STATE OF TENNESSEE

DEPARTMENT OF TRANSPORTATION

MATERIALS & TESTS DIVISION

GEOTECHNICAL ENGINEERING SECTION

GEOTECHNICAL GUIDELINES

September 2020

CHAPTER 1 – GENERAL

CHAPTER 2: ROADWAY DESIGN DELIVERIES

CHAPTER 3: STRUCTURAL FOUNDATION DELIVERIES

CHAPTER 1 - GENERAL

1-100.00 FOREWORD

This chapter and the forthcoming chapters in this Tennessee Department of Transportation (TDOT) Geotechnical Guidelines (Guidelines) provide information to establish uniform and standard procedures regarding geotechnical services provided for TDOT and the TDOT Geotechnical Engineering Section (TDOT GES). These Guidelines do not establish legal or administrative interpretations of TDOT's contracts. In the event of a discrepancy in the contract terms and these Guidelines, the contract terms govern.

Proper utilization of these guidelines will ensure enhanced uniformity in the execution of geotechnical services for TDOT and TDOT GES. These guidelines are not intended to be reference for unique geotechnical problems encountered, but perhaps these guidelines can be used to locate reference to solve such problems. These Guidelines should not be used as a substitute for sound engineering judgement. This document describes the different geotechnical services TDOT provides and establishes a consistent manner and a standard framework of performing and submitting this work.

1-200.00 RECOGNIZED TDOT REFERENCE DOCUMENTS

It is intended for this document to complement, and not conflict with, other recognized TDOT reference documents, particularly the TDOT Design Guidelines (DG), the TDOT Standard Drawing Library (Std. Dwg.), TDOT Standard Specifications for Road and Bridge Construction (TDOT Specifications), and the Special Provisions (SP). All work shall also comply with current AASHTO design documents.

The DG is a quite comprehensive document and serves to provide roadway designers the basis for the development of Construction Plans (Plans). The document does not provide structural guidance on bridges or retaining walls, but only the roadway design guidance.

The Std. Dwgs. are actually an appendix to the DG. Std. Dwgs. are referenced in the front of the Plans to avoid redundant design typical details. Typical design details for slope development are of particular interest.

Another recognized reference that everyone providing services for TDOT should have at their desk is the TDOT Specifications. The TDOT Specifications will eventually be part of the executed contract documents. The TDOT Specifications provides legally binding information on earthwork, subgrade, base, pavement, and structures. It should be recognized that many fairly standard earthwork notes developed by AIA and others in the industry are in conflict with the TDOT Specifications, and will take precedent if contained in the Plans.

Special Provisions (SPs) are developed for construction activities that are standard and consisted but so detailed it just makes sense to develop an SP and reference the SP in the plans.

To remain current with the state of the industry, the Geotechnical Guidelines are in a state of constant update and evaluation. Revisions, additions, deletions, and omissions will be necessary. Updates to these Guidelines will be made on a regular basis, or as necessary. Effort will be made to post the current Geotechnical Guidelines to TDOT's internet site.

1-300.00 ORGANIZATIONAL STRUCTURE

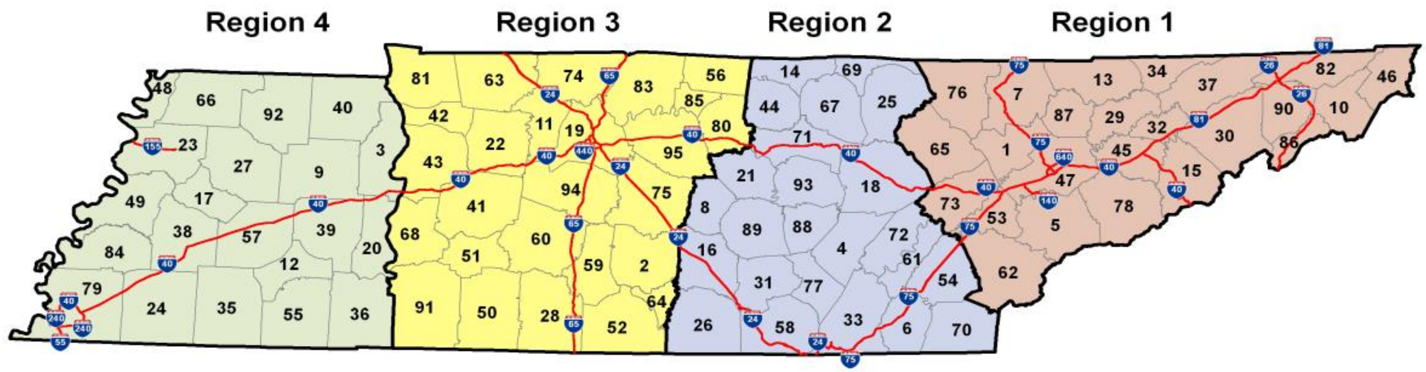
The TDOT Geotechnical Engineering Section (GES) is one functional Section of the Headquarters Materials and Tests Division (HQM&T). HQM&T has three other units: Field Operations, Laboratory Operations, and Research/New Product Evaluations. GES presently maintains an office staff in Region 3 Nashville, and Region 1 Knoxville (see Figure 1). Work flow within Regions 2-4 is typically completed by Nashville office resources, while work within Region 1 is typically completed by Knoxville office resources. Current, TDOT GES key staff contact information is provided:

Director of Materials and Tests Division
Vacant-Civil Engineering Director
6601 Centennial Blvd.
Nashville, TN 37248-0360
615 350-4100
Brian.egan@tn.gov

Geotechnical Engineering Section Manager
Robert Jowers, P.E. - Civil Engineering Manager 2
6601 Centennial Boulevard
Nashville, TN 37248-0360
(615) 350-4133
Robert.jowers@tn.gov

Nashville Geotechnical Office
Travis Smith, P.E. - Civil Engineering Manager 1
6601 Centennial Boulevard
Nashville, TN 37248-0360
(615) 350-4136
Travis.w.smith@tn.gov

Knoxville Geotechnical Office
Lori Fiorentino, P.E. - Civil Engineering Manager 1
7345 Region Lane
Knoxville, TN 37914
(865) 594-2701
Lori.Fiorentino@tn.gov



Alphabetical List of Counties in Tennessee

01 Anderson	17 Crockett	33 Hamilton	49 Lauderdale	65 Morgan	81 Stewart
02 Bedford	18 Cumberland	34 Hancock	50 Lawrence	66 Obion	82 Sullivan
03 Benton	19 Davidson	35 Hardeman	51 Lewis	67 Overton	83 Sumner
04 Bledsoe	20 Decatur	36 Hardin	52 Lincoln	68 Perry	84 Tipton
05 Blount	21 DeKalb	37 Hawkins	53 Loudon	69 Pickett	85 Trousdale
06 Bradley	22 Dickson	38 Haywood	54 McMinn	70 Polk	86 Unicoi
07 Campbell	23 Dyer	39 Henderson	55 McNairy	71 Putnam	87 Union
08 Cannon	24 Fayette	40 Henry	56 Macon	72 Rhea	88 Van Buren
09 Carroll	25 Fentress	41 Hickman	57 Madison	73 Roane	89 Warren
10 Carter	26 Franklin	42 Houston	58 Marion	74 Robertson	90 Washington
11 Cheatham	27 Gibson	43 Humphreys	59 Marshall	75 Rutherford	91 Wayne
12 Chester	28 Giles	44 Jackson	60 Maury	76 Scott	92 Weakley
13 Claiborne	29 Grainger	45 Jefferson	61 Meigs	77 Sequatchie	93 White
14 Clay	30 Greene	46 Johnson	62 Monroe	78 Sevier	94 Williamson
15 Cocke	31 Grundy	47 Knox	63 Montgomery	79 Shelby	95 Wilson
16 Coffee	32 Hamblen	48 Lake	64 Moore	80 Smith	

Figure 1 Tennessee Map shown with TDOT Regions and Counties

1-310.00 TDOT PROJECT NUMBERS DEFINED

For a variety of reasons, TDOT relies upon numbering systems to organize, sort and track project development. TDOT's Program Development and Administration Division assigns *PE-N* / *PE-D* numbers and *PIN* numbers. GES uses what is referred to as a *GES File Number* to internally organize *all* requests for geotechnical services, including non-programmed maintenance geotechnical support (subgrade settlement, landslides, rock falls, sinkholes, etc.). Below is a brief discussion on TDOT's use of various project numbers and how these numbers pertain to GES.

PPRM is a database that TDOT uses to schedule projects. The PPRM database organizes TDOT project numbers using TDOT pin numbers. The PPRM database describes in particular each activity of the project development process, and defines various Activities to accomplish. For convenience, this document refers to activity numbers by the denotation Act.XXX. It is important that GES staff have the PPRM database loaded on their workstation for reference to project schedule.

For the purpose of discussing the project numbers TDOT GES uses, let the project SR-115 (Alcoa Highway) from Woodson Drive to Cherokee Trail Interchange, Knox Co. serve as an example.

PIN NUMBER: Perhaps the most significant project reference TDOT uses is the *PIN* number. This is the individual number that is arbitrarily assigned to a given project by Program Development and Administration Division. This unique identifier number should be used in all subsequent documents regarding the project, including but not limited to the subject line of e-mails, letters, memoranda and reports. The PIN number is entered internally to query as it is cross related with all other reference numbers TDOT uses in various databases. It can be used in a quick search function. The inclusion of the PIN number in correspondence with TDOT can not be over stressed. The *PIN* number for the example project is shown below.

PIN Number Example
100241.03

GES FILE NUMBER: The GES file number is arbitrarily assigned by GES upon a customer request for geotechnical services. The GES number is used internally by the GES unit to cross reference all of the project numbers that TDOT has implemented over the years. This is essentially a file number, either for a paper / cabinet file or an electronic server file. By including the GES file number in documents and correspondence, the administrative resources required are reduced, since GES manages hundreds of projects.

GES File Number	County	Sequence	Fiscal Year
4706318	47	063	18

County - All counties in Tennessee are numbered in alphabetical order 1-95. Anderson County is 01 and Wilson County is 95. Development district projects use 96, region wide projects use 98 and statewide projects use 99. See *Figure 1 Tennessee Map shown withTDOT Regions and Counties.*

Sequence - Used with the GES File Number. A sequence number of 001 indicates the first project to be assigned a file number in a given fiscal year. Likewise a sequence number of 152 would be the 152nd project to be assigned a file number in a given fiscal year.

Fiscal Year – In the state of Tennessee, the fiscal year begins July 1 and ends June 30. So, if the example project's geotechnical services were requested to be performed in August of 2017, the project was given a 18 fiscal year.

TDOT PE NUMBERS: When a project begins it is programmed by TDOT Program Development and Administration Division by unique PE numbers. The PE number is also further subclassified as the PE-N (NEPA) and the PE-D (Design). The letters in the acronym, PE, stand for 'preliminary engineering'. This number is assigned for a project throughout the various phases of the project development such as survey, design, right-of-way (ROW) and construction. This number is also used on all reports, documents and correspondence.

The PE-N number should be used to capture resources used in developing project plans for purposes of submittal for environmental permitting, which is considered all work performed up to the point in time where R.O.W. Plans are complete and distributed. Afterwards, the PE-D number should be used to capture work activities associated with construction plans preparation.

Below is the PE-D for the example project, is 47026-with further explanation and discussion of how the number is assigned.

TDOT Project Number	County	Section Number	Job			Funds	
			Type Work	State System	Job Sequence Number	Federal	State
47026-1270-14	47	026	1	2	70	1	4

County - All counties in Tennessee are numbered in Alphabetical Order 1-95. Anderson County is 01 and Wilson County is 95. The example project is located in Knox Co., and that county is the alphanumeric number 47. Development district projects use 96, region wide projects use 98 and statewide projects use 99. See *Figure 1 Tennessee Map shown withTDOT Regions and Counties*.

Section Number - This is assigned by Planning. It is a number given to a section of a highway that has similar geometrics or operating characteristics. It is used to subdivide a roadway into convenient or logical units.

Job - This is essentially a series of four numbers that are assigned to a project, it has 3 components: a. Type Work, b. State System, c. Job Sequence Number.

Type Work - This code indicates what type of work is being performed under the project number. Geotechnical work performed for new projects are charged to the PE-N with a Code 0, up until ROW plans are issued, and after ROW plans are issued charges are assigned to 1.

Code	Description
0	PE for Planning and Environmental Studies (NEPA)
1	PE for Survey and Road Design
2	Right of Way Acquisition
3	Construction and Reconstruction
4	Routine Maintenance

5	PE for Structure Design
7	Planning and Research Projects
8	Resurfacing Projects
9	Outdoor Advertising, Mass Transit, Waterways and Rail

State System - This number indicates the roadway type.

Code	Description
1	Interstate
2	State Highway System (State Routes)
3	Rural System
4	Local County Roads
5	Local City Streets
6	No System
7	New Urban System

Job Sequence Number - Indicates the order in which a project number was assigned along a section of roadway. A job sequence number of 01 indicates the first project issued along that section. Likewise a job sequence number of 70 indicate the 70th project issued along that section.

Funds - Indicates the project funding source. There are two separate series of numbers associated with Funds: a. Federal and b. State. This is described further below.

Federal Funds - This code indicates the Federal appropriation authorized for the project.

Code	Description
0	No federal funds
1	Federal Aid - Primary
2	Federal Aid - Secondary

Code	Description
3	Federal Aid - Grade Crossing, Overhead Separations,
4	Federal Aid - Interstate
5	Federal Aid - Urban
6	Federal Aid - Appalachia
7	Federal Aid - HPR
8	Federal Aid - Forest Highways
9	Federal Aid – Other

<u>State Funds</u> **-** This number indicates TDOT's accounting fund used for the project.

Code	Description
3	Rural and Secondary Roads Fund
4	State Highway Fund
9	Aeronautics

TDOT TX (SpeedChart) Number: The PE-N and PE-D numbers are also used to obtain the TX (SpeedChart) numbers. No timesheet or pay invoice voucher can be made without a TX number. Each different functional business unit of TDOT requests and is assigned this TX number in order to capture and manage costs of project development for that particular business unit.

Federal Project Numbers: Another project number assigned by TDOT Program Development and Administration Division is the Federal Project #. If the project has Federal participation, the Federal Project # is typically the project number that should placed on the upper right hand corner of the plans. If you are internal to TDOT, see your supervisor to determine the correct number to place on your G-Sheets or R-sheets, or if a consultant seek your TDOT project overseer for guidance.

The Federal project number for the example project was assigned: R-STP/NH-115(29).

TDOT Contract Number: Lastly, when the construction plans have been turned in for letting, the Construction Division assigns an arbitrary alphanumeric number to the project, three letters and three numbers. This is the number used to administrate all construction and inspection costs. The example project has not been turned in for construction, yet, but for the sake of example, another project that is being considered at the time of writing is CNU224. Typically the number has three alphabet letters and three numbers.

1-320.00 CORRESPONDENCE WITH TDOT GES

Any and all TDOT correspondence should include project numbers. Much of TDOT's communication is done electronically using email and attachments. In addition to the issue, it is expected that the subject line of the email include the *PIN* number and the state route number and county number. Since TDOT GES staff typically work with dozens or even hundreds of projects that are in various stages of development, if the PIN number is used all email correspondence can be searched and reduces administration time.

1-400.00 TDOT GEOTECHNICAL CONSULTANTS

Consultants are procured for two purposes: 1) to provide specialized geotechnical services for which TDOT GES does not have in–house capability or expertise and 2) to provide additional geotechnical services of normal difficulty in order to meet an expedited schedule.

Procurement of consultant contracts is governed by TDOT Policy 301-01 Standard Procurement of Engineering and Technical Services which can be viewed on the TDOT Website. Other details of consultant contracts, including useful contacts and example documents such as letters of interest, Statement of Qualifications and invoices can also be viewed on the TDOT website under Roadway Design Division-Consultant Information address.

Note that TDOT GES is responsible for providing concurrence for all TDOT geotechnical consultant recommendations. TDOT GES is also responsible for uploading all delivered TDOT geotechnical consultant reports to the TDOT FILENET server.

The majority of geotechnical consultant agreements fall into two functional category types. One geotechnical contractual category type is as a geotechnical sub-consultant to a prime roadway design consultant, and is discussed in 1-410.00 Team Geotechnical Subconsultant Contracts. Another contractual category type is directly with TDOT GES under an "on-call" agreement, and is further discussed below in 1-420.00 On-Call Geotechnical Service Contracts.

1-410.00 TEAM GEOTECHNICAL SUBCONSULTANT CONTRACTS

This type of agreement is project specific, with the TDOT Headquarters Design Division formally entering into a contractual agreement with a design team typically consisting of a prime consultant and several subconsultants to perform engineering services associated with a transportation improvement project. One of those subconsultants could typically be a geotechnical engineering consultant. The prime roadway design consultant has contractual control of the work performed of their selected geotechnical subconsultant including scheduling work and paying invoices. Typically, TDOT GES initially coordinates with the geotechnical subconsultant, the roadway design consultant and the TDOT Project Delivery Division to concur with the geotechnical consultant on a contractual scope of work. Afterward, TDOT GES is responsible for deliverables concurrence to TDOT standard level of care.

1-420.00 ON-CALL GEOTECHNICAL SERVICE CONTRACTS

This functional category type of geotechnical consultant agreement is described as an "on-call" contractual agreement. In an "on-call" agreement the geotechnical consultant enters into an agreement directly with TDOT GES to perform geotechnical services for multiple projects over an established timeframe, as the need for services arises. Typically, multiple geotechnical consultants are procured by TDOT GES to provide services within a TDOT Region, for a multi-year period. These contracts include drilling and laboratory technical services as well as professional engineering and geological services. The consultants could be assigned geotechnical services for all of the various TDOT transportation improvement projects, such as but not limited to bridges, roadway widenings\realignments, retaining walls, and\or landslide\rockfall mitigations to meet the Department's schedule demands as appropriate.

Under an on-call work order contractual agreement, TDOT GES will be ultimately responsible for preparing the project scope of work. The geotechnical consultant will discuss the terms of the scope of work with TDOT GES oversight until approval is authorized by TDOT GES.

1-430.00 OTHER TDOT GEOTECHNICAL SERVICE CONTRACTS

Other contractual means that TDOT and TDOT GES use to provide customer service to geotechnical consultants are listed below in no particular order.

- Local governments often use TDOT funding for transportation projects. These projects, often termed LP projects, are managed by and through the TDOT Local Programs Development Office. Under LP policy, the geotechnical consultant is under the direction of the local government, but by virtue of TDOT funding, the geotechnical deliverables must comply with TDOT requirements and have concurrence with TDOT GES. TDOT GES is may be requested to review the consultants' scope of work, cost and technical documents or provide other technical input as required.

- TDOT Maintenance Division procures and administers "on-call" contracts for the purpose of providing engineering design and plans for roadway and bridge maintenance projects. These projects typically have included landslide\rockfall remediation, sinkhole remediation, small structure repair, paving and drainage issues. The geotechnical consultant is selected as a sub-consultant to the prime engineering consultant. The Maintenance

Division typically coordinates as required with TDOT GES in regard to the geotechnical consultant's scope of work and has been asked to concur with geotechnical engineering recommendations.

- TDOT Construction Division could procure geotechnical consultants for the purpose of providing Construction Engineering and Inspection (CEI) contracts to assist in administering the construction contract. Often, the geotechnical consultant is tasked on construction projects having complex geotechnical components including but not limited to top-down constructed walls, drilled shafts, or construction in a karst terrain.

- General contractors could also retain geotechnical engineering consultants to provide geotechnical services for TDOT projects, from time to time. Geotechnical engineers can assist the general contractor in obtaining approval for off-site borrow material or off-site waste areas in accordance with the *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*. General Contractors must hire geotechnical engineering firms after obtaining TDOT conceptual approval for a Value Engineering Change Proposal that requires geotechnical expertise. TDOT often relies on general contractors to design retaining walls in accordance with Special Provision 624 Regarding Retaining Walls. In all of these cases, the consultant geotechnical engineer is not working for TDOT directly but could be required to coordinate activities through TDOT GES, dependent upon specific Department circumstances.

1-500.00 SCOPE OF WORK

The full contract scope of work must be agreed upon and executed prior to any billable work being executed for TDOT. The scope of work is to include a cover letter, which provides a summary of the work to be completed at the site, as well as other supporting documentation as may be required. In the past, TDOT geotechnical consultants have provided spreadsheets of proposed boring locations, with accompanying plan sheets illustrating proposed boring locations.

Cost estimate preparation and any scope of work discussion is considered part of the cost of doing business with TDOT, and will not to be invoiced as a Manpower Cost. Following the executed approval of the contract, the geotechnical consultant is expected to deliver the terms of the contract, and is expected to invoice on those terms accordingly.

1-510.00 MAN-DAY COST ESTIMATE

Before any geotechnical work is performed by a TDOT geotechnical consultant, the scope of work including the "*Man-hour Requirements and Cost Estimate"* (Cost Estimate) form must be approved by TDOT GES. The Cost Estimate includes line item details for each item in the scope of work.

The Cost Estimate form is periodically updated to keep current, so contact TDOT GES to request the current Cost Estimate form and always verify the current Cost Estimate form is being used before executing any documents. The form is developed in Microsoft Excel, and can be sent electronically.

The total amount of geotechnical billings invoiced to the State shall never exceed the "Total Not-to-Exceed" costs shown on an approved "Man-hour and Requirements Cost Estimate Form." Individual item quantities are expected to vary slightly from the approved "Total Not-to-Exceed" amount depending upon the project requirements. In no case shall additional services be invoiced, or paid by the State, prior to the TDOT geotechnical consultant formally requesting and receiving an approved contract supplement.

The *"Man-hour Requirements and Cost Estimate"* form details expected items required for delivering the project. The following is a brief narrative of these items for guidance and information. If there are any discrepancies between the following narrative and the contract, the contract is, of course, binding.

Cost Cover Sheet – This sheet contains basic reference information including the project location data, Geotechnical Consultant Name, Date Prepared, Project Number, Geotechnical Office Number and Contact information for the preparer.

1.00 Drilling Costs – All drilling items are shown on this sheet and are to be listed on a per unit basis. For instance, SPT drilling\rock coring and sampling is charged on a per-foot basis, with all ancillary costs associated with drilling and sampling included in that per-foot cost. Specialty items not listed, could be added to this sheet, but never without the agreement of TDOT GES. The total estimated cost of drilling items is shown at the bottom of the page.

2.00 Laboratory Testing Costs – All laboratory testing items are shown on this sheet and are to be listed on a per unit basis. For instance, the Atterberg Limit test is charged on a per sample basis. Please note that tests which require multiple points, such as the C-U triaxial test are still charged on a per total test, not per point basis. So, a test which may take 3 samples to complete, would still be charged as only 1 single test, because several points are required in order to provide a complete single test result. Specialty items not listed may be added to this sheet with the agreement of TDOT GES. The total estimated cost of laboratory testing items is shown at the bottom of the page.

3.00 Manpower Costs – All expected manpower hours estimated for the project are to be detailed on this sheet. It breaks down cost by tasks and by category of staff. These are charged on a per man hour basis. The hourly rate is determined on sheet 3.01 Manpower Breakdown. If CAD services are to be provided by others, such as the Design Consultant, the CAD technicians estimated hours may be shown either on the Geotechnical Consultants cost estimate **or** on the Design Consultants cost estimate, not both. The total estimated cost of Man-hour costs is shown at the bottom of the page.

3.01 Manpower Breakdown – This portion of the Cost Estimate must be completed with accurate up to date information

Direct Pay Rate – This is the actual rate paid to a member(s) of the Geotechnical Consultants staff. Evidence that this is the case may be required by TDOT.

Maximum Overhead Rate – This rate is determined by audit and varies by Consultant. This maximum overhead rate only applies where there are state only funded projects. Federally funded projects use the overhead rate established by audit. For state funded only projects, if the consultant has an overhead rate higher than 1.45, the maximum allowable rate that may be used is 1.45.

Profit Multiplier – TDOT currently allows a profit multiplier of 2.35.

Profit Rate – For projects that are completed through a Design Consultant, the profit rate is the same as that established for the Design Consultant. This is typically no more than 0.12.

Hourly Rate – This is determined by the following formula:

= Direct Pay Rate + (Direct Pay Rate * Overhead Rate) + (Direct Pay Rate * Profit Multiplier *Profit Rate).

The following shows an example given: direct pay rate of $20.00; overhead rate of 1.75; profit multiplier of 2.35; and a profit rate of 0.12.

= $20.00 + ($20.00*1.75) + ($20.00*2.35*0.12) = $60.64

4.00 Other Costs – This sheet details other costs involved with the project that do not neatly fit onto one of the other sheets such as Per-Diem, Lodging and Mileage. Equipment rental and plans reproduction may also be included on this sheet. However, the only equipment rental which may be allowed will be specialty equipment. The consultant may not charge for standard geotechnical exploration nor supporting equipment, neither may laboratory testing equipment rental be charged. Charges will only be allowed with prior authorization from TDOT GES and this will only be granted in unusual cases. Further explanation and justification for these charges may be requested. Also, plans printing may not be charged by the Geotechnical Consultant if that function is to be handled by the Design Consultant, unless the Design Consultant is not charging TDOT for the printing. Items listed under other expenses may only be pre-approved, as is the case for equipment rental, and will only be granted in unusual cases. Appropriate item numbers will be assigned by TDOT as needed. As with other sheets, the total estimate of other expenses must be shown at the bottom of the page.

Costs-Summary – This final sheet summarizes the costs of Drilling Services, Laboratory Services, Manpower Requirements and Other Expenses in order to show a final "Total Not-to-Exceed" cost for the project.

CHAPTER 2 – ROADWAY DESIGN SUPPORT

2-100.00 ROADWAY GEOTECHNICAL SERVICES GENERAL

Geotechnical services are required for different aspects of roadway design projects contained in the TDOT Highway Program, and it is the intent of this document to offer guidance required in terms of scope and project intention in the least repetitive manner. With this said, roadway design geotechnical support will be discussed in four subsequent sub-chapters: 2-200.00 Preliminary Geotechnical Study, 2-300.00 Extensive Transportation Improvements, 2-400.00 Bridge and Approaches Improvements, and 2-500.00 Limited Extent Improvements. Other sub-chapters are dedicated to common guidance that could be required to deliver any of these aforementioned sub-chapters.

The report documents that summarize geotechnical services in support of roadway design and construction, shall be termed *Soils and Geology Reports*, for these purposes. The request for a *Soils & Geology Report* (PPRM #445) is initiated by the roadway designer of the TDOT Project Development Division at the Regional level as described in TDOT *Design Guidelines* (DG) Chapter 4 Preliminary Plans Development 4-201.05. The request for geotechnical services is made as part of the Initial Studies Request and is typically made during the Preliminary plans preparation phase. Ideally, the *Soils and Geology Report* delivered prior to R.O.W. plans distribution. The *Soils and Geology Report* purpose is to verify the slope design proposed in the plans and consider all geotechnical elements of the roadway design (including but not limited to undercutting, rock pads, slope reinforcement, geohazard mitigation, etc.). It is important to alert the roadway designer of any geotechnical considerations on the project that will require bid item costs, as the first project budget estimate is delivered during the R.O.W. Field Review phase.

In addition to geotechnical services provided by TDOT GES for the proposed roadway improvement, transportation projects often include structural elements such as bridges, retaining walls, noise walls or high mast lighting. For TDOT GES purposes of tracking, it is important to recognize, the *Soils and Geology Report* is focused only on the proposed roadway alignment, and not any of the structural elements aforementioned. These separate structural project elements will each get separate Foundation Reports, and corresponding GES project file numbers, later in the schedule. All geotechnical efforts required of the *Soils and Geology Report* should be directed toward the R.O.W. Field Review, obtaining Final R.O.W. Plans, and then assisting as necessary in preparation of Construction Plans.

As project plans are developed, the Field Reviews and Turn-In dates schedule should be kept mindful. The GEOTECHNCIAL sheets are to be inserted properly into the plan set, as well as appropriate geotechnical recommendations, notes, and bid item quantities. Included as an Appendix 4 is the TDOT Geotechnical Field Review \ Final Plans Checklist that can be used as a standard checklist for a plans review.

2-200.00 PRELIMINARY GEOTECHNICAL STUDY

The Preliminary Geotechnical Study (PGS) is conducted to identify geotechnical features along the proposed transportation alignment, or several alignments, from a higher level, for the purposes of an environmental document. The geotechnical features identified are intended to aid in the selection of the alignment that least impacts the environment. The PGS is a document prepared to comply with TDOT Environmental Division's *Tennessee Environmental Procedures Manual* Section 5.3.8. This study is required as indicated in PPRM Activity #225 "Complete Initial Geotechnical Technical Studies."

PGS Deliverable Objective: The PGS provides a preliminary assessment to the geologic feasibility of the project location, or possibly several locations, and is prepared to satisfy NEPA requirements of a preliminary geotechnical evaluation. The PGS deliverable is a geotechnical report summarizing the study area from a geologic perspective. It should offer professional opinion regarding geology features along the proposed alignment that could result in geoenvironmental or geotechnical risk.

Except for the most complex projects, drilling, sampling, and laboratory testing is not typically required, except for occasional projects believed to contain acid producing material (APM). The presence of APM along the proposed alignments is of concern. Specific attention should be paid to potential "aquatic features" such as sinkholes, streams, wetland locations, springs, and seeps. Other typical geotechnical concerns like landslides, rockfall, subsidence areas, soft or unstable ground should be recognized because they will affect the construction schedule. With no definite alignment or grade approved, the project schedule is premature for typical engineering analysis, although preliminary volume or cost computations could be requested on a case by case basis.

The PGS request for services typically arrives with "Conceptual Drawings" containing several proposed corridor alignment plan layouts shown against aerial photography. The PGS document should be entitled the *Preliminary Geotechnical Study,* delivered to FileNet, and a notification email of the upload sent to TDOT.Env.Permits@tn.gov and TDOT.Env.NEPA@tn.gov . Maps, drawings and photographs may be attached as required in order to bring clarification to key points.

2-300.00 EXTENSIVE ROADWAY IMPROVEMENTS

Extensive Roadway Improvements (ERI) projects tend to be larger in scale and scope than Limited Extent Roadway Improvements (LERI) projects discussed in 2-500.00 or Bridge and Approaches (B&AI) projects discussed in 2-400.00. The ERI projects involve significant traffic capacity and safety improvements. Examples of typical ERI projects would include a new roadway alignments over "open" ground, or a new or modified roadway interchange, or realignment lane widenings to an existing route.

Extensive Roadway Improvement Deliverable Objective: The ERI is to deliver geotechnical recommendations to the roadway designer necessary to prepare R.O.W. and Construction plans. Tasks to meet that end typically include drilling of test borings, laboratory analysis, and engineering analysis sufficient to prepare a geotechnical report document with geotechnical sheet drawings.

It is not the intent of this document to be a comprehensive geotechnical engineering reference, but instead be a guide to TDOT GES workflow. Some of the more useful references TDOT GES recognizes and frequently employs are listed below.

- Publication No. FHWA NHI-06-088 December 2006 NHI Course No. 132012 Soils and Foundations Reference Manual
- Training Course in Geotechnical and Foundation Engineering: Rock Slopes 1999 FHWA-HI-99-007
- Advanced Course on Slope Stability, Volume 1 1994 FHWA-SA-94-005

From the sampling and testing phase, sound engineering judgement must be used in selecting the geotechnical parameters for analysis. Engineering analyses expected in the *Soils & Geology Report* include but are not limited to:

- Compaction Information (maximum density, shrink\swell factors)
- Slope stability for cut slopes in soil

- Slope stability for embankment fills
- Slope stability for rock cuts
- Settlement analyses of embankments
- Rockfall hazard mitigation

The slope stability analysis should be performed with an industry recognized limit equilibrium software and engineering judgement. GES now uses Windows based GEOSTASE4 to analyze slope stability.

TDOT Standard Drawing RD01-S-11 DESIGN AND CONSTRUCTION DETAILS FOR ROADSIDE SLOPE DEVELOPMENT Typical slopes used for TDOT projects are 2H:1V or flatter in soil, but Footnote 4 states slope stability concerns are to be evaluated by TDOT GES. The economic impact of landslides occurring during construction on TDOT embankment slopes is of significant concern. It is recognized that 2:1 fill slopes are used in an attempt to lessen the impact of the roadway footprint, to limit R.O.W. acquisition, and to reduce the quantity of fill placement. It is felt, that the costs of contractor change orders and contractor time delays following a landslide are even more significant, especially if a particular slope segment could have been designed flatter, or with geosynthetic reinforcement. Slope "benches" provide a break in the slope, and are often used effectively in slope stability modelling to increase the CDR, but are difficult to construct in the field and differential weathering causes these "benches" to not provide positive drainage, as designed. Slopes flatter than 2:1 should be recommended as necessary, and it is advised to carefully evaluate 2:1 soil embankment slopes, particularly those 30 ft. or higher.

Surface sloughing and rilling of the sandy soils are such concern in Region 4 projects, it is typical to use 3:1 soil cut and fill slopes.

Structural buttress constructed of Graded Solid Rock on slopes as steep as 1.5:1 with good quality control have been used effectively to reduce the roadway footprint.

Typically, TDOT excavates unweathered (high quality, high RQD) rock cuts on vertical pre-split slopes. There are exceptions, if the rock is weathered and of inferior quality. If the rock is of sufficiently poor quality, if the bedrock elevation is inconsistent, or if the jointing pattern is not conducive to pre-split or steep 0.25:1 slopes, it is often advisable to set the rock slope design on a configuration typically used for soil slopes.

Consider proactive rock fall mitigation as appropriate. This may involve the use of rock bolts, welded wire mesh draping, rockfall catchment fences, shotcrete and other mitigation methods. Useful guidance for rockfall mitigation can be found in Chapter 4 Operations \ Maintenance Support.

CBR test results should be evaluated and recommendations made.

If poor embankment subgrade drainage conditions exist, consider measures to “bridge” the soft soil using a rock pad or lifts of sandy select fill. If the embankment is not of sufficient height that “bridging” can be accomplished, undercutting of unsuitable material is necessary.

If karst terrain drainage is prevalent, the different typical TDOT sinkhole treatments, combined with the use of rock pads, should be considered. The Soils and Geology report and drawings are used by the TDOT Environmental Division in preparation of permits related to karst features (sinkholes) or acid producing rock.

2-400.00 BRIDGE AND APPROACHES IMPROVEMENTS

TDOT’s replaces bridges for reasons of deficiency. There are geotechnical services required specifically for the roadway adjacent to the Bridge and Approaches Improvements (B&AI) project. GES receives the request to perform these geotechnical services for the B&AI project from the Project Development Division, per DG 4-201.05. The request for services is for the roadway only, and the request for the bridge foundation investigation is considered separate and will submitted on a different schedule and to a different client, the TDOT Structures Division (discussed in Chapter 3). Although all B&AI projects are functionally classified together, the size of the project scope varies widely with the size of waterway that the bridge is crossing. Some waterways consist of only a small tributary stream, or a flood plain overflow, but there are much more significant waterway bridge crossings over the Tennessee River or the Cumberland River.

Bridge and Approaches Deliverable Objective: Ultimately, the objective of the bridge approach embankment geotechnical study is to deliver geotechnical recommendations to the roadway designer providing guidance for plans preparation. B&AI projects and ETI projects are both in support of the roadway but differ in size and scope. Refer to ETI Deliverable Objectives for complete guidance on items to include in the B&AI *Soils & Geology*

Report, but for most B&AI projects typical geotechnical recommendations such as cut and fill slope ratios, special embankment preparation, and pavement evaluation are all that is required.

2-500.00 LIMITED EXTENT IMPROVEMENTS

The geotechnical services required of a Limited Extent Improvements (LEI) may be relatively smaller in size and scope than other Extensive Roadway Improvements but are functionally grouped together for purposes of discussion. Often, these projects are developed and let to contract on an accelerated time frame as compared to the schedule of a typical roadway alignment project. The guidance for the request of the geotechnical investigation for these projects is provided by DG 4-201.05. These projects could contain bridges and/or retaining walls, and if so there will be separate projects set up for the foundation investigations, but not for the bridge approach embankments, as in a bridge replacement project. Brief descriptions of these projects are given below.

Intersection Improvement: These projects typically consist of improvement of an existing roadway or highway intersection or interchange to enhance the capacity, efficiency or safety of the facility. The improvements may include lane widenings, lane additions, and\or signalization. Of note to the geotechnical professional is that these projects are usually located in urbanized, high traffic areas with numerous utilities in the project footprint. These conditions potentially limit the extent of subsurface investigation that can be accomplished for the project, without traffic control\impedance.

State Industrial Access (SIA) Projects: As described on the TDOT Website: “The State Industrial Access (SIA) Program” provides funding and technical assistance to improve highway access for new and expanding industries across the state. TDOT partners with local governments and prepares plans for projects that vary in scope from repaving an existing roadway to significant grading. Typically, these projects are developed and let to contract on an accelerated schedule and requires the geotechnical investigation be expedited in order to meet project schedules.

Road Safety Audit Review (RSAR) Projects: These projects result from a RSAR study performed under the TDOT Strategic Transportation Investment Division of a particular section of roadway with recurring safety issues (i.e. a high incidents of guardrail impacts, collisions, etc.). Based on the review there may be recommendations for improvements that can range from installing guardrail (which usually means shoulder\buffer widening), signing, to small alignment modifications of a road. TDOT GES would typically be requested to contribute support if the RSAR project involved excavation.

Limited Extent Projects Deliverable Objective: Providing geotechnical recommendations to the roadway designer is the objective deliverable. Scale is the only difference between smaller LEP projects and larger ETI projects. Therefore, refer to ETI Deliverable Objectives guidance for LEP items guidance.

2-600.00 ACID PRODUCING MATERIAL (APM) GUIDANCE

Naturally occurring acid producing materials (APM) exist in Middle and East Tennessee shales, sandstones, and siltstones. Though a high level of care was being exercised at TDOT in APM processing since the early 1990’s, environmental concerns began occurring on TDOT construction projects in the early 2000’s. Subsequently, several separate governmental agencies convened to satisfy those environmental concerns and develop strategic compliance measures. This guidance contained herein, with sound engineering geologist or geotechnical engineer judgement, can be used to implement those strategic compliance measures developed to produce reports and prepare GEOTECHNICAL engineering drawings for insertion into R.O.W.\ Construction plans.

Per TDOT Specifications 105.04, contractual order of coordination consists of Special Provisions (SPs), Plans, and the Spec Book. In the treatment and disposal of APM, it is important to understand the implications of this contractual order. Construction Division’s *Special Provision 107L Regarding Potentially Acid Producing Materials* (SP 107L) provides the Contractor standard contractual guidance of responsibilities in the APM handling process. The SP 107L document contains many references to the Plans, in fact it states that the APM “shall be treated and disposed of in accordance with the Plans.” The geotechnical engineer or engineering geologist should review the SP 107L and understand how the document compliments the construction Plans and avoid contradiction.

TDOT GES is responsible for preparing the APM GEOTECHNICAL engineering sheets (APM G-Sheets) for the Construction Plans. For consistency in appearance, TDOT GES maintains a set of standardized engineering drawings specifically developed for APM treatment and disposal processing in a template for modification. These APM G-sheets are included in the appendix for review information only. Current sheets are available upon request from GES. The APM drawings contain typical details, sections, notes, and specifications used to implement the strategic compliance measures. The APM drawings should not be modified without considerable judgement. When APM has been identified in the project limits of construction these engineering drawings should be included within the G-sheets submittal package.

Previous TDOT GES APM policy efforts centered around guidance contained in an internal document referred to as the *Standard Operating Procedures For Acid Producing Rock* (July, 2005) (GES SOP). Within the general time frame of 2005 environmental concerns occurred on TDOT projects and leaders determined that there was a need to retain an outside consulting firm to collaborate with separate governmental agencies, compile a syntheses of current APM technical literature, and develop best management practices for treating and disposing of APM for TDOT. This effort was finalized and is entitled the *Guideline for Acid Producing Rock Investigation, Testing, Monitoring and Mitigation* (October 2007) (APR Guidelines). The APR Guidelines formed the cornerstone of the current APM methodologies and engineering drawings in use today.

Prior to the award of a TDOT construction contract where APM is suspected, TDOT Environmental Division typically delivers a set of construction plan drawings to TDEC Division of Solid Waste for approval of a Special Waste Permit. The APR Guidelines and the GES SOP both contain sound technical information and feature best management practices necessary to prepare the *Soils & Geology Report* and G-Sheets to obtain the Special Waste Permit. APM treatment and processing is a unique site-specific endeavor that requires case by case engineering judgement and is rarely standard. The previous methods and practices employed, from blending to full encapsulation, have often been adjusted to fit site specific conditions. But regardless, initially all parties must come together and work toward the goal of obtaining an executed Special Waste Permit, and afterwards work toward staying in compliance with that permit. In order to deliver the APM requirements for treatment and disposal, the engineering geologist or geotechnical engineer must have a thorough understanding of SOP, APR Guidelines, and SP107L.

Acid Producing Material Deliverable Objective: APM treatment and disposal recommendations (with G-sheet engineering drawings) are required within the *Soils & Geology Report*. Projects containing potential or known APM in the proposed cut sections must be assessed. If test results reveal acid drainage could be a concern, an APM treatment and disposal plan must be established, and engineering drawings inserted into the field review plans. The APM treatment and disposal plans available are either on-site APM disposal or off-site APM disposal.

An initial desk study and project screening should be conducted on the project in accordance with APM Guidelines. If APM potential exists or is probable within the limits of the construction project, notify supervisor \ GES Project Monitor so meetings can be planned with TDOT PDD and TDOT environmental staff which may include both Region and Headquarters to address disposal (HQ Hazardous Materials Section) and stormwater management (Region\HQ Permits) to discuss APM treatment and disposal measures.

Conduct APM sampling in general accordance of APR Guidelines as part of the subsurface investigation for the project Soils & Geology Report. TDOT GES maintains on-call APM laboratory testing contracts with qualified firms. APM tests include paste pH, Acid Potential (AP), Neutralization Potential (NP), AP-NP (the calcium carbonate deficiency, or net acid-base account value) as well as tests of total sulfur and pyritic sulfur. Since TDOT requires APM testing be performed by one of these qualified laboratories, contact your GES supervisor or GES contract administrator for more information on how to use this laboratory service.

APM test results (AP-NP) should be plotted onto soil boring profile sticks against the proposed roadway profile. These test results, along with the roadway cross sections, can be reviewed and evaluated. Initial computations of APM volume required to be treated or disposed will have to be discussed with others. Discussions should also be held that center around construction and bidding practices.

The APM G-Sheets templates contain the current strategic compliance measures and serve as the framework of the APM treatment and disposal plan. These engineering drawings include details of construction which must be clearly understood and must be inserted into the plans with the G-sheets at Field Reviews. These APM guidance sheets are an important part of the deliverable objective as they will be inserted in the Plans. SP107L and the Construction plans are the contractual mechanism directing the APM treatment and disposal plan**.** SP107L states APM material shall be, “disposed of under the direction of the Engineer and in accordance with the contract plans and documents.”

There are two contractual bid items for the treatment and disposal of APM: on-site and off-site. In the past ten years, off-site treatment and disposal of APM has largely been the preferred contractual method. Perhaps this off-site preference has been due to the substantial embankment heights that are required.

Based on review of SP107L, APM Guidelines, GES SOP, and APM G-Sheets the following general guidance is summarized.

- If the bid item 203-01.07 RD & DRNG EXCV (ACID PRODUCING- OFF SITE DISPOSAL) CY is used all work necessary by the Contractor is considered incidental.
- Per SP107L, off-site disposal requires "APM be treated at an off-site waste area in accordance with the contract or hauled to a regulated landfill approved by TDOT Environmental Division."
- Contractors are responsible for their off-site waste area SWPPP and grading plan, and the grading plan must be developed in accordance with the requirements of the APM G-sheets.
- Material is to be sampled on a "lot" basis, in accordance with SP107L guidance, and tested for Net Neutralizing Potential (NNP), and the other test methods of the acid-base accounting tests found in the APM Guidelines and the GES SOP.
- If test results reveal an NNP of greater than zero, generally the material is deemed Non-APR and should be quantified and paid as 203-01 Road & Drainage Excavation (Unclassified), in accordance with guidance in the Plans.
- If test results reveal an NNP between -5 and zero, generally the material is considered Potential-APM and could be blended on-site or off-site, often with agricultural lime, in accordance with guidance in the Plans.
- If test results reveal an NNP less than -5, the material is considered moderate to high APM and must be encapsulated on-site or off-site, in accordance with the guidance in the Plans.

2-700.00 DRILLING AND SAMPLING REQUIREMENTS

The level of effort required to characterize the geotechnical conditions of a project site varies with the project scope and design requirements. The level of drilling and sampling resources felt reasonable is discussed in this section. Geophysical testing is also being employed to further characterize the site and compliment the drilling effort. Geophysical testing guidelines and requirements are discussed in section 2-710.00 Geophysical Methods.

The site characterization level of effort and resources expended should consider what level of risk the bidder would make on an estimate.

TDOT GES considers the drilling and sampling guidelines found in Publication No. FHWA NHI-01-031 Manual on Subsurface Investigations (2001) and NCHRP Web-Only Document 258 (2018) sound. The extent of a drilling and sampling program should consider the depth of the proposed excavation cuts, the height of the proposed embankment fills, and the variability of the local geological conditions. Smaller project scopes may only require a few test borings be advanced, and only a few days spent in the field, whereas complex project scopes require extensive drilling, and could take multiple months of field testing.

Inevitably, there will be key test boring locations that are inaccessible because the terrain is critically sloped or heavily wooded. In these locations, expensive and time-consuming clearing and leveling is sometimes required to access these proposed test boring locations. The resources spent on clearing access, should approximately equate the amount of subsurface information obtained.

Generally accepted GES practices for test borings and sampling frequency is presented in *Figure 2-1 TDOT Test Boring Frequency*. Test boring frequency is based on proposed geometrics of the roadway cross sections and should be considered a general guideline. This table is intended to be used for preparing a preliminary boring layout plan or to prepare a preliminary scope estimate. The site investigation can be adjusted based upon site conditions as necessary.

It is recognized that flight auger soundings are suitable to rapidly obtain refusal elevations and conduct preliminary soil surveys.

The soil and rock sampling conducted in conjunction with the drilling will also vary greatly depending on the size and nature of the project. Generally, TDOT GES finds the following sampling guidelines to be reasonable:

Bulk bag sample (approximately 50 pounds) of each type soil encountered during auger drilling process. The soil sample is subjected to Proctor Density testing and classification. A moisture content sample is also obtained. Samples should be taken whenever there is a change in sample texture, moisture content. If the soil is consistent, additional samples should be obtained on an approximate 1,500 feet station spacing.

Table 2-1 TDOT Test Boring Frequency[1]

Cut or Fill	Depth of Fill \ Height of Cut	Cut \ Fill Length	Number of Borings	Depth
Soil Cut	D < 40	L < 600’	At least 1	Located in deepest portion of the cut, at least 15 feet below ditchline.
	D < 40	L > 600’	Spaced out at no more than 400’ in length	Located in deepest portion of the cut, at least 15 feet below ditchline.
	D > 40	L < 600’	Spaced out at no more than 400’ in length, minimum of 2 borings	Attempt to sample deepest portion of the cut, at least 15 feet below ditchline.
	D > 40	L < 600’	Spaced out at no more than 300’ in length, minimum of 2 borings	Attempt to sample deepest portion of the cut, at least 15 feet below ditchline.
Rock Cuts	D > 10’	L < 200’	At least 2	To 5 feet below ditchline
	D > 10’	L > 200’	Spaced out at no more than 200’ in length. Minimum of 3	To 5 feet below ditchline
Fills	H < 30	L < 600’	At least 1	To 2 x depth of proposed embankment. Core at least 5 feet of rock if refusal is higher than 2 x embankment depth
	H < 30	L > 600’	At least 2, spaced no more than 400 feet apart	To 2 x depth of proposed embankment. Core at least 5 feet of rock if refusal is higher than 2 x embankment depth
	H > 30	L < 600’	At least 2	To 2 x depth of proposed embankment.
	H > 30	L > 600’	At least 2, spaced no more than 300 feet apart	Core at least 5 feet of rock if refusal is higher than 2 x embankment depth

[1] Includes rock core, split spoon sampling and Shelby tube sampling as appropriate. Please note that these guidelines may not be sufficient in structurally complex rock. Additional drilling will be required if needed to predict potential structural failures in rock cuts such as plane shear, wedge failure and toppling failures.

- Bulk bag sample (approximately 80 pounds) of each type soil encountered for Proctor\CBR testing for subgrade evaluation for pavement design. The CBR test sample frequency should be approximately spaced on 2,500 feet of alignment station.

- Standard Penetration Tests and/or Shelby Tube undisturbed sampling. Samples should be AASHTO classified to characterize all of the different soil types on the site. Strength and consolidation properties should be determined, using the appropriate test methods on the undisturbed tube samples. The moisture content should be determined across the site.

- Rock core samples should be obtained in cut areas. Typically, photographs of rock core are taken and made a part of the geotechnical boring record.

- If potential Acid Producing Material (APR) is suspected, sampling\testing frequency should be increased and conducted to properly characterize the site in preparation processing in accordance with Special Provision 107L. Also, additional information is found in 2-600.00 ACID PRODUCING MATERIALS GUIDANCE.

2-710.00 GEOPHYSICAL METHODS

Many testing applications are possible using geophysics. For this discussion, the topic of geophysics will be restricted to surficial methods that attempt to characterize the geotechnical properties of a proposed transportation site. The term surficial geophysical method implies that the measurements are taken from the existing ground surface, and not measured from a drilled test borehole.

TDOT feels geophysical methods are a reasonable manner to supplement conventional drilling on transportation projects geotechnical site characterizations and locate specific utilities on private property. These methods appear minimally invasive and provide value in consideration of major transportation improvement costs. These methods are particularly appealing when conventional drilling methods are unfavored due to environmentally sensitive access clearing, or because of time consuming lane closures in high traffic demand areas, or simply because the terrain is too rugged. In theory, the geophysics technology offers promise in delivering data on a condensed time schedule and can reduce some of the risks becoming associated with conventional drilling methods.

TDOT has used geophysical methods for some time on a limited scale. TDOT has found the most practical methods to be seismic methods and electrical methods, which will be discussed later in this section. Published guidance on geophysical testing methods has been available for many years, and TDOT finds the following guidance adequate:

- The United States Army Corps of Engineers EM 1110-1-1804 Geotechnical Investigations, 2001.
- NCHRP Syntheses 357 Use of Geophysics for Transportation Projects, 2006.
- FHWA-IF-04-021, Application of Geophysical Methods to Highway Related Problems, August 2004.
- NCHRP Synthesis 547, Advancements in Use of Geophysical Methods for Transportation Projects, 2020.
- NCHRP Web Only Document 258: Manual on Subsurface Investigations, 2018.

TDOT has been engaged in an FHWA EDC-5 initiative referred to as "Advanced Geotechnical Methods in Exploration" (A-GaME) since 2018. The emphasis of A-GaME is to expose different geophysical method solutions to DOTs in hopes of further integrating the geophysical methods of testing into a standard site characterization program. After obtaining training and gaining experience with geophysical test methods results, TDOT GES can determine better which methods are better suited to the unique geology of TDOT projects. It is felt TDOT GES site characterization efforts will be improved after the efforts of A-GaME.

Geophysical Methods Deliverable Objective: TDOT delivers *Soils and Geology Reports*, which characterize the site for roadway grading purposes, and delivers *Foundation Reports*, which characterize the site for purposes of a foundation or retention elements. TDOT GES also deliver *Project Memorandums* that characterize site roadway conditions, particularly subsidence due to sinkholes in karst terrain. Geophysical testing data can enhance all of these documents GES delivers.

The principal objective of TDOT GES surface geophysical methods is to further characterize subsurface features for proposed transportation improvement projects. TDOT seeks to supplement traditional drilling techniques, with geophysical methods to evaluate earth retaining structure foundations, bridge foundations, and explore roadway excavation cuts. Many surficial methods of geophysics are available for a range of objectives, but TDOT GES geotechnical investigations typically employ seismic and electrical geophysical methods.

Seismic Methods: It is generally recognized that seismic methods are the most frequently performed geophysical survey for engineering investigations. TDOT GES typically uses seismic refraction methods. Seismic refraction is a geophysical method used for investigating subsurface ground conditions by utilizing seismic waves to determine layer thickness of the subsurface ground structure. Based on a literature review, the seismic refraction method can also be used to find fractures in the bedrock and even voids beneath these fractures. TDOT GES has found seismic refraction a tool that can identify the approximate depth of rock, and other anomalies, particularly when “truthed” with conventional test borings. One drawback to seismic refraction is background noise in urban environments (i.e. near an airport).

Electrical methods: The measurement of voltage drop between multiple electrodes is another empirical method to evaluate subsurface materials. TDOT GES is most familiar with electrical resistivity imaging (ERI) methods, because such a system is owned. The ERI system is frequently used to evaluate karst sinkhole collapse sites. Drawbacks to using ERI methods include erroneous results can be attributed to power lines, buried metallic utilities, and metal fences.

Ground-penetrating radar (GPR) is another common electrical geophysical application. GPR transmits a high-frequency electromagnetic pulse from a radar antenna into the ground subsurface. One principal drawback TDOT GES recognizes is the erroneous GPR data results that can result in clayey soils, since much of Tennessee has deposits of residual clay.

2-800.00 LABORATORY TESTING

Engineering judgement should be used to determine the laboratory testing program assigned to supplement the drilling and sampling data. The objective is to adequately characterize the site.

Listed below are some statements that should be used as general guidance when selecting the appropriate level of soils laboratory testing program for roadway projects.

- General soil behavior can be assessed by performing AASHTO Soil Classification System and natural moisture tests to soil samples. AASHTO Soil Classification requires Liquid and Plastic Limit tests performed in accordance with AASHTO Designation T 89 and AASHTO Designation T 90, respectively. Natural moisture should be performed in accordance with T 265.
- Any rock encountered should be examined or tested to characterize the type of rock and the mineralogy, to the extent necessary for construction of the project.
- Slope stability analysis requires appropriate soil strength and in-situ unit weight test results. Appropriate triaxial testing, direct shear testing and unconfined compression testing should be assigned to evaluate the sampled soils.
- Embankment settlement should be assessed if deemed appropriate by having samples subjected to strength and consolidation tests.
- CBR (California Bearing Ratio) testing is often required to evaluate pavement subgrade conditions. Soil classification is to be performed on all CBR tests, as well as the natural moisture test.
- Lime stabilization tests should be considered if CBR test results consistently yield less than 5.
- Proctor density should be performed on appropriate areas from proposed cut sections so that roadway designers can compute earthwork quantities and inspectors can verify compaction. Soil classification shall be performed on all Proctor tests, as well as the natural moisture test.
- If felt appropriate, shrink and swell testing should be performed on proposed cut sections.
- In addition to RQD and other appropriate strength correlations, rock core samples could be subjected to compressive strength tests as deemed appropriate.
- If a durable rock such as Graded Solid Rock (per State Standard Specifications Section 203.02 B. 3) is required on the project, and rock in potential cut areas is deemed to meet Graded Solid Rock borrow quality requirements, the material should be sampled appropriately and subjected to sodium sulfate soundness testing (T 104) and LA Abrasion testing (T 96).
- If the rock is suspected of leaching acid drainage off the site, appropriate samples should be subjected to pH testing and other test methods found in Special Provision 107L (see 2-600.00 Acid Producing Materials Guidance for further reference).

2-900.00 *SOILS & GEOLOGY REPORT* STANDARD FORMAT

In general, the geotechnical report referred to as the *Soils & Geology Report* should contain the items below.

- Geologic features characterization.
- Recommended slope design.
- Evaluation of on-site borrow sources in the cut areas for structural fill
- Recommended shrink \ swell factors.
- All areas that require a “rock pad” bridge, prior to embankment fill placement should be identified and quantified.
- All areas that require “undercutting” and “backfilling with more suitable material” should be identified, specified, and quantified.
- Presence of sinkholes, acid producing material, existing landslides, or rockfall risks.
- The pavement subgrade should be evaluated and a design C.B.R. recommended so others can design the pavement section.
- Geotechnical Sheets that illustrate the project in the engineering drawing plans

2-910.00 *SOILS & GEOLOGY REPORT* ELEMENTS

Soils and Geology Report Checklist: This document is included in the Appendix and should be filled out and delivered to your supervisor \ TDOT GES Proctor concurrently with draft.

Executive Summary: This section is a brief one page narrative describing the site. It briefly describes significant geotechnical issues of the project or any significant design requirements.

Introduction: Brief summary of the project and location. Any special site conditions such as limited right of way, topography and geography are noted here.

Geology, Soils and Site Conditions: A complete description of site geology, soils and site terrain conditions should be provided.

Surface and Subsurface Exploration: Provide a summary of the exploration performed such as number and type of test borings, sampling techniques, site access issues, and property owner issues, etc.

Recommendations: This section of the report is best discussed in terms of project station interval segments that share proposed geometric roadway cross section characteristics. Each segment interval discussion should include, but not be limited by:

- Recommended cut slope ratios and/or embankment slope ratios
- Rock pads / Rock buttresses
- Undercutting and replacement of soft soils
- Mitigation of sinkholes
- Settlement issues – and settlement mitigation options
- Earthwork compaction information (maximum density, shrink\swell factors)

Each interval segment should have a corresponding Geotechnical Typical Section Sheet that illustrates the boring profile and other geotechnical recommendations, as necessary. For example, if a Geotechnical Typical Section Sheet is prepared that proposes a fill embankment on a 2:1 slope from interval segment station 30+00 to 36+00, there shall be a section in the *Soils and Geology Report* that specifically refers this interval segment, confirms the slope design, illustrates test boring results, and discusses these recommendations in more detail. There will be further guidance on Geotechnical Sheets (G-Sheets) in Section 2-920.00.

Pavement Subgrade Recommendations: The CBR values recommended for design of pavements should be presented and discussed in this section. Any special recommendations regarding the subgrade such as special compaction requirements, drainage requirements, or stabilization requirements should be discussed here.

Appendix: Documents and supporting information

- Geotechnical Sheets in tabloid size (See 920.00)
- Boring Logs
- Laboratory Testing Results
- Engineering Analyses
- Other relevant supporting information

2-920.00 ELEMENTS OF THE *GEOTECHNICAL SHEETS*

When the request for the *Soils and Geology Report* is made, it will typically include digital project plans in portable document format (pdf) and also Microstation CAD drawing files (.dgn). The project plans on .dgn files is required so that certain elements can be modified in order to develop the Geotechnical Sheets (G-Sheets). These G-sheets should be entitled GEOTECHNIAL, to match the Index of Sheets description.

In an effort to increase standardization and consistency of plans appearance, current G-Sheet cell templates should be used. Be certain to create the G-Sheets using the current cell templates.

The G-Sheet number, project number text, and year of construction is found in the upper right portion of the sheet cell. At time of Construction plans "turn-in" (see more in TDOT Design Guidelines, the G-Sheets must be processed to pdf, and affixed with an electronic seal of an engineer registered in Tennessee. Field Review plan sets do not require an engineer's seal to be affixed, but only Construction plan sets.

Great emphasis is to be placed on the quality of G-Sheets. Consideration should be given to using as few sheets. Geotechnical recommendations should be clearly recognized. Unnecessary blank "real estate" on any sheet should be avoided. An area beneath the sheet project information (upper right) should be left unused, for any unplanned plans revisions that could become necessary. Referencing in other MicroStation files is discouraged. An attempt to keep the drawing files simple is encouraged.

Specific information required on the individual G-sheets is discussed and described below.

GEOTECHNICAL – GEOTECHNICAL NOTES & EST. QTYS: Any geotechnical notes that are felt required to expound upon the 2-series sheets notes that are contained in the Construction Plans or the current *TDOT Standard Specifications for Road and Bridge Construction (Standard Specifications)* should be placed here. In the event of a contradiction in a plans note and the Standard Specifications, the plans governs, per *Standard Specifications* 105.04. So, study and understand the *Standard Specifications*, and avoid using unclear, ambiguous notes. On less complex projects, there may be no need for this sheet. Often, a note can be added to one of the Soils sheets listed below.

This is the appropriate sheet to place geotechnical related roadway quantities. The quantities should be inserted in a block with standard TDOT item number, description, and unit. Footnotes should be used to further define what costs\work the TDOT item number is to include.

GEOTECHNICAL – BORING LAYOUT A plan view sheet, based on the proposed layout showing test boring locations and geotechnical recommendations. This may show limits of recommended geotechnical work, such as a plan view of undercutting limits, rock pad limits, "select fill" bridges over low lying ground, or sinkhole treatment locations. Acid producing material, if present, should be denoted. Soils data, especially Proctor Density, should be shown. The construction personnel utilize the geotechnical information during the construction phase for material quality control (i.e. proctor density tests for compaction control). This boring layout sheet should not be cluttered with curve information (PI's, PT's, etc.) but appear clean. Unless it is critical to the geotechnical information being conveyed, remove all geometric design information that could be changed in the plans development process. If test borings are limited, consider reducing the sheet scale and limit the number of Geotechnical sheets.

GEOTECHNICAL – BORING PROFILE These sheets provide a profile view of the vertical roadway grade contrasted with boring profile "sticks" along the subject station interval. Actual graphical area patterns of the different soil or rock material shall be standard, and the boring legend provided. Soil layers should be identified in accordance with Roadway Design Guidelines Section 4-203.02 DEFINITION OF TERMS USED FOR EARTHWORK GRADING CALCULATIONS

GEOTECHNICAL – TYPICAL SECTIONS Boring profile "sticks" should be placed within the roadway cross sections provided in the Microstation design files to describe the geology encountered along the proposed roadway alignment. Sufficient information should be included to convey to the bidding contractors what material will be encountered. Sufficient information should be included to convey the slope design recommendations to the roadway designer. All Soils Typical Sections should have associated recommendations within the Soils and Geology Report. i.e. if a Soils Typical Section is provided that is a typical representation of the proposed slope geometry and geology from station segment between 30+00 to 34+50, there shall be a section in the Soils and Geology Report that specifically addresses this station segment. For bid preparation identify all soil horizons that will be excavated in accordance with Roadway Design Guidelines Section 4-203.02 DEFINITION OF TERMS USED FOR EARTHWORK GRADING CALCULATIONS.

GEOTECHNICAL – SPECIALTY SHEETS SUCH AS ACID PRODUCING MATERIAL, SINKHOLE TREATMENT, etc The latter sheets can convey to the bidder and the roadway designer any specific recommendations that cannot be adequately captured in earlier sheets.

2-930.00 DELIVERY PROCESS OF SOILS AND GEOLOGY REPORT

The final *Soils and Geology Reports* are to be delivered electronically to the TDOT supervisor \ contract administrator according to the following procedures. It is the intention that the electronic deliverables be uploaded to TDOT's server, FileNet, for distribution to TDOT Roadway Design Division \ Regional Project Delivery, TDOT Environmental Division.

A single deliverable, containing multiple files, should be compressed into a *.zip file. The file naming convention should follow the example below:

xxxxxx-yy-SoilsGeoRpt-GESzzzzzzz.zip

where: xxxxxx-yy is the PIN number

zzzzzzz is the GES number

example: 117511-00-SoilsGeoRpt-GES2504313

The *.zip compressed folder will contain:

- The *Soils and Geology Report Checklist* filled out in pencil and scanned to a pdf.
- The *Soils & Geology Report* (described above) will be combined into a pdf file with the following convention:

  xxxxxx-xx-SoilsGeoRpt-GESzzzzzzz.pdf
- The entire set of *Geotechnical Sheets* combined into a single .pdf format in the following naming convention:

  xxxxxx-xx-GeoShts-GESzzzzzzz.pdf
- The entire set of Geotechnical Sheets in separate .dgn files. During this stage of plans development, the naming convention of the sheets should follow something similar to the following:

  xxxxxx-xx-GeoSht-01,dgn

  where: 01 is the sheet number and increases sequentially.

2-940.00 DELIVERY OF GEOTECHNICAL SHEETS

Each scheduled PPRM project has a scheduled time where the Geotechnical Sheets are to be delivered for the R.O.W. Field Review, R.O.W. (final), Construction Field Review, and Construction (final). Guidance for delivery of these sheets should be in accordance with DG 1-105.00 Filenet Project Deliverables. The Geotechnical sheets are required, among other items, to be modified in the upper right corner of the sheet border to reflect the appropriate sheet number, year of construction, and project number. The Geotechnical sheets will be loaded onto FileNet by TDOT GES.

CHAPTER 3 – STRUCTURAL FOUNDATION DELIVERIES

3-000.00 GENERAL

This chapter discusses guidance on GES delivery methods of bridges, retaining walls, and noise walls geotechnical services to the Structures Division. Also discussed in the chapter is how GES and the Structures Division collaborate and deliver design services for the Traffic Operations related to high mast lighting, standard lighting, signing and signal structural foundations.

The geotechnical engineer should be familiar with AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS, current version (AASHTO BRIDGE SPECS). Where AASHTO BRIDGE SPECS specifies a calculation method, this shall be used. When no AASHTO BRIDGE SPECS specifies the calculations, TDOT requires that the methods used be generally accepted and have documentation in established engineering literature. If a new or unfamiliar method is applied, checks with other methods or documentation for the method may be requested. AASHTO BRIDGE SPECS contains guidance and requirements regarding geotechnical and structural foundation design. This document's intent is to provide some specific TDOT GES guidance that can be used in conjunction with AASHTO BRIDGE SPECS and other recognized reference standards to deliver quality documents and drawings.

Appropriate subsurface explorations may include techniques, but are not limited to, rock core drilling, roller cone wash borings, SPT samples, auguring and hollow-stem auguring. Rock Quality Designation (RQD) and recovery shall be recorded for all rock samples and photographs shall be taken of all rock cores. Some general guidelines employed at TDOT for sufficient drilling at bridge substructure locations are contained. GES finds it reasonable to supplement test borings with geophysical testing applications with proper site justifications. These recommendations need to be adjusted for each individual project based on engineering judgement, AASHTO BRIDGE SPECS and industry accepted geotechnical practice.

The drilling locations and depths performed for the site will vary according to the structure being proposed, the soil variability, and underlying rock conditions, but should generally comply with Table 10.4.2-1 Minimum Number of Exploration Points and Depth of Exploration of AASHTO BRIDGE SPECS. TDOT GES generally recommends advancing one to three borings per substructure, and one boring per fifty to one hundred feet of retaining wall length, but this number may be increased when there is significant site variability. Site access difficulties may prevent the location and number of test borings drilled at the site. The geotechnical engineer should consult the appropriate references such as AASHTO BRIDGE SPECS or other NHI publications on specific wall types for further details of recommended drilling/sampling/testing requirements.

Laboratory tests required to support and validate the bridge or retaining wall foundation recommendations should be assigned at the direction of the geotechnical engineer, but may include rock unconfined compressive testing, triaxial testing, direct shear, Atterberg limits, gradation-hydrometer analysis, classification, and pH.

3-100.00 BRIDGE FOUNDATION REPORTS

The Structures Division initiates the process of requesting a *Bridge Foundation Report* be produced by contacting the GES. Typically, this request is done via an email to TDOT.Geotech@tn.gov, and the 'Foundation Data Sheet' is attached. The 'Foundation Data Sheet' contains the bridge layout along with any other pertinent foundation information such as estimated scour depths. The request is copied to the appropriate Regional Survey Office as notification to perform a proposed bridge stakeout with existing elevations along key points along the abutment and pier(s) \ bent(s). Unless other agreements have been made, the survey stakeout will be provided by TDOT. The *Bridge Foundation Report* will then be assigned an individual GES number which initiates the project and work will proceed.

It is important to review the 'Foundation Data Sheet' provided by Structures Division and determine if there are any proposed retaining walls adjacent to the proposed bridge. If proposed retaining walls are indicated, then appropriate Retaining Wall Detail sheets could be required. Retaining Wall Reports are discussed in further detail in the subsequent section.

As a matter of emphasis, geotechnical recommendations for slope development and embankment grading are contained in a separate document referred to at TDOT as the *Soils & Geology Report*. The separate *Soils & Geology Report* document shall be delivered during the ROW plans development phase and is discussed in further detail in Chapter 2. Many embankment construction issues contained in the *Soils & Geology Report* could be of interest to the Structures Division, but to state clearly, the *Soils & Geology Report* is a separate document and is to be delivered much earlier in the plans development process to the TDOT Project Delivery Division \ Roadway Design Division.

Foundation alternatives such as those discussed further in subsequent section shall be discussed in the foundation report, but the foundation ultimately used will be selected by

Structures Division. Foundations supporting bridges are typically spread footings or deep foundations cast together in a concrete group in some manner. Typically, the abutment is founded upon structural embankment fill and therefore a deep foundation, using driven or pre-drilled piles are typically used. Bridge columns supporting a grade\flood plain crossing are referred to as bents, and bridge columns supporting a river crossing are referred to as piers.

TDOT GES, in conformance with AASHTO guidelines generally recommends advancing one to three borings per substructure.

Under normal operations, foundation application alternates have been selected based on the criteria below:

- Shallow foundations upon rock - Considered if rock is encountered within approximately 10 feet below existing ground elevation.
- Driven piles – Considered if rock is encountered greater than 10 feet below proposed foundation elevation. Pre-drilling is often necessary if refusal is encountered between 8-12 feet proposed footing elevation to meet “fixity” requirements.
- Drilled shafts socketed into rock - Excessive lateral design loads must be resisted or perhaps to reduce required excavation footprint.

Separate sections discuss shallow and deep foundations in more detail.

***Bridge Foundation Report* Preparation:** The document is to be formally referred to on the report title, correspondence, and conversation as the *Bridge Foundation Report*. The *Bridge Foundation Report* and Appendix shall include a detailed narrative of the investigation, engineering analysis, recommendations, boring logs, and Foundation Data sheet. Items in the *Bridge Foundation Report* should be contained in the following general format:

Executive Summary or Cover Letter – This section gives a brief summary of the report.

Introduction – Brief summary of the project and location. Any special design considerations should be noted here.

Geology, Soils and Site Conditions – General narrative of geology, physiographic region, topography, rock \ soils, and site conditions that may affect the structure.

Surface and Subsurface Exploration – General site characterization and narrative of the equipment and tools used during the subsurface exploration.

Recommendations – The recommendations should include all necessary foundation types and parameters deemed necessary for structural design of the foundation types recommended. Innovative foundation types will require rationale as to appropriateness over conventional foundations, as well as all necessary design parameters and possibly specifications for the structural engineer. This section should include as applicable, but not be limited to:

- Type(s) of foundations recommended
- Elevation of foundation bearing strata
- Elevation of initial encounter of rock (or refusal elevation)
- Nominal Bearing Resistance of rock (\ soil)
- Side friction and base resistance factors (deep foundation)
- Depth of rock socket (deep foundation)
- Lateral capacity of soil or rock (deep foundation)
- Foundation offset from grade separation (rock cut face, rock abutment slope, soil abutment slope, bench, etc.)

Appendix – Documents and supporting data

- Foundation Data Sheet (see section below)
- Boring Logs - these must include location data on the typed logs.
- Laboratory Testing
- Engineering Analyses (i.e. liquefaction, Lpile, etc.)
- Any other applicable documents

'Foundation Data Sheet' Drawing Format Requirements: The 'Foundation Data Sheet(s)' is the preliminary bridge layout electronic drawing prepared by the Structures Division. The sheet is a CAD drawing file in Microstation format (dgn). During the '*Bridge Foundation Report*' preparation, the 'Foundation Data Sheet' is modified and then delivered *unsealed* in electronic format back to the Structures Division, for further editing (delivery is discussed in 3-700.00). The 'Foundation Data Sheet' will be inserted into the Construction Plans by the Structures Division. GES maintains a current standard CAD format that must be used (line weight, line style, boring shape, material graphic patterns, etc.). The format is under frequent modification, so contact GES for current GES CAD standards. The following should be used as a checklist to assure completeness prior to turning in the Foundation Data sheet.

General Boring Layout – Test borings should be drawn onto the bridge layout plan.

Boring Profile – "Boring sticks" depicting some of the information found on drilling logs, such as elevation stratums of different material types. This looks "cleaner" if all the element modifications can be performed on one single design sheet. It is cumbersome in the field to flip sheets. Material types are to be shown as different defined graphical patterns (i.e. sand:dots, clay:forty-five degree lines, etc), with an associated legend on a similar scale. If a driven friction pile is the likely foundation (i.e. Coastal Plain \ West Tennessee) include frictional side resistance (f_s) and end bearing (q_b) values should be shown, along with liquefiable layers labeled with an asterisk. Indicate the boring number on top of each "boring stick". The borings should be shown on an appropriately scaled grid, indicating auger refusal (AR) or boring terminated (BT) as applicable.

Elevation Chart – Table depicting the station, offset, existing ground elevation, refusal\rock elevation of each test boring.

3-200.00 RETAINING WALL REPORTS

Typical wall construction workflow, since approximately 1999, follows that the Department provides a list of 'Acceptable Retaining Walls' and their associated contractual design requirements in the Plans, and the general contractor is responsible for wall selection, wall design, and wall installation. This retaining wall delivery process that TDOT employs, allows Contractors to prepare sealed engineered drawings for proprietary wall systems that have gone through an approval process and are listed on the qualified products list. Clearly, administering wall installations presents more challenges than simply building a roadway slope.

Under normal workflow, the Regional Project Development Division designers recognize the need for a grade separation in the Preliminary plans preparation. Upon this recognition, under guidance from T*DOT Design Guidelines* 2-900.02 Develop the Retaining Wall Geometric Layout Sheet, the roadway designer generates the conceptual layout of the wall. Other guidance the roadway designer uses to generate the conceptual layout that the geotechnical engineer may find useful is found in the TDOT Standard Drawings W-CIP-1, W-MSE-1, W-MSE-2, W-SG-1, and W-SP-1. The conceptual design geometric layout is then distributed electronically to the Structures Division with a request to evaluate if a retaining wall is feasible.

Typically, a retaining wall or some form of slope\grade steepening is recognized by PDD. Then a request letter termed PROPOSEED RETAINING WALL DESIGN (Design Guidelines Figure 2-32) initiates the request for Regional Survey Office to stake out points along the retaining wall (PPRM Act # 500 Stake Sounding Holes), and TDOT GES to develop a *Retaining Wall Foundation Report.* Collaboration between TDOT GES and the Structures Division should be established to ensure a quality product.

Following the retaining wall stake-out the retaining wall subsurface exploration and *Retaining Wall Foundation Report* development can occur. All draft *Retaining Wall Foundation Reports* funded by TDOT must be finalized \ concurred with GES and the Structures Division prior to Construction Plans turn-in. The draft report review process is intended to ensure consistent standard levels of care will be used on TDOT projects statewide.

Under normal operation, the final *Retaining Wall Foundation Report* will be delivered to the Structures Division by GES with a list of 'Acceptable Wall Types' that are felt reasonable and constructible for the individual site. The Structures Division ultimately determines additional structural requirements, which of the 'Acceptable Wall Types' will be considered, and exterior fascia requirements. The Structures Division is also responsible for delivery of retaining wall plans into Field Review and Construction plan sets.

Special Provision 624 Retaining Walls (SP 624) is the policy document that specifies contract administration. The practitioner should review and be intimately familiar with the document. Regardless of the 'Acceptable Wall Type' selected, the Basis of Payment is quite involved and Method of Measurement, per the square foot bid price.

Following the award of the construction contract, the contractor prepares and submits for approval retaining wall shop drawings to the Structures Division in compliance with Special Provision 624 - Retaining Walls (SP624). The retaining wall shop drawings must be in strict conformance to the Construction Plans, particularly the RETAINING WALL DETAILS sheets ('R-Sheets'). The R-sheets are discussed in a subsequent section with more detail, but generally stipulate geotechnical design parameters, site notes, and further guidance. It is the intent that all of the bidding Contractors use the same design parameters, in the same manner, in bid estimation. The Contractor submits retaining wall shop drawings to TDOT Structures Division for review, comment and approval. TDOT GES is copied on this submittal of shop drawings for review of the geotechnical aspects only. The Retaining Wall Review checklist, provided as Appendix 6 of this document, becomes useful in this task. Once the review process is finalized, the Structures Division is responsible for returning the retaining wall shop drawings to the Contractor so installation can begin.

Retaining Wall Foundation Report **Preparation:** This section will make no attempt to discuss every check that should be considered in retaining wall evaluation, but instead hopes to serve as a general guidance in the process of working with GES. Some of the more common problematic administrative issues that have occurred in the past are discussed. As the Contractor will design and build the structure, TDOT dictates what type of structure will be constructed by limiting the 'Acceptable Wall Types', and what design parameters, load factors, and resistance factors must be used. The concept of internal and external stability will be discussed, as well as foundation improvement. Finally, standard reporting consistency will also be addressed. TDOT GES finds Appendix 6 Retaining Wall Review checklist useful.

As discussed, the Design Guidelines 2-900.01 Retaining Wall Sheet Names, Number, and Order in Plans the roadway designer prepares and delivers the conceptual design geometric layout. This section discusses the standard arrangement that the retaining wall(s) will be presented in the plans.

For standardization and consistency GES keeps current MicroStation (dgn) design templates for use in developing the R-sheets. Please contact TDOT GES to receive current CAD files to initially develop the R-sheets. The 'R-sheet template' file and 'Typical Details' design files contain general notes, special notes, and details useful in sheet preparation.

Subsurface explorations are to be conducted in accordance with current industry standards, and the boring layout program should follow AASHTO BRIDGE SPECS (Table 10.4.2-1 Minimum Number of Exploration Points and Depth of Exploration). GES generally considers advancing one test boring per fifty to one hundred feet of retaining wall length reasonable, but this general rule of thumb should be adjusted as the engineer deems fit to meet the proposed structure and geologic site variability. Typical TDOT subsurface exploration plans advance borings a depth equal to approximately one and one half times the proposed wall height. If initial drilling indicates soft soil conditions, test borings should extend a depth equal to two times the corresponding proposed wall height, or to rock, or until a firm clay or dense sand is encountered.

Laboratory testing necessary to determine and verify the geotechnical design values shall be assigned. Typical tests GES assigns include classification tests, strength tests and consolidation tests. Generally, more sophisticated testing could be necessary for complex and\or critical wall heights (over 20 ft.). The engineering geologist or geotechnical engineer is responsible for selecting the appropriate strength parameters for the appropriate loading conditions that are necessary to properly evaluate the proposed retaining wall structure.

All retaining wall design principles are to be in accordance with current industry and the AASHTO BRIDGE SPECS requirements in effect at the time of the evaluation.

Acceptable Wall Type – Preparing plans in this current process TDOT employs is unique. Communication is required between the Divisions of PDD, Structures, GES, and Construction. The roadway designer initially recognizes that there are two grades that can not be separated in a stable manner using a typical roadway slope, and there is a need for a retaining wall. In review of the plans: Present Layout, Proposed Layout, Traffic Control Plan, and Roadway Cross-Sections; the civil engineer practicing the geotechnical discipline should begin formulating ideas of how to separate the two grades proposed with a constructed earth retaining structure.

There are many different slope steepening stabilization applications and retaining wall applications available, but recognize the finite time window that the Contractor has to prepare an estimate. Therefore, the number of 'Acceptable Wall Types' should be limited within reason. It has been recognized that the cast-in-place (CIP) concrete gravity walls, CIP concrete cantilever walls, or a mechanically stabilized earth (MSE) walls are consistently the most economical and require the least contract administration resources. In contrast, the top-down constructed walls are the most complex and most expensive.

Internal and External Stability Responsibilities: One of the cornerstones of the current retaining wall delivery process, is the concept whereby TDOT contractually manages external stability risk. External stability risk is managed through quantifying necessary foundation improvement required to satisfy global slope stability and settlement\bearing on the 'R-Geotechnical Design Notes and Requirements' plans sheet. The engineering geologist \ geotechnical engineer actually designs the foundation improvement necessary to meet required external stability requirements, and describes this work in terms of bid item descriptions and notes that the Contractor uses to estimate a bid. The Contractor will then design and install a retaining wall that meets internal stability requirements.

The *Retaining Wall Foundation Report* preparer is responsible for determining external stability requirements regarding **nominal bearing resistance**. For example, following preliminary calculations it is determined that the proposed wall would apply excessive vertical bearing pressures to the unimproved ground. Therefore, the foundation improvement required for stability is determined and recommended in detail in the 'R-Geotechnical Design Notes and Requirements' engineering sheet by the *Report* preparer. All foundation improvement must be clearly defined and quantified in the plan sheets. The foundation improvement detailed in the plan sheets must be sufficient so the proposed wall has an adequate CDR for nominal bearing resistance.

The *Retaining Wall Foundation Report* preparer is responsible for external stability requirements regarding **sliding**. For example, following preliminary calculations if it is determined that the base of the wall would be excessively wide for the given constraints of the site, proposed ground improvement shall be recommended to improve the sliding coefficient. The report preparer must evaluate the sliding coefficient and determine the effect of the size of the wall on the lateral requirements of the project.

The *Retaining Wall Foundation Report* preparer is responsible for external stability requirements regarding **global stability**. For example, following preliminary calculations it is determined that the proposed slope will not meet global stability requirements after the wall is constructed. The *Report* preparer is responsible for specifying the construction effort necessary to prepare a retaining wall building pad or platform that will satisfy global stability requirements. This includes but is not limited to the depth of undercutting required, the material required to backfill the undercut excavation, pile spacing\minimum pile tip elevation, deep foundation design parameters, compacted aggregate piers, soil nails, tie-back anchors, etc. The *Report* preparer shall convey in the 'R-Geotechnical Design Notes and Requirements' engineering sheet the construction effort in terms of item numbers, footnotes, and notes in the sheet.

In summary, evaluate the external and global stability based on the bearing capacity and sliding coefficients of the existing conditions or the improved foundation. For conventional C.I.P. concrete or M.S.E. walls, the base length is to be evaluated based on the sliding coefficients recommended, and if the base length is not constructible for reasons discussed above, then another acceptable wall type must be considered.

Retaining Wall Constructability Considerations - Preparing a *Retaining Wall Foundation Report,* and 'R-Sheets' for TDOT requires careful consideration, and considerably more effort than simply recommending basic design parameters to a retaining wall designer. Considerations must be given to any necessary temporary excavation slopes, utilities, or the traffic control plan. The following factors must be considered in the development of the *Retaining Wall Foundation Report*.

Consideration must be given to the wall types that could be built within the R.O.W. available to the State. Additionally, determination of wall types should consider impact to natural/environmental features, and whether encroachment is permissible. After all, if R.O.W. were available, or we could fill in an environmental feature, a roadway slope could be constructed, without the need for a retaining wall. When reviewing the Roadway Cross Sections and Present\Proposed Layouts consideration to construction methods should be given. Many wall types are not possible, because there is insufficient area between the R.O.W. line and the proposed wall to cut a temporary excavation behind the wall. Expensive temporary shoring, temporary walls, or even a temporary top-down constructed wall could be required. Evaluation of required easements to build a particular wall type should be given.

During the Field Reviews, discussion should be held, and decisions made to determine which of the traffic control phases the wall can be sequenced.

Be cognizant of the location of utilities during the development of the *Retaining Wall Foundation Report*. At the R.O.W. Field Review, the retaining wall construction sequence should be described to the stake holders (utility owners) and determine how the public can continue to obtain utility service. During the Construction Field Review, verify there will be no conflicts with existing utilities, verify relocation of utilities, or even resolve issues with relocated utilities that are within the footprint of the proposed wall.

Retaining Wall Foundation Report Requirements: The document is to be formally referred to as the *Retaining Wall Foundation Report.* Below a brief descriptive narrative of the general requirements is made.

Executive Summary or Cover Letter – This section gives a brief summary of the report. It also states if potentially acid producing materials were found or not found on a project.

Introduction – Brief summary of purpose of the wall, general size, general type (cut or fill) and location. Any special constraints such as limited right of way should be noted here.

Geology, Soils and Site Conditions – Geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Description of the site characterization should be made here.

Recommendations – Expound on 'Acceptable Wall Types'. Generally replicate the engineering sheet 'R-Geotechnical Design Notes & Requirements', and do not contradict the sheet. Provide discussion of necessary foundation improvements. Provide recommendations for construction purposes such as allowable temporary cut slopes, special drainage, undercutting or other pertinent recommendations. GES feels reasonable the geotechnical considerations below.

<u>Appropriate Internal Angle of Friction, φ (degrees):</u> Highly plastic clay material shall never be used as backfill. Retaining wall select backfill is graded stone and is not permitted to have a friction angle greater than 34 degrees without independent sampling and testing being performed (see R-sheets template and SP 624 Section F, Part 1).

<u>Unit Weight of In-situ\Retained Soil and Select Backfill (pcf):</u> TDOT GES recognizes on R-sheets template 'Unclassified Site or Borrow Soil' and 'Select Backfill Material'.

<u>Coefficient of Sliding (unitless):</u> AASHTO BRIDGE SPECS Table C3.11.5.3-1 Friction Angle for Dissimilar Materials (8th ed.) contains appropriate guidance on consideration of sliding resistance.

<u>Nominal Bearing Resistance (psf):</u> Based on appropriate bearing capacity analysis in accordance with AASHTO BRIDGE SPECES.

<u>Maximum temporary construction slopes:</u> Review applicable occupational safety regulations. GES typically recommends no steeper than 1:1 unless there is a justifiable reason to be more conservative. Recommendations for shoring can be made as necessary.

<u>Lateral Capacity of Rock:</u> For any walls using piles or shafts socketed into rock, the lateral capacity of the rock shall be provided.

<u>Foundation Improvements:</u> Foundation improvements needed to adequately meet CDR requirements should be described in the R-sheets in detail.

<u>Settlement:</u> Any detrimental effects to the proposed structure due to settlement should be evaluated according to the AASHTO BRIDGE SPECS.

<u>Global Stability:</u> Check the global slope stability of existing and proposed site conditions. Refer to AASHTO BRIDGE SPECS for further discussion of criteria.

<u>Seismic Considerations:</u> AASHTO BRIDGE SPECS 3.10.3.1 (8th ed.) Seismic site class definition should be provided. Based on the site class definition, TDOT Structures Division will determine the seismic acceleration coefficients per AASHTO BRIDGE SPECS as appropriate. Check liquefaction of soil and seismic stability as required.

<u>Unusual Site Issues:</u> Determine if any exceptional site problems exist that would require analysis. Where retaining walls are founded on soils in a slide complex area, the foundation alternatives shall be clearly evaluated and stated on the report and drawings. Discussion of risks of founding the retaining wall in a slide complex deposit shall be discussed and the potential influence of that slide deposit on the retaining wall and surrounding structures / roadway features shall be analyzed and discussed. Pile lateral squeeze is a concern GES has found reasonable to consider.

Appendix – R-Sheets, Boring Logs, Test Reports, etc.

3-300.00 NOISE WALL REPORTS

In a similar manner to bridges and retaining walls requests for services, the Structures Division sends a letter along with a set of plans to GES requesting geotechnical services be performed a noise wall. The Geotechnical Section conducts the geotechnical investigation and provides the Structures Division a report which provides subsurface data and foundation recommendations.

While there are various noise wall dimensions, construction methods and material properties, typically noise walls are 12 feet high and constructed of precast concrete panels set in place between precast concrete posts on 20 foot spacings. The typical diameter is 24 inches in diameter, and are essentially drilled shafts which are discussed more fully in 3-500.00. The depth of the foundation hole depends largely on soil or rock conditions. Other common foundation support methods include: 1) constructing the small diameter drilled shafts and then the posts are bolted onto the top of the shaft foundation and 2) constructing a shallow spread foundation with the precast posts then bolted to the shallow spread foundation.

Typically, one test boring is advanced for each proposed noise wall post. Having a test boring advanced for each wall post eliminates many construction administration risks, but the ability to achieve this ideal drilling pattern is influenced by site access conditions at the time of the subsurface exploration program, and not at the time of notice to proceed construction.

The typical subsurface exploration plan consists of drilling test borings and sampling SPT on 5 vertical feet intervals until rock is encountered or until such depth that sufficient foundation design information has been achieved. It may be reasonable to conduct undisturbed "Shelby Tube" sampling to further characterize the site. A maximum depth of 30 feet in soil is typically adequate. Once rock is encountered the rock should be cored until it has been determined that the rock is suitable for foundation support. A depth of rock core of 10 feet is generally sufficient unless significant voids or soil seams are encountered. Consider site grading plan requirements and existing ground elevations when determining the bottom elevation of the proposed noise wall and test boring elevations.

All samples including SPT, Shelby tubes and rock cores should be retained and taken to the laboratory for further inspection by the engineer/geologist. Representative SPT samples collected during drilling should be tested for the suite of classification testing and natural moisture content. Undisturbed samples collected should be tested for classification and unconfined compression, although triaxial testing and consolidation are thought beyond a typical reasonable scope to determine noise wall design values. Rock sample mineralogy composition inspection and perhaps unconfined compression testing is not thought unreasonable for a noise wall scope.

The elements of noise wall design, including the foundation type, post spacing, and panel design will be performed by the structural engineering designer. The geotechnical design values required include determination of nominal axial bearing components; end bearing and side friction bearing for the soil and rock layers.

In addition to the axial bearing geotechnical design values, lateral capacity design values are required. Depending on the structural engineering design method, the lateral design values may include nominal shear strength, modulus values such as E_{50} of the soil or rock, or recommended p-y analysis values. It is reasonable for the geotechnical engineer \ geologist to communicate with the structural engineering designer and discuss the design methodology that will be used so that appropriate information can be presented in the report and drawings.

Noise Wall Foundation Report Format Requirements: The document is to be formally referred to on the report title and in all correspondence as the *Noise Wall Foundation Report*. The *Noise Wall Foundation Report* and Appendix shall include a detailed narrative of the investigation, engineering analysis, recommendations, boring logs, and the engineering plans drawings. Items in the *Noise Wall Foundation Report* should be contained in the following general format:

Executive Summary or Cover Letter – This section gives a brief summary of the report.

Introduction – Brief summary of purpose of the noise wall, general size, location and known foundation design (i.e. whether it is known that the posts will be on 20 centers and on drilled shafts or footings). Any special constraints such as limited right of way are noted here.

Geology, Soils and Site Conditions – General narrative of geology, physiographic region, topography, rock \ soils, and site conditions that may affect the structure.

Surface and Subsurface Exploration – A summary of the exploration methods such as type drilling and/or coring conducted should be discussed. A description of pertinent subsurface conditions encountered during drilling should be discussed including soil and rock descriptions and discussion of any groundwater encountered. Useful soil and/or rock properties determined from drill testing and laboratory testing should be summarized.

.

Recommendations – Based on an understanding of the preferred foundation type, the geotechnical design parameters for the soil and rock layers should be provided here. Expected foundation installation conditions should be discussed such as whether drilling through soil and/or rock layers will be required and whether groundwater is expected. Typical recommendations would include:

- Type of foundations (typically 2 ft. drilled shaft)
- Description of the foundation bearing strata
- Elevation where rock was encountered (or refusal elevation)
- Ultimate shear strength of all materials
- Angle of internal friction of all materials
- Effective unit weight of all materials
- Modulus design values of all materials
- Side friction and base resistance values for axial capacity check
- Recommended rock socket depth

Appendix – Documents supporting the report

- Foundation Detail Sheets – half size pdf replication of engineered drawings as turned in. To be arranged in these three sheets:

  - Boring Layout and Geotechnical Notes Sheet – plan location of borings in relation to site, and any notes that are applicable
  - Boring Profile Sheet – Boring profiles showing numbering scheme, graphic pattern of stratigraphy, soil description, legend, SPT results, water table, and other pertinent information. This sheet should show a cross section showing the noise wall in relation to ROW line, and perhaps utilities.
  - Foundation Details Sheet – This sheet will be typically prepared and inserted by the structural foundation designer.
- Boring Logs – neatly typed boring records
- Laboratory Testing Results
- Engineering Analyses (i.e. liquefaction, Lpile, etc.)
- Any other documents felt applicable

3-400.00 SHALLOW FOUNDATIONS

Structures Division policy does not generally accept bridge spread footings founded on soil. The settlement risk and scour risk of footings founded on soil are felt excessive for consideration. So, for the purposes of this discussion, shallow foundations are assumed to bear upon bedrock.

For bridges where spread footings are the most likely foundation type, bearing capacity analysis is the primary calculation that must be performed. If an abutment is located above/on top of a rock cut TDOT generally accepted policy is to set back the front edge of the abutment substructure from a rock cut face a minimum of 10 feet. This is done to accommodate weathering of the rock cut face over time, reduce the influence of the foundation on the rock cut face and to account for the potential of over-break or mistakes during construction.

Shallow foundations bearing upon rock should be considered as potential foundation application type if rock is encountered within 10 feet below proposed bottom of substructure foundation elevation. Minimum drilling requirements require rock coring of 10 feet of competent bedrock below the footing elevation. Let competent bedrock for this purpose be defined as rock drilled within a 10-foot core run without encountering more than 3 instances of rock discontinuities-voids or very weathered seams-greater than two inches or a single discontinuity greater than 6 inches. If competent bedrock is not encountered for significant depths, the engineer or geologist must determine at what depth the test boring can be terminated.

Some bridge approaches and abutments are located in roadway cuts either at bridge level or below bridge level for an underpass situation. These cuts may involve soil material or rock. If an abutment is located above/on top of a rock cut TDOT generally accepted policy is to set back the front edge of the abutment substructure from a rock cut face a minimum of 10 feet. This is done to accommodate weathering of the rock cut face over time, reduce the influence of the foundation on the rock cut face and to account for the potential of over-break or mistakes during construction. Whether part of the bridge and approach investigation or the bridge foundation investigation, every rock cut shall be drilled and/or investigated sufficiently to determine if this "default" offset of 10 ft. is adequate at the bridge location. Rock structure and potential structural failure modes shall be investigated, and the rock shall be assessed for soundness. Where rock shows a high potential of weathering (shales, claystones, argillaceous limestones etc.) the weathering rate shall be assessed, and a further offset may be required. Any potential structural failure of the rock, such as plane shear failures, wedge failures or toppling failures shall be clearly discussed and analyzed. The likelihood of raveling failures at the top of the rock cut due to blasting error or discontinuous slabs of rock shall also be assessed. If a further offset is required due to site conditions, this shall be clearly discussed in the report and accounted for in the geotechnical drawings and subsequently the project construction plans.

If barge mobilization is necessary, advance one boring at the corner of each proposed seal footing.

3-500.00 DEEP FOUNDATIONS

The deep foundations TDOT Structures Division designs are typically driven pre-cast concrete \ steel pipe piles, steel H piles driven to refusal or pre-drilled to proposed pile tip elevation, drilled shafts, or micro-piles.

Driven Pre-Cast Concrete\Steel Pipe Piles*:* Bridges in the Coastal Plain Physiographic region of West Tennessee, west of the Tennessee River in TDOT Region 4, typically are designed for driven concrete "friction" piles or sometimes steel pipe (or even H piles). Bedrock depth is far greater than 100 feet in depth in the Coastal Plain Physiographic region, and driven concrete piles are a very straight forward foundation alternative. The design and inspection is very straightforward. Prime contractors typically have cranes and pile driving hammers available, so subcontractors are not necessary. Local pre-stressed concrete producers can economically deliver piles to the site. If a pile can be driven free of refusal for 50-75' in depth, friction piles should be considered as the recommended foundation application.

For structures having relatively small span lengths, a typical subsurface investigation for a driven pile foundation involves drilling only two test borings a depth of 80 feet below pile cap \ existing ground elevation. Longer bridge structures could require drilling at least one test boring of 80 feet per abutment and pier\bent depending on site access limitations. The borings must be advanced and sampled at least 10 feet below any layers that are predicted to liquefy, based on field classification and standard penetration test (SPT). TDOT GES typically drills and samples between 75-90 feet in depth. Engineering judgement and SPT sampling should be performed to arrive at design parameters for the purposes of:

- Pile capacity
- Liquefaction Analysis
- Scour calculations
- Corrosion potential tests

Samples shall be taken at least every 5 feet for a driven pile foundation investigation. Where CPT testing is performed, an adjacent SPT test boring shall be conducted for verification of soil type. All layers of soil shall be logged, and appropriate parameters recorded during exploration.

All dissimilar SPT samples shall have gradation, hydrometer, Atterberg limits, pH and Resistivity tests performed. Each sample shall be classified to AASHTO and USCS systems. Other testing may be performed as needed to provide enough information for the prediction of liquefaction and corrosion.

Engineering analysis for a driven pile foundation project should include a static pile capacity analysis. The capacity of a driven pile is composed of F_s (side friction) and Q_b (end bearing). There are many empirical methods to determine these values, GES and Structures Division uses the values presented in Table 3-1 Static Pile Capacity. The chart uses maximum values of F_s and Q_b achieved with N=30. For blow counts above this value, GES does not extrapolate further values, but uses the values for N=30. These values were developed through research of the correlation between SPT values and field load tests. The values were developed for CME drill rigs using automatic hammers calibrated to 60% energy

(N_{60}), so note other equipment may yield different results. These charts yield ultimate\nominal bearing values. The F_s and Q_b values should be reported alongside test boring profiles on the 'Foundation Data Sheet'.

Drilling and sampling should be accomplished such that a computational value of at least 100 T (ultimate\nominal) is achieved when considering one 14-inch square concrete pile. For steel or pipe piles, GES reduces the F_s values given by one third to account for roughness \ smoothness.

Ultimate pile load capacity should consider the estimated scour depth provided on the Foundation Data Sheet. GES simply neglects frictional contributions above the scour depth elevation shown.

West Tennessee is influenced by the New Madrid Seismic Zone, particularly near Reelfoot Lake, and pile length \ ultimate bearing capacity analyses should consider liquefaction analyses. Liquefaction analysis must be performed on all coarse-grained materials and TDOT Geotechnical typically performs these for every appropriate SPT sample taken. AASHTO requires that this analysis be performed within a seismic risk area for all multi-span. TDOT utilizes a Mathcad program incorporating the elements of Seed and Idris liquefaction charts to determine liquefaction potential for each layer. All layers that have the potential for liquefaction must be clearly noted on the foundation data sheet supplied with the foundation report. Critical and interstate bridges may require more complex analyses, please see current AASHTO guidelines for guidance. These analyses may justify the up-front costs of a site specific seismic analysis, CPT testing, soil-structure interaction considerations among others. If liquefaction analyses indicate significant liquefaction potential the engineer must determine and provide recommendations for mitigation. This may include recommendations for limiting or extending pile depths to avoid liquefaction layers, discounting bearing of piles in liquefaction layer, or ground improvement at the site. More liquefaction analysis and mitigation guidance is provided in the Publication FHWA-NHI-11-032, LRFD Seismic Analysis and Design of Transportation Geotechnical Features and Structural Foundation Reference Manual.

Typically, the Structures Division uses guidance from the Bridge Foundation Report and computes an estimated test pile length, and that test pile is driven in accordance with the ENR equation (*TDOT Standard Specifications for Road and Bridge Construction* Section 606) and subjected to a static load test. Load test results are evaluated by the Structures Division, and production pile lengths are verified \ evaluated prior to production pile driving.

Static Pile Capacity

Unit Length Concrete Piles

Clay					Silt					Sand				
	English Units		Metric Units			English Units		Metric Units			English Units		Metric Units	
N	Fs (TSF)	Qb (TSF)	Fs (kPa)	Qb(kPa)	N	Fs (TSF)	Qb (TSF)	Fs (kPa)	Qb(kPa)	N	Fs (TSF)	Qb (TSF)	Fs (kPa)	Qb(kPa)
1	0.06	0	6	0	1	0.04	0	4	0	1	0.01	0	1	0
2	0.11	0	11	0	2	0.08	0	8	0	2	0.03	0	3	0
3	0.16	0	15	0	3	0.12	0	11	0	3	0.05	0	5	0
4	0.20	0	19	0	4	0.17	0	16	0	4	0.07	0	7	0
5	0.25	2	24	192	5	0.22	5	21	479	5	0.09	11	9	1053
6	0.30	3	29	287	6	0.26	7	25	670	6	0.11	13	11	1245
7	0.35	3	34	287	7	0.30	8	29	766	7	0.13	15	12	1436
8	0.40	4	38	383	8	0.33	9	32	862	8	0.14	17	13	1628
9	0.45	4	43	383	9	0.36	10	34	958	9	0.16	19	15	1819
10	0.50	5	48	479	10	0.40	11	38	1053	10	0.18	22	17	2107
11	0.54	5	52	479	11	0.44	12	42	1149	11	0.20	24	19	2298
12	0.58	6	56	575	12	0.48	13	46	1245	12	0.22	26	21	2490
13	0.62	6	59	575	13	0.51	14	49	1341	13	0.24	28	23	2681
14	0.66	7	63	670	14	0.54	15	52	1436	14	0.26	30	25	2873
15	0.70	7	67	670	15	0.58	16	56	1532	15	0.28	32	27	3064
16	0.74	7	71	670	16	0.62	17	59	1628	16	0.30	35	29	3352
17	0.78	8	75	766	17	0.66	19	63	1819	17	0.32	37	31	3543
18	0.82	8	79	766	18	0.70	20	67	1915	18	0.34	39	33	3735
19	0.86	9	82	862	19	0.74	21	71	2011	19	0.36	41	34	3926
20	0.90	9	86	862	20	0.77	22	74	2107	20	0.38	43	36	4118
21	0.93	10	89	958	21	0.80	23	77	2202	21	0.40	45	38	4309
22	0.96	10	92	958	22	0.84	24	80	2298	22	0.42	48	40	4596
23	1.00	11	96	1053	23	0.87	25	83	2394	23	0.44	50	42	4786
24	1.04	11	100	1053	24	0.90	26	86	2490	24	0.46	52	44	4980
25	1.08	12	103	1149	25	0.93	27	89	2586	25	0.48	54	46	5171
26	1.10	12	105	1149	26	0.95	28	91	2681	26	0.50	56	48	5363
27	1.13	13	108	1245	27	0.97	29	93	2777	27	0.52	58	50	5554
28	1.16	13	111	1245	28	1.00	31	96	2969	28	0.54	61	52	5841
29	1.20	14	115	1341	29	1.03	32	99	3064	29	0.56	63	54	6033
30	1.24	14	119	1341	30	1.06	33	102	3160	30	0.58	65	56	6224

English Units

End Area of a 14" square Pile = 1.36 ft2
Surface Area of a one foot length of Pile = 4.67 ft2
A bearing of 100 Tons is required when piles end in sand (70' min. depth for liquef.)
A bearing of 125 tons is required when piles end in clay
Friction = 4.67*Depth*Fs (T)
End Bearing = 1.36*Qb (T)

Metric Units

End Area of a .356 m square Pile = .1265 m2
Surface Area of a 1 m length of Pile= 1.422 m2
A bearing of 890kN is required when piles end in sand (21.5 m min. depth for liquef.)
A bearing of 1100 kN is required when piles end in clay
Friciton = 1.422*Depth*Fs (kN)
End Bearing = .1265*Qb (kN)

Table 3-1 Static Pile Capacity Chart

H-Piles Driven to Refusal: When rock can be reached economically, support from an end bearing steel H-pile is a common deep foundation alternative. Driven piles in rock should be considered as a potential foundation type where rock is generally encountered greater than 10 feet below proposed bottom of substructure. Where end bearing H-piles are the most likely foundation type, analysis of pile tip elevation and pile installation issues are the predominant concerns.

When rock is encountered around 10 feet below the proposed footing elevation, and the structural engineer does not desire a spread footing but is concerned with the "fixity" length of a driven H-pile, there is guidance in the TDOT Spec Book for drilling a hole to a minimum pile depth and inserting the "H" pile into that hole, and then backfilling the anulus of the drilled hole with graded stone.

To enable an adequate penetration into sound rock, often a protective tip is affixed to the end of the pile. This is particularly applicable in some of the dipping rock formations of East Tennessee.

Depending upon the geologic formation of the site, the "approximate rock line" is highly variable in the dipping, fractured, and jointed rock in Tennessee. And appropriate subsurface explorations could include flight augering to refusal, but it is important to core drill as many borings as felt required to verify bedrock elevation and make certain that auger refusal elevation was not an anomaly such as a "floating" boulder or karst pinnacle. The structural engineer uses the subsurface site characterization as a basis to estimate total pile length. Core at least 10 feet of competent bedrock. Let competent bedrock for this purpose be defined as rock drilled within a 10-foot core run without encountering more than 3 instances of rock discontinuities\voids, or weathered seams\fractures greater than two inches, or a single discontinuity greater than 6 inches. If competent bedrock is not encountered for significant depths, the engineer or geologist must use professional judgement to determine the depth of test boring termination. Core recovery percentage and RQD should be computed and documented.

Drilled Shafts: As driven piles, drilled shaft axial design capacity is based on a frictional component and an end bearing component. Design of drilled shafts is typically conservatively restricted to relying on one or the other component, and TDOT typically designs for end bearing. GES recommends both frictional bearing resistance and end bearing resistance be recommended in the Foundation Report.

Large river crossings have used drilled shaft foundations previously. This is attributed to excessive barge impact loads that must be resisted laterally. Therefore, soil modulus values and often a p-y analysis shall be provided when deep foundations are considered.

Special Provision 625 ‘Drilled Shafts’ is the contractual specification document used to administer drilled shafts. The practitioner should review and understand the current SP 625. Among the many requirements, the document states the minimum qualification of the contractor, and states there must be a “work plan” submitted to the Engineer by the Contractor. Although an initial drilled shaft tip elevation based on the Foundation Report is provided in the construction plans, additional test borings of NQ or NX size (625.31 Core Drilling) is typically advised in the construction plans. These test borings are to be drilled into the precise field location the drilled shafts are proposed to further verify the shaft tip elevation. Following completion, these borings are to be evaluated by GES and Structures Division, concurrently, so that each shaft required has a verified shaft tip elevation. The document stipulates there must be a preconstruction conference to discuss the inspection requirements. Construction requirements also include that self-consolidating concrete must be used on drilled shafts.

Drilled shaft subsurface explorations require a minimum of one test boring per abutment shaft or bent/pier shaft. Great effort is to be made to achieve drilling access on the proposed drilled shaft location. In exploring the subsurface for use of drilled shafts, the rock should be cored at least 20-30 feet into competent bedrock for consideration of the initial shaft tip elevation. Let competent bedrock for this purpose be defined as rock drilled within a 10 foot core run without encountering more than 3 instances of rock discontinuities\voids, or weathered seams\fractures greater than two inches, or a single discontinuity greater than 6 inches. If competent bedrock is not encountered for significant depths, the engineer or geologist must use professional judgement to determine the depth of test boring termination. Core recovery percentage and RQD should be computed and documented.

Micropiles: Micropile foundations have applications in low-head room environments. TDOT has used micropiles in this application for Structures Division bridge rehabilitation projects. Another application that TDOT has used micropiles is to add additional capacity adjacent to an existing foundation. Micropile foundations have been used on certain TDOT ‘innovative contracting projects’ such as Design-Build and CMGC. The Special Provision 625MP Micropiles is the contractual document that offers guidance on micropiles. The same drilling guidance used for drilled shafts should be used in drilling for micropiles.

3-600.00 STANDARD LIGHTING AND HIGH-MAST LIGHTING REPORTS

Signs, Lighting, and Signal Foundations: Foundation design for standard signs, lighting, and signal foundations are to be performed by the contractor. Shop drawings are to be sealed by an engineer registered in Tennessee and must be delivered to the Structures Division for concurrence prior to installation. If the engineer of record feels a subsurface investigation or geotechnical report is warranted to deliver these shop drawings, that work shall be the responsibility of the Contractor.

GES is typically given the opportunity to review and comment on geotechnical issues at the Field Reviews.

- If light standards are included in the Construction Plans, it is suggested that the designer place a clarifying footnote alongside the bid item 714-08.20 FOUNDATION (ONLY) FOR <u>LIGHT STANDARDS</u> stating, "INCLUDES THE COST OF THE FOUNDATION DESIGN AND ANY SOIL SUBSURFACE EXPLORATION FELT REQUIRED FOR THE DESIGN OF THE __ FOUNDATION."

- If signal poles are included in the Construction Plans, Traffic Operation Memo No. 1702 should be reviewed, and it is suggested that the bid item series 730-23.XX be footnoted with the following text, "THIS BID ITEM INCLUDES THE COST OF THE FOUNDATION DESIGN AND, IF NECESSARY, THE SOIL EXPLORATION REQUIRED FOR THE DESIGN OF THE SIGNAL POLE FOUNDATION."

High Mast Lighting (HML) Foundations: GES is responsible for providing and delivering a *High Mast Lighting Foundation Report* (*HML Foundation Report*) to the Traffic Division in accordance with the TDOT Traffic Design Manual 15.4.5. The *HML Foundation Report* is prepared for the use of the HML foundation designer. The *HML Foundation Report* shall recommend design requirements to be used by <u>others</u> to design the HML foundation. GES will also typically be given the opportunity to review and comment on plans at Field Reviews.

Typically, HML structures are defined as structures being of heights greater than 55 feet above grade surface. Foundation design guidance for HML structures are found in Chapter 13 of AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, AASHTO BRIDGE SPECS, and NCHRP Report 411

Structural Supports for Highway Signs, Luminaries, and Traffic Signals. Further guidance can be found TDOT Traffic Design Manual; TDOT Traffic Division Standard Drawing T-L-1 *Standard Lighting Foundation Details*; Structure Division TDOT Standard Drawing STD-8-4 *Sign, Luminaire and Traffic Signal Supports*.

Under normal workflow, the Traffic Division initiates the process of requesting an *HML Foundation Report* by contacting the GES. Typically, this request is done with an email to TDOT.Geotech@tn.gov, with necessary electronic drawing files attached. The request is typically copied to the appropriate Regional Survey Office as notification to perform a proposed structure stakeout. Unless other agreements are clearly made, the survey stakeout will be provided by TDOT. The *HML Foundation Report* request will then be assigned an individual GES number which initiates the project, so a task i.d. (TX#) can be assigned, and work shall proceed.

Foundation Report Format Requirements: The document is to be formally referred to on the report title and in all correspondence as the *High Mast Lighting Foundation Report*. The Foundation Report and Appendices shall include a detailed narrative of the investigation, engineering analysis, design recommendations, boring logs, and Foundation Data sheet. According to the Traffic Manual, the typical foundation is a 4-foot diameter drilled shaft. Items included in the *HML Foundation Report* should be arranged in the following general format:

Executive Summary or Cover Letter – This section gives a brief summary of the report purpose.

Introduction – Brief summary of the project and location. Any special design considerations should be noted here.

Geology, Soils and Site Conditions – General narrative of geology, physiographic region, topography, rock \ soils, and site conditions that may affect the structure.

Surface and Subsurface Exploration – General site characterization and narrative of the equipment and tools used during the subsurface exploration. Standard test methods of any field tests are to be included.

Recommendations – Generally includes as applicable:

- Type of foundations (typically 4-foot diameter drilled shaft)
- Description of the foundation bearing strata
- Elevation where rock was encountered (or refusal elevation)
- Ultimate shear strength of all foundation materials
- Angle of internal friction of all foundation materials

- Effective unit weight of all materials
- Side friction and base resistance values for axial capacity check
- Recommended rock socket depth (typical minimum is a factor of drilled shaft diameter and 1.5-2.0)

Appendix – Documents supporting the report

- Foundation Detail Sheets – half size pdf replication of engineered drawings as turned in. To be arranged in these three sheets:
  - ➢ Boring Layout and Geotechnical Notes Sheet – plan location of borings in relation to site, and any pertinent notes that are applicable to foundation construction
  - ➢ Boring Profile Sheet – Boring profiles showing numbering scheme, graphic pattern of stratigraphy, soil description, legend, SPT results, water table, and other pertinent information
  - ➢ Foundation Details Sheet(s) – Inserted separately by the structural foundation designer (Structures Division or Engineering Consultant)
- Boring Logs – neatly typed boring records
- Laboratory Testing Results
- Engineering Analyses (i.e. liquefaction, Lpile, etc.)
- Any other documents felt applicable

3-700.00 FOUNDATION REPORTS STANDARD DELIVERY

Final TDOT GES *Foundation Reports* documents are to be turned in to the Structures Division or the Traffic Division in a standardized electronic delivery format described herein. The *Foundation Reports* will be sent as an email attachment unless the files are too large and then other file sharing systems are typically used. The general delivery process is described below.

- Standard email template form should be used. The subject should include the pin number and project description. The email should be sent and copied to the appropriate recipients. Standard GES email templates are kept current and should be requested.

- Combine digitally sealed report with attachments (boring logs, test results, bridge \ retaining wall \ noise wall \ HML sheets, etc.) into a single *.pdf file. If multiple walls or bridges, separate deliveries are required. Standard file naming convention for a bridge, retaining wall, noise wall, or high mast lighting project is as follows:

xxxxxx-yy-GeoFoundRptBrX-GESzzzzzzz.pdf
xxxxxx-yy-GeoFoundRptRWX-GESzzzzzzz.pdf
xxxxxx-yy-GeoFoundRptNoiseX-GESzzzzzzz.pdf
xxxxxx-yy-GeoFoundRptHMLX-GESzzzzzzz.pdf
where: xxxxxx-yy - the PIN number
zzzzzzz - the GES number
X – the bridge \ retaining wall \ noise wall number, if multiple structures.
example: 117511-00-GeoFoundRptRW02-GES2504313

- Unsealed cad drawing sheets in (*.dgn) format. The file name is to follow the convention below:

xxxxxx-yy-GeoFoundRptBrX-GESzzzzzzz.dgn
xxxxxx-yy-GeoFoundRptRWX-GESzzzzzzz.dgn
xxxxxx-yy-GeoFoundRptNoiseX-GESzzzzzzz.dgn
xxxxxx-yy-GeoFoundRptHMLX-GESzzzzzzz.dgn
where: xxxxxx-yy - the PIN number
zzzzzzz - the GES number
X – the bridge \ retaining wall \ noise wall *number*, if multiple structures.
example: 117511-00-GeoFoundRptRW02-GES2504313.dgn

CHAPTER 4 – OPERATIONS \ MAINTENANCE SUPPORT

4-000.00 GENERAL

This chapter discusses TDOT GES support of the Operations Division. TDOT Operations Division has a regional Maintenance component and a regional Construction component. GES supports the Operations Division - Maintenance by being available upon request to offer solution recommendations for geohazards including karst sinkholes, rockfalls, or landslides. Additionally, TDOT GES is available to make site visits upon request and offer support to the Operations Division - Construction to clarify any geotechnical recommendations made in the Construction Plans or any other geotechnical problems that might arise during the construction phase of a project.

As a matter of record, TDOT GES assigns an internal file number to track unplanned support given to Maintenance for landslides and rockfalls. Records of geotechnical support given during the construction phase are stored under the file number for that associated construction project.

4-100.00 LANDSLIDES AND ROCKFALLS

Unplanned landslide and rockfall occurrences affect state routes and take priority over other scheduled projects in the transportation improvement plan. The project size and project scale ranges from small soil failures that become noticed as cracks in the road, to large slope failures that occur on heavily trafficked routes and demand immediate action.

Typically, these project types will not be assigned to consultants since they occur on an emergency basis and rapid response is of high priority. A variety of methods are available to mitigate or repair landslides and rockfall sites. TDOT will often offer alternative solution recommendations for short term mitigation and long term mitigation repair.

Landslides and Rockfalls Deliverables Objective: Proposed mitigation for recognized landslide and rockfall risks within the project limits of a scheduled PPRM project are to be addressed in the *Soils and Geology Report*.

All too often, unplanned slope instabilities arise and upon discovery the Operations Division – Maintenance contacts TDOT GES for support or advisement, or if it is deemed beyond internal capabilities. TDOT GES will make a site visit and deliver an internal Project Memorandum to the requesting parties offering up recommended slope mitigation recommendations.

Statewide contract SWC191 Slope Stabilization, administered through the Engineering Operations office, has been used as a tool to stabilize slopes, particularly side hill template sections. Landslide risks are often first discovered by Regional Operations Division – Maintenance (TDOT Maintenance) staff. Then notification will be made to TDOT GES for an on site meeting to discuss the slope failure, and come to a concurrence on particular slope mitigation measures that should be used. Often a rock buttress installation or even a smaller “deep patch” installation will be an adequate solution. Other more complicated and costly mitigation measures that include soil nail wall or rail steel installations are considered as well. This contract compliments the TDOT Asset Management Plan effort to stabilize slopes in Tennessee.

Separately, rockfall risk within TDOT is mitered by the TDOT Rockfall Management Program (RMP). Initially, individual rock slope sites are evaluated using the standard Rockfall Hazard Rating System (RHRS) that evaluates risk on a number of factors including geometric design, ADT, and geologic instability mechanisms. These sites are entered into a database inventory and visualized on Arc-GIS system. Then, a list of programmed projects with the highest risk, based on data driven metrics, is produced and rockfall mitigation sheets are inserted into a set of roadway plans and let to contract. The RMP has a separate document that includes more details of the program last updated in 2017. TDOT GES is currently under an effort to combine the RMP with a landslide risk evaluation program under guidance of the TDOT *Transportation Asset Management Plan*.

Guidance used to develop rockfall mitigation plans is available. FHWA SA-93-085 *Rockfall: Characterization and Control* (1993) still provides useful reference. NCHRP Synthesis 555 *Estimating and Contracting Rock Slope Scaling Adjacent to Highways* is also a useful reference.

TDOT has Special Provisions (SP707D Rockfall Slope Drape, SP707E Pinned Rockfall Slope Mesh, and 707H Rockfall Barrier Systems that serve as contractual guidance to contractors.

TDOT GES maintains slope monitoring equipment. Presently, slope inclinometers are installed and monitored throughout the state to identify failure planes and evaluate rate of slope movement. Also, computer analyses is performed on site models using the software RocFall, developed by RocScience.

4-200.00 SINKHOLES AND SUBSIDENCE

When sinkholes and subsidence issues occur on TDOT R.O.W., TDOT GES is often required to perform further investigation, evaluation, and make mitigation recommendations. Because of underlying karst geology, there are areas of Tennessee prone to sinkhole drop-outs or collapses. Conversely, in urban areas sinkhole drop-outs can occur due to ruptured utility water lines. It is likely that sinkhole “domes” already existed in the natural geology, and after a triggering mechanism, like a roadway excavation that changes drainage, or a dramatic rainfall event, are exacerbated.

Roadway subsidence also could be due to differential settlement of soils. In West Tennessee erodible soils, soil piping, and poor drainage cause subsidence. Typically, it is the TDOT GES unit that evaluates subsidence that impacts the roadway, and determines what contributing factors are at work.

Normally, these project types are considered on an “emergency basis” and not assigned to consultants since a rapid response is required.

Sinkholes and Subsidence Deliverables Objective: Proposed mitigation for a recognized sinkhole within the project limits of a scheduled PPRM projects are addressed in the *Soils and Geology Report* and all guidance and details shown in the Geotechnical sheets. TDOT GES maintains a set of typical sinkhole drawing detail sheets devoted to karst sinkholes. The drawings have gained the approval of TDOT Environmental Division and TDEC in the past, so any deviations or modifications from accepted standards are scrutinized. In fact, the section discussing sinkholes in the *Soils and Geology Report* is used by TDOT Environmental Division to obtain environmental documents necessary for the project. These typical sinkhole drawing detail sheets contain typical details and notes that are common to most sinkhole mitigation plans and are included as Appendix 5 for information only.

Sinkholes and subsidence problems occurring on a state or federal route outside of a scheduled PPRM project are considered maintenance issues and as such are often initially discovered by TDOT Maintenance staff. Notification is typically made to TDOT GES and an on-site meeting is scheduled to investigate the sinkhole or subsidence and discuss remediation methods. After the on-site meeting, TDOT GES delivers a Project Memorandum to the TDOT Maintenance staff discussing the problem and recommending remediation alternatives.

Recommended sinkhole and subsidence mitigation alternatives can be driven by the impact to travelling users of the roadway, and the proposed traffic control plan required. Treatment methods found in the TDOT typical sinkhole drawing detail sheets provide a relatively permanent mitigation treatment but require using an excavator to expose the sinkhole “throat” before backfilling with graded solid rock. These typical treatment methods are generally preferred because the subsurface hydrogeology is not changed appreciably. However, little is generally known initially of the location of the sinkhole “throat” or other geometries of the excavation. If the “throat” is deep in the subsurface, a rather large excavation is possible, and haul time of spoil material becomes a factor.

Alternative methods to the TDOT treatments shown on the typical sinkhole drawing details for remediation have been used where an immediate, short-term repair is advisable. An immediate, short-term repair such as compaction grouting has been used with success. Using a remediation treatment such as compaction grouting allows the roadway to be opened to traffic rather quickly, but the subsurface hydrogeology is altered, and there is risk of another sinkhole “dome collapse” occurring elsewhere.

There is a statewide contract for Compaction Grouting & Slab Stabilization which is administered through the Engineering Operations office. This contract has been used to remediate sinkholes. TDOT SP 204CG – Compaction Grouting has been developed to serve as contractual guidance to contractors.

APPENDIX 1

RETAINING WALL SHOP DRAWING CHECKLIST

TDOT Geotechnical Engineering Section

Retaining Wall Review

TN TDOT Department of Transportation

Retaining Wall Information			
Project:			Wall No.:
Contractor Name			Contact:
Wall Supplier/Designer			Date :
Structures Contact			Reviewer
PE Number	Pin No.	GES File No.	Contract No.:

YES NO

☐ ☐ IS WALL TYPE SUBMITTED A TYPE LISTED AS ACCEPTABLE IN PLANS?
COMMENTS:

☐ ☐ IS WALL SYSTEM ON APPROVED SYSTEM LIST?
COMMENTS:

☐ ☐ DOES WALL GEOMETRY CONFORM TO PLANS?
COMMENTS:

☐ ☐ IS PLANS WALL GEOMETRY SAME AS PROVIDED FOR DURING ORIGINAL GEOTECHNICAL INVESTIGATION?
COMMENTS:

☐ ☐ DO WALL CALCULATIONS PROVIDE ASSUMED SOIL/ROCK PARAMETERS USED IN DESIGN?
COMMENTS:

☐ ☐ IS THE SOIL/ROCK PARAMETERS IN CONFORMANCE WITH CONTRACT PLANS REQUIREMENTS?
COMMENTS:

☐ ☐ DO CALCUALTIONS SHOW APPLIED BEARING FOR VARIOUS DESIGN CASES?
COMMENTS:

☐ ☐ IS APPLIED BEARING LESS THAN THE ALLOWABLE SHOWN IN PLANS?
COMMENTS:

☐ ☐ DO PLANS SHOW REQUIRED FOUNDATION IMPROVENT (I.E. UNDERCUTTING/ROCK REPLACEMENT?)
COMMENTS:

☐ ☐ DO CALCULATIONS DEMONSTRATE SLIDING IS CALCULATED USING APPRPOPRIATE PARAMETERS?
COMMENTS:

☐ ☐ DO PLANS CLEARLY DEFINE WHAT TYPE OF BACKFILL WILL BE USED?
COMMENTS:

DESIGN SUBMITTAL APPROVED AS SUBMITTED:

REQUIRED REVISIONS:

ATTACH ANY E-MAIL OR MAIL CORRESPONDENCE REGARDING THE WALL REVIEW TO THIS FORM

APPENDIX 2

SOILS AND GEOLOGY REPORT CHECKLIST

TDOT Geotechnical Engineering Section *Soils and Geology Report Checklist*

General Project Information		
Project Description:		Phone Number:
GES:		Date:
Pin Number:	Geo/Consultant:	TDOT Oversight:

General – For all sheets except first, develop a page header/footer containing brief description of project.

	Yes	No	N/A
Coversheet includes:			
• County	☐	☐	☐
• PPRMI Project Description	☐	☐	☐
• P.E. Project No.	☐	☐	☐
• PIN No.	☐	☐	☐
• Geotechnical Engineering File No.	☐	☐	☐
Sealed Scope & Liability Limitations on Letterhead (if applicable)	☐	☐	☐
Table of Contents (if applicable)	☐	☐	☐
Executive Summary: Brief Description of Project to include:			
• General slope recommendations	☐	☐	☐
• CBR value for pavement design	☐	☐	☐
• Describe special construction considerations recommended (rock pads, buttresses, undercut, grouting, acid producing material, etc.)	☐	☐	☐
Introduction:			
• Brief summary of project and any unusual considerations	☐	☐	☐
• Vicinity Location Map	☐	☐	☐
Existing Site Conditions and Geology:			
Existing geological conditions and effects on project (geography, topography, physiographic Region, geologic formations, unusual geologic conditions.	☐	☐	☐
Description of any geologic hazards present (rockfalls, sinkholes, wetlands, APR, seismic)	☐	☐	☐
Recommendations:			
• Specific recommendations presented in station to station format	☐	☐	☐
• Cut slope/fill slope recommendations	☐	☐	☐
• Unsuitable soil recommendations	☐	☐	☐
• Sinkhole treatment recommendations	☐	☐	☐
• APR mitigation recommendations	☐	☐	☐
• Do referenced typical cross sections correspond to intervals where treatment occurs	☐	☐	☐
Pavement Design Recommendations:			
• Was CBR test performed	☐	☐	☐
• Actual recommended CBR value for pavement design given in bold type	☐	☐	☐
Appendix:			
• Typed Boring Logs	☐	☐	☐
• Laboratory Test Results	☐	☐	☐
• Slope Stability Analysis Results	☐	☐	☐
• Site Specific Seismic Study (as required)	☐	☐	☐
• Unsealed Soils Sheets (see separate Soils Sheets checklist) w/app. Proj. phase stamp	☐	☐	☐

Electronic submittal to be loaded on TDOT FileNet server archiving: .zip files containing:

Sealed Soils & Geology Report combined with Appendix (PDF)

- File Naming Convention nnnnnn-nn-SoilsGeoRpt-GESyyyyyy.zip
- Where nnnnnn-nn represents the project pin no.
- Where yyyyyy represents the project GES no.

Un-Sealed Soils Sheets Folder for insertion to Field Review Plans (individual. Dgn files)

- File naming convention nnnnnn-nn-Soils-YYY-Descr.dgn
- Where nnnnnn-nn represents the project pin no.
- Where YYY represents the sequential sheet number (first to last)
- Where Descr represents the title block abbreviated sub-name (i.e. Notes, TypicalSec, Plan, SoilProf)

Separate Gint file folder with project pin no. contained in the file name

APPENDIX 3

TDOT GEOTECHNICAL CONSULTANT INVOICE CHECKLIST

TDOT GEOTECHNICAL CONSULTANT INVOICE CHECKLIST

Invoice Transmittal Letter

- ☐ Reference project's initial executed work order and any previous progress billing invoices.
- ☐ Verify standard invoice transmittal letter agrees with standard style recognized by TDOT. See example Consultant Information Attachment A-D https://www.tn.gov/tdot/business-redirect/consultantinfo.html
- ☐ Verify no personal or private information is shown (social security numbers, personal tax information, bank routing numbers, Federal ID numbers)
- ☐ Verify "Received" stamp is present and properly dated and signed
- ☐ Verify Invoice Date generally agrees with "Progress Billing" period and is not duplicate of prior invoices.
- ☐ Verify vendor's local office is shown (consultant name, address & telephone)
- ☐ Verify correct TDOT Agreement No. and Work Order No. (matches Work Order)
- ☐ Verify correct TDOT PIN No. (matches Work Order)
- ☐ Verify correct TDOT Project No. (matches Work Order)
- ☐ Verify correct Federal Project No. (matches Work Order, some projects have no Federal funding)
- ☐ Verify correct TDOT Project Description (matches Work Order)
- ☐ Verify correct GES No. (matches Work Order)
- ☐ Verify Pay Terms are clearly stated? (i.e. upon receipt, net 30 days, net 60 days)
- ☐ Verify if invoice is FINAL or Partial? (shown beside "Progress Billing No.")
- ☐ Verify "Progress Billing No." is correct does not duplicate previous "progress billing" numbers.
- ☐ Verify "Progress Billing" period is shown (i.e. Oct. 1 – Nov. 15) and agrees with Invoice Date.
- ☐ Does "Progress Billing" period span two fiscal years? (June\July billing has been reason for rejection)

Contrast the Invoice Transmittal Letter Summary to *GES Standard Invoice Form*

- ☐ Is "Amount Due this Invoice" in agreement with "Total Amount Billed this Cycle" ?
- ☐ Is "Work Order Ceiling" in agreement with "Not-To-Exceed Amount" ?
- ☐ Is "Amount Remaining" in agreement with "Amount Remaining After Billing" ?
- ☐ Is Invoice Transmittal Signed?
- ☐ Does "Remit to:" address agree with remittance address entered in Edison? (for ASA only)

TDOT GEOTECHNICAL CONSULTANT INVOICE CHECKLIST

GES Standard Invoice (xls spread sheet attachment)

☐ Verify "Cover Sheet" project information is correct.

☐ Review "1.00 Drilling Services" quantities and compare to work order, assess reasonableness (Project Monitor only)

☐ Review "2.00 Laboratory Services" testing quantities and compare to work order, assess reasonableness (Project Monitor only)

☐ Review "3.00 Manpower Requirements" and cross reference employee with required labor attachment including dates worked.

☐ Verify no staff has a Direct Pay Rate on "3.01 Manpower Breakdown" greater than $77.84.

☐ Verify Hourly Rate agrees on "3.00 Manpower Requirements" and "3.01 Manpower Breakdown".

☐ Verify 'Maximum Overhead Rate' matches work order or latest audited rate.

☐ Obtain current State of TN Travel Regulations.

☐ Verify Per Diem Travel Log for each staff member claiming travel expense is attached (Per diem is 75% of the per diem rate on Travel Days).

☐ Based on Per Diem Travel Log attachment, verify Item No. 4.10 Travel Day Per diem and 4.11 Non Travel Day Per Diem (Travel Day Per Diem rate is 75% of the Non Travel Day Per Diem).

☐ Verify Lodging Log for each staff member claiming travel expense is attached.

☐ Verify lodging receipts for each staff member claiming travel expense is attached.

- Hotel receipt must show a zero balance and have the hotel address and telephone number.
- If the room is shared, the names of the individuals sharing the room should be noted
- Lodging rate may exceed that allowed per the Travel Regulations, but travel expense claim will only be paid that allowed per Travel Regulations.
- Receipts must be legible with no "highlighting" that could result in obscured photocopies.

☐ Based on Lodging Log and receipts, verify Item No. 4.12 Lodging

☐ Passenger Mileage Log for each staff member claiming travel expense is required attachment.

☐ Based on Passenger Mileage Log, verify 4.20 Passenger Vehicle.

☐ Verify "Invoice Summary" totals of '1.00 Drilling Services', '2.00 Laboratory Services', "3.00 Manpower Requirements", and "4.00 Other Expenses" match preceding sheets. Check math.

APPENDIX 4

TDOT GEOTECHNICAL FIELD REVIEW \ FINAL PLANS CHECKLIST

TDOT Geotechnical Engineering Section
Plans Review Checklist
For Internal use only.

REVIEW TYPE:	☐ Prelim. ☐ ROW ☐ Const. ☐ Prebid
COUNTY:	
GES NUMBER:	
P.E. NO.:	
PIN NO.:	
DESCRIPTION:	
DESIGNER/SUPERVISOR:	
DATE OF REVIEW:	
DATE OF FILED REVIEW/BID:	
PROJECTED LETTING DATE:	

REVIEW THE FIELD REVIEW REPORT WITH RESPECT TO GES COMMENTS.

SAVE PDF OF THE COMPLETED CHECKLIST IN PROJECT FOLDER-> 04-Filenet -> 02-Plans

A. INDEX SHEET

- ☐ Verify Soils sheets are listed in the Index of sheets.
- ☐ Check Soils sheet numbers for accuracy.
- ☐ Verify any Geotech Std. Drawings included (RD01-S-11B, Rock slope catchment, etc.)
- ☐ Any proposed signs, signal, or lighting? Refer to *Signs_Signal_Lighting Plans Checklist* and *TDOT Geotechnical Manual* for guidance.
- ☐ Project Commitments

B. ESTIMATED ROADWAY QUANTITIES

- ☐ Verify items shown in Soils-Geotechnical Notes & Est. Qtys. are shown .
- ☐ Footnotes provided as appropriate.
- ☐ If the Item Number 730-23.XX (Pole/Signal Support) series is used, is it appropriately footnoted (See *TDOT Geotechnical Manual* for guidance)?

C. GENERAL NOTES / SPECIAL NOTES

- ☐ Review Grading notes and any scope of work notes for suitability.
- ☐ Will notes included by others cause geotechnical issues during construction?

D. TYPICAL SECTIONS

- ☐ Review for details of retaining walls, sinkhole repair or any other geotechnical issue.

E. PRESENT LAYOUT SHEET

- ☐ Relevant geohazard limits shown coincide with treatment limits in report and what is shown on soils sheets.

F. PROPOSED LAYOUT SHEET

- ☐ Proposed treatment limits shown (rock pads, undercutting, sinkholes etc.).

G. SOILS SHEETS

- ☐ Verify Soils sheets are what we delivered.
- ☐ Verify Soils sheets are sealed.

H. ROADWAY CROSS SECTIONS

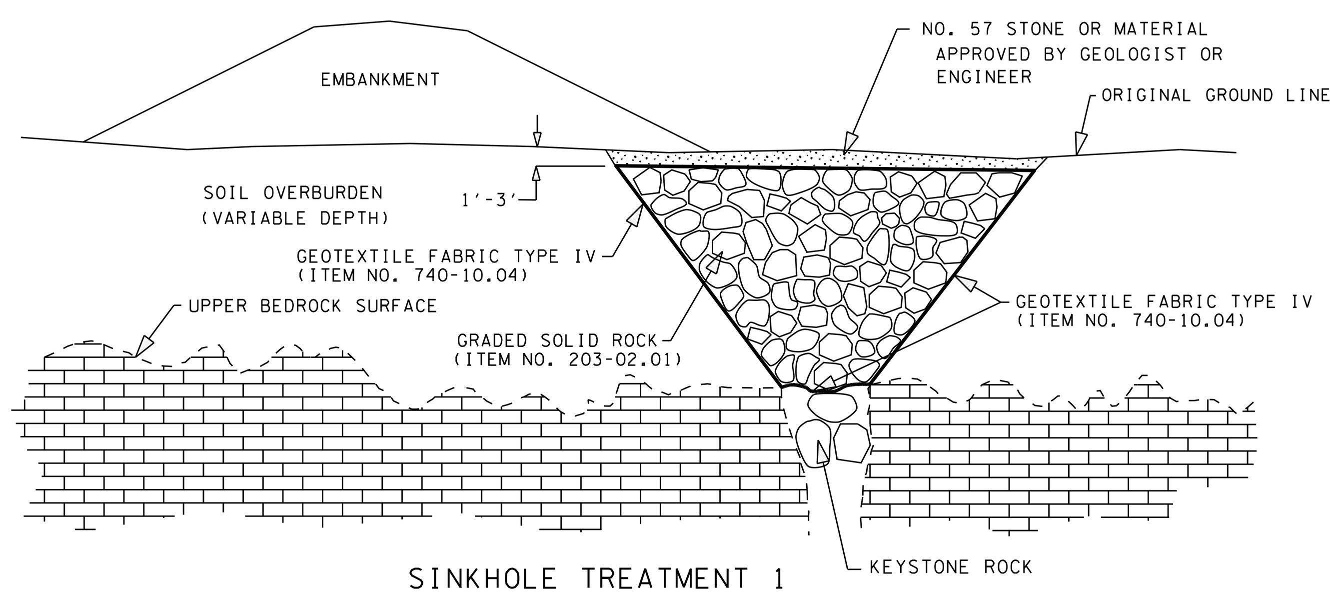
- ☐ Slope recommendations followed as indicated in Soils-Typical Sections.
- ☐ Verify slope design is reasonable.
- ☐ Slopes higher than 45 feet high are 2:1 benched or 3:1.
- ☐ Rock pads, buttresses should be shown.

Review Summary/Action Steps:

APPENDIX 5

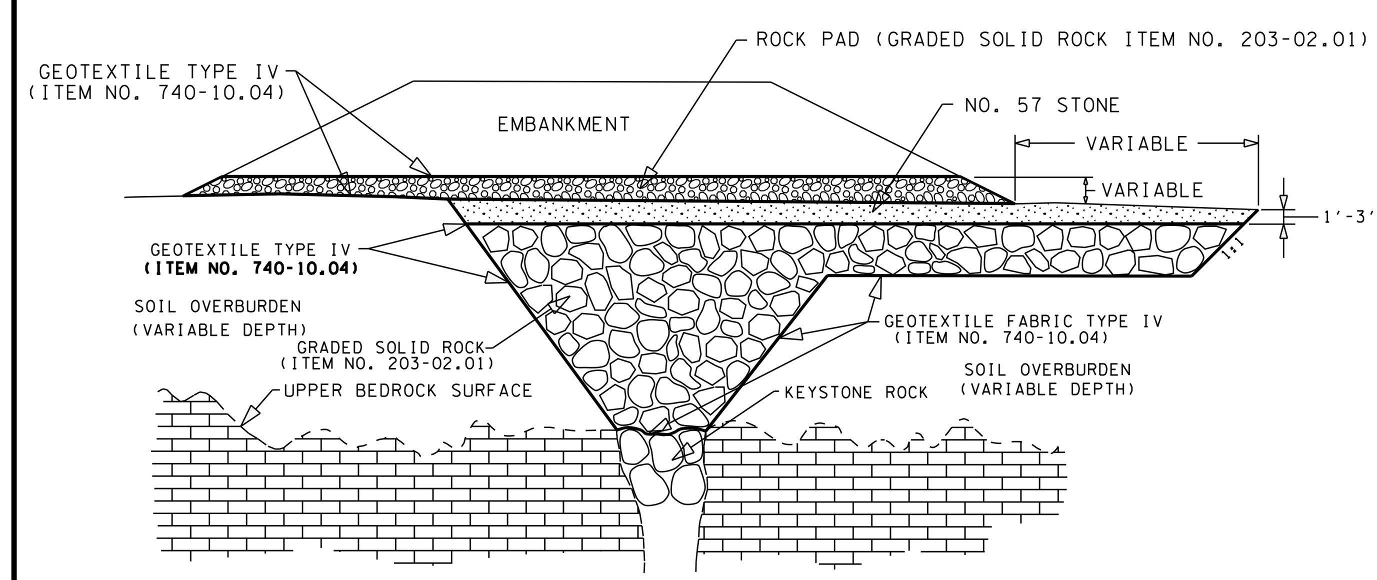
TTYPICAL SINKHOLE DRAWING DETAILS

TYPE	YEAR	PROJECT NO.	SHEET NO.

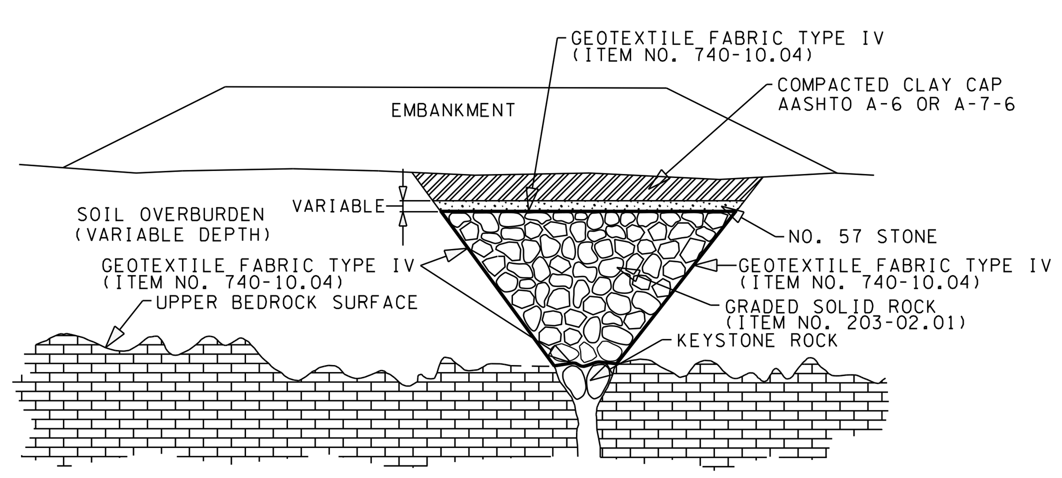


SINKHOLE TREATMENT 1

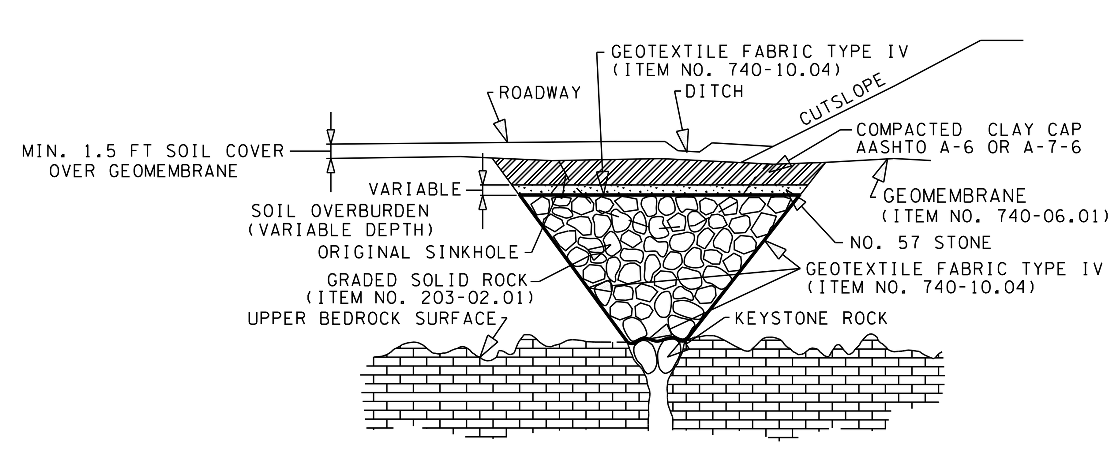
VARIABLE



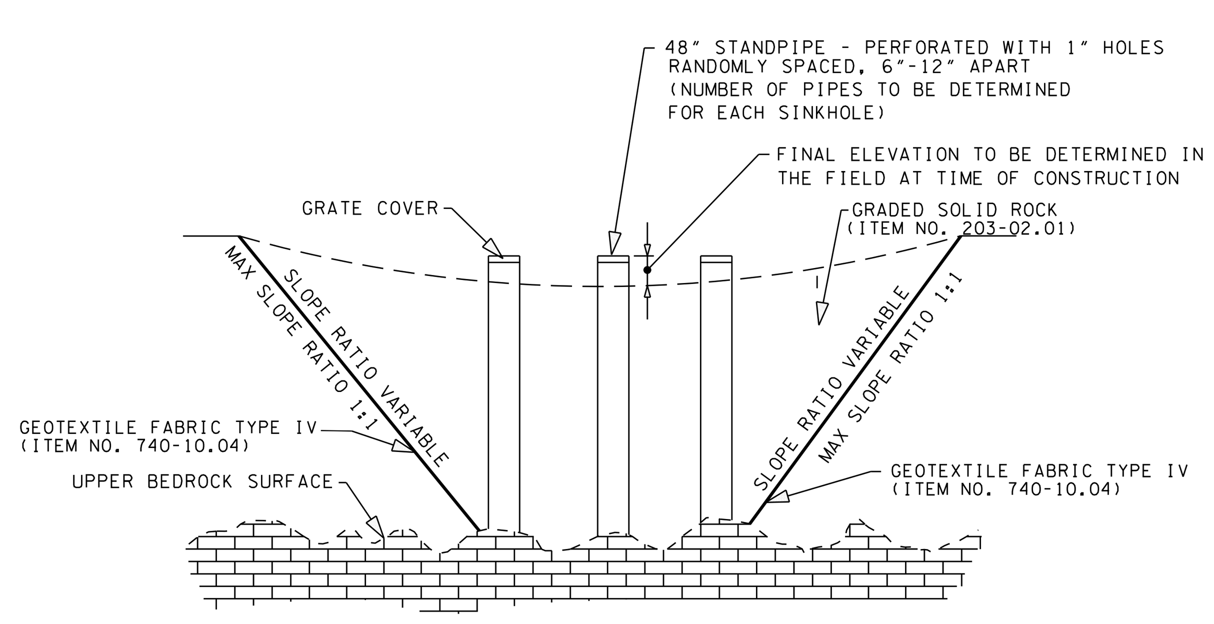
SINKHOLE TREATMENT 1A



SINKHOLE TREATMENT 2



SINKHOLE TREATMENT 2A



SINKHOLE TREATMENT 3

SINKHOLE TREATMENT 1, ACTIVE

NOTE: AFTER EXCAVATION IS COMPLETE AND ROCK OPENING IS EXPOSED, THE SITE AND TREATMENT METHOD SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS. THE TOP 1-3 FT. OF MATERIAL SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS.

SEQUENCE OF CONSTRUCTION:

1. EXCAVATE SINKHOLE TO DEFINE OPENING IN BEDROCK MAKING SURE TO REMOVE ALL SOIL AND DEBRIS.
2. FIT THE OPENING WITH KEYSTONE ROCK, WHICH SHALL BE OF SUFFICIENT SIZE TO LOCK IN PLACE WITHOUT CREATING AN AIRBLOCK TO SUBSURFACE DRAINAGE.
3. PLACE THE GEOTEXTILE FABRIC TYPE IV ON EXCAVATED SLOPES AND BASE OF SINKHOLE.
4. BACKFILL TO A MAXIMUM OF 1 FT. OF THE SPECIFIED GRADE WITH GRADED SOLID ROCK (CLASSIFICATION 203.02.01 BORROW EXCAVATION).
5. BACKFILL TO GRADE WITH A MINIMUM OF 1 FT. OF NO.57 STONE ON TOP OF THE GRADED SOLID ROCK AND GEOTEXTILE FABRIC TYPE IV.

SINKHOLE TREATMENT 1A ACTIVE

NOTE: AFTER EXCAVATION IS COMPLETE AND ROCK OPENING IS EXPOSED, THE SITE AND TREATMENT METHOD SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS. THE TOP 1-3 FT. MATERIAL SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS.

SEQUENCE OF CONSTRUCTION:

1. EXCAVATE SINKHOLE TO DEFINE OPENING IN BEDROCK MAKING SURE TO REMOVE ALL SOIL AND DEBRIS.
2. FIT THE OPENING WITH KEYSTONE ROCK, WHICH SHALL BE OF SUFFICIENT SIZE TO LOCK IN PLACE WITHOUT CREATING AN AIRBLOCK TO SUBSURFACE DRAINAGE.
3. PLACE THE GEOTEXTILE FABRIC TYPE IV ON EXCAVATED SLOPES AND BASE OF SINKHOLE.
4. BACKFILL TO WITHIN 1.5-3 FT.OF THE SPECIFIED GRADE WITH GRADED SOLID ROCK (CLASSIFICATION 203-02.01 BORROW EXCAVATION).
5. PLACE THE GEOTEXTILE FABRIC TYPE IV ON TOP OF GRADED SOLID ROCK.
6. BACKFILL TO GRADE WITH NO. 57 STONE.
7. CONSTRUCT EMBANKMENT INCLUDING ANY REQUIRED ROCK PAD IN ACCORDANCE WITH CONTRACT PLANS AND CROSS-SECTIONS.

SINKHOLE TREATMENT 2 AND 2A , INACTIVE

NOTE: AFTER EXCAVATION IS COMPLETE AND ROCK OPENING IS EXPOSED, THE SITE AND TREATMENT METHOD SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS. ANY CHANGE IN THE NO. 57 STONE FILL OR THE CLAY CAP SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS.

SEQUENCE OF CONSTRUCTION:

1. EXCAVATE SINKHOLE TO DEFINE OPENING IN BEDROCK MAKING SURE TO REMOVE ALL SOIL AND DEBRIS.
2. FIT THE OPENING WITH KEYSTONE ROCK, WHICH SHALL BE OF SUFFICIENT SIZE TO LOCK IN PLACE WITHOUT CREATING AN AIRBLOCK TO SUBSURFACE DRAINAGE.
3. PLACE THE GEOTEXTILE FABRIC TYPE IV ON EXCAVATED SLOPES AND BASE OF SINKHOLE.
4. BACKFILL WITH GRADED SOLID ROCK (CLASSIFICATION 203-02.01 BORROW EXCAVATION) UP TO SPECIFIED GRADE.
5. PLACE GEOTEXTILE FABRIC TYPE IV ON TOP OF GRADED SOLID ROCK. PLACE NO. 57 STONE ON TOP OF GETEXTILE FABRIC.
6. CONSTRUCT COMPACTED CLAY CAP. SOIL SHOULD BE OF TYPE AASHTO A-6 OR A-7-6.

FOR 2A INACTIVE ONLY

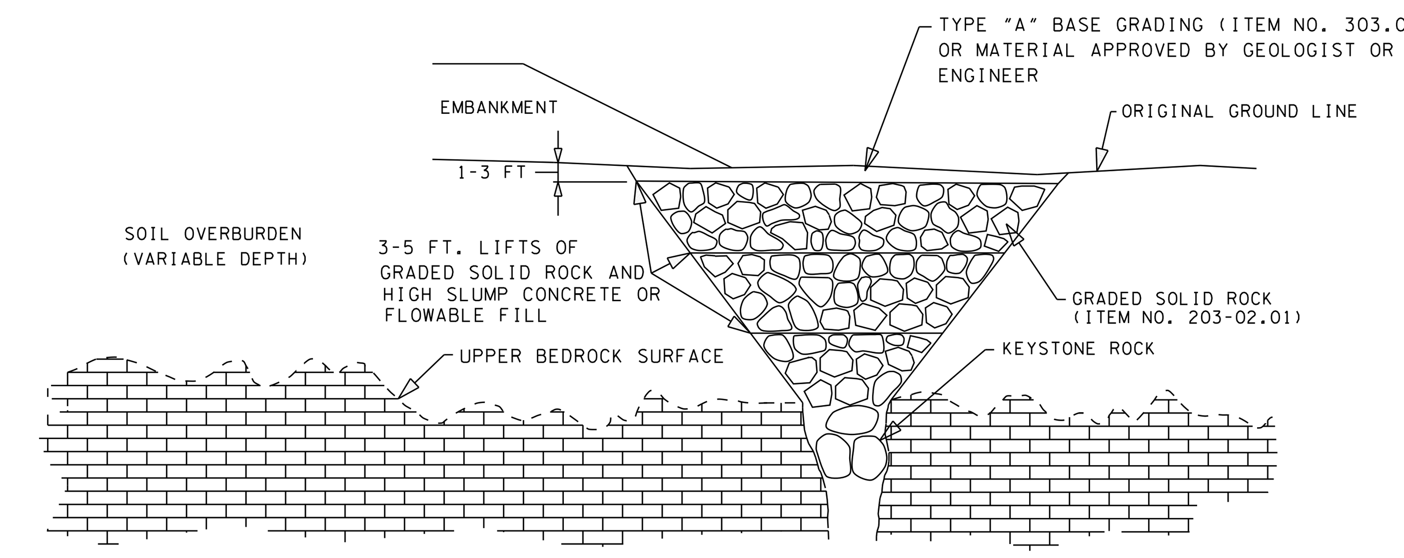
7. PLACE GEOMEMBRANE ON TOP OF SOIL CAP BEFORE CONSTRUCTION OF ANY OVERLYING STRUCTURES OR EMBANKMENTS. THERE SHOULD BE A MINIMUM OF 1.5 FT. OF SOIL PLACED OVER THE MEMBRANE.
8. DITCH SHOULD BE PAVED OR LINED WITH A GEOMEMBRANE.

SINKHOLE TREATMENT 3, ACTIVE

NOTE: AFTER EXCAVATION IS COMPLETE AND ROCK IS EXPOSED, THE SITE AND TREATMENT METHOD SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS.

SEQUENCE OF CONSTRUCTION

1. EXCAVATE SOIL DOWN TO BEDROCK OR TO LIMITS SPECIFIED BY THE ENGINEER OR GEOLOGIST.
2. LOCATE ALL OPENINGS WITHIN THE PITS, REMOVE ALL LOOSENED MATERIAL. ALL EXCAVATED MATERIALS SHALL BE REMOVED FROM THE BASIN.
3. INSTALL 48" DIAMETER VERTICAL STANDPIPES OVER THE LOCATED OPENINGS. THESE PIPES SHOULD BE PERFORATED FOR AT LEAST THE LOWER 5 FT. WITH 1" HOLES SPACED 6-12" APART.
4. PLACE GEOTEXTILE FABRIC TYPE IV AS SHOWN OR AS DIRECTED BY THE ENGINEER OR GEOLOGIST TO PREVENT THE LATERAL INFLOW OF FINES.
5. BACKFILL WITH A GRADED SOLID ROCK (203-20.01) TO A HEIGHT OF 3.5 FT. BELOW THE TOP OF THE STANDPIPE.
6. THE GRADED SOLID ROCK SHALL BE PLACED WITH A CLAMSHELL. NO END DUMPING WILL BE PERMITTED.



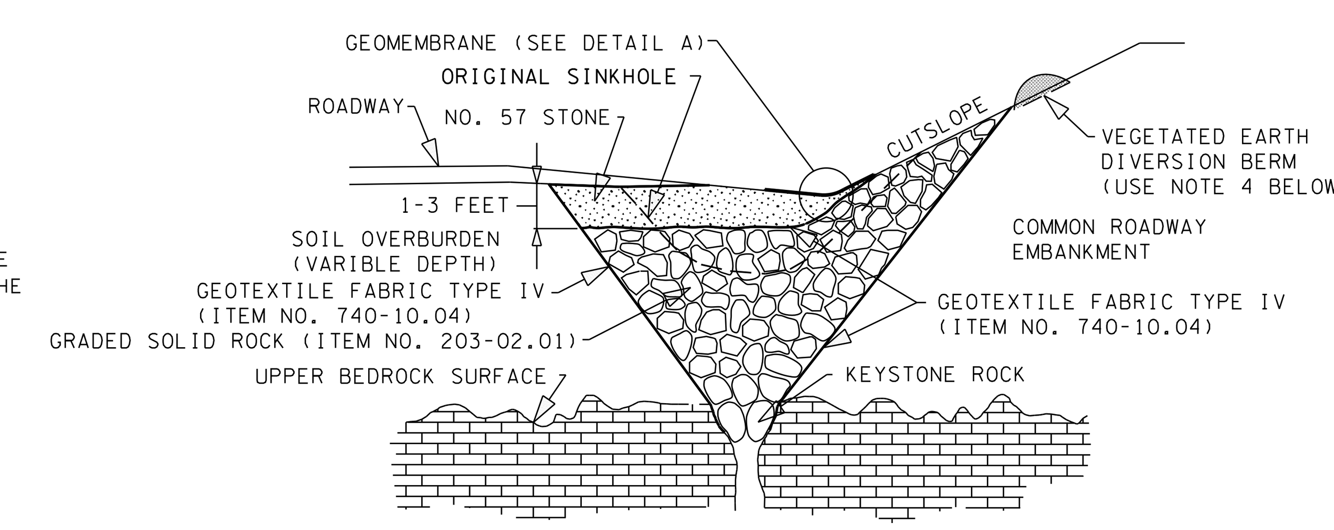
SINKHOLE TREATMENT 4,INACTIVE

NOTE: AFTER EXCAVATION IS COMPLETE AND ROCK OPENING IS EXPOSED, THE SITE AND TREATMENT METHOD SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS. ANY CHANGE IN THE NO.57 STONE FILL SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS.

SEQUENCE OF CONSTRUCTION

1. EXCAVATE SINKHOLE TO DEFINE OPENING IN BEDROCK MAKING SURE TO REMOVE ALL SOIL DEBRIS.
2. FIT THE OPENING WITH KEYSTONE ROCK, WHICH SHALL BE OF SUFFICIENT SIZE TO LOCK IN PLACE WITHOUT CREATING AN AIRBLOCK TO SUBSURFACE DRAINAGE.
3. ALTERNATE LAYERS OF GRADED SOLID ROCK (CLASSIFICATION 203-02.01 BORROW EXCAVATION) 3-5 FT. IN DEPTH AND HIGH SLUMP CONCRETE (OR FLOWABLE FILL). HIGH SLUMP CONCRETE SHALL BE CONCRETE WITH A SLUMP OF 7-9".

   HIGH SLUMP CONCRETE OR FLOWABLE FILL SHALL BE APPLIED AFTER A LAYER OF GRADED SOLID ROCK UNTIL THE CONCRETE (OR FLOWABLE FILL) JUST COVERS THE GRADED ROCK LAYER. THE NEXT LAYER OF GRADED SOLID ROCK SHALL BE PLACED IMMEDIATELY AFTER THE PLACEMENT OF THE CONCRETE (OR FLOWABLE FILL). THE PURPOSE OF THIS IS TO INTERMIX THE MATERIALS. THE WORK SHALL NOT BE INTERRUPTED AFTER THE PLACEMENT OF CONCRETE (OR FLOWABLE FILL) EXCEPT FOR THE TOP LAYER. IF WORK CANNOT BE FINISHED IN A SPECIFIED INTERVAL, WORK MAY BE STOPPED ONLY AFTER A COMPLETE LAYER OF GRADED SOLID ROCK HAS BEEN PLACED.
4. AFTER THE FINAL LAYER OF CONCRETE (OR FLOWABLE FILL) HAS BEEN SET, BACKFILL TO GRADE WITH TYPE "A" BASE GRADING (ITEM NO. 303.01) OR OTHER MATERIAL APPROVED BY THE ENGINEER OR GEOLOGIST.



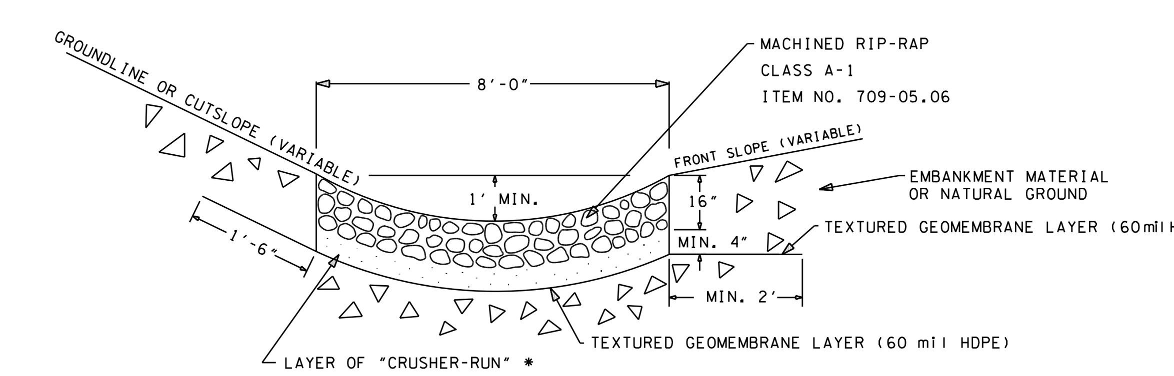
SINKHOLE TREATMENT 5 ACTIVE

NOTE: AFTER EXCAVATION IS COMPLETE AND ROCK OPENING IS EXPOSED, THE SITE AND TREATMENT METHOD SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS. ANY CHANGE IN THE NO. 57 STONE FILL SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS.

SEQUENCE OF CONSTRUCTION:

1. EXCAVATE SINKHOLE TO DEFINE OPENING IN BEDROCK MAKING SURE TO REMOVE ALL SOIL AND DEBRIS. COVER ALL EXPOSED SOIL SURFACES WITH GEOTEXTILE FABRIC (ITEM NO. 740-10.04) PRIOR TO BACKFILLING.
2. FIT THE OPENING WITH KEYSTONE ROCK, WHICH SHALL BE OF SUFFICIENT SIZE TO LOCK IN PLACE WITHOUT CREATING AN AIRBLOCK TO SUBSURFACE DRAINAGE.
3. BACKFILL WITH GRADED SOLID ROCK (CLASSIFICATION 203.02.01 BORROW EXCAVATION) UP TO 1-3 FEET OF EXISTING DITCHLINE GRADE. CONTINUE FILLING THE EXCAVATION SLOPE WITH GRADED SOLID ROCK ABOVE THE PLANNED EDGE OF THE GEOMEMBRANE LINER EDGE, GRADING THE ROCK TO CONFORM WITH THE SLOPE PROFILE AS SHOWN IN THE ABOVE ILLUSTRATION.
4. WHEN THE GRADED SOILD ROCK PLACMENT IS COMPLETE, A SMALL DRAINAGE DIVERSION BERM OF COMPACTED SOIL SHALL BE CONSTRUCTED AROUND THE TOP OF THE EXCAVATION LIMITS TO TO DIVERT SURFACE RUNOFF AROUND THE REPAIR TO THE DITCH BELOW. THE BERM SHALL BE NO MORE THAN 3-FEET WIDE AT THE BASE AND 1 FOOT TALL ABOVE THE SURROUNDING SLOPE. THE BERM SHALL BE KEYED INTO THE SOIL APPROXIMATELY 0.5-FOOT AND NOT PLACED ON TOP OF THE EXISTING VEGETATION. AFTER CONSTRUCTION OF THE BERM IS COMPLETED, SEED AND STRAW WILL BE REQUIRED TO CONTROL EROSION.
5. PLACE GEOTEXTILE FABRIC TYPE IV ON TOP OF GRADED SOLID ROCK. PLACE NO.57 STONE ON TOP OF GEOTEXTILE FABRIC.
6. DITCH SHOULD BE LINED WITH A GEOMEMBRANE AND COVERED WITH A MINIMUM OF 16 INCHES OF MACHINED RIP-RAP (CLASS A-1) OR MATERIAL APPROVED BY HYDRAULIC DESIGN.

GEOMEMBRANE LINED RIP-RAP DITCH

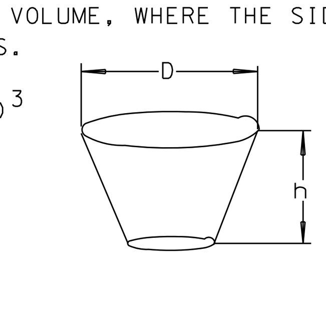


DETAIL A

ITEM NO. 203-02.01 GRADED SOLID ROCK (TONS)
BORROW EXCAVATION (GRADED SOLID ROCK) SHALL CONSIST OF THE REMOVAL AND SATISFACTORY PLACEMENT OF SOUND, NON-DEGRADABLE ROCK WITH A MAXIMUM SIZE OF 3 FT. (1 M). AT LEAST 50 PERCENT OF THE ROCK SHALL BE UNIFORMLY DISTRIBUTED BETWEEN 1 FT. (30 CM) AND 3 FT. (1 M) IN DIAMETER AND NO GREATER THAN 10 PERCENT SHALL BE LESS THAN 2 IN. (50 MM) IN DIAMETER. THE MATERUAL SHALL BE ROUGHLY EQUI-DIMENSIONAL IN SHAPE. THIN, SLABBY MATERIAL WITH AN ACCEPTABLE MECHANICAL SCREENING PROCESS THAT PRODUCES THE REQUIRED GRADATION. WHEN THE MATERIAL IS SUBJECTED TO FIVE ALTERATION OF THE SODIUM SULFATE SOUNDNESS TEST (AASHTO T 104), THE WEIGHTED PERCENTAGE OF LOSS SHALL BE NOT MORE THAN 12. THE MATERIAL SHALL BE APPROVED BY THE ENGINEER BEFORE USE.

EQUATION FOR ESTIMATING SINKHOLE VOLUME, WHERE THE SIDES OF THE SINKHOLE ARE AT 1:1 SLOPES.

$$\text{VOL. } 1:1 \approx 0.13D^3 - (0.5D - h)^3$$



FOR ESTIMATION PURPOSES, USE

$$1.7636 \ \frac{\text{TONS}}{\text{C.Y.}}$$

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

SINKHOLE STANDARD DRAWINGS SINKHOLE TREATMENT ILLUSTRATIONS 1,1A,2,2A,3,4 AND 5

APPENDIX 6

RETAINING WALL REVIEW CHECKLIST

TDOT Geotechnical Engineering Section

Retaining Wall Review

TN TDOT Department of Transportation

Retaining Wall Information			
Project:			Wall No.:
Contractor Name:			Contact:
Wall Supplier/Designer:			Date :
Structures Contact:			Reviewer:
PE Number:	Pin No.:	GES File No.:	Contract No.:

	Yes	No	N/A	Comments
Is wall type submitted one of the "Acceptable Wall Types" listed in the contract plans?	☐	☐	☐	
For proprietary walls only- Is the wall system and/or installer listed on the Qualified Products List, QPL 38: Retaining Wall Systems ?	☐	☐	☐	
Does wall geometry conform to plans (begin & end station limits, centerline offset, top of wall elevation, bottom of wall elevation, minimum embedment depth?)	☐	☐	☐	
Are contract plans and shop drawings plans wall geometry (Plan view, elevation) the same as provided for during original geotechnical investigation?	☐	☐	☐	
Do wall calculations provide assumed soil/rock parameters used in design?	☐	☐	☐	
Is the soil/rock parameters in conformance with contract plans requirements?	☐	☐	☐	
Do calculations and construction drawings show the most critical wall sections and any unique design cases (culvert passing through wall face, barrier rail, moment slab, bridge abutment, traffic loading, seismic design, etc) ?	☐	☐	☐	
Do wall calculations use the appropriate load and resistance factors as specified in the contract plans?	☐	☐	☐	
Do wall calculations indicate bearing stability is satisfied per LRFD and contract parameters? Does the nominal bearing capacity used comply with the contract plans? Is the CDR=>1.0	☐	☐	☐	
Do wall calculations indicate sliding stability is satisfied per LRFD and contract parameters? Is the appropriate coefficient of sliding friction used as specified in the contract plans? Is the CDR=>1.0 ?	☐	☐	☐	
Do wall calculations indicate the eccentricity is within the requirements specified in contract plans?	☐	☐	☐	
Do wall calculations include seismic analysis sections for external stability (bearing, sliding, eccentricity) ?	☐	☐	☐	
Do shop drawing construction drawings show required foundation improvement (i.e. undercutting/rock replacement/aggregate piers/piles?) Ensure foundation improvement details and dimensions are shown correctly on the shop drawing's details.	☐	☐	☐	

	Yes	No	N/A	Comments
Do plans clearly define what type of backfill will be used (retained and select backfill) ? Does gradation meet SP624 or other requirements?	☐	☐	☐	
Do calculations use the appropriate internal angle of friction for design (phi angle)? Do shop drawing construction drawings show required excavation and backfill zone, labeled “required” for select backfill zone, in order to use the design friction angle of select backfill (if required), or is the internal angle of friction for the retained fill utilized?	☐	☐	☐	
If the wall designer utilizes an effective angle of friction for the select backfill is greater than 34 degrees, has appropriate documentation of independent testing been submitted by the wall designer.	☐	☐	☐	
Do calculations use the appropriate foreslope and backslope angles, unit weight, traffic loading, etc?	☐	☐	☐	
Do shop drawing construction drawings and calculations show improvements required to ensure global stability is met?	☐	☐	☐	
Do shop drawing construction drawings show the retaining wall square footage? Is the square footage within an appropriate range in comparison to the contract plans estimate?	☐	☐	☐	
Are all wall elements within TDOT right of way? (anchors, straps, select backfill, etc must not infringe on drainage, slope, or construction easements)	☐	☐	☐	
Is the wall constructible as shown in the shop drawings with respect to traffic control and construction phasing?	☐	☐	☐	
Do shop drawing construction drawings show the drainage gutter (if required)?	☐	☐	☐	
Do shop drawing construction drawings show the appropriate wall finish/ fascia (if required, also check project commitments sheet)?	☐	☐	☐	
CIP walls Only -Do shop drawing construction drawings show or note required expansion and contraction joints ?	☐	☐	☐	
MSE walls only: Are the reinforcement lengths at least the minimum as required by the contract plans?	☐	☐	☐	
MSE walls only: Is the spacing of the reinforcement acceptable per contract documents and LRFD Design Spec. 11.10.2.3.1 ?	☐	☐	☐	
MSE walls only: Are the reinforcement lengths all the same length for each design section?	☐	☐	☐	
ANCHOR and SOIL NAIL Walls Only: Are all required proof/verification/other testing requirements clearly shown on the shop drawing construction drawings?	☐	☐	☐	
RETAINING WALL DATABASE ENTRY: Has Shp Dwg Submittal been entered in the ms access RW database? See link below	☐	☐	☐	

THIS FORM IS FOR INTERNAL USE ONLY. FOLLOWING COMPLETION OF THIS FORM AND DISCUSSION WITH SUPERVISOR, PREPARE AN EMAIL TO SUBMIT TO STRUCTURES. ENSURE REVIEW IS ALSO LOGGED IN THE "INCOMING SHOP DRAWING TRACKING SHEET" BY CRISSY'S DESK

RETAINING WALL DATABASE ENTRY HERE: Geotech Projects Go to "Forms"-> "Retaining Walls"
USE EMAIL TEMPLATE FOUND HERE: Shop Drawing Review- Email Template
SEE HERE FOR STRUCTURES PERSONNEL: TDOT Structures Personnel