Alaska
Department of
Transportation
and
Public Facilities

Alaska Geotechnical Report Preparation Guidelines

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Preface

This is one of a series of guides on geological/geotechnical investigations, procedures, and reports for the Alaska Department of Transportation & Public Facilities (DOT&PF). This is a guide for Department staff and consultants who prepare geotechnical data reports for use in the design and construction process.

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1. Guidelines for Preparation of Geotechnical Reports

1.1. Introduction

The geotechnical report is the tool the Department uses to describe project site conditions and to present formal design and construction recommendations to roadway design, bridge, and construction engineers. We cannot overstate the importance of the preparation of an adequate geotechnical report. The report is a critical reference during design, during construction, and following completion of the project if there are claims to resolve. The report must be as clear, concise, and accurate as possible.

To the extent possible, obtain the necessary geotechnical data early in the design phase so that the data and data interpretations are available throughout the design of the project. The various types of geotechnical information for a project are compiled into the formal geotechnical report as part of the project's materials report, which must be completed no later than the project contract advertising date for inclusion in the bid package.

1.2. What Does a Geotechnical Report Contain?

The report normally contains both factual data and data interpretation necessary to develop and present specific design and construction recommendations. You, the author, should exercise great care to differentiate factual data from interpretive data, and clearly identify the interpretive data as such.

The factual data can be presented in a wide variety of formats. Consistency of format is important to the extent that the minimum information necessary for the design and construction of a project is included in the geotechnical report. An annotated outline of a geotechnical report is presented in Chapter 2 of this guide. Department staff and consultants are expected to follow this guideline in preparing geotechnical reports.

1.2.1 Factual Information

The factual information included in a geotechnical report includes:

- Procedures and methods used in investigation
- Summary of or reference to all relevant existing data collected during the course of the investigation
- Geologic setting and relationship of geology to project
- New data developed during the investigation, including logs of test holes/test pits, laboratory test results, geophysical data, ground water information, etc.

1.2.2 Interpretive Information

This kind of information in the geotechnical report is derived from factual data. Engineering or geologic data are assessed, synthesized with pre-existing and new data and then translated into useable form to provide conclusions on conditions of soil, rock, groundwater, frozen soil, and other characteristics. It is often necessary to interpret geological data to clarify a geotechnical aspect of the project. Note that such data presentation tools as soil and rock profiles, geologic cross-sections, geological mapping, and rock structure mapping are interpretive in that they depict conditions at points between boring locations or other data collecting points. Indicated conditions at intermediate points are estimated, and should be presented in that light. Interpretive information includes:

- Interpretation of data and conditions on the project
- Analysis of data and conditions

1.2.3 Analysis and Recommendations

Design professionals use the factual information together with the interpreted information as the basis for analysis and design of facilities. This process includes the following products:

- Specific engineering recommendations for design

- Discussion of conditions that may be encountered during construction with recommendations for solutions to anticipated problems
- Recommendations for specific contractual provisions to address particular conditions or anticipated problems
- Recommendations for notes included with plan sets on various features, such as potential problems with drainage or erosion control, slope stability, slope design, location of support features, rockfall hazard mitigation methods and locations, etc.

1.3. What Is Excluded From the Report?

Some of the geotechnical information generated during the design phase is not ordinarily useful or pertinent during construction, so exclude it from the report. Such information may relate to superseded alignments or locations, technical or economic comparisons of design alternatives, details that are not adopted, or items deleted from the project scope. Make the decision as to what is pertinent and what is not on a project-by-project basis.

1.4. Setting a Geotechnical Baseline

One of the purposes of the geotechnical report is to set a baseline of geotechnical conditions. The baseline is a representation of the geotechnical conditions the parties to the construction contract may expect to encounter. The Department may prepare a formal geotechnical baseline report for use in complex projects or a geotechnical summary for inclusion in the special provisions. Absent an explicit, separate baseline report or summary, the baseline is established by the geotechnical report.

The conditions defined in the geotechnical report provide the basis for interpretation and analysis of claims under the differing site conditions (DSC) clause. Federal law requires that all federal-aid highway contracts include a differing site conditions clause. A contractor filing a DSC claim must contend either: (1) that ground conditions are materially different from those that would be expected from a reasonable interpretation of the contract documents, or (2) that an unusual, unknown physical condition exists that materially differs from those ordinarily encountered.

A significant portion of contractor claims and problems during construction involves subsurface conditions and soil/rock construction materials. This is due primarily to the complexity and variability of natural earth and rock formations and materials. Juries have awarded in the millions of dollars for contractor claims based on the DSC clause. The Army Corps of Engineers has documented that from 1980 to 1990, contract claims escalated by more than 200 percent, and by 1990 averaged more than $1 billion annually.

Because the geotechnical report is made available to bidders to use as an aid in preparing bids, it becomes a key document to both the Department and the contractor if a dispute regarding geotechnical conditions arises during construction of the project. Because of this, it is extremely important to prepare the report with the idea in mind that it may become the focal point of a geotechnical DSC claim. Errors, omissions, or misrepresentations in the report may lead to resolution in favor of the claimant. This could greatly increase the cost of the project. Conversely, a carefully prepared and accurate geotechnical report will do much to prevent DSC claims, or to provide the basis for an equitable resolution of a DSC claim in favor of the state.

1.5. Practices to Avoid

This section details some unwise practices by authors of geotechnical reports. Avoiding these common pitfalls will help avoid claims and contract disputes over geotechnical issues. The list of issues is not a comprehensive set of considerations or situations. The examples are used to illustrate some, but by no means all, of the issues that you should consider in a geotechnical report.

1.5.1 Incomplete, Ambiguous, or Subjective Statements

DSC claims have been awarded on the basis of, literally, one or two words in a report. The choice of words is so important that every author of a report should have reference to a glossary of geologic terms, a dictionary, and reliable reference texts in specialty fields such as engineering geology, groundwater, geophysics, and soil and rock mechanics. Check yourself whenever you have the slightest question as to the meaning a reader may assign a word. Reviewers of the report have an obligation to raise questions about such words or phrases. In a claim (or court) case, a tactic often used by the plaintiff or the plaintiff's attorney is to examine the geotechnical report in detail to find statements that will help the claim by being inaccurate, very broad, or ambiguous.

Ambiguities can result in a misunderstanding of what the author intended to convey. Words such as "isolated, some, few, numerous, rapidly, occasional, scattered, useable, "etc. should be used only if the meanings of such words are quantified to a narrow range of meaning within the context of the report.

1.5.2 Unnecessary or Overly Optimistic Interpretations

Data interpretations and geologic interpretations are often necessary in a geotechnical report, but be careful to ensure that a given interpretation or conclusion contributes to the technical merit of the report. As an example of an interpretation that is unnecessary and does not contribute to the technical merit of the report, consider the following statement that appeared in a geotechnical report:

> *"The sandy gravel deposit has a shallow water table (4'-6' below the surface) but as it is an elevated terrace, it will drain rapidly."*

This statement is improper for at least two reasons. First, it has no technical merit – the statement is pointless, since it is an outright guess. Unfortunately, such a statement appearing in a technical report will almost certainly be given more credibility by the reader than it deserves. Second, the term "drain rapidly" is subjective unless it is defined (in the report) to be within a range of values used to define drainage rates.

Certainly, the author in the above example should have pointed out the shallow water table, and a prudent interpretation of the geologic conditions would have been that the shallow groundwater could have an adverse effect on excavation operations. An example of a better statement to alert the reader to this risk is:

> *"The water table was noted at a depth of 4' to 6' below the surface, and any excavation deeper than this will probably require bailing or dewatering. Dewatering characteristics of the soils were not measured."*

Experience has shown that one of the most defensible reasons for geologic interpretations in a geotechnical report is to warn the reader about some geological feature or aspect that may pose a risk of geotechnical surprise.

1.6. Geotechnical Risk Factors

Risk factors perceived by contractors bidding on projects increase the bid cost of the projects. When they realize the risk during construction, the price of the project goes up due to claims or less confrontational changes to the contract through change orders or force account work. The presence of boulders, for example, is a risk factor that can greatly influence excavation costs, and their presence in ground that is being excavated often leads to contract disputes or DSC claims on the basis that they were not anticipated in significant quantities. This is an area where presentation of geological interpretations may be justified if, for example, boulders were noted in the geotechnical explorations for a project, but not in quantities that could be anticipated from interpretation of the geologic setting of the project. The purpose of including such interpretations is to alert the reader to the risk of boulders being present in significantly greater quantities than might be indicated by the exploration data alone.

1.6.1 Example 1

The following example demonstrates a situation where presentation of a geologic interpretation contributed to the technical merit of the report by pointing out the risk of boulders in a proposed cut.

Exploratory borings for a proposed deep cut detected only a few boulders, but geologic interpretation and construction histories of excavations in nearby areas in geologically similar terrains suggested a strong possibility that many boulders could be encountered. The following statement was put into the report:

> *"The proposed cut from Station 970 to Station 2060 will be into what is interpreted as an ancient terrace of the Copper River. Exploratory borings indicate boulders are present, and other excavations into ancient Copper River terraces have encountered concentrations of nested large boulders ranging in size from one to ten or more feet in diameter."*

Boulderous gravel was, in fact, encountered during excavation of the cut. There is no way to know if the above statement gets credit, but there was no claim filed for boulders.

A list of other geotechnical risk factors that may be present on any given transportation project in Alaska includes seismic potential, permafrost, deep seasonal frost, wet soils, soft ground, extremely moisture-sensitive soils (such as soils derived from volcanic ash, soils with glacial silt fines, or ancient weathered sands and gravels), areas where wet construction seasons or unusually short construction seasons commonly occur, potential landslides, or floods, to name a few. Most risk factors can usually be discussed on a wholly factual basis, but if interpretation will contribute to the technical merit of the report, include it.

1.6.2 Example 2

For example, consider the following case history:

> *"For design of a highway in an area in the interior of Alaska where the construction season is quite short (and often wet), test borings were made in the fall and early winter of the year. Laboratory tests of soil samples taken along the proposed route indicated that glacial silt soils in the upper five feet or so were below optimum moisture. Good borrow sources in the project area were sparse, so the soils were designed for incorporation into the highway embankment. However, when construction began, it became apparent that the soils were too wet to compact, and attempts to dry them failed dismally in the cool, damp weather that was common to the area. This project, with all the claims and extra charges, ultimately cost more than double the original cost estimate."*

This could have been avoided if geotechnical interpretations of the risk involved in trying to use the silts were made and presented on any or all of the following bases:

1. A study of construction histories of projects in similar geologic and environmental settings would have revealed that glacial silts were almost always a "problem soil" when attempts were made to compact them to modern moisture/density specifications.
2. An application of the knowledge that moisture content test results from samples of frost-susceptible soils taken within the seasonal frost penetration zone can be misleading. If the samples are taken during the fall and early winter months, the silts have had weeks to thaw and drain, and moisture content test results will be drier (sometimes a lot drier) than the soil will be during the early and mid-part of the construction season.
3. The risk of a very wet construction season, not uncommon in the environmental setting of the project, could spell disaster to an attempt to use the silts, even if they were as dry during the construction season as the test results indicated.

Obviously, had the decision been made to design the silts as waste, the cost of the project would have increased. It would have been necessary to locate and obtain rights to additional borrow sources, and also obtain additional right-of-way to accommodate a large quantity of wasted silt. To accomplish this, unless the decision was made early in the design process, may have delayed advertising the project for a year. Even considering all this extra time and expense, it is highly likely that the final cost of the project would have been much less if geotechnical interpretation had resulted in the silts being designed as waste.

1.7. Editing Boring Logs

If the logs shown in the report, variously referred to as the "final," "formal," or "drafted" logs, are not exact copies of the original field logs (and they usually are not), take care when editing, rewording, condensing, or otherwise changing the original field logs. Make sure that notes regarding such risk elements as boulders, water table measurements, caving or squeezing ground, or drilling characteristics are not inadvertently edited out.

Editing of field soil textural descriptions requires careful judgment. For example, it may be easy to interpret that a soil described in the field log as "fine sand" is likely a "silt" when three samples of the stratum are tested and classified as silt. The interpretation is much less clear when, for example, the soil is described as "coarse gravel," and test results of samples (which were taken with a Standard Penetration Test (SPT) split-spoon sampler) classify as "sand." The difficulty and critical nature of such interpretations mandates that a senior engineering geologist should either do them or check them.

Note in red on the field logs any differences between the field logs and the final logs. If the rationale for the change is not clear, briefly explain it. Retain field logs until the project is completed and any disputes resolved.

1.8. Specific Report Guidelines

Each geotechnical report will be different and project-specific, so a “cookbook” report guide is neither possible nor desirable, as long as the minimum basic information set forth above is included. For the purposes of uniformity throughout the Department, the format guideline will be used by each region, and by consultants hired by the Department.

Do not assume that all aspects of a project will be automatically covered in one of the sections of the report outline. Look at the report outlines and refer to the guideline text to be sure that subjects important to the project are covered. If a subject does not seem to fit into any of the sections, do not ignore it; find a place where it seems to best fit, add a subsection, or make a note somewhere in the report to address the item.

2. Annotated Outline: Geotechnical Report

The geotechnical report may take many forms depending on the requirements of the project and the specific preferences in the regions. The outline below represents the contents that will cover virtually all the Department's geotechnical reports. The format of the report is not important – the content of the report is the issue. Consistency among the regions is desirable.

2.1. Title Page

Include the project name, federal and state project number, the DOT&PF region, the date of publication by month and year, and necessary signatures. The signatories on the title page should include the author and the responsible engineer, but may also include other approving officials including the chief geologist, the regional geotechnical engineer, the regional materials engineer or the state materials engineer. State law and Department policy require that a civil engineer registered in the State of Alaska stamp engineering geology/geotechnical reports unless they are merely reporting data.

For reports prepared by a consultant, the stamp of the consulting engineer in responsible charge will appear on the title page. The consultant company name, address of the office that prepared the report, its telephone number, and the consultant project number should also be included on the title page.

2.2. Table of Contents

Use a table of contents to show the starting page number for each section and subsection in the report, and list all the appendices. If necessary, include a list of figures. These include vicinity maps, location maps, photographs, charts, flow diagrams, graphs, etc. Include figures within the body of the text close to the point where they are referenced. If warranted, include a list of tables. In the list, include page numbers. Locate tables close to their point of reference in the text. A table of contents is not necessary for a short report or a memorandum-style report.

2.3. General Location Map

This should show the location of the project with respect to the state map and nearby communities.

2.4. Specific Location Maps

These maps will show the beginning and end of the project, stationing, centerline alignment, existing roads, major topographic and drainage features, a north arrow, map scale, materials site locations, and highway milepost locations. Material sites should be shown on this drawing. If material sites are not near the alignment, use separate sheets as needed.

2.5. Summary

The summary is a brief (one page or less) discussion of the project scope, the geotechnical field investigation, and the results of the investigation. Identify in the summary the problem areas or issues and discuss analysis of the problems and recommendations for resolution. Include a brief description of potential material sources, their availability, and any conclusions about the adequacy of the sources to meet project requirements.

2.6. Introduction

Include in the introduction a detailed scope of the proposed project (including type of facility, roadway length, width, paved or unpaved, important design features, etc.), the purpose of the report and the investigation, dates of field exploration, and identification of personnel who conducted the exploration. Include a list of previous explorations or reports for the project and whether they have been supplemented or superceded by the current investigation. Note the investigative techniques and exploration methods used (e.g., review of published data, site reconnaissance and mapping, equipment types, method of subsurface exploration, laboratory testing, analyses, etc.).

Include the following statements:

> *"This report documents subsurface geotechnical conditions and provides analyses and interpretation of anticipated site conditions at the project. This report recommends design and construction criteria for the project. This report also establishes a geotechnical baseline to be used in assessing the existence and scope of changed or differing site conditions. This report is intended for use by the project design engineering staff, construction personnel, bidders and contractors."*

2.7. Other Reports and Investigations

List any additional reports that pertain to this project. Include information describing authorship and dates of completion. Document the literature and references used in researching the geotechnical conditions for the project. The literature may be geologic maps, topographic maps, aerial photographs, previously completed reports for this or adjacent projects, regional geology reports, "as-built" plans, construction completion reports, or other documents. Include pertinent maps in the appendix if they are of particular value to understanding the project's geotechnical conditions.

2.8. Physical Setting

2.8.1 Climate

Describe climatic conditions that will have an effect on the project design, construction, or maintenance. Present the range of temperatures in the vicinity of the project. Note nighttime conditions, if available, if night construction is possible. Describe seasonal conditions such as temperature extremes, heavy rain, snow, or fog that could limit construction seasons, the ability to reduce the moisture content of construction materials, affect traffic control, etc. Briefly state the mean annual temperature, the temperature extremes, mean annual precipitation, heaviest rainfall months, snowfall amounts, the date of general onset of freezing temperatures, the freezing and thawing indices, and the design freezing and thawing indices if available. This data may be in presented in table form. Include references to the sources of the data, including Web site addresses.

2.8.2 Topography, Drainage and Vegetation

Describe the landforms and drainages through which the project will pass. Describe topographic highs such as hills and ridges that will require cuts for the project alignment and the approximate depths of the cuts. Also describe topographic lows such as valleys, swales, marshes, and minor creeks that the embankment will traverse. Discuss depth below or height above profile grade. Measure and describe steepness of slopes along and perpendicular to the alignment. Describe slopes that will receive side hill cuts or fills. Note drainage patterns including creeks, intermittent streams, and rivers; and vegetation types, sizes, and density. Include special note of vegetation that indicates something about subsurface conditions (such as small spruce trees that indicate possible frozen ground; heavy growth of alder indicating presence of shallow groundwater; or leaning, curved trees that may indicate ground movement).

2.8.3 Significant Man-Made and Natural Features

The project may cross, abut, or parallel certain features that may be adversely affected by the project or may impact the project. For example, existing retaining walls could be affected by embankment placed upslope of the wall, even though the toe of fill is located well back from the wall. As another example, rock cuts can remove support from bedding planes and reduce the lateral support of materials or facilities well outside the right of way. Identify such situations in this part of the report for later consideration.

Similarly, there may be features such as rivers, wetlands, utilities, railroads, or political boundaries that require added clearance through retained fills or overly steep cut slopes. Include information on the presence of any underground utilities (e.g., petroleum lines, natural gas pipelines, water supply lines, etc.) as features for geotechnical consideration.

2.8.4 Regional Geology and Seismicity

Describe the regional geologic setting of the project area. Include geomorphic province, major topographic features (such as mountain ranges and valleys), and major characteristics such as depth of alluvium over bedrock, bedrock formations, and included rock types. Include discussion of known or documented geologic hazards such as landslides, rockslides, flooding, etc.

Describe the regional seismic setting, including names of known active faults, distances and directions from the project site, and maximum credible earthquake magnitudes. If appropriate, provide a map at a suitable scale to show the regional faulting within 75 miles, with the appropriate annotation showing relative proximity of the project location. Where the project includes construction of structures such as bridges and retaining walls, include the expected peak ground acceleration (PGA) of the specific site, with careful reference to the parameters of the PGA and the source of the information, whether U.S. Geological Service, American Association of State Highway and Transportation Officials (AASHTO), or other publications.

2.8.5 Site Geology

Describe the geology of the project site and a sufficiently large area surrounding the project to include geologic features of potential significance to the project. Provide enough detail characterizing the geologic setting so that a reader can visualize the site geology. Preparation of a geologic map in hillside or mountainous terrain is helpful. Emphasize properties or conditions of the soil and rock materials that will impact design or construction of the project. Where a structure is planned for construction in alluvial sediments, include an estimate of the age of the sediments and an estimate of the depth to bedrock at the specific site. A separate foundation investigation will normally be conducted for all but the simplest and smallest structures.

2.9. Field Investigation

2.9.1 Exploration

In this section, describe the intent of the investigation, with reference to the exploration plan. Then describe what was accomplished during the field investigation and any deviations from the exploration plan with explanations for the deviation. Include a summary description of the type, scope, and purpose of the field investigations. Include a section on problems encountered during the exploration program that may have design or construction implications.

If some portion of the planned or desired fieldwork could not be done for some reason (right-of-entry refused by property owner, for example), state what work was desired, why it could not be done, and possible consequences. In Section 2.10. “Station to Station Descriptions,” discuss the assumptions that you had to make as a result of the omitted fieldwork.

2.9.2 Drilling and Sampling

Briefly describe the number, type, and depths of borings, trenches, and test pits made for the field study. Provide a general statement about the types and intervals of samples taken (bulk, undisturbed, SPT, etc.) and the reasons for each type. State the status of the samples: whether they were taken to the laboratory, were used in testing, are in storage, or were discarded. Also include a statement about how drill holes or pits were completed (filled with cuttings, grouted, converted to an observation well, backfilled and compacted, etc.).

2.9.3 Geophysical Studies

Describe the type, scope, general locations, and intended purpose of any geophysical studies performed. Indicate the locations of field data collection sites/lines on a plan view map or location drawing. Show the data in the profile sheets where appropriate, or other data sheets. Present the data, including all graphs and interpretations made from raw field data, in the appendix and reference the data in this section. Include a statement about the storage location of the raw data in case anyone wishes to look at it.

2.9.4 Instrumentation

Describe any instrumentation installed during the field exploration (e.g., slope inclinometers, extensometers, piezometers and observation wells). Indicate their locations on the plan view map or location drawing. State why each was installed and present summaries of the data in an appendix. If a monitoring program must continue beyond the time of the initial investigation, provide a schedule and duration. Present and discuss relevant data from instrumentation monitored during original construction or from previous exploration programs of relevance to the project.

2.9.5 Exploration Notes

Describe and briefly discuss any aspect of the exploration program that may affect design or construction. Include such items as caving or squeezing in the borings, extremely hard drilling or alternating hard and soft drilling, and problems with access to certain sites or gaps in the exploration program. The intent of this section is to disclose conditions that may not be addressed in the geotechnical analyses and recommendations sections, but which may be indicative of potential geotechnical behavior during construction.

2.9.6 *In Situ Geotechnical Testing*

Describe the in situ testing performed for the subsurface exploration program (e.g., vane shear tests, pressuremeter tests, electronic cone penetration tests, in situ permeability, etc.). Reference the test methods used, and include modifications of existing test methods or unpublished test methods in the appendix. Explain why you used that method instead of a published method. Where the in situ test results lend themselves to a concise summary (i.e. general data in the form of result ranges) include the summary here, otherwise summarize as appropriate in an appendix.

2.9.7 *Laboratory Testing*

Describe laboratory testing performed for this report. Include a listing of the testing performed such as classification tests, quality tests, and special tests such as consolidation tests or triaxial tests, etc. Refer to the controlling standards for the test methods used in the testing program. Include modifications of existing test methods or unpublished tests methods in the appendix. Explain why you used that method instead of a published method. Provide the laboratory test results on an approved soils testing report form approved in your region.

2.10. Station-to-Station Descriptions

The station-to-station descriptions are the heart of the geotechnical report. The geologist breaks down the alignment into logical intervals based on differences in soil/rock conditions, terrain differences, and other factors. The description of these intervals includes all factual items of importance noted from visual inspections of the terrain conditions and factual engineering geology/geotechnical information obtained during surface mapping or observations and from the test holes and/or test pits in each interval discussed.

The discussion of the intervals may also include carefully identified geologic interpretation of the data by a qualified geologist. The interpretation is made to increase the usability and reliability of information that must be inferred between points of factual data. Obviously, geologic interpolation cannot provide certainty regarding subsurface conditions, but it can provide a rational basis for assumptions made by a geotechnical engineer in performing stability or settlement analysis, or in developing geotechnical design recommendations. Make clear to the reader the distinctions between what is factual and what is interpretive.

Subjects to discuss include:

- Topography
- Types and density of vegetative cover
- Surface drainage and groundwater conditions
- Detailed description of the soil and rock present in the interval
- Frozen ground conditions, including permafrost if applicable
- Geologic hazards such as slope stability (slides, slumps), rockfall potential, likely settlement areas
- Boulders and cobbles, if present on the ground surface or encountered or suspected in the subsurface

Where groundwater is encountered or might be expected, discuss the observations from drilling or test trenching and the results of any observation wells or piezometers.

Follow the procedures set out in the *Alaska Field Soil Classification Guide* and the *Field Rock Classification and Structural Mapping Guide* to identify and describe soil and rock materials encountered during the investigation. DOT&PF uses the Unified Soil Classification System field and lab methods from ASTM D2487 and D2488 to describe and identify soils.

Where rock slopes are present along the alignment, provide an assessment of the existing slopes for rockfall hazards. Where rock cuts are planned, present the results of field mapping and analysis as to the structural characteristics of the rock. Include a discussion of the depth and nature of overburden above the rock slopes and the expected groundwater conditions.

Where frozen ground is encountered or expected, discuss the expected characteristics that may affect construction, such as temperature (give thermistor results), presence of excess ice, expected thaw instability, etc.

You must fully describe and document geologic hazards with mapping, photography and other means. Also discuss and recommend mitigation of the hazards.

Where boulders or cobbles are encountered or suspected, give the best possible estimate of the percentage of each present. Describe the occurrence– nested boulders, disseminated through a soil layer, etc. Where possible, use the methods outlined in the *Field Soil Classification Guide* to measure the percentage of boulders and cobbles.

For small, uncomplicated projects, it may be practical and effective to present the descriptions on plan and profile sheets rather than in the text of the report.

2.11. Graphical Representation of Geotechnical Information

Present in this section the geological and geotechnical information acquired along the project route. The data and interpretive information is typically shown on location drawings and plan and profile sheets, easily obtainable from the design section for modification for use in the materials report. However, in many cases the test hole/test trench logs may be shown on separate sheets referenced to a location drawing. Plan and profile sheets may be inadequate to fairly represent the logs, because of space requirements or a significant deviation between the existing ground and the planned profile.

The plan view should show features such as:

- Muskeg areas, ridges and benches, steep side-hill terrain, and any other terrain features that may affect the design of the facility
- Existing or potential slides or slumps, and any other features that may put geologic constraints on the design
- Man-made features such as houses, bridges, retaining structures, pipelines, railroad tracks, etc.
- The location of all test holes, test pits, or probes

A profile view should show the test hole logs, which will include at least:

- The test hole number and date
- The top of the test hole plotted at its actual elevation, where possible
- The depth and thickness of each soil layer
- The textural description of the soils
- Sample locations and numbers, blow counts, and sample recovery
- Selected sample test data
- Water table
- Frozen soil
- Cobbles and/or boulders

Note that factual engineering geology/geotechnical information or comments regarding the drilling or surface features recorded on or with the field logs should not be edited out of the published report.

In addition to the station-to-station descriptions, other geotechnical data may be obtained during the course of the investigation that is best presented in a graphical format. The report may incorporate charts, graphs, photos, and auxiliary software output (rockfall plots, slope indicator data, etc.). In many instances, the insertion of a single photograph into the text can make otherwise confusing paragraphs clear.

2.12. Geotechnical Analysis and Design Recommendations Analysis

The Materials section staff use the geotechnical data and information obtained from the various field investigations, the laboratory testing data, and geologic interpretations of site conditions to determine and characterize the relevant engineering properties of the rock and soil materials encountered at the project site. A geotechnical engineer will do the detailed geotechnical analyses necessary for the formulation of geotechnical design recommendations. He or she may ask the project geologist for assistance in such geological interpretations as needed to help develop geotechnical parameters for the analyses.

The analysis alerts designers, construction staff, and contractors to potential problems, and may provide the basis for choosing from various alternative design solutions. The analysis also may help in assessment of risks associated with the alternative design solutions. This analysis is not intended to provide detailed solutions to engineering problems. Rather, the analysis provides the basic information, some guidance on potential problems, and some possible solutions available to the design engineer.

The quality of the analysis depends on several factors, including staff knowledge of engineering principles and practical experience in application of these principles to projects involving similar facilities and materials. The analysis requires frequent communication and an unrestricted flow of information between the regional Materials section staff, the design engineering staff, and later, the construction staff.

2.12.1 Recommendations

The engineering geologist provides the regional geotechnical engineer with the necessary data and interpretations for the formulation of geotechnical recommendations as soon as practicable following completion of the field investigation. The geotechnical engineer prepares the recommendations with the assistance of the engineering geology staff and sends them to the design staff as soon as possible. The recommendations, which will ultimately be included in final form in the geotechnical report, may be considered preliminary during early development of the design, and may be presented in a preliminary report format to the designer.

2.13. General Material Site Information

List here the number and identity of sites investigated and selected for possible use. Specific material site reports will be in a separate section of the report or may be published as a separate report, depending on the project scope and other factors. (Material Site investigations and the material site report are discussed separately in another part of the Geotechnical Procedures Manual.) Identify the status of the individual sites as “designated,” “available,” or “other material sources,” pursuant to the Standard Specifications. Discuss the rejected sites and the reasons for rejecting them, as this could be helpful in future exploration. Discuss the sites selected for possible use and their characteristics, interpreted quantity available, quality of material, and limitations of the information used to make the interpretation. Recommend specific limitations or problems with the sources and details required for mining plans. Include photos of the site and the specific areas investigated to establish conditions at the time of the investigation.