Exhibit C, Chapter 8-5I, Morgan County Code

Chapter 8-5I

GEOLOGIC HAZARDS ORDINANCE

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8-5I-010 **Purpose.** This Title and the regulations and restrictions contained herein are adopted and enacted for the following purposes:

(a) To protect the health, safety, and welfare of the citizens of Morgan County, protect Morgan County's infrastructure and financial health, and minimize adverse effects of geologic hazards to public health, safety, and property by encouraging wise land use;

(b) This chapter and its appendices address surface fault rupture, slope stability, liquefaction, debris flow, rock-fall, and avalanche hazards and present minimum standards and methods for evaluating

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geologic hazards;

(c) The applicant shall present the results of geologic hazards studies in compliance with this chapter and its appendices. The standards set forth in the appendices are minimum requirements. More complex projects may require more detailed and in-depth evaluations than outlined herein. In addition, the appendices shall not supersede other more stringent requirements that may be required by other regulatory agents, and;

(d) Geological Hazards Study Areas are defined in Section 8-5I-040, Geologic Hazards Study Areas. Site-specific geologic hazards assessments performed by qualified engineering geologists shall be required prior to developing projects located within a Geologic Hazards Study Area. In the event known or readily apparent geologic hazards exist in an area subject to a development application, and which area is not included in a Geologic Hazards Study Area, the applicant shall nevertheless submit the applicable study and the process outlined in this chapter shall be followed.

8-5I-020 Definitions.

As used in this chapter:

Acceptable and Reasonable Risk: No loss or significant injury to occupants, no release of hazardous or toxic substances, and minimal structural damage to buildings or infrastructure.

Accessory Building: Any structure not designed for human occupancy, which may include tool or storage sheds, gazebos, and swimming pools. Accessory dwelling units and businesses located in accessory buildings must comply with all requirements of main buildings.

Activity Class (faults): The level of activity of a fault based on the time of most recent movement (Holocene, movement in the past 10,000 years; Late Quaternary, movement in the past 130,000 years; Quaternary, movement in the past 1,600,000 years).

Alluvial Fan: A fan-shaped deposit where a fast-flowing stream flattens, slows, and spreads, typically at the exit of a canyon onto a flatter plain.

Avalanche: A large mass of predominantly snow and ice, but also including a mixture of soil or rock and organic debris, falling, sliding, or flowing rapidly under the force of gravity.

Buildable Area: Based on an accepted geologic hazards report, the portion of a site not impacted by geologic hazards, or the portion of a site where it is concluded the identified geologic hazards can be mitigated to an acceptable and reasonable risk. Buildable areas must be clearly marked on approved site plans and/or final approved plats, as appropriate.

County Council: The County Council of Morgan County.

Critical Facilities: Essential, hazardous, special occupancy facilities, and Occupancy Categories III and IV as defined in the currently adopted International Building Code, and lifelines such as major utility, transportation, and communication facilities and their connections to critical facilities.

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Debris Flow: A slurry of rock, soil, organic material, and water transported in an extremely fast and destructive flow that flows down channels and onto and across alluvial fans, including a continuum of sedimentation events and processes including debris flows, debris floods, mudflows, clear-water floods, and alluvial.fan flooding.

Development: All critical facilities, subdivisions, single-family dwellings, duplexes, and multi-family dwellings, commercial and industrial buildings; also additions to or intensification of existing buildings, storage facilities, pipelines and utility conveyances, and other land uses.

Engineering Geologist: A Utah-licensed geologist, who, through education, training, and experience, practices in the field of engineering geology.

Engineering Geology: Geologic work that is relevant to engineering and environmental concerns, and the public health, safety, and welfare. Engineering geology is the application of geological data, principles, and interpretation affecting planning, design, construction, and maintenance of engineered works, land use planning, and groundwater.

Essential Facility: Buildings and other structures intended to remain operational in the event of an adverse geologic event, including all structures defined in Table 1.

Fault: A fracture in the earth's crust forming a boundary between rock or soil masses that have moved relative to each other.

Fault Setback: An area on either side of a fault within which structures for human occupancy or critical facilities or their structural supports are not permitted.

Fault Scarp: A steep slope or cliff formed by movement along a fault.

Fault Trace: The intersection of a fault plane with the ground surface, often present as a fault scarp, or detected as a lineament on aerial photographs.

Fault Zone: A corridor of variable width along one or more fault traces, within which deformation has occurred.

Geologic Hazard: A surface fault rupture, liquefaction, slope stability, landslide, debris flow, rock fall, avalanche, and/or other hazardous geologic process.

Geologic Hazards Study Area: A potentially hazardous area as defined in **Section 8-5I-040** within which geologic hazards investigations are required prior to development.

Geotechnical Engineer: A professional, Utah-licensed engineer who, through education, training and experience, is competent in the field of geotechnical engineering.

Geotechnical Engineering: The investigation and engineering evaluation of earth materials including soil, rock, and man-made materials and their interaction with earth retention systems, foundations, and other

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civil engineering works. The practice involves the fields of soil mechanics, rock mechanics, and earth sciences and requires knowledge of engineering laws, formulas, construction techniques, and performance evaluation of engineering.

Governing Body: The Morgan County Council, or a designee of the Morgan County Council.

Infrastructure: Those improvements which are required to be installed and guaranteed in conjunction with an approved subdivision or other land use approval. Infrastructure may be public or private, on-site or off-site, depending on development design, and may include streets, curb, gutter, sidewalk, water and sanitary sewer lines, storm sewers, flood control facilities and other similar facilities.

Landslide: The downslope movement of a mass of soil, surficial deposits or bedrock, including a continuum of processes between landslides, earth-flows, debris flows and debris avalanches, and rock falls.

Liquefaction: A process by which certain water-saturated soils lose bearing strength because of earthquake-related ground shaking and subsequent increase of groundwater pore pressure.

Legal Lot of Record: A parcel of land which meets all zoning requirements to be eligible for the development of a dwelling, habitable structure, or other facility or structure, pursuant to all Morgan County requirements.

Morgan County: The Morgan County Public Works Director, Morgan County Engineer, Morgan County Planning and Development Services Director, Morgan County Zoning Administrator, Morgan County Building Official, Morgan County Council Administrator, County Council, Land Use Authority, or other Morgan County employee or designee.

Non-Buildable Area: That portion of a site which a geologic hazards report has concluded is impacted by geologic hazards that present an unreasonable and unacceptable risk, and where the siting of habitable structures, accessory structures which house an accessory dwelling unit or business, or critical facilities, is not permitted.

Rock fall: A rock or mass of rock, newly detached from a cliff or other steep slope which moves downslope by falling, rolling, toppling, or bouncing; includes rockslides, rock fall avalanches, and talus.

Setback: An area within which support of habitable structures or critical facilities is not permitted.

Slope Stability: The resistance of a natural or artificial slope or other inclined surface to failure by landsliding, usually assessed under both static and dynamic (earthquake-induced) conditions.

Snow avalanche (see Avalanche above)

Structure Designed for Human Occupancy: Any residential dwelling or any other structure used or intended for supporting or sheltering any use or occupancy by humans or businesses, but does not include an accessory building which houses no accessory dwelling unit or business.

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Talus: Rock fragments lying at the base of a cliff or a very steep rocky slope.

8-5I-030 Applicability.

The regulations contained in this chapter shall apply to all lands in unincorporated Morgan County.

Every legal lot of record and lot in a proposed land subdivision, within a Geologic Hazards Study Area as defined by this chapter, must have a buildable area safe for the intended use. Each buildable area must also have access from the nearest existing public or private street which is free of unreasonable and unacceptable geologic hazards. Any geologic hazards which must be mitigated in order to provide a buildable area and acceptable and reasonable access must be mitigated prior to the issuance of a building permit.

Detached accessory buildings which are not designed for human occupancy are not required to comply with the provisions of this ordinance. Also, the remodeling of existing structures designed for human occupancy may occur without compliance with this ordinance if no expansion of the existing building footprint is proposed. Complete demolitions and replacements of structures shall comply with this ordinance.

8-5I-040 Geologic Hazards Study Areas.

Geological Hazards Study Areas as defined within this section shall include, but not necessarily be limited to:

(a) Areas designated as Qm, Qms, Qms1, Qmsy, Qmso, Qmc, Qmg, Qac, Qg, Qga, Qgy, Qgmy, Qgay, Qgo, Qgao Qgm, Qgmo, Qmdf, Qaf, Qafy, Qafo, Qaf1, Qaf2, Qaf3, Qaf4, Qaf5, Qafb, Qafp, Qafoe, Qgr, Qmtr, Qmy, Qct, and Tn on the most recent and publically available version of the following geologic maps:

(1) King, J.K, 2009, Progress report geologic map of the Bybee Knoll quadrangle, Morgan and Weber Counties, Utah: Utah Geological Survey files, scale 1:24,000,

(2) Coogan, J.C. and King, J.K., 2009, Progress report geologic map of the Devils Slide quadrangle, Morgan and Summit Counties, Utah: Utah Geological Survey files, scale 1:24,000;

(3) Coogan, J.C., and King, J.K., 2006, Interim geologic map of the Durst Mountain quadrangle, Morgan and Weber Counties, Utah: Utah Geological Survey, Open-File Report 498, scale: 1:24,000;

(4) Coogan, J.C., 2004, Interim geologic map of the Francis Canyon 7.5' quadrangle, Morgan Rich, and Summit Counties, Utah: Utah Geological Survey Open-File Report 425, scale 1:24,000;

(5) Coogan, J.C., 2002, Progress report geologic map of the Heiners Creek quadrangle, Morgan and Summit Counties, Utah: Utah Geological Survey files, scale

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1:24,000;

(6) Coogan, J.C., 2002, Progress report geologic map of the Henefer quadrangle, Morgan and Summit Counties, Utah: Utah Geological Survey files, scale 1:24,000;

(7) Coogan, J.C., 2006, Interim geologic map of the Horse Ridge 7.5' quadrangle, Morgan Rich, and Weber Counties, Utah: Utah Geological Survey Open-File Report 480, scale 1:24,000;

(8) Coogan, J.C., 2004, Interim geologic map of the Lost Creek Dam 7.5' quadrangle, Morgan and Weber Counties, Utah: Utah Geological Survey Open-File Report 426, scale 1:24,000;

(9) Coogan, J.C., King, J.K., and McDonald, G.N., 2007, Progress report geologic map of the Morgan 7.5' quadrangle, Morgan County, Utah: Utah Geological Survey files, scale: 1:24,000;

(10) Coogan, J.C., 2004, Interim geologic map of the Peck Canyon 7.5' quadrangle, Morgan and Rich Counties, Utah: Utah Geological Survey Open-File Report 427, scale 1:24,000;

(11) King, J.K., and McDonald, G.N., 2002, Progress report geologic map of the Peterson quadrangle, Davis and Morgan Counties, and the east part of the Kaysville quadrangle, Davis County, Utah: Utah Geological Survey files, scale: 1:24,000;

(12) King, J.K, 2002, Progress report geologic map of the Shearing Corral quadrangle, Morgan, Rich, and Summit Counties, Utah: Utah Geological Survey files, scale 1:24,000;

(13) King, J.K., Yonkee, W.A., and Coogan, J.C., 2008, Interim geologic map of the Snow Basin and part of the Huntsville quadrangle, Davis, Morgan, and Weber Counties, Utah: Utah Geological Survey Open-File Report 536, scale 1:24,000; and

(14) Coogan, J.C. and King, J.K., 2001, Progress Report . Geologic map of the Ogden 30 by 60 minute quadrangle, Utah and Wyoming, year 3 of 3: Utah Geological Survey Open-File Report 380, 1:100,000.

(b) Areas designated as "Landslide" in Kaliser, B.N., 1972, Geologic hazards in Morgan County with applications to planning purposes, Utah Geological and Mineralogical Survey Bulletin 93, p. 56, 2 plates;

(c) Areas designated as fg, fgv, fgo, ld, lde, lds, ldl, ldr, and Tn on Van Horn, R., and Crittenden, Jr., M.D., 1987, Map showing surficial units and bedrock geology of the Fort Douglas quadrangle and parts of the Mountain Dell and Salt Lake City North quadrangles, Davis, Salt Lake, and Morgan Counties, Utah: U.S. Geological Survey Miscellaneous Investigation Series Map I.1762, scale 1:24,000;

(d) Areas designated as Qtc, Qf, Qba, Qfb, Qof, Ql, Qm, and Tn on Bryant, B., 1988, Geology of the Farmington Canyon Complex, Wasatch Mountains, Utah: U.S. Geological Survey Professional Paper

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1476, 54 p., scale 1:50,000 (part of Bountiful Peak quadrangle and west 1/2 of Porterville quadrangle, Morgan County, Utah);

(e) Low, moderate, and high landslide susceptibility areas identified by Giraud, R.E., and Shaw, L.M., 2007, Landslide susceptibility map of Utah: Utah Geological Survey Map M.228, 11 p., 1 pl., scale 1:500,000;

(f) Landslide areas identified by:

(1) Harty, K.M., 1992, Landslide map of Utah: Utah Geological Survey M.133, 28 p., 2 sheets, scale 1:500,000;

(2) Harty, K.M., 1992, Landslide map of the Ogden 30' x 60' quadrangle, Utah: Utah Geological Survey OFR.247, 11 p., 1 plate, scale 1:100,000, and;

(3) Harty, K.M., 1992, Landslide map of the Salt Lake City 30' x 60' quadrangle, Utah: Utah Geological Survey OFR.236, 17 p., 1 plate, scale 1:100,000.

(g) Areas requiring slope stability analyses as defined in Appendix B (Minimum Standards for Slope Stability Analyses).

(h) All properties located on alluvial fans;

(i) Drainage channels subject to flash flooding and debris flows; and

(j) Other previously identified geologic hazards that Morgan County finds to be of significance to the health, safety, and welfare of the citizens of Morgan County.

(k) Site-specific surface-fault-rupture studies are required for all critical facilities and structuresfor human occupancy along Holocene faults, and for critical facilities along late Quaternary and Quaternary faults. For non-critical facilities for human occupancy along late Quaternary and Quaternary faults, studies are considered optional (not required). See the U.S.G.S. Quaternary fault and fold database (http://earthquake.usgs.gov/regional/qfaults/) for Quaternary-age faults within Morgan County and to determine the activity class.

8-5I-050 Responsibility for Geologic Hazards Studies.

Geologic hazards studies often involve both engineering geology and geotechnical engineering. Engineering geologic studies shall be performed under the direct supervision of a Utah licensed geologist. Geotechnical engineering studies shall be performed under the direct supervision of a Utah licensed professional geotechnical engineer.

8-5I-060 Minimum Qualifications of the Geologist.

Engineering geology and the evaluation of geologic hazards is a specialized discipline within the practice of geology requiring technical expertise and knowledge of techniques not commonly used in other geologic

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investigations. Therefore, geologic hazards investigations involving engineering geologic studies shall be conducted, signed, and sealed by a professional geologist licensed in the State of Utah. Proof of qualifications shall be provided to Morgan County upon request.

As a guide to developers and property owners, the following additional qualifications may prove useful when selecting an engineering geologist:

(a) An undergraduate or graduate degree in geology, engineering geology, or geological engineering, or closely related field, from an accredited college or university;

(b) Five full years of experience in a responsible position in the field of engineering geology in Utah, or in a state with similar geologic hazards and regulatory environment.

8-5I-070 Minimum Qualifications of the Engineer.

Evaluation and mitigation of geologic hazards often require contributions from a qualified geotechnical engineer, particularly in the design of mitigation measures. Geotechnical engineering is a specialized discipline within the practice of civil engineering requiring technical expertise and knowledge of techniques not commonly used in civil engineering. Therefore, geologic hazards investigations requiring contributions from a qualified geotechnical engineer shall also be signed and sealed by a qualified geotechnical engineer, licensed as a professional engineer in the State of Utah. Proof of qualifications shall be provided to Morgan County upon request.

As a guide to developers and property owners, the following additional qualifications may prove useful when selecting an engineering geologist:

(a) A graduate degree in civil engineering, with an emphasis in geotechnical engineering; or a B.S. degree in civil engineering with 12 semester hours of post B.S. credit in geotechnical engineering, or course content closely related to evaluation of geologic hazards, from an accredited college or university;

(b) Five full years of experience in a responsible position in the field of geotechnical engineering in Utah, or in a state with similar geologic hazards and regulatory environment, and experience demonstrating the engineer's knowledge and application of appropriate techniques in participating in geologic hazards studies.

8-5I-080 Preliminary Activities.

This section shall apply to any geologic hazards investigation for the purpose of determining the feasibility of land use approval for concept plan, preliminary or final plat approval, commercial, institutional, or two-family and multi-family dwelling conditional use permit or site plan approval or for the purpose of exploring, evaluating or establishing locations for permanent improvements. A geologic hazards report shall be submitted to Morgan County as part of the land use application, pursuant to the requirements of this chapter, for any proposed development in a Geologic Hazards Study Area.

(a) Prior to land use application, the applicant shall schedule a scoping meeting with Morgan County to evaluate the engineering geologist's/geotechnical engineer's investigative approach. At this

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meeting, the applicant shall present a work plan that includes locations of anticipated geologic hazards and locations of proposed exploratory excavations, such as trenches, borings, and CPT soundings, which meet the minimum acceptable standards of practice, in accordance with this chapter and the adopted appendices. The investigation approach shall allow for flexibility due to unexpected site conditions. Field findings may require modifications to the work plan. Upon completion of a scoping meeting, an application for an excavation or grading permit, as necessary, may be submitted to Morgan County;

(b) Morgan County will arrange for a licensed geologist to attend the scoping meeting on behalf of the County, at the applicant's expense. Morgan County's geologist will provide verbal feedback to the applicant and their consultants regarding their proposed work plan and the requirements of this Chapter. Reimbursement to the County for the direct costs of any outsourced staff shall be paid by the applicant prior to the acceptance of a land use or building permit application.

(c) As required by the Morgan County Code and except as otherwise noted therein, no person shall commence or perform any land disturbance, grading, excavation, relocation of earth, or any other land disturbance activity, without first obtaining an excavation or grading permit. Application for an excavation or grading permit shall be filed with Morgan County on forms furnished by Morgan County for such purposes only after a scoping meeting has taken place; and

(d) The applicant shall specify a primary contact responsible for coordination with Morgan County during the land disturbance activity.

8-5I-090 Building Permits on Lots Recorded Prior to the Effective Date of this Ordinance.

(a) The following submittals and process are required prior to the issuance of a building permit for a new or replacement structure designed for human occupancy, and additions to structures designed for human occupancy for all lots within subdivisions recorded prior to the effective date of this ordinance which are on property noted as restricted for geologic hazards reasons on a recorded plat:

(1) A statement from a Utah licensed geologist identifying the presence or absence of any geologic hazards and describing the most suitable location on the lot for the proposed structure;

(2) A statement from a Utah licensed geotechnical engineer verifying that the slope stability of the proposed location of the structure will equal or exceed a 1.0 dynamic and 1.5 static factor of safety. The statement shall clearly identify any conditions or required mitigation methods;

(3) A statement from a Utah licensed structural engineer stating that he or she has reviewed the geologic and geotechnical reports and that he or she has designed the structure in accordance with their recommendations and to account for any identified geologic or geotechnical hazards in accordance with International Building Code standards;

(4) Written verification from the issuer of professional errors and omissions liability insurance, in the amount of $1,000,000.00, which covers the preparer of the statements from the licensed geologist, geotechnical engineer, and structural engineer, and which are in effect on the date of issuance of the building permit by the Building Official;

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(5) A hold harmless agreement, on a County approved form, which is executed and recorded on the subject property;

(6) A geologic hazards disclosure, on a County approved form, which is executed and recorded on the subject property; and

(7) All conditions of the adopted building and fire codes must be adhered to;

(b) Prior to the issuance of a certificate of occupancy for a new or replacement structure designed for human occupancy, and additions to structures designed for human occupancy for all lots within subdivisions recorded prior to the effective date of this ordinance, and which are within a geologic hazards study area:

(1) An excavation inspection report shall be submitted by a Utah licensed geotechnical engineer to the Building Official, prior to footing placement, which verifies that the proposed building was cited in accordance with the recommendations of the geotechnical report;

(2) The Building Official may require, at any time, written verification from a Utah licensed geotechnical or structural engineer that the structure conforms to the recommendations of the original reports and designs; and

(3) All requirements of the adopted building and fire codes must be met.

8-5I-095 Geologic Hazards Studies and Reports Required.

Any applicant requesting land use approval for a concept plan, preliminary or final plats, or commercial, institutional, or two-family and multi-family dwelling conditional use permit or site plan approval on a parcel or parcels of land within a Geologic Hazards Study Area or where there are known or readily apparent geologic hazards and the area is not included within a Geologic Hazards Study Area, shall submit to Morgan County three wet stamped paper copies and one electronic copy of a site-specific geologic hazards study report which relates specifically to the type of geologic hazard present on the site. The reports shall meet the submittal and preparation requirements of this chapter and its appendices.

8-5I-100 Geologic Hazards Reports.

(a) Each geologic hazards report shall be site-specific and shall identify all known or suspected potential geologic hazards, whether previously identified or previously unrecognized, that may affect the subject property;

(b) All geologic hazards reports shall include the qualifications and original signature and professional seal(s), both in blue ink, of the qualified professional(s). Geologic hazards reports co-prepared by an engineer and geologist must include both professionals' qualifications and original signature and seal in blue ink;

(c) Surface fault rupture hazard reports shall contain all requirements as described in

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Appendix A of this chapter, *Minimum Standards for Surface Fault Rupture Hazard Investigations.* Surface fault rupture hazard investigations shall be prepared by a qualified engineering geologist;

(d) Slope stability and landslide hazard reports shall contain all requirements as described in Appendix B of this chapter, *Minimum Standards for Slope Stability Analyses.* Slope stability and landslide hazard investigations shall be prepared by a qualified engineering geologist and a qualified geotechnical engineer;

(e) Liquefaction hazard reports shall contain all requirements as described in Appendix C of this chapter, *Minimum Standards for Liquefaction Hazard Investigations.* Liquefaction hazard investigations shall be prepared by a qualified geotechnical engineer;

(f) Debris flow hazard reports shall contain all requirements as described in Appendix D of this chapter, *Minimum Standards for Debris Flow Hazard Investigations.* Debris flow hazard investigations shall be prepared by a qualified engineering geologist. Mitigation measures will generally require contributions from qualified geotechnical engineers, hydrologists, or civil engineers. A qualified geotechnical engineer must stamp all reports that include engineering analysis and design;

(g) Rock fall hazard reports shall contain all requirements as described in Appendix E of this chapter, *Minimum Standards for Rock Fall Hazard Investigations.* Rock fall hazard studies shall be prepared by a qualified engineering geologist. Mitigation measures will generally require contributions from qualified geotechnical and civil engineers. A qualified geotechnical engineer must stamp all reports that include engineering analysis and design;

(h) Avalanche hazard reports shall contain all requirements as described in Appendix F, *Minimum Standards for Avalanche Hazard Investigations,* shall be prepared by a qualified avalanche expert, and shall include the avalanche expert's qualifications to perform the study (such as their experience in performing similar studies). A qualified geotechnical engineer must stamp all reports that include engineering analysis and design;

(i) All geologic hazards reports shall include, at a minimum:

(1) A 1:24,000.scale geologic map, with references, showing the general surface geology (landslides, alluvial fans, etc), bedrock geology where exposed, bedding attitudes, faults, other geologic structural features, and location of any geologic hazards;

(2) A detailed site geologic map and geologic cross section(s), at a scale equal to or more detailed than 1 inch = 100 feet, to illustrate local geologic structure. The site geologic map shall include locations of trenches, test pits, borings, etc, and site-specific geologic mapping performed as part of the geologic hazards investigation, including boundaries and features related to any geologic hazards, topography, and drainage. The site geologic map must show the location and boundaries of the property, geologic hazards, delineation of any recommended setback distances from hazards, and recommended locations for structures. Buildable and non-buildable areas shall be clearly identified;

(3) Trench and test pit logs, when applicable, prepared in the field and presented in

the geologic hazards report at a scale equal to or more detailed than 1 inch = 5 feet;

(4) Boring logs when applicable, prepared with standard geologic and engineering nomenclature;

(5) An evaluation of aerial photographs, oblique aerial photographs, and DEMs derived from detailed topography and/or LIDAR for the potential presence of geologic hazards;

(6) Listing of aerial photographs used, technical references with citations, and other supporting information, as applicable;

(7) Information regarding historical groundwater highs and lows must be indicated in the report. Any vegetation or surface features that indicate perennially wet conditions or surface creep shall be identified on the site geologic map and discussed in the report;

(8) Conclusions and recommendations, clearly supported by adequate data included in the report, that summarize the characteristics of the geologic hazards, and that address the potential effects of the geologic conditions and geologic hazards on the proposed development and occupants thereof, particularly in terms of risk and potential damage;

(9) Any specific recommendations for additional or more detailed studies;

(10) An evaluation of whether or not mitigation measures are required, including an evaluation of multiple mitigation options;

(11) Specific recommendations for avoidance or mitigation of the effects of the hazards, consistent with the purposes set forth in Section 8-5I-010, including design or performance criteria for engineered mitigation measures and all supporting calculations, analyses, modeling or other methods, and assumptions. Final design plans and specifications for engineered mitigation must be signed and stamped by a qualified geotechnical, civil and/or structural engineer, as appropriate;

(12) Data upon which recommendations and conclusions are based shall be clearly stated in the report; and

(13) A statement shall be provided regarding the suitability of the site for proposed development from a geologic hazards perspective.

(j) When a submitted report does not contain adequate data to support its findings, additional or more detailed studies shall be required by Morgan County to explain or quantify a particular geologic hazard or to describe how mitigation measures recommended in the report are appropriate and adequate.

(k) When a geologic hazard study area is indicated by a map referenced by this chapter, and which after a scoping meeting and the submittal of geologic information, is agreed by the applicant's consultants and the County that the mapped feature doesn't actually exist on the property, all efforts shall be made to avoid taking further unnecessary testing and review steps. Concurrence by the applicant's

consultants and the County shall constitute an amendment to the hazard maps removing the subject area from the geologic hazard study area.

8-5I-110 Submittal and Certification of Geologic Hazards Reports.

(a) All applicants for land use approval within a Geologic Hazards Study Area shall prepare and submit geologic hazard reports pursuant to the requirements of this chapter prior to any consideration for a concept plan, preliminary or final plat, or commercial, institutional, or two-family and multi-family dwelling or any conditional use permit which requires site plan approval. Additionally, the applicant is required to submit the following additional information:

(1) A written, stamped certification from a professional geologist, licensed in the State of Utah, that the geologic hazard reports have been prepared pursuant to the requirements of this Chapter.

(2) A written, stamped certification from a professional geologist and professional engineer, licensed in the state of Utah, that every proposed development lot or building pad does not present an unreasonable or unacceptable risk to the health, safety, and welfare of persons or property, including buildings, storm drains, public streets, culinary water facilities, utilities or critical facilities, whether off-site or on-site, because of the presence of geologic hazards or because of modifications to the site due to the proposed land use;

(3) A written, stamped certification from a professional geologist and professional engineer, licensed in the state of Utah, that every proposed development lot or building site demonstrates that, consistent with the state of the practice, the identified geologic hazards can be mitigated to a level where the risk to human life and damage to property are reduced to an acceptable and reasonable level in a manner which will not violate applicable federal, state, or local statutes, ordinances or regulations. Mitigation measures shall consider, in their design, the intended aesthetic functions of other governing ordinances of Morgan County, and;

(4) A written, stamped certification from a professional geologist and professional engineer, licensed in the state of Utah, along with a mitigation plan, if necessary, that demonstrates that the identified hazards or limitations will be addressed without impacting or adversely affecting off-site areas. Mitigation measures must be reasonable and practical to implement and shall not require ongoing maintenance by property owners.

(5) Written verification from the issuer of professional errors and omissions liability insurance, in the amount of $1,000,000.00, which covers the preparer of the statements from the licensed geologist and engineer, and which are in effect on the date of preparation of all required reports and certifications.

(b) Morgan County may set other requirements as are necessary to mitigate any geologic hazards and to ensure that the purposes of this chapter are met. These requirements may include, but are not limited to:

(1) Additional or more detailed studies and professional certifications to understand or

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quantify the hazard or determine whether mitigation measures recommended in the report are adequate;

(2) Specific mitigation requirements; establishing buildable and non-buildable areas; limitations on slope grading and controls on grading, or re-vegetation;

(3) Prior to receiving a grading, excavation, or building permit, final grading plans, when required, shall be prepared, signed and sealed by the licensed professional engineer and the engineering geologist and geotechnical engineer that prepared the geologic hazards and geotechnical report(s) to verify that their recommendations have been appropriately incorporated in the final grading plan and that building locations are approved.

(4) As-built grading plans, when required, shall be prepared, signed and sealed by the licensed professional engineer and the engineering geologist and geotechnical engineer that prepared the geologic hazards and geotechnical report(s) to verify that their recommendations have been appropriately incorporated and that building locations are approved, prior to the issuance of a building permit.

(5) Grading plans, when required, shall include, at a minimum, the following:

1. Maps of existing and proposed contours;

(ii) Present and proposed slopes for each graded area;

(iii) Existing and proposed drainage patterns;

(iv) Location and depth of all proposed cuts and fills;

(v) Description of methods to be employed to achieve stabilization and compaction;

(vi) Location and capacities of proposed drainage, structures, and erosion control measures based on maximum runoff for a 100 year storm;

(vii) Location of existing buildings or structures on or within 100 feet of the site, or which may be affected by proposed grading and construction; and

(viii) Plan for monitoring and documentation of testing, field inspections during grading, and reporting to Morgan County.

(6) Installation of monitoring equipment and seasonal monitoring of surface and subsurface geologic conditions, including groundwater levels, and;

(7) Other requirements such as time schedules for completion of the mitigation and phasing of development.

(c) Morgan County may also set requirements necessary to protect the health, safety, and welfare of the citizens of Morgan County, protect Morgan County's infrastructure and financial health, and minimize potential adverse effects of geologic hazards to public health, safety, and property as a condition of approval of any development which requires a geologic hazards report;

(d) Morgan County may require the engineering geologist and geotechnical engineer that prepared the geologic hazards and geotechnical report(s) be on site, at the cost of the applicant, during certain phases of construction, particularly during grading phases and the construction of retaining walls.

(e) For any real property with respect to which development has proceeded on the basis of a geologic hazards and/or geotechnical report which has been accepted by Morgan County, no final inspection shall be completed or certificate of occupancy issued or performance bond released until the engineering geologist and geotechnical engineer who signed and approved the report(s) certifies, in writing, that the completed improvements and structures conform to the descriptions and requirements contained in said report, and that all the required inspections were made and approved by the engineering geologist and geotechnical engineer that prepared said report(s). If the preparing geologist and engineer are unavailable, a geologist and engineer, similarly qualified and licensed in Utah shall provide the certifications.; and

(f) An applicant may appeal any decision made under the provisions of this chapter only after the land use authority has issued a final decision, and shall set forth the specific grounds or issues upon which the appeal is based. The appeal shall be submitted in writing to Morgan County in accordance with the appeals provisions of this title and Utah State Code.

(g) Morgan County shall retain a copy of each geologic hazards report in the Planning and Development Services Department project file, which will be available for public inspection;

8-5I-120 Disclosure When a Geologic Hazards Report is Required.

(a) Whenever a geologic hazards report is required under this chapter, the owner of the parcel shall record a notice running with the land in a form satisfactory to Morgan County prior to the approval of any development or subdivision of such parcel or commencement of construction activity. Disclosure shall include signing a Disclosure and Acknowledgment Form provided by Morgan County, which includes:

(1) Notice that the parcel is located within a Geologic Hazards Study Area or as otherwise defined in this chapter; and

(2) Notice that a geologic hazards report was prepared and is available for public inspection in Morgan County's files.

(b) Where geologic hazards, related setbacks, and non-buildable areas are delineated in a subdivision, the owner shall also place additional notification on the plat stating the above information, prior to final approval of the plat.

8-5I-130 Warning and Disclaimer.

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The Geologic Hazards Study Areas designated herein represent only those potentially hazardous areas known to Morgan County and should not be construed to include all possible potential hazards areas. The Geologic Hazards Ordinance and the Geologic Hazards Study Areas may be amended as new information becomes available pursuant to procedures set forth in Chapter 8-5I-040. The provisions of this chapter do not in any way assure or imply that areas outside the Geologic Hazards Study Areas are free from the possible adverse effects of geologic hazards. This chapter shall not create any liability on the part of Morgan County, any Morgan County officer, Morgan County reviewer, or Morgan County employee thereof for any damages from geologic hazards that result from reliance on this chapter or any administrative requirement or decision lawfully made hereunder.

8-5I-140 Change of Use.

No change in use which results in the conversion of a building or structure from one not used for human occupancy to one that is so used shall be permitted unless the building or structure complies with the provisions of this chapter.

8-5I-150 Conflicting Regulations.

In cases of conflict between the provisions of existing zoning classifications, building code, subdivision ordinance, or any other ordinance of Morgan County and the geologic hazards ordinance codified in this chapter, the most restrictive provision shall apply.

8-5I-160 Morgan County Hold Harmless Agreement.

Applicants receiving any permit or approval within a geologic hazards area shall be required to sign and record on the property a hold harmless agreement. An example of such an agreement is presented in Appendix G.

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Table 1, Essential Facilities

In the event of failure, the following buildings and structures represent a substantial hazard to human life:

1. Those where more than 300 people congregate in one area;
2. Elementary schools, secondary schools, or day care facilities with an occupancy greater than 250;
3. Those colleges or adult education facilities with an occupancy greater than 500;
4. Health care facilities with an occupancy greater than 50 or more resident patients but not having surgery or emergency treatment facilities;
5. Jails and detention facilities;
6. Any structure with an occupancy greater than 1000;
7. Power generating stations, water treatment or storage for potable water, waste water treatment facilities and other public utility facilities; and
8. Those containing toxic or explosive substances that would be dangerous to the public if released.

The following buildings and structures are designated as essential facilities, including but not limited to:

1. Hospitals and other care facilities having surgery or emergency treatment facilities;
2. Fire, rescue and police stations and emergency vehicle garages and fueling facilities;
3. Designated emergency shelters;
4. Designated emergency preparedness, communications, and operation centers and other facilities required for emergency response;
5. Power generating stations and other public utility facilities required as emergency backup facilities for facilities and structures included in this table;
6. Structures containing highly toxic materials as defined by the most recently adopted version of the IBC;
7. Aviation control towers, air traffic centers and emergency aircraft hangars;
8. Buildings and other structures having critical national defense functions; and
9. Water treatment and storage facilities required to maintain water pressure for fire suppression.

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APPENDIX A

Minimum Standards for Surface Fault Rupture Hazard Investigations

Morgan County Geologic Hazards Ordinance
Title 8, Chapter 5I of the Morgan County Code

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1.0 INTRODUCTION

"Surface fault rupture" is fault-related displacement of the ground surface that may occur in an earthquake. If a fault were to break the ground surface beneath a building, significant damage could occur, perhaps resulting in injuries or loss of life. To reduce the risk from surface faulting and help ensure that buildings are not sited unsafely across Quaternary faults considered to pose an unacceptable risk, the Morgan County Geologic Hazards Ordinance (**Chapter 5I of the Morgan County Code**) may require a site-specific geologic investigation for properties that contain Quaternary faults, depending on level of fault activity (activity class) and occupancy classes of proposed buildings (see Table A-1), as determined by Morgan County.

The primary purposes of the geologic investigation are to assess the surface-fault-rupture potential of the property and to assess the suitability of the property for the proposed development from the standpoint of surface fault rupture. If a fault is discovered and determined (or presumed) to be of importance to the proposed building type (see Table A-1), appropriate building setbacks from the fault are required such that structures are not located astride the fault trace. Building setbacks must be established prior to approval and development of the property.

A site-specific surface-fault-rupture-hazard study includes a field investigation, usually involving the excavation and geologic documentation of at least one trench, and a report. This appendix describes the *minimum* standards required by Morgan County for surface-fault-rupture-hazard studies.

The purpose of establishing minimum standards for surface-fault-rupture-hazard studies is to:

(a) Protect the health, safety, welfare, and property of the public by minimizing the potentially adverse effects of surface-fault-rupture and related hazards;

(b) Assist applicants of properties requiring fault investigations (see Section 1.2) in conducting reasonable and adequate studies;

(c) Provide consulting engineering geologists with a common basis for preparing proposals, conducting investigations, and recommending setbacks; and,

(d) Provide an objective framework for review of surface-fault-rupture study reports.

The procedures outlined herein are intended to provide the applicant and consulting engineering geologist with an outline of appropriate exploration methods, standardized report information, and expectations of Morgan County.

These standards constitute the minimum level of effort required in conducting surface-fault-rupture-hazard special studies in Morgan County. Considering the complexity of evaluating surface and near-surface faults, additional effort beyond the minimum standards may be required at some sites to adequately address surface-fault-rupture hazards. The information presented herein does not relieve engineering geologists from their duty to perform additional geologic services or recommend engineering services the

engineering geologists believe are necessary to assess surface-fault-rupture potential at a site.

1.1 References and Sources

The minimum standards presented herein were developed from the following sources:

(a) Utah Geological Survey guidelines for evaluating surface-fault-rupture hazards in Utah (Christenson and others, 2003);

(b) Utah Geological Survey Quaternary fault and fold database and map of Utah (Black and others, 2003; use updated version at http://earthquake.usgs.gov/regional/qfaults/);

(c) Fault setback requirements to reduce fault rupture hazards in Salt Lake County (Batatian and Nelson, 1999);

(d) Salt Lake County geologic hazards ordinance (Salt Lake County, 2002a; 2002b);

(e) Draper City geologic hazard ordinance (Draper City, 2008a; 2008b), and;

(f) Morgan County geologic hazard ordinance (Morgan County, 2006).

1.2 Properties Requiring a Fault Investigation

Surface-fault-rupture-hazard special-study-area maps have not been prepared for Morgan County at present. Such maps may be produced in the future and at that time will be adopted to become a part of this ordinance.

Requirements for site-specific studies depend on the level of fault activity (activity class- Holocene, late Quaternary, and Quaternary), which is based on the age of most recent movement. Morgan County requires site-specific studies for all critical facilities and structures for human occupancy along Holocene faults[1], and for critical facilities along late Quaternary[2] and Quaternary faults[3]. For non-critical facilities for human occupancy along late Quaternary and Quaternary faults, studies are considered optional (not required).

At present, the U.S.G.S. Quaternary fault and fold database (http://earthquake.usgs.gov/regional/qfaults/) documents the following Quaternary-age faults within Morgan County and provides evidence to determine the activity class as shown in parentheses (where data are inadequate to determine activity class, the fault is assumed to be Holocene pending detailed paleoseismic investigations):

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1 Holocene fault: a fault that has moved within the past 10,000 years (Christenson and others, 2003).

2 Late Quaternary fault: a fault that has moved in the past 130,000 years (Christenson and others, 2003).

3 Quaternary fault: a fault that has moved in the past 1.6 million years (Christenson and others, 2003).

- The Morgan fault (Holocene)
- The Saleratus Creek fault (activity class unknown, assumed Holocene), and;
- East Canyon fault (activity class unknown, assumed Holocene).
- East Canyon (East Side) fault (activity class unknown, assumed Holocene).

A site-specific fault study is required, prior to approval of any land use, for any property that the above-referenced faults cross. Development of said properties requires submittal and review of a site-specific fault study prior to receiving a land use or building permit from Morgan County. It is the responsibility of the applicant to retain a *qualified* engineering geologist to perform the fault study (see Morgan County Geologic Hazards Ordinance **Chapter 5I, Section 8-5I-060**).

In addition, a fault investigation may be required if onsite or nearby fault-related features not shown in the Quaternary fault and fold database (http://earthquake.usgs.gov/regional/qfaults/) are identified during the course of other geologic or geotechnical studies performed on or near the site or during construction.

Morgan County adopts the recommendations from the UGS guidelines for evaluating surface-fault-rupture hazards in Utah (Christenson and others, 2003):

(a) that the width of special-study areas vary depending on whether the fault is well defined or buried or approximately located:

(1) well-defined fault: fault trace is clearly detectable by a geologist qualified to conduct surface-fault-rupture investigations as a physical feature at or just below the ground surface (typically shown as a solid line on a geologic map);

Recommended special-study areas shall extend horizontally 500 feet on the downthrown and 250 feet on the upthrown side of mapped fault traces or outermost faults in a fault zone. In areas of high scarps where 250 feet on the upthrown side does not extend to the top of the scarp, the special-study area shall be increased to 500 feet on the upthrown side, and;

(2) Buried (concealed) or approximately located fault: fault trace is not evident at or just below the ground surface for a significant distance (typically shown as a dotted line for buried faults and a dashed line for approximately located faults on a geologic map), usually between well-defined traces. Recommended special-study areas extend horizontally 1,000 feet (306 m) on either side of the fault.

(b) The first step in a site-specific fault evaluation is to determine if the site is near one of the mapped Quaternary faults shown in the Quaternary fault and fold database (http://earthquake.usgs.gov/regional/qfaults/). If so, existing larger scale maps (if available) shall

then be examined (see Morgan County Geologic Hazards Ordinance **Chapter 5I, Section 8-5I-040)**, and aerial photograph interpretation and field investigations shall be performed and detailed maps prepared as outlined in Section 2.0 (also see the Surface Investigations section of the Utah surface-fault-rupture-hazard guidelines; Christenson and others, 2003) to determine whether the fault is within 500 feet of the site if the fault is well defined, or 1,000 feet if the fault is buried or approximately located. If faults are found or suspected within these distances, subsurface investigations shall be conducted as outlined in Section 2.2.2 (also see the Subsurface Investigations section of the Utah guidelines, and;

(c) At a minimum, studies as outlined in Section 2.0 (also see the Surface Investigations section of the Utah guidelines; Christenson and others, 2003) shall be conducted for all critical facilities, whether near a mapped Quaternary fault (http://earthquake.usgs.gov/regional/qfaults/) or not, to ensure that previously unknown faults are not present. If evidence for a fault is found, subsurface investigations are recommended.

2.0 MINIMUM STANDARDS FOR FAULT STUDIES

Following are the minimum standards for a comprehensive fault investigation. Fault investigations may be reported in conjunction with other geological and geotechnical investigations, or may be submitted separately. See Morgan County Geologic Hazards Ordinance (**Chapter 5I, Section 5I of the Morgan County Code**) for supplemental requirements.

2.1 Scoping Meeting

The applicant must schedule a scoping meeting with Morgan County to evaluate the fault investigation approach. At this meeting, the applicant shall present a site plan that includes: proposed building locations (if known), expected fault location(s) and orientation; and the proposed trench locations, orientation, length, and depth (see Section 2.3, Fault Investigation Method). The investigative approach shall allow for flexibility due to unexpected site conditions; field findings may require modifications to the work plan.

2.2 Fault Investigation Method

Inherent in fault study methods is the assumption that future faulting will recur along pre-existing faults and in a manner consistent with past displacement. The focus of fault investigations is therefore to accurately locate existing faults. If faults are documented, the investigation shall also:

(a) evaluate the age of movement along the fault trace(s), and;

(b) estimate amounts of past displacement, which is required in order to derive fault setbacks.

2.2.1 Previous Studies and Aerial Photograph Review

A fault investigation shall include review of available literature pertinent to the site and vicinity, including previous published and unpublished geologic/soils reports, and interpretation of available stereo-paired aerial photographs, oblique aerial photographs, and DEMs derived from detailed topography and LIDAR. The photographs reviewed should include more than one set and should include pre-urbanization aerial

photographs, if available. Efforts must be made to accurately plot the locations of mapped or inferred fault traces on the property as shown by previous studies in the area.

2.2.2 Exploration Methods

Subsurface exploration consisting of trenching is required. The engineering geologist shall clean and document ("log") trench exposures as described in Section 2.2.6. Existing faults may also be identified and mapped in the field by direct observation of young, fault-related geomorphic features, and by examination of aerial photographs.

When trenching is not feasible (i.e., the presence of shallow ground water, excessive thickness of fill, etc.), an alternative subsurface exploration program may be acceptable, depending upon site conditions. Such methods may consist of closely spaced Cone Penetration Test (CPT) soundings, a sufficient number of closely spaced downhole-logged bucket-auger borings, geophysical exploration techniques, or a combination of techniques.

When an alternative exploration program is proposed (in lieu of conventional trenching), a written description of the proposed exploration program along with an exploration plan shall be submitted to Morgan County for review, prior to implementation. The plan must include, at a minimum, a map of suitable scale showing the site limits, surface geologic conditions within several thousand feet of the site boundary, the location and type of the proposed alternative subsurface exploration, and the anticipated earth materials present at depth on the site.

The actual subsurface exploration program to be used on any specific parcel will be determined on an individual basis, considering the current state of technical knowledge about the fault zone and information gained from previous exploration on adjacent or nearby parcels. At all times, consideration must be given to safety, and trenching shall comply with all applicable safety regulations. Exploration methods shall be clearly described in the report.

2.2.3 Trench Siting

Exploratory trenches must be oriented approximately perpendicular to the anticipated trend of known fault traces. The trenches shall provide the minimum footage of trenching necessary to explore the portion of the property situated in the surface-fault-rupture special study area, such that the potential for surface-fault-rupture may be adequately assessed. When trenching to determine if faults might affect a proposed building site, the trench shall extend beyond the building footprint at least the minimum setback distance for the building type (see Table A-1).

Test pits or potholes alone are neither adequate nor acceptable. In some instances more than one trench may be required to cover the entire building area, particularly if the proposed development involves more than one building. Where feasible, trenches shall be located outside the proposed building footprint, as the trench is generally backfilled without compaction, which could lead to differential settlement beneath footings and slabs. Supplemental trenching may be required in order to:

(a) further refine fault locations (or the absence thereof);
(b) accurately define building restriction areas, and/or;

(c) provide additional exposures for evaluating the age of movement along fault traces.

2.2.4 Location Determination

All trenches and fault locations must be surveyed by a professional land surveyor, licensed in Utah. Fault locations shall be surveyed with an accuracy of at least 0.1 foot.

2.2.5 Depth of Excavation

The depth of the trenches will ultimately depend on the trench location, occurrence of ground water, stability of subsurface deposits, and the geologic age of the subsurface geologic units. As a minimum, however, trenches shall extend substantially below the A and B soil horizons and well into distinctly bedded Pleistocene-age materials, if possible. Where possible, the trenches shall extend below Holocene deposits and shall expose contacts between Holocene materials and the underlying older materials.

Appropriate safety measures pertaining to trench safety for ingress, egress, and working in or in the vicinity of the trench must be implemented and maintained. It is the responsibility of the applicant to ensure that fault trenches are excavated in compliance with current Occupational Safety and Health Administration excavation safety regulations.

Trench backfilling methods and procedures shall be documented in order to establish whether additional corrective excavation, backfilling, and compaction shall be performed at the time of site grading.

In cases where Holocene (i.e., active) faults may be present, but pre-Holocene deposits are below the practical limit of excavation, the trenches must extend at least through sediments that are clearly older than several fault recurrence intervals. The practical limitations of the trenching must be acknowledged in the report and recommendations must reflect resulting uncertainties.

2.2.6 Documenting Trench Exposures

Trench walls shall be cleaned of debris and backhoe smear prior to documentation. Trench logs shall be carefully drawn in the field at a minimum scale of 1-inch equals 5-feet (1:60) following standard and accepted fault trench investigation practices. Vertical and horizontal control must be used and shown on trench logs. Trench logs must document all significant geologic information from the trench and shall graphically represent the geologic units observed; see **Section 2.6.3(e)**. The strike, dip, and net vertical displacement (or minimum displacement) of faults must be noted.

2.2.7 Age Dating

The engineering geologist shall interpret the ages of geologic units exposed in the trench. When necessary, radiocarbon or other age determinations methods shall be used. If evidence of faulting is documented, efforts shall be made to date the time of latest movement (to determine whether Holocene displacement has occurred) using appropriate geologic and/or soil stratigraphic dating techniques. Soil stratigraphic dating techniques shall be performed by a qualified geologist or soil scientist experienced in using the techniques and soil-development rates in the area.

2.3 Field Review

A field review by Morgan County is required during exploratory trenching. The applicant must provide a minimum of 48-hours notice to schedule the field review with Morgan County. The trenches shall be open, safe, cleaned, and the field log completed at the time of the review. The field review allows Morgan County to evaluate the subsurface data (i.e., age and type of sediments; presence/absence of faulting, etc.) with the applicant. Discussions about questionable features or an appropriate setback distance are encouraged, but Morgan County will not help log the trench, explain the stratigraphy, or give verbal approval of the proposed development during the field review.

2.4 Recommendations for Fault Setbacks

To address wide discrepancies in fault setback recommendations, Morgan County has adopted the UGS recommended fault setback calculation methodology (Christenson and others, 2003). The applicant shall use this method to establish the recommended fault setback for critical facilities and structures designed for human occupancy. If another fault setback method is used, the applicant must provide justification in the report for the method used. Faults and fault setbacks must be clearly identified on site plans and maps.

Minimum setbacks are based on the type and occupancy of the proposed structures (see Table A-1). A setback shall be calculated using the formulas presented below, and then compared to the minimum setback established in Table A-1. The greater of the two shall be used as the setback. Minimum setbacks apply to both the upthrown and down-dropped sides of the fault.

Top of slope and/or toe of slope setbacks required by applicable building codes must also be considered and the greater setback must be used.

Downthrown Fault Block (Hanging Wall)

The fault setback for the downthrown block will be calculated using the following formula:

$$S = U\,(2D + F/\tan\Theta)$$

where:

- S = Setback within which structures for human occupancy are not permitted;
- U = Criticality Factor, based on the proposed occupancy of the structure (see **Table A-1**);
- D = Expected fault displacement per event (assumed to be equal to the net vertical displacement measured for each past event);
- F = Maximum depth of footing or subgrade portion of the building;
- Θ = Dip of the fault (degrees).

Upthrown Fault Block (Footwall)

The dip of the fault and depth of the subgrade portion of the structure are irrelevant in calculating the setback on the upthrown fault block. Therefore, the setback for the upthrown side of the fault will be calculated as:

$$S = U \times 2D$$

where:

S = Setback within which structures for human occupancy are not permitted;
U = Criticality Factor, based on the proposed occupancy of the structure (see Table A-1);
D = Expected fault displacement per event (assumed to be equal to the net vertical displacement measured for each past event).

The setback is measured from the portion of the building closest to the fault, whether subgrade or above grade. Minimum setbacks apply as discussed above.

2.5 Small Displacement Faults

Small-displacement faults are not categorically exempt from setback requirements. Some faults having less than 4 inches of displacement ("small displacement faults") may be exempt from setback requirements.

Specific structural risk-reduction options such as foundation reinforcement may be acceptable for some small-displacement faults in lieu of setbacks. Structural options must minimize structural damage.

Surface-fault-rupture hazard studies must still identify faults and fault displacements (both net vertical displacements and horizontal extension across the fault or fault zone), and consider the possibility that future displacement amounts may exceed past amounts. If structural risk-reduction measures are proposed for small displacement faults, the following criteria must be addressed:

(a) Reasonable geologic data indicating that future surface displacement along the particular fault will not exceed 4 inches;

(b) Specific structural mitigation to minimize structural damage, and;

(c) A structural engineer must provide appropriate designs and Morgan County shall review the designs.

2.6 Required Outline for Surface Fault Rupture Hazard Studies

The information described herein may be presented as a separate surface-fault-rupture-potential report or it may be incorporated within other geology or engineering reports that may be required for the property.

The report shall contain a conclusion regarding the potential risk of surface fault rupture on the subject property and a statement addressing the suitability of the proposed development from a surface-fault-rupture-hazard perspective. If exploration determines that there is a potential for surface rupture due to faulting, or if uncertainties associated with the exploration methods preclude the determination of absence of small fault displacements, the report shall provide estimates of the amplitude of fault displacements that might affect habitable structures.

Surface-fault-rupture-hazard reports submitted to Morgan County are expected to follow the outline and address the subjects presented below. However, variations in site conditions may require that additional items be addressed, or permit some of the subjects to be omitted (except as noted).

2.6.1 Report

(a) Purpose and scope of work: The report shall contain a clear and concise statement of the purpose of the investigation and the scope of work performed for the investigation;

(b) Geologic and tectonic setting: The report shall contain a clear and concise statement of the general geologic and tectonic setting of the site vicinity. The section shall include a discussion of active faults in the area, paleoseismicity of the relevant fault system(s), and shall reference relevant published and unpublished geologic literature;

(c) Site description and conditions: The report shall include information on geologic units, graded and filled areas, vegetation, existing structures, and other factors that may affect site development, choice of investigative methods, and the interpretation of data, and;

(d) Methods of investigation:

(1) Review of published and unpublished maps, literature and records concerning geologic units, faults, surface and ground water, and other factors;

(2) Interpretation of stereoscopic aerial photographs, oblique aerial photographs, and DEMs derived from detail topography and LIDAR to detect fault-related topography, vegetation or soil contrasts, and other lineaments of possible fault origin. Aerial photographs utilized shall be referenced in the report (i.e., photograph source, date, flightline numbers, and scale);

(3) Observations of surface features, both on-site and offsite, including mapping of geologic and soil units; geomorphic features such as scarps, springs, and seeps (aligned or not); faceted spurs, offset ridges or drainages; and geologic structures. Locations and relative ages of other possible earthquake-induced features such as sand blows, lateral spreads, liquefaction, and ground settlement shall be mapped and described. Slope failures, although they may not be conclusively tied to earthquake causes, shall also be noted, and;

(4) Subsurface investigations: The report shall include a description of the program of subsurface exploration, including trench logs, criteria for trench locations, and any other detailed, direct observation of continuously exposed geologic units, soils, and geologic structures. All trench logs shall be at a scale of at least 1 inch = 5 feet.

The report must describe the criteria used to evaluate the ages of the deposits encountered in the trench, and clearly evaluate the activity class (Holocene, late Quaternary, Quaternary) of any faults found.

(e) Conclusions: Conclusions must be supported by adequate data. Data must also be sufficient enough to allow technical reviewers to evaluate conclusions and recommendations, and shall contain, at a minimum:

(1) summary of data upon which conclusions are based;

(2) location of active faults, including orientation and geometry of faults, amount of net slip along faults, anticipated future offset, and delineation of setback areas, and;

(3) degree of confidence in and limitations of data and conclusions.

(f) Recommendations: Recommendations must be supported by adequate geologic data and appropriate reasoning behind each statement. Minimum recommendations shall include:

(1) recommended setback distances per Section 2.4. Supporting calculations must be included. Faults and setbacks must be shown on site maps and final recorded plat maps;

(2) other recommended building restrictions or use limitations (i.e., placement of detached garages, swimming pools, or other non-habitable structures), and;

(3) need for additional or future studies to confirm buildings are not sited across active faults, including inspection of building footing or foundation excavations by the applicant.

2.6.2 Report References

Reports must include citations of literature and records used in the study, referenced aerial photographs or images interpreted (air-photo source, date and flight number, scale), and any other sources of data and information, including well logs, personal communications, etc.

2.6.3 Illustrations

At a minimum, reports must include the following illustrations:

(a) Location Map: A site location map depicting topographic and geographic features and other pertinent data. Generally a 1:24,000-scale USGS topographic base map will suffice;

(b) Geologic Map: A regional-scale geologic map (1:24,000 to 1:50,000 scale) is generally adequate. The map shall show Quaternary and bedrock geologic units, faults, seeps or springs, soil or bedrock slumps, and other geologic and soil features existing on and adjacent to the project site. Geologic cross-sections may be included as needed to illustrate 3-dimensional relationships;

(c) Site Plan: A detailed site plan is required. The site plan shall be at a scale of at least 1 inch = 100 feet (or more detailed) and shall clearly show site boundaries, proposed building footprints, existing structures, streets, slopes, drainages, exploratory trenches, boreholes, test pits, geophysical traverses, and any other data pertinent data;

(d) Site-Specific Fault Map: If faulting is documented at a parcel, the report shall include a site-specific fault map. The fault map shall be at a scale of at least 1 inch = 100 feet and shall clearly show the surveyed locations of trenches (and any other exploratory techniques), surveyed location(s) of faults documented in the trenches, inferred location of the faults between trenches, recommended fault setback distance on each side of the faults, topographic contours, and proposed building locations, if known;

(e) Exploratory Trench Logs: Trench logs, prepared in the field, are required for each trench excavated as part of the study. Trench logs shall accurately depict all observed geologic features and conditions. Trench logs shall not be generalized or diagrammatic. The minimum scale is 1 inch = 5 feet (1:60) with no vertical exaggeration. Trench logs must accurately reflect the features observed in the trench (see Section 2.3.6);

Trench logs shall include trench orientation and indication of which trench wall was logged; trench top and bottom; stratigraphic contacts; stratigraphic unit descriptions including lithology, USCS soil classification, genesis (geologic origin), age, and contact descriptions; soil (pedogenic) horizons; marker beds; and deformation or offset of sediments, faults, and fissures. Other features of tectonic significance such as buried scarp free-faces, colluvial wedges, in-filled soil cracks, drag folds, rotated clasts, lineations, and liquefaction features including dikes, sand blows, etc. shall also be shown. Interpretations of the age and origin of the deposits and any faulting or deformation must be included, based on depositional sequence. Fault orientation and geometry (strike and dip), and amount of net displacement must be measured and noted;

(f) Exploratory boreholes and CPT soundings: Should boreholes or CPT soundings be utilized as part of the investigation, reports shall include the logs of the borings/soundings. Borehole logs must include lithology descriptions, interpretations of geologic origin, USCS soil classification or other standardized engineering soil classification (including an explanation of the classification scheme), sample intervals, penetrative resistance values, static ground-water depths and dates measured, total depth of borehole, and identity of the person logging the borehole. Electronic copies of CPT data files shall be provided to Morgan County, upon request;

(g) Geophysical data: All geophysical data, showing stratigraphic interpretations and fault locations, must be included in the report, along with correlations to trench or borehole logs to confirm interpretations, and;

(h) Photographs: Photographs of scarps, trench walls, or other features that enhance understanding of site conditions and fault-related conditions are not required but should be included when deemed appropriate.

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Draper City, 2008a, Article 4 - Special purpose and overlay zones, Title 9 – Land Use Development Code for Draper City, Chapter 9-19, Geologic Hazards Ordinance, adopted December 31, 2007-Ord 547, effective January 1, 2008.

Draper City, 2008b, Appendix B, Minimum standards for surface-fault-rupture-hazard studies: January 1, 2008, Draper City Geologic Hazards Ordinance, Chapter 9-19.

McCalpin, J.P., 1996, editor, Paleoseismology: Academic Press, 588 p.

Morgan County, 2006, Chapter 14 of the Morgan County Land Use Management Code.

Salt Lake County, 2002a, Geologic hazards ordinance, Chapter 19.75 of the Salt Lake County zoning code of ordinances, adopted July 2002: Salt Lake County Planning and Development Services Division, 2001 South State Street, Suite N3700, Salt Lake County, Utah, 84190-4200, 11p.

Salt Lake County, 2002b, Minimum standards for surface fault rupture hazard studies, Appendix A, Geologic hazards ordinance, Chapter 19.75 of the Salt Lake County zoning code of ordinances, adopted July 2002: Salt Lake County Planning and Development Services Division, 2001 South State Street, Suite N3700, Salt Lake County, Utah, 84190-4200, 9p

Table A-1
Study, setback, or other risk reduction measure requirements and criticality factors (U) for IBC building occupancy class

IBC building occupancy class	Study, setback or other risk-reduction-measure[1] requirements based on fault activity class[2]			Criticality[3]	U[3]	Minimum setback[4]
	H	LQ	Q			
A. Assembly	R	O	O	2	2.5	25 feet
B. Business	R	O	O	3	2.0	20 feet
E. Educational	R	R	R[5]	1	3.0	50 feet
F. Factory/industrial	R	O	O	3	2.0	20 feet
H. High hazard	R	R	R[5]	1	3.0	50 feet
I. Institutional	R	R	R[5]	1	3.0	50 feet
M. Mercantile	R	O	O	3	2.0	20 feet
R. Residential (R-1, R-2, and R-4)	R	O	O	3	2.0	20 feet
R-3. Residential (R-3, includes single-family homes)	R	O	O	4	1.5	15 feet
S. Storage	O	O	O	-	-	-
U. Utility and misc.	O	O	O	-	-	-
Table A-2	R	R	R[5]	1	3.0	50 feet

[1] Study, setback, or other risk-reduction-measure: R - required; or O - optional but not required based on the low likelihood of surface rupture; appropriate disclosure required in all cases.

[2] Fault activity class: H-Holocene, LQ-Late Quaternary, Q-Quaternary; appropriate disclosure required in all cases.

[3] Criticality is a factor based on relative importance and risk posed by a building; lower numbers indicate more critical facilities. Criticality is included in setback equations by the factor U. U is inversely proportional to criticality to increase setbacks for more critical facilities.

[4] Use the *greater* of the minimum or the calculated setback.

[5] Study required; setback or other risk-reduction measure considered prudent but decision shall be based on risk in consultation with the County; appropriate disclosure is required.

Table A-2
Additional Structures Requiring Geologic Investigation

Buildings and other structures that represent a substantial hazard to human life in the event of failure, but not limited to:

1. Buildings and other structures where more than 300 people congregate in one area.

2. Buildings and other structures with elementary school, secondary school or day care facilities with occupancy greater than 250.

3. Buildings and other structures with occupancy greater than 500 for colleges or adult education facilities.

4. Health care facilities with occupancy greater than 50 or more resident patients but not having surgery or emergency treatment facilities.

5. Jails and detention facilities.

6. Any other occupancy with occupancy greater than 1000.

7. Power generating stations, water treatment or storage for potable water, waste water treatment facilities and other public utility facilities.

8. Buildings and other structures containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released.

Buildings and other structures designed as essential facilities including, but not limited to:

1. Hospitals and other care facilities having surgery or emergency treatment facilities.

2. Fire, rescue and police stations and emergency vehicle garages and fueling facilities.

3. Designated emergency shelters.

4. Designated emergency preparedness, communications, and operation centers and other facilities required for emergency response.

5. Power-generating stations and other public utility facilities required as emergency backup facilities for facilities and structures included in this table.

6. Structures containing highly toxic materials as defined by the most recently adopted version of the IBC where the quantity of the material exceeds the maximum allowable quantities defined by the most recently adopted version of the IBC.

7. Aviation control towers, air traffic centers and emergency aircraft hangars.

8. Buildings and other structures having critical national defense functions.

9. Water treatment and storage facilities required to maintain water pressure for fire suppression.

APPENDIX B

Minimum Standards for Slope Stability Analyses

Morgan County Geologic Hazards Ordinance
Title 8, Chapter 5I of the Morgan County Code

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1.0 INTRODUCTION

The procedures outlined herein are intended to provide consultants with a general outline for performing quantitative slope stability analyses and to clarify the expectations of Morgan County. These standards constitute the minimum level of effort required in conducting quantitative slope stability analyses in Morgan County. Considering the complexity inherent in performing slope stability analyses, additional effort beyond the minimum standards presented herein may be required at some sites to adequately address slope stability. The information presented herein does not relieve consultants of their duty to perform additional geologic or engineering analyses they believe are necessary to assess the stability of slopes at a site.

The evaluation of landslides generally requires quantitative slope stability analyses. Therefore, the standards presented herein are directly applicable to landslide hazard investigations, and also constitute the minimum level of effort when performing landslide hazard investigations. This appendix does not address debris flows (see Appendix D) or rock falls (see Appendix E).

The purposes for establishing minimum standards for slope stability analyses are to:

(a) protect the health, safety, welfare, and property of the public by minimizing the potentially adverse effects of unstable slopes and related hazards;

(b) assist property owners and land developers in conducting reasonable and adequate studies;

(c) provide consulting engineering geologists and geotechnical engineers with a common basis for preparing proposals, conducting investigations, and mitigation; and,

(d) provide an objective framework for regulatory review of slope stability reports.

1.1 References and Sources

The minimum standards presented herein were developed, in part, from the following sources:

(a) Guidelines for Evaluating Landslide Hazards in Utah (Hylland, 1996).

(b) Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Landslide Hazards in California (Blake and others, 2002).

(c) CDMG Special Publication 117, Guidelines for Analyzing and Mitigating Landslide Hazards in California (1977).

(d) CDMG Special Publication 117, Guidelines for evaluating and mitigating seismic hazards in California (2008).

(e) Draper City geologic hazard ordinance; Draper City, 2008a; 2008b.

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1.2 Areas Requiring Slope Stability Analyses

Slope stability special-study-area maps have not been prepared for Morgan County at present. Such maps may be produced in the future and at that time will be adopted to become a part of this ordinance. Slope stability analyses shall be performed for all slopes that may be affected by the proposed development which meet the following criteria:

(a) cut and/or fill slopes steeper than, or equal to, about 2 horizontal (h) to 1 vertical (v).

(b) natural slopes steeper than or equal to 4 horizontal (h) to 1 vertical (v).

(c) natural and cut slopes with potentially adverse geologic conditions (e.g. bedding, foliation, or other structural features that are potentially adverse to the stability of the slope).

(d) natural and cut slopes which include a geologic hazard such as a landslide, irrespective of the slope height or slope gradient.

(e) buttresses and stability fills.

(f) cut, fill, or natural slopes of water-retention basins or flood-control channels.

(g) areas designated as Qm, Qms, Qms1, Qmsy, Qmso, Qmc, Qmg, Qac, Qg, Qga, Qgy, Qgmy, Qgay, Qgo, Qgao Qgm, Qgmo, and Tn on the most recent version of the following geologic maps (many of which are interim or in-progress):

(1) King, J.K, 2009, Progress report geologic map of the Bybee Knoll quadrangle, Morgan and Weber Counties, Utah: Utah Geological Survey files, scale 1:24,000,

(2) Coogan, J.C. and King, J.K., 2009, Progress report geologic map of the Devils Slide quadrangle, Morgan and Summit Counties, Utah: Utah Geological Survey files, scale 1:24,000;

(3) Coogan, J.C., and King, J.K., 2006, Interim geologic map of the Durst Mountain Quadrangle, Morgan and Weber Counties, Utah: Utah Geological Survey, Open-File Report 498, scale: 1:24,000;

(4) Coogan, J.C., 2004, Interim geologic map of the Francis Canyon 7.5' quadrangle, Morgan Rich, and Summit Counties, Utah: Utah Geological Survey Open-File Report 425, scale 1:24,000;

(5) Coogan, J.C., 2002, Progress report geologic map of the Heiners Creek quadrangle, Morgan and Summit Counties, Utah: Utah Geological Survey files, scale 1:24,000;

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(6) Coogan, J.C., 2002, Progress report geologic map of the Henefer quadrangle, Morgan and Summit Counties, Utah: Utah Geological Survey files, scale 1:24,000;

(7) Coogan, J.C., 2006, Interim geologic map of the Horse Ridge 7.5' quadrangle, Morgan Rich, and Weber Counties, Utah: Utah Geological Survey Open-File Report 480, scale 1:24,000;

(8) Coogan, J.C., 2004, Interim geologic map of the Lost Creek Dam 7.5' quadrangle, Morgan and Weber Counties, Utah: Utah Geological Survey Open-File Report 426, scale 1:24,000;

(9) Coogan, J.C., King, J.K., and McDonald, G.N., 2007, Progress report geologic map of the Morgan 7.5' quadrangle, Morgan County, Utah: Utah Geological Survey files, scale: 1:24,000;

(10) Coogan, J.C., 2004, Interim geologic map of the Peck Canyon 7.5' quadrangle, Morgan and Rich Counties, Utah: Utah Geological Survey Open-File Report 427, scale 1:24,000

(11) King, J.K., and McDonald, G.N., 2002, Progress report geologic map of the Peterson quadrangle, Davis and Morgan Counties, and the east part of the Kaysville quadrangle, Davis County, Utah: Utah Geological Survey files, scale: 1:24,000;

(12) King, J.K, 2002, Progress report geologic map of the Shearing Corral quadrangle, Morgan, Rich, and Summit Counties, Utah: Utah Geological Survey files, scale 1:24,000;

(13) King, J.K., Yonkee, W.A., and Coogan, J.C., 2008, Interim geologic map of the Snow Basin and part of the Huntsville quadrangle, Davis, Morgan, and Weber Counties, Utah: Utah Geological Survey Open-File Report 536, scale 1:24,000, and;

(14) Coogan, J.C. and King, J.K., 2001, Progress Report - Geologic map of the Ogden 30 by 60 minute Quadrangle, Utah and Wyoming, year 3 of 3: Utah Geological Survey Open-File Report 380, 1:100,000.

(h) areas designated as "Landslide" in Kaliser, B.N., 1972, Geologic hazards in Morgan County with applications to planning purposes, Utah Geological and Mineralogical Survey Bulletin 93, p.56, 2 plates;

(i) areas designated as ld, lde, lds, ldl, and Tn on Van Horn, R., and Crittenden, Jr., M.D., 1987, Map showing surficial units and bedrock geology of the Fort Douglas quadrangle and parts of the Mountain Dell and Salt Lake City North quadrangles, Davis, Salt Lake, and Morgan Counties, Utah: U.S. Geological Survey Miscellaneous Investigation Series Map I-1762, scale 1:24,000;

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(j) areas designated as Ql, Qm, and Tn on Bryant, B., 1988, Geology of the Farmington Canyon Complex, Wasatch Mountains, Utah: U.S. Geological Survey Professional Paper 1476, 54 p., scale 1:50,000 (part of Bountiful Peak quadrangle and west 1/2 of Porterville quadrangle, Morgan County, Utah);

(k) low, moderate, and high landslide susceptibility areas identified by Giraud, R.E., and Shaw, L.M., 2007, Landslide susceptibility map of Utah: Utah Geological Survey Map M-228, 11 p., 1 pl., scale 1:500,000;

(l) landslide areas identified by:

(1) Harty, K.M., 1992, Landslide map of Utah: Utah Geological Survey M-133, 28 p., 2 sheets, scale 1:500,000;

(2) Harty, K.M., 1992, Landslide map of the Ogden 30' x 60' quadrangle, Utah: Utah Geological Survey OFR-247, 11 p., 1 plate, scale 1:100,000, and;

(3) Harty, K.M., 1992, Landslide map of the Salt Lake City 30' x 60' quadrangle, Utah: Utah Geological Survey OFR-236, 17 p., 1 plate, scale 1:100,000.

Investigations shall address the potential for surficial instability, debris/mudflows (see Appendix D), rock falls (see Appendix E), and soil creep on all slopes that may affect the proposed development or be affected by the proposed development.

The preceding criteria constitute Morgan County Slope Stability Special Study Areas. A site-specific slope stability analysis is required within these areas, according to the applicability criteria found in MMC 8-5I-030. Development of said properties requires submittal and review of a site-specific slope stability analysis report prior to receiving a land use or building permit from the County. It is the responsibility of the applicant to retain a *qualified* engineering geologist and geotechnical engineer to perform the slope stability analysis (see Section 1.4).

When evaluating site conditions to determine the need for slope stability analyses, off-property conditions shall be considered (both up-slope to the top(s) of adjacent ascending slopes and down-slope to and beyond the toe(s) of adjacent descending slopes). Also, the consultant shall demonstrate that the proposed hillside development will not affect adjacent sites or limit adjacent property owners' ability to develop their sites.

1.3 Roles of Engineering Geologist and Engineering

The investigation of the static and seismic stability of slopes is an interdisciplinary practice. To provide greater assurance that the hazards are properly identified, assessed, and mitigated, involvement of both an engineering geologist and geotechnical engineer is required. Analyses shall be performed only by or under

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the direct supervision of licensed professionals, qualified and competent in their respective area of practice (see Section 1.4).

An engineering geologist shall provide appropriate input to the geotechnical engineer with respect to the potential impact of the geology, stratigraphy, and hydrologic conditions on the stability of the slope. The shear strength and other geotechnical earth material properties shall be evaluated by the geotechnical engineer. Qualified engineering geologists, geological engineers and geotechnical engineers may assess and quantitatively evaluate slope stability. However, the geotechnical engineer shall perform all design stability calculations. Ground motion parameters for use in seismic stability analysis may be provided by either the engineering geologist or geotechnical engineer.

1.4 Minimum Qualifications of the Licensed Professional

Slope stability analyses must be performed by qualified engineering geologists and qualified geotechnical engineers (see Morgan County Geologic Hazards Ordinance, **Chapter 5I of the Morgan County Code,** Sections **8-5I-060 and 8-5I-070**).

2.0 GENERAL REQUIREMENTS

Except for the derivation of the input ground motion for pseudostatic and seismic deformation analyses (see Section 12.0), slope stability analyses and evaluations should be performed in general accordance with the latest version of Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Landslide Hazards in California (Blake and others, 2002). Procedures for developing input ground motions to be used in Morgan County are described in Section 12.0. See Morgan County Geologic Hazard Ordinance (**Chapter 5I of the Morgan County Code**), for supplemental requirements.

3.0 SUBMITTALS

Submittals for review shall include boring logs; geologic cross sections; trench and test pit logs; laboratory data (particularly shear strength test results, including individual stress-deformation plots from direct shear tests); discussions pertaining to how idealized subsurface conditions and shear strength parameters used for analyses were developed; analytical results, including computer output files (when requested); and summaries of the slope stability analyses and conclusions regarding slope stability.

Subsurface geologic and groundwater conditions must be illustrated on geologic cross sections and must be utilized by the geotechnical engineer for the slope stability analyses. If on-site sewage or storm water disposal exists or is proposed, the slope stability analyses shall include the effects of the effluent plume on slope stability.

The results of any slope stability analyses must be submitted with pertinent backup documentation (e.g., calculations, computer output, etc.). Printouts of input data, output data (when requested), and graphical

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plots must be submitted for each computer-aided slope stability analysis. In addition, input data files, recorded on diskettes, CDs, or other electronic media may be requested to facilitate the County's review.

4.0 FACTORS OF SAFETY

The minimum acceptable static factor of safety is 1.5 for both gross and surficial slope stability. The minimum acceptable factor of safety for a calibrated pseudostatic analysis is 1.1 using the method of Stewart and others (2003) (see Section 12.0).

5.0 LANDSLIDES

Evaluation of landslides shall be performed in the preliminary phase of hillside developments. Where landslides are present or suspected, sufficient subsurface exploration shall be required to determine the basic geometry and stability of the landslide mass and the required stabilization measures. The depth of geologic exploration shall consider the regional geologic structure, the likely failure mode of the suspected failure, and past geomorphic conditions.

6.0 SITE INVESTIGATION AND GEOLOGIC STUDIES

Adequate evaluation of slope stability for a given site requires thorough and comprehensive geologic and geotechnical engineering studies. These studies are a crucial component in the evaluation of slope stability. Geologic mapping and subsurface exploration are normal parts of field investigation. Samples of earth materials shall be routinely obtained during subsurface exploration for geotechnical testing in the laboratory to determine the shear strength parameters and other pertinent engineering properties.

In general, geologic studies for slope stability consist of the following fundamental phases:

(a) study and review of published and unpublished geologic information (both regional and site specific);

(b) review and interpretation of available stereoscopic, oblique aerial photographs, and DEMs derived from detailed topographic maps and LIDAR;

(c) geologic field mapping, including, but not necessarily limited to, measurement of bedding, foliation, fracture, and fault attitudes and other geologic/structural parameters, and accurate delineation of any existing landslides;

(d) documentation and evaluation of subsurface groundwater conditions (including effects of seasonal and longer-term natural fluctuations as well as landscape irrigation), surface water, on-site sewage disposal, and/or storm water disposal;

(e) subsurface exploration (see Section 7.0);

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(f) analysis of the geologic failure mechanisms that could occur at the site (e.g., mode of failure and construction of the critical geologic cross sections), and;

(g) presentation and analysis of the data, including an evaluation of the potential impact of geologic conditions on the project.

Geologic and geotechnical reports shall demonstrate that each of these phases has been adequately performed and that the information obtained has been considered and logically evaluated. A statement shall be provided regarding the suitability of the site for proposed development from a geologic hazards perspective. Minimum criteria for the performance of each phase are also described and discussed in Blake and others (2002). See Morgan County Geologic Hazards Ordinance, **Chapter 5I of the Morgan County Code,** Section **8-5I-100** for additional report requirements.

7.0 SUBSURFACE EXPLORATION

The purpose of subsurface exploration is to identify potentially significant geologic materials and structures at a site and to provide samples for detailed laboratory characterization of materials from potentially critical zones. Subsurface exploration is almost always required and may be performed by a number of widely known techniques such as bucket-auger borings, conventional small-diameter borings, cone penetration testing (CPT), test pits, trenches, and/or geophysical techniques (see Section 4.2 of Blake and others, 2002). Exploration methods shall be clearly described in the report. A discussion of the applicability of some subsurface exploration techniques follows.

7.1 Trenching

Subsurface exploration consisting of trenching has proven, in some cases, to be necessary when uncertainty exists regarding whether or not a particular landform is a landslide. Care must be exercised with this exploration method because landslides characteristically contain relatively large blocks of intact geologic units, which in a trench exposure could give the false impression that the geologic unit is "in-place." Although limited to a depth of about 15 feet below existing grades, trenching has also proven to be a useful technique for verifying margins of landslides, although the geometry of a landslide can generally be readily determined from evaluation of stereoscopic aerial photographs, oblique aerial photographs, topographic maps, and/or DEMs derived from detailed topography and/or LIDAR. Once a landslide is identified, conventional subsurface exploration drilling techniques will be required (see Section 7.2 and 7.3). Slope stability analyses based solely on data obtained from trenches will not be accepted.

7.2 Methods for Bedded Formations

Conventional subsurface exploration techniques involving continuous core drilling with an oriented core barrel and deep bucket-auger borings shall be used to assess the subsurface soil and geologic conditions, particularly for geologic units with inclined bedding that includes weak layers.

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Although not commonly utilized in Utah, a 24-inch-diameter bucket-auger-boring with down-hole logging can provide valuable data (provided the consultant has determined the drill hole is safe to enter). The evaluation of safety of proposed subsurface exploration programs shall be the responsibility of the applicant's consultant(s).

Particular attention must be paid to the presence or absence of weak layers (e.g., clay, claystone, silt, shale, or siltstone units) during the exploration. Unless adequately demonstrated (through comprehensive and detailed subsurface exploration) that weak (clay, claystone, silt, shale, or siltstone) layers (even as thin as 1/16-inch or less) are not present, a weak layer shall be assumed to possibly occur anywhere in the stratigraphic profile (e.g., ubiquitous weak clay beds).

The depth of the subsurface exploration must be sufficient to assess the conditions at or below the level of the deepest potential failure surface possessing a factor of safety of 1.5 or less. A preliminary slope stability analysis may need to be performed to assist in the planning of the subsurface exploration program.

7.3 Other Geologic Units

For alluvium, fill materials, or other soil units that do not contain weak interbeds, other exploration methods such as small-diameter borings (e.g., rotary wash or hollow-stem-auger) or cone penetration testing may be suitable.

8.0 SOIL PARAMETERS

Soil properties, including unit weight and shear strength parameters (cohesion and friction angle), may be based on conventional field and laboratory tests as well as on field performance. Where appropriate (e.g., for landslide slip surfaces, along bedding planes, for surficial stability analyses, etc.), laboratory tests for saturated, residual shear strengths must be performed. Estimation of the shear resistance along bedding (or landslide) planes normally requires an evaluation of saturated residual along-bedding-strength values of the weakest interbedded (or slide-plane) material encountered during the subsurface exploration, or in the absence of sufficient exploration, the weakest material that may be present, consistent with site geologic conditions. Strength parameters derived solely from CPT data may not be appropriate for slope-stability analysis in some cases, particularly for strengths along existing slip surfaces where residual strengths have developed. Additional guidance on the selection of strength parameters for slope stability analyses is contained in Blake and others (2002).

8.1 Residual Shear Strength Parameters

Residual strength parameters may be determined using the direct shear or ring shear testing apparatus; however ring shear tests are preferred. If performed properly, direct shear test results may approach ring-shear test results. The soil specimen must be subjected to a sufficient amount of deformation (e.g., a significant number of shearing cycles in the direct shear test or a significant amount of rotation in the ring shear test) to assure that residual strength has been developed. In the direct-shear and ring-shear tests, stress-deformation curves can be used to determine when a sufficient number of cycles of shearing have been performed by showing that no further significant drop in shear strength results with the addition of

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more cycles or more rotation. The stress-deformation curves obtained during the shear tests must be submitted with the other pertinent laboratory test results. It shall be recognized that for most clayey soils, the residual shear strength envelope is curved and passes through the origin (e.g., at zero normal stress there is zero shear strength). Any "apparent shear strength" increases resulting from a non-horizontal shear surface (e.g., ramping) or "bulldozing" in residual direct shear tests shall be discounted in the interpretation of the strength parameters.

8.2 Interpretation

Inherent in the analyses, the geotechnical engineer will need to use judgment in the selection of appropriate shear test methods and in the interpretation of the results to develop shear strength parameters commensurate with slope stability conditions to be evaluated. Scatter plots of shear strength data may need to be presented to allow for assessment of idealized parameters. The report shall summarize shear strength parameters used for slope stability analyses and describe the methodology used to interpret test results and estimate those parameters.

Peak shear strengths may be used to represent across-bedding failure surfaces or compacted fill, in situations where strength degradations are not expected to occur (see Blake and others, 2002). Where peak strengths cannot be relied upon, fully softened (or lower) strengths shall be used.

Ultimate shear strength parameters shall be used in static slope stability analyses when there has not been past deformation. Residual shear strength parameters shall be used in static slope stability analyses when there has been past deformation.

Averaged strength parameters may be appropriate for some across-bedding conditions, if sufficient representative samples have been carefully tested. Analyses for along-bedding or along-existing-landslide slip surfaces shall be based on lower-bound interpretations of residual shear strength parameters and comparison of those results to correlations, such as those of Stark and others (2005).

8.3 Default Soil Parameters

In Morgan County, failure surfaces for known landslides commonly occur within the Norwood Tuff Formation. In cases when the failure surface has been sampled, tested, and back-calculations performed of historic landslides, relatively low residual-shear-strength values have been obtained; these values are cohesion equal to 0 psf and a friction angles equal to 7 to 9 degrees.

To assist in understanding shear strengths of these materials, the following shear strength parameters for landslide failure surfaces and along weak layers within the Norwood Tuff formation shall be used; cohesion equal to 0 psf and a friction angle equal to 7 degrees, unless otherwise demonstrated. If site-specific testing produces lower residual shear strength than these values, the site-specific test results should be used. If site-specific testing produces higher values, documentation must be provided to clearly

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demonstrate that the weakest materials were retrieved and tested and that the materials retrieved truly represent the basal landslide slip surface.

9.0 SOIL CREEP

The potential effects of soil creep shall be addressed where any proposed structure is planned in close proximity to an existing fill slope or natural slope. The potential effects on the proposed development shall be evaluated and mitigation measures proposed, including appropriate setback recommendations. Setback recommendations shall consider the potential affects of creep forces.

All reports in Morgan County Slope Stability Special Study Areas shall address the potential for surficial instability, debris flows (Appendix D), rock falls (Appendix E), and soil creep on all slopes that may affect the proposed development or be affected by the proposed development. Stability of slopes along access roads shall also be addressed.

10.0 GROSS STATIC STABILITY

Gross stability includes rotational and translational deep-seated failures of slopes or portions of slopes existing within or outside of but potentially affecting the proposed development. The following guidelines, in addition to those in Blake and others (2002), shall be followed when evaluating slope stability:

(a) stability shall be analyzed along cross sections depicting the most adverse conditions (e.g., highest slope, most adverse bedding planes, shallowest likely ground water table, steepest slope, etc.). Often analyses are required for different conditions and for more than one cross section to demonstrate which condition is most adverse. When evaluating the stability of an existing landslide, analyses must also address the potential for partial reactivation. Inclinometers may be used to help determine critical failure surfaces and, along with high-resolution GPS, the state of activity of existing landslides. The critical failure surfaces on each cross-section shall be identified, evaluated, and plotted on the large-scale cross section;

(b) if the long-term static factor of safety is less than 1.5, mitigation measures shall be required to bring the factor of safety up to the required level or the project may be redesigned to achieve a minimum factor of safety of 1.5;

(c) the temporary stability of excavations shall be evaluated and mitigation measures shall be recommended as necessary to obtain a minimum factor of safety of 1.3;

(d) long-term stability shall be analyzed using the highest known or anticipated groundwater level based upon a groundwater assessment performed under the requirements of Section 6.0;

(e) where back-calculation is appropriate, shear strengths utilized for design shall be no higher than the lowest strength computed using back calculation. If a consultant proposes to use shear

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strengths higher than the lowest back-calculated value, justification shall be required. Assumptions used in back-calculations regarding pre-sliding topography and groundwater conditions at failure must be discussed and justified;

(f) reports shall describe how the shear strength testing methods used are appropriate in modeling field conditions and long-term performance of the subject slope. The utilized design shear strength values shall be justified with laboratory test data and geologic descriptions and history, along with past performance history, if known, of similar materials;

(g) reports shall include shear strength test plots consisting of normal stress versus shear resistance (failure envelope). Plots of shear resistance versus displacement shall be provided for all residual and fully softened (ultimate) shear tests;

(h) the degree of saturation for all test specimens shall be reported. Direct shear tests on partially saturated samples may grossly overestimate the cohesion that can be mobilized when the material becomes saturated in the field. This potential shall be considered when selecting shear strength parameters. If the rate of shear displacement exceeds 0.005 inches per minute, the consultant shall provide data to demonstrate that the rate is sufficiently slow for drained conditions;

(i) shear strength values higher than those obtained through site-specific laboratory tests generally will not be accepted;

(j) if direct shear or triaxial shear testing is not appropriate to model the strength of highly jointed and fractured rock masses, the design strengths shall be evaluated in a manner that considers overall rock mass quality and be consistent with rock mechanics practice;

(k) shear strengths used in slope stability analyses shall be evaluated considering the natural variability of engineering characteristics inherent in earth materials. Multiple shear tests on each site material are likely to be required;

(l) Direct shear tests do not always provide realistic strength values (Watry and Lade, 2000). Correlations between liquid limit, percent clay fraction, and strength (fully softened and residual) with published data (e.g., Stark and others, 2005) shall be performed to verify tested shear strength parameters. Strength values used in analyses that exceed those obtained by the correlation must be appropriately justified;

(m) shear strengths for proposed fill slopes shall be evaluated using samples mixed and remolded to represent anticipated field conditions. Confirming strength testing may be required during grading;

(n) where bedding planes are laterally unsupported on slopes, potential failures along the unsupported bedding planes shall be analyzed. Similarly, stability analyses shall be performed where bedding planes form a dip-slope or near-dip-slope using composite potential failure surfaces that consist of

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potential slip surfaces along bedding planes in the upper portions of the slope in combination with slip surfaces across bedding planes in the lower portions of the slope;

(o) the stability analysis shall include the effect of expected maximum moisture conditions on soil unit weight;

(p) for effective stress analyses, measured groundwater conditions adjusted to consider likely unfavorable conditions with respect to anticipated future groundwater levels, seepage, or pore pressure shall be included in the slope stability analyses;

(q) tension crack development shall be considered in the analyses of potential failure surfaces. The height and location of the tension crack shall be determined by searching;

(r) anticipated surcharge loads as well as external boundary pressures from water shall be included in the slope stability evaluations, as deemed appropriate;

(s) analytical chart solutions may be used provided they were developed for conditions similar to those being analyzed. Generally though, computer-aided searching techniques shall be used, so that the potential failure surface with the lowest factor of safety can be located. Examples of typical searching techniques are illustrated on figures 9.1a through 9.1f in Blake and others (2002). However, verification of the reasonableness of the analytical results is the responsibility of the geotechnical engineer and/or engineering geologist, and;

(t) the critical potential failure surface used in the analysis may be composed of circles, wedges, planes, or other shapes considered to yield the minimum factor of safety most appropriate for the geologic site conditions. The critical potential failure surface having the lowest factor of safety with respect to shearing resistance must be sought. Both the lowest factor of safety and the critical failure surface shall be documented.

11.0 SURFICIAL STABILITY OF SLOPES

Surficial slope stability refers to slumping and sliding of near-surface sediments and is most critical during the snowmelt and rainy season or when excessive landscape water is applied. The assessment of surficial slope stability shall be based on analysis procedures for stability of an infinite slope with seepage parallel to the slope surface or an alternate failure mode that would produce the minimum factor of safety. The minimum acceptable depth of saturation for surficial stability evaluation shall be four feet.

11.1 Applicability and Procedures

Conclusions shall be substantiated with appropriate data and analyses. Residual shear strengths comparable to actual field conditions shall be used in completing surficial stability analyses. Surficial stability analyses shall be performed under rapid draw-down conditions where appropriate (e.g., for debris and detention basins).

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Where 2:1 or steeper slopes have soil conditions that can result in the development of an infinite slope with parallel seepage, calculations shall be performed to demonstrate that the slope has a minimum static factor of safety of 1.5, assuming a fully saturated 4-foot thickness. If conditions will not allow the development of a slope with parallel seepage, surficial slope stability analyses may not be required (provided the County concurs).

Surficial slope stability analyses shall be performed for fill, cut, and natural slopes assuming an infinite slope with seepage parallel to the slope surface or other failure mode that would yield the minimum factor of safety against failure. A suggested procedure for evaluating surficial slope stability is presented in Blake and others (2002).

11.2 Soil Properties

Soil properties used in surficial stability analyses shall be determined as noted in Section 8.1. Residual shear strength parameters for surficial slope stability analyses shall be developed for a stress range that is consistent with the near-surface conditions being modeled. As indicated in Section 8.1, it shall be recognized that for most clayey soils, the residual shear strength envelope is curved and passes through the origin (e.g., at zero normal stress there is zero shear strength). For sites with deep slip surfaces, the guidelines given by Blake and others (2002) should be followed.

11.3 Seepage Conditions

The minimum acceptable vertical depth for which seepage parallel to the slope shall be applied is four feet for cut or fill slopes. Greater depths may be necessary when analyzing natural slopes that have significant thicknesses of loose surficial material.

12.0 SEISMIC SLOPE STABILITY

In addition to static slope stability analyses, slopes shall be evaluated for seismic slope stability as well. Acceptable methods for evaluating seismic slope stability using calibrated pseudo-static limit-equilibrium procedures and simplified methods (e.g., those based on Newmark, 1965) to estimate permanent seismic slope movements are summarized in Blake and others (2002).

Nonlinear, dynamic finite element/finite difference numerical methods also may be used to evaluate slope movements resulting from seismic events as long as the procedures, input data, and results are thoroughly documented, and deemed acceptable by the County.

12.1 Ground Motion for Pseudostatic and Seismic Deformation Analyses

In regards to design ground accelerations for seismic slope-stability analyses, Morgan County prefers a probabilistic approach to determining the likelihood that different levels of ground motion will be exceeded at a particular site within a given time period. In order to more closely represent the seismic characteristics

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of the region, design ground motion parameters for seismic slope stability analyses shall be based on the peak accelerations with a 2.5 percent probability in 50 years (2,500-year return period).

Peak bedrock ground motions can be readily obtained via the internet from the United States Geological Survey (USGS) National Seismic Hazard Maps (USGS, 2008), Data and Documentation web page (http://earthquake.usgs.gov/research/hazmaps/products_data/2008/ or most recent version), which is based originally on Frankel and others (2002). PGAs obtained from the USGS web page should be adjusted for effects of soil/rock (site-class) conditions in accordance with Seed and others (2001) or other appropriate methods that consider the site-specific soil conditions and their potential for amplification/deamplification of the high frequency strong motion. Site specific response analysis may also be used to develop PGA values as long as the procedures, input data, and results are thoroughly documented, and deemed acceptable by the County.

12.2 Pseudo-Static Evaluations

Pseudo-static methods for evaluating seismic slope stability are acceptable as long as minimum factors of safety are satisfied, and due consideration is given in the selection of the seismic coefficient (kh) reduction in material shear strengths, and the factor of safety for pseudo-static conditions.

Pseudo-static seismic slope stability analyses can be performed using the "screening analysis" procedure described in Blake and others (2002). For that procedure a kh-value is selected from seismic source characteristics (modal magnitude, modal distance, and firm rock peak ground acceleration) and an acceptable level of deformation (5 cm) is specified. For that procedure, a factor of safety of 1.0 or greater is considered acceptable; otherwise, an analysis of permanent seismic slope deformation shall be performed.

12.3 Permanent Seismic Slope Deformation

For seismic slope stability analyses, estimates of permanent seismic displacement are preferred and may be performed using the procedures outlined in Blake and others (2002). It should be noted that Bray and Rathje (1998), referenced in Blake and others (2002), has been updated and superseded by Bray and Travasarou (2007), which is the County's currently preferred method. For those analyses, calculated seismic displacements shall be 5 cm or less, or mitigation measures shall be proposed to limit calculated displacements to 5 cm or less.

For specific projects, different levels of tolerable displacement may be possible, but site-specific conditions, which shall include the following, must be considered:

(a) the extent to which the displacements are localized or broadly distributed – broadly distributed shear deformations would generally be less damaging and more displacement could be allowed;

(b) the displacement tolerance of the foundation system – stiff, well-reinforced foundations with lateral continuity of vertical support elements would be more resistant to damage (and hence could

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potentially tolerate larger displacements) than typical slabs-on-grade or foundation systems with individual spread footings, and;

(c) the potential of the foundation soils to experience strain softening – slopes composed of soils likely to experience strain softening should be designed for relatively low displacements if peak strengths are used in the evaluation of the yield coefficient (k_y) due to the potential for progressive failure, which could involve very large displacements following strain softening.

In order to consider a threshold larger than 5 cm, the project consultant shall provide prior, acceptable justification to the County and obtain the County's approval. Such justification shall demonstrate, to the satisfaction of the County, that the proposed project will achieve acceptable performance.[1]

13.0 WATER RETENTION BASINS AND FLOOD CONTROL CHANNELS

Slope stability analyses shall be performed for cut, fill, or natural slopes of water-retention basins or flood-control channels. In addition to analyzing typical static and seismic slope stability, those analyses shall consider the effects of rapid drawdown, if such a condition could develop.

14.0 MITIGATION

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[1] The SP117 Guidelines Committee (Blake and others, 2002) struggled in its deliberations regarding this issue and was unable to reach unanimous consensus. However, it was the judgment of all but one of the committee members (14 out of the 15) that when the critical slip surface from slope stability analysis daylights within a structure that is likely to be occupied by people during an earthquake, and if calculated median displacements (u) can be maintained at less than 5 cm, it is unlikely that the building would be damaged sufficiently to significantly threaten its structural integrity. One of the committee members felt that the calculated median seismic displacements through occupied structures should be maintained at less than 15 cm, but other than having that opinion, he did not offer a specific justification for that choice. Neither of those values (5 or 15 cm) is necessarily the "correct" median value, because they are judgment-based.

Ideally, allowable displacements for analyses would be established from a database in which observed slope displacements from earthquakes are correlated to measures of damage in structures. Unfortunately, however, such data do not exist in sufficient quantity to be useful, and hence there is an insufficient basis for selecting allowable displacements empirically. Accordingly, allowable displacement levels are established from engineering judgment. A number of factors affect the degree to which slope displacements will be damaging to structures. Displacements that occur beneath occupied structures are more critical than those in garden areas or streets. Displacements that occur abruptly across a narrow shear surface can be more damaging than those that are broadly distributed across a wide zone of deformation. Moreover, different structural systems will have different tolerances to differential movements beneath their foundation.

In their recent paper, Bray and Travasarou (2007) describe displacements of 1 cm or less as "negligible" and displacements of 5 cm or less as "minor." In an oral presentation made to the Los Angeles Section of ASCE (on November 15, 2007), Jonathan Bray described seismic displacements of 15 cm to 1 m as "moderate" and those larger than 1 m as "large," but he cautioned that such general classifications depend on factors such as the foundation system, consequences of displacement, soil behavior, etc.

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When slope stability hazards are determined to exist on a project, measures to mitigate impacts from those hazards shall be implemented. Some guidance regarding mitigation measures is provided in Blake and others (2002). Slope stability mitigation methods include:

(a) hazard avoidance;

(b) grading to improve slope stability;

(c) reinforcement of the slope or improvement of the soil within the slope, and;

(d) reinforcement of the structure built on the slope to tolerate anticipated slope displacements.

Where mitigation measures that are intended to add stabilizing forces to the slope are to be implemented, consideration may need to be given to strain compatibility. For example, if a compacted fill buttress is proposed to stabilize laterally unsupported bedding or a landslide, the amount of deformation needed to mobilize the recommended shear strength in the buttress shall be considered to confirm that it will not result in adverse movements of the upslope bedding or landslide deposits. Similarly, if a series of drilled soldier piers is to be used to support a potentially unstable slope and a residential structure will be built on the piers, pier deformations resulting from movements needed to mobilize the soil's shear strength shall be compared to tolerable deflections in the supported structure.

14.1 Full Mitigation

Full mitigation of slope stability hazards shall be performed for developments in the County. Remedial measures that produce static factors of safety in excess of 1.5 and acceptable seismic displacement estimates shall be implemented as needed.

14.2 Partial Mitigation for Seismic Displacement Hazards

On some projects or portions thereof (such as small structural additions, residential "infill projects", non-habitable structures, and non-structural natural-slope areas), full mitigation of seismic slope displacements may not be possible, due to physical or economic constraints. In those cases, partial mitigation, to the extent that it prevents structural collapse, injury, and loss of life, may be possible if it can be provided consistent with IBC philosophies, and if it is approved by the County. The applicability of partial mitigations to specific projects shall be evaluated on a case-by-case basis.

15.0 NOTICE OF GEOLOGIC HAZARD AND WAIVER OF LIABILITY

For developments where full mitigation of seismic slope displacements is not implemented, a Notice of Geologic Hazard shall be recorded with the proposed development describing the displacement hazard at issue and the partial mitigation employed (see Morgan County Geologic Hazards Ordinance, **Chapter 5I of the Morgan County Code,** Section **8-5I-120)**. The Notice shall clearly state that the seismic displacement hazard at the site has been reduced by the partial mitigation, but not totally eliminated.

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In addition, the owner shall assume all risks, waive all claims against the County and its consultants, and indemnify and hold the County and its consultants harmless from any and all claims arising from the partial mitigation of the seismic displacement hazard (see Morgan County Geologic Hazards Ordinance, **Chapter 5I of the Morgan County Code,** Section **8-5I-160).**

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APPENDIX C

Minimum Standards for Liquefaction-Hazard Investigations

Morgan County Geologic Hazards Ordinance
Title 8, Chapter 5I of the Morgan County Code

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1.0 INTRODUCTION

The procedures outlined herein are intended to provide consultants with a general outline for performing liquefaction-hazard investigations and to specify the expectations of Morgan County. These standards constitute the *minimum* level of effort required in conducting liquefaction-hazard investigations in Morgan County. Considering the complexity inherent in performing liquefaction-hazard investigations, additional effort beyond the minimum standards presented herein may be required at some sites to adequately address the liquefaction potential at the site. The information presented herein does not relieve consultants of their duty to perform additional geologic or geotechnical engineering analyses they believe are necessary to adequately assess the liquefaction potential at a site.

The purpose of establishing minimum standards for liquefaction-hazard investigations is to:

(a) protect the health, safety, welfare, and property of the public by minimizing the potentially adverse effects of liquefaction and related hazards;

(b) assist property owners and land developers in conducting reasonable and adequate studies;

(c) provide consulting engineering geologists and geotechnical engineers with a common basis for preparing proposals, conducting investigations, and mitigation; and,

(d) provide an objective framework for regulatory review of liquefaction-hazard investigation reports.

1.1 References and Sources

The minimum standards presented herein were developed, in part, from the following sources:

(a) CDMG Special Publication 117, Guidelines for evaluating and mitigating seismic hazards in California (1997).

(b) CDMG Special Publication 117, Guidelines for evaluating and mitigating seismic hazards in California (2008).

(c) Recommended procedures for implementation of DMG Special Publication 117, guidelines for analyzing and mitigating liquefaction hazards in California (Martin and Lew, 1999).

(d) Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils, Technical Report NCEER-97-0022 (Youd and Idriss, 1997).

(e) Liquefaction Resistance of Soils: Summary Report from the 1996 and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, Journal of Geotechnical and Environmental Engineering (Youd et al., 2001).

(f) Salt Lake County geologic hazards ordinance (2002).

(g) Morgan County geologic hazard ordinance (2003).

(h) Draper City geologic hazard ordinance (Draper City, 2008a; 2008b).

1.2 Properties Requiring Liquefaction-Hazard Analyses

Liquefaction Potential special-study areas maps have not been prepared for Morgan County at present. Such maps may be produced in the future and at that time will be adopted to become a part of this ordinance. A site-specific liquefaction-hazard investigation is required, prior to approval of any land use. Development of said properties requires submittal and review of a site-specific liquefaction-hazard investigation prior to receiving a land use or building permit from the County. It is the responsibility of the applicant to retain a qualified engineering geologist and geotechnical engineer to perform the liquefaction-hazard investigation (see Morgan County Geologic Hazards Ordinance **Section 8-5I-060**).

A liquefaction-hazard analysis shall be performed in conjunction with any geotechnical or geologic hazards evaluation prepared within Morgan County. A liquefaction-hazard analysis must be performed for all critical and essential facilities regardless whether the site lies within a designated geologic hazards overlay zone area or not.

For all structures where liquefaction-hazard analysis indicates that ground settlement and/or lateral spread may be anticipated, the project structural engineer must provide documentation that the building is designed to accommodate the predicted ground settlements/displacements in such a manner as to be protective of life during and after the design seismic event.

1.3 Roles of Engineering Geology and Geotechnical Engineering

The investigation of liquefaction hazard is an interdisciplinary practice. The site investigation report must be prepared by a qualified geotechnical engineer (see Section 1.4), who must have competence in the field of seismic hazard evaluation and mitigation.

Because of the differing expertise and abilities of qualified engineering geologists and geotechnical engineers, the scope of the site investigation report for a project may require that both types of professionals prepare and review the report, each practicing in the area of their expertise. Involvement of both a qualified engineering geologist and geotechnical engineer will generally provide greater assurance that the hazard is properly identified, assessed, and mitigated.

Liquefaction-hazard analyses are the responsibility of the geotechnical engineer, although the engineering geologist should be involved in the application of screening criteria (Section 3.0) and general geologic site evaluation (Section 4.1) to map the likely extent of liquefiable deposits and shallow groundwater. Engineering properties of earth material shall be evaluated by the geotechnical engineer. The performance of the quantitative liquefaction-hazard analysis resulting in a numerical factor of safety and quantitative assessment of settlement and liquefaction-induced permanent ground displacement shall be performed by geotechnical engineers. The geotechnical and civil engineers shall develop all mitigation and design

recommendations. Ground motion parameters for use in quantitative liquefaction-hazard analyses may be provided by either the engineering geologist or geotechnical engineer.

1.4 Minimum Qualifications of the Licensed Professional

Liquefaction-hazard analyses must be performed by qualified engineering geologists and qualified geotechnical engineers (see Sections **8-5I-060 and 8-5I-070** of the Morgan County Geologic Hazards Ordinance, **Chapter 5I of the Morgan County Code**).

2.0 GENERAL REQUIREMENTS

Except for the derivation of input ground motion (see Section 5.0), liquefaction-hazard investigations should be performed in general accordance with the latest version of Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California (Martin and Lew, 1999). Additional protocol for liquefaction-hazard investigations is provided in Youd and Idriss (1997). See Morgan County Geologic Hazard Ordinance (**Chapter 5I of the Morgan County Code**) for supplemental requirements. Acceptable factors of safety are shown on the following table.

Type of Facility	Acceptable Factor of Safety
Critical facilities (essential facilities, hazardous facilities, and special occupancy structures as defined in section 9-19-20	1.3
Category III and IV in table 1604.58 of the most recently adopted edition of the IBC.	1.3
Industrial and commercial buildings.	1.25
Residential structures and subdivisions	1.2

3.0 PRELIMINARY SCREENING FOR LIQUEFACTION

Soil liquefaction is caused by strong seismic ground shaking where saturated, cohesionless, granular soil undergoes a significant loss in shear strength that can result in settlement and permanent ground displacement. Surface effects of liquefaction include: settlement, bearing capacity failure, ground oscillations, lateral spread and flow failure. It has been well documented that soil liquefaction may occur in clean sands, silty sands, and sandy silt, non-plastic silts and gravelly soils. The following conditions must be present for liquefaction to occur:

(a) soils *must be* submerged below the water table;

(b) soils *must be* loose to moderately dense;

(c) ground shaking *must be* relatively intense; and

(d) the duration of ground shaking *must be* sufficient for the soils to generate seismically-induced excess pore water pressure and lose their shearing resistance.

The following screening criteria may be applied to determine if further quantitative evaluation of liquefaction hazard is required:

(a) if the estimated maximum past-, current-, and maximum-future-groundwater-levels (i.e., the highest groundwater level applicable for liquefaction-hazard analyses) are determined to be deeper than 50 feet below the existing ground surface or proposed finished grade (whichever is deeper), liquefaction-hazard assessments are not required. For soil materials that are located above the level of the groundwater, a quantitative assessment of seismically induced settlement is required;

(b) if "bedrock" or similar lithified formational material underlies the site, those materials need not be considered liquefiable and no analysis of their liquefaction potential is necessary;

(c) if the corrected standard penetration blow count, $(N1)_{60}$, is greater than or equal to 33 in all samples with a sufficient number of tests, liquefaction-hazard assessments are not required. If cone penetration test soundings are made, the corrected cone penetration test tip resistance, qc1N, should be greater than or equal to 180 in all soundings in sand materials, otherwise liquefaction-hazard assessments are needed, and;

(d) if plastic soil ($PI \geq 20$) materials are encountered during site exploration, those materials may be considered non-liquefiable. Additional acceptable screening criteria regarding the effects of plasticity on liquefaction susceptibility are presented in Boulanger and Idriss (2004), Bray and Sancio (2006), and Seed and others (2003).

If the screening investigation clearly demonstrates the absence of liquefaction hazards at a project site and the County concurs, the screening investigation will satisfy the site investigation report requirement for liquefaction hazards. If not, a quantitative evaluation is required to assess the liquefaction hazards.

4.0 FIELD INVESTIGATIONS

Geotechnical field investigations are routinely performed for new projects as part of the normal development and design process. Geologic reconnaissance and subsurface explorations are normally performed as part of the field exploration program even when liquefaction-hazard assessments do not need to be investigated.

4.1 Geologic Reconnaissance

Geologic research and reconnaissance are important to provide information to define the extent of unconsolidated deposits that may be prone to liquefaction. Such information should be presented on geologic maps and cross sections and provide a description of the formations present at the site that includes the nature, thickness, and origin of Quaternary deposits with liquefaction potential. There also

should be an analysis of groundwater conditions at the site that includes the highest recorded water level and the highest water level likely to occur under the most adverse foreseeable conditions in the future.

During the field investigation, the engineering geologist should map the limits of unconsolidated deposits with liquefaction potential. Liquefaction typically occurs in cohesionless silt, sand, and fine-grained gravel deposits of Holocene to late Pleistocene age in areas where the groundwater is shallower than about 50 feet.

Shallow groundwater may exist for a variety of reasons, some of which are of natural and or manmade origin. Landscape irrigation, on-site sewage disposal, and unlined manmade lakes reservoirs, and storm-water detention basins may create a shallow groundwater table in sediments that were previously unsaturated.

4.2 Subsurface Explorations

Subsurface explorations shall consist of drilled-borings and/or cone penetration tests (CPTs). The exploration program shall be planned to determine the soil stratigraphy, groundwater level, and indices that could be used to evaluate the potential for liquefaction by either in situ testing or by laboratory testing of soil samples. Borings and CPT soundings must penetrate a minimum of 50 feet below final ground surface.

For saturated cohesionless soils where the SPT $(N1)_{60}$ values are less than 15, or where CPT tip resistances are below 60 tsf, grain-size analyses, hydrometers tests, and Atterberg Limits tests shall be performed on these soils to further evaluate their potential for permanent ground displacement (Youd et al., 2002) and other forms of liquefaction-induced ground failure and settlement. In addition, it is also recommended that these same tests be performed on saturated cohesionless soils with SPT $(N1)_{60}$ values between 15 and 30 to further evaluate the potential for liquefaction-induced settlement.

Where a structure may have subterranean construction or deep foundations (e.g., caissons or piles), the depth of investigation should extend to a depth that is a minimum of 20 feet below the lowest expected foundation level (e.g., caisson bottom or pile tip) or 50 feet below the existing ground surface or lowest proposed finished grade, whichever is deeper. If, during the investigation, the indices to evaluate liquefaction indicate that the liquefaction potential may extend below that depth, the exploration should be continued until a significant thickness (at least 10 feet, to the extent possible) of nonliquefiable soils are encountered.

5.0 GROUND MOTION FOR LIQUEFACTION-HAZARD INVESTIGATIONS

In regards to design ground accelerations for seismic slope-stability analyses, Morgan County prefers a probabilistic approach to determining the likelihood that different levels of ground motion will be exceeded at a particular site within a given time period. In order to more closely represent the seismic characteristics of the region, design ground motion parameters for seismic slope stability analyses shall be based on the peak accelerations with a 2.5 percent probability in 50 years (2,500-year return period). Peak bedrock ground motions can be readily obtained via the internet from the United States Geological Survey (USGS)

National Seismic Hazard Maps (USGS, 2008), Data and Documentation web page (http://earthquake.usgs.gov/research/hazmaps/products_data/2008/ or most current version), which is originally based on Frankel and others (2002). PGAs obtained from the USGS web page should be adjusted for effects of soil/rock (site-class) conditions in accordance with Seed and others (2001) or other appropriate methods that consider the site-specific soil conditions and their potential for amplification/deamplification of the high frequency strong motion.

Site specific response analysis may also be used to develop PGA values as long as the procedures, input data, and results are thoroughly documented, and deemed acceptable by the County.

6.0 REMEDIAL DESIGN

Sites, facilities, buildings, structures and utilities that are founded on or traverse liquefiable soils may require further remedial design and/or relocation to avoid liquefaction-induced damage. These should be investigated and evaluated on a site-specific basis with sufficient geologic and geotechnical evaluations to support the remedial design and/or mitigative plan. This design or plan may include: changes/modifications to the soil, foundation system, structural frame or support of the building, etc. and should be reviewed and approved by the County.

7.0 SUBMITTALS

Submittals for review shall include: boring logs; geologic cross-sections; laboratory data; discussions pertaining to how idealized subsurface conditions and parameters used for analyses were developed; analytical results, including computer output files (on request); and summaries of the liquefaction-hazard analyses and conclusions regarding liquefaction potential and likely types and amounts of ground failure. See Morgan County Geologic Hazard Ordinance (**Chapter 5I of the Morgan County Code**), for supplemental requirements.

Subsurface geologic and groundwater conditions must be illustrated on geologic cross-sections and must be utilized by the geotechnical engineer for the liquefaction-hazard analyses. If on-site sewage or storm-water disposal exists or is proposed, the liquefaction-hazard analyses shall include the effects of the effluent plume on liquefaction potential.

The results of any liquefaction-hazard analyses must be submitted with pertinent backup documentation (i.e., calculations, computer output, etc.). Printouts of input data, output data (on request), and graphical plots must be submitted for each computer-aided liquefaction-hazard analysis. In addition, input data files, recorded on diskettes, CDs, or other electronic media, may be requested to facilitate the County's review.

Appendix C - References

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Draper City, 2008a, Article 4 - Special purpose and overlay zones, Title 9 – Land Use Development Code for Draper City, Chapter 9-19, Geologic Hazards Ordinance, adopted December 31, 2007-Ord 547, effective January 1, 2008.

Draper City, 2008b, Appendix D, Minimum standards for liquefaction investigations and evaluations: January 1, 2008, Draper City Geologic Hazards Ordinance, Chapter 9-19.

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Seed, H.B., and Idriss, I.M., (1982), Ground motion and soil liquefaction during earthquakes: Earthquake Engineering Research Institute, Oakland, California, 135 p.

Seed, R.B., Cetin, K.O., Moss, R.E.S., Kammerer, A.M., Wu, J., Pestana, J.M., and Riemer, M.F., (2001), Recent advances in soil liquefaction engineering and seismic site response evaluation, Fourth International

Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, University of Missouri-Rolla, Rolla, Missouri, 2001, Paper No. SPL-2, 45 p.

Seed, R.B., Cetin, K.O., Moss, R.E.S., Kammerer, A.M., Wu, J., Pestana, J.M., and Riemer, M.F. (2001) Recent Advances in Soil Liquefaction Engineering and Seismic Site Response Evaluation, Proceedings, Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics and Symposium in Honor of Professor W.D. Liam Finn, San Diego, California, March 26-31, 2001, 45 pp.

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Youd, T.L., and Idriss, I.M., eds., (1997), Proceedings of the NCEER workshop on evaluation of liquefaction resistance of soils: National Center for Earthquake Engineering Research Technical Report NCEER 97-0022.

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APPENDIX D

Minimum Standards for Debris-Flow-Hazard Investigations

Morgan County Geologic Hazards Ordinance
Title 8, Chapter 5I of the Morgan County Code

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Appendix D
Debris Flow Hazard

1.0 INTRODUCTION

The procedures outlined herein are intended to provide consultants with a general outline for performing debris-flow-hazards investigations and to specify the expectations of Morgan County. These standards constitute the minimum level of effort required in conducting debris-flow-hazards investigations in Morgan County. Considering the complexity inherent in performing debris-flow-hazards investigations, additional effort beyond the minimum standards presented herein may be required at some sites to adequately address the debris-flow hazard at the site. The information presented herein does not relieve consultants of their duty to perform additional geologic or geotechnical engineering analyses they believe are necessary to adequately assess the debris-flow hazard at a site.

The purpose of establishing minimum standards for debris-flow-hazard investigations is to:

(a) protect the health, safety, welfare, and property of the public by minimizing the potentially adverse effects of debris-flow and related hazards;

(b) assist property owners and land developers in conducting reasonable and adequate studies;

(c) provide consulting engineering geologists and geotechnical engineers with a common basis for preparing proposals, conducting investigations, and mitigation; and,

(d) provide an objective framework for regulatory review of debris-flow-hazard investigation reports.

1.1 References and Sources

The minimum standards presented herein were developed, in part, from the following source:

(a) "Guidelines for the geologic evaluation of debris-flow hazards on alluvial fans in Utah," Utah Geological Survey Miscellaneous Publication 05-6 (2005).

(b) Salt Lake County geologic hazards ordinance (2002).

(c) Morgan County geologic hazard ordinance (2003).

(d) Draper City geologic hazard ordinance (Draper City, 2008a; 2008b).

1.2 Properties Requiring Debris-Flow-Hazard Investigations

Debris-flow-hazard special-study areas maps have not been prepared for Morgan County at present. Such maps may be produced in the future and at that time will be adopted to become a part of this ordinance. Debris-Flow-Hazard Study Areas as defined within this section include:

(a) areas designated as Qmdf, Qaf, Qafy, Qafo, Qaf1, Qaf2, Qaf3, Qaf4, Qaf5, Qafb, Qafp, and Qafoe on the most recent version of the following geologic maps (many of which are interim or in-progress):

(1) King, J.K, 2009, Progress report geologic map of the Bybee Knoll quadrangle, Morgan and Weber Counties, Utah: Utah Geological Survey files, scale 1:24,000,

(2) Coogan, J.C. and King, J.K., 2009, Progress report geologic map of the Devils Slide quadrangle, Morgan and Summit Counties, Utah: Utah Geological Survey files, scale 1:24,000;

(3) Coogan, J.C., and King, J.K., 2006, Interim geologic map of the Durst Mountain quadrangle, Morgan and Weber Counties, Utah: Utah Geological Survey, Open-File Report 498, scale: 1:24,000;

(4) Coogan, J.C., 2004, Interim geologic map of the Francis Canyon 7.5' quadrangle, Morgan Rich, and Summit Counties, Utah: Utah Geological Survey Open-File Report 425, scale 1:24,000;

(5) Coogan, J.C., 2002, Progress report geologic map of the Heiners Creek quadrangle, Morgan and Summit Counties, Utah: Utah Geological Survey files, scale 1:24,000;

(6) Coogan, J.C., 2002, Progress report geologic map of the Henefer quadrangle, Morgan and Summit Counties, Utah: Utah Geological Survey files, scale 1:24,000;

(7) Coogan, J.C., 2006, Interim geologic map of the Horse Ridge 7.5' quadrangle, Morgan Rich, and Weber Counties, Utah: Utah Geological Survey Open-File Report 480, scale 1:24,000;

(8) Coogan, J.C., 2004, Interim geologic map of the Lost Creek Dam 7.5' quadrangle, Morgan and Weber Counties, Utah: Utah Geological Survey Open-File Report 426, scale 1:24,000;

(9) Coogan, J.C., King, J.K., and McDonald, G.N., 2007, Progress report geologic map of the Morgan 7.5' quadrangle, Morgan County, Utah: Utah Geological Survey files, scale: 1:24,000;

(10) Coogan, J.C., 2004, Interim geologic map of the Peck Canyon 7.5' quadrangle, Morgan and Rich Counties, Utah: Utah Geological Survey Open-File Report 427, scale 1:24,000

(11) King, J.K., and McDonald, G.N., 2002, Progress report geologic map of the Peterson quadrangle, Davis and Morgan Counties, and the east part of the Kaysville quadrangle, Davis County, Utah: Utah Geological Survey files, scale: 1:24,000;

(12) King, J.K, 2002, Progress report geologic map of the Shearing Corral quadrangle, Morgan, Rich, and Summit Counties, Utah: Utah Geological Survey files, scale 1:24,000;

(13) King, J.K., Yonkee, W.A., and Coogan, J.C., 2008, Interim geologic map of the Snow Basin

and part of the Huntsville quadrangle, Davis, Morgan, and Weber Counties, Utah: Utah Geological Survey Open-File Report 536, scale 1:24,000, and;

(14) Coogan, J.C. and King, J.K., 2001, Progress Report - Geologic map of the Ogden 30 by 60 minute quadrangle, Utah and Wyoming, year 3 of 3: Utah Geological Survey Open-File Report 380, 1:100,000.

(b) areas designated as fg, fgv, fgo, lde on Van Horn, R., and Crittenden, Jr., M.D., 1987, Map showing surficial units and bedrock geology of the Fort Douglas quadrangle and parts of the Mountain Dell and Salt Lake City North quadrangles, Davis, Salt Lake, and Morgan Counties, Utah: U.S. Geological Survey Miscellaneous Investigation Series Map I-1762, scale 1:24,000;

(c) areas designated as Qf, Qba, Qfb, and Qof on Bryant, B., 1988, Geology of the Farmington Canyon Complex, Wasatch Mountains, Utah: U.S. Geological Survey Professional Paper 1476, 54 p., scale 1:50,000 (part of Bountiful Peak quadrangle and west 1/2 of Porterville quadrangle, Morgan County, Utah);

(d) other environmentally sensitive areas that the Morgan County Planning Commission and Morgan County Council find to be of significance to the health, safety, and welfare of the citizens of Morgan County;

(e) All properties located on alluvial fans, and;

(f) drainage channels and alluvial fans subject to flash flooding and debris flow.

2.0 MINIMUM STANDARDS FOR DEBRIS-FLOW-HAZARD INVESTIGATIONS

Following are the minimum standards for a comprehensive debris-flow-hazard investigation. Debris-flow-hazard investigations may be reported in conjunction with other geological and geotechnical investigations, or may be submitted separately. See Morgan County Geologic Hazard Ordinance (**Chapter 5I of the Morgan County Code**), for supplemental requirements. A site-specific debris-flow-hazard investigation is required, prior to approval of any land use, for any property defined herein. Development of said properties requires submittal and review of a site-specific debris-flow-hazard-investigation report prior to receiving a land use or building permit from the County.

Geologic evaluations of debris-flow hazards must be performed by a qualified engineering geologist (**Chapter 5I of the Morgan County Code, Section 8-5I-060**). It is the responsibility of the applicant to retain a qualified engineering geologist to perform the debris-flow-hazard investigation. A qualified geotechnical (**Chapter 5I of the Morgan County Code, Section 8-5I-070**) and civil engineer must sign and seal all studies that include engineering analysis and design.

2.1 Scoping Meeting

The applicant's consultant must schedule a scoping meeting with the County to evaluate the debris-flow-hazard investigation approach. At this meeting, the consultant should present a site plan that includes: proposed building locations (if known) and location of possible debris flows and debris-flow pathways (see Section 2.2). The investigative approach should allow for flexibility due to unexpected site conditions; field findings may require modifications to the work plan.

2.2 Debris-Flow-Hazard-Investigation Method

Debris-flow-hazard investigations shall be performed in general accordance with "Guidelines for the geologic evaluation of debris-flow hazards on alluvial fans in Utah," Utah Geological Survey Miscellaneous Publication 05-6 (Giraud, 2005).

2.3 Previous Studies and Aerial Photograph Review

A debris-flow-hazard investigation shall include review of available literature pertinent to the site and vicinity, including previous published and unpublished geologic/soils reports, and interpretation of available stereo-paired aerial photographs, oblique aerial photographs, and DEMs derived from detailed topographic maps and LIDAR. The photographs reviewed should include more than one set and should include pre-urbanization aerial photographs, if available. Efforts must be made to accurately plot the locations of mapped or inferred debris flows on the property as shown by previous studies in the area.

2.4 Field Review

A field review by the County is required during any subsurface exploration. The applicant must provide a minimum of 48-hours notice to schedule the field review with the County. Trenches and test pits should be open, safe, cleaned, and the field log completed at the time of the review. The field review allows the County to evaluate the subsurface data with the consultant. Discussions about questionable features are encouraged, but the County will not help log the trench, explain the stratigraphy, or give verbal approval of the proposed development during the field review.

2.5 Required Outline for Debris-Flow-Hazard Studies

The information described herein may be presented as a separate debris-flow-hazard report or incorporated within other geology or engineering reports that may be required for the property. The report shall include, at a minimum, the information listed in the "Report Guidelines" section of the Utah Geological Survey "Guidelines for the geologic evaluation of debris-flow hazards on alluvial fans in Utah," (Giraud, 2005). The study must consider the potential for fire-related debris flows as well as natural cloudburst storm and snowmelt-generated debris flows. See Morgan County Geologic Hazard Ordinance (**Chapter 5I of the Morgan County Code**), for supplemental requirements.

The report shall contain a conclusion regarding the potential risk from the debris-flow hazard on the subject property and a statement addressing the suitability of the proposed development from a debris-flow-hazard perspective. Debris-flow-hazard reports submitted to the County are expected to follow the outline and address the subjects presented below. However, variations in site conditions may require that additional items be addressed, or permit some of the subjects to be omitted (except as noted).

2.5.1 Report

(a) Purpose and scope of work: The report shall contain a clear and concise statement of the purpose of the investigation and the scope of work performed for the investigation.

(b) Geologic setting: The report shall contain a clear and concise statement of the general geologic setting of the site vicinity and should reference relevant published and unpublished geologic literature.

(c) Site description and conditions: The report shall include information on geologic units, graded and filled areas, vegetation, existing structures, and other factors that may affect site development, choice of investigative methods, and the interpretation of data.

(d) Methods of investigation:

(1) review of published and unpublished maps, literature and records concerning geologic units, surface and ground water, and other factors;

(2) stereoscopic interpretation of aerial photographs, oblique aerial photographs, and DEMs derived from detail topography and LIDAR to evaluate the presence of debris-flow deposits, drainage basins, and alluvial fans. Aerial photographs utilized shall be referenced in the report (i.e., photograph source, date, flightline numbers, and scale);

(3) geologic mapping which should include identifying and describing the active areas of alluvial fans. Mapping of debris-flow and other deposits generally focuses on landforms; the extent, type, character, and age of geologic deposits, specifically individual debris flows; and stratigraphic relations between deposits (Giruad, 2005), and;

(4) Subsurface exploration using test pits, trenches, and natural exposures is useful in obtaining sedimentologic and stratigraphic information regarding previous debris flows. Test-pit and trench excavations can provide information on flow type, thickness, the across- and down-fan extent of individual flows, and volume based on thickness and area. The report shall include a description of the program of subsurface exploration, including trench/test pit logs, criteria for trench/test pit locations, and a summary of trenching or other detailed, direct observation of continuously exposed geologic units, soils, and geologic structures. All trench/test pit logs shall be at a scale of at least 1 inch = 5 feet.

(e) Conclusions:

Conclusions must be supported by adequate data. Data must be sufficient to allow the County to evaluate the conclusions and recommendations, and shall contain, at a minimum:

(1) summary of data upon which conclusions are based;

(2) degree of confidence in and limitations of data and conclusions;

(3) the probability of debris-flow occurrence (if possible), including consideration of fire-related debris flows; estimates of debris-flow volume; delineation of hazard areas; and the likely effects of debris flows on the proposed development;

(4) geologic design parameters for debris-flow-control structures, as appropriate; implications of risk-reduction measures on adjacent properties, and need for long-term maintenance, and;

(5) the residual risk to development after risk-reduction measures are in place.

(f) Recommendations:

Recommendations must be supported by adequate geologic data and appropriate reasoning behind each statement. Minimum recommendations shall include:

(1) recommendations for mitigation should a debris-flow hazard be identified;

(2) recommendations for additional hydrologic, hydraulic, and/or engineering studies (if appropriate) to estimate peak flows and water volumes, route sediment, and design control structures, and to define buildable and non-buildable areas and design risk-reduction measures, and;

(3) recommended building restrictions or use limitations.

2.5.2 Report References

Reports must include citations of literature and records used in the study, referenced aerial photographs or images interpreted (air-photo source, date and flight number, scale), and any other sources of data and information, including well logs, personal communications, etc.

2.5.3 Illustrations

At a minimum, reports must include the following illustrations:

(a) Location Map: A site location map depicting topographic and geographic features and other pertinent data. Generally a 1:24,000-scale USGS topographic base map will suffice.

(b) Geologic Map: A regional-scale map (1:24,000 to 1:50,000 scale) is generally adequate. Depending on site complexity, a site-scale geologic map (1 inch= 200 ft or more detailed) may also be necessary. The map should show Quaternary and bedrock geologic units, debris-flow and alluvial-fan deposits, seeps or springs, soil or bedrock slumps, and other geologic, structural, and soil features existing on and adjacent to the project site. Geologic cross sections may be included as needed to illustrate 3-dimensional relationships.

(c) Site Plan: A detailed site plan is required. The site plan should be at a scale of at least 1 inch = 100 feet (or more detailed) and should clearly show site boundaries, proposed building footprints, existing structures, streets, slopes, drainages, exploratory trenches/test pits, boreholes, test pits, geophysical traverses, and any other data pertinent data.

(d) Site-Specific Geologic Map: The report shall include a site-specific geologic map. The site-specific geologic map should be at a scale of at least 1 inch = 200 feet and should clearly show exploratory techniques, topographic contours, active areas of alluvial fans, and proposed building locations, if known.

(e) Exploratory Trench/Test Pit Logs: Logs of trench/test pits, if performed, are required as part of the study. Trench/test pit logs shall accurately depict all observed geologic features and conditions. Trench/test pit logs shall not be generalized or diagrammatic. The minimum scale is 1 inch = 5 feet (1:60) with no vertical exaggeration. Trench/test pit logs must accurately reflect the features observed in the trench/test pit.

Trench/test pit logs shall include: trench/test pit orientation and indication of which trench/test pit wall was logged; trench/test pit top and bottom; stratigraphic contacts; stratigraphic unit descriptions including lithology, USCS soil classification, genesis (geologic origin), age, and contact descriptions; soil (pedogenic) horizons; previous debris flows. Test-pit and trench excavations shall provide information on flow type, thickness, the across- and down-fan extent of individual flows, and volume based on thickness and area marker beds; and deformation or offset of sediments, faults, and fissures. Interpretations of the age and origin of the deposits must be included.

(f) Photographs: Photographs of trench/test pit walls, or other features that enhance understanding of site geologic conditions are not required but should be included when deemed appropriate.

3.0 REMEDIAL DESIGN

Geologists, hydrologists, and engineers must work as a team to recommend reasonable, appropriate, risk-reduction techniques. Risk-reduction techniques should be investigated and evaluated on a site-specific basis with sufficient geologic and geotechnical evaluations to support the remedial design and/or mitigative plan. Risk-reduction and mitigation techniques must not adversely affect off-site areas and shall be reviewed and approved by the County.

REFERENCES

Giraud, R.E., 2005, Guidelines for the geologic evaluation of debris-flow hazards on alluvial fans in Utah, Utah Geologic Survey Miscellaneous Publication 05-6, 16 p.

Prochaska, A.B., Santi, P.M., and Higgins, J.D., 2008, Debris basin and deflection berm design for fire-related debris-flow mitigation: Environmental and Engineering Geoscience, v. XIV, no. 4, p. 297-313.

APPENDIX E

Minimum Standards for Rock-Fall-Hazard Investigations

Morgan County Geologic Hazards Ordinance
Title 8, Chapter 5I of the Morgan County Code

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3.0 REMEDIAL DESIGN 7

1.0 INTRODUCTION

The procedures outlined herein are intended to provide consultants with a general outline for performing rock-fall-hazard investigations and to specify the expectations of Morgan County. These standards constitute the minimum level of effort required in conducting rock-fall-hazard investigations in Morgan County. Considering the complexity inherent in performing rock-fall-hazard investigations, additional effort beyond the minimum standards presented herein may be required at some sites to adequately address the rock-fall hazard. The information presented herein does not relieve consultants of their duty to perform additional geologic or geotechnical engineering analyses they believe are necessary to adequately assess the rock-fall hazard at a site.

The purpose of establishing minimum standards for rock-fall-hazard investigations is to:

(a) protect the health, safety, welfare, and property of the public by minimizing the potentially adverse effects of rockfall and related hazards;

(b) assist property owners and land developers in conducting reasonable and adequate studies;

(c) provide consulting engineering geologists and geotechnical engineers with a common basis for preparing proposals, conducting investigations, and mitigation; and,

(d) provide an objective framework for regulatory review of rock-fall-hazard investigation reports.

1.1 References and Sources

The minimum standards presented herein were developed, in part, from the following sources:

(a) Colorado rockfall simulation program, version 4.0 (Jones and others, 2000): the Colorado rock-fall-simulation program was developed to model rock-fall behavior and provides a statistical analysis of probable rock-fall events at any given site

(b) Salt Lake County geologic hazards ordinance (2002).

(c) Draper City geologic hazard ordinance (Draper City, 2008a; 2008b).

(d) Rock-fall hazards, a guide for land-use planning (Nelson, 1993).

(e) Rockfall hazard mitigation methods (Branwer, 1994).

1.2 Properties Requiring Rock-Fall-Hazard Investigations

Rock-fall-hazard special-study areas maps have not been prepared for Morgan County at present. Such maps may be produced in the future and at that time will be adopted to become a part of this ordinance.

Rock fall, as used herein, may involve more than one rock, and for the purposes of this appendix includes large volumes such as rock slides.

Rock-Fall-Hazards Study Areas as defined within this section include all areas located at the base of rock and talus slopes, and other environmentally sensitive areas that Morgan County finds to be of significance to the health, safety, and welfare of the citizens of Morgan County. Rock-Fall-Hazards Study Areas also include:

(a) areas designated as Qmrf, Qmt, Qmtr, Qm, and Qmr on the most recent version of the following geologic maps (many of which are interim or in-progress):

(1) King, J.K, 2009, Progress report geologic map of the Bybee Knoll quadrangle, Morgan and Weber Counties, Utah: Utah Geological Survey files, scale 1:24,000,

(2) Coogan, J.C. and King, J.K., 2009, Progress report geologic map of the Devils Slide quadrangle, Morgan and Summit Counties, Utah: Utah Geological Survey files, scale 1:24,000;

(3) Coogan, J.C., and King, J.K., 2006, Interim geologic map of the Durst Mountain quadrangle, Morgan and Weber Counties, Utah: Utah Geological Survey, Open-File Report 498, scale: 1:24,000;

(4) Coogan, J.C., 2004, Interim geologic map of the Francis Canyon 7.5' quadrangle, Morgan Rich, and Summit Counties, Utah: Utah Geological Survey Open-File Report 425, scale 1:24,000;

(5) Coogan, J.C., 2002, Progress report geologic map of the Heiners Creek quadrangle, Morgan and Summit Counties, Utah: Utah Geological Survey files, scale 1:24,000;

(6) Coogan, J.C., 2002, Progress report geologic map of the Henefer quadrangle, Morgan and Summit Counties, Utah: Utah Geological Survey files, scale 1:24,000;

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(c) areas designated as Qtc on Bryant, B., 1988, Geology of the Farmington Canyon Complex, Wasatch Mountains, Utah: U.S. Geological Survey Professional Paper 1476, 54 p., scale 1:50,000 (part of Bountiful Peak quadrangle and west 1/2 of Porterville quadrangle, Morgan County, Utah);

2.0 MINIMUM STANDARDS FOR ROCK-FALL-HAZARD INVESTIGATIONS

Following are the minimum standards for comprehensive rock-fall-hazard investigations. Rock-fall-hazard investigations may be reported in conjunction with other geological and geotechnical investigations required for the property, or may be submitted separately. See Morgan County Geologic Hazard Ordinance (**Chapter 5I of the Morgan County Code**), for supplemental requirements. A site-specific rock-fall-hazard investigation is required, prior to approval of any land use, for any property defined herein. Development of said properties requires submittal and review of a site-specific rock-fall-hazard investigation report prior to receiving a land use or building permit from the County.

Geologic evaluations of rock-fall hazards must be performed by a qualified engineering geologist (see **Section 8-5I-060 of the Morgan County Code)**. It is the responsibility of the applicant to retain a qualified engineering geologist to perform the rock-fall-hazard investigation. A qualified geotechnical engineer (see **Section 8-5I-070 of the Morgan County Code)** must sign and seal all studies that include engineering design of mitigation measures.

2.1 Scoping Meeting

The applicant's consultant must schedule a scoping meeting with the County to evaluate the rock-fall-hazard investigation approach. At this meeting, the consultant should present a site plan that includes: proposed building locations (if known) and location of possible rock falls and rock-fall pathways. The investigative approach should allow for flexibility due to unexpected site conditions; field findings may require modifications to the work plan.

2.2 Rock-fall-Hazard-Investigation Method

The primary factor in determining the susceptibility of an area to rock falls is the presence of source areas for rock-fall fragments. Rock-fall source areas may be off-site and, in areas of steep terrain, may be at great distances from the site. The absence of outcrops or rocks on a slope may indicate a low hazard. General guidelines for evaluation of rock-fall susceptibility follow. See Morgan County Geologic Hazard Ordinance (**Chapter 5I of the Morgan County Code**), for supplemental requirements.

2.2.1 Previous Studies and Aerial Photograph Review

A rock-fall-hazard investigation shall include review of available literature pertinent to the site and vicinity, including previous published and unpublished geologic and geotechnical engineering reports, and interpretation of available stereo-paired aerial photographs, oblique aerial photographs, and DEMs derived from detailed topographic maps and LIDAR. The photographs reviewed should include more than one set and should include pre-urbanization aerial photographs, if available. Efforts must be made to accurately plot the locations of mapped or inferred rock falls on the property as shown by previous studies in the area.

2.2.2 Site Reconnaissance

A site reconnaissance shall be performed to document potential source areas (on- and off-site) and the presence (or absence) of rocks on the property that likely emanated from a potential source area.

2.2.3 Geologic Mapping

Rock-fall areas shall be delineated on a detailed site geologic map, at a scale equal to or more detailed than 1 inch = 100 feet. The site geologic map shall include the location and boundaries of the property, locations of rock-fall deposits, rock-fall-source areas, rock-fall-runout areas, etc., delineation of recommended setback distances from the hazard, and recommended locations for structures. Buildable and non-buildable areas shall be clearly identified. If applicable, a site rock stability priority rating assessment should be included.

2.2.4 Design of Remedial Measures

As with other geologic hazards, the best remedial measure, where feasible, is avoidance. If the proposed development cannot be designed around a rock-fall area, or rock-fall pathways cannot be accurately delineated or predicted, mitigation measures shall be proposed. Design of mitigation measures shall be performed by a qualified geotechnical engineer.

2.3 Required Outline for Rock-Fall-Hazard Studies

Rock-fall-hazard reports submitted to the County are expected to follow the outline and address the subjects presented below. However, variations in site conditions may require that additional items be addressed, or permit some of the subjects to be omitted (except as noted). The report shall contain a conclusion regarding the potential risk of rock-fall-hazard on the subject property and a statement addressing the suitability of the proposed development from a rock-fall-hazard perspective. See Morgan County Geologic Hazard Ordinance (**Chapter 5I of the Morgan County Code**), for supplemental requirements.

2.3.1 Report

(a) Purpose and scope of work: The report shall contain a clear and concise statement of the purpose of the investigation and the scope of work performed for the investigation.

(b) Geologic setting: The report shall contain a clear and concise statement of the general geologic setting of the site vicinity and should reference relevant published and unpublished geologic literature.

(c) Site description and conditions: The report shall include information on geologic units, graded and filled areas, vegetation, existing structures, and other factors that may affect site development, choice of investigative methods, and the interpretation of data.

(d) Methods of investigation:

(1) review of published and unpublished maps, literature and records concerning geologic units, surface and ground water, and other factors;

(2) stereoscopic interpretation of aerial photographs, oblique aerial photographs, and DEMs derived from detail topography and LIDAR to evaluate the presence of rock-fall deposits, rock-fall pathways, rock-fall-source areas, etc. Aerial photographs utilized shall be referenced in the report (i.e., photograph source, date, flightline numbers, and scale), and;

(3) geologic mapping which should include location and boundaries of the property, locations of rock-fall areas, rock-fall-source areas, rock-fall-runout areas, etc.

(4) computer simulations using rock-fall-simulation programs (Jones and others, 2000) and estimates of rock-fall shadow angles (Wieczorek and others, 1998; Lund and others, 2008).

(e) Conclusions:

Conclusions must be supported by adequate data. Data must be sufficient to allow the County to evaluate the conclusions and recommendations, and shall contain, at a minimum:

(1) summary of data upon which conclusions are based;

(2) degree of confidence in and limitations of data and conclusions;

(3) the probability of rock-fall occurrence (if possible), estimates of rock-fall volume, delineation of rock-fall-hazard areas, and the likely effects of rock-falls on the proposed development;

(4) geologic design parameters for rock-fall mitigation, as appropriate, implications of risk-reduction measures on adjacent properties, and need for long-term maintenance, and;

(5) the residual risk to development after risk-reduction measures are in place.

(f) Recommendations:

Recommendations must be supported by adequate geologic data and appropriate reasoning behind each statement. Minimum recommendations shall include:

(1) recommendations for mitigation should a rock-fall hazard be identified;

(2) recommendations for additional engineering geologic and/or geotechnical engineering studies (if appropriate) to quantify the rock-fall hazard, to define buildable and non-buildable areas, and/or to design risk-reduction measures, and;

(3) other recommended building restrictions or use limitations.

2.3.2 Report References

Reports must include citations of literature and records used in the study, referenced aerial photographs or images interpreted (air-photo source, date and flight number, scale), and any other sources of data and information.

2.3.3 Illustrations

At a minimum, reports must include the following illustrations:

(a) Location map: A site location map depicting topographic and geographic features and other pertinent data. Generally a 1:24,000-scale USGS topographic base map will suffice.

(b) Regional geologic map: A regional-scale map (1:24,000 to 1:50,000 scale) is generally adequate. Depending on site complexity, a site-scale geologic map (1 inch= 200 ft or more detailed) may also be necessary. The map should show Quaternary and bedrock geologic units, rock-fall deposits, seeps or springs, soil or bedrock slumps, and other geologic, structural, and soil features existing on and adjacent to the project site. Geologic cross-sections may be included as needed to illustrate 3-dimensional relationships.

(c) Site plan: A detailed site plan is required. The site plan should be at a scale of at least 1 inch = 100 feet (or more detailed) and should clearly show site boundaries, proposed building footprints, existing structures, streets, slopes, drainages, and any other pertinent data.

(d) Site-specific geologic map: The report shall include a site-specific geologic map. The site-specific geologic map should be at a scale of at least 1 inch = 100 feet and should clearly show topographic contours, rock-fall deposits, rock-fall pathways, rock-fall-source areas, etc., and proposed building locations, if known.

(e) Photographs: Photographs of features that enhance understanding of site geologic conditions are not required but should be included when deemed appropriate.

3.0 REMEDIAL DESIGN

Geologists and geotechnical engineers must work as a team to recommend reasonable, appropriate, risk-reduction techniques. Risk-reduction techniques should be investigated and evaluated on a site-specific basis with sufficient geologic and geotechnical evaluations to support the remedial design and/or mitigative plan. Risk-reduction and mitigation techniques must not adversely affect off-site areas and shall be reviewed and approved by the County.

REFERENCES

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APPENDIX F

Minimum Standards for Avalanche Hazard Investigations

Morgan County Geologic Hazards Ordinance
Title 8, Chapter 5I of the Morgan County Code

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1.0 INTRODUCTION

The procedures outlined herein are intended to provide applicants with a general outline for performing avalanche-hazard investigations and to specify the expectations of Morgan County. These standards constitute the minimum level of effort required in conducting avalanche-hazard investigations in Morgan County. Considering the complexity inherent in performing avalanche- hazard investigations, additional effort beyond the minimum standards presented herein may be required at some sites to adequately address the avalanche-hazard potential. The information presented herein does not relieve consultants of their duty to perform additional geologic or engineering analyses they believe are necessary to adequately assess the avalanche hazard at a site.

The purpose of establishing minimum standards for avalanche-hazard investigations is to:

(a) protect the health, safety, welfare, and property of the public by minimizing the potentially adverse effects of avalanche and related hazards;

(b) assist property owners and land developers in conducting reasonable and adequate studies;

(c) provide qualified avalanche experts and engineers with a common basis for preparing proposals, conducting investigations, and mitigation; and,

(d) provide an objective framework for regulatory review of avalanche hazards investigations reports.

1.1 References and Sources

The minimum standards presented herein were developed, in part, from:

(a) the Salt Lake County geologic hazards ordinance (Salt Lake County, 2002), and;

(b) Colorado Geological Survey document Snow-Avalanche Hazard Analysis for Land Use Planning and Engineering (Mears, 1992)

1.2 Properties Requiring Avalanche-Hazard Investigations

Avalanche hazard special-study areas maps have not been prepared for Morgan County at present. Such maps may be produced in the future and at that time will be adopted to become a part of this ordinance.

Avalanche-Hazards Study Areas as defined within this section include all areas located within and/or immediately adjacent to the mountainous areas of Morgan County, and other environmentally sensitive areas that Morgan County finds to be of significance to the health, safety, and welfare of the citizens of Morgan County. As a basis for evaluation, elevations above 7,000 feet, and which include slopes greater than 35% shall be considered Avalanche Hazards Study Areas.

2.0 MINIMUM STANDARDS FOR AVALANCHE-HAZARD INVESTIGATIONS

Following are the minimum standards for comprehensive avalanche-hazard investigations. Avalanche-hazard investigations may be reported in conjunction with other geological and geotechnical investigations required for the property, or may be submitted separately. See Morgan County Geologic Hazard Ordinance (**Chapter 5I of the Morgan County Code**), for supplemental requirements. A site-specific avalanche-hazard investigation is required, prior to approval of any land use, for any property defined herein. Development of said properties requires submittal and review of a site-specific avalanche-hazard investigation report prior to receiving a land use or building permit from the County.

Evaluations of avalanche hazards must be performed by a qualified avalanche expert (see **Section 8-5I-060 of the Morgan County Code)**. It is the responsibility of the applicant to retain a qualified avalanche expert to perform the avalanche-hazard investigation. A qualified engineer (see **Section 8-5I-070 of the Morgan County Code)** must sign and seal all studies that include engineering design of mitigation measures.

2.1 Scoping Meeting

The applicant must schedule a scoping meeting with the County to evaluate the avalanche-hazard-investigation approach. At this meeting, the applicant should present a site plan that includes: proposed building locations (if known) and location of possible avalanche-source areas and avalanche pathways. The investigative approach should allow for flexibility due to unexpected site conditions; field findings may require modifications to the work plan.

2.2 Avalanche-Hazard-Investigation Method

Avalanche-hazard reports shall be prepared in general accordance with the Colorado Geological Survey document "Snow-Avalanche Hazard Analysis for Land Use Planning and Engineering" (Mears, 1992) or other appropriate references. See Morgan County Geologic Hazard Ordinance (**Chapter 5I of the Morgan County Code**), for supplemental requirements.

Avalanche-hazard reports shall be prepared by a qualified avalanche expert, and shall include the avalanche expert's qualifications to perform the study (such as their experience in performing similar studies).

2.2.1 Previous Studies and Aerial Photograph Review

An avalanche-hazard investigation shall include review of available literature pertinent to the site and vicinity, including previous published and unpublished reports, and interpretation of available stereo-paired aerial photographs, oblique aerial photographs, and DEMs derived from detailed topographic maps and LIDAR. The photographs reviewed should include more than one set and should include pre-urbanization aerial photographs, if available. Efforts must be made to accurately plot the locations of mapped or inferred avalanche source areas or avalanche pathways on the property as shown by previous studies in the area.

2.2.2 Site Reconnaissance

A site reconnaissance shall be performed to document potential avalanche source areas and avalanche pathways.

2.2.3 Avalanche Mapping

Avalanche areas shall be delineated on a detailed site avalanche map, at a scale equal to or more detailed than 1 inch = 100 feet. The site avalanche map shall include the location and boundaries of the property, locations of avalanche areas, avalanche-source areas, avalanche-runout areas, etc., delineation of recommended setback distances from the hazard, and recommended locations for structures. Avalanche-source areas may be off-site and, in areas of steep terrain, may be at great distances from the site. Buildable and non-buildable areas shall be clearly identified.

2.2.4 Design of Remedial Measures

As with most geologic hazards, the best remedial measure, where feasible, is avoidance. If the proposed development cannot be designed around an avalanche area, mitigation measures shall be proposed (see Section 2.3.1 (e)). Design of mitigation measures shall be performed by a qualified engineer.

2.3 Required Outline for Avalanche-Hazard Studies

Avalanche-hazard reports submitted to the County are expected to follow the outline and address the subjects presented below. However, variations in site conditions may require that additional items be addressed, or permit some of the subjects to be omitted (except as noted). The report shall contain a conclusion regarding the potential risk of avalanche hazard on the subject property and a statement addressing the suitability of the proposed development from an avalanche hazard perspective. See Morgan County Geologic Hazard Ordinance (**Chapter 5I of the Morgan County Code**), for supplemental requirements.

2.3.1 Report

(a) Purpose and scope of work: The report shall contain a clear and concise statement of the purpose of the investigation and the scope of work performed for the investigation.

(b) Avalanche setting: The report shall contain a clear and concise statement of the general avalanche setting of the site vicinity and should reference relevant published and unpublished literature.

(c) Site description and conditions: The report shall include information on avalanche deposits, vegetation, existing structures, and other factors that may affect site development, choice of investigative methods, and the interpretation of data.

(d) Methods of investigation:

(1) review of published and unpublished maps, literature and records concerning avalanche conditions;

(2) stereoscopic interpretation of aerial photographs, oblique aerial photographs, and DEMs derived from detail topography and LIDAR to evaluate the presence of avalanche deposits, avalanche pathways, avalanche source areas, etc. Aerial photographs utilized shall be referenced in the report (i.e., photograph source, date, flightline numbers, and scale), and;

(3) mapping which should include location and boundaries of the property, locations of avalanche areas, avalanche-source areas, avalanche-runout areas, etc.

(e) Delineation of Avalanche Areas;

If the avalanche analysis indicates that the site may be impacted by avalanches, the report shall delineate the following areas:

(1) a "red zone" of high avalanche potential [return period of twenty-five years or less, and/or impact pressures over 600 pounds per square foot (psf)] within which critical facilities or structures for human occupancy are not permitted;

(2) a "blue zone" (return period between twenty-five and three hundred years, and impact pressures less than 600 psf) within which critical facilities or structures for human occupancy shall only be permitted when at least one of the following requirements has been met:

(2i) the structure is designed to incorporate direct protection measures that address the estimated impact forces (flowing snow/debris and powder blast loading). The estimated impact forces shall be calculated by the avalanche expert. The structure shall be designed by, and the plans stamped by, a qualified structural engineer licensed in the State of Utah, or;

(2ii) appropriate engineering controls (i.e. deflection structures, snow retention nets, dams, etc.) are designed and installed to mitigate the avalanche hazard. Design or performance criteria for engineered mitigation measures (including estimated impact forces, flow heights, location and dimensions of the mitigation structures) and all supporting modeling or other analyses, calculations, and assumptions, shall be calculated by the avalanche expert and included in the report. Final design plans and specifications for engineered mitigation must be signed and stamped by a qualified professional geotechnical or structural engineer, as appropriate, licensed in the State of Utah.

(f) Conclusions:

Conclusions must be supported by adequate data. Data must be sufficient to allow the County to evaluate the conclusions and recommendations, and shall contain, at a minimum:

(1) summary of data upon which conclusions are based;

(2) degree of confidence in and limitations of data and conclusions;

(3) the probability of avalanche occurrence (if possible), estimates of avalanche volume, delineation of avalanche hazard areas, and the likely effects of avalanches on the proposed development;

(4) engineering design parameters for avalanche mitigation, as appropriate, implications of risk-reduction measures on adjacent properties, and need for long-term maintenance, and;

(5) the residual risk to development after risk-reduction measures are in place.

(g) Recommendations:

Recommendations must be supported by adequate geologic data and appropriate reasoning behind each statement. Minimum recommendations shall include:

(1) recommendations for mitigation should an avalanche hazard be identified;

(2) recommendations for additional engineering studies (if appropriate) to quantify the avalanche hazard, to define buildable and non-buildable areas, and/or to design risk-reduction measures, and;

(3) other recommended building restrictions or use limitations.

2.3.2 Report References

Reports must include citations of literature and records used in the study, referenced aerial photographs or images interpreted (air-photo source, date and flight number, scale), and any other sources of data and information.

2.3.3 Illustrations

At a minimum, reports must include the following illustrations:

(a) Location map: A site location map depicting topographic and geographic features and other pertinent data. Generally a 1:24,000-scale USGS topographic base map will suffice.

(b) Site plan: A detailed site plan is required. The site plan should be at a scale of at least 1 inch = 100 feet (or more detailed) and should clearly show site boundaries, proposed building footprints, existing structures, streets, slopes, drainages, and any other pertinent data.

(c) Site-specific avalanche map: The report shall include a site-specific avalanche map. The site-specific map should be at a scale of at least 1 inch = 100 feet and should clearly show topographic

contours, avalanche deposits, avalanche pathways, avalanche-source areas, etc., and proposed building locations, if known.

(d) Photographs: Photographs of features that enhance understanding of site geologic conditions are not required but should be included when deemed appropriate.

3.0 REMEDIAL DESIGN

Risk-reduction techniques should be investigated and evaluated on a site-specific basis with sufficient evaluations to support the remedial design and/or mitigative plan. Risk-reduction and mitigation techniques must not adversely affect off-site areas and shall be reviewed and approved by the County.

REFERENCES

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APPENDIX G
Morgan County Hold Harmless Agreement

OWNERS ACKNOWLEDGEMENTS OF RESPONSIBILITY AND INDEMNIFICATION

STATE OF UTAH)
)§
COUNTY OF MORGAN)

We, the undersigned owners of the property located at: _____, Morgan County, Utah. Agree to indemnify and hold Morgan County harmless from any claim, damages, or liability that may arise against the County or its employees, agents or representatives related to improvements constructed on the property that may be damaged due to geologic hazards, regardless of level of identification of said hazard. We further acknowledge that failure of the County or any agents of the County to observe or recognize hazardous, unknown or unsightly conditions, or to recommend denial of this use because of said unrecognized hazardous, unknown or unsightly conditions shall not relieve the developer or owner from responsibility for the condition or damages resulting there from and shall not result in the County, its officer or agents being responsible for the conditions and damages resulting there from.

_____
Property Owner

_____
Property Owner

Subscribed and sworn to before me this _____ day of _____, 20___.

_____
Notary Public