County of Santa Cruz

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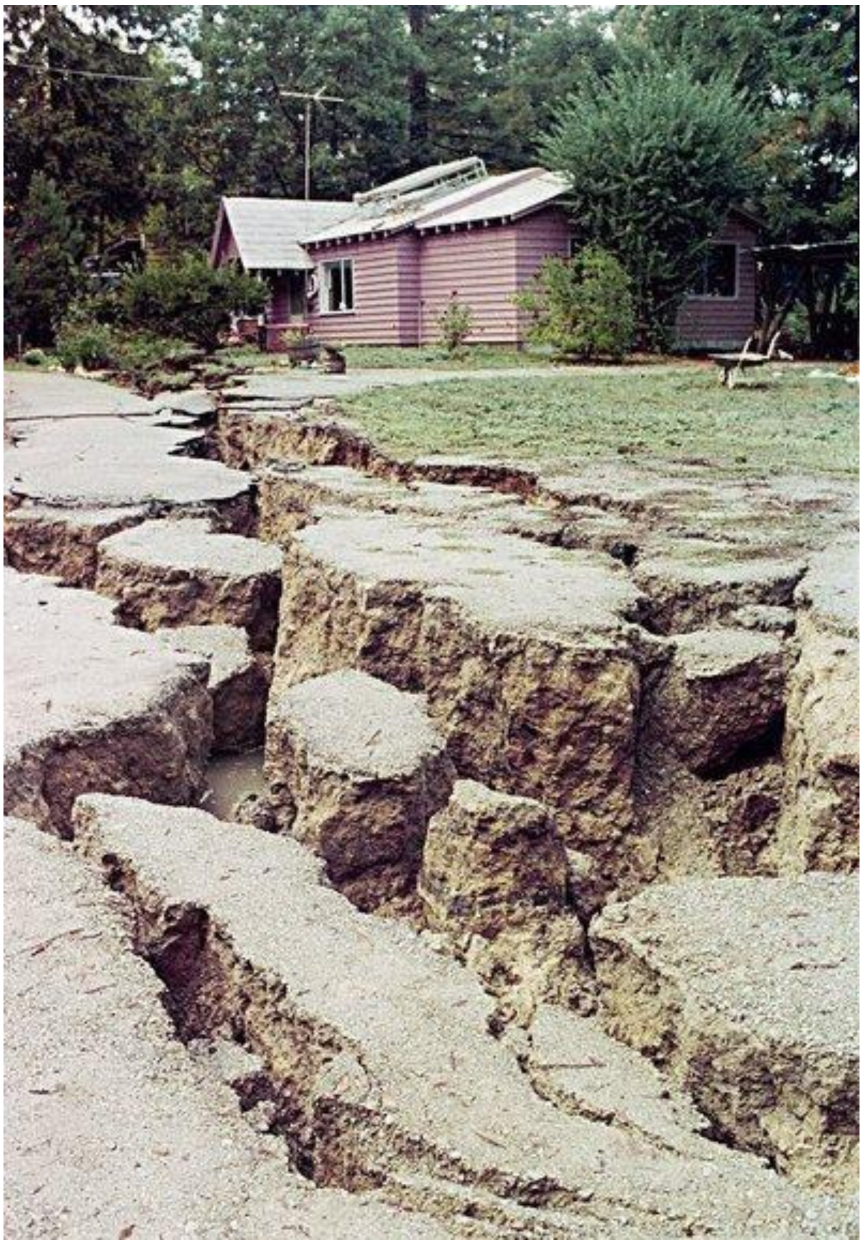
GUIDELINES FOR ENGINEERING GEOLOGIC REPORTS



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INTRODUCTION
These guidelines have been established to help the orderly and timely review of Engineering Geologic and Geologic Hazards Assessment Reports submitted to the County of Santa Cruz in compliance with the Santa Cruz County General Plan, the Local Coastal Program, Santa Cruz County Code, and applicable state regulations, including:

- Geologic Hazards Section of the County Code (SCCC Chapter 16.10);
- California Building Code as adopted by the County of Santa Cruz (SCCC Chapter 12.10);
- Abatement of Structural and Geologic Hazards (SCCC Chapter 12.10.425);
- Sewage Disposal (SCCC Chapter 7.38.120 (G) and (H);
- Mining Regulations (SCCC Chapter 16.54);
- Public Safety and Conservation and Open Space Elements of the SCCC General Plan;
- Local Coastal Program (SCCC Chapter 13.20);
- Grading Regulations (SCCC Chapter 16.20)
- Drainage Regulations (SCCC Chapter 16.22);
- The Alquist-Priolo Earthquake Fault Zoning Act of 1972
- The Seismic Hazards Mapping Act of 1990
- County of Santa Cruz Design Criteria

These guidelines are intended to:

- Assure the safe development of property in the County of Santa Cruz.
- Inform the engineering geologist, the geotechnical engineer, applicants, and other interested parties of the type of information that is required in an engineering geologic report.
- Assist in siting Onsite Wastewater Disposal Systems (OWDS).
- Implement Chapter 16.10 of the Santa Cruz County Code and the California Building Code as adopted by the County of Santa Cruz.

Due to changes in the state of knowledge and practice, it is expected that these guidelines will be updated periodically. Anyone practicing engineering geology in Santa Cruz County should check the County website periodically to help ensure that they are using the most current version of the guidelines.

These guidelines apply to situations where a full engineering geologic report is required to support safe and prudent development as determined by the County of Santa Cruz or as recommended by the project engineering geologist. There may be situations that do not require a full geologic report, where geologic input is required as part of a project geotechnical investigation, or where a geologic opinion is required for a parcel boundary adjustment. In those cases, the scope of the geologic investigation may be tailored to the needs of the specific project in consultation with the County Geologist.

The County of Santa Cruz requires engineering geologic reports for most development within areas considered to be susceptible to the geologic hazards. Areas considered susceptible to geologic hazards include beaches and coastal bluffs, state or county designated fault zones, areas of steep terrain susceptible to landsliding, drainage ways and alluvial fans subject to debris flow hazard, flood plains, areas of karst terrain, and areas where soil liquefaction during earthquakes is considered possible. Projects considered to be “development” for the purposes of engineering geologic report requirements are defined in section 16.10.040 (19) of the Santa Cruz County Code. The definition of development used in these guidelines includes tiny homes on wheels, which are considered habitable structures that must be sited in areas judged free of significant geologic hazards. It is the role of the County Geologist, under the authority of the Chief Building Official and the Planning Director, to establish when engineering geologic reports are necessary for a project and to review such reports for consistency with these guidelines, applicable Federal, State and local codes, and the local standard of practice for geology.

Consultants are encouraged to contact the County Geologist to discuss requirements prior to commencing fieldwork. Contact with the County Geologist is required <u>prior to trenching</u> when investigating fault rupture and co-seismic ground cracking hazards. The ultimate objective of coordination between the geologic consultant and the County Geologist is to facilitate the report reviews and to avoid prolonged delays in project approvals due to the review process.

Geologic Hazard Assessments (GHAs) may be performed for a project by the County Geologist at the request of the project owner or their representatives. The GHA allows the County Geologist to prepare an initial geologic assessment of the project, to meet on site with project proponents or project consultants, and to provide a recommendation for the scope of site-specific engineering geologic investigations, if it is determined that an engineering geologic report is needed for the project.

Once an engineering geologic report is completed for the project by the project engineering geologist, the report must be submitted to the County for technical review. The report may be submitted as a stand-alone report review, or the report may be submitted at the time a discretionary or building permit application is made. The County **strongly** recommends that the engineering geologic report be submitted as early as possible in the project planning process so that the findings of the approved engineering geologic report can be incorporated into the project design prior to submittal of complete development plans. The results of the engineering geologic report may place constraints on where development may be located and may affect development of site access roads and other infrastructure.

These guidelines are general and do not address every possible situation. County geologic staff may allow deviations from these guidelines, if the Planning Director or designee determines the intent of the guidelines have been met. The following California Geological Survey (CGS) Notes, State Statutes, and other jurisdictional standards are included by reference as part of these guidelines:

- *Guidelines for Evaluating the Hazard of Surface Fault Rupture –* California Geological Survey Note 49
- *Earthquake Fault Zones: a guide for government agencies, property owners/developers, and geoscience practitioners for assessing fault rupture hazards in California* - California Geological Survey Special Publication 42
- *Checklist for the Review of Engineering Geology and Seismology Reports for California Public Schools, Hospitals, and Essential Services Buildings* – California Geological Survey Note 48
- *Guidelines for Preparing Geologic Reports for Regional-Scale Environmental and Resource Management Planning* – California Geological Survey Note 52
- *Guidelines for Geologic Reports for Timber Harvests* – California Geological Survey Note 45
- *Guidelines for Evaluating and Mitigating Seismic Hazards in California* – California Geological Survey Special Publication 117A, September 2008, or most current.
- *Recommended Procedures for Implementation of DMG Special Publication 117: Guidelines for Analyzing and Mitigating Landslide Hazards in California -* Southern California Earthquake Center (SCEC), June 2002 or most current.
- Chapter 6 of the Santa Cruz County General Plan, the Local Coastal Program, Chapters 16.10, 16.20, and 16.22 of the Santa Cruz County Code, and the California Building Code as adopted by the County of Santa Cruz
- *Procedures to obtain changes to septic constraint areas* -- Published by the Santa Cruz County Environmental Health Department.
- *Local Area Management Plan (LAMP) for Onsite Wastewater Treatment Systems* – Santa Cruz County Environmental Health Department

- *Caltrans Soil and Rock Logging, Classification, and Presentation Manual 2022 Edition*

WHO MAY CONDUCT ENGINEERING GEOLOGIC INVESTIGATIONS AND PREPARE ENGINEERING GEOLOGIC REPORTS

In accordance with Article 3, Section 7835 of the Geologist and Geophysicist Act, 7835, *"All geologic plans, specifications, reports, or documents shall be prepared by a professional geologist or licensed certified specialty geologist, or by a subordinate employee under his or her direction. In addition, they shall be signed by the professional geologist or licensed certified specialty geologist and stamped with his or her seal, both of which shall indicate his or her responsibility for them."*

All documents that include geologic data, interpretations, or recommendations shall be signed, dated, and stamped by a California Certified Engineering Geologist (CEG) ***or*** a California registered Professional Geologist (PG) with experience in engineering geology ("project engineering geologist").

A complete site investigation requires a team effort between the project engineering geologist and the project geotechnical and/or civil engineer(s). Coordination of the geotechnical engineering investigation and the engineering geologic investigation is essential to provide accurate site characterization and to avoid discordant conclusions between the two disciplines. In many cases, the results of an engineering geology investigation will serve to clarify site conditions when the geologic complexity of the site makes it difficult or impossible for the project civil or geotechnical engineer(s), acting strictly in an engineering capacity, to do so alone. Geotechnical engineering guidelines are presented in a separate document titled "Guidelines for Geotechnical Investigation Reports."

INFORMATION TO BE INCLUDED IN ENGINEERING GEOLOGIC REPORTS

PROJECT INFORMATION

1. State the purpose and goals of the geologic investigation.

2. Provide the property address and Assessor's Parcel Number (APN) and a map with sufficient detail to accurately locate the property within the County. If a street address has not been assigned to the project site by the County, the report shall provide a description of the project site location such as the direction and distance from a road intersection or an established address.

3. Describe the proposed development project including the proposed development envelopes and planned uses of any structures, significant proposed grading or drainage measures, and the locations and condition of existing or proposed access roads.

4. Indicate who the report was prepared for and their interest in the property being investigated.

5. Describe the scope of the services of the engineering geologic investigation, including any work that was performed by a civil engineer and/or geotechnical engineer that is used as part of the geologic analysis. The scope of work shall be detailed enough to permit the reviewing geologist to understand the means and methods employed and performed in the investigation.

6. Provide a description of existing site conditions, including topography, vegetation, hydrologic features, drainage, existing structures and improvements, on-site wastewater treatment systems, and any other site characteristics that may impact development.

REGIONAL GEOLOGIC SETTING

The regional geologic setting must include a description of the regional geology and seismicity to provide a context for the site-specific geologic observations that contribute to the geologic site characterization (see below.)

A summary of the regional geology will include general descriptions of topographic setting, geologic units, stratigraphy, geologic structure, geomorphology, hydrology, and general seismicity. Maps depicting the regional geology and regional seismicity must be included as figures in the report.

GEOLOGIC SITE CHARACTERIZATION

Geologic site characterization provides the information that is necessary to evaluate the potential impact of geologic conditions on the proposed development and to allow the engineering geologist, geotechnical/civil engineer(s), and designer to formulate and incorporate mitigation measures into the project to promote safe and prudent development with respect to geologic conditions.

The site characterization shall include the following elements:

1. Evaluation of Existing Geologic and Geotechnical Work: A substantive body of both published and unpublished information exists to assist in the geologic site characterization. An essential part in any site investigation is the review of available geologic maps, unpublished consulting reports (especially those near the property) and published geologic papers and reports. These sources of information are essential to understanding the regional and site-specific geologic conditions. Basic information sources for the County include:

    - Geologic Map of Santa Cruz County by Earl Brabb (1989)
    - Preliminary map of landslide deposits in Santa Cruz County, California by Cooper-Clark and Associates (1975)
    - Faults and their potential hazards in Santa Cruz County, California by Hall et al. (1974)

- Preliminary Map of Landslide Features and Coseismic Fissures Triggered by the Loma Prieta Earthquake of October 17, 1989 by Spittler and Harp (1990)

These and other important geologic references for Santa Cruz County are listed in the REFERENCES section at the end of this document. The information from these sources can be accessed through the County of Santa Cruz GIS portal at: https://gis.santacruzcounty.us/gisweb/. Geologic maps of the 7.5 minute topographic quadrangles making up Santa Cruz County are available through the U.S. Geological Survey and the American Association of Petroleum Geologists store (maps by Thomas Dibblee). Maps can be located through the U.S. Geological Survey's National Geologic Map Database at: https://ngmdb.usgs.gov/ngmdb/ngmdb_home.html. If unpublished consulting reports are cited in the geologic investigation, copies of these reports shall be made available to County staff, if requested.

The report shall include a local geologic map at a larger scale than the regional geologic map, typically at a scale of 1" = 500' to 1" = 2000', with the parcel outlined and references for the sources of the geologic data and other pertinent information shown on the map. The report shall state clearly if the property falls within any geologic hazard zone(s) defined by the State of California or the County of Santa Cruz. Hazard zones may relate to liquefaction, landsliding, tsunami, fault rupture, or flooding.

2. *Review and evaluation of Aerial Photographs, LiDAR, and other remote sensing information*: Numerous sources of information exist for remote images. Multiple vintages of stereographic aerial photos of Santa Cruz County are available in the UCSC air photo collection (https://guides.library.ucsc.edu/maps). Moderate resolution digitized aerial photos useful for reconnaissance work are available at: http://mil.library.ucsb.edu/ap_indexes/FrameFinder/. Lidar coverage for all of Santa Cruz County is available for viewing or download through the County of Santa Cruz GIS portal (https://gis.santacruzcounty.us/gisweb/). Other lidar coverages may be available through other sources, such as Open Topography (http://opentopo.sdsc.edu/login). Review of remote sensing data is a fundamental part of the geologic site characterization.

3. *Geologic Mapping:* The report must include independent geologic mapping of the subject area at an appropriate scale and in sufficient detail to support a complete engineering geologic evaluation of the site. An accurate geologic map is fundamental to construction of geologic cross sections, planning of later phases of the site investigation, and analysis of geologic hazards. In connection with this objective, it may be necessary for the engineering geologist to extend the mapping into areas adjacent to the site of interest. All mapping shall be done on a base with satisfactory horizontal and vertical control and must include accurate depiction of topographic relief. This mapping must include:

   a. A large-scale site geologic map (1" = 100' or larger scale) which shows the location of existing or proposed improvements (building sites, roads, septic system, etc.), legacy grading or timber activities, parcel boundaries, and geomorphic and geologic information for the subject parcel or project site, including slope directions and gradients, drainage patterns, important geomorphic features, mapped distribution of geologic units, strike and dip of bedding, orientations of fractures, joints, shears and other geologic structures where relevant, and the locations of all geologic cross section lines. The scale shall be sufficient to accurately depict geologic information relevant to the site analysis. Mapping of geomorphic features shall be completed with special care to identify areas of past slope instability, debris flow potential, faulting, near surface groundwater, seeps or springs, accelerated erosion, and legacy grading.

b. The map must also depict the locations of all exploratory borings, subsurface excavations, and geophysical transects or locations, and must include an explanation that defines all symbols and lithologic units displayed on the map. The map should be at a similar scale as the improvement plans, and the pertinent geologic information must be transferable to civil or architectural plans, as needed.

4. *Subsurface Exploration and Instrumentation:* Subsurface exploration and/or instrumentation are essential to most site investigations. The precise nature and scope of the subsurface investigation will depend on the characteristics of each particular site and the types of geologic hazards to be analyzed. Geologic mapping (described above) shall be used to plan subsurface explorations so that accurate geologic cross-sections can be constructed and the existence of landsliding, faulting, or other hazardous geologic conditions can be specifically characterized. More discussion of subsurface exploration is provided in the following section on Geologic Hazards and Constraints Analysis.

5. *Interpretive geologic cross-section(s):* Interpretive geologic cross-sections shall be completed through all building sites, other significant site development locations, and through areas of significant proposed grading. The cross sections shall depict geologic units, geologic structure, ground water levels, landsliding and other pertinent geologic features at the same scale as the site geologic map. Cross sections shall also show the locations of existing and proposed improvements. In most cases, cross sections should be drawn without vertical exaggeration.

6. *Summary discussion of site characteristics:* A summary discussion shall be provided in the engineering geologic report with a synthesis of the geologic information obtained from the steps outlined above. The report shall contain brief, but complete descriptions of all geologic materials and important geomorphic or structural geologic features recognized or inferred on the site. Discussion of surface water and ground water conditions shall also be included, especially where slope stability is an issue. Where interpretations are added to the recording of direct observations, the basis for such interpretations shall be clearly stated.

GEOLOGIC HAZARDS AND CONSTRAINTS ANALYSIS

The engineering geologist must analyze the data to determine how geologic features of the site, as summarized in the geologic site characterization, potentially affect the proposed development and how the development may contribute to, or be impacted by existing geologic hazards and constraints on the subject property or on adjacent properties. A primary goal of this analysis is to assist the developer in avoiding, mitigating, and/or accepting these hazards within the compass of the County Code.

The hazards and constraints analysis must follow logically from the data and observations presented in the site engineering geologic characterization.

To assure proper communication, the engineering geologist must document their analysis and assessment with the understanding that there will be multiple types of reviewers, such as civil engineer(s), who may rely on the engineering geologic report to develop necessary engineered mitigations. The following is a list of the principal geologic hazards that affect sites in Santa Cruz County, with specific requirements for each category:

Ground Surface Rupture Hazard

Ground surface rupture hazards due to faulting shall be explored and analyzed in designated fault zones and any other areas where a risk of ground surface rupture may reasonably be thought to exist based on review of available data and/or site geologic mapping.

Typically, the advancing and logging of fault trenches will be required to clear building sites within State or County designated fault zones. Trenching is also likely to be required in areas adjacent to designated fault zones where geomorphic evidence is suggestive of active faulting. The engineering geologist shall contact the County Geologist prior to any trenching to permit the County Geologist or designated staff to observe the trench exposure.

California Geologic Survey Note 49 "*Guidelines for Evaluating the Hazard of Surface Fault Rupture*" and Special Publication 42 "*Earthquake Fault Zones: a guide for government agencies, property owners/developers, and geoscience practitioners for assessing fault rupture hazards in California*" provide basic guidelines for the exploration of ground surface rupture hazard.

The engineering geologist shall include the following in the engineering geologic report for sites where surface rupture due to active faulting is a concern:

a. *Regional and site-specific identification of surface faulting relevant to the subject site.* A site-specific fault map shall be compiled from available published and unpublished geologic reports and maps showing confirmed and suspected faults and fault-related features.

b. *Lineation study*: A lineation study shall be completed based upon inspection of stereographic aerial photos, relief maps, LiDAR imagery, or other remote sensing data. Multiple vintages of aerial photos shall be inspected whenever possible. The geologic analysis must show mapped locations of any lineations relative to the subject site, identify their origin to the extent possible, and make conclusions about the significance of the lineation with respect to the subject site. The lineation study is an important step that may influence selection of development sites and planning for the trenching studies.

c. *Subsurface exploration of faulting that may impact the subject site.* For fault hazard studies, subsurface investigations will almost always be necessary and will usually include a trench through the proposed building envelope, with adequate trench length beyond the building envelope to demonstrate an acceptable setback from any active fault. The trench(es) must be carefully logged at a scale of 1” = 5’ or larger, with special attention given to features that may assist in developing an age assessment of any faulting observed within the trench. The trenches shall be sufficiently deep to expose bedrock structure that can confirm or exclude the existence of faulting or to expose layered surficial deposits of sufficient age to confirm or exclude the existence of faulting of Holocene age. Trench logs must include descriptions of earth materials and geologic features of note encountered in the trench.

Assigning ages to geologic deposits for the purpose of assessing the activity of a fault observed in a trench can often be problematic. Priority should be given to retrieving samples for analytical dating from the trenches. In some cases, age dating using the degree of pedogenic soil profile development is the only time datum available at a site. Where pedogenic soil profile dating is to be used, soil descriptions should be detailed enough to develop a soil profile index (e.g., Harden, 1982) and shall be collected by someone experienced in soil profile description.

Trenching in areas of landsliding, where non-tectonic deformation may obscure faulting, may require specialized methods of investigation such as multiple, closely spaced borings or geophysical surveys. Any use of borings or geophysical surveys in a surface rupture investigation must be discussed and approved in advance by the County Geologist.

d. *Building envelopes and setbacks from faults*: Recommendations for building placement with respect to surface rupture hazard must be developed based upon the results of the regional study, the lineation analysis, and the site exploration (trenching). Setbacks must conform to County Code. Please note SCCC 16.10.070(B)(2) states*:*

> *“habitable structures shall be set back a <u>minimum</u> of 50 feet from the edge of the area of fault induced offset… This setback may be reduced to a minimum of 25 feet from the edge of this zone, based upon paleoseismic studies that include observation trenches. Reductions of the required setback may only occur when both the consulting geologist preparing the study and the County Geologist observe the trench and concur that the reduction is appropriate. Critical structures and facilities shall be set back a minimum of 100 feet from the edge of the area of fault induced offset or ground distortion of active and potentially active fault traces.”*

50 feet may not be a sufficient setback in all cases, such as at sites where the proposed development is positioned on the hanging wall block of a large thrust fault. Where a dipping fault extends back under the proposed building site, the minimum setback must be measured orthogonally from the plane of the fault where it extends under the proposed building site to the deepest foundation element of the proposed structure (i.e., if the building is to be sited on 20’ deep piers, the setback must be measured from the fault plane to the base of the nearest pier). Observations from past earthquakes have shown that ground surface distortions sufficient to damage structures may extend beyond the zone of brittle surface rupture, so caution shall be exercised in stipulating fault setbacks.

e. *Construction recommendations*: In addition to setbacks, the engineering geologist shall provide a summary that includes discussion of recency of faulting, relative risk posed by ground surface rupture, and design recommendations for foundations if a potential for non-brittle ground deformation (warping or bending) is considered possible away from areas of direct surface offset, whether due to distributed small movements on fractures or broad areas of ground distortion. The recommendations shall include a designated building envelope that incorporates the recommended setbacks.

Co-seismic (ridge top) ground cracking due to seismic shaking

Ridge crests and steep slopes may experience ground cracking during large earthquakes, termed co-seismic ground cracking. The effects of this type of ground cracking can be similar to that of fault related ground deformation, but co-seismic ground cracking does not take place along active faults and is not subject to the same regulatory requirements. Narrow, steep-sided ridgetops are subject to cracking by strong seismic shaking. Older landslides may also be reactivated by seismic shaking in the form of small incremental displacements, resulting in ground cracking around the margins and less commonly, within the body of the older landslide mass. Proposed building sites on ridge crests and on steep slopes in areas of older landsliding must be evaluated for potential ground cracking.

The evaluation of co-seismic ground cracking hazards is based principally on determining whether a site has been subject to ground cracking in the past. Evidence for past ground cracking is observable in geologic trenches as soil-filled older cracks extending into bedrock, offset pedogenic soil horizons, open fractures in the subsurface, or areas of dispersed extensional deformation of geologic materials. The Preliminary Map of Landslide Features and Coseismic Fissures Triggered by the Loma Prieta Earthquake of October 17, 1989 (Spittler and Harp, 1990) provides a record of the distribution of ground cracking from the Loma Prieta Earthquake in the Summit area of Santa Cruz County. Landslides and other geologic features in the Santa Cruz Mountains, California, resulting from the Loma Prieta Earthquake of October 17, 1989 (Manson, et al., 1992) provides a wealth of information about landsliding and ground cracking due to the earthquake. Evaluation of coseismic ground cracking accompanying the earthquake: Trenching studies and case histories (Nolan and Weber, 1998) presents a paleoseismic-style study of past ground cracking in the Santa Cruz

Summit Ridge area. It should be noted that the maps accompanying these publications do not record all ground deformation that occurred due to the 1989 earthquake. As well, post-earthquake trenching studies have shown that not all previous instances of ground cracking were reactivated in the 1989 earthquake.

Where evidence of past ridge top ground cracking is observed, development shall be located to avoid areas of past ground cracking. Where areas of past ground cracking cannot be avoided, trenching observations shall be used to provide design displacements for structures to be sited in areas where past ground cracking has occurred. If the site is located on or near the crest of a ridge that may be subject to strong seismic shaking, the engineering geologist shall provide the following:

a. Investigation of the area of proposed development for evidence of past ground cracking with geologic trenches. Trenches shall be at least 5’ deep or extend at least 1’ below the base of the “B” pedogenic soil horizon(s).

b. Recommended setbacks from any observed past ground cracks, where possible.

c. Estimates of vertical and horizontal displacements, to be used by the project engineer(s) for foundation design if an area free of ground crack hazard cannot be identified.

Analysis of Slope Instability and Landsliding

Slope instability includes processes ranging from rock falls, debris flows, and slumps to soil creep and erosion. Geologic exploration is used to identify the types of slope processes that may impact a site, to evaluate the level of risk posed by each process, and to provide mitigation recommendations where the level of risk must be reduced to permit development.

If a potential for landsliding has been identified by aerial photo analysis or field mapping, the engineering geologic investigation must include accurate mapping of existing landslides and must identify conditions that may affect slope stability. Where prior landsliding that would impact the proposed project has been confirmed or where a potential for landsliding is thought to exist, the engineering geologic investigation is extended to collect information on which qualitative and quantitative slope stability assessments can be based.

Geologic mapping at the investigation site must identify all existing relevant landslide deposits to provide plan dimensions of the landslide mass(es) and to document geomorphic evidence for stability or instability. The geologic map and cross sections are used to plan subsurface investigations, which can confirm the existence of landsliding where surface identification of landsliding is equivocal, and to develop two- or three-dimensional geometry of the landslide for qualitative or quantitative stability analysis.

The type of subsurface explorations used for landslide investigations will depend upon the mechanism of failure, the size of the landslide, site geology, and the methods that will be used to analyze the landslide. Methods of subsurface investigation include test pitting, trenching, down-hole logging of large diameter borings, and logging of small diameter borings, either with interval sampling or continuous coring. Explorations for slope instability shall be extended to a depth sufficient to confirm that the deepest extent of landsliding has been identified and to evaluate both the geologic and groundwater conditions that may cause future instability. In some cases, it may be necessary to install and monitor inclinometers, piezometers, or other types of slope instrumentation for a period of time to provide sufficient data for accurate stability modelling. If non-standard techniques of exploration are considered, the County Geologist shall be consulted to confirm acceptability.

A wide range of geophysical methods may provide additional tools that can supplement subsurface information obtained by other means. Geophysical explorations must be completed by a professional geophysicist, unless otherwise approved by the County Geologist, before the actual geophysical work is started.

Modeling of landslides or potentially unstable slopes requires an adequate program of material sampling and testing. In all cases, strength values must be site-specific and may not be chosen from published, generalized strength values or off-site sources, unless specifically approved by the County Geologist or Geotechnical Engineer. Modeling large landslides should always be approached with an appreciation of the difficulty in exploring, characterizing, and representing site-specific geology and earth material strengths appropriate for the site. The procedures from SCEC June 2002 (or most current) and California Geological Survey Special Publication 117A (2008) can be used as a minimum standard.

Shallow, mobile landslides will require exploration of both source areas and deposition areas. For debris flows, trenching or exploratory drilling studies in the deposition area can show the age and size of past debris flows, which can be used to set design parameters for mitigating design. Borings may be used to extrapolate the data from trenches to help identify the limits of deposition. Mapping of older debris flow scars on slopes above a site can also help the engineering geologist to evaluate the likelihood of debris flow formation and to formulate probable debris flow volumes for design. Debris flows are a particular problem after wildfires have removed vegetation from hillsides.

Instrumentation that monitors slope movements is encouraged in situations where recent slope movements are evident or on-going movement is suspected. A slope instrumentation plan must be submitted to the County for concurrence (unless the County defers the initial submittal). Deformation gages and similar instrumentation must be installed per manufacturer recommendations, and readings must be retained. A final report must be submitted to the County for review and acceptance.

a. *Landslides*: the following items are generally required when landslide(s) are identified which may potentially affect a development:

i. The geometry of the landslide mass must be determined with emphasis on plan form, depth, and any variations in the landslide geometry in three dimensions. A minimum of one longitudinal and one transverse geologic cross section should be prepared. Include data available from exploratory borings, trenches, wells, geophysical surveys, or instrumentation such as inclinometers.

ii. Describe and analyze any structural or stratigraphic factors that may impact landslide stability, such as dip slope conditions, joint sets, or weak stratigraphic layers.

iii. Describe and analyze the significance of groundwater conditions within the slide mass. This may include monitoring of piezometers or nearby water wells, evaluation of subsurface material for oxidation or reduction, etc.

iv. Describe the failure surface (depth, thickness, parting, texture, moisture conditions, etc.).

v. Identify the failure mechanism associated with past or potential future slope movement.

vi. Evaluate the potential for the landslide to enlarge through lateral or headward progressive failure.

vii. Identify the potential risk to life and property from slope instability. In many instances, identifying risks posed by slope instability will require performance of quantitative slope stability analyses, which will typically involve the services of a geotechnical or civil engineer. The division of responsibility between the engineering geologist and geotechnical professional is discussed in SCEC (2002) publication, excerpted here:

> *"Involvement of both geologists and geotechnical engineers will generally provide greater assurance that the hazards are properly identified, assessed, and mitigated… The geologist should provide appropriate input to the geotechnical engineer with respect to the potential impact of the subsurface geologic structure, earth materials, stratigraphy, and hydrogeologic conditions on the stability of the slope. The shear strength and other geotechnical earth material properties should be evaluated by the geotechnical engineer. The geotechnical engineer should perform the stability calculations. The ground motion parameters for use in seismic stability analysis may be provided by either the (engineering) geologist or the (geotechnical) engineer…"*

In general, the engineering geologist provides the geologic model of the slope to be analyzed, and the geotechnical engineer selects the engineering properties of the geologic materials and performs the stability calculation based on the model, in consultation with the geologist.

In some cases, it may not be practical or feasible to perform a quantitative slope stability analysis that will provide a realistic assessment of a particular site's stability. There are numerous landslides in the Santa Cruz Mountains that are tens or hundreds of acres in size and up to a few hundred feet deep. These landslide masses also may be compound, with nested landslide masses of differing history and stability. If the size and complexity of the landslide being analyzed precludes a realistic quantitative analysis <u>for the scale of the project being proposed</u>, other means may be necessary to evaluate landslide risk. In some cases, the landslide geometry (such as buttressing at the landslide toe or low inclination of basal rupture surface) may support a geologic argument for landslide stability.

The evaluation of landslide risk can include an evaluation of the age and magnitude of the most recent landslide movements. Where the age of movement is included as part of the risk assessment, care must be taken to distinguish between the initial age of formation of the landslide and the age of the most recent reactivation of the landslide. Experience in Santa Cruz County has shown that many large, older landslide masses that may have initially failed in pre-Holocene time can undergo periodic reactivation due to earthquake shaking.

The landslide reactivations observed after the 1989 Loma Prieta earthquake were incremental, ranging from a few inches to several feet, rather than catastrophic, where displacements would be measured in tens or hundreds of feet. The amount of displacement may be proportional to the duration of strong shaking, so displacements during events larger than the 1989 M 6.9 Loma Prieta earthquake may be greater than those observed in 1989. The incremental displacement takes place during the period of intense shaking and stops after the cessation of shaking.

Evidence for past reactivation of a landslide may be visible geomorphically in the form of geologically recent appearing scarps and sharply defined headward or lateral margins. However, it is typically necessary to trench at the head scarp or at lateral margins to determine the timing and displacement magnitude of past reactivation events. Care should be taken to identify and evaluate key features that can be used to constrain the amount of past landslide movement. Past landslide reactivations with small displacements might not be recognized in field studies due to weathering and degradation of geomorphic features over time.

Two types of analyses can be considered in using age and magnitude of past movements in the assessment of risk:

- <u>Analysis based on age criteria:</u> If it can be demonstrated that the most recent movement of the landslide mass is early Holocene or older, the risk of significant (damaging) renewed movement during a standard building lifetime (50 years) may be judged acceptable, unless site conditions include destabilizing conditions that might not have been present in the past. Such destabilizing conditions could include downcutting by stream erosion at the toe of the landslide mass that has removed a stabilizing buttress or development of septic systems on the landslide mass that raise ground water levels, as two examples.

- <u>Analysis of past displacement history:</u> If it can be demonstrated that the landslide has a history of limited incremental displacement by documenting evidence for two or more past incremental movements, it may be acceptable to permit a project that includes foundations designed to withstand ground displacements on the order of those associated with past displacements This approach is only permissible where no other building site(s) subject to lower geologic risks exist on the parcel. Trenching studies are used to locate buildings away from areas with large past displacements, such as landslide margins or internal scarps. Foundations are then designed for displacements comparable in magnitude to past displacements observed in trenching studies through the building area.

For age-related risk assessments, the engineering geologist develops a movement history of the landslide from trenching to constrain the timing and magnitude of past landslide movements. Observation of undeformed pre-Holocene stratigraphic units or pedogenic soils combined with observations of the geomorphic expression of the landslide may be used to estimate the minimum age of past movements. Radiometric dating methods can be used to clarify the age of stratigraphic layers or pedogenic soils. The engineering geologist will log the trench at a detailed scale and document observed relationships, including sample locations used for age dating. If age estimates are to be developed from observation of pedogenic soils, the soil horizons shall be described in detail.

Use of either age or displacement criteria in the risk assessment will <u>only</u> be supported as part of a <u>fully scoped engineering geologic investigation</u>. The investigation shall evaluate the landslide for geologic factors that could lead to destabilization of the landslide in the near term and for the potential for catastrophic, rather than incremental displacements. It must be understood that a long period of stability does not, by itself, demonstrate that a landslide will continue to remain stable. However, age and displacement criteria can be accepted in support of an argument that the risk of renewed or catastrophic movement during a standard building lifetime is low where no other means of assessing landslide risk are feasible.

viii. The geologic risk assessment must also evaluate the potential impact of the proposed development on slope stability of the site and surrounding area, including the impact of any proposed septic system.

ix. Development of mitigating design:

- Identify and provide estimates of risk from potential landsliding;

- Formulate setbacks from areas of potential instability;
- Provide geologic input for the engineering design of risk-reduction structures such as retaining or impact walls and building foundations, or for landslide stabilization measures such as pin pier walls or fill buttresses;
- Develop appropriate monitoring and maintenance programs to assure success of risk-reduction or stabilization measures;
- Review civil engineering design work including risk-reduction structures, building, and grading plans.

b. *Debris or Mud Flow Hazards:* debris flows represent a significant hazard to life and property. In addition to the above items under the general slope stability discussion, the following are essential:

i. Evaluate potential debris flow source areas. Steep slopes above a potential development site shall be evaluated for the existence of existing debris flow or small-scale landslide scars.

ii. Estimate age and thickness of past debris flows by trenching in deposition areas.

iii. Estimate design debris volumes from older debris flow scars in source areas and past debris flow deposits.

iv. Establish setbacks from debris and mud flow hazards, where possible, or provide volume and velocity estimates for the engineering design of risk-reduction structures where setting back is not an option.

v. Develop appropriate monitoring and maintenance programs to assure success of risk-reduction structures, where deemed necessary.

c. Rock Slope Stability

The evaluation of stability in rock slopes is distinct from stability analysis of soil materials whose field performance is well predicted by the Mohr-Coulomb strength criteria. The analysis of rock slope stability involves analysis of materials whose material strength may preclude shear failure of intact material: failures are instead facilitated by fractures or other inhomogeneities that propagate through the rock. Failure mechanisms include plane, wedge, circular, and toppling failures. A common error in the evaluation of stability in natural slopes is to employ an analytical procedure intended for (relatively) uniform soils to rock slopes.

Rock slope stability analysis incorporates a number of specialized techniques that are heavily dependent on geological data, mostly structural geologic data on the orientation of discontinuities (joints, shears) and their qualities such as length, spacing, roughness, and infilling material. Rock compressive strength and ground water conditions are also important. Kinematic analyses using field-derived geologic data can be performed as a screening level evaluation of potential rock slope failures.

In evaluating rock slope stability, the project engineering geologist may need to work closely with an engineer experienced in the evaluation of rock slopes. Collection of geologic data will be guided by the needs of the analytical procedures chosen by the project engineer. If certain rock block or rock wedge failures are identified, then recommendations for setbacks and/or scaling might provide reasonable mitigation. In other cases, strengthening of rock slopes by rock bolts, anchors, or retaining walls may be required.

d. *Accelerated Erosion and Slope Creep*

These two hazards are relevant on sites with moderate to steep slopes and friable soils. Soil creep will occur on slopes mantled by moderately to highly expansive soils. Accelerated erosion is most likely to occur where loose, cohesionless soils occur on slopes. Erosion hazard can usually be mitigated by a well-designed site drainage system. Soil creep may be obvious at a site, but it may also be necessary to review the results of exploratory drilling and laboratory testing of soil samples to recognize the potential for soil creep. The project geotechnical engineer shall provide recommendations to mitigate soil creep where needed.

Seismic Shaking Hazard

The report shall provide a description of potential seismic shaking intensities that may be anticipated at the development site. *Also refer to Santa Cruz County "Standards for Geotechnical Investigation Reports.".*

a. Literature Review: The report must include a summary of historical regional and local seismicity and quantitative or qualitative estimates of the intensity of historical ground shaking. The review shall include a discussion of active faults within 25 miles of the subject site. The review shall also include a clear conclusion as to the potential impact of seismicity on the proposed development.

b. Deterministic and Probabilistic Seismic Shaking Estimates: The project engineering geologist shall provide either deterministic or probabilistic estimates of the peak ground accelerations that may be expected at the site as part of the discussion of potential seismic shaking risks. The engineering geologist shall also provide a discussion of site-specific characteristics that may serve to amplify or dampen site shaking. Selection of ground motions for design shall be based on the most current edition of the California Building Code and may be performed by the project engineering geologist or by the project civil or geotechnical engineer. Where deterministic ground motions are to be used as part of a site-specific ground motion procedure (per ASCE 7-16 section 21.2.2 or any subsequent revision of that standard), the geologist shall work with the earthquake engineering consultant to select deterministic ground motion estimates for the analysis.

Liquefaction, Seismically Induced Ground Deformation and Lateral Spreading

Seismically induced ground deformation includes liquefaction, lateral spreading, lurch cracking, and settlement. Refer to Geotechnical Report Guidelines for details on mitigation of these hazards. The engineering geologist shall assist the geotechnical (soils) engineer in analysis and preparation of mitigation measures for these hazards.

Liquefaction results from a loss of soil strength due to elevated pore water pressures in saturated sediments during seismic events. The quantitative evaluation of liquefaction susceptibility is the province of the project civil or geotechnical engineer. However, where geologic conditions on the site are conducive to liquefaction, it is incumbent on the project engineering geologist to recognize the potential for liquefaction and to integrate drilling and cone penetrometer data into a stratigraphic model to support the engineering analysis of liquefaction potential.

Lateral spreading and lurch cracking are ground failures induced by liquefaction in shallow earth materials. In lurch cracking, blocks of relatively dry surficial soil layers shift randomly over underlying liquefied material, resulting in cracks at the ground surface with horizontal and vertical offsets. Lateral spreading occurs where the soil layers overlying a liquified soil zone are free to move laterally. Lateral spreading occurs most commonly along stream or river banks where the steep bank provides a “free face” that allows the adjacent terrain to slide or flow into the channel. The engineering geologist shall address and identify the following:

a. If liquefaction potential is identified in an area of shallow slopes, the slopes must be evaluated for the potential for lateral spreading or lurch cracking to occur, especially where combined with a “free face” such as a steep stream or river bank that will permit lateral movement of a large soil mass. Evidence for past lateral spreading, lurch cracking, or liquefaction may be identified in trenches in areas suspected of liquefaction potential or may be gleaned from reports on damage from historical earthquakes. Topographic maps, LiDAR relief maps, and aerial photographs may also be useful in analyzing areas of liquefiable soils for evidence of past lateral spreading events.

b. The geometry of potential lateral spreading may be evaluated by exploration with emphasis on mapping of soil ages or soil densities, geomorphology, and ground water elevations. Lateral spreading analyses shall be accompanied by a minimum of one geologic cross section constructed parallel to the expected direction of flow.

c. Graphic representation of the extent of lateral spreading, if recognized, must be shown on the geologic map with a designation of areas considered to be at risk of future lateral spreading.

d. Identify the potential risk to life and property from lateral spreading.

e. Development of design values:

   i. Designate a building envelope.

ii. Develop a risk analysis that identifies alternatives and mitigations for lateral spreading.

iii. Provide geologic recommendations for the engineering design of risk-reduction structures.

iv. Develop appropriate monitoring and maintenance programs to assure success of risk-reduction grading and structures, if deemed necessary.

Coastal Bluffs and Beaches

The most recent *Coastal Engineering Manual* by the Department of the Army U.S. Corps of Engineers and *FEMA's Coastal Construction Manual* provide the guidelines for coastal analysis and construction with regard to site exploration and related geologic issues. Geologists should be aware that coastal projects involve a variety of permitting concerns that don't exist in other settings. Anyone not experienced in working on coastal projects shall discuss the study approach with County Planning staff.

FEMA has published base flood elevations for coastal flooding (effective date 9/28/17 or most current) for the Santa Cruz County coastline. These base flood elevations supersede any base flood elevations established by local wave run-up studies. If project engineers are required to perform separate analyses to evaluate wave impact forces for seawall and revetment design, the engineering geologist must work with the project engineer to develop an exploration plan which satisfies the goals of these required analyses. The FEMA Flood Insurance Rate maps also define areas of Primary Frontal Dunes which have special siting requirements for development.

The FEMA flood study does not include the impacts of sea level rise, which will become increasingly important in the future. The issue of sea level rise due to warming of the global climate is a developing field. Current estimates of the rate of sea level rise will undoubtably be revised in the future and the project engineering geologist should be familiar with the most current estimates of sea level rise when engaging on any coastal development project.

The following minimum areas shall be addressed in a *coastal study*. Typically, these studies will include both the work of the engineering geologist and civil engineer(s):

a. Investigate and develop a history of storm impacts on erosion of beach sand or coastal bluffs in the vicinity of the development.

b. Provide a description of manmade beach or coastal bluff protection structures on the subject property and adjacent properties.

c. Provide an evaluation of the current state or condition of existing beach or shoreline protection structures with recommendations for repair, maintenance, or removal, as needed.

d. Establish setbacks from coastal bluffs based upon analysis of erosion rates at the study site according to setback requirements established by the Local Coastal Program (LCP). In most cases, coastal erosion rates are estimated from comparison of survey maps and/or aerial imagery of different ages. For coastal bluffs, the retreat rate at the base of the bluff is the principal value of interest. However, in practice it may only be possible to estimate erosion rates based on the location of the bluff crest. Where the coastal bluff is comprised by Quaternary terrace deposits overlying bedrock, the estimated retreat rate shall be applied to the base of the bluff, and the existing bluff profile retreated landward, unless there is an overhang at the base of the bluff or other condition that indicates that a bluff failure is imminent. In such case, the overhang or incipient failure shall be assumed to fail immediately and the resulting bluff profile shall then be retreated landward.

   At sites where the toe of the bluff is protected by structures that will be maintained over the long term, the analysis can assume that no retreat due to wave erosion will occur at the toe of the bluff, and the required setback will be based on the equilibrium slope of the bluff derived from static and pseudo-static slope stability analysis conducted according to the County geotechnical guidelines. In areas where there is a potential for scour of beach sand at the base of the bluff, the static stability analysis must assume that any beach deposits at the toe of the bluff have been removed by scour. Pseudo-static analysis may assume a typical winter beach profile. Pseudo-static analysis shall include topographic amplification of seismic shaking where warranted by the height and steepness of the bluff.

e. Discuss the potential impacts of sea level rise on the proposed project.

f. Provide geologic information to support engineering design of shoreline protection structures, including a geologic map and geologic cross-section(s), as required.

g. Provide sand loss calculations for any proposed shoreline structure using current California Coastal Commission methodology.

h. Develop appropriate monitoring and maintenance programs to assure success of shoreline protection structures.

i. Review civil engineering design work including shoreline protection structures, building, and grading plans.

j. Where a shoreline protection structure is proposed, work with the project engineers to provide an alternatives analysis, as required by SCCC 16.10.070 (H)(3)(c), and develop impact mitigations using the identified future conditions.

k. Review and provide permitting history and maintenance agreements for coastal protection structures relied upon for project development.

Onsite Wastewater Treatment Systems (OWTS)

The goal of these guidelines with regards to Onsite Wastewater Treatment Systems (hereafter OWTS) is to assure these systems are placed in geologically appropriate locations that are best suited to the disposal of effluent. To this end, the engineering geologist must assist the OWTS designer in locating the systems away from areas of potential slope instability, adverse surface or subsurface water conditions, and/or in locations that contain fill or erosive conditions. As such, the geologic evaluation should be performed before the septic system design studies. The geologic evaluation shall include the following, when appropriate:

a. Provide a clear description of site-specific geology and indicate how the site geology may affect effluent disposal.

b. Where data exists, identify the depth to groundwater and evaluate seasonal groundwater conditions.

c. Review any exploratory trenches or test pits.

d. Evaluate potential sources of instability, including erosion and areas of fill, and establish setback recommendations from any areas of potential instability.

e. Review of the proposed Onsite Wastewater Treatment System design to assure compliance with recommendations.

CONCLUSIONS AND RECOMMENDATIONS

The principal contribution of the report to the project is the presentation of clear conclusions and recommendations that follow logically from the geologic observations presented in the site geologic characterization and the hazards and constraints analysis. The conclusions must be presented in a concise, complete manner, including an evaluation of the risk to the development from all identified geologic constraints, and recommendations to reduce risk to a level comparable to other risks faced by citizens of the region in day-to-day life (“ordinary” risk). The report shall also contain recommendations for post-construction maintenance, where necessary. Opinions and conclusions must be clearly supported by data and the analysis.

In some circumstances the recommendations of the engineering geologist may identify concerns which need analysis by a licensed geotechnical engineer or civil engineer. In these cases, the engineer will need to assist the engineering geologist in evaluating particular geologic constraints. Geotechnical or civil engineers will typically analyze slope stability concerns, establish special foundation criteria, develop erosion control and remedial grading plans, establish floodway and floodplain boundaries, and design debris/mud flow deflection walls and other structural elements.

All engineering geologic and geotechnical work must be coordinated and completed before the proposed development is submitted to the County for review. The Department of Community Development and Infrastructure staff welcomes involvement during the exploration phase and report writing process, but the actual coordination of the work necessary to complete the report is ultimately the responsibility of the consultant(s) and the owner(s)/applicant(s). The conclusions and recommendations shall include:

1. A statement of the potential geologic hazards posed to the development.

2. The engineering geologist must render a finding regarding the geologic suitability of the site for the intended use predicated upon completion of his/her recommendations and those of the geotechnical/civil engineer.

DOCUMENTATION AND IMPLEMENTATION

1. *Photographs, Maps, and Graphic Presentation of Exploration:* Copies of all relevant photographs, logs of boring, trench and test pit logs, maps and cross sections must be included in the report. All these documents must include clear documentation and be appropriately dimensioned. Unless indicated elsewhere in these guidelines, the CALTRANS Soil and Rock Logging, Classification, and Presentation Manual should be used in the sampling, and presentation of data from boring and other exploration techniques. Other methods of sampling and presentation are acceptable as long as they assure the same level of accuracy, detail and clarity.

2. *Bibliography and Reference List*: The GSA Reference Guidelines and Examples should be used for References cited and the bibliography. Other formats can be used as long as they contain similar information.

3. *Signature and license registration*: All professional geologists can prepare engineering geologic reports for the County of Santa Cruz if they are so qualified. All reports must be signed and stamped by a licensed Professional Geologist or Certified Engineering Geologist.

4. *Plan Review:* The project engineering geologist must review the project plans submitted for the project for conformance with the engineering geologic report recommendations. Coastal Development applications shall include a plan review letter approving the preliminary landscape and drainage design and proposed development location. A plan review letter approving the plans must be submitted prior to issuance of a building permit. The plan review letter must be accompanied by a fully executed Consultant Plan Review Form (PLG-300).

5. *Construction Observation:* Depending on the recommendations made in the engineering geologic report, it may be necessary for the project engineering geologist to observe and approve aspects of the project during construction. In practice, construction observations

include, at a minimum, confirming whether the proposed building is correctly located within the recommended geologically suitable building envelope. For projects such as landslide repairs, construction observation will require extensive involvement of the project engineering geologist to verify landslide depths and to confirm appropriate keyway depths, installation of drains, and to develop as-built plans.

6. *Final Reports*: The engineering geologist must issue a letter at completion of work to certify that development has occurred as per the approved report recommendations and the letter shall render a finding as to the adequacy of the project for the intended use. The completion letter shall be accompanied by a fully executed Geologist Final Inspection Form (PLG305). A supplemental report with revised maps must be submitted if new information is disclosed during site development or the project is conditioned for an as-built engineering geology report. If a supplemental report or as-built plans are required, the engineering geologist must observe and approve clean outs, keyways and benches, removals, and in some cases foundations. The as-built plans must include removal bottom locations and elevations and drain locations and elevations. Geologic information gathered from these inspections shall be submitted in a final report with appropriate graphics to document the inspections.

7. *Change of Consultant:* If the project engineering geologist changes during the course of a project, the new project engineering geologist shall complete, sign, and stamp a Transfer of Responsibility Form (PLG-250).