APPENDIX A

DESIGN MEMORANDUMS

APPENDIX A.1

CAP TREATMENT LAYER CONCEPTUAL DESIGN MEMORANDUM

1st Street Turning Basin Sediment Cap Treatment Layer Conceptual Design
Gowanus Canal Superfund Site, Brooklyn, New York

PREPARED FOR:	Christos Tsiamis, USEPA Region II
COPY TO:	File
PREPARED BY:	CH2M HILL
DATE:	October 15, 2018

Introduction

On March 2, 2010, the U.S. Environmental Protection Agency Region II (USEPA) placed the Gowanus Canal on the National Priorities List. The selected remedy for this Superfund site, as detailed in the September 2013 Record of Decision (ROD), addressed sediment containing elevated concentrations of polycyclic aromatic hydrocarbons (PAHs) and non-aqueous phase liquids (NAPLs) (USEPA, 2013). Components of the selected remedy included dredging of accumulated (soft) sediment, in situ stabilization/solidification (ISS) of native sediment with upward mobile NAPL, and capping over ISS-treated and native sediments to prevent both NAPL and dissolved contaminant migration into the canal.

The ROD also included the excavation and restoration of the 1st Street Turning Basin (TB).

The Potentially Responsible Parties (PRPs) (referred to as the Remedial Design Group or RD Group) are designing the selected remedy in the canal and its turning basins except that New York City (NYC) is designing the excavation and remedy for the 1st Street TB.

In November 2017, the RD Group submitted to EPA for review the draft 65% design for the upper section of the Gowanus Canal (Remedial Target Area 1 or RTA-1). Appendix B-15 Treatment Layer Design Evaluation presented the methodology to design the treatment layer components of the cap. The primary analysis tool used was the CapSim model version 3.5 (Reible Research Group, 2017; Lampert, 2010). The treatment layer components include a layer of oleophilic clay (OC) mixed with sand to capture migrating mobile NAPL and an overlying layer of granular activated carbon (GAC) mixed with sand to treat (via sorption) dissolved contamination. CapSim is used to predict the service life of the sand and GAC layer based on the groundwater specific discharge and pore water concentration entering the sand + GAC containing layer.

The cap components for the 1st Street TB remain as designed by the RD Group and will include a 6-inch leveling sand layer and an 8-inch OC and sand layer with no less than 25% OC by dry weight that will underlie the sand + GAC layer and a 6-inch isolation and filter layer and a 6-inch armor layer using articulated concrete blocks that will overly the sand + GAC layer.

This technical memorandum (TM) presents the evaluation of the required thickness and composition for the sand + GAC treatment component of the cap for the bottom of the excavated 1st Street TB cap. The evaluation uses the same analysis tool and input parameters as used by the RD Group for the design of this layer for RTA-1 except that where available, information specific to the 1st Street TB is used.

Based on the layout presented in this TM, NYC will be developing a detailed design for the 1st Street TB including cap. The cap designs for RTA-1 and the 1st Street TB must be integrated at their point of confluence.

Methodology

This TM uses CapSim Version 3.5 to develop the thickness and composition for the sand + GAC treatment layer for the cap for the bottom of the excavated 1st Street TB. The reader is referred to Appendix B-15 Treatment Layer Design Evaluation in the Draft 65% Design for RTA-1 (November 20, 2017) for detailed description of the tool and input parameters.

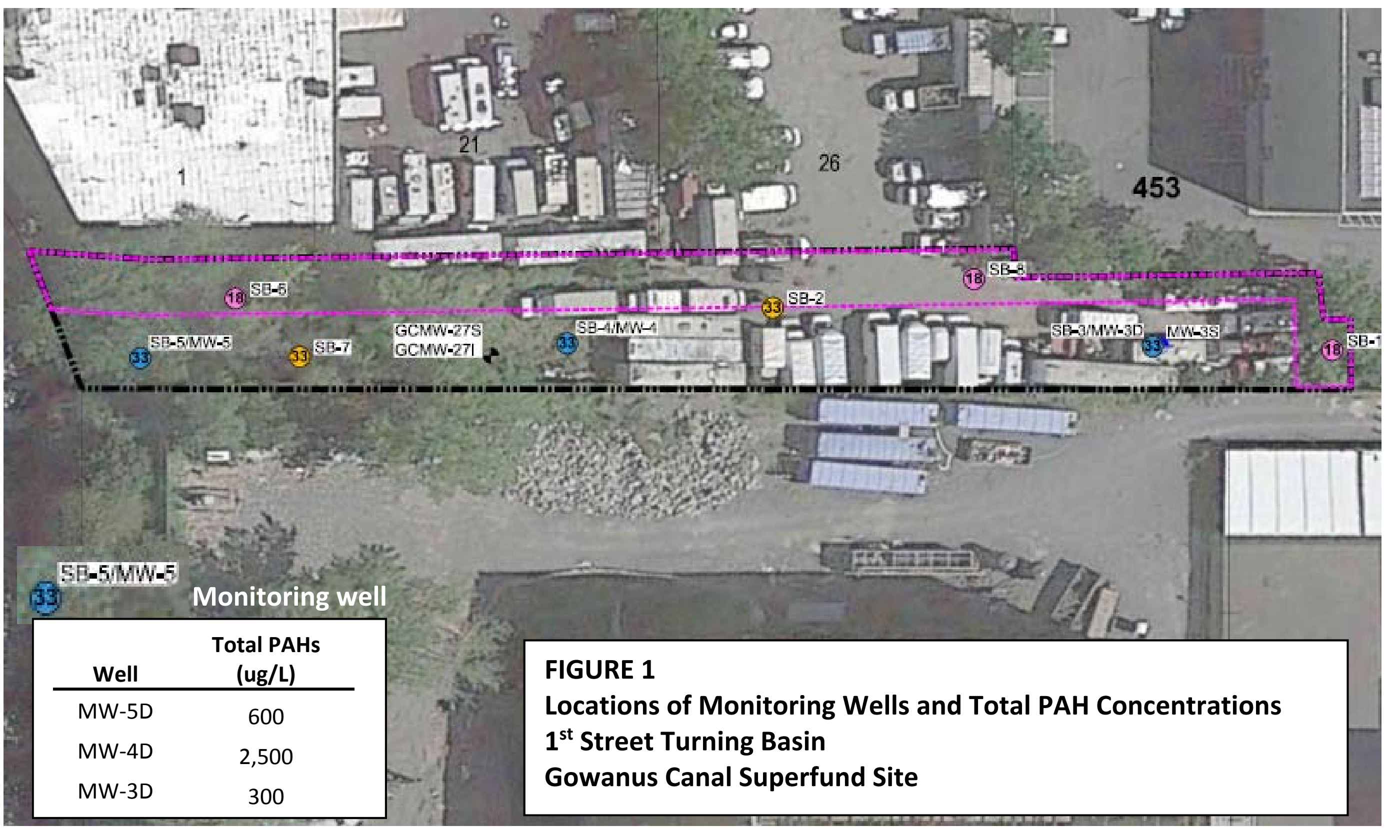
The tool was applied to the 1st Street TB using the same input parameters (including a target 100-year design life) as used by the RD Group for the design of the treatment layer for the canal cap except for the following two input parameters which were based on information specific to the 1st Street TB:

- Dissolved concentrations in groundwater to be adsorbed by the sand + GAC layer
- Groundwater specific discharge (groundwater upwelling velocities)

Dissolved Concentrations in Groundwater.

Groundwater data is available along the length of the 1st Street TB from several monitoring wells installed to investigate conditions in the infilled basin. The results were documented in the Environmental Sampling and Analysis 30% Field Activity Summary Report (AKRF/KSE, November 2017). The locations of these monitoring wells and the total PAH concentrations measured are shown in Figure 1 below.

The results indicate that the total concentrations vary along the length of the TB with the highest concentration near the middle, lower concentration in the west section near intersection with the main canal, and the lowest concentration in the east section.



Well	Total PAHs (ug/L)
MW-5D	600
MW-4D	2,500
MW-3D	300

FIGURE 1
Locations of Monitoring Wells and Total PAH Concentrations
1st Street Turning Basin
Gowanus Canal Superfund Site

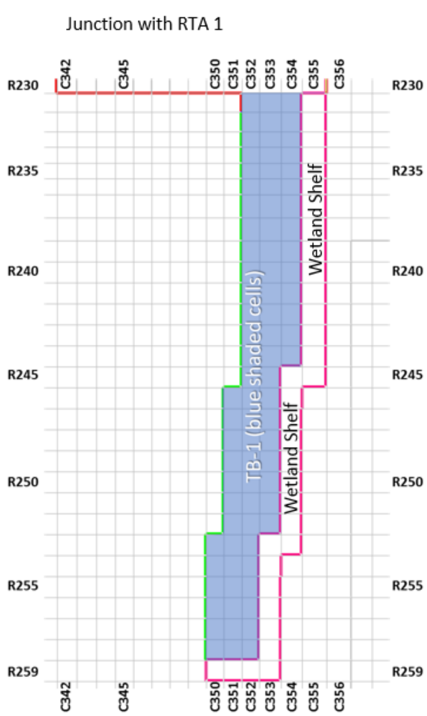
Specific Groundwater Discharge

Direct measurements of groundwater specific discharge are not available for the currently infilled 1st Street TB. The RD group incorporated the physical setting of the restored turning basin into a groundwater model developed to support the remedial design for the canal. The model is described in detail in PD-12 GROUNDWATER MODEL CALIBRATION REPORT, GOWANUS CANAL SUPERFUND SITE, BROOKLYN, NEW YORK (Geosyntec, November 2017). The model was utilized to calculate the groundwater specific discharges to support the remedial design including specific discharges along the 1st Street TB.

Figure 2 represents groundwater specific discharges extracted from the groundwater model for the 1st Street TB for the model layers near the proposed bottom of the TB. The model breaks the canal in cells and provides a value for the specific discharge for each cell. The left part of the figure shows in blue the layout of the planned 1st Street TB excavation. The right part of the figure shows the specific discharges for each cell. The length of the planned 1st Street TB excavation is divided in three sections to correspond to the 3 concentration ranges measured along its length.

- Section 1: Reflects the concentration measured in MW-5D and covers the section from the intersection of the canal until the mid-point between MW-5D and MW-4D
- Section 2: Reflects the concentrations measured in MW-4D and covers the section from the mid-point with MW-5D to the mid-point between MW-4D and MW-3D
- Section 3: Reflects the concentration in MW-3D and covers the section from the mid-point with MW-4D to the end of the planned 1st Street TB excavation

FIGURE 2
Groundwater Specific Discharges (based on groundwater model scenario 15c)
1st Street Turning Basin, Gowanus Canal Superfund Site



Groundwater specific discharge output (ft/day)

Row↓ Column→	350	351	352	353	354
231			0.42	0.42	0.42
232			0.39	0.39	0.39
233			0.37	0.37	0.37
234			0.36	0.35	0.35
235			0.34	0.34	0.34
236			0.33	0.33	0.33
237			0.32	0.32	0.32
238			0.31	0.31	0.31
239			0.30	0.30	0.30
240			0.30	0.29	0.29
241			0.29	0.29	0.29
242			0.29	0.28	0.32
243			0.29	0.28	0.31
244			0.29	0.28	0.31
245			0.29	0.28	
246		0.29	0.28	0.28	
247		0.29	0.29	0.29	
248		0.29	0.29	0.29	
249		0.29	0.29	0.29	
250		0.29	0.29	0.29	
251		0.29	0.29	0.29	
252		0.29	0.29	0.29	
253	0.30	0.29	0.29		
254	0.30	0.29	0.29		
255	0.30	0.29	0.33		
256	0.30	0.29	0.33		
257	0.29	0.28	0.33		
258	0.33	0.33	0.32		
259	0.00	0.00	0.00		

Section 1
Total PAH concentration - 600 ug/L
Maximum specific discharge - 0.42 ft/day

Section 2
Total PAH concentration - 2500 ug/L
Maximum specific discharge - 0.32 ft/day

Section 3
Total PAH concentration - 300 ug/L
Maximum specific discharge - 0.33 ft/day

Notes:
Specific Discharge based on groundwater model for cell range of polygon around well area
Total PAH concentration based on TB-1 Environmental Sampling Report

CapSim Model Results

CapSim kinetic simulations were run to determine the thickness and composition of the sand + GAC treatment layer.

Table 1 lists for each of the three sections of the 1st Street TB the thickness of the sand + GAC treatment layer corresponding the maximum groundwater specific discharges and the concentration measured in the groundwater in that section.

GAC Treatment Layer Zone	Groundwater Upwelling (ft/day) (calculated)	Groundwater Upwelling (cm/yr)	Pore water Concentration (ug/L)	Treatment Layer Thickness		Layer Composition (% Weight)		Sorption Coefficients		
				(in)	(cm)	GAC	Sand	K_F (µg/kg/(µg/L)^N)	k_{sorp} (1/year)	N
Section 1	0.42	4,672.58	600	16	25.4	43%	57%	1,250,714	6,307	0.45
Section 2	0.32	3,560.06	2,500	29	40.6	44%	56%	1,250,714	6,307	0.45
Section 3	0.33	3,671.32	300	7	10.2	45%	55%	1,250,714	6,307	0.45

Notes:
1-Targeted chemical flux is calculated based on the groundwater specific discharge and pore water concentration input parameters.
2-Modeled chemical flux is calculated as the average of chemical flux output reported by CapSim output files at the bottom of the cap treatment layer over 100 years. The discrepancy between targeted and modeled chemical flux is anticipated to be due to: a) numerical dispersion; and b) dispersive flux.
3-Sorption parameters for naphthalene were used to represent sorption characteristics of total PAHs.

Based on the performed analysis, the thickness of the sand + GAC layer would increase in the middle of the turning basin (Section 2). For example, the thickness would begin at 16 inches in Section 1 at the intersection of RTA-1 and TB-1, increase to 29 inches in Section 2, and then decrease to 7 inches in Section 3, thus creating the potential for stagnant water in Section 3.

To design a cap of a more uniform thickness across the length of the turning basin, the CapSim model was run to determine the GAC content of a 29-inch thick layer in Section 3. The results are shown below.

GAC Treatment Layer Zone	Groundwater Upwelling (ft/day) (calculated)	Groundwater Upwelling (cm/yr)	Pore water Concentration (ug/L)	Treatment Layer Thickness		Layer Composition (% Weight)		Sorption Coefficients		
				(in)	(cm)	GAC	Sand	K_F (µg/kg/(µg/L)^N)	k_{sorp} (1/year)	N
Section 3	0.33	3,671.32	300	29	40.6	8%	92%	1,250,714	6,307	0.45

Conclusions

CapSim Version 3.5 was used to develop the thickness and composition for the sand + GAC treatment layer for the cap in the 1st Street TB. The tool was applied to the 1st Street TB using the same input parameters (including a target 100-year design life) used by the RD Group for the design of the treatment layer for the canal except for the following two input parameters which were based on updated information specific to the 1st Street TB:

- Dissolved concentrations in groundwater to be adsorbed by the sand + GAC layer
- Maximum specific groundwater discharge and resulting groundwater upwelling velocities

Following review of the results from a constructability prospective, the following design was selected for the sand + GAC treatment layer:

- Section 1 – 16 inches with 43% GAC (cap type 1)
- Section 2 – 29 inches with 44% GAC (cap type 2)
- Section 3 –29 inches with 8% GAC (cap type 3)

The cap profile along the 1st Street TB is shown on Figure 3 (figure adapted from AKRF design package) along with the cap design for the main channel. To avoid abrupt change if thickness of the sand + GAC layer at station 100, the designer may consider beginning to increase the thickness of the Section 1 cap starting around Station 80 until the design thickness of 29 inches is reached at Station 100 at which point, the composition would be changed to the Section 2 cap design. The designer may also wish to consider an alternative transition. Note that the cap design for the 1st Street TB was discussed with the RD Group so that the design elevation of top of cap for RTA-1 matches the design elevation of top of cap for the 1st Street TB at their intersection. The coordination was based on elevation of -16 feet for the 1st Street TB excavation at its intersection with the main canal and a cap thickness beginning in Section 1 of the turning basin that incorporates 16 inches of sand + GAC.

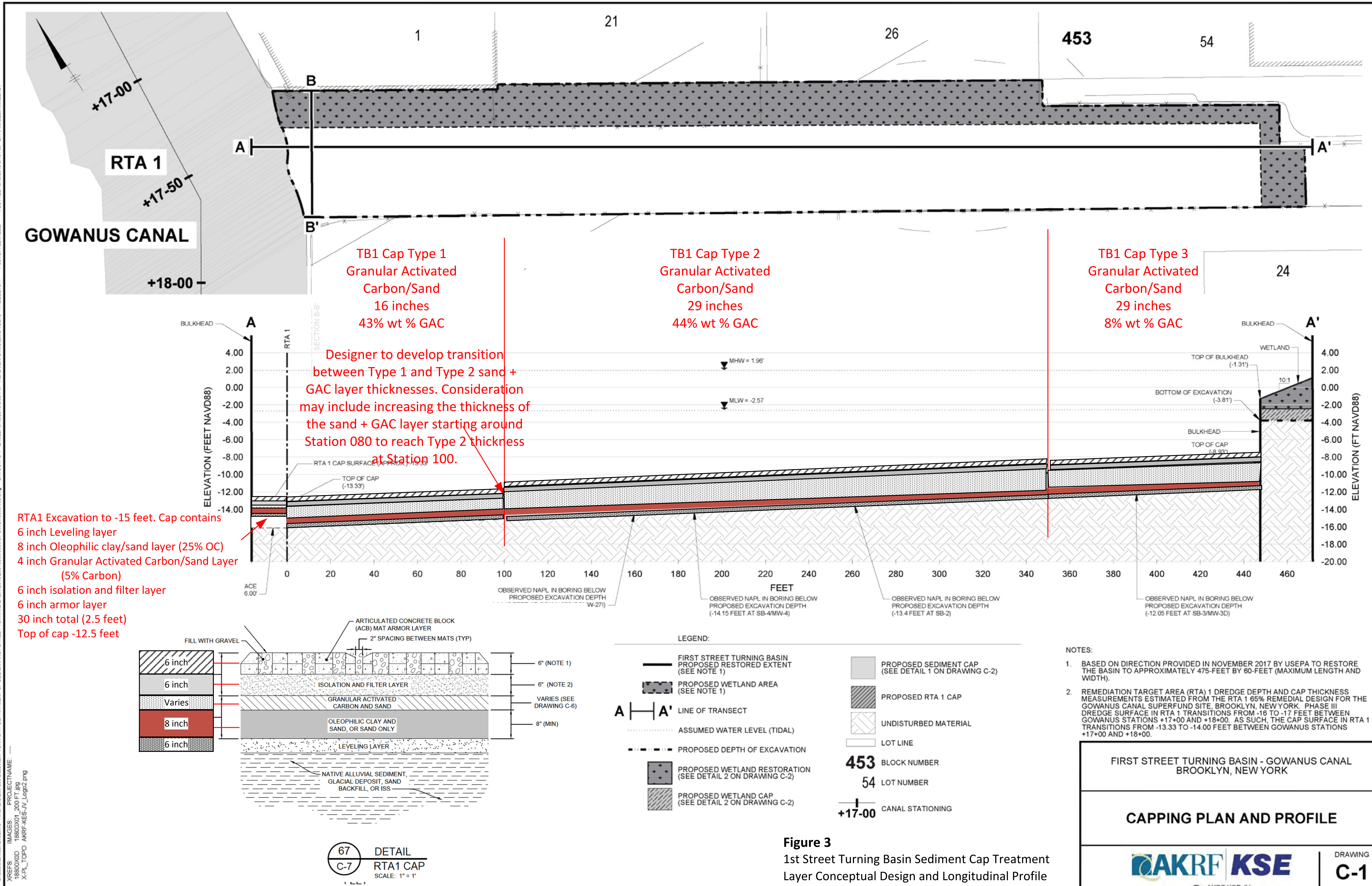


Figure 3
1st Street Turning Basin Sediment Cap Treatment Layer Conceptual Design and Longitudinal Profile

APPENDIX A.2

PRELIMINARY BULKHEAD DESIGN MEMORANDUM

AKRF-KSE JV
440 Park Avenue South
7th Floor
New York, NY 10016
tel: 212 696-0670
fax: 212 213-3191

CLIENT: NYCDDC

PROJECT ID: PW77GOWAN

PROJECT NAME: DESIGN SERVICES FOR EXCAVATION AND CAPPING OF FILLED FIRST STREET TURNING BASIN – GOWANUS CANAL

PROJECT LOCATION: BOROUGH OF BROOKYLN, NEW YORK

October 26, 2017

Preliminary Bulkhead Design Memorandum for the Excavation and Capping of Filled First Street Turning Basin – Gowanus Canal, Brooklyn, NY

Support of Excavation/Bulkhead Options

The geotechnical investigation performed at the Former First Street Turning Basin site included nine borings, two of which were drilled to approximately 100 feet below the ground surface. All other borings were drilled to approximately 60 feet below the ground surface. A piezometer was installed in one of the borings for monitoring groundwater elevations. A boring location plan and preliminary geologic profiles are attached as Exhibit 1.

The preliminary results of the subsurface investigation revealed a subsurface profile generally consisting of approximately 20 feet of fill overlying lenses of organic clays and silts of varying thickness, overlying deep sand deposits of varying density. Rock was not encountered in the borings and is relatively deep. Some of the borings encountered obstructions as deep as 15 to 20 feet below the ground surface. The groundwater table encountered in the borings was at approximately El. 3. Elevations are referenced to NAVD88.

The geotechnical investigation also included six test pits along the basin perimeter. Test pits excavation depth varied from approximately 7.5 to 13.5 feet below the ground surface. Water was not encountered at the time the test pits were excavated. The original timber crib bulkhead was encountered in one of the test pits excavated adjacent to the south perimeter of the basin. A timber crib structure was not encountered at any of the other five test pits.

Various alternatives were evaluated for support of excavation (SOE) along the basin perimeter during soil/sediment removal and for the permanent bulkheads. The alternatives considered are based on the preliminary results of the subsurface investigation and the following assumptions:

1) No external bracing permitted beyond the basin property lines.
2) Soil/sediment removal within the basin will be performed in a dewatered condition.
3) The SOE/Bulkheads are to support existing grades (El. 8±) on the north and east perimeters and higher grades (El. 13± to 19±) along the south perimeter for the planned Powerhouse site development.
4) A 20’ wide shelf within the tidal zone along the north and east perimeters of the basin.
5) The SOE walls are to be relatively impermeable.
6) Obstructions that can hinder driven wall systems

North and East Perimeter

Options considered for the north and east perimeters along with advantages and disadvantages for each option are presented in Figure 1 and Table 1, respectively.

The required wall height along these perimeters is not relatively high and cantilever elements can be designed to support the excavation. Due to the potential for buried obstructions, three options were evaluated that generally mitigate this risk; steel sheet piling inserted in an excavated cement-bentonite trench, a driven combination wall with pipe piles and sheet piling, and drilled secant piles.

Since the required SOE wall depth along these perimeters is likely to be relatively shallow, the cement-bentonite trench with inserted sheet piling appears technically viable, results in the least wall thickness, and may be more cost-effective than the other two options. The C-B trench reduces the length of driving and pile driving vibrations thereby reducing the risk of damage to adjacent structures. The trench also removes obstructions within the fill zone, thereby reducing risk to the project.

South Perimeter

Options considered for the south perimeter along with advantages and disadvantages for each option are presented in Table 2 and Figure 1.

The required SOE/Bulkhead wall height along the south perimeter is relatively high and a significantly more robust wall system will be required compared to the north and east perimeters. Due to the high potential for buried obstructions, two wall systems were considered to mitigate or reduce this risk including, driven interlocked pipe piles, and drilled secant piles. Both wall systems will have comparable wall thickness.

The drilled secant piles offer the most benefits from a constructability standpoint compared to the driven king pile wall. The method for constructing secant piles is essentially vibration free, thereby reducing risk of damage to adjacent structures. A drilled wall is best suited for penetrating buried obstructions, thereby reducing risk of delays and unanticipated costs during construction.

Shelf Perimeter

Options considered for the shelf perimeter along with advantages and disadvantages for each option are presented in Table 3 and Figure 2, respectively.

The required wall height to construct the shelf is moderate and can be achieved with heavy z-sheeting or king pile sections. Due to the high potential for encountering obstructions during driving, the sheeting/king piles can be inserted in a cement-bentonite trench excavated to a specified depth and driving the remaining height to the final penetration depth.

Alternatively, the shelf can be constructed using a rip rap revetment sloping down from the shelf to the basin bottom. This approach is not impacted by obstructions and results in a more environmentally friendly option. Some disadvantages are it complicated the environmental cap construction and narrows the available basin flow area below water.

SHEET 1 OF 2

FILE 12541

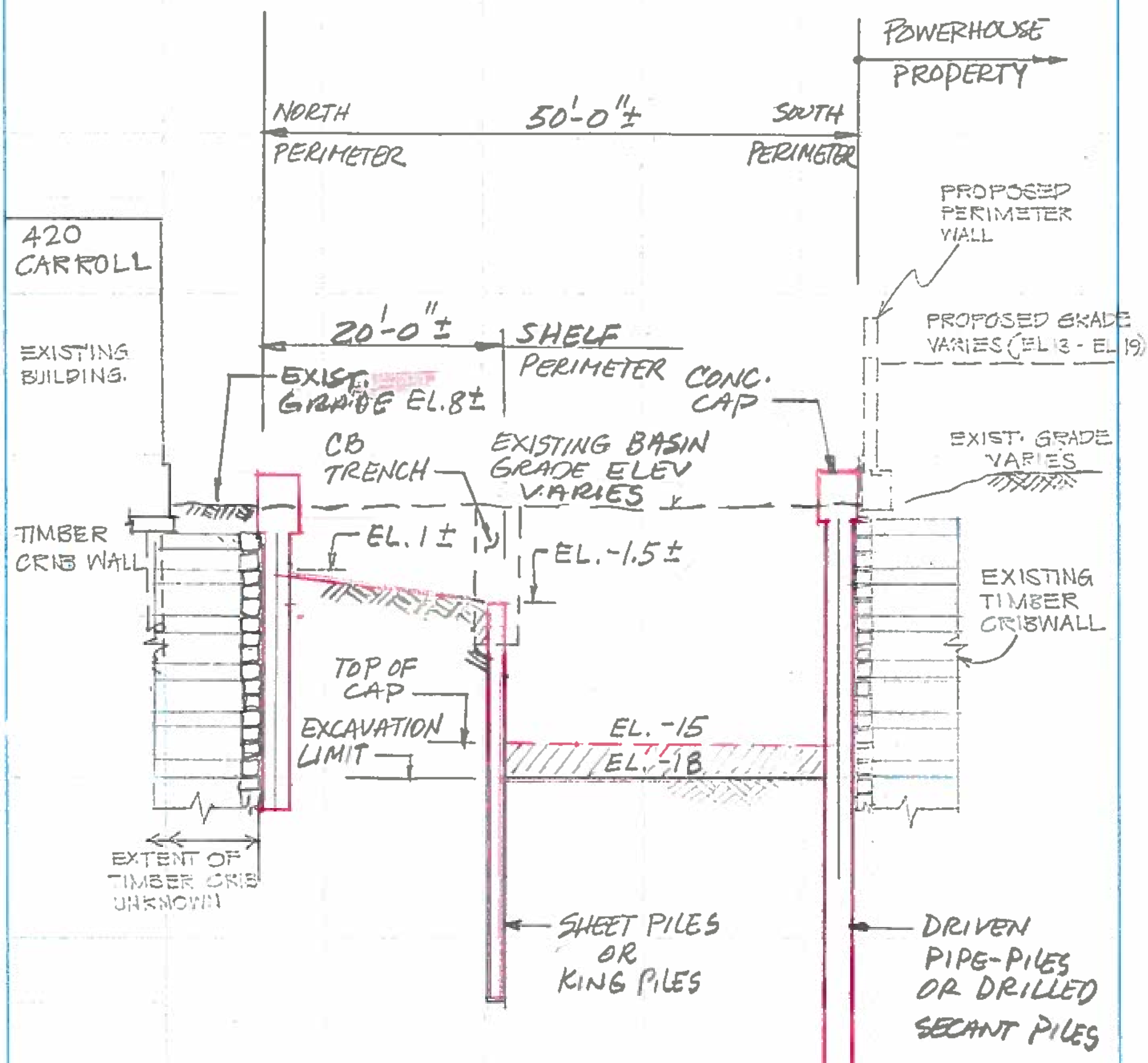
MUESER RUTLEDGE CONSULTING ENGINEERS

MADE BY RJ/DD DATE 10-24-17

PROJECT FIRST STREET TURNING BASIN

CHECKED BY ______ DATE ______

SUBJECT SOE/BULKHEAD OPTIONS



SECTION LOOKING EAST
N.T.S.

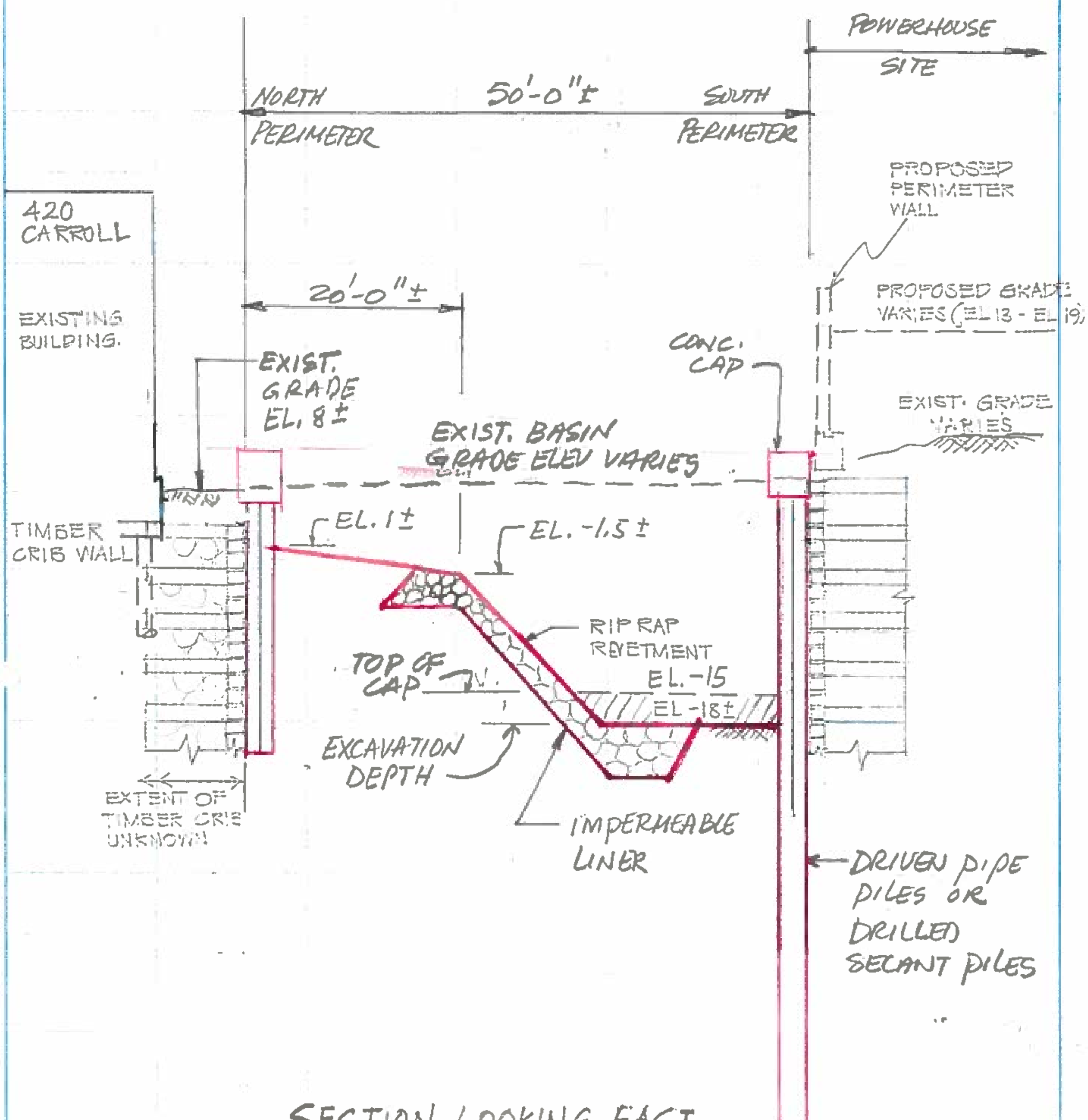
FIGURE 1

MUESER RUTLEDGE CONSULTING ENGINEERS

SHEET 2 OF 2
FILE 12541
MADE BY RJ/DD DATE 10-24-17
CHECKED BY ____ DATE ____

PROJECT FIRST STREET TURNING BASIN

SUBJECT SOE / BULKHEAD OPTIONS



SECTION LOOKING EAST
NTS

FIGURE 2

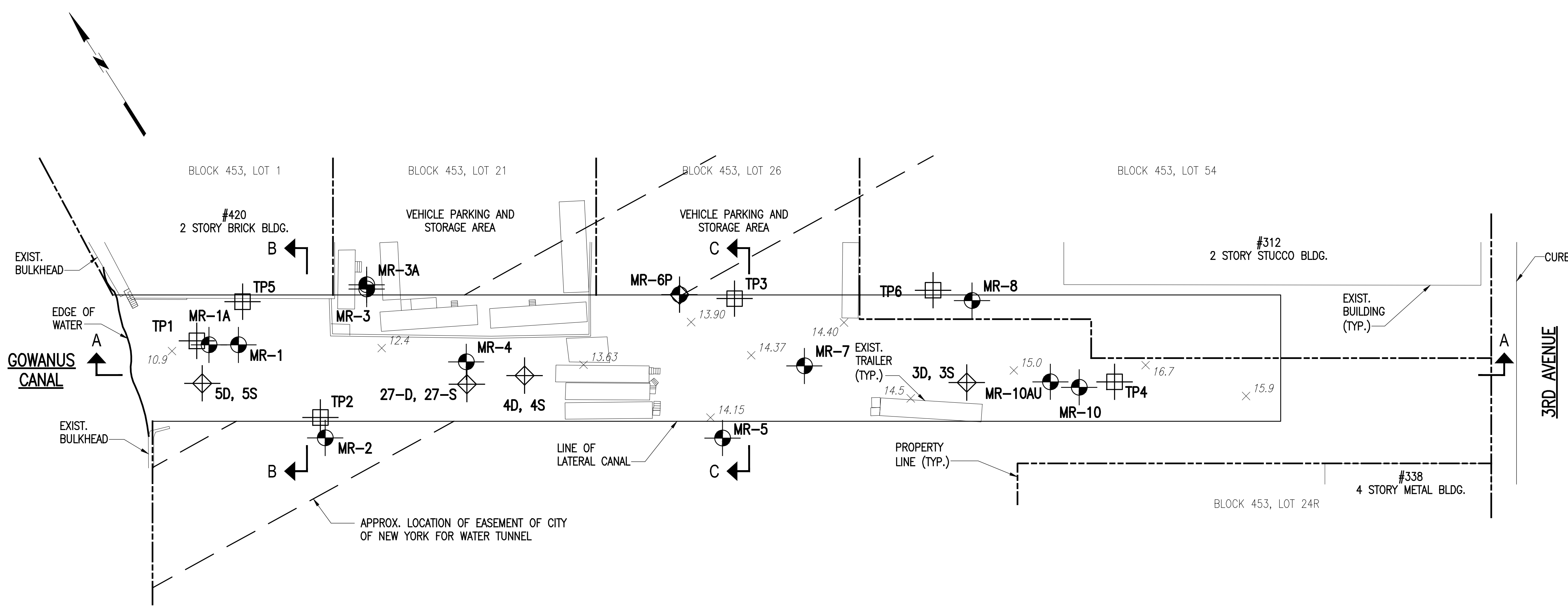
Table 1. North and East Perimeter

SOE/Bulkhead Type	Advantages	Disadvantages
I. Cement-Bentonite Trench with Inserted Steel Sheet Piling	Trench provides opportunity for removing obstructions prior to driving	Requires staging area for the C-B mixing plant
	Does not require a finish wall for the permanent bulkhead	Generates spoils that will require pre-treatment for disposal
	Relatively fast construction time compared to secant pile option	Requires treating interlocks with sealant to minimize potential for leaching from adjacent sites
	Reduces ground vibrations and the potential for damage to adjacent structures	Limited cantilever wall height
	Results in a relatively narrow wall thickness compared to other options	
II. Combination Driven Pipe Piles and Steel Sheet Piling	Driven king piles have increased potential to penetrate obstructions during driving	Requires treating interlocks with sealant to minimize potential for leaching from adjacent sites
	Open end pipe piles provide opportunity to remove obstructions by drilling inside the pile if required	Vibrations during installation could potentially cause adverse effects to adjacent structures
	Can support relatively high wall heights without bracing	Installation of sheet pile sections may be difficult in soils with obstructions
		Subject to corrosion and not as durable as secant piles
		Wall thickness
III. Drilled Secant Piles	Installation can occur in difficult ground conditions	Slower construction time than other options.
	Can be incorporated into permanent bulkhead wall	Wall thickness
	Provides good groundwater cut-off	Requires a finish wall for the permanent bulkhead for aesthetic purposes
	Eliminates vibrations and minimizes potential for settlement of adjacent structures	

Table 2. South Perimeter

SOE/Bulkhead Type	Advantages	Disadvantages
I. Driven Interlocked Pipe Piles	Driven king piles have increased potential for penetrating obstructions during driving	Requires treating interlocks with sealant to minimize potential for leaching from adjacent sites
	Open end pipe piles provide opportunity to drill past obstructions by drilling inside the pile if required	Vibrations during installation could potentially cause damage to adjacent structures
	Does not require a finish wall for aesthetic purposes	Wall thickness
		Steel will be subject to corrosion and is less durable than a secant pile wall
II. Drilled Secant Piles	Good for installation in difficult ground conditions	Slower construction time frame.
	Can be incorporated into permanent bulkhead wall	Wall thickness
	Greater durability compared to steel wall options	Requires a finish wall for aesthetic purposes
	Eliminates vibrations and minimizes potential for damage to adjacent structures	

Table 3. Shelf Perimeter		
SOE/Bulkhead Type	**Advantages**	**Disadvantages**
I. Cement-Bentonite Trench with Inserted and/or Driven Steel Sheet Piling or King Pile Wall	Trench provides opportunity for removing obstructions prior to driving	Requires staging area for the C-B mixing plant
	Does not require a finish wall for the permanent bulkhead	Generates spoils that will require pre-treatment for disposal
	Relatively faster construction time compared to Option II	Requires treating interlocks with sealant to minimize potential for leaching from adjacent sites
	Trench can be extended to required sheeting depth to eliminate pile driving vibrations	Limited cantilever wall height
II. Rip Rap Revetment	Not impacted by obstructions	Reduces basin width below the water line and leaves more contaminated soil in place compared to Option I
	Vibration-free method reducing potential for damage to adjacent structures	Complicates environmental cap construction
	Environmentally friendly	



NOTES:

1. BASE PLAN OBTAINED FROM AKRF PERFORMED BY B.THAYER ASSOCIATES DATED XXX.
2. ELEVATIONS SHOWN ON THIS SURVEY REFER TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).
3. BORINGS MR-1 TO MR-10 AND TEST PITS TP1 TO TP6 WERE MADE BY ASSOCIATED ENVIRONMENTAL SERVICES LTD. BETWEEN AUGUST 14, 2017 AND SEPTEMBER 22, 2017 UNDER THE CONTINUOUS INSPECTION OF MRCE'S RESIDENT ENGINEER.
4. BORINGS MR-2 AND MR-5 WERE MEASURED OFF EXISTING FEATURES. APPROXIMATE GROUND SURFACE ELEVATIONS WERE PROVIDED BY ROUX ASSOCIATES.
5. AS DRILLED LOCATIONS AND GROUND SURFACE ELEVATIONS FOR BORINGS MR-1 TO MR-10 AND TEST PITS TP1 TO TP6 WERE SURVEYED BY B.THAYER ASSOCIATES ON SEPTEMBER 18TH, 2017 AND COMPLETED ON OCTOBER 4, 2017.
6. STRATIFICATIONS SHOWN ON THE GEOLOGIC SECTIONS ARE BASED ON NECESSARY INTERPOLATION BETWEEN BORINGS AND MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS.
7. FOR GEOLOGIC SECTIONS A-A, B-B, AND C-C, SEE DRAWING GS-1.
8. SEE DRAWING NO. GS-R FOR BORING LEGEND AND A SUMMARY OF MRCE SOIL CLASSIFICATION SYSTEM.

LEGEND:

MR-6P
- MRCE BORING DRILLED IN 2017
- "P" INDICATES PIEZOMETER
- "A" INDICATES OFFSET
- "U" INDICATES UNDISTURBED SAMPLES

TP1
- MRCE TEST PIT PERFORMED IN 2017

3S, 3D
- MONITORING WELL INSTALLED BY OTHERS

10.9
- GROUND SURFACE SPOT ELEVATION

FIRST STREET TURNING BASIN

BROOKLYN NY

AKRF

NEW YORK NY

MUESER RUTLEDGE CONSULTING ENGINEERS

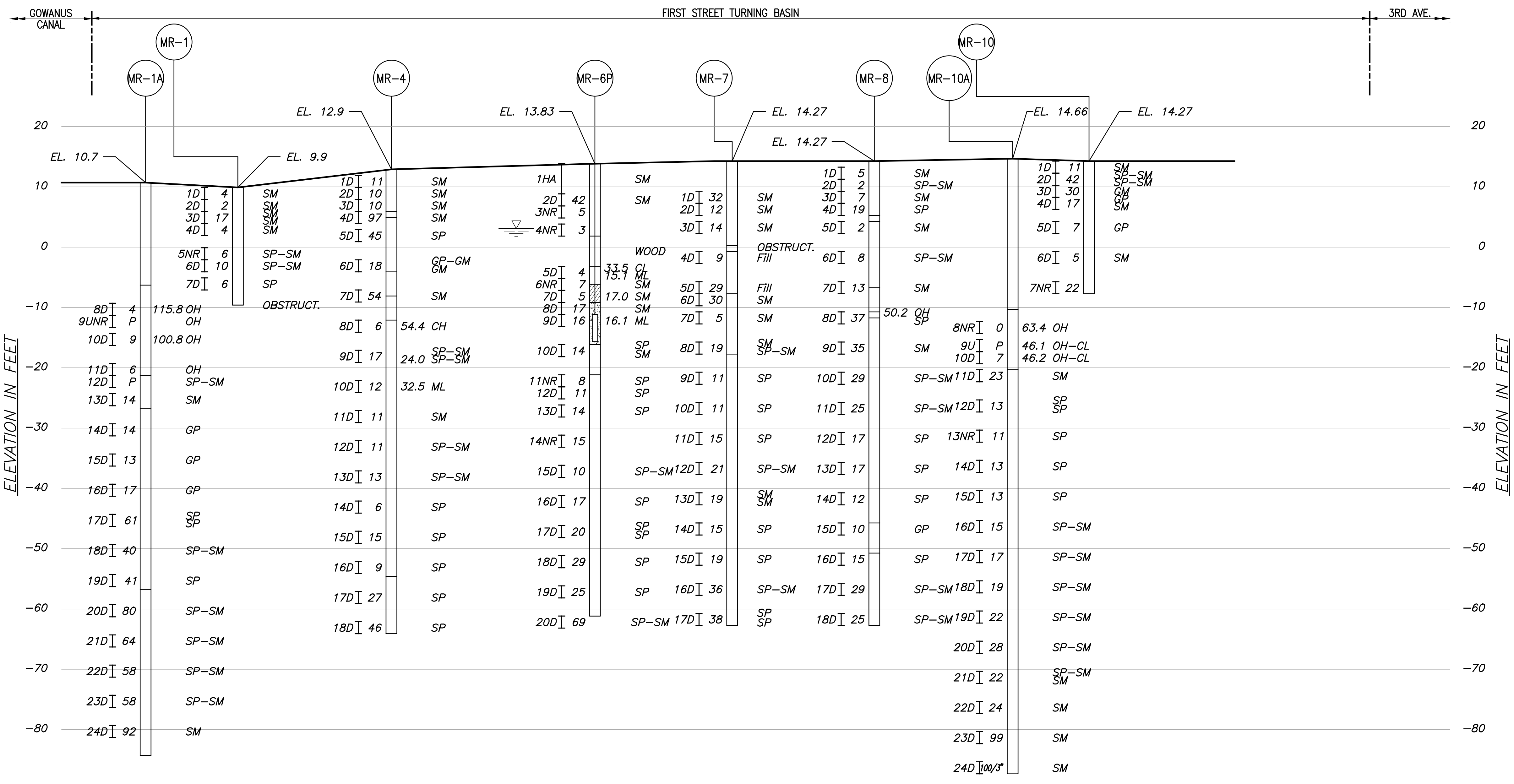
14 PENN PLAZA – 225 W. 34TH STREET, NY, NY 10122

SCALE	MADE BY: E.H.	DATE: XX-XX-XXXX	FILE NUMBER
AS NOTED	CH'KD BY:	DATE: XX-XX-XXXX	12541

GENERAL BORING LOCATION PLAN

DRAWING NUMBER B-1

NOTES:
1. FOR GENERAL NOTES, SEE DRAWING NO. B-1.



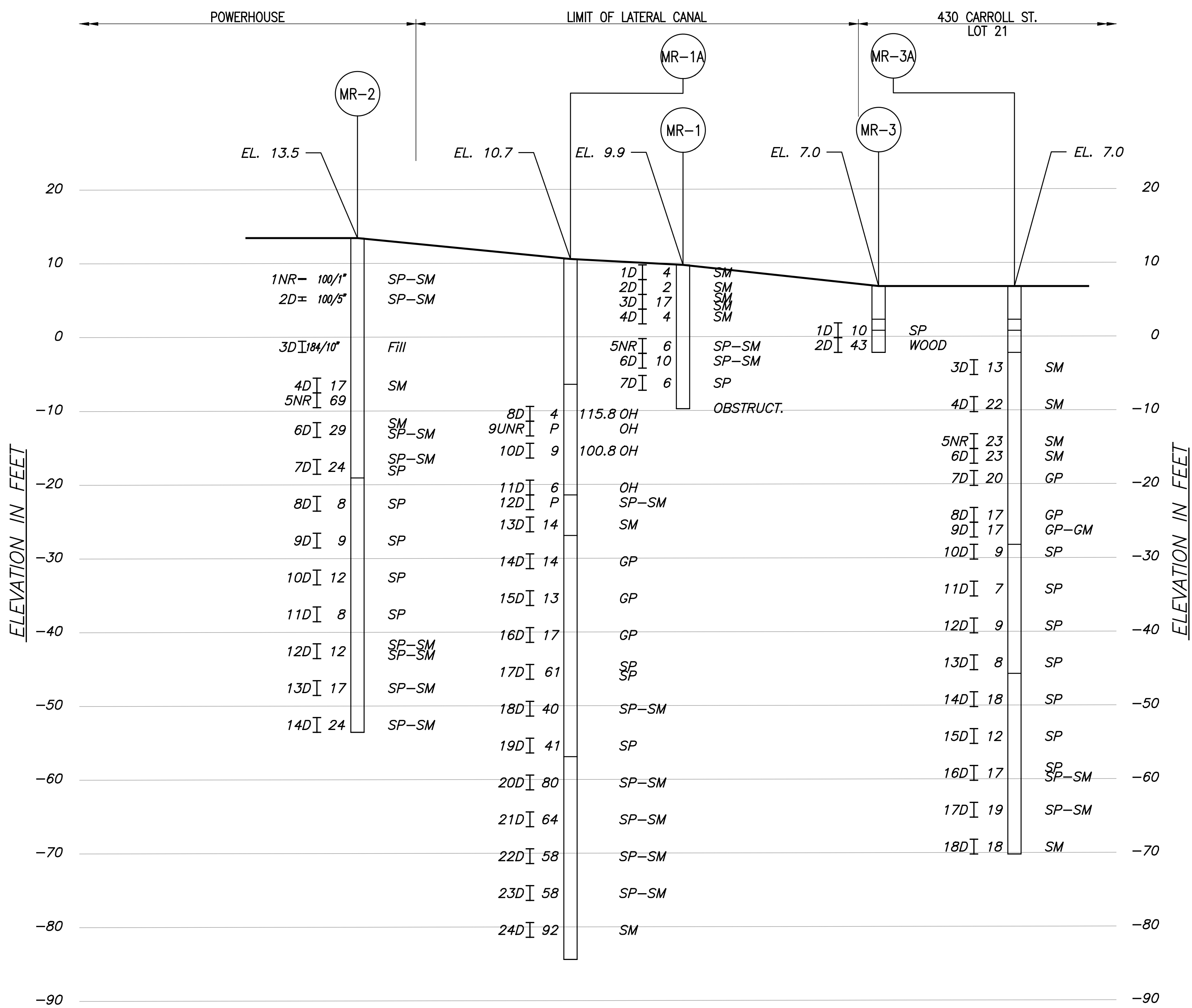
SECTION A-A
SCALE: GRAPHICAL

GRAPHIC SCALE
HORIZONTAL: 30' 20' 10' 0 30' 60'
VERTICAL: 10' 5' 0 10' 20'

FIRST STREET TURNING BASIN	
BROOKLYN	NY
AKRF	
NEW YORK	NY
MUESER RUTLEDGE CONSULTING ENGINEERS 14 PENN PLAZA – 225 W. 34TH STREET, NY, NY 10122	
SCALE: AS NOTED	MADE BY: E.H. DATE: XX-XX-XXXX CH'KD BY: DATE: XX-XX-XXXX
FILE NUMBER	12541
GEOLOGIC SECTION A-A	DRAWING NUMBER GS-1

NOTES:

1. FOR GENERAL NOTES, SEE DRAWING NO. B-1.



SECTION B-B

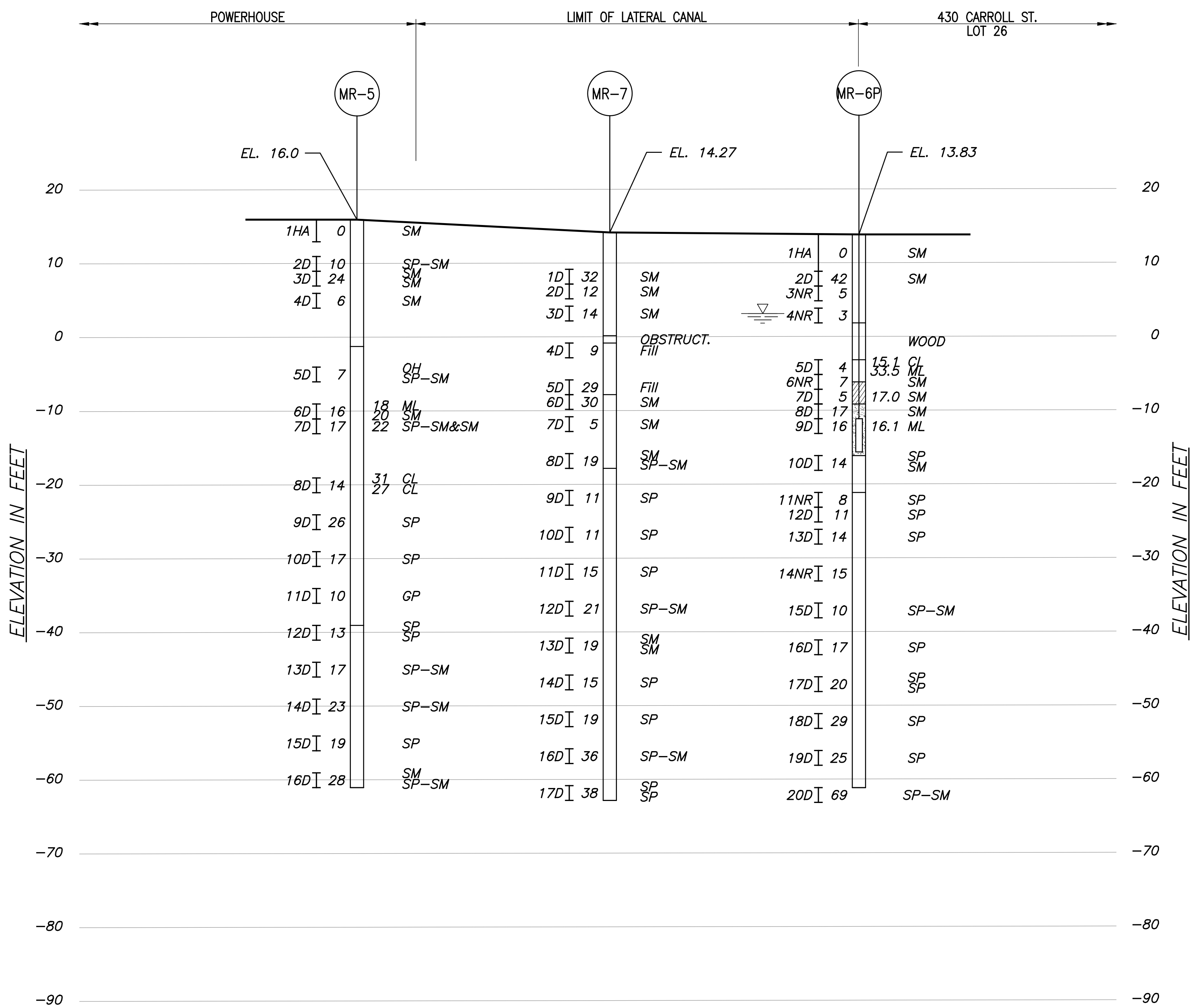
SCALE: GRAPHICAL

GRAPHIC SCALE

10' 5' 0 10' 20'

FIRST STREET TURNING BASIN	
BROOKLYN	NY
AKRF	
NEW YORK	NY
MUESER RUTLEDGE CONSULTING ENGINEERS 14 PENN PLAZA – 225 W. 34TH STREET, NY, NY 10122	
SCALE: AS NOTED	MADE BY: E.H. DATE: XX-XX-XXXX
	CH'KD BY: DATE: XX-XX-XXXX
FILE NUMBER	12541
GEOLOGIC SECTION B-B	DRAWING NUMBER GS-2

NOTES:
1. FOR GENERAL NOTES, SEE DRAWING NO. B-1.



SECTION C-C
SCALE: GRAPHICAL

GRAPHIC SCALE
10' 5' 0 10' 20'

FIRST STREET TURNING BASIN
BROOKLYN NY

AKRF
NEW YORK NY

MUESER RUTLEDGE CONSULTING ENGINEERS
14 PENN PLAZA – 225 W. 34TH STREET, NY, NY 10122

SCALE	MADE BY: E.H.	DATE: XX-XX-XXXX	FILE NUMBER
AS NOTED	CH'KD BY:	DATE: XX-XX-XXXX	12541

GEOLOGIC SECTION
C-C

DRAWING NUMBER
GS-3

APPENDIX A.3

SOIL DESIGN PARAMETERS MEMORANDUM

MRCE
built on firm foundations

MEMORANDUM

Date: December 4, 2017

To: Office

From: Athena C. DeNivo

Re: Geotechnical Design Parameters
Excavation and Capping of First Street Turning Basin
450 Carroll Street, Brooklyn, NY

File: 12541

Based on the geotechnical information available at the First Street Turning Basin Site we have developed geotechnical design parameters for the temporary structure and permanent bulkheads.

Soil Stratum	Unit Weight γ (pcf)	Service Load		Seismic Load	
		Friction Angle (°)	Undrained Shear Strength (psf)	Friction Angle (°)	Residual Shear Strength (psf)
(F) Fill above GW @ Elev. +3	115	30	-	-	-
(F) Fill below GW @ Elev. +3	115	30	-	-	80
(F) Fill below GW @ Elev. -8	115	30	-	-	100
(O) Organic Silty Clay	90	-	400	-	400
(S1) Upper Sand @ Elev. -21	120	32	-	-	190
(S1) Upper Sand @ Elev. -51	120	32	-	-	275
(S2) Lower Sand	125	34	-	34	-
(T) Till	130	36	-	36	-

Geotechnical design parameters provided are developed using information provided in the November 15, 2017 MRCE Geotechnical Investigation Report.

MUESER RUTLEDGE CONSULTING ENGINEERS

Athena C. DeNivo, PE

AE:ACD:F\125\12541 - First St Turning Basin\Memorandums\Design Parameters\Geotechnical Design Parameters Memo 12.11.17.docx

APPENDIX A.4

LIQUEFACTION ASSESSMENT MEMORANDUM

MRCE
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MEMORANDUM

Date: December 12, 2017

To: Office

From: Christos Zoupantis, Jesse Richins

Re: Liquefaction Evaluation
Excavation and Capping of First Street Turning Basin
450 Carroll Street, Brooklyn, NY

File: 12541

Structural design of the new bulkheads for the excavated First Street Turning Basing must comply with the 2014 New York City Building Code (Code). The Code requires an assessment of the potential hazard of soil liquefaction under the Code design seismic event. This memorandum provides a brief description of subsurface conditions encountered in the borings and summarized the project liquefaction assessment. Elevations in this memorandum are referenced to NAVD 88.

Subsurface Conditions

Subsurface conditions are described in detail in the November 15, 2017 MRCE Geotechnical Investigation Report. Existing ground surface elevations at the time MRCE borings were performed range from Elev. +9 to Elev. +16. Additional grading was performed on the Powerhouse site property to the south with an average ground surface at Elev. +17 along the proposed bulkhead. The uppermost soil stratum is a miscellaneous granular fill (Stratum F) which ranges in thickness from 19 to 33 feet. Stratum F is intermittently underlain by Organic Silty Clay (Stratum O). The thickness of Stratum O ranges from 3 to 14 feet, with the thicker deposits on the east and west end of the site. Below Strata F and O are sand deposits. The Upper Sand (Stratum S1) is loose to medium compact fine to coarse sand approximately 20 to 60 feet thick. The underlying Lower Sand (Stratum S2) consists of medium compact to compact fine to coarse sand. Stratum S2 sand is approximately 15 to 38 feet thick. Very compact Glacial Till (Stratum T) was encountered about 90 feet below grade at the east and west ends of the site.

Groundwater levels in piezometer MR-6P ranged from approximately Elev. +2 at low tide to +3 at high tide.

Liquefaction Evaluation

In general only loose granular soils and low-plasticity fine grained soils below the groundwater table are subject to liquefaction. Liquefaction susceptibility was evaluated using the Code Liquefaction Assessment Diagram (NYCBC Figure 1813.1), which compares the SPT N_{60} Values to liquefaction “screening lines.” The SPT N_{60} Values are the field measured N-values from an Automatic Hammer normalized to an energy ratio of 60 percent. The screening indicated layers potentially liquefiable as shown on attached Figure L-1.

A simplified liquefaction assessment was performed to evaluate the liquefaction potential of the underlying soils below the ground water table using the Seed and Idriss (1971) simplified procedure, as modified by the NCEER Workshops (Youd et al, 2001). Based on field SPT N-values recorded in the borings, the Code requires analyzing liquefaction potential using a PGA_M of 0.33g for the Geometric Mean Maximum Considered Earthquake (MCE_G) adjusted for Site Class effects. The simplified liquefaction analysis using the Code specified criteria found that some soils below the groundwater table are susceptible to liquefaction under the MCE_G. Liquefaction potential is predominant between depths of 11 and 22 feet in Stratum F, and between depths of 35 to 65 feet in the Stratum S1 (See Figure L-1).

Liquefaction can result in a significant loss of soil strength and stiffness, along with liquefaction induced ground settlement. MRCE estimated the residual shear strength of liquefied soil using the Idriss & Boulanger (2008) procedures. The analysis estimates show that residual shear strength ranges from 80 to 100 psf at depths between 11 and 22 feet, and from 190 to 275 psf at depths between 35 and 65 feet. The residual shear strengths of the liquefiable zones should be used for design of the bulkheads in the post-seismic liquefied case conditions.

For the design seismic event, dynamic load increment additions in active earth pressures should be included in the design of the bulkhead. The dynamic load increment should be based on the PGA_M (0.33g) and the "Conclusions and Recommendations" included in Mikola and Sitar (UCB GT 13-01, 2013). As the peak seismic load typically occurs before liquefaction is induced, the dynamic load increment can be considered apart from the lateral load induced by liquefied soil.

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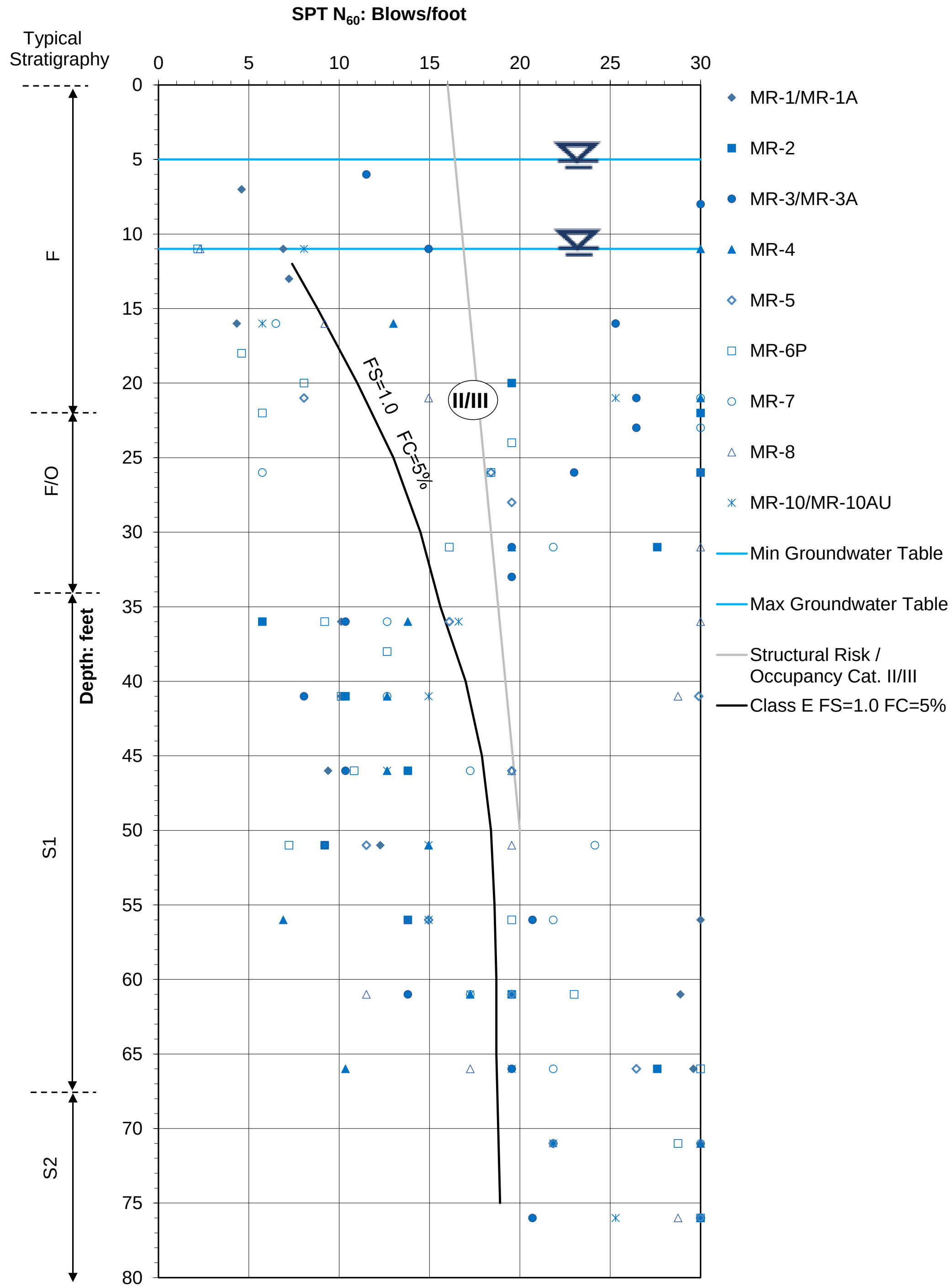
Christos Zoupantis

Attachments:
Figure L-1 – Simplified Liquefaction Assessment

CZ:AE:JR:ACD:DD:PWD:F:\125\12541 - First St Turning Basin\Geotechnical\Subsurface Investigation\Seismic\Liquefaction Evaluation Memo 2017-12-13.docx



NOTES:

1. Structural Risk/Occupancy Category II/III screening line corresponds to the New York City Building Code 2014 Liquefaction Assessment Diagram (figure 1813.1).
2. Simplified liquefaction screening line corresponds to a Factor of Safety (FS) of 1.0 against liquefaction for Fines Contents (FC) of 5% under the 2014 New York City Building Code MCE_G.
3. SPT N_{60} values above water table were not plotted.
4. SPT N_{60} values falling to the right of the appropriate screening line indicate that liquefaction is unlikely under the MCE_G.

FIRST STREET TURNING BASIN			
Brooklyn			New York
AKRF-KSE, JOINT VENTURE			
New York			New York
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14 PENN PLAZA – 225 W 34TH STREET, NEW YORK NY 10122			
SCALE	MADE BY: CZ	DATE: 11-28-17	FILE No.
N/A	CH'KD BY: JR	DATE: 11-29-17	12541
LIQUEFACTION ASSESSMENT			FIGURE L-1

APPENDIX A.5

SLOPE STABILITY MEMORANDUM

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MEMORANDUM

Date: December 8, 2017

To: Office

From: Athena C. DeNivo

Re: Preliminary Slope Stability Analysis
Excavation and Capping of First Street Turning Basin
450 Carroll Street, Brooklyn, NY

File: 12541

SLOPE STABILITY ANALYSIS

Preliminary slope stability analyses were performed using Slope/W 2007 software, a component of the Geo-Studio 2007 software package published by GEO-SLOPE International, Ltd. Analyses were performed using the Spencer method of slices with critical slip surfaces. Analyses assume two-dimensional conditions. The software analyzes a wide range of slip surfaces and identifies the slip surface with the minimum factor of safety (FS) as critical slip surface.

SUBSURFACE CONDITIONS

Subsurface conditions are described in detail in the November 15, 2017 MRCE Geotechnical Investigation Report. Existing ground surface elevations at the time MRCE borings were performed range from Elev. +9 to Elev. +16. Additional grading was performed on the Powerhouse site property to the south with an average ground surface at Elev. +17 along the proposed bulkhead. The uppermost soil stratum is a miscellaneous granular fill (Stratum F) which ranges in thickness from 19 to 33 feet. Stratum F is intermittently underlain by Organic Silty Clay (Stratum O). The thickness of Stratum O ranges from 3 to 14 feet, with the thicker deposits on the east and west end of the site. Below Strata F and O are sand deposits. The Upper Sand (Stratum S1) is loose to medium compact fine to coarse sand approximately 20 to 60 feet thick. The underlying Lower Sand (Stratum S2) consists of medium compact to compact fine to coarse sand. Stratum S2 and is approximately 15 to 38 feet thick. Very compact Glacial Till (Stratum T) was encountered about 90 feet below grade on the east and west ends of the site. Refer to Appendix A for the boring location plan and geologic sections.

MRCE liquefaction analysis summarized in our December 12, 2017 memorandum indicated that Strata F and S1 are liquefiable below the ground water table between depths of 11 to 22 feet and 35 to 65 feet below ground surface.

DESIGN PARAMETERS

Geotechnical design parameters summarized in our December 4, 2017 memorandum and provided bellow in Table 1 were used for this slope stability analysis.

Table 1. Design Parameters

Soil Stratum	Unit Weight γ (pcf)	Service Load		Seismic Load	
		Friction Angle (°)	Undrained Shear Strength (psf)	Friction Angle (°)	Residual Shear Strength (psf)
(F) Fill above GW @ Elev. +3	115	30	-	-	-
(F) Fill below GW @ Elev. +3	115	30	-	-	80
(F) Fill below GW @ Elev. -8	115	30	-	-	100
(O) Organic Silty Clay	90	-	400	-	400
(S1) Upper Sand @ Elev. -21	120	32	-	-	190
(S1) Upper Sand @ Elev. -51	120	32	-	-	275
(S2) Lower Sand	125	34	-	34	-
(T) Till	130	36	-	36	-

ANALYSIS

Analysis was performed for three different cases at the First Street Turning Basin site and preformed individual analysis for each case described below:

- Case 1: Temporary Construction
- Case 2: Service Condition
- Case 3: Seismic Condition

Case 1- Temporary Construction
Sections analyzed for Temporary Construction were evaluated under the following assumptions:

- Existing ground surface at Elev. +13 north of the Turning Basin
- Existing ground surface is at Elev.+17 south of the Turning Basin with a construction surcharge of 600 psf
- Groundwater at Elev. +3 outside of the Turning Basin
- Proposed top of wetland shelf on the north and east side of the Turning Basin at Elev. 0
- Excavation on the south of the wetland shelf in the Turning Basin to Elev. -21

Case 2- Service Condition
Sections analyzed for Service were under the following assumptions:

- Existing ground surface at Elev. +13 north of the Turning Basin
- Existing ground surface at Elev. +19 south of the Turning Basin with a surcharge of 250 psf
- Groundwater at Elev. +3 outside of the Turning Basin
- Proposed top of wetland shelf on the north and east side of the Turning Basin at Elev. 0
- Backfill with equivalent excavated material from Elev.-21 to Elev.-18
    - Assumed to have similar properties as bentonite cap
- Install Bentonite cap from Elev. -18 to Elev.-15

Case 3- Seismic Condition
Sections analyzed for Seismic were under the following assumptions:

- Existing ground surface at Elev. +13 north of the Turning Basin
- Existing ground surface at Elev. +19 south of the Turning Basin
- Groundwater at Elev. +3 outside of the Turning Basin

- Proposed top of wetland shelf on the north and east side of the Turning Basin at Elev. 0
- Horizontal seismic coefficient (k_h) of .165g applied to liquefiable layers
- Backfill with equivalent excavated material from Elev.-21 to Elev.-18
  - Assumed to have similar properties as the bentonite cap
- Bentonite cap from Elev. -18 to Elev.-15

For temporary construction failure slopes through the Turning Basin were evaluated in the:
- North to South direction
- South to North direction.

For the static and seismic conditions, failure slopes through the Turning Basin were evaluated in the:
- North to South direction
- South to North direction
- East to West direction.

BOUNDARY CONDITIONS

Slope/W models extents were configured to analyze global stability of a 60 foot wide Turning Basin with a 20 foot wide wetland shelf along the northern and eastern end of the site.

For the North-South evaluations, horizontal extents of the model ranged from 50 feet south of the Turning Basin and 290 feet north of the Turning Basin. For the South-North evaluations, the horizontal extents of the model ranged from 20 feet north of the Turning Basin and 250 south of the Turning Basin. The vertical extents of the model extended to Elev. -65.

For the East-West evaluations, horizontal extents of the model ranged from 200 feet west of the wetland shelf and 230 feet east of the proposed bulkhead. The vertical extents of the model extended to Elev. -65.

These extents provide an adequate range to allow the entry and exit evaluation to include the critical slip surfaces.

RESULTS

Refer to the Table 2 below for results of cases analyzed for global stability.

The following minimum slope stability factors of safety (FS) are considered acceptable:
- Temporary Construction FS=1.3
- Service FS= 1.5
- Seismic FS= 1.0

Table 2: Preliminary Slope Stability Factors of Safety

Descriptions	Section A-A East	Section B-B		Section C-C	
	East-West	North-South	South-North	North-South	South-North
Case 1: Temporary Construction*	NA	3.1	2.9	3.1	3.2
Case 2: Service	2.8	3.4	3	3.6	3.9
Case 3: Seismic	1.0	1.3	1.3	1.3	1.8

*Temporary Construction for Section A-A East is not applicable.

Local stability for the wetland shelf was analyzed; no failure is anticipated to occur within the Turning Basin. Refer to Appendix B for slope stability results for the above mentioned cases.

LIMITATIONS

Slope/W analyses assume two-dimensional conditions for a three dimensional situation.

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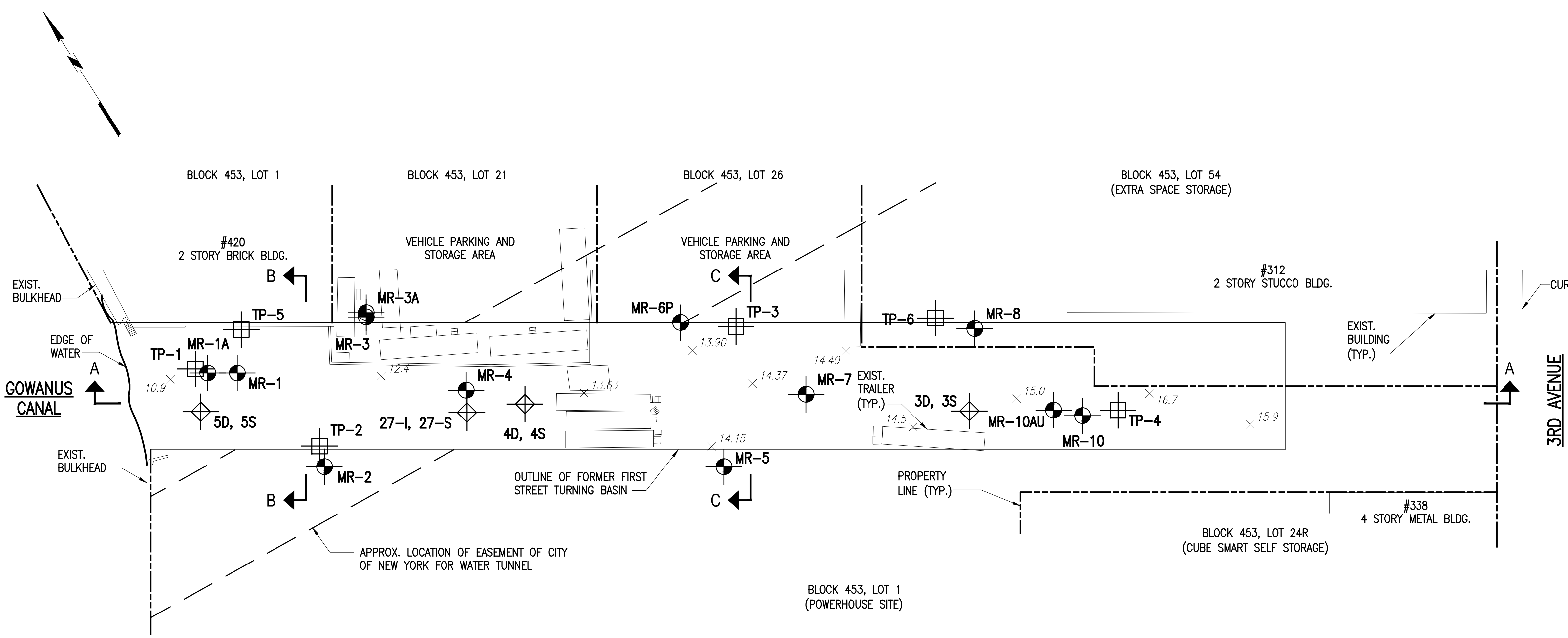
Athena C. DeNivo, PE

AE:PWD:ACD:F\125\12541 - First St Turning Basin\Memorandums\Slope Stability\Slope Stability Memo 12.13.17.doc.docx

APPENDIX A

Boring Location Plan and Geologic Sections



PLAN

30' 20' 10' 0 30' 60'

NOTES:

1. BASE DRAWING TAKEN FROM SURVEY DRAWING BY B.THAYER ASSOCIATES DATED OCTOBER 10, 2017.
2. ELEVATIONS REFER TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).
3. BORINGS MR–1 TO MR–8 AND MR–10 AND TEST PITS TP–1 TO TP–6 WERE MADE BY ASSOCIATED ENVIRONMENTAL SERVICES LTD. BETWEEN AUGUST 14, 2017 AND SEPTEMBER 22, 2017 UNDER THE CONTINUOUS INSPECTION OF MRCE. BORING MR–9 WAS REMOVED FROM THIS INVESTIGATION DUE TO ACCESS ISSUES.
4. AS DRILLED LOCATIONS AND GROUND SURFACE ELEVATIONS FOR BORINGS MR–1 TO MR–8 AND MR–10 AND TEST PITS TP–1 TO TP–6 WERE SURVEYED BY B.THAYER ASSOCIATES ON SEPTEMBER 18, 2017 AND COMPLETED ON OCTOBER 4, 2017.
5. BORINGS MR–2 AND MR–5 WERE MEASURED OFF LOCATIONS OF EXISTING FEATURES. APPROXIMATE GROUND SURFACE ELEVATIONS WERE PROVIDED BY ROUX ASSOCIATES.
6. FOR GEOLOGIC SECTIONS A–A, B–B, AND C–C, SEE DRAWINGS GS–1 TO GS–3.
7. STRATIFICATIONS SHOWN ON THE GEOLOGIC SECTIONS ARE BASED ON NECESSARY INTERPOLATION BETWEEN BORINGS AND MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS.
8. SEE DRAWING NO. GS–R FOR BORING LEGEND AND SOIL CLASSIFICATION TERMINOLOGY.

LEGEND:

MR–6P
– MRCE BORING DRILLED IN 2017
– "P" INDICATES PIEZOMETER
– "A" INDICATES OFFSET
– "U" INDICATES UNDISTURBED SAMPLES

TP1
– MRCE TEST PIT PERFORMED IN 2017

3S, 3D
– MONITORING WELL CLUSTER INSTALLED BY OTHERS (SEE APPENDIX E)
– "S" SHALLOW MONITORING WELLS SET IN THE FILL STRATUM
– "D" DEEP MONITORING WELLS SET IN THE UPPER SAND STRATUM

10.9 – GROUND SURFACE SPOT ELEVATION

FIRST STREET TURNING BASIN

BROOKLYN NEW YORK

AKRF – KSE
JOINT VENTURE

NEW YORK NEW YORK

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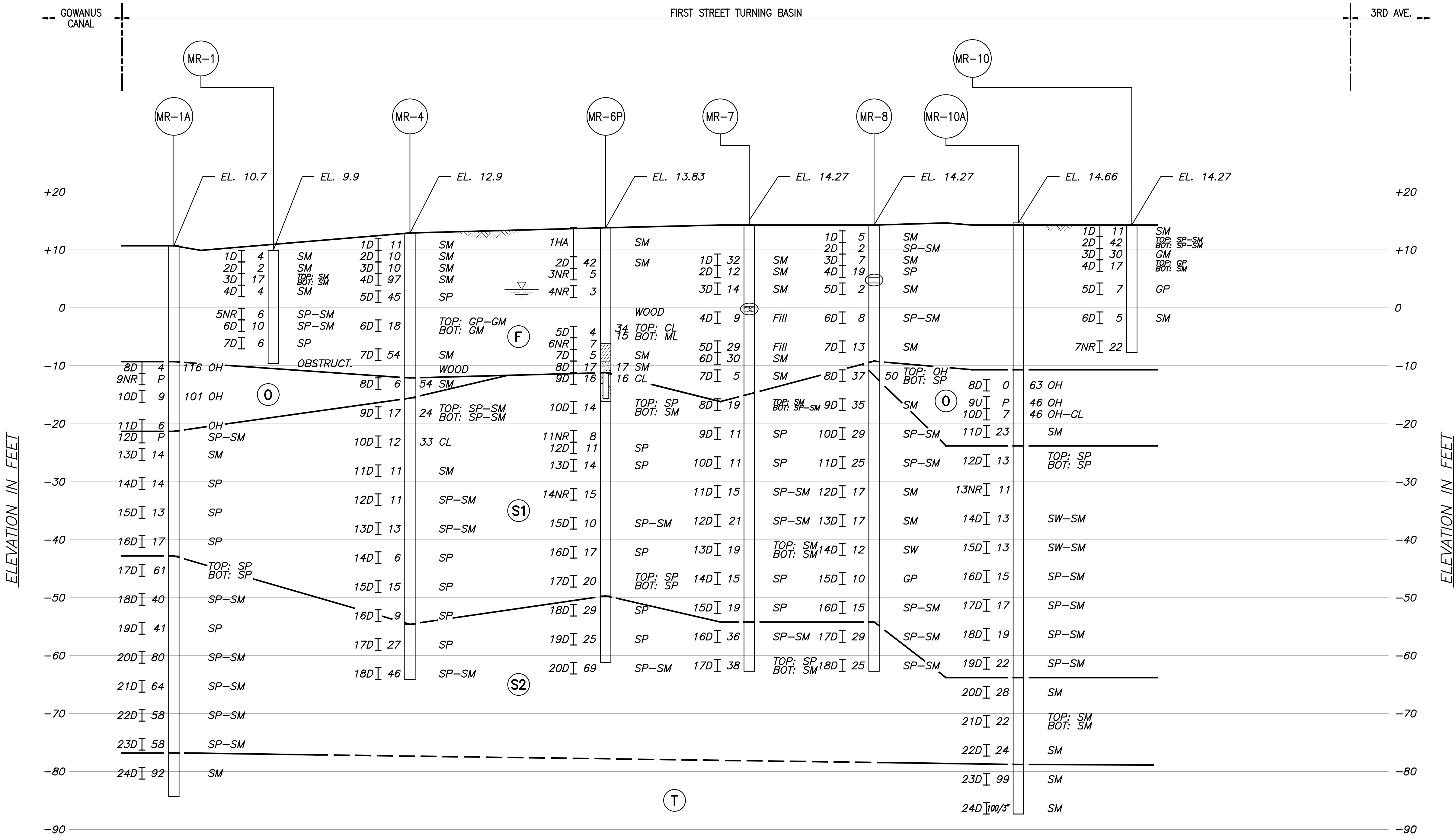
SCALE	MADE BY: H.Y.	DATE: 11–03–2017	FILE NUMBER
GRAPHIC	CH'KD BY: A.E.	DATE: 11–14–2017	12541

BORING AND TEST PIT LOCATION PLAN

DRAWING NUMBER
B–1

NOTES:

1. FOR GENERAL NOTES, SEE DRAWING NO. B-1.



SECTION A-A

GENERAL STRATA DESCRIPTIONS:

(F) **FILL** – LOOSE TO COMPACT BROWN TO BLACK FINE TO COARSE SAND, SOME TO TRACE SILT, GRAVEL, BRICK, CONCRETE, WOOD, METAL, BOULDERS AND VARIOUS OBSTRUCTIONS

(O) **ORGANIC SILTY CLAY** – SOFT BLACK ORGANIC SILTY CLAY, SOME TO TRACE PEAT, FINE TO COARSE SAND, AND WOOD

(S1) **LOWER SAND (S1)** – LOOSE TO MEDIUM COMPACT BROWN TO RED FINE TO COARSE SAND, SOME TO TRACE SILT AND GRAVEL

(S2) **UPPER SAND (S2)** – MEDIUM COMPACT TO VERY COMPACT BROWN TO GRAY FINE TO COARSE SAND, TRACE TO SOME GRAVEL AND SILT

(T) **TILL** – VERY COMPACT BROWN COARSE TO FINE SAND, SOME SILT AND GRAVEL, TRACE MICA

GRAPHIC SCALE

HORIZONTAL: 30' 20' 10' 0 30' 60'

VERTICAL: 10' 5' 0 10' 20'

FIRST STREET TURNING BASIN

BROOKLYN NEW YORK

AKRF – KSE JOINT VENTURE

NEW YORK NEW YORK

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14 PENN PLAZA – 225 W. 34TH STREET, NY, NY 10122

SCALE	MADE BY: H.Y.	DATE: 11-03-2017	FILE NUMBER
GRAPHIC	CH'KD BY: A.E.	DATE: 11-14-2017	12541

GEOLOGIC SECTION A-A

DRAWING NUMBER GS-1

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Printed on: Wednesday, Nov 15, 2017 – 08:57:37 AM
Printed by: Howard Yang
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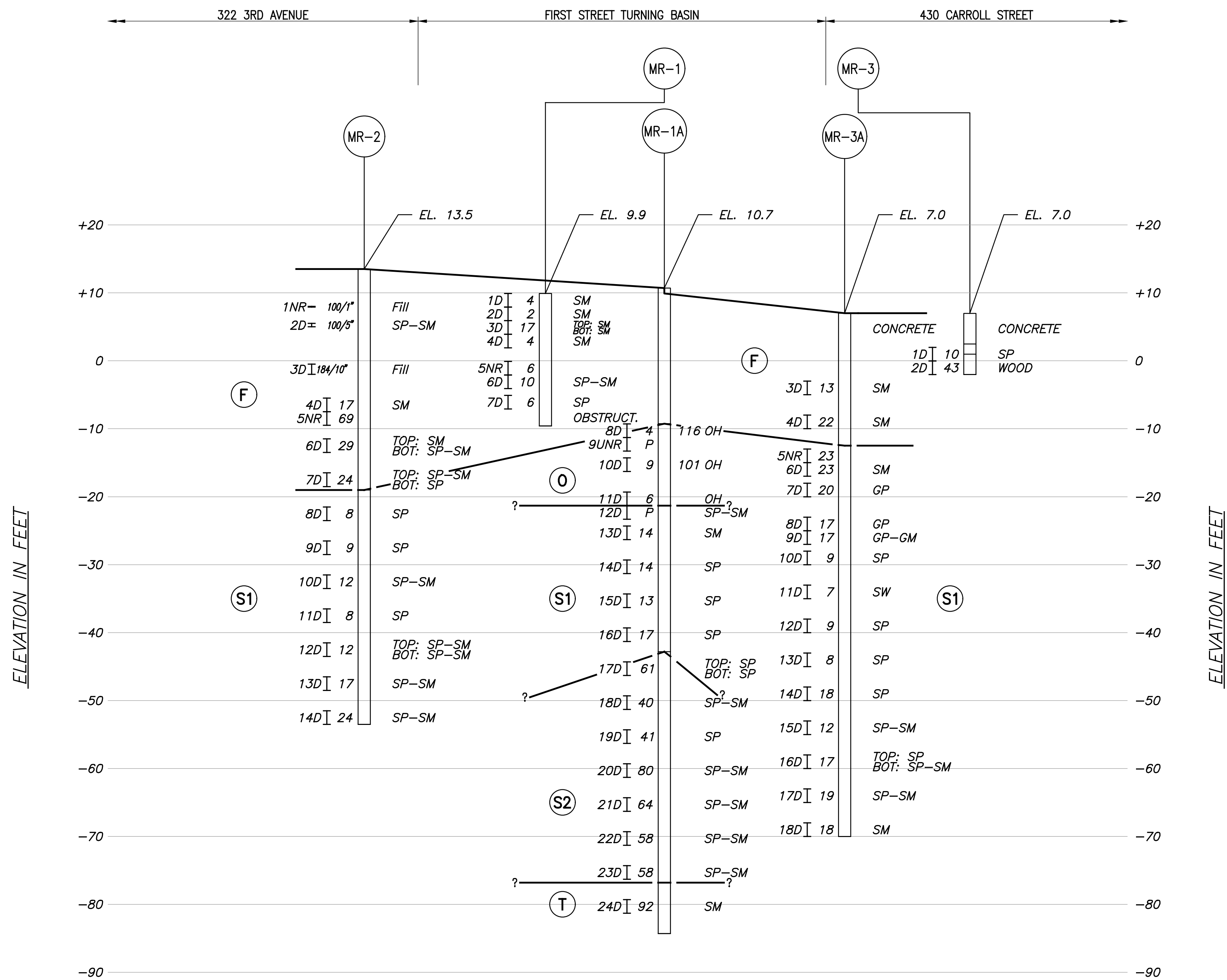
NOTES:

1. FOR GENERAL NOTES, SEE DRAWING NO. B-1.



SECTION B-B

GENERAL STRATA DESCRIPTIONS:

(F) **FILL** – LOOSE TO COMPACT BROWN TO BLACK FINE TO COARSE SAND, SOME TO TRACE SILT, GRAVEL, BRICK, CONCRETE, WOOD, METAL, BOULDERS AND VARIOUS OBSTRUCTIONS

(O) **ORGANIC SILTY CLAY** – SOFT BLACK ORGANIC SILTY CLAY, SOME TO TRACE PEAT, FINE TO COARSE SAND, AND WOOD

(S1) **LOWER SAND (S1)** – LOOSE TO MEDIUM COMPACT BROWN TO RED FINE TO COARSE SAND, SOME TO TRACE SILT AND GRAVEL

(S2) **UPPER SAND (S2)** – MEDIUM COMPACT TO VERY COMPACT BROWN TO GRAY FINE TO COARSE SAND, TRACE TO SOME GRAVEL AND SILT

(T) **TILL** – VERY COMPACT BROWN COARSE TO FINE SAND, SOME SILT AND GRAVEL, TRACE MICA

GRAPHIC SCALE

HORIZONTAL: 30' 20' 10' 0 30' 60'

VERTICAL: 10' 5' 0 10' 20'

FIRST STREET TURNING BASIN

BROOKLYN NEW YORK

AKRF – KSE JOINT VENTURE

NEW YORK NEW YORK

MUESER RUTLEDGE CONSULTING ENGINEERS

14 PENN PLAZA – 225 W. 34TH STREET, NY, NY 10122

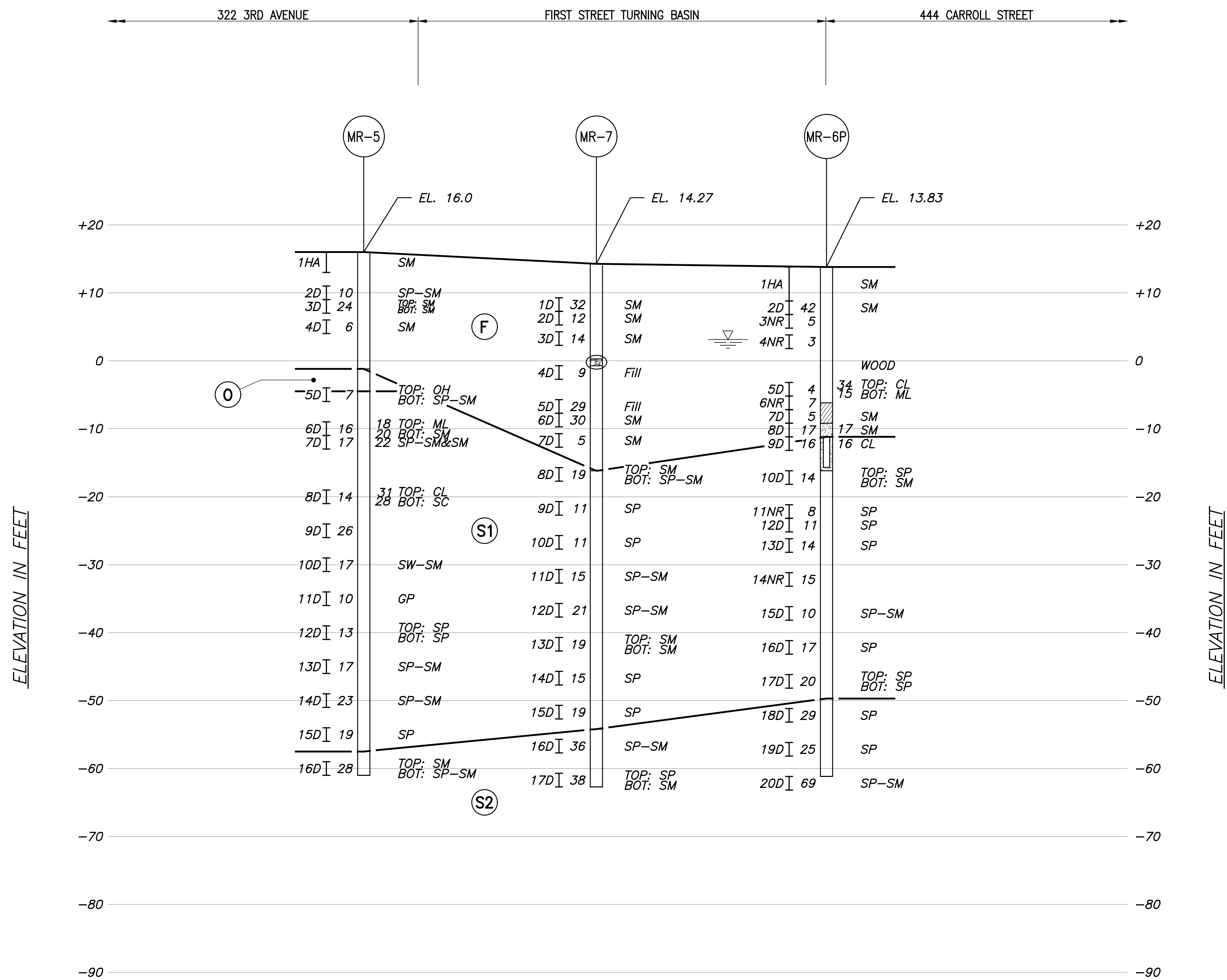
SCALE	MADE BY: H.Y.	DATE: 11-03-2017	FILE NUMBER
GRAPHIC	CH'KD BY: A.E.	DATE: 11-14-2017	12541

GEOLOGIC SECTION B-B

DRAWING NUMBER GS-2

NOTES:

1. FOR GENERAL NOTES, SEE DRAWING NO. B-1.



SECTION C-C

GENERAL STRATA DESCRIPTIONS:

(F) **FILL** – LOOSE TO COMPACT BROWN TO BLACK FINE TO COARSE SAND, SOME TO TRACE SILT, GRAVEL, BRICK, CONCRETE, WOOD, METAL, BOULDERS AND VARIOUS OBSTRUCTIONS

(O) **ORGANIC SILTY CLAY** – SOFT BLACK ORGANIC SILTY CLAY, SOME TO TRACE PEAT, FINE TO COARSE SAND, AND WOOD

(S1) **LOWER SAND (S1)** – LOOSE TO MEDIUM COMPACT BROWN TO RED FINE TO COARSE SAND, SOME TO TRACE SILT AND GRAVEL

(S2) **UPPER SAND (S2)** – MEDIUM COMPACT TO VERY COMPACT BROWN TO GRAY FINE TO COARSE SAND, TRACE TO SOME GRAVEL AND SILT

(T) **TILL** – VERY COMPACT BROWN COARSE TO FINE SAND, SOME SILT AND GRAVEL, TRACE MICA

GRAPHIC SCALE

HORIZONTAL: 30' 20' 10' 0 30' 60'

VERTICAL: 10' 5' 0 10' 20'

FIRST STREET TURNING BASIN

BROOKLYN NEW YORK

AKRF – KSE JOINT VENTURE

NEW YORK NEW YORK

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14 PENN PLAZA – 225 W. 34TH STREET, NY, NY 10122

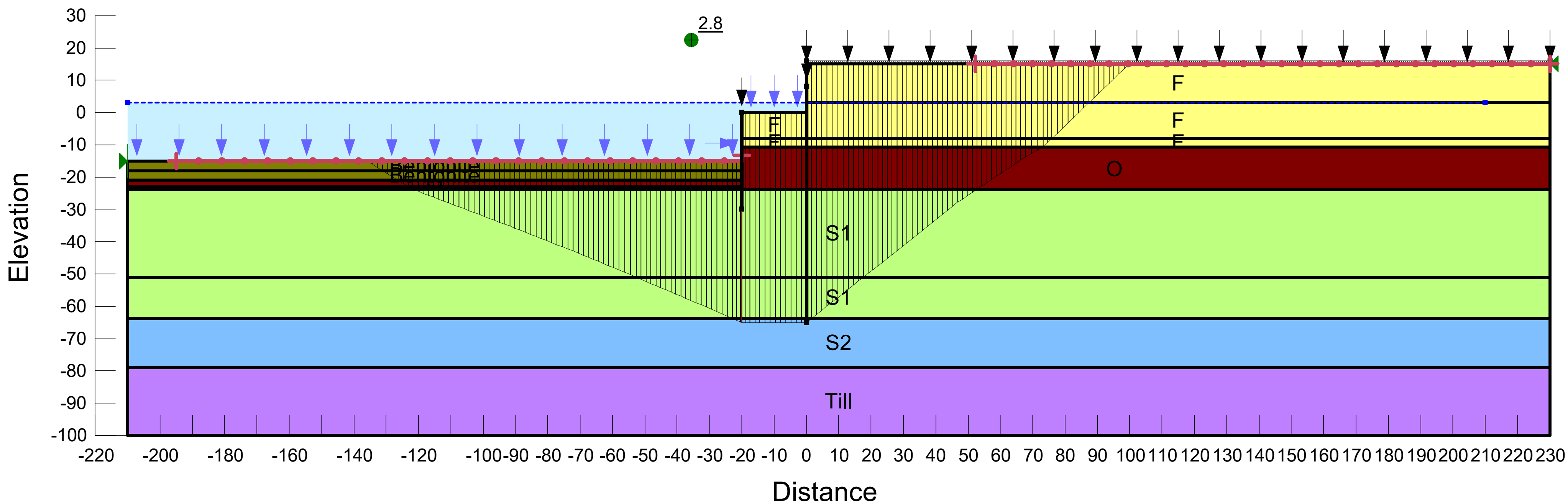
SCALE	MADE BY: H.Y.	DATE: 11-03-2017	FILE NUMBER
GRAPHIC	CH'KD BY: A.E.	DATE: 11-14-2017	12541
GEOLOGIC SECTION C-C			DRAWING NUMBER GS-3

APPENDIX B

Slope Stability Results

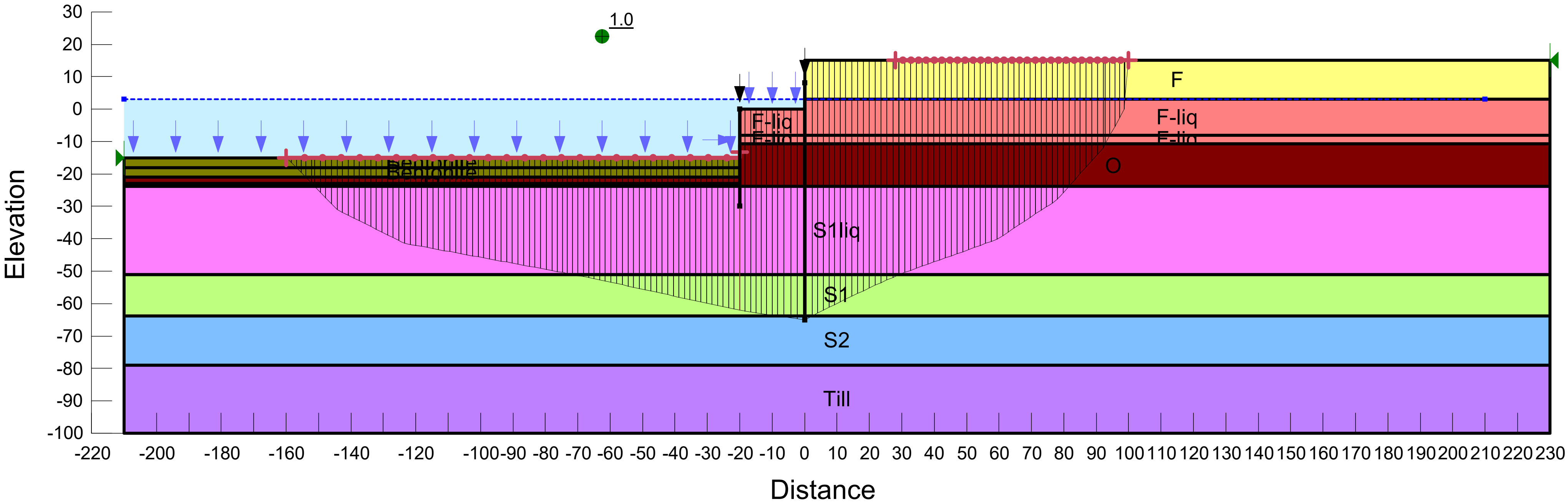
Section A-A Case 2: East-West Service

Name: F	Model: Mohr-Coulomb	Unit Weight: 115 pcf	Cohesion: 0 psf	Phi: 30 °
Name: S1	Model: Mohr-Coulomb	Unit Weight: 120 pcf	Cohesion: 0 psf	Phi: 32 °
Name: S2	Model: Mohr-Coulomb	Unit Weight: 125 pcf	Cohesion: 0 psf	Phi: 34 °
Name: Till	Model: Mohr-Coulomb	Unit Weight: 130 pcf	Cohesion: 0 psf	Phi: 36 °
Name: O	Model: Undrained (Phi=0)	Unit Weight: 90 pcf	Cohesion: 400 psf	
Name: Bentonite	Model: Undrained (Phi=0)	Unit Weight: 90 pcf	Cohesion: 400 psf	

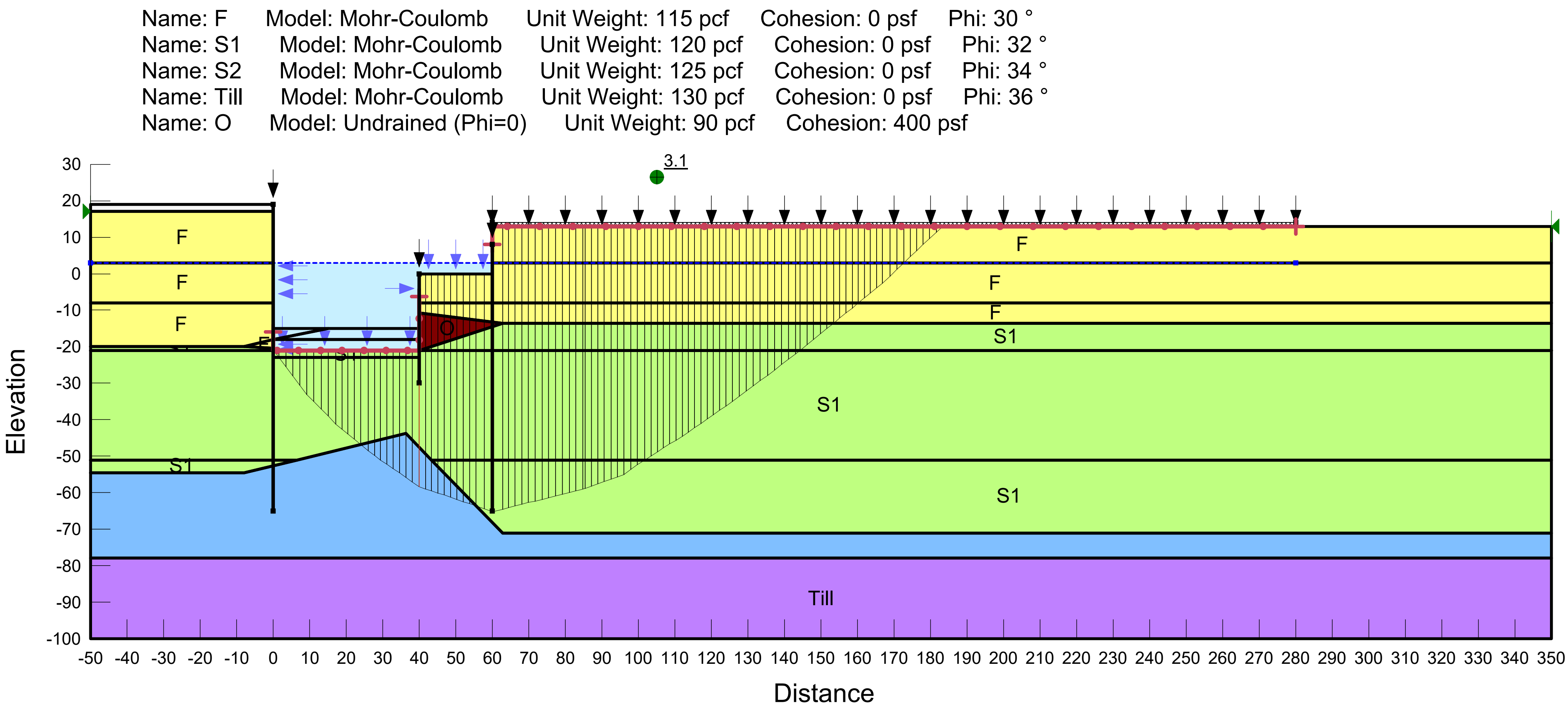


Section A-A Case 3: East-West Seismic

Name: F Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 0 psf Phi: 30 °
Name: S1 Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: F-liq Model: S=f(depth) Unit Weight: 115 pcf C-Top of Layer: 80 psf C-Rate of Change: 1.82 psf/ft Limiting C: 100 psf
Name: S1liq Model: Undrained (Phi=0) Unit Weight: 120 pcf Cohesion: 230 psf
Name: S2 Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 34 °
Name: Till Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 36 °
Name: O Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf
Name: Bentonite Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf

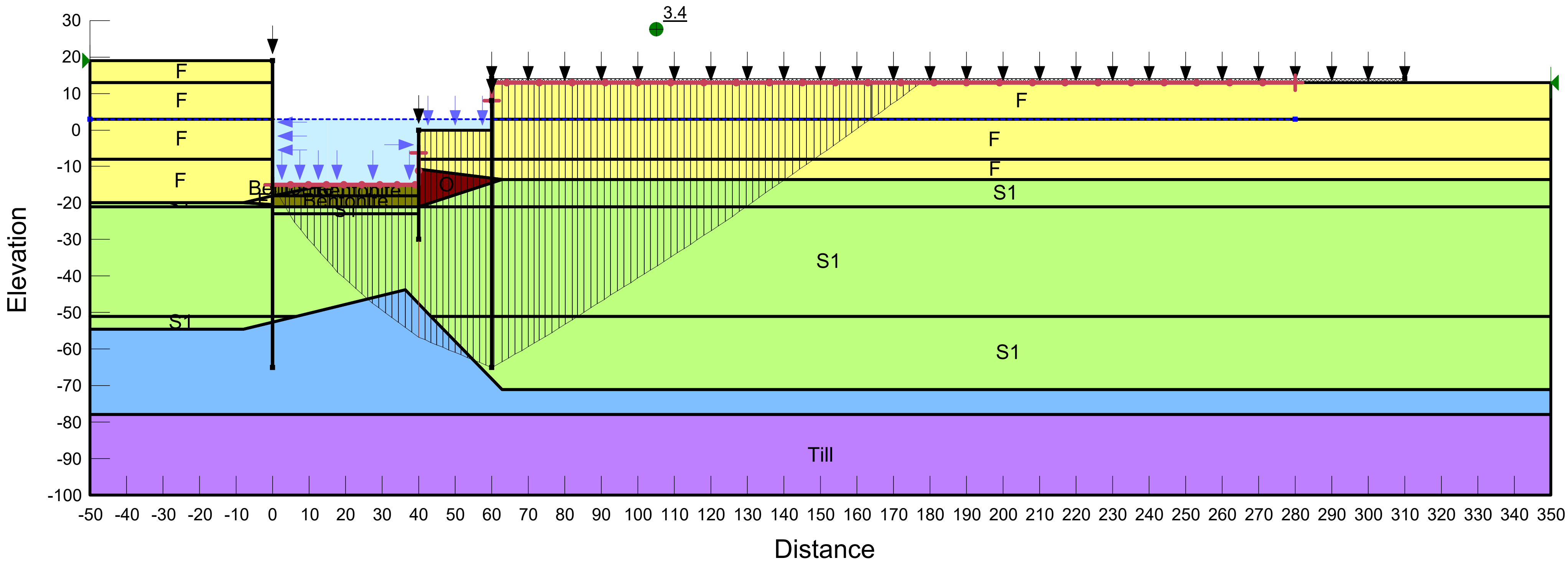


Section B-B Case 1: North-South Temporary Construction



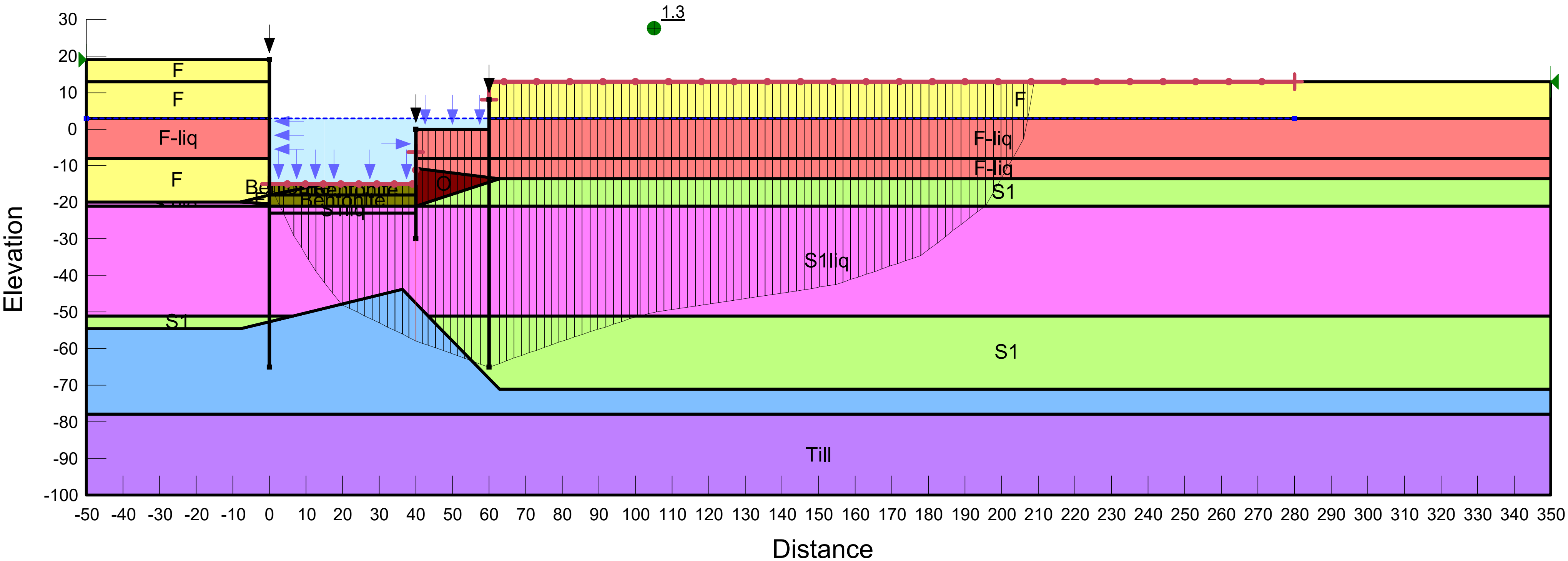
Section B-B Case 2: North-South Service

Name: F Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 0 psf Phi: 30 °
Name: S1 Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: S2 Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 34 °
Name: Till Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 36 °
Name: O Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf
Name: Bentonite Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf



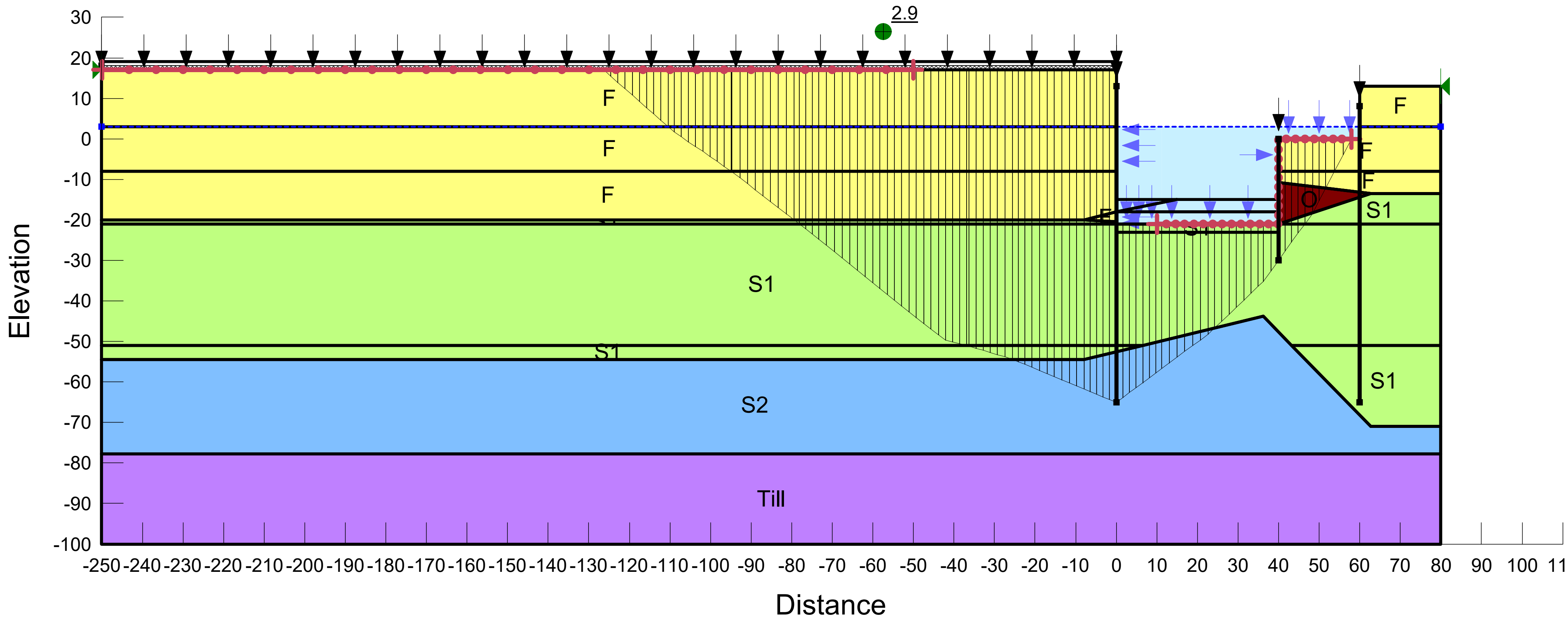
Section B-B Case 3: North-South Seismic

Name: F Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 0 psf Phi: 30 °
Name: S1 Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: F-liq Model: S=f(depth) Unit Weight: 115 pcf C-Top of Layer: 80 psf C-Rate of Change: 1.82 psf/ft Limiting C: 100 psf
Name: S1liq Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 190 psf C-Rate of Change: 2.83 psf/ft Limiting C: 275 psf
Name: S2 Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 34 °
Name: Till Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 36 °
Name: O Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf
Name: Bentonite Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf



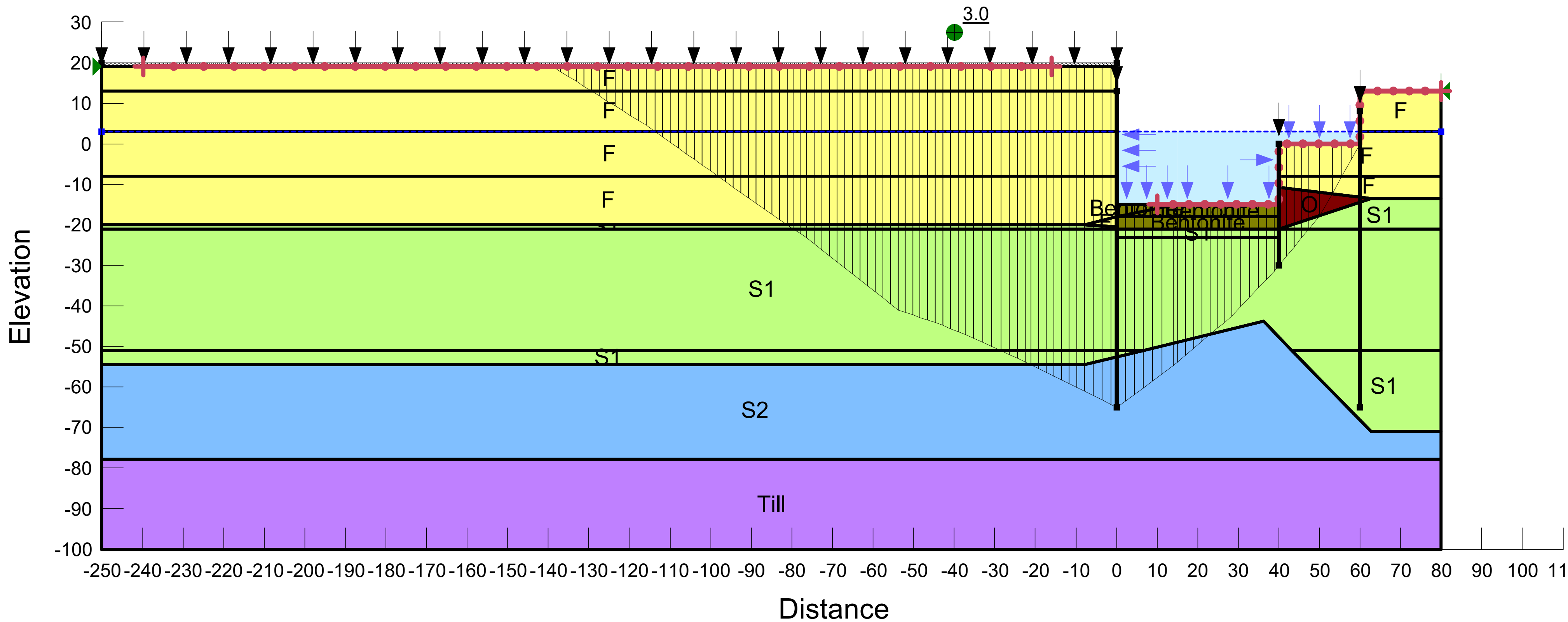
Section B-B Case 1: South-North Temporary Construction

Name: F Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 0 psf Phi: 30 °
Name: S1 Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: S2 Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 34 °
Name: Till Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 36 °
Name: O Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf



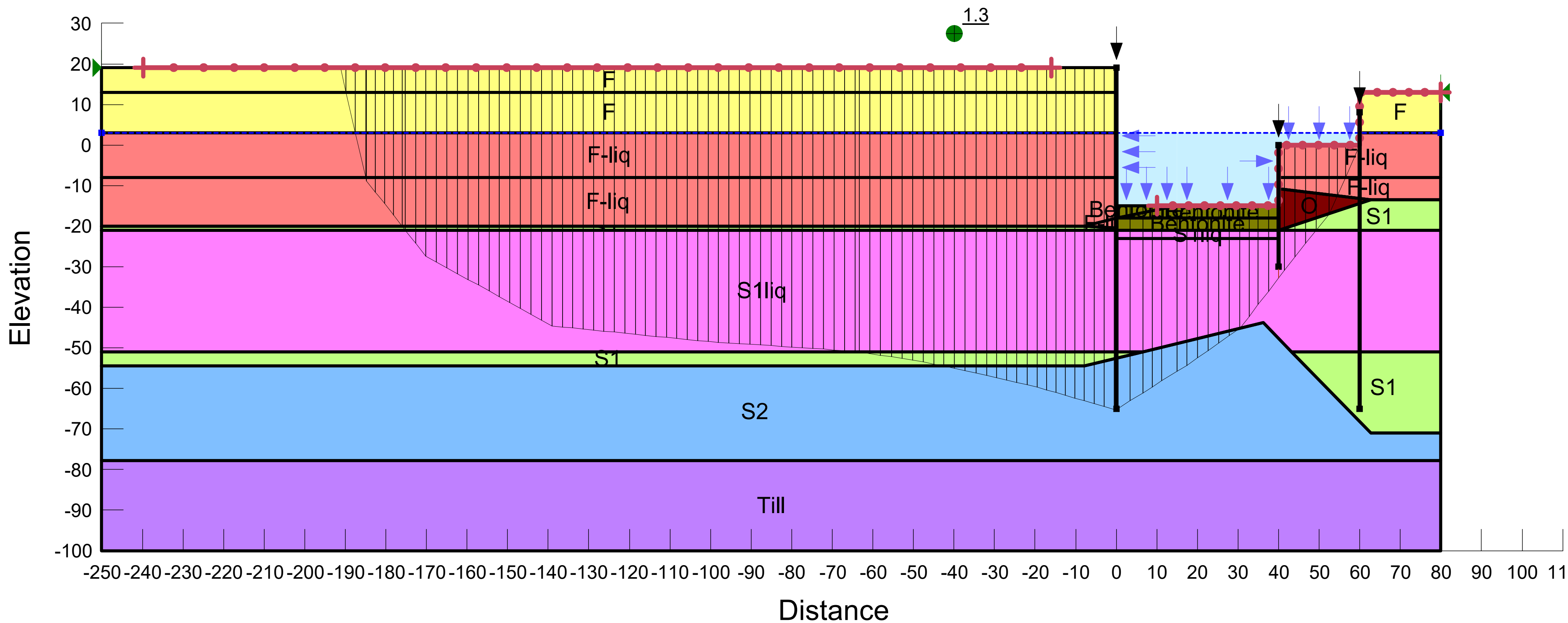
Section B-B Case 2: South-North Service

Name: F Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 0 psf Phi: 30 °
Name: S1 Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: S2 Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 34 °
Name: Till Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 36 °
Name: O Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf
Name: Bentonite Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf



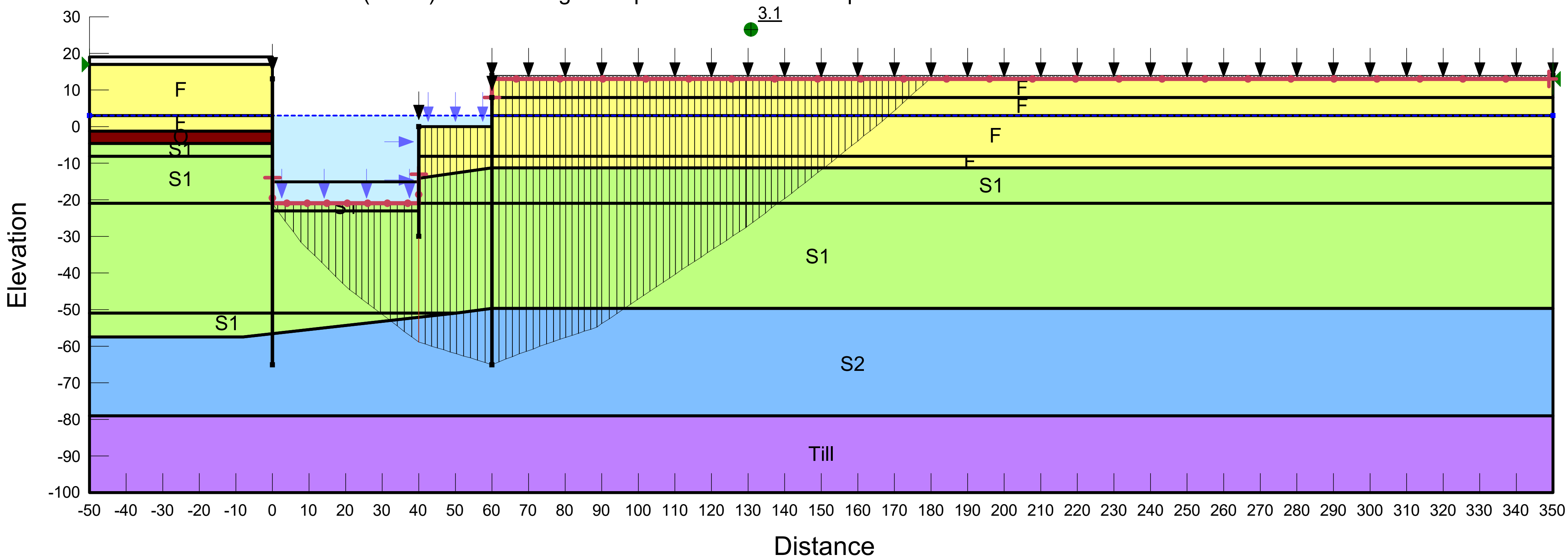
Section B-B Case 3: South-North Seismic

Name: F Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 0 psf Phi: 30 °
Name: S1 Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: F-liq Model: S=f(depth) Unit Weight: 115 pcf C-Top of Layer: 80 psf C-Rate of Change: 1.82 psf/ft Limiting C: 100 psf
Name: S1liq Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 190 psf C-Rate of Change: 2.83 psf/ft Limiting C: 275 psf
Name: S2 Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 34 °
Name: Till Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 36 °
Name: O Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf
Name: Bentonite Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf



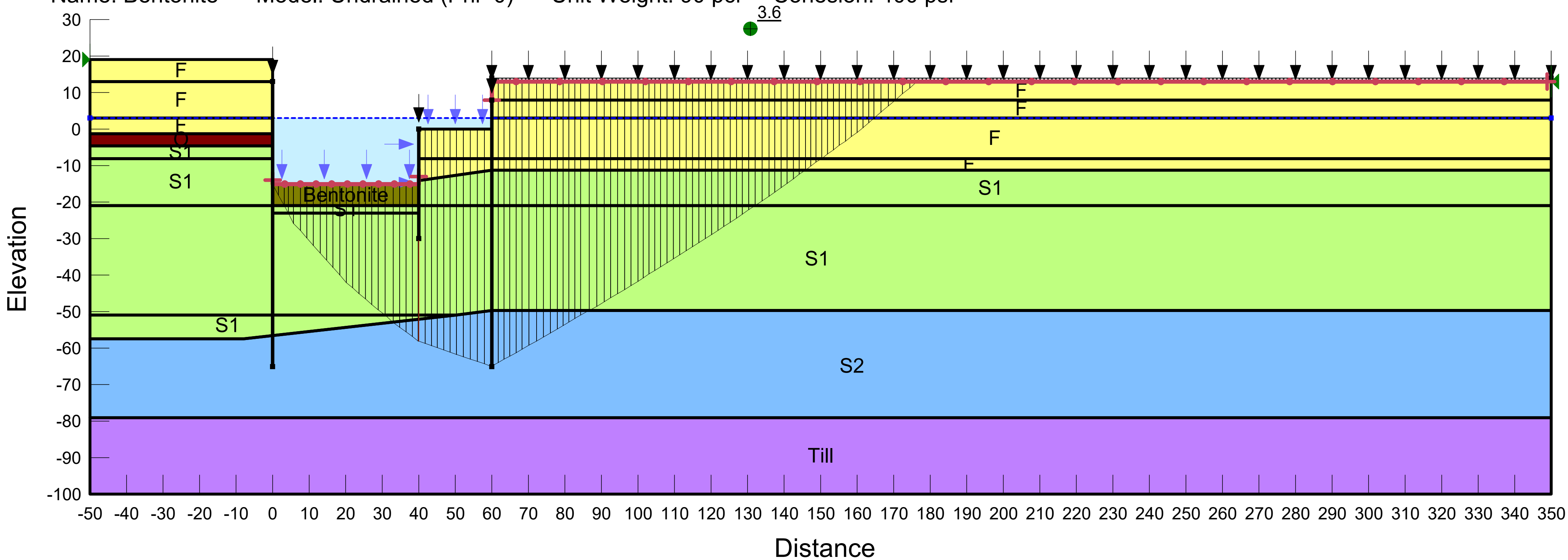
Section C-C Case 1: North-South Temporary Construction

Name: F Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 0 psf Phi: 30 °
Name: S1 Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: S2 Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 34 °
Name: Till Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 36 °
Name: O Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf



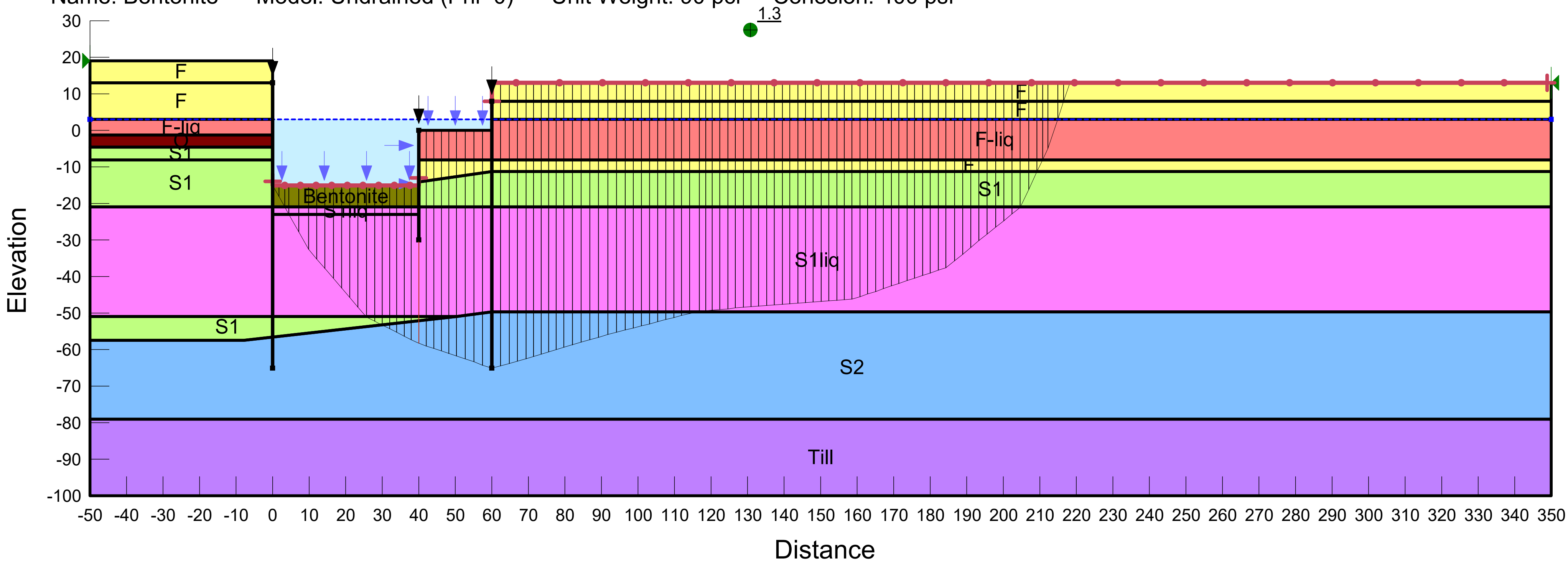
Section C-C Case 2: North-South Service

Name: F Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 0 psf Phi: 30 °
Name: S1 Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: S2 Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 34 °
Name: Till Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 36 °
Name: O Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf
Name: Bentonite Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf

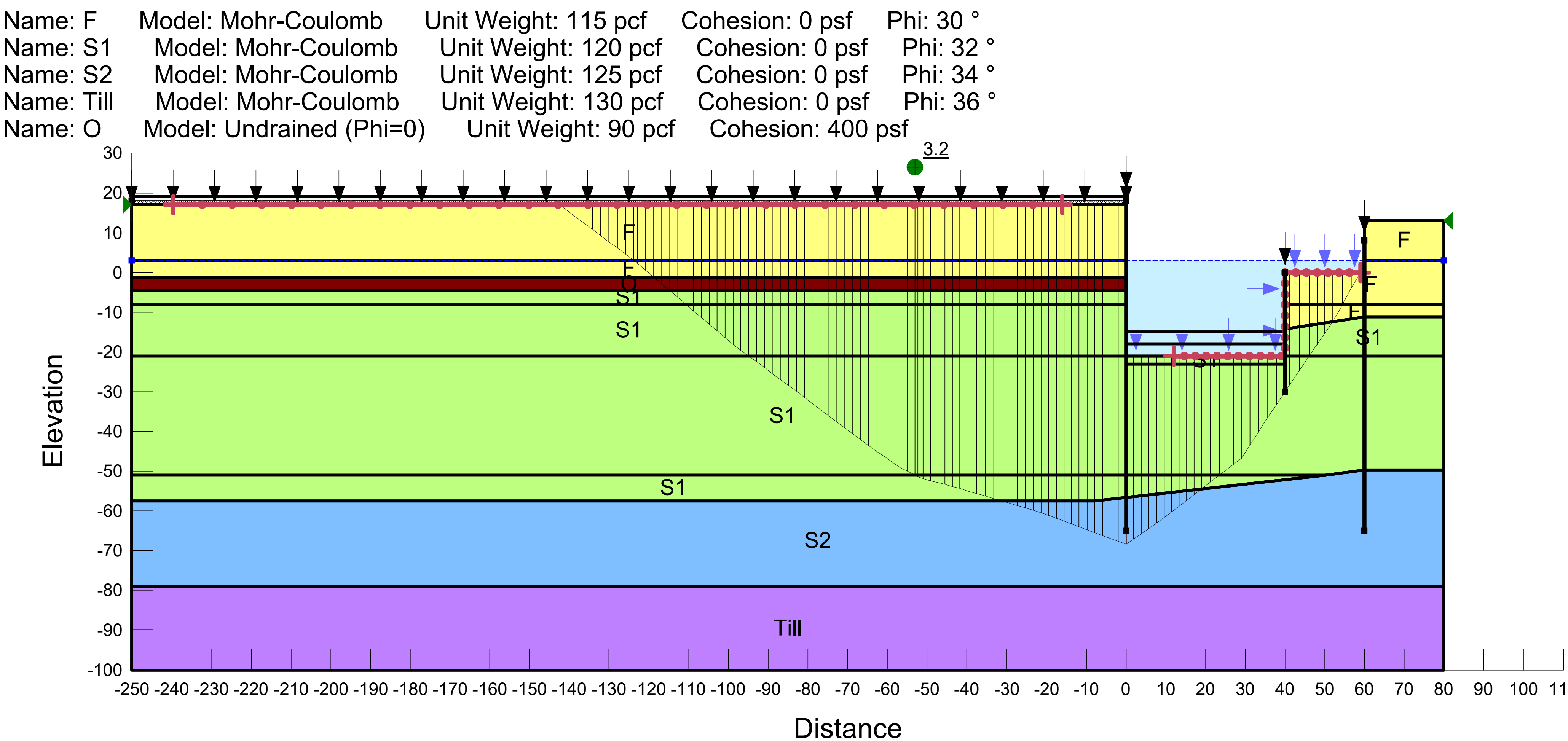


Section C-C Case 3: North-South Seismic

Name: F Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 0 psf Phi: 30 °
Name: S1 Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: F-liq Model: S=f(depth) Unit Weight: 115 pcf C-Top of Layer: 80 psf C-Rate of Change: 1.82 psf/ft Limiting C: 100 psf
Name: S1liq Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 190 psf C-Rate of Change: 2.83 psf/ft Limiting C: 275 psf
Name: S2 Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 34 °
Name: Till Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 36 °
Name: O Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf
Name: Bentonite Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf

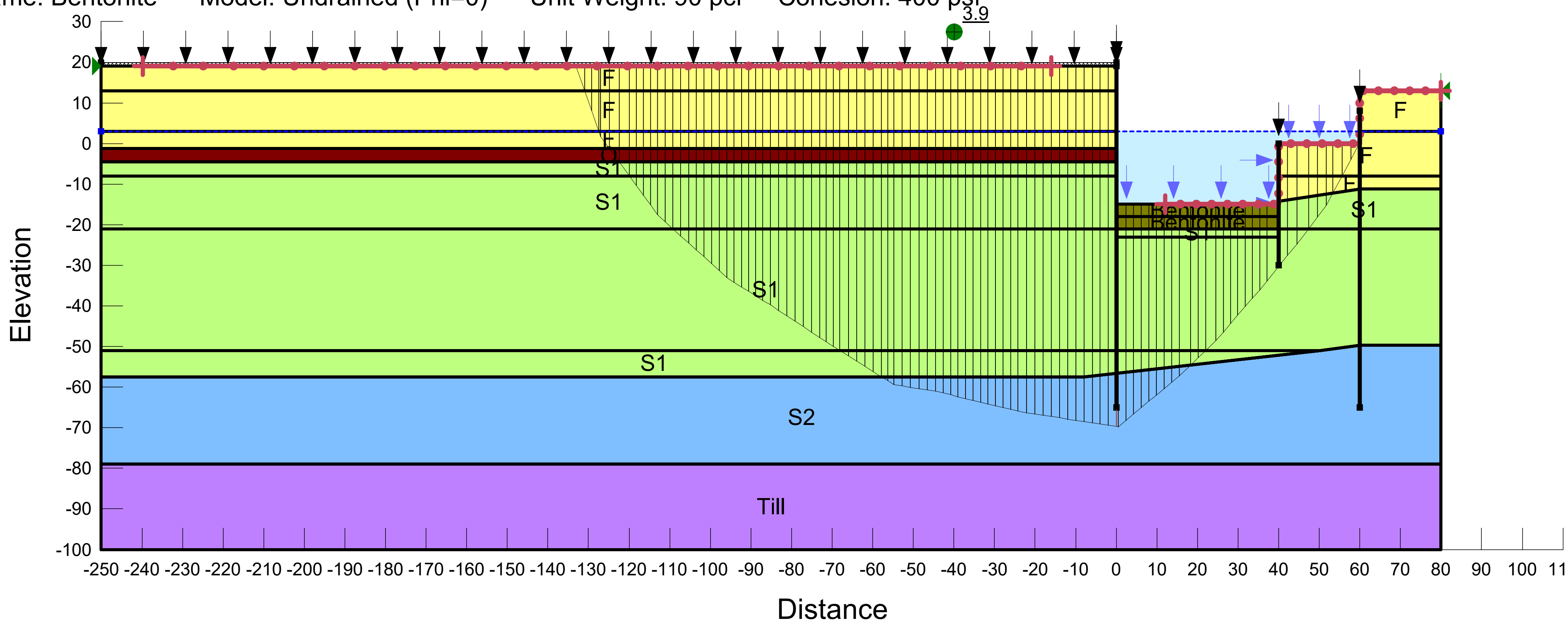


Section C-C Case 1: South-North Temporary Construction



Section C-C Case 2: South-North Service

Name: F Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 0 psf Phi: 30 °
Name: S1 Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: S2 Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 34 °
Name: Till Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 36 °
Name: O Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf
Name: Bentonite Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf



Section C-C Case 3: South-North Seismic

Name: F Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 0 psf Phi: 30 °
Name: S1 Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: F-liq Model: S=f(depth) Unit Weight: 115 pcf C-Top of Layer: 80 psf C-Rate of Change: 1.82 psf/ft Limiting C: 100 psf
Name: S1liq Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 190 psf C-Rate of Change: 2.83 psf/ft Limiting C: 275 psf
Name: S2 Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 34 °
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Name: O Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf
Name: Bentonite Model: Undrained (Phi=0) Unit Weight: 90 pcf Cohesion: 400 psf