GEODESIGN INCORPORATED

GEOTECHNICAL | CONSTRUCTION | ENVIRONMENTAL
ENGINEERS and SCIENTISTS

GEOTECHNICAL STRUCTURE REPORT

REPLACEMENT OF CULVERT
NEW HAVEN MAINLINE (MP 65.6)
MILFORD, CONNECTICUT

STATE PROJECT NO. 301-175

Prepared for:
H.W. Lochner, Incorporated
55 Hartland Street, Suite 401 East
Hartford, Connecticut 06108

Prepared By:
Geo**Design**, Inc.
984 Southford Road
Middlebury, Connecticut 06762

Geo**Design** File No. 0331-020.00
October 2017

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1.0 INTRODUCTION

1.1 GENERAL

This report summarizes the subsurface exploration program, geotechnical design and construction recommendations for the proposed culvert replacement at Milepost 65.6 of the New Haven Mainline where the railroad crosses an unnamed stream in Milford, Connecticut. The site location is shown on Figure 1 (Appendix 1), Locus Plan.

H.W. Lochner (HWL) is the Prime Designer for the project and Geo**Design**, Inc. (Geo**Design**) is the Geotechnical Sub Consultant for HWL.

1.2 DATUM

Elevations (El.) referenced in this report are in stated feet and are based on NAVD 88. The coordinates are based on Connecticut State Plane Coordinate System, NAD 1983.

1.3 DESIGN CRITERIA

Our recommendations are based on load and resistance factor design, the 2014 with 2015 and 2016 Interim Revisions AASHTO LRFD Bridge Design Specifications, the 2003 ConnDOT Bridge Design Manual (last revised February 2011), and the 2017 American Railway and Maintenance-of-way Association (AREMA) Manual for Railway Engineering.

2.0 EXISTING CONDITIONS AND PROPOSED CONSTRUCTION

2.1 EXISTING CONDITIONS

The New Haven Mainline currently crosses an unnamed stream at approximate Milepost 65.6. In this area the Mainline has four tracks that are supported on an embankment. The crossing stream, which primarily consists of storm water from the Eastern Steel Road industrial area north of the Mainline, is carried by an existing 2 foot by 2 foot stone masonry culvert. The existing culvert extends approximately perpendicular to the Mainline, has an inlet elevation of 30.9 and an outlet elevation of 29.6. It is approximately 89 feet long. The top of the overlying railroad embankment is at approximate Elevation 43.

The culvert has experienced a partial collapse of masonry blocks, which has caused a reduction in its hydraulic capacity. Additionally, at the culvert's outlet end (on the south side of the Mainline) the railroad embankment is sloughing, further impeding water flow. Figure 2, Boring Location Plan (Appendix 1) depicts the approximate plan location of the existing culvert and other site features.

2.2 PROPOSED REPLACEMENT

A replacement culvert is proposed approximately 16 to 20 feet west (centerline to centerline) of the existing culvert at Milepost 65.6. Due to the high volume of traffic on the mainline and the depth of the new culvert below the track level, the preferred method of culvert replacement is by jacking below the embankment. The proposed culvert replacement is sized to be hydraulically adequate to accommodate a 100-year storm.

The new culvert structure will consist of twin 48" diameter reinforced concrete pipes (RCP). Based on the upstream and downstream inverts of El. 28.1 and 27.6, and bottom of end wall footings set 2.5 feet below these levels, at El. 25.6 and 25.1, respectively.

Standard CTDOT endwalls will be constructed. A permanent access road is to be constructed near the culvert's downstream end to provide Metro North Railroad access. This road will only be used for maintenance of the culvert and the adjacent railroad embankment. Traffic on the access road will be very minimal.

The proposed construction consists of jacking the RCP piping below the Metro North railroad embankment. It will be the responsibility of the pipe manufacturer to supply lubricant ports as required by the Contractor's equipment and by subsurface conditions. The design and location of the ports shall be approved prior to pipe manufacture.

2.3 JACKING AND RECEIVING PITS

Due to the location of the stream to the north of the railroad embankment and the rise in grade to the north while at the south grades are relatively level, there are advantages to installing the jacking pit be on the north (upstream) side of the railroad. However, during design development it was decided to jack from the downstream end, by installing the jacking and receiving pits on the downstream (south) and upstream (north) sides of the railroad, respectively.

The proposed pits will be located approximately 30 feet south and north of the nearest railroad track. Based on the present profile, we anticipate that the pipe inverts will be at about El. 27.6 (south) and El. 28.1 (north). Based, in part, on a discussion with a pipe jacking contractor, we expect the jacking pit to be approximately 20 foot wide by approximately 26 feet long, the receiving pit to be approximately 20 foot wide by approximately 10 feet long, and the working surface inside the jacking pit will be at about El. 24.

3.0 PUBLISHED GEOLOGY

Two published maps were consulted (*1:125,000 scale, Bedrock Geology of Connecticut, John Rodgers, 1985 and (1:125,000 scale, Surficial Materials Map of Connecticut, Janet Radway Stone, 1992)* to obtain information on the regional geology in the area of the proposed culvert replacement.

The surficial material in this locale is mapped as glacial till, consisting of a variable mixture of gravel, sand, silt, and clay that is intermixed with cobbles and boulders. The underlying bedrock is mapped as green, fine grained greenstone.

4.0 SUBSURFACE EXPLORATIONS

A Geo**Design** representative observed and logged three test borings (B-1 through B-3) that were drilled by New England Boring Contractors of CT, Inc. on September 21, 2016, October 18, 2016, and April 9, 2017. Exploration locations are depicted on Figure 2 (Appendix 1) and test boring logs are included in Appendix 2. The locations and elevations of the explorations were obtained by taping from existing site features and interpolation from topographic mapping provided by HWL.

Test borings were drilled to explore subsurface conditions in the vicinity of the culvert alignment. Solid stem auger, hollow-stem auger and drive and wash drilling methods were used to advance the boreholes to elevations ranging from approximately El. 16.5 to 12, which correspond to depths ranging from approximately 26.5 feet to 31 feet below the top of the rail embankment (El. 43). The borings were terminated approximately 11.5 to 16 feet below the culvert invert at the railroad centerline. Test borings were terminated in natural, glacial till material.

Representative soil samples in Borings B-1 and B-2 were obtained by split barrel sampling procedures in general accordance with ASTM D-1586. The split-spoon sampling procedure (SPT) utilizes a standard 2-inch O.D. split-barrel sampler that is driven into the bottom of the boring with a 140-pound hammer falling a distance of 30 inches. The number of blows required to advance the sampler the middle 12-inches of a normal 24-inch penetration is recorded as the SPT Resistance Value (N). The blows are indicated on the boring logs at their depth of occurrence and provide an indication of the relative consistency of the material.

Due to access restrictions at Boring B-3, a tripod-mounted drill rig (with a low height of pulley) had to be used. As a result non-standard SPT testing was performed in this boring. A standard 2-inch O.D. split-barrel sampler and a 140-pound hammer were used; however the hammer fall was 18-inches rather than 30-inches.

Bedrock was not encountered during subsurface explorations.

5.0 SUBSURFACE CONDITIONS

Excluding the presence of Fill, the explorations were generally consistent with published surficial geologic mapping. The generalized subsurface profile in the area of the proposed culvert replacement, as inferred from the boring data, is summarized as follows:

- Railroad Fill/Fill – 5 to 15 feet thick (to about El. 28 to 27.5); over
- Organic Clayey Silt – 1 to 1.5 feet thick (to about El. 29.5 to 26.5)
- Glacial Till – 10+ feet thick

Figure 3, Profile A-A', (Appendix 1) depicts a generalized subsurface profile in the vicinity of the proposed culvert. The profile includes material types, groundwater levels, and SPT N-values. Stratification lines on the logs and profiles are interpretive and represent approximate boundaries between material types.

The following presents a summary description of the major strata encountered.

5.1 RAILROAD FILL/FILL

The thickness, character, and consistency of the Railroad Fill will vary between exploration locations.

5.1.1 Ballast

Approximately twelve inches of Railroad Ballast was encountered below track level in Boring B-2, and generally consisted of fine to coarse gravel.

5.1.2 Miscellaneous Fill

Miscellaneous Fill was encountered in Borings B-1 at ground surface and B-2 just below the Ballast. The Miscellaneous Fill generally consisted of very loose to medium dense, brown fine to coarse sand with varying amounts of gravel and silt (0 to 35%). Trace minus (0 to 5%) amounts of wood fragments was encountered in B-1.

5.2 ORGANIC CLAYEY SILT

Organic Clayey Silt encountered below the Miscellaneous Fill in all borings. This material generally consisted of stiff to very stiff, dark brown, Organic Clayey Silt with varying amounts of fine to coarse sand (10 to 50%) and gravel (0 to 20%).

5.3 GLACIAL TILL

Glacial Till was encountered below the Miscellaneous Fill or the Organic Clayey Silt in all borings. This material generally consisted of medium dense to very dense, gray-brown fine to coarse sand with varying amounts of fine to coarse gravel (5 to 50%) and silt (5 to 35%).

5.4 GROUNDWATER AND SURFACE WATER

Groundwater was encountered at depths of 0 to 4 feet below the ground surface at Borings B-1 and B-3 (near both ends of the culvert). These correspond to approximate Elevations 28.5 to 31.0. Groundwater levels measured during explorations are shown on Figure 3 (Appendix 1), and included on the logs (Appendix 2).

The stream level was surveyed at approximately El. 30 in the location of the proposed culvert inlet and El.28 at the location of the proposed culvert outlet.

Our groundwater measurements took place over a relatively short period of time and are not indicative of the true yearly groundwater regime. Groundwater levels will vary due to seasonal factors, temperature, precipitation, construction activity and other conditions which may be different from the time of the exploration program.

6.0 SOILS LABORATORY TESTING

Soils laboratory testing consisted of four gradation tests on representative soil samples retrieved in the borings. Tested samples were from the Glacial Till stratum. They were tested in accordance with ASTM D422. Fines content (percentage by weight passing the No. 200 sieve) of the Glacial Till samples ranged from 9 to 34%. Laboratory testing results are included in Appendix 3.

7.0 GEOTECHNICAL ENGINEERING RECOMMENDATIONS

7.1 EXISTING CONDITIONS

The existing stone masonry culvert has an inlet invert elevation of approximately 30.9 and an outlet invert elevation of approximately 29.6. Based on the boring data we assume that the culvert bears on soil. The new culvert is sufficiently distant that it is not anticipated to interfere with the existing one.

7.2 JACKING AND RECEIVING PITS

Based on the results of the subsurface explorations and laboratory testing, we recommend the following geotechnical parameters for design of the jacking/receiving pit support and the jacking pit reaction:

Miscellaneous Fill

- Phi (angle of internal friction) = 31 degrees
- Saturated unit weight (γ_{sat}) = 120 pounds per cubic foot (pcf)

- Moist unit weight (γ_m) = 116 pcf
- Effective unit weight (γ') for saturated soil = 57.6 pcf
- Coefficient of Active Earth Pressure (K_a) = 0.32
- Coefficient of Passive Earth Pressure (K_p) = 3.26 (jacking pit reaction only)

Organic Clayey Silt

- Phi (angle of internal friction) = 30 degrees
- Saturated unit weight (γ_{sat}) = 118 pounds per cubic foot (pcf)
- Moist unit weight (γ_m) = 114 pcf
- Effective unit weight (γ') for saturated soil = 55.6 pcf
- Coefficient of Active Earth Pressure (K_a) = 0.34
- Coefficient of Passive Earth Pressure (K_p) = 3.04 (jacking pit reaction only)

Glacial Till

- Phi (angle of internal friction) = 38 degrees
- Saturated unit weight (γ_{sat}) = 140 pounds per cubic foot (pcf)
- Moist unit weight (γ_m) = 132 pcf
- Effective unit weight (γ') for saturated soil = 77.6 pcf
- Coefficient of Active Earth Pressure (K_a) = 0.24
- Coefficient of Passive Earth Pressure (K_p) = 4.23 (jacking pit reaction only)

Groundwater

- Design Groundwater level North of Embankment = El. 30
- Design Groundwater level South of Embankment = El. 28

The general stratigraphy varies by location and can be approximated as follows:

North Jacking pit:

- Fill: ground surface to El. 27
- Organic Clayey Silt: El. 27 to 25
- Glacial Till: El. 25 to 12

Center of Railroad Embankment:

- Fill: ground surface to El. 28
- Organic Clayey Silt: El. 28 to 26.5
- Glacial Till: El. 26.5 to 16.5

South Jacking Pit:

- Organic Clayey Silt: Ground Surface to El. 30
- Glacial Till: El. 30 to 16

7.3 GEOTECHNICAL STATIC DESIGN PARAMETERS

Because endwalls will be located outside the railroad live load influence limit they will not be designed, rather standard CTDOT endwalls will be used. We expect that for endwalls:

- Bottom of footing embedded 2.5 feet below ground surface;
- Bottom of footing is below water table;
- Footing bears on compacted granular fill.

We recommend the following static design parameters:

General:

- Unit weight of backfill above the water table of 128 pcf
- Unit weight of backfill below the water table of 65.6 pcf
- Backfill Angle of Internal Friction (φ') = 34°

Bearing and Settlement:

- Nominal (Ultimate) Bearing Resistance (Natural Soils) = 2 Tons per square foot
- Bearing Resistance Factor (φ_b) = 0.45
- Predicted Settlement of the headwalls is estimated to less than one inch.

Sliding/Overturning:

- Coefficient of Friction for Sliding = 0.55 (AASHTO LRFD Table 3.11.5.3-1)
- Coefficient of Friction for Soil against Wall (tan delta) = 0.40
- Coefficient of At-Rest Earth Pressure (K_o) = 0.45
- Coefficient of Active Earth Pressure, (K_a) = 0.28
- Sliding Resistance Factor (φ_τ) = 0.9 - Pre-cast Concrete
  0.8 - Cast-in-place Concrete
- Earth pressure calculations should assume a surface surcharge of a minimum of 24 inches of soil depth or 250 psf, in addition to surcharge loading (e.g., Cooper E80) in accordance with AREMA

  Computation of lateral forces should be based on AASHTO Section 3.11, Earth Pressure, using the above recommended parameters.

7.4 BEARING STRATA

We recommend that footings bear on granular fill or compacted granular fill over the dense glacial till soil. The overlying miscellaneous fill and organic clayey silt should be excavated from the foundation area prior to placement of fill. Standard endwall footings should be

embedded 2.5 feet below grade in accordance with Connecticut Department of Transportation standard details.

7.5 SEISMIC DESIGN

By inspection, the saturated site soils are not prone to liquefaction. We recommend classifying the site soils as AREMA Type 1, "stiff soil conditions where the soil depth is less than 200 feet and the soil types overlying rock are stable deposits of sands, gravels or stiff clays". We recommend a Seismic Site Coefficient of 1.0 for design.

8.0 MATERIAL AND COMPACTION REQUIREMENTS

8.1 REUSE OF ON-SITE MATERIAL

Excavated materials are not anticipated to be suitable for re-use as Granular Fill or Pervious Structure Backfill due to its elevated fines content (amount passing No. 200 sieve).

8.2 GRANULAR FILL

Culvert Bedding shall consist of Granular Fill per ConnDOT Standard Form 817, Section M.02.01, in cases where its thickness is less than two feet. Compacted Granular Fill shall consist of Granular Fill per ConnDOT Standard Form 817, Section M.02.02.

8.3 COMPACTED GRANULAR FILL

In cases where fill is required below foundation level to a thickness of more than two feet, we recommend use of Compacted Granular Fill. When placing Compacted Granular Fill beneath footings, the limits of the fill should extend laterally outside a line drawn down 1H:1V away from the outside edges of the footings.

8.4 PERVIOUS STRUCTURE BACKFILL

Pervious Structure Backfill shall consist of ConnDOT Standard Form 817, Section M.02.05. Pervious Structure Backfill should be used to backfill the ends of the culvert and associated walls. The limits of backfill should extend upwards from the bottom of the culvert or heel at a slope of 1.5H:1V (Horizontal:Vertical) to the intersection of unexcavated, undisturbed materials.

9.0 CONSTRUCTION RECOMMENDATIONS

9.1 SUBGRADE PREPARATION

Subgrade preparation should be conducted in such a way as to minimize disturbance. The final six inches of excavation should be made with a smooth-edged blade, attached to the bucket of

the excavator or, alternatively, hand-shovel to remove the loose, disturbed material such that the subgrade is essentially undisturbed.

Construction operations should be planned to mitigate disturbance to the final subgrade. The base of footing excavations should be free of water and loose soils prior to placing concrete. Disturbed subgrades soils should be over-excavated to firm stable ground and replaced by Granular Fill.

9.2 TEMPORARY GROUNDWATER CONTROL

Surface water and groundwater in the area of the culvert will impact temporary groundwater control during construction. Water inflows will need to be temporarily controlled using a diversion barriers and routing existing flow into the existing culvert to allow construction to occur in the dry. Methods to control groundwater may include sumps fitted with non-woven filter material to minimize loss of fines, sheeting, trenches, and deep well points.

Notwithstanding, the contractor should review the plans and borings and interpret the means and methods best suited to control water during construction. The contractor's means and methods should be developed to meet American Railway Engineering and Maintenance-of-Way Association (AREMA) construction requirements; and insure that no dewatering-induced settlements greater than permissible values are permitted to impact existing rail lines and structures.

9.3 PROTECTION OF EXISTING EMBANKMENT

The existing railroad embankment must be protected by the contractor at all times during construction.

9.4 TEMPORARY EXCAVATIONS

The Fill and natural site soils are classified as OSHA Class "C" soil and can be cut at a maximum one vertical to one and a half horizontal (1V:1.5H) slope up to a maximum excavation depth of 20 feet. These maximum slope and excavation depths assume no surcharge load (i.e. stockpiles, construction equipment, etc.) at the top of the excavations or groundwater seepage. Given the shallow groundwater, this cut geometry will only apply above the groundwater levels.

If excavations cannot be sloped up in accordance with OSHA requirements, a temporary excavation support system will be required. The system should be chosen and installed by the contactor and designed by a Professional Engineer registered in the State of Connecticut.

9.5 ABANDONNING EXISTING CULVERT

Once the new culvert has been put into service, we recommend grouting the entire length of the existing culvert with cementitious grout.

9.6 DEFORMTION MONITORING POINTS and MONITORING

Deformation monitoring points (DMPs) should be installed to allow monitoring of track movements. DMP's should be installed prior to start of jacking/receiving pit installation and start of pipe jacking. After three baseline readings have been obtained, the DMP's should be read twice per shift during jacking, and then once a day for two weeks, and finally weekly for one month after end of jacking or until end of construction.

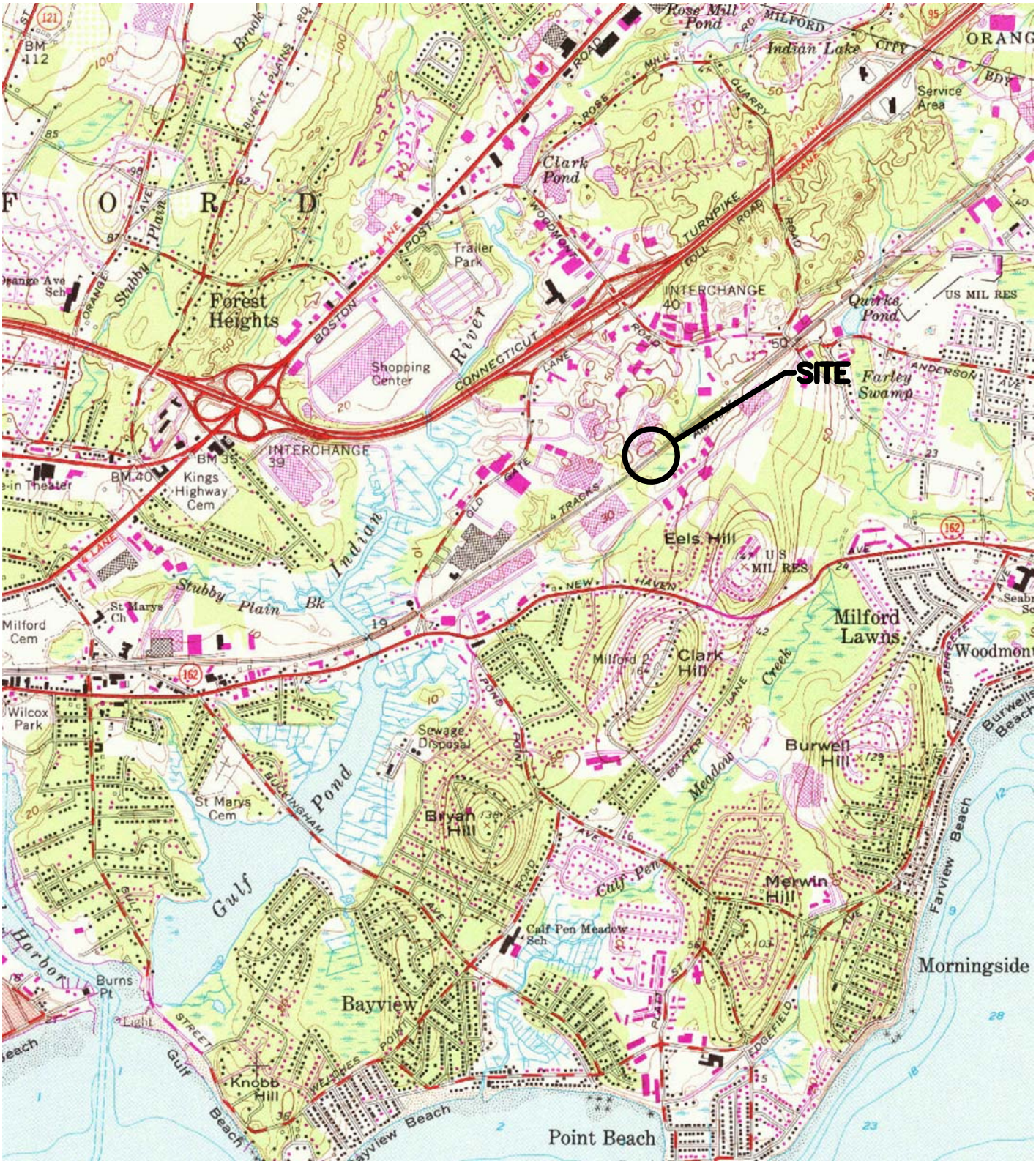
The DMPs should be installed on Track 1, 2 3 and 4, on the ties at the approximate center of the twin-pipe alignment, and at 10-foot intervals in both directions extending away from the pipes to a distance of 30 feet (total of 7 DMPs at each track, or 28 total).

10.0 LIMITATIONS

This report is subject to the Limitations in Appendix 4.

Appendix 1

Figures



GEODESIGN INCORPORATED

Geotechnical | Construction | Environmental
Engineers and Scientists
984 SOUTHFORD ROAD • MIDDLEBURY, CONNECTICUT 06762
TELEPHONE: 203.758.8836 • FACSIMILE: 203.758.8842

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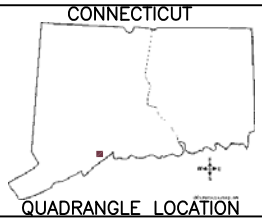


QUADRANGLE LOCATION

MP 65.6 NEW HAVEN MAIN LINE
MILFORD, CONNECTICUT

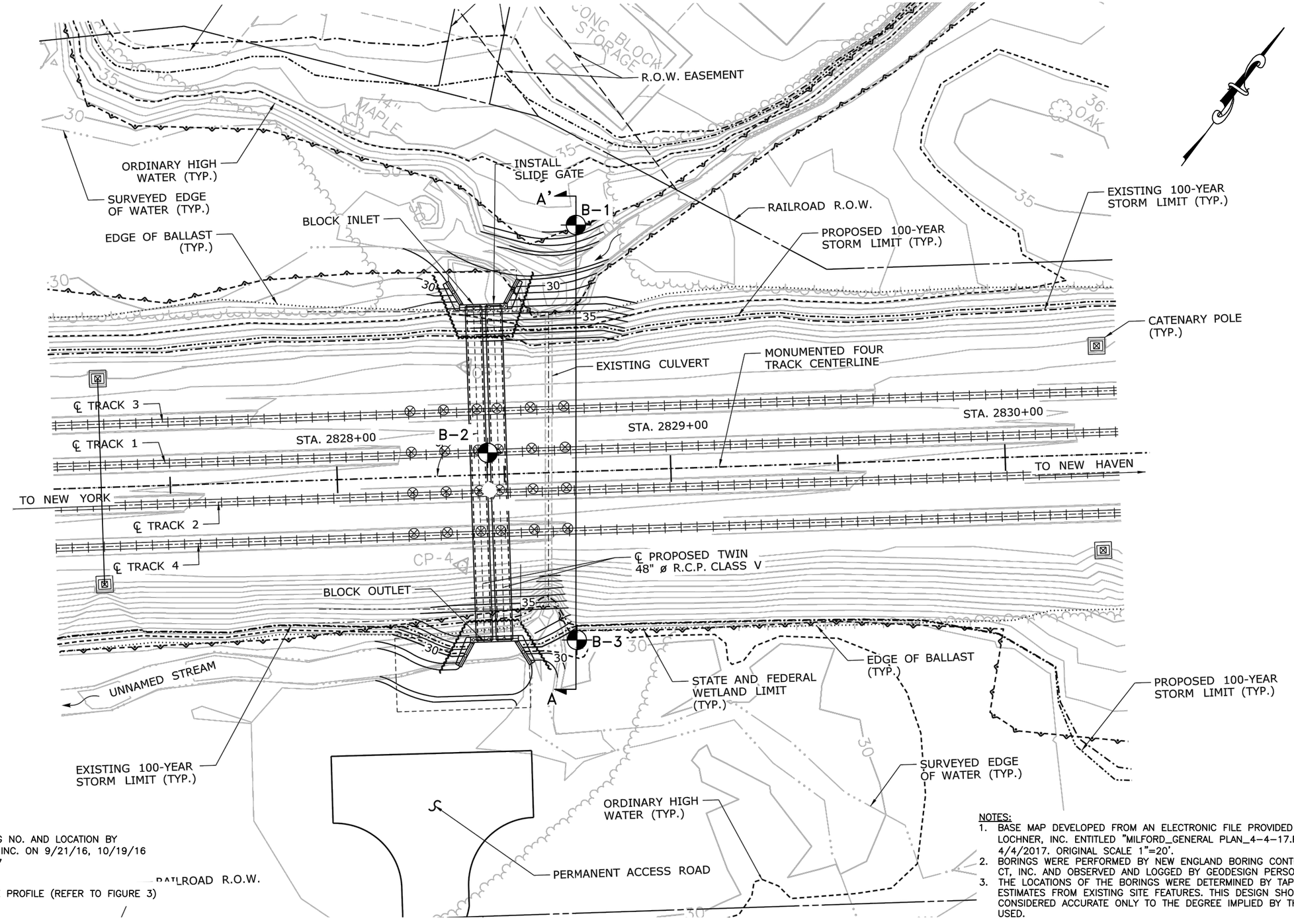
REFERENCE:
U.S.G.S. 7.5 MINUTE QUADRANGLE: MILFORD, CONNECTICUT.
FIGURE WAS CREATED USING U.S.G.S. TOPOGRAPHICAL MAP.

SCALE IN FEET

0 1000 2000 4000

DRAWN BY:	VAM
REVIEWED BY:	ULF
PROJECT NO.	0331–020.00
DATE	9/27/16
FIGURE NO.	1

M:\CL\0331\20 – Milford Culvert\CADD\Figures 1–3.dwg Vincent McClelland 9/27/2016 12:29 PM GEO Standard Pen Table.ctb



LEGEND

B-1 — TEST BORING NO. AND LOCATION BY GEODESIGN, INC. ON 9/21/16, 10/19/16 AND 4/9/17

A — A' — SUBSURFACE PROFILE (REFER TO FIGURE 3)

NOTES:

1. BASE MAP DEVELOPED FROM AN ELECTRONIC FILE PROVIDED BY H.W. LOCHNER, INC. ENTITLED "MILFORD_GENERAL PLAN_4-4-17.PDF" DATED 4/4/2017. ORIGINAL SCALE 1"=20'.
2. BORINGS WERE PERFORMED BY NEW ENGLAND BORING CONTRACTORS OF CT, INC. AND OBSERVED AND LOGGED BY GEODESIGN PERSONNEL.
3. THE LOCATIONS OF THE BORINGS WERE DETERMINED BY TAPING AND VISUAL ESTIMATES FROM EXISTING SITE FEATURES. THIS DESIGN SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.

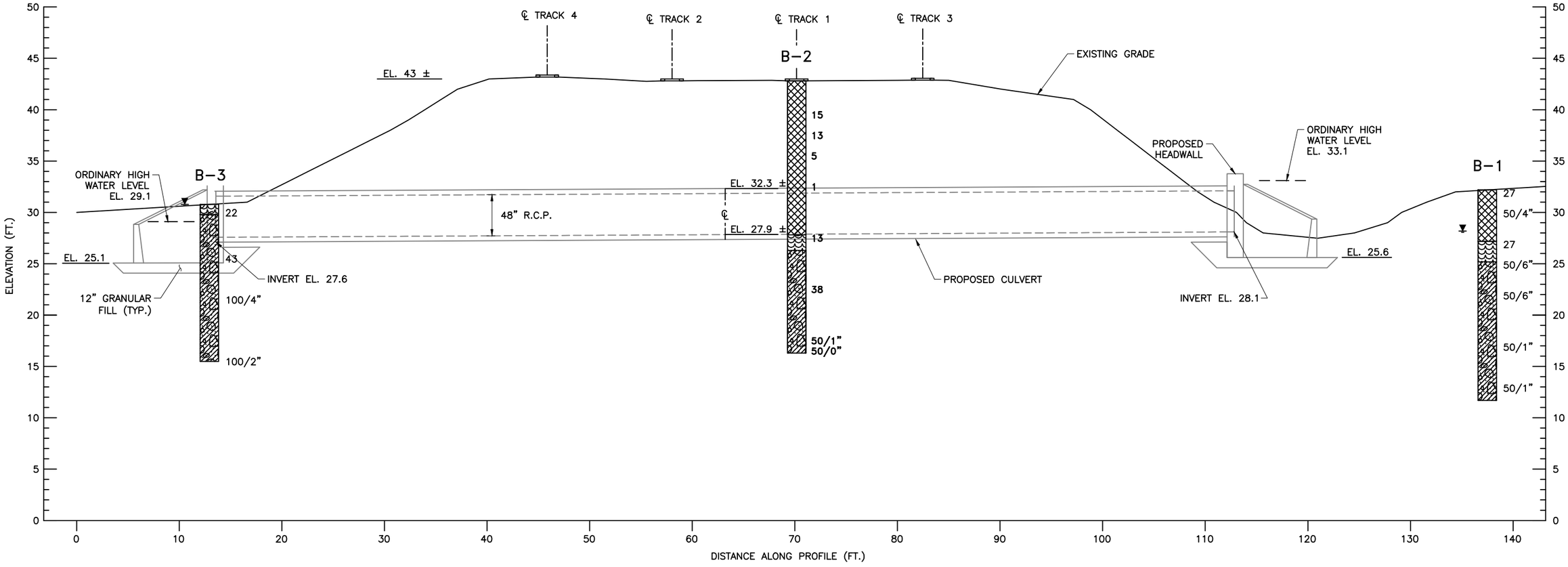
DESIGNED BY ULF						
DRAWN BY VAM						
CHECKED BY ULF	NO.	DATE	REVISIONS	DRWN	CHKD	APPVD
APPROVED BY ULF						

SCALE 1" = 30'

30' 15' 0' 30'

GEODESIGN INCORPORATED
Geotechnical | Construction | Environmental Engineers and Scientists
984 SOUTHFORD ROAD • MIDDLEBURY, CONNECTICUT 06762
TELEPHONE: 203.758.8836 • FACSIMILE: 203.758.8842

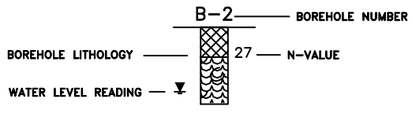
PROJECT: REPLACEMENT OF CULVERT AT MP 65.6 NEW HAVEN MAINLINE	PROJECT NO.: 0331-020.00
	SCALE: 1"=30' DATE: 4/10/17
DWG. TITLE: BORING LOCATION PLAN	FIGURE NO.: 2



LEGEND

- MISCELLANEOUS FILL
- ORGANIC CLAYEY SILT
- GLACIAL TILL

EXPLANATION:



NOTES:
1. REFER TO FIGURE 2 FOR PLAN LOCATION OF SUBSURFACE PROFILE.
2. NONE STANDARD SPT PERFORMED ON BORING B-3, HAMMER FALL = 18-INCHES VS. 30-INCHES.

DESIGNED BY ULF						
DRAWN BY VAM						
CHECKED BY ULF						
APPROVED BY ULF	NO.	DATE	REVISIONS	DRWN	CHKD	APPVD

SCALE 1" = 10'
10' 5' 0' 10'

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Geotechnical | Construction | Environmental
Engineers and Scientists
984 SOUTHFORD ROAD • MIDDLEBURY, CONNECTICUT 06762
TELEPHONE: 203.758.8836 • FACSIMILE: 203.758.8842

PROJECT	REPLACEMENT OF CULVERT AT MP 65.6 NEW HAVEN MAINLINE
DWG. TITLE	SUBSURFACE PROFILE A-A'
PROJECT NO.	0331-020.00
SCALE / DATE	1"=10' / 4/10/17
FIGURE NO.	3

Appendix 2

Boring Logs

Driller: Orrin Cone	**Connecticut DOT Boring Report**	Hole No.: B-1
Inspector: Vincent McClelland	Town: Milford, Connecticut	Stat./Offset: MP 65.6
Engineer: GeoDesign, Inc.	Project No.: 301-175 (Geo: 0331-020.00)	Northing: 645970.61
Start Date: 9-21-16	Route No.:	Easting: 926004.71
Finish Date: 9-21-16	Bridge No.:	Surface Elevation: 32.3
Project Description: Replacement of Culvert at MP 65.6 New Haven Mainline		
Casing Size/Type: SSA-4" OD	Sampler Type/Size: SS:1-3/8" ID	Core Barrel Type: None
Hammer Wt.: N/A Fall: N/Ain.	Hammer Wt.: 140 Fall: 30 in.	
Groundwater Observations: @4' after .5 hours		

Depth (ft)	SAMPLES: Sample Type/No.	Blows on Sampler per 6 inches	Pen. (in.)	Rec. (in.)	RQD %	Generalized Strata Description	Material Description and Notes	Elevation (ft)
0	S-1	6 12 15 14	24	6		Miscellaneous Fill	Medium dense, black-brown fine to coarse SAND and fine to coarse GRAVEL, little Silt, trace Asphalt, trace Organic Fibers	
	S-2	8 13 50/4"	16	5			Very dense, brown fine to coarse SAND, some Silt, some fine to coarse Gravel, trace Asphalt, trace Organic Fibers	30
5	S-3	28 14 13 15	24	6		Organic Clayey Silt	Very stiff, dark brown fine to coarse Organic Clayey SILT and fine to coarse SAND, little fine Gravel	
	S-4	17 78 50/6"	18	14		Glacial Till	Very dense, gray-brown fine to medium SAND, some coarse to fine Gravel, some Silt	25
10	S-5	60 50/6"	12	6			Very dense, gray-brown fine to medium SAND, some Silt, some coarse Gravel	20
15	S-6	65 50/1"	7	7			Very dense, gray-brown fine to coarse GRAVEL and fine to coarse SAND, little Silt	15
	S-7	50/1"	1	0			Very dense, no recovery	
20							END OF BORING 20.5ft	10
25								5
30								

Sample Type: S = Split Spoon C = Core UP = Undisturbed Piston V = Vane Shear Test

Proportions Used: Trace = 1 - 10%, Little = 10 - 20%, Some = 20 - 35%, And = 35 - 50%

Total Penetration in

Earth: 20.5ft Rock: 0ft

No. of Soil Samples: 7 No. of Core Runs: 0

NOTES: 1.) Inferred boulders/ cobbles from 3.3' to 5.2' based on drill rod chatter and drilling difficulty. 2.) Auger refusal at 5.2', hole offset 1' north, augered to 5' for Sample 3. 3.) After Sample 5, switched to H.S.A. 3.25-inch I.D. casing. 4.) Auger refusal at 15.6' on inferred boulder. H.S.A. 3.25-inch I.D. casing replaced with 4-inch I.D. F.J. Casing, 300 lb hammer, 30" hammer fall. 5.) Inferred boulders/cobbles from 15.6' to 16' and 19' to 20.5' based on drill rod chatter and drilling difficulty. Rollerbit minutes/foot were 4 minutes from 19' to 20' and 2 minutes from 20' to 20.5'.

Connecticut DOT Boring Report

Driller: Bradley Enos	Town: Milford, Connecticut	Hole No.: B-2	
Inspector: Vincent McClelland	Project No.: 301-175 (Geo: 0331-020.00)	Stat./Offset: MP 65.6	
Engineer: GeoDesign, Inc.	Route No.:	Northing: 645900.18	
Start Date: 4-9-17	Bridge No.:	Easting: 926024.35	
Finish Date: 4-9-17		Surface Elevation: 43	

Project Description: Replacement of Culvert at MP 65.6 New Haven Mainline

Casing Size/Type: FJ-3" ID	Sampler Type/Size: SS:1-3/8" ID	Core Barrel Type: None
Hammer Wt.: 140 lb. Fall: 30in.	Hammer Wt.: 140 lb. Fall: 30 in.	

Groundwater Observations: @None

Depth (ft)	Sample Type/No.	Blows on Sampler per 6 inches	Pen. (in.)	Rec. (in.)	RQD %	Casing Blows per 12"	Generalized Strata Description	Material Description and Notes	Elevation (ft)
0							Miscellaneous Fill		40
						12			
	S-1	8 6 9 17	24	14		16		Medium dense, brown fine to coarse SAND, little fine to coarse Gravel, little Silt	
5						14			
	S-2	11 10 3 4	24	6				Medium dense, brown fine to coarse SAND, little fine to coarse Gravel, trace Silt	35
	S-3	11 3 2 2	24	6				Loose, brown fine to medium SAND, little coarse Gravel, trace Silt	
10	S-4	1 0 1 2	24	12				Very loose, brown fine to coarse SAND, some Silt, trace fine Gravel	30
15	S-5	6 6 7 12	24	1			Organic Clayey Silt / Glacial Till	Stiff, gray-black Organic SILT and CLAY, little coarse Sand	25
20	S-6	16 18 20 21	24	10				Dense, brown fine to coarse SAND and fine to coarse GRAVEL, trace Silt	20
25	S-7	50/1"	1	0				Very dense, no recovery	15
	S-8	25 50/0"	6	6				Very dense, gray-brown fine to coarse SAND and fine to coarse GRAVEL, trace Silt	
								END OF BORING 26.5ft	
30									

Sample Type: S = Split Spoon C = Core UP = Undisturbed Piston V = Vane Shear Test

Proportions Used: Trace = 1 - 10%, Little = 10 - 20%, Some = 20 - 35%, And = 35 - 50%

Total Penetration in Earth: 26.5ft Rock: 0ft

No. of Soil Samples: 8 No. of Core Runs: 0

NOTES: 1.) Borehole started using hand using shovels from 0' to 3'. Railroad ballast observed from 0 to 1 foot depth. 2.) No significant changes in drill water color observed from 12' to 15'. 3.) Open hole drilling methods used below 15'. 4.) Inferred cobbles/ boulders intermittently from 22' to 26.5' based on drill rod chatter and drilling difficulty. 5.) Borehole backfilled with portland cement grout. 6.) No groundwater observations were made due to use of water to advance boring and limited time available on track.

Connecticut DOT Boring Report

Driller: Orrin Cone	Town: Milford, Connecticut	Hole No.: B-3	
Inspector: Vincent McClelland	Project No.: 301-175 (Geo: 0331-020.00)	Stat./Offset: MP 65.6	
Engineer: GeoDesign, Inc.	Route No.:	Northing: 645871.33	
Start Date: 10-18-16	Bridge No.:	Easting: 926079.29	
Finish Date: 10-19-16		Surface Elevation: 31	

Project Description: Replacement of Culvert at MP 65.6 New Haven Mainline

Casing Size/Type: FJ-3" ID	Sampler Type/Size: SS:1-3/8" ID	Core Barrel Type: None
Hammer Wt.: 140 lb. Fall: 18in.	Hammer Wt.: 140 lb. Fall: 18 in.	

Groundwater Observations: @0 after 0 hours

Depth (ft)	SAMPLES: Sample Type/No.	Blows on Sampler per 6 inches	Pen. (in.)	Rec. (in.)	RQD %	Generalized Strata Description	Material Description and Notes	Elevation (ft)
0	S-1	1 2 20 10	24	13		Organic Silt / Glacial Till	Top 10": Stiff, dark brown ORGANIC SILT, little fine Sand, trace Organic Fibers Bottom 3": Medium dense, gray fine to coarse SAND and SILT, trace fine Gravel	30
5	S-2	4 17 26 38	24	6			Medium dense, gray-brown fine to coarse SAND, some fine to coarse Gravel, some Silt	25
	S-3	100/4"	4	3			Very dense, gray-brown fine to coarse SAND and fine GRAVEL, trace Silt	
10								20
15	S-4	100/2"	2	1			Very dense, light brown fine to medium SAND, some fine to coarse Gravel, some Silt END OF BORING 15.3ft	15
20								10
25								5
30								

Sample Type: S = Split Spoon C = Core UP = Undisturbed Piston V = Vane Shear Test

Proportions Used: Trace = 1 - 10%, Little = 10 - 20%, Some = 20 - 35%, And = 35 - 50%

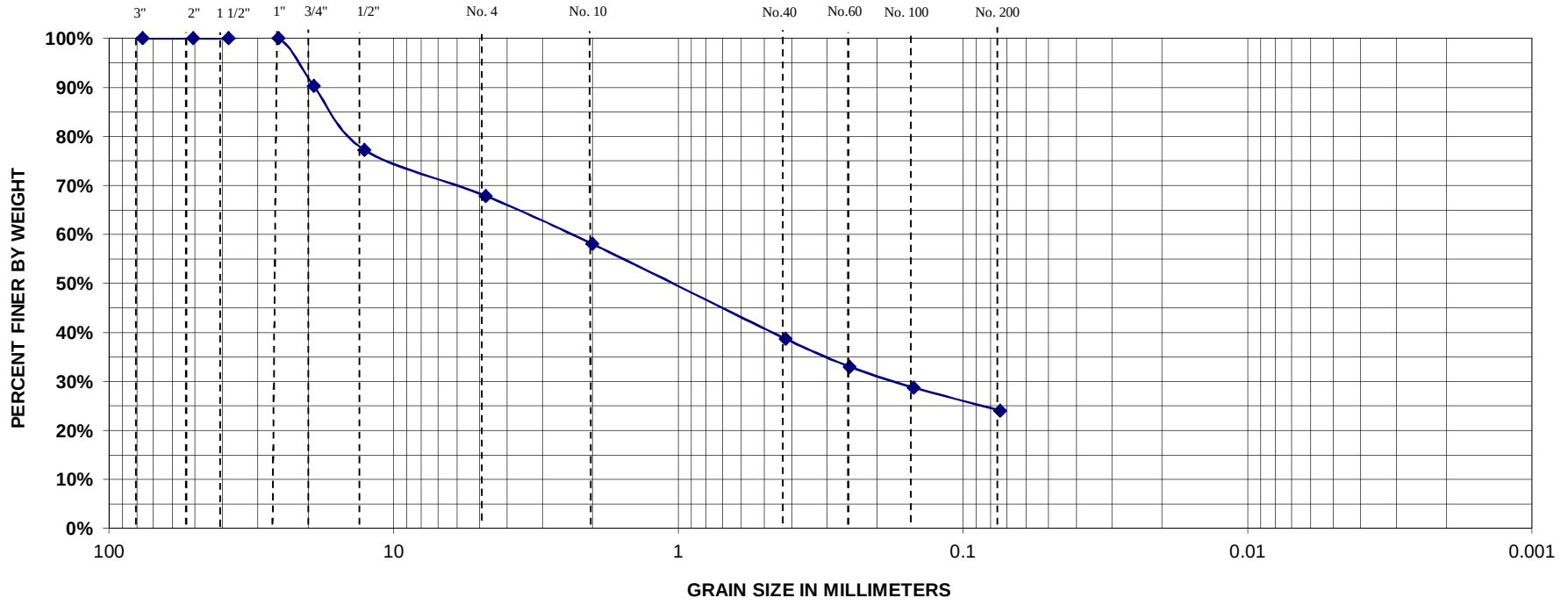
Total Penetration in Earth: 15.2ft Rock: 0ft

No. of Soil Samples: 4 No. of Core Runs: 0

NOTES: 1.) Drilling performed using a tripod mounted rig and chop and flush methods. 2.) Robert Marshall of GeoDesign, Inc. served as inspector on 10-19-16 from a depth of approximately 12' to end of boring. 3.) Open hole attempted below 15' with very difficult advance of chopping bit, with 4" progess in approximately 0.75 hours. **4.) Standard SPT could not be performed with tripod mounted rig due to low height of pulley, Hammer Fall = 18".**

Appendix 3

Laboratory Testing Results



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

GRADATION TEST

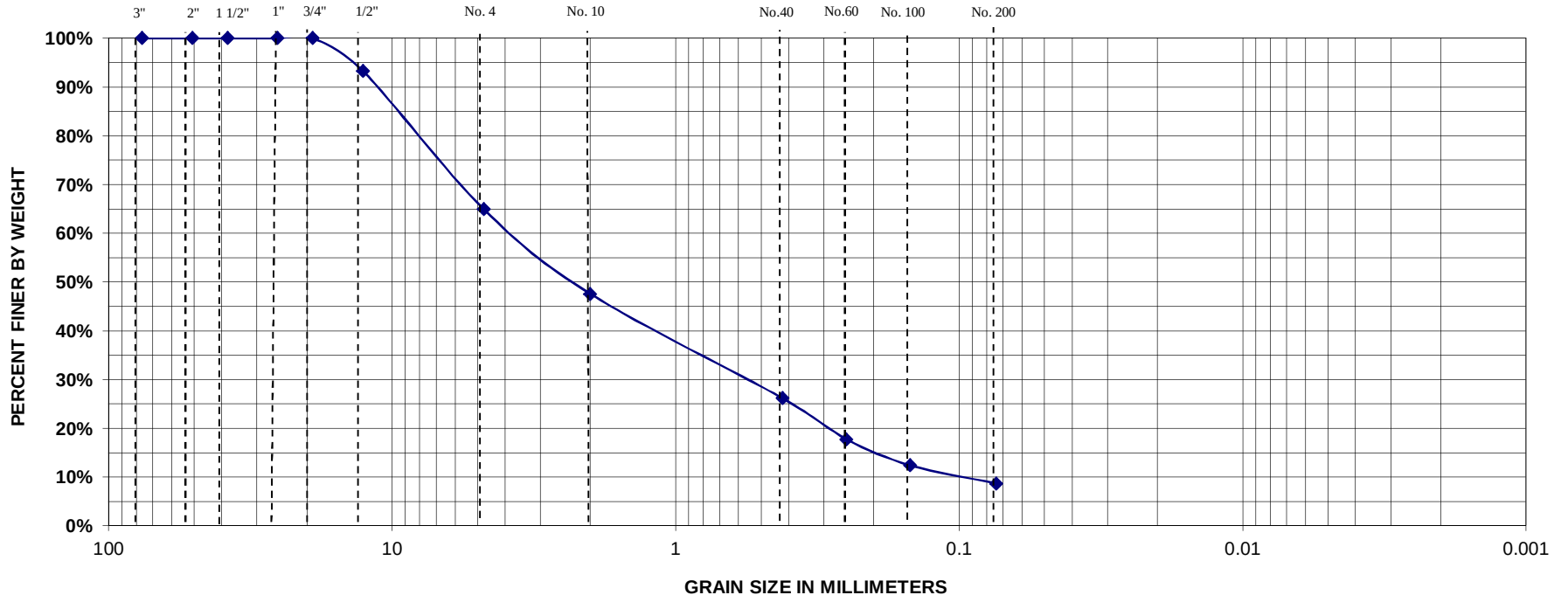
Culvert at MP 65.6; Milford, CT

BORING NO.	B-3
SAMPLE NO.	S-2
DEPTH	5-7'
TECH.	RJM
REVIEWER	ULF
DATE	12/19/16
FILE NO.	331-020.00

BURMISTER SOIL CLASSIFICATION SYSTEM

TEST NO.	MATERIAL SOURCE	DESCRIPTION
1 of 4	Jar sample	Fine to coarse SAND, some fine to coarse Gravel, some (24%) Silt 13.1% moisture content

GEODESIGN INCORPORATED
984 Southford Road • Middlebury, Connecticut 06762
Phone: 203.758.8836 • Fax: 203.758.8842 • www.geodesign.net



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

GRADATION TEST

Culvert at MP 65.6; Milford, CT

BORING NO.	B-3
SAMPLE NO.	S-3
DEPTH	9-9.3'
TECH.	RJM
REVIEWER	ULF
DATE	12/19/16
FILE NO.	331-020.00

BURMISTER SOIL CLASSIFICATION SYSTEM

TEST NO.	MATERIAL SOURCE	DESCRIPTION
2 of 4	Jar sample	Fine to coarse SAND and fine GRAVEL, trace (9%) Silt 12.7 % moisture content

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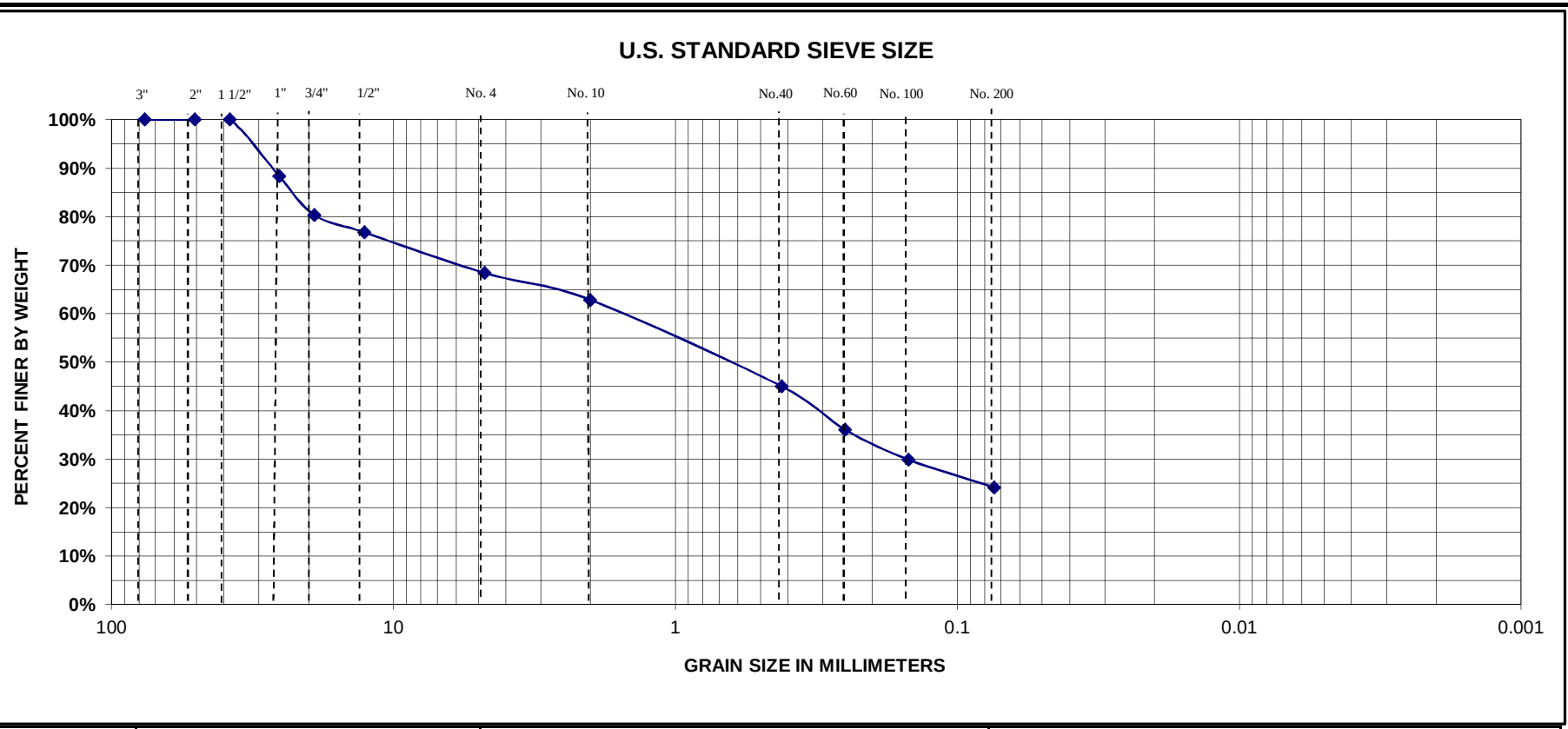

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

GRADATION TEST

Culvert at MP 65.6; Milford, CT

BORING NO.	B-1
SAMPLE NO.	S-4
DEPTH	7-8.5'
TECH.	RJM
REVIEWER	ULF
DATE	02/03/17
FILE NO.	331-020.00

BURMISTER SOIL CLASSIFICATION SYSTEM

TEST NO.	MATERIAL SOURCE	DESCRIPTION
3 of 4	Jar sample	Fine to medium SAND, some coarse to fine Gravel, some (24%) Silt 13.8 % moisture content

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COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

GRADATION TEST

Culvert at MP 65.6; Milford, CT

BORING NO.	B-1
SAMPLE NO.	S-5
DEPTH	10-11.0'
TECH.	RJM
REVIEWER	ULF
DATE	02/03/17
FILE NO.	331-020.00

BURMISTER SOIL CLASSIFICATION SYSTEM

TEST NO.	MATERIAL SOURCE	DESCRIPTION
4 of 4	Jar sample	Fine to medium SAND, some (34%) Silt, some coarse Gravel 13.6 % moisture content

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Appendix 4

Limitations

GEOTECHNICAL LIMITATIONS

Explorations

1. The analyses and recommendations submitted in this report are based in part upon the data obtained from widely spaced subsurface explorations. The nature and extent of variations between these explorations may not become evident until construction. If variations then appear evident, it will be necessary to reevaluate the recommendations of this report.

2. The generalized soil profile described in the text is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized and have been developed by interpretations of widely spaced explorations and samples; actual soil transitions are probably more erratic. For specific information, refer to the boring logs.

3. Water level readings and moisture conditions have been made in the explorations, and from the samples at times and under conditions stated on the logs. These data have been reviewed and interpretations have been made in the text of this report. However, it must be noted that fluctuations in the level of the groundwater and moisture condition may occur due to variations in rainfall, temperature, and other factors occurring since the time measurements were made.

Review

4. In the event that any changes in the nature, design or location of the proposed structures is planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report modified or verified in writing by Geo**Design**, Inc. We recommend that we be provided the opportunity to review and comment on the finalized project design and relevant construction specifications in order that earthwork and foundation recommendations may be properly interpreted and implemented in the design and specifications.

Use of Report

5. This report has been prepared for the exclusive use of H.W. Lochner and their design team, for specific application to the Replacement of Culvert New Haven Mainline (MP 65.6), State Project No. 301-175, in Milford, Connecticut, as described in Geo**Design**'s scope of services/ contract and related documents, in accordance with generally accepted soil and foundation engineering practices. No other warranty, express or implied, is made.

6. This report has been prepared for this specific project by Geo**Design**, Inc. This report is for design purposes only and is not sufficient to prepare an accurate bid. Contractors wishing a copy of the report may secure it with the understanding that its scope is limited to design considerations only, unless otherwise specified in the report.

7. The scope of our services did not include environmental assessment or investigation for the presence of hazardous or toxic materials in the soil, surface water, groundwater or air, on, below, or around this site.