United States Department of Agriculture
Soil Conservation Service
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ENGINEERING - GEOLOGY NOTE NO. 3
210-VI

SUBJECT: ENG - GEOLOGIC INVESTIGATION

Purpose. This geology note provides methodology for geologic investigations. The note discusses investigational procedures and documentation to be developed. Appropriate technical references are cited. The objective is to develop technical consistency in the planning, execution, and documentation of Soil Conservation Service geologic investigations.

Filing Instructions. File with other geology notes.

Distribution. This geology note should be useful to all geologists, civil engineers, design engineers, and construction engineers. Initial distribution is shown on the reverse side. Additional copies may be obtained from Central Supply by ordering item No. GN-3.

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Enclosure

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May 30, 1984

GEOLOGY NOTE 3

# GEOLOGIC INVESTIGATION PROCESS

U.S. Department of Agriculture
Soil Conservation Service
Engineering Division

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## DISCUSSION

The objectives of geology investigations in the Soil Conservation Service (SCS) are:

(1) determine geologic conditions and how they will affect or be affected by project formulation and installation and the design, construction, and operation of structures and land treatment measures;

(2) describe geologic conditions and effects for the consideration of other technical disciplines and program managers.

Geologic investigations vary widely in intensity and objective. This Geology Note discusses the primary elements to be considered for all geologic investigations and documentation. The application of individual judgement and initiative and the use of pertinent technical references and state-of-the-art procedures are basic requirements. Of equal importance is the timely consultation with other technical disciplines during the investigation process. These are activities which reflect good engineering practices and expected professional performance. Finally, the geologist must keep in mind that information developed during these investigations may be utilized in support of legal action involving SCS operations.

## GEOLOGIC INVESTIGATIONS

Geologic investigations include, but are not limited to, the following activities:

1. Reconnaissance. The reconnaissance investigation provides the basis for future project planning and operational investigations. A thorough examination of the technical literature related to site conditions and local geologic processes is a vital part of this activity. This includes a review of existing aerial photography and other remote sensing resources, and examination of field conditions and proposed activities.

The reconaissance investigation provides the initial assessment of geologic effects on the project and project impacts upon geologic conditions. The result of this investigation will be a 3-dimensional preview based upon regional geology, geomorphic analysis and site specifics. The details of geology effects and project impacts will be further defined as the geologic investigation process. The reconnaissance process should include liberal "what if" considerations of the geology and the direction investigations and analyses could take to resolve them.

2. Geologic Mapping. The project geologic maps are the principal technical resource from which further investigations and analyses are developed. The development of these maps and subsequent geologic cross sections are the primary responsibility of the geologist. Geologic mapping is the examination and documentation of basic geology information such as lithology, stratigraphy, structure, and geohydrology. Geologic maps display this data base from which working hypotheses can be developed. The geotechnical assessment is not complete without adequate geologic mapping.

Geologic mapping may be the adaptation of previous work verified by field checks and remote sensing interpretation. Or, in the absence of published references, it may require original field mapping. The mapping should make use of remote sensing imagery and subsurface data such as drilling, geophysical surveys, and geohydrologic studies. These data should then be combined with geologic field data to produce the maps. The map scale should be suitable for the purpose intended. For example, 1" = 50' might be required for a dam site analysis while a scale of 1" = 1000' may be adequate for the erosion study of a land treatment project. The maps should be periodically reviewed and updated as additional geologic information is acquired.

In addition to the traditional presentations of stratigraphy and structure, geologic maps should address the following conditions:

1. Overburden characteristics
2. Erosion and sedimentation
3. Landslides
4. Subsidence
5. Solution, depositional and structural voids.
6. Geohydrology
7. Seismic related geomorphology

Map presentations should include the use of structure contours, isopachs, and computer graphic illustration to clarify the presentation of geologic data.

3. Determination of Investigational Objectives. When the geologic map is complete, the geologist with other technical disciplines, will identify project investigation objectives. These objectives vary in nature and scope depending upon specific project conditions. However, the identification process should be similar. Investigation objectives identify additional data requirements, verify theorized conditions, and show where expansion of existing information is needed.

Objectives may include specific project design data such as bedrock material, sediment yield, seepage conditions, ground water yield, etc. Or, they may address data needed to complete geologic interpretations such as seismic potential, future erosion rates, ground water overdraft, slope stability, etc. The investigation objectives should be developed from analysis of the geologic map and requirements identified by other technical disciplines.

4. Selection of Investigation Methods. The investigation objectives will generally influence the selection of investigation procedures and equipment. The geologist and engineer will determine the mix of direct (drilling, backhoe, etc.) and indirect (geophysics, remote imagery, etc.) investigative methods needed. If indirect investigation data are not correllated with direct investigation data, it should be made clear that the information presented is unconfirmed.

Selection of procedures and equipment should also consider the type of information needed (fault location, bedrock samples in place tests, spring flow rates, etc.) and the reliability level required. An investigation that includes geologic mapping in combination with direct and indirect methods will normally produce the desired results.

Instrumentation such as observation wells, peizometers, slope indicators and others should be included as an integral part of the investigation. This is particularly important when geologic processes which impact the design process or would be modified by the project occur at extremely slow rates. A joint review of instrumentation needs should be made by the geologist and the responsible engineer.

5. Investigational Safety. Many of the procedures used in geologic investigations are hazardous. The geologist must constantly evaluate the potential for accidents. Of particular concern are the risks involved with pit wall failures, rock falls, slope failures and overhead hazards, such as power lines and dead trees or limbs. Equipment with associated moving parts and suspended objects also constitute high risk situations. Underground utilities are a particular hazard. The geologist and drilling crew must assure that locations of utilities are known (National Engineering Manual, Part 503). The geologist must anticipate these conditions during investigation planning and execution and act accordingly to protect personnel and equipment.

6. Confirmation of Projected Geologic Conditions. Geologic investigations project surface information based upon geologic principles and processes to predict subsurface conditions. The subsurface investigation is then developed to confirm these geologic projections or detect anomalous conditions that require further definition. It is vital to the geologic investigation process that preliminary geologic interpretations be confirmed by direct investigation to the extent possible. Differing conditions, including those identified during construction, should be evaluated and reconciled with known surface conditions and the geologic maps modified accordingly. As all data are integrated, the confidence level in understanding the geologic picture will be improve.

7. Investigation of Anomalous Geologic Conditions. Anomalous conditions will most likely be encountered as the investigation progresses. These conditions will require further examination. If the geologic picture is refined as data are collected, the investigation can usually be modified to answer the anomalies at the time they are encountered. This reduces the possibility of "surprises" during design and construction. Additional investigations during design, construction, and post construction may still be needed to clarify or supplement existing data.

8. Documentation and Illustration of Investigational Data. One of the most important phases of the geologic investigation is the presentation of the data acquired. The construction of the geologic map and appropriate cross sections are fundamental. Block diagrams, field section sketches and fence diagrams clarify the geologic concepts and are strongly recommended.

Photography must be utilized in all geologic investigations. This includes the documentation of geomorphology, surface geology and core samples. Unless black and white photographs are specifically required, color prints should be standard. Some means to show the scale of the photograph must be included. Scale is particularly important when photographing outcrops and core samples.

Computer graphics provide excellent means of illustrating both surface and subsurface information. Numerous programs are available which will produce isopachs, oblique views, and various excavation elevations from subsurface and topographic data. These presentations significantly enhance the presentation of subsurface data to other technical specialists.

9. Investigation Report. The investigation report provides a detailed assessment of the geologic conditions. It may include any or all of the following:

a. Investigation Findings. These include factual data such as maps and photographs, core samples, drilling logs, field test data and soil and rock laboratory tests.

b. Geologic Interpretation. Interpretations include subsurface geologic maps and cross sections, 3-dimensional projections, isopach and structure contour maps and potentiometric maps which are developed through interpretation of findings by the application of geologic principles and processes.

c. Professional Opinions. This section includes information of a professional judgement nature which is developed from investigational and/or interpretive data. Examples are assessments of rock unit permeability, area limits, fault location and movement potential, slope foundation instability situations and other geologic effects which are judgemental in nature but which warrant the attention of other technical disciplines or management.

Narratively and graphically, the investigation report is the authoritative document which describes the site geology and geologic conditions. When providing geologic data in support of engineering design, the geologist should not present the findings in a manner which could be construed to dictate design direction. The report must be written and documented accurately and be of sufficient detail to provide the needed technical information. The author must consider that the users of the investigation report and the supporting documentation may not always have the services or a staff geologist.

10. As-Built Geology Information. The geologic investigation is not complete until the geology exposed during construction is evaluated and documented. The exposure of the foundation during construction provides the opportunity to verify geologic information used as a basis for design assumptions. The documentation of the exposed geology is the basis for analyzing and planning remedial treatment if required during the operation and maintenance of the structure. Finally, the examination provides valuable professional experience for geologists and engineers. Because of these requirements, the as-built geologic documentation is a vital element in the investigation process.

Under "As-Built Geology," the geologist should specifically provide:

(1) Geologic maps and structure sections of foundations, cutslopes, and other major excavations including borrow areas.

(2) Orientation and description of rock structure surfaces, rock discontinuities and voids.

(3) Reference photographs.

(4) Documentation of geotechnical reviews, geologic input to design modifications, changed site conditions, and instrumentation and monitoring data of geologic conditions.

11. Monitoring and Evaluation. Each geologic investigation should consider post construction monitoring and evaluation of geologic conditions and the necessary instrumentation required to accomplish this activity. A monitoring and evaluation plan should be prepared by the geologist and responsible engineer and implemented when conditions indicate that geologic changes are likely to occur as a result of the project.

## CONCLUSION

The adequate planning, execution, and documentation of geologic investigations are vital to SCS operations. The geotechnical information must be developed not only for design, but also to support operation and maintenance activities. The possibility that the data will be presented during litigation must be considered at all times and documentation prepared accordingly. And most importantly, the geologic information must not be developed unilaterally, but in concert with other disciplines to insure appropriate consideration of project needs.

## REFERENCES

The following references are provided as examples of accepted procedures for investigations and data presentation. The investigator should periodically review these and other related references.

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