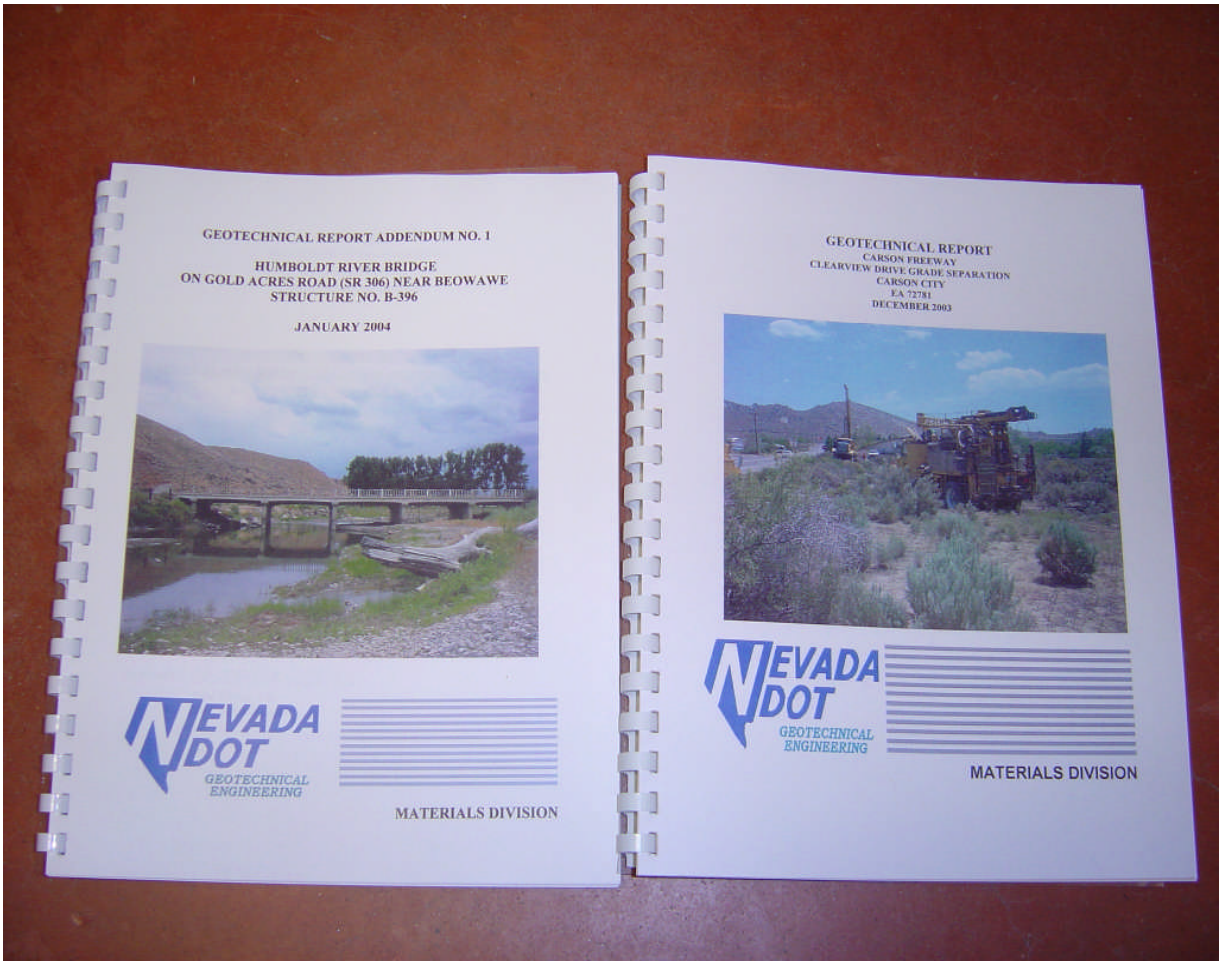
GEOTECHNICAL POLICIES AND PROCEDURES MANUAL

CHAPTER 12

PRESENTATION OF GEOTECHNICAL INFORMATION



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1. INTRODUCTION

Upon completion of the geotechnical investigation and analysis, the information and findings must be compiled in a standard report format. The report serves as the permanent record of all geotechnical data known to be pertinent to the project and is referred to throughout the design, construction, and service life of the project. The data and recommendations are typically compiled in a Geotechnical Report. The intent of the Geotechnical Report is to present the data collected in a clear manner, to draw conclusions from the data, and to make recommendations for the geotechnical aspects of the project. The primary clients that use the report are roadway designers, Bridge Engineers, construction personnel, and contractors. The Geotechnical Report is a professional document, and must be prepared under the direction of a registered professional engineer. When Consultants prepare reports, the Consultant's recommendations must be reviewed, documented and retained by the Geotechnical Engineer assigned to the project. All final reports, calculations, boring logs, details, etc. must be submitted to the Department on Compact Disks (CD) in addition to paper copies. All boring logs must be prepared using the "gINT" software program with printouts in the Department's format. The Department's final decision on the use of the Consultant's recommendations should be documented (i.e., in a memorandum to the Project Manager in charge of the project). This Chapter describes the format for presentation of geotechnical data. General outlines of the topics to be discussed in the Geotechnical Report are presented.

2. GEOTECHNICAL REPORT ORGANIZATION

The Geotechnical Report contains factual data, interpretations, engineering studies and analyses, and recommendations for design and construction. The report should be formatted to present information using a standardized approach, so that users are able to locate information readily and consistently. The format and contents of the Geotechnical Report are somewhat dependent on the type of project. The general outline for a Geotechnical Report is as follows:

- Title Page
- Table of Contents
- Executive Summary (optional)
- Introduction
  - General
  - Scope
  - Other reports and investigations
- Project Description
- Geologic Conditions and Seismicity
  - Local Geology
  - Faulting and Seismicity

- Field Investigations (summary, with details in Appendices A, B, D, and E)
- Laboratory Analyses (summary, with details in Appendix C)
- Discussion (with supporting figures in Appendix A)
  - Anticipated Subsurface Conditions (soil, rock, groundwater)
  - Geologic Hazards
  - General Site Evaluation
- Summary of Engineering Analyses and Calculations (typically a summary will suffice in a main section of the Geotechnical Report, and the detailed documentation of analyses and calculation could be in an appendix or as a separate report.)
- Recommendations
  - Site Grading and Earthwork
    - Use of Materials
    - Embankments
    - Cut Slopes
    - Drainage
  - Rock Slopes (slope angles, stabilization, rockfall mitigation)
  - Foundations
    - Spread Footings
    - Driven Piles
    - Drilled Shafts
    - Micropiles
  - Retaining Walls
  - Construction Specifications
  - Recommended Construction Observations, Testing and Instrumentation
  - Closure
- References
- Appendix A: Figures
  - Site Location Map
  - Soil Boring Location Map
  - Geologic Mapping
  - Supporting Photographs of Site Conditions
  - Interpreted Geologic Cross-Sections
  - Recommended Design Details
- Appendix B: Subsurface Explorations Data
  - Boring Log Key
  - Boring Logs
  - Test Pit Logs
  - Geophysical Data
- Appendix C: Laboratory Test Results
  - Test Result Summary Sheets

- Particle Size Distribution Report Sheets (gradation curves)
- Consolidation/Hydrocollapse Test Report Sheets and/or Summary Table
- Triaxial Test Results Sheets and/or Summary Table
- Direct Shear Test Report Sheets and/or Summary Table
- Chemical Analysis Results Sheets and/or Summary Table

- Appendix D: In Situ Test Results
- Appendix E: Instrumentation Results

Much less commonly, a Geotechnical Baseline Report may be required, particularly in conjunction with solicitations for Design-Build projects. The Geotechnical Baseline Report outline is similar to the above outline, except that it is strictly a factual report, and no analyses or design recommendations are presented. Geotechnical Reports should be prepared using a formal technical report writing style. The reports are read by various parties within the Department and by the Department's agents (Consultants, contractors, attorneys, etc). In litigation matters, the Geotechnical Report could be read by opposing legal counsel looking for weaknesses, misstatements, errors, omissions, evidence of substandard work or implied conditions. Internal report reviews are critical to verify that reports meet the Department's standards before the reports are distributed. Reports and report drafts are discoverable in legal proceedings, and can be used by opposing counsel in an attempt to cast doubt on the competency of the Department's Geotechnical Engineer.

The Geotechnical Report typically is used by the Department as the basis for resolving contractor claims of changed conditions. The Geotechnical Report should divulge all subsurface information used for design. The report writers and reviewers should be aware that the information contained in the report is typically used by contractors to prepare their bids. Since some words and phrases can have double meanings, it is important, to avoid the use of incomplete, ambiguous, and subjective statements. Reports should be reviewed specifically for such content and the questionable words and phrases replaced with clearer terms. Geotechnical interpretations are needed to describe and justify the assumptions made in areas where conditions are unknown. Unnecessary interpretations and statements or overly optimistic statements should be avoided.

Guidance for checking the completeness of Geotechnical Reports is provided in the FHWA publication "Checklist and Guidelines for Review of Geotechnical Reports and Preliminary Plans and Specifications" (1985). Checklists are provided for various types of geotechnical investigations and construction elements, in the following categories:

- Site investigation information
- Shallow foundations
- Pile foundations
- Drilled shaft foundations
- Retaining walls
- Bridge approach embankments over soft ground

- Centerline cuts and embankments
- Landslide corrections
- Material sites
- PS&E review checklist
- Minimum geotechnical engineering analyses required for embankments, cut slopes, structure foundations, and retaining walls
- Guideline minimum boring, sampling, and testing criteria

In addition, recent FHWA technical publications for different types of geotechnical construction (such as soil nailing and ground anchors) provide guidance on documentation relevant to those areas. Analyses and computations should be checked by an independent Geotechnical Engineer following appropriate QA/QC procedures. Reviews should utilize the guidelines in FHWA publication "Checklist and Guidelines for Review of Geotechnical Reports and Preliminary Plans and Specifications" (1985), as well as this Manual, and FHWA design reference manuals.

To maximize the benefits of the geotechnical investigation, the Geotechnical Engineer should interact with the project design and construction engineers throughout the duration of the project. The geotechnical input should be considered and incorporated into the project as the design is developed. If the project design is altered as project development advances, the geotechnical recommendations may have to be modified from those presented in the Geotechnical Report. When the project approaches the final design stage, the Geotechnical Engineer should determine if an additional or a final Geotechnical Report should be prepared to reflect modified assumptions and recommendations incorporated in the final design plans.

The following offices should be provided copies of Geotechnical Reports, as applicable:

- Project Manager
- District Engineer
- Construction Engineer
- Structural Design Division
- Roadway Design Division
- FWHA Project Engineer (for Federally funded projects)

In addition to writing the report, the Geotechnical Engineer should review all phases of the plans and specifications to ensure that the geotechnical recommendations have been correctly incorporated. The Department "Standard Specifications for Road and Bridge Construction" and Pull Sheet specifications should not be changed for projects except with the approval of the Assistant Materials Engineer.

3. TITLE PAGE

The title page should include the formal name of the project, the project identification number, the county, the date the report was finalized, and the names with titles of report

preparers and their signatures (which includes the author, the reviewer, and approval by the overseeing engineer).

4. TABLE OF CONTENTS

The table of contents should list the report sections and subsections, followed by appendices. A list of tables and figures should be included. A table of contents is not necessary for a short report or technical memorandum.

5. EXECUTIVE SUMMARY

The Executive Summary may be desirable for larger reports to help provide the most important findings and recommendations in a short and simple manner. An Executive Summary is not necessary for a short report or technical memorandum.

6. INTRODUCTION

This section introduces the scope of work as it relates to the general project description (a more detailed project description is provided in the next report section). A list of previous reports and investigations that are relevant to the current project and site should be identified in this introductory section.

7. PROJECT DESCRIPTION

This section describes the elements of the project and the geotechnical-related items. Provide a list of project information that was received during the course of the investigation (alignment, foundation layout, 30% plans, scour estimate, etc.). The details should include the various grading requirements and structure needs. Project constraints should be identified. Design loads and seismic criteria should be addressed. Provide a description of width, composition, and condition of existing roadway. Provide the estimated depths of scour used (typically determined by the Hydraulics Engineer), if applicable. A vicinity map is useful to show the general location of the project.

8. GEOLOGIC CONDITIONS AND SEISMICITY

This section describes the known and published geology of the site and vicinity, as well as the regional and local seismicity. Provide a description of significant geologic and topographic features of the site. The principal geologic formations are described, along with their soil and rock characteristics. The general thicknesses (and contact elevations) of the principal geologic units should be described based on available information. Describe both natural and man-made features that are of construction importance or need to be protected. Include pertinent geologic mapping. Identify the closest relevant faults and areas of seismic activity, along with the published expected peak horizontal ground acceleration (as stated in reliable geologic publications and the AASHTO “Standard Specifications for Highway Bridges Design Manual”).

9. FIELD INVESTIGATIONS

This section presents an overview of the exploration program. Information presented here should include geologic reconnaissance work, the method of subsurface explorations, in situ testing, and instrumentation. The sampling methods should be briefly described. Each boring and test pit should be identified and labeled, along with its depth and purpose. Provide a sentence referencing the exploration logs, in situ test results, and instrumentation results in the appendices.

10. LABORATORY ANALYSES

List the types of tests performed and summarize the results, leaving the details in the appendix. Briefly describe key findings from the laboratory tests. Provide a sentence referencing the laboratory test results in the appendix.

11. DISCUSSION

The subsurface conditions should be described along the route of the project. This might require splitting the discussion into sections along the alignment. Describe the engineering characteristics and anticipated behavior of each soil and rock unit. Identify potentially difficult or problematic conditions. Describe any precedent information such as past slope performance or instabilities and ground settlement evidence. The groundwater regimes throughout the project should be described. Describe any potential geologic hazards, such as unstable slopes and rockfall hazards.

12. CALCULATIONS

A complete set of the analysis computations should be adequately documented and saved in a separate file or report. All calculations by Consultants are reviewed by the Geotechnical Engineer. The Geotechnical Engineer reviews and makes recommendations back to the Consultants to be incorporated into the calculations. Consultants remain responsible for the accuracy and completeness of all deliverables.

13. ANALYSES

Provide an overview of the geotechnical engineering analyses and studies performed. Describe the purpose of each set of analyses, and provide the assumptions used, the corresponding results, and impact on the project. Details should be included in an appendix, if necessary. When applicable, analyses for alternate foundations including spread footings, driven piles and drilled shafts should be provided for all structures. A description of the analyses performed and an explanation of why specific foundation alternatives were eliminated should be included.

14. RECOMMENDATIONS

The Geotechnical Engineer must provide recommendations for all earthwork, rock slopes, retaining walls, foundations and geotechnical problems. The excavated materials must be described in terms of their behavior and its suitability for use as Borrow material. Address how the materials satisfy Department standards for Borrow materials. Unsuitable materials must be addressed and their locations identified. If groundwater or seepage could impact the project, describe any recommended drainage systems and their locations. Estimate earthwork shrink/swell factors to allow for computation of earthwork quantities.

Provide recommendations for embankment construction, including methods to ensure slope stability and manage settlement. Estimate the magnitude and rate of settlement. Evaluate possible alternatives if magnitude or time required for settlement is excessive, and recommend treatment based on economic analysis, time and environmental constraints. When addressing stability, describe the factor of safety criteria and the level achieved with the recommended approach. Evaluate possible treatment alternatives if the factor of safety is too low. Provide recommendations for any ground improvement. Reinforced slopes, if to be used, should be detailed for design. Landslide mitigation measures require detailed design recommendations.

Provide rock slope recommendations including the design of slopes (appropriate cut slope angles) and fallout area dimensions. The potential for rockfall should be described and any recommended mitigations should be detailed.

Foundation recommendations should be provided for all structures including bridges, soundwalls, earth retaining walls, channels, box culverts and poles. Address the use of both shallow and deep foundations and describe advantages and disadvantages for each. Provide detailed recommendations for preferred foundation types. For shallow foundations, provide the recommended elevations of bottom of footings and the allowable soil pressures based on settlements and bearing capacities. Describe suitable pile types and reasons for design selections and exclusions. Provide plots of soil resistance for selected pile size alternates. Plots should be developed indicating both Davisson's curve and ultimate soil resistance versus elevation, and should show end bearing and skin friction as well as total resistance. Depth of scour should be accounted for on each plot. Separate pile analyses for recommended pile sizes are to be performed for each boring. A corresponding pile capacity curve for each analysis should be provided. When more than one boring is drilled at a pile group location or when it is appropriate to generalize the soil strata, one design analysis is performed for each pile size. Recommendations for piles include:

- Lateral capacity
- Vertical (axial) capacity
- Seismic criteria and design parameters
- Minimum pile length or tip elevation (related to axial capacity)
- Minimum pile spacing

- Estimated pile settlement or pile group settlement
- Effects of scour, down drag, and lateral squeeze, if applicable.
- Pile cap depths or elevations
- Maximum driving resistance to be encountered in reaching the estimated bearing elevation including the estimated amounts of scour used in the capacity analysis
- Recommended locations of test piles and pile installation criteria for dynamic monitoring
- Selection of load test types, locations and depths, where applicable

Recommend which retaining wall types are appropriate for the project. Provide detailed recommendations for design of the preferred wall type(s). Provide loads and factored soil resistance with respect to sliding and overturning for walls other than cantilever walls included in the Department "Standard Plans for Road and Bridge Construction", and address overall stability of walls. Include any requirements for tiebacks, geotextiles, reinforcing materials, etc. Include MSE reinforcement lengths and locations if lengths vary. See NDOT, "Bridge Design and Procedures Manual" for details.

Describe the effect of roadway construction (vibratory rollers, utility excavations, settlements, etc.) on surrounding structures and any possible impacts they may have on the use of the structures during construction. Structures in close proximity to construction activities must be evaluated for potential damages caused by these activities. When warranted, recommendations such as time restraints on certain operations, underpinning, and monitoring need to be provided to reduce the damaging effects of the construction. Where there is a potential impact on existing buildings in the surrounding area, include the structure's address, type of construction, the estimated vibration level that may cause damage, the usage (storage building, hospital, etc.), what the potential problem may be and what actions should be taken to minimize the impact in the report.

The Department's "Standard Specifications for Road and Bridge Construction" must be utilized wherever possible for simplicity and contractor familiarity. Provide specifications and details where the Standard Specifications do not apply or do not address the planned construction operation for the project. There is no need to repeat the Department's Standard Specifications in the Geotechnical Report.

Provide recommendations for geotechnical testing, observations, and/or instrumentation, depending on the needs of the project and the relative complexity or criticality of the work to be performed. Describe the benefit of performing the testing and instrumentation, and the possible consequences if they are not performed or if the instruments are accidentally damaged. List the tests and instruments to be used and their planned locations.

Comments on construction issues are helpful to both the Department's Resident Engineer and the contractor. Unless otherwise specified by the Department, provide information about anticipated water, soil, and rock conditions that might affect construction operations, sequences, and methods. These conditions might include soft foundation soils, quick soils, extremely weathered or fractured rock, massive rock, high moisture contents,

presence of subsurface boulders, buried drainage systems, and/or springs that could interfere with construction. Identify design features that were specifically included to address geotechnical problems during construction. Discuss the design features and possible consequences of not implementing these features. Identify restrictions, such as not being allowed to place fill or temporary stockpiles in sensitive or unstable areas, and provide information on temporary cut slopes.

15. REFERENCES

Cite the references used in the geotechnical evaluations and analyses.

16. FIGURES

Figures are typically presented in Appendix A. The main figures should include:

- Topographic site plan, usually with a vicinity map
- Boring location map
- Geologic mapping
- Supporting photographs of site conditions
- Geologic cross-sections and typical sections along the alignment, if approved by the Principal Geotechnical Engineer
- Recommended design details

17. SUBSURFACE EXPLORATIONS DATA

The details of the exploration methods are in the main body of the Geotechnical Report and do not need to be repeated in the appendices. On large projects, a Summary Table with borings listed in numerical order and their corresponding stationing locations may be included to allow the reader to find boring locations and numbers readily. Subsurface exploration data including Boring Logs, Test Pit Logs, and/or Geophysical plots are typically presented in Appendix B. A key to Boring Logs needs to be included.

18. LABORATORY TESTS RESULTS

A Summary Table of laboratory test results and detailed graphs of results of tests such as consolidation, shear strength, triaxial, and gradation are typically presented in Appendix C.

19. IN SITU TESTS RESULTS

Details of any in situ testing (other than SPT) and corresponding test data and results are typically presented in Appendix D.

20. INSTRUMENTATION RESULTS

Details of the instrumentation installations and the monitoring program are typically presented in Appendix E. The results of the monitoring program are typically included.

21. REFERENCES

AASHTO, “Manual on Subsurface Investigations,” 1988

AASHTO, “Standard Specifications for Highway Bridge Design Manual”

FHWA, “Checklist and Guidelines for Review of Geotechnical Reports and Preliminary Plans and Specifications,” FHWA-PD-97-002, 1985

FHWA, Engineering Notebook Issuance GT-15, “Geotechnical Differing Site Conditions,” May 1996

FHWA, “Soils and Foundations Workshop Reference Manual,” NHI Course No. 132012, FHWA NHI-00-045, August 2000

NDOT, “Bridge Design and Procedures Manual, Structural Division”

NDOT, “Standard Specifications for Road and Bridge Construction”