SAND, some medium to
	70						coarse Gravel, t. Rd.Br. Clay (VH-PI) 18/24
	61						
	46						
		20	13	6	25-27		Rd.Br. CLAY (VH-PI) little coarse t.f. Gravel
-22.0		10	10			27	trace fine Rd.Br. Sand 6/24
							Bottom of Hole

FORM N20

HOWARD, NEEDLES, TAMMEN & BERGENDOFF

CONSULTING ENGINEERS

Boring No. D-145
Sheet No. 1 of 2

BORINGS FOR

Route 17 Widening
(PROJECT)

Warren George, Inc.
(CONTRACTOR)

CONTRACT NO. ______ PURPOSE Embankment Culvert STRUCTURE NO. ______

LOCATION Route 17 (East Side) RDWY. NB STA. 145+00 OFF. 76'Rt.

RIG NO. 3	TYPE Acker-Skid	DRILLER J. Cockman	HELPER(S) V. Larance			
DATE	6-17-65					
TIME STARTED	1300					
TIME FINISHED	1450					
WEATHER	Clear					
DEPTH REACHED	22'					

GROUND ELEVATION 11.1 M.L.W. ELEVATION -1.6

ZERO OF BORING LOG IS ELEV. 11.1 ELEVATION GROUND WATER -1.6

PAY QUANTITIES										
LINEAL FEET OF BORING					SAMPLES			LIN. FT. OF ROCK CORE		
					ORDINARY DRY	UNDIST. DRY				
2½"	3"	4"						1⅜"	1⅝"	
ITEM #	ITEM #	ITEM #	ITEM #	ITEM #	ITEM #	ITEM #	ITEM #	ITEM #	ITEM #	ITEM #
22'					5					

	UNIT WEIGHT	SIZE	WEIGHT OF HAMMER	AV. FALL
CASING		2½"	300#	24"
ORDINARY DRY SAMPLES		2"OD, 1-3/8"ID	140#	30"

UNDISTURBED SAMPLES TYPE ______ DIMENSIONS ______

GENERAL REMARKS G.W. Level 6-17-65 @ 1450, -1.6 (hole was filled in by Contractor because if left open it would be hazardous to personnel of American Truck Leasing Corp.)

INSPECTOR J. W. Kopas RESIDENT ENGINEER George Sable

FORM N21

HOWARD, NEEDLES, TAMMEN & BERGENDOFF
CONSULTING ENGINEERS

Boring No. D-145
Sheet No. 2 of 2

BORINGS FOR

Route 17 Widening

CONTRACT NO. ________ PURPOSE Embankment Culvert

ELEV.	BLOWS ON CASING	BLOWS ON SPOON FOR 6" PENETRAT'N.		SAMPLE NO.	SAMPLE DEPTH	LOG	MATERIAL & REMARKS
11.1							
10.6	0	25	38	1	0-2	0.5	BLACK TOP & CRUSHED STONE (driveway) 8/24
	13	29	20				Fill-Black & Br. Cinders, some medium to
8.1	12					3.0	coarse Gravel, parts of Brick
	26						
	48						
	34	8	24	2	5-7		Rd. Br. coarse to fine SAND & GRAVEL, trace
	33	24	18				of Rd. Br. Clay (VH-PI) 12/24
	23						
	22						
	20						
	28	12	17	3	10-12		Rd. Br. fine SAND, trace Silt 18/24
	37	21	22				
	48						
	61						
	46						
	16	9	8	4	15-17		-Same-
	25	9	13				
	68						
	81						
	73						
		26	28	5	20-22		-Same-
-10.9		28	17			27.0	
							Bottom of Hole

FORM N20

Form SO-2 2/79

NEW JERSEY DEPARTMENT OF TRANSPORTATION

ROUTE: LOCAL NAME: Roadway Boring TEST HOLE NO. 404W-163

SECTION: Moonachie Ave., Moonachie FAUS M-9748(001)

STATION: 35 + 00 OFFSET: 80' Lt. REFERENCE LINE: South BL GROUND LINE ELEVATION: +4.4'

BORINGS MADE BY: Augustine DATE STARTED: 12-10-82

INSPECTOR: Henry DATE COMPLETED: 12-14-82

Elevation G.W.T.

0 Hr. Filled in Dry +3.8' Date: 12-14-82

24 Hr. Same Date: 12-15-82

ft. P.P. Installed Date:

Depth	Casing Blows	Sample No.	Depth from	Depth to	Blows on Spoon 0–6	6–12	12–18	Rec.	Sample ID and Profile Change	Strata
	11	S-1	0.0'	1.5'	5	30	40	1.2'	Dark Brown CF Sand, and Silt, little MF Gravel	
	42									
	21	S-2	1.5'	3.0'	29	21	23	1.0'	Brown CF Sand, some Silt, some CF Gravel Cinders	
	24									
5	25									
	24	S-3	5.0'	6.5'	7	15	13	1.5'	Orange Brown/Grey CF SAND, some (-) Silt	
	20									
	5									
	12									
10	16									
	15	S-4	10.0'	11.5'	4	6	7	0		
	20								- - - - - - - - - -	12.0'
	14									
	10									
15	8									
	10	S-5	15.0'	16.5'	3	3	4	1.5'	Grey varved Silty CLAY	
	9									
	9									
	10									
20	12									
		S-6	20.0'	21.5'	3	2	3	1.3'	Same	
									Bottom of Hole	21.5'
25										
30										
35										
40										

Nominal I.D. of Drive Pipe	2½"	XX
Nominal I.D. of Split Barrel Sampler	1½"	
Weight of hammer on Drive Pipe	300 lbs.	
Weight of hammer on Split Barrel Sampler	140 lbs.	
Drop of hammer on Drive Pipe	24"	
Drop of hammer on Split Barrel Sampler	30"	

Core Dia. ________

Soil descriptions represent a field identification after D.M. Burmister unless otherwise noted.

The Contractor shall make his own subsurface investigations in order to satisfy himself of the actual subsurface conditions. The Information contained on this log is not warranted to show the actual subsurface conditions. The Contractor agrees that he will make no claims against the State if he finds that the actual conditions do not conform to those indicated by this log.

New Jersey Department of Transportation

Bureau of Geotechnical Engineering

Approximate Change in Strata ________

Inferred Change in Strata - - - - - - - -

Form SO-2 2/79

NEW JERSEY DEPARTMENT OF TRANSPORTATION

ROUTE: LOCAL NAME: Roadway Boring TEST HOLE NO. 404W - 165

SECTION: Moonachie Ave., Moonachie FAUS #9748 (001)

STATION: 38+00 OFFSET: 80' Lt. REFERENCE LINE: South BL GROUND LINE ELEVATION: +4.0'

BORINGS MADE BY: Bronston DATE STARTED: 9-17-82

INSPECTOR: Henry DATE COMPLETED: 9-17-82

Elevation G.W.T.

0 Hr. +2.0' Caved In Date: 9-17-82

24 Hr. Same Date: 9-20-82

_____ ft. P.P. Installed Date:

CASING BLOWS	SAMPLE NO.	DEPTH		Blows on Spoon 0/6	6/12	12/18	REC.	Sample ID and Profile Change	
10	S-1	0.0'	1.5'	5	22	25	0.2'	Brown SILT some, CF Sand, little (-) F Gravel	
25	S-2	1.5'	3.0'	19	16	15	0.9'	Brown SILT and, CF Sand, trace F Gravel	
21									3.0'
7	S-3	3.0'	4.5'	6	3	7	1.3'	Dark Brown PEAT	
10	S-4	4.5'	6.0'	9	10	9	0.3'		4.5'
18								Grey MF SAND, some Silt	
10	S-5	6.0'	7.5'	7	8	3	0.2'	Brown CF Sand, some Silt, some CF Gravel	
5	S-6	7.5'	9.0'	5	5	7	0.2'	Same	
7									9.0'
9	S-7	9.0'	10.5'	3	6	8	1.5'	Grey Clayey SILT	
10	S-8	10.5'	12.0'	4	6	9	1.5'	Grey varved CLAY	
8									
11	S-9	12.0'	13.5'	7	8	9	1.5'	Same	
10	S-10	13.5'	15.0'	3	4	6	1.5'	Same	
12									
	S-11	15.0'	16.5'	4	4	5	1.5'	Same	
									16.5'
								Bottom of Hole	

Nominal I.D. of Drive Pipe	2½" XXX
Nominal I.D. of Split Barrel Sampler	1½"
Weight of hammer on Drive Pipe	300 lbs.
Weight of hammer on Split Barrel Sampler	140 lbs.
Drop of hammer on Drive Pipe	24"
Drop of hammer on Split Barrel Sampler	30"

Core Dia. _____

Soil descriptions represent a field identification after D.M. Burmister unless otherwise noted.

The Contractor shall make his own subsurface investigations in order to satisfy himself of the actual subsurface conditions. The Information contained on this log is not warranted to show the actual subsurface conditions. The Contractor agrees that he will make no claims against the State if he finds that the actual conditions do not conform to those indicated by this log.

New Jersey Department of Transportation

Bureau of Geotechnical Engineering

Approximate Change in Strata _____

Inferred Change in Strata - - - - -

Form SO-2 2/79

NEW JERSEY DEPARTMENT OF TRANSPORTATION

ROUTE: LOCAL NAME: Roadway Boring TEST HOLE NO. 404W - 166

SECTION: Moonachie Ave., Moonachie FAUS# M-9748(001)

STATION: 41 + 00 OFFSET: 85' Lt. REFERENCE LINE: South BL GROUND LINE ELEVATION: +6.4'

BORINGS MADE BY: Augustine DATE STARTED: 9-30-82

INSPECTOR: Henry DATE COMPLETED: 9-30-82

Elevation G.W.T.

0 Hr. -1.3' Date: 09-30-82

24 Hr. -1.9' Date: 10-01-82

______ ft. P.P. Installed Date:

Depth	CASING BLOWS	SAMPLE NO.	DEPTH		Blows on Spoon 0/6	6/12	12/18	REC.	Sample ID and Profile Change	
	16	S-1	0.0'	1.5'	4	23	56	1.0'	Brown CF SAND, and (-) Silt, trace F Gravel	
	27									
	29	S-2	1.5'	3.0'	150	61	42	1.5'	Brown CF Sand, some Silt, some CF Gravel	
	20	S-3	3.0'	4.5'	19	18	30	1.2'	Dark Brown F SAND, some (+) Silt, reeds	
5	40									
	55	S-4	4.5'	6.0'	24	27	30	1.5'	Grey F SAND, little (+) Silt	
	46	S-5	6.0'	7.5'	19	24	18	1.5'	Orange Brown F SAND, little Silt	
	39									
	38	S-6	7.5'	9.0'	14	21	13	1.3'	Orange Brown MF SAND, little Silt	
10	22	S-7	9.0'	10.5'	10	14	10	1.2'	Grey MF SAND, some (+) Silt	
	26								- - - - - - - - - -	11.0'
	15	S-8	10.5'	12.0'	10	11	15	1.5'	Grey CLAY & SILT	
	19									
	22									
15	20									
		S-9	15.0'	16.5'	16	15	18	1.5'	Grey varved CLAY	
										16.5'
									Bottom of Hole	
20										
25										
30										
35										
40										

Nominal I.D. of Drive Pipe	2½"	XXX
Nominal I.D. of Split Barrel Sampler	1½"	
Weight of hammer on Drive Pipe	300 lbs.	
Weight of hammer on Split Barrel Sampler	140 lbs.	
Drop of hammer on Drive Pipe	24"	
Drop of hammer on Split Barrel Sampler	30"	

Core Dia. ______

Soil descriptions represent a field identification after D.M. Burmister unless otherwise noted.

The Contractor shall make his own subsurface investigations in order to satisfy himself of the actual subsurface conditions. The Information contained on this log is not warranted to show the actual subsurface conditions. The Contractor agrees that he will make no claims against the State if he finds that the actual conditions do not conform to those indicated by this log.

New Jersey Department of Transportation

Bureau of Geotechnical Engineering

Approximate Change in Strata ______

Inferred Change in Strata - - - - - - - -

1-B. Permanent notes, New Jersey Geological Survey.

85' to bedrock

2-B. Permanent notes, New Jersey Geological Survey.

191' to bedrock

3-B. Hackensack Water Company. Well #1.

0 - 1	fill
1 - 4	muck
4 - 28	gray sand and clay
28 - 60	gray clay
60 - 79	light brown clay
79 - 106	sandy brown clay
106 - 110	gravel, sand and clay
110 - 113	gravel and sand
113 - 115	medium coarse sand (active)
115 - 120	sand and gravel
120 - 126	clay with sand and gravel
126 - 130	clay with gravel
130 - 137	red hardpan
137 - 139	sand and gravel
139 - 146	red hardpan
154 - 170	silty red brown and gray clay
170 - 182	red silty sandy clay
182 - 188	coarse sand and clay
188 - 208	red hardpan
208 - 214	red clay and sand
214 - 237	red hardpan
237 - 238	red sands
238 - 243	red rock

4-B. Hackensack Water Company. Well #2.

0 - 2	fill
2 - 7	muck
7 - 25	gray clay
25 - 27	red clay
27 - 44	red sand and gravel (active)
44 - 59	sand and gravel "
59 - 63	fine sand with gravel "
63 - 74	coarse sand less gravel (active)
74 - 77	coarse sand and gravel "
77 - 83	fine sand and gravel "
83 - 87	coarse sand and gravel "
87 - 92	fine sand and clay
92 - 109	fine red sand
109 - 130	red clay with sand
130 - 150	red clay, sand with gravel
150 - 167	brown sand and clay
167 - 174	brown sand
174 - 179	red sandy clay
179 - 192	red sand with gravel
192 - 251	red clay sand and little gravel
251 - 263	red clay and sand
263 - 271	red rock and sandstone

2-C. Hackensack Water Company.

0 - 10	marsh
10 - 38	clay
38 - 86	sand and gravel

3-C. Hackensack Water Company.

0 - 4	marsh
4 - 110	clay, some sand
110 - 130	sand and gravel
130 - 137	clay
137 - 154	sand gravel and clay
154 - 237	mostly clay some sand and gravel
237 - 250	sand
250 -	red sandstone, shale

130 - 137	clay
137 - 154	sand gravel and clay
154 - 237	mostly clay some sand and gravel
237 - 250	sand
250 -	red sandstone, shale

3-G. Sewage Disposal Plant

175 - 235	gravel
269 -	red shale

No. 153 Elev. +4.65

0'0"-4'8"	Miscellaneous Fill, Paper, Wood, Rip-Rap
4'8"-9'0"	Fine Silty Sand, Some Decayed Vegetation
9'0"-11'0"	Medium Gray Sand
11'0"-18'0"	Brown-Gray Clay, Layers of Fine Sand
18'0"-29'0"	Layers of Sand, Layers of Silty Clay
29'0"-43'0"	Gray Clay, Brown Clay
43'0"-54'0"	Red Clay
54'0"-70'0"	Red Silty Sand, Layers of Gray Clay, Trace of Red Clay

W. L. 1'6"

105	Parillo, 1959 well 3B	0-1	fill
		1-4	muck
		4-28	gray sand and clay (Qmt over Qhkl)
		28-60	gray clay (Qhkl)
		60-79	light brown clay (Qhkl)
		79-106	sandy brown clay (Qhkl)
		106-110	gravel, sand, and clay (Qbnf)
		110-113	gravel and sand (Qbnf)
		113-115	medium-to-coarse sand, active (Qbnf)
		115-120	sand and gravel (Qbnf)
		120-126	clay with sand and gravel (Qbnf or Qt)
		126-130	clay with gravel (Qbnf or Qt)
		130-137	red hardpan (Qt or Qbnl)
		137-139	sand and gravel (Qbnf or Qt)
		139-146	red hardpan (Qt or Qbnl)
		146-154	NR
		154-170	silty red-brown and gray clay (Qbnl)
		170-182	red silty sandy clay (Qbnl)
		182-188	coarse sand and clay (Qbnl or Qt)
		188-208	red hardpan (Qt or Qbnl)
		208-214	red clay and sand (Qbnl or Qt)
		214-237	red hardpan (Qt or Qbnl)
		237-238	red sands (Qt or Qbnl)
		238-243	red rock

106	Parillo, 1959 well 4B	(abbreviated log)	
		0-2	fill (af)
		2-7	muck (Qm)
		7-25	gray clay (Qhkl)
		25-27	red clay (Qhkl)
		27-87	sand and gravel, active (Qbnf)
		87-130	fine sand and clay (Qbnl)
		130-150	red clay, sand with gravel (Qbnl)
		150-167	brown sand and clay (Qbnl)
		167-174	brown sand (Qbnf)
		174-179	red sandy clay (Qbnf)
		179-192	red sand with gravel (Qbnf)
		192-251	red clay sand and little gravel (Qbnl or Qt)
		251-263	red clay and sand (Qbnl or Qt)

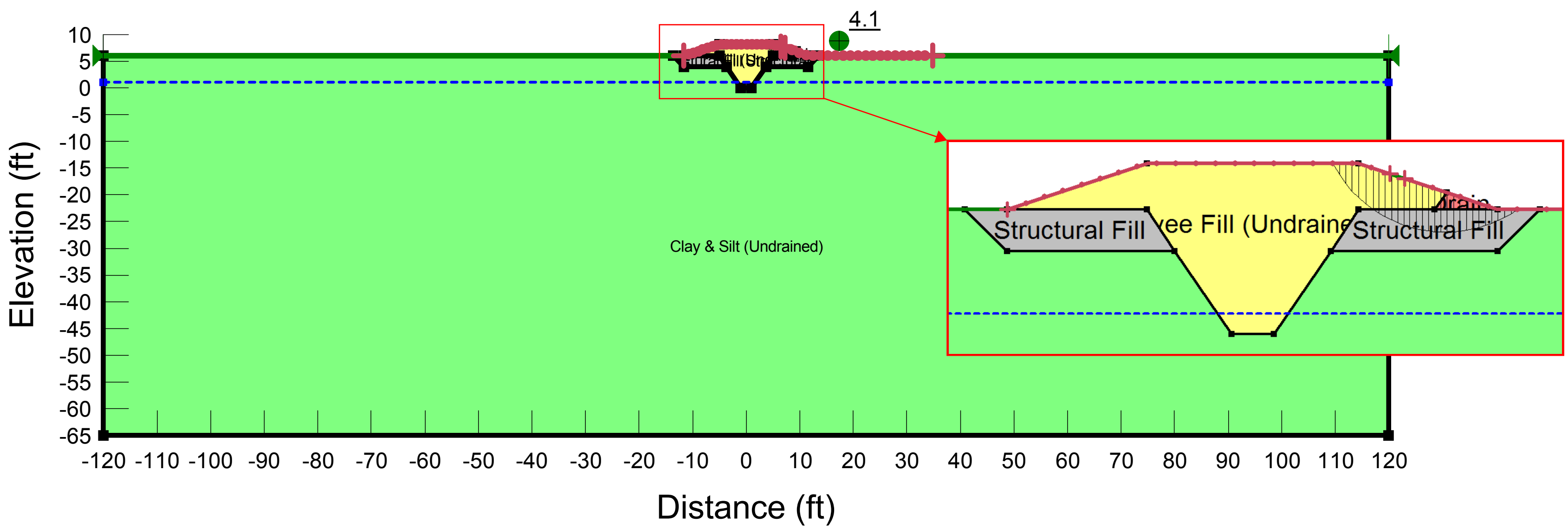
109	Parillo, 1959 well 4G	0-4	marsh muck (Qm)
		4-110	clay with some sand (Qhkl)
		110-130	sand and gravel (Qbnf)
		130-137	clay (Qbnl)
		137-154	sand, gravel, and clay (Qbnf)
		154-237	mostly clay (Qbnl)
		237-238	sand (Qt or Qbnl)
		238-243	red rock
210	26-2828	0-223	clay and fine sand (Qhkl over Qbnl)
		223-400	rock

Attachment C1-B

Details of Seepage and Slope Stability Analysis for Levees from GeoStudio

1. Stability Landside (Case I: End of Construction)

Name: Levee Fill (Undrained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 200 psf Phi: 15 °
Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay & Silt (Undrained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 500 psf Phi: 0 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °

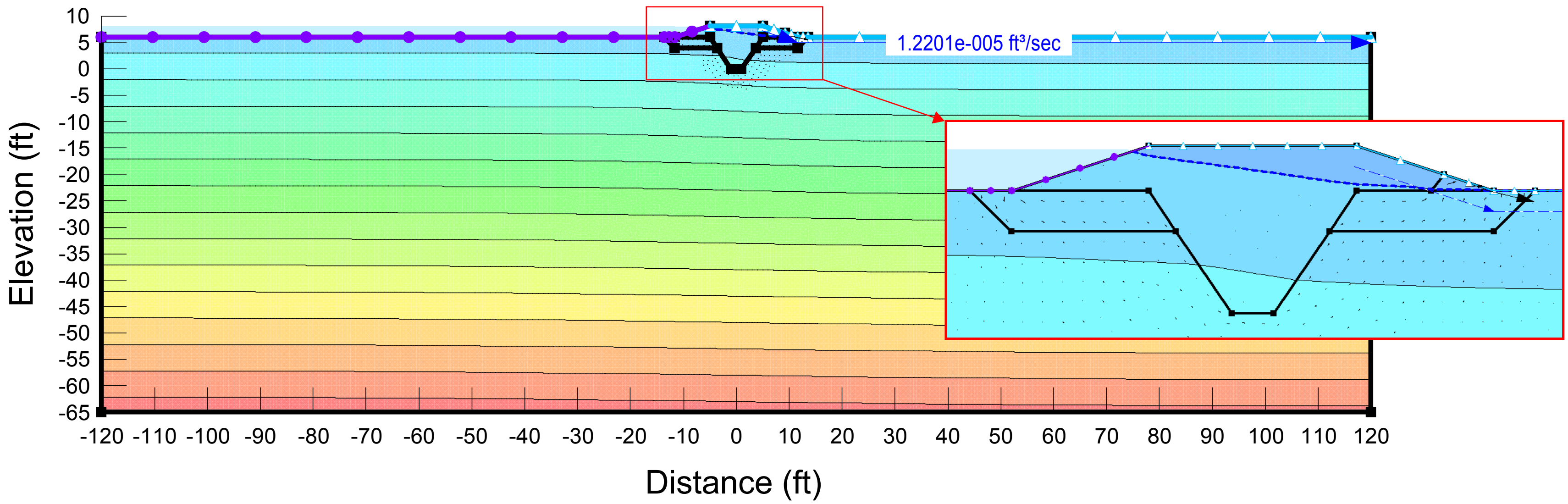


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 2 ft Levee Rev 1.gsz

Figure B.1: Output from slope stability analysis on the landside of the 2.2 ft levee in Soil Areas 1 to 3 at the end of construction by GeoStudio 2007 SLOPE/W.

2. Case II: Steady State Seepage

Name: Levee Fill (Undrained) Model: Saturated / Unsaturated K-Function: Levee Fill Vol. WC. Function: VWC - Levee Fill
Name: Structural Fill Model: Saturated Only K-Sat: 1.66e-005 ft/sec Volumetric Water Content: 0 ft³/ft³
Name: Clay & Silt (Undrained) Model: Saturated Only K-Sat: 6.6e-006 ft/sec Volumetric Water Content: 0 ft³/ft³
Name: Drain Model: Saturated / Unsaturated K-Function: Drain Vol. WC. Function: VWC - Drain



Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 2 ft Levee Rev 1.gsz

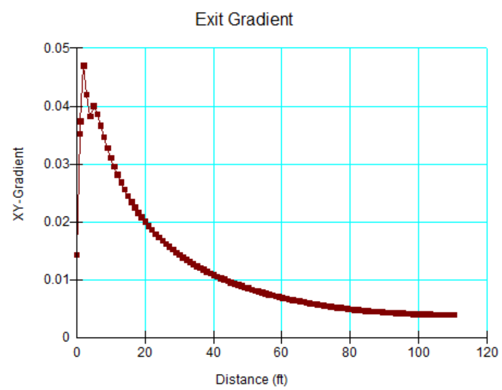
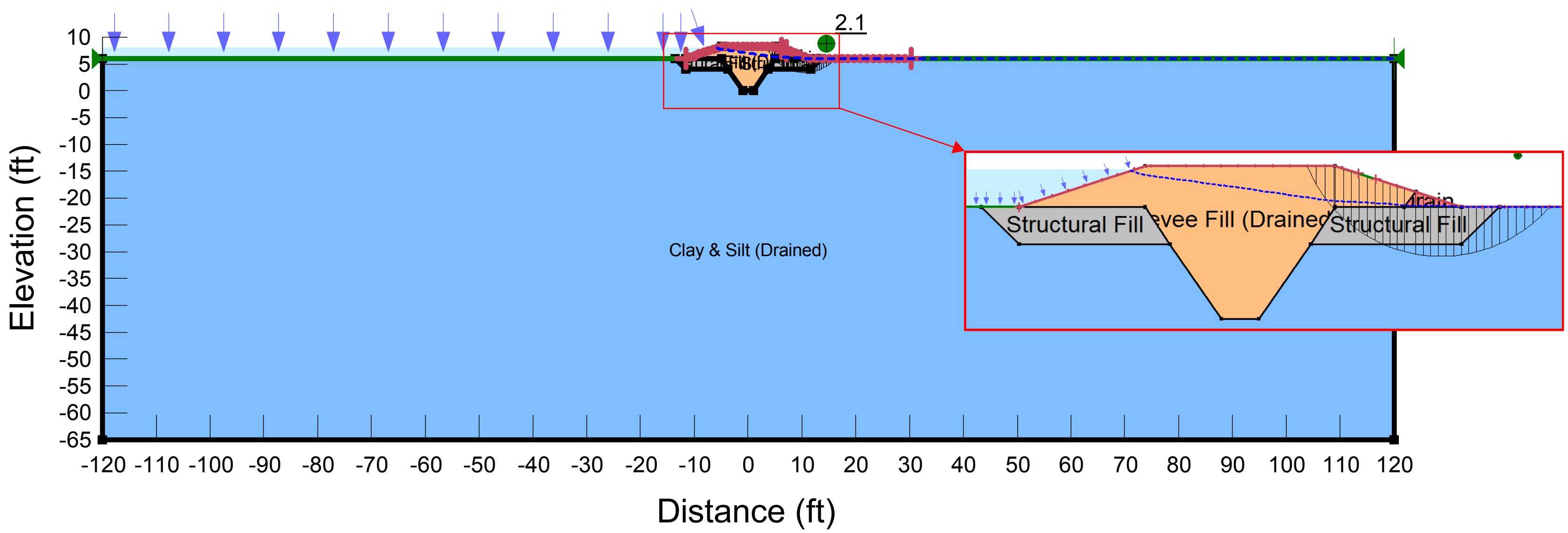


Figure B.2: Output from seepage analysis for the 2.2 ft levee in Soil Areas 1 to 3 at steady state with full flood stage by GeoStudio 2007 SEEP/W.

2. Stability Landside (Case II: Steady State)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay & Silt (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 25 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °

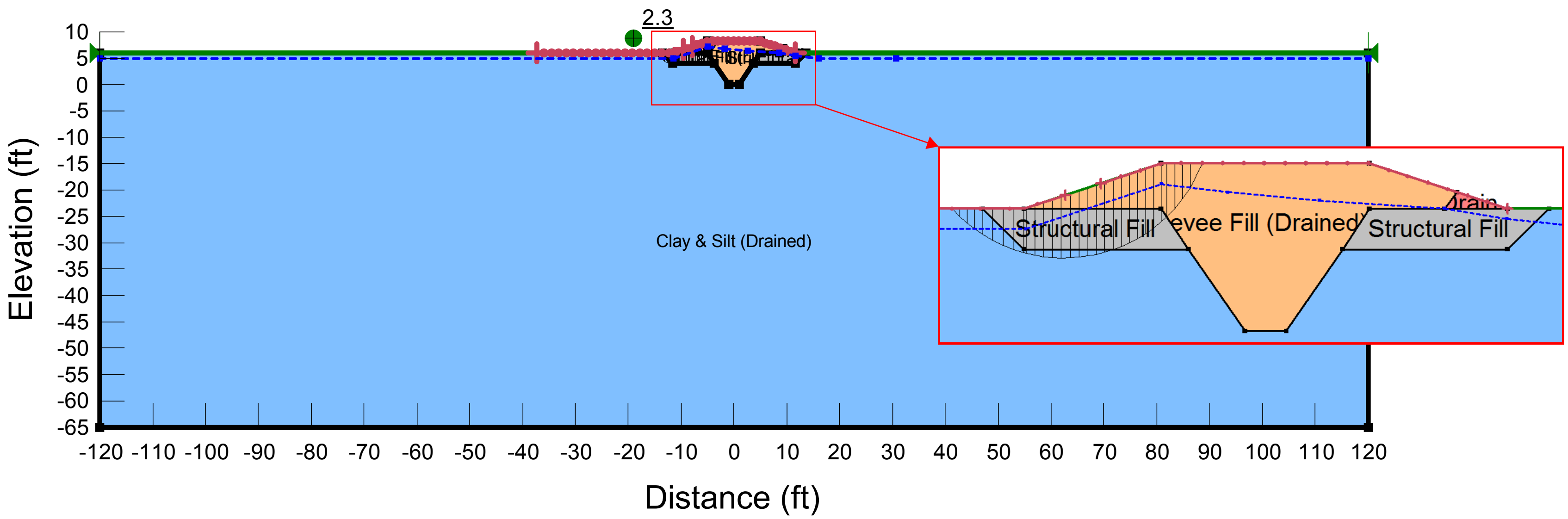


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 2 ft Levee Rev 1.gsz

Figure B3: Output from slope stability analysis on the landside of the 2.2 ft levee in Soil Areas 1 to 3 at steady seepage with full flood stage by GeoStudio 2007 SLOPE/W.

3. Stability (Case III: Rapid Drawdown)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay & Silt (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 25 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °

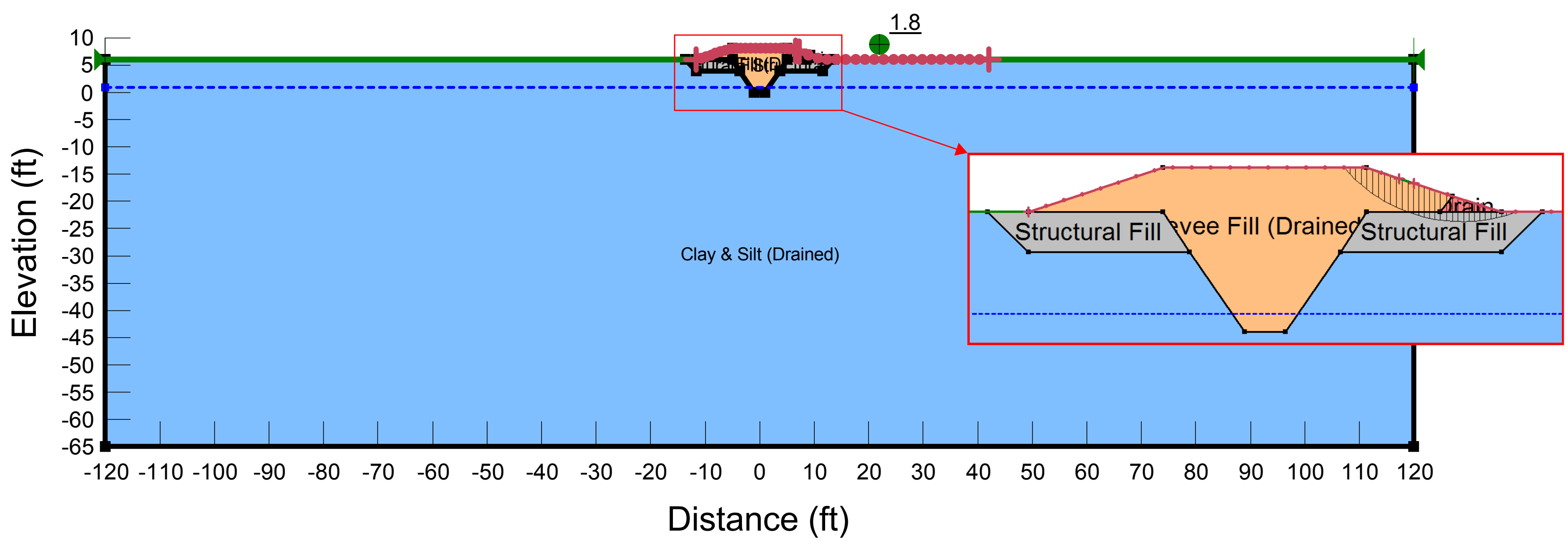


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 2 ft Levee Rev 1.gsz

Figure B.4: Output from slope stability analysis on the riverside of the 2.2 ft levee in Soil Areas 1 to 3 at rapid drawdown from full flood stage by GeoStudio 2007 SLOPE/W.

4. Stability Landside (Case IV: Seismic Loading)

Name: Structural Fill   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 32 °
Name: Clay & Silt (Drained)   Model: Mohr-Coulomb   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 25 °
Name: Drain   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 32 °
Name: Levee Fill (Drained)   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 50 psf   Phi: 25 °

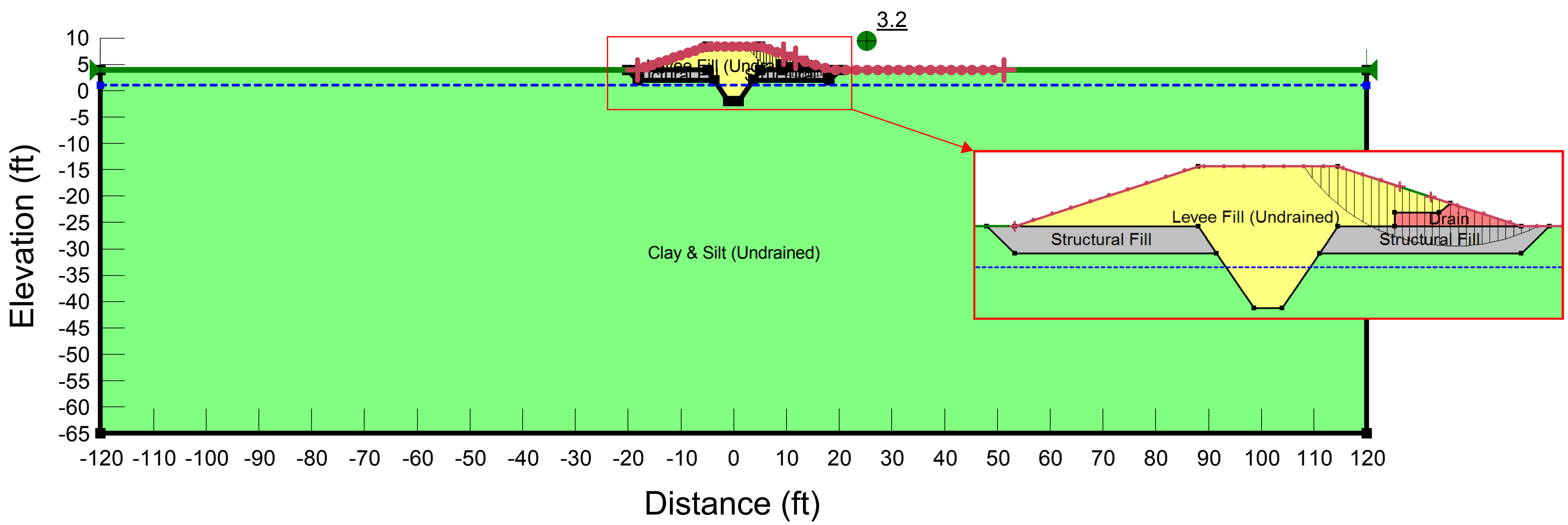


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 2 ft Levee Rev 1.gsz

Figure B.5: Output from slope stability analysis on the landside of the 2.2 ft levee in Soil Areas 1 to 3 at seismic loading by GeoStudio 2007 SLOPE/W.

1. Stability Landside (Case I: End of Construction)

Name: Levee Fill (Undrained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 200 psf Phi: 15 °
Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay & Silt (Undrained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 500 psf Phi: 0 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °

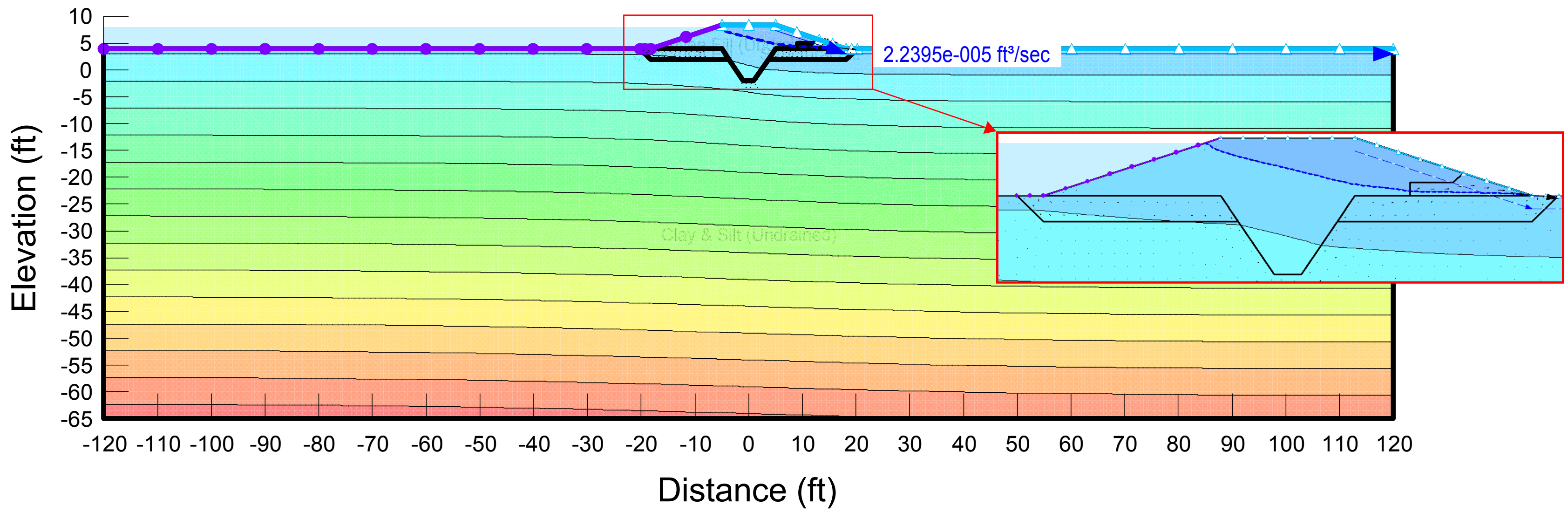


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 4 ft Levee Rev 1.gsz

Figure B.6: Output from slope stability analysis on the landside of the 4.4 ft levee in Soil Areas 1 to 3 at the end of construction by GeoStudio 2007 SLOPE/W.

2. Case II: Steady State Seepage

Name: Levee Fill (Undrained) Model: Saturated / Unsaturated K-Function: Levee Fill Vol. WC. Function: VWC - Levee Fill
Name: Structural Fill Model: Saturated Only K-Sat: 1.66e-005 ft/sec Volumetric Water Content: 0 ft³/ft³
Name: Clay & Silt (Undrained) Model: Saturated Only K-Sat: 6.6e-006 ft/sec Volumetric Water Content: 0 ft³/ft³
Name: Drain Model: Saturated / Unsaturated K-Function: Drain Vol. WC. Function: VWC - Drain



Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 4 ft Levee Rev 1.gsz

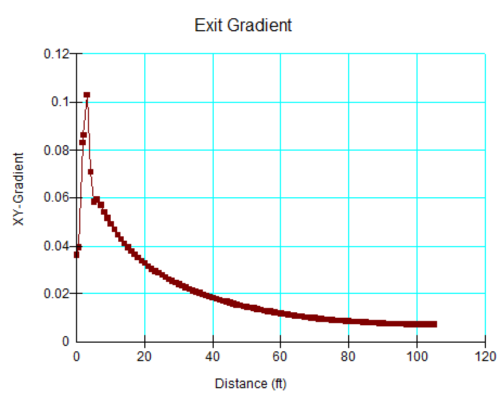
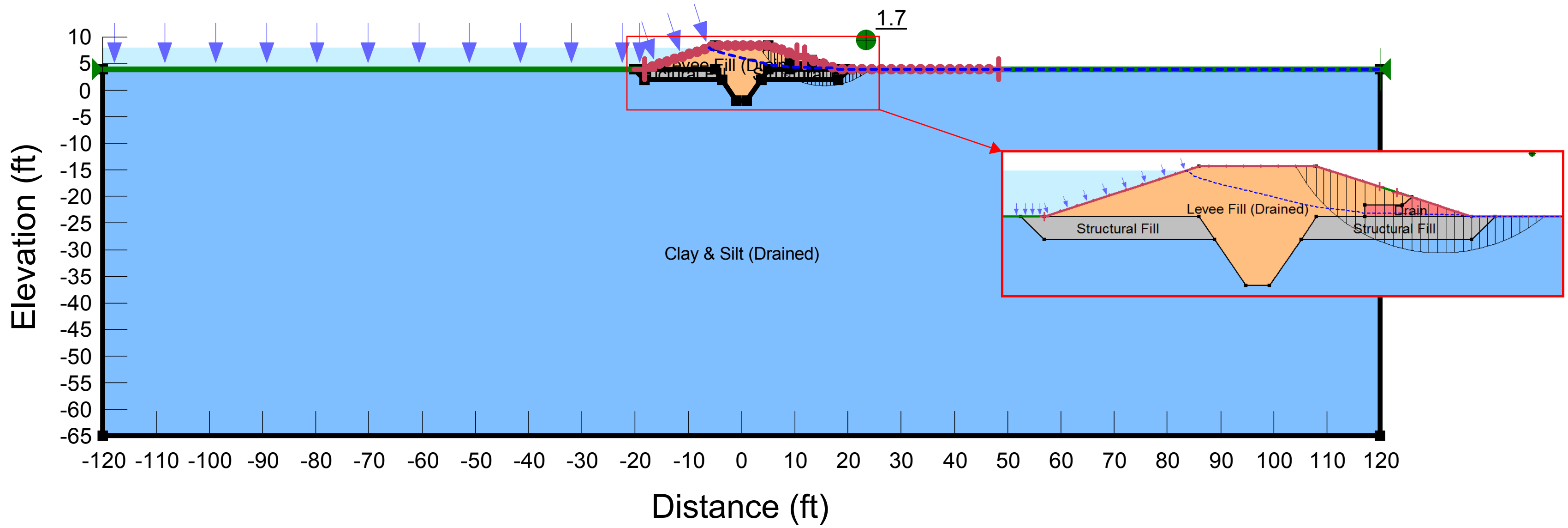


Figure B.7: Output from seepage analysis for the 4.4 ft levee in Soil Areas 1 to 3 at steady state with full flood stage by GeoStudio 2007 SEEP/W.

2. Stability Landside (Case II: Steady State)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay & Silt (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 25 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °

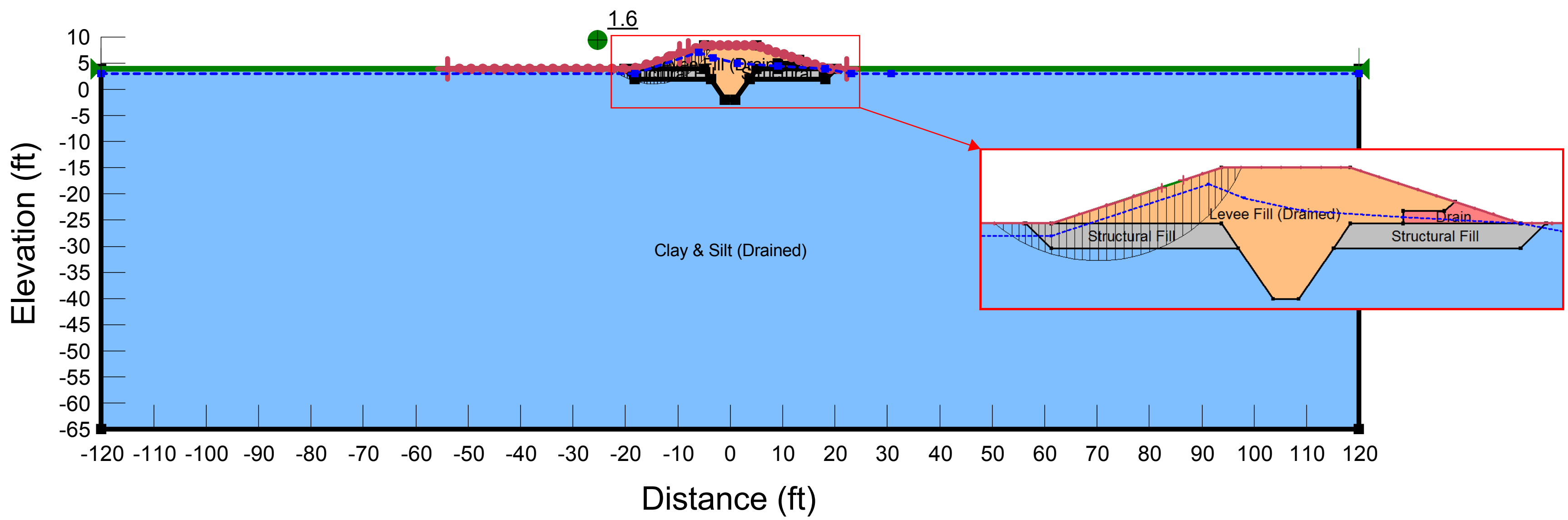


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 4 ft Levee Rev 1.gsz

Figure B.8: Output from slope stability analysis on the landside of 4.4 ft levee in Soil Areas 1 to 3 at steady seepage with full flood stage by GeoStudio 2007 SLOPE/W.

3. Stability (Case III: Rapid Drawdown)

Name: Structural Fill   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 32 °
Name: Clay & Silt (Drained)   Model: Mohr-Coulomb   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 25 °
Name: Drain   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 32 °
Name: Levee Fill (Drained)   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 50 psf   Phi: 25 °

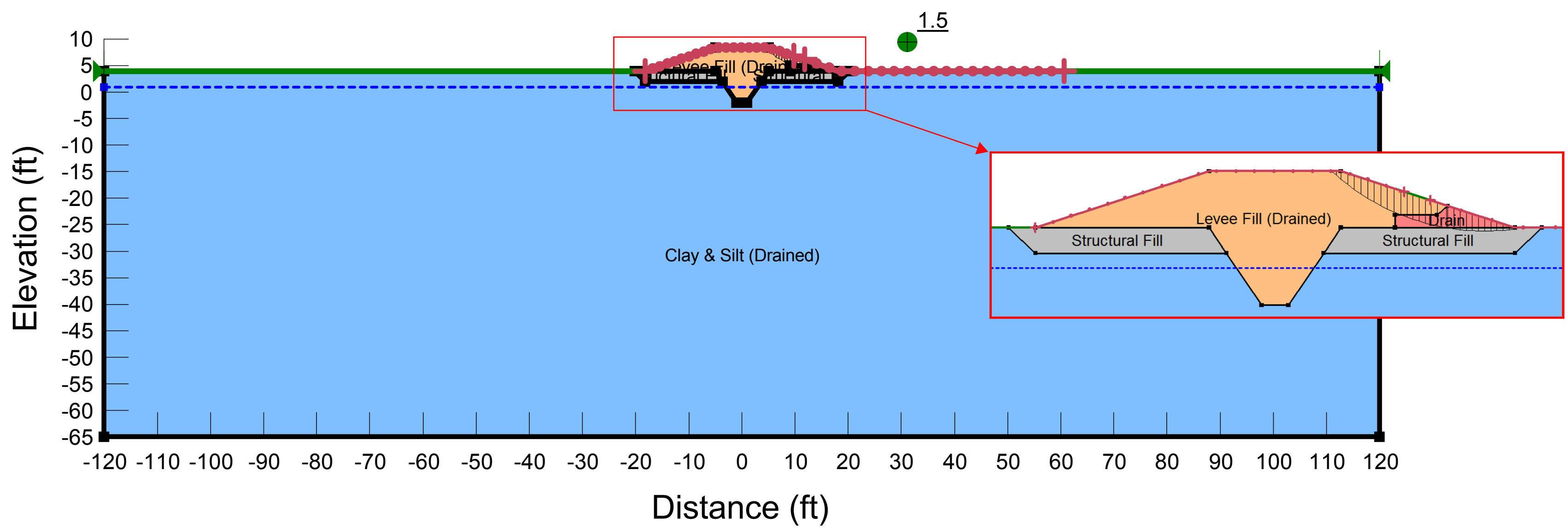


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 4 ft Levee Rev 1.gsz

Figure B.9: Output from slope stability analysis on the riverside of 4.4 ft levee in Soil Areas 1 to 3 at rapid drawdown from full flood stage by GeoStudio 2007 SLOPE/W.

4. Stability Landside (Case IV: Seismic Loading)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay & Silt (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 25 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °

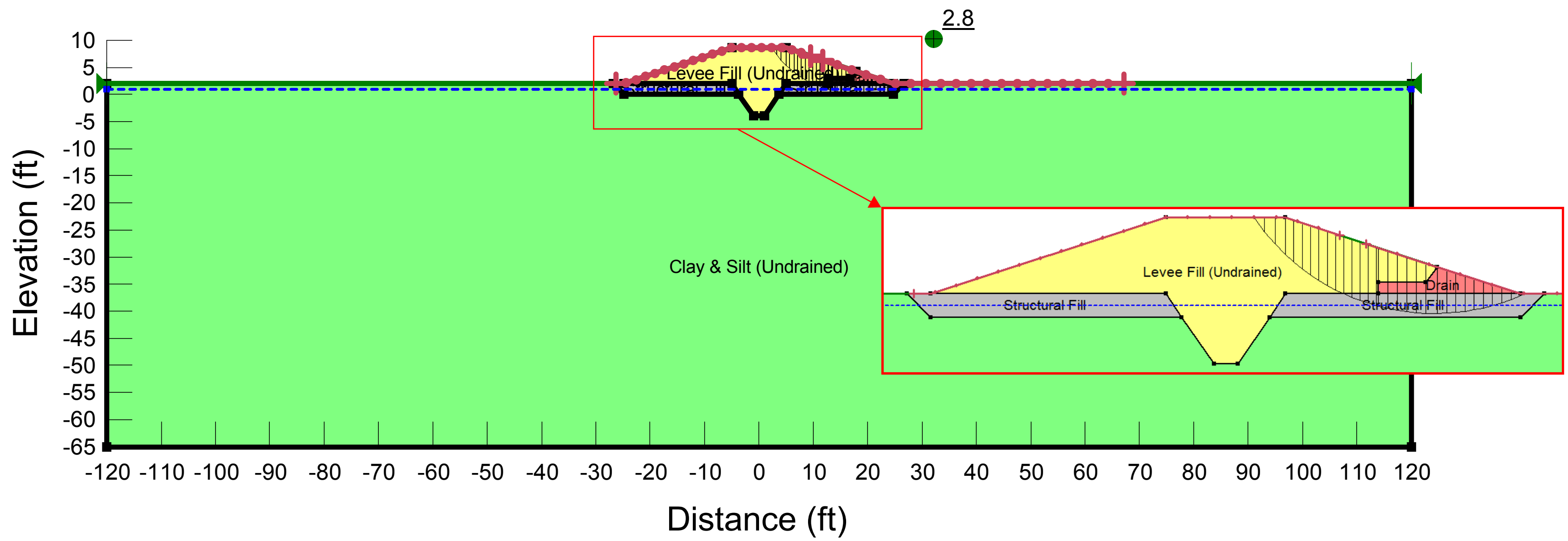


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 4 ft Levee Rev 1.gsz

Figure B.10: Output from slope stability analysis on the landside of 4.4 ft levee in Soil Areas 1 to 3 at seismic loading by GeoStudio 2007 SLOPE/W.

1. Stability Landside (Case I: End of Construction)

Name: Levee Fill (Undrained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 200 psf Phi: 15 °
Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay & Silt (Undrained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 500 psf Phi: 0 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °

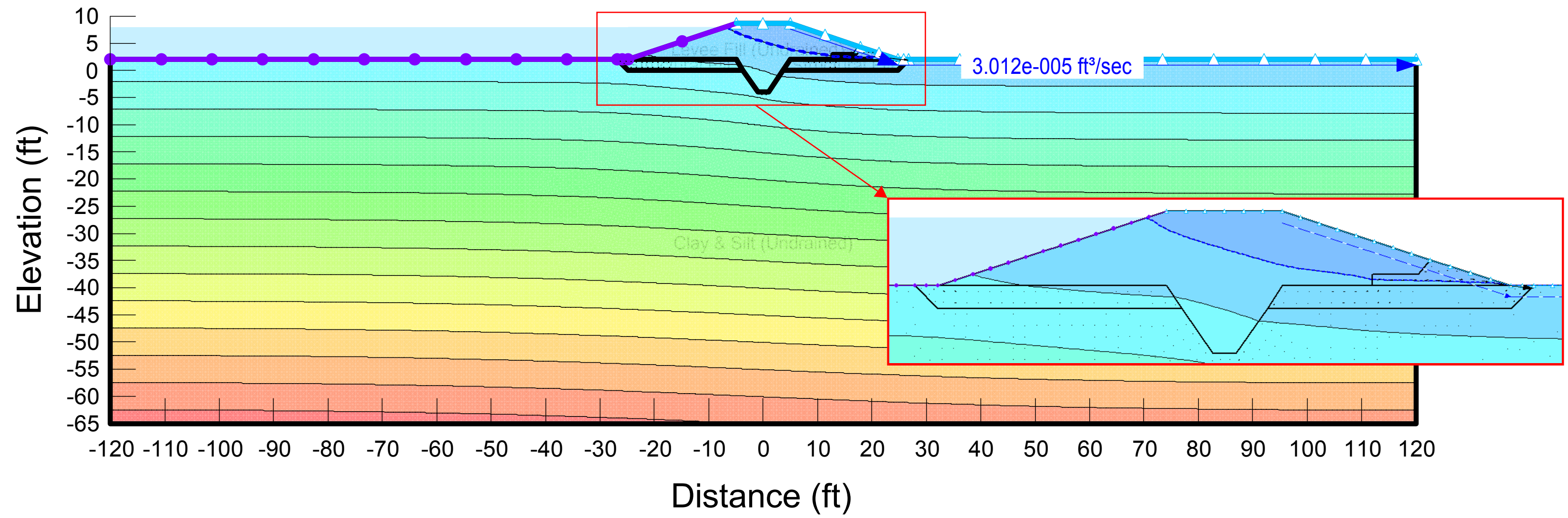


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 6 ft Levee Rev 1.gsz

Figure B.11: Output from slope stability analysis on the landside of the 6.6 ft levee in Soil Areas 1 to 3 at the end of construction by GeoStudio 2007 SLOPE/W.

2. Case II: Steady State Seepage

Name: Levee Fill (Undrained) Model: Saturated / Unsaturated K-Function: Levee Fill Vol. WC. Function: VWC - Levee Fill
Name: Structural Fill Model: Saturated Only K-Sat: 1.66e-005 ft/sec Volumetric Water Content: 0 ft³/ft³
Name: Clay & Silt (Undrained) Model: Saturated Only K-Sat: 6.6e-006 ft/sec Volumetric Water Content: 0 ft³/ft³
Name: Drain Model: Saturated / Unsaturated K-Function: Drain Vol. WC. Function: VWC - Drain



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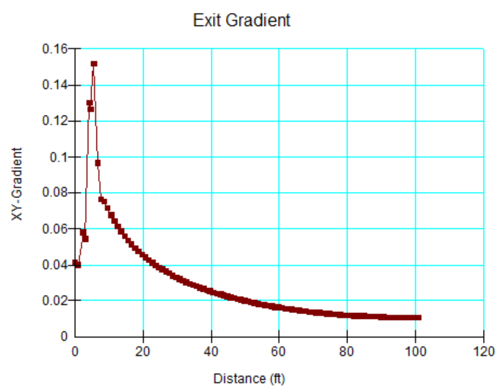
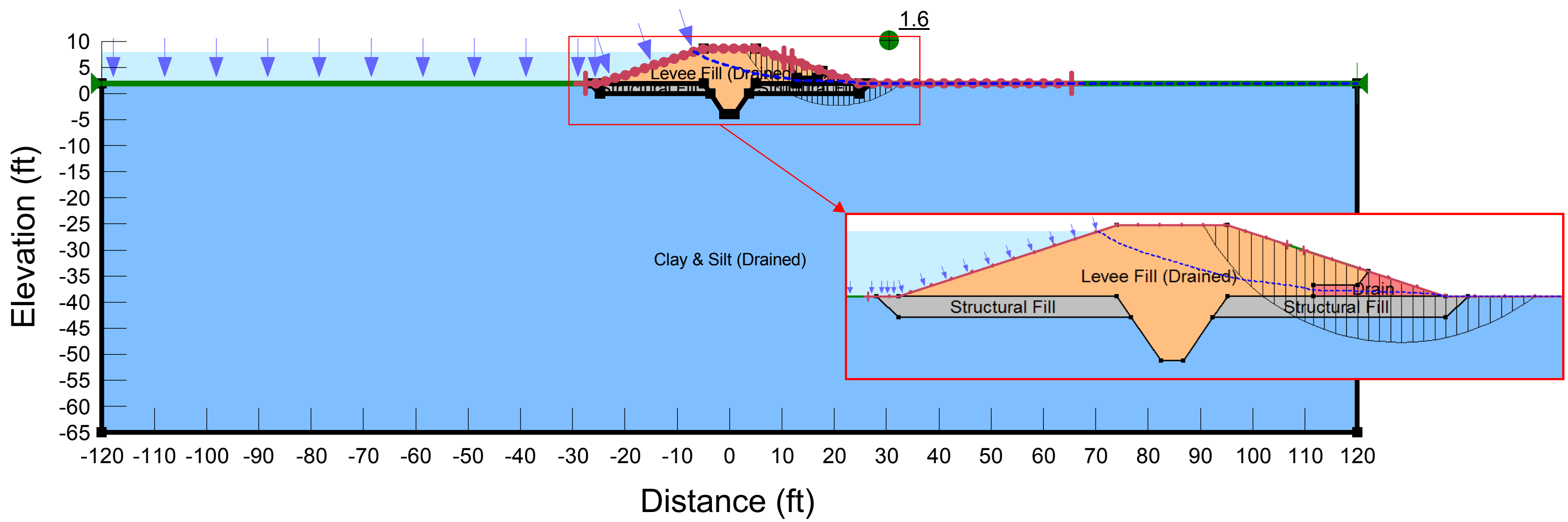


Figure B.12: Output from seepage analysis for the 6.6 ft levee in Soil Areas 1 to 3 at steady state with full flood stage by GeoStudio 2007 SEEP/W.

2. Stability Landside (Case II: Steady State)

Name: Structural Fill   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 32 °
Name: Clay & Silt (Drained)   Model: Mohr-Coulomb   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 25 °
Name: Drain   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 32 °
Name: Levee Fill (Drained)   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 50 psf   Phi: 25 °

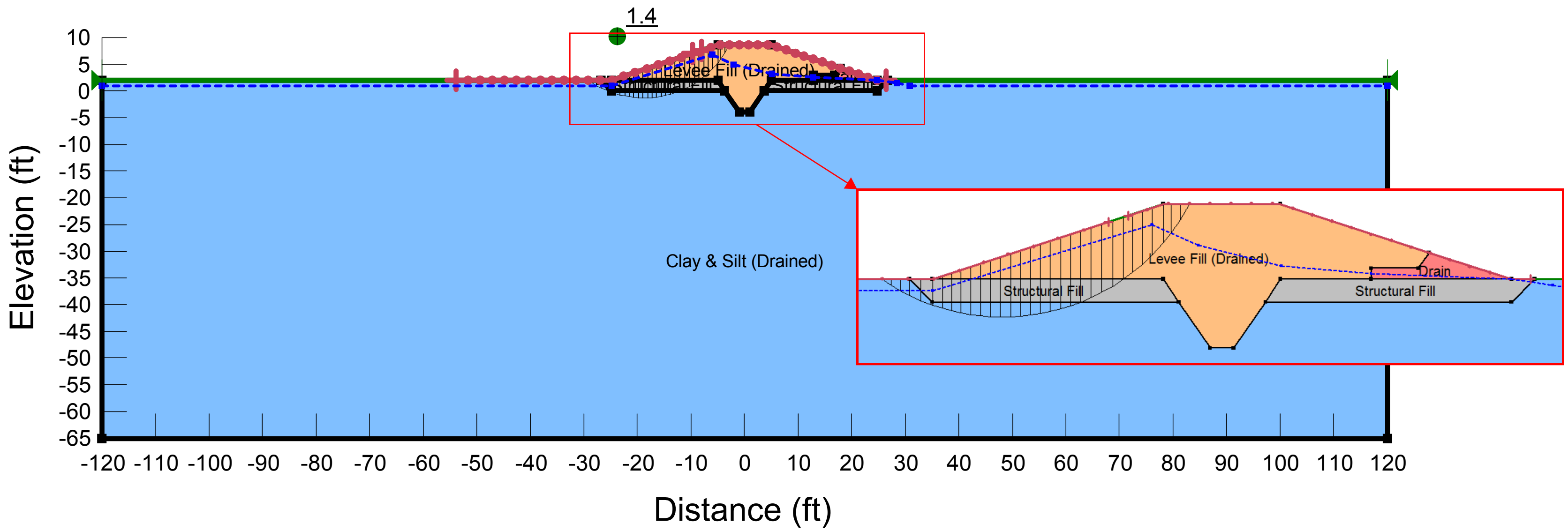


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 6 ft Levee Rev 1.gsz

Figure B.13: Output from slope stability analysis on the landside of the 6.6 ft levee in Soil Areas 1 to 3 at steady seepage with full flood stage by GeoStudio 2007 SLOPE/W.

3. Stability (Case III: Rapid Drawdown)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay & Silt (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 25 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °

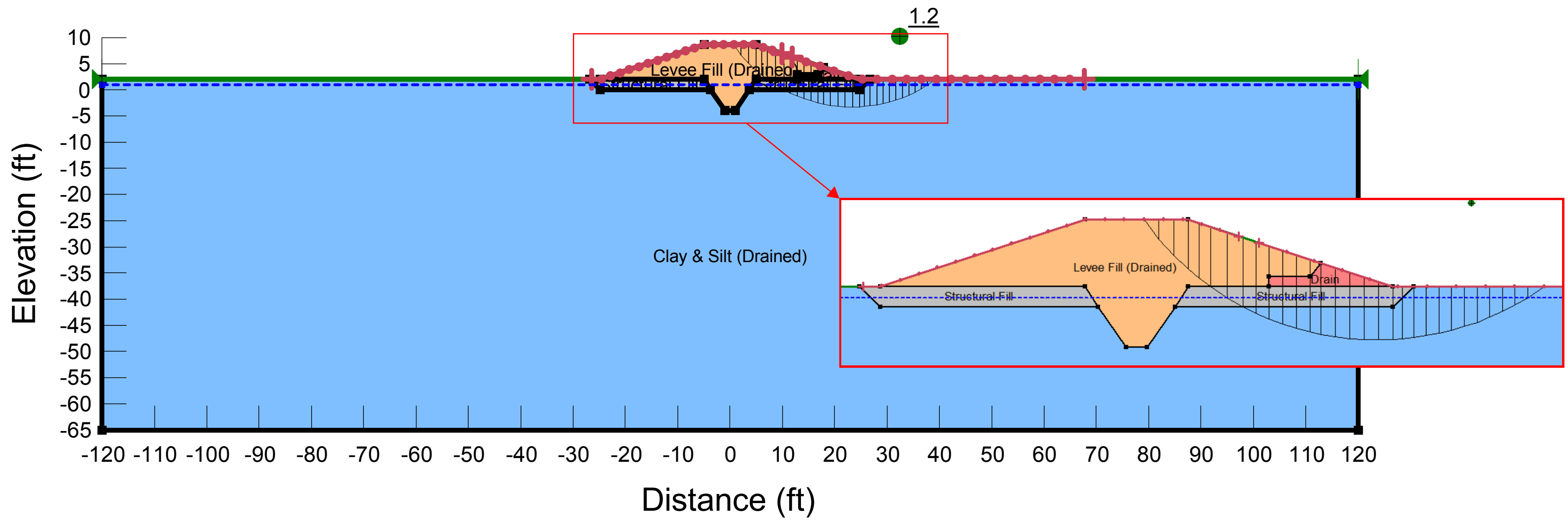


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 6 ft Levee Rev 1.gsz

Figure B.14: Output from slope stability analysis on the riverside of the 6.6 ft levee in Soil Areas 1 to 3 at rapid drawdown from full flood stage by GeoStudio 2007 SLOPE/W.

4. Stability Landside (Case IV: Seismic Loading)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay & Silt (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 25 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °

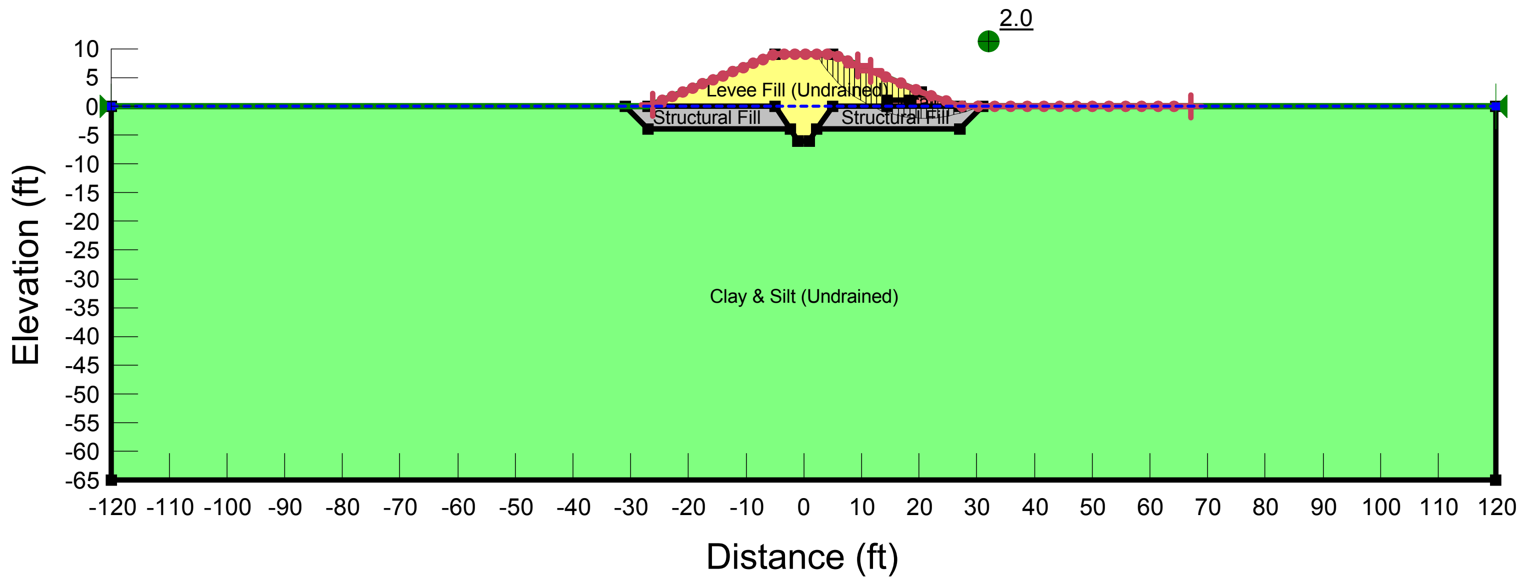


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 6 ft Levee Rev 1.gsz

Figure B.15: Output from slope stability analysis on the landside of the 6.6 ft levee in Soil Areas 1 to 3 at seismic loading by GeoStudio 2007 SLOPE/W.

1. Stability Landside (Case I: End of Construction)

Name: Levee Fill (Undrained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 200 psf Phi: 15 °
Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay & Silt (Undrained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 500 psf Phi: 0 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °

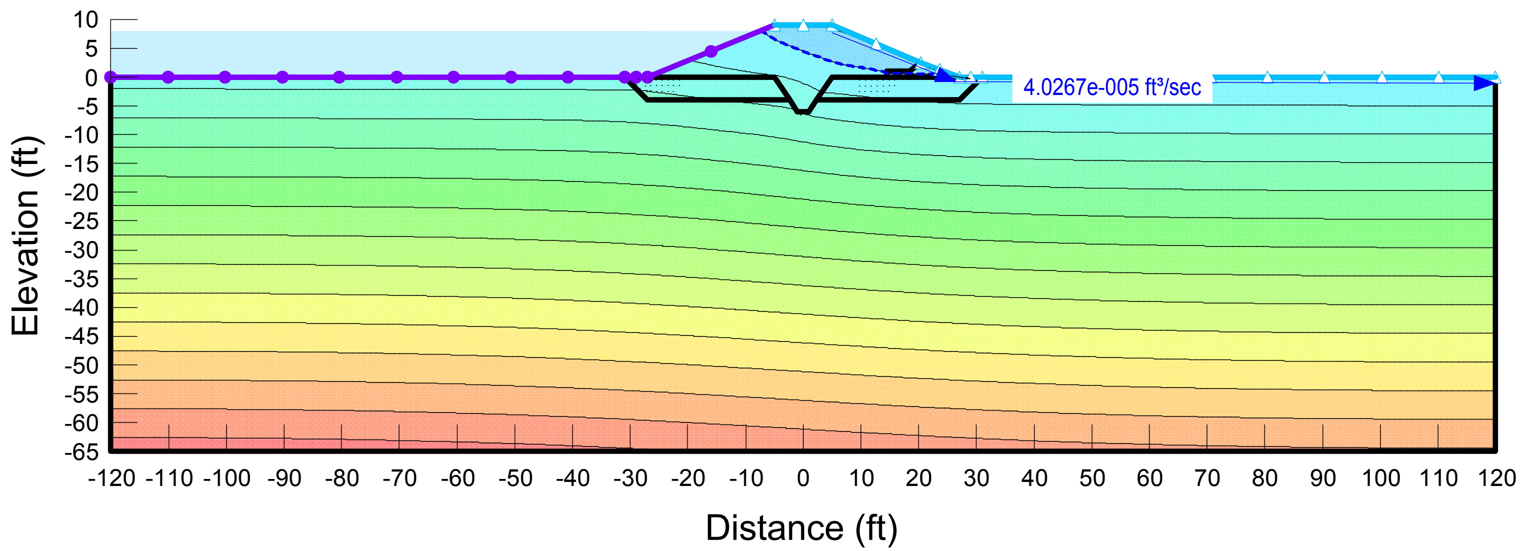


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 8 ft Levee Rev 1.gsz

Figure B.16: Output from slope stability analysis on the landside of the 8.8 ft levee in Soil Areas 1 to 3 at the end of construction by GeoStudio 2007 SLOPE/W.

2. Case II: Steady State Seepage

Name: Levee Fill (Undrained) Model: Saturated / Unsaturated K-Function: Top Fill Vol. WC. Function: VWC - Top Fill
Name: Structural Fill Model: Saturated Only K-Sat: 1.66e-005 ft/sec Volumetric Water Content: 0 ft³/ft³
Name: Clay & Silt (Undrained) Model: Saturated Only K-Sat: 6.6e-006 ft/sec Volumetric Water Content: 0 ft³/ft³
Name: Drain Model: Saturated / Unsaturated K-Function: Drain Vol. WC. Function: VWC - Top Fill



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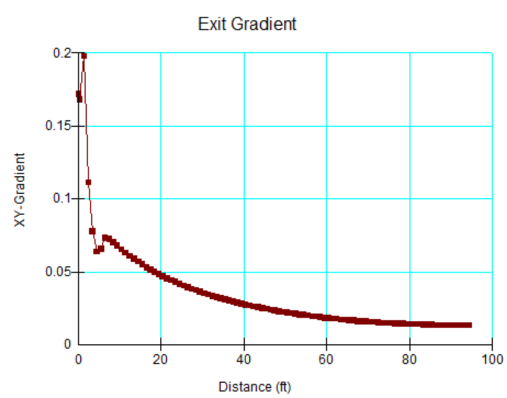
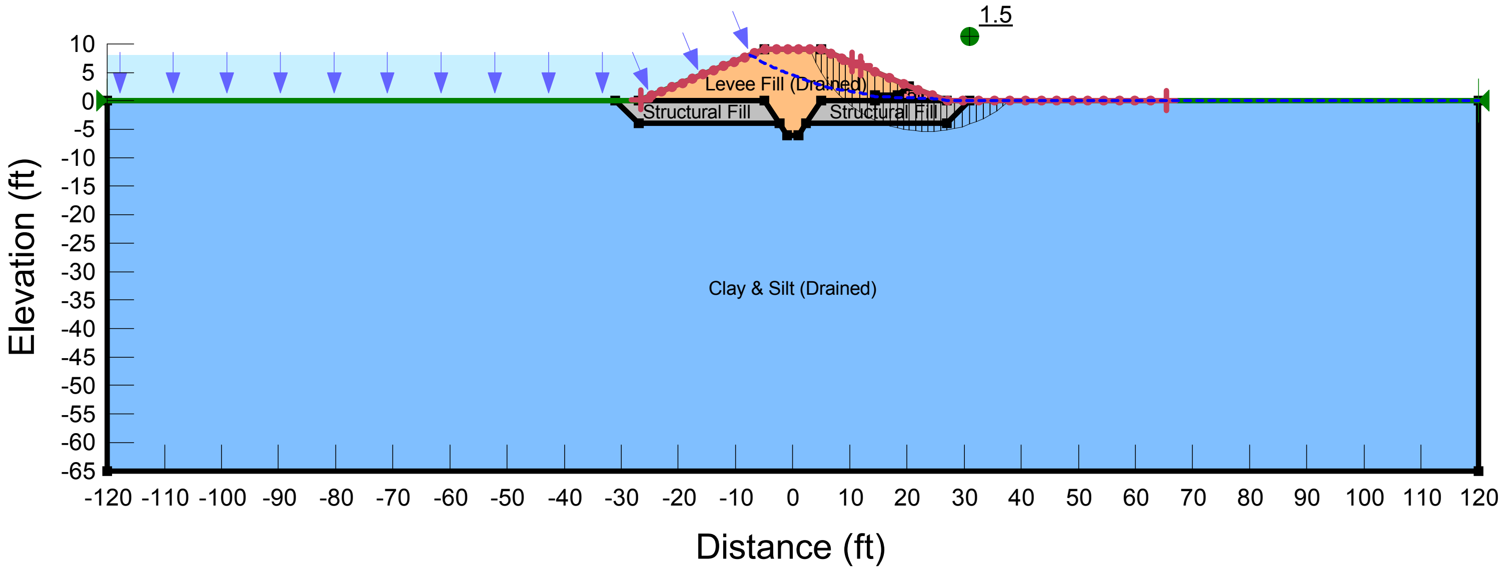


Figure B.17: Output from seepage analysis for the 8.8 ft levee in Soil Areas 1 to 3 at steady state with full flood stage by GeoStudio 2007 SEEP/W.

2. Stability Landside (Case II: Steady State)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay & Silt (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 25 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °

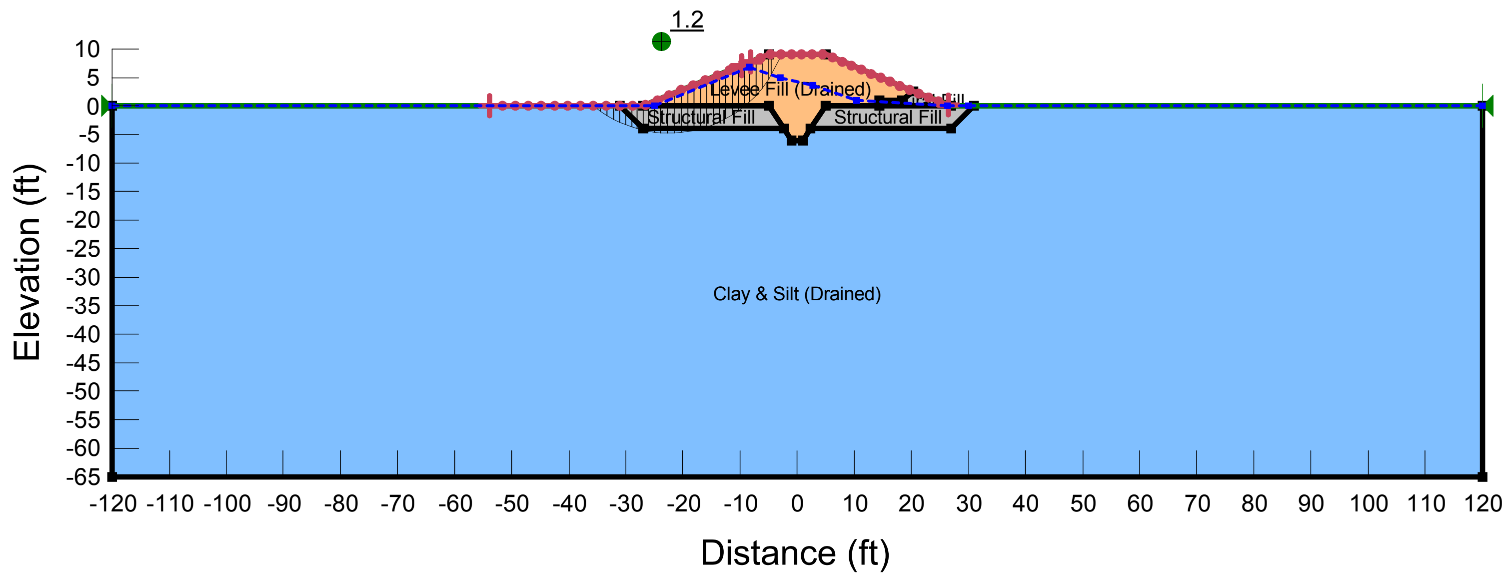


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 8 ft Levee Rev 1.gsz

Figure B.18: Output from slope stability analysis on the landside of the 8.8 ft levee in Soil Areas 1 to 3 at steady seepage with full flood stage by GeoStudio 2007 SLOPE/W.

3. Stability (Case III: Rapid Drawdown)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay & Silt (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 25 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °

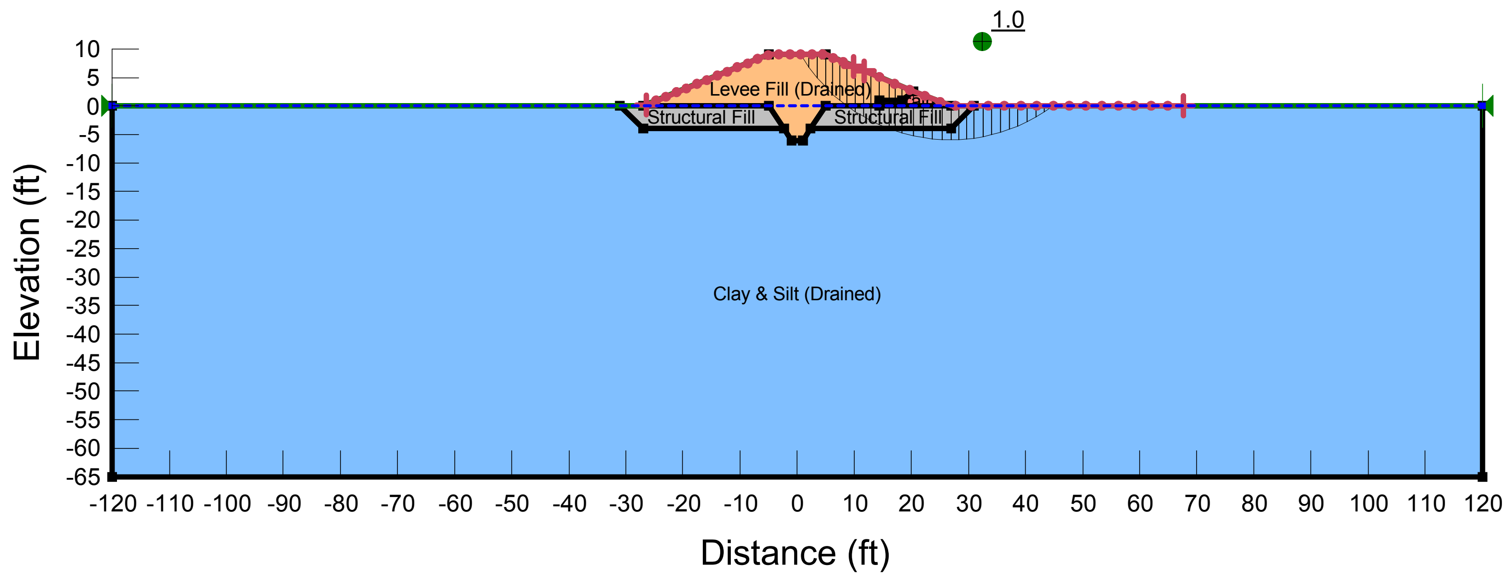


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 8 ft Levee Rev 1.gsz

Figure B.19: Output from slope stability analysis on the riverside of the 8.8 ft levee in Soil Areas 1 to 3 at rapid drawdown from full flood stage by GeoStudio 2007 SLOPE/W.

4. Stability Landside (Case IV: Seismic Loading)

Name: Structural Fill   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 32 °
Name: Clay & Silt (Drained)   Model: Mohr-Coulomb   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 25 °
Name: Drain   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 32 °
Name: Levee Fill (Drained)   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 50 psf   Phi: 25 °

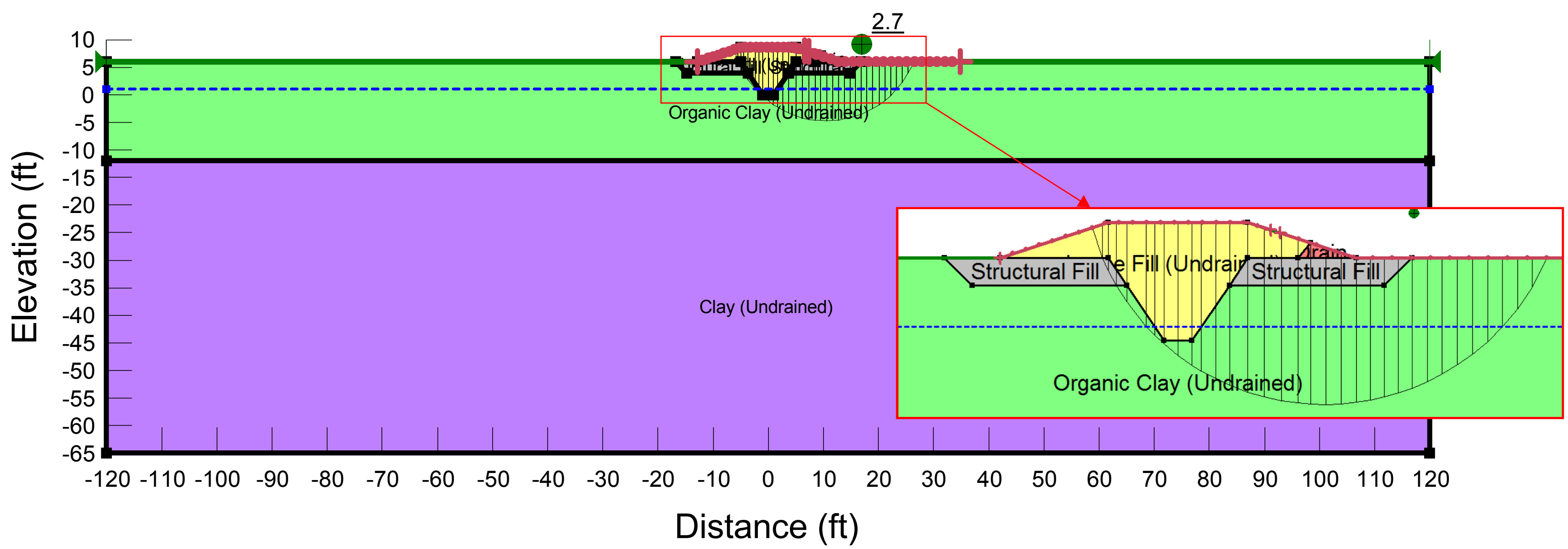


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 1 to 3\File Name: Zone 1 to 3 - 8 ft Levee Rev 1.gsz

Figure B.20: Output from slope stability analysis on the landside of the 8.8 ft levee in Soil Areas 1 to 3 at seismic loading by GeoStudio 2007 SLOPE/W.

1. Stability Landside (Case I: End of Construction)

Name: Levee Fill (Undrained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 200 psf Phi: 15 °
Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Organic Clay (Undrained) Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 200 psf Phi: 0 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay (Undrained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 300 psf Phi: 0 °

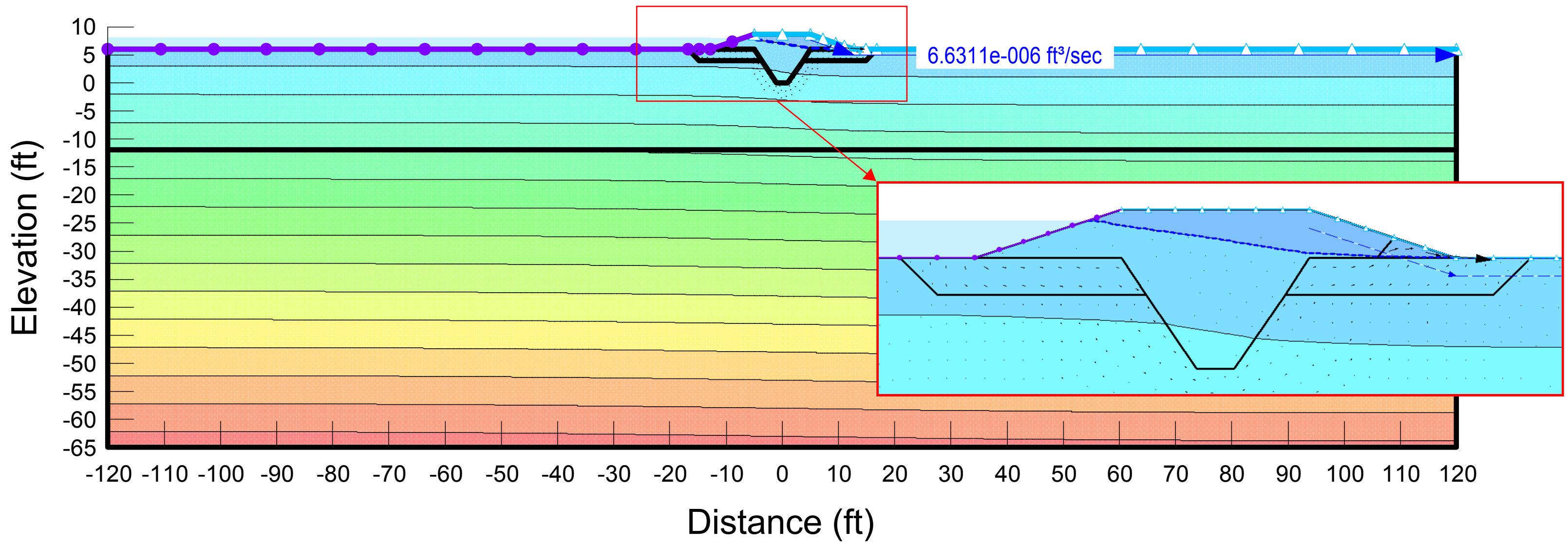


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 2 ft Levee Rev 1.gsz

Figure B.21: Output from slope stability analysis on the landside of the 2.6 levee in Soil Areas 4 to 7 at the end of construction by GeoStudio 2007 SLOPE/W.

2. Case II: Steady State Seepage

Name: Levee Fill (Undrained)   Model: Saturated / Unsaturated   K-Function: Levee Fill   Vol. WC. Function: VWC - Levee Fill
Name: Structural Fill   Model: Saturated Only   K-Sat: 1.66e-005 ft/sec   Volumetric Water Content: 0 ft³/ft³
Name: Organic Clay (Undrained)   Model: Saturated Only   K-Sat: 3.3e-006 ft/sec   Volumetric Water Content: 0 ft³/ft³
Name: Drain   Model: Saturated / Unsaturated   K-Function: Drain   Vol. WC. Function: VWC - Drain
Name: Clay (Undrained)   Model: Saturated Only   K-Sat: 3.3e-006 ft/sec   Volumetric Water Content: 0 ft³/ft³



Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 2 ft Levee Rev 1.gsz

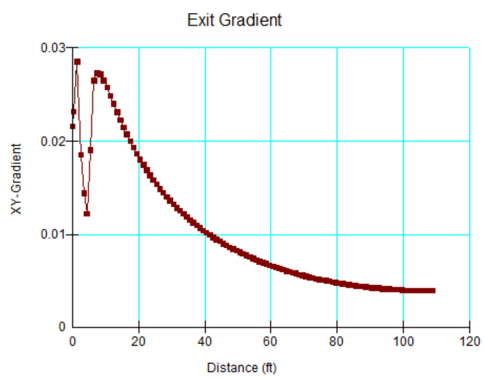
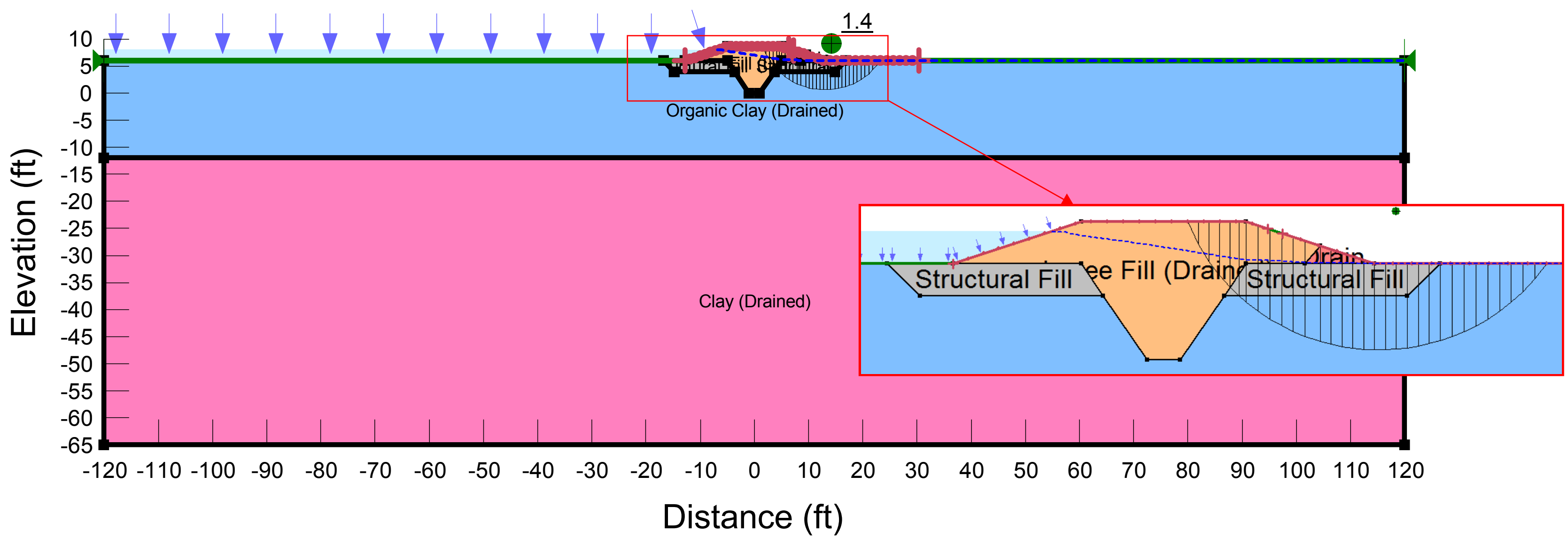


Figure B.22: Output from seepage analysis for the 2.6 levee in Soil Areas 4 to 7 at steady state with full flood stage by GeoStudio 2007 SEEP/W.

2. Stability Landside (Case II: Steady State)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Organic Clay (Drained) Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 0 psf Phi: 20 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °
Name: Clay (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 22 °

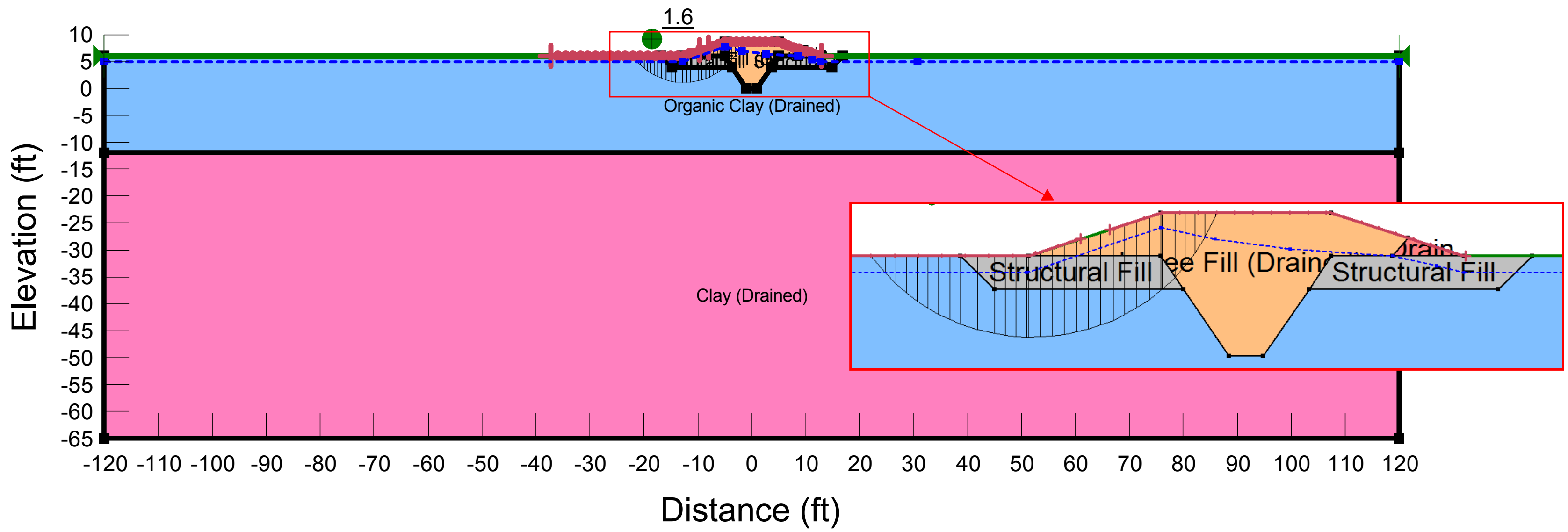


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 2 ft Levee Rev 1.gsz

Figure B.23: Output from slope stability analysis on the landside of the 2.6 levee in Soil Areas 4 to 7 at steady seepage with full flood stage by GeoStudio 2007 SLOPE/W.

3. Stability (Case III: Rapid Drawdown)

Name: Structural Fill   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 32 °
Name: Organic Clay (Drained)   Model: Mohr-Coulomb   Unit Weight: 85 pcf   Cohesion: 0 psf   Phi: 20 °
Name: Drain   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 32 °
Name: Levee Fill (Drained)   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 50 psf   Phi: 25 °
Name: Clay (Drained)   Model: Mohr-Coulomb   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 22 °

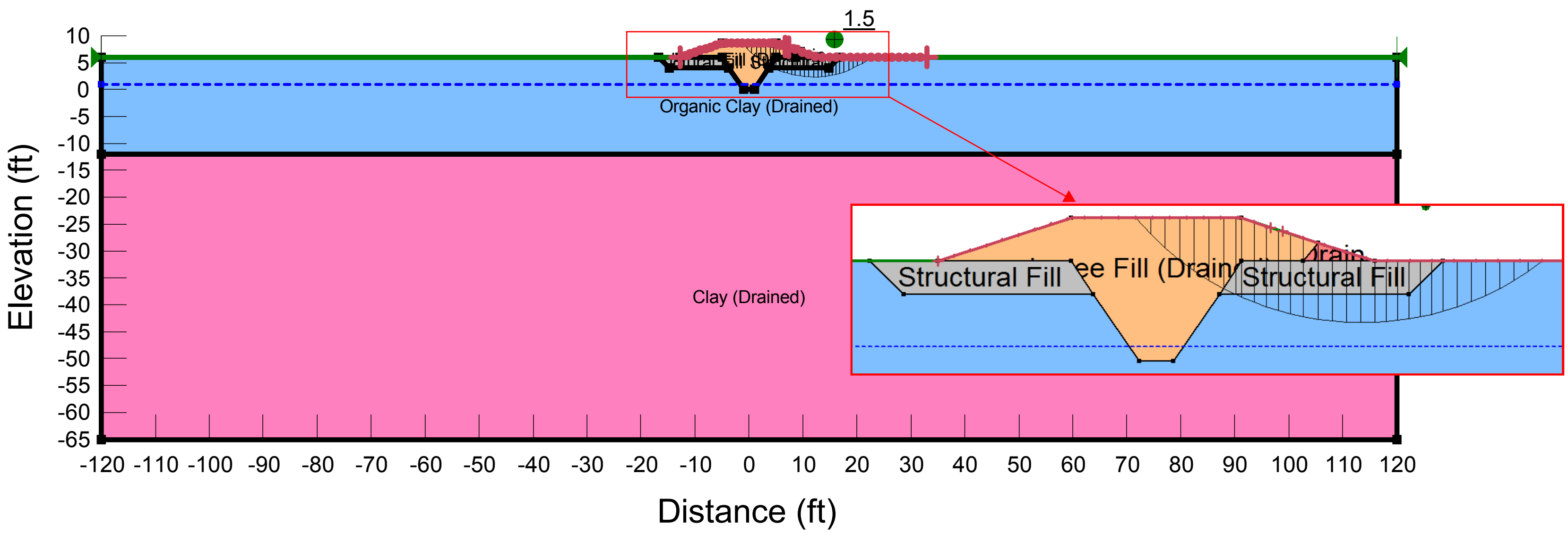


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 2 ft Levee Rev 1.gsz

Figure B.24: Output from slope stability analysis on the riverside of the 2.6 levee in Soil Areas 4 to 7 at rapid drawdown from full flood stage by GeoStudio 2007 SLOPE/W.

4. Stability Landside (Case IV: Seismic Loading)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Organic Clay (Drained) Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 0 psf Phi: 20 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °
Name: Clay (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 22 °

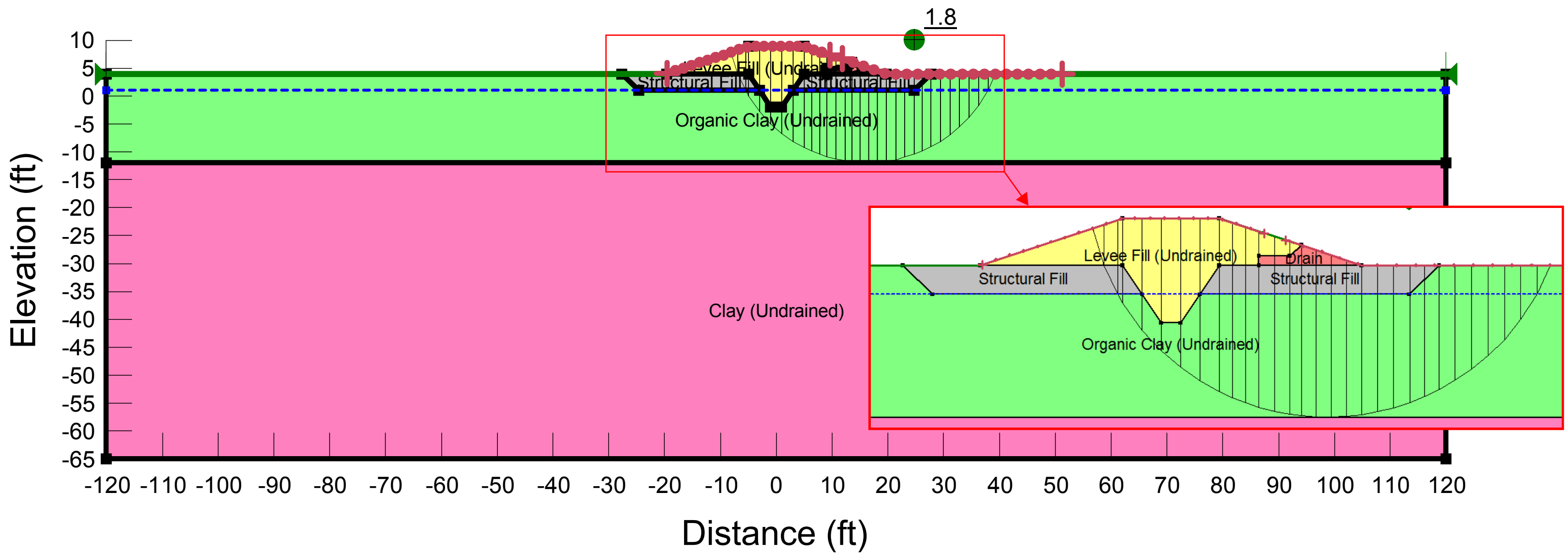


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 2 ft Levee Rev 1.gsz

Figure B.25: Output from slope stability analysis on the landside of the 2.6 levee in Soil Areas 4 to 7 at seismic loading by GeoStudio 2007 SLOPE/W.

1. Stability Landside (Case I: End of Construction)

Name: Levee Fill (Undrained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 200 psf Phi: 15 °
Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Organic Clay (Undrained) Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 200 psf Phi: 0 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay (Undrained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 300 psf Phi: 0 °

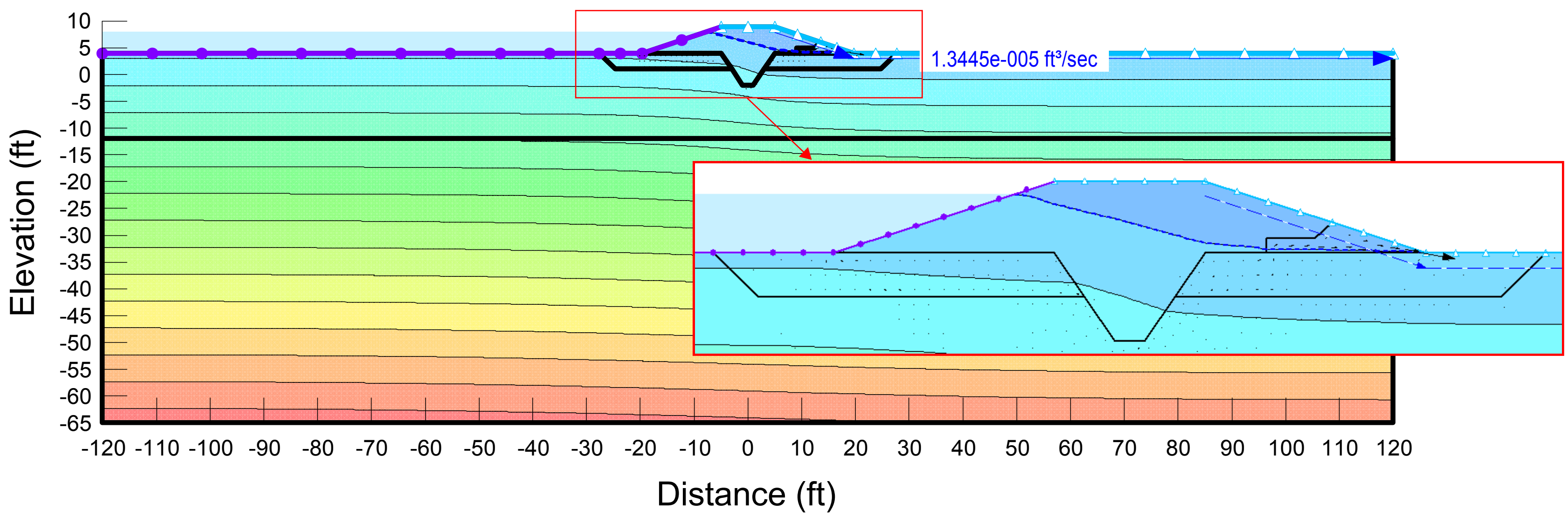


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 4 ft Levee Rev 1.gsz

Figure B.26: Output from slope stability analysis on the landside of the 4.9 ft levee in Soil Areas 4 to 7 at the end of construction by GeoStudio 2007 SLOPE/W.

2. Case II: Steady State Seepage

Name: Levee Fill (Undrained) Model: Saturated / Unsaturated K-Function: Levee Fill Vol. WC. Function: VWC - Levee Fill
Name: Structural Fill Model: Saturated Only K-Sat: 1.66e-005 ft/sec Volumetric Water Content: 0 ft³/ft³
Name: Organic Clay (Undrained) Model: Saturated Only K-Sat: 3.6e-006 ft/sec Volumetric Water Content: 0 ft³/ft³
Name: Drain Model: Saturated / Unsaturated K-Function: Drain Vol. WC. Function: VWC - Drain
Name: Clay (Undrained) Model: Saturated Only K-Sat: 3.3e-006 ft/sec Volumetric Water Content: 0 ft³/ft³



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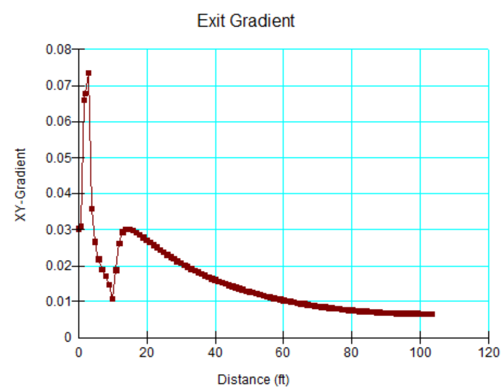
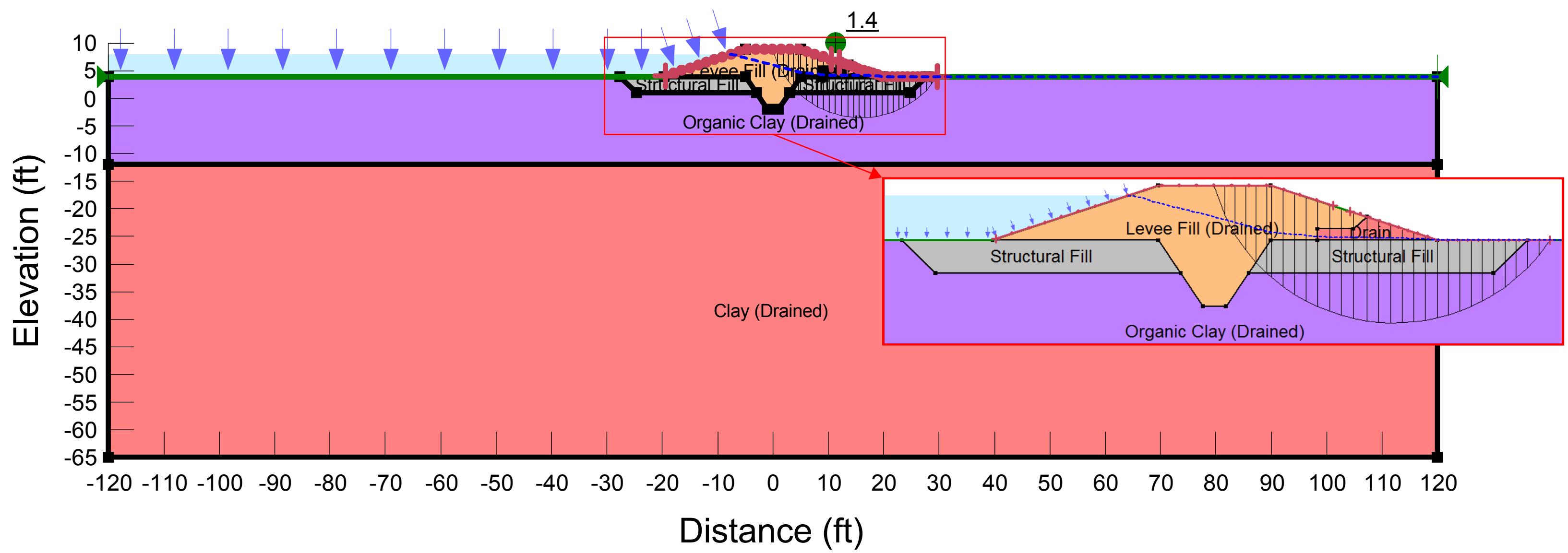


Figure B.27: Output from seepage analysis for the 4.9 ft levee in Soil Areas 4 to 7 at steady state with full flood stage by GeoStudio 2007 SEEP/W.

2. Stability Landside (Case II: Steady State)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °
Name: Organic Clay (Drained) Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 0 psf Phi: 20 °
Name: Clay (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 22 °

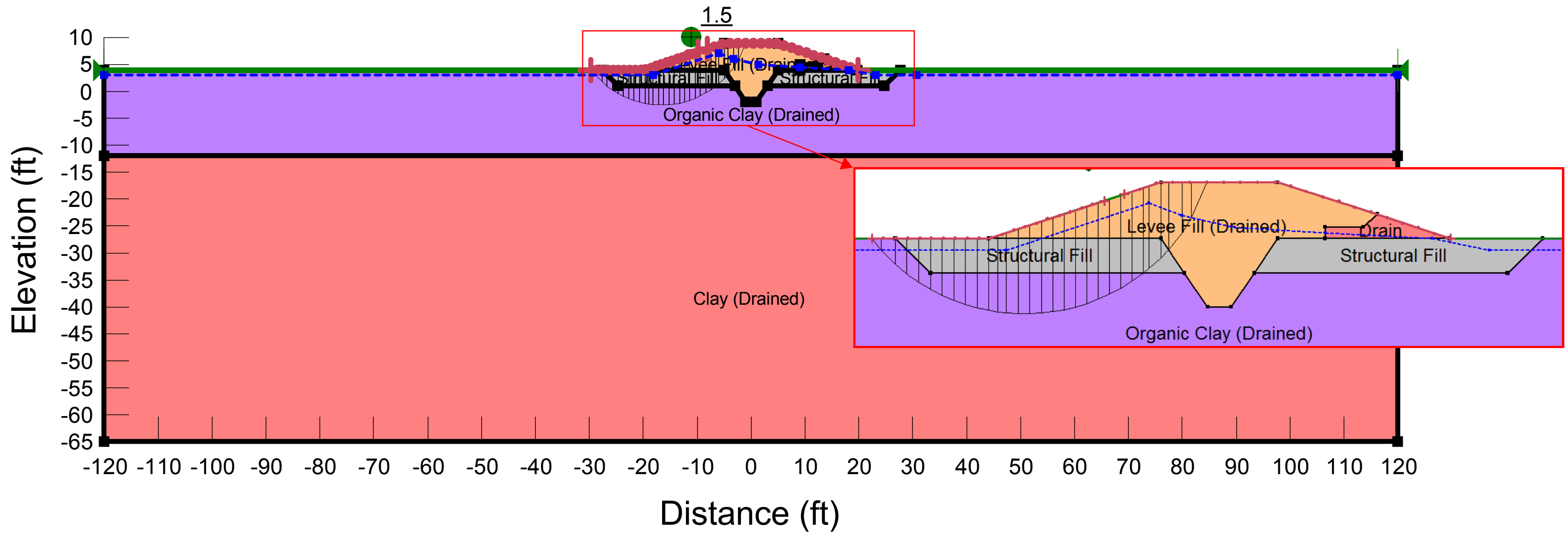


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 4 ft Levee Rev 1.gsz

Figure B.28: Output from slope stability analysis on the landside of the 4.9 ft levee in Soil Areas 4 to 7 at steady seepage with full flood stage by GeoStudio 2007 SLOPE/W.

3. Stability (Case III: Rapid Drawdown)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °
Name: Organic Clay (Drained) Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 0 psf Phi: 20 °
Name: Clay (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 22 °

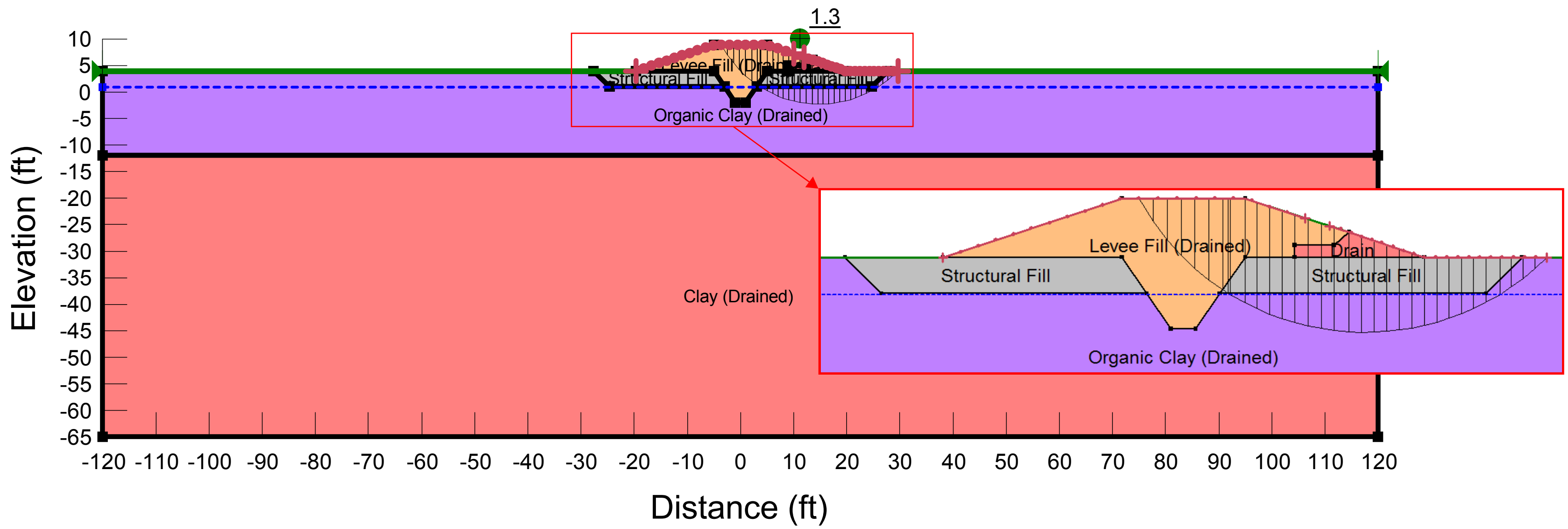


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 4 ft Levee Rev 1.gsz

Figure B.29: Output from slope stability analysis on the riverside of the 4.9 ft levee in Soil Areas 4 to 7 at rapid drawdown from full flood stage by GeoStudio 2007 SLOPE/W.

4. Stability Landside (Case IV: Seismic Loading)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °
Name: Organic Clay (Drained) Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 0 psf Phi: 20 °
Name: Clay (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 22 °

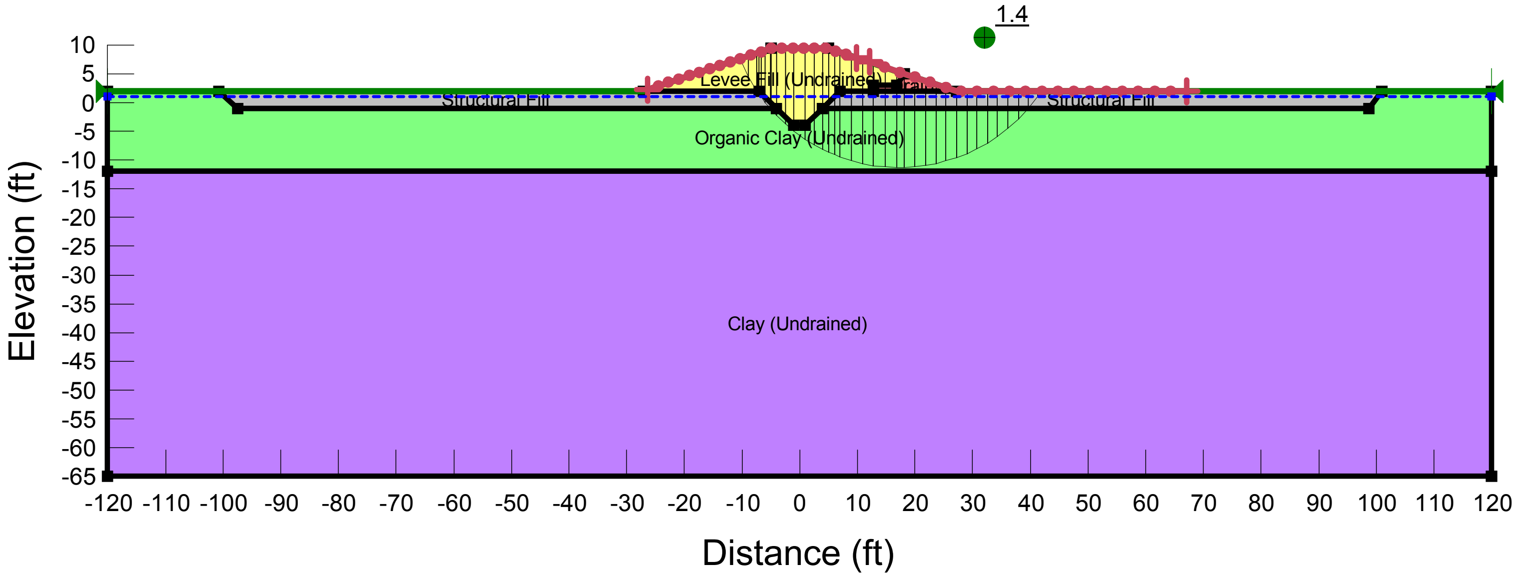


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 4 ft Levee Rev 1.gsz

Figure B.30: Output from slope stability analysis on the landside of the 4.9 ft levee in Soil Areas 4 to 7 at seismic loading by GeoStudio 2007 SLOPE/W.

1. Stability Landside (Case I: End of Construction)

Name: Levee Fill (Undrained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 200 psf Phi: 15 °
Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Organic Clay (Undrained) Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 200 psf Phi: 0 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay (Undrained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 300 psf Phi: 0 °

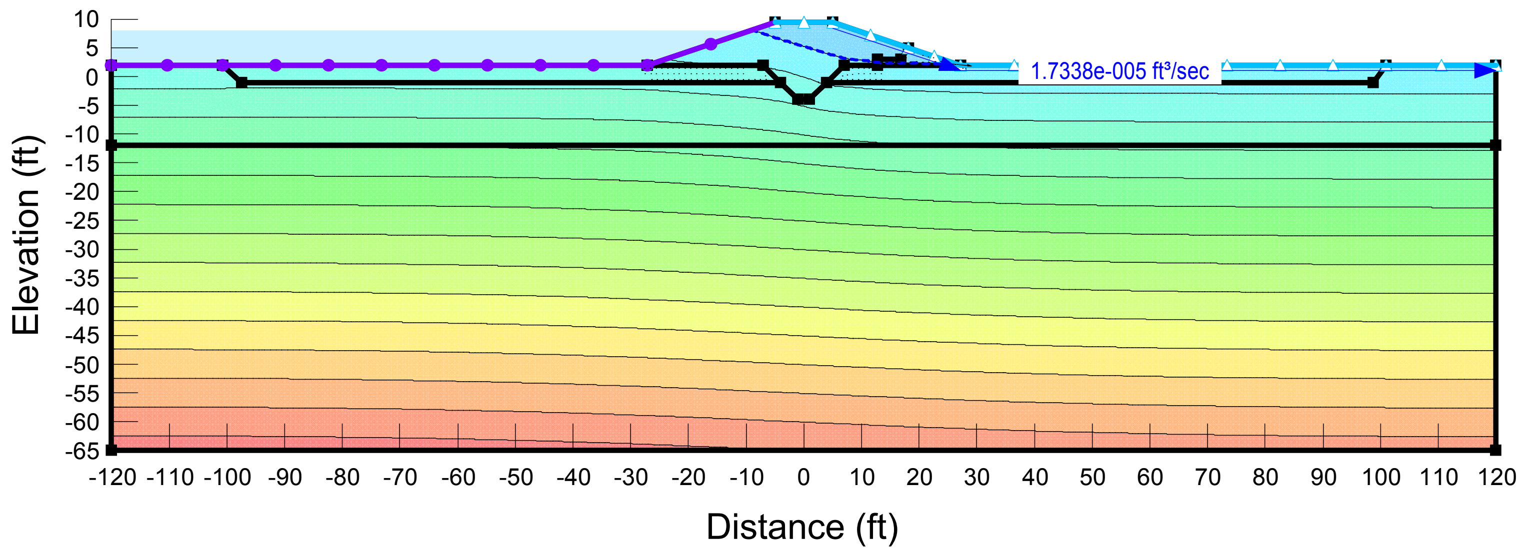


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 6 ft Levee Rev 1.gsz

Figure B.31: Output from slope stability analysis on the landside of the 7.2 ft levee in Soil Areas 4 to 7 at the end of construction by GeoStudio 2007 SLOPE/W.

2. Case II: Steady State Seepage

Name: Levee Fill (Undrained) Model: Saturated / Unsaturated K-Function: Levee Fill Vol. WC. Function: VWC - Levee Fill
Name: Structural Fill Model: Saturated Only K-Sat: 1.66e-005 ft/sec Volumetric Water Content: 0 ft³/ft³
Name: Organic Clay (Undrained) Model: Saturated Only K-Sat: 3.3e-006 ft/sec Volumetric Water Content: 0 ft³/ft³
Name: Drain Model: Saturated / Unsaturated K-Function: Drain Vol. WC. Function: VWC - Drain
Name: Clay (Undrained) Model: Saturated Only K-Sat: 3.3e-006 ft/sec Volumetric Water Content: 0 ft³/ft³



Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 6 ft Levee Rev 1.gsz

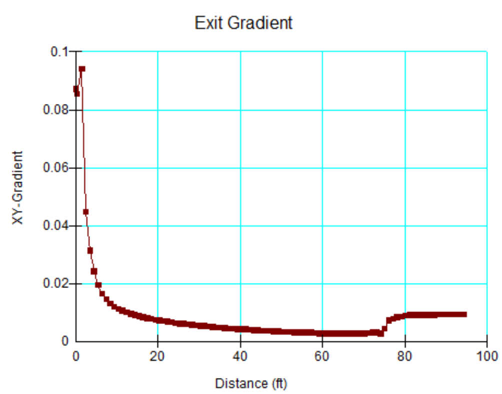
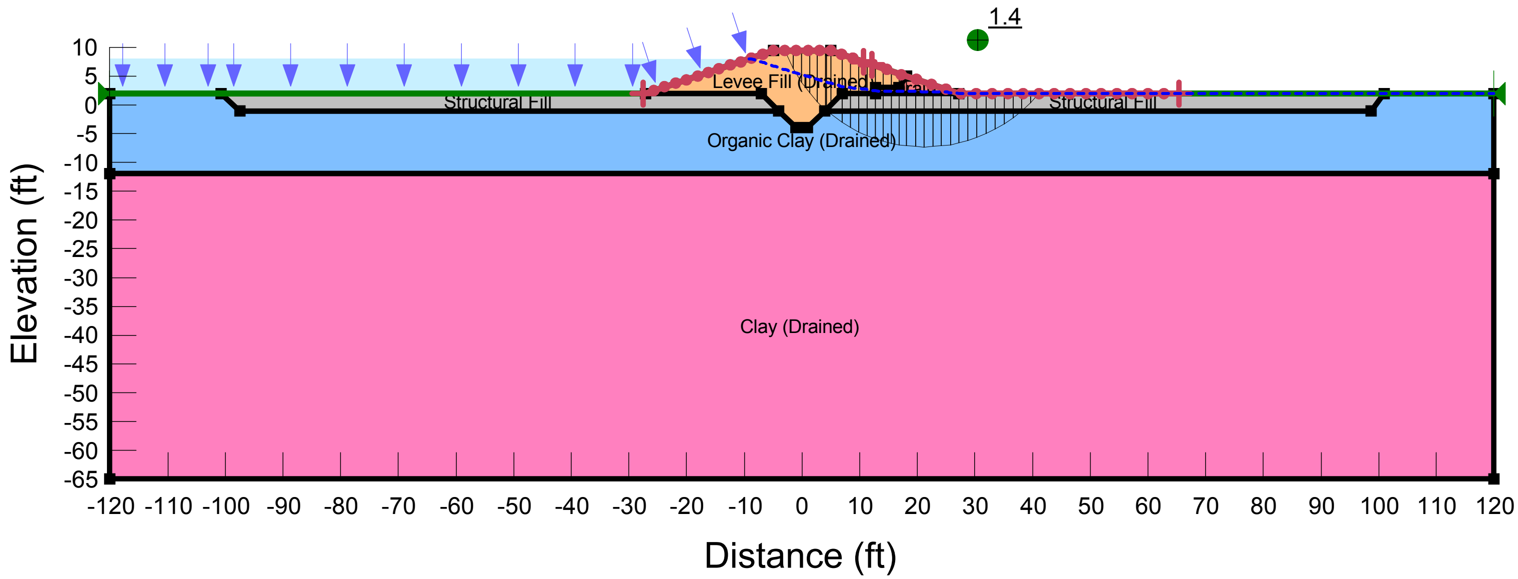


Figure B.32: Output from seepage analysis for the 7.2 ft levee in Soil Areas 4 to 7 at steady state with full flood stage by GeoStudio 2007 SEEP/W.

2. Stability Landside (Case II: Steady State)

Name: Structural Fill   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 32 °
Name: Organic Clay (Drained)   Model: Mohr-Coulomb   Unit Weight: 85 pcf   Cohesion: 0 psf   Phi: 20 °
Name: Drain   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 32 °
Name: Levee Fill (Drained)   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 50 psf   Phi: 25 °
Name: Clay (Drained)   Model: Mohr-Coulomb   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 22 °

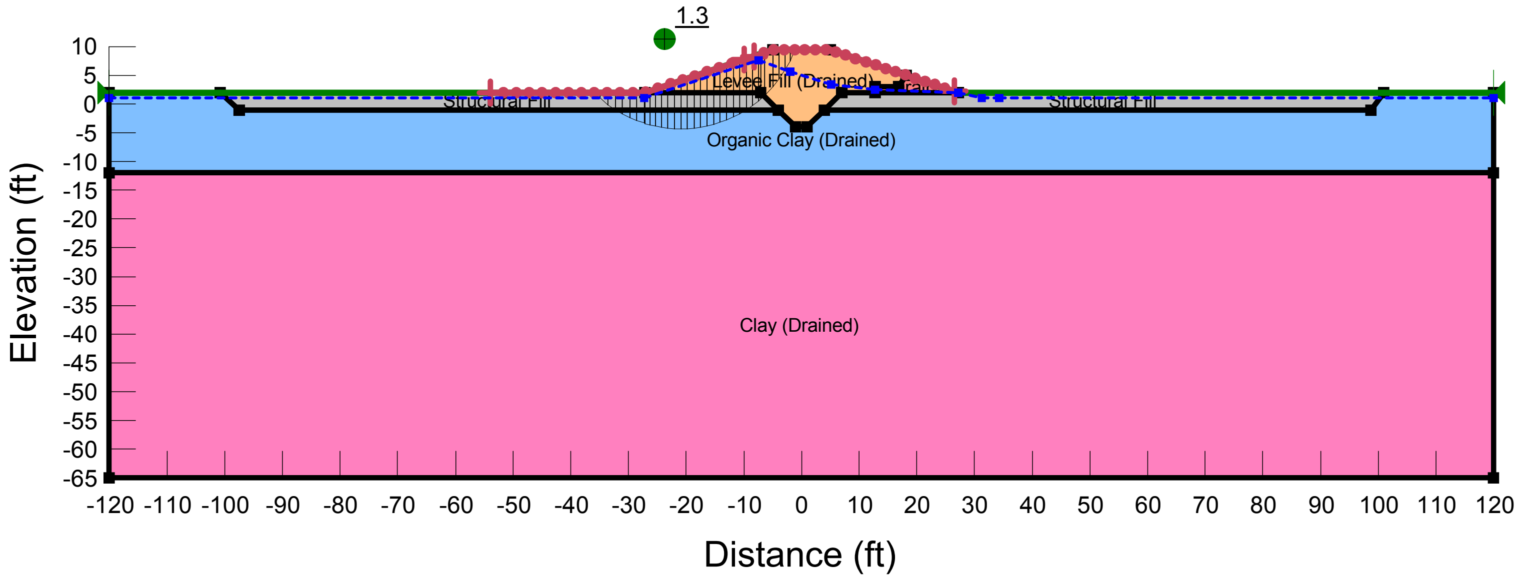


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 6 ft Levee Rev 1.gsz

Figure B.33: Output from slope stability analysis on the landside of the 7.2 ft levee in Soil Areas 4 to 7 at steady seepage with full flood stage by GeoStudio 2007 SLOPE/W.

3. Stability (Case III: Rapid Drawdown)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Organic Clay (Drained) Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 0 psf Phi: 20 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °
Name: Clay (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 22 °

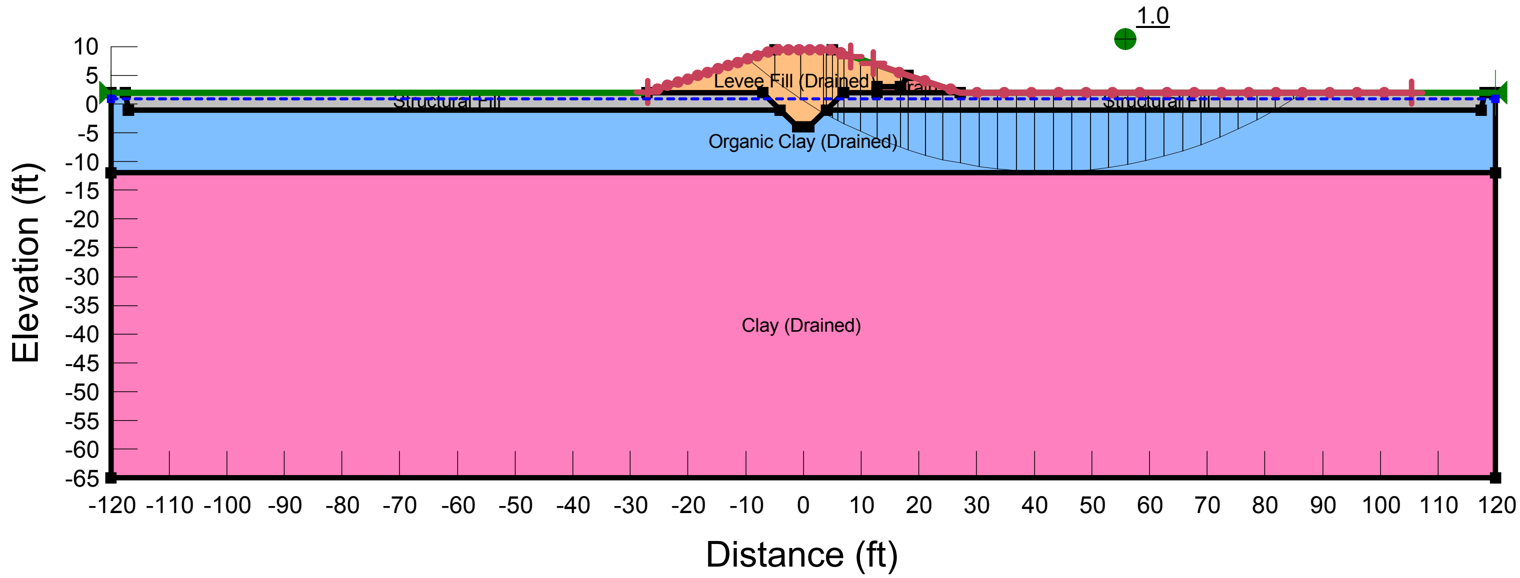


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 6 ft Levee Rev 1.gsz

Figure B.34: Output from slope stability analysis on the riverside of the 7.2 ft levee in Soil Areas 4 to 7 at rapid drawdown from full flood stage by GeoStudio 2007 SLOPE/W.

4. Stability Landside (Case IV: Seismic Loading)

Name: Structural Fill   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 32 °
Name: Organic Clay (Drained)   Model: Mohr-Coulomb   Unit Weight: 85 pcf   Cohesion: 0 psf   Phi: 20 °
Name: Drain   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 32 °
Name: Levee Fill (Drained)   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 50 psf   Phi: 25 °
Name: Clay (Drained)   Model: Mohr-Coulomb   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 22 °

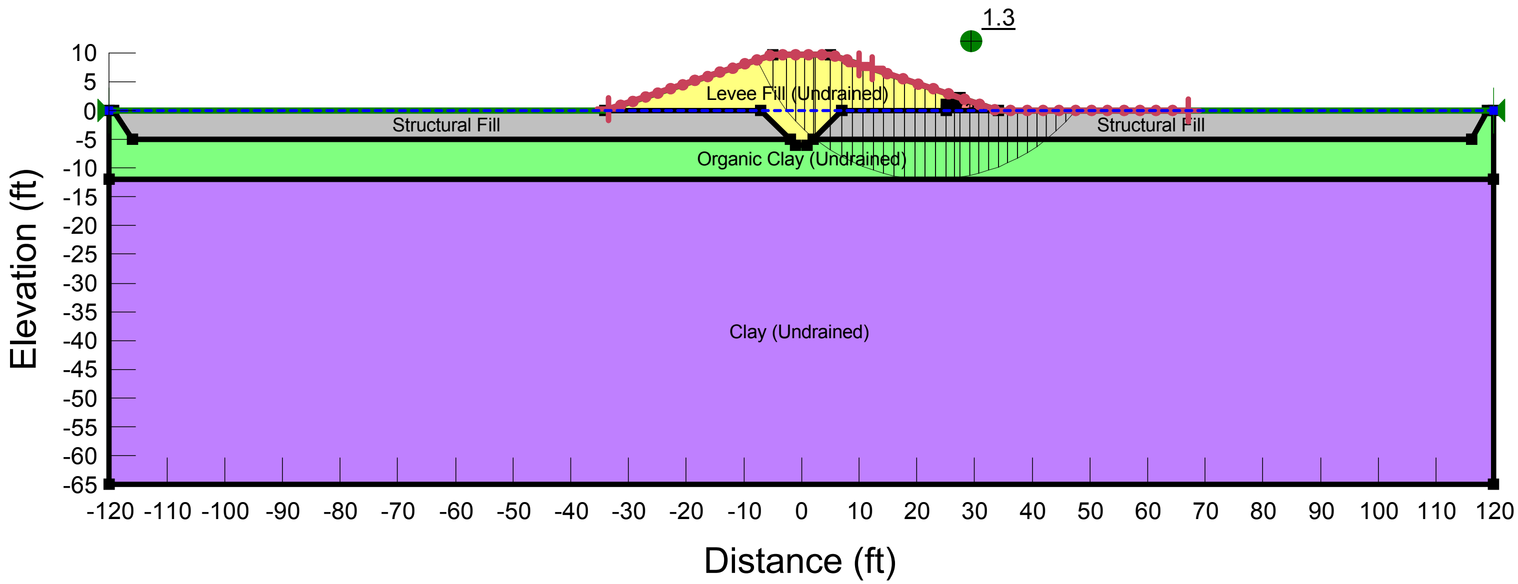


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 6 ft Levee Rev 1.gsz

Figure B.35: Output from slope stability analysis on the landside of the 7.2 ft levee in Soil Areas 4 to 7 at seismic loading by GeoStudio 2007 SLOPE/W.

1. Stability Landside (Case I: End of Construction)

Name: Levee Fill (Undrained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 200 psf Phi: 15 °
Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Organic Clay (Undrained) Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 200 psf Phi: 0 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Clay (Undrained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 300 psf Phi: 0 °

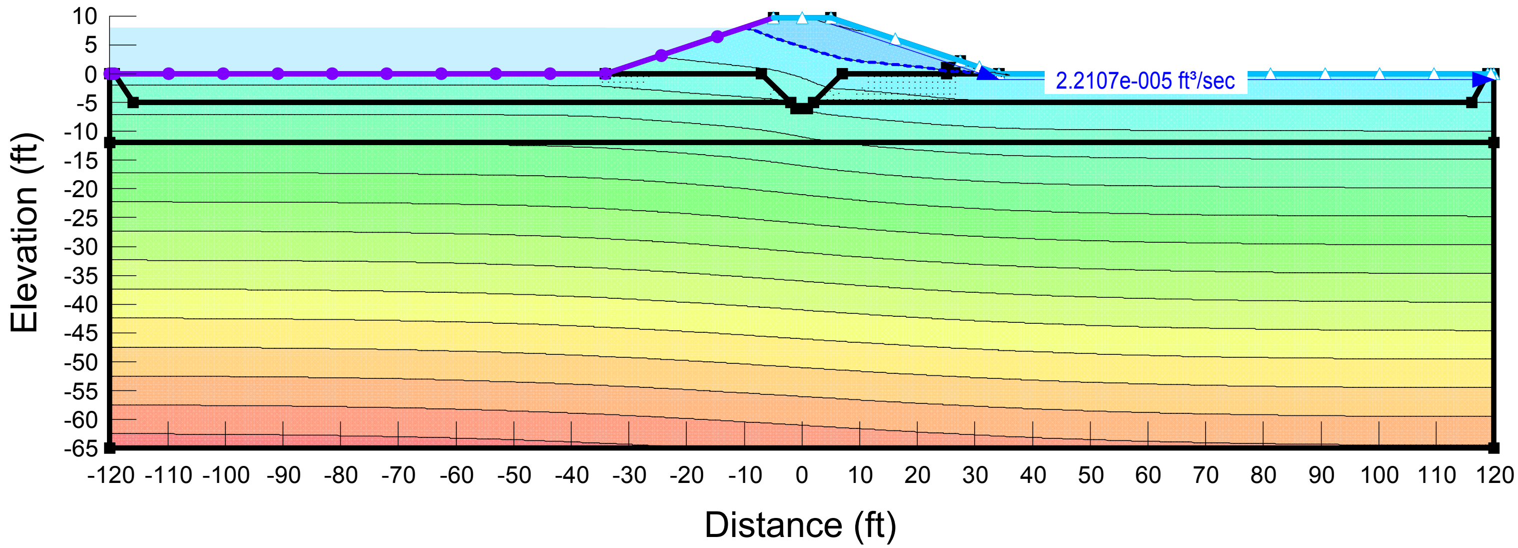


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 8 ft Levee Rev 1.gsz

Figure B.36: Output from slope stability analysis on the landside of the 7.2 ft levee in Soil Areas 4 to 7 at the end of construction by GeoStudio 2007 SLOPE/W.

2. Case II: Steady State Seepage

Name: Levee Fill (Undrained) Model: Saturated / Unsaturated K-Function: Levee Fill Vol. WC. Function: VWC - Levee Fill
Name: Structural Fill Model: Saturated Only K-Sat: 1.66e-005 ft/sec Volumetric Water Content: 0 ft³/ft³
Name: Organic Clay (Undrained) Model: Saturated Only K-Sat: 3.3e-006 ft/sec Volumetric Water Content: 0 ft³/ft³
Name: Drain Model: Saturated / Unsaturated K-Function: Drain Vol. WC. Function: VWC - Drain
Name: Clay (Undrained) Model: Saturated Only K-Sat: 3.3e-006 ft/sec Volumetric Water Content: 0 ft³/ft³



Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 8 ft Levee Rev 1.gsz

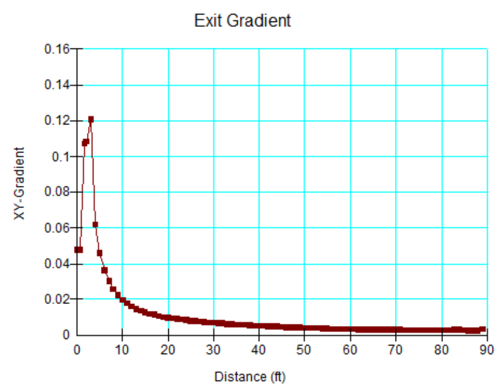
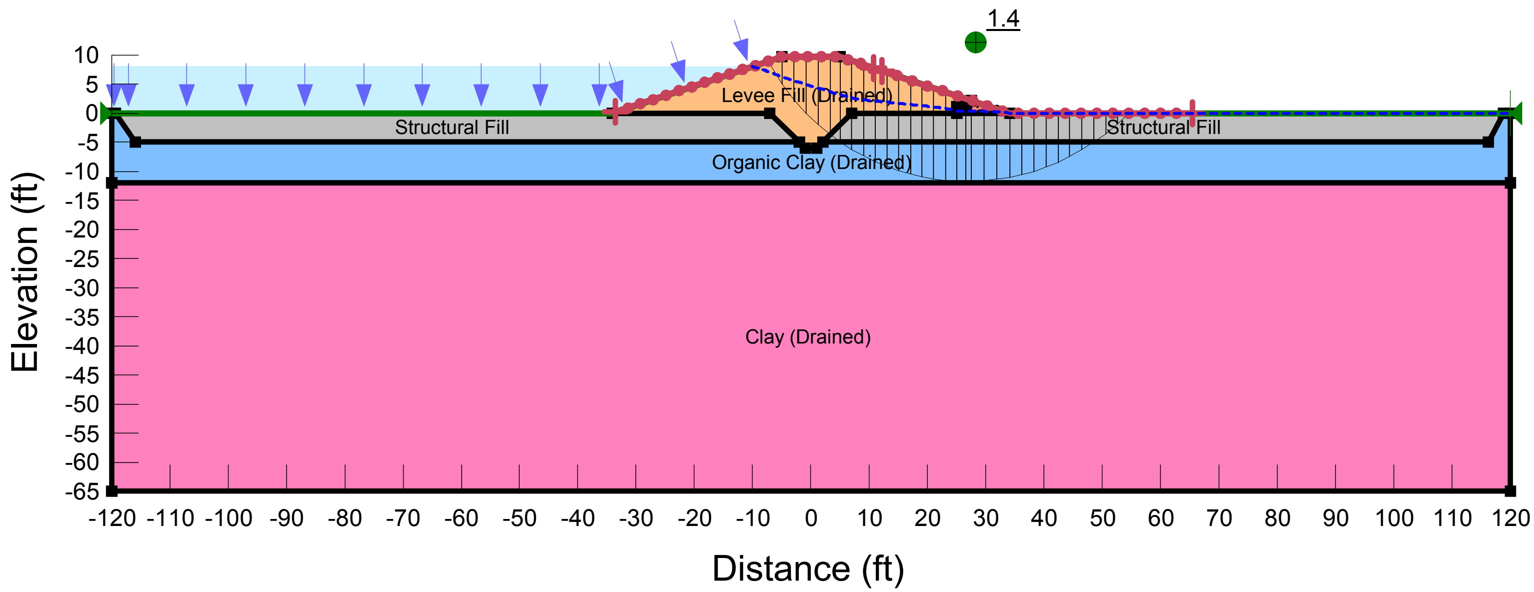


Figure B.37: Output from seepage analysis for the 7.2 ft levee in Soil Areas 4 to 7 at steady state with full flood stage by GeoStudio 2007 SEEP/W.

2. Stability Landside (Case II: Steady State)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Organic Clay (Drained) Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 0 psf Phi: 20 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °
Name: Clay (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 22 °

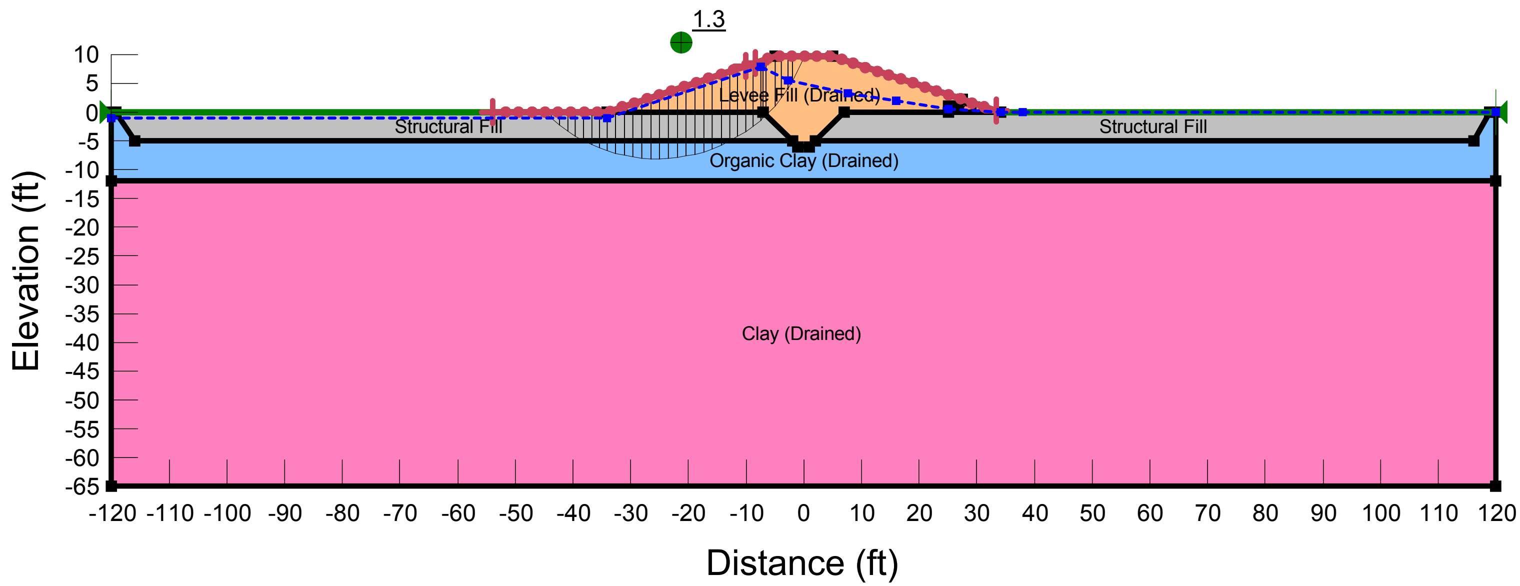


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 8 ft Levee Rev 1.gsz

Figure B.38: Output from slope stability analysis on the landside of the 7.2 ft levee in Soil Areas 4 to 7 at steady seepage with full flood stage by GeoStudio 2007 SLOPE/W.

3. Stability (Case III: Rapid Drawdown)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Organic Clay (Drained) Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 0 psf Phi: 20 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °
Name: Clay (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 22 °

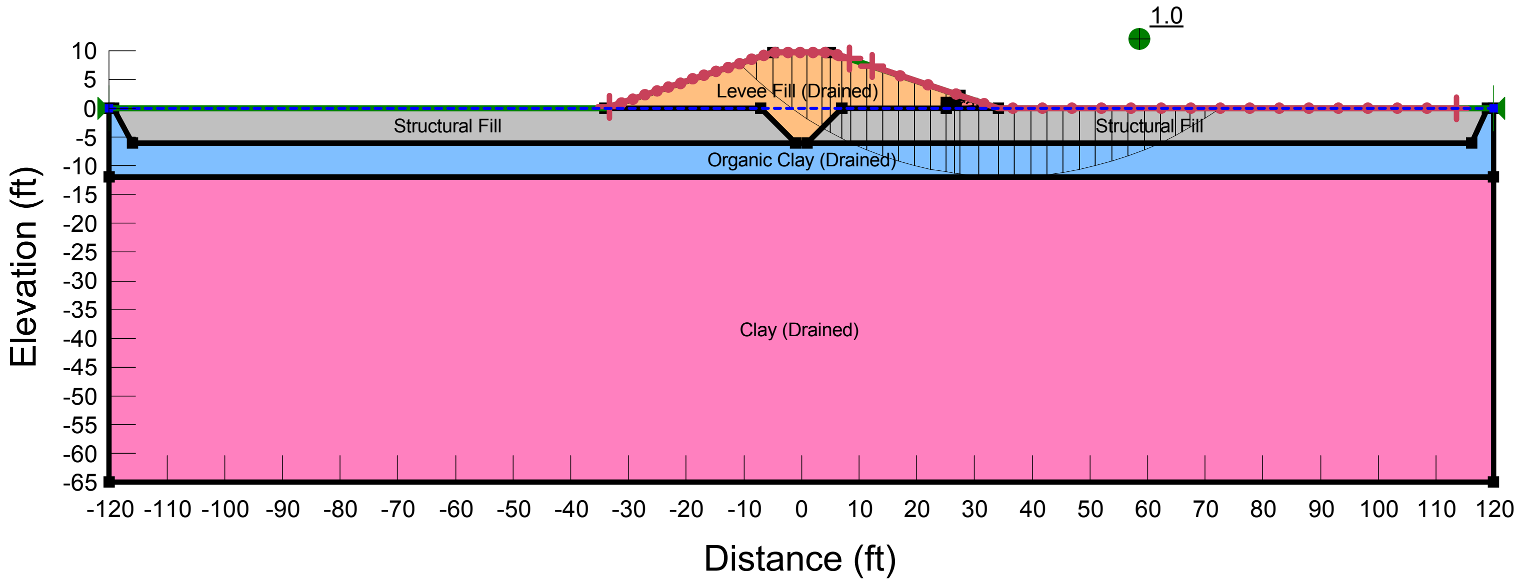


Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 8 ft Levee Rev 1.gsz

Figure B.39: Output from slope stability analysis on the riverside of the 7.2 ft levee in Soil Areas 4 to 7 at rapid drawdown from full flood stage by GeoStudio 2007 SLOPE/W.

4. Stability Landside (Case IV: Seismic Loading)

Name: Structural Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Organic Clay (Drained) Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 0 psf Phi: 20 °
Name: Drain Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Levee Fill (Drained) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 50 psf Phi: 25 °
Name: Clay (Drained) Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 22 °



Directory: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\File Name: Zone 4 to 7 - 8 ft Levee Rev 1.gsz

Figure B.40: Output from slope stability analysis on the landside of the 7.2 ft levee in Soil Areas 4 to 7 at seismic loading by GeoStudio 2007 SLOPE/W.

Attachment C1-C

Details of Consolidation Settlement Analysis for Levees

PRIMARY CONSOLIDATION SETTLEMENT FOR 2.2 FT LEVEE IN SOIL AREAS 1 TO 3

New Medowlands Flood Protection

Bergen County, New Jersey

AECOM

Calculated by: AH **Date:** 11/16/2016 **Checked by:** LC

Soil Parameters:

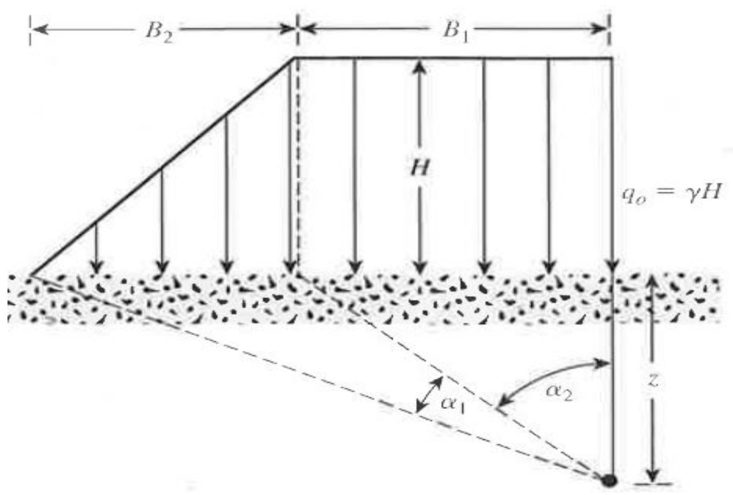
Layer No.	Soil Description	Total Unit Weight (pcf)	Layer Thickness (ft)	Bottom Depth of Layer (ft)	Initial Void Ratio, e_0	Compression Index, C_c
1	Structural Fill	120	2	2		
2	Clay & Silt	110	74	76	1.03	0.17

Depth to Groundwater Table from Ground Surface = 5 ft

Elevations:

Top of Levee = + 8.2 ft
Bottom of Levee/Ground Surface = + 6 ft
Bottom of Clay & Silt = - 70 ft
Groundwater Table = + 1 ft

Increase in Vertical Stress in Soil due to Levee:



$$\Delta\sigma_z = \frac{q_o}{\pi}\left[\left(\frac{B_1 + B_2}{B_2}\right)(\alpha_1 + \alpha_2) - \frac{B_1}{B_2}(\alpha_2)\right]$$

$$\alpha_1\,(\text{radians}) = \tan^{-1}\left(\frac{B_1 + B_2}{z}\right) - \tan^{-1}\left(\frac{B_1}{z}\right)$$

$$\alpha_2 = \tan^{-1}\left(\frac{B_1}{z}\right)$$

H = 2.2 ft
B_1 = 5 ft
B_2 = 6.6 ft

γ = 120 pcf
q_0 = 264 psf

Settlement Calculation:

Sub-Layer No.	Thickness (ft)	Mid Depth of Sub-Layer (ft)	Initial Overburden Pressure, σ'_0 (psf)	α_1 (rad.)	α_2 (rad.)	Increase in Overburden Pressure, $\Delta\sigma'_z$ (psf)	$\sigma'_0 + \Delta\sigma'_z$ (psf)	C_c	Settlement (ft)
1	2	3	330	0.3	1.0	129	459	0.17	0.024
2	2	5	550	0.4	0.8	122	672	0.17	0.015
3	2	7	645	0.4	0.6	112	758	0.17	0.012
4	2	9	740	0.4	0.5	102	843	0.17	0.009
5	2	11	836	0.4	0.4	93	928	0.17	0.008
6	2	13	931	0.4	0.4	84	1015	0.17	0.006
7	2	15	1026	0.3	0.3	77	1103	0.17	0.005
8	2	17	1121	0.3	0.3	70	1191	0.17	0.004
9	2	19	1216	0.3	0.3	65	1281	0.17	0.004
10	2	21	1312	0.3	0.2	60	1371	0.17	0.003
11	2	23	1407	0.3	0.2	55	1462	0.17	0.003
12	2	25	1502	0.2	0.2	52	1554	0.17	0.002
13	2	27	1597	0.2	0.2	48	1645	0.17	0.002
14	2	29	1692	0.2	0.2	45	1738	0.17	0.002
15	2	31	1788	0.2	0.2	43	1830	0.17	0.002
16	2	33	1883	0.2	0.2	40	1923	0.17	0.002
17	2	35	1978	0.2	0.1	38	2016	0.17	0.001
18	2	37	2073	0.2	0.1	36	2110	0.17	0.001
19	2	39	2168	0.2	0.1	35	2203	0.17	0.001
20	2	41	2264	0.2	0.1	33	2297	0.17	0.001
21	2	43	2359	0.1	0.1	32	2390	0.17	0.001
22	2	45	2454	0.1	0.1	30	2484	0.17	0.001
23	2	47	2549	0.1	0.1	29	2578	0.17	0.001
24	2	49	2644	0.1	0.1	28	2672	0.17	0.001
25	2	51	2740	0.1	0.1	27	2766	0.17	0.001
26	2	53	2835	0.1	0.1	26	2861	0.17	0.001
27	2	55	2930	0.1	0.1	25	2955	0.17	0.001
28	2	57	3025	0.1	0.1	24	3049	0.17	0.001
29	2	59	3120	0.1	0.1	23	3144	0.17	0.001
30	2	61	3216	0.1	0.1	23	3238	0.17	0.001
31	2	63	3311	0.1	0.1	22	3333	0.17	0.000
32	2	65	3406	0.1	0.1	21	3427	0.17	0.000
33	2	67	3501	0.1	0.1	21	3522	0.17	0.000
34	2	69	3596	0.1	0.1	20	3616	0.17	0.000
35	2	71	3692	0.1	0.1	19	3711	0.17	0.000
36	2	73	3787	0.1	0.1	19	3806	0.17	0.000
37	2	75	3882	0.1	0.1	18	3900	0.17	0.000

Total Primary Consolidation Settlement = 1 in

Reference:

Das, B. M. (2006). Principles of Geotechnical Engineering, Nelson, Ontario, Canada, 686 p.

PRIMARY CONSOLIDATION SETTLEMENT FOR 4.4 FT LEVEE IN SOIL AREAS 1 TO 3

New Medowlands Flood Protection

Bergen County, New Jersey

AECOM

Calculated by: AH **Date:** 11/16/2016 **Checked by:** LC

Soil Parameters:

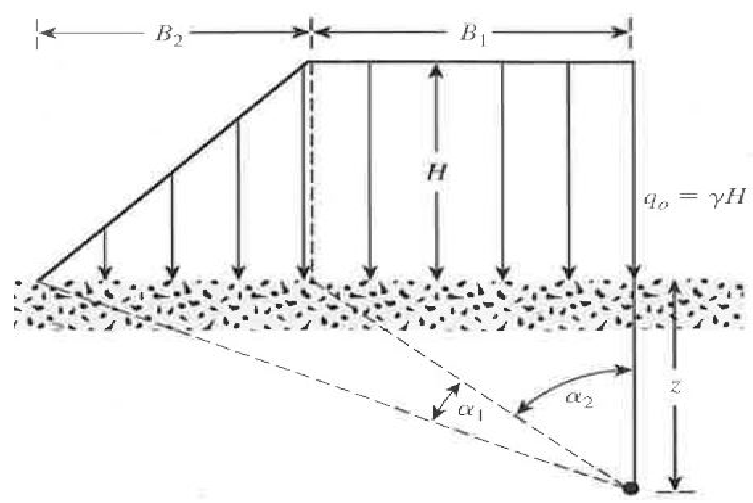
Layer No.	Soil Description	Total Unit Weight	Layer Thickness	Bottom Depth of Layer	Initial Void Ratio, e_0	Compression Index, C_c
		(pcf)	(ft)	(ft)		
1	Structural Fill	120	2	2		
2	Clay & Silt	110	72	74	1.03	0.17

Depth to Groundwater Table from Ground Surface = 3 ft

Elevations:

Top of Levee =	+ 8.4 ft
Bottom of Levee/Ground Surface =	+ 4 ft
Bottom of Clay & Silt =	- 70 ft
Groundwater Table =	+ 1 ft

Increase in Vertical Stress in Soil due to Levee:



$$\Delta\sigma_z = \frac{q_o}{\pi}\left[\left(\frac{B_1 + B_2}{B_2}\right)(\alpha_1 + \alpha_2) - \frac{B_1}{B_2}(\alpha_2)\right]$$

$$\alpha_1\,(\text{radians}) = \tan^{-1}\left(\frac{B_1 + B_2}{z}\right) - \tan^{-1}\left(\frac{B_1}{z}\right)$$

$$\alpha_2 = \tan^{-1}\left(\frac{B_1}{z}\right)$$

H = 4.4 ft

B_1 = 5 ft

B_2 = 13.2 ft

γ = 120 pcf

q_0 = 528 psf

Settlement Calculation:

Sub-Layer No.	Thickness	Mid Depth of Sub-Layer	Initial Overburden Pressure, σ'_0	α_1	α_2	Increase in Overburden Pressure, $\Delta\sigma'_z$	$\sigma'_0 + \Delta\sigma'_z$	C_c	Settlement
	(ft)	(ft)	(psf)	(rad.)	(rad.)	(psf)	(psf)		(ft)
1	2	3	330	0.4	1.0	261	591	0.17	0.042
2	2	5	425	0.5	0.8	252	677	0.17	0.034
3	2	7	520	0.6	0.6	239	760	0.17	0.028
4	2	9	616	0.6	0.5	225	841	0.17	0.023
5	2	11	711	0.6	0.4	211	922	0.17	0.019
6	2	13	806	0.6	0.4	197	1003	0.17	0.016
7	2	15	901	0.6	0.3	184	1085	0.17	0.013
8	2	17	996	0.5	0.3	172	1168	0.17	0.012
9	2	19	1092	0.5	0.3	161	1252	0.17	0.010
10	2	21	1187	0.5	0.2	151	1337	0.17	0.009
11	2	23	1282	0.5	0.2	141	1423	0.17	0.008
12	2	25	1377	0.4	0.2	133	1510	0.17	0.007
13	2	27	1472	0.4	0.2	126	1598	0.17	0.006
14	2	29	1568	0.4	0.2	119	1687	0.17	0.005
15	2	31	1663	0.4	0.2	113	1776	0.17	0.005
16	2	33	1758	0.4	0.2	107	1865	0.17	0.004
17	2	35	1853	0.3	0.1	102	1955	0.17	0.004
18	2	37	1948	0.3	0.1	97	2046	0.17	0.004
19	2	39	2044	0.3	0.1	93	2137	0.17	0.003
20	2	41	2139	0.3	0.1	89	2228	0.17	0.003
21	2	43	2234	0.3	0.1	85	2319	0.17	0.003
22	2	45	2329	0.3	0.1	82	2411	0.17	0.003
23	2	47	2424	0.3	0.1	79	2503	0.17	0.002
24	2	49	2520	0.3	0.1	76	2596	0.17	0.002
25	2	51	2615	0.2	0.1	73	2688	0.17	0.002
26	2	53	2710	0.2	0.1	71	2781	0.17	0.002
27	2	55	2805	0.2	0.1	68	2873	0.17	0.002
28	2	57	2900	0.2	0.1	66	2966	0.17	0.002
29	2	59	2996	0.2	0.1	64	3060	0.17	0.002
30	2	61	3091	0.2	0.1	62	3153	0.17	0.001
31	2	63	3186	0.2	0.1	60	3246	0.17	0.001
32	2	65	3281	0.2	0.1	58	3340	0.17	0.001
33	2	67	3376	0.2	0.1	57	3433	0.17	0.001
34	2	69	3472	0.2	0.1	55	3527	0.17	0.001
35	2	71	3567	0.2	0.1	54	3620	0.17	0.001
36	2	73	3662	0.2	0.1	52	3714	0.17	0.001

Total Primary Consolidation Settlement = 3 in

Reference:

Das, B. M. (2006). Principles of Geotechnical Engineering, Nelson, Ontario, Canada, 686 p.

PRIMARY CONSOLIDATION SETTLEMENT FOR 6.6 FT LEVEE IN SOIL AREAS 1 TO 3

New Medowlands Flood Protection

Bergen County, New Jersey

AECOM

Calculated by: AH **Date:** 11/16/2016 **Checked by:** LC

Soil Parameters:

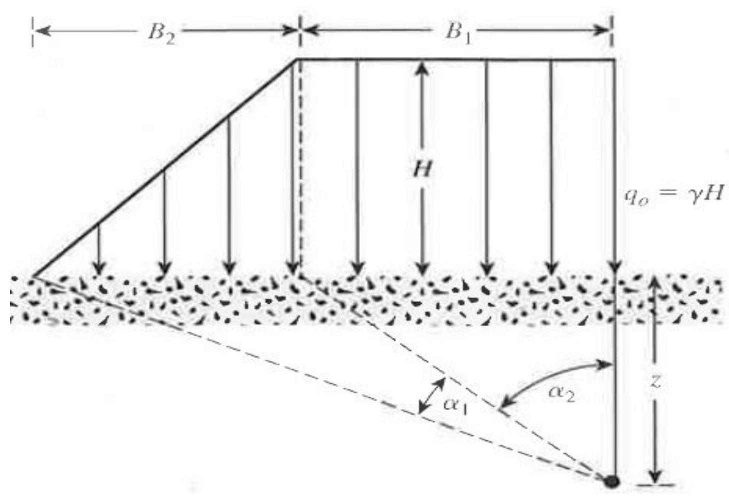
Layer No.	Soil Description	Total Unit Weight	Layer Thickness	Bottom Depth of Layer	Initial Void Ratio, e_0	Compression Index, C_c
		(pcf)	(ft)	(ft)		
1	Structural Fill	120	2	2		
2	Clay & Silt	110	70	72	1.03	0.17

Depth to Groundwater Table from Ground Surface = 1 ft

Elevations:

Top of Levee = + 8.6 ft
Bottom of Levee/Ground Surface = + 2 ft
Bottom of Clay & Silt = - 70 ft
Groundwater Table = + 1 ft

Increase in Vertical Stress in Soil due to Levee:



$$\Delta\sigma_z = \frac{q_o}{\pi}\left[\left(\frac{B_1 + B_2}{B_2}\right)(\alpha_1 + \alpha_2) - \frac{B_1}{B_2}(\alpha_2)\right]$$

$$\alpha_1\,(\text{radians}) = \tan^{-1}\left(\frac{B_1 + B_2}{z}\right) - \tan^{-1}\left(\frac{B_1}{z}\right)$$

$$\alpha_2 = \tan^{-1}\left(\frac{B_1}{z}\right)$$

H = 6.6 ft
B_1 = 5 ft
B_2 = 19.8 ft

γ = 120 pcf
q_0 = 792 psf

Settlement Calculation:

Sub-Layer No.	Thickness	Mid Depth of Sub-Layer	Initial Overburden Pressure, σ'_0	α_1	α_2	Increase in Overburden Pressure, $\Delta\sigma'_z$	$\sigma'_0 + \Delta\sigma'_z$	C_c	Settlement
	(ft)	(ft)	(psf)	(rad.)	(rad.)	(psf)	(psf)		(ft)
1	2	3	205	0.4	1.0	392	598	0.17	0.078
2	2	5	300	0.6	0.8	383	684	0.17	0.060
3	2	7	396	0.7	0.6	370	765	0.17	0.048
4	2	9	491	0.7	0.5	354	845	0.17	0.039
5	2	11	586	0.7	0.4	337	923	0.17	0.033
6	2	13	681	0.7	0.4	320	1001	0.17	0.028
7	2	15	776	0.7	0.3	304	1080	0.17	0.024
8	2	17	872	0.7	0.3	288	1160	0.17	0.021
9	2	19	967	0.7	0.3	273	1240	0.17	0.018
10	2	21	1062	0.6	0.2	259	1321	0.17	0.016
11	2	23	1157	0.6	0.2	246	1403	0.17	0.014
12	2	25	1252	0.6	0.2	234	1487	0.17	0.012
13	2	27	1348	0.6	0.2	223	1571	0.17	0.011
14	2	29	1443	0.5	0.2	213	1655	0.17	0.010
15	2	31	1538	0.5	0.2	203	1741	0.17	0.009
16	2	33	1633	0.5	0.2	194	1827	0.17	0.008
17	2	35	1728	0.5	0.1	186	1914	0.17	0.007
18	2	37	1824	0.5	0.1	178	2002	0.17	0.007
19	2	39	1919	0.4	0.1	171	2090	0.17	0.006
20	2	41	2014	0.4	0.1	164	2178	0.17	0.006
21	2	43	2109	0.4	0.1	158	2267	0.17	0.005
22	2	45	2204	0.4	0.1	152	2356	0.17	0.005
23	2	47	2300	0.4	0.1	147	2446	0.17	0.004
24	2	49	2395	0.4	0.1	141	2536	0.17	0.004
25	2	51	2490	0.4	0.1	137	2627	0.17	0.004
26	2	53	2585	0.3	0.1	132	2717	0.17	0.004
27	2	55	2680	0.3	0.1	128	2808	0.17	0.003
28	2	57	2776	0.3	0.1	124	2900	0.17	0.003
29	2	59	2871	0.3	0.1	120	2991	0.17	0.003
30	2	61	2966	0.3	0.1	117	3083	0.17	0.003
31	2	63	3061	0.3	0.1	113	3175	0.17	0.003
32	2	65	3156	0.3	0.1	110	3267	0.17	0.002
33	2	67	3252	0.3	0.1	107	3359	0.17	0.002
34	2	69	3347	0.3	0.1	104	3451	0.17	0.002
35	2	71	3442	0.3	0.1	102	3544	0.17	0.002

Total Primary Consolidation Settlement = 6 in

Reference:

Das, B. M. (2006). Principles of Geotechnical Engineering, Nelson, Ontario, Canada, 686 p.

PRIMARY CONSOLIDATION SETTLEMENT FOR 8.8 FT LEVEE IN SOIL AREAS 1 TO 3
New Medowlands Flood Protection
Bergen County, New Jersey

AECOM

Calculated by: AH **Date:** 11/16/2016 **Checked by:** LC

Soil Parameters:

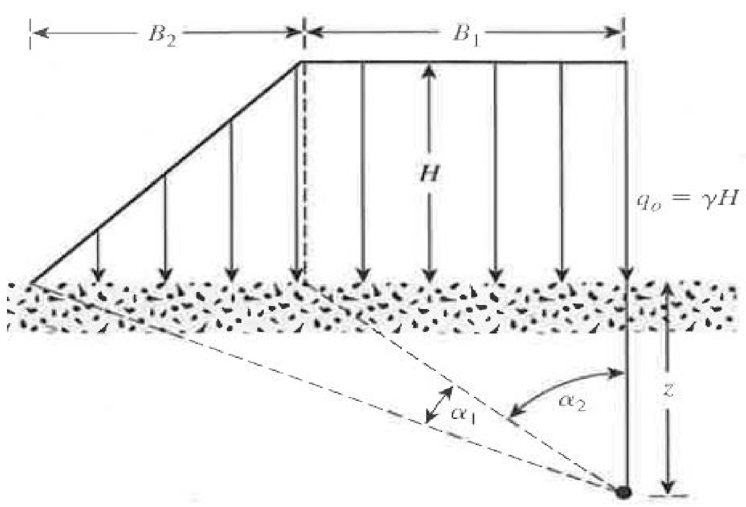
Layer No.	Soil Description	Total Unit Weight (pcf)	Layer Thickness (ft)	Bottom Depth of Layer (ft)	Initial Void Ratio, e_0	Compression Index, C_c
1	Structural Fill	120	4	4		
2	Clay & Silt	110	66	70	1.03	0.17

Depth to Groundwater Table from Ground Surface = 0 ft

Elevations:

Top of Levee =	+ 8.8 ft
Bottom of Levee/Ground Surface =	+ 0 ft
Bottom of Clay & Silt =	- 70 ft
Groundwater Table =	+ 1 ft

Increase in Vertical Stress in Soil due to Levee:



$$\Delta\sigma_z = \frac{q_o}{\pi}\left[\left(\frac{B_1 + B_2}{B_2}\right)(\alpha_1 + \alpha_2) - \frac{B_1}{B_2}(\alpha_2)\right]$$

$$\alpha_1 \text{(radians)} = \tan^{-1}\left(\frac{B_1 + B_2}{z}\right) - \tan^{-1}\left(\frac{B_1}{z}\right)$$

$$\alpha_2 = \tan^{-1}\left(\frac{B_1}{z}\right)$$

H = 8.8 ft
B_1 = 5 ft
B_2 = 26.4 ft

γ = 120 pcf
q_0 = 1056 psf

Settlement Calculation:

Sub-Layer No.	Thickness (ft)	Mid Depth of Sub-Layer (ft)	Initial Overburden Pressure, σ'_0 (psf)	α_1 (rad.)	α_2 (rad.)	Increase in Overburden Pressure, $\Delta\sigma'_z$ (psf)	$\sigma'_0 + \Delta\sigma'_z$ (psf)	C_c	Settlement (ft)
1	2	5	238	0.6	0.8	515	753	0.17	0.084
2	2	7	333	0.7	0.6	501	834	0.17	0.067
3	2	9	428	0.8	0.5	484	913	0.17	0.055
4	2	11	524	0.8	0.4	466	990	0.17	0.046
5	2	13	619	0.8	0.4	448	1066	0.17	0.040
6	2	15	714	0.8	0.3	429	1143	0.17	0.034
7	2	17	809	0.8	0.3	411	1221	0.17	0.030
8	2	19	904	0.8	0.3	394	1298	0.17	0.026
9	2	21	1000	0.7	0.2	377	1377	0.17	0.023
10	2	23	1095	0.7	0.2	362	1456	0.17	0.021
11	2	25	1190	0.7	0.2	347	1537	0.17	0.019
12	2	27	1285	0.7	0.2	332	1618	0.17	0.017
13	2	29	1380	0.7	0.2	319	1699	0.17	0.015
14	2	31	1476	0.6	0.2	306	1782	0.17	0.014
15	2	33	1571	0.6	0.2	294	1865	0.17	0.012
16	2	35	1666	0.6	0.1	283	1949	0.17	0.011
17	2	37	1761	0.6	0.1	273	2034	0.17	0.010
18	2	39	1856	0.6	0.1	263	2119	0.17	0.010
19	2	41	1952	0.5	0.1	254	2205	0.17	0.009
20	2	43	2047	0.5	0.1	245	2292	0.17	0.008
21	2	45	2142	0.5	0.1	237	2379	0.17	0.008
22	2	47	2237	0.5	0.1	229	2466	0.17	0.007
23	2	49	2332	0.5	0.1	221	2554	0.17	0.007
24	2	51	2428	0.5	0.1	214	2642	0.17	0.006
25	2	53	2523	0.4	0.1	208	2731	0.17	0.006
26	2	55	2618	0.4	0.1	202	2820	0.17	0.005
27	2	57	2713	0.4	0.1	196	2909	0.17	0.005
28	2	59	2808	0.4	0.1	190	2999	0.17	0.005
29	2	61	2904	0.4	0.1	185	3088	0.17	0.004
30	2	63	2999	0.4	0.1	180	3179	0.17	0.004
31	2	65	3094	0.4	0.1	175	3269	0.17	0.004
32	2	67	3189	0.4	0.1	170	3360	0.17	0.004
33	2	69	3284	0.4	0.1	166	3451	0.17	0.004

Total Primary Consolidation Settlement = 7 in

Reference:

Das, B. M. (2006). Principles of Geotechnical Engineering, Nelson, Ontario, Canada, 686 p.

SECONDARY CONSOLIDATION SETTLEMENT FOR LEVEES IN SOIL AREAS 1 TO 3

New Medowlands Flood Protection

Bergen County, New Jersey

AECOM

Calculated by: AH **Date:** 11/16/2016 **Checked by:** LC

Equations:

$$S_s = \frac{C_\alpha}{1+e_o} H_c \log\left(\frac{t_2}{t_1}\right)$$

Where,

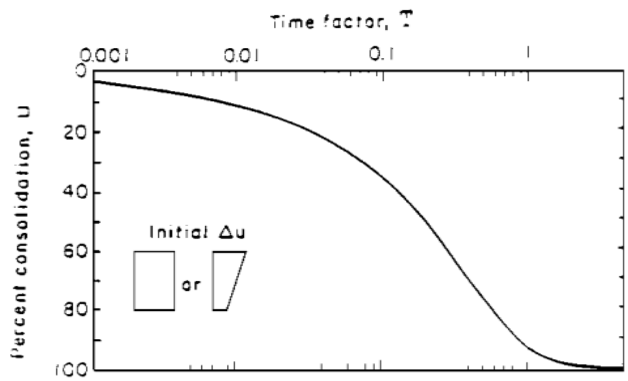
H_c = Initial Height of Compressible Soil Layer

e_0 = Void Ratio at Initial Vertical Effective Stress

C_α = Secondary Compression Index

t_1 = Time when Secondary Settlement Begins

t_2 = Arbitrary Time that Could Represent the Service Life of the Structure



$$t = \frac{TH_d^{\ 2}}{c_v}$$

Where,

T = Time Factor

H_d = Length of Longest Drainage Path in Compressible Layer under Consideration (ft)

C_v = Coefficient of Consolidation

Settlement Calculation:

C_α =	0.0035	
H_c =	74	ft
H_d =	37	ft
e_o =	1.03	
C_v =	260	ft^2/yr
Time Factor at 90% Consolidation, T_{90} =	0.9	
t_1 =	5	yr
t_2 =	50	yr
Secondary Consolidation (Creep) Settlement =	**2**	**in**

Reference:

Das, B. M. (2006). Principles of Geotechnical Engineering, Nelson, Ontario, Canada, 686 p.

PRIMARY CONSOLIDATION SETTLEMENT FOR 2.6 FT LEVEE IN SOIL AREAS 4 TO 7

New Medowlands Flood Protection

Bergen County, New Jersey

AECOM

Calculated by: AH **Date:** 11/16/2016 **Checked by:** LC

Soil Parameters:

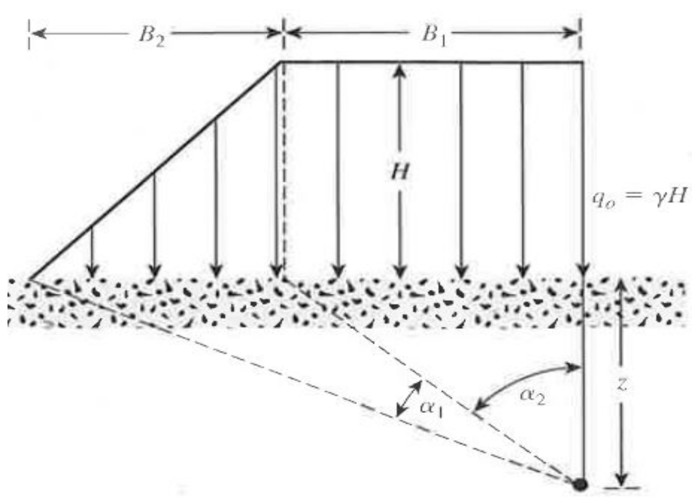
Layer No.	Soil Description	Total Unit Weight	Layer Thickness	Bottom Depth of Layer	Initial Void Ratio, e_0	Compression Index, C_c
		(pcf)	(ft)	(ft)		
1	Structural Fill	120	2	2		
1	Organic Clay	85	16	18	1.46	0.45
2	Clay	110	53	71	1.03	0.17

Depth to Groundwater Table from Ground Surface = 5 ft

Elevations:

Top of Levee =	+ 8.6 ft
Bottom of Levee/Ground Surface =	+ 6 ft
Bottom of Organic Clay =	- 12 ft
Bottom of Clay =	- 65 ft
Groundwater Table =	+ 1 ft

Increase in Vertical Stress in Soil due to Levee:



$$\Delta\sigma_z = \frac{q_o}{\pi}\left[\left(\frac{B_1 + B_2}{B_2}\right)(\alpha_1 + \alpha_2) - \frac{B_1}{B_2}(\alpha_2)\right]$$

$$\alpha_1 \text{(radians)} = \tan^{-1}\left(\frac{B_1 + B_2}{z}\right) - \tan^{-1}\left(\frac{B_1}{z}\right)$$

$$\alpha_2 = \tan^{-1}\left(\frac{B_1}{z}\right)$$

H = 2.6 ft

B_1 = 5 ft

B_2 = 7.8 ft

γ = 120 pcf

q_0 = 312 psf

Settlement Calculation:

Sub-Layer No.	Thickness	Mid Depth of Sub-Layer	Initial Overburden Pressure, σ'_0	α_1	α_2	Increase in Overburden Pressure, $\Delta\sigma'_z$	$\sigma'_0 + \Delta\sigma'_z$	C_c	Settlement
	(ft)	(ft)	(psf)	(rad.)	(rad.)	(psf)	(psf)		(ft)
1	2	3	255	0.3	1.0	153	408	0.45	0.090
2	2	5	425	0.4	0.8	145	570	0.45	0.057
3	2	7	470	0.5	0.6	135	605	0.45	0.049
4	2	9	515	0.5	0.5	124	639	0.45	0.041
5	2	11	561	0.4	0.4	113	674	0.45	0.035
6	2	13	606	0.4	0.4	103	709	0.45	0.030
7	2	15	651	0.4	0.3	95	746	0.45	0.026
8	2	17	696	0.4	0.3	87	783	0.45	0.023
9	2	19	766	0.3	0.3	80	847	0.17	0.007
10	2	21	862	0.3	0.2	74	936	0.17	0.006
11	2	23	957	0.3	0.2	69	1026	0.17	0.005
12	2	25	1052	0.3	0.2	65	1117	0.17	0.004
13	2	27	1147	0.3	0.2	60	1208	0.17	0.004
14	2	29	1242	0.2	0.2	57	1299	0.17	0.003
15	2	31	1338	0.2	0.2	54	1391	0.17	0.003
16	2	33	1433	0.2	0.2	51	1484	0.17	0.003
17	2	35	1528	0.2	0.1	48	1576	0.17	0.002
18	2	37	1623	0.2	0.1	46	1669	0.17	0.002
19	2	39	1718	0.2	0.1	44	1762	0.17	0.002
20	2	41	1814	0.2	0.1	42	1855	0.17	0.002
21	2	43	1909	0.2	0.1	40	1949	0.17	0.002
22	2	45	2004	0.2	0.1	38	2042	0.17	0.001
23	2	47	2099	0.2	0.1	37	2136	0.17	0.001
24	2	49	2194	0.2	0.1	35	2230	0.17	0.001
25	2	51	2290	0.1	0.1	34	2323	0.17	0.001
26	2	53	2385	0.1	0.1	33	2417	0.17	0.001
27	2	55	2480	0.1	0.1	31	2511	0.17	0.001
28	2	57	2575	0.1	0.1	30	2606	0.17	0.001
29	2	59	2670	0.1	0.1	29	2700	0.17	0.001
30	2	61	2766	0.1	0.1	29	2794	0.17	0.001
31	2	63	2861	0.1	0.1	28	2888	0.17	0.001
32	2	65	2956	0.1	0.1	27	2983	0.17	0.001
33	2	67	3051	0.1	0.1	26	3077	0.17	0.001
34	2	69	3146	0.1	0.1	25	3172	0.17	0.001
35	1	70	3194	0.1	0.1	25	3219	0.17	0.000

Total Primary Consolidation Settlement = 5 in

Reference:

Das, B. M. (2006). Principles of Geotechnical Engineering, Nelson, Ontario, Canada, 686 p.

PRIMARY CONSOLIDATION SETTLEMENT FOR 4.9 FT LEVEE IN SOIL AREAS 4 TO 7

New Medowlands Flood Protection

Bergen County, New Jersey

AECOM

Calculated by: AH **Date:** 11/16/2016 **Checked by:** LC

Soil Parameters:

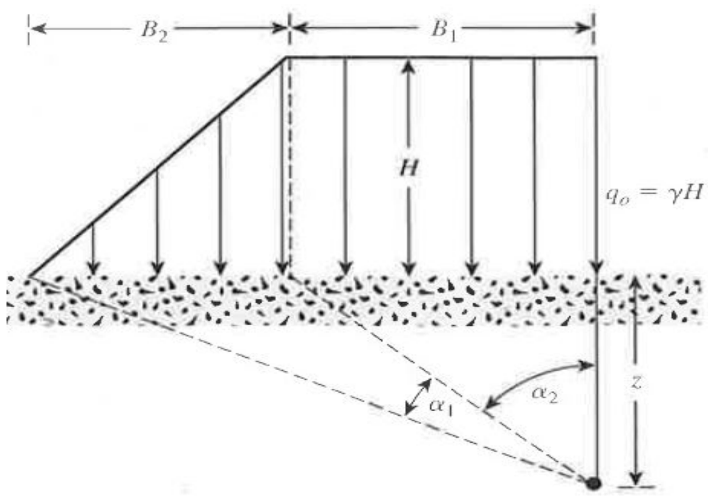
Layer No.	Soil Description	Total Unit Weight	Layer Thickness	Bottom Depth of Layer	Initial Void Ratio, e_0	Compression Index, C_c
		(pcf)	(ft)	(ft)		
1	Structural Fill	120	3	3		
2	Organic Clay	85	13	16	1.46	0.45
3	Clay	110	53	69	1.03	0.17

Depth to Groundwater Table from Ground Surface = 3 ft

Elevations:

Top of Levee = + 8.9 ft
Bottom of Levee/Ground Surface = + 4 ft
Bottom of Organic Clay = - 12 ft
Bottom of Clay = - 65 ft
Groundwater Table = + 1 ft

Increase in Vertical Stress in Soil due to Levee:



$$\Delta\sigma_z = \frac{q_o}{\pi}\left[\left(\frac{B_1 + B_2}{B_2}\right)(\alpha_1 + \alpha_2) - \frac{B_1}{B_2}(\alpha_2)\right]$$

$$\alpha_1\,(\text{radians}) = \tan^{-1}\left(\frac{B_1 + B_2}{z}\right) - \tan^{-1}\left(\frac{B_1}{z}\right)$$

$$\alpha_2 = \tan^{-1}\left(\frac{B_1}{z}\right)$$

H = 4.9 ft
B_1 = 5 ft
B_2 = 14.7 ft

γ = 120 pcf
q_0 = 588 psf

Settlement Calculation:

Sub-Layer No.	Thickness	Mid Depth of Sub-Layer	Initial Overburden Pressure, σ'_0	α_1	α_2	Increase in Overburden Pressure, $\Delta\sigma'_z$	$\sigma'_0 + \Delta\sigma'_z$	C_c	Settlement
	(ft)	(ft)	(psf)	(rad.)	(rad.)	(psf)	(psf)		(ft)
1	2	4	278	0.5	0.9	287	564	0.45	0.137
2	2	6	323	0.6	0.7	276	598	0.45	0.119
3	2	8	368	0.6	0.6	262	630	0.45	0.103
4	2	10	413	0.6	0.5	247	660	0.45	0.090
5	2	12	458	0.6	0.4	232	690	0.45	0.079
6	2	14	504	0.6	0.3	217	721	0.45	0.069
7	2	16	549	0.6	0.3	204	752	0.17	0.023
8	2	18	644	0.6	0.3	191	835	0.17	0.019
9	2	20	739	0.5	0.2	180	919	0.17	0.016
10	2	22	834	0.5	0.2	169	1003	0.17	0.013
11	2	24	930	0.5	0.2	159	1089	0.17	0.012
12	2	26	1025	0.5	0.2	151	1175	0.17	0.010
13	2	28	1120	0.4	0.2	143	1263	0.17	0.009
14	2	30	1215	0.4	0.2	135	1350	0.17	0.008
15	2	32	1310	0.4	0.2	129	1439	0.17	0.007
16	2	34	1406	0.4	0.1	122	1528	0.17	0.006
17	2	36	1501	0.4	0.1	117	1618	0.17	0.005
18	2	38	1596	0.3	0.1	112	1708	0.17	0.005
19	2	40	1691	0.3	0.1	107	1798	0.17	0.004
20	2	42	1786	0.3	0.1	102	1889	0.17	0.004
21	2	44	1882	0.3	0.1	98	1980	0.17	0.004
22	2	46	1977	0.3	0.1	95	2071	0.17	0.003
23	2	48	2072	0.3	0.1	91	2163	0.17	0.003
24	2	50	2167	0.3	0.1	88	2255	0.17	0.003
25	2	52	2262	0.3	0.1	85	2347	0.17	0.003
26	2	54	2358	0.3	0.1	82	2439	0.17	0.002
27	2	56	2453	0.2	0.1	79	2532	0.17	0.002
28	2	58	2548	0.2	0.1	77	2625	0.17	0.002
29	2	60	2643	0.2	0.1	74	2717	0.17	0.002
30	2	62	2738	0.2	0.1	72	2810	0.17	0.002
31	2	64	2834	0.2	0.1	70	2904	0.17	0.002
32	2	66	2929	0.2	0.1	68	2997	0.17	0.002
33	2	68	3024	0.2	0.1	66	3090	0.17	0.002

Total Primary Consolidation Settlement = 9 in

Reference:

Das, B. M. (2006). Principles of Geotechnical Engineering, Nelson, Ontario, Canada, 686 p.

PRIMARY CONSOLIDATION SETTLEMENT FOR 7.2 FT LEVEE IN SOIL AREAS 4 TO 7

New Medowlands Flood Protection

Bergen County, New Jersey

AECOM

Calculated by: AH **Date:** 11/16/2016 **Checked by:** LC

Soil Parameters:

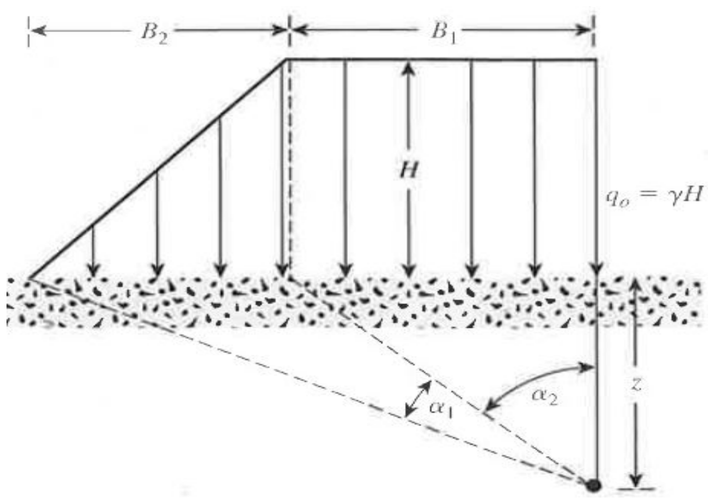
Layer No.	Soil Description	Total Unit Weight	Layer Thickness	Bottom Depth of Layer	Initial Void Ratio, e_0	Compression Index, C_c
		(pcf)	(ft)	(ft)		
1	Structural Fill	120	6	6		
2	Organic Clay	85	8	14	1.46	0.45
3	Clay	110	53	67	1.03	0.17

Depth to Groundwater Table from Ground Surface = 1 ft

Elevations:

Top of Levee = + 9.2 ft
Bottom of Levee/Ground Surface = + 2 ft
Bottom of Organic Clay = - 12 ft
Bottom of Clay = - 65 ft
Groundwater Table = + 1 ft

Increase in Vertical Stress in Soil due to Levee:



$$\Delta\sigma_z = \frac{q_o}{\pi}\left[\left(\frac{B_1 + B_2}{B_2}\right)(\alpha_1 + \alpha_2) - \frac{B_1}{B_2}(\alpha_2)\right]$$

$$\alpha_1 \text{ (radians)} = \tan^{-1}\left(\frac{B_1 + B_2}{z}\right) - \tan^{-1}\left(\frac{B_1}{z}\right)$$

$$\alpha_2 = \tan^{-1}\left(\frac{B_1}{z}\right)$$

H = 7.2 ft
B_1 = 5 ft
B_2 = 21.6 ft

γ = 120 pcf
q_0 = 864 psf

Settlement Calculation:

Sub-Layer No.	Thickness	Mid Depth of Sub-Layer	Initial Overburden Pressure, σ'$_0$	α_1	α_2	Increase in Overburden Pressure, Δσ'$_z$	σ'$_0$ + Δσ'$_z$	C_c	Settlement
	(ft)	(ft)	(psf)	(rad.)	(rad.)	(psf)	(psf)		(ft)
1	2	7	221	0.7	0.6	405	626	0.45	0.201
2	2	9	266	0.7	0.5	389	655	0.45	0.174
3	2	11	311	0.8	0.4	372	683	0.45	0.151
4	2	13	356	0.7	0.4	355	711	0.45	0.133
5	2	15	426	0.7	0.3	338	764	0.17	0.042
6	2	17	522	0.7	0.3	321	843	0.17	0.035
7	2	19	617	0.7	0.3	306	922	0.17	0.029
8	2	21	712	0.7	0.2	291	1003	0.17	0.025
9	2	23	807	0.6	0.2	277	1084	0.17	0.021
10	2	25	902	0.6	0.2	264	1166	0.17	0.019
11	2	27	998	0.6	0.2	252	1249	0.17	0.016
12	2	29	1093	0.6	0.2	241	1333	0.17	0.014
13	2	31	1188	0.5	0.2	230	1418	0.17	0.013
14	2	33	1283	0.5	0.2	220	1503	0.17	0.012
15	2	35	1378	0.5	0.1	211	1589	0.17	0.010
16	2	37	1474	0.5	0.1	203	1676	0.17	0.009
17	2	39	1569	0.5	0.1	195	1763	0.17	0.009
18	2	41	1664	0.5	0.1	187	1851	0.17	0.008
19	2	43	1759	0.4	0.1	180	1939	0.17	0.007
20	2	45	1854	0.4	0.1	174	2028	0.17	0.007
21	2	47	1950	0.4	0.1	168	2117	0.17	0.006
22	2	49	2045	0.4	0.1	162	2207	0.17	0.006
23	2	51	2140	0.4	0.1	157	2297	0.17	0.005
24	2	53	2235	0.4	0.1	152	2387	0.17	0.005
25	2	55	2330	0.4	0.1	147	2477	0.17	0.004
26	2	57	2426	0.3	0.1	142	2568	0.17	0.004
27	2	59	2521	0.3	0.1	138	2659	0.17	0.004
28	2	61	2616	0.3	0.1	134	2750	0.17	0.004
29	2	63	2711	0.3	0.1	130	2841	0.17	0.003
30	2	65	2806	0.3	0.1	127	2933	0.17	0.003
31	2	67	2902	0.3	0.1	123	3025	0.17	0.003

Total Primary Consolidation Settlement = 12 in

Reference:

Das, B. M. (2006). Principles of Geotechnical Engineering, Nelson, Ontario, Canada, 686 p.

PRIMARY CONSOLIDATION SETTLEMENT FOR 9.8 FT LEVEE IN SOIL AREAS 4 TO 7
New Medowlands Flood Protection
Bergen County, New Jersey

AECOM

Calculated by: AH **Date:** 11/16/2016 **Checked by:** LC

Soil Parameters:

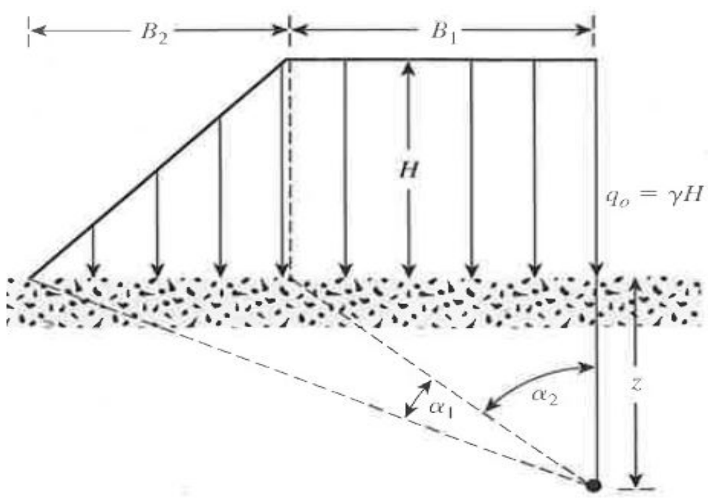
Layer No.	Soil Description	Total Unit Weight	Layer Thickness	Bottom Depth of Layer	Initial Void Ratio, e_0	Compression Index, C_c
		(pcf)	(ft)	(ft)		
1	Structural Fill	120	4	4		
2	Organic Clay	85	8	12	1.46	0.45
3	Clay	110	53	65	1.03	0.17

Depth to Groundwater Table from Ground Surface = 0 ft

Elevations:

Top of Levee =	+ 9.8 ft
Bottom of Levee/Ground Surface =	+ 0 ft
Bottom of Organic Clay =	- 12 ft
Bottom of Clay =	- 65 ft
Groundwater Table =	+ 0 ft

Increase in Vertical Stress in Soil due to Levee:



$$\Delta\sigma_z = \frac{q_o}{\pi}\left[\left(\frac{B_1 + B_2}{B_2}\right)(\alpha_1 + \alpha_2) - \frac{B_1}{B_2}(\alpha_2)\right]$$

$$\alpha_1 \text{(radians)} = \tan^{-1}\left(\frac{B_1 + B_2}{z}\right) - \tan^{-1}\left(\frac{B_1}{z}\right)$$

$$\alpha_2 = \tan^{-1}\left(\frac{B_1}{z}\right)$$

H = 9.8 ft
B_1 = 5 ft
B_2 = 29.4 ft

γ = 120 pcf
q_0 = 1176 psf

Settlement Calculation:

Sub-Layer No.	Thickness	Mid Depth of Sub-Layer	Initial Overburden Pressure, σ'_0	α_1	α_2	Increase in Overburden Pressure, $\Delta\sigma'_z$	$\sigma'_0 + \Delta\sigma'_z$	C_c	Settlement
	(ft)	(ft)	(psf)	(rad.)	(rad.)	(psf)	(psf)		(ft)
1	2	5	113	0.6	0.8	575	688	0.45	0.348
2	2	7	158	0.7	0.6	561	719	0.45	0.291
3	2	9	203	0.8	0.5	544	747	0.45	0.250
4	2	11	249	0.8	0.4	525	774	0.45	0.219
5	2	13	319	0.8	0.4	506	825	0.17	0.069
6	2	15	414	0.8	0.3	487	901	0.17	0.057
7	2	17	509	0.8	0.3	469	978	0.17	0.047
8	2	19	604	0.8	0.3	451	1055	0.17	0.041
9	2	21	700	0.8	0.2	433	1133	0.17	0.035
10	2	23	795	0.8	0.2	416	1211	0.17	0.031
11	2	25	890	0.7	0.2	400	1290	0.17	0.027
12	2	27	985	0.7	0.2	385	1370	0.17	0.024
13	2	29	1080	0.7	0.2	370	1451	0.17	0.021
14	2	31	1176	0.7	0.2	357	1532	0.17	0.019
15	2	33	1271	0.7	0.2	344	1614	0.17	0.017
16	2	35	1366	0.6	0.1	331	1697	0.17	0.016
17	2	37	1461	0.6	0.1	320	1781	0.17	0.014
18	2	39	1556	0.6	0.1	308	1865	0.17	0.013
19	2	41	1652	0.6	0.1	298	1950	0.17	0.012
20	2	43	1747	0.6	0.1	288	2035	0.17	0.011
21	2	45	1842	0.5	0.1	279	2121	0.17	0.010
22	2	47	1937	0.5	0.1	270	2207	0.17	0.009
23	2	49	2032	0.5	0.1	262	2294	0.17	0.009
24	2	51	2128	0.5	0.1	254	2381	0.17	0.008
25	2	53	2223	0.5	0.1	246	2469	0.17	0.008
26	2	55	2318	0.5	0.1	239	2557	0.17	0.007
27	2	57	2413	0.5	0.1	232	2645	0.17	0.007
28	2	59	2508	0.4	0.1	226	2734	0.17	0.006
29	2	61	2604	0.4	0.1	220	2823	0.17	0.006
30	2	63	2699	0.4	0.1	214	2913	0.17	0.006
31	1	64	2746	0.4	0.1	211	2957	0.17	0.003

Total Primary Consolidation Settlement = 20 in

Reference:

Das, B. M. (2006). Principles of Geotechnical Engineering, Nelson, Ontario, Canada, 686 p.

SECONDARY CONSOLIDATION SETTLEMENT FOR LEVEES IN SOIL AREAS 4 TO 7

New Medowlands Flood Protection

Bergen County, New Jersey

AECOM

Calculated by: AH **Date:** 11/16/2016 **Checked by:** MS

Equations:

$$S_s = \frac{C_\alpha}{1+e_o} H_c \log\left(\frac{t_2}{t_1}\right)$$

Where,

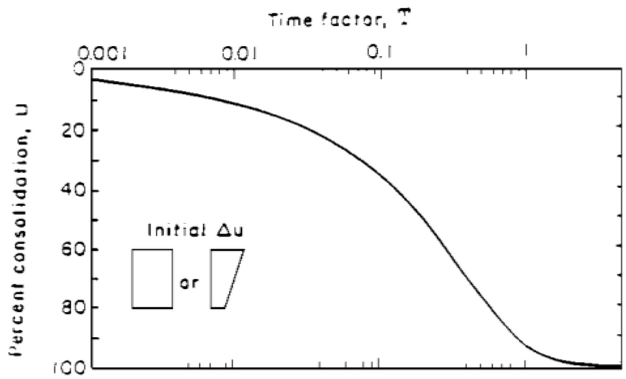
H_c = Initial Height of Compressible Soil Layer

e_0 = Void Ratio at Initial Vertical Effective Stress

C_α = Secondary Compression Index

t_1 = Time when Secondary Settlement Begins

t_2 = Arbitrary Time that Could Represent the Service Life of the Structure



$$t = \frac{TH_d^{\,2}}{c_v}$$

Where,

T = Time Factor

H_d = Length of Longest Drainage Path in Compressible Layer under Consideration (ft)

C_v = Coefficient of Consolidation

Settlement Calculation:

C_α =	0.0035	
H_c =	69	ft
H_d =	34.5	ft
e_o =	1.03	
C_v =	260	ft^2/yr
Time Factor at 90% Consolidation, T_{90} =	0.9	
t_1 =	4	yr
t_2 =	50	yr
Secondary Consolidation (Creep) Settlement =	**2**	**in**

Reference:

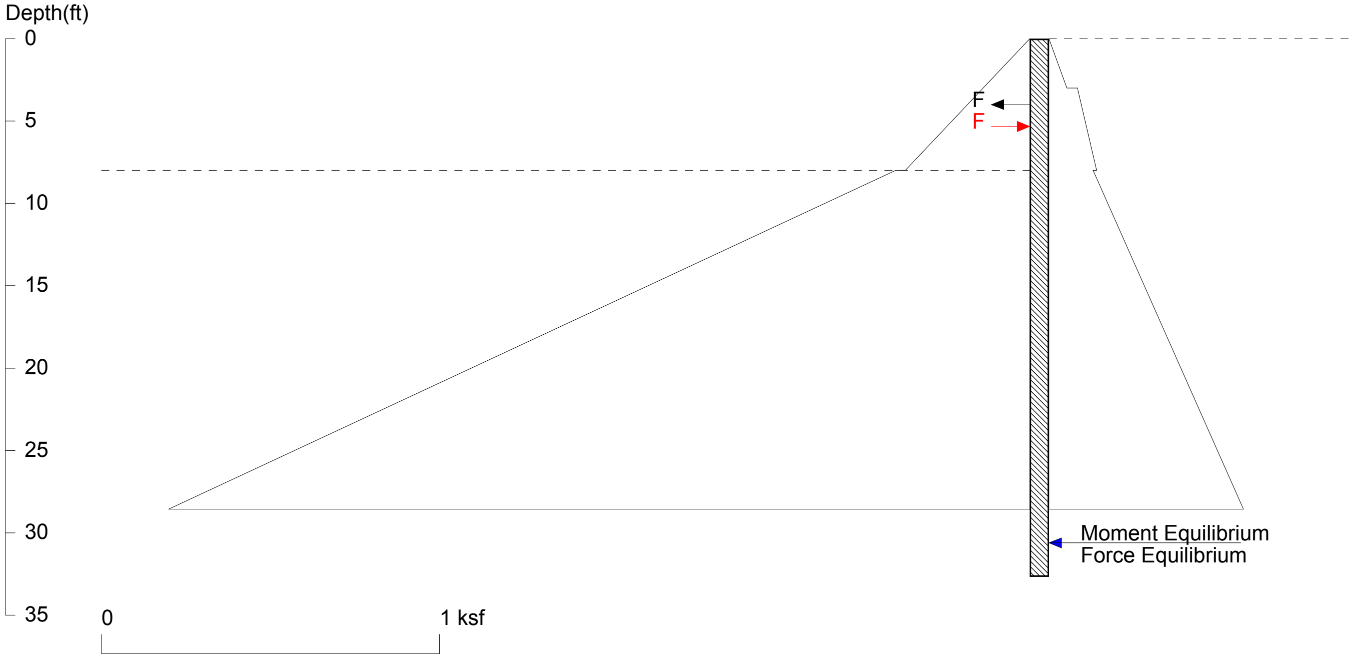
Das, B. M. (2006). Principles of Geotechnical Engineering, Nelson, Ontario, Canada, 686 p.

Attachment C1-D

Output of Sheet Pile Analysis in Soil Areas 4 to 7 from Shoring Suite

New Meadowlands - Sheet Pile for Levee

Zone 4 to 7 - Sheet Pile for 6 ft Levee



<ShoringSuite> CIVILTECH SOFTWARE USA www.civiltechsoftware.com

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File: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\Sheet Pile fo

Wall Height=8.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=24.67 Min. Pile Length=32.67
MOMENT IN PILE: Max. Moment=74.38 per Pile Spacing=1.0 at Depth=18.25

PILE SELECTION:
Request Min. Section Modulus = 27.0 in3/ft=1454.06 cm3/m, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66
AZ17 has Section Modulus = 31.0 in3/ft=1666.56 cm3/m. It is greater than Min. Requirements!
Top Deflection = 1.46(in) based on E (ksi)=29000.00 and I (in4)/foot=231.3

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	3.000	0.053	0.017698
3.000	0.084	8.000	0.140	0.011267
*	Below	Base		
8.000	0.130	40.00	0.823	0.021656

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
0.0	0.00	8.0	0.37	0.046
8.0	0.40	40.0	3.75	0.105

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	8.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

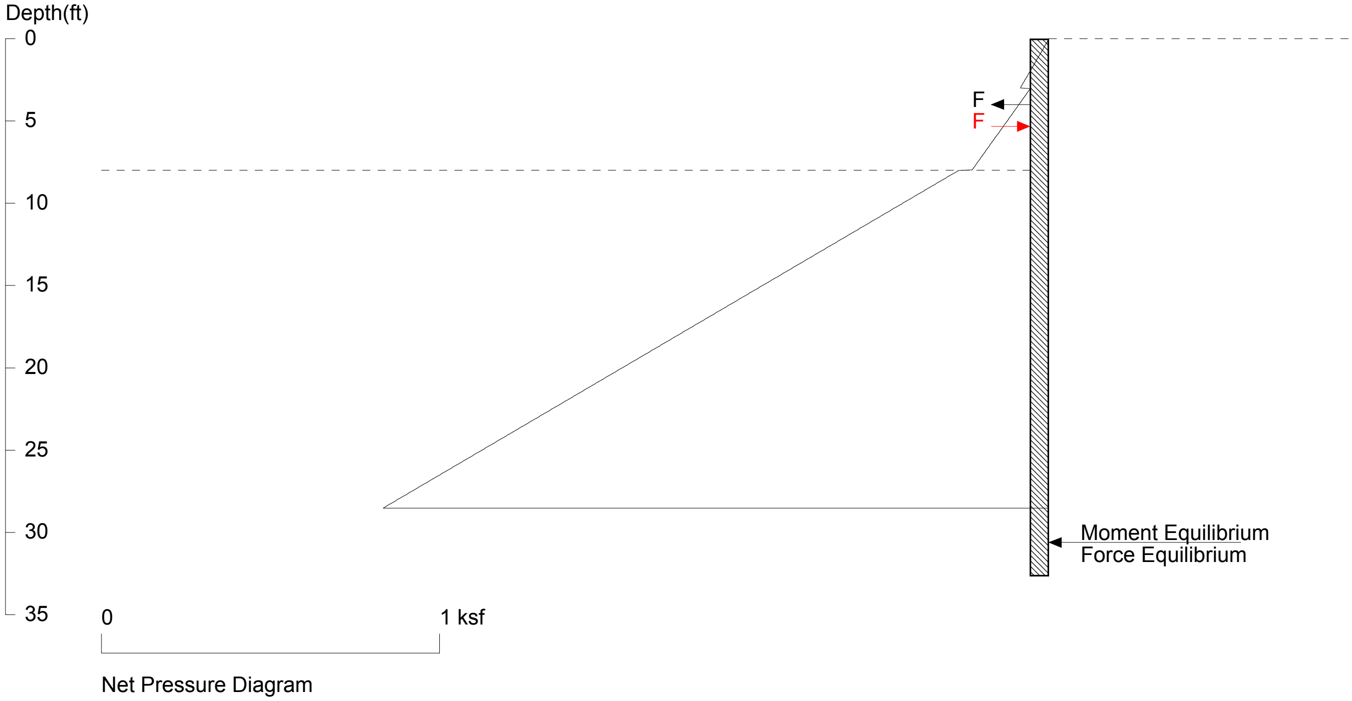
EXTERNAL FORCE ACTING ON WALL (Pusing on Wall - Positive; Against Wall - Negative)

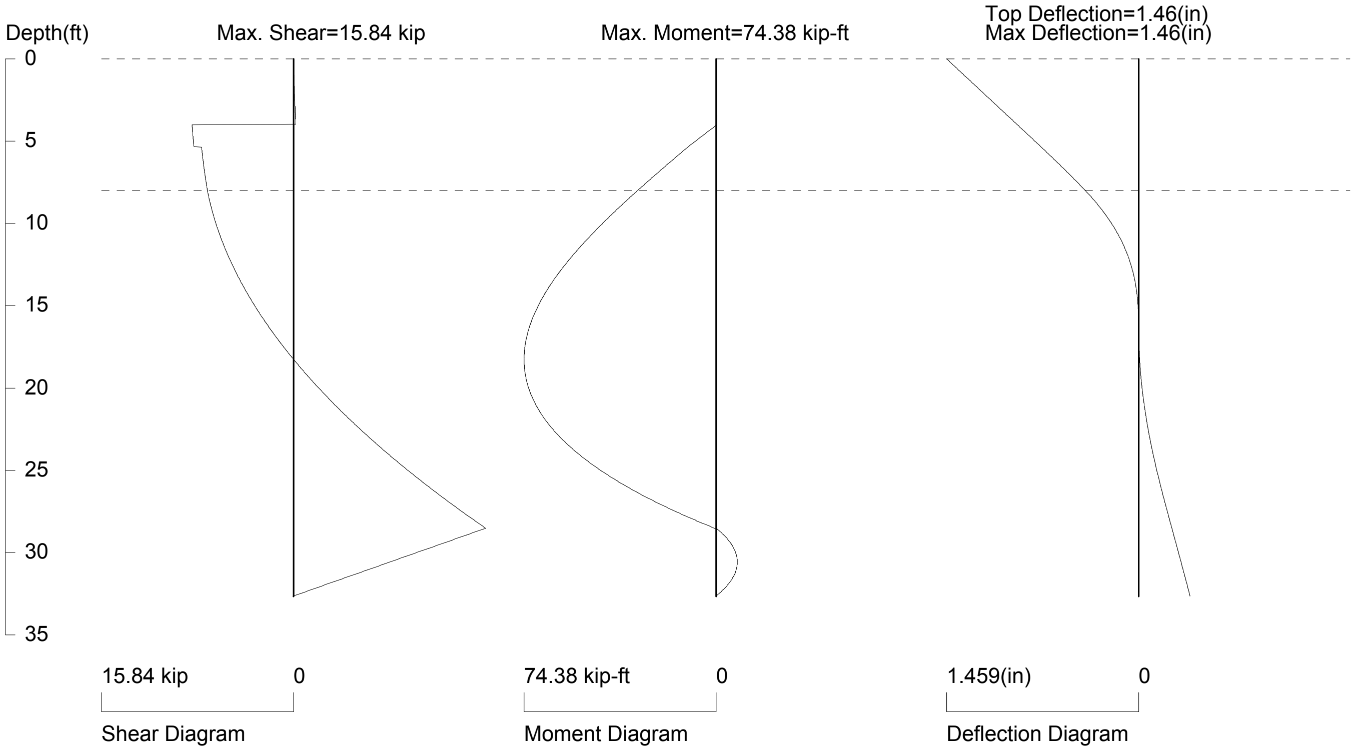
No.	Z force	Force	Angle	Spacing
1	4.00	8.57	0.0	1.00
2	5.33	-0.63	0.0	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

New Meadowlands - Sheet Pile for Levee

Zone 4 to 7 - Sheet Pile for 6 ft Levee





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

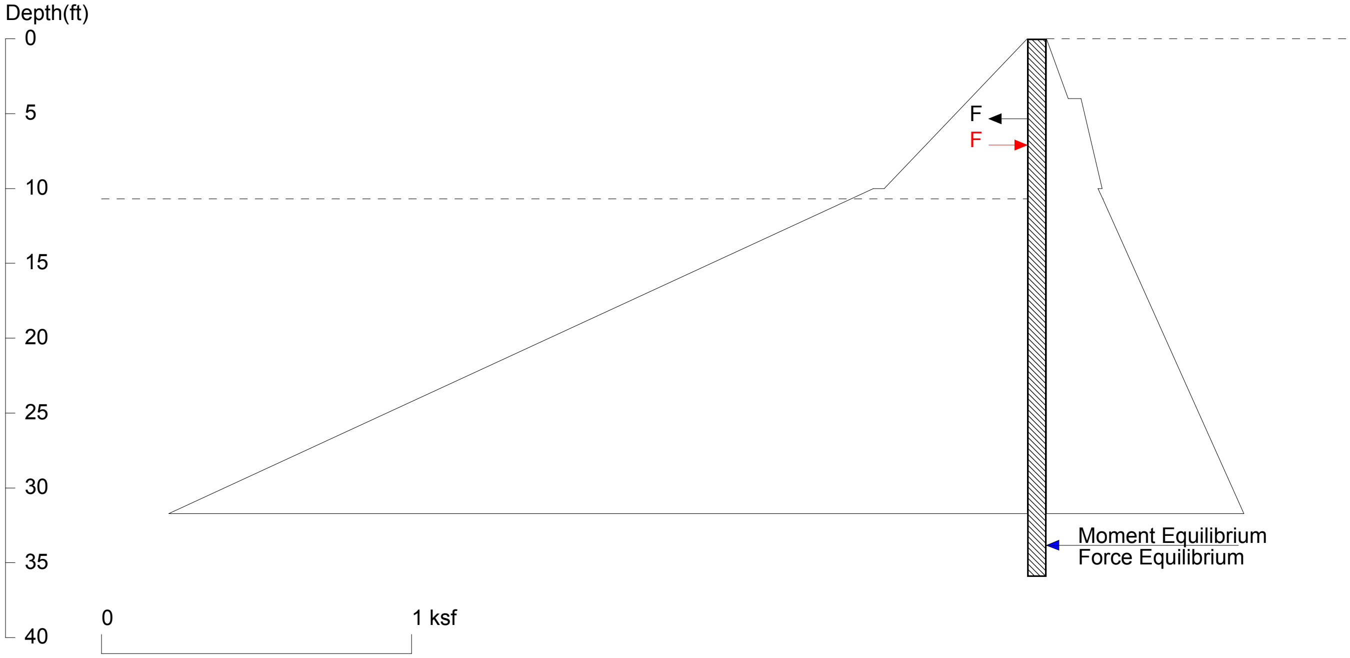
Based on pile spacing: 1.0 foot or meter

User Input Pile, AZ17: E (ksi)=29000.0, I (in4)/foot=231.3

lands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\Sheet Pile for 6 ft Levee - CT Shoring\Zone 4 to 7 - Sheet Pile for 6

New Meadowlands - Sheet Pile for Levee

Zone 4 to 7 - Sheet Pile for 8 ft Levee



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File: Z:\Meadowlands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\Sheet Pile fo

Wall Height=10.7 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=25.23 Min. Pile Length=35.93
MOMENT IN PILE: Max. Moment=93.56 per Pile Spacing=1.0 at Depth=20.62

PILE SELECTION:
Request Min. Section Modulus = 34.0 in3/ft=1828.99 cm3/m, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66
AZ19 has Section Modulus = 36.1 in3/ft=1940.74 cm3/m. It is greater than Min. Requirements!
Top Deflection = 2.23(in) based on E (ksi)=29000.00 and I (in4)/foot=270.8

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	4.000	0.071	0.017698
4.000	0.112	10.00	0.179	0.011296
10.00	0.167	10.70	0.182	0.021656
*	Below	Base		
10.70	0.182	53.50	1.109	0.021656

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
0.0	0.00	10.0	0.46	0.046
10.0	0.50	53.5	5.05	0.105

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	10.70	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

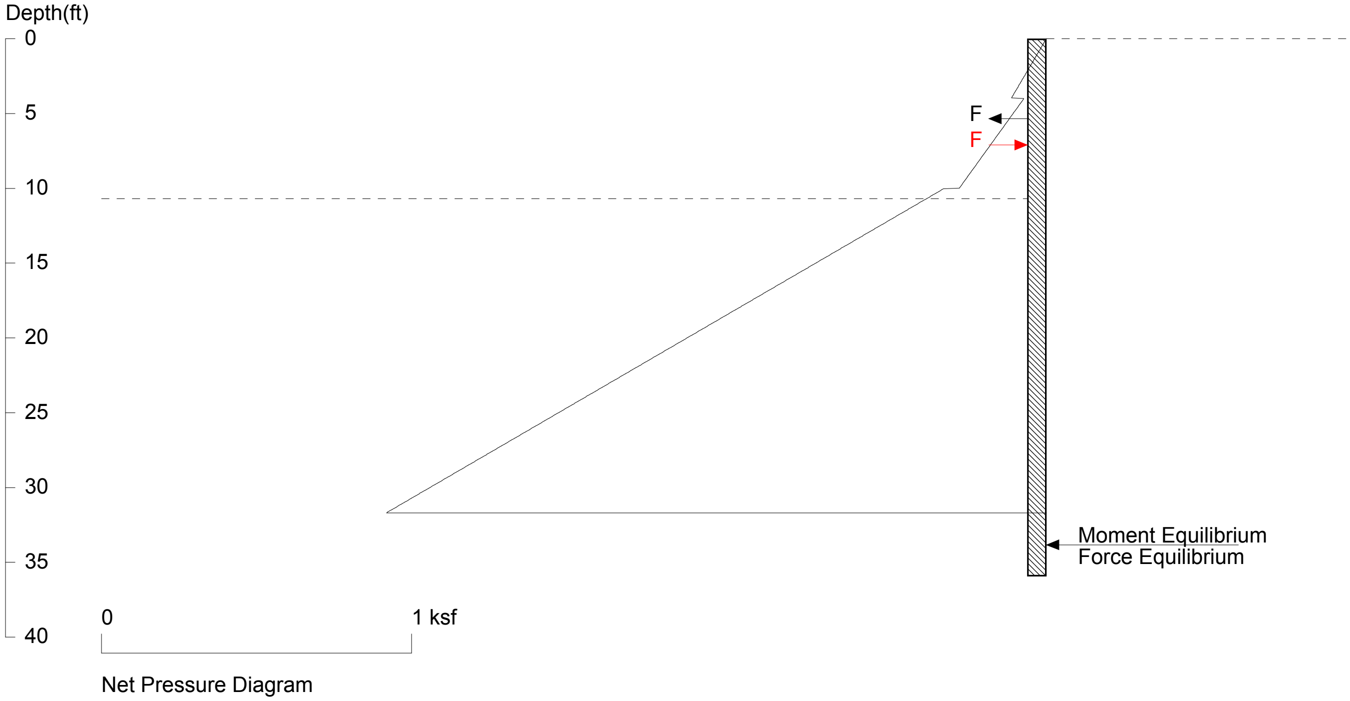
EXTERNAL FORCE ACTING ON WALL (Pusing on Wall - Positive; Against Wall - Negative)

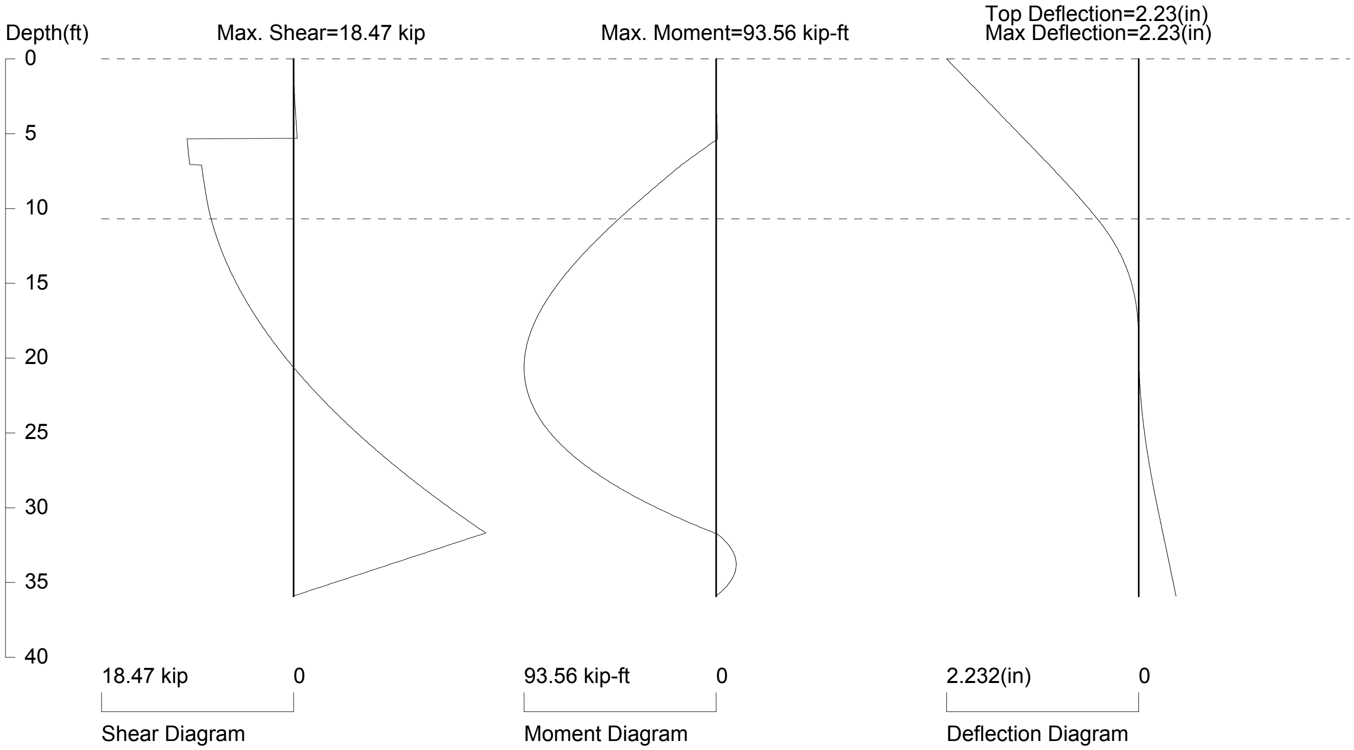
No.	Z force	Force	Angle	Spacing
1	5.35	10.60	0.0	1.00
2	7.10	-1.13	0.0	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

New Meadowlands - Sheet Pile for Levee

Zone 4 to 7 - Sheet Pile for 8 ft Levee





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 1.0 foot or meter

User Input Pile, AZ19: E (ksi)=29000.0, I (in4)/foot=270.8

lands\Feasibility Analysis for Flood Protection\Levee\Seepage and Slope Stability - Zone 4 to 7\Sheet Pile for 6 ft Levee - CT Shoring\Zone 4 to 7 - Sheet Pile for 8

Plots of Lateral Deflection, Bending Moment and Shear Force versus Depth of Sheet Pile from PYWall

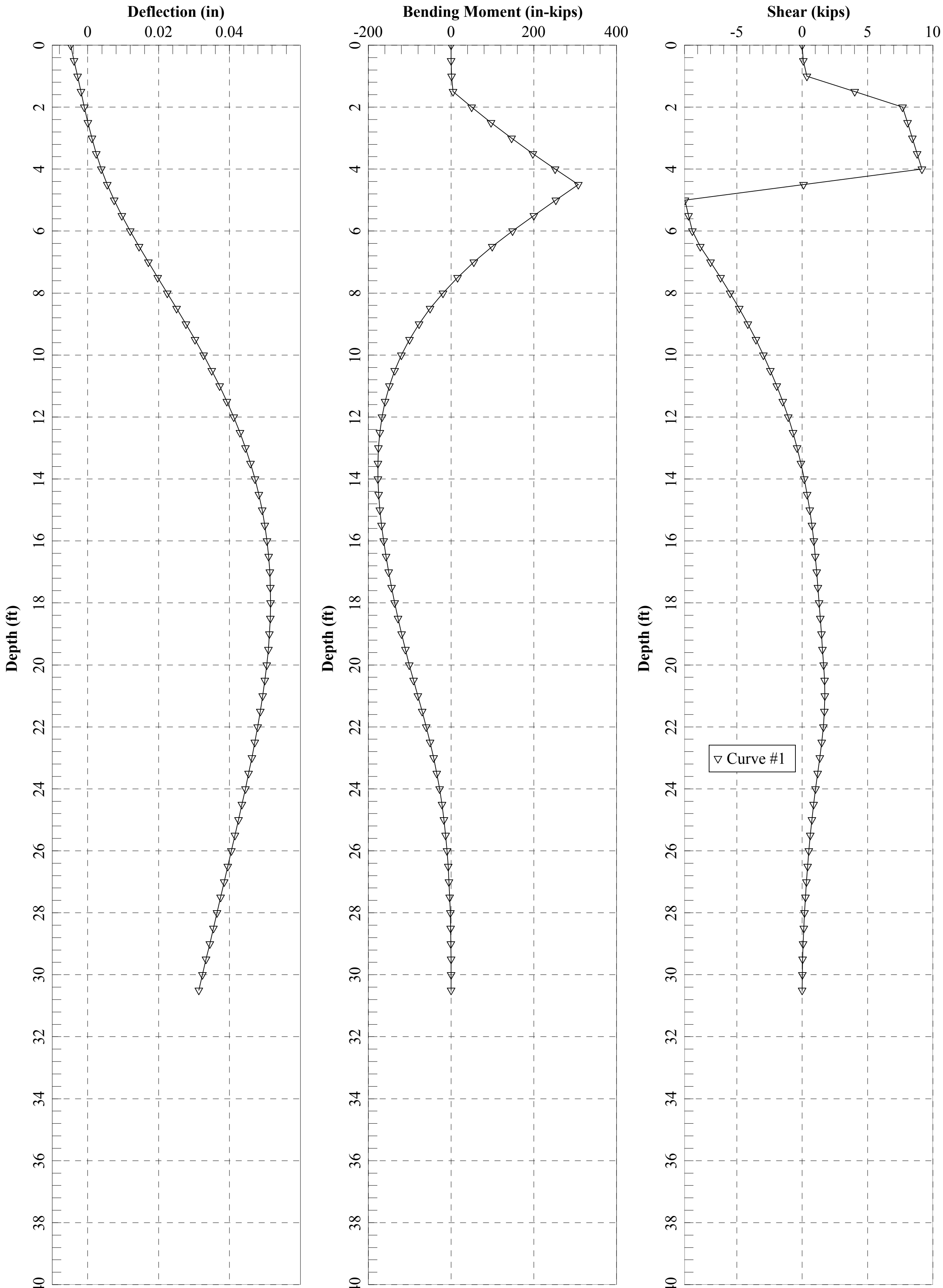


Figure E.1: Lateral Deflection, Bending Moment and Shear Force with Depth for 6 ft Double Sheet Pile Wall at No Flood Condition for Zone 4 to 7.

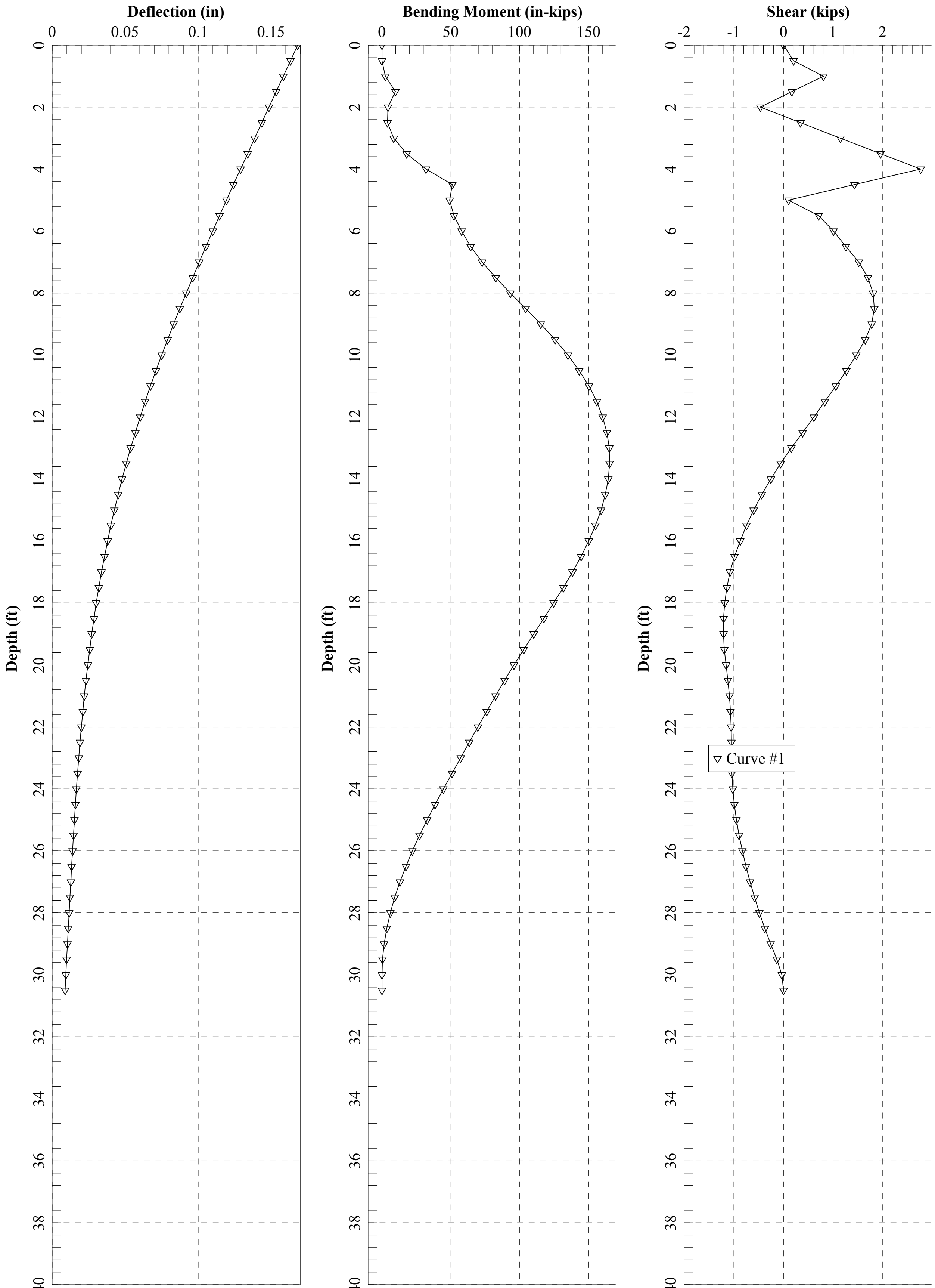


Figure E.2: Lateral Deflection, Bending Moment and Shear Force with Depth for 6 ft Double Sheet Pile Wall at Full Flood Stage for Zone 4 to 7.

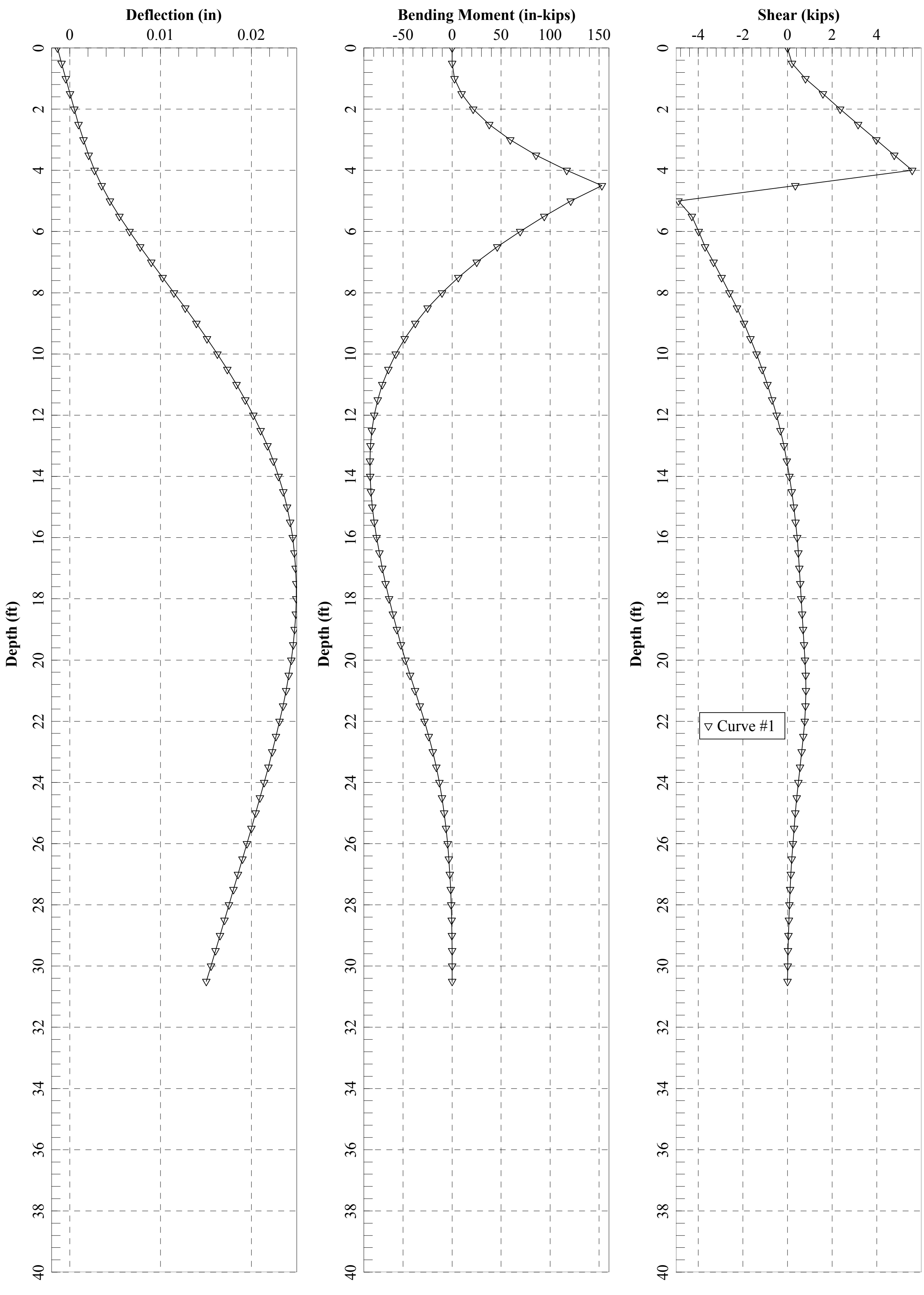


Figure A.3: Lateral Deflection, Bending Moment and Shear Force with Depth for 6 ft Double Sheet Pile Wall at Rapid Drawdown from Full Flood Stage for Zone 4 to 7.

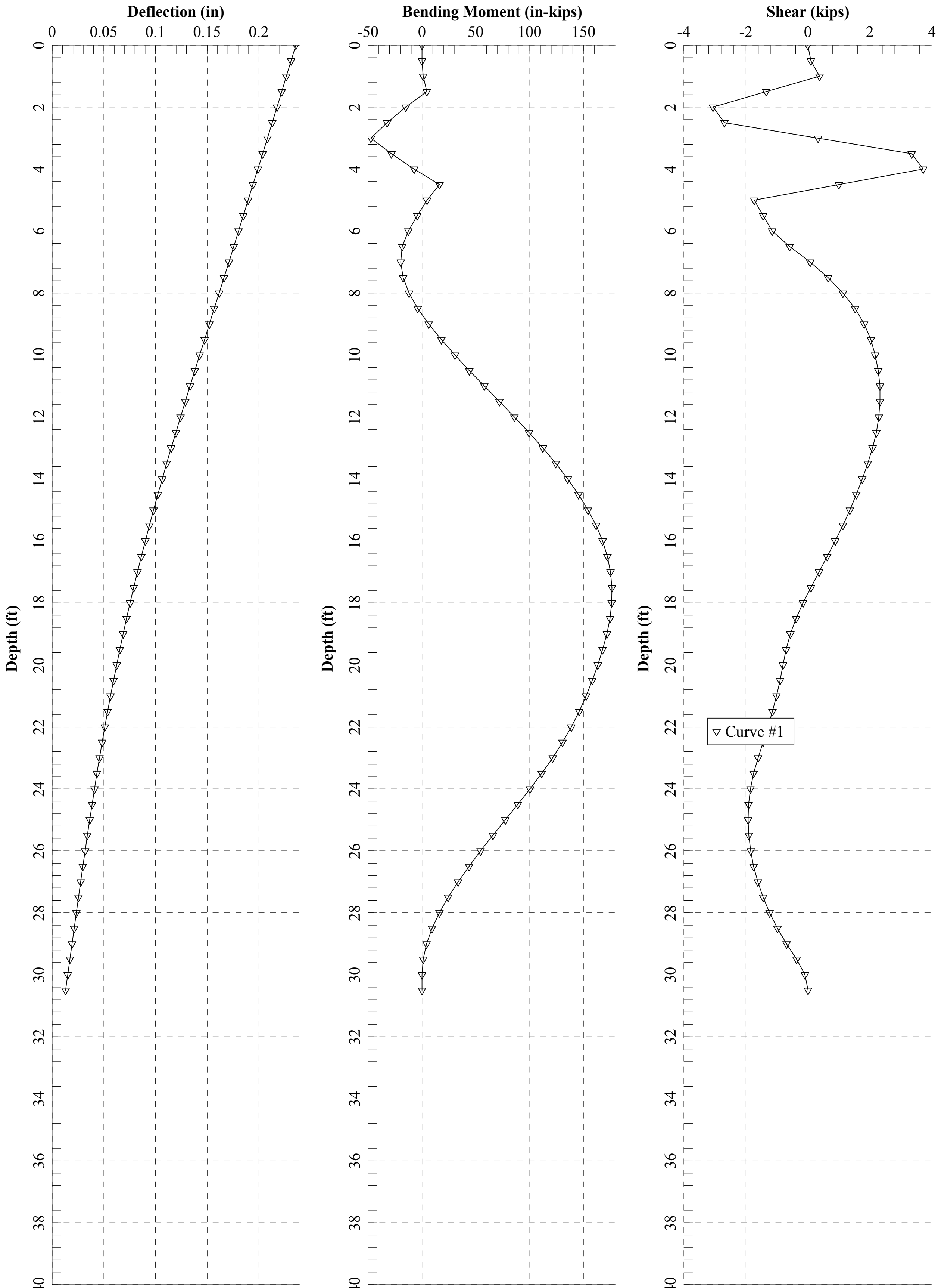


Figure E.4: Lateral Deflection, Bending Moment and Shear Force with Depth for 6 ft Double Sheet Pile Wall at Seismic Loading for Zone 4 to 7.

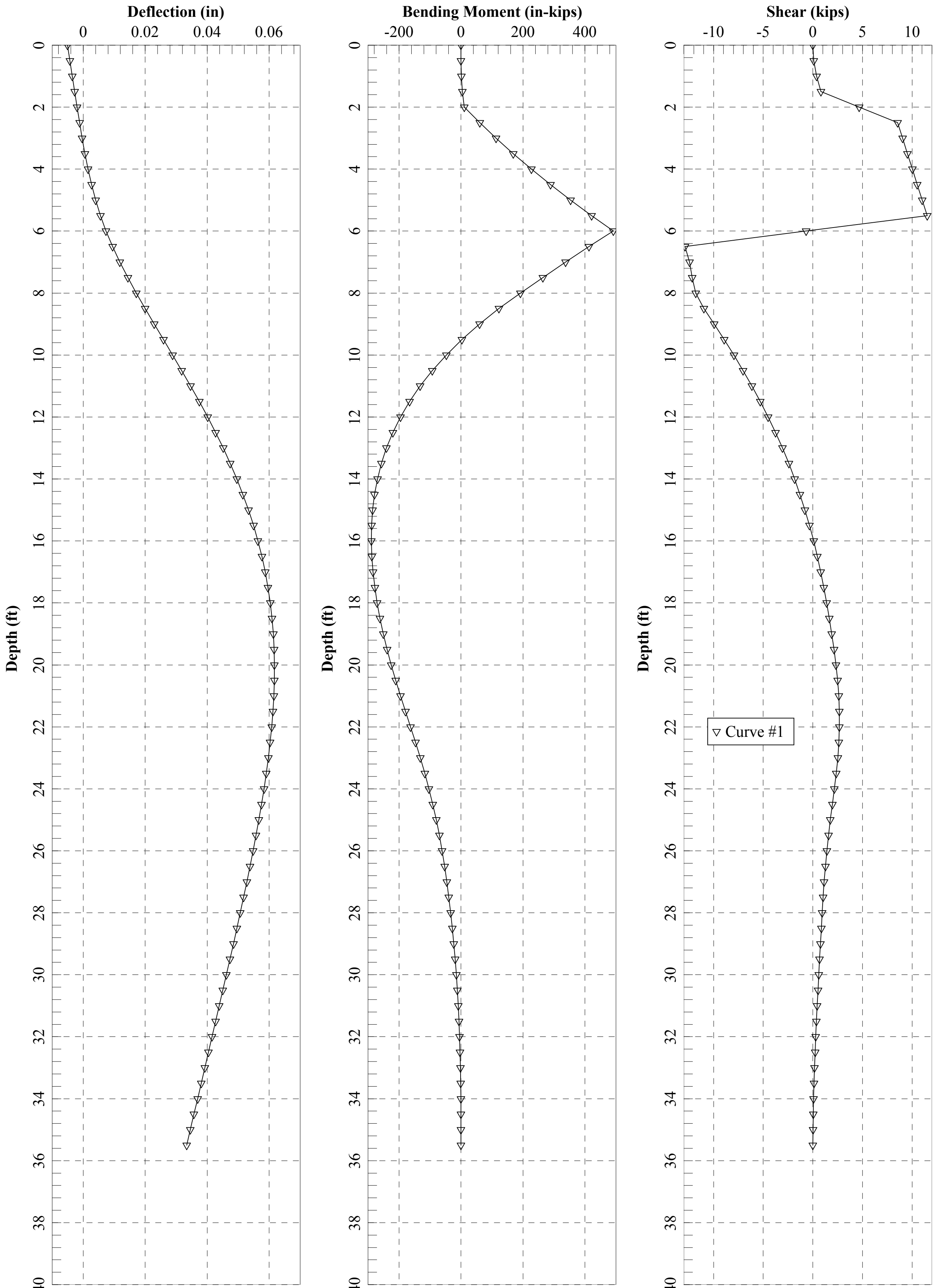


Figure E.5: Lateral Deflection, Bending Moment and Shear Force with Depth for 8 ft Double Sheet Pile Wall at No Flood Condition for Zone 4 to 7.

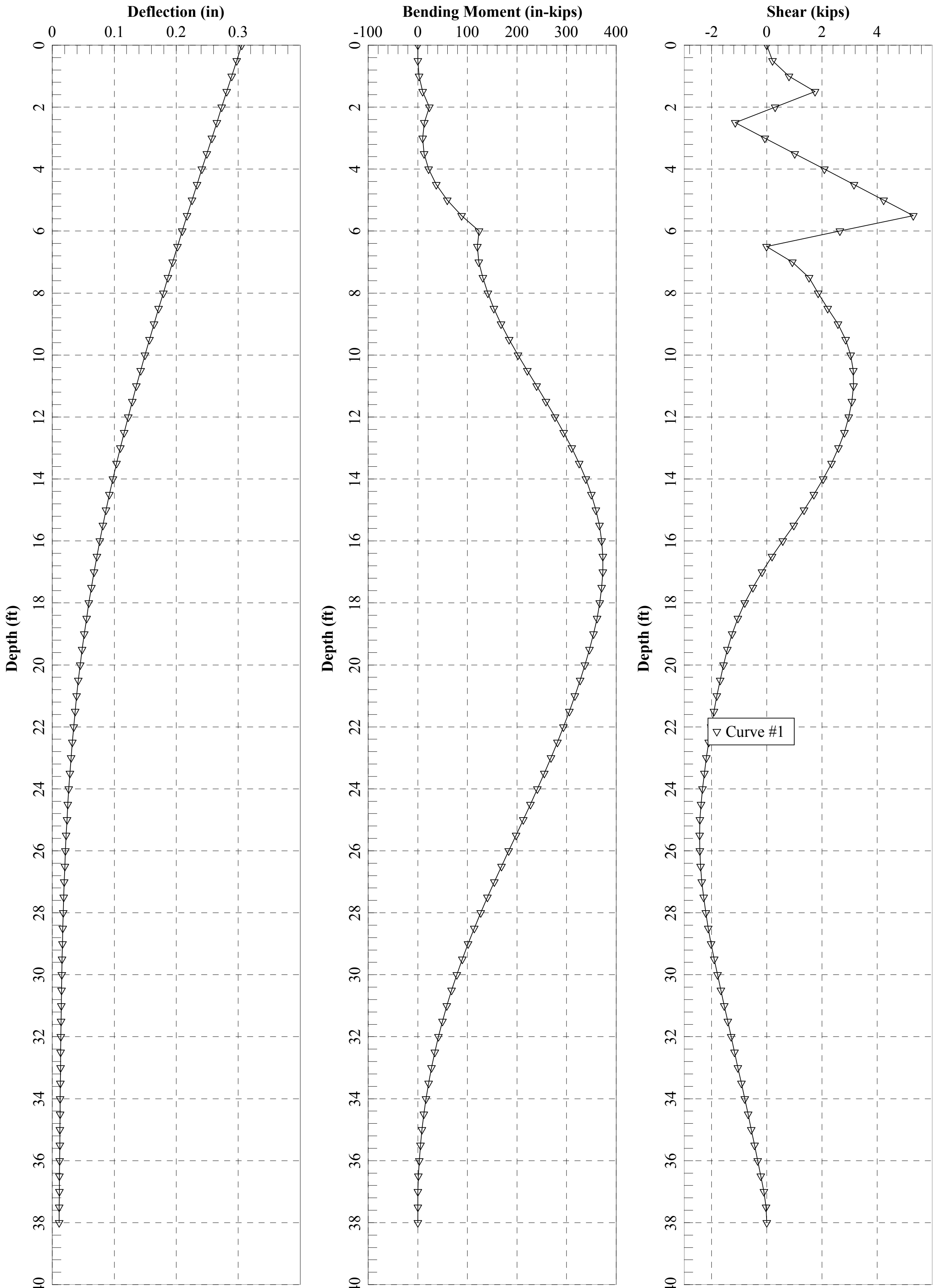


Figure E.6: Lateral Deflection, Bending Moment and Shear Force with Depth for 8 ft Double Sheet Pile Wall at No Flood Condition for Zone 4 to 7.

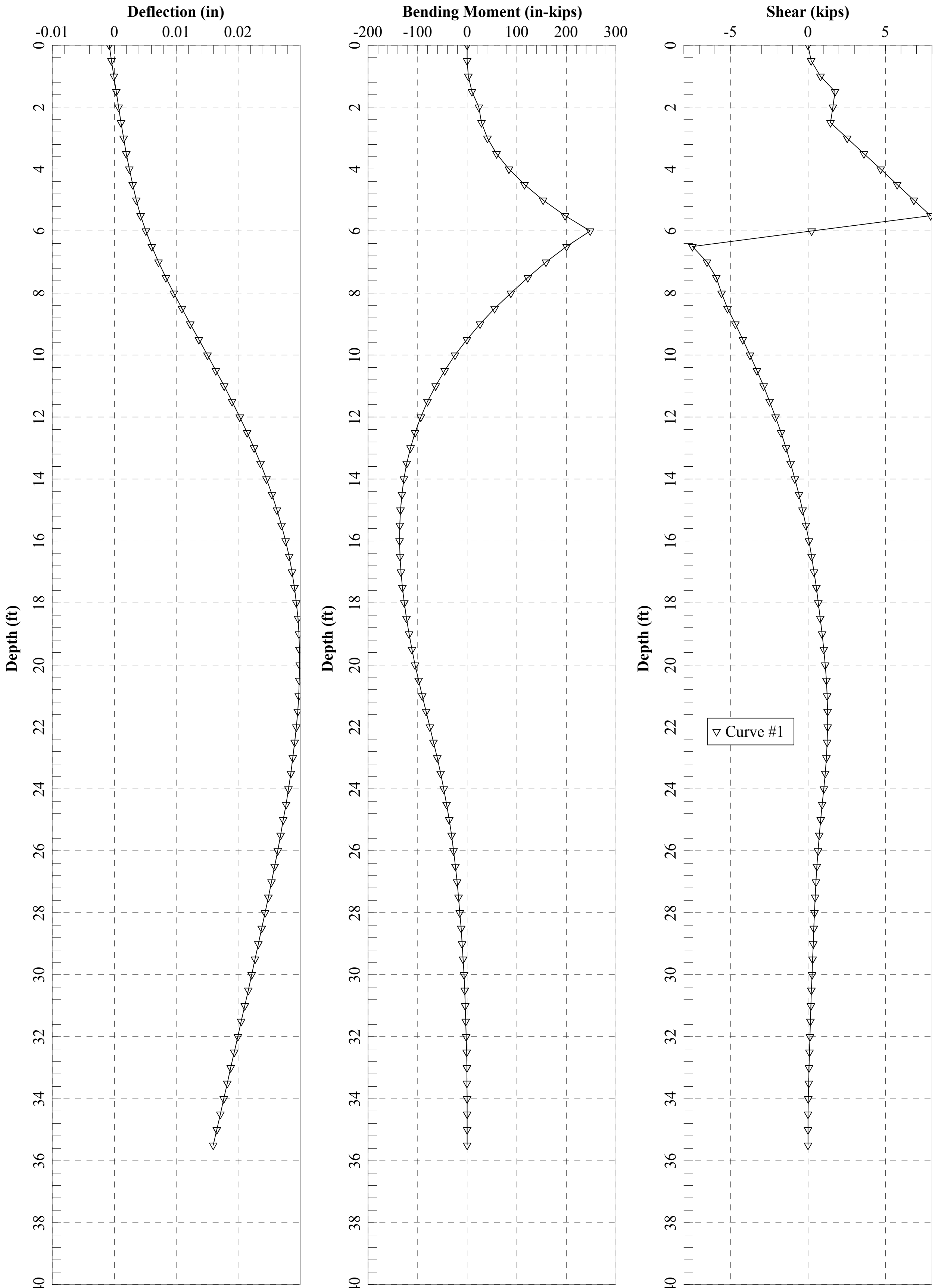


Figure E.7: Lateral Deflection, Bending Moment and Shear Force with Depth for 8 ft Double Sheet Pile Wall at Rapid Drawdown from Full Flood Stage for Zone 4 to 7.

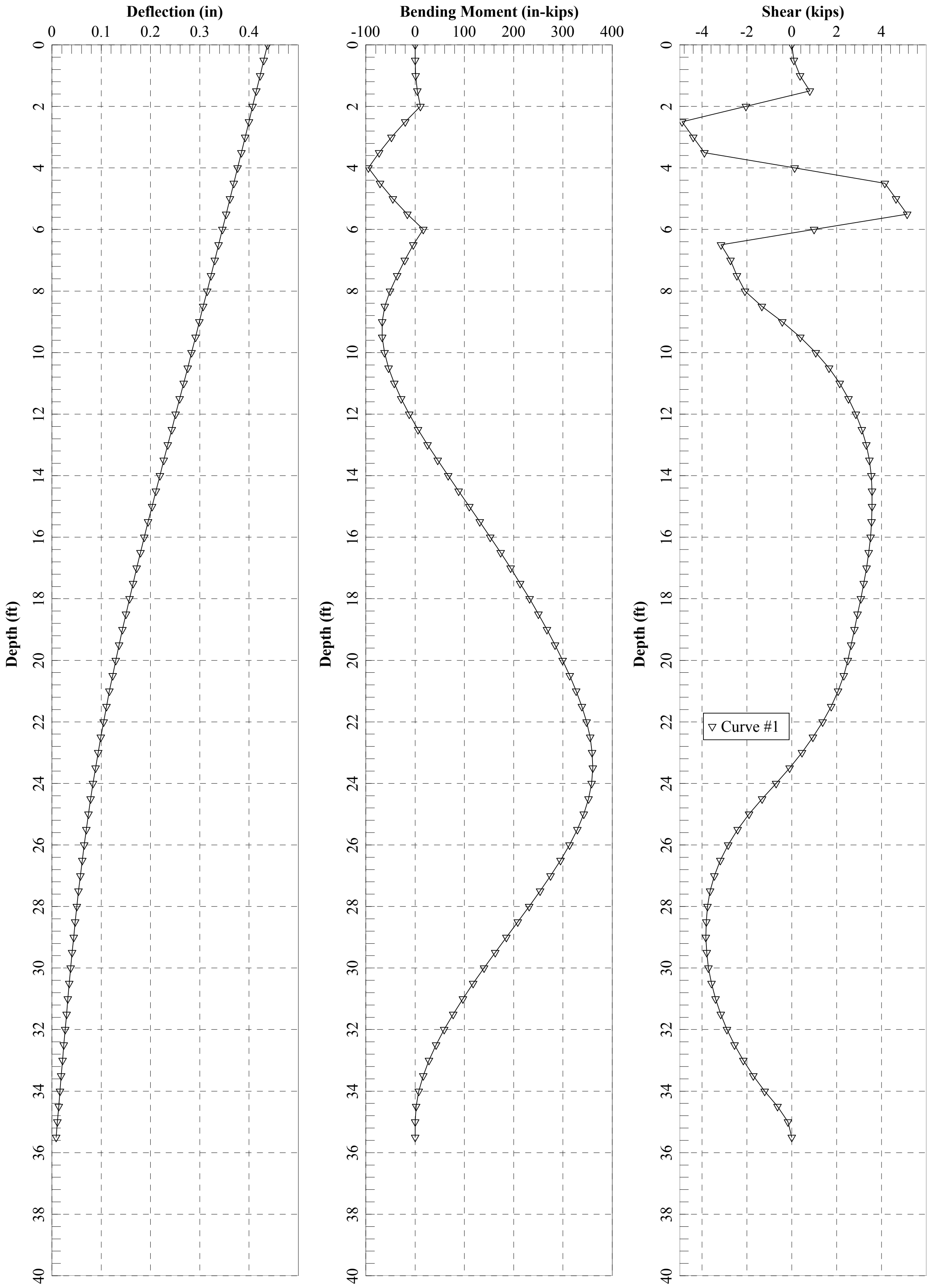


Figure E.8: Lateral Deflection, Bending Moment and Shear Force with Depth for 8 ft Double Sheet Pile Wall at Seismic Loading for Zone 4 to 7.

Attachment C1-F

Output from PYWall Analysis for 8 ft Double Sheet Pile Wall in Soil Area 4

```
==========================================================================

                 PYWALL for Windows, Version 2015.5.4

                  Serial Number :  166868598

                  A Program for the Analysis of
                  Flexible Retaining Walls
                (c) Copyright ENSOFT, Inc., 1987-2015
                      All Rights Reserved

==========================================================================


This program is licensed to :

AECOM / URS Corp
Clifton, NJ

Path to file locations      : Z:\Meadowlands\Feasibility Analysis for Flood Protection\Braced Sheet
Piles\PYWall Analysis\8 ft Full Flood Stage\
Name of input data file     : Zone4_8ft_Braced_Sheet_Pile_Wall_Full_Flood_Stage_Final_Total35ft.py5d
Name of output file         : Zone4_8ft_Braced_Sheet_Pile_Wall_Full_Flood_Stage_Final_Total35ft.py5o
Name of plot output file    : Zone4_8ft_Braced_Sheet_Pile_Wall_Full_Flood_Stage_Final_Total35ft.py5p

--------------------------------------------------------------------------
                     Time and Date of Analysis
--------------------------------------------------------------------------

          Date:  December 23, 2016     Time:  15:56:06

 New Meadowlands_Zone4_6ft_Braced_Wall_Full_Flood_Stage


 **************************************************
 *        PROGRAM CONTROL PARAMETERS              *
 **************************************************

 NO OF POINTS FOR SPECIFIED DEFLECTIONS AND SLOPES  =  0
 NO OF POINTS FOR WALL STIFFNESS AND LOAD DATA      =  1
 GENERATE EARTH PRESSURE INTERNALLY                 =  1
 GENERATE SOIL RESISTANCE (P-Y) CURVES INTERNALLY   =  1
 NO OF P-Y MODIFICATION FACTORS FOR GEN. P-Y CURVES =  0
 NO OF USER-SPECIFIED SOIL RESISTANCE (P-Y) CURVES  =  0
 NUMBER OF INCREMENTS                               =  75
 INCREMENT LENGTH                                   =   6.000 IN
 FREE HEIGHT OF WALL                                =  96.000 IN
 MAXIMUM ALLOWABLE DEFLECTION                       =  10.000 IN
 DEFLECTION CLOSURE TOLERANCE                       = 0.00001 IN



 **************************************************
 *        STIFFNESS AND LOAD DATA                 *
 **************************************************
 EI - FLEXURAL RIGIDITY,  Q - TRANSVERSE LOAD,
 S - STIFFNESS OF TRANSVERSE RESISTANCE,
 T - TORQUE,              P - AXIAL LOAD,
 R - STIFFNESS OF TORSIONAL RESISTANCE.

FROM TO CONTD     EI         Q        S'        T         R         P

              LBS-IN**2     LBS     LBS/IN    IN-LBS   IN-LBS     LBS
  0  75  0  0.583E+11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  4   4  0  0.583E+11 0.000E+00 0.184E+05 0.000E+00 0.000E+00 0.000E+00
 12  12  0  0.583E+11 0.000E+00 0.356E+05 0.000E+00 0.000E+00 0.000E+00


 **************************************************
 *               WALL INFORMATION                 *
 **************************************************


 FREE HEIGHT OF WALL                     =  0.960E+02 IN
 WIDTH FOR EARTH PRESSURE, WA            =  0.551E+02 IN
 WIDTH FOR SOIL RESISTANCE, WP           =  0.551E+02 IN
 DEPTH TO THE WATER TABLE AT BACKFILL    =  0.000E+00 IN
 DEPTH TO THE WATER TABLE AT EXCAVATION =  0.960E+02 IN
```

UNIT WEIGHT OF WATER = 0.360E-01 LBS/IN**3
SLOPE OF THE BACKFILL (deg.) = 0.000E+00
MODIFICATION FOR ACTIVE EARTH PRESSURE = 0.100E+01

****
* SURCHARGE INFORMATION *
****

UNIFORM SURFACE PRESSURE = 0.000E+00 LBS/IN**2

****
* SOIL INFORMATION *
****

LAYER NO.	TOTAL THICKNESS IN	COHESION PSI	PHI DEG	TOTAL UNIT WEIGHT PCI	DRAINED T OR F	ZTOP IN
1	96.0	0.0	32.0	0.069	T	0.00
2	144.0	0.0	20.0	0.049	T	96.00
3	636.0	0.0	22.0	0.064	T	240.00

****
* EFFECTIVE OVERBURDEN STRESS *
****

DEPTH IN	STRESS LBS/IN**2
0.000E+00	0.000E+00
0.960E+02	0.321E+01
0.240E+03	0.511E+01

****
* ACTIVE AND PASSIVE EARTH PRESSURE COEFFICIENT *
****

LAYER NO.	ACTIVE EARTH COEFFICIENT	PASSIVE EARTH COEFFICIENT
1	0.307E+00	0.325E+01
2	0.490E+00	0.204E+01
3	0.455E+00	0.220E+01

****
* ACTIVE EARTH PRESSURE OF EACH LAYER *
****

LAYER NO	PA1 LBS/IN**2	Z1 IN	PA2 LBS/IN**2	Z2 IN	PA3 LBS/IN**2	Z3 IN	PA4 LBS/IN**2
1	0.00	48.00	47.35	64.00	0.00	0.00	0.00

****
* ACTIVE WATER PRESSURE OF EACH LAYER *
****

LAYER NO	PW1	Z1	PW2	Z2
1	0.00	48.00	165.89	64.00

DEPTH IN	ACTIVE EARTH PRESSURE LBS/IN
0.000E+00	0.000E+00
0.600E+01	0.672E+02
0.120E+02	0.134E+03
0.180E+02	0.179E+03
0.240E+02	0.179E+03
0.300E+02	0.179E+03

0.360E+02	0.179E+03
0.420E+02	0.179E+03
0.480E+02	0.179E+03
0.540E+02	0.179E+03
0.600E+02	0.179E+03
0.660E+02	0.179E+03
0.720E+02	0.179E+03
0.780E+02	0.179E+03
0.840E+02	0.134E+03
0.900E+02	0.672E+02
0.960E+02	0.000E+00
0.101E+03	0.865E+02
0.107E+03	0.865E+02
0.113E+03	0.865E+02
0.119E+03	0.865E+02
0.125E+03	0.865E+02
0.131E+03	0.865E+02
0.137E+03	0.865E+02
0.143E+03	0.865E+02
0.149E+03	0.865E+02
0.155E+03	0.865E+02
0.161E+03	0.865E+02
0.167E+03	0.865E+02
0.173E+03	0.865E+02
0.179E+03	0.865E+02
0.185E+03	0.865E+02
0.191E+03	0.865E+02
0.197E+03	0.865E+02
0.203E+03	0.865E+02
0.209E+03	0.865E+02
0.215E+03	0.865E+02
0.221E+03	0.865E+02
0.227E+03	0.865E+02
0.233E+03	0.865E+02
0.239E+03	0.865E+02
0.245E+03	0.805E+02
0.251E+03	0.805E+02
0.257E+03	0.805E+02
0.263E+03	0.805E+02
0.269E+03	0.805E+02
0.275E+03	0.805E+02
0.281E+03	0.805E+02
0.287E+03	0.805E+02
0.293E+03	0.805E+02
0.299E+03	0.805E+02
0.305E+03	0.805E+02
0.311E+03	0.805E+02
0.317E+03	0.805E+02
0.323E+03	0.805E+02
0.329E+03	0.805E+02
0.335E+03	0.805E+02
0.341E+03	0.805E+02
0.347E+03	0.805E+02
0.353E+03	0.805E+02
0.359E+03	0.805E+02
0.365E+03	0.805E+02
0.371E+03	0.805E+02
0.377E+03	0.805E+02
0.383E+03	0.805E+02
0.389E+03	0.805E+02
0.395E+03	0.805E+02
0.401E+03	0.805E+02
0.407E+03	0.805E+02
0.413E+03	0.805E+02
0.419E+03	0.805E+02
0.425E+03	0.805E+02
0.431E+03	0.805E+02
0.437E+03	0.805E+02
0.443E+03	0.805E+02
0.449E+03	0.805E+02

```
**************************************************
*        SOIL LAYERS AND STRENGTH DATA           *
**************************************************
```

X AT THE SURFACE OF EXCAVATION SIDE = 96.00 IN

2 LAYER(S) OF SOIL

LAYER 1
THE SOIL IS A SILT

LAYER 2
THE SOIL IS A SILT

DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH
4 POINTS

X,IN	WEIGHT,LBS/IN**3
96.0000	0.1319D-01
240.0000	0.1319D-01
240.0000	0.2766D-01
876.0000	0.2766D-01

DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH
4 POINTS

X,IN	S,LBS/IN**2	PHI,DEGREES	E50
96.00	0.0000D+00	20.000	0.2000D-01
240.00	0.0000D+00	20.000	0.2000D-01
240.00	0.0000D+00	22.000	0.2000D-01
462.00	0.0000D+00	22.000	0.2000D-01

P-Y CURVES DATA

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
0.10	55.12	20.0	0.132E-01	2.83	2.14	0.727E-01	0.192E+00

Y IN	P LBS/IN
0.000E+00	-0.868E+02
0.766E-01	-0.865E+02
0.153E+00	-0.864E+02
0.230E+00	-0.864E+02
0.306E+00	-0.864E+02
0.383E+00	-0.864E+02
0.459E+00	-0.864E+02
0.536E+00	-0.863E+02
0.612E+00	-0.863E+02
0.689E+00	-0.863E+02
0.766E+00	-0.863E+02
0.842E+00	-0.863E+02
0.919E+00	-0.863E+02
0.207E+01	-0.862E+02
0.572E+02	-0.862E+02
0.112E+03	-0.862E+02
0.167E+03	-0.862E+02

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
96.10	55.12	20.0	0.132E-01	1.62	1.16	0.699E+02	0.184E+03

Y IN	P LBS/IN
0.000E+00	0.868E+02
0.766E-01	0.244E+03
0.153E+00	0.272E+03
0.230E+00	0.291E+03
0.306E+00	0.305E+03
0.383E+00	0.317E+03
0.459E+00	0.327E+03

0.536E+00	0.336E+03
0.612E+00	0.345E+03
0.689E+00	0.352E+03
0.766E+00	0.359E+03
0.842E+00	0.365E+03
0.919E+00	0.371E+03
0.207E+01	0.456E+03
0.572E+02	0.456E+03
0.112E+03	0.456E+03
0.167E+03	0.456E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
36.00	55.12	20.0	0.132E-01	2.37	1.74	0.262E+02	0.690E+02

Y IN	P LBS/IN
0.000E+00	-0.868E+02
0.766E-01	-0.539E+01
0.153E+00	0.907E+01
0.230E+00	0.187E+02
0.306E+00	0.261E+02
0.383E+00	0.322E+02
0.459E+00	0.374E+02
0.536E+00	0.420E+02
0.612E+00	0.462E+02
0.689E+00	0.499E+02
0.766E+00	0.533E+02
0.842E+00	0.565E+02
0.919E+00	0.595E+02
0.207E+01	0.103E+03
0.572E+02	0.103E+03
0.112E+03	0.103E+03
0.167E+03	0.103E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
132.00	55.12	20.0	0.132E-01	1.28	0.90	0.960E+02	0.253E+03

Y IN	P LBS/IN
0.000E+00	0.868E+02
0.766E-01	0.265E+03
0.153E+00	0.298E+03
0.230E+00	0.319E+03
0.306E+00	0.336E+03
0.383E+00	0.349E+03
0.459E+00	0.361E+03
0.536E+00	0.371E+03
0.612E+00	0.380E+03
0.689E+00	0.389E+03
0.766E+00	0.397E+03
0.842E+00	0.404E+03
0.919E+00	0.410E+03
0.207E+01	0.507E+03
0.572E+02	0.507E+03
0.112E+03	0.507E+03
0.167E+03	0.507E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí

72.00	55.12	20.0	0.132E-01	1.90	1.37	0.523E+02	0.138E+03

Y IN	P LBS/IN
0.000E+00	-0.868E+02
0.766E-01	0.473E+02
0.153E+00	0.713E+02
0.230E+00	0.873E+02
0.306E+00	0.996E+02
0.383E+00	0.110E+03
0.459E+00	0.118E+03
0.536E+00	0.126E+03
0.612E+00	0.133E+03
0.689E+00	0.139E+03
0.766E+00	0.145E+03
0.842E+00	0.150E+03
0.919E+00	0.155E+03
0.207E+01	0.227E+03
0.572E+02	0.227E+03
0.112E+03	0.227E+03
0.167E+03	0.227E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
168.00	55.12	20.0	0.132E-01	1.05	0.70	0.122E+03	0.322E+03

Y IN	P LBS/IN
0.000E+00	0.868E+02
0.766E-01	0.269E+03
0.153E+00	0.305E+03
0.230E+00	0.329E+03
0.306E+00	0.348E+03
0.383E+00	0.364E+03
0.459E+00	0.377E+03
0.536E+00	0.389E+03
0.612E+00	0.400E+03
0.689E+00	0.410E+03
0.766E+00	0.419E+03
0.842E+00	0.427E+03
0.919E+00	0.435E+03
0.207E+01	0.548E+03
0.572E+02	0.548E+03
0.112E+03	0.548E+03
0.167E+03	0.548E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
108.00	55.12	20.0	0.132E-01	1.50	1.07	0.785E+02	0.207E+03

Y IN	P LBS/IN
0.000E+00	-0.868E+02
0.766E-01	0.780E+02
0.153E+00	0.108E+03
0.230E+00	0.128E+03
0.306E+00	0.143E+03
0.383E+00	0.156E+03
0.459E+00	0.167E+03
0.536E+00	0.176E+03
0.612E+00	0.185E+03
0.689E+00	0.193E+03
0.766E+00	0.200E+03
0.842E+00	0.207E+03
0.919E+00	0.213E+03
0.207E+01	0.303E+03
0.572E+02	0.303E+03

0.112E+03	0.303E+03
0.167E+03	0.303E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
204.00	55.12	20.0	0.132E-01	0.95	0.58	0.148E+03	0.391E+03

Y IN	P LBS/IN
0.000E+00	0.868E+02
0.766E-01	0.264E+03
0.153E+00	0.306E+03
0.230E+00	0.334E+03
0.306E+00	0.357E+03
0.383E+00	0.376E+03
0.459E+00	0.392E+03
0.536E+00	0.407E+03
0.612E+00	0.420E+03
0.689E+00	0.432E+03
0.766E+00	0.443E+03
0.842E+00	0.454E+03
0.919E+00	0.463E+03
0.207E+01	0.606E+03
0.572E+02	0.606E+03
0.112E+03	0.606E+03
0.167E+03	0.606E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
143.90	55.12	20.0	0.132E-01	1.19	0.83	0.105E+03	0.276E+03

Y IN	P LBS/IN
0.000E+00	-0.868E+02
0.766E-01	0.953E+02
0.153E+00	0.129E+03
0.230E+00	0.151E+03
0.306E+00	0.168E+03
0.383E+00	0.182E+03
0.459E+00	0.194E+03
0.536E+00	0.205E+03
0.612E+00	0.215E+03
0.689E+00	0.223E+03
0.766E+00	0.231E+03
0.842E+00	0.239E+03
0.919E+00	0.246E+03
0.207E+01	0.347E+03
0.572E+02	0.347E+03
0.112E+03	0.347E+03
0.167E+03	0.347E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
239.90	55.12	20.0	0.132E-01	0.89	0.52	0.174E+03	0.460E+03

Y IN	P LBS/IN
0.000E+00	0.868E+02
0.766E-01	0.268E+03
0.153E+00	0.315E+03
0.230E+00	0.347E+03

0.306E+00	0.374E+03
0.383E+00	0.396E+03
0.459E+00	0.415E+03
0.536E+00	0.432E+03
0.612E+00	0.448E+03
0.689E+00	0.462E+03
0.766E+00	0.476E+03
0.842E+00	0.488E+03
0.919E+00	0.500E+03
0.207E+01	0.672E+03
0.572E+02	0.672E+03
0.112E+03	0.672E+03
0.167E+03	0.672E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
144.10	55.12	22.0	0.132E-01	1.34	0.94	0.105E+03	0.301E+03

Y IN	P LBS/IN
0.000E+00	-0.805E+02
0.766E-01	0.131E+03
0.153E+00	0.170E+03
0.230E+00	0.197E+03
0.306E+00	0.217E+03
0.383E+00	0.234E+03
0.459E+00	0.248E+03
0.536E+00	0.261E+03
0.612E+00	0.272E+03
0.689E+00	0.282E+03
0.766E+00	0.292E+03
0.842E+00	0.301E+03
0.919E+00	0.309E+03
0.207E+01	0.429E+03
0.572E+02	0.429E+03
0.112E+03	0.429E+03
0.167E+03	0.429E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
240.10	55.12	22.0	0.132E-01	0.90	0.53	0.175E+03	0.502E+03

Y IN	P LBS/IN
0.000E+00	0.805E+02
0.766E-01	0.271E+03
0.153E+00	0.321E+03
0.230E+00	0.356E+03
0.306E+00	0.385E+03
0.383E+00	0.408E+03
0.459E+00	0.429E+03
0.536E+00	0.448E+03
0.612E+00	0.465E+03
0.689E+00	0.480E+03
0.766E+00	0.495E+03
0.842E+00	0.508E+03
0.919E+00	0.521E+03
0.207E+01	0.707E+03
0.572E+02	0.707E+03
0.112E+03	0.707E+03
0.167E+03	0.707E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
199.50	55.12	22.0	0.172E-01	1.01	0.66	0.189E+03	0.544E+03

Y IN	P LBS/IN
0.000E+00	-0.805E+02
0.766E-01	0.191E+03
0.153E+00	0.250E+03
0.230E+00	0.290E+03
0.306E+00	0.321E+03
0.383E+00	0.347E+03
0.459E+00	0.370E+03
0.536E+00	0.390E+03
0.612E+00	0.408E+03
0.689E+00	0.425E+03
0.766E+00	0.440E+03
0.842E+00	0.454E+03
0.919E+00	0.467E+03
0.207E+01	0.661E+03
0.572E+02	0.661E+03
0.112E+03	0.661E+03
0.167E+03	0.661E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
295.50	55.12	22.0	0.172E-01	0.88	0.50	0.280E+03	0.806E+03

Y IN	P LBS/IN
0.000E+00	0.805E+02
0.766E-01	0.361E+03
0.153E+00	0.440E+03
0.230E+00	0.496E+03
0.306E+00	0.541E+03
0.383E+00	0.580E+03
0.459E+00	0.614E+03
0.536E+00	0.644E+03
0.612E+00	0.671E+03
0.689E+00	0.697E+03
0.766E+00	0.721E+03
0.842E+00	0.743E+03
0.919E+00	0.764E+03
0.207E+01	0.107E+04
0.572E+02	0.107E+04
0.112E+03	0.107E+04
0.167E+03	0.107E+04

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
255.00	55.12	22.0	0.195E-01	0.89	0.52	0.274E+03	0.787E+03

Y IN	P LBS/IN
0.000E+00	-0.805E+02
0.766E-01	0.211E+03
0.153E+00	0.290E+03
0.230E+00	0.345E+03
0.306E+00	0.389E+03
0.383E+00	0.426E+03
0.459E+00	0.459E+03
0.536E+00	0.488E+03
0.612E+00	0.515E+03
0.689E+00	0.540E+03
0.766E+00	0.562E+03
0.842E+00	0.584E+03

0.919E+00	0.604E+03
0.207E+01	0.898E+03
0.572E+02	0.898E+03
0.112E+03	0.898E+03
0.167E+03	0.898E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
351.00	55.12	22.0	0.195E-01	0.88	0.50	0.377E+03	0.108E+04

Y IN	P LBS/IN
0.000E+00	0.805E+02
0.766E-01	0.458E+03
0.153E+00	0.564E+03
0.230E+00	0.640E+03
0.306E+00	0.700E+03
0.383E+00	0.752E+03
0.459E+00	0.797E+03
0.536E+00	0.838E+03
0.612E+00	0.875E+03
0.689E+00	0.909E+03
0.766E+00	0.941E+03
0.842E+00	0.971E+03
0.919E+00	0.100E+04
0.207E+01	0.141E+04
0.572E+02	0.141E+04
0.112E+03	0.141E+04
0.167E+03	0.141E+04

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
310.50	55.12	22.0	0.209E-01	0.88	0.50	0.359E+03	0.103E+04

Y IN	P LBS/IN
0.000E+00	-0.805E+02
0.766E-01	0.278E+03
0.153E+00	0.379E+03
0.230E+00	0.451E+03
0.306E+00	0.509E+03
0.383E+00	0.558E+03
0.459E+00	0.601E+03
0.536E+00	0.640E+03
0.612E+00	0.675E+03
0.689E+00	0.708E+03
0.766E+00	0.738E+03
0.842E+00	0.767E+03
0.919E+00	0.793E+03
0.207E+01	0.119E+04
0.572E+02	0.119E+04
0.112E+03	0.119E+04
0.167E+03	0.119E+04

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
406.50	55.12	22.0	0.209E-01	0.88	0.50	0.469E+03	0.135E+04

Y IN	P LBS/IN
0.000E+00	0.805E+02

0.766E-01	0.550E+03
0.153E+00	0.682E+03
0.230E+00	0.776E+03
0.306E+00	0.852E+03
0.383E+00	0.916E+03
0.459E+00	0.973E+03
0.536E+00	0.102E+04
0.612E+00	0.107E+04
0.689E+00	0.111E+04
0.766E+00	0.115E+04
0.842E+00	0.119E+04
0.919E+00	0.122E+04
0.207E+01	0.174E+04
0.572E+02	0.174E+04
0.112E+03	0.174E+04
0.167E+03	0.174E+04

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
365.90	55.12	22.0	0.220E-01	0.88	0.50	0.443E+03	0.127E+04

Y IN	P LBS/IN
0.000E+00	-0.805E+02
0.766E-01	0.362E+03
0.153E+00	0.487E+03
0.230E+00	0.576E+03
0.306E+00	0.648E+03
0.383E+00	0.708E+03
0.459E+00	0.762E+03
0.536E+00	0.809E+03
0.612E+00	0.853E+03
0.689E+00	0.893E+03
0.766E+00	0.931E+03
0.842E+00	0.966E+03
0.919E+00	0.999E+03
0.207E+01	0.148E+04
0.572E+02	0.148E+04
0.112E+03	0.148E+04
0.167E+03	0.148E+04

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
461.90	55.12	22.0	0.220E-01	0.88	0.50	0.559E+03	0.161E+04

Y IN	P LBS/IN
0.000E+00	0.805E+02
0.766E-01	0.640E+03
0.153E+00	0.797E+03
0.230E+00	0.910E+03
0.306E+00	0.100E+04
0.383E+00	0.108E+04
0.459E+00	0.114E+04
0.536E+00	0.120E+04
0.612E+00	0.126E+04
0.689E+00	0.131E+04
0.766E+00	0.136E+04
0.842E+00	0.140E+04
0.919E+00	0.144E+04
0.207E+01	0.205E+04
0.572E+02	0.205E+04
0.112E+03	0.205E+04
0.167E+03	0.205E+04

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

Zone4_8ft_Braced_Sheet_Pile_Wall_Full_Flood_Stage_Final_Total35ft.py5o
New Meadowlands_Zone4_6ft_Braced_Wall_Full_Flood_Stage

RESULTS -- ITERATION 5

STA I	X IN	DEFL. IN	SLOPE	MOMENT LBS-IN	SHEAR LBS	NET REACT/STA LBS	EI LBS-IN**2
0	0.000E+00	0.306E+00	-0.134E-02	-0.449E-07	-0.749E-08	0.000E+00	0.292E+11
1	0.600E+01	0.297E+00	-0.134E-02	-0.899E-07	0.202E+03	0.403E+03	0.583E+11
2	0.120E+02	0.289E+00	-0.134E-02	0.242E+04	0.807E+03	0.807E+03	0.583E+11
3	0.180E+02	0.281E+00	-0.134E-02	0.968E+04	0.175E+04	0.107E+04	0.583E+11
4	0.240E+02	0.273E+00	-0.134E-02	0.234E+05	0.302E+03	-0.397E+04	0.583E+11
5	0.300E+02	0.265E+00	-0.133E-02	0.133E+05	-0.114E+04	0.107E+04	0.583E+11
6	0.360E+02	0.257E+00	-0.133E-02	0.968E+04	-0.682E+02	0.107E+04	0.583E+11
7	0.420E+02	0.249E+00	-0.133E-02	0.125E+05	0.101E+04	0.107E+04	0.583E+11
8	0.480E+02	0.241E+00	-0.133E-02	0.218E+05	0.208E+04	0.107E+04	0.583E+11
9	0.540E+02	0.233E+00	-0.133E-02	0.375E+05	0.316E+04	0.107E+04	0.583E+11
10	0.600E+02	0.225E+00	-0.132E-02	0.596E+05	0.423E+04	0.107E+04	0.583E+11
11	0.660E+02	0.218E+00	-0.132E-02	0.882E+05	0.531E+04	0.107E+04	0.583E+11
12	0.720E+02	0.210E+00	-0.130E-02	0.123E+06	0.265E+04	-0.640E+04	0.583E+11
13	0.780E+02	0.202E+00	-0.129E-02	0.120E+06	-0.143E+02	0.107E+04	0.583E+11
14	0.840E+02	0.194E+00	-0.128E-02	0.123E+06	0.927E+03	0.807E+03	0.583E+11
15	0.900E+02	0.187E+00	-0.127E-02	0.131E+06	0.153E+04	0.403E+03	0.583E+11
16	0.960E+02	0.179E+00	-0.125E-02	0.142E+06	0.186E+04	0.259E+03	0.583E+11
17	0.102E+03	0.172E+00	-0.124E-02	0.153E+06	0.220E+04	0.421E+03	0.583E+11
18	0.108E+03	0.164E+00	-0.122E-02	0.168E+06	0.258E+04	0.325E+03	0.583E+11
19	0.114E+03	0.157E+00	-0.120E-02	0.184E+06	0.285E+04	0.231E+03	0.583E+11
20	0.120E+03	0.150E+00	-0.118E-02	0.202E+06	0.304E+04	0.139E+03	0.583E+11
21	0.126E+03	0.143E+00	-0.116E-02	0.221E+06	0.313E+04	0.508E+02	0.583E+11
22	0.132E+03	0.136E+00	-0.114E-02	0.240E+06	0.314E+04	-0.349E+02	0.583E+11
23	0.138E+03	0.129E+00	-0.111E-02	0.259E+06	0.308E+04	-0.864E+02	0.583E+11
24	0.144E+03	0.122E+00	-0.108E-02	0.277E+06	0.297E+04	-0.137E+03	0.583E+11
25	0.150E+03	0.116E+00	-0.105E-02	0.294E+06	0.281E+04	-0.185E+03	0.583E+11
26	0.156E+03	0.110E+00	-0.102E-02	0.310E+06	0.260E+04	-0.233E+03	0.583E+11
27	0.162E+03	0.104E+00	-0.990E-03	0.325E+06	0.234E+04	-0.279E+03	0.583E+11
28	0.168E+03	0.979E-01	-0.956E-03	0.339E+06	0.204E+04	-0.324E+03	0.583E+11
29	0.174E+03	0.923E-01	-0.921E-03	0.350E+06	0.171E+04	-0.345E+03	0.583E+11
30	0.180E+03	0.869E-01	-0.884E-03	0.359E+06	0.135E+04	-0.366E+03	0.583E+11
31	0.186E+03	0.817E-01	-0.847E-03	0.366E+06	0.975E+03	-0.387E+03	0.583E+11
32	0.192E+03	0.767E-01	-0.809E-03	0.371E+06	0.578E+03	-0.407E+03	0.583E+11
33	0.198E+03	0.720E-01	-0.771E-03	0.373E+06	0.185E+03	-0.379E+03	0.583E+11
34	0.204E+03	0.675E-01	-0.732E-03	0.373E+06	-0.180E+03	-0.350E+03	0.583E+11
35	0.210E+03	0.632E-01	-0.694E-03	0.371E+06	-0.509E+03	-0.309E+03	0.583E+11
36	0.216E+03	0.591E-01	-0.656E-03	0.367E+06	-0.798E+03	-0.269E+03	0.583E+11
37	0.222E+03	0.553E-01	-0.619E-03	0.361E+06	-0.105E+04	-0.230E+03	0.583E+11
38	0.228E+03	0.517E-01	-0.582E-03	0.354E+06	-0.126E+04	-0.193E+03	0.583E+11
39	0.234E+03	0.483E-01	-0.546E-03	0.346E+06	-0.143E+04	-0.157E+03	0.583E+11
40	0.240E+03	0.451E-01	-0.511E-03	0.337E+06	-0.158E+04	-0.123E+03	0.583E+11
41	0.246E+03	0.422E-01	-0.477E-03	0.327E+06	-0.170E+04	-0.118E+03	0.583E+11
42	0.252E+03	0.394E-01	-0.443E-03	0.317E+06	-0.181E+04	-0.111E+03	0.583E+11
43	0.258E+03	0.369E-01	-0.411E-03	0.306E+06	-0.192E+04	-0.104E+03	0.583E+11
44	0.264E+03	0.345E-01	-0.381E-03	0.294E+06	-0.202E+04	-0.953E+02	0.583E+11
45	0.270E+03	0.323E-01	-0.351E-03	0.281E+06	-0.211E+04	-0.866E+02	0.583E+11
46	0.276E+03	0.303E-01	-0.323E-03	0.268E+06	-0.219E+04	-0.777E+02	0.583E+11
47	0.282E+03	0.284E-01	-0.296E-03	0.255E+06	-0.226E+04	-0.689E+02	0.583E+11
48	0.288E+03	0.267E-01	-0.270E-03	0.241E+06	-0.233E+04	-0.605E+02	0.583E+11
49	0.294E+03	0.252E-01	-0.246E-03	0.227E+06	-0.239E+04	-0.526E+02	0.583E+11
50	0.300E+03	0.238E-01	-0.223E-03	0.213E+06	-0.242E+04	-0.264E+02	0.583E+11
51	0.306E+03	0.225E-01	-0.202E-03	0.198E+06	-0.244E+04	-0.264E+01	0.583E+11
52	0.312E+03	0.214E-01	-0.183E-03	0.183E+06	-0.243E+04	0.189E+02	0.583E+11
53	0.318E+03	0.203E-01	-0.165E-03	0.169E+06	-0.240E+04	0.383E+02	0.583E+11
54	0.324E+03	0.194E-01	-0.148E-03	0.155E+06	-0.236E+04	0.558E+02	0.583E+11
55	0.330E+03	0.185E-01	-0.133E-03	0.141E+06	-0.229E+04	0.714E+02	0.583E+11
56	0.336E+03	0.178E-01	-0.119E-03	0.127E+06	-0.221E+04	0.853E+02	0.583E+11
57	0.342E+03	0.171E-01	-0.107E-03	0.114E+06	-0.212E+04	0.977E+02	0.583E+11
58	0.348E+03	0.165E-01	-0.955E-04	0.102E+06	-0.202E+04	0.109E+03	0.583E+11
59	0.354E+03	0.160E-01	-0.857E-04	0.897E+05	-0.191E+04	0.119E+03	0.583E+11
60	0.360E+03	0.155E-01	-0.770E-04	0.787E+05	-0.179E+04	0.121E+03	0.583E+11
61	0.366E+03	0.150E-01	-0.694E-04	0.683E+05	-0.166E+04	0.122E+03	0.583E+11
62	0.372E+03	0.146E-01	-0.629E-04	0.587E+05	-0.154E+04	0.123E+03	0.583E+11
63	0.378E+03	0.143E-01	-0.573E-04	0.498E+05	-0.142E+04	0.124E+03	0.583E+11
64	0.384E+03	0.140E-01	-0.526E-04	0.417E+05	-0.129E+04	0.124E+03	0.583E+11
65	0.390E+03	0.137E-01	-0.487E-04	0.343E+05	-0.117E+04	0.124E+03	0.583E+11
66	0.396E+03	0.134E-01	-0.455E-04	0.276E+05	-0.105E+04	0.123E+03	0.583E+11
67	0.402E+03	0.131E-01	-0.430E-04	0.217E+05	-0.925E+03	0.123E+03	0.583E+11
68	0.408E+03	0.129E-01	-0.410E-04	0.165E+05	-0.803E+03	0.122E+03	0.583E+11
69	0.414E+03	0.126E-01	-0.395E-04	0.121E+05	-0.682E+03	0.120E+03	0.583E+11

70	0.420E+03	0.124E-01	-0.385E-04	0.834E+04	-0.563E+03	0.117E+03	0.583E+11
71	0.426E+03	0.122E-01	-0.378E-04	0.531E+04	-0.447E+03	0.115E+03	0.583E+11
72	0.432E+03	0.119E-01	-0.374E-04	0.298E+04	-0.333E+03	0.113E+03	0.583E+11
73	0.438E+03	0.117E-01	-0.371E-04	0.132E+04	-0.221E+03	0.112E+03	0.583E+11
74	0.444E+03	0.115E-01	-0.371E-04	0.328E+03	-0.110E+03	0.110E+03	0.583E+11
75	0.450E+03	0.113E-01	-0.370E-04	0.000E+00	-0.273E+02	0.546E+02	0.292E+11

END OF ANALYSIS

Attachment C1-G

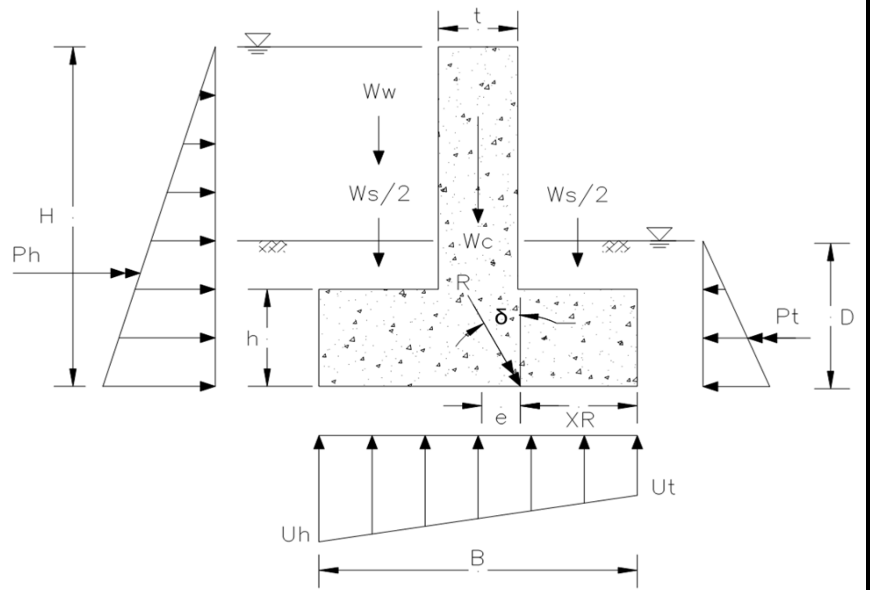
Details of Bearing Capacity Calculations for Flood Walls in Soil Areas 1 to 3

BEARING CAPACITY CALCULATION FOR FLOOD WALL IN SOIL AREA 1 WITH BASE WIDTH 4 FT
New Medowlands Flood Protection
Bergen County, New Jersey

CALCULATED BY: AH **DATE: 11/10/2016** **CHECKED BY: MS**

Input:

Cohesion, c =	1,000	psf
Friction angle, ϕ =	0	deg.
Width of the geometric base, B =	4.0	ft
Depth from the soil surface to the base of the structural wedge, D =	4.0	ft
Height of water level from base on heel side, H =	8.0	ft
Width of top, t =	1.5	ft
Base height, h =	2.0	ft
Total unit weight of overlying soil, γ =	110	pcf
Total unit weight of concrete, γ_c =	150	pcf
Angle ground surface makes with the horizontal, β =	0	deg.
Angle slip plane of structural wedge makes with horizontal, α =	0	deg.
Total weight of concrete, W_c =	2,550	lb
Total weight of soil over base, W_s =	550	lb
Total weight of water over base, W_w =	312	lb
Force due to water pressure on heel side, P_h =	1,997	lb
Force due to water pressure on toe side, P_t =	499	lb
Uplift pressure on heel end, U_h =	499	psf
Uplift pressure on toe end, U_t =	250	psf
Total horizontal force, ΣF_H =	-1,498	lb
Total vertical force, ΣF_V =	1,914	lb
Total moment about the toe end, ΣM =	-734	lb-ft
Distance of resultant force (R) from toe end, X_R =	0.4	ft
Eccentricity of the load with respect to geometric base width, e =	1.6	ft
Effective width of the base, $\overline{B}$ =	0.8	ft
Angle line of action of load makes with line drawn normal to base, δ =	38	deg.
Effective overburden pressure, q_0 =	190	psf
Bearing capacity factor, N_q =	1.00	
Bearing capacity factor, N_c =	5.14	
Bearing capacity factor, N_γ =	0.00	
Embedment factor, ξ_{cd} =	2.04	
Embedment factor, ξ_{qd} =	1.00	
Embedment factor, $\xi_{\gamma d}$ =	1.00	
Inclination factor, ξ_{ci} =	0.33	
Inclination factor, ξ_{qi} =	0.33	
Inclination factor, $\xi_{\gamma i}$ =	0.00	
Base tilt factor, ξ_{qt} =	1.00	
Base tilt factor, $\xi_{\gamma t}$ =	1.00	
Base tilt factor, ξ_{ct} =	1.00	
Ground slope factor, ξ_{qg} =	1.00	
Ground slope factor, $\xi_{\gamma g}$ =	1.00	
Ground slope factor, ξ_{cg} =	1.00	



Sign conventions: ΣF_H: ← +; ΣF_V: ↓ +; ΣM: ↺ +

$$e = \frac{B}{2} - X_R$$

$$\overline{B} = B - 2e$$

$$q_0 = \gamma' D \text{ when } \beta = 0, \gamma' D \cos[\text{abs}(\beta)] \text{ when } \beta > 0$$

$$N_q = \left[e^{(\pi \tan\phi)}\right] \tan^2\left(45^\circ + \frac{\phi}{2}\right)$$

$$N_c = 5.14 \text{ when } \phi = 0, (N_q - 1)\cot\phi \text{ when } \phi > 10^\circ$$

$$N_\gamma = (N_q - 1)\tan(1.4\phi)$$

$$\xi_{cd} = 1 + 0.2\left(\frac{D}{\overline{B}}\right)\tan\left(45^\circ + \frac{\phi}{2}\right)$$

$$\xi_{qd} = \xi_{\gamma d} = 1 \text{ when } \phi = 0, 1 + 0.1\left(\frac{D}{\overline{B}}\right)\tan\left(45^\circ + \frac{\phi}{2}\right) \text{ when } \phi > 10^\circ$$

$$\xi_{ci} = \xi_{qi} = \left(1 - \frac{\delta^\circ}{90^\circ}\right)^2$$

$$\xi_{\gamma i} = 0 \text{ when } \delta > \phi, \left(1 - \frac{\delta^\circ}{\phi^\circ}\right)^2 \text{ when } \delta < \phi$$

$$\xi_{qt} = \xi_{\gamma t} = (1 - \alpha\tan\phi)^2, \alpha \text{ in rad.}$$

$$\xi_{ct} = 1 - \left(\frac{2\alpha}{\pi + 2}\right) \text{ when } \phi = 0, \xi_{qt} - \left(\frac{1 - \xi_{qt}}{N_c \tan\phi}\right) \text{ when } \phi > 0, \alpha \text{ in rad.}$$

$$\xi_{qg} = \xi_{\gamma g} = (1 - \tan\beta)^2$$

$$\xi_{cg} = 1 - \left(\frac{2\beta}{\pi + 2}\right) \text{ when } \phi = 0, \xi_{qg} - \left(\frac{1 - \xi_{qg}}{N_c \tan\phi}\right) \text{ when } \phi > 0, \beta \text{ in rad.}$$

Output:

Normal component of ultimate bearing capacity of the foundation, q_{ult} =	3.6	ksf
Normal component of allowable bearing capacity of the foundation, q_{all} =	1.2	ksf

$$q_{ult} = \left[(\xi_{cd}\,\xi_{ci}\,\xi_{ct}\,\xi_{cg}\,cN_c) + (\xi_{qd}\,\xi_{qi}\,\xi_{qt}\,\xi_{qg}\,q_0 N_q) + \frac{(\xi_{\gamma d}\,\xi_{\gamma i}\,\xi_{\gamma t}\,\xi_{\gamma g}\,\overline{B}\gamma' N_\gamma)}{2}\right]$$

$$q_{all} = \frac{q_{ult}}{3}$$

Reference:

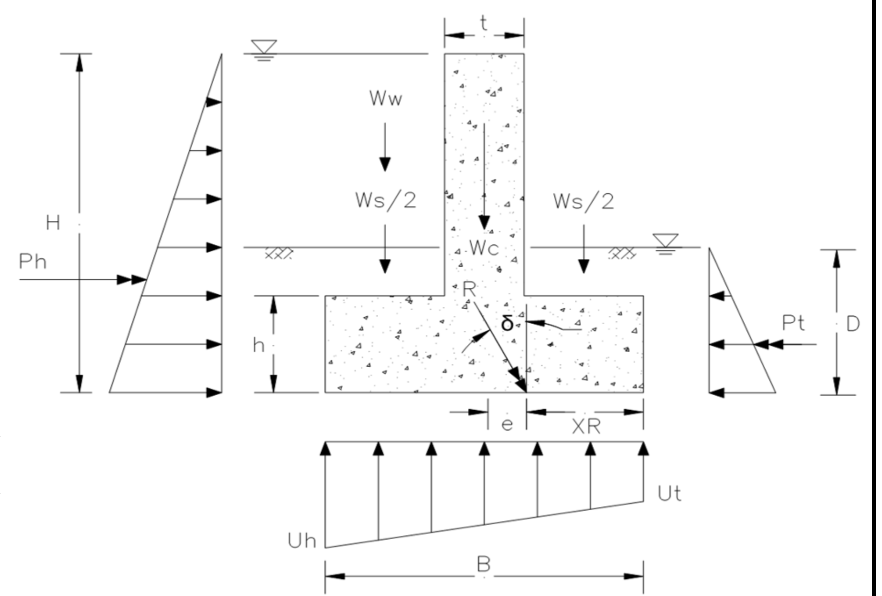
USACE (1989). Engineering and Design, Retaining and Flood Walls, Engineering Manual EM 1110-2-2502, Department of the Army, U. S. Army Corps of Engineers, Washington, DC.

BEARING CAPACITY CALCULATION FOR FLOOD WALL IN SOIL AREA 1 WITH BASE WIDTH 6 FT
New Medowlands Flood Protection
Bergen County, New Jersey

CALCULATED BY: AH | **DATE: 11/10/2016** | **CHECKED BY: MS**

Input:

Cohesion, c =	1,000	psf
Friction angle, ϕ =	0	deg.
Width of the geometric base, B =	6.0	ft
Depth from the soil surface to the base of the structural wedge, D =	4.0	ft
Height of water level from base on heel side, H =	8.0	ft
Width of top, t =	1.5	ft
Base height, h =	2.0	ft
Total unit weight of overlying soil, γ =	110	pcf
Total unit weight of concrete, γ_c =	150	pcf
Angle ground surface makes with the horizontal, β =	0	deg.
Angle slip plane of structural wedge makes with horizontal, α =	0	deg.



Total weight of concrete, W_c =	3,150	lb	
Total weight of soil over base, W_s =	990	lb	
Total weight of water over base, W_w =	562	lb	
Force due to water pressure on heel side, P_h =	1,997	lb	
Force due to water pressure on toe side, P_t =	499	lb	
Uplift pressure on heel end, U_h =	499	psf	
Uplift pressure on toe end, U_t =	250	psf	
Total horizontal force, ΣF_H =	-1,498	lb	← +
Total vertical force, ΣF_V =	2,455	lb	↓ +
Total moment about the toe end, ΣM =	3,011	lb-ft	+ (counterclockwise)
Distance of resultant force (R) from toe end, X_R =	1.2	ft	
Eccentricity of the load with respect to geometric base width, e =	1.8	ft	$e = \frac{B}{2} - X_R$
Effective width of the base, $\overline{B}$ =	2.5	ft	$\overline{B} = B - 2e$
Angle line of action of load makes with line drawn normal to base, δ =	31	deg.	
Effective overburden pressure, q_0 =	190	psf	$q_0 = \gamma' D$ when $\beta = 0$, $\gamma' D \cos[\text{abs}(\beta)]$ when $\beta > 0$
Bearing capacity factor, N_q =	1.00		$N_q = [e^{(\pi \tan\phi)}] \tan^2\left(45^\circ + \frac{\phi}{2}\right)$
Bearing capacity factor, N_c =	5.14		$N_c = 5.14$ when $\phi = 0$, $(N_q - 1)\cot\phi$ when $\phi > 10^\circ$
Bearing capacity factor, N_γ =	0.00		$N_\gamma = (N_q - 1)\tan(1.4\phi)$
Embedment factor, ξ_{cd} =	1.33		$\xi_{cd} = 1 + 0.2\left(\frac{D}{\overline{B}}\right)\tan\left(45^\circ + \frac{\phi}{2}\right)$
Embedment factor, ξ_{qd} =	1.00		$\xi_{qd} = \xi_{\gamma d} = 1$ when $\phi = 0$, $1 + 0.1\left(\frac{D}{\overline{B}}\right)\tan\left(45^\circ + \frac{\phi}{2}\right)$ when $\phi > 10^\circ$
Embedment factor, $\xi_{\gamma d}$ =	1.00		
Inclination factor, ξ_{ci} =	0.42		$\xi_{ci} = \xi_{qi} = \left(1 - \frac{\delta^\circ}{90^\circ}\right)^2$
Inclination factor, ξ_{qi} =	0.42		
Inclination factor, $\xi_{\gamma i}$ =	0.00		$\xi_{\gamma i} = 0$ when $\delta > \phi$, $\left(1 - \frac{\delta^\circ}{\phi^\circ}\right)^2$ when $\delta < \phi$
Base tilt factor, ξ_{qt} =	1.00		$\xi_{qt} = \xi_{\gamma t} = (1 - \alpha \tan\phi)^2$, α in rad.
Base tilt factor, $\xi_{\gamma t}$ =	1.00		
Base tilt factor, ξ_{ct} =	1.00		$\xi_{ct} = 1 - \left(\frac{2\alpha}{\pi + 2}\right)$ when $\phi = 0$, $\xi_{qt} - \left(\frac{1 - \xi_{qt}}{N_c \tan\phi}\right)$ when $\phi > 0$, α in rad.
Ground slope factor, ξ_{qg} =	1.00		$\xi_{qg} = \xi_{\gamma g} = (1 - \tan\beta)^2$
Ground slope factor, $\xi_{\gamma g}$ =	1.00		
Ground slope factor, ξ_{cg} =	1.00		$\xi_{cg} = 1 - \left(\frac{2\beta}{\pi + 2}\right)$ when $\phi = 0$, $\xi_{qg} - \left(\frac{1 - \xi_{qg}}{N_c \tan\phi}\right)$ when $\phi > 0$, β in rad.

Output:

Normal component of ultimate bearing capacity of the foundation, q_{ult} =	3.0	ksf	$q_{ult} = \left[(\xi_{cd}\xi_{ci}\xi_{ct}\xi_{cg} c N_c) + (\xi_{qd}\xi_{qi}\xi_{qt}\xi_{qg} q_0 N_q) + \frac{(\xi_{\gamma d}\xi_{\gamma i}\xi_{\gamma t}\xi_{\gamma g}\overline{B}\gamma' N_\gamma)}{2}\right]$
Normal component of allowable bearing capacity of the foundation, q_{all} =	1.0	ksf	$q_{all} = \frac{q_{ult}}{3}$

Reference:

USACE (1989). Engineering and Design, Retaining and Flood Walls, Engineering Manual EM 1110-2-2502, Department of the Army, U. S. Army Corps of Engineers, Washington, DC.

BEARING CAPACITY CALCULATION FOR FLOOD WALL IN SOIL AREA 1 WITH BASE WIDTH 8 FT

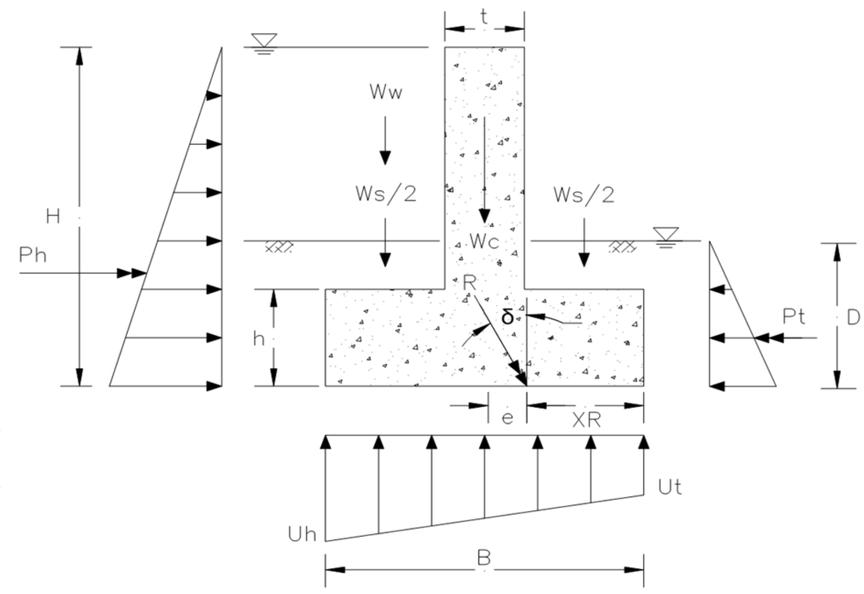
New Medowlands Flood Protection

Bergen County, New Jersey

CALCULATED BY: AH | **DATE: 11/10/2016** | **CHECKED BY: MS**

Input:

Cohesion, c =	1,000	psf	
Friction angle, ϕ =	0	deg.	
Width of the geometric base, B =	8.0	ft	
Depth from the soil surface to the base of the structural wedge, D =	4.0	ft	
Height of water level from base on heel side, H =	8.0	ft	
Width of top, t =	1.5	ft	
Base height, h =	2.0	ft	
Total unit weight of overlying soil, γ =	110	pcf	
Total unit weight of concrete, γ_c =	150	pcf	
Angle ground surface makes with the horizontal, β =	0	deg.	
Angle slip plane of structural wedge makes with horizontal, α =	0	deg.	
Total weight of concrete, W_c =	3,750	lb	
Total weight of soil over base, W_s =	1,430	lb	
Total weight of water over base, W_w =	811	lb	
Force due to water pressure on heel side, P_h =	1,997	lb	
Force due to water pressure on toe side, P_t =	499	lb	
Uplift pressure on heel end, U_h =	499	psf	
Uplift pressure on toe end, U_t =	250	psf	
Total horizontal force, ΣF_H =	-1,498	lb	← +
Total vertical force, ΣF_V =	2,996	lb	↓ +
Total moment about the toe end, ΣM =	7,920	lb-ft	↺ +
Distance of resultant force (R) from toe end, X_R =	2.6	ft	
Eccentricity of the load with respect to geometric base width, e =	1.4	ft	$e = \frac{B}{2} - X_R$
Effective width of the base, $\overline{B}$ =	5.3	ft	$\overline{B} = B - 2e$
Angle line of action of load makes with line drawn normal to base, δ =	27	deg.	
Effective overburden pressure, q_0 =	190	psf	$q_0 = \gamma' D$ when $\beta = 0$, $\gamma' D \cos[\mathrm{abs}(\beta)]$ when $\beta > 0$
Bearing capacity factor, N_q =	1.00		$N_q = [e^{(\pi \tan\phi)}] \tan^2\left(45^\circ + \frac{\phi}{2}\right)$
Bearing capacity factor, N_c =	5.14		$N_c = 5.14$ when $\phi = 0$, $(N_q - 1)\cot\phi$ when $\phi > 10^\circ$
Bearing capacity factor, N_γ =	0.00		$N_\gamma = (N_q - 1)\tan(1.4\phi)$
Embedment factor, ξ_{cd} =	1.15		$\xi_{cd} = 1 + 0.2\left(\frac{D}{\overline{B}}\right)\tan\left(45^\circ + \frac{\phi}{2}\right)$
Embedment factor, ξ_{qd} =	1.00		$\xi_{qd} = \xi_{\gamma d} = 1$ when $\phi = 0$, $1 + 0.1\left(\frac{D}{\overline{B}}\right)\tan\left(45^\circ + \frac{\phi}{2}\right)$ when $\phi > 10^\circ$
Embedment factor, $\xi_{\gamma d}$ =	1.00		
Inclination factor, ξ_{ci} =	0.50		$\xi_{ci} = \xi_{qi} = \left(1 - \frac{\delta^\circ}{90^\circ}\right)^2$
Inclination factor, ξ_{qi} =	0.50		
Inclination factor, $\xi_{\gamma i}$ =	0.00		$\xi_{\gamma i} = 0$ when $\delta > \phi$, $\left(1 - \frac{\delta^\circ}{\phi^\circ}\right)^2$ when $\delta < \phi$
Base tilt factor, ξ_{qt} =	1.00		$\xi_{qt} = \xi_{\gamma t} = (1 - \alpha\tan\phi)^2$, α in rad.
Base tilt factor, $\xi_{\gamma t}$ =	1.00		
Base tilt factor, ξ_{ct} =	1.00		$\xi_{ct} = 1 - \left(\frac{2\alpha}{\pi + 2}\right)$ when $\phi = 0$, $\xi_{qt} - \left(\frac{1 - \xi_{qt}}{N_c \tan\phi}\right)$ when $\phi > 0$, α in rad.
Ground slope factor, ξ_{qg} =	1.00		$\xi_{qg} = \xi_{\gamma g} = (1 - \tan\beta)^2$
Ground slope factor, $\xi_{\gamma g}$ =	1.00		
Ground slope factor, ξ_{cg} =	1.00		$\xi_{cg} = 1 - \left(\frac{2\beta}{\pi + 2}\right)$ when $\phi = 0$, $\xi_{qg} - \left(\frac{1 - \xi_{qg}}{N_c \tan\phi}\right)$ when $\phi > 0$, β in rad.



Output:

Normal component of ultimate bearing capacity of the foundation, q_{ult} =	3.0	ksf	$q_{ult} = \left[(\xi_{cd}\,\xi_{ci}\,\xi_{ct}\,\xi_{cg}\,cN_c) + (\xi_{qd}\,\xi_{qi}\,\xi_{qt}\,\xi_{qg}\,q_0 N_q) + \frac{(\xi_{\gamma d}\,\xi_{\gamma i}\,\xi_{\gamma t}\,\xi_{\gamma g}\,\overline{B}\gamma' N_\gamma)}{2}\right]$
Normal component of allowable bearing capacity of the foundation, q_{all} =	1.0	ksf	$q_{all} = \frac{q_{ult}}{3}$

Reference:

USACE (1989). Engineering and Design, Retaining and Flood Walls, Engineering Manual EM 1110-2-2502, Department of the Army, U. S. Army Corps of Engineers, Washington, DC.

BEARING CAPACITY CALCULATION FOR FLOOD WALL IN SOIL AREAS 2 & 3 WITH BASE WIDTH 4 FT

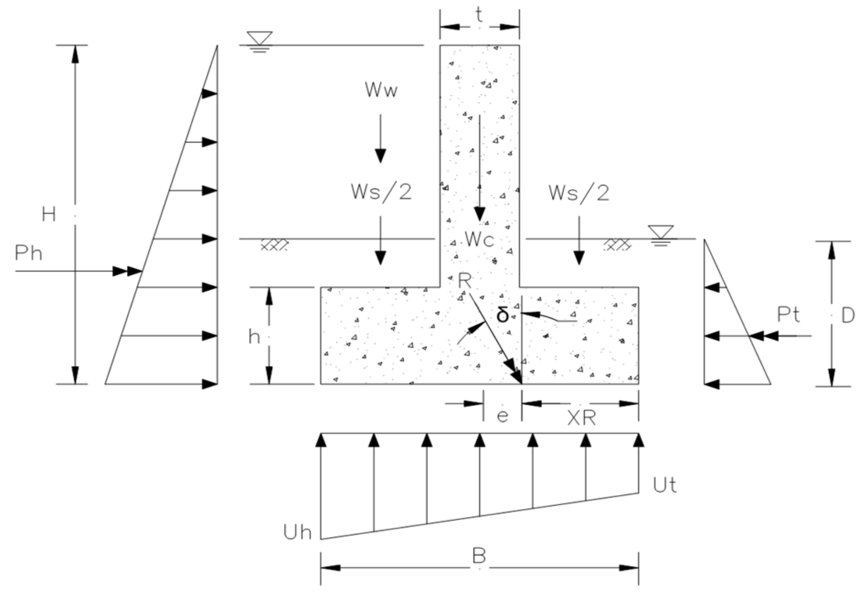
New Medowlands Flood Protection

Bergen County, New Jersey

CALCULATED BY: AH | **DATE: 11/10/2016** | **CHECKED BY: MS**

Input:

Parameter	Value	Unit	Equation
Cohesion, c =	500	psf	
Friction angle, ϕ =	0	deg.	
Width of the geometric base, B =	4.0	ft	
Depth from the soil surface to the base of the structural wedge, D =	4.0	ft	
Height of water level from base on heel side, H =	8.0	ft	
Width of top, t =	1.5	ft	
Base height, h =	2.0	ft	
Total unit weight of overlying soil, γ =	110	pcf	
Total unit weight of concrete, γ_c =	150	pcf	
Angle ground surface makes with the horizontal, β =	0	deg.	
Angle slip plane of structural wedge makes with horizontal, α =	0	deg.	
Total weight of concrete, W_c =	2,550	lb	
Total weight of soil over base, W_s =	550	lb	
Total weight of water over base, W_w =	312	lb	
Force due to water pressure on heel side, P_h =	1,997	lb	
Force due to water pressure on toe side, P_t =	499	lb	
Uplift pressure on heel end, U_h =	499	psf	
Uplift pressure on toe end, U_t =	250	psf	
Total horizontal force, ΣF_H =	-1,498	lb	← +
Total vertical force, ΣF_V =	1,914	lb	↓ +
Total moment about the toe end, ΣM =	-734	lb-ft	+ ↺
Distance of resultant force (R) from toe end, X_R =	0.4	ft	
Eccentricity of the load with respect to geometric base width, e =	1.6	ft	$e = \frac{B}{2} - X_R$
Effective width of the base, $\overline{B}$ =	0.8	ft	$\overline{B} = B - 2e$
Angle line of action of load makes with line drawn normal to base, δ =	38	deg.	
Effective overburden pressure, q_0 =	190	psf	$q_0 = \gamma' D$ when $\beta = 0$, $\gamma' D \cos[\text{abs}(\beta)]$ when $\beta > 0$
Bearing capacity factor, N_q =	1.00		$N_q = \left[e^{(\pi \tan\phi)}\right] \tan^2\left(45^\circ + \frac{\phi}{2}\right)$
Bearing capacity factor, N_c =	5.14		$N_c = 5.14$ when $\phi = 0$, $(N_q - 1)\cot\phi$ when $\phi > 10^\circ$
Bearing capacity factor, N_γ =	0.00		$N_\gamma = (N_q - 1)\tan(1.4\phi)$
Embedment factor, ξ_{cd} =	2.04		$\xi_{cd} = 1 + 0.2\left(\frac{D}{\overline{B}}\right)\tan\left(45^\circ + \frac{\phi}{2}\right)$
Embedment factor, ξ_{qd} =	1.00		$\xi_{qd} = \xi_{\gamma d} = 1$ when $\phi = 0$, $1 + 0.1\left(\frac{D}{\overline{B}}\right)\tan\left(45^\circ + \frac{\phi}{2}\right)$ when $\phi > 10^\circ$
Embedment factor, $\xi_{\gamma d}$ =	1.00		
Inclination factor, ξ_{ci} =	0.33		$\xi_{ci} = \xi_{qi} = \left(1 - \frac{\delta^\circ}{90^\circ}\right)^2$
Inclination factor, ξ_{qi} =	0.33		
Inclination factor, $\xi_{\gamma i}$ =	0.00		$\xi_{\gamma i} = 0$ when $\delta > \phi$, $\left(1 - \frac{\delta^\circ}{\phi^\circ}\right)^2$ when $\delta < \phi$
Base tilt factor, ξ_{qt} =	1.00		$\xi_{qt} = \xi_{\gamma t} = (1 - \alpha \tan\phi)^2$, α in rad.
Base tilt factor, $\xi_{\gamma t}$ =	1.00		
Base tilt factor, ξ_{ct} =	1.00		$\xi_{ct} = 1 - \left(\frac{2\alpha}{\pi + 2}\right)$ when $\phi = 0$, $\xi_{qt} - \left(\frac{1 - \xi_{qt}}{N_c \tan\phi}\right)$ when $\phi > 0$, α in rad.
Ground slope factor, ξ_{qg} =	1.00		$\xi_{qg} = \xi_{\gamma g} = (1 - \tan\beta)^2$
Ground slope factor, $\xi_{\gamma g}$ =	1.00		
Ground slope factor, ξ_{cg} =	1.00		$\xi_{cg} = 1 - \left(\frac{2\beta}{\pi + 2}\right)$ when $\phi = 0$, $\xi_{qg} - \left(\frac{1 - \xi_{qg}}{N_c \tan\phi}\right)$ when $\phi > 0$, β in rad.



Output:

Parameter	Value	Unit	Equation
Normal component of ultimate bearing capacity of the foundation, q_{ult} =	1.8	ksf	$q_{ult} = \left[(\xi_{cd}\xi_{ci}\xi_{ct}\xi_{cg} c N_c) + (\xi_{qd}\xi_{qi}\xi_{qt}\xi_{qg} q_0 N_q) + \frac{(\xi_{\gamma d}\xi_{\gamma i}\xi_{\gamma t}\xi_{\gamma g}\overline{B}\gamma' N_\gamma)}{2}\right]$
Normal component of allowable bearing capacity of the foundation, q_{all} =	0.6	ksf	$q_{all} = \frac{q_{ult}}{3}$

Reference:

USACE (1989). Engineering and Design, Retaining and Flood Walls, Engineering Manual EM 1110-2-2502, Department of the Army, U. S. Army Corps of Engineers, Washington, DC.

BEARING CAPACITY CALCULATION FOR FLOOD WALL IN SOIL AREAS 2 & 3 WITH BASE WIDTH 6 FT

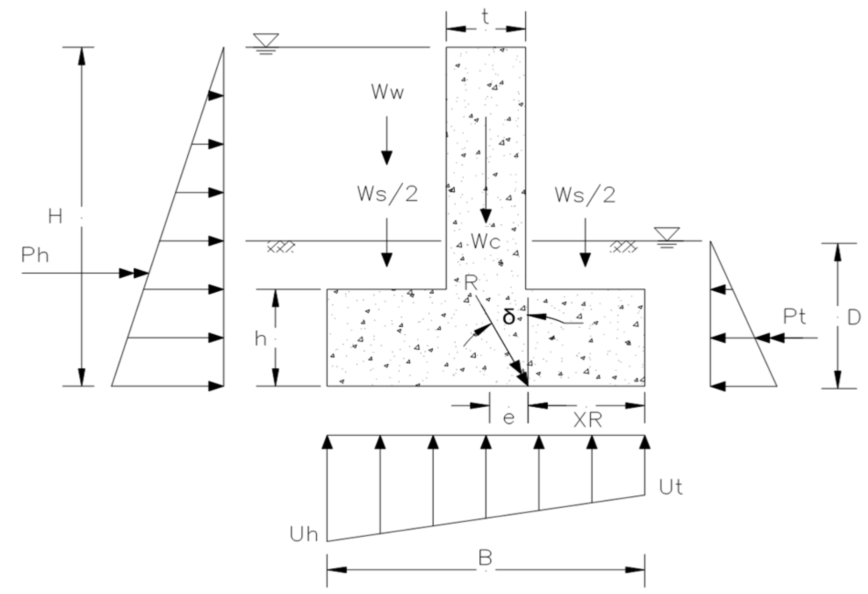
New Medowlands Flood Protection

Bergen County, New Jersey

CALCULATED BY: AH **DATE:** 11/10/2016 **CHECKED BY:** MS

Input:

Parameter	Value	Unit	Formula
Cohesion, c =	500	psf	
Friction angle, ϕ =	0	deg.	
Width of the geometric base, B =	6.0	ft	
Depth from the soil surface to the base of the structural wedge, D =	4.0	ft	
Height of water level from base on heel side, H =	8.0	ft	
Width of top, t =	1.5	ft	
Base height, h =	2.0	ft	
Total unit weight of overlying soil, γ =	110	pcf	
Total unit weight of concrete, γ_c =	150	pcf	
Angle ground surface makes with the horizontal, β =	0	deg.	
Angle slip plane of structural wedge makes with horizontal, α =	0	deg.	
Total weight of concrete, W_c =	3,150	lb	
Total weight of soil over base, W_s =	990	lb	
Total weight of water over base, W_w =	562	lb	
Force due to water pressure on heel side, P_h =	1,997	lb	
Force due to water pressure on toe side, P_t =	499	lb	
Uplift pressure on heel end, U_h =	499	psf	
Uplift pressure on toe end, U_t =	250	psf	
Total horizontal force, ΣF_H =	-1,498	lb	← +
Total vertical force, ΣF_V =	2,455	lb	↓ +
Total moment about the toe end, ΣM =	3,011	lb-ft	+ (counterclockwise)
Distance of resultant force (R) from toe end, X_R =	1.2	ft	
Eccentricity of the load with respect to geometric base width, e =	1.8	ft	$e = \frac{B}{2} - X_R$
Effective width of the base, $\overline{B}$ =	2.5	ft	$\overline{B} = B - 2e$
Angle line of action of load makes with line drawn normal to base, δ =	31	deg.	
Effective overburden pressure, q_0 =	190	psf	$q_0 = \gamma' D$ when $\beta = 0$, $\gamma' D \cos[\text{abs}(\beta)]$ when $\beta > 0$
Bearing capacity factor, N_q =	1.00		$N_q = [e^{(\pi \tan\phi)}] \tan^2\left(45^\circ + \frac{\phi}{2}\right)$
Bearing capacity factor, N_c =	5.14		$N_c = 5.14$ when $\phi = 0$, $(N_q - 1)\cot\phi$ when $\phi > 10^\circ$
Bearing capacity factor, N_γ =	0.00		$N_\gamma = (N_q - 1)\tan(1.4\phi)$
Embedment factor, ξ_{cd} =	1.33		$\xi_{cd} = 1 + 0.2\left(\frac{D}{\overline{B}}\right)\tan\left(45^\circ + \frac{\phi}{2}\right)$
Embedment factor, ξ_{qd} =	1.00		$\xi_{qd} = \xi_{\gamma d} = 1$ when $\phi = 0$, $1 + 0.1\left(\frac{D}{\overline{B}}\right)\tan\left(45^\circ + \frac{\phi}{2}\right)$ when $\phi > 10^\circ$
Embedment factor, $\xi_{\gamma d}$ =	1.00		
Inclination factor, ξ_{ci} =	0.42		$\xi_{ci} = \xi_{qi} = \left(1 - \frac{\delta^\circ}{90^\circ}\right)^2$
Inclination factor, ξ_{qi} =	0.42		
Inclination factor, $\xi_{\gamma i}$ =	0.00		$\xi_{\gamma i} = 0$ when $\delta > \phi$, $\left(1 - \frac{\delta^\circ}{\phi^\circ}\right)^2$ when $\delta < \phi$
Base tilt factor, ξ_{qt} =	1.00		$\xi_{qt} = \xi_{\gamma t} = (1 - \alpha\tan\phi)^2$, α in rad.
Base tilt factor, $\xi_{\gamma t}$ =	1.00		
Base tilt factor, ξ_{ct} =	1.00		$\xi_{ct} = 1 - \left(\frac{2\alpha}{\pi + 2}\right)$ when $\phi = 0$, $\xi_{qt} - \left(\frac{1 - \xi_{qt}}{N_c \tan\phi}\right)$ when $\phi > 0$, α in rad.
Ground slope factor, ξ_{qg} =	1.00		$\xi_{qg} = \xi_{\gamma g} = (1 - \tan\beta)^2$
Ground slope factor, $\xi_{\gamma g}$ =	1.00		
Ground slope factor, ξ_{cg} =	1.00		$\xi_{cg} = 1 - \left(\frac{2\beta}{\pi + 2}\right)$ when $\phi = 0$, $\xi_{qg} - \left(\frac{1 - \xi_{qg}}{N_c \tan\phi}\right)$ when $\phi > 0$, β in rad.



Output:

Parameter	Value	Unit	Formula
Normal component of ultimate bearing capacity of the foundation, q_{ult} =	1.5	ksf	$q_{ult} = \left[(\xi_{cd}\xi_{ci}\xi_{ct}\xi_{cg} cN_c) + (\xi_{qd}\xi_{qi}\xi_{qt}\xi_{qg} q_0 N_q) + \frac{(\xi_{\gamma d}\xi_{\gamma i}\xi_{\gamma t}\xi_{\gamma g}\overline{B}\gamma' N_\gamma)}{2}\right]$
Normal component of allowable bearing capacity of the foundation, q_{all} =	0.5	ksf	$q_{all} = \frac{q_{ult}}{3}$

Reference:

USACE (1989). Engineering and Design, Retaining and Flood Walls, Engineering Manual EM 1110-2-2502, Department of the Army, U. S. Army Corps of Engineers, Washington, DC.

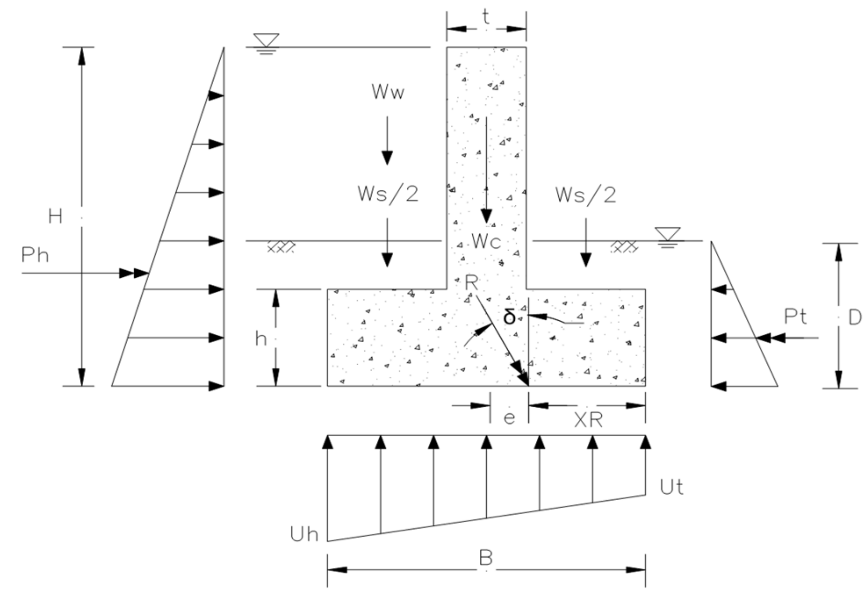
BEARING CAPACITY CALCULATION FOR FLOOD WALL IN SOIL AREAS 2 & 3 WITH BASE WIDTH 8 FT

New Medowlands Flood Protection

Bergen County, New Jersey

CALCULATED BY: AH | **DATE: 11/10/2016** | **CHECKED BY: MS**

Input:



Parameter	Value	Unit	Formula
Cohesion, c =	500	psf	
Friction angle, ϕ =	0	deg.	
Width of the geometric base, B =	8.0	ft	
Depth from the soil surface to the base of the structural wedge, D =	4.0	ft	
Height of water level from base on heel side, H =	8.0	ft	
Width of top, t =	1.5	ft	
Base height, h =	2.0	ft	
Total unit weight of overlying soil, γ =	110	pcf	
Total unit weight of concrete, γ_c =	150	pcf	
Angle ground surface makes with the horizontal, β =	0	deg.	
Angle slip plane of structural wedge makes with horizontal, α =	0	deg.	
Total weight of concrete, W_c =	3,750	lb	
Total weight of soil over base, W_s =	1,430	lb	
Total weight of water over base, W_w =	811	lb	
Force due to water pressure on heel side, P_h =	1,997	lb	
Force due to water pressure on toe side, P_t =	499	lb	
Uplift pressure on heel end, U_h =	499	psf	
Uplift pressure on toe end, U_t =	250	psf	
Total horizontal force, ΣF_H =	-1,498	lb	← +
Total vertical force, ΣF_V =	2,996	lb	↓ +
Total moment about the toe end, ΣM =	7,920	lb-ft	+ (counterclockwise)
Distance of resultant force (R) from toe end, X_R =	2.6	ft	
Eccentricity of the load with respect to geometric base width, e =	1.4	ft	$e = \frac{B}{2} - X_R$
Effective width of the base, $\overline{B}$ =	5.3	ft	$\overline{B} = B - 2e$
Angle line of action of load makes with line drawn normal to base, δ =	27	deg.	
Effective overburden pressure, q_0 =	190	psf	$q_0 = \gamma' D$ when $\beta = 0$, $\gamma' D\cos[\text{abs}(\beta)]$ when $\beta > 0$
Bearing capacity factor, N_q =	1.00		$N_q = \left[e^{(\pi\tan\phi)}\right]\tan^2\left(45^\circ + \frac{\phi}{2}\right)$
Bearing capacity factor, N_c =	5.14		$N_c = 5.14$ when $\phi = 0$, $(N_q - 1)\cot\phi$ when $\phi > 10^\circ$
Bearing capacity factor, N_γ =	0.00		$N_\gamma = (N_q - 1)\tan(1.4\phi)$
Embedment factor, ξ_{cd} =	1.15		$\xi_{cd} = 1 + 0.2\left(\frac{D}{\overline{B}}\right)\tan\left(45^\circ + \frac{\phi}{2}\right)$
Embedment factor, ξ_{qd} =	1.00		$\xi_{qd} = \xi_{\gamma d} = 1$ when $\phi = 0$, $1 + 0.1\left(\frac{D}{\overline{B}}\right)\tan\left(45^\circ + \frac{\phi}{2}\right)$ when $\phi > 10^\circ$
Embedment factor, $\xi_{\gamma d}$ =	1.00		
Inclination factor, ξ_{ci} =	0.50		$\xi_{ci} = \xi_{qi} = \left(1 - \frac{\delta^\circ}{90^\circ}\right)^2$
Inclination factor, ξ_{qi} =	0.50		
Inclination factor, $\xi_{\gamma i}$ =	0.00		$\xi_{\gamma i} = 0$ when $\delta > \phi$, $\left(1 - \frac{\delta^\circ}{\phi^\circ}\right)^2$ when $\delta < \phi$
Base tilt factor, ξ_{qt} =	1.00		$\xi_{qt} = \xi_{\gamma t} = (1 - \alpha\tan\phi)^2$, α in rad.
Base tilt factor, $\xi_{\gamma t}$ =	1.00		
Base tilt factor, ξ_{ct} =	1.00		$\xi_{ct} = 1 - \left(\frac{2\alpha}{\pi + 2}\right)$ when $\phi = 0$, $\xi_{qt} - \left(\frac{1 - \xi_{qt}}{N_c\tan\phi}\right)$ when $\phi > 0$, α in rad.
Ground slope factor, ξ_{qg} =	1.00		$\xi_{qg} = \xi_{\gamma g} = (1 - \tan\beta)^2$
Ground slope factor, $\xi_{\gamma g}$ =	1.00		
Ground slope factor, ξ_{cg} =	1.00		$\xi_{cg} = 1 - \left(\frac{2\beta}{\pi + 2}\right)$ when $\phi = 0$, $\xi_{qg} - \left(\frac{1 - \xi_{qg}}{N_c\tan\phi}\right)$ when $\phi > 0$, β in rad.

Output:

Parameter	Value	Unit	Formula
Normal component of ultimate bearing capacity of the foundation, q_{ult} =	1.6	ksf	$q_{ult} = \left[(\xi_{cd}\xi_{ci}\xi_{ct}\xi_{cg}cN_c) + (\xi_{qd}\xi_{qi}\xi_{qt}\xi_{qg}q_0N_q) + \frac{(\xi_{\gamma d}\xi_{\gamma i}\xi_{\gamma t}\xi_{\gamma g}\overline{B}\gamma' N_\gamma)}{2}\right]$
Normal component of allowable bearing capacity of the foundation, q_{all} =	0.5	ksf	$q_{all} = \frac{q_{ult}}{3}$

Reference:

USACE (1989). Engineering and Design, Retaining and Flood Walls, Engineering Manual EM 1110-2-2502, Department of the Army, U. S. Army Corps of Engineers, Washington, DC.

Attachment C1-H

Details of Primary Consolidation Settlement Analysis for Flood Walls in Soil Areas 1 to 3

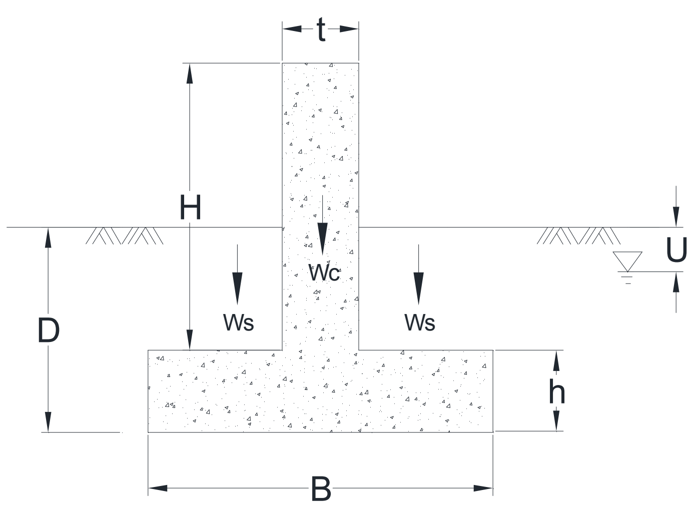
Additional Stress Calculation for Floodwall with 2' Height in Soil Area 3

New Medowlands Flood Protection

Bergen County, New Jersey

Calculated by: LC Date: 11/22/2016 CHECKED BY: MS

Floodwall base, B =	2.5	ft
Depth from ground to base, D =	3.5	ft
Groundwater table, U =	5	ft (below ground surface)
Width of top wall, t =	0.833	ft
Wall height, H=	4.5	ft
Base height, h =	1	ft
Total unit weight of origional soil, γ =	110	pcf
Total unit weight of compacted soil	120	pcf
Total unit weight of concrete, γ_c =	150	pcf
Total weight of concrete, W_c =	937	lb
Total weight of compacted soil over base, W_s =	500	lb
Existing soil pressure	385	psf
Contact pressure	575	psf
Additional pressure	190	psf



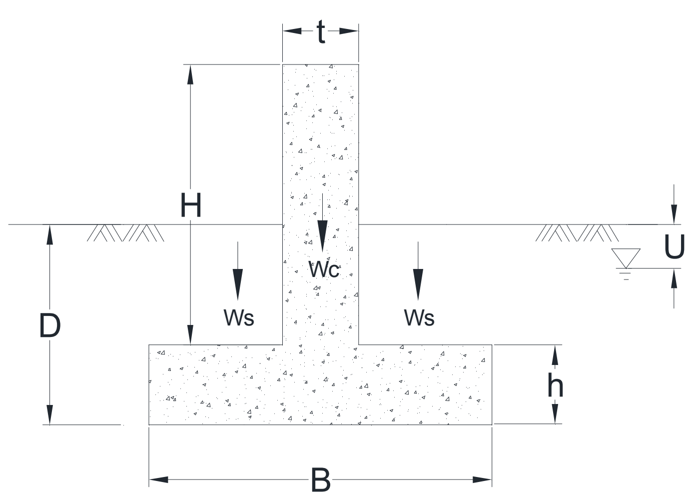
Additional Stress Calculation for Floodwall with 4' Height in Soil Area 3

New Medowlands Flood Protection

Bergen County, New Jersey

Calculated by: LC Date: 11/22/2016 CHECKED BY: MS

Floodwall base, B =	4	ft
Depth from ground to base, D =	3.5	ft
Groundwater table, U =	3	ft (below ground surface)
Width of top wall, t =	1	ft
Wall height, H=	6.5	ft
Base height, h =	1	ft
Total unit weight of origional soil, γ =	110	pcf
Total unit weight of compacted soil	120	pcf
Total unit weight of concrete, γ_c =	150	pcf
Total weight of concrete, W_c =	1450	lb
Total weight of compacted soil over base, W_s =	900	lb
Existing soil pressure	354	psf
Contact pressure	588	psf
Additional pressure	234	psf



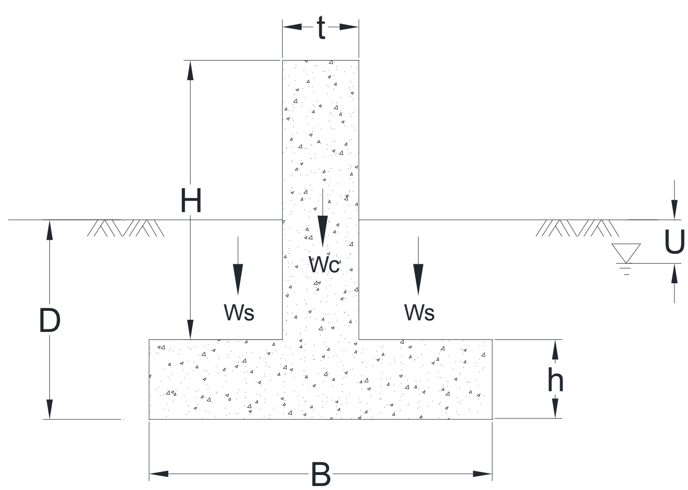
Additional Stress Calculation for Floodwall with 6' Height in Soil Area 3

New Medowlands Flood Protection

Bergen County, New Jersey

Calculated by: LC Date: 11/22/2016 CHECKED BY: MS

Floodwall base, B =	8	ft
Depth from ground to base, D =	4	ft
Groundwater table, U =	1	ft (below ground surface)
Width of top wall, t =	1.5	ft
Wall height, H=	8.5	ft
Base height, h =	1.5	ft
Total unit weight of origional soil, γ =	110	pcf
Total unit weight of compacted soil	120	pcf
Total unit weight of concrete, γ_c =	150	pcf
Total weight of concrete, W_c =	2823	lb
Total weight of compacted soil over base, W_s =	1342	lb
Existing soil pressure	253	psf
Contact pressure	521	psf
Additional pressure	268	psf



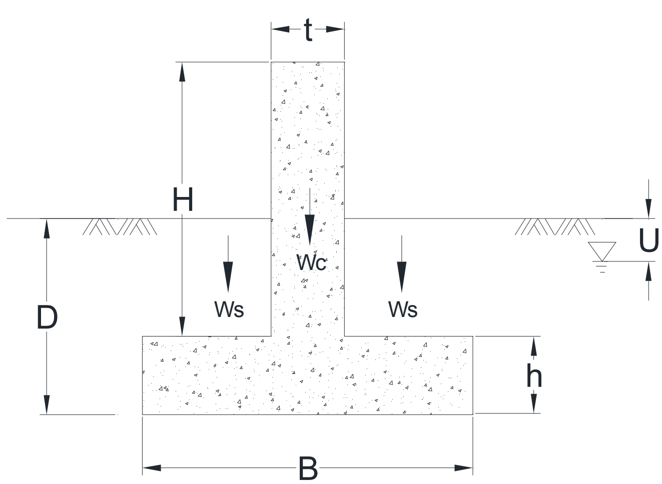
Additional Stress Calculation for Floodwall with 8' Height in Soil Area 3

New Medowlands Flood Protection

Bergen County, New Jersey

Calculated by: LC Date: 11/22/2016 CHECKED BY: MS

Floodwall base, B =	12	ft
Depth from ground to base, D =	4	ft
Groundwater table, U =	1	ft (above ground surface)
Width of top wall, t =	1.5	ft
Wall height, H=	10.5	ft
Base height, h =	1.5	ft
Total unit weight of origional soil, γ =	110	pcf
Total unit weight of compacted soil	120	pcf
Total unit weight of concrete, γ_c =	150	pcf
Total weight of concrete, W_c =	3612	lb
Total weight of compacted soil over base, W_s =	1512	lb
Existing soil pressure	190	psf
Contact pressure	427	psf
Additional pressure	237	psf

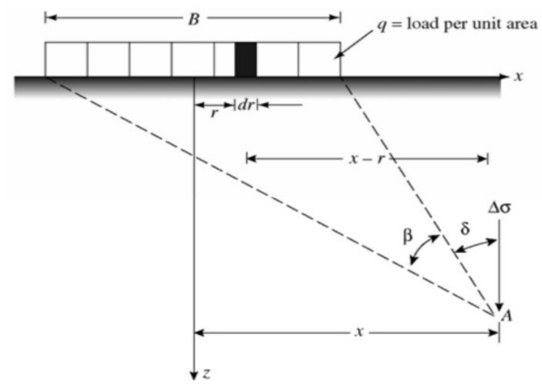


SETTLEMENT CALCULATION -NEW MEADOWLAND

2' Height 2.5' Width Soil Area 3

Soil Parameters

Layer No.	Soil	Unit Weight (pcf)	Thickness (ft)	Void Ratio, e_0	C_c	Cr	Consoildation	Ground surface El.	Groundwater Table El.	Top of Wall El.
1	Clay & Silt	110	70	1.03	0.17	0.012	Normal	+6 ft	+1 ft	+8 ft



Increase in Vertical Stress in Soil due to Vertical Strip Load

$$\Delta\sigma_2 = \frac{q}{\pi}[\beta + \sin\beta\cos(\beta + 2\delta)]$$

Footing Width B=	2.5	ft
Surcharge q=	190	psf
Footing Depth D=	3.5	ft (below ground surface)
GW Table Depth=	5	ft (below ground surface)

Settlement

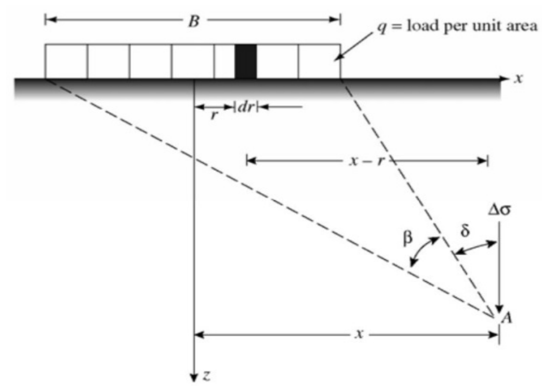
Sub Layer No.	Thickness Hc (ft)	Depth (ft)	Initial stress, σ'_{0} (psf)	β	δ	Preconstruction stress, σ'_p (psf)	Increase stress, $\Delta\sigma_z$ (psf)	Fianl Stress σ'f (psf)	Recompression Settlement (in)	Compression Settlement (in)
1	2	4.5	110	1.8	2.2	495.0	167	662	0.093	0.254
2	2	6.5	236	0.8	2.7	621.4	91	712	0.060	0.119
3	2	8.5	332	0.5	2.9	716.6	58	775	0.047	0.068
4	2	10.5	427	0.4	3.0	811.8	42	854	0.040	0.044
5	2	12.5	522	0.3	3.0	907.0	33	940	0.034	0.031
6	2	14.5	617	0.2	3.0	1002.2	27	1029	0.030	0.023
7	2	16.5	712	0.2	3.0	1097.4	23	1121	0.027	0.018
8	2	18.5	808	0.2	3.1	1192.6	20	1213	0.024	0.015
9	2	20.5	903	0.1	3.1	1287.8	18	1306	0.022	0.012
10	2	22.5	998	0.1	3.1	1383.0	16	1399	0.020	0.010
11	2	24.5	1093	0.1	3.1	1478.2	14	1493	0.019	0.008
12	2	26.5	1188	0.1	3.1	1573.4	13	1587	0.017	0.007
13	2	28.5	1284	0.1	3.1	1668.6	12	1681	0.016	0.006
14	2	30.5	1379	0.1	3.1	1763.8	11	1775	0.015	0.006
15	2	32.5	1474	0.1	3.1	1859.0	10	1869	0.014	0.005
Total Primary Settlement							**1.10**	**in**		

SETTLEMENT CALCULATION -NEW MEADOWLAND

4' Height 4' Width Soil Area 3

Soil Parameters

Layer No.	Soil	Unit Weight (pcf)	Thickness (ft)	Void Ratio, e_0	C_c	Cr	Consoildation	Ground surface El.	Groundwater Table El.	Top of Wall El.
1	Clay & Silt	110	70	1.03	0.17	0.012	Normal	+4 ft	+1 ft	+8 ft



Increase in Vertical Stress in Soil due to Vertical Strip Load

$$\Delta\sigma_2 = \frac{q}{\pi}[\beta + \sin\beta\cos(\beta + 2\delta)]$$

Footing Width B=	4	ft
Surcharge q=	234	psf
Footing Depth D=	3.5	ft (below ground surface)
GW Table Depth=	3	ft (below ground surface)

Settlement

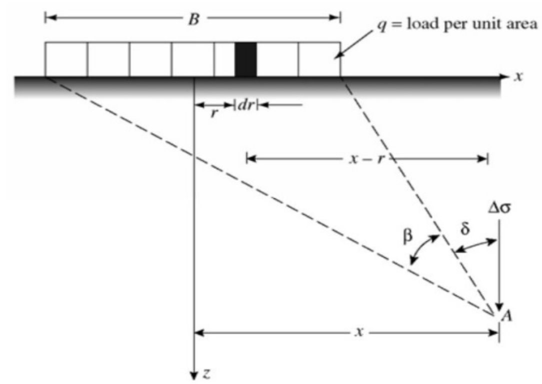
Sub Layer No.	Thickness Hc (ft)	Depth (ft)	Initial stress, $\sigma'_{0\ (psf)}$	β	δ	Preconstruction stress, σ'p (psf)	Increase stress, $\Delta\sigma_{z\ (psf)}$	Fianl Stress σ'f (psf)	Recompression Settlement (in)	Compression Settlement (in)
1	2	4.5	48	2.2	2.0	401.4	225	626	0.131	0.388
2	2	6.5	143	1.2	2.6	496.6	156	653	0.077	0.239
3	2	8.5	238	0.8	2.8	591.8	108	700	0.056	0.146
4	2	10.5	333	0.6	2.9	687.0	81	768	0.045	0.097
5	2	12.5	428	0.4	2.9	782.2	64	846	0.037	0.069
6	2	14.5	524	0.4	3.0	877.4	53	930	0.032	0.051
7	2	16.5	619	0.3	3.0	972.6	45	1018	0.028	0.040
8	2	18.5	714	0.3	3.0	1067.8	39	1107	0.025	0.032
9	2	20.5	809	0.2	3.0	1163.0	35	1198	0.022	0.026
10	2	22.5	904	0.2	3.0	1258.2	31	1289	0.020	0.021
11	2	24.5	1000	0.2	3.0	1353.4	28	1382	0.019	0.018
12	2	26.5	1095	0.2	3.1	1448.6	26	1474	0.017	0.015
13	2	28.5	1190	0.2	3.1	1543.8	24	1568	0.016	0.013
14	2	30.5	1285	0.1	3.1	1639.0	22	1661	0.015	0.012
15	2	32.5	1380	0.1	3.1	1734.2	20	1755	0.014	0.010
Total Primary Settlement							**1.73**	**in**		

SETTLEMENT CALCULATION -NEW MEADOWLAND

6' Height 8' Width Soil Area 3

Soil Parameters

Layer No.	Soil	Unit Weight (pcf)	Thickness (ft)	Void Ratio, e_0	C_c	Cr	Consoildation	Ground surface El.	Groundwater Table El.	Top of Wall El.
1	Clay & Silt	110	70	1.03	0.17	0.012	Normal	+2 ft	+1 ft	+8 ft



Increase in Vertical Stress in Soil due to Vertical Strip Load

$$\Delta\sigma_2 = \frac{q}{\pi}[\beta + \sin\beta\cos(\beta + 2\delta)]$$

Footing Width B=	8	ft
Surcharge q=	268	psf
Footing Depth D=	4	ft (below ground surface)
GW Table Depth=	1	ft (below ground surface)

Settlement

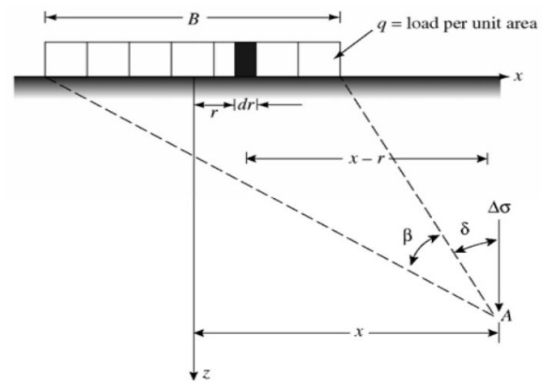
Sub Layer No.	Thickness Hc (ft)	Depth (ft)	Initial stress, σ'_{0} (psf)	β	δ	Preconstruction stress, σ'p (psf)	Increase stress, $\Delta\sigma_z$ (psf)	Fianl Stress σ'f (psf)	Recompression Settlement (in)	Compression Settlement (in)
1	2	5	48	2.7	1.8	300.4	266	567	0.114	0.554
2	2	7	143	1.9	2.2	395.6	240	636	0.063	0.414
3	2	9	238	1.3	2.5	490.8	198	689	0.045	0.296
4	2	11	333	1.0	2.6	586.0	162	748	0.035	0.213
5	2	13	428	0.8	2.7	681.2	135	816	0.029	0.157
6	2	15	524	0.7	2.8	776.4	114	891	0.024	0.120
7	2	17	619	0.6	2.8	871.6	99	970	0.021	0.094
8	2	19	714	0.5	2.9	966.8	87	1054	0.019	0.075
9	2	21	809	0.5	2.9	1062.0	77	1139	0.017	0.061
10	2	23	904	0.4	2.9	1157.2	70	1227	0.015	0.051
11	2	25	1000	0.4	3.0	1252.4	63	1316	0.014	0.043
12	2	27	1095	0.3	3.0	1347.6	58	1406	0.013	0.037
13	2	29	1190	0.3	3.0	1442.8	54	1496	0.012	0.032
14	2	31	1285	0.3	3.0	1538.0	50	1588	0.011	0.028
15	2	33	1380	0.3	3.0	1633.2	46	1680	0.010	0.024
Total Primary Settlement							**2.64**	**in**		

SETTLEMENT CALCULATION -NEW MEADOWLAND

8' Height 12' Width Soil Area 3

Soil Parameters

Layer No.	Soil	Unit Weight (pcf)	Thickness (ft)	Void Ratio, e_0	C_c	Cr	Consoildation	Ground surface El.	Groundwater Table El.	Top of Wall El.
1	Clay & Silt	110	70	1.03	0.17	0.012	Normal	0.0 ft	+1 ft	+8 ft



Increase in Vertical Stress in Soil due to Vertical Strip Load

$$\Delta\sigma_2 = \frac{q}{\pi}[\beta + \sin\beta\cos(\beta + 2\delta)]$$

Footing Width B=	12	ft
Surcharge q=	237	psf
Footing Depth D=	4	ft (below ground surface)
GW Table Depth=	1	ft (above ground surface)

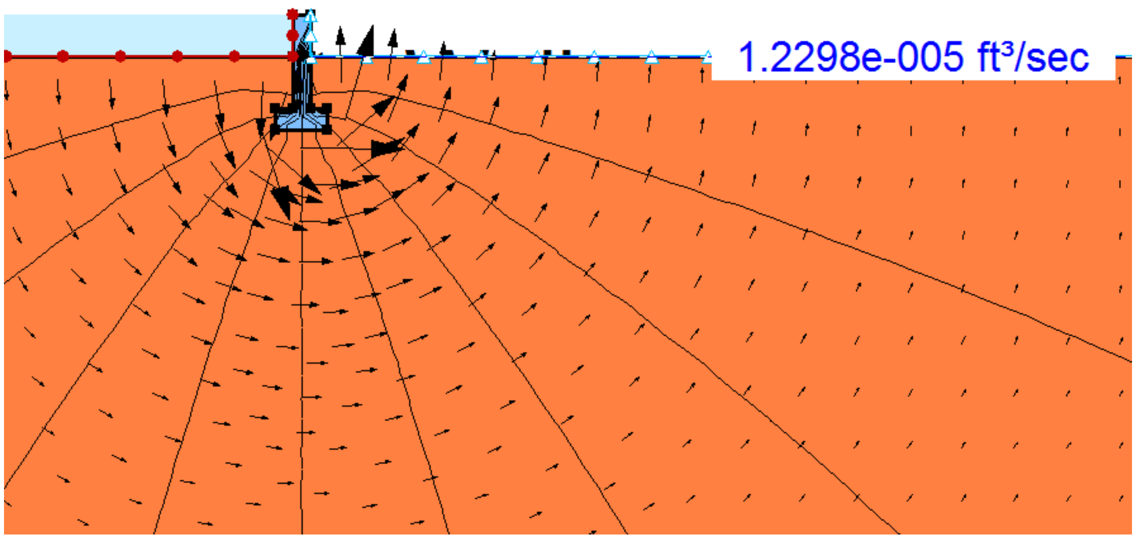
Settlement

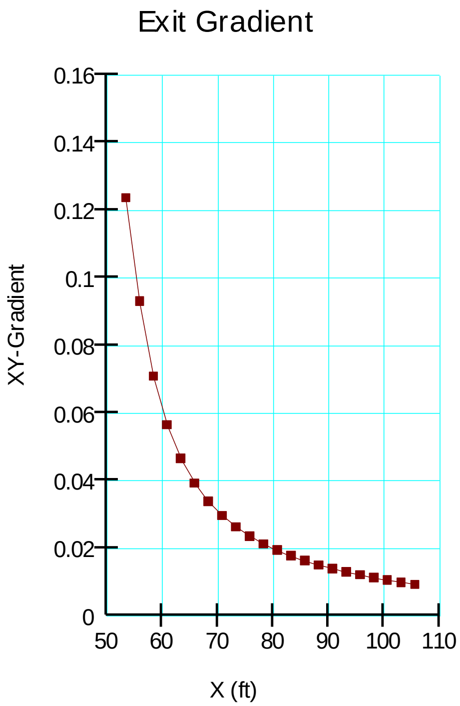
Sub Layer No.	Thickness Hc (ft)	Depth (ft)	Initial stress, $\sigma'_{0\ (psf)}$	β	δ	Preconstruction stress, σ'p (psf)	Increase stress, $\Delta\sigma_{z\ (psf)}$	Fianl Stress σ'f (psf)	Recompression Settlement (in)	Compression Settlement (in)
1	2	5	48	2.8	1.7	238.0	237	475	0.099	0.602
2	2	7	143	2.2	2.0	333.2	227	561	0.052	0.454
3	2	9	238	1.8	2.3	428.4	206	635	0.036	0.343
4	2	11	333	1.4	2.4	523.6	181	705	0.028	0.260
5	2	13	428	1.2	2.6	618.8	158	777	0.023	0.199
6	2	15	524	1.0	2.6	714.0	139	853	0.019	0.155
7	2	17	619	0.9	2.7	809.2	123	932	0.017	0.123
8	2	19	714	0.8	2.8	904.4	109	1014	0.015	0.100
9	2	21	809	0.7	2.8	999.6	99	1098	0.013	0.082
10	2	23	904	0.6	2.8	1094.8	89	1184	0.012	0.069
11	2	25	1000	0.6	2.9	1190.0	82	1272	0.011	0.058
12	2	27	1095	0.5	2.9	1285.2	75	1361	0.010	0.050
13	2	29	1190	0.5	2.9	1380.4	70	1450	0.009	0.043
14	2	31	1285	0.4	2.9	1475.6	65	1541	0.009	0.038
15	2	33	1380	0.4	2.9	1570.8	61	1632	0.008	0.033
Total Primary Settlement							**2.97**	**in**		

Details of Seepage Analysis Results for T-walls for Soil Areas 1 to 3 from GeoStudio

AECOM

Name: Clay & Silt Model: Saturated Only K-Sat: 6.6e-006 ft/sec
Name: Concrete Wall Model: Saturated Only K-Sat: 1e-015 ft/sec
Name: Bedrock Model: Saturated Only K-Sat: 1.3e-007 ft/sec

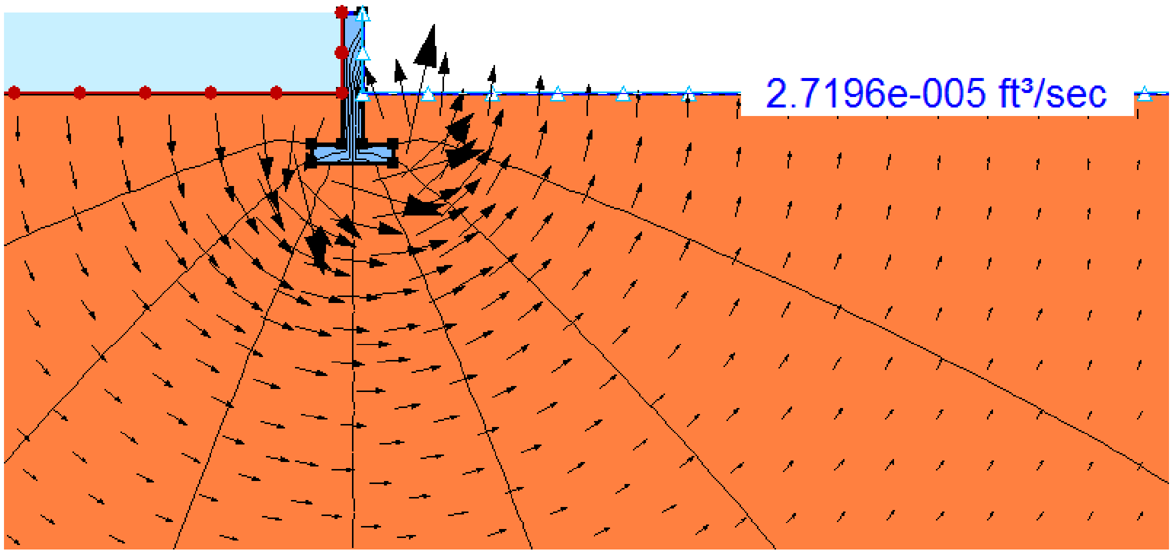


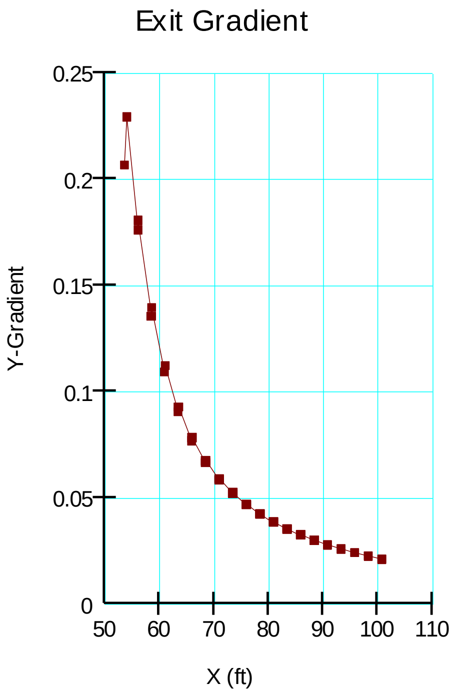


2'-0'' HT CONCRETE FLOOD WALL SEEPAGE ANALYSIS

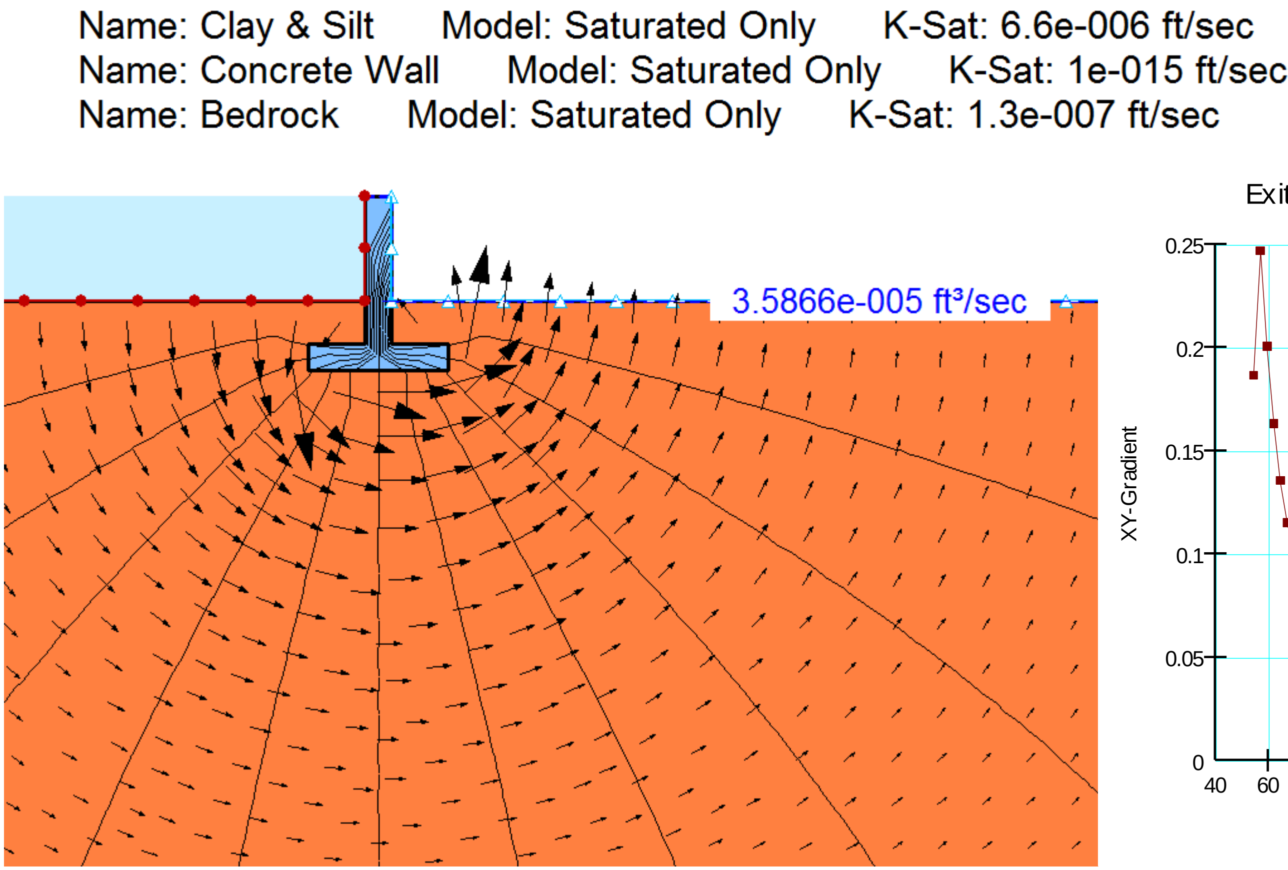
AECOM

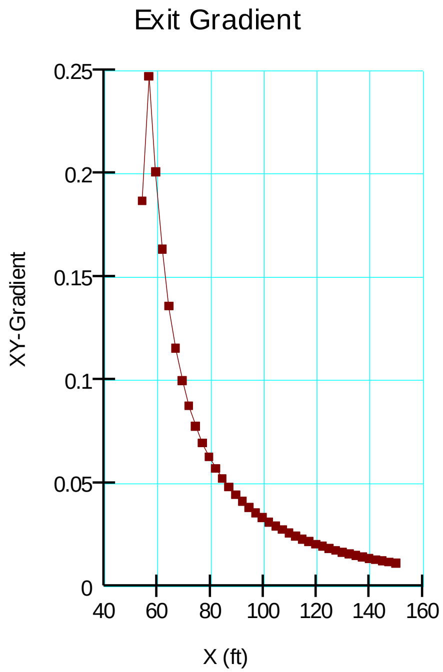
Name: Clay & Silt Model: Saturated Only K-Sat: 6.6e-006 ft/sec
Name: Concrete Wall Model: Saturated Only K-Sat: 1e-015 ft/sec
Name: Bedrock Model: Saturated Only K-Sat: 1.3e-007 ft/sec





4’-0’’ HT CONCRETE FLOOD WALL SEEPAGE ANALYSIS

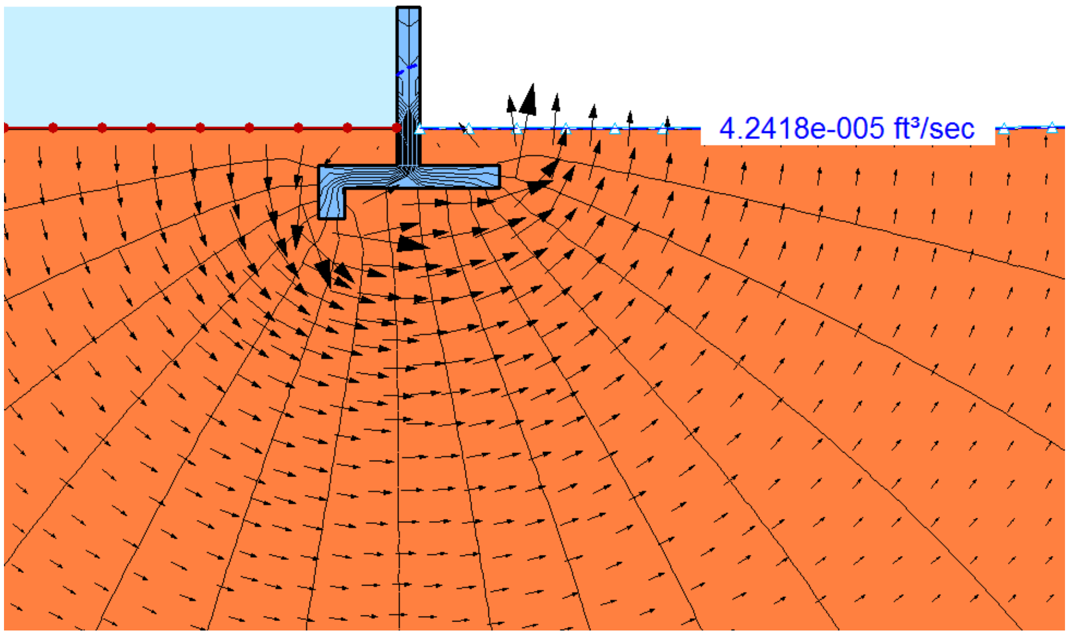


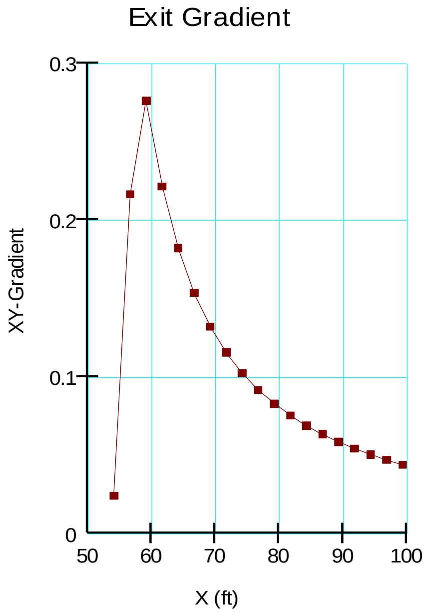


6’-0’’ HT CONCRETE FLOOD WALL SEEPAGE ANALYSIS

AECOM

Name: Clay & Silt   Model: Saturated Only   K-Sat: 6.6e-006 ft/sec
Name: Concrete Wall   Model: Saturated Only   K-Sat: 1e-015 ft/sec
Name: Bedrock   Model: Saturated Only   K-Sat: 1.3e-007 ft/sec



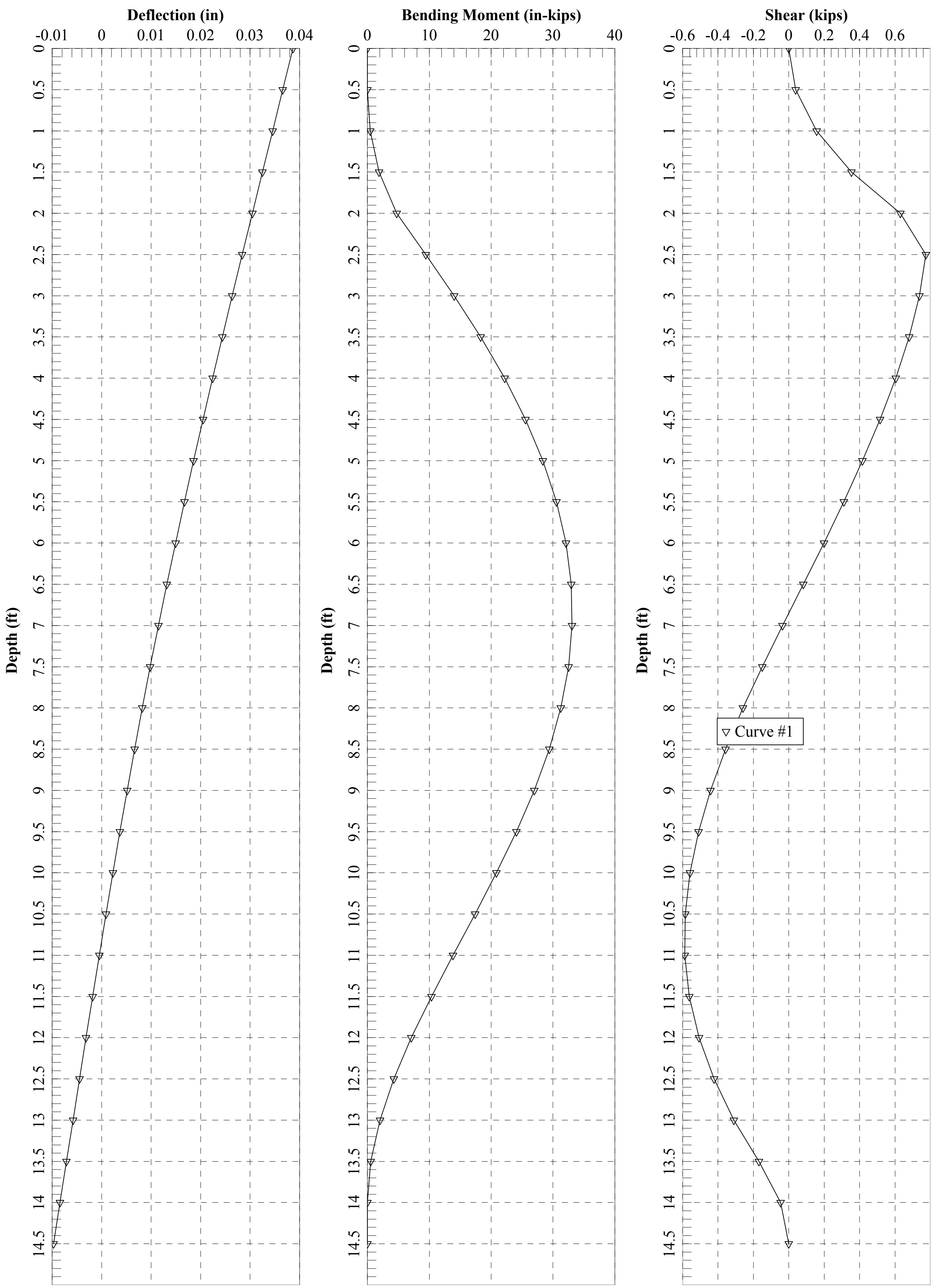


8'-0'' HT CONCRETE FLOOD WALL SEEPAGE ANALYSIS

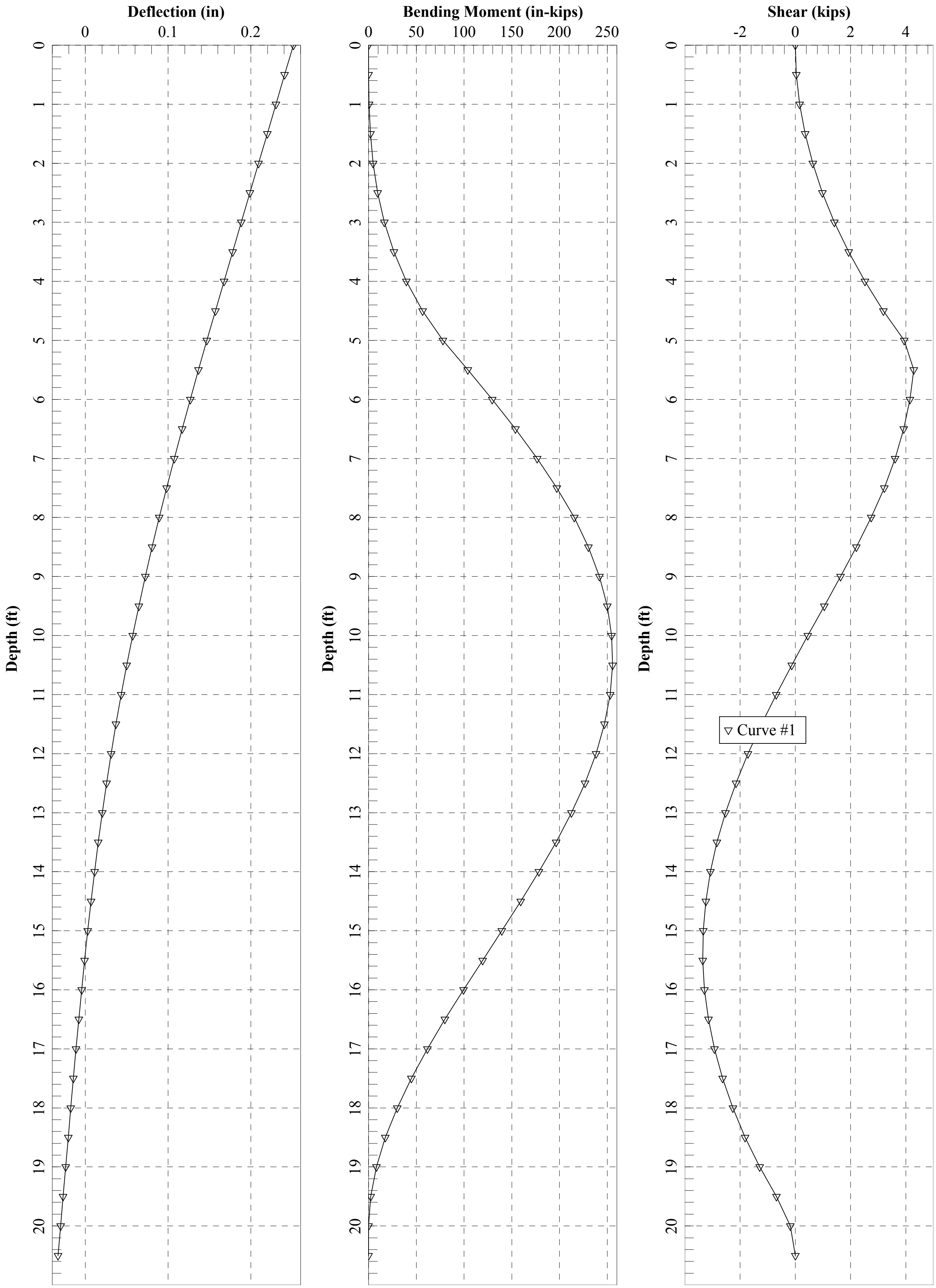
Attachment C1-J

Plots of Lateral Deflection, Bending Moment and Shear Force versus Embedded Depth of I-walls from PYWall

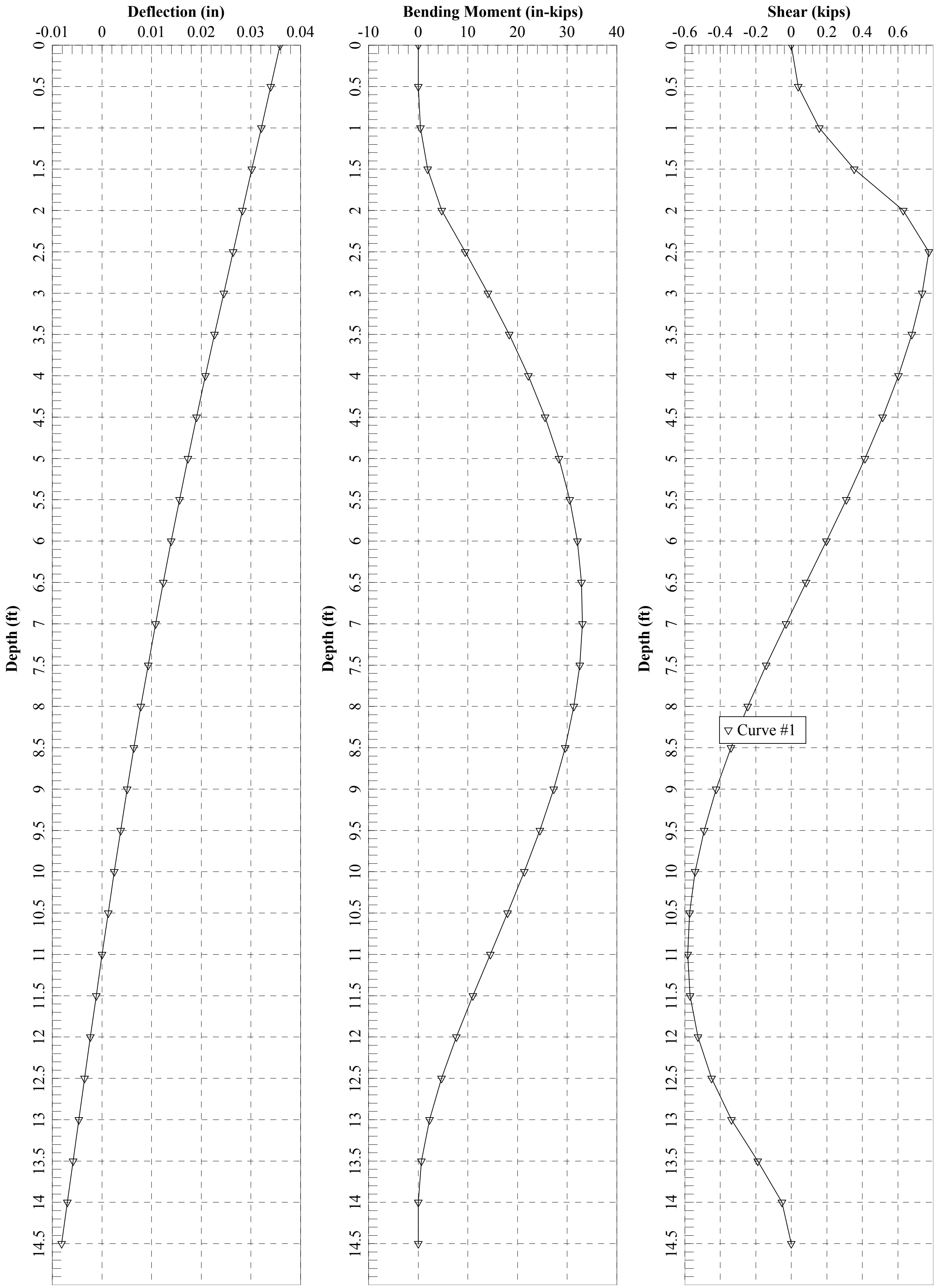
Results of 2 ft I-Wall Analysis for Soil Area 4



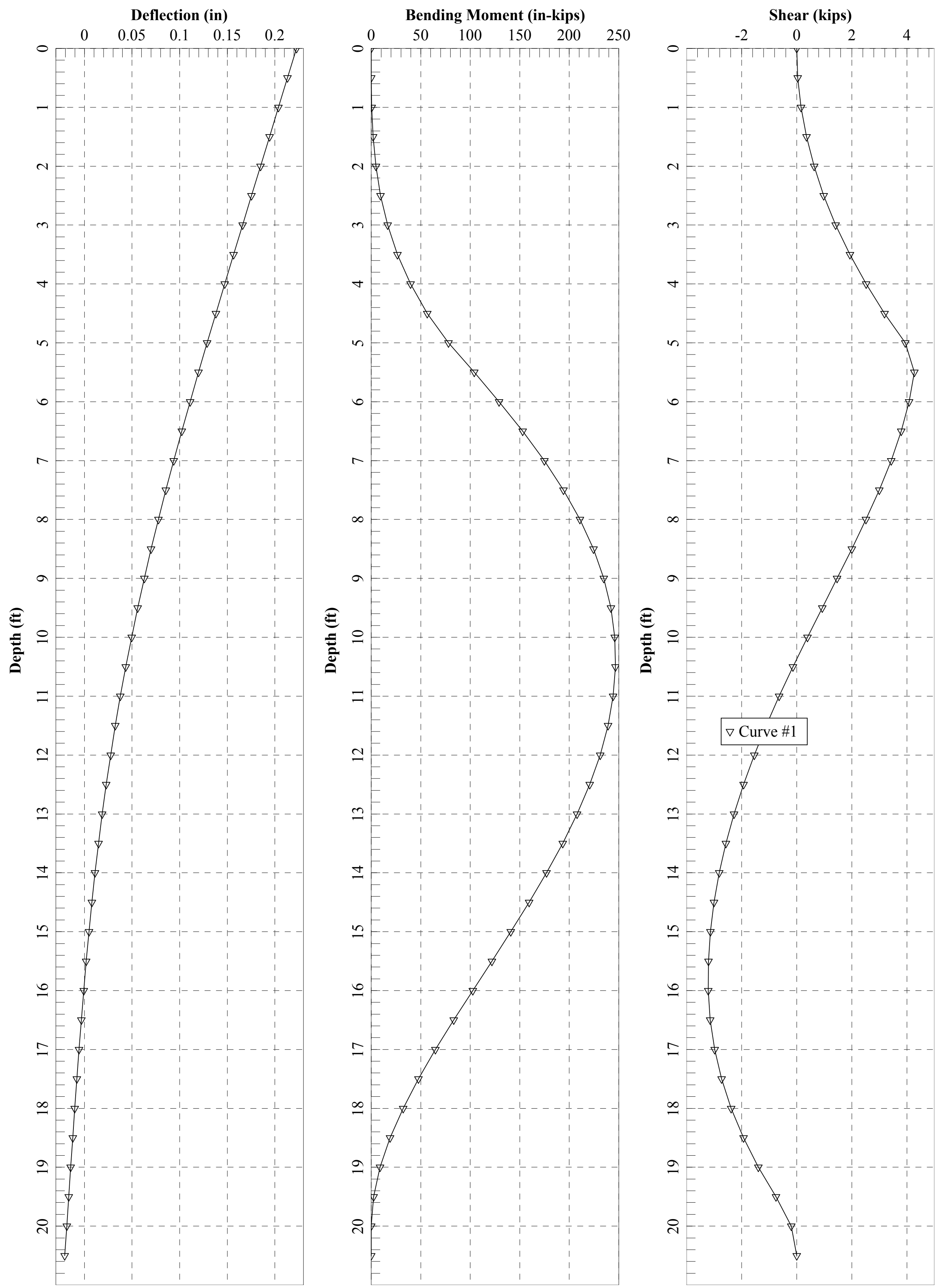
Results of 5 ft I-Wall Analysis for Soil Area 4



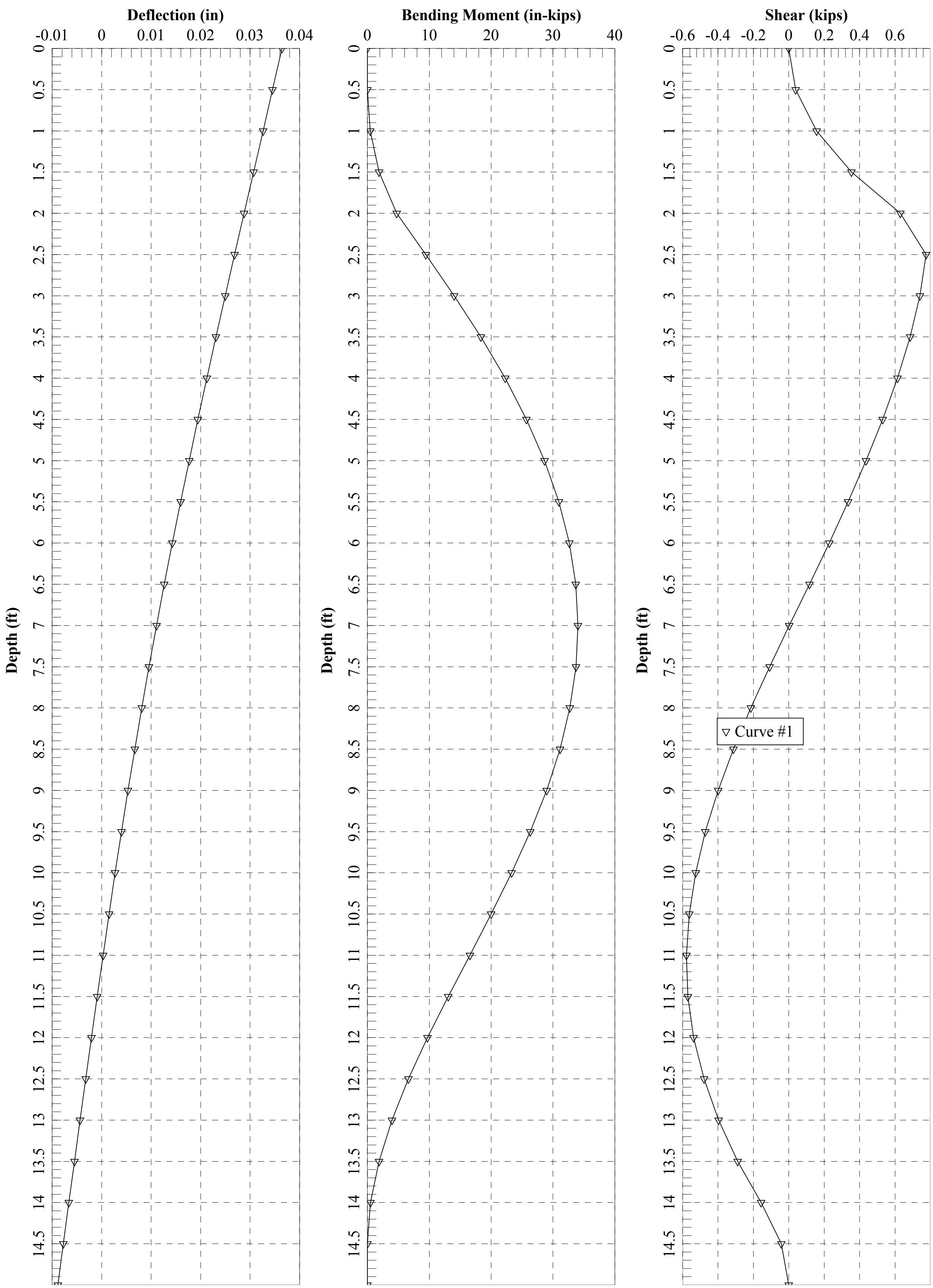
Results of 2 ft I-Wall Analysis for Soil Area 5



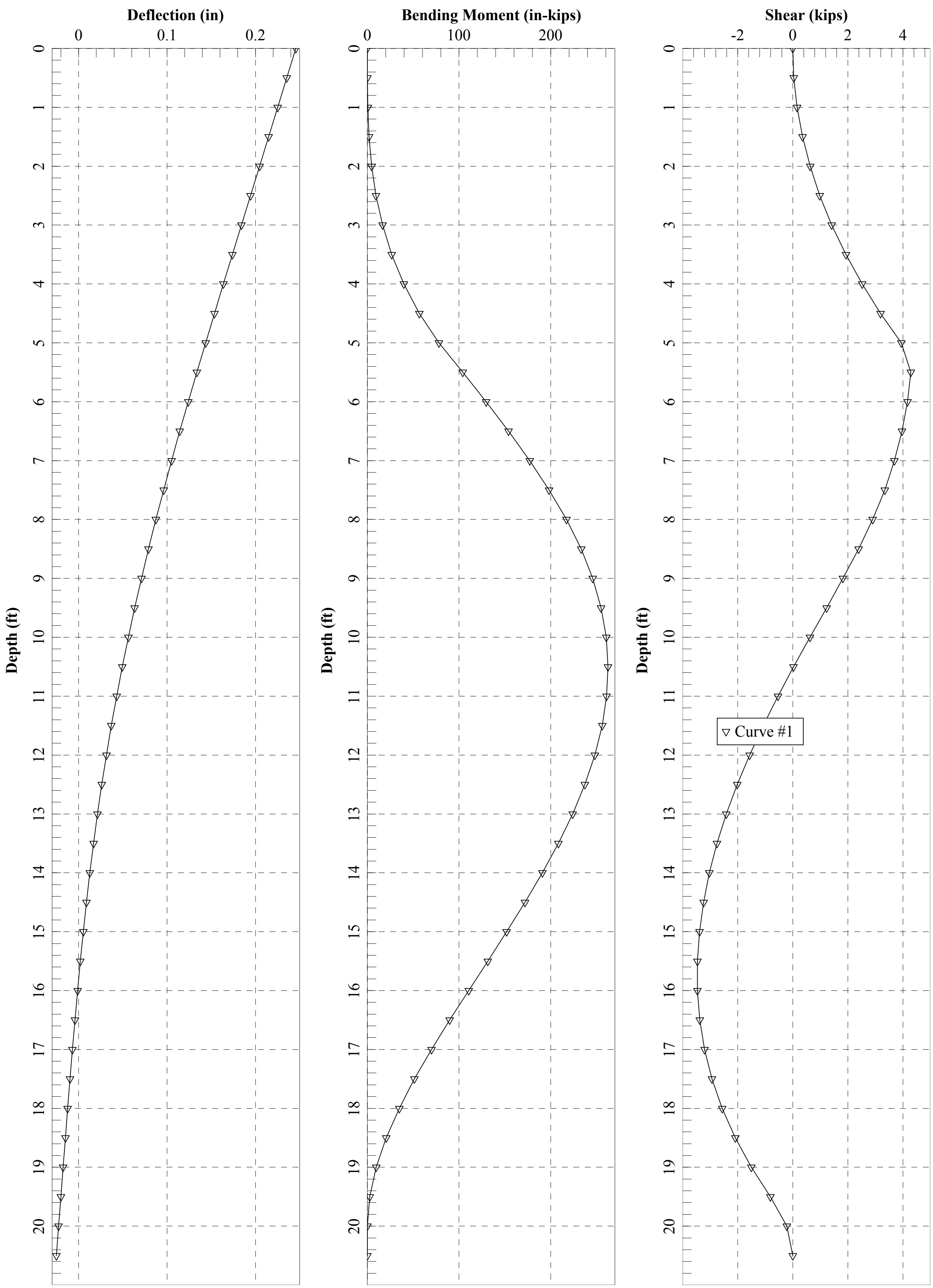
Results of 5 ft I-Wall Analysis for Soil Area 5



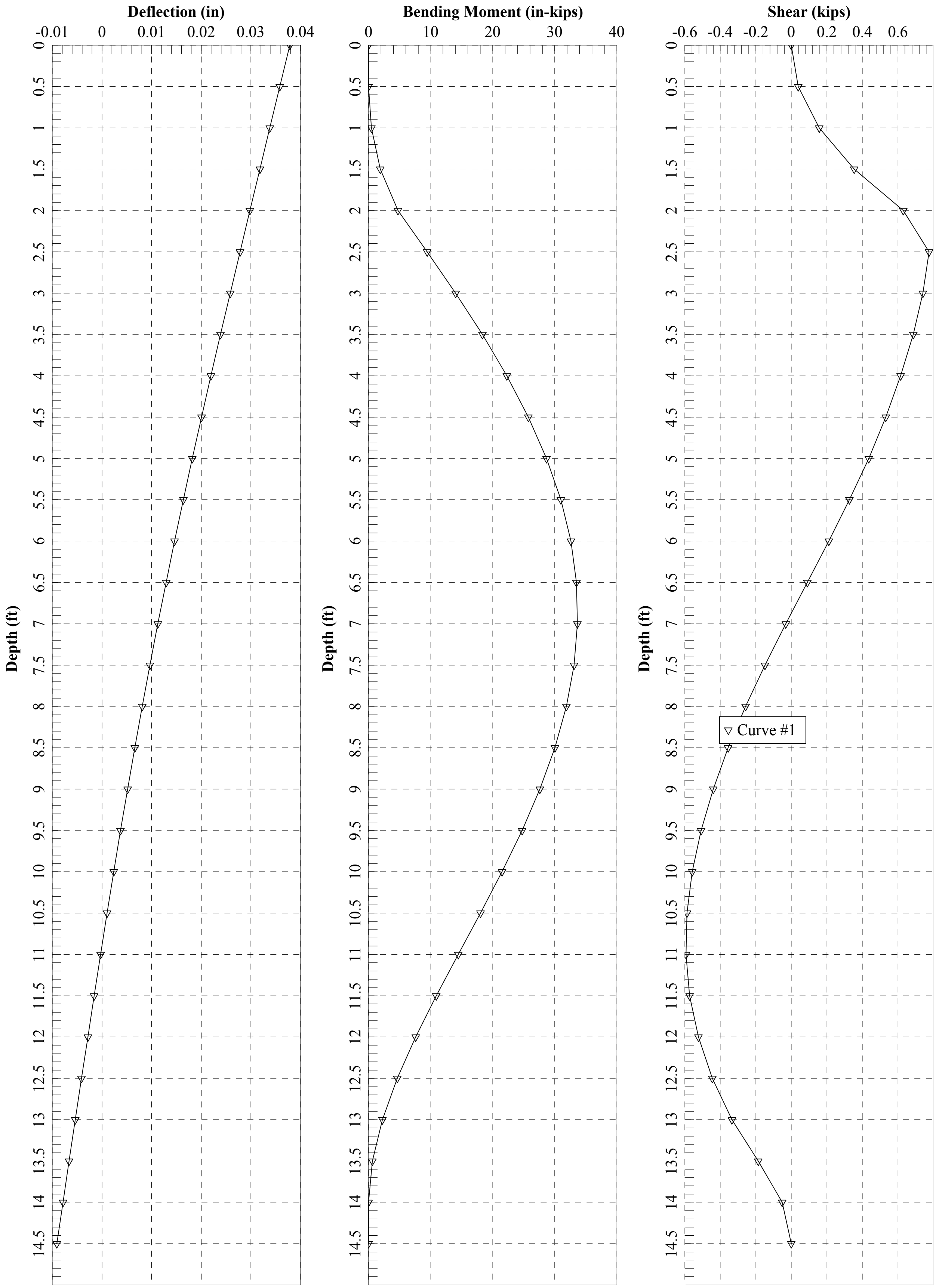
Results of 2 ft I-Wall Analysis for Soil Area 6



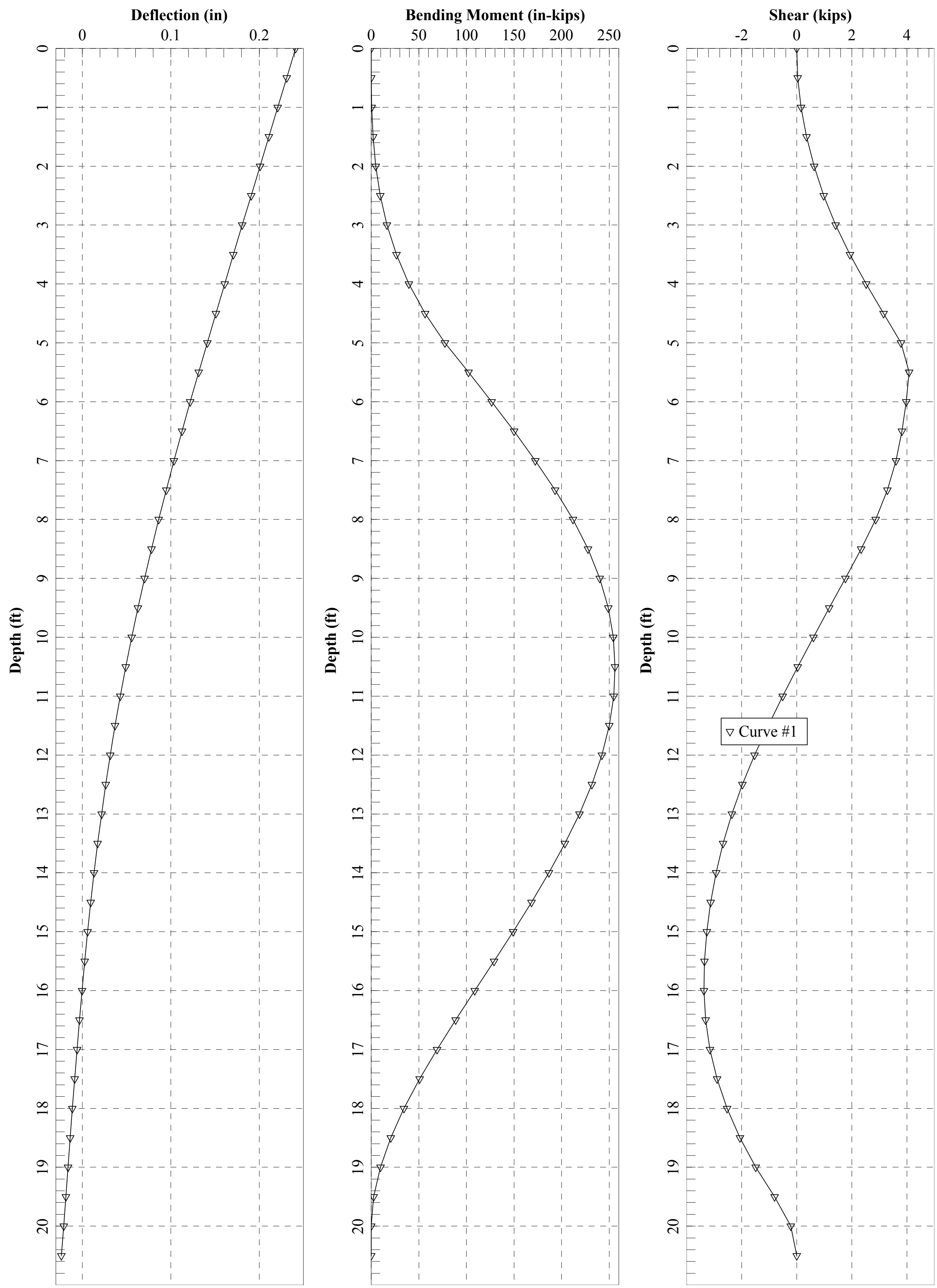
Results of 5 ft I-Wall Analysis for Soil Area 6



Results of 2 ft I-Wall Analysis for Soil Area 7



Results of 5 ft I-Wall Analysis for Soil Area 7



Attachment C1-K

Output from PYWall Analysis for 2 ft I-wall in Soil Area 4

```
==========================================================================

                 PYWALL for Windows, Version 2015.5.11

                  Serial Number :  166868598

                  A Program for the Analysis of
                  Flexible Retaining Walls
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                      All Rights Reserved

==========================================================================


This program is licensed to :

AECOM / URS Corp
Clifton, NJ

Path to file locations      : Q:\Geotechnical\Meadowlands\Calculations for New
Alternatives\I-Wall\2 ft I-Wall\
Name of input data file     : Zone4_2ft_I_Wall_AZ12.py5d
Name of output file         : Zone4_2ft_I_Wall_AZ12.py5o
Name of plot output file    : Zone4_2ft_I_Wall_AZ12.py5p

--------------------------------------------------------------------------
                     Time and Date of Analysis
--------------------------------------------------------------------------

          Date:  October 16, 2017     Time:  17:24:46

 New Meadowlands_Zone4_2ft_I_Wall


 **************************************************
 *         PROGRAM CONTROL PARAMETERS             *
 **************************************************

 NO OF POINTS FOR SPECIFIED DEFLECTIONS AND SLOPES  =  0
 NO OF POINTS FOR WALL STIFFNESS AND LOAD DATA      =  1
 GENERATE EARTH PRESSURE INTERNALLY                 =  1
 GENERATE SOIL RESISTANCE (P-Y) CURVES INTERNALLY   =  1
 NO OF P-Y MODIFICATION FACTORS FOR GEN. P-Y CURVES =  0
 NO OF USER-SPECIFIED SOIL RESISTANCE (P-Y) CURVES  =  0
 NUMBER OF INCREMENTS                               =  28
 INCREMENT LENGTH                                   =     6.000 IN
 FREE HEIGHT OF WALL                                =    24.000 IN
 MAXIMUM ALLOWABLE DEFLECTION                       =     3.000 IN
 DEFLECTION CLOSURE TOLERANCE                       = 1.000E-05 IN




 **************************************************
 *         STIFFNESS AND LOAD DATA                *
 **************************************************
 EI - FLEXURAL RIGIDITY,  Q - TRANSVERSE LOAD,
 S - STIFFNESS OF TRANSVERSE RESISTANCE,
 T - TORQUE,              P - AXIAL LOAD,
 R - STIFFNESS OF TORSIONAL RESISTANCE.

FROM TO CONTD     EI        Q        S'        T         R         P
```

			LBS-IN**2	LBS	LBS/IN	IN-LBS	IN-LBS	LBS
0	28	0	0.230E+11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

```
**************************************************
*                WALL INFORMATION                *
**************************************************
```

FREE HEIGHT OF WALL = 0.240E+02 IN
WIDTH FOR EARTH PRESSURE, WA = 0.606E+02 IN
WIDTH FOR SOIL RESISTANCE, WP = 0.606E+02 IN
DEPTH TO THE WATER TABLE AT BACKFILL = 0.000E+00 IN
DEPTH TO THE WATER TABLE AT EXCAVATION = 0.240E+02 IN
UNIT WEIGHT OF WATER = 0.360E-01 LBS/IN**3
SLOPE OF THE BACKFILL (deg.) = 0.000E+00
MODIFICATION FOR ACTIVE EARTH PRESSURE = 0.100E+01

```
**************************************************
*              SURCHARGE INFORMATION             *
**************************************************
```

UNIFORM SURFACE PRESSURE = 0.000E+00 LBS/IN**2

```
**************************************************
*                SOIL INFORMATION                *
**************************************************
```

LAYER NO.	TOTAL THICKNESS IN	COHESION PSI	PHI DEG	TOTAL UNIT WEIGHT PCI	DRAINED T OR F	ZTOP IN
1	24.0	0.0	0.0	0.036	T	0.00
2	216.0	0.0	20.0	0.049	T	24.00
3	636.0	0.0	22.0	0.064	T	240.00

```
**************************************************
*           EFFECTIVE OVERBURDEN STRESS          *
**************************************************
```

DEPTH IN	STRESS LBS/IN**2
0.000E+00	0.000E+00
0.240E+02	0.406E-02
0.240E+03	0.285E+01

```
**************************************************
* ACTIVE AND PASSIVE EARTH PRESSURE COEFFICIENT  *
**************************************************
```

LAYER NO.	ACTIVE EARTH COEFFICIENT	PASSIVE EARTH COEFFICIENT	OPTIONAL EARTH COEFFICIENT
1	0.100E+01	0.100E+01	0.000E+00
2	0.490E+00	0.204E+01	0.000E+00
3	0.455E+00	0.220E+01	0.000E+00

```
**************************************************
*      ACTIVE EARTH PRESSURE OF EACH LAYER       *
**************************************************
```

LAYER NO	PA1 LBS/IN**2	Z1 IN	PA2 LBS/IN**2	Z2 IN	PA3 LBS/IN**2	Z3 IN	PA4 LBS/IN**2
1	0.00	12.00	0.00	16.00	0.00	18.74	0.02

```
**************************************************
*      ACTIVE WATER PRESSURE OF EACH LAYER       *
**************************************************
```

LAYER NO	PW1	Z1	PW2	Z2
1	0.00	12.00	10.37	16.00

DEPTH IN	ACTIVE EARTH PRESSURE LBS/IN
0.000E+00	0.000E+00
0.600E+01	0.131E+02
0.120E+02	0.262E+02
0.180E+02	0.394E+02
0.240E+02	0.526E+02
0.300E+02	0.121E+00
0.360E+02	0.121E+00
0.420E+02	0.121E+00
0.480E+02	0.121E+00
0.540E+02	0.121E+00
0.600E+02	0.121E+00
0.660E+02	0.121E+00
0.720E+02	0.121E+00
0.780E+02	0.121E+00
0.840E+02	0.121E+00
0.900E+02	0.121E+00
0.960E+02	0.121E+00
0.102E+03	0.121E+00
0.108E+03	0.121E+00
0.114E+03	0.121E+00
0.120E+03	0.121E+00
0.126E+03	0.121E+00
0.132E+03	0.121E+00
0.138E+03	0.121E+00
0.144E+03	0.121E+00
0.150E+03	0.121E+00
0.156E+03	0.121E+00
0.162E+03	0.121E+00
0.168E+03	0.121E+00

```
**************************************************
*        SOIL LAYERS AND STRENGTH DATA           *
**************************************************
```

X AT THE SURFACE OF EXCAVATION SIDE = 24.00 IN

1 LAYER(S) OF SOIL

LAYER 1
THE SOIL IS A SILT

DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH
4 POINTS

X,IN	WEIGHT,LBS/IN**3
24.0000	0.1319D-01
240.0000	0.1319D-01
240.0000	0.2766D-01
876.0000	0.2766D-01

DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH
2 POINTS

X,IN	S,LBS/IN**2	PHI,DEGREES	E50
24.00	0.0000D+00	20.000	0.2000D-01
180.00	0.0000D+00	20.000	0.2000D-01

P-Y CURVES DATA

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
0.10	60.62	20.0	0.132E-01	2.83	2.14	0.800E-01	0.211E+00

Y IN	P LBS/IN
0.000E+00	-0.121E+00
0.842E-01	0.245E-01
0.168E+00	0.714E-01
0.253E+00	0.106E+00
0.337E+00	0.134E+00
0.421E+00	0.157E+00
0.505E+00	0.179E+00
0.589E+00	0.198E+00
0.674E+00	0.216E+00
0.758E+00	0.232E+00
0.842E+00	0.247E+00
0.926E+00	0.262E+00
0.101E+01	0.276E+00
0.227E+01	0.476E+00
0.326E+02	0.476E+00
0.629E+02	0.476E+00
0.932E+02	0.476E+00

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
24.10	60.62	20.0	0.132E-01	2.55	1.89	0.193E+02	0.508E+02

Y IN	P LBS/IN
0.000E+00	0.121E+00
0.842E-01	0.470E+02
0.168E+00	0.573E+02
0.253E+00	0.643E+02
0.337E+00	0.698E+02
0.421E+00	0.744E+02
0.505E+00	0.784E+02
0.589E+00	0.819E+02
0.674E+00	0.851E+02
0.758E+00	0.880E+02
0.842E+00	0.907E+02
0.926E+00	0.932E+02
0.101E+01	0.956E+02
0.227E+01	0.130E+03
0.326E+02	0.130E+03
0.629E+02	0.130E+03
0.932E+02	0.130E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
39.00	60.62	20.0	0.132E-01	2.37	1.75	0.312E+02	0.822E+02

Y IN	P LBS/IN
0.000E+00	-0.121E+00
0.842E-01	0.914E+02
0.168E+00	0.106E+03
0.253E+00	0.115E+03
0.337E+00	0.122E+03
0.421E+00	0.128E+03
0.505E+00	0.133E+03
0.589E+00	0.138E+03
0.674E+00	0.142E+03
0.758E+00	0.145E+03
0.842E+00	0.149E+03
0.926E+00	0.152E+03
0.101E+01	0.154E+03
0.227E+01	0.195E+03
0.326E+02	0.195E+03
0.629E+02	0.195E+03
0.932E+02	0.195E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
63.00	60.62	20.0	0.132E-01	2.08	1.52	0.504E+02	0.133E+03

Y IN	P LBS/IN

0.000E+00	0.121E+00
0.842E-01	0.159E+03
0.168E+00	0.214E+03
0.253E+00	0.221E+03
0.337E+00	0.227E+03
0.421E+00	0.231E+03
0.505E+00	0.235E+03
0.589E+00	0.238E+03
0.674E+00	0.241E+03
0.758E+00	0.243E+03
0.842E+00	0.246E+03
0.926E+00	0.248E+03
0.101E+01	0.250E+03
0.227E+01	0.277E+03
0.326E+02	0.277E+03
0.629E+02	0.277E+03
0.932E+02	0.277E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
78.00	60.62	20.0	0.132E-01	1.91	1.39	0.624E+02	0.164E+03

Y IN	P LBS/IN
0.000E+00	-0.121E+00
0.842E-01	0.197E+03
0.168E+00	0.302E+03
0.253E+00	0.303E+03
0.337E+00	0.305E+03
0.421E+00	0.305E+03
0.505E+00	0.306E+03
0.589E+00	0.307E+03
0.674E+00	0.307E+03
0.758E+00	0.308E+03
0.842E+00	0.308E+03
0.926E+00	0.308E+03
0.101E+01	0.309E+03
0.227E+01	0.314E+03
0.326E+02	0.314E+03
0.629E+02	0.314E+03
0.932E+02	0.314E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
102.00	60.62	20.0	0.132E-01	1.66	1.19	0.816E+02	0.215E+03

Y IN	P LBS/IN
0.000E+00	0.121E+00
0.842E-01	0.258E+03
0.168E+00	0.341E+03

0.253E+00	0.355E+03
0.337E+00	0.364E+03
0.421E+00	0.372E+03
0.505E+00	0.379E+03
0.589E+00	0.384E+03
0.674E+00	0.389E+03
0.758E+00	0.393E+03
0.842E+00	0.397E+03
0.926E+00	0.401E+03
0.101E+01	0.404E+03
0.227E+01	0.356E+03
0.326E+02	0.356E+03
0.629E+02	0.356E+03
0.932E+02	0.356E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
117.00	60.62	20.0	0.132E-01	1.52	1.08	0.935E+02	0.247E+03

Y IN	P LBS/IN
0.000E+00	-0.121E+00
0.842E-01	0.295E+03
0.168E+00	0.352E+03
0.253E+00	0.375E+03
0.337E+00	0.391E+03
0.421E+00	0.405E+03
0.505E+00	0.417E+03
0.589E+00	0.426E+03
0.674E+00	0.435E+03
0.758E+00	0.443E+03
0.842E+00	0.450E+03
0.926E+00	0.457E+03
0.101E+01	0.463E+03
0.227E+01	0.374E+03
0.326E+02	0.374E+03
0.629E+02	0.374E+03
0.932E+02	0.374E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
141.00	60.62	20.0	0.132E-01	1.32	0.93	0.113E+03	0.297E+03

Y IN	P LBS/IN
0.000E+00	0.121E+00
0.842E-01	0.308E+03
0.168E+00	0.364E+03
0.253E+00	0.401E+03
0.337E+00	0.429E+03
0.421E+00	0.453E+03

0.505E+00	0.473E+03
0.589E+00	0.491E+03
0.674E+00	0.507E+03
0.758E+00	0.521E+03
0.842E+00	0.535E+03
0.926E+00	0.547E+03
0.101E+01	0.559E+03
0.227E+01	0.391E+03
0.326E+02	0.391E+03
0.629E+02	0.391E+03
0.932E+02	0.391E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
155.90	60.62	20.0	0.132E-01	1.21	0.84	0.125E+03	0.329E+03

Y IN	P LBS/IN
0.000E+00	-0.121E+00
0.842E-01	0.303E+03
0.168E+00	0.369E+03
0.253E+00	0.415E+03
0.337E+00	0.450E+03
0.421E+00	0.480E+03
0.505E+00	0.506E+03
0.589E+00	0.529E+03
0.674E+00	0.550E+03
0.758E+00	0.568E+03
0.842E+00	0.586E+03
0.926E+00	0.602E+03
0.101E+01	0.617E+03
0.227E+01	0.396E+03
0.326E+02	0.396E+03
0.629E+02	0.396E+03
0.932E+02	0.396E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
179.90	60.62	20.0	0.132E-01	1.07	0.72	0.144E+03	0.379E+03

Y IN	P LBS/IN
0.000E+00	0.121E+00
0.842E-01	0.303E+03
0.168E+00	0.385E+03
0.253E+00	0.442E+03
0.337E+00	0.488E+03
0.421E+00	0.527E+03
0.505E+00	0.561E+03
0.589E+00	0.592E+03
0.674E+00	0.620E+03

0.758E+00	0.645E+03
0.842E+00	0.669E+03
0.926E+00	0.692E+03
0.101E+01	0.713E+03
0.227E+01	0.406E+03
0.326E+02	0.406E+03
0.629E+02	0.406E+03
0.932E+02	0.406E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

New Meadowlands_Zone4_2ft_I_Wall

RESULTS -- ITERATION 3

STA I	X IN	DEFL. IN	SLOPE	MOMENT LBS-IN	SHEAR LBS	NET REACT/STA LBS	EI LBS-IN**2
0	0.000E+00	0.386E-01	-0.341E-03	0.000E+00	0.000E+00	0.000E+00	0.115E+11
1	0.600E+01	0.366E-01	-0.341E-03	0.000E+00	0.393E+02	0.786E+02	0.230E+11
2	0.120E+02	0.345E-01	-0.341E-03	0.471E+03	0.157E+03	0.157E+03	0.230E+11
3	0.180E+02	0.325E-01	-0.341E-03	0.189E+04	0.354E+03	0.236E+03	0.230E+11
4	0.240E+02	0.304E-01	-0.340E-03	0.472E+04	0.630E+03	0.316E+03	0.230E+11
5	0.300E+02	0.284E-01	-0.338E-03	0.945E+04	0.775E+03	-0.260E+02	0.230E+11
6	0.360E+02	0.264E-01	-0.335E-03	0.140E+05	0.738E+03	-0.486E+02	0.230E+11
7	0.420E+02	0.244E-01	-0.331E-03	0.183E+05	0.680E+03	-0.676E+02	0.230E+11
8	0.480E+02	0.224E-01	-0.326E-03	0.222E+05	0.604E+03	-0.829E+02	0.230E+11
9	0.540E+02	0.205E-01	-0.319E-03	0.256E+05	0.516E+03	-0.947E+02	0.230E+11
10	0.600E+02	0.186E-01	-0.312E-03	0.284E+05	0.417E+03	-0.103E+03	0.230E+11
11	0.660E+02	0.167E-01	-0.305E-03	0.306E+05	0.311E+03	-0.108E+03	0.230E+11
12	0.720E+02	0.149E-01	-0.297E-03	0.321E+05	0.199E+03	-0.115E+03	0.230E+11
13	0.780E+02	0.132E-01	-0.288E-03	0.329E+05	0.822E+02	-0.118E+03	0.230E+11
14	0.840E+02	0.115E-01	-0.279E-03	0.331E+05	-0.355E+02	-0.117E+03	0.230E+11
15	0.900E+02	0.982E-02	-0.271E-03	0.325E+05	-0.150E+03	-0.113E+03	0.230E+11
16	0.960E+02	0.822E-02	-0.263E-03	0.313E+05	-0.259E+03	-0.104E+03	0.230E+11
17	0.102E+03	0.667E-02	-0.255E-03	0.294E+05	-0.358E+03	-0.929E+02	0.230E+11
18	0.108E+03	0.516E-02	-0.247E-03	0.270E+05	-0.442E+03	-0.769E+02	0.230E+11
19	0.114E+03	0.370E-02	-0.241E-03	0.241E+05	-0.510E+03	-0.586E+02	0.230E+11

```
    20   0.120E+03   0.227E-02  -0.235E-03   0.209E+05  -0.559E+03  -0.380E+02
0.230E+11
    21   0.126E+03   0.880E-03  -0.230E-03   0.174E+05  -0.585E+03  -0.152E+02
0.230E+11
    22   0.132E+03  -0.485E-03  -0.226E-03   0.138E+05  -0.587E+03   0.109E+02
0.230E+11
    23   0.138E+03  -0.183E-02  -0.223E-03   0.103E+05  -0.562E+03   0.399E+02
0.230E+11
    24   0.144E+03  -0.316E-02  -0.220E-03   0.710E+04  -0.507E+03   0.700E+02
0.230E+11
    25   0.150E+03  -0.447E-02  -0.219E-03   0.427E+04  -0.423E+03   0.986E+02
0.230E+11
    26   0.156E+03  -0.578E-02  -0.218E-03   0.203E+04  -0.310E+03   0.127E+03
0.230E+11
    27   0.162E+03  -0.709E-02  -0.218E-03   0.549E+03  -0.169E+03   0.155E+03
0.230E+11
    28   0.168E+03  -0.839E-02  -0.218E-03   0.554E-09  -0.457E+02   0.914E+02
0.115E+11


     END OF ANALYSIS
```

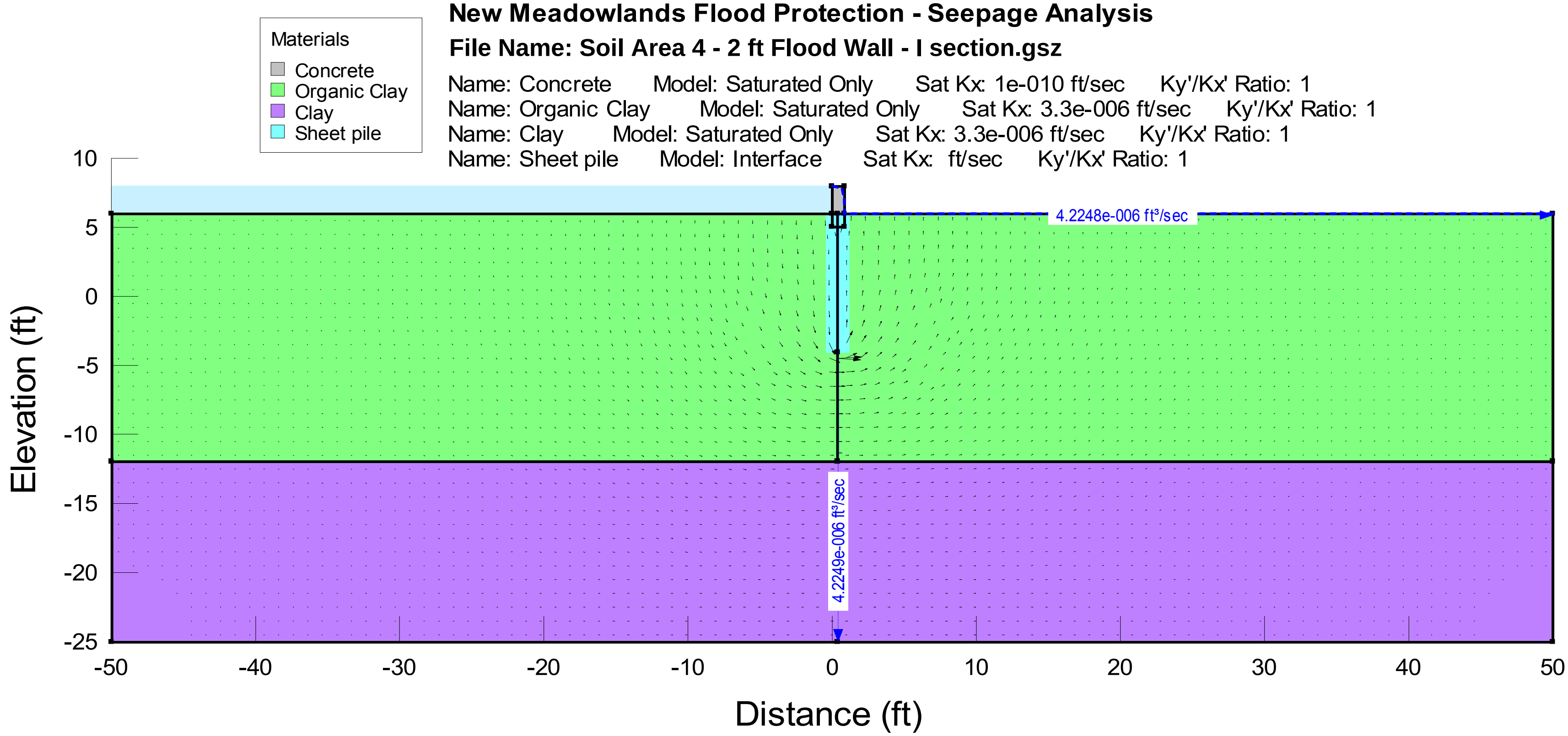
Attachment C1-L

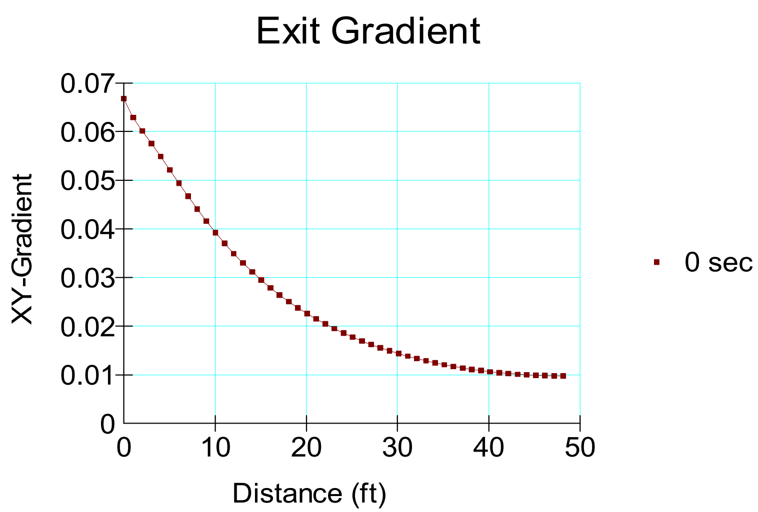
Details of Seepage Analysis Results for I-walls with Sheet Piles in Soil Areas 4 to 7 from GeoStudio

New Meadowlands Flood Protection - Seepage Analysis

File Name: Soil Area 4 - 2 ft Flood Wall - I section.gsz

Name: Concrete Model: Saturated Only Sat Kx: 1e-010 ft/sec Ky'/Kx' Ratio: 1
Name: Organic Clay Model: Saturated Only Sat Kx: 3.3e-006 ft/sec Ky'/Kx' Ratio: 1
Name: Clay Model: Saturated Only Sat Kx: 3.3e-006 ft/sec Ky'/Kx' Ratio: 1
Name: Sheet pile Model: Interface Sat Kx: ft/sec Ky'/Kx' Ratio: 1



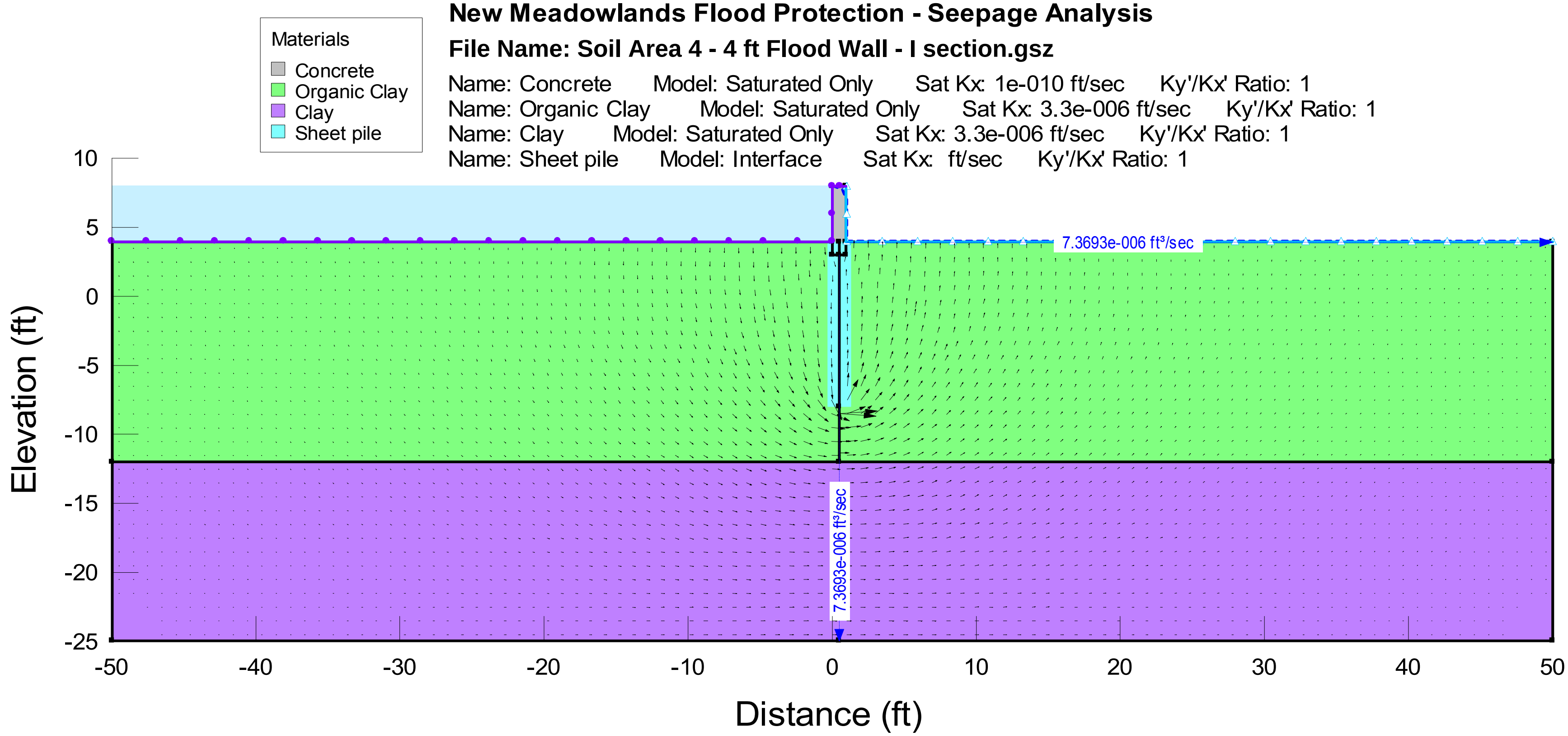


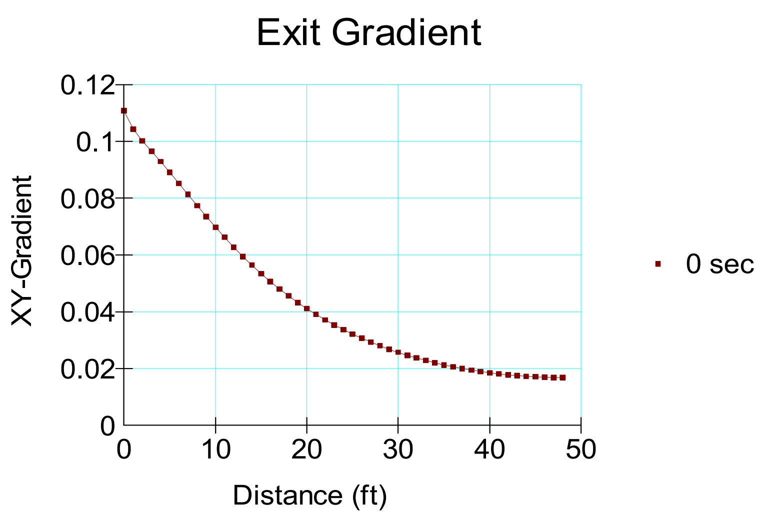
NEW MEADOWLANDS FLOOD PROTECTION SEEPAGE ANALYSIS	
AECOM CLIFTON, NEW JERSEY	
SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	FIGURE NO. L.1

New Meadowlands Flood Protection - Seepage Analysis

File Name: Soil Area 4 - 4 ft Flood Wall - I section.gsz

Name: Concrete Model: Saturated Only Sat Kx: 1e-010 ft/sec Ky'/Kx' Ratio: 1
Name: Organic Clay Model: Saturated Only Sat Kx: 3.3e-006 ft/sec Ky'/Kx' Ratio: 1
Name: Clay Model: Saturated Only Sat Kx: 3.3e-006 ft/sec Ky'/Kx' Ratio: 1
Name: Sheet pile Model: Interface Sat Kx: ft/sec Ky'/Kx' Ratio: 1

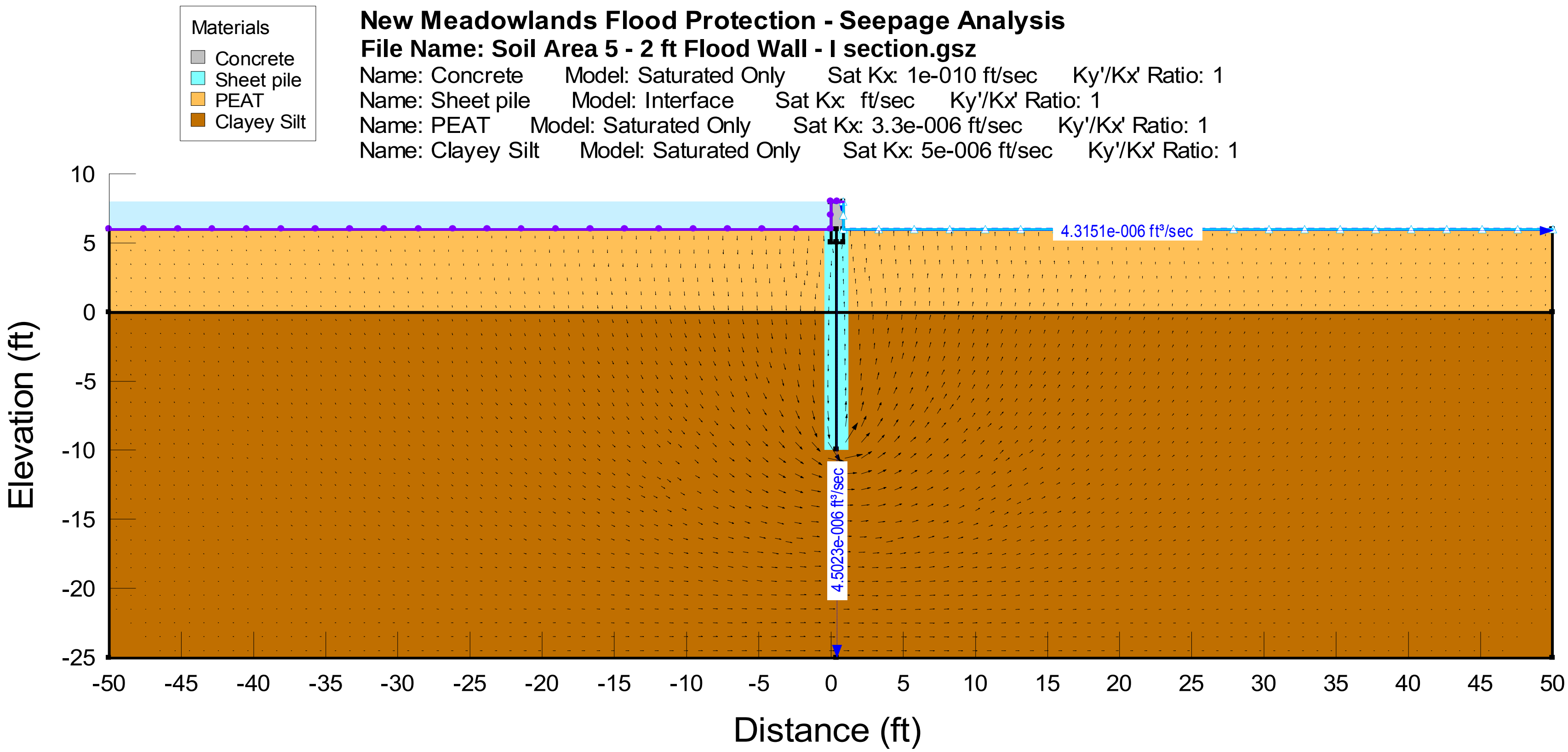


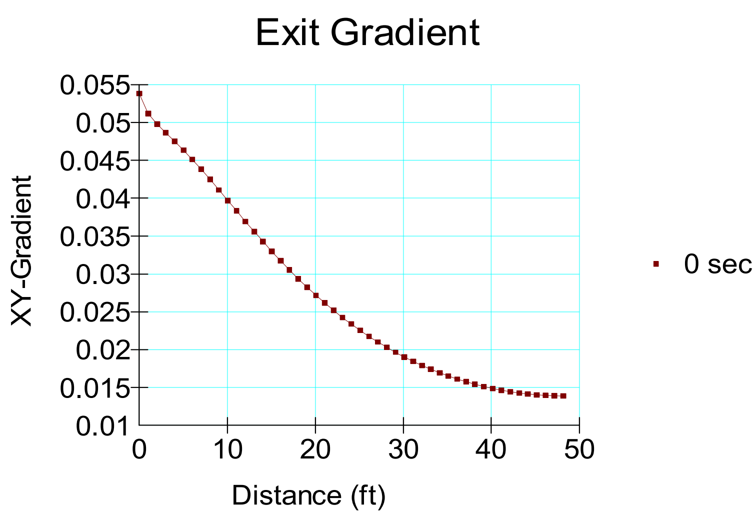


NEW MEADOWLANDS FLOOD PROTECTION SEEPAGE ANALYSIS	
AECOM CLIFTON, NEW JERSEY	
SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	**FIGURE NO. L.2**

New Meadowlands Flood Protection - Seepage Analysis
File Name: Soil Area 5 - 2 ft Flood Wall - I section.gsz

Name: Concrete Model: Saturated Only Sat Kx: 1e-010 ft/sec Ky'/Kx' Ratio: 1
Name: Sheet pile Model: Interface Sat Kx: ft/sec Ky'/Kx' Ratio: 1
Name: PEAT Model: Saturated Only Sat Kx: 3.3e-006 ft/sec Ky'/Kx' Ratio: 1
Name: Clayey Silt Model: Saturated Only Sat Kx: 5e-006 ft/sec Ky'/Kx' Ratio: 1

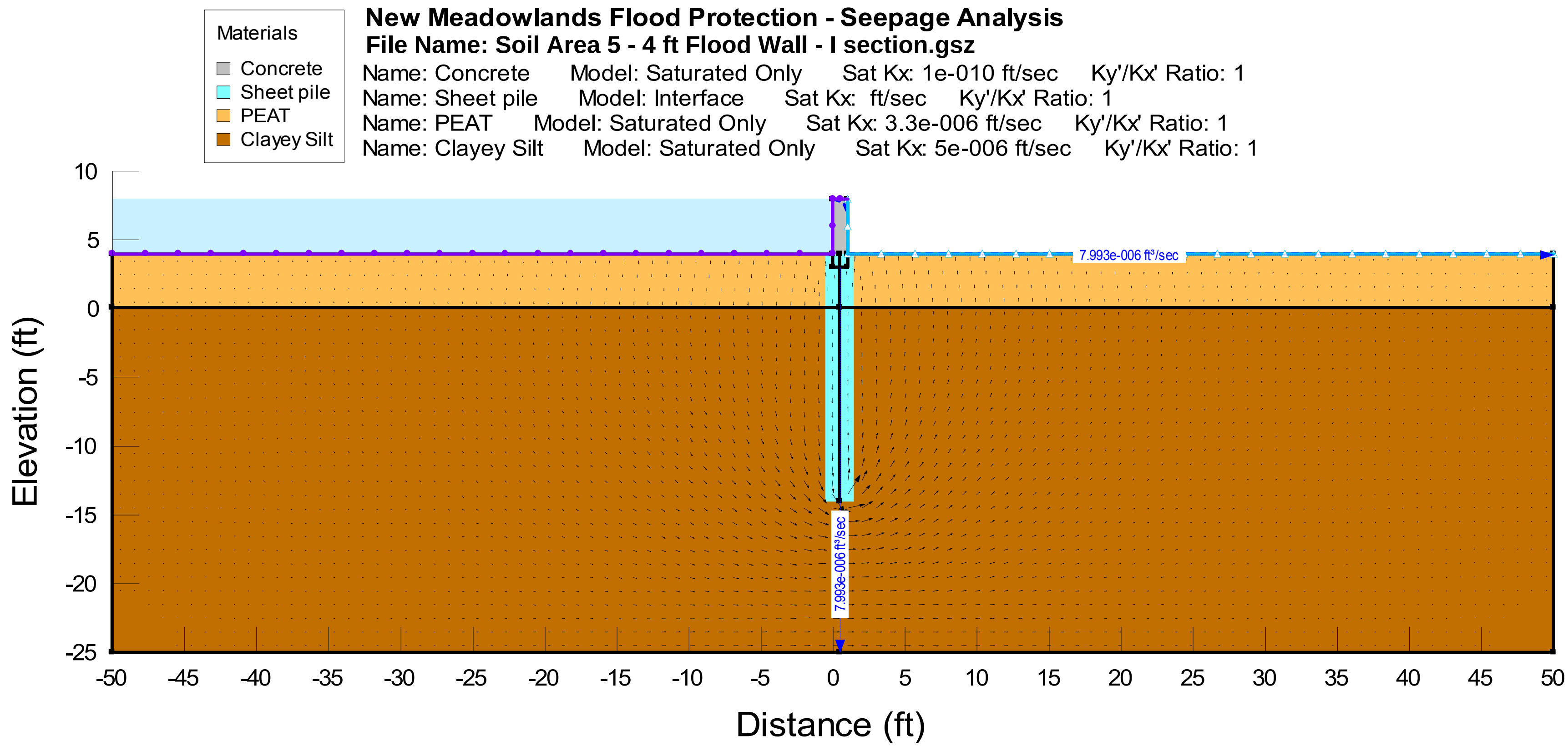


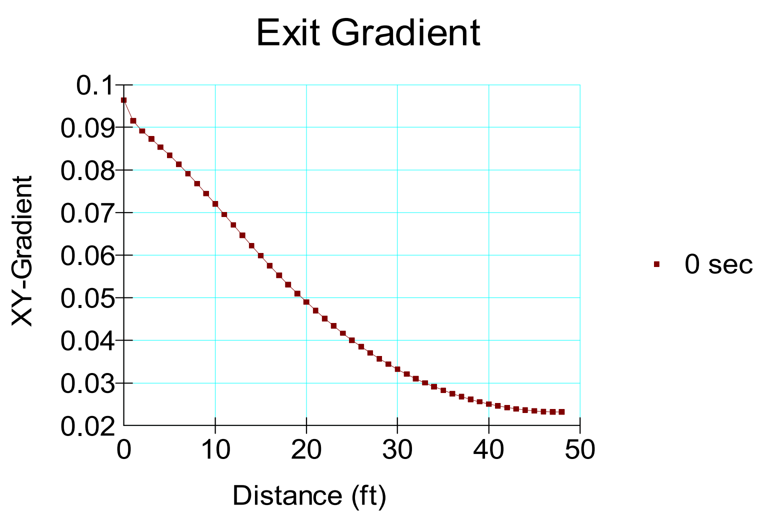


NEW MEADOWLANDS FLOOD PROTECTION
SEEPAGE ANALYSIS

AECOM
CLIFTON, NEW JERSEY

SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	**FIGURE NO. L.3**

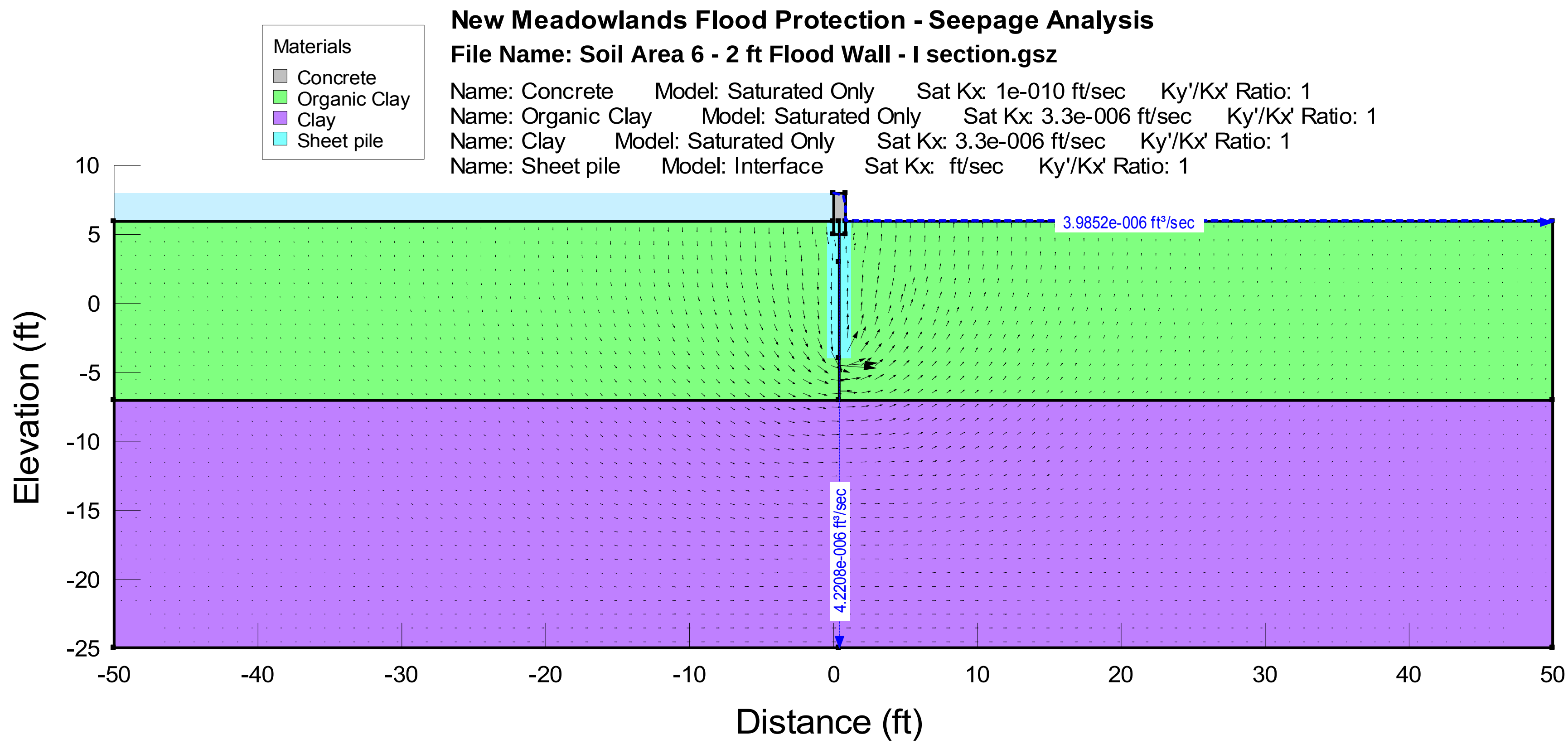


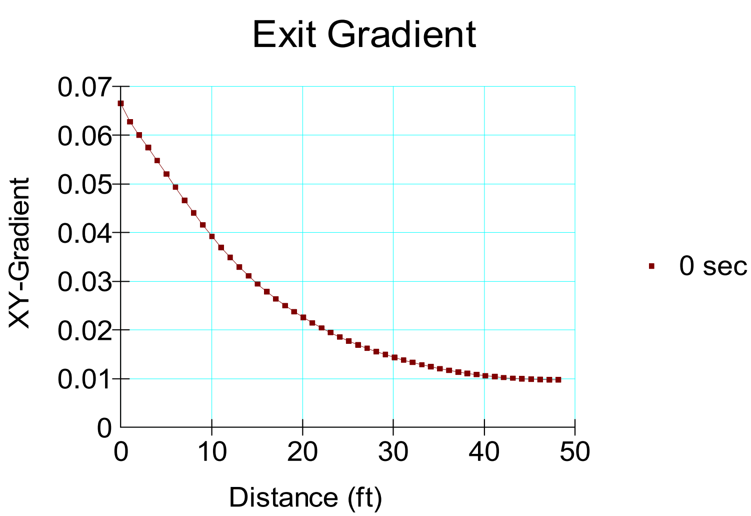


NEW MEADOWLANDS FLOOD PROTECTION
SEEPAGE ANALYSIS

AECOM
CLIFTON, NEW JERSEY

SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	**FIGURE NO. L.4**

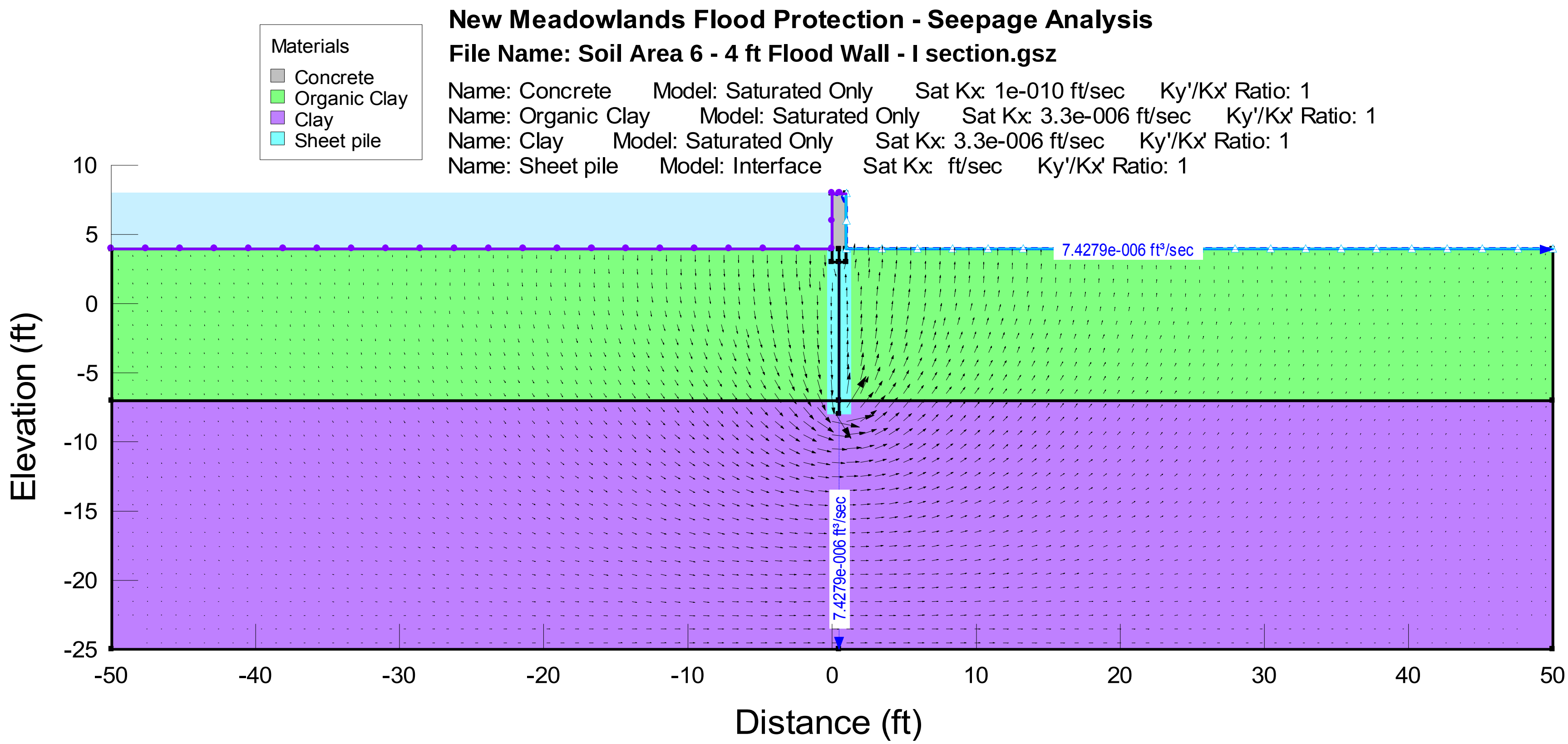


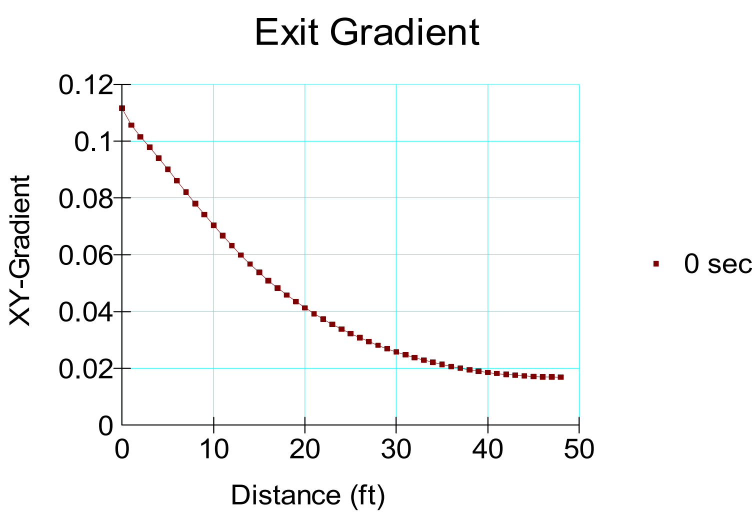


NEW MEADOWLANDS FLOOD PROTECTION
SEEPAGE ANALYSIS

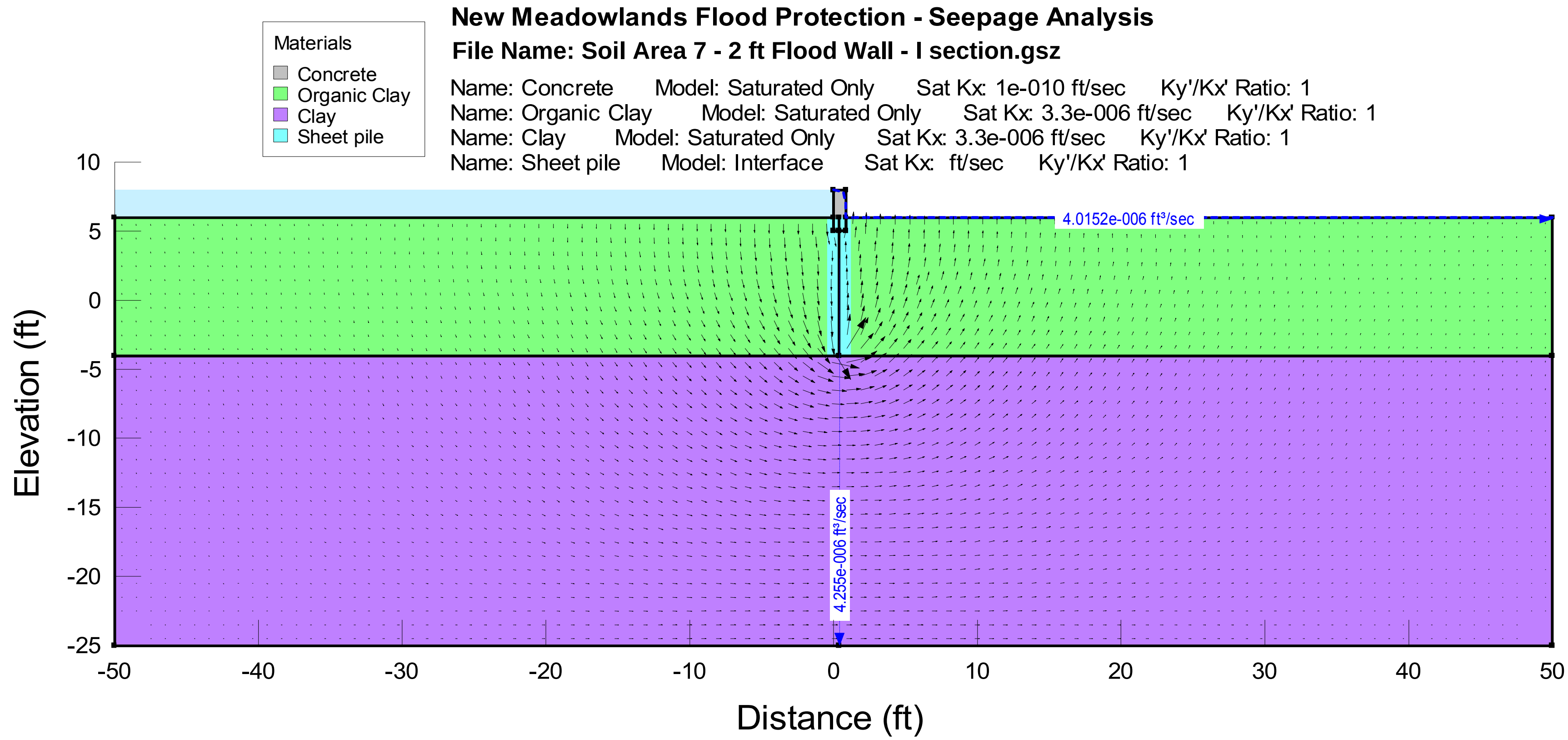
AECOM
CLIFTON, NEW JERSEY

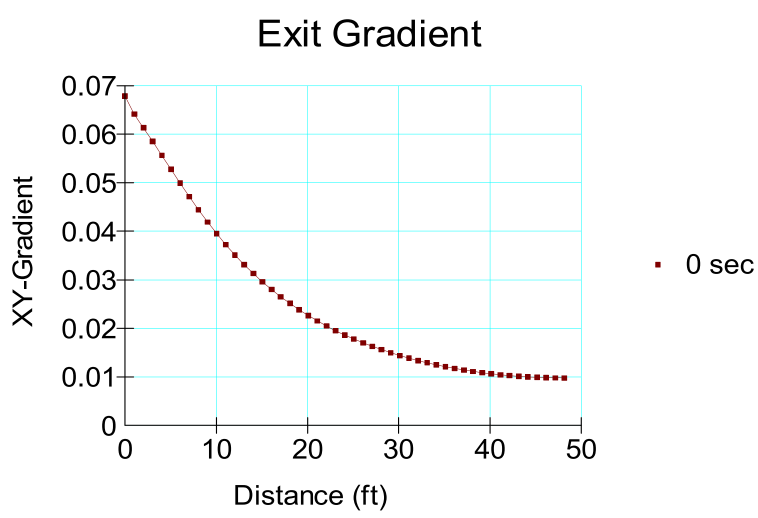
SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	**FIGURE NO. L.5**





NEW MEADOWLANDS FLOOD PROTECTION SEEPAGE ANALYSIS	
AECOM CLIFTON, NEW JERSEY	
SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	**FIGURE NO. L.6**

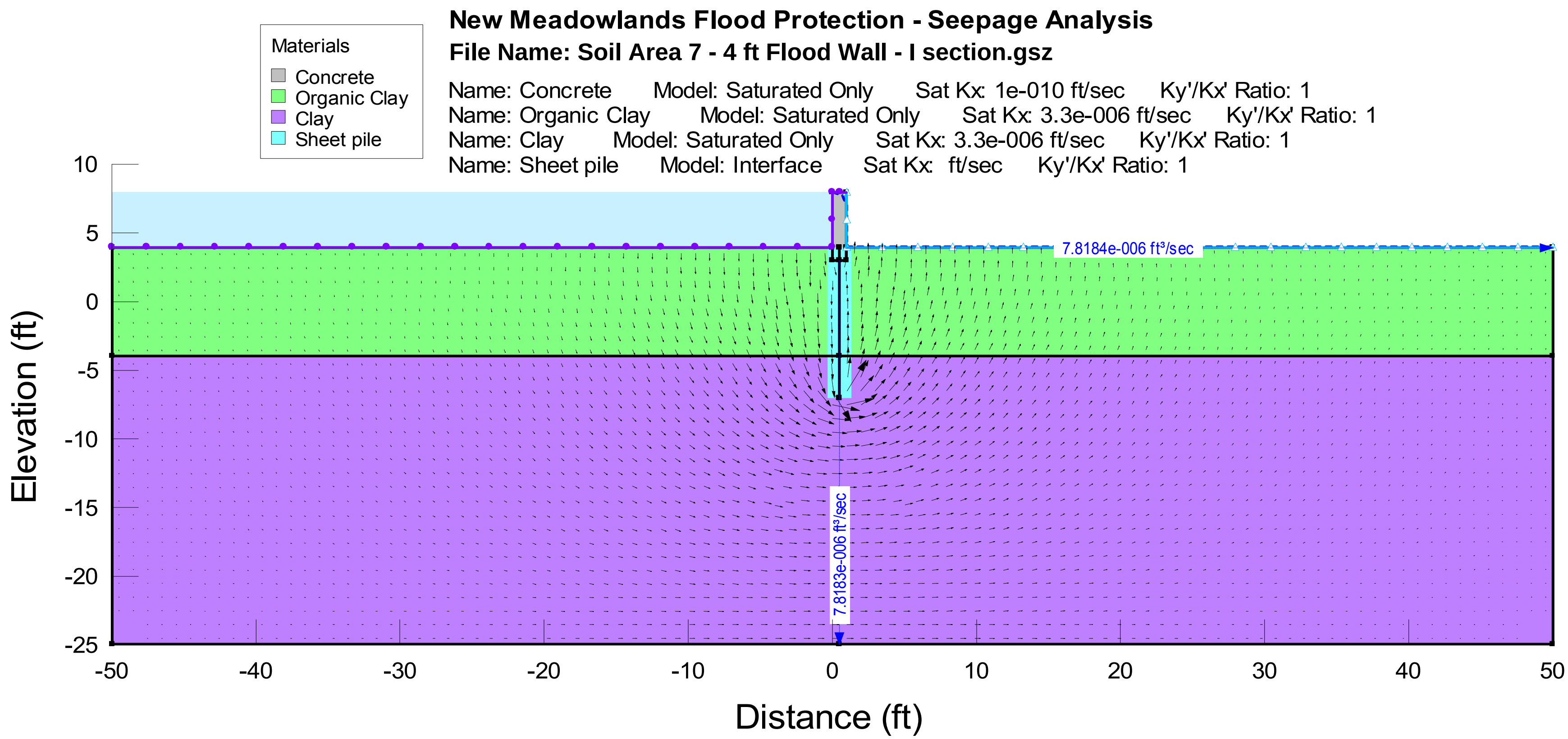


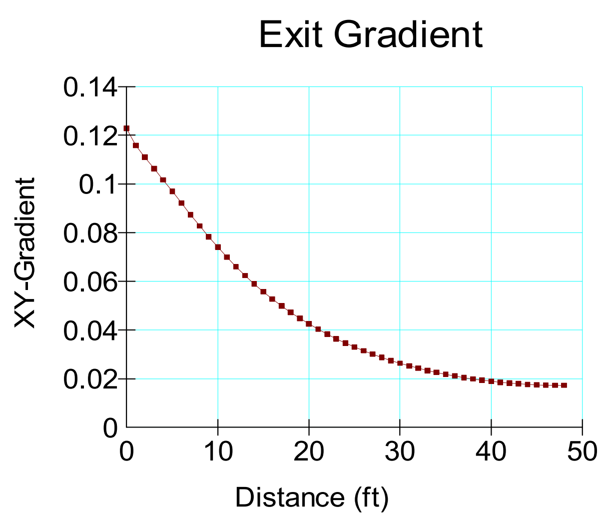


NEW MEADOWLANDS FLOOD PROTECTION
SEEPAGE ANALYSIS

AECOM
CLIFTON, NEW JERSEY

SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	**FIGURE NO. L.7**



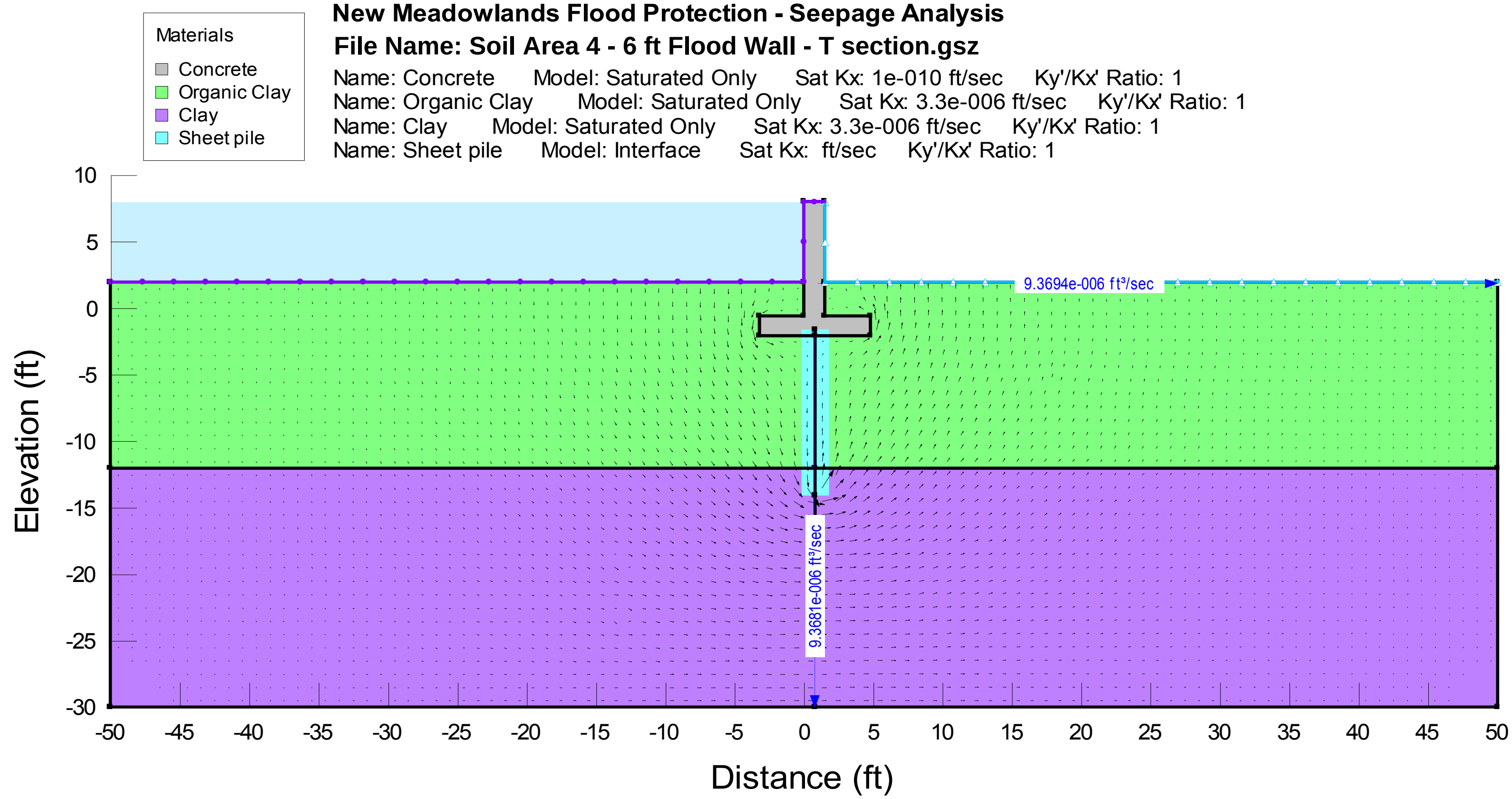


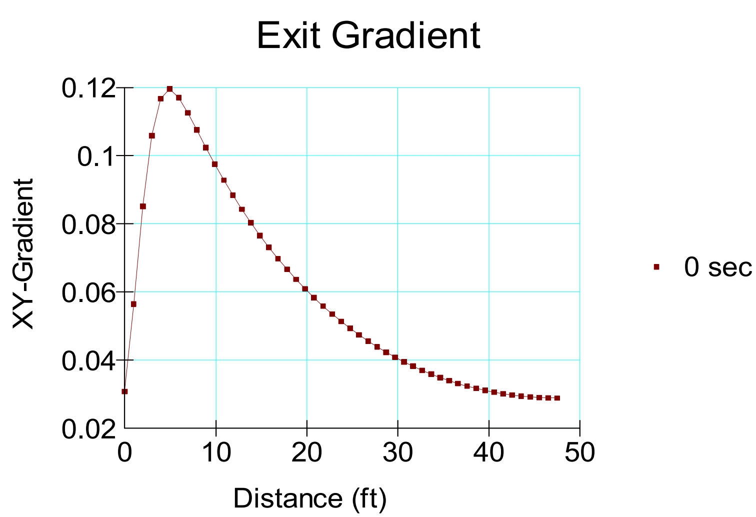
NEW MEADOWLANDS FLOOD PROTECTION
SEEPAGE ANALYSIS

AECOM
CLIFTON, NEW JERSEY

SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	**FIGURE NO. L.8**

Details of Seepage Analysis Results for T-walls with Sheet Piles in Soil Areas 4 to 7 from GeoStudio





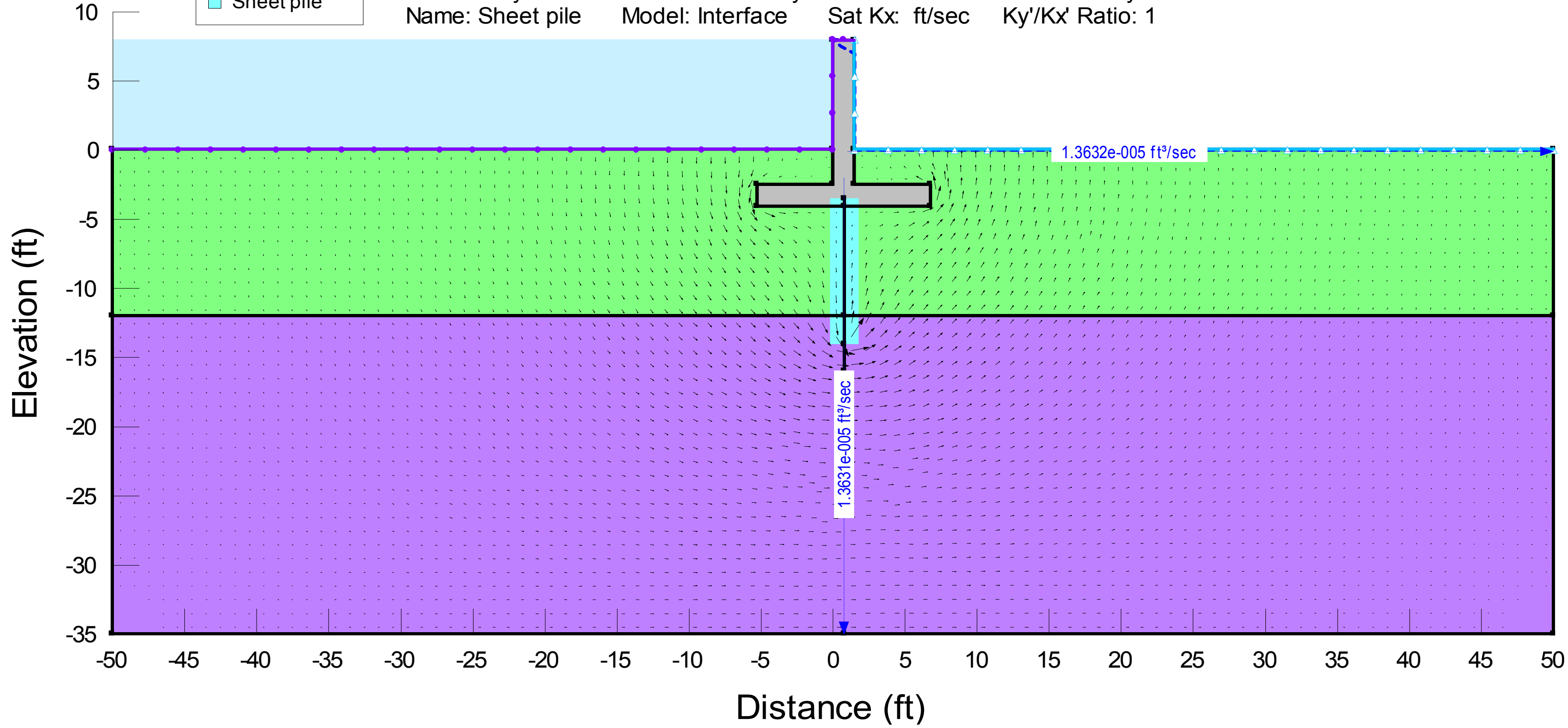
NEW MEADOWLANDS FLOOD PROTECTION SEEPAGE ANALYSIS

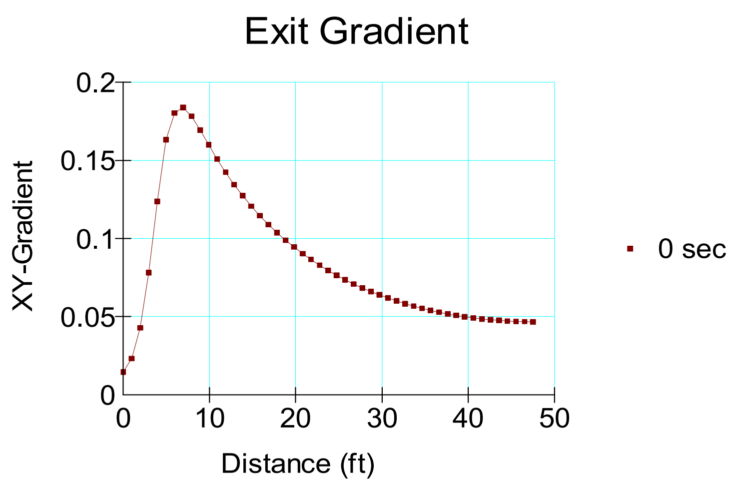
AECOM
CLIFTON, NEW JERSEY

SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	**FIGURE NO. M.1**

New Meadowlands Flood Protection - Seepage Analysis
File Name: Soil Area 4 - 8 ft Flood Wall - T section.gsz

Name: Concrete Model: Saturated Only Sat Kx: 1e-010 ft/sec Ky'/Kx' Ratio: 1
Name: Organic Clay Model: Saturated Only Sat Kx: 3.3e-006 ft/sec Ky'/Kx' Ratio: 1
Name: Clay Model: Saturated Only Sat Kx: 3.3e-006 ft/sec Ky'/Kx' Ratio: 1
Name: Sheet pile Model: Interface Sat Kx: ft/sec Ky'/Kx' Ratio: 1

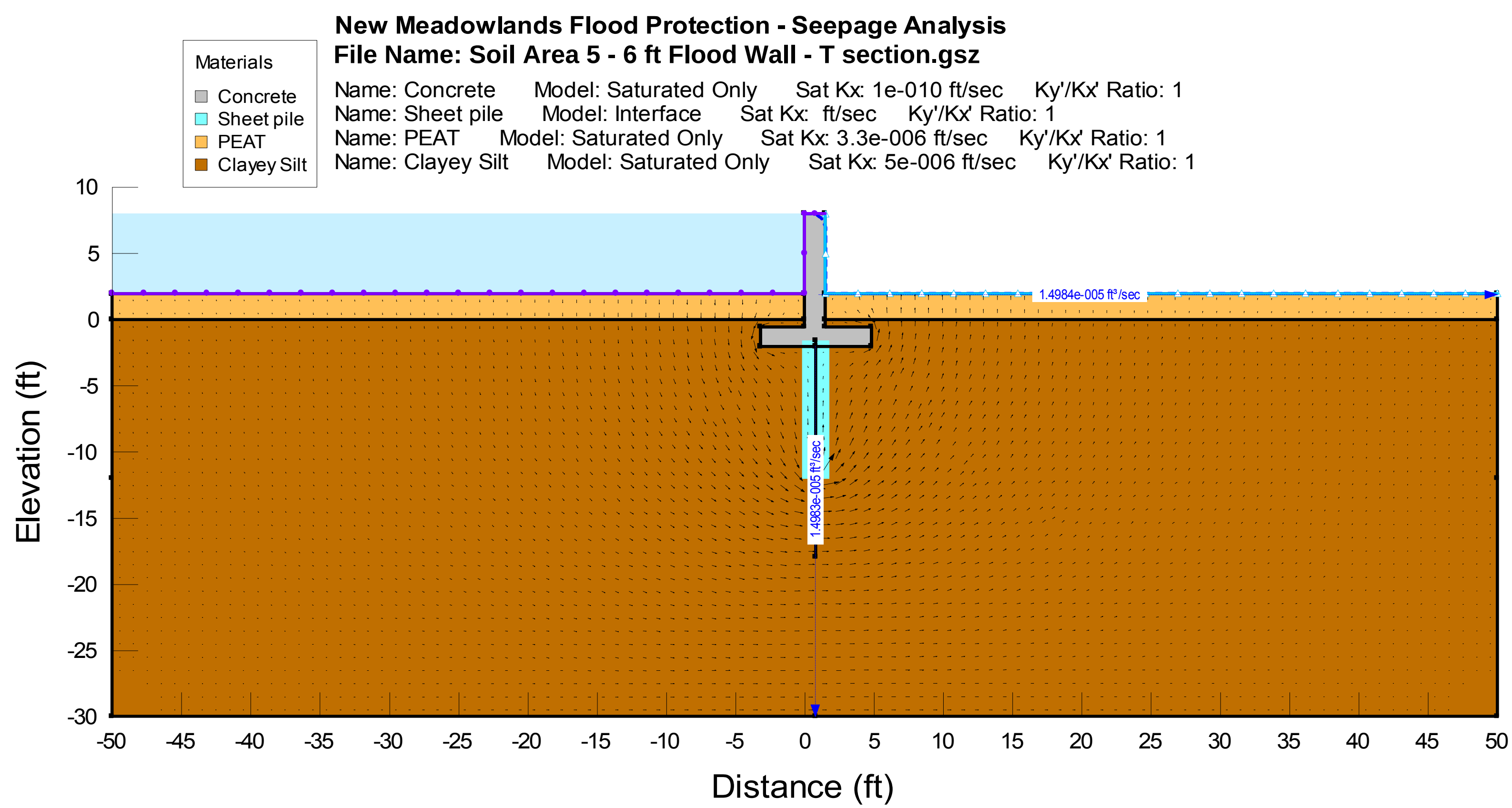


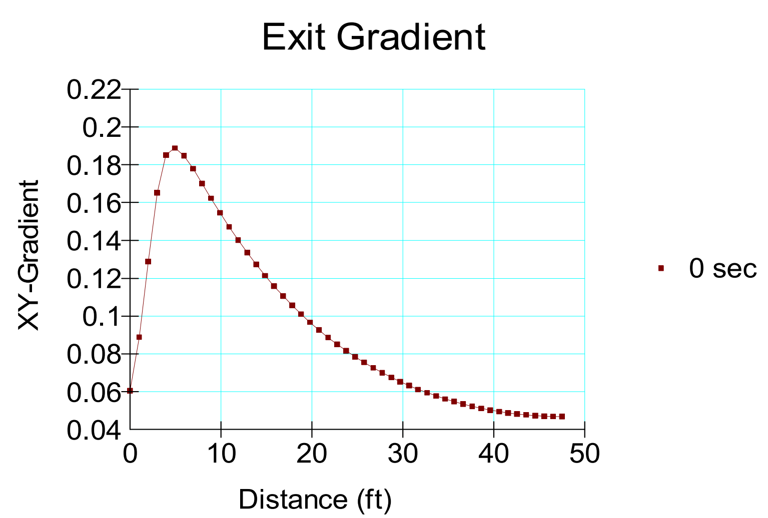


NEW MEADOWLANDS FLOOD PROTECTION
SEEPAGE ANALYSIS

AECOM
CLIFTON, NEW JERSEY

SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	**FIGURE NO. M.2**

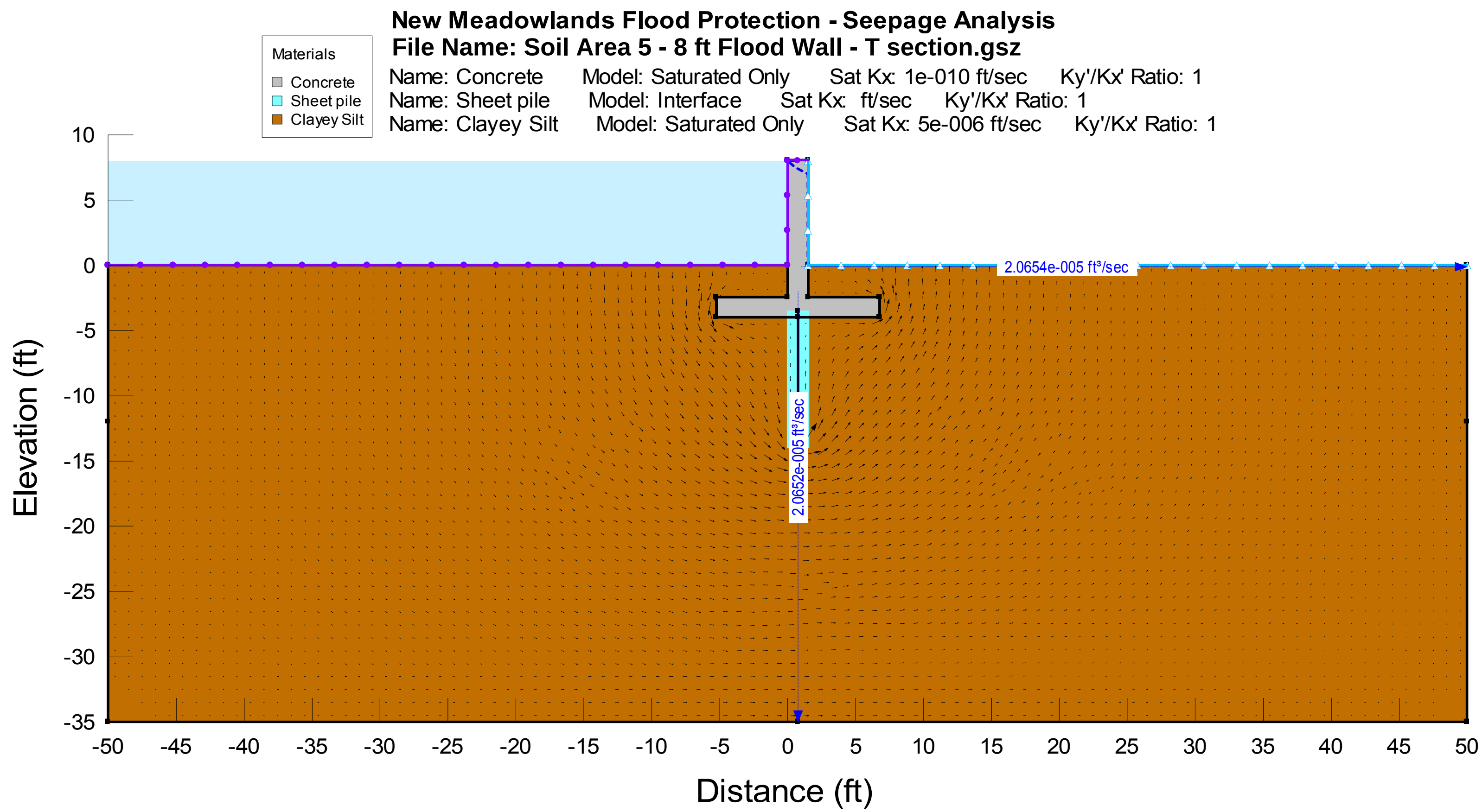


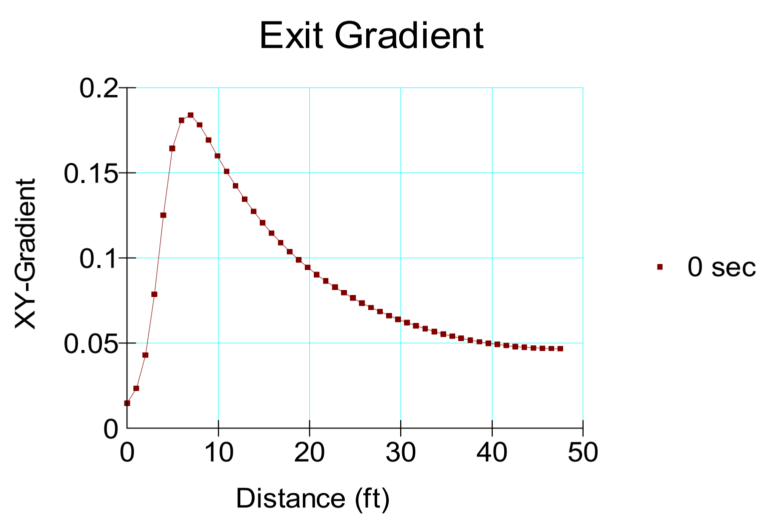


NEW MEADOWLANDS FLOOD PROTECTION
SEEPAGE ANALYSIS

AECOM
CLIFTON, NEW JERSEY

SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	**FIGURE NO. M.3**

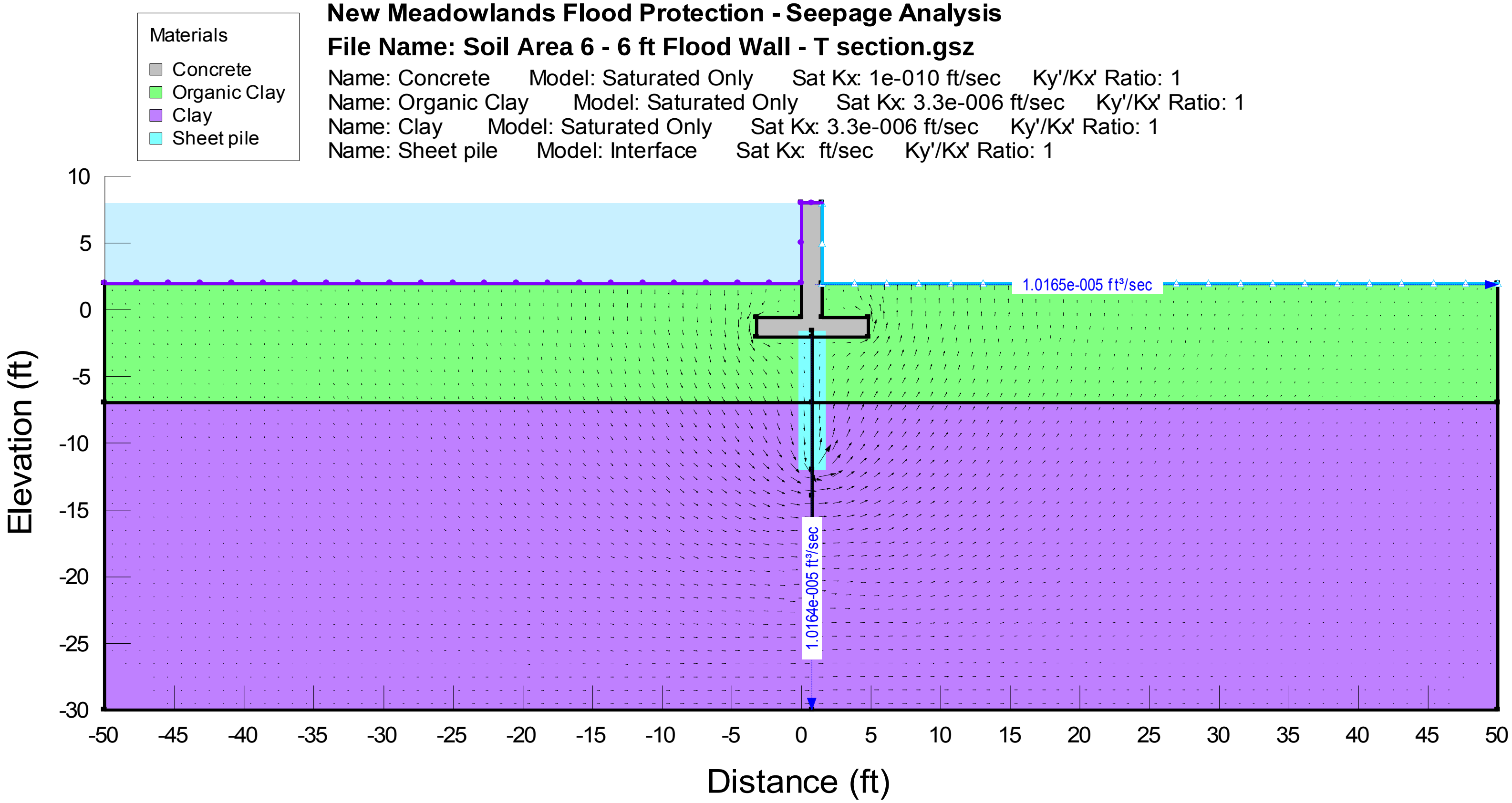


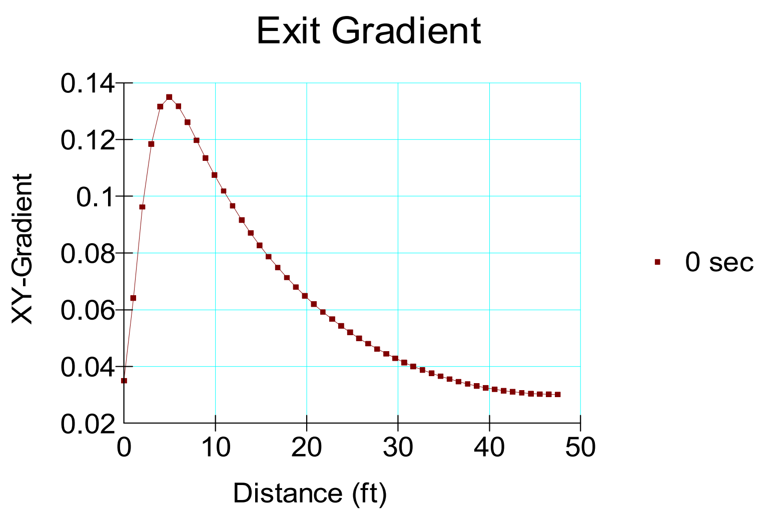


NEW MEADOWLANDS FLOOD PROTECTION
SEEPAGE ANALYSIS

AECOM
CLIFTON, NEW JERSEY

SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	**FIGURE NO. M.4**

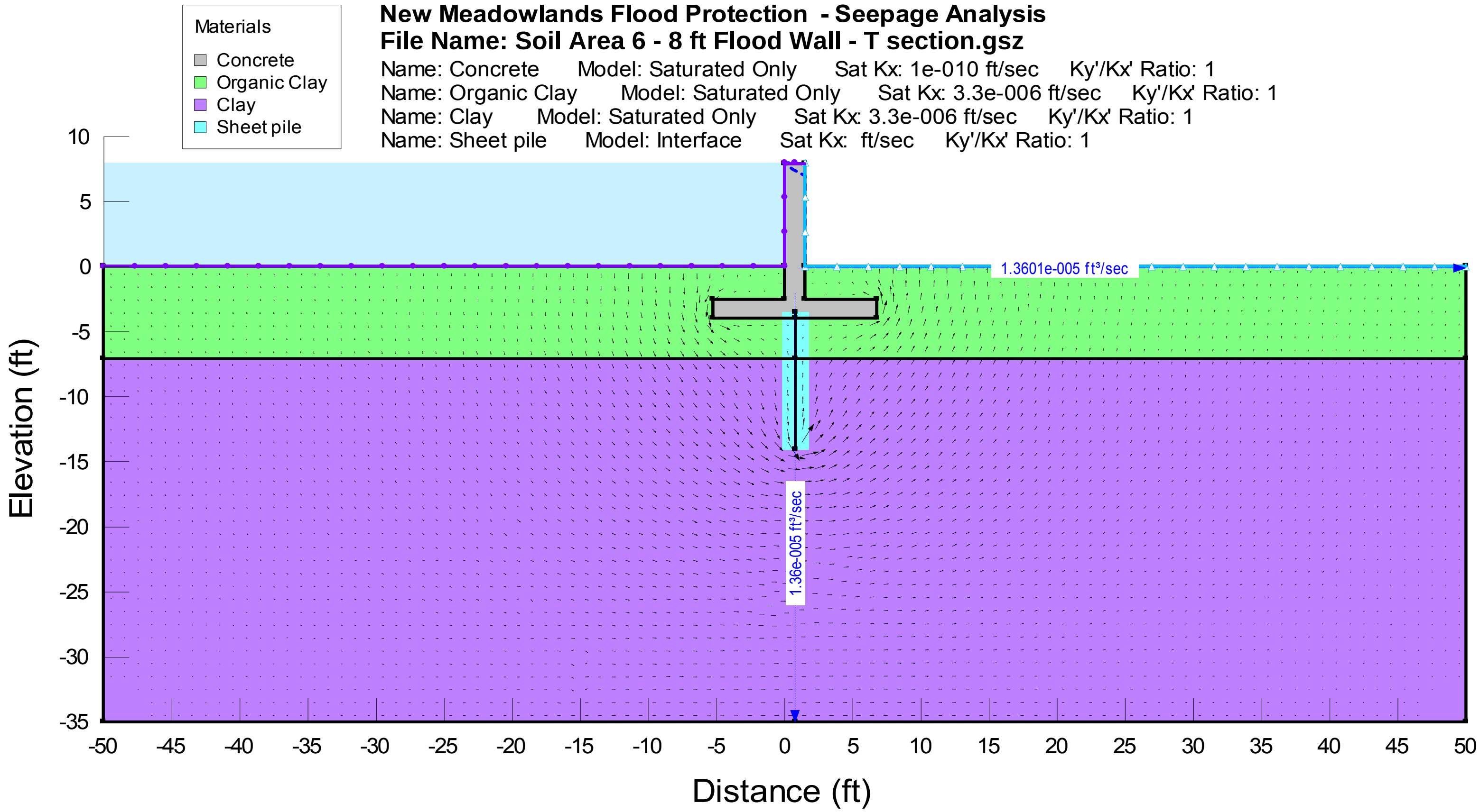


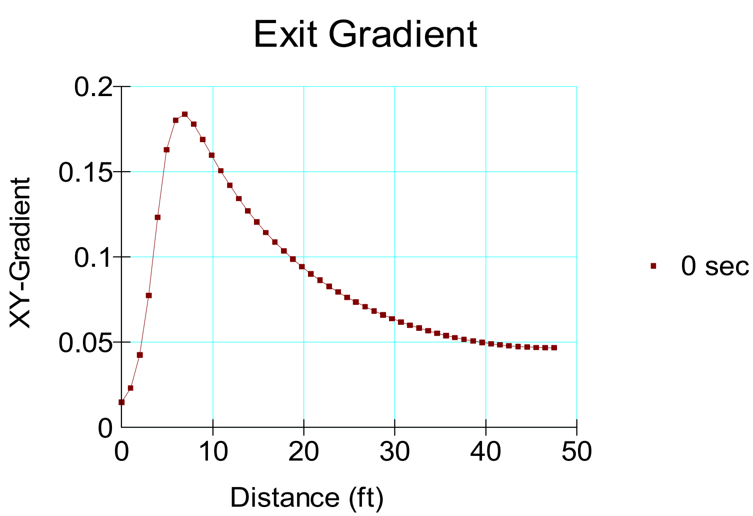


NEW MEADOWLANDS FLOOD PROTECTION
SEEPAGE ANALYSIS

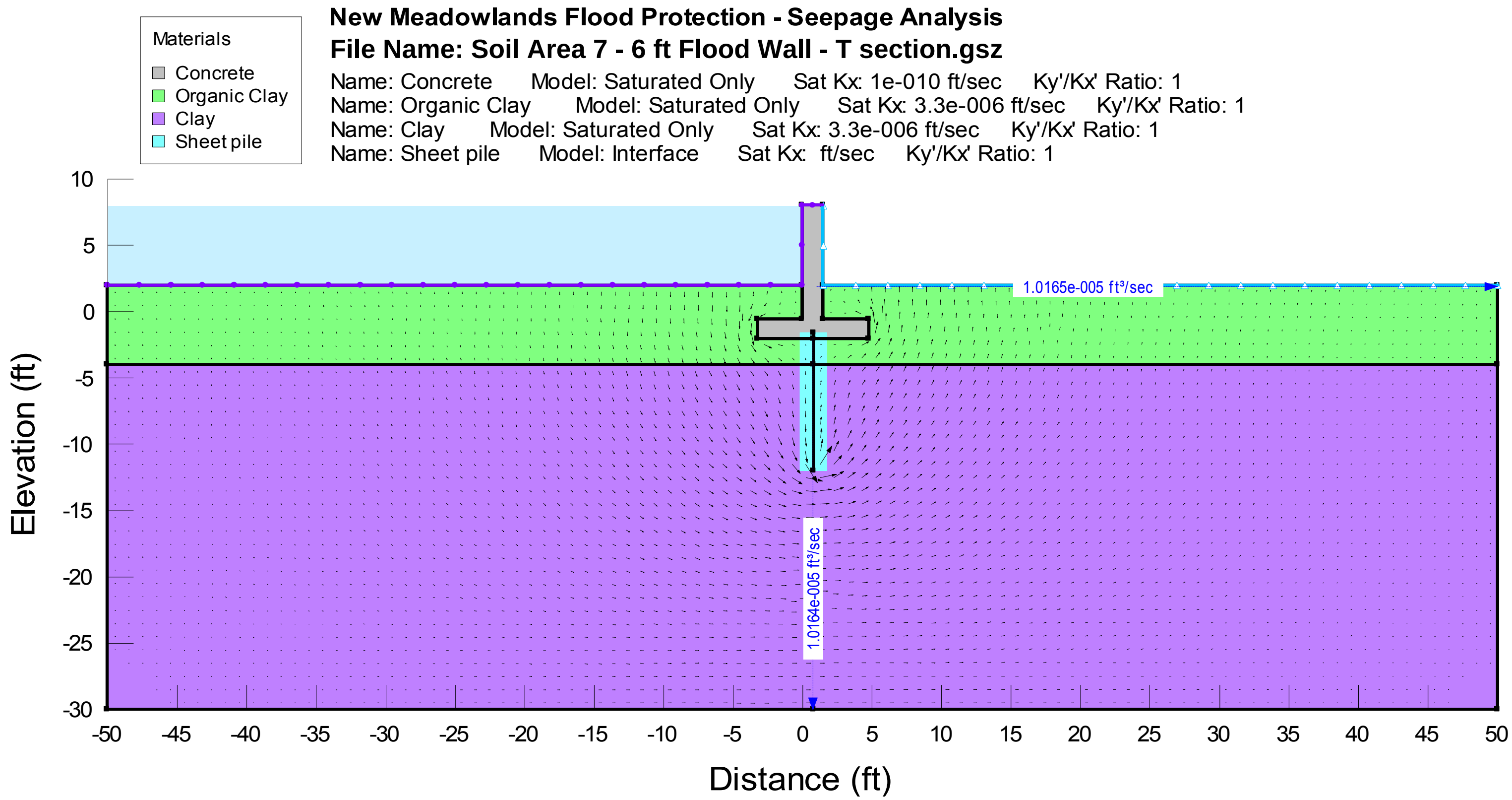
AECOM
CLIFTON, NEW JERSEY

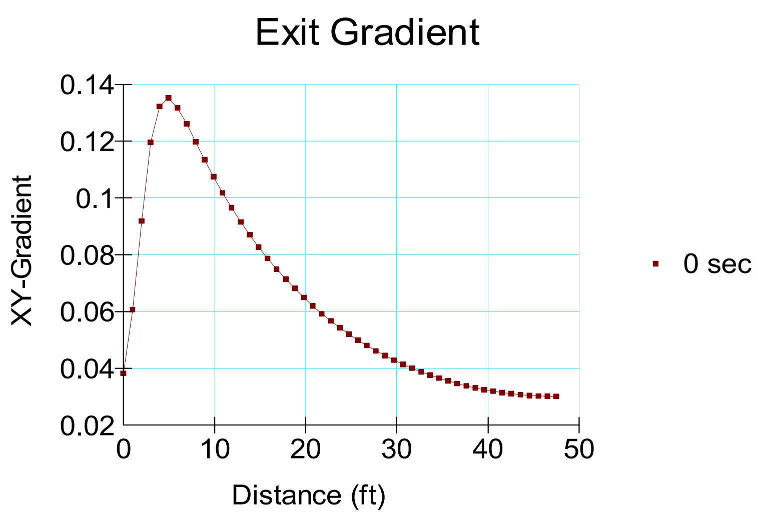
SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	**FIGURE NO. M.5**





NEW MEADOWLANDS FLOOD PROTECTION SEEPAGE ANALYSIS	
AECOM CLIFTON, NEW JERSEY	
SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	FIGURE NO. M.6

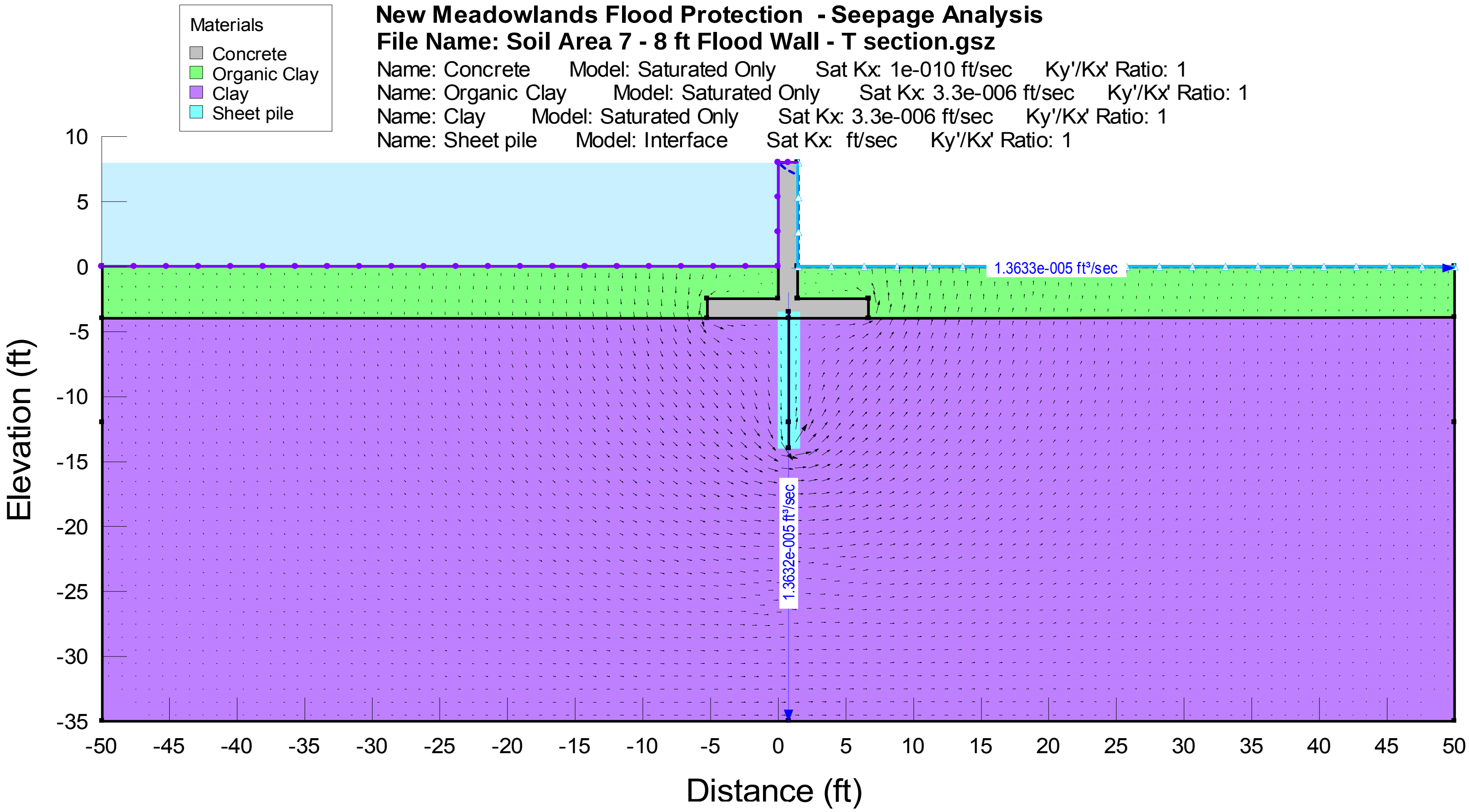


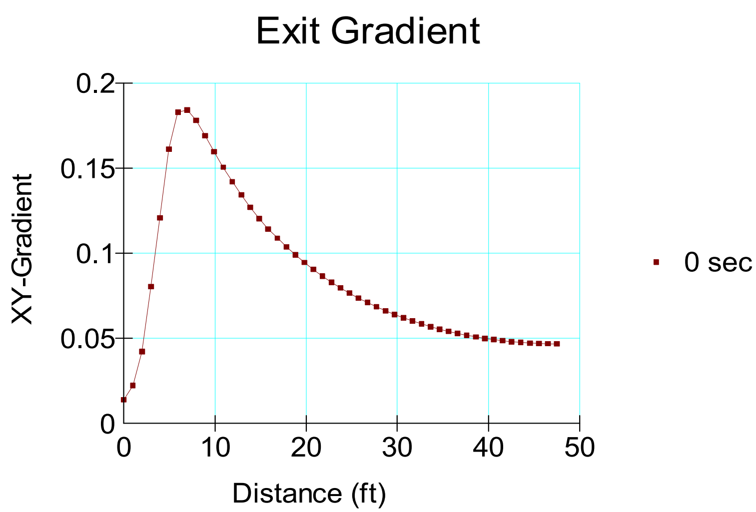


NEW MEADOWLANDS FLOOD PROTECTION
SEEPAGE ANALYSIS

AECOM
CLIFTON, NEW JERSEY

SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	**FIGURE NO. M.7**





NEW MEADOWLANDS FLOOD PROTECTION SEEPAGE ANALYSIS	
AECOM CLIFTON, NEW JERSEY	
SCALE: NTS	PROJ NO: 60513717
DATE: December 15, 2016	FIGURE NO. M.8

Attachment C1-N

Output from GROUP Analysis for 8 ft T-wall in Soil Areas 4 to 7

===

GROUP for Windows, Version 2014.9.3

Serial Number : 208076662

Analysis of A Group of Piles
Subjected to Axial and Lateral Loading

===

Time and Date of Analysis

Date: January 18, 2017   Time: 10:21:13

***** COMPUTATION RESULTS *****

6 Ft Floodwall

***** LOAD CASES RESULTS *****

LOAD CASE : 1
CASE NAME : Load Case
LOAD TYPE : Dead, DL

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD, LBS	HOR. LOAD Y, LBS	HOR. LOAD Z, LBS
23460.0	37750.0	0.00000

MOMENT X ,IN-LBS	MOMENT Y,IN-LBS	MOMENT Z,IN-LBS
0.00000	0.00000	1.98036E+06

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0107729	0.29516	-3.04885E-18

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
-3.59271E-20	-3.95063E-19	2.22889E-03

THE GLOBAL STRUCTURAL COORDINATE SYSTEM
----

* PILE TOP DISPLACEMENTS *

PILE GROUP	DISP. X,IN	DISP. Y,IN	DISP. Z,IN	ROT. X,RAD	ROT. Y,RAD	ROT. Z,RAD
1	-6.9467E-02	0.2952	-4.3422E-18	-3.5927E-20	-3.9506E-19	2.2289E-03
2	9.1013E-02	0.2952	-1.7555E-18	-3.5927E-20	-3.9506E-19	2.2289E-03
MINIMUM	-6.9467E-02	0.2952	-4.3422E-18	-3.5927E-20	-3.9506E-19	2.2289E-03
Pile N.	1	1	1	1	1	1
MAXIMUM	9.1013E-02	0.2952	-1.7555E-18	-3.5927E-20	-3.9506E-19	2.2289E-03
Pile N.	2	1	2	1	1	1

* PILE TOP REACTIONS *

PILE GROUP	FOR. X,LBS	FOR. Y,LBS	FOR. Z,LBS	MOM X,LBS-IN	MOM Y,LBS-IN	MOM Z,LBS-IN
1	2.4825E+04	2.2608E+04	3.7312E-13	7.2175E-12	-4.7230E-11	1.4548E+06
2	-1365.1	1.5142E+04	-3.7312E-13	-3.4158E-11	4.7206E-11	1.4684E+06
MINIMUM	-1365.1	1.5142E+04	-3.7312E-13	-3.4158E-11	-4.7230E-11	1.4548E+06
Pile N.	2	2	2	2	1	1
MAXIMUM	2.4825E+04	2.2608E+04	3.7312E-13	7.2175E-12	4.7206E-11	1.4684E+06
Pile N.	1	1	1	1	2	2

THE PILE COORDINATE SYSTEM (LOCAL AXES)
----

* PILE TOP DISPLACEMENTS *

PILE GROUP	DISP. x,IN	DISP. y,IN	DISP. z,IN	ROT. x,RAD	ROT. y,RAD	ROT. z,RAD
1	2.5143E-02	0.3022	-4.3422E-18	-1.5625E-19	-3.6462E-19	2.2289E-03
2	-4.6521E-03	-0.3088	-3.4392E-17	1.7226E-19	6.4643E-19	-2.2289E-03
MINIMUM	-4.6521E-03	-0.3088	-3.4392E-17	-1.5625E-19	-3.6462E-19	-2.2289E-03
Pile N.	2	2	2	1	1	2
MAXIMUM	2.5143E-02	0.3022	-4.3422E-18	1.7226E-19	6.4643E-19	2.2289E-03
Pile N.	1	1	1	2	2	1

* PILE TOP REACTIONS *

PILE GROUP	AXIAL,LBS	LAT. y,LBS	LAT. z,LBS	MOM x,LBS-IN	MOM y,LBS-IN	MOM z,LBS-IN
1	3.0596E+04	1.3830E+04	3.7312E-13	-7.7307E-12	-4.7149E-11	1.4548E+06
2	-5977.4	-1.3979E+04	-1.4812E-12	8.4969E-12	1.3669E-10	-1.4684E+06
MINIMUM	-5977.4	-1.3979E+04	-1.4812E-12	-7.7307E-12	-4.7149E-11	-1.4684E+06
Pile N.	2	2	2	1	1	2
MAXIMUM	3.0596E+04	1.3830E+04	3.7312E-13	8.4969E-12	1.3669E-10	1.4548E+06
Pile N.	1	1	1	2	2	1

PILE GROUP	STRESS,LBS/IN**2
1	1.4496E+04
2	1.3468E+04
MINIMUM	1.3468E+04
Pile N.	2
MAXIMUM	1.4496E+04
Pile N.	1

* EFFECTS FOR LATERALLY LOADED PILE *

* MINIMUM VALUES AND LOCATIONS *

PILE	DISPL. y-DIR IN	DISPL. z-DIR IN	MOMENT z-DIR LBS-IN	MOMENT y-DIR LBS-IN	SHEAR y-DIR LBS	SHEAR z-DIR LBS	SOIL REACT y-DIR LBS/IN	SOIL REACT z-DIR LBS/IN	TOTAL STRESS LBS/IN**2	FLEX. RIG. z-DIR LBS-IN**2	FLEX. RIG. y-DIR LBS-IN**2

******	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
1	-4.3405E-03	-4.3422E-18	-1.4548E+06	-4.7149E-11	-2614.6	-5.7564E-14	-23.019	-2.0797E-15	1429.7	2.1141E+10	7.5690E+09
x(FT)	30.000	0.0000	0.0000	0.0000	26.000	25.000	30.000	26.000	55.000	0.0000	0.0000
2	-0.3485	-4.7886E-17	-2.8730E+05	-2.0666E-11	-1.3776E+04	-1.4583E-12	-81.017	-9.6049E-15	279.32	2.1141E+10	7.5690E+09
x(FT)	3.0000	4.0000	19.000	17.000	0.0000	0.0000	12.000	12.000	54.000	0.0000	0.0000
Min.	-0.3485	-4.7886E-17	-1.4548E+06	-4.7149E-11	-1.3776E+04	-1.4583E-12	-81.017	-9.6049E-15	279.32	2.1141E+10	7.5690E+09
Pile N.	2	2	1	1	2	2	2	2	2	1	1

* MAXIMUM VALUES AND LOCATIONS *

PILE	DISPL. y-DIR IN	DISPL. z-DIR IN	MOMENT z-DIR LBS-IN	MOMENT y-DIR LBS-IN	SHEAR y-DIR LBS	SHEAR z-DIR LBS	SOIL REACT y-DIR LBS/IN	SOIL REACT z-DIR LBS/IN	TOTAL STRESS LBS/IN**2	FLEX. RIG. z-DIR LBS-IN**2	FLEX. RIG. y-DIR LBS-IN**2
******	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
1	0.3422	8.9706E-18	2.8479E+05	4.6238E-12	1.3644E+04	3.7712E-13	80.531	2.7222E-15	1.4496E+04	2.1141E+10	7.5690E+09
x(FT)	3.0000	7.0000	19.000	19.000	0.0000	0.0000	12.000	12.000	0.0000	0.0000	0.0000
2	4.4274E-03	1.0468E-19	1.4684E+06	1.3669E-10	2623.3	2.3900E-13	23.272	1.6395E-14	1.3468E+04	2.1141E+10	7.5690E+09
x(FT)	30.000	28.000	0.0000	0.0000	26.000	25.000	30.000	26.000	0.0000	0.0000	0.0000
Max.	0.3422	8.9706E-18	1.4684E+06	1.3669E-10	1.3644E+04	3.7712E-13	80.531	1.6395E-14	1.4496E+04	2.1141E+10	7.5690E+09
Pile N.	1	1	2	2	1	1	1	2	1	1	1

***** SUMMARY FOR LOAD CASES AND COMBINATIONS *****

* TABLE L * COMPUTATION ON PILE CAP

***** LOAD CASES RESULTS *****

LOAD CASE : 1

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

LOAD X,LBS	LOAD Y,LBS	LOAD Z,LBS	MOM X,IN-LBS	MOM Y,IN-LBS	MOM Z,IN-LBS
23460.0	37750.0	0.00000	0.00000	0.00000	1.98036E+06

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

DISP X,IN	DISP Y,IN	DISP Z,IN	ROT X,RAD	ROT Y,RAD	ROT Z,RAD
0.0107729	0.29516	-3.04885E-18	-3.59271E-20	-3.95063E-19	2.22889E-03

Plots of Lateral Deflection, Bending Moment and Shear Force versus Depth of L-walls from PYWall

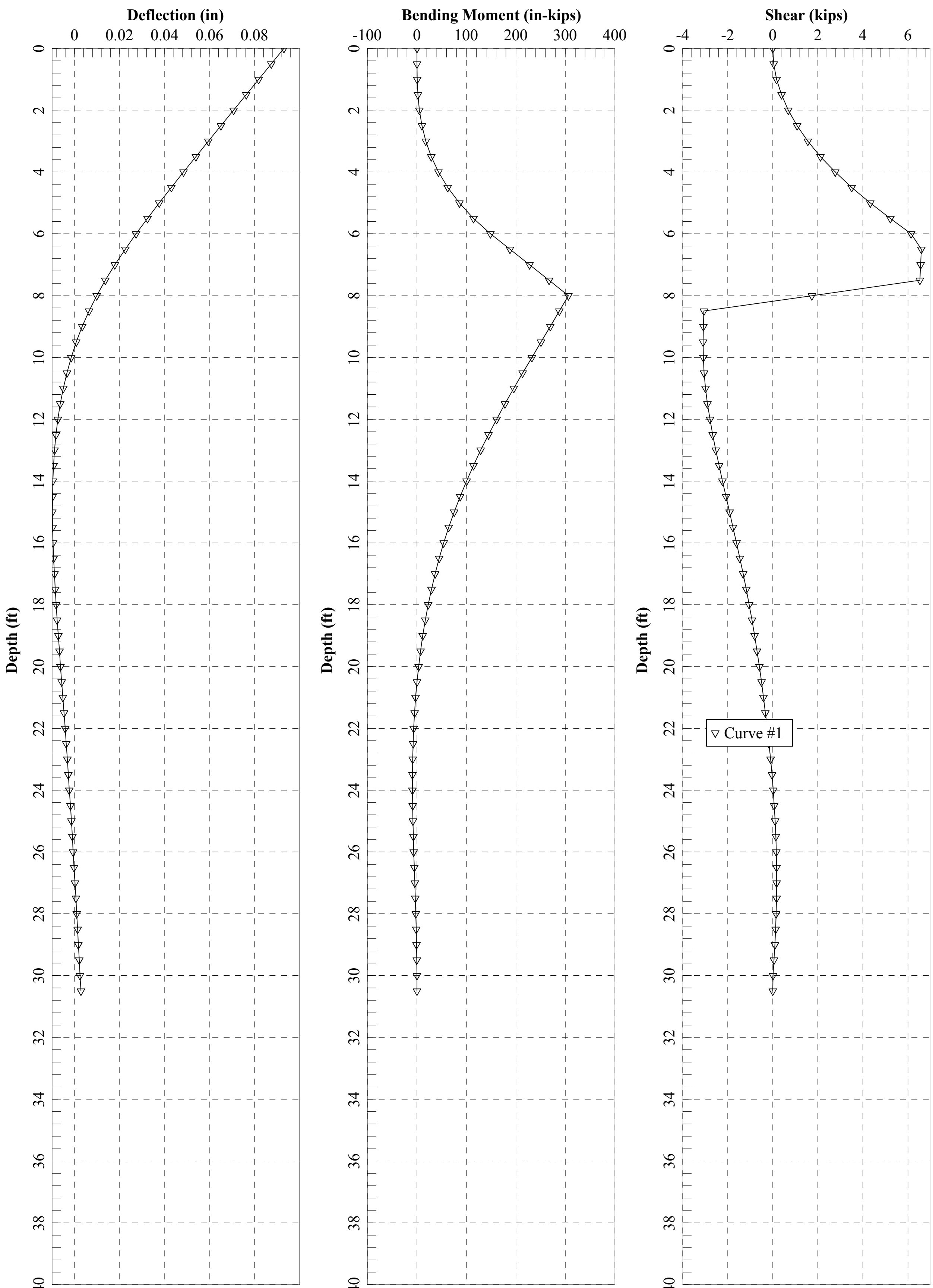


Figure O.1: Lateral Deflection, Bending Moment and Shear Force with Depth for 6 ft L-wall with Sheet Pile Supported by Batter Steel Piles at Full Flood Condition for Zone 4 to 7.

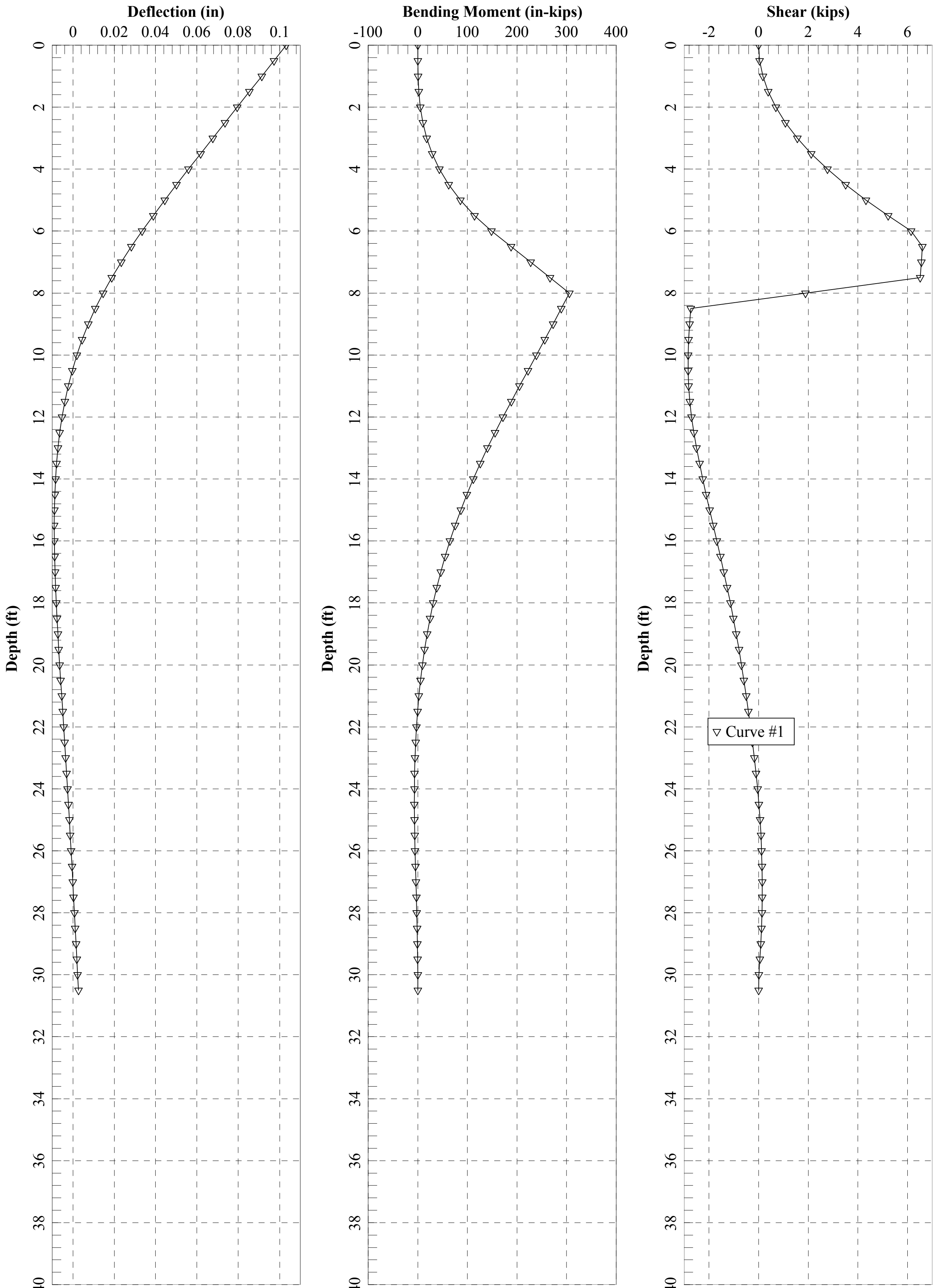


Figure O.2: Lateral Deflection, Bending Moment and Shear Force with Depth for 6 ft L-wall with Sheet Pile Supported by Batter Micropiles at Full Flood Condition for Zone 4 to 7.

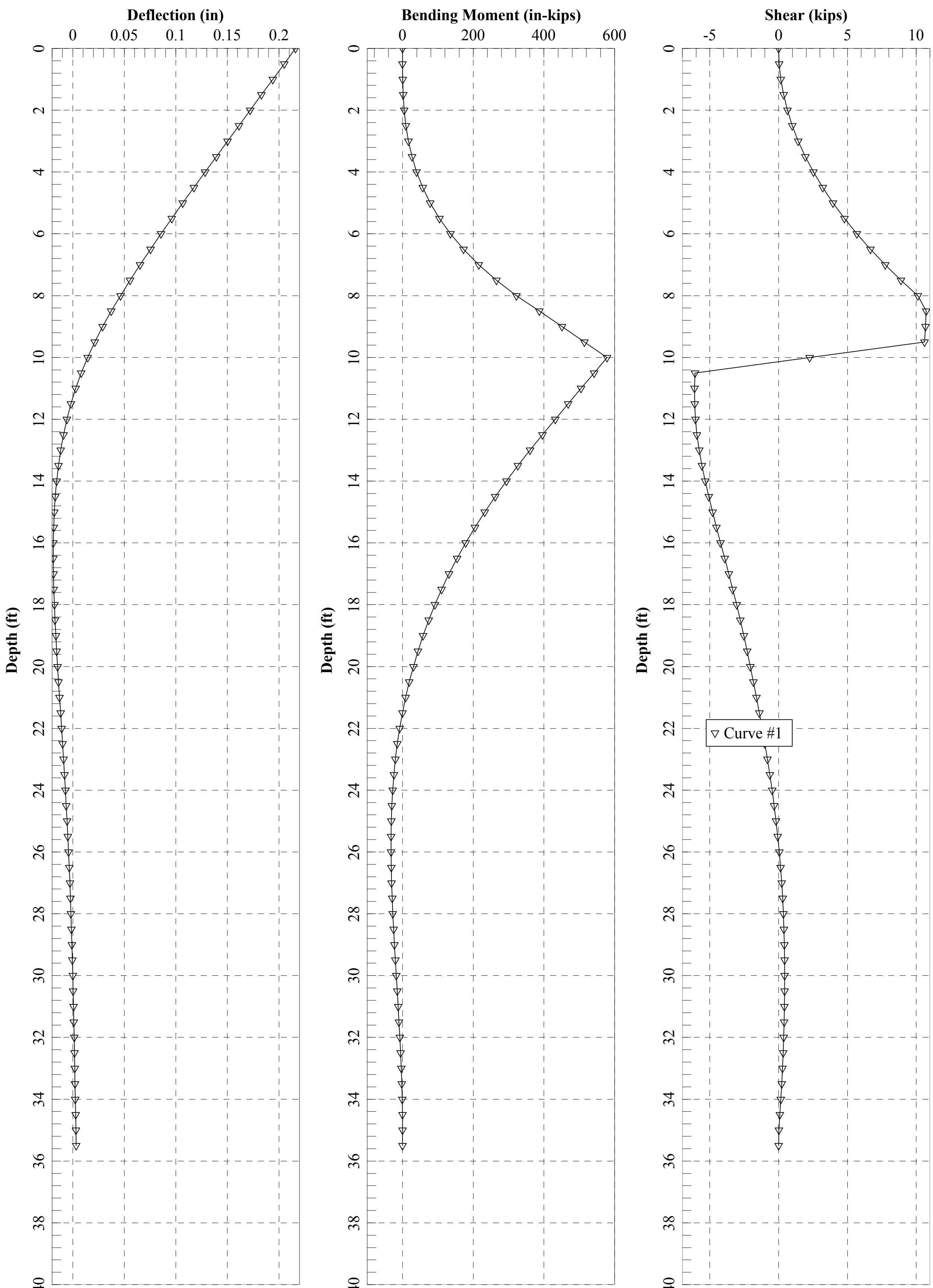


Figure O.3: Lateral Deflection, Bending Moment and Shear Force with Depth for 8 ft L-wall with Sheet Pile Supported by Batter Steel Piles at Full Flood Condition for Zone 4 to 7.

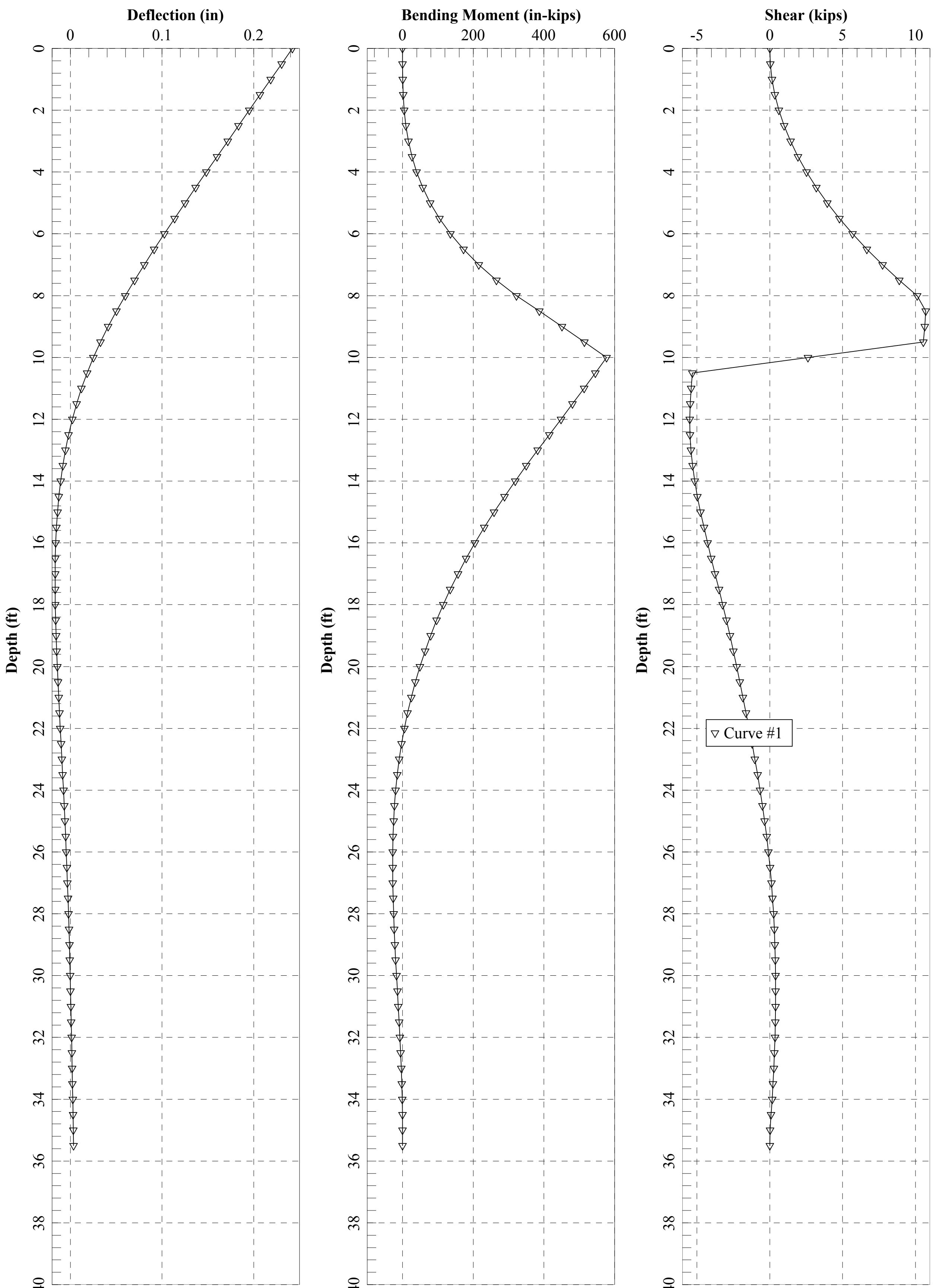


Figure O.4: Lateral Deflection, Bending Moment and Shear Force with Depth for 8 ft L-wall with Sheet Pile Supported by Batter Micropiles at Full Flood Condition for Zone 4 to 7.

Attachment C1-P

Output from PYWall Analysis for 6 ft L-wall in Soil Areas 4 to 7

Zone4_6ft_L_Wall_with_Batter_HP_Steel_Pile.py5o

```
==========================================================================

                    PYWALL for Windows, Version 2015.5.4

                     Serial Number :  166868598

                     A Program for the Analysis of
                     Flexible Retaining Walls
                   (c) Copyright ENSOFT, Inc., 1987-2015
                         All Rights Reserved

==========================================================================


This program is licensed to :

AECOM / URS Corp
Clifton, NJ

Path to file locations      : Z:\Meadowlands\Feasibility Analysis for Flood Protection\Batter Pile
Supported Sheet Pile Wall\PYWall Analysis\
Name of input data file     : Zone4_6ft_L_Wall_with_Batter_HP_Steel_Pile.py5d
Name of output file         : Zone4_6ft_L_Wall_with_Batter_HP_Steel_Pile.py5o
Name of plot output file    : Zone4_6ft_L_Wall_with_Batter_HP_Steel_Pile.py5p

--------------------------------------------------------------------------
                       Time and Date of Analysis
--------------------------------------------------------------------------

          Date:  January 23, 2017     Time:  14:08:51

 New Meadowlands_Zone4_6ft_Double_Sheet_Pile_Wall_Full_Flood


 **************************************************
 *        PROGRAM CONTROL PARAMETERS              *
 **************************************************

 NO OF POINTS FOR SPECIFIED DEFLECTIONS AND SLOPES  =  0
 NO OF POINTS FOR WALL STIFFNESS AND LOAD DATA      =  1
 GENERATE EARTH PRESSURE INTERNALLY                 =  1
 GENERATE SOIL RESISTANCE (P-Y) CURVES INTERNALLY   =  1
 NO OF P-Y MODIFICATION FACTORS FOR GEN. P-Y CURVES =  0
 NO OF USER-SPECIFIED SOIL RESISTANCE (P-Y) CURVES  =  0
 NUMBER OF INCREMENTS                               =  60
 INCREMENT LENGTH                                   =   6.000 IN
 FREE HEIGHT OF WALL                                =  72.000 IN
 MAXIMUM ALLOWABLE DEFLECTION                       =  10.000 IN
 DEFLECTION CLOSURE TOLERANCE                       = 0.00001 IN



 **************************************************
 *        STIFFNESS AND LOAD DATA                 *
 **************************************************
 EI - FLEXURAL RIGIDITY,  Q - TRANSVERSE LOAD,
 S - STIFFNESS OF TRANSVERSE RESISTANCE,
 T - TORQUE,              P - AXIAL LOAD,
 R - STIFFNESS OF TORSIONAL RESISTANCE.

FROM TO CONTD     EI         Q        S'        T         R         P

             LBS-IN**2     LBS     LBS/IN    IN-LBS   IN-LBS     LBS
   0  60  0  0.250E+11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  16  16  0  0.250E+11 0.000E+00 0.970E+06 0.000E+00 0.000E+00 0.000E+00


 **************************************************
 *                WALL INFORMATION                *
 **************************************************


 FREE HEIGHT OF WALL                     =  0.720E+02 IN
 WIDTH FOR EARTH PRESSURE, WA            =  0.606E+02 IN
 WIDTH FOR SOIL RESISTANCE, WP           =  0.606E+02 IN
 DEPTH TO THE WATER TABLE AT BACKFILL    =  0.000E+00 IN
 DEPTH TO THE WATER TABLE AT EXCAVATION  =  0.720E+02 IN
 UNIT WEIGHT OF WATER                    =  0.360E-01 LBS/IN**3
```

SLOPE OF THE BACKFILL (deg.) = 0.000E+00
MODIFICATION FOR ACTIVE EARTH PRESSURE = 0.100E+01

```
**************************************************
*               SURCHARGE INFORMATION            *
**************************************************
```

UNIFORM SURFACE PRESSURE = 0.000E+00 LBS/IN**2

```
**************************************************
*                 SOIL INFORMATION               *
**************************************************
```

LAYER NO.	TOTAL THICKNESS IN	COHESION PSI	PHI DEG	TOTAL UNIT WEIGHT PCI	DRAINED T OR F	ZTOP IN
1	72.0	0.0	0.1	0.036	T	0.00
2	168.0	0.0	20.0	0.049	T	72.00
3	636.0	0.0	22.0	0.064	T	240.00

```
**************************************************
*           EFFECTIVE OVERBURDEN STRESS          *
**************************************************
```

DEPTH IN	STRESS LBS/IN**2
0.000E+00	0.000E+00
0.720E+02	0.122E-01
0.240E+03	0.223E+01

```
**************************************************
* ACTIVE AND PASSIVE EARTH PRESSURE COEFFICIENT  *
**************************************************
```

LAYER NO.	ACTIVE EARTH COEFFICIENT	PASSIVE EARTH COEFFICIENT
1	0.997E+00	0.100E+01
2	0.490E+00	0.204E+01
3	0.455E+00	0.220E+01

```
**************************************************
*      ACTIVE EARTH PRESSURE OF EACH LAYER       *
**************************************************
```

LAYER NO	PA1 LBS/IN**2	Z1 IN	PA2 LBS/IN**2	Z2 IN	PA3 LBS/IN**2	Z3 IN	PA4 LBS/IN**2
1	0.00	36.00	0.44	48.00	0.00	0.00	0.00

```
**************************************************
*      ACTIVE WATER PRESSURE OF EACH LAYER       *
**************************************************
```

LAYER NO	PW1	Z1	PW2	Z2
1	0.00	36.00	93.31	48.00

DEPTH IN	ACTIVE EARTH PRESSURE LBS/IN
0.000E+00	0.000E+00
0.600E+01	0.144E+02
0.120E+02	0.289E+02
0.180E+02	0.433E+02
0.240E+02	0.577E+02
0.300E+02	0.721E+02
0.360E+02	0.867E+02

0.420E+02	0.101E+03
0.480E+02	0.115E+03
0.540E+02	0.130E+03
0.600E+02	0.144E+03
0.660E+02	0.154E+03
0.720E+02	0.154E+03
0.770E+02	0.362E+00
0.830E+02	0.362E+00
0.890E+02	0.362E+00
0.950E+02	0.362E+00
0.101E+03	0.362E+00
0.107E+03	0.362E+00
0.113E+03	0.362E+00
0.119E+03	0.362E+00
0.125E+03	0.362E+00
0.131E+03	0.362E+00
0.137E+03	0.362E+00
0.143E+03	0.362E+00
0.149E+03	0.362E+00
0.155E+03	0.362E+00
0.161E+03	0.362E+00
0.167E+03	0.362E+00
0.173E+03	0.362E+00
0.179E+03	0.362E+00
0.185E+03	0.362E+00
0.191E+03	0.362E+00
0.197E+03	0.362E+00
0.203E+03	0.362E+00
0.209E+03	0.362E+00
0.215E+03	0.362E+00
0.221E+03	0.362E+00
0.227E+03	0.362E+00
0.233E+03	0.362E+00
0.239E+03	0.362E+00
0.245E+03	0.336E+00
0.251E+03	0.336E+00
0.257E+03	0.336E+00
0.263E+03	0.336E+00
0.269E+03	0.336E+00
0.275E+03	0.336E+00
0.281E+03	0.336E+00
0.287E+03	0.336E+00
0.293E+03	0.336E+00
0.299E+03	0.336E+00
0.305E+03	0.336E+00
0.311E+03	0.336E+00
0.317E+03	0.336E+00
0.323E+03	0.336E+00
0.329E+03	0.336E+00
0.335E+03	0.336E+00
0.341E+03	0.336E+00
0.347E+03	0.336E+00
0.353E+03	0.336E+00
0.359E+03	0.336E+00

****
*   SOIL LAYERS AND STRENGTH DATA   *
****

X AT THE SURFACE OF EXCAVATION SIDE   =   72.00 IN

2 LAYER(S) OF SOIL

LAYER 1
THE SOIL IS A SILT

LAYER 2
THE SOIL IS A SILT

DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH
4 POINTS

X,IN	WEIGHT,LBS/IN**3
72.0000	0.1319D-01
240.0000	0.1319D-01
240.0000	0.2766D-01

876.0000 0.2766D-01

DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH
4 POINTS

X,IN	S,LBS/IN**2	PHI,DEGREES	E50
72.00	0.0000D+00	20.000	0.2000D-01
240.00	0.0000D+00	20.000	0.2000D-01
240.00	0.0000D+00	22.000	0.2000D-01
372.00	0.0000D+00	22.000	0.2000D-01

P-Y CURVES DATA

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
0.10	60.62	20.0	0.132E-01	2.83	2.14	0.800E-01	0.211E+00

Y IN	P LBS/IN
0.000E+00	-0.362E+00
0.842E-01	-0.109E+00
0.168E+00	-0.326E-02
0.253E+00	0.300E-01
0.337E+00	0.555E-01
0.421E+00	0.764E-01
0.505E+00	0.943E-01
0.589E+00	0.110E+00
0.674E+00	0.124E+00
0.758E+00	0.137E+00
0.842E+00	0.148E+00
0.926E+00	0.159E+00
0.101E+01	0.169E+00
0.227E+01	0.314E+00
0.629E+02	0.314E+00
0.124E+03	0.314E+00
0.184E+03	0.314E+00

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
72.10	60.62	20.0	0.132E-01	1.98	1.44	0.576E+02	0.152E+03

Y IN	P LBS/IN
0.000E+00	0.362E+00
0.842E-01	0.153E+03
0.168E+00	0.181E+03
0.253E+00	0.199E+03
0.337E+00	0.213E+03
0.421E+00	0.225E+03
0.505E+00	0.235E+03
0.589E+00	0.243E+03
0.674E+00	0.251E+03
0.758E+00	0.258E+03
0.842E+00	0.265E+03
0.926E+00	0.271E+03
0.101E+01	0.276E+03
0.227E+01	0.358E+03
0.629E+02	0.358E+03
0.124E+03	0.358E+03
0.184E+03	0.358E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
42.00	60.62	20.0	0.132E-01	2.34	1.72	0.336E+02	0.885E+02

Y IN	P LBS/IN
0.000E+00	-0.362E+00
0.842E-01	0.103E+03
0.168E+00	0.121E+03
0.253E+00	0.133E+03
0.337E+00	0.143E+03
0.421E+00	0.151E+03
0.505E+00	0.157E+03
0.589E+00	0.163E+03
0.674E+00	0.168E+03
0.758E+00	0.173E+03
0.842E+00	0.177E+03
0.926E+00	0.182E+03
0.101E+01	0.185E+03
0.227E+01	0.240E+03
0.629E+02	0.240E+03
0.124E+03	0.240E+03
0.184E+03	0.240E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
114.00	60.62	20.0	0.132E-01	1.55	1.10	0.912E+02	0.240E+03

Y IN	P LBS/IN
0.000E+00	0.362E+00
0.842E-01	0.197E+03
0.168E+00	0.232E+03
0.253E+00	0.256E+03
0.337E+00	0.274E+03
0.421E+00	0.289E+03
0.505E+00	0.302E+03
0.589E+00	0.313E+03
0.674E+00	0.323E+03
0.758E+00	0.333E+03
0.842E+00	0.341E+03
0.926E+00	0.349E+03
0.101E+01	0.356E+03
0.227E+01	0.463E+03
0.629E+02	0.463E+03
0.124E+03	0.463E+03
0.184E+03	0.463E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
84.00	60.62	20.0	0.132E-01	1.84	1.33	0.672E+02	0.177E+03

Y IN	P LBS/IN
0.000E+00	-0.362E+00
0.842E-01	0.167E+03
0.168E+00	0.198E+03
0.253E+00	0.218E+03
0.337E+00	0.233E+03
0.421E+00	0.246E+03
0.505E+00	0.257E+03
0.589E+00	0.266E+03
0.674E+00	0.275E+03
0.758E+00	0.283E+03
0.842E+00	0.290E+03
0.926E+00	0.296E+03

0.101E+01	0.303E+03
0.227E+01	0.392E+03
0.629E+02	0.392E+03
0.124E+03	0.392E+03
0.184E+03	0.392E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
156.00	60.62	20.0	0.132E-01	1.21	0.84	0.125E+03	0.329E+03

Y IN	P LBS/IN
0.000E+00	0.362E+00
0.842E-01	0.220E+03
0.168E+00	0.260E+03
0.253E+00	0.287E+03
0.337E+00	0.307E+03
0.421E+00	0.324E+03
0.505E+00	0.339E+03
0.589E+00	0.352E+03
0.674E+00	0.363E+03
0.758E+00	0.374E+03
0.842E+00	0.383E+03
0.926E+00	0.392E+03
0.101E+01	0.401E+03
0.227E+01	0.521E+03
0.629E+02	0.521E+03
0.124E+03	0.521E+03
0.184E+03	0.521E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
126.00	60.62	20.0	0.132E-01	1.44	1.02	0.101E+03	0.266E+03

Y IN	P LBS/IN
0.000E+00	-0.362E+00
0.842E-01	0.204E+03
0.168E+00	0.241E+03
0.253E+00	0.266E+03
0.337E+00	0.285E+03
0.421E+00	0.301E+03
0.505E+00	0.314E+03
0.589E+00	0.326E+03
0.674E+00	0.337E+03
0.758E+00	0.346E+03
0.842E+00	0.355E+03
0.926E+00	0.364E+03
0.101E+01	0.371E+03
0.227E+01	0.483E+03
0.629E+02	0.483E+03
0.124E+03	0.483E+03
0.184E+03	0.483E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
198.00	60.62	20.0	0.132E-01	1.02	0.66	0.158E+03	0.417E+03

Y IN	P LBS/IN
0.000E+00	0.362E+00

0.842E-01	0.221E+03
0.168E+00	0.267E+03
0.253E+00	0.298E+03
0.337E+00	0.322E+03
0.421E+00	0.343E+03
0.505E+00	0.360E+03
0.589E+00	0.375E+03
0.674E+00	0.389E+03
0.758E+00	0.402E+03
0.842E+00	0.414E+03
0.926E+00	0.425E+03
0.101E+01	0.435E+03
0.227E+01	0.583E+03
0.629E+02	0.583E+03
0.124E+03	0.583E+03
0.184E+03	0.583E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
167.90	60.62	20.0	0.132E-01	1.14	0.78	0.134E+03	0.354E+03

Y IN	P LBS/IN
0.000E+00	-0.362E+00
0.842E-01	0.221E+03
0.168E+00	0.262E+03
0.253E+00	0.290E+03
0.337E+00	0.312E+03
0.421E+00	0.330E+03
0.505E+00	0.345E+03
0.589E+00	0.358E+03
0.674E+00	0.370E+03
0.758E+00	0.381E+03
0.842E+00	0.391E+03
0.926E+00	0.401E+03
0.101E+01	0.410E+03
0.227E+01	0.537E+03
0.629E+02	0.537E+03
0.124E+03	0.537E+03
0.184E+03	0.537E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
239.90	60.62	20.0	0.132E-01	0.91	0.54	0.192E+03	0.506E+03

Y IN	P LBS/IN
0.000E+00	0.362E+00
0.842E-01	0.209E+03
0.168E+00	0.261E+03
0.253E+00	0.297E+03
0.337E+00	0.326E+03
0.421E+00	0.350E+03
0.505E+00	0.371E+03
0.589E+00	0.390E+03
0.674E+00	0.407E+03
0.758E+00	0.423E+03
0.842E+00	0.438E+03
0.926E+00	0.451E+03
0.101E+01	0.464E+03
0.227E+01	0.651E+03
0.629E+02	0.651E+03
0.124E+03	0.651E+03
0.184E+03	0.651E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
168.10	60.62	22.0	0.132E-01	1.28	0.90	0.134E+03	0.387E+03

Y IN	P LBS/IN
0.000E+00	-0.336E+00
0.842E-01	0.262E+03
0.168E+00	0.310E+03
0.253E+00	0.343E+03
0.337E+00	0.368E+03
0.421E+00	0.389E+03
0.505E+00	0.407E+03
0.589E+00	0.422E+03
0.674E+00	0.436E+03
0.758E+00	0.449E+03
0.842E+00	0.461E+03
0.926E+00	0.472E+03
0.101E+01	0.482E+03
0.227E+01	0.630E+03
0.629E+02	0.630E+03
0.124E+03	0.630E+03
0.184E+03	0.630E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
240.10	60.62	22.0	0.132E-01	0.97	0.60	0.192E+03	0.552E+03

Y IN	P LBS/IN
0.000E+00	0.336E+00
0.842E-01	0.248E+03
0.168E+00	0.306E+03
0.253E+00	0.346E+03
0.337E+00	0.377E+03
0.421E+00	0.404E+03
0.505E+00	0.427E+03
0.589E+00	0.447E+03
0.674E+00	0.466E+03
0.758E+00	0.483E+03
0.842E+00	0.498E+03
0.926E+00	0.513E+03
0.101E+01	0.527E+03
0.227E+01	0.726E+03
0.629E+02	0.726E+03
0.124E+03	0.726E+03
0.184E+03	0.726E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
201.00	60.62	22.0	0.156E-01	1.08	0.73	0.190E+03	0.545E+03

Y IN	P LBS/IN
0.000E+00	-0.336E+00
0.842E-01	0.306E+03
0.168E+00	0.367E+03
0.253E+00	0.408E+03
0.337E+00	0.440E+03
0.421E+00	0.466E+03
0.505E+00	0.489E+03
0.589E+00	0.509E+03
0.674E+00	0.527E+03

0.758E+00	0.544E+03
0.842E+00	0.559E+03
0.926E+00	0.573E+03
0.101E+01	0.586E+03
0.227E+01	0.779E+03
0.629E+02	0.779E+03
0.124E+03	0.779E+03
0.184E+03	0.779E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
273.00	60.62	22.0	0.156E-01	0.90	0.53	0.258E+03	0.741E+03

Y IN	P LBS/IN
0.000E+00	0.336E+00
0.842E-01	0.279E+03
0.168E+00	0.352E+03
0.253E+00	0.404E+03
0.337E+00	0.446E+03
0.421E+00	0.481E+03
0.505E+00	0.512E+03
0.589E+00	0.539E+03
0.674E+00	0.564E+03
0.758E+00	0.587E+03
0.842E+00	0.609E+03
0.926E+00	0.629E+03
0.101E+01	0.648E+03
0.227E+01	0.923E+03
0.629E+02	0.923E+03
0.124E+03	0.923E+03
0.184E+03	0.923E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
234.00	60.62	22.0	0.173E-01	0.98	0.62	0.245E+03	0.704E+03

Y IN	P LBS/IN
0.000E+00	-0.336E+00
0.842E-01	0.327E+03
0.168E+00	0.402E+03
0.253E+00	0.453E+03
0.337E+00	0.493E+03
0.421E+00	0.527E+03
0.505E+00	0.557E+03
0.589E+00	0.583E+03
0.674E+00	0.606E+03
0.758E+00	0.628E+03
0.842E+00	0.648E+03
0.926E+00	0.666E+03
0.101E+01	0.683E+03
0.227E+01	0.937E+03
0.629E+02	0.937E+03
0.124E+03	0.937E+03
0.184E+03	0.937E+03

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
306.00	60.62	22.0	0.173E-01	0.89	0.51	0.320E+03	0.921E+03

Y IN	P LBS/IN
0.000E+00	0.336E+00
0.842E-01	0.330E+03
0.168E+00	0.421E+03
0.253E+00	0.486E+03
0.337E+00	0.537E+03
0.421E+00	0.581E+03
0.505E+00	0.620E+03
0.589E+00	0.654E+03
0.674E+00	0.685E+03
0.758E+00	0.714E+03
0.842E+00	0.741E+03
0.926E+00	0.767E+03
0.101E+01	0.790E+03
0.227E+01	0.114E+04
0.629E+02	0.114E+04
0.124E+03	0.114E+04
0.184E+03	0.114E+04

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Pui
267.00	60.62	22.0	0.186E-01	0.90	0.53	0.300E+03	0.863E+03

Y IN	P LBS/IN
0.000E+00	-0.336E+00
0.842E-01	0.327E+03
0.168E+00	0.413E+03
0.253E+00	0.474E+03
0.337E+00	0.522E+03
0.421E+00	0.563E+03
0.505E+00	0.599E+03
0.589E+00	0.631E+03
0.674E+00	0.660E+03
0.758E+00	0.687E+03
0.842E+00	0.712E+03
0.926E+00	0.735E+03
0.101E+01	0.757E+03
0.227E+01	0.108E+04
0.629E+02	0.108E+04
0.124E+03	0.108E+04
0.184E+03	0.108E+04

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Pui
339.00	60.62	22.0	0.186E-01	0.88	0.50	0.381E+03	0.110E+04

Y IN	P LBS/IN
0.000E+00	0.336E+00
0.842E-01	0.382E+03
0.168E+00	0.489E+03
0.253E+00	0.566E+03
0.337E+00	0.627E+03
0.421E+00	0.679E+03
0.505E+00	0.725E+03
0.589E+00	0.766E+03
0.674E+00	0.804E+03
0.758E+00	0.839E+03
0.842E+00	0.871E+03
0.926E+00	0.901E+03
0.101E+01	0.930E+03
0.227E+01	0.135E+04
0.629E+02	0.135E+04
0.124E+03	0.135E+04
0.184E+03	0.135E+04

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
299.90	60.62	22.0	0.196E-01	0.89	0.51	0.355E+03	0.102E+04

Y IN	P LBS/IN
0.000E+00	-0.336E+00
0.842E-01	0.369E+03
0.168E+00	0.470E+03
0.253E+00	0.542E+03
0.337E+00	0.599E+03
0.421E+00	0.648E+03
0.505E+00	0.690E+03
0.589E+00	0.728E+03
0.674E+00	0.763E+03
0.758E+00	0.795E+03
0.842E+00	0.825E+03
0.926E+00	0.853E+03
0.101E+01	0.879E+03
0.227E+01	0.126E+04
0.629E+02	0.126E+04
0.124E+03	0.126E+04
0.184E+03	0.126E+04

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	Puc	Puí
371.90	60.62	22.0	0.196E-01	0.88	0.50	0.441E+03	0.127E+04

Y IN	P LBS/IN
0.000E+00	0.336E+00
0.842E-01	0.441E+03
0.168E+00	0.566E+03
0.253E+00	0.654E+03
0.337E+00	0.725E+03
0.421E+00	0.785E+03
0.505E+00	0.838E+03
0.589E+00	0.886E+03
0.674E+00	0.929E+03
0.758E+00	0.969E+03
0.842E+00	0.101E+04
0.926E+00	0.104E+04
0.101E+01	0.107E+04
0.227E+01	0.156E+04
0.629E+02	0.156E+04
0.124E+03	0.156E+04
0.184E+03	0.156E+04

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

New Meadowlands_Zone4_6ft_Double_Sheet_Pile_Wall_Full_Flood

RESULTS -- ITERATION 3

STA I	X IN	DEFL. IN	SLOPE	MOMENT LBS-IN	SHEAR LBS	NET REACT/STA LBS	EI LBS-IN**2
0	0.000E+00	0.930E-01	-0.933E-03	0.000E+00	0.000E+00	0.000E+00	0.125E+11
1	0.600E+01	0.874E-01	-0.933E-03	0.000E+00	0.433E+02	0.866E+02	0.250E+11
2	0.120E+02	0.818E-01	-0.933E-03	0.519E+03	0.173E+03	0.173E+03	0.250E+11
3	0.180E+02	0.762E-01	-0.932E-03	0.208E+04	0.390E+03	0.260E+03	0.250E+11
4	0.240E+02	0.706E-01	-0.931E-03	0.519E+04	0.693E+03	0.346E+03	0.250E+11
5	0.300E+02	0.650E-01	-0.930E-03	0.104E+05	0.108E+04	0.433E+03	0.250E+11
6	0.360E+02	0.595E-01	-0.926E-03	0.182E+05	0.156E+04	0.520E+03	0.250E+11

7	0.420E+02	0.539E-01	-0.920E-03	0.291E+05	0.212E+04	0.607E+03	0.250E+11
8	0.480E+02	0.484E-01	-0.912E-03	0.436E+05	0.277E+04	0.691E+03	0.250E+11
9	0.540E+02	0.430E-01	-0.899E-03	0.623E+05	0.351E+04	0.778E+03	0.250E+11
10	0.600E+02	0.376E-01	-0.881E-03	0.857E+05	0.433E+04	0.866E+03	0.250E+11
11	0.660E+02	0.324E-01	-0.857E-03	0.114E+06	0.522E+04	0.924E+03	0.250E+11
12	0.720E+02	0.273E-01	-0.826E-03	0.148E+06	0.615E+04	0.925E+03	0.250E+11
13	0.780E+02	0.225E-01	-0.785E-03	0.188E+06	0.660E+04	-0.218E+02	0.250E+11
14	0.840E+02	0.179E-01	-0.735E-03	0.228E+06	0.657E+04	-0.358E+02	0.250E+11
15	0.900E+02	0.137E-01	-0.676E-03	0.267E+06	0.653E+04	-0.411E+02	0.250E+11
16	0.960E+02	0.980E-02	-0.607E-03	0.306E+06	0.174E+04	-0.955E+04	0.250E+11
17	0.102E+03	0.638E-02	-0.536E-03	0.288E+06	-0.306E+04	-0.314E+02	0.250E+11
18	0.108E+03	0.337E-02	-0.469E-03	0.269E+06	-0.308E+04	-0.191E+02	0.250E+11
19	0.114E+03	0.752E-03	-0.407E-03	0.251E+06	-0.309E+04	-0.336E+01	0.250E+11
20	0.120E+03	-0.151E-02	-0.349E-03	0.232E+06	-0.308E+04	0.237E+02	0.250E+11
21	0.126E+03	-0.343E-02	-0.295E-03	0.214E+06	-0.304E+04	0.519E+02	0.250E+11
22	0.132E+03	-0.505E-02	-0.246E-03	0.196E+06	-0.298E+04	0.765E+02	0.250E+11
23	0.138E+03	-0.639E-02	-0.201E-03	0.178E+06	-0.289E+04	0.976E+02	0.250E+11
24	0.144E+03	-0.746E-02	-0.161E-03	0.161E+06	-0.279E+04	0.116E+03	0.250E+11
25	0.150E+03	-0.831E-02	-0.124E-03	0.145E+06	-0.266E+04	0.130E+03	0.250E+11
26	0.156E+03	-0.895E-02	-0.910E-04	0.129E+06	-0.253E+04	0.142E+03	0.250E+11
27	0.162E+03	-0.940E-02	-0.618E-04	0.114E+06	-0.238E+04	0.149E+03	0.250E+11
28	0.168E+03	-0.969E-02	-0.361E-04	0.100E+06	-0.223E+04	0.154E+03	0.250E+11
29	0.174E+03	-0.984E-02	-0.135E-04	0.874E+05	-0.207E+04	0.156E+03	0.250E+11
30	0.180E+03	-0.986E-02	0.603E-05	0.755E+05	-0.192E+04	0.157E+03	0.250E+11
31	0.186E+03	-0.976E-02	0.228E-04	0.644E+05	-0.176E+04	0.155E+03	0.250E+11
32	0.192E+03	-0.958E-02	0.371E-04	0.543E+05	-0.161E+04	0.153E+03	0.250E+11
33	0.198E+03	-0.932E-02	0.490E-04	0.451E+05	-0.146E+04	0.149E+03	0.250E+11
34	0.204E+03	-0.899E-02	0.589E-04	0.368E+05	-0.131E+04	0.142E+03	0.250E+11
35	0.210E+03	-0.861E-02	0.668E-04	0.294E+05	-0.117E+04	0.135E+03	0.250E+11
36	0.216E+03	-0.819E-02	0.731E-04	0.228E+05	-0.104E+04	0.128E+03	0.250E+11
37	0.222E+03	-0.774E-02	0.778E-04	0.169E+05	-0.917E+03	0.120E+03	0.250E+11
38	0.228E+03	-0.726E-02	0.813E-04	0.117E+05	-0.801E+03	0.112E+03	0.250E+11
39	0.234E+03	-0.676E-02	0.835E-04	0.727E+04	-0.693E+03	0.104E+03	0.250E+11
40	0.240E+03	-0.626E-02	0.848E-04	0.342E+04	-0.594E+03	0.952E+02	0.250E+11
41	0.246E+03	-0.574E-02	0.853E-04	0.146E+03	-0.500E+03	0.923E+02	0.250E+11
42	0.252E+03	-0.523E-02	0.850E-04	-0.258E+04	-0.410E+03	0.886E+02	0.250E+11
43	0.258E+03	-0.472E-02	0.841E-04	-0.477E+04	-0.324E+03	0.841E+02	0.250E+11
44	0.264E+03	-0.422E-02	0.827E-04	-0.646E+04	-0.242E+03	0.789E+02	0.250E+11
45	0.270E+03	-0.373E-02	0.810E-04	-0.768E+04	-0.166E+03	0.730E+02	0.250E+11
46	0.276E+03	-0.325E-02	0.791E-04	-0.845E+04	-0.963E+02	0.666E+02	0.250E+11
47	0.282E+03	-0.278E-02	0.770E-04	-0.883E+04	-0.333E+02	0.593E+02	0.250E+11
48	0.288E+03	-0.233E-02	0.749E-04	-0.885E+04	0.221E+02	0.516E+02	0.250E+11
49	0.294E+03	-0.188E-02	0.728E-04	-0.857E+04	0.697E+02	0.435E+02	0.250E+11
50	0.300E+03	-0.145E-02	0.708E-04	-0.802E+04	0.109E+03	0.351E+02	0.250E+11
51	0.306E+03	-0.103E-02	0.690E-04	-0.726E+04	0.140E+03	0.263E+02	0.250E+11
52	0.312E+03	-0.625E-03	0.673E-04	-0.634E+04	0.161E+03	0.171E+02	0.250E+11
53	0.318E+03	-0.226E-03	0.659E-04	-0.532E+04	0.174E+03	0.760E+01	0.250E+11
54	0.324E+03	0.166E-03	0.648E-04	-0.426E+04	0.177E+03	-0.186E+01	0.250E+11
55	0.330E+03	0.552E-03	0.639E-04	-0.320E+04	0.170E+03	-0.109E+02	0.250E+11
56	0.336E+03	0.933E-03	0.632E-04	-0.222E+04	0.155E+03	-0.197E+02	0.250E+11
57	0.342E+03	0.131E-02	0.628E-04	-0.135E+04	0.131E+03	-0.286E+02	0.250E+11
58	0.348E+03	0.169E-02	0.626E-04	-0.646E+03	0.973E+02	-0.383E+02	0.250E+11
59	0.354E+03	0.206E-02	0.625E-04	-0.178E+03	0.539E+02	-0.485E+02	0.250E+11
60	0.360E+03	0.244E-02	0.625E-04	-0.151E-09	0.148E+02	-0.296E+02	0.125E+11

END OF ANALYSIS

Plots of Ultimate Axial Capacities versus Length of Friction Piles from APILE

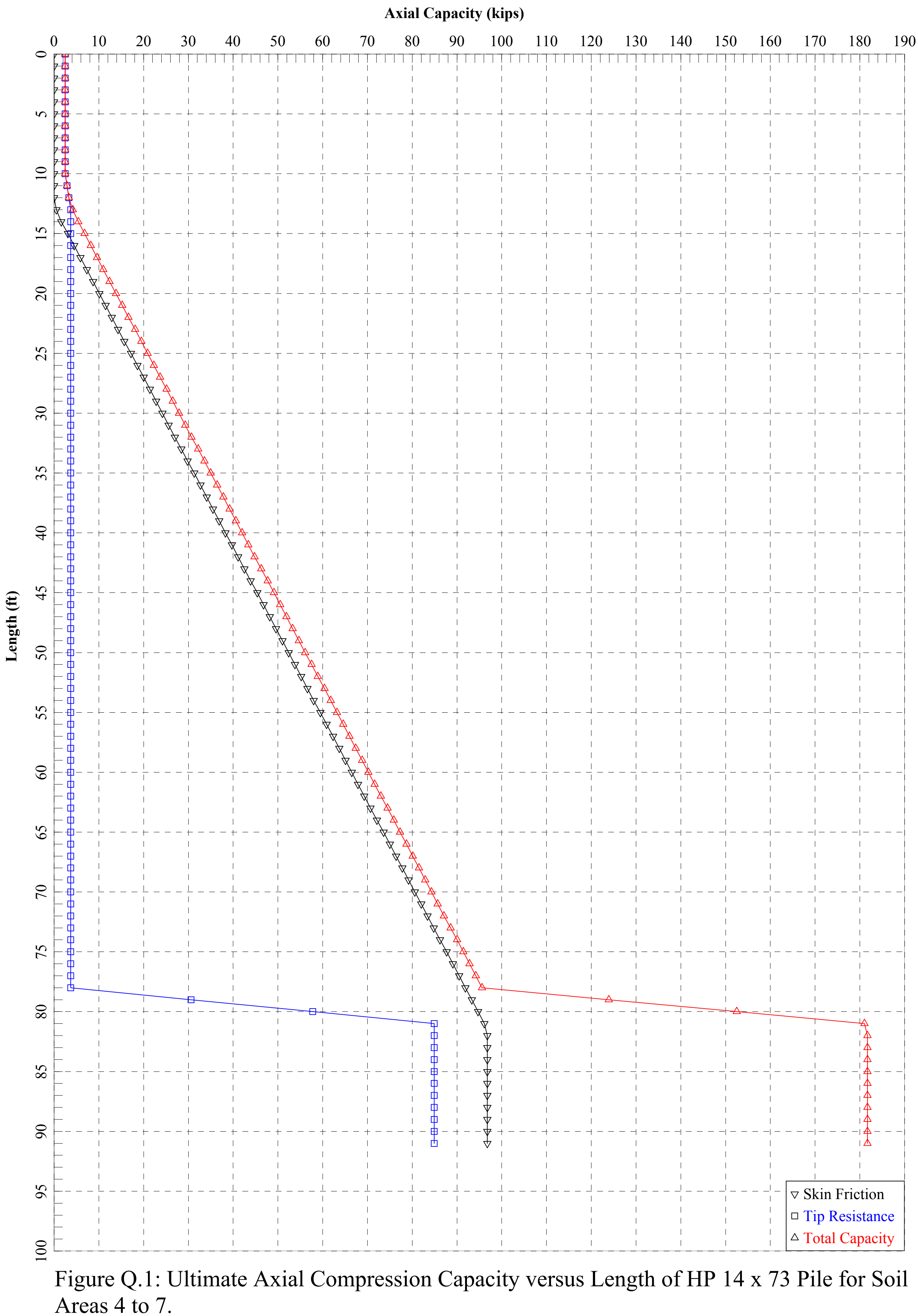


Figure Q.1: Ultimate Axial Compression Capacity versus Length of HP 14 x 73 Pile for Soil Areas 4 to 7.

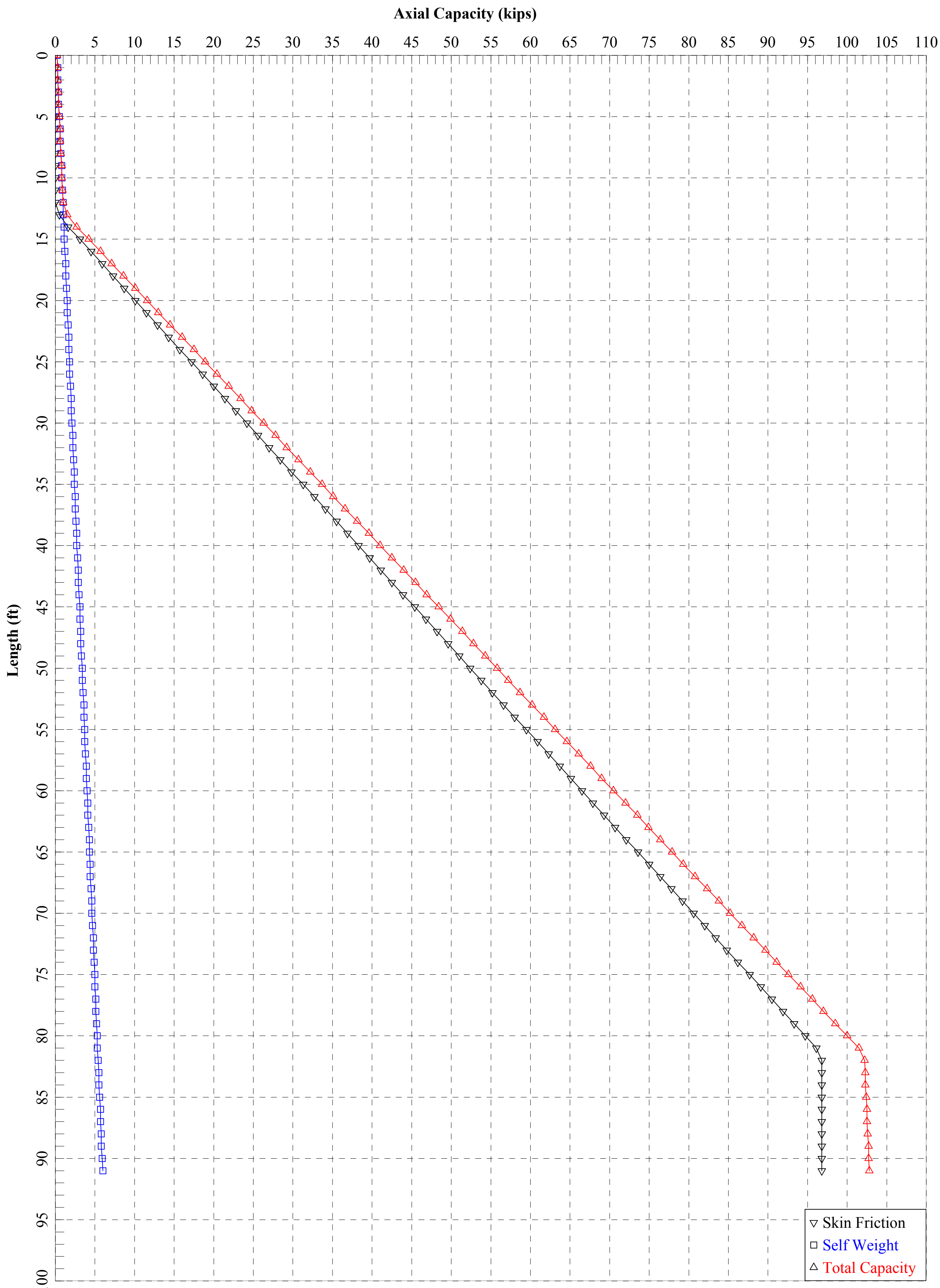


Figure Q.2: Ultimate Axial Tension Capacity versus Length of HP 14 x 73 Pile for Soil Areas 4 to 7.

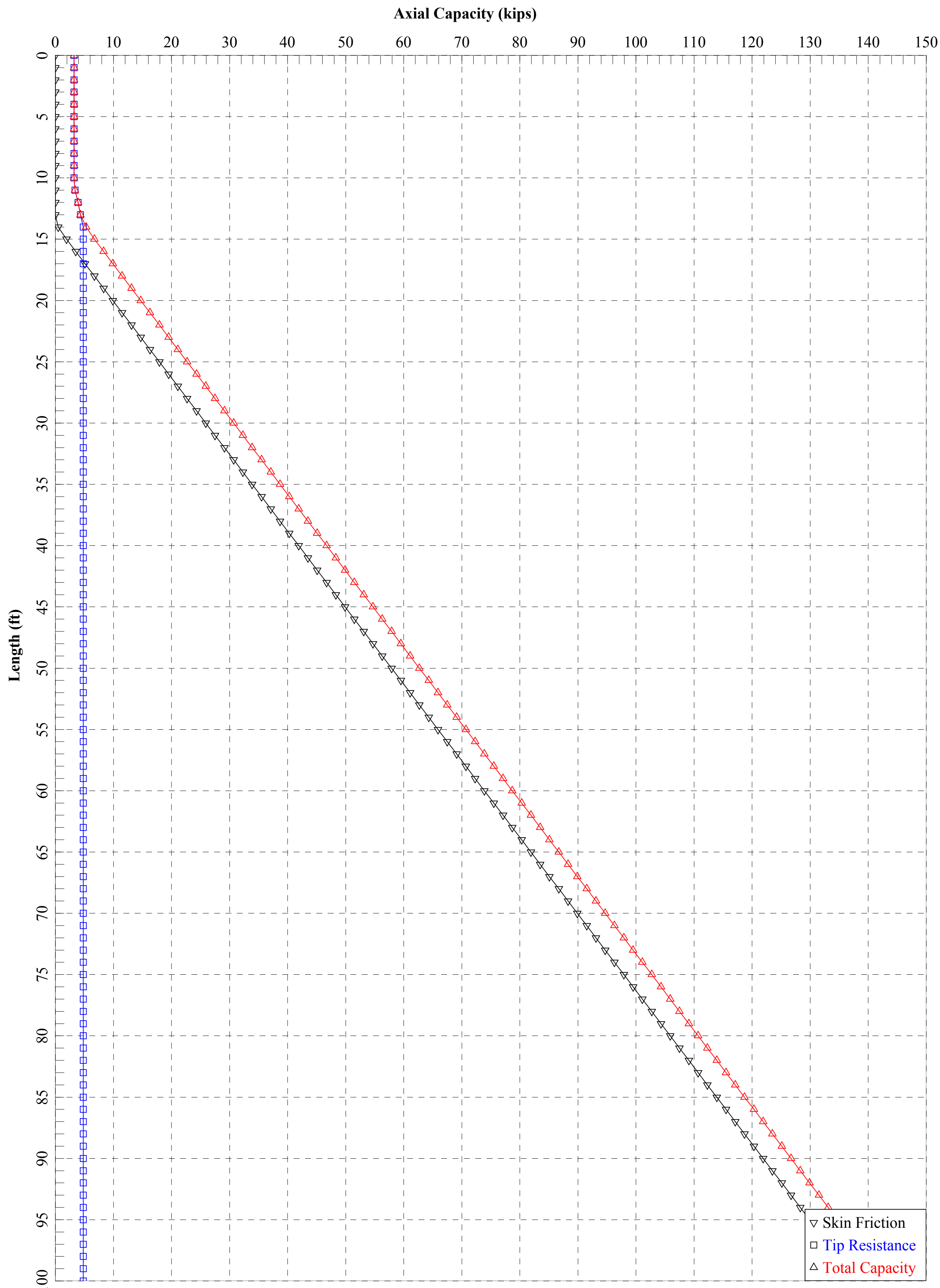


Figure Q.3: Ultimate Axial Compression Capacity versus Length of HP 16 x 141 Pile for Soil Areas 4 to 7.

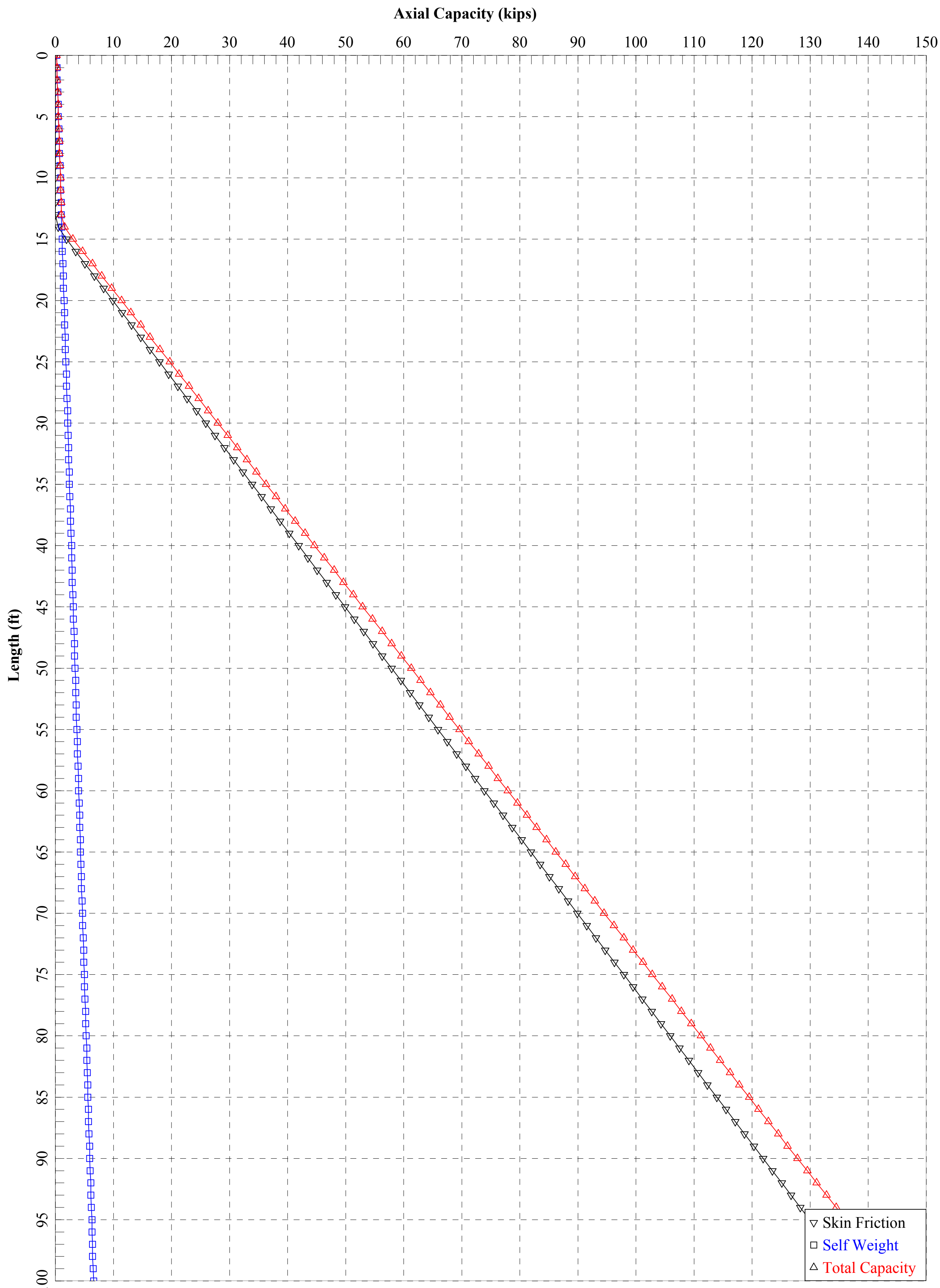


Figure Q.4: Ultimate Axial Tension Capacity versus Length of HP 16 x 141 Pile for Soil Areas 4 to 7.

Attachment C1-R

Output from APILE Analysis for Axial Capacity of Driven Piles

1

AXIALLY LOADING PILE ANALYSIS PROGRAM - APILEplus
VERSION 5.0 - (C) COPYRIGHT ENSOFT,INC.,1987-2008.

Flood Protection Feasibility Analysis - HP 14x73 Pile

DESIGNER : A. Hossain

DATE : 10/06/2016

PILE PROPERTIES :

PERIMETER OF PILE WITH NONCIRCULAR SECTION	=	64.00 IN.
TIP AREA OF PILE WITH NONCIRCULAR SECTION	=	1.78 SQF
OUTSIDE DIAMETER OF CIRCULAR PILE	=	11.88 IN.
INTERNAL DIAMETER OF CIRCULAR PILE	=	0.00 IN.
PILE LENGTH	=	100.00 FT.
MODULUS OF ELASTICITY	=	0.290E+08 PSI
LENGTH OF ENHANCED END SECTION	=	0.60 FT.
INTERNAL DIAMETER OF ENHANCED END SECTION	=	0.00 IN.

LENGTH OF SURFACE SECTION WITH ZERO SKIN FRICTION = 14.00 FT.
INCREMENT OF PILE LENGTH USED IN COMPUTATION = 1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/CF	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	CLAY	0.00	22.60	0.00	0.00
14.00	CLAY	0.00	22.60	0.00	0.00
14.00	CLAY	0.00	47.60	0.00	0.00
105.00	CLAY	0.00	47.60	0.00	0.00

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08	0.10E+08	0.20	0.00	0.00	0.00	0.00
0.10E+08	0.10E+08	0.20	0.00	0.00	0.00	0.00
0.10E+08	0.10E+08	0.30	0.00	0.00	0.00	0.00
0.10E+08	0.10E+08	0.30	0.00	0.00	0.00	0.00

SET MAXIMUM UNIT FRICTION AND MAXIMUM UNIT BEARING
TO BE 0.10E+08 BECAUSE THE USER DOES NOT PLAN TO
LIMIT THE COMPUTED DATA.

1

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* COMPUTATION RESULT *
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******************** ******************** *******************
* FED. HWY. METHOD * * ARMY CORPS METHOD * * LAMBDA 2 METHOD *
******************** ******************** *******************

PILE PENETR-ATION FT.	TOTAL SKIN FRIC KIP	END BEARING KIP	ULTIM CAPAC-ITY KIP	TOTAL SKIN FRIC KIP	END BEARING KIP	ULTIM CAPAC-ITY KIP	TOTAL SKIN FRIC KIP	END BEARING KIP	ULTIM CAPAC-ITY KIP
0.0	0.0	3.2	3.2	0.0	3.2	3.2	0.0	3.2	3.2
1.0	0.0	3.2	3.2	0.0	3.2	3.2	0.0	3.2	3.2
2.0	0.0	3.2	3.2	0.0	3.2	3.2	0.0	3.2	3.2
3.0	0.0	3.2	3.2	0.0	3.2	3.2	0.0	3.2	3.2
4.0	0.0	3.2	3.2	0.0	3.2	3.2	0.0	3.2	3.2
5.0	0.0	3.2	3.2	0.0	3.2	3.2	0.0	3.2	3.2
6.0	0.0	3.2	3.2	0.0	3.2	3.2	0.0	3.2	3.2
7.0	0.0	3.2	3.2	0.0	3.2	3.2	0.0	3.2	3.2
8.0	0.0	3.2	3.2	0.0	3.2	3.2	0.0	3.2	3.2
9.0	0.0	3.2	3.2	0.0	3.2	3.2	0.0	3.2	3.2
10.0	0.0	3.2	3.2	0.0	3.2	3.2	0.0	3.2	3.2
11.0	0.0	3.4	3.4	0.0	3.4	3.4	0.0	3.4	3.4
12.0	0.0	3.9	3.9	0.0	3.9	3.9	0.0	3.9	3.9
13.0	0.0	4.3	4.3	0.0	4.3	4.3	0.0	4.3	4.3
14.0	0.5	4.8	5.3	0.5	4.8	5.3	0.0	4.8	4.8
15.0	1.7	4.8	6.5	1.9	4.8	6.7	3.8	4.8	8.6
16.0	3.1	4.8	7.9	3.5	4.8	8.3	4.7	4.8	9.5
17.0	4.5	4.8	9.3	5.1	4.8	9.9	5.6	4.8	10.4
18.0	6.0	4.8	10.8	6.7	4.8	11.5	6.6	4.8	11.4
19.0	7.4	4.8	12.2	8.3	4.8	13.1	7.7	4.8	12.5
20.0	8.8	4.8	13.6	9.9	4.8	14.7	8.7	4.8	13.5
21.0	10.3	4.8	15.1	11.5	4.8	16.3	9.8	4.8	14.6
22.0	11.7	4.8	16.5	13.1	4.8	17.9	10.9	4.8	15.7
23.0	13.1	4.8	17.9	14.7	4.8	19.5	12.0	4.8	16.8
24.0	14.5	4.8	19.3	16.3	4.8	21.1	13.2	4.8	18.0
25.0	16.0	4.8	20.8	17.9	4.8	22.7	14.4	4.8	19.2
26.0	17.4	4.8	22.2	19.5	4.8	24.3	15.6	4.8	20.4
27.0	18.8	4.8	23.6	21.1	4.8	25.9	16.8	4.8	21.6
28.0	20.2	4.8	25.0	22.7	4.8	27.5	18.1	4.8	22.9
29.0	21.7	4.8	26.5	24.3	4.8	29.1	19.4	4.8	24.2
30.0	23.1	4.8	27.9	25.9	4.8	30.7	20.7	4.8	25.5
31.0	24.5	4.8	29.3	27.5	4.8	32.3	22.0	4.8	26.8
32.0	26.0	4.8	30.8	29.1	4.8	33.9	23.4	4.8	28.2
33.0	27.4	4.8	32.2	30.7	4.8	35.5	24.7	4.8	29.5
34.0	28.8	4.8	33.6	32.3	4.8	37.1	26.2	4.8	31.0
35.0	30.2	4.8	35.0	33.9	4.8	38.7	27.6	4.8	32.4
36.0	31.7	4.8	36.5	35.5	4.8	40.3	29.0	4.8	33.8
37.0	33.1	4.8	37.9	37.1	4.8	41.9	30.5	4.8	35.3
38.0	34.5	4.8	39.3	38.7	4.8	43.5	32.0	4.8	36.8
39.0	35.9	4.8	40.7	40.3	4.8	45.1	33.6	4.8	38.4
40.0	37.4	4.8	42.2	41.9	4.8	46.7	35.1	4.8	39.9
41.0	38.8	4.8	43.6	43.5	4.8	48.3	36.7	4.8	41.5
42.0	40.2	4.8	45.0	45.1	4.8	49.9	38.3	4.8	43.1
43.0	41.7	4.8	46.5	46.7	4.8	51.5	39.9	4.8	44.7
44.0	43.1	4.8	47.9	48.3	4.8	53.1	41.6	4.8	46.4
45.0	44.5	4.8	49.3	49.9	4.8	54.7	43.3	4.8	48.1
46.0	45.9	4.8	50.7	51.5	4.8	56.3	45.0	4.8	49.8
47.0	47.4	4.8	52.2	53.1	4.8	57.9	46.7	4.8	51.5
48.0	48.8	4.8	53.6	54.7	4.8	59.5	48.4	4.8	53.2
49.0	50.2	4.8	55.0	56.3	4.8	61.1	50.2	4.8	55.0
50.0	51.6	4.8	56.4	57.9	4.8	62.7	52.0	4.8	56.8
51.0	53.1	4.8	57.9	59.5	4.8	64.3	53.8	4.8	58.6
52.0	54.5	4.8	59.3	61.1	4.8	65.9	55.6	4.8	60.4
53.0	55.9	4.8	60.7	62.7	4.8	67.5	57.5	4.8	62.3
54.0	57.4	4.8	62.2	64.3	4.8	69.1	59.4	4.8	64.2
55.0	58.8	4.8	63.6	65.9	4.8	70.7	61.3	4.8	66.1
56.0	60.2	4.8	65.0	67.5	4.8	72.3	63.2	4.8	68.0
57.0	61.6	4.8	66.4	69.1	4.8	73.9	65.1	4.8	69.9
58.0	63.1	4.8	67.9	70.7	4.8	75.5	67.1	4.8	71.9
59.0	64.5	4.8	69.3	72.3	4.8	77.1	69.1	4.8	73.9
60.0	65.9	4.8	70.7	73.9	4.8	78.7	71.1	4.8	75.9
61.0	67.3	4.8	72.1	75.5	4.8	80.3	73.1	4.8	77.9
62.0	68.8	4.8	73.6	77.1	4.8	81.9	75.4	4.8	80.2
63.0	70.2	4.8	75.0	78.7	4.8	83.5	77.8	4.8	82.6
64.0	71.6	4.8	76.4	80.3	4.8	85.1	80.3	4.8	85.1
65.0	73.1	4.8	77.9	81.9	4.8	86.7	82.8	4.8	87.6
66.0	74.5	4.8	79.3	83.5	4.8	88.3	85.3	4.8	90.1
67.0	75.9	4.8	80.7	85.1	4.8	89.9	87.8	4.8	92.6
68.0	77.3	4.8	82.1	86.7	4.8	91.5	90.4	4.8	95.2
69.0	78.8	4.8	83.6	88.3	4.8	93.1	93.0	4.8	97.8
70.0	80.2	4.8	85.0	89.9	4.8	94.7	95.7	4.8	100.5
71.0	81.6	4.8	86.4	91.5	4.8	96.3	98.4	4.8	103.2
72.0	83.0	4.8	87.8	93.1	4.8	97.9	101.1	4.8	105.9
73.0	84.5	4.8	89.3	94.7	4.8	99.5	103.9	4.8	108.7
74.0	85.9	4.8	90.7	96.3	4.8	101.1	106.7	4.8	111.5

75.0	87.3	4.8	92.1	97.9	4.8	102.7	109.5	4.8	114.3
76.0	88.8	4.8	93.6	99.5	4.8	104.3	112.4	4.8	117.2
77.0	90.2	4.8	95.0	101.1	4.8	105.9	115.3	4.8	120.1
78.0	91.6	4.8	96.4	102.7	4.8	107.5	118.2	4.8	123.0
79.0	93.0	4.8	97.8	104.3	4.8	109.1	121.2	4.8	126.0
80.0	94.5	4.8	99.3	105.9	4.8	110.7	124.2	4.8	129.0
81.0	95.9	4.8	100.7	107.5	4.8	112.3	127.3	4.8	132.1
82.0	97.3	4.8	102.1	109.1	4.8	113.9	130.4	4.8	135.2
83.0	98.7	4.8	103.5	110.7	4.8	115.5	133.5	4.8	138.3
84.0	100.2	4.8	105.0	112.3	4.8	117.1	136.6	4.8	141.4
85.0	101.6	4.8	106.4	113.9	4.8	118.7	139.8	4.8	144.6
86.0	103.0	4.8	107.8	115.5	4.8	120.3	143.0	4.8	147.8
87.0	104.5	4.8	109.3	117.1	4.8	121.9	146.3	4.8	151.1
88.0	105.9	4.8	110.7	118.7	4.8	123.5	149.6	4.8	154.4
89.0	107.3	4.8	112.1	120.3	4.8	125.1	152.9	4.8	157.7
90.0	108.7	4.8	113.5	121.9	4.8	126.7	156.3	4.8	161.1
91.0	110.2	4.8	115.0	123.5	4.8	128.3	159.7	4.8	164.5
92.0	111.6	4.8	116.4	125.1	4.8	129.9	163.1	4.8	167.9
93.0	113.0	4.8	117.8	126.7	4.8	131.5	166.6	4.8	171.4
94.0	114.4	4.8	119.2	128.3	4.8	133.1	170.1	4.8	174.9
95.0	115.9	4.8	120.7	129.9	4.8	134.7	173.7	4.8	178.5
96.0	117.3	4.8	122.1	131.5	4.8	136.3	177.3	4.8	182.1
97.0	118.7	4.8	123.5	133.1	4.8	137.9	180.9	4.8	185.7
98.0	120.1	4.8	124.9	134.7	4.8	139.5	184.5	4.8	189.3
99.0	121.6	4.8	126.4	136.3	4.8	141.1	188.2	4.8	193.0
100.0	123.0	4.8	127.8	137.9	4.8	142.7	191.9	4.8	196.7

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* API RP-2A (1994) *
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PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	3.2	3.2
1.00	0.0	3.2	3.2
2.00	0.0	3.2	3.2
3.00	0.0	3.2	3.2
4.00	0.0	3.2	3.2
5.00	0.0	3.2	3.2
6.00	0.0	3.2	3.2
7.00	0.0	3.2	3.2
8.00	0.0	3.2	3.2
9.00	0.0	3.2	3.2
10.00	0.0	3.2	3.2
11.00	0.0	3.4	3.4
12.00	0.0	3.9	3.9
13.00	0.0	4.3	4.3
14.00	0.3	4.8	5.1
15.00	1.1	4.8	5.9
16.00	2.0	4.8	6.8
17.00	3.0	4.8	7.8
18.00	4.0	4.8	8.8
19.00	5.1	4.8	9.9
20.00	6.2	4.8	11.0
21.00	7.3	4.8	12.1
22.00	8.5	4.8	13.3
23.00	9.8	4.8	14.6
24.00	11.0	4.8	15.8
25.00	12.4	4.8	17.2
26.00	13.7	4.8	18.5
27.00	15.1	4.8	19.9
28.00	16.5	4.8	21.3
29.00	18.0	4.8	22.8
30.00	19.5	4.8	24.3
31.00	21.0	4.8	25.8
32.00	22.6	4.8	27.4
33.00	24.2	4.8	29.0
34.00	25.8	4.8	30.6
35.00	27.4	4.8	32.2
36.00	29.0	4.8	33.8
37.00	30.6	4.8	35.4
38.00	32.2	4.8	37.0
39.00	33.8	4.8	38.6
40.00	35.4	4.8	40.2
41.00	37.0	4.8	41.8
42.00	38.6	4.8	43.4

43.00	40.2	4.8	45.0
44.00	41.8	4.8	46.6
45.00	43.4	4.8	48.2
46.00	45.0	4.8	49.8
47.00	46.6	4.8	51.4
48.00	48.2	4.8	53.0
49.00	49.8	4.8	54.6
50.00	51.4	4.8	56.2
51.00	53.0	4.8	57.8
52.00	54.6	4.8	59.4
53.00	56.2	4.8	61.0
54.00	57.8	4.8	62.6
55.00	59.4	4.8	64.2
56.00	61.0	4.8	65.8
57.00	62.6	4.8	67.4
58.00	64.2	4.8	69.0
59.00	65.8	4.8	70.6
60.00	67.4	4.8	72.2
61.00	69.0	4.8	73.8
62.00	70.6	4.8	75.4
63.00	72.2	4.8	77.0
64.00	73.8	4.8	78.6
65.00	75.4	4.8	80.2
66.00	77.0	4.8	81.8
67.00	78.6	4.8	83.4
68.00	80.2	4.8	85.0
69.00	81.8	4.8	86.6
70.00	83.4	4.8	88.2
71.00	85.0	4.8	89.8
72.00	86.6	4.8	91.4
73.00	88.2	4.8	93.0
74.00	89.8	4.8	94.6
75.00	91.4	4.8	96.2
76.00	93.0	4.8	97.8
77.00	94.6	4.8	99.4
78.00	96.2	4.8	101.0
79.00	97.8	4.8	102.6
80.00	99.4	4.8	104.2
81.00	101.0	4.8	105.8
82.00	102.6	4.8	107.4
83.00	104.2	4.8	109.0
84.00	105.8	4.8	110.6
85.00	107.4	4.8	112.2
86.00	109.0	4.8	113.8
87.00	110.6	4.8	115.4
88.00	112.2	4.8	117.0
89.00	113.8	4.8	118.6
90.00	115.4	4.8	120.2
91.00	117.0	4.8	121.8
92.00	118.6	4.8	123.4
93.00	120.2	4.8	125.0
94.00	121.8	4.8	126.6
95.00	123.4	4.8	128.2
96.00	125.0	4.8	129.8
97.00	126.6	4.8	131.4
98.00	128.2	4.8	133.0
99.00	129.8	4.8	134.6
100.00	131.4	4.8	136.2

AN ASTERISK WILL BE PLACED IN THE END-BEARING COLUMN
IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION
OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

```
*************************************************
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING                      *
*************************************************
```

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		
			0.0000E+00	0.0000E+00
			0.0000E+00	0.1000E-01
			0.0000E+00	0.2000E-01

			0.0000E+00	0.4000E-01
			0.0000E+00	0.6000E-01
			0.0000E+00	0.8000E-01
			0.0000E+00	0.1200E+00
			0.0000E+00	0.1600E+00
			0.0000E+00	0.5000E+00
			0.0000E+00	0.1000E+02
2	10	0.7025E+01		
			0.0000E+00	0.0000E+00
			0.0000E+00	0.1000E-01
			0.0000E+00	0.2000E-01
			0.0000E+00	0.4000E-01
			0.0000E+00	0.6000E-01
			0.0000E+00	0.8000E-01
			0.0000E+00	0.1200E+00
			0.0000E+00	0.1600E+00
			0.0000E+00	0.5000E+00
			0.0000E+00	0.1000E+02
3	10	0.1396E+02		
			0.0000E+00	0.0000E+00
			0.1562E+00	0.1000E-01
			0.3299E+00	0.2000E-01
			0.6858E+00	0.4000E-01
			0.8420E+00	0.6000E-01
			0.8681E+00	0.8000E-01
			0.8420E+00	0.1200E+00
			0.8073E+00	0.1600E+00
			0.8073E+00	0.5000E+00
			0.8073E+00	0.1000E+02
4	10	0.1400E+02		
			0.0000E+00	0.0000E+00
			0.1562E+00	0.1000E-01
			0.3299E+00	0.2000E-01
			0.6858E+00	0.4000E-01
			0.8420E+00	0.6000E-01
			0.8681E+00	0.8000E-01
			0.8420E+00	0.1200E+00
			0.8073E+00	0.1600E+00
			0.8073E+00	0.5000E+00
			0.8073E+00	0.1000E+02
5	10	0.5952E+02		
			0.0000E+00	0.0000E+00
			0.3750E+00	0.1000E-01
			0.7917E+00	0.2000E-01
			0.1646E+01	0.4000E-01
			0.2021E+01	0.6000E-01
			0.2083E+01	0.8000E-01
			0.2021E+01	0.1200E+00
			0.1937E+01	0.1600E+00
			0.1937E+01	0.5000E+00
			0.1937E+01	0.1000E+02
6	10	0.1050E+03		
			0.0000E+00	0.0000E+00
			0.3750E+00	0.1000E-01
			0.7917E+00	0.2000E-01
			0.1646E+01	0.4000E-01
			0.2021E+01	0.6000E-01
			0.2083E+01	0.8000E-01
			0.2021E+01	0.1200E+00
			0.1937E+01	0.1600E+00
			0.1937E+01	0.5000E+00
			0.1937E+01	0.1000E+02

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.5317E-01	0.1000E-03
0.3760E+00	0.5000E-02
0.5317E+00	0.1000E-01
0.1189E+01	0.5000E-01
0.1681E+01	0.1000E+00
0.2378E+01	0.2000E+00
0.3760E+01	0.5000E+00
0.4800E+01	0.1000E+01
0.4800E+01	0.2000E+01

LOAD VERSUS SETTLEMENT CURVE
****

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.5199E+00	0.6474E-03	0.5317E-01	0.1000E-03
0.3904E+01	0.4941E-02	0.1125E+00	0.1000E-02
0.1932E+02	0.2420E-01	0.3760E+00	0.5000E-02
0.3972E+02	0.4895E-01	0.5317E+00	0.1000E-01
0.1145E+03	0.1848E+00	0.1189E+01	0.5000E-01
0.1158E+03	0.2391E+00	0.1681E+01	0.1000E+00
0.1141E+03	0.6377E+00	0.3760E+01	0.5000E+00
0.1152E+03	0.1140E+01	0.4800E+01	0.1000E+01
0.1152E+03	0.2140E+01	0.4800E+01	0.2000E+01

****
* COMPUTE INTERNALLY-GENERATED LOAD-TRANSFER *
* (t-z) CURVES FOR VERIFICATION *
****

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		
			0.0000E+00	0.0000E+00
			0.0000E+00	0.1000E-01
			0.0000E+00	0.2000E-01
			0.0000E+00	0.4000E-01
			0.0000E+00	0.6000E-01
			0.0000E+00	0.8000E-01
			0.0000E+00	0.1200E+00
			0.0000E+00	0.1600E+00
			0.0000E+00	0.5000E+00
			0.0000E+00	0.1000E+02

Attachment C1-S

Compression Capacity Calculation for Driven Pile Bearing on Rock

POINT BEARING CAPACITY OF PILES RESTING ON ROCK IN SOIL AREA 5
New Medowlands Flood Protection
Bergen County, New Jersey

AECOM

Calculated by: AH **Date:** 12/8/2016 **Checked by:**

Equations:

$$Q_{p(all)} = \frac{[q_{u(design)}(N_\varnothing + 1)]A_p}{FOS}$$

$$q_{u(design)} = \frac{q_{u(lab)}}{5}$$

$$N_\varnothing = \tan^2\left(45 + {\varnothing'}/{2}\right)$$

Where,

$Q_{p(all)}$ = Allowable Point Bearing Capacity of Piles

$q_{u(lab)}$ = Laboratory Unconfined Compression Strength of Rock

$q_{u(design)}$ = Design Unconfined Compression Strength of Rock

ϕ' = Drained Angle of Friction

A_p = Tip Area of pile

FOS = Factor of Safety

Pile End Bearing Calculation:

ϕ' =	15	deg.
N_ϕ =	1.70	
$q_{u(lab)}$ =	5,500	psi
$q_{u(design)}$ =	1,100	psi
Pile Type =	HP14×73 Steel	
A_p =	198.56	in^2
FOS =	2	
Ultimate Point Bearing Capacity =	**589**	**kip**
Allowable Point Bearing Capacity =	**295**	**kip**

References:

1. Das, B. M. (2006). Principles of Foundation Engineering, Cengage Learning, Stamford, Connecticut, 750p.
2. United States Army Corps of Engineers (1991). Engineering and Design, Design of Pile Foundations, Engineering Manual EM 1110-2-2906.

POINT BEARING CAPACITY OF PILES RESTING ON ROCK IN SOIL AREA 5

New Medowlands Flood Protection

Bergen County, New Jersey

AECOM

Calculated by: AH **Date:** 12/8/2016 **Checked by:**

Equations:

$$Q_{p(all)} = \frac{[q_{u(design)}(N_{\emptyset} + 1)]A_p}{FOS}$$

$$q_{u(design)} = \frac{q_{u(lab)}}{5}$$

$$N_{\emptyset} = \tan^2\left(45 + {\emptyset'}/_{2}\right)$$

Where,

$Q_{p(all)}$ = Allowable Point Bearing Capacity of Piles

$q_{u(lab)}$ = Laboratory Unconfined Compression Strength of Rock

$q_{u(design)}$ = Design Unconfined Compression Strength of Rock

ϕ' = Drained Angle of Friction

A_p = Tip Area of pile

FOS = Factor of Safety

Pile End Bearing Calculation:

ϕ' =	15	deg.
N_{ϕ} =	1.70	
$q_{u(lab)}$ =	5,500	psi
$q_{u(design)}$ =	1,100	psi
Pile Type =	HP16×171 Steel	
A_p =	256	in^2
FOS =	2	
Ultimate Point Bearing Capacity =	**760**	**kip**
Allowable Point Bearing Capacity =	**380**	**kip**

References:

1. Das, B. M. (2006). Principles of Foundation Engineering, Cengage Learning, Stamford, Connecticut, 750p.
2. United States Army Corps of Engineers (1991). Engineering and Design, Design of Pile Foundations, Engineering Manual EM 1110-2-2906.

Attachment C1-T

Details of Micropile Axial Capacity Calculations

MICROPILE DESIGN - 2015 INTERNATIONAL BUILDING CODE NEW JERSEY EDITION

Project Name: New Meadowlands - Soil Areas 4 to 7 **Calculated by : LC**

Project Number : 60481054 **Checked by : KV**

Outside Diameter of Casing:	***11.875***	in.
Thickness of Casing:	***0.582***	in.
Inside Diameter of Casing	10.711	in.
Diameter of Bond Zone :	***11.5***	in.
Perimeter of Bond Zone :	36.1	in.
Area of Bond Zone :	103.9	sq.in.
Center to Center Spacing :	***3.0***	ft
Cased length :	***15***	ft
Soil unit weight :	***110***	pcf
Wedge angle (for single row calc.):	***30***	degrees
Allowable Bond Stress (Compression):	***5***	psi
Allowable Bond Stress (Tension):	***3***	psi

GEOTECHNICAL CAPACITY

Bond Zone Length (ft)	Compression (tons)	Tension: Failure at grout/soil interface (tons)	Tension: Single Row - Failure thru soil (tons)	Tension: Multiple Rows - Failure thru soil (tons)
5	5	4	22	10
10	11	7	22	12
15	16	11	22	15
20	22	14	22	17
25	27	18	22	20
30	33	22	22	22
35	38	22	22	22
40	43	22	22	22

STRUCTURAL CAPACITY

Cased Section :

Rebar Diameter:	1.25	in	Rebar Number:	***10***		
Number of Rebars:	***1***		Rebar & casing clearance		4.7 in.	(Minimum = 1 inch)
Total Rebar Area:	1.23	sq.in.				
Rebar Steel Yield Stress:	***60***	ksi	A615 Grade 60			
Allow. Rebar Stress:	24	ksi				
Casing Steel Yield Stress :	***45***	ksi	Minimum 45 ksi			
Allow. Casing Stress:	18	ksi				
Grout Compr. Stress:	***4***	ksi	Minimum 4 ksi			
Casing Steel Area:	20.6	sq.in.				
Grout Area :	88.9	sq.in.				
Rebar Strength (Comp.):	15	tons	Rebar Strength (Tension):		22 tons	
Steel Casing Strength:	186	tons				
Grout Strength :	53	tons				
Total :	**254**	**tons**				

Uncased Section :

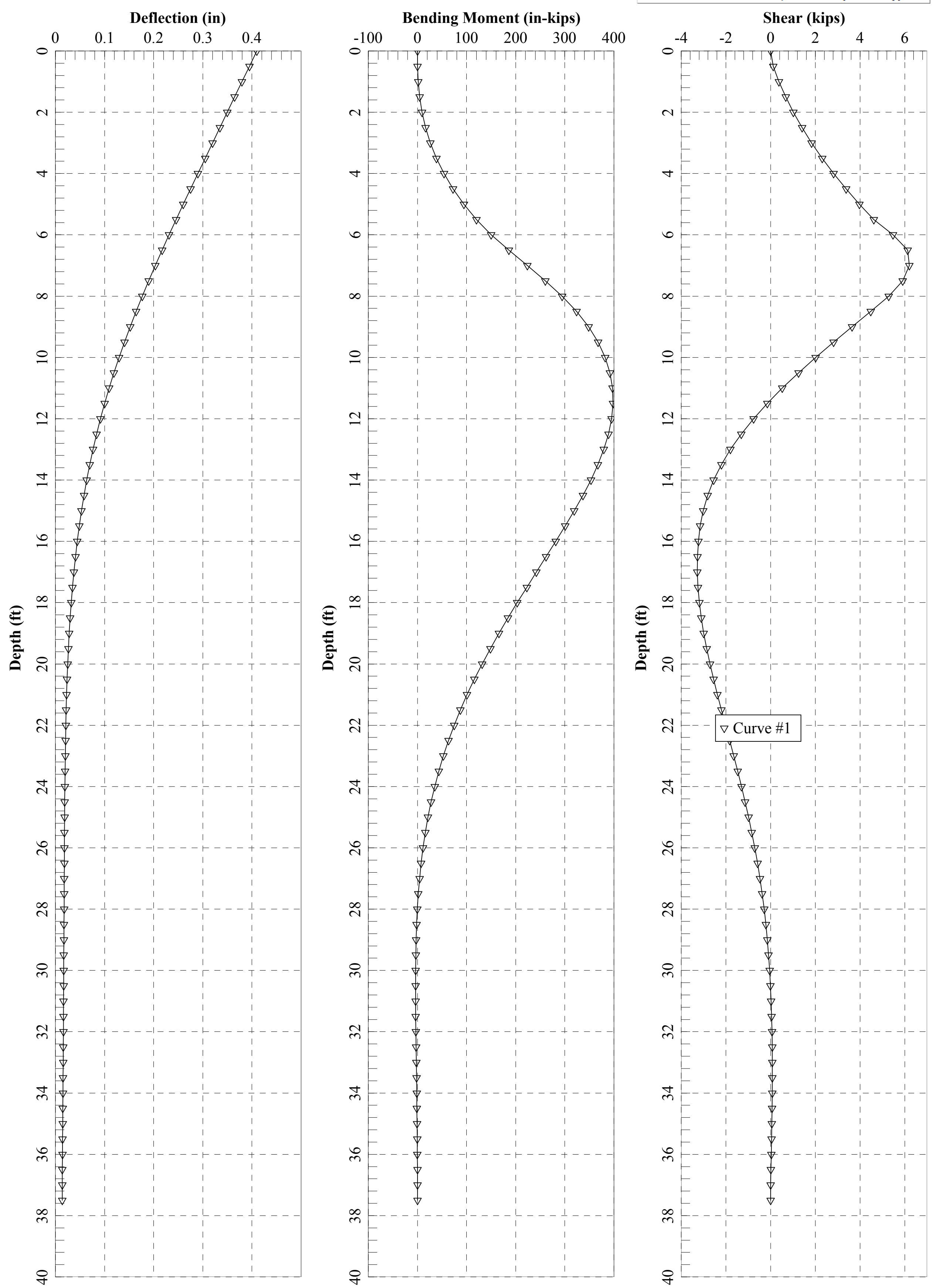
Rebar Diameter:	1.25	in	Rebar Number:	***10***		
Number of Rebars:	***1***		Grout cover :		5.1	(Minimum = 2.5 inches)
Rebar Diameter:	0	in	Rebar Number:	***0***		
Number of Rebars:	***1***		Grout cover :		5.8	(Minimum = 2.5 inches)
Total Rebar Area:	1.23	sq.in.				
Rebar Steel Yield Stress:	***60***	ksi	A615 Grade 60			
Allow. Rebar Stress:	24	ksi				
Grout Compr. Stress:	4	ksi				
Grout Area :	102.6	sq.in.				
Rebar Strength (Comp.):	15	tons	Load carried by the steel:		19%	
Grout Strength :	62	tons				
Total :	**76**	**tons**				

Attachment C1-U

Plots of Lateral Deflection, Bending Moment and Shear Force versus Embedded Depth of Cantilever Sheet Pile Walls from PYWall

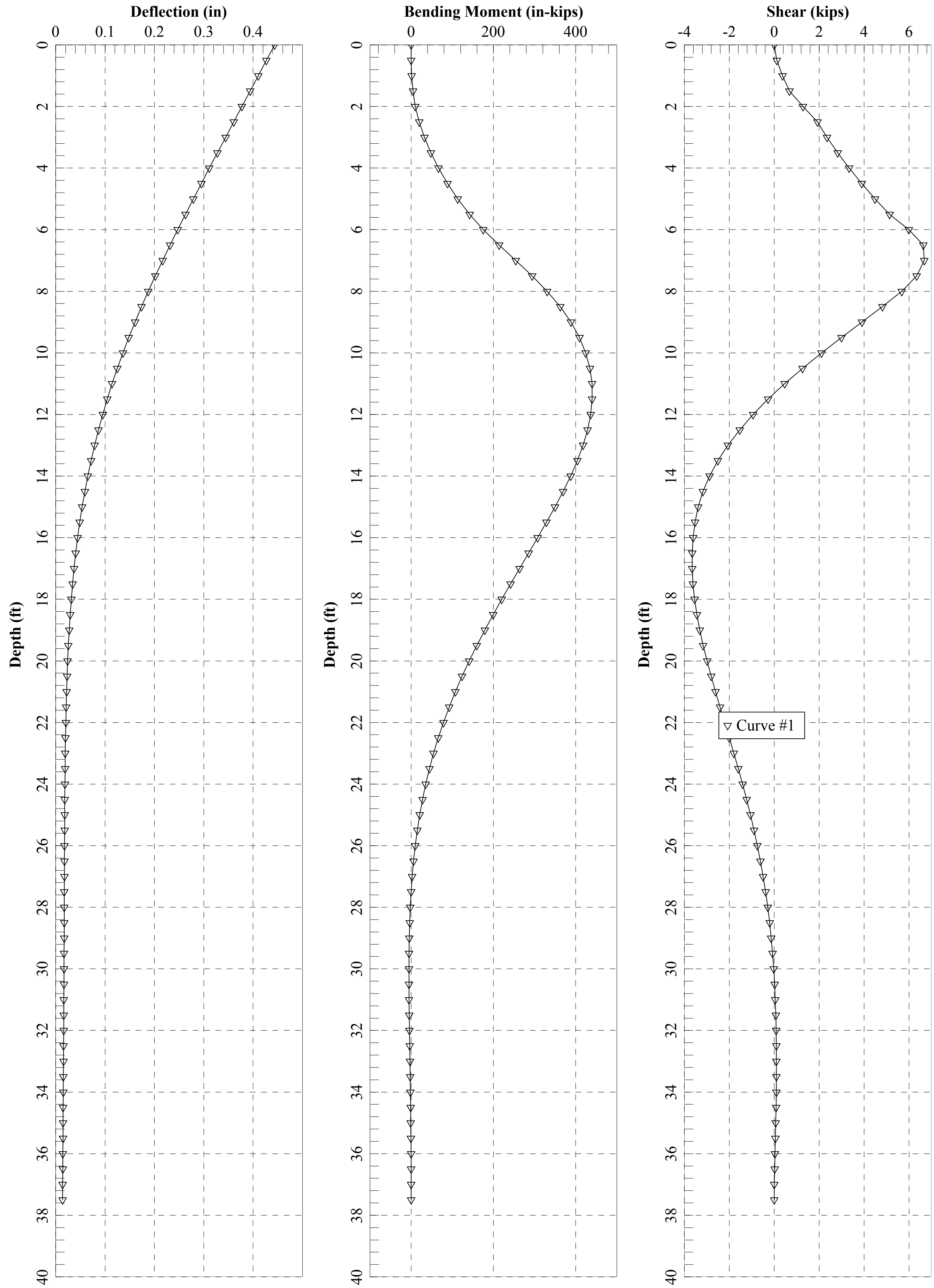
Cantilever Sheet Pile Wall with 6 ft Height for Soil Areas 1-3 - No Flood Condition

Factored axial load, F =	0.00	kips
Max. bending moment, M =	4.00E+02	kips-in
Area (pile), A =	28.6	in^2
Section modulus (pile), S =	117	in^3
F/A + M/S =	**3.41**	ksi
So,	**< 33 ksi (<=0.66Fy), OK**	



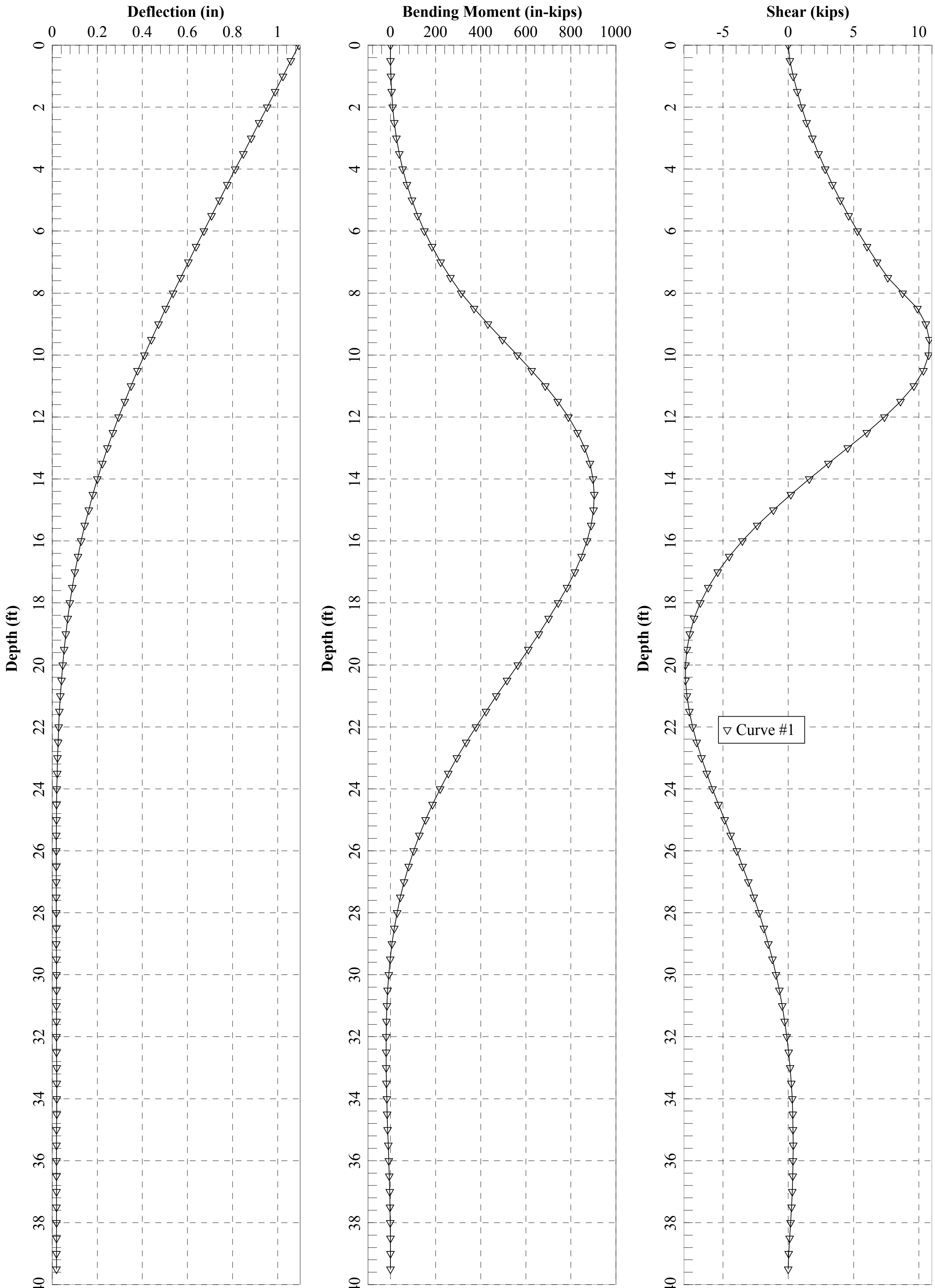
Cantilever Sheet Pile Wall with 6 ft Height for Soil Areas 1-3 - No Flood and Seismic

Factored axial load, F =	0.00	kips
Max. bending moment, M =	4.40E+02	kips-in
Area (pile), A =	28.6	in^2
Section modulus (pile), S =	117	in^3
F/A + M/S =	**3.75**	ksi
So,	**< 33 ksi (<=0.66Fy), OK**	



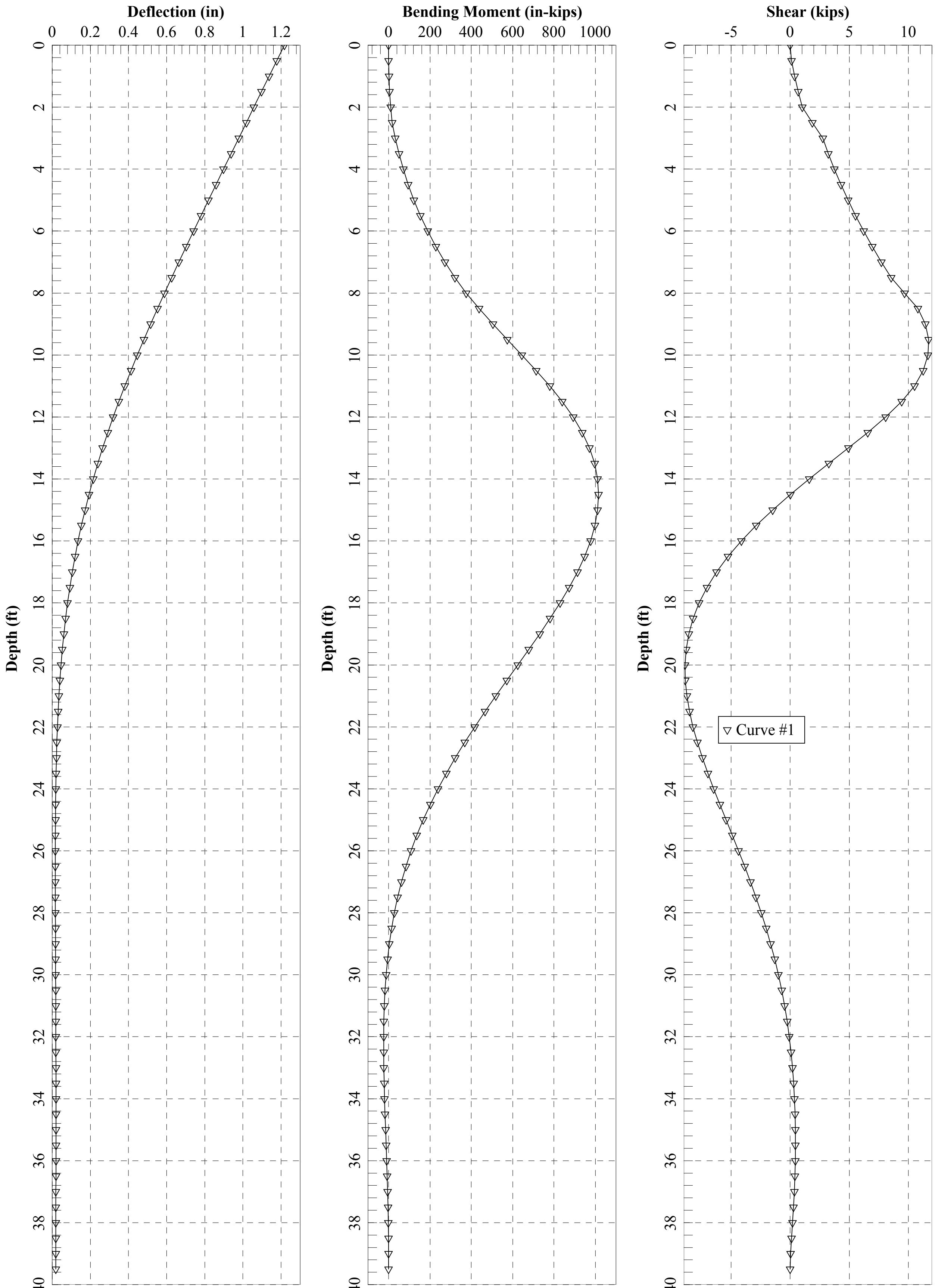
Cantilever Sheet Pile Wall with 8 ft Height for Soil Areas 1-3 - No Flood Condition

Factored axial load, F =	0.00	kips
Max. bending moment, M =	9.00E+02	kips-in
Area (pile), A =	28.6	in^2
Section modulus (pile), S =	117	in^3
F/A + M/S =	**7.68**	ksi
So,	**< 33 ksi (<=0.66Fy), OK**	



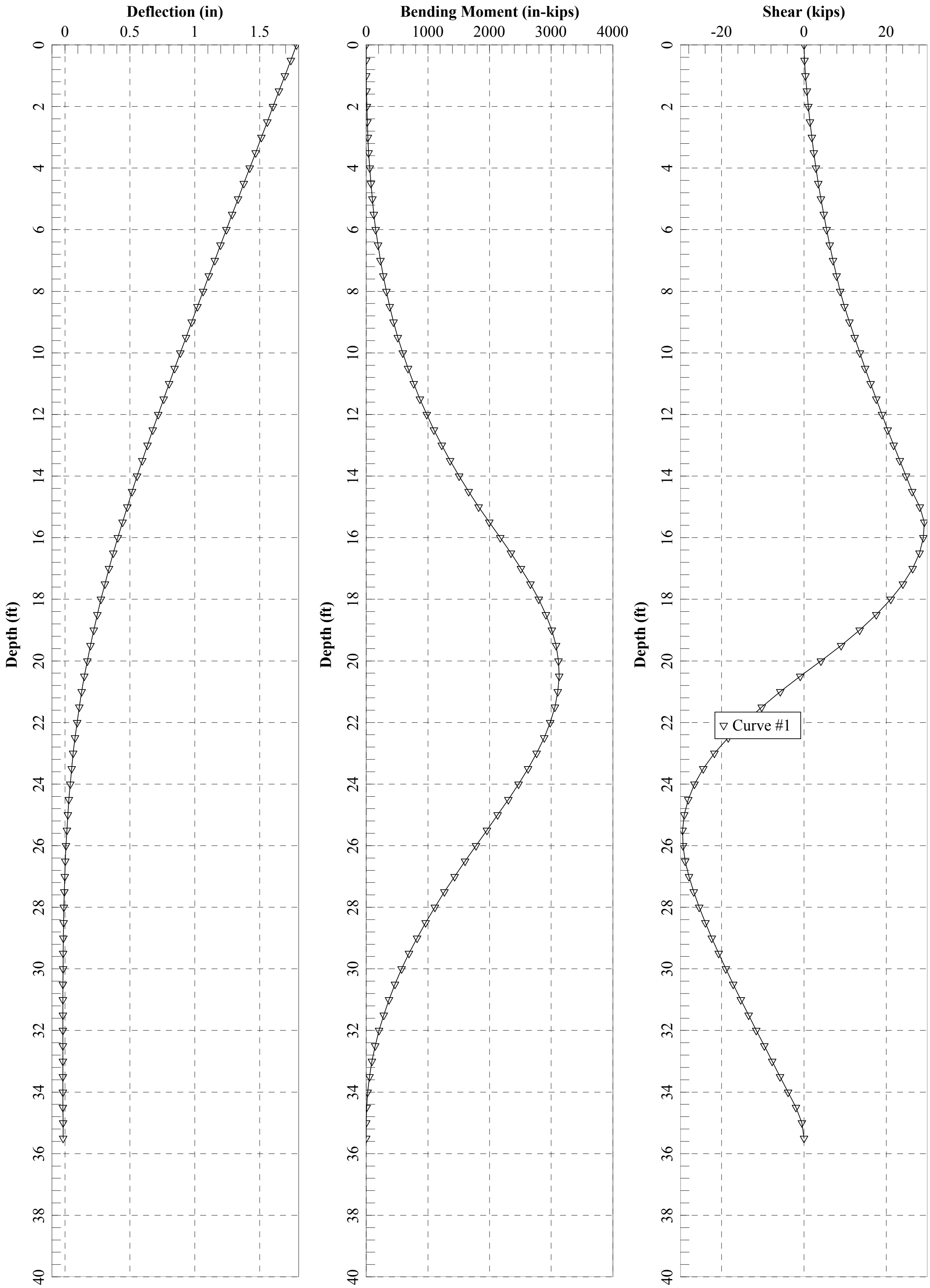
Cantilever Sheet Pile Wall with 8 ft Height for Soil Areas 1-3 - No Flood and Seismic

Factored axial load, F =	0.00	kips
Max. bending moment, M =	1.02E+03	kips-in
Area (pile), A =	28.6	in^2
Section modulus (pile), S =	117	in^3
F/A + M/S =	**8.70**	ksi
So,	**< 33 ksi (<=0.66Fy), OK**	



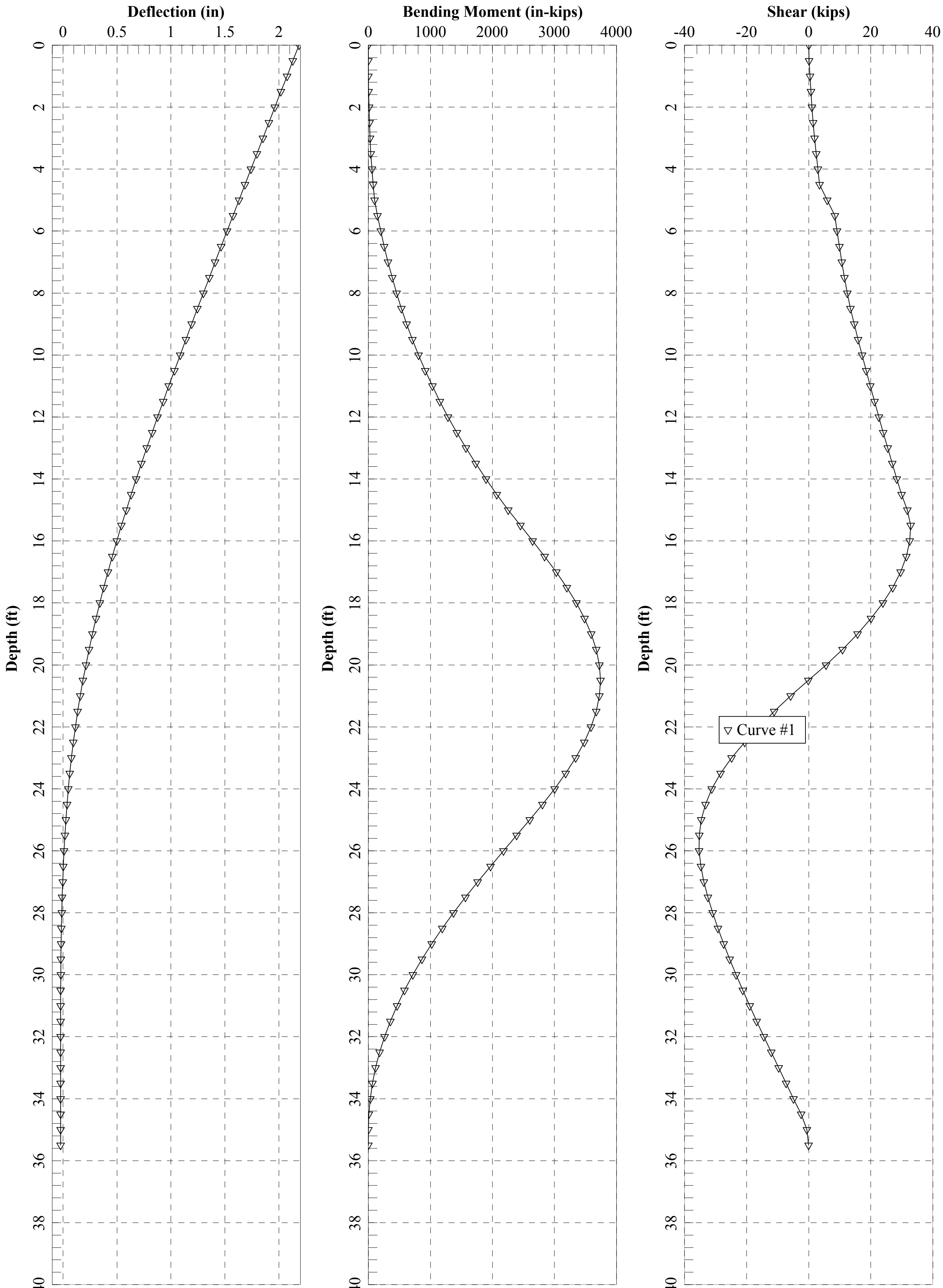
Cantilever Sheet Pile Wall with 15 ft Height (Not Grouted)
for Soil Area 2, Bedrock @ -27 ft or Lower
No Flood Condition

Factored axial load, F =	0.00	kips
Max. bending moment, M =	3.12E+03	kips-in
Area (pile), A =	40.5	in^2
Section modulus (pile), S =	244.00	in^3
F/A + M/S =	**12.79**	ksi
So, <	**33 ksi (<=0.66Fy), OK**	

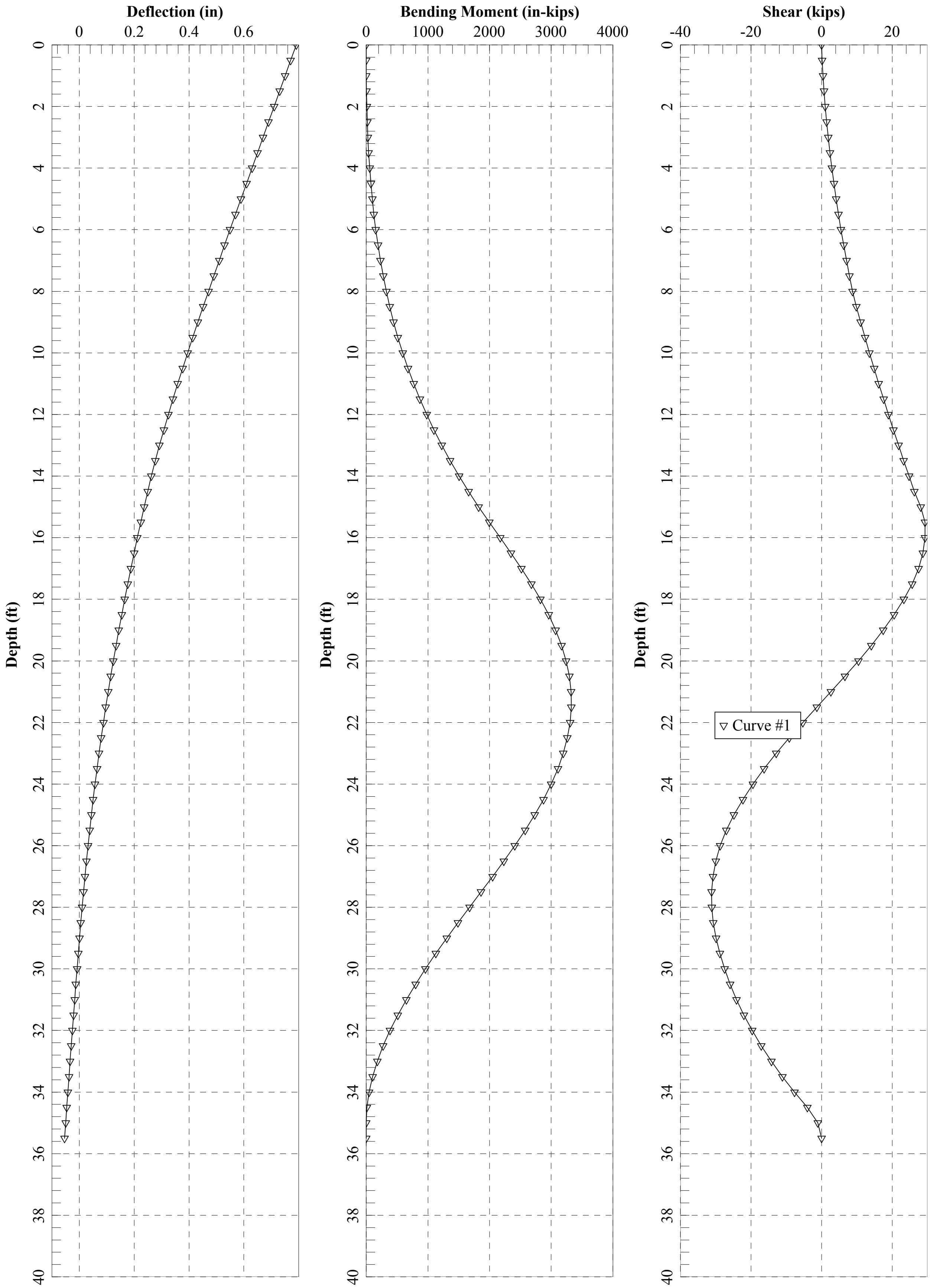


Cantilever Sheet Pile Wall with 15 ft Height (Not Grouted)
for Soil Area 2, Bedrock @ -27 ft or Lower
No Flood and Seismic

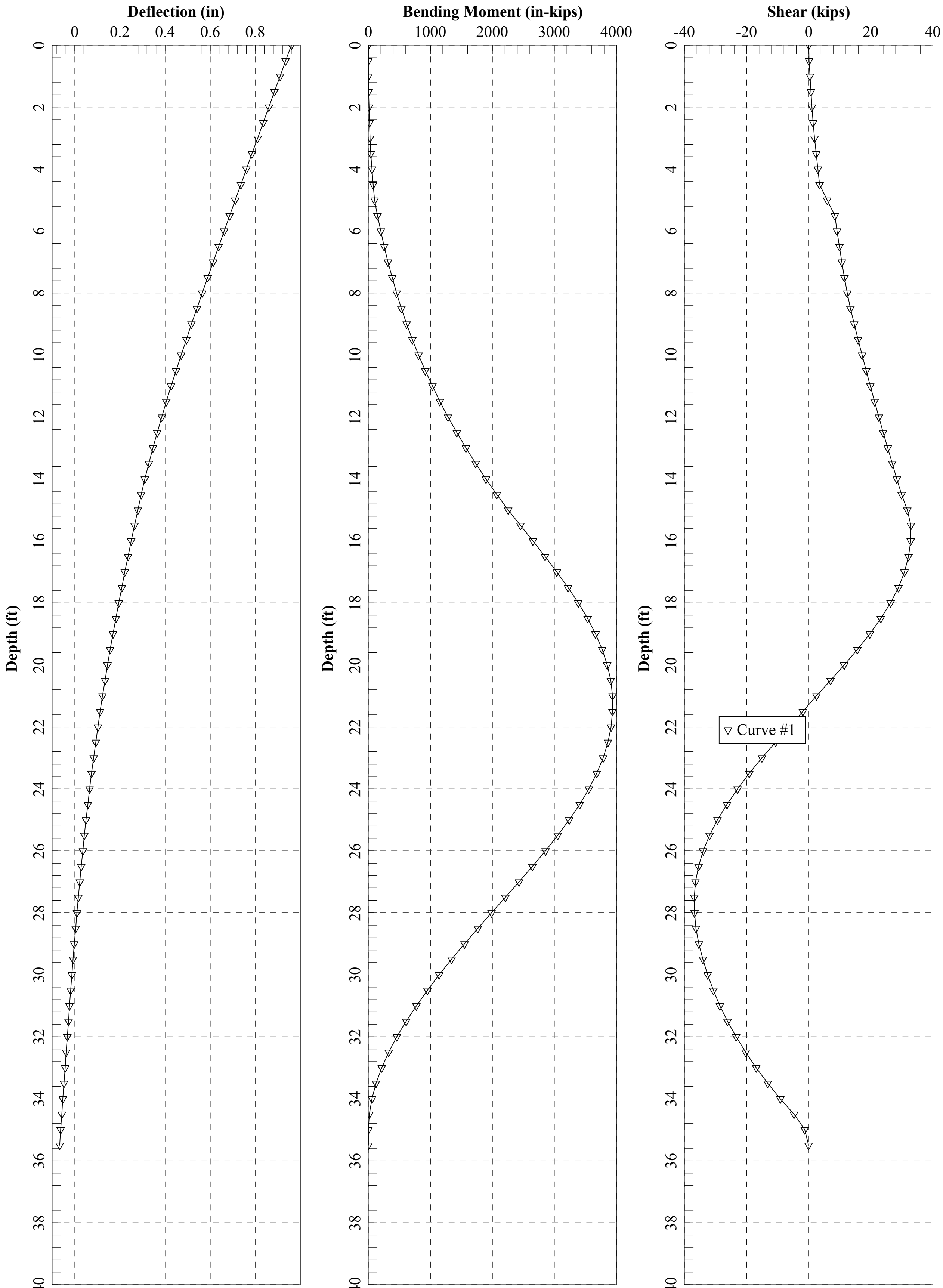
Factored axial load, F =	0.00	kips
Max. bending moment, M =	3.70E+03	kips-in
Area (pile), A =	40.5	in^2
Section modulus (pile), S =	244.00	in^3
F/A + M/S =	**15.16**	ksi
So,	**< 33 ksi (<=0.66Fy), OK**	



Cantilever Sheet Pile Wall with 15 ft Height (Grouted)
for Soil Area 2, Bedrock @ -27 ft or Lower
No Flood Condition



Cantilever Sheet Pile Wall with 15 ft Height (Grouted)
for Soil Area 2, @ -27 ft or Lower
No Flood and Seismic



Output from PYWall Analysis for Cantilever Sheet Pile Wall in Soil Area 2

Cantilever Sheet Pile Wall with 15 ft Height (Not Grouted)
for Soil Area 2, Bedrock @ -27 ft or Lower
No Flood Condition

```
     Cantilever Sheet Pile Wall Bedrock @-27ft or Lower_No_Flood.py5o
=========================================================================

                    PYWALL for Windows, Version 2015.5.11

                     Serial Number :  166868598

                     A Program for the Analysis of
                     Flexible Retaining Walls
                   (c) Copyright ENSOFT, Inc., 1987-2016
                         All Rights Reserved

=========================================================================


This program is licensed to :

AECOM / URS Corp
Clifton, NJ

Path to file locations      : Q:\Geotechnical\Meadowlands\Calculations for New
Alternatives\Cantilever Sheet Pile Wall\PYWall Analysis\Proposed Section\No
Flood_With Out Grout\
Name of input data file     : Cantilever Sheet Pile Wall Bedrock @-27ft or
Lower_No_Flood.py5d
Name of output file         : Cantilever Sheet Pile Wall Bedrock @-27ft or
Lower_No_Flood.py5o
Name of plot output file    : Cantilever Sheet Pile Wall Bedrock @-27ft or
Lower_No_Flood.py5p

-------------------------------------------------------------------------
                     Time and Date of Analysis
-------------------------------------------------------------------------

          Date:  October 18, 2017     Time:  16:38:27

 Cantilever Sheet Pile Wall Bedrock @-27ft or Lower_No_Flood


 **************************************************
 *        PROGRAM CONTROL PARAMETERS              *
 **************************************************

 NO OF POINTS FOR SPECIFIED DEFLECTIONS AND SLOPES  =  0
 NO OF POINTS FOR WALL STIFFNESS AND LOAD DATA      =  1
 GENERATE EARTH PRESSURE INTERNALLY                 =  1
 GENERATE SOIL RESISTANCE (P-Y) CURVES INTERNALLY   =  1
 NO OF P-Y MODIFICATION FACTORS FOR GEN. P-Y CURVES =  0
 NO OF USER-SPECIFIED SOIL RESISTANCE (P-Y) CURVES  =  0
 NUMBER OF INCREMENTS                               =  70
 INCREMENT LENGTH                                   =      6.000 IN
 FREE HEIGHT OF WALL                                =    180.000 IN
 MAXIMUM ALLOWABLE DEFLECTION                       =     18.000 IN
 DEFLECTION CLOSURE TOLERANCE                       = 1.000E-05 IN



 **************************************************
 *        STIFFNESS AND LOAD DATA                 *
 **************************************************
 EI - FLEXURAL RIGIDITY,  Q - TRANSVERSE LOAD,
 S - STIFFNESS OF TRANSVERSE RESISTANCE,
 T - TORQUE,              P - AXIAL LOAD,
```

R - STIFFNESS OF TORSIONAL RESISTANCE.

FROM	TO	CONTD	EI	Q	S'	T	R	P
			LBS-IN**2	LBS	LBS/IN	IN-LBS	IN-LBS	LBS
0	70	0	0.662E+11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

```
**************************************************
*                 WALL INFORMATION               *
**************************************************
```

```
FREE HEIGHT OF WALL                     =  0.180E+03 IN
WIDTH FOR EARTH PRESSURE, WA            =  0.630E+02 IN
WIDTH FOR SOIL RESISTANCE, WP           =  0.630E+02 IN
DEPTH TO THE WATER TABLE AT BACKFILL    =  0.960E+02 IN
DEPTH TO THE WATER TABLE AT EXCAVATION  =  0.960E+02 IN
UNIT WEIGHT OF WATER                    =  0.360E-01 LBS/IN**3
SLOPE OF THE BACKFILL (deg.)            =  0.000E+00
MODIFICATION FOR ACTIVE EARTH PRESSURE  =  0.100E+01
```

```
**************************************************
*               SURCHARGE INFORMATION            *
**************************************************
```

UNIFORM SURFACE PRESSURE = 0.174E+01 LBS/IN**2

```
**************************************************
*                 SOIL INFORMATION               *
**************************************************
```

LAYER NO.	TOTAL THICKNESS IN	COHESION PSI	PHI DEG	TOTAL UNIT WEIGHT PCI	DRAINED T OR F	ZTOP IN
1	96.0	0.0	32.0	0.064	T	0.00
2	84.0	0.3	22.0	0.064	T	96.00
3	300.0	0.0	36.0	0.075	T	180.00

```
**************************************************
*           EFFECTIVE OVERBURDEN STRESS          *
**************************************************
```

DEPTH IN	STRESS LBS/IN**2
0.000E+00	0.174E+01
0.960E+02	0.785E+01
0.180E+03	0.102E+02

```
**************************************************
* ACTIVE AND PASSIVE EARTH PRESSURE COEFFICIENT  *
**************************************************
```

LAYER NO.	ACTIVE EARTH COEFFICIENT	PASSIVE EARTH COEFFICIENT	OPTIONAL EARTH COEFFICIENT

1	0.307E+00	0.325E+01	0.000E+00
2	0.455E+00	0.220E+01	0.000E+00
3	0.260E+00	0.385E+01	0.000E+00

```
*************************************************
*     ACTIVE EARTH PRESSURE OF EACH LAYER       *
*************************************************
```

LAYER NO	PA1 LBS/IN**2	Z1 IN	PA2 LBS/IN**2	Z2 IN	PA3 LBS/IN**2	Z3 IN	PA4 LBS/IN**2
1	51.21	48.00	90.13	64.00	0.00	0.00	0.00
2	299.90	138.00	44.39	152.00	-39.35	0.00	0.00

```
*************************************************
*     ACTIVE WATER PRESSURE OF EACH LAYER       *
*************************************************
```

LAYER NO	PW1	Z1	PW2	Z2
2	0.00	138.00	127.01	152.00

DEPTH IN	ACTIVE EARTH PRESSURE LBS/IN
0.000E+00	0.336E+02
0.600E+01	0.410E+02
0.120E+02	0.484E+02
0.180E+02	0.558E+02
0.240E+02	0.630E+02
0.300E+02	0.706E+02
0.360E+02	0.781E+02
0.420E+02	0.851E+02
0.480E+02	0.926E+02
0.540E+02	0.100E+03
0.600E+02	0.108E+03
0.660E+02	0.115E+03
0.720E+02	0.122E+03
0.780E+02	0.130E+03
0.840E+02	0.137E+03
0.900E+02	0.144E+03
0.960E+02	0.152E+03
0.102E+03	0.200E+03
0.108E+03	0.205E+03
0.114E+03	0.210E+03
0.120E+03	0.214E+03
0.126E+03	0.219E+03
0.132E+03	0.224E+03
0.138E+03	0.229E+03
0.144E+03	0.234E+03
0.150E+03	0.238E+03
0.156E+03	0.243E+03
0.162E+03	0.248E+03
0.168E+03	0.253E+03
0.174E+03	0.257E+03
0.180E+03	0.264E+03
0.186E+03	0.166E+03
0.192E+03	0.166E+03
0.198E+03	0.166E+03

0.204E+03	0.166E+03
0.210E+03	0.166E+03
0.216E+03	0.166E+03
0.222E+03	0.166E+03
0.228E+03	0.166E+03
0.234E+03	0.166E+03
0.240E+03	0.166E+03
0.246E+03	0.166E+03
0.252E+03	0.166E+03
0.258E+03	0.166E+03
0.264E+03	0.166E+03
0.270E+03	0.166E+03
0.276E+03	0.166E+03
0.282E+03	0.166E+03
0.288E+03	0.166E+03
0.294E+03	0.166E+03
0.300E+03	0.166E+03
0.306E+03	0.166E+03
0.312E+03	0.166E+03
0.318E+03	0.166E+03
0.324E+03	0.166E+03
0.330E+03	0.166E+03
0.336E+03	0.166E+03
0.342E+03	0.166E+03
0.348E+03	0.166E+03
0.354E+03	0.166E+03
0.360E+03	0.166E+03
0.366E+03	0.166E+03
0.372E+03	0.166E+03
0.378E+03	0.166E+03
0.384E+03	0.166E+03
0.390E+03	0.166E+03
0.396E+03	0.166E+03
0.402E+03	0.166E+03
0.408E+03	0.166E+03
0.414E+03	0.166E+03
0.420E+03	0.166E+03

****
*   SOIL LAYERS AND STRENGTH DATA   *
****

X AT THE SURFACE OF EXCAVATION SIDE   =   180.00 IN

1 LAYER(S) OF SOIL

LAYER 1
THE SOIL IS A SAND

DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH
2 POINTS

X,IN	WEIGHT,LBS/IN**3
180.0000	0.3923D-01
480.0000	0.3923D-01

DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH
2 POINTS

X,IN	S,LBS/IN**2	PHI,DEGREES	E50
180.00	0.0000D+00	36.000	-----
432.00	0.0000D+00	36.000	-----

P-Y CURVES DATA

AT THE EXCAVATION SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
IN	IN		LBS/IN**3				
0.10	63.00	36.00	0.39E-01	2.83	2.14	0.89E+00	0.15E+02

Y	P
IN	LBS/IN
0.000	-166.347
0.088	-165.253
0.175	-164.159
0.263	-163.381
0.350	-163.153
0.438	-162.963
0.525	-162.800
0.613	-162.656
0.700	-162.527
0.788	-162.409
0.875	-162.301
0.963	-162.200
1.050	-162.106
2.362	-160.738
65.362	-160.738
128.363	-160.738
191.363	-160.738

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
IN	IN		LBS/IN**3				
180.10	63.00	36.00	0.39E-01	1.11	0.75	0.57E+04	0.27E+05

Y	P
IN	LBS/IN
0.000	166.347
0.088	1216.171
0.175	1530.787
0.263	1756.889
0.350	1939.687
0.438	2095.823
0.525	2233.548
0.613	2357.634
0.700	2471.127
0.788	2576.105
0.875	2674.055
0.963	2766.088
1.050	2853.054
2.362	4123.061
65.362	4123.061

128.363	4123.061
191.363	4123.061

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
63.00	63.00	36.00	0.39E-01	2.11	1.54	0.11E+04	0.95E+04

Y IN	P LBS/IN
0.000	-166.347
0.088	522.716
0.175	965.314
0.263	1109.674
0.350	1223.134
0.438	1318.043
0.525	1400.382
0.613	1473.552
0.700	1539.691
0.788	1600.241
0.875	1656.223
0.963	1708.392
1.050	1757.321
2.362	2469.328
65.362	2469.328
128.363	2469.328
191.363	2469.328

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
243.00	63.00	36.00	0.39E-01	0.92	0.56	0.97E+04	0.37E+05

Y IN	P LBS/IN
0.000	166.347
0.088	886.362
0.175	1204.943
0.263	1453.164
0.350	1664.484
0.438	1852.014
0.525	2022.534
0.613	2180.097
0.700	2327.354
0.788	2466.158
0.875	2597.860
0.963	2723.484
1.050	2843.829
2.362	4612.757
65.362	4612.757
128.363	4612.757
191.363	4612.757

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
IN	IN		LBS/IN**3				
126.00	63.00	36.00	0.39E-01	1.48	1.05	0.31E+04	0.19E+05

Y	P
IN	LBS/IN
0.000	-166.347
0.088	995.819
0.175	1292.103
0.263	1499.297
0.350	1663.921
0.438	1802.737
0.525	1923.938
0.613	2032.214
0.700	2130.530
0.788	2220.894
0.875	2304.736
0.963	2383.114
1.050	2456.836
2.362	3531.092
65.362	3531.092
128.363	3531.092
191.363	3531.092

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
IN	IN		LBS/IN**3				
306.00	63.00	36.00	0.39E-01	0.88	0.50	0.15E+05	0.46E+05

Y	P
IN	LBS/IN
0.000	166.347
0.088	854.281
0.175	1209.469
0.263	1497.076
0.350	1748.046
0.438	1974.873
0.525	2184.148
0.613	2379.871
0.700	2564.696
0.788	2740.491
0.875	2908.636
0.963	3070.184
1.050	3225.962
2.362	5522.841
65.362	5522.841
128.363	5522.841
191.363	5522.841

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
189.00	63.00	36.00	0.39E-01	1.06	0.71	0.62E+04	0.29E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	832.264
0.175	1146.193
0.263	1373.781
0.350	1558.809
0.438	1717.504
0.525	1857.944
0.613	1984.822
0.700	2101.138
0.788	2208.947
0.875	2309.721
0.963	2404.560
1.050	2494.310
2.362	3805.902
65.362	3805.902
128.363	3805.902
191.363	3805.902

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
369.00	63.00	36.00	0.39E-01	0.88	0.50	0.21E+05	0.56E+05

Y IN	P LBS/IN
0.000	166.347
0.088	973.810
0.175	1397.038
0.263	1741.101
0.350	2042.099
0.438	2314.656
0.525	2566.500
0.613	2802.330
0.700	3025.265
0.788	3237.507
0.875	3440.681
0.963	3636.029
1.050	3824.528
2.362	6604.745
65.362	6604.745
128.363	6604.745
191.363	6604.745

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
251.90	63.00	36.00	0.39E-01	0.90	0.53	0.10E+05	0.38E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	495.368
0.175	807.943
0.263	1055.374
0.350	1268.170
0.438	1458.435
0.525	1632.480
0.613	1794.101
0.700	1945.794
0.788	2089.311
0.875	2225.936
0.963	2356.643
1.050	2482.195
2.362	4330.023
65.362	4330.023
128.363	4330.023
191.363	4330.023

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
431.90	63.00	36.00	0.39E-01	0.88	0.50	0.28E+05	0.65E+05

Y IN	P LBS/IN
0.000	166.347
0.088	1111.451
0.175	1606.823
0.263	2009.534
0.350	2361.841
0.438	2680.858
0.525	2975.632
0.613	3251.661
0.700	3512.598
0.788	3761.019
0.875	3998.826
0.963	4227.474
1.050	4448.104
2.362	7702.239
65.362	7702.239
128.363	7702.239
191.363	7702.239

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

Cantilever Sheet Pile Wall Bedrock @-27ft or Lower_No_Flood

RESULTS -- ITERATION 6

STA I X DEFL. SLOPE MOMENT SHEAR NET REACT/STA

	IN	IN		LBS-IN	LBS	LBS	EI LBS-IN**2
------	----	----	-----	------	------	---------	----------
0	0.000E+00	0.178E+01	-0.753E-02	0.000E+00	0.000E+00	0.000E+00	0.331E+11
1	0.600E+01	0.174E+01	-0.753E-02	0.000E+00	0.123E+03	0.246E+03	0.662E+11
2	0.120E+02	0.169E+01	-0.753E-02	0.148E+04	0.391E+03	0.290E+03	0.662E+11
3	0.180E+02	0.165E+01	-0.753E-02	0.469E+04	0.704E+03	0.335E+03	0.662E+11
4	0.240E+02	0.160E+01	-0.753E-02	0.992E+04	0.106E+04	0.378E+03	0.662E+11
5	0.300E+02	0.156E+01	-0.752E-02	0.174E+05	0.146E+04	0.423E+03	0.662E+11
6	0.360E+02	0.151E+01	-0.752E-02	0.275E+05	0.191E+04	0.469E+03	0.662E+11
7	0.420E+02	0.147E+01	-0.752E-02	0.403E+05	0.240E+04	0.510E+03	0.662E+11
8	0.480E+02	0.142E+01	-0.752E-02	0.562E+05	0.293E+04	0.556E+03	0.662E+11
9	0.540E+02	0.138E+01	-0.751E-02	0.755E+05	0.351E+04	0.601E+03	0.662E+11
10	0.600E+02	0.133E+01	-0.750E-02	0.983E+05	0.413E+04	0.646E+03	0.662E+11
11	0.660E+02	0.129E+01	-0.749E-02	0.125E+06	0.480E+04	0.688E+03	0.662E+11
12	0.720E+02	0.124E+01	-0.748E-02	0.156E+06	0.551E+04	0.733E+03	0.662E+11
13	0.780E+02	0.120E+01	-0.746E-02	0.191E+06	0.627E+04	0.779E+03	0.662E+11
14	0.840E+02	0.115E+01	-0.744E-02	0.231E+06	0.707E+04	0.824E+03	0.662E+11
15	0.900E+02	0.111E+01	-0.742E-02	0.276E+06	0.791E+04	0.866E+03	0.662E+11
16	0.960E+02	0.106E+01	-0.739E-02	0.326E+06	0.880E+04	0.911E+03	0.662E+11
17	0.102E+03	0.102E+01	-0.736E-02	0.382E+06	0.986E+04	0.120E+04	0.662E+11
18	0.108E+03	0.976E+00	-0.732E-02	0.444E+06	0.111E+05	0.123E+04	0.662E+11
19	0.114E+03	0.932E+00	-0.728E-02	0.514E+06	0.123E+05	0.126E+04	0.662E+11
20	0.120E+03	0.888E+00	-0.723E-02	0.592E+06	0.136E+05	0.129E+04	0.662E+11
21	0.126E+03	0.845E+00	-0.717E-02	0.677E+06	0.149E+05	0.132E+04	0.662E+11
22	0.132E+03	0.802E+00	-0.711E-02	0.771E+06	0.162E+05	0.134E+04	0.662E+11
23	0.138E+03	0.760E+00	-0.703E-02	0.872E+06	0.176E+05	0.137E+04	0.662E+11
24	0.144E+03	0.718E+00	-0.695E-02	0.982E+06	0.190E+05	0.140E+04	0.662E+11
25	0.150E+03	0.676E+00	-0.685E-02	0.110E+07	0.204E+05	0.143E+04	0.662E+11
26	0.156E+03	0.636E+00	-0.675E-02	0.123E+07	0.218E+05	0.146E+04	0.662E+11
27	0.162E+03	0.595E+00	-0.663E-02	0.136E+07	0.233E+05	0.149E+04	0.662E+11
28	0.168E+03	0.556E+00	-0.650E-02	0.151E+07	0.248E+05	0.152E+04	0.662E+11

29	0.174E+03	0.517E+00	-0.636E-02	0.166E+07	0.263E+05	0.154E+04	0.662E+11
30	0.180E+03	0.480E+00	-0.620E-02	0.182E+07	0.281E+05	0.207E+04	0.662E+11
31	0.186E+03	0.443E+00	-0.603E-02	0.200E+07	0.292E+05	0.167E+03	0.662E+11
32	0.192E+03	0.407E+00	-0.584E-02	0.217E+07	0.290E+05	-0.602E+03	0.662E+11
33	0.198E+03	0.373E+00	-0.563E-02	0.234E+07	0.281E+05	-0.133E+04	0.662E+11
34	0.204E+03	0.340E+00	-0.541E-02	0.251E+07	0.264E+05	-0.201E+04	0.662E+11
35	0.210E+03	0.308E+00	-0.518E-02	0.266E+07	0.241E+05	-0.265E+04	0.662E+11
36	0.216E+03	0.278E+00	-0.493E-02	0.280E+07	0.211E+05	-0.325E+04	0.662E+11
37	0.222E+03	0.249E+00	-0.467E-02	0.292E+07	0.176E+05	-0.379E+04	0.662E+11
38	0.228E+03	0.222E+00	-0.441E-02	0.301E+07	0.136E+05	-0.428E+04	0.662E+11
39	0.234E+03	0.196E+00	-0.413E-02	0.308E+07	0.906E+04	-0.473E+04	0.662E+11
40	0.240E+03	0.172E+00	-0.385E-02	0.312E+07	0.415E+04	-0.509E+04	0.662E+11
41	0.246E+03	0.150E+00	-0.357E-02	0.313E+07	-0.909E+03	-0.502E+04	0.662E+11
42	0.252E+03	0.129E+00	-0.328E-02	0.311E+07	-0.574E+04	-0.464E+04	0.662E+11
43	0.258E+03	0.110E+00	-0.300E-02	0.306E+07	-0.102E+05	-0.435E+04	0.662E+11
44	0.264E+03	0.932E-01	-0.273E-02	0.298E+07	-0.145E+05	-0.414E+04	0.662E+11
45	0.270E+03	0.776E-01	-0.246E-02	0.288E+07	-0.184E+05	-0.368E+04	0.662E+11
46	0.276E+03	0.636E-01	-0.221E-02	0.276E+07	-0.218E+05	-0.304E+04	0.662E+11
47	0.282E+03	0.511E-01	-0.196E-02	0.262E+07	-0.245E+05	-0.241E+04	0.662E+11
48	0.288E+03	0.400E-01	-0.173E-02	0.247E+07	-0.266E+05	-0.180E+04	0.662E+11
49	0.294E+03	0.303E-01	-0.152E-02	0.230E+07	-0.281E+05	-0.122E+04	0.662E+11
50	0.300E+03	0.218E-01	-0.132E-02	0.213E+07	-0.291E+05	-0.673E+03	0.662E+11
51	0.306E+03	0.145E-01	-0.113E-02	0.196E+07	-0.295E+05	-0.161E+03	0.662E+11
52	0.312E+03	0.828E-02	-0.961E-03	0.178E+07	-0.294E+05	0.345E+03	0.662E+11
53	0.318E+03	0.299E-02	-0.808E-03	0.160E+07	-0.288E+05	0.764E+03	0.662E+11
54	0.324E+03	-0.142E-02	-0.670E-03	0.143E+07	-0.279E+05	0.107E+04	0.662E+11
55	0.330E+03	-0.505E-02	-0.548E-03	0.127E+07	-0.268E+05	0.125E+04	0.662E+11
56	0.336E+03	-0.799E-02	-0.440E-03	0.111E+07	-0.254E+05	0.140E+04	0.662E+11
57	0.342E+03	-0.103E-01	-0.346E-03	0.963E+06	-0.240E+05	0.153E+04	0.662E+11
58	0.348E+03	-0.121E-01	-0.265E-03	0.824E+06	-0.224E+05	0.163E+04	0.662E+11
59	0.354E+03	-0.135E-01	-0.196E-03	0.695E+06	-0.207E+05	0.171E+04	0.662E+11
60	0.360E+03	-0.145E-01	-0.138E-03	0.576E+06	-0.190E+05	0.178E+04	

```
0.662E+11
    61   0.366E+03  -0.152E-01  -0.912E-04   0.467E+06  -0.172E+05   0.183E+04
0.662E+11
    62   0.372E+03  -0.156E-01  -0.533E-04   0.370E+06  -0.153E+05   0.186E+04
0.662E+11
    63   0.378E+03  -0.158E-01  -0.237E-04   0.283E+06  -0.134E+05   0.189E+04
0.662E+11
    64   0.384E+03  -0.159E-01  -0.144E-05   0.208E+06  -0.115E+05   0.191E+04
0.662E+11
    65   0.390E+03  -0.158E-01   0.146E-04   0.145E+06  -0.964E+04   0.192E+04
0.662E+11
    66   0.396E+03  -0.157E-01   0.253E-04   0.927E+05  -0.772E+04   0.192E+04
0.662E+11
    67   0.402E+03  -0.155E-01   0.319E-04   0.521E+05  -0.579E+04   0.193E+04
0.662E+11
    68   0.408E+03  -0.153E-01   0.353E-04   0.232E+05  -0.386E+04   0.193E+04
0.662E+11
    69   0.414E+03  -0.151E-01   0.366E-04   0.579E+04  -0.193E+04   0.193E+04
0.662E+11
    70   0.420E+03  -0.149E-01   0.369E-04   0.000E+00  -0.483E+03   0.966E+03
0.331E+11
```

END OF ANALYSIS

Cantilever Sheet Pile Wall with 15 ft Height (Not Grouted)
for Soil Area 2, Bedrock @ -27 ft or Lower
No Flood and Seismic

```
      Cantilever Sheet Pile Wall Bedrock @-27ft or Lower_Seismic.py5o
=========================================================================

                  PYWALL for Windows, Version 2015.5.11

                   Serial Number :  166868598

                   A Program for the Analysis of
                   Flexible Retaining Walls
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Path to file locations      : Q:\Geotechnical\Meadowlands\Calculations for New
Alternatives\Cantilever Sheet Pile Wall\PYWall Analysis\Proposed
Section\Seismic_With Out Grout\
Name of input data file     : Cantilever Sheet Pile Wall Bedrock @-27ft or
Lower_Seismic.py5d
Name of output file         : Cantilever Sheet Pile Wall Bedrock @-27ft or
Lower_Seismic.py5o
Name of plot output file    : Cantilever Sheet Pile Wall Bedrock @-27ft or
Lower_Seismic.py5p

-------------------------------------------------------------------------
                     Time and Date of Analysis
-------------------------------------------------------------------------

          Date:  October 19, 2017     Time:  15:19:15

 Cantilever Sheet Pile Wall Bedrock @-27ft or Lower_Seismic


 **************************************************
 *        PROGRAM CONTROL PARAMETERS              *
 **************************************************

 NO OF POINTS FOR SPECIFIED DEFLECTIONS AND SLOPES  =  0
 NO OF POINTS FOR WALL STIFFNESS AND LOAD DATA      =  1
 GENERATE EARTH PRESSURE INTERNALLY                 =  1
 GENERATE SOIL RESISTANCE (P-Y) CURVES INTERNALLY   =  1
 NO OF P-Y MODIFICATION FACTORS FOR GEN. P-Y CURVES =  0
 NO OF USER-SPECIFIED SOIL RESISTANCE (P-Y) CURVES  =  0
 NUMBER OF INCREMENTS                               =  70
 INCREMENT LENGTH                                   =     6.000 IN
 FREE HEIGHT OF WALL                                =   180.000 IN
 MAXIMUM ALLOWABLE DEFLECTION                       =    18.000 IN
 DEFLECTION CLOSURE TOLERANCE                       = 1.000E-05 IN



 **************************************************
 *        STIFFNESS AND LOAD DATA                 *
 **************************************************
 EI - FLEXURAL RIGIDITY,  Q - TRANSVERSE LOAD,
 S - STIFFNESS OF TRANSVERSE RESISTANCE,
 T - TORQUE,              P - AXIAL LOAD,
```

R - STIFFNESS OF TORSIONAL RESISTANCE.

FROM	TO	CONTD	EI	Q	S'	T	R	P
			LBS-IN**2	LBS	LBS/IN	IN-LBS	IN-LBS	LBS
0	70	0	0.662E+11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
10	10	0	0.662E+11	0.361E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00

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**************************************************
*                WALL INFORMATION                *
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FREE HEIGHT OF WALL                        =  0.180E+03 IN
WIDTH FOR EARTH PRESSURE, WA               =  0.630E+02 IN
WIDTH FOR SOIL RESISTANCE, WP              =  0.630E+02 IN
DEPTH TO THE WATER TABLE AT BACKFILL       =  0.960E+02 IN
DEPTH TO THE WATER TABLE AT EXCAVATION     =  0.960E+02 IN
UNIT WEIGHT OF WATER                       =  0.360E-01 LBS/IN**3
SLOPE OF THE BACKFILL (deg.)               =  0.000E+00
MODIFICATION FOR ACTIVE EARTH PRESSURE     =  0.100E+01
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**************************************************
*              SURCHARGE INFORMATION             *
**************************************************
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UNIFORM SURFACE PRESSURE = 0.174E+01 LBS/IN**2

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**************************************************
*                SOIL INFORMATION                *
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LAYER NO.	TOTAL THICKNESS IN	COHESION PSI	PHI DEG	TOTAL UNIT WEIGHT PCI	DRAINED T OR F	ZTOP IN
1	96.0	0.0	32.0	0.064	T	0.00
2	84.0	0.3	22.0	0.064	T	96.00
3	300.0	0.0	36.0	0.075	T	180.00

```
**************************************************
*           EFFECTIVE OVERBURDEN STRESS          *
**************************************************
```

DEPTH IN	STRESS LBS/IN**2
0.000E+00	0.174E+01
0.960E+02	0.785E+01
0.180E+03	0.102E+02

```
**************************************************
* ACTIVE AND PASSIVE EARTH PRESSURE COEFFICIENT  *
**************************************************
```

LAYER ACTIVE EARTH PASSIVE EARTH OPTIONAL EARTH

NO.	COEFFICIENT	COEFFICIENT	COEFFICIENT
1	0.307E+00	0.325E+01	0.000E+00
2	0.455E+00	0.220E+01	0.000E+00
3	0.260E+00	0.385E+01	0.000E+00

```
**************************************************
*      ACTIVE EARTH PRESSURE OF EACH LAYER       *
**************************************************
```

LAYER NO	PA1 LBS/IN**2	Z1 IN	PA2 LBS/IN**2	Z2 IN	PA3 LBS/IN**2	Z3 IN	PA4 LBS/IN**2
1	51.21	48.00	90.13	64.00	0.00	0.00	0.00
2	299.90	138.00	44.39	152.00	-39.35	0.00	0.00

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**************************************************
*      ACTIVE WATER PRESSURE OF EACH LAYER       *
**************************************************
```

LAYER NO	PW1	Z1	PW2	Z2
2	0.00	138.00	127.01	152.00

DEPTH IN	ACTIVE EARTH PRESSURE LBS/IN
0.000E+00	0.336E+02
0.600E+01	0.410E+02
0.120E+02	0.484E+02
0.180E+02	0.558E+02
0.240E+02	0.630E+02
0.300E+02	0.706E+02
0.360E+02	0.781E+02
0.420E+02	0.851E+02
0.480E+02	0.926E+02
0.540E+02	0.100E+03
0.600E+02	0.108E+03
0.660E+02	0.115E+03
0.720E+02	0.122E+03
0.780E+02	0.130E+03
0.840E+02	0.137E+03
0.900E+02	0.144E+03
0.960E+02	0.152E+03
0.102E+03	0.200E+03
0.108E+03	0.205E+03
0.114E+03	0.210E+03
0.120E+03	0.214E+03
0.126E+03	0.219E+03
0.132E+03	0.224E+03
0.138E+03	0.229E+03
0.144E+03	0.234E+03
0.150E+03	0.238E+03
0.156E+03	0.243E+03
0.162E+03	0.248E+03
0.168E+03	0.253E+03
0.174E+03	0.257E+03
0.180E+03	0.264E+03
0.186E+03	0.166E+03
0.192E+03	0.166E+03

0.198E+03	0.166E+03
0.204E+03	0.166E+03
0.210E+03	0.166E+03
0.216E+03	0.166E+03
0.222E+03	0.166E+03
0.228E+03	0.166E+03
0.234E+03	0.166E+03
0.240E+03	0.166E+03
0.246E+03	0.166E+03
0.252E+03	0.166E+03
0.258E+03	0.166E+03
0.264E+03	0.166E+03
0.270E+03	0.166E+03
0.276E+03	0.166E+03
0.282E+03	0.166E+03
0.288E+03	0.166E+03
0.294E+03	0.166E+03
0.300E+03	0.166E+03
0.306E+03	0.166E+03
0.312E+03	0.166E+03
0.318E+03	0.166E+03
0.324E+03	0.166E+03
0.330E+03	0.166E+03
0.336E+03	0.166E+03
0.342E+03	0.166E+03
0.348E+03	0.166E+03
0.354E+03	0.166E+03
0.360E+03	0.166E+03
0.366E+03	0.166E+03
0.372E+03	0.166E+03
0.378E+03	0.166E+03
0.384E+03	0.166E+03
0.390E+03	0.166E+03
0.396E+03	0.166E+03
0.402E+03	0.166E+03
0.408E+03	0.166E+03
0.414E+03	0.166E+03
0.420E+03	0.166E+03

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**************************************************
*         SOIL LAYERS AND STRENGTH DATA          *
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X AT THE SURFACE OF EXCAVATION SIDE = 180.00 IN

1 LAYER(S) OF SOIL

LAYER 1
THE SOIL IS A SAND

DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH
2 POINTS

X,IN	WEIGHT,LBS/IN**3
180.0000	0.3923D-01
480.0000	0.3923D-01

DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH
2 POINTS

X,IN	S,LBS/IN**2	PHI,DEGREES	E50
180.00	0.0000D+00	36.000	-----
432.00	0.0000D+00	36.000	-----

P-Y CURVES DATA

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
0.10	63.00	36.00	0.39E-01	2.83	2.14	0.89E+00	0.15E+02

Y IN	P LBS/IN
0.000	-166.347
0.088	-165.253
0.175	-164.159
0.263	-163.381
0.350	-163.153
0.438	-162.963
0.525	-162.800
0.613	-162.656
0.700	-162.527
0.788	-162.409
0.875	-162.301
0.963	-162.200
1.050	-162.106
2.362	-160.738
65.362	-160.738
128.363	-160.738
191.363	-160.738

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
180.10	63.00	36.00	0.39E-01	1.11	0.75	0.57E+04	0.27E+05

Y IN	P LBS/IN
0.000	166.347
0.088	1216.171
0.175	1530.787
0.263	1756.889
0.350	1939.687
0.438	2095.823
0.525	2233.548
0.613	2357.634
0.700	2471.127
0.788	2576.105
0.875	2674.055
0.963	2766.088
1.050	2853.054
2.362	4123.061

65.362	4123.061
128.363	4123.061
191.363	4123.061

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
63.00	63.00	36.00	0.39E-01	2.11	1.54	0.11E+04	0.95E+04

Y IN	P LBS/IN
0.000	-166.347
0.088	522.716
0.175	965.314
0.263	1109.674
0.350	1223.134
0.438	1318.043
0.525	1400.382
0.613	1473.552
0.700	1539.691
0.788	1600.241
0.875	1656.223
0.963	1708.392
1.050	1757.321
2.362	2469.328
65.362	2469.328
128.363	2469.328
191.363	2469.328

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
243.00	63.00	36.00	0.39E-01	0.92	0.56	0.97E+04	0.37E+05

Y IN	P LBS/IN
0.000	166.347
0.088	886.362
0.175	1204.943
0.263	1453.164
0.350	1664.484
0.438	1852.014
0.525	2022.534
0.613	2180.097
0.700	2327.354
0.788	2466.158
0.875	2597.860
0.963	2723.484
1.050	2843.829
2.362	4612.757
65.362	4612.757
128.363	4612.757
191.363	4612.757

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
126.00	63.00	36.00	0.39E-01	1.48	1.05	0.31E+04	0.19E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	995.819
0.175	1292.103
0.263	1499.297
0.350	1663.921
0.438	1802.737
0.525	1923.938
0.613	2032.214
0.700	2130.530
0.788	2220.894
0.875	2304.736
0.963	2383.114
1.050	2456.836
2.362	3531.092
65.362	3531.092
128.363	3531.092
191.363	3531.092

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
306.00	63.00	36.00	0.39E-01	0.88	0.50	0.15E+05	0.46E+05

Y IN	P LBS/IN
0.000	166.347
0.088	854.281
0.175	1209.469
0.263	1497.076
0.350	1748.046
0.438	1974.873
0.525	2184.148
0.613	2379.871
0.700	2564.696
0.788	2740.491
0.875	2908.636
0.963	3070.184
1.050	3225.962
2.362	5522.841
65.362	5522.841
128.363	5522.841
191.363	5522.841

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
189.00	63.00	36.00	0.39E-01	1.06	0.71	0.62E+04	0.29E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	832.264
0.175	1146.193
0.263	1373.781
0.350	1558.809
0.438	1717.504
0.525	1857.944
0.613	1984.822
0.700	2101.138
0.788	2208.947
0.875	2309.721
0.963	2404.560
1.050	2494.310
2.362	3805.902
65.362	3805.902
128.363	3805.902
191.363	3805.902

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
369.00	63.00	36.00	0.39E-01	0.88	0.50	0.21E+05	0.56E+05

Y IN	P LBS/IN
0.000	166.347
0.088	973.810
0.175	1397.038
0.263	1741.101
0.350	2042.099
0.438	2314.656
0.525	2566.500
0.613	2802.330
0.700	3025.265
0.788	3237.507
0.875	3440.681
0.963	3636.029
1.050	3824.528
2.362	6604.745
65.362	6604.745
128.363	6604.745
191.363	6604.745

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
251.90	63.00	36.00	0.39E-01	0.90	0.53	0.10E+05	0.38E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	495.368
0.175	807.943
0.263	1055.374
0.350	1268.170
0.438	1458.435
0.525	1632.480
0.613	1794.101
0.700	1945.794
0.788	2089.311
0.875	2225.936
0.963	2356.643
1.050	2482.195
2.362	4330.023
65.362	4330.023
128.363	4330.023
191.363	4330.023

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
431.90	63.00	36.00	0.39E-01	0.88	0.50	0.28E+05	0.65E+05

Y IN	P LBS/IN
0.000	166.347
0.088	1111.451
0.175	1606.823
0.263	2009.534
0.350	2361.841
0.438	2680.858
0.525	2975.632
0.613	3251.661
0.700	3512.598
0.788	3761.019
0.875	3998.826
0.963	4227.474
1.050	4448.104
2.362	7702.239
65.362	7702.239
128.363	7702.239
191.363	7702.239

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

Cantilever Sheet Pile Wall Bedrock @-27ft or Lower_No_Flood

RESULTS -- ITERATION 5

STA I	X	DEFL.	SLOPE	MOMENT	SHEAR	NET REACT/STA	EI
	IN	IN		LBS-IN	LBS	LBS	LBS-IN**2
------	----	----	-----	------	------	---------	----------
0	0.000E+00	0.219E+01	-0.926E-02	0.000E+00	0.000E+00	0.000E+00	0.331E+11
1	0.600E+01	0.213E+01	-0.926E-02	0.000E+00	0.123E+03	0.246E+03	0.662E+11
2	0.120E+02	0.207E+01	-0.926E-02	0.148E+04	0.391E+03	0.290E+03	0.662E+11
3	0.180E+02	0.202E+01	-0.926E-02	0.469E+04	0.704E+03	0.335E+03	0.662E+11
4	0.240E+02	0.196E+01	-0.926E-02	0.992E+04	0.106E+04	0.378E+03	0.662E+11
5	0.300E+02	0.191E+01	-0.926E-02	0.174E+05	0.146E+04	0.423E+03	0.662E+11
6	0.360E+02	0.185E+01	-0.925E-02	0.275E+05	0.191E+04	0.469E+03	0.662E+11
7	0.420E+02	0.180E+01	-0.925E-02	0.403E+05	0.240E+04	0.510E+03	0.662E+11
8	0.480E+02	0.174E+01	-0.925E-02	0.562E+05	0.293E+04	0.556E+03	0.662E+11
9	0.540E+02	0.169E+01	-0.924E-02	0.755E+05	0.351E+04	0.601E+03	0.662E+11
10	0.600E+02	0.163E+01	-0.923E-02	0.983E+05	0.594E+04	0.426E+04	0.662E+11
11	0.660E+02	0.158E+01	-0.922E-02	0.147E+06	0.841E+04	0.688E+03	0.662E+11
12	0.720E+02	0.152E+01	-0.921E-02	0.199E+06	0.912E+04	0.733E+03	0.662E+11
13	0.780E+02	0.146E+01	-0.919E-02	0.256E+06	0.988E+04	0.779E+03	0.662E+11
14	0.840E+02	0.141E+01	-0.916E-02	0.318E+06	0.107E+05	0.824E+03	0.662E+11
15	0.900E+02	0.135E+01	-0.913E-02	0.384E+06	0.115E+05	0.866E+03	0.662E+11
16	0.960E+02	0.130E+01	-0.909E-02	0.456E+06	0.124E+05	0.911E+03	0.662E+11
17	0.102E+03	0.125E+01	-0.904E-02	0.533E+06	0.135E+05	0.120E+04	0.662E+11
18	0.108E+03	0.119E+01	-0.899E-02	0.618E+06	0.147E+05	0.123E+04	0.662E+11
19	0.114E+03	0.114E+01	-0.893E-02	0.710E+06	0.159E+05	0.126E+04	0.662E+11
20	0.120E+03	0.108E+01	-0.886E-02	0.809E+06	0.172E+05	0.129E+04	0.662E+11
21	0.126E+03	0.103E+01	-0.878E-02	0.916E+06	0.185E+05	0.132E+04	0.662E+11
22	0.132E+03	0.979E+00	-0.870E-02	0.103E+07	0.198E+05	0.134E+04	0.662E+11
23	0.138E+03	0.927E+00	-0.860E-02	0.115E+07	0.212E+05	0.137E+04	0.662E+11
24	0.144E+03	0.876E+00	-0.849E-02	0.129E+07	0.226E+05	0.140E+04	0.662E+11
25	0.150E+03	0.825E+00	-0.836E-02	0.142E+07	0.240E+05	0.143E+04	0.662E+11
26	0.156E+03	0.776E+00	-0.823E-02	0.157E+07	0.254E+05	0.146E+04	0.662E+11
27	0.162E+03	0.727E+00	-0.808E-02	0.173E+07	0.269E+05	0.149E+04	0.662E+11
28	0.168E+03	0.679E+00	-0.791E-02	0.190E+07	0.284E+05	0.152E+04	

							0.662E+11
29	0.174E+03	0.632E+00	-0.773E-02	0.207E+07	0.299E+05	0.154E+04	0.662E+11
30	0.180E+03	0.586E+00	-0.754E-02	0.226E+07	0.317E+05	0.207E+04	0.662E+11
31	0.186E+03	0.541E+00	-0.733E-02	0.245E+07	0.328E+05	0.118E+03	0.662E+11
32	0.192E+03	0.498E+00	-0.709E-02	0.265E+07	0.325E+05	-0.700E+03	0.662E+11
33	0.198E+03	0.456E+00	-0.685E-02	0.284E+07	0.315E+05	-0.148E+04	0.662E+11
34	0.204E+03	0.416E+00	-0.658E-02	0.303E+07	0.296E+05	-0.220E+04	0.662E+11
35	0.210E+03	0.377E+00	-0.630E-02	0.320E+07	0.271E+05	-0.288E+04	0.662E+11
36	0.216E+03	0.340E+00	-0.600E-02	0.335E+07	0.239E+05	-0.351E+04	0.662E+11
37	0.222E+03	0.305E+00	-0.569E-02	0.348E+07	0.201E+05	-0.409E+04	0.662E+11
38	0.228E+03	0.272E+00	-0.537E-02	0.359E+07	0.157E+05	-0.463E+04	0.662E+11
39	0.234E+03	0.241E+00	-0.504E-02	0.367E+07	0.109E+05	-0.509E+04	0.662E+11
40	0.240E+03	0.211E+00	-0.471E-02	0.372E+07	0.558E+04	-0.550E+04	0.662E+11
41	0.246E+03	0.184E+00	-0.437E-02	0.374E+07	-0.109E+03	-0.588E+04	0.662E+11
42	0.252E+03	0.159E+00	-0.403E-02	0.372E+07	-0.581E+04	-0.552E+04	0.662E+11
43	0.258E+03	0.136E+00	-0.369E-02	0.367E+07	-0.111E+05	-0.507E+04	0.662E+11
44	0.264E+03	0.115E+00	-0.337E-02	0.359E+07	-0.160E+05	-0.473E+04	0.662E+11
45	0.270E+03	0.954E-01	-0.305E-02	0.348E+07	-0.206E+05	-0.448E+04	0.662E+11
46	0.276E+03	0.781E-01	-0.274E-02	0.334E+07	-0.248E+05	-0.396E+04	0.662E+11
47	0.282E+03	0.626E-01	-0.244E-02	0.318E+07	-0.284E+05	-0.318E+04	0.662E+11
48	0.288E+03	0.488E-01	-0.216E-02	0.300E+07	-0.312E+05	-0.242E+04	0.662E+11
49	0.294E+03	0.367E-01	-0.190E-02	0.281E+07	-0.332E+05	-0.169E+04	0.662E+11
50	0.300E+03	0.260E-01	-0.165E-02	0.260E+07	-0.346E+05	-0.994E+03	0.662E+11
51	0.306E+03	0.168E-01	-0.143E-02	0.239E+07	-0.353E+05	-0.345E+03	0.662E+11
52	0.312E+03	0.893E-02	-0.122E-02	0.218E+07	-0.353E+05	0.294E+03	0.662E+11
53	0.318E+03	0.221E-02	-0.103E-02	0.197E+07	-0.347E+05	0.825E+03	0.662E+11
54	0.324E+03	-0.344E-02	-0.862E-03	0.176E+07	-0.337E+05	0.117E+04	0.662E+11
55	0.330E+03	-0.813E-02	-0.711E-03	0.156E+07	-0.324E+05	0.140E+04	0.662E+11
56	0.336E+03	-0.120E-01	-0.578E-03	0.137E+07	-0.309E+05	0.161E+04	0.662E+11
57	0.342E+03	-0.151E-01	-0.462E-03	0.119E+07	-0.292E+05	0.177E+04	0.662E+11
58	0.348E+03	-0.175E-01	-0.362E-03	0.102E+07	-0.274E+05	0.191E+04	0.662E+11
59	0.354E+03	-0.194E-01	-0.276E-03	0.863E+06	-0.254E+05	0.203E+04	0.662E+11

60	0.360E+03	-0.208E-01	-0.205E-03	0.717E+06	-0.234E+05	0.212E+04	0.662E+11
61	0.366E+03	-0.219E-01	-0.146E-03	0.583E+06	-0.212E+05	0.219E+04	0.662E+11
62	0.372E+03	-0.226E-01	-0.983E-04	0.462E+06	-0.190E+05	0.225E+04	0.662E+11
63	0.378E+03	-0.230E-01	-0.613E-04	0.355E+06	-0.167E+05	0.229E+04	0.662E+11
64	0.384E+03	-0.233E-01	-0.334E-04	0.261E+06	-0.144E+05	0.233E+04	0.662E+11
65	0.390E+03	-0.234E-01	-0.133E-04	0.182E+06	-0.121E+05	0.236E+04	0.662E+11
66	0.396E+03	-0.235E-01	0.262E-06	0.117E+06	-0.968E+04	0.238E+04	0.662E+11
67	0.402E+03	-0.234E-01	0.854E-05	0.659E+05	-0.729E+04	0.240E+04	0.662E+11
68	0.408E+03	-0.234E-01	0.129E-04	0.294E+05	-0.488E+04	0.242E+04	0.662E+11
69	0.414E+03	-0.233E-01	0.145E-04	0.736E+04	-0.245E+04	0.244E+04	0.662E+11
70	0.420E+03	-0.232E-01	0.149E-04	0.638E-08	-0.614E+03	0.123E+04	0.331E+11

END OF ANALYSIS

Cantilever Sheet Pile Wall with 15 ft Height (Grouted)
for Soil Area 2, Bedrock @ -27 ft or Lower
No Flood Condition

```
Cantilever Sheet Pile Wall Bedrock @-27ft or Lower_Composite_No_Flood.py5o
==========================================================================

                  PYWALL for Windows, Version 2015.5.11

                   Serial Number :  166868598

                   A Program for the Analysis of
                   Flexible Retaining Walls
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==========================================================================


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Clifton, NJ

Path to file locations      : Q:\Geotechnical\Meadowlands\Calculations for New
Alternatives\Cantilever Sheet Pile Wall\PYWall Analysis\Proposed Section\No
Flood_With Grout\
Name of input data file     : Cantilever Sheet Pile Wall Bedrock @-27ft or
Lower_Composite_No_Flood.py5d
Name of output file         : Cantilever Sheet Pile Wall Bedrock @-27ft or
Lower_Composite_No_Flood.py5o
Name of plot output file    : Cantilever Sheet Pile Wall Bedrock @-27ft or
Lower_Composite_No_Flood.py5p

--------------------------------------------------------------------------
                     Time and Date of Analysis
--------------------------------------------------------------------------

          Date:  October 18, 2017     Time:  16:46:00

 Cantilever Sheet Pile Wall Bedrock @-27ft or Lower_Composite_No_Flood


 **************************************************
 *        PROGRAM CONTROL PARAMETERS              *
 **************************************************

 NO OF POINTS FOR SPECIFIED DEFLECTIONS AND SLOPES  =  0
 NO OF POINTS FOR WALL STIFFNESS AND LOAD DATA      =  2
 GENERATE EARTH PRESSURE INTERNALLY                 =  1
 GENERATE SOIL RESISTANCE (P-Y) CURVES INTERNALLY   =  1
 NO OF P-Y MODIFICATION FACTORS FOR GEN. P-Y CURVES =  0
 NO OF USER-SPECIFIED SOIL RESISTANCE (P-Y) CURVES  =  0
 NUMBER OF INCREMENTS                               =  70
 INCREMENT LENGTH                                   =      6.000 IN
 FREE HEIGHT OF WALL                                =    180.000 IN
 MAXIMUM ALLOWABLE DEFLECTION                       =     18.000 IN
 DEFLECTION CLOSURE TOLERANCE                       = 1.000E-05 IN



 **************************************************
 *        STIFFNESS AND LOAD DATA                 *
 **************************************************
 EI - FLEXURAL RIGIDITY,  Q - TRANSVERSE LOAD,
 S - STIFFNESS OF TRANSVERSE RESISTANCE,
 T - TORQUE,              P - AXIAL LOAD,
```

R - STIFFNESS OF TORSIONAL RESISTANCE.

FROM	TO	CONTD	EI	Q	S'	T	R	P
			LBS-IN**2	LBS	LBS/IN	IN-LBS	IN-LBS	LBS
0	30	0	0.662E+11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
30	70	0	0.341E+12	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

```
**************************************************
*                WALL INFORMATION                *
**************************************************
```

```
FREE HEIGHT OF WALL                         =  0.180E+03 IN
WIDTH FOR EARTH PRESSURE, WA                =  0.630E+02 IN
WIDTH FOR SOIL RESISTANCE, WP               =  0.630E+02 IN
DEPTH TO THE WATER TABLE AT BACKFILL        =  0.960E+02 IN
DEPTH TO THE WATER TABLE AT EXCAVATION      =  0.960E+02 IN
UNIT WEIGHT OF WATER                        =  0.360E-01 LBS/IN**3
SLOPE OF THE BACKFILL (deg.)                =  0.000E+00
MODIFICATION FOR ACTIVE EARTH PRESSURE      =  0.100E+01
```

```
**************************************************
*             SURCHARGE INFORMATION              *
**************************************************
```

UNIFORM SURFACE PRESSURE = 0.174E+01 LBS/IN**2

```
**************************************************
*                SOIL INFORMATION                *
**************************************************
```

LAYER NO.	TOTAL THICKNESS IN	COHESION PSI	PHI DEG	TOTAL UNIT WEIGHT PCI	DRAINED T OR F	ZTOP IN
1	96.0	0.0	32.0	0.064	T	0.00
2	84.0	0.3	22.0	0.064	T	96.00
3	300.0	0.0	36.0	0.075	T	180.00

```
**************************************************
*          EFFECTIVE OVERBURDEN STRESS           *
**************************************************
```

DEPTH IN	STRESS LBS/IN**2
0.000E+00	0.174E+01
0.960E+02	0.785E+01
0.180E+03	0.102E+02

```
**************************************************
* ACTIVE AND PASSIVE EARTH PRESSURE COEFFICIENT  *
**************************************************
```

LAYER   ACTIVE EARTH   PASSIVE EARTH   OPTIONAL EARTH

NO.	COEFFICIENT	COEFFICIENT	COEFFICIENT
1	0.307E+00	0.325E+01	0.000E+00
2	0.455E+00	0.220E+01	0.000E+00
3	0.260E+00	0.385E+01	0.000E+00

```
**************************************************
*      ACTIVE EARTH PRESSURE OF EACH LAYER       *
**************************************************
```

LAYER NO	PA1 LBS/IN**2	Z1 IN	PA2 LBS/IN**2	Z2 IN	PA3 LBS/IN**2	Z3 IN	PA4 LBS/IN**2
1	51.21	48.00	90.13	64.00	0.00	0.00	0.00
2	299.90	138.00	44.39	152.00	-39.35	0.00	0.00

```
**************************************************
*      ACTIVE WATER PRESSURE OF EACH LAYER       *
**************************************************
```

LAYER NO	PW1	Z1	PW2	Z2
2	0.00	138.00	127.01	152.00

DEPTH IN	ACTIVE EARTH PRESSURE LBS/IN
0.000E+00	0.336E+02
0.600E+01	0.410E+02
0.120E+02	0.484E+02
0.180E+02	0.558E+02
0.240E+02	0.630E+02
0.300E+02	0.706E+02
0.360E+02	0.781E+02
0.420E+02	0.851E+02
0.480E+02	0.926E+02
0.540E+02	0.100E+03
0.600E+02	0.108E+03
0.660E+02	0.115E+03
0.720E+02	0.122E+03
0.780E+02	0.130E+03
0.840E+02	0.137E+03
0.900E+02	0.144E+03
0.960E+02	0.152E+03
0.102E+03	0.200E+03
0.108E+03	0.205E+03
0.114E+03	0.210E+03
0.120E+03	0.214E+03
0.126E+03	0.219E+03
0.132E+03	0.224E+03
0.138E+03	0.229E+03
0.144E+03	0.234E+03
0.150E+03	0.238E+03
0.156E+03	0.243E+03
0.162E+03	0.248E+03
0.168E+03	0.253E+03
0.174E+03	0.257E+03
0.180E+03	0.264E+03
0.186E+03	0.166E+03
0.192E+03	0.166E+03

```
  0.198E+03           0.166E+03
  0.204E+03           0.166E+03
  0.210E+03           0.166E+03
  0.216E+03           0.166E+03
  0.222E+03           0.166E+03
  0.228E+03           0.166E+03
  0.234E+03           0.166E+03
  0.240E+03           0.166E+03
  0.246E+03           0.166E+03
  0.252E+03           0.166E+03
  0.258E+03           0.166E+03
  0.264E+03           0.166E+03
  0.270E+03           0.166E+03
  0.276E+03           0.166E+03
  0.282E+03           0.166E+03
  0.288E+03           0.166E+03
  0.294E+03           0.166E+03
  0.300E+03           0.166E+03
  0.306E+03           0.166E+03
  0.312E+03           0.166E+03
  0.318E+03           0.166E+03
  0.324E+03           0.166E+03
  0.330E+03           0.166E+03
  0.336E+03           0.166E+03
  0.342E+03           0.166E+03
  0.348E+03           0.166E+03
  0.354E+03           0.166E+03
  0.360E+03           0.166E+03
  0.366E+03           0.166E+03
  0.372E+03           0.166E+03
  0.378E+03           0.166E+03
  0.384E+03           0.166E+03
  0.390E+03           0.166E+03
  0.396E+03           0.166E+03
  0.402E+03           0.166E+03
  0.408E+03           0.166E+03
  0.414E+03           0.166E+03
  0.420E+03           0.166E+03


 **************************************************
 *         SOIL LAYERS AND STRENGTH DATA          *
 **************************************************


    X AT THE SURFACE OF EXCAVATION SIDE     =     180.00 IN

    1 LAYER(S) OF SOIL

    LAYER  1
    THE SOIL IS A SAND


    DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH
                       2 POINTS

                X,IN   WEIGHT,LBS/IN**3
            180.0000     0.3923D-01
            480.0000     0.3923D-01


    DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH
                       2 POINTS
```

X,IN	S,LBS/IN**2	PHI,DEGREES	E50
180.00	0.0000D+00	36.000	-----
432.00	0.0000D+00	36.000	-----

P-Y CURVES DATA

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
0.10	63.00	36.00	0.39E-01	2.83	2.14	0.89E+00	0.15E+02

Y IN	P LBS/IN
0.000	-166.347
0.088	-165.253
0.175	-164.159
0.263	-163.381
0.350	-163.153
0.438	-162.963
0.525	-162.800
0.613	-162.656
0.700	-162.527
0.788	-162.409
0.875	-162.301
0.963	-162.200
1.050	-162.106
2.362	-160.738
65.362	-160.738
128.363	-160.738
191.363	-160.738

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
180.10	63.00	36.00	0.39E-01	1.11	0.75	0.57E+04	0.27E+05

Y IN	P LBS/IN
0.000	166.347
0.088	1216.171
0.175	1530.787
0.263	1756.889
0.350	1939.687
0.438	2095.823
0.525	2233.548
0.613	2357.634
0.700	2471.127
0.788	2576.105
0.875	2674.055
0.963	2766.088
1.050	2853.054
2.362	4123.061

65.362	4123.061
128.363	4123.061
191.363	4123.061

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
63.00	63.00	36.00	0.39E-01	2.11	1.54	0.11E+04	0.95E+04

Y IN	P LBS/IN
0.000	-166.347
0.088	522.716
0.175	965.314
0.263	1109.674
0.350	1223.134
0.438	1318.043
0.525	1400.382
0.613	1473.552
0.700	1539.691
0.788	1600.241
0.875	1656.223
0.963	1708.392
1.050	1757.321
2.362	2469.328
65.362	2469.328
128.363	2469.328
191.363	2469.328

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
243.00	63.00	36.00	0.39E-01	0.92	0.56	0.97E+04	0.37E+05

Y IN	P LBS/IN
0.000	166.347
0.088	886.362
0.175	1204.943
0.263	1453.164
0.350	1664.484
0.438	1852.014
0.525	2022.534
0.613	2180.097
0.700	2327.354
0.788	2466.158
0.875	2597.860
0.963	2723.484
1.050	2843.829
2.362	4612.757
65.362	4612.757
128.363	4612.757
191.363	4612.757

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
IN	IN		LBS/IN**3				
126.00	63.00	36.00	0.39E-01	1.48	1.05	0.31E+04	0.19E+05

Y	P
IN	LBS/IN
0.000	-166.347
0.088	995.819
0.175	1292.103
0.263	1499.297
0.350	1663.921
0.438	1802.737
0.525	1923.938
0.613	2032.214
0.700	2130.530
0.788	2220.894
0.875	2304.736
0.963	2383.114
1.050	2456.836
2.362	3531.092
65.362	3531.092
128.363	3531.092
191.363	3531.092

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
IN	IN		LBS/IN**3				
306.00	63.00	36.00	0.39E-01	0.88	0.50	0.15E+05	0.46E+05

Y	P
IN	LBS/IN
0.000	166.347
0.088	854.281
0.175	1209.469
0.263	1497.076
0.350	1748.046
0.438	1974.873
0.525	2184.148
0.613	2379.871
0.700	2564.696
0.788	2740.491
0.875	2908.636
0.963	3070.184
1.050	3225.962
2.362	5522.841
65.362	5522.841
128.363	5522.841
191.363	5522.841

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
189.00	63.00	36.00	0.39E-01	1.06	0.71	0.62E+04	0.29E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	832.264
0.175	1146.193
0.263	1373.781
0.350	1558.809
0.438	1717.504
0.525	1857.944
0.613	1984.822
0.700	2101.138
0.788	2208.947
0.875	2309.721
0.963	2404.560
1.050	2494.310
2.362	3805.902
65.362	3805.902
128.363	3805.902
191.363	3805.902

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
369.00	63.00	36.00	0.39E-01	0.88	0.50	0.21E+05	0.56E+05

Y IN	P LBS/IN
0.000	166.347
0.088	973.810
0.175	1397.038
0.263	1741.101
0.350	2042.099
0.438	2314.656
0.525	2566.500
0.613	2802.330
0.700	3025.265
0.788	3237.507
0.875	3440.681
0.963	3636.029
1.050	3824.528
2.362	6604.745
65.362	6604.745
128.363	6604.745
191.363	6604.745

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
251.90	63.00	36.00	0.39E-01	0.90	0.53	0.10E+05	0.38E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	495.368
0.175	807.943
0.263	1055.374
0.350	1268.170
0.438	1458.435
0.525	1632.480
0.613	1794.101
0.700	1945.794
0.788	2089.311
0.875	2225.936
0.963	2356.643
1.050	2482.195
2.362	4330.023
65.362	4330.023
128.363	4330.023
191.363	4330.023

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
431.90	63.00	36.00	0.39E-01	0.88	0.50	0.28E+05	0.65E+05

Y IN	P LBS/IN
0.000	166.347
0.088	1111.451
0.175	1606.823
0.263	2009.534
0.350	2361.841
0.438	2680.858
0.525	2975.632
0.613	3251.661
0.700	3512.598
0.788	3761.019
0.875	3998.826
0.963	4227.474
1.050	4448.104
2.362	7702.239
65.362	7702.239
128.363	7702.239
191.363	7702.239

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

Cantilever Sheet Pile Wall Bedrock @-27ft or Lower_Composite_No_Flood

RESULTS -- ITERATION 6

STA I	X	DEFL.	SLOPE	MOMENT	SHEAR	NET REACT/STA	EI
	IN	IN		LBS-IN	LBS	LBS	LBS-IN**2
------	----	----	-----	------	------	---------	----------
0	0.000E+00	0.791E+00	-0.336E-02	0.000E+00	0.000E+00	0.000E+00	0.331E+11
1	0.600E+01	0.771E+00	-0.336E-02	0.000E+00	0.123E+03	0.246E+03	0.662E+11
2	0.120E+02	0.751E+00	-0.336E-02	0.148E+04	0.391E+03	0.290E+03	0.662E+11
3	0.180E+02	0.731E+00	-0.336E-02	0.469E+04	0.704E+03	0.335E+03	0.662E+11
4	0.240E+02	0.710E+00	-0.336E-02	0.992E+04	0.106E+04	0.378E+03	0.662E+11
5	0.300E+02	0.690E+00	-0.336E-02	0.174E+05	0.146E+04	0.423E+03	0.662E+11
6	0.360E+02	0.670E+00	-0.336E-02	0.275E+05	0.191E+04	0.469E+03	0.662E+11
7	0.420E+02	0.650E+00	-0.336E-02	0.403E+05	0.240E+04	0.510E+03	0.662E+11
8	0.480E+02	0.630E+00	-0.335E-02	0.562E+05	0.293E+04	0.556E+03	0.662E+11
9	0.540E+02	0.610E+00	-0.335E-02	0.755E+05	0.351E+04	0.601E+03	0.662E+11
10	0.600E+02	0.590E+00	-0.334E-02	0.983E+05	0.413E+04	0.646E+03	0.662E+11
11	0.660E+02	0.570E+00	-0.333E-02	0.125E+06	0.480E+04	0.688E+03	0.662E+11
12	0.720E+02	0.550E+00	-0.332E-02	0.156E+06	0.551E+04	0.733E+03	0.662E+11
13	0.780E+02	0.530E+00	-0.330E-02	0.191E+06	0.627E+04	0.779E+03	0.662E+11
14	0.840E+02	0.510E+00	-0.328E-02	0.231E+06	0.707E+04	0.824E+03	0.662E+11
15	0.900E+02	0.490E+00	-0.326E-02	0.276E+06	0.791E+04	0.866E+03	0.662E+11
16	0.960E+02	0.471E+00	-0.323E-02	0.326E+06	0.880E+04	0.911E+03	0.662E+11
17	0.102E+03	0.452E+00	-0.320E-02	0.382E+06	0.986E+04	0.120E+04	0.662E+11
18	0.108E+03	0.433E+00	-0.316E-02	0.444E+06	0.111E+05	0.123E+04	0.662E+11
19	0.114E+03	0.414E+00	-0.312E-02	0.514E+06	0.123E+05	0.126E+04	0.662E+11
20	0.120E+03	0.395E+00	-0.307E-02	0.592E+06	0.136E+05	0.129E+04	0.662E+11
21	0.126E+03	0.377E+00	-0.301E-02	0.677E+06	0.149E+05	0.132E+04	0.662E+11
22	0.132E+03	0.359E+00	-0.294E-02	0.771E+06	0.162E+05	0.134E+04	0.662E+11
23	0.138E+03	0.342E+00	-0.287E-02	0.872E+06	0.176E+05	0.137E+04	0.662E+11
24	0.144E+03	0.325E+00	-0.279E-02	0.982E+06	0.190E+05	0.140E+04	0.662E+11
25	0.150E+03	0.308E+00	-0.269E-02	0.110E+07	0.204E+05	0.143E+04	0.662E+11
26	0.156E+03	0.292E+00	-0.259E-02	0.123E+07	0.218E+05	0.146E+04	0.662E+11
27	0.162E+03	0.277E+00	-0.247E-02	0.136E+07	0.233E+05	0.149E+04	0.662E+11
28	0.168E+03	0.263E+00	-0.234E-02	0.151E+07	0.248E+05	0.152E+04	

```
0.662E+11
    29   0.174E+03   0.249E+00  -0.220E-02   0.166E+07   0.263E+05   0.154E+04
0.662E+11
    30   0.180E+03   0.236E+00  -0.209E-02   0.182E+07   0.281E+05   0.207E+04
0.204E+12
    31   0.186E+03   0.224E+00  -0.205E-02   0.200E+07   0.293E+05   0.321E+03
0.341E+12
    32   0.192E+03   0.212E+00  -0.201E-02   0.217E+07   0.293E+05  -0.316E+03
0.341E+12
    33   0.198E+03   0.200E+00  -0.197E-02   0.235E+07   0.287E+05  -0.931E+03
0.341E+12
    34   0.204E+03   0.188E+00  -0.193E-02   0.252E+07   0.275E+05  -0.153E+04
0.341E+12
    35   0.210E+03   0.177E+00  -0.188E-02   0.268E+07   0.257E+05  -0.210E+04
0.341E+12
    36   0.216E+03   0.165E+00  -0.184E-02   0.283E+07   0.233E+05  -0.255E+04
0.341E+12
    37   0.222E+03   0.155E+00  -0.179E-02   0.296E+07   0.206E+05  -0.293E+04
0.341E+12
    38   0.228E+03   0.144E+00  -0.173E-02   0.307E+07   0.175E+05  -0.326E+04
0.341E+12
    39   0.234E+03   0.134E+00  -0.168E-02   0.317E+07   0.141E+05  -0.354E+04
0.341E+12
    40   0.240E+03   0.124E+00  -0.162E-02   0.324E+07   0.104E+05  -0.377E+04
0.341E+12
    41   0.246E+03   0.114E+00  -0.156E-02   0.329E+07   0.659E+04  -0.395E+04
0.341E+12
    42   0.252E+03   0.105E+00  -0.150E-02   0.332E+07   0.264E+04  -0.394E+04
0.341E+12
    43   0.258E+03   0.963E-01  -0.145E-02   0.333E+07  -0.130E+04  -0.395E+04
0.341E+12
    44   0.264E+03   0.878E-01  -0.139E-02   0.331E+07  -0.528E+04  -0.400E+04
0.341E+12
    45   0.270E+03   0.796E-01  -0.133E-02   0.326E+07  -0.918E+04  -0.380E+04
0.341E+12
    46   0.276E+03   0.718E-01  -0.127E-02   0.320E+07  -0.129E+05  -0.356E+04
0.341E+12
    47   0.282E+03   0.644E-01  -0.122E-02   0.311E+07  -0.163E+05  -0.330E+04
0.341E+12
    48   0.288E+03   0.572E-01  -0.116E-02   0.300E+07  -0.194E+05  -0.301E+04
0.341E+12
    49   0.294E+03   0.504E-01  -0.111E-02   0.287E+07  -0.223E+05  -0.269E+04
0.341E+12
    50   0.300E+03   0.439E-01  -0.106E-02   0.273E+07  -0.248E+05  -0.236E+04
0.341E+12
    51   0.306E+03   0.376E-01  -0.102E-02   0.258E+07  -0.270E+05  -0.200E+04
0.341E+12
    52   0.312E+03   0.317E-01  -0.973E-03   0.241E+07  -0.287E+05  -0.149E+04
0.341E+12
    53   0.318E+03   0.259E-01  -0.932E-03   0.223E+07  -0.300E+05  -0.102E+04
0.341E+12
    54   0.324E+03   0.205E-01  -0.894E-03   0.205E+07  -0.308E+05  -0.572E+03
0.341E+12
    55   0.330E+03   0.152E-01  -0.860E-03   0.186E+07  -0.312E+05  -0.154E+03
0.341E+12
    56   0.336E+03   0.102E-01  -0.829E-03   0.168E+07  -0.311E+05   0.239E+03
0.341E+12
    57   0.342E+03   0.527E-02  -0.801E-03   0.149E+07  -0.307E+05   0.609E+03
0.341E+12
    58   0.348E+03   0.539E-03  -0.776E-03   0.131E+07  -0.299E+05   0.957E+03
0.341E+12
    59   0.354E+03  -0.405E-02  -0.755E-03   0.113E+07  -0.288E+05   0.121E+04
0.341E+12
```

```
   60   0.360E+03  -0.852E-02  -0.737E-03   0.961E+06  -0.275E+05   0.146E+04
0.341E+12
   61   0.366E+03  -0.129E-01  -0.721E-03   0.801E+06  -0.259E+05   0.170E+04
0.341E+12
   62   0.372E+03  -0.172E-01  -0.708E-03   0.650E+06  -0.241E+05   0.195E+04
0.341E+12
   63   0.378E+03  -0.214E-01  -0.698E-03   0.512E+06  -0.220E+05   0.220E+04
0.341E+12
   64   0.384E+03  -0.255E-01  -0.690E-03   0.386E+06  -0.197E+05   0.246E+04
0.341E+12
   65   0.390E+03  -0.297E-01  -0.684E-03   0.275E+06  -0.171E+05   0.272E+04
0.341E+12
   66   0.396E+03  -0.338E-01  -0.680E-03   0.181E+06  -0.142E+05   0.299E+04
0.341E+12
   67   0.402E+03  -0.378E-01  -0.678E-03   0.105E+06  -0.111E+05   0.327E+04
0.341E+12
   68   0.408E+03  -0.419E-01  -0.676E-03   0.479E+05  -0.769E+04   0.355E+04
0.341E+12
   69   0.414E+03  -0.460E-01  -0.676E-03   0.124E+05  -0.399E+04   0.384E+04
0.341E+12
   70   0.420E+03  -0.500E-01  -0.676E-03   0.329E-07  -0.103E+04   0.207E+04
0.170E+12
```

END OF ANALYSIS

Cantilever Sheet Pile Wall with 15 ft Height (Grouted)
for Soil Area 2, Bedrock @ -27 ft or Lower
No Flood and Seismic

```
 Cantilever Sheet Pile Wall Bedrock @-27ft or Lower_Composite_Seismic.py5o
==========================================================================

                PYWALL for Windows, Version 2015.5.11

                 Serial Number :  166868598

                 A Program for the Analysis of
                 Flexible Retaining Walls
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==========================================================================


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Clifton, NJ

     Path to file locations      : Q:\Geotechnical\Meadowlands\Calculations for New
Alternatives\Cantilever Sheet Pile Wall\PYWall Analysis\Proposed
Section\Seismic_With Grout\
     Name of input data file     : Cantilever Sheet Pile Wall Bedrock @-27ft or
Lower_Composite_Seismic.py5d
     Name of output file         : Cantilever Sheet Pile Wall Bedrock @-27ft or
Lower_Composite_Seismic.py5o
     Name of plot output file    : Cantilever Sheet Pile Wall Bedrock @-27ft or
Lower_Composite_Seismic.py5p

--------------------------------------------------------------------------
                     Time and Date of Analysis
--------------------------------------------------------------------------

          Date:  October 19, 2017     Time:  15:18:37

 Cantilever Sheet Pile Wall Bedrock @-27ft or Lower_Composite_Seismic


 **************************************************
 *        PROGRAM CONTROL PARAMETERS              *
 **************************************************

 NO OF POINTS FOR SPECIFIED DEFLECTIONS AND SLOPES  =  0
 NO OF POINTS FOR WALL STIFFNESS AND LOAD DATA      =  2
 GENERATE EARTH PRESSURE INTERNALLY                 =  1
 GENERATE SOIL RESISTANCE (P-Y) CURVES INTERNALLY   =  1
 NO OF P-Y MODIFICATION FACTORS FOR GEN. P-Y CURVES =  0
 NO OF USER-SPECIFIED SOIL RESISTANCE (P-Y) CURVES  =  0
 NUMBER OF INCREMENTS                               =  70
 INCREMENT LENGTH                                   =     6.000 IN
 FREE HEIGHT OF WALL                                =   180.000 IN
 MAXIMUM ALLOWABLE DEFLECTION                       =    18.000 IN
 DEFLECTION CLOSURE TOLERANCE                       = 1.000E-05 IN



 **************************************************
 *        STIFFNESS AND LOAD DATA                 *
 **************************************************
 EI - FLEXURAL RIGIDITY,  Q - TRANSVERSE LOAD,
 S - STIFFNESS OF TRANSVERSE RESISTANCE,
 T - TORQUE,              P - AXIAL LOAD,
```

R - STIFFNESS OF TORSIONAL RESISTANCE.

FROM	TO	CONTD	EI	Q	S'	T	R	P
			LBS-IN**2	LBS	LBS/IN	IN-LBS	IN-LBS	LBS
0	30	0	0.662E+11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
30	70	0	0.341E+12	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
10	10	0	0.662E+11	0.361E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00

```
**************************************************
*                WALL INFORMATION                *
**************************************************
```

```
FREE HEIGHT OF WALL                      =  0.180E+03 IN
WIDTH FOR EARTH PRESSURE, WA             =  0.630E+02 IN
WIDTH FOR SOIL RESISTANCE, WP            =  0.630E+02 IN
DEPTH TO THE WATER TABLE AT BACKFILL     =  0.960E+02 IN
DEPTH TO THE WATER TABLE AT EXCAVATION   =  0.960E+02 IN
UNIT WEIGHT OF WATER                     =  0.360E-01 LBS/IN**3
SLOPE OF THE BACKFILL (deg.)             =  0.000E+00
MODIFICATION FOR ACTIVE EARTH PRESSURE   =  0.100E+01
```

```
**************************************************
*              SURCHARGE INFORMATION             *
**************************************************
```

UNIFORM SURFACE PRESSURE = 0.174E+01 LBS/IN**2

```
**************************************************
*                SOIL INFORMATION                *
**************************************************
```

LAYER NO.	TOTAL THICKNESS IN	COHESION PSI	PHI DEG	TOTAL UNIT WEIGHT PCI	DRAINED T OR F	ZTOP IN
1	96.0	0.0	32.0	0.064	T	0.00
2	84.0	0.3	22.0	0.064	T	96.00
3	300.0	0.0	36.0	0.075	T	180.00

```
**************************************************
*           EFFECTIVE OVERBURDEN STRESS          *
**************************************************
```

DEPTH IN	STRESS LBS/IN**2
0.000E+00	0.174E+01
0.960E+02	0.785E+01
0.180E+03	0.102E+02

```
**************************************************
* ACTIVE AND PASSIVE EARTH PRESSURE COEFFICIENT  *
**************************************************
```

LAYER NO.	ACTIVE EARTH COEFFICIENT	PASSIVE EARTH COEFFICIENT	OPTIONAL EARTH COEFFICIENT
1	0.307E+00	0.325E+01	0.000E+00
2	0.455E+00	0.220E+01	0.000E+00
3	0.260E+00	0.385E+01	0.000E+00

```
**************************************************
*      ACTIVE EARTH PRESSURE OF EACH LAYER       *
**************************************************
```

LAYER NO	PA1 LBS/IN**2	Z1 IN	PA2 LBS/IN**2	Z2 IN	PA3 LBS/IN**2	Z3 IN	PA4 LBS/IN**2
1	51.21	48.00	90.13	64.00	0.00	0.00	0.00
2	299.90	138.00	44.39	152.00	-39.35	0.00	0.00

```
**************************************************
*      ACTIVE WATER PRESSURE OF EACH LAYER       *
**************************************************
```

LAYER NO	PW1	Z1	PW2	Z2
2	0.00	138.00	127.01	152.00

DEPTH IN	ACTIVE EARTH PRESSURE LBS/IN
0.000E+00	0.336E+02
0.600E+01	0.410E+02
0.120E+02	0.484E+02
0.180E+02	0.558E+02
0.240E+02	0.630E+02
0.300E+02	0.706E+02
0.360E+02	0.781E+02
0.420E+02	0.851E+02
0.480E+02	0.926E+02
0.540E+02	0.100E+03
0.600E+02	0.108E+03
0.660E+02	0.115E+03
0.720E+02	0.122E+03
0.780E+02	0.130E+03
0.840E+02	0.137E+03
0.900E+02	0.144E+03
0.960E+02	0.152E+03
0.102E+03	0.200E+03
0.108E+03	0.205E+03
0.114E+03	0.210E+03
0.120E+03	0.214E+03
0.126E+03	0.219E+03
0.132E+03	0.224E+03
0.138E+03	0.229E+03
0.144E+03	0.234E+03
0.150E+03	0.238E+03
0.156E+03	0.243E+03
0.162E+03	0.248E+03
0.168E+03	0.253E+03
0.174E+03	0.257E+03
0.180E+03	0.264E+03
0.186E+03	0.166E+03

```
 0.192E+03           0.166E+03
 0.198E+03           0.166E+03
 0.204E+03           0.166E+03
 0.210E+03           0.166E+03
 0.216E+03           0.166E+03
 0.222E+03           0.166E+03
 0.228E+03           0.166E+03
 0.234E+03           0.166E+03
 0.240E+03           0.166E+03
 0.246E+03           0.166E+03
 0.252E+03           0.166E+03
 0.258E+03           0.166E+03
 0.264E+03           0.166E+03
 0.270E+03           0.166E+03
 0.276E+03           0.166E+03
 0.282E+03           0.166E+03
 0.288E+03           0.166E+03
 0.294E+03           0.166E+03
 0.300E+03           0.166E+03
 0.306E+03           0.166E+03
 0.312E+03           0.166E+03
 0.318E+03           0.166E+03
 0.324E+03           0.166E+03
 0.330E+03           0.166E+03
 0.336E+03           0.166E+03
 0.342E+03           0.166E+03
 0.348E+03           0.166E+03
 0.354E+03           0.166E+03
 0.360E+03           0.166E+03
 0.366E+03           0.166E+03
 0.372E+03           0.166E+03
 0.378E+03           0.166E+03
 0.384E+03           0.166E+03
 0.390E+03           0.166E+03
 0.396E+03           0.166E+03
 0.402E+03           0.166E+03
 0.408E+03           0.166E+03
 0.414E+03           0.166E+03
 0.420E+03           0.166E+03


 **************************************************
 *        SOIL LAYERS AND STRENGTH DATA           *
 **************************************************


    X AT THE SURFACE OF EXCAVATION SIDE     =     180.00 IN

    1 LAYER(S) OF SOIL

    LAYER  1
    THE SOIL IS A SAND


    DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH
                       2 POINTS

                X,IN   WEIGHT,LBS/IN**3
            180.0000     0.3923D-01
            480.0000     0.3923D-01


    DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH
```

2 POINTS

X,IN	S,LBS/IN**2	PHI,DEGREES	E50
180.00	0.0000D+00	36.000	-----
432.00	0.0000D+00	36.000	-----

P-Y CURVES DATA

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
0.10	63.00	36.00	0.39E-01	2.83	2.14	0.89E+00	0.15E+02

Y IN	P LBS/IN
0.000	-166.347
0.088	-165.253
0.175	-164.159
0.263	-163.381
0.350	-163.153
0.438	-162.963
0.525	-162.800
0.613	-162.656
0.700	-162.527
0.788	-162.409
0.875	-162.301
0.963	-162.200
1.050	-162.106
2.362	-160.738
65.362	-160.738
128.363	-160.738
191.363	-160.738

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
180.10	63.00	36.00	0.39E-01	1.11	0.75	0.57E+04	0.27E+05

Y IN	P LBS/IN
0.000	166.347
0.088	1216.171
0.175	1530.787
0.263	1756.889
0.350	1939.687
0.438	2095.823
0.525	2233.548
0.613	2357.634
0.700	2471.127
0.788	2576.105
0.875	2674.055
0.963	2766.088
1.050	2853.054

2.362	4123.061
65.362	4123.061
128.363	4123.061
191.363	4123.061

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
IN	IN		LBS/IN**3				
63.00	63.00	36.00	0.39E-01	2.11	1.54	0.11E+04	0.95E+04

Y	P
IN	LBS/IN
0.000	-166.347
0.088	522.716
0.175	965.314
0.263	1109.674
0.350	1223.134
0.438	1318.043
0.525	1400.382
0.613	1473.552
0.700	1539.691
0.788	1600.241
0.875	1656.223
0.963	1708.392
1.050	1757.321
2.362	2469.328
65.362	2469.328
128.363	2469.328
191.363	2469.328

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
IN	IN		LBS/IN**3				
243.00	63.00	36.00	0.39E-01	0.92	0.56	0.97E+04	0.37E+05

Y	P
IN	LBS/IN
0.000	166.347
0.088	886.362
0.175	1204.943
0.263	1453.164
0.350	1664.484
0.438	1852.014
0.525	2022.534
0.613	2180.097
0.700	2327.354
0.788	2466.158
0.875	2597.860
0.963	2723.484
1.050	2843.829
2.362	4612.757
65.362	4612.757
128.363	4612.757

191.363	4612.757

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
126.00	63.00	36.00	0.39E-01	1.48	1.05	0.31E+04	0.19E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	995.819
0.175	1292.103
0.263	1499.297
0.350	1663.921
0.438	1802.737
0.525	1923.938
0.613	2032.214
0.700	2130.530
0.788	2220.894
0.875	2304.736
0.963	2383.114
1.050	2456.836
2.362	3531.092
65.362	3531.092
128.363	3531.092
191.363	3531.092

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
306.00	63.00	36.00	0.39E-01	0.88	0.50	0.15E+05	0.46E+05

Y IN	P LBS/IN
0.000	166.347
0.088	854.281
0.175	1209.469
0.263	1497.076
0.350	1748.046
0.438	1974.873
0.525	2184.148
0.613	2379.871
0.700	2564.696
0.788	2740.491
0.875	2908.636
0.963	3070.184
1.050	3225.962
2.362	5522.841
65.362	5522.841
128.363	5522.841
191.363	5522.841

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
189.00	63.00	36.00	0.39E-01	1.06	0.71	0.62E+04	0.29E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	832.264
0.175	1146.193
0.263	1373.781
0.350	1558.809
0.438	1717.504
0.525	1857.944
0.613	1984.822
0.700	2101.138
0.788	2208.947
0.875	2309.721
0.963	2404.560
1.050	2494.310
2.362	3805.902
65.362	3805.902
128.363	3805.902
191.363	3805.902

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
369.00	63.00	36.00	0.39E-01	0.88	0.50	0.21E+05	0.56E+05

Y IN	P LBS/IN
0.000	166.347
0.088	973.810
0.175	1397.038
0.263	1741.101
0.350	2042.099
0.438	2314.656
0.525	2566.500
0.613	2802.330
0.700	3025.265
0.788	3237.507
0.875	3440.681
0.963	3636.029
1.050	3824.528
2.362	6604.745
65.362	6604.745
128.363	6604.745
191.363	6604.745

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
251.90	63.00	36.00	0.39E-01	0.90	0.53	0.10E+05	0.38E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	495.368
0.175	807.943
0.263	1055.374
0.350	1268.170
0.438	1458.435
0.525	1632.480
0.613	1794.101
0.700	1945.794
0.788	2089.311
0.875	2225.936
0.963	2356.643
1.050	2482.195
2.362	4330.023
65.362	4330.023
128.363	4330.023
191.363	4330.023

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
431.90	63.00	36.00	0.39E-01	0.88	0.50	0.28E+05	0.65E+05

Y IN	P LBS/IN
0.000	166.347
0.088	1111.451
0.175	1606.823
0.263	2009.534
0.350	2361.841
0.438	2680.858
0.525	2975.632
0.613	3251.661
0.700	3512.598
0.788	3761.019
0.875	3998.826
0.963	4227.474
1.050	4448.104
2.362	7702.239
65.362	7702.239
128.363	7702.239
191.363	7702.239

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

Cantilever Sheet Pile Wall Bedrock @-27ft or Lower_Composite_No_Flood

RESULTS -- ITERATION 5

STA I	X	DEFL.	SLOPE	MOMENT	SHEAR	NET REACT/STA	EI
	IN	IN		LBS-IN	LBS	LBS	LBS-IN**2
------	----	----	-----	------	------	---------	----------
0	0.000E+00	0.960E+00	-0.415E-02	0.000E+00	0.000E+00	0.000E+00	0.331E+11
1	0.600E+01	0.935E+00	-0.415E-02	0.000E+00	0.123E+03	0.246E+03	0.662E+11
2	0.120E+02	0.910E+00	-0.415E-02	0.148E+04	0.391E+03	0.290E+03	0.662E+11
3	0.180E+02	0.885E+00	-0.415E-02	0.469E+04	0.704E+03	0.335E+03	0.662E+11
4	0.240E+02	0.860E+00	-0.415E-02	0.992E+04	0.106E+04	0.378E+03	0.662E+11
5	0.300E+02	0.835E+00	-0.415E-02	0.174E+05	0.146E+04	0.423E+03	0.662E+11
6	0.360E+02	0.810E+00	-0.415E-02	0.275E+05	0.191E+04	0.469E+03	0.662E+11
7	0.420E+02	0.785E+00	-0.414E-02	0.403E+05	0.240E+04	0.510E+03	0.662E+11
8	0.480E+02	0.761E+00	-0.414E-02	0.562E+05	0.293E+04	0.556E+03	0.662E+11
9	0.540E+02	0.736E+00	-0.413E-02	0.755E+05	0.351E+04	0.601E+03	0.662E+11
10	0.600E+02	0.711E+00	-0.412E-02	0.983E+05	0.594E+04	0.426E+04	0.662E+11
11	0.660E+02	0.686E+00	-0.411E-02	0.147E+06	0.841E+04	0.688E+03	0.662E+11
12	0.720E+02	0.662E+00	-0.410E-02	0.199E+06	0.912E+04	0.733E+03	0.662E+11
13	0.780E+02	0.637E+00	-0.408E-02	0.256E+06	0.988E+04	0.779E+03	0.662E+11
14	0.840E+02	0.613E+00	-0.405E-02	0.318E+06	0.107E+05	0.824E+03	0.662E+11
15	0.900E+02	0.588E+00	-0.402E-02	0.384E+06	0.115E+05	0.866E+03	0.662E+11
16	0.960E+02	0.564E+00	-0.398E-02	0.456E+06	0.124E+05	0.911E+03	0.662E+11
17	0.102E+03	0.541E+00	-0.394E-02	0.533E+06	0.135E+05	0.120E+04	0.662E+11
18	0.108E+03	0.517E+00	-0.388E-02	0.618E+06	0.147E+05	0.123E+04	0.662E+11
19	0.114E+03	0.494E+00	-0.382E-02	0.710E+06	0.159E+05	0.126E+04	0.662E+11
20	0.120E+03	0.471E+00	-0.375E-02	0.809E+06	0.172E+05	0.129E+04	0.662E+11
21	0.126E+03	0.449E+00	-0.368E-02	0.916E+06	0.185E+05	0.132E+04	0.662E+11
22	0.132E+03	0.427E+00	-0.359E-02	0.103E+07	0.198E+05	0.134E+04	0.662E+11
23	0.138E+03	0.406E+00	-0.349E-02	0.115E+07	0.212E+05	0.137E+04	0.662E+11
24	0.144E+03	0.385E+00	-0.338E-02	0.129E+07	0.226E+05	0.140E+04	0.662E+11
25	0.150E+03	0.365E+00	-0.326E-02	0.142E+07	0.240E+05	0.143E+04	0.662E+11
26	0.156E+03	0.346E+00	-0.312E-02	0.157E+07	0.254E+05	0.146E+04	0.662E+11
27	0.162E+03	0.328E+00	-0.297E-02	0.173E+07	0.269E+05	0.149E+04	0.662E+11

28	0.168E+03	0.311E+00	-0.281E-02	0.190E+07	0.284E+05	0.152E+04	0.662E+11
29	0.174E+03	0.294E+00	-0.263E-02	0.207E+07	0.299E+05	0.154E+04	0.662E+11
30	0.180E+03	0.279E+00	-0.250E-02	0.226E+07	0.317E+05	0.207E+04	0.204E+12
31	0.186E+03	0.264E+00	-0.244E-02	0.245E+07	0.329E+05	0.283E+03	0.341E+12
32	0.192E+03	0.250E+00	-0.240E-02	0.265E+07	0.329E+05	-0.386E+03	0.341E+12
33	0.198E+03	0.236E+00	-0.235E-02	0.285E+07	0.322E+05	-0.103E+04	0.341E+12
34	0.204E+03	0.222E+00	-0.230E-02	0.304E+07	0.308E+05	-0.165E+04	0.341E+12
35	0.210E+03	0.208E+00	-0.224E-02	0.322E+07	0.289E+05	-0.224E+04	0.341E+12
36	0.216E+03	0.195E+00	-0.219E-02	0.338E+07	0.263E+05	-0.282E+04	0.341E+12
37	0.222E+03	0.182E+00	-0.213E-02	0.353E+07	0.233E+05	-0.337E+04	0.341E+12
38	0.228E+03	0.169E+00	-0.206E-02	0.366E+07	0.197E+05	-0.381E+04	0.341E+12
39	0.234E+03	0.157E+00	-0.200E-02	0.377E+07	0.157E+05	-0.411E+04	0.341E+12
40	0.240E+03	0.145E+00	-0.193E-02	0.385E+07	0.115E+05	-0.435E+04	0.341E+12
41	0.246E+03	0.134E+00	-0.186E-02	0.391E+07	0.702E+04	-0.454E+04	0.341E+12
42	0.252E+03	0.123E+00	-0.179E-02	0.393E+07	0.252E+04	-0.446E+04	0.341E+12
43	0.258E+03	0.112E+00	-0.172E-02	0.394E+07	-0.191E+04	-0.441E+04	0.341E+12
44	0.264E+03	0.102E+00	-0.165E-02	0.391E+07	-0.630E+04	-0.439E+04	0.341E+12
45	0.270E+03	0.924E-01	-0.159E-02	0.386E+07	-0.107E+05	-0.440E+04	0.341E+12
46	0.276E+03	0.831E-01	-0.152E-02	0.378E+07	-0.150E+05	-0.428E+04	0.341E+12
47	0.282E+03	0.742E-01	-0.145E-02	0.368E+07	-0.192E+05	-0.395E+04	0.341E+12
48	0.288E+03	0.657E-01	-0.139E-02	0.355E+07	-0.229E+05	-0.360E+04	0.341E+12
49	0.294E+03	0.575E-01	-0.133E-02	0.340E+07	-0.263E+05	-0.321E+04	0.341E+12
50	0.300E+03	0.497E-01	-0.127E-02	0.324E+07	-0.293E+05	-0.280E+04	0.341E+12
51	0.306E+03	0.423E-01	-0.121E-02	0.305E+07	-0.319E+05	-0.237E+04	0.341E+12
52	0.312E+03	0.351E-01	-0.116E-02	0.285E+07	-0.340E+05	-0.177E+04	0.341E+12
53	0.318E+03	0.283E-01	-0.111E-02	0.264E+07	-0.355E+05	-0.120E+04	0.341E+12
54	0.324E+03	0.218E-01	-0.107E-02	0.243E+07	-0.364E+05	-0.672E+03	0.341E+12
55	0.330E+03	0.155E-01	-0.103E-02	0.221E+07	-0.368E+05	-0.174E+03	0.341E+12
56	0.336E+03	0.942E-02	-0.992E-03	0.199E+07	-0.368E+05	0.294E+03	0.341E+12
57	0.342E+03	0.357E-02	-0.959E-03	0.177E+07	-0.363E+05	0.733E+03	0.341E+12
58	0.348E+03	-0.209E-02	-0.930E-03	0.155E+07	-0.354E+05	0.111E+04	0.341E+12
59	0.354E+03	-0.758E-02	-0.904E-03	0.134E+07	-0.341E+05	0.140E+04	

```
0.341E+12
    60   0.360E+03  -0.129E-01  -0.882E-03   0.114E+07  -0.326E+05   0.169E+04
0.341E+12
    61   0.366E+03  -0.182E-01  -0.864E-03   0.951E+06  -0.307E+05   0.199E+04
0.341E+12
    62   0.372E+03  -0.233E-01  -0.849E-03   0.773E+06  -0.286E+05   0.229E+04
0.341E+12
    63   0.378E+03  -0.284E-01  -0.837E-03   0.608E+06  -0.261E+05   0.259E+04
0.341E+12
    64   0.384E+03  -0.333E-01  -0.827E-03   0.459E+06  -0.234E+05   0.291E+04
0.341E+12
    65   0.390E+03  -0.383E-01  -0.820E-03   0.328E+06  -0.203E+05   0.322E+04
0.341E+12
    66   0.396E+03  -0.432E-01  -0.816E-03   0.216E+06  -0.169E+05   0.355E+04
0.341E+12
    67   0.402E+03  -0.481E-01  -0.813E-03   0.125E+06  -0.132E+05   0.388E+04
0.341E+12
    68   0.408E+03  -0.529E-01  -0.811E-03   0.571E+05  -0.916E+04   0.423E+04
0.341E+12
    69   0.414E+03  -0.578E-01  -0.810E-03   0.148E+05  -0.476E+04   0.458E+04
0.341E+12
    70   0.420E+03  -0.627E-01  -0.810E-03   0.657E-07  -0.123E+04   0.247E+04
0.170E+12

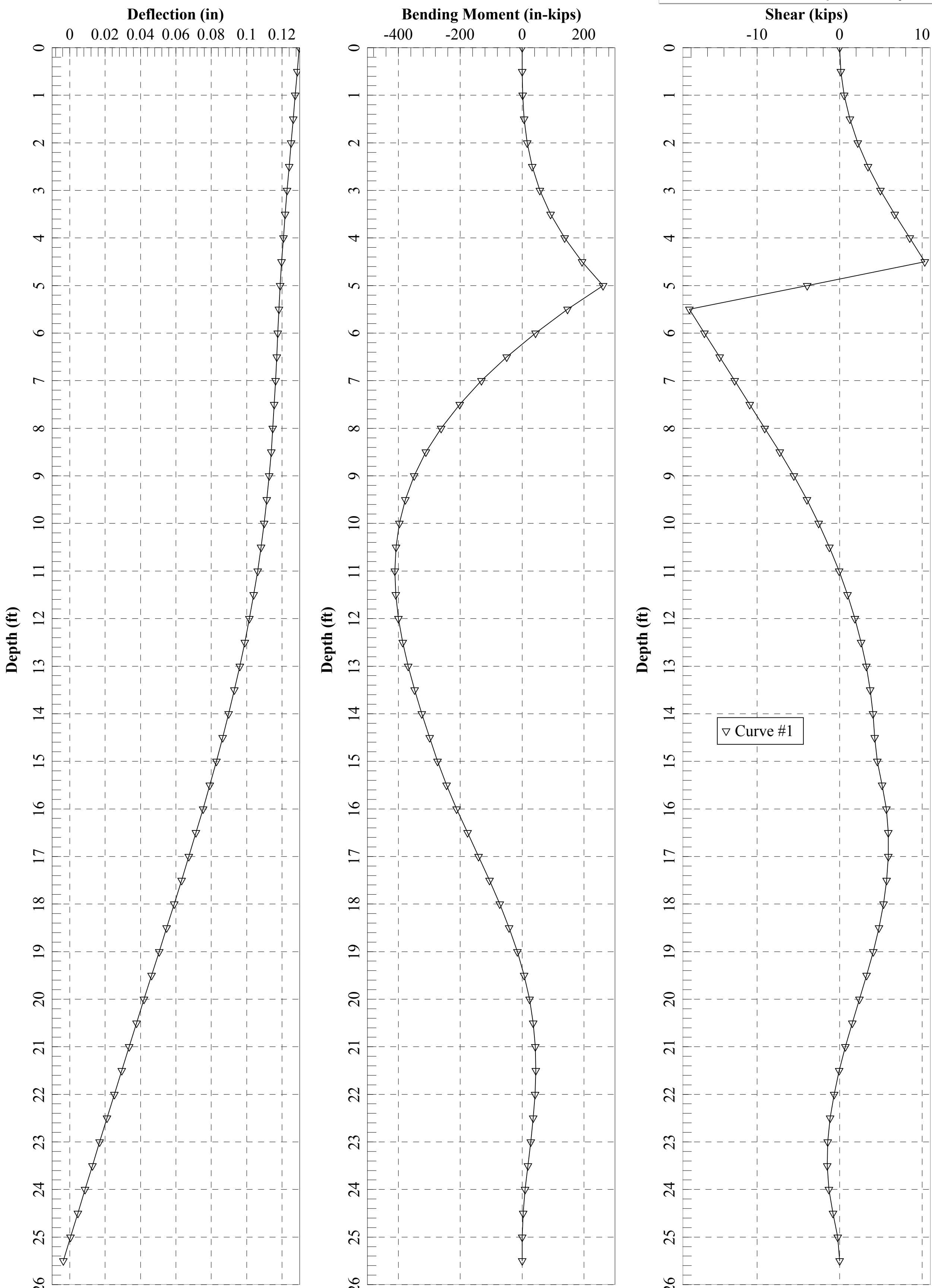

     END OF ANALYSIS
```

Attachment C1-W

Plots of Lateral Deflection, Bending Moment and Shear Force versus Embedded Depth of Anchored Sheet Pile Walls from PYWall

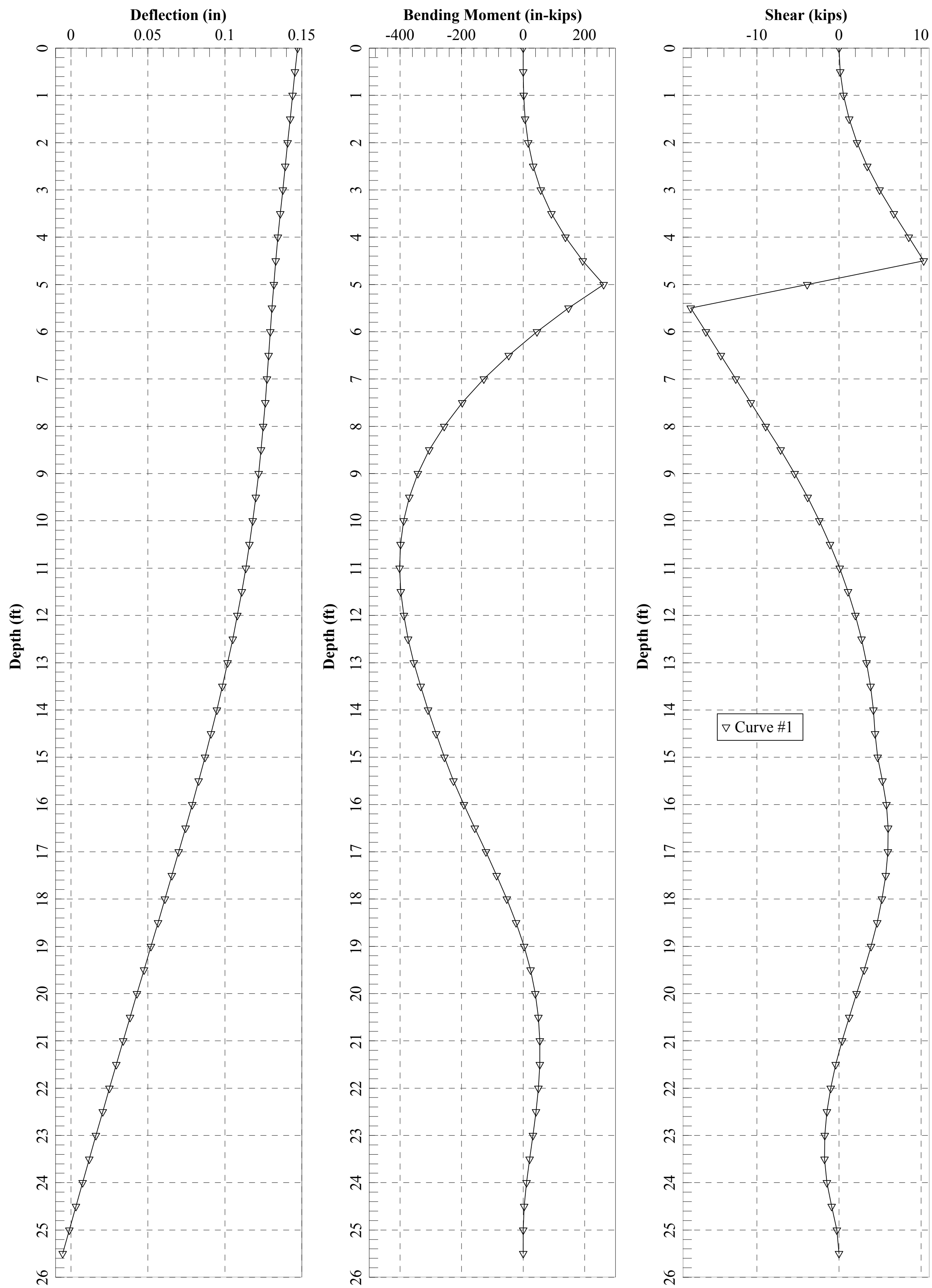
Anchored Sheet Pile Wall with 15 ft Height for Soil Area 2
Bedrock Higher than -27'
No Flood Condition

Factored axial load, F	=	0.00	kips
Max. bending moment, M	=	4.10E+02	kips-in
Area (pile), A	=	40.5	in^2
Section modulus (pile), S	=	244.00	in^3
F/A + M/S	=	**1.68**	ksi
So,	**<**	**33 ksi (<=0.66Fy), OK**	



Anchored Sheet Pile Wall with 15 ft Height for Soil Area 2
Bedrock Higher than -27'
No Flood and Seismic

Factored axial load, F =	0.00	kips
Max. bending moment, M =	4.00E+02	kips-in
Area (pile), A =	40.5	in^2
Section modulus (pile), S =	244.00	in^3
F/A + M/S =	**1.64**	ksi
So,	**< 33 ksi (<=0.66Fy), OK**	



Attachment C1-X

Output from PYWall Analysis for Anchored Sheet Pile Wall in Soil Area 2

Anchored Sheet Pile Wall with 15 ft Height for Soil Area 2
Bedrock Higher than -27'
No Flood Condition

```
     Anchored Sheet Pile Wall Bedrock Higher than -27ft_No_Flood.py5o
==========================================================================

                 PYWALL for Windows, Version 2015.5.11

                  Serial Number :  166868598

                  A Program for the Analysis of
                  Flexible Retaining Walls
                (c) Copyright ENSOFT, Inc., 1987-2016
                      All Rights Reserved

==========================================================================


This program is licensed to :

AECOM / URS Corp
Clifton, NJ

Path to file locations      : Q:\Geotechnical\Meadowlands\Calculations for New
Alternatives\Anchored Wall\PYWall Analysis\Proposed Section\No Flood\
Name of input data file     : Anchored Sheet Pile Wall Bedrock Higher than
-27ft_No_Flood.py5d
Name of output file         : Anchored Sheet Pile Wall Bedrock Higher than
-27ft_No_Flood.py5o
Name of plot output file    : Anchored Sheet Pile Wall Bedrock Higher than
-27ft_No_Flood.py5p

--------------------------------------------------------------------------
                     Time and Date of Analysis
--------------------------------------------------------------------------

          Date:  October 18, 2017     Time:  17:00:59

 Anchored_Sheet_Pile_Wall_Bedrock_Higher_than_-27ft_No_Flood


 **************************************************
 *        PROGRAM CONTROL PARAMETERS              *
 **************************************************

 NO OF POINTS FOR SPECIFIED DEFLECTIONS AND SLOPES  =  0
 NO OF POINTS FOR WALL STIFFNESS AND LOAD DATA      =  1
 GENERATE EARTH PRESSURE INTERNALLY                 =  1
 GENERATE SOIL RESISTANCE (P-Y) CURVES INTERNALLY   =  1
 NO OF P-Y MODIFICATION FACTORS FOR GEN. P-Y CURVES =  0
 NO OF USER-SPECIFIED SOIL RESISTANCE (P-Y) CURVES  =  0
 NUMBER OF INCREMENTS                               =  50
 INCREMENT LENGTH                                   =     6.000 IN
 FREE HEIGHT OF WALL                                =   180.000 IN
 MAXIMUM ALLOWABLE DEFLECTION                       =    18.000 IN
 DEFLECTION CLOSURE TOLERANCE                       = 1.000E-05 IN



 **************************************************
 *        STIFFNESS AND LOAD DATA                 *
 **************************************************
 EI - FLEXURAL RIGIDITY,  Q - TRANSVERSE LOAD,
 S - STIFFNESS OF TRANSVERSE RESISTANCE,
 T - TORQUE,              P - AXIAL LOAD,
 R - STIFFNESS OF TORSIONAL RESISTANCE.
```

FROM	TO	CONTD	EI	Q	S'	T	R	P
			LBS-IN**2	LBS	LBS/IN	IN-LBS	IN-LBS	LBS
0	50	0	0.662E+11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
10	10	0	0.662E+11	0.000E+00	0.270E+06	0.000E+00	0.000E+00	0.000E+00

```
**************************************************
*                WALL INFORMATION                *
**************************************************
```

```
FREE HEIGHT OF WALL                      =  0.180E+03 IN
WIDTH FOR EARTH PRESSURE, WA             =  0.630E+02 IN
WIDTH FOR SOIL RESISTANCE, WP            =  0.630E+02 IN
DEPTH TO THE WATER TABLE AT BACKFILL     =  0.960E+02 IN
DEPTH TO THE WATER TABLE AT EXCAVATION   =  0.960E+02 IN
UNIT WEIGHT OF WATER                     =  0.360E-01 LBS/IN**3
SLOPE OF THE BACKFILL (deg.)             =  0.000E+00
MODIFICATION FOR ACTIVE EARTH PRESSURE   =  0.100E+01
```

```
**************************************************
*              SURCHARGE INFORMATION             *
**************************************************
```

UNIFORM SURFACE PRESSURE = 0.174E+01 LBS/IN**2

```
**************************************************
*                SOIL INFORMATION                *
**************************************************
```

LAYER NO.	TOTAL THICKNESS IN	COHESION PSI	PHI DEG	TOTAL UNIT WEIGHT PCI	DRAINED T OR F	ZTOP IN
1	96.0	0.0	32.0	0.064	T	0.00
2	84.0	0.3	22.0	0.064	T	96.00
3	240.0	0.0	36.0	0.075	T	180.00

```
**************************************************
*           EFFECTIVE OVERBURDEN STRESS          *
**************************************************
```

DEPTH IN	STRESS LBS/IN**2
0.000E+00	0.174E+01
0.960E+02	0.785E+01
0.180E+03	0.102E+02

```
**************************************************
* ACTIVE AND PASSIVE EARTH PRESSURE COEFFICIENT  *
**************************************************
```

LAYER NO.	ACTIVE EARTH COEFFICIENT	PASSIVE EARTH COEFFICIENT	OPTIONAL EARTH COEFFICIENT

1	0.307E+00	0.325E+01	0.000E+00
2	0.455E+00	0.220E+01	0.000E+00
3	0.260E+00	0.385E+01	0.000E+00

```
**************************************************
*      ACTIVE EARTH PRESSURE OF EACH LAYER       *
**************************************************
```

LAYER NO	PA1 LBS/IN**2	Z1 IN	PA2 LBS/IN**2	Z2 IN	PA3 LBS/IN**2	Z3 IN	PA4 LBS/IN**2
1	51.21	48.00	90.13	64.00	0.00	0.00	0.00
2	299.90	138.00	44.39	152.00	-39.35	0.00	0.00

```
**************************************************
*      ACTIVE WATER PRESSURE OF EACH LAYER       *
**************************************************
```

LAYER NO	PW1	Z1	PW2	Z2
2	0.00	138.00	127.01	152.00

DEPTH IN	ACTIVE EARTH PRESSURE LBS/IN
0.000E+00	0.336E+02
0.600E+01	0.456E+02
0.120E+02	0.913E+02
0.180E+02	0.137E+03
0.240E+02	0.183E+03
0.300E+02	0.228E+03
0.360E+02	0.274E+03
0.420E+02	0.304E+03
0.480E+02	0.304E+03
0.540E+02	0.304E+03
0.600E+02	0.304E+03
0.660E+02	0.304E+03
0.720E+02	0.304E+03
0.780E+02	0.304E+03
0.840E+02	0.304E+03
0.900E+02	0.304E+03
0.960E+02	0.304E+03
0.102E+03	0.297E+03
0.108E+03	0.274E+03
0.114E+03	0.251E+03
0.120E+03	0.228E+03
0.126E+03	0.205E+03
0.132E+03	0.183E+03
0.138E+03	0.159E+03
0.144E+03	0.137E+03
0.150E+03	0.114E+03
0.156E+03	0.913E+02
0.162E+03	0.687E+02
0.168E+03	0.456E+02
0.174E+03	0.228E+02
0.180E+03	0.000E+00
0.185E+03	0.166E+03
0.191E+03	0.166E+03
0.197E+03	0.166E+03

0.203E+03	0.166E+03
0.209E+03	0.166E+03
0.215E+03	0.166E+03
0.221E+03	0.166E+03
0.227E+03	0.166E+03
0.233E+03	0.166E+03
0.239E+03	0.166E+03
0.245E+03	0.166E+03
0.251E+03	0.166E+03
0.257E+03	0.166E+03
0.263E+03	0.166E+03
0.269E+03	0.166E+03
0.275E+03	0.166E+03
0.281E+03	0.166E+03
0.287E+03	0.166E+03
0.293E+03	0.166E+03
0.299E+03	0.166E+03

```
**************************************************
*        SOIL LAYERS AND STRENGTH DATA           *
**************************************************
```

X AT THE SURFACE OF EXCAVATION SIDE = 180.00 IN

1 LAYER(S) OF SOIL

LAYER 1
THE SOIL IS A SAND

DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH
2 POINTS

X,IN	WEIGHT,LBS/IN**3
180.0000	0.3923D-01
420.0000	0.3923D-01

DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH
2 POINTS

X,IN	S,LBS/IN**2	PHI,DEGREES	E50
180.00	0.0000D+00	36.000	-----
312.00	0.0000D+00	36.000	-----

P-Y CURVES DATA

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
0.10	63.00	36.00	0.39E-01	2.83	2.14	0.89E+00	0.15E+02

Y IN	P LBS/IN
0.000	-166.347
0.088	-165.253

0.175	-164.159
0.263	-163.381
0.350	-163.153
0.438	-162.963
0.525	-162.800
0.613	-162.656
0.700	-162.527
0.788	-162.409
0.875	-162.301
0.963	-162.200
1.050	-162.106
2.362	-160.738
65.362	-160.738
128.363	-160.738
191.363	-160.738

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
180.10	63.00	36.00	0.39E-01	1.11	0.75	0.57E+04	0.27E+05

Y IN	P LBS/IN
0.000	166.347
0.088	1216.171
0.175	1530.787
0.263	1756.889
0.350	1939.687
0.438	2095.823
0.525	2233.548
0.613	2357.634
0.700	2471.127
0.788	2576.105
0.875	2674.055
0.963	2766.088
1.050	2853.054
2.362	4123.061
65.362	4123.061
128.363	4123.061
191.363	4123.061

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
33.00	63.00	36.00	0.39E-01	2.46	1.82	0.43E+03	0.50E+04

Y IN	P LBS/IN
0.000	-166.347
0.088	194.591
0.175	547.253
0.263	634.550
0.350	702.891

0.438	759.891
0.525	809.227
0.613	852.985
0.700	892.474
0.788	928.572
0.875	961.906
0.963	992.933
1.050	1022.002
2.362	1444.811
65.362	1444.811
128.363	1444.811
191.363	1444.811

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
213.00	63.00	36.00	0.39E-01	1.00	0.64	0.77E+04	0.32E+05

Y IN	P LBS/IN
0.000	166.347
0.088	1060.581
0.175	1384.549
0.263	1626.038
0.350	1825.885
0.438	1999.555
0.525	2154.862
0.613	2296.393
0.700	2427.110
0.788	2549.053
0.875	2663.698
0.963	2772.152
1.050	2875.270
2.362	4385.590
65.362	4385.590
128.363	4385.590
191.363	4385.590

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
66.00	63.00	36.00	0.39E-01	2.08	1.51	0.11E+04	0.10E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	555.528
0.175	997.314
0.263	1146.289
0.350	1263.418
0.438	1361.420
0.525	1446.460
0.613	1522.043

0.700	1590.373
0.788	1652.937
0.875	1710.787
0.963	1764.702
1.050	1815.274
2.362	2551.215
65.362	2551.215
128.363	2551.215
191.363	2551.215

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
246.00	63.00	36.00	0.39E-01	0.92	0.55	0.99E+04	0.37E+05

Y IN	P LBS/IN
0.000	166.347
0.088	866.965
0.175	1183.762
0.263	1431.874
0.350	1643.803
0.438	1832.336
0.525	2004.104
0.613	2163.077
0.700	2311.859
0.788	2452.270
0.875	2585.641
0.963	2712.981
1.050	2835.077
2.362	4630.488
65.362	4630.488
128.363	4630.488
191.363	4630.488

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
99.00	63.00	36.00	0.39E-01	1.72	1.24	0.21E+04	0.15E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	916.466
0.175	1226.339
0.263	1413.482
0.350	1561.323
0.438	1685.459
0.525	1793.479
0.613	1889.710
0.700	1976.880
0.788	2056.832
0.875	2130.876

0.963	2199.978
1.050	2264.877
2.362	3209.886
65.362	3209.886
128.363	3209.886
191.363	3209.886

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
279.00	63.00	36.00	0.39E-01	0.89	0.52	0.12E+05	0.42E+05

Y IN	P LBS/IN
0.000	166.347
0.088	844.975
0.175	1180.094
0.263	1448.345
0.350	1680.702
0.438	1889.560
0.525	2081.420
0.613	2260.209
0.700	2428.519
0.788	2588.175
0.875	2740.516
0.963	2886.565
1.050	3027.121
2.362	5097.625
65.362	5097.625
128.363	5097.625
191.363	5097.625

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
131.90	63.00	36.00	0.39E-01	1.43	1.01	0.34E+04	0.20E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	1001.347
0.175	1301.714
0.263	1512.063
0.350	1679.344
0.438	1820.496
0.525	1943.802
0.613	2054.008
0.700	2154.113
0.788	2246.153
0.875	2331.574
0.963	2411.449
1.050	2486.598
2.362	3581.766

65.362	3581.766
128.363	3581.766
191.363	3581.766

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
IN	IN		LBS/IN**3				
311.90	63.00	36.00	0.39E-01	0.88	0.50	0.15E+05	0.47E+05

Y	P
IN	LBS/IN
0.000	166.347
0.088	855.270
0.175	1214.494
0.263	1506.123
0.350	1761.026
0.438	1991.692
0.525	2204.718
0.613	2404.112
0.700	2592.534
0.788	2771.861
0.875	2943.476
0.963	3108.439
1.050	3267.580
2.362	5614.537
65.362	5614.537
128.363	5614.537
191.363	5614.537

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

Anchored_Sheet_Pile_Wall_Bedrock_Higher_than_-27ft_No_Flood

RESULTS -- ITERATION 3

STA I	X	DEFL.	SLOPE	MOMENT	SHEAR	NET REACT/STA	EI
	IN	IN		LBS-IN	LBS	LBS	LBS-IN**2
------	----	----	-----	------	------	---------	----------
0	0.000E+00	0.130E+00	-0.192E-03	0.000E+00	0.000E+00	0.000E+00	0.331E+11
1	0.600E+01	0.129E+00	-0.192E-03	0.000E+00	0.137E+03	0.274E+03	0.662E+11
2	0.120E+02	0.127E+00	-0.191E-03	0.164E+04	0.548E+03	0.548E+03	0.662E+11
3	0.180E+02	0.126E+00	-0.191E-03	0.657E+04	0.123E+04	0.820E+03	0.662E+11
4	0.240E+02	0.125E+00	-0.190E-03	0.164E+05	0.219E+04	0.110E+04	0.662E+11
5	0.300E+02	0.124E+00	-0.188E-03	0.329E+05	0.342E+04	0.137E+04	0.662E+11
6	0.360E+02	0.123E+00	-0.184E-03	0.575E+05	0.493E+04	0.164E+04	0.662E+11
7	0.420E+02	0.122E+00	-0.177E-03	0.920E+05	0.666E+04	0.183E+04	

```
0.662E+11
     8   0.480E+02   0.121E+00  -0.167E-03   0.137E+06   0.849E+04   0.183E+04
0.662E+11
     9   0.540E+02   0.120E+00  -0.152E-03   0.194E+06   0.103E+05   0.183E+04
0.662E+11
    10   0.600E+02   0.119E+00  -0.131E-03   0.261E+06  -0.393E+04  -0.303E+05
0.662E+11
    11   0.660E+02   0.118E+00  -0.112E-03   0.147E+06  -0.182E+05   0.183E+04
0.662E+11
    12   0.720E+02   0.118E+00  -0.104E-03   0.430E+05  -0.164E+05   0.183E+04
0.662E+11
    13   0.780E+02   0.117E+00  -0.104E-03  -0.496E+05  -0.145E+05   0.183E+04
0.662E+11
    14   0.840E+02   0.116E+00  -0.112E-03  -0.131E+06  -0.127E+05   0.183E+04
0.662E+11
    15   0.900E+02   0.116E+00  -0.127E-03  -0.202E+06  -0.109E+05   0.183E+04
0.662E+11
    16   0.960E+02   0.115E+00  -0.148E-03  -0.262E+06  -0.905E+04   0.183E+04
0.662E+11
    17   0.102E+03   0.114E+00  -0.174E-03  -0.311E+06  -0.725E+04   0.178E+04
0.662E+11
    18   0.108E+03   0.113E+00  -0.204E-03  -0.349E+06  -0.554E+04   0.164E+04
0.662E+11
    19   0.114E+03   0.111E+00  -0.237E-03  -0.377E+06  -0.397E+04   0.150E+04
0.662E+11
    20   0.120E+03   0.110E+00  -0.272E-03  -0.397E+06  -0.253E+04   0.137E+04
0.662E+11
    21   0.126E+03   0.108E+00  -0.309E-03  -0.408E+06  -0.123E+04   0.123E+04
0.662E+11
    22   0.132E+03   0.106E+00  -0.346E-03  -0.411E+06  -0.643E+02   0.110E+04
0.662E+11
    23   0.138E+03   0.104E+00  -0.383E-03  -0.408E+06   0.962E+03   0.956E+03
0.662E+11
    24   0.144E+03   0.102E+00  -0.420E-03  -0.400E+06   0.185E+04   0.820E+03
0.662E+11
    25   0.150E+03   0.990E-01  -0.455E-03  -0.386E+06   0.260E+04   0.684E+03
0.662E+11
    26   0.156E+03   0.961E-01  -0.489E-03  -0.368E+06   0.322E+04   0.548E+03
0.662E+11
    27   0.162E+03   0.931E-01  -0.522E-03  -0.348E+06   0.370E+04   0.412E+03
0.662E+11
    28   0.168E+03   0.899E-01  -0.552E-03  -0.324E+06   0.404E+04   0.274E+03
0.662E+11
    29   0.174E+03   0.865E-01  -0.581E-03  -0.299E+06   0.425E+04   0.137E+03
0.662E+11
    30   0.180E+03   0.829E-01  -0.606E-03  -0.273E+06   0.456E+04   0.495E+03
0.662E+11
    31   0.186E+03   0.792E-01  -0.630E-03  -0.244E+06   0.514E+04   0.665E+03
0.662E+11
    32   0.192E+03   0.753E-01  -0.651E-03  -0.211E+06   0.566E+04   0.371E+03
0.662E+11
    33   0.198E+03   0.714E-01  -0.668E-03  -0.176E+06   0.590E+04   0.110E+03
0.662E+11
    34   0.204E+03   0.673E-01  -0.683E-03  -0.141E+06   0.590E+04  -0.116E+03
0.662E+11
    35   0.210E+03   0.632E-01  -0.694E-03  -0.106E+06   0.569E+04  -0.308E+03
0.662E+11
    36   0.216E+03   0.590E-01  -0.702E-03  -0.724E+05   0.530E+04  -0.464E+03
0.662E+11
    37   0.222E+03   0.548E-01  -0.707E-03  -0.420E+05   0.475E+04  -0.631E+03
0.662E+11
    38   0.228E+03   0.505E-01  -0.710E-03  -0.154E+05   0.406E+04  -0.754E+03
0.662E+11
```

```
   39   0.234E+03   0.462E-01  -0.710E-03   0.673E+04   0.326E+04  -0.836E+03
0.662E+11
   40   0.240E+03   0.420E-01  -0.709E-03   0.238E+05   0.241E+04  -0.875E+03
0.662E+11
   41   0.246E+03   0.377E-01  -0.706E-03   0.356E+05   0.153E+04  -0.873E+03
0.662E+11
   42   0.252E+03   0.335E-01  -0.702E-03   0.422E+05   0.698E+03  -0.802E+03
0.662E+11
   43   0.258E+03   0.293E-01  -0.698E-03   0.440E+05  -0.515E+02  -0.697E+03
0.662E+11
   44   0.264E+03   0.251E-01  -0.695E-03   0.416E+05  -0.679E+03  -0.559E+03
0.662E+11
   45   0.270E+03   0.210E-01  -0.691E-03   0.358E+05  -0.115E+04  -0.388E+03
0.662E+11
   46   0.276E+03   0.168E-01  -0.688E-03   0.278E+05  -0.144E+04  -0.185E+03
0.662E+11
   47   0.282E+03   0.127E-01  -0.686E-03   0.186E+05  -0.151E+04   0.517E+02
0.662E+11
   48   0.288E+03   0.862E-02  -0.685E-03   0.969E+04  -0.131E+04   0.347E+03
0.662E+11
   49   0.294E+03   0.451E-02  -0.684E-03   0.289E+04  -0.808E+03   0.651E+03
0.662E+11
   50   0.300E+03   0.405E-03  -0.684E-03  -0.399E-09  -0.241E+03   0.482E+03
0.331E+11
```

TIE BACK RESULTS

N	STA	X IN	HOR.FORCE/STA. LBS	FORCE/STA. LBS	FORCE/TIE BACK LBS
1	10	0.600E+02	-0.3215E+05	-0.5222E+05	-0.9947E+05

END OF ANALYSIS

Anchored Sheet Pile Wall with 15 ft Height for Soil Area 2
Bedrock Higher than -27'
No Flood and Seismic

```
     Anchored Sheet Pile Wall Bedrock Higher than -27ft_Seismic.py5o
==========================================================================

                    PYWALL for Windows, Version 2015.5.11

                     Serial Number :  166868598

                     A Program for the Analysis of
                     Flexible Retaining Walls
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==========================================================================


     This program is licensed to :

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     Path to file locations      : Q:\Geotechnical\Meadowlands\Calculations for New
Alternatives\Anchored Wall\PYWall Analysis\Proposed Section\Seismic\
     Name of input data file     : Anchored Sheet Pile Wall Bedrock Higher than
-27ft_Seismic.py5d
     Name of output file         : Anchored Sheet Pile Wall Bedrock Higher than
-27ft_Seismic.py5o
     Name of plot output file    : Anchored Sheet Pile Wall Bedrock Higher than
-27ft_Seismic.py5p

     --------------------------------------------------------------------------
                          Time and Date of Analysis
     --------------------------------------------------------------------------

               Date:  October 19, 2017     Time:  15:20:16

      Anchored_Sheet_Pile_Wall_Bedrock_Higher_than_-27ft_Seismic.


      **************************************************
      *        PROGRAM CONTROL PARAMETERS              *
      **************************************************

      NO OF POINTS FOR SPECIFIED DEFLECTIONS AND SLOPES  =  0
      NO OF POINTS FOR WALL STIFFNESS AND LOAD DATA      =  1
      GENERATE EARTH PRESSURE INTERNALLY                 =  1
      GENERATE SOIL RESISTANCE (P-Y) CURVES INTERNALLY   =  1
      NO OF P-Y MODIFICATION FACTORS FOR GEN. P-Y CURVES =  0
      NO OF USER-SPECIFIED SOIL RESISTANCE (P-Y) CURVES  =  0
      NUMBER OF INCREMENTS                               =  50
      INCREMENT LENGTH                                   =     6.000 IN
      FREE HEIGHT OF WALL                                =   180.000 IN
      MAXIMUM ALLOWABLE DEFLECTION                       =    18.000 IN
      DEFLECTION CLOSURE TOLERANCE                       = 1.000E-05 IN



      **************************************************
      *        STIFFNESS AND LOAD DATA                 *
      **************************************************
      EI - FLEXURAL RIGIDITY,  Q - TRANSVERSE LOAD,
      S - STIFFNESS OF TRANSVERSE RESISTANCE,
      T - TORQUE,              P - AXIAL LOAD,
      R - STIFFNESS OF TORSIONAL RESISTANCE.
```

FROM	TO	CONTD	EI	Q	S'	T	R	P
			LBS-IN**2	LBS	LBS/IN	IN-LBS	IN-LBS	LBS
0	50	0	0.662E+11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
10	10	0	0.662E+11	0.361E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
10	10	0	0.662E+11	0.000E+00	0.270E+06	0.000E+00	0.000E+00	0.000E+00

```
**************************************************
*                WALL INFORMATION                *
**************************************************
```

```
FREE HEIGHT OF WALL                        =  0.180E+03 IN
WIDTH FOR EARTH PRESSURE, WA               =  0.630E+02 IN
WIDTH FOR SOIL RESISTANCE, WP              =  0.630E+02 IN
DEPTH TO THE WATER TABLE AT BACKFILL       =  0.960E+02 IN
DEPTH TO THE WATER TABLE AT EXCAVATION     =  0.960E+02 IN
UNIT WEIGHT OF WATER                       =  0.360E-01 LBS/IN**3
SLOPE OF THE BACKFILL (deg.)               =  0.000E+00
MODIFICATION FOR ACTIVE EARTH PRESSURE     =  0.100E+01
```

```
**************************************************
*              SURCHARGE INFORMATION             *
**************************************************
```

UNIFORM SURFACE PRESSURE = 0.174E+01 LBS/IN**2

```
**************************************************
*                SOIL INFORMATION                *
**************************************************
```

LAYER NO.	TOTAL THICKNESS IN	COHESION PSI	PHI DEG	TOTAL UNIT WEIGHT PCI	DRAINED T OR F	ZTOP IN
1	96.0	0.0	32.0	0.064	T	0.00
2	84.0	0.3	22.0	0.064	T	96.00
3	240.0	0.0	36.0	0.075	T	180.00

```
**************************************************
*           EFFECTIVE OVERBURDEN STRESS          *
**************************************************
```

DEPTH IN	STRESS LBS/IN**2
0.000E+00	0.174E+01
0.960E+02	0.785E+01
0.180E+03	0.102E+02

```
**************************************************
* ACTIVE AND PASSIVE EARTH PRESSURE COEFFICIENT  *
**************************************************
```

LAYER ACTIVE EARTH PASSIVE EARTH OPTIONAL EARTH

NO.	COEFFICIENT	COEFFICIENT	COEFFICIENT
1	0.307E+00	0.325E+01	0.000E+00
2	0.455E+00	0.220E+01	0.000E+00
3	0.260E+00	0.385E+01	0.000E+00

```
**************************************************
*      ACTIVE EARTH PRESSURE OF EACH LAYER       *
**************************************************
```

LAYER NO	PA1 LBS/IN**2	Z1 IN	PA2 LBS/IN**2	Z2 IN	PA3 LBS/IN**2	Z3 IN	PA4 LBS/IN**2
1	51.21	48.00	90.13	64.00	0.00	0.00	0.00
2	299.90	138.00	44.39	152.00	-39.35	0.00	0.00

```
**************************************************
*      ACTIVE WATER PRESSURE OF EACH LAYER       *
**************************************************
```

LAYER NO	PW1	Z1	PW2	Z2
2	0.00	138.00	127.01	152.00

DEPTH IN	ACTIVE EARTH PRESSURE LBS/IN
0.000E+00	0.336E+02
0.600E+01	0.456E+02
0.120E+02	0.913E+02
0.180E+02	0.137E+03
0.240E+02	0.183E+03
0.300E+02	0.228E+03
0.360E+02	0.274E+03
0.420E+02	0.304E+03
0.480E+02	0.304E+03
0.540E+02	0.304E+03
0.600E+02	0.304E+03
0.660E+02	0.304E+03
0.720E+02	0.304E+03
0.780E+02	0.304E+03
0.840E+02	0.304E+03
0.900E+02	0.304E+03
0.960E+02	0.304E+03
0.102E+03	0.297E+03
0.108E+03	0.274E+03
0.114E+03	0.251E+03
0.120E+03	0.228E+03
0.126E+03	0.205E+03
0.132E+03	0.183E+03
0.138E+03	0.159E+03
0.144E+03	0.137E+03
0.150E+03	0.114E+03
0.156E+03	0.913E+02
0.162E+03	0.687E+02
0.168E+03	0.456E+02
0.174E+03	0.228E+02
0.180E+03	0.000E+00
0.185E+03	0.166E+03
0.191E+03	0.166E+03

0.197E+03	0.166E+03
0.203E+03	0.166E+03
0.209E+03	0.166E+03
0.215E+03	0.166E+03
0.221E+03	0.166E+03
0.227E+03	0.166E+03
0.233E+03	0.166E+03
0.239E+03	0.166E+03
0.245E+03	0.166E+03
0.251E+03	0.166E+03
0.257E+03	0.166E+03
0.263E+03	0.166E+03
0.269E+03	0.166E+03
0.275E+03	0.166E+03
0.281E+03	0.166E+03
0.287E+03	0.166E+03
0.293E+03	0.166E+03
0.299E+03	0.166E+03

****
*   SOIL LAYERS AND STRENGTH DATA   *
****

X AT THE SURFACE OF EXCAVATION SIDE = 180.00 IN

1 LAYER(S) OF SOIL

LAYER 1
THE SOIL IS A SAND

DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH
2 POINTS

X,IN	WEIGHT,LBS/IN**3
180.0000	0.3923D-01
420.0000	0.3923D-01

DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH
2 POINTS

X,IN	S,LBS/IN**2	PHI,DEGREES	E50
180.00	0.0000D+00	36.000	-----
312.00	0.0000D+00	36.000	-----

P-Y CURVES DATA

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
0.10	63.00	36.00	0.39E-01	2.83	2.14	0.89E+00	0.15E+02

Y IN	P LBS/IN
0.000	-166.347

0.088	-165.253
0.175	-164.159
0.263	-163.381
0.350	-163.153
0.438	-162.963
0.525	-162.800
0.613	-162.656
0.700	-162.527
0.788	-162.409
0.875	-162.301
0.963	-162.200
1.050	-162.106
2.362	-160.738
65.362	-160.738
128.363	-160.738
191.363	-160.738

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
180.10	63.00	36.00	0.39E-01	1.11	0.75	0.57E+04	0.27E+05

Y IN	P LBS/IN
0.000	166.347
0.088	1216.171
0.175	1530.787
0.263	1756.889
0.350	1939.687
0.438	2095.823
0.525	2233.548
0.613	2357.634
0.700	2471.127
0.788	2576.105
0.875	2674.055
0.963	2766.088
1.050	2853.054
2.362	4123.061
65.362	4123.061
128.363	4123.061
191.363	4123.061

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
33.00	63.00	36.00	0.39E-01	2.46	1.82	0.43E+03	0.50E+04

Y IN	P LBS/IN
0.000	-166.347
0.088	194.591
0.175	547.253
0.263	634.550

0.350	702.891
0.438	759.891
0.525	809.227
0.613	852.985
0.700	892.474
0.788	928.572
0.875	961.906
0.963	992.933
1.050	1022.002
2.362	1444.811
65.362	1444.811
128.363	1444.811
191.363	1444.811

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
213.00	63.00	36.00	0.39E-01	1.00	0.64	0.77E+04	0.32E+05

Y IN	P LBS/IN
0.000	166.347
0.088	1060.581
0.175	1384.549
0.263	1626.038
0.350	1825.885
0.438	1999.555
0.525	2154.862
0.613	2296.393
0.700	2427.110
0.788	2549.053
0.875	2663.698
0.963	2772.152
1.050	2875.270
2.362	4385.590
65.362	4385.590
128.363	4385.590
191.363	4385.590

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
66.00	63.00	36.00	0.39E-01	2.08	1.51	0.11E+04	0.10E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	555.528
0.175	997.314
0.263	1146.289
0.350	1263.418
0.438	1361.420
0.525	1446.460

0.613	1522.043
0.700	1590.373
0.788	1652.937
0.875	1710.787
0.963	1764.702
1.050	1815.274
2.362	2551.215
65.362	2551.215
128.363	2551.215
191.363	2551.215

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
246.00	63.00	36.00	0.39E-01	0.92	0.55	0.99E+04	0.37E+05

Y IN	P LBS/IN
0.000	166.347
0.088	866.965
0.175	1183.762
0.263	1431.874
0.350	1643.803
0.438	1832.336
0.525	2004.104
0.613	2163.077
0.700	2311.859
0.788	2452.270
0.875	2585.641
0.963	2712.981
1.050	2835.077
2.362	4630.488
65.362	4630.488
128.363	4630.488
191.363	4630.488

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
99.00	63.00	36.00	0.39E-01	1.72	1.24	0.21E+04	0.15E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	916.466
0.175	1226.339
0.263	1413.482
0.350	1561.323
0.438	1685.459
0.525	1793.479
0.613	1889.710
0.700	1976.880
0.788	2056.832

0.875	2130.876
0.963	2199.978
1.050	2264.877
2.362	3209.886
65.362	3209.886
128.363	3209.886
191.363	3209.886

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
279.00	63.00	36.00	0.39E-01	0.89	0.52	0.12E+05	0.42E+05

Y IN	P LBS/IN
0.000	166.347
0.088	844.975
0.175	1180.094
0.263	1448.345
0.350	1680.702
0.438	1889.560
0.525	2081.420
0.613	2260.209
0.700	2428.519
0.788	2588.175
0.875	2740.516
0.963	2886.565
1.050	3027.121
2.362	5097.625
65.362	5097.625
128.363	5097.625
191.363	5097.625

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE EXCAVATION SIDE

DEPTH BELOW GS IN	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
131.90	63.00	36.00	0.39E-01	1.43	1.01	0.34E+04	0.20E+05

Y IN	P LBS/IN
0.000	-166.347
0.088	1001.347
0.175	1301.714
0.263	1512.063
0.350	1679.344
0.438	1820.496
0.525	1943.802
0.613	2054.008
0.700	2154.113
0.788	2246.153
0.875	2331.574
0.963	2411.449
1.050	2486.598

2.362	3581.766
65.362	3581.766
128.363	3581.766
191.363	3581.766

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

AT THE BACKFILL SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
IN	IN		LBS/IN**3				
311.90	63.00	36.00	0.39E-01	0.88	0.50	0.15E+05	0.47E+05

Y	P
IN	LBS/IN
0.000	166.347
0.088	855.270
0.175	1214.494
0.263	1506.123
0.350	1761.026
0.438	1991.692
0.525	2204.718
0.613	2404.112
0.700	2592.534
0.788	2771.861
0.875	2943.476
0.963	3108.439
1.050	3267.580
2.362	5614.537
65.362	5614.537
128.363	5614.537
191.363	5614.537

P-Multiplier = 0.100E+01 Y-Multiplier = 0.100E+01

Anchored_Sheet_Pile_Wall_Bedrock_Higher_than_-27ft_No_Flood

RESULTS -- ITERATION 4

STA I	X	DEFL.	SLOPE	MOMENT	SHEAR	NET REACT/STA	EI
	IN	IN		LBS-IN	LBS	LBS	LBS-IN**2
------	----	----	-----	------	------	---------	----------
0	0.000E+00	0.147E+00	-0.269E-03	0.000E+00	0.000E+00	0.000E+00	0.331E+11
1	0.600E+01	0.146E+00	-0.269E-03	0.000E+00	0.137E+03	0.274E+03	0.662E+11
2	0.120E+02	0.144E+00	-0.269E-03	0.164E+04	0.548E+03	0.548E+03	0.662E+11
3	0.180E+02	0.142E+00	-0.269E-03	0.657E+04	0.123E+04	0.820E+03	0.662E+11
4	0.240E+02	0.141E+00	-0.268E-03	0.164E+05	0.219E+04	0.110E+04	0.662E+11
5	0.300E+02	0.139E+00	-0.265E-03	0.329E+05	0.342E+04	0.137E+04	0.662E+11
6	0.360E+02	0.138E+00	-0.261E-03	0.575E+05	0.493E+04	0.164E+04	0.662E+11

7	0.420E+02	0.136E+00	-0.255E-03	0.920E+05	0.666E+04	0.183E+04	0.662E+11
8	0.480E+02	0.135E+00	-0.244E-03	0.137E+06	0.849E+04	0.183E+04	0.662E+11
9	0.540E+02	0.133E+00	-0.229E-03	0.194E+06	0.103E+05	0.183E+04	0.662E+11
10	0.600E+02	0.132E+00	-0.209E-03	0.261E+06	-0.386E+04	-0.302E+05	0.662E+11
11	0.660E+02	0.131E+00	-0.190E-03	0.148E+06	-0.180E+05	0.183E+04	0.662E+11
12	0.720E+02	0.130E+00	-0.181E-03	0.448E+05	-0.162E+05	0.183E+04	0.662E+11
13	0.780E+02	0.128E+00	-0.181E-03	-0.471E+05	-0.144E+05	0.183E+04	0.662E+11
14	0.840E+02	0.127E+00	-0.189E-03	-0.128E+06	-0.126E+05	0.183E+04	0.662E+11
15	0.900E+02	0.126E+00	-0.204E-03	-0.198E+06	-0.107E+05	0.183E+04	0.662E+11
16	0.960E+02	0.125E+00	-0.225E-03	-0.257E+06	-0.891E+04	0.183E+04	0.662E+11
17	0.102E+03	0.123E+00	-0.250E-03	-0.305E+06	-0.711E+04	0.178E+04	0.662E+11
18	0.108E+03	0.122E+00	-0.279E-03	-0.342E+06	-0.540E+04	0.164E+04	0.662E+11
19	0.114E+03	0.120E+00	-0.312E-03	-0.370E+06	-0.382E+04	0.150E+04	0.662E+11
20	0.120E+03	0.118E+00	-0.346E-03	-0.388E+06	-0.239E+04	0.137E+04	0.662E+11
21	0.126E+03	0.116E+00	-0.382E-03	-0.398E+06	-0.109E+04	0.123E+04	0.662E+11
22	0.132E+03	0.114E+00	-0.418E-03	-0.401E+06	0.788E+02	0.110E+04	0.662E+11
23	0.138E+03	0.111E+00	-0.454E-03	-0.397E+06	0.111E+04	0.956E+03	0.662E+11
24	0.144E+03	0.108E+00	-0.490E-03	-0.388E+06	0.199E+04	0.820E+03	0.662E+11
25	0.150E+03	0.105E+00	-0.524E-03	-0.373E+06	0.275E+04	0.684E+03	0.662E+11
26	0.156E+03	0.102E+00	-0.557E-03	-0.355E+06	0.336E+04	0.548E+03	0.662E+11
27	0.162E+03	0.984E-01	-0.588E-03	-0.333E+06	0.384E+04	0.412E+03	0.662E+11
28	0.168E+03	0.948E-01	-0.617E-03	-0.309E+06	0.418E+04	0.274E+03	0.662E+11
29	0.174E+03	0.910E-01	-0.644E-03	-0.283E+06	0.439E+04	0.137E+03	0.662E+11
30	0.180E+03	0.870E-01	-0.669E-03	-0.256E+06	0.471E+04	0.495E+03	0.662E+11
31	0.186E+03	0.830E-01	-0.690E-03	-0.226E+06	0.528E+04	0.649E+03	0.662E+11
32	0.192E+03	0.788E-01	-0.709E-03	-0.193E+06	0.577E+04	0.343E+03	0.662E+11
33	0.198E+03	0.744E-01	-0.725E-03	-0.157E+06	0.598E+04	0.720E+02	0.662E+11
34	0.204E+03	0.701E-01	-0.738E-03	-0.121E+06	0.594E+04	-0.162E+03	0.662E+11
35	0.210E+03	0.656E-01	-0.747E-03	-0.857E+05	0.568E+04	-0.358E+03	0.662E+11
36	0.216E+03	0.611E-01	-0.753E-03	-0.528E+05	0.524E+04	-0.516E+03	0.662E+11
37	0.222E+03	0.566E-01	-0.757E-03	-0.229E+05	0.464E+04	-0.684E+03	0.662E+11
38	0.228E+03	0.520E-01	-0.758E-03	0.290E+04	0.389E+04	-0.806E+03	

```
0.662E+11
    39   0.234E+03   0.475E-01  -0.757E-03   0.238E+05   0.305E+04  -0.884E+03
0.662E+11
    40   0.240E+03   0.429E-01  -0.754E-03   0.395E+05   0.215E+04  -0.917E+03
0.662E+11
    41   0.246E+03   0.384E-01  -0.750E-03   0.496E+05   0.124E+04  -0.906E+03
0.662E+11
    42   0.252E+03   0.339E-01  -0.745E-03   0.543E+05   0.372E+03  -0.824E+03
0.662E+11
    43   0.258E+03   0.295E-01  -0.740E-03   0.541E+05  -0.392E+03  -0.706E+03
0.662E+11
    44   0.264E+03   0.251E-01  -0.735E-03   0.496E+05  -0.102E+04  -0.553E+03
0.662E+11
    45   0.270E+03   0.207E-01  -0.731E-03   0.418E+05  -0.148E+04  -0.366E+03
0.662E+11
    46   0.276E+03   0.163E-01  -0.728E-03   0.318E+05  -0.174E+04  -0.145E+03
0.662E+11
    47   0.282E+03   0.119E-01  -0.725E-03   0.210E+05  -0.175E+04   0.112E+03
0.662E+11
    48   0.288E+03   0.757E-02  -0.724E-03   0.108E+05  -0.149E+04   0.425E+03
0.662E+11
    49   0.294E+03   0.323E-02  -0.723E-03   0.314E+04  -0.898E+03   0.749E+03
0.662E+11
    50   0.300E+03  -0.111E-02  -0.723E-03   0.797E-09  -0.262E+03   0.524E+03
0.331E+11
```

TIE BACK RESULTS

N	STA	X IN	HOR.FORCE/STA. LBS	FORCE/STA. LBS	FORCE/TIE BACK LBS
1	10	0.600E+02	-0.3562E+05	-0.5786E+05	-0.1102E+06

END OF ANALYSIS

Attachment C1-Y

Calculations for conceptual design of pile foundations at pump station and forebay

HDR

Project: New Meadowlands	Computed: WAJ	Date: 9/6/17
Subject: Pump Station Pile Layout	Checked:	Date:
Task:	Page:	of: 1
Job #:	No:	

Ref: Saginaw Pipe

Pump Station – Estimated Weight

Screw Pump – 72" vanes 36" ϕ Pipe (assume 1/4" wall thickness) = 96 lb/ft

Add ≈ 20 lbs/ft

116 lb/ft

May not be conservative: increase 36" pipe thickness

Say 1/2" thick = 190 lb/ft

\+ 20 lb/ft

210 lb/ft

Approximate length – scaled from pdf ≈ 25'

25' x 210 lb/ft x 8 pumps = 42,000 lbs

Add 10% Detail Factor for Mech Equip / Misc = 46,200 lbs

Column of Water in Screw = $\pi \cdot 3^2 (25')(62.4)$ = 44,000 x 8 = 353,000 lbs

Building / Crane

Conc Walls: 12" Concrete Thick (assume) x 10' height x 94' long (2) x150 = 282,000 lb

Conc Floor: 12" thick x 94' x 12' wide x150 = 169,200 lb

Conc Motor Supports = 3' x 5' x 5' deep wedge = 1,125 lb (8) = 9000 lb

Conc Roof: (assume) ≈ same as floor = 169,200 lb

Misc Loads ≈ 15% add → 629,400 lb

≈ 725,000 lb

Concrete Intake

Walls: 2' x 10' x 94' (2) x 150 = 564,000 lb

Base: 2' x 12' x 94' x 150 = 339,000 lb

Add 10% Detail Factor – screen, etc = 993,000 lb

Water (Full) = 10' x 12' x 94' x 62.4 = 704,000 lb

Concrete Pump Base Slab

Slab: 2' x 25' x 94' x 150 = 705,000 lb

Approach Slab: 2' x 6' x 94' x 150 = 169,200 lb

875,000 lb

HDR

Project: New Meadowlands	Computed: WDJ	Date: 9/6/17
Subject: Pump Station Pile Layout	Checked:	Date:
Task:	Page:	of: 2
Job #:	No:	

Discharge Channel / Spillway

Walls: 2' x 15' x 94' x 150 423,000
Bot Slab: 2' x 20' x 94' x 150 = 564,000
Water: 15' x 20' x 94' x 62.4 = 1.8 M lb

Spillway: 2' x 12' x 94' x 150 = 338,400 lb
Water: ≈ 3' x 12' x 94' x 62.4 = 212,000 lb

3337 k

Note: This desktop analysis neglects lateral forces due to pumping operations. Outer perimeter piles can be battered to counteract lateral forces. Will increase axial load ~15% to account for lateral effects

Total Axial Load ≈ 7033k ⇒ **7050k** + 15% = **USE 8100k**

Soil Area(?): Organic clay to -7 (ignore skin friction per AECOM TM)
Clay -7 to -75
Bedrock @ -75
Very little end bearing until bedrock

Per Table 22 (5.24.1 Friction Piles AECOM TM)

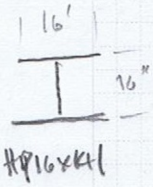
HP 14x73 - 60 ft piles ≈ Allowable Compression Capacity = 32k

HP 16x141 - 67 ft piles ≈ Allowable = 45k

(Neglect Micropiles)

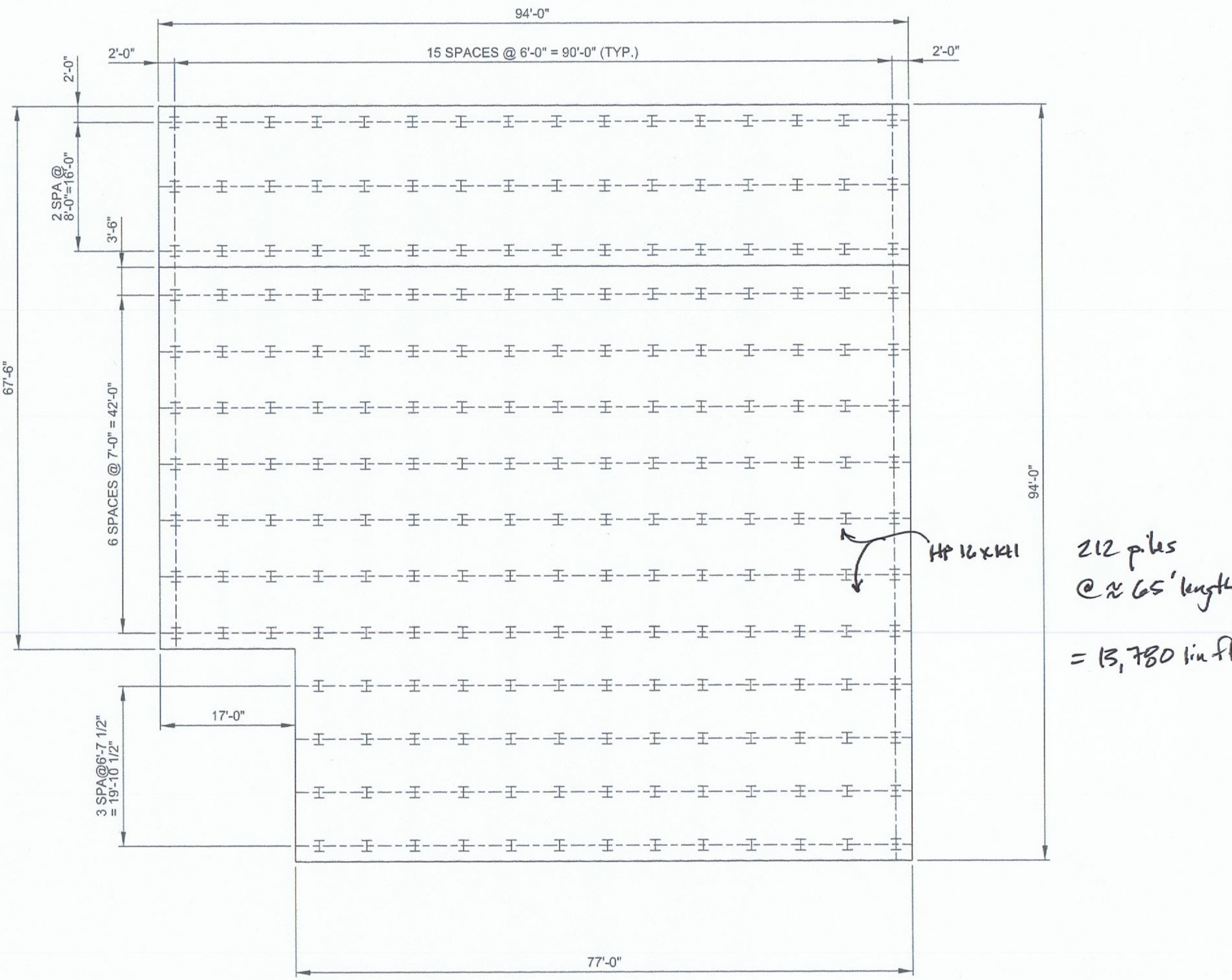
Same piles with end bearing / rock : Allowable compression = 200k

Assume friction piles ≈ 8100k / 45k = 180 piles minimum



Develop conceptual pile layout ≈ 6 ft spacing as target.
(see sketch) = 212 piles for feasible layout

212 piles @ ≈ 65' length = **13,780 lin. ft HP 16x141**



PUMP STATION CONCEPTUAL PILE LAYOUT

N.T.S.

HDR

Project: New Meadowlands	Computed: WDJ	Date: 9/7/17
Subject: Pump Station Pile Layout	Checked:	Date:
Task:	Page:	of: 4
Job #:	No:	

Pile Driving – Production Rates

Ref: USACE NEW ORLEANS – St. Bernard Floodwalls ⇒ HP 14x89 ≈ 95 FT long
LPV 146
800 FT/DAY or ≈ 8 piles/day
JiM Model
115 Hyd Impact Hammer

Ref: SMITH CANAL FLOOD GATE – Miter Gate – 60' opening
STOCKTON, CA
36" ϕ steel pipe piles
≈ 2000 Blows/day
6 piles per day 95' long piles
≈ 570 FT/DAY

* USE LPV 146 as ASSUMED PRODUCTION RATE

212 piles @ 8 piles/day ≅ 27 DAYS

since pile group is in a small area – set up/take down should be very efficient. 27 – 30 days is reasonable

Forebay Piles (Assume similar for Energy Dis. Structure – size)

Assume 2' Thick walls/slab

Concrete: Walls
$2' \times 16' \times 40' (0.150) \times 2 = 384^k$
$2 \times 16 \times 60'$ (assumed length) $\times (0.150)(2) = 576^k$

Slab: assume 3' Thick: $3 \times 40 \times 60' (0.150) = 1080^k$

Flap Gates: $8.7' \times 6.0' \times 0.5"$ Thick (4 gates) (.490 KCF) $\cong 4^k$

Water: $40 \times 60 \times 16\ (62.4) \cong 2400^k$

Total $\cong$ **4500^k**

Piles: Assume HP 16x141 $4500^k / 45^k$ allow capacity = 100 piles

$4500^k / 200^k = 23$ piles req'd. ← Cannot get piles spaced (≤5' spg) closely enough to fit. Assume drive to bedrock

Forebay Piles (cont'd)

23 piles min req'd – will be spaced too far out and induce larger moments in base slab.

Increase to 40 piles total ≈ 8x5 pattern – see sketch.

Stilling Basin – similar size – use same pile layout

Forebay: 40 x 75' = 3,000 Lin FT

Stilling Basin: 3,000 Lin ft

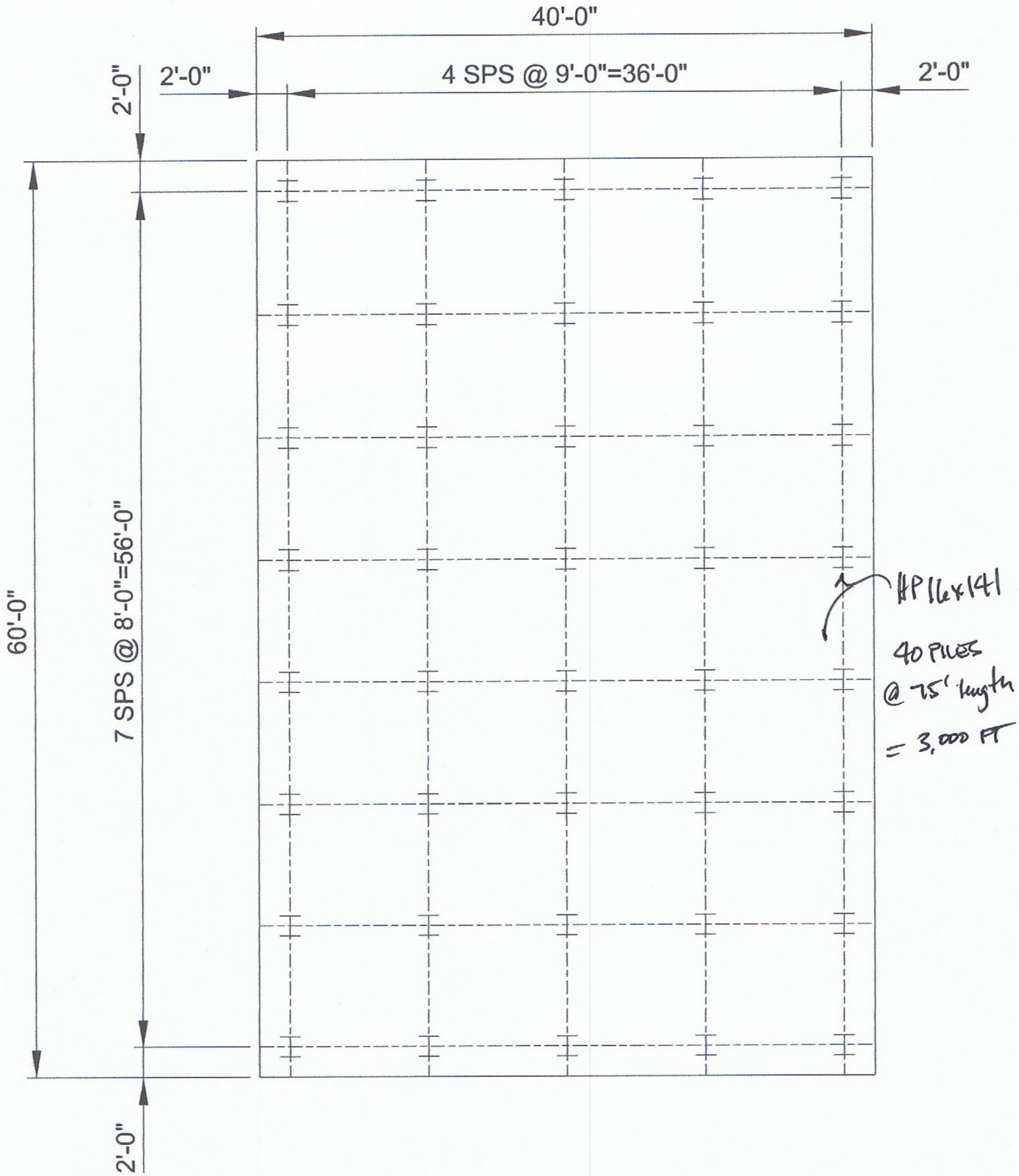
6,000 Lin FT (80 piles) @ 8 piles/day ≅ 10 days

Increase to 15 days since contractor will need to change sites @ stilling basin.

Total HP 16x141 = 212 @ 65' = 13,780 FT
80 @ 75' = 6,000 FT

≈ 45 days Installation

19,780 LIN FT



FOREBAY CONCEPTUAL PILE LAYOUT

N.T.S.

DRAFT

Subappendix C2 – Structural Analysis

For the Feasibility Study of Rebuild by Design Meadowlands Flood Protection Project

June 2018

Boroughs of Little Ferry, Moonachie, Carlstadt, and Teterboro and the Township of South Hackensack, Bergen County, New Jersey

REBUILD BY DESIGN
MEADOWLANDS

Prepared by AECOM for the State of New Jersey Department of Environmental Protection

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Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

ACI	American Concrete Institute
ASCE	American Society of Civil Engineers
EM	Engineer Manual
ETL	Engineer Technical Letter
FEMA	Federal Emergency Management Agency
ft	Feet
ICC	International Code Council
in	Inches
kip-in	Kilopound-inches
lf	Linear feet
LOP	Line of protection
LRFD	Load and Resistance Factor Design
NAVD88	North American Vertical Datum of 1988
pcf	Per cubic foot
plf	Per linear foot
psf	Per square foot
USACE	United States Army Corps of Engineers
USS	United States Steel

.

1.0 Project Background

The Rebuild by Design Meadowlands Flood Protection Project (the Proposed Project) would provide a solution that would reduce flooding risk and enhance resiliency in the Boroughs of Little Ferry, Teterboro, Moonachie, Carlstadt, and the Township of South Hackensack, Bergen County, New Jersey. This subappendix is focused on the Structural Design aspects of the Project's Alternative 1 line of protection (LOP), located along the western bank of the Hackensack River and within Berry's Creek. The proposed design concepts evaluated would simultaneously improve access to the waterfront and provide flood protection when needed, through a combination of floodwalls, sheet pile walls, deployable flood barriers, walkways, and tie-ins to the existing floodplain boundary. This subappendix presents the relevant information used to design the structures of the Proposed Project.

Based on the location with respect to the Hackensack River, the Alternative 1 LOP is divided into four reaches: the Northern Segment, Central Segment, Southern Segment, and Berry's Creek (**Figure C2-1**). Also, based on the subsurface conditions and the bedrock elevations obtained from the existing borings, the Project Area is categorized into seven Soil Areas from Area 1 to 7 (**Figure C1-1** in **Subappendix C1**). The structural engineering portion of the Proposed Project is to design structural components, such as floodwalls (T-walls), sheet pile walls (single sheet pile walls and double sheet pile walls), and walkways to withstand flood and wave loads in a design event, as well as other structures including drainage structures, boardwalks, and miscellaneous site improvements.

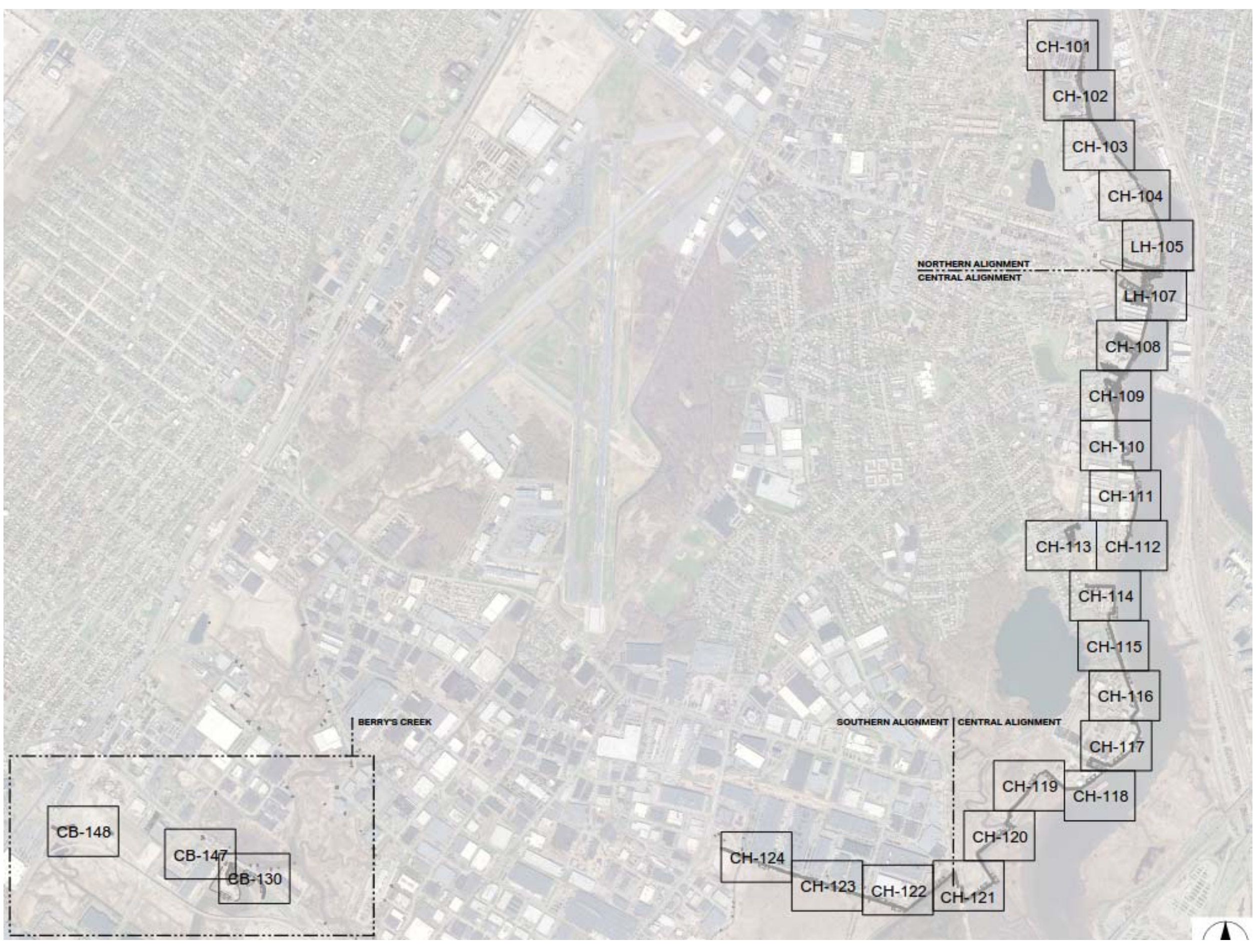


Figure C2-1: RBDM Alternative 1 Key Plan

2.0 Alternative 1 Line of Protection Segments

The Alternative 1 LOP proposed alignment is divided into four segments: three segments along the Hackensack River and one segment near Berry's Creek. The three segments along the Hackensack River are the Northern Segment, Central Segment, and Southern Segment, going from upstream to downstream of the Hackensack River.

Table C2-1 shows the segments of the Alternative 1 LOP along the Hackensack River, the stations of the segments, and their corresponding flood-protection strategies and soil areas. For the stationing of the segments, a drawing set from CH-101 to CH-124 is referred and can be found in **Appendix F**. The high ground represents the locations where the elevation is greater than +7 feet North American Vertical Datum of 1988 (NAVD 88) and the flood-protection strategy is determined to be not necessary.

Table C2-1: Alternative 1 Segments and Stations along the Hackensack River

Segment	Station	Strategies	Soil Areas
Northern Segment	0+00 to 38+77	Cantilever Sheet Pile Walkway	Soil Area 2
	38+77 to 44+36	Single Sheet Pile Wall	Soil Area 3
	44+36 to 56+50	High Ground	Soil Area 3
Central Segment	56+50 to 66+00	Grading with Sheet Pile	Soil Area 3 (Fluvial Park)
	66+00 to 67+00	High Ground	Soil Area 3 (Fluvial Park)
	67+00 to 85+40	Cantilever Walkway	Soil Area 3
	85+40 to 125+40	Concrete Floodwall	Soil Area 3
	125+40 to 140+52	High Ground	Soil Areas 3 and 4
	140+52 to 225+00	Single/Double Sheet Pile Wall	Soil Areas 4 and 5
Southern Segment	225+00 to 266+90	Single/Double Sheet Pile Wall	Soil Area 5

2.1 Northern Segment

The Northern Segment is from station 00+00 to station 56+50. It includes the upstream Hackensack River area and stretches down to the proposed Fluvial Park underneath US Route 46, which is a starting point of the next segment, the Central Segment. The Northern Segment falls in Soil Areas 2 and 3. For the Northern Segment, cantilever sheet pile walkway and single sheet pile wall were proposed.

2.2 Central Segment

The Central Segment stretches from station 56+50 to station 225+00. The Central Segment starts from the proposed Fluvial Park, which covers stations 56+50 to 67+05, extends along the west bank of the Hackensack River, and ends near Williams/Transco Gas Pipeline Road. The proposed Fluvial Park would be located at the waterfront of the Hackensack River and underneath US Route 46.

The Central Segment is located in Soil Areas 3, 4, and 5. Fluvial Park, an elevated walkway, grading with sheet pile, concrete floodwall, cantilever walkway, and single and double sheet pile wall were proposed for the Central Segment.

2.3 Southern Segment

The Southern Segment starts from station 225+00 and ends at station 266+90. The Southern Segment stretches along Commerce Boulevard, protecting the inland buildings. Two viewing platforms were proposed to be located at station points 246+00-247+00 and 255+00-256+00. Soil Area 5 belongs to the Southern Segment. Single and double sheet pile wall were proposed for the Southern Segment.

2.4 Berry's Creek

Berry's Creek Line of Protection involves Soil Areas 6 and 7. Single sheet pile wall, storm surge barrier, and closure gate were proposed for this segment.

3.0 Structural Measures

Structural measures were proposed to protect the Project Area from storm surge and flooding. The proposed measures include concrete floodwalls (T-walls), sheet pile walls, and walkways. The flood-protection strategy was designed to elevation +8 feet (NAVD88), which includes 1 foot of freeboard.

3.1 Concrete Floodwalls

T-shaped concrete floodwalls were proposed at various design heights throughout the Project Area. They are divided into a shallow foundation concrete floodwall and a deep foundation concrete floodwall, depending on their foundation forms.

3.1.1 Shallow Foundation Concrete Floodwall (Central Segment)

T-walls on shallow foundations were considered for all flood heights for Soil Areas 1 to 3 (the soil areas without organic soil layer). Prior to the construction of the T-walls on shallow foundations, the top soil would need to be inspected down to 6 feet depth by excavating trenches. If the existing soil material is not suitable for construction, it would be replaced by proper structural fill.

The shallow foundation concrete floodwall consists of a continuous concrete footing. The bottom of the footing was designed to be below the frost line depth, 3 feet (2015 New Jersey International Residential Code). The shallow foundation concrete floodwall was proposed for the Central Segment from station 85+40 to station 125+40.

3.1.2 Deep Foundation Concrete Floodwall (Central Segment)

T-walls with sheet piles and deep foundations were considered for the protected part of the cantilever walkway near the existing pump station at the Central Segment, which would be located between stations 75+00 and 76+00. The deep foundation concrete floodwall was proposed from station 75+17 to station 75+90, where the cantilever walkway section at the pump station was proposed. The foundation would consist of a pile cap with vertical continuous sheet piles and two battered H-Piles (3V:1H) at every 12 feet.

3.2 Sheet Pile Walls

Two types of sheet pile walls were evaluated for the Proposed Project; single sheet pile wall and double sheet pile wall. In the proposed Fluvial Park, the sheet pile wall was proposed to be embedded below grade to stabilize the grading.

3.2.1 Single Sheet Pile Wall (All Segments)

A single sheet pile wall consists of driven sheet piles capped by a concrete wall. For greater resistance against the flood and wave load and aesthetic purpose, a 2-feet -thick concrete casing on both protected and flood sides of sheet pile was proposed. Single sheet pile walls were considered for the height above grade from 2 feet to 5 feet. The single sheet pile wall was proposed in all segments of the Project Area, including Berry's Creek.

3.2.2 Double Sheet Pile Wall (Central and Southern Segments)

A double sheet pile wall structure consists of two sheet pile walls connected by walers and struts and the space between filled with sand. The waler was designed to be located at two-thirds the height of each sheet pile, and struts connect the walers at every 10 feet. Double sheet pile walls were considered for the height above grade from 5 feet to 8 feet.

Two sections of double sheep pile wall were proposed: 6 feet and 8 feet height. For the segment whose height above grade is greater than 5 feet and less than or equal to 6 feet, “6 feet double sheet pile wall” section was suggested to be used. For the height above grade greater than 6 feet and less than or equal to 8 feet, “8 feet double sheet pile wall” section was suggested. Both double sheet pile wall sections are 5 feet wide.

The double sheet pile wall section was also proposed for the 10’-wide cantilever walkway section in the Central Segment, which would be from station 67+00 to station 72+45. In this section, a concrete walkway was proposed to be installed on the light weight soil fill between the sheet piles.

3.2.3 Grading with Sheet Pile at Fluvial Park (Central Segment)

Fluvial Park, part of the Central Segment, is a park proposed from station 56+50 to station 67+05, which stretches underneath US Route 46. In the proposed Fluvial Park, the boardwalk was designed to be located near the Hackensack River, where the public would have access to a better waterfront view. Underneath and inland from the boardwalk, a planting zone was proposed. More inland from the planting zone would be the grading area with sheet piles embedded for the purpose of stable soil ground.

Sheet pile wall was proposed to be embedded 5 feet inland the boundary of riparian planting zone. The purpose of the embedded sheet pile wall would be to stabilize the inland area and to cut-off seepage. The crest elevation of the grade would be no lower than +8 feet (NAVD 88). The grading with sheet pile was proposed from station 56+50 to station 66+00.

3.3 Walkway

Several walkway sections were proposed as both flood protection strategies and boardwalks. The walkway sections were proposed for the Northern Segment and Central Segment.

3.3.1 Cantilever Sheet Pile Walkway (Northern Segment)

The 16-feet wide cantilever sheet pile walkway would consist of driven sheet pile and backfill behind the sheet pile. On top of the backfill, a concrete cap would be placed for a pedestrian and vehicle passage. Planting zone would be implemented on the protected side of the concrete cap for public realm purpose. Concrete eco panels would be mechanically attached to the front of sheet pile. The cantilever sheet pile walkway was proposed for the Northern Segment from station 00+00 to 38+77.

Two sections of cantilever sheet pile walkway were developed: with and without the lateral support system. The section without the lateral support system was proposed for the soil profile where the bedrock layer is found to be lower than -27 feet (NAVD 88), while the section with the system was proposed for the profile where bedrock is encountered above -27 feet (NAVD 88). Once the actual soil profile is investigated, either section could be used in the next level of development.

3.3.2 Cantilever Walkway (Central Segment)

The cantilever walkway sections were developed to serve as both flood-protection structures and boardwalks near the Hackensack River in the Central Segment. The cantilever walkway sections stretch from station 67+00 to station 85+40. Four different walkway sections were designed based on their widths and locations.

Two 25-feet wide walkway options were designed. Both options would use a single sheet pile wall as the means of flood protection on the flood side, but one option would utilize a vertical concrete wall, while the other would implement a 1V:2H slope of soil fill on the protected side. The option with the vertical concrete wall is 8 feet maximum height, while the option with the sloped soil fill has the maximum height of 6 feet. Either detail could be applicable and is to be determined in the next level of development.

The 25-feet wide walkway sections were also proposed for the transitional station from 10-feet wide walkway to 25-feet wide walkway, by varying the width of the walkway. The section was proposed for segment from station 75+90 to 85+40 as the 25-feet wide walkway and from station 72+45 to 75+17 as the transitional walkway.

A separate, proposed 25-feet wide walkway section was developed to accommodate the existing pump station, which is located between stations 75+00 and 76+00. While the other 25-feet wide walkway sections would include light weight soil fill below the concrete walkway, the walkway section near the pump station would not include the fill. Instead, it would implement a concrete column at every 24 feet on the flood side to allow the discharge from the existing pipe lines. Breaking wave loads were considered in the design of the concrete column. On the protected side there would be a deep foundation concrete floodwall as a flood protection strategy. This section was proposed from station 75+17 to station 75+90.

For the narrow segment where 25-feet wide walkway is not available, a 10-feet wide walkway section was considered using a double sheet pile wall. The 10-feet wide walkway section could be realized by installing a concrete walkway on the light weight soil fill between the sheet pile walls. Each sheet pile would be cased with concrete by 6 inches on its exposed surfaces. The maximum height of the 10-feet wide walkway would be 8 feet and 6 inches. This section was proposed from station 67+00 to 72+45.

3.3.3 Fluvial Park Elevated Walkway (Central Segment)

An elevated walkway section was developed to serve as a boardwalk in the proposed Fluvial Park. The 25-feet wide walkway section has the concept of a pier bridge, where two columns would support the walkway at every 24 feet. Since the elevated walkway section would only serve as a boardwalk, it is not considered part of the flood protection strategy and does not follow the station line. The elevated walkway was designed to be a concrete frame system with wood slat decking as a floor system.

3.4 Cross Section Summary

Table C2-2 shows the structural cross sections and their features. Details are provided in Alternative 1 Plan Sheets S-401 to S-409 in **Appendix F**. The crest elevation of all sections is set to +8 feet (NAVD 88), which includes 1 foot of freeboard.

Table C2-2: Section Summary

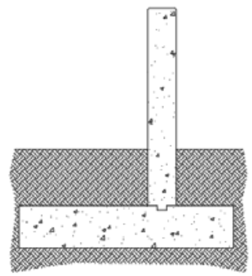
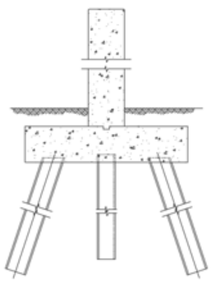
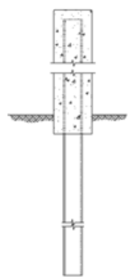
Type	Segment	Length	Typical Section View	Features	Summary of Analysis
Concrete Floodwall (Shallow Foundation)	Central Segment	2,500 lf.		The shallow foundation concrete floodwall is designed from 1 ft. to 10 ft. height for Soil Areas 1, 2, and 3. Total 9 sections are developed with an increment of 1 ft.	Targeted sliding safety factor = 1.33 Actual smallest sliding safety factor = 1.40 Targeted base area in compression = 75% Actual smallest base area in compression = 100% Targeted bearing capacity safety factor = 2 Actual smallest bearing capacity safety factor = 2.01
Concrete Floodwall (Deep Foundation)	Central Segment	90 lf. (solely used for cantilever walkway at pumping station)		The deep foundation concrete floodwall incorporates two battered H-Piles (3V:1H) and continuous sheet pile wall at the center of the footing. The section is implemented as the protected part of cantilever walkway section near the existing pump stations at Central Segment.	Compression capacity of H-Pile 14x73 is 15 ton. The maximum deflection of H-Pile 14x73 is 0.31 in.
Single Sheet Pile Wall	Northern Segment, Central Segment, Southern Segment, Berry's Creek	10,900 lf. (including 400 lf. for Berry's Creek)		The single sheet pile wall consists of driven sheet pile capped by a concrete wall. The section is considered for the height above grade from 2 ft. to 5 ft.	2 ft. wall: AZ12 Maximum deflection = 0.04 in. Maximum bending moment = 34 kip-in. Allowable moment = 1,934 kip-in. 5 ft. wall: AZ12 Maximum deflection = 0.25 in. Maximum bending moment = 264 kip-in. Allowable moment = 1,934 kip-in.

Table C2-2: Section Summary (Continued)

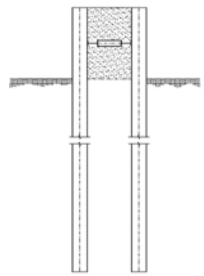
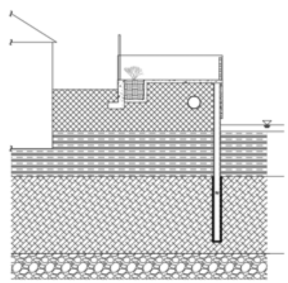
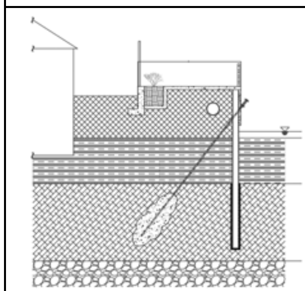
Type	Segment	Length	Typical Section View	Features	Summary of Analysis
Double Sheet Pile Wall	Central Segment, Southern Segment	2,000 lf.		The double sheet pile wall consists of two sheet piles connected by struts and the space between the sheet piles filled with sand. Two sections of double sheet pile wall are developed: 6 ft. and 8 ft. height.	6 ft. wall: AZ19 Maximum deflection = 0.40 in. Maximum bending moment = 345 kip-in. Allowable moment = 3,996 kip-in. 8 ft. wall: AZ26 Maximum deflection = 0.77 in. Maximum bending moment = 648 kip-in. Allowable moment = 5,558 kip-in.
Cantilever Sheet Pile Walkway Bedrock -27 ft. (NAVD88) or Lower	Northern Segment	3,900 lf.		The cantilever sheet pile walkway consists of driven sheet pile and backfill behind the sheet pile. On the top of backfill, concrete cap would be placed for pedestrians and vehicles passage. Planting zone would be implemented on the protected side of the concrete cap. Concrete eco panel would be mechanically attached to the front of sheet pile. Drainage pipe would be located inside the backfill.	15 ft. wall: AZ25 (with 2 ft. thick grout) Maximum deflection = 0.79 in. Maximum bending moment = 3,320 kip-in. Allowable moment = 4,028 kip-in.
Cantilever Sheet Pile Walkway Bedrock Higher than -27 ft. (NAVD88)				When the bedrock elevation is higher than -27 ft. (NAVD88), a lateral support system is considered for the cantilever sheet pile walkway. The lateral support system consists of battered rock anchor and concrete deadman. Drainage pipe would be located inside the backfill.	15 ft. wall: AZ25 Maximum deflection = 0.77 in. Maximum bending moment = 648 kip-in. Allowable moment = 4,028 kip-in.

Table C2-2: Section Summary (Continued)

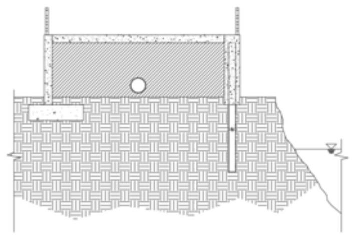
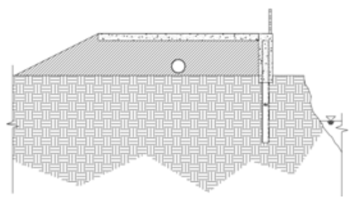
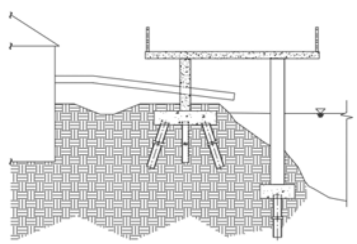
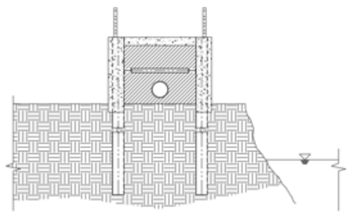
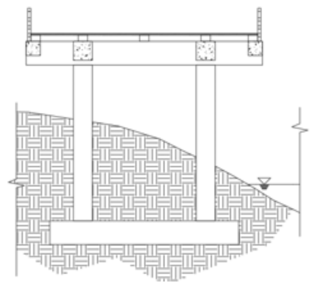
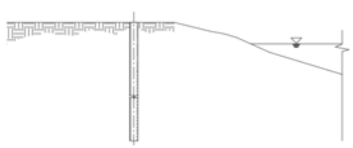
Type	Segment	Length	Typical Section View	Features	Summary of Analysis
Cantilever Walkway 25 ft. Width Option 1	Central Segment	1,250 lf.		Both 25'-wide cantilever walkway options use single sheet pile wall section as means of flood-protection. Option 1 utilizes vertical concrete wall on the protected side. The maximum height of the section is 8 ft. Drainage pipe would be located inside the light weight soil fill.	8 ft. wall: AZ12 Maximum deflection = 1.1 in. Maximum bending moment = 900 kip-in. Allowable moment = 1,934 kip-in. Retaining Wall on the protected side Targeted sliding safety factor = 1.5 Actual sliding safety factor = 2.51 Targeted overturning safety factor = 1.5 Actual overturning safety factor = 3.49
Cantilever Walkway 25 ft. Width Option 2				The 25'-wide cantilever walkway option 2 implements a 1V:2H slope of light weight soil fill on the protected side. The maximum height of the sections is 6 ft. Drainage pipe would be located inside the light weight soil fill.	6 ft. wall: AZ12 Maximum deflection = 0.41 in. Maximum bending moment = 400 kip-in. Allowable moment = 1,934 kip-in.
Cantilever Walkway 25 ft. Width Pump Station	Central Segment	90 lf.		The 25'-wide cantilever walkway near the existing pump station utilizes the deep foundation concrete floodwall as a flood-protection strategy on the protected side. Concrete column is implemented at every 24 ft. on the flood side to accommodate the discharge of the existing pipeline from the pump station. Drainage channel would be located between the existing pump station and the walkway section.	Slab efficiency = 95.44% Wall efficiency = 2.13% (bearing strength), 3.48% (axial compression) Column efficiency = 14.04% (breaking wave loads considered)

Table C2-2: Section Summary (Continued)

Type	Segment	Length	Typical Section View	Features	Summary of Analysis
Cantilever Walkway 10 ft. Width	Central Segment	540 lf.		For the narrow segment where 25'-wide walkway is not available, 10'-wide walkway section is considered, using double sheet pile wall. The maximum height of the section is 8 ft.-6 in. Drainage pipe would be located inside the light weight soil fill between sheet piles.	6 ft. wall: AZ19 Maximum deflection = 0.40 in. Maximum bending moment = 345 kip-in. Allowable moment = 3,996 kip-in. 8 ft. wall: AZ26 Maximum deflection = 0.77 in. Maximum bending moment = 648 kip-in. Allowable moment = 5,558 kip-in.
Fluvial Park-Elevated Walkway	Central Segment (Fluvial Park)	1,250 lf.		The 25'-wide walkway section at Fluvial Park has the concept of pier bridge, where two columns support the walkway at every 24 ft. Since the elevated walkway section only serves as a boardwalk, it is not a part of flood protection strategies. Wood slat decking system is used for the floor system of the walkway section.	Center beams efficiency = 61.82% Side beams efficiency = 58.02% (moment), 92.79% (torsion) Girder efficiency = 43.11% Column efficiency = 4.83%
Fluvial Park-Grading with Sheet Pile	Central Segment (Fluvial Park)	950 lf.		The grading with sheet pile at Fluvial Park includes a sheet pile wall embedded below grade 5 ft. inland of riparian planting zone. The embedded sheet pile wall would stabilize the existing grade and cut-off seepage.	

lf = linear feet
ft = feet
in = inches
kip-in = kilopound-inches

4.0 Applicable Codes, Standards, and Guidelines

All structural design and construction shall be in accordance with the following codes:

- International Code Council (ICC), International Building Code New Jersey Edition: 2015 (New Jersey Building Code)
- ICC, International Residential Code New Jersey Edition: 2015 (New Jersey Residential Code)
- American Concrete Institute (ACI) 318-14, Building Code Requirements for Structural Concrete and Commentary
- American Society of Civil Engineers (ASCE) 7-10, Minimum Design Loads for Buildings and Other Structures
- United States Army Corps of Engineers (USACE) Engineer Manual (EM) 1110-2-2502, Retaining & Floodwalls
- USACE EM 1110-2-2504, Design of Sheet Pile Walls
- USACE EM 1110-2-2906, Design of Pile Foundations
- USACE Engineer Technical Letter (ETL) 1110-2-575, Evaluation of I-Walls
- Federal Emergency Management Agency (FEMA), P-55, Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas
- FEMA, P-259, Engineering Principles and Practices of Retrofitting Floodprone Residential Structures
- United States Steel (USS), Steel Sheet Piling Design Manual, 1984

5.0 Geotechnical Design Criteria

The Project Area was divided into seven soil areas based on the subsurface conditions and the bedrock elevations (**Figure C1-1** in **Subappendix C1**). Based on the existing borings, no organic soil layer was identified in Soil Areas 1 to 3, while an organic clay or peat layer was found in Soil Areas 4 to 7. Information on the soil profiles of Soil Areas 1 to 7 can be found in **Figure C1-2** to **Figure C1-9** and **Table C1-1** to **Table C1-7** in **Subappendix C1**.

6.0 Design Loading

Since the failure of the flood protection strategy could lead a substantial risk to human life, the risk category of the sections was determined to be Category IV. The structural sections were designed based on the minimum design load, referred to ASCE 7-10.

6.1 Dead Loads (*D*)

Dead Loads include the self-weight of building materials and permanent loads on all structures. **Table C2-3** shows a list of common building materials and their self-weight.

Table C2-3: Materials and Self-weights

Material	Weight
Concrete, Normal Weight	150 pcf
Soil Fill	120 pcf
Light Weight Soil Fill	60 pcf
Structural Compacted Fill	130 pcf
Walkway Railing	10 plf
Wood Slat Deck	10 psf
Wood Slat Deck Finishing	5 psf

pcf = per cubic foot
psf = per square foot

Mechanical and electrical equipment Dead Load are based upon the manufacturer's technical specification sheets, when available.

6.2 Live Loads (*L*)

- Walkway and Elevated Platforms: 60 psf (ASCE 7-10 Table 4-1)
- Sidewalks, Vehicular Driveways, and Yards subject to Trucking: 250 psf (ASCE 7-10 Table 4-1)
- Handrails and Guardrails: 200 lb. of concentrated load and 50 per linear foot (plf) of uniformly distributed load (ASCE 7-10 4.5.1)
- Vehicle Barrier Systems: 6,000 lb. of concentrated load (ASCE 7-10 4.5.3)

6.3 Fluids (*F*) & Flood (F_a) Loads

- Hydrostatic Loads
  - o Include lateral water pressures and uplift pressures under the concrete floodwall (T-wall)
  - o Unit weight of water, γ_w = 62.4 pcf for fresh water or 64.0 pcf for salt water
- Wave Loads
  - o Result from water waves propagating over the water surface and striking a building or other structure
  - o Coefficient of drag for breaking waves, C_D = 2.25 for square piles or columns
  - o Design still water depth, d_s, as produced by the coastal modelling report in Subappendix B1

Note: Parameters are listed in ASCE 7-10 Chapter 5: "Flood Loads"

6.4 Soil Loads (*H*)

In the design of structures below grade, the lateral pressure of adjacent soil shall be considered. Using Rankine's theory, active and passive coefficient of earth pressure was estimated with a given internal friction angle of soil.

6.5 Design Loading Combinations

The loads designed for in the Proposed Project follow Load and Resistance Factor Design (LRFD) Load Combinations from ASCE 7-10 and Flood Load Combinations from Chapter 16 of the New Jersey Building code, 2015. **Table C2-4** shows design load combinations in LRFD.

The sliding and overturning stability and bearing capacity of concrete floodwall (T-wall) was checked using service load combination, not LRFD combination. In the next phase of design, load combinations of USACE would be used for reinforced concrete design of the concrete floodwall (T-wall), by referring to EM 1110-2-2104.

Table C2-4: Design Load Combinations*

LRFD Load Combinations with ASCE 7-10 2.3.3	
1	$1.4(D + F)$
2	$1.2(D + F) + 1.6(L + H)$
3	$1.2(D + F) + 1.6H + f_1L$
4	$1.2(D + F) + f_1L + 1.6H + 1.0F_a$
5	$1.2(D + F) + f_1L + 1.6H$
6	$0.9D + 1.6H + 1.0F_a$
7	$0.9(D + F) + 1.6H$

*New Jersey Building Code [2015] Section 1605

Where:

- D = dead load
- F = load due to fluids with well-defined pressures and maximum heights (hydrostatic and uplift pressure included in this category)
- Fa = flood load (breaking wave load included in this category)
- H = load due to lateral earth pressure, ground water pressure, or pressure of bulk materials (active, at-rest, and passive soil pressure included in this category)
- L = live load
- f1 = 1 for places of public assembly live loads in excess of 100 pounds per square foot, and parking garages; and 0.5 for other live loads

7.0 Conceptual Material Specifications

7.1 Structural Concrete

- Normal Weight Concrete (150 pcf)
- Concrete Compressive Strength, f'_c = 5,000 psi compressive strength at 28 days

7.2 Reinforcing Steel

- #4 bars or higher, Grade 60 in accordance with ACI 318-14

7.3 Steel

- Sheet Pile Sections: ASTM A572 Grade 50
- HP Sections: ASTM A572 Grade 50
- W Sections: ASTM A992
- C Sections: ASTM A36
- Steel Rods: ASTM A36
- Anchor Bolts: ASTM F1554 Grade 36 or 55
- Machine Bolts: ASTM A307, Grade A or B

- High Strengths Bolts: ASTM A325-N (Bearing Type)
- Heavy Hex Nuts: ASTM A563, Galvanized
- Plate Washers: ASTM A36, Galvanized
- Hardened Steel Washers: ASTM F436, Galvanized
- Filler Weld Metal: E70XX – Structural Steel or E90XX – Reinforcing Steel
- Electrodes: E70XX – General Structural Steel Welding, E7018 – Complete Penetration Structural Steel Welding, or E90XX – Reinforcing Steel Welding
- Galvanization: ASTM A123 or A153 and Repairs per ASTM A780
- Stainless Steel: ASTM A240 and A276, Type 316

8.0 Structural Analysis

Structural analysis consists of shallow foundation concrete floodwall design, cantilever sheet pile walkway design, cantilever walkway design and its relevant designs, and Fluvial Park elevated walkway design. Microsoft Excel Spreadsheet and hand-written calculation were used for calculating equations and SAP2000 was used for structural modeling, SAP2000.

For the shallow foundation concrete floodwall, nine sections were designed for wall heights from 2-feet to 10-feet with an increment of 1 foot. Each section has been checked for sliding and overturning stability and soil bearing capacity with service load combination. In accordance with USACE EM 1110-2-2502, the load Case I2 was considered, which addresses an Inland Flood Wall case with water level to top of wall. **Table C2-5** shows stability criteria used in the design of the shallow foundation concrete floodwall.

Table C2-5: Inland Flood Wall Stability Criteria*

Criteria	Minimum Required
Sliding Factor of Safety	1.33
Minimum Base Area in Compression in Soil Foundation (Overturning Criteria)	75%
Bearing Capacity Safety Factor	2.0

* Load Case I2: Water to Top of Wall

The cantilever walkway design consisted of the retaining wall design on the protected side of Cantilever Walkway 25’ Width Option 1 and global stability check of Cantilever Walkway at Main Street Pump Station. The sliding and overturning stability has been checked for the retaining wall on the protected side of the Cantilever Walkway Option 1. At the Main Street Pump Station, the concrete slab, the wall on the protected side, and the column on the flood side were designed to include the breaking wave load on the cantilevered structure considered in this Subappenix.

The concrete frame of the Fluvial Park Elevated Walkway consists of two central beams, two side beams, one girder connecting those four beams at every 24 feet, and two columns below every intersection of the girder and two central beams. Torsional capacity has been checked in the design of the side beams due to the presence of the walkway railing on them. Based on the loads from the concrete frame design, a spread footing has been designed with the assumption of 7 feet column length.

8.1 Structural Components Evaluated

This Feasibility Study includes structural analyses for the following design conditions:

- Concrete Floodwall (T-wall) Design 1’ to 2’
- Concrete Floodwall (T-wall) Design 2’ to 3’
- Concrete Floodwall (T-wall) Design 3’ to 4’
- Concrete Floodwall (T-wall) Design 4’ to 5’
- Concrete Floodwall (T-wall) Design 5’ to 6’
- Concrete Floodwall (T-wall) Design 6’ to 7’
- Concrete Floodwall (T-wall) Design 7’ to 8’
- Concrete Floodwall (T-wall) Design 8’ to 9’
- Concrete Floodwall (T-wall) Design 9’ to 10’
- Concrete Retaining Wall Design for Cantilever Walkway Option 1
- Cantilever Walkway at Pumping Station
- Cantilever Walkway at Pumping Station Column on Breaking Wave Loads Check
- Fluvial Park Elevated Walkway Concrete Frame Design
- Fluvial Park Elevated Walkway Footing Design

9.0 Calculations

- Attachment C2-A – Shallow Foundation Concrete Flood Wall Design for Soil Area 3
- Attachment C2-B – Concrete Retaining Wall Design for Cantilever Walkway Option 1
- Attachment C2-C – Cantilever Walkway at Main Street Pump Station
- Attachment C2-D – Breaking Wave Loads Check for Cantilever Walkway at Main Street Pump Station
- Attachment C2-E – Fluvial Park Elevated Walkway Concrete Frame Design
- Attachment C2-F – Fluvial Park Elevated Walkway Footing Design

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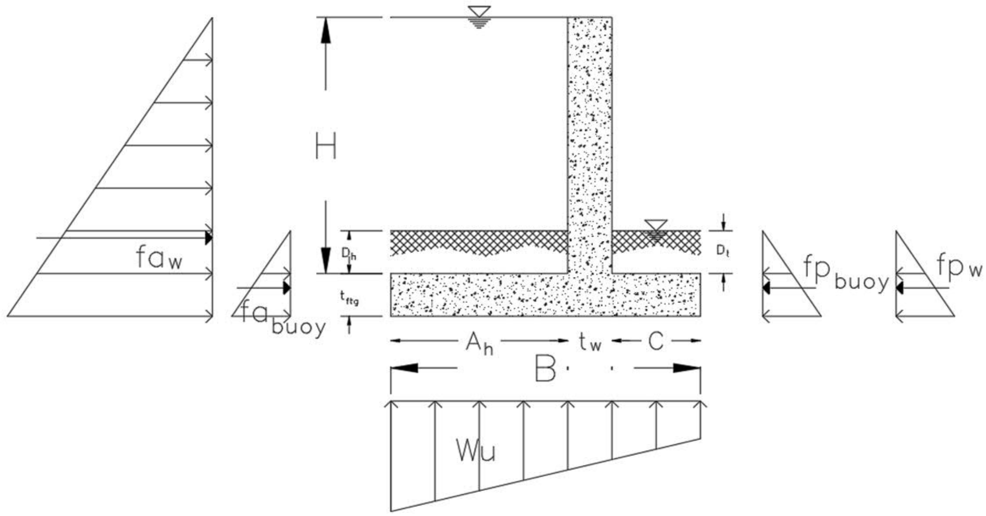
ATTACHMENTS

Attachment C2-A

Shallow Foundation Concrete Flood Wall Design for Soil Area 3



Parameters

H =	4.5 ft	
D_h =	2.5 ft	
D_t =	2.5 ft	
t_{ftg} =	1 ft	
A_h =	1.25 ft	
C =	1.25 ft	
t_{wall} =	1 ft	
B =	3.5 ft	
γ_{conc} =	150 pcf	unit weight of concrete (pcf)
γ_w =	62.4 pcf	specific weight of water (pcf)
γ_{soil} =	120 pcf	unit weight of the soil (pcf)
γ_{buoy} =	57.6 pcf	specific weight of submerged soil (pcf)
Soil Area	3	
Φ =	25 °	internal friction angle of drained soil
K_p =	2.46	passive soil pressure coefficient
Ka =	0.41	active soil pressure coefficient
μ =	0.40	coefficient of friction between the footing and the soil
Load Case	I2	from EM 1110-2-2502 Table 4-2
Sliding F.S. =	1.33	
Overturning Base Area in Compression =	75 %	
Bearing F.S. =	2	

Gravity Forces acting downaward

Wwall =	675.0	lb/lf	weight of the stem of wall
Wftg =	525.0	lb/lf	weight of the footing of wall
Wst =	375.0	lb/lf	weight of the soil above toe
Wsh =	180.0	lb/lf	weight of the soil above heel
Wwh =	351.0	lb/lf	weight of the water above heel
WG =	2106.0	lb/lf	total gravity forces acting downward

Uplift Forces acting upward

WU =	218.4	lb/lf	total uplift forces acting upward

Sliding Forces

fa_w =	943.80	lb/lf	lateral hydrostatic force due to standing water from riverside
fa_{buoy} =	143.19	lb/lf	active saturated soil force over heel
f_S =	1086.99	lb/lf	total sliding forces

Resisting Forces

fp_{buoy} =	869.27	lb/lf	passive saturated soil force over toe
fp_w =	382.20	lb/lf	lateral hydrostatic force from landside
ffr =	842.40	lb/lf	friction force between the footing and the soil
f_R =	2093.87	lb/lf	total resisting forces

Moment Arms from Toe

Moment Arms of Stabilizing Moment

d_{Wwall} =	1.75	ft
d_{Wftg} =	1.75	ft
d_{Wst} =	0.625	ft
d_{Wsh} =	2.875	ft
d_{Wwh} =	2.875	ft
d_{fpbuoy} = d_{fpw} =	1.2	ft

Moment Arms of Overturing Moment

d_{faw} =	1.833	ft
d_{fabuoy} =	1.167	ft
d_{WU} =	1.944	ft

Stabilizing Moment about Toe

M_{ST} = 5321.05 lb-ft/ft

Overturning Moment about Toe

M_{OT} = 2322.02 lb-ft/ft

Resultant

ΣV =	1887.60	lb/ft	↓ +
ΣH =	1006.88	lb/ft	← +
ΣM =	2999.03	lb-ft/ft	+ ↺
X_R =	1.59	ft	
Resultant Ratio =	0.45		

Sliding Stability Check

FS(SL) = 1.93 ➡ Acceptable

Overturning Stability Check

Base Area in Compression = 100 % ➡ Acceptable

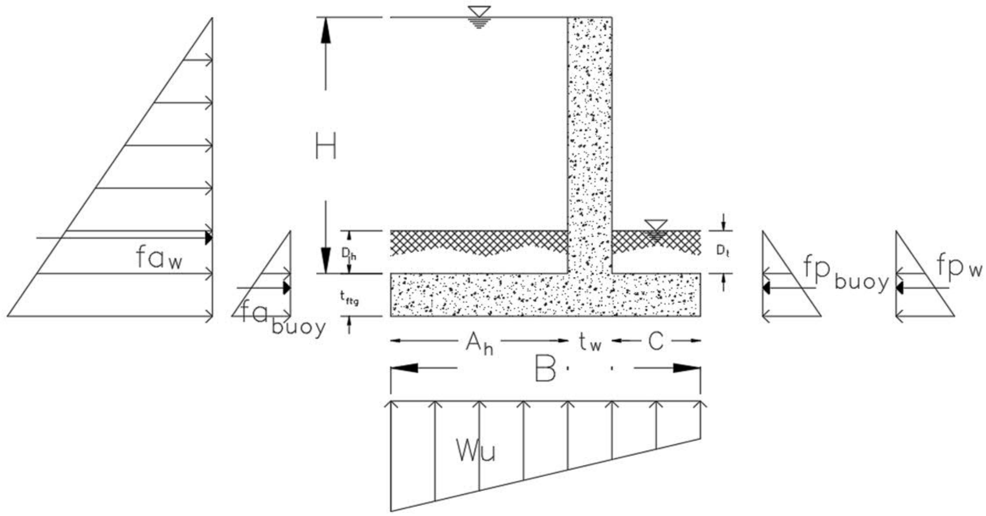
Bearing Capacity Check (from EM 1110-2-2502, Department of the Army, U. S. Army Corps of Engineers)

N' =	1887.6	lb	
T =	1006.9	lb	
α =	0.00	°	
e =	0.16	ft	
$\bar{B}$ =	3.18	ft	
δ =	28.08	°	(Figure 5-1)
γ' =	57.6	pcf	
D =	3.5	ft	
qo =	201.6	psf	[5-8a]
β =	0	°	

Nq =	10.662	[5-3a]	ξqt =	1	[5-6a]
Nc =	20.721	[5-3b]	ξγt =	1	[5-6a]
Nγ =	6.766	[5-3d]	ξct =	1	[5-6c]
ξcd =	1.346	[5-4a]	ξγg =	1	[5-7a]
ξqd =	1.173	[5-4c]	ξqg =	1	[5-7a]
ξγd =	1.173	[5-4c]	ξcg =	1	[5-7d]
ξqi =	0.473	[5-5a]			
ξci =	0.473	[5-5a]			
ξγi =	0.000	[5-5b]			

Q = 3792.48 lb [5-2]

FS = 2.01 [5-1] ➡ Acceptable



Parameters

H =	5.5	ft
D_h =	2.5	ft
D_t =	2.5	ft
t_{ftg} =	1	ft
A_h =	2	ft
C =	2	ft
t_{wall} =	1	ft
B =	5	ft

γ_{conc} =	150	pcf	unit weight of concrete (pcf)
γ_w =	62.4	pcf	specific weight of water (pcf)
γ_{soil} =	120	pcf	unit weight of the soil (pcf)
γ_{buoy} =	57.6	pcf	specific weight of submerged soil (pcf)

Soil Area	3	
Φ =	25 °	internal friction angle of drained soil
K_p =	2.46	passive soil pressure coefficient
Ka =	0.41	active soil pressure coefficient
μ =	0.40	coefficient of friction between the footing and the soil

Load Case	I2	from EM 1110-2-2502 Table 4-2
Sliding F.S. =	1.33	
Overturning Base Area in Compression =	75 %	
Bearing F.S. =	2	

Gravity Forces acting downaward

Wwall =	825.0	lb/lf	weight of the stem of wall
Wftg =	750.0	lb/lf	weight of the footing of wall
Wst =	600.0	lb/lf	weight of the soil above toe
Wsh =	288.0	lb/lf	weight of the soil above heel
Wwh =	686.4	lb/lf	weight of the water above heel
WG =	3149.4	lb/lf	total gravity forces acting downward

Uplift Forces acting upward

WU =	468.0	lb/lf	total uplift forces acting upward

Sliding Forces

fa_w =	1318.20	lb/lf	lateral hydrostatic force due to standing water from riverside
fa_{buoy} =	143.19	lb/lf	active saturated soil force over heel
f_S =	1461.39	lb/lf	total sliding forces

Resisting Forces

fp_{buoy} =	869.27	lb/lf	passive saturated soil force over toe
fp_w =	382.20	lb/lf	lateral hydrostatic force from landside
ffr =	1259.76	lb/lf	friction force between the footing and the soil
f_R =	2511.23	lb/lf	total resisting forces

Moment Arms from Toe

Moment Arms of Stabilizing Moment

d_{Wwall} =	2.5	ft
d_{Wftg} =	2.5	ft
d_{Wst} =	1	ft
d_{Wsh} =	4	ft
d_{Wwh} =	4	ft
d_{fpbuoy} = d_{fpw} =	1.2	ft

Moment Arms of Overturing Moment

d_{faw} =	2.167	ft
d_{fabuoy} =	1.167	ft
d_{WU} =	2.847	ft

Stabilizing Moment about Toe

M_{ST} = 9895.15 lb-ft/ft

Overturning Moment about Toe

M_{OT} = 4355.65 lb-ft/ft

Resultant

ΣV =	2681.40	lb/ft	↓ +
ΣH =	1049.84	lb/ft	← +
ΣM =	5539.50	lb-ft/ft	+ ↺
X_R =	2.07	ft	
Resultant Ratio =	0.41		

Sliding Stability Check

FS(SL) = 1.72 ➡ Acceptable

Overturning Stability Check

Base Area in Compression = 100 % ➡ Acceptable

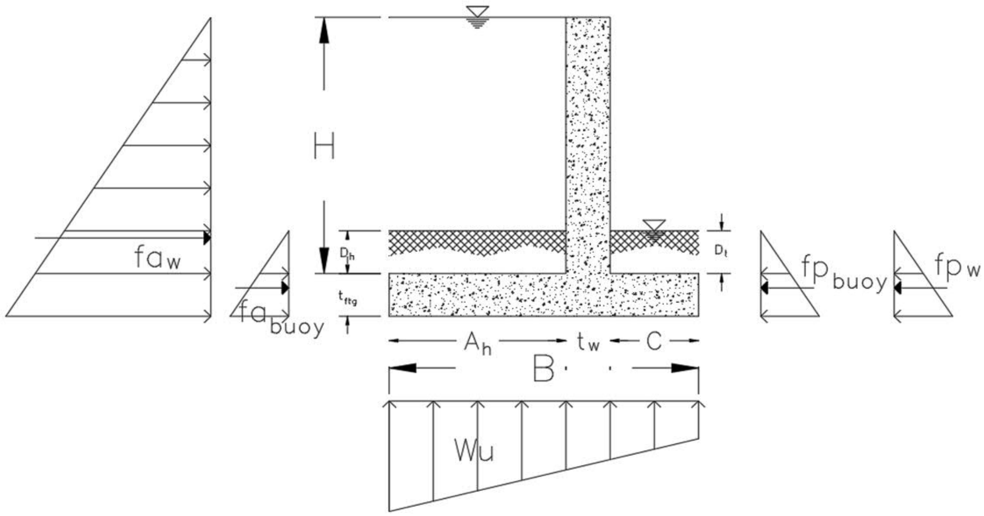
Bearing Capacity Check (from EM 1110-2-2502, Department of the Army, U. S. Army Corps of Engineers)

N' =	2681.4	lb	
T =	1049.8	lb	
α =	0.00	°	
e =	0.43	ft	
$\bar{B}$ =	4.13	ft	
δ =	21.38	°	(Figure 5-1)
γ' =	57.6	pcf	
D =	3.5	ft	
qo =	201.6	psf	[5-8a]
β =	0	°	

Nq =	10.662	[5-3a]	ξqt =	1	[5-6a]
Nc =	20.721	[5-3b]	ξγt =	1	[5-6a]
Nγ =	6.766	[5-3d]	ξct =	1	[5-6c]
ξcd =	1.266	[5-4a]	ξγg =	1	[5-7a]
ξqd =	1.133	[5-4c]	ξqg =	1	[5-7a]
ξγd =	1.133	[5-4c]	ξcg =	1	[5-7d]
ξqi =	0.581	[5-5a]			
ξci =	0.581	[5-5a]			
ξγi =	0.021	[5-5b]			

Q = 5928.00 lb [5-2]

FS = 2.21 [5-1] ➡ Acceptable



Parameters

H =	6	ft	
D_h =	2	ft	
D_t =	2	ft	
t_{ftg} =	1.5	ft	
A_h =	2.5	ft	
C =	2.5	ft	
t_{wall} =	1	ft	
B =	6	ft	
γ_{conc} =	150	pcf	unit weight of concrete (pcf)
γ_w =	62.4	pcf	specific weight of water (pcf)
γ_{soil} =	120	pcf	unit weight of the soil (pcf)
γ_{buoy} =	57.6	pcf	specific weight of submerged soil (pcf)
Soil Area	3		
Φ =	25	°	internal friction angle of drained soil
K_p =	2.46		passive soil pressure coefficient
Ka =	0.41		active soil pressure coefficient
μ =	0.40		coefficient of friction between the footing and the soil
Load Case	I2		from EM 1110-2-2502 Table 4-2
Sliding F.S. =	1.33		
Overturning Base Area in Compression =	75	%	
Bearing F.S. =	2		

Gravity Forces acting downaward

Wwall =	900.0	lb/lf	weight of the stem of wall
Wftg =	1350.0	lb/lf	weight of the footing of wall
Wst =	600.0	lb/lf	weight of the soil above toe
Wsh =	288.0	lb/lf	weight of the soil above heel
Wwh =	936.0	lb/lf	weight of the water above heel
WG =	4074.0	lb/lf	total gravity forces acting downward

Uplift Forces acting upward

WU =	748.8	lb/lf	total uplift forces acting upward

Sliding Forces

fa_w =	1755.00	lb/lf	lateral hydrostatic force due to standing water from riverside
fa_{buoy} =	143.19	lb/lf	active saturated soil force over heel
f_S =	1898.19	lb/lf	total sliding forces

Resisting Forces

fp_{buoy} =	869.27	lb/lf	passive saturated soil force over toe
fp_w =	382.20	lb/lf	lateral hydrostatic force from landside
ffr =	1629.60	lb/lf	friction force between the footing and the soil
f_R =	2881.07	lb/lf	total resisting forces

Moment Arms from Toe

Moment Arms of Stabilizing Moment

d_{Wwall} =	3	ft
d_{Wftg} =	3	ft
d_{Wst} =	1.25	ft
d_{Wsh} =	4.75	ft
d_{Wwh} =	4.75	ft
d_{fpbuoy} = d_{fpw} =	1.2	ft

Moment Arms of Overturing Moment

d_{faw} =	2.500	ft
d_{fabuoy} =	1.167	ft
d_{WU} =	3.462	ft

Stabilizing Moment about Toe

M_{ST} = 14774.05 lb-ft/ft

Overturning Moment about Toe

M_{OT} = 7146.55 lb-ft/ft

Resultant

ΣV =	3325.20	lb/ft	↓ +
ΣH =	982.88	lb/ft	← +
ΣM =	7627.50	lb-ft/ft	+ ↺
X_R =	2.29	ft	
Resultant Ratio =	0.38		

Sliding Stability Check

FS(SL) = 1.52 — Acceptable

Overturning Stability Check

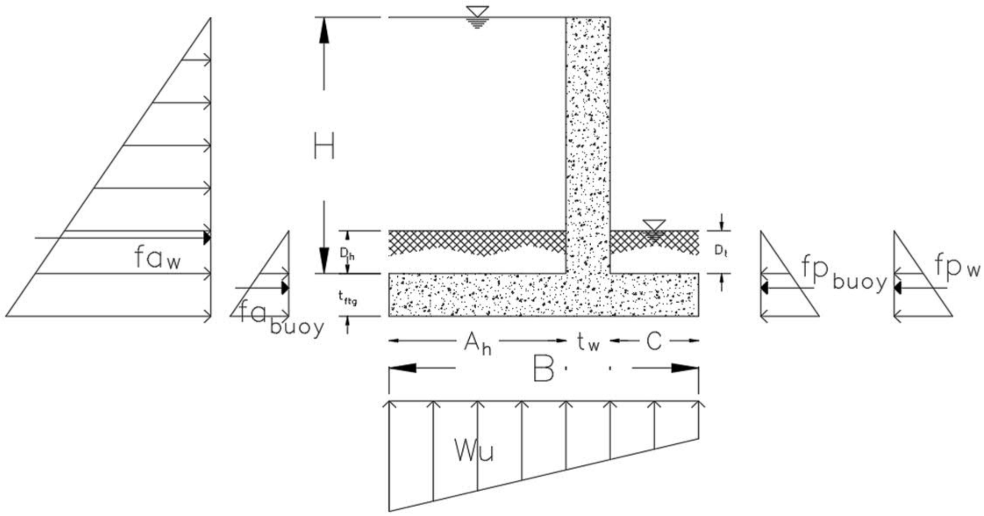
Base Area in Compression = 100 % — Acceptable

Bearing Capacity Check (from EM 1110-2-2502, Department of the Army, U. S. Army Corps of Engineers)

N' =	3325.2	lb	
T =	982.9	lb	
α =	0.00	°	
e =	0.71	ft	
$\bar{B}$ =	4.59	ft	
δ =	16.47	°	(Figure 5-1)
γ' =	57.6	pcf	
D =	3.5	ft	
qo =	201.6	psf	[5-8a]
β =	0	°	

Nq =	10.662	[5-3a]	ξqt =	1	[5-6a]
Nc =	20.721	[5-3b]	ξγt =	1	[5-6a]
Nγ =	6.766	[5-3d]	ξct =	1	[5-6c]
ξcd =	1.240	[5-4a]	ξγg =	1	[5-7a]
ξqd =	1.120	[5-4c]	ξqg =	1	[5-7a]
ξγd =	1.120	[5-4c]	ξcg =	1	[5-7d]
ξqi =	0.668	[5-5a]			
ξci =	0.668	[5-5a]			
ξγi =	0.117	[5-5b]			

Q =	7906.07	lb	[5-2]
FS =	2.38	[5-1]	Acceptable



Parameters

H =	7	ft	
D_h =	2	ft	
D_t =	2	ft	
t_{ftg} =	1.5	ft	
A_h =	4.5	ft	
C =	2	ft	
t_{wall} =	1	ft	
B =	7.5	ft	
γ_{conc} =	150	pcf	unit weight of concrete (pcf)
γ_w =	62.4	pcf	specific weight of water (pcf)
γ_{soil} =	120	pcf	unit weight of the soil (pcf)
γ_{buoy} =	57.6	pcf	specific weight of submerged soil (pcf)
Soil Area	3		
Φ =	25	°	internal friction angle of drained soil
K_p =	2.46		passive soil pressure coefficient
Ka =	0.41		active soil pressure coefficient
μ =	0.40		coefficient of friction between the footing and the soil
Load Case	I2		from EM 1110-2-2502 Table 4-2
Sliding F.S. =	1.33		
Overturning Base Area in Compression =	75	%	
Bearing F.S. =	2		

Gravity Forces acting downaward

Wwall =	1050.0	lb/lf	weight of the stem of wall
Wftg =	1687.5	lb/lf	weight of the footing of wall
Wst =	480.0	lb/lf	weight of the soil above toe
Wsh =	518.4	lb/lf	weight of the soil above heel
Wwh =	1965.6	lb/lf	weight of the water above heel
WG =	5701.5	lb/lf	total gravity forces acting downward

Uplift Forces acting upward

WU =	1170.0	lb/lf	total uplift forces acting upward

Sliding Forces

fa_w =	2254.20	lb/lf	lateral hydrostatic force due to standing water from riverside
fa_{buoy} =	143.19	lb/lf	active saturated soil force over heel
f_S =	2397.39	lb/lf	total sliding forces

Resisting Forces

fp_{buoy} =	869.27	lb/lf	passive saturated soil force over toe
fp_w =	382.20	lb/lf	lateral hydrostatic force from landside
ffr =	2280.60	lb/lf	friction force between the footing and the soil
f_R =	3532.07	lb/lf	total resisting forces

Moment Arms from Toe

Moment Arms of Stabilizing Moment

d_{Wwall} =	2.5	ft
d_{Wftg} =	3.75	ft
d_{Wst} =	1	ft
d_{Wsh} =	5.25	ft
d_{Wwh} =	5.25	ft
$d_{fpbuoy} = d_{fpw}$ =	1.2	ft

Moment Arms of Overturing Moment

d_{faw} =	2.833	ft
d_{fabuoy} =	1.167	ft
d_{WU} =	4.397	ft

Stabilizing Moment about Toe

M_{ST} = 23934.17 lb-ft/ft

Overturning Moment about Toe

M_{OT} = 11697.92 lb-ft/ft

Resultant

ΣV =	4531.50	lb/ft	↓ +
ΣH =	1134.68	lb/ft	← +
ΣM =	12236.25	lb-ft/ft	+ ↺
X_R =	2.70	ft	
Resultant Ratio =	0.36		

Sliding Stability Check

FS(SL) = 1.47 → Acceptable

Overturning Stability Check

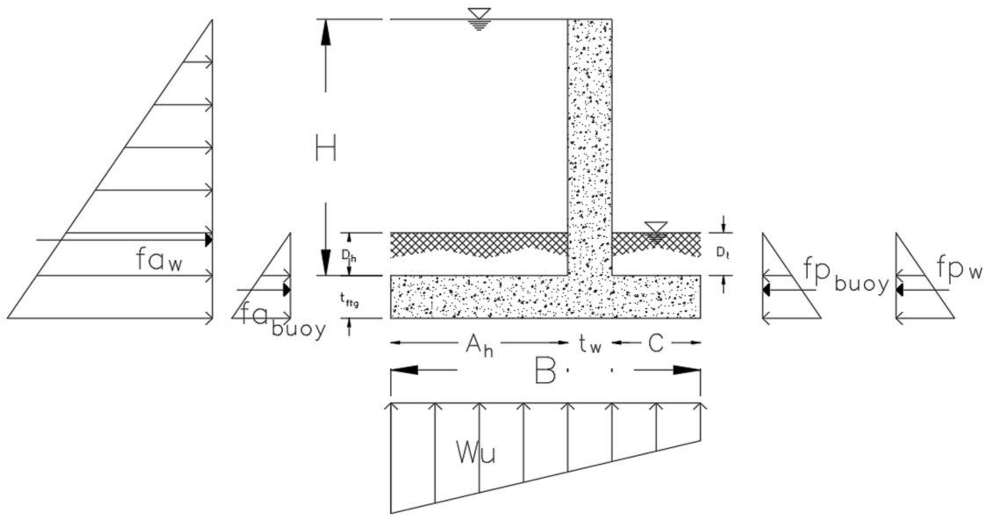
Base Area in Compression = 100 % → Acceptable

Bearing Capacity Check (from EM 1110-2-2502, Department of the Army, U. S. Army Corps of Engineers)

N' =	4531.5	lb	
T =	1134.7	lb	
α =	0.00	°	
e =	1.05	ft	
$\bar{B}$ =	5.40	ft	
δ =	14.06	°	(Figure 5-1)
γ' =	57.6	pcf	
D =	3.5	ft	
qo =	201.6	psf	[5-8a]
β =	0	°	

Nq =	10.662	[5-3a]	ξqt =	1	[5-6a]
Nc =	20.721	[5-3b]	ξγt =	1	[5-6a]
Nγ =	6.766	[5-3d]	ξct =	1	[5-6c]
ξcd =	1.203	[5-4a]	ξγg =	1	[5-7a]
ξqd =	1.102	[5-4c]	ξqg =	1	[5-7a]
ξγd =	1.102	[5-4c]	ξcg =	1	[5-7d]
ξqi =	0.712	[5-5a]			
ξci =	0.712	[5-5a]			
ξγi =	0.192	[5-5b]			

Q =	10305.44	lb	[5-2]
FS =	2.27	[5-1]	→ Acceptable



Parameters

H =	8	ft	
D_h =	2	ft	
D_t =	2	ft	
t_{ftg} =	1.5	ft	
A_h =	5	ft	
C =	2.5	ft	
t_{wall} =	1.5	ft	
B =	9	ft	
γ_{conc} =	150	pcf	unit weight of concrete (pcf)
γ_w =	62.4	pcf	specific weight of water (pcf)
γ_{soil} =	120	pcf	unit weight of the soil (pcf)
γ_{buoy} =	57.6	pcf	specific weight of submerged soil (pcf)
Soil Area	3		
Φ =	25	°	internal friction angle of drained soil
K_p =	2.46		passive soil pressure coefficient
Ka =	0.41		active soil pressure coefficient
μ =	0.40		coefficient of friction between the footing and the soil
Load Case	I2		from EM 1110-2-2502 Table 4-2
Sliding F.S. =	1.33		
Overturning Base Area in Compression =	75	%	
Bearing F.S. =	2		

Gravity Forces acting downaward

Wwall =	1800.0	lb/lf	weight of the stem of wall
Wftg =	2025.0	lb/lf	weight of the footing of wall
Wst =	600.0	lb/lf	weight of the soil above toe
Wsh =	576.0	lb/lf	weight of the soil above heel
Wwh =	2496.0	lb/lf	weight of the water above heel
WG =	7497.0	lb/lf	total gravity forces acting downward

Uplift Forces acting upward

WU =	1684.8	lb/lf	total uplift forces acting upward

Sliding Forces

fa_w =	2815.80	lb/lf	lateral hydrostatic force due to standing water from riverside
fa_{buoy} =	143.19	lb/lf	active saturated soil force over heel
f_S =	2958.99	lb/lf	total sliding forces

Resisting Forces

fp_{buoy} =	869.27	lb/lf	passive saturated soil force over toe
fp_w =	382.20	lb/lf	lateral hydrostatic force from landside
ffr =	2998.80	lb/lf	friction force between the footing and the soil
f_R =	4250.27	lb/lf	total resisting forces

Moment Arms from Toe

Moment Arms of Stabilizing Moment

d_{Wwall} =	3.25	ft
d_{Wftg} =	4.5	ft
d_{Wst} =	1.25	ft
d_{Wsh} =	6.5	ft
d_{Wwh} =	6.5	ft
$d_{fpbuoy} = d_{fpw}$ =	1.2	ft

Moment Arms of Overturing Moment

d_{faw} =	3.167	ft
d_{fabuoy} =	1.167	ft
d_{WU} =	5.344	ft

Stabilizing Moment about Toe

M_{ST} =	37140.55	lb-ft/ft

Overturning Moment about Toe

M_{OT} =	18086.90	lb-ft/ft

Resultant

ΣV =	5812.20	lb/ft	↓ +
ΣH =	1291.28	lb/ft	← +
ΣM =	19053.65	lb-ft/ft	+ ↺
X_R =	3.28	ft	
Resultant Ratio =	0.36		

Sliding Stability Check

FS(SL) = 1.44 → Acceptable

Overturning Stability Check

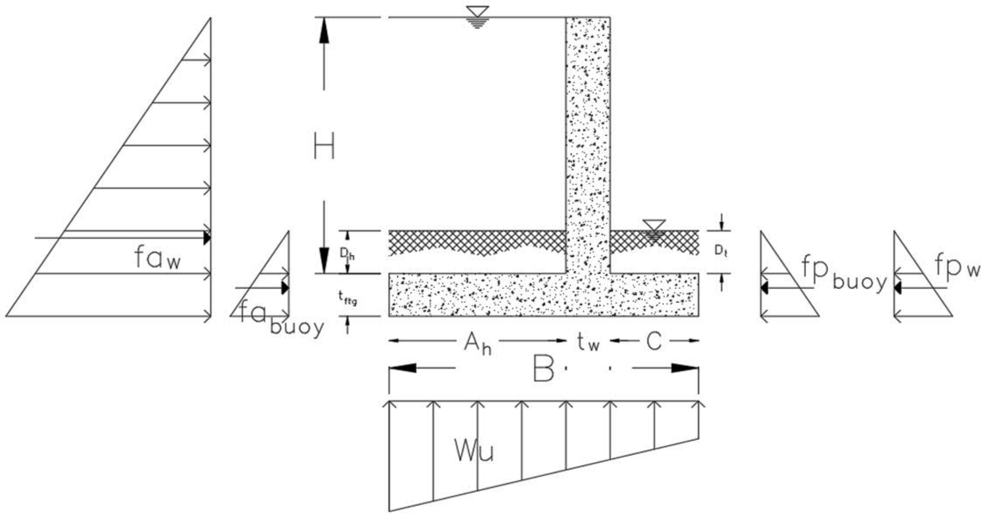
Base Area in Compression = 100 % → Acceptable

Bearing Capacity Check (from EM 1110-2-2502, Department of the Army, U. S. Army Corps of Engineers)

N' =	5812.2	lb	
T =	1291.3	lb	
α =	0.00	°	
e =	1.22	ft	
$\bar{B}$ =	6.56	ft	
δ =	12.53	°	(Figure 5-1)
γ' =	57.6	pcf	
D =	3.5	ft	
qo =	201.6	psf	[5-8a]
β =	0	°	

Nq =	10.662	[5-3a]	ξqt =	1	[5-6a]
Nc =	20.721	[5-3b]	ξγt =	1	[5-6a]
Nγ =	6.766	[5-3d]	ξct =	1	[5-6c]
ξcd =	1.168	[5-4a]	ξγg =	1	[5-7a]
ξqd =	1.084	[5-4c]	ξqg =	1	[5-7a]
ξγd =	1.084	[5-4c]	ξcg =	1	[5-7d]
ξqi =	0.741	[5-5a]			
ξci =	0.741	[5-5a]			
ξγi =	0.249	[5-5b]			

Q =	13578.28	lb	[5-2]
FS =	2.34	[5-1]	→ Acceptable



Parameters

H =	9	ft	
D_h =	2	ft	
D_t =	2	ft	
t_{ftg} =	2	ft	
A_h =	6.5	ft	
C =	3	ft	
t_{wall} =	1.5	ft	
B =	11	ft	
γ_{conc} =	150	pcf	unit weight of concrete (pcf)
γ_w =	62.4	pcf	specific weight of water (pcf)
γ_{soil} =	120	pcf	unit weight of the soil (pcf)
γ_{buoy} =	57.6	pcf	specific weight of submerged soil (pcf)
Soil Area	3		
Φ =	25	°	internal friction angle of drained soil
K_p =	2.46		passive soil pressure coefficient
Ka =	0.41		active soil pressure coefficient
μ =	0.40		coefficient of friction between the footing and the soil
Load Case	I2		from EM 1110-2-2502 Table 4-2
Sliding F.S. =	1.33		
Overturning Base Area in Compression =	75	%	
Bearing F.S. =	2		

Gravity Forces acting downaward

Wwall =	2025.0	lb/lf	weight of the stem of wall
Wftg =	3300.0	lb/lf	weight of the footing of wall
Wst =	720.0	lb/lf	weight of the soil above toe
Wsh =	748.8	lb/lf	weight of the soil above heel
Wwh =	3650.4	lb/lf	weight of the water above heel
WG =	10444.2	lb/lf	total gravity forces acting downward

Uplift Forces acting upward

WU =	2402.4	lb/lf	total uplift forces acting upward

Sliding Forces

fa_w =	3775.20	lb/lf	lateral hydrostatic force due to standing water from riverside
fa_{buoy} =	187.02	lb/lf	active saturated soil force over heel
f_S =	3962.22	lb/lf	total sliding forces

Resisting Forces

fp_{buoy} =	1135.37	lb/lf	passive saturated soil force over toe
fp_w =	499.20	lb/lf	lateral hydrostatic force from landside
ffr =	4177.68	lb/lf	friction force between the footing and the soil
f_R =	5812.25	lb/lf	total resisting forces

Moment Arms from Toe

Moment Arms of Stabilizing Moment

d_{Wwall} =	3.75	ft
d_{Wftg} =	5.5	ft
d_{Wst} =	1.5	ft
d_{Wsh} =	7.75	ft
d_{Wwh} =	7.75	ft
$d_{fpbuoy} = d_{fpw}$ =	1.3	ft

Moment Arms of Overturing Moment

d_{faw} =	3.667	ft
d_{fabuoy} =	1.333	ft
d_{WU} =	6.561	ft

Stabilizing Moment about Toe

M_{ST} =	63096.98	lb-ft/ft

Overturning Moment about Toe

M_{OT} =	29854.88	lb-ft/ft

Resultant

ΣV =	8041.80	lb/ft	↓ +
ΣH =	1850.03	lb/ft	← +
ΣM =	33242.10	lb-ft/ft	+ ↺
X_R =	4.13	ft	
Resultant Ratio =	0.38		

Sliding Stability Check

FS(SL) =	1.47		Acceptable

Overturning Stability Check

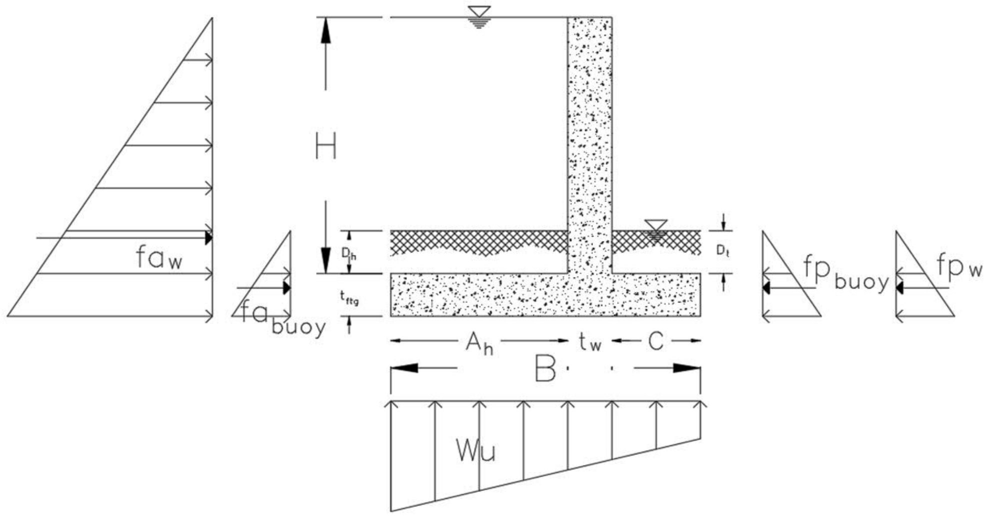
Base Area in Compression =	100	%	Acceptable

Bearing Capacity Check (from EM 1110-2-2502, Department of the Army, U. S. Army Corps of Engineers)

N' =	8041.8	lb	
T =	1850.0	lb	
α =	0.00	°	
e =	1.37	ft	
$\bar{B}$ =	8.27	ft	
δ =	12.96	°	(Figure 5-1)
γ' =	57.6	pcf	
D =	4	ft	
qo =	230.4	psf	[5-8a]
β =	0	°	

Nq =	10.662	[5-3a]	ξqt =	1	[5-6a]
Nc =	20.721	[5-3b]	ξγt =	1	[5-6a]
Nγ =	6.766	[5-3d]	ξct =	1	[5-6c]
ξcd =	1.152	[5-4a]	ξγg =	1	[5-7a]
ξqd =	1.076	[5-4c]	ξqg =	1	[5-7a]
ξγd =	1.076	[5-4c]	ξcg =	1	[5-7d]
ξqi =	0.733	[5-5a]			
ξci =	0.733	[5-5a]			
ξγi =	0.232	[5-5b]			

Q =	19339.14	lb	[5-2]
FS =	2.40	[5-1]	Acceptable



Parameters

$H =$	10	ft	
$D_h =$	2	ft	
$D_t =$	2	ft	
$t_{ftg} =$	2	ft	
$A_h =$	7.5	ft	
$C =$	3.5	ft	
$t_{wall} =$	1.5	ft	
$B =$	12.5	ft	
$\gamma_{conc} =$	150	pcf	unit weight of concrete (pcf)
$\gamma_w =$	62.4	pcf	specific weight of water (pcf)
$\gamma_{soil} =$	120	pcf	unit weight of the soil (pcf)
$\gamma_{buoy} =$	57.6	pcf	specific weight of submerged soil (pcf)
Soil Area	3		
$\Phi =$	25	°	internal friction angle of drained soil
$K_p =$	2.46		passive soil pressure coefficient
$Ka =$	0.41		active soil pressure coefficient
$\mu =$	0.40		coefficient of friction between the footing and the soil
Load Case	I2		from EM 1110-2-2502 Table 4-2
Sliding F.S. =	1.33		
Overturning Base Area in Compression =	75	%	
Bearing F.S. =	2		

Gravity Forces acting downaward

Wwall =	2250.0	lb/lf	weight of the stem of wall
Wftg =	3750.0	lb/lf	weight of the footing of wall
Wst =	840.0	lb/lf	weight of the soil above toe
Wsh =	864.0	lb/lf	weight of the soil above heel
Wwh =	4680.0	lb/lf	weight of the water above heel
WG =	12384.0	lb/lf	total gravity forces acting downward

Uplift Forces acting upward

WU =	3120.0	lb/lf	total uplift forces acting upward

Sliding Forces

fa_w =	4492.80	lb/lf	lateral hydrostatic force due to standing water from riverside
fa_{buoy} =	187.02	lb/lf	active saturated soil force over heel
f_S =	4679.82	lb/lf	total sliding forces

Resisting Forces

fp_{buoy} =	1135.37	lb/lf	passive saturated soil force over toe
fp_w =	499.20	lb/lf	lateral hydrostatic force from landside
ffr =	4953.60	lb/lf	friction force between the footing and the soil
f_R =	6588.17	lb/lf	total resisting forces

Moment Arms from Toe

Moment Arms of Stabilizing Moment

d_{Wwall} =	4.25	ft
d_{Wftg} =	6.25	ft
d_{Wst} =	1.75	ft
d_{Wsh} =	8.75	ft
d_{Wwh} =	8.75	ft
$d_{fpbuoy} = d_{fpw}$ =	1.3	ft

Moment Arms of Overturing Moment

d_{faw} =	4.000	ft
d_{fabuoy} =	1.333	ft
d_{WU} =	7.520	ft

Stabilizing Moment about Toe

M_{ST} = 85159.43 lb-ft/ft

Overturning Moment about Toe

M_{OT} = 41683.97 lb-ft/ft

Resultant

ΣV =	9264.00	lb/ft	↓ +
ΣH =	1908.35	lb/ft	← +
ΣM =	43475.45	lb-ft/ft	+ ↶
X_R =	4.69	ft	
Resultant Ratio =	0.38		

Sliding Stability Check

FS(SL) = 1.41 → **Acceptable**

Overturning Stability Check

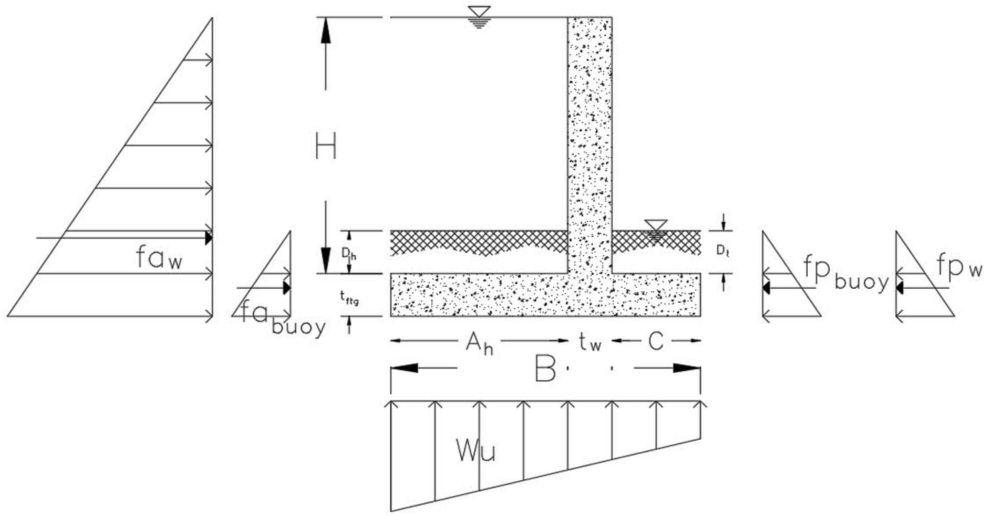
Base Area in Compression = 100 % → **Acceptable**

Bearing Capacity Check (from EM 1110-2-2502, Department of the Army, U. S. Army Corps of Engineers)

N' =	9264.0	lb	
T =	1908.4	lb	
α =	0.00	°	
e =	1.56	ft	
$\bar{B}$ =	9.39	ft	
δ =	11.64	°	(Figure 5-1)
γ' =	57.6	pcf	
D =	4	ft	
qo =	230.4	psf	[5-8a]
β =	0	°	

Nq =	10.662	[5-3a]	ξqt =	1	[5-6a]
Nc =	20.721	[5-3b]	ξγt =	1	[5-6a]
Nγ =	6.766	[5-3d]	ξct =	1	[5-6c]
ξcd =	1.134	[5-4a]	ξγg =	1	[5-7a]
ξqd =	1.067	[5-4c]	ξqg =	1	[5-7a]
ξγd =	1.067	[5-4c]	ξcg =	1	[5-7d]
ξqi =	0.758	[5-5a]			
ξci =	0.758	[5-5a]			
ξγi =	0.286	[5-5b]			

Q =	23877.91	lb	[5-2]
FS =	2.58	[5-1]	→ **Acceptable**



Parameters

H =	11	ft	
D_h =	2	ft	
D_t =	2	ft	
t_{ftg} =	2.5	ft	
A_h =	8	ft	
C =	4	ft	
t_{wall} =	2	ft	
B =	14	ft	
γ_{conc} =	150	pcf	unit weight of concrete (pcf)
γ_w =	62.4	pcf	specific weight of water (pcf)
γ_{soil} =	120	pcf	unit weight of the soil (pcf)
γ_{buoy} =	57.6	pcf	specific weight of submerged soil (pcf)
Soil Area	3		
Φ =	25	°	internal friction angle of drained soil
K_p =	2.46		passive soil pressure coefficient
Ka =	0.41		active soil pressure coefficient
μ =	0.40		coefficient of friction between the footing and the soil
Load Case	I2		from EM 1110-2-2502 Table 4-2
Sliding F.S. =	1.33		
Overturning Base Area in Compression =	75	%	
Bearing F.S. =	2		

Gravity Forces acting downaward

Wwall =	3300.0	lb/lf	weight of the stem of wall
Wftg =	5250.0	lb/lf	weight of the footing of wall
Wst =	960.0	lb/lf	weight of the soil above toe
Wsh =	921.6	lb/lf	weight of the soil above heel
Wwh =	5491.2	lb/lf	weight of the water above heel
WG =	15922.8	lb/lf	total gravity forces acting downward

Uplift Forces acting upward

WU =	3931.2	lb/lf	total uplift forces acting upward

Sliding Forces

fa_w =	5686.20	lb/lf	lateral hydrostatic force due to standing water from riverside
fa_{buoy} =	236.70	lb/lf	active saturated soil force over heel
f_S =	5922.90	lb/lf	total sliding forces

Resisting Forces

fp_{buoy} =	1436.95	lb/lf	passive saturated soil force over toe
fp_w =	631.80	lb/lf	lateral hydrostatic force from landside
ffr =	6369.12	lb/lf	friction force between the footing and the soil
f_R =	8437.87	lb/lf	total resisting forces

Moment Arms from Toe

Moment Arms of Stabilizing Moment

d_{Wwall} =	5	ft
d_{Wftg} =	7	ft
d_{Wst} =	2	ft
d_{Wsh} =	10	ft
d_{Wwh} =	10	ft
$d_{fpbuoy} = d_{fpw}$ =	1.5	ft

Moment Arms of Overturing Moment

d_{faw} =	4.500	ft
d_{fabuoy} =	1.500	ft
d_{WU} =	8.420	ft

Stabilizing Moment about Toe

M_{ST} = 122401.13 lb-ft/ft

Overturning Moment about Toe

M_{OT} = 59044.79 lb-ft/ft

Resultant

ΣV =	11991.60	lb/ft	↓ +
ΣH =	2514.98	lb/ft	← +
ΣM =	63356.34	lb-ft/ft	+ ↺
X_R =	5.28	ft	
Resultant Ratio =	0.38		

Sliding Stability Check

FS(SL) = 1.42 ➡ Acceptable

Overturning Stability Check

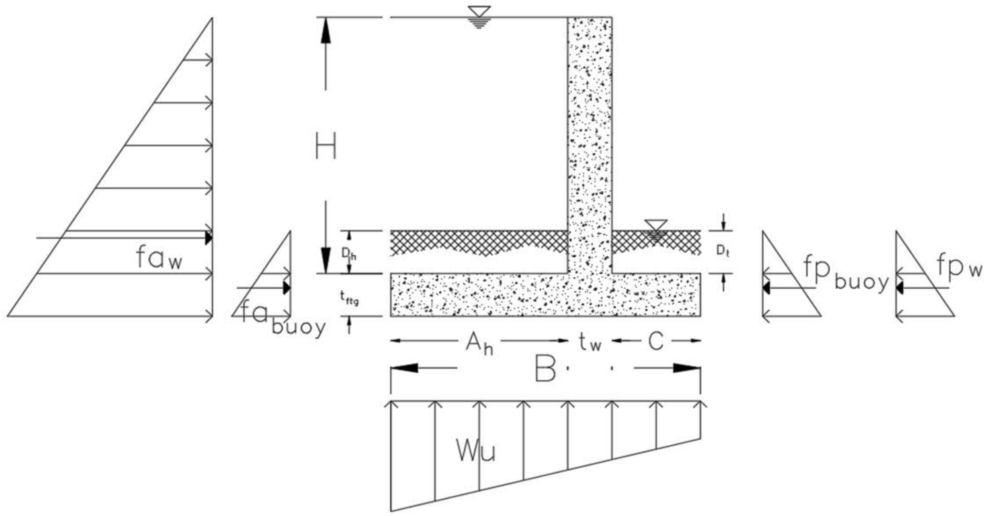
Base Area in Compression = 100 % ➡ Acceptable

Bearing Capacity Check (from EM 1110-2-2502, Department of the Army, U. S. Army Corps of Engineers)

N' =	11991.6	lb	
T =	2515.0	lb	
α =	0.00	°	
e =	1.72	ft	
$\bar{B}$ =	10.57	ft	
δ =	11.84	°	(Figure 5-1)
γ' =	57.6	pcf	
D =	4.5	ft	
qo =	259.2	psf	[5-8a]
β =	0	°	

Nq =	10.662	[5-3a]	ξqt =	1	[5-6a]
Nc =	20.721	[5-3b]	ξγt =	1	[5-6a]
Nγ =	6.766	[5-3d]	ξct =	1	[5-6c]
ξcd =	1.134	[5-4a]	ξγg =	1	[5-7a]
ξqd =	1.067	[5-4c]	ξqg =	1	[5-7a]
ξγd =	1.067	[5-4c]	ξcg =	1	[5-7d]
ξqi =	0.754	[5-5a]			
ξci =	0.754	[5-5a]			
ξγi =	0.277	[5-5b]			

Q =	29920.62	lb	[5-2]
FS =	2.50	[5-1]	➡ Acceptable



Parameters

H =	12	ft
D_h =	2	ft
D_t =	2	ft
t_{ftg} =	2.5	ft
A_h =	9	ft
C =	5	ft
t_{wall} =	2	ft
B =	16	ft

γ_{conc} =	150	pcf	unit weight of concrete (pcf)
γ_w =	62.4	pcf	specific weight of water (pcf)
γ_{soil} =	120	pcf	unit weight of the soil (pcf)
γ_{buoy} =	57.6	pcf	specific weight of submerged soil (pcf)

Soil Area	3		
Φ =	25	°	internal friction angle of drained soil
K_p =	2.46		passive soil pressure coefficient
Ka =	0.41		active soil pressure coefficient
μ =	0.40		coefficient of friction between the footing and the soil

Load Case	I2		from EM 1110-2-2502 Table 4-2
Sliding F.S. =	1.33		
Overturning Base Area in Compression =	75	%	
Bearing F.S. =	2		

Gravity Forces acting downaward

Wwall =	3600.0	lb/lf	weight of the stem of wall
Wftg =	6000.0	lb/lf	weight of the footing of wall
Wst =	1200.0	lb/lf	weight of the soil above toe
Wsh =	1036.8	lb/lf	weight of the soil above heel
Wwh =	6739.2	lb/lf	weight of the water above heel
WG =	18576.0	lb/lf	total gravity forces acting downward

Uplift Forces acting upward

WU =	4992.0	lb/lf	total uplift forces acting upward

Sliding Forces

fa_w =	6559.80	lb/lf	lateral hydrostatic force due to standing water from riverside
fa_{buoy} =	236.70	lb/lf	active saturated soil force over heel
f_S =	6796.50	lb/lf	total sliding forces

Resisting Forces

fp_{buoy} =	1436.95	lb/lf	passive saturated soil force over toe
fp_w =	631.80	lb/lf	lateral hydrostatic force from landside
ffr =	7430.40	lb/lf	friction force between the footing and the soil
f_R =	9499.15	lb/lf	total resisting forces

Moment Arms from Toe

Moment Arms of Stabilizing Moment

d_{Wwall} =	6	ft
d_{Wftg} =	8	ft
d_{Wst} =	2.5	ft
d_{Wsh} =	11.5	ft
d_{Wwh} =	11.5	ft
d_{fpbuoy} = d_{fpw} =	1.5	ft

Moment Arms of Overturing Moment

d_{faw} =	4.833	ft
d_{fabuoy} =	1.500	ft
d_{WU} =	9.707	ft

Stabilizing Moment about Toe

M_{ST} = 165127.13 lb-ft/ft

Overturning Moment about Toe

M_{OT} = 80516.43 lb-ft/ft

Resultant

ΣV =	13584.00	lb/ft	↓ +
ΣH =	2702.66	lb/ft	← +
ΣM =	84610.71	lb-ft/ft	+ ↶
X_R =	6.23	ft	
Resultant Ratio =	0.39		

Sliding Stability Check

FS(SL) = 1.40 → Acceptable

Overturning Stability Check

Base Area in Compression = 100 % → Acceptable

Bearing Capacity Check (from EM 1110-2-2502, Department of the Army, U. S. Army Corps of Engineers)

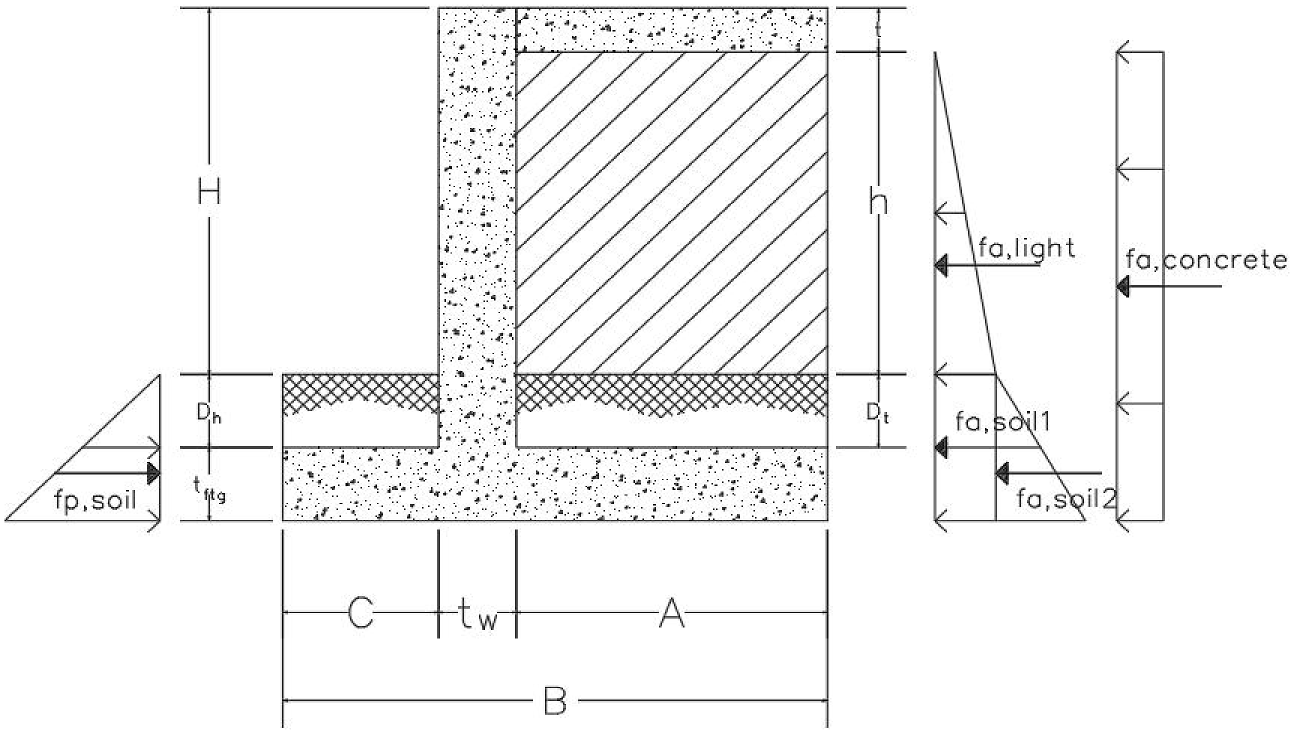
N' =	13584.0	lb	
T =	2702.7	lb	
α =	0.00	°	
e =	1.77	ft	
$\bar{B}$ =	12.46	ft	
δ =	11.25	°	(Figure 5-1)
γ' =	57.6	pcf	
D =	4.5	ft	
qo =	259.2	psf	[5-8a]
β =	0	°	

Nq =	10.662	[5-3a]	ξqt =	1	[5-6a]
Nc =	20.721	[5-3b]	ξγt =	1	[5-6a]
Nγ =	6.766	[5-3d]	ξct =	1	[5-6c]
ξcd =	1.113	[5-4a]	ξγg =	1	[5-7a]
ξqd =	1.057	[5-4c]	ξqg =	1	[5-7a]
ξγd =	1.057	[5-4c]	ξcg =	1	[5-7d]
ξqi =	0.766	[5-5a]			
ξci =	0.766	[5-5a]			
ξγi =	0.302	[5-5b]			

Q =	37513.36	lb	[5-2]
FS =	2.76	[5-1]	→ Acceptable

Attachment C2-B

Concrete Retaining Wall Design for Cantilever Walkway Option 1



Parameters

H =	8	ft	
D_h =	1	ft	
D_t =	1	ft	
t_{ftg} =	2	ft	
A =	4	ft	
C =	2	ft	
t_{wall} =	1	ft	
B =	7	ft	
t =	1	ft	
h =	7	ft	
γ_{conc} =	150	pcf	unit weight of concrete (pcf)
$\gamma_{lightsoil}$ =	60	pcf	unit weight of light soil (pcf)
γ_{soil} =	120	pcf	unit weight of soil (pcf)
ϕ =	25	°	internal friction angle of soil
ϕ,light =	40	°	internal friction angle of light soil
Soil Area	3		
Kp =	2.46		passive pressure coefficient of soil
Ka =	0.41		active pressure coefficient of soil
Kp,light =	4.60		passive pressure coefficient of light soil
Ka,light =	0.22		active pressure coefficient of light soil
qallowable =	1420	psf	allowable soil bearing pressure below the footing
μ =	0.5		coefficient of friction between the footing and the soil
Live Load on walkway =	310	psf	walkway (60 psf) + driveway (250 psf)
Dead Load on walkway =	150	psf	weight of concrete slab
S (Surcharge on walkway) =	460	psf	LL + DL

Gravity Forces acting downaward

Wwall =	1350.0	lb/lf	weight of the stem of wall
Wftg =	2100.0	lb/lf	weight of the footing of wall
Wst =	240.0	lb/lf	weight of the soil above toe
Wsh =	480.0	lb/lf	weight of the soil above heel
Wwh =	1680.0	lb/lf	weight of the light soil above heel
Wc =	600.0	lb/lf	weight of the concrete slab above light soil
WG =	6450.0	lb/lf	total gravity forces acting downward

Sliding Forces

fa_{light} =	319.64	lb/lf	active lightweight soil force
$fa_{soil,1}$ =	273.98	lb/lf	active soil force rectangular
$fa_{soil,2}$ =	219.16	lb/lf	active soil force triangular
$fa_{concrete}$ =	1000.24	lb/lf	lateral force by concrete (surcharge effect)
f_S =	1813.02	lb/lf	total sliding forces

Resisting Forces

fp =	1330.51	lb/lf	passive soil force
ffr =	3225.00	lb/lf	friction force between the footing and the soil
f_R =	4555.51	lb/lf	total resisting forces

Moment Arms from Toe

Moment Arms of Stabilizing Moment

d_{Wwall} =	2.5	ft
d_{Wftg} =	3.5	ft
d_{Wst} =	1	ft
d_{Wsh} =	5	ft
d_{Wwh} =	5	ft
d_{Wc} =	5	ft
d_{fp} =	1	ft

Moment Arms of Overturning Moment

$d_{falight}$ =	5.3	ft
$d_{fasoil,1}$ =	1.5	ft
$d_{fasoil,2}$ =	2	ft
$d_{faconcrete}$ =	5	ft

Stabilizing Moment about Toe

M_{ST} = 26095.51 lb-ft/ft

Overturning Moment about Toe

M_{OT} = 7482.18 lb-ft/ft

Eccentricity

e = 0.61 ft

Soil Pressure created by the Forces acting on the Wall

q_{toe} =	1406.53	psf	soil pressure at toe
q_{heel} =	436.33	psf	soil pressure at heel

Sliding Stability Check

FS(SL) = 2.51 → Acceptable

Overturning Stability Check

FS(OT) = 3.49 → Acceptable

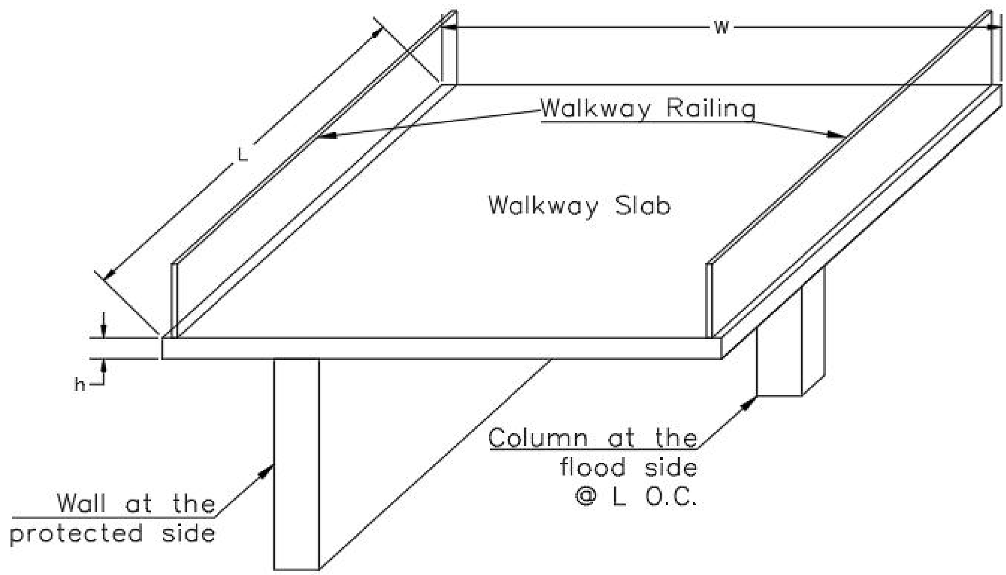
Soil Bearing Capacity Check

qallowable = 1420 psf
qmax = 1406.53 psf

→ Acceptable

Attachment C2-C

Cantilever Walkway Design at Main Street Pump Station



Material Properties

γc =	150 pcf	concrete density
fc' =	5 ksi	28 day compressive strength
fy =	60 ksi	steel reinforcing stress
β_1 =	0.8	ACI 318-14 Table 22.2.2.4.3
λ =	1	normal-weight concrete

Geometric Properties

W =	25 ft	total width of walkway
L =	24 ft	distance between columns

Loads

Dead Loads

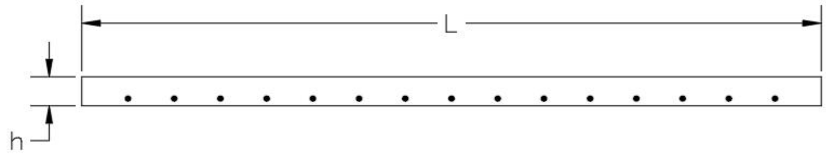
Walkway Railing	10 plf

Live Loads

Walkway and Elevated Platforms	60 psf
Vehicular Driveway	250 psf

Slab Design

L = 24 ft



Reinforcement

Try # 8
Number of Rebars 8
db = 1 in
As,b = 6.28 in2

Loads

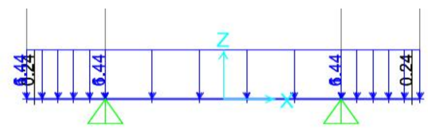
Dead Loads

Concrete 300 plf
Walkway railing 240 lb

Live Loads

Walkway and elevated platforms 1440 plf
Vehicular driveway 6000 plf

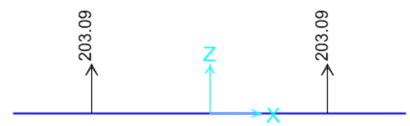
Mu = 252.20 ft-kips (From SAP-2000)
Vu = 121.68 kips (From SAP-2000)
Reaction at wall and column (Pu) = 203.09 kips (From SAP-2000)



Parameters

Try h = 12 in

Clear cover = 2 in ACI 318-14 Table 20.6.1.3.1
d = 9.5 in
a = 0.31 in



Moment Check

Mn = 293.61 ft-kips
ϕ_b = 0.9 ACI 318-14 Table 21.2.2

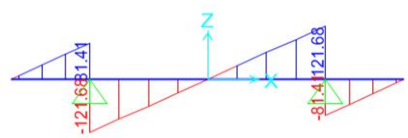
ϕ_bMn = 264.25 ft-kips
Mu = 252.20 ft-kips

→ **Acceptable** efficiency = 95.44%

Minimum Width

bmin = 19.3 in
L = 288 in

→ **Acceptable**



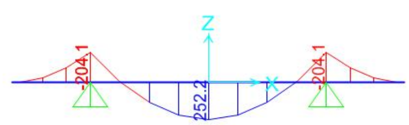
Steel Area Check

ρ = 0.0023
ρmax = 0.0212 → Acceptable ρ when εt equals 0.005
ρmin = 0.0023 → Acceptable ACI 318-14 Table 7.6.1.1

Spacing of Reinforcement Check (ACI 318-14 Chapter 25.2.1)

spacing,min = 1.00 in
spacing = 36.00 in

→ **Acceptable**



Shear Check

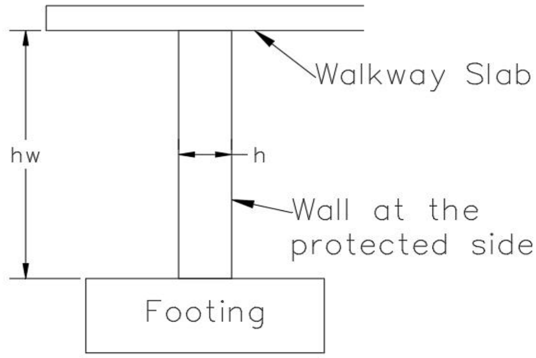
Vc = 386.93 kips ACI 318-14 Equation 22.5.5.1
ϕ_v = 0.75 ACI 318-14 Table 21.2.1

ϕ_vVc = 290.20 kips
Vu = 121.68 kips

→ **Shear Stirrups Not Required** ACI 318-14 Chapter 7.6.3.1

Wall Design

L = 24 ft



Transverse (Horizontal) Reinforcement

Try # 5
Spacing(st) = 12 in
dt = 0.625 in

Longitudinal (Vertical) Reinforcement

Try # 5
Spacing(sl) = 18 in
dl = 0.625 in

Loads (From SAP-2000)

Pu = 203.09 kips

Parameters

Try h = 12 in
Try hw = 9.5 ft

Clear cover = 3 in — ACI 318-14 Table 20.6.1.3.1

Bearing Strength Check (ACI 318-14 Table 22.8.3.2 (c))

Bn = 14688.00 kips
ϕ = 0.65 — ACI 318-14 Table 21.2.1

ϕBn = 9547.20 kips
Bu = 203.09 kips → Acceptable — efficiency = 2.13%

Horizontal Length of Wall Considered as Effective for Resisting Each Concentrated Load (ACI 318-14 Chapter 11.2.3.1)

Leffective = 24 ft

Axial Compression Check

Ag =	3456 in2	gross area of the wall section
lc =	114 in	vertical distance between supports
k =	0.8	effective length factor (ACI 318-14 Table 11.5.3.2)
Pn =	8967.9 kips	ACI 318-14 Equation 11.5.3.1
ϕ_p =	0.65	ACI 318-14 Table 21.2.2

ϕ_pPn,max = 5829.14 kips
Pu = 203.09 kips → Acceptable — efficiency = 3.48%

Minimum Wall Thickness (ACI 318-14 Table 11.3.1.1)

hmin = 4.56 in
h = 12.00 in → Acceptable

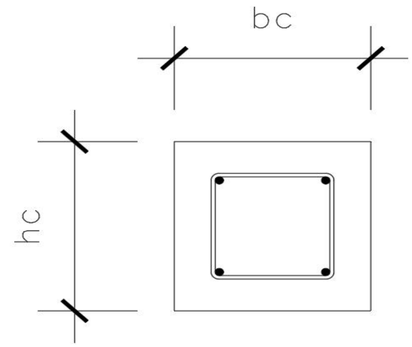
Spacing of Reinforcement Check (ACI 318-14 Chapter 11.7.2.1 & 11.7.3.1)

sl, max = 18 in → Acceptable
st, max = 18 in → Acceptable

Minimum Reinforcement Check (ACI 318-14 Table 11.6.1)

Longitudinal Reinforcement
ρl, min = 0.0012
As,l min = 0.173 in2/ft
As,l = 0.20 in2/ft → Acceptable

Transverse Reinforcement
ρt, min = 0.0020
As,t min = 0.288 in2/ft
As,t = 0.31 in2/ft → Acceptable



Column Design

Ties

Try #	3	
Number of Legs	2	
Spacing between ties =	18	in
dt =	0.375	in
As,t =	0.22	in2

Longitudinal Reinforcement

Try #	9	
Number of Rebars	6	
db =	1.128	in
As,b =	6.00	in2

Loads (From SAP-2000)

Pu =	203.09	kips

Parameters

Try hc =	24	in	
Try bc =	24	in	
Clear cover =	3	in	ACI 318-14 Table 20.6.1.3.1

Axial Compression Check

Ag =	576	in2	gross concrete area
Ast =	6.00	in2	total area of longitudinal reinforcement
Po =	2782.28	kips	ACI 318-14 Equation 22.4.2.2
Pn,max =	2225.82	kips	ACI 318-14 Table 22.4.2.1
ϕ_p =	0.65		ACI 318-14 Table 21.2.2

ϕ_pPn,max =	1446.78	kips	→ Acceptable
Pu =	203.09	kips	efficiency = 14.04%

Number of Longitudinal Reinforcement Check (ACI 318-14 Chapter 10.7.3.1)

nmin =	4	→ Acceptable
n =	6	

Size of Ties Check (ACI 318-14 Chapter 25.7.2.2)

Minimum Tie Size =	3	→ Acceptable
Tie Size =	3	

Spacing of Ties Check (ACI 318-14 Table 9.7.6.2.2)

smax =	18	in	→ Acceptable
s =	18	in	

Steel Area Check (ACI 318-14 Chapter 10.6.1.1)

Ast =	6.00	in2	
Ast,max =	46.08	in2	→ Acceptable
Ast,min =	5.76	in2	→ Acceptable

Spacing of Longitudinal Reinforcement Check (ACI 318-14 Chapter 25.2.3)

spacing,min =	1.69	in	→ Acceptable
spacing =	6.93	in	

Attachment C2-D

Breaking Wave Loads Check for Cantilever Walkway Main Street Pump Station

AECOM

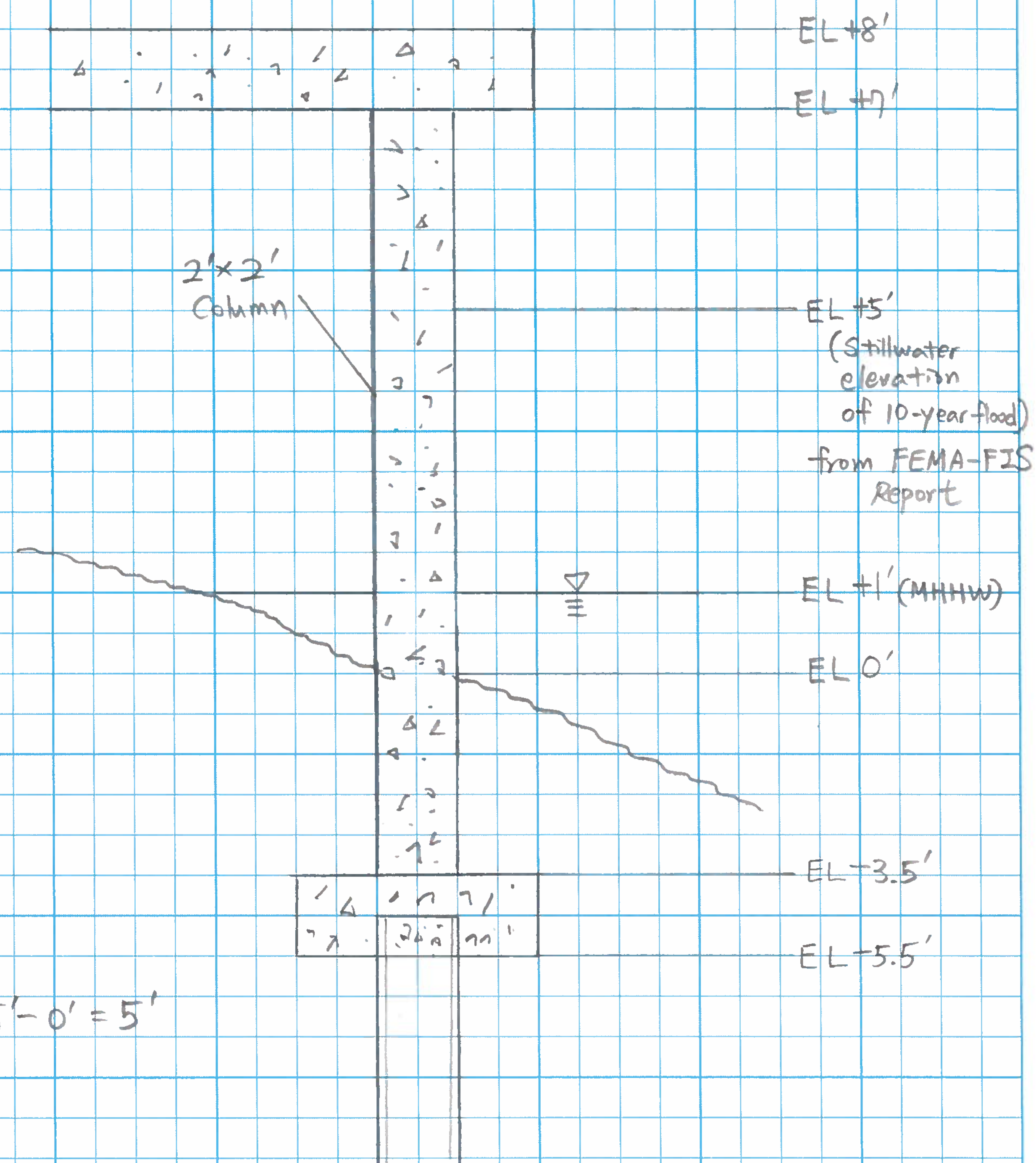
JOB TITLE Rebuild by Design Meadowlands – Cantilever Walkway at Pumping Station Column on Breaking Wave Loads Check

PROJECT/JOB NO. 60513717 CALCULATION NO.

COMPUTED BY DATE

VERIFIED BY DATE

SCALE SHEET NO. 1 OF



$d_s = 5' - 0' = 5'$

design stillwater depth

$F_D = 0.5\,\gamma_w C_D D H_b^2$ (ASCE 7-10 Equation 5.4-4: Breaking Wave Loads on Vertical Pilings and Columns)

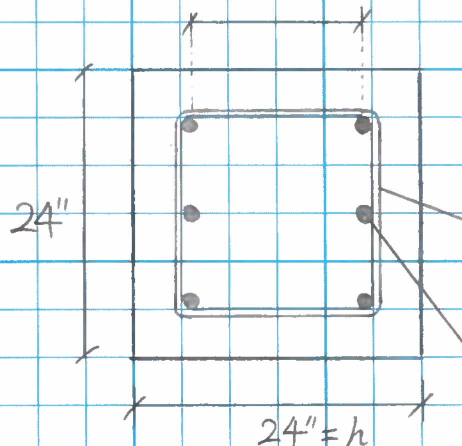
$= 0.5 \times 62.4\,\text{pcf} \times 2.25 \times (1.4 \times 2') \times (0.78 \times 5')^2$

$F_D = 2989.68\ \text{lbs} = 2.99\ \text{kips}$ acting at the still water elevation

4x4 = 1 in

Clear Cover — diameter of tie — diameter of longitudinal reinforcement

$$24'' - 2\times 3'' - 2\times 0.375'' - 2\times \frac{1.128''}{2} = 16.12'' = \gamma h$$



$$\gamma = \frac{16.12''}{24''} = 0.67$$

6#9 bars ($A_s = 6\,in^2 \Rightarrow \rho_g = \frac{6\,in^2}{24''\times 24''} = 0.01$)

From SAP-2000,

$$P_u = 203.09^k$$

$$P_n = \frac{203.09^k}{0.65} = 312.45^k$$

From Breaking Wave Loads,

$$M_u = F_D \times (5' - (-3.5')) \times 1.6 = 2.99^k \times 8.5' \times 1.6 = 40.66\text{ ft-k}$$

$$M_n = \frac{40.66\text{ ft-k}}{0.65} = 62.55\text{ ft-k}$$

$$e = \frac{M_n}{P_n} = \frac{62.55\text{ ft-k}}{312.45^k} = 0.2\text{ ft} = 2.4''$$

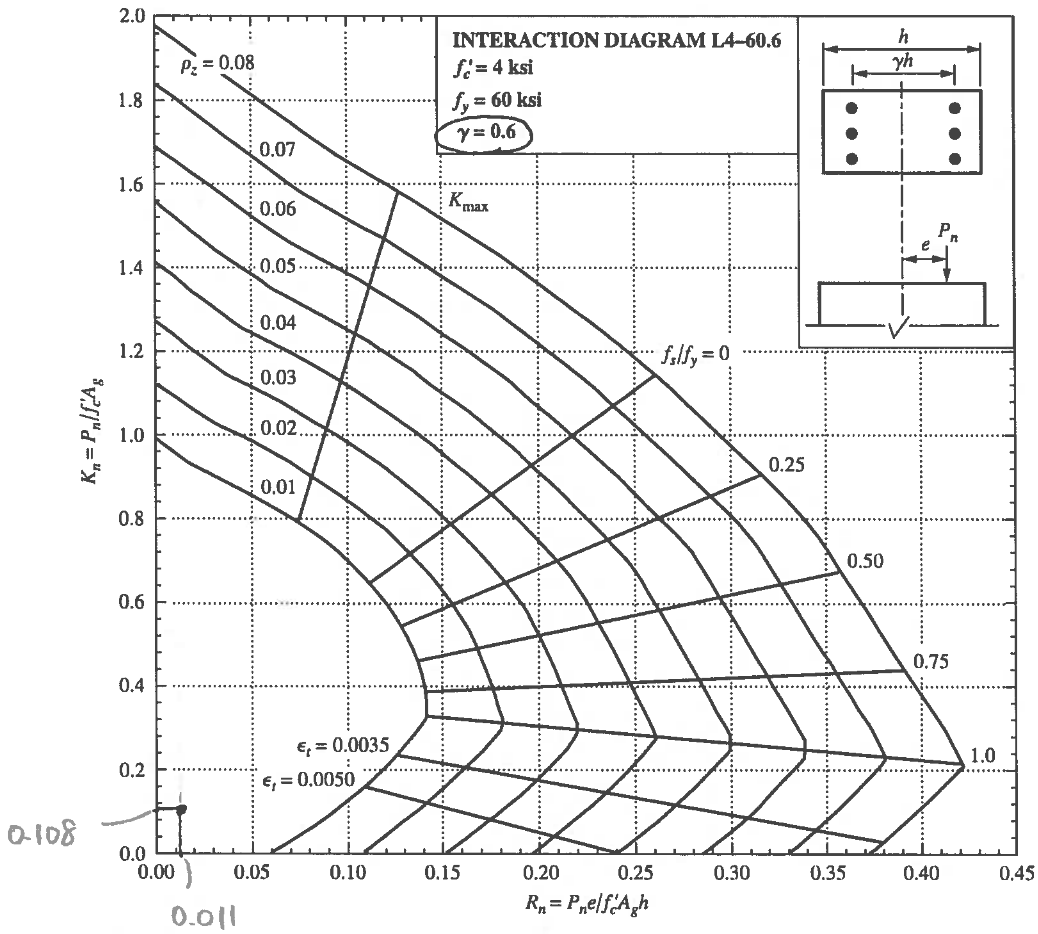
From Column Interaction Diagram,

$$K_n = \frac{P_n}{f_c' A_g} = \frac{312.45^k}{5^{ksi}\times(24''\times 24'')} = 0.108$$

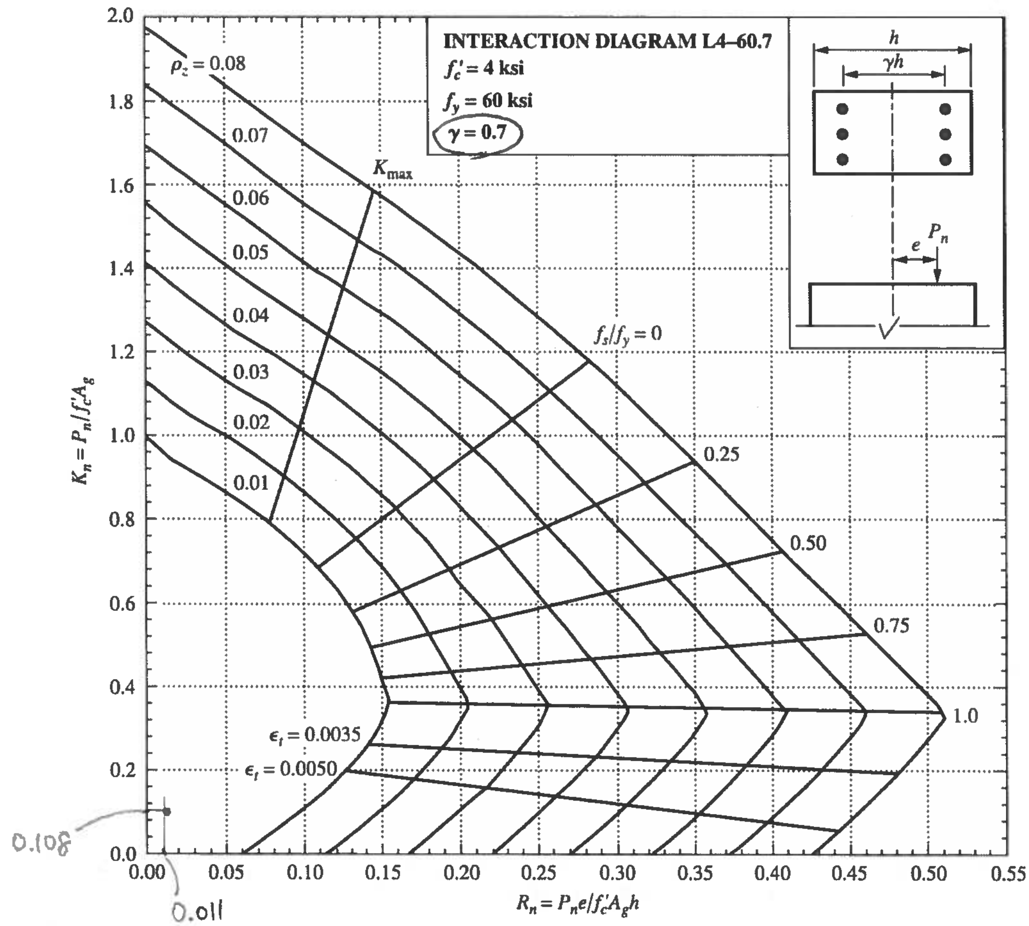
$$R_n = \frac{P_n e}{f_c' A_g h} = \frac{312.45^k \times 2.4''}{5^{ksi}\times(24''\times 24'')\times 24''} = 0.011$$

From the attached interaction diagrams ($\gamma = 0.6$ & $\gamma = 0.7$), it is clear that the coordinate of (R_n, K_n) is within the area under $\rho_g = 0.01$ for $\gamma = 0.67$.

(The interaction diagrams are based on $f_c' = 4^{ksi}$, a rather conservative value.)



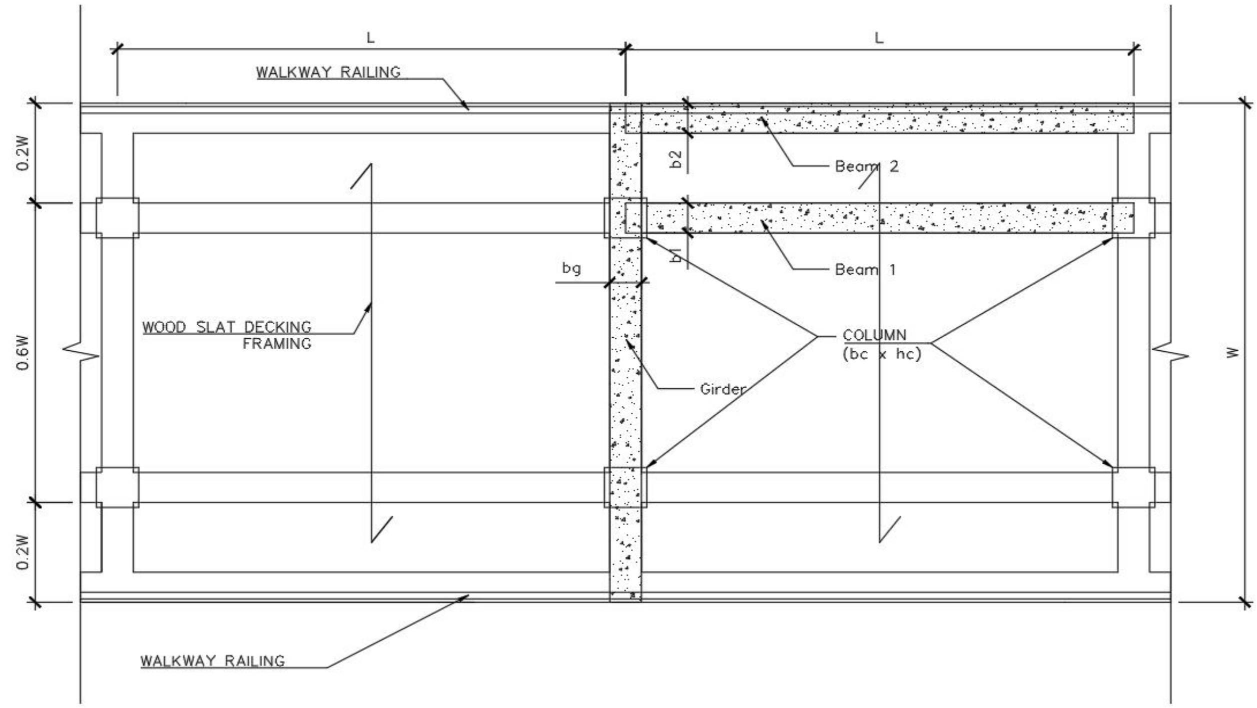
GRAPH 2 Column interaction diagrams for rectangular tied columns with bars on end faces only. (Published with the permission of the American Concrete Institute.)

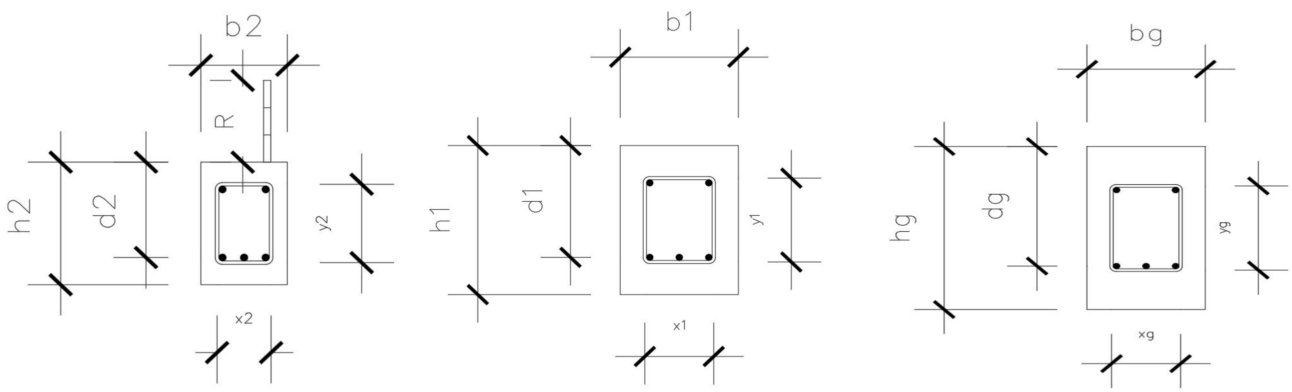


GRAPH 3 Column interaction diagrams for rectangular tied columns with bars on end faces only. (Published with the permission of the American Concrete Institute.)

Attachment C2-E

Fluvial Park Elevated Walkway Concrete Frame Design





Material Properties

γc =	150 pcf	concrete density
fc' =	5 ksi	28 day compressive strength
fy =	60 ksi	steel reinforcing stress
β_1 =	0.8	ACI 318-14 Table 22.2.2.4.3
λ =	1	normal-weight concrete

Geometric Properties

W =	25 ft	total width of walkway
L =	24 ft	distance between columns

Loads

Dead Loads

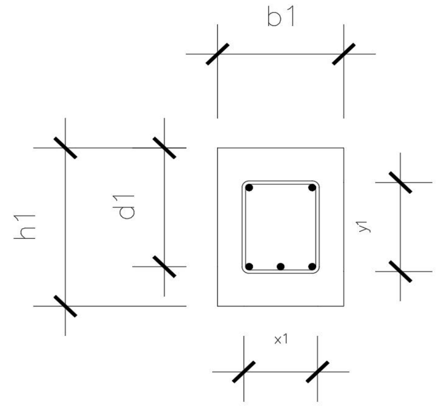
Wood	10 psf
Finishes	5 psf
Walkway Railing	10 plf

Live Loads

Walkway and Elevated Platforms	60 psf

Beam 1 Design

L1 =	24	ft
Tributary Width =	10	ft



Stirrups

Try #	3	
Number of Legs	2	
Spacing between ties =	10	in
dt =	0.375	in
As,t =	0.22	in2

Reinforcement

Try #	8	
Number of Rebars	3	
db =	1	in
As,b =	2.36	in2

Loads

Dead Loads

Wood	100	plf
Concrete	600	plf
Finishes	50	plf

Live Loads

Pedestrian bridge	600	plf
wu =	1.86	klf
Mu =	133.92	ft-kips
Vu =	22.32	kips

Parameters

Try h1 =	24	in	
Try b1 =	24	in	
Clear cover =	2	in	ACI 318-14 Table 20.6.1.3.1
d1 =	21.125	in	
a1 =	1.39	in	

Moment Check

Mn =	240.71	ft-kips	
ϕ_b =	0.9		ACI 318-14 Table 21.2.2
ϕ_bMn =	216.64	ft-kips	
Mu =	133.92	ft-kips	

➡ Acceptable — efficiency = 61.82%

Minimum Width

bmin =	9.3	in
b1 =	24	in

➡ Acceptable

Steel Area Check

ρ =	0.0046		
ρmax =	0.0212	Acceptable	ρ when εt equals 0.005
ρmin =	0.0035	Acceptable	ACI 318-14 Chapter 9.6.1.2

Spacing of Reinforcement Check (ACI 318-14 Chapter 25.2.1)

spacing,min =	1.00	in
spacing =	8.13	in

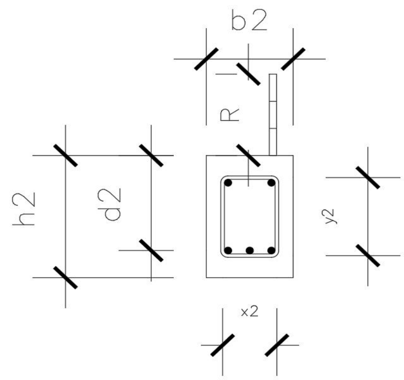
➡ Acceptable

Shear Check

Vc =	71.70	kips	ACI 318-14 Equation 22.5.5.1
ϕ_v =	0.75		ACI 318-14 Table 21.2.1
ϕ_vVc =	53.78	kips	
Vu =	22.32	kips	

➡ Shear Stirrups Not Required — ACI 318-14 Chapter 9.6.3.1

Beam 2 Design (Spandrel Beam: Torsion Considered)



L2 =	24	ft
Tributary Width =	2.5	ft

Stirrups

Try #	4	
Number of Legs	2	
Spacing between ties =	6	in
dt =	0.5	in
As,t =	0.39	in2

Reinforcement

Try #	6	
Number of Rebars	3	
db =	0.75	in
As,b =	1.33	in2

Loads

Dead Loads

Wood	25	plf
Concrete	337.5	plf
Finishes	12.5	plf
Walkway railing	10	plf

Live Loads

Pedestrian bridge	150	plf
wu =	0.70	klf
Mu =	50.54	ft-kips
Vu =	8.42	kips

Parameters

Try h2 =	18	in	
Try b2 =	18	in	
Clear cover =	2	in	ACI 318-14 Table 20.6.1.3.1
d2 =	15.125	in	
a2 =	1.04	in	

Moment Check

Mn =	96.79	ft-kips		
ϕ_b =	0.9		ACI 318-14 Table 21.2.2	
ϕ_bMn =	87.11	ft-kips	Acceptable	efficiency = 58.02%
Mu =	50.54	ft-kips		

Minimum Width

bmin =	8.75	in	Acceptable
b2 =	18	in	

Steel Area Check

ρ =	0.0049	
ρmax =	0.0212	Acceptable ρ when εt equals 0.005
ρmin =	0.0035	Acceptable ACI 318-14 Chapter 9.6.1.2

Spacing of Reinforcement Check (ACI 318-14 Chapter 25.2.1)

spacing,min =	1.00	in	Acceptable
spacing =	5.38	in	

Shear Check

Vc =	38.50	kips	ACI 318-14 Equation 22.5.5.1
ϕ_v =	0.75		ACI 318-14 Table 21.2.1
ϕ_vVc =	28.88	kips	Shear Stirrups Not Required ACI 318-14 Chapter 9.6.3.1
Vu =	8.42	kips	

Torsion Check

Walkway railing live loads

Uniform loads =	50	plf	ASCE 7-10 Chapter 4.5.1
Concentrated loads =	200	lbs	ASCE 7-10 Chapter 4.5.1
R =	42	in	Walkway railing height
Tu =	7.84	ft-kips	
x2 =	13.5	in	horizontal distance between the centerline of the outermost closed stirrup
y2 =	13.5	in	vertical distance between the centerline of the outermost closed stirrup
Acp =	324	in2	area enclosed by outside perimeter of concrete cross section
pcp =	72	in	outside perimeter of concrete cross section
Aoh =	182.25	in2	area enclosed by cneterline of the outermost closed stirrup
Ao =	154.91	in2	gross area enclosed by the torsional shear flow path (0.85*Aoh)
ph =	54	in	perimeter of the centerline of the outermost closed stirrup
θ =	45	°	
At =	0.196	in2	area of one leg of a closed stirrup resisting torsion
Tth =	8.59	ft-kips	ACI 318-14 Table 22.7.4.1(a)
ϕ_t =	0.75		ACI 318-14 Table 21.2.1
ϕ_tTth =	6.44	ft-kips	→ Torsion Stirrups Required
Tu =	7.84	ft-kips	

Longitudinal torsional reinforcement

Try #	4		
Number of Rebars	2		
dl =	0.5	in	diameter of longitudinal torsional reinforcement
As,l =	0.39	in2	area of longitudinal torsional reinforcement
Tn =	11.27	ft-kips	ACI 318-14 Chapter 22.7.6.1
ϕ_t =	0.75		ACI 318-14 Table 21.2.1
ϕ_tTn =	8.45	ft-kips	→ Acceptable
Tu =	7.84	ft-kips	efficiency = 92.79%

Cross-sectional limits check (ACI 318-14 Chapter 22.7.7.1)

$$\sqrt{\left(\frac{V_u}{b_w d}\right)^2 + \left(\frac{T_u p_h}{1.7A_{oh}^2}\right)^2} = 95.14 \text{ psi}$$

$$\phi\left(\frac{V_c}{b_w d} + 8\sqrt{f_c'}\right) = 530.33 \text{ psi}$$

→ Acceptable

Spacing of torsion stirrups check (ACI 318-14 Chapter 9.7.6.3.3)

smax =	6.75	in	→ Acceptable
s =	6	in	

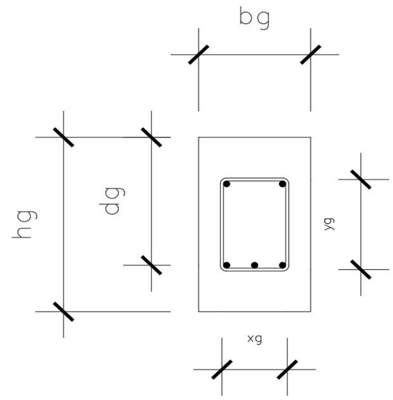
Minimum transverse torsional reinforcement check (ACI 318-14 Chapter 9.6.4.2)

At,min =	0.047729708	in2	→ Acceptable
At =	0.196	in2	

Minimum longitudinal reinforcement check (ACI 318-14 Chapter 9.6.4.3)

Al,min =	0.14	in2	→ Acceptable
Al =	0.39	in2	

Girder Design (SAP-2000 Model used)



Lg = 25 ft

Stirrups

Try #	3	
Number of Legs	2	
Spacing between ties =	12	in
dt =	0.375	in
As,t =	0.22	in2

Reinforcement

Try #	7	
Number of Rebars	3	
db =	0.875	in
As,b =	1.80	in2

Loads (From SAP-2000)

Reactions from Dead Loads

R_D from Beam 1 =	18	kips
R_D from Beam 2 =	9.24	kips

Reactions from Live Loads

R_L from Beam 1 =	14.4	kips
R_L from Beam 2 =	3.6	kips
Mu =	92.68	ft-kips
Vu =	20.22	kips
Reaction at each column (Pu) =	69.93	kips

Parameters

Try hg =	30	in	
Try bg =	18	in	
Clear cover =	2	in	ACI 318-14 Table 20.6.1.3.1
dg =	27.1875	in	
ag =	1.41	in	

Moment Check

Mn =	238.85	ft-kips	
ϕ_b =	0.9		ACI 318-14 Table 21.2.2
ϕ_bMn =	214.96	ft-kips	Acceptable — efficiency = 43.11%
Mu =	92.68	ft-kips	

Minimum Width

bmin =	9.075	in	Acceptable
b1 =	18	in	

Steel Area Check

ρ =	0.0037	
ρmax =	0.0212	Acceptable — ρ when εt equals 0.005
ρmin =	0.0035	Acceptable — ACI 318-14 Chapter 9.6.1.2

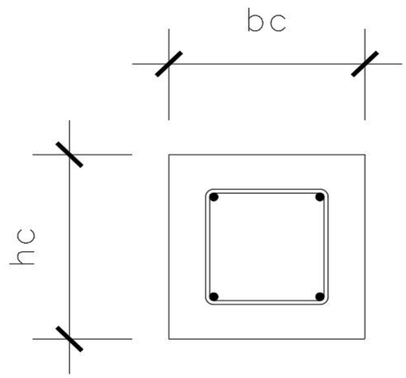
Spacing of Reinforcement Check (ACI 318-14 Chapter 25.2.1)

spacing,min =	1.00	in	Acceptable
spacing =	5.31	in	

Shear Check

Vc =	69.21	kips	ACI 318-14 Equation 22.5.5.1
ϕ_v =	0.75		ACI 318-14 Table 21.2.1
ϕ_vVc =	51.91	kips	Shear Stirrups Not Required — ACI 318-14 Chapter 9.6.3.1
Vu =	20.22	kips	

Column Design



Ties

Try #	3	
Number of Legs	2	
Spacing between ties =	18	in
dt =	0.375	in
As,t =	0.22	in2

Longitudinal Reinforcement

Try #	9	
Number of Rebars	6	
db =	1.128	in
As,b =	6.00	in2

Loads (From SAP-2000)

Pu =	69.93	kips

Parameters

Try hc =	24	in	
Try bc =	24	in	
Clear cover =	3	in	ACI 318-14 Table 20.6.1.3.1

Axial Compression Check

Ag =	576	in2	gross concrete area
Ast =	6.00	in2	total area of longitudinal reinforcement
Po =	2782.28	kips	ACI 318-14 Equation 22.4.2.2
Pn,max =	2225.82	kips	ACI 318-14 Table 22.4.2.1
ϕ_p =	0.65		ACI 318-14 Table 21.2.2

ϕ_pPn,max =	1446.78	kips	Acceptable
Pu =	69.93	kips	efficiency = 4.83%

Number of Longitudinal Reinforcement Check (ACI 318-14 Chapter 10.7.3.1)

nmin =	4	Acceptable
n =	6	

Size of Ties Check (ACI 318-14 Chapter 25.7.2.2)

Minimum Tie Size =	3	Acceptable
Tie Size =	3	

Spacing of Ties Check (ACI 318-14 Table 9.7.6.2.2)

smax =	18	in	Acceptable
s =	18	in	

Steel Area Check (ACI 318-14 Chapter 10.6.1.1)

Ast =	6.00	in2	
Ast,max =	46.08	in2	Acceptable
Ast,min =	5.76	in2	Acceptable

Spacing of Longitudinal Reinforcement Check (ACI 318-14 Chapter 25.2.3)

spacing,min =	1.69	in	Acceptable
spacing =	6.93	in	

Attachment C2-F

Fluvial Park Elevated Walkway Footing Design

AECOM

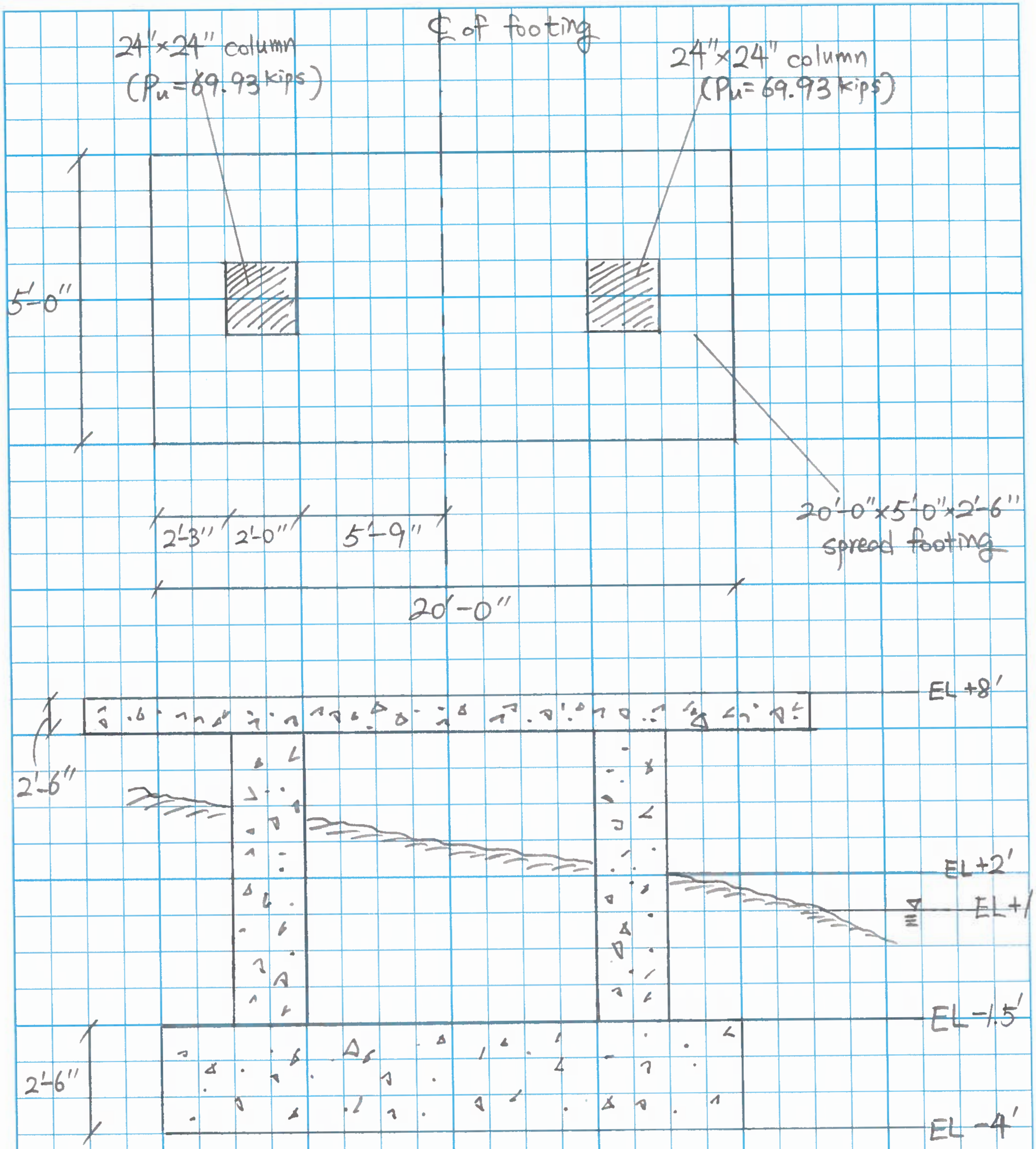
JOB TITLE Rebuild by Design Meadowlands–Fluvial Park Elevated Walkway Footing Design

PROJECT/JOB NO. 60513717 CALCULATION NO. ____

COMPUTED BY ____ DATE ____

VERIFIED BY ____ DATE ____

SCALE ____ SHEET NO. 1 OF ____



Assume the length of column

$8' - 2.5' - (-1.5') = 7'$

↑ EL of Top of Walkway; ↑ Thickness of walkway; ↑ EL. of Bottom of Column

4x4 = 1 in

AECOM

JOB TITLE RBDM - Fluvial Park Elevated Walkway Footing Design

PROJECT/JOB NO. 60513717 CALCULATION NO. ____

COMPUTED BY ____ DATE ____

VERIFIED BY ____ DATE ____

SCALE ____ SHEET NO. 2 OF ____

Weight of column

$2' \times 2' \times 7' \times 150\,pcf = 4.2$ kips

$P_u = 69.93$ kips

Total Factored Load per column

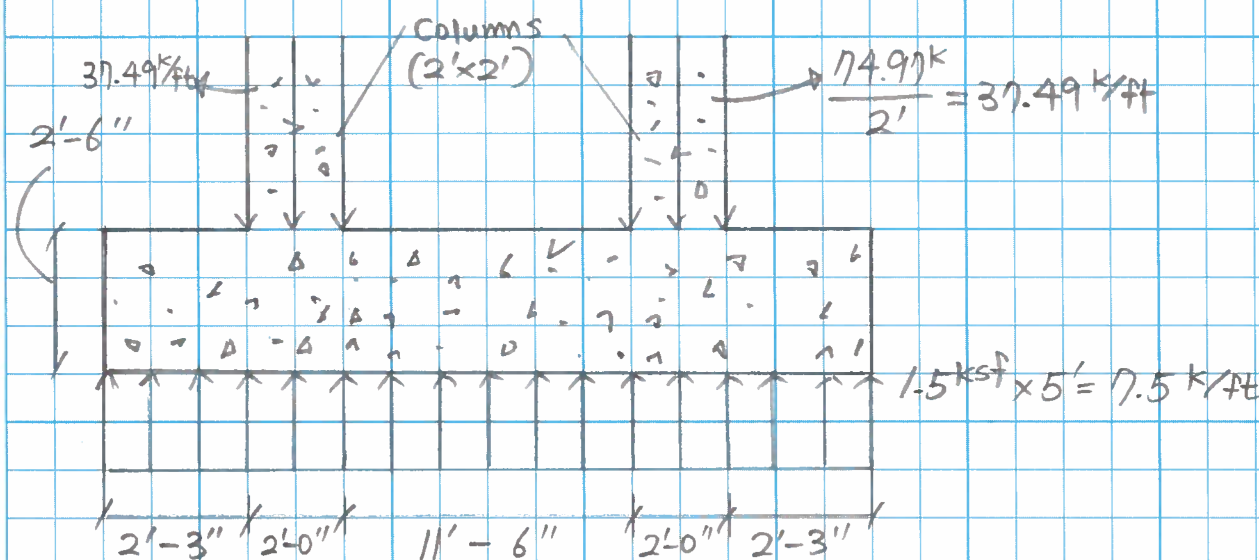
$69.93^k + 1.2 \times 4.2^k = 74.97$ kips/column

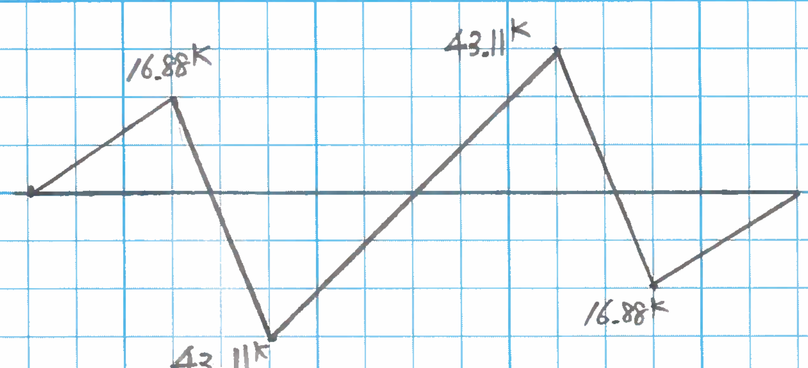
Footing Area

$20' \times 5' = 100\,ft^2$

Bearing Pressure for Strength Design

$$q_u = \frac{74.97^k/\text{column} \times 2\ \text{columns}}{100\,ft^2} = 1.5\,ksf$$





Shear Diagram

4x4 = 1 in

AECOM

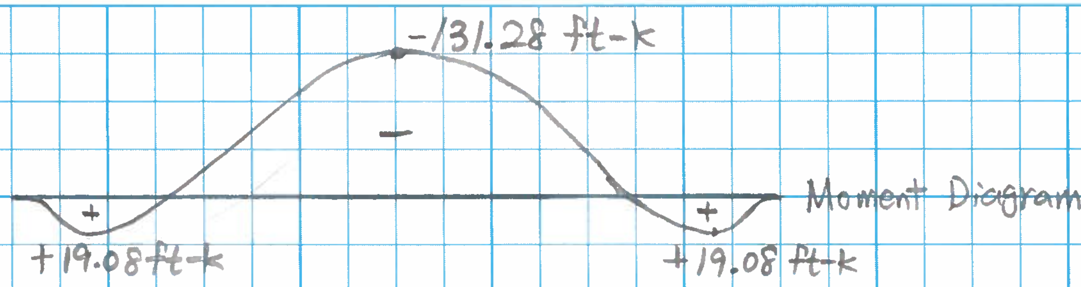
JOB TITLE RBDM-Fluvial Park Elevated Walkway Footing Design

PROJECT/JOB NO. 60513717 CALCULATION NO.

COMPUTED BY DATE

VERIFIED BY DATE

SCALE SHEET NO. 3 OF



Footing Thickness = 2'-6" = 30"

Assume $d = 25.5''$

* Depth Required for One-way shear

From shear diagram, the largest shear force is 43.11 kips.

$$V_{u1} = 43.11^k - 7.5^{k/ft} \times 25.5'' \times \frac{1'}{12''} = 27.17^{kips}$$

$$d_{req'd} = \frac{V_{u1}}{\phi 2\sqrt{f'_c}\, b} = \frac{27.17^k \times \frac{1000\,lb}{1^k}}{0.75 \times 2 \times \sqrt{5000}\,psi \times 5' \times \frac{12''}{1'}} = 4.27''$$

* Depth Required for Two-way shear

From symmetry,

V_{u2} at right column = V_{u2} at left column = V_{u2}

$$V_{u2} = 74.97^k - \left\{(24'' + 25.5'') \times \frac{1'}{12''}\right\}^2 \times 1.5^{ksf} = 49.45^{kips}$$

$$b_o = 4 \times (24'' + 25.5'') = 198''$$

$$d_{req'd,1} = \frac{V_{u2}}{\phi 4 \lambda \sqrt{f'_c}\, b_o} = \frac{49.45^k \times \frac{1000\,lb}{1^k}}{0.75 \times 4 \times 1 \times \sqrt{5000}\,psi \times 198''} = 1.18''$$

$$d_{req'd,2} = \frac{V_{u2}}{\phi\left(2 + \frac{4}{\beta_c}\right)\lambda\sqrt{f'_c}\, b_o}$$ ⇒ not applicable since $\beta_c = 1$ (square column)

$$d_{req'd,3} = \frac{V_{u2}}{\phi\left(\frac{\alpha_s d}{b_o} + 2\right)\lambda\sqrt{f'_c}\, b_o} = \frac{49.45^k \times \frac{1000\,lb}{1^k}}{0.75\left(\frac{40 \times 25.5''}{198''} + 2\right) \times 1 \times \sqrt{5000}\,psi \times 198''} = 0.66''$$

($\alpha_s = 40$ for interior column)

4x4 = 1 in

Since $d = 25.5''$ is greater than all required depths, design is **OK.**

* Design of Longitudinal Steel

$M_u = 131.28$ ft-k from moment diagram

$$R_n = \frac{M_u}{\phi b d^2} = \frac{131.28 \text{ ft-k} \times \frac{12''}{1'} \times \frac{1000 \text{ lb}}{1^k}}{0.9 \times 5' \times \frac{12''}{1'} \times (25.5'')^2} = 44.87 \text{ psi}$$

$$\rho = \frac{0.85 f_c'}{f_y}\left(1 - \sqrt{1 - \frac{2R_n}{0.85 f_c'}}\right) = \frac{0.85 \times 5000 \text{ psi}}{60{,}000 \text{ psi}}\left(1 - \sqrt{1 - \frac{2 \times 44.87 \text{ psi}}{0.85 \times 5000 \text{ psi}}}\right)$$

$$= 0.000752 < \rho_{min} \text{ for flexure}$$

Use ρ = larger of

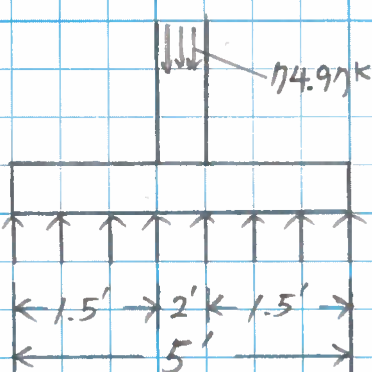
$$\frac{200}{f_y} = \frac{200}{60{,}000} = 0.0033$$

$$\frac{3\sqrt{f_c'}}{f_y} = \frac{3 \times \sqrt{5000}}{60{,}000} = 0.00354 \leftarrow$$

$$A_s = \rho b d = 0.00354 \times 60'' \times 25.5'' = 5.42 \text{ in}^2$$

Use **7 #8 bars** ($A_s = 5.53$ in^2)

* Design of Steel in Short Direction



$M_u = 1.5' \times 15.0^{k/ft} \times \frac{1.5'}{2} = 16.88$ ft-k

Assume steel spread over width = column width + $2 \times (d/2)$

$= 24'' + 2 \times \frac{25.5''}{2} = 49.5''$

$74.97^k / 5' = 15.0^{k/ft}$

$$R_n = \frac{M_u}{\phi b d^2} = \frac{16.88 \text{ ft-k} \times \frac{12''}{1'} \times \frac{1000 \text{ lb}}{1^k}}{0.9 \times 49.5'' \times (25.5'')^2} = 6.99 \text{ psi}$$

$$\rho = \frac{0.85 f_c'}{f_y}\left(1 - \sqrt{1 - \frac{2R_n}{0.85 f_c'}}\right) = 0.00012 < \rho_{min} \text{ for flexure} \Rightarrow \rho = 0.00354$$

$$A_s = \rho b d = 0.00354 \times 49.5'' \times 25.5'' = 4.47 \text{ in}^2$$

Use **6 #8 bars** ($A_s = 4.71$ in^2)

4x4 = 1 in

DRAFT

Subappendix C3 – Berry's Creek Surge Barrier Design

For the Feasibility Study of Rebuild by Design Meadowlands Flood Protection Project

June 2018

Boroughs of Little Ferry, Moonachie, Carlstadt, and Teterboro and the Township of South Hackensack, Bergen County, New Jersey

REBUILD BY DESIGN
MEADOWLANDS

Prepared by AECOM for the State of New Jersey Department of Environmental Protection

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Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AISC	American Institute of Steel Construction, Inc.
ASD	Allowable Strength Design
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
AWI	American Welding Society
ASTM	American Society for Testing and Materials
CFD	Computational Fluid Dynamics Model
CFR	Code of Federal Regulations
cfs	Cubic feet per second
DM	Design Manual
EM	Engineer Manual
ETL	Engineer Technical Letter
FEMA	Federal Emergency Management Agency
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling System
ICC	International Code Council
ksi	Kilopounds per square inch
LRFD	Load and Resistance Factor Design
NAVD 88	North American Vertical Datum of 1988
NAVFAC	Naval Facilities Engineering Command
pcf	Per cubic foot
psf	Per square foot
psi	pounds per square inch
RBDM	Rebuild by Design Meadowlands
UNS	Unified Numbering System
USACE	United States Army Corps of Engineers

1.0 Design Requirements

A conceptual study of Berry's Creek Option 1, Surge Barrier and pump station, was prepared to a level needed to develop a cost estimate for feasibility review purposes. The floodgate and pump station was part of the Proposed Project's Alternative 1 (Structural Flood Protection) system. Drawings of gates and pump stations with similar load conditions along with a stability analysis were used in preparing the concept plans. The stability analysis consisted of a pile foundation design and only load cases that typically govern design were considered. A more detailed design would be required if a future re-evaluation led to the selection of the Surge Barrier option for construction.

The water stage of elevation 7.0 feet (referenced to the North American Vertical Datum of 1988 [NAVD 88] was used as the design stage for the Alternative 1, Berry's Creek Option 1 system. This stage does not meet the 1 percent storm event criteria mandated for Federal Emergency Management Agency (FEMA) Certification. An elevation of 7.0 feet (NAVD 88) was selected largely for economic reasons. In holding 7.0 feet (NAVD 88), the Paterson Plank Road (Route 120) embankment and adjacent higher natural ground would provide a shorter line of protection, thus reducing the overall cost of the Proposed Project. The floodgate and pump stations were considered critical structures and were designed adding 3 feet of freeboard above the system design stage. This adjustment in elevation satisfied the 2.6 feet future Sea Level Rise and also complies with the 3 feet increase over the Base Flood Elevation as specified in 33 Code of Federal Regulations (CFR) 65.10. The floodgate width of 100 feet (two 50 feet gates) matched the existing width of Berry's Creek channel immediately south of the Paterson Plank Road Bridge. The 1,000 cubic feet per second (cfs) pump capacity was estimated based on Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) modeling of Berry's Creek drainage area under the design events. A detailed drainage study would be required if this option is advanced. The pumps are only used when the floodgates are closed. The pumps prevent the protected side stage from increasing due to impounded water. There are no navigation demands. Approach guide walls and fenders were not required.

2.0 Existing Conditions and Site Selection

The site for the Berry's Creek surge barrier protection located to the flood side of Paterson Plank Road was selected for four main reasons (see **Figure C3-1**). The site allows for an easy tie into the Paterson Plank embankment which would act as a permanent levee. The width of Berry's Creek is narrower and the channel invert higher than other sections along Berry's Creek. Also, a trucking lot to the west of Berry's Creek canal has adequate acreage to construct the complex in its entirety; only one property would need to be acquired. Lastly, the close proximity to Paterson Plank Road allows easy access for construction and future maintenance.

The ground elevation ranges from 5.0 to 7.0 feet (NAVD 88) on both banks of Berry's Creek as shown below. The channel invert is at -9.6 feet (NAVD 88). The soil profile consists of a combination of fill and organic upper layer, followed by a thin sand strata with clay extending down to glacial till at a depth of 80 feet. The elevation of bedrock ranges from 80 to 100 feet below ground. The pile foundation would tip in bedrock.

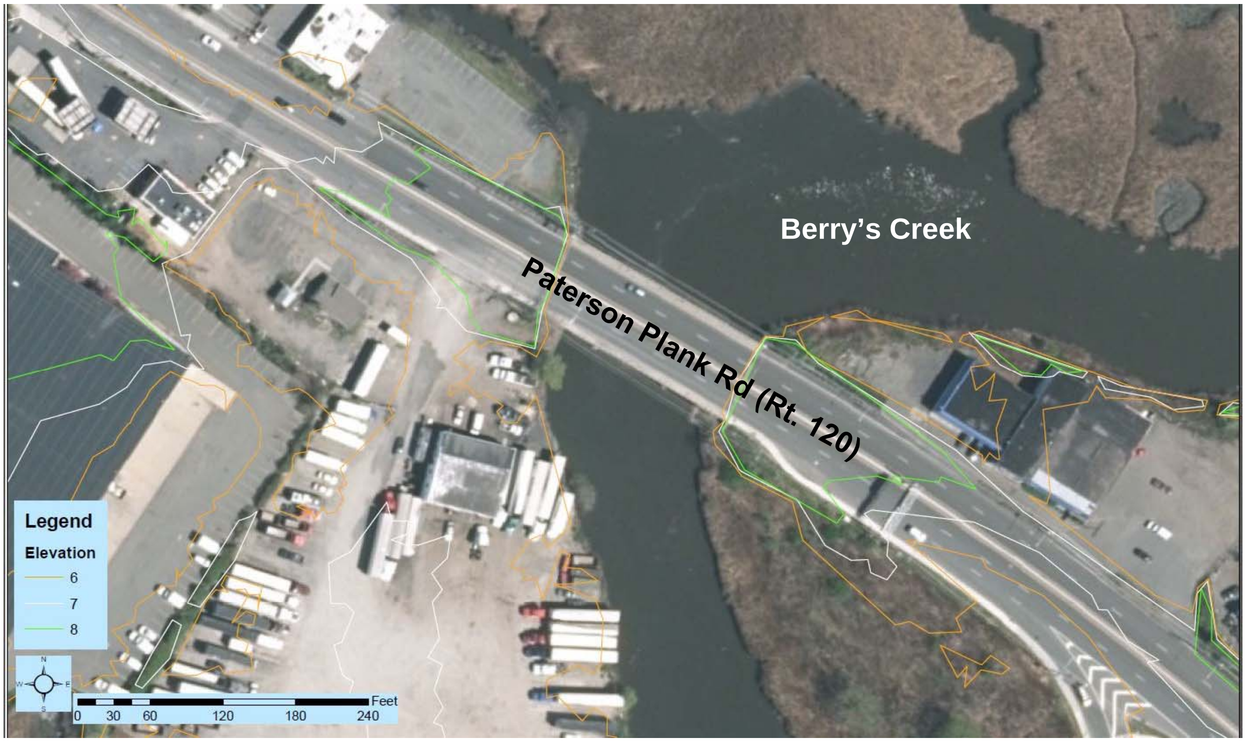

Figure C3-1: Example Contours at Berry's Creek Surge Barrier Site

3.0 Pump Selection

Submersible and vertical lift pumps were considered. The low head, high capacity vertical lift pump was recommended for the Proposed Project. The pumps would be self-priming. The 1,000 cfs drainage would require three 350 cfs pumps, intakes are 96-inch diameter pipe. Pumps would be electric powered with a backup diesel or natural gas generator. The concrete intake basin invert would be at -16 feet (NAVD 88). The open bell intake was selected as a cost saving measure. The more proficient formed suction intake should be evaluated in the detailed design. The pumps would be housed in a pre-engineered metal building designed to withstand hurricane force winds. The building would enclose the pumping equipment and control office. The pump station and intake basin are pile founded, as shown in **Figure C3-2**. A more economical pump station design was also considered. The alternative station is similar to the more durable alternative except that the intake basin would be directly below the pump station and would include a minimal pre-engineered shelter that houses four 250 cfs vertical lift pumps powered by diesel engines. The intake basin walls would be constructed of driven sheet piling which also serves as the braced excavation. The base would be a pile supported concrete slab. The maintenance costs for the alternative are therefore greater.

If advanced, the pump capacity would require modeling to assure the station functions at its designed capacity without cavitation and flow regime issues to the pumps. This would lend itself to Computational Fluid Dynamics Model (CFD) done to confirm that the flow to the station and that the flows would be laminar and not turbulent and of sufficient capacity and velocity for the various storm events for which the station is being designed. The model could be quickly accomplished and helps to define the inlet geometry and overall configuration leading to the station.

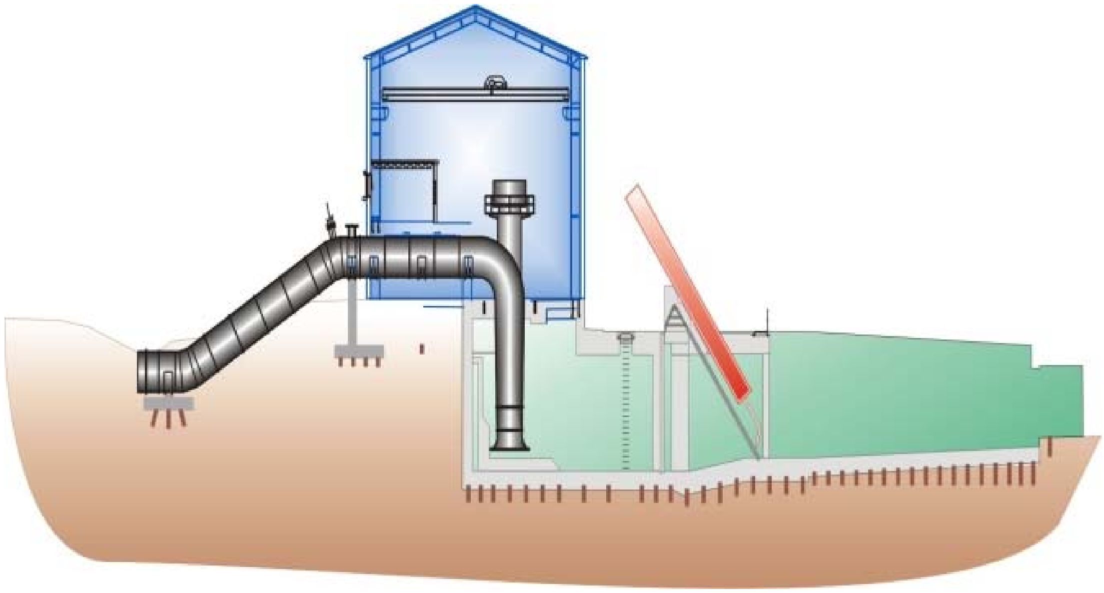

Figure C3-2: Schematic of Pump

As noted above for the pump types, electric, fuel oil, and/or natural gas could be options for the types of engines driving the pumps. Therefore, consideration for the types of fuel and storage needs to be further investigated. Commercial electrical power would be considered the primary source, a backup generator is recommended to operate the system should power be unavailable during a storm event. The backup generator would provide power to both the pumps and the floodgate. Trash racks would also be required; the type can range from simple, fixed trash grates to catenary type mechanized systems.

4.0 Flood Gate Selection

Several gate types were considered. They include tainter, vertical lift, sluice, and a floating barge gate. Miter gates were not considered due to the presence of reverse heads. The miter gate only operates under a static condition as found in a lock where the chamber stage is adjusted to create a steady state condition. The torque tube, as well as any bottom hinged gate, was not considered due to the concern for siltation. High degrees of sediment affect operability and greatly increase maintenance cost. The floating barge gate has lower first costs, but is difficult to operate and like the miter gate and only operates smoothly in a static head condition. The floating gate is more economical, but less reliable, durable, and operable than the tainter gate. The tainter gate and vertical lift gates cost and footprint are similar. The tainter gate was selected for the Proposed Project as it has a long history of successful long, lasting operation and is the most dominant gate type found on hydraulic structures operated by the United States Army Corps of Engineers (USACE) and Bureau of Reclamation.

The tainter gate would be a truss-frames with all the water load placed on the hinge bushing, which is located high above the water. The tainter is commonly used for drainage structures and spillways where overhead obstruction of the hinge axis is not a concern. Tainter gates are not common where marine traffic is present as the tainter gate, even in the raised position, presents an overhead obstruction. The minimal recreational marine traffic at Berry's Creek is not a factor when considering the tainter gate. The tainter gate can be used to pass direct or reverse flows and can resist significant heads from both directions. The tainter gate can be readily operated against a reverse head and can be opened regardless of the level of impounded rainfall. This is a consideration if internal pump capacity is minimal and draining trapped water is a design consideration. The tainter gate would be supported in a reinforced concrete monolith that is pile founded. The gate hinge would be mounted to a concrete trunnion that would be built into the monolith piers. The trunnion would be located above the high water stage. Either a cable drive or hydraulic struts would operate the gates. Piers would be built to an elevation to allow full operation of the struts or cables and to support the winch or strut hydraulics. Gate operations would be controlled from an operating room built into the adjacent pump station. The backup power would be supplied by the pump station generator.

A lower cost sluice gate alternative was also considered. The sluice gate housing would be an all-steel construction. The gate structure would be constructed in the wet and no braced excavation would be required. Support bents would be all-welded pipe trusses with steel sheet piles providing the closure walls. The gate sill would be a concrete sill tremied between two rows of sheet piling approximately 10 feet wide. The first cost would be less than the conventional, concrete flood gate. The maintenance of the steel frames both below water and in the splash zone would require a significant amount of inspection and repairs during the life of the structure.

5.0 Structural Analysis and Design

5.1 General

This design criterion includes a general description and definition of the basic structural design criteria that would control the design of the pump station and flood gate at the Berry's Creek Surge Barrier. The design elements defined herein represent a study level conceptual design using the best available information and comparable representative projects. A thorough analysis was deferred until this option was determined feasible for construction.

5.2 Codes and Standards

The following is a list of general references and industry codes and standards which are applicable to structural design. Local codes would govern in case of conflicting requirements. All of the general codes and standards listed below apply to design elements, such as the pump station, operations/control buildings, and bridge, but are not necessarily limited to, the following:

- American Association of State Highway and Transportation Officials (AASHTO), Load and Resistance Factor Design (LRFD) 3rd Edition, 2004 with Interim Revisions excluding Section 6 of 2006
- American Concrete Institute (ACI) 318-14, Building Code Requirements for Structural Concrete
- ACI 350R-06, Concrete Sanitary Engineering Structures
- American Institute of Steel Construction, Inc. (AISC), Manual of Steel Construction, 14th Edition
- American Society of Civil Engineers (ASCE) 7-10, Minimum Design Loads for Buildings and Other Structures
- International Code Council (ICC), International Building Code New Jersey Edition: 2015
- American Society for Testing and Materials (ASTM)
- American Welding Society (AWS) D1.1-10, Structural Welding Code, or latest edition
- AWS D1.6-10, Stainless Steel Welding Code, or latest edition
- USACE Engineer Manual (EM) 1110-2-2000 Standard Practice for Concrete for Civil Works Structures

- USACE EM 1110-2-2102, Water Stops and Other Preformed Joint Material for civil Works Structures
- USACE EM 1110-2-2104, Strength Design for Reinforced Concrete Hydraulic Structures
- USACE EM 1110-2-2100, Stability Analysis of Concrete Structures
- USACE EM 1110-2-2502, Retaining and Flood Walls
- USACE EM 1110-2-2906, Design of Pile Foundations
- USACE EM 1110-2-3104, Structural and Architectural Design of Pumping Stations
- USACE Engineer Technical Letter (ETL) 1110-2-584, Design of Hydraulic Steel Structures
- 44 CFR 65.10, FEMA Levee Mapping and Certification

5.3 General Design Load Parameters

5.3.1 Load Combinations

Structures, components, and foundations would be designed so that their design strength equals or exceeds the effects of the factored loads in USACE EM1110-2-2104 or ASCE 7-10. Load combinations per EM 1110-2-2104 would be applicable to Berry's Creek and are listed in **Table C3-1**:

Table C3-1: Strength Load Combinations (Concrete Design)

Load Combinations		Strength Design									
		Reduction Factor (Rf)	Hydraulic Factor (Hf)	Dead (D)	Live (L)	Hydro-Static (H)	Uplift (U)	Wind (W)	Soil (S)	Settle-ment (ST)	Impact (I)
Construction											
Construction Condition	A1	0.86	1.3	1.7	-	-	-	1.7	-	1.7	-
Operation											
Normal Operation Condition	B1	1	1.3	1.7	1.7	1.7	1.7	-	1.7	-	1.7
Start-up Condition	B2	1	1.3	1.7	1.7	1.7	1.7	-	1.7	-	1.7
High Head Condition	B3	1	1.3	1.7	1.7	1.7	1.7	-	1.7	-	1.7
Reverse Head	B4	0.86	1.3	1.7	1.7	1.7	1.7		1.7	-	1.7
Hurricane											
Storm Surge Condition	C1	0.75	1.3	1.7	1.7	1.7	1.7	1.7	1.7	-	1.7
Maintenance											
Maintenance Conditions	D1	0.86	1.3	1.7	1.7	1.7	1.7	-	1.7	-	1.7

5.3.2 Hydraulic Stages

See **Table C3-2** for hydrulic stages and designed water surface elevations (in feet NAVD 88).

Table C3-2: Hydraulic Stages and Design Water Surface Elevations

Stage	Flood Side (elevation feet NAVD 88)	Protected Side(elevation feet NAVD 88)
Normal	1.0	1.0
Max. Direct Water*	7.0	0.0
Max. Reverse Water	0.0	5.0

* Stages do not meet the 100-year levels required for FEMA Certification

5.3.3 Dead Loads (D)

Dead loads would be determined in accordance with applicable engineering manuals and ASCE 7-10, and would include the self-weight of all permanent construction components including foundations, slabs, walls, roofs, actual weights of equipment, overburden pressures, and all permanent non-removable stationary construction (see **Table C3-3**).

Table C3-3: Unit Weights

Item	Weight [Pcf]
Water (Fresh)	62.4
Semi-compacted Fill	110
Fully Compacted Granular Fill, wet	120
Fully Compacted Granular Fill, Effective	58
Fully Compacted Clay Fill, wet	110
Fully Compacted Clay Fill, Effective	48
Riprap	130
Silt	94
Reinforced Concrete (Normal weight)	150
Steel	490

pcf = per cubic foot

5.3.4 Live Loads (L)

Live loads for building structures would be determined in accordance with applicable engineering manuals and ASCE 7-10.

5.3.4.1 Roof Live Loads

Roof Live Loads are as follows:

- Roof Live Loads: 60 per square foot (psf)

5.3.4.2 Equipment weight

Equipment weights were not included in the recon design stability analysis. Equipment weights would be included in a detailed design, the effects of vibrations would be included in the design of the pump supports. To help dampen vibration, equipment would be supported on concrete having a weight at least 3 times the total weight of the equipment or 15 times the rotating weight, whichever is greater. Vibration during the pumps operation would include a dynamic factor of 1.3. A refined analytical approach would be performed if required.

5.3.4.3 Floor Live Loads

Floor Live Loads are as follows:

- Minimum unless noted otherwise: 100 psf
- Grating floors: 100 psf or a 200-pound concentrated load
- Stairs and landings: 100 psf or a 200-pound concentrated load
- Operating Floors: 250 psf
- Equipment and Storage Rooms: 300 psf
- Control room: 125 psf
- Service Bridge: The minimum condition of the following vehicles: 50 tons crane or AASHTO H-20 truck.

5.3.4.4 Live Load Surcharge (LS)

A minimum vertical live load surcharge of 200 psf would be applied on floor slab and base slab during construction.

A minimum horizontal live load surcharge of 300 psf would be applied to all abutment walls and wing walls of hydraulic structures in addition to other live loads that may be applicable in accordance with AASHTO.

5.3.5 Soil Pressures (S)

Structures are designed for lateral and vertical soil pressures. Lateral pressures are determined using the at-rest coefficients, K_0 obtained from data provided in Subappendix C1:

- Lateral Soils at-rest Pressure Coefficients:
  - K0 = 0.8 for Clay; and
  - K0 = 0.48 for Granular Material.

Per Naval Facilities Engineering Command (NAVFAC) Design Manual (DM) 7.2, the following coefficients of friction are recommended:

- Mass Concrete on Rock: tan(35) = 0.70;
- Mass Concrete on Medium Clays: tan(18) = 0.32; and
- Mass Concrete on Medium Sands: tan(26) = 0.48.

Per the values of K_0 provided above, Active and Passive Earth Pressure Coefficients have been determined as follows:

- Clays:
  - K_0=0.8, the corresponding friction angle is Ø =11.54° (K_0=1-sin(Ø))
  - Assume level backfill, and use Rankine Theory
  - $K_a=\tan^2(45-Ø/2) = \tan^2(45-11.54/2) = 0.667$
  - $K_p=\tan^2(45+Ø/2) = \tan^2(45+11.54/2) = 1.500$

- Granular Material:
  - K_0=0.48, the corresponding friction angle is Ø =31.6° (K_0=1-sin(Ø))
  - Assume level backfill, and use Rankine Theory
  - K_a=tan2(45-Ø/2) = tan2(45-31.6/2) = 0.316
  - K_p=tan2(45+Ø/2) = tan2(45+31.6/2) = 3.170.

5.3.6 Hydrostatic Loads (H)

Hydrostatic loads for which structures would be designed refer to the vertical and horizontal loads induced by a static water head and buoyant pressures, excluding uplift pressures. Dynamic Wave Load is neglected in this RECON Design but must be considered in advanced design. The inland location would preclude a wind driven wave.

5.3.7 Uplift Loads (U)

Uplift loads for which structures would be designed are defined by two uplift conditions: Uplift Condition A, assumes the sheet pile cutoff wall is fully effective, and Uplift Condition B, assumes the sheet pile cutoff wall is ineffective (pressure assumed to be vary linearly across the base). The dewatered construction case may govern; however, a reduced load factor should be considered for the short-term loading.

5.3.8 Wind Loads (W)

Structures are designed for wind loads established by ASCE No. 7, “Minimum Design Loads for Buildings and Other Structures.”

5.3.9 Impact Loads (I)

Elements supporting reciprocating or rotating equipment and cranes proper allowance, or as determined by analysis, would be made for impact in addition to other loads. The following minimum impact loads would be used**:**

- Traveling cranes and hoists: 25 percent of the lifted loads;
- Rotating equipment: 20 percent of the total machine weight;
- Reciprocating equipment: 50 percent of the total machine weight (consideration would be given to the deflection of beams supporting reciprocating and rotating machines); and
- The use of isolators can be considered in reducing the effects of machinery impact (the reduction would be based on manufacturers’ recommendations).

5.3.9.1 Operational Impact Loads

Elements supporting reciprocating or rotating equipment and cranes proper allowance, or as determined by analysis, would be made for impact in addition to other loads. The following minimum impact loads would be used:

- Traveling cranes and hoists: 25 percent of the lifted loads;
- Rotating equipment: 20 percent of the total machine weight;
- Reciprocating equipment: 50 percent of the total machine weight (consideration would be given to the deflection of beams supporting reciprocating and rotating machines); and

- The use of isolators can be considered in reducing the effects of machinery impact (the reduction would be based on manufacturer's recommendations).

5.3.9.2 Pedestrian Railing Loads

Pedestrian railing loads are as follows:

- 200 pounds (minimum) concentrated load at top of railing in any direction and any location;
- 50 pounds per foot transverse and vertical simultaneously on all longitudinal members (rails).=; and
- 50 pounds per foot, multiplied by post spacing at height to center of top rail at each post.

5.3.10 Access Bridge

Access bridge would be designed per AASHTO for highway truck railing loadings.

5.3.11 Settlement Loads (ST)

Structures are designed for forces generated by settlement (downdrag) in coordination with the Geotechnical Design. Downdrag forces are applied to sustained load cases (i.e., construction). The downdrag force exerted by settling soil adjacent to the proposed pump station and floodgate is applied to the perimeter of the structure. Downdrag forces are also included in the structural check of the piles. Downdrag loads are obtained from the geotechnical engineer on a case-by-case basis as applicable. An explanation of the computation of downdrag forces on piles is provided in Subappendix C1.

5.4 Concrete Design Criteria

Concrete structures that would be permanently exposed to water and the splash zone would be designed in accordance with EM 1110-2-2104 or the ACI 350R Concrete Sanitary Engineering Structures and would comply with the ACI 318 latest edition strength design method, unless otherwise required. Concrete structures that would not be exposed to water, nor harsh environment, would be designed in accordance with ACI-318-14. Typical design materials are as follows unless otherwise noted:

- Structural concrete: 5,000 pounds per square inch (psi) @ 28 days with a maximum water/cement ratio = 0.40; and,
- Steel reinforcement: 60,000 psi (ASTM A615)

5.5 Steel Design Criteria

Steel design would utilize the ETL 1110-2-584 and the AISC Steel Construction Manual, 15th edition. Either Allowable Strength Design (ASD) or LRFD design methods are permissible. Typical design materials are as follows unless otherwise noted:

- Structural steel rolled shapes: ASTM 572, Grade 50 or ASTM A992, Grade 50
- Plates: ASTM A36, Grade 36
- Bolts and nuts: ASTM A325, min. ¾" or ASTM A490
- Anchor Bolts: ASTM F1554, (¾" diameter or greater)
- Corrosion stainless steel: ASTM A240 (freshwater) or ASTM A316 (saltwater)
- Sheet Piles: ASTM A572, Grade 50

- Stainless Steel Embedded Anchors: ASTM A276, Type 316 or Unified Numbering System (UNS) S21800

Components that would be exposed to the elements would be either hot-dipped galvanized or primed, painted and sealed with coats of (16 mils minute) epoxy, see

Figure C3-3. Steel gates and steel sheet pile structures would be painted with an epoxy painting system.

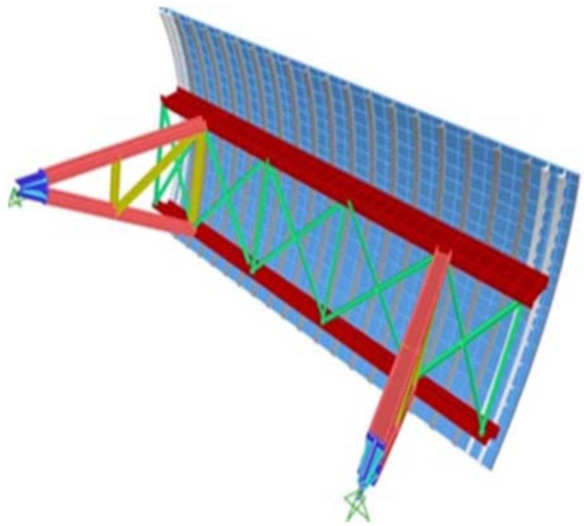

Figure C3-3: Schematic of Steel Gates and Steel Pile Structure

5.6 Pile Foundation Design Criteria

All forces applied to the primary concrete structures would be resisted by the pile foundation. The pump station and floodgate would be supported independently and are not designed to transmit load to any adjoining structure. Pile designs are based on a soil structure interactive analysis, with the pile supports input as springs in accordance with EM 1110-2-2906. Group effects would be applied as required.

Piles could be steel pipe piles, steel H-piles, or square pre-stressed concrete piles. Pipe piles satisfy ASTM A252 with a minimum yield strength of 45 kilopound per square inch (ksi). H-piles satisfy ASTM A572, Grade 50. Steel piles are designed structurally per AISC ASD, 15th Edition, as modified by EM 1110-2-2906. Concrete square piles require a design strength equal to 6,000 psi at 28 days. Pre-stressed concrete piles (hollow or solid) are designed to satisfy both strength and serviceability requirements. Strength design follows the basic criteria set forth by ACI, except the strength reduction factor is 0.7 for all failure modes and the load factor is 1.9 for both dead and live loads. The pre-stressed concrete pile is designed for an axial strength limited to 80 percent of pure axial strength and a minimum eccentricity equal to 10 percent of the pile width. Control of cracking is achieved by limiting the concrete compressive stress to 0.4f'c and the tensile stress to zero. Combined axial and bending are considered when analyzing the stresses in the piles. Loads, deflections and stresses are presented for each design case.

5.7 Operation

5.7.1 Flood Gate

The flood gate would operate against the maximum 10 feet direct differential head and 4 feet reverse head. Both gate types, tainter and the alternative sluice, are suitable for operation against the Proposed Project differentials. The multiple sluice gates provide redundancy since if one gate does not function, the volume of flood waters entering the protected side would be reduced. The tainter gate is a more durable gate and would reduce the risk of operation. This is supported by years of successful operation in USACE and Bureau of Reclamation civil works projects. Given the short warning of tidal storms, it is doubtful that a backup gate (emergency bulkhead) could be installed in advance of the fast approaching surge; none were included in the cost. The sluice gate, not a slide gate, would include rollers and guides that extend below water. The tainter gate would have all the moving parts above water, which would allow a continuous visual inspection, less maintenance, and easy access when maintenance is required. The tainter gate in particular could operate against a head and could be closed as the storm approaches. The tainter gate could also be opened against a reversed head. This capability would greatly reduce the duration that the adjacent pumps must be operated. The tainter and sluice gates could be stored above the water surface sufficiently to reduce corrosion. Both gate types can be monitored and operated remotely by the inclusion of a supervisory control and data acquisition (SCADA) system.

The tainter gate design includes bulkhead recesses needed to dewater the gate bay for inspections and repair while the sluice gate alternative does not. Minor repairs to the sluice gate guides could be made with divers. A braced excavation would need to be installed around the alternative sluice gate structure should major underwater repairs be required.

It is anticipated that the alternative all-steel sluice gate would need a full inspection and repair every 15 years. Recoating of the steel walls and sluice gates would be needed at each dewatering. The concrete structure and tainter gate would need to be dewatered for inspection every 20 to 25 years. Repairs are expected to be minor. The gates, regardless of type, would need to be exercised at least 3 times per year.

5.7.2 Pump Station

The vertical lift pumps are self-priming. Pumps would be activated in advance of floodgate closures. Pumps could be automated, provided a manual override is available. The electric motors would work off available commercial power. A back up diesel generator would be included, as commercial power is not reliable in storm events. A trash rack would also be included on the intake side. It is recommended that a mechanical rake also be included in the design. The more economical mechanical trash rake would be sufficient. An enhancement would be the inclusion of a catenary driven rake or a hydraulic strut actuated rake.