Utah State Office of Education – Geologic-Hazard Report Guidelines and Review Checklist for New Utah Public School Buildings

July 23, 2012

To ensure that proposed school building sites are investigated for potential geologic hazards, the Utah State Office of Education (USOE) recommends the preparation of geologic-hazard reports (http://www.schools.utah.gov/finance/Facilities.aspx) by Utah-licensed geologists and subsequent review of those reports by the Utah Geological Survey (UGS). The purpose of the report review is to ensure that site-specific geologic-hazard investigations are sufficiently thorough, that the report conclusions regarding any identified geologic hazards are valid, that proposed mitigation measures are reasonable, and that geologic hazards are addressed uniformly and effectively throughout the state. These guidelines and review checklist have been prepared to assist in the preparation of geologic-hazard reports for new Utah public school buildings, to facilitate the review of those reports by the UGS, and to provide feedback related to geologic hazards to school-site development consultants. In addition to the guidelines and review checklist, this document includes a list of references cited and a glossary of geologic-hazard terms.

The suitability of a proposed school site relative to geologic hazards is a safety-related issue. These guidelines and subsequent review are non-regulatory, but the guidelines cite relevant sections of the *2009 International Building Code* (International Code Council, 2009) that indicate specific geologic hazards that should be addressed in a geologic-hazard assessment of a proposed site. The need for detailed studies can generally be assessed by consulting regional geologic-hazard maps available for various parts of the state; however, these maps are not a substitute for site-specific geologic-hazard investigations.

The complex and interdisciplinary nature of geologic hazards often requires engineering geologists, engineers, and other design professionals to work together to prepare geologic-hazard reports and integrate them into the project design. Involvement of both engineering geologists and engineers, including geotechnical, civil, and structural, will generally provide greater assurance that geologic hazards are properly identified, assessed, and mitigated. Preparation of geologic-hazard reports must be performed by Utah-licensed Professional Geologists. The UGS will review geologic-hazard reports from a geologic perspective; however, if hazard evaluation or risk reduction measures include engineering analyses, design, and/or recommendations, a Utah-licensed Professional Engineer specializing in geotechnical engineering must review them.

The UGS Geologic Hazards Program has developed a Web site for consultants and design professionals (http://geology.utah.gov/ghp/consultants/index.htm) containing recommended guidelines for geologic-hazard reports and for evaluating surface fault rupture and landslides in Utah; published UGS geologic-hazard maps, reports, site-specific studies, geologic maps, and hydrogeology publications; historical aerial photography; important external publications in the literature (including many of the papers cited in this document); and links to external Web sites. While this Web site should be used during geologic-hazard investigations as a source of current, published information on Utah's geologic hazards, it is not a complete source for all geologic-hazard information. As a result, a thorough literature search and review should be performed.

UGS review of geologic-hazard reports (http://geology.utah.gov/ghp/school-site_review/index.htm) encompasses 16 items associated with the project and geologic hazards as indicated on the accompanying checklist. UGS staff will review the submitted report for pertinent information related to each item, determine if the report adequately addresses the item, and provide brief comments on the item, if needed.

CONTACTS

Utah Geological Survey (UGS), Geologic Hazards Program (GHP)
http://geology.utah.gov/ghp/index.htm
Program Manager – Steve Bowman [(801) 537-3304], stevebowman@utah.gov

Northern/Central Utah (Box Elder, Cache, Carbon, Daggett, Davis, Duchesne, Emery, Grand, Juab, Millard, Morgan, Rich, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, Wasatch, and Weber Counties)

Department of Natural Resources Building
1594 West North Temple, P.O. Box 146100
Salt Lake City, Utah 84114-6100
(801) 537-3300, FAX (801) 537-3400

School-Site Review Coordinator - Richard Giraud [(801) 537-3351], richardgiraud@utah.gov

Southern Utah (Beaver, Garfield, Iron, Kane, Piute, San Juan, Washington, and Wayne Counties)

Southern Utah Regional Office
88 East Fiddler Canyon Road, Suite C
Cedar City, Utah 84721
(435) 865-9034, FAX (435) 865-9037

School-Site Review Coordinator – William Lund [(435) 865-9034], billlund@utah.gov

USOE School-Site Geologic-Hazard Report Guidelines and Review Checklist

Project:		**USOE Project #:**		**Adequately Documented**	**Additional Information Needed**
Location:		**First Review:** ☐	**Review # :** ☐		
		Reviewed By:			
School District:	**County:**	**Review Date:**			

1. Project Description and Location

Provide a description of the size, type of construction, intended foundation system, grade/floor elevations, building area (square feet), and International Building Code (IBC) building occupancy category (Table 1604.5). Provide a marked location on an index map using a 7-1/2 minute USGS topographic map or equivalent base map; indicate the ¼-section, township, and range; and provide the site latitude and longitude to three decimal places with datum.	☐	☐
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2. Site Geology and Geologic Maps

Describe site geology according to *Guidelines for Preparing Engineering Geologic Reports in Utah* (AEG, 1986) and current ASTM D420 standard. The degree of detail and scale of site geologic mapping should be compatible with the geologic complexity of the site, type of building, and layout. For hillside sites, describe geology of both the site and adjacent properties, including any known or mapped landslides. The site geologic maps should be 1:12,000-scale or larger (such as 1:1200). List the source, project code, line and frame numbers, date, and scale for aerial photography used in the report. For more information, see *Recommended Report Guidelines* at http://geology.utah.gov/ghp/consultants/rpt_guidelines.htm, *Historical Aerial Photography* at http://geology.utah.gov/ghp/consultants/aerial_compilations.htm, and *Useful Websites* at http://geology.utah.gov/ghp/consultants/geohaz_websites.htm.	☐	☐
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3. Regional Fault Map

Provide a regional fault map showing the location of all mapped or known Quaternary faults, including fault orientation (trend of surface trace, sense of displacement, etc.) and fault activity class (age category) (Christenson and others, 2003) within 10 miles of the site. For more information, see *USGS Quaternary Fault and Fold Database of the U.S.* at http://earthquake.usgs.gov/regional/qfaults/, the *UGS Paleoseismology of Utah Series* at http://geology.utah.gov/ghp/consultants/paleoseismic_series.htm, *Geographic Information System Database Showing Geologic-Hazard Special Study Areas, Wasatch Front, Utah* at http://geology.utah.gov/online/c/c-106.pdf, and links at http://geology.utah.gov/ghp/consultants/index.htm.	☐	☐
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4. Subsurface Information

Provide subsurface engineering geologic and geotechnical information, including a site-specific plan view map showing exploration sites (borings, test pits, trenches, etc.), existing ground-water levels, and areas of existing and planned cuts and fills. A site geologic cross section(s) summarizing subsurface geologic conditions is recommended. The degree of detail and scale of site geologic cross sections should be compatible with the geologic complexity of the site, type of building, and layout. All exploration logs must be provided.	☐	☐
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5. Surface Faulting

Evaluate the surface-faulting hazard for any faults on the site having Quaternary displacement in accordance with the *Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah* (Christenson and others, 2003). If the fault age (activity class) is unknown, the fault should be considered Holocene unless data are adequate to rule out Holocene displacement. Surface-fault-rupture special-study areas are defined for most Quaternary faults along the Wasatch Front, and generally extend a minimum of 500 feet from the fault on the downthrown side and 250 feet on the upthrown side. Where a surface-fault-rupture special-study area has not been defined, the need for a site-specific fault-hazard investigation should be determined based on distance between the site and nearest mapped Quaternary fault, and whether the fault trace is well defined, buried, or approximately located (see guidelines in Christenson and others, 2003, p. 4). If on-site investigations reveal the presence of a Quaternary fault, an appropriate building setback should be established following the method described in Christenson and others (2003, p. 8). For schools, Christenson and others (2003) recommend a minimum building setback of 50 feet from the trace of faults having an activity class of Holocene or late Quaternary, and consider building setbacks prudent for faults having an activity class of Quaternary. For more information, see *Recommended Report Guidelines* at http://geology.utah.gov/ghp/consultants/rpt_guidelines.htm, *Geologic Maps* at http://geology.utah.gov/maps/geomap/index.htm, *Geographic Information System Database Showing Geologic-Hazard Special Study Areas, Wasatch Front, Utah* at http://geology.utah.gov/online/c/c-106.pdf, Bonilla and Lienkaemper (1991), and McCalpin (2009).	☐	☐
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6. Seismic Ground Shaking and Design Parameters

Evaluate the seismic ground-shaking hazard and provide seismic design parameters (site coefficients, mapped spectral accelerations, and design spectral response acceleration parameters) according to IBC Section 1613.5. Characterize the upper 100 feet of the building site profile to determine the site class as outlined in IBC Table 1613.5.2. If the building site profile is Site Class F, site-specific evaluation is required by the IBC and outlined in ASCE Standard 7. The IBC occupancy category of schools with an occupant load greater than 250 is Category III; however, if the school is designated as an essential facility, the occupancy category is IV. For more information, see *Useful Websites* at http://geology.utah.gov/ghp/consultants/geohaz_websites.htm, and *External Publications* at http://geology.utah.gov/ghp/consultants/outside_pubs.htm.	☐	☐
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7. Liquefaction

Evaluate the liquefaction hazard at the site. IBC Section 1803.5.11 requires a liquefaction evaluation if the structure is determined to be in Seismic Design Category C. IBC Section 1803.5.12 requires a liquefaction evaluation and an assessment of potential consequences of any liquefaction and mitigation measures if the structure is in Seismic Design Categories D, E, or F. The evaluation should address the possibility of local perched ground water and the raising of ground-water levels by seasonal or longer-term climatic fluctuations, landscape irrigation, and soil absorption systems (septic systems, infiltration basins, etc.). A minimum boring depth of 50 feet below the existing ground surface is recommended for evaluating the liquefaction hazard. From site borings, report Standard Penetration Test (SPT) blow counts using the current ASTM D1586 standard. The Cone Penetration Test (CPT) according to the current ASTM D3441 standard may be used, but only concurrent with SPT data for reliable correlation. Include complete liquefaction analysis information, including all calculations. Minimum acceptable safety factors for liquefaction generally range from 1.15 to 1.3. The final choice of an acceptable safety factor depends on many factors, such as the ground-motion parameters used, site conditions, likely ground-failure mode (settlement, lateral spread, etc.), and the critical nature of the structure or facility. Lower safety factors may be justified for large, infrequent earthquakes (e.g., the maximum credible earthquake (MCE) or the 2% probability of exceedance in 50-year event), less damaging failure modes, and non-essential facilities. Determine the likely ground-failure mode, amount of displacement, and acceptable safety factor, and evaluate cost-effective liquefaction mitigation. As the UGS will review liquefaction from a geologic standpoint, additional engineering review by others will be required. For more information, see Martin and Lew (1999), Youd and others (1999, 2001), Seed and others (2003), *Geologic Hazards Maps* at http://geology.utah.gov/maps/geohazmap/index.htm, and *External Publications* at http://geology.utah.gov/ghp/consultants/outside_pubs.htm.	☐	☐
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8. Seismically-Induced Settlement or Ground Failure

Evaluate the potential for seismically-induced settlement or ground failure (other than liquefaction), such as from sensitive clays or loose, granular soils, and tectonic subsidence accompanying surface faulting. For Seismic Design Category C, IBC Section 1803.5.11 requires an assessment of surface displacement due to faulting or lateral spreading. For Seismic Design Categories D, E, and F, IBC Section 1803.5.12 requires an assessment of potential consequences of soil strength loss, including estimating differential settlement, lateral movement, and reduction in foundation soil bearing capacity, and addressing mitigation measures. As the UGS will review seismically induced settlement or ground failure from a geologic standpoint, additional engineering review by others will be required. For more information, see Keaton (1986) for potential consequences of regional tectonic subsidence along the Wasatch fault and *External Publications* at http://geology.utah.gov/ghp/consultants/outside_pubs.htm.	☐	☐
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9. Problem Soil and Rock and Shallow Ground Water

Evaluate the potential for problem soil and/or rock and shallow ground water. The evaluation should consider collapsible, expansive, soluble, organic, erodible, piping, and corrosive soil and/or rock. If collapsible soils are present, the site should be classified as Site Class F according to IBC Table 1613.5.2, and a site-specific geotechnical evaluation is required. IBC Section 1803.5.3 outlines site soil classification and additional criteria for expansive soils. The evaluation should also consider non-engineered fill, mine subsidence, shallow bedrock, karst, breccia pipes, sinkholes, caliche, and active sand dunes, as applicable. When evaluating the depth to ground water, consider perched, irrigation-induced, and other ground-water conditions outlined in Items 7 and 10 of this checklist. For more information, see *Geologic Hazards Maps* at http://geology.utah.gov/maps/geohazmap/index.htm and *External Publications* at http://geology.utah.gov/ghp/consultants/outside_pubs.htm.	☐	☐
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10. Soil and Rock Slope Stability, Debris Flows, and Rock Fall

Evaluate the potential for slope failure in general accordance with the *Guidelines for Evaluating Landslide Hazards in Utah* (Hylland, 1996) and debris flows in accordance with the *Guidelines for the Geologic Evaluation of Debris-Flow Hazards on Alluvial Fans in Utah* (Giraud, 2005). The slope stability evaluation must consider immediately adjacent property, constructed cut and fill slopes, existing landslides, appropriate seismic ground-shaking levels (pseudo-static coefficients), and development- and climatic-induced ground-water conditions. The evaluation must also consider rock fall, debris flow, and snow avalanche hazards, where appropriate. For hillside sites, include slope stability evaluation of both the site and adjacent properties. IBC Section 1808.7 outlines building setbacks from slopes and IBC Appendix J outlines grading provisions for cuts and fills, drainage, slope benching, and erosion control. For more information, see *Recommended Report Guidelines* at http://geology.utah.gov/ghp/consultants/rpt_guidelines.htm, Blake and others (2002), *Geologic Hazards Maps* at http://geology.utah.gov/maps/geohazmap/index.htm, and *External Publications* at http://geology.utah.gov/ghp/consultants/outside_pubs.htm.	☐	☐
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11. Flooding

Evaluate the potential for flooding and erosion on alluvial fans and from streams, lakes, dam failures, canals, and ditches. Determine the Federal Emergency Management Agency (FEMA) flood zone on a current, official flood map (http://msc.fema.gov). IBC Appendix G outlines flood-resistant construction guidelines. For more information, see *Geologic Hazards Maps* at http://geology.utah.gov/maps/geohazmap/index.htm, *Useful Websites* at http://geology.utah.gov/ghp/consultants/geohaz_websites.htm, dam failure maps at http://www.waterrights.utah.gov/daminfo/default.asp, and National Research Council (1996).	☐	☐
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12. Seiches and Other Earthquake- or Landslide-Induced Flooding

Evaluate the potential for seiches and other earthquake- or landslide-induced flooding if the site is located near a lake or reservoir.	☐	☐
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13. Radon

Optionally, evaluate the potential for naturally occurring radon gas at the site (not required by the 2009 IBC; however, radon potential should be evaluated). For more information, see *Geologic Hazards Maps* at http://geology.utah.gov/maps/geohazmap/index.htm, *Useful Websites* at http://geology.utah.gov/ghp/consultants/geohaz_websites.htm, and Environmental Protection Agency (1994).	☐	☐
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14. Geologic-Hazard Zones, Maps, and Ordinances

Review and cite applicable geologic-hazard zones, maps, ordinances, and applicable zoning and building regulations required by the permitting jurisdiction. For more information, see *Useful Websites* at http://geology.utah.gov/ghp/consultants/geohaz_websites.htm and *Geographic Information System Database Showing Geologic-Hazard Special Study Areas, Wasatch Front, Utah* at http://geology.utah.gov/online/c/c-106.pdf.	☐	☐
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15. Report Background Information and References

List references and Web sites used in research, analysis, and the report. Avoid using out-of-date and/or superseded maps and reports. For more information, see *Geologic-Hazard Resources for Consultants and Design Professionals* page and links at http://geology.utah.gov/ghp/consultants/index.htm. Note that other information sources may exist and should be evaluated with a thorough literature search and review.	☐	☐
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16. Utah-Licensed Professional Geologist/Engineer Seal

The geologic hazards report must be stamped and signed by the engineering geologist who conducted the investigation. The geologist must be licensed to practice geology in Utah. The Utah Division of Occupational and Professional Licensing (DOPL) defines a Professional Geologist (PG) as a person licensed to engage in the practice of geology before the public, but does not define or license geologic specialists, such as engineering geologists. The UGS considers an engineering geologist to be a person who through education, training, and experience is able to assure that geologic factors affecting engineering works are recognized, adequately interpreted, and presented for use in engineering practice and/or the protection of the public; this person shall have a Bachelor's degree in geology, engineering geology, or a closely related field from an accredited university and at least three full years of experience in a responsible engineering geology position. If a geotechnical report or other engineering analysis and/or recommendations are included with the geologic-hazard report, a Professional Engineer (PE) licensed in Utah must also stamp and sign the report or pertinent sections. For more information, see *Useful Websites* at http://geology.utah.gov/ghp/consultants/geohaz_websites.htm.	☐	☐
Review Comments:		

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GLOSSARY OF GEOLOGIC-HAZARD TERMS AS DEFINED BY THE UTAH GEOLOGICAL SURVEY

Active sand dunes – Shifting sand moved by wind. May present a hazard to existing structures (burial) or roadways (burial, poor visibility).

Alluvial fan – A generally low, cone-shaped deposit formed by deposition from a stream issuing from mountains as it flows onto a lowland.

Alluvial-fan flooding – Flooding of an alluvial-fan surface by overland (sheet) flow or flow in channels (stream flow, debris flow) branching outward from a canyon mouth. See also, alluvial fan.

Avalanche (snow) – A large mass of snow or ice that moves rapidly down a mountain slope.

Canal/ditch flooding – Flooding due to overtopping or breaching of canals or ditches.

Collapsible soil – Soil that has considerable strength in its dry, natural state, but that settles significantly due to hydrocompaction when wetted. Usually associated with young alluvial fans, debris flows, and loess.

Dam-failure flooding – Flooding downstream from a dam caused by an unintentional release of water due to a partial or complete dam failure.

Debris flow – Slurry of rock, soil, organic matter, and water (generally >60% sediment by volume) that flows down channels and onto alluvial fans. May be initiated by erosion during a cloudburst storm or by a shallow (slip surface generally less than 10 feet deep) slope failure on a steep mountain slope. Debris flows can quickly travel long distances from their source areas, presenting hazards to life and property along stream channels and on or near downstream alluvial fans.

Earthquake – A sudden motion or trembling of the earth as stored elastic strain energy is released by fracture and movement of rocks along a fault.

Earthquake-induced flooding – Flooding caused by a seiche, tectonic subsidence, increase in spring discharge or rise in water table, disruption of streams and canals caused by an earthquake. See also, seiche, tectonic subsidence.

Erosion – Removal and transport of soil or rock from a land surface, usually through chemical or mechanical means.

Expansive soil and/or rock – Soil or rock that swells when wetted and shrinks when dried. Typically associated with high clay content, particularly sodium-rich clay.

Ground shaking – The shaking or vibration of the ground during an earthquake.

Holocene – The period of time between about 11,800 years ago and the present (Holocene Epoch). Also the geologic deposits that formed during that time (Holocene Series). See also, Quaternary.

Hyperconcentrated flow – Slurry of rock, soil, organic matter, and water (generally 20-60% sediment by volume) that flows down channels and onto alluvial fans. May be initiated by erosion during a cloudburst storm or by a shallow (slip surface generally less than 10 feet deep) slope failure on a steep mountain slope. Hyperconcentrated flows can travel long distances from their source areas, presenting hazards to life and property along stream channels and on or near downstream alluvial fans.

Lake flooding – Flooding around a lake caused by a rise in lake level.

Landslide – General term referring to any type of slope failure, but usage here refers chiefly to large-scale rotational slumps and slow-moving earth flows.

Liquefaction – Sudden, large decrease in shear strength of a saturated, cohesionless soil (generally sand, silt) caused by a collapse of soil structure and temporary increase in pore water pressure during earthquake ground shaking. Liquefaction may induce ground failure, including lateral spreads and flow-type landslides.

Mine subsidence – Subsidence of the ground surface due to the collapse of underground mines.

Non-engineered fill – Soil, rock, or other fill material placed by humans without engineering specification, observation, and testing. Such fill may be uncompacted, contain voids and/or oversize, low-strength, and/or decomposable material; be subject to differential subsidence; and may have a low bearing capacity and/or poor stability characteristics.

Organic deposits (peat) – An unconsolidated surface deposit of semicarbonized plant remains in a water-saturated environment, such as a bog or swamp. May also occur as thin interbeds in soil or in a dried-out state. Organic deposits are highly compressible, have a high water-holding capacity, and can oxidize and shrink rapidly when drained.

Piping – Subsurface erosion of soil or rock by ground-water flow, forming narrow voids. Pipes can remove support of overlying soil and rock, resulting in collapse.

Problem soil and rock – Geologic materials having characteristics that make them susceptible to volumetric changes, collapse, subsidence, or other engineering geologic problems.

Quaternary – The period of time between 2.6 million years ago and the present (Quaternary Period). Also the geologic deposits that formed during that time (Quaternary System). The Quaternary comprises the Holocene and Pleistocene Epochs/Series. Note that prior to June 2009, the beginning of the Quaternary had generally been defined as 1.8 million years ago. See also, Holocene.

Radon – A radioactive gas that occurs naturally through the decay of uranium and radium. Radon can be present in high concentrations in soil derived from rock such as granite, shale, phosphate, and certain metamorphic rocks. Exposure to elevated levels of radon can cause an increased risk of lung cancer.

Rock fall – The relatively free falling or precipitous movement of rock from a slope by rolling, falling, toppling, or bouncing. The rock-fall runout zone encompasses the area at risk from falling rocks below a rock-fall source.

Sensitive clay – Clay soil that experiences a particularly large loss of strength when disturbed and is subject to failure during earthquake ground shaking.

Shallow bedrock – Bedrock at depths sufficiently shallow to be encountered in construction excavations.

Shallow ground water – Ground water within about 10 feet of the ground surface. A rising water table can cause flooding of basements, crawlspaces, and septic drain fields.

Slope failure – Downslope movement of soil or rock by falling, toppling, sliding, or flowing. See also, landslide.

Soluble soil or rock (karst) – Soil or rock containing minerals that are soluble in water, such as calcium carbonate (principal component of limestone), dolomite, and gypsum. Dissolution of minerals and rocks can cause subsidence and formation of sinkholes.

Stream flooding – Overbank flooding of floodplains along streams; area subject to flooding generally indicated by extent of floodplain or calculated extent of the 100- or 500-year flood.

Subsidence – Permanent lowering of the normal level of the ground surface by hydrocompaction, piping, karst, collapse of underground mines, loading, decomposition or oxidation of organic soil, faulting, or settlement of non-engineered fill.

Surface faulting (surface fault rupture) – Propagation of an earthquake-generating fault rupture to the ground surface, displacing the surface and forming a scarp.

Tectonic subsidence – Lowering and tilting of a basin floor on the downdropped side of a fault during an earthquake.