Geotechnical Design Reports

February 2021

DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES

Table of Content

INTRODUCTION

This document provides the standards for the District Preliminary Geotechnical Report (DPGR), Preliminary Geotechnical Design Report (PGDR), and the Geotechnical Design Report (GDR). DPGR, PGDR, and GDR are issued for geotechnical components involving Caltrans assets other than bridge foundations and special design earth retaining systems.

GEOTECHNICAL REPORTING FOR CALTRANS PROJECT DELIVERY

Geotechnical reports are produced in the following phases:

- **Phases K and 0**

  DPGR *(WBS 150.15.20 or WBS 160.10.80)* – The DPGR provides preliminary recommendations to District Project Engineers in Design and Planning and is used to develop the Project Initiation Document (PID), Environmental Impact Report (EIR), Environmental Impact Statement (EIS), Project Study Report (PSR), and/or Project Report (PR).

  PGDR *(WBS 160.10.82)* – The PGDR provides preliminary geotechnical design recommendations to District Project Engineers. The PGDR describes existing site conditions and provides preliminary geotechnical recommendations before the end of Project Approval and Environmental Document (PA&ED).

- **Phase 1**

  GDR *(WBS 230.05.70.15)* – The GDR provides subsurface information from the geotechnical investigation, analysis and design, recommendations, and notes for editing the Special Provisions.

GENERAL CONTENT AND PRACTICE REQUIREMENTS

Technical Content

DPGR, PGDR, and GDR must meet the requirements identified in this document and the following FHWA checklist and guidelines:

- FHWA 2003 ED-88-053, *Checklist and Guidelines for Review of Geotechnical Reports and Preliminary Plans and Specifications*
- FHWA 2016 GEC 014, *Assuring Quality in Geotechnical Reporting Documents*

Identify Special-Design Project Components

Throughout project development, continually verify whether a project component meets the design parameters shown on the Standard Plans. When a project component does not satisfy the design parameters shown on the Standard Plans, notify the Project Engineer that the project component needs to be special designed.

For Earth Retaining Systems (ERS), verify whether the horizontal seismic coefficient of the site does not exceed the standard design parameters. For sign post foundations and

sound wall foundations, verify whether the subsurface engineering properties and ground geometry satisfy the design parameters as shown on the Standard Plans.

Review Project Documents and Contract Package

For DPGR and PGDR, review project documents and plans to ensure the information presented in the report is consistent with project documents and plans before issuing the report.

For GDR, review the draft Plans and Special Provisions, to ensure geotechnical recommendations provided in the GDR have been incorporated and information provided in the GDR is consistent with the contract Plans and Special Provisions. There must be no inconsistencies between the GDR, Plans, and Special Provisions, because the GDR is part of the contract package.

Report Signing and Stamping

For geotechnical design performed by Caltrans, sign and stamp the reports following *Communication and Reporting section* of the *Offices of Geotechnical Design – Quality Management Plan*.

Report Format

For DPGR and PGDR, organize the report as follows: *Introduction, Geotechnical Investigation, Geotechnical Conditions, Geotechnical Design Evaluation, Recommendations, and References (Optional)*.

For GDR, organize the report as follows: *Introduction, Geotechnical Investigation, Geotechnical Conditions, Analysis and Design, Recommendations, Notes for Specifications, Notes for Construction (Reserved), and References (Optional)*. Section Numbering is not required.

Include subsections and the subsection titles outlined in this document when presenting corresponding information.

Not every topic covered in this document is required to be included in a report. A report may be only two or three pages, or may be tens of pages, depending on the scope and complexity of the project. To address project-specific unique design issues that are not covered in this document, add additional sections or subsections.

A report must provide relevant and useful geotechnical design information for the Project Engineer and the Specifications Engineer to produce the Plans, Specifications and Estimates (PS&E) package. When presenting the results of an analysis or design, include geotechnical models, diagrams and photos showing essential design and geotechnical features to make the presentation self-contained.

For geotechnical design performed by Caltrans, prepare the report using current departmental memorandum format with the subject line of "*Report Name for Structure/Project/location Name*", for example "Geotechnical Design Report for Highway 5 Widening", "Preliminary Geotechnical Design Report for …", or "District Preliminary Geotechnical Report for …". Refer to *Communication and Reporting* section of *Offices of Geotechnical Design – Quality Management Plan* for details. The reports should include

project name, District, County, Route, begin and end Post Miles, Project ID, Expenditure Authorization (EA) number, project component name, author, and date.

Geotechnical Project File Content

Geotechnical Design Performed by Caltrans

Caltrans PS&E package should include only one set of subsurface information, either in the Boring Records format as an appendix in the report, or in the Log of Test Boring (LOTB) format in the Plans. To prevent potential inconsistency in the contract, a PS&E package must not include both the Boring Records and LOTBs.

Include Boring Records in the appendix of the Geotechnical Design Report when LOTBs are not included in the Plans. Do not include LOTBs or As-built LOTBs in the Geotechnical Design Report. For As-built LOTB sheets, send the MicroStation files or scanned copies of the As-built LOTB sheets to the Project Engineer to be included in the Contract Plans.

Geotechnical Design Performed by Consultant

The report must consist of the following: cover sheet, table of contents, main contents per this document, and appendices. The cover of the report and any addenda/amendments to the report must include the following information: project name, Caltrans District, County, Route, begin and end Post Miles, Project ID, Expenditure Authorization (EA) number, project component ID, project component name, author, and date.

Include calculation package in the appendix of the GDR.

Submit either the Boring Records, or the LOTBs and As-built LOTBs as part of the GDR. Refer to the Caltrans *Soil and Rock Logging, Classification, and Presentation Manual* for direction on the preparation of the LOTBs and As-built LOTBs.

Submit electronic copy of cone penetration test (CPT) data (both original and interpreted) and graphs in PDF format.

Exceptions

For geotechnical design performed by Caltrans, exception to the standards presented in this document requires prior approval under *Offices of Geotechnical Design – Quality Management Plan*.

DISTRICT PRELIMINARY GEOTECHNICAL REPORT AND PRELIMINARY GEOTECHNICAL DESIGN REPORT

The main function of a DPGR is to provide preliminary geotechnical design and recommendations. A DPGR typically includes evaluation of geologic hazards, existing site conditions, seismicity, and feasibility of identified geotechnical options. The assessment and recommendations provided in the DPGR can influence the scope, cost, and selection of project components.

Caltrans project deliverables that require a DPGR as supporting document are the PID, EIR/EIS, and the PSR/PR.

The main function of a PGDR is to present evaluation of project alternatives under consideration for project scoping and cost estimating, and geotechnical design considerations.

A PGDR typically provides geotechnical input for:

- Evaluation of geologic hazards, existing site conditions, seismicity, geotechnical options and feasibility study
- Assessment of emergency repair needs for landslide, rockfall, and scour
- Preliminary geotechnical analysis of project components

The expected objective, scope, and content of each DPGR and PGDR depend on the nature of each project. Adapt the scope and content of DPGR and PGDR to the specific needs of the project.

Cover the following subjects in the DPGR and PGDR. When a partial or complete geotechnical investigation has been performed, include applicable sections of the GDR in the DPGR and PGDR.

1 INTRODUCTION

Include a concise introduction of the project and its location on the State Highway System. State the type and purpose of the report. Refer to the request or contract received for the preparation of the report. Provide additional information relevant to the background of the project.

1.1 Project Description

Provide a brief description of the project based on information supplied in the Project Report. Include Project Datum reference, and a Vicinity Map showing the project site locations.

Describe the components of the project that require geotechnical information and recommendations. Maps, drawings, or plans are effective in showing the locations and alignments of the project components.

Use tables to provide summary information for project components, such as: the begin and end of slope, sound wall, and ERS alignment, or the location of the culvert, sign post, and infiltration basin. Refer to Table 1 as an example.

Table 1 – Description of the Proposed Slope, ERS, etc.

ID No.	Slope or ERS Type	Begin	End	Length (feet)	Maximum Design Height (feet)	Notes
		Sta. or PM	Sta. or PM			

When presenting locations based on station and offset, reference the highway or project alignment, instead of individual component alignments. For project components that traverse the highway, such as culverts, reference the component alignment.

1.2 Exception to Policy

List exceptions to Departmental policies and procedures relating to the DPGR, or PGDR. Include the approved Request for Exception form(s) in the appendix.

2 GEOTECHNICAL INVESTIGATION

Summarize existing information, including as-built plans, information from previous geotechnical investigations, existing reports, published geologic reports and maps.

Describe geotechnical, geologic, and any site reconnaissance performed.

3 GEOTECHNICAL CONDITIONS

Describe site geology, surface, and geotechnical conditions that affect the geotechnical design of project components based on the results of the geotechnical investigation.

3.1 Geology

Describe project site geology and known subsurface conditions. Include:

- Description of the regional geologic settings relevant to the project
- General geology of the site relevant to the project
- Geologic hazards – landslide or slope failure, rockfall, or debris flow at the site
- Expansive, collapsible, or other unsuitable materials
- Geologic maps showing:
  - Relevant geologic features, such as faults, bedding, major joint attitudes, and folds
  - Locations of geologic cross-sections
  - Layout line of project components

3.2 Topsoil – Soil Survey Review

Describe the soil survey review performed and the assessment. Provide a list of soil survey reports and maps reviewed and the base map used, such as the maps of California Soil/Vegetation Survey, or USDA Soil Survey. When the maps describe the soils as erodible, provide the depth and lateral distribution of the erodible soil, and engineering classification.

3.3 Surface Conditions

Describe site topography, surface water and drainage conditions, significant natural features, and land use history. Describe the performance of existing cut, fill, and natural slopes. Describe soil erosion and scour, and historical maintenance issues, that may affect the proposed project components.

Identify existing and proposed above-ground structures, facilities, and utilities near each proposed project component that may affect the design and construction of the project component.

3.4 Subsurface Conditions

Summarize subsurface conditions based on information obtained from literature study, and previous and current geotechnical investigation. Identify existing and proposed underground facilities and utilities near each proposed project component that may affect the design and construction of the project component.

3.5 Groundwater

Summarize the groundwater conditions from available information. Provide a summary table of measured groundwater table elevation, following Table 2.

Table 2 – Measured Groundwater Table

Location or Borehole No.	Ground Surface Elevation (feet)	Groundwater Table or Piezometric Elevation		Date Measured	Notes
		Depth (feet)	Elevation (feet)		

Provide preliminary interpreted groundwater table elevations for design. Provide:

- Direction and gradient of groundwater, artesian conditions, and confined aquifers
- Perched water tables
- Potentially significant seasonal variations
- Observed influences on the groundwater table

- Describe features observed to infer groundwater, streams, springs, seeps, and vegetation.

3.6 Seismic Hazards

Provide preliminary seismic information.

In PGDR, include preliminary seismic hazard assessment for the entire project site and, where appropriate, to each relevant project components.

For project components with long alignment or covering a large area, divide the project component into segments based on differences in:

- site-to-source distance,
- subsurface conditions, and
- characteristic features of the project component.

Provide seismic hazard evaluation for each segment of the project component.

3.6.1 Site Seismic Parameters

- Geospatial information (latitude/longitude in decimal degrees) of representative location(s) where V_{S30} values are evaluated.
- The time-averaged shear-wave velocity (V_{S30}) for the top 30 m of the earth materials, how it was determined (e.g., CPT or SPT correlations, Seismic CPT, and geophysical methods).

Refer to *Design Acceleration Response Spectrum* module to determine V_{S30}.

3.6.2 Ground Motion Parameters

Obtain design Horizontal Peak Ground Acceleration (HPGA), mean earthquake moment magnitude (M), and mean site to fault source distance (R) based on procedures described in *Design Acceleration Response Spectrum* module. Summarize seismic design information in Table 3 below.

Table 3. Recommended Ground Motion Parameters for Geotechnical Design

Project Component ID	Site Parameters			Design Ground Motion Parameters (Return Period = 975 years)		
	Locations		Shear-Wave Velocity V_{S30}, (m/sec)	Horizontal Peak Ground Acceleration (HPGA)(1) (g)	Mean Earthquake(1) M, Moment Magnitude	Mean Site-to-Fault Source Distance(1) R, (km)
	Latitude, degrees	Longitude, degrees				
	XXX.XXXX	XXX.XXXX	XXX.X	X.XX	X.XX	XX.XX

1. Based on Caltrans web tool ARS Online (Version 3.xx)

3.6.3 Parameters for Seismic Slope Stability Analysis

- Design horizontal seismic coefficient for seismic slope stability analysis for projects components that require slope stability assessment

3.6.4 Fault Rupture

Refer to the *Fault Rupture* module.

3.6.5 Liquefaction

Refer to the *Liquefaction Evaluation* module.

3.6.6 Liquefaction-Induced Lateral Spreading

Refer to the *Liquefaction-Induced Lateral Spreading* module.

4 GEOTECHNICAL DESIGN EVALUATION

Describe the geotechnical design evaluation performed and a summary of the results. These may include:

- Feasibility and cost ranking of mitigation options for landslide, slope instability, or rockfall
- Review of geotechnical options for ERS, slopes, or sound walls
- Review of geotechnical issues for environmental or project reports

Discuss how project may affect geotechnical design considerations, such as right-of-way, traffic control, environmental constraints, allowable construction window, and constructability.

5 RECOMMENDATIONS

Provide recommendations such as:

- Scope of geotechnical monitoring, investigation, and design – for the DPGR that assist in development of the PID
- Summary of geotechnical design considerations – for the DPGR that assist the development of environmental impact reports or PSR
- Comparison of feasible options – for the PGDR that assist in type selection

6 REFERENCES

Cite references following the author-date format. Refer to *ASCE Publishing in ASCE Journals, A Guide for Authors* for details.

Examples:
Arizona Dept. of Commerce. (2005). “Community profile: Hualapai Indian Reservation.” <http://www.azcommerce/com/doclib/commune/hualapai.pdf> (Mar. 17, 2014).

Irish, J. L., and Resio, D. T. (2013). “Method for estimating future hurricane flood probabilities and associated uncertainty.” J. Waterway, Port, Coastal, Ocean Eng., 10.1061/(ASCE)WW.1943-5460.0000157, 04013015.

Karam, G. N. (1991). “Effect of fiber volume on the strength properties of short fiber reinforced cements with application to bending strength of WFRC.” Proc., 6th Technical. Conf. of the American Society for Composites, A. Smith, ed., Vol. 1, Technomics, Lancaster, PA, 548–557.

Smith, R. L., Bailey, R. A., and Ross, C. A. (1970). Geologic map of the Jemez Mountains, New Mexico, U.S. Geol. Surv. Misc. Invest. Map, I-571.

REPORT COPY LIST

Refer to *Report Distribution* in *Communication and Reporting* section of *Offices of Geotechnical Design - Quality Management Plan*.

APPENDICES

1. **Site Map and Cross-Section** – should be embedded in the report and readable. Only place large format figures in the appendices.
2. **Geologic Map and Cross-Section** – should be embedded in the report and readable, with an appropriate legend. Only place large format figures in the appendices.
3. **Subsurface Profiles** – should be embedded in the report and readable. Only place large format figures in the appendices.
4. **Photos** – photos that enhance readability should be embedded in the report. Only place supporting photos in the appendices.
5. **Calculation Package**

   For reports prepared by Caltrans, do not include calculation package in the appendix. The calculation package, both digital and scanned files, should be stored in Project Record Management System.

   For reports prepared by consultants, include the calculation package in the appendix.

   Include:

   a. The objectives of each calculation, such as time rate of settlement or bearing capacity
   b. List of all given information and assumptions used to simplify the calculation, and the source of the information
   c. Developed geotechnical models for the calculation
   d. Equations used and meaning of the terms used in the equations
   e. Copies of the curves or tables used in the calculation and their source
   f. Load and resistance factors, or factor of safety, used for each calculation
   g. For the calculation performed using computer spreadsheets – step-by-step calculation for one example to demonstrate the basis of the spreadsheet. A computer spreadsheet is not a substitute for the step-by-step calculation.
   h. Summary of the calculation results that form the basis of geotechnical recommendations, including a sketch of the design, if appropriate
6. **Exception to Policy –** Include the approved *Request for Exception* form.

GEOTECHNICAL DESIGN REPORT

Cover the following subjects in the GDR.

1 INTRODUCTION

Include a concise introduction of the project and its location on the State Highway System. State the type and purpose of the report. Refer to the request or contract received for the preparation of this report. Provide additional information that are relevant to the project.

1.1 Project Description

Provide a brief description of the project based on information supplied in the Project Report. Include Project Datum reference and a Vicinity Map showing the project location(s).

Describe the components of the project covered in the GDR. Maps, drawings, or plans are effective in showing the locations and alignments of the project components.

Use the following table as a template to provide summary information for project components, such as: the begin and end of slope, sound wall, and ERS alignment, or the location of the culvert, signpost, or infiltration basin.

Obtain from the Project Engineer permanent geospatial information of the project components, such as latitude and longitude (in degrees and accurate to 6 decimal places), or northing and easting. Enter this information into the table. For project components that traverse the highway, such as culverts, reference the component alignment, in addition to the latitude and longitude or northing and easting.

To ensure the geospatial information presented in this table is consistent with those shown on the Plans, verify the geospatial information with the Project Engineer before issuing the report.

Table 4 – Description of the Proposed Slope, ERS, etc.

ID No.	Slope or ERS	Begin		End		Length (feet)	Design Height (feet)	Notes
		Northing/Easting (Latitude/Longitude)		Northing/Easting (Latitude/Longitude)			Max.	

1.2 Exception to Policy

List exceptions to Departmental policies and procedures relating to the GDR. Include the approved Request for Exception forms in the appendix.

2 GEOTECHNICAL INVESTIGATION

Describe the geotechnical and geologic investigation performed, including literature study of available information.

2.1 Subsurface Exploration

Describe tasks performed for subsurface exploration such as trenching, boring, Standard Penetration Test (SPT), Cone Penetration Test (CPT), geophysical tests, and other in-situ tests, such as pressuremeter test. Follow the *Soil and Rock Logging, Classification and Presentation Manual* when presenting results of the subsurface exploration.

Summarize the boreholes and CPTs performed in Table 2.

Table 5. Borehole/CPT Summary List

Borehole /CPT No.	Adjacent Project Component	Northing/Easting (Latitude/Longitude)		Project Center Line Station/Offset, ft (Optional)		Ground Surface Elevation, ft	Depth, ft	Date Completed

Briefly describe the type, installation, and monitoring of in-situ instrumentation, such as slope indicator and survey monitoring points, and recorded data.

Refer to the *Geotechnical Investigations* module for Caltrans practice on subsurface exploration.

2.2 Laboratory Test

List soil and rock laboratory tests and corrosion test performed.

2.3 Geologic Mapping

Describe geologic mapping performed.

3 GEOTECHNICAL CONDITIONS

Provide geotechnical conditions of the sites. The information provided in this section is the basis for geotechnical analyses and design.

3.1 Geology

Describe project site geology and subsurface conditions, including a general description of regional geology relevant to the project. Present information only, not how it relates to design and construction. A generalized discussion is sufficient. Include:

- Soil and rock types, geologic units, and geologic properties
- Depth to bedrock

- For rock slopes – rock structure, weathering degree, fractures intensity, bedding and joints, rock hardness and strength, and potential for seepage
- Geologic hazards – landslide, slope failure, rockfall, or debris flow
- Heaving or expansive materials
- Collapsible foundation materials
- Other unsuitable materials

Include geologic maps showing:

- Geologic structures, units, and significant features, such as faults, bedding, major joint attitudes, and folds
- Locations of geologic cross-sections
- Layout line of project components

Include geologic cross-sections that illustrate the relationship of geologic conditions to the project components.

3.2 Surface Conditions

Describe site topography, surface water and drainage conditions, significant natural features, and land use history. Describe the performance of existing cut, fill, and natural slopes. Describe soil erosion and scour, and historical maintenance issues, that may affect the proposed project components.

Identify existing and proposed above-ground structures, facilities, and utilities near each proposed project component that may affect the design and construction of the project component.

3.3 Subsurface Conditions

Summarize subsurface conditions based on information obtained from geotechnical investigation, and literature. Identify existing and proposed underground facilities and utilities near each proposed project component that may affect the design and construction of the project component.

Exercise judgment on whether a subsurface profile/cross-section is needed for a project component.

For essential project components, including cuts, fills, landslides, structures, and walls, provide interpreted longitudinal subsurface profiles/cross-sections along the layout line or perpendicular to the layout line of the project components and representative cross-sections of subsurface profiles where analysis and evaluation were performed.

Present interpreted subsurface profiles/cross-sections used in the analyses and design.

Keep the interpretive information in the profiles and cross-sections to a minimum. Delineate stratification lines with dashed lines and question marks where not reasonably

certain. Note the potential for variability in the interpreted stratification in the report, if a detailed stratification is provided.

3.4 Groundwater

Describe the groundwater conditions and describe gradient and direction of groundwater if possible.

Provide a summary of measured groundwater as in Table 3. Describe the method and equipment used, and literature study, to determine ground water table level and observe flow and seepage.

Table 6 – Measured Groundwater Table

Location or Borehole No.	Ground Surface Elevation (feet)	Groundwater Table or Piezometric Elevation		Date Measured	Notes
		Depth (feet)	Elevation (feet)		

Present interpreted groundwater table elevations for design, historical high groundwater table elevation, and whether fluctuation of the groundwater should be expected. Describe features observed to infer groundwater, streams, springs, seeps, and vegetation.

3.5 Seismic Hazards

Provide seismic hazard assessment for the entire project site and, where appropriate, to each relevant project components.

For project components with long alignment or covering a large area, divide the project component into segments based on differences in:

- site-to-source distance,
- subsurface conditions, and
- characteristic features of the project component.

Provide seismic hazard evaluation for each segment of the project component.

3.5.1 Site Seismic Parameters

- Geospatial information (latitude/longitude in decimal degrees) of representative location(s) where V_{S30} values are evaluated.
- The time-averaged shear-wave velocity (V_{S30}) for the top 30 m of the earth materials, how it was determined (e.g., CPT or SPT correlations, Seismic CPT, and geophysical methods). Refer to the *Design Acceleration Response Spectrum* module for how to determine V_{S30}.

3.5.2 Ground Motion Parameters

Obtain design Horizontal Peak Ground Acceleration (HPGA), mean earthquake moment magnitude (M), and mean site to fault source distance (R) based on procedures described in the *Design Acceleration Response Spectrum* module. Summarize seismic design information in Table 4 below.

Table 7. Recommended Ground Motion Parameters for Geotechnical Design

Project Component ID	Site Parameters			Design Ground Motion Parameters (Return Period = 975 years)		
	Locations		Shear-Wave Velocity V_{S30}, m/sec	Horizontal Peak Ground Acceleration (HPGA) (1), g	Mean Earthquake (1) M, Moment Magnitude	Mean Site-to-Fault Source Distance (1) R, km
	Latitude, degrees	Longitude, degrees				
	XXX.XXXX	XXX.XXXX	XXX.X	X.XX	X.XX	XX.XX

1. Based on Caltrans web tool ARS Online (Version 3.xx)

3.5.3 Parameters for Seismic Slope Stability Analysis

Design horizontal seismic coefficient for seismic slope stability analysis for projects components require slope stability assessment

3.5.4 Fault Rupture

Refer to the *Fault Rupture* module.

3.5.5 Liquefaction

Refer to the *Liquefaction Evaluation* module.

3.5.6 Liquefaction-Induced Lateral Spreading

Refer to the *Liquefaction-Induced Lateral Spreading* module.

4 Analyses and Design

Document the analyses and design performed. For a project includes multiple project components, organize this section based on project components, instead of types of analyses, is recommended for clarity.

4.1 Project Design Information

Document and date project design information provided by other design team members, and design decisions made by the project design team that set the criteria and parameters for geotechnical design. These may include:

- Maximum allowable total and differential settlement, and lateral displacement
- Existing foundation
- Underground utilities

- Available construction easement and access
- Environmental constraints, such as construction noise and vibration restrictions
- Allowed construction season
- Allowed traffic control schedule

These criteria and parameters can affect the selection of component types and construction methods or require special analysis methods or design steps.

4.2 Soil/Rock Engineering Properties

Provide a summary table of the engineering properties that corresponds to the soil/rock layers shown in the interpreted subsurface profiles (Section 3.3), such as:

- Soil shear strength, unit weight, and compressibility
- Rock shear and compressive strengths, modulus, composition, weathering, bedding, and degree of fracturing

Table 5 shows an example of the presentation of essential interpreted soil engineering properties.

Table 8 – Soil Engineering Properties

Layer No.	Depth of the Top of Layer, feet	General Soil Description	SPT N Value	Interpreted Soil Engineering Properties		
				Unit Weight (g), pcf	Apparent Cohesion (*C*), psf	Apparent Friction Angle (ϕ), degrees

For engineering properties interpreted from laboratory tests, include the analysis of the test results and how those test results apply to the specific site conditions. For engineering properties and profiles correlated and interpreted from in-situ testing data, such as those obtained using SPT or CPT, include the correlation formula used. For engineering properties derived from back-analysis based on measured data or observed evidences, include the analyses and assumptions used.

Include information, data, and deliberation that substantiate the interpreted soil/rock engineering parameters.

4.3 Geotechnical Model and Analyses

Discuss the geotechnical model used for analysis and design. Include:

- The design element, such as a wall, footing, or slope, located in context to the original and finish grades
- Subsurface profiles derived from the information presented in Section 3.3 *Subsurface Condition*
- External loads

For slope stability or numerical analysis, the computer-generated output cross-section with soil/rock engineering properties used for the analysis, may be substituted as the geotechnical model.

Include relevant plans and cross-sections used for the geotechnical models in the appendix.

Present the geotechnical analysis and design performed. Include analysis methods used, assumptions made, calculation steps, and a summary of results. These may include:

- Immediate and time-dependent settlement, displacement, and deformation analyses
- Bearing capacity calculation
- Slope stability analyses – analysis approach, assessment of failure mechanisms, and back-analyses performed
- Analyses performed to determine soil strength properties and geotechnical nominal resistances
- For Standard-Plan ERS, verification of the geotechnical site conditions and interpreted soil engineering properties that meet or exceed those assumed and shown in the Standard Plans
- Evaluation of seismic hazards and seismic design parameters
- Evaluation of corrosivity of the sites that need corrosivity evaluation – include corrosion test results in the Appendix.

5 RECOMMENDATIONS

To ensure completeness of the recommendations, refer to corresponding modules in the Geotechnical Manual, and FHWA manuals and the Checklist. Also, consult with the project team members for their needs of geotechnical information and recommendations.

5.1 Embankment

(Refer to the Geotechnical Manual)

5.2 Slope Stabilization and Landslide Mitigation

(Refer to the Geotechnical Manual)

5.3 Erosion Control and Scour Mitigation

- Recommendations for geotechnical erosion protection measures, such as erosion control mats or blankets, flattening the slope, geosynthetics reinforced slope surface, and diverting surface water
- Recommendations for slope protection measures, such as riprap, gabion baskets, geosynthetics wrapped slope

Refer to *Caltrans Erosion Control Toolbox* provided by Caltrans Landscape Architect Design for erosion control measures that are not directly based on geotechnical methods.

5.4 Rockfall Hazard Mitigation

(Refer to the Geotechnical Manual)

5.5 Excavated Slope

(Refer to the Geotechnical Manual)

5.6 Reinforced Soil Slope

- Elevation view of the slope that shows layout of geosynthetic reinforcements, embedment lengths, elevations, and beginning and ending stations
- Cross-section view of the slope that shows surficial stability reinforcements, geotechnical erosion control details, and subdrain details
- List of geosynthetic reinforcements, with corresponding Long-Term Strength (LTS)
- Required engineering properties of backfill material

5.7 Standard Plan Earth Retaining System

(Refer to the Geotechnical Manual)

5.8 Sound Walls

(Refer to the Geotechnical Manual)

5.9 Ground Improvement

(Refer to the Geotechnical Manual)

5.10 Trenchless Method for Culvert Installation

(Refer to the Geotechnical Manual)

5.11 Best Management Practices for Stormwater and Leach Fields

Obtain from Project Engineer the locations and depths that need percolation test. Provide:

- Recommendations for the design of Best Management Practices (BMPs) for stormwater
- Summary and discussion of percolation tests in the following table format
- Summary and discussion of fines content tests at trench invert in the following table format

Table 9 – Summary of Percolation Tests

Basin No.	Borehole No.	Percolation Rate, minutes/inch (CTM 749 or 750)	Soil at Test Depth

Table 10 – Fines Content at Trench Invert

Trench No.	Clay Content, %	Combined Fines Content, %

5.12 Sign and Light Post Foundations

(Refer to the Geotechnical Manual)

5.13 Source Material Site Evaluation

- Summary of locations of the source material, gradation, and compaction tests
- Acceptability of the source materials

5.14 Instrumentation and Monitoring

- The needs for long-term instrumentation monitoring or construction performance evaluation
- List and layout of instruments, monitoring schedule, and data format – electronic or hard copy
- Methods of evaluation, threshold values for action, and responsible parties

6 NOTES FOR SPECIFICATIONS

Refer to the *Geotechnical Notes for Specifications* module.

7 REFERENCES

Cite references following the author-date format. Refer to *ASCE Publishing in ASCE Journals, A Guide for Authors* for details.

Examples:

Arizona Dept. of Commerce. (2005). "Community profile: Hualapai Indian Reservation." <http://www.azcommerce/com/doclib/commune/hualapai.pdf> (Mar. 17, 2014).

Irish, J. L., and Resio, D. T. (2013). "Method for estimating future hurricane flood probabilities and associated uncertainty." J. Waterway, Port, Coastal, Ocean Eng., 10.1061/(ASCE)WW.1943-5460.0000157, 04013015.

Karam, G. N. (1991). "Effect of fiber volume on the strength properties of short fiber reinforced cements with application to bending strength of WFRC." Proc., 6th Technical. Conf. of the American Society for Composites, A. Smith, ed., Vol. 1, Technomics, Lancaster, PA, 548–557.

Smith, R. L., Bailey, R. A., and Ross, C. A. (1970). Geologic map of the Jemez Mountains, New Mexico, U.S. Geol. Surv. Misc. Invest. Map, I-571.

REPORT COPY LIST

Refer to *Report Distribution* in *Communication and Reporting* section of *Offices of Geotechnical Design - Quality Management Plan*.

APPENDICES

1. **Site Map and Cross-Section** – should be embedded in the report and readable. Only place large format figures in the appendices.
2. **Geologic Map and Cross-Section** – should be embedded in the report and readable, with an appropriate legend. Only place large format figures in the appendices.
3. **Subsurface Profiles** – should be embedded in the report and readable. Only place large format figures in the appendices.
4. **Borehole Location Map** (with approximate borehole locations) – should be embedded in the report. Only place large format figures in the appendices. Overlaying borehole locations and project component alignments on Google Earth image or a map with relevant topographic features is recommended.
5. **Boring Records** – Generate Boring Records using current Data Interchange for Geotechnical and Geoenvironmental Specialists (DIGGS) schemas and data dictionaries (ex. gINT) is recommended.
6. **Digital Photos of Rock Cores** – In addition to presenting the digital photos of rock cores in the appendices, the digital photo files should also be archived in Caltrans archive (GeoDOG).
7. **Laboratory Test Data** (including Corrosion Test Report) – In addition to the laboratory test results, summarize and provide the summary tables and graphs of the interpretation of laboratory test results. Note unreliable data. Note: Digital files should be archived in Caltrans archive.
8. **Geophysical Test Data** – digital files should be archived in Caltrans archive.
9. **In-Situ Test Data** –digital files should be archived in Caltrans archive.
10. **Photos** – photos that enhance readability should be embedded in the report. Only place supporting photos in the appendices.
11. **Calculation Package**

    For reports prepared by Caltrans, do not include calculation package in the appendix. The calculation package, both digital and scanned files, should be stored in Project Record Management System.

    For geotechnical design performed by consultants, include calculation package in the appendix.

    Include:

    a. The objectives of each calculation, such as time rate of settlement or bearing capacity
    b. List and descriptions of all given information and assumptions used to simplify the calculation, and the source of the information

c. The developed geotechnical model (Section 4.2 Geotechnical Model and Analyses) for each calculation
d. Equations used and meaning of the terms used in the equations
e. Copies of the curves or tables used in the calculation and their source or reference.
f. Load and resistance factors, or factor of safety, used for the design
g. If the calculation is performed using computer spreadsheets – step-by-step calculation for one example to demonstrate the basis of the spreadsheet. A computer spreadsheet is not a substitute for the step-by-step calculation.
h. Summary of the calculation results that form the basis of geotechnical recommendations, including a sketch of the design, if appropriate.

12. **Exception to Policy –** Include the approved *Request for Exception* form.