Chapter 2 - Quality Control & Quality Assurance

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2.1 General

The Oregon Department of Transportation recognizes that its success will be determined, in part, by the quality of services and products that it provides for its customers. Assuring quality requires not only a commitment but also a consistent systematic approach that can be documented. The ODOT geotechnical quality control program endeavors to go beyond the review of work products to result in a continuous improvement of the processes and products associated with geotechnical services.

The ultimate goal of quality control is to achieve an overall quality of work in all endeavors that meets or exceeds the goals of the agency. Within that context, the intent of implementing this quality control program includes the following:

- To emphasize the importance of quality in achieving the goals of the Agency. In particular, to emphasize communication, collaboration, and care in completing geologic and geotechnical engineering work. This is consistent with the values enunciated in ODOT's Mission Statement, **"EXCELLENCE: We use our skills and expertise to continuously strive to be more efficient, effective and innovative."**
- To assist in leveraging the highest levels of experience and technical expertise available, with respect to all projects, not just those that are large or complicated.
- To assure and document compliance of Geotechnical Reporting Documents (GRDs) with design codes, standards of practice, legal requirements and organizational policy.
- To allow for an analysis of the strengths and weaknesses of completed projects in order to develop a process of continual improvement.
- To develop skills and support to individual project designers. Collaborating with other experienced individuals helps the Professional of Record be more confident in their work and results.
- To provide mentoring for designers to develop experience and expand their abilities. Often, the best training comes from working on a project with a reviewer who has more experience. Similarly, experienced staff often learns from recent graduates and young staff that have been exposed to recent advances in the profession through their educational experience and offer a fresh perspective..
- To identify and address mistakes, oversights and logic errors and to compensate for inexperience. All people can and do make mistakes despite their knowledge, experience, or level of effort. A collaborative approach to work and the involvement of independent reviewers will nearly always result in the elimination of mistakes or errors of logic that would not be identified by a single dedicated individual.

The Quality Control (QC) process is not intended to relieve Professionals of Record (POR) from responsibility for their work products but rather to critically review with a fresh perspective and identify fatal flaws. Ultimately, the POR is responsible for self-checking their work and maintaining compliance with applicable manuals, standards of practice, errors, and omissions.

This manual uses the term Geotechnical Reporting Documents (GRD) which is derived from the FHWA document, "Assuring Quality in Geotechnical Reporting Documents" to describe the range of deliverables associated with geotechnical work (Sheahan et al., 2016). The FHWA report describes GRDs as "Documents used to communicate geotechnical site conditions, design and construction recommendations to the engineers designing project elements including bridges, roadways, drainage, etc., and construction engineers, and the contractors bidding the work." These documents take many forms, including: Geotechnical Data Reports, Geotechnical Engineering Reports, Geotechnical Baseline Reports, and Geotechnical Design Memos, emails, among others."

2.1.1 Consultant Work Products

When GRDs are developed by Consultants for ODOT projects, those documents will be completed under the requirements of this chapter or under a Consultant-specific quality control plan, reviewed and approved by ODOT, which meets or exceeds the requirements of this chapter. The responsibility for QC rests with the Consultant. ODOT responsibilities with respect to Consultant work consist of Quality Assurance (QA). A QA review is not intended to replace the QC responsibilities of the Consultant. Work products that contain demonstrable errors at the time of submission to ODOT will not only need correction but are indicative of a failure in the Consultant's QC processes and may require deeper, programmatic review and action.

2.2 Geotechnical Quality Standards

A variety of guidance documents exist with respect to geotechnical work completed by and for ODOT. The predominate standard is the ODOT Geotechnical Design Manual which takes precedent over codes such as the *AASHTO LRFD Bridge Design Specifications* (A.A.S.H.T.O., 2020), and various FHWA design manuals.

> "The ODOT Project Delivery QA/QC Program website provides an overview of the ODOT Project Delivery QA/QC Program, access to the quality standards of practice. The Project Delivery Statewide Quality Management Program Manual can be found there, as well as a listing of the quality plans and guidance documents, including the region Technical Center quality plans, the technical discipline quality plans, and the transportation project management statewide quality plan. There is also a listing of the associated quality forms and checklists." (ODOT Discipline Quality Template).

2.3 Roles and Responsibilities

The roles and responsibilities for implementing geotechnical quality control throughout the project design and construction are described in this section. Each project team shall consist of four professionals; two Geotechnical Engineers one designated as the POR, and one as the designated reviewer, two Engineering Geologists one designated as the POR, and one as the designated reviewer.

A variety of engineers and geologists as well as technicians and office staff will be involved in the development of GRDs. However, the responsibility for those documents rests, by law (OAR

820-005-0075, 2022), with professionals licensed in the fields of Engineering Geology and Engineering. The Professionals of Record (Engineering Geologists and Geotechnical Engineers) are responsible for acting within their own level of competence and knowledge (OAR 820-020-0020). A professional working outside of their competence is potentially endangering the public and is violating State law (OAR 820-020-0020).

For each project, the QC team shall consist of at least four individuals, the Engineering Geology and Geotechnical Engineering Professionals of Record as well as the Engineering Geology and Geotechnical Engineering Reviewers. The nature and responsibility of each is described below.

Engineering Geologist Professional of Record (Engineering Geologist POR). The Engineering Geologist POR on ODOT projects shall be the person in responsible charge for geologic interpretations and decisions made on the project. They will be registered as a Certified Engineering Geologist with the State of Oregon.

Geotechnical Engineer Professional of Record (Geotechnical Engineer POR). The Geotechnical Engineer POR on ODOT projects shall be the person in responsible charge for geotechnical decisions made on the project. They will be registered as a Professional Engineer with the State of Oregon and will be especially qualified in Geotechnical Engineering.

Engineering Geology Reviewer. The Engineering Geology Reviewer will provide primary technical review for geologic aspects of the project. They will be registered as a Certified Engineering Geologist with the State of Oregon.

Geotechnical Engineering Reviewer. The Geotechnical Engineering Reviewer will provide primary technical review for all Geotechnical Engineering aspects of the project. They will be registered with the State of Oregon as a Professional Engineer and will be especially qualified in Geotechnical Engineering.

ODOT Geology/Geotechnical Supervisor. Each ODOT region has a supervisor who has direct personnel responsibility over the Geologists and Engineers that work within the Geology/Geotechnical section of that region. Where such individuals are not geo-professionals, they may make use of a lead worker who has the expertise and assists in addressing technical issues.

ODOT Region Management. The management team of each ODOT region is ultimately responsible for the management of staff and resources within the region.

ODOT Headquarters Staff. Senior Geologists and Engineers are located in the ODOT Technical Services Center in Salem. Those professionals are responsible for standards and policies, including the development of this manual, for geotechnical work throughout ODOT as well as for agency wide QA reviews.

2.4 Geotechnical Process

The process described by this section defines the minimum level of communication and collaboration necessary to meet the requirements of the ODOT Geotechnical QC plan. Members of the project team are encouraged to freely communicate throughout the life of the project in

order to assure a high level of service and quality and reduce significant amounts of rework, errors, or omissions.

2.4.1 Quality Control Reviews

Quality control reviews are undertaken to assist the POR in developing documents that are free of errors and mistaken assumptions. The reviews are also intended to assure consistency of the documents with applicable standards and guidance and consistency between calculation results and recommendations. Lastly, quality reviews should verify that previous QC review comments have been understood and addressed.

For expediency and consistency, the review of GRDs is assisted by a variety standard templates and checklists. The development and implementation of these templates and checklists is intended to assist designers and reviewers in completing their mission and to provide reminders of applicable guidance and standards. It is important to note that the use of these tools is not intended to replace sound professional judgement nor to relieve the POR from their personal responsibilities.

2.4.2 Reviewer Authority

Reviewer Authority Most often, the Reviewer and POR will address recommendations and changes in a collaborative manner and create a work product that satisfies both parties. However, situations will arise where that is not tenable. For those cases, guidance is needed to address the authority of Reviewers to require changes in the work products or tasks. The relationship between a reviewer and the licensed professional in responsible charge is also a part of that discussion.

- ODOT has the right, responsibility, and authority to establish the procedures, policies, codes, standards of practice and level of quality under which work products and tasks will be conducted. The only limitation is that practice standards should be no less than the standard of care in the industry.
- All workers, especially licensed professionals, have a duty to complete assigned work in a manner that meets the policies and procedures of their employer. Licensed professionals also have a duty to always protect the safety of the public and to practice within their level of competence and according to the standard of care in the industry. There is no conflict between these duties unless an employer tries to require a licensed professional to do something that exceeds their professional competence and/or endangers the public.
- Recommended changes to the work will generally fall into three categories, those that represent different ways to analyze or view the work that are suggested or advisory, those that represent serious differences of opinion but do not violate the Standard of Care or impact the safety of the public, and those that do violate the Standard of Care or impact the safety of the public.
- Compromise and open-minded communication is crucial. Further, it is the POR's first duty to try and solve the matter with the reviewer. The reviewer should make every possible effort to explain their position to the POR and listen to feedback. Failing

resolution between the parties, the resolution will vary depending on the nature of the dispute.

- For changes requested by the Reviewer that would fall into the first category and would be considered suggestions and feedback, the POR should respond to the reviewer but does not need to document their choice to not incorporate the suggested changes.
- For the second category, serious differences, not violating the Standard of Care or impacting the safety of the public, the POR should respond to each item individually and document why they are not implementing the recommendation. It may be necessary for the reviewer to permanently document their dissent from the decision made.
- For differences that either party (POR or Reviewer) considers to violate the Standard of Care or impact safety of the public and that cannot be resolved, the POR shall work with the Unit Manager and subsequently the Technical Center Manager prior to seeking other ways of resolving the problem.
- Reviewers cannot require licensed professionals to change work in a way that would endanger the public or violate the Standard of Care.
- Licensed professionals will still be expected to seal work products and accept technical responsibility for projects to which mandatory changes have been made by reviewers. Only if the changes jeopardize the safety of the public or violate the Standard of Care would the licensed professional have an argument for not being responsible for sealing the work.

Disputes. Differences in engineering opinion exist and it is likely that Reviewers and PORs will find areas of disagreement. On first identifying areas of disagreement, it is incumbent upon the parties to discuss the issue and attempt to come to a solution that is satisfactory to both parties. When an impasse has been reached, the issue will be reviewed by Headquarters geotechnical staff that will be made available to both parties. Ultimately, it may be necessary for one of the parties to recuse themselves from the project.

2.5 Glossary

Quality Control. - Quality Control consists of the daily processes, practices, and checks in place to control the quality of the engineering works as they are being developed.

Quality Assurance. - Quality Assurance is a program undertaken to assure developed work products were completed and documented in accordance with established Quality Control requirements.

Geotechnical Reporting Documents. - Geotechnical Reporting Documents (GRDs), as defined by the FHWA, are documents used to communicate geotechnical site conditions, design and construction recommendations to the engineers designing project elements including bridges, roadways, drainage, etc., construction engineers, and the contractors bidding the work (Sheahan et al., 2016).

Geotechnical Design Manual. - The Geotechnical Design Manual (GDM), of which this chapter is a part, establishes standard policies and procedures regarding geotechnical work performed for ODOT. The purpose of the GDM is to establish investigation and design standards with the

goal of optimizing design, minimizing over-conservatism as well as under-design. All state of Oregon projects are required to meet the design standards in the GDM.

Responsible Charge. - To be in Responsible Charge of work, the Geotechnical Engineer or Engineering Geologist shall have supervision and control over the work from the inception and will be responsible for engineering or geologic decisions, respectively. Supervision and control means establishing the nature of, directing and guiding the preparation of, and approving the work product and accepting responsibility for the work product. This includes; spending time directly supervising the work to assure that the person working under the licensee is familiar with the significant details of the work; providing oversight, inspection, observation and direction regarding the work being performed; providing adequate training for persons rendering services and working on projects under the licensee; maintaining readily accessible contact with the person providing services or performing work by direct proximity or by frequent communication about the services provided or the work performed; and applying the licensee's seal and signature to a document (OAR 820-005-0075, 2022).

Professional of Record. - The Professional of Record (POR) is the Engineering Geologist or Geotechnical Engineer in responsible charge of geology or engineering work for a project.

Engineering Geologist. - A professional Geologist holding current Certified Engineering Geologist registration with the Oregon State Board of Geologist Examiners (OSBGE) (ORS 672.505, 2021).

Geotechnical Engineer. - A professional Engineer registered as a Professional Engineer with the Oregon State Board of Examiners for Engineering and Land Surveying (OSBEELS), especially qualified in Geotechnical Engineering (ORS 672.002, OAR 820-040-0040).

2.6 Geotechnical Documentation

> "As project QC work is done, quality records are created that provide reviewable evidence documenting that quality work was done. These quality records also provide the basis for QA reviews and/or audits (performed by professional auditors)" (ODOT Discipline Quality Template).

Documentation of the quality control process is necessary to allow for assurance that the QC process was completed per the requirements, and to allow for the subsequent completion of QA. Feedback with respect to the ability of this plan to meet the needs of the Agency can only be received if the process is documented.

Documentation needs to be synchronized with the work being completed and must not be postponed to the end of the project. Each stage of documentation should be completed and saved in ProjectWise to assure that the QC process was completed in a timely manner and was being implemented throughout the project life rather than hastily assembled at close-out.

Table 2-1 lists all the documents required for review by the QC team, the basis for the document, and what type of endorsement with date is necessary. As previously discussed, the official project file including all the documents listed in Table 2-1, are saved in the ProjectWise project folder. Much of the review documentation is completed with the Geotechnical

Engineering and Engineering Geology Quality Control, ODOT forms 734-5199 and 734-5200, respectively.

The reviewer signing the work product will be one who conducted the review to identify mistakes, oversights or logic errors. The reviewer does not stamp the work unless he or she was in responsible charge of some discrete portion of the project. A reviewer in responsible charge of the work would sign as a co-author and not as a reviewer.

All other reviewed work products or tasks will be documented in the project file. A separate sheet attached to the file will list the items for review and provide for recording an initial and a date from the reviewer indicating that the review has been accomplished.

Reviewer's comments and notes should be in writing to the greatest extent possible to promote good communication, provide documentation, and minimize misunderstandings. However, to the maximum extent possible, all reviews should be presented verbally to the PORs. This maintains the congenial and professional relationships that helps to ease whatever technical disagreements that may arise. The reviewer's comments are retained in ProjectWise.

Electronic file saving allows for significant time and effort savings with respect to documentation. ODOT will rely heavily on ProjectWise to document the QC process. The POR is responsible for verifying that all required QC documentation is stored in appropriate locations in ProjectWise.

> "Quality records in ProjectWise are stored in their regular discipline or milestone directory, with either "QC" or "QA" in the document title or description, to facilitate searches for quality documentation. A set of quality files from each discipline or milestone folder in ProjectWise will be created in the ProjectWise "7_quality" folder. The set naming convention will use the discipline code (TD) as follows:
>
> *TD*_K#####_##" (ODOT Discipline Quality Template).

Table 2-1 Geotechnical Deliverables Documentation Quality Control Requirements

Phase	Document	Basis of Requirement	Document	Endorsement
Scoping	Scoping Notes	Project Delivery Guidance	Scoping Notes	Initial and date
Kickoff	Geologic and Geotechnical Scope of Work	Project Delivery Guidance	734-5199 & 734-5200,	Name & date
DAP	Initial Site Visit & Reconnaissance Memo	GDM	734-5200	Name & date, Name & date
	Exploration Program/Plan	GDM	734-5199 & 734-5200,	Name & date Name & date
	Laboratory Program/Plan	GDM	734-5199 & 734-5200	Name & date Name & date

Phase	Document	Basis of Requirement	Document	Endorsement
	Field Explorations and Draft Logs	GDM	gINT Template	Initial and date
	Final Geologic Models	GDM	734-5200	Name & date
	95% Geology Report	GDM	734-5200	Name & date
	95% Geotechnical Data Sheets	GDM	734-5200	Name & date
	Analysis/Design	GDM	Calc Book	Initial and date
	Material Source/Disposal Site Concepts	GDM	734-5200	Name & date
	Geotechnical Memo	GDM	734-5199	Name & date
	Design Deviation Request	GDM	734-5199, 734-5200	Name & date, Name & date
	Draft DAP Plans and Estimates	Project Delivery Guidance	Plans, Estimates	Initial and date
	Final DAP Plans and Estimates	GDM	Plans, Estimates	Initial and date
Preliminary	Geotechnical Report	GDM	Geotechnical Report, 734-5199, 734-5200	Signature & date, Name & date, Name & date
	Final Geotechnical Data Sheets	GDM	Final GDS, 734-5200	Name & date, Name & date
	Preliminary Material Source/Disposal Site Plans and Estimates	GDM	734-5200	Name & date
	Preliminary Geotechnical Plans and Estimates	Project Delivery Guidance	Plans, Estimates	Initial and date
Advanced Plans	Geotechnical Report	GDM	Geotechnical Report, 734-5199, 734-5200	Initial and date,
	Advanced Geotechnical Plans and Estimates	Project Delivery Guidance	734-5199, 734-5200	Name & date, Name & date
	Advanced Special Provisions	Project Delivery Guidance	734-5199, 734-5200	Name & date, Name & date
	Advanced Material Source/Disposal Site Plans	GDM	Plans, 734-5199	Name & date, Name & date

Phase	Document	Basis of Requirement	Document	Endorsement
Final Plans	Geotechnical Report Addenda	GDM	Addenda	Initial and date
	Final Geotechnical Plans and Estimates	Project Delivery Guidance	Plans, Estimate,	Initial and date
	Final Special Provisions	Project Delivery Guidance	Special Provisions	Initial and date
PS&E	Geotechnical Reporting Documents Addenda	GDM	Addenda, 734-5199, 734-5200	Initial and date,
Construction	Significant Project Changes	GDM	Plans, special provisions	Initial and date

Regardless of the documentation type, each deliverable will be stored in ProjectWise with electronically signed documentation confirming that a thorough QC review has been completed at the time of production. Each electronic signature or initial should be considered a valid secure signature with no errors. The electronic signatures will include at least the name and date the document was signed. A hard copy with wet signature may be used to provide additional information, but at least an electronic document with electronic signature should be included in the project file in order to track timelines.

In the event of a minor or moderate technical disagreement between reviewer and designer, the parties may select to write a short justification and include with the electronic documentation. If there is a major technical disagreement, the issue should be elevated to appropriate staff consistent with the previously stated policies. Stylistic differences do not need to be officially documented.

To the extent reasonable, unsealed drafts of professional deliverables should be retained within the ProjectWise project file. Electronic version control should be in accordance with file naming convention detailed elsewhere in this manual. Drafts should be retained in the ProjectWise project file.

2.7 Project Phases

The ODOT project delivery process, as it relates to geotechnical services, is detailed in a timeline/swimlane table included as Appendix A of this chapter. The timeline shows the interrelationships of the responsible parties as well as the typical deadlines for deliverables.

For clarity, the ODOT project delivery process has been broken down into a series of milestones or phases. The following sections detail the nature of each deliverable as well as the assumed process associated with production.

2.7.1 Scoping Notes

Scoping is completed in order to identify which projects will be programmed into a future STIP. At scoping, subject matter experts (including Engineering Geologists and/or Geotechnical Engineers) review the business case (purpose & need) for a proposed project, as provided by the Program Manager, and identify the project elements required to meet the purpose & need, and draft "scoping level" estimates. This review frequently includes a site visit. Scoping teams draft scoping notes outlining project elements and risks by discipline. Scoping teams also provide cost estimates to establish the budget required to deliver the complete project. These estimates have a large contingency and are typically based on average historic bid item prices.

Geo-professionals, Engineering Geologists and Geotechnical Engineers, should participate in all scoping efforts. If a project is determined to have no Geologic or Geotechnical elements based on the existing business case, then the geo-professional should document this in the scoping notes (and the scoping notes will be short). It should be the responsibility of the geo-professional to assess the project and determine whether there are Geologic or Geotechnical elements, rather than the Program Manager or Project Leader.

The geo-professional assigned by the Region to assist in scoping will produce Scoping Notes and a Scoping Estimate. The notes need to clearly outline known Geologic and Geotechnical elements (retaining walls, bridge foundations, rockfall mitigation) and risks associated with unknowns (mitigating liquefaction, need for sound walls, foundation type based on soil conditions), as well as proposed methods for reducing risk during the project. The Scoping Estimate includes a cost estimate for design and a summary of resource needs.

2.7.2 Initial Site Visit/Reconnaissance Memo

The purpose of the initial site visit is to observe existing conditions of the site, evaluate performance of existing slopes/structures, identify errors or omissions in existing data (survey, layout, etc.), locate utilities, strategize logistics for exploration and note any discrepancies with the scope.

A site visit by the Professionals of Record is essential. However, the Reviewers should also attend the site visit to concur with the POR's observations and provide a second set of eyes which may observe different conditions or identify issues that the POR does not observe.

After the completion of the initial site visit, the Engineering Geology or Geotechnical Engineering POR should create a written summary with applicable sketches and photographs. This document does not need to be a formal memo but needs to be complete with respect to what was observed in the field and may be incorporated into the Exploration Plan. The initial site visit summary should be reviewed by the project Engineering Geology and Geotechnical Engineering Reviewers.

2.7.3 Exploration Program/Plan

The Exploration Plan is intended to document the agreed upon strategies for geotechnical exploration at any phase of a project between the Engineering Geologist POR, and the

Geotechnical Engineer POR. The Exploration Plan is created prior to field exploration taking place, and should be a communication tool for the field staff, drillers, the Project Leader, and managers involved in resourcing, scheduling, and financing the exploration. The Exploration Plan must be flexible, as changes are very likely to occur (and even encouraged) during the course of field explorations when actual field data is obtained. Additionally, the assumptions made during creation of the Exploration Plan may change, and the PORs may determine that more or less may be needed from the field exploration. Good communications between the field personnel and the PORs is key while explorations are conducted.

Guidance on the development of the exploration plan is included in Chapter 4 of this manual, including a template for use on ODOT projects. As a minimum, the Exploration Plan should contain a listing of the proposed number and type of explorations tabulated along with estimated sampling and footage of drilling types (Auger, Core, etc.), as well as the proposed instrumentation types and depths of installation. Exploration plans should have included a site map with the features to be explored along with the holes superimposed on that location.

Responsibilities. Perhaps more than any other element of a geotechnical project, the development of the exploration plan requires the collaborative involvement of Geologists and Engineers. For that reason, the typical roles of the project geo-professionals are described below.

The Engineering Geologist POR is ultimately responsible for the characterizing the geologic conditions pertinent to the project at the site. They are therefore responsible for directing the field exploration to obtain geologic data and engineering data needed to complete that characterization and to allow for the project design. Therefore, the Engineering Geologist POR is the owner of the Exploration Plan, and will typically be the one to direct changes to the Exploration Plan while field work is occurring.

The Geotechnical Engineer POR is responsible for anticipating needs for analysis and design prior to field explorations, and clearly communicating the requirements for field data to the Engineering Geologist. The Geotechnical Engineer will typically provide information that helps determine the location, depth and spacing of drill holes as well as the specific needs for field samples, testing, groundwater, and any monitoring requirements for long term studies. It is therefore critical that the geotechnical engineer be fully engaged in development of the Exploration Plan, and has confidence that the field explorations will provide the required data. During the course of field explorations, the geotechnical engineer will remain fully engaged to ensure that assumptions made during creation of the Exploration Plan are correct. If it becomes apparent that changes to the Exploration Plan may be needed, then requested changes are communicated to the engineering geologist.

The Engineering Geologist Reviewer is responsible for understanding the goals of the project and the requirements from the geotechnical engineer POR. The Exploration Plan is then reviewed to see if it is likely to deliver the requirements to characterize the geologic conditions for the project. The Engineering Geologist reviewer typically discusses the Exploration Plan with the Engineering Geologist POR in order to gain good understanding of the goals and objectives of the Exploration Plan, then documents the review.

The Geotechnical Engineer Reviewer is responsible for understanding the goals of the project and the data requirements from the geotechnical engineer POR. The Geotechnical Engineer reviewer typically reviews the data requirements with the Geotechnical Engineer POR to help ensure that the data requirements are complete and sufficient. The Exploration Plan is then reviewed to see if it is likely to deliver the data required for analysis and design. That review is also documented.

2.7.4 Laboratory Program/Plan And Sample Selection

The Geologist and Engineer PORs should jointly determine the laboratory tests needed for the project elements as exploration proceeds. Samples should be submitted for testing as soon as possible after retrieval from the field so that any unusual results can be further evaluated by submittal of additional samples, and to avoid a backlog of work at the lab.

Guidance on the development of the Laboratory Plan is included in Chapter 3 of this manual, including a template for use on ODOT projects.

Classification and logging of soil and rock is addressed by Chapter 5 of this manual and the ODOT Soil and Rock Classification Manual. In completing the initial soil classification, a check-classifier is assigned to the project to provide verification of the initial classification. The Check-Classifier must be a geologist or engineer familiar with the project and trained in soil classification.

The typical process for completing the laboratory plan is summarized below:

- Check-classifier assigned by Engineering Geologist POR
- Check-classifications performed
- Significant discrepancies between the Engineering Geologist POR classifications and check classifications are typically resolved by additional laboratory testing
- Geologist properly labels all containers to be sent to the lab
- Engineering Geologist and Engineer PORs develop laboratory plan
    - Determine critical areas for testing
    - Complete sample inventory
        - Verify that undisturbed samples were taken in fine-grained soils
    - Assure that critical areas have been adequately sampled
    - Verify field tests (Torvane, Pocket Penetrometer)
    - Develop testing parameters
    - Include special testing instructions on the Sample Data Form
- Engineering Geologist POR verifies that representative tests are to be performed in all of the potential engineering geologic units encountered
- Undisturbed samples are stored and shipped upright and isolated from vibrations or jarring

The Engineering Geologist POR and Geotechnical Engineer POR review the results of the laboratory testing to assure that all requested tests were completed according to their requirements and that the results are consistent with their expected material properties. Additional testing may be necessary if questionable or surprising results are obtained.

2.7.5 Field Explorations And Draft Drill Logs

The completion of field explorations and development of draft drill logs are covered in depth in Chapter 4 and Chapter 5 of this manual. Final exploration logs are one of the products of a site characterization for project design. They represent the culmination of a lengthy process that starts with the siting of exploration points and ends with an evaluation of materials in the context of the engineering geologic characteristics of the project area. The final logs are comprised of a description of the engineering geologic units encountered with or without the individual sample descriptions and classifications.

The process of drill log production takes place in three general phases. Field logging includes the collection and description of samples at the exploration site. Office evaluation, check classification, and laboratory testing is the second phase. The final phase is the incorporation of laboratory testing and correction of sample classification and description based on these results, and the subsequent modification of the unit descriptions. The unit descriptions may be further modified during creation of the subsurface model.

Field Phase. The primary roles of the field geologist or engineer consist of recording exploration activities on the standard form, collecting samples in accurately labeled receptacles, transporting samples to the office or laboratory, and description of samples according to the ODOT Soil and Rock Classification Manual. The field geologist is responsible for entering the field log into the gINT program. This is an essential QC step for the field geologist to assure that descriptions are complete, appropriately entered, and match their initial field interpretation.

Throughout the field exploration process, the relevant staff should be aware of the expense involved in mobilizing exploration equipment and therefore the need to extract the maximum value possible from each field effort. In particular, oversampling generally results in a modest additional cost while remobilizing to address gaps in sampling results in very high additional costs.

It is critical that field staff communicate preliminary results on timely basis with the PORs. The conditions encountered and samples collected should be discussed with the PORs in real time, to the extent possible. This is particularly true for situations where the conditions encountered in the field differ materially from those anticipated and discussed prior to beginning field activities.

In general, these activities are under the direction of the Engineering Geologist POR in consultation with the Geotechnical Engineer POR.

Office Laboratory Phase. The process for developing and implementing the laboratory testing program as well as check classification are discussed in the previous section of this manual.

Analysis and Finalization Phase. Once complete, the laboratory test results are entered into the gINT program for inclusion on the exploration log, where appropriate. The laboratory results are used to refine sample descriptions which then necessitate adjustments to the engineering geologic units. Typically, this would consist of simple refinements of the descriptions and classifications. Adjustments to the units themselves may be needed if the lab test results require it. As the Engineering Geologist POR compiles the logs in this iteration, the engineering

geologic units in the individual borings are complete enough to construct a preliminary or intermediate geologic model of the site. The Engineering Geologist POR should review the relationships between explorations in the model. Where necessary, adjustments to the units may take place based on stratigraphic position, material properties, or other engineering geologic considerations. Finally, the Geotechnical Engineer POR and Engineering Geologist POR review the subsurface model together to consider any final adjustments to support engineering analysis.

2.7.6 Geology Summary

The Geology Summary would typically consist of the first 12 Sections of the Geotechnical Design Report. For projects where the design team deems it prudent, the Geology Summary may be produced as a fully executed memo or report. In either case, the document will be reviewed by the Engineering Geologist Reviewer. The report should be considered "final" by the POR and Reviewer and should be ready to present to the report users for their review and comment.

The Geology Summary is prepared by, or under the direct supervision of, the Engineering Geologist POR assigned to the project. The Engineering Geologist POR should maintain close communication with the Geotechnical Engineer POR to ensure that the required information is provided. The format and contents are discussed in detail in Chapter 4 of this manual. Typically the Geology Summary should include, but is not limited to the following:

- Project Description
- Summary of Surface Conditions
- Regional and Site Geology
- Regional and Site Seismicity
- Summary of Office Studies
- Summary of Field Exploration
- Summary of Laboratory Testing
- Soil and Rock Materials and Subsurface Conditions
- Subsurface Profiles
- Geotechnical Data Sheets
- Surface hydrology and subsurface hydrogeologic conditions
- Summary of Geologic Hazards
- Engineering Geologic Recommendations
- Appendices

The information to be presented in the Geology Summary should be discussed with the Reviewer and agreed to prior to and during preparation. A draft document should be submitted to the Engineering Geologist Reviewer for review and comment prior to publication with an agreed-upon lead-time.

The Engineering Geologist Reviewer is responsible for maintaining close communication with the POR and understanding the project area and proposed project features. The Reviewer should corroborate any identified geologic hazards, the regional and site geology and the regional and site seismicity. The Reviewer should also perform independent checks of the soil

and rock material classifications. Upon receipt of the draft, the Reviewer should review all aspects of the report for accuracy, overall presentation, and conformance with ODOT standards and return any comments within the agreed to timeframe.

Generally, the content of the Geotechnical Memo is developed utilizing information contained in the Geology Summary. In order to complete the Geotechnical Memo in sufficient time for submittal during DAP, it is crucial that the Geology Summary be completed as soon as practical after completion of the borings and laboratory program. The deliverable date for the Geology Summary should be discussed and agreed to at the geotechnical kick off meeting.

2.7.7 Draft Geotechnical Data Sheets

At this point in the project, the Geotechnical Data Sheets should be prepared in draft form with the information available.

2.7.8 Analysis And Design

The review of analysis and design, including calculations, presents a number of challenges with respect to well documented QC. Most significant is that this work is often continuous and spans numerous milestones. Further, the review of preliminary calculations may be important since a critical early error will compound through later work. Lastly, calculations are completed by staff at multiple levels and backgrounds, ranging from quite inexperienced to the most senior staff. Calculations need technical review by a competent individual other than the person completing the calculations. These reviews need to occur at both a preliminary and a final level.

Calculation review includes contemporaneous preliminary review and final review.

Preliminary Review is completed at the time of the calculations and is completed for each phase/round of calculation.

- If calculations are completed by a junior staff, contemporaneous preliminary review will be by the POR.
- If calculations are completed by the POR, review can be by the assigned Reviewer.

At the preliminary stage, review only need constitute the “second set of eyes.” As such, the reviewer need not be more senior but must be trained in the appropriate discipline and capable of completing the review.

Preliminary reviews will be documented by a simple initial or checkmark system on physical calculations, electronic initials on electronic documents.

At each reporting milestone, final review of all calculations completed to date will be made by both the POR and the Senior Reviewer. The final review at each stage will result in a signed calculation cover sheet as well as marked up calculations.

Calculation review would include checking each parameter used whether measured or assumed, methodology used, and outcome. For software based calculations, the complete input and output files should be reviewed. Note that review of spreadsheets requires access to the original spreadsheet in order to verify all formulas and calculations. For this reason, the use of spreadsheets for calculations is discouraged. Math Cad or similar programs are preferred for

electronic calculations as they facilitate the review of the actual embedded formulas. The exception would be spreadsheets that have been developed at ODOT and that have undergone a rigorous QC process.

The final documentation of calculations will consist of a compiled calc book that will include electronic copies (scans where necessary) of all calculations relevant to final design. The calc book will be reviewed and signed by the applicable PORs and Reviewers.

2.7.9 Geotechnical Memo

Preliminary Geotechnical Reports may be prepared for larger, more complex projects but are not standard for all projects. For most projects, preliminary recommendations are more appropriately conveyed via a simple memo. Regardless of the level of detail, the primary purpose of preliminary geotechnical documents is to support the Bridge and Roadway designers in preparation of the TS&L Report and to be included in the DAP submittal. Since the preliminary documentation is typically presented in memo form, this manual uses the term Geotechnical Memo in spite of the fact that this document could be a fully executed geotechnical report.

A Geotechnical Memo is typically finalized 75 percent of the way through the DAP timeline. At this stage, a geological reconnaissance of the project site has usually been conducted and the subsurface exploration program is complete. Draft gINT drill logs should be available and some preliminary geotechnical analysis can be performed to characterize key elements of the design, assess potential hazards, evaluate potential design alternatives and estimate preliminary costs.

Roles and Responsibilities. The Geotechnical Memo is prepared by the Geotechnical Engineer POR assigned to the project. The POR should maintain close communication with the Bridge, Hydraulic and Roadway designers, as well as the Geotechnical Engineer Reviewer, to ensure that the required information is provided. Typically the Geotechnical Memo includes a brief description of the proposed project, the anticipated subsurface conditions (based on existing geologic knowledge of the site, as-built plans and records and other existing information), and presents preliminary foundation design recommendations such as foundation types and approximate geometry. The rationale for selecting the recommended foundation type should be presented. The potential for liquefaction and associated effects should also be discussed as well as any other geologic hazards that may affect design.

The information to be presented in the Geotechnical Memo should be discussed with the reviewer and agreed to prior to preparation. A draft of the Geotechnical Memo should be submitted to the Geotechnical Engineer Reviewer for review and comment prior to publication with an agreed-upon lead-time.

The Geotechnical Engineer Reviewer is responsible for maintaining close communication with the POR and understanding the project goals and proposed features. The Reviewer should review the draft for accuracy, perform independent checks on any geometry provided, and return any comments within the agreed-upon timeframe.

The recommendations included in the Geotechnical Memo are generally preliminary and may include numbers, such as bearing capacities, which could change after subsequent analysis and

design. The preliminary nature of the recommendations should be explicitly discussed in the Geotechnical Memo so as to allow other members of the design team to use them appropriately.

2.7.10 Design Deviation Request

As the layout of the project progresses, there may arise situations where deviations from the requirements of the GDM and/or AASHTO guidance are necessary in order to complete the project. Those situations will require the submission and approval of a Geotechnical Design Deviation Request. The deviation approval process takes time and as such, the deviation request should be submitted as soon as possible after the need for approval is identified. Deviation requests should be prepared with the involvement of the Geology and Geotechnical PORs and should be reviewed by the Geology and Geotechnical Reviewers prior to submission.

2.7.11 Geotechnical Report

Throughout the Preliminary Phase, Draft Plan Sheets (Wall Sheets and Geotech Data Sheets) are prepared and submitted to the project team.

The most significant deliverable during this time would be a geotechnical report (GTR). The report should be complete and contain final recommendations (based on the project details available at the time of publication). Elements of a GTR should, as a minimum, include the following.

- Project Description
- Summary of Surface Conditions
- Regional and Site Geology
- Regional and Site Seismicity
- Summary of Office Studies
- Summary of Field Exploration
- Summary of Laboratory Testing
- Soil and Rock Materials and Subsurface Conditions
- Subsurface Profiles
- Geotechnical Data Sheets
- Surface hydrology and subsurface hydrogeological conditions
- Summary of Geologic and Geotechnical Hazards
- Analysis of Unstable Slopes
- Recommendations for Stabilization of Unstable Slopes
- Earthwork Recommendations
- Recommendations for stable cut and fill slopes
- Settlement estimates for proposed embankments
- Techniques to mitigate settlements (if necessary) including lightweight fill and/or preloading/surcharging
- Rock Slope and Rock Excavation Recommendations
- Bridge and Other Structure Recommendations
- Seismic Design Parameters and Recommendations
- Summary of Liquefaction Analysis

- Retaining Wall and Reinforced Slope Recommendations
- Traffic Structure, Soundwall and Building Recommendations
- Recommendations for Infiltration/Detention Facilities
- Recommendations for Non-Standard Foundation Designs
- Long-Term Construction Monitoring Needs
- Construction Issues and Recommendations
- Appendices

Detailed guidance on the development of the GTR is included in Chapter 4 of this manual, including a template for use on ODOT projects.

2.7.12 Special Provisions

Geology and geotechnical professionals are frequently responsible for the development of special provisions that relate to earthwork, foundations, retaining walls, and material sources. Regardless of who is responsible for creating these deliverables, the geology and geotechnical PORs and Reviewers should be involved and should be afforded the opportunity to review and approve the special provisions.

2.7.13 Geotechnical Report And Complete Plans And Specifications

Plans, special provisions, and estimates that are within the purview of geotechnical engineering or engineering geology are issued during the Final Plans Phase.

2.7.14 Edits To Geotechnical Report By Addenda

In general, the final GTR should not be edited. Significant changes to the project scope or details may require a reissued report but for most projects, information issues subsequent to the completion of the GTR should be by addenda. Addenda that modify or expand geologic or engineering recommendations should be treated in the same manner as the final report and should be reviewed by the appropriate professional reviewer.

2.7.15 Geo Contributions To PS&E

During the PS&E phase, the geotechnical team may be called upon to provide additional recommendations and/or addenda to the GTR as well as make edits to the plans and special provisions. As with original documentation, modifications to recommendations should be reviewed and documented by the entire team.

2.7.16 Significant Project Changes After PS&E

As previously noted, changes issued after the final report has been sealed should generally be addressed through addenda rather than reissuing the report. Changes that modify or expand the geologic or engineering recommendations should be treated in the same manner as the final report and should be reviewed by the appropriate professional Reviewer.

2.8 Quality Assurance

Quality Assurance (QA) is a system to maximize the effectiveness of the QC procedures. The QA process will assist in measuring the effectiveness of the QC efforts in order to provide input into continuous improvement of the work, assist in identifying technical development needs, and consistency with Agency products.

Competency Building. The QA process will assist in developing an agency-wide vision of the current needs with respect to technical knowledge and competence. The evaluation of where projects succeed or fail, and the role of the QC program in assuring success will provide data to be used in identifying gaps or weaknesses within the current knowledge base.

Continuous Improvement. Beyond project specific compliance, the QA process supports continuous improvement within both the QC program as well as within the practice community providing geotechnical services for ODOT projects.

2.8.1 Quality Assurance Process

In order to achieve the goals stated above, the QA process will need to be objective, transparent, and effectively communicated. Two types of reviews will be conducted, a completeness review and a project review.

Completeness Review. Initial information on completed projects will be gathered from ProjectWise and DocExpress. The QA team will complete an initial review and evaluation, focused on the completeness and timeliness of the QC documentation and will write up their findings and recommendations in a draft version of a short, project-specific report. The draft report will be provided to the POR and their direct supervisor. The POR will provide the QA team with any applicable clarification or additional information available, which will be incorporated in the final completeness review.

Project Review. An in-depth review of the project documentation will address how well the project met standards and the extent to which the QC process contributed to the success of the project. The results of the in-depth reviews will be collected and evaluated for inclusion in an annual summary report.

The completeness review is conducted by a permanent QA team which consists of the State Geotechnical Engineer, an Engineering Geologist, and a Geotechnical Engineer from the GEEG Section. The project review is conducted by the permanent QA team along with two regional representatives, one Geotechnical Engineer and one Engineering Geologist. The regional representatives will be selected by the three permanent members to ensure an independent review is conducted.

In general, projects selected for review by the permanent members of the QA team will be selected by one of the following ways:

- When challenges or problems occur during construction.
- By request from the Regions. A region may, based on concerns or known project issues, request a QA review on any project.

- Randomly. Projects from throughout the regions will be selected randomly for QA review.
- By size. Any project with over $200k in Geotechnical PE costs will be subject to QA review.

Summary Report. The results from both the Completeness and Project Reviews will be collected and summarized in an annual report. That report will not present specific projects but rather an analysis of issues and trends with respect to quality control and project success. The report will contain generalized findings and recommendations. The report will be presented to the Geo-Management, Geo-Staff, and the Quality Program Manager.

2.9 References

Officials, A. A. S. H.T.O. (2020). AASHTO LRFD Bridge Design Specifications, 9th Edition. In (pp. 1914). Washington, DC: AASHTO.

Peltz, T. R., Mohney, C., Ortiz, S. C., Frost, R., Collins, J., Anderson, S., & Albright, S. (2018). *Implementation of FHWA Geo-Professional Program Review*.

Rogers, T., & Siel, B. (2018). *Oregon Department of Transportation Geo-Professional Program Review*.

Sheahan, J., Zdinak, A., & DiMaggio, J. (2016). Assuring Quality in Geotechnical Reporting Documents. *Geotechnical Engineering Circular*, *14*(FHWA-HIF–17-016).

Appendix 2-A Geo Project Development Process through Scoping

9.28.2018

Geotech Engineer POR

Engineering Geologist

Geotech Reviewer

Geologist Reviewer

Geo Supervisory

Region Staff

Tools/ Templates

Scoping

QC'ed Step
QC Reviewers must have licensure in the content being reviewed; RGs do not review engineering content

Both Geo resources must be licensed; both professionals participate

Learn what projects they were assigned to scope

Determine if Geo participation is needed

Complex/need QC Reviewer?

No

Yes

Request Reviewer

Scoping team meets (multiple meetings over time). Field or Desk possible.

Create project scoping notes (iterative process)

Learn what projects they were assigned to scope

Determine if Geo participation is needed

Complex/need QC Reviewer?

No

Yes

Request Reviewer

Scoping team meets (multiple meetings over time) Field or Desk possible.

Create project scoping notes (iterative process)

For complex projects, quality check scoping notes

For complex projects, quality check scoping notes

Participate in deciding how scoping will happen

Respond to request for resources for scoping

Communicate how the process will work (who will do what)

Assign Reviewer

Fund Manager writes business cases for projects

Arrive at 150% list (Area Manager)

Determine how scoping will happen

Send out spreadsheet to get resources for project scoping

Scoping Leader calls team meeting (multiple meetings over time). Either Field or Desk.

Scoping Leader receives scoping notes (150%)

Consolidate scoping notes from all contributors

Scoping Notes

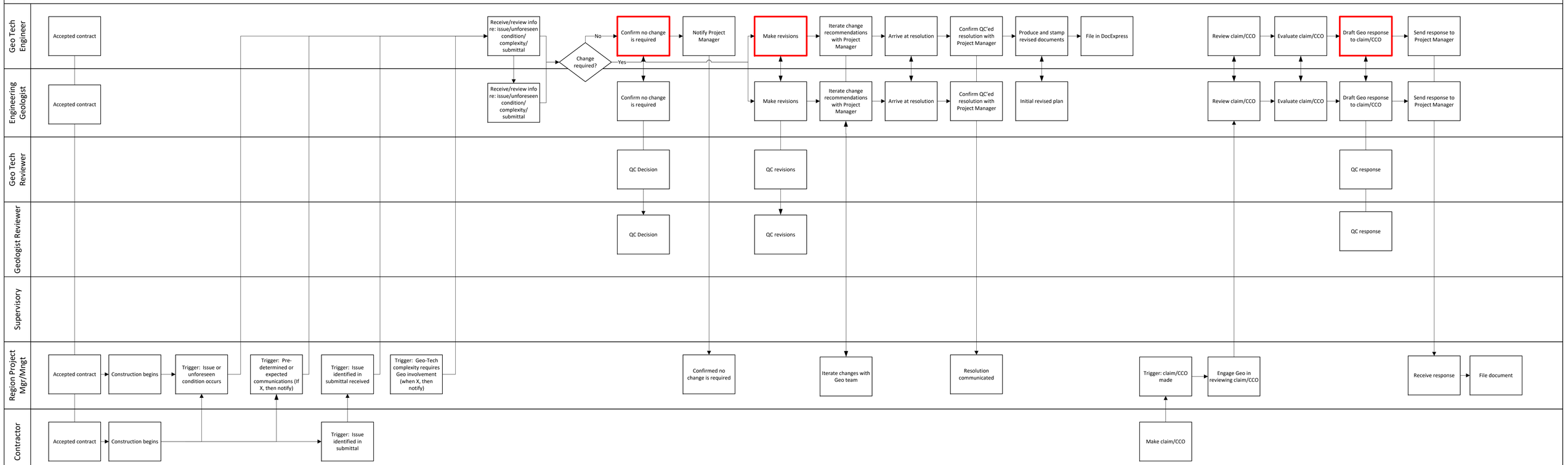
Stored in ProjectWise
All notes collected under a project number assigned at Scoping

Appendix 2-B Geo Project Development Process

11.16.2018

Appendix 2-C Geo Program Process: Construction

9.28.2018



Appendix 2-D Quality Assurance

9.28.2018