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December 2, 2016

PRPA 1606.01
PRPA Project No: 16-022.P

Lisa Urban Magee
Chief Engineer
Philadelphia Regional Port Authority
3460 North Delaware Avenue
Philadelphia, PA 19134

RE: Geotechnical Engineering Services
Emergency Design Services
Tioga Marine Terminal – Apron Collapse
3601 N Delaware Avenue
Philadelphia, Pennsylvania

Dear Ms. Magee:

As requested, Pennoni performed a field exploration to establish the existing fill characteristics, the presence and extent of voids and loose material, and to determine the type and extent of fill replacement required in the affected sheet pile cells and connecting arcs. Holes in the sheeting of the cofferdams and arches lead to the erosion of subsoils and corresponding voids and collapse of the apron.

Following is a report of our findings and recommendations for stabilizing the soil fill below the apron.

LOCATION AND SURFACE FEATURES

The site is located within the Tioga Marine Terminal in Philadelphia, Pennsylvania. The failing concrete slab on grade serves as a loading pad at the Tioga 1 Wharf. The total length of the wharf is approximately 3160 ft and traverses in the northeasterly/southwesterly direction. The surface slab failure is located within cofferdam Number 28, which corresponds to current wharf stationing 15+25. Defects were also observed in the steel sheet piling during a dive study completed by S.T. Hudson Engineers Inc., as a subconsultant of Pennoni, of cofferdam Number 34 which corresponds to the approximate current warf stationing of 18+225. The areas of interest are bound on the east by a substation followed by the Betsy Ross Bridge, on the south by the Delaware River, on the west by Kinder Morgan Terminals followed by General Pulaski Park, and on the north by a long rectangular storage building followed by North Delaware Avenue.

The topography of the site is relatively flat. Evidence of below ground utilities was not observed on the project site.

OBJECTIVES

Our objectives were to establish the existing fill characteristics, the presence and extent of voids and loose material, and present conclusions and recommendations regarding stabilizing voids and/or soft subsoils encountered within the cofferdams and connecting arches.

FIELD WORK

On October 31, 2016, four borings were drilled by Sano Drilling, Inc. The boring locations were selected and established in the field by Pennoni personnel; the approximate locations are shown on the Boring Location Plans, Drawings No. LP-1 and LP-2. Sampling was performed in general accordance with ASTM D 1586. The boring logs and location plans are attached.

Our D. Marano, PE directed the field work; our D. Copeland, EIT, observed the field operations.

LAB WORK

The soil samples collected during our fieldwork were delivered to our laboratory. Representative soil samples were selected and tested to determine moisture contents, plasticity indices and gradation characteristics of the subsoils. Laboratory testing results and a list of testing procedures are presented in Appendix B.

GEOLOGY

The project site is located within the Lowland and Intermediate Upland section of the Atlantic Coastal Plain Province. The dominant topographic features of this section include very low local relief and a flat upper terrace surface cut by narrow, steep-sided to open valleys, shallow valleys; includes the Delaware River floodplain. The underlying subsurface material types consist of unconsolidated to poorly consolidated sand and gravel deposits, underlain by very complex, faulted and folded schist, gneiss, and other metamorphic rocks.

Available geological data indicates that the subject site is underlain by the Trenton Gravel Formation which is subsequently underlain by the Wissahickon Formation. The Trenton Gravel Formation consists of gray to pale-reddish brown, very gravelly sand with interbedded and crossbedded sand and clay-silt layers.

The Wissahickon Formation consists of a coarsely crystalline, excessively micaceous schist. Fracturing results in a well developed, platy pattern. This Formation is fissile to thinly bedded, moderately resistant to weathering, and often highly weathered to a moderate depth (10 to 15 ft).

SUBSOILS

The borings disclosed a concrete layer at the surface which ranged in thickness from 8 to 18 inches. The concrete was underlain by 34 to 40 in. of processed aggregate in Borings B-1 and B-2. A fill layer was encountered below the surface layer and processed aggregate, where encountered; the fill layer ranged from 11.5 to 14 ft thick. The subsoils encountered in the test borings, including the fill, have been grouped by us into four principal strata based on their engineering properties and our interpretation of their origin. Brief strata descriptions are presented below.

STRATUM	DESCRIPTION
F	FILL: Fine to medium to coarse SAND, with varying amounts of Silt and coarse to fine Gravel size Rock Fragments; very loose to very dense
1	Fine to medium to coarse SAND with varying amounts of fine to coarse Gravel size Rock Fragments and Silt; very loose to very dense
2	Coarse GRAVEL and COBBLES with trace amounts of F Sand; very dense
3	CLAY with trace amounts of F Sand; very stiff

FINDINGS

The first attempt to advance boring B-1 was terminated at a depth of 16 in. below existing grade. The auger cuttings disclosed concrete fragments, which may be an indication that an obstruction or possible foundation is present in the vicinity. Boring B-1 was offset 2 ft to the north and advanced to a depth of 50 ft. Boring B-3 was advanced and sampled to auger refusal which occurred at 2.5 ft below existing grade. Refusal at this location was indicative of a steel obstruction. All borings disclosed a granular fill layer underlying the surface concrete and stone layers (where encountered), to depths ranging from 13 to 18 ft below existing grade; Standard Penetration Test (SPT) N Values indicate that the fill has a relative density that varies from “very loose” to “very dense”. The fill was underlain by fine to medium SAND to depths ranging from 43 to 50 ft below existing; SPT N Values indicate that the Stratum 1 soils have a relative density that varies from “very loose” to “very dense”. Stratum 1 was underlain by coarse GRAVEL and COBBLES in boring B-2; SPT N Values indicate that the relative density of the Stratum 2 soils are very dense. Stratum 1 was underlain by CLAY in Borings B-1 and B-3A; SPT N values indicate that the Stratum 2 soil has a consistency that is “very stiff”.

Groundwater was encountered in the borings a depth of 10 ft below the concrete slab.

CONCLUSIONS AND RECOMMENDATIONS

Based on the data disclosed in the borings, and our experience, it is our professional opinion that the subsoils within the cofferdam and arches can be improved by one of or a combination of ground modification methods consisting of vibro compaction, compaction grouting and/or jet grouting. These options were discussed with the design team, and it is our opinion that the most feasible and cost effective approach of stabilizing the subsoils consists of a combination of jet grouting and compaction grouting. Jet grouting performed immediately adjacent to the steel sheet piling inherently applies lower pressures to the sheets and will create a barrier and seal the outer areas that will allow for the inner section of the cofferdams to be stabilized by compaction grouting. This combined process will consolidate the very loose to medium dense soils and fill any voids that may still be present near the holes in the sheeting. A preliminary stabilization plan has been developed and is presented under separate cover.

Jet grouting (replacement) is a grouting technique that creates in situ grouted soils. The technique that used high-speed water jets from a drill bit to erode into subsoils; as the drill bit is withdrawn, grout is pumped through horizontal nozzles and mixes with or displaces the soils. The jets erode and mix the in-situ soil as the drill stem and jet grout monitor are rotated and raised. The original soft/loose soils are replaced with a stronger and/or more impermeable grout-soil mixture. Depending on the application and soils to be treated, one of three variations is used: the single fluid system (slurry grout jet), the double fluid system (slurry grout jet surrounded by an air jet) and the triple fluid system (water jet surrounded by an air jet, with a lower grout jet). The jet grouting process constructs a range of elements from grout-soil panels to full grout columns. The injection points should be established within the arcs upstream and downstream of sheet pile cells 28 and 34 and within the eastern (waterrside) half inner circle of the cells. Anticipated depth of grout pipes is expected to be about 45 to 50 ft below existing grades. The jet grouting should be completed in the presence of a representative of Pennoni.

Compaction grouting consists of injecting a low slump sand, cement, and fly ash (optional) mix into the subsoils at a pressure about 300 to 400 psi, in this case only near the center of the cofferdam (landside), or at a pressure on the order of 200 to 250 psi in areas near the steel sheet piling (water side). The objective of compaction grouting is to fill voids and improve the consistency/density of soft/loose soils thereby re-establishing uniform bearing conditions and minimize the potential for long-term subsidence. Temporary casings are installed by drilling them into firm/dense subsoils and then withdrawing the casing in 1 to 2 ft increments as the grout is injected by pumping at a predetermined pressure. The pipes are withdrawn to the next increment when any of the criteria presented below are met:

- 1.0 to 1.5 cubic yards of grout per 2 ft increment are injected;
- ground heave is observed;
- a predetermined pressure at the injection point is observed;
- grout exits the ground through cracks in the soil or around the pipes; or
- structural movement is observed.

The injection points should be established within the sheet pile cells 28 and 34. Anticipated depth of grout pipes is expected to be about 45 to 50 ft below existing grades. The compaction grouting should be completed in the presence of a representative of Pennoni.

EARTHWORK

Before the placement of new fills, and slabs, existing concrete and bituminous concrete must be removed from within the proposed footprint. Pavement millings and concrete can be re-used in load bearing fills provided there are no associated environmental issues and the material is crushed so that largest particle size does not exceed a diameter greater than 3 inches.

Exposed subgrades should be thoroughly proof-rolled, in the presence of a representative from Pennoni, using a loaded dump truck or equivalent where space allows. Where space is limited, subgrade soils should be manually probed in an attempt to disclose unstable surface areas. Any unsuitable area found should be excavated and replaced with suitably compacted fill, or the unstable soils should be stabilized by adjusting the moisture content of the subgrade soils and compacting them, or stabilized by other methods (placing a geotextile and stone layer, etc.).

Visual observations and laboratory testing indicate that the near surface fills consist of predominantly granular soils. The laboratory test results indicate that the present moisture contents (6.2% to 8.5%) of the soils are near the optimum moisture content normally associated with these soils to achieve the desired degree of compaction. Adjusting the moisture contents of the encountered soils before use in any compacted fills and/or subgrade preparation may be required. We recommend that grades preventing the accumulation of water be maintained including leaving the subgrade higher than design prior to placing concrete.

Granular fills should be placed in layers not exceeding 10 to 12 in. loose thickness. This criterion may be adjusted by the Geotechnical Engineer in the field depending on the conditions present at the time of construction, on the compaction equipment used, and on the fill material selected. Fills for support of the slabs and pavements should be compacted to at least 95 percent of the laboratory determined maximum dry density, ASTM D 1557.

Specifications should indicate that the percentage of maximum dry density attained in the field is not the only criteria to be used for assessing fill compaction. Observation of the behavior of the fill under the loads of construction equipment should also be used. If the test results indicate that the percentage of compaction is being achieved, but the soil mass is moving under the equipment, placement of additional fill should not be continued until the movement is stabilized. Otherwise, settlement of the fill may occur.

CONSTRUCTION DIFFICULTIES

Although there are existing splash zone repairs and additional mudline repairs that will occur prior to the grouting operations, there is a potential for grout to leak through the sheeting at unforeseen holes between the upper and lower repairs. Also, even though the previous full height inspection of the sheeting found no problem areas it is recommended that Ultrasonic Tests (UT) be performed before the jet grouting occurs in order to detect any significant loss of section at the sheeting due to corrosion. In addition, it is recommended that divers be in the water during the initial stage of jet grouting performed immediately adjacent to the steel sheet piles to detect leaks and for at least 25% of the remaining jet grouting operations for the same reasons.

RECOMMENDATIONS FOR FURTHER GEOTECHNICAL SERVICES

Our experience on numerous construction projects is that the interests of the project team are best served by retaining the Geotechnical Engineer to provide construction observations during earthwork and foundation construction operations. To determine if soils, other materials, and ground water conditions encountered during construction are similar to those encountered in the borings, and that they have comparable engineering properties or influences on the design of the structures, we recommend that Pennoni should provide field observation services during excavation; construction of compacted fill; preparation of slabs, and pavement subgrades; and installation/construction of foundations, slabs, and pavements.

LIMITATIONS

This work has been done in accordance with our authorized scope of work and in accordance with generally accepted professional practice in the fields of geotechnical and foundation engineering. This warranty is in lieu of all other warranties either expressed or implied. Our conclusions and recommendations are based on the data revealed by this exploration. We are not responsible for any conclusions or opinions drawn from the data included herein, other than those specifically stated, nor are the recommendations presented in this report intended for direct use as construction specifications. This report is intended for use with regard to the specific project described herein; any changes in loads, structures, or locations should be brought to our attention so that we may determine how they may affect our conclusions. An attempt has been made to provide for normal contingencies but the possibility remains that unexpected conditions may be encountered during construction. If this should occur, or if additional or contradictory data are revealed in the future, we should be notified so that modifications to this report can be made, if necessary. If we do not review relevant construction documents and witness the relevant construction operations, then we cannot be responsible for any problems that may result from misinterpretation or misunderstanding of this report or failure to comply with our recommendations.

We trust that the information presented in this report is what you require at this time and we thank you for the opportunity to assist you with this project. If you have any questions, or if you need any further assistance with this project, please contact this office at your earliest convenience.

Respectfully yours,

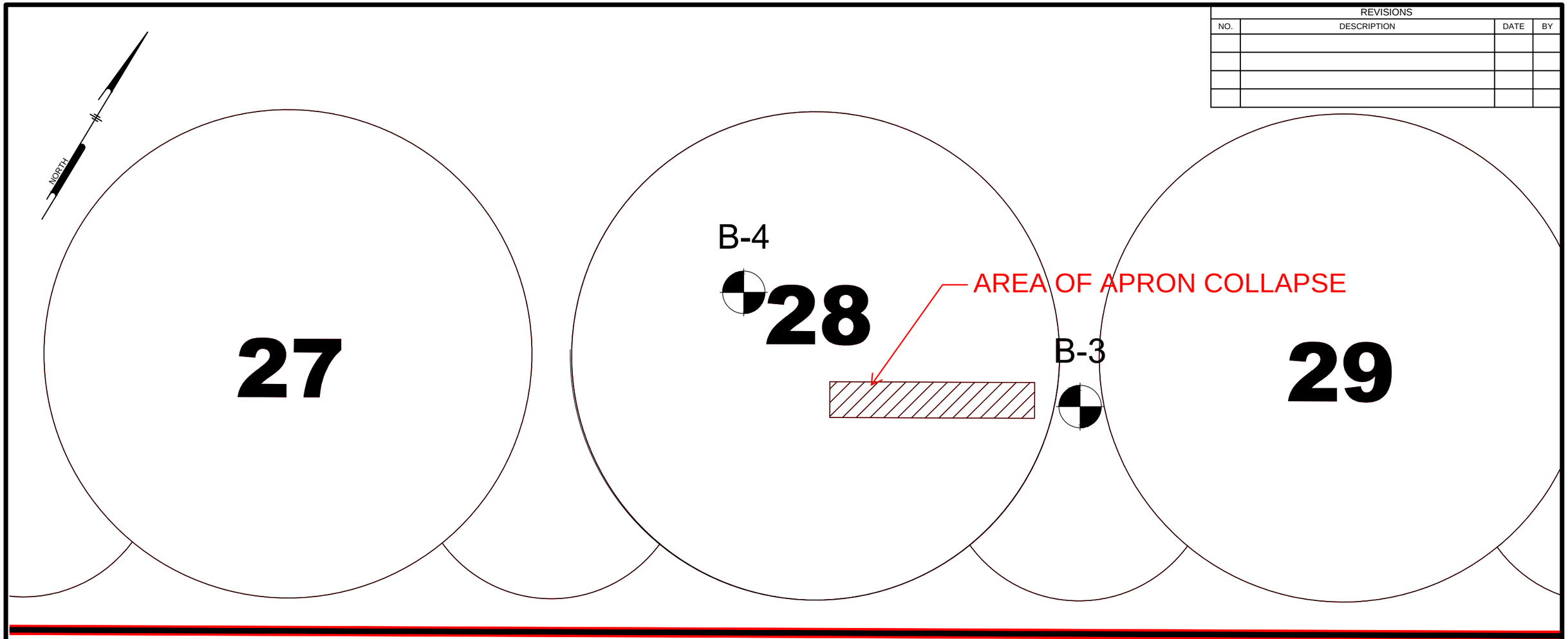
PENNONI ASSOCIATES INC.

David A. Copeland
Graduate Engineer

Daniel P. Marano Jr., PE
Staff Engineer

Attachments: Boring Log, B-1 through B-4; Boring Location Plans, LP-1 and LP-2; Boring Log Key Sheet; Summary of Laboratory Test Data, Table L-1; Gradation Curves, Figure S-1 and S-2; Laboratory Testing Procedures; Important Information about This Geotechnical Engineering Report

REVISIONS			
NO.	DESCRIPTION	DATE	BY



LEGEND

B-1

INDICATES APPROXIMATE TEST BORING LOCATION AND IDENTIFYING NUMBER.

NOTES

WATER LEVELS, WHERE SHOWN, ARE THOSE OBSERVED AT THE TIME NOTED AND MAY NOT REFLECT DAILY OR SEASONAL VARIATIONS IN THE GROUND WATER LEVEL.

THE SUBSURFACE CONDITIONS REVEALED BY THIS STUDY REPRESENT CURRENT CONDITIONS AT THE SPECIFIED TEST LOCATIONS ONLY AND MAY NOT BE INDICATIVE OF CONDITIONS AT OTHER LOCATIONS.

0 10' 20'

PENNONI ASSOCIATES INC.
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ALL DOCUMENTS PREPARED BY PENNONI ASSOCIATES ARE INSTRUMENTS OF SERVICE IN RESPECT OF THE PROJECT. THEY ARE NOT INTENDED OR REPRESENTED TO BE SUITABLE FOR REUSE BY OWNER OR OTHERS ON THE EXTENSIONS OF THE PROJECT OR ON ANY OTHER PROJECT. ANY REUSE WITHOUT WRITTEN VERIFICATION OR ADAPTATION BY PENNONI ASSOCIATES FOR THE SPECIFIC PURPOSE INTENDED WILL BE AT OWNERS SOLE RISK AND WITHOUT LIABILITY OR LEGAL EXPOSURE TO PENNONI ASSOCIATES; AND OWNER SHALL INDEMNIFY AND HOLD HARMLESS PENNONI ASSOCIATES FROM ALL CLAIMS, DAMAGES, LOSSES AND EXPENSES ARISING OUT OF OR RESULTING THEREFROM.

TIOGA MARINE TERMINAL APRON COLLAPSE
3601 N DELEWARE AVE
PHILADELPHIA, PA

BORING LOCATION PLAN

PHILADELPHIA REGIONAL PORT ATHORITY
3460 N DELEWARE AVE
PHILADELPHIA, PA 19134

PROJECT	PRPA 1606
DATE	2016-11-22
DRAWING SCALE	1"=10
DRAWN BY	DAC
APPROVED BY	DPM

LP-1

SHEET 1 OF 2

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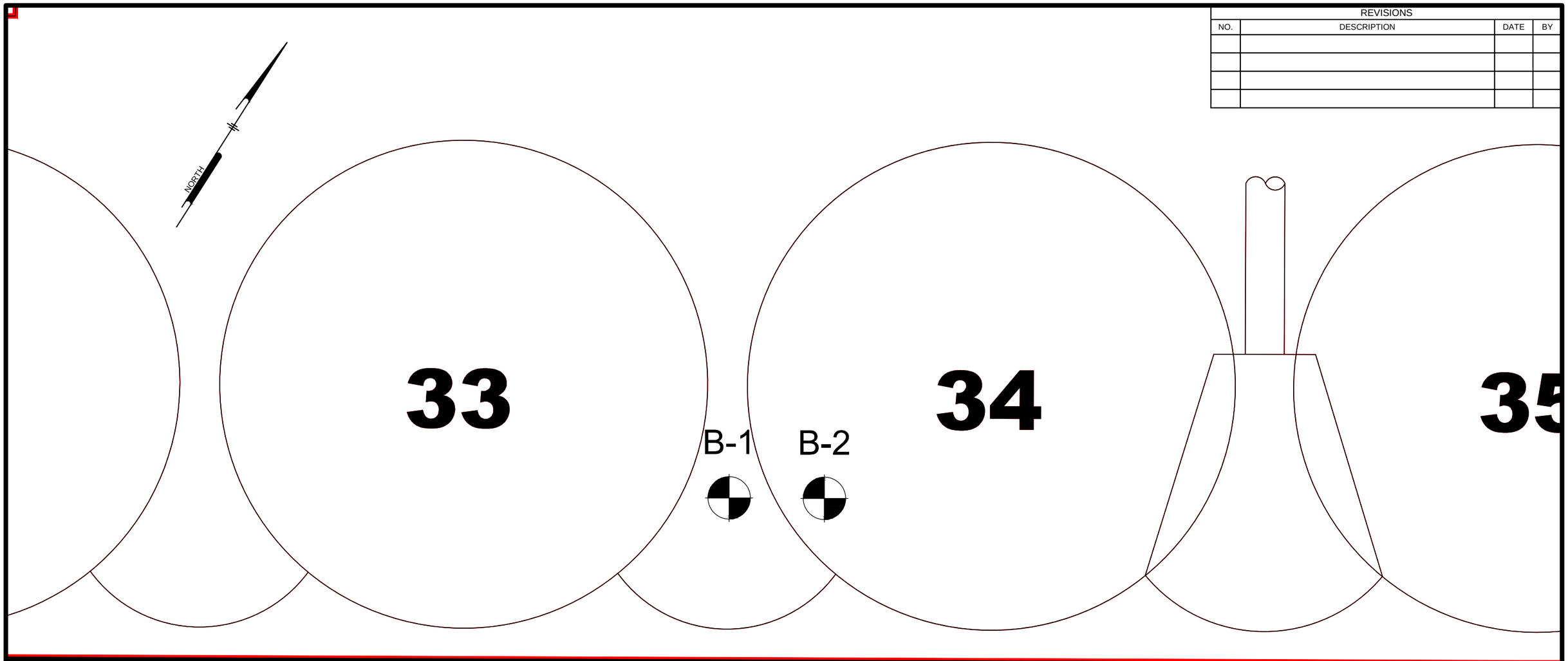
REVISIONS			
NO.	DESCRIPTION	DATE	BY



DELAWARE RIVER

0 10' 20'

LEGEND

B-1

INDICATES APPROXIMATE TEST BORING LOCATION AND IDENTIFYING NUMBER.

NOTES

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TIOGA MARINE TERMINAL APRON COLLAPSE
3601 N DELEWARE AVE
PHILADELPHIA, PA

BORING LOCATION PLAN

PHILADELPHIA REGIONAL PORT ATHORITY
3460 N DELEWARE AVE
PHILADELPHIA, PA 19134

PROJECT	PARPA 1606
DATE	2016-11-23
DRAWING SCALE	1"=10'
DRAWN BY	DAC
APPROVED BY	DPM

LP-2

SHEET 2 OF 2

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BORING LOG

CLIENT Philadelphia Regional Port Authority
PROJECT NAME Tioga Marine Terminal Slab Failure
PROJECT NUMBER PRPA 1606
PROJECT LOCATION 3601 N Delaware Ave, Philadelphia, PA
DATE STARTED 10/31/16 **COMPLETED** 10/31/16
GROUND ELEVATION
DRILLING CONTRACTOR Sano Drilling Inc.
WATER ENCOUNTERED:
DRILLING METHOD Hollow Stem Auger w/ Mud
DURING DRILLING 10.00
DRILLER / HELPER S. Parisano/J. Tessitor
AT END OF DRILLING 10.00
LOGGED BY D. Copeland **CHECKED BY** D. Marano
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY (in.)	BLOW COUNTS	GRAPHIC LOG	STRATA	DESCRIPTION (Depth / Elev.)	REMARKS
0						0.7 8 in. BITUMINOUS CONCRETE 1.2 6 in. VOID 34 in. PROCESSED AGGREGATE (No. 3 Ballast Stone) 4.0	
5	S-1	16	2-4-5-5		P	FILL: Brown F SAND, trace Silt 6.0	Moist
	S-2	12	6-8-12-12			FILL: Brown F/M/C SAND, some F/C Gravel size Rock Fragments, little Silt 8.0	
10 ▼	S-3	12	9-11-13-9		F	FILL: Brown F GRAVEL, some F/M Sand, trace Silt 13.0	
15	S-4	4	13-50/3"			FILL: Dark brown F/C Gravel size ROCK FRAGMENTS, trace F Sand, trace Silt, trace Cinder 18.0	Wet
20	S-5	16	3-3-3-3		1	Brown F GRAVEL AND F/M SAND	
25	S-6	16	4-2-3-4				
						28.0	
30	S-7	10	6-6-5-3			Brown C/F GRAVEL AND M/F/C SAND, trace Silt	
35	S-8	1	8-7-7-5				

NOTES:
1st attempt 2 ft south of B-1. Boring attempt terminated 16 in. deep. Possible caisson.

(Continued Next Page)

Pennoni

BORING LOG

CLIENT Philadelphia Regional Port Authority
PROJECT NAME Tioga Marine Terminal Slab Failure
PROJECT NUMBER PRPA 1606
PROJECT LOCATION 3601 N Delaware Ave, Philadelphia, PA

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY (in.)	BLOW COUNTS	GRAPHIC LOG	STRATA	DESCRIPTION (Depth / Elev.)	REMARKS
40	S-9	16	6-5-4-5		1	Brown C/F GRAVEL AND M/F/C SAND, trace Silt *(continued)*	
						43.0	
45	S-10	24	8-9-12-14		3	Light gray to white CLAY	
50	S-11	24	8-12-12-15			50.0	

Boring terminated at 50.0 feet.

NOTES:
1st attempt 2 ft south of B-1. Boring attempt terminated 16 in. deep. Possible caisson.

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BORING LOG

CLIENT Philadelphia Regional Port Authority
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WATER ENCOUNTERED:
DURING DRILLING 10.00
DRILLING METHOD Hollow Stem Auger w/ Mud
AT END OF DRILLING 10.00
DRILLER / HELPER S. Parisano/J. Tessitor
AFTER DRILLING ---
LOGGED BY D. Copeland **CHECKED BY** D. Marano

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY (in.)	BLOW COUNTS	GRAPHIC LOG	STRATA	DESCRIPTION (Depth / Elev.)	REMARKS
0					P	0.7 8 in. BITUMIOUNS CONCRETE 40 in. PROCESSED AGGREGATE (No. 3 Ballast Stone) 4.0	
5	S-1	4	8-6-5-2		F	FILL: Brown F SAND, trace F Gravel size Rock Fragments, trace Silt	Moist
	S-2	10	5-6-13-16				
10 ▼	S-3	2	6-9-10-15				
						13.0	
15	S-4	18	6-6-7-9			FILL: Brown F/C GRAVEL AND M/C/F SAND, trace Silt	Wet
						18.0	
20	S-5	6	5-3-3-3		1	Brown F/C GRAVEL AND F/C SAND	
25	S-6	1	3-3-4-5				
						28.0	
30	S-7	16	6-4-2-3			Brown M/F/C SAND, some F Gravel, trace Silt	
35	S-8	16	3-4-4-3				

NOTES:

(Continued Next Page)

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BORING LOG

CLIENT Philadelphia Regional Port Authority
PROJECT NAME Tioga Marine Terminal Slab Failure
PROJECT NUMBER PRPA 1606
PROJECT LOCATION 3601 N Delaware Ave, Philadelphia, PA

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY (in.)	BLOW COUNTS	GRAPHIC LOG	STRATA	DESCRIPTION (Depth / Elev.)	REMARKS
40	S-9	10	6-9-16-17		1	Brown M/F/C SAND, some F Gravel, trace Silt *(continued)* — 40.0	
					2	Brown C GRAVEL AND COBBLES, trace F Sand — 42.0	Hard augering 40' to 42' Auger refusal at 42 ft

Boring terminated at 42.0 feet.

NOTES:

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BORING LOG

CLIENT Philadelphia Regional Port Authority
PROJECT NAME Tioga Marine Terminal Slab Failure
PROJECT NUMBER PRPA 1606
PROJECT LOCATION 3601 N Delaware Ave, Philadelphia, PA
DATE STARTED 11/1/16 **COMPLETED** 11/1/16
GROUND ELEVATION
DRILLING CONTRACTOR Sano Drilling Inc.
WATER ENCOUNTERED:
DRILLING METHOD Hollow Stem Auger w/ Mud
DURING DRILLING ---
DRILLER / HELPER S. Parisano/J. Tessitor
AT END OF DRILLING ---
LOGGED BY D. Copeland **CHECKED BY** D. Marano
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY (in.)	BLOW COUNTS	GRAPHIC LOG	STRATA	DESCRIPTION (Depth / Elev.)	REMARKS
0					P	1.5 18 in. CONCRETE	Dry Possible steel obstruction at 2.5' Auger refusal at 2.5 ft
					F	2.5 FILL: Brown F SAND, some F Gravel size Rock Fragments	
						Boring terminated at 2.5 feet.	

NOTES:
Possible steel obstruction at 2.5'. Offset 1' south to drill B-3A.

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BORING LOG

CLIENT Philadelphia Regional Port Authority
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DATE STARTED 11/1/16 **COMPLETED** 11/1/16
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DRILLING METHOD Hollow Stem Auger w/ Mud
DRILLER / HELPER S. Parisano/J. Tessitor
LOGGED BY D. Copeland **CHECKED BY** D. Marano

PROJECT NAME Tioga Marine Terminal Slab Failure
PROJECT LOCATION 3601 N Delaware Ave, Philadelphia, PA
GROUND ELEVATION ---
WATER ENCOUNTERED:
DURING DRILLING 10.00
AT END OF DRILLING 10.00
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY (in.)	BLOW COUNTS	GRAPHIC LOG	STRATA	DESCRIPTION (Depth / Elev.)	REMARKS
0					P	18 in. CONCRETE (1.5)	
					F	FILL: Brown F/M/C SAND, trace F Gravel, trace Silt (6.0)	Damp
5	S-1	22	2-2-2-2				
	S-3	18	4-3-3-2			FILL: Brown F/C SAND, trace F Gravel (8.0)	
10 ▼	S-4	3	2-3-3-4			FILL: Brown F SAND AND C GRAVEL (13.0)	Wet
15	S-5	16	1-1-2-3		1	Brown M/F/C SAND, trace F Gravel, trace Silt (18.0)	
20	S-6	8	3-3-3-3			Brown F/M/C SAND (28.0)	
25	S-7	3	2-3-3-3				
30	S-8	12	2-2-2-2			Brown F SAND, trace F Gravel (33.0)	
35	S-9	20	1-1-1-1			Dark brown F/M SAND, some F Gravel, trace Silt	

NOTES:

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Pennoni

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PROJECT NUMBER PRPA 1606
PROJECT LOCATION 3601 N Delaware Ave, Philadelphia, PA

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY (in.)	BLOW COUNTS	GRAPHIC LOG	STRATA	DESCRIPTION (Depth / Elev.)	REMARKS
					1	Dark brown F/M SAND, some F Gravel, trace Silt *(continued)*	
40	S-10	3	3-4-3-4				
45	S-11	16	3-3-3-3			44.0 Brown M/C/F SAND	
						48.0	
50	S-12	24	8-10-11-10		3	50.0 Light gray to white CLAY, trace F Sand	

Boring terminated at 50.0 feet.

NOTES:

Pennoni

BORING LOG

CLIENT Philadelphia Regional Port Authority
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PROJECT LOCATION 3601 N Delaware Ave, Philadelphia, PA
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AT END OF DRILLING 10.00
LOGGED BY D. Copeland **CHECKED BY** D. Marano
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY (in.)	BLOW COUNTS	GRAPHIC LOG	STRATA	DESCRIPTION (Depth / Elev.)	REMARKS
0					P	0.7 8 in. CONCRETE	
	S-1	10	6-8-6-8			FILL: Brown F SAND, trace F Gravel size Rock Fragments	
5	S-2	10	6-8-10-14			6.0	
	S-3	16	13-13-14-12		F	FILL: Brown F SAND	Damp
10 ▼	S-4	16	5-5-5-5				
						13.0	
15	S-5	4	2-2-3-2			Brown C/M/F SAND AND F GRAVEL	Wet
						18.0	
20	S-6	18	1-1-1-1			Brown M/F/C SAND, some F Gravel, trace Silt	
25	S-7	18	1-2-1-1		1		
30	S-8	18	1-2-1-2				
						33.0	
35	S-9	16	4-4-4-10			Brown F/C GRAVEL, trace F Sand	

NOTES:

(Continued Next Page)

Pennoni

BORING LOG

CLIENT Philadelphia Regional Port Authority **PROJECT NAME** Tioga Marine Terminal Slab Failure

PROJECT NUMBER PRPA 1606 **PROJECT LOCATION** 3601 N Delaware Ave, Philadelphia, PA

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY (in.)	BLOW COUNTS	GRAPHIC LOG	STRATA	DESCRIPTION (Depth / Elev.)	REMARKS
						Brown F/C GRAVEL, trace F Sand *(continued)*	
						38.0	
40	S-10	8	13-22-22-20			Brown C/M SAND AND C/F GRAVEL	
					1	43.0	
45	S-11	16	9-14-21-23			Light brown M/F/C SAND, trace Silt, trace Gravel	
						48.0	
50	S-12	22	11-22-24-29			Light gray to white F SAND	
						50.0	

Boring terminated at 50.0 feet.

NOTES:

TEST BORING/TEST PIT/AUGER PROBE LOG KEY SHEET

COLUMN	DESCRIPTION
Depth	Depth in feet below ground surface
Description	Description of sample including color, texture, and classification of subsurface material as applicable. Estimated depths to bottom of strata as interpolated from the boring are also shown.
Stratum	Strata numbers as assigned by the geotechnical engineer
Sample No.	Split barrel sample and sample number (S-x) Undisturbed Tube sample and sample number (U-x) Rock core run and core number (R-x) NR indicates no recovery
Blow Counts	For soils sample (ASTM D 1586): indicates number of blows obtained for each 6 inches penetration of the standard split-barrel sampler. For rock coring (ASTM D 2113): indicates percent recovery (REC) per run and rock quality designation (RQD). RQD is the sum of rock pieces that are 4 inches or longer in length in one core run divided by the total core run.
Recovery	For soil samples indicates the length of recovery in the sample spoon
Remarks	Special conditions or test data as noted during drilling

Ground Water: Free water level as shown ( )*; * Free water level as noted may not be indicative of daily, seasonal, or long term fluctuations.

DESCRIPTIVE TERMS

RELATIVE PROPORTIONS

Descriptive Term	Symbol	Estimated Percentages
Trace	tr	1 to 10
Little	l	10 to 20
Some	sm	20 to 35
And	and	35 to 50

GRADATION OF COARSE GRAINED COMPONENTS

Soil Component	Size Range	Particle Size Maximum	Particle Size Minimum
Boulders		-	12"
Cobbles		12"	3"
Gravel	Coarse	3"	¾"
	Fine	¾"	#4 Sieve
Sand	Coarse	#4 Sieve	#10 Sieve
	Medium	#10 Sieve	#40 Sieve
	Fine	#40 Sieve	#200 Sieve
Silt		#200 Sieve	.005 mm
Clay		.005 mm	-

COMPOSITION OF COARSE-GRAINED COMPONENTS

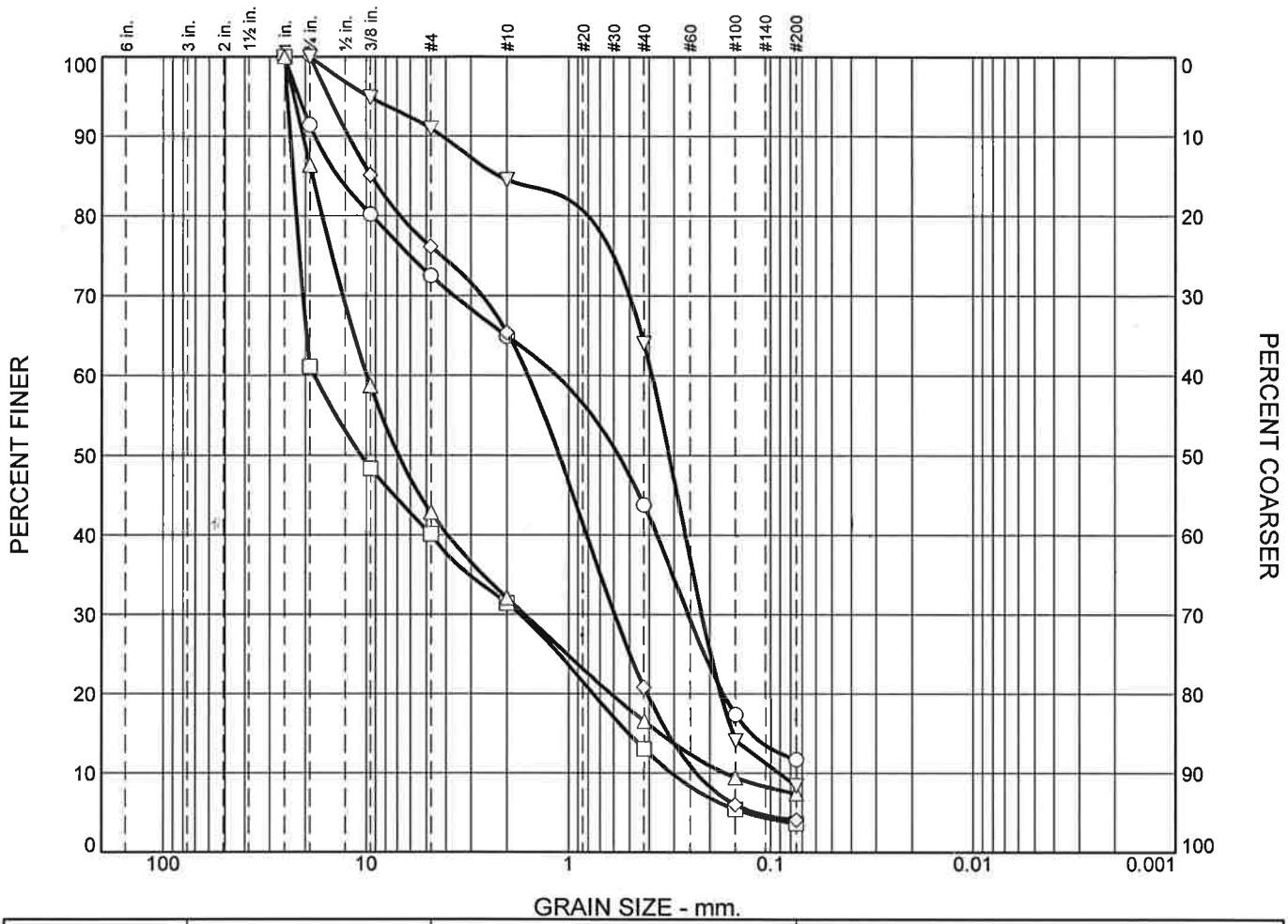
Gradation Designation	Symbol	Defining Proportions
Coarse to Fine	CF	All fractions greater than 10% of the component
Coarse to Medium	CM	Less than 10% Fine
Medium to Fine	MF	Less than 10% Coarse
Coarse	C	Less than 10% Fine and Medium
Medium	M	Less than 10% Coarse and Fine
Fine	F	Less than 10% Coarse and Medium

SUMMARY OF LABORATORY DATA

BORING NUMBER	SAMPLE NUMBER	DEPTH (ft)	SOIL GROUP SYMBOL	GRAIN SIZE DISTRIBUTION			PLASTICITY				MOISTURE CONTENT w %	VOLUMETRIC				COMPACTION DATA			PERMEABILITY (E-6 CM/SEC)	FALLING/CONSTANT HEAD	CALIFORNIA BEARING RATIO (CBR) %	SHEAR STRENGTH		
				GRAVEL %	SAND %	SILT/CLAY %	LIQUID LIMIT w_l	PLASTIC LIMIT w_p	PLASTICITY INDEX I_P	LIQUIDITY INDEX I_L		SPECIFIC GRAVITY (G)	DRY UNIT WEIGHT (pcf)	VOID RATIO (e)	DEGREE OF SATURATION %	MAXIMUM DRY DENSITY (pcf)	OPTIMUM MOISTURE CONTENT %	STANDARD/MODIFIED				UNCONFINED COMPRESSIVE STRENGTH (tsf)	COHESION (tsf)	AXIAL STRAIN (%)
B-1	S-2	6-8	SP-SM	28	61	11					8.5													
	S-7	28-30	GP	60	36	4					10.0													
	S-11	43-45					34	23	11	-0.2	21.1													
B-2	S-4	13-15	GW-GM	57	35	8					8.8													
	S-8	33-35	SP	24	72	4					16.9													
B-3	S-1	4-6	SP-SM	9	83	8					6.2													
	S-5	13-15	SP	9	87	4					22.9													
	S-9	33-35	SP-SM	27	65	8		NP			26.6													
B-4	S-6	18-20	SP	29	69	2					15.5													
	S-11	43-45	SP-SM	1	91	8					13.3													

PENNONI ASSOCIATES INC.	DRAWN BY: JRM CHECKED BY: DPM	DATE: 11/11/2016 DATE: 11/11/2016	PROJECT: TIOGA MARINE TERMINAL SLAB FAILURE LOCATION: 3601 N DELAWARE AVE, PHILADELPHIA, PA	JOB No.: PRPA-1606 TABLE No.: L-1

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

MATERIAL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-1	S-2	6-8	F/M/C SAND, SOME F/C GRAVEL, LITTLE SILT	SP-SM
□	B-1	S-7	28-30	C/F GRAVEL AND M/F/C SAND, TRACE SILT	GP
△	B-2	S-4	13-15	F/C GRAVEL AND M/C/F SAND, TRACE SILT	GW-GM
◇	B-2	S-8	33-35	M/F/C SAND, SOME F GRAVEL, TRACE SILT	SP
▽	B-3	S-1	4-6	F/M/C SAND, TRACE F GRAVEL, TRACE SILT	SP-SM

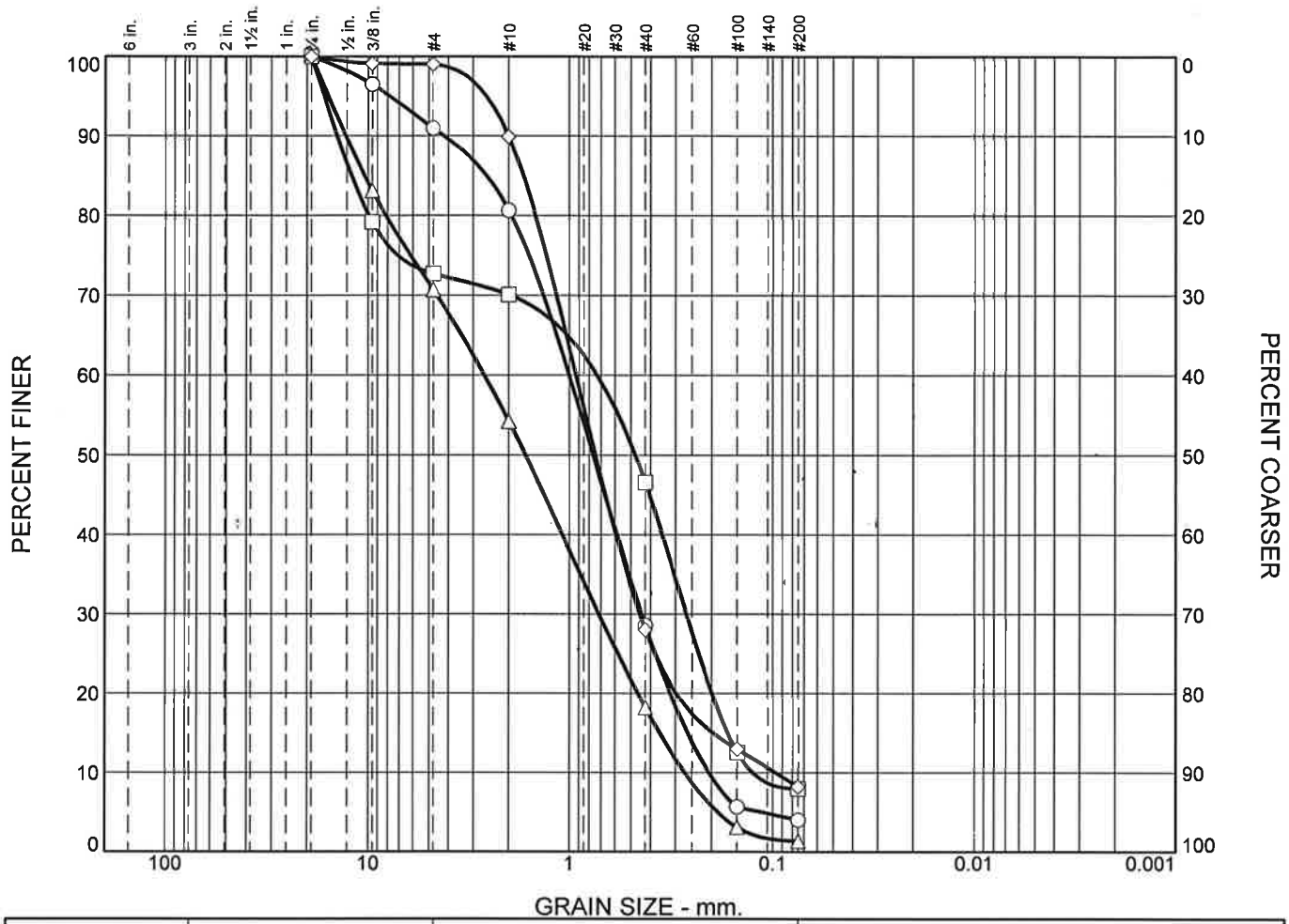
PENNONI ASSOCIATES INC.

Client: Philadelphia Regional Port Authority

Project: Tioga Marine Terminal Slab Failure

Project No.: PRPA-1606 **Figure** S-1

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

MATERIAL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-3	S-5	13-15	M/F/C SAND, TRACE F GRAVEL, TRACE SILT	SP
□	B-3	S-9	33-35	F/M SAND, SOME F GRAVEL, TRACE SILT	SP-SM
△	B-4	S-6	18-20	M/F/C SAND, SOME F GRAVEL, TRACE SILT	SP
◇	B-4	S-11	43-45	M/F/C SAND, TRACE SILT, TRACE GRAVEL	SW-SM

PENNONI ASSOCIATES INC.

Client: Philadelphia Regional Port Authority
Project: Tioga Marine Terminal Slab Failure

Project No.: PRPA-1606 **Figure** S-2

LABORATORY TESTING PROCEDURES

All testing is either done in accordance with the indicated ASTM Designation-latest edition, or with other standard or generally accepted engineering practice as described:

1. Consolidation Test of Soils
   Preparation of samples and testing procedures generally follow the methods described in Lambe, op. Cit. In addition, the time of loading may be selected on the basis of:

   a. Controlled rate of percent of consolidation
   b. Controlled pore pressure gradient
   c. Controlled strain

   The method of test is selected to suit the soil type in question and the test is conducted in accordance with generally accepted engineering practice.

2. Atterberg Limits – Plasticity Indices
   a. Liquid limit of soils, ASTM D 4318
   b. Plastic limit and plasticity index of soils, ASTM D 4318
   c. Shrinkage factors of soils, ASTM D 427

   (Moisture content is also determined with the Atterberg Limit test, and liquidity index is also computed)

3. Moisture Content of Soil
   ASTM D 2216

4. Particle Size Analysis of Soils
   ASTM D 421, Dry preparation of soil samples; ASTM D 422, Sieve and/or hydrometer analysis.

5. Triaxial Compression Test of Soils
   Sample preparation, apparatus, and testing generally follow the procedures outlined in Soil Testing for Engineers, T.W. Lambe, John Wiley & Sons, Inc., New York, 1951 and in The Measurement of Soil Properties in the Triaxial Test, Alan W. Bishop & D.J. Henkel, 2nd Edition, St. Martin's Press, New York, 1962

6. Unconfined Compression Strength of Cohesive Soil
   ASTM D 2166

7. Specific Gravity of Soils
   ASTM D 854

8. Unit Weight Determination of Soils
   See ASTM D 2166 for preparation of specimen except that sample size may differ. For moisture content see ASTM D 2216.

9. Visual Identification of Soil Samples
   All soil samples are visually identified and/or classified. The classification system used is shown in Table L-1.

10. Identification of Rock
    Rock core samples are identified by the character and appearance of newly fractured surfaces of unweathered pieces, by core conditions and characteristics, and by the determination of simple physical and chemical properties.

11. Compaction Test of Soils
    a. Moisture-density relations of soils using 5.5 lb. hammer and 12 in. drop, ASTM D 698
    b. Moisture-density relations of soils using 10 lb. hammer and 18 in. drop, ASTM D 1557

12. Maximum and Minimum Densities of Granular Soils
    Testing procedures follow D.M. Burmeister, "Suggested Method of Test for Maximum and Minimum Densities of Granular Soils" cited in Proceedings for Testing Soils, Fourth Edition, ASTM, Philadelphia. 1964, pp 175-177.

13. Bearing Ratio of Laboratory Compacted Soils
    ASTM D 1883 (Sometimes called California Bearing Ratio or CBR)

14. Organic Content
    A modified dichromate oxidation method using ferrous ammonium sulfate is employed in determining the percent of organic matter in soil.

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a constructor — a construction contractor — or even another civil engineer. Because each geotechnical- engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply this report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical-engineering report that was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical-engineering report whose adequacy may have been affected by*: the passage of time; man-made events, such as construction on or adjacent to the site; or natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Contact the geotechnical engineer before applying this report to determine if it is still reliable.* A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ — sometimes significantly — from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide geotechnical-construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly

problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold- prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical- engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.

GEOTECHNICAL BUSINESS COUNCIL
of the Geoprofessional Business Association

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