Geotechnical Engineering Report

DEWA 310424 Route 209 Potential Slope Failure
Delaware and Dingman Twps., Pennsylvania

June 29, 2023

Terracon Project No. J6215080

Prepared for:

Vanasse Hangen Brustlin, Inc.
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Prepared by:

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June 29, 2023

Terracon GeoReport

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Attn: Mr. Tyson Rosser, P.E.
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Re: Geotechnical Engineering Report
DEWA 310424 Route 209 Potential Slope Failure
Delaware Water Gap National Recreation Area
Delaware and Dingman Twps., Pennsylvania
Terracon Project No. J6215080

Dear Mr. Rosser:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with NPS IDIQ Task Order 140P2023F0054 dated February 1, 2023. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the potential repair of slope failures for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

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ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES
SITE LOCATION AND EXPLORATION PLANS
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Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Engineering Report

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INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the repair of potential slope failures along Route 209 within the Delaware Gap National Park between Delaware and Dingman Townships, Pennsylvania. The purposes of these services were to observe the condition of the slopes, investigate the subsurface soil conditions in specific area and provide potential recommendations for repairing the slopes. In addition, it is our understanding that the National Park Service (NPS) would also like to relocate portions of the McDade Trail closer to Route 209. Finally, there are several stormwater sewers culverts that traverse Route 209 and discharge on the east side of the road. The slope failures are generally located at the culvert discharge locations.

The field geotechnical engineering Scope of Services for this project included the advancement of eleven test borings (5 culvert borings and 6 wall borings) to depths ranging from approximately 18 to 50 feet below existing ground surface. Please note that culvert boring C-5 was eliminated based on discussion with the project team. However, NPS provided a geotechnical report that was prepared by the US Department of Transportation (USDOT) in February 2012 for a soldier pile wall that was installed in the area of Milepost 15.3 along Route 209 which is located immediately north of the proposed C-5 boring location. This report is included as part of this report.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs and as separate graphs in the **Exploration Results** section.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration.

Item	Description
Parcel Information	The project is located within the Delaware Water Gap National Recreation Area between Delaware and Dingman Twps., Pennsylvania.
Existing Improvements	Existing roadway and walking trail.
Current Ground Cover	Asphalt within the roadway. The slopes generally consist of vegetation and various diameter trees.
Existing Topography (from Google Earth™)	The grades are variable ranging from elevation +380 feet to elevation +485 feet.

PROJECT BACKGROUND

The NPS has identified several areas of concern with respect to the stability of the slope along the east side of Route 209. The following is a list of areas provided by NPS.

- Mile Post (MP)14.1 reinforced concrete pipe (RCP)
- MP 15 RCP
- MP 16.1 to 17.8 with specific slope failures at MP 16.8 – 18" RCP, MP 17.2 – 18" RCP and attention at 17.5 and 17.8. The Inlet at 17.5 does not appear to have an outfall and the slope is sluffing at 17.8.

On January 12, 2023, a site visit was performed with members of NPS, VHB and Terracon to observe the conditions and identify areas of concern where additional subsurface investigation consisting of test borings would be warranted.

GEOTECHNICAL CHARACTERIZATION

Subsurface Profile

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	**Fill**	Silty sand with gravel to silty gravel with sand and poorly grade gravel with asphalt
2	**Boulders**	Boulders
3	**Gravel**	Clayey/silty gravel with sand to clayey gravel and poorly graded gravel with silt and sand
4	**Sand**	Silty/clayey sand with gravel to silty sand and poorly graded sand with silt and gravel
5	**Weathered Bedrock**	Completely to highly weathered shale
6	**Bedrock**	Shale

Special attention should be provided to the following specific conditions that were encountered in the borings.

- Uncontrolled fill (Model Layer 1) was encountered in C-3, C-6, W-1 and W-3 through W-5 below the pavement and was approximately 1 to 4 feet thick.
- A layer of loose sand (Model Layer 4) and loose gravel (Model Layer 3) was encountered in C-1, C-2, C-4, C-6 and W-4 at depths of approximately 4 to 10 feet below the top of pavement and was approximately 2 to 5 feet thick.
- A layer of boulders (Model Layer 2) was encountered in W-4 at a depth of approximately 26.5 feet and was approximately 10 feet thick.
- The weathered bedrock (Layer 5) was distinguished from Layer 6 in that the drillers were able to advance the borehole through this layer without coring.

Please note that not all model layers were encountered in each boring performed for this study, nor were they generally encountered in the same order.

Groundwater Conditions

Groundwater and/or water seepage was encountered in four of the explorations performed for this study. Observed groundwater depth below ground surface at these locations is summarized in the following table:

Exploration	Approximate Depth to Groundwater below existing surface grades (feet)
C-3	18
C-6	18.5

W-1	28
W-4	9

Please note, however, that water seepage levels in the borings where coring was performed were difficult to observe due to the use of water as drilling fluid while coring. Zones of perched or trapped seepage may be encountered seasonally at higher elevations, particularly at the soil-fill interface. Fluctuations in groundwater level may occur because of seasonal variations in the amount of rainfall, runoff, and other factors that may differ from those present at the time the explorations were performed. Additionally, grade adjustments on and around the site, as well as surrounding drainage improvements, may affect the water table. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

GEOTECHNICAL OVERVIEW

Summary of Site Visit

As previously discussed, a site visit was performed on January 12, 2023 with members of NPS, VHB and Terracon to observe the conditions of the slopes in the general area of the downslope discharge of the stormwater culverts. These culverts generally consist of 18-inch reinforced concrete pipe (RCP). At the time of the site visit, spillways and/or rip rap were not present. It is our understanding that rip rap was installed at each of the pipe discharge locations on the slope in 2012 and 2013. However, overtime erosion of the slopes in these areas has allowed the rip-rap to migrate down the slopes. Since the rip-rap is no longer present, soil erosion/scour has continued unabated and is exacerbated during heavy rain events. The erosion/scour has developed undermining of the soil beneath the lead section of RCP in each area. As the area of undermining increases, the remaining soils can no longer support the weight of the pipe section and as a result that section of pipe will fall down the slope. The erosion/scour then continues to undermine the pipe and eventually the next section of pipe is exposed/undermined. In addition to the undermining of each pipe section, the unabated water is saturating the surrounding soils, causing additional material to slough off the slope which is widening each area of concern. This erosion condition is also removing the adjacent vegetation and trees, which act to stabilize the surficial soils of the slope. Based on the current conditions, the unabated water flow will continue to erode the slope over time. Therefore, it will be critical that the culverts/pipes be repaired to their original condition, spillways and/or rip rap should be installed to protect the slopes, as well as to divert the water away from the slope, followed by the restoration of the slopes in these areas.

In the area of MP 17 to 17.2, the NPS was also concerned that a potential slope failure was developing in this general area. Approximately 300 feet west of the area, there is a small waterfall. The water enters the ground from a short distance east of the waterfall. It is not known where

this water travels. There was no visual evidence of water discharge along the slope. However, NPS is not sure if this water source is affecting the slope in this area.

Finally, the NPS is concerned that there are other sections of the slope that are failing beyond the areas identified above. Based on available mapping, the slopes in various areas ranged from 1:2 to steeper than 1:1, with a majority of the areas 1:1 and greater. In the areas where slopes were 1:1 and greater there was no evidence of longitudinal cracking along the pavement surface which would be indicative of a potential slope failure condition. Based on visual observations only, any sloughing in these areas is most likely the result of the type of material that is present within the slope. The soils are naturally trying to achieve their natural angle of repose, which is most likely 32 to 45 degrees (1:1.5 to 1:1), depending on the type of soils.

Geotechnical Considerations

Culverts

A total of five culvert borings were performed at locations identified by the project team. The results of these borings indicated relatively stable soil conditions consisting of sand and gravel . A layer of natural loose sand and/or gravel soils (relative density based on N-values) was observed in four of the borings (C-1, C-2, C-4 and C-6) at depths ranging from approximately 4 to 10 feet below the pavement surface and was approximately 2 to 5 feet thick. The soils beneath this loose layer consisted of natural medium dense to very dense sand and gravel soils (relative density based on N-values). Since the loose soils were only encountered in the culvert borings, these loose soils are possibly the result of previous construction activities to install the culverts/RCP and/or erosion/scour of the soils at the face of the slope and are not indicative of a slope failure. Please note that based on the encountered materials at these locations, it was difficult to differentiate between the fill and natural soils. Further recommendations related to the replacement of the culverts are provided in subsequent sections of this report. Please note that boring C-3 was performed in an area where a small waterfall is located. The water currently enters the ground surface however, a discharge location has not been able to be identified. At this location, we did encounter groundwater at a depth of approximately 18 feet below the existing ground surface.

As discussed above, a geotechnical investigation was performed by the USDOT in the area of the soldier pile wall located immediately north of the C-5 location. A total of 5 borings were performed as part of this investigation. The borings extended to depths ranging from approximately 27 to 92 feet below the existing ground surface. Subsurface conditions generally consisted of sand and gravel with occasional layers of silt and varying percentages of cobbles and boulders. In addition, occasional layers of loose sand were encountered in each of the borings at various depths. Finally, uncontrolled fill was encountered in four of the boring below the pavement section and extended to depths ranging from 5 to 7 feet below the existing

pavement surface. The fill soils and/or near surface loose sands will not be suitable for support of new culvert structures. Recommendations to address these materials is provided in subsequent sections of this report. A copy of the USDOT report is included in the **Supporting Information** section of this report.

Slope Failures

Slope failures typically occur when driving forces overcome resisting forces. The driving force is typically gravity and the resisting force is the slope materials shear strength. Some reasons for failures are:

- Raising groundwater levels within the slope, which could potentially reduce the shear strength of the soils.
- Reduction in the tensile strength of the soils. This is evident by cracking of the surface soils in an area of concern.
- Where highly plastic clay soils are present within a slope area, under sustained loading these soils undergo constant deformation such as during freeze/thaw cycles, shrink/swell cycles, etc.
- Leaching groundwater through the slope face.
- Significant increases of loads at the top of the slope.

Any one of these items identified above on their own and/or in combination can contribute to a slope failure. As discussed above, there was no visual evidence within the road pavement and/or along the slope that would indicate a possible slope failure is occurring. Please note that it is very difficult to see the face of the slope in general due to the presence of vegetation. The test borings that were performed in limited areas along the top of the slope did not encounter soils conditions that could lead to the development of a slope failure. However, in the areas where the slopes become very steep (greater than 1:1), the exposed soils generally consisted of sand soils with limit fines which can lead to surficial sloughing, especially when exposed to rain and snow. In addition, in some of these steep locations, surface water and/or water from the culverts has begun eroding the surface of the slopes. This has resulted in the loss of vegetation on the slope. The vegetation acts as a natural protection of the slope similar to synthetic and/or metal netting/mesh. The exposed soils on the face of the slopes are subject to natural raveling due to the type of soils present at the site (generally sand and gravel soils, with low percentages of fines that were present in the borings). These materials generally have a natural repose of approximately 32 to 45 degrees depending on the relative density of the soil, as well as the percentage of coarse material within the soil matrix. In addition, the exposed soils are more easily susceptible to wash out as a result of rain events, especially when there is no vegetation present. This is more indicative of a surficial sloughing condition then a true slope failure condition.

The following are systems that can be utilized to address the surficial sloughing

Slopes of 1:2 to 1:1

- SlopeGrid-Slope Stabilization Grid
- Steep Slope Erosion Control Mat
- Erosion Control Matting such as Coir Mat 70

Slopes Greater Than 1:1

- Steep Slope Erosion Control Mats
- Erosion Control Matting such as Coir Mat 90
- Soil Nailing

All these stabilization blankets, matting and/or geogrid can be installed on slopes where retaining walls or the placement of additional fill material in front of the slopes or walls is not possible due to space constraints, costs, etc. These materials can generally be rolled and/or placed as mats down the exposed slope in the areas where there is no vegetation present. These systems are then anchored in place with pins down the face of the slope. These materials can provide the protection that is necessary to avoid further sloughing of the slope face, as well as promote the growth of new vegetation further stabilizing the face of the slope.

Soil nailing is also an option to address the surficial sloughing of the steep slopes. Soil nailing generally consists of drilling and installing grouted slender reinforcing elements at a slight downward inclination as a grid pattern within the slope. The nails strengthen and stabilize the slope. The nails are typically installed by a design-build contractor. It should be noted that depending on the quantity of nails required for the intended slope, the cost of installation can be extremely expensive. In addition, the soil nail heads would be exposed at the surface. As a result, additional measures would need to be installed to cover the nail heads.

Walls

A total of six borings (W-1 to W-6) were performed at locations identified by the project team. In general, relatively dense soil conditions were observed within these borings. A layer of loose sand was observed in W-4 at a depth of approximately 6 feet and was approximately 2 feet in thickness. In addition, weathered shale bedrock was encountered in four of the locations (W-1, W-3, W-5 and W-6) below the natural soils at depths ranging from approximately 8 to 43 feet below the existing ground surface.

Retaining Walls

It is our understanding that NPS is looking for specific options to address the surficial sloughing that is occurring at locations along the east side of Route 209. In addition to addressing the surficial sloughing, portions of the existing McDade Trail, which is located parallel to the Route 209, may be relocated to a higher elevation adjacent to the road. As discussed above, in the areas of steep slopes especially with limited space at the toe of slope, the use of either matting and/or geogrid would be a more appropriate option to address the surficial sloughing in lieu of very tall retaining walls, especially in areas of limited space at the toe of slope.

However, in areas with no space constraints, it may be possible to utilize a retaining wall to remediate the surficial sloughing, as well as accommodate the relocation of portions of the trail. The following types of retaining walls could be considered to address the surficial slope sloughing, as well as support the relocated trail:

- Cast-in-place gravity walls
- MSE walls
- Gabion basket walls
- Soldier pile and lagging walls

A general description of each wall is provided in a subsequent section of this report. Please note that once a wall location and type are finalized, additional geotechnical investigation will most likely be warranted in order to develop a complete design of the wall.

The **General Comments** section provides an understanding of the report limitations.

EARTHWORK

In the event that NPS elects to replace each of the culverts, earthwork that is anticipated would include stripping, excavation and backfill of the new culverts. The following sections provide recommendations that should be included as part of the earthwork specification that is prepared for the project. The following recommendations include critical quality criteria, as necessary, for the installation of the new culverts.

Stripping and Loose/Soft Soil Removal

Prior to any earthwork operations, the pavement should be saw cut and removed, followed by the removal of the existing culvert structures. The asphalt will not be suitable for reuse as structural fill, therefore the asphalt will need to be disposed properly offsite.

Following the removal of the existing culverts, the loose sand and/or gravel encountered in C-1, C-2, C-4 and C-6, which was generally on the order of 2 to 5 feet in thickness, should then be removed in its entirety from within, as well as two feet beyond each side of the new culvert/pipe. A Terracon geotechnical engineer should be present to confirm that the unsuitable materials have been removed, and to assist the Contractor in limiting the removal of suitable native materials.

Excavations

As a minimum, temporary excavations should be sloped or braced, as required by Occupational Health and Safety Administration (OSHA) regulations, to provide stability and safe working conditions. The contractor, by his contract, is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations, as required, to maintain stability of both the excavation sides and bottom. All excavations should comply with applicable local, State and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

Reuse of Materials

Soil materials generated during the excavation for the replacement culverts are expected to consist of sand and gravel. These materials would be suitable for reuse as compacted structural fill, provided the material is at a moisture content suitable for compaction, free of any deleterious materials and generally has a maximum particle size of 6 inches.

Imported Fill Materials

In the event that imported fill is needed to complete the backfill of the culvert, we recommend that the material consist of inorganic, readily compactable, well-graded granular soils with no more than 15 percent fines (no more than 15 percent passing the No. 200 sieve). Additionally, we recommend excluding gradations greater than 6 inches. The moisture content of the fill material should be controlled by wetting, aeration, or blending, as necessary to achieve the required compaction. Typically, this requires maintaining moisture contents to within approximately 2 to 3 percent of the optimum moisture content.

Backfill Placement

Structural fill should be installed in controlled layers uniformly compacted to at least 95 percent of the fill material's maximum dry density, as determined by ASTM D1557 Test Procedures. The layer thickness should be adjusted as needed depending on the type of compaction equipment used and the condition of the fill materials at the time of construction, but should be no greater than 12 inches in loose thickness. It should be expected that thinner lifts will be required to achieve the required compaction in confined areas where portable compaction equipment is used.

Groundwater

Groundwater and/or water seepage at the culvert locations was only encountered in C-3 at a depth of approximately 18 feet below the existing ground surface. Zones of perched or trapped seepage may be encountered at higher elevations, particularly at the soil-fill interface. The contractor should therefore be prepared to provide dewatering equipment as needed to maintain relatively dry excavations.

RETAINING WALLS

In general, most of the slopes along the road are at 1:1 and steeper, are on the order of 30 to 40 feet in height and have limited space at the toe of slope prior to reaching the Delaware River. Retaining walls, such as cast-in-place gravity, MSE and gabion, are most likely not an option to address the surficial sloughing in these hill fill areas. In these areas, matting, geogrid, erosion blankets, etc. are most likely option to address the face of the slope. However, in areas where slope heights are on the order of 10 to 20 feet, as well as the presence of sufficient space at the toe of the slope (20 to 30 feet or more), the use of a retaining wall could be installed to address the surface of the slope. This is especially true in areas where the McDade Trail may be relocated to higher elevation adjacent to Route 209.

This report identifies wall alternatives that can be implemented in the study area based on the subsurface information identified in the limited borings that were conducted. The feasibility of implementing the wall alternatives identified below will be highly contingent on geometric space constraints and costs to construct these walls. If a retaining wall is deemed the best solution to address surficial sloughing of a specific section of slope and/or the relocation of the trail, additional subsurface investigations may be warranted, including additional topographic surveying to better define the geometry of the wall.

Cast-in-Place Concrete Gravity Walls

These walls consist of steel reinforced concrete that retains the soil by gravity. A typical wall contains large cantilever foundations that extend several feet behind the wall. These walls can be designed for heights ranging from 10 to 20 feet or greater. However, the higher the wall, the greater the length of the cantilever foundation. As a result, sections of Route 209 would need to be removed to facilitate construction. We have provided some preliminary design bearing pressures for this type of wall in the event that this type of wall addresses the needs of NPS.

Mechanically Stabilized Earth (MSE) Walls

MSE is a composite structure consisting of alternating layers of compacted backfill and soil reinforcement elements that are fixed to a wall face. The reinforcing elements typically consist of

soil reinforcement extending approximately 0.7H of the height of the wall. As an example, if the height of the wall is 20 feet, the reinforcement would extend a minimum of 14 feet behind the wall. MSE walls are normally designed at the time of construction by the wall manufacturer or by an engineer retained by the earthwork contractor, since the various MSE wall system designs are proprietary. As discussed above, this type of wall would be best suited for slope areas where there is sufficient space at the bottom of the slope in order to facilitate the construction of this wall. With this type of wall construction, removal of portions of Route 209 would be required to facilitate the construction of the wall elements.

Gabion Basket Walls

Gabion basket walls consist of metal wire baskets filled with varying sizes of broken rock. The walls should be designed in accordance with the manufacturers guidelines and should include appropriate filter fabric to prevent clogging of the baskets with backfill material, as well as a drainage system as discussed below for all wall types. This type of wall is best suited for wall heights on the order of 5 to 10 feet.

Soldier Pile and Lagging

This type of wall consists of either driven or drilled in steel I-beams with pre-cast concrete planks are installed within the webs of the I-beams. The embedment of the I-beams is dependent on the height of wall, but it is typically 1.3H to 1.5H of the exposed face. For wall faces greater than 15 feet, a tie-back and waler system will need to be installed. If tie-backs are required, sections of Route 209 may need to be removed in order to facilitate the installation of the tie-backs. This type of wall could address most of the slope areas, however these walls can be costly and as result, may preclude their use for slope repair and/or the relocation of the trail.

Typical Wall Foundation Design Parameters

For the gravity, MSE and gabion walls, if the wall areas have been prepared in accordance with the requirements noted in **Earthwork**, the following preliminary design parameters are applicable for shallow foundations.

Shallow Foundation Design Recommendations

Item	Description
Maximum Net Allowable Bearing Pressure, Soil [1,2]	4,000 psf
Maximum Net Allowable Bearing Pressure, Rock [3]	10 tsf
Minimum Embedment below Finished Grade for frost protection [4]	42 inches
Estimated Total Settlement from Structural Loads [5]	1 inch

Item	Description
1.	The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. An appropriate factor of safety has been applied.
2.	Unsuitable or soft soils should be over-excavated and replaced per the recommendations presented in the **Earthwork**.
3.	Rock bearing pressure must be field verified by a Terracon geotechnical engineer or geologist at all foundation locations. Localized areas of poor-quality rock that would not support a design bearing pressure of 10 tsf should be anticipated.
4.	Foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footing, the thickness of compacted fill, and the quality of the earthwork operations.
5.	Embedment necessary to minimize the effects of frost and/or seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.

Exterior foundations should be established a minimum of 42 inches below the proposed adjacent exterior grades, or deeper if required by the local building official, to provide protection from frost penetration.

Foundations should not be designed to bear partially on soil and partially on rock. Where this condition occurs, the rock should be over-excavated a minimum of 12-inches, backfilled with clean crushed stone (No. 57 stone or equivalent) and the soil bearing pressure utilized for design.

Shallow Foundation Construction Considerations

The base of foundation excavations should be free of water, loose soil, and loose or overblast rock materials before placing concrete. In addition, all foundations bearing in rock should be leveled to have no more than a 10 percent inclination. We recommend that the foundations bearing in soil be underlain by a layer of crushed stone (No. 57 stone or equivalent) or lean concrete approximately 6 inches in thickness to protect the native subgrade materials from disturbance. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Should the soils at the bearing level become wet, disturbed, or frozen prior to the placement of the crushed stone, or if unsuitable bearing soils are encountered at planned subgrade levels, the materials should be removed prior to placing concrete. As discussed above, a Terracon geotechnical engineer should be retained to observe the subgrade preparation activities, to provide guidance regarding any remedial earthwork required, and to evaluate the suitability of the subgrades to support the design foundation loads.

Lateral Earthwork Design Parameters

The following table provides preliminary design parameters that may be utilized for the design of the various walls. Please note that the excavation support systems should be designed by a professional engineer in the Commonwealth of Pennsylvania. The design should include an allowance for surcharge loads such as traffic, etc. Once the design is complete, Terracon should

be allowed to review the design to confirm that the appropriate design parameters have been utilized.

Description	Value (at-rest condition)
Unit Weight – Fill (pcf)	115
Unit Weight – Loose Sand (pcf)	105
Unit Weight – Medium Dense to Dense Sand/Gravel (pcf)	125
Unit Weight – Very dense Sand/Gravel (pcf)	130
Unit Weight – Weathered Shale (pcf)	140
Angle of Internal Friction, fill	28°
Angle of Internal Friction, loose sand	28°
Angel of Internal Friction, medium dense sand	32°
Angel of Internal Friction, dense to very dense sand/gravel	36°
Coefficient of Active Earth Pressure (Ka)	0.31
Coefficient of Passive Pressure Earth Pressure (Kp)	3.3
Coefficient of Earth Pressure At-rest (Ko)	0.47
Base Friction	0.5

Retaining Wall Drainage

The gravity walls and all MSE walls should be designed to include drainage (discussed below) so that hydrostatic pressure from precipitation and surface runoff is not permitted to develop behind the wall. In addition, all of the walls should also be designed to account for surcharge loads from traffic, landscaping, as well as temporary construction loads.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the geotechnical engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either expressed or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

FIGURES

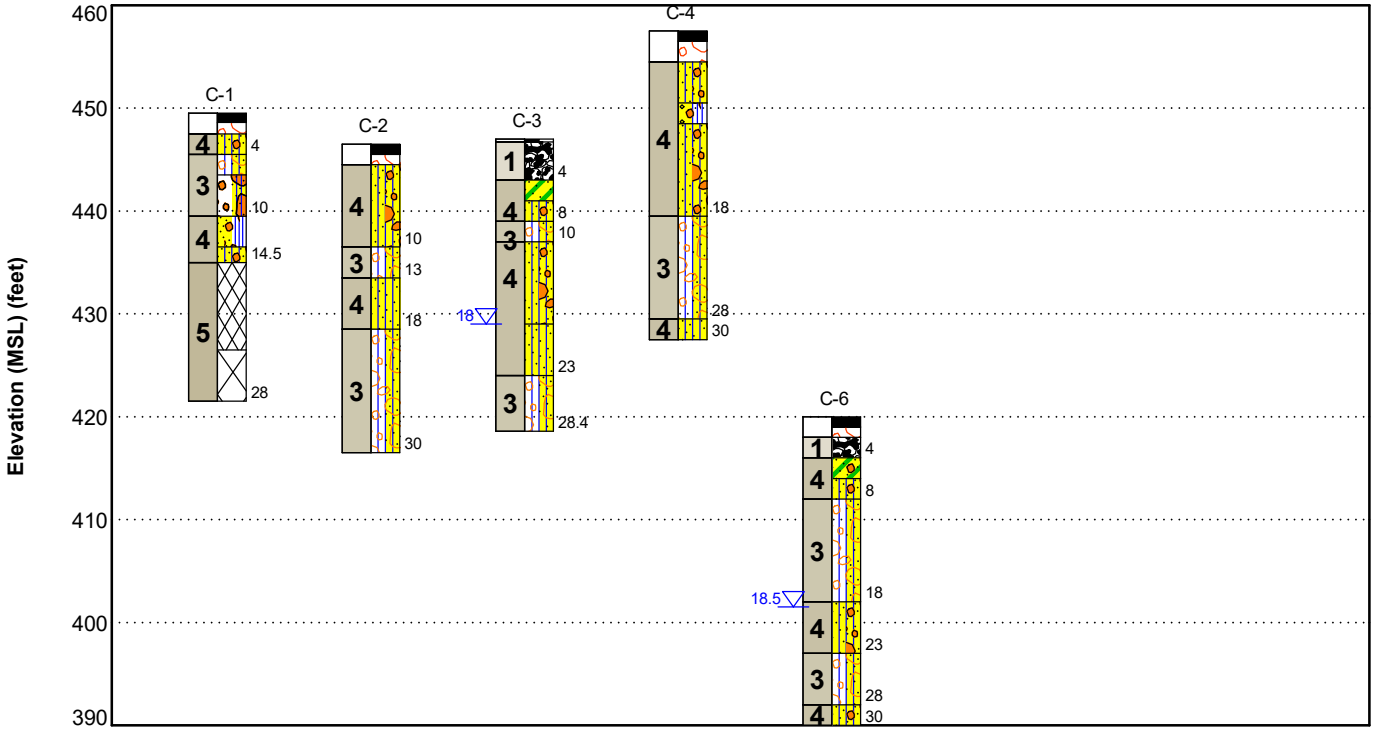
Contents:

GeoModel (2 pages)

ATTACHMENTS

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

GeoModel



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	Fill	Silty sand with gravel to silty gravel with sand and poorly graded gravel with asphalt
2	Boulders	Boulders
3	Gravel	Clayey/Silty gravel with sand to clayey gravel and poorly graded gravel with silt and sand
4	Sand	Silty/Clayey sand with gravel to silty sand and poorly graded sand with silt and gravel
5	Weathered Bedrock	Completely to highly weathered shale
6	Bedrock	Shale

LEGEND

- Asphalt
- Aggregate Base Course
- Silty Sand with Gravel
- Silty Gravel with Sand
- Poorly-graded Gravel with Silt and Sand
- Poorly-graded Sand with Silt and Gravel
- Highly Weathered Shale
- Weathered Rock
- Silty Sand
- Boulders and Cobbles
- Fill
- Clayey Sand
- Well-graded Sand with Silt and Gravel
- Clayey Sand with Gravel

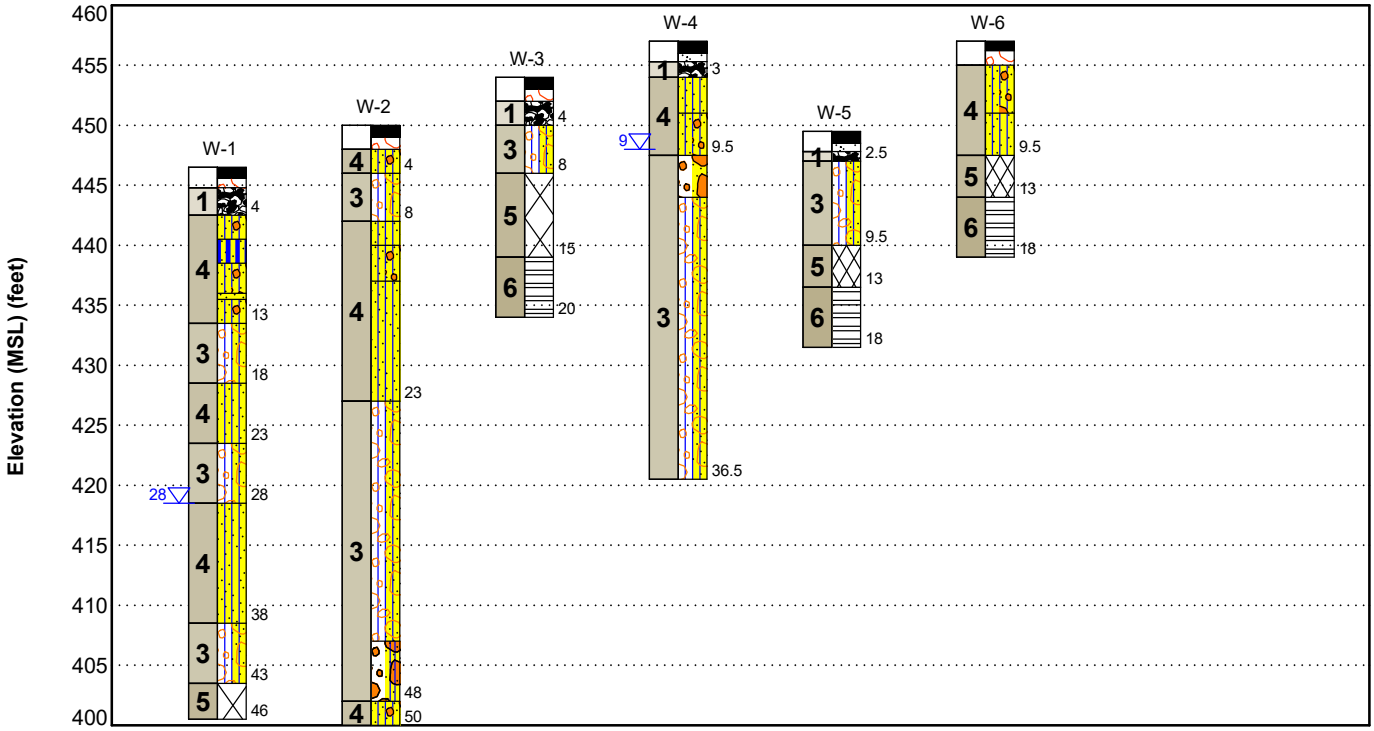
NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project.

First Water Observation

The groundwater levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

GeoModel



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
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2	Boulders	Boulders
3	Gravel	Clayey/Silty gravel with sand to clayey gravel and poorly graded gravel with silt and sand
4	Sand	Silty/Clayey sand with gravel to silty sand and poorly graded sand with silt and gravel
5	Weathered Bedrock	Completely to highly weathered shale
6	Bedrock	Shale

LEGEND

- Asphalt
- Fill
- Sandy Silt
- Silty Gravel with Sand
- Weathered Rock
- Shale
- Poorly-graded Gravel with Sand
- Aggregate Base Course
- Silty Sand with Gravel
- Poorly-graded Sand
- Silty Sand
- Poorly-graded Gravel with Silt and Sand
- Concrete
- Highly Weathered Shale

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project.

First Water Observation

The groundwater levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Locations	Type of Exploration (Borings/Test Pits)	Explored Depth (feet) [1]	Location
5	Borings	28 to 30	Culverts
6	Borings	18 to 50	Walls

1. Below pavement surface

Boring Layout and Elevations: The borings were located in the field by Terracon. Elevations were obtained from topographic plans provided by VHB. If elevations and a more precise boring layout are desired, we recommend borings be surveyed following completion of fieldwork.

Subsurface Exploration Procedures: We advanced the borings with a truck-mounted rotary drill rig using hollow stem continuous flight augers. Four samples were obtained within in the upper 10 feet of each boring. In the split barrel sampling procedure, used at the site, a standard 2-inch outer diameter split barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the middle 12 inches of a normal 24-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. The rock core samples were obtained with a NQ-size rock coring equipment. We observed and recorded groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled after their completion. Pavements were patched with cold-mix asphalt.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a geotechnical engineer. Our exploration team prepared field boring logs as part of the drilling operations. Final boring logs were prepared from the field logs. The final boring logs represent the geotechnical engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil strata, as necessary, for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils

The laboratory testing program included examination of soil samples by an engineer. Based on the material's texture and plasticity, we described and classified the soil samples in accordance with the Unified Soil Classification System.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Site Location (2 pages)
Exploration Plan (3 pages)

Note: All attachments are one page unless noted above.

SITE LOCATION

DEWA 310424- Pavement Rehabilitation of Highway 209 ■ Dingman and Delaware, PA
June 29, 2023 ■ Terracon Project No. J6215080

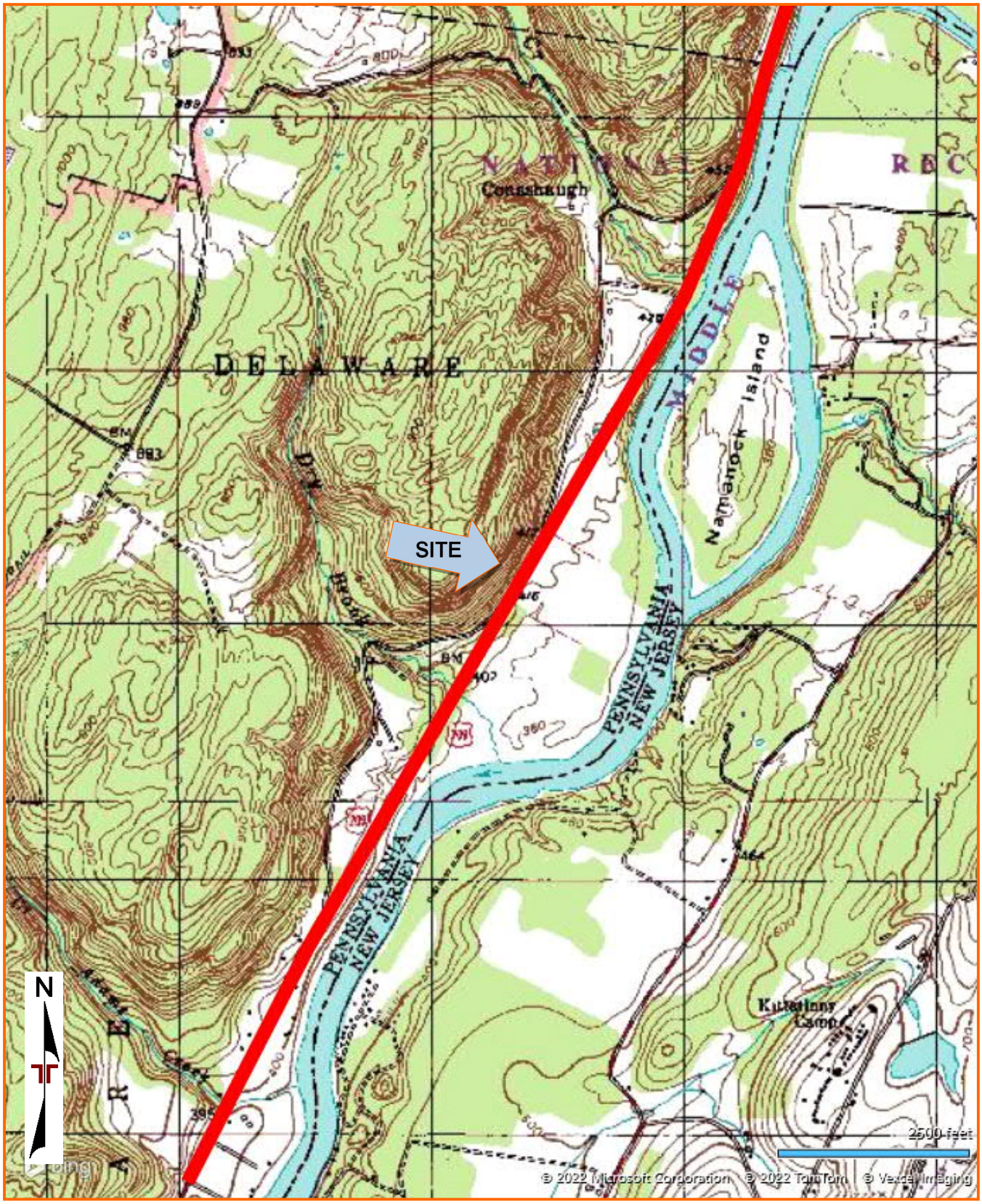


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: EDGEMERE, PA (1/1/1992), MILFORD, PA (1/1/1995), LAKE MASKENOZHA, PA (1/1/1995) and CULVERS GAP, NJ (1/1/1997).

SITE LOCATION

DEWA 310424- Pavement Rehabilitation of Highway 209 ■ Dingman and Delaware, PA
June 29, 2023 ■ Terracon Project No. J6215080

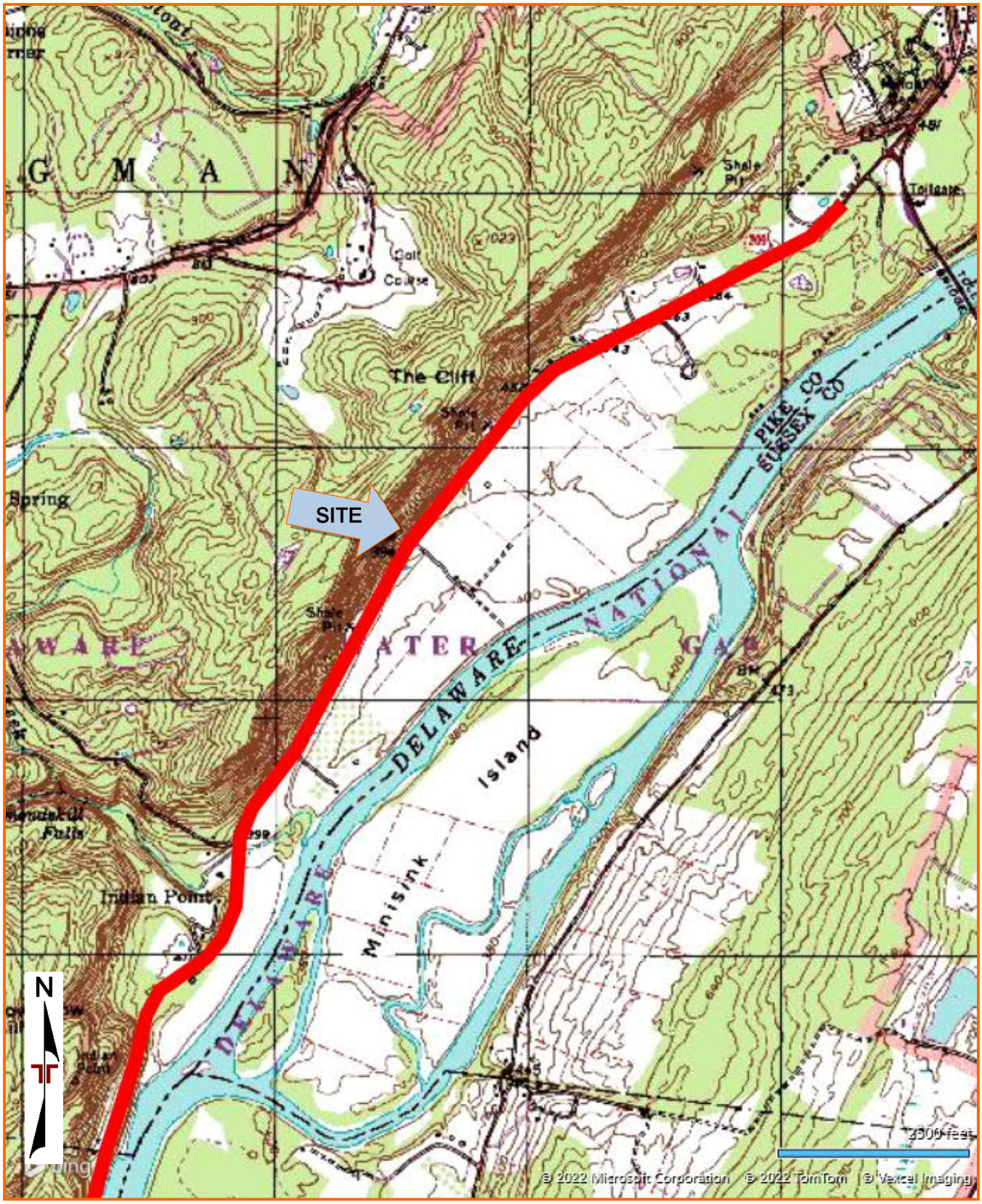
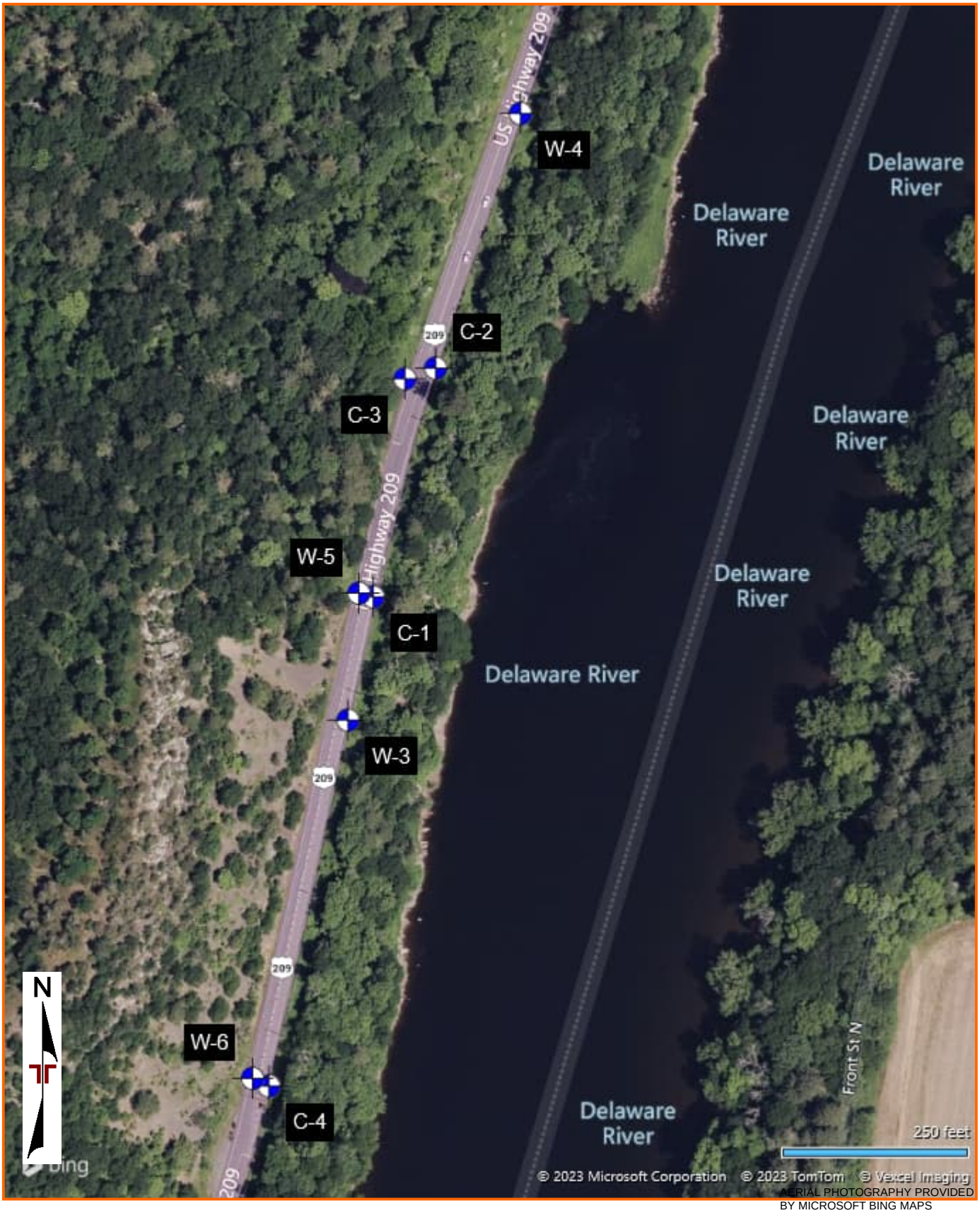


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: MILFORD, PA (1/1/1995).

EXPLORATION PLAN

DEWA 310424- Pavement Preservation and Rehabilitation of Highway 209 ■ Dingman, PA
June 29, 2023 ■ Terracon Project No. J6215080



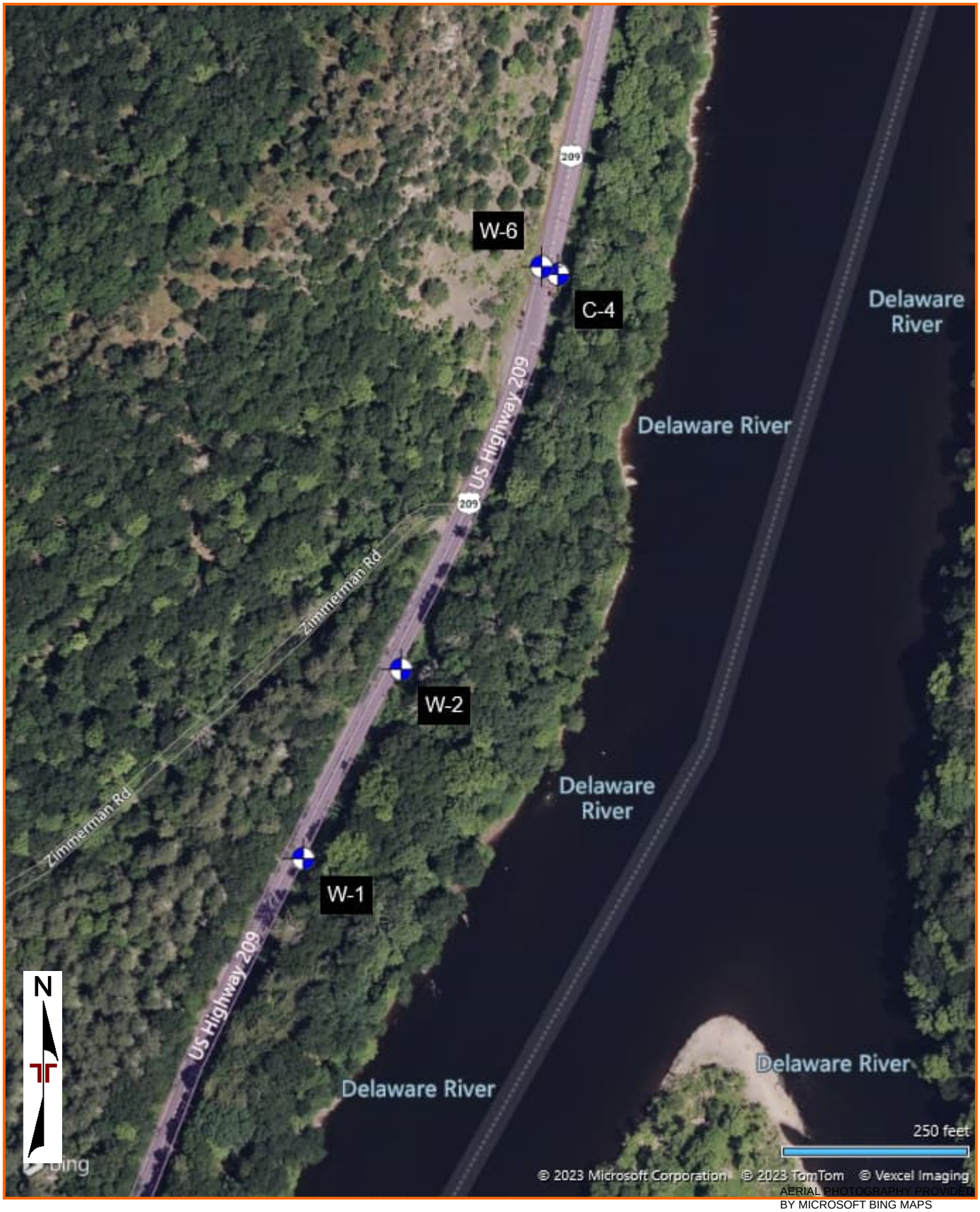
AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

EXPLORATION PLAN

DEWA 310424- Pavement Preservation and Rehabilitation of Highway 209 ■ Dingman, PA

June 29, 2023 ■ Terracon Project No. J6215080



AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

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AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

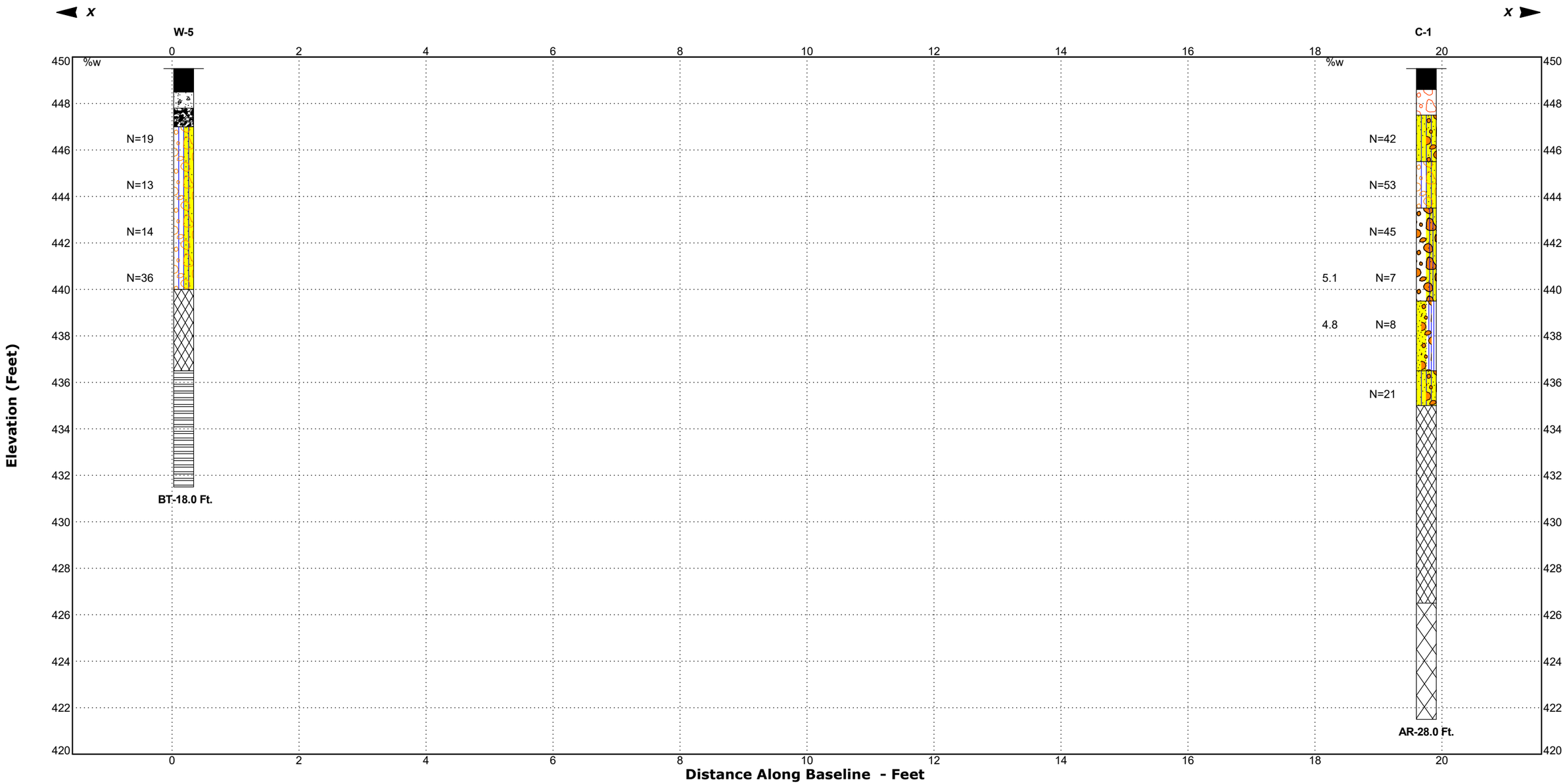
DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Subsurface Profile

W-5 to C-1

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ



Notes	Water Level Observations	Explanation
See Exploration Plan for orientation of soil profile. See General Notes in Supporting Information for symbols and soil classifications. Soils profile provided for illustration purposes only. Soils between borings may differ AR - Auger Refusal BT - Boring Termination	▽ Water Level Reading at time of drilling. Water Level Reading after drilling.	C-1 — Borehole Number Moisture Content — %w LL PL — Liquid and Plastic Limits Sampling (See General Notes) Borehole Lithology AR BT — Borehole Termination Type

Material Legend

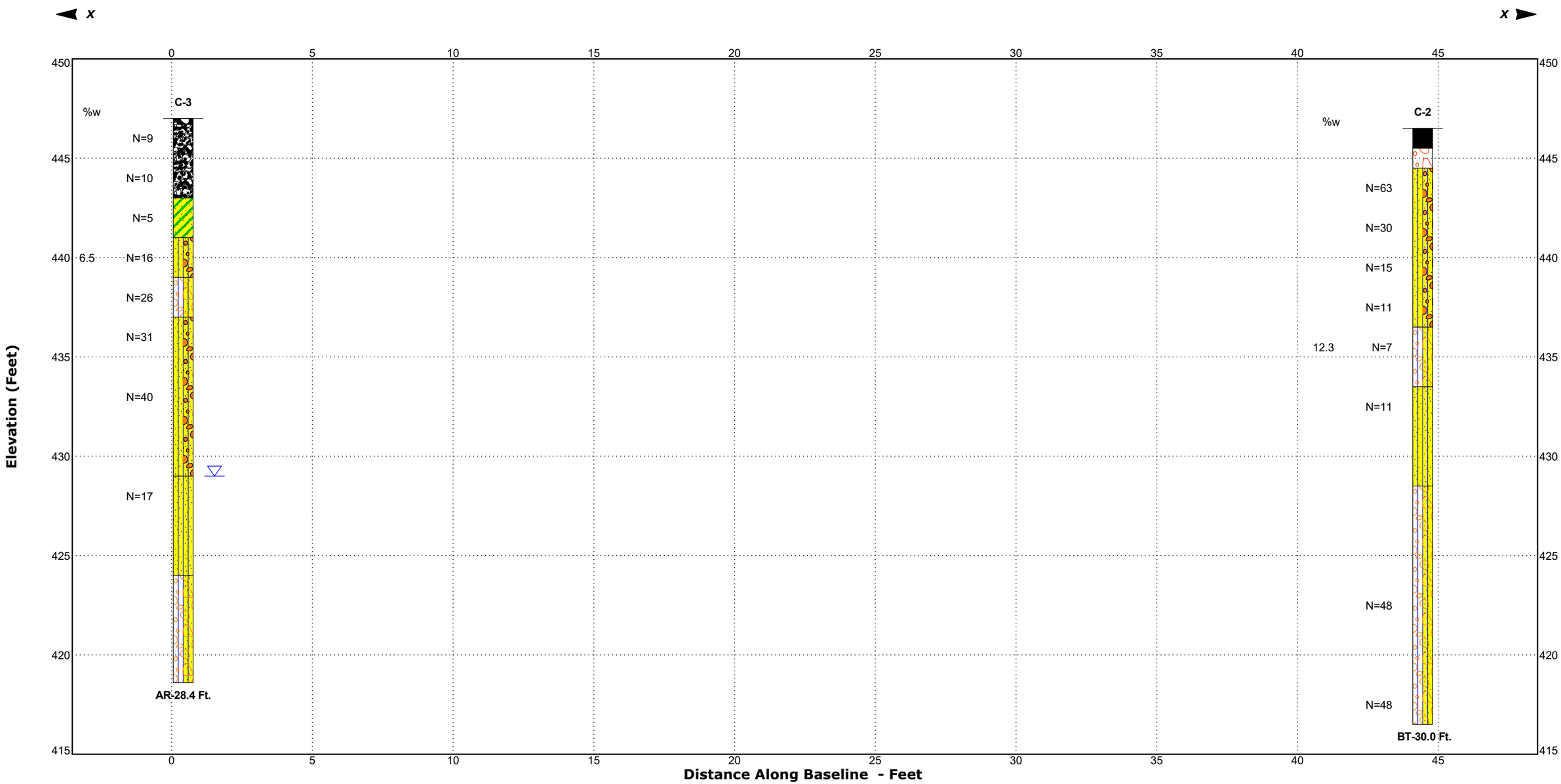
Asphalt
Aggregate Base Course
Silty Sand with Gravel
Silty Gravel with Sand
Poorly-graded Gravel with Silt and Sand
Poorly-graded Sand with Silt and Gravel
Highly Weathered Shale
Weathered Rock
Concrete
Fill

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Subsurface Profile

C-3 to C-2

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ



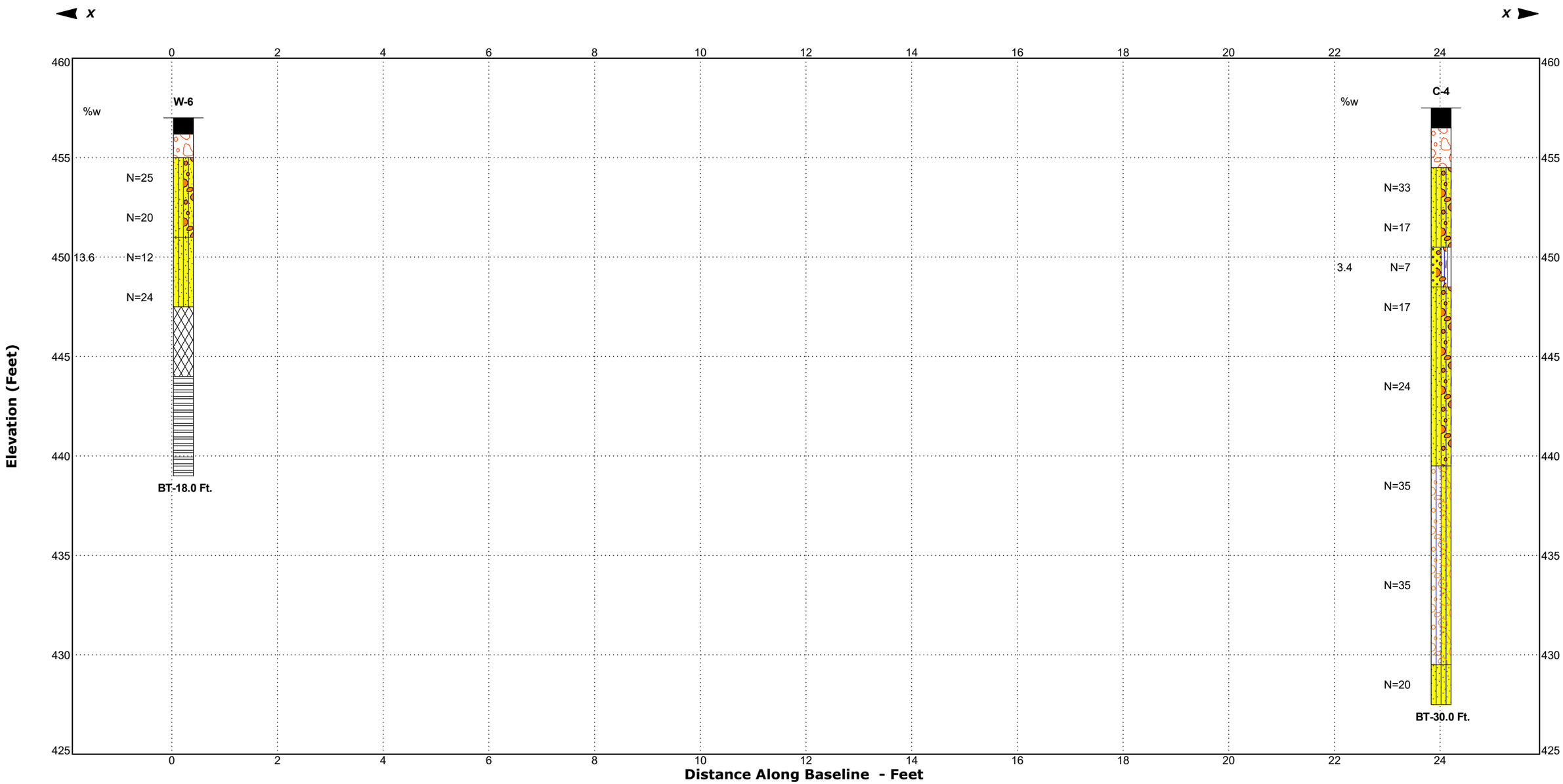
Notes	Water Level Observations	Explanation	Material Legend
See Exploration Plan for orientation of soil profile. See General Notes in Supporting Information for symbols and soil classifications. Soils profile provided for illustration purposes only. Soils between borings may differ AR - Auger Refusal BT - Boring Termination	Water Level Reading at time of drilling. Water Level Reading after drilling.	C-2 — Borehole Number Moisture Content — %w LL PL — Liquid and Plastic Limits Sampling (See General Notes) Borehole Lithology AR BT — Borehole Termination Type	Asphalt Aggregate Base Course Silty Sand with Gravel Silty Gravel with Sand Silty Sand Boulders and Cobbles Fill Clayey Sand

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Subsurface Profile

W-6 to C-4

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ



Notes	Water Level Observations	Explanation
See Exploration Plan for orientation of soil profile. See General Notes in Supporting Information for symbols and soil classifications. Soils profile provided for illustration purposes only. Soils between borings may differ AR - Auger Refusal BT - Boring Termination	Water Level Reading at time of drilling. Water Level Reading after drilling.	C-4 — Borehole Number Moisture Content — %w LL PL — Liquid and Plastic Limits Sampling (See General Notes) Borehole Lithology AR BT — Borehole Termination Type

Material Legend

Asphalt
Aggregate Base Course
Silty Sand with Gravel
Well-graded Sand with Silt and Gravel
Silty Gravel with Sand
Silty Sand
Highly Weathered Shale
Shale

EXPLORATION RESULTS

Contents:

Boring Logs (C-1 to C-4, C-6 and W-1 to W-6)
Grain Size Distribution (5 pages)

Note: All attachments are one page unless noted above.

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Boring Log No. C-1

Location: See Exploration Plan

Latitude: 41.2750° Longitude: -74.8410°

Model Layer	Graphic Log	Depth (Ft.)	Description	Elevation: 449.5 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)
		0.9	**ASPHALT**, 11"	448.6						
		2.0	**DENSE GRADE AGGREGATE**, 13"	447.5						
4		4.0	**SILTY SAND WITH GRAVEL (SM)**, gray, dense	445.5				18	19-20-22-21 N=42	
3		6.0	**SILTY GRAVEL WITH SAND (GM)**, gray, very dense	443.5	5			19	16-20-33-34 N=53	
		10.0	**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)**, gray, loose to dense	439.5				22	34-21-24-16 N=45	
								13	8-3-4-3 N=7	5.1
4		13.0	**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)**, gray, loose	436.5	10			17	6-3-5-8 N=8	4.8
		14.5	**SILTY SAND WITH GRAVEL (SM)**, gray, medium dense	435				19	9-9-12-35 N=21	
5		23.0	**COMPLETELY WEATHERED SHALE**, gray	426.5	15			22	41-17-28-50/4" N=45	
		28.0	**HIGHLY WEATHERED SHALE**, dark gray	421.5	20			1	50/1"	
			Auger Refusal at 28 Feet		25			0	50/0"	

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Notes

Advancement Method
HSA

Abandonment Method
Boring backfilled with Auger Cuttings
Surface capped with asphalt

Drill Rig
Acker Rebel

Hammer Type
Automatic

Driller
Nick P.

Logged by
NP

Boring Started
02-24-2023

Boring Completed
02-24-2023

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Boring Log No. C-2

Location: See Exploration Plan

Latitude: 41.2758° Longitude: -74.8407°

Model Layer	Graphic Log	Depth (Ft.)	Description	Elevation: 446.5 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)
		1.0	**ASPHALT**, 12"	445.5						
		2.0	**DENSE GRADE AGGREGATE**, 12"	444.5						
4			**SILTY SAND WITH GRAVEL (SM)**, brown, medium dense to very dense					20	25-32-31-27 N=63	
					5			18	13-18-12-11 N=30	
								14	9-10-5-7 N=15	
		10.0		436.5				1	2-2-9-5 N=11	
3			**SILTY GRAVEL WITH SAND (GM)**, brown, loose		10			7	2-5-2-3 N=7	12.3
		13.0		433.5						
4			**SILTY SAND (SM)**, brown, medium dense					10	5-4-7-6 N=11	
					15					
		18.0		428.5						
3			**SILTY GRAVEL WITH SAND (GM)**, brown to gray, dense to very dense					5	50/5"	
					20					
								14	38-27-21-22 N=48	
					25					
								24	21-22-26-36 N=48	
		30.0		416.5	30					
			Boring Terminated at 30 Feet							

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Notes

Advancement Method
HSA

Abandonment Method
Boring backfilled with Auger Cuttings
Surface capped with asphalt

Drill Rig
Acker Rebel

Hammer Type
Automatic

Driller
Nick P.

Logged by
NP

Boring Started
02-23-2023

Boring Completed
02-23-2023

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Boring Log No. C-3

Location: See Exploration Plan

Latitude: 41.2758° Longitude: -74.8409°

Model Layer	Depth (Ft.)	Elevation: 447 (Ft.) +/-	Recovery (In.)	Field Test Results	Water Content (%)
	0.3	**GRAVEL**, 4" — 446.7			
1		**FILL -**, silty sand with gravel, gray	9	2-4-5-5 N=9	
			9	5-4-6-4 N=10	
	4.0	443			
		CLAYEY SAND (SC), yellow brown, medium dense	0	3-2-3-7 N=5	
	6.0	441			
4		**SILTY SAND WITH GRAVEL (SM)**, gray, medium dense	15	9-7-9-10 N=16	6.5
	8.0	439			
3		**SILTY GRAVEL WITH SAND (GM)**, gray to brown, medium dense	12	10-13-13-16 N=26	
	10.0	437			
4		**SILTY SAND WITH GRAVEL (SM)**, brown, dense	16	14-14-17-19 N=31	
			12	12-11-29-22 N=40	
	18.0	429			
		SILTY SAND (SM), gray, medium dense	15	12-9-8-11 N=17	
	23.0	424			
3		**SILTY GRAVEL WITH SAND (GM)**, with cobbles and boulders, gray	2	50/3"	
	28.4	418.6	4	50/5"	
		Spoon Refusal at 28.4 Feet			

Depth (Ft.): 5, 10, 15, 20, 25

Water Level Observations: ▽ While sampling

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
Acker Rebel

Hammer Type
Automatic

Driller
Nick P.

Logged by
NP

Boring Started
02-21-2023

Boring Completed
02-21-2023

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Boring Log No. C-4

Location: See Exploration Plan

Latitude: 41.2732° Longitude: -74.8415°

Elevation: 457.5 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Elevation	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)
		ASPHALT, 12"	1.0	456.5				
		DENSE GRADE AGGREGATE, 24"	3.0	454.5		5	50/5"	
4		**SILTY SAND WITH GRAVEL (SM)**, brown, medium dense to dense	7.0	450.5		20	17-18-15-14 N=33	
						12	10-9-8-5 N=17	
		WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM), brown, loose	9.0	448.5		21	5-4-3-4 N=7	3.4
		SILTY SAND WITH GRAVEL (SM), brown, medium dense	18.0	439.5		20	8-9-8-10 N=17	
						19	9-8-16-42 N=24	
3		**SILTY GRAVEL WITH SAND (GM)**, brown to gray, dense	28.0	429.5		11	30-19-16-12 N=35	
						6	23-26-9-12 N=35	
4		**SILTY SAND (SM)**, brown, medium dense	30.0	427.5		20	7-9-11-15 N=20	
		Boring Terminated at 30 Feet						

Depth (Ft.): 5, 10, 15, 20, 25, 30

Water Level Observations

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Notes

Advancement Method
HSA

Abandonment Method
Boring backfilled with Auger Cuttings
Surface capped with asphalt

Drill Rig
Acker Rebel

Hammer Type
Automatic

Driller
Nick P.

Logged by
NP

Boring Started
02-21-2023

Boring Completed
02-22-2023

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Boring Log No. C-6

Location: See Exploration Plan

Latitude: 41.2351° Longitude: -74.8687°

Model Layer	Graphic Log	Depth (Ft.)	Elevation: 420 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)
		1.0	**ASPHALT**, 12" 419						
		2.0	**DENSE GRADE AGGREGATE**, 12" 418						
1		4.0	**FILL -**, silty sand with gravel, gray 416				9	19-50/5"	
4		6.0	**CLAYEY SAND WITH GRAVEL (SC)**, brown, loose 414	5			11	3-2-7-9 N=9	15.7
4		8.0	**SILTY SAND WITH GRAVEL (SM)**, brown, medium dense 412				11	7-8-8-9 N=16	
3		18.0	**SILTY GRAVEL WITH SAND (GM)**, brown, medium dense 402	10			18	20-11-12-12 N=23	
							12	11-10-12-26 N=22	
				15			17	15-13-18-10 N=31	
4		23.0	**SILTY SAND WITH GRAVEL (SM)**, brown, dense 397	20	▽		18	23-11-39-27 N=50	
3		28.0	**SILTY GRAVEL WITH SAND (GM)**, gray, dense 392	25			7	26-17-24-18 N=41	
4		30.0	**SILTY SAND WITH GRAVEL (SM)**, gray, dense 390	30			20	39-21-16-15 N=37	
			Boring Terminated at 30 Feet						

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
▽ While sampling

Drill Rig
Acker Rebel

Hammer Type
Automatic

Driller
Nick P.

Logged by
NP

Boring Started
02-21-2023

Boring Completed
02-21-2023

Notes

Advancement Method
HSA

Abandonment Method
Boring backfilled with Auger Cuttings
Surface capped with asphalt

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Boring Log No. W-1

Location: See Exploration Plan

Latitude: 41.2710° Longitude: -74.8428°

Elevation: 446.5 (Ft.) +/-

Model Layer	Depth (Ft.)	Description	Elevation	Recovery (In.)	Field Test Results	Water Content (%)
	0.9	**ASPHALT**, 11"	445.6			
	1.7	**DENSE GRADE AGGREGATE**, 9"	444.8			
1	4.0	**FILL -**, silty sand with gravel, brown	442.5	15	26-23-27-32 N=50	
4	6.0	**SILTY SAND WITH GRAVEL (SM)**, brown, medium dense	440.5	14	32-18-12-10 N=30	
4	8.0	**SANDY SILT (ML)**, brown, medium dense	438.5	12	7-3-9-16 N=12	20.8
4	10.5	**SILTY SAND WITH GRAVEL (SM)**, brown, medium dense	436	14	11-13-9-11 N=22	
	11.0	**POORLY GRADED SAND (SP)**, brown, medium dense	435.5	16	10-7-11-19 N=18	
4	13.0	**SILTY SAND WITH GRAVEL (SM)**, brown, medium dense	433.5			
3	18.0	**SILTY GRAVEL WITH SAND (GM)**, brown, dense	428.5	8	23-14-16-19 N=30	
4	23.0	**SILTY SAND (SM)**, brown, medium dense	423.5	14	14-7-7-10 N=14	5.2
3	28.0	**SILTY GRAVEL WITH SAND (GM)**, brown, dense	418.5	20	32-17-26-28 N=43	
4		**SILTY SAND (SM)**, with shale chips, brown, very dense		8	15-38-50/2"	

Depth (Ft.): 5, 10, 15, 20, 25, 30

Water Level Observations: ▽ While sampling

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Advancement Method
HSA

Abandonment Method
Boring backfilled with Auger Cuttings
Surface capped with asphalt

Drill Rig
Acker Rebel

Hammer Type
Automatic

Driller
Nick P.

Logged by
NP

Boring Started
02-22-2023

Boring Completed
02-22-2023

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Boring Log No. W-1

Location: See Exploration Plan

Latitude: 41.2710° Longitude: -74.8428°

Depth (Ft.) Elevation: 446.5 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)
4		**SILTY SAND (SM)**, with shale chips, brown, very dense *(continued)*						
						5	50/5"	
			35					
		38.0 408.5						
3		**SILTY GRAVEL WITH SAND (GM)**, dark gray, very dense				17	38-40-50/5"	3.2
			40					
		43.0 403.5						
5		**HIGHLY WEATHERED SHALE**, dark gray				4	50/4"	
			45					
		46.0 400.5						
		Auger Refusal at 46 Feet				0	50/0"	

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations

While sampling

Notes

Advancement Method
HSA

Abandonment Method
Boring backfilled with Auger Cuttings
Surface capped with asphalt

Drill Rig
Acker Rebel

Hammer Type
Automatic

Driller
Nick P.

Logged by
NP

Boring Started
02-22-2023

Boring Completed
02-22-2023

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Boring Log No. W-2

Location: See Exploration Plan

Latitude: 41.2717° Longitude: -74.8423°

Model Layer	Graphic Log	Depth (Ft.)	Elevation: 450 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)
		1.0	**ASPHALT**, 12" 449						
		2.0	**DENSE GRADE AGGREGATE**, 12" 448						
4		4.0	**SILTY SAND WITH GRAVEL (SM)**, brown to gray, dense 446				22	15-24-20-20 N=44	
3		8.0	**SILTY GRAVEL WITH SAND (GM)**, gray to brown, very dense 442	5			2	28-32-36-28 N=68	
							3	50/5"	
4		10.0	**SILTY SAND (SM)**, brown, medium dense 440				16	20-15-11-12 N=26	
		13.0	**SILTY SAND WITH GRAVEL (SM)**, brown, very dense 437	10			8	35-50/3"	
		23.0	**SILTY SAND (SM)**, brown, dense 427	15			22	23-23-20-28 N=43	4.1
				20			22	16-21-25-35 N=46	
3			**SILTY GRAVEL WITH SAND (GM)**, brown to gray, very dense	25			15	30-31-50/3"	
				30			24	41-32-30-32 N=62	

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Notes

Advancement Method
HSA

Abandonment Method
Boring backfilled with Auger Cuttings
Surface capped with asphalt

Drill Rig
Acker Rebel

Hammer Type
Automatic

Driller
Nick P.

Logged by
NP

Boring Started
02-22-2023

Boring Completed
02-22-2023

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Boring Log No. W-2

Location: See Exploration Plan

Latitude: 41.2717° Longitude: -74.8423°

Depth (Ft.) Elevation: 450 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)
3		**SILTY GRAVEL WITH SAND (GM)**, brown to gray, very dense *(continued)*						
						1	50/1"	
			35					
						5	50/5"	
			40					
		43.0 407						
		POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM), gray, very dense				21	25-22-29-41 N=51	4.9
			45					
		48.0 402						
4		**SILTY SAND WITH GRAVEL (SM)**, gray, dense				23	19-19-17-28 N=36	
		50.0 400	50					
		Boring Terminated at 50 Feet						

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Notes

Advancement Method
HSA

Abandonment Method
Boring backfilled with Auger Cuttings
Surface capped with asphalt

Drill Rig
Acker Rebel

Hammer Type
Automatic

Driller
Nick P.

Logged by
NP

Boring Started
02-22-2023

Boring Completed
02-22-2023

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Boring Log No. W-3

Location: See Exploration Plan

Latitude: 41.2745° Longitude: -74.8411°

Model Layer	Graphic Log	Depth (Ft.)	Elevation: 454 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)
		1.0	**ASPHALT**, 12" 453						
		2.0	**DENSE GRADE AGGREGATE**, 12" 452						
1		4.0	**FILL -**, silty sand with gravel, gray 450				24	29-18-24-35 N=42	
3		8.0	**SILTY GRAVEL WITH SAND (GM)**, brown, medium dense to dense 446	5			10	20-25-24-19 N=49	
							15	9-7-14-26 N=21	
5		15.0	**HIGHLY WEATHERED SHALE**, dark gray 439				1	50/4"	
				10			1	50/1"	
6		20.0	**SHALE**, Dark gray shale, extremely close to close fracture spacing with horizontal to high angle fractures, moderately to slightly weathered, weak to medium strong rock. Run 1: 15'-20' REC: 91% RQD: 0% 434	15			55		
			Boring Terminated at 20 Feet	20					

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Notes

Advancement Method
HSA

Abandonment Method
Boring backfilled with Auger Cuttings
Surface capped with asphalt

Drill Rig
Acker Rebel

Hammer Type
Automatic

Driller
Nick P.

Logged by
NP

Boring Started
02-24-2023

Boring Completed
02-24-2023

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Boring Log No. W-4

Location: See Exploration Plan

Latitude: 41.2767° Longitude: -74.8403°

Model Layer	Depth (Ft.)	Elevation: 457 (Ft.) +/-	Recovery (In.)	Field Test Results	Water Content (%)
	1.0	**ASPHALT**, 12" 456			
	1.7	**CONCRETE**, 8" 455.3			
1	3.0	**FILL -**, silty gravel with sand, gray 454	15	14-15-6-4 N=21	
4	6.0	**SILTY SAND (SM)**, brown, medium dense to dense 451	8	4-14-17-4 N=31	
4	9.5	**SILTY SAND WITH GRAVEL (SM)**, brown, loose to dense 447.5	14	5-3-3-3 N=6	11.0
			21	14-15-16-44 N=31	
3	13.0	**POORLY GRADED GRAVEL WITH SAND (GP)**, gray, dense to very dense 444	0	50/1"	
3		**SILTY GRAVEL WITH SAND (GM)**, gray, very dense	4	18-50/5"	
3			19	20-31-27-22 N=58	4.2
3			3	50/5"	
3		with cobbles and boulders	10		

Depth (Ft.): 5, 10, 15, 20, 25, 30

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
While sampling

Notes

Advancement Method
HSA

Abandonment Method
Boring backfilled with Auger Cuttings
Surface capped with asphalt

Drill Rig
Diedrich D-50

Hammer Type
Automatic

Driller
Sean W.

Logged by
NP

Boring Started
02-23-2023

Boring Completed
03-01-2023

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Boring Log No. W-4

Location: See Exploration Plan

Latitude: 41.2767° Longitude: -74.8403°

Depth (Ft.) Elevation: 457 (Ft.) +/-

Model Layer	Graphic Log		Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)
3		**SILTY GRAVEL WITH SAND (GM)**, gray, very dense *(continued)* 36.5 420.5	35			6		
		Boring Terminated at 36.5 Feet						

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations

While sampling

Notes

Advancement Method
HSA

Abandonment Method
Boring backfilled with Auger Cuttings
Surface capped with asphalt

Drill Rig
Diedrich D-50

Hammer Type
Automatic

Driller
Sean W.

Logged by
NP

Boring Started
02-23-2023

Boring Completed
03-01-2023

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Boring Log No. W-5

Location: See Exploration Plan

Latitude: 41.2750° Longitude: -74.8411°

Elevation: 449.5 (Ft.) +/-

Model Layer	Graphic Log	Depth (Ft.)	Description	Elevation	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)
		1.0	**ASPHALT**, 12"	448.5						
		1.7	**CONCRETE**, 8"	447.8						
1		2.5	**FILL -**, silty gravel with sand, brown	447						
3		9.5	**SILTY GRAVEL WITH SAND (GM)**, brown to gray, medium dense to dense	440	5			15	11-11-8-8 N=19	
								16	4-6-7-5 N=13	
								18	5-6-8-7 N=14	
								20	10-19-17-36 N=36	
5		13.0	**COMPLETELY WEATHERED SHALE**, dark gray	436.5	10			2	50/5"	
6		18.0	**SHALE**, Dark gray shale, extremely close to close fracture spacing with horizontal to low angle fractures, slightly to completely weathered, very weak to medium strong rock. Run 1: 13'-18' REC: 100% RQD; 0%	431.5	15			60		
			Boring Terminated at 18 Feet							

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Drill Rig
Diedrich D-50

Hammer Type
Automatic

Driller
Sean W.

Logged by
NP

Boring Started
02-27-2023

Boring Completed
02-27-2023

Notes

Advancement Method
HSA

Abandonment Method
Boring backfilled with Auger Cuttings
Surface capped with asphalt

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Boring Log No. W-6

Location: See Exploration Plan

Latitude: 41.2732° Longitude: -74.8416°

Model Layer	Graphic Log	Depth (Ft.)	Description	Elevation: 457 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)
		0.8	**ASPHALT**, 10"	456.2						
		2.0	**DENSE GRADE AGGREGATE**, 14"	455				2	16-21-23	
4		6.0	**SILTY SAND WITH GRAVEL (SM)**, brown, medium dense	451	5			22	13-14-11-12 N=25	
								20	9-9-11-9 N=20	
		9.5	**SILTY SAND (SM)**, brown, medium dense	447.5				22	6-6-6-6 N=12	13.6
								17	4-5-19-50 N=24	
5		13.0	**COMPLETELY WEATHERED SHALE**, dark gray	444	10			7	50-50/2"	
6		18.0	**SHALE**, Dark gray shale, extremely close to close fracture spacing with horizontal to high angle fractures, slightly to completely weathered, very weak to medium strong rock. Run 1: 13'-18' REC: 100% RQD: 45%	439	15			60		
			Boring Terminated at 18 Feet							

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Notes

Advancement Method
HSA

Abandonment Method
Boring backfilled with Auger Cuttings
Surface capped with asphalt

Drill Rig
Diedrich D-50

Hammer Type
Automatic

Driller
Sean W.

Logged by
NP

Boring Started
02-27-2023

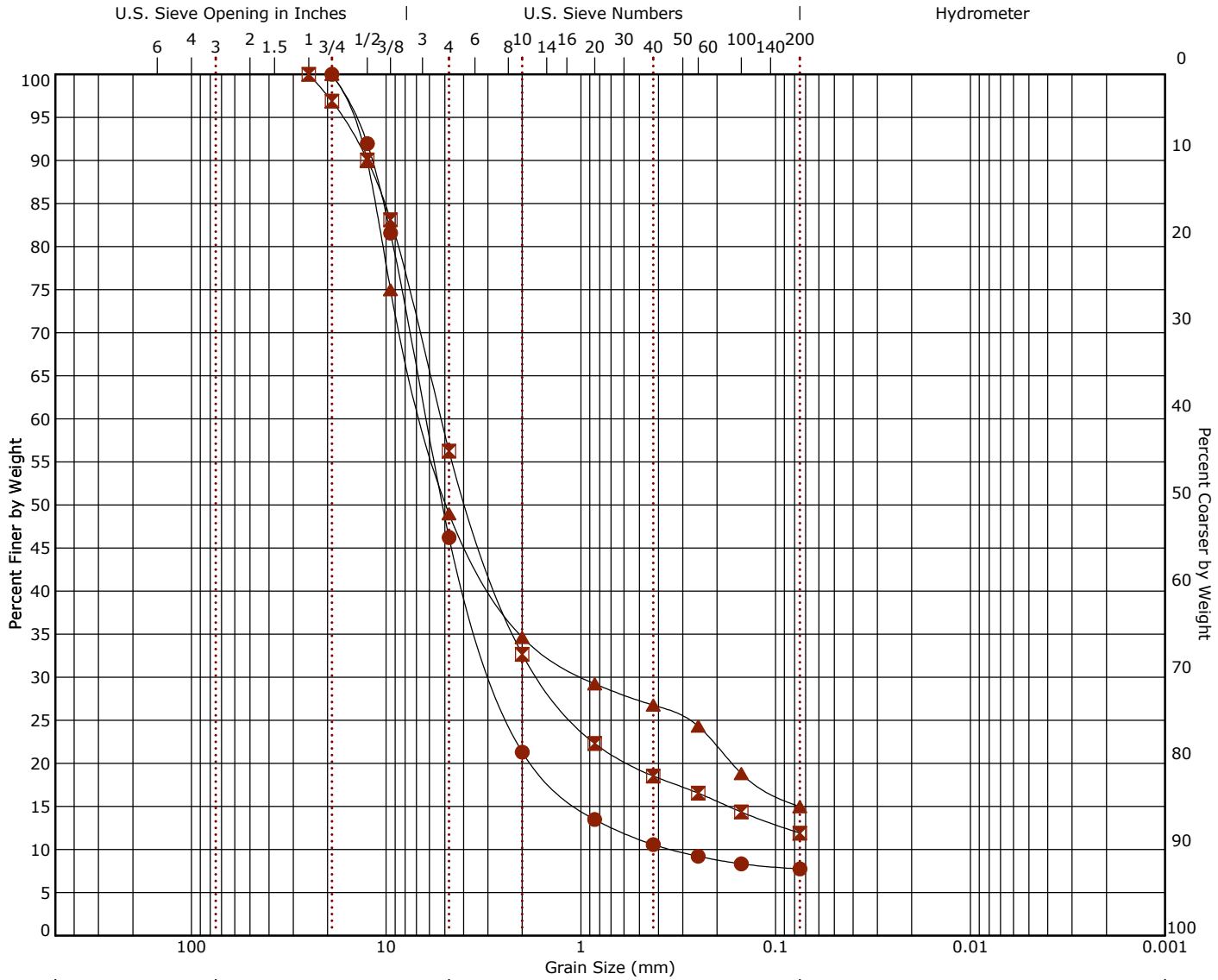
Boring Completed
02-27-2023

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Grain Size Distribution

ASTM D422 / ASTM C136



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	% Cobbles	% Gravel	% Sand	% Fines	% Silt	% Clay	USCS
●	C-1	8 - 10	0.0	53.8	38.5	7.7			GP-GM
⊠	C-1	10 - 12	0.0	43.7	44.4	11.9			SP-SM
▲	C-2	10 - 12	0.0	51.0	34.0	15.0			GM

	Description
●	POORLY GRADED GRAVEL WITH SILT AND SAND
⊠	POORLY GRADED SAND WITH SILT AND GRAVEL
▲	SILTY GRAVEL WITH SAND

	Remarks
●	
⊠	
▲	

●		⊠		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
3/4"	100.0	1"	100.0	3/4"	100.0
1/2"	91.95	3/4"	96.88	1/2"	89.86
3/8"	81.57	1/2"	90.05	3/8"	74.99
#4	46.22	3/8"	83.12	#4	48.97
#10	21.3	#4	56.26	#10	34.62
#20	13.48	#10	32.65	#20	29.23
#40	10.56	#20	22.31	#40	26.76
#60	9.21	#40	18.53	#60	24.33
#100	8.33	#60	16.54	#100	18.81
#200	7.75	#100	14.34	#200	14.98
		#200	11.9		

Grain Size	●	⊠	▲
D_{60}	6.224	5.231	6.372
D_{30}	2.705	1.606	0.96
D_{10}	0.341		

Coefficients	●	⊠	▲
C_c	3.45	11.24	
C_u	18.26	119.24	

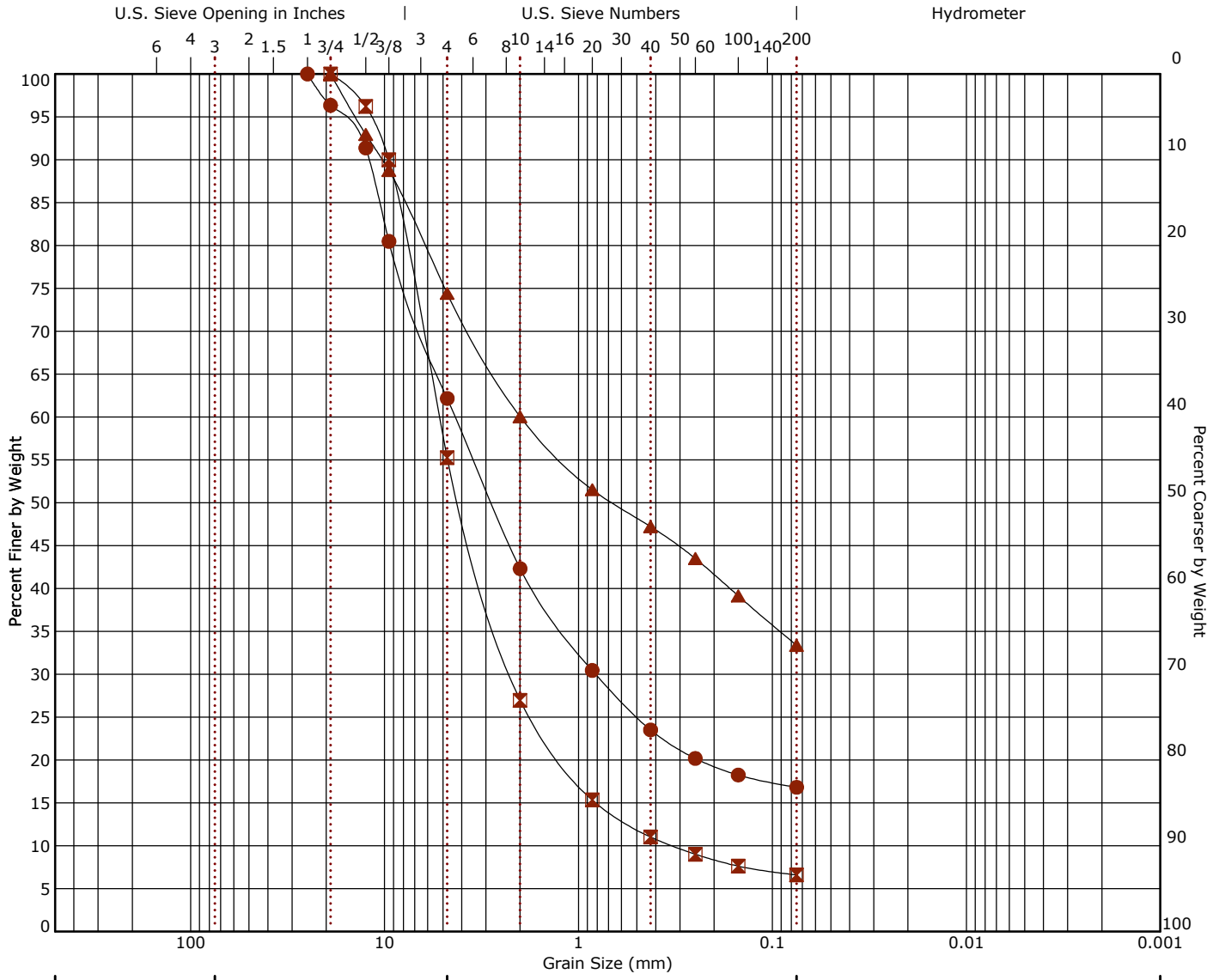
Laboratory tests are not valid if separated from original report.

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Grain Size Distribution

ASTM D422 / ASTM C136



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	% Cobbles	% Gravel	% Sand	% Fines	% Silt	% Clay	USCS
●	C-3	6 - 8	0.0	37.8	45.3	16.8			SM
⊠	C-4	7 - 9	0.0	44.7	48.7	6.6			SW-SM
▲	C-6	4 - 6	0.0	25.6	41.0	33.4			SC

	Description
●	SILTY SAND WITH GRAVEL
⊠	WELL GRADED SAND WITH SILT AND GRAVEL
▲	CLAYEY SAND WITH GRAVEL

	Remarks
●	
⊠	
▲	

●		⊠		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
1"	100.0	3/4"	100.0	#4	74.4
3/4"	96.35	1/2"	96.21	#10	60.03
1/2"	91.37	3/8"	89.99	#20	51.52
3/8"	80.48	#4	55.25	#40	47.22
#4	62.16	#10	26.97	#60	43.5
#10	42.31	#20	15.34	#100	39.13
#20	30.45	#40	11.02	#200	33.37
#40	23.5	#60	9.02	3/4"	100.0
#60	20.19	#100	7.62	1/2"	92.94
#100	18.24	#200	6.59	3/8"	88.76
#200	16.82				

Grain Size	●	⊠	▲
D_{60}	4.324	5.222	1.994
D_{30}	0.813	2.194	
D_{10}		0.324	

Coefficients	●	⊠	▲
C_c		2.84	
C_u		16.10	

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Pavement Rehabilitation
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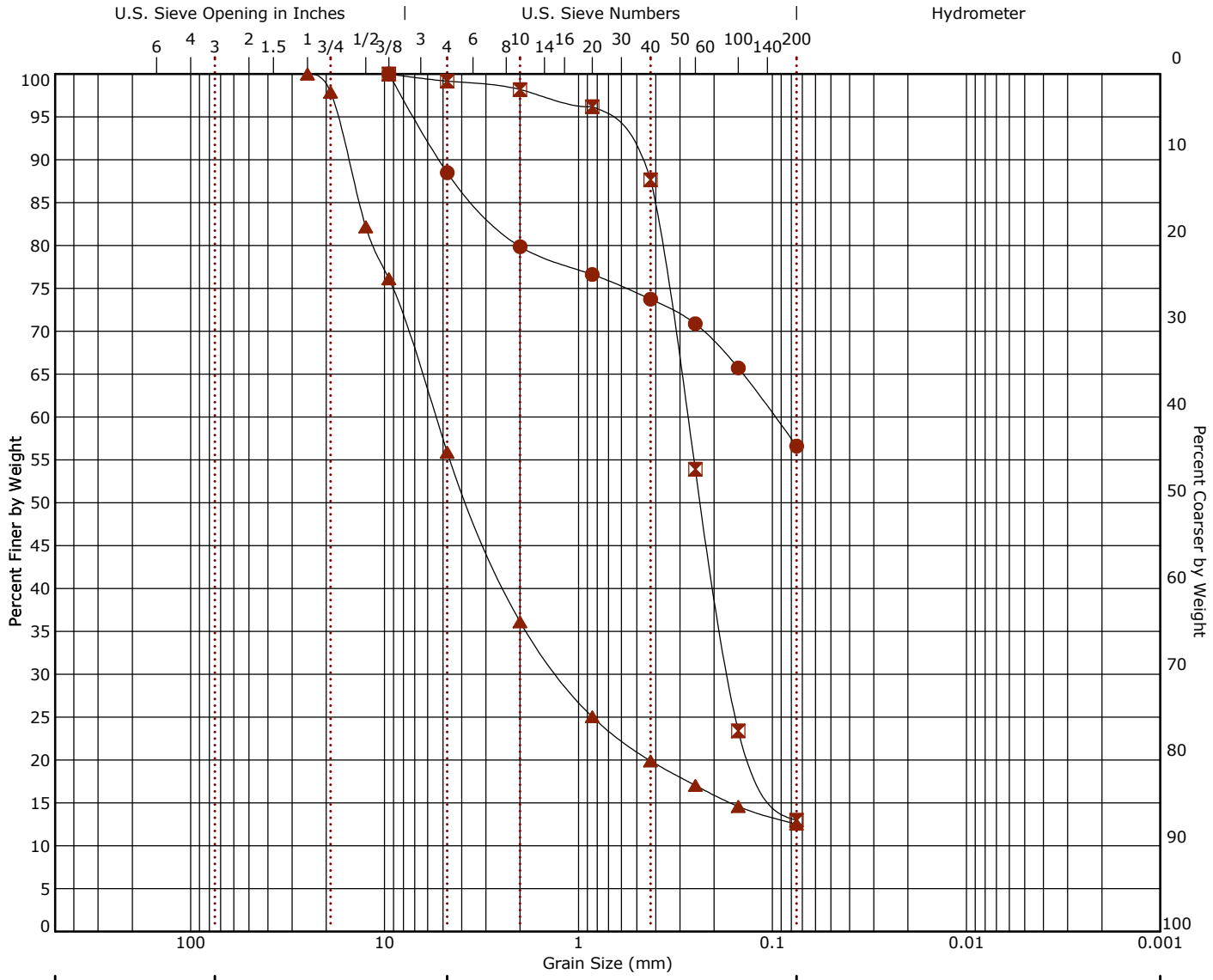
Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Grain Size Distribution

ASTM D422 / ASTM C136



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	% Cobbles	% Gravel	% Sand	% Fines	% Silt	% Clay	USCS
●	W-1	6 - 8	0.0	11.5	31.9	56.6			ML
⊠	W-1	18 - 20	0.0	0.8	86.2	13.0			SM
▲	W-1	38 - 39.4	0.0	44.1	43.4	12.5			GM

	Description
●	SANDY SILT
⊠	SILTY SAND
▲	SILTY GRAVEL WITH SAND

	Remarks
●	
⊠	
▲	

● Sieve	● % Finer	⊠ Sieve	⊠ % Finer	▲ Sieve	▲ % Finer
3/8"	100.0	3/8"	100.0	1"	100.0
#4	88.49	#4	99.17	3/4"	97.89
#10	79.86	#10	98.18	1/2"	82.17
#20	76.62	#20	96.19	3/8"	76.11
#40	73.75	#40	87.66	#4	55.89
#60	70.88	#60	53.89	#10	36.1
#100	65.71	#100	23.41	#20	25.05
#200	56.6	#200	12.98	#40	19.89
				#60	17.04
				#100	14.58
				#200	12.52

Grain Size	●	⊠	▲
D_{60}	0.097	0.275	5.468
D_{30}		0.168	1.247
D_{10}			

Coefficients	●	⊠	▲
C_c			
C_u			

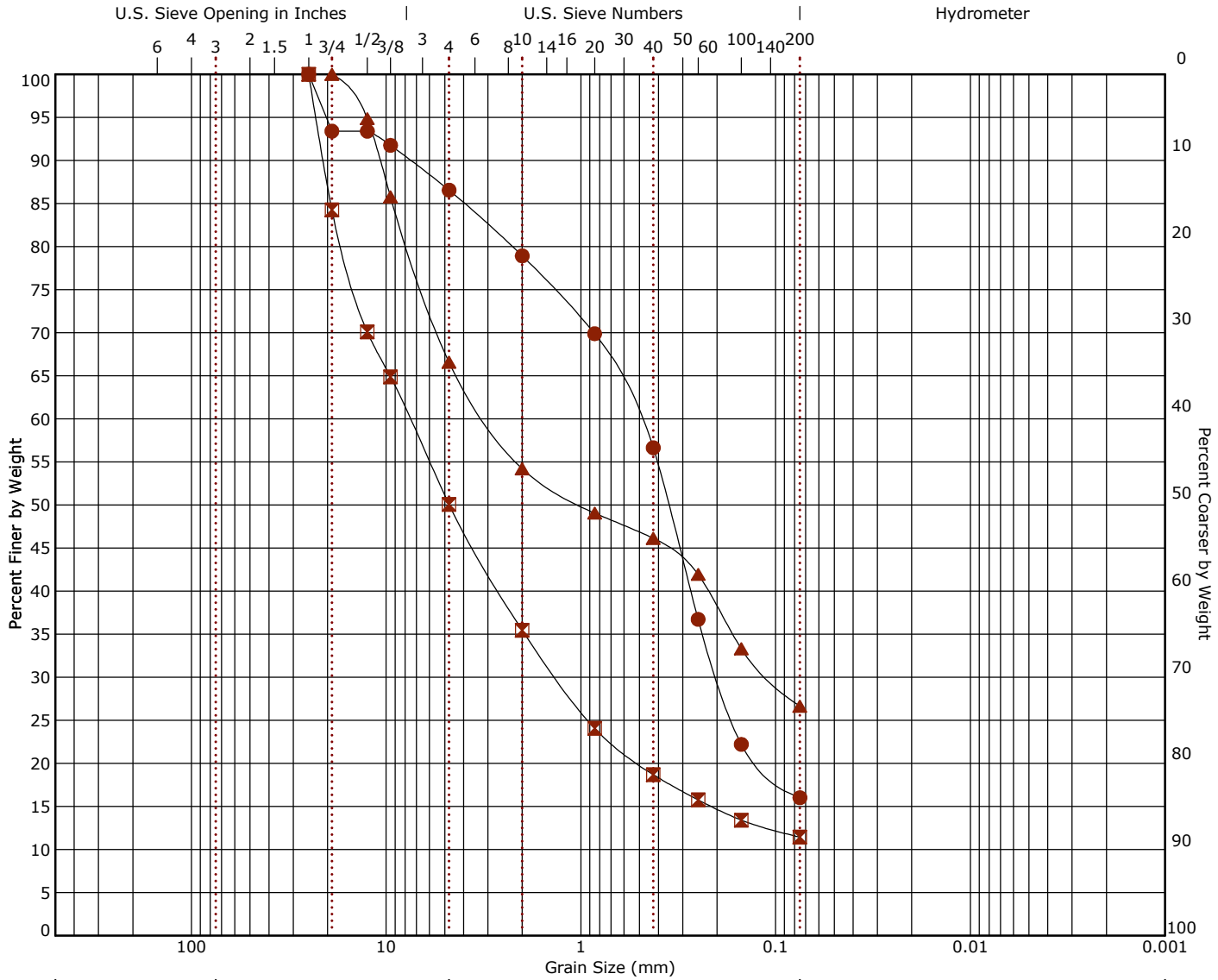
Laboratory tests are not valid if separated from original report.

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Grain Size Distribution

ASTM D422 / ASTM C136



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	% Cobbles	% Gravel	% Sand	% Fines	% Silt	% Clay	USCS
●	W-2	13 - 15	0.0	13.5	70.5	16.0			SM
⊠	W-2	43 - 45	0.0	49.9	38.6	11.4			GP-GM
▲	W-4	6 - 8	0.0	33.4	39.9	26.6			SM

	Description
●	SILTY SAND
⊠	POORLY GRADED GRAVEL WITH SILT AND SAND
▲	SILTY SAND WITH GRAVEL

	Remarks
●	
⊠	
▲	

● Sieve	● % Finer	⊠ Sieve	⊠ % Finer	▲ Sieve	▲ % Finer
1"	100.0	1"	100.0	3/4"	100.0
3/4"	93.4	3/4"	84.26	1/2"	94.86
1/2"	93.4	1/2"	70.08	3/8"	85.77
3/8"	91.76	3/8"	64.88	#4	66.56
#4	86.55	#4	50.07	#10	54.19
#10	78.92	#10	35.44	#20	49.05
#20	69.88	#20	24.06	#40	46.13
#40	56.64	#40	18.69	#60	41.94
#60	36.72	#60	15.76	#100	33.31
#100	22.21	#100	13.41	#200	26.63
#200	16.01	#200	11.43		

Grain Size	●	⊠	▲
D_{60}	0.507	7.561	3.002
D_{30}	0.197	1.329	0.106
D_{10}			

Coefficients	●	⊠	▲
C_c		5.14	
C_u		166.56	

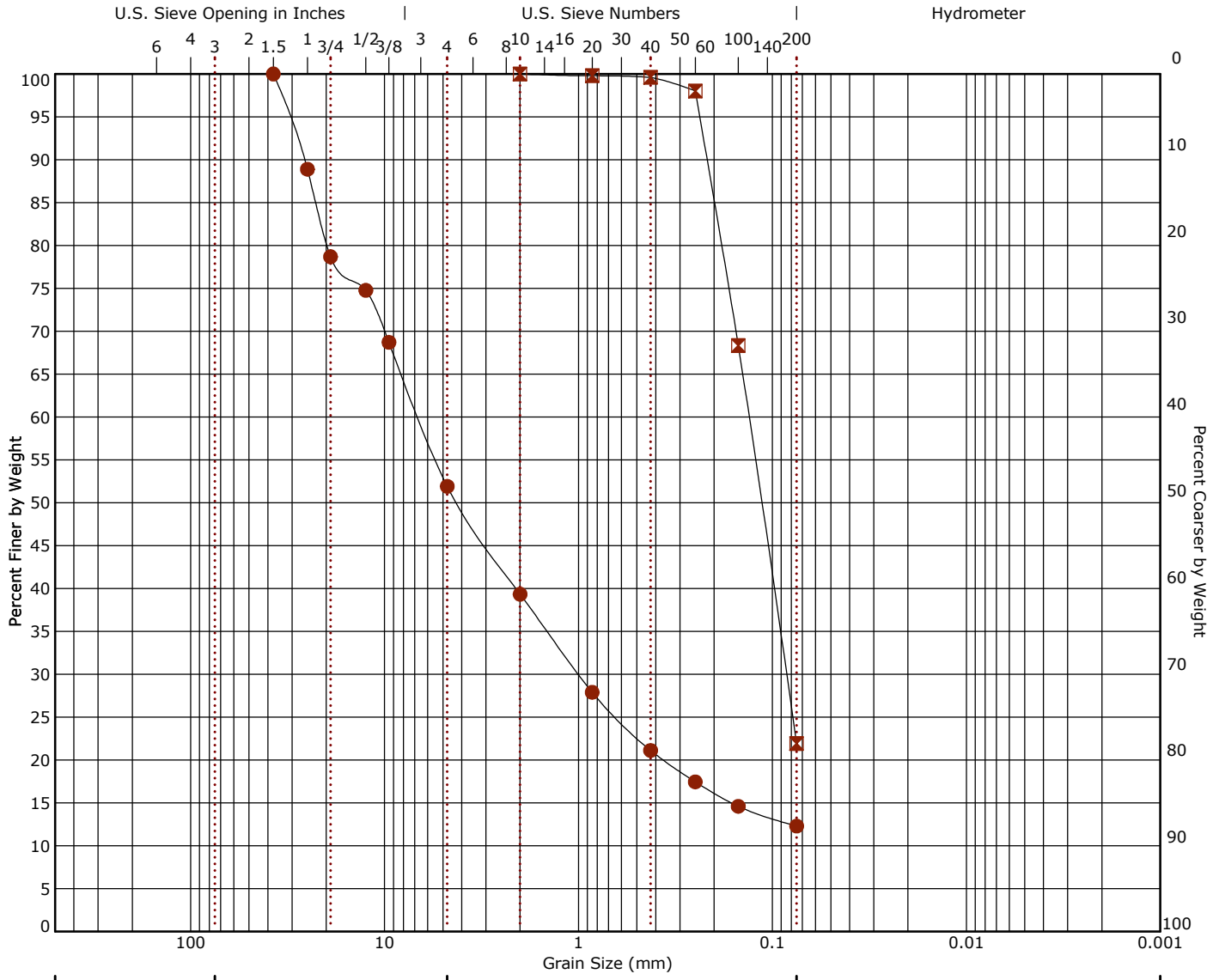
Laboratory tests are not valid if separated from original report.

Pavement Rehabilitation
Route 209 | Dingman and Delaware, PA
Terracon Project No. J6215080

Terracon
4081 Hadley Rd, Ste B
South Plainfield, NJ

Grain Size Distribution

ASTM D422 / ASTM C136



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	% Cobbles	% Gravel	% Sand	% Fines	% Silt	% Clay	USCS
●	W-4	19 - 21	0.0	48.1	39.6	12.3			GM
⊠	W-6	6 - 8	0.0	0.0	78.1	21.9			SM

	Description
●	SILTY GRAVEL WITH SAND
⊠	SILTY SAND

Remarks
●
⊠

● Sieve	● % Finer	⊠ Sieve	⊠ % Finer	Sieve	% Finer
1 1/2"	100.0	#10	100.0		
1"	88.89	#20	99.8		
3/4"	78.69	#40	99.6		
1/2"	74.77	#60	98.03		
3/8"	68.71	#100	68.33		
#4	51.91	#200	21.91		
#10	39.33				
#20	27.89				
#40	21.12				
#60	17.45				
#100	14.6				
#200	12.3				

Grain Size	●	⊠
D_{60}	6.632	0.132
D_{30}	0.995	0.085
D_{10}		

Coefficients	●	⊠
C_c	3.98	
C_u	176.58	

Laboratory tests are not valid if separated from original report.

SUPPORTING INFORMATION

Contents:

General Notes
Unified Soil Classification System
USDOT Report

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

Pavement Rehabilitation ■ Dingman and Delaware, PA

Terracon Project No. J6215080

SAMPLING	WATER LEVEL	FIELD TESTS
Rock Core Standard Penetration Test	**Water Initially Encountered** **Water Level After a Specified Period of Time** **Water Level After a Specified Period of Time** **Cave In Encountered** Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	**N** Standard Penetration Test Resistance (Blows/Ft.) **(HP)** Hand Penetrometer **(T)** Torvane **(DCP)** Dynamic Cone Penetrometer **UC** Unconfined Compressive Strength **(PID)** Photo-Ionization Detector **(OVA)** Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

LOCATION AND ELEVATION NOTES

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or [Cc<1 or Cc>3.0] [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F, G, H]
			Fines classify as CL or CH		GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or [Cc<1 or Cc>3.0] [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G, H, I]
			Fines classify as CL or CH		SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A"		CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K, L, M, N]
			Liquid limit - not dried			Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K, L, M]
			PI plots below "A" line		MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K, L, M, P]
			Liquid limit - not dried			Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

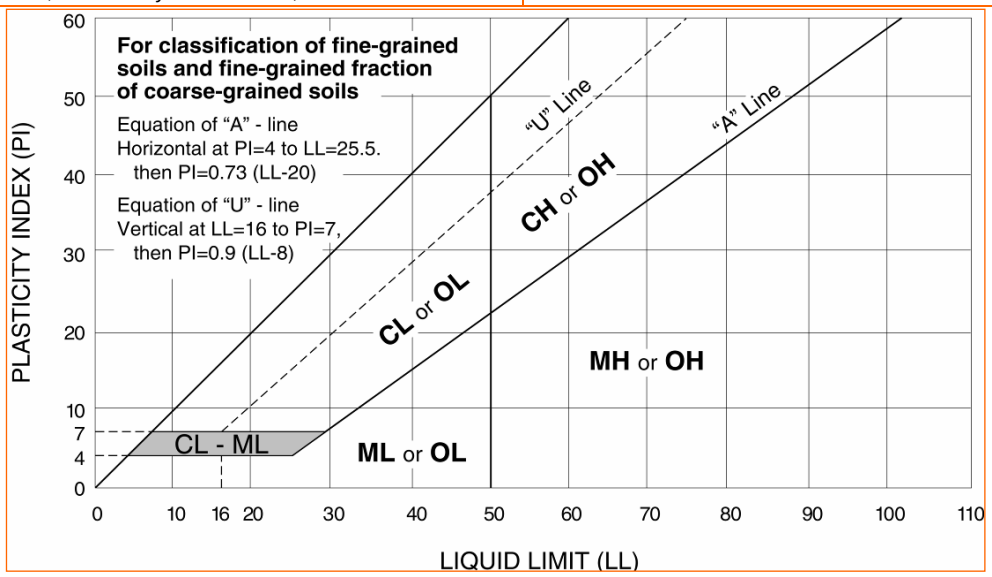
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



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***SUBJECT:* Project ERFO DEWA 14(15) – Preliminary Geotechnical Recommendations for Landslide Repair**

TO	MESSAGE/COMMENT	FROM/DATE
S. Nawaz Highway Design Manager Through: R. Kotadia Project Manager Through: A. Teikari Supervisor Highway Engineer	This Geotechnical Memorandum summarizes the results of our subsurface exploration, laboratory testing, and design analyses and presents our geotechnical evaluations and recommendations for the slide repair on U.S. Route 209 at Milepost 15.3. The project site is located in Delaware Water Gap, National Recreation Area in Pike County, Pennsylvania. The general location of the landslide is shown on Figure 1, Attachment 1. **GENERAL PROJECT INFORMATION** **Background and Project Description** A major landslide at MP 15.3 of U.S. Rte. 209 in Delaware Water Gap was reported by the Park on October 31, 2011. It caused drop and separation in sections of pavement on the centerline and both northbound and southbound lanes. The event occurred after Hurricanes Irene and Lee that hit the area in September 2011 and caused major flooding. The damage also included McDade hike/Bike Trail, which is located in close proximity to Rte. 209. A drainage culvert in the vicinity of the slide area also was destroyed. This section of Rte. 209 is currently supported by a retaining wall consisting of soldier piles and lagging. The presence of such a wall is indicative that the area is prone to landslides. Our review of the available information indicated that landslides were reported in the area as far back as 1985. The project includes slide repair through the installation of deep concrete drilled piers for the prevention of future slope instability, re-alignment of the bike trail to run alongside Rte 209, and the installation of a new retaining wall to support Rte. 209 and the bike trail. Restoration of the site drainage features including reconstruction of the damaged culvert also will be required. Site drainage in the slide area should consist of ditches on west side of the road, which are lined with an impervious material to prevent runoff infiltration into the slope. Lined ditches also should be constructed on the east side of the roadway in the slide area to prevent runoff from the pavement flowing over the slope.	M. Abouzakhm, PE Division Geotechnical Engineer Through: S. Whittemore Technical Services Engineer 2/03/2012

cc: TS Reading, Highway (R.K. and S.N.), All w/ attachment

Site Geology

A previous geotechnical study (Soils and Foundations Report No. 4-92) indicated that the slide is underlain by Kame Terrace Deposits. These deposits were formed from the silts and sediments which accumulated on the glacier and then settled while the glacial ice slowly melted. These deposits consist mainly of fine silts and sands 3 ft to 15 ft thick, overlying sands and coarse bedded gravels, with occasional lenses of silts and clays. Some Kame deposits in this area have a thickness ranging from 130 ft to 150 ft.

PROCEDURES AND RESULTS

General

A subsurface exploration program was conducted from November 9th through 18th, 2011 by the Eastern Federal Land Highway Division (EFLHD) Subsurface Exploration Team. A total of six (6) soil borings (Borings B-1 through B-6) were drilled along the road and in the vicinity of the existing landslide. Shallow auger refusal was encountered in B-5 and the drilling crew abandoned the boring after offsetting the location twice. Borings B-1, B-2, and B-4 extended to a depth of 92 ft. Boring B-3 extended to a depth of 87 ft and auger refusal was encountered at a depth of 27 ft Boring B-6. All depths are below existing site grades.

Five (5) additional pavement cores (C-1 through C-6) were performed during the field work. The purpose of these cores was to evaluate the pavement thickness across the slide area. It should be noted that pavement core C-1 was drilled in the location of Boring B-1.

The soil borings were laid out by EFLHD field personnel by referencing ground-surface topography, measuring distances from existing surface features, and estimating right-angles. Ground surface elevations at the boring locations were determined from the topography plans provided by the Survey Division. The boreholes were backfilled with auger cuttings and soil upon completion. The approximate location of the soil borings is shown on Figure 2 “Borings Location Map”, Attachment 1.

Sampling

The borings were drilled with a CME 750 ATV-mounted rotary drill rig. The boreholes were advanced using 3¾ –in (inside diameter) hollow stem augers (HSA).

Soil samples were obtained using 2¼- in (outside diameter) split-barrel (split-spoon) sampler driven during Standard Penetration Tests (SPT) in general accordance with AASHTO T206. Soil samples were typically recovered at 2.5 ft and 5.0 ft intervals by driving the split-spoon sampler a distance of 24 inches into the undisturbed soil under the impact of a 140 lb. automatic hammer free-falling 30 inches. The total number of blows recorded for the middle twelve inches of the 24-inch sample range is designated as the “Standard Penetration

Resistance" or N-value.

The number of blows required to advance the sampler through each 6-in. Interval was recorded on the field boring logs. Upon completion of the SPT's, the sampler was removed from the ground and sample recovery measurements were made and recorded for each sampling event. A field description by color, texture, and moisture was made for each recovered sample. Representative portions of split-spoon samples were preserved in glass jars for laboratory testing. The SPT N-values were recorded on the boring logs.

After examination by the drilling personnel, all information was logged. Soil samples collected in the field were delivered to EFLHD Materials Testing facility in Sevierville, TN for laboratory testing and storage. The sampling sequence and associated samples for the boring is presented in Attachment No. 3.

Data Summary

The results of field tests and measurements were recorded on the driller's logs and appropriate data sheets in the field. These data sheets and logs contain information concerning the boring methods, samples attempted and recovered, indications of the presence of various materials such as gravel, pebbles, organic matter, and observations of groundwater. They also contain interpretations by the exploration foreman of the subsurface conditions based on the performance of the equipment and cuttings brought to the surface by the drilling tools. Therefore, the field data represents both factual and interpretative information.

The boring logs in Attachment No. 3 represent compilation of field and laboratory data and description of the soil samples by a geotechnical engineer. These records, occasionally, may not include all data recorded on driller's logs and field data sheets, but do include all information considered relevant to the design and preparation of this report.

Groundwater level readings were made in the boreholes at the times and under the conditions stated on the boring logs. Fluctuations in groundwater levels due to seasonal variations, rainfall, temperature, and other factors not evident at the time measurements were made should be expected.

Laboratory Testing

A laboratory-testing program was conducted on representative soil samples recovered during the subsurface exploration to evaluate the engineering parameters required for the geotechnical analyses. The laboratory tests included, natural moisture content (AASHTO T-265), Atterberg limits (AASHTO T-89/90), particle size analysis (AASHTO T-88), and soil classification (AASHTO M-145). The results of the laboratory testing program are presented in Attachment No.3 and are summarized in Table 1.

Table 1 – Summary of Soil Laboratory Testing Results

Boring No.	Sample Depth (ft)	AASHTO Classification	USCS Classification	MC (%)	LL (%)	PL (%)	PI (%)
B-1/J-10	*35-37*	*A-1-b*	*Silty SAND (SM)*	*14.5*	*NP*	*NP*	*NP*
B-2/J-10	*35-37*	*A-4(0)*	*Sandy SILT (ML)*	*17.0*	*NP*	*NP*	*NP*
B-2/J-15	*60-62*	*A-4(0)*	*Silty SAND (SM)*	*14.3*	*NP*	*NP*	*NP*
B-3/J-4	*10-12*	*A-1-b*	*Silty GRAVEL with Sand (GM)*	*12.2*	*NP*	*NP*	*NP*
B-3/J-11	*40-42*	*A-4(0)*	*SILT with Sand (ML)*	*17.6*	*NP*	*NP*	*NP*
B-4/J-12	*45-47*	*A-4(0)*	*Sandy SILT (ML)*	*21.1*	*NP*	*NP*	*NP*
B-6/J-1	*3-5*	*A-4(2)*	*Sandy Lean CLAY (CL)*	*18.4*	*20*	*29*	*9*

NP: Non Plastic

Findings

Description of the subsurface conditions encountered during our subsurface exploration is provided below. The stratification lines designating the interfaces between soil types in the boring logs in Attachment No. 2 represent approximate boundaries. In the field, the transition between materials may be gradual or may not exist. It should be noted that one or more of the units may be absent at specific locations.

The subsurface profile encountered in the borings can be summarized as follows:

Pavement – Pavement thicknesses encountered in the soil borings ranged from 0.6 ft in Boring C-5 to 2.4 ft in Boring B-3.

Fill (Silty Sand, Gravelly Sand, and Sandy Clay) - Materials identified as man-placed fill, probably associated with the existing embankment, were encountered in the soil borings. The fill layer extended to depths of 5 ft below existing site grades in Boring B-1, B-3, and B-6 to 7 ft below existing site grades in Boring B-2. SPT N-values for the fill materials ranged from 7 blows per foot (bpf) in Boring B-2 to 24 bpf in Boring B-1. It should be noted that

cobbles and boulders were encountered in the top 5 ft in Boring B-4 and no split spoon sampling was performed within this layer.

Natural Deposits (Silt, Sandy Silt, Silty Sand, Sand, Sandy Gravel, and Gravel) – Natural deposits were encountered underneath the fill layer and extended to the termination depths of the soil borings. N-values for these deposits ranged between 7 and 48 bpf.

Since cobbles and boulders were encountered in Boring B-4 and auger refusal was encountered in Boring B-5, it is possible that cobbles, boulders, and auger refusal can be encountered at different locations and depths throughout the site.

The contractor should be aware that auger refusal was encountered at varying depths and locations at the site during our drilling operations and should be anticipated in the project site.

Groundwater – The highest groundwater was encountered at a depth of 32 ft below existing site grades in Boring B-1.

Fluctuations in groundwater levels due to seasonal variations, rainfall, site topography, temperature, and other factors not evident at the time measurements were made should be expected.

DESIGN ANALYSIS

Options considered for the site included the installation of drilled piers to stabilize the existing slope along with the construction of a new H-pile retaining wall to support the failed road section and installing soil nails to stabilize the bike trail. Another option considered was the re-alignment of the bike trail to run alongside Rte. 209, the installation of drilled piers to stabilize the existing slope along with and the construction of a new H-pile retaining wall to support the road and trail. The latter option was selected and was considered in this study.

Geotechnical Analysis

A slope stability analysis was performed using the computer program SLOPE W (2005).

Design analyses were performed based on data obtained from our subsurface exploration program and laboratory test results, where available. The soil properties presented in Table 2 below were developed based on empirical correlations between available laboratory test results and SPT N-values. Design analyses were performed using a generalized subsurface profile and using the material properties below and the subsurface profiles as presented in Attachment 2.

Table 2 – Soil Parameters

Material Type	Unit Weight, γ (pcf)	Friction Angle, Φ (deg.)	Cohesion, c (psf)
Medium dense Silty Sand	125	23	0
Medium dense to dense Silty Sand	125	25	0

Our analysis yielded a minimum factor of safety for global stability of 1.385. Computer outputs are included in Attachment No. 5.

H-piles and soils anchors analyses were performed using Shoring Suite (V8) and the computer outputs are also included in Attachment No. 5.

RECOMMENDATIONS

Soil Anchors

Minimum bonded length:50 ft
Minimum unbounded length: 20 ft
Reinforcement Direction: 15 degree from horizontal
Anchor Design Load (DL): 60 kips
Lock off Load: 1.0 DL

We recommend that all anchors should be proof-tested to 1.33 DL and the minimum of six (6) anchors be performance tested to 2.0 DL. Anchors, plates, and bolts should be corrosion protected.

Drilled Piers and H-Piles

Pier Diameters: 2 ft
Pile Size: HP 14x89
Pile E: 29,000 ksi
I: 904 in^4 /pile
Pile Lengths: 60 ft (minimum)
Pier and Pile Spacing: 5 ft center to center

CONSTRUCTION CONSIDERATIONS

Excavations – All excavations are to be performed in accordance with applicable OSHA, Federal, State, and Local regulations and with Section 204 of the FP-03 Specifications.

Ground and Surface Water Management: Control of storm or seepage water flowing into open excavations and through soil strata will be necessary in order to maintain dry conditions during construction. The contractor should control the flow of surface and seepage water into excavations at all times. Storm water

collection and control during construction may be performed using collection trenches and sumps, if accumulation does occur.

Backfill Material: The portion of the on-site excavated material that meets the select granular backfill requirement in accordance with Section 704.10 of the FP-03 and the SCR can be used as backfill material. Backfill material should be placed and compacted in accordance with Section 204, and the specified maximum dry density should be achieved within a water content of ±2%.

Auger Refusal: Cobble, boulders, and auger refusal were encountered during our drilling operations and should be anticipated. The contractor should be aware of such subsurface conditions in his bidding process.

DISCLAIMER/LIMITATIONS CLAUSE

The subsurface explorations and test described in the section Procedures and Results have been conducted in accordance with standard practices and procedures (except as specifically noted). The results of these exploration and test represent conditions at the specific locations indicated. Subsurface conditions between these locations may vary. The Analysis and Conclusions sections and the Recommendations section of this report include interpretations and recommendations developed by the Government in the process of preparing the design. These interpretations are not intended as a substitute for the personal investigation, independent interpretation, and judgment of the Contractor.

Enclosures:

Attachment No. 1 – Figures
Attachment No. 2 – Borings Location Map and Soil Profile
Attachment No. 3 – Boring Logs
Attachment No. 4 – Laboratory Test Results
Attachment No. 5 – Computer Output

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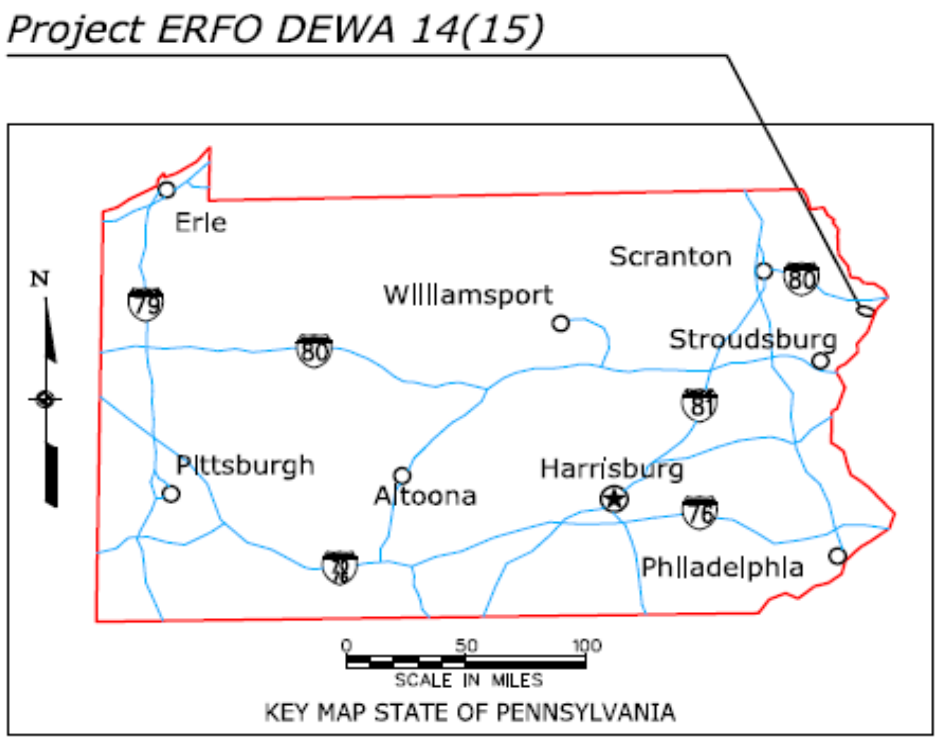
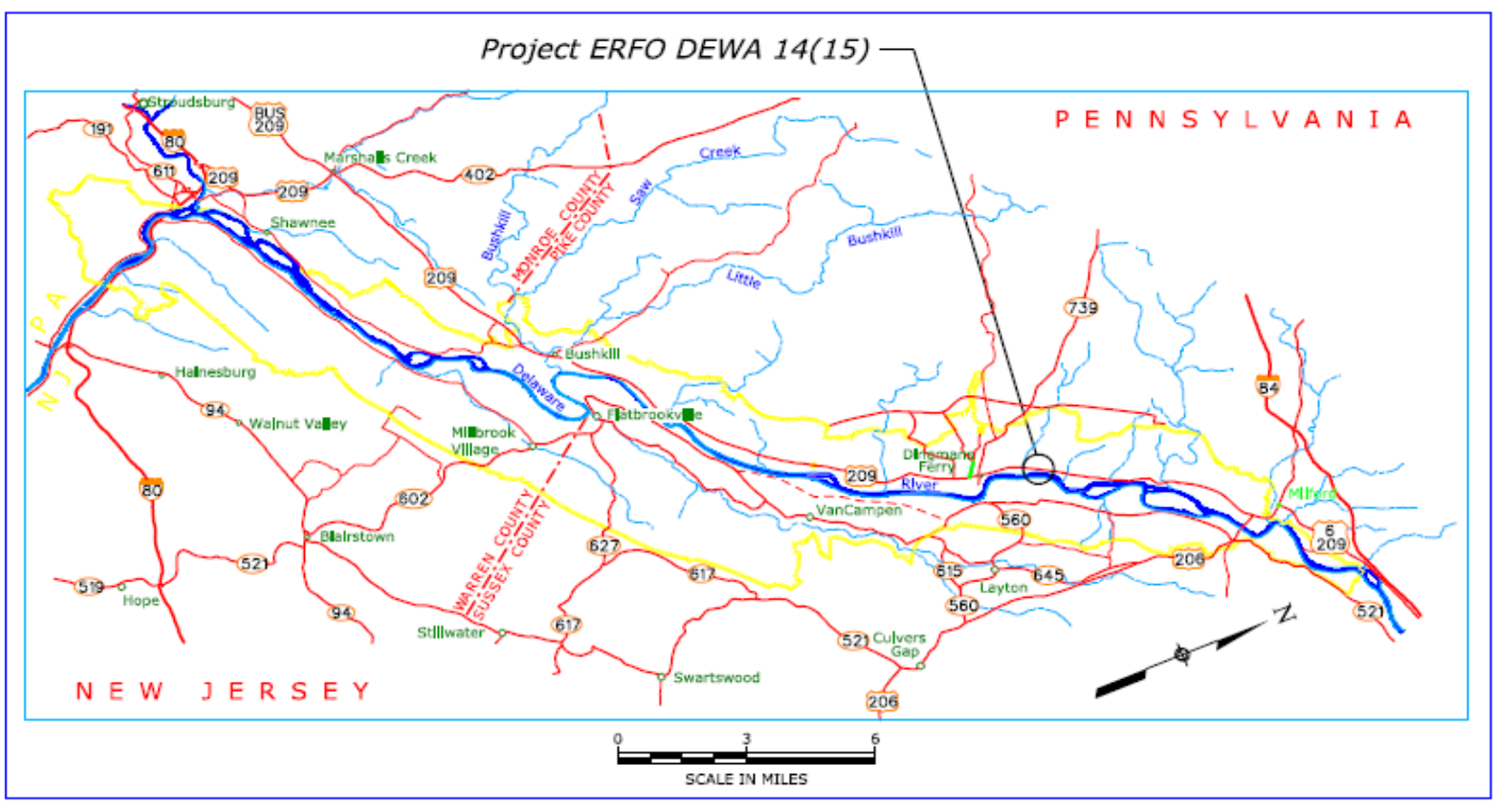
Attachment No. 1 – Figures





U.S. DEPARTMENT OF TRANSPORTATION FEDERAL LANDS HIGHWAY DIVISION EASTERN FEDERAL LANDS HIGHWAY DIVISION STERLING, VIRGINIA	**PROJECT LOCATION MAP** DELAWARE WATER GAP SLIDE AT MP15.3	REG	STATE	PROJECT	SHEET NO.	TOTAL SHEETS
		NE	PA	ERFO DEWA 14(15)	1	1

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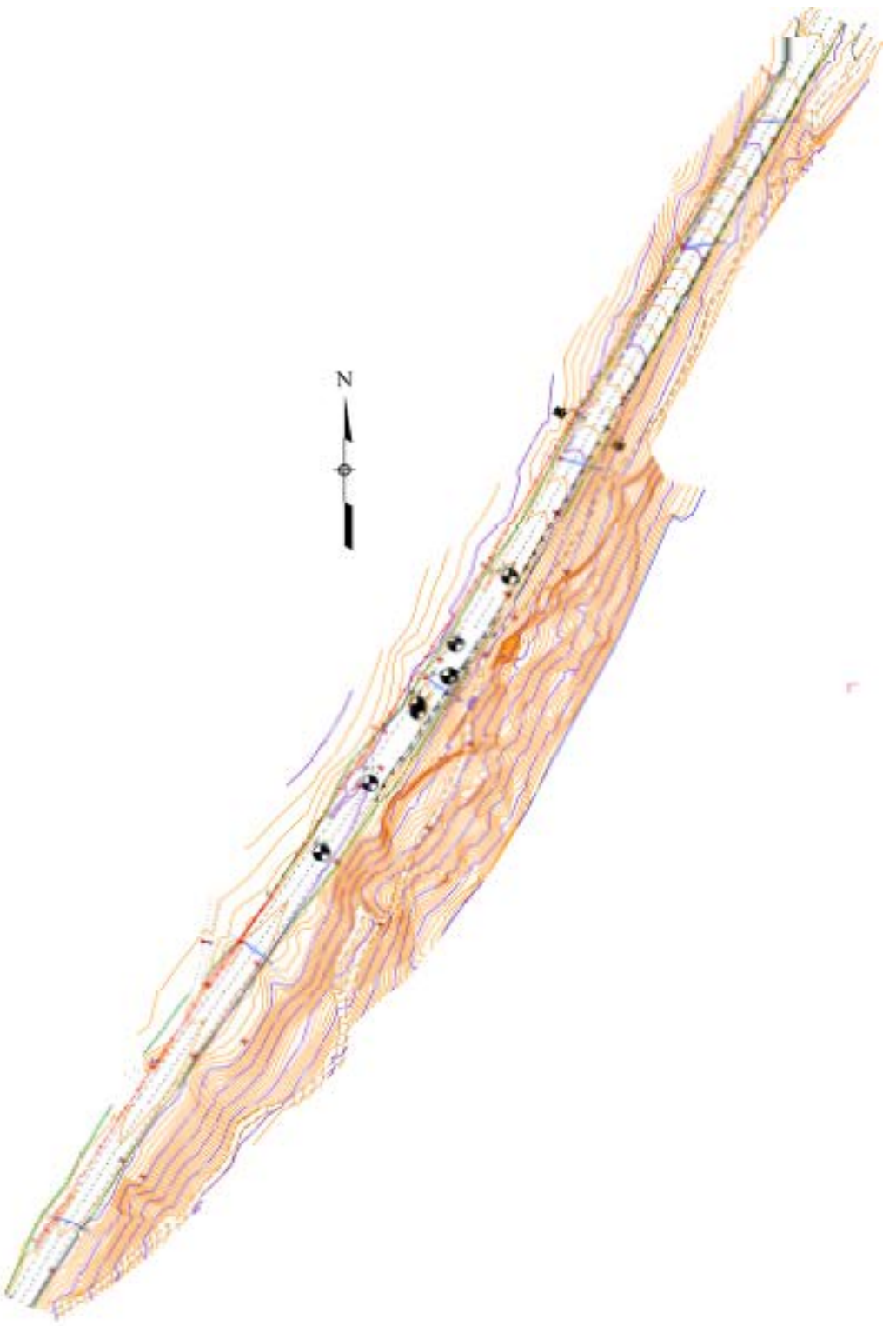
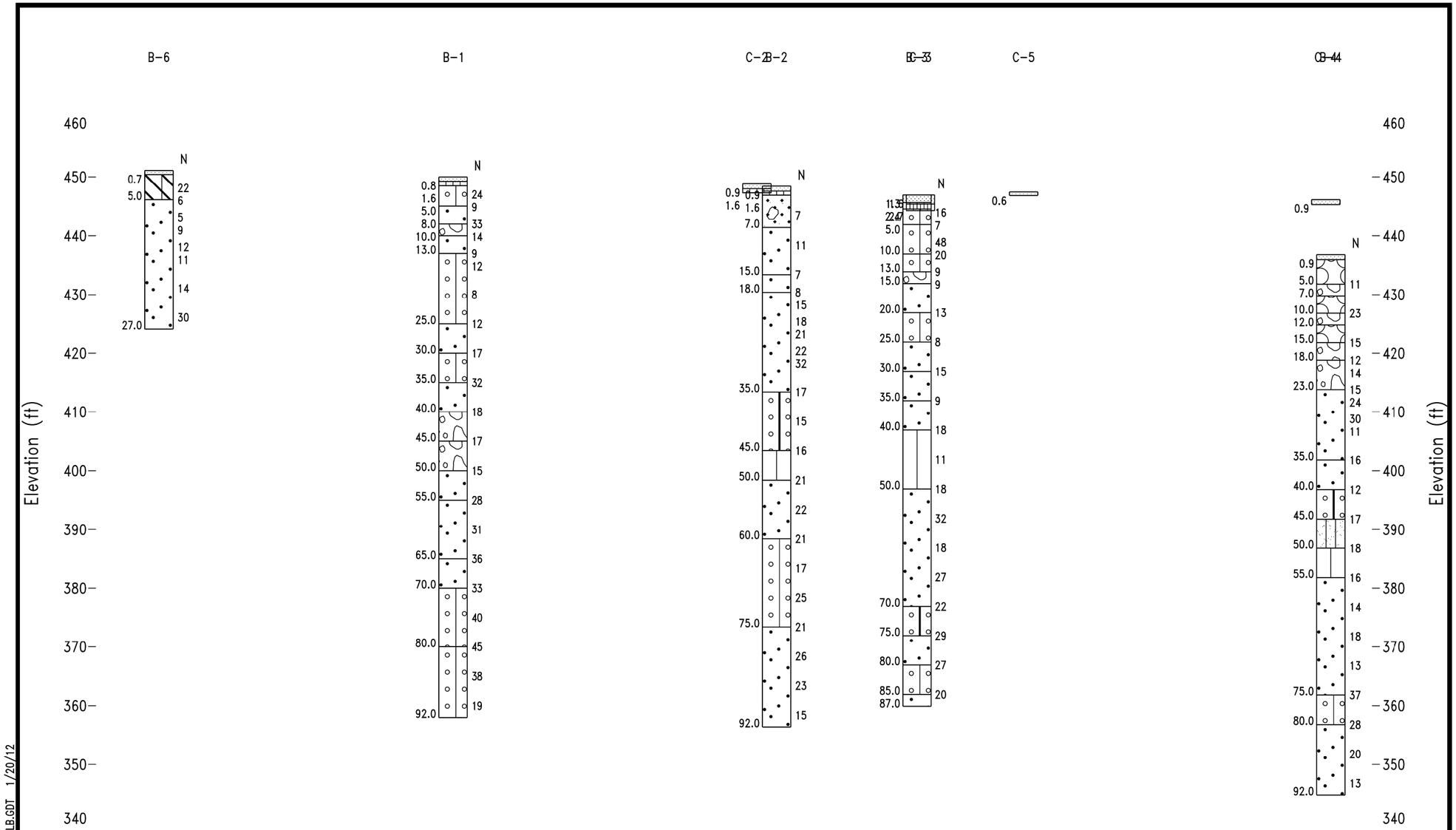
Attachment No. 2 – Borings Location Map and Soil Profile



U.S. DEPARTMENT OF TRANSPORTATION FEDERAL LANDS HIGHWAY DIVISION EASTERN FEDERAL LANDS HIGHWAY DIVISION STERLING, VIRGINIA	**BORINGS LOCATION MAP** DELAWARE WATER GAP SLIDE AT MP15.3	REG	STATE	PROJECT	SHEET NO.	TOTAL SHEETS
		NE	PA	ERFO DEWA 14(15)	2	2



LEGEND

▽ – Depth water was encountered during drilling.

▼ – Groundwater depth monitored after boring completion or after 24 hours.

Note: Strata changes shown on this profile represent generalizations based on average conditions indicated by soil test borings.

GENERALIZED SUBSURFACE PROFILE Section DEWA 14(15)		
Scale: 1H = 2.5V	Date: 1/20/12	Drawn By: M Elias
DEWA 14(15) Pike County, PA		
		Drawing No:

STRATIGRAPHY N GW DEWA14(15).GPJ TLB.GDT 1/20/12

Attachment No. 3 – Boring Logs

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: B-1 | Sheet: 1 of 4

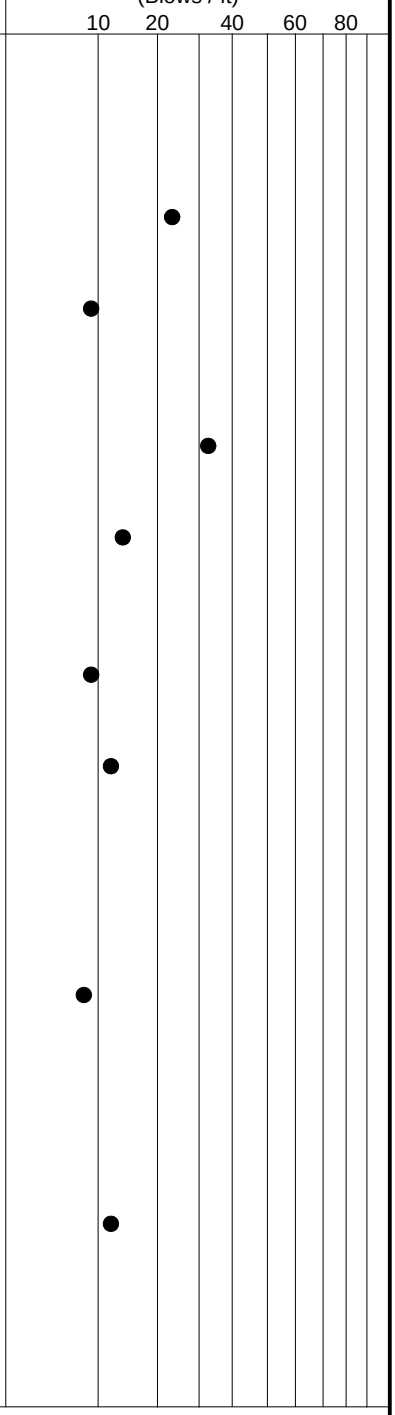
Project Location: Pike County, PA | Boring Location: Sta. 105+23.7

Groundwater Depth:		Surface Elevation:	450.0 ft	Boring Began:	11/12/11
Encountered at:		Caved at:		Boring Method:	HSA
At Completion:	32.0 ft	Hammer Wt. & Type:	140 lbs/Automatic	Hole Diameter:	8 in.
After ___ hrs		Hammer Drop:	30 in	Rock Core Diam:	

Completed:	11/14/11
Inspector:	M. Rosa
Operator:	R. Kingsley
Weather:	Sunny (40's)

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.
449.3		0.8	Asphalt Concrete (AC) Pavement					
448.5		1.6	Portland Cement Concerete (PCC) Pavement					
			Medium dense, brown, **SILTY SAND** , little to some gravel (Dry to moist) **-Possible FILL-**			J-1	1.0	9-14-10-7
445.0		5.0		5				
			Loose, brown, coarse **SAND** , little silt and gravel (Moist)			J-2	1.3	3-5-4-3
442.0		8.0						
			Dense, gray , **GRAVEL** , some brown coarse sand , little silt (Moist)			J-3	0.7	4-16-17-9
440.0		10.0		10				
			Medium dense, brown, fine to coarse **SAND** , little silt and gravel (Moist)			J-4	1.2	4-8-6-5
437.0		13.0						
			Loose to medium dense, brown, **SILTY SAND** , little gravel (Moist)			J-5	1.1	3-2-7-9
				15		J-6	1.1	5-7-5-5
				20		J-7	0.8	3-4-4-3
425.0		25.0		25				
			Medium dense, brown, **SAND** , little silt and gravel (Moist)			J-8	0.8	4-6-6-4
420.0		30.0		30				

▼ Water Content %
Plastic Limit ├──┤ Liquid Limit
● Standard Penetration Test Data (Blows / ft)



Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
Ground water measured at the end of drilling.
Boring was backfilled with auger cuttings.
Boring B-1 was drilled in the same location as Boring C-1.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: B-1 | Sheet: 2 of 4

Project Location: Pike County, PA | Boring Location: Sta. 105+23.7

Groundwater Depth:		Surface Elevation:	450.0 ft	Boring Began:	11/12/11	Completed:	11/14/11
Encountered at:	▽	Caved at:		Boring Method:	HSA	Inspector:	M. Rosa
At Completion:	32.0 ft ▼	Hammer Wt. & Type:	140 lbs/Automatic	Hole Diameter:	8 in.	Operator:	R. Kingsley
After ___ hrs	▽	Hammer Drop:	30 in	Rock Core Diam:		Weather:	Sunny (40's)

Elevation (feet)	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		Medium dense, brown, **SILTY SAND** , some gravel (Wet)			J-9	0.8	6-8-9-16	
415.0	35.0		35					
		Dense, brown, coarse **SAND** , little silt, clay and gravel (Wet)			J-10	2.0	7-10-22-22	
410.0	40.0		40					
		Medium dense, gray and black , **GRAVEL** , some sand and clay (Wet)			J-11	0.8	4-6-12-11	
405.0	45.0		45					
		Medium dense, gray , **GRAVEL** , little sand (Wet)			J-12	0.4	3-5-12-12	
400.0	50.0		50					
		Medium dense, brown and black, fine to coarse **SAND** , little silt (Wet) - Brown silt at 51.4'			J-13	2.0	3-7-8-10	
395.0	55.0		55					
		Medium dense to dense, brown , fine to coarse **SAND** , little silt (Moist)			J-14	1.4	4-12-16-21	
			60					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
Ground water measured at the end of drilling.
Boring was backfilled with auger cuttings.
Boring B-1 was drilled in the same location as Boring C-1.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: B-1 | Sheet: 3 of 4

Project Location: Pike County, PA | Boring Location: Sta. 105+23.7

Groundwater Depth:		Surface Elevation:	450.0 ft	Boring Began:	11/12/11	Completed:	11/14/11
Encountered at:		Caved at:		Boring Method:	HSA	Inspector:	M. Rosa
At Completion:	32.0 ft	Hammer Wt. & Type:	140 lbs/Automatic	Hole Diameter:	8 in.	Operator:	R. Kingsley
After ___ hrs		Hammer Drop:	30 in	Rock Core Diam:		Weather:	Sunny (40's)

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
			Medium dense to dense, brown , fine to coarse **SAND** , little silt (Moist) *(Continued)*			J-15	1.2	9-15-16-22	
385.0		65.0		65					
			Dense , brown and gray , **SAND** , little silt (Moist)			J-16	1.2	10-15-21-26	
380.0		70.0		70					
			Dense, brown, **SILTY SAND** (Moist) -Clay seam at 76' -Silt seam at 76.4'			J-17	1.3	9-15-18-21	
				75					
						J-18	1.4	12-19-21-34	
370.0		80.0		80					
			Medium dense to dense, brown, fine **SAND** , little silt (Moist)			J-19	1.6	12-20-25-33	
				85					
						J-20	1.6	12-16-22-18	
				90					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
Ground water measured at the end of drilling.
Boring was backfilled with auger cuttings.
Boring B-1 was drilled in the same location as Boring C-1.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: B-1 | Sheet: 4 of 4

Project Location: Pike County, PA | Boring Location: Sta. 105+23.7

Groundwater Depth:		Surface Elevation:	450.0 ft	Boring Began:	11/12/11
Encountered at:		Caved at:		Boring Method:	HSA
At Completion:	32.0 ft	Hammer Wt. & Type:	140 lbs/Automatic	Hole Diameter:	8 in.
After ___ hrs		Hammer Drop:	30 in	Rock Core Diam:	

Completed:	11/14/11
Inspector:	M. Rosa
Operator:	R. Kingsley
Weather:	Sunny (40's)

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
358.0		92.0			SPT	J-21	2.0	2-7-12-21	●
			Borehole terminated @ 92 ft						
				95					
				100					
				105					
				110					
				115					
				120					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
Ground water measured at the end of drilling.
Boring was backfilled with auger cuttings.
Boring B-1 was drilled in the same location as Boring C-1.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: B-2 | Sheet: 1 of 4

Project Location: Pike County, PA | Boring Location: Sta. 106+59.8

Groundwater Depth:		Surface Elevation:	448.4 ft	Boring Began:	11/11/11
Encountered at:		Caved at:		Boring Method:	HSA
At Completion:	84.1 ft	Hammer Wt. & Type:	140 lbs/Automatic	Hole Diameter:	8 in.
After ___ hrs		Hammer Drop:	30 in	Rock Core Diam:	

Completed:	11/11/11
Inspector:	M. Rosa
Operator:	R. Kingsley
Weather:	Sunny (30's)

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.
447.6		0.9	Asphalt Concrete (AC) Pavement					
446.9		1.6	Portland Cement Concerete (PCC) Pavement					
			Loose , brown, **GRAVELY SAND** , little silt (Moist) **-Possible FILL-**	5		J-1	0.3	2-4-3-9
441.4		7.0	Loose, brown, **SAND** , little silt and gravel (Moist)	10		J-2	0.6	4-4-7-8
433.4		15.0	Loose, brown, **SAND** , little silt (Moist)	15		J-3	0.9	3-3-4-3
430.4		18.0	Loose to medium dense, brown, **SAND** , little silt , little to some gravel (Dry to moist)	20		J-4	1.4	4-4-4-5
						J-5	1.5	5-8-7-8
				25		J-6	1.2	7-9-9-6
						J-7	1.2	7-10-11-9
				30		J-8	1.3	6-11-11-11

▼ Water Content %
Plastic Limit ├──┤ Liquid Limit
● Standard Penetration Test Data (Blows / ft)

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
Ground water measured at the end of drilling and after 17 hrs.
Boring was backfilled with auger cuttings.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) Boring No.: B-2 Sheet: 2 of 4

Project Location: Pike County, PA Boring Location: Sta. 106+59.8

Groundwater Depth:		Surface Elevation:	448.4 ft	Boring Began:	11/11/11	Completed:	11/11/11
Encountered at:		Caved at:		Boring Method:	HSA	Inspector:	M. Rosa
At Completion:	84.1 ft	Hammer Wt. & Type:	140 lbs/Automatic	Hole Diameter:	8 in.	Operator:	R. Kingsley
After ___ hrs		Hammer Drop:	30 in	Rock Core Diam:		Weather:	Sunny (30's)

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
			Loose to medium dense, brown, **SAND** , little silt , little to some gravel (Dry to moist) *(Continued)*			J-9	1.3	10-17-15-20	
413.4		35.0		35					
			Medium dense, brown, **SANDY SILT** , [A-4(0)] (Moist) Silty clay seam at (35.0' and 35.2')			J-10	1.5	7-7-10-10	
				40					
						J-11	1.4	6-7-8-13	
403.4		45.0		45					
			Medium dense, brown, **SILT** , little sand (Wet)			J-12	1.4	6-6-10-10	
398.4		50.0		50					
			Medium dense, brown, **SAND** , little silt (Moist)			J-13	1.7	7-9-12-10	
				55					
						J-14	1.6	7-10-12-17	
388.4		60.0		60					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
Ground water measured at the end of drilling and after 17 hrs.
Boring was backfilled with auger cuttings.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: B-2 | Sheet: 3 of 4

Project Location: Pike County, PA | Boring Location: Sta. 106+59.8

Groundwater Depth:		Surface Elevation:	448.4 ft	Boring Began:	11/11/11
Encountered at:		Caved at:		Boring Method:	HSA
At Completion:	84.1 ft	Hammer Wt. & Type:	140 lbs/Automatic	Hole Diameter:	8 in.
After ___ hrs		Hammer Drop:	30 in	Rock Core Diam:	

Completed:	11/11/11
Inspector:	M. Rosa
Operator:	R. Kingsley
Weather:	Sunny (30's)

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
			Medium dense, brown, **SILTY SAND** , [A-4(0)] (Moist to wet)		SPT	J-15	1.5	5-10-11-13	●
			-Red-brown clay seam at 60.4'						
				65	SPT	J-16	1.7	7-8-9-10	●
				70	SPT	J-17	2.0	10-13-12-15	●
373.4		75.0		75					
			Medium dense, brown , fine **SAND** , little silt (Moist to wet)		SPT	J-18	1.5	7-10-11-17	●
				80	SPT	J-19	1.4	8-13-13-15	●
				85	SPT	J-20	2.0	7-11-12-15	●
				90					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
Ground water measured at the end of drilling and after 17 hrs.
Boring was backfilled with auger cuttings.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: B-2 | Sheet: 4 of 4

Project Location: Pike County, PA | Boring Location: Sta. 106+59.8

Groundwater Depth:		Surface Elevation:	448.4 ft	Boring Began:	11/11/11
Encountered at:		Caved at:		Boring Method:	HSA
At Completion:	84.1 ft	Hammer Wt. & Type:	140 lbs/Automatic	Hole Diameter:	8 in.
After	hrs	Hammer Drop:	30 in	Rock Core Diam:	

Completed:	11/11/11
Inspector:	M. Rosa
Operator:	R. Kingsley
Weather:	Sunny (30's)

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
			Medium dense, brown , fine **SAND** , little silt (Moist to wet) *(Continued)*			J-21	2.0	3-5-10-16	●
356.4		92.0	Borehole terminated @ 92 ft						
				95					
				100					
				105					
				110					
				115					
				120					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
Ground water measured at the end of drilling and after 17 hrs.
Boring was backfilled with auger cuttings.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: B-3 | Sheet: 1 of 3

Project Location: Pike County, PA | Boring Location: Sta. 107+18.8

Groundwater Depth:	Surface Elevation: 446.9 ft	Boring Began:	11/9/11	Completed:	11/10/11
Encountered at:	Caved at:	Boring Method:	HSA	Inspector:	M. Rosa
At Completion:	Hammer Wt. & Type: 140 lbs/Automatic	Hole Diameter:	8 in.	Operator:	R. Kingsley
After ____ hrs	Hammer Drop: 30 in	Rock Core Diam:		Weather:	Sunny (50's)

Elevation (feet)	Layer Depth (ft)	MATERIAL DESCRIPTION (Density, Color, Plasticity, Size, Proportions, Moisture)	Depth Scale (ft)	Sample Type	No.	Rec.	Blows per 6 in.
445.6	1.3	Asphalt Concrete (AC) Pavement					
444.5	2.4	Portland Cement Concerete (PCC) Pavement					
441.9	5.0	Medium dense, brown and gray, **SILTY SAND** , little to some gravel (Dry) **-Possible FILL-**	5	SPT	J-1	0.5	5-9-7-7
436.9	10.0	Loose to dense, brown , **SILTY SAND** , little to some gravel (Moist) -Limestone boulders encountered during augering	10	SPT	J-2	0.9	4-4-3-4
				SPT	J-3	0.7	8-29-19-14
433.9	13.0	Medium dense, brown , **SILTY SAND** (Moist)		SPT	J-4	0.8	3-8-12-9
431.9	15.0	Loose, brown and black, **SANDY GRAVEL** , little silt (Moist)	15	SPT	J-5	0.8	7-5-4-8
426.9	20.0	Loose, brown and black, **SAND** , some gravel , little silt (Moist)	20	SPT	J-6	1.1	4-5-4-3
421.9	25.0	Medium dense, brown, **SILTY SAND** , little gray gravel (Moist)	25	SPT	J-7	0.5	5-7-6-4
416.9	30.0	Loose, brown and gray, **SAND** , little silt (Moist)	30	SPT	J-8	1.2	4-4-4-4

▼ Water Content %
Plastic Limit ├──┤ Liquid Limit
● Standard Penetration Test Data (Blows / ft)
10 20 40 60 80

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water encountered during dilling.
Boring was backfilled with auger cuttings.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: B-3 | Sheet: 2 of 3

Project Location: Pike County, PA | Boring Location: Sta. 107+18.8

Groundwater Depth:	Surface Elevation: 446.9 ft	Boring Began:	11/9/11	Completed:	11/10/11
Encountered at:	Caved at:	Boring Method:	HSA	Inspector:	M. Rosa
At Completion:	Hammer Wt. & Type: 140 lbs/Automatic	Hole Diameter:	8 in.	Operator:	R. Kingsley
After ____ hrs	Hammer Drop: 30 in	Rock Core Diam:		Weather:	Sunny (50's)

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
			Medium dense, brown and gray, **SAND**, little silt, little gravel (Moist)		SPT	J-9	1.1	6-7-8-12	●
411.9		35.0		35					
			Loose, gray and black, coarse **SAND**, little silt (Moist to wet)		SPT	J-10	1.6	6-5-4-6	●
406.9		40.0		40					
			Medium dense, brown, **SILT**, little sand [A-4(0)] (Wet)		SPT	J-11	1.7	9-9-9-7	●
				45	SPT	J-12	1.5	5-6-5-6	●
396.9		50.0		50					
			Medium dense to dense, brown, **SAND**, little silt, (Wet) - Red-brown clay seam (0.1') at 60.7'		SPT	J-13	1.9	7-9-9-9	●
				55	SPT	J-14	1.3	11-15-17-18	●
				60					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water encountered during dilling.
Boring was backfilled with auger cuttings.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) Boring No.: B-3 Sheet: 3 of 3

Project Location: Pike County, PA Boring Location: Sta. 107+18.8

Groundwater Depth:	Surface Elevation: 446.9 ft	Boring Began:	11/9/11	Completed:	11/10/11
Encountered at:	Caved at:	Boring Method:	HSA	Inspector:	M. Rosa
At Completion:	Hammer Wt. & Type: 140 lbs/Automatic	Hole Diameter:	8 in.	Operator:	R. Kingsley
After hrs	Hammer Drop: 30 in	Rock Core Diam:		Weather:	Sunny (50's)

Elevation (feet)	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	Sample Type	No.	Rec.	Blows per 6 in.
		Medium dense to dense, brown , **SAND** , little silt, (Wet) - Red-brown clay seam (0.1') at 60.7' *(Continued)*			J-15	1.6	8-9-9-8
			65		J-16	1.7	7-12-15-15
376.9	70.0		70				
		Medium dense , brown , **SILT** , little sand (Wet) - Red-brown clay seam at 70.3' and 71.2'			J-17	1.7	4-10-12-15
371.9	75.0		75				
		Medium dense , brown , **SAND** , little silt (Moist)			J-18	1.5	11-13-16-16
366.9	80.0		80				
		Medium dense, brown, **SILTY SAND** (Moist)			J-19	1.4	11-15-12-14
361.9	85.0		85				
		Medium dense , brown, **SAND** , little silt (Wet)			J-20	2.0	4-8-12-11
359.9	87.0						
		Borehole terminated @ 87 ft					
			90				

▼ Water Content %
Plastic Limit ├──┤ Liquid Limit
● Standard Penetration Test Data (Blows / ft)

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water encountered during dilling.
Boring was backfilled with auger cuttings.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

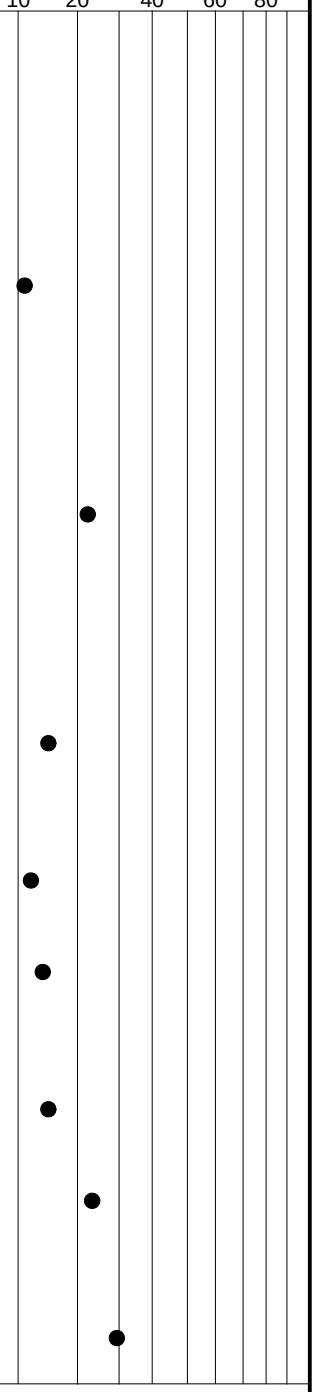
Project Name: ERFO DEWA 14(15) Boring No.: B-4 Sheet: 1 of 4

Project Location: Pike County, PA Boring Location: Sta. 108+89.5

Groundwater Depth:	Surface Elevation: 446.1 ft	Boring Began:	11/14/11	Completed:	11/15/11
Encountered at:	Caved at:	Boring Method:	HSA	Inspector:	M. Rosa
At Completion:	Hammer Wt. & Type: 140 lbs/Automatic	Hole Diameter:	8 in.	Operator:	R. Kingsley
After hrs	Hammer Drop: 30 in	Rock Core Diam:		Weather:	Cloudy/Light rain

Elevation (feet)	Layer Depth (ft)	MATERIAL DESCRIPTION (Density, Color, Plasticity, Size, Proportions, Moisture)	Depth Scale (ft)	Sample Type	No.	Rec.	Blows per 6 in.
445.3	0.9	Asphalt Concrete (AC) Pavement					
441.1	5.0	**COBBLES** and **BOULDERS**	5				
439.1	7.0	Medium dense, gray , **GRAVEL** , some brown and black coase sand, little silt (Dry)			J-1	1.1	3-6-5-6
436.1	10.0	**COBBLES** and **BOULDERS**	10				
434.1	12.0	Medium dense, gray , **GRAVEL** , some brown and black coase sand, little silt (dry)			J-2	0.6	5-6-17-14
431.1	15.0	**COBBLES** and **BOULDERS**	15				
428.1	18.0	Medium dense, gray, **GRAVEL** (Dry) -Boulders at 17' to 18'			J-3	0.5	5-8-7-9
423.1	23.0	Medium dense, gray, **GRAVEL** , brown-gray coarse sand, little silt (Moist) -Boulders at 17' to 18'	20		J-4	0.5	4-7-5-10
					J-5	0.5	5-9-5-3
		Medium dense, gray-brown, fine to coarse **SAND** and (Moist)	25		J-6	1.2	5-6-9-11
					J-7	1.3	11-13-11-11
			30		J-8	1.3	28-20-10-8

▼ Water Content %
Plastic Limit ├──┤ Liquid Limit
● Standard Penetration Test Data (Blows / ft)



Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water encountered during dilling.
Boring was backfilled with auger cuttings.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

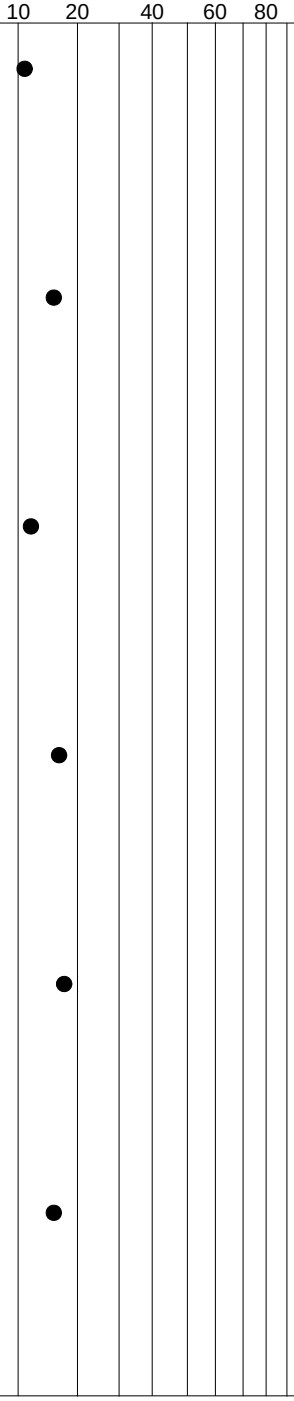
Project Name: ERFO DEWA 14(15) | Boring No.: B-4 | Sheet: 2 of 4

Project Location: Pike County, PA | Boring Location: Sta. 108+89.5

Groundwater Depth:	Surface Elevation: 446.1 ft	Boring Began:	11/14/11	Completed:	11/15/11
Encountered at:	Caved at:	Boring Method:	HSA	Inspector:	M. Rosa
At Completion:	Hammer Wt. & Type: 140 lbs/Automatic	Hole Diameter:	8 in.	Operator:	R. Kingsley
After ____ hrs	Hammer Drop: 30 in	Rock Core Diam:		Weather:	Cloudy/Light rain

Elevation (feet)	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.
		Medium dense, gray-brown, fine to coarse **SAND** and (Moist) *(Continued)*			J-9	1.2	8-7-4-6
411.1	35.0		35				
		Medium dense, brown-gray, **SAND** , little silt (Moist) -Brown silt seam (0.2') at 35.9' -Boulders at 37' to 40'			J-10	1.1	10-8-8-5
406.1	40.0		40				
		Medium dense, light brown , **SANDY SILT** (Wet) -Red clay seam (0.1') at 40.7'			J-11	1.3	9-6-6-6
401.1	45.0		45				
		Medium dense, light brown, **SANDY SILT** , little clay [A-4(0)] (Wet) -Red clay seam at 49.9'			J-12	1.6	6-8-9-13
396.1	50.0		50				
		Medium dense, brown, **SILT** , little clay , little sand (Wet)			J-13	1.5	8-9-9-9
391.1	55.0		55				
		Medium dense , brown-gray , fine to coarse **SAND** , little silt (Moist)			J-14	1.4	5-7-9-12
			60				

▼ Water Content %
Plastic Limit ├──┤ Liquid Limit
● Standard Penetration Test Data (Blows / ft)



Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water encountered during dilling.
Boring was backfilled with auger cuttings.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: B-4 | Sheet: 3 of 4

Project Location: Pike County, PA | Boring Location: Sta. 108+89.5

Groundwater Depth:	Surface Elevation: 446.1 ft	Boring Began:	11/14/11	Completed:	11/15/11
Encountered at:	Caved at:	Boring Method:	HSA	Inspector:	M. Rosa
At Completion:	Hammer Wt. & Type: 140 lbs/Automatic	Hole Diameter:	8 in.	Operator:	R. Kingsley
After ___ hrs	Hammer Drop: 30 in	Rock Core Diam:		Weather:	Cloudy/Light rain

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
			Medium dense , brown-gray , fine to coarse **SAND** , little silt (Moist) *(Continued)*		SPT	J-15	1.4	5-6-8-10	●
				65	SPT	J-16	1.4	6-8-10-11	●
				70	SPT	J-17	1.7	2-5-8-10	●
371.1		75.0		75					
			Dense, brown, **SILTY SAND** (Moist) -Red clay seam at 75.5'		SPT	J-18	1.5	9-17-20-23	●
366.1		80.0		80					
			Medium dense , brown, **SAND** , little silt (Moist to wet)		SPT	J-19	1.6	10-13-15-18	●
				85	SPT	J-20	1.6	3-8-12-13	●
				90					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water encountered during dilling.
Boring was backfilled with auger cuttings.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: B-4 | Sheet: 4 of 4

Project Location: Pike County, PA | Boring Location: Sta. 108+89.5

Groundwater Depth:	Surface Elevation: 446.1 ft	Boring Began:	11/14/11	Completed:	11/15/11
Encountered at:	Caved at:	Boring Method:	HSA	Inspector:	M. Rosa
At Completion:	Hammer Wt. & Type: 140 lbs/Automatic	Hole Diameter:	8 in.	Operator:	R. Kingsley
After ____ hrs	Hammer Drop: 30 in	Rock Core Diam:		Weather:	Cloudy/Light rain

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
			Medium dense , brown, **SAND** , little silt (Moist to wet) *(Continued)*			J-21	1.8	2-5-8-13	●
354.1		92.0	Borehole terminated @ 92 ft						
				95					
				100					
				105					
				110					
				115					
				120					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water encountered during dilling.
Boring was backfilled with auger cuttings.

BORING LOG

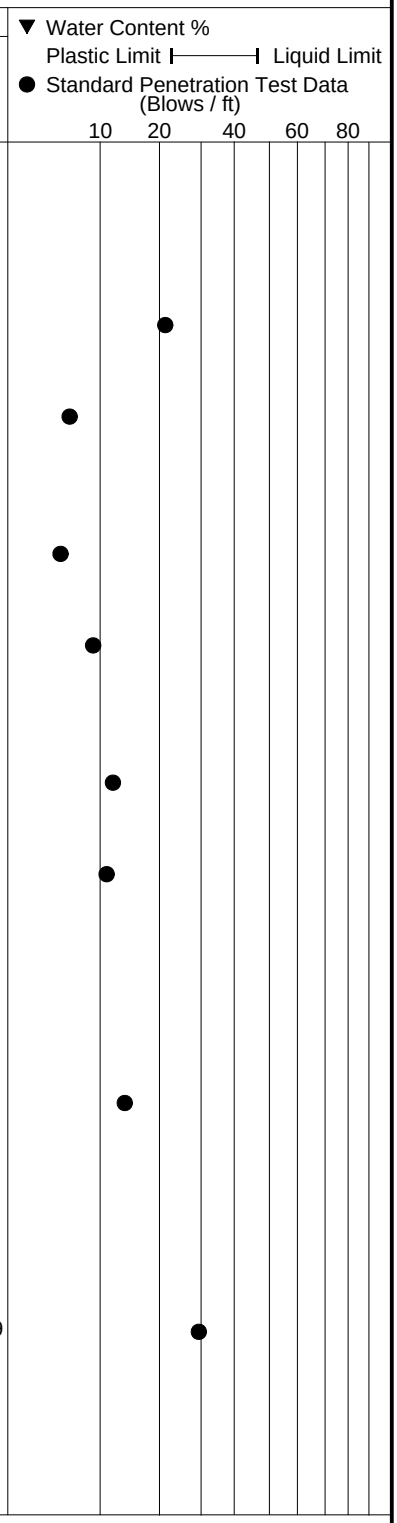
U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: B-6 | Sheet: 1 of 1

Project Location: Pike County, PA | Boring Location: Sta. 104+00.5

Groundwater Depth:	Surface Elevation: 451.1 ft	Boring Began:	11/12/11	Completed:	11/12/11
Encountered at:	Caved at:	Boring Method:	HSA	Inspector:	M. Rosa
At Completion:	Hammer Wt. & Type: 140 lbs/Automatic	Hole Diameter:	8 in.	Operator:	R. Kingsley
After ____ hrs	Hammer Drop: 30 in	Rock Core Diam:		Weather:	Sunny (30's)

Elevation (feet)	Layer Depth (ft)	MATERIAL DESCRIPTION (Density, Color, Plasticity, Size, Proportions, Moisture)	Depth Scale (ft)	Type	No.	Rec.	Blows per 6 in.
450.4	0.7	Asphalt Concrete (AC) Pavement					
		Very stiff, brown, **SANDY CLAY** [A-4-(2)] (Moist) **-Possible FILL-**		SPT	J-1	1.3	3-15-7-6
446.1	5.0	Loose to medium dense, brown, fine to coarse **SAND** and **GRAVEL**, little silt (Moist)	5	SPT	J-2	1.5	2-3-3-3
				SPT	J-3	1.5	4-3-2-1
			10	SPT	J-4	1.1	4-3-6-10
				SPT	J-5	0.5	4-5-7-7
			15	SPT	J-6	1.1	4-4-7-4
			20	SPT	J-7	1.1	2-5-9-7
			25	SPT	J-8	1.0	11-13-17-19
424.1	27.0	Borehole terminated @ 27 ft (Auger refusal)	30				



Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water encountered during dilling.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: C-2 | Sheet: 1 of 1

Project Location: Pike County, PA | Boring Location: Sta. 106+51.4

Groundwater Depth:	Surface Elevation: 448.8 ft	Boring Began:	11/9/11	Completed:	11/9/11
Encountered at:	Caved at:	Boring Method:	Core	Inspector:	M. Rosa
At Completion:	Hammer Wt. & Type: 140 lbs/Automatic	Hole Diameter:	4 in.	Operator:	R. Kingsley
After ____ hrs	Hammer Drop: 30 in	Rock Core Diam:		Weather:	Sunny (40's)

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture
448.0		0.9	Asphalt Concrete (AC) Pavement
447.3		1.6	Portland Cement Concerete (PCC) Pavement
			Coring terminated @ 1.55 ft

Depth Scale (ft): 5, 10, 15, 20, 25, 30

SAMPLE: Type | No. | Rec. | Blows per 6 in.

▼ Water Content %
Plastic Limit ├──┤ Liquid Limit
● Standard Penetration Test Data (Blows / ft)
10 20 40 60 80

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
Borehole was backfilled with stones and patched with asphalt.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: C-3 | Sheet: 1 of 1

Project Location: Pike County, PA | Boring Location: Sta. 107+19.6

Groundwater Depth:	Surface Elevation: 446.9 ft	Boring Began:	11/10/11	Completed:	11/10/11
Encountered at:	Caved at:	Boring Method:	Core	Inspector:	M. Rosa
At Completion:	Hammer Wt. & Type: 140 lbs/Automatic	Hole Diameter:	4 in.	Operator:	R. Kingsley
After ____ hrs	Hammer Drop: 30 in	Rock Core Diam:		Weather:	Sunny (50's)

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture
			Asphalt Concrete (AC) Pavement
445.4		1.6	
			Portland Cement Concerete (PCC) Pavement
444.3		2.7	-Pavement sample could not be extracted from the hole, pavemnt thickness was estimated.
			Coring terminated @ 2.65 ft

Depth Scale (ft): 5, 10, 15, 20, 25, 30

SAMPLE: Type | No. | Rec. | Blows per 6 in.

▼ Water Content %
Plastic Limit ├──┤ Liquid Limit
● Standard Penetration Test Data (Blows / ft)
10 20 40 60 80

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
Borehole was backfilled with stones and patched with asphalt.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: C-4 | Sheet: 1 of 1

Project Location: Pike County, PA | Boring Location: Sta. 108+90.2

Groundwater Depth:	Surface Elevation: 446.1 ft	Boring Began:	11/10/11	Completed:	11/10/11
Encountered at:	Caved at:	Boring Method:	Core	Inspector:	M. Rosa
At Completion:	Hammer Wt. & Type: 140 lbs/Automatic	Hole Diameter:	4 in.	Operator:	R. Kingsley
After hrs	Hammer Drop: 30 in	Rock Core Diam:		Weather:	Sunny (50's)

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
445.3		0.9	Asphalt Concrete (AC) Pavement -Gravel at the bottom of the sample						
			Coring terminated @ 0.85 ft						
				5					
				10					
				15					
				20					
				25					
				30					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
Borehole was backfilled with stones and patched with asphalt.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: ERFO DEWA 14(15) | Boring No.: C-5 | Sheet: 1 of 1

Project Location: Pike County, PA | Boring Location: Sta. 107+63.9

Groundwater Depth:	Surface Elevation: 447.4 ft	Boring Began:	11/10/11	Completed:	11/10/11
Encountered at:	Caved at:	Boring Method:	Core	Inspector:	M. Rosa
At Completion:	Hammer Wt. & Type: 140 lbs/Automatic	Hole Diameter:	4 in.	Operator:	R. Kingsley
After ____ hrs	Hammer Drop: 30 in	Rock Core Diam:		Weather:	Sunny (50's)

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
446.8		0.6	Asphalt Concrete (AC) Pavement -Base course layer encountered underneath the pavement						
			Coring terminated @ 0.85 ft						
				5					
				10					
				15					
				20					
				25					
				30					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
Borehole was backfilled with stones and patched with asphalt.

Use this form in lieu of transmittal slips within Dept. of Trans. When message comment is to be retained as file material. Do not prepare carbons. Not to be used in lieu of Form FHWA-121 for informal correspondence.

Attachment No. 4 – Laboratory Testing Results

Particle Size Distribution Report

	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	4.3	11.7	8.9	37.4	18.6	19.1	
□	0.0	0.0	14.8	14.7	17.4	16.2	36.9	
△	0.0	1.1	13.8	15.6	27.0	26.0	16.5	
◇	0.0	0.0	0.4	2.4	23.1	54.7	19.4	
▽	0.0	0.0	0.0	0.0	0.7	84.0	15.3	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	DESCRIPTION	USCS
○	Rte. 209	B-1/J-2	5-7		
□	Rte. 209	B-1/J-5	13-15		
△	Rte. 209	B-1/J-10	35-37	Silty sand	SM
◇	Rte. 209	B-1/J-14	55-57		
▽	Rte. 209	B-1/J-21	90-92		

Particle Size Distribution Report

FEDERAL HIGHWAY ADMINISTRATION

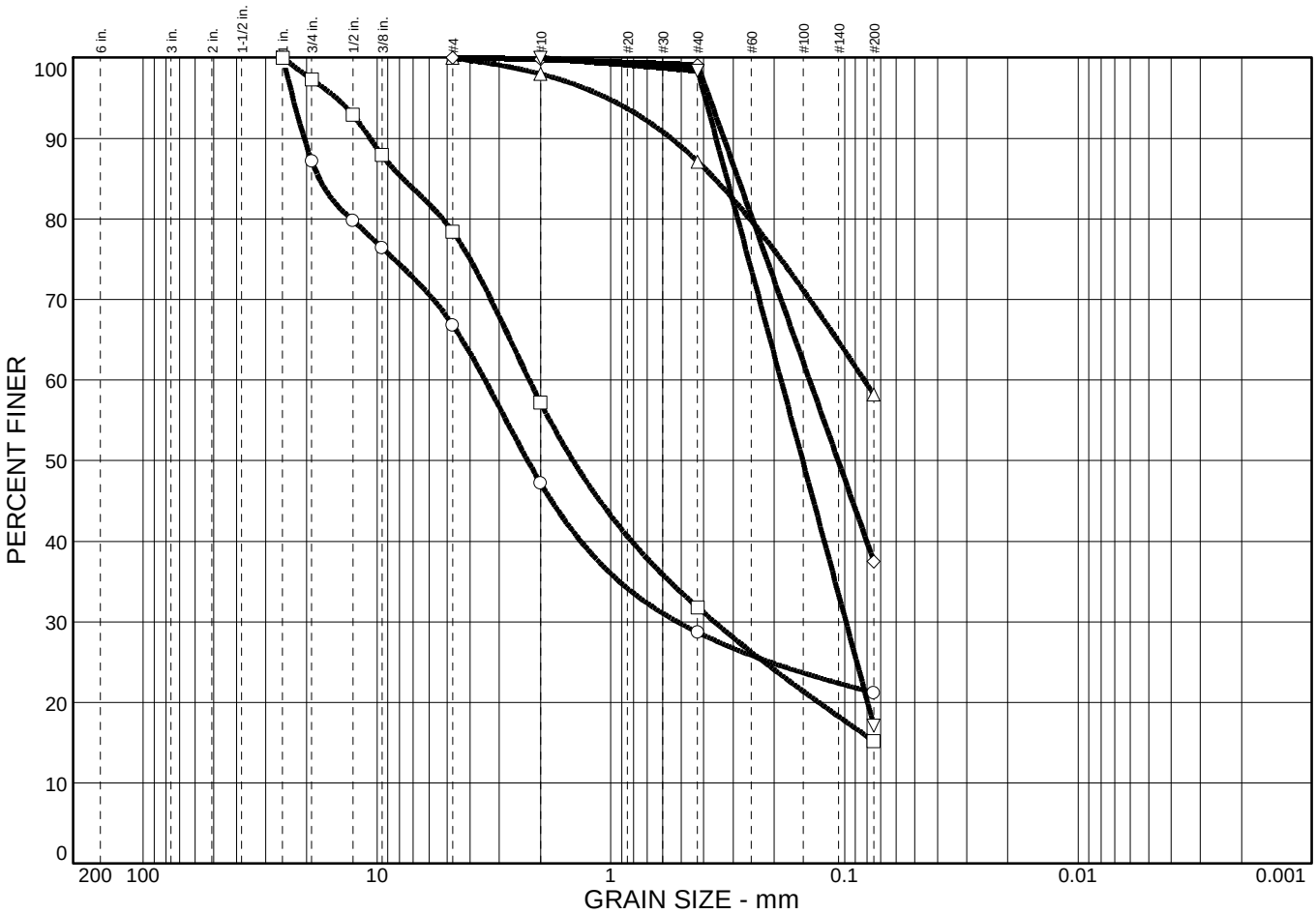
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Client: EFLHD / FHWA

Project:

Project No.: ERFO DEWA 14(15)

Particle Size Distribution Report



	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	12.8	20.4	19.6	18.5	7.5	21.2	
□	0.0	2.7	18.9	21.2	25.4	16.6	15.2	
△	0.0	0.0	0.0	2.0	10.9	28.9	58.2	
◇	0.0	0.0	0.0	0.2	0.7	61.6	37.5	
▽	0.0	0.0	0.0	0.0	1.6	81.3	17.1	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	DESCRIPTION	USCS
○	Rte. 209	B-2/J-1	5-7		
□	Rte. 209	B-2/J-5	20-22		
△	Rte. 209	B-2/J-10	35-37	Sandy silt	ML
◇	Rte. 209	B-2/J-15	60-62	Silty sand	SM
▽	Rte. 209	B-2/J-20	85-87		

Particle Size Distribution Report

FEDERAL HIGHWAY ADMINISTRATION

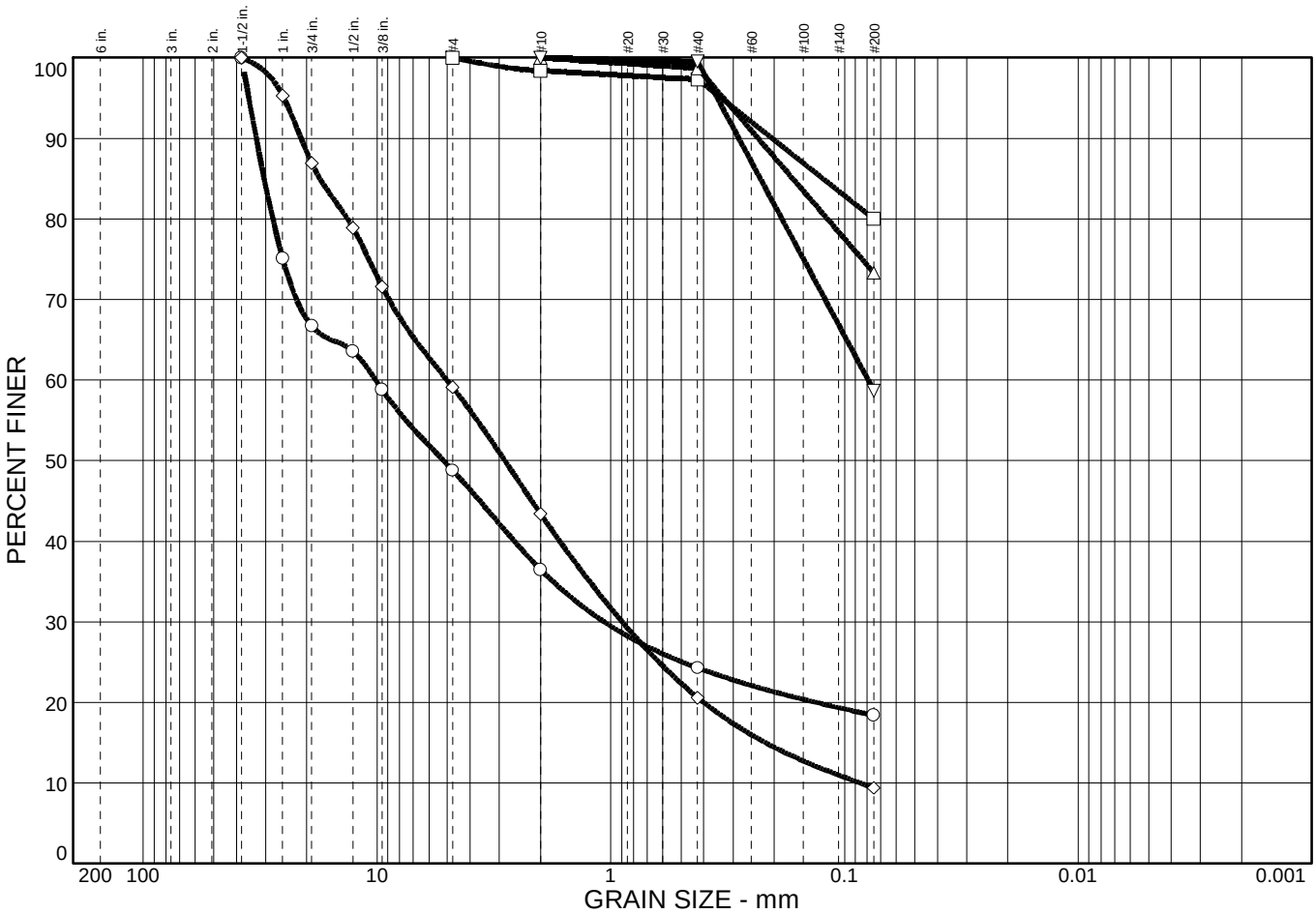
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Client: EFLHD / FHWA

Project:

Project No.: ERFO DEWA 14(15)

Particle Size Distribution Report



	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	33.3	17.9	12.3	12.2	5.9	18.4	
□	0.0	0.0	0.0	1.6	1.1	17.3	80.0	
△	0.0	0.0	0.0	0.0	1.3	25.4	73.3	
◇	0.0	13.1	27.8	15.7	22.8	11.2	9.4	
▽	0.0	0.0	0.0	0.0	0.5	40.8	58.7	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	DESCRIPTION	USCS
○	Rte. 209	B-3/J-4	10-12	Silty gravel with sand	GM
□	Rte. 209	B-3/J-11	40-42	Silt with sand	ML
△	Rte. 209	B-3/J-17	70-72		
◇	Rte. 209	B-4/J-6	23-25		
▽	Rte. 209	B-4/J-12	45-47	Sandy silt	ML

Particle Size Distribution Report

FEDERAL HIGHWAY ADMINISTRATION

EASTERN FEDERAL LANDS HIGHWAY DIVISION

Client: EFLHD / FHWA

Project:

Project No.: ERFO DEWA 14(15)

Particle Size Distribution Report

	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.1	6.4	79.1	14.4	
□	0.0	1.3	6.2	7.5	20.2	12.2	52.6	
△	0.0	18.5	23.8	18.4	15.3	8.4	15.6	
◇	0.0	0.0	0.0	2.5	6.1	11.8	79.6	
▽	0.0	0.0	0.0	2.6	2.3	83.7	11.4	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	DESCRIPTION	USCS
○	Rte. 209	B-4/J-15	60-62		
□	Rte. 209	B-6/J-1	3-5	Sandy lean clay	CL
△	Rte. 209	B-6/J-8	25-27		
◇	Rte. 209	B-3/Bucket	50-55	Silt with sand T-288=2401 ohm's T-289=7.7 ph	ML
▽	Rte. 209	B-4/Bucket	60-65	Poorly graded sand with silty clay T-288= 2134 ohm's T-289= 8.0 ph	SP-SC

Particle Size Distribution Report

FEDERAL HIGHWAY ADMINISTRATION

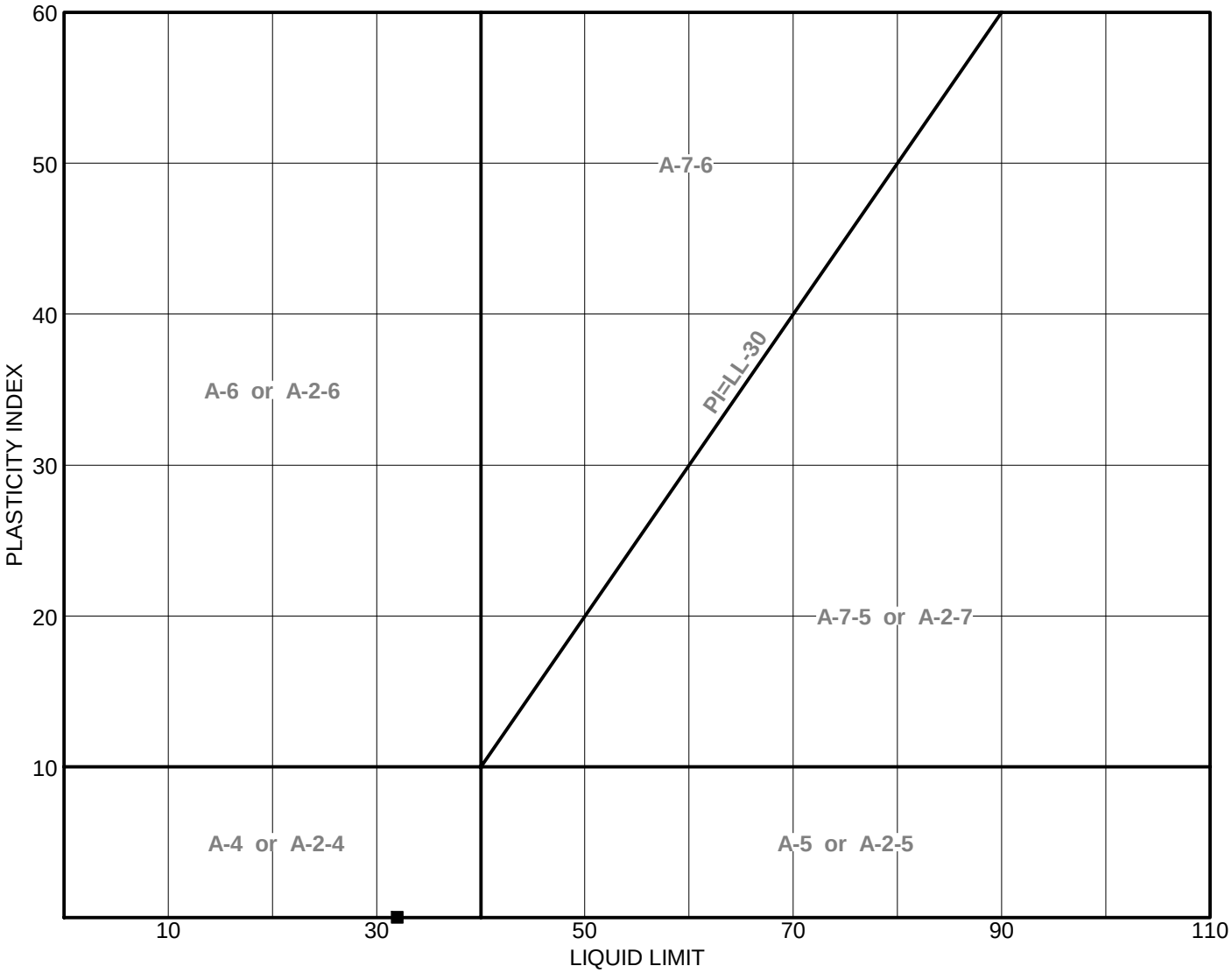
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Client: EFLHD / FHWA

Project:

Project No.: ERFO DEWA 14(15)

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	AASHTO
●	Rte. 209	B-1/J-10	35-37	14.5	NP	NV	NP	A-1-b
■	Rte. 209	B-2/J-10	35-37	17.0	NP	32	NP	A-4(0)
▲	Rte. 209	B-2/J-15	60-62	14.3	NP	NV	NP	A-4(0)
◆	Rte. 209	B-3/J-4	10-12	12.2	NP	NV	NP	A-1-b
▼	Rte. 209	B-3/J-11	40-42	17.6	NP	NV	NP	A-4(0)

LIQUID AND PLASTIC LIMITS TEST REPORT

FEDERAL HIGHWAY ADMINISTRATION

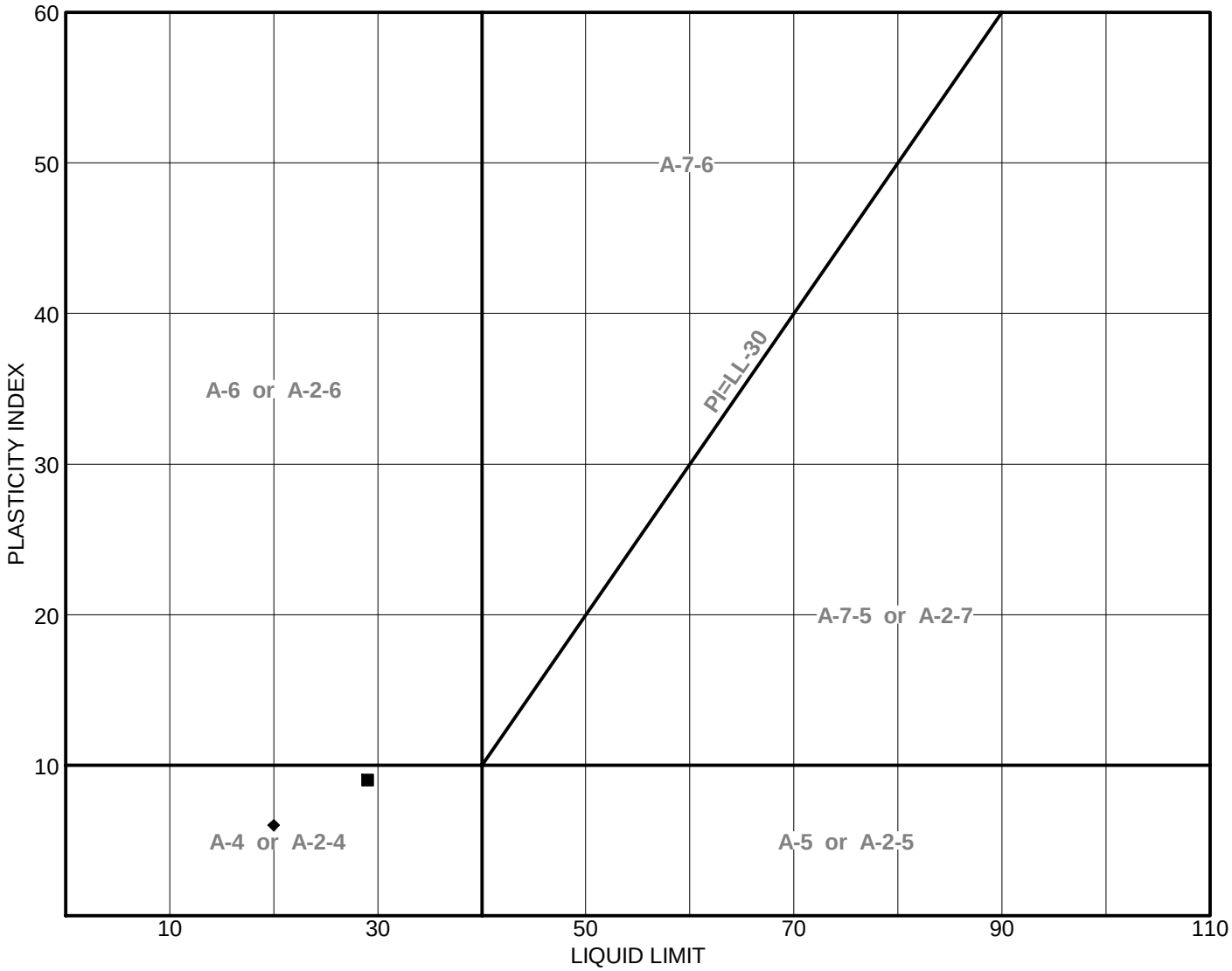
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Client: EFLHD / FHWA

Project:

Project No.: ERFO DEWA 14(15)

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	AASHTO
●	Rte. 209	B-4/J-12	45-47	21.1	NP	NV	NP	A-4(0)
■	Rte. 209	B-6/J-1	3-5	18.4	20	29	9	A-4(2)
▲	Rte. 209	B-3/Bucket	50-55		NP	NV	NP	A-4(0)
◆	Rte. 209	B-4/Bucket	60-65		14	20	6	A-2-4(0)

LIQUID AND PLASTIC LIMITS TEST REPORT

FEDERAL HIGHWAY ADMINISTRATION

EASTERN FEDERAL LANDS HIGHWAY DIVISION

Client: EFLHD / FHWA

Project:

Project No.: ERFO DEWA 14(15)

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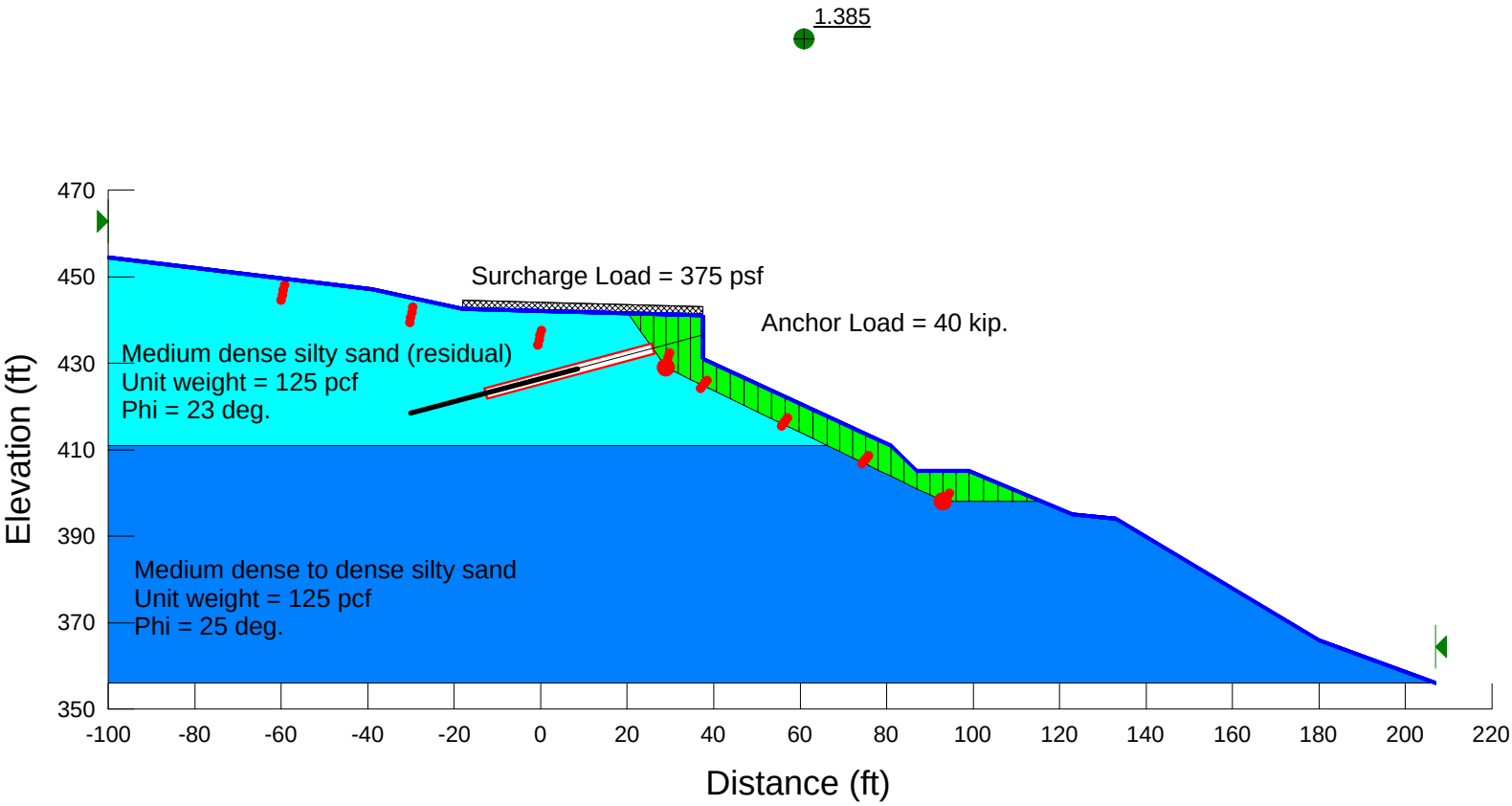
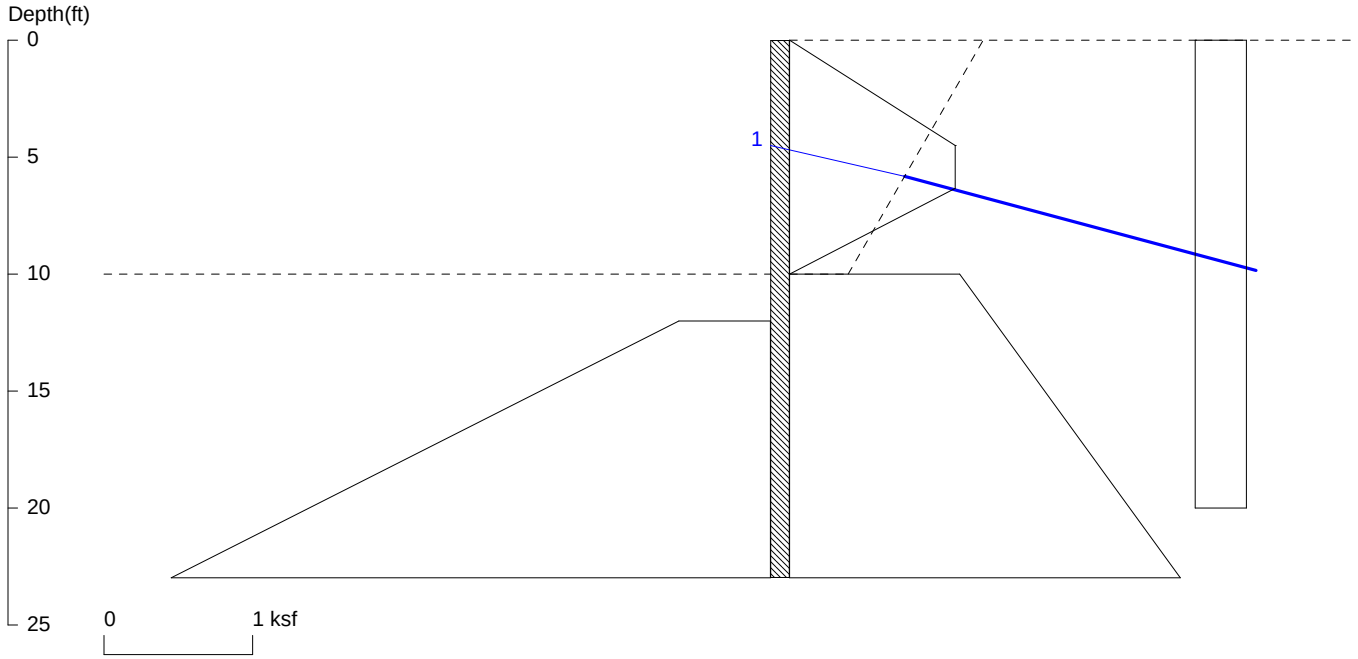
Attachment No. 5 – Computer Output

PROJECT ERFO DEWA 14(15)
Soldier Pile & Lagging RW
Wet condition
Bond F.S. = 2



ERFO DEWA 14(15)



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File: M:\PROJECTS\dewa\14(15)\Techserv\Geotech\Design Analysis\DEWA14(15)-Prelim.sh8

Wall Height=10.0 Pile Diameter=2.0 Pile Spacing=5.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=12.98 Min. Pile Length=22.98 (in graphics and analysis)
MOMENT IN PILE: Max. Moment=60.72 per Pile Spacing=5.0 at Depth=11.54

PILE SELECTION:
Request Min. Section Modulus = 26.5 in3/pile=434.19 cm3/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=0.55
HP14X89 has Section Modulus = 131.0 in3/pile=2146.70 cm3/pile. It is greater than Min. Requirements!
Top Deflection = -0.07(in) based on E (ksi)=29000.00 and I (in4)/pile=904.0

BRACE FORCE: Strut, Tieback, Plate Anchor, and Deadman

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	L_free	Fixed Length
1. Tieback	4.5	15.0	5.0	57.0	55.0	14.7	5.1	18.1

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE): Pressures below will be multiplied by a Factor =1.5

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0	4.5	0.743	0.165111
4.5	0.743	6.33	0.743	0.000000
6.33	0.743	10	0	-0.20245
10	0.763	999	76.17	0.076246
0	0.23	10	0.23	0.000000
10	0.23	20	0.23	0.000000

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
12	0.616	999	307.8	0.3112

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	5.00
2	10.00	2.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	10.00	2.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

****

SHORING WALL CALCULATION SUMMARY
The leading shoring design and calculation software
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****

ShoringSuite Software is developed by CivilTech Software, Bellevue, WA, USA.
The calculation method is based on the following references:

1. FHWA 98-011, FHWA-RD-97-130, FHWA SA 96-069, FHWA-IF-99-015
2. STEEL SHEET PILING DESIGN MANUAL by Pile Buck Inc., 1987
3. DESIGN MANUAL DM-7 (NAVFAC), Department of the Navy, May 1982
4. TRENCHING AND SHORING MANUAL Revision 12, California Department of Transportation, January 2000
6. EARTH SUPPORT SYSTEM & RETAINING STRUCTURES, Pile Buck Inc. 2002
5. DESIGN OF SHEET PILE WALLS, EM 1110-2-2504, U.S. Army Corps of Engineers, 31 March 1994
7. EARTH RETENTION SYSTEMS HANDBOOK, Alan Macnab, McGraw-Hill. 2002
8. AASHTO HB-17, American Association of State and Highway Transportation Officials, 2 September 2002

UNITS: Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft, Friction/Bearing/Pressure - ksf, Pres. Slope - kip/ft3, Deflection - in

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Date: 1/18/2012 File: M:\PROJECTS\dewa\14(15)\Techserv\Geotech\Design Analysis\DEWA14(15)-Prelim.sh8

Title: ERFO DEWA 14(15)
Subtitle:

**********INPUT DATA**********

Wall Type: 2. Soldier Pile, Drilled
Wall Height: 10.00
Pile Diameter: 2.00
Pile Spacing: 5.00
Factor of Safety (F.S.): 1.00
Lateral Support Type (Braces): 3. Tieback
Top Brace Increase (Multi-Bracing): No
Brace Position (One Brace Case): Normal Brace*
No-Load Zone:
Vertical Depth for No-Load Zone: 10.00
H-Distance (Input H/V ratio) for No-Load Zone: 0.25
Angle from H. Line for No-Load Zone: 60.00
Embedment Option: 1. Yes
Friction at Pile Tip: No
Pile Properties:
Steel Strength, Fy: 50 ksi = 345 MPa
Allowable Fb/Fy: 0.55
Elastic Module, E: 29000.00
Moment of Inertia, I: 904
User Input Pile: HP14X89

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *
The pressures below will be multiplied by a Factor =1.5

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Above	Base		
2	0.000	0	4.5	0.743	0.165111
3	4.5	0.743	6.33	0.743	0.000000
4	6.33	0.743	10	0	-0.20245
5	10	0.763	999	76.17	0.076246

6	0	0.23	10	0.23	0.000000
7	10	0.23	20	0.23	0.000000

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Below	Base		
2	12	0.616	999	307.8	0.3112

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	5.00
2	10.00	2.00

* PASSIVE SPACE *

No.	Z depth	Spacing
1	10.00	2.00

* BRACE: STRUT, TIEBACK, ANCHOR PLATE, OR DEADMAN *

No.	Z brace	Angle	Spacing	Input1*	Input2*	Type
1	4.50	15.0	5.00	1.00	1.00	Tieback

*For Tieback: Input1 = Diameter; Input2 = Bond Stength
*For Plate: Input1 = Diameter; Input2 = Allowable Pressure
*For Deaman: Input1 = Horz. Width; Input2 = Allowable Pressure; Angle = 0

**********CALCULATION**********

The calculated moment and shear are per pile spacing. Sheet piles are per one foot or meter; Soldier piles are per pile.

Top Pressures start at depth = 0.00

NUMBER OF BRACE LEVEL = 1

```
        |      D1=0.00
        |
        |<--   D2=4.50         R1=55.04
        |
        |
        |
      ==|==    D3=10.00
        |
        |      D4=22.98
```

D1 - TOP DEPTH
D2 - BRACE DEPTH R1 - REACTION
D3 - EXCAVATION BASE
D4 - PILE TIP

```
   TOTAL REACTION: R1 = 55.04
   TOTAL PRESSURES ACTING ON WALL = 55.04
      Total Reactions = Total Pressures,    OK!
   ____________________________________________________
   BRACE NO.1 AT DEPTH = 4.50
       R1 = Brace Load = 55.04
   ____________________________________________________


*********************************RESULTS****************************************

* EMBEDMENT *
MINIMUM EMBEDMENT = 12.98,  TOTAL MINIMUM PILE LENGTH = 22.98

* MOMENT IN PILE (per pile spacing)*
Pile Spacing:  sheet piles are one foot or one meter; soldier piles are one pile.
 No.    Depth           M @ Brace       Mmax in Span    Depth of Mmax
-------------------------------------------------------------------------------
 1      4.50            35.45           60.72           11.54
-------------------------------------------------------------------------------
Overall Maximum Moment = 60.72 at 11.54
Maximum Shear = 34.62
Moment and Shear are per pile spacing: 5.0 foot or meter

* BRACE: STRUT, TIEBACK, ANCHOR PLATE, OR DEADMAN *
The calculated brace force are per brace spacing.

 No.    DEPTH           Tangle          SPACING         HORIZONTAL      VERTICAL
TOTAL LOAD
-------------------------------------------------------------------------------------
----------
 1      4.50            15.0            5.00            55.04           14.75
56.99

 No.    DEPTH           Free length     Type and Data
-------------------------------------------------------------------------------------
----------
 1      4.50            5.09            Tieback, Bond length = 18.14
-------------------------------------------------------------------------------------
----------

* VERTICAL LOADING *
Vertical Loading from Braces = 14.75
Vertical Loading from External Load = 0.00
Total Vertical Loading = 14.75


****************************SPECIFIED PILE **********************************

   Overall Maximum Moment = 60.72 at 11.54
   The pile selection is based on the magnitude of the moment only. Axial force is
neglected.

   Request Min. Section Modulus = 26.50 in3/pile = 434.19 cm3/pile, Fy= 50 ksi = 345
MPa, Fb/Fy=0.55

   HP14X89 has been found in Soldier Pile list!
   (English Units):
   Area= 26.1 in.  Depth= 13.8 in.  Width= 14.7 in.  Height= 14 in.
   Flange thickness= 0.615 in.   Web thickness= 0.615 in.
   Ix= 904 in4/pile   Sx= 131 in3/pile   Iy= 326 in4/pile   Sy= 44.3 in3/pile
   (Metric Units):
```

Ix= 376.24 x100cm4/pile Sx= 2146.70 cm3/pile Iy= 135.68 x100cm4/pile Sy= 725.94 cm3/pile

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

HP14X89 is capable to support the shoring!
Top deflection = -0.071(in)
Max. deflection = 0.104(in)

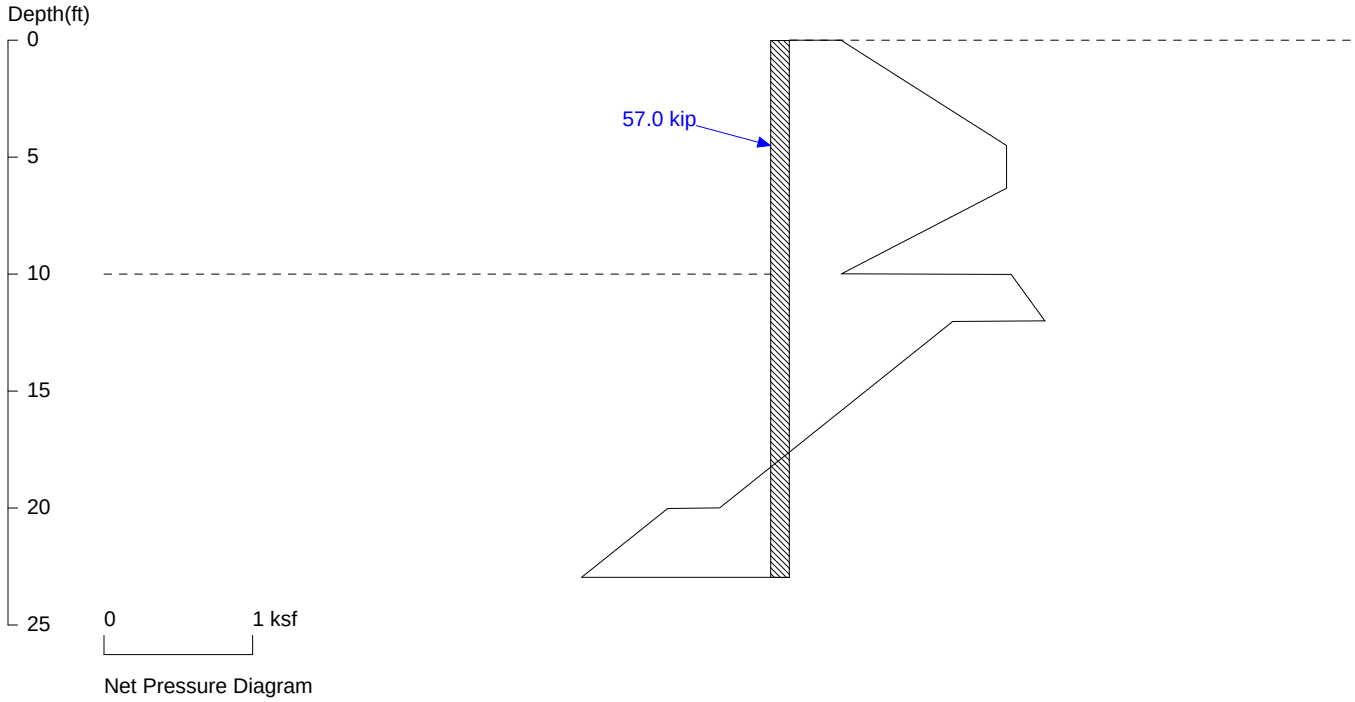
********** LAGGING SIZE ESTIMATION **********
Max. Pressure above base = 1.46
Piles are more rigid than timber lagging, only portion of pressures are acting to lagging, 30-50% arching is suggested.

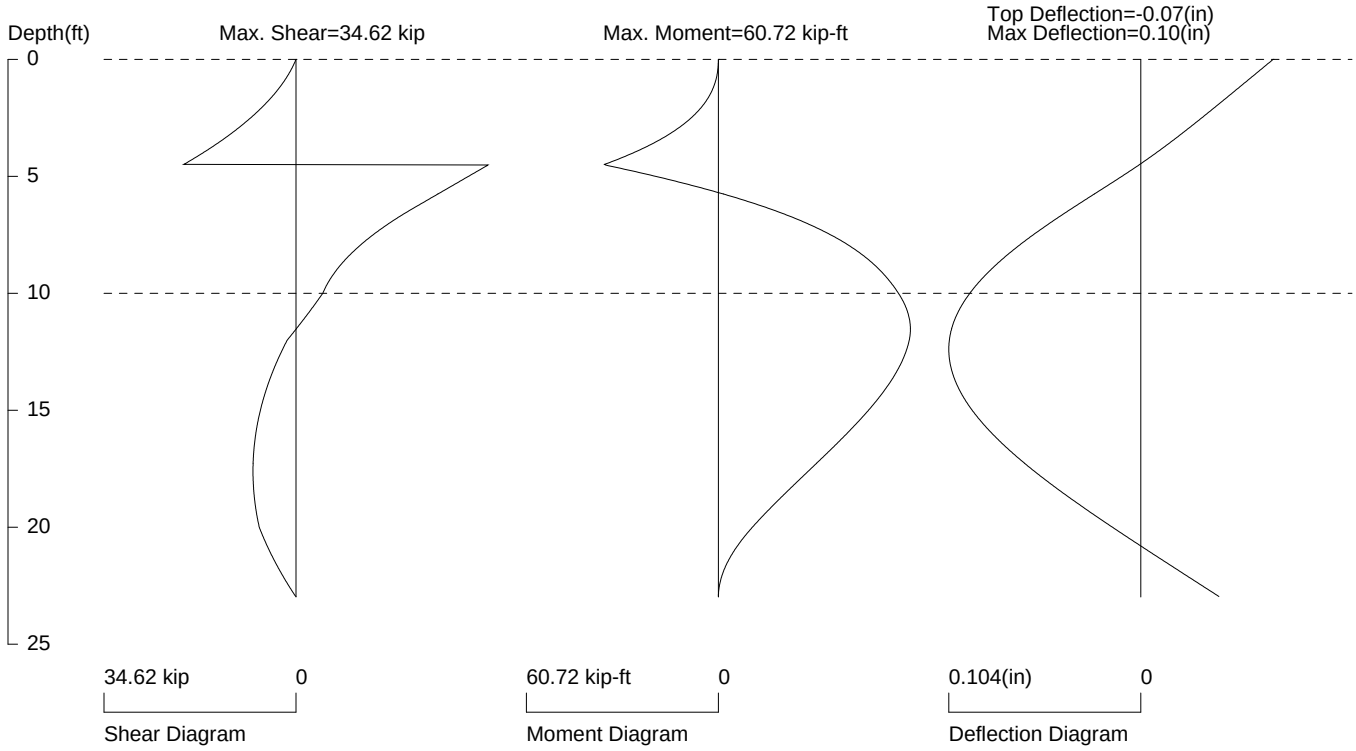
If 50% arching is used for lagging design, Design Pressure = 0.73
Pile Spacing =5.0, Max. Moment in lagging = 2.28
For 4"x12" Timber, Section Modules S=23.47 in3. The request allowable bending strength, fb=M/S=1.17
For 6"x12" Timber, Section Modules S=57.98 in3. The request allowable bending strength, fb=M/S=0.47

If 30% arching is used for lagging design, Design Pressure = 0.44
Pile Spacing =5.0, Max. Moment in lagging = 1.37
For 4"x12" Timber, Section Modules S=23.47 in3. The request allowable bending strength, fb=M/S=0.70
For 6"x12" Timber, Section Modules S=57.98 in3. The request allowable bending strength, fb=M/S=0.28

Unit: Pressure: ksf, Spacing: ft, Moment: kip-ft, Bending Strength, fb: ksi

ERFO DEWA 14(15)





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 5.0 foot or meter

User Input Pile, HP14X89: E (ksi)=29000.0, I (in4)/pile=904.0

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Attachment No. 6 – Representative Site Photographs

Photo No. 1 Rte 209, existing retaining wall and bike trail

Photo No. 2 Rte 209, note existing retaining wall

Photo No. 3 Cracks

Photo No. 4 Road cracks

Photo No. 5 Drop in pavement

Photo No. 6 Existing retaining wall

Photo No. 7 Impacted bike trail

Photo No. 8 Impacted area