

DATE: March 6, 2015

SUBJECT: Bentley gINT® Geotechnical Engineering
Software Required for PennDOT Projects

TO: District Executives

FROM: R. Scott Christie, P. E. /s/
Deputy Secretary for Highway Administration

This time neutral Strike-Off Letter (SOL) requires the use of Bentley's gINT® software for all PennDOT projects with geotechnical constituents for new engineering agreements or new supplements executed after March 12, 2015. The implementation of gINT software is a PennDOT Next Generation Initiative.

Bentley's gINT ® software is designed to manage geotechnical data and create standardized geotechnical reports. gINT Software options include gINT Professional and gINT Professional Plus. gINT Professional Plus differs from gINT Professional in its database capability.

PennDOT is requiring Central Office and the Districts to use gINT Professional Plus V8i. Business Partners responsible for geotechnical constituents in the project development process are required to purchase and use gINT Professional V8i. The gINT project files from the Districts and Business Partners are to be submitted to create and populate a geotechnical database for statewide use/reference.

Districts and Business Partners must use PennDOT's gINT library and data template to create gINT project files, collect specified geotechnical data and create standardized geotechnical reports. Detailed information for integrating gINT into the project development process for both Districts and Business Partners is provided in [Attachment A](#).

Please note that material descriptions in PennDOT's gINT library coincide with the May 2014 Edition of Publication 222 Geotechnical Investigation Manual. The May 2014 Publication 222 material descriptions are in effect for all PennDOT projects using gINT software.

If you have any questions regarding gINT software use for PennDOT Projects, or implementation of gINT for PennDOT projects, please contact Kerry Petrasic, P.E., at (717) 787-4319 or e-mail kpetrasic@pa.gov, or Beverly Miller, P.E., at (717) 787-1497 or e-mail bevemiller@pa.gov.

Attachment

3203/4815/BLM/KWP

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**Attachment A: Details for Incorporating Bentley gINT Software on
PennDOT Projects with Geotechnical Components**

The implementation of Bentley gINT® software for PennDOT projects with geotechnical components affects various aspects of the project development process. Detailed information for Districts and Business Partners for obtaining gINT software and PennDOT's gINT data template and library, and for integrating gINT into the project development process is available by clicking any of the items in the list, below:

1. [Obtaining Bentley gINT® Software](#)
2. [PennDOT gINT Web Page](#)
3. [Download of the PennDOT gINT Library and Data Template](#)
4. [Submission of Completed gINT Project Files to PennDOT](#)
5. [User Notification: Updates/Enhancements to the PennDOT gINT Library and Data Template](#)
6. [gINT Field Data Collection Tool](#)
7. [Publication Updates:](#)
 - [Attachment B](#): Publication 14M Design Manual Part 3, Ch. 5 Soil Profile Plan.
 - [Attachment C](#): Publication 15M Design Manual Part 4, Various Sections
 - Publication 293, Geotechnical Engineering Manual, Chapter 1

ftp://ftp.dot.state.pa.us/public/pdf/BOCM_MTD_LAB/PUBLICATIONS/Pub_293/Pub_293.pdf

8. [gINT Material Descriptions and Publication 222 Geotechnical Investigation Manual](#)
9. [ECMS Updates for gINT: "gINT Required" Field and Update of WBS Codes](#)
10. [PennDOT Central Office and District Access to gINT Database](#)
11. [Creating Structure Boring Logs and Soil Profile Plans using gINT Reports](#)
12. [Bentley gINT® Software Training](#)
13. [gINT Training for PennDOT Projects – PennDOT Users and Business Partners](#)
14. [gINT in the Construction Phase](#)
15. [Future phases of gINT Software Implementation for PennDOT Projects](#)

1.) Obtaining Bentley gINT® Software

PennDOT:

gINT Professional Plus V8i is covered under PennDOT's Enterprise License Service Agreement with Bentley. gINT Professional Plus V8i was previously deployed to select District Geotechnical personnel participating in PennDOT gINT user acceptance testing. Those individuals will retain their copy of gINT software. All other pertinent PennDOT Geotechnical personnel requiring gINT software should contact their IT Support or IT Service Desk and request gINT software. Directions for installing gINT Software for internal PennDOT staff on designated geotechnical workstations is available on PennDOT's intranet site by clicking on the "Systems" tab, and then "gINT".

Note that gINT software may be "signed out" /moved to a lap top for use in the field and then re-connected with the network.

PennDOT has a sufficient number of concurrent gINT licenses. However, PennDOT personnel using gINT will need to be diligent in logging off when gINT is not in use in order to guarantee availability to all PennDOT gINT users.

Business Partners:

Geotechnical Business Partners are required to use gINT Professional Version 8i software with the PennDOT gINT library and data Template to produce a gINT project file and create standardized geotechnical reports for PennDOT projects. Business Partners can purchase gINT Professional software from Bentley (1-800-BENTLEY; www.bentley.com).

Completed gINT project files from both PennDOT Districts and PennDOT Business Partners are to be uploaded to the PennDOT gINT webpage for inclusion in PennDOT's gINT geotechnical database. For additional details regarding transfer of project files reference "[Submission of Completed gINT Project Files to PennDOT](#)", below.

2.) PennDOT gINT WebPage

A gINT webpage is available on the PennDOT website, <http://www.dot.state.pa.us> (click on "Design & Construction", and then on the "Construction", and "gINT" links).

Please visit the gINT webpage on the PennDOT website for information and links regarding the following:

- Joining the gINT Subscription List
- Downloading of the PennDOT gINT library and data template
- Uploading of completed gINT project files

- Samples of completed gINT project files
- Downloading of the gINT Field Data Collection Tool
- Frequently asked questions
- Example structure boring log sheets
- Links to PennDOT geotechnical publications (Publications 222 and 293)
- Error/enhancement request form
- List of known issues and proposed fixes, suggested enhancements

3.) Download of the PennDOT gINT Library and Data Template

A gINT data template and library have been customized for PennDOT to facilitate standardization and expedite production of standardized geotechnical reports for PennDOT projects. The reports include, but are not limited to: Engineer’s Log, Structure Boring Logs, various lab test summaries, project summaries.

Users must join the gINT Subscription List on the PennDOT website, gINT Webpage to receive login information for the FTP site to download the PennDOT gINT library and data template. Go to <http://www.dot.state.pa.us> and click on “Design & Construction”, and then click on the “Construction” and “gINT” links.

4.) Submission of Completed gINT Project Files to PennDOT:

PennDOT Districts and Business Partners are required to submit (upload) completed gINT project files for inclusion in PennDOT’s geotechnical database. Users must join the gINT subscription list on PennDOT’s gINT webpage (<http://www.dot.state.pa.us> ; click on “Design & Construction”, and then click on the “Construction” and “gINT” links) to receive login information to upload completed gINT project files. To upload the completed gINT project, follow the instructions provided with the login information. After the gINT project file has been uploaded to the FTP site, users are reminded to update the “gINT Required” field in ECMS. (Please see “[ECMS Updates: Verification of gINT Project File Upload and Update of WBS Codes](#)”, below.)

Note: Users will only have the ability to place files on the FTP site. If changes are required to gINT project files that have been submitted/“uploaded” to the FTP site, Districts and Business Partners should use the “Contact Us” link provided on PennDOT’s gINT web page to convey the issue to PennDOT personnel for resolution. Modifications to information placed on the FTP site can only be made by authorized PennDOT personnel.

5.) User Notification: Updates/Enhancements to PennDOT gINT Library and Data Template

Districts and Business Partners must join the gINT subscription list on PennDOT's gINT web page (<http://www.dot.state.pa.us>; click on "Design & Construction", and then click on the "Construction" and "gINT" links.) to receive e-mail notice of updates or enhancements made to the PennDOT gINT data template and/or library. District Geotechnical Engineers will receive automatic notification of updates or enhancements made to PennDOT's gINT data template and library.

6.) gINT Field Data Collection Tool

The gINT Field Data Collection Tool is a Microsoft Access application which allows users to enter PennDOT's gINT geotechnical data into an Excel spreadsheet for import into gINT software at a later time. The gINT Field Data Collection Tool is available to Districts and Business partners on PennDOT's gINT web page (<http://www.dot.state.pa.us>; click on "Design & Construction", and then on the "Construction" and "gINT" links) by clicking on "gINT Field Data Collection Tool".

Note: The gINT Field Data Tool cannot be used to produce a gINT project file or any of the standardized geotechnical reports that are available by using gINT software with PennDOT's gINT library. The gINT Field Data Tool is only for data collection, verification and import of data into gINT software.

7.) Publication Updates: Pub. 14 M Design Manual Part 3, Pub. 15M Design Manual Part 4, Publication 293 Geotechnical Engineering Manual

Modifications to Design Manual Part 3 Chapter 5 Soil Profile Plan, portions of Design Manual Part 4, and Publication 293 Part 1 were required to address the implementation of gINT software.

DM-3: The modifications to Design Manual Part 3, Chapter 5 Soil Profile Plan were required to address the updated plan format and use of gINT software for displaying geotechnical information on Soil Profile plans. The revised pages to DM-3 are included in [Attachment B](#)

DM-4: Design Manual Part 4, Policy and Procedure, Part 6 Geotechnical has been revised to reference Publications 222 and 293 (for geotechnical exploration and submission of geotechnical reports), and to address the use of gINT software. As a result, most of DM-4 P.P. Part 6 Geotechnical has been deleted. The revised pages for DM-4 are included in [Attachment C](#).

An updated version of DM-4, annotating the addition associated with this SOL, can be also found:

ftp://ftp.dot.state.pa.us/public/Bureaus/design/Pub15M/2012_Edition/DM-4_May_2012.pdf

Pub. 293 Part 1: Publication 293 Part 1 has been completely re-written and is currently available free of charge through the Department's website

ftp://ftp.dot.state.pa.us/public/pdf/BOCM_MTD_LAB/PUBLICATIONS/Pub_293/Pub_293.pdf .

8.) gINT Material Descriptions and Publication 222 Geotechnical Investigation Manual

Descriptions for all soil and rock core samples for PennDOT projects using gINT software are to be in accordance with the May 2014 Edition of Publication 222 (released via SOL 481-14-05 on June 10, 2014). This ensures materials descriptions will coincide with gINT library for PennDOT projects. The May 2014 Edition of Publication 222 contains detailed information regarding the input for the gINT project file and is available on the PennDOT website ftp://ftp.dot.state.pa.us/public/pdf/bocm_mtd_lab/publications/pub_222/publication%20222.pdf . The materials description method found in the June 2012 and preceding editions of Publication 222 are not valid for PennDOT projects using gINT software.

9.) ECMS Updates for gINT: “gINT Required” Field and Update of WBS Codes

“gINT Required” Field

When a PennDOT project has geotechnical constituents such as core borings, a test pit or laboratory testing, a completed gINT project file is to be submitted to PennDOT via the gINT web page (<http://www.dot.state.pa.us>; click on “Design & Construction”, and then on the “Construction” and “gINT” links) for inclusion into the PennDOT geotechnical database.

The ECMS Project Detail Information screen has been revised to include a “gINT Required” field. After the gINT project file has been uploaded to the FTP site accessible from the PennDOT gINT web page, the ECMS “gINT Required” field is to be updated to indicate “yes”, verifying that the gINT project file has been provided to PennDOT. The same gINT project file name used for placing the file on the PennDOT web page FTP link is to be entered into ECMS. Only projects with geotechnical constituents require a gINT project file be submitted to ECMS.

WBS Codes

The ECMS WBS Codes have been updated to reflect the above publication revisions and to require the use of gINT software use for PennDOT projects with geotechnical components.

10.) PennDOT Central Office and District Access to gINT Database:

At this time, only PennDOT personnel have read-only access to gINT project files on the SQL server. Instructions for internal PennDOT staff to access the SQL database are available on PennDOT's intranet site, by clicking on the "Systems" tab, and then "gINT".

11.) Creating Structure Boring Logs and Soil Profile Plans with gINT Reports:

PennDOT Users:

A web-based application "Structure Boring Log Report Builder" designed to facilitate/automate placement of the individual structure boring logs, general notes and lab test summary PDFs on the structure boring log plans is available to PennDOT personnel. The application can be found on the "Systems" tab of the PennDOT Intranet under "gINT. A link to the "Structure Boring Log Report Builder" is also available to PennDOT CADD Clients on the CADD Intranet site. A user guide is provided with the application.

Please note that the Structure Boring Log Report Builder cannot be used for automated placement of the Pile Installation Information Table report on the General Notes sheet of the bridge plans. The Pile Installation Information Table produced using gINT must be "raster referenced" onto the General Notes sheet of the bridge plans.

Instructions for placement of gINT PDF Soil Fence Log reports on Soil Profile Plans, on soil profile plans are available on PennDOT's gINT web page <http://www.dot.state.pa.us> (click on "Design & Construction", and then on the "Construction" and "gINT" links).

Business Partners:

Obtaining gINT Plan Sheet Cells:

Please note that all Business partners using CADD must register to use PennDOT's standardized CADD resource files.

To register, please contact Denise Reis, CADD Manager:

Denise M. Reis
CADD Manager
Pennsylvania Department of Transportation
Engineering District 3-0
715 Jordan Avenue
P.O. Box 218
Montoursville, PA 17754-0218

Phone: 570-368-4310
Fax: 570-368-4379
email: dreis@pa.gov

Business Partners may obtain PennDOT's gINT plan sheet drawings from the CADD Resource Files download facility on PennDOT's web site:

<http://www.dot.state.pa.us/Internet/pdBulletin.nsf/Login?OpenForm>

If you require help with accessing the site, please contact Denise Reis, contact information provided above.

The gINT plan sheets are stored as a cell within the **SSHEET.cel** cell library. The cell is named **gINT Sheets**. Instructions for placing the gINT output onto these sheets are found on each sheet. The gINT plan sheets are drawn proportionally to a 22" x 34" plan sheet. Business Partners are responsible for ensuring the final plot of the gINT sheets are to the correct scale.

Sample structure boring sheets demonstrating the placement of the structure boring logs, general notes and legend, notes for verification of classification of materials and endorsement of the accuracy of the borings, and lab test data are available on PennDOT's gINT web page <http://www.dot.state.pa.us> (click on "Design & Construction", and then on the "Construction" and "gINT" links) by clicking on "Sample Structure Boring Log Sheets".

12.) Training for Bentley's gINT® Software:

For PennDOT Users:

Bentley instructor-led web-based training sessions for gINT were provided to a limited number of PennDOT Geotechnical personnel in November 2013 (for subsequent participation in PennDOT gINT user acceptance testing). Additional web-based gINT Fundamentals training sessions will be available in 2015. Please note that the Bentley led gINT Fundamentals training is limited to 24 persons. Detailed information regarding the gINT Fundamentals training, including start and end times for each session, will be e-mailed to PennDOT District Geotechnical Engineers.

For Business Partners:

Business Partners should contact Bentley (1-800-BENTLEY) regarding web-based, self-paced, or group training for gINT software.

13.) gINT Training for PennDOT Projects: PennDOT Users and Business Partners

A one-day web-based training will be offered in spring 2015 for both PennDOT and consultant users. The training will cover gINT input for PennDOT Projects, creating of gINT output reports, using gINT reports on structure boring logs and soil profile plans, upload of project files using the PennDOT gINT website, and ECMS requirements regarding the gINT project file. Time will also be allotted for a general question and answer period to address any other issues anticipated or encountered in the project development process related to gINT implementation for PennDOT.

PennDOT Districts and Business Partners on the gINT subscription list

(<http://www.dot.state.pa.us>, click on “Design & Construction”, and then on the “Construction” and “gINT” links) will receive an e-mail with additional information concerning the gINT training for PennDOT projects. The information will also be placed on the ECMS Training Calendar.

14.) gINT in the Construction Phase

The “Pile Installation Table” placed on structure plans (reference DM-4 P.P. Section 1.7.5.2) is intended for capturing and recording test pile capacities achieved at the time of driving. To ensure that these test pile capacities, as well as the driving method and pile tip elevation are documented and easily accessible in the future, applicable input fields and the Pile Installation Table are included in PennDOT’s gINT data template and library.

Please note that Project Office Manual Section C.10.14 Form CS-1005 “Pile Driving Log” has been updated. The Form CS-1005 states that a copy of the completed form is to be sent to the District Geotechnical Engineer. The pile driving results are to be input/included in the gINT project file/the gINT database.

If any additional geotechnical sampling or testing is conducted during the construction phase, the information is to be included into the gINT project file for future use and reference. As the gINT database is populated, ready access to existing geotechnical information will result in cost and time savings resulting from taking fewer or more representative borings, reduced or better use of geotechnical testing methods; known existing pile type, pile tip location and capacity etc.

15.) Future phases of gINT Software Implementation for PennDOT Projects

Note that the implementation of gINT software represents the first phase of gINT software use by PennDOT. Future phases of gINT Implementation are planned to address other items, and may include the following:

- gINT and Google Earth
- gINT Civil Tools Software Library to facilitate placement of soil fences on soil profile plans
- Using gINT to place boring locations on the boring location plan.
- Plot of soil fences relative elevation/location
- gINT using eCAMMS data to produce graphs/reports for lab results

Attachment B: Publication 14M, Design Manual Part 3,
Chapter 5 Soil Profile Plan, Replacement Pages

Summary of Changes to Publication 14M Design Manual Part 3, Chapter 5 Soil Profile Plan:

- Replaced references to Bureau of Design with Bureau of Project Delivery.
- Variation from PennDOT gINT Soil Fence report formats must be approved by the Chief Geotechnical Engineer.
- Include reference to Pub. 222 regarding the use of gINT software as customized for PennDOT (PennDOT gINT data template and PennDOT gINT library).
- Indicate that the legend for the soil and rock symbols and respective descriptions is to be created by gINT with the PennDOT gINT library.
- Provide requirements for soil profile reports.
- Included sample PennDOT gINT soil fence reports.
- Revised note for each subsurface boring sheet to coordinate with DM-4.

CHAPTER 5

SOIL PROFILE PLANS

5.0 INTRODUCTION

The intrinsic physical and chemical properties of undisturbed soils and their location both vertically and laterally with respect to a proposed grade line are vital factors which may affect route location and are the basic factors which shall dictate the physical cross sections of a highway facility. The slopes of cuts and fills, benching, drainage, pavement type and methods of excavating and placing embankment may all be affected by subsurface conditions.

The frequency of test holes, the number of samples to be tested and any special tests which may be required shall be determined by the District Geotechnical Engineer.

Soil Profile Plans, as discussed in this Chapter, pertain only to the standard ANSI D size, 34 in x 22 in which are submitted with the Construction Plans to the Director, Bureau of Project Delivery.

Variation from these guidelines may be made for a specific project, when justified, by obtaining the approval of the Chief Geotechnical Engineer.

Reference Publication 222 Geotechnical Investigation Manual for further information regarding the use of gINT software customized for PennDOT for characterizing geotechnical information and for geotechnical reports available. For preparation of fence logs and other geotechnical reports reference Publication 293.

5.1 TITLE SHEET

The Title Sheet for all soil profiles shall indicate the following information:

1. A legend produced using gINT software with the PennDOT gINT Library containing the soils and rock symbology and respective descriptions as utilized in borings for the project.
2. Headings for the following:
 - a. Abbreviations and Symbols.
 - b. General Notes.
3. A 5.5 in square for the Location Map.
4. Identification Block.

The information placed under items 2.a, 2.b, above are self-explanatory; however, a note indicating the date of the approval of line and grade upon which the soil profile is based should be added.

The Title Sheet shall contain the State Route Number, Section Number and County and the Stationing Limits shall be given as required for Construction Plans in [Chapter 2 of this Manual](#).

List any equalities on the drawing preferably below the "From Sta ___ to Sta ___" designation. The size of lettering shall conform to that presented in [Chapter 13 of this Manual or to PennDOT gINT](#).

In the lower right-hand corner of the Title Sheet, provide a Signature Block and include the following information:

1. Name of the Engineering firm doing the soils work.
2. Client (Consultant or Department).
3. Seal and signature of the responsible registrants doing the soils work.
4. Date.

When the geotechnical work is being done by the District, include the following information:

1. District Number.
2. Seal and/or signature of the District Soils Engineer.
3. Date.

The responsible registrants doing the geotechnical work shall also place either a black ink rubber stamp seal or a facsimile seal on all subsequent sheets.

5.2 INDEX SHEET

The Index Sheet shall contain an Index Map, to a minimum scale of 1" = 500', with the following data indicated, where applicable:

1. Construction or survey centerlines or baselines for mainline, ramps, side roads and channel changes.
2. Edge of streams.
3. North Arrow.
4. Political subdivisions.
5. Existing roads (State Routes, Township roads and local road names).
6. Railroads.
7. Equality stations.
8. Identification of all ramps.
9. PC's, PT's, etc. (circles only).
10. Label stations at 500 ft intervals.
11. Indicate the extent of work by the designation "Limit of Work" for the mainline and "Start Work" and "Stop Work" for side roads with the State Route Number, Section Number, Township and County.
12. Spot locations of auger and test boring holes and place a Legend at bottom of the sheet, as indicated below:

LEGEND



AUGER BORING



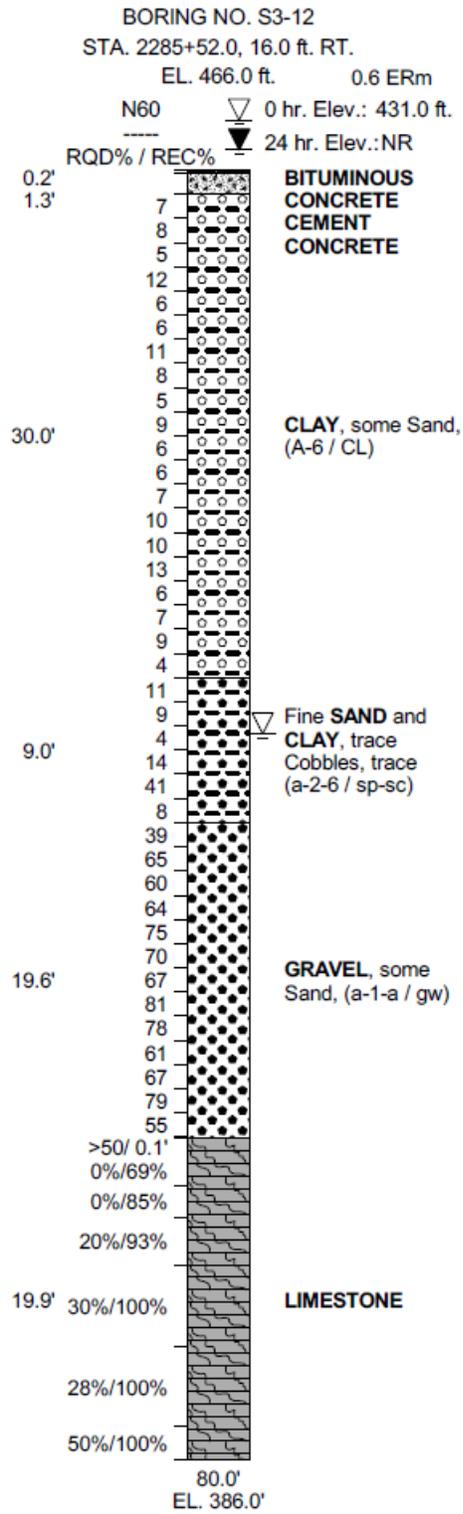
TEST BORING

13. Bar Scale.
14. Outline of proposed and existing bridges.
15. Complete the Identification Block in the upper right-hand corner.
16. Scale at bottom of sheet.

5.3 PLAN SHEET

The Soil Profile shall be plotted to a horizontal scale of 1" = 50' and a vertical scale 1" = 10' and shall contain the following data:

1. Label stations horizontally at 100 ft intervals below the datum line. No overlap from the preceding sheet is necessary. Indicate equality stations.
2. Elevations of datum line and elevations at 10 ft. intervals at each end of the sheet.
3. Existing ground elevations along the construction centerline or baseline shall be plotted at 50 ft intervals and these points connected with a solid, thin ink line.
4. Final grade line (graphic representation).
5. Locations of test holes plotted on profile with a solid 0.25 in wide rectangle or hollow 0.25 in wide rectangle from existing ground to depth of hole. gINT Software with the PennDOT gINT Library is to be used to prepare the solid or hollow test hole representations.
6. From all test holes, using gINT Software with the PennDOT gINT Library indicate in double scale 1" = 5' a core 0.5 in wide with symbols for soils encountered and their depths and place this vertically above or below the test hole shown on profile. No interpretation shall be shown between test holes. See example gINT Fence Log Report (produced with PennDOT gINT Library) below:



7. Use gINT software with the PennDOT gINT Library and Laboratory Test Summary Report to tabulate tests performed on soil samples and the test result:

- a. Sample Number (if visually identified, refer to sample compared with).
- b. Boring Number.
- c. Station.
- d. Offset.
- e. Soil Classification.
- f. Liquid Limit.
- g. Plasticity Index.
- h. Mechanical Analysis - Grading.
- i. Natural Moisture.
- j. Maximum Density.
- k. Optimum Moisture.
- l. California Bearing Ratio.

8. When more than one test or auger boring is made at a station, an accurate graphic cross section of the proposed highway facility shall be drawn in the upper portion of the sheet for that particular station, preferably to a horizontal scale of 1" = 25' and a vertical scale of 1" = 10'. On this section, show the outline of the pavement, median, shoulder, swale, cut and fill slopes and locations and depths of borings. A separate sheet may be used for showing cross sections.

9. When two soil profiles are plotted on the same sheet, they shall be plotted to read from top to bottom.

10. Add the following note to each subsurface boring sheet:

THIS SHEET IS INCLUDED FOR THE CONVENIENCE OF THE DEPARTMENT. SEE SECTION 102.05 OF PUBLICATION 408.

Attachment C: Publication 15M, Design Manual Part 4,
Replacement Pages; Various Sections

Summary of Changes to Publication 15M Design Manual Part 4:

- Revised DM-4 PP Section 1.7.5.2 to address moving the Pile Installation Table from the General Notes to the structure boring plan sheets as it will be created by gINT using the PennDOT gINT library.
- Revised DM-4 PP Chapter 6 Procedures for Geotechnical Explorations to eliminate duplication of requirements already contained/addressed by Publication 293 and Publication 222.
- Minor revisions to Sections PP 1.9.3.3.1(d), A1.9.4.3.1(b)5, A1.9.4.3.1(c), A1.9.4.3.2 to remove references to portions of Chapter 6 that have been deleted.

1.7.5.2 Notes for Pile Installation Information

The following pile installation table is to be included on the General Notes sheet of the bridge plans and is to be produced using gINT Software with the PennDOT gINT Library Pile Installation Information Report. After installation, the test pile information as indicated in the table is to be input into the PennDOT gINT Project Files, and the completed table is to be placed on the “as-built” plans. If borings are not taken, or do not exist for the piles, the pile installation table may be created and completed without the use of gINT, and is to be placed on the General Notes sheet of the bridge plans.

Substructure Unit	Pile Type	Pile Tip (None/Normal/Heavy Duty)	Pile Tip Elevation	Factored Design Load (kips)	Ultimate Pile Capacity at End of Driving (kips)	WEAP or PDA

1.7.6 Notes for Reinforced Concrete Box and Arch Culverts

Do not exceed a 2 ft. difference in fill elevation on the sides during placement of the backfill. Do not allow the wheels of rollers to come closer than 1 ft. to the face of the structure during compaction of the backfill.

1.7.7 Notes for Steel Beams and Girders

1. If beams (girders) cannot be shipped in the lengths shown on the plans, field splice(s) will be permitted at the request of the Contractor, but no compensation will be allowed for the splices (see PP1.7.10, Instruction 6).
2. If beams (girders) can be fabricated in lengths longer than the sections shown on the plans by eliminating field splices, field splice(s) may be omitted at the request of the Contractor. The Contractor assumes full responsibility for securing a hauling permit. Approval for elimination of a field splice at the shop drawing stage does not obligate the Department to issue a hauling permit (see PP1.7.10, Instruction 7).
3. Do not use form support systems that will cause unacceptable overstress or deformation to permanent bridge members.
4. All fasteners are 7/8 in. diameter HS bolts, except as noted.
5. Ream subdrilled or subpunched holes for field splices in the fabrication shop.
6. Prepare bearing areas as specified in Publication 408, Section 1001.3(k)9.
7. Do not make welds by manual shielded metal arc process for primary girder welds, such as flange-to-web welds or for shop splices of webs and flanges.
8. Do not weld permanent metal deck forms or other attachments to girder top flanges in tension areas. (Tension areas of top flanges are designated on the plans.) Threaded studs for the support of the overhang deck forming bracket is permitted provided the threaded stud is attached with the same welding processing as the shear studs.
9. Welding of reinforcement bars during fabrication or construction is not permitted unless specified.
10. Provide welded stud shear connectors manufactured from steel conforming to ASTM A 108.
11. Set anchor bolts to template or in preformed holes. Do not drill unless specifically indicated on plans. Fill the preformed holes with non-shrink grout. Fill the clearance between anchor bolts and holes in masonry plates with approved non-hardening caulking compound conforming to Publication 408, Section 705.8.
12. Paint structural steel in accordance with Publication 408, Section 1060.
13. Fabricate all members or member components designated as fracture-critical members (FCM) to conform to the requirements of Design Manual, Part 4, Section 6.6.2, and AASHTO LRFD Bridge Design Specifications, Article 6.6.2,

and Publication 408, Sections 1105.02(a)5 and 1105.03(m)9. Meet the base metal Charpy V-notch (CVN) requirements for Zone 2.

14. Metallize structural steel in accordance with the special provision - Shop Metallizing and Painting of New Structural Steel. The flange, bearing stiffener plates and splice plates indicated are oversized in width to accommodate the reduction due to edge grinding.
15. Stability of partial girders and complete girders is to be maintained by the Contractor during erection, until all girders and diaphragms are in-place and all bolts are properly installed. Erection loads including self weight of the steel members, wind loading and construction live load effects are to be evaluated by the contractor for stability, stresses and deflections on the steel members during any stage of erection.
16. An alternate slab placement sequence may be permitted at the request of the Contractor. Submit for review and approval to the Department a revised slab placement sequence with support calculations and computer stress analysis. Satisfy the requirements of the original slab placement sequence. Obtain written approval prior to the use of the revised slab placement sequence and/or camber values. No compensation will be allowed for the development and approval of the revised slab placement sequence and camber values. The Department will be the sole judge of the acceptability of the revised slab placement sequence and camber values.
17. Consultant to specify if heat-curved beams (girders) are (are not) permitted.
18. See D6.7.2, D6.7.2.2.P, D6.10.3.2.5.2P, and D6.13.2.8 for additional notes to be shown on contract drawings.

1.7.8 Welding Notes for Rehabilitation of Structures or where Field Welding is Permitted

1. Welding specifications: AASHTO/AWS D1.5M/D1.5 Bridge Welding Code (specify year) consistent with Pub 408 1105.03(m) and the contract special provisions. Do not field-weld on any part of the existing bridge, except where shown on the drawings, without prior approval of the Engineer.
2. Welding of existing structural steel: Use the shielded metal arc process and low hydrogen electrodes which are compatible with the base metal as specified, and in accordance with an approved Weld Procedure Specification.
3. Make tack welds with the same type of electrode and incorporate in the final weld. No other tack welding will be permitted.
4. Do not weld when surfaces to be welded are moist or exposed to rain, snow, or wind, or when welders are exposed to inclement conditions that will adversely affect the quality of the work.
5. Do not weld or burn when the temperature is below 0° F. Preheat and maintain the temperature of the metal to at least 70° F when the temperature of the metal is between 0° F and 32° F during welding or burning.
6. Preheat the steel to the specified minimum temperature for a distance equal to the thickness of the part being welded, but not less than 3 in. in all directions from the point of welding.
7. Remove by application of heat any moisture present at point of weld. Provide windbreaks for protection from direct wind.
8. Prior to placing the weld, thoroughly clean all portions of new and existing surfaces to receive welds of all foreign matter, including paint film, for a distance of 2 in. from each side of the outside lines of the weld.
9. Test completed welds using visual and nondestructive methods in accordance with AASHTO/AWS D1.5m/D1.5 Bridge Welding Code Chapter 6.

1.7.9 Utility Notes

Coordinate, locate, and conduct all work related to public and private utilities in accordance with Publication 408, Sections 105.06 and 107.12

- (12) Bridge-mounted lighting poles, sound barriers and signs, if required.
- (c) Report on alternate studies and justification for the recommended bridge types
- (1) Cost comparison for all types considered during type, size and location study. (The cost estimate shall be arranged so as to indicate total cost per substructure unit and major portion of superstructure, e.g., rolled beam span, plate girder span.)
 - (2) Justification for recommended alternate
 - (3) Address the need to account for future widening and future redecking requirements into the recommended bridge
 - (4) Design Requirements for Contractor-Designed Alternate Structures and Design-Build Projects.
 - Permissible changes to the bridge geometrics (span, bridge width, abutments, and piers) and vertical and horizontal alignment.
 - Permissible Material Types (e.g., weathering steel, proprietary walls, etc.).
 - Permissible Number of Deck Joints (typically, this will be the number of deck expansion joints provided in the as-designed structure; however, this limitation should not be so restrictive that it eliminates the use of individual superstructure material types for the alternate).
 - Future Redecking Requirements (as applicable)
 - Maximum Number of Permissible Construction Stages.
 - Number of Required Lanes.
 - Minimum Lane Width(s).
 - Lane Location Limitations (if any).
 - Need to Maintain Pedestrian Traffic.
 - Minimum Number of Beams.
 - Design requirements for the individual stages.
 - Future Widening Requirements (as applicable).
 - Environmental Requirements Related to the Structure (as specified in the environmental clearance document - EIS, EA, CEE, or EER).
 - Other.
- (d) Foundation exploration plans
- Submission requirements are discussed in Pub. 293, Section 1.5.3.
- (e) Additional information to be supplied by the designer
- (1) Route and section number, index map and segment/offset of limits
 - (2) Program under which project will be financed (Federal-aid classifications, 100% State-funded, Department Force, or special program) , the WBS code and MPMS number.
 - (3) Name of designer (Consultant or District Office)
 - (4) List of proposed structures by station and type
 - (5) Design traffic data including current and projected ADTT and class of highways on relevant roads
 - (6) Date of line and grade approval and design speed
 - (7) Statement on balance of earthwork for project

- (8) Statement whether project is designed for free or controlled access
- (9) Prints or roadway plans showing approved typical sections; also pavement-type approval when available
- (10) Copy of waterway approval (from Department of Environmental Protection) and results of acidity tests of water and soil, if applicable
- (11) Copy of the minutes of the Design Field View approval as defined in Design Manual, Part 1, Chapter 2, and available road plans.
- (12) For rehabilitation projects, the following information shall be provided:
 - a. Age of existing structure, present and cumulative ADTT, portion to be replaced, type of steel-for-steel bridges, date of last inspection, type of diaphragm connections, i.e., welded or riveted, type and location of deterioration, deck drainage, expansion dam type, barrier type, and other pertinent items.
 - b. Live load ratings of the bridge at present and after rehabilitation.
 - c. Fatigue-prone details, such as out-of-plane bending problem areas, cover-plated beams, remaining fatigue life with and without retrofit, fatigue problems observed during inspection, recommended retrofit for existing fatigue-prone details, and other pertinent items.
 - d. Proposed scope of work.
- (13) For structures involving railroads, the following information shall be provided:
 - a. Completed Form D-4279 "Railroad Crossing Data for Design", as well as railroad right-of-way cross-sections, 500 ft. each side of proposed structure, degree of track curvature and rate of superelevation, if applicable.
 - b. Existing railroad drainage facilities and conditions in the vicinity of the structure site shall be investigated and described.
 - c. For situations in which railroads are overpassed by a highway structure, the procedures to determine track clearances are discussed in Design Manual, Part 1C, Chapter 4, Section 11D "Clearance of Track where Railroads are Overpassed by a Highway Structure", D2.3.3.4, and Publication 371, Grade Crossing Manual.
 - d. All contacts with the railroad companies shall be through the District Executive unless authorization is given to consultants, in which case copies of all correspondence and memoranda of meetings shall accompany submission of plans to the District.
 - e. A copy of the railroad company's letter of approval of acceptance regarding horizontal and vertical clearances, type of design live loading, type of steel and allowable stresses for various structural members shall be submitted with TS&L submission, as well as a request for temporary support for railroad tracks, if needed.
 - f. Demolition procedures including a schematic plan shall be provided for the removal of structures over or adjacent to railroads. The procedures and schematic must be coordinated with railroad representatives (see item d above).
- (14) Copies of all available structure foundation exploration information from Design Manual, Part 1C, Chapter 4, Section 11F and Publication 293. (Provide a statement concerning mining in the area and any previous foundation problems, if any.)
- (15) Pedestrian count and information concerning possible future development which might warrant need for sidewalks and/or pedestrian protective fence.

- (16) Address problem areas so that there are no surprises at the final plan submission (kink in girders rather than curved girders, etc.). If problems or questions arise after approval is given, they should be brought to the attention of the Department.
- (17) Address safety areas which are structure related and were noted at the Design Field View.
- (f) Completed applicable Q/A Forms D-501, D-502, D-503 and/or D-504 (refer to Appendix A).

1.9.3.3.2 Streamlined TS&L

A Streamlined Submission, as a result of a Bridge Pro-Team meeting, shall include the information outlined in PP1.9.3.3.1(a) with signature blocks, (b) and (f).

The submission shall also include meeting minutes from the Pro-Team Bridge Scoping capturing all alternates discussed with reasoning behind decisions to pursue or exclude. All involved parties including the appropriate reviewing authorities, not just meeting attendees, should review and approve the minutes. The minutes should be made available to consultants for review during agreement advertisement for projects where consultants are used for design.

1.9.4 Foundations

1.9.4.1 General

The foundation exploration and report preparation shall be done as outlined in Chapter 6, and outlined herein.

Submit the TS&L Report and Structure Geotechnical Foundation Report for Retaining Walls, VMS/DMS support structures, and Sound Barrier Walls concurrently.

1.9.4.2 Responsibility

Refer to Table PP1.9-2 for the review and approval responsibility for foundations.

1.9.4.2.1 Responsibility of District

The foundation approval may be granted by the District Bridge Engineer or designee: However, input from the District Geotechnical Engineer should be considered. The District may consult BDTD and the Geotechnical Engineers and Geotechnical Section of the Innovation and Support Services Division about unusual cases.

The designer shall submit two sets of foundation plans to the District for approval.

1.9.4.2.2 Responsibility of BDTD

The designer shall submit to the District three sets of foundation plans for PennDOT oversight projects and four sets for Federal oversight projects.

The District Bridge Engineer and the District Geotechnical Engineer shall review the submission. The District Executive shall forward the submission to BDTD with the District's recommendation. The District shall submit to BDTD one set of the foundation submission for BDTD approval responsibility and two sets for FHWA approval responsibility projects.

If the District desires to revise the Consultant's recommendations, the revision shall be marked on the plans in red, with an explanation where necessary.

BDTD will review the submission and, after obtaining necessary FHWA approval, will approve it if it is found satisfactory. Submission of revised plans will be requested if necessary. The Geotechnical Section of the Innovation and Support Services Division may be consulted about unusual or complex foundations.

1.9.4.3 Submission Requirement

Foundation Submission requirements are divided into two categories, Standard and Streamlined. Standard Foundation submissions are required on all projects unless a Streamlined Submission is agreed upon by the District, BDTD and FHWA (if applicable).

1.9.4.3.1 Standard Foundation

The following information shall be included in the foundation submission:

(a) Foundation submission letter

The letter shall include the following for each substructure unit:

- (1) Proposed bottom of footing elevation.
- (2) Applicable core borings - B1, B2, etc. Identify bearing stratum. Show percentage of gross recovery and RQD for rock stratum and reasons for low gross recovery and/or RQD when applicable. For spread footing on soils, show average N value below the footing elevation to a depth equal to 1.5 times the width of the footing. For footings on piles, show average N value at least 10 ft below the estimated pile tip.
- (3) Rock and/or soil data for each layer below the footing, listed on Figures 1.9.4.3-1 and 1.9.4.3-2, used to compute the nominal foundation bearing resistance in tsf. (See also QA Form D505)
- (4) Pile type and size, pile tip reinforcement when required, rock and/or soil data for each layer below the footing, listed on Figure 1.9.4.3-3, used to compute the pile load resistance and driving method.
- (5) Estimated pile tip elevation, bottom of pedestal, drilled shaft and length of socket into bedrock for each substructure unit when applicable.
- (6) Caisson or Micropile type, size and the rock and/or soil data for each layer below footing, listed on Figure 1.9.4.3-3, used to compute the resistance.
- (7) Estimated settlement for footings on soils, fill material settlement that may affect the foundation, etc.
- (8) Scour depth for each substructure unit, if stream crossing.
- (9) If piles, caissons or micropiles are in a corrosive environment, submit information as stated in D10.7.5.5P.

(b) Foundation plans

The following information shall be shown on foundation plans:

- (1) Preliminary plans (dated), including plans and elevation showing type and elevation of the bottom of the footing and elevation of pile tip, recommended for each substructure unit.
- (2) Soil profile along the substructure units and longitudinal profile along the centerline of the structure (for uneven bearing stratum or when requested by the engineer).
- (3) Plotted logs of core borings and boring layouts, grouped for each substructure. The title block on the structure boring log sheets shall follow the example given in Figure PP1.6.2-1 except as follows:
 - Do not include "Recommended" and the accompanying line.
 - Substitute "Geotechnical Engineer" or "Chief Geotechnical Engineer" for "Bridge Engineer" or "Chief Bridge Engineer" below the signature line on the first sheet only; omit this title on subsequent sheets which only need to be dated.
 - Do not include the supplemental drawing note under the sheet number.
- (4) If settlement is a problem, a settlement control scheme or mitigation plan, after approval, shall be included in the final plans or in the proposal.
- (5) Foundation investigation information: The subsurface exploration data which are used in making recommendations concerning foundations shall include an *endorsement*, including the date and signature of a qualified geotechnical engineer or engineering geologist, stating that the information, as submitted, accurately

represents the conditions encountered by the test boring program, including boring logs, earth samples, rock cores, classification of materials, and depth of borings.

Furthermore, the boring log sheets that are part of the bridge plans shall have the following note and initials of the geotechnical engineer or engineering geologist on each sheet: "The description of the materials encountered have been verified." (Initials).

For bridge construction plans prepared by District personnel, the District Geotechnical Engineer shall verify the accuracy of foundation data secured by drilling contractors or Department forces.

Endorsement shall be shown on the first sheet of the plotted test borings. In addition, the following note shall be shown on each test boring sheet: "This sheet is included for the convenience of the Department. Refer to Publication 408 Section 102.05 for further information."

The plotted test borings shall include all information contained on the boring logs.

- (6) Pile type, size and tip reinforcement for pile-supported footings. (See also QA Form D505)
- (7) Nominal size of drilled shafts, including the rock socket for footings supported on caissons.
- (8) Identification of substructure unit at each test boring, elevation of bottom of footings at each test boring, and elevation of bottom of pedestals and/or drilled shafts and/or pile tip.
- (9) Finished ground elevation at face of abutments or piers along the roadway, stream, or railroad.
- (10) Approved "Contour Grading and Drainage Plan" for interchange areas and other areas when applicable.
- (11) For foundations of structures over or along a stream, scour computation for abutments, piers and retaining walls and proposed scour countermeasures (including size and extent of riprap) calculated using finalized hydraulic data shall be included in the report.
- (12) Foundation information of existing or nearby structures (type of foundation, footings elevations, sign of settlement due to scour, etc.).
- (13) For bridge replacement structures over a stream or river, submit the following information on the *existing* structure:
 - a. Date built
 - b. Type of superstructure
 - c. Type of substructures
 - d. Type of foundation and piles if known and applicable
 - e. Bottom of footing elevation
 - f. Stream bed elevation
 - g. Waterway opening larger or smaller than proposed structure
 - h. Any scour or settlement due to scour
 - i. Debris accumulation problem
 - j. Containment within banks or lack of containment of upstream flood water

- k. Reason for structure being replaced
- l. Reason for substructure failure, if applicable
- m. Approximate value of bearing pressure or pile load

For additional information concerning release of information and documents, see PP1.6.3.4.

(c) Geotechnical Report

Include foundation alternates studied (spread footings, piles, caissons, pedestals, etc.) including possible use of prefabricated proprietary walls, cost comparison when applicable, available driller's and Engineer's logs, and justification for the recommended foundation type, including allowable settlement or ultimate strength. If settlement is a problem, a settlement control scheme or mitigation plan, after approval, shall be included in the final plans or in the proposal. Reference Publication 293, Section 1.5.7 for additional requirements.

(d) Completed Q/A Form D-505 for Foundations (refer to Appendix A).

1.9.4.3.2 Streamlined Foundation

A Streamlined Submission, as a result of a Bridge Pro-Team meeting, shall include the information outlined in PP1.9.4.3.1(a), (b), (c) and (d).

The submission shall also include a Foundation approval letter with signature blocks, to the District, listing items from PP1.9.4.3.1(a) and meeting minutes capturing all alternates discussed with reasoning behind decisions to pursue or exclude. All involved parties including the appropriate reviewing authorities, not just meeting attendees, should review and approve the minutes. The minutes should be made available to consultants for review during agreement advertisement for projects where consultants are used for design.

1.9.4.4 Special Considerations

Based upon past experience, the following list of precautionary items is provided:

- (a) Foundation in limestone/dolomite area shall be evaluated conservatively, i.e., use a smaller resistance per pile, provide grouting if necessary, etc. History of sinkhole activity must be checked.
- (b) Piles or other deep foundations shall be recommended for substructure units in flood plain unless the footing will be supported on bedrock. Exceptions must be evaluated with extreme caution.
- (c) Interference of inclined piles of the same and adjoining substructure units must be checked.
- (d) For structure widening, watch for undercutting of existing foundation. Foundation column alternates may be considered. Similarly, foundation adjoining operating railroad or other property must be evaluated for the use of foundations column, caissons, etc., to eliminate cost of sheet piling or other similar costly measures.
- (e) Foundations for non-flexible walls or substructure units must be set below the frost depth.
- (f) Pile overdrive requirements may be needed for Conemaugh (clay stone and clay shale), decomposed mica schist and similar formations, if load test history indicates such a need.

1.9.4.5 Foundation Approval

The following items shall be included, as a minimum, in the foundation approval letter:

- (a) All data outlined in PP1.9.4.3.1(a).
- (b) Reasons for lower than normal allowable foundation pressures, pile loads, etc.
- (c) Specific pile-driving method.
- (d) Precautionary notes (for example, "Note that piles will terminate on limestone bedrock and considerable variation in the pile tip elevations may result").
- (e) A note to the effect that a copy of the foundation approval letter is to be given to the field office for the Inspector's guidance during construction.

1.9.5 Final Review of Plans

1.9.5.1 Responsibility

Refer to Tables PP1.9-1 and PP1.9-3 for review and approval responsibility for final plans.

Except for minor projects designed using the procedures in Design Manual, Part 1X, Appendix AB, the review of the final plans shall be conducted by either the District or BDTD, whichever has the final plan approval responsibility.

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
DESIGN MANUAL

PART 4

VOLUME 1

PART A: POLICIES AND PROCEDURES

CHAPTER 6 – PROCEDURES FOR GEOTECHNICAL EXPLORATIONS

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6.1 GENERAL

Procedures followed for geotechnical exploration, reconnaissance, foundation exploration for final design, and preparation and management of subsurface boring, sampling and testing contracts shall meet the requirements of the following publications:

- (a) Publication 14M – Design Manual, Part 3 (Chapter 5 “Soil Profile Plans”)
- (b) Publication 15M – Design Manual, Part 4 (Section 10 “Foundations” and Chapter 1, Article 1.9.4 “Foundations”)
- (c) Publication 222 – Geotechnical Investigation Manual
- (d) Publication 293 – Geotechnical Engineering Manual, Parts 1 and 2

Procedures followed for entry onto Railroad Right-of-Way including, temporary railroad right of way permit/agreement, Department scope of work details and method of payment, consultant/contractor railroad right-of- way requirements and method of payment and entry onto railroad property shall meet the requirements of the latest edition of Publication 371 Grade Crossing Manual, Chapters 4, 7 and 10.

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10.4 SOIL AND ROCK PROPERTIES**10.4.2 Subsurface Exploration**

The following shall supplement A10.4.2.

Perform subsurface explorations in accordance with Policies and Procedures, Chapter 6; and Publication 293, Geotechnical Engineering Manual, Part 2.

C10.4.2

The following shall supplement AC10.4.2

Areas of karst geology present special challenges because of the unique weathering, erosion, drainage and subsidence features that may be found there. Karst refers to a set of physical conditions, landforms, and bedrock attributes that may be present in areas that are underlain by bedrock that is soluble in water. In Pennsylvania, karst conditions are associated with carbonate rocks such as limestone and dolomite. The PA Geologic Survey (DCNR, 2000) has mapped the distribution of limestone and dolomite in Pennsylvania. Characteristics of karst areas include irregular and pinnacled bedrock surfaces; soil overburden mixed with rock fragments; and open cavities, conduits or caverns within the bedrock.

Sinkhole development is often associated with karst areas. Overburden soils are typically residual material resulting from weathering of the underlying bedrock. This residual soil can migrate or be washed into openings in the rock. As the soil continues to migrate into the openings in the rock a very soft zone or void develops in the overburden soil. When insufficient material remains to support the overlying soils, the roof collapses and a sinkhole develops. Sinkhole development is often associated with the movement of water. Sinkholes can be naturally occurring due to the percolation of surface water from natural drainage patterns. Sinkhole development can also be triggered by changes in drainage patterns due to development, construction activity that removes a portion of the overburden leaving insufficient material to bridge underlying voids, or dewatering and the associated drop in groundwater level. *For further description of sinkholes, sinkhole remediation and sinkhole prevention see the Ground Subsidence Management Guidelines (issued via SOL 421-08-05).*

Prior to planning a subsurface investigation in karst areas a thorough review of published and unpublished information should be performed in accordance with Publication 293. Carefully review historic aerial photographs to identify sinkhole scars, closed depressions and possible zones of bedrock fracturing. Stereoscopic aerial photographs are more effective than individual photos in identifying these features. Review available mapping of karst features and sinkholes (Kochanov).

During the review of published and unpublished information and when performing field reconnaissance (Pub. 293) particular attention should be paid to the presence of karst landforms such as sinkholes, closed depressions, resurgent springs and bedrock outcrops. Areas that farmers avoid could be pinnacles or sinkholes. Changes in vegetation sometimes indicate sinkhole activity. Forested areas in fully farmed lands may also indicate areas of shallow rock. Old sinkholes may have been used as dumps, and can be

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found below debris piles. Any trends in karst features should be noted (e.g. sinkhole alignment). Information on past sinkhole activity may be gained from interviews with local residents, municipal officials or local contractors.

Publication 293 provides guidance regarding selection of number and depth of borings, drilling techniques, sampling methods, in-situ testing and geophysical testing. Test borings with Standard Penetration Test (SPT) sampling in soil and rock coring are recommended for any subsurface investigation in karst areas. It is important that the boring logs include observations of such conditions as soft or wet zones in the soil overburden, drill water return (or the lack of), reaction of rock core samples to dilute HCL solution, and voids or soil-filled seams in bedrock. It is desirable to obtain SPT samples of soil seams in bedrock. In order to do this it will be necessary to advance casing below the top of rock or to use NX drilling tools. NX core barrels are large enough to accommodate a 2-inch split-barrel sampler for SPT sampling.

Test borings with SPT sampling and rock coring are relatively expensive and time consuming and provide data at the boring location only. Because subsurface conditions in karst areas are highly variable supplemental techniques such as pneumatic-powered, track-mounted percussion drilling (air-track), electronic cone penetrometer and geophysical methods can be valuable in obtaining a more complete understanding of subsurface conditions at the site. In all cases it is desirable to obtain data with the supplementary methods close to SPT/rock core borings so the results can be correlated.

Air-track drilling has the advantages of mobility, speed of drilling and relative economy. It is effective at penetrating boulders and ledges. An experienced operator can qualitatively detect voids, zones of broken rock and the soil/rock interface. However, when drilling rock, it is difficult to distinguish between raveling decomposed rock zones and zones of residual soil or between zones of soft soil and open cavities. Air-track drilling can be problematic through thick overburden or in intensely weathered bedrock with numerous clay-filled cavities and steeply sloping rock surface.

Use of an electric cone penetrometer can provide data on soft soils or cavities within the soil overburden, geotechnical data, and inferred top of rock at a relatively reasonable cost. Disadvantages are the inability to penetrate cobbles, boulders or ledges.

Since karst areas are characterized by highly variable subsurface conditions, geophysical investigations can be helpful to supplement and refine intrusive subsurface investigation programs, such as SPT, CPT, etc. See A10.4.5 for a general discussion of geophysical tests and references for detailed guidelines.

In karst areas, physical properties of interest include top of rock profile, voids or soil-filled seams in bedrock, voids in the overburden soils and soft zones in the overburden