Guidelines for Evaluating Potential Surface Fault Rupture/Land Subsidence Hazards in Nevada

The Nevada Earthquake Safety Council recommends the use of the following Guidelines for Evaluating Potential Surface Fault Rupture/Land Subsidence Hazards. The Council recognizes that the governing standards are the current locally adopted codes and ordinances.

The Nevada Earthquake Safety Council facilitates public input, develops consensus about seismic issues within the public and private sectors, and is the public advisory body for state seismic policy and the Nevada Earthquake Risk Reduction Program of the Division of Emergency Management. The Board of Directors of the Council, which votes on policy recommendations, has 21 members, from both southern and northern Nevada, representing business and industry; city, county, and state governments, including the Assembly and Senate; geosciences; engineering; community organizations; universities; building officials; insurance; and primary-secondary education.

The first version of these guidelines was dated 30 July 1996; minor typographical errors were corrected on 24 November 1997. The Nevada Earthquake Safety Council approved this Revision 1 on 20 November 1998.

Jonathan G. Price
Director/State Geologist, Nevada Bureau of Mines and Geology, and
Secretary, Nevada Earthquake Safety Council

Guidelines for Evaluating Potential Surface Fault Rupture/Land Subsidence Hazards in Nevada (Revision 1)

I. INTRODUCTION

These guidelines were prepared by a subcommittee of the Geoscience Committee on Seismic Hazard Issues at the request of the Nevada Earthquake Safety Council, which is affiliated with the Division of Emergency Management, Department of Motor Vehicles and Public Safety, Division of Special Services.

Significant seismic hazards are present in Nevada. With the increase in population, the evaluation of fault rupture and fissuring is becoming more important for land use planning and development. The intent of these guidelines is to provide a standardized minimum level of investigation for fault rupture and fissuring in Nevada. They were prepared using established guidelines for surface fault rupture evaluation in California and Utah, and the current standard of practice in the greater metro Las Vegas, Reno, Sparks and Carson City areas.

These guidelines were prepared by The Association of Engineering Geologists, Great Basin Section in Reno, Nevada and the Southwestern Section in Las Vegas, Nevada in conjunction with the Nevada

Bureau of Mines and Geology, the University of Nevada, Reno, other Nevada professional geological organizations and the private geological consulting community.

II. WHEN TO PERFORM ANALYSIS

The investigation of sites for potential surface rupture or hazards due to differential subsidence and fissuring shall be included in all geotechnical investigations.

III. DESCRIPTION OF THE INVESTIGATION

A. INTRODUCTION

A competent professional should perform geologic investigations. Because of the complexity of this analysis, the competent professional performing each investigation must determine what is appropriate and necessary to obtain the highest quality information. The most useful technique at one site may be inappropriate for another site.

B. RESEARCH

Review of the region's seismic history, based on existing maps and technical literature.

1. Specific to Fault Rupture Hazard:

    a. Historic earthquakes, epicenter locations, and magnitudes in the vicinity of the site.

    b. Location of fault traces that may affect the site, including maps of faults and a discussion of the tectonics and other relationships of significance to the proposed construction.

    c. Location and chronology of other earthquake-induced features, such as settlement, landslides and liquefaction.

    d. Review of local groundwater data (water-level fluctuations, groundwater impediments, water quality variations, or anomalies indicating possible faults).

2. Specific to Differential Subsidence and Fissure Hazard:

    a. Identify and locate any faults, scarps, and fissures in the vicinity of the site.

    b. Review available land level lines of past ground surface movement in the vicinity of the site, including degree of differential subsidence across nearby faults and proximity of regional subsidence bowls.

c. Review groundwater development in the vicinity including the location of nearby high-capacity wells. Review available well maintenance records of nearby wells for signs of possible subsidence-induced damage.

d. Review of subsurface units from available well driller's logs for nearby water wells and available historic water level data from nearby wells.

C. AERIAL PHOTOGRAPHS

Analysis should include interpretation of aerial photographs and other remotely sensed images for fault-related topography, vegetation, soil contrasts, and lineaments of possible fault or fissure origin. Where possible, analysis may include low-sun-angle aerial photography and/or aerial reconnaissance.

D. SURFACE INVESTIGATION

A competent professional shall inspect the site.

1. Non-Specific:

a. Mapping of surface features, including geologic units and structures and topographic features both on and beyond the site. For normal and strike-slip faults these features commonly include:

Normal faults	Strike-Slip Faults
Over-steepened base of mountain fronts	Scarps in Quaternary deposits and landforms
Scarps in Quaternary deposits and landforms, and offsets in Quaternary deposits	Scarps, and laterally offset streams and ridges, and offsets in Quaternary deposits
Grabens in Quaternary deposits	Rift valleys
Faceted spurs	Shutter ridges
Zigzag fault patterns	Pressure ridges
Wine glass canyons	Sag ponds
Fissures, springs, vegetation alignments	Fissures, spring and vegetation alignments

b. Conduct visual inspections for signs of ground movement (distress) of man-made structures on adjacent developments. Review available soils reports to determine the geotechnical conditions of sites in the area.

2. Specific to Fault Rupture Hazard:

a. If any Quaternary age surface rupture is mapped or otherwise interpreted to be present on the site, the feature shall be further investigated as described below in Section III E.

E. SUBSURFACE INVESTIGATION

A subsurface investigation shall consist of trenching and other excavating, with appropriate logging and documentation to permit detailed and direct observation of exposed geologic units and features.

1. Non-Specific:

    a. This includes trenching across potentially active faults and suspicious zones to determine the following: location and recency of movement, width of disturbance, physical condition of fault zone materials, type of displacement, geometry of fault features, slip rate, and recurrence interval.

    b. Borings or test pits to collect data to evaluate depth and type of materials present, groundwater depth, and to verify fault-plane geometry. Data points should be sufficient in number and adequately spaced to permit correlations and interpretations.

    c. Geophysical surveys conducted to facilitate the evaluation of the types of site materials and their physical properties, ground water conditions, and fault displacements.

2. Specific to Differential Subsidence and Fissure Hazard:

    a. Detailed trench logging at the site should focus on determining the location and possible causes of fissuring. Compare trenches across fissures in areas on the site and in areas where fissures are not observed at the surface. Additional objectives should be determining the width of the fissure zones and the general geometry and depth of fissures. Analysis of trenches should help determine feasible means of site remediation.

F. SPECIAL INVESTIGATIVE METHODS

1. Special investigative methods may be used when conditions or critical structures demand a more intensive investigation.

    a. Aerial reconnaissance overflights, including special photography.

    b. Geodetic and strain measurements, micro-seismicity monitoring, or other monitoring techniques.

    c. Radiometric age analysis (C14, K-Ar), stratigraphic correlation (fossils, mineralogy), soil profile development, paleomagnetism, or other age-dating techniques to identify age of faulted or unfaulted units or surfaces.

IV. SUGGESTED OUTLINE FOR POTENTIAL SURFACE RUPTURE SECTION OF GEOTECHNICAL INVESTIGATION REPORTS

The following subjects should be addressed, or at least considered, in any geologic report on faults. Some of the investigative methods described herein should be carried out beyond the site being investigated. It is not expected that all of the methods identified would be used in a single investigation.

A. TEXT

1. Purpose and scope of investigation.

2. Geologic setting.

3. Site description and conditions, including information on geologic units, aquifer conditions, graded and filled areas, vegetation, existing structures, and other factors that may affect the choice of investigative methods and the interpretation of data.

4. Methods of investigation utilized.

5. Conclusions.

    a. Location (or absence) of all surface ruptures on or adjacent to the site.

    b. Type of faults and nature of anticipated offset: Direction of relative displacement, and maximum possible displacement.

    c. Statement of relative risk addressing the probability or relative potential for future surface displacement. This may be stated in semi-quantitative terms such as low, moderate, or high, or in terms of slip rates determined for specific fault segments.

    d. Degree of confidence in, and limitations of, the data and conclusions.

6. Recommendations

a. Set-back distances from faults and fissures. State, Federal or local guidelines may dictate minimum standards otherwise, the minimum set-back distance for occupied structures from Holocene active faults shall be fifty (50) feet. Furthermore, no critical facility shall be placed directly over the trace of a Late Quaternary active fault. When necessary, set-back distances from fissures and Late Quaternary and Quaternary active faults will be recommended by the competent professional.

b. Provide mitigative measures for appropriate structures that cannot avoid crossing faults and fissures. Examples include, but are not limited to, critical pipelines, aqueducts, flood channels, railroads, and roadways.

c. Need for additional studies, or inspection during construction.

B. REFERENCES

1. Literature and records cited or reviewed; citations should be complete.

2. Aerial photographs or images interpreted including type, date, scale, source, and index numbers.

3. Other sources of information, including well records, personal communications, and other data sources.

C. ILLUSTRATIONS

Illustrations are essential to the understanding of the report and to reduce the length of text.

1. Location map - identify site locality, significant faults, geographic features, regional geology, seismic epicenters, and other pertinent data. A 1:24,000 scale is recommended.

2. Site development map. Show site boundaries, existing and proposed structures, graded areas, streets, exploratory trenches, borings, geophysical traverses, and other data. Recommended scale is 1 inch equals 200 feet (1:2,400) or larger.

3. Geologic map. Shows distribution of geologic units (if more than one), faults and other structures, geomorphic features, aerial photo lineaments, and springs, on topographic map at 1:24,000 scale or larger. Can be combined with C(1) or C(2).

4. Geologic cross-sections.

5. Logs of exploratory trenches and borings. Show details of observed features and conditions; should not be generalized or diagrammatic. Trench logs should show topography and geologic structure at the same horizontal and vertical scale.

6. Geophysical data and geologic interpretations.

7. Photographs of scarps, surface ruptures, trenches, samples, or other features that enhance understanding of the site conditions.

D. APPENDIX

Supporting data not included above (e.g., water well data).

E. AUTHENTICATION

Signature of competent professional who conducted the investigation.

V. DEFINITIONS

Active Fault: Active faults for the Basin and Range physiographic province are categorized as follows:

Holocene Active Fault - a fault that has moved within the last 10,000 years.

Late Quaternary Active Fault - a fault that has moved within the last 130,000 years.

Quaternary Active Fault - a fault that has moved within the last 1,600,000 years.

Competent Professional: A geological professional with an academic degree who is qualified to analyze geological data relevant to these guidelines, to make hazard recommendations, and to prepare a written geologic report on fault and/or fissure investigations for engineering purposes. The competent professional will have a minimum of three years demonstrated experience in conducting geologic site investigations, including fault or fissure hazard evaluations, for engineering purposes. The competent professional will satisfy the definition of Professional Geologist under Nevada State law (NRS 514.005).

Critical Facility: A building or structure that is considered critical to the function of the community or the project under consideration. Examples include, but are not limited to, hospitals, fire stations, emergency management operations centers, and schools.

Differential Land Subsidence: Subsidence across pre-existing faults.

Earth Fissure: Ground cracks or voids found in the near surface of the earth. Earth fissures in Nevada are believed to have formed in response to tensional or horizontal stresses from regional land subsidence or to ground shaking from earthquakes resulting in ground deformation or both.

Fault: A fracture or a zone of fracturing along which there has been displacement of the sides relative to one another parallel to the fracture.

Fault Line (Trace): The line or trace of a fault plane on the ground surface or on a reference plane formed by the intersection of a fault and the earth's surface.

Fault Scarp: A steep slope or cliff formed directly by movement along the fault and representing the exposed surface of a fault before modification by erosion and weathering.

Fault Zone: A fault expressed as a zone of numerous small fractures or angular rock fragments or fault gouge (finely ground rocks). A fault zone may be up to hundreds of meters wide.

Inactive Fault: A fault without recognized activity within Quaternary time (within the past 1,600,000 years).

Land Subsidence: The gradual downward settling or sinking of the earth's surface.

Lineament: Linear or curvilinear geomorphic feature interpreted to be of tectonic origin which does not clearly exhibit fault scarp characteristics and cannot be differentiated by age.

Occupied Structures: A structure for human occupancy is a building, as defined by the Uniform Building Code, which is expected to have a human occupancy rate of more than 2,000 man hours per year.

Set-Backs: Minimum distance a structure for human occupancy must be from a surface rupture.

Subsidence-Induced Movement: Renewed movement of a fault induced by historical land subsidence. Subsidence induced movement may occur on a fault regardless of earthquake activity on the fault.

Surface Rupture: A fracture or break in the ground surface resulting from faulting, fissuring, or land subsidence.

VI. RELEVANT REFERENCES

To limit the length of this document, references relevant to these guidelines were not included. However, pertinent references associated with these guidelines are available online at the Nevada Bureau of Mines and Geology web site (www.nbmg.unr.edu).