



HURRICANE CITY UTAH

Mayor

Nanette Billings

City Manager

Kaden DeMille

City Council

*David Hirschi
Kevin Thomas
Clark Fawcett
Drew Ellerman
Joseph Prete*

Hurricane City Council Meeting Agenda

February 6, 2025

4:00 PM

City Council Chambers 147 N 870 W, Hurricane

Notice is hereby given that the City Council will hold a Regular Meeting in the City Council Chambers 147 N 870 W, Hurricane, UT. [Meeting Link on Webex](#) Meeting number: 2630 456 5376 Meeting password: HCcouncil Join from a video or application Dial 26304565376@cityofhurricane.webex.com. You can also dial 173.243.2.68 and enter your meeting number. Join by phone +1-415-655-0001 US Toll Access code:26304565376. A silent roll call will be taken, followed by the Pledge of Allegiance and prayer by invitation. **THOSE WISHING TO SPEAK DURING PUBLIC FORUM MUST SIGN IN WITH THE RECORDER BY 6:00 P.M.**

4:00 p.m. Joint Work Meeting with the Planning Commission

1. Discussion about the rockfall zone.
2. Agenda Summary

5:00 p.m. Pre-meeting

6:00 p.m. - Call to Order

Prayer

Thought

Pledge of Allegiance

Declaration of any conflicts of interest

Minutes of the Regular City Council Meeting for January 2, 2025, and January 16, 2025

2024 annual report from Washington County Mosquito Abatement - Sean Amodt

Presentation by Hurricane Youth City Council

Public Forum – Comments from Public

Please Note: In order to be considerate of everyone attending the meeting and to more closely follow the published agenda, public comments will be limited to 3 minutes per person per item. A spokesperson representing a group to summarize their concerns will be allowed 5 minutes to speak. Repetitious commentary will not be allowed. If you need additional time, please request agenda time with Cindy Beteag in writing before 12:00 p.m. the Tuesday one week before the Council meeting.

OLD BUSINESS

1. Consideration and possible approval of an **amended and extended reimbursement agreement** with Mellon Valley, L.C. and Elim Valley Planning and Development, LLC

NEW BUSINESS

1. Public Hearing to take comments on the following:
 - a. Proposed amendments to the 2024-2025 Fiscal Year Budget
2. Consideration and possible approval of **Resolution 2025-13 approving & adopting amendments to the 2024-2025 budget** - Paige Chapman
3. Consideration and possible approval of **updates to the Hurricane City Airport Rules and Regulations and the Minimum Standards for Commercial Aeronautical Activities**
4. Consideration and possible approval of **Resolution 2025-14 approving the Interlocal Agreement for Election Services** with Washington County - Cindy Beteag
5. Consideration and possible approval of Ordinance ZC24-06 and PSP24-09 a **Zone Change Amendment and a Preliminary Site Plan** request located approximately 5210 W 2250 S from A-5 (Agricultural, one unit per 5 acres) to RR (Recreation Resort). Parcel numbers H-4138-A, H-4138-G, and H-4-2-15-112. Chris Wyler, Applicant; CivilScience, Agent.
6. Consideration and possible approval of **Resolution 2025-16 amending the rental fee** for the Fine Arts Building - Tiffani Wright
7. Consideration and possible approval of **Ordinance 2025-02 amending Title 7, Chapter 5** regarding regulations of the Hurricane City Cemetery - Cindy Beteag
8. Consideration and possible approval of Resolution 2025-15 approving a **Memorandum of Understanding (MOU) for the construction of SR-7 Exit 19 Interchange** and Sand Hollow State Park Entrance - Arthur LeBaron
9. Consideration and possible approval of **awarding a contract** for the 1100 West Widening Project - Arthur LeBaron
10. Consideration and possible approval of **Resolution 2025-17 Appointing a representative and alternates to the UAMPS Board of Directors** - Scott Hughes
11. Consideration and possible approval of a **Declaration of Covenants, Conditions and Restrictions** between Hurricane City, Western Mortgage & Realty Company, and the Gateway at Sand Hollow Master Association
12. Continued **training** for Municipal Officials
13. Mayor, Council, and staff reports
14. Closed Meeting held pursuant to Utah Code section 52-4-205, upon request

Adjournment

I hereby certify that the above notice was posted to the city website, (www.cityofhurricane.com) posted to the state public notice website, and at the following locations:

1. City office – 147 North 870 West, Hurricane, UT
 2. The Post Office – 1075 West 100 North, Hurricane, UT
 3. The library – 36 South 300 West, Hurricane, UT
-
- _____ for the City Recorder

Agenda Summary for Hurricane City Council February 6, 2025

4:00 p.m. Work Meeting

Joint work meeting with the Planning Commission to discuss the rockfall zone.

5:00 p.m. Pre-Meeting

6:00 p.m. Call to Order

Minutes of the regular City Council meeting for January 2, 2025, and January 16, 2025.

2024 annual report from Washington County Mosquito Abatement. Sean Amodt

Presentation by the Hurricane Youth City Council.

Old Business

1. On January 16th, 2025, the Council voted to extend by 24 months the reimbursement agreement for Elim Valley. The draft agreement in the packet is consistent with the vote and direction given by the Council at that meeting. The key terms of the Amended and Extended Reimbursement Agreement are as follows: (1) The remaining 173 road impact fee vouchers may be used within the next 24 months; (2) Each voucher may be used to offset the road impact for one residential unit—the current impact fee for one residential unit is \$2,294; and (3) If the road impact fee goes up, the developer is required to pay the increased amount, but if the fee goes down, there is no credit, offset, or carryover. -Summary drafted by Dayton Hall, City Attorney.

New Business

1. Public Hearing for budget amendments.
2. Every year budget amendments are necessary due to unknown factors, like increase interest rates, increase in program costs, or grant opportunities.

The General Ledger (GL) codes from 103335-103963 are all revenue codes in the general fund. We have received more money than was budgeted for, and so these GL codes are included. Some big ones are 103335 airport grants, 103635 insurance reimbursement (reimbursement from employee for health insurance and health insurance kickback), 103716 Gymnastic, 103731 Dance and 103736 Art are doing great! Of course 103810 interest earnings have continued to have higher than average interest rates.

GL codes from starting in the 10's group are all general fund, 20 is Special Revenue Fund for Highway, 40 Equipment fund for Enterprise Funds, 41 is Capital Project for Veteran's Memorial, 42 Impact Project for Streets, 43 Impact Project for Parks, 45 Capital Project for City Office, 47 RAP Tax, 49 Equipment Lease Fund, 50 Pressurized Irrigation Fund, 55 Drainage Fund, 75 Dixie Springs Special Assessment, and 81 Redevelopment Agency

Fund. I have noted on the supplemental documentation why the budget amendment was needed. – Paige Chapman

3. Introduction

This agenda item is a proposal to update the Hurricane City Airport (1) Rules and Regulations and (2) Minimum Standards for Commercial Aeronautical Activities. These standards were last updated in 2009. The proposed updates are the result of discussions by the Airport Board and contributions by Board members and an informal sub-committee. The proposed updates were recommended unanimously by the Airport Board on January 21, 2025.

Summary of Updates

The agenda packet for this item includes a redlined version of the proposed amendments that shows each revision, as well as a 'clean' copy that incorporates the proposed amendments. The Council is encouraged to review the proposed amendments within the packet. A summary of the key revisions for each document is below:

- Rules and Regulations:
 - The process to obtain a business license to conduct commercial activity at the airport is changed and clarified. After review by the Airport Manager, complete applications for a business license will be forwarded to the City's business licensing officer and issued in the normal course. Business licenses for airport businesses will no longer be approved by the City Council. However, the requirement for a commercial lease approved by the City Council is still a requirement to conduct Commercial Activity at the Airport. In other words, the City Council's approval of a commercial hangar for a commercial use constitutes the City's approval for that type of business if the other requirements are met.
 - Except for the Airport Manager, residential occupancy of a hangar is prohibited.
 - The City is expressly permitted to conduct inspections of hangars.
 - The City's Noise Abatement Procedures, which were previously adopted by the Council in an independent document, are incorporated into the Rules and Regulation.
 - Many technical and grammatical changes are proposed.
- Minimum Standards for Commercial Aeronautical Activities:
 - The process to apply for approval of a commercial aeronautical activity is simplified and clarified. The process is made consistent with the business licensing requirements as described in the Rules and Regulations.
 - Revisions to the different requirements for specific types of commercial activities are proposed.

4. In preparation for the 2025 municipal elections, Washington County has provided the cities and towns within the County with two alternative contracts for election services. One is for full election services, and the other is for limited election services. The full service agreement is consistent with how the County has conducted elections in the past. The County will assume responsibility for the election, with the City Council acting as the Board of Canvassers. The County's expenses will be passed on to the City. The limited service agreement is substantially different from the procedures that have been followed in the past, with the City taking possession of the ballots after signature verification and removing the ballots from the County's property. The County would not assist or have any involvement from the time the City takes possession of the ballots, so the City would be solely responsible to transport, secure, tally, and store the ballots in the manner and following the process required by the Utah Code. Also, under this agreement, voters at the County voting locations will have to vote by provisional ballots to ensure those municipal ballots are not inserted into the County's tabulating machine. The City would still reimburse the County for its costs to print, mail, and process the ballots for signature verification. Staff has the same concerns and reservations with the limited service agreement as were expressed when these discussions occurred in the last municipal election. Assuming possession of the ballots and responsibility for the election midway through the process will increase the risk of legal claims against the City that the ballot transition or vote counting was flawed. Allowing the County to assume the responsibility and liability of the election process from the beginning to the end is the legally prudent method to handle the municipal election. Also, the limited-service agreement will require a substantial investment of time by the City Attorney and the City Recorder to become experts in election law and to ensure that all of the legal and technical requirements of the election process are met. Staff recommends that the Council approve the full service agreement with the County for election services. -Dayton Hall, City Attorney.
5. The applicant requests approval to rezone and add approximately 3.37 acres to the existing Pecan Valley Resort. The current zoning of the 3.37 acres is Agricultural A-5 and it is proposed they be rezoned to Recreation Resort. The request includes a site plan with additional parking spaces to support nearby clubhouses and amenities, the construction of pickleball courts, and the construction of 17 housing units. The Planning Commission heard this item on January 23, 2025, and unanimously recommended approval upon condition that it will not increase the current number of already approved Recreation Resort units within the overall Pecan Valley development, and that the development agreement for Pecan Valley Resort be updated to include the additional acreage. The applicant has agreed that the 17 proposed units will be a density

transfer to the new site and will not increase the existing unit count for the overall resort. --Gary Cupp

Findings:

- The application meets the standards of the General Plan Map in that the action would bring the zoning of the subject property into consistency with the general plan, but it does not meet policies in the Moderate Income Housing Plan.
- Generally, the proposal is harmonious with the surrounding uses to the north, south, and east.
- The proposed amendment will have an impact on the area; however, the impact could be considered minimal in light of the overall Recreation Resort development that has already been approved around the subject property.
- Services are currently adequate to serve the property.
- The application does not meet some of the requirements of rezoning a property to Recreation Resort; specifically, the overall development will be larger than the recommended 20 acres and the property is not located adjacent to a master planned road.
- The Preliminary Site Plan provided is acceptable for the zone change application.

Recommendation:

Staff recommends approval. While the zone change may not meet all the considerations for rezoning to the Recreation Resort designation, the proposal does establish consistency with the general plan by eliminating a small island of inconsistent zoning. And even though the Pecan Valley Resort has already exceeded the 20-acre maximum area recommended by City ordinance for a Recreation Resort zone, the addition of 3.37 acres to the Pecan Valley Resort would be a negligible increase that would eliminate a small portion of agriculturally zoned land that would likely never be used for agricultural purposes and align the site with the general plan. The property is almost an island of agriculturally zoned land bounded on three sides by the Pecan Valley Resort; therefore, staff recommends approval of the requested zone change subject to the condition that it will not increase the current number of already approved Recreation Resort units within the overall Pecan Valley development, and that the development agreement also be updated to include the additional acreage.

Alternatively, the City Council could reasonably deny the application, since the zone change does not meet all the conditions for rezoning to the Recreation Resort designation in that it:

- exceeds the recommended 20 acres for Recreation Resort developments;
- is not consistent with the existing development agreement;
- is not located adjacent to major collectors, minor arterials, or major arterial roads;

- does not add significant commercial viability to the area nor does it provide commercial amenities; and
- would result in the loss of agricultural lands.

6. The current rate for use of the Theater is \$100 per hour with a cap of \$400. We have not had any written hours of rental times and would like to get those defined.

We currently require a \$100 cleaning deposit for rentals that happen outside our regular business hours at the Community Center. So all weekend rentals we take a deposit for but we have not been doing the same for the FA building.

I am asking for the following changes

- That the rental rate for the Fine Arts building be updated to \$100 per hour, with no cap on the number of hours requested for rental, and the hourly rate will apply for all hours of use.
- That a \$100 cleaning deposit will be required for all rentals of the Fine Arts building. This deposit will be fully refundable upon the satisfactory inspection of the facility after the rental.
- That the Fine Arts building will be available for rental between the hours of 8:00 AM and 10:00 PM.
- That this new rate structure shall take effect July 1, 2025. - Tiffani Wright

7. In 2017, the City Council adopted a resolution limiting the number of cemetery plots a resident could purchase at the residential rate. Staff has now proposed incorporating this limitation into the ordinance to make it more accessible and easier to locate. Last year, the Council also discussed how to define a "resident," and a clear definition has been added to the ordinance for clarity.

While updating the chapter, staff reviewed it for other necessary revisions. All changes are highlighted in red. Key updates include:

- Changing the term "lot" to "plot" for consistency.
- Updating the authorized signers of certificates to align with current practices.
- Revising the allowable materials for vault construction.
- Removing the section that allows a portion of the cemetery to be contracted with religious and fraternal organizations. This section was removed because the term "reasonable portion" was not clearly defined. However, if the Council wishes to retain this section, it will need to define what constitutes a "reasonable portion," as a group has expressed interest in purchasing approximately 50 plots.
- Updating regulations on monument sizes.

These changes aim to clarify and modernize the ordinance for better implementation and understanding. - Cindy Beteag

8. Hurricane City has partnered with Utah State Parks, UDOT, and WCWCD to construct an entry into Sand Hollow State Park at the 3200 West interchange on SR-7. At the request of Utah State Parks, Hurricane City has agreed to manage the design and construction of this project, which will include the design and construction of the exit and entrance ramps for westbound traffic on SR-7, 3200 West Street, a new State Park entrance station and parking area, and associated utilities. A memorandum of understanding has been drafted by the Hurricane City Attorney and circulated amongst the stakeholders for review and is now ready for approval by each respective board. – Arthur LeBaron

The proposed MOU has been proposed by Hurricane City and all edits are acceptable to staff.

It is recommended for approval.

9. The Hurricane City Council directed staff to acquire the road right-of-way and associated public utility easement on the west side of 1100 West from 1300 South to 3000 South to accommodate a transmission powerline. During the acquisition process, many of the property owners requested the City make some improvements on 1100 West which include relocation of utilities along with some safety improvements. The right-of-way acquisition is complete and the City is obligated to fulfill promises made in purchase agreements to relocate irrigation services, etc. by April 1, 2025. The City has completed improvement plans that include all of the obligatory relocations and safety measures, and put it out to bid, with bids being due on February 5, 2025. A bid tabulation and recommendation for award will be sent to the Council as soon as possible after the bid opening.– Arthur LeBaron

Staff will review the bids and send a recommendation to the Council as soon as possible after the bid opening on February 5th.

10. Our UAMPS Representative is already set up with Scott Hughes as the representative and Brian Anderson as the alternate. This Resolution will just add Michael Ramirez as an additional available alternate. - Crystal Wright
11. To provide for the maintenance and upkeep of landscaping along roadways within the Gateway PID area and within roundabouts, a set of CC&Rs for the Gateway at Sand Hollow Master Association have been drafted. The CC&Rs provide that the Association will provide the maintenance of the landscaping, even though most of the area to be maintained has been dedicated to the City. The intent is to ensure that the roundabouts and roadways, including the privately owned areas between the sidewalks and the privacy walls, are maintained. The City's signature is required on the CC&Rs because the City will grant the Association access and permission to maintain landscaping within the public right-of-way. There are also indemnify provisions between the Association and the City. The proposed CC&Rs are the product of

coordination and negotiation between Western Mortgage, the Association's attorneys, and the City. The City Attorney approves the contract as to form. -Dayton Hall, City Attorney.

12. Continued training for Municipal Officials

13. Mayor, Council, and staff reports.

14. Closed Meeting upon request.

MEMORANDUM

TO: Mayor Nanette Billings and Hurricane City Council
FROM: Dayton Hall, City Attorney
DATE: January 14, 2025
RE: Summary of Utah Code and Hurricane City Ordinances Governing Rock-Fall Hazards

I. Introduction

Mayor Billings requested that I research the Utah Code requirements as it relates to rock-fall zones within Hurricane City. I also reviewed the City's specific ordinance related to rock falls. This memorandum summarizes the results of my research.

II. The Utah Code Authorizes—But Does Not Specifically Require—The City To Regulate Development in Rock Fall Areas.

Utah Code section 10-9a-505(1)(c) states that a “municipality *may* enact an ordinance regulating land use and development in a flood plain or *potential geologic hazard* area to:

- (i) protect life; and
- (ii) prevent:
 - (A) the substantial loss of real property; or
 - (B) substantial damage to real property.”¹

Rock falls are included within the definition of a geologic hazard, and a potential geologic hazard area includes areas designated by a Utah Geological Survey map as needing further study to determine the area's potential for geologic hazard.²

III. A 2009 Utah Geological Survey Map Designates Some Areas Within Hurricane City As Having A Potential Rock-Fall Hazard And Recommends Additional Review Of Those Areas.

In May of 2009 the Utah Department of Natural Resources published Utah Geological Survey Special Study 127 pertaining to Rock-Fall Hazard areas within Hurricane City. The map is available here: <https://www.cityofhurricane.com/DocumentCenter/View/167>. The language on the map explains how it should be used:

The Rock-Fall-Hazard Map shows areas of relative rock-fall hazard ... where site-specific hazard studies are recommended prior to construction.... These studies can resolve uncertainties inherent in generalized hazard mapping and help ensure

¹ Emphasis added.

² Utah Code § 10-9a-103 (18), (52).

safety by identifying the need for rock-fall-resistant design or mitigation. For most areas, site-specific assessment may only require a field geologic evaluation to determine if a rock-fall source is present. However, if a source is identified, additional work to adequately assess the hazard is needed.

IV. In 2014 Hurricane City Adopted An Ordinance Regulating Development Within The Rock-Fall Hazard Area Designated on the Utah Geological Survey Map

The City code requires that the above-referenced Utah Geological Survey Map be reviewed when considering a site for development.³ When the map indicates that geologic hazards may be located on the site, the Code requires a geology report prepared by a state licensed professional engineering geologist or a state licensed professional engineer who is trained and experienced in the practice of geotechnical engineering.⁴ The geology report must include “conclusions and recommendations regarding the effects of the geologic conditions and any potential hazards on the proposed development, and recommendations to minimize any hazard to life or property, or any adverse impact on the natural environment.”⁵

Specific to the rockfall zone, the City code states that no structure shall be allowed in any rockfall hazard area as shown on the Utah Geological Survey map unless a site-specific study finds that the development is not within a rockfall zone.⁶ The code grants some flexibility as to how detailed the report needs to be: “the adequacy, implementation, and acceptance of the site-specific study shall be determined by the City Engineer or designee.” For example, if a proposed development is identified as a potential hazard area on the Utah Geological Survey map, but it is apparent that the property does not present a rockfall hazard, a very simple report could be acceptable to move forward with the development.

The relevant City code can be found here:

https://library.municode.com/ut/hurricane/codes/code_of_ordinances?nodeId=TIT10LAUSRE_CH28DEARSPCO_S10-28-2NAHAADCOCO

V. Additional Resources

The Utah Department of Natural Resources published an article in 1987 entitled *Suggested Approach to Geological Hazards Ordinances in Utah* by Gary E. Christenson. The article is available here: <https://ugspub.nr.utah.gov/publications/circular/c-79.pdf>.

Some relevant portions of the article are provided below:

Once the possible existence of a hazard(s) is determined, the ordinance should include a means of requiring geotechnical investigations performed by qualified

³ Hurricane City Code 10-28-2(B)(10).

⁴ *Id.*

⁵ *Id.*

⁶ Hurricane City Code 10-28-2(C)(4).

engineering geologists and engineers to address hazards and recommend appropriate action prior to development. These investigations may find that no hazards exist at the site and recommend that no action is necessary. If the hazard is found to exist and development is still proposed, recommended actions may include site abandonment, land-use restrictions such as setbacks from faults, mandatory disclosure of hazards to potential buyers, reduced density, placement of engineered structures, and/or recommendations for further studies.

In the final step, reports of these investigations along with recommendations for action to mitigate hazards should be submitted to the governmental entity and reviewed by qualified engineering geologists and engineers. If reviewers believe the investigations are sufficient and mitigating measures satisfactory, they should recommend approval of the development. If the investigation does not adequately or accurately address hazards or if recommended mitigation measures are thought to be inadequate, the reviewers should not approve the plans and recommend that either discussions be initiated to solve problems or that further study be performed. If the report shows the hazards cannot be adequately mitigated for the proposed land use, reviewers should recommend disapproval.

...

At whatever point in the process, the principal goal of a geologic hazards ordinance must be to provide a means for local government to require site-specific geologic hazards investigations where necessary in order to demonstrate that the land is suited for the proposed use or to recommend measures necessary to make the land suitable. In Utah, the responsibility for providing these investigations lies with the landowner or person requesting a permit from the local planning commission. The preliminary determination of where such investigations should be required must be made by local government.

GUIDELINES FOR INVESTIGATING GEOLOGIC HAZARDS AND PREPARING ENGINEERING-GEOLOGY REPORTS, WITH A SUGGESTED APPROACH TO GEOLOGIC-HAZARD ORDINANCES IN UTAH SECOND EDITION

Steve D. Bowman and William R. Lund, editors



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Cover photo: August 2014 Parkway Drive landslide, North Salt Lake. The landslide damaged the Eagle Ridge Tennis and Swim Club (white tent structure), severely damaged a house (directly above the tent structure), and removed part of the backyard of a second home. This landslide illustrates the significant impact geologic hazards can have on individuals, property owners, local governments, and the community.

Photo credit: Gregg Beukelman, August 14, 2014.

Suggested citation:

Bowman, S.D., and Lund, W.R., editors, 2020, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, second edition: Utah Geological Survey Circular 128, 170 p., 5 appendices, <https://doi.org/10.34191/C-128>.



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2020

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UTAH GEOLOGICAL SURVEY
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CONTENTS

PREFACE	xii
CHAPTER 1: INTRODUCTION	1
OVERVIEW	3
COSTS OF GEOLOGIC HAZARDS	4
Landslide Hazards	4
Landslides	4
Rockfall	4
Debris Flows	5
Snow Avalanches	6
Earthquake Hazards	6
Flooding Hazards	6
Floods and Flash Floods	7
Debris Flows	7
Dam and Water Conveyance Structure Failure	7
Problem Soil and Rock Hazards	10
Land Subsidence and Earth Fissures	10
Radon Gas	13
UGS GEOLOGIC-HAZARD GUIDELINES BACKGROUND	13
CURRENT UGS GEOLOGIC-HAZARD GUIDELINES	13
ACKNOWLEDGMENTS	14
CHAPTER 2: GUIDELINES FOR CONDUCTING ENGINEERING-GEOLOGY INVESTIGATIONS AND PREPARING ENGINEERING-GEOLOGY REPORTS IN UTAH	15
INTRODUCTION	17
ENGINEERING-GEOLOGY INVESTIGATIONS	17
When Geologic-Hazard Special Study Maps Are Not Available	18
International Building/Residential Code and Local Requirements	18
Investigator Qualifications	19
Literature Searches and Information Resources	19
Available UGS Information	19
Aerial Photography	20
Lidar Elevation Data	21
Excavation Safety	21
Site Characterization	21
Geologic Mapping	23
Laboratory Testing	24
Geochronology	24
ENGINEERING-GEOLOGY REPORTS	26
General Information	27
Descriptions of Geologic Materials, Features, and Conditions	27
Assessment of Geologic Hazards and Project Suitability	28
Identification and Extent of Geologic Hazards	28
Suitability of Proposed Development in Relation to Geologic Conditions and Hazards	28
Report Structure and Content	28
FIELD REVIEW	29
REPORT REVIEW	30
DISCLOSURE	30
ACKNOWLEDGMENTS	30
CHAPTER 3: GUIDELINES FOR EVALUATING SURFACE-FAULT-RUPTURE HAZARDS IN UTAH	31
INTRODUCTION	33
Purpose	33
Background	34
CHARACTERIZING FAULT ACTIVITY	37
Rupture Complexity	37
Earthquake Timing and Recurrence	39
Displacement	39
Slip Rate	39

SOURCES OF PALEOSEISMIC INFORMATION.....	41
SURFACE-FAULTING-HAZARD INVESTIGATION.....	42
When to Perform a Surface-Faulting-Hazard Investigation.....	42
Minimum Qualifications of the Investigator	42
Investigation Methods	42
Literature Review	42
Analysis of Aerial Photographs and Remote Sensing Data	44
Fault Mapping	44
Trenching.....	44
Trench number and location.....	45
Trench depth	46
Trench logging and interpretation.....	46
Geochronology	46
Other Subsurface Investigation Methods	47
Cone penetrometer test soundings.....	47
Boreholes.....	47
Geophysical investigations	47
Special Cases.....	47
Sub-Lacustrine Faults.....	47
Grabens.....	48
SURFACE-FAULTING MITIGATION.....	49
Background	49
Surface-Faulting Special-Study Maps.....	49
Hazardous Fault Avoidance.....	50
Fault Activity Classes.....	50
Investigation Recommendations	51
Fault Setbacks	51
Downthrown block.....	52
Upthrown block	52
Example of a fault setback calculation	52
Surface Deformation from Slip on a Buried Fault	53
Paleoseismic Data Required for Engineering-Design Mitigation of Surface Faulting	53
HAZARDOUS FAULT CRITERIA	55
SURFACE-FAULTING-INVESTIGATION REPORT	56
FIELD REVIEW.....	58
REPORT REVIEW	58
DISCLOSURE	58
ACKNOWLEDGMENTS	58
CHAPTER 4: GUIDELINES FOR EVALUATING LANDSLIDE HAZARDS IN UTAH	59
INTRODUCTION	61
Purpose.....	61
Background	61
Landslide Causes.....	63
Landslide Hazards.....	64
LANDSLIDE-HAZARD INVESTIGATION.....	64
When to Perform a Landslide-Hazard Investigation.....	64
Minimum Qualifications of Investigator	65
Investigation Methods	65
Literature Review	65
Analysis of Remote-Sensing Data.....	66
Geologic Investigations.....	66
Geotechnical-Engineering Investigations.....	68
Slope-Stability Analysis	68
Static Slope-Stability Analysis	68
Seismic Slope-Stability Analysis	69
Estimation of Displacement	69
Other Investigation Methods.....	69

LANDSLIDE-HAZARD MITIGATION.....	70
LANDSLIDE-INVESTIGATION REPORT	70
FIELD REVIEW.....	72
REPORT REVIEW	72
DISCLOSURE.....	72
ACKNOWLEDGMENTS	72

CHAPTER 5: GUIDELINES FOR THE GEOLOGIC INVESTIGATION OF DEBRIS-FLOW HAZARDS ON

ALLUVIAL FANS IN UTAH.....	75
INTRODUCTION	77
Background	77
Purpose	78
SOURCES OF DEBRIS-FLOW INFORMATION	78
DEBRIS-FLOW-HAZARD INVESTIGATION	80
When to Perform a Debris-Flow-Hazard Investigation	80
Minimum Qualifications of Investigator	80
Alluvial-Fan Evaluation	80
Defining the Active-Fan Area.....	80
Mapping Alluvial-Fan and Debris-Flow Deposits	81
Determining the Age of Debris-Flow Deposits.....	83
Subsurface Exploration	83
Drainage-Basin and Channel Evaluation	84
Debris-Flow Initiation	84
Debris-Flow Susceptibility of the Basin	84
Channel Sediment Bulking and Flow-Volume Estimation.....	85
DEBRIS-FLOW-RISK REDUCTION	86
DESIGN CONSIDERATIONS FOR RISK REDUCTION.....	87
Considering Frequency and Magnitude in Design	87
Debris-Flow-Hazard Zones	88
Estimating Geologic Parameters for Engineering Design.....	88
DEBRIS-FLOW-INVESTIGATION REPORT	89
FIELD REVIEW.....	91
REPORT REVIEW	91
DISCLOSURE.....	91
ACKNOWLEDGMENTS	91

CHAPTER 6: GUIDELINES FOR EVALUATING LAND-SUBSIDENCE AND EARTH-FISSURE HAZARDS IN UTAH.....

IN UTAH.....	93
INTRODUCTION	95
Purpose	95
Background	96
Land-Subsidence and Earth-Fissure Formation	96
Land-Subsidence Hazards	96
Earth-Fissure Hazards	98
SOURCES OF LAND-SUBSIDENCE AND EARTH-FISSURE INFORMATION	99
LAND-SUBSIDENCE AND EARTH-FISSURE INVESTIGATION	101
Disclaimer	101
When to Perform a Land-Subsidence and Earth-Fissure-Hazard Investigation.....	102
Minimum Qualifications of Investigator	102
Basin-Wide Investigation Guidelines.....	102
Remote Sensing.....	102
Aerial photographs	102
InSAR	103
Lidar.....	103
High-Precision GPS/GNSS Survey Network.....	103
Site-Specific Investigation Guidelines	104
Literature Review.....	104
Analysis of Aerial Photographs and Remote Sensing Data	104
Surface Investigation.....	104

Subsurface Investigation	104
Other Investigation Methods	106
LAND-SUBSIDENCE AND EARTH-FISSURE MITIGATION	106
LAND-SUBSIDENCE AND EARTH-FISSURE INVESTIGATION REPORT	107
FIELD REVIEW	109
REPORT REVIEW	109
DISCLOSURE	110
ACKNOWLEDGMENTS	110
CHAPTER 7: GUIDELINES FOR EVALUATING ROCKFALL HAZARDS IN UTAH	111
INTRODUCTION	113
Purpose	113
Background	113
SOURCES OF ROCKFALL INFORMATION	114
ROCKFALL-HAZARD INVESTIGATION	114
When to Perform a Rockfall-Hazard Investigation	114
Minimum Qualifications of Investigator	115
Investigation Methods	115
Literature Review	115
Analysis of Aerial Photographs and Remote-Sensing Data	116
Site Characterization	116
Rockfall shadow angle	117
Rockfall modeling software	118
Rockfall probability	118
Other Investigation Methods	118
ROCKFALL MITIGATION	119
ROCKFALL-INVESTIGATION REPORT	120
FIELD REVIEW	122
REPORT REVIEW	123
DISCLOSURE	123
ACKNOWLEDGMENTS	123
CHAPTER 8: GUIDELINES FOR EVALUATION OF GEOLOGIC RADON HAZARD IN UTAH	125
INTRODUCTION	127
Purpose	128
Background	128
Geology of Radon	129
SOURCES OF UTAH RADON INFORMATION	129
Utah Department of Environmental Quality Radon Program	129
Utah Geological Survey	130
RADON-HAZARD INVESTIGATION	131
When to Perform a Radon-Hazard Investigation	131
Minimum Qualifications of Investigator	131
Site-Specific Radon Source Investigation	131
Investigation Purpose and Scope	131
Literature Review	132
Analysis of Aerial Photographs and Remote-Sensing Data	132
Regional Geology and Geologic Maps	132
Site Specific Geology and Geologic Maps	132
Subsurface Investigation	132
Visual Examination of Site Geologic Material	132
National Uranium Resource Evaluation Hydrogeochemical and Stream Sediment	132
Radon Soil Gas Testing	133
Conclusions	133
RADON CONTROL	134
FIELD REVIEW	134
REPORT REVIEW	134
DISCLOSURE	134
RADON-HAZARD INVESTIGATION REPORT OUTLINE	134

CHAPTER 9: SUGGESTED APPROACH TO GEOLOGIC-HAZARD ORDINANCES IN UTAH	137
INTRODUCTION	139
PURPOSE	139
ORDINANCE DEVELOPMENT	140
When to Perform a Geologic-Hazard Investigation	140
Minimum Qualifications of the Investigator	140
Geologic-Hazard Special Study Maps	140
Utah Geological Survey Geologic-Hazard Maps	140
Where Geologic-Hazard Maps Are Not Available	141
Scoping Meeting	141
ENGINEERING-GEOLOGY INVESTIGATIONS AND REPORTS	141
PROJECT REVIEW	141
Field Review	141
Report Review	142
Report Archiving	142
ENFORCEMENT	142
DISCLOSURE	143
MODEL ORDINANCE	143
CHAPTER 10: ENGINEERING-GEOLOGY INVESTIGATION AND REPORT GUIDELINES FOR NEW UTAH PUBLIC SCHOOL BUILDINGS (UTAH STATE OFFICE OF EDUCATION)	145
INTRODUCTION	147
SCHOOL SITE GEOLOGIC HAZARDS AND INVESTIGATION	147
UGS SCHOOL SITE GEOLOGIC-HAZARD REPORT REVIEW	147
CONTACTS	148
REFERENCES	149
APPENDICES	171
APPENDIX A: REPORT REVIEW CHECKLISTS	173
APPENDIX B: GLOSSARY OF GEOLOGIC-HAZARD AND OTHER TERMS	199
APPENDIX C: LIGHT DETECTION AND RANGING (LIDAR) BACKGROUND AND APPLICATION	207
APPENDIX D: INTERFEROMETRIC SYNTHETIC APERTURE RADAR (INSAR) BACKGROUND AND APPLICATION	217
APPENDIX E: GEOLOGIC HAZARD MODEL ORDINANCE	225

FIGURES

Figure 1. August 2014 Parkway Drive landslide, North Salt Lake	5
Figure 2. House on Springhill Drive, North Salt Lake City, Utah, severely damaged by the Springhill landslide	5
Figure 3. House in Rockville, Utah, destroyed by a rockfall on December 12, 2013, that resulted in the death of the two house occupants	6
Figure 4. September 12, 2002, Santaquin, Utah, fire-related debris flow	7
Figure 5. Comparison of 2006 National Agriculture Imagery Program (NAIP) 1-meter color orthophoto imagery and 2006 2-meter airborne LiDAR imagery in the Snowbasin area, Weber County, Utah	22
Figure 6. Comparison of 2009 High-Resolution Orthophotography (HRO) 1-foot color imagery and 2011 1-meter airborne lidar imagery in the International Center area, Salt Lake City, Utah	22
Figure 7. Scarp caused by surface faulting on the Nephi segment of the Wasatch fault zone	34
Figure 8. Normal fault diagram and excavation photograph	35
Figure 9. Normal fault surface-faulting damage to a building, 1959 Hebgen Lake, Montana, M 7.3 earthquake	35
Figure 10. Example of a surface-faulting special-study-area map along the Hurricane fault zone in southwestern Utah	36
Figure 11. Map view of rupture complexity along part of the Salt Lake City segment of the Wasatch fault zone	38
Figure 12. Surface faulting associated with the 1934 Hansel Valley, Utah, M 6.6 earthquake	39
Figure 13. Schematic cross section through a normal fault zone	40
Figure 14. Thrust fault exhibiting several feet of displacement at a complex bend in an otherwise normal-slip fault zone	40
Figure 15. Fault trench length and orientation to investigate a building footprint	44

Figure 16. Three possible fault configurations from fault exposures in only two trenches.....	45
Figure 17. Potential problems caused by improper trench locations.....	45
Figure 18. Schematic diagram illustrating fault setback calculation.....	51
Figure 19. Distribution of probability density functions showing timing of single segment surface-faulting earthquakes on the five central segments of the Wasatch fault zone for the past ~6500 years.....	54
Figure 20. August 2014 Parkway Drive landslide, North Salt Lake, Utah.....	62
Figure 21. Diagram of an idealized landslide showing commonly used nomenclature for its parts.....	62
Figure 22. The 1983 Thistle, Utah, landslide buried parts of two State highways and the Denver and Rio Grande Railroad.....	63
Figure 23. The 2005 landslide below the Davis-Weber Canal in South Weber, Davis County, that demolished a barn and covered part of State Route 60.....	65
Figure 24. Cross section of typical rotational landslide.....	69
Figure 25. Example of a drainage basin and alluvial fan at Kotter Canyon, north of Brigham City, Utah.....	78
Figure 26. Active and inactive alluvial fans, feeder channel, and intersection point.....	81
Figure 27. Approximate proximal, medial, and distal fan areas on the Kotter Canyon alluvial fan, north of Brigham City, Utah.....	82
Figure 28. Channel sediment and cross section used to estimate sediment volume available for bulking.....	86
Figure 29. Schematic cross section of a typical Utah alluvial basin showing the effect of groundwater-level decline on the compaction of fine-grained horizons and resulting ground subsidence within the alluvial basin-fill aquifer.....	97
Figure 30. (A) Schematic section of a valley basin showing how buried bedrock topography affects the formation and location of earth fissures. (B) Schematic diagram showing initiation of earth fissures at depth due to horizontal tension stress, and development of fissures expressed at the surface as hairline cracks, aligned sinkholes, and erosional gullies.....	97
Figure 31. Earth fissure in Cedar Valley expressed as an uneroded primary ground crack.....	98
Figure 32. Sinkholes aligned along an earth fissure in Cedar Valley.....	98
Figure 33. Earth fissure in Escalante Valley eroded after intercepting surface water runoff.....	99
Figure 34. Damage to street pavement by an earth fissure in Cedar Valley across which differential displacement is occurring at a rate of about 2 inches per year.....	99
Figure 35. Earth-fissure scarp in Cedar Valley blocking an ephemeral drainage and causing water to pond along the fissure in a feed lot.....	100
Figure 36. Earth fissure in a subdivision near Phoenix, Arizona, enhanced by erosion during a cloudburst storm.....	100
Figure 37. Earth fissure intersecting an irrigation canal embankment near Phoenix, Arizona.....	101
Figure 38. Remains of a home severely damaged by an earth fissure and eventually torn down in the Windsor Park subdivision, Las Vegas, Nevada.....	101
Figure 39. Bare-earth lidar image of earth fissures in Cedar Valley, Utah.....	103
Figure 40. Protruding well head due to land subsidence resulting from groundwater mining.....	105
Figure 41. Vertical earth fissure in Cedar Valley exposed in the end of an erosional gully formed along the fissure by infiltration of surface runoff.....	105
Figure 42. Rockfall damage to a house in southern Utah.....	114
Figure 43. Site showing rockfall source, acceleration zone, and runout zone.....	114
Figure 44. Unreinforced rockery wall typical of many constructed in recent years in Utah.....	115
Figure 45. Dust clouds created by numerous rockfalls during the 1988 M 5.3 San Rafael Swell earthquake.....	115
Figure 46. Typical rockfall path profile and components of a rockfall shadow angle.....	117
Figure 47. Weathered rockfall boulder with subsequent erosion of soil from around the boulder base indicating that this rockfall occurred in the distant past and the area may no longer be in an active rockfall-hazard area.....	117
Figure 48. Rockfall-hazard zones mapped by the UGS, and historical rockfalls and their travel paths in the Town of Rockville, Utah.....	119
Figure 49. House in Rockville, Utah, in September 2010 and destroyed by a large rockfall in 2013.....	120
Figure 50. Rockfall in 1947 through the roof of a maintenance building in Zion National Park and in the roof of the same maintenance building. Photos courtesy of National Park Service.....	120
Figure 51. Rockfall fence installed to mitigate rockfall hazard and protect the Zion National Park maintenance building.....	121
Figure 52. National Uranium Resource Evaluation HSSR data collection points in Utah and the surrounding area.....	133

TABLES

Table 1. Summary of known geologic-hazard fatalities in Utah.....	4
Table 2. Utah landslide fatalities since 1850.....	5
Table 3. Utah rockfall fatalities since 1850.....	6
Table 4. Utah debris-flow fatalities since 1847.....	7
Table 5. Utah snow avalanche fatalities since 1847.....	8
Table 6. Utah earthquake fatalities since 1847	10
Table 7. Utah flood fatalities since 1847.....	11
Table 8. Utah dam and water conveyance structure failure fatalities since 1847	12
Table 9. Utah radon gas fatalities since 1973.....	12
Table 10. Potential information sources for engineering-geology investigations in Utah.....	20
Table 11. Recommended minimum subsurface exploration frequency and depth for constructed features.....	23
Table 12. Classification of geochronologic methods potentially applicable to geologic-hazard investigations.....	26
Table 13. Fault setback recommendations and criticality factors for modified IBC risk category of buildings and other structures	43
Table 14. Unified Landslide Classification System	67
Table 15. Summary of landslide mitigation approaches.....	71
Table 16. Geomorphic and sedimentologic criteria for differentiating water and sediment flows.....	83
Table 17. Estimated fatalities from radon gas in Utah from 1973 to 2016	127
Table 18. Example of short-term radon test results reported by county and ZIP code from the DEQ-RP website.....	130
Table 19. Utah Geological Survey radon-hazard-potential investigations conducted in Utah through 2018.....	130

PREFACE

The purpose of these guidelines for investigating geologic hazards and preparing engineering-geology reports is to provide recommendations for appropriate, minimum investigative techniques, standards, and report content to ensure adequate geologic site characterization and geologic-hazard investigations to protect public safety and facilitate risk reduction. Such investigations provide important information on site geologic conditions that may affect or be affected by development, as well as the type and severity of geologic hazards at a site, and recommend solutions to mitigate the effects and the cost of the hazards, both at the time of construction and over the life of the development. The accompanying suggested approach to geologic-hazard ordinances and school-site investigation guidelines are intended as an aid for land-use planning and regulation by local Utah jurisdictions and school districts, respectively. Geologic hazards that are not accounted for in project planning and design often result in additional unforeseen construction and/or future maintenance costs, and possible injury or death.

These guidelines are chiefly intended for Engineering Geologists performing geologic site investigations and for preparing engineering-geology reports on behalf of owners/developers seeking approval for site-specific development projects. The guidelines also provide a technical (scientific) basis for geologic-hazard ordinances and land-use regulations implemented by local jurisdictions. The guidelines and accompanying investigation checklists (appendix A) will be helpful to regulatory-authority Engineering Geologists conducting technical reviews of engineering-geology/geologic-hazard reports in support of the planning and development permit process.

Chapters 2, 3, 4, 5, 9, and 10 update and revise the following Utah Geological Survey (UGS) guidelines, which were previously individually published as:

- *Guidelines for Evaluating Landslide Hazards in Utah* (1996), Utah Geological Survey Circular 92
- *Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah* (2003), Utah Geological Survey Miscellaneous Publication 03-6
- *Guidelines for Preparing Geologic Reports in Utah* (1986), Utah Geological and Mineral Survey Miscellaneous Publication M
- *Guidelines for the Geologic Evaluation of Debris-Flow Hazards on Alluvial Fans in Utah* (2005), Utah Geological Survey Miscellaneous Publication 05-06
- *Suggested Approaches to Geologic Hazards Ordinances in Utah* (1987), Utah Geological Survey Circular 79
- Utah State Office of Education – Geologic-Hazard Report Guidelines and Review Checklist for New Utah Public School Buildings (2012), https://geology.utah.gov/ghp/school-site_review/pdf/ssr_checklist.pdf.

Chapters 6, 7, and 8 provide new guidelines for investigating land-subsidence and earth-fissure hazards, rockfall hazards, and geologic radon hazard, respectively. We combined all of the UGS geologic-hazard-related guidelines into one volume to ensure users have easy and convenient access to all of the guidelines in one document, and to facilitate future updates. As the UGS develops additional geologic-hazard investigation guidelines, this publication will be updated as necessary. Users should refer to the UGS web page for the most current information and guidelines: <https://doi.org/10.34191/C-128>.

Guideline Editors

Steve D. Bowman, Ph.D., P.E., P.G., *Geologic Hazards Program (GHP) Manager*
William R. Lund, P.G., *GHP Senior Scientist Emeritus*

CHAPTER 1 INTRODUCTION

by
Steve D. Bowman, Ph.D., P.E., P.G.



Dump truck crushed by rockfall on November 23, 1947, in Zion National Park (photo courtesy of the National Park Service).

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CHAPTER 1: INTRODUCTION

by Steve D. Bowman, Ph.D., P.E., P.G.

OVERVIEW

Geologic hazards affect Utah, negatively impacting life safety, health, property, and the state's economy. While many geologic hazards are not life threatening, they are often costly when not recognized and properly accommodated in project planning and design, and may result in additional, significant construction and/or future maintenance costs and injury or death. To ensure that future development within Utah is protected from geologic hazards, the Utah Geological Survey (UGS) recommends that a comprehensive engineering-geology investigation be performed for all development subject to local permitting. Such investigations provide valuable information on site geologic conditions that may affect or be affected by development, as well as the type and severity of geologic hazards at a site, and recommend solutions to mitigate the effects and the cost of the hazards, both at the time of construction and over the life of the development. Engineering-geology investigations and accompanying geologic-hazard evaluations may be performed independently, or be included as part of a more broadly based geotechnical investigation before project engineering design.

The guidelines presented herein provide recommendations for appropriate, minimum investigative techniques, standards, and report content to ensure adequate geologic site characterization and geologic-hazard investigations to protect public safety and facilitate risk reduction. Chapter 2 presents guidelines for conducting engineering-geology investigations and preparing engineering-geology reports; chapters 3 through 8 provide guidance for evaluating surface-fault-rupture, landslide, debris-flow, land-subsidence and earth-fissure, rock-fall hazards, and radon gas. These guidelines are intended to ensure effective site investigations and geologic-hazard recognition and mitigation at the municipal or county level. Chapter 9 provides a suggested approach to geologic-hazard ordinances and effective review of engineering-geology reports in Utah. Chapter 10 provides guidance on reviewing Utah school-site engineering-geology reports and the UGS review of these reports.

Geologic hazards are defined in Utah Code as a “geologic condition that presents a risk to life, of substantial loss of real property, or of substantial damage to real property” (Title 17, Chapter 27a, Section 103, http://le.utah.gov/xcode/Title17/Chapter27A/17-27a-S103.html?v=C17-27a-S103_2015051220150512). Geologic hazards that have occurred in the recent geologic past and have the potential to occur in the future in Utah include, but are not limited to:

- Landslide Hazards, including
 - Landslides
 - Rockfall
 - Debris flows
 - Snow avalanches
- Earthquake Hazards, including
 - Ground shaking
 - Surface fault rupture
 - Liquefaction
 - Tectonic deformation
- Flooding Hazards, including
 - River, lake, or sheet flooding
 - Debris flows
 - Shallow groundwater
 - Dam and water conveyance structure failure
 - Seiches
 - Tsunamis
- Problem Soil and Rock Hazards, including
 - Collapsible soils
 - Expansive soil and rock
 - Shallow bedrock
 - Corrosive soil and rock
 - Wind-blown sand
 - Breccia pipes and karst
 - Piping and erosion
 - Land subsidence and earth fissures
 - Caliche
 - Soluble soil and rock
 - Radon gas
- Volcanic Hazards, including
 - Volcanic eruption
 - Lava flows
 - Ash clouds

COSTS OF GEOLOGIC HAZARDS

Geologic hazards that are not accounted for in project planning and design often result in additional unforeseen construction and/or future maintenance costs, and possible injury or death. There is only limited information on the direct and indirect economic costs of geologic hazards in the United States, including Utah; however, some information is available for large landslide events. For example, landslides in the United States cause between \$1.6 and \$3.2 billion (2013 dollars) in damages each year (Committee on Ground Failure Hazards, 1985).

Since 1847, approximately 6172 fatalities from geologic hazards have been documented in Utah (table 1), as well as a significantly larger, but undetermined number of injuries. Radon gas exposure (lung cancer) has been Utah's most deadly geologic hazard, with over 5729 fatalities (data only available from 1973 to 2016), followed by landslide hazards with 337 documented fatalities, and then flooding hazards with 101 documented fatalities. As debris flows are both a landslide and flooding hazard, fatalities are listed in both hazard categories. Using the economic value of a statistical life of \$11.6 million (2016 dollars; U.S. Department of Transportation, 2014), the 6172 fatalities are valued at \$71.6 trillion. The estimated economic value of human life is not considered in the hazard economic costs given below.

In almost all cases, it is more cost effective to perform a comprehensive engineering-geology investigation to identify and characterize geologic hazards and implement appropriate mitigation in project design and construction, rather than relying on additional maintenance over the life of the project or to incur costly change orders during construction.

Landslide Hazards

Landslide hazards have resulted in at least 341 fatalities in Utah since 1850, with 89.8% of deaths from snow avalanches and 10.2% of deaths from landslides (rock and soil), rockfall, and debris flows (table 2). While nearly all the recorded snow avalanche deaths since 1950 have been caused by human-triggered avalanches, many of these events have occurred at or near developed areas where appropriate mitigation measures should be employed.

Landslides

The 1983 Thistle landslide, Utah's largest natural (non-mining related) historical landslide, resulted in direct costs of \$200 million, including \$81 million in lost revenue by the Denver and Rio Grande Western Railroad (now Union Pacific Railroad; University of Utah, 1984). The Utah Department of Transportation estimates that repairs from damage to Utah State Highway 14 from a major 2011 landslide cost between \$13 and \$15 million (Dave Fadling, Utah Depart-

Table 1. Summary of known geologic-hazard fatalities in Utah.

Geologic Hazard		Fatalities			
Landslide Hazards					
Landslides ¹		4	1.2%	341	5.7%
Rockfall		16	4.5%		
Debris Flows ²		15	4.5%		
Snow Avalanches ³		306	89.8%		
Earthquake Hazards					
Ground Shaking		2	100%	2	<0.1%
Flooding Hazards					
Flooding		81	80.1%	101	1.7%
Debris Flows ²		15	14.9%		
Dam and Water Conveyance Structure Failure ¹		5	5.0%		
Problem Soils					
Radon Gas ⁴	1973–2016	5729 ⁵	–	5729	92.6%
Total:		6172			

¹ Because of uncertainty in event initiation, three fatalities are listed in both the "Landslides" and "Dam and Water Conveyance Structure Failure" categories.

² Debris flows are both a landslide and flooding hazard.

³ The majority of post-1950 snow avalanche fatalities are in the backcountry from human-induced avalanches; however, many have occurred near or in developed areas where appropriate mitigation measures should be used.

⁴ Limited data are available and contain various assumptions; exact number of fatalities is unknown.

⁵ Based on World Health Organization general estimate that 14% of lung cancer cases are attributable to radon gas (Sasha Zaharoff, Utah Department of Health, written communication, 2015) and data from the Utah Environmental Public Health Tracking Network, 2018 <http://epht.health.utah.gov/epht-view/query/result/ucr/UCRCntyICDO2/Count.html>.

ment of Transportation, verbal communication, 2012). The 2014 Parkway Drive landslide in North Salt Lake severely damaged a house and tennis and swim club, and threatens other houses and nearby regional natural gas pipelines (figure 1; Bowman, 2015); remediation is expected to cost \$2 million (KSL, 2015), not including emergency response or homeowner relocation costs.

The Springhill landslide in North Salt Lake resulted in demolition of 18 homes since movement began around the late 1990s. Due to ongoing movement and subsequent public safety hazards, the City of North Salt Lake applied for a Federal Emergency Management Agency grant in 2011, to mitigate landslide hazards by purchasing 11 affected homes and demolishing them at a cost of \$2.5 million (City of North Salt Lake, 2011). Figure 2 shows one of the affected homes.

Rockfall

Rockfall has caused significant damage to structures and property and resulted in at least 16 deaths in Utah since 1850 (table 3). Many of these fatalities were recreation related, and there-

Table 2. Utah landslide fatalities since 1850, based on newspaper, report, and scientific descriptions of events.

Date	Location	Fatalities	Notes	References ¹
3/12/2005	Kanab Creek, Kanab	1	Stream bank collapse	UGS RI 269, p. 17–24
7/11/2009	Logan Bluffs, Logan	3	Canal/landslide failure, home destroyed with three occupants ²	UGS, Survey Notes, 2009, v. 41, no. 3, p. 10
Total:		4		

¹ RI (Report of Investigation), UGS (Utah Geological Survey).

² It is unknown if a landslide initially caused the canal failure or if the canal failure caused the landslide; therefore, the three fatalities are included in both the “Landslides” and “Dam and Water Conveyance Structure Failure” categories.



Figure 1. August 2014 Parkway Drive landslide, North Salt Lake. The landslide damaged the Eagle Ridge Tennis and Swim Club (white tent structure), severely damaged a house (directly above the tent structure), and removed part of the backyard of a second home. Photo credit: Gregg Beukelman, August, 14, 2014.

fore, the hazard outside of developed areas should not be discounted. Utah’s most recent rockfall-related fatalities are from the December 12, 2013, rockfall in Rockville, Utah (Lund and others, 2014), where two people died when numerous large rockfall boulders struck their home (figure 3), completely destroying two buildings. Seven major rockfalls have been documented in Rockville since 1976 (Knudsen, 2011).

Debris Flows

Debris flows have caused significant damage to structures and property and resulted in at least 15 deaths in Utah since 1847 (table 4). Damage to 29 homes and two businesses from the September 12, 2002, Santaquin, Utah, fire-related debris flow (figure 4) totaled about \$500,000 (Brad Bartholomew, Utah Division of Emergency Management, verbal communication, 2012). As debris flows are both a landslide and flooding hazard, fatalities are listed in both hazard categories.



Figure 2. House on Springhill Drive, North Salt Lake City, Utah, severely damaged by the Springhill landslide. This home had been “red tagged” by the city building official as unsafe to enter. Photo credit: Gregg Beukelman, February 29, 2012.

Table 3. Utah rockfall fatalities since 1850, based on newspaper, report, and scientific descriptions of events.

Date	Location	Fatalities	Notes	References ¹
4/25/1874	Hyrum Canyon, Hyrum	2	Broken ledge	UGS OFR 514
10/20/1892	Ogden Canyon, near Kilns	1	—	UGS OFR 514
5/5/1895	Weber Canyon	1	Railroad engineer	UGS OFR 514
2/7/1909	Ruby-Westwater	1	Railroad worker, possibly in Colorado	UGS OFR 514
7/29/1937	Price	2	Occurred after rain storm	UGS OFR 514
1960s–1970s?	Timpanogos Cave National Monument	?	—	NPS communication
7/25/1994	Hanging Rock Picnic Area, American Fork Canyon	1	—	USGS OFR 1229
1/14/1995	Big Cottonwood Canyon	1	—	UGS RI 228
7/29/1995	Hanging Rock Picnic Area, American Fork Canyon	1	—	UGS OFR 373, USGS OFR 1229
8/2/1999	Lake Powell, Goosenecks of San Juan Arm, Glen Canyon National Recreation Area	1	Camper struck on head, boulder rolled onto tent	UGS OFR 373, PI 94; NPS Geologic Hazard Events
10/1/2007	Lake Powell, Lake Canyon, Glen Canyon National Recreation Area	2	Rock slab collapse onto boat from overhanging alcove roof	NPS Geologic Hazard Events; http://www.ksl.com/?nid=148&sid=1897666
12/12/2013	368 West Main Street, Rockville	2	Home destroyed	UGS RI 273
3/2/2019	Stansbury Island	1	Hiker trapped by bolder	https://www.ksl.com/article/46502502
Total:		16		

¹ NPS (National Park Service), OFR (Open-File Report), PI (Public Information series), RI (Report of Investigation), UGS (Utah Geological Survey), USGS (U.S. Geological Survey).



Figure 3. House in Rockville, Utah, destroyed by a rockfall on December 12, 2013, that resulted in the death of the two house occupants. Photo credit: Tyler Knudsen, December 13, 2013.

Snow Avalanches

Snow avalanches have resulted in at least 303 fatalities in Utah since 1847, with 193 from avalanches in developed areas and 110 from winter sports-related avalanches (table 5). Whereas most of the winter sports-related fatalities were caused by human-triggered avalanches, many occurred at or near developed areas, where appropriate mitigation measures should be employed to protect from avalanches triggered within or adjacent to developed areas.

Earthquake Hazards

Although only two fatalities (ground shaking related) from earthquakes have occurred in Utah since 1847 (table 6), scenario modeling predicts 2000 to 2500 fatalities, 7400 to 9300 life-threatening injuries, 55,400 buildings completely damaged, 21 billion tons of debris, and \$33.2 billion in estimated short-term, direct economic losses from a major (magnitude [M] 7.0) earthquake on the Salt Lake City segment of the Wasatch fault zone (Earthquake Engineering Research Institute [EERI], 2015). About 90,200 unreinforced masonry buildings (URM), or over 61% of the total number of buildings in the 12-county area, will be moderately damaged or totally destroyed (EERI, 2015). Such an event will likely take decades to recover from and will be the single-most costly geologic hazard event to affect Utah.

Damage from the 2008 Wells (population 1657), Nevada, earthquake (M 6.0), the most recent damaging earthquake near Utah, totaled approximately \$10.6 million, with nearly half of the approximately 80 non-residential buildings damaged and 10 severely damaged (dePolo, 2011). The Wells earthquake is an important analog for rural Utah towns and cities, with similar URM building stock and fragile economic conditions.

Flooding Hazards

Flooding hazards have caused significant damage to structures and property and resulted in at least 101 fatalities in Utah since 1847, with 80.1% of deaths from floods and flash floods,

Table 4. Utah debris-flow fatalities since 1847, based on newspaper, report, and scientific descriptions of events.

Date	Location	Fatalities	Notes	References ¹
8/13/1923	Farmington Creek, Farmington	6	Campers	UGS files
6/11/1965	Sheep Creek, Flaming Gorge National Recreation Area	7	Campers	UGA Publication 28
5/13/1984	Clear Creek, Carbon County	1	Slope above house	UGS files
5/14/1984	Middle Fork Canyon, Carr Fork mine, Tooele County	1	Dozer operator	UGS files, Brough and others (1987)
Total:		15		

¹ UGA (Utah Geological Association), UGS (Utah Geological Survey).



Figure 4. September 12, 2002, Santaquin, Utah, fire-related debris flow. This debris flow moved and partially buried several vehicles, broke through a house wall, and entered other houses through broken basement windows and doors. Photo taken September 12, 2002.

14.9% from debris flows, and 5.0% from dam and water conveyance structure failures. Sixteen major flood events since 1923 have caused over \$1.3 trillion in damage (Utah Division of Emergency Management, 2014), and to date, flooding is Utah's most economically costly geologic hazard. As debris flows are both a landslide and flood hazard, fatalities are listed in both hazard categories.

Floods and Flash Floods

Floods and flash floods have caused significant damage to structures and property and resulted in at least 81 fatalities in Utah since 1847 (table 7). Flash floods produced Utah's most deadly,

single-event geologic hazard (20 fatalities), when on September 14, 2015, seven canyoneers in Keyhole Canyon in Zion National Park and 13 people in two vehicles in Hildale drowned in flash flooding resulting from a single summer thunderstorm.

Debris Flows

See debris-flow hazards in the Landslide Hazards section above.

Dam and Water Conveyance Structure Failure

Dam and water conveyance structure failures have caused significant damage to structures and property and resulted in five

Table 5. Utah snow avalanche fatalities since 1847, based on newspaper, report, and scientific descriptions of events.

Date	Location ¹	Fatalities		Notes	References ²
		Sports	Other		
1847–1949	Various ³	118		–	Brough
2/13/1885	Emma mine, Alta	–	16	Covered 3/4th of town	Brough
1/28/1903	Near Park City	–	3	Miners	Brough, O'Malley
1/31/1911	Alta	–	4	Miners	Brough
3–4/1920	Canyons around Salt Lake Valley	–	9	Also first few days of April	Brough
2/17/1926	Bingham Canyon	–	39 ⁴	Homes destroyed	Deseret News
1950–1957	Various	1			Brough
3/9/1958	Snowbasin, Mt. Ogden	2	–	Rescuers	NWS/UAC
3/29/1964	Snowbasin	–	1	Worker	NWS/UAC
2/12/1967	Pharaohs Glen	2	–	Climbers	NWS/UAC
2/19/1968	Rock Canyon	1	–	Hiker	NWS/UAC
1/29/1970	Alta	1	–	In-bounds skier	NWS/UAC
1/29/1970	Park West	1	–	In-bounds skier	NWS/UAC
1/6/1976	Alta	1	–	Out-of-bounds skier	NWS/UAC
3/3/1976	Snowbird	1	–	In-bounds skier	NWS/UAC
1/19/1979	Helper	–	1	Worker	NWS/UAC
4/2/1979	Lake Desolation	1	–	Backcountry skier	NWS/UAC
1/11/1980	Evergreen Ridge	1	–	Out-of-bounds skier	NWS/UAC
2/1/1981	Cardiff	1	–	Hiker	NWS/UAC
3/1/1981	Millcreek	1	–	Backcountry skier	NWS/UAC
3/22/1982	Near Park West	1	–	Backcountry skier	NWS/UAC
1/2/1984	Superior Peak	1	–	Backcountry skier	NWS/UAC
2/22/1985	Powder Mountain	1	–	Backcountry skier	NWS/UAC
3/19/1985	Park City	1	–	In-bounds wet slide	NWS/UAC
11/13/1985	Sunset Peak, BCC	2	–	Backcountry skiers	NWS/UAC
1/6/1986	Provo Canyon	1	–	Backcountry skier	NWS/UAC
2/17/1986	BCC	1	–	Backcountry snowboarder	NWS/UAC
2/19/1986	Alta	1	–	In-bounds skier	NWS/UAC
11/20/1986	Sugarloaf, Alta	1	–	Hiker, unopened area	NWS/UAC
2/15/1987	Twin Lakes Reservoir	1	–	Backcountry skier	NWS/UAC
11/25/1989	Tony Grove Lake	1	–	Backcountry skier	NWS/UAC
2/12/1992	Gold Basin, La Sal Mountains	4	–	Backcountry skiers	NWS/UAC
4/1/1992	Mineral Basin, Snowbird	1	–	Backcountry skier	NWS/UAC
1/16/1993	Sundance	1	–	Backcountry skier, closed area	NWS/UAC
2/25/1993	Pinecrest, Emigration Canyon	1	–	Backcountry skier	NWS/UAC
4/3/1993	Wolverine Cirque	1	–	Backcountry skier	NWS/UAC
2/18/1994	10,420' Peak, BCC	1	–	Backcountry skier	NWS/UAC
11/7/1994	Snowbird	1	–	Backcountry skier, pre-season	NWS/UAC
1/14/1995	Ben Lomond Peak	2	–	Snowmobilers	NWS/UAC
1/23/1995	Midway	–	1	Resident in roof slide.	NWS/UAC
2/12/1995	Gobblers Knob, BCC	1	–	Backcountry skier	NWS/UAC
2/2/1996	Solitude	1	–	Patroller	NWS/UAC
3/27/1996	Maybird Gulch, LCC	1	–	Backcountry skier	NWS/UAC
12/7/1996	Bountiful Peak	1	–	Snowmobiler	NWS/UAC
12/26/1996	Flagstaff Peak	1	–	Snowmobiler	NWS/UAC

Table 5. Continued

Date	Location ¹	Fatalities		Notes	References ²
		Sports	Other		
1/11/1997	Logan Peak	3	–	Campers	NWS/UAC
1/25/1997	Provo Canyon	1	–	Climber	NWS/UAC
1/17/1998	Near Coalville	1	–	Snowmobiler	NWS/UAC
1/18/1998	Sanpete County	1	–	Snowmobiler	NWS/UAC
2/26/1998	Near Weber State	1	–	Hiker (possible suicide)	NWS/UAC
11/7/1998	Snowbird	1	–	Snowboarder, pre-season	NWS/UAC
1/2/1999	Wasatch Plateau	2	–	Snowboarders	NWS/UAC
1/29/1999	Mt. Nebo	1	–	Snowmobiler	NWS/UAC
2/6/1999	Little Willow Canyon	1	–	Hiker	NWS/UAC
1/11/2000	Squaretop, Canyons	2	–	Out-of-bounds skiers	NWS/UAC
2/27/2001	Near Canyons	1	–	Out-of-bounds skier	NWS/UAC
3/10/2001	Oakley, Uinta Mountains	2	–	Snowmobilers	NWS/UAC
4/28/2001	Stairs Gulch, BCC	2	–	Climbers	NWS/UAC
12/14/2001	Willard Basin	1	–	Snowmobiler	NWS/UAC
1/31/2002	Windy Ridge, Uinta Mountains	1	–	Backcountry skier	NWS/UAC
3/16/2002	Pioneer Ridge, Brighton	2	–	Out-of-bounds snowboarders	NWS/UAC
2/15/2003	Gobblers Knob, BCC	1	–	Backcountry skier	NWS/UAC
12/26/2003	Aspen Grove, Timpanogos	3	–	Backcountry snowboarders	NWS/UAC
2/26/2004	Empire Canyon, Park City	1	–	Snowshoer	NWS/UAC
12/10/2004	Twin Lakes Pass, SLC	1	–	Backcountry skier	NWS/UAC
12/11/2004	Trout Creek, Strawberry	1	–	Snowmobiler	NWS/UAC
	Mineral Fork, SLC	2	–	Snowshoers	NWS/UAC
1/8/2005	Choke Cherry, Mt. Pleasant	1	–	Snowmobiler	NWS/UAC
	Ephraim Canyon	1	–	Snowboarder	NWS/UAC
1/14/2005	Dutch Draw, Park City	1	–	Snowboarder	NWS/UAC
3/31/2005	Whiskey Hill	1	–	Snowboarder	NWS/UAC
12/31/2005	Emerald Lake, Timpanogos	1	–	Snowshoer	NWS/UAC
3/11/2006	Taylor Canyon, Ogden	1	–	Snowboarder	NWS/UAC
4/3/2006	Pioneer Ridge, Brighton	1	–	Out-of-bounds snowboarder	NWS/UAC
2/17/2007	Signal Peak	1	–	Snowmobiler	NWS/UAC
	Tower Mountain	1	–	Snowmobiler	NWS/UAC
2/18/2007	Hells Canyon, Snowbasin	1	–	Out-of-bounds skier	NWS/UAC
2/21/2007	Gobblers Knob, BCC	1	–	Backcountry skier	NWS/UAC
12/23/2007	Canyons	1	–	Skier	NWS/UAC
12/25/2007	Thousand Peaks	1	–	Snowmobiler	NWS/UAC
12/31/2007	Co-op Creek	1	–	Snowmobiler	NWS/UAC
12/14/2008	Mt. Baldy, Snowbird	1	–	In-bounds skier	NWS/UAC
12/24/2008	Providence Canyon	2	–	Snowmobilers	NWS/UAC
12/29/2008	Windy Ridge-Moffit Basin	1	–	Snowmobiler	NWS/UAC
1/24/2010	Hells Canyon, Snowbasin	1	–	Out-of-bounds skier	NWS/UAC
1/27/2010	Silver Fork, BCC	1	–	Out-of-bounds skier	NWS/UAC
1/29/2010	Grandview Peak	1	–	Snowmobiler	NWS/UAC
4/4/2010	Francis Peak	1	–	Snowmobiler	NWS/UAC
3/26/2011	Big Horseshoe Bowl	1	–	Backcountry skier	NWS/UAC
11/13/2011	Gad Valley, Snowbird	1	–	Skier, pre-season	NWS/UAC

Table 5. Continued

Date	Location ¹	Fatalities		Notes	References ²
		Sports	Other		
1/28/2012	Kesler Ridge	1	–	Backcountry snowboarder	NWS/UAC
2/5/2012	Fish Lake	1	–	Snowmobiler	NWS/UAC
2/23/2012	Dutch Canyon, Canyons	1	–	Out-of-bounds snowboarder	NWS/UAC
3/3/2012	Beaver Basin	1	–	Snowmobiler	NWS/UAC
2/8/2014	Tibble Fork Reservoir	1	–	Snowshoer	NWS/UAC
2/9/2014	Huntington Reservoir	1	–	Snowmobiler	NWS/UAC
3/7/2014	Whitney Reservoir	1	–	Snowmobiler	NWS/UAC
1/21/2015	Gobblers Knob	1	–	Backcountry skier	http://www.sltrib.com/news/3446097-155/1-person-rescued-from-utah-avalanche
1/31/2016	Shale Shot, Summit County	1	–	Backcountry skier	http://www.ksl.com/?sid=38367916
1/18/2019	Electric Lake	1	–	Skier	NWS/UAC
1/25/2019	East Face of Laurel Peak	1	–	Snowmobiler	NWS/UAC
2/7/2019	Circleville Mountain	1	–	Snowmobiler	NWS/UAC
2/9/2019	Chalk Creek	1	–	Snowmobiler	NWS/UAC
2/15/2019	Near Canyon Village, Summit County	1	–	Backcountry snowboarder	https://www.ksl.com/article/46691198
Totals:		113	192		
		305			

¹ BCC (Big Cottonwood Canyon), LCC (Little Cottonwood Canyon), SLC (Salt Lake City).

² Brough (Brough and others, 1987), Deseret News (1986); NWS (National Weather Service, Salt Lake City Weather Forecast Office, 2015a), O'Malley (2017), UAC (Utah Avalanche Center, 2015).

³ Most of these fatalities occurred in the early mining days of Utah.

⁴ Brough and others (1987) indicate 36 fatalities.

Table 6. Utah earthquake fatalities since 1847, based on newspaper, report, and scientific descriptions of events.

Date	Location	Fatalities	Notes	References ¹
3/12/1934	Hansel Valley fault zone (M6.6)	2	Trench collapse (1) and death of sick woman (1)	UOSS
Total:		2		

¹ UOSS (University of Utah Seismograph Stations).

fatalities in Utah since 1847 (table 8). The failure of Quail Creek dam on December 31, 1988, resulted in approximately \$12 million in damage and cost \$8 million to rebuild (UDEM, 2014). Most Utah dam and canal failures have resulted from piping, erosion, and other soil or rock problems.

Problem Soil and Rock Hazards

Problem soils, such as expansive, compressible, and/or collapsible soils, can cause extensive damage to structures and foundations. Problem soils may also damage pavements after construction, resulting in high maintenance and/or replacement costs, along with increased legal and financial liability from pavement separation and/or gaps causing tripping hazards. In addition, future maintenance may disrupt business

activities, resulting in increased costs and/or lost revenue. While no deaths have been reported in Utah from problem soil hazards, they have caused an undetermined, but very significant, amount of infrastructure damage and resulting economic impact.

Land Subsidence and Earth Fissures

Land subsidence and earth fissures due to groundwater mining have caused significant damage in Utah, including in the Escalante (Lund and others, 2005), Cedar (Kaiser, 1978; Knudsen and others, 2014), and Parowan (DuRoss and Kirby, 2004) Valleys. While damage cost estimates for Utah are not available, between 1990 and 2000, the federal government and the State of Nevada spent over \$7.5 million to move residents

Table 7. Utah flood fatalities since 1847, based on newspaper, report, and scientific descriptions of events.

Date	Location	Fatalities ¹	Notes	References ²
7/17/1863	Pine Creek, Iron County	4	Cloudbursts flood Pine Creek to a level of 20 feet.	NWS
7/23/1878	Skull Valley	2	A cloudburst at Johnson's settlement.	NWS
8/16/1889	Wood Canyon, Mayfield	1	Flash flood	NWS
7/14/1896	Eureka	3	Torrential rain flooded town.	NWS, Brough
7/28/1896	Eureka	4	Raging torrent down Main Street.	NWS
8/22/1896	Clear Creek Canyon, Joseph	1	Wagonload of laborers caught in a flooded stream.	NWS
10/7/1896	Mill Creek, Moab	1	Man drowned attempting to cross.	NWS
10/16/1889	Mayfield	1	Boy drowned in flash flood.	Brough
8/4/1900	Orangeville	1	Creek flooded by heavy rain.	NWS
8/4/1901	Coyote (La Sal)	1	Girl drowned in flood.	Brough
8/5/1901	Gorge 15 miles below Escalante	1	Boy drowned swimming when freshet came down gully.	NWS
8/6/1901	Winter Quarters, Scofield	2	—	NWS
8/10/1903	Dry Creek, Toquerville	1	Man trapped in flash flood.	NWS
9/1/1909	Ashley River, Vernal ³	1	Man drowned in flash flood while driving a wagon across.	NWS
6/19/1918	Pleasant Creek, Mount Pleasant	1	Intense cloudburst causing extensive flooding.	NWS
8/2/1922	Magna	1	Boy drowned in flood.	NWS
8/13/1923	Willard	2	Fatalities in home damaged by flood.	Brough
7/4/1925	Five Mile Creek, Vernal	1	Child drowned when swept from automobile by a flood.	NWS
8/16/1928	Nine Mile Canyon, Price	1	Man drowned from heavy flooding that covered his automobile.	NWS
8/13/1930	Mona	1	Mud on highway, boy killed.	Brough
8/1931	Cisco	1	Woman swept to death.	Brough
7/21/1934	Lost Creek, Salina	1	Boy drowned in a sudden flood.	NWS
7/29/1936	Ferron	1	Woman drowned in cloudburst flood down a dry wash.	NWS
7/30/1936	Minersville	1	Cloudburst flood.	NWS
7/29/1937	Price	1	Flood rolled boulders into a home.	Brough
8/31/1939	Diamond Creek, Book Cliffs	1	Woman swept to death by flood waters.	NWS
8/5/1948	Sunnyside	1	Body in debris after flash flood.	NWS
8/26/1952	Buckhorn Wash Proving Ground, Castle Dale	1	Man drowned in tunnel when cloudburst flooded the tunnel.	NWS
9/17/1961	Virgin River Narrows, Zion NP	5	Party of 26 caught in flash flood, 14 foot flood crest in some locations.	NWS
	Wahweap Creek, Glen Canyon City	1	Girl drowned in flash flood.	NWS
9/5/1970	Four Corners area	2	Drove car off washed-out bridge.	NWS
2/18/1980	Kolob Creek, Virgin	1	Car driving across creek carried down stream, drowning.	NWS
2/18/1986	Box Elder County	1	Boy drowned in rain-swollen canal.	NWS
9/14/1996	White Canyon, Blanding	1	Hiking party of 13 caught in flash flood.	NWS
7/27/1998	Virgin River Narrows, Zion NP	2	Flash flood.	NWS
9/5/1998	Ice Cream Canyon, Glen Canyon NRA	1	Girl swept away from flash flood, canyon wall gave away.	NWS
5/13/2001	Washington County	1	Boy swept off cliff by flash flood.	NWS

Table 7. Continued

Date	Location	Fatalities ¹	Notes	References ²
1/10/2005	Red Cliff Recreation Area	1	Party of 2 caught in dry wash flood in their vehicle	NWS
7/30/2006	Garleys Wash, Carbon County	2	Family offroading vehicle was hit with flash flood	NWS
9/10/2008	Slot Canyon in Garfield County	2	Party of 8 caught in slot canyon flash flood.	NWS
10/1/2012	La Verkin Creek, Washington County	1	Girl playing in backyard swept away by flash flood	NWS
9/27/2014	Virgin River Narrows, Zion NP	1	Man killed from flash flood	NWS
9/14/2015	Keyhole Canyon, Zion NP	7	Hiking party of 7 caught in flash flood	UGS files, https://www.ksl.com/article/36545005
	Short Creek, Hildale	13	Sixteen individuals in two vehicles caught in flash flood	UGS files, https://www.ksl.com/article/36545005
Total:		81		

¹ Not including vehicular fatalities (crashes, skidding, etc.) caused by flooding.

² Brough (Brough and others, 1987), NWS (National Weather Service, Salt Lake City Weather Forecast Office, 2015b), UGS (Utah Geological Survey).

³ Brough and others (1987) indicates fatalities occurring near Myton.

Table 8. Utah dam and water conveyance structure failure fatalities since 1847, based on newspaper, report, and scientific descriptions of events.

Date	Location	Fatalities	Notes	References ¹
5/16/1963	Little Deer Creek Dam, Uinta Mountains	1	Dam failure, four year old boy died	UDEM
6/24/1983	DMAD Dam, Delta	1	Dam failure, man drowned from flash flood	NWS, UDEM
7/11/2009	Logan Bluffs, Logan	3	Canal/landslide failure, home destroyed with three occupants ²	UGS, Survey Notes, 2009, v. 41, no. 3, p. 10
Total:		5		

¹ NWS (National Weather Service, Salt Lake City Weather Forecast Office, 2015b), UDEM (Utah Division of Emergency Management, 2014), UGS (Utah Geological Survey).

² It is unknown if a landslide initially caused the canal failure or if the canal failure caused the landslide; therefore, the three fatalities are included in both the "Landslides" and "Dam and Water Conveyance Structure Failure" categories.

Table 9. Utah radon gas fatalities since 1973.

Date	Fatalities ¹	References
1973–2001	1460 ²	UEPH
2002–2011	3816 ³	UEPH
2012	98 ^{2,3}	UEPH
2013	87 ^{2,3}	UEPH
2014	87 ^{2,3}	UEPH
2015	90 ^{2,3}	UEPH
2016	91 ^{2,3}	UEPH
Total:	5729	

¹ Limited data are available and contain various assumptions; exact number of fatalities is unknown.

² Based on general World Health Organization estimate that 14% of lung cancer cases are attributable to radon gas.

³ UEPH (Utah Environmental Public Health Tracking Network, 2018).

from and demolish the Windsor Park Subdivision in North Las Vegas due to earth fissures from groundwater withdrawal in the Las Vegas Valley (Harris, 2001).

Radon Gas

Between 1973 and 2016, there were approximately 5729 fatalities in Utah attributable to lung cancer caused by radon gas, having an estimated total first-year treatment cost of \$2.7 to \$3.6 million (based on World Health Organization general estimate that 14% of lung cancer cases are attributable to radon gas [Sasha Zaharoff, Utah Department of Health, written communication, 2015], data from <http://epht.health.utah.gov/epht-view/query/result/ucr/UCRCntyICDO2/Count.html>, and Utah Environmental Public Health Tracking Network, 2015). Thousands of fatalities before 1973 from radon gas are likely. To date, lung cancer fatalities caused by radon gas are Utah's most deadly geologic hazard. Geologic conditions directly affect indoor radon gas concentrations; however, indoor radon gas concentrations are highly dependent on building construction methods; see chapter 2, section on International Building/Residential Code and Local Requirements for more information.

UGS GEOLOGIC-HAZARD GUIDELINES BACKGROUND

Recognizing Utah's susceptibility to geologic hazards, as evidenced by damage to infrastructure and injury or death to Utah citizens, the UGS began developing and/or collaborating on guidelines starting in the 1980s and continuing into the 2000s for (1) conducting engineering-geology investigations and preparing engineering-geology reports, (2) evaluating landslide, surface-fault-rupture, and debris-flow hazards, and (3) developing geologic-hazard ordinances. Full citations for those documents are presented below; this publication updates and supersedes these guidelines:

- Engineering Geology Reports – Association of Engineering Geologists (Utah Section), 1986, Guidelines for preparing engineering geologic reports in Utah: Utah Geological and Mineral Survey Miscellaneous Publication M, 2 p.
- Geologic Hazard Ordinances – Christenson, G.E., 1987, Suggested approach to geologic hazards ordinances in Utah: Utah Geological and Mineral Survey Circular 79, 16 p.
- Landslides – Hylland, M.D., 1996, Guidelines for evaluating landslide hazards in Utah: Utah Geological Survey Circular 92, 16 p.
- Surface Fault Rupture – Christenson, G.E., Batatian, L.D., and Nelson, C.V., 2003, Guidelines for evaluating surface-fault-rupture hazards in Utah: Utah Geological Survey Miscellaneous Publication 03-6, 14 p.

- Debris Flows – Giraud, R.E., 2005, Guidelines for the geologic evaluation of debris-flow hazards on alluvial fans in Utah: Utah Geological Survey Miscellaneous Publication 05-6, 16 p.
- Utah School-Site Reports – Bowman, S.D., Giraud, R.E., and Lund, W.R., 2012, Utah State Office of Education—geologic-hazard report guidelines and review checklist for new Utah public school buildings: Utah Geological Survey: Online, http://geology.utah.gov/ghp/school-site_review/pdf/ssr_checklist.pdf.

CURRENT UGS GEOLOGIC-HAZARD GUIDELINES

This publication provides revised and updated guidelines for conducting engineering-geology investigations and preparing engineering-geology reports (chapter 2); for investigating surface-fault-rupture (chapter 3), landslide (chapter 4), and debris-flow (chapter 5) hazards; for implementing geologic-hazard ordinances (chapter 9); and for preparing and reviewing engineering-geology reports for school sites (chapter 10). Additionally, the UGS has prepared new investigation guidelines for evaluating land-subsidence and earth-fissure hazards (chapter 6), rockfall hazards (chapter 7), and radon gas (chapter 8). All of the current guidelines are now combined into one publication to reduce duplication of topics, form a more complete reference, and facilitate easier updates and additions to the guidelines in the future.

These guidelines represent the recommended minimum acceptable level of effort for conducting geologic-hazard investigations and preparing engineering-geology reports in Utah. These guidelines identify important issues and general methods for investigating geologic hazards; they do not discuss all methods and are not a step-by-step primer for hazard investigations. The level of detail appropriate for a particular investigation depends on several factors, including the type, nature, and location of proposed development; the geology and physical characteristics of the site; and the level of risk acceptable to property owners, users, and land-use regulators.

The state-of-practice of geologic-hazard investigations continues to evolve as new or improved techniques become available and are incorporated into hazard investigations. The methods outlined in these guidelines are considered to be practical and reasonable methods for obtaining planning, design, and risk-reduction information, but these methods may not apply in all cases. The Engineering Geologist in charge of a geologic-hazard investigation is responsible for understanding the appropriateness of the various methods and where they apply.

As the UGS revises existing or develops new geologic-hazard guidelines, this publication will be updated as appropriate. Us-

ers should refer to the UGS web page for the most current information and guidelines: <https://geology.utah.gov/hazards/assistance/consultants/>.

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CHAPTER 2

GUIDELINES FOR CONDUCTING ENGINEERING- GEOLOGY INVESTIGATIONS AND PREPARING ENGINEERING-GEOLOGY REPORTS IN UTAH

by

Steve D. Bowman, Ph.D., P.E., P.G., and William R. Lund, P.G.



Excavation of a test pit for a geotechnical investigation in Utah.

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CHAPTER 2: GUIDELINES FOR CONDUCTING ENGINEERING-GEOLOGY INVESTIGATIONS AND PREPARING ENGINEERING-GEOLOGY REPORTS IN UTAH

by Steve D. Bowman, Ph.D., P.E., P.G., and William R. Lund, P.G.

INTRODUCTION

The Utah Geological Survey (UGS) recommends that for all development subject to local permitting, a comprehensive engineering-geology investigation be performed to ensure that site geologic conditions are adequately characterized and accommodated in project design, and that the project is protected from geologic hazards. Investigation results should be presented in an engineering-geology report, which depending on project type and scope, may be a stand-alone document, or if conducted concurrently with a geotechnical-engineering investigation, may be part of a more comprehensive geotechnical report. In many, if not most, instances, engineering-geology investigations focus on geologic hazards, and the investigations and subsequent reports are often termed “geologic-hazard” investigations and reports. Engineering-geology investigations provide valuable information on site geologic conditions and the nature of geologic hazards present, and provide recommendations for accommodating geologic conditions in project design and for solutions to mitigate geologic hazards, both at the time of construction and over the life of the development.

Chapter 1 of this publication identifies the numerous geologic hazards in Utah that may affect present and future development. Engineering-geology investigations should be comprehensive and address all geologic hazards at a site. As the UGS continues to develop guidance for investigating other geologic hazards, those guidelines will be available on the UGS website (see chapter 1), and this publication will be periodically updated. The UGS website contains links to other guidance documents for investigating geologic hazards not currently covered by UGS guidelines; those guidance documents should be consulted as necessary by geologists conducting geologic-hazard investigations (<https://geology.utah.gov/hazards/assistance/consultants/useful-websites/>).

The UGS Geologic Hazards Program developed these engineering-geology investigation and report preparation guidelines based on current engineering-geology state-of-practice, and previous guidelines prepared by the Utah Section of the Association of Engineering Geologists (1986; see chapter 1) published by the UGS. The 1986 guidelines were based on a series of guidelines developed in California since 1973, by

the California Division of Mines and Geology (CDMG, now California Geological Survey) (CDMG, 1973, 1975a, 1975b, 1975c, 2011a; Slosson, 1984). Those guidelines were subsequently updated and modified by the California Board for Geologists and Geophysicists (CBGG, now California Board for Professional Engineers, Land Surveyors, and Geologists) (CBGG, 1998a, 1998b, 1998c, 1998d).

ENGINEERING-GEOLOGY INVESTIGATIONS

The engineering-geology investigation required for a development depends on site geologic conditions, geologic hazards present, and the nature of the proposed development (structure type, size, placement, and occupancy; required cuts, fills, and other grading; groundwater conditions; and the specific purpose and use of the development). An engineering-geology investigation must address all pertinent geologic conditions that could affect, or be affected by, the proposed development. This can only be accomplished through proper identification and interpretation of site-specific geologic conditions and processes, and nearby features that may affect the site and/or development.

The scope of investigation and specific investigation methods will vary depending on project requirements and the regulatory agency that reviews and approves the project. However, the UGS considers these engineering-geology investigation guidelines and the geologic-hazard investigation guidelines in later chapters to represent the minimum acceptable level of effort in conducting engineering-geology/geologic-hazard investigations in Utah. Additionally, while withdrawn, ASTM International (ASTM) Standard D420 *Standard Guide to Site Characterization for Engineering Design and Construction Purposes* (ASTM, 2003) contains valuable information about performing geotechnical investigations. If soil and/or rock testing is part of the investigation, the organization performing the testing should meet the requirements of ASTM Standard D3740 *Standard Practice for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction* (ASTM, 2012a) and the Laboratory Testing section below. These standards are not meant to be inflexible descriptions of requirements and do not address all concerns.

When Geologic-Hazard Special Study Maps Are Not Available

Where geologic-hazard special study maps are not available, the first step in a geologic-hazard investigation is to determine if the site is near mapped or otherwise known geologic hazards. If so, larger scale maps (if available) should be examined, aerial photograph and other remote sensing imagery interpreted, and a field investigation performed to produce a detailed geologic map (see below) to determine if a geologic hazard(s) is present that will affect the site. If evidence for a hazard(s) is found, the UGS recommends that a site investigation be performed in accordance with the guidelines presented in this chapter and chapters 3 through 7 as applicable.

International Building/Residential Code and Local Requirements

The 2018 International Building and Residential Codes (IBC/IRC; International Code Council, 2017a, 2017b), adopted statewide in Utah after July 1, 2019 (Title 15A, <https://le.utah.gov/xcode/Title15A/15A.html>), specify requirements for geotechnical investigations that also include evaluation of some geologic hazards. Local governments (Utah cities, counties, and special service districts) may also adopt ordinances related to geologic hazards that must be followed for development projects. These ordinances may include hillside development regulations. Existing ordinances vary significantly throughout the state, and it is the responsibility of the investigator to know the requirements and ordinances that apply to a site. A comprehensive geologic-hazard investigation will almost always exceed IBC/IRC and local minimum requirements.

Whereas the 2018 IBC Section 1803.2 allows the building official to “waive the requirement for a geotechnical investigation where satisfactory data is available that demonstrates an investigation is not necessary...,” the UGS strongly recommends against this practice due to the often variable subsurface conditions present in Utah.

The 2018 IBC/IRC specify seismic provisions for earthquake hazards. Section 1613.1 of the IBC states, “Every structure, and portion thereof...shall be designed and constructed to resist the effects of earthquake motions...” and Section R301.1 of the IRC states, “Buildings and structures, and all parts thereof, shall be constructed to safely support all loads, including...seismic loads as prescribed by this code.” Both the IBC and IRC assign structures, with some exceptions, to a Seismic Design Category (IBC Section 1613.2.5 and IRC Section R301.2.2.1). Engineering-geology and geotechnical investigations are often needed to properly determine the seismic design parameters required to implement the code requirements. Seismic provisions of the IBC and IRC are intended to minimize injury and loss of life by ensuring the structural integrity of a building, but do not ensure that a structure or its contents will not be damaged during an earthquake.

Specifically, the 2018 IBC (Section 1803.5.11) requires an investigation for all structures in Seismic Design Categories C, D, E, or F to include an evaluation of slope instability, liquefaction, differential settlement, and surface displacement due to faulting or lateral spreading. Although the 2018 IRC does not specifically mention liquefaction and other seismic hazards, IRC Section R401.4 leaves the need for soil tests up to the local building official in areas likely to have expansive, compressive, shifting, or other questionable soil characteristics; however, investigators conducting engineering-geology or geotechnical investigations should always provide an evaluation of these hazards, and if present, provide recommendations to mitigate the hazard and/or risk.

For flooding, the 2018 IBC (Section 1612.1) and IRC (Section R301.1) state that construction of new buildings and structures and additions to existing buildings and structures must be designed and constructed to resist the effects of flood hazards and flood loads. These requirements apply to construction in flood-hazard areas (Zone A and other zones identified by the local jurisdiction) identified on Flood Insurance Rate Maps by the Federal Emergency Management Agency. IBC Appendix G provides important information on flood-resistant construction.

The 2018 IBC/IRC addresses issues related to problem soil and rock in Chapter 18, Soils and Foundations, and Chapter 4, Foundations, respectively. IBC Section 1803.5.3 and IRC Section R401.4 contain requirements for soil investigations in areas where expansive soil may be present.

For shallow groundwater, the 2018 IBC Section 1805 and IRC Section R406 contain dampproofing and waterproofing requirements for structures built in wet areas. IBC Section 1803.5.4 contains requirements for soil investigations in areas of shallow groundwater.

The 2018 IBC does not address radon hazards; however, investigators should always evaluate radon potential, and if present, provide recommendations to mitigate the risk from radon exposure. Appendix F, Radon Control Methods of the 2018 IRC and ASTM Standard E1465-08a *Standard Practice for Radon Control Options for the Design and Construction of New Low-Rise Residential Buildings* (ASTM, 2009), though while withdrawn, since not updated within eight years, describe radon-resistant construction techniques. The adoption of 2018 IRC appendix F and implementation of its construction techniques is at the discretion of local jurisdictions, but radon hazard should be evaluated during a comprehensive engineering-geology investigation regardless.

For tsunami-generated flood hazards, the 2018 IBC appendix M contains brief tsunami regulatory criteria. No tsunami hazard maps have been developed for Utah (Great Salt Lake or Utah Lake, where sub-lacustrine faults exist). The adoption of 2018 IBC appendix M is at the discretion of local jurisdictions, but tsunami hazard should be evaluated during a comprehensive engineering-geology investigation regardless for areas near Great Salt Lake, Utah Lake, and Bear Lake. The potential for

ground-shaking-related seiche waves on these lakes should also be evaluated as appropriate.

Investigator Qualifications

Engineering-geology investigations and accompanying geologic-hazard evaluations often are interdisciplinary in nature, and in Utah, must be performed by qualified, experienced, Utah licensed Professional Geologists (PG, specializing in engineering geology) and Professional Engineers (PE, specializing in geological and/or Geotechnical Engineering) often working as a team. The Utah Division of Occupational and Professional Licensing (DOPL, <https://dopl.utah.gov/>) defines a Professional Geologist as a person licensed to engage in the practice of geology before the public, but does not define or license geologic specialists, such as Engineering Geologists. The DOPL issues Professional Geologist (<https://dopl.utah.gov/geo/index.html>) and Professional Engineer (<https://dopl.utah.gov/eng/index.html>) licenses in Utah, based on approved education and experience criteria, and also performs enforcement actions against licensees and others as necessary to protect Utah citizens and organizations.

Accordingly, engineering-geology investigations shall be performed by or under the direct supervision of a Utah licensed Professional Geologist, who must stamp and sign the final report. The evaluation of geologic hazards is a specialized area within the practice of engineering geology, requiring technical expertise and knowledge of techniques not commonly used in other geologic disciplines. In addition to meeting the qualifications for geologist licensure in Utah, minimum recommended qualifications of the Engineering Geologist in charge of a geologic-hazards investigation include five full years of experience in a responsible position directly in the field of engineering geology. This experience should include familiarity with local geology and hydrology, and knowledge of appropriate techniques for evaluating and mitigating geologic hazards.

Geologists performing engineering-geology investigations are ethically bound first and foremost to protect public safety and property, and as such must adhere to the highest ethical and professional standards in their investigations. Conclusions, drawn from information gained during the investigation, should be consistent, objective, and unbiased. Relevant information gained during an investigation may not be withheld. Differences in opinion regarding conclusions and recommendations and perceived levels of acceptable risk may arise between geologists performing investigations and regulatory-authority geologists working as reviewers for a public agency. Adherence to these minimum guidelines should reduce differences of opinion and simplify the review process.

Literature Searches and Information Resources

A thorough literature search is an important part of engineering-geology investigations and subsequent reports. The search

should be performed soon after the initiation of an investigation to collect geologic and other data to develop an appropriate investigation scope and to discover geologic conditions and other hazards that may impact a site.

Published and unpublished geologic and engineering literature, maps, and other records (such as aerial photography and other remote sensing imagery) relevant to the site and the site region's geology, geologic hazards, soils, hydrology, and land use should be reviewed as part of the engineering-geology investigation. These materials are available from a wide variety of sources (table 10), including the UGS; UGS Library (<https://geology.utah.gov/library/>); U.S. Geological Survey; U.S. Bureau of Reclamation; city, county, state, and university libraries; Natural Resources Conservation Service; Federal Emergency Management Agency; and city and county governments (typically planning and community development departments). Additional information on seismic hazards and risk is available from the Utah Seismic Safety Commission at <https://ussc.utah.gov>.

Available UGS Information

The UGS Geologic Hazards Program has a web page for consultants and design professionals (<https://geology.utah.gov/hazards/assistance/consultants/useful-websites/>). In addition to the recommended guidelines in this document, the page includes geologic-hazard reports relevant to surface-fault-rupture, landslide, debris-flow, land-subsidence and earth-fissure, and rockfall hazards in Utah; published UGS geologic-hazard maps, reports, and site-specific studies; geologic maps; hydrogeology publications; historical aerial photography; ground-water data; relevant non-UGS publications; and links to external geologic-hazard-related websites.

The UGS Geologic Hazards Program Geologic Hazards Mapping Initiative develops modern, comprehensive geologic-hazard map sets on U.S. Geological Survey (USGS) 1:24,000-scale quadrangles in urban areas of Utah (Bowman and others, 2009; Castleton and McKean, 2012) as PDFs and full GIS products. These map sets typically include 10 or more individual geologic-hazard maps (liquefaction, surface-fault rupture, flooding, landslides, rockfall, debris flow, radon, collapsible soils, expansive soil and rock, shallow bedrock, and shallow groundwater). Some quadrangles may have more maps if additional geologic hazards are identified within the mapped area. The Magna, Copperton, and Tickville spring quadrangle map sets (Castleton and others, 2011, 2014, 2018) within Salt Lake Valley have been published, with mapping continuing in Salt Lake and Utah Valleys. Similar UGS geologic-hazard map sets are available for the St. George–Hurricane metropolitan area (Lund and others, 2008), high-visitation areas in Zion National Park (Lund and others, 2010), the State Route 9 corridor between La Verkin and Springdale (Knudsen and Lund, 2013), and the Moab quadrangle (Castleton and others, 2018). Detailed surface-fault-rupture-hazard

Table 10. Potential information sources for engineering-geology investigations in Utah.

Source	Maps				Publications and Reports						Aerial Photography	Lidar
	Topographic	Geologic	Geologic Hazard	Flooding	Geology	Soils	Seismology	Geotechnical	Geologic-Hazard and Geotechnical Investigations	Hydrology and Groundwater		
Utah Geological Survey ¹	x	x	x		x		x		x	x	x	x
City or county planning and community development departments			x	x					x		x	x
City, county, and university libraries	x	x	x		x	x		x		x	x	
Federal Emergency Management Agency ²				x								
Natural Resources Conservation Service ³						x				x		
U.S. Geological Survey (USGS) ⁴	x	x	x		x		x			x		x
University of Utah Seismograph Stations ⁵							x					
USDA Aerial Photography Field Office ⁶											x	
USGS EROS Data Center ⁷											x	x
Utah Automated Geographic Reference Center ⁸	x	x		x							x	x
Utah Division of Water Rights – Dam Safety Program ⁹				x								
OpenTopography ¹⁰												x

¹ <https://geology.utah.gov/>² <https://msc.fema.gov/>³ <https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=UT>⁴ <https://www.usgs.gov/>⁵ <https://quake.utah.edu/>⁶ <https://www.fsa.usda.gov/programs-and-services/aerial-photography/>⁷ <https://eros.usgs.gov/>⁸ <https://gis.utah.gov/>⁹ <https://www.waterrights.utah.gov/daminfo/>¹⁰ <http://opentopography.org/>

maps have been published for the southern half of the Colinston segment, and the Levan and Fayette segments of the Wasatch fault zone (Harty and McKean, 2015; Hiscock and Hylland, 2015) and fault-trace mapping for the entire Wasatch fault zone is available in the *Utah Quaternary Fault and Fold Database* (<https://geology.utah.gov/apps/qfaults>). Mapping is currently underway for Cache Valley (East and West Cache fault zones and other faults), and the East and West Bear Lake, Hurricane, Oquirrh, Sevier, Topliiff Hills, and Washington fault zones. The UGS routinely partners with local governments to expedite the publication of geologic-hazard special study maps in critical areas.

The UGS GeoData Archive System (<https://geodata.geology.utah.gov>) contains unpublished Utah geology-related scanned documents, photographs (except aerial), and other digital materials from our files and from other agencies or organizations in one easy-to-use web-based system. Resources available to the public are in the public domain/record and may contain reports (such as geologic-hazard and geotechnical reports) submitted to state and local governments as part of their permit review process. Reports for nearby developments can provide valuable insight into local geologic conditions and help develop appropriate and adequate investigations. Metadata describing each resource are searchable, along with spatial

searching for resources that are local in nature. Reports within the system may be downloaded as text-searchable PDF files. Not all resources are available to all users due to end-user, copyright, and/or distribution restrictions. Users are also encouraged to search the UGS Library (<https://geology.utah.gov/library/>) for books and similar materials.

While the UGS website provides a source of much current, published information on Utah's geology and geologic hazards, it is not a complete source for all available geologic-hazard information, and investigators should search and review other relevant literature and data as necessary.

Aerial Photography

Aerial photography can provide an important historical view of a site to determine geomorphic activity, such as landslides and debris flows; document past land use and land cover; and provide a means to map in urbanized areas with significant to complete contemporary land-surface disturbance (as shown in Bowman, 2008). In Utah, the earliest known aerial photography dates from 1935, covering the Navajo Indian Reservation. The earliest known aerial photography along the Wasatch Front dates from 1936, and much subsequent aerial photography was acquired by the U.S. Department of Agriculture

(USDA) Agricultural Adjustment Administration (now the Farm Service Agency) for use in national programs in conservation, land-use planning, and ensuring compliance with farm output (Monmonier, 2002). An extensive collection of public-domain aerial photography of Utah is available from the UGS (as of June 2020, over 96,000 images are available at <https://geology.utah.gov/map-pub/data-databases/aerial-imagery/>, and described in Bowman, 2012) and the USDA Aerial Photography Field Office (<https://www.fsa.usda.gov/index>) in Salt Lake City, Utah. Avery and Berlin (1992) discuss the acquisition, analysis, and interpretation of aerial photography in detail.

Low-sun-angle aerial photography, pioneered by Slemmons (1969), can be a valuable tool to identify geomorphic features related to geologic hazards, including fault scarps, earth fissures, landslide scarps, and other features. The UGS recently published two compilations of low-sun-angle aerial photography obtained by others in the 1970s and 1980s—one along the Wasatch fault zone and East and West Cache fault zones in northern Utah and southern Idaho (Bowman and others, 2015b), and the other along the Hurricane and Washington fault zones in southern Utah (Bowman and others, 2011).

Lidar Elevation Data

Light detection and ranging (lidar) is a technique of transmitting laser pulses and measuring the reflected returns to measure the distance to an object or surface. Lidar is commonly used to determine ground surface elevations to create highly accurate, bare-earth digital elevation models of the ground surface where the effects of vegetation have been removed. A lidar instrument can send pulses at a rapid rate, making a high point-spacing density (for example, several returns per square meter) possible, much denser than would be possible by traditional surveying methods. Lidar can measure the ground surface with accuracies of a few inches horizontally and a few tenths of an inch vertically (Carter and others, 2001). Landslides, fault scarps, and other features that are difficult to detect visually because of vegetation, access, or other issues, are often clearly visible in lidar data (figures 5 and 6). First developed in the 1960s with early laser components (Miller, 1965; Shepherd, 1965), lidar has evolved from simple electronic distance measurement systems used in surveying (Shan and Toth, 2009) into a sophisticated surface mapping technique on multiple platforms including airplanes, helicopters, ground vehicles, stationary tripods, etc.

Since 2011, the State of Utah, including the UGS, has collected over 44,898 square miles of 0.5-meter or 1-meter (ground cell size) lidar elevation data across the state. These data generally include bare-earth digital elevation models (DEM), first-return digital surface models (DSM), lidar intensity images, and appropriate metadata files. The UGS data are available at <https://geology.utah.gov/resources/data-databases/lidar-elevation-data/>. Public domain lidar data in Utah are also available from

the Utah Automated Geographic Reference Center (<https://gis.utah.gov/data/elevation-and-terrain/>), OpenTopography (<https://opentopography.org/>), and may also be available from city and county governments. Additional information on lidar, including background, acquisition, processing, and analysis is presented in appendix C and in Bowman and others (2015a).

Excavation Safety

Excavation safety is of utmost importance when digging test pits and trenches, and performing other subsurface exploration. Two workers are killed every month in the United States from trench collapses (Occupational Safety and Health Administration [OSHA], 2011). Proper excavation methods, including following allowable minimum trench widths and maximum vertical slope heights, are necessary for all excavations. Excavations are regulated under federal code (29 CFR 1926 Subpart P – Excavations; <https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926SubpartP>). More information on excavation safety is available online from OSHA (<https://www.osha.gov/SLTC/trenchingexcavation/index.html>) and the State of Utah Labor Commission (<https://laborcommission.utah.gov/divisions/uosh/uosh-resources/>).

Site Characterization

The Utah Department of Transportation (2011), Federal Highway Administration (2003), National Highway Institute (2002), U.S. Department of Defense (2004), U.S. Bureau of Reclamation (1998a, 1998b, 2001), and the guidelines contained in this publication provide information regarding site characterization methods and techniques.

As part of site characterization, an adequate number, spacing, and location of subsurface exploration and subsequent laboratory testing are necessary, and will depend upon the specific project and local ordinances and requirements. Table 11 contains recommended minimum spacing and depth of subsurface exploration for a variety of constructed features. Often, engineering-geology investigations will require additional subsurface exploration (including increased depths) due to complex structural configurations; complex and/or variable geologic conditions; complex or large structural, seismic, or other loading; and other conditions. It is imperative that subsurface exploration extends to sufficient depths to adequately characterize geologic conditions and provide input data to engineering analysis, design, and mitigation of geologic hazards.

Extensive professional engineering geology and geotechnical experience and judgement are required to design an appropriate engineering-geologic site investigation. Reliance on input values from other projects, published general ranges or values, and data not directly acquired from the site should not be used for final reports and design. Review and

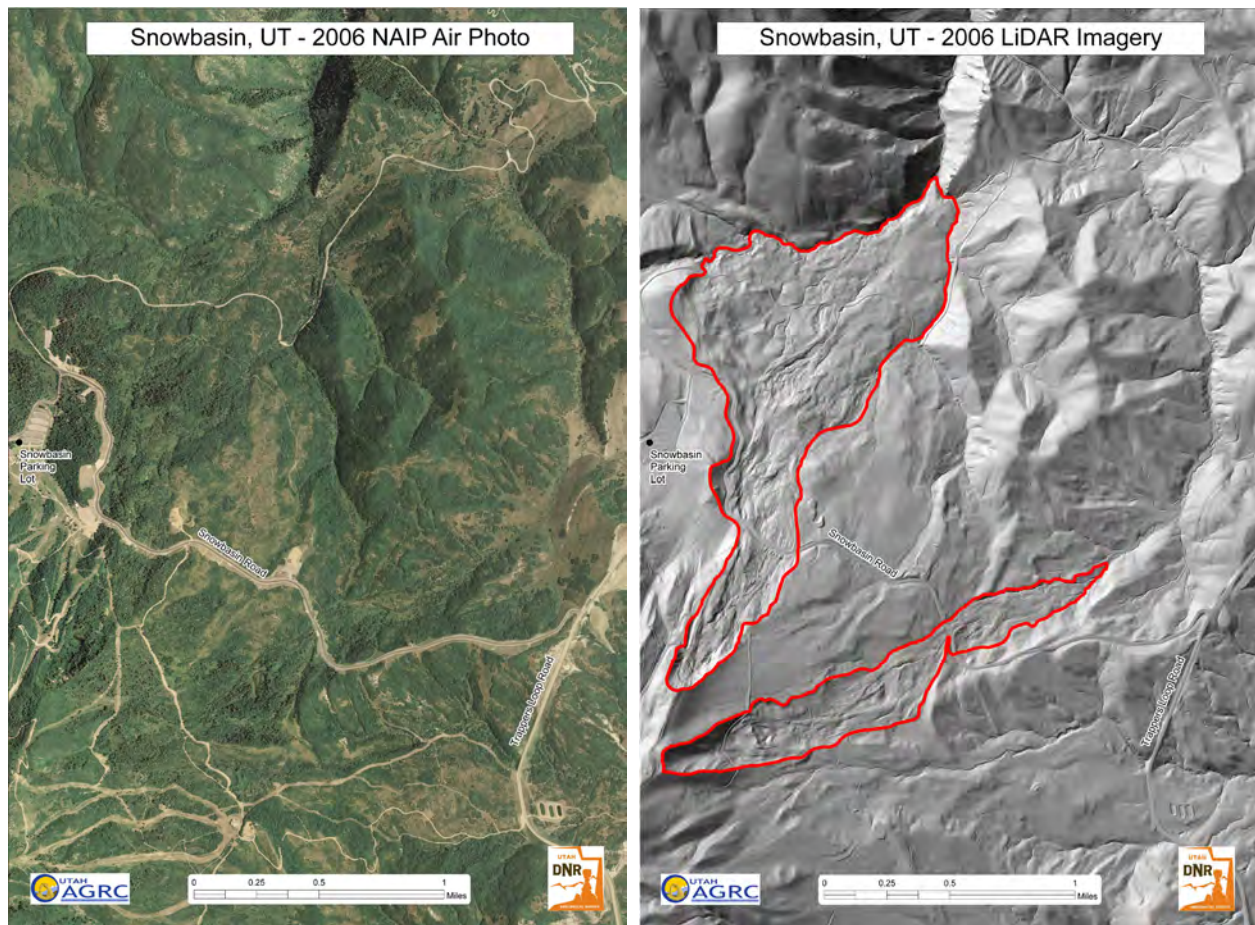


Figure 5. Comparison of 2006 National Agriculture Imagery Program (NAIP) 1-meter color orthophoto imagery (left) and 2006 2-meter airborne LiDAR imagery (right) in the Snowbasin area, Weber County, Utah. Red lines outline the Green Pond and Bear Wallow landslides that are clearly visible in the lidar imagery, but barely visible to undetectable in the NAIP imagery. Data from the Utah Automated Geographic Reference Center (2006a, 2006b).

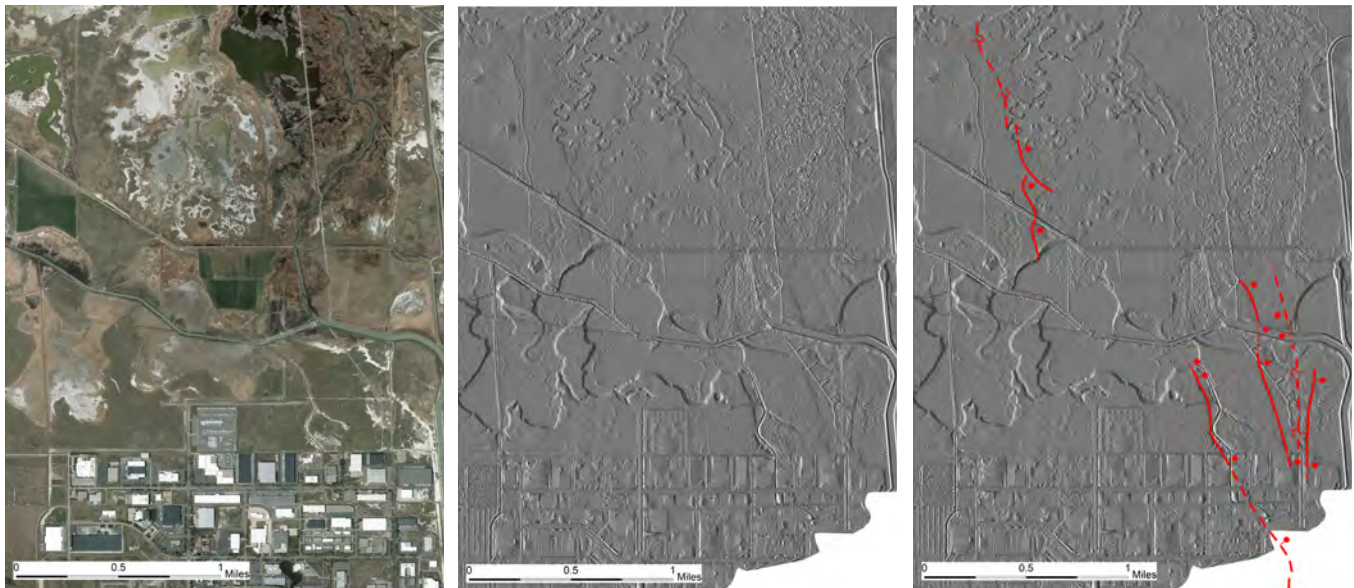


Figure 6. Comparison of 2009 High-Resolution Orthophotography (HRO) 1-foot color imagery (left) and 2011 1-meter airborne lidar imagery (middle and right) in the International Center area, Salt Lake City, Utah. Fault scarps indicated by red lines show traces of the Granger fault, West Valley fault zone, that are clearly visible in the lidar imagery, but barely visible to undetectable in the HRO imagery. Salt Lake International Airport visible to the right on each image. Data from Utah Automated Geographic Reference Center (2009, 2011).

Table 11. Recommended minimum subsurface exploration frequency and depth for constructed features (modified from Utah Department of Transportation, 2011, 2014; American Association of State Highway and Transportation Officials, 2014).

Constructed Feature ¹		Frequency and Location ²	Minimum Depth ²
Pavements	Roadway Pavements	200 to 1000 feet	≥10 feet below pavement bottom elevation
Slopes	Cut Slopes	Every 200 to 600 feet, minimum of one for every cut ≥15 feet in depth	≥15 feet below base of cut and into competent soil or rock
	Embankments	Every 200 to 600 feet	≥2x embankment height
Structures	Buried Structures	One or more at each location	≥15 feet below foundation bottom elevation
	Shallow Foundations	Maximum 70 foot spacing	≥10 feet below foundation bottom or fully penetrating unsuitable soils, whichever is deeper
	Retaining Walls	100 to 200 feet with locations alternating in front of and behind the wall; for anchored walls, additional locations in the anchorage zone; and for soil-nail walls, additional locations behind at a distance 1–1.5x the height of the wall, all 100 to 200 foot spaced.	To a depth below wall bottom where stress increase is < 10 percent of existing overburden stress and between 1 to 2x the wall height, or fully penetrating unsuitable soils, whichever is deeper
	Sound and Other Freestanding Walls	Every 250 to 500 feet	≥10 feet below foundation bottom elevation

¹ See chapter 3 for surface-fault-rupture, chapter 4 for landslide, chapter 5 for debris-flow, chapter 6 for land-subsidence and earth-fissure, and chapter 7 for rockfall hazard investigation subsurface exploration recommendations.

² Additional subsurface exploration (borings, test pits, etc.) and/or increased depths will often be needed, due to complex and/or variable geology; structural, seismic, and other loads; and/or other conditions. Extensive professional engineering geology and geotechnical experience and judgement is needed.

acceptance of engineering-geology investigation proposals should strongly consider the frequency, spacing, and depth of subsurface exploration to ensure the proposed investigation will adequately characterize the site; cost should not be a significant proposal selection factor. Proposals submitted to local governments should be reviewed by the regulatory-authority Engineering Geologist as defined below in the Field Review and Report Review sections. Poorly developed engineering-geology investigations will result in inadequate input data for subsequent engineering analysis, design, and mitigation of geologic hazards; may result in cost overruns/change orders, decreased project performance, and increased maintenance costs; and may increase potential costs to local governments, and ultimately, the taxpayer.

Geologic Mapping

Site geologic mapping should be performed in sufficient detail to define the geologic conditions present at and adjacent to the site. For most purposes, published geologic maps lack the necessary detail to provide a basis for understanding site-specific geologic conditions, and new, larger scale, independent geologic mapping is required. If suitable geologic maps are available, they must be updated to reflect topographic and geologic changes that have occurred since map publication. Extending mapping into adjacent areas will likely be necessary to define geologic conditions impacting the project area. Often, geologic mapping will be more useful to the project if performed with the intent of creating an engineering-geologic map that specifically focuses on site geologic conditions and geologic hazards as they affect the proposed development.

Mapping should be performed on a suitable topographic base map at an appropriate scale and accuracy applicable to the project. The type, date, and source of the base map should be indicated on each map. Mapping for most projects should be at a scale of 1:10,000 or larger to show pertinent features with sufficient detail. In certain cases where detailed topographic base maps at scales larger than 1:24,000 (U.S. Geological Survey [USGS] 7-1/2 minute quadrangles) are not available, geologic mapping may be performed on aerial photography of suitable scale to document pertinent features. On small-scale maps, one inch commonly equals 2000 feet (1:24,000) or more, whereas on large-scale maps, one inch commonly equals 500 feet (1:6000) or less. The base map should also include locations of proposed structures, pavements, and utilities.

The geologist performing the geologic mapping and preparing the final map should pay particular attention to the nature of bedrock and surficial materials, structural features and relations, three-dimensional distribution of earth materials exposed and inferred in and adjacent to the site shown on a cross section(s), and potential geologic hazards (such as landslides, rock-fall and debris-flow deposits, springs/seeps, aligned vegetation possibly indicative of a fault, and problem soil and rock). A clear distinction should be made between observed and inferred features and relations. Doelling and Willis (1995) provide guidelines for geologic maps submitted to the UGS for publication that may also be applied to mapping for engineering-geology/geologic-hazard investigations.

Engineering-geology mapping may be performed using the Genesis-Lithology-Qualifier (GLQ) system, which promotes

communication of geologic information to non-geologists (Keaton, 1984). The GLQ system incorporates the Unified Soil Classification System (USCS; ASTM, 2017), which has been used for many years in geotechnical and civil engineering, rather than the conventional time-rock system employed on most geologic maps. An important aspect when mapping for engineering-geology purposes is to map units having distinctive engineering-geology/geologic-hazard characteristics. The USDA system of soil classification for agriculture is generally inappropriate for engineering-geology mapping and delineating geologic hazards. The Unified Rock Classification System (Williamson, 1984) provides a systematic and reproducible method of describing rock weathering, strength, discontinuities, and density in a manner directly usable by Engineering Geologists and engineers. The Geological Strength Index (GSI) provides a system to describe rock mass characteristics and estimate strength (Marinos and Hoek, 2000; Marinos and others, 2005; Hoek and others, 2013). For altered materials, Watters and Delahaut (1995) provide a system for classification that can be incorporated into overall rock classification.

Laboratory Testing

An appropriate suite of samples should be tested to determine site soil and/or rock properties that match the scope and requirements of the project. Too often soil classification testing is incomplete in that testing is performed on one sample for moisture content, another for plasticity index (PI), and perhaps a third sample for fines content (-#200 mesh percent). An accurate soil classification cannot be determined from these tests performed independently of each other. An adequate number of samples should be tested to determine the laboratory-based soil classification (PI and gradation) as a check on field-derived (visual-manual) soil classification to reduce error.

Laboratory testing of geologic samples collected as part of an engineering-geology investigation should conform to current ASTM and/or American Association of State Highway and Transportation Officials (AASHTO) standards, as appropriate to the specific project. In addition, testing laboratories should be accredited by the AASHTO Materials Reference Laboratory (AMRL, <http://www.amrl.net/AmrlSitefinity/default/aap.aspx>) and may also be validated by the U.S. Army Corps of Engineers Materials Testing Center (<https://www.erd.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/9254/Article/476661/materials-testing-center.aspx>) to ensure compliance with current laboratory testing standards and quality control procedures. Most ASTM engineering-geology-related test standards are contained in Volumes 4.08 and 4.09 (Soil and Rock).

Complete laboratory test results should be placed in an appendix with a summary of results in the report text as needed. Test results should clearly state the laboratory identification, sample identification and location, test method standard used, date of testing, equipment identification (if applicable), laboratory technician performing the test, test data, and note any irregularity or changes from the standardized test method.

Geochronology

Evaluating geologic hazards frequently requires determining the timing (age), rate, and recurrence of past (paleo) geologic-hazard events. This is particularly true for characterizing earthquake hazards, which includes the investigation of surface-fault-rupture hazard (chapter 3). However, determining the timing and rate at which other geologic hazards occur is also useful for many kinds of geologic-hazard investigations. Therefore, Engineering Geologists conducting geologic-hazard investigations in Utah should have a good working knowledge of the more useful and commonly applied geochronologic methods.

When applying geochronologic methods to geologic-hazard investigations, investigators should keep certain conventions of terminology in mind. By definition, a “date” is a specific point in time, whereas an “age” is an interval of time measured backward from the present. It is generally accepted to use the word “date” as a verb to describe the process of producing age estimates (e.g., dating organic sediments using ^{14}C). However, when used as a noun, “date” carries the implication of calendar years and a high degree of accuracy that is generally not appropriate (Colman and Pierce, 2000). Most “dates” are more accurately described as “age estimates” or “ages,” exceptions being dates derived from the historical record, and some dates derived from tree rings, glacial varves, or coral growth bands (Colman and Pierce, 2000). The North American Stratigraphic Code (NASC) (North American Commission on Stratigraphic Nomenclature, 2005) makes a distinction between ages determined by chronologic methods and intervals of time. The NASC recommends that the International System of Units (SI [metric system]) symbols ka and Ma (kilo-annum and mega-annum, or thousands and millions of years ago, respectively, measured from the present) be used for ages, and informal abbreviations such as kyr and myr be used for time intervals (e.g., 1.9 ± 0.3 ka for the age of an earthquake, but 1.9 kyr to describe the interval of elapsed time since that earthquake). Radiocarbon ages are typically reported with the abbreviation yr B.P. (years before present; by convention radiocarbon ages are measured from A.D. 1950). Because radiocarbon ages depart from true calendar ages due to variations in atmospheric production of radiocarbon, radiocarbon ages must be calibrated to account for the variation. When calendar-calibrated radiocarbon ages are reported, the designation “cal” is included (e.g., 9560 ± 450 cal yr B.P.). By convention, the abbreviations yr B.P. and cal yr B.P. are restricted to radiocarbon ages (Colman and Pierce, 2000).

Many geochronologic methods are available to Engineering Geologists conducting engineering-geology investigations. The methods typically fall into one of two general categories: well established and experimental (Noller and others, 2000). Well-established methods are widely accepted and applied by the geologic community, and importantly, are usually commercially available. Experimental methods are

new, usually still under development, not fully tested, and not widely accepted or applied. Experimental methods commonly are in the “research phase” of development, and as such are not usually available for most engineering-geology investigations. Colman and Pierce (2000) classified geochronologic methods according to their shared assumptions, mechanisms, or applications as follows.

1. Sidereal (calendar or annual) methods, which determine calendar dates or count annual events.
2. Isotopic methods, which measure changes in isotopic composition due to radioactive decay and/or growth.
3. Radiogenic methods, which measure cumulative effects of radioactive decay, such as crystal damage and electron energy traps.
4. Chemical and biological methods, which measure the results of time-dependent chemical or biological processes.
5. Geomorphic methods, which measure the cumulative results of complex, interrelated, physical, chemical, and biological processes on the landscape.
6. Correlation methods, which establish age equivalence using time-independent properties.

Geochronologic methods may also be categorized by the results they produce. Colman and Pierce (2000) further identified four general result-based categories: numerical-age, calibrated-age, correlated-age, and relative-age methods. The methods are described here in order of decreasing precision.

1. Numerical-age methods produce quantitative estimates of age and uncertainty and are sometimes called “absolute ages,” but are more appropriately referred to as “numerical” ages.
2. Calibrated-age methods provide approximate numerical ages, and are based on systematic changes that depend on environmental variables such as temperature or lithology and must be calibrated using independent numerical ages (McCalpin and Nelson, 2009). These methods should not be confused with “calibrated” radiocarbon ages.
3. Correlated-age methods do not directly measure age and produce age estimates by demonstrating equivalence to independently dated deposits or events.
4. Relative-age methods provide an ordinal ranking (first, second, third, etc.) of an age sequence, and may provide an estimate of the magnitude of the age difference between members of the sequence.

Table 12 is modified from Colman and Pierce (2000) and McCalpin and Nelson (2009), and classifies the more commonly applied geochronologic methods by result and method. All of the methods in table 11 are potentially applicable to engineering-geology investigations. Methods shown in *italic type* are known to have been used in Utah; methods

shown in **bold italic type** are commonly employed in Utah. Geologists conducting engineering-geology investigations in Utah should develop a working knowledge of those commonly applied techniques, both for potential use on future projects, and to develop an understanding of the nature and limitations of the different kinds of age estimates reported in the literature.

Evaluating uncertainty associated with an age, numerical or otherwise, is critical to constraining the timing and re-occurrence of past geologic-hazard events. Many numerical ages are reported with a laboratory estimate of the precision (analytical reproducibility) of the age, commonly expressed as one or two standard deviations (σ or 2σ) around a mean. Frequently, the largest source of error in paleoevent dating is sample context error, or the error involved in inferring the time of an event from the age of an accurately dated (how closely a reported age corresponds to the actual age) sample (McCalpin and Nelson, 2009). Sample context error is often much larger than the 2σ deviation laboratory precision estimate, and must be carefully evaluated and explicitly acknowledged when calculating paleo-hazard event timing and recurrence. Where accurate information on earthquake timing and recurrence are of critical importance (e.g., where development is proposed directly across an active fault trace), it is recommended that timing and recurrence be modeled using OxCal ^{14}C calibration and analysis software (Bronk Ramsey, 1995, 2001, 2010), which probabilistically models the time distributions of undated events by incorporating stratigraphic ordering information for numerical (e.g., ^{14}C and luminescence) ages (Bronk Ramsey, 2008, 2009). See Lienkaemper and Bronk Ramsey (2009) and DuRoss and others (2011) for additional discussions on the use of OxCal in paleoseismic investigations.

Evaluating paleo-hazard event timing and recurrence from available age estimates, which may be limited by a lack of datable material or by time or budget constraints, is often a difficult task. However, given the often critical nature of determining geologic-hazard activity, the Engineer-Geologist conducting a geologic-hazard investigation is responsible for evaluating the geologic conditions at the site, and for selecting the dating methods best suited to constrain paleo-hazard timing and associated uncertainty. Rarely can a single analysis of a single sample by any dating method provide a definitive age for a paleo-hazard event (McCalpin and Nelson, 2009). Multiple samples evaluated by multiple techniques provide an improved basis for determining paleo-hazard timing and recurrence, and in instances where such data are critical to hazard evaluation and project design, the analysis will benefit from retaining an expert in the application and interpretation of geochronologic methodologies.

Critical, but often overlooked, aspects of geochronologic dating, particularly numerical dating, are proper sample collection and handling prior to delivery to the laboratory. Most commercial dating laboratories post sample collection and

Table 12. Classification of geochronologic methods potentially applicable to geologic-hazard investigations (after Colman and Pierce [2000] and McCalpin and Nelson [2009]).

TYPE OF RESULT ¹					
Numerical Age		Calibrated Age		Correlated Age	Relative Age
TYPE OF METHOD ²					
Calendar Year	Isotopic	Radiogenic	Chemical/ Biological	Correlation	Geomorphic
<i>Historical records</i>	<i>Radiocarbon (¹⁴C)</i>	Fission track	<i>Amino-acid racemization</i>	<i>Stratigraphy</i>	<i>Soil-profile development</i>
<i>Dendrochronology</i>	<i>K-Ar and ⁴⁰Ar/³⁹Ar</i>	<i>Thermoluminescence</i>	Obsidian and tephra hydration	<i>Paleomagnetism</i>	<i>Rock and mineral weathering</i>
Varve chronology	Uranium series	<i>Optically stimulated luminescence</i>	Lichenometry	<i>Tephrochronology</i>	<i>Scarp morphology and other progressive landform modification</i>
	<i>Cosmogenic isotopes other than ¹⁴C; e.g., ²⁶Al, ³⁶Cl, ¹⁰Be, ³He</i>	Infrared stimulated luminescence	Soil chemistry	<i>Paleontology</i>	Rate of deposition
	U-Pb, Th-Pb	Electron-spin resonance	Rock varnish chemistry	<i>Archeology</i>	Rate of deformation
				Stable isotopes	<i>Relative geomorphic position</i>
					<i>Stone coatings (CaCO₃)</i>
					Precariously balanced rocks

¹ Boundaries between “Type of Result” categories are dashed to show that results produced by geochronologic methods in one category may in some instances contribute to results typical of another category; i.e., boundaries between the categories are not sharply defined.

² Geochronologic methods shown in italic type are known to have been applied to geologic-hazard investigations in Utah. Methods shown in bold italic type are commonly employed for geologic-hazard investigations in Utah.

handling instructions on their websites (e.g., Beta Analytic Radiocarbon Dating, 2014; Utah State University Luminescence Laboratory, 2014). Improper sample collection and handling may result in incorrect ages, ages that are difficult to interpret, or no useful age information at all. Where samples are collected from trenches that are then closed, or from other ephemeral or hard-to-access sample locations, it may not be possible to resample if the original samples are compromised by bad sampling and handling techniques.

ENGINEERING-GEOLOGY REPORTS

Engineering-geology reports will be prepared for projects at sites where geologic conditions range from relatively simple to complex; with some, many, or no geologic hazards present; and with varying types of development (structures, pavements, underground facilities, site grading, landscaping, etc.) and uses. As a result, the format and scope of an engineering-geology report should reflect project and regulatory requirements, and succinctly and clearly inform the reader of the geologic conditions present at and adjacent to the project site, and procedures and recommendations to mitigate geologic hazards. Reports should include a discussion of geologic conditions and hazards present that were

not investigated, and why they were not investigated (e.g., limited scope and/or budget), and provide recommendations for future, more comprehensive investigation if necessary. All reports, addenda, and related materials should be dated and properly referenced or numbered, so that any revisions and a report timeline may be clearly determined.

The type and nature of the report should be clear to the end-user and reviewer so the report will be used for its intended purpose. Three types of engineering-geology reports are in general use: reconnaissance, preliminary investigation, and final investigation/design.

- **Reconnaissance Reports** – Present summary geologic information on a particular project based on a limited literature review and site visit, but without subsurface exploration. Often used for real-estate due-diligence activities and in preparation for in-depth investigations and subsequent final design reports. These reports should present only general conclusions, recommend additional investigation as necessary, and users should be clearly informed about report limitations. These reports should not be used for final design or construction.
- **Preliminary Investigation Reports** – Present incomplete geologic information during an investigation, in-

cluding preliminary results of subsurface exploration, laboratory testing, and other activities. Often used during a project to inform other project professionals (such as engineers and architects) of geologic issues and preliminary conclusions and recommendations prior to the completion of a final investigation report. Users should be clearly informed about report limitations. These reports should not be used for final design or construction.

- **Final Investigation/Design Reports** – Present the results of a completed geologic investigation of a project, including literature review results, aerial photograph and other remote sensing interpretation, subsurface exploration, laboratory testing, geologic analysis, cross sections, and final geologic conclusions and recommendations. These reports are suitable for permit review and approval, final project design, and decision making related to the project.

General Information

Each report should include sufficient background information to inform the reader (client, reviewing agency, etc.) of the general site setting, proposed land use, and the purpose, scope, and limitations of the geologic investigation. Reports should address:

- Location and size of the project site, and its general setting with respect to major or regional geologic and geomorphic features, including a detailed location map indicating the site.
- Purpose and scope of the geologic investigation and report.
- Name(s) of geologist(s) who performed the geologic investigation, developed interpretations and conclusions, and wrote the report. In addition, the name(s) of others who were involved with recording field observations and/or performing laboratory testing should be clearly stated on all results.
- Topography and drainage conditions within and adjacent to the project site.
- General nature, distribution, and abundance of soil and rock within the project site.
- Basis of interpretations and conclusions regarding the project site geology. Nature and source of available subsurface information and geologic publications, reports, and maps. Suitable explanations of the available data should provide a regulatory-authority reviewer with the means of evaluating the reliability and accuracy of the data. Reference to cited publications and field observations must be made to substantiate opinions and conclusions.
- Building setbacks and areas designated to avoid geologic hazards.
- Disclosure of known or suspected geologic hazards affecting the project site, including information on past performance of existing facilities (such as buildings, utilities, pavements, etc.) in the immediate vicinity of the site.

Descriptions of Geologic Materials, Features, and Conditions

Engineering-geology reports should contain detailed descriptions of geologic materials (soil, intermediate geomaterials, and rock), structural features, and hydrologic conditions within and adjacent to the project site. The following is a general list; however, it is not a complete guide to geologic descriptions and additional information may be necessary.

- **Soils** (unconsolidated alluvial, colluvial, eolian, glacial, lacustrine, marine, residual, mass movement, volcanic, or fill [uncontrolled or engineered] deposits).
 - Identification of material, relative age, and degree of activity of originating process.
 - Distribution, dimensional characteristics, thickness and variations, degree of pedogenic soil development, and surface expression.
 - Physical characteristics (color, grain size, lithology, particle angularity and shape, density or consistency, moisture condition, cementation, strength).
 - Special physical or chemical features (indications of shrink/swell, gypsum, corrosive soils, etc.).
 - Special engineering characteristics or concerns.
- **Rock**
 - Identification of rock type/lithology.
 - Relative age and formation.
 - Surface expression, areal distribution, and thickness.
 - Physical characteristics (color, grain size, stratification, strength, variability).
 - Special physical or chemical features (voids, gypsum, corrosive nature, etc.).
 - Distribution and extent of weathering and/or alteration.
 - Special engineering characteristics or concerns.
- **Structural Features** (faults, fractures, folds, and discontinuities)
 - Occurrence, distribution, dimensions, orientation, and variability; include projections into the project area or site.
 - Relative ages, where applicable.
 - Special features of faults (topographic expression, zones of gouge and breccia, nature of offsets, movement timing, youngest and oldest faulted units).
 - Special engineering characteristics or concerns.
- **Hydrologic Conditions**
 - Distribution, occurrence, and variations of drainage courses (rivers, streams, ephemeral and dry drainages), ponds, lakes, swamps, springs, and seeps.
 - Identification and characterization of aquifers, depth to groundwater, and seasonal fluctuations.
 - Relations to topographic and geologic features and units.

- Evidence for earlier occurrence of water at locations now dry (vegetation changes, peat deposits, mineral deposits, historical records, etc.).
- Special engineering characteristics or concerns (such as a fluctuating water table).
- Seismic Conditions
 - Description of the seismotectonic setting of the project area or site (earthquake size, frequency, and location of significant historical earthquakes).
 - Current IBC/IRC seismic design parameters.

Assessment of Geologic Hazards and Project Suitability

The evaluation of geologic hazards in relation to a proposed development is a major focus of most engineering-geology investigations. This involves (1) the effects of the geologic features and hazards on the proposed development (grading; construction of buildings, utilities, etc.; and land use), and (2) the effects of the proposed development on future geologic processes within and adjacent to the site (such as constructed cut slopes causing slope instability and/or erosion problems). A clear understanding of all geologic hazards that may affect the construction, use, and maintenance of a proposed development is required to ensure development proceeds in a cost-effective and safe manner for the design professional, owner, contractor, user, community, and environment.

Identification and Extent of Geologic Hazards

Common geologic hazards encountered in Utah and that should be addressed in a comprehensive geologic-hazards investigation are listed below, along with specific guidelines contained in this publication as separate chapters or available elsewhere as short references.

- Earthquake Hazards, including
 - Surface-fault-rupture – chapter 3
 - Ground shaking – see 2018 IBC Section 1613.1 and IRC Section R301.1
 - Liquefaction
 - Lateral spreading
 - Tectonic deformation
- Landslide Hazards, including
 - Landslides – chapter 4
 - Debris flows – chapter 5
 - Rockfall – chapter 7
 - Snow avalanches – see Mears (1992) for guidance
 - Earthquake-induced landslides – chapter 4
- Flooding Hazards, including

- River, lake, or sheet flooding – see 2018 IBC appendix G, and commonly addressed in locally adopted FEMA regulations
- Debris flows – chapter 5
- Shallow groundwater – see 2018 IBC Section 1805 and IRC Section R406
- Dam and water conveyance structure failure
- Seiches
- Tsunamis – see 2018 IBC appendix M
- Problem Soil and Rock, including
 - Breccia pipes and karst
 - Caliche
 - Collapsible soils
 - Corrosive soil and rock
 - Expansive soil and rock
 - Ground subsidence and earth fissures – chapter 6
 - Gypsiferous soil and rock
 - Piping and erosion
 - Radon – chapter 8 and see 2018 IRC appendix F, Radon Control Methods and ASTM Standard E1465-08a
 - Shallow bedrock
 - Wind-blown sand
- Volcanic Hazards, including
 - Lava flows
 - Volcanic eruption and ash clouds

Suitability of Proposed Development in Relation to Geologic Conditions and Hazards

Once the geologic conditions and hazards at a site have been identified and investigated, the suitability of a proposed development in relation to these conditions and hazards must be determined. A proposed development may be found to be incompatible with one or more geologic conditions and/or hazards, resulting in development design changes. If these changes can be made early in the design process, significant cost savings may be realized.

Report Structure and Content

Engineering-geology reports should generally follow the recommended report format presented below; however, the content and scope of these reports should reflect applicable project and regulatory requirements, and may be combined with geotechnical investigation reports as appropriate. Relevant and well-drafted figures and/or tables should be included in the report as needed. Subcontractor reports, such as geophysical reports, should be included as an appendix and referenced in the text.

1. Introduction
 - Description of project and location
 - Investigation purpose
 - Investigation scope
2. Geology
 - Description of regional geologic setting
 - Description of site-specific geology, including cross section(s)
3. Geologic Investigation
 - Results of literature reviews and prior work
 - Description of aerial photography and other imagery analysis
 - Description of geologic mapping and surface investigation
 - Description of geophysical investigation
 - Description of subsurface investigation
 - Test pits
 - Trenches
 - Drilling
 - Description of laboratory testing
 - Description of other work or investigation
4. Investigation Results and Interpretations
 - Geologic hazards
 - Geologic conditions that could affect the site and/or development.
 - Avoidance and/or mitigation options
5. Conclusions and Recommendations
 - Conclusions and recommendations should be clear and concise, and be supported by investigation-derived observations, data, and external references.
 - Limitations of the investigation and data.
 - Recommendations for future investigation, if needed.
6. References
 - Reports must provide complete references for all cited literature and data not collected as part of the investigation.
 - For aerial photography and other imagery, report project code, project name, acquisition date, scale, and frame identification for all frames used.
7. Appendices
 - Supporting laboratory test results and data, separated as necessary into individual appendices or sections.
8. Plates
 - Oversize maps, drawings, or other figures related to the report and properly named, numbered, and referenced within the report.

Figures and plates should use clear, high-quality graphics and commonly accepted scale values so users may make measurements with commercially available engineering scales. Figures and plates should rarely be drawn not-to-scale, and this method should never be used with site maps and drawings in locating site features and proposed development. Appropriate explanation information, including symbol definitions and north arrow, should be used as appropriate. Figure sizes should not exceed one page, preferably tabloid (11 x 17 inches) maximum page size. Plate sizes should generally not exceed 24 x 36 inches (Architectural D size) for ease of use and printing on commonly available large-format printers.

Summaries of data and/or condensed conclusions at the front of reports should be used with caution, as results are often used by readers without understanding the background information necessary to effectively interpret the data and/or recommendations.

Engineering-geology reports must be stamped, signed, and dated by the Engineering Geologist who conducted the investigation. In addition, any oversize plates should also be stamped, signed, and dated. The geologist must be licensed to practice geology in Utah. If a geotechnical report or other engineering analysis and/or recommendations are included with the engineering-geology report, an engineer licensed to practice in Utah must also stamp, sign, and date the report or pertinent sections.

FIELD REVIEW

Once an engineering-geology site investigation is complete, the UGS strongly recommends a technical field review of the site by the regulatory-authority Engineering Geologist. Field reviews are critical to ensuring that site geologic conditions are adequately characterized and that geologic hazards are identified and evaluated. The field review should take place after trenches or test pits are logged, but before they are closed so subsurface site conditions can be directly observed and evaluated. In general, adequate site characterization is seldom possible by opening, logging, reviewing, and closing trenches or test pits in one day; however, the UGS recognizes that for safety or other reasons, it may be necessary in some instances to open and close such excavations in a single day.

Although not required, the UGS appreciates being afforded the opportunity to participate in field reviews of proposed development sites. The UGS is particularly interested in obtaining earthquake timing, recurrence, and displacement data for Utah Quaternary faults, and information on land subsidence and earth fissures associated with groundwater mining. Contact the UGS Geologic Hazards Program in Salt Lake City at 801-537-3300, or the UGS Southern Regional Office in Cedar City at 435-865-9036.

REPORT REVIEW

The UGS recommends regulatory review of all reports by a Utah licensed Professional Geologist experienced in engineering-geology investigations (see Investigator Qualifications section) and acting on behalf of local governments to protect public health, safety, and welfare, and to reduce risks to future property owners (Larson, 1992, 2015). The reviewer should evaluate the technical content, conclusions, and recommendations presented in a report, in relation to the geology of the site, the proposed development, and the recommended hazard mitigation method(s). The reviewer should always participate in the field review of the site, and should advise the local government regarding the need for additional work, if warranted.

DISCLOSURE

The UGS recommends disclosure during real-estate transactions whenever an engineering-geology investigation has been performed for a property to ensure that prospective property owners are made aware of geologic hazards present on the property, and can make their own informed decision regarding risk. Disclosure should include a Disclosure and Acknowledgment Form provided by the jurisdiction, which indicates an engineering-geology report was prepared and is available for public inspection.

Additionally, prior to approval of any development, subdivision, or parcel, the UGS recommends that the regulating jurisdiction require the owner to record a restrictive covenant with the land identifying any geologic hazard(s) present. Where geologic hazards are identified on a property, the UGS recommends that the jurisdiction require the owner to delineate the hazards on the development plat prior to receiving final plat approval.

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The Intermountain Section of the Association of Environmental and Engineering Geologists, the Utah Section of the American Society of Civil Engineers, Robert Tepel, and Gregg Beukelman, Rich Giraud, and Adam McKean (Utah Geological Survey) provided insightful comments and additional data that substantially improved the utility of these guidelines.

CHAPTER 3

GUIDELINES FOR EVALUATING SURFACE-FAULT-RUPTURE HAZARDS IN UTAH

by

*William R. Lund, P.G., Gary E. Christenson, P.G. (UGS, retired), L. Darlene Batatian, P.G. (Terracon, Inc.),
and Craig V. Nelson, P.G. (Western Geologic, LLC)*



*Airport East paleoseismic trench on the Taylorsville fault, West Valley fault zone, Salt Lake County, Utah, on September 4, 2015.
Photo credit: Adam Hiscock.*

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CHAPTER 3: GUIDELINES FOR EVALUATING SURFACE-FAULT-RUPTURE HAZARDS IN UTAH

by William R. Lund, P.G., Gary E. Christenson, P.G. (UGS, retired), L. Darlene Batatian, P.G. (Terracon, Inc.), and Craig V. Nelson, P.G. (Western Geologic, LLC)

INTRODUCTION

These guidelines update and revise Utah Geological Survey Miscellaneous Publication 03-6—*Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah* (Christenson and others, 2003). The intent of these guidelines is to provide Engineering Geologists with standardized minimum recommended criteria for performing surface-faulting investigations for new buildings for human occupancy and for International Building Code (IBC) Risk Category II, III, and IV facilities (International Code Council [ICC], 2017a) to reduce risk from future surface faulting. However, performing a surface-faulting investigation and adherence to the investigation recommendations in these guidelines does not guarantee safety. Significant uncertainty often remains due to limited paleoseismic data related to the practical limitations of conducting such investigations (epistemic uncertainty), and natural variability in the location, recurrence, and displacement of successive surface-faulting earthquakes (aleatory variability). Aleatory variability in fault behavior cannot be reduced; therefore, predicting exactly when, where, and how much ground rupture will occur during future surface-faulting earthquakes is not possible. New faults may form, existing faults may propagate beyond their present lengths, elapsed time between individual surface-faulting earthquakes can vary by hundreds or thousands of years and be affected by clustering, triggering, and multi- or partial-segment ruptures. For those reasons, developing property in the vicinity of hazardous faults will always involve a level of irreducible, inherent risk.

These guidelines outline (1) appropriate investigation methods, (2) report content, (3) map, trench log, and illustration criteria and scales, (4) mitigation recommendations, (5) minimum criteria for review of reports, and (6) recommendations for geologic-hazard disclosure. However, these guidelines do not include systematic descriptions of all available investigative techniques or topics, nor does the UGS suggest that all techniques or topics are appropriate for every hazard investigation.

Considering the complexity of evaluating surface and near-surface faults, additional effort beyond the minimum criteria recommended in these guidelines may be required at some sites to adequately address surface-faulting hazard. The information presented in these guidelines does not relieve Engineering Geologists of their duty to perform additional geologic investigations necessary to fully assess the surface-faulting hazard at a

site. As required by Utah state law (Utah Code, 2011), surface-faulting investigation reports and supporting documents must be signed and stamped by the licensed Utah Professional Geologist in responsible charge of the investigation.

Purpose

A surface-faulting investigation uses the characteristics of past surface faulting at a site as a scientific basis for providing recommendations to reduce the risk for damage, injury, or death from future, presumably similar, surface faulting. The purpose of these guidelines is to provide appropriate minimum surface-faulting investigation and report criteria to:

- protect the health, safety, and welfare of the public by minimizing the potentially adverse effects of surface faulting;
- assist local governments in regulating land use in hazardous areas and provide standards for ordinances;
- assist property owners and developers in conducting reasonable and adequate surface-faulting investigations;
- provide Engineering Geologists with a common basis for preparing proposals, conducting investigations, and recommending surface-faulting risk-mitigation strategies; and
- provide an objective framework for preparation and review of surface-faulting reports.

These guidelines pertain only to new buildings for human occupancy and high-risk-category facilities. These guidelines are not intended for siting linear lifelines (highways, utilities, pipelines), which commonly must cross faults; large water impoundments (dams, dikes, lagoons); hazardous waste facilities; or nuclear power generation or repository facilities. Surface-faulting investigation methods are similar for these facilities (e.g., Hanson and others, 1999; American National Standards Institute/American Nuclear Society, 2008), but due to their potential for catastrophic failure, hazard investigations, including surface-faulting hazard, are typically controlled by regulations promulgated by a regulating/permitting authority (e.g., U.S. Nuclear Regulatory Commission, 2011).

These guidelines only address surface-fault rupture, which is displacement of the ground surface along a tectonic fault during an earthquake (figure 7). These guidelines do not ad-



Figure 7. Scarp caused by surface faulting on the Nephi segment of the Wasatch fault zone (photo credit F.B. Weeks, USGS). Note man sitting on horse for scale.

dress (1) ground-surface displacements caused by non-tectonic faults as defined by Hanson and others (1999), including those resulting from landsliding (described in chapter 4), (2) non-tectonic fault creep or post-seismic slip, (3) earth fissures caused by land subsidence due to groundwater mining (Knudsen and others, 2014; chapter 6), or (4) other earthquake hazards and non-earthquake geologic hazards that displace the ground surface, which should be addressed as part of a comprehensive geologic-hazards site investigation (see chapters 1 and 2).

These guidelines do not supersede pre-existing state or federal regulations or local geologic-hazard ordinances, but provide useful information to supplement adopted ordinances/regulations, and assist in preparation of new ordinances. The UGS believes adherence to these guidelines will help ensure adequate, cost-effective investigations and minimize report review time.

Background

Earthquakes produce a variety of hazards, including strong ground shaking, liquefaction, and landslides, as well as surface faulting (e.g., Smith and Petley, 2009). In Utah, faults

capable of causing surface faulting are chiefly normal faults along which fault displacement at the ground surface is primarily vertical, with one side dropping down relative to the other along a fault plane dipping beneath the downthrown fault block (figure 8). Surface faulting commonly recurs along existing fault traces (Bonilla, 1970; McCalpin, 1987, 2009; Kerr and others, 2003) for earthquakes $\geq M$ 6.75 (Working Group on Utah Earthquake Probabilities [WGUEP], 2016). Past major earthquakes on the central five most active segments of the Wasatch fault zone have generated average displacements for individual surface-faulting earthquakes of about 6.6 feet (DuRoss, 2008; DuRoss and Hylland, 2015). However, single-event displacements more than twice that large have been documented on the Weber (14.8 feet; Nelson and others, 2006) and Provo (15.4 feet; Olig, 2011 [compiled in Bowman and Lund, 2013]) segments.

Displacements during surface-faulting earthquakes on other Utah normal faults are less well documented, but limited available data indicate that for comparable rupture lengths, displacements are similar to the central Wasatch fault zone segments. Consequently, if a normal fault were to displace the ground surface beneath a building or critical structure (e.g., large water or petroleum storage tanks, telecommunications tower, electrical switching station), significant structural damage or collapse may occur (figure 9), possibly causing injuries and loss of life. Therefore, site-specific investigations are required to accurately locate faults that present a potential surface-faulting hazard, determine their level of activity and displacement characteristics, and implement appropriate risk-reduction measures prior to development.

Consideration of surface faulting in land-use planning and regulation in Utah began in earnest in the early 1970s when Cluff and others (1970, 1973, 1974; compiled in Bowman and others, 2015b) completed their investigations and maps of major faults along the Wasatch Front in northern Utah. These aerial-photograph-based maps presented the first comprehensive compilation of fault locations available to local governments, and increased awareness of the hazard posed by the Wasatch, East Cache, and West Cache fault zones. Early paleoseismic trenching investigations (Swan and others, 1980, 1981a, 1981b; compiled in Bowman and Lund, 2013) further highlighted the hazard by documenting multiple, large, geologically recent surface-faulting earthquakes on the central part of the Wasatch fault zone.

In subsequent years, maps designating special-study areas within which surface-faulting investigations are recommended, have been prepared by or with the assistance of the Utah Geological Survey (UGS) at varying levels of detail for Cache, Davis, Iron, Salt Lake, eastern Tooele, Utah, western Wasatch, and Weber Counties (adopted by and on file with the respective county planning departments). More recently, the UGS has prepared similar maps for the St. George-Hurricane metropolitan area (figure 10; Lund and others, 2008), high-visitation areas of Zion National Park (Lund and others, 2010), and

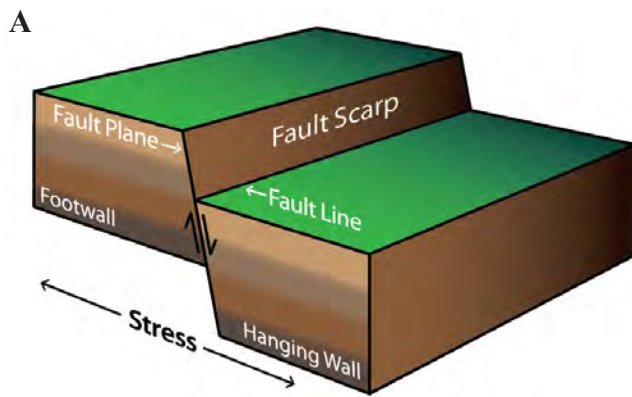


Figure 8. Normal fault: (A) schematic diagram, (B) exposed in an excavation (photo courtesy of David Simon).



Figure 9. Normal fault surface-faulting damage to a building, 1959 Hebgen Lake, Montana, M 7.3 earthquake. (Photograph by I.J. Witkind, USGS.)

the State Route 9 corridor between La Verkin and Springdale (Knudsen and Lund, 2013) in Washington County. Additionally, the UGS is preparing geologic-hazard-map sets for select 7.5-minute quadrangles in Utah (see <https://geology.utah.gov/hazards/info/maps/>). Where Quaternary faults are present in the quadrangles, the hazard-map sets contain a surface-faulting-hazard map (e.g., Castleton and others, 2011).

The Utah Quaternary Fault and Fold Database (<https://geology.utah.gov/apps/qfaults>) has the most current mapped hazardous fault traces and UGS-designated special-study areas for Utah. The entire Wasatch and West Valley fault zones have been mapped in detail, along with designated special-study areas for these faults in Utah. Mapping is currently underway for Cache Valley (East and West Cache fault zones and other faults) and the East and West Bear Lake, Hurricane, Oquirrh, Sevier, Topliiff Hills, and Washington fault zones. Users should refer to this website for the most current data.

Recognizing the risk from earthquakes, some local governments began adopting rudimentary ordinances requiring fault and other geologic-hazard investigations prior to development in the 1970s. Guided by publication of UGS Circular 79, *Suggested Approach to Geologic Hazard Ordinances in Utah* (Christenson, 1987) and U.S. Geological Survey (USGS) Professional Paper 1519, *Applications of Research from the U.S. Geological Survey Program, Assessment of Regional Earthquake Hazards and Risk Along the Wasatch Front, Utah* (Gori, 1993), some Wasatch Front counties and municipalities had adopted and were enforcing modern hazard ordinances by the mid-1990s. Local government staff relied heavily on developers' consultants as professional experts responsible for evaluating the hazards and recommending risk-reduction measures for proposed developments. Consultants' reports would sometimes be sent to the UGS for review, but in general, technical regulatory reviews were not systematically performed prior to 1985.

This informal review process lasted until June 1985, when the UGS initiated the Wasatch Front County Hazards Geologist Program, funded through the USGS National Earthquake Hazards Reduction Program (Christenson, 1993). Geologists hired by Weber, Davis, Salt Lake, Utah, and Juab Counties began preparing surface-faulting and other geologic-hazard maps and assisting city and county planning departments in requiring and reviewing site-specific hazard investigations. This program directly resulted in or spurred development of various published guidelines for surface-faulting investigations in Utah including those of the Association of Engineering Geologists, Utah Section (1987); Nelson and Christenson (1992); Robison (1993); Christenson and Bryant (1998); Batatian and Nelson (1999); Salt Lake County (2002b); and Christenson and others (2003). The county geologist program came to an end in Weber, Davis, Utah, and Juab Counties in the late 1980s after USGS funding expired. The county geologist program in Salt Lake County persisted with local funding until 2006.

Most Wasatch Front and other urban counties and municipalities now have hazard ordinances that require geologic-hazards investigations prior to approving new development. Several of these ordinances adopt surface-faulting-hazard special-study maps (Christenson and Shaw, 2008), which define areas where site-specific investigations are required prior to approval of new development to protect life, safety,

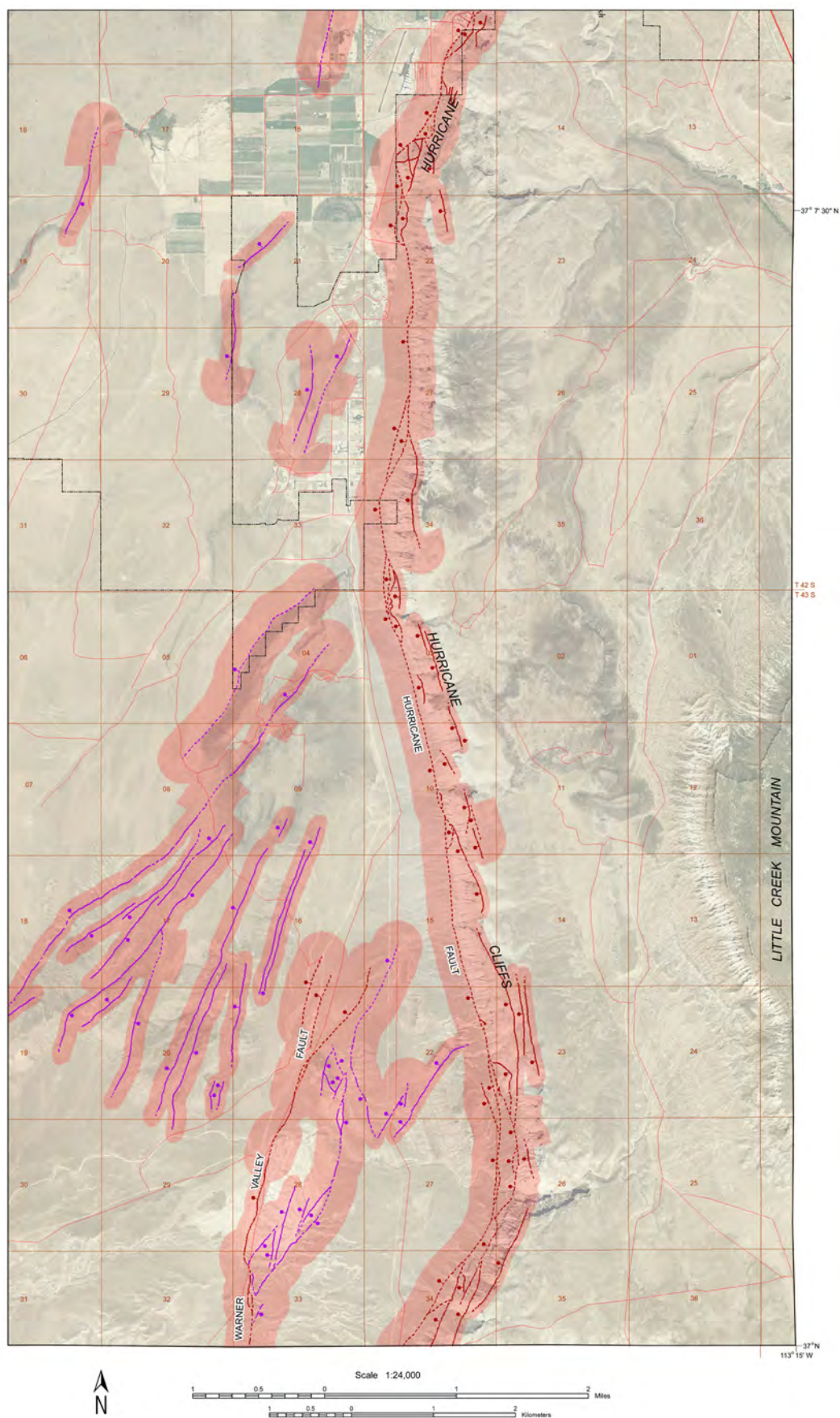


Figure 10. Example of a surface-faulting special-study-area map along the Hurricane fault zone in southwestern Utah (from Lund and others, 2008). Site-specific investigations are required within the shaded areas to address surface-faulting hazard prior to approval of new development.

and welfare from surface faulting (figure 10). Most geologic-hazard ordinances in Utah mitigate surface faulting by prohibiting construction of habitable structures and high-risk-category facilities across “active” faults (hazard avoidance). The ordinances typically define “active” (hazardous) faults as faults having evidence for displacement during the Holocene Epoch (the period of time extending from the present back to about 10,000 radiocarbon years before present [^{14}C yr B.P.], or about 11,700 calibrated years before present [cal yr B.P.]). Presently, a few municipalities and counties with geologic-hazard ordinances retain consultants to review surface-faulting investigations, while others rely on non-technical staff to make the reviews.

Designing a building to withstand surface faulting has generally been considered impractical for economic, engineering, and architectural reasons, and it is only within the relatively recent past that the geotechnical community has begun a serious discussion regarding using engineering design to mitigate surface-faulting risk (e.g., Bray, 2015). Therefore, avoiding active fault traces that pose a surface-faulting hazard has been the risk-reduction measure most often applied in Utah. A typical surface-faulting investigation in Utah documents the presence or absence of faults determined to be active at a site. When active faults are present, a fault setback is recommended based on the width of the deformation zone and the amount and direction of displacement along the fault.

However, hazard ordinances adopted by the cities of Draper, Holladay, and Cottonwood Heights, and Salt Lake, Morgan, and Wasatch Counties allow exceptions to this norm, and permit construction across active faults expected to have ≤ 4 inches of future displacement, their reasoning being that a “normal” residential foundation system can withstand 4 inches of vertical displacement without catastrophic collapse. The Draper and Morgan County ordinances do not categorically exempt small-displacement faults from fault setback requirements. In those ordinances, if engineering-design surface-faulting mitigation is proposed for small displacement faults, the following criteria must be addressed: (1) reasonable geologic data must be available indicating that future surface displacement along the fault will not exceed 4 inches, (2) a structural engineer must provide an appropriate design to minimize structural damage, and (3) the design must receive adequate review.

Under a special City of Draper (2005) “Review Protocol” regulating issuance of building permits for structures astride active faults in subdivisions approved prior to adoption of Draper’s geologic-hazard ordinance in 2003, it is permissible under specified conditions to construct “super-engineered” structures across subsequently discovered active faults within previously approved building lots. To obtain approval for a super-engineered structure, Draper requires (1) a statement from a Utah licensed geologist describing the most suitable location on the lot for the proposed structure, (2) a statement from a Utah licensed Geotechnical Engineer describing the suitability and constructability of the proposed structure at

the location described by the geologist, and (3) a statement from a Utah licensed structural engineer stating that the geologic and geotechnical reports have been reviewed, and that the proposed structure is designed in accordance with their recommendations and accounts for the identified hazards in accordance with the International Building Code (IBC) (International Code Council [ICC], 2017a). When Draper approves construction of a structure astride an active fault pursuant to the review protocol, a disclosure of the geologic condition at the site must be recorded with the County Recorder on a form approved by the City as a condition of issuing a building permit. Under the review protocol, Draper has approved construction of structures across Holocene-active faults exhibiting as much as 6 feet of vertical displacement (David Dobbins, City of Draper Manager, verbal communication, 2015).

CHARACTERIZING FAULT ACTIVITY

In Utah, minimum requirements for surface-faulting investigations and implementing hazard-mitigation measures are predicated on the ability of the Engineering Geologist to characterize a fault’s physical characteristics and recent earthquake history (strike, dip, sense of displacement, rupture complexity, and timing and displacement of the most recent surface-faulting earthquake). Where site geologic conditions are favorable and time and budget permit, it also may be possible to determine the timing and displacement for multiple paleoearthquakes, from which earthquake recurrence and fault slip rate can be calculated. Engineering Geologists conducting surface-faulting investigations should be thoroughly familiar with the techniques of paleoseismic investigations (e.g., McCaig, 2009; DuRoss, 2015; see also Investigator Qualifications section in chapter 2). Parameters required to fully characterize fault activity are briefly described in the following sections.

Rupture Complexity

Rupture complexity refers to the width and distribution of deformed land around a fault trace (Kerr and others, 2003; Treiman, 2010). Normal faults are by far the most common type of Quaternary fault in Utah; patterns of ground deformation resulting from past surface faulting are highly variable, and in some cases change significantly over short distances along the strike of the fault (figure 11). Geologic mapping and trench exposures across zones of surface-fault deformation show that common patterns of normal-slip faulting range from (1) very narrow zones where virtually all deformation takes place on a single master fault (e.g., DuRoss and others, 2014), (2) broader shear zones up to several feet wide with a master fault and several smaller, usually sympathetic, subsidiary faults (e.g., Lund and others, 2015), (3) grabens that range from a few to tens of feet wide and contain a few to numerous antithetic and sympathetic faults of variable displacement (e.g., Lund and others, 1991; Olig, 2011 [compiled in Bowman and Lund,

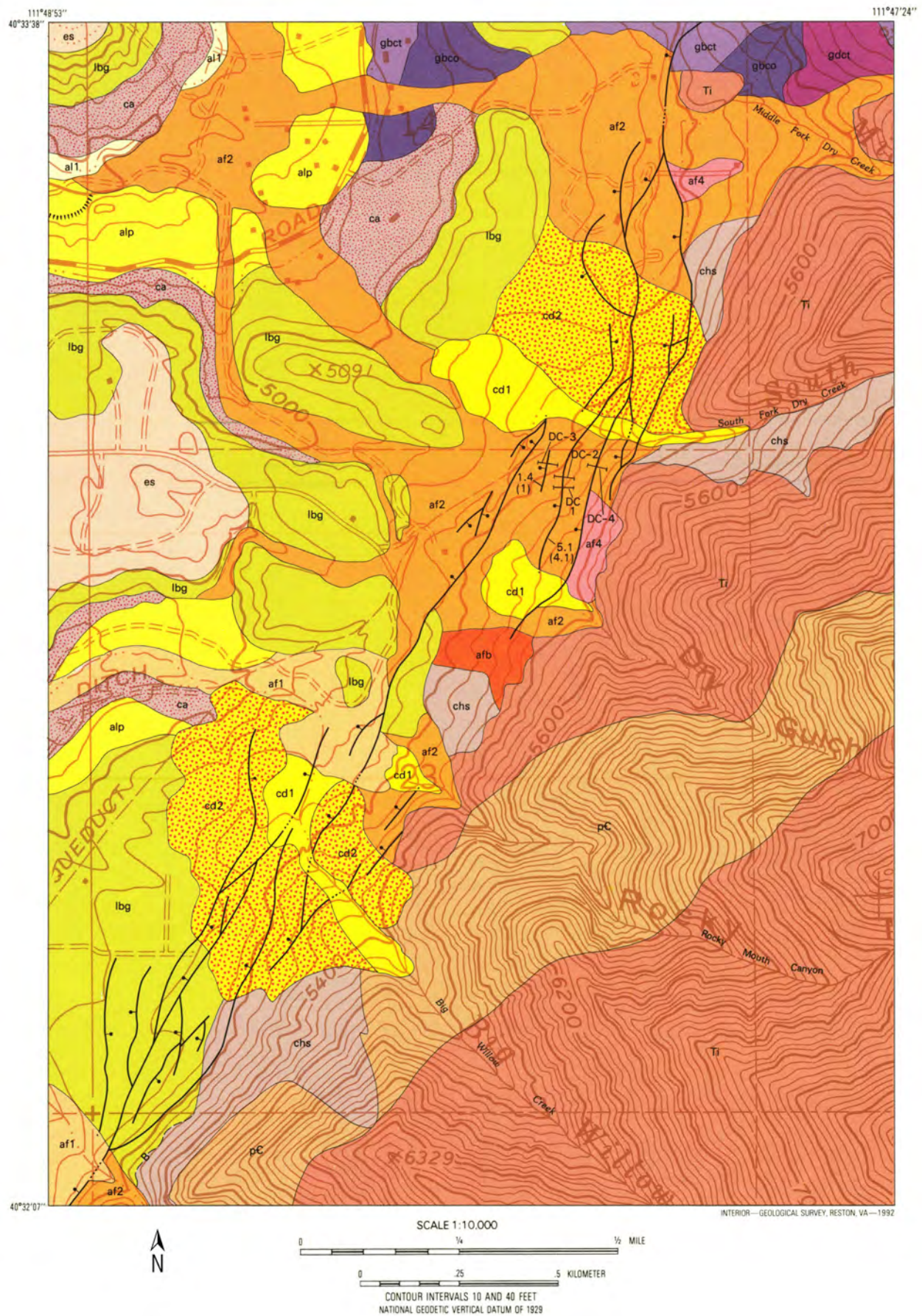


Figure 11. Map view of rupture complexity along part of the Salt Lake City segment of the Wasatch fault zone (from Personius and Scott, 1992).

2013]), (4) bifurcated fault zones tens to hundreds of feet wide consisting of several individually prominent strands, not all of which may be active in every surface-faulting earthquake (e.g., Black and others, 1996; DuRoss and others, 2009), and (5) zones of folding, warping, and flexure that lack discrete fault rupture (e.g., Hylland and others, 2014).

Earthquake Timing and Recurrence

Minimum data necessary to characterize past fault activity and estimate the probability of surface faulting within a future time frame of interest include (1) timing of the most recent surface-faulting earthquake, (2) a well-constrained average recurrence interval based on a recommended minimum of three closed earthquake cycles (four paleoearthquakes; more is better), and (3) the variability (uncertainty) associated with the timing of each paleoearthquake and resulting average recurrence interval. Paleoseismic trenching investigations show that individual recurrence intervals (time between two surface-faulting earthquakes) for Utah Quaternary faults range from several hundred to multiple thousands of years, and may exhibit uniform, quasi-uniform, or non-uniform recurrence.

The greater the number of past surface-faulting earthquakes identified and dated, the greater the confidence that the resulting average recurrence interval accurately reflects the fault's long-term activity level (Coppersmith and Youngs, 2000; DuRoss and others, 2011). Additionally, the greater the understanding of variability in recurrence intervals, the greater the confidence that the elapsed time since the most recent surface-faulting earthquake is a reliable indicator of where the fault lies in its current earthquake cycle. However, for fault-avoidance (fault setback) mitigation, it is only necessary to determine the timing of the most recent surface-faulting earthquake (see Hazardous Fault Avoidance section below).

Displacement

Utah's Quaternary faults typically exhibit normal-slip displacement with the master fault dipping at moderate to high angles ($50^\circ \pm 15^\circ$; Lund, 2012; WGUEP, 2016) beneath the downthrown (hanging wall) block (figure 8). Single-event displacements from past Utah surface-faulting earthquakes range from about 20 inches (1934 Hansel Valley earthquake—Utah's only historical surface-faulting earthquake; Walter, 1934; figure 12) to > 15 feet (Olig, 2011 [compiled in Bowman and Lund, 2013]) on the five central, Holocene-active segments of the Wasatch fault zone. Single-earthquake displacements on other Utah Quaternary faults for which paleoseismic trenching data are available typically range from < 3 to about 10 feet (see UGS *Paleoseismology of Utah* series and Lund, 2005). The 1983 M 6.9 Borah Peak, Idaho, earthquake showed that normal-slip displacement can vary significantly along strike (Crone and others, 1987), and Lund and others (2015) reported an approximately 50 percent variation in displacement at a point in successive earthquakes on the Fort Pearce section



Figure 12. Surface faulting associated with the 1934 Hansel Valley, Utah, M 6.6 earthquake (photograph from the University of Utah Seismograph Stations photo archive).

of the Washington fault zone in southern Utah. Wesnousky (2008) discussed displacement and geometrical characteristics of earthquake surface faulting using a worldwide data set of historical surface-faulting earthquakes. His analysis showed that earthquake epicenters do not appear to have a systematic correlation with the maximum slip observed on a fault.

Displacements on sympathetic and antithetic faults in shear zones and grabens produced by surface-faulting earthquakes (figure 13) are generally less than 3 feet, but may be larger. Fault trenching investigations show that low-angle thrust faults and high-angle reverse faults may form in grabens along normal-slip master faults (e.g., Lund and others, 1991; Olig, 2011 [compiled in Bowman and Lund, 2013]; Crone and others, 2014; Simon and others, 2015). Such faults commonly have small displacements (tens of inches or less); however, a low-angle thrust fault formed at a complex bend in the otherwise normal-slip Washington fault zone exhibited multiple feet of reverse-fault displacement placing Mesozoic bedrock over Quaternary basin-fill deposits (Simon and others, 2015; figure 14).

Slip Rate

Quaternary normal faults in the Basin and Range Province typically produce large, infrequent, nearly instantaneous displacements during earthquakes that are separated by recurrence intervals (time between two successive earthquakes) ranging from hundreds to thousands of years. A slip rate nor-

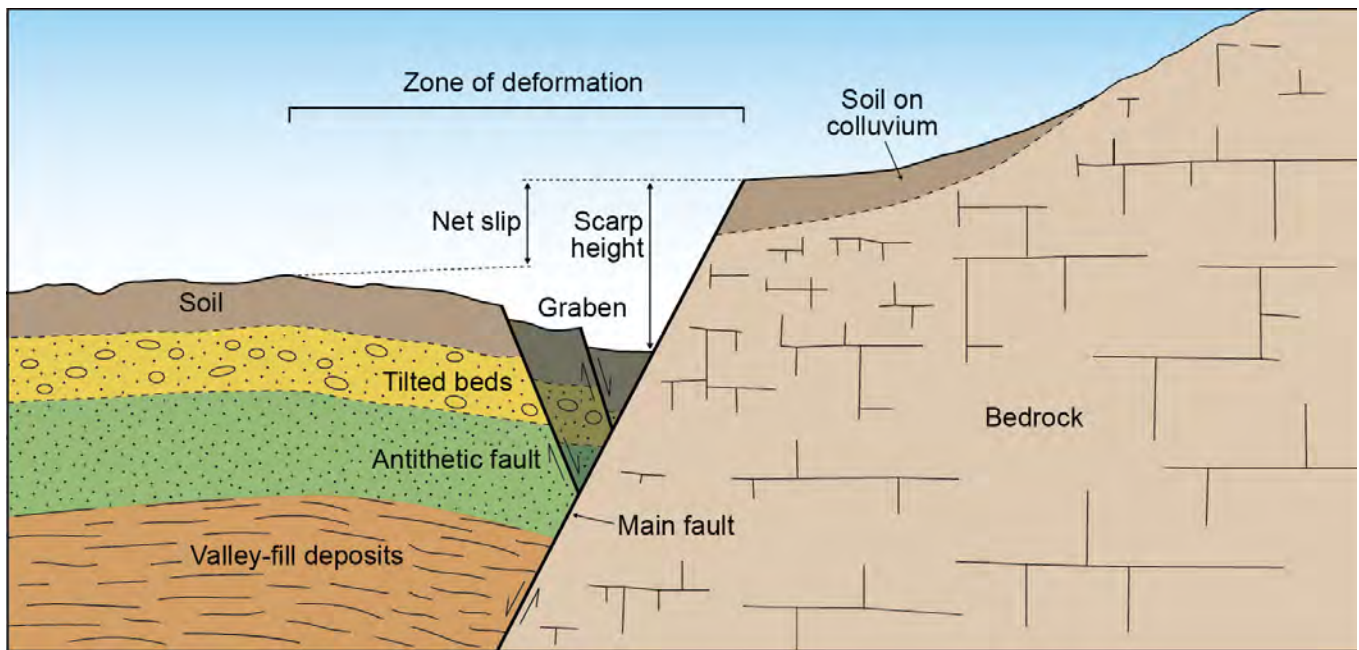


Figure 13. Schematic cross section through a normal fault zone.

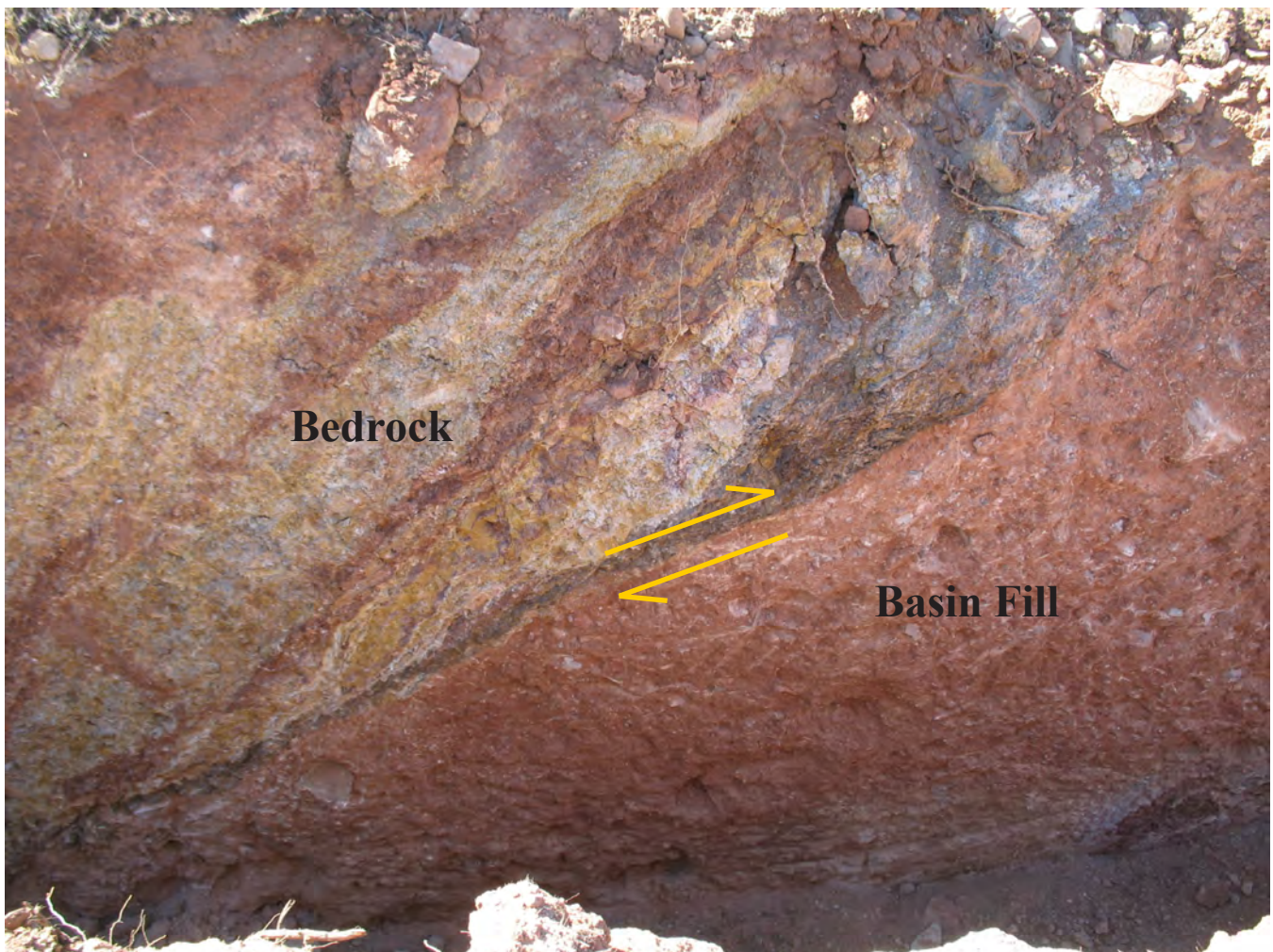


Figure 14. Thrust fault exhibiting several feet of displacement at a complex bend in an otherwise normal-slip fault zone. The fault places Mesozoic bedrock on top of Quaternary basin-fill deposits. Photo taken in January 2012.

malizes fault displacement over time by dividing a known per-event displacement by the known length of the previous recurrence interval. Slip rates are typically reported in mm/yr or m/kyr, and for a normal fault may either be calculated vertically, or in a down-dip direction (net slip) if a fault's dip at depth is known. A slip rate may be "open" or "closed" (Chang and Smith, 2002; McCalpin, 2009). A closed slip rate is determined by dividing a known per-event vertical displacement by the known length of the previous recurrence interval. It is implicit in a closed slip rate that the time interval of interest is bracketed (closed) by surface-faulting earthquakes of known age. Accurately characterizing a fault's long-term slip rate requires calculating a composite slip rate across multiple closed recurrence intervals to obtain a long-term average of fault activity. Generally, the higher the slip rate, the more active (hazardous) the fault.

Open-interval slip rates span the time and displacement between the oldest dated displaced deposit and the present. Open-interval slip rates are less precise than closed-interval slip rates because they typically include one partial earthquake cycle prior to the earliest fault displacement of the deposit, and a second partial cycle from the time of the most recent earthquake to the present. Information on earthquake timing and per-event displacement is not available for most of Utah's more than 200 known Quaternary faults/fault segments, but it may be possible in some instances to calculate an open slip rate from a displaced geologic feature or unit of known or estimated age (e.g., geomorphic surfaces related to Lake Bonneville). Some slip rates determined in this manner may be very long term and incorporate very broad estimates of displacement (sometimes thousands of feet) over very long time intervals (sometimes millions of years). In those instances, the resulting open slip rates may represent a reasonable estimate of long-term slip on a fault, but most open slip rates contain large time and displacement uncertainties that make them broadly constrained estimates at best, and of questionable value for surface-faulting investigations.

As discussed above, there are numerous caveats to consider when using slip rate to characterize fault activity. If the slip rate comes from the geologic literature (see Sources of Paleoseismic Information section below), questions when evaluating the applicability of the slip rate for use in a surface-faulting investigation include: (1) Is the slip rate a vertical or net slip rate? (2) Is the slip rate open or closed? (3) If closed, over what period of time and how many closed recurrence intervals does the slip rate characterize fault activity? (4) If open, how well constrained are the timing and displacement data used to calculate the rate? (5) If open, does the slip rate reflect relevant (late Quaternary) fault activity (a slip rate calculated over several millions of years, as is sometimes done, may incorporate changes in a region's tectonic setting and be of little value when characterizing contemporary surface-faulting hazard)? Additionally, because displacement typically varies along a rupture, slip rate depends on where along the fault displacement is measured (i.e., lower slip rate at fault tips compared to center).

Where available, average displacement based on multiple site displacements is preferred when calculating a slip rate (e.g., DuRoss, 2008).

SOURCES OF PALEOSEISMIC INFORMATION

Detailed paleoseismic investigations of Utah Quaternary faults began in the 1970s and continue to the present day. The UGS has performed or assisted with numerous research paleoseismic investigations in Utah, and has published the results of many of those investigations in its *Paleoseismology of Utah* series (<https://geology.utah.gov/hazards/info/paleoseismology/>). The *Paleoseismology of Utah* series also includes compilations of early and now hard-to-find, "legacy" investigations and aerial photograph sets by Woodward-Lundgren and Associates (Bowman and others, 2015), the U.S. Bureau of Reclamation (Lund and others, 2011), the U.S. Soil Conservation Service (Bowman and others, 2011), and researchers funded through the National Earthquake Hazards Reduction Program (Bowman and Lund, 2013). Additionally, the Utah Quaternary Fault Parameters Working Group (UQFPWG, <https://geology.utah.gov/hazards/info/workshops/working-groups/q-faults/>) posts the results of their annual review of paleoseismic research conducted in Utah on the UGS website. Lund (2005) reported the results of the UQFPWG's initial evaluation of Utah paleoseismic trench data, and provided consensus recurrence-interval and vertical slip-rate parameters for Utah Quaternary faults with trenching data through 2004. Although superseded in some cases, the data for many faults in this compilation remain the best currently available. Lund (2014) revises and expands the Utah Hazus fault database to provide parameters for scenario earthquakes on all known Late Quaternary and younger faults/fault segments in Utah (82) thought capable of generating a $\geq M$ 6.75 earthquake.

The *Utah Quaternary Fault and Fold Database* (UGS, 2019) and the *Quaternary Fault and Fold Database of the United States* (USGS, 2019) contain summary paleoseismic information for Utah's known Quaternary faults. Both databases are periodically updated, although the national database may be updated less frequently than the Utah database. Therefore, Engineering Geologists conducting surface-faulting investigations should always search for the most recent paleoseismic information available for a Quaternary fault of interest. The paleoseismic data in the databases are reported as published in the geologic literature and are of variable quality—users must make their own evaluation of the data's suitability for their intended purpose. Additionally, the databases are limited to Utah's "known" Quaternary faults—other, as yet unrecognized, potentially hazardous faults may exist in Utah (e.g., McKean and Kirby, 2014), and Engineering Geologists performing surface-faulting investigations or hazard investigations for high-risk-category facilities regardless of location, should consider the possibility that an unrecognized fault may be present at or close to the site.

See the Literature Search and Information Resources section in chapter 2 for information on other geologic-hazard reports, maps, archives, and databases maintained by the UGS and others that may be relevant to surface-faulting-hazard investigations, as well as information on the UGS' extensive aerial photograph and light detection and ranging (lidar) imagery collections.

Finally, *Paleoseismology* (McCalpin, 2009) is a widely recognized general reference for conducting paleoseismic investigations and evaluating seismic risk. Much information contained in that publication is applicable to conducting site-specific, surface-faulting investigations for human-occupied structures and high-risk infrastructure.

SURFACE-FAULTING-HAZARD INVESTIGATION

When to Perform a Surface-Faulting-Hazard Investigation

Geologic hazards are best addressed prior to land development. In areas of known or suspected Quaternary faulting, the UGS recommends that a surface-faulting-hazard investigation be made for all new buildings for human occupancy and for modified IBC Risk Category II(a), II(b), III, and IV facilities (table 13, modified from IBC table 1604.5 [ICC, 2017a]). Utah jurisdictions that have adopted surface-faulting special-study maps identify zones along known hazardous faults within which they require a site-specific investigation. At a minimum, the UGS recommends that investigations as outlined in chapter 2 be conducted for all IBC Risk Category III and IV facilities, whether near a mapped Quaternary fault or not, to ensure that previously unknown faults are not present. If a hazard is found, the UGS recommends a comprehensive investigation be conducted. Additionally, in some instances an investigation may become necessary when existing infrastructure is discovered to be on or adjacent to a Quaternary fault.

The level of investigation conducted for a particular project depends on several factors, including (1) site-specific geologic conditions, (2) type of proposed or existing development, (3) level of acceptable risk, and (4) governmental permitting requirements, or regulatory agency rules and regulations. A surface-faulting-hazard investigation may be conducted separately, or as part of a comprehensive geologic-hazard and/or geotechnical site investigation (see chapter 2).

Minimum Qualifications of the Investigator

Surface-faulting related engineering-geology investigations and accompanying geologic-hazard evaluations performed

before the public shall be conducted by or under the direct supervision of a Utah licensed Professional Geologist (Utah Code, Title 58-76) who must sign and seal the final report. Often these investigations are interdisciplinary in nature, and where required, must be performed by qualified, experienced, Utah licensed Professional Geologists (PG, specializing in engineering geology) and Professional Engineers (PE, specializing in geological and/or geotechnical engineering) working as a team. See Investigator Qualifications section in chapter 2.

Investigation Methods

Inherent in surface-faulting investigations is the assumption that future faulting will recur along pre-existing faults (Bonilla, 1970; McCalpin, 1987, 2009; Kerr and others, 2003) in a manner generally consistent with past displacements (Schwartz and Coppersmith, 1984; Crone and others, 1987; DuRoss and others, 2014). In Utah, minimum requirements for an investigation designed to mitigate surface-faulting hazard by setting back from active (hazardous) faults are (1) determine whether a Quaternary fault(s) is present at a site, (2) map fault complexity, (3) determine the timing of the most recent surface-faulting earthquake, and (4) determine the amount and direction (dip) of past displacement. Where site geologic conditions and time and budget permit, the UGS recommends determining the timing and displacement of multiple paleoearthquakes so average earthquake recurrence and associated variability, and a fault slip rate can be calculated to better characterize fault activity. Fully characterizing past fault activity in this manner is a necessary requirement for engineering-design mitigation of surface faulting (see Paleoseismic Data Required for Engineering-Design Mitigation of Surface Faulting section below).

A site-specific surface-faulting investigation typically includes at a minimum (1) literature review, (2) analysis of stereoscopic aerial photographs and other remote-sensing data, and (3) field investigation, usually including surficial geologic mapping and subsurface investigations typically consisting of excavating and logging trenches (see chapter 2).

Literature Review

Prior to the start of field investigations, an Engineering Geologist conducting a surface-faulting investigation should review published and unpublished (if available) geologic literature, geologic and topographic maps, consultant's reports, and records relevant to the site and region's geology (see also the Literature Searches and Information Resources section in chapter 2), with particular emphasis on information pertaining to the presence and activity level of Quaternary faults. The Sources of Paleoseismic Information section in this chapter presents numerous sources of information on Utah's Quaternary faults; however, the list of sources is not exhaustive, and Engineering Geologists should identify and review all available information relevant to their site of interest.

Table 13. Fault setback recommendations and criticality factors (U) for modified IBC risk category of buildings and other structures (modified from ICC, 2017a, IBC table 1604.5)¹.

IBC Risk Category ²	Study and Fault Setback Recommendations ³ Fault Activity Classes			Criticality ⁴	U ⁴	Minimum Setback ⁵
	Holocene	Late Quaternary	Quaternary			
I—Buildings and other structures that represent a low hazard to human life in the event of failure	Optional	Optional	Optional	4	–	–
II(a)—Single family dwellings.	Recommended	Prudent	Optional	3	1.5	15 feet
II(b)—Buildings and other structures except those listed in Risk Categories I, II(a), III, and IV	Recommended	Recommended	Prudent	2	2	20 feet
III—Buildings and other structures that represent a substantial hazard to human lives in the event of failure	Recommended	Recommended	Recommended ⁶	1	3	50 feet
IV—Buildings and other structures designated as essential facilities	Recommended	Recommended	Recommended ⁶	1	3	50 feet

¹ See ICC (2017a) chapter 3, Use and Occupancy Classification (p. 45) and chapter 16, Structural Design, table 1604.5 (p. 364) for a complete list of structures/facilities included in each IBC Risk Category. Check table 1604.5 if a question exists regarding which Risk Category a structure falls under.

² For purposes of these guidelines, Risk Category II has been divided into subcategories II(a) and II(b) to reflect the lower hazard associated with single family dwellings and apartment complexes and condominiums with <10 dwelling units.

Risk Category I—includes but not limited to agricultural facilities, certain temporary facilities, and minor storage facilities.

Risk Category II(a)—single family dwellings;

Risk Category II(b)—buildings and other structures except those listed in Risk Categories I, II(a), III, and IV; includes but not limited to:

- a. many business, factory/industrial, and mercantile facilities;
- b. public assembly facilities with an occupant load ≤ 300 (e.g., theaters, concert halls, banquet halls, restaurants, community halls);
- c. adult education facilities such as colleges and universities with an occupant load ≤ 500 ;
- d. other residential facilities (e.g., boarding houses, hotels, motels, care facilities, dormitories with >10 dwelling units).

Risk Category III—includes but not limited to:

- a. public assembly facilities with an occupant load > 300, schools (elementary, secondary, day care);
- b. adult education facilities such as colleges and universities with an occupant load > 500;
- c. Group I-2 occupancies (medical facilities without surgery or emergency treatment facilities) with an occupant load > 50;
- d. Group I-3 occupancies (detention facilities for example jails, prisons, reformatories) with an occupant load > 5;
- e. any other occupancy with an occupant load > 5000;
- f. power-generating stations, water treatment plants, wastewater treatment facilities and other public utility functions not included in risk category IV;
- g. buildings and other structures not included in risk category IV that contain quantities of toxic or explosive materials.

Risk Category IV—includes but not limited to:

- a. Group I-2 occupancies having surgery or emergency treatment facilities;
- b. fire, rescue, ambulance, and police stations and emergency vehicle garages;
- c. designated emergency shelters; emergency preparedness, communication, and operations centers and other facilities required for emergency response;
- d. power-generating stations and other public utility facilities required as emergency backup facilities for Risk Category IV structures;
- e. buildings and other structures containing quantities of highly toxic materials;
- f. aviation control towers, air traffic control centers, and emergency aircraft hangars;
- g. buildings and other structures having critical national defense functions;
- h. water storage facilities and pump structures required to maintain water pressure for fire suppression.

³ Study and setback or other risk-reduction measure:

- a. Recommended;
- b. Prudent, but decision should be based on risk assessment; or
- c. Optional, but need not be required by local government based on the low likelihood of surface faulting.

Appropriate disclosure is recommended in all cases.

⁴ Criticality is a factor based on relative importance and risk posed by a building; lower numbers indicate more critical facilities. Criticality is included in fault-setback equations by the factor U. U is inversely proportional to criticality to increase fault setbacks for more critical facilities.

⁵ Use minimum fault setback or the calculated fault setback, whichever is greater.

⁶ Study recommended; fault setback or other risk-reduction measure considered prudent, but decision should be based on risk assessment; appropriate disclosure recommended.

Analysis of Aerial Photographs and Remote Sensing Data

A surface-faulting investigation should include interpretation of stereoscopic aerial photographs (from multiple years if available), lidar imagery (appendix C—Lidar Background and Application), and other remotely sensed data (e.g., Bunds and others, 2015) for evidence of past surface faulting including fault scarps, other fault-related geomorphic features, and fault-related lineaments, including vegetation lineaments, gullies, vegetation/soil contrasts, and aligned springs and seeps (see also the Literature Searches and Information Resources section of chapter 2). Where possible, the analysis should include both low-sun-angle and normal high-sun-angle stereoscopic aerial photography. Examination of the oldest available aerial photographs may show evidence of surface faulting subsequently obscured by later development or other ground disturbance. The area interpreted should extend beyond the site boundaries to identify faults that might affect the site and to adequately characterize patterns of surface faulting.

Google Earth and Bing Maps, among other providers of Internet-based, free aerial imagery, are becoming increasingly valuable as rapid site reconnaissance tools, and provide high-resolution, often color, non-stereoscopic aerial orthophotography of the entire state of Utah. For most locations, Google Earth also includes a historical imagery archive that permits evaluation of site conditions several years to decades before present.

Fault Mapping

Surface faulting can be a complex phenomenon involving both brittle fracture and plastic deformation (Treiman, 2010). The most direct surface method for locating faults and evaluating fault activity is to map fault scarps and surficial geology. Faults may be identified by examining geologic maps, aerial photographs and other remote-sensing imagery, and by directly observing fault-related geomorphic features. Topographic profiling of fault scarps can aid in estimating the number, age, and displacement of past surface-faulting earthquakes (Bucknam and Anderson, 1979; Andrews and Bucknam, 1987; Hanks and Andrews, 1989; Machette, 1989; Hylland, 2007; McCalpin, 2009). Detailed mapping helps identify fault scarps and other fault-related features such as sag ponds, springs, aligned or disrupted drainages, faceted spurs, grabens, and displaced landforms (e.g., terraces, shorelines) and/or geologic units. Site-specific surficial geologic mapping depicts relations between faults and geologic units to help determine the location and age of faults, and is necessary to identify potential trench locations. The area mapped should extend beyond the site boundaries as necessary to locate and evaluate evidence of other faults that may affect the site.

Special care is required when investigating faults that cross landslides. Geomorphic and subsurface features in fault zones and landslides may be similar, and investigations may be inconclusive regarding the origin of such features (e.g., Hart and others, 2012; Crone and others, 2014; Hoopes and others, 2014). Therefore, report conclusions should address uncertainties in the investigation, and recommendations for hazard reduction should consider both fault and landslide hazards when present.

See the Geologic Mapping section of chapter 2 for additional discussion on geologic mapping as it applies to geologic-hazard investigations.

Trenching

Trenching is generally required for surface-faulting investigations to accurately locate faults, determine paleoearthquake timing, document the nature and extent of rupture complexity, and measure fault displacements and orientations (Taylor and Cluff, 1973; Hathaway and Leighton, 1979; Slemmons and dePolo, 1992; Price, 1998; California Geological Survey, 2002; McCalpin, 2009; DuRoss, 2015). Trenches across normal faults are usually excavated perpendicular to the fault scarp. Because fault displacement may vary along strike, the investigation should determine the maximum displacement(s) along the fault trace(s) within the part of the site to be developed, and at least one trench should be excavated across the highest part of each scarp.

Zones of deformation are common along major normal fault traces (figure 11). Such deformation typically consists of a graben or multiple discrete displacements on secondary faults. The trench investigation should define the width of the deformation zone, and for sites in a graben, trenches should be excavated perpendicular to the bounding faults across the entire part of the site within the graben to investigate for faults and/or shears in the graben floor. Ground deformation in the absence of surface faulting may occur above buried normal faults. In those instances, trenching should extend across the entire deformation zone such that the deformation can be adequately documented and characterized.

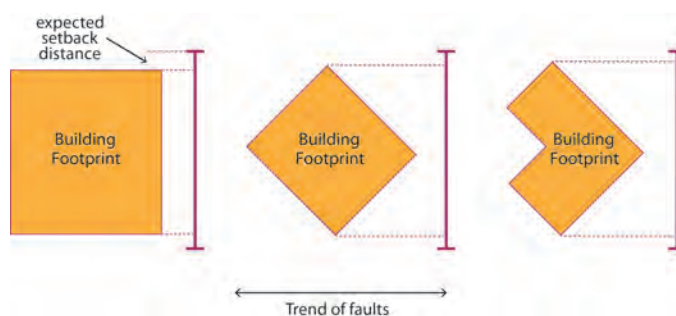


Figure 15. Fault trench length and orientation to investigate a building footprint. Trenching must extend beyond the footprint of at least the expected setback distance for the IBC Building Risk Category class (from Christenson and others, 2003).

Trench number and location: The purpose of a trenching investigation and objectives in locating trenches may vary depending on the type of development and project design phase during which the investigation is performed. When investigations are performed prior to site design, such as for multi-unit subdivisions, commercial development, etc., trenches are used to locate faults and recommend risk-mitigation measures to aid in project design. When investigations are performed after building locations have been laid out or structures already constructed and subsequently found to be on or near a hazardous fault, trenches may be used to identify faults trending through building footprints (figure 15). Trenches should be oriented perpendicular, or as close to perpendicular as possible, to the trend of the mapped fault trace at or near the site, and be of adequate length to intercept faults projecting toward proposed or existing structures and potential setback areas. In some instances, placing trenches off-site on adjacent or nearby properties may be necessary to adequately characterize the hazard.

More than one trench may be necessary to investigate a site or building footprint, particularly when the proposed development is large, involves more than one building, and/or is characterized by complex faulting (figure 16). Trenches should provide continuous coverage across a site (one trench or overlapping trenches; figure 17). Geologic mapping (figure 11) and paleoseismic trenching (see publications in the UGS Paleoseismology of Utah series) have shown that patterns of ground deformation resulting from past surface faulting on normal faults in Utah are highly variable, and may change significantly over short distances along the strike of the fault. While a single trench provides data at a specific fault location, multiple trenches are often required to characterize along-strike variability of the fault and provide a more comprehensive understanding of faulting at the site. For that reason, the UGS recommends that subsurface data generally not be extrapolated more than 300 feet without additional subsurface information. Complex fault zones may require closer trench spacing. When

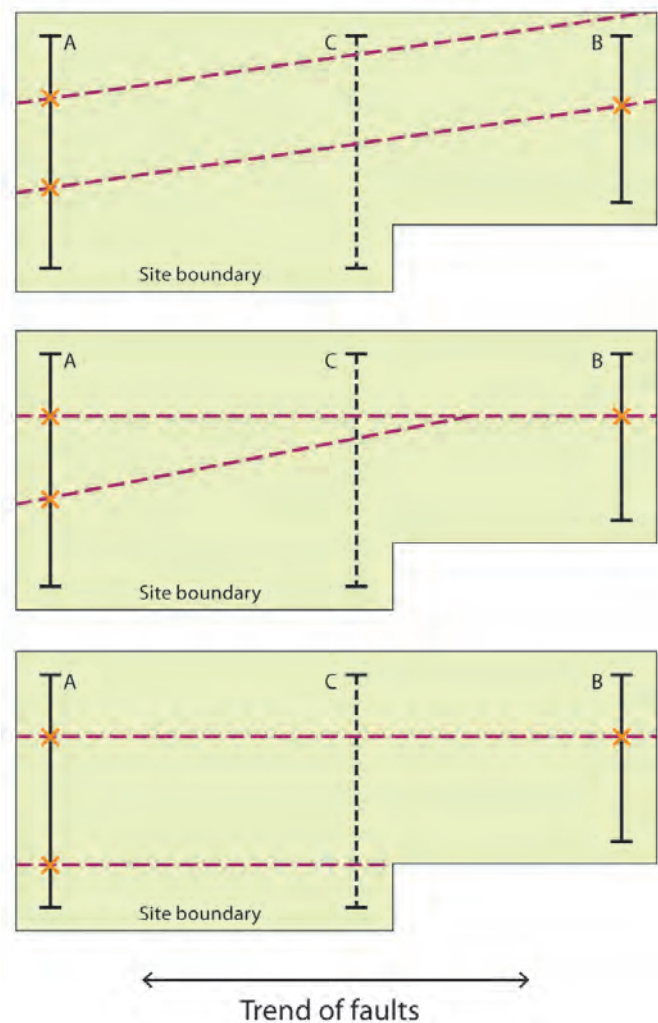


Figure 16. Three possible fault configurations (dashed lines) from fault exposures (x) in only two trenches (A and B) showing the need to measure fault orientation and excavate additional trenches (C) to clarify fault-trend geometry, particularly when fault traces are not mappable at the surface (from Christenson and others, 2003).

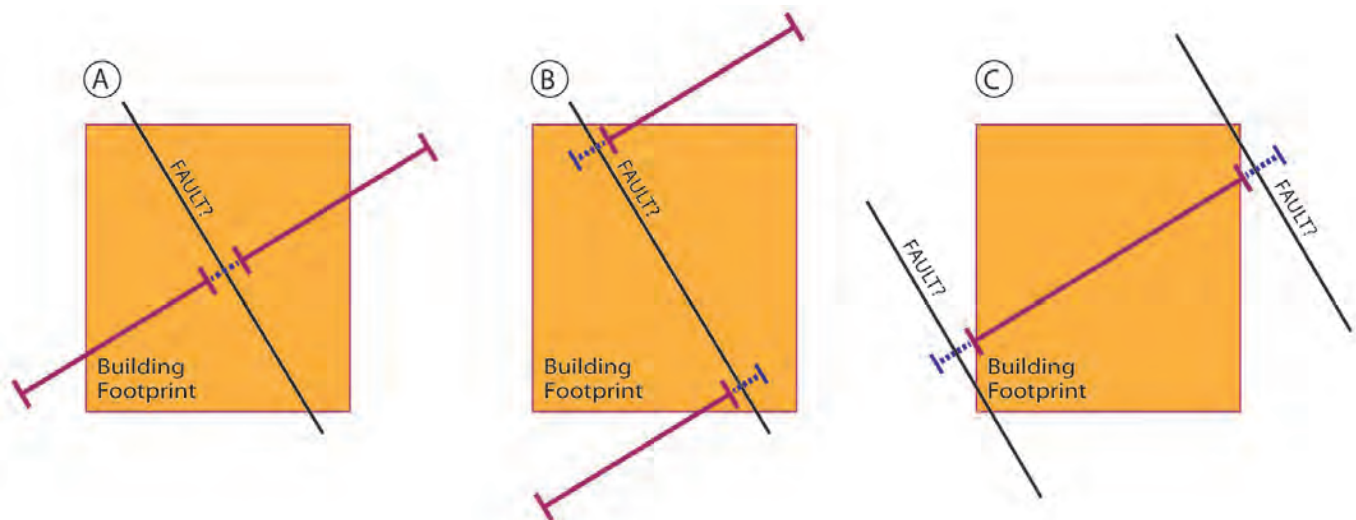


Figure 17. Potential problems caused by improper trench locations: (A) gap between trenches, (B) trenches without adequate overlap, and (C) trench does not fully cover building footprint given fault trend. Dashed lines indicate additional trench length needed (from Christenson and others, 2003).

trenches must be offset to accommodate site conditions, sufficient overlap should be provided to avoid gaps in trench coverage. Tightly spaced trenches may only need minor (a few tens of feet) overlap; however, more widely spaced trenches require greater overlap to ensure continuous site coverage. Care should be taken not to offset trenches at a common surficial feature that could be related to prehistoric surface faulting (e.g., a change in surface slope across the site).

Test pits may provide some useful information regarding subsurface site conditions; however, they are not an acceptable alternative to trenches for evaluating surface-faulting hazard. A series of aligned test pits perpendicular to the fault trend may help locate a main fault trace, but cannot conclusively demonstrate the presence or absence of faulting because faults trending between test pits would not be exposed.

Trenches and faults should be accurately located on site plans and fault maps. The UGS recommends that trenches and faults (projected to the ground surface) be surveyed rather than located using a hand-held GPS device.

Trench depth: Trenches should at a minimum be deep enough to expose (1) native, undisturbed geologic units, (2) evidence of the most recent surface faulting, and (3) all relevant aspects of fault geometry (dip, width of shear zones and grabens, and subsidiary hanging-wall and footwall faults). Ideally, to demonstrate a lack of faulting, trenches should extend to the base of Holocene deposits (for Holocene faults), late Quaternary deposits (for late Quaternary faults), and Quaternary deposits (for Quaternary faults). Each site and fault is unique and exceptions are possible, but in general, one recurrence interval (time between the most recent and penultimate surface-faulting earthquakes) is not sufficient to characterize surface-faulting recurrence or estimate the probability of the next surface-faulting earthquake. Therefore, where engineering-design is proposed to mitigate surface faulting and additional information on past earthquake displacement and timing is required for design purposes, deeper trenches may be necessary to adequately characterize the fault's earthquake history.

Where the maximum trench depth achievable, generally 12 to 15 feet, is not sufficient to adequately characterize past fault activity, and a potentially hazardous fault may be concealed by unfaulted younger deposits, the practical limitations of trenching should be acknowledged in the report and uncertainties should be reflected in report conclusions and recommendations. In cases where an otherwise well-defined hazardous fault is buried too deeply at a particular site to be exposed in trenches, the uncertainty in its location can be addressed by increasing fault setback distances along a projected trace (see Hazardous Fault Avoidance section below).

Trench investigations should be performed in compliance with current Occupational Safety and Health Administration (OSHA) excavation safety regulations and standards

(<http://www.osha.gov/SLTC/trenchingexcavation/construction.html>) (see chapter 2, Excavation Safety section). Additionally, for some projects, the design engineer may want trenches to be backfilled as engineered (compacted) fill to avoid future soil settlement.

Trench logging and interpretation: In preparation for logging, trench walls should be carefully cleaned to permit direct observation of the geology. Trenches should be logged at a minimum scale of 1 inch equals 5 feet (1:60); in some instances, small but important features may be best documented with local detailed logs at larger scale (e.g., 1 inch = 1 foot [1:12]). All logs should be prepared in the field under the direct supervision of an experienced Utah licensed Professional Geologist. Vertical and horizontal logging control should be used and shown on the log. The logs should not be generalized or diagrammatic, and may be on a rectified photomosaic base. The log should document all pertinent information from the trench (e.g., Birkeland and others, 1991; U.S. Bureau of Reclamation, 1998b; Walker and Cohen, 2006; McCalpin, 2009; DuRoss, 2015), including:

- Trench and test-pit orientation and indication of which wall was logged
- Horizontal and vertical control
- Top and bottom of trench wall(s)
- Stratigraphic contacts
- Detailed lithology and soil classification and descriptions
- Contact descriptions
- Pedogenic soil horizons
- Marker beds
- Fissures and faults
- Fissure and fault orientations and geometry (strike and dip)
- Fault displacement
- Sample locations

Geochronology: The Engineering Geologist interprets the ages of sediments exposed in a trench to determine the timing of past surface faulting. In the Bonneville basin of northwestern Utah, the relation of deposits to latest Pleistocene Bonneville lake-cycle chronology (Gilbert, 1890; Currey, 1982, 1990; Currey and others, 1988; Oviatt and others, 1992; Godsey and others, 2005, 2011; Benson and others, 2011; Janecke and Oaks, 2011; Hylland and others, 2012; Miller and others, 2013; Oviatt, 2015) is commonly used to infer ages of sediments, and thus estimate the timing of surface faulting. The same is also true for Pleistocene-age glacial deposits found at the mouths of some Wasatch Range canyons. For example, unfaulted Lake Bonneville highstand sediments or glacial deposits in a trench provide evidence that faulting has not occurred at that site since the latest Pleistocene (past ~14 to 18 kyr). However, outside the Lake Bonneville basin, and within

the basin above the highest lake shoreline, determining the age of surficial deposits is less straightforward and commonly requires advanced knowledge of local Quaternary stratigraphy and geomorphology, and familiarity with geochronologic dating methods.

At sites lacking deposits of known age, a variety of geochronologic methods are available to determine the age of deposits and constrain the timing of past surface faulting (see Geochronology section, chapter 2). Engineering Geologists conducting surface-faulting investigations in Utah should have a proficient working knowledge of useful and commonly applied geochronologic techniques (see chapter 2, table 4). That knowledge must extend to evaluating sources of age uncertainty, in particular sample context uncertainty, and the proper protocols for collecting and handling samples to preserve sample integrity and prevent contamination. In instances where geochronologic data are critical to surface-faulting investigation and project design, the investigation may benefit from retaining an expert in the application and interpretation of geochronologic methodologies.

Numerical dating methods may include, but are not limited to, radiocarbon, optically stimulated luminescence and other luminescence techniques, $^{39}\text{Ar}/^{40}\text{Ar}$, K-Ar, tephrochronology, dendrochronology, and cosmogenic isotopes (Curtis, 1981; Forman, 1989; Noller and others, 2000; McCalpin, 2009; Gray and others, 2015). Relative dating techniques may be applied (but not limited) to, soil (pedogenic) profile development, slope morphometric dating, stratigraphic relations, relative geomorphic position, and fossils (Forman, 1989; Birkeland and others, 1991; Noller and others, 2000; McCalpin, 2009).

Other Subsurface Investigation Methods

Other investigation methods, such as cone penetrometer test soundings, boreholes, and geophysical techniques, can supplement trenching and extend the depth of investigation. The same depth relations for Holocene, late Quaternary, and Quaternary faults as described for trenching also apply to these other subsurface investigation methods.

Cone penetrometer test soundings: Although an indirect investigation method, cone penetrometer test (CPT) soundings are in some circumstances an applicable investigative method for evaluating the presence of faults where trenching is either not possible, or the deposits of interest are too thick to investigate with a trench. CPT soundings permit collection of data on geologic units and groundwater, and in some instances, can identify offset in geologic units indicative of faulting. The number and spacing of CPT soundings should be sufficient to reliably interpret site stratigraphy, correlations, and interpretations.

Boreholes: Boreholes are useful for general characterization of subsurface site conditions (e.g., geologic units, groundwater) where Quaternary faults are present, particularly where

trenching is not possible. However, vertical boreholes generally do not provide sufficient resolution to confidently identify and characterize subsurface faults, and seldom can prove the presence or absence of a fault or determine the time of faulting. Better results identifying faults may be obtained where directional drilling and sampling are possible. However, continuous core and other sampling methods rarely yield 100 percent recovery, and may miss faults. Therefore, boreholes should only be used to supplement other subsurface investigation methods, or be utilized when no other method of subsurface investigation is feasible. When used, boreholes should be sufficient in number and adequately spaced to permit reliable correlations and interpretations.

Geophysical investigations: Geophysical investigations are indirect, non-destructive methods that can be reliably interpreted when site-specific surface and subsurface geologic conditions are known. Geophysical methods should seldom be employed without knowledge of site geology; however, where no other subsurface geologic information is available, geophysical methods may provide the only economically viable means to perform deep geologic reconnaissance (e.g., Chase and Chapman, 1976; Telford and others, 1990; Sharma, 1998; U.S. Bureau of Reclamation, 2001; Milsom and Erikson, 2011; Reynolds, 2011).

Although geophysical methods may detect the presence and location of shallow fault planes, such methods alone never prove the absence of a fault at depth or the time (age) of faulting. Geophysical methods can provide critical stratigraphic information on both basin-fill and bedrock units that may not otherwise be available. Geophysical techniques used may include, but are not limited to, high-resolution seismic reflection, high-resolution seismic tomography, ground penetrating radar, seismic refraction, magnetic profiling, electrical resistivity, and gravity.

Special Cases

Sub-Lacustrine Faults: Quaternary-active normal faults are present beneath Great Salt Lake (Great Salt Lake fault zone and the Carrington fault), Utah Lake (Utah Lake faults), and Bear Lake (West Bear Lake fault, southern section). Currently, there are no known subaerial exposures of the Great Salt Lake, Carrington, and Utah Lake faults. The Great Salt Lake, Carrington, and Utah Lake faults were identified and their lengths and segmentation defined based on geophysical investigations (Mikulich and Smith, 1974; Cook and others, 1980; Viveiros, 1986; Mahapatre and Johnson, 1998; Dinter and Pechmann, 2000, 2005; Colman and others, 2002; Dinter, 2015).

The southern section of the West Bear Lake fault is mapped as mostly submerged along its trace in Utah, but the central and northern sections of the fault are exposed subaerially in Idaho (McCalpin, 2003). McCalpin (2003) trenched the central section but provided no data for the southern section.

Additionally, McCalpin (2003) noted seismic profiling by Colman (2001) that imaged secondary normal faults west of the East Bear Lake fault beneath the lake, and many of these faults show progressively increasing throw with depth and age. Several faults reportedly cut the youngest sediments in the lake, as well as the modern lake floor (Colman, 2001).

Paleoseismic evidence (including stratigraphic displacements, subsidiary fault terminations, and differential tilting) interpreted from high-resolution seismic reflection profiles show that the Great Salt Lake fault zone consists of four seismically independent segments. Radiocarbon ages from event horizons sampled in drill cores indicate at least three large surface-faulting earthquakes have occurred on each of these segments in the past 12 kyr (Dinter and Pechmann, 2000, 2005, 2014, 2015). The Carrington fault is less well studied, but is ~19 miles long with scarps as high as 5 feet. Earthquake times are unconstrained on the Carrington fault, but based on similarities of other lakebed scarps, the slip rate and recurrence interval of the Carrington fault are thought to be similar to the segments of the Great Salt Lake fault zone (WGUEP, 2016).

The Utah Lake faults are a complex system of east- and west-dipping normal faults. Seismic reflection profiles suggest that as many as eight surface-rupturing, north-striking faults displace very young lake sediments 3 to 10 feet (Dinter, 2015). Because these faults occupy a similar hanging-wall position in relation to the Provo segment of the Wasatch fault zone as does the West Valley fault zone to the Salt Lake City segment of the Wasatch fault zone, best available information for the West Valley fault zone is currently used as an analog for the Utah Lake faults.

McCalpin (2003) arbitrarily subdivided the West Bear Lake fault into three geometric sections (north, central, and south) by placing section boundaries along the fault at the same latitude as the section boundaries he established for the East Bear Lake fault. McCalpin (2003) established the section boundaries of the East Bear Lake fault based on the gross morphology of the Bear Lake valley, because he lacked sufficient paleoseismic data for either fault to establish seismogenic fault segments. The southern section of the West Bear Lake fault is exposed in rare cuts, such as the roadcut on U.S. 30 east of Pickleville, Utah. McCalpin (2003) states the linear western shore of Bear Lake south of Pickleville is probably controlled by a fault, although he noted the seismic profile of Skeen (1976; McCalpin [2003], figure 8) does not depict a fault projecting northward at that location.

In summary, McCalpin (2003) concluded the southern section of the West Bear Lake fault requires additional fieldwork to locate fault strands, especially any strands submerged beneath Bear Lake. He further concluded investigating submerged fault traces would require specialized offshore paleoseismic techniques and that “perhaps it would be better to start by mapping any on-land fault traces before going offshore.”

Based on available evidence, faults beneath Great Salt Lake, Utah Lake, and Bear Lake are potential sources of large earthquakes. Although subaerial exposures have not yet been verified, careful investigation of surface faulting remains prudent for projects proposed in areas where faults beneath Great Salt Lake, Utah Lake, and Bear Lake project onshore. If evidence of surface faulting is found, a subsurface investigation should be conducted to fully characterize the surface-faulting hazard.

Additionally, future surface faulting on these faults could generate a tsunami and/or seiche, potentially damaging facilities and infrastructure on or near the lakeshore, along with flooding associated with coseismic tilting of the lakebed.

Grabens: Coseismic antithetic faulting may form grabens along all or part of the length of Quaternary-age normal faults during surface-faulting earthquakes. Grabens may range from a few to tens of feet or more wide (see Rupture Complexity section). Where a site proposed for development is known or suspected to be within a graben, the site-specific surface-fault-rupture-hazard investigation should characterize all faults within the boundaries of the site that may pose a surface-fault-rupture hazard to the proposed development (i.e., synthetic and antithetic faults, including faults within the graben floor).

From a surface-faulting-hazard perspective, the site is suitable for development if results of a site-specific surface-fault-rupture-hazard investigation determine no hazardous faults (see table 13 and Fault Activity Classes section) impact the proposed development, including meeting setback criteria for fault avoidance (see Fault Setbacks section, which includes a graben example) and considering any deep foundations.

Surface faulting may subject structures within a graben to coseismic displacement and ground tilting from the main and antithetic faults. Designing structures to withstand the effects of coseismic, near-field surface faulting on multiple faults is the responsibility of the geotechnical and structural engineers. The geologist conducting a site-specific surface-faulting-hazard investigation is responsible for providing the structural design team, to the extent possible, with quantified data (which is largely controlled by the site location within the graben) on fault displacement and ground tilting, such that safe building designs are possible. However, if the main and principal antithetic graben-bounding faults do not lie within the boundaries of the site investigated, it is incumbent on the design team, depending on the criticality of the structure and/or development, to complete a supplemental investigation of those faults to characterize the extent of possible coseismic faulting and tilting that may occur within the graben during a future surface-faulting earthquake.

When data on coseismic displacement and ground tilting within a graben cannot be obtained from a surface-faulting-hazard investigation, it may be possible to provide estimates of displacement and ground tilting from a nearby site(s) or published data. The practical limitations of such data and rec-

ommendations that clearly reflect the resulting uncertainties should be acknowledged in the report.

SURFACE-FAULTING MITIGATION

Background

Municipal and county geologic-hazard ordinances in Utah use the term “active” fault as a synonym for “hazardous,” and typically define activity (relative hazard) by applying an age criterion: “active” faults have evidence of displacement during the Holocene (approximately the past 11,700 years). The Holocene criterion has precedence, principally from past application in California for implementing the Alquist-Priolo Earthquake Zoning Act (Bryant, 2010; Tepel, 2010; California Geological Survey, 2011b, 2013), and in the Western States Seismic Policy Council’s (WSSPC) definitions of fault activity categories in the Basin and Range Province (WSSPC, 2011). However, several historical surface-faulting earthquakes in the Basin and Range Province occurred on normal faults with no evidence of previous Holocene activity (Walter, 1934; Bull and Pearthree, 1988; Bell and Katzer, 1990; Pearthree, 1990; Bell and others, 2004; Caskey and others, 2004; Suter, 2006; Wesnousky, 2008). Those earthquakes demonstrate that a single Holocene criterion is not sufficient to identify potentially hazardous faults in the interior western United States that may produce future surface faulting in a time frame relevant to land-use management and regulation.

Until recently (e.g., Bray 2001, 2009a, 2009b, 2015), designing a structure to withstand fault displacement at the ground surface was generally considered impractical. For that reason, the standard of practice in Utah has been to avoid construction on active faults by locating the fault and setting back a prescribed distance from it (Christenson and others, 2003). However, since the release of the Christenson and others (2003) guidelines, some Utah jurisdictions have adopted ordinances that permit construction across active faults that show ≤ 4 inches of displacement. Additionally, under a special “Review Protocol” the City of Draper (2005) permits “super-engineering” of foundations under limited circumstances (Dobbins and Simon, 2015) to mitigate surface-faulting displacements that are greater than the 4 inches permitted in the city’s current geologic-hazard ordinance. Super-engineered foundations designed to accommodate as much as 6 feet of vertical displacement have been approved by the City of Draper (David Dobbins, Draper City Manager, verbal communication, 2015).

Considering the limited paleoseismic data available for most Utah Quaternary faults, and the length of their surface-faulting recurrence intervals (typically hundreds to thousands of years), the UGS considers fault setback and avoidance the safest and most effective surface-faulting-mitigation option for most Utah faults. However, recognizing that engineering-design mitigation of surface faulting is now permitted by some Utah jurisdictions, these guidelines include a review of the fault

parameter data required to fully characterize past fault activity, and recommendations regarding the kind and amount of paleoseismic data necessary for engineering-design mitigation of surface faulting (see Paleoseismic Data Required for Engineering-Design Mitigation of Surface Faulting section below).

Additionally, discussion has begun in Utah (UQFPWG, 2013; Lund, 2015) and elsewhere (e.g., Shlemon, 2010, 2015; Gath, 2015) regarding the appropriateness of using the long time interval represented by the Holocene for evaluating surface-faulting hazard. The Hazardous Fault Criteria section below discusses this issue relative to Utah’s normal-slip faults, and provides recommendations for the kind of information on past earthquake timing necessary for implementing data-driven decisions regarding surface-faulting mitigation.

Surface-Faulting Special-Study Maps

As a critical first step to ensure that surface-faulting hazard is adequately addressed in land-use planning and regulation, local governments should adopt surface-faulting special-study maps published by the UGS which define areas within which a surface-faulting investigation is required prior to development (figure 10). The UGS has prepared or assisted with preparation of surface-faulting special-study maps for Cache, Davis, Iron, Salt Lake, eastern Tooele, Utah, western Wasatch, and Weber Counties (on file with the respective municipal and county planning departments). Similar UGS special-study-area maps are available for the St. George-Hurricane metropolitan area (Lund and others, 2008), high-visitation areas in Zion National Park (Lund and others, 2010), the Magna and Copperton 7.5-minute quadrangle areas in Salt Lake Valley (Castleton and others, 2011, 2014), and the State Route 9 corridor between La Verkin and Springdale (Knudsen and Lund, 2013). The UGS is conducting a long-term, geologic-hazard-mapping initiative to prepare geologic-hazard-map sets for select 7.5-minute quadrangles in Utah (Castleton and McKean, 2012). Where Quaternary faults are present, these hazard-map sets will include surface-faulting special-study maps (e.g., Castleton and others, 2011).

The UGS recommends that the width of special-study areas defined along faults vary depending upon whether a fault is well defined (Bryant and Hart, 2007), approximately located, or buried. The trace of a well-defined fault is clearly detectable as a physical feature at the ground surface (typically shown as a solid line on a geologic map) by a geologist qualified to conduct surface-faulting investigations. For a well-defined fault, the UGS recommends that special-study areas extend horizontally 500 feet on the downthrown side and 250 feet on the upthrown side of mapped fault traces or the outermost faults in a fault zone (figure 10; e.g., Lund and others, 2008, 2010; Castleton and others, 2011, 2014; Knudsen and Lund, 2013). In areas of high scarps where 250 feet on the upthrown side does not extend to the top of the scarp, the UGS recommends that the special-study area increase to 500 feet on the

upthrown side (Robison, 1993). An approximately located or buried fault is not evident at the ground surface for a significant distance, and is typically shown as a dashed line for approximately located faults and as a dotted line for buried faults on a geologic map. The UGS recommends that special-study areas for approximately located or buried faults extend horizontally 1000 feet on either side of the estimated fault location (e.g., Lund and others, 2008, 2010; Castleton and others, 2011, 2014; Knudsen and Lund, 2013).

Where special-study-area maps are not available, the first step in a surface-faulting investigation is to determine if the site is near a mapped Quaternary fault (see discussion of the *Quaternary Fault and Fold Database of the United States* [USGS, 2019] and *Utah Quaternary Fault and Fold Database* [UGS, 2019] in the Sources of Paleoseismic Information section above). If so, existing larger scale maps (if available) should be examined, aerial photographs and other remote-sensing data interpreted, and field investigations performed to produce detailed geologic maps as outlined in these guidelines to determine whether the fault is within 500 feet of the site if the fault is well defined, or within 1000 feet if the fault is approximately located or buried. If faults are found or suspected within these distances, the UGS recommends trenching or other subsurface investigations as outlined in these guidelines. Also, investigations as outlined in the Surface-Faulting-Hazard Investigation section should be conducted for all IBC Risk Category III and IV facilities (ICC, 2017a), whether near a mapped Quaternary fault or not, to ensure that previously unknown faults are not present. If evidence for a fault is found, the UGS recommends a subsurface investigation. See also the Engineering-Geology Investigations section of chapter 2 for additional information on performing geologic-hazard field investigations.

Hazardous Fault Avoidance

Utah's Quaternary faults exhibit a wide range of recurrence intervals and slip rates. Ideally, decisions regarding the need to mitigate surface faulting should be based on a risk assessment that considers the time of the most recent surface faulting and the average recurrence interval between previous surface-faulting earthquakes to determine the probability of surface faulting within a future time frame of interest (see Characterizing Fault Activity section above). However, with the possible exception of the five central, Holocene-active segments of the Wasatch fault zone (DuRoss and Hylland, 2015; DuRoss and others, 2016; WGUEP, 2016), available paleoseismic data for faults in Utah are generally insufficient to make such data-based risk determinations, and the ability to acquire the new earthquake timing, recurrence, and displacement data necessary to do so may be limited by site geologic conditions, property access, and/or budget and time constraints. Additionally, the natural variability of fault behavior (aleatory variability) and the uncertainty resulting from lack of necessary data to characterize fault activity (epistemic uncertainty) may combine to preclude the confident determination of the probability of future earthquake timing, displacement, and rupture complexity at a site. Therefore, setting back from and thereby avoiding poten-

tially hazardous faults is often the most technically feasible and effective method to mitigate surface faulting. It is also the most satisfactory and safest (conservative) long-term solution for both current and future land owners, since the hazard is avoided regardless of the timing of the next surface-faulting earthquake. For those reasons, avoidance is the principal surface-faulting risk-mitigation technique specified by geologic-hazard ordinances in Utah, and the UGS considers avoidance the safest long-term surface-faulting mitigation option presently available.

Fault Activity Classes

A fault avoidance mitigation strategy relies on a "time-of-most-recent-rupture" fault activity classification to identify active (hazardous) faults for which avoidance is deemed necessary. The previous version of these guidelines (Christenson and others, 2003) adopted the then-current fault activity class definitions for the Basin and Range Province proposed by WSSPC (<https://www.wsspc.org/>). Those definitions were first adopted by WSSPC in 1997, and evolved through subsequent revisions in 2005, 2008, 2011, and 2018. Beginning in 2011, the policy recommendation included a substantial change to the fault activity class definition for the Quaternary to comply with revisions to the *Global Chronostratigraphical Correlation Table for the Last 2.7 Million Years*, v. 2010 (International Commission on Stratigraphy, 2009; Cohen and Gibbard, 2010). These revisions redefined the lower boundary of the Quaternary from 1.8 to ~2.6 (actual 2.588) Ma. In compliance with the new standard (now generally accepted within the international geologic community), the UGS adopted 2.6 Ma as the lower boundary for the Quaternary for the *Utah Quaternary Fault and Fold Database*. Conversely, the USGS for purposes of seismic-hazard analysis continues to define the base of the Quaternary as 1.6 Ma in the *Quaternary Fault and Fold Database of the United States* (the USGS has adopted 2.6 Ma for other purposes). It is beyond the scope of these guidelines to resolve this discrepancy; the UGS recommends that both fault databases be consulted when performing a surface-faulting investigation.

For the purpose of these guidelines, the UGS follows the WSSPC (2018) definitions of fault activity classes:

- Late Pleistocene-Holocene fault – a fault whose movement in the past 15,000 years before present has been large enough to break the ground surface.
- Late Quaternary fault – a fault whose movement in the past 130,000 years before present has been large enough to break the ground surface.
- Quaternary fault – a fault whose movement in the past 2.6 million years before present has been large enough to break the ground surface.

The last two classes are inclusive; that is, Holocene faults are included within the definition of Late Quaternary faults, and both Holocene and Late Quaternary faults are included in Quaternary faults. The activity class of a fault is the youngest class

based on the demonstrated age of most recent surface faulting. The UGS recommends that in the absence of information to the contrary, all Quaternary faults be considered Holocene unless there are adequate data to confidently assign them to the Late Quaternary or Quaternary activity class.

The *Quaternary Fault and Fold Database of the United States* (USGS, 2019) and the *Utah Quaternary Fault and Fold Database* (UGS, 2019) summarize existing fault data for known Utah Quaternary faults, and estimate the timing of most recent surface faulting. However, neither fault compilation was prepared for use in assigning activity classes for land-use planning and regulation. The timing reported for the most recent surface faulting represents best (non-conservative) age estimates based on data in existing studies. These estimates, particularly for many pre-Holocene faults, typically are based on limited reconnaissance studies and are not adequate to determine activity classes to assess the need for site-specific surface-faulting investigations. Additionally, while the databases are periodically updated, new information for a fault may become available that has not yet been incorporated into the databases. It is the responsibility of the Engineering Geologist performing a surface-faulting investigation to ensure that all sources of paleoseismic data available for a site have been identified and reviewed.

Investigation Recommendations

When avoidance using fault setback is the risk-mitigation option selected, the UGS recommends that surface-faulting investigations be performed based on the modified IBC Risk Categories shown in table 13 and the following WSSPC (2018) fault activity classes:

- **Holocene faults** – recommended for all structures for human occupancy and all IBC Risk Category II(a), II(b), III, and IV structures.
- **Late Quaternary faults** – recommended for all IBC Risk Category II(b), III, and IV structures. Investigations for IBC Risk Category II(a) and other structures for human occupancy remain prudent, but local governments should base decisions on an assessment of whether risk-reduction measures are justified by weighing the probability of occurrence against the risk to lives and potential economic loss. Earthquake risk-assessment techniques are summarized by Reiter (1990), Yeats and others (1997), and McCalpin (2009).
- **Quaternary faults** – investigations are recommended for all IBC Risk Category III and IV structures. Investigations for IBC Risk Category II(b) structures and other structures for human occupancy remain prudent because a low likelihood of surface faulting still exists.

As noted above, the UGS recommends that in the absence of information to the contrary, all Quaternary faults be considered Holocene unless there are data to confidently assign them to a Late Quaternary or Quaternary activity class.

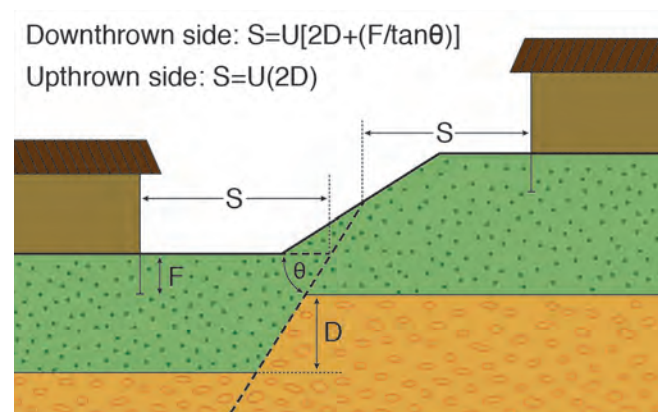


Figure 18. Schematic diagram illustrating fault setback calculation (modified from Christenson and others, 2003).

Fault Setbacks

The UGS recommends that Salt Lake County’s formulas for calculating fault setbacks for normal faults (Batatian and Nelson, 1999; Salt Lake County, 2002b; Christenson and others, 2003) as presented below be used throughout Utah. Unlike a simple “one setback distance fits all” approach (i.e., McCalpin, 1987), the Salt Lake County setback formulas adjust setback distances based on maximum anticipated fault displacements (greater setbacks for greater displacements), and also account for deep foundations and basements in structures close to a fault trace on the downthrown side of the fault. The method should be used to calculate the recommended fault setback distance for structures, depending on their IBC Risk Category (ICC, 2017a) and fault activity class, as shown in table 13. Table 13 is a revision of table 1 in Christenson and others (2003), and replaces IBC Building Occupancy Classes with IBC Risk Categories (ICC, 2017a), thus tying setback distances directly to risk. Variables used in the equations are shown on figure 18, and an example of a fault setback calculation is given below. Note that where an antithetic fault(s) is present at a site, a fault setback distance must be determined for it as well. This calculation method is for use with normal faults only. If reverse, thrust, or strike-slip faults are present (e.g., figure 14), the Engineering Geologist should provide the geologic justification in the report for the fault setback determination method used. Faults and fault setbacks should be clearly identified on the site-specific geology or fault map (see Surface-Faulting-Investigation Report Guidelines section below).

Table 13 presents minimum fault setback recommendations for IBC Risk Categories (Risk Category II subdivided into categories II(a) and II(b) for purposes of these guidelines). The calculated fault setback using the formulas presented below is compared to the minimum fault setback in table 13, and the greater of the two is used. Minimum fault setbacks in table 13 apply to both the downthrown and upthrown blocks. These fault setbacks apply only to surface faulting; greater setbacks

may be necessary for slope, property boundary, or other considerations.

Downthrown block: The fault setback for the downthrown block is calculated using the formula:

$$S = U * \left[2D + \left(\frac{F}{\tan \theta} \right) \right]$$

where:

- S = Fault setback distance within which buildings are not permitted (feet).
- U = Criticality factor, based on IBC Risk Category (table 13).
- D = Expected maximum fault displacement per earthquake (maximum vertical displacement) (feet).
- F = Maximum depth of footing or subgrade portion of the building (feet).
- θ = Fault dip (degrees).

Fault displacement is the maximum vertical displacement measured for an individual surface-faulting earthquake at the site (not necessarily the displacement of the most recent surface-faulting event). If a range of displacements is possible (e.g., because of uncertainty in how geologic layers or contacts are correlated or projected into the fault zone), the largest possible displacement value should be used. If per-earthquake displacements cannot be measured on site, the maximum displacement based on paleoseismic data from nearby paleoseismic investigations on the fault or segment may be used. In the absence of nearby data, consult DuRoss (2008) and DuRoss and Hylland (2015) for the range of displacements measured on the central segments of the Wasatch fault zone. Lund (2005) reports limited displacement information for some other Utah Quaternary faults.

Fault setback distances on the downthrown block are measured from where the fault intersects the final grade level for the building (figure 18). For dipping faults, if the fault trace daylight(s) in the face of a scarp above final building(s) grade, the fault setback is taken from where the fault would intersect the final grade level for the building(s), rather than where it daylight(s) in the scarp.

Upthrown block: Because the fault setback is measured from the portion of the building closest to the fault, whether subgrade or at grade, the dip of the fault and depth of the subgrade portion of the structure are irrelevant in calculating the fault setback on the upthrown block. The fault setback for the upthrown side of the fault is calculated as:

$$S = U * (2D)$$

Fault setback distances on the upthrown block are measured from where the fault trace daylight(s) at the surface, commonly in a scarp. Minimum fault setback distances apply as discussed above. Note that S and D are measured in feet for comparison to minimum fault setbacks in table 13.

Example of a fault setback calculation: Here, we consider a hypothetical example where trenching along the Wasatch fault zone in southern Salt Lake County identified the main trace of the fault and an antithetic fault crossing a property. Maximum displacement (D) on the main fault for the most recent surface-faulting earthquake at the site was 8.5 feet. The main fault dipped 70 degrees (θ) to the west. Displacement on the antithetic fault was 2 feet, dipping 50 degrees to the east. Development plans call for a 250-seat theater (Risk Category II(b); criticality factor [U] = 2) with basements requiring 8-foot foundation depths (F). The setback from the main fault is calculated as follows:

Downthrown (western) block

$$\begin{aligned} &= U * \left[2D + \left(\frac{F}{\tan \theta} \right) \right] \\ &= 2 * \left[(2)(8.5 \text{ feet}) + \left(\frac{8 \text{ feet}}{\tan 70^\circ} \right) \right] \\ &= 2 * (17 \text{ feet} + 3 \text{ feet}) \\ &= 40 \text{ feet} \end{aligned}$$

Upthrown (eastern) block

$$\begin{aligned} &= U * (2D) \\ &= 2 * (2) * (8.5 \text{ feet}) \\ &= 34 \text{ feet} \end{aligned}$$

The 40- and 34-foot calculated setback distances are to be applied respectively, because they are greater than the 20-foot minimum fault setback (see table 13).

We do not know whether the 2-foot displacement on the antithetic fault represents cumulative displacements from multiple surface-faulting earthquakes, or resulted from a single surface-faulting earthquake; therefore, we must assume all displacement occurred during a single earthquake. The setback from the antithetic fault is calculated as follows:

Downthrown (eastern) block

$$\begin{aligned} &= U * \left[2D + \left(\frac{F}{\tan \theta} \right) \right] \\ &= 2 * \left[(2)(2 \text{ feet}) + \left(\frac{8 \text{ feet}}{\tan 50^\circ} \right) \right] \\ &= 2 * (4 \text{ feet} + 7 \text{ feet}) \\ &= 22 \text{ feet} \end{aligned}$$

Upthrown (western) block

$$\begin{aligned} &= U * (2D) \\ &= 2 * (2) * (2 \text{ feet}) \\ &= 8 \text{ feet} \end{aligned}$$

The 22-foot calculated fault setback is greater than the 20-foot minimum setback (see table 13); therefore, the fault

setback on the downthrown block is 22 feet. Because 8 feet is less than the 20-foot minimum fault setback, the fault setback on the upthrown block is 20 feet.

Surface Deformation from Slip on a Buried Fault

Surface deformation (folding, warping, monoclinical flexures) from slip on a buried fault that did not produce discrete fault rupture at the ground surface has occurred along some Utah Quaternary faults (e.g., Keaton, 1986; Keaton and others, 1987b; Hylland and others, 2014). Zones of surface deformation can be narrow (a few feet to tens of feet) resulting from localized extensional or compressional strain at the axis of a fold or warp, or broad zones (tens to hundreds of feet) of tilting or rotation (Erslev, 1991; Kelson and others, 2001; Chen and others, 2007). Narrow zones of deformation may produce scarp-like geomorphic features (Keaton and others, 1987b; Hylland and others, 2014); broad zones may be subtle and difficult to detect at the ground surface. In some instances (typically trenches with well-defined stratigraphy), it is possible to determine net displacement across a fold or warp. Keaton and others (1987b) measured 3.9–4.9 feet of vertical displacement in a fold resulting from what they interpreted as a single earthquake on the central part of the Taylorsville fault. Hylland and others (2014) measured 1.6 feet of vertical displacement across a 26-foot-wide zone of broad warping on the Granger fault. Both the Taylorsville and Granger faults are part of the West Valley fault zone in Salt Lake Valley.

The potential surface-faulting hazard presented by tectonic surface deformation in the absence of discrete faulting is difficult to assess because past rupture on the causative fault did not extend to the ground surface. It is unknown whether future rupture on the fault will continue to deform the ground surface without surface faulting, or if future rupture will extend to the surface and create a surface-faulting hazard.

Surface deformation caused by slip on a buried fault lacks a discrete zone of displacement and in some cases may be many feet wide. Therefore, with the possible exception of the axis of a tight kink fold, establishing standard fault setback distances or implementing a standardized method for calculating fault setbacks for surface deformation as is done for surface faulting is generally not possible (see Hazardous Fault Avoidance section above). Past mitigation measures employed in Utah for structures built in surface deformation zones have consisted of engineering-design techniques such as reinforced slab-on-grade foundations and flexible utility lines and hookups (Bill Black, Western GeoLogic, written communication, 2014).

Quantifying the future effects of surface faulting at a site within a surface deformation zone may not be possible even after a careful investigation, because tectonic surface deformation may expand over time, or future rupture on the causative fault may eventually extend to the ground surface. Therefore, the UGS does not make a standard recommendation for mitigating tectonic surface deformation in the absence of discrete fault-

ing, but rather recommends that the Engineering Geologist in responsible charge of the surface-faulting investigation make and justify an appropriate mitigation recommendation based on the results of a site-specific hazard investigation. Whether that recommendation is to set back from a narrow deformation zone or to implement engineering-design mitigation methods will depend on individual site conditions and project considerations. Barrell (2010) provides an example from New Zealand of the classification and proposed mitigation of tectonic surface deformation in the absence of surface faulting.

Paleoseismic Data Required for Engineering-Design Mitigation of Surface Faulting

Most geologic-hazard ordinances in Utah limit surface-faulting mitigation to setting back a prescribed distance from an active (hazardous) fault (see Hazardous Fault Avoidance section above). However, some Utah jurisdictions now permit construction across Holocene-active faults having ≤ 4 inches of displacement. Some of these ordinances specify that reasonable geologic data must be available to show that future surface displacement along the fault will not exceed 4 inches, and require that a structural engineer provide an appropriate engineering design to minimize structural damage. Additionally, under a special “Review Protocol” the City of Draper (2005) has permitted “super-engineered” foundations designed to accommodate surface-faulting displacements of as much as 6 feet (David Dobbins, Draper City Manager, verbal communication, 2015).

Utah’s engineering-design surface-faulting mitigation approaches are based on the assumptions that (1) a small displacement (≤ 4 inches) on a fault would not cause catastrophic structural collapse, and therefore does not represent a life-safety hazard to building occupants, and (2) a super-engineered foundation will provide life-safety protection in the event of much larger (multiple feet) displacements beneath an inhabited structure. Common to both approaches is the need to characterize past surface-faulting displacement to establish a reliable design displacement value for engineering-mitigation design. The design displacement value must be such that it will not be significantly exceeded (within 2σ uncertainty limits) during future surface-faulting earthquakes.

Displacement data for normal-slip faults in Utah (DuRoss, 2008), as well as worldwide datasets (e.g., Wesnousky, 2008; Hecker and others, 2013) show that considerable variation in displacement at a point may occur between successive earthquakes on a fault. Therefore, the displacement at a point produced by the most recent surface-faulting earthquake may not be a good predictor of future surface-faulting displacement at the same location. DuRoss (2008) documents as much as 6.9 feet difference in displacement at a point between successive surface-faulting earthquakes on the five central segments of the Wasatch fault zone. Lund and others (2015) reported $\sim 50\%$ variation in displacement at a point between the two most recent surface-faulting earthquakes on the Fort Pearce

section of the Washington fault zone in northwestern Arizona. Hecker and others (2013) evaluated a worldwide dataset of faults having displacement information from multiple earthquakes, and determined that the coefficient of variation (standard deviation divided by the mean) for slip at a point is ~ 0.5 , indicating significant displacement variability between earthquakes. McCalpin (1987) acknowledged the possible variability of displacement on secondary faults between earthquakes, and recommended that human-occupied structures not be sited across small-displacement faults (≤ 12 in) without careful subsurface documentation of the location and past displacement styles (direction and amount) of the faults.

A review of possible engineering-design methods to mitigate surface faulting is beyond the scope of these guidelines (see Bray, 2015, for a review of design techniques); however, all such methods rely on the ability of the Engineering Geologist

to estimate within reasonable uncertainty limits (2σ) displacement at a point from future surface-faulting earthquakes. As discussed above, this is not a simple task, and can only be reliably achieved where site geology permits evaluating the fault's displacement history over multiple paleoearthquakes. Displacement data for a single paleoearthquake (most recent event) at a site does not provide a statistically significant basis for estimating probable future maximum earthquake displacement.

For engineering mitigation of surface faulting on normal-slip faults in Utah, the UGS recommends that displacements be determined for a minimum of three surface-faulting earthquakes at the site of interest (more if site geology permits), and that engineering-design mitigation be based on the maximum displacement observed on the fault in question including appropriate displacement uncertainty limits. Because displacement during a surface-faulting earthquake can vary sig-

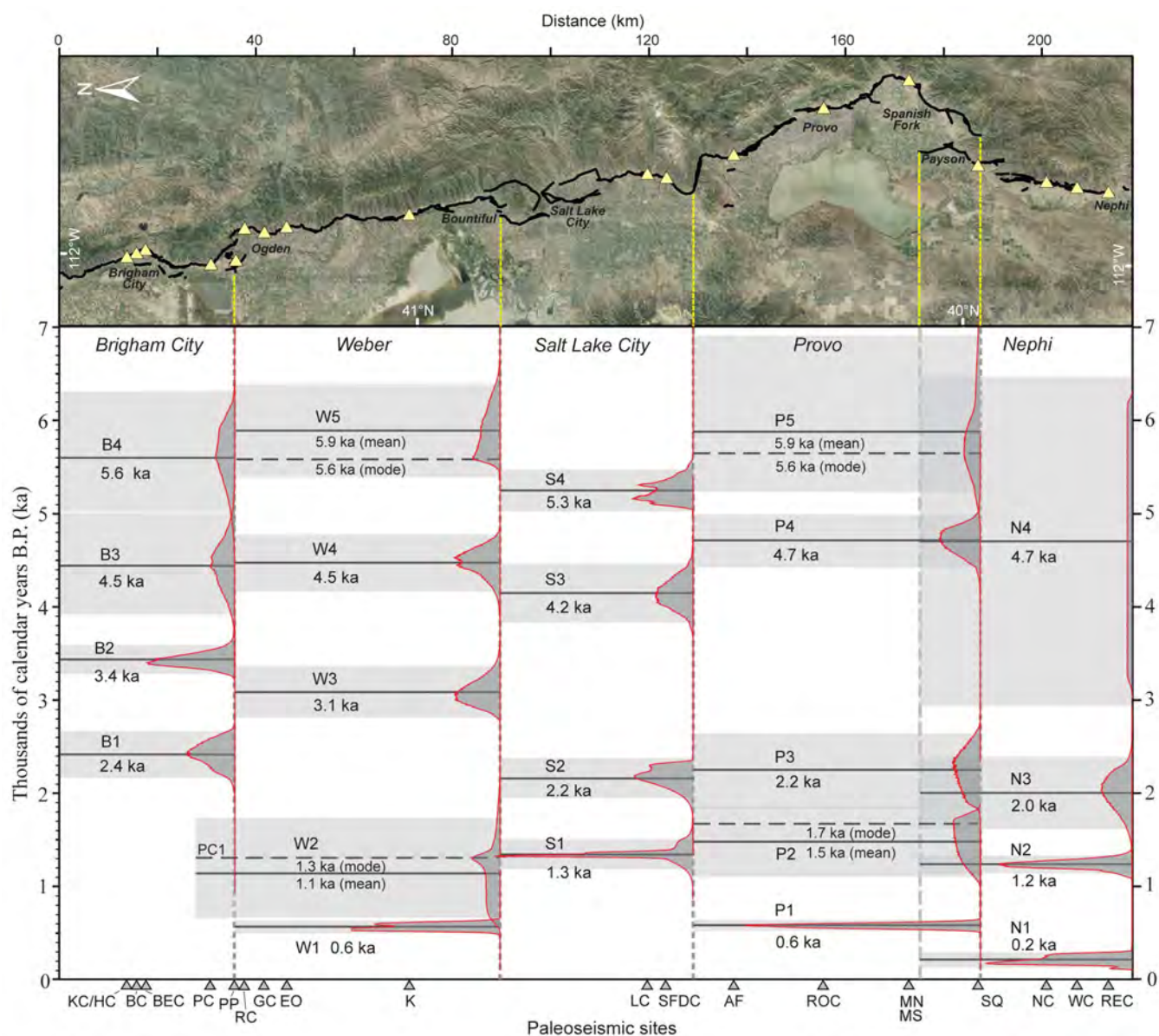


Figure 19. Distribution of probability density functions showing timing of single segment surface-faulting earthquakes on the five central segments of the Wasatch fault zone for the past ~ 6500 years (from WGUEP, 2016).

nificantly along fault strike (Crone and others, 1987; DuRoss, 2008; Hecker and others, 2013), displacement data used for engineering-design mitigation should be site specific; use of an offsite displacement value introduces an unacceptable level of uncertainty in the displacement design parameter.

Given the limited paleoseismic information available for most Utah Quaternary faults (the five central, Holocene-active segments of the Wasatch fault zone excepted), acquiring the detailed displacement data necessary for engineering mitigation of surface faulting will likely require a more detailed and costly (both in terms of time and money) paleoseismic investigation than is necessary to simply locate and setback from a potentially hazardous fault. Additionally, many sites will not possess the geologic conditions necessary to identify and characterize displacement for a minimum of three paleoearthquakes. For those reasons, the UGS believes fault setback and avoidance will remain the surface-faulting-mitigation option most frequently employed in Utah.

HAZARDOUS FAULT CRITERIA

Some geologists and engineers, chiefly in California, are re-evaluating what constitutes a hazardous fault with regard to public health, safety, and welfare (e.g., Shlemon, 2010, 2015; Gath, 2015). As a result, the Holocene criterion used in California to define an “active” (hazardous) fault has been called into question as being unreasonably long when compared to the time intervals used to mitigate other kinds of natural hazards. Those geologists argue that no specific deterministic recurrence number should be used to define a hazardous fault, but rather mitigating surface faulting should be data driven, and rely on professional judgment, cost, available technology, and social constraints (acceptable risk) (Shlemon, 2010, 2015; Gath, 2015). Some Utah geologists have similarly begun discussing the appropriateness of the Holocene active-fault criterion as commonly applied in Utah (UQFPWG, 2013; Lund, 2015), and likewise advocate data-based decisions regarding surface-faulting mitigation when sufficient paleoseismic data are available.

Characterizing fault activity for engineering mitigation of surface faulting requires determining the fault’s average surface-faulting recurrence and variability over multiple paleoearthquake cycles, as well as the time of most recent surface faulting. By comparing elapsed time since the most recent surface faulting earthquake with a well-constrained average recurrence interval, it is possible to estimate the probability that the fault will generate a future surface-faulting earthquake in a time interval of interest, although uncertainties may remain high, particularly for long-recurrence faults. Only when such detailed paleoseismic data are available can decisions regarding surface-faulting mitigation be reliably data driven. The following examples illustrate this point.

On the central Wasatch fault zone where earthquake timing and surface-faulting recurrence and variability are well constrained

(figure 19), the average recurrence interval for surface faulting on the Salt Lake City segment for the past four surface-faulting earthquakes (three closed earthquake cycles) is 1300 ± 100 years, and the elapsed time since the most recent surface faulting is 1300 ± 200 years (DuRoss and Hylland, 2015; DuRoss and others, 2016), indicating that the Salt Lake City segment has met or exceeded its average recurrence interval and may produce a surface-faulting earthquake at any time. A note of caution: when evaluating average surface-faulting recurrence, “at any time” may range from now to hundreds of years from now. Individual recurrence intervals for the four most recent Salt Lake City segment earthquakes range from 800 ± 300 years to 1900 ± 300 years (DuRoss and Hylland, 2015). Conversely, the elapsed time since the most recent surface faulting on the Nephi segment is 200 ± 70 years (Crone and others, 2014; DuRoss and others, 2016), and the average recurrence for the past two earthquake cycles (three earthquakes) is 1100 ± 200 years, indicating that the Nephi segment may not generate another surface-faulting earthquake for several hundred years. Available paleoseismic data show that on average the Salt Lake City segment is more hazardous than the Nephi segment, even though both segments have experienced multiple Holocene earthquakes, and as such would be treated in the same manner when implementing a fault avoidance strategy to mitigate surface faulting (see Hazardous Fault Avoidance section above). Whether mitigating surface faulting differently on the Nephi and Salt Lake City segments based on available paleoseismic data is advisable, and what form different mitigation strategies might take, depends on society’s ability to accept seismic risk, and remains a matter for future policy discussion.

Conversely, trenching by Olig and others (1999, 2000, 2001 [compiled in Bowman and Lund, 2013]) on the Mercur fault (Southern Oquirrh Mountains fault zone) identified a Holocene earthquake between 1500 and 4000 years ago, thus placing the Mercur fault in the Holocene activity class (see Hazardous Fault Avoidance section above). However, average surface-faulting recurrence on the Mercur fault is 13,000–19,000 years over the past 90,000 years. Therefore, even though the uncertainty in average recurrence is high (intervals vary from 2000 to 40,000 years), the likelihood of future rupture in a planning time frame is probably low on the Mercur fault, possibly lower than for many Late Quaternary faults that lack Holocene surface faulting.

These examples illustrate that fully characterizing surface-faulting hazard requires more paleoseismic information than simply determining the timing and displacement of the most recent surface-faulting earthquake. Timing and displacement data for multiple surface-faulting earthquakes (recommend a minimum of three closed earthquake cycles [four earthquakes]) is necessary to (1) compare the elapsed time since the most recent surface-faulting earthquake with an even minimally statistically relevant average recurrence, and (2) estimate the probability of future surface faulting within a time frame of interest. A Late Quaternary fault with a recurrence interval $\geq 10,000$ years may be approaching or have exceeded its average recurrence, and be potentially more hazardous

than either the Nephi segment, which has experienced multiple Holocene surface-faulting earthquakes, or the Mercur fault, which experienced surface faulting ~1500–4000 years ago, but has highly non-uniform earthquake recurrence. Consequently, the Holocene-activity criterion as currently applied in Utah to implement fault setback requirements may result in overly conservative risk-mitigation measures in some instances, and in other cases contribute to ignoring possible hazardous Late Quaternary faults that are near or beyond their average recurrence interval.

The UGS recommends that where sufficient paleoseismic data are available to characterize earthquake timing and displacement over multiple earthquake cycles (see recommendation above), those data may be used in conjunction with good professional judgment to replace the Holocene-activity criterion for a hazardous fault, and be used to determine which faults require surface-faulting risk mitigation, and which may require lesser or no mitigation, regardless of activity class. Where paleoseismic data are lacking or are insufficient to fully characterize earthquake activity as described above, the UGS recommends that those faults be treated as Holocene active and appropriate fault setbacks determined and applied (see Hazardous Fault Avoidance section above). We reiterate that the safest form of surface-faulting mitigation remains avoidance, which places a structure out of harm's way regardless of future earthquake timing or displacement.

SURFACE-FAULTING-INVESTIGATION REPORT

The report prepared for a site-specific surface-faulting investigation in Utah should, at a minimum, address the topics below. Site conditions may require that additional items be included; these guidelines do not relieve Engineering Geologists from their duty to perform additional geologic investigations as necessary to adequately assess surface-faulting hazard at a site. The report presenting the investigation results must be prepared, stamped, and signed by a Utah licensed Professional Geologist (Utah Code, 2011) with experience in conducting surface-faulting investigations. Reports co-prepared by a Utah licensed Professional Engineer must include the engineer's stamp and signature. The guidelines below pertain specifically to surface-faulting investigations, and expand on the general guidance provided in the Engineering-Geology Investigations and Engineering-Geology Reports sections of chapter 2.

A. Text

- a. Purpose and scope of investigation. Describe the location and size of the site and proposed type and number of buildings if known.
- b. Geologic and tectonic setting. The report should contain a clear and concise statement of the general geologic and tectonic setting of the site vicinity. The section should include a discussion of active faults

in the area, paleoseismicity of the relevant fault system(s), historical seismicity, geodetic measurements where pertinent, and should reference relevant published and unpublished geologic literature.

- c. Site description and conditions. Include information on geologic and soil units, geomorphic features, graded and filled areas, vegetation, existing structures, and other factors that may affect fault recognition, choice of investigative methods, and interpretation of data.
- d. Methods and results of investigation.
 1. Literature Review. Summarize published and unpublished maps, literature, and records concerning geologic and soil units, faults, surface water and groundwater, topography, and other relevant factors pertinent to the site.
 2. Interpretation of Remote-Sensing Imagery. Describe the results of remote-sensing imagery interpretation, including stereoscopic aerial photographs, lidar, and other remote-sensing data (e.g., Bunds and others, 2015) as available, conducted to identify fault-related topography, vegetation or soil contrasts, and other lineaments of possible fault origin. List source, date, flight-line numbers, and scale of aerial photos or other imagery used.
 3. Surface Investigations. Describe pertinent surface features, both onsite and offsite, including mapping of geologic units; geomorphic features such as scarps, springs and seeps (aligned or not), faceted spurs, and disrupted drainages; and geologic structures. Describe and assign ages to features associated with earthquake-induced strong ground shaking such as sand blows, lateral spreads, and other evidence of liquefaction and ground settlement. Describe the results of scarp profiling including age and displacement estimates for past surface-faulting earthquakes. Landslides, although they may not be conclusively associated with an earthquake cause, should be identified and described, particularly if they affect fault recognition and mapping.
 4. Subsurface Investigations. Describe fault trenching and other subsurface investigations conducted to evaluate surface faulting at the site. The strike, dip, and vertical displacement (or minimum displacement if total displacement cannot be determined) of faults should be recorded. Trench logs should be included with the report and should be prepared in the field at a scale of 1 inch = 5 feet or larger. Describe the criteria used to determine the age and geologic origin of the deposits in the trenches, and clearly evaluate the evidence for the presence or absence of Holocene, Late Quaternary, or Quaternary faults.

5. Other Investigation Methods. When special conditions or requirements for critical facilities demand a more intensive investigation, describe the methods used to supplement the trenching program and the purpose/result of those methods. These may include, but are not limited to: (a) boreholes and test pits, (b) CPT soundings, (c) geophysical investigations, and (d) geochronology (see Other Subsurface Investigation Methods section above).
- e. Conclusions.
 1. Conclusions must be supported by adequate data, and the report should present those data in a clear and concise manner.
 2. Data provided should include evidence establishing the presence or absence of faulting, fault location(s), fault geometry, earthquake timing, and displacement (at a minimum the most recent surface-faulting earthquake), including ages and geologic origin of faulted and unfaulted geologic units and surfaces. If engineering mitigation of surface faulting is proposed, the UGS recommends that paleoearthquake displacement information be obtained for a minimum of the three most recent surface-faulting earthquakes at the site, and that engineering design be based on the largest displacement observed and account for any uncertainty in the displacement measurement.
 3. Degree of confidence in, and limitations of, the data and conclusions.
 - f. Recommendations.
 1. Recommendations must be supported by the report conclusions and be presented in a clear and concise manner.
 2. Fault setback recommendations should include justification for the fault setback distance chosen with supporting data.
 3. When engineering-design mitigation of surface faulting is recommended, design recommendations must be data driven and based on sufficient paleoseismic information that epistemic uncertainty regarding the fault's past and probable future displacement is minimized and aleatory variability is adequately characterized (see Paleoseismic Data Required for Engineering-Design Mitigation of Surface Faulting and Hazardous Fault Criteria sections above).
 4. Other recommended building restrictions, use limitations, or risk-reduction measures such as placement of detached garages or other non-habitable structures in fault zones, or use of engineering-design mitigation for small-displacement faults.
5. Limitations on the investigation and recommendations for additional investigation to better quantify the hazard if necessary.
- B. References
 - a. Literature and records cited or reviewed; citations should be complete (see References section of this publication for examples).
 - b. Remote-sensing images interpreted including type, date, project identification codes, scale, source, and photo index numbers.
 - c. Other sources of information used, including well records, personal communication, and other data sources.
 - C. Illustrations. Should include at a minimum:
 - a. Location map. A general location map should show the site and significant physiographic and cultural features, generally at 1:24,000 scale or larger and indicating the Public Land Survey System $\frac{1}{4}$ -section, township, and range; and the site latitude and longitude to four decimal places with datum.
 - b. Site development map. The development map should show site boundaries, existing and proposed structures, graded and filled areas (including engineered and non-engineered fill), and streets. The map scale may vary depending on the size of the site and area covered by the study; the minimum recommended scale is 1 inch = 200 feet (1:2400) or larger when necessary. The site development map may be combined with the site-specific geology map (below).
 - c. Regional geology map. A regional-scale (1:24,000 to 1:50,000) map should show the geologic setting, including geologic units, Quaternary and other faults, and general geologic structures within a 10-mile radius of the site.
 - d. Site-specific geology map. A site-scale geologic map should show (1) geologic units, (2) faults, (3) seeps or springs, (4) landslides, (5) lineaments investigated for evidence of faulting, (6) other geologic features existing on and near the site, and (7) locations of trenches, test pits, boreholes, CPT soundings, and geophysical lines as appropriate. Scale of site geologic maps will vary depending on the size of the site and area of study; minimum recommended scale is 1 inch = 200 feet (1:2400) or larger when necessary. If site-specific investigations reveal the presence of a hazardous Quaternary fault and fault avoidance is the mitigation strategy employed, an appropriate fault setback should be shown either on the site-specific geology map, or on a separate surface-fault-rupture-hazard map depending on site scale and complexity.
 - e. Geologic/topographic cross sections. Site geologic cross sections should be included as needed to illustrate three-dimensional geologic relations.

- f. Trench and test pit log(s). Logs are required for each trench and test pit excavated as part of the investigation whether faults are encountered or not. Logs are hand- or computer-drawn maps of excavation walls that show details of geologic units and structures. Logs should be to scale and not generalized or diagrammatic, and may be on a rectified photomosaic base. The scale (horizontal and vertical) should be 1 inch = 5 feet (1:60) or larger as necessary and with no vertical exaggeration. Logs should be prepared in the field and accurately reflect the features observed in the excavation, as noted below. Photographs are not a substitute for trench logs.

Logs should include (1) trench and test-pit orientation and indication of which wall was logged, (2) horizontal and vertical control, (3) top and bottom of trench wall(s), (4) stratigraphic contacts, (5) detailed lithology and soil classification and descriptions, (6) contact descriptions, (7) pedogenic soil horizons, (8) marker beds, (9) faults and fissures, (10) fault orientation and geometry (strike and dip), (11) fault displacement, and (12) sample locations (e.g., Birkeland and others, 1991; Bonilla and Lienkaemper, 1991; U.S. Bureau of Reclamation, 1998b; Walker and Cohen, 2006; McCalpin, 2009; DuRoss, 2015).

Other features of tectonic significance should be shown, including but not limited to (1) open or in-filled fissures, (2) colluvial wedges, (3) drag folds, (4) rotated clasts, (5) lineations, and (6) liquefaction features including sand dikes and blows (e.g., DuRoss and others, 2014; DuRoss, 2015).

Logs should include interpretations and evidence for the age and origin of geologic units. Study limitations should be clearly stated for suspected Holocene faults where unfaulted Holocene deposits are deeper than practical excavation depths.

- g. Borehole and CPT logs. Boreholes and CPT logs should include the geologic interpretation of deposit genesis for all layers and whether or not evidence of faulting was encountered. Logs should not be generalized or diagrammatic. Because boreholes are typically multipurpose, borehole logs may also contain standard geotechnical, geologic, and ground-water data.
- h. Geophysical data and interpretations.
- i. Photographs that enhance understanding of site surface and subsurface (trench and test pit walls) conditions with applicable metadata.

D. Authentication

The report must be stamped and signed by a Utah licensed Professional Geologist in principal charge of the investigation (Title 58-76-10 – Professional Geologists Licensing Act [Utah Code, 2011]). Final

geologic maps, trench logs, cross sections, sketches, drawings, and plans prepared by, or under the supervision of, a professional geologist also must bear the stamp of the professional geologist (Utah Code, 2011). Reports co-prepared by a Utah licensed Professional Engineer and/or Utah licensed Professional Land Surveyor must include the engineer's and/or surveyor's stamp and signature.

E. Appendices

Include supporting data relevant to the investigation not given in the text such as maps; trench, test pit, and borehole logs; cross sections; conceptual models; fence diagrams; survey data; water-well data; geochronology laboratory reports; and qualifications statements/resume.

FIELD REVIEW

The UGS recommends a field review of trenches and trench logs by the regulatory-authority geologist once a surface-faulting hazard investigation is complete. The field review should take place after trenches or test pits are logged, but before they are closed so subsurface site conditions can be directly observed and evaluated. See Field Review section in chapter 2.

REPORT REVIEW

The UGS recommends regulatory review of all reports by a Utah licensed Professional Geologist experienced in surface-faulting hazard investigations and acting on behalf of local governments to protect public health, safety, and welfare, and to reduce risks to future property owners (Larson, 1992, 2015). See Report Review section in chapter 2.

DISCLOSURE

The UGS recommends disclosure during real-estate transactions whenever an engineering-geology investigation has been performed. See Disclosure section in chapter 2.

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CHAPTER 4

GUIDELINES FOR EVALUATING LANDSLIDE HAZARDS IN UTAH

by

Gregg S. Beukelman, P.G., and Michael D. Hylland, P.G.



Landslide near 4785 Brentwood Circle, Provo. Photo date: March 30, 2011.

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CHAPTER 4: GUIDELINES FOR EVALUATING LANDSLIDE HAZARDS IN UTAH

by Gregg S. Beukelman, P.G., and Michael D. Hylland, P.G.

INTRODUCTION

These guidelines outline the recommended minimum acceptable level of effort for evaluating landslide hazards in Utah. Guidelines for landslide-hazard investigations in Utah were first published by the Utah Geological Survey (UGS) in 1996 as *Guidelines for Evaluating Landslide Hazards in Utah* (Hylland, 1996) and are updated here. The objective of these guidelines is to promote uniform and effective statewide implementation of landslide investigation and mitigation measures to reduce risk. These guidelines do not include systematic descriptions of all available investigative or mitigation techniques or topics, nor is it suggested that all techniques or topics are appropriate for every project. Variations in site conditions, project scope, economics, and level of acceptable risk may require that some topics be addressed in greater detail than is outlined in these guidelines. However, all elements of these guidelines should be considered in landslide-hazard investigations, and may be applied to any project site, large or small.

Purpose

These guidelines were developed by the UGS to assist geologists and Geotechnical Engineers performing landslide-hazard investigations, and to help technical reviewers rigorously assess the conclusions and recommendations in landslide-hazard-investigation reports. These guidelines are applicable to both natural and development-induced landslide hazards, and are limited to evaluating the potential for rotational and translational slides (classification after Cruden and Varnes, 1996). The guidelines do not address other types of mass movement such as debris flows or rockfalls, or phenomena such as land subsidence and earth fissures. Debris-flow-hazard investigations are addressed in chapter 5 of this publication, land-subsidence and earth-fissure investigations in chapter 6, and rockfall-hazard investigations in chapter 7.

These landslide guidelines are intended to:

- protect the health, safety, and welfare of the public by minimizing the potentially adverse effects of landslides (figure 20 shows examples of damage from a recent urban landslide);
- assist local governments in regulating land use in hazardous areas and provide standards for ordinances;
- assist property owners and developers in conducting reasonable and adequate landslide investigations;

- provide Engineering Geologists with a common basis for preparing proposals, conducting investigations, and recommending landslide-mitigation strategies; and
- provide an objective framework for preparation and review of reports.

These guidelines do not supersede pre-existing state or federal regulations or local geologic-hazard ordinances, but provide useful information to (1) supplement adopted ordinances/regulations, and (2) assist in preparation of new ordinances. If study or risk-mitigation requirements in a local government ordinance exceed recommendations given here, ordinance requirements take precedence.

Background

A landslide can be defined as a downslope movement of rock, soil, or both, in which much of the material moves as a coherent or semi-coherent mass with little internal deformation, and movement occurs on either a curved (rotational slide) or planar (translational slide) rupture surface (Hylland and Bobrowsky, 2008). Occasionally, individual landslides may involve multiple types of movement if conditions change as the displaced material moves downslope. For example, a landslide may initiate as a rotational slide and then become a translational slide as it progresses downslope. These guidelines address evaluating the potential for new or reactivated rotational and translational slides, but do not address liquefaction-induced landslides such as lateral spreads. Snow avalanches and ice falls are likewise not discussed. Figure 21 shows the position and terms used for the different parts of a landslide. These and other relevant terms are defined in the glossary in appendix B.

Landslides include both natural and human-induced variables, making landslide-hazard investigation a complex task. Slope instability can result from many factors, including geomorphic, hydrologic, and geologic conditions, and modification of these conditions by human activity; the frequency and intensity of precipitation; and seismicity. Existing landslides can represent either marginally stable slopes or unstable slopes that are actively moving. Site conditions must be evaluated in terms of proposed site modifications associated with structure size and placement, slope modification by cutting and filling, and changes to groundwater conditions.



Figure 20. August 2014 Parkway Drive landslide, North Salt Lake, Utah. The effects of this landslide illustrate how damage can occur at various parts of the slide. The landslide severely damaged the Eagle Ridge Tennis and Swim Club (white tent structure), and one house (directly above the tent structure) at its toe, partially destroyed a home's backyard along its left flank (behind orange fencing near center of photograph), and threatened streets and pipelines near the crown. Photo date August 14, 2014.



Figure 21. Diagram of an idealized landslide showing commonly used nomenclature for its parts.

Many Utah landslides are considered dormant, but recent slope failures are commonly reactivations of pre-existing landslides, suggesting that even so-called dormant landslides may continue to exhibit slow creep or are capable of renewed movement if stability thresholds are exceeded (Ashland, 2003). Past slope failures can be used to identify the geologic, hydrologic, and topographic conditions that may reactivate existing landslides and initiate new landslides. In addition to natural conditions that contribute to landsliding, human-induced conditions, such as modification of slopes by grading or a human-caused change in hydrologic conditions, can create or increase an area's susceptibility to landsliding. Investigation of landslide hazards should be based on the identification and understanding of conditions and processes that promote instability.

Slope steepness is an important factor in slope stability. In Salt Lake County, 56 percent of all slope failures occurred on hillsides where slopes range between 31 and 60 percent which prompted Salt Lake County to lower the maximum allowable buildable slope from 40 percent to 30 percent in 1986 (Lund, 1986).

Landslides occur in all 50 states; however, the coastal states and the Intermountain West are the primary regions of landslide activity. Nationally, landslides result in 25 to 50 deaths annually, and cause approximately \$5.1 billion (2019 dollars) in damage (Highland, 2004). In 2014, an approximately 650-foot-high slope near Oso, Washington, underlain by glacial till and lacustrine deposits and having a history of previ-

ous landsliding, failed and rapidly inundated a neighborhood claiming the lives of 43 people, making it the deadliest landslide in United States history (Keaton and others, 2014).

Annual losses from landslide damage in Utah vary, but are often in the millions of dollars. For example, during the wet year of 1983, Utah landslides had a total estimated direct cost exceeding \$250 million dollars (Anderson and others, 1984). The 1983 Thistle landslide (figure 22), Utah's single most destructive failure of a natural slope, is recognized in terms of direct and indirect costs as one of the most expensive individual landslides in United States history with damage costs over \$688 million in 2000 dollars (Highland and Schuster, 2000). Although landslide losses in Utah are poorly documented, Ashland (2003) estimated losses from damaging landslides in 2001 exceeded \$3 million including the costs to repair and stabilize hillsides along state and federal highways. This estimate remains the most recent landslide damage estimate for Utah; however, total losses during that year are unknown because of incomplete cost documentation of landslide activity.

Landslide Causes

Landslides can have several contributing causes, but only one trigger (Varnes, 1978; Cruden and Varnes, 1996). Contributing causes may include, but are not limited to, geological conditions such as weak, weathered, or sheared rock or sediment; morphologic modification processes like tectonic uplift or fluvial erosion at the toe of a slope; physical processes such



Figure 22. The 1983 Thistle, Utah, landslide buried parts of two State highways and the Denver and Rio Grande Railroad. The landslide also dammed two streams, resulting in a 3-mile-long and 200-foot-deep lake that inundated the town of Thistle and posed a flooding hazard to communities downstream. Aerial photograph provided by the USGS National Landslide Information Center.

as earthquakes; or human-related causes such as grading of a slope or modification of groundwater conditions. By definition, a trigger is an external force that causes a near-immediate response in the form of slope deformation by rapidly increasing the stresses or reducing the strength of slope materials (Wieczorek, 1996). Engineering Geologists investigating existing landslides should look for dominant causes and the trigger of the landslide to ensure that the cause of the slope failure will be corrected by any proposed mitigation.

In Utah, natural landslides are primarily triggered by intense rainfall, rapid snowmelt, rapid stream erosion, water level change or, to a much lesser degree, seismic activity. Slopes can become unstable as they are saturated by intense rainfall, snowmelt, and changes in groundwater levels. Rapid erosion due to surface-water changes along earth dams and in the banks of lakes, reservoirs, canals, and rivers can undercut banks and increase the possibility of landsliding. Earthquakes in steep landslide-prone areas, such as northern Utah, greatly increase the likelihood of landslides because of ground shaking, liquefaction of susceptible deposits, or dilation of soil, which allows rapid infiltration of water. Utah's best-documented earthquake-induced landslide is the Springdale landslide in the southwestern part of the state which was triggered by the 1992 magnitude 5.8 St. George earthquake (Jibson and Harp, 1995). The potential for earthquake-triggered landslides along the Wasatch Front has long been recognized (Keaton and others, 1987a; Solomon and others, 2004; Ashland, 2008), but no mapped landslide in this area, excluding liquefaction-induced lateral spreads (Hylland and Lowe, 1998; Harty and Lowe, 2003), has been documented as having been conclusively triggered by a major earthquake.

Humans can contribute to landslides by improper grading, such as undercutting the bottom or loading the top of a slope, disturbing drainage patterns, changing groundwater conditions, and removing vegetation during development. In addition, landscape irrigation, on-site wastewater disposal systems, or leaking pipes can promote landsliding in once-stable areas. Identification of a site's susceptibility to landsliding followed by proper engineering and hazard mitigation can improve the long-term stability of the site and reduce risk from future slope failures.

Landslide Hazards

Landslides account for considerable property damage and a potential loss of life in areas having steep slopes and abundant rainfall. The potential benefit of landslide-hazard investigations is achieving a meaningful reduction in losses through awareness and avoidance. Landslides may affect developed areas whether the development is directly on or only near a landslide. Landslides can occur either over a wide area where many homes, businesses, or entire developments are involved, or on a local scale where a single structure or part of a structure is affected. Buildings constructed on landslides without proper engineering and hazard mitigation can experience distress or complete destruction. Landslides can also do indirect

damage to dwellings or businesses by affecting common utilities such as sewer, water, and storm drain pipes, electrical and gas lines, and roadways.

Fast-moving landslides are typically the most destructive, particularly if they move so rapidly that they overwhelm pre-slide mitigation measures or move too fast for mitigation measures to be designed and implemented (see figure 23). Whereas a fast-moving landslide may completely destroy a structure, a slower landslide may only slightly damage it, and may provide time to implement mitigation measures. However, left unchecked, even a slow landslide can destroy structures over time. In North Salt Lake City, Utah, the very slow moving Springhill landslide affected a residential development from 1998 to 2014, until a total of 18 houses on the slide were either destroyed by landslide movement or deemed unfit for occupancy and demolished. An open-space geologic park has now been constructed on the landslide footprint (Beukelman, 2012). Landslides often continue to move for days, weeks, months, or years, and may become dormant for a time only to reactivate again later. It is therefore prudent not to rebuild on a landslide unless effective mitigation measures are implemented; even then, such efforts may not guarantee future stability.

LANDSLIDE-HAZARD INVESTIGATION

When to Perform a Landslide-Hazard Investigation

Geologic hazards are best addressed prior to land development. The UGS recommends that a landslide-hazard investigation be made for all new buildings for human occupancy and for modified International Building Code (IBC) Risk Category II(a), II(b), III, and IV facilities (table 1604.5 [International Code Council (ICC), 2017a]) that are proposed on slopes. Utah jurisdictions that have adopted landslide-special-study maps identify zones of known landslide susceptibility within which they require a site-specific investigation. The UGS recommends that investigations as outlined in these guidelines be conducted in slope areas for all IBC Risk Category III and IV facilities, whether near a mapped landslide-susceptible area or not, to ensure that previously unknown landslides are not present. If a hazard is found, the UGS recommends a comprehensive investigation be conducted. Additionally, in some instances an investigation may become necessary when existing infrastructure is discovered to be on or adjacent to a landslide.

The level of investigation conducted for a particular project depends on several factors, including (1) site-specific geologic conditions, (2) type of proposed or existing development, (3) level of acceptable risk, and (4) governmental permitting requirements, or regulatory agency rules and regulations. A landslide-hazard investigation may be conducted separately, or as part of a comprehensive geologic-hazard and/or geotechnical site investigation (see chapter 2).



Figure 23. The 2005 landslide below the Davis-Weber Canal in South Weber, Davis County, that demolished a barn and covered part of State Route 60. The landslide occurred in one of the steeper parts of the slope composed of prehistoric landslide deposits that reactivated.

Minimum Qualifications of Investigator

Landslide-related engineering-geology investigations and accompanying geologic-hazard evaluations performed before the public shall be conducted by or under the direct supervision of a Utah licensed Professional Geologist (Utah Code, Title 58-76) who must sign and seal the final report. Often these investigations are interdisciplinary in nature, and where required, must be performed by qualified, experienced, Utah licensed Professional Geologists (PG, specializing in engineering geology) and Professional Engineers (PE, specializing in geological and/or geotechnical engineering) working as a team. See Investigator Qualifications section in chapter 2.

Investigation Methods

In evaluating landslide hazards the geologic principle of “*the past is the key to the future*” proves useful. This principle means that future landslides are most likely to result from the same geologic, geomorphic, and hydrologic conditions that produced landslides in the past. Estimating the types, extent, frequency, and perhaps even consequences of future landslides is often possible by a careful analysis of existing landslides. Caution is required, however, as the absence of past landslides does not rule out the possibility of future landslides, particularly those resulting from human-induced changes such as site grading or changes in groundwater conditions.

These guidelines present two levels of landslide-hazard investigation: (1) geologic and (2) geotechnical engineering. In general, a geologic investigation is performed by an Engineering Geologist. A geotechnical-engineering investigation is an extension of the geologic investigation and is primarily a quantitative slope-stability analysis. This analysis is generally performed by a Geotechnical Engineer with input from an Engineering Geologist. All levels of investigation require an initial in-depth review of existing information including published and unpublished literature and available remote-sensing data.

Literature Review

Existing maps and reports are important sources of background information for landslide-hazard investigations. Published and unpublished geologic and engineering literature, maps, cross sections, and records relevant to the site and site region’s topography, geology, hydrology, and past history of landslide activity should be reviewed in preparation for landslide-hazard investigations. The objective of a literature review is to obtain information that will aid in the identification of potential landslide hazards, and to help in planning the most efficient and effective surface mapping and subsurface exploration program.

The UGS and the U.S. Geological Survey (USGS) provide useful resources for landslide-hazard investigations. UGS maps

show known landslides at a statewide scale (1:500,000; Harty, 1991) and at 30 x 60-minute quadrangle scale (1:100,000; Elliott and Harty, 2010). Landslide polygons from these maps, along with new landslide mapping, are in the *Utah Landslide Database* (<https://gis.utah.gov/data/geoscience/landslides/>). However, these small-scale maps may not be suitable as the only resource for landslide locations for a site- or a development-scale investigation. Additionally, Giraud and Shaw (2007) prepared a statewide landslide susceptibility map of Utah at a scale of 1:500,000. Large landslide deposits are commonly shown on modern geologic maps, and the UGS and others commonly map surficial (Quaternary) geology on USGS 7.5-minute quadrangle maps (1:24,000 scale [1" = 2000']). Additional sources of relevant information including links to several UGS-maintained web pages are presented in the Literature Searches and Information Resources section in chapter 2.

Analysis of Remote-Sensing Data

Landslides leave geomorphic signatures in the landscape, many of which can be recognized in various kinds of remote-sensing imagery. Analysis of remote-sensing data should include interpretation of stereoscopic aerial photographs, and if available, light detection and ranging (lidar) imagery and other remotely sensed images. Interferometric synthetic aperture radar (InSAR) data may prove useful when investigating large, complex landslides. Where possible, the aerial photography analysis should include both stereoscopic low-sun-angle and vertical imagery. Landslide evidence visible on aerial photographs and lidar often includes main and internal scarps formed by surface displacement, hummocky topography, toe thrusts, back-rotated blocks, chaotic bedding in displaced bedrock, denuded slopes, shear zones along the landslide flanks, vegetation lineaments, and vegetation/soil contrasts. Examination of repeat aerial photographs and/or lidar and InSAR imagery from multiple years may help reconstruct the history of landslide movement. The area analyzed should extend sufficiently beyond the site boundaries to identify off-site landslides that might affect the site. In addition, nearby landsliding affecting a geologic unit that extends onsite should be evaluated for landslide susceptibility of that unit.

A variety of remote-sensing data is available for much of Utah. For information on availability of remote sensing data see the Aerial Photography section in chapter 2, and the lidar and InSAR discussions in appendices C and D, respectively.

Geologic Investigations

The primary purpose of a geologic investigation is to determine a hazard's potential relative to proposed development, and evaluate the need for additional geotechnical-engineering studies. In general, a geologic investigation should address site geologic conditions that relate to slope stability such as topography, the nature and distribution of soil and rock, land-

forms, vegetation patterns, hydrology, and existing landslides. The study should extend beyond the site boundaries as necessary to adequately characterize the hazard. Comprehensive information for landslide identification and investigation is provided by Hall and others (1994), Turner and Schuster (1996), and Cornforth (2005).

A geologic-hazard investigation must include a site visit to document surface and shallow subsurface conditions such as topography, type and relative strength of soil and rock, nature and orientation of bedrock discontinuities such as bedding or fractures, groundwater depth, and active erosion. Mapping and related field studies also help unravel the geologic history of slope stability, which may help in estimating past movement parameters. Engineering geologic mapping at various scales is relevant for different purposes. Investigators should map the site surficial geology in sufficient detail to define the geologic conditions present both at and adjacent to the site, placing special emphasis on geologic units of known landslide susceptibility. Baum and others (2008) suggest that large-scale mapping (1:50–1:1000) showing geologic (lithology, structure, geomorphology) and hydrologic (springs, sag ponds) details are needed for investigations of landslides and landslide-prone sites, and mapping at small (1:25,000–1:100,000) and intermediate scales is more appropriate to put landslides and landslide-prone areas in context with regional and local geology. For most purposes, published geologic maps are not sufficiently detailed to provide a basis for understanding site-specific conditions, and new, larger scale, independent geologic mapping is necessary; however, features such as slope inclination, height, and aspect can be schematically illustrated on the geologic map if a detailed topographic base map is not available.

During site geologic mapping, particular attention should be paid to mapping landslide features with accompanying photos, detailed notes, and sketches where appropriate. Evidence of recent landslide activity, including scarps, hummocky topography, shear zones, and disturbed vegetation (e.g., "jackstrawed" trees), should be described and located. The landslide type, relative age, and cause of movement need to be evaluated for existing slope failures. The site geologic map should also show areas of surface water and evidence for shallow groundwater (such as phreatophyte vegetation, springs, or modern tufa deposits).

If the site has been developed previously, structures that show signs of distress, both on and near the site, should be mapped. Cracks in pavement, foundations, and other brittle materials can provide information about the stress regime produced by landslide movement, and should be mapped in detail with special attention paid to rigid linear infrastructure such as curbs, gutters, and sidewalks. Surface observations should be supplemented by subsurface exploration using a backhoe, drill rig, and/or hand tools such as a shovel, auger, or probe rod where appropriate.

Careful mapping and characterization of rock and soil units are critical to any geologic-hazards evaluation. Several classification systems have been developed to guide the investigator during this process including the Unified Soil Classification System (ASTM, 2017) that provides information on geotechnical behavior of unconsolidated deposits. The Unified Rock Classification System (Williamson, 1984) provides a systematic and reproducible method of describing rock weathering, strength, discontinuities, and density in a manner directly usable by Engineering Geologists and engineers. The Geological Strength Index (GSI) provides a system to describe rock mass characteristics and estimate strength (Marinos and Hoek, 2000; Marinos and others, 2005; Hoek and others, 2013). For altered materials, Watters and Delahaut (1995) provide a classification system that can be incorporated into an overall rock classification. The method described by Williamson and others (1991) for constructing field-developed cross sections can facilitate topographic profiling and subsurface interpretation.

Landslide features become modified with age. Evaluation of the timing of the most recent movement of a slide can provide important information for landslide-hazard assessments. Active landslides have sharp, well-defined surface features, whereas landslides that have been inactive for tens of thousands of years have features that are subdued and poorly defined (Keaton and DeGraff, 1996). The change of landslide features from sharp to subdued with age is the basis of an age classification developed by McCalpin (1984). Features included in this classification system include main scarp, lateral flanks, and surface morphology, as well as vegetation patterns and landslide toe relationships. Wiczorek (1984) developed a classification system based on activity, degree of certainty of identification of the landslide boundaries, and the dominant movement type. These two systems were combined into the Unified Landslide Classification System (Keaton and DeGraff, 1996) outlined in table 14.

Christenson and Ashland (2006) suggested that care be taken when applying these classifications and inferring that a mature or old geomorphic expression implies adequate stability and suitability for development. They report that many historical landslides in Utah have involved partial reactivations of old landslides—in particular, clay-rich landslides that typically move at very slow rates for short periods of time. For such landslides, geomorphic expression may not be a reliable indicator of stability.

Pertinent data and conclusions from the landslide-hazard geologic investigation must be adequately documented in a written report. The report should note distinctions between observed and inferred features and relationships, and between measured and estimated values. Although geologic investigations will generally result in a qualitative hazard assessment (for example, low, moderate, or high), the report should clearly state if a hazard exists and comment on development feasibility and implications relative to landsliding. If a hazard is found and the proposed development is considered feasible, the report should both clearly state the extent of the hazard and give justification for accepting the risk, or recommend appropriate hazard-reduction measures or more detailed study. Kockelman (1986), Rogers (1992), Turner and Schuster (1996), and Cornforth (2005) describe numerous techniques for reducing landslide hazards. Hazard-reduction measures (for example, building setbacks or special foundations) must be based on supporting data, such as measured slope inclination; height, thickness, and physical properties of slope materials; groundwater depth; and projections of stable slopes. The basis for all conclusions and recommendations must be presented so that a technical reviewer can evaluate their validity. Guidelines for reports are provided in the Landslide-Investigation Report section below.

Table 14. *Unified Landslide Classification System (from Keaton and Rinne, 2002).*

Age of Most Recent Activity ¹		Dominant Material ²		Dominant Type of Slope Movement ²	
Symbol	Definition	Symbol	Definition	Symbol	Definition
A	Active	R	Rock	L	Fall
R	Reactivated	S	Soil	T	Topple
S	Suspended	E	Earth	S	Slide
H	Dormant-historic	D	Debris	P	Spread
Y	Dormant-young			F	Flow
M	Dormant-mature				
O	Dormant-old				
T	Stabilized				
B	Abandoned				
L	Relict				

See appendix B for definition of terms. Landslides classified using this system are designated by one symbol from each group in the sequence activity-material-type. For example, MDS signifies a mature debris slide, HEF signifies a historic earth flow, and ARLS signifies an active rock fall that translated into a slide.

¹ Based on activity state (see Cruden and Varnes, 1996, table 3-2, page 38) and age classification (see Keaton and DeGraff, 1996, table 9-1, page 186).

² See Keaton and DeGraff (1996), table 3-2, page 38.

Geotechnical-Engineering Investigations

A detailed geotechnical-engineering investigation generally should be performed as part of final design/mitigation activities when a geologic evaluation indicates the existence of a hazard. A geotechnical-engineering investigation, which involves a quantitative slope-stability analysis, requires subsurface exploration, geotechnical laboratory testing, topographic profiling, and preparation of geologic cross sections. Some investigations may include slope-movement monitoring or deformation analysis using photogrammetric or remote sensing methods, high resolution GPS surveys, inclinometers, piezometers, and/or extensometers. The results of the investigation must be validated by adequate documentation of appropriate input parameters and assumptions, and all supporting data for conclusions and recommendations must be included in the report to permit a detailed technical review. Subsurface exploration locations must be accurately shown on site plans and geologic maps. Where precise locations are necessary, they should be surveyed rather than located using a hand-held GPS device.

Slope stability is affected by soil, rock, and groundwater conditions. Engineering properties of earth materials and characterization of geologic structures can be inferred from surface conditions, but subsurface exploration is required to obtain definitive data and samples for laboratory testing. Development of a subsurface exploration plan and selection of methods should be based on the results of a geologic investigation, considerations of study objectives, surface conditions, and size of landslide. The exploration program should provide values for the undisturbed and residual shear strength and friction angle of all geologic materials, and depth to groundwater. If a landslide is present, subsurface exploration must be of sufficient scope to determine slide geometry with relative confidence. At a minimum, a "best estimate" of the slide geometry should be made and appropriate analyses performed using the best-estimate geometry.

Drilling and trenching are the most commonly used methods for subsurface exploration of landslides. Geophysical techniques are sometimes used where drilling is not feasible or to aid extrapolating measurements between boreholes. The most commonly used geophysical techniques include seismic refraction, seismic reflection, ground-penetrating radar, and methods based on electrical resistivity. Geotechnical laboratory testing should be performed on samples obtained from the ground surface or from subsurface exploration to evaluate physical and engineering characteristics such as unit weight, moisture content, plasticity, friction angle, and cohesion. McGuffey and others (1996) and Cornforth (2005) give detailed descriptions of various types of available sampling techniques.

In some cases, samples can be used to determine the geologic age of slope materials and possibly the age of previ-

ous landslide movement. For example, radiometric analysis of wood or charcoal fragments found beneath the toe of a landslide may be useful in determining the approximate age of landslide movement (Baum and others, 2008). However, care should be taken in the collection of samples to ensure that they are relevant to understanding the behavior of the landslide. The heterogeneous nature and complex history of most landslides make it important that the relationship of samples and their locations to the structure and overall geometry of the landslide is well understood.

At least one geologic cross section should be constructed through the slope(s) of concern to evaluate subsurface geologic conditions relative to the topographic profile. Cross sections should extend at least to the maximum postulated depth of potential slip surfaces and be at an appropriate scale (generally between 1:120 [1 inch = 10 feet] and 1:600 [1 inch = 50 feet]) for the size of the slope, type of proposed development, and purpose of investigation.

Geotechnical-engineering investigations should include static and pseudostatic analyses of the stability of existing and proposed slopes using appropriate shear-strength parameters, under existing and development-induced conditions, and considering the likely range of groundwater conditions. Numerous computer software packages are available for quantitative slope-stability analysis, including deterministic and probabilistic soil- and rock-slope models. A slope-stability evaluation addressing post-earthquake conditions may be warranted in some cases. Blake and others (2002) provide a detailed discussion of landslide analysis and mitigation.

Slope-Stability Analysis

Geotechnical-engineering investigations include a quantitative slope-stability (factor-of-safety of static and seismic conditions) analysis of existing and proposed slopes. The factor of safety (FS) is defined as:

$$FS = \frac{\text{Resisting forces}}{\text{Driving forces}}$$

When the FS equals one (available soil shear strength exactly balances the shear stress induced by gravity, groundwater, and seismicity), slope loading is considered to be at the point of failure (Blake and others, 2002). The analysis requires measured profiles of existing slopes and other input parameters (e.g., shear strength, groundwater levels, and slope loading; see figure 24).

Static Slope-Stability Analysis

The static stability of slopes is usually analyzed by segmenting a profile of the soil into a series of slices and calculating the average FS for all those slices using a limit equilibrium method. Such analyses require knowledge of the slope geometry and estimates of soil-strength parameters. As a gen-

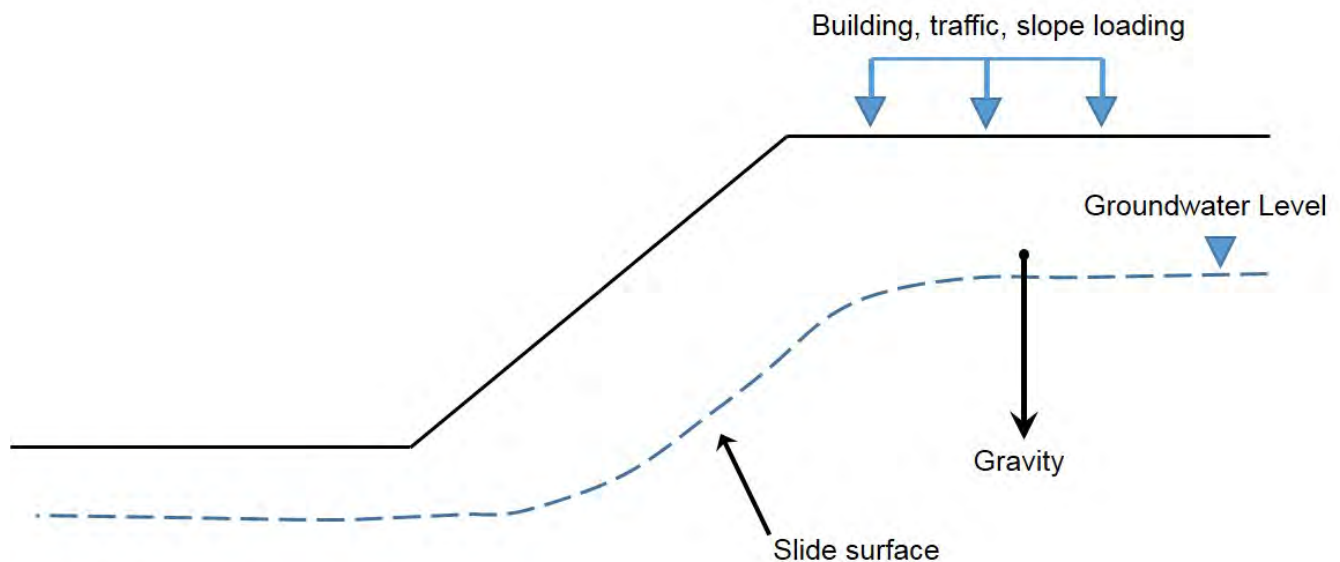


Figure 24. Cross section of typical rotational landslide. Development activities can affect the equilibrium between driving and resisting forces by either increasing driving forces (e.g., construction of building stock, roadways, and grading activities) or decreasing resisting forces (e.g., landscape watering that raises groundwater levels).

eral guideline, the UGS recommends a static FS greater than 1.5 for peak-strength conditions and/or where site characteristics and engineering properties of the geologic materials involved are well constrained. Where these characteristics and properties are not well understood, a higher FS is warranted. For existing landslides where measured residual-strength parameters are available and a back analysis is completed, a minimum FS of 1.3 is acceptable.

Seismic Slope-Stability Analysis

Methods for assessing slope stability during earthquakes have evolved since the mid-twentieth century when Terzaghi (1950) formalized the pseudostatic analysis technique. Methods developed to assess stability of slopes during earthquakes now fall into three general categories: (1) pseudostatic analysis, (2) stress-deformation analysis, and (3) permanent-displacement analysis (Jibson, 2011). Each of these types of analysis has strengths and weaknesses, and each can be appropriately applied in different situations. Pseudostatic analysis, because of its crude characterization of physical processes, tends to yield inconsistent and often conservative results (Jibson, 2011), making it most suitable for preliminary or screening analyses. Stress-deformation analysis is very complex and expensive for routine applications, and is best suited for large earth structures such as dams and embankments. For a pseudostatic FS, the UGS recommends using an appropriate seismic coefficient (typically 1/3 to 2/3 of a peak horizontal ground acceleration [PGA]) with a minimum FS ≥ 1.1 representing stable slope conditions, using low-range strength values and conservative groundwater levels.

Permanent-displacement analysis bridges the gap between the overly simplistic pseudostatic analysis and overly complex

stress-deformation analysis. Newmark's (1965) permanent-displacement method estimates the displacement of a potential landslide block subjected to seismic shaking from a specific strong-motion record. A modification of this method (Jibson and Jibson, 2003) now permits modeling landslides that are not assumed to be rigid blocks and does a better job of modeling the dynamic response of the landslide material, thus yielding a more accurate displacement estimate (Jibson, 2011).

Estimation of Displacement

Despite advances in modeling of landslide displacement and runout, precisely predicting or estimating the velocity or total displacement of landslide materials is still beyond the capability of modern modeling methods (Baum and others, 2008). The most reliable methods of estimating future landslide movements continue to rely on the presence of preexisting landslide deposits. Preexisting landslides provide "ground-truth" data (Baum and others, 2008) from which estimates of future landslide movement can be based, with the confidence that these estimates include site conditions and slope characteristics similar to those under consideration.

Other Investigation Methods

In addition to the methods described above, other methods may be used in landslide-hazard investigations where conditions permit or when requirements for critical structures or facilities include more intensive investigation or monitoring over extended time periods. Other methods may include, but are not limited to:

- Aerial reconnaissance flights, including high-resolution aerial photography, lidar, and other remote-sensing imagery.

- Installation of piezometers.
- Installation of inclinometers.
- Local high-precision surveying or geodetic measurements, including comparison surveys with infrastructure design grades and long-term monitoring employing repeat surveys. Highly stable survey monuments are required, such as those developed by UNAVCO; see <https://www.unavco.org/instrumentation/monumentation/types/types.html> for details.
- Geochronologic analysis, including but not limited to radiometric dating (e.g., ^{14}C , $^{40}\text{Ar}/^{39}\text{Ar}$), luminescence dating, soil-profile development, fossils, tephrochronology, and dendrochronology (see Geochronology section of chapter 2).

LANDSLIDE-HAZARD MITIGATION

Avoidance or mitigation may be required where slope-stability factors of safety are lower than required by the governing agency, or for slopes that have unacceptably large calculated earthquake-induced displacements. Even slopes proven during analysis to be stable may require mitigation to avoid degradation of shear strengths from weathering if site grading exposes weak geologic materials, or to remain stable under anticipated future conditions such as higher groundwater levels, toe erosion, or increased loading of the landslide mass during development (see table 14). The most common methods of mitigation are (1) hazard avoidance, (2) site grading to improve slope stability, (3) improvement of the soil or reinforcement of the slope, and (4) reinforcement of structures built on the slope to tolerate the anticipated displacement (Blake and others, 2002).

LANDSLIDE-INVESTIGATION REPORT

Landslide-hazard reports prepared for investigations in Utah should, at a minimum, address the topics below. Individual site conditions may require that additional items be included. The report should be prepared, stamped, and signed by a Utah licensed Professional Geologist with experience in conducting landslide-hazard investigations. Reports co-prepared by a Utah licensed Professional Engineer should include the engineer's stamp and signature. The report preparation guidelines below expand on the general guidance provided in chapter 2.

A. Text

- a. Purpose and scope of investigation, including a description of the proposed project.
- b. Geologic and hydrologic setting, including previous landslide activity on or near the site. Expected seasonal fluctuation of groundwater conditions.

- c. Site description and conditions, including dates of site visits and observations. Include information on geologic and soil units, hydrology, topography, graded and filled areas, vegetation, existing infrastructure, presence of landslides on or near the site, evidence of landslide-related distress to existing infrastructure, and other factors that may affect the choice of investigative methods and interpretation of data.
- d. Methods and results of investigation.
 1. Review of published and unpublished maps, literature, and records regarding geologic units, geomorphic features, surface water and groundwater, and previous landslide activity.
 2. Results of interpretation of remote-sensing imagery including stereoscopic aerial photographs, lidar, and other remote-sensing data as available.
 3. Results of GPS surveying of ground surface.
 4. Results of surface investigation including mapping of geologic and soil units, landslide features if present, other geomorphic features, and landslide-related distress to existing infrastructure.
 5. Results of subsurface exploration including trenching, boreholes, and geophysical investigations.
 6. Results of field and laboratory testing of geologic materials.
- e. Conclusions.
 1. Existence (or absence) and location of landslides on or adjacent to the site and their spatial relation to existing/proposed infrastructure.
 2. Statement of relative risk that addresses the probability or relative potential for future landsliding and, if possible, the rate and amount of anticipated movement. This may be stated in semi-quantitative terms such as low, moderate, or high as defined within the report, or quantified in terms of landslide movement rates.
 3. Degree of confidence in, and limitations of, the data and conclusions. Evidence on which the conclusions are based should be clearly stated and documented in the report.
- f. Recommendations.
 1. If a landslide-hazard exists on the site, provide setback or other mitigation recommendations as necessary, and justify based on regional and site-specific data.
 2. Limitations on the investigation, and recommendations for additional investigation to better understand or quantify hazards.
 3. Construction testing, observation, inspection, and long-term monitoring.

Table 15. Summary of landslide mitigation approaches (modified from Holtz and Schuster, 1996).

Procedure	Best Application	Limitations	Remarks
Avoid Problem			
Relocate facility	As an alternative anywhere	None if studied during planning phase; large cost if location already is selected and design is complete; large cost if reconstruction is required	Detailed studies of proposed relocation should ensure improved conditions
Completely or partially remove unstable materials	Where small volumes of excavation are involved and where poor soils are encountered at shallow depths	May be costly to control excavation; may not be best alternative for large landslides; may not be feasible because of property rights	Analytical studies must be performed; depth of excavation must be sufficient to ensure firm support
Install bridge	At side-hill locations with shallow soil movements	May be costly and not provide adequate support capacity for lateral forces to restrain landslide mass	Analysis must be performed for anticipated loadings as well as structural capability
Reduce Driving Forces			
Drain surface	In any design scheme; must also be part of any remedial design	Will only correct surface infiltration or seepage due to surface infiltration	Slope vegetation should be considered in all cases
Drain subsurface	On any slope where lowering of groundwater table will increase slope stability	Cannot be used effectively when sliding mass is impervious	Stability analysis should include consideration of seepage forces
Reduce weight	At any existing or potential slide	Requires lightweight materials that may be costly or unavailable; excavation waste may create problems	Stability analysis must be performed to ensure proper placement of lightweight materials
Increase Resisting Forces			
<i>Apply external force</i>			
Use buttress and counter weight fills; toe berms	At an existing landslide; in combination with other methods	May not be effective on deep-seated landslides; must be founded on a firm foundation	Consider reinforced steep slopes for limited property access
Use structural systems	To prevent movement before excavation; where property access is limited	Will not stand large deformations; must penetrate well below sliding surface	Stability and soil-structure analyses are required
Install anchors	Where property access is limited	Requires ability of foundation soils to resist shear forces by anchor tension	Study must be made of in situ soil shear strength; economics of method depends on anchor capacity, depth, and frequency
Increase internal strength			
Drain subsurface	Where water table is above shear surface	Requires experienced personnel to install and ensure effective operation	
Use reinforced backfill	On embankments and steep fill slopes; landslide reconstruction	Requires long-term durability of reinforcement	Must consider stresses imposed on reinforcement during construction
Install in situ reinforcement	As temporary structures in stiff soils	Requires long-term durability of nails, anchors, and micropiles	Requires thorough soils investigation and properties testing
Biotechnical stabilization	On soil slopes of modest heights	Climate; may require irrigation in dry seasons; longevity of selected plants	Design is by trial and error plus local experience

B. References

- a. Literature and records cited or reviewed; citations should be complete (see References section of this publication for examples).
- b. Remote-sensing images interpreted; list type, date, project identification codes, scale, source, and index numbers.
- c. Other sources of information, including well records, personal communication, and other data sources.

C. Illustrations

- a. Location map—showing site location and significant physiographic and cultural features, generally at 1:24,000 scale or larger and indicating the Public Land Survey System ¼-section, township, and range; and the site latitude and longitude to four decimal places with datum.
- b. Site development map—showing site boundaries, existing and proposed structures, graded and filled areas (including engineered and non-engineered fill), streets, exploratory test pits, trenches, boreholes, and geophysical traverses. The map scale may vary depending on the size of the site and area covered by the study; the minimum recommended scale is 1 inch = 200 feet (1:2400) or larger where necessary.
- c. Geologic map(s)—showing distribution of bedrock and unconsolidated geologic units, faults or other geologic structures, extent of existing landslides, geomorphic features, and, if appropriate, features mapped using lidar data. Scale of site geologic maps will vary depending on the size of the site and area of study; minimum recommended scale is 1 inch = 200 feet (1:2400) or larger where necessary. For large projects, a regional geologic map and regional lidar coverage may be required to adequately depict all important geologic features and recent landslide activity.
- d. Geologic cross sections, if needed, to provide three-dimensional site representation.
- e. Logs of exploratory trenches, test pits, cone penetrometer test soundings, and boreholes—showing details of observed features and conditions. Logs should not be generalized or diagrammatic. Trench and test pit logs should show geologic features at the same horizontal and vertical scale and may be on a rectified photomosaic base.
- f. Geophysical data and interpretations.
- g. Photographs that enhance understanding of site surface and subsurface (trench and test pit walls) conditions with applicable metadata.

D. Authentication

Report signed and sealed by a Utah licensed Professional Geologist in principal charge of the inves-

tigation (Title 58-76-10 – Professional Geologists Licensing Act [Utah Code, 2011]). Final geologic maps, trench logs, cross sections, sketches, drawings, and plans prepared by, or under the supervision of, a professional geologist also must bear the seal of the professional geologist (Utah Code, 2011). Reports co-prepared by a Utah licensed Professional Engineer and/or Utah licensed Professional Land Surveyor must include the engineer's and/or surveyor's stamp and signature.

E. Appendices

Supporting data not included in the body of the report (e.g., water-well data, survey data, groundwater and deformation monitoring data, etc.).

FIELD REVIEW

The UGS recommends a technical field review by the regulatory-authority geologist once a landslide-hazard investigation is complete. The field review should take place after any trenches or test pits are logged, but before they are closed so subsurface site conditions can be directly observed and evaluated. See Field Review section in chapter 2.

REPORT REVIEW

The UGS recommends regulatory review of all reports by a Utah licensed Professional Geologist experienced in landslide-hazard investigations and acting on behalf of local governments to protect public health, safety, and welfare, and to reduce risks to future property owners (Larson, 1992, 2015). See Report Review section in chapter 2.

DISCLOSURE

The UGS recommends disclosure during real-estate transactions whenever an engineering-geology investigation has been performed. See Disclosure section in chapter 2.

ACKNOWLEDGMENTS

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CHAPTER 5

GUIDELINES FOR THE GEOLOGIC INVESTIGATION OF DEBRIS-FLOW HAZARDS ON ALLUVIAL FANS IN UTAH

by
Richard E. Giraud, P.G.



September 12, 2002, fire-related debris flow in Santaquin subdivision following the 2001 Mollie wildfire.

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CHAPTER 5: GUIDELINES FOR THE GEOLOGIC INVESTIGATION OF DEBRIS-FLOW HAZARDS ON ALLUVIAL FANS IN UTAH

by Richard E. Giraud, P.G.

INTRODUCTION

These guidelines outline the recommended minimum acceptable level of effort for evaluating debris-flow hazards on alluvial fans in Utah. These guidelines were originally published in 2005 (Giraud, 2005). The guidelines below provide updated information on debris-flow-hazard investigation in Utah. The objective of these guidelines is to promote uniform and effective statewide implementation of debris-flow hazard investigation and mitigation measures to reduce risk. These guidelines do not include systematic descriptions of all available investigative or mitigation techniques or topics, nor is it suggested that all techniques or topics are appropriate for every project. Variations in site conditions, project scope, economics, and level of acceptable risk may require that some topics be addressed in greater detail than is outlined in these guidelines. However, all elements of these guidelines should be considered in debris-flow hazard investigations, and may be applied to any project site, large or small.

Background

Debris flows and related sediment flows are fast-moving flow-type landslides composed of a slurry of rock, mud, organic matter, and water that move down drainage-basin channels onto alluvial fans (figure 25). Debris flows generally initiate on steep slopes or in channels by the addition of water from intense rainfall or rapid snowmelt. Flows typically incorporate additional sediment and vegetation as they travel down-channel. When flows reach an alluvial fan and lose channel confinement, they spread laterally and deposit the entrained sediment. In addition to being debris-flow-deposition sites, alluvial fans are also favored sites for urban development; therefore, a debris-flow-hazard investigation is necessary when developing on alluvial fans. The hazard investigation may indicate that risk reduction is necessary for sustainable development on the alluvial fan. A debris-flow-hazard investigation requires an understanding of the debris-flow processes that govern sediment supply, sediment bulking, flow volume, flow frequency, and deposition. However, a uniform level of acceptable risk for debris flows based on recurrence or frequency/volume relations, such as the 100-year flood or the 2% in 50-year exceedance probability for earthquake ground shaking, has not been established in Utah.

Historical records of sedimentation events in Utah indicate that debris flows are highly variable in terms of size, material properties, travel distance, and depositional behavior; therefore, a high level of precision for debris-flow design parameters is not yet possible, and conservative engineering parameters and designs must be used where risk reduction is necessary. Debris-flow-hazard investigations follow the premise that areas where debris flows have deposited sediment in the recent geologic past are likely sites for future debris-flow activity. Debris-flow-hazard investigations use geomorphic, sedimentologic, and stratigraphic information from existing debris-flow deposits and sediment-volume estimates from the feeder channel and drainage basin to estimate the hazard within the active depositional area of an alluvial fan. A complete debris-flow-hazard investigation typically involves geologic, hydrologic, hydraulic, and engineering evaluations. The nature of the proposed development and the anticipated risk-reduction measures required typically determine the scope of the hazard investigation.

Large-volume debris flows are low-frequency events, and the interval between large flows is typically deceptively tranquil. The debris-flow hazard on alluvial fans can be difficult to recognize, particularly on alluvial fans that are subject to high-magnitude, low-frequency events (Jakob, 2005). Debris flows pose a hazard very different from other types of landslides and floods due to their rapid movement and destructive power. Debris flows can occur with little warning. Fifteen people have been killed by debris flows in Utah (chapter 1, table 4). Thirteen of the victims died in two different night events when fast-moving debris flows allowed little chance of escape. In addition to threatening lives, debris flows can damage buildings and infrastructure by sediment burial, erosion, direct impact, and associated water flooding. The 1983 Rudd Canyon debris flow in Farmington deposited approximately 90,000 cubic yards of sediment on the alluvial fan, damaged 35 houses, and caused an estimated \$3 million in property damage (Deng and others, 1992).

Variations in sediment-water concentrations produce a continuum of sediment-water flow types that build alluvial fans. Beverage and Culbertson (1964), Pierson and Costa (1987), Costa (1988), and Pierson (2005a, 2005b) describe the following flow types based on generalized sediment-water con-

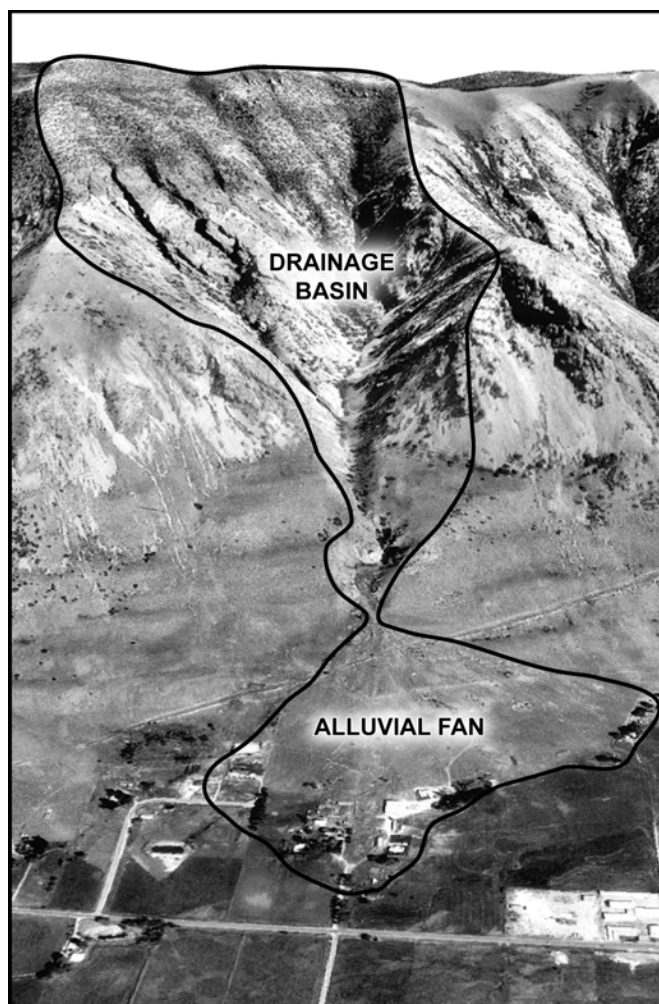


Figure 25. Example of a drainage basin and alluvial fan at Kotter Canyon, north of Brigham City, Utah.

centrations and resulting flow behavior: stream flow (less than 20% sediment by volume), hyperconcentrated flow (20 to 60% sediment by volume), and debris flow (greater than 60% sediment by volume). These categories are approximate because the exact sediment-water concentration and flow type depend on the grain-size distribution and physical-chemical composition of the flows. Also, field observations and video recordings of poorly sorted water-saturated sediment provide evidence that no unique flow type adequately describes the range of mechanical behaviors exhibited by these sediment flows (Iverson, 2003). All three flow types can occur during a single event. The National Research Council (1996) report *Alluvial-Fan Flooding* considers stream, hyperconcentrated, and debris-flow types of alluvial-fan flooding. The term debris flow has been used in Utah to describe hyperconcentrated flows (Wieczorek and others, 1983).

These guidelines address only hazards associated with hyperconcentrated- and debris-flow sediment-water concentrations and not stream-flow flooding on alluvial fans. The term debris flow is used here in a general way to include all flows within the hyperconcentrated- and debris-flow sediment-water con-

centration range. These are the most destructive flows, and it can be difficult to distinguish between hyperconcentrated and debris flows based on their deposits or their effect on infrastructure. Stream flow involves sediment transport by entrained bed load and suspended sediment load associated with water transport. Sheetfloods are unconfined stream flows that spread over the alluvial fan (Blair and McPherson, 1994). Debris-flow and stream-flow-flooding hazards may be managed differently in terms of land-use planning and protective measures, but because debris-flow and stream-flow hazards are often closely associated, concurrent investigations of both debris-flow and stream-flow components of alluvial-fan flooding is often beneficial.

Purpose

The Utah Geological Survey (UGS) developed these guidelines to help Engineering Geologists evaluate debris-flow hazards on alluvial fans to ensure safe and sustainable development. The purpose of a debris-flow-hazard investigation is to determine whether or not a debris-flow hazard exists, describe the hazard, and if needed, provide geologic parameters necessary for hydrologists and engineers to design risk-reduction measures. The objective is to determine active depositional areas, frequency and magnitude (volume) of previous flows, and likely impacts of future sedimentation events. Dynamic analysis of debris flows using hydrologic, hydraulic, and other engineering methods to design site-specific risk-reduction measures is not addressed by these guidelines.

These guidelines will assist Engineering Geologists in evaluating debris-flow hazards in Utah, engineers in designing risk-reduction measures, and land-use planners and technical reviewers in reviewing debris-flow-hazard reports. The Engineering Geologist has the responsibility to (1) conduct a study that is thorough and cost effective, (2) be familiar with and apply appropriate investigation methods, (3) record accurate observations and measurements, (4) use proper judgment, and (5) present valid conclusions and recommendations supported by adequate data and sound interpretations. The geologist must also understand and clearly state the uncertainties and limitations of the investigative methods used and the uncertainties associated with design-parameter estimates.

SOURCES OF DEBRIS-FLOW INFORMATION

Sources of information for debris-flow-hazard investigations include U.S. Geological Survey (USGS) and UGS maps that show debris-flow source areas at a nationwide scale (1:2,500,000; Brabb and others, 2000), statewide scale (1:500,000; Brabb and others, 1989; Harty, 1991), and 30 x 60-minute quadrangle scale (1:100,000) for the entire state (Elliott and Harty, 2010). The 30 x 60-minute quadrangle maps show both the source and depositional areas of some

historical debris flows. Alluvial-fan deposits are commonly shown on modern geologic maps, and the UGS and others map surficial (Quaternary) geology on USGS 7½-minute-scale quadrangle maps (1:24,000). Wasatch Front counties have maps available in county planning offices showing special-study areas where debris-flow-hazard investigations are required. Surficial geologic maps generally show alluvial-fan deposits of different ages and differentiate stream alluvium from alluvial-fan deposits.

Numerous investigators have studied debris-flow processes and performed debris-flow-hazard investigations in Utah. Many studies address the 1983 and 1984 debris flows that initiated during a widespread rapid-snowmelt period. Christenson (1986) discussed mapping, hazard evaluation, and mitigation measures following the debris flows of 1983. Wiczorek and others (1983, 1989) described the potential for debris flows and debris floods and mitigation measures along the Wasatch Front between Salt Lake City and Willard. Lips (1985, 1993) mapped 1983 and 1984 landslides and debris flows in central Utah. Paul and Baker (1923), Woolley (1946), Bailey and others (1947), Croft (1962), Butler and Marsell (1972), Marsell (1972), Keate (1991), Elliott and Kirschbaum (2007), and Elliott and Harty (2010) documented different debris-flow events in Utah. Other debris-flow events and investigation reports can be found in the UGS *GeoData Archive System* (<https://geodata.geology.utah.gov/>), a collection of consultant's and other geologic-hazard reports and data maintained by the UGS (see chapter 2).

Several researchers investigated different aspects of the 1983 and 1984 Davis County debris flows. Pack (1985), for the purpose of landslide susceptibility mapping, used a multivariate analysis to evaluate factors related to initiation of debris slides in 1983 that then transformed into debris flows. Pierson (1985) described flow composition and dynamics of the 1983 Rudd Canyon debris flow in Farmington. Santi (1988) studied the kinematics of debris-flow transport and the bulking of colluvium and channel sediment during a 1984 debris flow in Layton. Mathewson and others (1990) studied bedrock aquifers and the location of springs and seeps that initiated colluvial slope failures in 1983 and 1984 that then transformed into debris flows. Keaton (1988) and Keaton and others (1991) developed a probabilistic model to assess debris-flow hazards on alluvial fans. Williams and Lowe (1990) estimated channel sediment bulking rates by comparing cross-channel profiles of channels that discharged historical debris flows with channels that had not discharged flows in historical time. Deng and others (1992) studied debris-flow impact forces, types of house damage, and economic losses from the 1983 Rudd Canyon debris flow.

Outside of Utah others have outlined approaches for evaluating debris-flow hazards and methods for estimating design parameters for debris-flow-risk reduction. Hungr and others (1984) described approaches to estimate debris-flow frequency, volume, peak discharge, velocity, and runout distance in

western Canada. VanDine (1985) described conditions conducive to debris flows, triggering events, effects, and mitigation in the southern Canadian Cordillera. Hungr and others (1987) described debris-flow-engineering concepts and risk reduction in source, transport, and deposition zones in British Columbia. Jackson (1987) outlined methods for evaluating debris-flow hazards on alluvial fans in the Canadian Rocky Mountains based on the presence of debris-flow deposits, alluvial-fan geomorphic features, deposit ages, debris-flow frequency, and basin conditions. Jackson (1987) also provided a flow chart summarizing debris-flow-hazard evaluation. Jackson and others (1987) used geomorphic and sedimentologic criteria to distinguish alluvial fans prone to debris flows and those dominated by stream-flow processes. Ellen and others (1993) used digital simulations to map debris-flow hazards in the Honolulu District of Oahu, Hawaii. VanDine (1996) summarized the use of debris-flow control structures for forest engineering applications in British Columbia. Boyer (2002) discussed acceptable debris-flow-risk levels for subdivisions in British Columbia and provided a suggested outline for debris-flow studies on alluvial fans. Jakob and Hungr (2005) are editors of *Debris-flow Hazards and Related Phenomena*, a book that provides an excellent overview of debris-flow science, mitigation, and case histories.

U.S. Natural Resources Conservation Service (NRCS, formerly Soil Conservation Service) soil surveys show soils on alluvial fans and in drainage basins. These soil surveys provide information on soil type, depth, permeability, erodibility, slope steepness, vegetation, and parent material. Some soil surveys document historical debris-flow activity.

Newspaper articles and event reports often provide descriptions of historical debris flows and photographs showing impacts on developed areas (Elliott and Kirschbaum, 2007). Written observations and photographs of historical debris flows provide useful information on flow volume, flow velocity, flow depth, deposit thickness, deposit areas, and building damage. Comparison of historical debris-flow deposits with prehistoric deposits indicates whether the historical debris flow is a typical event relative to other flows preserved in the sedimentary record.

Stereoscopic aerial photographs are a fundamental tool for evaluating drainage basins and alluvial fans. Interpretation of aerial photographs can provide information on historical debris-flow events, surficial geology, soils, bedrock exposures, channel characteristics, landslides, previous debris flows, relative deposit ages, erosional areas, land use, vegetation types, and time brackets for historical debris flows. Reviewing the oldest and most recent photos available is useful to evaluate drainage-basin and alluvial-fan changes through time. Obtaining aerial photographs taken after historical debris flows allows direct mapping of sediment sources and deposits. The UGS maintains the *Utah Aerial Imagery* database of historical aerial photography in Utah (<https://geodata.geology.utah.gov/imagery/>).

DEBRIS-FLOW-HAZARD INVESTIGATION

A debris-flow-hazard investigation is necessary when developing on active alluvial fans where relatively recent debris deposition has occurred. The investigation requires application of quantitative and objective procedures to estimate the location and recurrence of flows, assess their impacts, and provide recommendations for risk-reduction measures if necessary. The hazard investigation must consider the intended land use because site usage has direct bearing on the degree of risk to people and structures. The UGS recommends critical facilities and structures for human occupancy not be placed in active debris-flow travel and deposition areas unless methods are used to either eliminate or reduce the risk to an acceptable level. In some cases, risk-reduction measures may be needed retroactively to protect existing development.

To evaluate the hazard on active alluvial fans, the frequency, magnitude or volume (deposit area and thickness), and runout distance of past debris flows must be determined. The geologic methods presented here rely on using the geologic characteristics of existing alluvial-fan deposits as well as drainage-basin and feeder-channel sediment-supply conditions to estimate the characteristics of past debris flows. Historical records can provide direct evidence of debris-flow volume, frequency, and depositional area. However, the observation period in Utah is short, and in many areas debris flows either have not occurred or have not been documented. Therefore, geologic methods provide the principal means of determining the history of debris-flow activity on alluvial fans. Multiple geologic methods should be used whenever possible to compare results of different methods to understand the appropriateness, validity, and limitations of each method and increase confidence in the hazard investigation.

Where stream flow dominates on an alluvial fan, a stream-flow-flooding investigation is necessary, but a debris-flow-hazard investigation is not required. The National Research Council (1996) report *Alluvial-Fan Flooding* and the Federal Emergency Management Agency (2003) *Guidance for Alluvial Fan Flooding Analysis and Mapping* provide guidance for evaluating the stream-flow component of alluvial-fan flooding.

When to Perform a Debris-Flow-Hazard Investigation

Geologic hazards are best addressed prior to land development. The UGS recommends that a debris-flow-hazard investigation be made for all new buildings for human occupancy and for modified International Building Code (IBC) Risk Category II(a), II(b), III, and IV facilities (see table 13 in chapter 3 of this publication, modified from IBC table 1604.5 [International Code Council, 2017a]) on or adjacent to alluvial fans. Utah jurisdictions that have adopted debris-flow special-study maps identify zones in known debris-flow-susceptible areas within which they require site-specific investigation. The

UGS recommends that investigations as outlined in these guidelines be conducted for sites on or adjacent to alluvial fans for all IBC Risk Category III and IV facilities, whether near a mapped debris-flow susceptible area or not, to ensure that a previously unknown debris-flow hazard is not present. If a hazard is found, the UGS recommends a comprehensive investigation be conducted. Additionally, in some instances an investigation may become necessary when existing infrastructure is discovered to be on or adjacent to a debris-flow-susceptible area.

The level of investigation conducted for a particular project depends on several factors, including (1) site-specific geologic conditions, (2) type of proposed or existing development, (3) level of acceptable risk, and (4) governmental permitting requirements, or regulatory agency rules and regulations. A debris-flow-hazard investigation may be conducted separately, or as part of a comprehensive geologic-hazard and/or geotechnical site investigation (see chapter 2).

Minimum Qualifications of Investigator

Debris-flow-related engineering-geology investigations and accompanying geologic-hazard evaluations performed before the public shall be conducted by or under the direct supervision of a Utah licensed Professional Geologist (Utah Code, Title 58-76-10) who must sign and seal the final report. Often these investigations are interdisciplinary in nature, and where required, must be performed by qualified, experienced, Utah licensed Professional Geologists (PG, specializing in engineering geology) and Professional Engineers (PE, specializing in geological and/or geotechnical engineering) working as a team. See Investigator Qualifications section in chapter 2.

Alluvial-Fan Evaluation

Alluvial fans are landforms composed of a complex assemblage of debris-, hyperconcentrated-, and stream-flow deposits. Alluvial-fan geomorphology, sedimentology, and stratigraphy provide a long-term depositional history of the frequency, volume, and depositional behavior of past flows, and provide a geologic basis for estimating debris-flow hazards.

Defining the Active-Fan Area

The first step in an alluvial-fan evaluation is determining the active-fan area using mapping and alluvial-fan dating techniques. The active-fan area is where relatively recent deposition, erosion, and alluvial-fan flooding have occurred (figure 26). In general, sites of sediment deposition during Holocene time (past 11,700 years; post-Lake Bonneville in northwest Utah) are considered active unless proven otherwise. Aerial photographs, detailed topographic maps, and field verification of the extent, type, character, and age of alluvial-fan deposits are used to map active-fan areas. Some areas of Utah have light detection and ranging (lidar) coverage, and the lidar data

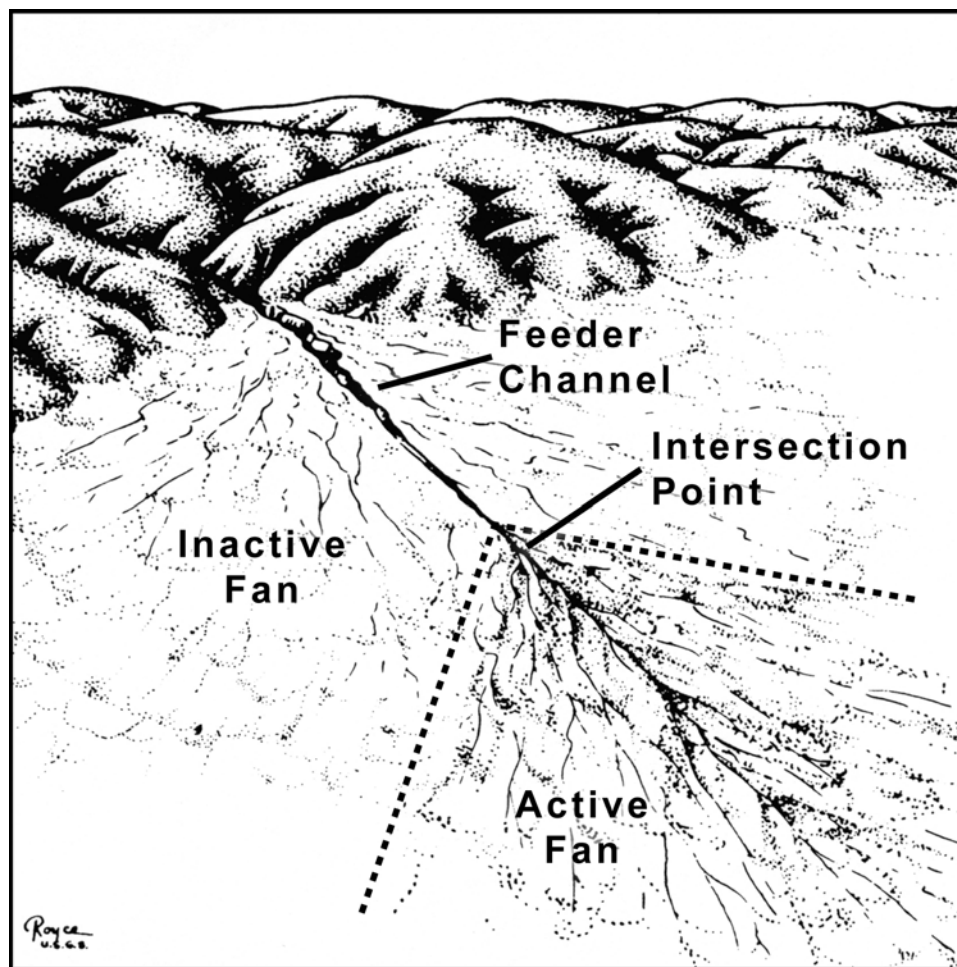


Figure 26. Active and inactive alluvial fans, feeder channel, and intersection point. Modified from Bull (1977). Reproduced with permission by Edward Arnold (Publishers) Ltd., London.

can be used to develop detailed topographic maps and hill-shade images to aid in mapping alluvial-fan deposits. The UGS maintains an archive of lidar data (<https://geology.utah.gov/map-pub/data-databases/lidar/>).

The youngest debris-flow deposits generally indicate debris flows produced during the modern climate regime, and are important for estimating the likely volume and runout of future flows. The active fan is often used as a zoning tool to identify special-study areas where detailed debris-flow-hazard investigations are required prior to development. The National Research Council (1996) report *Alluvial-Fan Flooding* provides criteria for differentiating active and inactive alluvial fans.

Mapping Alluvial-Fan and Debris-Flow Deposits

Geologic mapping is critical for 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. Recent debris-flow deposits are generally mapped based on their distinctive surface morphology and composi-

tion. Peterson (1981), Christenson and Purcell (1985), Wells and Harvey (1987), Bull (1991), Whipple and Dunne (1992), Doelling and Willis (1995), Hereford and others (1996), and Webb and others (1999) provide examples and suggestions for mapping alluvial-fan deposits.

The geomorphic, sedimentologic, and stratigraphic relations recognized during mapping of alluvial-fan deposits provide insight into debris-flow recurrence, volumes, and depositional behavior, and therefore debris-flow hazard in the proximal, medial, and distal fan areas (figure 27). The intersection point or apex of the active fan is where the feeder channel ends and sediment flows lose confinement and begin to spread laterally, thin, and deposit sediment (figure 26; Blair and McPherson, 1994). Most feeder channels lose confinement on the upper fan, but others may incise the inactive upper fan and convey sediment and flood flows farther downfan via a fanhead trench or channel (figure 26).

In proximal fan areas, debris flows generally have the highest velocity and greatest flow depth and deposit thickness, and are therefore the most destructive. In distal fan areas, debris flows generally have lower velocities and shallower flow depths and

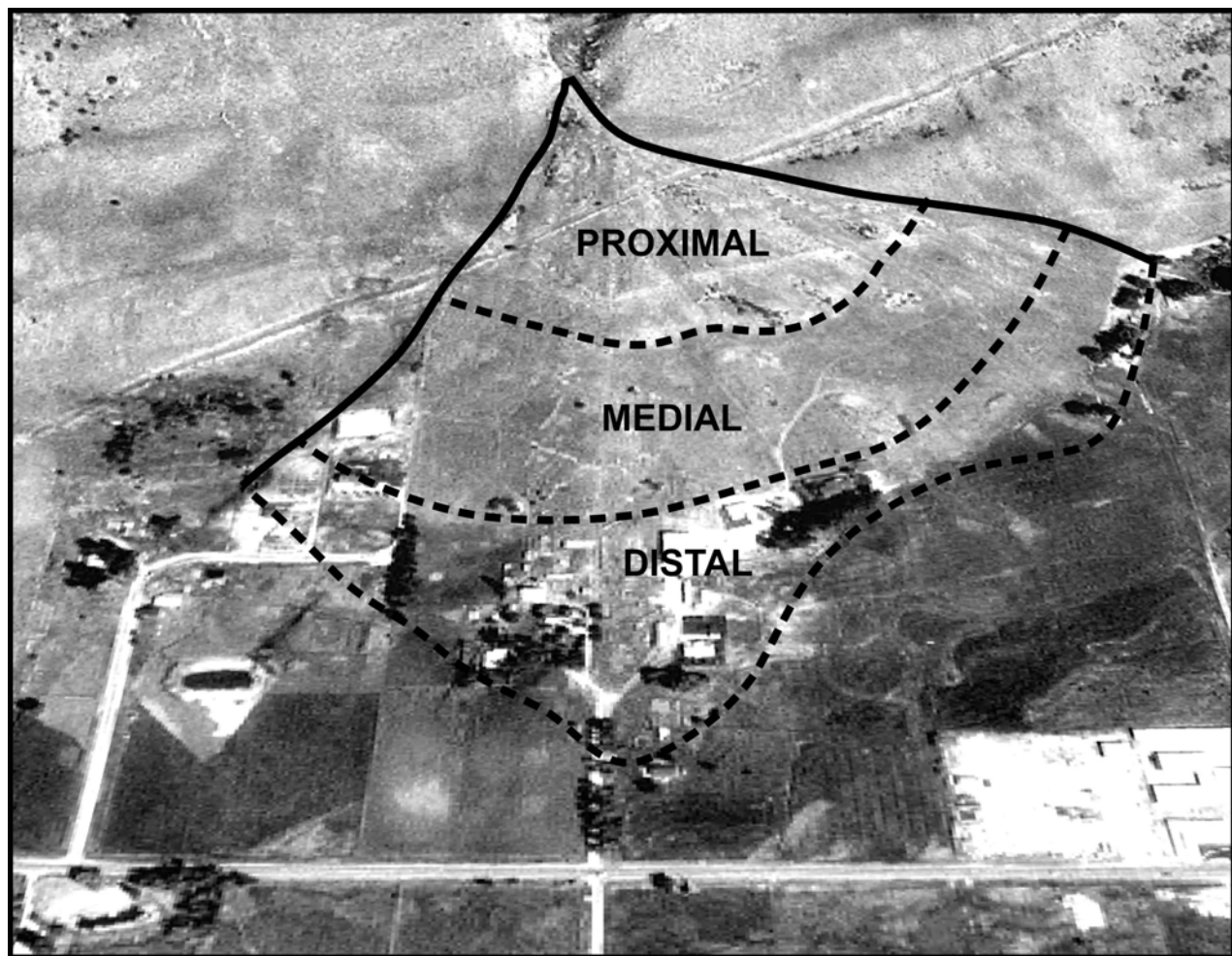


Figure 27. Approximate proximal, medial, and distal fan areas on the Kotter Canyon alluvial fan, north of Brigham City, Utah.

deposits, and therefore are less destructive. Often, distal fan areas are dominated by stream-flow processes only. However, some debris flows may create their own channels by producing levees on the fan and convey sediment farther downfan, or block the active channel and avulse (make an abrupt change in course) to create new channels. Unpredictable flow behavior is typical of debris flows and must be considered when evaluating debris-flow depositional areas, runout distances, and depositional behavior on alluvial fans.

The proximal part of an alluvial fan is generally made up of vertically stacked debris-flow lobes and levees that result in thick, coarse deposits that exhibit the roughest surface on the fan (figure 27). Hyperconcentrated flows may be interbedded with debris flows in the proximal fan area, but are generally thinner and have smoother surfaces due to their higher initial water content. Proximal fan deposits generally transition to thinner and finer grained deposits downfan, resulting in smoother fan surfaces in medial and distal fan areas (figure 27). Coarser grained sedimentary facies grade downfan into finer grained facies deposited by more dilute sediment flows. The downfan decrease in grain size generally corresponds with a decrease in fan-slope angle. Coarser grained debris-

flow deposits generally create steeper proximal-fan slopes (6° – 8°), while finer grained stream-flow deposits form gentle distal-fan slopes (2° – 3°) (National Research Council, 1996).

Differences in bedding, sediment sorting, grain size, and texture are useful to distinguish debris-, hyperconcentrated-, and stream-flow deposits. Costa and Jarrett (1981, p. 312–317), Wells and Harvey (1987, p. 188), Costa (1988, p. 118–119), Harvey (1989, p. 144), the National Research Council (1996, p. 74), and Meyer and Wells (1997, p. 778) provide morphologic and sedimentologic criteria (surface morphology, internal structures, texture, grain size, and sorting) for differentiating the three flow types. In general, debris-flow deposits are matrix supported and poorly sorted, hyperconcentrated-flow deposits are clast supported and poorly to moderately sorted, and stream-flow deposits are clast supported and moderately to well sorted. Table 16 is modified from Costa (1988) and shows geomorphic and sedimentologic characteristics of debris-, hyperconcentrated-, and stream-flow deposits. Grain-size analysis is useful in classifying deposits into the different flow types (Pierson, 1985). In addition to the primary process of debris-flow deposition, secondary processes of weathering and erosion by fluvial and/or eolian activity can rework de-

Table 16. *Geomorphic and sedimentologic criteria for differentiating water and sediment flows (modified from Costa, 1988, and Pierson, 2005a).*

Flow Type	Landforms and Deposits	Sedimentary Structures	Sediment Characteristics
Stream flow	Bars, fans, sheets, splays; channels have large width-to-depth ratio	Horizontal or inclined stratification to massive; weak to strong imbrication; cut-and-fill structures; ungraded to graded	Beds well to moderately sorted; clast supported
Hyperconcentrated flow	Similar to water flood, rectangular channel	Weak stratification to massive; weak imbrication; thin gravel lenses; normal and reverse grading	Poorly to moderately sorted; clast supported
Debris flow	Marginal levees, terminal lobes, trapezoidal to U-shaped channel	No stratification; weak to no imbrication; inverse grading at base; normal grading near top	Very poor to extremely poor sorting; matrix supported; extreme range of particle sizes; may contain megaclasts

bris-flow deposits. The subsequent reworking of debris-flow deposits can change the morphology and texture of the fan surface and can introduce uncertainty of mapping individual debris-flow deposits.

More than one flow type may occur during a sedimentation event. Keaton (1988) described an ideal vertical alluvial-fan stratigraphic sequence based on deposits in Davis County and published eyewitness accounts. The ideal sequence resulting from a single debris flow consists of a basal plastic debris-flow deposit, sequentially overlain by a viscous debris-flow, hyperconcentrated-flow, and finally a stream-flow deposit owing to time-varying availability of sediment and water. Janda and others (1981) identified a similar vertical sequence in debris-flow deposits at Mount St. Helens, Washington, and attributed the vertical sequence to rapid transitions between flow types.

Lidar is a powerful tool for mapping alluvial-fan deposits (appendix C). The digital elevation model and derived detailed topography, hillshade, and hillslope maps aid the debris-flow investigator in characterizing the alluvial-fan feeder channel, the fan surface, fan deposits, fan channels, and presenting the alluvial-fan-hazard information.

Determining the Age of Debris-Flow Deposits

Both relative and numerical geochronologic techniques (Noller and others, 2000; Geochronology section in chapter 2) are useful for dating debris-flow deposits and determining the frequency of past debris flows on a fan. Relative dating methods include geomorphic position of debris-flow deposits, boulder weathering, rock varnish, soil-profile development (including pedogenic carbonate accumulation), lichen growth, and vegetation age and pattern. The amount of soil development on a buried debris-flow surface is an indicator of the relative amount of time between debris flows at a particular location. Numerical dating techniques include sequential photographs, historical records, vegetation age, and isotopic dating, principally radiocarbon. Radiocarbon ages of paleosols buried by

debris flows can provide closely limiting maximum ages of the overlying flow (Forman and Miller, 1989). Radiocarbon ages of detrital charcoal within a debris-flow deposit provide a more broadly limiting maximum age. The applicability and effectiveness of radiocarbon dating of debris-flow events is governed by the presence and type of datable material and available financial resources (Lettis and Kelson, 2000).

Subsurface Exploration

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-fan and downfan extent of individual flows, and volume based on thickness and area. The type, number, and spacing of excavations depend on the purpose and scale of the hazard investigation, geologic complexity, rate of downfan and across-fan transitions in flow type and thickness, and anticipated risk-reduction measures. T-shaped test pits or trenches expose three-dimensional deposit relations. Excavations in the proximal fan areas generally need to be deeper due to thicker deposits. To evaluate the entire fan, tens of excavations may be required.

Mulvey (1993) used subsurface stratigraphic data from seven test pits to estimate flow types, deposit thicknesses, the across-fan and downfan extent of deposits, deposit volumes, and age of deposits to interpret the depositional history of a 2-acre post-Bonneville fan in Centerville. On the Jones Creek fan in Washington State, Jakob and Weatherly (2005) used subsurface stratigraphic data and radiocarbon ages from trenches to determine the frequency of debris flows; a subsequent risk analysis demonstrated the need for mitigation measures. Blair and McPherson (1994) used across-fan and downfan stratigraphic cross sections to display, analyze, and interpret the surface and subsurface interrelations of fan slope, deposit levees and lobes, deposit and sediment facies, and grain size. However stratigraphic interpretation can be problematic. Debris-flow deposits in a sedimentary sequence that have similar

grain sizes and lack an intervening paleosol or other distinct layer may be difficult to distinguish. The lack of distinction between individual debris-flow deposits can lead to underestimating debris-flow recurrence and overestimating debris-flow magnitude (Major, 1997).

Drainage-Basin and Channel Evaluation

Drainage-basin and channel evaluations determine the conditions and processes that govern sediment supply and transport to the fan surface, and provide an independent check of alluvial-fan evaluations. Drainage-basin and channel evaluation involves estimating the erosion potential of the basin and feeder channel and the volume, grain size, and gradation of sediment that could be incorporated into a debris flow. The evaluation also considers different debris-flow initiation mechanisms. The results of the drainage-basin and channel evaluation are used to estimate the probability of occurrence and design volumes of future debris flows. In some cases, evaluation of the drainage basin and channel may be performed independently of the alluvial-fan evaluation. For example, a wildfire in a drainage basin may initiate a post-burn analysis of the drainage basin and channels to estimate or revise the erodible sediment volume and the probability of post-fire debris flows.

Debris-Flow Initiation

Debris flows initiate in the drainage basin and require a hydrologic trigger such as intense or prolonged rainfall, rapid snowmelt, and/or groundwater discharge. Intense thunderstorm rainfall, often referred to as cloudburst storms by early debris-flow investigators in Utah (for example, Woolley, 1946; Butler and Marsell, 1972), has generated numerous debris flows. Conditions in the drainage basin important in initiating debris flows are the basin relief, channel gradient, bedrock and surficial geology, vegetation and wildfire, and land use. Exposed bedrock on hillsides promotes rapid surface-water runoff, which helps generate debris flows. Wildfires can destroy rainfall-intercepting vegetation and create conditions that promote rapid surface-water runoff. All of these conditions may work in combination to promote debris flows.

In Utah, above-normal precipitation from 1980 through 1986 produced numerous snowmelt-generated landslides (mostly debris slides) that transformed into debris flows and then traveled down channels (Brabb and others, 1989; Harty, 1991). Many of these debris flows occurred during periods of rapid snowmelt and high stream flows, when Santi (1988) indicates that saturated channel sediment is more easily entrained into debris flows. Above-normal snowpacks in 2005 and 2011 also produced snowmelt debris flows, but the rapid snowmelt pattern was not as widespread as the 1980–86 period.

In contrast to wet climate conditions, dry conditions often lead to wildfires that partially or completely burn drainage-basin vegetation, creating conditions for increased runoff and ero-

sion. Relatively small amounts of intense thunderstorm rainfall (a few tenths of an inch per hour) are capable of triggering fire-related debris flows (McDonald and Giraud, 2010; Cannon and others, 2008).

During the drought years of 1999–2004 in northern Utah, 26 debris flows occurred in 7 wildfire areas, including repeated flows from single drainages in different storms and multiple flows from different drainages during the same storm (Giraud and McDonald, 2007). The fire-related debris flows were generated by erosion and progressive sediment bulking of runoff rather than by landslides. These debris flows initiated in a similar manner to the 1920s and 1930s debris flows from overgrazed and burned watersheds in northern Utah studied by Bailey and others (1947) and Croft (1962), and burned areas in the western U.S. studied by Cannon (2001). The debris flows produced from the drainage basins show a wide range of channel sediment-bulking rates, flow volumes, and runout distances (Giraud and McDonald, 2007).

Debris-flow-hazard investigations following a wildfire address burn severity and hillslope and channel conditions. Wells (1987), Florsheim and others (1991), Cannon and others (1995), Meyer and others (1995), Cannon and Reneau (2000), Kirkham and others (2000), Robichaud and others (2000), and Cannon (2001) discuss post-burn conditions and debris-flow susceptibility following wildfires. Cannon and others (2010) developed empirical models based on statistical data from recently burned basins in the Intermountain Western United States including Utah, to predict the probability and volume of post-fire debris flows. Input data include topographic parameters, soil characteristics, burn severity, and rainfall totals and intensities. Cannon and others' (2010) methodology estimates probability and volume of debris flows at a specific point in time following a wildfire. As vegetation regrows and soil conditions return to pre-burn conditions the probability of a debris flow decreases. Gartner and others (2008) found that most fire-related debris flows generally occur within two years following the wildfire. Post-fire debris-flow methodology is not appropriate for determining the volume and probability of non-fire-related debris flows, which generally are larger volume and less frequent.

Debris-Flow Susceptibility of the Basin

Debris-flow susceptibility is related to the runoff, erosion, and landslide potential of drainage-basin slopes and the volume of erodible sediment stored in drainage-basin channels. Characterizing drainage-basin morphologic parameters, mapping bedrock and surficial geology, and estimating the volume of erodible channel sediment provides information on the likelihood and volume of future debris flows.

Important basin parameters include area, relief, and length and gradient of channels. A description of the types and density of vegetation and land use provides information on the possible

effects of wildfire and land use on surface-water runoff and erosion. Small, steep drainage basins are well suited for generating debris flows because of their efficiency in concentrating and accelerating overland surface-water flow.

Both surficial and bedrock geology play a role in the susceptibility of drainage basins to produce flows. Some bedrock weathers rapidly and provides an abundant supply of channel sediment, whereas resistant bedrock supplies sediment at a slower rate. Exposed cliff-forming bedrock greatly increases runoff.

Some bedrock, such as shale, weathers and generates fine-grained clay-rich sediment, whereas other bedrock types generate mostly coarse sediment. The clay content of debris flows directly influences flow properties. Costa (1984) states that small changes (1% to 2%) in clay content in a debris flow can greatly increase mobility due to reduced permeability and increased pore pressure. The presence of silt and clay in a slurry aids in maintaining high pore pressure to enhance flow mobility and runout (Iverson, 2003).

Surficial geologic deposits that influence the sediment supply include (1) colluvium on steep slopes susceptible to forming debris slides, (2) partially detached shallow landslides, (3) foot-slope colluvium filling the drainage-basin channel that may contribute sediment by bank erosion and sloughing, and (4) stream-channel alluvium.

Mapping debris slides in a drainage basin and determining their potential to transform into debris flows is important in evaluating debris-flow susceptibility. Most of the 1983–84 debris flows along the Wasatch Front initiated as shallow debris slides in steep colluvial slopes below the retreating snowline (Anderson and others, 1984; Pack, 1985). Aerial-photograph analysis can show colluvium on steep slopes and previous debris slides or partially detached debris slides. A literature search of historical debris slides in the area and in areas of similar geology may help identify debris-slide susceptibility. For example, documented relations exist between debris slides and debris flows in drainage basins in the Precambrian Farmington Canyon Complex of Davis County (Pack, 1985) and in the Tertiary-Cretaceous rocks of the Wasatch Plateau (Lips, 1985).

Drainage basins that experience rapid snowmelt events have an increased debris-flow hazard. Sustained rapid snowmelt can produce large volumes of melt water with melt rates averaging 1.5 inches of water per day for 12 days or more (Giraud, 2010; Giraud and Lund, 2010). Pack (1985) and Mathewson and others (1990) determined that in the 1983–84 Davis County debris flows, water infiltration into fractured bedrock aquifers from rapid snowmelt perched and increased pore-water pressure in steep colluvial slopes that triggered localized colluvial landslides (debris slides) that transformed into debris flows. Trandafir and others (2015) found that rapid snowmelt, water infiltration, and increased pore-water pressure in steep moraine slopes can also trigger landslides that transform

into debris flows. Santi (1988) suggested that sediment bulking is more likely when passage of a debris flow occurs during periods of stream flow and associated saturated channel sediment, and will result in larger debris-flow volumes.

Wieczorek and others (1983, 1989) used groundwater levels, the presence of partially detached landslide masses, and estimates of channel sediment bulking to evaluate debris-flow potential along the Wasatch Front between Salt Lake City and Willard. Superelevated levees, mud lines, and trim lines along channels are evidence of peak discharge. Measurements from these features are useful in estimating velocity and peak flow (Johnson and Rodine, 1984). Determining the age of vegetation growing on the levees provides a minimum age of past debris-flow activity.

Land use and land-use changes within a drainage basin may also influence debris-flow susceptibility. Land development often creates impervious surfaces that increase the rate and volume of runoff. Development may also remove vegetation and expose soils, promoting erosion, increasing sediment yield, and decreasing natural slope stability within the drainage basin. Debris-flow-hazard investigations must address development-induced conditions where applicable.

Channel Sediment Bulking and Flow-Volume Estimation

Sediment supply, erosion conditions, and hydrologic conditions of the drainage basin and channel determine the sediment and water concentration (flow type) and flow volume that reaches an alluvial fan. Estimating channel sediment volume available for entrainment or bulking is critical because study of historical debris flows indicates 80% to 90% of the debris-flow volume comes from the channel (Croft, 1967; Santi, 1988; Keaton and Lowe, 1998). Most estimates of potential sediment bulking are based on a unit-volume analysis of erodible sediment stored in the channel, generally expressed in cubic yards per linear foot of channel (Hungr and others, 1984; VanDine, 1985; Williams and Lowe, 1990; Hungr and others, 2005). The sediment volume stored in individual relatively homogeneous channel reaches is estimated, and then the channel-reach volumes are summed to obtain a total volume. The total channel volume is an upper bound volume and needs to be compared to historical (VanDine, 1996) and mapped alluvial-fan flow volumes to derive a design volume. If easily eroded soils and slopes prone to landsliding are present, then appropriate volumes for landslide and hillslope contributions determined from other drainage-basin landslide volumes should be added to the channel volume.

Estimating a potential sediment-bulking rate requires field inspection of the drainage basin and channels. Channel sediment-bulking estimates cannot rely on empirical methods because they are only approximate and have low reliability due to the wide scatter of data which reflects the wide range of

topographical, geological, and climatic environments in Utah. Field inspection and channel sediment-bulking rate measurements of the material likely to be mobilized are the best methods to arrive at more precise estimates of debris-flow volume. Measuring cross-channel profiles and estimating the erodible depth of channel sediment is necessary to estimate the sediment volume available for bulking (figure 28). Even though a great deal of geologic judgment may be required to make the volume estimate, this is probably the most reliable and practical method for bedrock-floored channels. The design volume should not be based solely on empirical bulking of specific flood flows (for example, bulking a 100-year flood with sediment) because empirical bulking does not consider shallow landslide-generated debris flows (National Research Council, 1996), channel bedrock reaches with no stored sediment, and the typically longer recurrence period of debris flows. The channel inspection should also provide a description of the character and gradation of sediment and wood debris that could be incorporated into future debris flows.

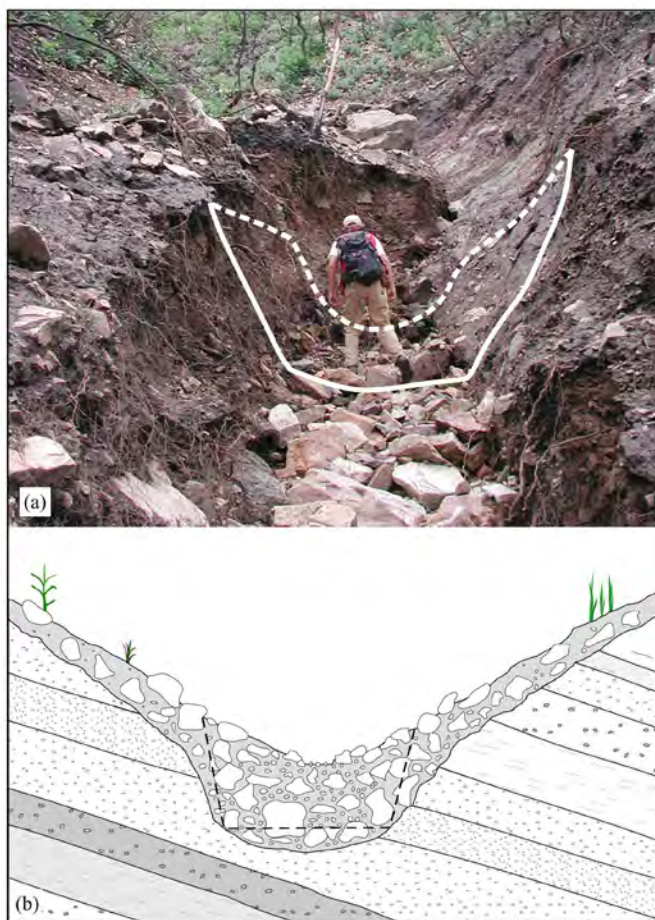


Figure 28. Channel sediment and cross section used to estimate sediment volume available for bulking. (a) Channel erosion from the September 10, 2002, fire-related debris flow on Dry Mountain east of Santaquin, Utah. Solid line shows the eroded channel after the debris flow, dashed line shows the estimated channel prior to debris-flow passage. (b) Sketch of channel cross section showing stored channel sediment above bedrock. Dashed line shows the estimated upper bound width and depth of channel sediment available for sediment bulking.

Hungr and others (1984), VanDine (1985), and Williams and Lowe (1990) used historical flow volumes and channel sediment bulking rates to estimate potential debris-flow volumes. Williams and Lowe (1990), following the 1983 debris flows in Davis County, compared cross-channel profiles of drainages that had discharged historical debris flows with those that had not to estimate the amount of channel sediment bulked by historical flows. They estimated an average bulking rate of 12 yd³/ft of channel for historical debris flows and used it to estimate flow volumes for drainage basins lacking historical debris flows, but recommended using this estimate only for perennial streams in Davis County. Bulking rates for intermittent and ephemeral streams are generally lower. For example, Mulvey and Lowe (1992) estimated a bulking rate of 5 yd³/ft for the 1991 Cameron Cove debris flow in Davis County. The 1999–2004 fire-related debris flows in northern Utah have a wide range of estimated bulking rates (0.01 to 2.02 yd³/ft; Giraud and McDonald, 2007). Santi and others (2008) studied 46 fire-related debris flows in Utah, Colorado, and California, and similarly found a wide range of bulking rates (0.12 to 4.0 yd³/ft). Hungr and others (1984), VanDine (1985, 1996), and Williams and Lowe (1990) all concluded that channel length and channel sediment storage are the most important factors in estimating future debris-flow volumes.

Some drainage basins may have recently discharged a debris flow, leaving little sediment available in the feeder channel for sediment bulking for future debris flows. Keaton and others (1991) stated that channels with recent debris flows will discharge future flows of less volume until the feeder channel has recharged with sediment. In these situations, an evaluation must consider remaining channel sediment as well as the rate of sediment recharge to the channel (National Research Council, 1996; Bovis and Jakob, 1999). The percent of channel length lined by bedrock is a distinct indication of the volume of sediment remaining because sediment cannot be scoured from bedrock reaches. Williams and Lowe (1990) suggested that in Davis County the drainage basins capable of producing future large debris flows are basins that have not discharged historical debris flows. However, drainage basins having a limited debris-flow volume potential due to lack of channel sediment may still have a high stream-flow-flooding potential.

DEBRIS-FLOW-RISK REDUCTION

Eisbacher and Clague (1984), Hungr and others (1987), VanDine (1996), and Huebl and Fiebigler (2005) group debris-flow-risk reduction into two categories: passive and active. Passive methods involve avoiding debris-flow-hazard areas either permanently or at times of imminent danger. Passive methods do not prevent, control, or modify debris flows. Active methods modify the hazard using debris-flow-control structures to prevent or reduce the risk. These types of structures require engineering design using appropriate geologic inputs. In terms of development on alluvial fans, active risk-

reduction measures with control structures generally attempt to maximize the buildable space and provide a reasonable level of protection.

Hungr and others (1987) and VanDine (1996) divide debris-flow-control structures along lower channel reaches and on alluvial fans into two basic types: open structures (which constrain flow) and closed structures (which contain debris). Examples of open debris-flow-control structures include unconfined deposition areas, impediments to flow (baffles), check dams, lined channels, lateral walls or berms, deflection walls or berms, and terminal walls, berms, or barriers. Examples of closed debris-flow-control structures include debris racks, or other forms of debris-straining structures located in the channel, and debris barriers and associated storage basins with a debris-straining structure (outlet) incorporated into the design.

In Utah, engineered sediment storage basins are the most common type of control structure used to reduce debris-flow risks. These structures generally benefit the community as well as the individual developer or landowner, but they are typically expensive, require periodic maintenance and sediment removal, and must often be located in areas not owned or controlled by an individual developer. For these reasons, debris-flow- and flood-risk-reduction structures are commonly government public works or shared public-private responsibilities, rather than solely a developer or landowner responsibility. This is particularly true in urban settings where the delineated hazard area may include more than one subdivision and other pre-existing development. In some cases, local flood-control agencies such as Davis County Flood Control manage both debris-flow and stream-flooding hazards.

DESIGN CONSIDERATIONS FOR RISK REDUCTION

The debris-flow hazard at a particular site depends on the site's location on the alluvial fan. Both debris-flow impact and sediment burial are more likely and of greater magnitude in proximal fan areas than in medial and distal fan areas (figure 27). Decisions regarding acceptable risk and appropriate control-structure design involve weighing the probability of occurrence in relation to the consequences of a debris flow and the residual risk level after implementing risk-reduction measures. Therefore, hazard investigations estimate the likely size, frequency, and depositional area of debris flows on an alluvial fan as accurately as possible.

Considering Frequency and Magnitude in Design

The frequency and magnitude of past debris flows are fundamental indicators of future debris-flow activity. To address the past frequency and volume of debris flows, detailed geologic studies involving geochronology are generally required.

Little information exists on the past frequency of debris flows on most alluvial fans in Utah. Studies by Keaton (1988), Lips (1993), and Mulvey (1993) indicate that large-volume, destructive debris flows on the alluvial fans they studied have return periods of a few hundred to thousands of years. Fire-related debris flows in Utah are more frequent and vegetation types for fires that produced fire-related debris flows have fire-return periods of 0 to 300 years for stand-replacing fires (Giraud and McDonald, 2007). However, return periods vary widely among alluvial fans and few data exist to quantify debris-flow frequency-magnitude relations. Other difficulties in quantifying debris-flow frequency-magnitude relationships include:

- Frequencies are time-dependent. Many drainages must recharge channel sediment following a large-volume debris flow; the magnitude and frequency of future debris flows depend on the size of and time since the last event.
- Statistically-based cloudburst rainfall volumes typically used for stream-flooding evaluations (for example, the 100-year storm) are not applicable to debris-flow volumes because debris-flow discharges do not relate directly to flood discharges, and in Utah many debris flows are caused by rapid snowmelt rather than cloudburst storms.
- Wildfires and land-use changes in the drainage basin introduce significant uncertainty because they can temporarily greatly increase debris-flow frequency.

Because of these complexities, generally accepted return periods for design of debris-flow risk-reduction measures based on probabilistic models do not exist, unlike for earthquake ground shaking and flooding, which have established design return periods of 2500 years (International Building Code) and 100 years (FEMA's National Flood Insurance Program), respectively.

Although Keaton (1988) and Keaton and others (1991) developed a probabilistic model for debris flows in Davis County where a relatively complete record of historical debris flows exists, the high degree of irregularity and uncertainty in return periods limited their results and the practical application of their model. In some cases rather than assigning an absolute probability of debris-flow occurrence, many debris-flow practitioners assign a relative probability of occurrence (VanDine, 1996) based on frequencies in similar basins and fans in the geographic areas that have experienced historical debris flows.

The UGS believes Holocene-age (past 11,700 years) debris-flow deposits on an alluvial fan are sufficient evidence of a potential hazard to warrant site-specific debris-flow-hazard studies and appropriate implementation of risk-reduction measures. Holocene sediments were deposited under climatic conditions similar to the present and therefore indicate a current hazard unless geologic and topographic conditions on the alluvial fan have changed. If site-specific data on debris-flow recurrence are sufficient to develop a probabilistic model, then the model may be used in consultation with local government regulators to help determine an appropriate level of risk reduction.

Debris-Flow-Hazard Zones

Debris-flow-hazard zones identify potential impacts and associated risks, help determine appropriate risk-reduction measures, and aid in land-use planning decisions. Hungr and others (1987) outline three debris-flow-hazard zones: (1) a direct impact zone where high-energy flows increase the risk of impact damage due to flow velocity, flow thickness, and the maximum clast size; (2) an indirect impact zone where impact risk is lower, but where damage from sediment burial and debris-flow and water transport is high; and (3) a flood zone potentially exposed to flooding due to channel blockage and water draining from debris deposits. These zones roughly equate to proximal, medial, and distal fan areas, respectively (figure 27). Historical debris-flow records, deposit characteristics, and detailed topography are required to outline these hazard zones. Site-specific studies are required to define which zone applies to a particular site and to determine the most appropriate land use and risk-reduction techniques to employ.

Estimating Geologic Parameters for Engineering Design

Geologic estimates of debris-flow design parameters are necessary for engineering design of risk-reduction structures. The most appropriate data often come from historical or late Holocene debris flows that can be mapped on the fan surface. Flow and deposit characteristics are also necessary to estimate peak discharge and calibrate computer-based hydraulic flow routing models (O'Brien and Julien, 1997).

Geologic parameters required for engineering design vary depending on the risk-reduction structure proposed. Engineering designs for debris-flow risk-reduction structures are site specific (VanDine and others, 1997), and generally involve quantifying specific fan, feeder channel, deposit, and flow parameters. Geomorphic fan parameters include areas of active deposition, surface gradients, surface roughness (channels, levees, lobes), and topography. Feeder channel parameters include channel gradient, channel capacity, and indications of previous flows. Deposit parameters include area, thickness, volume, surface gradient, gradation, and largest clast size. Due to their perishable nature, flow parameters are difficult to determine unless measured immediately after an event, and are often inferred from deposit characteristics or evidence from the feeder channel. The flow parameters include estimates of flow type(s), volume, frequency, depth, velocity, peak discharge, and runout distance.

Debris flows can have significantly higher peak discharge than stream-flow flooding. Estimating peak discharge is critical because it controls maximum velocity and flow depth, impact forces, ability to overrun protective barriers, and runout distance (Hungr, 2000). VanDine (1996) stated that debris-flow discharges can be up to 40 times greater than a 200-year flood, which shows the importance of carefully estimating

peak discharge when designing protective structures. Pierson (1985) described flow composition and dynamics of the 1983 Rudd Canyon debris flow in Davis County, and included some flow properties typically considered in engineering design. Costa (1984) also listed specific physical properties of debris flows. Keaton (1990) described field and laboratory methods to predict slurry characteristics based on sedimentology and stratigraphy of alluvial-fan deposits. Flow characteristics are also important to help estimate associated water volume. Prochaska and others (2008) provided debris basin and deflection berm design criteria for fire-related debris-flow risk reduction.

Estimating debris-flow volume is necessary where debris storage basins are planned (Santi, 2014). Because debris-flow behavior is difficult to predict and flows difficult to route, debris storage basins and deflection walls or berms are common methods of debris-flow risk reduction. The routing of debris flows off an alluvial fan is a difficult and complex task. O'Brien and Julien (1997) stated that channel conveyance of debris flows off an alluvial fan is not recommended because there are numerous factors that can cause the flow to plug the conveyance channel. Debris basins typically capture sediment at the drainage mouth before the debris flow travels unpredictably across the alluvial fan. For debris basin capacity, the thickness and area of individual flows on the alluvial fan and erodible channel sediment volumes are needed to estimate design debris volumes. Estimates of sediment stored in channels are usually maximum or "worst-case" volumes that represent an upper volume limit. Channel estimates may exceed the alluvial-fan estimates because typically not all channel sediment is eroded and deposited on the fan, and the channel estimate includes suspended sediment transported off the fan by stream flows. Conversely, the alluvial-fan estimate may exceed the channel estimate if a recent large flow has removed most channel sediment. VanDine (1996) considered the design volume to be the reasonable upper limit of material that will ultimately reach the fan. In a study on the precision and accuracy of debris-flow volume measurement for historical debris flows, Santi (2014) found that volume measurement uncertainty is typically at least $\pm 10\%$ – 20% . Estimates of prehistoric debris flow volumes likely have greater uncertainty.

Flow volume is also important in modeling runout and deposition. O'Brien and Julien (1997), in their hydraulic modeling of debris-flow runout, emphasized the importance of making conservative estimates of the available volume of sediment in the drainage basin, and comparing that volume to alluvial-fan deposit volumes to determine an appropriate modeling volume.

Geologic design parameters are also needed for the design of other types of engineered risk-reduction structures. For deflection walls and berms or for foundation reinforcement, fan gradient, flow type (debris versus hyperconcentrated versus stream), flow depth, peak flow, flow velocity, and debris size and gradation are important to ensure that the structure has the appropriate height, side slope, and curvature to account for run-up and impact forces. For design of debris barriers,

flow volume, depth, deposition area, and gradient are needed to determine the appropriate storage volume. The size and gradation of debris, flow velocity, and the anticipated flow type are important in the design of debris-straining structures. Flow types are important to help estimate associated water volumes. Baldwin and others (1987), VanDine (1996), Deng (1997), and VanDine and others (1997) have described other design considerations for debris-flow-control structures.

Even though geologic investigations use quantitative and objective procedures, estimating design parameters for risk-reduction structures has practical limits. As stated earlier, historical records of debris flows show flows to be highly variable in terms of size, material properties, and travel and depositional behavior. Many debris-flow design-parameter estimates have high levels of uncertainty and often represent a best approximation of a complex natural process; therefore, appropriate limitations and engineering factors of safety must be incorporated in risk-reduction-structure design. Investigators must clearly state the limitations of the investigation methods employed and the uncertainties associated with design-parameter estimates.

DEBRIS-FLOW-INVESTIGATION REPORT

The UGS recommends that a report prepared for a site-specific debris-flow investigation in Utah at a minimum address the topics below. Site conditions may require that additional items be included to fully evaluate debris-flow hazard at a site; these guidelines do not relieve Engineering Geologists from their duty to perform additional geologic investigations as necessary to adequately assess the debris-flow hazard. The report guidelines below pertain specifically to debris-flow investigations on alluvial fans, and expand on the general report preparation guidance provided in the Engineering-Geology Investigations and Engineering-Geology Reports sections of chapter 2.

A. Text

- a. Purpose and scope of investigation. Describe the location and size of the site and proposed type and number of buildings or other infrastructure if known.
- b. Geologic and topographic setting. The report should contain a clear and concise statement of the site and site region's geologic and topographic setting. The section should include a discussion of debris-flow activity in the area and should reference pertinent published and unpublished geologic literature.
- c. Site description and conditions. Include dates of site visits and observations. Include information on surficial and bedrock geology, topography, vegetation, existing structures, evidence of previous debris flows on or near the site, and other factors that may affect the choice of investigative methods and interpretation of data.

d. Methods and results of investigation.

1. Literature Review. Summarize published and unpublished topographic and surficial and bedrock geologic maps, literature, historical records regarding debris flows and alluvial-fan flooding, and other relevant factors pertinent to the site.
2. Interpretation of Remote-Sensing Imagery. Describe the results of remote-sensing-imagery interpretation, including stereoscopic aerial photographs, lidar, and other remote-sensing data when available. List source, date, flight-line numbers, and scale of aerial photos or other imagery used.
3. Alluvial Fan Evaluation. Include a site-scale geologic map showing areas of active-fan deposition (generally Holocene-age alluvial fans) and other surficial deposits, including older debris-flow and alluvial-fan deposits and their relative age. Include test pit and trench logs (generally at 1 inch = 5 feet) showing descriptions of geologic units, layer thicknesses, maximum grain sizes, and interpretation of flow types. Show basis for design flow-volume estimates (deposit thickness and area estimates); a range of estimates is suggested based on maximum, average, and minimum thickness and area estimates. Indicate runout distance, spatial extent, thickness, flow type, and deposit characteristics of historical flows, if present. Provide deposit age estimates or other evidence used to estimate the frequency of past debris flows. Evaluate the debris-flow hazard based on anticipated probability of occurrence and volume, flow type, flow depth, deposition area, runout, gradation of debris, flow impact forces, and stream-flow inundation and sediment burial depths.
4. Drainage Basin and Channel Evaluation. Include a vicinity geologic map (1:24,000 scale) on a topographic base of the drainage basin showing bedrock and surficial geology, including shallow landslides (debris slides) and a measurement of drainage-basin morphologic parameters. Provide an estimate of the susceptibility of the drainage basin to shallow landsliding, likely landslide volume(s), and volume of historical landslides, if present. Provide an estimate of the susceptibility of the drainage basin slopes to erosion. Include a longitudinal channel profile, showing gradients from headwaters to the alluvial fan. Include cross-channel profiles and a map showing their locations. Provide a basis for channel volume estimates including initial debris slides, total feeder channel length, length of channel lined by bedrock, cross-channel profiles, and estimated volume of channel sediment.

available for sediment bulking including estimated bulking rate(s) in cubic yards per linear foot of channel.

e. Conclusions.

1. Conclusions must be supported by adequate data, and the report should present those data in a clear and concise manner.
2. Provide the probability of debris-flow occurrence (if possible), estimates of debris-flow volume, a map showing hazard areas, and a discussion on the likely effects of debris flows on the proposed development.
3. Degree of confidence in, and limitations of, the data and conclusions.

f. Recommendations.

1. Recommendations must be supported by the report conclusions and be presented in a clear and concise manner.
2. Provide recommendations for hydrologic, hydraulic, and engineering studies to define buildable and non-buildable areas (if appropriate) and design risk-reduction measures.
3. Provide geologic design parameters for debris-flow-control structures, as appropriate.
4. Discuss implications of risk-reduction measures on adjacent properties, and the need for long-term maintenance.
5. If recommendations are provided for debris-storage basins, both alluvial-fan and channel volume estimates must be compared to select an appropriate design debris volume. For flows that may initiate as debris slides, an appropriate debris-slide volume must be included. Due to uncertainties inherent in both methods, the volume estimates may differ significantly. Rationale for the chosen volume estimate must be provided.
6. If recommendations are provided for debris-flow-deflection structures or debris-flow-resistant construction (reinforcement of foundations, flood-proofing), hydraulic modeling of debris-flow discharge, run-up, and runout, and calculation of impact forces is recommended. Specific information on flow type(s), deposit distribution and thickness, flow velocity, peak flow, and runout is necessary to calibrate models.
7. Discuss residual risk to development (if appropriate) after risk-reduction measures are in place.

As noted in f (2) above, the geologic evaluation is often only the first step in the debris-flow-hazard investigation and risk-reduction process. Depending on the risk-reduction techniques considered, subsequent hydrologic, hydraulic, and/or engineering studies may be needed to esti-

mate peak flows and water volumes, route sediment, and design control structures. Geologists, hydrologists, and engineers must work as a team to recommend reasonable, appropriate, cost-effective risk-reduction techniques.

B. References

- a. Literature and records cited or reviewed; citations should be complete (see References section of this publication for examples).
- b. Remote-sensing images interpreted; list type, date, project identification codes, scale, source, and index numbers.
- c. Other sources of information, personal communication, and other data sources.

C. Illustrations. Should include at a minimum:

- a. Location map. Showing the site and significant physiographic and cultural features, generally at 1:24,000 scale or larger and indicating the Public Land Survey System $\frac{1}{4}$ -section, township, and range; and the site latitude and longitude to four decimal places with datum.
- b. Site development map. Showing site boundaries, existing and proposed structures, other infrastructure, and site topography. The map scale may vary depending on the size of the site and area covered by the study; the minimum recommended scale is 1 inch = 200 feet (1:2400) or larger when necessary. The site development map may be combined with the site-specific geology map (see item "c" below).
- c. Site-specific geology map. A site-scale geology map of the drainage basin and alluvial fan as discussed above. Scale of site-specific geology maps will vary depending on the size of the site and area of study; minimum recommended scale is 1 inch = 200 feet (1:2400) or larger when necessary.
- d. Debris-flow hazard map. Showing the debris-flow hazard on different parts of the alluvial fan based on results of the investigation.
- e. Photographs that enhance understanding of the debris-flow hazard at the site with applicable metadata.

D. Authentication

The report must be signed and stamped by a Utah licensed Professional Geologist in principal charge of the investigation (Title 58-76-10 – Professional Geologists Licensing Act [Utah Code, 2011]). Final geologic maps, trench logs, cross sections, sketches, drawings, and plans, prepared by or under the supervision of a professional geologist, also must bear the stamp of the professional geologist (Utah Code, 2011). Reports co-prepared by a Utah licensed Professional Engineer and/or Utah licensed Professional Land Surveyor must include the engineer's or surveyor's stamp and signature.

F. Appendices

Include supporting data relevant to the investigation not given in the text such as maps, cross sections, conceptual models, survey data, geochronology laboratory reports, laboratory test data, and qualifications statements/resume.

FIELD REVIEW

The UGS recommends a technical field review by the regulatory-authority geologist once a debris-flow-hazard investigation is complete. The field review should take place after any trenches or test pits are logged, but before they are closed so subsurface site conditions can be directly observed and evaluated. See Field Review section in chapter 2.

REPORT REVIEW

The UGS recommends regulatory review of all reports by a Utah licensed Professional Geologist experienced in debris-flow-hazard investigations and acting on behalf of local governments to protect public health, safety, and welfare, and to reduce risks to future property owners (Larson, 1992, 2015). See Report Review section in chapter 2.

DISCLOSURE

The UGS recommends disclosure during real-estate transactions whenever an engineering-geology investigation has been performed. See Disclosure section in chapter 2.

ACKNOWLEDGMENTS

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CHAPTER 6

GUIDELINES FOR EVALUATING LAND-SUBSIDENCE AND EARTH-FISSURE HAZARDS IN UTAH

by
William R. Lund, P.G.



Displacement across an earth fissure that formed in response to groundwater mining in Cedar Valley, Utah.

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CHAPTER 6: GUIDELINES FOR EVALUATING LAND-SUBSIDENCE AND EARTH-FISSURE HAZARDS IN UTAH

by William R. Lund, P.G.

INTRODUCTION

Land subsidence and earth fissures related to groundwater mining (long-term groundwater pumping in excess of aquifer recharge) are human-caused geologic hazards, and as such must be addressed during land development in subsiding areas. These guidelines present the recommended minimum acceptable level of effort for investigating land subsidence and earth fissures related to groundwater mining in Utah at both basin-wide and site-specific scales. Basin-wide investigations rely on a combination of remote sensing methods and high-precision surveying to identify subsidence area boundaries, subsidence rates, and earth-fissure locations. Site-specific investigations evaluate the effects of land subsidence and earth fissures at a site, and typically include a literature review, aerial-photograph and other remote-sensing data analysis, and field investigation, usually including surficial geologic mapping and trenching, and in some instances boreholes, cone penetrometer test (CPT) soundings, and geophysical investigations. The Utah Geological Survey (UGS) recommends a land-subsidence and earth-fissure investigation for all new buildings for human occupancy and International Building Code (IBC) Risk Category II, III, and IV facilities (International Code Council [ICC], 2017a) proposed in areas of known or suspected susceptibility to land subsidence and earth fissures.

The intent of these guidelines is to assist Engineering Geologists performing land-subsidence and earth-fissure investigations, and to reduce, to the lowest level possible, epistemic uncertainty (lack of necessary data) in evaluating land-subsidence and earth-fissure hazards by conducting adequate hazard investigations. Aleatory variability (natural randomness) in the occurrence of subsidence and formation of earth fissures cannot be reduced; therefore, predicting exactly where and when future land subsidence and earth fissures will occur is not possible. As long as groundwater mining continues, new areas of land subsidence may appear and earth fissures may form. For those reasons, developing property in or near areas of land subsidence and earth fissures will always involve a level of irreducible, inherent risk. Additionally, even with innovative engineering design, limiting certain kinds of land use (e.g., water conveyance or retention structures, pipelines and canals, liquid waste disposal systems, hazardous materials processing and storage facilities) may be necessary in areas of rapid subsidence and/or earth fissuring.

These guidelines outline (1) appropriate investigation methods, (2) report content, (3) map, trench log, and illustration criteria and scales, (4) mitigation recommendations, (5) minimum criteria for review of reports, and (6) recommendations for geologic-hazard disclosure. However, these guidelines do not include systematic descriptions of all available investigative techniques or topics, nor are all techniques or topics appropriate for every hazard investigation.

Considering the complexity of evaluating land-subsidence and earth-fissure hazards, additional effort beyond the minimum criteria recommended in these guidelines may be required to adequately evaluate such hazards. The information presented in these guidelines does not relieve Engineering Geologists of the duty to perform additional geologic investigations necessary to fully assess these hazards either at regional or site-specific scales. As required by Utah state law (Utah Code, 2011), land-subsidence and earth-fissure investigation reports and supporting documents must be signed and stamped by the licensed Utah Professional Geologist in responsible charge of the investigation.

Purpose

These guidelines apply specifically to land subsidence and earth fissures caused by groundwater pumping in excess of recharge. These guidelines may also be applicable in whole or part for evaluating land subsidence and earth fissures resulting from other causes (e.g., near-surface soil desiccation [giant desiccation cracks], collapsible soil, highly organic soil, karst sinkhole formation, soil piping, underground mining, and oil and gas pumping).

The purpose of these guidelines is to provide appropriate minimum land-subsidence and earth-fissure investigation and report criteria to:

- protect the health, safety, and welfare of the public by minimizing the potentially adverse effects of land subsidence and earth fissures;
- assist local governments in regulating land use in hazardous areas and provide standards for ordinances;
- assist property owners and developers in conducting reasonable and adequate investigations;
- provide Engineering Geologists with a common basis for preparing proposals, conducting investigations, and

recommending land-subsidence- and earth-fissure-mitigation strategies; and

- provide an objective framework for preparation and review of reports.

These guidelines are not intended to supersede pre-existing state or federal regulations or local geologic-hazard ordinances, but provide useful information to supplement adopted ordinances/regulations, and assist in preparation of new ordinances. The UGS believes adherence to these guidelines will help ensure adequate, cost-effective investigations and minimize report review time.

Background

Subsidence and earth fissures related to groundwater mining occur when groundwater is pumped from an aquifer at a rate greater than aquifer recharge, resulting in dewatering of the aquifer. Bringing recharge and discharge into balance will slow or stop land-subsidence and earth-fissure formation—a process successfully implemented in some areas experiencing land-subsidence and earth-fissure problems (Ingebritsen and Jones, 1999; Bell and others, 2002). Both the cause and cure for groundwater-mining-related land subsidence and earth fissures are typically societal in nature. It is rare that a single groundwater producer (individual or organization) causes land-subsidence and earth-fissure formation, and it is equally rare that a single producer can effect a cure. This is particularly true of Utah's alluvial valleys, each with many stakeholders, where only collective action by all involved (producers, consumers, managers, and regulators) can prevent or reverse groundwater mining.

Land-Subsidence and Earth-Fissure Formation

In the United States, more than 17,000 square miles in 45 states have been directly affected by land subsidence, and more than 80% of the subsidence has occurred because of groundwater mining (Galloway and others, 1999). Land subsidence due to groundwater mining in thick, unconsolidated sediments results from a decrease in fluid (pore water) pressure as the water in fine-grained sediments moves into adjacent coarser grained sediments as the aquifer is dewatered (Leake, 2004). The decrease in pressure increases the effective stress in the dewatered portion of the aquifer and transfers the entire overburden stress (weight) to the aquifer matrix. The change in effective stress causes the aquifer matrix to change volume (compact) (Galloway and others, 1999). Initial matrix compaction is elastic and will recover if the aquifer is recharged. However, once collapse exceeds the elastic limit of the matrix material, compaction becomes permanent, aquifer storage is reduced, and land subsidence ensues (Galloway and others, 1999).

As an aquifer is dewatered, most subsidence results from the compression of fine-grained sediment layers (aquitards; figure 29) as they drain into adjacent coarser grained aquifer mate-

rial. Silt and clay layers have higher porosity, lower permeability, and lower matrix strength than coarse-grained sediment (sand and gravel). Coarse granular materials may settle almost instantaneously after dewatering, but because of their much lower permeability, fine-grained layers may require decades to fully drain and compress, and may continue to compress even after groundwater withdrawal is brought into equilibrium with recharge (Bell and others, 2002; Budhu and Shelke, 2008). The relation between groundwater-level decline and land subsidence is complex and varies as a function of total aquifer thickness, composition, and compressibility. In some areas of Arizona, about 300 feet of groundwater decline produced only 0.6 foot of subsidence. In other areas, a similar water-level decline generated land subsidence of as much as 18 feet (Arizona Land Subsidence Group, 2007).

Earth fissures are linear cracks in the ground that form in response to horizontal tensional stresses that develop when land subsidence causes different parts of an aquifer to compact by different amounts (figure 30) (Leake, 2004; Arizona Division of Emergency Management, 2007). Earth fissures may be hundreds of feet deep, range from a few feet to miles long, and can be expressed as hairline cracks (figure 31), aligned sinkholes (figure 32), or gullies tens of feet wide (figure 33) where fissures intercept surface flow and are enlarged by erosion (Carpenter, 1999). Earth fissures typically form along the edge of basins, usually parallel to mountain fronts; over zones of changing sediment characteristics and density; or above subsurface bedrock highs often coincident with pre-existing bedrock faults (figure 30) (Arizona Land Subsidence Group, 2007). Some earth fissures exhibit differential displacements of several inches to several feet as aquifers compact unevenly across them (figure 34).

Land-Subsidence Hazards

Land-subsidence hazards may include (1) change in elevation and slope of streams, canals, and drains, (2) damage to bridges, roads, railroads, storm drains, sanitary sewers, water lines, canals, airport runways, and levees, (3) damage to private and public buildings, and (4) failure of well casings from forces generated by compaction of fine-grained layers in aquifer systems (Leake, 2004; Lin and others, 2009). Over half of the area of the San Joaquin Valley in California has subsided due to groundwater mining, resulting in one of the largest human-caused alterations of Earth's surface topography (Galloway and others, 1999). Near Mendota, California, in the San Joaquin Valley, subsidence in excess of 28 feet necessitated expensive repairs to two major central California water projects (California Aqueduct and Delta-Mendota Canal; Galloway and others, 1999). In Mexico City, rapid land subsidence caused by groundwater mining and associated aquifer compaction has damaged colonial-era buildings, buckled highways, and disrupted water supply and wastewater drainage (Viets and others, 1979; Galloway and others, 1999). Early oil and gas production and a long history of groundwater pumping in the Houston-Galveston area, Texas, have

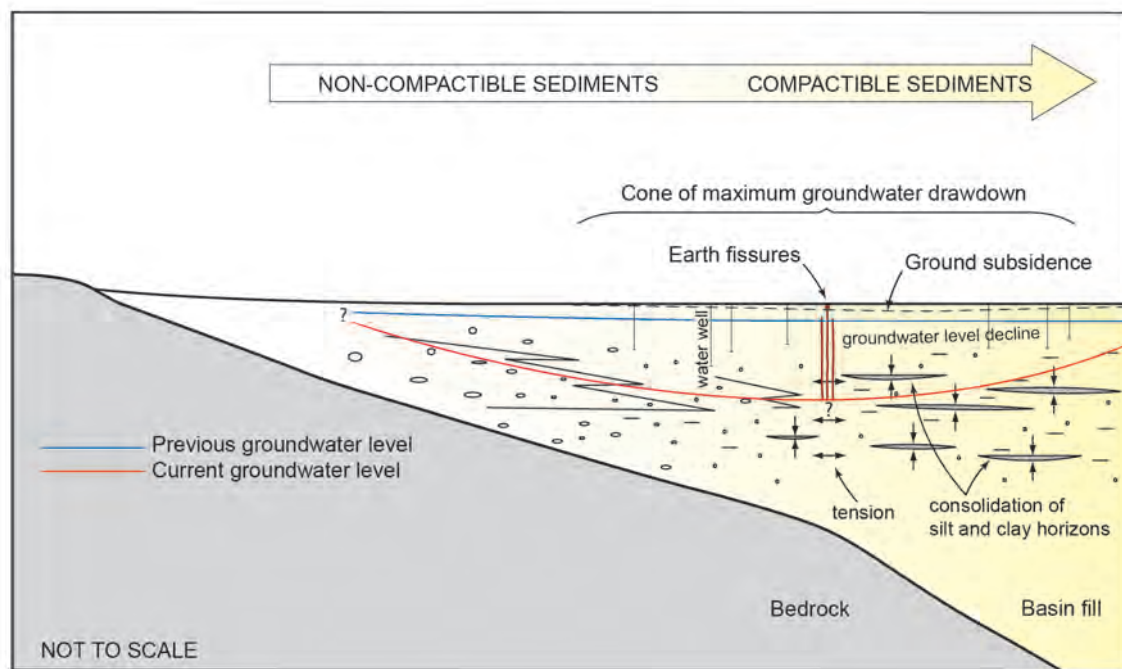


Figure 29. Schematic cross section of a typical Utah alluvial basin showing the effect of groundwater-level decline on the compaction of fine-grained horizons and resulting ground subsidence within the alluvial basin-fill aquifer. Note that as groundwater levels decline fine-grained horizons begin to compact both above and below the water table.

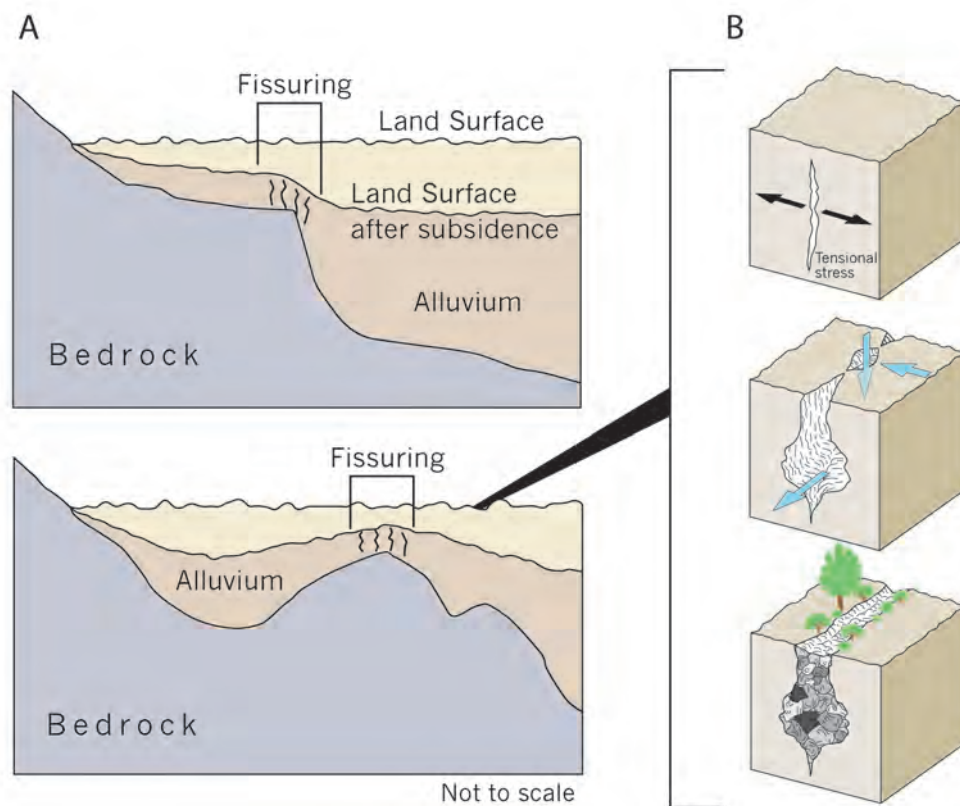


Figure 30. (A) Schematic section of a valley basin showing how buried bedrock topography affects the formation and location of earth fissures. (B) Schematic diagram showing initiation of earth fissures at depth due to horizontal tensional stress, and development of fissures expressed at the surface as hairline cracks, aligned sinkholes, and erosional gullies (after Carpenter, 1999).



Figure 31. Earth fissure in Cedar Valley expressed as an uneroded primary ground crack. This fissure could be traced for 900 feet before becoming obscured by recent agricultural activity. Photo taken in August 2009.

created severe and costly coastal-flooding hazards associated with land subsidence (Galloway and others, 1999; Harris-Galveston Subsidence Districts, 2010). Lin and others (2009) reported significant land-subsidence and earth-fissure damage related to groundwater mining in the Beijing area, including damage to the new Capital International Airport.

Earth-Fissure Hazards

Earth-fissure hazards may include (1) creating conduits that connect nonpotable or contaminated surface and near-surface water to a principal aquifer used for public water supply (Pavelko and others, 1999; Bell, 2004) (figure 35), (2) changing runoff/flood patterns, (3) deforming or breaking buried utilities and well casings, (4) causing buildings and other infrastructure to deform or collapse, and (5) endangering livestock and wildlife, and posing a life-safety hazard to humans (Arizona Division of Emergency Management, 2007). Although known earth fissures in Utah are chiefly limited to rural areas (Escalante Desert—Lund and others, 2005; Cedar Valley—Knudsen and others, 2014), elsewhere in the western United States, earth fissures related to land subsidence have become a major factor in land development in urban areas (Shlemon, 2004). Examples from Arizona and Nevada show the extent of damage that can result from earth fissures related to groundwater mining.



Figure 32. Sinkholes aligned along an earth fissure in Cedar Valley. Photo taken in May 2009.

Earth fissures were first recognized in Arizona in 1927; since that time their number and frequency have increased as land subsidence due to groundwater mining has likewise increased (Arizona Division of Emergency Management, 2007). More than 1100 square miles of Arizona, including parts of the Phoenix and Tucson metropolitan areas, are now affected by subsidence and numerous associated earth fissures (figure 36) (Arizona Land Subsidence Group, 2007; Conway, 2013). Damage caused by earth fissures in Arizona currently totals in the tens of millions of dollars, and includes cracked, displaced, or collapsed freeways and secondary roads; broken pipes and utility lines; damaged and breached canals (figure 37); cracked building foundations; deformed railroad tracks; collapsed and sheared well casings; damaged dams and flood-control structures; and livestock deaths (Viets and others, 1979; Arizona Division of Emergency Management, 2007; Arizona Land Subsidence Group, 2007).

Likewise, long-term groundwater mining in excess of recharge in Nevada's Las Vegas Valley has produced water-table declines of 100 to 300 feet (Pavelko and others, 1999) and as much as 6 feet of land subsidence (Bell and others, 2002; Bell and Amelung, 2003). By the early 1990s, the Windsor Park subdivision in North Las Vegas was so impacted by earth fissures (figure 38) that 135 homes had to be abandoned and removed at a cost of about \$20 million, and another 105 homes



Figure 33. Earth fissure in Escalante Valley eroded after intercepting surface water runoff. Photo taken in January 2005.

required significant repairs (Bell, 2003; Saines and others, 2006). Most earth fissures in Las Vegas Valley are associated with pre-existing bedrock faults (Bell and Price, 1991; Bell and others, 2002; Bell and Amelung, 2003; Bell, 2004). Artificial aquifer recharge has caused a decline in subsidence rates in Las Vegas Valley since 1991 of 50%–80%, depending upon location (Bell and others, 2002).

SOURCES OF LAND-SUBSIDENCE AND EARTH-FISSURE INFORMATION

The UGS has investigated land subsidence and earth fissures over the past decade in selected areas of Utah (DuRoss and Kirby, 2004; Lund and others, 2005; Forester, 2006, 2012; Katzenstein, 2013; Knudsen and others, 2014). Additionally, see the Literature Searches and Information Resources section in chapter 2 for information on other geologic-hazard reports, maps, archives, and databases maintained by the UGS that may be relevant to land subsidence and earth fissures, as well as information on the UGS' extensive aerial photograph and light detection and ranging (lidar) imagery collections.

Water-level data are available from the U.S. Geological Survey National Water Information System (<https://waterdata.usgs.gov/nwis>) and UGS Groundwater Monitoring Data Portal (<https://geology.utah.gov/map-pub/maps/interactive-maps/groundwater-monitoring/>).



Figure 34. Damage to street pavement by an earth fissure in Cedar Valley across which differential displacement is occurring at a rate of about 2 inches per year. Photo taken July 2015.

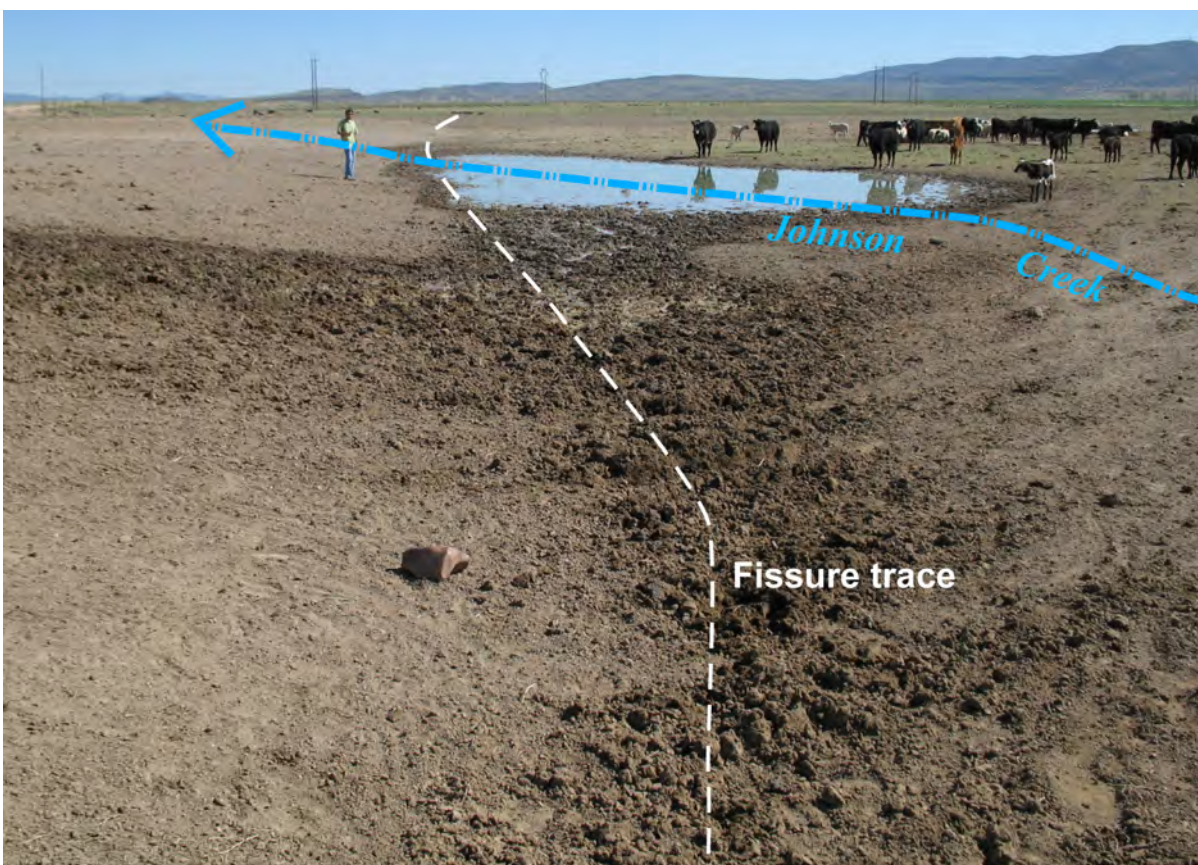


Figure 35. Earth-fissure scarp in Cedar Valley blocking an ephemeral drainage and causing water to pond along the fissure in a feed lot. Photo taken in May 2009.



Figure 36. Earth fissure in a subdivision near Phoenix, Arizona, enhanced by erosion during a cloudburst storm. Photo credit: Brian Conway.



Figure 37. Earth fissure intersecting an irrigation canal embankment near Phoenix, Arizona. Photo credit U.S. Bureau of Reclamation (after Carpenter, 1999).

LAND-SUBSIDENCE AND EARTH-FISSURE INVESTIGATION

Disclaimer

Land subsidence and earth fissures related to groundwater mining are geologic hazards, and as such must be addressed during land development in subsiding areas. However, land subsidence and earth fissures will likely continue to occur and expand as long as groundwater mining continues. Additionally, given the low permeability of many fine-grained sediment layers in Utah's basin-fill aquifers, subsidence may continue in a diminishing fashion for some time (possibly decades) after recharge and discharge are balanced as dewatered fine-grained deposits continue to drain and compact (Galloway and others, 1999).

The fact that land subsidence is not currently occurring in an area experiencing groundwater mining provides no guarantee that subsidence will not commence there in the future. Likewise, the absence of detectable earth fissures at the ground surface in a subsiding area provides no assurance that fissures are not present in the shallow subsurface or will not form in the future. As long as groundwater mining continues, land subsidence and earth fissures present long-term hazards to infrastructure that a hazard investigation, no matter how detailed, can only partially identify and mitigate. For those reasons, it is not possible to establish a standardized method for



Figure 38. Remains of a home severely damaged by an earth fissure and eventually torn down in the Windsor Park subdivision, Las Vegas, Nevada.

calculating setbacks from earth fissures as is done for Utah's hazardous faults (chapter 3). Setback distances from fissures or from areas of anticipated future fissure growth, or other forms of land-subsidence and earth-fissure mitigation should be designed and justified based on site-specific data. To fully ensure the safety of existing infrastructure and future development in subsiding areas, it is necessary to bring aquifer discharge and recharge into balance so that groundwater mining stops and hazards dissipate.

When to Perform a Land-Subsidence and Earth-Fissure-Hazard Investigation

Geologic hazards are best addressed prior to land development in affected areas. The UGS recommends that a land-subsidence and earth-fissure-hazard investigation be made for all new buildings for human occupancy and for modified IBC Risk Category II(a), II(b), III, and IV facilities (see table 12 in chapter 3, modified from IBC table 1604.5 [ICC, 2017a]) that are proposed in confirmed or suspected land-subsidence areas. Utah jurisdictions that have adopted land-subsidence and earth-fissure special-study maps identify zones in known land-subsidence and earth-fissure-susceptible areas within which they require site-specific investigations. The UGS recommends that investigations as outlined in these guidelines be conducted in alluvial valleys for all IBC Risk Category III and IV facilities to ensure that previously unknown land-subsidence areas and earth-fissures are not present. If a hazard is found, the UGS recommends a comprehensive investigation be conducted. Additionally, in some instances an investigation may become necessary when existing infrastructure is discovered to be on or adjacent to a subsiding area.

The level of investigation conducted for a particular project depends on several factors, including (1) site-specific geologic conditions, (2) type of proposed or existing development, (3) level of acceptable risk, and (4) governmental permitting requirements, or regulatory agency rules and regulations. A land-subsidence and earth-fissure-hazard investigation may be conducted separately, or as part of a comprehensive geologic-hazard and/or geotechnical site investigation (see chapter 2).

Minimum Qualifications of Investigator

Land-subsidence and earth-fissure-related engineering-geology investigations and accompanying geologic-hazard evaluations performed before the public shall be conducted by or under the direct supervision of a Utah licensed Professional Geologist (Utah Code, Title 58-76) who must sign and seal the final report. Often these investigations are interdisciplinary in nature, and where required, must be performed by qualified, experienced, Utah licensed Professional Geologists (PG, specializing in engineering geology) and Professional Engineers (PE, specializing in geological and/or geotechnical engineering) working as a team. See Investigator Qualifications section in chapter 2.

Basin-Wide Investigation Guidelines

Land subsidence typically affects a large area (tens to hundreds of square miles) within groundwater basins subject to groundwater mining. The first consideration when evaluating land subsidence and earth fissures as geologic hazards is to determine whether a proposed site and/or project is inside or outside of a subsiding area. If outside, land subsidence and earth fissures are not hazards; if inside or if in an adjacent area that may be affected by future subsidence and fissuring, a variety of negative consequences become possible and require careful evaluation. Within a subsiding area, the rate of subsidence and location of existing earth fissures are critical considerations for hazard investigations. Therefore, identifying and periodically monitoring basin-wide subsidence boundaries (subject to change over time with continued groundwater mining), subsidence amount and rate (likely also variable over time) within those boundaries, and the location of existing earth fissures are first-order, basin-wide priorities for land-subsidence and earth-fissure investigations.

Available techniques for identifying subsidence boundaries, subsidence rates, and earth-fissure locations on a basin-wide scale fall into two principal categories: remote-sensing applications and high-precision Global Positioning System (GPS)/Global Navigation Satellite System (GNSS) monitoring networks (surveyed benchmarks).

Remote Sensing

Remote-sensing applications directly applicable to land-subsidence and earth-fissure investigations include analysis of stereoscopic aerial photographs (from multiple years if available), interferometric synthetic aperture radar (InSAR) imagery, lidar imagery, and other remote sensing data as available.

Aerial photographs: Analysis of stereoscopic aerial photograph pairs is a standard remote-sensing technique long applied to many kinds of geologic investigations, and requires little further explanation here. Where possible, the analysis should include both stereoscopic low-sun-angle and vertical aerial photography. Applicable to both basin-wide and site-specific investigations, aerial photograph analysis can reveal the presence of earth fissures, particularly those subject to erosion or across which differential displacement is occurring, as well as other geomorphic evidence of land subsidence (sink-holes, local subsidence bowls, displaced or warped linear infrastructure, road damage, etc.). Examination of repeat aerial photographs from multiple years may show fissure growth (Knudsen and others, 2014), or the progressive development of other subsidence-related features.

Google Earth and Bing Maps, among other providers of Internet-based, free aerial imagery, are becoming increasingly valuable as rapid reconnaissance tools, and provide high-resolution, often color, non-stereoscopic aerial orthophotographs.

For many locations, Google Earth includes a historical imagery archive that permits evaluation of site conditions several years to decades before present.

InSAR: InSAR is a side-looking, active (produces its own illumination) radar imaging system that transmits a pulsed microwave signal toward the Earth and records both the amplitude and phase of the back-scattered signal that returns to the antenna (Arizona Department of Water Resources [ADWR], no date, 2010; Zebker and Goldstein, 1986; Zebker and others, 1994; appendix D – InSAR Background and Application). InSAR uses interferometric processing to compare the amplitude and phase signals received during one pass of the SAR (synthetic aperture radar) platform (typically Earth-orbiting satellites) over a specific geographic area, with the amplitude and phase signals received during a second pass over the same area but at a different time (ADWR, no date). InSAR’s chief advantage for subsidence monitoring is that it offers an accurate, rapid, and cost-efficient way to determine the horizontal and vertical extent of land subsidence and subsidence rate variability over a large area to an accuracy of about 1 centimeter. Forster (2006, 2012) demonstrated that long-term subsidence in southwest Utah is detectable and measurable with InSAR, and Katzenstein (2013) used InSAR to identify an approximately 100-square-mile area in Cedar Valley, Iron County, Utah, affected by subsidence resulting from ground-water mining.

Lidar: Lidar is a remote sensing, laser system that measures the properties of scattered light to accurately determine the distance to a target (reflective surface). Lidar is similar to radar, but uses laser pulses instead of radio waves, and commonly is collected from fixed-wing aircraft or helicopters. Lidar produces a rapid collection of points (typically more than 70,000 per second) that results in very dense and accurate elevation data over a large area (National Oceanic and Atmospheric Administration [NOAA], 2008). The resulting highly accurate, georeferenced elevation points can be used to generate three-dimensional representations of the Earth’s surface and its features (NOAA, 2008). After processing, lidar data can be used to produce a “bare-earth” terrain model (e.g., figure 39), in which vegetation and manmade structures have been removed. Lidar has several advantages over traditional photogrammetric methods; chief among them are (1) high accuracy, (2) high point density, (3) large coverage area, and (4) the ability to resample areas quickly and efficiently, which creates the ability to map discrete elevation changes over time at a very high resolution (NOAA, 2008).

Lidar offers two important advantages over conventional aerial photography for documenting and mitigating land subsidence and earth fissures. First, high-resolution, bare-earth lidar images can be used to identify and map currently unrecognized earth fissures that are not apparent on conventional aerial photography (Knudsen and others, 2014). Second, repeat lidar surveys can be used to generate displacement maps

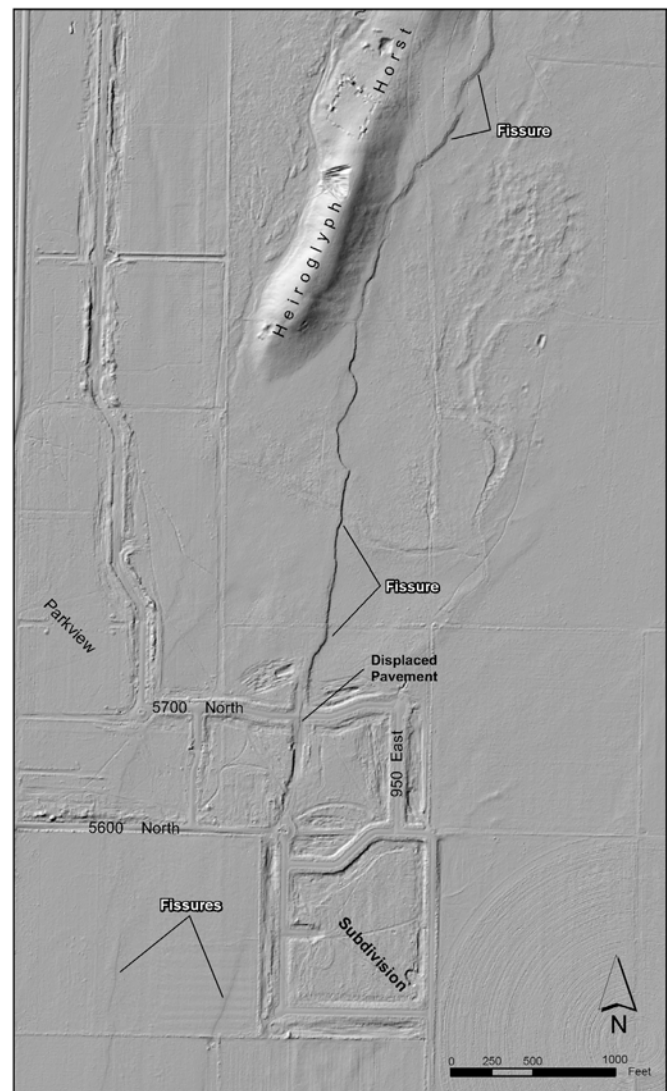


Figure 39. Bare-earth lidar image of earth fissures in Cedar Valley, Utah. These fissures exhibit vertical down-to-the-east displacement and are well expressed on lidar imagery (hillshade image, illumination from the northwest).

to define the boundaries of subsidence areas, and may allow monitoring of existing earth fissure growth and new fissure formation. Appendix C (Lidar Background and Application) presents additional information about lidar technology, imagery acquisition and processing, and cost.

High-Precision GPS/GNSS Survey Network

The accuracy and coverage of benchmark networks in Utah’s alluvial valleys are variable. In many areas, benchmarks, particularly older monuments, have been destroyed or disturbed by agricultural or development activities. Constraints on the number and locations of existing benchmarks may allow for only a general determination of the areal and vertical extent of land subsidence in valley areas, and may not permit adequate monitoring of either the rate or distribution of ongoing subsidence. Additionally, reported elevations of many older benchmarks

(e.g., disturbed benchmarks, vertical angle benchmarks, and some third-order leveled benchmarks) may not be sufficiently accurate to permit meaningful comparisons with new GPS/GNSS-derived survey data. Estimated uncertainties associated with both historical leveling and GNSS elevation data should be discussed and included in subsidence calculations.

Where accurate, long-term monitoring of subsidence is important for aquifer management or hazard investigations, the UGS recommends that following acquisition of InSAR and lidar data to better define the basin-wide boundaries of subsiding areas and earth-fissure locations, those data be used to site a network of high-precision GPS/GNSS survey monuments in subsidence and fissure “hot spots.” Periodic resurveying of the benchmarks using GPS/GNSS methods permits repeated high-precision (1–5 mm horizontal/vertical) subsidence monitoring in areas most important for implementing best aquifer management practices and hazard evaluation and mitigation. For increased accuracy, detailed subsidence studies typically employ static GPS survey methods rather than RTK surveys (<https://new.az-water.gov/hydrology/field-services/gps>).

GPS/GNSS surveys should follow the latest versions of the National Geodetic Survey guidelines for establishing ellipsoid (Zilkoski and others, 1997) and orthometric (Zilkoski and others, 2008) heights. High-quality floating sleeved rod or other appropriate monuments that reduce near-surface soil movements, such as from expansive soils, are recommended for precise vertical measurements. For bedrock sites, UNAVCO has developed stable mounting structures to isolate GPS/GNSS instruments from near-surface soil movements (<https://www.unavco.org/instrumentation/monumentation/types/types.html>).

Site-Specific Investigation Guidelines

Literature Review

The following published and unpublished information (as available) should be reviewed in preparation for both basin-wide and site-specific land-subsidence and earth-fissure investigations:

1. Published and unpublished geologic and engineering literature, maps, cross sections, and records relevant to the site and site region’s geology and hydrology, and past history of land subsidence and earth-fissure formation.
2. Survey data that may indicate past land subsidence, particularly as-built plans of linear infrastructure such as roads, canals, dams, airport runways, and levees for historical elevation data, or as-built design grades that can be compared to current elevations. Be aware of any historical vertical datum changes and/or shifts, including geoid changes.
3. Maintenance records of nearby wells for signs of subsidence-related damage.
4. Water-level data and subsurface geologic units from nearby water-well and geotechnical borehole logs.

5. Borehole geophysical data from deep wells in the area.
6. Pumping history of nearby water wells.

The Sources of Land Subsidence and Earth-Fissure Information section above provides information on Utah’s geology and past significant instances of land subsidence and earth fissure formation; however, that list of sources is not exhaustive, and Engineering Geologists should identify and review all available information relevant to their site of interest.

Analysis of Aerial Photographs and Remote Sensing Data

Analysis of remote sensing data should include interpretation of stereoscopic aerial photographs (from multiple years if available), InSAR and lidar imagery, and other remotely sensed images as available for evidence of land-subsidence- and earth-fissure-related lineaments, including vegetation lineaments, gullies, scarps formed by surface displacement across fissures, and vegetation/soil contrasts. Where possible, the analysis should include both stereoscopic low-sun-angle and vertical aerial photography. Examination of repeat aerial photographs and/or lidar imagery from multiple years may show fissure growth (Knudsen and others, 2014). The area interpreted should extend sufficiently beyond the site boundaries to identify off-site subsidence areas or fissures that might affect the site. Note that analysis of InSAR and lidar data has become “state of practice” for land-subsidence and earth-fissure investigations; therefore, investigations not employing those techniques are at best reconnaissance-level investigations.

Surface Investigation

Surface investigations should include mapping of (1) geologic and soil units, (2) fissures and sinkholes, (3) faults and other geologic structures, (4) geomorphic features and surfaces, (5) vegetation lineaments, (6) animal burrowing patterns, and (7) deformation of engineered structures both on and beyond the site, as appropriate. Special attention should be paid to linear infrastructure such as roadways, railroads, canals, dams, levees, airport runways, etc. Level surveys of linear infrastructure and comparison with as-built elevations may detect the presence or absence of measurable subsidence, and in the case of dams, levees, and other fluid conveyance and retention facilities, should be made to determine if infrastructure integrity and safety have been compromised. Protruding well heads often provide evidence of land subsidence, and in some instances may allow measurement of subsidence at a point (figure 40). Observed features should be documented with detailed photographs, including metadata (date, location, feature observed, etc.).

Subsurface Investigation

Earth fissures related to groundwater mining tend to be vertical to near-vertical features (figures 30 and 41) extending to hundreds of feet deep. In an uneroded state, the aperture of an earth fissure may be 0.25 to 1 inch or less (figure 31), and may



Figure 40. Protruding well head due to land subsidence resulting from groundwater mining. Photo taken September 2014.



Figure 41. Vertical earth fissure in Cedar Valley exposed in the end of an erosional gully formed along the fissure by infiltration of surface runoff. Photo taken August 2009.

be open or filled. Situations may arise where surficial expression of earth fissures is lacking, but the presence or absence of shallow subsurface earth fissures that could lead to future surface expression should be assessed. Lateral subsurface investigation methods such as trenching or shallow geophysics tend to be most effective in these situations. Subsurface characterization may be especially important when assessing

whether subsurface conditions are consistent with a surface feature being a subsidence-related earth fissure or a less hazardous giant desiccation crack. Subsurface investigation techniques may include, but are not limited to:

1. Trenching or test pits with appropriate logging and documentation to permit detailed and direct observation of continuously exposed geologic units, soils, fissures, and other geologic features. This includes trenching across known or suspected earth fissures and fissure zones to determine their location and width, geometry and depth, and displacement. When uneroded or filled, earth fissures are often very subtle features, so logging should be performed in sufficient detail to detect their presence.

In preparation for logging, trench walls should be carefully cleaned to permit direct observation of the geology. Trenches should be logged at a minimum scale of 1 inch = 5 feet (1:60), and all logs should be prepared in the field under the direct supervision of a Utah licensed Professional Geologist. Vertical and horizontal logging control should be used and shown on the log. The logs should not be generalized or diagrammatic, and may be on a rectified photomosaic base. The log should document all pertinent information from the trench, including (1) trench orientation and indication of which wall was logged, (2) horizontal and vertical control, (3) top and bottom of trench wall(s), (4) stratigraphic contacts, (5) lithology and soil classification, (6) pedogenic soil horizons, (7) marker beds, (8) fissures and faults, (9) fissure/ fault orientations and geometry (strike and dip), (10) fissure displacement and aperture, and (11) sample locations (e.g., Birkeland and others, 1991; Bonilla and Lienkaemper, 1991; U.S. Bureau of Reclamation, 1998b; Walker and Cohen, 2006; McCalpin, 2009). Logs should be prepared for all trenches, even if fissures are not encountered.

2. The trench should be deep enough to expose all relevant aspects of fissure geometry (dip, width, associated subsidiary features). Where the maximum trench depth achievable, generally 15 to 20 feet, is not sufficient to adequately characterize suspected fissures, the practical limitations of trenching should be acknowledged in the report and uncertainties should be reflected in report conclusions and recommendations. Boreholes, CPT soundings, and geophysical techniques (see no. 4 below) may help extend the depth of investigation.

More than one trench may be necessary to investigate a site or building footprint, particularly when the proposed development is large, involves more than one building, and/or is characterized by complex fissure patterns. Generally, subsurface data should not be extrapolated more than 300 feet without additional subsurface information. Complex fissure zones may require closer trench spacing. When trenches must be offset to accommodate site conditions, sufficient overlap should be provided to avoid gaps in trench coverage perpendicular to the fissure. Tightly spaced trench-

es may only need minor (a few tens of feet) overlap; however, more widely spaced trenches require greater overlap to ensure continuous site coverage.

Test pits may provide useful information regarding site subsurface conditions; however, test pits are not an acceptable alternative to trenches. A series of aligned test pits perpendicular to the fissure trend cannot adequately demonstrate the presence or absence of fissuring because fissures trending between test pits may not be detected.

Trenches and fissures should be accurately located on site plans and geologic maps. The UGS recommends that trenches and fissures (projected to the ground surface) be surveyed rather than located using a hand-held GPS device.

Trench investigations should be performed in compliance with current Occupational Safety and Health Administration (OSHA) excavation safety regulations and standards (<https://www.osha.gov/SLTC/trenching-excavation/construction.html>). See Excavation Safety section in chapter 2 for additional information.

3. Boreholes and CPT soundings permit collection of data on geologic units and groundwater, and may verify fissure plane geometry. Vertically focused investigation methods such as boreholes and CPT soundings are useful for general subsurface characterization in a potential fissure zone; however, an uneroded earth fissure in the subsurface is a very small target for vertically directed investigation methods. CPT soundings should be done in conjunction with continuously logged boreholes to correlate CPT data with the physical characteristics of subsurface geologic units. Data points should be sufficient in number and adequately spaced to permit reliable correlations and interpretations; however, it may not be possible to detect an earth fissure in a borehole or CPT sounding.
4. Geophysical investigations are indirect, non-destructive methods that can be reliably interpreted when site-specific surface and subsurface geologic conditions are known. Geophysical methods should seldom be employed without knowledge of site geology; however, where no other subsurface geologic information is available, geophysical methods may provide the only economically viable means of deep geologic reconnaissance (e.g., Chase and Chapman, 1976; Telford and others, 1990; Sharma, 1998; U.S. Bureau of Reclamation, 2001; Milsom and Eriksen, 2007; Reynolds, 2011).

Although geophysical methods can be used to detect the presence and location of shallow earth fissures, such methods alone never prove the absence of a fissure at depth. Geophysical methods can provide critical information concerning subsidence potential, especially compressible basin-fill and bedrock geometry that may not otherwise be available. Geophysical techniques may include, but are not limited to, high-resolution seismic

reflection, ground penetrating radar, seismic refraction, magnetic profiling, electrical resistivity, and gravity.

Other Investigation Methods

Other methods may be incorporated in land-subsidence and earth-fissure investigations when conditions permit or requirements for critical structures or facilities require more intensive investigation or monitoring over extended time periods. Possible methods may include, but are not limited to:

1. Aerial reconnaissance flights, including high-resolution aerial photography.
2. Installation of piezometers.
3. Local high-precision surveying or geodetic measurements, including comparison surveys with infrastructure design grades and long-term monitoring employing repeat surveys.
4. Strain (displacement) measurement both at the surface and in boreholes as part of a long-term monitoring program (Galloway and others, 1999).
5. Geochronologic analysis, including but not limited to radiometric dating (e.g., ^{14}C , $^{40}\text{Ar}/^{39}\text{Ar}$), luminescence dating, soil-profile development, fossils, tephrochronology, and dendrochronology (see Geochronology section of chapter 2).

LAND-SUBSIDENCE AND EARTH-FISSURE MITIGATION

Early recognition and avoidance of areas subject to land subsidence and earth fissures are the most effective means of mitigating land-subsidence and earth-fissure hazards. However, because avoidance may not always be a viable or cost-effective option, especially for existing facilities (figures 34, 37, and 38), the UGS provides the following general recommendations (modified from Price and others [1992], Ken Euge [Geological Consultants, Inc., written communication, 2010], and Knudsen and others [2014]) to reduce the impact of land subsidence and earth fissures. However, other mitigation techniques may be available/appropriate at a specific site, and the Engineering Geologist should base mitigation recommendations on site-specific data.

- Stop mining groundwater and manage basin-fill aquifers as renewable resources. Adopt best aquifer management practices to bring long-term recharge of basin-fill aquifers into balance with long-term discharge. Possible strategies for achieving safe yield include:
 - a. Import water from other basins.
 - b. Recharge aquifers artificially, including aquifer storage and recovery projects.
 - c. Relocate concentrations of high-discharge wells to dispersed locations away from subsiding areas.

- d. Establish a subsidence abatement district responsible for setting water policy and priorities (such as reducing water rights, permitting production wells, or taxing groundwater pumping) and for developing continued subsidence mitigation strategies. This function may naturally fall to water conservancy districts, where such districts already exist.
- e. Implement water conservation practices to reduce groundwater consumption over time (reduce groundwater pumping) to achieve safe yield.
- Define basin-wide land-subsidence- and earth-fissure-hazard zones and require that land subsidence and earth fissures be carefully investigated on a site-specific basis in those areas prior to new development.
- Avoid land-subsidence areas and earth fissures where and when possible.
- When avoidance is not possible, land subsidence and earth fissures should be integrated into project design to provide a factor of safety for development. Because earth fissures caused by groundwater mining may expand over time and new fissures may form if groundwater mining persists, it is not possible to establish standard setback distances or implement a standardized method for calculating fissure setbacks as is done for hazardous faults (chapter 3). Therefore, the UGS does not make a standard setback recommendation, but rather recommends that the Engineering Geologist in responsible charge of the land-subsidence and earth-fissure investigation make and justify an appropriate setback based on the results of a site-specific hazard investigation.
- Keep water out of earth fissures to prevent erosion; control surface runoff.
- Limit irrigation in earth-fissure areas; landscape with drought-resistant native vegetation.
- Prevent construction of retention basins or dry wells and avoid effluent disposal (including on-site wastewater disposal) in earth-fissure areas.
- Establish a long-term, basin-wide monitoring program (InSAR, lidar, high-precision GPS/GNSS surveying) to track the occurrence, magnitude, and growth of subsidence areas and earth fissures.
- Recognize that without effective mitigation of groundwater mining, the long-term consequences of land subsidence and earth fissures are potentially serious. Because areas of land subsidence and earth fissures will expand over time with continued groundwater mining, quantifying the future effects of land subsidence and earth fissures at a site may not be possible even after a careful hazard investigation. Additionally, even with innovative engineering design, limiting certain kinds of land use (e.g., water conveyance or retention structures, pipelines and canals, liquid waste disposal systems, hazardous materials processing and storage

facilities) may be necessary in areas of rapid ongoing subsidence or rapid earth fissuring.

- Disclose the presence of land subsidence and earth fissures during real-estate transactions so prospective property owners can make their own informed decisions regarding risk.

LAND-SUBSIDENCE AND EARTH-FISSURE INVESTIGATION REPORT

The UGS recommends that a report prepared for a land-subsidence and earth-fissure investigation in Utah should, at a minimum, address the topics below. Site conditions may require that additional items be included to fully evaluate these hazards; these guidelines do not relieve Engineering Geologists from their duty to perform additional geologic investigations as necessary to adequately assess land-subsidence and earth-fissure hazards. The report presenting the investigation results must be prepared, stamped, and signed by a Utah licensed Professional Geologist (Utah Code, 2011) with experience in conducting land-subsidence and earth-fissure investigations. Reports co-prepared by a Utah licensed Professional Engineer or Utah licensed Professional Land Surveyor must include the engineer's and/or surveyor's stamp and signature. The report guidelines below pertain to investigations of land-subsidence and earth-fissure hazards resulting from groundwater mining, and expand on the general guidance provided in the Engineering-Geology Investigations and Engineering-Geology Reports sections of chapter 2.

A. Text

- a. Purpose and scope of investigation. If a site-specific investigation, describe the location and size of the site and proposed type and number of buildings or other infrastructure if known.
- b. Geologic, topographic, and hydrologic setting. The report should contain a clear and concise statement of the region/site's geologic, topographic, and hydrologic setting. The section should include a discussion of known land subsidence or earth fissures in the area, and should reference pertinent published and unpublished geologic literature.
- c. Site description and conditions. Include dates of site visits and observations. Include information on geologic and soil units, hydrology, topography, distribution and condition of existing benchmarks, graded and filled areas, vegetation, existing structures, presence of fissures on or near the site, evidence of land subsidence, and other factors that may affect the choice of investigative methods and interpretation of data.
- d. Methods and results of investigation.

1. Literature Review. Summarize published and unpublished topographic and geologic maps, literature, and records regarding geologic units, faults, geomorphic features, surface water and groundwater, benchmark elevation data, previous land subsidence and earth fissures, and other relevant factors pertinent to the site.
 2. Interpretation of Remote-Sensing Imagery. Describe the results of remote-sensing-imagery interpretation, including stereoscopic aerial photographs, InSAR, lidar, and other remote-sensing data when available, conducted to identify evidence of land subsidence and earth fissures. List source, date, flight-line numbers, and scale of aerial photos or other imagery used.
 3. Surface Investigation. Describe pertinent surface features including mapping of geologic and soil units; geomorphic features such as scarps, springs, and seeps; fissures; faults; and describe methodology and quality of data used to determine the amount and distribution of subsidence including sources of historical elevation data, surveying methods, and accuracy/uncertainties involved with subsidence calculations.
 4. Subsurface Investigation. Describe trenching and other subsurface investigations (test pits, borings, CPT soundings, geophysics) conducted to evaluate earth fissures at the site. The strike, dip, and vertical displacement (or minimum displacement if total displacement cannot be determined) across fissures should be recorded. Trench logs should be included with the report and should be prepared in the field at a scale of 1 inch = 5 feet or larger.
- e. Conclusions.
1. Conclusions must be supported by adequate data, and the report should present those data in a clear and concise manner.
 2. Data provided should include evidence establishing the presence or absence of land subsidence and earth fissures on or near a site and relation to proposed or existing infrastructure. Report displacement across earth fissures if present.
 3. Statement of relative risk that addresses the probability or relative potential for growth of existing or future earth fissures and the rate and amount of anticipated land subsidence. This may be stated in semi-quantitative terms such as low, moderate, or high as defined within the report, or quantified in terms of fissure growth rates or land subsidence rates.
 4. Degree of confidence in, and limitations of, the data and conclusions.
- f. Recommendations.
1. Recommendations must be supported by the report conclusions and be presented in a clear and concise manner.
 2. If earth fissures are present on site, provide setback or other mitigation recommendations as necessary, and justify based on site-specific data.
 3. Mitigation measures to control fissure growth and reduce risk from land subsidence, such as preventing surface water from entering fissures, strengthening structures that must bridge fissures, and using flexible utility connections in subsidence areas or where utilities cross fissures displaying differential displacement.
 4. Construction testing, observation, inspection, and long-term monitoring.
 5. Limitations on the investigation and recommendations for additional investigation to better understand or quantify hazards.
- B. References
- a. Literature and records cited or reviewed; citations should be complete (see References section of this publication for examples).
 - b. Remote-sensing images interpreted; list type, date, project identification codes, scale, source, and index numbers.
 - c. Other sources of information, including survey data, well records, personal communication, and other data sources.
- C. Illustrations. Should include at a minimum:
- a. Location map. Showing the area investigated (region or site specific) and significant physiographic and cultural features, generally at 1:24,000 scale or larger and indicating the Public Land Survey System $\frac{1}{4}$ -section, township, and range; and the site latitude and longitude to four decimal places with datum.
 - b. Site development map. For site-specific investigations showing site boundaries, existing and proposed structures, other infrastructure, and site topography. The map scale may vary depending on the size of the site and area covered by the study; the minimum recommended scale is 1 inch = 200 feet (1:2400) or larger when necessary. The site development map may be combined with the site-specific geology map (see below).
 - c. Regional geology/land-subsidence map. A regional-scale (1:24,000 to 1:50,000) map showing the investigation area's geologic setting, including geologic units, faults, other geologic structures, areas of land subsidence, and earth fissures within a 10-mile radius of the development site. Depending on project size and complexity, it may be necessary to show a larger area.

- d. Site-specific geology map. For site-specific investigations, a site-scale geology map showing (1) distribution of geologic and soil units, (2) earth fissures, (3) land-subsidence areas, (4) faults, (5) springs and seeps, whether aligned or not, (6) other relevant geomorphic features, and (7) trench and boring locations, wells and piezometers, geophysical transects, survey lines, relevant benchmarks, and other kinds of monitoring locations. Scale of site geologic maps will vary depending on the size of the site and area of investigation; minimum recommended scale is 1 inch = 200 feet (1:2400) or larger when necessary.

If on-site investigations reveal the presence of land subsidence or earth fissures, the boundary and magnitude of the subsiding area and earth-fissure locations should be shown on either the site-specific geologic map or on a separate land-subsidence and earth-fissure-hazard map depending on site scale and complexity. If earth-fissure avoidance is the mitigation strategy employed, an appropriate setback should be shown either on the site-specific geology map, or on a separate land-subsidence and earth-fissure-hazard map.

- e. Geologic/topographic cross sections. Site geologic cross sections should be included as needed to illustrate three-dimensional geologic relations.
- f. Trench and test pit log(s). Logs are required for each trench and test pit excavated as part of the investigation whether earth fissures are encountered or not. Logs are hand- or computer-drawn maps of excavation walls that show details of geologic units and structures. Logs should be to scale and not generalized or diagrammatic, and may be on a rectified photomosaic base. The scale (horizontal and vertical) should be 1 inch = 5 feet (1:60) or larger as necessary and with no vertical exaggeration. Logs should be prepared in the field and accurately reflect the features observed in the excavation, as noted below. Photographs are not a substitute for trench logs.

The log should document all pertinent information from the trench, including (1) trench and test-pit orientation and indication of which wall was logged, (2) horizontal and vertical control, (3) top and bottom of trench wall(s), (4) stratigraphic contacts, (5) lithology and soil classification, (6) pedogenic soil horizons, (7) marker beds, (8) fissures and faults, (9) fissure orientations and geometry (strike and dip), (10) fissure displacement, and (11) sample locations (e.g., Birkeland and others, 1991; U.S. Bureau of Reclamation, 1998b; Walker and Cohen, 2006; McCalpin, 2009). Logs should be prepared for all trenches, even if fissures are not encountered.

Logs should include interpretations and evidence for the age and origin of geologic units. Study limi-

tations should be clearly stated for suspected earth fissures where unfissured deposits are deeper than practical excavation depths.

- g. Borehole and CPT sounding logs. Borehole and CPT sounding logs should include the geologic interpretation of deposit genesis for all layers encountered; logs should not be generalized or diagrammatic. Because boreholes are typically multipurpose, borehole logs may also contain standard geotechnical, geologic, and groundwater data.
- h. Geophysical data and interpretations.
- i. Photographs that enhance understanding of site surface and subsurface (trench and test pit walls) conditions with applicable metadata.

D. Authentication

The report must be signed and sealed by a Utah licensed Professional Geologist in principal charge of the investigation (Title 58-76-10 – Professional Geologists Licensing Act [Utah Code, 2011]). Final geologic maps, trench logs, cross sections, sketches, drawings, and plans, prepared by or under the supervision of a professional geologist, also must bear the seal of the professional geologist (Utah Code, 2011). Reports co-prepared by a Utah licensed Professional Engineer and/or Utah licensed Professional Land Surveyor must include the engineer's or surveyor's stamp and signature.

E. Appendices

Include supporting data relevant to the investigation not given in the text such as maps, boring logs, cross sections, conceptual models, fence diagrams, survey data, water-well data, geochronology laboratory reports, laboratory test data, and qualifications statements/resume.

FIELD REVIEW

The UGS recommends a technical field review by the regulatory-authority geologist once a land-subsidence and earth-fissure-hazard investigation is complete. The field review should take place after any trenches or test pits are logged, but before they are closed so subsurface site conditions can be directly observed and evaluated. See Field Review section in chapter 2.

REPORT REVIEW

The UGS recommends regulatory review of all reports by a Utah licensed Professional Geologist experienced in land-subsidence and earth-fissure-hazard investigations and acting on behalf of local governments to protect public health, safety, and welfare, and to reduce risks to future property owners (Larson, 1992, 2015). See Report Review section in chapter 2.

DISCLOSURE

The UGS recommends disclosure during real-estate transactions whenever an engineering-geology investigation has been performed. See Disclosure section in chapter 2.

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CHAPTER 7

GUIDELINES FOR EVALUATING ROCKFALL HAZARDS IN UTAH

by

William R. Lund, P.G., and Tyler R. Knudsen, P.G.



Rockfall in 2013 that damaged a residence in St. George, Utah, and severely injured the occupant.

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CHAPTER 7: GUIDELINES FOR EVALUATING ROCKFALL HAZARDS IN UTAH

by William R. Lund, P.G., and Tyler R. Knudsen, P.G.

INTRODUCTION

These guidelines present the recommended minimum acceptable level of effort for investigating rockfall hazards in Utah, and are intended for site-specific investigations for new structures for human occupancy and for International Building Code (IBC) Risk Category II, III, and IV facilities (International Code Council [ICC], 2017a). The intent of these guidelines is to assist Engineering Geologists performing rockfall investigations, and to reduce, to the lowest level possible, epistemic uncertainty (lack of necessary data) in evaluating rockfall hazard by conducting adequate hazard investigations. Aleatory variability (natural randomness) in rockfall behavior cannot be reduced; therefore, predicting exactly when and where future rockfalls will occur and how large they will be is not possible. For that reason, developing property on or near rockfall-susceptible areas will always involve a level of irreducible, inherent risk.

These guidelines outline (1) appropriate investigation methods, (2) report content, (3) map and illustration criteria and scales, (4) mitigation recommendations, (5) minimum criteria for review of reports, and (6) recommendations for geologic-hazard disclosure. However, these guidelines do not include systematic descriptions of all available investigative techniques or topics, nor does the UGS suggest that all techniques or topics are appropriate for every hazard investigation.

Considering the complexity of evaluating rockfall hazard, additional effort beyond the minimum criteria recommended in these guidelines may be required at some sites to adequately address rockfall hazard. The information presented in these guidelines does not relieve Engineering Geologists of the duty to perform additional geologic investigations necessary to fully assess the rockfall hazard at a site. As required by Utah state law (Utah Code, 2011), rockfall investigation reports and supporting documents must be signed and stamped by the licensed Utah Professional Geologist in responsible charge of the investigation.

Purpose

A rockfall-hazard investigation uses the characteristics of past rockfalls at a site as a scientific basis for providing recommendations to reduce the risk for damage and injury from future, presumably similar, rockfalls.

The purpose of these guidelines is to provide appropriate minimum rockfall investigation and report criteria to:

- protect the health, safety, and welfare of the public by minimizing the adverse effects of rockfalls;
- assist local governments in regulating land use in hazardous areas and provide standards for ordinances;
- assist Engineering Geologists in conducting reasonable and adequate investigations;
- provide Engineering Geologists with a common basis for preparing proposals, conducting investigations, and recommending rockfall-mitigation strategies; and
- provide an objective framework for preparation and review of reports.

These guidelines are not intended to supersede pre-existing state or federal regulations or local geologic-hazard ordinances, but provide useful information to supplement adopted ordinances/regulations, and assist in preparation of new ordinances. The UGS believes adherence to these guidelines will help ensure adequate, cost-effective investigations and minimize report review time.

Background

Rockfall is a natural mass-wasting process that involves the dislodging and rapid downslope movement of individual rocks and rock masses (Cruden and Varnes, 1996). The widespread combination of steep slopes capped by well-jointed bedrock makes rockfall among the most common slope-failure types in Utah. Rockfall poses a hazard because falling, rolling, or bouncing rocks and boulders can cause significant property damage and be life threatening (Smith and Petley, 2009) (figure 42). At least 20 deaths directly attributable to rockfalls have occurred in Utah since 1850 (Hylland, 1995; Case, 2000; Castleton, 2009; Lund and others, 2010, 2014; chapter 1). Significant damaging or fatal rockfalls in Utah include Big Cottonwood Canyon and the San Juan River in 1999 (Castleton, 2009); the Town of Rockville in 2002 (Lund, 2002a, 2002b; Rowley and others, 2002), 2010 (Knudsen, 2011), and 2013 (Lund and others, 2014); Provo in 2005 (Giraud and Christenson, 2010) and 2009 (Giraud and others, 2010); State Route 14 in 2009 (Lund and others 2009a, 2009b); and St. George in 2013 (Lund, 2013). See Case (2000) for a list of notable Utah rockfalls in the 1980s and 1990s.



Figure 42. Rockfall damage to a house in southern Utah. Rockfall boulder leaning against wall passed entirely through the house and struck a vehicle in the driveway. Photo credit: Dave Black, Rosenberg Associates, photo taken February 2010.

Rockfalls occur where a source of rock exists above a slope steep enough to allow rapid downslope movement of dislodged rocks by falling, rolling, bouncing, and sliding (figure 43). Rockfall sources include bedrock outcrops or boulders on steep mountainsides or near the edges of escarpments such as cliffs, bluffs, and terraces. Talus cones and scree-covered slopes are indicators of a high rockfall hazard, but other less obvious areas may also be vulnerable (Lund and others, 2010). Slope modifications such as cuts for roads and building pads and clearing slope vegetation for development or from wildfire can increase or create rockfall hazards, as can construction of non-engineered and/or poorly constructed rockery walls, which are becoming increasingly common in Utah urban areas (figure 44).

Rockfalls may be triggered by freeze/thaw action, rainfall, changes in groundwater conditions, weathering and erosion of the rock and/or surrounding material, and root growth (Smith and Petley, 2009). Rockfall is the most common type of mass movement caused by earthquakes. Keefer (1984) stated that earthquakes as small as magnitude (M) 4.0 can trigger rockfalls. In Utah, the 1988 M_L 5.3 San Rafael Swell earthquake triggered multiple rockfalls (figure 45) (Case, 2000), and the 1992 M_L 5.8 St. George earthquake caused numerous rockfalls in Washington County (Black and others, 1995). However, many rockfalls occur with no identifiable trigger. Although not well documented, rockfalls in Utah appear to occur more frequently during spring and summer months (Case, 2000). This is likely due to spring snowmelt, summer cloudburst storms, and large daily temperature variations (Castleton, 2009).

SOURCES OF ROCKFALL INFORMATION

The Utah Geological Survey (UGS) has investigated numerous rockfalls over the past three and a half decades (see Back-



Figure 43. Site showing rockfall source (cliff at top of slope), acceleration zone (steep slope below cliff), and runout zone (base of steep slope near barn and corral). See figure 46 for related information. Photo credit: Dave Black, Rosenberg Associates, photo taken February 2010.

ground section above). Additionally, the Literature Searches and Information Resources section in chapter 2 provides information on other geologic-hazard reports, maps, archives, and databases maintained by the UGS and others that may be relevant to rockfalls, as well as information on the UGS' extensive aerial photograph and light detection and ranging (lidar) imagery collections.

Rockfall Characterization and Control (Turner and Schuster, 2012) is the best currently available general reference for investigating and mitigating rockfall hazard. Although chiefly concerned with the effects of rockfall on transportation corridors, much of the information contained in this comprehensive publication is directly applicable to site-specific investigations for human-occupied structures and high-risk infrastructure.

ROCKFALL-HAZARD INVESTIGATION

When to Perform a Rockfall-Hazard Investigation

Geologic hazards are best addressed prior to land development. The UGS recommends that a rockfall-hazard investigation be made for all new buildings for human occupancy and for modified IBC Risk Category II(a), II(b), III, and IV facilities (modified from IBC table 1604.5 [ICC, 2017a]; see table 13 in chapter 3) that are proposed on or adjacent to areas where bedrock crops out on steep slopes. Utah jurisdictions that have adopted rockfall special-study maps identify zones in known rockfall-susceptible areas within which they require a site-specific investigation. The UGS recommends that investigations as outlined in these guidelines be conducted for all IBC Risk Category III and IV facilities on or adjacent to areas where bedrock crops out on steep slopes, whether near a mapped rockfall area or not, to ensure that a previously un-



Figure 44. Unreinforced rockery wall typical of many constructed in recent years in Utah. Strong ground shaking during an earthquake may cause such walls to fail and generate urban rockfalls. Photo taken January 2013.



Figure 45. Dust clouds created by numerous rockfalls during the 1988 *M* 5.3 San Rafael Swell earthquake (photo courtesy of Terry A. Humphrey, U.S. Bureau of Land Management).

known rockfall hazard is not present. If a hazard is found, the UGS recommends a comprehensive investigation be conducted. Additionally, in some instances an investigation may become necessary when existing infrastructure is discovered to be on or adjacent to a rockfall-susceptible area.

The level of investigation conducted for a particular project depends on several factors, including (1) site-specific geologic conditions, (2) type of proposed or existing development, (3) level of acceptable risk, and (4) governmental permitting requirements, or regulatory agency rules and regulations. A landslide-hazard investigation may be conducted separately, or as part of a comprehensive geologic-hazard and/or geotechnical site investigation (see chapter 2).

Minimum Qualifications of Investigator

Rockfall-related engineering-geology investigations and accompanying geologic-hazard evaluations performed be-

fore the public shall be conducted by or under the direct supervision of a Utah licensed Professional Geologist (Utah Code, Title 58-76) who must sign and seal the final report. Often these investigations are interdisciplinary in nature, and where required, must be performed by qualified, experienced, Utah licensed Professional Geologists (PG, specializing in engineering geology) and Professional Engineers (PE, specializing in geological and/or geotechnical engineering) working as a team. See Investigator Qualifications section in chapter 2.

Investigation Methods

Inherent in rockfall investigations is the assumption that future rockfalls will in most instances occur in areas subject to previous rockfalls, and in a manner generally consistent with past rockfall events. A site-specific rockfall investigation typically includes at a minimum:

- Literature review.
- Analysis of stereoscopic aerial photographs and other remote-sensing imagery.
- Site characterization, usually including surficial geologic mapping, measuring rockfall shadow angles, and characterizing rockfall source areas, acceleration zones, and runout areas.
- Other investigations as necessary to fully evaluate the rockfall hazard at a site (e.g., computer modeling, boreholes, geophysics, slope and groundwater instrumentation and monitoring) (see also chapter 2).

Literature Review

Prior to the start of field investigations, an Engineering Geologist conducting a rockfall investigation should review published and unpublished (as available) geologic literature,

geologic and topographic maps, cross sections, consultant's reports, and records relevant to the site and site region's geology (see the Literature Searches and Information Resources section in chapter 2), with particular emphasis on information pertaining to the presence of known rockfall sources and the past history of rockfalls at or near the site of interest. The Sources of Rockfall Information section above provides information on Utah's geology and past significant rockfalls; however, the list of sources is not exhaustive, and Engineering Geologists should identify and review all available information relevant to their site of interest.

Analysis of Aerial Photographs and Remote-Sensing Data

A rockfall investigation should include interpretation of stereoscopic aerial photographs (from multiple years if available), available lidar imagery (appendix C), and other remotely sensed data for evidence of rockfall sources and past rockfall activity (see the Literature Searches and Information Resources section in chapter 2). Examination of the oldest available aerial photographs may show evidence of rockfalls subsequently obscured by development or other ground disturbance. The area interpreted should extend sufficiently beyond the site boundaries to identify evidence of off-site rockfall sources that might affect the site and adequately characterize patterns of rockfall occurrence. Aerial photographs and other remote-sensing imagery may prove useful in identifying and mapping local joints, faults, and other bedrock discontinuities, and regional geologic structures that may contribute to rockfall hazard at a site.

Google Earth and Bing Maps, among other providers of Internet-based, free aerial imagery, are becoming increasingly valuable as rapid site-reconnaissance tools, and provide high-resolution, often color, non-stereoscopic aerial orthophotographs of many sites of interest. For many locations, Google Earth also includes a historical imagery archive that permits evaluation of site conditions several years to decades before present.

Site Characterization

Rockfall is a surface phenomenon, and as such, the presence and severity of a rockfall hazard depend chiefly on site topography and the characteristics of the rockfall source. Higgins and Andrew (2012a, table 2-1) identify several types of rock slope failures ranging from simple to complex that may contribute to rockfalls. Readers requiring information on rockfall failure mechanisms are directed to Higgins and Andrew (2012a) for a discussion of each failure type and the conditions under which they occur. Climatic factors such as precipitation and temperature affect erosion, freeze-thaw cycles, and groundwater conditions, and are common rockfall triggers. Earthquakes are a less common phenomena, but earthquakes may trigger numerous nearly simultaneous rockfalls.

A first-order consideration when performing a rockfall investigation is whether or not the conditions for rockfall are present at or near the site of interest. If either a rock source or a slope steep enough to permit rockfall debris to move rapidly downslope are absent, there is no rockfall hazard. The determination of whether a rockfall hazard is present or not can often be made quickly from analysis of aerial photographs or other remote sensing data, or from a brief site reconnaissance.

If conditions for rockfall are present on or adjacent to a site (a rockfall may not follow a direct path downslope), evaluating the severity of the hazard requires determining the characteristics of three rockfall-hazard components: (1) the rock source, which generally consists of a bedrock unit that exhibits a relatively consistent pattern of rockfall susceptibility where it crops out on or above steep slopes (e.g., the Shinarump Conglomerate Member of the Chinle Formation in southwestern Utah), although talus, cliff-retreat deposits, glacial moraines, and any steep slope in unconsolidated deposits that contain large cobbles and boulders may also source rockfalls, (2) the acceleration zone, where the rockfall debris gains momentum as it travels downslope; this zone often includes a talus slope, which becomes less apparent with decreasing relative hazard and may be absent where the hazard is low, and (3) the run-out zone, which includes gentler slopes and valley bottoms at the base of the acceleration-zone slope where boulders roll or bounce as they decelerate and eventually come to a stop (figure 46) (Evans and Hungr, 1993; Wiczeorek and others, 1998; Higgins and Andrews, 2012b).

Rockfall investigations should include mapping susceptible geologic units and talus slopes, and topographic features that may affect rockfall hazard. Rockfall sources should be evaluated for (1) rock type (lithology; e.g., U.S. Bureau of Reclamation, 1998b; Walker and Cohen, 2006), (2) weathering, (3) discontinuities (bedding, joints, faults, shear zones, foliation, schistosity, veins, etc.; e.g., U.S. Bureau of Reclamation, 1998b), and (4) potential clast size. The presence of bedrock discontinuities in a rock source, and their relation to cliff faces/slope are of particular importance. Discontinuities may divide a rock source into blocks or wedges and enhance the ability of a bedrock unit to source rockfalls (provide detachment surfaces), and can also affect the size and shape of rockfall debris. Important properties of discontinuities include (1) orientation, (2) spacing, (3) persistence, (4) roughness, (5) weathering, (6) aperture width, (7) aperture filling, and (8) seepage (U.S. Bureau of Reclamation, 1998b; Higgins and Andrew, 2012b). Discontinuity spacing and other rock-mass data are normally recorded by making a scanline survey along a rock outcrop surface or from rock cores (U.S. Bureau of Reclamation, 1998b; Higgins and Andrews, 2012b).

Groundwater conditions should be carefully investigated. The presence of groundwater can greatly increase the potential for rockfall by (1) reducing shear strength along failure surfaces, (2) decreasing cohesion in infilling materials, (3) increasing

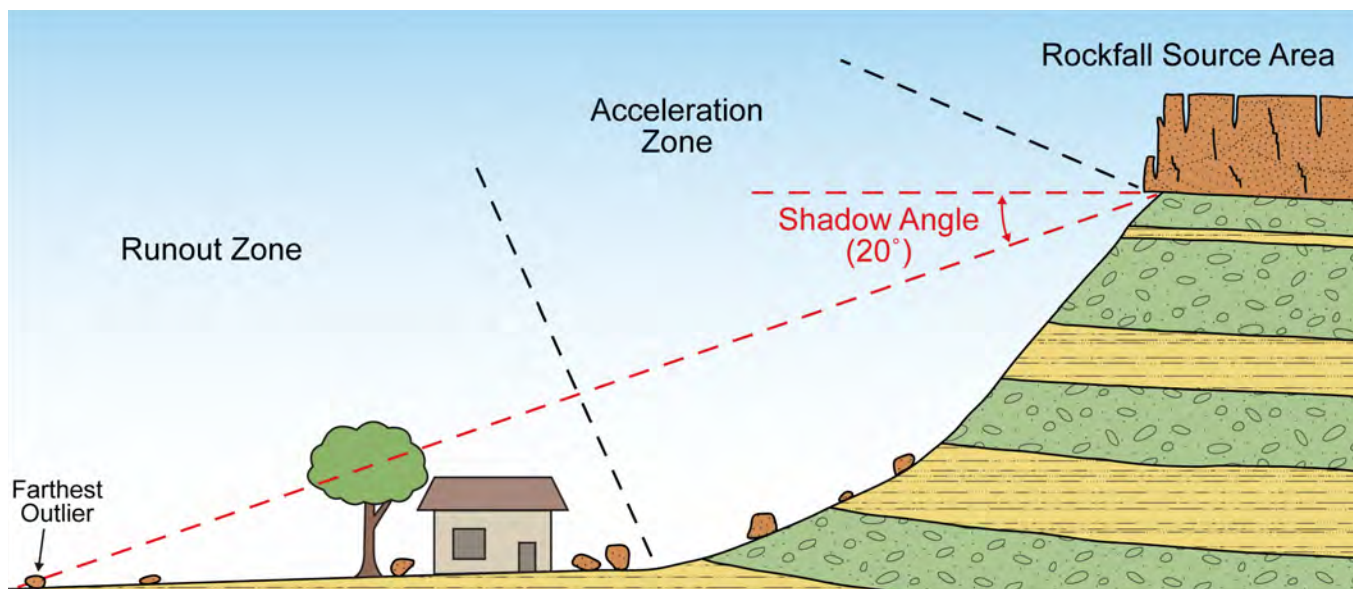


Figure 46. Typical rockfall path profile and components of a rockfall shadow angle (modified from Lund and others, 2008).

forces that may induce pressure along discontinuities, and (4) enhancing freeze-thaw cycles (Higgins and Andrew, 2012a). Groundwater conditions may exhibit seasonal variations, and thus may require long-term monitoring to accurately gauge their effect on rockfall conditions.

The acceleration zone should be evaluated for (1) slope angle, (2) aspect, (3) substrate, (4) surface roughness, (5) vegetation, and (6) launch points (abrupt changes in slope) that may cause rockfall debris to become airborne. The presence of gullies, previously fallen boulders, and other sometimes subtle geomorphic or topographic features in the acceleration zone can deflect the path of a rockfall toward a site, even though the rockfall source is not directly above the site of interest. In runout zones, rockfall deposits should be evaluated for (1) distribution, (2) clast size, (3) amount of embedding, and (4) weathering of rockfall boulders as an indicator of rockfall age (figure 47).

Rockfall shadow angle: At undeveloped sites, or where rockfall debris has not been disturbed or removed from the runout zone, empirically establishing the outer boundary of the area affected by rockfall is often possible by measuring a rockfall shadow angle (Evans and Hungr, 1993; Wiczorek and others, 1998; Turner and Duffy, 2012). A shadow angle is the angle between a horizontal line and a line extending from the base of the rock source to the outer limit of the runout zone as defined by the farthest outlier rockfall debris at a site (figure 46). Shadow angles vary depending on (1) rock type, (2) rock shape, (3) slope steepness, (4) slope characteristics (such as surface roughness, vegetation, etc.), and (5) rock source height (Knudsen and Lund, 2013). Multiple measurements are necessary to establish a representative shadow angle; for example, Lund and others (2010) and Knudsen and Lund (2013) measured dozens of shadow angles in Zion Canyon in southwestern Utah to determine that an angle of 22° is generally applicable to the geologic and topographic conditions found

there. Structures and other infrastructure that are set back from the boundary of the runout zone determined using the shadow-angle technique are at greatly reduced risk from rockfall.

The UGS recommends establishing the extent of the rockfall runout zone at a site using a shadow angle based on the distribution of past rockfall debris, since each past rockfall represents a field test of rockfall susceptibility at the site. However, where rockfall debris has been disturbed or removed, determining the limit of the runout-zone boundary can be difficult or impossible. In those situations, it may be necessary to determine a shadow angle at a nearby undisturbed site with similar geologic and topographic conditions, which can then be applied to the site of interest. Alternatively, in some instances it may be possible to estimate the boundary of the runout zone below a rock source using rockfall modeling software.



Figure 47. Weathered rockfall boulder with subsequent erosion of soil from around the boulder base indicating that this rockfall occurred in the distant past and the area may no longer be in an active rockfall-hazard area. Photo taken March 2004.

Rockfall modeling software: The numerical simulation of rockfall trajectories is chiefly based on the principles of Newtonian mechanics and can provide reasonably precise estimates of rockfall trajectories, velocities, and kinetic energies (Turner and Duffy, 2012). Numerous rockfall computer models incorporating a variety of assumptions have been developed over the past three decades. Two-dimensional (2-D) simulations based on a “typical” slope profile have been most commonly applied (e.g., Colorado Rockfall Simulation Program [Jones and others, 2000]; Rocfall [RocScience, 2011]); however, it has long been recognized that 2-D models only partially reflect the realities of a three-dimensional (3-D) slope (Turner and Duffy, 2012). Multiple 2-D profiles need to be run to help account for the 3-D nature of rockfalls and the surrounding topography. Appropriate input data are critical, and therefore, the use of “typical” values should be avoided. Often, extensive fieldwork is needed to determine rock shape, surface roughness, vegetation, etc. for model input values. Attempts have been and are being made to develop 3-D rockfall models, although most current models require significantly greater computational capability and considerable experience to apply and interpret properly. Geographic information system (GIS) software is increasingly being used to evaluate landslide and rockfall hazards. Soeters and van Westen (1996) provided a comprehensive review of GIS techniques and how they can be used to assess slope instability and establish hazard zones. More recently, Fell and others (2008a, 2008b) defined and elaborated on the role of GIS analysis in landslide susceptibility, hazard, and risk zoning, and Van Westen and others (2008) provided a review of spatial information and GIS techniques in landslide hazard assessment (Turner and Duffy, 2012).

Providing detailed information on the use of rockfall simulation software is beyond the scope of these guidelines. Investigators may wish to consult Turner and Duffy (2012) for an extensive summary of the uses and limitations of current computational rockfall modeling techniques. Most analytical methods only model the interaction between a single rock block and the ground surface during successive impacts as the block rolls or bounces downslope. Collisions or impacts among multiple moving blocks are typically not evaluated, unless sophisticated discrete element numerical modeling is used. Interactions among multiple rock blocks frequently occur during rockfalls; thus, most analytical models represent a significant simplification over reality (Turner and Jayaprakash, 2012). Therefore, rockfall computer simulation models are only reliable when they have been carefully calibrated against field observations (Turner and Duffy, 2012).

Rockfall probability: A rockfall investigation, performed as described above, will establish the presence or absence of a rockfall hazard at a site and define a boundary beyond which the risk from future rockfalls is much reduced. However, determining (predicting) the exact timing of future rockfalls is not possible, and is not likely to become possible in the foreseeable future. As a general rule, the more rockfall debris on or at the base of a slope, the more frequent rockfalls are,

and the higher the hazard. However, with sufficient data it is possible to estimate the probability (x % chance in y years) of future rockfalls at a site. Conducting a probabilistic analysis requires information on both the number and timing of past rockfalls (Turner, 2012). Only a few areas in Utah have both a high rockfall hazard and a history of rockfall damage to structures to have produced a significant record of historical rockfalls. Rockville, Utah, is one such place, where six large rockfalls have occurred over the past 13 years (figure 48) (Knudsen, 2011; Lund and others, 2014), resulting in an average recurrence interval (average repeat time) for large rockfalls of 2.2 years. The annual probability of a large rockfall in Rockville based on the 13-year record is 46%. Three of the rockfalls struck and damaged inhabited structures, and one of the three caused two fatalities (figure 49). Such well-documented rockfall histories are rare, so in most instances, timing of past rockfalls must be determined by other means. In Yosemite National Park, Stock and others (2012a, 2012b) used cosmogenic beryllium-10 exposure ages to date the surfaces of rockfall boulders exposed to cosmogenic radiation for the first time following the rockfall. They integrated the number of identified rockfall events, rockfall timing data, and computer simulations of rockfall runout to develop a hazard boundary with a 10% probability of exceedance in 50 years for rockfall-susceptible areas of Yosemite Valley. Such detailed probabilistic rockfall-hazard investigations are costly both in terms of time and money, and are beyond the scope of most rockfall investigations. However, a probabilistic rockfall investigation may be required when evaluating hazard and risk for high-value infrastructure or for areas of prolonged high human occupancy in rockfall-susceptible areas.

Other Investigation Methods

Other investigation methods may be incorporated in rockfall investigations when conditions permit or requirements for critical structures or facilities make more intensive investigation or monitoring necessary. Possible investigation methods may include, but are not limited to:

- Aerial reconnaissance flights.
- Instrumentation and monitoring, which may include conventional high-precision surveying or geodetic measurements, terrestrial photogrammetry, airborne and/or terrestrial lidar and radar technologies, strain (displacement) measurement both at the surface and in boreholes, and groundwater piezometers (Andrew and others, 2012).
- Drilling to recover rock core for characterizing rock sources, installing slope monitoring instruments, and investigating and monitoring groundwater conditions.
- Geophysical investigations to better define discontinuity patterns in rockfall source areas. Geophysical techniques may include (1) high-resolution seismic reflection, (2) ground penetrating radar, (3) seismic refraction, (4) refraction microtremor (ReMi), (5) magnetic profiling, (6) electrical resistivity, and (7) gravity.

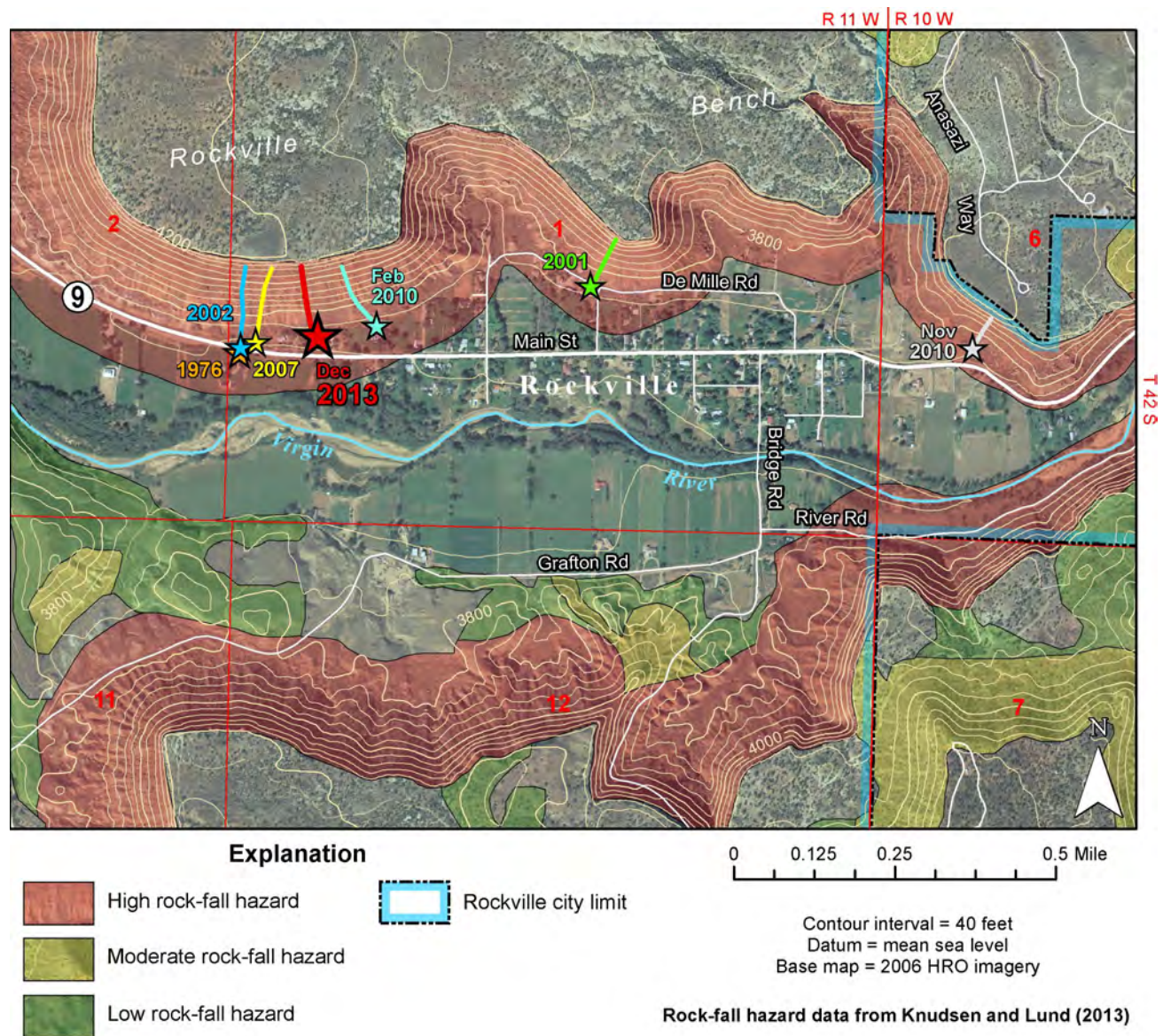


Figure 48. Rockfall-hazard zones mapped by the UGS, and historical rockfalls and their travel paths in the Town of Rockville, Utah.

Geophysical methods should not be employed without knowledge of site geology; however, where no other subsurface geologic information is available, geophysical methods may provide the only economically viable means to characterize rock-mass discontinuities (e.g., Telford and others, 1990; U.S. Bureau of Reclamation, 2001; Milsom and Eriksen, 2011; Reynolds, 2011).

- Geochronologic analysis, chiefly, but not limited to, application of various cosmogenic isotope dating techniques to rockfall-boulder surfaces to estimate times of boulder emplacement.

ROCKFALL MITIGATION

Early recognition and avoidance of areas subject to rockfall are the most effective means of mitigating rockfall hazard. Deter-

mining the boundary of the rockfall runout zone and siting all new buildings for human occupancy and IBC Risk Category II, III, and IV facilities (ICC, 2017a) outside that zone will substantially reduce rockfall risk. However, because the boundary of a rockfall runout zone seldom can be established with a high level of precision, the UGS recommends that structures for human occupancy or high-risk facilities be set back an appropriate distance from the runout-zone boundary to provide an additional factor of safety from rockfalls. Rockfall hazard is highly dependent on site geologic and topographic conditions; therefore, the UGS does not make a standard setback recommendation, but rather recommends that the Engineering Geologist in responsible charge of the rockfall investigation make and justify an appropriate setback based on the results of the site-specific hazard investigation. Where investigation results provide confidence in the runout-zone boundary, additional setback can be minimized. Where the boundary is uncertain, a larger setback is appropriate.

A



B



Figure 49. (A) House in Rockville, Utah, September 2010. (B) The same house in December 2013, destroyed by a large rockfall. The two occupants in the house were killed.

Avoidance may not always be a viable or cost-effective option, especially for existing facilities (figure 50), and many techniques are available to mitigate rockfall hazard. Rockfall mitigation is often conducted by specialized design-build manufacturers and/or contractors, often using proprietary techniques and/or materials. Mitigation techniques include, but are not limited to, (1) rock stabilization, (2) engineered structures, and (3) modification of at-risk structures or facilities. Rock-stabilization methods are physical means of reducing the hazard at its source using rock bolts and anchors, steel mesh, scaling, or shotcrete on susceptible outcrops. Engineered catchment or deflection structures such as rockfall fences (figure 51), berms, or benches can be placed below source areas, or at-risk structures themselves can be designed to stop, deflect, retard, or retain falling rocks. Such methods, however, may increase rockfall hazard if not properly designed and maintained. Detailed information on rockfall mitigation techniques is given in “Part 3: Rockfall Mitigation” of

A



B



Figure 50. (A) Rockfall in 1947 through the roof of a maintenance building in Zion National Park. (B) Rockfall in 2010 through the roof of the same maintenance building. Photos courtesy of National Park Service.

Rockfall Characterization and Control (Turner and Schuster, 2012). Conversely, in areas where a site-specific investigation indicates that rockfalls are possible but the hazard is low, it may be possible to conclude that the level of risk is acceptable and that no hazard-reduction measures are required (Lund and others, 2010). However, disclosure of the presence of a rockfall hazard at a site during real-estate transactions is necessary to ensure that prospective property owners can make their own informed decision regarding rockfall risk (Knudsen and Lund, 2013; see also Disclosure section below).

ROCKFALL-INVESTIGATION REPORT

The UGS recommends that a report prepared for a site-specific rockfall investigation in Utah at a minimum address the topics below. Site conditions may require that additional items



Figure 51. Rockfall fence installed to mitigate the rockfall hazard and protect the Zion National Park maintenance building. Photo taken June 2014.

be included to fully evaluate rockfall hazard at a site; these guidelines do not relieve Engineering Geologists from their duty to perform additional geologic investigations as necessary to adequately assess rockfall. The report guidelines below pertain specifically to rockfall investigations, and expand on the general report preparation guidance provided in the Engineering-Geology Investigations and Engineering-Geology Reports sections of chapter 2.

A. Text

- a. Purpose and scope of investigation. Describe the location and size of the site and proposed type and number of buildings or other infrastructure if known.
- b. Geologic and topographic setting. The report should contain a clear and concise statement of the site and site region's geologic and topographic setting. The section should include a discussion of rockfall activity in the area, historical seismicity if relevant to rockfall susceptibility, and should reference pertinent published and unpublished geologic literature.
- c. Site description and conditions. Include dates of site visits and observations. Include information on geologic units, topography, vegetation, existing structures, evidence of previous rockfalls on or near the site, and other factors that may affect the choice of investigative methods and interpretation of data.
- d. Methods and results of investigation.
 1. Literature Review. Summarize published and unpublished topographic and geologic maps, literature, and records regarding geologic units; rock sources; faults, joints, and other discontinuities; surface water and groundwater; topographic and geomorphic features; previous rockfalls; and other relevant factors pertinent to the site.
 2. Interpretation of Remote-Sensing Imagery. Describe the results of remote-sensing-imagery in-

terpretation, including stereoscopic aerial photographs, lidar, and other remote-sensing data when available. List source, date, flight-line numbers, and scale of aerial photos or other imagery used.

3. Surface Investigations. Describe pertinent surface features including mapping of rockfall sources (geologic units, talus slopes, precarious boulders, etc.) and discontinuities (bedding, joints, faults, foliation, schistosity, etc.), and other structural or geomorphic features that may affect the location, size, frequency, and path of rockfalls.
4. Shadow-Angle Analysis and/or Rockfall Computer Modeling. Describe the methods and results of shadow-angle analysis or computer modeling used to identify rockfall runout-zone boundaries, including a description and listing of the input parameters and how they were obtained.
5. Rockfall Pathway Analysis. Describe gullies, previously fallen rockfall debris, and other geomorphic or topographic features in the rockfall acceleration and runout zones that may affect the rockfall path. Note that when struck by rapidly moving rockfall debris, previously fallen boulders often shatter in whole or part and contribute material (including flyrock) to the rockfall rather than effectively shielding the site from hazard (Knudsen, 2011; Lund and others, 2014).
6. Other Investigation Methods. When special conditions or requirements for critical facilities demand a more intensive investigation, describe the methods used to supplement the rockfall investigation and the purpose/result of those methods. These may include, but are not limited to (a) aerial reconnaissance, (b) drilling and rock core analysis, (c) geophysical investigations, (d) slope and groundwater instrumentation and monitoring, and (e) geochronology.

B. Conclusions.

- a. Conclusions must be supported by adequate data, and the report should present those data in a clear and concise manner.
- b. Data provided should include evidence establishing the presence or absence of a rockfall hazard on or adjacent to the site and relation to existing or proposed infrastructure.
- c. Statement of relative risk that addresses the relative potential for future rockfalls. This may be stated in semi-quantitative terms such as low, moderate, or high as defined within the report, or as a probability if combined with information on the number and timing of past rockfalls.
- d. Degree of confidence in, and limitations of, the data and conclusions.

C. Recommendations.

- a. Recommendations must be supported by the report conclusions and be presented in a clear and concise manner.
- b. Rockfall runout-zone boundaries and additional setbacks should include the justification for the setback distance chosen based on shadow angle and/or rockfall computer modeling, and include an appropriate statement or measure of boundary confidence/uncertainty.
- c. Other recommended mitigation methods such as building/structure design or use restrictions, risk-reduction measures such as placement of detached garages or other non-habitable structures in rockfall zones, or engineering-design methods in the rockfall source area or runout zone to mitigate rockfall risk.
- d. Recommendations for long-term monitoring if necessary.
- e. Limitations on the investigation and recommendations for additional investigation to better understand or quantify the hazard.

D. References

- a. Literature and records cited or reviewed; citations should be complete (see References section of this publication for examples).
- b. Remote-sensing images interpreted; list type, date, project identification codes, scale, source, and index numbers.
- c. Other sources of information, including well records, personal communication, and other data sources.

E. Illustrations. Should include at a minimum:

- a. Location map. Showing the site and significant physiographic and cultural features, generally at 1:24,000 scale or larger and indicating the Public Land Survey System $\frac{1}{4}$ -section, township, and range; and the site latitude and longitude to four decimal places with datum.
- b. Site development map. Showing site boundaries, existing and proposed structures, other infrastructure, and site topography. The map scale may vary depending on the size of the site and area covered by the study; the minimum recommended scale is 1 inch = 200 feet (1:2400) or larger when necessary. The site development map may be combined with the site-specific geology map (see item “c” below).
- c. Site-specific geology map. A site-scale geology map showing (1) geologic units, (2) bedding, faults, joints, other discontinuities, and relevant geologic structures, (3) distribution of bedrock and unconsolidated-deposit rockfall sources, (4) rockfall pathways and runout zones, (5) seeps or springs, (6) other slope failures, and (7) bore-

holes, geophysical transects, scanline transects, and slope and groundwater-monitoring locations. Scale of site-specific geology maps will vary depending on the size of the site and area of study; minimum recommended scale is 1 inch = 200 feet (1:2400) or larger when necessary.

- d. Geologic/topographic cross sections. Site geologic cross sections should be included as needed to illustrate three-dimensional geologic relations.
- e. Rockfall hazard map. If site-specific investigations reveal the presence of a rockfall hazard, rockfall runout zones and appropriate additional recommended setbacks based on shadow angle and/or rockfall computer modeling should be shown either on a rockfall-hazard map, or on the site-specific geology map depending on site scale and complexity.
- f. Borehole logs. Borehole logs should include the geologic interpretation of deposit genesis for all layers encountered; logs should not be generalized or diagrammatic. Because boreholes are typically multipurpose, borehole logs may also contain standard geotechnical, geologic, and groundwater data.
- g. Geophysical data and interpretations.
- h. Photographs that enhance understanding of the rockfall hazard at the site with applicable metadata; photographs of rock core if acquired during drilling.

F. Authentication

- a. The report must be signed and stamped by a Utah licensed Professional Geologist in principal charge of the investigation (Title 58-76-10 – Professional Geologists Licensing Act [Utah Code, 2011]). Final geologic maps, trench logs, cross sections, sketches, drawings, and plans, prepared by or under the supervision of a professional geologist, also must bear the stamp of the professional geologist (Utah Code, 2011). Reports co-prepared by a Utah licensed Professional Engineer and/or Utah licensed Professional Land Surveyor must include the engineer's or surveyor's stamp and signature.

G. Appendices

- a. Include supporting data relevant to the investigation not given in the text such as maps, boring logs, cross sections, conceptual models, fence diagrams, survey data, water-well data, geochronology laboratory reports, laboratory test data, and qualifications statements/resume.

FIELD REVIEW

The UGS recommends a technical field review by the regulatory-authority geologist once a rockfall-hazard investigation is complete. See Field Review section in chapter 2.

REPORT REVIEW

The UGS recommends regulatory review of all reports by a Utah licensed Professional Geologist experienced in rockfall-hazard investigations and acting on behalf of local governments to protect public health, safety, and welfare, and to reduce risks to future property owners (Larson, 1992, 2015). See Report Review section in chapter 2.

DISCLOSURE

The UGS recommends disclosure during real-estate transactions whenever an engineering-geology investigation has been performed. See Disclosure section in chapter 2.

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CHAPTER 8

GUIDELINES FOR EVALUATION OF GEOLOGIC RADON HAZARD IN UTAH

by

by William R. Lund, P.G., Jessica J. Castleton, P.G., and Steve D. Bowman, Ph.D., P.E., P.G.



Farmington Canyon Complex bedrock, shown here along the Wasatch Range, is a uranium-bearing geologic unit that can significantly contribute to a high radon gas hazard.

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CHAPTER 8: GUIDELINES FOR EVALUATION OF GEOLOGIC RADON HAZARD IN UTAH

by William R. Lund, P.G., Jessica J. Castleton, P.G., and Steve D. Bowman, Ph.D., P.E., P.G.

INTRODUCTION

Radon is a radioactive gas that emanates from uranium-bearing rock and soil and may concentrate in enclosed spaces like underground mines or buildings. Radon is a major contributor to the ionizing radiation dose received by the general population and is the second leading cause of lung cancer after smoking (World Health Organization [WHO], 2009). Lung cancer risk increases proportionally with increasing radon exposure. However, most radon-induced lung cancers are caused by low and moderate radon concentrations, rather than by high radon concentrations, because fewer people are exposed to high indoor radon concentrations (WHO, 2009).

Between 1973 and 2016, an estimated 5639 fatalities in Utah are attributable to lung cancer caused by radon gas (WHO, 2009; Utah Environmental Public Health Tracking Network, 2019 [table 17]). Thousands of additional fatalities before 1973 undoubtedly occurred, making radon-induced lung cancer Utah’s historically deadliest geologic hazard. Uncertainty in radon occurrence and abundance cannot be reduced; therefore, predicting exactly when and where radon will be present in a potentially hazardous concentration is not possible. For that reason, developing property on or near radon-susceptible areas will always involve a level of irreducible, inherent risk.

Evaluation of geologic radon hazard can be done predevelopment and post-development. Incorporating radon-control

measures in new construction is less costly and more effective than installing post-construction, radon-mitigation systems in buildings that develop dangerous levels of indoor radon (U.S. Environmental Protection Agency [EPA], 2001, 2003; WHO, 2009; Kansas State University, undated). A site-specific, predevelopment, radon-hazard investigation uses local geology and radon test data, where available, as a scientific basis to determine if uranium-bearing bedrock and/or unconsolidated deposits (radon source; also imported fill or mine waste in some instances) are present at a site. If a radon source is present, a potential exists for structures built on the site to develop dangerous levels of indoor radon (radon hazard).

Although the influence of site geology on radon hazard is significant (source and pathways for radon movement), the influence of non-geologic factors, such as occupant lifestyle, building design and construction, building maintenance, season, and weather are also important, and can cause indoor radon levels to fluctuate greatly over a period of hours to months in structures built on the same geologic unit. Indoor radon measurements have shown that some buildings constructed on uranium-bearing geologic units can have low indoor radon levels, while other buildings constructed on uranium-poor geologic units can have high indoor radon levels (Otton, 1992; Solomon and others, 1993; EPA, 2017). Varley and Flowers (1998) found only a very weak correlation between the overall radon concentration in soil gas and indoor radon levels. Therefore, site geology alone is not a direct predictor of future indoor radon levels or individual ra-

Table 17. Estimated fatalities from radon gas in Utah from 1973 to 2016.

Year		Fatalities ¹
1973–2001	Estimated lung cancer deaths from radon gas.	1460 ²
2002–2011		3816 ³
2012		98 ²
2013		87 ²
2014		87 ²
2016		91 ²
Total		5639

¹ Limited data are available and contain various assumptions; exact number of fatalities is unknown.
² Based on World Health Organization general estimate that 14% of lung cancer cases are attributable to radon gas, <https://epht.health.utah.gov/>.
³ Utah Department of Health, Utah Environmental Public Health Tracking Network, 2019, <https://epht.health.utah.gov/>.

don exposure (Utah Department of Health, 2015). However, Varley and Flowers (1998) did observe a stronger correlation with indoor radon levels at sites having high radon soil gas concentrations, indicating that site geology is a useful general predictor of future radon hazard.

These guidelines outline (1) appropriate investigation methods, (2) report content, (3) map and illustration criteria and scales, (4) mitigation recommendations, (5) minimum criteria for review of reports, and (6) recommendations for geologic-hazard disclosure. However, these guidelines do not include systematic descriptions of all available investigative techniques or topics, nor does the Utah Geological Survey (UGS) suggest that all techniques or topics are appropriate for every radon-hazard investigation.

Given the complexity of evaluating radon hazard prior to site development, additional effort beyond the minimum criteria recommended in these guidelines may be required to adequately assess the potential hazard. The information presented in these guidelines does not relieve Engineering Geologists of the duty to perform additional geologic investigations as necessary to fully assess radon hazard. As required by Utah state law (Title 58, Chapter 76), site-specific, geologic radon-hazard-investigation reports and supporting documents must be signed and stamped by the licensed Utah Professional Geologist in responsible charge of the investigation.

Purpose

These guidelines present the minimum recommended standard of practice for Engineering Geologists conducting site-specific, predevelopment, radon-hazard investigations to determine if uranium-bearing bedrock or unconsolidated deposits capable of generating radon are present at a site. The guidelines are intended for new structures for human occupancy and for International Building Code (IBC) Risk Category II, III, and IV facilities (International Code Council [ICC], 2017a, 2017b).

These guidelines provide appropriate, minimum predevelopment investigation and report criteria to:

- protect the health, safety, and welfare of the public by minimizing the adverse health effects of radon;
- assist local governments in regulating land use in potential radon-hazard areas and provide standards for ordinances;
- assist Engineering Geologists in conducting reasonable and adequate radon-hazard investigations;
- provide Engineering Geologists with a common basis for preparing proposals, conducting investigations, and recommending radon-mitigation strategies; and
- provide an objective framework for preparation and review of radon-hazard reports.

These guidelines are not intended to supersede pre-existing state or federal regulations or local geologic hazard ordinances but provide useful information to supplement adopted ordinances/regulations and assist in preparation of new ordinances. The UGS recommends that adhering to these guidelines will help ensure adequate, cost-effective investigations and minimize report review time.

Background

Radon is an odorless, tasteless, colorless radioactive gas that is naturally occurring and results from the radioactive decay of uranium, which is found in small concentrations in nearly all soil and rock. Radon has been classified as a known human carcinogen and has been recognized as a significant health problem by groups such as the U.S. Centers for Disease Control, the American Lung Association, the American Medical Association, and the American Public Health Association (EPA, 2003). The EPA (2017) estimated that radon is responsible for about 21,000 lung cancer deaths every year in the United States (U.S.). About 2900 of these deaths (14.5%) occur among people who have never smoked. Cao and others (2017) revised the EPA estimate to 15,600–19,300 radon-induced lung cancer deaths annually in the U.S, based on data from underground miners also exposed to diesel engine exhaust.

Since even a single alpha particle can cause major genetic damage to a cell, radon-related DNA damage can occur at any level of radon exposure. Therefore, there is no threshold concentration below which radon does not have the potential to cause lung cancer (WHO, 2009). Current estimates of the proportion of lung cancers attributable to radon range from 3% to 14%, depending on the average radon concentration in the country concerned and the calculation methods; the analyses indicate that the lung cancer risk increases proportionally with increasing radon exposure (WHO, 2009; Kim and others, 2016). Radon is much more likely to cause lung cancer in people who smoke, or who have smoked in the past, than in lifelong non-smokers; however, radon is the primary cause of lung cancer among people who have never smoked.

Although outdoor radon concentrations rarely reach dangerous levels because air movement and open space dissipate the gas, radon is highly mobile and can enter buildings through foundation cracks and other openings such as around utility pipes. Indoor radon concentrations may reach hazardous levels. The EPA (2017) recommends that action be taken to reduce indoor radon levels that are ≥ 4 picocuries per liter (pCi/L), and cautions that indoor radon levels < 4 pCi/L may still pose a risk of lung cancer. However, WHO (2009) recommends that action be taken at levels ≥ 100 Becquerel per meter (Bq/m^3 ; ≥ 2.7 pCi/L), based on 13 European case-controlled studies of $> 14,000$ participants that showed a very significant 8% and 16% increase in lung cancer per 2.7 pCi/L radon concentration increase, based on measured

and long-term average radon concentrations, respectively. In addition, WHO (2009) analysis of seven North American and two Chinese case-controlled studies, found an 11% and 13% increase in lung cancer per 2.7 pCi/L radon concentration increase, based on measured radon concentrations, respectively. Based on these 22 case-controlled studies of 21,169 participants, the WHO found a 10% weighted average increase in lung cancer per 2.7 pCi/L radon concentration increase, based on measured radon concentrations. The WHO also estimated a 20% increase in lung cancer per 2.7 pCi/L radon concentration increase, based on long-term average radon concentrations, as long-term data were not available for the North American or Chinese studies. As there is no known threshold concentration below which radon exposure presents no risk (WHO, 2009), radon mitigation should be seriously considered whenever radon is detected or where there is a potential geologic source of radon. As a result, the UGS strongly recommends that radon mitigation be performed where indoor radon levels are ≥ 2.7 pCi/L.

Geology of Radon

Radon gas is by far the most important natural source of ionizing radiation. Radon (^{222}Rn) is a noble gas formed from radium (^{226}Ra), which is a decay product of uranium (^{238}U) (Sprinkel and Solomon, 1990; Otton, 1992; WHO, 2009). Radon gas, which has a half-life of 3.8 days, emanates from uranium-bearing bedrock and soils. Therefore, it is possible to estimate the potential for elevated indoor radon levels based on the uranium content of the geologic deposits at a site (EPA, 2017). Most soil and rock contain small amounts of uranium (1–3 ppm [parts per million]). Granitic rocks, metamorphic rocks, some light-colored volcanic rocks, black shale, and soils derived from those rock types are often associated with elevated uranium content (as much as 100 ppm; Otton, 1992). The higher the uranium content, the greater the probability that buildings built on a site will develop elevated indoor radon levels.

The permeability of site geologic units and the presence of groundwater affect the mobility of radon from its source (Otton, 1992). If a radon source is present, the ability of radon to move upward into structures is facilitated by high-permeability soils (those composed primarily of sand, gravel, cobbles, and boulders). Conversely, radon movement is impaired where permeability is low (silt, clay). However, if the less-permeable deposits (silt, clay) are themselves derived from uranium-bearing bedrock, those deposits effectively are a radon source. In bedrock, faults, joints, and fractures, along with the rock's primary porosity and permeability, influence the rate of radon migration. If the source of radon is below the groundwater table and the overlying sediment is not derived from a uranium-bearing bedrock unit, saturation of soil by groundwater may inhibit radon gas movement by dissolving radon in the water, reducing its ability to migrate upward through the soil. However, in areas where groundwater is used as a source of culinary water, radon may en-

ter a building through its water system (Otton, 1992). Short transit times from source to user may not permit radon in groundwater to dissipate before entering a building, allowing radon to escape into indoor air as people take showers, wash dishes and clothes, or otherwise use water. Areas most likely to have high levels of radon in groundwater are typically areas that have high uranium concentrations in underlying geologic units (Otton, 1992). In Utah, groundwater has not been observed to inhibit the movement of radon gas because the source of the radon gas is typically not below the groundwater table but within or above it (Castleton and others, 2018b).

SOURCES OF UTAH RADON INFORMATION

The broad-based EPA interactive Radon Zone Map (<https://www.epa.gov/radon/find-information-about-local-radon-zones-and-state-contact-information>) identifies seven Utah counties (Carbon, Duchesne, Grand, Piute, Sanpete, Sevier, and Uintah) as Radon Zone 1—counties with predicted average indoor radon screening levels >4 pCi/L. All remaining Utah counties are identified as Radon Zone 2—counties with predicted average indoor radon screening levels from 2 to 4 pCi/L. No Utah counties are in Radon Zone 3—counties with predicted average indoor screening levels <2 pCi/L. The explanation accompanying the EPA Radon Zone Map states:

The purpose of this map is to assist national, state and local organizations to target their resources and to implement radon-resistant building codes. This map is not intended to be used to determine if a home in a given zone should be tested for radon. Homes with elevated levels of radon have been found in all three zones. All homes should be tested regardless of geographic location. EPA recommends that this map be supplemented with any available local data in order to further understand and predict the radon potential for a specific area.

Radon mapping is completed at a regional scale, and it is possible that radon hazard can be significantly higher or lower when examined at a local scale, as is evident by indoor radon testing in existing structures. Local radon data for Utah are available from two principal sources, the Utah Department of Environmental Quality Radon Program (DEQ-RP) (<https://deq.utah.gov/ProgramsServices/programs/radiation/radon/>) and the Utah Geological Survey (<https://geology.utah.gov/>).

Utah Department of Environmental Quality Radon Program

The DEQ-RP website reports short-term, indoor radon test results by county and ZIP code. The test results are binned

into ranges and the results are totaled for each bin; the total number of tests and maximum and average test values are reported by ZIP code and for the county (e.g., table 18). Individual test results at specific locations are not reported, and not all ZIP codes have test result information. Average completed radon test levels (measured in pCi/L) and percent of completed radon tests >4.0 pCi/L are available from the Utah Environmental Public Health Tracking website (<https://epht.health.utah.gov/epht-view/query/selection/radon/RadonSelection.html>). Access to more detailed data than provided on the websites requires Institutional Review Board certification from the DEQ. In addition, the DEQ-RP

website includes numerous links to general information on the geology, chemistry, health effects, and mitigation of radon hazard.

Utah Geological Survey

The UGS began investigating radon hazard in the late 1980s, and prepared a generalized, statewide map of potential radon-hazard areas, based chiefly on the location of uranium-bearing bedrock (Sprinkel, 1987). The DEQ-RP surveyed indoor radon levels in several potential radon-hazard areas identified on the map (Sprinkel and Solomon, 1990; Solo-

Table 18. Example of short-term radon test results reported by county and ZIP code from the DEQ-RP website.

UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY							
Division of Radiation Control							
Short Term Radon Test Results by County and ZIP Code as of March 2018							
BEAVER COUNTY							
ZIP Code	<4 pCi/L	4–10 pCi/L	10–20 pCi/L	>20 pCi/L	Maximum	Average	Total Tests
84713	92	57	46	178	664.0	44.3	373
84731	2	0	0	0	2.9	2.6	2
84751	11	3	2	0	13.1	3.7	16
84752	3	7	3	2	25.9	9.4	15
Beaver	108	67	51	180	664.0	41.2	406

Table 19. Utah Geological Survey radon-hazard-potential investigations conducted in Utah through 2018.

Location	Reference ^{1,2}
Radon-hazard potential in the Sandy-Draper area, Salt Lake County, Utah	Solomon (1993a)
Radon-hazard potential in the Provo-Orem area, Utah County, Utah	Solomon (1993b)
Radon-hazard-potential areas in Sandy, Salt Lake County, and Provo, Utah County, Utah	Solomon and others (1994)
Radon-hazard potential of the southern St. George basin, Washington County, and Ogden Valley, Weber County, Utah	Solomon (1995)
Radon-hazard potential of western Salt Lake Valley, Salt Lake County, Utah ³	Black (1996a)
Radon-hazard potential in western Salt Lake Valley, Salt Lake County, Utah ³	Black (1996b)
Radon-hazard potential in Tooele Valley, Tooele County, Utah	Black (1996c)
Radon-hazard potential in the lower Weber River area, Weber and Davis Counties, Utah	Black (1996d)
Radon-hazard potential of the lower Weber River area, Tooele Valley, and southeastern Cache Valley, Cache, Davis, Tooele, and Weber Counties, Utah	Black and Solomon (1996)
Radon-hazard potential in the St. George area, Washington County, Utah	Solomon (1996a)
Radon-hazard potential of the central Sevier Valley, Sevier County, Utah ³	Solomon (1996b)
Radon-hazard potential in central Sevier Valley, Sevier County, Utah ³	Solomon (1996c)
Radon-hazard potential in Ogden Valley, Weber County, Utah	Solomon (1996d)
Radon-hazard potential in southeastern Cache Valley, Cache County, Utah	Solomon and Black (1996)
Radon-hazard potential of Beaver basin area, Beaver County, Utah	Bishop (1998)
Geologic hazards of the Magna quadrangle, Salt Lake County, Utah	Castleton and others (2011)
Geologic hazards of the Copperton quadrangle, Salt Lake County, Utah	Castleton and others (2014)
Geologic hazards of the Moab quadrangle, Grand County, Utah	Castleton and others (2018b)
Geologic radon hazard susceptibility map of eastern Davis County, Utah	Castleton and others (2018a)

¹Radon-hazard investigations are listed chronologically.

²Available digitally by county at <https://geology.utah.gov/map-pub/maps/geologic-hazard-maps/>.

³For some study areas, the UGS released both a detailed investigation (Special Study) and summary pamphlet (Public Information Series) reporting radon hazard for the same area and with the same title.

mon and others, 1993a, 1993b). Clusters of indoor radon levels >4 pCi/L were identified, and the UGS and DEQ-RP subsequently conducted detailed geologic field investigations and indoor radon surveys in those areas. Results of the UGS investigations (table 19) include maps of relative radon hazard. Black (1993) prepared a revised statewide radon-hazard map that includes both bedrock and unconsolidated geologic units associated with elevated radon levels. Most recently, the UGS has produced 7.5-minute quadrangle radon-hazard maps, either as part of comprehensive geologic-hazard map sets (Castleton and others, 2011, 2014, 2018a), or at the request of county health departments (Castleton and others, 2018b).

Currently available UGS radon-hazard investigations and maps (table 19) include many of the most populous areas of Utah. Site-specific, predevelopment, radon-hazard investigations in a location that has an available UGS radon-hazard investigation and map can use those data to help determine appropriate mitigation measures. However, the investigations and maps do not include all potential radon-hazard areas in Utah. Site-specific, predevelopment, radon-hazard investigations are necessary where radon-hazard mapping is not available to determine if geologic, soils, and hydrologic conditions are conducive to producing a radon hazard.

RADON-HAZARD INVESTIGATION

When to Perform a Radon-Hazard Investigation

Geologic hazards are best addressed prior to land development. The UGS recommends that in areas previously mapped by the UGS as having moderate to high radon-hazard, a radon-control system be installed in all new structures for human occupancy and in IBC Risk Category II, III, and IV facilities (ICC, 2018a), and that installation of a radon-control system be seriously considered in low hazard areas (see comments above about no safe lower limit of radon exposure for lung cancer).

For new construction in areas lacking UGS radon-hazard maps, the UGS recommends that a site-specific, predevelopment, geologic investigation be performed to determine if a radon source is present at a site. If a radon source is present, a potential exists for elevated indoor radon levels (radon hazard) and the UGS recommends that a radon-control system be installed in all new structures for human occupancy and in IBC Risk Category II, III, and IV facilities (ICC, 2017a). The level of investigation conducted at a site depends on several factors, including (1) site-specific geologic/hydrologic conditions, (2) type of proposed development, and (3) governmental permitting requirements, or regulatory agency rules and regulations. An investigation to determine if a radon source is present at a site may be conducted separately or as part of a comprehensive geologic-hazard and/or geotechnical site investigation (see Chapter 2).

Minimum Qualifications of Investigator

Geologic investigations to evaluate radon hazard performed before the public in Utah shall be conducted by or under the direct supervision of a Utah licensed Professional Geologist (Utah Code: Title 58, Chapter 76) familiar with the geology of radon, and who must sign and seal the final report. Often radon-hazard investigations are interdisciplinary in nature, and where required, must include a licensed Professional Engineer working as a team with a Professional Geologist. See Investigator Qualifications section in Chapter 2.

Although radon technicians are not licensed by the State of Utah, DEQ-RP maintains a list of radon measurers in Utah certified by the American Association of Radon Scientists and Technologists through their National Radon Proficiency Program (<http://aarst-nrpp.com/wp/database-search/>).

The report prepared for a site-specific, predevelopment, geologic investigation to determine if a radon source is present at a site should, at a minimum, address the topics below. Site conditions or local regulations may require that additional items be included to fully evaluate potential radon sources; these guidelines do not relieve Engineering Geologists from their duty to perform additional geologic investigations as necessary to adequately assess radon hazard. The report guidelines below pertain to site-specific, predevelopment radon-hazard investigations, and expand on the general report preparation guidance provided in the Engineering-Geology Investigations and Engineering-Geology Reports sections of Chapter 2.

Site-Specific Radon Source Investigation

Investigation Purpose and Scope

The geologic hazard investigation required for a development depends on site geologic conditions and the specific purpose and use of the development. The purpose and scope of the investigation should be clearly outlined and include a description of the location, size, proposed type of development and number of buildings at the site as well as information on other infrastructure if known.

A predevelopment, site-specific, geologic field investigation can determine if potentially uranium-bearing bedrock (granitic and metamorphic rocks, black shale, light-colored volcanic rock, and some uranium bearing sedimentary rock units) or soils derived from them are present at a site. Three bedrock units of particular concern in Utah are the Moss Back Member of the Chinle Formation, the Salt Wash Member of the Morrison Formation, and the Manning Canyon Formation. These rock units are known to possess locally high levels of uranium. Other geologic units may possess high levels of uranium and should be investigated as necessary as possible radon gas sources.

Literature Review

Review published and available unpublished geology, soils, and hydrology literature and maps; consultant's reports; and DEQ-RP radon test data relevant to the site and site vicinity. Particular emphasis should be placed on determining if uranium-bearing geologic units are present on site (surface and subsurface) or in the near site vicinity, and if radon has been detected in groundwater. The Sources of Utah Radon Information section provides information on radon in general and radon occurrence in Utah; however, the list of sources is not exhaustive, and Engineering Geologists should identify and review all available information relevant to their site of interest.

Analysis of Aerial Photographs and Remote-Sensing Data

Unlike many geologic hazards, radon does not produce a geomorphic signature at the ground surface. However, interpretation of stereoscopic aerial photographs (from multiple years if available), lidar imagery (appendix C), and other remotely sensed data may help identify geologic units of known or suspected elevated uranium content; transport of possible uranium-bearing material to the site by debris-flow, flood, or other process; evidence of shallow groundwater (ponds, marshes, phreatic vegetation); and low-permeability soil. Examination of the oldest available aerial photographs may show evidence of site conditions prior to development or other ground disturbance. The interpreted area should extend sufficiently beyond the site boundaries to identify evidence of geologic, soil, and hydrologic conditions that might affect radon levels at the site.

Regional Geology and Geologic Maps

Geologic mapping should be performed regionally to determine offsite radon sources that may contribute to local geology. Mapping should be performed on a suitable topographic base map at an appropriate scale and accuracy applicable to the project. The type, date, and source of the base map should be indicated on each map. The base map should also include locations of proposed structures, pavements, and utilities.

Site Specific Geology and Geologic Maps

Site geologic mapping should be performed in sufficient detail to define the geologic conditions present at and adjacent to the site. For most purposes, published geologic maps lack the necessary detail to provide a basis for understanding site-specific geologic conditions, and new, smaller scale, independent geologic mapping is required. If suitable geologic maps are available, they must be updated to reflect topographic and geologic changes that have occurred since map publication. Extending mapping into adjacent areas will likely be necessary to define geologic conditions impacting the project area. Often, geologic mapping will be more useful to the project if performed with the intent of creating an engineering-geologic map that specifically focuses on site geologic conditions and geologic hazards as they affect the proposed development.

Subsurface Investigation

Buried uranium-bearing bedrock and soils that contribute to the development of radon gas at the surface must be identified. A subsurface investigation can be conducted by excavating test pits or trenches, and, where necessary, by drilling boreholes to an appropriate depth. Geologic cross sections utilizing the most up-to-date geologic mapping may also help identify buried sources of radon.

Each test pit, trench, or borehole excavated for the investigation should be logged. Logs should show details of geologic units and structures. Logs should be to scale and not generalized or diagrammatic and may be on a rectified photomosaic base. The scale (horizontal and vertical) should be 1 inch = 5 feet (1:60) or larger as necessary with no vertical exaggeration. Logs should be prepared in the field and accurately reflect the geologic materials and features observed in the excavation. Borehole logs should include identification of subsurface geologic units and processes. Photographs are not a substitute for trench logs, although photomosaic bases can be used and are often good for documenting the conditions. All logs should include the identity of the person who made the log.

Visual Examination of Site Geologic Material

Visual examination (including a binocular microscope) of bedrock or rock clasts in soils in natural exposures, or in the walls of test pits or trenches, is often sufficient to show whether potentially uranium-bearing geologic materials are present at a site. Where natural exposures are lacking and test pits and trenches are not practical, it may be necessary to drill test boreholes to sample subsurface deposits to evaluate the presence of uranium-bearing material.

National Uranium Resource Evaluation Hydrogeochemical and Stream Sediment

The National Uranium Resource Evaluation Program (NURE) was initiated by the Atomic Energy Commission (now the U.S. Department of Energy) in 1973 with the goal of identifying uranium resources in the United States. The Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) component of the program began in 1975 with the goal of systematically sampling stream sediments, soils, groundwater, and surface water over the entire United States. The NURE HSSR program ended prematurely in 1980. Of the 625 2-degree quadrangles that cover the lower 48 states and Alaska, only 307 quadrangles were completely sampled, and another 86 quadrangles were partially sampled. In Utah, NURE HSSR coverage is available for most areas in Utah, except for some areas along the Wasatch Front, the valleys of the Wasatch Back, and the Uinta Mountains (figure 52).

In 1985, the NURE HSSR data became the responsibility of the USGS. The data are contained in two major geographic information system (GIS) database files: one for water samples and one for stream sediment, soil, and bedrock samples.



Figure 52. National Uranium Resource Evaluation (NURE) HSSR data collection points in Utah and the surrounding area (USGS, 2004).

NURE HSSR data include sample locations and test results. Where available, investigators can use NURE HSSR data to identify the uranium content of sediment, soils, and bedrock at or near a site of interest. Uranium content is reported in parts per million (ppm) (USGS, 2004); a value <1.5 ppm is considered low hazard potential, 1.5–2.5 ppm moderate hazard potential, and >2.5 ppm high hazard potential (USGS, 1993). The USGS (1993) established the value for indicating uranium content as the eU field; however, the NURE program reformatted the data for digital release and to include more chemical constituents (Smith, 2006). The U_DN_PPM field in the GIS data is used to indicate the concentration of uranium in sediment as ppm determined by delayed neutron counting. This field can be used to determine the relative hazard contributed by uranium to indoor radon hazard. The NURE GIS data and metadata can be accessed on the USGS website at <https://mrdata.usgs.gov/nure/sediment/>. Geologic units in which NURE data points exist can be applied to unconsolidated material derived from the same geologic unit in locations other than the site and interpreted to represent the uranium content of sediment, soils, and bedrock at the site if the material is determined to be geologically similar.

Radon Soil Gas Testing

Varley and Flowers (1998) discovered only a limited correlation between soil gas test results and levels of indoor radon in the United Kingdom. The EPA does not recommend radon

soil gas testing to determine if a structure should include a radon-control system (EPA, 2001). The EPA's objection to radon soil gas testing is based on the generally poor correlation of test results with indoor radon levels. Conversely, the Czech Republic has adopted a national radon-hazard investigation protocol (Neznal and others, 2004) that relies heavily on soil gas and soil permeability measurements to determine if installation of radon-control systems is warranted in new construction. The Czech protocol calls for a minimum of 15 soil gas and 15 soil permeability tests per average Czech single-family home building site (80 m [262 ft] x 80 m [262 ft]).

Although radon soil gas measurements are not a direct predictor of indoor radon levels (Varley and Flowers, 1998), radon soil gas measurements can confirm if a radon source is present at a site. If radon soil gas is detected, even at low levels (<2.7 pCi/L), a potential exists for elevated radon levels in structures built on the site. The UGS recommends that radon soil gas measurements be made at sites where potentially uranium-bearing geologic units may be present if other methods to determine the presence of uranium-bearing material are unsuccessful or inadequate. Radon soil gas measurements may be particularly useful in identifying a radon source at sites underlain by fine-grained soils where visual examination of potentially uranium-bearing material is not possible. The type, number, and distribution of radon soil gas measurements made for a site-specific radon-hazard investigation will depend on the geologic characteristics (type and distribution of potentially uranium-bearing geologic deposits) of the site being investigated.

A detailed discussion of the methods and protocols for sampling radon soil gas is beyond the scope of these guidelines. The reader is referred to Papastefanou (2007) and Baskaran (2016) for summaries of the most commonly employed techniques for measuring radon soil gas.

Conclusions

The radon evaluation report should include a comprehensive analysis of geologic conditions at and adjacent to the site, and a determination of whether material may have been transported from another location. The report should, if necessary, include a subsurface investigation conducted by geologic logging of test pits, trenches, or boreholes, and preparation of a geologic cross section(s). All material present at the site should be evaluated for its potential as a source of radon gas. A hazard statement should be included if radon gas may potentially affect structures. If surficial or subsurface uranium-bearing bedrock or soil is determined to be at the site, the UGS recommends installation of passive radon mitigation systems. The degree of confidence in and limitations of the data and conclusions must be clearly stated in the report.

If the investigation reveals the presence of uranium-bearing material and engineering-design mitigation of the radon hazard is proposed, the recommendation must be based on ad-

equate data used to characterize the hazard. The UGS highly recommends a radon-control system be installed for new construction if the site is in an area mapped as moderate or high indoor radon hazard potential and that installation of a radon-control system be seriously considered in low hazard areas, or where a site-specific investigation identified uranium-bearing material at the site that could contribute to a source of radon gas. Passive radon-control systems are commonly used in new construction (EPA, 1995), as they can be easily installed during site grading and foundation preparation construction activities. Active radon-control systems are commonly used in existing construction, as passive systems may be difficult and expensive to install in existing buildings and their performance is generally poor in these conditions.

RADON CONTROL

The World Health Organization (2009) states: “Installing radon prevention measures in new structures for human occupancy is generally the most cost effective and efficient way to limit radon exposure in individual households. Over time, this approach will lead to a greater reduction in the total number of lung cancers attributed to radon exposure than the alternative method of only reducing radon in existing buildings that exceed the radon action level.”

Therefore, the UGS recommends that a radon-control system be incorporated in all new construction intended for human occupancy and for IBC Risk Category II, III, and IV facilities (ICC, 2018a) in areas mapped by the UGS as having moderate or high radon hazard, or in areas lacking radon-hazard maps, where a site-specific, predevelopment, geologic investigation determined that a radon source is present at a site. In areas mapped by the UGS as having a low radon hazard, the UGS recommends that consideration be given to incorporating a radon-control system in all new construction as above.

Appendix F of the ICC’s 2018 International Residential Code (ICC, 2018b) addresses radon-resistant new construction techniques. While not currently adopted by Utah Code, adopting Appendix F would significantly help reduce the hazard and risk from radon gas, Utah’s most deadly geologic hazard, by sealing foundations and venting the building foundation subgrade soils, allowing the upward-flowing radon gas to be dissipated into the air above the building. Typical costs for adopting radon-resistant construction measures are around \$500 for a new residential home. Active radon mitigation systems installed in existing structures typically range from \$1,200 to \$1,700.

EPA Publication EPA/402-K-01-002 (2001), *Building Radon Out – A Step by Step Guide on How to Build Radon Resistant Homes*, provides specific guidance on how to incorporate radon-prevention systems in new construction. EPA Publication EPA 402-95-012 (1995), *Passive Radon Control System for*

New Construction, provides architectural drawings (CAD format) intended for architects, home builders, designers, radon mitigators, and others interested in the installation of passive radon-control systems in one and two-family dwellings.

FIELD REVIEW

The UGS recommends a technical field review once a radon-hazard investigation is complete. The field review should take place after any test pits, trenches, and boreholes are logged, but before they are closed so subsurface site conditions can be directly observed and evaluated. See Field Review section in Chapter 2.

REPORT REVIEW

The UGS recommends regulatory review of all reports by a Utah licensed Professional Geologist experienced in radon-hazard investigations and acting on behalf of local governments to protect public health, safety, and welfare, and to reduce risks to future property owners (Larson, 1992, 2015). See Report Review section in Chapter 2.

DISCLOSURE

The UGS recommends disclosure during real-estate transactions whenever an engineering-geology investigation has been performed. See Disclosure section in Chapter 2.

RADON-HAZARD INVESTIGATION REPORT OUTLINE

Radon-hazard reports prepared for investigations in Utah should, at a minimum, address the topics below. Individual site conditions may require that additional items be included. The report should be prepared, stamped, and signed by a Utah licensed Professional Geologist with experience conducting radon-hazard investigations. Reports co-prepared by a Utah licensed Professional Engineer should include the engineer’s stamp and signature. The report preparation guidelines below expand on the general guidance provided in chapter 2.

A. Text

1. Purpose and scope of investigation. Describe the location and size of the site and proposed type and number of buildings or other infrastructure if known.
2. Geologic and topographic setting. Describe the site and site vicinity geologic and topographic settings, and reference pertinent published and unpublished

geologic, soils, and hydrologic literature, particularly regarding uranium-bearing geologic units.

3. Site description and conditions. Describe site geologic units, soils, groundwater, topography, vegetation, existing structures, known instances of high indoor radon levels at or near the site, and other factors that may affect the choice of investigative methods and interpretation of data. Include dates of site visits and observations.
4. Methods and results of investigation.
 - a. Literature Review. Summarize published and unpublished geologic maps, literature, and records regarding geologic and soil units; surface water and groundwater; topographic and geomorphic features; outdoor and indoor radon test results at or near the site; and other relevant factors pertinent to the site.
 - b. Interpretation of Aerial Photographs and Remote-Sensing Imagery. Describe the results of remote-sensing-imagery interpretation (stereoscopic aerial photographs, lidar, or other remote-sensing data) conducted to identify geologic, soils, or hydrologic conditions that may contribute to a radon hazard at the site. List source, project, date, flight-line numbers, and scale of aerial photos or other imagery used.
 - c. Surface Investigations. Describe pertinent surface features including the extent and characteristics of bedrock units and soils, discontinuities (bedding, joints, faults, foliation, schistosity, etc.), and other structural or geomorphic features that may affect radon hazard at the site.
 - d. Subsurface Investigations. Describe natural exposures, test pits, trenches, or boreholes used to evaluate the presence of potentially uranium-bearing geologic units (granitic rock, metamorphic rock, light-colored volcanics, black shale, uranium-bearing sedimentary bedrock, and soils derived from them) on site. Show test-pit, trench, and borehole locations on the geologic map.
 - e. Visual Examination of Site Geologic Materials. Describe the method used to evaluate site bedrock and unconsolidated deposits for the presence of potentially uranium-bearing material, examination results, and interpretation.
 - f. Radon Soil Gas Testing. Describe the method and sampling protocol used to make radon soil gas measurements, present test results and interpretations. Show soil gas test locations on the geologic map.

- g. Other Investigation Methods. When special conditions or requirements for critical facilities demand a more intensive investigation, describe the methods used to supplement the radon-source investigation and the purpose/result of those methods. These may include, but are not limited to, enhanced soil gas monitoring, soil permeability tests, and long-term groundwater monitoring.

B. Conclusions

1. Conclusions must be supported by adequate data, and the report should present those data in a clear and concise manner.
2. Data provided should include evidence establishing the presence or absence of a potential radon source on site and of soil and groundwater characteristics that may enhance or inhibit the movement of radon gas into buildings.
3. Statement of risk that addresses the relative potential for a radon hazard. This may be stated in semi-quantitative terms such as low, moderate, or high as defined by the relative uranium-enrichment of geologic deposits on site, radon soil gas measurements, and other geologic, soil, and groundwater characteristics conducive to creating or limiting a radon hazard. The statement should note that even at low radon concentration levels, a significant risk of cancer exists, and that installation of a radon-control system should be seriously considered.
4. Degree of confidence in, and limitations of, the data and conclusions.

C. Recommendations

1. In areas mapped by the UGS as having moderate to high radon hazard (table 18), the UGS recommends that a radon-control system be installed in all new structures intended for human occupancy and in IBC Risk Category II, III, and IV facilities (ICC, 2018a). In low hazard areas, the UGS recommends that consideration be given to installing a radon-control system.
2. At sites lacking UGS radon-hazard mapping, and where a site-specific, predevelopment investigation determines that a radon source is present, the UGS recommends that a radon-control system be installed in all new construction intended for human occupancy and for IBC Risk Category II, III, and IV facilities (ICC, 2018a).

D. References

1. Literature and records cited or reviewed; citations should be complete (see References for examples).

2. Remote-sensing images interpreted; list type, date, project identification codes, scale, source, and index numbers.
3. Other sources of information, including well records, personal communication, and other data sources.

E. Illustrations. Should include at a minimum:

1. Location map. Showing the site and significant physiographic and cultural features, generally at 1:24,000 scale or smaller and indicating the site latitude and longitude to four decimal places minimum with datum.
2. Site development map. Showing site boundaries, existing and proposed structures, other infrastructure, and site topography. The map scale may vary depending on the size of the site and area covered by the study; the minimum recommended scale is 1 inch = 200 feet (1:2400) or larger when necessary. The site development map may be combined with the site-specific geology map (below).
3. Site-specific geology map. A site-scale geology map showing (1) distribution of bedrock and unconsolidated deposits, (2) bedding, faults, joints, other discontinuities, and relevant geologic structures, (3) seeps or springs, and (4) test pits, trenches, boreholes, soil-gas-test locations, and groundwater-monitoring locations. Scale of site-specific geology maps will vary depending on the size of the site and area of study; minimum recommended scale is 1 inch = 200 feet (1:2400) or larger when necessary.
4. Test-pit, trench, and borehole logs. Test-pit, trench, and borehole logs should include the geologic interpretation of deposit genesis for all layers encountered; logs should not be generalized or diagrammatic. Because boreholes are typically multipurpose, borehole logs may also contain standard geotechnical, geologic, and groundwater data.
5. Geophysical data and interpretations.
6. Photographs that enhance understanding of the radon hazard at the site with applicable metadata.

F. Authentication.

The report must be signed and stamped by a Utah licensed Professional Geologist in principal charge of the investigation (Title 58-76-10 – Professional Geologists Licensing Act [Utah Code, 2011]). Final geologic maps, test-pit, trench and borehole logs, cross sections, sketches, drawings, and plans, prepared by, or under the supervision of a professional geologist also must bear the stamp of the professional geologist (Utah Code, 2011). Reports co-prepared by a Utah

licensed Professional Engineer and/or Utah licensed Professional Land Surveyor must include the engineer's or surveyor's stamp and signature.

G. Appendices.

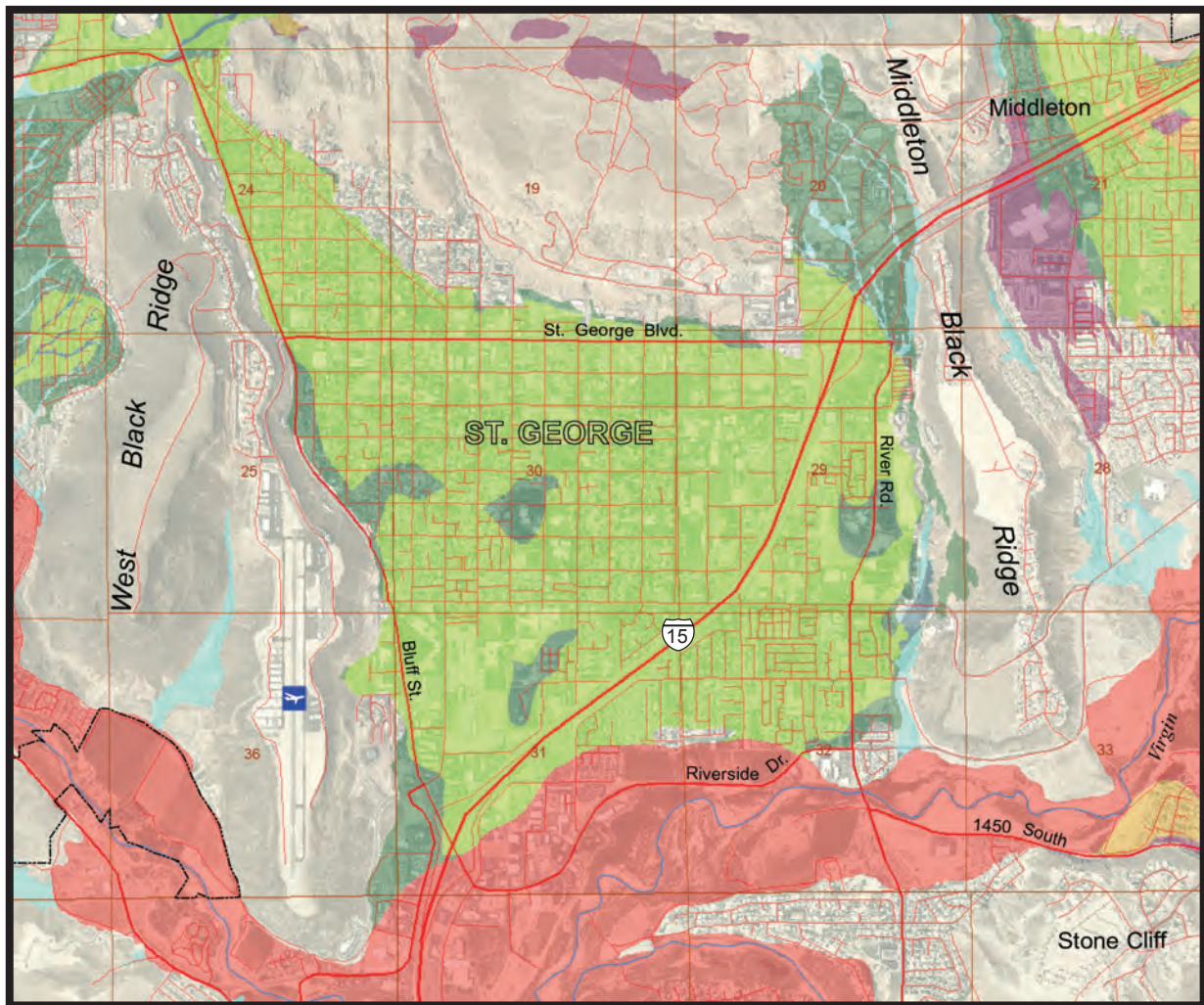
Include supporting data relevant to the investigation not given in the text such as maps, borehole logs, cross sections, conceptual models, fence diagrams, survey data, water-well data, and laboratory test data.

CHAPTER 9

SUGGESTED APPROACH TO GEOLOGIC-HAZARD ORDINANCES IN UTAH

by

William R. Lund, P.G., Steve D. Bowman, Ph.D., P.E., P.G., and Gary E. Christenson, P.G.



Shallow groundwater geologic-hazard special study map of part of St. George, Utah, from UGS Special Study 127.

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CHAPTER 9: SUGGESTED APPROACH TO GEOLOGIC-HAZARD ORDINANCES IN UTAH

by William R. Lund, P.G., Steve D. Bowman, Ph.D., P.E., P.G., and Gary E. Christenson, P.G.

INTRODUCTION

This chapter updates and revises Utah Geological and Mineral Survey Circular 79, *Suggested Approach to Geologic Hazards Ordinances in Utah* (Christenson, 1987), and is intended for municipal and county officials responsible for planning for and permitting future land development in their jurisdictions. While the 2018 International Building Code (IBC) and International Residential Code (IRC) are adopted statewide as part of the State Construction and Fire Codes Act (<https://le.utah.gov/xcode/Title15A/15A.html>), geologic hazards are typically not a part of these codes. A geologic-hazard ordinance protects the health, safety, and welfare of citizens by minimizing the adverse effects of geologic hazards (see chapter 1 of this publication for a definition of a geologic hazard). Geologic hazards can be considered at various times during planning and development, but generally are best addressed early in the process before development proceeds. Some geologic hazards cannot be mitigated, or are too costly to mitigate, and therefore should be avoided. Other hazards can be effectively mitigated by means other than avoidance, and need not affect land use significantly, as long as the hazard is identified, characterized, and accommodated in project planning and design. Conversely, failure to identify and mitigate geologic hazards may result in significant additional construction and/or future maintenance costs or result in property damage, injury, and/or death. Chapter 1 and Castleton and McKean (2012) discuss the various geologic hazards commonly encountered in Utah.

Where master plans and zoning ordinances have already been adopted, amendments can be used to address geologic hazards, although it may be too late to change the existing land use to one more compatible with the hazards. Geologic-hazard or sensitive-land overlay zones are effective for areas where zoning ordinances are already in place. The overlay zone (or zones, if hazards are considered separately) includes areas where hazards have been identified and places restrictions on development. Overlay zones may be placed over existing zone maps requiring that development conform to overlay regulations. Geologic hazards may also be addressed in development codes and subdivision ordinances.

PURPOSE

This chapter presents a suggested approach for implementing a geologic-hazard ordinance at the municipal or county

level in Utah. Effective geologic-hazard ordinances are science based, and it is chiefly the science-based (technical) components of a geologic-hazard ordinance that are discussed here. Administrative aspects of ordinance adoption and implementation are left to the specific requirements and needs of individual jurisdictions; however, the Utah Geological Survey (UGS) recommends that ordinances include (1) a requirement for a thorough regulatory review (Larson, 2015) of engineering-geology reports and other geological documents submitted as part of the development permitting process, and (2) an enforcement requirement, including site inspection, to ensure that geologic-hazard mitigation recommendations are in fact incorporated in project construction as approved.

This chapter is not a comprehensive review of all possible approaches or types of ordinances, overlay zones, or development codes in which geologic hazards may be addressed. A model ordinance is provided in Appendix E based in part on proven-effective ordinances in Utah (e.g., Salt Lake City [updated 2014], Salt Lake County [2002a], City of Draper [2010], Iron County [2011], and Morgan County [2019]) that could serve as models for future geologic-hazard ordinances in other jurisdictions. Additional recommendations for reducing losses from geologic hazards, including those related to ordinances, were outlined by the 2006–2007 Governor’s Geologic Hazards Working Group (Christenson and Ashland, 2008).

Other chapters in this publication address (1) minimum acceptable requirements for engineering-geology investigations and subsequent reports prepared in support of the development permitting process (chapter 2), and (2) the minimum acceptable level of effort recommended to investigate surface-fault-rupture, landslide, debris-flow, ground-subsidence and earth-fissure, rockfall, and radon hazards (chapters 3–8). As the UGS develops additional geologic-hazard guidelines in the future, the new guidelines will be incorporated in updates of this publication. The UGS recommends that, at a minimum, municipalities and counties incorporate the standards presented in this publication in their geologic-hazard ordinances, which are referenced in the provided model ordinance (Appendix E). Experience has shown that requirements established in a geologic-hazard ordinance, even if identified as minimum acceptable standards, typically become the maximum level of effort expended in the development permitting process (Slosson, 1984). Therefore, it is incumbent on municipalities and counties to establish science-based technical requirements and

standards in their ordinances that ensure that geologic hazards are adequately identified, characterized, reported upon, and mitigated in their jurisdictions.

ORDINANCE DEVELOPMENT

A comprehensive geologic-hazard ordinance helps protect the health, safety, and welfare of citizens by minimizing the adverse effects of geologic hazards. In almost all cases, it is more cost effective to perform a comprehensive engineering-geology investigation to identify and characterize geologic hazards and implement appropriate mitigation in project design and construction, rather than relying on additional maintenance over the life of the project, incurring costly change orders during construction, and/or increasing public liability to hazards. Often, local governments are left to mitigate geologic-hazard issues after an event, such as a landslide (for example, the 2014 Parkway Drive landslide in North Salt Lake), which in many cases is costly to taxpayers and may have been avoided.

Geologic-hazard ordinances should, at a minimum, consider the hazards known within that jurisdiction. Higher levels of safety can be achieved by investigating all of the geologic hazards commonly encountered in Utah (see chapter 1 and appendix B of this publication, and Neuendorf and others [2011] for geologic-hazard definitions). While not all of these hazards are likely to be present within every local jurisdiction, those not present can quickly be eliminated from further consideration by a comprehensive engineering-geology investigation. Documenting the absence of a hazard is often as important as documenting the presence of one.

When to Perform a Geologic-Hazard Investigation

Geologic hazards are best addressed prior to land development in affected areas. The UGS recommends that a comprehensive geologic-hazard investigation be performed for all new buildings for human occupancy, and for all IBC Risk Category II, III, and IV facilities (IBC table 1604.5 [International Code Council, 2017a]) proposed in areas of known or suspected geologic hazards. The level of investigation conducted for a particular project depends on several factors, including (1) site-specific geologic conditions, (2) type of proposed or existing development, use, and operation, (3) level of acceptable risk, and (4) governmental permitting requirements, or regulatory agency rules and regulations. A geologic-hazard investigation may be conducted separately, or as part of a comprehensive engineering-geology and/or geotechnical site investigation (chapter 2).

Minimum Qualifications of the Investigator

Minimum qualifications for the geologist in responsible charge of an engineering-geology investigation and for regulatory-authority

geologists are detailed in chapter 2. In addition, geologic-hazard ordinances should specify conflict of interest requirements. It is imperative that regulatory-authority geologists hold themselves to the highest ethical standards to eliminate conflicts of interest and bias that may jeopardize the review process.

Geologic-Hazard Special Study Maps

A critical first step to ensure that geologic hazards are adequately addressed in land-use planning and regulation is preparation by local jurisdictions of geologic-hazard special study maps, which define areas where geologic-hazard investigations are required prior to development. The UGS publishes comprehensive geologic-hazard map sets for selected areas in Utah, showing delineated special-study areas where detailed investigations are recommended. These maps are prepared by qualified, experienced hazard and Engineering Geologists using best available scientific information, but are necessarily generalized and designed only to indicate areas where hazards may exist and where site-specific geologic-hazard investigations are necessary. Because geologic-hazard maps are prepared at a non-site-specific scale (generally 1:24,000 or smaller), hazards may exist but not be shown in some areas on the maps. The fact that a site is not in a geologic-hazard study area for a particular hazard does not exempt the Engineering Geologist in responsible charge of the investigation from evaluating a hazard if evidence is found that one exists.

Utah Geological Survey Geologic-Hazard Maps

The UGS has prepared or assisted with preparation of geologic-hazard map sets for Cache, Davis, Grand, Iron, Salt Lake, eastern Tooele, Utah, western Wasatch, and Weber Counties (on file with the respective county planning departments and may be available at <https://geology.utah.gov/hazards/info/maps/>). Many of these maps have become dated, only a few hazards were mapped, and more accurate mapping methods are now available. The current UGS Geologic Hazards Program (<https://geology.utah.gov/about-us/geologic-hazards-program/>) Geologic Hazards Mapping Initiative develops modern, comprehensive geologic-hazard map sets on U.S. Geological Survey 1:24,000-scale quadrangles in urban areas of Utah (Bowman and others, 2009; Castleton and McKean, 2012) as PDFs and full GIS products. These map sets typically include 10 or more individual geologic-hazard maps (liquefaction, surface-fault rupture, flooding, landslides, rockfall, debris flow, radon, collapsible soils, expansive soil and rock, shallow bedrock, and shallow groundwater). Some quadrangles may have additional maps of wind-blown sand, piping and erosion, land subsidence and earth fissures, or other geologic hazards identified within the mapped area.

The Magna, Copperton, and Tickville Spring quadrangle map sets (Castleton and others, 2011, 2014, 2015b) within Salt Lake Valley have been published, with mapping continuing in Salt Lake and Utah Valleys. Similar UGS geologic-hazard map sets are available for the St. George–Hurricane metro-

politan area (Lund and others, 2008), high-visitation areas in Zion National Park (Lund and others, 2010), the State Route 9 corridor between La Verkin and Springdale (Knudsen and Lund, 2013), and the Moab area (Castleton and others 2018). Additionally, detailed surface-fault-rupture-hazard maps have been published for the Wasatch fault zone (Harty and McKean, 2015; Hiscock and Hylland, 2015); with mapping on other segments ongoing. The UGS routinely partners with local governments to expedite the publication of geologic-hazard special study maps in critical areas and can provide guidance on how to use and interpret the maps.

Where Geologic-Hazard Maps Are Not Available

Where comprehensive geologic-hazard map sets are not available, the local government should consider partnering with the UGS to develop the appropriate maps consistent with those available in other areas. The UGS creates these area maps for local and state agencies as delegated by Utah Code.

If funding or other impediments to preparing geologic-hazard maps occur, geologic-hazard ordinances should state that the first step in a geologic-hazard investigation is to determine if the site is near mapped or otherwise known geologic hazards. If so, larger scale maps (if available) should be examined, aerial photograph and other remote sensing imagery interpreted, and a field investigation performed to produce a detailed geologic map as outlined in chapter 2 to determine if a geologic hazard(s) is present that will affect the site. If evidence for a hazard(s) is found, the UGS recommends that a site investigation be performed in accordance with the guidelines presented in chapter 2, and in chapters 3–8 as applicable.

Scoping Meeting

Due to the interdisciplinary and complex nature of many geologic-hazard investigations, the UGS recommends that geologic-hazard ordinances include a provision for a pre-investigation scoping meeting between the permitting authority (municipality or county) and the consultant performing the investigation (and project owner if needed) to discuss any building code and/or local ordinance requirements that apply to the project. These meetings can reduce the uncertainty regarding applicable requirements and speed the project/permit approval process. The geologist representing the permitting/regulatory entity, building official, and planner should attend at a minimum. Several scoping meetings and/or site visits may be needed on complex projects.

ENGINEERING-GEOLOGY INVESTIGATIONS AND REPORTS

Chapter 2 provides guidelines for conducting site-specific engineering-geology investigations and preparing engineering-geology reports. Chapters 3–8 provide guidelines for

investigating surface-fault-rupture, landslide, debris-flow, ground-subsidence and earth-fissure, rockfall, and radon gas hazards. These chapters are intended as guidance for consultants characterizing site geologic conditions; investigating geologic hazards; and reporting investigation results, conclusions, and recommendations. Local governments may adopt these guidelines by reference into geologic-hazard ordinances to establish minimum engineering-geology investigation and report requirements and minimum criteria for investigating geologic hazards in their jurisdictions.

For purposes of land development, an engineering-geology investigation should address all aspects of site geology that affect or are likely to be affected by the proposed development. A site-specific engineering-geology investigation should focus on the geologic hazards present at a site and their potential effect on the proposed project if not avoided or mitigated. In some instances, an investigation may be specific to a single hazard (e.g., a surface-fault-rupture investigation along the Wasatch fault zone), but more typically an engineering-geology investigation will address all hazards at the site. If the investigation identifies a hazard(s) that presents an unacceptable risk to development if not mitigated, the report must include a hazard-mitigation plan that defines how hazards will be addressed in project design. The plan should be in sufficient detail and with sufficient supporting data to allow local governments to evaluate the effectiveness and adequacy of proposed mitigation measures.

PROJECT REVIEW

Effective project review, including field and report review, is necessary to ensure the project conforms to applicable codes and ordinances.

Field Review

As part of the project review, upon completion of fieldwork for a site-specific engineering-geology investigation, a technical field review by the regulatory-authority geologist is critical to ensure that the investigation adequately identified and characterized all geologic hazards at the site. The field review should take place before any test pits or trenches excavated for the investigation, and that may expose evidence of geologic hazards, are closed. Although not required, the UGS appreciates being afforded the opportunity to participate in geologic-hazard field reviews and particularly surface-fault-rupture investigation trenches to help improve our mapping. Contact the UGS Geologic Hazards Program in Salt Lake City at (801) 537-3300, or the UGS Southern Regional Office in Cedar City at (435) 865-9036.

Report Review

Before final design and permit approval, a qualified, Utah-licensed Professional Geologist, specializing in engineering geology (i.e., regulatory-authority geologist), should review engineering-geology reports and other geologic materials (maps, cross sections, etc.) submitted in support of the development permitting process. The same minimum qualifications recommended for an investigator (see the Investigator Qualifications section in chapter 2) apply to the regulatory-authority Engineering Geologist. If a geotechnical report or other engineering analysis and/or recommendations are included with the engineering-geology report, a qualified, Utah-licensed Professional Engineer, specializing in geological and/or geotechnical engineering, must review the report or pertinent sections and, as necessary, participate in field reviews. If the report is deemed adequate, the permitting process may proceed and report recommendations may be implemented (see Enforcement section below). If the report is deemed inadequate, further work can be required or the development can be denied.

Appendix A presents checklists for reviewing an engineering-geology report and for reviewing surface-fault-rupture-, landslide-, debris-flow-, ground-subsidence and earth-failure-, and rockfall-hazard investigations. These checklists, which follow the recommendations in chapter 2 and chapters 3–8, give a concise view of engineering-geology report requirements and geologic-hazard-investigation criteria, respectively, and can provide report authors with valuable feedback information to revise their reports following a thorough review by the regulatory-authority geologist and engineer as necessary. Digital files of these checklists are provided as Microsoft Word 2007+ (docx) form document files. The reviewer should complete the Report and Review section, select the appropriate section information check box (either adequately documented or additional information needed) and enter comments for each section in the Review Comments field, which will automatically expand as text is entered, and enter any other comments and notes in the last section, along with affixing a Utah Professional Geologist stamp.

Local governments or other agencies that do not have a qualified Engineering Geologist on staff, should retain a licensed Professional Geologist with the recommended qualifications to perform field and report reviews as needed. This individual should not be employed by, subcontracted to, or have any significant contact with the consultants or firms that performed the investigations and reports under review to eliminate any real or perceived conflict of interest.

Report Archiving

The UGS requests reviewing local governments to submit copies (an original preferred) of final engineering-geology reports for scanning, digital cleanup, and entry into the UGS

GeoData Archive System (<https://geodata.geology.utah.gov>) so these reports will be available for the preparation of future UGS geologic hazard maps and for reference by the local government and other users. If original PDF files are available (not scanner derived), a paper copy is not needed; however, the UGS would prefer to scan paper copies to retain high quality control and for conformance with archive project specifications. Paper copies will be returned to the local government once digital archiving of the report is complete, along with text-searchable PDF files for each report, if requested. Please submit reports for archiving to:

Utah Geological Survey
Geologic Hazards Program-GeoData
1594 W. North Temple, P.O. Box 146100
Salt Lake City, Utah 84114

with a return address and contact information.

ENFORCEMENT

Identification and characterization of geologic hazards and incorporation of subsequent mitigation recommendations into project planning and design are critical steps for protecting the health, safety, and welfare of Utah's citizens. However, these efforts are ineffective if hazard-mitigation procedures required for project approval are not followed during construction. An effective geologic-hazard ordinance must contain an enforcement provision to ensure that mitigation requirements are implemented. Most Utah municipalities and counties do not have a qualified Engineering Geologist or Geotechnical Engineer on staff or retainer to regularly perform the construction observation, inspection, and compliance documentation necessary to verify that the geologic-hazard mitigation requirements have been followed. In those instances, the UGS recommends that a qualified representative (Engineering Geologist and/or Geotechnical Engineer as appropriate) from the consulting firm that made the hazard-mitigation recommendations be retained by the developer to monitor project construction and document compliance with mitigation requirements. Large and/or complex projects may also require a consulting firm retained by the local permitting authority as part of a comprehensive quality assurance/quality control (QA/QC) program.

Utah municipalities and counties should consider sharing the services of an Engineering Geologist/Geotechnical Engineer to review the project and submitted reports. This could be accomplished through a local Association of Governments or similar level partnership.

Final, as-built project drawings and other documentation, as appropriate, and a document stating that report recommendations were implemented, should be stamped and signed by the geologist/engineer making the inspections and submitted to the regulatory authority to verify that the required hazard-

mitigation provisions were satisfactorily implemented. This provision may be added as part of the final building inspection and approval process.

DISCLOSURE

The UGS recommends disclosure during real-estate transactions whenever an engineering-geology investigation has been performed for a property to ensure that prospective property owners are made aware of geologic hazards present on the property, and can make their own informed decision regarding risk. Disclosure should include a Disclosure and Acknowledgment Form provided by the jurisdiction, which indicates an engineering-geology report was prepared and is available for public inspection.

Additionally, prior to approval of any development, subdivision, or parcel, the UGS recommends that the regulating jurisdiction require the owner to record a restrictive covenant with the land identifying any geologic hazard(s) present. Where geologic hazards are identified on a property, the UGS recommends that the jurisdiction require the owner to delineate the hazards on the development plat prior to receiving final plat approval.

MODEL ORDINANCE

A geologic hazards model ordinance is provided in Appendix E.

CHAPTER 10

ENGINEERING-GEOLOGY INVESTIGATION AND REPORT GUIDELINES FOR NEW UTAH PUBLIC SCHOOL BUILDINGS (UTAH STATE OFFICE OF EDUCATION)

by

Steve D. Bowman, Ph.D., P.E., P.G., Richard E. Giraud, P.G., and William R. Lund, P.G.



Public school building in North Ogden, Utah, with Ben Lomond Peak in background.

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CHAPTER 10: ENGINEERING-GEOLOGY INVESTIGATION AND REPORT GUIDELINES FOR NEW UTAH PUBLIC SCHOOL BUILDINGS (UTAH STATE OFFICE OF EDUCATION)

by Steve D. Bowman, Ph.D., P.E., P.G., Richard E. Giraud, P.G., and William R. Lund, P.G.

INTRODUCTION

To ensure that proposed schools are protected from geologic hazards, the Utah State Office of Education (USOE) recommends that an engineering-geology investigation be performed to investigate possible geologic hazards at new school sites and that subsequent reports prepared by Utah-licensed Professional Geologists be reviewed by the Utah Geological Survey (UGS) (<https://schools.utah.gov/file/25868575-d184-42d6-a9a0-778da7fdb3bb>). The purpose of the UGS review is to ensure that site-specific geologic-hazard investigations are sufficiently thorough, report conclusions are valid, proposed mitigation measures are reasonable, geologic hazards are addressed uniformly and effectively throughout the state, and school-site development consultants receive useful feedback related to geologic hazards. These guidelines are intended to be used in conjunction with the geologic-hazard guidelines presented in this publication (chapters 3–8).

identified, assessed, and mitigated. Preparation of geologic-hazard reports must be performed by a Utah-licensed Professional Geologist, and should follow the engineering-geology report (chapter 2) and individual geologic-hazard guidelines contained in this publication (chapters 3–8).

The geologic-hazards section of the UGS website includes information for consultants and design professionals (<https://geology.utah.gov/hazards/assistance/consultants/>) that contains these recommended guidelines (this publication); published UGS geologic-hazard maps, reports, site-specific studies, geologic maps, and hydrogeology publications; aerial photography; important external publications (including many of the papers cited in this volume); and links to relevant external websites. Although the UGS website contains many resources useful for engineering-geology investigations, it is not a complete source for all geologic-hazard information. As a result, a thorough literature search and review should always be performed for school-site investigations.

SCHOOL SITE GEOLOGIC HAZARDS AND INVESTIGATION

Geologic hazards represent a safety issue for Utah schools. These guidelines and subsequent UGS review of engineering-geology reports are non-regulatory, but the guidelines cite relevant sections of the 2015 International Building Code (International Code Council, 2014a) adopted statewide that indicate specific geologic hazards that should be addressed in a geologic-hazard assessment of a proposed site. The need for detailed investigations can generally be assessed by consulting regional geologic-hazard maps (<https://geology.utah.gov/hazards/info/maps/>) available for various parts of the state; however, these maps are not a substitute for site-specific engineering-geology/geologic-hazard investigations.

The complex and interdisciplinary nature of geologic-hazard investigations often requires that Engineering Geologists, engineers, and other design professionals work together to investigate the hazards, prepare geologic-hazard reports, and integrate report recommendations into project design. Involvement of both Engineering Geologists and engineers, including geotechnical, civil, and structural, will generally provide greater assurance that geologic hazards are properly

UGS SCHOOL SITE GEOLOGIC-HAZARD REPORT REVIEW

UGS review of engineering-geology school-site reports (<https://geology.utah.gov/hazards/assistance/school-sites/>) encompasses 20 items associated with the project and geologic hazards as indicated on the Engineering-Geology Report Review Checklist in appendix A. UGS staff will review the submitted report for pertinent information related to each item, determine if the report adequately addresses each item, and provide brief comments on the items, as needed.

The UGS reviews engineering-geology reports from a geologic perspective; however, if hazard-investigation or risk-reduction measures include engineering analyses, design, specifications, and/or recommendations, a Utah-licensed Professional Engineer specializing in geotechnical engineering must also review the report.

To request an engineering-geology report review for a school site, contact the UGS School-Site Review Coordinator (see Contacts section below) for your particular site location.

CONTACTS

Utah Geological Survey (UGS), Geologic Hazards Program (GHP)
<https://geology.utah.gov/about-us/geologic-hazards-program/>
Program Manager – Steve Bowman [(801) 537-3304],
stevebowman@utah.gov

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

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

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

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

Southern Utah Regional Office
646 North Main Street
Cedar City, Utah 84721
(435) 865-9036, FAX (435) 865-2789

School-Site Review Coordinator – Tyler Knudsen
[(435) 865-9036], tylerknudsen@utah.gov

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APPENDICES

APPENDIX A

REPORT REVIEW CHECKLISTS



The Wasatch fault zone at the mouths of Little Cottonwood and Bells Canyons, Salt Lake Valley, Utah.

This appendix contains recommended report review checklists for combined geologic-hazard/engineering-geology reports (including school sites) and reports specific to a single hazard (surface fault rupture, landslides, debris flows, rockfall, and land subsidence and earth fissures) as described in this publication. These checklists are intended to promote uniformity in report preparation and review, and to provide a minimum acceptable level of geologic-hazard investigation. Digital fill-in versions of these checklists are also available at <https://geology.utah.gov/hazards/assistance/consultants/>.

For additional information, see chapter 2 of Bowman, S.D., and Lund, W.R., editors, 2020, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, second edition: Utah Geological Survey Circular 128, p. 15–30, <https://doi.org/10.34191/C-128>.

Report Title:						
Report Type: _ Reconnaissance _ Preliminary _ Final _ Combined Engineering Geology/Geotechnical _ Other						
Author:			Project #:		Adequately Documented	Additional Information Needed
Location:			County:			
Reviewing Organization:			File #:			
Reviewed By:			Utah PG License #:			
First Review:		Review # ____:	Final Approval:			

Are the purpose and scope of the engineering-geology investigation appropriate and adequate for the proposed project?		
<i>Review Comments:</i>		

Is the description of the size, type of construction, intended foundation system, grade/floor elevations, building area (square feet), and International Building Code (IBC) risk category (Table 1604.5) appropriate and adequate for the proposed project? Reports should provide a marked location on an index map using a 7-1/2 minute U.S. Geological Survey (USGS) topographic map or equivalent base map; parcel number; provide the site latitude and longitude to four decimal places with datum; and a site development map adequate to show site boundaries, existing and proposed structures, other infrastructure, and relevant site topography. The scale of site development maps will vary depending on the size of the site and area of investigation; recommended scale is 1 inch = 200 feet (1:2400) or larger, as necessary	
<i>Review Comments:</i>	

Is the engineering-geology-investigation literature review appropriate and adequate for the proposed project? Are references properly cited in the report and reference list?		
<i>Review Comments:</i>		

Is the analysis of aerial photography and other remote-sensing data (as available) appropriate and adequate for the proposed project? Are aerial photographs and remote-sensing data properly documented and referenced?		
<i>Review Comments:</i>		

5. Regional Geology and Geologic/Fault Maps

Are the description and analysis of the regional geology and geologic/Quaternary fault maps appropriate and adequate for the proposed project?

Reports should provide a regional-scale (1:24,000 to 1:50,000) map showing the geology and location of all mapped or known Quaternary faults, including fault orientation (trend of surface trace, sense of displacement, etc.) and fault activity class (age category) within 10 miles of the site.

Review Comments:

6. Site-Specific Geology and Geologic Maps

Are the description and analysis of the site-specific geology, geologic maps, and cross sections appropriate and adequate for the proposed project?

Reports should describe site geology according to Guidelines for Conducting Engineering-Geology Investigations and Preparing Engineering-Geology Reports in Utah (Chapter 2), and provide a site-scale geologic map(s) showing geologic and soil units, Quaternary and other faults, seeps or springs, slope failures, lineaments investigated for evidence of faulting, and other geologic features existing on and near the project site.

Maps should show locations of trenches, test pits, boreholes, geoprobe holes, cone penetration test (CPT) soundings, and geophysical lines. Scale of site geologic maps will vary depending on the size of the site and area of investigation; recommended scale is 1 inch = 200 feet (1:2400) or larger, as necessary. Site geologic cross sections should be included as needed to illustrate three-dimensional geologic relations. The degree of detail and scale of site geologic mapping should be compatible with the geologic complexity of the site, type of building, and layout. For hillside sites, describe geology of both the site and adjacent properties, including any known or mapped landslides

Review Comments:

7. Surface-Fault-Rupture

Are the description and analysis of the potential for surface-fault rupture, and building setbacks appropriate and adequate for the proposed project?

Reports should evaluate the surface-faulting hazard for any faults on the site having Quaternary displacement. If the fault age (activity class) is unknown, the fault should be considered Holocene, unless data are adequate to determine otherwise.

If on-site investigations reveal the presence of a Quaternary fault, and fault avoidance is the surface-faulting-mitigation method chosen, an appropriate fault setback should be established following the method described in Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah (Chapter 3, this volume), and shown on either the site-specific geologic map or on a separate surface-faulting-hazard map depending on site scale and complexity. The degree of confidence in and limitations of data and conclusions must be clearly stated and documented in the report.

Review Comments:

8. Subsurface Investigation

Are the description and analysis of the subsurface investigation appropriate and adequate for the proposed project?

Reports should provide subsurface engineering-geology and geotechnical information, including a site-specific plan view map showing exploration sites (borings, test pits, trenches, etc.), existing groundwater levels, and areas of existing and planned cuts and fills.

Logs are required for all boreholes, standard penetration tests (SPT), and CPT soundings. Logs should include the geologic interpretation of deposit genesis for all layers. Because boreholes are typically multipurpose, borehole logs may also contain geotechnical, geologic, and groundwater data. All logs should include the identity of the person who made the log

Review Comments:

9. Seismic Ground Shaking and Design Parameters

Are the description and analysis of seismic ground shaking and seismic design parameters appropriate and adequate for the proposed project?

Reports should include an evaluation of the seismic ground-shaking hazard and provide seismic-design parameters (site coefficients, mapped spectral accelerations, and design spectral response acceleration parameters) according to IBC Section 1613.5 or International Residential Code (IRC) Section 301.2.2. Characterize the upper 100 feet of the building site profile to determine the site class as outlined in IBC Table 1613.5.2. If the building site profile is Site Class F, site-specific evaluation is required by the IBC and outlined in ASCE Standard 7.

Review Comments:

10. Liquefaction

Are the description and analysis of liquefaction appropriate and adequate for the proposed project?

Reports should include an evaluation of the liquefaction hazard at the site. IBC Section 1803.5.11 requires a liquefaction evaluation if the structure is determined to be in Seismic Design Category C. IBC Section 1803.5.12 requires a liquefaction evaluation and an assessment of potential consequences of any liquefaction and mitigation measures if the structure is in Seismic Design Categories D, E, or F. See IRC Section 401.4 for residential structures. The evaluation should address the possibility of local perched groundwater and the raising of groundwater levels by seasonal or longer term climatic fluctuations, landscape irrigation, and soil absorption systems (septic systems, infiltration basins, etc.).

A minimum boring depth of 50 feet below the existing ground surface is recommended for evaluating liquefaction hazard. From site borings, report SPT blow counts using the current ASTM D1586 standard (ASTM, 2011). CPT data according to the current ASTM D5778 standard (ASTM, 2012b) may be used, but only concurrent with SPT data for reliable correlation. Include complete liquefaction analysis information, including all calculations. Minimum acceptable safety factors for liquefaction generally range from 1.15 to 1.3. The final choice of an acceptable safety factor depends on many factors, such as the ground-motion parameters used, site conditions, likely ground-failure mode (settlement, lateral spread, etc.), and the critical nature of the structure or facility. Lower safety factors may be justified for large, infrequent earthquakes (e.g., the maximum credible earthquake (MCE) or the 2% probability of exceedance in 50-year event), less damaging failure modes, and non-essential facilities. Determine the likely ground-failure mode, amount of displacement, and acceptable safety factor, and evaluate cost-effective liquefaction mitigation. As this review of liquefaction is from a geologic standpoint, additional engineering review by a Utah-licensed Professional Engineer will be necessary.

Review Comments:

11. Seismically Induced Settlement or Ground Failure

Are the description and analysis of seismically induced settlement or ground failure appropriate and adequate for the proposed project?

Reports should include an evaluation of the potential for seismically induced settlement or ground failure (other than liquefaction), such as from sensitive clays or loose, granular soils, and tectonic subsidence accompanying surface faulting. For Seismic Design Category C, IBC Section 1803.5.11 requires an assessment of surface displacement due to faulting or lateral spreading. For Seismic Design Categories D, E, and F, IBC Section 1803.5.12 requires an assessment of potential consequences of soil strength loss, including estimating differential settlement, lateral movement, and reduction in foundation soil bearing capacity, and addressing mitigation measures. See IRC Section 401.4 for residential structures. As this review of seismically induced settlement or ground failure is from a geologic standpoint, additional engineering review by a Utah-licensed Professional Engineer is necessary.

Review Comments:

12. Problem Soil and Rock and Shallow Groundwater

Are the description and analysis of problem soil and rock and shallow groundwater appropriate and adequate for the proposed project?

Reports should include an evaluation of the potential for problem soil and/or rock and shallow groundwater. The evaluation should consider collapsible, expansive, soluble, organic, erosion, piping, and corrosive soil and/or rock. If collapsible soils are present, the site should be classified as Site Class F according to IBC Table 1613.5.2, and a site-specific geotechnical evaluation is required. IBC Section 1803.5.3 outlines site soil classification and additional criteria for expansive soils. See IRC Section 401.4 for residential structures. The evaluation should also consider non-engineered fill, mine- and groundwater-induced subsidence, shallow bedrock, karst, breccia pipes, sinkholes, caliche, and active sand dunes, as applicable. The evaluation should address the possibility of local perched groundwater and the raising of groundwater levels by seasonal or longer term climatic fluctuations, landscape irrigation, and soil absorption systems (septic systems, infiltration basins, etc.).

Review Comments:

13. Soil and Rock Slope Stability, Debris Flows, and Rockfall

Are the description and analysis of slope stability, debris flows, and rockfall appropriate and adequate for the proposed project?

Reports should provide an evaluation of the potential for slope failure in accordance with the Guidelines for Evaluating Landslide Hazards in Utah (Chapter 4), debris flows in accordance with the Guidelines for the Geologic Evaluation of Debris-Flow Hazards on Alluvial Fans in Utah (Chapter 5), and rockfall in accordance with Guidelines for Evaluation of Rockfall Hazards in Utah (Chapter 7). The slope stability evaluation must consider immediately adjacent property, constructed cut and fill slopes, existing landslides, appropriate seismic ground-shaking levels (pseudo-static coefficients), and development- and climatic-induced groundwater conditions. The evaluation must also consider snow avalanche hazards, where appropriate. IBC Section 1808.7 outlines building setbacks from slopes and IBC Appendix J outlines grading provisions for cuts and fills, drainage, slope benching, and erosion control.

Review Comments:

14. Flooding

Are the description and analysis of flooding appropriate and adequate for the proposed project?

Reports should provide an evaluation of the potential for flooding and erosion on alluvial fans and from streams, lakes, dam failures, canals, and ditches. Determine the Federal Emergency Management Agency flood zone on a current, official flood map (<http://msc.fema.gov>). IBC Appendix G outlines flood-resistant construction guidelines.

Review Comments:

15. Seiches, Tsunamis, and Other Earthquake- or Landslide-Induced Flooding

Are the description and analysis of seiches, tsunamis, and other earthquake- or landslide-induced flooding appropriate and adequate for the proposed project?

Reports should provide an evaluation of the potential for seiches and other earthquake- or landslide-induced flooding if the site is near a lake or reservoir.

Review Comments:

16. Radon

Are the description and analysis of radon hazards appropriate and adequate for the proposed project?

Reports should provide an evaluation of the potential for naturally occurring radon gas at the site.

Review Comments:

17. Geologic-Hazard Zones, Maps, and Ordinances

Are the description and application of applicable geologic-hazard zones, maps, and ordinances appropriate and adequate for the proposed project?

Review and cite applicable geologic-hazard zones, maps, ordinances, and zoning and building regulations required by the permitting jurisdiction.

Review Comments:

18. Conclusions

Are the report conclusions, including the description, analysis, and statement of geologic hazards supported with geologic evidence and appropriate reasoning? Are the conclusions appropriate and adequate for the proposed project?

The degree of confidence in and limitations of data and conclusions must be clearly stated and documented in the report.

Review Comments:

19. Recommendations

Are the report recommendations for geologic-hazard mitigation supported by the investigation data and report conclusions?

Any limitations on the investigation and recommendations for additional investigation must be clearly stated and documented in the report.

Review Comments:

20. Utah-Licensed Professional Geologist/Engineer Seal

Is the report stamped by a Utah-licensed Professional Geologist (PG), and if the report contains engineering analysis and/or recommendations, by a Utah-licensed Professional Engineer (PE), in responsible charge of the project?

The engineering-geology report must be stamped and signed by the engineering geologist who conducted the investigation (Utah Code 58-76-602). The geologist must be licensed to practice geology in Utah. The Utah Division of Occupational and Professional Licensing (DOPL) defines a PG as a person licensed to engage in the practice of geology before the public, but does not define or license geologic specialists, such as engineering geologists. The UGS considers an engineering geologist to be a person who through education, training, and experience is able to assure that geologic factors affecting engineering works are recognized, adequately interpreted, and presented for use in engineering practice and/or the protection of the public; this person shall have a Bachelor's degree in geology or engineering geology from an accredited university and at least five full years of experience in a responsible charge engineering-geology position. If a geotechnical report or other engineering analysis and/or recommendations are included with the engineering-geology report, a PE licensed in Utah must also stamp and sign the report or pertinent sections. For more information, see <https://dopl.utah.gov/>.

Review Comments:

Review Summary, Notes, and Reviewer Professional Geologist (PG) Stamp

Review Comments:

Reviewer's Utah PG Stamp

For additional information, see chapters 2 and 3 of Bowman, S.D., and Lund, W.R., editors, 2020, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, second edition: Utah Geological Survey Circular 128, p. 15–58, <https://doi.org/10.34191/C-128>.

Report Title:						
Report Type: _ Reconnaissance _ Preliminary _ Final _ Combined Engineering Geology/Geotechnical _ Other						
Author:			Project #:		Adequately Documented	Additional Information Needed
Location:			County:			
Reviewing Organization:			File #:			
Reviewed By:			Utah PG License #:			
First Review:	Review # ____:		Final Approval:			

Are the purpose and scope of the surface-faulting investigation appropriate and adequate for the proposed project?		
<i>Review Comments:</i>		

Is the description of the size, type of construction, intended foundation system, grade/floor elevations, building area (square feet), and International Building Code (IBC) risk category (Table 1604.5) appropriate and adequate for the proposed project?	
Reports should provide a marked location on an index map using a 7-1/2 minute U.S. Geological Survey (USGS) topographic map or equivalent base map; parcel number; provide the site latitude and longitude to four decimal places with datum; and a site development map adequate to show site boundaries, existing and proposed structures, other infrastructure, and relevant site topography. The scale of site development maps will vary depending on the size of the site and area of investigation; recommended scale is 1 inch = 200 feet (1:2400) or larger, as necessary.	
<i>Review Comments:</i>	

Is the surface-fault-rupture-hazard investigation literature review appropriate and adequate for the proposed project?		
Are references properly cited in the report and reference list?		
<i>Review Comments:</i>		

Is the analysis of aerial photography and other remote-sensing data (as available) appropriate and adequate for the proposed project? Are aerial photographs and remote-sensing data properly documented and referenced?		
Report should list the source; project code; roll, line, and frame numbers; date; and scale for aerial photography used.		
<i>Review Comments:</i>		

5. Regional Geology and Geologic/Fault Maps

Are the description and analysis of the regional geology and geologic/Quaternary fault maps appropriate and adequate for the proposed project?		
Reports should provide a regional-scale (1:24,000 to 1:50,000) map showing the geology and location of all mapped or known Quaternary and other faults, including fault orientation (trend of surface trace, sense of displacement, etc.) and fault activity class (age category) (Chapter 3) within 10 miles of the site.		
<i>Review Comments:</i>		

6. Site-Specific Geology and Geologic Maps

Are the description and analysis of the site-specific geology, geologic maps, and cross-sections appropriate and adequate for the proposed project?		
Reports should describe site geology according to Guidelines for Conducting Engineering-Geology Investigations and Preparing Engineering-Geology Reports in Utah (Chapter 2), and provide a site-scale geologic map(s) showing geologic and soil units, Quaternary and other faults, seeps or springs, slope failures, lineaments investigated for evidence of faulting, and other geologic features existing on and near the project site. Maps should show locations of trenches, test pits, boreholes, geoprobe holes, cone penetrometer test (CPT) soundings, and geophysical lines. Scale of site geologic maps will vary depending on the size of the site and area of investigation; recommended scale is 1 inch = 200 feet (1:2400) or larger as necessary. Site geologic cross sections should be included as needed to illustrate three-dimensional geologic relations. The degree of detail and scale of site geologic mapping should be compatible with the geologic complexity of the site, type of building, and layout. For hillside sites, describe geology of both the site and adjacent properties, including any known or mapped landslides.		
If on-site investigations reveal the presence of a hazardous Quaternary fault, and fault avoidance is the surface-faulting-mitigation method chosen, a fault setback should be established following the method described in the Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah (Chapter 3). The fault setback should be shown on either the site-specific geologic map or on a separate surface-faulting-hazard map depending on site scale and complexity		
<i>Review Comments:</i>		

7. Trench and Test Pit Logs

Are trench and test pit logs appropriate and adequate for the proposed project?		
Reports should include logs for each trench and test pit excavated as part of the investigation whether faults are encountered or not. Logs should show details of geologic units and structures. Logs should be to scale and not generalized or diagrammatic, and may be on a rectified photomosaic base. The scale (horizontal and vertical) should be 1 inch = 5 feet (1:60) or larger as necessary with no vertical exaggeration. Logs should be prepared in the field and accurately reflect the features observed in the excavation. Photographs are not a substitute for trench logs. All logs should include the identity of the person who made the log.		
<i>Review Comments:</i>		

8. Borehole and CPT Logs

Are boreholes and CPT soundings appropriately located and interpreted for the proposed project?		
Reports should include logs for all boreholes and CPT soundings. Logs should include the geologic interpretation of deposit genesis for all layers and whether or not evidence of faulting was encountered. Because boreholes are typically multipurpose, borehole logs may also contain geotechnical, geologic, and groundwater data. All logs should include the identity of the person who made the log.		
<i>Review Comments:</i>		

9. Geophysical Interpretations

Are geophysical lines (if any) appropriately located on the site-specific geology map and adequately interpreted for the proposed project?		
Reports should include complete geophysical logs and accompanying data and field/geophysical interpretation reports.		
<i>Review Comments:</i>		

10. Conclusions

Are the report conclusions, including the description, analysis, and statement of relative surface-faulting hazard, supported with geologic evidence and appropriate reasoning? Are the conclusions appropriate and adequate for the proposed project?

The report should evaluate the surface-faulting hazard present at the site and state the relation to existing or proposed infrastructure. The report should include a statement of relative risk and address the potential for future surface faulting. The degree of confidence in and limitations of data and conclusions must be clearly stated and documented in the report.

Review Comments:

11. Recommendations

Are the report recommendations for surface-faulting mitigation supported by the investigation data and report conclusions?

If the investigation reveals the presence of a hazardous Quaternary fault(s), and fault avoidance is the surface-faulting- mitigation method chosen, an appropriate fault setback should be established following the method described in Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah (Chapter 3) and shown on either the site-specific geologic map or on a separate surface-faulting-hazard map depending on site scale and complexity. If engineering-design mitigation of surface faulting is proposed, the recommendation must be based on adequate data to characterize the faults past displacement history sufficient for engineering-design purposes (recommend three closed seismic cycles – four paleoearthquakes; see Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah [Chapter 3]). Any limitations on the investigation and recommendations for additional investigation must be clearly stated and documented in the report.

Review Comments:

12. Utah-Licensed Professional Geologist/Engineer Seal

Is the report stamped by a Utah-licensed Professional Geologist (PG), and if the report contains engineering analysis and/or recommendations, by a Utah-licensed Professional Engineer (PE) in responsible charge of the project?

The engineering-geology report must be stamped and signed by the engineering geologist who conducted the investigation (Utah Code 58-76-602). The geologist must be licensed to practice geology in Utah. The Utah Division of Occupational and Professional Licensing (DOPL) defines a PG as a person licensed to engage in the practice of geology before the public, but does not define or license geologic specialists, such as engineering geologists. The UGS considers an engineering geologist to be a person who through education, training, and experience is able to assure that geologic factors affecting engineering works are recognized, adequately interpreted, and presented for use in engineering practice and/or the protection of the public; this person shall have a Bachelor's degree in geology, engineering geology, or a closely related field from an accredited university and at least five full years of experience in a responsible engineering-geology position. If a geotechnical report or other engineering analysis and/or recommendations (including liquefaction analysis) are included with the engineering-geology report, a PE licensed in Utah must also stamp and sign the report or pertinent sections. For more information, see <https://dopl.utah.gov/>.

Review Comments:

Review Summary, Notes, and Reviewer Professional Geologist (PG) Stamp

Review Comments:

Reviewer's Utah PG Stamp

For additional information, see chapters 2 and 4 of Bowman, S.D., and Lund, W.R., editors, 2020, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, second edition: Utah Geological Survey Circular 128, p. 15–30, 59–73, <https://doi.org/10.34191/C-128>.

Report Title:			
Report Type: _ Reconnaissance _ Preliminary _ Final _ Combined Engineering Geology/Geotechnical _ Other			
Author:		Project #:	
Location:		County:	
Reviewing Organization:		File #:	
Reviewed By:		Utah PG License #:	
First Review:	Review # ____:	Final Approval:	

Are the purpose and scope of the landslide-hazards investigation appropriate and adequate for the proposed project?		
<i>Review Comments:</i>		

Is the description of the size, type of construction, intended foundation system, grade/floor elevations, building area (square feet), and International Building Code (IBC) risk category (Table 1604.5) appropriate and adequate for the proposed project? Reports should provide a marked location on an index map using a 7-1/2 minute U.S. Geological Survey topographic map or equivalent base map; parcel number; provide the site latitude and longitude to four decimal places with datum; and a site development map adequate to show site boundaries, existing and proposed structures, other infrastructure, and relevant site topography. The scale of site development maps will vary depending on the size of the site and area of investigation; recommended scale is 1 inch = 200 feet (1:2400) or larger, as necessary.		
<i>Review Comments:</i>		

Is the landslide-hazard-investigation literature review appropriate and adequate for the proposed project? Are references properly cited in the report and reference list?		
<i>Review Comments:</i>		

Is the analysis of aerial photography and other remote sensing data (as available) appropriate and adequate for the proposed project? Are aerial photographs and remote-sensing data properly documented and referenced?		
Report should list the source; project code; roll, line, and frame numbers; date; and scale for aerial photography used.		
<i>Review Comments:</i>		

5. Regional Geology and Geologic/Fault Maps

Are the description and analysis of the regional geology and geologic/Quaternary fault maps appropriate and adequate for the proposed project?		
Reports should provide a regional-scale (1:24,000 to 1:50,000) map showing the geology and location of all mapped or known Quaternary and other faults, including fault orientation (trend of surface trace, sense of displacement, etc.) and fault activity class (age category) within 10 miles of the site.		
<i>Review Comments:</i>		

6. Site-Specific Geology and Geologic Maps

Are the description and analysis of the site-specific geology, geologic maps, and cross-sections appropriate and adequate for the proposed project?		
Reports should describe site geology according to Guidelines for Conducting Engineering-Geology Investigations and Preparing Engineering-Geology Reports in Utah (Chapter 2), and provide a site-scale geologic map(s) showing geologic and soil units, Quaternary and other faults, seeps or springs, slope failures, lineaments investigated for evidence of faulting, and other geologic features existing on and near the project site. Maps should show locations of trenches, test pits, boreholes, geoprobe holes, cone penetrometer test (CPT) soundings, and geophysical lines. Scale of site geologic maps will vary depending on the size of the site and area of investigation; recommended scale is 1 inch = 200 feet (1:2400) or larger as necessary. Site geologic cross sections should be included as needed to illustrate three-dimensional geologic relations. The degree of detail and scale of site geologic mapping should be compatible with the geologic complexity of the site, type of building, and layout, and should describe the geology of both the site and adjacent properties, including any known or mapped landslides.		
<i>Review Comments:</i>		

7. Landslide Hazard Map

Is the map showing landslide-hazard-zone boundaries and additional recommended setbacks (if any) appropriate and adequate for the proposed project?		
If on-site investigations reveal the presence of a landslide hazard, the boundary of the hazard zone with an appropriate building setback should be shown on either the site-specific geologic map or on a separate landslide-hazard map depending on site scale and complexity, and include a statement on uncertainty.		
<i>Review Comments:</i>		

8. Subsurface Investigation

Is the description and analysis of the subsurface investigation, including piezometers and/or slope instrumentation (if any), appropriate and adequate for the proposed project?		
Reports should provide subsurface engineering-geology and geotechnical information, including a site-specific plan view map showing exploration sites (borings, test pits, trenches, etc.), existing groundwater levels, and areas of existing and planned cuts and fills. Logs are required for all boreholes, standard penetration tests (SPT), and CPT soundings. Logs should include the geologic interpretation of deposit genesis for all layers. Because boreholes are typically multipurpose, borehole logs may also include geotechnical, geologic, and groundwater data. All logs should include the identity of the person who made the log.		
<i>Review Comments:</i>		

9. Geophysical Interpretations

Are geophysical lines (if any) appropriately located on the site-specific geology map and adequately interpreted for the proposed project?		
Reports should include complete geophysical logs and accompanying data and field/geophysical interpretation reports.		
<i>Review Comments:</i>		

10. Conclusions

Are the report conclusions, including the description, analysis, and statement of landslide hazards supported with geologic evidence and appropriate reasoning? Are the conclusions appropriate and adequate for the proposed project?

The report should evaluate the landslide hazard present at or adjacent to the site and state the relation to existing or proposed infrastructure. The report should include a statement of relative risk and address the potential for future landslides. Boundaries of landslide hazard zones must be defined and include a statement/measure of boundary uncertainty. The degree of confidence in and limitations of data and conclusions must be clearly stated and documented in the report.

Review Comments:

11. Recommendations

Are the report recommendations for landslide-hazard mitigation supported by the investigation data and report conclusions?

If a landslide hazard is present on site, the report should provide and justify building setbacks or other mitigation recommendations to control landslides and reduce risk. Any limitations on the investigation and recommendations for additional investigation must be clearly stated and documented in the report.

Review Comments:

12. Utah-Licensed Professional Geologist/Engineer Seal

Is the report stamped by a Utah-licensed Professional Geologist (PG), and if the report contains engineering analysis and/or recommendations, by a Utah-licensed Professional Engineer (PE) in responsible charge of the project?

The engineering-geology report must be stamped and signed by the engineering geologist who conducted the investigation (Utah Code 58-76-602). The geologist must be licensed to practice geology in Utah. The Utah Division of Occupational and Professional Licensing (DOPL) defines a PG as a person licensed to engage in the practice of geology before the public, but does not define or license geologic specialists, such as engineering geologists. The UGS considers an engineering geologist to be a person who through education, training, and experience is able to assure that geologic factors affecting engineering works are recognized, adequately interpreted, and presented for use in engineering practice and/or the protection of the public; this person shall have a Bachelor's degree in geology, engineering geology, or a closely related field from an accredited university and at least five full years of experience in a responsible engineering-geology position. If a geotechnical report or other engineering analysis and/or recommendations (including liquefaction analysis) are included with the engineering-geology report, a PE licensed in Utah must also stamp and sign the report or pertinent sections. For more information, see <https://dopl.utah.gov/>.

Review Comments:

Review Summary, Notes, and Reviewer Professional Geologist (PG) Stamp

Review Comments:

Reviewer's Utah PG Stamp

For additional information, see chapters 2 and 5 of Bowman, S.D., and Lund, W.R., editors, 2020, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, second edition: Utah Geological Survey Circular 128, p. 15–30, 75–91, <https://doi.org/10.34191/C-128>.

Report Title:						
Report Type: _ Reconnaissance _ Preliminary _ Final _ Combined Engineering Geology/Geotechnical _ Other						
Author:			Project #:		Adequately Documented	Additional Information Needed
Location:			County:			
Reviewing Organization:			File #:			
Reviewed By:			Utah PG License #:			
First Review:	Review # ____:		Final Approval:			

Are the purpose and scope of the debris-flow-hazard investigation appropriate and adequate for the proposed project?		
<i>Review Comments:</i>		

Is the description of the size, type of construction, intended foundation system, grade/floor elevations, building area (square feet), and International Building Code (IBC) risk category (Table 1604.5) appropriate and adequate for the proposed project? Reports should provide a marked location on an index map using a 7-1/2 minute U.S. Geological Survey (USGS) topographic map or equivalent base map; parcel number; provide the site latitude and longitude to four decimal places with datum; and a site development map adequate to show site boundaries, existing and proposed structures, other infrastructure, and relevant site topography. The scale of site development maps will vary depending on the size of the site and area of investigation; recommended scale is 1 inch = 200 feet (1:2400) or larger, as necessary.		
<i>Review Comments:</i>		

Is the debris-flow-hazard-investigation literature review appropriate and adequate for the proposed project? Are references properly cited in the report and reference list?		
<i>Review Comments:</i> 		

Is the analysis of aerial photography and other remote-sensing data (as available) appropriate and adequate for the proposed project? Are aerial photographs and remote-sensing data properly documented and referenced?		
Report should list the source; project code; roll, line, and frame numbers; date; and scale for aerial photography used.		
<i>Review Comments:</i>		

5. Regional Geology and Geologic/Fault Maps

Are the description and analysis of the regional geology and geologic/Quaternary fault maps appropriate and adequate for the proposed project?		
Reports should provide a regional-scale (1:24,000 to 1:50,000) map showing the geology and location of all mapped or known Quaternary and other faults, including fault orientation (trend of surface trace, sense of displacement, etc.) and fault activity class (age category) within 10 miles of the site.		
<i>Review Comments:</i>		

6. Site-Specific Geology and Geologic Maps

Are the description and analysis of the site-specific geology, geologic maps, and cross-sections appropriate and adequate for the proposed project?		
Reports should describe site geology according to Guidelines for Conducting Engineering-Geology Investigations and Preparing Engineering-Geology Reports in Utah (Chapter 2, this volume), and provide a site-scale geologic map(s) showing geologic and soil units, Quaternary and other faults, seeps or springs, slope failures, lineaments investigated for evidence of faulting, and other geologic features existing on and near the project site. Maps should show locations of trenches, test pits, boreholes, geoprobe holes, cone penetrometer test soundings, and geophysical lines. Scale of site geologic maps will vary depending on the size of the site and area of investigation; recommended scale is 1 inch = 200 feet (1:2400) or larger as necessary. Site geologic cross sections should be included as needed to illustrate three-dimensional geologic relations.		
The degree of detail and scale of site geologic mapping should be compatible with the geologic complexity of the site, type of building, and layout. For hillside sites, describe geology of both the site and adjacent properties, including any known or mapped landslides.		
<i>Review Comments:</i>		

7. Alluvial-Fan Evaluation

Is the alluvial-fan evaluation appropriate and adequate for the proposed project?		
Report should provide a site-scale surficial geologic map of the alluvial fan showing debris flow and alluvial deposits. The map should be provided at an appropriate scale for the fan investigated. The fan evaluation should provide basis for design flow-volume estimates (deposit thickness and area estimates). The fan evaluation should also state the anticipated probability of occurrence and volume, flow type(s), flow depth, deposition area, runout, gradation of debris, flow impact forces, stream-flow inundation and sediment burial depths, and age estimates or other evidence used to estimate the frequency of past debris flows.		
<i>Review Comments:</i>		

8. Drainage-Basin and Channel Evaluation

Is the drainage-basin and channel evaluation adequate for the proposed project?		
Report should provide a site-scale geologic map of the drainage basin showing surficial and bedrock geology at an appropriate scale for the drainage basin investigated. The evaluation should include an estimate of the susceptibility of the drainage basin to shallow landsliding, likely landslide volume(s), and volume of historical landslides, if present. A longitudinal channel profile, showing gradients from headwaters to the alluvial fan should be provided along with cross-channel profiles and a map showing their locations. The evaluation should include a basis for channel volume estimates including initial debris slides, total feeder channel length, length of channel lined by bedrock, and estimated volume of channel sediment available for sediment bulking, including estimated bulking rate(s) in cubic yards per linear foot of channel.		
<i>Review Comments:</i>		

9. Frequency and Magnitude Considerations for Risk Reduction

Are the debris-flow frequency and magnitude estimates of geologic parameters for engineering design appropriate for proposed risk-reduction measures?		
Investigators must state how the frequency and magnitude were determined and why they are appropriate for use in design of risk-reduction measures.		
<i>Review Comments:</i>		

10. Estimated Geologic Parameters for Engineering Design

Are the estimates of geologic parameters for engineering design appropriate for proposed risk-reduction structures?		
Many debris-flow design-parameter estimates have high levels of uncertainty; investigators must clearly state the limitations of the evaluation methods employed and the uncertainties associated with design-parameter estimates.		
<i>Review Comments:</i>		

11. Conclusions

Are the report conclusions, including the description, analysis, and statement of debris-flow hazards supported with geologic evidence and appropriate reasoning? Are the conclusions appropriate and adequate for the proposed project?		
Report should evaluate the debris-flow hazard present at or adjacent to the site and state the hazards relation to existing or proposed infrastructure. The report should include a statement of relative risk or quantified risk, address future debris-flow potential, and address the potential impacts from future debris flows. The limitations and uncertainty of data and conclusions must be clearly stated and documented in the report.		
Review Comments:		

12. Recommendations

Are the report recommendations for debris-flow hazard mitigation supported by the investigation data and report conclusions?		
Any limitations on the investigation and recommendations for additional investigation must be clearly stated and documented in the report.		
Review Comments:		

13. Utah-Licensed Professional Geologist/Engineer Seal

Is the report stamped by a Utah-licensed Professional Geologist (PG), and if the report contains engineering analysis and/or recommendations, by a Utah-licensed Professional Engineer (PE) in responsible charge of the project?		
The engineering-geology report must be stamped and signed by the engineering geologist who conducted the investigation (Utah Code 58-76-602). The geologist must be licensed to practice geology in Utah. The Utah Division of Occupational and Professional Licensing (DOPL) defines a PG as a person licensed to engage in the practice of geology before the public, but does not define or license geologic specialists, such as engineering geologists. The UGS considers an engineering geologist to be a person who through education, training, and experience is able to assure that geologic factors affecting engineering works are recognized, adequately interpreted, and presented for use in engineering practice and/or the protection of the public; this person shall have a Bachelor's degree in geology, engineering geology, or a closely related field from an accredited university and at least five full years of experience in a responsible engineering-geology position. If a geotechnical report or other engineering analysis and/or recommendations (including liquefaction analysis) are included with the engineering-geology report, a PE licensed in Utah must also stamp and sign the report or pertinent sections. For more information, see https://dopl.utah.gov/ .		
Review Comments:		

Review Summary, Notes, and Reviewer Professional Geologist (PG) Stamp

Review Comments:	Reviewer's Utah PG Stamp
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For additional information, see chapters 2 and 6 of Bowman, S.D., and Lund, W.R., editors, 2020, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, second edition: Utah Geological Survey Circular 128, p. 15–30, 93–110, <https://doi.org/10.34191/C-128>.

Report Title:							
Report Type: ☐ Reconnaissance ☐ Preliminary ☐ Final ☐ Combined Engineering Geology/Geotechnical ☐ Other							
Author:			Project #:			Adequately Documented	Additional Information Needed
Location:			County:				
Reviewing Organization:			File #:				
Reviewed By:			Utah PG License #:				
First Review:	Review # ____:		Final Approval:				

Are the purpose and scope of the land-subsidence and earth-fissure-hazard investigation appropriate and adequate for the proposed project?		
<i>Review Comments:</i>		

Is the description of the size, type of construction, intended foundation system, grade/floor elevations, building area (square feet), and International Building Code (IBC) risk category (Table 1604.5) appropriate and adequate for the proposed project? Reports should provide a marked location on an index map using a 7-1/2 minute U.S. Geological Survey (USGS) topographic map or equivalent base map; parcel number; provide the site latitude and longitude to four decimal places with datum; and a site development map adequate to show site boundaries, existing and proposed structures, other infrastructure, and relevant site topography. The scale of site development maps will vary depending on the size of the site and area of investigation; recommended scale is 1 inch = 200 feet (1:2400) or larger, as necessary.		
<i>Review Comments:</i>		

Is the land-subsidence and earth-fissure-hazard investigation literature review appropriate and adequate for the proposed project? Are references properly cited in the report and reference list?		
<i>Review Comments:</i>		

Is the analysis of aerial photography and other remote-sensing data (as available) appropriate and adequate for the proposed project? Are aerial photographs and remote-sensing data properly documented and referenced?		
Report should list the source; project code; roll, line, and frame numbers; date; and scale for aerial photography used.		
<i>Review Comments:</i>		

5. Regional Geology and Geologic/Fault/Subsidence Maps

Is the description and analysis of the regional geology and geologic/Quaternary fault/subsidence maps appropriate and adequate for the proposed project?

Reports should provide a regional-scale (1:24,000 to 1:50,000) map showing the geology and location of all mapped or known Quaternary and other faults, including fault orientation (trend of surface trace, sense of displacement, etc.) and fault activity class (age category) within 10 miles of the site.

Review Comments:

6. Site-Specific Geology and Geologic Maps

Are the description and analysis of the site-specific geology, geologic maps, and cross-sections appropriate and adequate for the proposed project?

Reports should describe site geology according to Guidelines for Conducting Engineering-Geology Investigations and Preparing Engineering-Geology Reports in Utah (Chapter 2, this volume), this volume and provide a site-scale geologic map(s) showing geologic and soil units, Quaternary and other faults, seeps or springs, slope failures, lineaments investigated for evidence of faulting, and other geologic features existing on and near the project site. Maps should show locations of trenches, test pits, boreholes, geoprobe holes, cone penetrometer test (CPT) soundings, and geophysical lines. Scale of site geologic maps will vary depending on the size of the site and area of investigation; recommended scale is 1 inch = 200 feet (1:2400) or larger as necessary. Site geologic cross sections should be included as needed to illustrate three-dimensional geologic relations.

The degree of detail and scale of site geologic mapping should be compatible with the geologic complexity of the site, type of building, and layout. For hillside sites, describe geology of both the site and adjacent properties, including any known or mapped landslides.

Review Comments:

7. Subsurface Investigation

Are the description and analysis of the subsurface investigation, including wells, piezometers, and instrumentation (if any), appropriate and adequate for the proposed project?

Reports should provide subsurface engineering-geology and geotechnical information, including a site-specific plan view map showing exploration sites (borings, CPT soundings, test pits, trenches, etc.), existing groundwater levels, and areas of existing and planned cuts and fills. Logs are required for all boreholes, Standard Penetration Tests (SPT), and CPT soundings. Logs should include the geologic interpretation of deposit genesis for all layers. Because boreholes are typically multipurpose, borehole logs may also include geotechnical, geologic, and groundwater data. All logs should include the identity of the person who made the log.

Review Comments:

8. Benchmarks and Other Elevation Data

Are benchmarks and other elevation data appropriately located on the regional and site-specific geology maps and adequately interpreted for the proposed project?

Reports should include background data on elevation data used for the project, including surveying reports.

Review Comments:

9. Geophysical Interpretations

Are geophysical lines (if any) appropriately located on the site-specific geology map and adequately interpreted for the proposed project?

Reports should include complete geophysical logs and accompanying data and field/geophysical interpretation reports.

Review Comments:

10. Conclusions

Are the report conclusions, including the description, analysis, and statement of land subsidence and earth fissures supported with geologic evidence and appropriate reasoning? Are the conclusions appropriate and adequate for the proposed project?

The report should evaluate the land-subsidence and earth-fissure hazard present at or adjacent to the site and state the relation to existing or proposed infrastructure. The report should include a statement of relative risk and address the potential for future land subsidence or earth fissure formation. The degree of confidence in and limitations of data and conclusions must be clearly stated and documented in the report.

Review Comments:

11. Recommendations

Are the report recommendations for land-subsidence and earth-fissure-hazard mitigation supported by the investigation data and report conclusions?

If a land subsidence and/or earth-fissure hazard is present on site, the report must provide and justify earth-fissure setbacks and/or other land-subsidence or earth-fissure mitigation recommendations to reduce risk. Any limitations on the investigation and recommendations for additional investigation must be clearly stated and documented in the report.

Review Comments:

13. Utah-Licensed Professional Geologist/Engineer Seal

Is the report stamped by a Utah-licensed Professional Geologist (PG), and if the report contains engineering analysis and/or recommendations, by a Utah-licensed Professional Engineer (PE) in responsible charge of the project?

The engineering-geology report must be stamped and signed by the engineering geologist who conducted the investigation (Utah Code 58-76-602). The geologist must be licensed to practice geology in Utah. The Utah Division of Occupational and Professional Licensing (DOPL) defines a PG as a person licensed to engage in the practice of geology before the public, but does not define or license geologic specialists, such as engineering geologists. The UGS considers an engineering geologist to be a person who through education, training, and experience is able to assure that geologic factors affecting engineering works are recognized, adequately interpreted, and presented for use in engineering practice and/or the protection of the public; this person shall have a Bachelor's degree in geology, engineering geology, or a closely related field from an accredited university and at least five full years of experience in a responsible engineering-geology position. If a geotechnical report or other engineering analysis and/or recommendations (including liquefaction analysis) are included with the engineering-geology report, a PE licensed in Utah must also stamp and sign the report or pertinent sections. For more information, see <https://dopl.utah.gov/>.

Review Comments:

Review Summary, Notes, and Reviewer Professional Geologist (PG) Stamp

Review Comments:

Reviewer's Utah PG Stamp

For additional information, see chapters 2 and 7 of Bowman, S.D., and Lund, W.R., editors, 2020, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, second edition: Utah Geological Survey Circular 128, p. 15–30, 111–123, <https://doi.org/10.34191/C-128>.

Report Title:						
Report Type: _ Reconnaissance _ Preliminary _ Final _ Combined Engineering Geology/Geotechnical _ Other						
Author:			Project #:		Adequately Documented	Additional Information Needed
Location:			County:			
Reviewing Organization:			File #:			
Reviewed By:			Utah PG License #:			
First Review:	Review # ____:		Final Approval:			

Are the purpose and scope of the rockfall-hazard investigation appropriate and adequate for the proposed project?		
<i>Review Comments:</i>		

Is the description of the size, type of construction, intended foundation system, grade/floor elevations, building area (square feet), and International Building Code (IBC) risk category (Table 1604.5) appropriate and adequate for the proposed project? Reports should provide a marked location on an index map using a 7-1/2 minute U.S. Geological Survey (USGS) topographic map or equivalent base map; parcel number; provide the site latitude and longitude to four decimal places with datum; and a site development map adequate to show site boundaries, existing and proposed structures, other infrastructure, and relevant site topography. The scale of site development maps will vary depending on the size of the site and area of investigation; recommended scale is 1 inch = 200 feet (1:2400) or larger, as necessary.		
<i>Review Comments:</i>		

Is the rockfall-hazard-investigation literature review appropriate and adequate for the proposed project? Are references properly cited in the report and reference list?		
<i>Review Comments:</i>		

Is the analysis of aerial photography and other remote-sensing data (as available) appropriate and adequate for the proposed project? Are aerial photographs and remote-sensing data properly documented and referenced? Report should list the source; project code; roll, line, and frame numbers; date; and scale for aerial photography used.		
<i>Review Comments:</i>		

4. Regional Geology and Geologic/Fault Maps

Is the description and analysis of the regional geology and geologic/Quaternary fault maps appropriate and adequate for the proposed project?

Reports should provide a regional-scale (1:24,000 to 1:50,000) map showing the geology and location of all mapped or known Quaternary and other faults, including fault orientation (trend of surface trace, sense of displacement, etc.) and fault activity class (age category) within 10 miles of the site.

Review Comments:

5. Site-Specific Geology and Geologic Maps

Is the description and analysis of the site-specific geology, geologic maps, and cross-sections appropriate and adequate for the proposed project?

Reports should describe site geology according to Guidelines for Conducting Engineering-Geology Investigations and Preparing Engineering-Geology Reports in Utah (Chapter 2, this volume), and provide a site-scale geologic map(s) showing geologic and soil units, Quaternary and other faults, seeps or springs, slope failures, lineaments investigated for evidence of faulting, and other geologic features existing on and near the project site. Maps should show locations of trenches, test pits, boreholes, geoprobe holes, cone penetrometer test (CPT) soundings, and geophysical lines. Scale of site geologic maps will vary depending on the size of the site and area of investigation; recommended scale is 1 inch = 200 feet (1:2400) or larger as necessary. Site geologic cross sections should be included as needed to illustrate three-dimensional geologic relations.

The degree of detail and scale of site geologic mapping should be compatible with the geologic complexity of the site, type of building, and layout. For hillside sites, describe geology of both the site and adjacent properties, including any known or mapped landslides and rockfall source areas.

Review Comments:

6. Rockfall-Hazard Map

Is the map showing rockfall runout zone boundaries and additional recommended setbacks (if any) appropriate and adequate for the proposed project?

If on-site investigations reveal the presence of a rockfall hazard, the boundary of the rockfall runout zone with an appropriate building setback (if any) should be shown with a statement/measure of runout zone boundary uncertainty. In general, the greater the uncertainty in the runout zone boundary, the greater the setback distance.

Review Comments:

7. Boreholes/Piezometers/Slope Monitoring Instrumentation Logs

Are boreholes, piezometers, and slope instrumentation (if any) locations appropriately located, documented, and interpreted for the proposed project?

The report should provide surface and subsurface engineering-geology and geotechnical information, including a site-specific plan view map showing exploration sites (borings, CPT soundings, test pits, trenches, etc.), existing groundwater levels, and areas of existing and planned cuts and fills. Logs are required for all boreholes and CPT soundings, and should include the geologic interpretation of deposit genesis, weathering, fracturing, and other data relevant to rockfall genesis. Because boreholes are typically multipurpose, borehole logs may also include geotechnical, geologic, and groundwater data. All logs should include the identity of the person who made the log.

Review Comments:

8. Scanline and Geophysical Interpretations

Are scanlines and geophysical lines (if any) appropriately located on the site-specific geology map and adequately interpreted for the proposed project?

Reports should include complete geophysical logs and accompanying data and field/geophysical interpretation reports.

Review Comments:

9. Conclusions

Are the report conclusions, including the description, analysis, and statement of relative rockfall hazard supported with geologic evidence and appropriate reasoning? Are the conclusions appropriate and adequate for the proposed project?

Report must evaluate the rockfall hazard present at or adjacent to the site and state the hazards relation to existing or proposed infrastructure. The report should include a statement of relative risk and address the potential for future rockfalls. Boundaries of rockfall runout zones must be defined and include a statement/measure of boundary uncertainty. The degree of confidence in and limitations of data and conclusions must be clearly stated and documented in the report.

Review Comments:

10. Recommendations

Are the report recommendations for rockfall-hazard mitigation supported by the investigation data and report conclusions?

If a rockfall hazard is present on site, the report must provide and justify runout zones and building setbacks or other mitigation recommendations to control rockfalls and reduce risk. Any limitations on the investigation and recommendations for additional investigation must be clearly stated and documented in the report.

Review Comments:

11. Utah-Licensed Professional Geologist/Engineer Seal

Is the report stamped by a Utah-licensed Professional Geologist (PG), and if the report contains engineering analysis and/or recommendations, by a Utah-licensed Professional Engineer (PE) in responsible charge of the project?

The engineering-geology report must be stamped and signed by the engineering geologist who conducted the investigation (Utah Code 58-76-602). The geologist must be licensed to practice geology in Utah. The Utah Division of Occupational and Professional Licensing (DOPL) defines a PG as a person licensed to engage in the practice of geology before the public, but does not define or license geologic specialists, such as engineering geologists. The UGS considers an engineering geologist to be a person who through education, training, and experience is able to assure that geologic factors affecting engineering works are recognized, adequately interpreted, and presented for use in engineering practice and/or the protection of the public; this person shall have a Bachelor's degree in geology, engineering geology, or a closely related field from an accredited university and at least five full years of experience in a responsible engineering-geology position. If a geotechnical report or other engineering analysis and/or recommendations (including liquefaction analysis) are included with the engineering-geology report, a PE licensed in Utah must also stamp and sign the report or pertinent sections. For more information, see <https://dopl.utah.gov/>.

Review Comments:

Review Summary, Notes, and Reviewer Professional Geologist (PG) Stamp

Review Comments:

Reviewer's Utah PG Stamp

For additional information, see chapters 2 and 8 of Bowman, S.D., and Lund, W.R., editors, 2020, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, second edition: Utah Geological Survey Circular 128, p. 15–30, 125–136, <https://doi.org/10.34191/C-128>.

Report Title:						
Report Type: _ Reconnaissance _ Preliminary _ Final _ Combined Engineering Geology/Geotechnical _ Other						
Author:			Project #:		Adequately Documented	Additional Information Needed
Location:			County:			
Reviewing Organization:			File #:			
Reviewed By:			Utah PG License #:			
First Review:		Review # ____:	Final Approval:			

Are the purpose and scope of the radon-hazard investigation appropriate and adequate for the proposed project? For more information, see Guidelines for Conducting Engineering-Geology Investigations and Preparing Engineering-Geology Reports in Utah (Chapter 2, this volume).		
<i>Review Comments:</i>		

Is the description of the size, type of construction, intended foundation system, grade/floor elevations, building area (square feet), and International Building Code (IBC) risk category (Table 1604.5) appropriate and adequate for the proposed project? Reports should provide a marked location on an index map using a 7-1/2 minute U.S. Geological Survey (USGS) topographic map or equivalent base map; parcel number; provide the site latitude and longitude to four decimal places with datum; and a site development map adequate to show site boundaries, existing and proposed structures, other infrastructure, and relevant site topography. The scale of site development maps will vary depending on the size of the site and area of investigation; recommended scale is 1 inch = 200 feet (1:2400) or larger, as necessary. For more information, see Guidelines for Conducting Engineering-Geology Investigations and Preparing Engineering-Geology Reports in Utah (Chapter 2, this volume).		
<i>Review Comments:</i>		

Is the radon-hazard investigation literature review appropriate and adequate for the proposed project? Are references properly cited in the report and reference list? For more information, see Guidelines for Conducting Engineering-Geology Investigations and Preparing Engineering-Geology Reports in Utah (Chapter 2, this volume) and https://geology.utah.gov/hazards/assistance/consultants/.		
<i>Review Comments:</i>		

4. Analysis of Aerial Photographs and Other Remote-Sensing Data

Is the analysis of aerial photography and other remote-sensing data (as available) appropriate and adequate for the proposed project? Are aerial photographs and remote-sensing data properly documented and referenced?

Report should list the source; project code; roll, line, and frame numbers; date; and scale for aerial photography used. For more information, see <https://geology.utah.gov/map-pub/publications/aerial-photographs/> and <https://geology.utah.gov/resources/data-databases/lidar-elevation-data/>.

Review Comments:

5. Regional Geology and Geologic Maps

Are the description and analysis of regional geology and geology maps appropriate and adequate for the proposed project?

For more information, see Guidelines for Conducting Engineering-Geology Investigations and Preparing Engineering-Geology Reports in Utah (Chapter 2, this volume).

Review Comments:

6. Site-Specific Geology and Geologic Maps

Are the description and analysis of the site-specific geology, geologic maps, and cross-sections appropriate and adequate for the proposed project?

Reports should describe site geology according to Guidelines for Conducting Engineering-Geology Investigations and Preparing Engineering-Geology Reports in Utah (Chapter 2, this volume), and provide a site-scale geologic map(s) showing geologic and soil units, Quaternary and other faults, seeps or springs, slope failures, lineaments, and other geologic features existing on and near the project site. Maps should show locations of trenches, test pits, and radon-soil-gas test locations. Scale of site geologic maps will vary depending on the size of the site and area of investigation; recommended scale is 1 inch = 200 feet (1:2400) or larger as necessary. Site geologic cross sections should be included as needed to illustrate three-dimensional geologic relations. The degree of detail and scale of site geologic mapping should be compatible with the geologic complexity of the site, type of building, and layout. For hillside sites, describe geology of both the site and adjacent properties, including any known or mapped landslides.

For more information, see Guidelines for Conducting Engineering-Geology Investigations and Preparing Engineering-Geology Reports in Utah (Chapter 2, this volume) and <https://geology.utah.gov/hazards/assistance/consultants/>.

Review Comments:

7. Subsurface investigation: Trench, Test Pit, and Boring Logs

Are trench, test pit, and borehole logs appropriate and adequate for the proposed project?

Reports should include logs for each trench, test pit, and borehole excavated as part of the investigation. Logs should show details of geologic units and structures. Logs should be to scale and not generalized or diagrammatic, and may be on a rectified photomosaic base. The scale (horizontal and vertical) should be 1 inch = 5 feet (1:60) or larger as necessary with no vertical exaggeration. Logs should be prepared in the field and accurately reflect the geologic materials and features observed in the excavation. Photographs are not a substitute for trench logs. All logs should include the identity of the person who made the log.

Review Comments:

8. Visual Examination of Site Geologic Material

Have site geologic materials (soil and bedrock, both at the surface and at depth) been adequately examined for the presence of potentially radon-generating geologic material (granitic and metamorphic rock, light-colored volcanic rock, black shale, certain sedimentary rock units [see description in text], and soils derived from them)? Reports should include results for all geologic-material examinations, whether or not evidence of potentially radon generating material was identified. All geologic-material examinations should describe the examination method employed (hand lense, binocular microscope, etc.) and the identity of the person who made the examination.		
<i>Review Comments:</i>		

9. Local Uranium Content Data /Evaluation of Hydrogeochemical Data/ Radon-Soil-Gas Tests

Has the uranium content for geologic units present been identified? Is there hydrogeochemical data available within the geologic units either at the site or at a similar location? Are radon-soil-gas tests needed and appropriately located and interpreted for the proposed project? Reports should include results for all radon soil-gas tests, whether or not evidence of radon gas was detected. All radon-soil-gas tests should include the identity of the person who made the test.		
<i>Review Comments:</i>		

10. Conclusions

Are the report conclusions, including the description, analysis, and statement of relative radon hazard, supported with geologic and radon-test evidence and appropriate reasoning? Are the conclusions appropriate and adequate for the proposed project? The report should evaluate the radon hazard present at the site. The report should include a statement of relative hazard. The degree of confidence in and limitations of data and conclusions must be clearly stated and documented in the report.		
<i>Review Comments:</i>		

11. Recommendations

Are the report recommendations for radon-hazard mitigation supported by the investigation data and report conclusions? If the investigation reveals the presence of radon gas and engineering-design mitigation of the radon hazard is proposed, the recommendation must be based on adequate data used to characterize the hazard. Any limitations on the investigation and recommendations for additional investigation must be clearly stated and documented in the report.		
<i>Review Comments:</i>		

12. Utah-Licensed Professional Geologist/Engineer Seal

Is the report stamped by a Utah-licensed Professional Geologist (PG), and if the report contains engineering analysis and/or recommendations, by a Utah-licensed Professional Engineer (PE) in responsible charge of the project?

The engineering-geology report must be stamped and signed by the engineering geologist who conducted the investigation (Utah Code 58-76-602). The geologist must be licensed to practice geology in Utah. The Utah Division of Occupational and Professional Licensing (DOPL) defines a PG as a person licensed to engage in the practice of geology before the public, but does not define or license geologic specialists, such as engineering geologists. The UGS considers an engineering geologist to be a person who through education, training, and experience is able to assure that geologic factors affecting engineering works are recognized, adequately interpreted, and presented for use in engineering practice and/or the protection of the public; this person shall have a Bachelor's degree in geology, engineering geology, or a closely related field from an accredited university and at least five full years of experience in a responsible engineering-geology position. If a geotechnical report or other engineering analysis and/or recommendations (including liquefaction analysis) are included with the engineering-geology report, a PE licensed in Utah must also stamp and sign the report or pertinent sections. For more information, see <http://dopl.utah.gov/>.

Review Comments:

Review Summary, Notes, and Reviewer Professional Geologist (PG) Stamp

Review Comments:

Reviewers Utah PG Stamp

APPENDIX B

GLOSSARY OF GEOLOGIC-HAZARD AND OTHER TERMS



The Organ, typical Entrada Sandstone monolith in Arches National Park. The Three Gossips can be seen in the background. Photo credit: Gregg Beukelman, May 5, 2014.

Suggested citation: Bowman, S.D., 2020, Glossary of geologic-hazard and other terms, in Bowman, S.D., and Lund, W.R., editors, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, second edition: Utah Geological Survey Circular 128, appendix B, p. 199–206, <https://doi.org/10.34191/C-128>.

GLOSSARY OF GEOLOGIC-HAZARD AND OTHER TERMS

Abandoned landslide – Inactive landslide which is no longer affected by its original causes. An example would be of a landslide whose movement is caused by stream erosion at its toe. The stream then changes course and the movement stops.

Acceptable and reasonable risk – A level of risk at which it is expected that there will be no loss of life or significant injury to occupants, no release of hazardous or toxic substances, and no more than minimal structural damage (i.e., physically and economically reasonable to repair) to critical infrastructure, critical facilities, or to structures designed for human occupancy, in the event that the anticipated geologic hazard were to occur.

Active landslide – Landslide that is currently moving; first-time movement or reactivated.

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

Activity class (of a fault) – The level of activity as defined by WSSPC (2018) of a fault based on the time of most recent rupture of the ground surface. Holocene activity class means movement of a fault that has broken the ground surface in approximately the past 11,700 years, shown as “<15,000 years” on the Quaternary Fault and Fold Database of the United States); Late Quaternary activity class means movement of a fault that has broken the ground surface in approximately the past 130,000 years; and, Quaternary activity class means movement of a fault that has broken the ground surface in approximately the past 2.6 million years. Depending on local conditions, faults in any activity class may be buried or concealed.

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

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

Alluvial-fan surface, active – An alluvial-fan surface where the fan-building processes of flooding, debris flow, sediment deposition, and erosion are active or potentially active during storm or snowmelt events. Active portions of the fan have generally shallow stream channels, often braiding into several channels that distribute alluvium broadly across the fan surface. Active alluvial-fan surfaces receiving periodic sedimentation are typically rough (numerous boulders and cobbles at the surface) and support sparse vegetation.

Alluvial-fan surface, inactive – An alluvial-fan surface where the fan-building processes are no longer active. Inactive fan surfaces are stable and usually marked by well-developed soil and plant succession. Stream channels are generally single strand, incised below the inactive fan surface, and associated with a flat, low floodplain terrace. Floods along channels on inactive alluvial-fan surfaces behave as normal riverine floods.

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

Buildable area – That portion of a site, lot, or parcel that is entitled to contain the proposed improvement (for example, complies with zoning and building setbacks); and, either will not be impacted by a geologic hazard, or has all identified geologic hazards mitigated to an acceptable and reasonable risk. Any mitigation necessary to deem a geologically hazardous area as “buildable” must be based on an approved geologic-hazard report and engineered methods.

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

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

Complex landslide – Landslide activity where a landslide exhibits at least two types of movement (fall, topple, slide, spread, or flow) in sequence.

- Composite landslide – Landslide activity where a landslide exhibits at least two types of movement (fall, topple, slide, spread, or flow) in different parts of the displaced mass at the same time.
- Creep – (a) Deformation that continues under constant stress. (b) A very slow to extremely slow rate of movement; not a recommended term, use very slow or extremely slow instead.
- Crown – Non-displaced ground adjacent to the highest part of the main scarp of a landslide.
- Dam-failure flooding – Flooding downstream from a dam caused by an unintentional release of water due to a partial or complete dam failure.
- Debris – Any surficial accumulation of loose material that contains a significant proportion of coarse material; 20% to 80% of inorganic particles are larger than 2 mm (the upper limit of sand-size particles).
- Debris flow – Slurry of rock, soil, organic matter, and water (generally >60% sediment by volume) that flows down channels and onto alluvial fans. May be initiated by erosion during a cloudburst storm or by a shallow (slip surface generally less than 10 feet deep) slope failure on a steep mountain slope. Debris flows can quickly travel long distances from their source areas, presenting hazards to life and property along stream channels and on or near downstream alluvial fans.
- Development – For purposes of these guidelines, development includes the installation and construction of roads, utility lines/conveyances, subdivision improvements, buildings, structures, and physical improvements accessory to any of these uses.
- Displaced material – Material moved from its original position by a landslide; includes both the depleted and accumulated masses (depletion and accumulation).
- Dormant landslide – Inactive landslide that can be reactivated by its original or other causes.
- Dormant-historic landslide – Slopes with evidence of previous landslide activity that have undergone most recent movement within preceding 100 years.
- Dormant-young landslide – slopes with evidence of previous landslide activity that have undergone most recent movement during an estimated period of 100–5000 years before present.
- Dormant-mature landslide – Slopes with evidence of previous landslide activity that have undergone most recent movement during an estimated period of 5000–10,000 years before present.
- Dormant-old landslide – Slopes with evidence of previous landslide activity that have undergone most recent movement during an estimated period greater than 10,000 years before present.
- Earth – Unconsolidated material that contains 80% or more of inorganic particles smaller than 2 mm (the upper limit of sand-size particles).
- Earth fissure – A linear tension crack in the ground that extends upward from the groundwater table and is a direct result of land subsidence caused by groundwater depletion. The surface expression of earth fissures may range from less than a yard to several miles long and from less than half an inch to tens of feet wide. Earth fissures change runoff/flood patterns, break buried pipes and utilities, cause infrastructure to collapse, provide a direct conduit to the groundwater table for contaminants, and may pose a life-safety hazard. Earth fissures can quickly erode into sinkholes/gullies when washed out by surface runoff, and some can experience vertical offset.
- Earthquake – A sudden motion or trembling of the Earth as stored elastic strain energy is released by fracture and movement of rocks along a fault.
- Earthquake-induced flooding – Flooding caused by a seiche, tectonic subsidence, increase in spring discharge, rise in the water table, or disruption of streams and canals caused by an earthquake. See also, seiche, tectonic subsidence.

Engineering Geologist – A Utah-licensed geologist, who through education, training, and experience practices in the field of engineering geology. The term “Geologist” as used in this publication, specifically refers to an Engineering Geologist qualified to study the specific geologic hazard(s) identified. The Engineering Geologist in principal charge of investigations should have a minimum of five years of experience in a responsible position in the field of engineering geology either in Utah or in a state with similar geologic hazards.

Engineering geology – The application of the geological sciences to engineering practice for the purpose of assuring that the geologic factors affecting the location, design, construction, operation, and maintenance of engineering works are recognized and adequately provided for in the interest of the public health, safety, and welfare.

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

Essential facilities –Infrastructure and facilities intended to remain operational in the event of an adverse geologic event or natural disaster. They include, but are not limited to, those uses listed under Risk Category IV as defined in the International Building Code (IBC, table 1604.5, p. 336; International Code Council, 2014a).

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

Fall – Landslide movement that starts with the detachment of soil or rock from a steep slope along a surface on which little or no shear displacement takes place.

Fault – A fracture in the Earth's crust forming a boundary between rock or soil masses that have moved relative to each other, due to tectonic forces. When the fracture extends to the Earth's surface, it is known as a surface-fault rupture, or fault trace.

Fault scarp – A steep slope or cliff formed by movement along a fault.

Fault setback – A specified distance on either side of a fault within which essential facilities and other structures designed for human occupancy are not permitted.

Fault trace, or surface-fault rupture – The intersection of a fault plane with the ground surface, often present as a fault scarp, or detected as a lineament.

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

Flank – Non-displaced material adjacent to the sides of the rupture surface of a landslide; compass directions are preferable in describing the flanks, but “left” and “right” can be used looking downslope.

Flow – A spatially continuous movement in which surfaces of shear are short-lived, closely spaced, and usually not preserved. The distribution of velocities in the displaced mass resembles that of a viscous liquid.

Geologic evaluation – The review of a geologic study area to determine the hazard potential relative to the proposed development, and to verify the need for geologic studies and reports. Geologic evaluations are performed by Engineering Geologists, or Geotechnical Engineers with input from Engineering Geologists

Geologic study area – A potential geologically hazardous area, within which geologic-hazard investigations are required prior to development.

Geologically hazardous area – An area that, because of its susceptibility to a geologic hazard, is not suitable for the siting of structures designed for human occupancy or critical facilities, consistent with public health or safety concerns, unless the hazard is mitigated to an acceptable and reasonable level.

Geotechnical Engineer: A professional, Utah-licensed engineer who, through education, training and experience, is competent in the field of geotechnical engineering and should have either (1) 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; or (2) 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 knowledge and application of appropriate techniques in geologic-hazards investigations.

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 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.

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

Hazard mitigation – An action taken to avoid, minimize, or compensate for the risk to human life and public and private property from identified hazards.

Holocene – The period of time between about 11,700 years ago and the present (Holocene Epoch). Also the geologic deposits that formed during that time (Holocene Series). See also, Quaternary.

Hydrocompaction – Where the ground subsides due to unconsolidated soils becoming saturated with water and losing their structural strength (soil bonds being dissolved by water), and the ground compacting under the weight above.

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

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

Landslide – General term referring to a wide variety of mass-movement landforms and processes involving the downslope transport, under gravitational influence, of soil and rock materials

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

Main scarp – Steep surface of undisturbed material at the upslope extent of a landslide; caused by movement of the displaced material away from the undisturbed ground; the visible part of the surface of rupture.

Mine subsidence – Subsidence of the ground surface due to the collapse of underground mines; may also cause earth fissures.

Minor scarp – Steep surface on the displaced material of a landslide produced by differential movements within the displaced material.

Non-buildable area – An area that contains a geologic hazard that presents an unreasonable and unacceptable risk, such that the siting of structures designed for human occupancy, critical facilities, and other specified development improvements are prohibited in that area by permitting agencies.

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

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

- Piping – Subsurface erosion of soil or rock by groundwater flow, forming narrow voids. Pipes can remove support of overlying soil and rock, resulting in collapse.
- Problem soil and rock – Geologic materials having characteristics that make them susceptible to volumetric changes, collapse, subsidence, or other engineering geologic problems.
- Quaternary – The period of time between 2.6 million years ago and the present (Quaternary Period). Also the geologic deposits that formed during that time (Quaternary System). The Quaternary comprises the Holocene and Pleistocene Epochs/Series. See also, Holocene.
- Radon – A radioactive gas that occurs naturally through the decay of uranium and radium. Radon can be present in high concentrations in soil derived from rock such as granite, shale, phosphate, and certain metamorphic rocks. Exposure to elevated levels of radon can cause an increased risk of lung cancer.
- Reactivated landslide – Landslide that is again active after being inactive.
- Relic landslide – Landslide that clearly developed under different geomorphic conditions, perhaps thousands of years ago.
- Rockfall – The relatively free falling or precipitous movement of rock from a slope by rolling, falling, toppling, or bouncing. The rockfall runout zone encompasses the area at risk from falling rocks below a rockfall source.
- Rotational slide – Landslide in which the surface of rupture is curved concave upward and movement is roughly rotational about an axis parallel to the ground surface and transverse across the landslide.
- Rupture surface – Surface that forms, or has formed, the lower boundary of the displaced material of a landslide below the original ground surface.
- Sediment bulking – Erosion and incorporation of channel sediment by a debris flow.
- Sensitive clay – Clay soil that experiences a particularly large loss of strength when disturbed, and therefore is subject to failure during earthquake ground shaking.
- Setback, geologic hazard – An area subject to risk from a geologic hazard, within which construction of critical facilities and structures designed for human occupancy are not permitted.
- Shallow bedrock – Bedrock at depths sufficiently shallow to be encountered in construction excavations.
- Shallow groundwater – Groundwater at depths sufficiently shallow to be encountered in construction excavations, typically within 10 feet of the ground surface or less. A rising water table can cause flooding of basements, crawlspaces, and septic drain fields.
- Slide – A downslope movement of a soil or rock mass occurring dominantly on surfaces of rupture or on relatively thin zones of intense shear strain.
- Slope failure – Downslope movement of soil or rock by falling, toppling, sliding, or flowing. See also, landslide.
- Slope stability analysis – Analysis of static and dynamic stability of engineered and natural slopes of soil and rock.
- Soil – Aggregate of solid, typically inorganic particles that either was transported or was formed in situ by weathering of rock; subdivided into earth and debris.
- Soluble soil or rock (karst) – Soil or rock containing minerals that are soluble in water, such as calcium carbonate (principal component of limestone), dolomite, and gypsum. Dissolution of minerals and rocks can cause subsidence and formation of sinkholes.

Spread – An extension of a cohesive soil or rock mass combined with a general subsidence of the fractured mass of cohesive material into softer underlying material.

Stabilized landslide – Landslide that has stopped moving after mitigation measures have been applied.

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

Structure designed for human occupancy – Any building or structure containing a habitable space, or classified as an assembly, business, educational, factory and industrial, institutional, mercantile, or residential occupancy classification under the adopted International Building Code.

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

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

Suspended landslide – Landslide that have moved within the last annual cycle of seasons but that are not moving at present.

Talus – Accumulated rock fragments lying at the base of a cliff or a steep rocky slope.

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

Toe – Lower, usually curved, margin of the displaced material of a landslide, the most distant from the top of a landslide.

Topple – A forward rotation out of the slope of a mass of soil or rock about a point or axis below the center of gravity of the displaced mass

Translational – Type of landslide that moves along a roughly planar surface with little rotation or backward tilting.

Trigger – Cause that puts a slope into a marginal state of activity leading to a landslide.

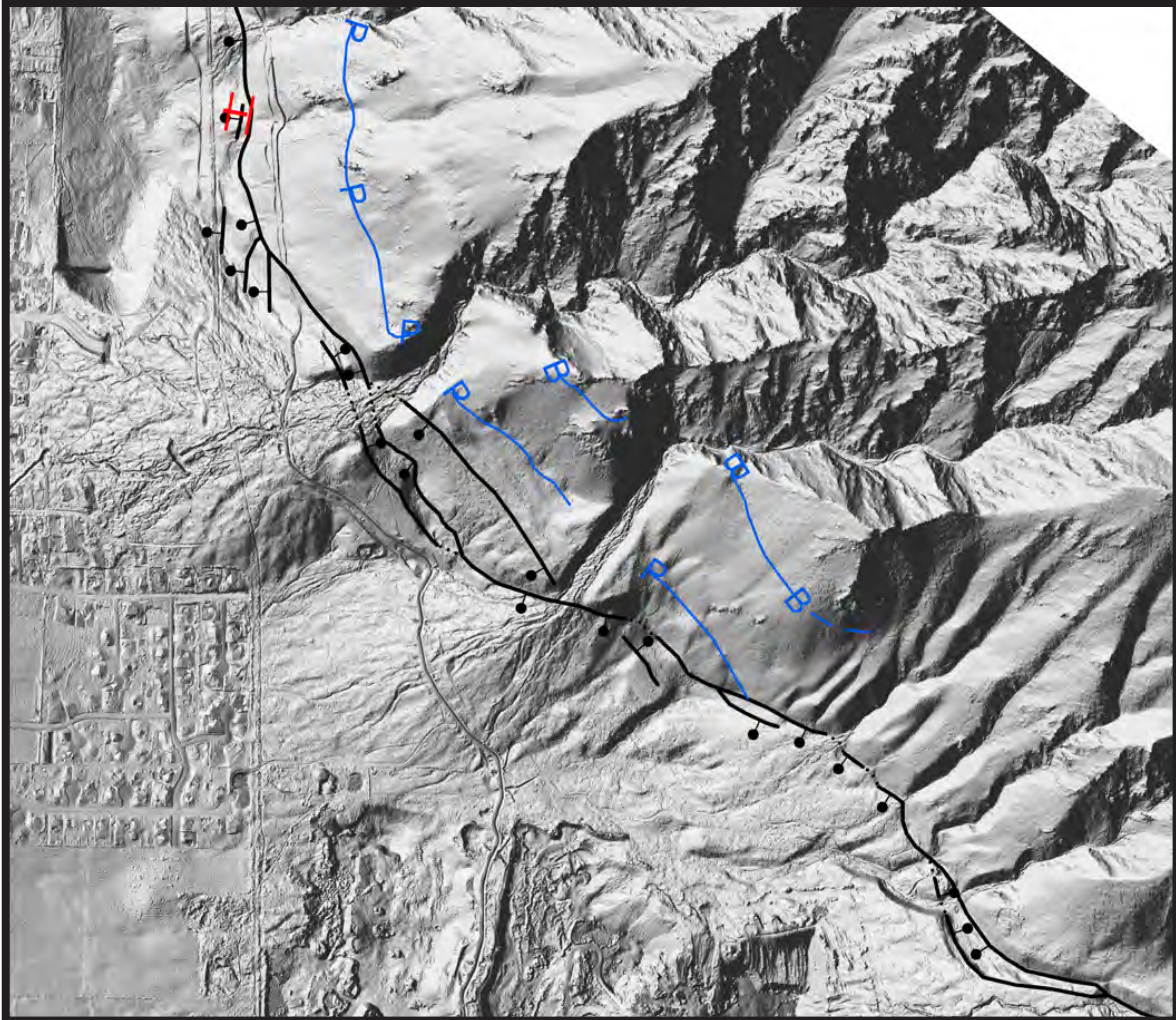
Zone of accumulation – Portion of a landslide within which the displaced material lies above the original ground surface.

Zone of depletion – Portion of a landslide within which the displaced material lies below the original ground surface.

APPENDIX C

LIGHT DETECTION AND RANGING (LIDAR)

BACKGROUND AND APPLICATION



Bare-earth lidar DEM showing the Bonneville and Provo shorelines of Pleistocene Lake Bonneville and the trace of the Wasatch fault zone. Image credit: Adam McKean.

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LIGHT DETECTION AND RANGING (LIDAR) BACKGROUND AND APPLICATION

by Steve D. Bowman, Ph.D., P.E., P.G.

INTRODUCTION

Light detection and ranging (lidar) technology uses transmitted and reflected laser pulses to measure the distance to an object. Lidar transmitted from an airborne platform (fixed-wing aircraft or helicopter) is commonly used to determine ground surface elevations to create highly accurate, bare-earth digital elevation models (DEM). A lidar instrument can send many thousands of laser pulses at a rapid rate, which allows a high point spacing density, much greater than is possible using traditional surveying methods. Landslides (figure C1), fault scarps (figure C2), earth fissures (figure C3), and other features that are difficult or not possible to detect visually because of vegetation, access, or other issues, may often be clearly shown in lidar data.

Unlike radar interferometry (InSAR), most lidar data are acquired by private aerial imaging and mapping firms. In 1996, only one vendor was selling commercial lidar systems (Baltasvias, 1999); today there are numerous commercial vendors producing lidar scanning systems including Leica Geosystems, Toposys (now Trimble), Optech, and Riegl, along with numerous aerial imaging and mapping firms employing the technology. Most of these systems are small and light enough to be installed and operated in small, single-engine aircraft, and more recently, in remotely operated, unmanned aircraft.

LIDAR BACKGROUND AND ACQUISITION

First developed in the 1960s with early laser components (Miller, 1965; Shepherd, 1965), lidar has evolved from simple electronic distance measurement systems used in surveying (Shan and Toth, 2009) into a sophisticated surface mapping technique on multiple platforms, including terrestrial, airborne, or spaceborne. Lidar may be applied using one of two general methods: profiling or scanning. Profiling involves acquiring elevation data along a single flight path of the platform. Scanning involves acquiring elevation data along a swath parallel to the flight path of the platform, or in the case of terrestrial scanners, along a path parallel to the angular rotation path of the stationary scanner. In addition, the reflected light backscatter, intensity, and other parameters can be measured for additional applications. Lidar can measure the ground surface with accuracies of a few inches horizontally and a few tenths of inches vertically (Carter and others, 2001) and can penetrate thick

vegetation canopies as shown on figure C1 from the Snowbasin, Utah, area. For more detailed information than provided here, Renslow (2012) provides a comprehensive review of airborne lidar systems and processing.

Lidar may be acquired from three different platforms: terrestrial, airborne, and spaceborne. The most common acquisition platform is airborne, with the lidar unit mounted in the floor of an airplane or helicopter (figure C4). Terrestrial lidar is commonly used to map steep slopes, such as cut or mine slopes, and fault or landslide scarps.

Due to the long path length of emitted and reflected laser light, spaceborne lidar systems require high-power lasers with high electrical input requirements. Consequently, few spaceborne lidar systems are in use, with the exception of profiling systems, which typically are employed for atmospheric and/or ocean monitoring and research, such as the NASA ICESat satellite (NASA, 2010).

Lidar systems typically use either a neodymium-doped yttrium aluminum garnet (Nd:YAG) or gallium arsenide (GaAs) laser (Shan and Toth, 2009) driven by a power source and sophisticated electronics, and for aircraft acquisition, are coupled with a GPS or more recently, a Global Navigation Satellite System (GNSS) inertial measurement unit (IMU) to determine precise three-dimensional position information. Figure C5 shows a Leica ALS70 instrument mounted in an aircraft used for the 2011 State of Utah acquisition. The position information is used during processing raw sensor data to point cloud and to bare-earth data to correct for aircraft flight path drift (yaw, pitch, and roll) and other irregularities. During acquisition of terrestrial lidar, each instrument location is measured with GPS or GNSS, which is used for subsequent processing to a three-dimensional model.

While scanning systems generally comprise a laser aimed at a rotating mirror, various manufacturers use different methods, including standard rotating mirrors (Optech and Leica Geosystems ALS scanners); rotating optical polygon scanners (Riegl scanners); Palmer scanning with a wobbling mirror (NASA Airborne Topographic Mapper [ATM] and Airborne Oceanographic Lidar [AOL] scanners; and tilted, rotating mirrors with a fiber optic array (Toposys scanners) (Leica Geosystems, 2008a; National Oceanic and Atmospheric Administration, 2008; Shan and Toth, 2009).

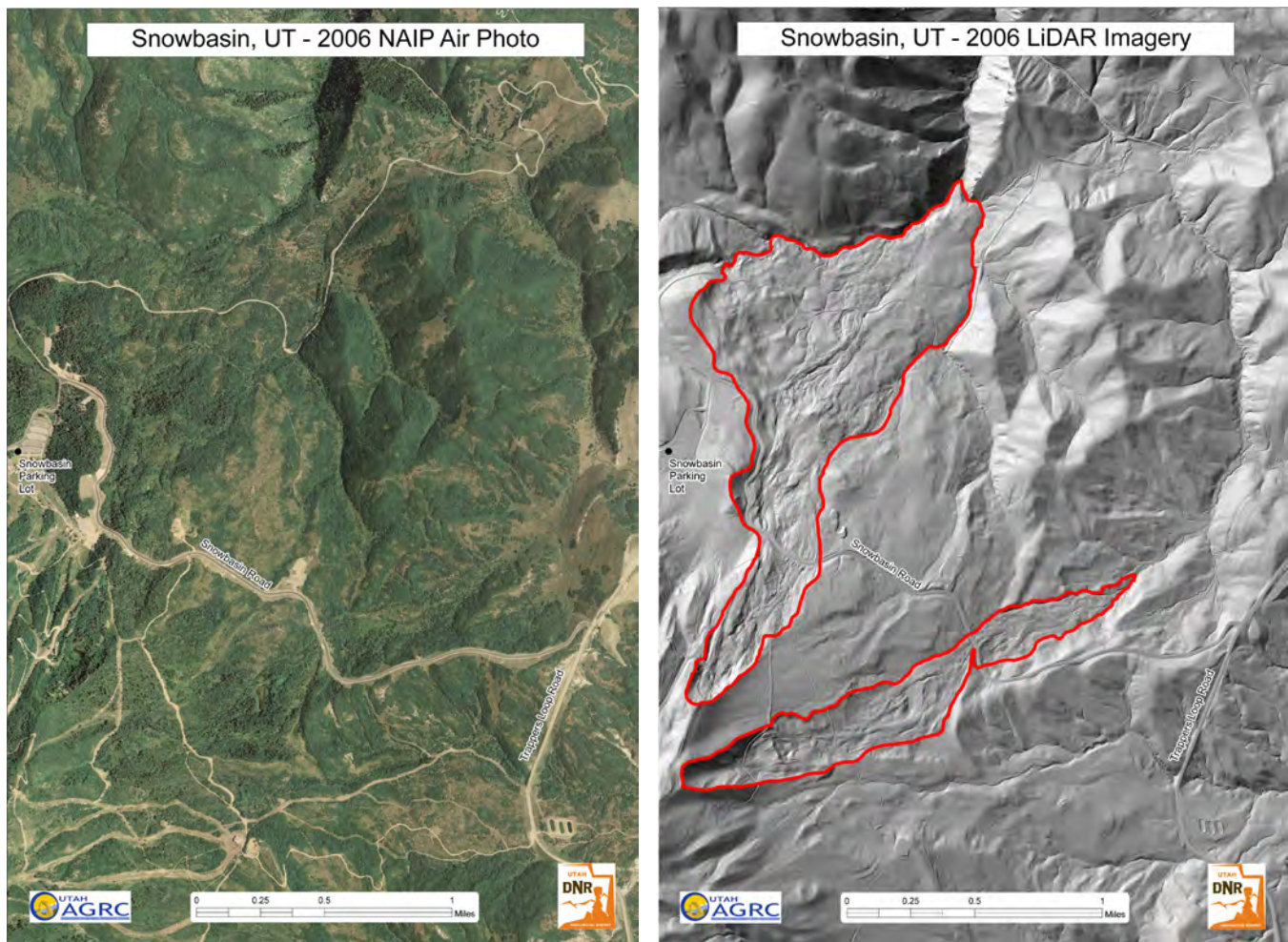


Figure C1. Comparison of 2006 National Agriculture Imagery Program (NAIP) 1-meter color orthophoto imagery (left) and 2006 2-meter airborne lidar imagery (right) in the Snowbasin area, Weber County, Utah. Red lines outline the Green Pond and Bear Wallow landslides that are clearly visible in the lidar imagery, but barely visible to undetectable in the NAIP imagery. Data from the Utah Automated Geographic Reference Center (AGRC) (2006a, 2006b), and graphics generated by the Utah Geological Survey, Geologic Hazards Program, undated.

Lidar data acquired from the reflected laser pulses (figures C6 and C7) are converted to raw point cloud data—a collection of range measurements (straight-line distance from platform system to the imaged ground surface) and sensor orientation parameters (Fernandez and others, 2007) in the lidar system. The intensity of returned laser pulses can also be used to determine general surface texture, although ground surface classification can be difficult.

For use in elevation and most geologic studies, the point cloud data must first be converted to bare-earth data that have vegetation and other non-native features (buildings, etc.) removed, and then be georeferenced to a coordinate system. The point cloud data are converted by using the range and orientation of each laser shot (pulse) to place the shot in a three-dimensional reference frame (Fernandez and others, 2007). Bare-earth lidar data may then be processed by a variety of remote sensing image software to develop DEMs, shaded-relief hillshade and slopeshade images at various sun (illumination) angles, or a combination of these image types. Hillshade images show the ground surface illuminated from a particular angle, in a line-

of-sight style. Slopeshade images show the ground surface slope angle with steep slopes shaded and shallow slopes illuminated so topography is not masked by illumination shadow. Digital surface models (DSM) can also be produced that retain vegetation and non-native features, representing the highest return of the imaged surface. Often, numerous shaded-relief images with different illumination angles are needed for interpretation of fault scarps, landslides, and other geologic features, due to different feature aspect angles and will vary with each project and the feature(s) of interest.

Lidar Data Acquisition and Specifications

Acquisition of new lidar data should follow specifications matching the specific project for which it is acquired. The U.S. Geological Survey (USGS), in partnership with several other organizations, developed a comprehensive lidar acquisition, processing, and handling specification (Heidemann, 2018; <https://pubs.usgs.gov/tm/11b4/>) suitable for most geologic projects and is widely used. In addition, the Federal Emergency Management Agency (FEMA) developed standards for li-

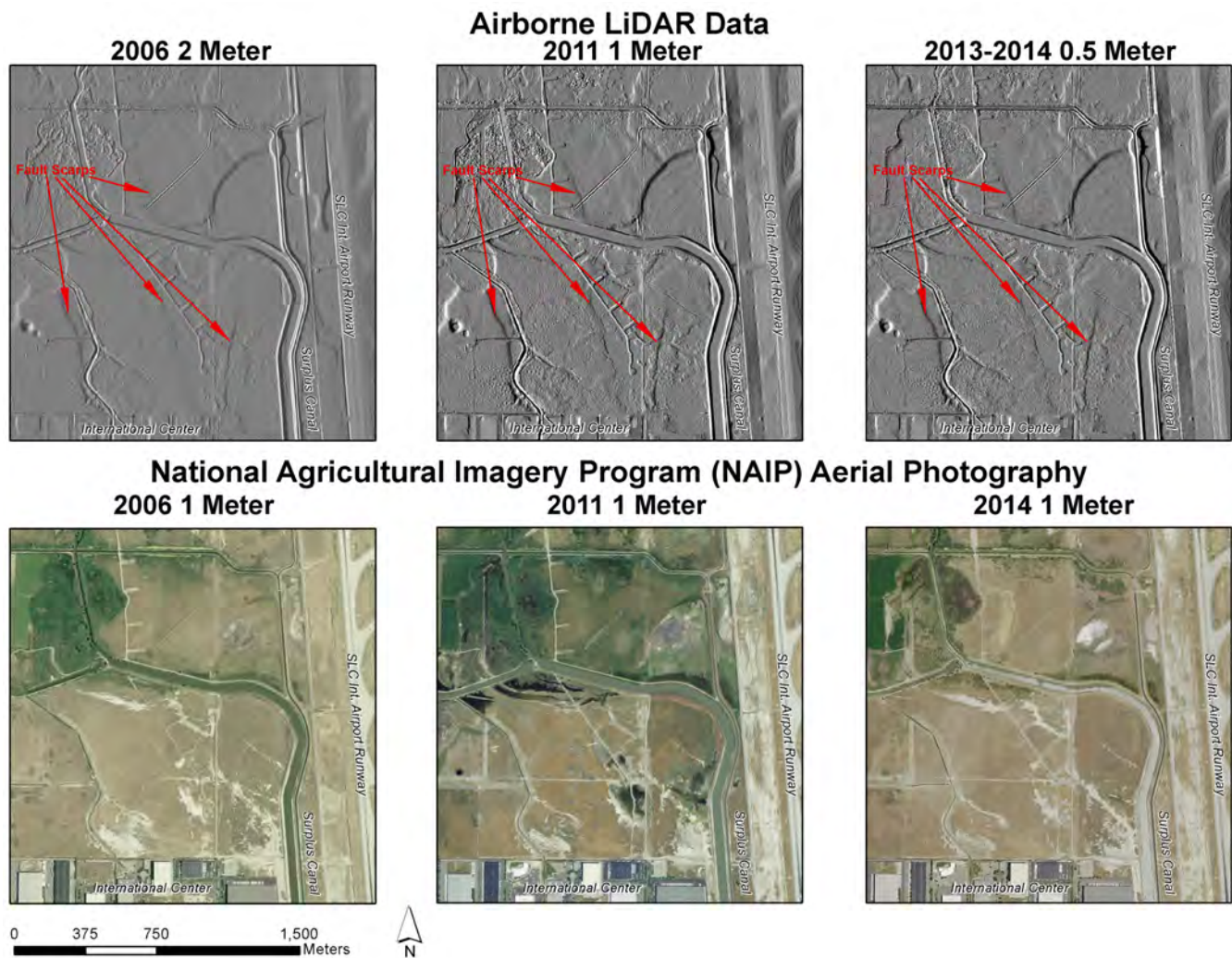


Figure C2. Comparison of 2006 (2 meter), 2011 (1 meter), and 2013–2014 (0.5 meter) airborne lidar imagery (top row) to 2006, 2011, and 2014 (1 meter; bottom row) National Agriculture Imagery Program (NAIP) imagery in the International Center area, Salt Lake City, Utah. Fault scarps indicated by red arrows show traces of the Granger fault, West Valley fault zone, that are clearly visible in the lidar imagery, but barely visible to undetectable in the NAIP imagery. Salt Lake International Airport visible to the right on each image. Data from the AGRC (2006b, 2009).

dar data used in flood mapping analyses included in RiskMap (Bellomo, 2010) that integrate with the USGS specification. One-meter or better ground cell size data is often needed for detailed landslide, fault, and other geologic investigations as shown on figure C2.

The Utah Geological Survey (UGS) and Utah Automated Geographic Reference Center (AGRC) partners with other governmental agencies to acquire lidar data in Utah, and collectively has acquired over 44,898 square miles of 0.5- and 1-meter data. If lidar data is acquired for a specific project, we suggest consider donating the data to AGRC for public distribution (contact information available at <https://gis.utah.gov/about/contact/>) once the project is complete.

Issues with Lidar Acquisition and Processing

Variable vegetation and tree canopy cover density and thickness and/or steep, mountainous terrain can result in difficult

post-acquisition processing of the raw lidar data to bare-earth data. Vegetation-related issues can introduce additional height error and may cause additional scattering of the transmitted laser pulse, resulting in less laser energy reflected back to the receiving sensor. Various laser backscatter methods may be used to resolve canopy height issues. Increased flight line overlap may be needed in steep, mountainous areas to ensure adequate ground point density and to minimize potential shadow areas. These issues can be reduced with good project specifications, should be addressed by the data acquisition vendor prior to data delivery, and should be checked during a quality control process by the data purchaser before final data acceptance.

LIDAR DATA AVAILABILITY AND ANALYSIS

Lidar coverage in Utah is mainly limited to urban areas, and has predominantly been collected for FEMA RiskMap flood map-

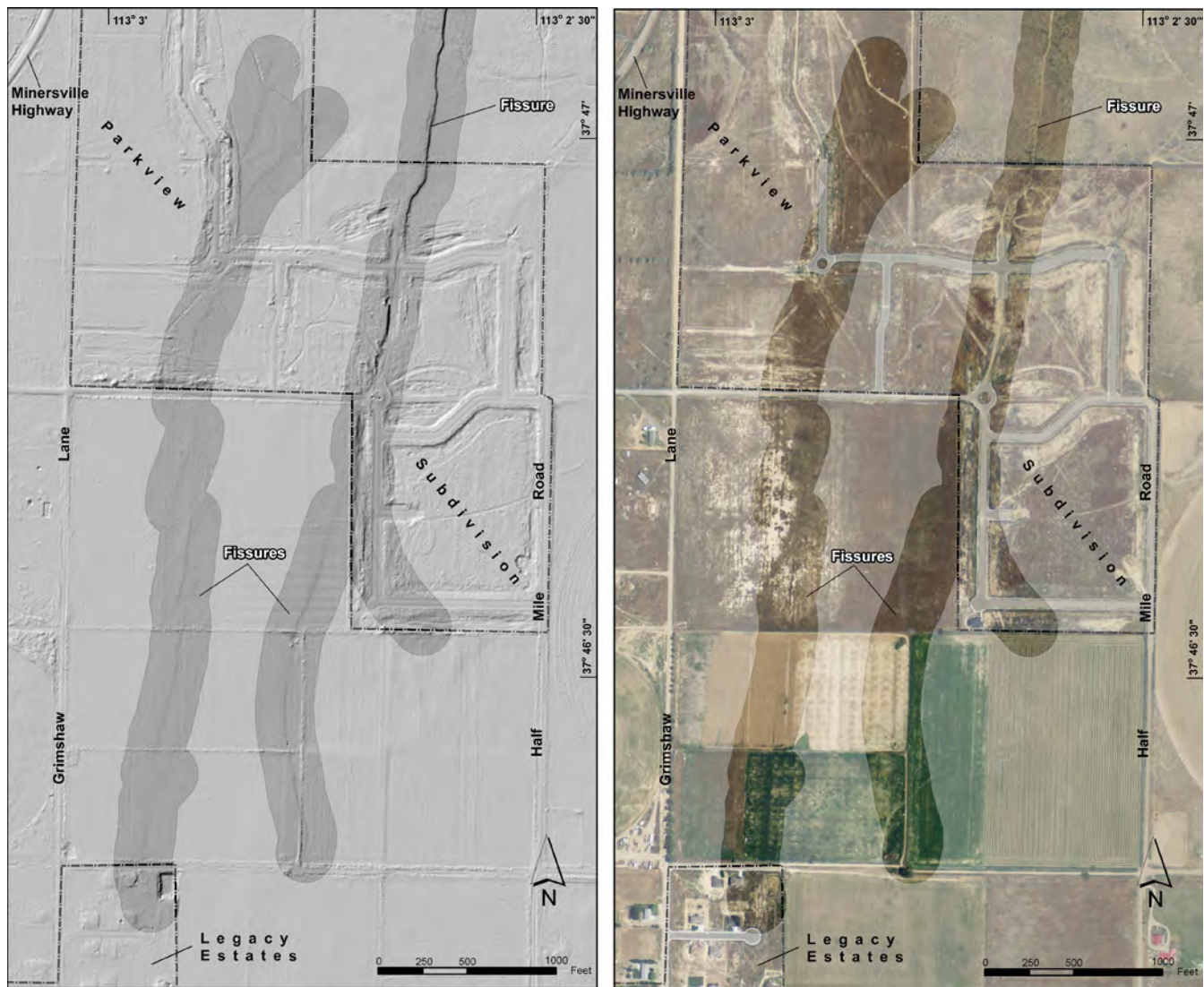


Figure C3. Comparison of 2011 bare-earth lidar image (left; Knudsen and others, 2014, data from UGS, 2011) and 2011 National Agriculture Imagery Program (NAIP; AGRC, 2011) 1-meter color orthophoto imagery (right) showing where Enoch-graben-west fissures intersect the Parkview and Legacy Estates subdivisions. Fissures that are clearly identifiable in the lidar image are barely visible to undetectable in the NAIP imagery, particularly in the southern half of the image. Shading added to highlight fissure traces. Graphics generated by Tyler Knudsen, Utah Geological Survey, Geologic Hazards Program, 2014.

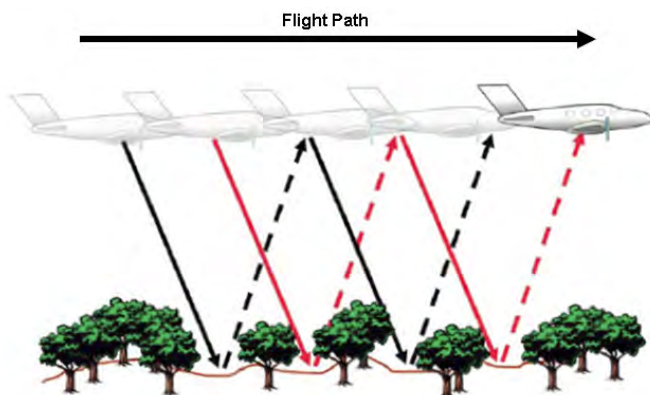


Figure C4. General imaging geometry of an airborne lidar instrument. Dashed lines indicate reflected laser pulses that may be detected if sensor crosses the reflected path (modified from Leica Geosystems, 2008b).

ping projects, land-use planning, and fault trace mapping. Available data is generally 1- to 2-meter ground cell size in bare-earth, digital elevation model format. However, high-quality 0.5-meter data acquired in 2013–2014 by the UGS, AGRC, and other partners, is now available for Salt Lake and Utah Valleys, and along the entire Wasatch and West Valley fault zones. Raw point cloud data for some areas may be available. Available data coverage can be searched using the AGRC Raster Data Discovery Application (<https://mapserv.utah.gov/raster/>) or <ftp://ftp.agrc.utah.gov/LiDAR/>, and OpenTopography (<https://www.opentopography.org>), a National Science Foundation-supported portal to high-resolution topography data and analysis tools.

Lidar data are not directly viewable without suitable software, such as Global Mapper (<https://www.bluemarblegeo.com/products/global-mapper.php>), Fusion (<http://forsys.cfr.washington.edu/fusion/fusionlatest.html>), FugroViewer



Figure C5. Leica ALS70 lidar instrument mounted in a Piper Navajo aircraft used for the 2013 Utah acquisition by the Utah Geological Survey and partners (photo credit: Watershed Sciences, Inc.)

(<https://www.fugroviewer.com/>), and ESRI ArcGIS. Data from OpenTopography may be processed online to Google Earth KMZ files using user-selected parameters (such as hillshade altitude and azimuth), and is generally the easiest way to access the data for most users without the use of specialized software.

UGS Lidar Data

The UGS acquires lidar data with its partners in support of various geologic mapping and research projects. In 2011, approximately 1902 square miles (4927 km²) of 1-meter lidar data was acquired for the Cedar and Parowan Valleys, Great Salt Lake shoreline/wetland areas, Hurricane fault zone, Lowry Water area, Ogden Valley, and North Ogden, Utah. The 2011 lidar acquisition was performed by Utah State University, LASSI Service Center through a partnership with AGRC and the Utah Division of Emergency Management (UDEM).

In late 2013, the UGS and its partners acquired 0.5-meter lidar of Salt Lake and Utah Valleys, the West Valley fault zone, and along the entire length of the Wasatch fault zone from north of Malad City, Idaho, south to Fayette, Utah. The 2013 lidar acquisition was performed by Watershed Sciences, Inc. through a partnership with AGRC, USGS, Salt Lake County Surveyors Office, and UDEM.

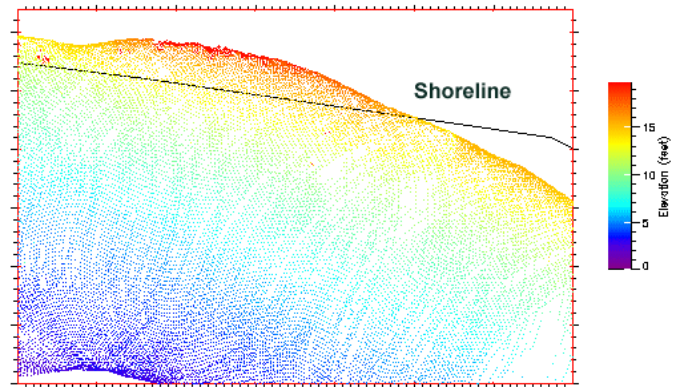


Figure C6. Scanning swath from the ATM-2 lidar scanner showing oscillating scanning motion (modified from National Oceanic and Atmospheric Administration, 2008). Individual laser data points are shown as colored dots.

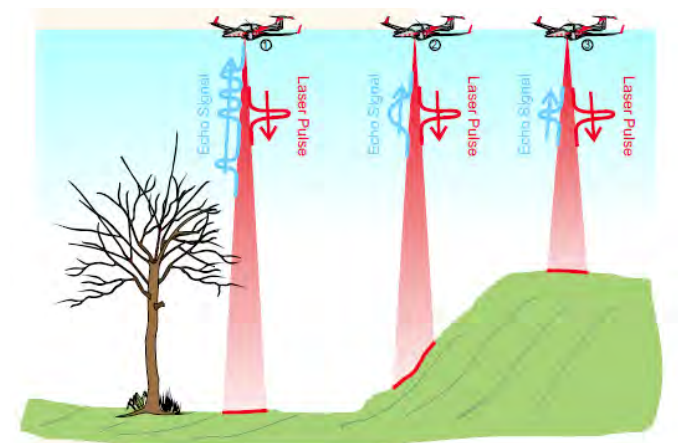


Figure C7. Typical lidar transmitted and received pulses for flat, but partially obscured; sloping; and flat, smooth terrain from left to right (modified from Riegl Laser Measurement Systems GmbH, 2010).

The 2011 datasets include raw LAS (industry standard lidar format), LAS, DEM, DSM, and metadata (XML metadata, project tile indexes, and area completion reports) files. This lidar data is available from the AGRC Raster Data Discovery Application (DEM data and metadata only, <https://mapserv.utah.gov/raster>), is included in the USGS National Elevation Dataset (<https://ned.usgs.gov/>) that is part of The National Map (DEM data and metadata only, <https://nationalmap.gov/viewer.html>), and OpenTopography (all data and metadata, <http://www.opentopography.org/id/OTLAS.042013.26912.1>).

The datasets acquired by the UGS and its partners are in the public domain and can be freely distributed with proper credit to the UGS and its partners. For more information about UGS lidar acquisitions and data, see <https://geology.utah.gov/map-pub/data-databases/lidar/>.

Data Analysis

Bare-earth lidar data can be used to create DEMs (often supplied by the vendor), and subsequently to determine ground

subsidence and for ground surface modeling, and/or hillshade and slopeshade images that can be used for geologic feature mapping, such as landslides (figure C1), faults (figure C2), scarps (figures C1 and C2), shorelines, etc. Often, numerous shaded-relief (hillshade and slopeshade) images with different illumination angles are needed for interpretation of fault scarps, landslides, and other geologic features, due to different feature aspect angles and will vary with each project and the feature(s) of interest. Use of GIS software will assist with geologic mapping, by allowing various data sets, such as aerial orthoimagery, to be overlain on the lidar data.

Landslides

Landslides may be difficult to detect using aerial photography in vegetated areas, as illustrated on figure C1. Bare-earth DEMs with hillshade and/or slopeshade illumination methods are often used to delineate landslides and internal landslide features. McDonald and Giraud (in preparation) used 1-meter lidar data in the Lowry Water area of the Wasatch Plateau to map and inventory landslides at a scale of 1:12,000 in a densely vegetated (conifer forest and brush) area.

Faults

Traditionally, faults have been mapped using a combination of low-sun-angle (preferably stereoscopic) aerial photography and field reconnaissance. Additional information on aerial photography is available in chapter 2 of this publication. However, small fault scarps may not be visible on aerial photography, and/or barely visible in the field. A lidar-derived slopeshade image with a slope gradient from 0 to 45 degrees (white to black) is often useful in mapping. McKean and Hylland (2013) used 1-meter lidar data near Great Salt Lake for mapping subtle fault scarps that were not apparent on aerial photography, and were very difficult to recognize in the field, as a part of geologic mapping of the Baileys Lake quadrangle. Starting in 2014, the UGS mapped traces of the Wasatch fault zone at a scale of 1:10,000 using 0.5-meter lidar data (Harty and McKean, 2015; Hiscock and Hylland, 2015). Fault trace mapping at this level of detail and scale would not be possible without high-quality lidar data.

Earth Fissures

Lidar is often invaluable for mapping earth fissures. While larger earth fissures with significant vertical and/or horizontal displacement are often visible on aerial photography, smaller to “hairline” earth fissures are often not visible on aerial photography, due to little or no vertical displacement and/or contrast change across the fissure. Knudsen and others (2014) used 1-meter lidar data of Cedar Valley to map over 8.3 miles of earth fissures, while previous aerial-photography-based mapping only revealed 3.9 miles of fissures.

Ground Subsidence

For determining ground subsidence, at least one repeat data acquisition is required to determine the magnitude using lidar data. However, several repeat acquisitions would be necessary to determine the ongoing rate of ground subsidence over a specified time period. These acquisitions must be timed correctly to avoid snow cover and to have similar vegetation coverage conditions to ensure similar data processing of each lidar acquisition. Once two or more DEMs are available over an area, they can be subtracted from each other to determine the change in elevation over a given time period. By using three or more DEMs and the corresponding elevation differences, an estimate of the rate of change in elevation can be determined.

The rate of change may also be influenced by seasonal changes in groundwater levels and ground temperature that may overprint ground subsidence changes, as soil material volume changes result in an inflation or deflation signal. The major drawbacks to this method are the relatively high cost of lidar data when used in a repeat acquisition application and the variable vertical accuracy of the data, which can be significant if data acquisition is not carefully controlled.

CONCLUSIONS

Lidar is a valuable new tool for detecting, mapping, and understanding geologic hazards, particularly in areas that are difficult to access and/or visually observe, and is often critical to use in highly vegetated areas. Lidar has allowed the mapping of many geologic hazards at unprecedented levels of detail that was not possible previously using traditional methods. Geologic hazard investigations should utilize lidar data whenever possible, and on large and/or complex projects where data does not currently exist, lidar data acquisition should be seriously considered with data donated to the public domain where possible.

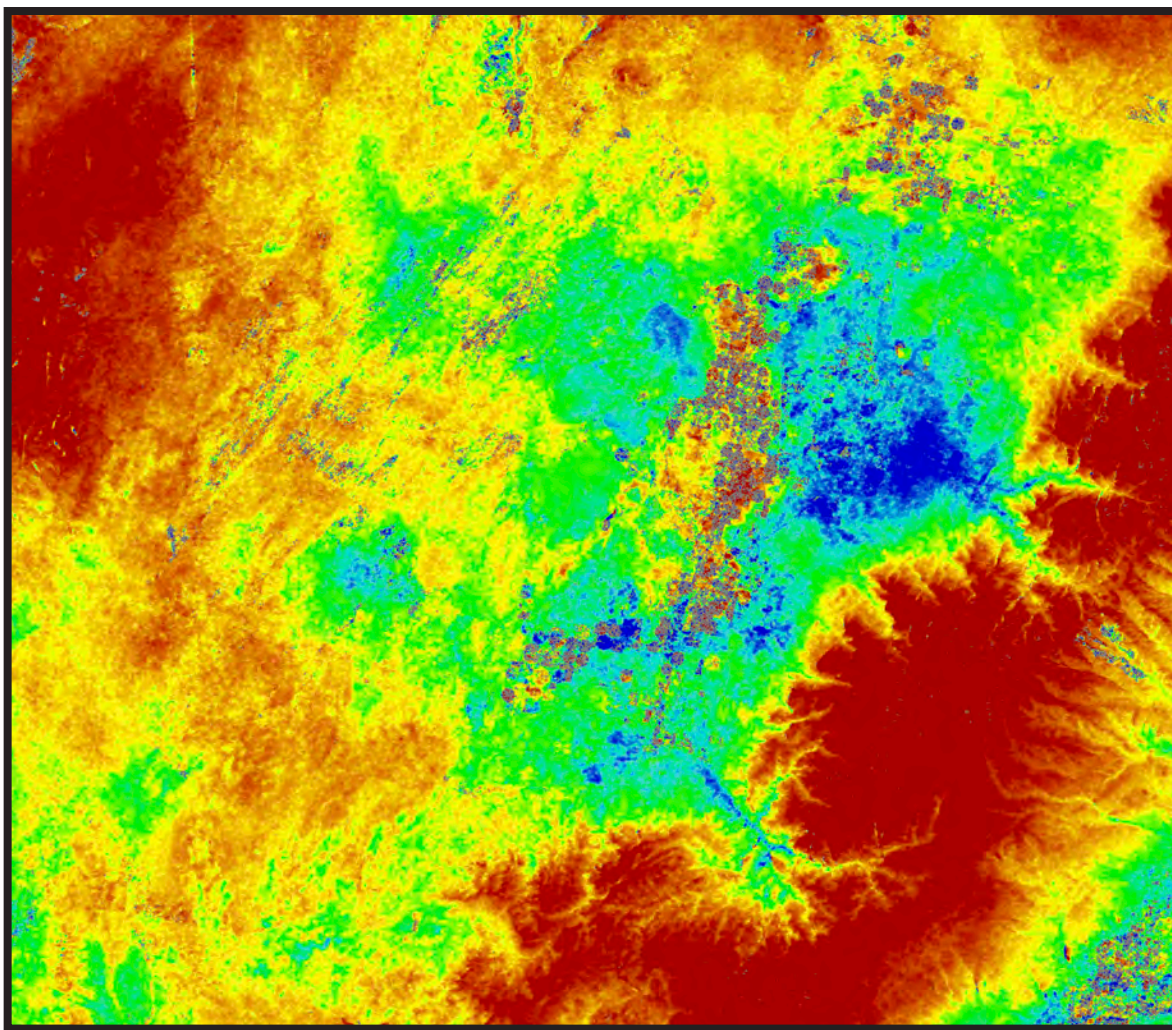
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APPENDIX D

INTERFEROMETRIC SYNTHETIC APERTURE RADAR (INSAR) BACKGROUND AND APPLICATION



InSAR interferogram of Cedar Valley, Utah, and vicinity.

Suggested citation: Bowman, S.D., 2020, Interferometric synthetic aperture radar (InSAR) background and application, *in* Bowman, S.D., and Lund, W.R., editors, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, second edition: Utah Geological Survey Circular 128, appendix D, p. 217–224, <https://doi.org/10.34191/C-128>.

INTERFEROMETRIC SYNTHETIC APERTURE RADAR (INSAR) BACKGROUND AND APPLICATION

by Steve D. Bowman, Ph.D., P.E., P.G.

INTRODUCTION

Radar interferometry is a process of using phase differences between two or more correlated radar images over the same area to measure surface displacements or topography. Interferometric synthetic aperture radar (InSAR) may now be applied worldwide, due to the availability of high-quality interferometric datasets from various spaceborne (ERS-1, ERS-2, JERS-1, ALOS, ALOS-2, Radarsat-1, Radarsat-2, ENVISAT, SRTM, SIR-C, TerraSAR-X, TanDEM-X, and COSMO-SKYMED) and airborne platforms. Only ALOS-2, Radarsat-2, Sentinel-1, TerraSAR-X, TanDEM-X, and COSMO-SKYMED satellites are still operational; ERS-1, ERS-2, ENVISAT, Radarsat-1, ALOS, and JERS-1 have failed.

InSAR Spaceborne Acquisition Platforms

The United States does not have operating synthetic aperture radar (SAR) satellites and relies on research and academic data access agreements with the European Space Agency (ESA), the Canadian Space Agency (CSA), and others. Commercial users must purchase all SAR data. However, the United States (National Aeronautics and Space Administration [NASA]) operated the Shuttle Radar Topographic Mission (SRTM) during 11 days in February 2000, and the Shuttle Imaging Radar (SIR-C) mission during 11 days in April 1994, and again in September–October 1994, that flew aboard the Space Shuttle (Jet Propulsion Laboratory, 2010a, 2010b), along with several other radar satellite platforms that are no longer operational. NASA is currently investigating developing the L- and S-band NISAR radar satellite in a joint mission with the Indian Space Research Organization.

The ESA has a long history of SAR satellites, beginning with the launch of ERS-1 in July 1991, followed by a second edition of the satellite, the ERS-2, in April 1995 (ESA, 2008). During 1995 to 1996, the ERS-1 and ERS-2 satellite tandem mission was developed where the satellite space orbits were adjusted to support InSAR between ERS-1/2 image pairs. The ERS-1 and ERS-2 satellites failed in March 2000 (ESA, 2008) and September 2011 (ESA, 2012b), respectively. ESA launched the next-generation radar satellite ENVISAT (which also included other sensors) in March 2002 (ESA, 2010), that failed on April 8, 2012 (ESA, 2012a).

Japan, through their Japan Aerospace Exploration Agency (JAXA), developed the JERS-1 satellite that was launched on February 11, 1992, and ended operation on October 12, 1998 (JAXA, 2010a). JAXA launched the next-generation radar satellite ALOS on January 24, 2006, and ended operation in May 2011 (JAXA, 2010b). JAXA launched ALOS-2, the successor to ALOS, in May 2014 (JAXA, undated). Canada, through the CSA and a partnership with a private company, developed the Radarsat-1 and Radarsat-2 satellites with launches in November 1995 and December 2007, respectively (CSA, 2010). Radarsat-1 failed on March 29, 2013 (CSA, 2013). Germany, through the German Aerospace Center (DLR) and a partnership with a private company, developed the TerraSAR-X satellite that was launched on June 15, 2007 (DLR, 2009), and a tandem, almost identical satellite, TanDEM-X that was launched on June 21, 2010 (DLR, 2010).

InSAR BACKGROUND AND PROCESSING TECHNIQUES

First developed by Richman (1971) and Graham (1974) with very limited datasets, InSAR for mapping surface displacements and topography was later investigated by Zebker and Goldstein (1986), Gabriel and others (1989), Goldstein and others (1993), and many others who contributed new processing techniques. The mapping of coseismic displacements resulting from the 1992 Landers earthquake (Zebker and others, 1994) was one of the early applications of InSAR. Later applications included glacier monitoring, volcano deformation monitoring, landslide detection, subsidence monitoring, and other applications. Hanssen (2001) used InSAR to map the displacement field of the Cerro Prieto geothermal field in Mexico, and documented about 8 cm/year (3.1 inches/year) of subsidence resulting from the extraction of water and steam for geothermal power production. Rosen and others (2000) gave an in-depth review and discussion of InSAR concepts, theory, and applications.

Use of InSAR requires an interferometric dataset, a suitable temporal and spatial baseline, and images that correlate together (matching similar locations in each image). InSAR may be applied in one of two methods: differential or topographic interferometry. Differential InSAR measures small-scale ground displacements due to subsidence, earthquakes, glacier movements, landslides, and other ground movement with the effects of topography removed. Topographic InSAR

measures ground topography with no ground displacement, resulting in a digital elevation model (DEM). A DEM can be thought of as a three-dimensional topographic map. Differential InSAR can measure displacements to sub-centimeter accuracy and topographic InSAR can measure topography to tens of meters, depending on sensor and platform characteristics. As shown on figure D1, two satellite image acquisitions with slightly different satellite locations (defined as Orbit 1 and Orbit 2 locations) are needed for InSAR.

InSAR Theory

Radar interferometry works by measuring the phase differences of two complex-format radar images or images that retain phase information (real and imaginary electrical components of the reflected radar signal). Standard radar images do not retain phase information and cannot be used in InSAR processing and analysis. The interferometric phase, ϕ is defined as:

$$\phi = \phi_1 - \phi_2 = \frac{4\pi}{\lambda} (\rho_2 - \rho_1)$$

where ϕ_1 = phase of Image #1, ϕ_2 = phase of Image #2, λ = radar wavelength, ρ_1 = range of Image #1, and ρ_2 = range of Image #2 (Rosen and others, 2000). Figure D2 shows the imaging geometry of a radar satellite during data acquisition, including the range direction.

The two complex-format radar images typically have short temporal and spatial baselines—the time between the two image acquisitions and the distance between the imaging locations (satellite three-dimensional position) of the two images, respectively. The two images must also cover nearly the same area on the ground surface. The critical baseline, B_c or maximum baseline distance that can be processed, is defined as:

$$B_c = \frac{\lambda r}{2 * R \cos \theta}$$

where λ = radar wavelength, r = radar path length, R = ground range resolution, and θ = local incidence angle (Hanssen, 2001).

2001). Table D1 shows the common spaceborne radar platforms and operating radar bands. For C-band systems, $B_c \sim 1100$ m; L-band systems, $B_c \sim 4500$ m; and X-band systems, $B_c \sim 100$ m. The actual usable baseline for ERS-1/2 and Radarsat-1/2 (C-band platforms) is typically 500–600 m or less. Two radar images that generally match the above characteristics can form an interferometric pair.

InSAR data processing generally begins with raw sensor data, or single-look complex (SLC) data, and involves raw data processing and co-registering two or more images. The second image (and others if used) must be precisely aligned with the first image with sub-pixel accuracy; otherwise, additional

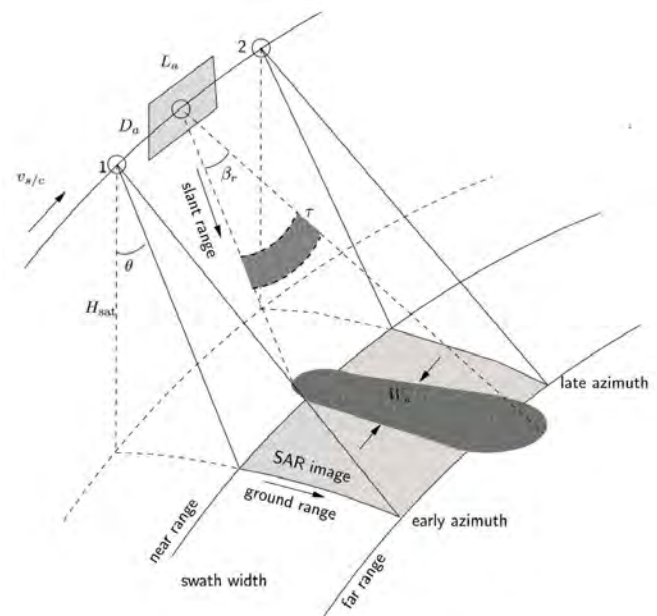


Figure D2. Imaging geometry of a radar satellite. As the satellite moves in a forward direction (to the upper right in the figure), the satellite images the light gray swath on the ground surface. The dark gray area on the ground surface indicates the area covered by a single radar pulse (modified from Hanssen, 2001).

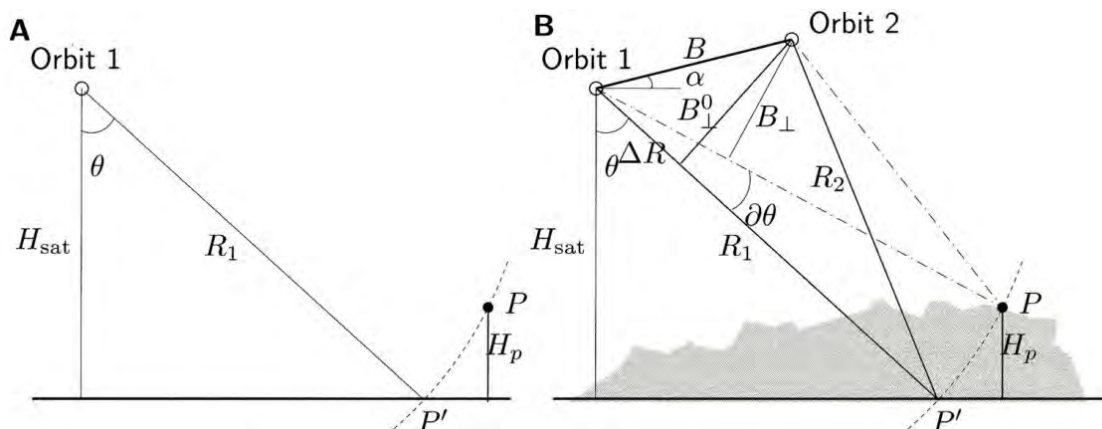


Figure D1. Satellite geometry for single-pass (A) and interferometric (B) radar acquisition. Using two different satellite space positions allows for the height difference, H_p to be determined (modified from Hanssen, 2001).

Table D1. Radar bands, wavelengths, and InSAR spaceborne platforms showing year date ranges of operation and launch/operating country.

Radar Band	Wavelength Range (cm)	Civilian Space InSAR Platforms ^{1,2}	
		Non-Operational	Operating
X	2.4 – 3.8	X-SAR (SIR-C, 1994, USA) STRM (2000, USA)	TerraSAR-X (2007+, Germany/EU) TanDEM-X (2010+, Germany/EU) COSMO-SkyMed 1 (2007+, Italy/EU) COSMO-SkyMed 2 (2007+, Italy/EU) COSMO-SkyMed 3 (2008+, Italy/EU) COSMO-SkyMed 4 (2010+, Italy/EU) KOMPSAT-5 (2013+, South Korea)
C	3.8 – 7.5	ERS-1 (1991-2000, EU) ERS-2 (1995-2011, EU) SIR-C (1994, USA) ENVISAT (2002-2012, EU) Radarsat-1 (1995-2013, Canada) RISAT-1 (2012–2017, India)	Radarsat-2 (2007+, Canada) Sentinel-1A (2014+, EU) Sentinel-1B (2016+, EU)
S	8 – 15	--	Proposed: NISAR (USA/India)
L	15 – 30	Seasat ³ (1978, USA) JERS-1 (1992-1998, Japan) SIR-C (1994, USA) ALOS (2006-2011, Japan)	ALOS-2 (2014+, Japan) SAOCOM 1A (2018+, Argentina) Proposed: SAOCOM 1B (2019?, Argentina) Proposed: NISAR (USA/India)

¹ EU – European Union, USA – United States of America.

² All systems are satellite-based, with the exception of SIR-C and SRTM, which were flown on the now-defunct Space Shuttle.

³ The USA's only civilian radar satellite, Seasat, operated for 105 days in 1978 (JPL, 1998). Seasat data has been used in some InSAR analysis; however, the data was never intended to be used for InSAR, custom processing software is required, and products are relatively poor when compared to more modern data products.

error is introduced into the process and later processing steps will fail. After co-registration, the complex phase information of the first image is multiplied by the conjugate (inverse) phase of the second image to generate an interferogram or interference image.

The interferogram contains topographic and ground displacement information with each cycle of phase (or phase change of 0 to 2π radians) representing a specific quantity of change. At this point in the processing chain, the interferogram is in radar coordinates, which later must be registered to ground coordinates (such as latitude/longitude, Universal Transverse Mercator [UTM], or other coordinate system).

Phase Unwrapping

One of the most difficult steps in InSAR processing is the phase unwrapping process. This process utilizes the phase information from the interferogram to determine the magnitude of surface displacements or topography (depending on the analysis method) present in the image. Phase unwrapping may use branch-cut, least squares, and error minimization criteria methods (Rosen and others, 2000). Branch-cut methods utilize phase differences and integrating that difference. The phase-unwrapped solution should be independent of the path of integration (Madsen and Zebker, 1998); however, this may not always be the case. Phase residues may result from this process, across which phase unwrapping is not possible. If an area is enclosed by these errors, the area will not be unwrapped, and no information will be obtained. Many of the branch-cut

algorithms are automated and do not require user intervention during processing. An existing DEM, which must cover all of the ground area covered in the radar image, is often used to generate seed points to help in automatic guiding of the phase unwrapping process. Least squares phase unwrapping follows the general procedures of the branch-cut methods, but with least-squares estimation.

Figure D3 shows a final, unwrapped, geocoded interferogram from Envisat data of Cedar Valley (Iron County) and the surrounding region. Specific color fringes in the Beryl-Enterprise area, Quichipa Lake, and Enoch graben show vertical displacement directly related to ground subsidence. The variable colors in the rest of the image are the result of incomplete removal of topography and/or atmospheric noise in the data.

After phase unwrapping of the interferogram and depending on the analysis method used, a displacement map may be generated if the effects of topography are removed using an existing DEM, or a DEM may be created if the interferogram contains little to no surface displacements.

Issues With InSAR Processing

Problems associated with InSAR are chiefly (1) shadowing present in the original radar data from topographic relief (particularly when applied to mapping mountainous areas where steep mountains block the inclined radar signal), and (2) decorrelation caused by changes in the imaged area. These changes may be due to freezing, thawing, precipitation, vegetation,

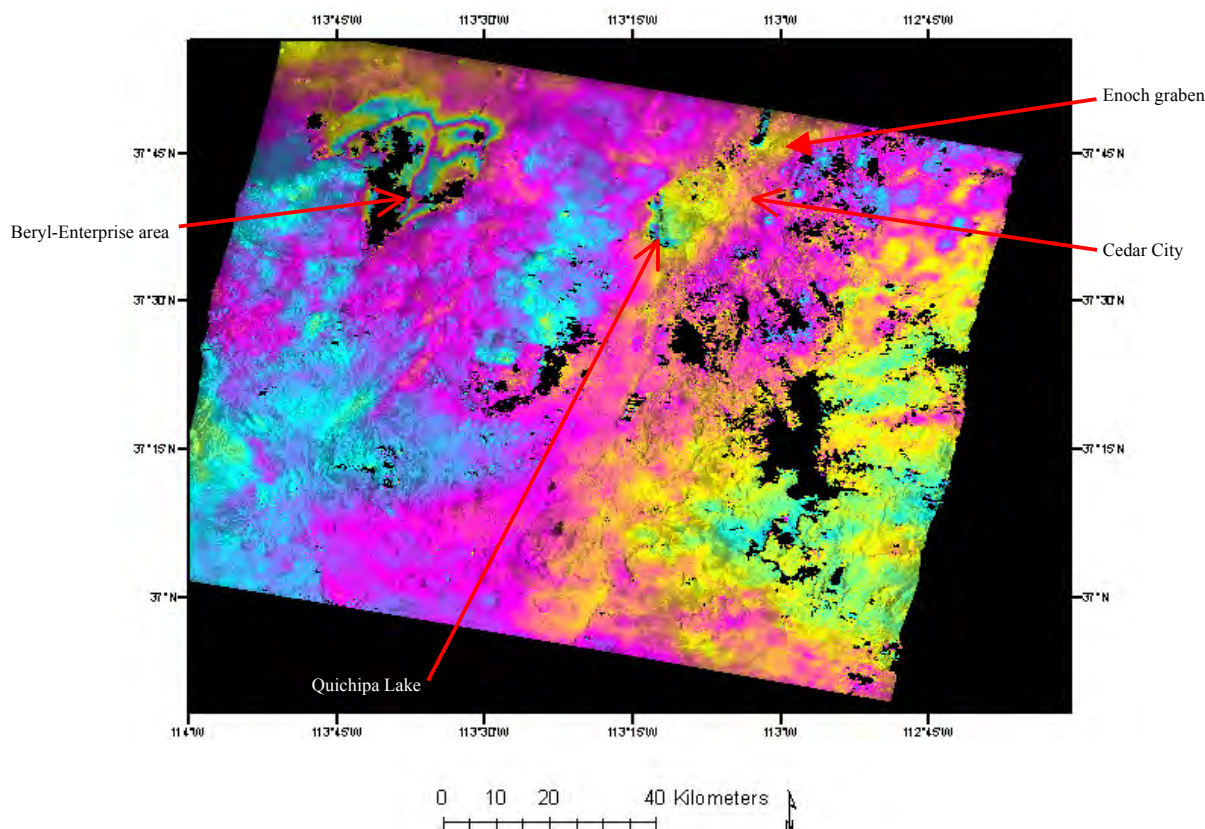


Figure D3. Unwrapped interferogram of an entire Envisat frame, processed by the UGS, covering the time period of August 11, 2009, to August 31, 2010, showing significant subsidence near Quichipa Lake, Enoch graben, and the Beryl-Enterprise area resulting from groundwater withdrawal. Each specific color cycle represents 3 cm of deformation; the variable colors in the rest of the image are the result of incomplete removal of topography and/or atmospheric noise in the data. Area outside the Envisat frame shown in black on the edges; black areas within interferogram denote areas of no data from shadowing or from no correlation between the two images used to create the interferogram. Envisat data ©2009, 2010 European Space Agency.

wind, motion of water, and human-induced changes, such as changes in land use. Agricultural fields are constantly changing due to vegetation (crop) changes in height and size, and from tilling of fields that may cause significant decorrelation. Vegetated areas may also exhibit decorrelation, due to wind moving vegetation, such as in forests.

Increased time between two radar image acquisitions will result in increased temporal decorrelation and is directly related to ground surface parameters. Zebker and Villasenor (1992) found that increasing the time between acquisitions decreased correlation significantly for lava flows and forests in Oregon; however, the Death Valley, California, valley floor did not experience this correlation decrease. Some geographic areas typically have low temporal decorrelation, including many desert and low-vegetation-density areas; high-temporal-decorrelation areas include many moderately to highly vegetated and/or forested areas, active agricultural lands, and other areas subject to surface disturbance. Persistent scatterers, a relatively new technique utilizing point scatterers (Hooper and others, 2004), may be used to match common points between radar images, such as the centers of pivoting agricultural sprinklers, reflective metallic objects that may act as near-corner reflectors, or other stationary reflective objects.

SAR DATA AVAILABILITY AND PROCESSING

SAR data suitable for use in differential interferometric processing is available for many areas in Utah from ESA (ERS-1, ERS-2, and ENVISAT) and Japanese (ALOS and ALOS-2) satellites. InSAR satellites have commonly been designed, launched, and managed by joint government-commercial funding and operation agreements, and as such, two cost levels of data exist. Academic and government researchers typically acquire data through governmental agreements and partnerships, with data access proposals often required. All other use requires commercial purchase from private vendors, and all data is typically subject to third-party data transfer restrictions. Commercial purchases of ERS-1, ERS-2, and ENVISAT data in the existing ESA data archive cost approximately \$560 per scene (2013).

Due to the large amount of data generated by a radar system, available satellite on-board data storage, and high power (electrical) use of a radar system, radar data is not continuously acquired as in other imaging satellites, such as the Landsat series (1-7). Rather, specific, pre-determined areas of the Earth's surface are imaged on each path of the satellite within

the power and data storage capabilities of the satellite. These pre-determined areas are based on requirements of the satellite program, scientific investigator requests, and commercial purchases. In many cases, radar data are downlinked to ground stations within radio receiving range (ground station mask), so additional data may be acquired beyond the limits of on-board data storage, or are transmitted to a satellite communications network that in turn transmits to ground stations. This pre-planning and equipment adds additional cost to new data acquisitions, which is reflected in the higher cost of new acquisitions to the end-user.

Data Analysis and Applications

Due to the complexities of processing InSAR data, and that most InSAR processing software is generally expensive (commercial versions) or difficult to obtain (due to licensing and/or export restrictions), prospective users of InSAR should seek out a competent remote sensing researcher familiar with InSAR data and processing.

InSAR is particularly suited to detecting and monitoring ground deformation, such as that caused by seismic deformation and groundwater-withdrawal- or mining-induced land subsidence. Prior to the widespread use of lidar, InSAR was used to create DEMs, and is still used to create DEMs of large areas today, such as in Alaska and Antarctica, although with lower resolution (larger ground cell size) than lidar.

Seismic Deformation

Detecting and monitoring seismic deformation was one of the early applications of InSAR, including the 1999 M_w 7.1 Hector Mine, California, earthquake (Simons and others, 2002). However, InSAR has yet to be applied in Utah for seismic deformation as no active faults in the state are known to creep, and a surface rupturing earthquake has not occurred in Utah since InSAR data have become available.

Ground Subsidence

InSAR has been applied to detecting and monitoring ground subsidence throughout the Intermountain West, including for groundwater-withdrawal-induced subsidence in Utah (Forester, 2006, 2012; Knudsen and others, 2014), Nevada (Katzenstein, 2008), and Arizona (Arizona Department of Water Resources, undated). Interferograms and derivative ground deformation maps can be used to show areas and magnitudes of ground deformation that can assist with developing detailed ground deformation monitoring and groundwater management programs.

deformation, such as that caused by seismic deformation and groundwater-withdrawal- or mining-induced land subsidence. Large surface areas can be covered with repeat coverages, allowing time-series analysis of deformation. InSAR has allowed the mapping of ground deformation at unprecedented levels of detail over large regional areas that was not possible previously using traditional methods.

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CONCLUSIONS

InSAR is a valuable, evolving tool for detecting, mapping, and understanding geologic hazards, particularly related to ground

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APPENDIX E

GEOLOGIC HAZARD MODEL ORDINANCE



Mississippian and Tertiary bedrock (left) is mantled by Lake Bonneville gravels above Salt Lake City. The Warm Springs fault scarp, where not removed by aggregate mining, trends along the right side of the photograph towards downtown. Photo by Adam McKean.

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GEOLOGIC HAZARD MODEL ORDINANCE

by Steve D. Bowman, Ph.D., P.E., P.G.

The Geologic Hazard Model Ordinance by the Utah Geological Survey (UGS) is based on work with Morgan County in updating their geologic hazards ordinance, and prior geologic hazard ordinances used in Draper City, Salt Lake City, and Salt Lake County, Utah. The current Morgan County ordinance was developed by Lance Evans, Elliott Lips, Andy Harris, Mark Miller, Rich Giraud, and Steve Bowman, based on the prior county ordinance and extensive new information. Many individuals too numerous to list here have aided in preparing and writing the prior ordinances over the years and their work was critical in developing the current model ordinance. The model ordinance reflects the statewide adopted 2018 International Building Code and related standards.

The Geologic Hazards Model Ordinance presented below was made to be easily adaptable to conditions in Utah cities and counties. The UGS has not published comprehensive geologic hazard maps for all of Utah. However, Geologic Hazard Study Areas are defined in the ordinance for areas where current mapping is not available, based upon specific geologic and other conditions.

Adapting and Using the Model Ordinance

Sections of text within the model ordinance that need to be customized for each city or county are denoted in brackets []. Bracketed text as [x] should have the city or county name inserted in its place, as [unincorporated x/City/County] should have one word selected, and [various text] should be adjusted to your specific requirements. Some [various text] bracket text can be deleted, depending upon your specific situation. Text indicated as [list of geologic units specific to your area] delineate a list of specific geologic units from recent UGS mapping of your city or county that have characteristics contributing to the specific listed hazard.

GEOLOGIC HAZARD MODEL ORDINANCE

1.1 – Purpose

1.2 – Definitions

1.3 – Applicability

1.4 – Geologic Hazard Study Areas

1.5 – Geologic Hazard Investigations and Reports Required for Development

1.6 – Minimum Investigator Professional Qualifications

1.7 – Preliminary Activities

1.8 – Building Permits on Parcels Recorded Prior to the Effective Date of This Ordinance

1.9 – Geologic Hazard Investigations and Reports

1.10 – Geologic Hazard Investigation Field Review

1.11 – Submittal and Certification of Geologic Hazard Reports

1.12 – Disclosure When a Geologic Hazard Report is Required

1.13 – Warning and Disclaimer

1.14 – Change of Use

1.15 – Hold Harmless Agreement

1.16 – Conflicting Regulations

1.17 – References

1.1 – Purpose

The purpose of this geologic hazard ordinance is to promote and protect the health, safety, and welfare of the citizens of [x], protect the infrastructure and financial health of [x], and minimize adverse effects of geologic hazards to public health, safety, and property by encouraging wise land use and development.

1.2 – Definitions

As used in this geologic hazard ordinance, the following terms have the following meanings:

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 during a hazard event allowing occupants egress outside.

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 as buildings designed for human occupancy.

ACTIVITY CLASS OF FAULTS: The activity level of a fault is based on the latest Western States Seismic Policy Council (WSSPC) policy recommendation defining surface faulting (<https://www.wsspc.org/public-policy/adopted-recommendations/>). WSSPC Policy Recommendation 18-3 states that based on the time of most recent movement: latest Pleistocene-Holocene faults are defined as movement in the past 15,000 years, late Quaternary faults are defined as movement in the past 130,000 years, and Quaternary faults are defined as movement in the past 2,600,000 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 may also include a mixture of soil, rock, and/or organic debris that falls, slides, and/or flows rapidly downslope under the force of gravity.

BUILDABLE AREA: Based on an accepted geologic hazard investigation 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, and where structures may be safely located. Buildable areas must be clearly marked on approved site plans and/or final approved plats, as appropriate.

[CITY/COUNTY] COUNCIL: The [city/county] council of [x].

CRITICAL FACILITIES: Essential, hazardous, special occupancy, and all Risk Categories III and IV structures, as defined in the statewide adopted International Building Code (IBC), and lifelines, such as major utility, transportation, communication facilities, and their connections to critical facilities.

DEBRIS FLOW: A slurry of rock, soil, organic material, and water transported in an extremely fast and destructive manner that flows down channels and onto and across alluvial fans; includes a continuum of sedimentation events and processes, including debris flows, debris floods, mudflows, sheet flooding, and alluvial fan flooding.

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

ENGINEERING GEOLOGIST: A Utah-licensed Professional Geologist, who, through education, training, and experience, practices in the field of engineering geology and geologic hazards meeting the requirements of Section 1.6.

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

ESSENTIAL FACILITY: Buildings and other structures intended to remain operational in the event of an adverse geologic event, including all structures with an occupancy greater than 1000 shall also be considered IBC Risk Category III when not meeting the criteria for IBC Risk Category IV; and IBC Risk Category IV buildings and other structures are designated as essential (critical) facilities.

FAULT: A fracture in the Earth's crust forming a boundary between rock and/or soil masses that have moved relative to each other, due to tectonic forces. When the fracture extends to the Earth's surface, it is known as surface fault rupture, or a fault trace.

FAULT SCARP: A steep slope or cliff formed by movement along a fault.

FAULT SETBACK: A specified distance on either side of a fault within which structures for human occupancy or critical facilities and their structural supports are not permitted.

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 or other imagery.

FAULT ZONE: A corridor of variable width along one or more fault traces, within which ground deformation has occurred as a result of fault movement.

GEOLOGIC HAZARD: A geologic condition that presents a risk to life, of substantial loss of real property, or of substantial damage to real property (Utah Code 17-27a-103[19]: <https://le.utah.gov/xcode/Title17/Chapter27A/17-27a-S103.html>) and includes, but not limited to surface fault rupture, liquefaction, landslides, slope stability, debris flows, rock-falls, avalanches, radon gas, and other hazards.

GEOLOGIC HAZARD STUDY AREA: A potentially hazardous area as defined in Section 1.4 of this ordinance within which geologic hazard investigations are required prior to development.

GEOTECHNICAL ENGINEER: A Utah-licensed Professional Engineer who, through education, training, and experience, is competent in the field of geotechnical or geological engineering meeting the requirements of Section 1.6.

GEOTECHNICAL ENGINEERING: The investigation and engineering evaluation of earth materials, including soil,

rock, and manmade materials and their interaction with earth retention systems, foundations, and other civil engineering works. The practice involves the fields of soil and rock mechanics and the earth sciences, and requires the knowledge of engineering laws, formulas, construction techniques, and performance evaluation.

GOVERNING BODY: The [x], or a designee of the [Council/Commission].

HAZARDOUS FAULT: A fault with movement in the past 2,600,000 years (Quaternary).

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.

INTERNATIONAL BUILDING CODE (IBC): The latest, statewide adopted International Code Council International Building Code (Utah Code Title 15A, <https://le.utah.gov/xcode/Title15A/15A.html>). An online version of the 2018 IBC is available at <https://codes.iccsafe.org/content/IBC2018> and the 2018 International Residential Code (IRC) is available at <https://codes.iccsafe.org/content/IRC2018>.

LANDSLIDE: The downslope movement of a mass of soil, surficial deposits, and/or bedrock, including a continuum of processes between landslides, earth flows, debris flows, debris avalanches, and rockfalls.

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 [x] requirements.

LIQUEFACTION: A sudden, large decrease in shear strength of a saturated, cohesionless soil (generally sand and silt) caused by a collapse of soil structure and temporary increase in pore water pressure during earthquake ground shaking. May lead to ground failure, including lateral spreads and flow-type landslides.

NON-BUILDABLE AREA: That portion of a site which a geologic hazard investigation 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, are not permitted.

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

SETBACK: An area subject to risk from a geologic hazard within which habitable structures or critical facilities and their supports are not permitted.

SLOPE STABILITY: The resistance of a natural or constructed slope to failure by landsliding and assessed under both static and dynamic (earthquake-induced) conditions.

SNOW AVALANCHE: See definition of Avalanche.

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, includes all Risk Category II structures as defined in the currently adopted International Building Code, but does not include an accessory building that houses no accessory dwelling unit or business.

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

[x]: The [x] Public Works Director, Engineer, Planning and Development Services Director, Zoning Administrator, Building Official, Council Administrator, County Council, land use authority, or another [x] employee or designee.

1.3 - Applicability

The regulations contained in this ordinance shall apply to all lands under the jurisdiction of [x]. Every legal lot of record, lot in a proposed land subdivision, and parcel within a Geologic Hazard Study Area as defined by this ordinance must have a safe buildable area 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 with acceptable and reasonable access must be mitigated prior to issuance of the final plat approval.

Detached accessory buildings that are not designed for human occupancy are not required to comply with the provisions of this ordinance. In addition, the remodeling of existing structures designed for human occupancy may occur without compliance with this ordinance, if no expansion of the existing structure footprint, foundation, and no structure use change is proposed. Complete or substantial demolition and replacement of structures shall comply with this ordinance.

As defined in the statewide adopted 2018 International Building Code (IBC), Table 1604.5, [x] considers IBC Risk Category III buildings and other structures to represent a substantial hazard to human life in the event of failure, except that any structure with an occupancy greater than 1000 shall also be considered IBC Risk Category III when not meeting the criteria for IBC Risk Category IV; and IBC Risk Category IV buildings and other structures are designated as essential (critical) facilities.

1.4 – Geologic Hazard Study Areas

Geologic Hazard Study Areas in [x] are defined as, but are not necessarily limited to:

- A. Designated Special Study Areas by the Utah Department of Natural Resources, Utah Geological Survey (UGS, <https://geology.utah.gov>), including those areas designated per Utah Code 79-3-202(f) around hazardous faults and are in the *Utah Quaternary Fault and Fold Database* (<https://geology.utah.gov/apps/qfaults/>); and
- B. Surface-fault-rupture hazard areas defined in Section 1.9-B.3; and
- C. Landslide hazard areas defined in Section 1.9-C.1; and
- D. Liquefaction hazard areas defined in Section 1.9-D.1 and;
- E. Debris flow hazard areas defined in Section 1.9-E.1; and
- F. Rockfall hazard areas defined in Section 1.9-F.1; and
- G. Land subsidence and earth fissure hazard areas defined in Section 1.9-G.1; and
- H. Radon gas hazard areas defined in Section 1.9-H.1; and
- I. Problem soil and rock hazard areas defined in Section 1.9-I.1; and
- J. Snow avalanche hazard areas defined in Section 1.9-J.1; and
- K. Geologic-based flood hazard areas defined in Section 1.9-K.1; and
- L. Other areas where the topography; geology, including soils and bedrock conditions, either on the subject property or adjacent indicate the presence of geologic hazards, other previously identified geologic hazards; and environmentally sensitive areas that [x] finds to be of significance to the health, safety, and welfare of the citizens of [x]; and
- M. Site-specific surface-fault-rupture investigations are required for all critical facilities and structures for human occupancy (International Building Code [IBC] Risk Category II, III, and IV) along latest Pleistocene-Holocene faults and for critical facilities (IBC Risk Category IV) along late Quaternary and Quaternary faults. For noncritical facilities for human occupancy (IBC Risk Category II and III) along late Quaternary and Quaternary faults, investigations are recommended, but not required. See the UGS *Utah Quaternary Fault and Fold Database* (<https://geology.utah.gov/apps/qfaults/>) to locate Quaternary age faults within [x] and to determine their activity class.

The applicant's professional consultants will find geologic information available from the UGS and other sources useful in planning site development, preparing for the scoping meeting, and in performing geologic hazard investigations and subsequent analysis. Available UGS information includes:

- Geologic maps (<https://geology.utah.gov/apps/intgeo-map/>)
- Geologic hazard maps and data (<https://geology.utah.gov/hazards/info/maps/>)
- Aerial photographs (<https://geology.utah.gov/resources/data-databases/aerial-photographs/>)
- Prior geologic and geotechnical reports (<https://geodata.geology.utah.gov>)
- Other information (<https://geology.utah.gov>)

Lidar elevation data are available at <https://gis.utah.gov/data/elevation-and-terrain/> and <https://opentopography.org>.

In areas where UGS geologic hazard maps are not available and where geologic maps are used to define Geologic Hazard Study Areas, note that geologic hazard maps are based on significant other data sources beyond geologic maps and that not all of a geologic unit may be prone to geologic hazard(s).

1.5 – Geologic Hazard Investigations and Reports Required for Development

Any applicant requesting land-use approval for a concept plan; preliminary or final plats; a commercial, institutional, or one-, two-, and multi-family dwelling conditional use permit; or site plan approval on a parcel or parcels of land within a Geologic Hazard Study Area or where there are known or readily apparent geologic hazards and the area is not included within a current Geologic Hazard Study Area, shall submit to [x] [three wet stamped paper copies and one] an unlocked PDF digital copy of a site-specific geologic hazard investigation report that specifically relates to the geologic hazards present on and adjacent to that may affect the site.

1.6 – Minimum Investigator Professional Qualifications

Geologic hazard investigations often involve both engineering geology and geotechnical engineering. Engineering geology investigations shall be performed under the direct supervision of a Utah-licensed Professional Geologist specializing in engineering geology as defined in Section 1.6. Geotechnical engineering investigations shall be performed under the direct supervision of a Utah-licensed Professional Engineer specializing in geotechnical engineering as defined in Section 1.6. Licenses may be verified with the Utah Division of Occupational & Professional Licensing (<https://secure.utah.gov/llv/search/index.html>).

Engineering geology and the evaluation of geologic hazards is a specialized discipline within the practice of geology requiring the technical expertise and knowledge of techniques not commonly used in other geologic investigations. Therefore, geologic hazard investigations involving engineering geology and geologic hazard investigations shall be conducted, signed, and sealed by a Utah-licensed Professional Geologist specializing in engineering geology and geologic hazards. Proof of qualifications shall be provided to [x] upon request.

The minimum qualifications required by [x] for an Engineering Geologist, include:

- A. An undergraduate or graduate degree in geology, engineering geology, or geological engineering, or closely related field, from an accredited college or university; and
- B. Five full-time years of experience in a responsible position in the field of engineering geology and geologic hazards in Utah, or in a state with similar geologic hazards and regulatory environment, and experience demonstrating the geologist's knowledge and application of appropriate techniques in geologic hazard investigations; and
- C. An active Utah Professional Geologist license in good standing.

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 the technical expertise and knowledge of techniques not commonly used in civil engineering. Therefore, geologic hazard investigations that include engineering design and related tasks shall be conducted, signed, and sealed by a Utah-licensed Professional Engineer, specializing in geotechnical engineering and geologic hazards. Proof of qualifications shall be provided to [x] upon request.

The minimum qualifications required by [x] for a Geotechnical Engineer, include:

- A. A graduate degree in civil or geological engineering, with an emphasis in geotechnical engineering; or a B.S. degree in civil or geological 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 ABET accredited college or university program; and
- B. Five full-time years of experience in a responsible position in the field of geotechnical engineering and geologic hazards 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 geologic hazard investigations; and

- C. An active Utah Professional Engineer license in good standing.

1.7 – Preliminary Activities

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

- A. Prior to a land-use application, the applicant shall schedule a scoping meeting with [x] to evaluate the Engineering Geologist's and Geotechnical Engineer's investigative approach and work plan. The investigation approach shall allow for flexibility due to unexpected site conditions. Field findings may require modifications to the work plan. At this meeting, the applicant shall present a work plan that includes the locations of anticipated geologic hazards and proposed subsurface exploratory excavations, such as test pits, trenches, borings, and cone penetrometer test (CPT) soundings, which meet the minimum acceptable regional standards of practice, this ordinance, and includes:
 - 1. A property location map; and
 - 2. A geologic map; and
 - 3. A topographic map with contours; and
 - 4. A slope map or lidar imagery, if available; and
 - 5. A map showing the location of the proposed development, including structures, roads, depths of basements and foundations, etc.; locations of proposed subsurface exploration, such as trenches, borings, test pits, etc.; with a description of the proposed development; and
 - 6. A map showing the slope stability analysis cross-section locations, if existing landslides are present on or near the proposed site and/or slope instability is anticipated.

Upon successful completion of a scoping meeting, an application for an [excavation or grading] permit, as necessary, may be submitted to [x].

- B. [x] will arrange for a Utah-licensed Professional Geologist, specializing in engineering geology, to attend the scoping meeting on behalf of the [City/County, at the applicant's expense]. [x] geologist will provide verbal feedback to the applicant and their consultants regard-

ing their proposed work plan and the requirements of this article. [Reimbursement to the City/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]; and

- C. As required by this code and except as otherwise noted herein, 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 [x] on forms furnished by the [City/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 [x] during the land disturbance activities.

1.8 – Building Permits on Parcels Recorded Prior to the Effective Date of These Ordinances

- A. The following submittals and processes 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 parcels recorded prior to the effective date hereof which are on property noted as [restricted (R) or otherwise designated] for geologic hazard reasons on a recorded plat or within designated Geologic Hazard Study Areas:
 - 1. A statement from an Engineering Geologist identifying the presence or absence of any geologic hazards and describing the buildable area on the lot for the proposed structure; and
 - 2. A statement from a Geotechnical Engineer verifying that the slope stability of the proposed structure location will have a ≥ 1.1 dynamic (pseudostatic) and ≥ 1.5 static factor of safety. The statement shall clearly identify the anticipated conditions, such as the seismic ground acceleration and pseudostatic coefficients used, and any required mitigation measures to achieve the required factors of safety; and
 - 3. A statement from a Utah-licensed Professional Structural Engineer stating that they have reviewed the geologic and geotechnical reports, which may be combined into one report, and that they have designed the structure in accordance with the report recommendations, accounting for any identified geologic and geotechnical hazards in accordance with the currently statewide adopted International Building Code and related standards; and
 - 4. Written verification from the consultant's issuer of professional errors and omissions liability insurance,

in the amount of [\$2,000,000.00] per consultant, which covers the licensed Professional Engineering Geologist, Geotechnical Engineer, and Structural Engineer, and which are in effect on the date of issuance of the building permit by the [City/County] Building Official; and

- 5. A Hold Harmless Agreement on a [city/county] approved form, which is executed and recorded on the subject property; and
 - 6. A Geologic Hazards Disclosure on a [city/county] approved form, which is executed and recorded for the subject property; and
 - 7. All conditions of the adopted statewide building and fire codes (see <https://le.utah.gov/xcode/Title15A/15A.html>) 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 parcels recorded prior to the effective date hereof, and which are within a Geologic Hazards Study Area:
 - 1. An Excavation Inspection Report shall be submitted by a Geotechnical Engineer to the [City/County] Building Official prior to footing placement, which verifies that the proposed building was in accordance with the recommendations of the geologic and geotechnical reports, which may be combined into one report; and
 - 2. The [City/County] Building Official may require, at any time, written verification from a Geotechnical Engineer or a Utah-licensed Professional Structural Engineer, that the structure conforms to the recommendations of the original reports and designs, and if not, provides appropriate as-built drawings documenting the changes; and
 - 3. All requirements of the statewide adopted Utah State Construction and Fire Codes Act (<https://le.utah.gov/xcode/Title15A/15A.html>) must be met.

1.9 – Geologic Hazard Investigations and Reports

Each geologic hazard investigation and report shall be site-specific and shall identify all known or suspected potential geologic hazards, whether previously identified or unrecognized, that may affect the subject property, both on and adjacent to the property. A geologic hazard report may be combined with a geotechnical report and/or contain information on multiple hazards.

- A. A field review by [x] is required during subsurface exploration activities (test pits, trenches, drilling, etc.) to allow the [City/County] to evaluate the subsurface conditions, such as the age and type of deposits encountered, the

presence or absence of landslides and faults, etc. with the applicant's consultant. Discussions about questionable features or appropriate setback distances are appropriate, but [x] will not assist with field logging, explaining stratigraphy, or give approval of the proposed development during the field review. Exploratory trenches when excavated, shall be open, safe, and in compliance with applicable federal Occupational Safety and Health Administration, State of Utah, and other excavation safety regulations, have the walls appropriately cleaned, and a field log completed by the time of the review. The applicant must provide a minimum notice of [2 days] to [x] for scheduling the field review.

- B. Surface fault rupture is a displacement of the ground surface along a tectonic fault during an earthquake. If a fault were to displace the ground surface beneath a building or other structure, significant structural damage or collapse may occur, possibly causing injuries and loss of life. As a result, [x] requires site-specific surface-fault-rupture hazard investigations and submittal of a report for all properties that contain Quaternary faults, depending on the fault activity level and the IBC Risk Category of proposed structures. These investigations and reports shall conform with the *Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah* (Lund and others, 2020; UGS Circular 128, Chapter 3, <https://doi.org/10.34191/C-128>), as appropriate, including:

1. The requirement for site-specific investigation of surface faulting depends on the fault activity level as defined by the most recent Western States Seismic Policy Council (WSSPC) Policy Recommendation (PR, <https://www.wsspc.org/public-policy/adopted-recommendations/>) for faults that cross properties with proposed structures. The current PR is 18-3: *Definitions of Recency of Surface Faulting for the Basin and Range Province* and defines latest Pleistocene-Holocene, late Quaternary, and Quaternary faults as:
 - a. Latest Pleistocene-Holocene fault – A fault whose movement in the past 15 ka (15,000 years) has been large enough to break the ground surface.
 - b. Late Quaternary fault – A fault whose movement in the past 130 ka (130,000 years) has been large enough to break the ground surface.
 - c. Quaternary fault – A fault whose movement in the past 2.6 Ma (2.6 million years) has been large enough to break the ground surface.

[x] requires site-specific investigation on parcels with latest Pleistocene-Holocene faults for all new critical facilities and structures for human occupancy (IBC Risk Category II, III, and IV structures), on parcels with latest Pleistocene-Holocene and late Quaternary faults for all new critical facilities (IBC

Risk Category III and IV structures), and on parcels with the faults listed in item 2 below.

Investigations are required for all critical facilities, whether near a mapped Quaternary fault or not, to ensure that previously unknown faults are not present. If evidence for a Quaternary fault is found, subsurface investigations are required and trenching to locate a suitable buildable area may be necessary (IBC Sections 1704.6.1 and 1803.5.11).

2. The UGS *Utah Quaternary Fault and Fold Database* (<https://geology.utah.gov/apps/qfaults/>) provides the latest information on Quaternary faulting in Utah to determine fault activity levels as defined above and where surface-fault-rupture Geologic Hazard Study Areas have been defined. Where data are inadequate to determine the fault activity class, the fault shall be assumed to be latest Pleistocene-Holocene, pending detailed surface-fault-rupture and/or paleoseismic investigations. The database currently includes the following mapped Quaternary faults within [x]:

- [xxx] fault – [age]

[x] may require a site-specific investigation if on-site and/or nearby fault-related features not shown in the database are identified during other geologic and/or geotechnical investigations and/or during project construction.

3. Surface-fault-rupture hazard maps show the locations of fault traces and recommended special study areas. These maps and data are published by the UGS in the *Utah Quaternary Fault and Fold Database* [but are currently not available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, investigations are required within Geologic Hazard Study Areas as defined by:
 - a. Areas that horizontally extend 500 feet on the downthrown and 250 feet on the upthrown side of well-defined Quaternary faults (solid lines) and 1000 feet on both sides of buried or inferred Quaternary faults (dotted lines). For traces of buried or inferred Quaternary faults less than 1000 feet long that lie between and on-trend with well-defined faults or lie at the tail end of a well-defined Quaternary faults, the well-defined Quaternary fault special-study-area zone is used (Figure 1A and 1B); and
 - b. In areas where a buffer “window” exists, the window is filled in if its width is less than the greater of the two surrounding buffers (Figure 1C). In situations where the ground expression of the fault scarp is larger than the special-study zone, in which case the zone does not cover the entire fault scarp, the 1000-foot buffer is used; and

- c. Well-defined Quaternary faults are those Quaternary fault traces that are clearly identifiable by a geologist qualified to conduct surface-fault-rupture hazard investigations as a physical feature at or just below the ground surface (typically shown as a solid line on geologic maps), and buried or inferred Quaternary faults are those Quaternary fault traces that are not evident at or just below the ground surface by a qualified geologist (typically shown as a dotted line for buried faults and a dotted line for inferred faults on geologic maps).
4. When an alternative subsurface exploration plan is proposed in lieu of paleoseismic trenching, a map and written description and plan shall be submitted to [x] for review, prior to the scoping meeting and exploration implementation. The plan must include at a minimum, a map of suitable scale showing the site limits, surface geologic conditions within 2000 feet of the site boundary, the location and type of the proposed exploration, the anticipated subsurface geologic conditions, and a through description of why the alternative exploration is being proposed.
5. Small-displacement faults with less than 4 inches of displacement are not exempted from structure setback requirements. However, if structural risk-

reduction measures are proposed for these faults, the following criteria must be met:

- a. Reasonable geologic data indicating that future surface displacement along the faults will not exceed 4 inches following the *Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah* (Lund and others, 2020; UGS Circular 128, Chapter 3, <https://doi.org/10.34191/C-128>), and
 - b. Specific structural mitigation to minimize structural damage and ensure safe occupant egress designed by a Utah-licensed Structural Engineer with plans and specifications reviewed and approved by [x].
- C. Landslides are the downslope movement of earth (soil, rock, and/or debris) materials and can cause significant property damage, injury, and/or death. The evaluation of landslides generally requires quantitative slope stability analyses, involving Engineering Geologists and Geotechnical Engineers experienced in landslide investigation, analysis, and mitigation. 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. Slope stability and landslide hazard investigations and reports shall conform with the *Guidelines for Evaluating Landslide Hazards in Utah* (UGS Circular 128, Chapter 4, <https://doi.org/10.34191/C-128>), as appropriate, and

1. Landslide hazard maps show the location of previous landsliding, areas of potential landsliding, and recommended Geologic Hazard Study Areas. These maps are published by the UGS (<https://geology.utah.gov/hazards/info/maps/>) [but are not currently available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, investigations are required within Geologic Hazard Study Areas as defined by:

- a. Cut and fill slopes steeper than, or equal to, 50 percent (2H:1V) and natural slopes steeper than or equal to 30 percent (3.3H:1V); and
- b. Natural and cut slopes with geologic conditions, such as an existing landslide or other geologic hazard; bedding, foliation, or other structural features that are potentially averse to slope stability; and
- c. Buttresses and stability fills and cut, fill, and natural slopes of water-retention basins or flood-control channels; and
- d. Mapped landslide areas in the UGS *Utah Landslide Database*, (<https://gis.utah.gov/data/geoscience/landslides/>); and

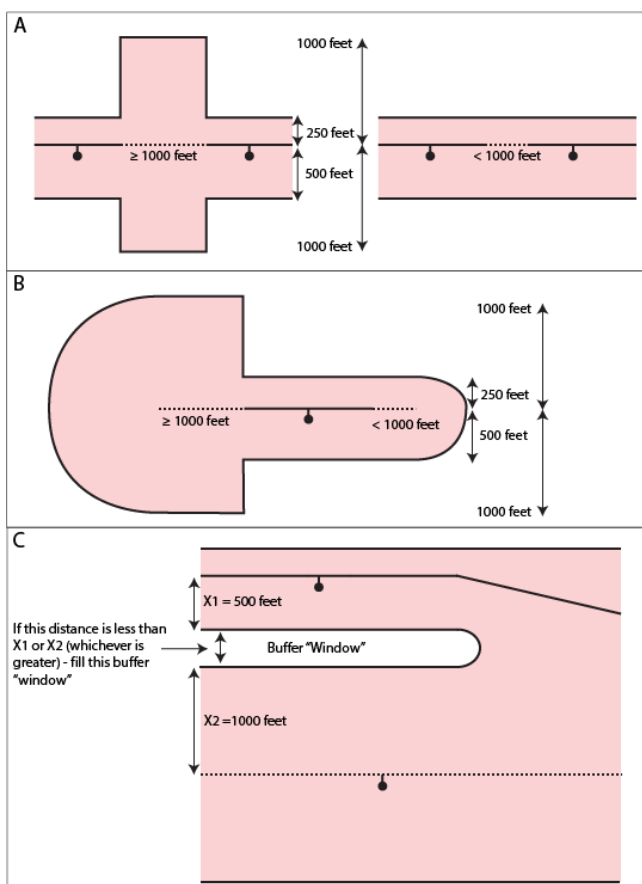


Figure 1. Areas around Quaternary faults defining surface-fault-rupture Geologic Hazard Study Areas.

- e. Low, moderate, and high landslide susceptibility areas identified in the *Landslide Susceptibility Map of Utah* (Giraud and Shaw, 2007; UGS Map M-228, <https://ugspub.nr.utah.gov/publications/maps/m-228/m-228.pdf>); and
 - f. Units [list of geologic units specific to your area] on the most recent geologic maps published by the UGS (<https://geology.utah.gov/>). Most maps are available in the UGS *Interactive Geologic Map Portal*, (<https://geology.utah.gov/apps/intgeomap/>), but contact the UGS for interim, progress update, and other non-final maps that may be available, but not online.
1. Development of properties within these areas require submittal and review of a site-specific geologic hazard report discussing landslide hazards, prior to receiving a land-use or building permit from [x]. It is the responsibility of the applicant to retain a qualified Engineering Geologist and Geotechnical Engineer to perform the slope stability analysis.
 2. When evaluating site conditions to determine the need for slope stability analyses, off-property conditions shall be considered (both up-slope to the tops of adjacent, ascending slopes and down-slope to and beyond the toes of adjacent, descending slopes). Also, the professionals shall demonstrate that the proposed hillside development will not affect adjacent sites or limit adjacent property owners' ability to develop their sites.
 3. Investigations shall also address the potential for surficial instability, rock slope instability, debris/mudflows, rockfalls, and soil creep on all slopes that may affect the proposed development, be affected by the proposed development, and along access roads. Intermediate geomaterials (IGM), those earth materials with properties between soil and rock, if present, shall be appropriately investigated, sampled, and tested.
 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 slope stability. The shear strength and other geotechnical properties shall be evaluated by the Geotechnical Engineer. Qualified Engineering Geologists 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 the Geotechnical Engineer.
 5. Except for the derivation of the input ground motions for pseudostatic and seismic deformation analyses described below, slope stability analyses and evaluations shall 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 [x] are described below. If on-site sewage and/or stormwater or other water disposal exists or is proposed, the slope stability analyses shall also include the effects of the effluent plume on slope stability.
 6. The minimum acceptable static factor of safety (FS) is 1.5 for both overall and surficial slope stability and 1.1 for a calibrated pseudostatic analysis using Stewart and others (2003) or other method pre-approved by [x].
 7. Soil and/or rock sampling and testing shall be based on current ASTM International and/or American Association of Highway Officials (AASHTO) standards, as appropriate. Laboratory tests shall be performed using current ASTM International or AASHTO standards, as appropriate, in a laboratory accredited by the AASHTO Materials Reference Laboratory and/or the U.S. Army Corps of Engineers to ensure compliance with current laboratory testing standards and quality control procedures. The final report shall include complete laboratory test results reported in conformance with current ASTM International or AASHTO standards, as appropriate.
 8. Soil and/or rock properties, including unit weight and shear strength parameters (cohesion and friction angle), shall be based on conventional laboratory tests on appropriate samples. Where appropriate, such as 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 enough exploration, the weakest material that may be present, consistent with site geologic conditions. Soil strength parameters derived solely from CPT data are most often not appropriate for slope-stability analysis in many 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).
 9. Residual strength parameters may be determined using direct or ring shear testing equipment; however, ring shear tests are preferred. If performed properly, direct shear test results may approach ring shear test

results. The specimen must be subjected to enough deformation (such as, 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 and ring shear tests, stress-deformation curves can be used to determine when an enough shearing cycles have been performed by showing that no further significant drop in shear strength results with the addition of more cycles or 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 (for example, at zero normal stress there is zero shear strength). Any apparent shear strength increases resulting from a non-horizontal shear surface, such as ramping or bulldozing in residual direct shear tests, shall be discounted in the interpretation of the strength parameters.

10. 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 the 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, including:
 - a. 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; and
 - b. 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; and
 - c. Averaged strength parameters may be appropriate for some across-bedding conditions, if enough representative samples have been carefully tested. Analyses for along bedding or along-existing-landslide slip surfaces shall be based on the lower-bound interpretations of residual shear strength parameters and comparison of those results to correlations, such as those of Stark and others (2005).
11. The potential effects of soil creep shall be addressed where any proposed structure is planned near an existing fill or natural slope. The potential effects on the proposed development shall be evaluated and mitigation measures proposed, including appropriate setback recommendations that consider the potential effects of creep forces.
12. Gross stability includes rotational and translational deep-seated slope failures 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, such as the highest slope, most adverse bedding planes, shallowest likely groundwater table, steepest slope, etc. Often, analyses are required for different conditions and for more than one cross section to demonstrate which condition is the most adverse. When evaluating the stability of an existing landslide, analyses must also address the potential for partial reactivation. Inclometers may be used to help determine critical failure surfaces, and along with high-precision GPS/GNSS, the activity state of existing landslides. The critical failure surfaces on each cross-section shall be identified, evaluated, and plotted on the large-scale cross section; and
 - b. Rock slope stability shall be based on current rock mechanics practice, using the methods of Wyllie and Mah (2004), based on Hoek and Bray (1981); Practical Rock Engineering (<https://www.rocscience.com/assets/resources/learning/hoek/Practical-Rock-Engineering-Full-Text.pdf>); Federal Highway Administration (1989); and similar references, such as <https://www.rocscience.com/learning/hoek-corner/publications>; and
 - c. If the long-term static FS is ≤ 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 FS of ≥ 1.5 ; and
 - d. The temporary stability of excavations shall be evaluated, and mitigation measures shall be recommended as necessary to obtain a minimum FS of ≥ 1.3 ; and
 - e. Long-term slope stability shall be analyzed using the highest known and anticipated groundwater level based upon a groundwater assessment as described in the *Guidelines for Evaluating Landslide Hazards in Utah* (Beukelman and Hylland, 2020; UGS Circular 128, Chapter 4, <https://doi.org/10.34191/C-128>), along with groundwater sensitivity analyses; and
 - f. Slope stability and analysis input parameters, such as groundwater elevations and conditions, cannot

- be contingent on uncontrollable factors, such as limiting landscape irrigation, etc.; and
- g. Where back-calculation is appropriate, shear strengths utilized for design shall be no higher than the lowest strength computed using back calculation. If a professional proposes to use shear 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; and
 - h. Reports shall describe how the shear strength testing methods used are appropriate in modeling field conditions and the long-term performance of the analyzed 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; and
 - i. 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; and
 - j. 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 Geotechnical Engineer shall provide data to demonstrate that the rate is sufficiently slow for drained conditions; and
 - k. Shear strength values higher than those obtained through site-specific laboratory tests will generally not be accepted; and
 - l. 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 current rock mechanics practice; and
 - m. 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; and
 - n. Shear strengths for proposed fill slopes shall be evaluated using samples mixed and remolded to represent anticipated field conditions. Tests to confirm strengths may be required during grading; and
 - o. Where bedding planes and/or discontinuities are laterally unsupported in slopes, potential failures along the unsupported bedding planes and/or discontinuities shall be analyzed. Similarly, stability analyses shall be performed where bedding planes and/or discontinuities form a dip-slope or near-dip-slope using composite, potential failure surfaces that consist of potential slip surfaces along bedding planes and/or discontinuities in the upper portions of the slope, in combination with slip surfaces across bedding planes and/or discontinuities in the lower portions of the slope; and
 - p. The stability analysis shall include the effect of expected maximum moisture conditions on unit weight; and
 - q. For effective stress analyses, measured groundwater conditions adjusted to consider likely unfavorable conditions with respect to anticipated future groundwater levels, seepage and pore pressure shall be included in the slope stability analyses; and
 - r. 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 modeling; and
 - s. Anticipated surcharge loads, as well as external boundary pressures from groundwater, shall be included in the slope stability evaluations, as deemed appropriate; and
 - t. Generally, computer-aided modeling techniques should be used, so that the potential failure surface with the lowest factor of safety can be located. However, analytical chart solutions may be used, provided they were developed for conditions like those being analyzed. Examples of typical modeling techniques are illustrated on Figures 9.1a to 9.1f in Blake and others (2002). However, verification of the reasonableness of the analytical results is the responsibility of the Geotechnical Engineer and Engineering Geologist, and
 - u. The critical potential failure surface used in the analysis may be composed of circles, wedges, planes, or other shapes considered to yield the minimum FS 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 FS and the critical failure surface shall be documented.
13. Surficial slope stability refers to slumping and sliding of near-surface materials and is most critical during the snowmelt and rainy season or when excessive landscape irrigation 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 saturation depth for surficial stability evaluation shall be 4 feet.

- a. Residual shear strengths comparable to actual field conditions shall be used in surficial stability analyses. Surficial stability analyses shall be performed under rapid draw-down conditions, where appropriate, such as for debris and detention basins; and
 - b. Where 2H:1V 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 FS 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 if approved by [x]; and
 - c. 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 FS against failure. A suggested procedure for evaluating surficial slope stability is presented in Blake and others (2002); and
 - d. Soil properties used in surficial stability analyses shall be determined as noted for residual strengths above. 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. It shall be recognized that for most clayey soils, the residual shear strength envelope is curved and passes through the origin (for example, 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; and
 - e. The minimum acceptable vertical depth for which seepage parallel to the slope shall be applied is 4 feet for cut or fill slopes. Greater depths may be necessary when analyzing natural slopes that have significant thicknesses of loose surficial material.
14. In addition to static slope stability analyses, slopes shall be evaluated for seismic slope stability. Acceptable methods for evaluating seismic slope stability include using calibrated pseudostatic limit-equilibrium procedures and simplified methods, such as, those based on Newmark (1965), to estimate permanent seismic slope movements and 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, if the procedures, input data, and results are thoroughly documented, and deemed acceptable by [x].
- a. Regarding design ground accelerations for seismic slope-stability analyses, [x] prefers a probabilistic approach to determining the likelihood that different levels of ground motion will be exceeded at a site within a given time period. 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% probability in 50 years (2,500-year return period); and
 - b. Peak ground accelerations (PGA) shall be used from the most recent USGS National Seismic Hazard Maps (<https://www.usgs.gov/natural-hazards/earthquake-hazards/maps>) and 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 or de-amplification of the high-frequency strong motion. Site-specific response analysis may also be used to develop PGA values if the procedures, input data, and results are thoroughly documented, and deemed acceptable by [x]; and
 - c. Pseudostatic methods for evaluating seismic slope stability are acceptable if minimum factors of safety are satisfied, and due consideration is given in the selection of the seismic coefficient (k) reduction in material shear strengths, and the factor of safety for pseudostatic conditions; and
 - d. Pseudostatic seismic slope stability analyses can be performed using the “screening analysis” procedure described in Blake and others (2002). For that procedure, a k-value is selected from seismic source characteristics (modal magnitude and distance, and firm rock PGA) and ≤ 2 inches (5 cm) of deformation is specified. For that procedure, a factor of safety of ≥ 1.0 is considered acceptable; otherwise, an analysis of permanent seismic slope deformation shall be performed.
15. 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 Trava-sarou (2007), which is [x] currently preferred method. For those analyses, calculated seismic displacements shall be ≤ 2 inches (5 cm), or mitigation measures shall be proposed to limit calculated displacements to ≤ 2 inches (5 cm).

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; and
- 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 could 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.

To consider a threshold larger than 2 inches, the project professional shall provide prior, acceptable justification to [x] and obtain the [City's/County's] approval. Such justification shall demonstrate, to the satisfaction of [x], that the proposed project will achieve acceptable performance.

16. Slope stability analyses shall be performed for cut, fill, and 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 occur.
17. 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) and methods include:
 - a. Hazard avoidance; or
 - b. Grading to improve slope stability; and/or
 - c. Reinforcement of the slope and/or improvement of the soil within the slope, and/or;
 - d. Reinforcement of the structures 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 compat-

ibility. 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 piers is to be used to support a potentially unstable slope and a 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.

18. Full mitigation of slope stability hazards shall be performed for developments in [x]. Remedial measures that produce static $FS \geq 1.5$ and acceptable seismic displacement estimates shall be implemented as needed.
 19. On some projects or portions of, 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 and/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 consistent with IBC design criteria, and if it is approved by [x]. The applicability of partial mitigation to specific projects shall be evaluated on a case-by-case basis.
 20. For developments when 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. The Notice shall clearly state that the seismic displacement hazard at the site has been reduced by the partial mitigation, but not eliminated. In addition, the owner shall assume all risks, waive all claims against [x] and its consultants, and indemnify and hold [x] and its consultants harmless from any and all claims arising from the partial mitigation of the seismic displacement hazard.
- D. Liquefaction is a process by which strong shaking during an earthquake causes the ground to temporarily lose its strength and to behave like a viscous liquid rather than a solid material. Liquefaction can cause buildings to tip and settle; roads to crack, deform and flood; buried storage tanks to rise towards the surface; and other types of damage to buildings and infrastructure. Liquefaction hazard investigation reports shall conform with the requirements described below and be prepared by a qualified Geotechnical Engineer as defined above.

1. Liquefaction hazard maps show the location and relative anticipated severity of liquefaction during an earthquake. These maps are published by the UGS[but are not currently available for [x]. Once these

maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, Geologic Hazard Study Areas are defined by:

- a. Within Federal Emergency Management Agency (FEMA)-defined flood Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, and Zone AR/A areas; and
 - b. Units [list of geologic units specific to your area] on the most recent geologic maps published by the UGS (<https://geology.utah.gov/>). Most maps are available in the UGS *Interactive Geologic Map Portal* (<https://geology.utah.gov/apps/intgeo-map/>), but contact the UGS for interim, progress update, and other non-final maps that may be available, but not online; and
 - c. For all IBC Risk Category III and IV facilities, regardless whether the site lies within a designated Geologic Hazard Study Area or not.
2. A liquefaction-hazard investigation shall be performed in conjunction with any geotechnical and/or geologic hazards investigation prepared within [x].
 3. For all structures where liquefaction-hazard analyses indicate 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 and displacements in such a manner as to be protective of life (collapse prevention) during and after the design seismic event.
 4. The investigation of liquefaction hazard is an interdisciplinary practice. The site investigation report must be prepared by a qualified Geotechnical Engineer, 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 and general geologic site evaluation to map the likely extent of liquefiable deposits and shallow groundwater. Engineering

properties of earth materials shall be evaluated and the performance of quantitative liquefaction-hazard analyses resulting in a numerical factor of safety and quantitative assessment of settlement and liquefaction-induced permanent ground displacement shall be performed by the Geotechnical Engineer. The Geotechnical and Structural 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.

Except for the derivation of input ground motion, liquefaction-hazard investigations shall 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, 2001), *Assessment of the Liquefaction Susceptibility of Fine-Grained Soils* (Bray and Sancio, 2006), *SPT-Based Liquefaction Triggering Procedures* (Idriss and Boulanger, 2010), and the *State of the Art and Practice in the Assessment of Earthquake-Induced Soil Liquefaction and Its Consequences* (Committee on State of the Art and Practice in Earthquake Induced Soil Liquefaction Assessment, 2016). Acceptable factors of safety for liquefaction are shown in Table 1.

5. 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, sandy silt, non-plastic silts, and gravelly soils. The following conditions must be present for liquefaction to occur:
 - a. Soils must be saturated, either below the water table or above a confining layer, and
 - b. Soils must be loose to moderately dense, and
 - c. Earthquake ground shaking must be relatively intense, and
 - d. The duration of ground shaking must be large enough for the soils to generate seismically induced excess pore water pressure and lose their shearing resistance.
6. The following screening criteria may be applied to determine if further quantitative evaluation of liquefaction hazard is required:

Table 1. Minimum factors of safety for various International Building Code facility types.

Type of Facility	Minimum Factor of Safety (FS)
Critical Facilities, including essential or hazardous facilities and special occupancy structures	1.3
IBC Category III and IV Structures	
Industrial and Commercial Structures	1.25
IBC Category II(b) Structures	

- 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 groundwater level, a quantitative assessment of seismically induced settlement is required; and
- b. If bedrock underlies the site, those materials need not be considered liquefiable and no analysis of their liquefaction potential is necessary; and
- c. If the corrected Standard Penetration Test (SPT) blow count, $(N_1)_{60}$, is ≥ 33 in all samples with an acceptable number of blow counts recorded, liquefaction-hazard assessments are not required. If CPT soundings are made, the corrected CPT tip resistance, q_{cIN} , should be ≥ 180 in all soundings in sandy soils; otherwise, liquefaction-hazard assessments are needed; and
- d. If plastic soils with a Plasticity Index $(PI) \geq 18$ 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). Youd and others (2002) provide additional guidance on analyzing lateral spreads.

If the screening investigation clearly demonstrates the absence of liquefaction hazards at a project site and [x] 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.

7. Geologic research and reconnaissance are important to provide information to define the extent of unconsolidated deposits that may be prone to liquefaction. Such information shall 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 shall also 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, including seasonal changes.

During the field investigation, the Engineering Geologist shall 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, but other soil types are may also be liquefiable.

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

8. Subsurface exploration shall consist of drilled borings and/or CPT soundings. 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 in-situ testing or laboratory testing of soil samples. If borings are utilized, the use of mud-rotary drilling methods is highly recommended to achieve minimal disturbance of the in-situ soils. If mud-rotary drilling is not used, a through explanation is required in the submitted report. Borings and CPT soundings must penetrate a minimum of 45 feet below the final ground surface. If during the investigation, the liquefaction evaluation indices the liquefaction potential may extend below 45 feet, the exploration shall be continued for a minimum of 10 feet, to the extent possible, until non-liquefiable soils are encountered.

For saturated cohesionless soils where the SPT $(N_1)_{60}$ values are < 15 or where CPT tip resistances are < 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 and others, 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 (N_1)60 values between 15 and 30 to further evaluate the potential for liquefaction-induced settlement.

Where a structure may have below grade construction and/or deep foundations, such as drilled shafts or piles, the investigation depth shall extend to a minimum of 20 feet below the lowest expected foundation level (e.g., drilled shaft or pile tip) or to 45 feet below the existing ground surface or lowest proposed finished grade, whichever is deeper. If during the investigation, the liquefaction evaluation indices indicate that liquefaction potential may extend below that depth, the exploration shall be continued at least 10 additional feet, to the extent possible, until non-liquefiable soils are encountered.

9. For the design ground accelerations used in liquefaction analyses, [x] prefers a probabilistic approach to determining the likelihood that different levels of ground motion will be exceeded at a site within a given time period. 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% probability in 50 years (2,500-year return period). PGA values shall be obtained from the USGS *National Seismic Hazard Maps and Site-Specific Data* webpage (<https://www.usgs.gov/natural-hazards/earthquake-hazards/maps>) using the latest long-term model. PGAs obtained from the USGS shall be adjusted for effects of soil/rock (site-class) conditions in accordance with Seed and others (2001) or other appropriate and documented methods that are deemed acceptable by the [x] that consider the site-specific soil conditions and their potential for amplification or deamplification of the high frequency strong ground motion.

Site specific response analysis may also be used to develop PGA values if the procedures, input data, and results are thoroughly documented and deemed acceptable by [x].

10. 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 shall be investigated and evaluated on a site-specific basis with appropriate geologic and geotechnical investigation to support the remedial design and/or mitigative plan. This design or plan may include changes/modifications to the soil, permanent dewatering, earthquake drains, foundation systems, building

structural frame or support, etc. Remedial design and/or mitigation measures shall be reviewed and approved by [x].

11. Liquefaction hazard reports shall include: boring logs, geologic cross-sections, laboratory data, a detailed explanation pertaining to how idealized subsurface conditions and parameters used for the analyses were developed, analytical results and software output files, and summaries of the liquefaction-hazard analyses and conclusions regarding liquefaction potential and likely types and magnitudes of ground failure in addition to the other report requirements detailed in this chapter.

Subsurface geologic and groundwater conditions developed by the Engineering Geologist 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 documentation, including calculations, software output, etc. Documentation of input data, output data, and graphical plots must be submitted for each computer-aided liquefaction-hazard analysis and included as an appendix to the report. Additional information and/or data may be requested to facilitate [x] review.

- E. Debris flows are fast-moving, flow-type landslides composed of a slurry of rock, mud, organic matter, and water that move down drainage basin channels onto alluvial fans. In addition to threatening lives, debris flows can damage structures and infrastructure by sediment burial, erosion, direct impact, and associated water flooding. Debris flow hazard investigations and reports shall conform with the *Guidelines for the Geologic Investigation of Debris-Flow Hazards on Alluvial Fans in Utah* (Giraud, 2020; UGS Circular 128, Chapter 5, <https://doi.org/10.34191/C-128>); and

Debris flow hazard maps show the locations of previous debris flows, areas of potential debris flows, and recommended special study areas. These maps are published by the UGS[but are currently not available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, Geologic Hazard Study Areas are defined by:

1. All properties located on alluvial fans and drainage channels subject to flash flooding and debris flows; and
2. Units [list of geologic units specific to your area] on the most recent geologic maps published by the UGS

- (<https://geology.utah.gov/>). Most maps are available in the UGS *Interactive Geologic Map Portal* (<https://geology.utah.gov/apps/intgeomap/>), but contact the UGS for interim, progress update, and other non-final maps that may be available, but not online.
- F. Rockfall is a type of landslide and a natural mass-wasting process that involves the dislodging and rapid downslope movement of individual rocks and rock masses. Rockfall hazard investigations and reports shall conform with the *Guidelines for Evaluating Rockfall Hazards in Utah* (Lund and Knudsen, 2020; UGS Circular 128, Chapter 7, <https://doi.org/10.34191/C-128>); and
1. Rockfall hazard maps show the locations of known rockfall, areas of potential rockfall, and recommended special study areas. These maps are published by the UGS[but are currently not available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, Geologic Hazard Study Areas are defined by:
 - a. All properties containing or directly below bed-rock cliffs; and
 - b. Units [list of geologic units specific to your area] on the most recent geologic maps published by the UGS (<https://geology.utah.gov/>). Most maps are available in the UGS *Interactive Geologic Map Portal* (<https://geology.utah.gov/apps/intgeomap/>), but contact the UGS for interim, progress update, and other non-final maps that may be available, but not online.
- G. Land subsidence is the sinking of the ground surface caused by groundwater depletion and/or underground mine subsidence or collapse. Subsidence often causes earth fissures which are permanent, linear tension cracks in the ground that extend upward from the groundwater table. Land subsidence and earth fissure investigations and reports shall conform with the *Guidelines for Evaluating Land-Subsidence and Earth Fissure Hazards in Utah* (Lund, 2020; UGS Circular 128, Chapter 6, <https://doi.org/10.34191/C-128>) and:
1. Land subsidence and earth fissure maps show the location of known land subsidence and earth fissures and recommended special study areas. These maps are published by the UGS[but are currently not available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, Geologic Hazard Study Areas are defined by the:
 - [Escalante Desert in Iron County]
 - [Parowan Valley in Iron County]
 - [Cedar Valley in Iron County]
- H. Radon is a radioactive gas that emanates from uranium-bearing rock and soil and may concentrate in enclosed spaces in buildings. Radon is a major contributor to the ionizing radiation dose received by the general population, is the second leading cause of lung cancer after smoking and has resulted in the majority of geologic hazard related deaths in Utah. Radon gas hazard investigations and reports shall conform with the *Guidelines for Site-Specific Evaluation of Radon Hazard in Utah* (Lund and others, 2020; UGS Circular 128, Chapter 8, <https://doi.org/10.34191/C-128>); and
1. Radon gas hazard maps show the location of known radon gas hazard and recommended special study areas. These maps are published by the UGS[but are currently not available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, Geologic Hazard Study Areas are defined by:
 - a. Carbon, Duchesne, Grand, Piute, Sanpete, Sevier, and Uinta Counties as listed in Table AF101(1) of the 2018 International Residential Code, Appendix F of high radon potential (EPA Zone 1); and
 - b. All other Utah counties are considered at least a moderate potential for radon.
- I. Problem soil and rock hazards consist of caliche, collapsible soils, corrosive soils, expansive soil and rock, piping and erosion, shallow bedrock, soluble soil and rock, wind-blown sand, and other similar geologic hazards. While the UGS has not prepared guidelines for these problem soil and rock hazards, investigations of these hazards shall conform to *Guidelines for Investigating Geologic Hazards and Preparing Engineering-Geology Reports, With a Suggested Approach to Geologic-Hazard Ordinances in Utah, Second Edition* (Bowman and Lund, editors, 2020; <https://doi.org/10.34191/C-128>).
1. Specific problem soil and rock hazard maps show the location of known hazards and recommended special study zones. These maps are published by the UGS[but are currently not available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, Geologic Hazard Study Areas are defined for specific problem soil and rock hazards below, or for those geologic hazards not listed, in Section 1.4:
 - a. Caliche: [list of geologic units specific to your area].
 - b. Collapsible Soils: [list of geologic units specific to your area].
 - c. Corrosive Soils: [list of geologic units specific to your area].

- d. Expansive Soil and Rock: [list of geologic units specific to your area].
 - e. Piping and Erosion: [list of geologic units specific to your area].
 - f. Soluble Soil and Rock: Units [list of geologic units specific to your area].
 - g. Wind-Blown Sand: [list of geologic units specific to your area].
 - h. Geologic units listed above are those on the most recent geologic maps published by the UGS (<https://geology.utah.gov/>). Most maps are available in the UGS *Interactive Geologic Map Portal* (<https://geology.utah.gov/apps/intgeomap/>), but contact the UGS for interim, progress update, and other non-final maps that may be available, but not online.
- J. Snow avalanches are landslides consisting mainly of snow and ice, but can contain soil, rock, and/or debris. These investigations and reports shall be prepared by a qualified snow avalanche expert Utah-licensed as a Professional Geologist and/or Engineer, conform with the guidelines and methods described in Colorado Geological Survey Bulletin 49: *Snow-Avalanche Hazard Analysis for Land Use Planning and Engineering* (Mears, 1992); and
1. Avalanche hazard maps show the locations of previous avalanches, areas of potential avalanches, and recommended special study areas. These maps are currently not available for [x]. Once these maps are available, at that time they will be adopted to become part of this ordinance. As a result, investigations are required within Geologic Hazard Study Areas as defined by those areas within [x] above elevations of [5000] feet with an adequate snow supply to produce snow avalanches and which include slopes greater than 47 percent (2.1H:1V, 25 degrees); and
 2. 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, and buildable and non-buildable areas; 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; and
 3. If the avalanche analysis indicates that the site may be impacted by avalanches, the report shall delineate the following areas:
 - a. A “red zone” of high avalanche potential corresponding to a return period of 25 years or less, and/or impact pressures ≥ 600 pounds per square foot (psf) within which critical facilities or structures for human occupancy are not permitted; and
 - b. A “blue zone” corresponding to a return period between 25 and 300 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:
 - i. The structure is designed to incorporate direct protection measures that address the estimated impact forces of flowing snow/debris and powder blast loading. The estimated impact forces shall be calculated by the avalanche expert and the structure shall be designed by, and the plans stamped by, a qualified, Utah-licensed Professional Structural Engineer, or;
 - ii. Appropriate engineering controls (such as, 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, Utah-licensed Geotechnical or Professional Structural Engineer, as appropriate.
4. The report shall include:
- a. The probability of avalanche occurrence, if possible, estimates of avalanche volumes, and the likely effects of avalanches on the proposed development; and
 - b. A description of the avalanche expert’s qualifications to perform the investigation; and
 - c. Engineering design parameters for avalanche mitigation, as appropriate, implications of the risk-reduction measures on the development and adjacent properties, and the need for long-term maintenance.
- K. While flooding hazards are typically addressed by locally adopted Federal Emergency Management Agency regulations, many areas outside of federally designated 100-year flood zones (Zone A and related) are susceptible to flooding and cause significant damage in Utah. While the UGS has not prepared guidelines for flooding hazards, investigations of these hazards shall conform to the *Guidelines for Conducting Engineering-Geology*

Investigations and Preparing Engineering-Geology Reports in Utah (Bowman and Lund, 2020; UGS Circular 128, Chapter 2, <https://doi.org/10.34191/C-128>).

1. Geologic-based flooding hazard maps show the location of known young flood-related geologic materials (deposits) and recommended special study zones. These maps are published by the UGS[but are currently not available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, Geologic Hazard Study Areas are defined by:
 - a. Units [list of geologic units specific to your area] on the most recent geologic maps published by the UGS (<https://geology.utah.gov/>). Most maps are available in the UGS *Interactive Geologic Map Portal* (<https://geology.utah.gov/apps/intgeo-map/>), but contact the UGS for interim, progress update, and other non-final maps that may be available, but not online.
- L. All geologic hazard reports shall meet the submittal and preparation requirements of this ordinance, the *Guidelines for Conducting Engineering-Geology Investigations and Preparing Engineering-Geology Reports in Utah* (Bowman and Lund, 2020; UGS Circular 128, Chapter 2, <https://doi.org/10.34191/c-128>), and the following:
 1. A 1:24,000-scale geologic map with references, showing the general surface geology, including landslides, rockfall, alluvial fans, bedrock geology where exposed, bedding attitudes, faults, other geologic structural features, and the location of any other known geologic hazards; and
 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 all subsurface exploratory trenches, test pits, borings, etc., and site-specific geologic mapping performed as part of the geologic hazard 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; and
 3. Trench and test pit logs, when applicable, with standard geologic nomenclature at a scale equal to or more detailed than 1 inch = 5 feet. Field logs shall be kept by the consultant and may be requested by [x] for further review during the project; and
 4. Boring logs, when applicable, shall be prepared with standard geologic and engineering nomenclature and format; and
 5. 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; and
 6. An evaluation of whether mitigation measures are required, including an evaluation of multiple, viable mitigation options that include specific recommendations for avoidance or mitigation of the effects of the hazards, consistent with the purposes set forth in Section 1.1, 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, Utah-licensed Engineer (specializing in geotechnical or civil) and/or Structural Engineer, as appropriate; and
 7. A statement by the Engineering Geologist shall be provided regarding the suitability of the site for the proposed development from a geologic hazard perspective; and
 8. All geologic hazard reports shall be signed and stamped by the Utah-licensed professional(s) that prepared the reports in accordance with Utah Code 58-76-603 (Professional Geologists, <https://le.utah.gov/xcode/Title58/Chapter76/58-76.html>) and 58-22-603 (Professional Engineers, <https://le.utah.gov/xcode/Title58/Chapter22/58-22.html>).

When a submitted report does not contain adequate data to support its findings, additional or more detailed investigations shall be required by [x] to explain and/or quantify the geologic hazard and/or to describe how mitigation measures recommended in the report are appropriate and adequate.

When a final geologic hazard report indicates that a geologic hazard does not exist within an adopted Geologic Hazard Study Area indicated by a map referenced by this article, [x] will consider the new geologic information in potentially revising the adopted hazard maps to remove the specific area from the adopted Geologic Hazard Study Area. [x] will also forward this information to the Utah Geological Survey for potential update of their hazard maps.

1.10 – Geologic Hazard Investigation Field Review

A field review by [x] is required during subsurface exploration activities (test pits, trenches, drilling, etc.) to allow the [City/County] to evaluate the subsurface conditions, such as the age and type of deposits encountered, the presence or absence of faulting, etc. with the applicant's geologic consultant. Discussions about questionable features or appropriate setback distances are acceptable, but [x] will not assist with field logging, explaining stratigraphy, or give verbal approval of the proposed development during the field review. Exploratory trenches when excavated, shall be open, safe, and in compliance with applicable federal Occupational Safety and Health Administration, State of Utah, and other excavation safety regulations, have the walls appropriately cleaned, and a field log completed by the time of the review. The applicant must provide [x] with a minimum notice of [2 days] to schedule the field review.

1.11 – Submittal and Certification of Geologic Hazard Reports

- A. All applicants for land use approval within a Geologic Hazard Study Area shall prepare and submit a geologic hazard report (may be combined with geotechnical and/or other geologic reports) pursuant to the requirements of this article prior to any consideration for a concept plan; preliminary or final plat; commercial, institutional, or one-, two-, 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 with the report:
 1. A written, stamped certification from a Utah-licensed Professional Geologist that the geologic hazard report has been prepared pursuant to the requirements of this ordinance; and
 2. A written, stamped certification from a Utah-licensed Professional Geologist and a Professional Engineer that every proposed development lot, building pad, and parcel 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, on adjacent properties, or on site, because of the presence of geologic hazards or because of modifications to the site due to the proposed land use; and
 3. A written, stamped certification from a Utah-licensed Professional Geologist and a Professional Engineer that every proposed development lot, building site, and parcel layout demonstrates that, consistent with regional standards of 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, and local statutes, ordinances, and regulations. Mitigation measures shall consider in their design, the intended aesthetic functions of other governing ordinances of [x]; and
 4. A written, stamped certification from a Utah-licensed Professional Geologist and a Professional Engineer 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, including adjacent properties. Mitigation measures must be reasonable and practical to implement and shall not require ongoing maintenance by property owners; and
 5. Written verification from the issuer of professional errors and omissions liability insurance, in the amount of [\$2,000,000.00] each, which covers the Utah-licensed Professional Geologist and Professional Engineer, and which are in effect on the date of preparation and submittal of all required reports and certifications.
- B. [x] may set other requirements as are necessary to mitigate any geologic hazards and to ensure that the purposes of this article are met. These requirements may include, but are not limited to:
 1. Additional or more detailed investigations and professional certifications to understand or quantify the hazards and/or determine whether mitigation measures recommended in the report are adequate; and
 2. Specific mitigation requirements, establishing buildable and non-buildable areas, limitations on slope grading, controls on grading, and/or revegetation; and
 3. Prior to receiving a grading, excavation, or building permit, final grading plans, when required, shall be prepared, signed and sealed by the Utah licensed Engineering Geologist and Geotechnical Engineer that prepared the geologic hazard and geotechnical report(s) to verify that their recommendations have been appropriately incorporated in the final grading plan and that building locations are approved; and
 4. As built grading plans, when required, shall be prepared, signed, and sealed by the Utah licensed Engineering Geologist and Geotechnical Engineer that prepared the geologic hazard 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; and
 5. Grading plans, when required, shall include, at a minimum, the following:

- a. Maps of existing and proposed contours and the source and accuracy of topographic data used; and
 - b. Present and proposed slopes for each graded area; and
 - c. Existing and proposed drainage patterns; and
 - d. Location and depth of all proposed cuts and fills; and
 - e. Description of the methods to be employed to achieve soil and/or rock stabilization and compaction, as appropriate; and
 - f. Location and capacities of proposed structures, and drainage and erosion control measures based on maximum runoff for a 100-year storm or greater; and
 - g. Location of existing buildings, structures, roads, wells, retention and other basins, and on-site sewage disposal systems on or within 100 feet of the site that may be affected by the proposed grading and construction; and
 - h. A plan for construction monitoring and documentation of testing, field inspection during grading, and reporting to [x]; and
6. Installation of monitoring equipment for surface and subsurface geologic conditions, including determining groundwater levels; and
 7. Other requirements, such as time schedules for completion of the mitigation and phasing of development.
- C. [x] may also set requirements necessary to protect the health, safety, and welfare of the citizens of [x], protect the infrastructure and financial health of [x], and minimize potential adverse effects of geologic hazards to the public health, safety, and property as a condition of approval of any development which requires a geologic hazard report.
- D. [x] may require the Engineering Geologist and Geotechnical Engineer that prepared the geologic hazard and/or geotechnical report(s) be on site, at the cost of the applicant, during certain phases of construction, particularly during grading phases, the construction of retaining walls in excess of 4 feet in exposed height, and geologic hazard mitigation.
- E. [x] shall review any proposed land use that requires preparation of a geologic report under this article to determine the possible risks to the health, safety, and welfare of persons, property, and [City/County] infrastructure from geologic hazards.
1. Prior to consideration of any request for preliminary plat approval or site plan approval, the geologic report, if required, shall be submitted to [x] for review.
 2. [x] will complete each review in a reasonable time frame, not to exceed [45 days].
 3. All direct costs associated with the review of the geologic report shall be paid by the applicant.
 4. [x] shall determine whether the report complies with the following standards:
 - a. A suitable geologic hazards report has been prepared by qualified, Utah-licensed professionals; and
 - b. The proposed land use does not present an unreasonable risk to the health, safety, and welfare of persons or property, including buildings, storm drains, public streets, culinary and other water facilities, utilities or critical facilities, whether off-site or on-site, or to the aesthetics and natural functions of the landscape, such as slopes, streams or other waterways, drainage, or wildlife habitat, 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; and
 - c. The proposed land use demonstrates that, consistent with the current, regional state of 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, and local statutes, ordinances, and regulations. Mitigation measures should consider in their design, the intended aesthetic functions of other governing ordinances, such as the [x] Sensitive Lands Overlay Zone. The applicant must include with the geologic report, a mitigation plan that defines how 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, especially if such measures require on-going maintenance by property owners; and
 - d. Should a geologic report be found deficient with respect to this ordinance and/or the current, regional state of practice, a letter will be provided to the applicant summarizing the specific deficiencies. If a submitted report is found deficient three times or a report was excessively deficient, [x] will notify the Utah Division of Occupational & Professional Licensing about the licensed professional(s) deficient reports that were submitted to a public entity that were not in compliance with Utah Rules R156-76-502 (Professional

Geologists, <https://rules.utah.gov/publicat/code/r156/r156-76.htm>) and/or R156-22-502 (Professional Engineers, <https://rules.utah.gov/publicat/code/r156/r156-22.htm>).

- F. For any real property with respect to which development has proceeded on the basis of a geologic hazard and/or geotechnical report which has been accepted by [x], no final inspection shall be completed, Certificate of Occupancy issued, or performance bond released until the Engineering Geologist and Geotechnical Engineer who signed, stamped, and approved the report(s), certifies in writing, that the completed development, improvements, and structures conform to the descriptions and requirements contained within the 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 Engineering Geologist and Geotechnical Engineer are unavailable, an Engineering Geologist and Geotechnical Engineer, similarly qualified and licensed in Utah, shall provide the certifications.
- G. An applicant may appeal any decision made under the provisions of this article 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 [x] in accordance with the appeals provision ordinances of [x] and current State of Utah code.
- H. [x] shall retain a copy of each geologic hazard and/or geotechnical report in the [xx project file] that will be available for public inspection and will provide a copy to the UGS for archiving. Currently, the UGS archives these reports in the *GeoData Archive System* (<https://geodata.geology.utah.gov>).

1.12 – Disclosure Required When a Geologic Hazard Report is Required

- A. Whenever a geologic hazard report is required under this article; the owner of the parcel shall record a notice running with the land on a form provided by [x] 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 [x], which includes:
 1. Notice that the parcel is located within a Geologic Hazard Study Area or as otherwise defined in this article; and
 2. Notice that a geologic hazard report was prepared and is available for public inspection in [x] files.
 3. 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 by [x].

1.13 – Warning and Disclaimer

The Geologic Hazard Study Areas designated herein represent only those potentially geologic hazardous areas known to [x] and should not be construed to include all possible potential hazard areas. The geologic hazard ordinance and the Geologic Hazard Study Areas may be amended as new information becomes available, pursuant to procedures set forth in this ordinance. The provisions of this ordinance do not in any way assure or imply that areas outside the Geologic Hazard Study Areas are free from the possible adverse effects of geologic hazards. This article shall not create any liability on the part of [x], its officers, reviewers, or employees thereof, for any damages from geologic hazards that result from reliance on this ordinance or any administrative requirement or decision lawfully made hereunder.

1.14 – 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 article.

1.15 – Hold Harmless Agreement

Applicants receiving any permit or approval within a Geologic Hazard Study Area shall be required to sign and record on the property a *Hold Harmless Agreement* available from [x].

1.16 – Conflicting Regulations

In cases of conflict between the provisions of existing zoning classifications, building codes, the subdivision ordinance, or any other ordinance of [x] and this geologic hazard ordinance, the most restrictive provision shall apply.

1.17 - References

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Minutes of the Hurricane City Council meeting held on January 02, 2025, in the Council Chambers at 147 North 870 West, Hurricane, Utah at 3:30 p.m.

Members Present: Mayor Nanette Billings and **Council Members:** David Hirschi, Kevin Thomas, Clark Fawcett, and Drew Ellerman.

Members Excused: Joseph Prete.

Also Present: City Manager Kaden DeMille, City Attorney Dayton Hall, Police Chief Kurt Yates, Power Superintendent Scott Hughes, Public Works Director Mike Vercimak, City Planner Gary Cupp, Assistant Planner Fred Resch III, Street Superintendent Weston Walker, Recreation Director Tiffani Wright, City Engineer Arthur LeBaron, Building Official Larry Palmer, HR Director Sel Lovell, and City Recorder Cindy Beteag. Parks Superintendent Darren Barney, Water Superintendent Ken Richins

AGENDA

3:30 p.m. Work Meeting

Discussion on PDO zoning and affordable housing

Mayor Billings explained that the primary objective of today's discussion is to address the PDO (Planned Development Overlay) zone—its purpose, how it is utilized, and its connection to affordability. Gary Cupp noted that the PDO code has been opened for amendments based on prior discussions. One key amendment already added is a provision allowing for a density bonus if affordable housing is included in a development. He clarified that while the PID homes are not pursuing affordable housing projects, questions arose during the Council's deliberations about whether affordable housing should be a requirement to qualify for PDO zoning. Councilman Thomas expressed uncertainty about making it a requirement but supported the idea of offering a density bonus as an incentive for including affordable housing. However, he stressed that PDO zoning should not be granted solely for reduced setbacks. Councilman Ellerman agreed, stating that he would prefer to adjust setback regulations in other zones rather than apply PDO zoning to every development. Mr. Cupp added that the Planning staff deemed the PID applications consistent with PDO zone requirements, as they include parks and trails as part of the development. Karl Rasmussen pointed out that the developers are not merely seeking reduced setbacks but are proposing a cohesive theme for their projects. These developments include walls, landscaping, parks, and interconnected trails, enhancing the overall design. He noted that the trails are planned to encircle the developments and connect with other trails in the area, aligning with the benefits of theme-based projects permitted under the PDO. Brent Moser stated that a group of developers believes setback regulations should be re-evaluated and updated. He also reiterated their commitment to providing affordable housing. Mayor Billings explained the Council aims to support first-time homebuyers trying to enter the housing market. Mr. Moser concluded by noting the importance of

40 maintaining multiple zoning options to cater to a range of price brackets, ensuring a diversity of
41 housing opportunities.

42 Troy Ence of Ence Homes stated that his company is purchasing 180 lots within the PID area. He
43 explained that they have a product built under R1-4 zoning in the county that has proven to be
44 popular, and the development proposed in Hurricane represents an upgrade from that
45 standard. He asked the Council for their definition of affordability. Councilman Hirschi shared a
46 perspective he heard from an architect suggesting that two decades ago builders earned a 5%
47 commission on homes, compared to 30% today, and questioned if this disparity contributes to
48 rising home prices. Mr. Ence disagreed, stating that the claim was inaccurate and that no one is
49 making such a high profit. He stated that the current housing market is entirely different due to
50 significantly higher costs. Mayor Billings noted that affordability may not be tied to a specific
51 number but rather depends on an individual's income. While she acknowledged that no single
52 development can resolve the entire affordability issue, she encouraged builders to contribute
53 where possible. She suggested exploring cost-saving measures, such as using less expensive
54 materials or offering sweat equity opportunities for portions of the developments. Mr. Ence
55 explained that sweat equity is challenging to implement because it does not align with the rapid
56 timelines required for their builds. He shared an example of one of their most affordable homes
57 in Washington, priced at \$299,000 for 800 square feet. To keep costs low, they use basic
58 materials such as laminate countertops and avoid higher-end finishes like tile.

59 Councilman Hirschi asked whether the Council would need to offer concessions to encourage
60 affordable housing. Mr. Ence explained that reducing setbacks would lower costs, as larger
61 setbacks increase lot prices by \$30,000 and add expenses for concrete and landscaping. Mayor
62 Billings asked if it was unreasonable to require developers to designate 5% of their projects as
63 affordable housing. Mr. Moser noted the Council still hasn't defined what qualifies as
64 affordable. He added that Mr. Ence's homes are priced lower than many in the county, but
65 Mayor Billings countered that even these prices are unaffordable for some. Mr. Ence stated he
66 thinks they are already addressing affordability, noting self-help homes exclude commissions.
67 Councilman Thomas suggested setting aside lots specifically for affordable housing, while Mr.
68 Moser proposed incorporating this into R1-4 zoning. However, Mr. Ence cautioned that mixing
69 self-help homes into subdivisions could create quality issues and suggested clustering them in
70 one area. Mr. Moser added that second-hand sales often return to market value, highlighting
71 the ongoing need for new affordable housing. He also noted that many self-help homes include
72 deed restrictions to maintain affordability.

73 Councilman Ellerman stated attainable is different for everyone. He mentioned one idea would
74 be is to give the developer the amount of lots they are requesting but allow a few more that are
75 designated as affordable. He wants to see the State designate some land for this issue. He
76 stated people might need to go back to the old days and have less house. He has gone and
77 looked at other developments with smaller setbacks and they have worked. Councilman
78 Thomas stated if someone builds the home themselves and uses basic items like shingles, flooring,
79 counter tops and shorter ceilings then they would sell cheaper and faster. Mr. Ence stated they
80 offer exactly what he is saying except for shingles. He feels the PDO zoning looks good over

time because they have an HOA that oversees it. Rob Robinson added that Ence Homes builds a quality home at a good price. He feels it is a disfavor to put a self-help home in a development with a theme. They are a different quality and cleanliness. He stated prices of labor and products has increased dramatically. Developers that build volume homes can get smaller margins on the subcontractors. They are doing what they can to get affordable products. Mr. Ence stated he couldn't do the product he wants if he didn't get the smaller setbacks. The setbacks are a big factor. Mr. Rasmussen inquired about the 20-foot garage setbacks used in Washington. Councilman Ellerman confirmed it works well, as they measure from the property line, which includes an extra foot between the sidewalk and the property line. While oversized vehicles occasionally cause issues, they are rare. Councilman Thomas agreed, pointing out that setbacks must be measured from the back of the sidewalk, not the curb.

Discussion regarding sponsoring the Epson Tour at Copper Rock

Mayor Billings explained that the discussion about sponsoring the golf tournament began five years ago when the City committed to a three-year sponsorship to bring it to the area. Last year, the event was funded as a City event, but it was not included in this year's budget because the Council decided not to selectively sponsor individual events. Councilman Hirschi felt the tournament was good for the City and wanted further discussion. Mayor Billings added that every new event is asking for the City to sponsor but we don't have the money to do that. She is struggling of what is fair and what is the best use of the taxpayer's money.

Penny James Garcia stated it is a partnership not a sponsorship. The City receives a large amount of amenities for the partnership. She feels there is a year-round benefit that brings more people here. She showed one of seven commercials that will be showed on the golf channel that highlights the valley and Zion National Park. She stated hosting a professional golf tournament builds the prestige of golfing in our valley on a worldwide basis. They have over 500 articles that are published about the event that show the City as a sponsorship. There is only one Epson Tour in Utah and only 20 tour events total. There is only one LPGA Legends Championship per year, and they will be coming back here in 2025. It may not ever happen again and that is why they are asking for help. She thinks it will move Hurricane higher on the golf map. The tournament spends thousands of dollars to local businesses. There is also a lot of economic benefits from this tournament. She thinks it has allowed the City to increase their green fees at Sky Mountain. She added that Greater Zion and the Governor's Office have spent millions of dollars in the past two years to market golf because of the economic benefits. She is asking for the continued partnership. She thinks it is a small investment for substantial returns.

Chad with Greater Zion agreed they have invested a lot in golf over the last few years. They received a lot of coverage for what they did. They entered into a marketing agreement for 2025 because they look at it is a better deal than if they spent the money to get the same coverage on their own. This event has brought a lot more events to area. He stated their goal with Golf Plus is to encourage people to use local vendors for all the different activities in the area.

5:00 p.m. Pre-meeting - Discussion of Agenda Items, Department Reports

Fred Resch III reported that he sent a letter to a business regarding parking violations. The business is in the process of relocating and requested an extension until early March. Councilman Ellerman felt this timeline was too long. Dayton Hall explained that under the usual procedure, a revocation letter would be issued, giving the business 30 days to comply before their license is revoked. The Council agreed to proceed with the standard process and issue the revocation letter.

Gary Cupp announced The Dark Sky Summit will be in St. George. They want us to participate as they feel there is light spillage from Hurricane. He stated lunch will be provided but they need to RSVP if they want to go.

Arthur LeBaron stated the City Council approved the road dedication plat for Hurricane Garden Homes a year ago, and it has now been signed. He also noted that construction on 100 North is set to begin soon. A preconstruction and public input meeting have been held, but the project has been delayed as the contractor awaits delivery of manholes.

Weston Walker reported that construction on 2050 South and 100 North will begin soon, though no official start date has been set for 2050 South. While the sewer has been updated, storm drain improvements are still pending. Crews are nearly finished chip sealing the older parts of town and have started mowing the wash, with plans to use a mulching machine next week. Councilman Hirschi expressed his appreciation for the diagonal striping and suggested extending it about half a block north of 100 North for additional diagonal parking. Mr. Walker agreed to add it to the rotation and noted that restriping near Chums will be necessary after the chip sealing is completed.

Mike Vercimak commented it has been a slow couple weeks with the holidays, but development continues. A new project was kicked off today with a preconstruction meeting.

Darren Barney reported the Parks crews are getting caught up on projects that they can't do during mowing seasons.

Paige Chapman stated the annual audit is finished and she handed out the financial reports. She explained everything was materially correct but there were two findings. One was because we saved too much money and the other was a timing issue because the building remodel fund didn't have a budget. She explained the Council approved the project, but it wasn't officially appropriated in the budget. Invoices came at the end of the fiscal year when she was on maturity leave so she didn't see them come through. She mentioned there is a code of ethics that needs to be signed annually.

Ken Richins stated the excavation for the irrigation ponds on 1300 South for the expansion project is underway, with the contractor estimating a few months to complete. Installation of pipes along 1300 South is also progressing. The Sky Ranch Well drilling has reached 400 feet through the lava, but the water level remains unknown. He added that crews worked through the night on New Year's to address a break they were called out to repair.

157 Scott Hughes reported crews are working on getting the Christmas decorations down. They are
158 still working on the rebuild of generator #6. It is costing more and taking longer than expected
159 but he hopes it brings power back up where it is supposed to be. They still have a lineman
160 position open.

161 Larry Palmer stated he hopes to have the yearend report for the Council at the next meeting.
162 Applebee's has turned in their building permit, Ice Burg has submitted a remodel in the
163 Chevron on 700 West, and the last phase for a development on Old Hwy 91 has been
164 submitted.

165 Chief Yates mentioned they have been having a lot of issues with burglaries in the Elim Valley
166 area and he is happy to report they have caught the suspect. The suspect has been very brass
167 and enters homes when the homeowners are present. They believe the suspect is tied to other
168 communities. Holidays bring family fights and custodial interference.

169 Sel Lovell stated the City is about to start a new training system. It will be more than just HR
170 focused. It will allow department heads to pick training that is specific to their department. He
171 is hoping for better videos with this system. Parks, Power, and Police have open positions.
172 Mayor Billings thanked the committee for the Christmas party.

173 Dayton Hall explained that the City has approved the conceptual plan for the civic center, but it
174 was not a zone change or land use decision—it was just a vision for the property. The City will
175 need to go through the zone change process and update the ordinance, which staff is currently
176 working on. Once the update is agreed upon, it will go back to the Planning Commission for a
177 recommendation to the Council, followed by a public hearing and further zone change
178 procedures. The current zoning does not support the proposed plan. Mr. Hall clarified that the
179 Planning Department intends to apply a PDO (Planned Development Overlay) to the Public
180 Facility zone as part of the ordinance update. Councilman Fawcett expressed a desire for a
181 public hearing to clarify the process and address concerns from citizens who believe the Council
182 has made decisions behind closed doors. Mr. Hall noted that the letter he saw today referenced
183 State Codes that don't apply to the City's current process, suggesting misinformation is
184 circulating. Councilman Hirschi asked if a public meeting now would be helpful for clarity. Mr.
185 Hall responded that while it might provide an opportunity for feedback, the Council could only
186 listen to comments at this stage. Councilman Fawcett expressed that while people want a large
187 park, they may not understand the need for new public facilities and the City's limited budget.
188 He explained that a large park would undermine the City's goal of reducing fees without raising
189 taxes. He highlighted the importance of understanding what the entire community wants, not
190 just the surrounding property owners. Mr. Hall suggested that community input should be
191 sought during the zone change process. Councilman Ellerman proposed holding multiple open
192 houses in different neighborhoods to gather feedback when the time comes. Mr. Hall agreed
193 that engaging the community is crucial, as there is a perception that the City has already
194 approved more than planned. Councilman Fawcett clarified that the City is working to build
195 public facilities without raising taxes, but if the current plan is rejected, taxes may need to
196 increase. He also noted that while the Council did not favor high density, it was necessary to

fund the project. Mr. Hall and Mr. Cupp will continue working on the ordinance, which will be presented to the Council after the Planning Commission's recommendation. The Council agreed to hold multiple open houses before beginning the zone change process.

6:00 p.m. - Call to Order –

Mayor Billings welcomed everyone and called the meeting to order.

Prayer: Kami Collard

Thought and Pledge led by Mayor Billings

Declaration of any conflicts of interest

None Declared.

Presentation of the 2023-2024 annual audit – Hinton Burdick

Chad Atkinson presented the FY24 audit. He stated they offered a clean opinion on the audit which is the highest you can get. They were no findings for the internal control for financial reports. They also issued an independent audit report that is required by State which had two findings. There was a fund that went over their budget and then there was a fund balance which means there was too much in the General Fund. He reviewed the fund balances for each fund.

Public Forum – Comments From Public

Rob Robinson works with Elim Valley. He explained they are looking at getting on agenda for the 16th in relation to the reimbursement agreement that was signed in 2008 that has since expired. After visiting with Dayton Hall and Mayor Billings he was directed to come ask the Council if he could be on the agenda to discuss events that have happened to extend the agreement. Mayor Billings explained she asked him to come request an agenda item because this is for an exception and the Council hasn't been in favor of allowing exceptions. She stated the certificates do not have an expiration date, but the reimbursement agreement does. Dayton Hall added that reimbursement agreement between parties does have an expiration date but the vouchers that are associated with it do not. Mayor Billings stated the Council might want to hear what reasons are for why the vouchers weren't used in a timely manner. Mr. Hall explained the Council adopted rules and procedures for how you get on the agenda which are a recommendation from another board, the mayor puts it on, or agreement from two council members. Mr. Robinson was directed to seek approval from the Council to determine if two members would support adding the topic to the agenda. The Council members agreed to consider the request and inform the Mayor of their decision.

Kami Collard is here asking for transparency regarding the City Civic Center project. She expressed concerns about widespread misinformation and confusion about when residents should attend meetings to provide input. She noted that the survey sent out to residents caused issues for many, leading to further frustration. She shared that the current plans appear to involve extensive housing, traffic, and retail development, and while she acknowledged the

need for a public building, she and others are worried about the proposed zone change. Specifically, she questioned the process since the City is both requesting and granting the change. She pointed out the community's desire to understand the process and have a voice in it. Mayor Billings stated the Council has received the letters. However, some of the codes that were cited don't apply. The only thing that has been approved is the concept plan. No zone changes have happened. She explained the Planning Commission is working on the ordinance then it would be a zone change. Before that happens there will be some open houses for the community to give input. The City hired a company to find a way to fund the public facilities. Kevin Thomas explained what they saw on the map was a way to fund it without raising taxes. Ms. Collard stated what is being proposed was very startling. It is very high density, and it caught them off guard. She asked if the City would be willing to sell it back to developers for the portion that isn't needed. Mayor Billings explained that the plans include open space and a park, but the remainder of the land is necessary to fund the public facilities.

OLD BUSINESS

1. Consideration and possible approval of Ordinance 2024-07 amending Title 10, Chapters 11, 13, and 50 to add a new zoning classification R1-4, residential one unit per 4,000 square feet. Hurricane City, Applicant

Gary Cupp explained this item has been continued a few times. Staff is proposing the following: 4,000 square foot average lot area, 6,000 square foot maximum lot area, 50-foot minimum lot width, 12-acre maximum development area, ADUs, accessory buildings, and air b&bs will not be permitted, and the setbacks would be 25' for the front, 10' for the rear, and 5 and 10' for the sides. The intent of this zoning is to have a smaller development that would be more affordable. Councilman Fawcett clarified it limits the square footage of the building and how much of the lot can be covered. Mayor Billings asked the Council if they were comfortable with a front setback of 20' instead of the 25' based on the premeeting conversation. Councilman Ellerman stated he is comfortable with it. They do it in Washington and he hasn't seen a problem. Mr. Hall clarified Washington is 21' because there is foot behind the sidewalk that is city owned. The Council could change it to 21' instead of 20' if they want to match Washington. Councilman Ellerman stated there is a need for homes in Southern Utah. His only reservation is he doesn't want to see this zone everywhere. Mr. Cupp explained there is a provision in the ordinance that states they shall be evenly distributed throughout the City. Council will still have the say of where they should be allowed. Councilman Ellerman stated there is a way to limit where they can be located for example, they can't be located near a development that is more than two zone districts away. Council discussed if twelve acres was too much.

Councilman Ellerman stated he went and looked these types of developments in other cities. He stated 5' setbacks on both sides didn't feel a lot different than R1-6 lots. Depth is what was different. They were all smaller developments around 8-10 acres. He suggested putting it at a maximum of ten acres for now and if it is successful then they can update it in the future. Councilman Fawcett explained his reason for supporting this is to make more affordable

housing but if people build two stories, then it isn't affordable. Councilman Ellerman stated 85% of homes he saw were two story. However, they could put a limit on a development where there couldn't be more than two homes next to each other that are two story. He likes this zone because they have ownership and no common area. He asked if the Council could require a development agreement. Dayton Hall stated they can't require it, but they can recommend it. He stated the Council has broad discretion on zone changes. If the Council doesn't like a zone change but would be more inclined to approve it if the developer would agree to a development agreement with their requests, then that could be recommended. He stated legally they could defend it if they approve one and not another if they feel they are too close together but politically it would be hard. Mayor Billings mentioned Councilman Prete will not be at the next meeting either. Mr. Hall confirmed the changes the Council agree on are no more than two zoning districts from adjacent properties and changing the maximum acres to less. Councilman Thomas added the other change would be to allow a 21' front setback. Councilman Ellerman pointed out Councilman Prete provided his comments on this item, and he doesn't think he will change his mind. Councilman Ellerman stated he is comfortable with 22'. Councilman Thomas stated he introduced this, but he is not married to it. He agreed he didn't think Councilman Prete will ever be in favor of it. Councilman Ellerman sees the housing problems we are having, and this is a way to help that.

Kevin Thomas motioned to approve Ordinance 2024-07 amending Title 10, Chapters 11, 13, and 50 to add a new zoning classification R1-4 subject to the following changes: maximum of ten (10) acres, it can only be located in areas where the surrounding properties are no more than two steps different in zones, and a front setback of 21' from property line but no case shall be less than 21' from back of sidewalk. Seconded by Drew Ellerman. Motion failed with Drew Ellerman and Kevin Thomas voting aye. David Hirschi, Clark Fawcett, and Mayor Billings voting nay.

Kevin Thomas motioned to approve Ordinance 2024-07 amending Title 10, Chapters 11, 13, and 50 to add a new zoning classification R1-4 subject to the following changes: maximum of ten (10) acres, it can only be located in areas where the surrounding properties are no more than two steps different in zones, and a front setback of 25' from property line. Seconded by Clark Fawcett. Motion carried with Kevin Thomas, Drew Ellerman, and Clark Fawcett voting aye. David Hirschi voted nay.

2. Consideration and possible approval of the location of new pickleball courts - Tiffani Wright/Darren Barney

Darren Barney explained he and Tiffani Wright met this morning at the pickleball courts with Councilman Thomas and Councilman Hirschi to discuss options. They are proposing to leave the courts where they are but tear out and redo them in post tension and then rotate the east and west courts. They will have to extend the courts to the south side, and they would have to

remove four trees and redo the sidewalk to make it straight. They would get two more courts that way because they would all go north and south. This would also help with maintenance of cleaning up the trees. Tiffani Wright added that this will leave the use of the open space there. Councilman Fawcett stated they might replant some trees in the future, but it would cut into the grass area. Mrs. Wright explained this space is just used it for practice.

David Hirschi motioned to approve the pickleball courts in their current location but extending the court to the south and changing the courts so there will be six courts all running north and south. Seconded by Kevin Thomas. Councilman Ellerman asked about putting the courts over by splash pad. Councilman Hirschi explained that would take away too much green space. If they moved the green space over to the current court location, then it wouldn't be used as much. Councilman Hirschi added that they are still thinking of putting the pump track close to the courts but that isn't being discussed tonight. Motion carried unanimously. Kaden DeMille directed Darren Barney to get engineering for the cost estimates.

CONSENT AGENDA

1. Consideration and possible approval of Resolution 2025-03 Appointing Clark Fawcett to the Washington County Water Conservancy District Board
2. Consideration and possible approval of Resolution 2025-04 Appointing Joseph Prete to the Ash Creek Special Service District Board
3. Consideration and possible approval of Resolution 2025-05 Appointing Drew Ellerman to the Hurricane Valley Fire Special Service District Board
4. Consideration and possible approval of appointing Clark Fawcett to the Hurricane City Water Board
5. Consideration and possible approval of appointing David Hirschi to the Hurricane City Power Board

Drew Ellerman motioned to approve the consent agenda. Seconded by Kevin Thomas. Motion carried unanimously.

NEW BUSINESS

1. Consideration and possible approval of sponsoring the Epson Tour at Copper Rock

Mayor Billings explained if the Council approves this then they would have to open the budget and amend it. Kaden DeMille added that if the Council approves this then they need to decide

where they are going to pull the money from. He stated last year \$65,000 came out of the golf's fund and \$20,000 was from RAP tax. Previous years it all came out of RAP tax, but they are trying to protect that money for the pool renovations. Kent Abegglen stated he thinks Copper Rock does a great job getting exposure for golf in the area, but he hesitates about it coming out of the golf fund because they are trying to save up to redo the thirty-year-old irrigation system and the pro shop remodel. He stated the equipment is also six years old, so a new lease needs to be done. They need that money to keep the facility top notch. He understands and supports golf, but he doesn't know if the advertisement is needed to bring more people. He would hate to deplete funds and then not have it for our needs. He questioned who we say yes to and who do we say no to when there are other events that come in that bring more people. He added that Copper Rock does a great job, and they promote it well, but he doesn't think it is Sky Mountain's role to fund them. They don't want to bond or finance anything in the future. They have saved this money to use. Jeff Beteag agreed there are a lot of needs at our golf course. It is 30 years old. There are going to be costs going forward and they already don't have the money to do everything they want right now.

Penny James Garcia stated Sky Mountain is amazing to work with. She doesn't want to harm that golf course. She presented during the work meeting, and it is her belief that Sky Mountain was able to raise their green fees because of Copper Rock and Sand Hollow. Mr. Abegglen agreed that is somewhat true, but it still has to be affordable for locals. He thinks it has helped some but more on volume than price. Ms. Garcia stated she not suggesting taking the money from Sky Mountain. She thinks it could come from RAP tax or sales tax. Mayor Billings explained the RAP tax money is already committed and this wasn't budgeted. The Council said last year was the last year, so it wasn't planned for. Ms. Garcia reiterated that this is not a donation it is a partnership.

David Hirschi motioned to deny sponsorship of the Epson Tour. Seconded by Kevin Thomas. Motion carried with David Hirschi, Kevin Thomas, and Clark Fawcett voting aye. Drew Ellerman voted nay.

2. Consideration and possible approval of Resolution 2025-01 adopting a fee for dog licensing shipping and handling - Chief Yates

Chief Yates announced the transition to an online dog licensing system, aiming to modernize the process and improve compliance. Currently, licensing must be done in person, but the new system will allow for online registration. To cover the costs of shipping receipts and tags, a \$2.50 fee is proposed, which includes credit card processing fees, as noted by Councilman Fawcett. Chief Yates stated that in-person licensing will remain an option and expressed hope that the convenience of the new system will increase compliance, which is currently at an all-time low.

Kevin Thomas motioned to approve Resolution 2025-01 adopting a fee for dog licensing shipping and handling. Seconded by David Hirschi. Motion carried unanimously.

3. Consideration and possible approval of Ordinance 2025-01 Amending Title 3, Chapter 1, Sections 6 and 9 with regards to business licensing procedures - Cindy Beteag

Cindy Beteag explained that this proposal stems from the Council's discussion last month and is focused on making all fees nonrefundable. Councilman Fawcett raised concerns about not refunding fees if a license application is denied. Mrs. Beteag clarified that in cases where an application is mistakenly accepted, the City has traditionally refunded the full amount. She also noted that staff do not accept applications for uses that are not permitted. Councilman Thomas highlighted that the policy does not prevent the City from issuing refunds but specifies that refunds are not guaranteed. Dayton Hall agreed, stating that staff retain sufficient discretion to handle such situations appropriately.

Clark Fawcett motioned to approve Ordinance 2025-01 Amending Title 3, Chapter 1, Sections 6 and 9 with regards to business licensing procedures. Seconded by Drew Ellerman. Motion carried unanimously.

4. Consideration and possible approval of the design for the central island of the roundabout on Sand Hollow Road- Arthur LeBaron

Mayor Billings mentioned the email that was sent out yesterday with a rendering. She has visited with a few developers and the staff. She explained everyone wants it to look nice, but they also need to be practical because there are a lot of utilities below it, including a sixty-inch Water District water line. She would prefer to see a statue instead of trees or bushes. Arthur LeBaron explained he is not looking for a final decision tonight. There were enough different opinions that he wanted to take to the highest level in the City. In talking to JUC members he thinks they would rather see them as concrete pavers instead of stacked rock. Mayor Billings commented this is being paid for by the PID. She stated when she talked to them, they mentioned they wanted to do something with fishing, biking, ATV's, swimming, golf, etc. Councilman Ellerman asked why they would have to go underneath. Mr. LeBaron explained it would just maintenance in the future because there are utilities below it. They would rather see a terrace of pavers than rocks. He explained there was a water line that had to be repaired that is under a major feature of the Sand Hollow roundabout and it was very costly and hard to match. Councilman Ellerman asked if there was a big cost difference between the concrete and rock. Mr. LeBaron stated it is not a cost issue. It is the maintenance. There are some zones within the circle that don't have any utilities that they could locate items above. Councilman Fawcett stated he would like to try and minimize it as much as possible, but he would like to see something in there like the biking, triathlon, swimming, etc. Mr. LeBaron thinks there needs to be an agreement with the developers for future maintenance. Mayor Billings suggested not having irrigation lines and only having rocks and statues. That would be minimal upkeep for the

City. Ken Richins added it would be better if it wasn't raised because the utilities under it are already deep. Councilman Ellerman stated this will be a large roundabout, so it needs to be a good statement. Dayton Hall added that the Water District has two major lines below it and they did up an agreement that states they can only do certain things over the line. It states the HOA has to cover the maintenance costs. He stated the City could do something similar if that is what the Council wants. Mayor Billings pointed out it will be dedicated to the City so she thinks it would be better to just mitigate the risk. Mr. Hall stated the Water District also included language in the agreement stating that if they have to make repairs to their water lines, then they won't be responsible for the repairs to the actual land.

Drew Ellerman motioned to continue the approval of the design so staff can provide more details. Seconded by Kevin Thomas. Motion carried with David Hirschi, Kevin Thomas, and Drew Ellerman voting aye. Clark Fawcett absent.

5. Discussion regarding the creation of a Complaints and Violations Committee - Mayor Billings

Mayor Billings explained State has new statute that if a complaint is received about the Council then it goes to the State if there isn't a local committee. She stated hopefully they never have to use it, but it is a protection for the Council. She thinks it would be handled better locally then on the State level. This would be set up like the Appeals Board. Dayton Hall stated this can be extended to the staff if they are doing business and don't disclose it. He explained if a complaint comes in then it goes to State Ethics Committee if there isn't a local committee. Councilman Ellerman prefers it to be handled locally. Mayor Billings recommended coming back with three members. Mr. Hall stated it would have to be created by ordinance. She invited the Council to recommend people for this board. Mr. Hall mentioned there is new disclosures laws. Staff is working on the form. Council has a deadline of January 31st to have it filled by out and submitted.

6. Consideration and possible approval of Resolution 2025-02 amending the fees for cemetery plots

Mayor Billings explained the reason this was brought up is because a group came in and asked about purchasing a large number of plots because our nonresidential is lower than other municipalities in the County. She questioned if it needed to be raised so it didn't bring more people here. Cindy Beteag clarified the Council previously discussed what defines a resident and the majority of Council determined it should be based on where they are registered to vote. Councilman Ellerman asked if there were any provisions in the code so someone couldn't purchase a large number of lots and then sell them to other people cheaper than what the City sells them for. Mayor Billings explained the code does not allow the resale of plots. Mrs. Beteag explained the 2017 resolution that was passed had a cap on how many residential plots could be purchased and then it goes to the nonresidential rate. Staff wants to put that in the

ordinance if that is how the Council wants to do it. Council was in favor of keeping that limit. Residential rates are \$550. Council directed staff to bring the other changes back including defining what a resident is by where they are registered to vote or a valid identification with a Hurricane address.

Drew Ellerman motioned to approve Resolution 2025-02 amending the fees for cemetery plots. Seconded by David Hirschi. Motion carried unanimously.

7. Open and public meeting training

A video from Utah State Legislator on Open and Public Meetings and on the budget process was shown to the Council.

8. Mayor, Council, and staff reports

Kaden DeMille reminded the Council of the What's Up conference next Thursday.

Councilman Hirschi stated Kent Abegglen mentioned what he wanted to discuss. They have saved the money for new irrigation lines and a remodel.

Mayor Billings asked the Council members for recommendation for complaints and violations committee and on the following seats that will be opening soon. She mentioned Michelle Cloud and Rebecca Bronemann's terms are expiring for Planning Commission. Water Board has no seats expiring. On the Power Board Dave Imlay's term is expiring. Appeals Board has no seats expiring. On the Beautification Board Steve Baugh and Leah Evans are expiring. On the Airport Board Kate Wadsworth and Scott Freeman are expiring however, Mr. Freeman has only done one term, and Mrs. Wadsworth has resigned. On the Historical Committee Lee Beatty's term is expiring.

9. Closed Meeting held pursuant to Utah Code section 52-4-205, upon request

Drew Ellerman motioned at 8:50 p.m. to go into a closed session to discuss the purchase of water shares. Seconded by Kevin Thomas. Motion carried unanimously.

Adjournment: Kevin Thomas motioned to go out of closed session and adjourn the meeting at 9:28 p.m. Seconded by Drew Ellerman. Motion carried unanimously.

Minutes of the Hurricane City Council meeting held on January 16, 2025, in the Council Chambers at 147 North 870 West, Hurricane, Utah at 5 p.m.

Members Present: Mayor Nanette Billings and **Council Members:** David Hirschi, Kevin Thomas, Clark Fawcett (online), and Drew Ellerman.

Members Excused: Joseph Prete

Also Present: City Manager Kaden DeMille, City Attorney Dayton Hall, Police Chief Kurt Yates, Power Superintendent Scott Hughes, Public Works Director Mike Vercimak, City Planner Gary Cupp, Assistant Planner Fred Resch III, Water Supervisor Kory Wright, Recreation Director Tiffani Wright, City Engineer Arthur LeBaron, Building Official Larry Palmer, HR Director Sel Lovell, and City Recorder Cindy Beteag.

AGENDA

5:00 p.m. Pre-meeting - Discussion of Agenda Items, Department Reports

Larry Palmer reported nine single family, three town homes (a total of 17 units), and one commercial building permits were received since the last council meeting. The commercial building will be the third building at the Ace Hardware Subdivision. He also presented a year-end comparison of building permits for 2023 and 2024. Single family permits - 184 in 2023 to 289 in 2024. Townhomes - 155 in 2023 to 142 in 2024. Condos - 67 in 2023 to 70 in 2024. Commercial - 70 in 2023 to 56 in 2024. Apartments - 0 in 2023 to 3 in 2024 (a total of 32 units). ADUs - 33 in 2023 to 56 in 2024. A total valuation of \$120 million for 2023 and \$133 million for 2024. He stated the building valuations are about 40% lower than what it should be. They are working to get the building valuations up to today's valuations.

Chief Yates stated that the department has been actively testing to fill vacant positions. He announced that Travis Hall will be promoted to lieutenant over investigations. Jerod Brisk is set to retire this spring or early summer, and Justin Grey will step into his role as lieutenant over patrol at that time. Additionally, Omar Torrez, Trent Leslie, and Jason Barker have been promoted to sergeant positions to address the resulting vacancies.

Tiffani Wright stated regular programming has resumed, with all programs running at full capacity. Casting for the spring play, *Hunchback*, has been completed. She noted that the gym is being actively reserved, not only by local clubs and occasionally the high school team but also by volleyball groups from outside the area. Preparations for the upcoming pool season are underway. Mayor Billings added that she has been working on securing a grant for the pool. A decision on the grant is expected by March.

Kory Wright shared that crews have been extremely busy addressing numerous leaks but praised the team for consistently getting the job done, even with the high volume of after-hours calls. The irrigation project on 1300 South is progressing well, with the south pond beginning to take shape. So far, there have been minimal complaints about the project, and a

kickoff meeting held last night was well-received, with attendees offering positive feedback and asking many questions. The Sky Ranch Well has reached a depth of 800 feet, and the Dixie Springs Well is set to go out for bids soon. Regarding water resources, the Stratton and West Wells had a surplus of 350 million gallons last year, while Ash Creek and Toquerville had 188 million gallons left over. The city used about 200 million gallons more water in town. However, we are feeding LaVerkin in January, February, and March.

Sel Lovell stated they have been holding a lot of interviews. The Assistant Public Works position was advertised, and they are getting a lot of good applicants.

Mike Vercimak stated that since the last Council meeting, they have held three pre-construction meetings and approved additional construction drawings for housing units. The Streets Department continues work on crack sealing and is preparing to advertise for the upcoming chip and slurry seal project.

Arthur LeBaron stated he has been busy with a lot of the same projects Mr. Vercimak mentioned. He has also been working on the easements for power from 600 North to 3000 South. The Chip and slurry seal are out for bid and some foundation repair at the Bradshaw Hotel. He stated Interstate Rock has been wanting to start on 100 North, but the project manager needs to wait until March 1st to start because they are too busy right now with other city projects.

Gary Cupp mentioned they have a small Planning Commission agenda next week. There is a zone change that will come to the Council soon for Chris Wyler's request to rezone about three acres to recreation resort in relation to the lot split that was done illegally, which has been corrected, allowing the project to move forward. He mentioned there has been a code problem with Living Earth Farms across from the pecan farm where they converted an existing building into a retail farm store. They did it without permits and now they are trying to correct the problems. It is currently not a permitted use. It came up about other places allowing small farm retail stores in the agriculture zones. If the Council is in favor of allowing something like that, then we would have to update the code. He stated Mayor Billings suggested allowing it by a conditional use permit. However, Mr. Cupp explained there is a larger issue of the property in general because of all the violations. Staff doesn't want to expand uses with all the other violations. Mayor Billings mentioned the development agreement that was supposed to be signed. She suggested a work meeting to discuss it. She explained they are currently only allowed to do a fruit stand, but they had all products that are made at home. However, some of the products were not their own. She is not against having farm related stores. Mr. Cupp stated he would recommend it in straight agriculture not residential agricultural. He would want to limit so it isn't a large retail store. Dayton Hall provided additional context, explaining that the property has a long history of violations, including unsafe living conditions. Previously, the Council approved a zone change for the north end of the property on the condition that the owner move trailers, connect to the sewer, and close all illegal businesses. However, the development agreement was never signed, and compliance has not been achieved. Instead, the owner has placed tiny homes in the area designated for trailers and brought in additional

trailers, none of which have been relocated. Hall emphasized that while the Council appreciates the concept of the farm store, the property must be brought into compliance before any expansion can be considered.

Cindy Beteag handed out the new conflict of interest forms and told the Council of the new requirements. Dayton Hall explained this is the same information that is required under the election code, but the State changed the code so now it has to be done every year, and it has to be posted on the City website.

6:00 p.m. - Call to Order –

Mayor Billings welcomed everyone and called the meeting to order.

Prayer, Thought, and Pledge led by Rick Stout.

Declaration of any conflicts of interest

Councilman Thomas declared a potential conflict on new business #7.

Swearing in of Police Chief Kurt Yates

Mayor Billings stated she is thankful for all the support of the new police chief. She announced the promotions of Travis Hall to lieutenant and Omar Torrez, Trent Leslie, and Jason Barker have been promoted to sergeant positions. She hasn't heard one negative thing about Chief Yates. She thanked him for his leadership. She also thanked his wife, Mandy, for her support with Chief's position.

Chief Kurt Yates was sworn in by City Recorder Cindy Beteag.

Chief Yates thanked everyone for their support.

Public Forum – Comments From Public

No comments.

CONSENT AGENDA

1. Minutes of the Regular City Council Meeting for December 19, 2024
2. Consideration and possible approval of Resolution 2025-06 appointing Clark Fawcett to the Ash Creek Special Service District Board
3. Consideration and possible approval of Resolution 2025-07 appointing members to the Planning Commission
4. Consideration and possible approval of Resolution 2025-08 appointing members to the Power Board
5. Consideration and possible approval of Resolution 2025-09 appointing members to the Beautification Board
6. Consideration and possible approval of Resolution 2025-10 appointing members to the Airport Board
7. Consideration and possible approval of Resolution 2025-11 appointing members to the Historical Preservation Committee

Mayor Billings explained Michelle Smith and Amy Werrett are being appointed the Planning Commission, Dave Imlay is being reappointed to the Power Board, Leah Evans and Steve Baugh are being reappointed to the Beautification Committee and Mike Parker will be appointed as a new member, Scott Freeman will be reappointed to the Airport Board and Jason Campbell will be appointed as a new member, and Lee Beatty is being reappointed to the Historical Committee. Clark Fawcett arrived in person at 6:18 p.m.

Drew Ellerman motioned to approve the consent agenda. Seconded by Kevin Thomas. Motion carried unanimously.

OLD BUSINESS

1. Consideration and possible approval of the design for the central island of the roundabout on Sand Hollow Road- Arthur LeBaron

The developers asked for this item to be tabled until they can bring back more information.

David Hirschi motioned to table the approval of the design for the central island of the roundabout on Sand Hollow Road. Seconded by Clark Fawcett. Motion carried unanimously.

NEW BUSINESS

1. Consideration and possible approval of sponsoring the Hurricane Utah Farmers Market by way of waiving the rental and power fees, extending the season, and banner placement across 100 West - Annie Spendlove

Mayor Billings stated this Farmers Market has been going on for five years. There have been no issues. They hold it on 100 West. They are requesting to be open every Saturday between March to November except for Peach Days, Easter Car Show, and July 4th.

Kevin Thomas motioned to approve sponsoring the Hurricane Utah Farmers Market by way of waiving the rental and power fees, extending the season, and allowing a banner placement across 100 West. Seconded by David Hirschi. Motion carried unanimously.

Annie Spendlove stated they have been able to provide \$7000 worth of food assistant the previous year through their programs.

2. Consideration and possible approval of Resolution 2025-12 authorizing the Community Education Channel Agency Third Amended Interlocal Cooperation Agreement

Mayor Billings read the following summary provided in the packet written by Kaden DeMille. "Since 1995 Hurricane City has been a member and participating agency in the Community

Education Channel Agency Interlocal Cooperation Agreement. The purpose of the agreement was to fund, operate, and finance a community education channel that would be staffed through students enrolled at Dixie College. Over the decades the interlocal agreement was amended for several reasons, all of which were purposed to continue the operation of the Community Education Channel Agency. This amendment has the purpose to wind-up, dissolve, and distribute the assets of the CEC. As a matter of interesting local history, the original interlocal agreement was signed by Dixie College, the second amendment of the interlocal agreement was signed by Dixie State College, and the third amendment will be signed by Utah Tech University. This history also manifests the reason for dissolution of the CEC Agency, simply put, technology has passed by the purpose for the CEC and the participating agencies no longer use the services of the CEC to broadcast public meetings.”

Kaden DeMille noted a steady decline in revenues, largely due to fewer people subscribing to television services, making the dissolution inevitable. He added that the specialized broadcasting equipment, which none of the cities can utilize, will be returned to Utah Tech for students' use. Councilman Fawcett explained that while the original intent was to teach students how to broadcast, many residents were unable to access the content. He believes the equipment will be better utilized by the students.

Clark Fawcett motioned to approve Resolution 2025-12 authorizing the Community Education Channel Agency Third Amendment Interlocal Cooperation Agreement. Seconded by David Hirschi. Motion carried unanimously.

3. Consideration and possible approval of a Memorandum of Understanding with the Shivwits Band of Paiutes regarding the use of property owned by the Shivwits Band within Hurricane City boundaries. -Mark Echo Hawk.

Mayor Billings read the following summary provided in the packet written by Dayton Hall. “The Shivwits Band of Paiutes have submitted a fee-to-trust application to the Bureau of Indian Affairs for two parcels of land adjacent to SR-9 between the Maverik by Walmart and 3700 West Street. The Shivwits have requested that the City Council support of the application. The Shivwits currently own the land, but if the application is approved, the land will be transferred to the U.S. federal government to be held in trust for the benefit of the Shivwits, which means the land will essentially become a part of the reservation. This item was introduced to the City many months ago, and the City and the Shivwits have been working through the identified potential issues with the fee-to-trust approval. The full draft MOU is in the packet. A summary of the key terms is as follows: The MOU will not be effective unless the fee-to-trust application is approved. Improvements on the property will comply with the City’s commercial zoning standards, the Utah Building Code, and the City’s Standards. Improvements will be inspected by a licensed building inspector. Normal impact fees will be paid to the City prior to vertical development. Utility services will be applied for and provided the same as any other customer.

197 Recognizing that the property will be removed from the City's tax base as far as property taxes
198 and sales taxes, which are used by the City to maintain its operations and services, the Shivwits
199 will pay an annual Community Contribution Fee that has been estimated to approximate the
200 amount of revenue that would be generated by a comparable travel plaza. The Community
201 Contribution Fee will be 1% of the current land value, increasing by 3% annually to account for
202 inflation."

203 Mayor Billings shared that the city has held multiple meetings with the Shivwits Band,
204 expressing admiration for how they utilize their funds and gratitude for their decision to invest
205 in Hurricane. Mark Echo Hawk, who has served as the tribe's attorney for nearly two decades,
206 provided an overview of the Shivwits Band and thanked everyone for their collaborative efforts.
207 He highlighted the tribe's long history as a sovereign entity, federally recognized since the early
208 1900s, and their focus on supporting their people by investing in governmental partnerships
209 and integrating into the community. He acknowledged the challenges the tribe has faced but
210 highlighted their resilience. He explained that the elected band council oversees advancing the
211 interests of the tribe, primarily through the government-owned Shivwits Band, which generates
212 revenue through economic development rather than a tax base. Committed to being good
213 neighbors, the Shivwits Band has purchased land in Hurricane, which they are in the process of
214 designating as tribal land. Plans for the property include a travel plaza, hospitality and retail
215 facilities, and a Shivwits cultural hall. He mentioned their intention to work closely with the City
216 to build a strong government-to-government relationship, create jobs, and ensure their
217 projects meet Hurricane's standards, even though they could adhere to their own codes. They
218 are coordinating with City staff to address sewer and drainage requirements, committing to pay
219 impact fees, and ensuring compliance with local expectations. The Shivwits Band is also seeking
220 a letter of support from the city to strengthen their application with the Bureau of Land
221 Management, which considers community input when evaluating tribal land applications. Echo
222 Hawk noted their existing store is well-managed and expressed excitement about collaborating
223 with the city on this new endeavor.

224 Mayor Billings noted that the police chief appreciates having an agreement in place, mentioning
225 that a similar arrangement with Ivins has been successful. Councilman Fawcett expressed
226 concern that the pricing at the proposed development might be significantly lower than that of
227 surrounding businesses, potentially impacting them negatively. He questioned whether it is
228 responsible for the council to support something that could harm other local businesses.

229 Mark Echo Hawk responded by acknowledging that while the Shivwits Band aims to maintain a
230 competitive advantage, their intention is not to drive anyone out of business. He explained that
231 in other instances, they have made efforts to be mindful of nearby competition and are open to
232 discussions with other retailers to find a balance. While it is natural to aim for competitive
233 pricing, they are willing to work to ensure it remains reasonable. Councilman Thomas voiced his
234 full support for the proposal, and Councilman Ellerman shared his enthusiasm for the
235 scholarships the Shivwits Band provides to students, noting that they awarded 14 scholarships
236 last semester.

Kevin Thomas motioned to approve the Memorandum of Understanding with the Shivwits Band of Paiutes. Seconded by Drew Ellerman. Motion carried unanimously.

A member from the Shivwits Band stated she will be teaching a class about their tribe on February 26th at 6 p.m. at the Utah Tech Library Cove in the Bowling Auditorium.

4. Consideration and possible approval of an asphalt path to the water cisterns off of the 60 East walking path - Lee Beatty

Mayor Billings explained that she kept this item on the agenda to gather the Council's thoughts. If the Council supports the idea, they can explore the associated costs and consider including it in the budget. Lee Beatty suggested that the trail should be ADA-accessible and paved with asphalt. Councilman Fawcett recalled that the City had previously discussed the project, but nearby property owners were strongly opposed at the time. He recommended seeking their input again before moving forward. Councilman Hirschi clarified that the location is at the Three Falls Trailhead and is not adjacent to anyone's backyard. Councilman Thomas questioned how frequently the trail would be accessed by wheelchairs. Mayor Billings responded that the project isn't solely for accessibility but also to stabilize the area and prevent erosion. The Council agreed to proceed with exploring the costs. Councilman Ellerman clarified the City doesn't have the equipment to do it ourselves. He will ask if Washington City still has one that they will let us use it.

5. Consideration and possible approval of the relocation of the Hinton Home next to the museum - Lee Beatty

Mayor Billings explained that the Hinton Home is currently located on the Wells Fargo property, which they intend to sell. However, Wells Fargo would like the home moved before the sale, as the prospective buyers do not want it designated as a historical site. One potential location for the home is east of the splash pad, though staff raised concerns about that site due to past vandalism in the area. As an alternative, Mayor Billings suggested placing the home near the bell tower. Regardless of the location, a concrete slab will be needed to support the structure. Merlin Spendlove mentioned that measurements taken last week indicate the home is approximately 20x30 feet. He noted that if it were placed near the splash pad, the Sons of Utah Pioneers would prefer it to face the museum. Darren Barney presented the master plan, which originally designated the northeast corner near the parking lot as the intended location for the home. Wells Fargo has agreed to cover the cost of moving the home, but the City would be responsible for the slab. Councilman Thomas suggested asking Wells Fargo to pay for the slab as well. Dayton Hall noted the importance of preserving the home and determining its ownership, as whoever owns it has the final say on its future. Kaden DeMille brought up the possibility of temporarily storing the home on the property west of the city office, which includes old structures intended for incorporation into the Civic Center. However, he questioned whether the Council would want the home there, given that development on the

property is still a long way off. Councilman Thomas expressed concerns that storing the home there for an extended period could compromise its structural integrity. The Council ultimately expressed a preference for placing the home at its originally approved location. Tiffani Wright noted that the plaque in front of the home states it was donated to the Hurricane Valley Heritage Park Foundation.

Kevin Thomas motioned to approve the relocation of the Hinton Home to the location where it was master planned. Seconded by David Hirschi. Motion carried unanimously. Council was in favor of asking Wells Fargo if they will pay for the concrete slab in addition to paying to move it.

6. Consideration and possible approval of the relocation of the Pine Valley monument on SR-9 to another location - David Hirschi

Merlin Spendlove presented the current location of the monument at the corner of SR-9 and Telegraph, explaining that it is largely unnoticed. To visit the site, one must enter the Shadow Ridge subdivision. Before the road improvements, there was a small parking area where people could stop to view the monument. Mayor Billings explained that the monument highlights the geological features of Pine Mountain. Mr. Spendlove noted that the sign on the monument is now illegible, but the Sons of Utah Pioneers (SUP) specialize in restoring such landmarks and are committed to preserving it. He stressed the historical significance of the monument and expressed a preference for keeping it on the bench where visitors can still see Pine Mountain. Mayor Billings added that one consideration against relocating it to the "Welcome to Hurricane" sign area is that UDOT has restrictions that prevent the development of a park there, making it a less viable option. Mr. Spendlove suggested that the columns could be moved, and the sign redone if a more accessible location is identified. Arthur LeBaron shared photos he had taken of the monument and noted that the back indicates it was part of an Eagle Scout project in 1986, possibly when the current wooden structure was added. He proposed relocating the monument to a trailhead near Pine Mountain, with the Cottonwood Trailhead as his top choice. However, since this trailhead is outside city limits, coordination with the BLM would be required. Mr. Spendlove supported this suggestion. Councilman Fawcett proposed an alternative location near the trail off 600 North to the Cinder Knolls. However, Councilman Thomas pointed out that the Cottonwood Trailhead is closer to Pine Mountain, while the 600 North trail attracts visitors primarily interested in the Cinder Knolls, making information on Pine Mountain less relevant there. Councilman Fawcett acknowledged the appeal of keeping the monument within city limits but understood the advantages of the Cottonwood Trailhead, which sees high usage. Mr. Spendlove reiterated his preference for the Cottonwood Trailhead. The Council directed him to consult with the SUP about the proposed locations and to work with the BLM to determine if the monument can be placed at one of the suggested sites. Leah Evans noted that the Beautification Committee is always seeking projects and offered their assistance with these efforts.

7. Consideration and possible approval of an amendment extending the term of a reimbursement agreement for Elim Valley

Mayor Billings read the following summary provided in packet written by Dayton Hall. “This agenda item is a request from the original Elim Valley developers to extend the term of an expired reimbursement agreement. On May 16, 2008, the City entered into a Reimbursement Agreement with Elim Valley Planning & Development, LLC and Mellon Valley, LC (the “Developers”). The Developers dedicated a portion of Sand Hollow Road to the City and, in exchange, the City entered into the Reimbursement Agreement in which the Developers were issued 196 streets impact fee vouchers valued at \$3898, for a total value of 764,008. A few of the vouchers were used in the first phases of Elim Valley, but most were not used. The Reimbursement Agreement states that “This Agreement shall expire fifteen (15) years from the date of signature, regardless of the total amount of reimbursement paid by City to Developer.” The Reimbursement Agreement also provides that the “term may be extended if agreed upon by both Parties.” The Developers are requesting that the term be extended. The term was agreed to in 2008, and the City has no legal obligation to extend the term. If the Council agrees to extend the term and allow the expired vouchers to be used, the amount of revenue that will be forfeited for the streets impact fee fund will be \$689,946.00.”

Mayor Billings explained that the agreement expired a year and a half ago and noted that the expiration date was not printed on the vouchers. Lorin Walker, representing Elim Valley Planning and Development, provided context for their request to extend the agreement. He pointed out that a clause in the original agreement allows for extensions and explained why they believe an extension is justified. After signing the agreement, the housing crisis occurred, and no one was buying homes. Additionally, they were tied up in legal disputes for several years, preventing development from moving forward. Now that those issues have been resolved, they are ready to proceed and are requesting a one-year extension to utilize the vouchers. Mayor Billings stated that before placing the item on the agenda, she asked Dayton Hall to confirm whether the entities involved in the agreement were still valid, which they are. This means the agreement would remain with the same parties. Councilman Ellerman clarified that the current streets impact fee is \$2,294, which is lower than when the vouchers were issued. As a result, the vouchers now represent greater value to the City. He also noted that the City gained land value through the agreement and said he would consider an extension based on that. Councilman Hirschi confirmed that no zoning changes are being requested. He asked why the original agreement included a 15-year expiration date. Dayton Hall explained that from an administrative perspective, it is challenging to track agreements for such a long period, and they did not want the agreement to remain open-ended. Councilman Ellerman added that it is common to include expiration dates in agreements to avoid indefinite obligations and felt that 15 years was a generous term. Councilman Hirschi remarked that the era of offering incentives to attract businesses has passed. He acknowledged the complexity of the situation, noting that times have changed and the agreement has already expired.

Mr. Walker explained that this is a large-scale project originally anticipated to take 30 years to complete. He urged the Council to consider the timing of events, noting that there was a period when building activity had essentially stopped. He stated that the inability to develop was beyond the developer's control. Councilman Ellerman pointed out that the original approval was for over 10,000 lots. Mayor Billings added that the projected density has since decreased by several thousand lots. Councilman Fawcett acknowledged the challenges the developers faced but questioned why no one had proactively addressed the issue before the agreement expired. He stressed the importance of monitoring such a significant agreement and asked why it wasn't being tracked. Mr. Walker explained that the developers were overwhelmed by legal issues at the time, and this agreement was unintentionally overlooked. Rob Robinson, who has worked for Elim Valley for 17 years and oversees their contracts, stated that he had never seen this particular agreement before. Despite managing thousands of documents, he did not have this one in his records. He noted that while he has all the vouchers, none of them indicate an expiration date. He only became aware of the agreement when they approached Ence Homes. At that point, he contacted Tami Jones about the vouchers and learned that the agreement had expired. Mr. Walker and Mr. Robinson added that they are only requesting a one-year extension. They now have builders lined up and are ready to move forward. They also reminded the Council that they provided the City with land for the road and are seeking fair treatment and some form of compensation. Councilman Fawcett stated that while he wants to be fair, it is ultimately the developers' responsibility to track their agreements. He expressed openness to making exceptions if there are valid reasons, but reiterated the importance of accountability in such matters.

Councilman Ellerman reviewed the numbers, explaining what was originally approved, what has been used, and the remaining balance. He noted that 173 vouchers are still available and that the streets impact fee is \$1,600 lower today than when the agreement was signed. Dayton Hall confirmed that the applicant would accept one voucher per building permit. Councilman Fawcett observed that other developments have been allowed to carry over the dollar value of agreements rather than specific vouchers. Mr. Hall advised that if the Council decides to extend this contract, the terms need to be clearly defined and specific in the agreement. Councilman Fawcett agreed, adding that the reasoning for any extension must be carefully documented. Councilman Ellerman acknowledged that extending the agreement would reduce the streets fund but reminded the Council to consider the value of the land the City received through the original agreement. Councilman Thomas recused himself from voting but expressed his opinion that this is not about the dollar amount. He stated that the contract has expired, and this is not an extension but rather a new arrangement. He also pointed out that if the development were starting today, no vouchers would be issued under current practices. Councilman Fawcett explained that this situation is unique because the City initiated the road to provide access to Sand Hollow. Councilman Ellerman stated that while many numbers were discussed, he is not comfortable simply rejecting the developers' request without offering a solution. He supported the idea of allowing some use of the vouchers with a compromise to impose a minor penalty. Councilman Fawcett agreed, favoring a balanced approach that acknowledges the lapse in tracking while allowing partial use of the vouchers. Councilman Ellerman also noted a

preference to avoid using vouchers in future agreements. In response, Arthur LeBaron clarified that the City's ordinance currently requires agreements to be structured this way. Mr. Walker adjusted his request, stating that a one-year extension would not be sufficient and that two to three years would be more appropriate. Mayor Billings pointed out Councilman Prete would probably be unable to vote due to a conflict of interest, and three votes would be needed to approve any agreement.

Drew Ellerman motioned to create a new contract that will allow the developer to use 173 vouchers. The contract will be limited to 24 months and if impact fees go up, they will have to pay the difference but if they go down, they don't get a credit. One voucher per lot. This new contract is due to the fact that the street impact has gone down since the agreement was approved, there was a downturn in the economy right after the original contract was signed, and the property was in litigation for years. Seconded by Clark Fawcett. Motion carried unanimously. Dayton Hall clarified the contract will come back to the Council for final approval.

8. Consideration and possible approval of an agreement with Downtown Redevelopment Services LLC regarding the zoning overlay for the downtown masterplan - Gary Cupp

Gary Cupp began by explaining that the Council adopted the downtown master plan last year, which outlined the current conditions and the desired future for the downtown area. To achieve that vision, the plan includes an implementation schedule, and part of that involves creating a downtown overlay zone. The designated downtown area spans from 200 North to 200 South and from 300 West to the bend in State Street. The goal of the overlay zone is to foster a mixed-use, walkable, and vibrant district while streamlining the development approval process. This would help create an economically viable area to attract businesses. The overlay zone would establish guidelines for development, including an architectural theme, façade improvement programs, and a vacant property ordinance. The proposed contractor, who prepared the original master plan, would continue the project under a \$23,000 contract already included in this year's budget. Councilman Fawcett raised concerns about traffic issues, noting that local traffic is already a problem in the area. He questioned whether making the area more active and viable would exacerbate those problems. He also asked how the area could be made pedestrian-friendly given the heavy traffic on SR-9 and the lack of alternative routes. Mr. Cupp responded that the intent is to create a walkable environment, but Councilman Thomas pointed out that the Council lacks a unified vision for downtown. He argued that hiring a consultant would be a waste of money if the Council cannot agree on what they want. Mr. Cupp clarified that the purpose of the consultant would be to provide guidance on how the downtown area should look. While it is part of a general plan element, he acknowledged that the Council might not see it as a priority right now. Mayor Billings suggested they consider rezoning and gathering input from residents to determine what they want for the space. Councilman Ellerman argued against spending money on a consultant, sharing that Washington City manages development along major roads by using conditional use permits. This approach allows the Council to influence the

design and theme of buildings over time, which, he suggested, could achieve the same results as hiring a consultant.

Mayor Billings recalled that when the issue was previously discussed, Councilman Thomas introduced concepts that resembled the look of Ace Hardware, and she noted that everyone seemed to be in favor of that design. She expressed support for using conditional use permits. Mr. Cupp explained that the ordinance would need to be updated to allow this approach. Councilman Thomas suggested that the Council should model their approach after the Ace Hardware design, but he noted that the real point of disagreement is the building's function, and the number of stories allowed on the City's property. Both Councilman Hirschi and Mayor Billings emphasized the importance of preserving green space in the downtown area. In response, Councilman Ellerman argued that to create a walkable community, buildings should be at least two stories, with retail on the lower level and residential space above, a design trend that is gaining popularity. Mr. Cupp acknowledged that mixed-use developments are not currently permitted and would require code updates if the Council desires such a change. Councilman Hirschi reiterated his preference to maintain open space, while Councilman Fawcett agreed, stating that the Council needs to take a leadership role in setting the vision and planning for the area. Mayor Billings noted that establishing an overlay district remains important, whether or not this particular contractor is chosen, to guide future development. Councilman Thomas argued that excluding the City property from the plan would undermine the district's effectiveness, as it is centrally located. Mr. Cupp clarified that the City property had been designated as a catalyst property. Councilman Ellerman suggested keeping the City property as a gathering space while focusing on planning the look and feel of surrounding developments. He stressed the importance of providing developers with a clear theme. Mr. Cupp pointed out the need to consider the urgency of the situation. Councilman Ellerman recommended updating the code to allow for conditional use permits in the designated area, with aesthetic standards approved by the City Council. Dayton Hall added that the Council would need to outline specific conditions. Councilman Ellerman offered to send ordinance samples to the staff for review.

4o mini

David Hirschi motioned to deny the agreement with Downtown Redevelopment Services LLC. Seconded by Kevin Thomas. Motion carried unanimously.

9. Consideration and possible approval of a renewed contract with Alpha Engineering for engineering services - Dayton Hall

Mayor Billings read the following summary provided in the packet written by Dayton Hall. "The proposed contract is consistent with the City's current relationship with Alpha Engineering. Although the City accepted these rates in a proposal by Alpha in 2015, there was never a signed contract. The lack of a signed contract surfaced this month when the Utah Board of Water Resources requested a copy of the engineering services contract as part of the Board's award of a zero-interest loan to the City for the construction of the pressurized irrigation system and the new culinary water tank and well. A contract with Alpha Engineering is required prior to the

Board's meeting on January 30th. Staff recommends approval of the contract. The City Attorney approves the contract as to form." Glen Carnahan with Alpha Engineering expressed gratitude for the long-standing relationship with the City.

Drew Ellerman motioned to approve the contract with Alpha Engineering. Seconded by Kevin Thomas. Motion carried unanimously by a roll call vote.

- 10.** Consideration and possible approval of ZC25-01, a Zone Change Amendment request to rezone a property located at 808 S 920 W from RA-1 (Residential Agriculture, one unit per acre) to RA-0.5 (Residential Agriculture, one unit per half acre).

Mayor Billings read the following summary provided in packet written by Gary Cupp. The applicant requests a zone change from Residential Agricultural RA-1 to Residential Agricultural RA-0.5 on 1.05 acres located on the west side of 920 W and north of 900 S. The applicant has stated that their purpose is to facilitate a lot split to build two homes. The Planning Commission heard this item on 1/9/2025. No objections to the project were voiced during the public hearing for this item and the Planning Commission voted 7 in favor with 1 abstention to approve the zone change request. Findings - Staff has reviewed the proposed zone change and finds that the project: The application meets the standards within the General Plan and General Plan Map. The zone change is harmonious with existing development in the area in that most of the surrounding development is large lot single family homes. The proposed zone change will not adversely impact the area and is within the parameters of the General Plan. Services are adequate to serve the area and proposed project Staff recommends approval. Councilman Ellerman clarified the property between the property and the street is already owned by the City. Karl Rasmussen explained they will split the lot for two half acre lots.

Kevin Thomas motioned to approve ZC25-01 a zone change amendment request to rezone property located at 808 S 920 West from RA-1 to RA-0.5. Seconded by David Hirschi. Motion carried unanimously.

11. Mayor, Council, and staff reports

Councilman Fawcett shared his experience serving on the Washington County Water Conservancy District (WCWCD) board, noting that it has been insightful to review their budget. He mentioned that the board recently approved contracts with Ivins, Santa Clara, and Washington for reclaimed water use. During discussions, Hurricane's contract was raised, with the District expressing concerns with the City wanting to do their own thing. He told Morgan that he plans to meet with her to address these concerns. Additionally, he mentioned a group trip to San Diego to tour a reuse plant. He highlighted the District's satisfaction with the conservation efforts, including their initiative to buy back sod. Councilman Hirschi suggested

that if Councilman Fawcett decides not to run for re-election, he should petition the WCWCD board to ensure that an elected official remains on the board. Councilman Fawcett affirmed that he would appreciate the Council's input, allowing him to represent their concerns at the board level.

Mayor Billings noted that she will be attending the inauguration next week, where she plans to meet with several Utah senators and congresspeople.

12. Closed Meeting held pursuant to Utah Code section 52-4-205, upon request

Kevin Thomas motioned to go into a closed session at 9:25 p.m. to the discuss the potential purchase of water rights or water shares. Seconded by Drew Ellerman. Motion carried unanimously.

David Hirschi motioned to go out of closed session at 10:00 p.m. Seconded by Drew Ellerman. Motion carried unanimously.

Councilman Ellerman asked if Smith's was coming to Hurricane. Mayor Billings stated they are in discussions but right now only Maverick and Panda Express have committed for the Elim Valley area.

Adjournment: David Hirschi motioned to adjourn at 10:04 p.m. Seconded by Kevin Thomas. Motion carried unanimously.

January 2025 Newsletter- (Summary review of 2024)

Dear Board members,

2024 was an eventful year. We have grown and progressed in many ways and have learned a lot in the process. Here are some of the highlights from the whole year.

-Middleton Pond water diversion project- We diverted spring water past one pond/basin into another, hoping that we could reduce the number of mosquitoes coming from that location, and later gain access if needed for the clearing of the reeds.



-DWR willow planting- The crew joined up with the DWR to plant new willow shoots in areas of Springs Marsh that had been burned earlier.

Cyanobacteria training- We received training from Hannah Bonner, who is an Environmental Scientist for the Division of Water Quality. She taught us how to look for and to identify toxic Cyanobacteria/algae that can be found in most bodies of water throughout the state. When these algae blooms grow, they can become toxic if ingested, especially by smaller animals.



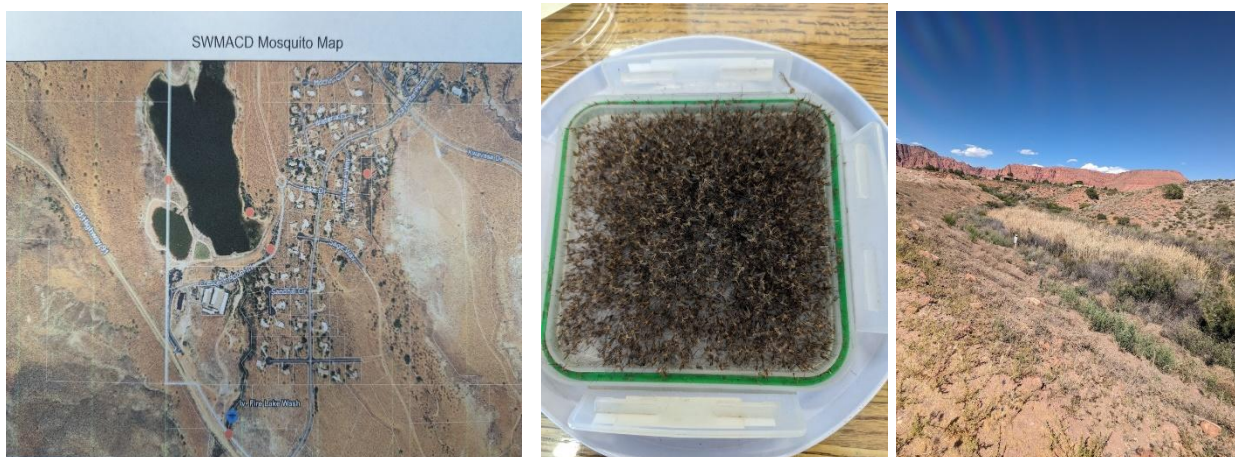
USU research projects- We helped out with a few research projects for students from Utah State University. They were finding out the distribution of the Culex

pipiens/quinguefasciatus mosquitoes. We provided samples and we showed them their natural habitat.

Program implementation for Shivwits band- We spent quite a bit of time mentoring and training the Ute tribe/ Shivwits band members, located at the reservation by Ivins, so they could establish a new surveillance and abatement program there. We mostly worked with Travis Duran, who spearheaded their program. Together we identified potential mosquito habitat and trapping locations. They had a couple of interns that came and helped in the lab to sort and identify the mosquitoes. At the end of the season, they presented all their data at the Annual Utah Mosquito Abatement Association meeting held down here in St. George.



Fire Lake insect study- We were tasked by the City of Ivins and some residents to measure the potential insect problems around Fire Lake and Ivins Reservoir, so we could gather information about the impacts of building a future reservoir closer to the city. From that study, we ended up finding a major mosquito problem (over 2500 mosquitoes in the first trap we set) in a wash down from the reservoirs, which we have now added to our regular monitoring route.



Tick surveillance- The state Health Department started monitoring ticks in the state to identify some of the diseases that might be here. Official research had not ever been done in our area, so this was new to all involved. We partnered up with them a few times this year to do “tick drags” in potential tick habitat areas. This consisted of us dragging a cloth attached to a stick through the bushes hoping to have ticks attach to the cloth. This method was effective, and we were able to find quite a few ticks around our area that were not found in any other parts of the state. These particular ticks are known to carry tularemia and other diseases.



MOU for mosquito fish- We worked with Randy Oplinger, who is the Assistant Aquatics Section Chief for native species at the Natural Resources Division of Wildlife Resources, to create a new MOU for the use of mosquito fish in the state. We were told long ago that we were not allowed to use mosquito fish because they were afraid that they would get into the Virgin River, (even though they are already there). Together we were able to carve out a few exceptions and could be allowed to use them, but right now it would cost too much to create a program to be able to utilize them effectively. We can at least use them if we need them.

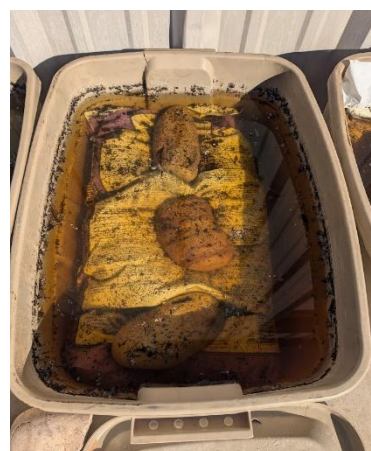
Aedes aegypti- The aegypti issue this last season started early. In the spring, we were already called out to areas that had problems the year before. We were able to resolve some of the early issues, but the dry weather exacerbated the problem, and we ended up trapping and treating in about 12 different neighborhoods. They were relentless. We were able to find out more about their habitat and hiding places. We also hired a crew to help with the inspections. This helped diffuse the situation a bit and gave relief to us and the public.

During this time, we also were able to develop a new tool to help us fight the buggers. We developed, calibrated, and then tested a new hand-held WALS (Wide-Area Larvicide) blower. This is a leaf blower converted over to spray out larvicide in a mist, so that we can get the product to places that we can't access physically or with other products. It is like a fogger but for larvicide product. We didn't have a lot of time to test it this season, but I'm sure we will put it to work a lot this next season.



To better handle the hundreds of aegypti service calls, we also improved our new hand-held fogger. We made it spray better and easier to use in the many backyards that we inspected through the season.

We also started some initial testing of the potting soils and mulches that we suspect are the culprit in bringing the aegypti to the area. We don't have any conclusive data yet, but we are hopeful of identifying the true problem soon, so we can better home in on the real problem.



DNR Education week and STEAM nights- We spent time this last season doing more educational outreach. We had our regular STEAM nights where we did presentations at elementary schools around the area. We also teamed up with the local DNR office for their education week. They have school children from across the County bused out to areas where they can show them what they do to survey and protect the native wildlife in the area. We were able to share a bit about what we do alongside their program. I think it will be a great partnership for years to come.



Health Department article and social media segments- I was asked to write an article for the Health Department magazine that goes out to all the citizens in their coverage area. (put link here)

I wrote about our work here and what that means to public health. Because it would be published in the fall, the health department wanted to do some social media segments to inform the public sooner. They videoed me out in the field with a trap and dipping for larvae. They did another segment at the shop where we showed off the lab and some of our other equipment. The final segment was at the Natural Science Museum over at what used to be called Dixie. This is where I got my start with mosquito abatement under Dr. Barnum's instruction and guidance. We started with the lab being a single table within the museum. We showed everyone our humble beginning as well as all of the other cool stuff found in the museum

All of this work with them lead to our District receiving the "Friend of Public Health" award at their annual staff conference. I was also lucky enough to get to be their keynote speaker. I presented about how to become MAD (Mosquito Abatement District) and what we do here. I then had them participate in a crazy relay race showing off what they had learned from my presentation. It was a ton of fun.



Overall, it was an exciting, full year of learning and progress. We hope that we can build upon the lessons learned this last season on our way to becoming the best we can.

We appreciate each of your efforts in assisting us to make this District the best that it can be. Please keep up the good work.

Thank you,



STAFF COMMENTS

Item: Consideration and possible approval of an amended and extended reimbursement agreement with Mellon Valley, L.C. and Elim Valley Planning and Development, LLC.

Discussion: On January 16th, 2025, the Council voted to extend by 24 months the reimbursement agreement for Elim Valley. The draft agreement in the packet is consistent with the vote and direction given by the Council at that meeting. The key terms of the Amended and Extended Reimbursement Agreement are as follows: (1) The remaining 173 road impact fee vouchers may be used within the next 24 months; (2) Each voucher may be used to offset the road impact for one residential unit—the current impact fee for one residential unit is \$2,294; and (3) If the road impact fee goes up, the developer is required to pay the increased amount, but if the fee goes down, there is no credit, offset, or carryover. - Summary drafted by Dayton Hall, City Attorney.

Findings:

Recommendation:

AMENDED AND EXTENDED REIMBURSEMENT AGREEMENT

This Amended and Extended Reimbursement Agreement ("Agreement") is made and entered into on February 6, 2025 (the "Effective Date"), by and between the Hurricane City, a Utah municipal corporation, (hereinafter referred to as "City") and Mellon Valley, L.C. and Elim Valley Planning & Development, LLC (hereinafter referred to collectively as "Developer") (City and Developer are referred to individually as a "Party" and collectively as the "Parties").

Recitals

- A. In a Reimbursement Agreement dated May 16, 2008, the City agreed to pay Developer in exchange for the dedication of a portion of Sand Hollow Road by issuing Developer one hundred ninety-six (196) road impact fee vouchers.
- B. The Developer dedicated a portion of Sand Hollow Road as contemplated by the 2008 Reimbursement Agreement.
- C. The 2008 Reimbursement Agreement provides that the agreement shall expire fifteen (15) years from the date of signature, regardless of the total amount of reimbursement paid by the City to Developer. The 2008 Reimbursement Agreement also provides that the term of the agreement may be extended if agreed upon by both Parties.
- D. The 2008 Reimbursement Agreement expired on May 16, 2023.
- E. Of the 196 original vouchers issued, 173 remain unused.
- F. The inability of Developer to use the vouchers was caused by several unforeseen circumstances, including the downturn of the economy in 2008 and litigation involving and encumbering the subject property.
- G. Due to the unique and unforeseen circumstances surrounding the development of the subject property, and recognizing the dedication of the roadway by Developer, the Parties have agreed to extend the term of the 2008 Reimbursement Agreement to twenty-four (24) months after the Effective Date of this Agreement.

Agreement

Now, therefore, in consideration of the premises recited above and the terms set forth below, and for other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, City and Developer hereby agree as follows:

- 1. This Agreement replaces the 2008 Reimbursement Agreement in its entirety, and the 2008 Reimbursement Agreement shall have no force or effect.
- 2. Developer, or its assigns, shall be entitled to use the one hundred seventy-three (173) road impact fee vouchers remaining from the 2008 Reimbursement Agreement (the "Vouchers"). The Vouchers may be redeemed solely for building permits for structures to be constructed within the property described at **Exhibit A**, attached hereto.
- 3. One Voucher is redeemable to offset the road impact fee for one residential unit. The current road impact fee for one residential unit is currently \$2,294. If the road impact fee is increased to an amount more than \$2,294 during the term of this Agreement, the

additional amount over \$2,294 shall be paid with each permit. If the road impact fee is decreased to an amount less than \$2,294, Developer will not be entitled to any credit, offset, or carryover.

4. No interest shall be paid on any amount due under the terms of this Agreement.
5. This Agreement shall expire on February 6, 2027, regardless of the total amount of reimbursement paid by the City to Developer.

IN WITNESS THEREOF, this Agreement has been executed by City and by a duly authorized representative of Developer as of the date first written above.

Hurricane City, a Utah Municipal Corporation

By: _____
Mayor Nanette Billings

ATTEST: _____

Recorder

DEVELOPER – Mellon Valley, L.C.

By:
Its: Manager

DEVELOPER – Elim Valley Planning & Development,
LLC

By:
Its: Manager

STATE OF IDAHO)
 :SS
COUNTY OF _____)

On the ____ day of _____, 2022, personally appeared before me _____, who being by me duly sworn, did say that he is the Manager of Mellon Valley, L.C. and Elim Valley Planning & Development, LLC and that the within and foregoing instrument was signed on behalf of said entities with proper authority and duly acknowledged to me that he executed the same.

Notary Public

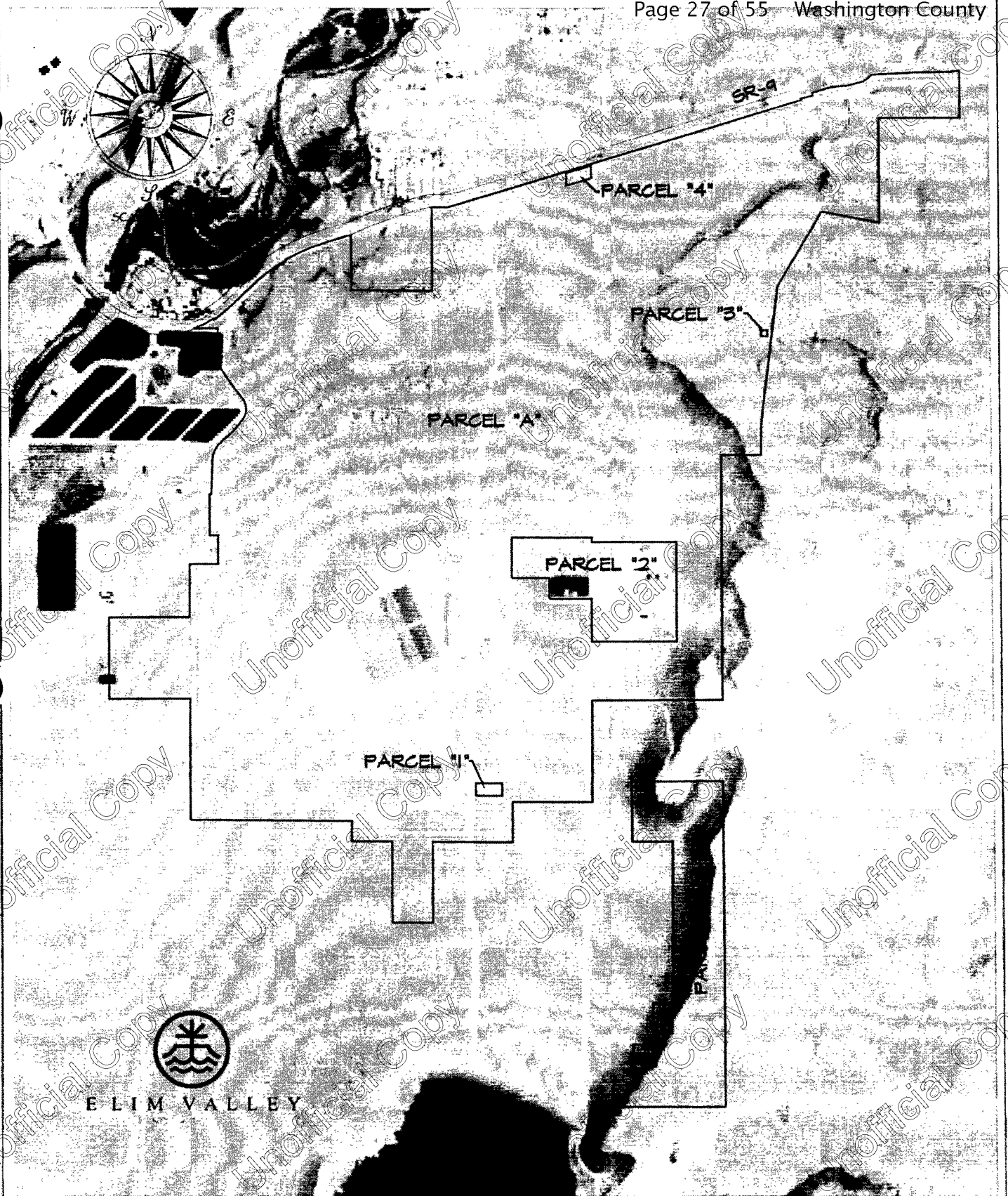


EXHIBIT "A" MAP
NTS



EXHIBIT "A"

ELIM VALLEY
LEGAL DESCRIPTION-PARCEL "A"

Beginning at the Southeast corner of Section 12, Township 42 South, Range 14 West, Salt Lake Base & Meridian, and running;

thence North 89°39'33" West 7.45 feet along the South Section line of said Section 12;

thence South 00°05'20" West 330.63 feet;

thence North 89°38'57" West 1,315.51 feet;

thence South 00°05'20" West 330.63 feet;

thence North 89°38'57" West 1,315.51 feet;

thence South 00°03'25" West 661.13 feet;

thence North 89°38'49" West 1,322.87 feet to the Center Section line of Section 13 Township 42 South, Range 14 West, Salt Lake Base & Meridian;

thence South 00°01'09" West 1,321.77 feet along said Center Section line;

thence North 89°37'30" West 661.24 feet;

thence North 00°00'17" East 1,321.72 feet;

thence North 89°38'55" West 661.57 feet;

thence North 00°00'21" West 330.34 feet;

thence North 89°40'14" West 1,325.52 feet;

thence North 89°48'05" West 1,325.34 feet;

thence North 00°04'20" West 1,971.59 feet to the East and West running 1/16th line of the Southeast Quarter of Section 11 Township 42 South, Range 14 West, Salt Lake Base & Meridian;

thence South 89°43'24" West 1,327.48 feet along said 1/6th line to the Center Section line of said Section 11;

thence North 00°05'30" West 1,323.28 feet along said Center Section line;

thence North 89°45'34" East 1,327.43 feet along the Center Section line;

thence North 00°03'28" West 858.04 feet;

thence North 89°54'53" East 466.69 feet;

thence North 00°03'20" West 466.69 feet;

thence South 89°54'53" West 134.63 feet;

thence North 00°02'54" West 661.92 feet;

thence North 89°59'32" East 26.64 feet;

thence North 01°55'31" East 551.57 feet;

thence North 05°30'35" East 25.00 feet;

thence northerly 87.72 feet along an arc of a 400.00 foot radius curve to the right (center bears South 84°29'25" East long chord bears North 11°47'31" East 87.54 feet

NOV 2 2006

- 2 -

with a central angle of $12^{\circ}33'52''$);

thence northeasterly 212.41 feet along an arc of a 400.00 foot radius curve to the right (center bears South $71^{\circ}55'34''$ East long chord bears North $33^{\circ}17'11''$ East 209.92 feet with a central angle of $30^{\circ}25'30''$);

thence North $48^{\circ}29'56''$ East 250.77 feet;

thence North $42^{\circ}44'37''$ East 146.42 feet;

thence North $35^{\circ}39'06''$ East 152.80 feet;

thence northerly 324.23 feet along an arc of a 250.00 foot radius curve to the left (center bears North $54^{\circ}20'54''$ West long chord bears North $01^{\circ}30'07''$ West 301.98 feet with a central angle of $74^{\circ}18'26''$);

thence North $38^{\circ}39'20''$ West 256.21 feet;

thence North $35^{\circ}11'28''$ West 316.56 feet;

thence northerly 265.46 feet along an arc of a 420.00 foot radius curve to the right (center bears North $54^{\circ}48'32''$ East long chord bears North $17^{\circ}05'03''$ West 261.06 feet with a central angle of $36^{\circ}12'50''$);

thence North $01^{\circ}01'22''$ East 374.68 feet;

thence northerly 57.01 feet along an arc of a 351.35 foot radius curve to the left (center bears North $81^{\circ}43'04''$ West long chord bears North $03^{\circ}38'01''$ East 56.95 feet with a central angle of $09^{\circ}17'50''$);

thence South $89^{\circ}52'56''$ West 386.70 feet to the Southerly Right of Way line of State Route 9, and running the following (6) courses along said south line;

thence northeasterly 340.68 feet along an arc of a 1,532.39 foot radius curve to the left (center bears North $20^{\circ}24'55''$ West long chord bears North $63^{\circ}12'57''$ East 339.97 feet with a central angle of $12^{\circ}44'16''$);

thence South $31^{\circ}43'22''$ East 25.01 feet;

thence northeasterly 258.89 feet along an arc of a 1,557.39 foot radius curve to the left (center bears North $33^{\circ}07'49''$ West long chord bears North $52^{\circ}06'27''$ East 258.59 feet with a central angle of $09^{\circ}31'28''$);

thence North $47^{\circ}20'43''$ East 689.70 feet;

thence northeasterly 1,258.99 feet along an arc of a 2,775.00 foot radius curve to the right (center bears South $42^{\circ}39'18''$ East long chord bears North $60^{\circ}20'32''$ East 1,248.22 feet with a central angle of $25^{\circ}59'40''$);

thence North $73^{\circ}20'22''$ East 494.46 feet;

thence South $00^{\circ}22'05''$ West 898.65 feet to the Center Section line of Section 1 Township 42 South, Range 14 West, Salt Lake Base & Meridian;

thence South $89^{\circ}35'08''$ East 1,327.22 feet along said Center Section line;

thence North $00^{\circ}10'33''$ East 1,350.90 feet to the Southerly Right of Way line of State Route 9, and running Northeasterly the following (16) courses along said south line;

thence South $89^{\circ}58'12''$ East 254.45 feet;

thence North $73^{\circ}19'03''$ East 413.47 feet;

thence easterly 134.73 feet along an arc of a 22,763.31 foot radius curve to the right (center bears South $16^{\circ}40'57''$ East long chord bears North $73^{\circ}29'14''$ East 134.75 feet with a central angle of $00^{\circ}20'21''$);

NOV 2 2006

- 3 -

thence North 73°39'24" East 1,951.74 feet;
thence North 73°39'24" East 3,609.85 feet;
thence North 00°08'36" West 19.03 feet;
thence North 73°38'48" East 214.52 feet;
thence North 16°37'33" West 36.32 feet;
thence North 73°39'24" East 350.33 feet;
thence North 84°56'32" East 254.78 feet;
thence North 75°40'25" East 283.52 feet;
thence North 51°40'18" East 174.13 feet;
thence North 87°28'01" East 687.67 feet;
thence North 89°03'09" East 384.16 feet;
thence South 89°56'48" East 163.49 feet;
thence North 84°49'43" East 213.73 feet to the East Section line of Section 31
Township 41 South, Range 13 West, Salt Lake Base & Meridian;
thence South 00°14'57" East 756.21 feet along said East Section line to the
Southeast Corner of said Section 31;
thence South 89°58'42" West 50.03 feet;
thence South 89°55'25" West 1,298.32 feet;
thence South 00°05'38" West 1,688.70 feet;
thence North 79°32'12" West 977.04 feet;
thence South 31°21'48" West 1,412.00 feet;
thence South 07°15'46" West 2,239.94 feet;
thence South 00°00'47" East 495.70 feet to the South Section line of Section 6,
Township 42 South, Range 13 West, Salt Lake Base & Meridian;
thence South 89°56'34" West 662.21 feet along said South Section line to the
Northwest Corner of Sectional Lot 1, Section 7, Township 42 South, Range 13 West,
Salt Lake Base & Meridian;
thence South 00°00'25" East 2,642.64 feet along the West line's of Sectional Lot's
1 & 6 to the Center Section line and the Northeast corner of Sectional Lot 7, of said
Section 7;
thence South 00°00'22" West 1,320.08 feet along the West line of said Lot 7 to the
Southeast corner of Sectional Lot 8;
thence South 89°50'33" West 2,141.15 feet along the South line of Sectional Lot's 8
& 9 to the West Section line of said Section 7;
thence South 00°02'18" West 1,321.40 feet along said West line to the Point of
Beginning.

Containing 91,741,842 square feet or 2,106.103 acres

Less and excepting any portion of land lying within the following described (+) parcels

PARCEL 1

NOV 2 2006

- 4 -

Beginning at a point being North 89°39'31" West 173.50 feet along the South Section line and South 33.00 feet from the 16th corner common to Sections 12 and 13 Township 42 South, Range 14 West, Salt Lake Base & Meridian, and running;

thence South 00°02'07" West 200.00 feet;
thence North 89°39'31" West 435.60 feet;
thence North 00°02'07" East 200.00 feet;
thence South 89°39'31" East 435.60 feet to the Point of Beginning.

Containing 87,119 square feet or 2.000 acres.

PARCEL 2

Beginning at the 1/16th corner common to Section's 12 and 7, said corner being located South 00°02'27" West 1,322.53 feet along the East Section line from the Northeast Corner of Section 12, Township 42 South, Range 14 West, Salt Lake Base & Meridian, and running;

thence South 00°02'18" West 73.47 feet;
thence South 89°57'42" East 1,400.00 feet;
thence South 00°02'18" West 1,617.00 feet;
thence North 89°57'42" West 1,400.00 feet;
thence North 00°01'56" East 368.50 feet;
thence North 00°02'43" East 330.49 feet;
thence North 89°39'27" West 702.43 feet;
thence North 00°01'48" East 330.50 feet;
thence North 89°39'24" West 622.36 feet to the 1/16th line;
thence North 00°00'59" East 660.95 feet along the 1/16th line;
thence South 89°39'30" East 1,325.10 feet along the 1/16th line to the Point of Beginning.

Containing 3,371,714 square feet or 77.404 acres.

PARCEL 3

Beginning at a point being North 89°52'29" East 2,803.74 feet along the Center Section line and South 629.44 feet from the West Quarter corner of Section 6, Township 42 South, Range 13 West, Salt Lake Base & Meridian, and running;

thence East 100.00 feet;
thence South 100.00 feet;
thence West 100.00 feet;
thence North 100.00 feet to the Point of Beginning.

NOV 2 2006

- 5 -

Containing 10,000 square feet or 0.230 acres.

PARCEL 4

Beginning at a point being South 00°15'22" West 304.47 feet along the East Section line of Section 1, from the Northeast corner of Section 1, Township 42 South, Range 14 West, Salt Lake Base & Meridian, and running;

thence South 00°15'22" West 200.00 feet along said East Section line;
thence South 73°53'22" West 435.60 feet;
thence North 00°15'22" East 200.00 feet;
thence North 73°53'22" East 435.60 feet to the Point of Beginning.

Containing 83,590 square feet or 1.919 acres.

LEGAL DESCRIPTION -PARCEL "B"

Beginning at a point being North 89°51'09" East 329.10 feet along the South Section line from the Southwest Corner of Section 18, Township 42 South, Range 13 West, Salt Lake Base & Meridian, and running;

thence North 00°00'41" West 352.39 feet;
thence North 89°59'19" East 330.00 feet;
thence North 00°00'41" West 660.00 feet;
thence North 89°59'19" East 330.00 feet;
thence North 00°00'31" East 660.22 feet;
thence North 89°59'28" East 330.00 feet;
thence North 00°00'32" West 2,640.00 feet;
thence South 89°59'28" West 660.00 feet;
thence North 00°00'32" West 978.17 feet to the North Section line of said Section 18;
thence North 89°47'40" East 1,490.83 feet along said North line;
thence South 00°10'22" East 2,647.63 feet;
thence South 00°14'04" East 2,643.87 feet to the South Section line of said Section 18;
thence South 89°51'09" West 1,838.96 feet along said South line to the Point of Beginning.

Containing 6,087,510 square feet or 139.750 acres.

NOV 2 2006



STAFF COMMENTS

Item: Consideration and possible approval of Resolution 2025-13 approving & adopting amendments to the 2024-2025 budget.

Discussion: Every year budget amendments are necessary due to unknown factors, like increase interest rates, increase in program costs, or grant opportunities.

The General Ledger (GL) codes from 103335-103963 are all revenue codes in the general fund. We have received more money than was budgeted for, and so these GL codes are included. Some big ones are 103335 airport grants, 103635 insurance reimbursement (reimbursement from employee for health insurance and health insurance kickback), 103716 Gymnastic, 103731 Dance and 103736 Art are doing great! Of course 103810 interest earnings have continued to have higher than average interest rates.

GL codes from starting in the 10's group are all general fund, 20 is Special Revenue Fund for Highway, 40 Equipment fund for Enterprise Funds, 41 is Capital Project for Veteran's Memorial, 42 Impact Project for Streets, 43 Impact Project for Parks, 45 Capital Project for City Office, 47 RAP Tax, 49 Equipment Lease Fund, 50 Pressurized Irrigation Fund, 55 Drainage Fund, 75 Dixie Springs Special Assessment, and 81 Redevelopment Agency Fund. I have noted on the supplemental documentation why the budget amendment was needed. – Paige Chapman

Findings:

Recommendation:

RESOLUTION

**A RESOLUTION OF THE CITY COUNCIL OF HURRICANE, UTAH, APPROVING
AND ADOPTING AMENDMENTS TO THE 2024-2025 BUDGET**

WHEREAS, the City Council of Hurricane, Utah previously adopted a budget for the fiscal year 2024-2025; and

WHEREAS, the City Council, after public hearing, deems it necessary and desirable for the efficient operation of the financial affairs of Hurricane City that said budget be amended,

BE IT HEREBY RESOLVED by the City Council of Hurricane, Utah that the 2024-2025 Budget, shall be and is hereby amended as provided in Exhibit "A", a copy of which is attached hereto and incorporated herein.

PASSED AND APPROVED THIS 6th day of February 2025.

Nanette Billings, Mayor

ATTEST:

Cindy Beteag, Recorder

The foregoing Resolution was presented at a regular meeting of the Hurricane City Council held at the Hurricane City Office Building on the 6th day of February 2025. Whereupon a motion to adopt and approve said Resolution was made by _____ and seconded by _____. A roll call vote was then taken with the following results:

	Yea	Nay	Abstain	Absent
David Hirschi	___	___	___	___
Kevin Thomas	___	___	___	___
Clark Fawcett	___	___	___	___
Drew Ellerman	___	___	___	___
Joseph Prete	___	___	___	___

Cindy Beteag, Recorder

GL Account

Notes

103335 Airport Grant	\$	50,000.00
103350 Department of Safety	\$	20,000.00
103358 State Liquor Fund	\$	2,300.00
103462 Copies, maps, ordiances	\$	500.00
103512 Court order comm service	\$	100.00
103635 Insurance Reimb	\$	60,000.00
103660 Safe Keep Money	\$	3,000.00
103680 Penalties & Late Fees	\$	200.00
103709 Flag Football	\$	1,200.00
103711 Youth Competitive Basketball	\$	2,200.00
103716 Gymnastics	\$	13,000.00
103722 Baseball Concession Rev	\$	1,500.00
103731 Dance Registration Fees	\$	15,000.00
103736 Art Program Fees	\$	9,700.00
103750 Peach Days Ad	\$	1,200.00
103756 Peach Days Misc Revenues	\$	1,700.00
103773 Neon Night Run	\$	1,300.00
103789 Gym Rental	\$	6,000.00
103810 Interest Earnings	\$	300,000.00
103944 Donations Shop with a Cop	\$	12,000.00
103945 Donation Com CTR	\$	200.00
103946 Donations to Animal Control	\$	1,100.00
103952 Baseball Sponsorships	\$	500.00
103953 Basketball Sponsorships	\$	1,000.00
103955 Football Sponsorships	\$	1,000.00
103959 Race Sponsorships	\$	1,000.00
103961 Volleyball Sponsorships	\$	1,000.00
103963 Fine Arts Show Sponsorships	\$	5,000.00

104253 Interpreter Fees \$ 1,000.00

Increase in people needing an interpreter

104328 Telephone \$ 2,100.00

Didn't budget for ESI

104514 Health Insurance \$ 7,500.00

Change in health insurance for City Treasurer, needed to increase budget

104833 Audit and Accounting \$ 5,000.00

Fees for audit and single audit increased

104851 Casualty Insurance \$ 2,000.00

Fee Increased

104864 Utah Leagues of Cities \$ 1,400.00

Fee Increased

104976 Employee Incentive/Awards \$ 1,000.00

Had more service awards than budgeted

104975 Contingency Fund \$ 319,140.00

Balancing Entry

105014 Health Insurance \$ 13,800.00

Hired a FT Custodian and he qualifies for benefits

105015 Retirement \$ 3,860.00

105525 Maintenance Equipment \$ 500.00

School Crossing didn't have a budget for this.

106270 Airport Grant-Projects \$ 115,000.00

Don't know when and how much the grant is, until it comes in.

106525 Autocad Maintenance fees \$ 600.00

AutoCad subscription increased

106611 Wages-GIS \$ 2,500.00

Meriella earned a pay increase due to earning Masters

106615 Retirement-GIS \$ 500.00

107277 Rec 1 Maintenance Fees \$ 800.00

Costs have increased

107328 Telephone-Swimming \$ 500.00

Pool Manager has a phone allowance

107384 Capital Projects \$ 26,000.00

Pool Repairs

107458 Concessions \$ 8,500.00

Theater is selling more snacks for shows

Total \$ 511,700.00 \$ 511,700.00

203810 Interest \$ 350,000.00

Interest rates are still going better than expected

204072 600 N. Trail \$ 500,000.00

Didn't budget for this

413810 Interest \$ 10,000.00

Interest rates are still going better than expected

413950 Donations for Veterans Memorial \$ 100,000.00

We don't typically budget for donations until we receive them

414070 Veterans Memorial \$ 200,000.00

Didn't budget for this

424070 600 N. Street \$ 1,500.00

Property Tax

424071 1480 W Property \$ 110,000.00

Didn't budget for this

424072 700 W Ext	\$ 150,000.00		Didn't budget for this
424075 1100 W	\$ 1,500,000.00		Didn't budget for this
424076 Sandhollow Turf	\$ 250,000.00		Didn't budget for this
434068 Rodeo Grounds	\$ 20,000.00		Finishing up project
434077 Gyms	\$ 300,000.00		Gym project
453478 Lease Revenue		\$ 9,500.00	Little corner house rent
453890 Misc		\$ 18,000.00	This is from a closure at SBSU
473810 Interest Income		\$ 50,000.00	Interest rates are still going better than expected
493891 Gain on Sale		\$ 31,000.00	We don't typically budget until it's accrued
503715 Sand Hollow Charges		\$ 100,000.00	Increase in irrigation
503720 Connection Fees		\$ 18,000.00	Increase in connections
503850 Grants		\$ 1,500,000.00	Secondary Meters Reimbursement from State
503870 Bond Proceeds		\$ 615,000.00	Bond for secondary meters
503915 Impact Fees		\$ 1,000,000.00	Just started collecting
505031 Professional Services	\$ 25,000.00		Impact Fee Study
505070 Cap. Outlay	\$ 15,000.00		Engineering
505071 Secondary Meters	\$ 500,000.00		Secondary Meters costs
553810 Interest Income		\$ 75,000.00	Received more interest due to reimbursement revenue
553890 Misc. Revenue		\$ 7,000,000.00	Frog Hollow Reimbursements
555079 Projects	\$ 7,000,000.00		Frog Hollow
753805 Special Assessment Rev		\$ 20,000.00	Don't really know until property is bought in the assessment area.
754031 Professional Services	\$ 1,000.00		Don't really know until property is bought in the assessment area.
813810 Interest Income		\$ 8,000.00	Interest rates are still going better than expected
814032 Admin Fees	\$ 3,000.00		
814090 Transfer to Other Funds	\$ 188,002.76		Close account and move funds to fund 40
403930 Transfer from Other Funds		\$ 188,002.76	
Budget Line Item Transfers			
108960 Karate Clothes	\$ 1,300.00		Move this to Art
109648 Supplies-Art		\$ 1,300.00	To buy Pottery Wheels
103736 Art Program Fees Revenue	\$ 2,300.00		Move this to Art
109648 Supplies-Art		\$ 2,300.00	To buy Pottery Wheels

STAFF REPORT FOR CITY COUNCIL MEETING

AGENDA ITEM

TO: Hurricane City Council
FROM: Dayton Hall, City Attorney
DATE: February 6, 2025
RE: Consideration and possible approval of updates to the Hurricane City Airport Rules and Regulations and the Minimum Standards for Commercial Aeronautical Activities

I. Introduction

This agenda item is a proposal to update the Hurricane City Airport (1) Rules and Regulations and (2) Minimum Standards for Commercial Aeronautical Activities. These standards were last updated in 2009. The proposed updates are the result of discussions by the Airport Board and contributions by Board members and an informal sub-committee. The proposed updates were recommended unanimously by the Airport Board on January 21, 2025.

II. Summary of Updates

The agenda packet for this item includes a redlined version of the proposed amendments that shows each revision, as well as a ‘clean’ copy that incorporates the proposed amendments. The Council is encouraged to review the proposed amendments within the packet. A summary of the key revisions for each document is below:

A. Rules and Regulations:

- The process to obtain a business license to conduct commercial activity at the airport is changed and clarified. After review by the Airport Manager, complete applications for a business license will be forwarded to the City’s business licensing officer and issued in the normal course. Business licenses for airport businesses will no longer be approved by the City Council. However, the requirement for a commercial lease approved by the City Council is still a requirement to conduct Commercial Activity at the Airport. In other words, the City Council’s approval of a commercial hangar for a commercial use constitutes the City’s approval for that type of business if the other requirements are met.
- Except for the Airport Manager, residential occupancy of a hangar is prohibited.
- The City is expressly permitted to conduct inspections of hangars.

- The City's Noise Abatement Procedures, which were previously adopted by the Council in an independent document, are incorporated into the Rules and Regulation.
- Many technical and grammatical changes are proposed.

B. Minimum Standards for Commercial Aeronautical Activities:

- The process to apply for approval of a commercial aeronautical activity is simplified and clarified. The process is made consistent with the business licensing requirements as described in the Rules and Regulations.
- Revisions to the different requirements for specific types of commercial activities are proposed.

Hurricane City Municipal Airport Hurricane, Utah

Rules and Regulations

Adopted and Approved
December 17, 2009
date of approval]
Hurricane City Council

Table of Contents

Commented [DH1]: Update

Table of Contents	2
Introduction	4
Purpose	4
Definitions	5
Airport Manager	8
Permission to Use Airport Conditional	8
Approval of Aviation Operations	8
Rules and Regulations	9
A. Compliance w/ State and Other Regulations	9
B. Vehicle Operations	9
C. Security	10
D. Aircraft Operations	12
E. Aircraft Parking	13
F. Vehicle Parking	14
G. Safety Prohibitions	14
H. Accidents / Incidents	16
I. Nuisances	16
J. Pedestrians	17
K. Rules and Regulations Availability	17
L. Refuse	17
M. Construction	17
N. Special Events	18
O. Noise Sensitive Areas	18

Self Services	18
Revenue Producing Commercial Activities	18
Storage and Maintenance	18
Structure Design	19
Commercial Standards	20
Enforcement / Appeal	20

PURPOSE

These Rules and Regulations, hereafter referred to as “regulations”, have been adopted by the Hurricane City Council and approved through *resolution* by this council. These regulations are designed to establish the structure necessary to ensure the continued viability and safety of the airport for its users and for the citizens of Hurricane.

These Standards are intended to be reasonable, non-arbitrary and non-discriminatory. These standards apply equally to everyone using the airport and shall be observed, abided by, and obeyed.

All aeronautical activities, operations, piloting of aircraft, business, and other activities at the airport shall be conducted in accordance with these rules and regulations, ~~and Hurricane City's Minimum Standards for Commercial Aeronautical Activities,~~ other Hurricane City Codes, [Federal Aviation Administration, Utah Department of Transportation, and National Fire Prevention Association FAA, UDOT and NFPA](#) standards as appropriate.

DEFINITIONS

As used in this chapter, the following words and terms shall have the meanings ascribed to them in this section:

ACCIDENT - An occurrence associated with the operation of an aircraft which any person suffers death or serious injury or in which the aircraft receives substantial damage, takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury or in which the aircraft receives substantial damage.

AERIAL APPLICATIONS - The business of making aerial applications of fire retardants, fertilizers, pesticides, seeding or other dusts or sprays.

AGL – refers to actual altitude above average elevation of terrain or “above ground level”.

AIR SALES OPERATOR - A person, firm or corporation engaged in the business of buying, selling and exchanging new or used aircraft.

AIR TAXI OPERATOR - A person, firm or corporation engaged directly in air transportation of passengers and/or property subject to the provisions of FAR Part 119 and FAR part 135 of the federal aviation regulations and holding any required certification from the Federal Aviation Administration the state of Utah.

AIRCRAFT - Any device used or intended to be used for flight in the air, including, but not limited to, airplanes, ultralights, balloons, and gliders of all types.

AIRCRAFT HANGAR – A building on the airport with the primary purpose of storing an aircraft. An office, restroom, or similar facility may be contained within a hangar, but not to such extent that an aircraft cannot then be stored within the hangar. Residential occupancy of a hangar by any person(s) is prohibited with the exception of the Airport Manager. Incidental storage within a hangar is authorized but the aircraft stored within must be readily available for flight, or if being constructed, must be under active construction.

AIRCRAFT RADIO - Instrument, Propeller and Accessories Shop - A person, firm or corporation engaged in FAA approved aircraft, radio, and instrumentation or propeller business, including sales, service, repair, exchange and installation of new and/or used aircraft radio equipment, instruments or propellers and parts.

AIRPORT - All ~~city~~ City owned or leased real or personal property comprising the Hurricane City Municipal Airport as now existing or as the same may hereafter be expanded and developed.

AIRPORT BUILDING STANDARDS – The Hurricane City Airport Minimum Building Standards as adopted and amended from time to time.

AIRPORT MANAGER - The duly appointed manager of the Hurricane City Airport or his/her designee.

AIRPORT MINIMUM STANDARDS – The Hurricane City Airport Minimum Standards for Commercial Aeronautical Services, as adopted and amended from time to time.

AOA - Airport Operations Area

BASED AIRCRAFT – Any aircraft habitually parked or stored on the airport, whether in a hangar or without. This also includes any aircraft or similar vehicle transported onto the airport and assembled and flown from the airport.

CITY – ~~the City of Hurricane~~[Hurricane City](#).

CITY COUNCIL – The governing body of the municipality which owns the Airport ~~and~~, is ~~the~~ final authority in all matters of policy.

COMMERCIAL ACTIVITY - The conduct of any aspect of a business or concession on the airport for revenue, whether intended to be profit producing or nonprofit.

CONTROLLED ACCESS AREA - All areas of the airport enclosed by fence or other barrier and to which vehicular access may be obtained only through electronically activated gates.

FAA – The Federal Aviation Administration or duly designated representative thereof.

FIXED BASE OPERATOR (FBO) - A person, firm or corporation subject to the provisions of a lease engaging in the delivery of fuel and oil products into aircraft, in addition to ~~any number at least two~~ of the following services:

- ~~The sales, service, exchange, renting or leasing of new and used aircraft, and/or aircraft parts, accessories and hardware;~~
- ~~The repair, overhaul, maintenance and modification of general aviation aircraft and/or aircraft equipment-using FAA certified mechanic(s) or under the provisions of an FAA approved Part 145 repair station; under the provisions of an FAA approved maintenance station;~~
- ~~The conduct of FAA approved pilot flight and ground school training under the provisions of FAR Part 61 or FAR Part 141; and-~~
- ~~Charter flight services which may include aerial photography, advertising, map making and aerial application crop dusting services.~~

FLIGHT SCHOOL OPERATOR - A person, firm or corporation engaged in an FAA approved pilot flight training school ~~under the provisions of FAR Part 61 or FAR Part 141~~, limited to dual and solo flight training in fixed and ~~or~~ rotary wing aircraft and such related ground school instruction as is necessary to prepare a student pilot to take a written examination and ~~practical test for pilot certificate or appropriate aircraft rating flight check ride for a pilot's license or appropriate aircraft rating~~ from the FAA.

FUEL HANDLING - The transportation, delivery, fueling and draining of fuel or fuel waste products.

FUEL STORAGE AREA - Any portion of the airport designated temporarily or permanently by the Airport Manager as areas in which AvGas or any type of fuel may be stored or loaded.

GENERAL AVIATION SPECIALTY SHOPS - Aircraft Maintenance: A person, firm or corporation engaged in the business of providing FAA approved routine, normal and preventive maintenance of general aviation aircraft.

LAW ENFORCEMENT OFFICER (LEO) – Any sworn peace officer, City Police, County Sheriff, UHP, or similar law enforcement personnel that may be on the Airport in the line of assigned duty.

MOVEMENT AREA - The runways, taxiways and other areas of an airport which are used for taxiing or hover taxiing, air taxiing, take off and landing of aircraft, exclusive of loading

ramps and aircraft parking areas.

OPERATIONAL AREA - Any place on the airport not leased or designated to anyone for occupancy.

PARK OR PARKING - The standing of an aircraft or vehicle, whether occupied or not.

PUBLIC AREA - Those areas normally used by the general public, including structures and facilities such as roadways, sidewalks and terminal buildings that are maintained and kept at the airport for use by the general public.

SASO – A specialized aeronautical service provider performing less than full FBO services.

SELF-SERVICE – The fueling, washing, servicing, repair, touch-up painting or maintenance of an aircraft performed by the owner or operator of the aircraft by themselves, and using his or her own tools and equipment. Self-Service can-not be contracted out to another party. Maintenance, preventive maintenance, repair, alterations, is authorized under Self-Service provided the Self-Service is performed in accordance with FAR FAR Parts 43, 65, 91, or 103 as 43, FAR 65, FAR 91 and FAR 103, appropriate to the aircraft.

SIDA - Security Identification Display Area

THROUGH-the-FENCE OPERATIONS – “Through-the-fence” are those activities permitted by an airport sponsor through an agreement that permits access to the public landing area by independent entities or operators offering an aeronautical activity or to owners of aircraft based on land adjacent to, but not part of, the airport property. activities are prohibited at the Hurricane City Airport.

Recreational, light sport and glider aircraft that are designed to be transported by a trailer shall not be considered through-the-fence operations as long as NO commercial activity takes place.

AIRPORT MANAGER

The City Council may employ a qualified individual to manage, direct, and coordinate the operations and maintenance of the airport in order to ensure compliance with all federal, state and city regulations. The Airport Manager is authorized to take all reasonable actions necessary to protect and safeguard the public while present at the airport and to oversee all airport operations consistent with these standards. The Airport Manager shall coordinate airport affairs with the Federal Aviation Administration, Utah Department of Transportation Aeronautical Division and other applicable agencies to ensure that the ongoing needs of the airport are met.

PERMISSION TO USE AIRPORT CONDITIONAL

Any permission granted by the ~~city~~City, directly or indirectly, expressed or by implication, to enter upon or use the airport or any part thereof, including, but not limited to, operators, crew members and passengers, spectators, sightseers, pleasure and commercial vehicles, officers and employees of airlines, lessees and other persons occupying space at the airport, persons doing business with the airport, its lessee, sub lessee and permittees, and all other persons whatsoever whether or not of the type indicated, is conditioned upon compliance with this chapter and any rules, regulations or procedures promulgated hereunder; entry upon or into the airport by any person shall be deemed to constitute an agreement by such person to comply with this chapter and such rules, regulations and procedures. The ~~city~~City reserves the right to deny any or all usage of the airport to any person or persons for cause.

APPROVAL OF AVIATION OPERATIONS

~~Any commercial activities or operations conducted at the airport shall require the approval of the City Council. Any person wishing to commence activities or operations at the airport shall make application for city approval through the Airport Manager. Such application shall state in writing how the applicant will comply with each requirement set forth in the Airports Minimum Standards for Commercial Aeronautical Activities policy; and any other applicable provisions of this chapter. Any person wishing to commence commercial activities or operations at the airport shall submit all information and material in accordance with Section II of the Airports Minimum Standards for Commercial Aeronautical Activities as well as a City business license application to the Airport Manager. If the application is complete, the Airport Manager will turn the package overforward the complete materials to the business licensing officer. If the application is incomplete, the Airport Manager will advise the applicant in writing of the deficiencies within ten (10) business days.~~

~~The business licensing officer will collect payment from the applicant once they~~

have upon receipt of a complete application. The application will then be reviewed to ensure that all licensing requirements are met including but not limited to the following:

1. Verification of professional license (if applicable).
2. Business name registered with the Department of Commerce.
3. A passed fire inspection is completed.
4. An active sales tax number for the City is provided (if applicable).
5. For any new construction a certificate of occupancy must be issued first.

RULES AND REGULATIONS

The following rules and regulations will govern the conduct of all persons at the airport, whether engaged in aeronautical activities or otherwise:

A. Compliance with State and Other Regulations

1. No person shall navigate, land aircraft upon, or conduct any aircraft operations on or from the airport other than in conformity with FAA rules and regulations.
- ~~2. No person shall drive on any street, parking lot, driveway or frontage road, whether it be inside or outside of the controlled access area, any vehicle which is required under the laws of the state to be inspected and registered unless such vehicle has been inspected and registered and has attached thereto in proper position a valid and unexpired certificate of inspection as required by the laws of the state. Properties around the airport affected by airport operations shall be subject to compliance with all FAA, UDOT and City standards.~~
- ~~3.2.~~ All vehicles operated on airport property within the controlled access area shall be maintained in a safe operating condition in accordance with the Utah Department of Transportation (UDOT) codes and standards. All fuel trucks operating on the airport must meet UDOT standards and adhere to the Uniform Fire Code (UFC), National Fire Protection Agency (NFPA) or any City Fire regulations.

B. Vehicle Operations

1. Only bona fide emergency vehicles, airport maintenance vehicles, and those vehicles belonging to aircraft owners, and/or operators, and hangar owners may be operated on the ramp, taxiway, runway portions of the airport. With the operations of ground vehicles on the taxiway or runway being further restricted to those situations necessary to respond ~~otto~~ an emergency, airport maintenance, or to the positioning of or retrieval of gliders or ultralight aircraft. In all cases the operator of a ground vehicle will give the right of way to all pedestrians and all aircraft taxing, taking off or landing.
2. No vehicles shall ever be parked unattended on the runway, nor shall any vehicle ever be parked unattended on any portion of any taxiway or ramp such as to deny or restrict the free passage of any aircraft to/from any hangar, tiedown or parking spot.
- ~~3.~~ No motor home, travel trailer, boat trailer, horse trailer, utility trailer, ~~automobile or~~ any other type of powered or unpowered vehicle, ~~(except~~

~~those trailers specifically designed and constructed to store/transport gliders and ultralight aircraft) shall be stored in the hangar at the airport; provided, however, that the following are permitted except:~~ 1. Trailers specially designed and constructed to store/transport gliders and ultralight aircraft; 2. Mobile refueling equipment used for refueling aircraft by an authorized fuel provider; 3. Trailers and equipment used by airport personnel for airport maintenance activities; 4. Operational automobiles parked in long term parking; 5. City Public Facilities storage. If stored in public view, these items may only be stored in those areas that have been designated by the Airport Manager at the airport. ~~Glider and ultralight trailers may only be stored outside in those areas that have been designated by the Airport Manager.~~

4.3. No bicycles, motorbikes, motorcycles, or ~~atv's (all terrain all-terrain vehicles)~~ shall be operated on any portion of the runway, taxiway, or ramp except where such operation is approved by the Airport Manager and is conducted by the owner/operator of any aircraft or the lessee of any hangar at the airport.

5.4. Except for emergency response vehicles and aircraft in the act of taking off or landing, ~~No~~ no person may operate a motor vehicle on any portion of the airport at a speed greater than 15 MPH, ~~emergency response vehicles, and aircraft in the act of taking off or landing excepted,~~ nor may any person operate any vehicle in a careless or reckless fashion.

6.5. General vehicle parking on the airport will only be in those locations designated by the Airport Manager. Lease holders may park in areas adjacent to their leased facilities, when in the opinion of the Airport Manager, such parking will not create a hazard or conflict with any airport operation or activity. The Airport Manager will have the authority to move, or have moved, at the vehicle owner's expense, any vehicle parked in an inappropriate location.

C. Security:

1. The Airport Manager as well as hangar owners should be aware of those people who are on the airport as visitors. Visitors should be questioned as to the reason for their presence at the airport. The Hurricane City Police Department should be immediately notified of

any suspicious person/s or activities.

D. Aircraft Operation:

1. Every person operating an aircraft shall comply with and operate such aircraft in accordance with these Rules and Regulations, and all pertinent rules and regulations of the Federal Aviation Administration (FAA), UDOT/Aero and any other appropriate governmental agencies. Every person operating an aircraft is responsible for the safety of his/her operation and for the safety of others exposed to such operation, and therefore shall exercise good operating procedures at all times. Aircraft shall not be operated carelessly or negligently nor in disregard of the rights and safety of others.

~~2. Hand propping, when necessary, may only be performed by a certified pilot with sufficient chocking or tie downs in place to stabilize the aircraft. Such activity is at the pilots own risk. A licensed qualified pilot or aircraft mechanic/repairman must be in the cockpit and at the controls of the aircraft whenever an aircraft engine is operating.~~

~~3.2.~~ The Hurricane City Airport is a non-towered airport. Even though radio communications are not required, it is highly recommended that pilots have radio equipment permitting two-way communication to monitor the airport common traffic advisory frequency (CTAF) while in the vicinity of the airport.

~~4.3.~~ All aircraft shall comply with the FAA Federal Aviation Regulations (FAR) and follow the appropriate taxiway and runway guidance markings and lighting when operating on the airport.

~~5.4.~~ Any aircraft weighing more than 12,500 lbs. aircraft gross weight the load bearing capacity is prohibited on the runway, taxiways or apron, unless approved by the Airport Manager.

~~6.~~ Under no circumstances shall any person approach any aircraft, other than a pilot or certified licensed aircraft mechanic, whether it is fixed wing or rotorcraft, until all blades or propellers have come to a complete stop. The only exception will be emergency hot fueling in compliance with the operators hot fueling safety procedures, as described in section G.1.e. of this section.

~~5.~~
~~7.6.~~ Except in an emergency, Rrotorcraft in training are not permitted to perform autorotations to a running or skidding landing, or any other type of running or skidding landing, on any taxiway, runway, or other paved surface at the airport.

~~8.7.~~ Lighter than air or hot air balloons are not permitted to land or take off from the airport without prior approval from the Airport Manager.

~~9.8.~~ Parachuting activity over or onto the airport shall be conducted in accordance with all relevant requirements of FAR Part 105.

~~10.9.~~ ~~Ultralight~~Ultralight operations at the Hurricane Airport shall be conducted in accordance with all relevant requirements of FAR Part 103, except for such deviations from that part as may be authorized by an FAA issued Grant of Exception.

~~11.10.~~ The traffic pattern and rules for operating in that traffic pattern for the Hurricane Airport are as follows:

- a. The recommended primary runway shall be runway 198. The traffic pattern shall be a ~~right-hand~~right-hand pattern and shall be flown by the powered aircraft (other than ultralights and similar aircraft) at an altitude of at least 800 to 1,000 feet above the published field elevation.
- b. The traffic pattern for runway 136 shall be a standard left hand pattern and shall be flown by powered aircraft (other than ultralights and similar aircraft) at an altitude of at least 800 to 1,000 feet above the published field elevation.
- c. The traffic pattern for ultralights, powered parachutes, and similar aircraft shall be the same as for other powered aircraft except it shall be flown at an altitude of at least 500 feet above the published field elevation.
- ~~d.~~ When departing south on runway 198 turn a right crosswind prior to the gravel pit (located left of runway centerline) to avoid a traffic conflict with any traffic from Sky Ranch. traffic, that is either departing north or on a right base leg landing to the south.

~~12.~~ Hurricane Airport is an uncontrolled airport, therefore pilots shall adhere to the "see ~~and avoid~~ and avoid be seen" concept. The CTAF for radio equipped aircraft is currently 123.05 mhz. frequency for radio equipped aircraft is 122.8 mhz.

11. Use of an aviation transceiver to broadcast intentions is encouraged.

~~13.12.~~ Aircraft are prohibited from taking off or landing anywhere on the Airport property other than the paved runway. Two exceptions to this rule are: 1. Helicopters may ~~side steps~~side step onto a paved taxiway provided the helicopter does not interfere with the normal movement of aircraft on the taxiway, and 2. Aircraft in an emergency situation. 3. Powered parachutes in approved taxiway by manager.

E. Aircraft Parking

1. All aircraft will be parked in areas designated by the Airport Manager. Each

aircraft owner or operator occupying a hangar or tie down is responsible for adequately securing his/her own aircraft.

2. Helicopter operations shall be limited to areas designated designated helicopter parking areas unless approved otherwise by the Airport Manager.
- ~~3.~~ Major repairs to aircraft or engines in a private hangar *shall not* be made unless it's in accordance with FAR Parts 43, 65, 91, or 103. FAA FAR 43, FAR 65, FAR 91 and FAR 103.

4.3. Minor general maintenance or repairs to personal aircraft such as oil changes is permitted as applicable in FAA Part 43, appendix A(C)

5.4. No derelict, non flyable or un-airworthy aircraft will be permitted to tie down ~~anywhere within in any movement or non-movement area of at~~ the airport ~~for longer than a over a period of~~ 30 days ~~period~~ without the permission of the Airport Manager. Aircraft in violation of this paragraph may be removed by the Airport Manager at the owner's expense.

6.5. The city assumes no responsibility for damages by a third party or theft to aircraft or vehicles operated or parked at the airport. Transient and long term aircraft parking fees are set from time to time by the Airport Manager and the City Council.

F. Reserved Hangar Use

1. ~~The primary purpose of an aircraft hangar is the storage of aircraft. An office, restroom, or similar facility may be contained within a hangar, but not to such extent that an aircraft cannot then be stored within the hangar.~~

7.2. ~~Residential occupancy of a hangar of any length of time by any person(s) is prohibited with the exception of the Airport Manager. Incidental storage within a hangar is authorized but the aircraft stored within must be readily available for flight, or if being constructed, must be under active construction.~~

F.G. Safety Prohibitions

1. All persons using the ~~airport-Airport~~ or the facilities of the ~~airport-Airport~~ in any way must exercise the utmost care to guard against fire and injuries to persons and property. The following are not authorized on the ~~Hurricane~~-City Airport:

- a. Smoking within fifty feet (50') of any aircraft, fuel truck or fuel storage tank of any kind.
- b. Refueling or defueling of any aircraft is prohibited in any hangar.
- c. Refueling during an electrical storm is prohibited.
- d. While fueling aircraft, electronic devices such as cell phones, two way radio's, pagers, etc., shall not be worn or used until all fueling operations have been completed.
- e. Hot fueling aircraft while the propellers or blades are in motion is ~~not~~ permitted if the operator complies with the provisions of the FAA's operators hot fueling safety procedures, without the authorization from the Airport Manager or his/her designee.
- f. Fueling shall be done in strict accordance with NFPA 407 requirements, ~~Hurricane~~-City fire codes, and/or other applicable fire or hazardous materials regulations.
- g. ~~Aircraft fueling from drums, small containers or similar items is not~~

~~permitted on the airport without prior approval of a "Self-Fueling" application, appropriate insurance coverage, and indemnification of the City of Hurricane. Self-fueling one's own aircraft from drums, small containers, or fuel systems is not permitted onat the aAirport unless verification has been completed by the Airport Manager that the following items have been received; appropriate insurance coverage has been obtained for conducting self-fueling operations including adding the City as an additional insured on such insurance coverage and completing an indemnification agreement with the City.~~

- h. Fuel services shall be administered only by an authorized fuel provider ~~Fixed-Based Operator (FBO)~~ that adheres to the Airport Minimum Commercial Aeronautical Standards ~~and FAA PART 139 regulations~~. All fuel for aircraft must be purchased from an authorized fuel provider source on the airport unless approved by the Airport Manager and the requirements of G.1.g. are complied with.

- i. "Flagging" and/or "Hawking" is prohibited at the Airport. For the purposes of these regulations, this is defined as: Any method or means used from any location to attract incoming aircraft for the purposes of selling fuel or providing other services (except the use of fixed signs, such signage to be approved by the Airport Manager.)
- j. Flying any type of drone or model aircraft at the airport is prohibited unless prior approval is given by the Airport Manager. Each drone or model aircraft operator must have in his/her possession a remote pilot certificate issued by the FAA, as applicable, and must adhere to the provisions of FAR Part 107 or Part 101 depending on the type of operation being conducted.
- i.k. No parachutes, powered or otherwise, shall depart from or land at the Hurricane City American Legion Equestrian Park located adjacent to the Airport.

2. The following is prohibited in aircraft storage hangars:

- a. Starting or taxiing an aircraft
- b. Refueling of any aircraft
- c. Major alterations are limited to self-service maintenance procedures as outlined in FAA FAR 43, FAR 65, FAR 91 and FAR 103. Fire codes such as International Fire Codes (IFC), National Fire Protection Association (NFPA), or local City Fire regulations shall apply. Major aircraft repairs and alterations as defined by the FAA may be completed by individuals (SASO operations or aircraft owners) that hold the Proper FAA credentials and/or certifications to do so. ~~Hangar~~Hangar owners may construct a homebuilt aircraft in their hangar with the approval of the ~~ai~~Airport Mmanager. Self-serve minor maintenance is limited to preventative maintenance as outlined in FAR Parts 43, 65, 91, or 103 as applicable. All safety rules and regulations as described in this document as well as the City's Minimum Standards for the City-Airport, ~~document~~ shall be complied with.
- d. Painting is prohibited. Self-service touch-up painting may be authorized with prior approval from the Airport Manager.
- e. Welding is prohibited.
- f. Open flame tools are prohibited.
- g. Storage of any Hazardous Materials other than oily waste rags is prohibited. Suitable small metal receptacles with self closing covers shall be provided by tenants for the storage of such items.
- h. Open storage of flammable materials is prohibited. One (1) suitable fire safe container, no larger than four (4) feet in width, and eight (8) feet in height, and complies with OSHA, UL, or NFPA Standards, may

be used to store limited amounts of flammable materials such as small spray paint cans, that may be needed to support self-service maintenance requirements.

- i. ~~Storage of non-aeronautic equipment or materials unless approved by the Airport Manager.~~

~~The City is permitted to do~~authorized to conduct inspections of all areas leased to hangar tenants, including inspections of the interiors of hangars, of the inside of the hangars and the five feet of property surrounding the hangar that is leased upon request. A tenant's refusal to allow such inspections shall constitute a violation of these Rules and Regulations.

G.H. Accidents

Persons involved in an aircraft accident affecting airport operations or damaging city property shall make a full verbal report to the Airport Manager or his/her designee within one hour after the accident. The report must include names and addresses, time, place, cause, injuries and other information requested by the Airport Manager. When a written report of an accident is required by the FAA or NTSB, a copy of such report shall be submitted to the Airport Manager. At accident scenes, aircraft owners (and) the pilots or agents will promptly remove disabled aircraft, parts and accident debris unless directed by the Airport Manager ~~of FAA~~ NTSB, or local authorities to delay such action pending an accident investigation. Damage sustained to the

airport facility, grounds or buildings will be assessed as a claim against the responsible party.

H.I. Nuisances

1. Dismantled aircraft, aircraft parts, dismantled or inoperative aircraft or any other unsafe, un-kept, unsightly miscellaneous item or items in disrepair shall not be left over a period of 30 days in open view. This includes all movement areas as well as non movement areas. If the Airport Manager determines that a violation has occurred, he shall so advise the owner. If not corrected within thirty (30) days, [the Airport Manager he](#) may remove such items and bill the owner or operator for associated costs. Conditions involving safety issues shall be corrected within ~~twenty-four~~[twenty-four](#) (24) hours.
2. Any person, including the operators of an aircraft, causing overflowing of fuel and / or spilling of excess oil or grease on any apron will [notify the call](#) Airport Manager immediately. The involved person shall be responsible for cleaning such areas and repair any damage thereto.
3. At no time shall engines be "run up" when other aircraft, hangars, shops, buildings or persons are in the path of the propulsion stream. Any person operating any vehicle or aircraft (including fixed wing and rotor) shall be responsible for damage or cleanup caused by such operations (i.e., scattering of debris from prop blast or rotor down wash).

H.J. Pedestrians

1. Hangar owners and aircraft operators may walk on any runway or taxiway when necessary to gain access to an aircraft, glider, or ultralight. This also applies to pilots and ground crew when involved in the launch or recovery of such aircraft; and for airport maintenance and debris removal, and to emergency personnel in the performance of their duties. Anyone walking on the runway shall remain alert for any aircraft operating in the traffic pattern.
2. On all areas of the airport, pedestrians will give way to all moving aircraft.

J.K. Operators to keep the Rules and Regulations Availability

All commercial operators with valid leases to perform aeronautical business on the airport shall keep a current copy of these [rules and regulations standards](#) prominently posted in their place of business and available for viewing to all who enter the facilities. It is the responsibility of all owners of aircraft based at the airport and pilots who regularly use the airport to be familiar with the contents of this document. The operators bear the responsibility for compliance and ignorance is not an excuse for violation of any part of these [rules and regulations standards](#).

K.L. Refuse

No person shall throw, dump or deposit any waste, refuse or garbage on the airport. All waste, refuse or garbage from airport operators or construction crews shall be placed and kept in closed garbage containers and all operating areas shall be kept in a safe, neat, clean and orderly manner at all times and in such manner as to minimize any hazards. Garbage containers and temporary restroom facilities must be in place before any construction starts.

L.M. Construction

In addition to the requirements of this paragraph, all construction at the Airport shall comply with the City's generally applicable ordinances, standards, and regulations governing such construction. Before any construction project begins on the airport, the contractor or his/her designated project supervisor will be required to attend a one hour training class on Airport Familiarization and Safety. The contractor is required to have in place one port a potty and one enclosed refuse dumpster prior to the start of construction per City Building Ordinance. The Airport Manager or his designee will attend the pre-inspection meeting to discuss the operations at the Airport. Attendance at the post inspection by the Airport designee will also be required before any final inspection is approved.

M.N. Special Events

Special events include but are not limited to the following:

Air shows	War bird shows
Balloon festivals	Fly-in meets or open house
Air races	Parachute team demonstrations

These special events require written permission and approval from the Airport Manager.

N.O. Noise Sensitive Areas

1. In addition to complying with [FAR Part 91.119 for maintaining minimum altitudes over congested areas such as FAA regulations for minimum altitude over flights, per FAA FAR Part 91.119](#), over the residential ~~areassections~~ of ~~the Hurricane~~ City, pilots are expected to use good judgment and flight procedures that result in minimum noise over ~~noise-sensitive areas~~ such as Zion National Park located 20 NM north east of the Airport. Compliance with the City's noise policy is strongly encouraged.

2. Noise abatement procedures.

The following voluntary procedures are defined to abate excessive noise at the airport:

a. Runway 19 should be used whenever wind conditions allow for safe landing and takeoff operations. If departing to the north using Runway 1,

- a left crosswind turn should be executed as soon as safely practical to avoid unnecessary overflight of residential areas.
- b. All aircraft shall make a practical effort to reach pattern altitude (1000' AGL) before turning downwind. All aircraft departing the airport pattern area are to make a reasonable effort to climb to a minimum altitude of 1000' AGL before doing so utilizing the standard pattern legs as defined in Section 4-3-3 of the Aeronautical Information Manual (AIM).
 - c. All arriving aircraft utilizing the traffic pattern are to maintain a minimum of 1000' AGL until established in the pattern per guidelines found in the AIM.
 - d. Helicopters shall make a practical effort to vary the downwind distance from the runway when performing repetitive pattern work in order to reduce sustained ground noise under a particular flight path. See AIM 4-3-3(b).
 - e. Simulated forced landings and/or auto-rotations should not initiate until the aircraft reaches the typical pattern altitude of 1000' AGL.
 - f. Unless otherwise approved by the Airport Manager or a Memorandum of Understanding agreement between the City and the applicable entity, repetitive aircraft training operations should be limited to (2) 30 minute sessions within a 24 hour period Monday through Saturday for helicopters and/or aircraft that exceed 80 (eighty) decibel levels per noise measurement levels determined and defined in FAA Circular AC 36-1H. Repetitive pattern work for these aircraft is not to be flown on Sundays. This restriction shall not apply in emergencies, where necessitated by safety considerations, or when required by the Federal Aviation Administration.
 - g. Aircraft are not to be started, run-up, or depart the Airport between sunset and sunrise other than to make an immediate departure from the airport area.
 - h. All aircraft arriving between sunset and sunrise to be limited to one (1) full stop approach and landing sequence.
 - i. Repetitive pattern work, touch and go's, stop and go's, low approaches, or practice autorotations are not to be conducted between sunset and sunrise. 2.

EXCEPTIONS

The following categories of aircraft are exempt from airport noise abatement guidelines:

- a. Aircraft operated by or under contact of the United States of America, any State, county, city, subdivision or special district of a state including military, firefighting, search & rescue, disaster relief, and medical evacuation flights;
- b. Aircraft used for emergency purposes during an emergency officially

proclaimed by competent authority pursuant to the laws of the United States, the State of Utah, Washington County, or Hurricane City;

- c. Civil Air Patrol aircraft when engaged in actual search and rescue missions;
- d. Aircraft which have declared an inflight emergency;
- e. Aircraft operating as air ambulance for medical purposes.
- f. Aircraft engaged in take-offs or landings while conducting tests under the direction of the Airport Director.

SELF-SERVICES

The owner of an aircraft located on the airport is permitted to wash, ~~in designated wash areas only, or~~ and to perform minor repairs and alterations to his/her own aircraft, provided there is no attempt to perform such services for others. ~~Washing of aircraft is not allowed on any ramp area without prior approval from the Airport Manager or designee.~~

Commercial Activities

- a. No person shall operate a Commercial Activity of any nature that is based at or operated from the ~~the Hurricane~~ Airport unless the conduct of that activity has been approved by the City. A business not directly involved in any form of Aeronautical activity may be allowed only if such business would serve and support the airport and the flying community (e.g. and airport restaurant). ~~Potential commercial activities will undergo review and recommendation of the Airport Manager and the Airport Authority Board.~~
- b. Any ~~commercial~~ **Commercial activity** ~~Activity~~ based out of the airport shall require a business license from the ~~City of Hurricane~~ **the City** in addition to a commercial lease signed for the facility from which the ~~commercial~~ **Commercial** ~~activity~~ **aActivity** or business will be conducted.
- c. All ~~commercial~~ **Commercial activity** ~~Activity~~ must comply with all Federal, State and local regulations and with the ~~City's~~ **mMinimum** ~~S~~**standards** for ~~commercial operation~~ **Commercial Aeronautical Activities**.

STORAGE AND MAINTENANCE

Aircraft storage hangars shall be used primarily for aircraft storage. ~~only unless there is prior written approval of the Airport Manager. Storage in connection with commercial activities performed in the hangars shall be with prior written approval of the Airport Manager.~~ No uncovered trash containers shall be maintained in any outside area, and areas to be used for trash or garbage containers shall be only those areas designated by the Airport Manager. All hangars and other premises including an area five (5) feet from the outside hangar wall on the airport shall be maintained by the lessee in a condition as to repair, cleanliness and general maintenance that is equal to the level of maintenance maintained by the City in comparable areas. Fuel and oil storage facilities must be approved by and in a location designated by the Airport Manager. Such storage shall comply with any regulations adopted pursuant to the Airports Commercial Standards, Rules and Regulations, as well as applicable federal, state and local fire codes pertaining to fire safety, including, but not limited to, the City Building Code, and the Uniform Fire Code.

STRUCTURE DESIGN

In order to assure an aesthetic appearance and harmonious design of airport improvements, new construction and remodeling or repainting of existing structures shall comply with the Airport Building Standards.

COMMERCIAL STANDARDS

In addition to compliance with the regulations set forth herein, the City Council has adopted Minimum Standards for Commercial ~~Operations~~ Aeronautical Activities at the ~~A~~airport to carry out the purposes of this chapter and serve the best interests of the ~~C~~city. Such standards shall be made available to all members of the public, both at the city recorder's office and from the Airport ~~M~~anager. Failure to comply with such standards shall be considered a violation of this chapter, and the Airport Manager may deny the use and privileges of the airport to any such violator, subject to the appeal rights contained in the Enforcement; Appeal section of this chapter.

ENFORCEMENT; APPEAL

The primary concern of Airport Management is the safe and efficient operations of the Airport.

A. Citations

The City may issue citations for violations of this chapter, including the rules and regulations contained in this chapter, and/or promulgated pursuant to the Commercial Standards of this Chapter. The city may take enforcement action as set forth herein or it may initiate legal action as it may deem appropriate.

B. Appeal

Any person, who feels aggrieved by staff enforcement of this chapter, rules and regulations promulgated hereunder, or the Minimum Standards for Commercial ~~Operations~~ Aeronautical Activities promulgated hereunder, may Appeal any decision. Appeals shall be made in writing to the City Manager, who after due consideration, shall rule on the matter. Final appeal may be made to the Mayor and City Council. The sole exception to the appeal process herein provided shall apply to criminal citations under state or city traffic law and emergency or safety issues.

Minimum Standards For Commercial Aeronautical Activities

~~As amended November 13, 2009~~

~~As amended~~ Adopted and Approved
[date of approval]
Hurricane City Council

TABLE OF CONTENTS

Table of Contents	2
Introduction/General	3
Section I. Definitions	5
Section II. Application Requirements	9
Section 111. General Conditions and Requirements	11
Section IV. Action upon Application	17
Section V. Minimum Standards	19
A. Fixed Base Operators	19
B. Specialized Aviation Service Operators	26
1. New and/or used aircraft sales	27
2. Flight Instruction and/or aircraft rental	27
3. Air Charter -Air Taxi service	28
4. Aerial applications and seeding operations	28
5. Specialized aircraft repair service	29
6. Air Charter - Air tour flights	30
7. Commercial hangar leasing	30
8. Airframe or power plant/specialized aircraft	31
9. Specialized commercial activities	32
Section VI. Minimum Insurance Requirements	34
Section VII. Lease Terms and Conditions	34
Section VIII. Non Commercial Activities	35

INTRODUCTION

The Hurricane Municipal Airport ("Airport") is the primary general aviation air transportation facility for the ~~City of Hurricane~~ Hurricane City, Washington County and southwest Utah. The Airport is owned by the ~~City of Hurricane~~ Hurricane City and daily operations of the Airport are overseen by the Airport Manager, who is appointed by the City.

These Minimum Standards for Commercial Aeronautical Activities ("Standards") have been developed and adopted to protect and promote in a reasonable manner the best interests of the public by requiring a minimum level and quality of facilities and services required of commercial aeronautical businesses at the Hurricane Municipal Airport. These Standards are designed to provide reasonable opportunity, without discrimination, for the non-exclusive conduct of ~~commercial~~ aeronautical activities at the Airport.

The City reserves the right to review and amend these Standards from time to time and may promulgate revisions deemed necessary to address proposed activities or to protect or improve the Airport or the quality of service provided to the public.

It should be emphasized that this document specifies the ~~mm,mum~~ minimum standards that must be met to conduct commercial aeronautical activities at the airport. Applicants and operators are encouraged to exceed these minimums whenever possible.

GENERAL

- A. No entity, including those under sublease, shall engage in any commercial aeronautical activity or business of any nature whatsoever on Airport property, except with the prior written approval of the City.
- B. Such written approval by the City is issued through either a signed lease agreement with the City if land and/or facilities are leased from the City, or a written Lease Agreement under the Minimum Standards if the activity will be operating under a sublease from an existing Airport Tenant.
- C. In the event these Minimum Standards, as they now exist or are hereafter amended, conflict with applicable Federal Aviation Regulations, the latter shall be deemed to control. If one or more clauses, sections or provisions of these Standards shall be held to be unlawful, invalid or unenforceable by final judgement of any court of competent jurisdiction, the invalidity of such clauses,

sections or provisions shall in no way affect any other clauses, sections or provisions of these Standards.

- D. These Standards do not pertain to ~~scheduled commercial air carrier operations under Federal Aviation Regulation 14CFR Part 121 or to~~ military operations.
- E. All activities at the Hurricane Municipal Airport are subject to and must comply with all existing and future applicable laws, ordinances, rules and regulations of the Hurricane Municipal Airport, ~~the City of Hurricane the City~~, the State of Utah, the Federal government and all other governmental bodies having jurisdiction.

SECTION I - DEFINITIONS

As used in these Standards, the following definitions apply:

Aeronautical Activity - Any activity that involves, makes possible, or is required for the operation of aircraft or that contributes to or is required for the safety of such operations. Activities within this definition, commonly conducted on airports, include, but are not limited to, the following: general and corporate aviation, air taxi and charter operations, scheduled and nonscheduled air carrier operations, pilot training, aircraft rental and sightseeing, aerial photography, crop dusting, aerial advertising and surveying, aircraft sales and services, aircraft storage, sale of aviation petroleum products, repair and maintenance of aircraft, sale of aircraft parts, parachute or ultralight activities, and any other activities that, because of their direct relationship to the operation of aircraft, can appropriately be regarded as aeronautical activities. Activities, such as model aircraft and model rocket operations, are not aeronautical activities.

Agreement - A written contract, executed by both parties, and enforceable by law between ~~the City of Hurricane~~ the City and an Entity granting a concession, transferring rights or interest in land and/or improvements, and/or prohibiting the conduct of certain activities.

Aircraft Maintenance - The repair, adjustment, maintenance, alteration, preservation, and/or inspection of Aircraft airframe or power plant, including the replacement of parts. Major repairs include major alterations to the airframe, power plant, or propeller, as defined in 14 CFR Part 43. Minor repairs include normal, routine annual inspection with attendant maintenance, repair, calibration, or adjustment of Aircraft airframe or power plant and associated accessories. Preventive maintenance means simple or minor preservation operations and the replacement of small standard parts not involving complex assembly operations, as defined by 14 CFR Part 43.

Airframe and Power plant Mechanic - A person who holds an Aircraft mechanic certificate with both the airframe and power plant ratings issued by the FAA under the provisions of 14 CFR Part 65.

Airport Layout Plan - The currently approved, scaled dimensional layout diagram of the entire Airport property, indicating current proposed usage for each identifiable segment as approved by the Federal Aviation Administration and ~~the City of Hurricane~~ the City.

City of Hurricane Hurricane City - Referred to as the "City", means the ~~City of Hurricane~~ Hurricane City, the fee simple owner and operator of the property that comprises the Hurricane Municipal Airport.

Commercial Operator - An Entity engaging in a Commercial Aeronautical Activity.

Commercial Aeronautical Activity - Any aeronautical activity which involves or makes possible the operation of aircraft, the purpose of such activity being to secure income, earnings, compensation or profit, whether or not such objectives are accomplished.

Entity - A person, persons, firm, partnership, limited liability company, unincorporated proprietorship, association, group or corporation.

Exclusive Right - A power, privilege, or other right excluding or preventing another from enjoying or exercising a like power, privilege, or right. An Exclusive Right may be conferred either by express agreement, by imposition of unreasonable standards or requirements, or by any other means. Such a right conferred on one or more Entities, but excluding others from enjoying or exercising a similar right or rights, would be an Exclusive Right.

Federal Aviation Administration (FAA) - All branches, offices and officers of the United States Department of Transportation, Federal Aviation Administration

Fixed Base Operator (FBO) - A commercial tenant which provides for aircraft services as outlined in section V.

General Aviation - All aviation with exception of air carriers (including cargo) and government. General aviation aircraft are utilized for commercial and noncommercial purposes including business, corporate, recreational/pleasure, charter/air taxi, industrial/special purpose, and instructional.

Manager - means the Airport Manager of the Hurricane Municipal Airport as appointed by the ~~City of Hurricane~~ the City.

Master Plan - The current Master Plan report, which is an assembly of appropriate documents and drawings covering the development of the Airport from a physical, economical, social, and political jurisdictional perspective and adopted by the ~~City of Hurricane~~ the City and any amendments, modifications, revisions, or substitutions thereof. The Airport Layout Plan (ALP) is a part of the Master Plan.

Minimum Standards - Qualifications, standards and criteria, established by the ~~City of Hurricane~~ the City as the minimum requirements to be met as a condition for the right to conduct a commercial aeronautical activity on the Airport.

National Fire Protection Association (NFPA) - All codes, standards, rules and regulations contained in the standards of the National Fire Protection Association, as may be amended from time to time.

Non-Commercial Flying Club - any combination in which three or more persons are associated (directly or indirectly) as individuals or as any association or legal entity to provide such persons the privilege of piloting club-owned aircraft based on the Airport. The flying club shall be operated on a non-profit basis so that it does not receive greater revenue than the amount necessary for the operation, maintenance, acquisition and replacement of its aircraft. The non-profit status shall be substantiated by documentary proof from the Internal Revenue Service.

Non-Commercial Operator - An Entity that either owns or leases and operates Aircraft for personal or recreational purposes. In the case of a business, the operation of Aircraft must be an ancillary Activity to support the business's purposes by providing transportation for the exclusive use of its employees, agents, and/or customers. ~~Notwithstanding~~ Notwithstanding the foregoing, the Non-Commercial Operator shall neither offer nor engage in Commercial Aeronautical Activities. For purposes of these Minimum Standards, all government agencies shall be considered Non-Commercial Operators.

Operator - Means the entity responsible for the operations of a commercial aeronautical activity.

Repairman - A person who holds an aircraft repairman certificate, with appropriate ratings, issued by the FAA under the provisions of 14 CFR Part 65.

Repair Station - A certificated Aircraft Maintenance facility approved by the FAA to perform specific maintenance functions. These facilities are certificated under 14 CFR Part 145.

Rules and Regulations - the rules and regulations as may be promulgated and adopted from time to time by the City to protect the public health, safety, interest and welfare of the Hurricane Municipal Airport.

Specialized Aviation Service Operator (SASO) - A commercial aeronautical activity that provides one or more commercial services as outlined in section V.

Hurricane Municipal Airport - referred to as the "Airport", means the property allocated for the operation of the Hurricane Municipal Airport in the ~~City of Hurricane~~ Hurricane City, State of Utah, as depicted on the current Airport Layout Plan.

Through the Fence Operations - "Through-the-fence" are those activities permitted by an airport sponsor through an agreement that permits access to the public landing area by independent entities or operators offering an aeronautical activity or to owners of aircraft based on land adjacent to, but not part of, the airport property. ~~activities are prohibited at the Hurricane Municipal Airport.~~

Recreational, light sport, and glider aircraft that are designed to be transported by a trailer shall not be considered ~~THROUGH~~ through the ~~FENCE-fence~~ Operations as long as NO commercial activity takes place.

SECTION II - APPLICATION REQUIREMENTS

Applications for permission to conduct any commercial aeronautical activity or for a land or facility lease to conduct such activity at the Airport shall be made in writing to the Airport Manager. Applicants are strongly encouraged to visit with the Airport Manager to discuss the applicant's proposed activity prior to the preparation and submission of a detailed application.

The applicant shall submit all information and material necessary or requested by the City to establish to the City's satisfaction that the applicant will qualify and comply with these Standards. Failure by the Applicant to submit any of the requested information may be grounds for denial of the application. ~~At a minimum, such applications must include fill of the following:~~ All such applications must include all that are applicable to the applicant of the following:

1. Name, mailing address and phone number of applicant(s).
2. Type and structure of the organization; if incorporated, the names of the officers; if a partnership, the names of the partners.
3. Individual or business name and mailing address to appear on the lease or agreement.
4. A statement of past experience in the specified aviation business or commercial activity for which the application is being made.
5. A list of any applicable Federal, State or local certifications and licenses currently held or to be obtained. Include copies of currently held licenses or certificates.
6. A description of the amount of land, number of buildings, building space, etc. the applicant desires to lease. If the activity will be conducted under a sublease from an existing leaseholder, a copy of the proposed sublease must be provided.
7. A description of the services to be offered, including all of the intended services upon completion or the installation of the facility.
8. Proposed commencement date of the proposed construction or site improvements, proposed completion date and proposed date of commencement of operations.
9. A description of the building space to be constructed, including square footages, building types and intended use of each. For buildings proposed to be constructed, the applicant shall provide certification that it will comply with all building standards as adopted by the ~~City of Hurricane~~ the City as they apply to the Airport.

10. The estimated total cost of construction and improvements.
11. A site plan drawing depicting construction intended for the lease area (must be compatible with the Airport's current Airport Layout Plan).
12. The hours of operations and number of employees.
13. The number and type of aircraft to be based upon the leasehold to be leased or subleased by the Operator.
14. A certificate of insurance or other satisfactory evidence of the ability to obtain insurance coverage as required in Section VI.

~~The applicant shall also submit the following supporting documentation if requested by the Airport Board:~~

- ~~1. Financial Statement – A current financial statement of the applicant prepared or certified by a Certified Public Accountant and or financial references acceptable to the City.~~
- ~~2. Assets – A written listing of the assets owned or to be purchased and utilized in conjunction with the commercial aeronautical activity at the Airport.~~
- ~~3. Credit Report – A current credit report covering all areas in which the applicant had done business within the last ten years.~~
- ~~4. References – A list of persons or businesses for which the City has the authority to contact.~~
- ~~5. Authorization for release of information.~~

~~A written authorization for the Federal Aviation Administration, all aviation or aeronautic commissions, administrators, or departments of states in which the applicant has engaged in aviation business to supply the City with all information in their files relating to the application or its operation. The applicant shall execute such forms, releases and discharges as may be requested by any of these agencies.~~

SECTION III - GENERAL CONDITIONS AND REQUIREMENTS

The following general conditions and requirements [shall apply to all commercial aeronautical activities and](#) will be included in all commercial aeronautical activity leases or any written agreement. These are basic clauses only and more specific clauses, covenants and language, dependent upon the particular activity authorized by the City, may be included in the lease or agreement:

If an Operator desires to sublease space to another Operator, the Operator must obtain the written approval from the City to sublease the space. The sub lessee must apply for and obtain a permit to operate at the Airport, and must satisfy the applicable Minimum Standards to provide sub lessee's proposed Commercial Aeronautical Activity.

A. NON DISCRIMINATION:

Premises are to be operated for the use and benefit of the public. Non-discrimination means:

1. To furnish good, prompt and efficient services adequate to meet the demands for its service at the Airport;
2. To furnish said service on an equal and non-discriminatory basis to all users thereof;
3. To charge reasonable and non-discriminatory prices for each unit of sale or service, provided that the Operator may be allowed to make reasonable and non-discriminatory discounts, rebates or other similar types of price reductions to volume purchasers;
4. The Operator, his agents and employees will not discriminate against any person or class of persons by reason of race, color, creed or national origin in providing any services or in the use of any of its facilities provided for the public in any manner. The Operator further agrees to comply with enforcement procedures as the United States might demand that the City take in order to comply with the Airport's Federal Assurances.

B. AIRCRAFT SERVICE BY OWNERS OR OPERATORS OF AIRCRAFT

It is to be clearly understood by all Operators under these Standards that no right or privilege has been granted which would serve to prevent other aircraft owners or operators (commercial or non-commercial) on the Airport from performing any service on their own aircraft. This does not

preclude the Operator under these Standards from restricting the activities of others on its own leasehold.

C. NON-EXCLUSIVE RIGHT

The granting of rights and privileges to engage in Aeronautical Activities shall not be construed in any manner as affording the Operator any exclusive right of use of the premises and/or facilities at the Airport, other than those premises and/or facilities which may be assigned exclusively to the Operator, and then only to the extent provided in a written Agreement.

D. RIGHTS RESERVED

~~The City of Hurricane~~ The City further reserves the right to designate specific Airport areas for activities in accordance with the Airport Layout Plan (ALP) as may be amended from time to time. Such designation shall give consideration to the nature and extent of current and/or future activities and the land and/or improvements that may be available and/or used for specific activities and shall be consistent with the safe, orderly, and efficient use of the Airport.

~~The City of Hurricane~~ The City reserves the right to take any action it considers necessary to protect the navigable airspace and aerial approaches of the airport against obstruction, together with the right to prevent Operators from erecting, or permitting to be erected, any building or other structure on or adjacent to the airport which, in the opinion of the City, would limit the usefulness of the Airport or constitute a hazard to aircraft.

~~The City of Hurricane~~ The City reserves the right to prohibit any Entity from using the Airport or engaging in activities at the Airport (and/or revoke or suspend any privileges granted to any Entity) upon determination by ~~the City of Hurricane~~ the City that such Operator has not complied with these Minimum Standards, the Rules and Regulations, applicable regulatory measures, directives issued by the City, or has otherwise jeopardized the safety of Entities utilizing the Airport or the land and/or improvements located at the Airport.

If the City determines there are more qualified applicants seeking to provide a particular Commercial Aeronautical Activity than there is space or demand at the airport for such service, the City may select the Commercial Aeronautical Activity provider through a competitive solicitation or request for proposals.

E. GROUNDS FOR DENIAL

The City may reject any proposal or application for any one (1) or more reasons including, but not limited to, the following:

The Entity, for any reason, does not fully meet the qualifications, standards, and requirements established by ~~the City of Hurricane~~the City.

The Entity's proposed activities and/or improvements will create a safety hazard at or on the Airport.

The City would be required to expend funds and/or supply labor and/or materials in connection with the proposed activities and/or Improvements that the City is unwilling and/or unable to spend and/or will result in a financial loss or hardship to ~~the City of Hurricane~~the City.

No appropriate, adequate, or available land and/or improvement exists at the Airport to accommodate the proposed activity of the Entity (at the time the proposal or application are submitted), nor is such availability contemplated within a reasonable time frame.

The proposed activities and/or improvements do not comply with the Master Plan of the Airport or the ALP then in effect or anticipated to be in effect within the time frame proposed by the Entity.

The development or use of the land requested by the Entity will result in a congestion of Aircraft and/or the improvements will, in the sole discretion of the City, unduly interfere with activities of any existing Operator on the Airport and/or prevent adequate access to the leased premises of any existing Operator.

The Entity has intentionally or unintentionally misrepresented or omitted material fact in the proposal, on the application, and/or in supporting documentation.

The Entity has failed to make full disclosure in the proposal, on the application, and/or in supporting documentation.

The Entity or an officer, director, agent, representative, shareholder, or employee of the Entity has a record of violating or is in violation of City regulatory measures (or any other airport sponsor), the FAA, or any other regulatory measure applicable to the Airport and/or the Entity's proposed Activity.

The Entity or an officer, director, agent, representative, or shareholder of the Entity has defaulted in the performance of any lease, sublease, agreement, or permit at the Airport or at any other airport.

The Entity does not exhibit adequate financial responsibility or capability to

undertake the proposed activity.

F. AIRPORT DEVELOPMENT

The City reserves the right to further develop Airport property or improve the landing areas of the Airport as it sees fit, regardless of the desires or views of the Operator and without interference or hindrance.

Location. FBOs and SASOs may be situated only in those areas of the Airport specified for such use in the Airport Layout Plan (ALP) and the Airport Master Plan or otherwise approved by the Airport Board.

G. MAINTENANCE OF LANDING AREA AND ALL PUBLICLY OWNED FACILITIES

The City reserves the right, but shall not be obligated to the Operator, to maintain and keep in repair the landing areas of the Airport and all publicly owned facilities of the Airport, together with the right to direct and control all activities of the Operator in this regard.

H. NATIONAL EMERGENCY

During time of war or national emergency, the City shall have right to lease the landing area or any part thereof to the United States Government for military use, and if such lease is executed, the provisions of this instrument insofar as they are inconsistent with the provisions of the lease to the U.S. Government, shall be suspended.

I. AIRPORT OBSTRUCTIONS

The City reserves the right to take any action it considers necessary to protect the aerial approaches of the Airport against obstructions, together with the right to prevent the Operator from erecting or permitting to be erected, any building or other structure on or adjacent to the Airport, which, in the opinion of the City, would limit the usefulness of the Airport or constitute a hazard to aircraft. FAA Part 77 regulations also apply.

J. SUBORDINATION

These minimum standards shall be subordinate to the provisions of any existing or future agreement between the City and the United States, relative to the operation and maintenance of the Airport, the execution of

which has been or may be required as a condition precedent to the

expenditure of Federal funds for the development of the Airport.

K. HAZARDOUS MATERIALS AND WASTE

The Operator shall not discharge, deposit or store any waste or hazardous materials on the Airport. The Operator's operating area shall be kept in a safe, neat, clean and orderly manner at all times and in such a manner to minimize any hazards. The operator must comply with the Airport's Stormwater Pollution Prevention Plan as appropriate. Examples of hazardous materials and waste include, but are not limited to, garbage; used fluids such as oil, chemicals, or fuel; scrap materials or other debris.

L. OPERATION AREA

The Operator shall not conduct any of its business or activities on any area except those specified in the lease or agreements under these Minimum Standards.

M. COMPLIANCE WITH APPLICABLE RULES AND REGULATIONS

The Operator shall comply with all federal, state and local rules and regulations which may pertain to its operation on the Airport and all future revisions thereto.

N. APPROVAL OF CONSTRUCTION

No buildings, structures, tiedowns, ramps, paving, taxi area, drains, earthwork or any other improvements or additions to the Airport shall be placed or constructed, or altered or removed at the Airport without the prior written approval of the City. Applicable City permits must be obtained by the Operator prior to any such work. The Operator must conform to all requirements in the Airport Building Standards.

A pre-construction meeting must take place with the Airport Manager or designee before any work can begin. A post inspection meeting must take place before final approval of the project can be awarded.

O. CHANGE IN SERVICES OFFERED

Once a lease or agreement is entered into, the Operator may not add or delete services offered without the prior consent of the City. Any additional services contemplated must meet the requirements outlined in these standards. A change in services offered may require a change in leased area. Any such modification may be subject to a modification of rates and charges.

P. RIGHT OF RELOCATION

The City shall have the right to relocate the Operator's Premises when necessary to accommodate the Airport development. The need for such relocation shall be solely determined by the City. If relocation becomes necessary, the City shall provide the Operator with a replacement area substantially equivalent in size and amenities. Should Operator disagree with the replacement location, Operator shall have the right, within ten (10) calendar days of receipt of the Cities written notice of impending relocation, to provide written notice to the Airport Manager that Operator disagrees with the replacement location. Upon such notice by Operator, the parties shall, for a period not to exceed thirty (30) days from the date of such notice, negotiate in good faith in an attempt to resolve the matter to the satisfaction of both parties; however if for any reason the disagreement is not resolved within thirty (30) days, the City shall have the right to unilaterally decide the matter, and Operator agrees to and shall abide by the Cities decision, subject to such rights of termination as Operator may have under its Lease or Permit. If the City requires the Operator to relocate its facilities during the term of its Agreement, the City will reimburse the Operator for its documented actual and reasonable out- of-pocket relocation expenses, if any, but the City shall have no liability for increased overhead or operating costs, or lost profits or revenue of Operator, if any, arising out of such relocation.

Q. THROUGH THE FENCE ACTIVITIES

"Through-the-fence" Activities are prohibited at the Hurricane Municipal Airport.

Recreational, light sport and glider aircraft that are designed to be transported by a trailer shall not be considered THROUGH the FENCE Operations as long as NO commercial activity takes place. ~~Flight instruction and flight certification are hereby specifically exempted from through the fence regulations.~~

SECTION IV - ACTION UPON APPLICATION

Upon receipt of an application to conduct a commercial general aviation activity under these standards, the Airport Manager will review the application to ensure its completeness and compliance with the requirements of Section II, Application Requirements.

- A. Applicant shall submit all information and material in accordance with Section II as well as a City business license application to the Airport Manager. If the application is complete, the Airport Manager will turn the packet over to the business licensing officer. If the application is incomplete, the Airport Manager will advise the applicant in writing of the deficiencies.
- B. The business licensing officer will collect payment from the applicant once they have a complete application. The application will then be reviewed to ensure that all licensing requirements are met including but not limited to the following:
 - 1. Verification of professional license (if applicable).
 - 2. Business name registered with the Department of Commerce.
 - 3. A passed fire inspection is completed.
 - 4. An active sales tax number for Hurricane is provided (if applicable).
 - 4.5. For any new construction a certificate of occupancy must be issued first.
- ~~B. If the application is found to be complete in accordance with Section II, the Airport Manager will schedule consideration of the proposed activity at the next possible City Council Meeting. If the application is incomplete, the Airport Manager will advise the applicant in writing of the deficiencies.~~
- ~~C. The Airport Manager will recommend approval or denial of the proposed activity to the Hurricane Airport Board and the Hurricane City Council which has the ultimate authority to approve or disapprove any proposed commercial aeronautical activity. City Council consideration of a proposed activity will take place during a regular City Council meeting.~~
- ~~D.C. The City Council may not consider any application to conduct a commercial aeronautical activity unless the applicant or a duly appointed representative is present at the City Council meeting.~~
- ~~E. In consideration of the application, the City Council may deny the application based on one or more of the following terms:~~
 - 1. ~~NOT QUALIFIED: The applicant does not meet the qualifications,~~

~~standards or requirements established by these Standards.~~

- ~~2. SAFETY HAZARDS: The applicant's proposed operation or construction would create a safety hazard at the Airport.~~
- ~~3. CITY EXPENDITURE: The approval of the application would require the City to expend funds, labor or materials in connection with the operation.~~
- ~~4. AVAILABILITY: There is no appropriate, adequate or available space or building at the Airport to accommodate the applicant's proposal.~~
- ~~5. NON-COMPLIANCE WITH AIRPORT LAYOUT/MASTER PLAN: The proposed operation, development or construction does not comply with the Airport's Layout or Master Plans.~~
- ~~6. CONGESTION: The development or use of the area requested will result in depriving existing Airport operators of portions of the area in which they are conducting operations; or will result in a congestion of general operating areas or buildings; or will result in unduly interfering with the operations at the Airport regarding aircraft traffic or service, or preventing unrestricted access to any airport area.~~
- ~~7. MISREPRESENTATION: Any party applying for or having an interest in the business has supplied the City with any false information or has misrepresented any material fact in the application or in supporting documents; or has failed to make full disclosure on the application or in supporting documents.~~
- ~~8. HISTORY OF VIOLATIONS: Any party applying for or having an interest in the business has a record of violating these Minimum Standards or any Federal, State, or local rules and regulations of any other airport, the City of Hurricane, or the Hurricane Municipal Airport.~~
- ~~9. DEFAULTED PERFORMANCE: Any party applying for or having an interest in the business has defaulted in the performance of any other lease agreement with another airport or public agency, the City of Hurricane, or the Hurricane Municipal Airport.~~
- ~~10. COMPETITIVE BIDDING: The party applying was not the successful bidder in an open and competitive bidding environment.~~

SECTION V - MINIMUM STANDARDS

A. FIXED BASE OPERATOR

A fixed base operator (FBO) is any entity who shall have entered into a written agreement with the City to provide on the Airport and serve the public with the following:

- sale of aviation jet fuel, aviation gasoline and oil
- ramp services, aircraft loading, unloading and towing
- aircraft repair and maintenance
- Commercial aircraft storage.

In addition to the general requirements of the Minimum Standards, each Fixed Based Operator at the Airport shall comply with the following minimum standards set forth in this section.

NOTE: Only FBO's will be authorized to offer retail sales and/or delivery into-plane of aircraft fuels. City also retains its right to offer retail sales and/or delivery into-plane of aircraft fuels.

Such services may be provided by the FBO or under contract with another operator. If such service requirements are to be provided by another operator, that operator shall separately apply for approval under these standards and shall be responsible for payment of all fees, rates or charges established by the City. Fixed Base Operators must meet the following general minimum standards and requirements as well as those for the specific services they provide:

Scope of Activity

Unless otherwise stated in these Minimum Standards, FBO's employees using FBO's vehicles and equipment must provide all required products and services.

FBO's products and services shall include the following:

- (1) Aviation Fuels and Lubricants (Jet Fuel, Avgas, and Aircraft Lubricants):
 - a. FBO shall deliver and dispense Jet Fuel, Avgas, and Aircraft lubricants into all General Aviation Aircraft normally frequenting the Airport.
 - b. FBO shall provide a response time of no more than 30 minutes during required hours of activity (excepting situations beyond the control of the FBO).

- c. FBO shall provide fueling services after hours, 24 hours per day, by means of on-call personnel. A 30 minute response time from notification shall be achieved (excepting situations beyond the control of the FBO).

(2) Passenger, Crew, and Aircraft Ground Services, Support, and Amenities

- a) FBO shall meet, direct, and park all aircraft arriving on Operator's leased premises.
- b) FBO shall provide a lounge for pilots and their crew members.
- c) FBO shall provide arrival and departure services for aircraft using Operator's leased premises including crew and passenger baggage handling.
- d) FBO shall provide parking and tie-down of aircraft upon the Operator's leased premises.
- e) FBO shall provide for hangar storage of aircraft.
- f) FBO shall provide oxygen, nitrogen, and compressed air services.
- g) FBO shall provide lavatory services and aircraft cleaning services.
- h) FBO shall make available aircraft ground power units.
- i) FBO shall provide courtesy transportation, utilizing Operator's vehicles, for passengers, crew, and baggage, as necessary and/or appropriate.
- j) FBO shall make available crew and passenger ground transportation arrangements (limousine, shuttle, and rental car).
- k) FBO shall make available aircraft catering arrangements.

(3) Aircraft Maintenance

a. FBO shall provide aircraft maintenance on the airframe, power plants, and associated systems of general aviation aircraft up to turboprop aircraft normally frequenting the airport. In addition, FBO shall be properly certified as an FAA Aircraft Repair facility and have available a certified A & P mechanic during normal business hours.

b. FBO can meet these Minimum Standards for the provision of Aircraft Maintenance by and through authorized sub-lessee(s) who meet the minimum standards for Aircraft Maintenance Operator and operates from the FBO's leased premises.

LEASED PREMISES

FBO shall have adequate land, ~~Apron~~apron, paved tie-down, facilities (hangars, terminal, maintenance, and fuel storage), and vehicle parking to accommodate all activities of FBO and all approved sub-lessees. A comprehensive site plan for all activities must be approved by the ~~Airport Board~~City and may require a Development Agreement approved by the City.

(1) Vehicle Parking - All landside vehicle parking belonging to the lessee shall comply with ~~the City of Hurricane~~the City zoning ordinance requirements. Storage of trailers, motorhomes, un-operational vehicles, etc., in the landside or airside parking areas of a leased facility or business is not allowed. Areas other than leased site parking may be subject to time limited parking regulations as posted. Items left over fifteen (15) days may be towed at the owner's expense unless approved by the Airport Manager.

FUEL STORAGE

FBO shall construct or install and maintain an on-Airport aboveground fuel storage facility at the Airport with appropriate leak containment provisions, unless otherwise authorized or required, in a location consistent with the Airport Master Plan and approved by the City.

Fuel storage facility shall have a total capacity for three (3) days peak supply of fuel for aircraft being serviced by an FBO.

FBO shall, at its sole expense, maintain the fuel storage facility, all improvements thereon, and all appurtenances thereto, in a presentable condition consistent with good business practice and equal or better than in appearance and character to other similar improvements on the Airport. Security fencing surrounding the Operators fuel storage facility must be in place at all times.

FBO shall demonstrate that satisfactory arrangements have been made with a reputable aviation petroleum supplier/distributor for the delivery of aviation fuels in the quantities that are necessary to meet the requirements set forth herein.

FUELING EQUIPMENT

All equipment necessary to adequately support all required activities shall be provided and maintained in accordance with good maintenance practices and all applicable FAA, NFPA, EPA and/or UDOT regulations.

FUELING INSPECTIONS

Hurricane Municipal Airport, Airport Operations Department, under FAA Part 139.321 regulations, are required to inspect an FBO's fueling equipment and employee training records every 90 days for compliance. Findings of non compliance issues may violate the operating lease of the Operator. A Letter of Correction or violation must be repaired no later than 30 days from the inspection date.

GENERAL EQUIPMENT

FBO shall have the following equipment:

- (1) Adequate equipment for providing sufficient ground power units for aircraft normally frequenting the Airport
- (2) One (1) courtesy vehicle (capable of accommodating four (4) passengers) to provide transportation of passengers, crews, and baggage to and from destinations on the Airport and local area hotels and restaurants in close proximity
- (3) One (1) aircraft tug (and tow bar) with at least a rating capacity sufficient to meet the towing requirement of the heaviest general aviation aircraft normally frequenting the Airport
- (4) One (1) Fuel Spill kit
- (5) Adequate number of approved and regularly inspected dry chemical fire extinguisher units shall be maintained within all hangars, on apron areas, at fuel storage facilities, and on all ground handling and refueling vehicles

(6) All equipment reasonably necessary for the proper performance of Aircraft Maintenance in accordance with applicable FAA regulations and manufacturers' specifications

(7) All vehicles shall display proper company identification placards and a rotating beacon as required by the current FAA FAR Part 139 regulations for access into all Airport Operation Areas.

PERSONNEL

Provide qualified employees to perform all required activities. Where required, the Operator shall provide the City with copies of all necessary personnel training certificates and licenses. All personnel must attend an Airport Familiarization class upon hire and attend a refresher course once annually.

COMMUNICATIONS

The FBO shall at all times maintain an active telephone service with current telephone numbers that can be accessed by the public during required business hours. Each FBO is required to monitor the local CTAF during business hours.

AIRPORT SECURITY

The Operator, its employees, agents, customers, and contractors, shall comply fully with The Airport Security Plan. Transportation Security Administration Part 1542 and 1544 applies.

The Operator shall designate a responsible person for the coordination of all security communications and procedures with the Airports Security Coordinator.

The Operator shall develop and maintain a Security Plan. Operator's Security Plan shall be submitted to the Airports Security Coordinator no later than 7 days before Operator commences activities at the Airport. The Operator is solely responsible for implementation of and compliance with The Operator's security plan.

HOURS OF OPERATION

The FBO shall provide service hours that best serve the public requirements. Hours of operation shall not be less than 8 hours per day, seven days per week. Hours of operation may be seasonally adjusted with prior approval of the Airport Manager and shall be conspicuously posted. The FBO shall provide a 24 hour fueling capability (including "on call" service) to the customer or provide a self serve fueling system that will accept alternative payment.

AIRCRAFT REMOVAL

Recognizing that aircraft removal is the responsibility of the aircraft owner/operator, the FBO shall be prepared to lend assistance within 30 minutes upon request, or as soon as practical, in order to maintain the operational readiness of the Airport. The FBO shall prepare an Aircraft Removal Plan and have the equipment readily available that is necessary to remove the general aviation aircraft normally

frequenting the Airport.

INSURANCE

Except as otherwise provided for herein, the FBO shall maintain, at a minimum, the coverage and limits of insurance set forth by ~~the City of Hurricane~~the City as outlined in Section VI.

RAMP SERVICES, REPAIR AND MAINTENANCE

- a. *Maintenance:* The FBO shall provide, at least eight hours per day, six days per week, adequate equipment, facilities and appropriately certificated personnel for performing at least preventive aircraft airframe and powerplant repair and maintenance as outlined in Federal Aviation Regulation 14CFR Part 43, appendix A.
- b. *Ramp Services:* The FBO shall provide adequate equipment and trained personnel during posted business hours to meet public requirements for all ramp services including but not limited to aircraft marshalling and towing, ground power service and lavatory service.

AIRCRAFT LOADING, UNLOADING AND TOWING

The FBO shall provide adequate loading, unloading and towing equipment and trained operators to accommodate the based and transient general aviation aircraft generally utilizing the airport.

B. SPECIALIZED AVIATION SERVICE OPERATOR (SASO)

A Specialized Aviation Service Operator (SASO) is any entity who shall have entered into a written agreement with the City to provide on the Airport and serve the public with *one or more* of the following activities or services:

1. Airframe or powerplant repair
- 4.2. Aircraft Inspection & Avionics Certification
3. Aircraft flight instruction ~~and/or aircraft rental~~
- 2.4. Aircraft rental
- 3.5. Aerial application
- 4.6. Air charter-air taxi service
- 5.7. Air charter-air tours
- 6.8. Commercial Hangar Leasing
- 7.9. Specialized Commercial Activities

Facilities shall include appropriate customer and administrative areas.

SERVICES AND STANDARDS

~~Fixed Base Operators and~~ Specialized Aviation Service Operators must meet the following minimum standards and requirements according to the service(s) provided:

1. NEW AND/OR USED AIRCRAFT SALES

- a. *Building:* ~~For businesses involved in aircraft sales, The FBO/the~~ SASO shall provide suitable office space, as determined by the Airport Manager, for conducting sales and keeping proper records in connection herewith.
- b. *Records:* The ~~FBO/SASO~~ shall provide records of all sales of aircraft to the Airport manager. The FBO shall remit any and all applicable fees and/or taxes as established by City, ~~and/or~~ State of Utah, ~~and/or~~ Airport.
- c. *Personnel:* The ~~FBO/SASO~~ shall provide, (or contract for) during posted business hours, at least one person having a current pilot certificate with appropriate ratings for the types of aircraft being demonstrated for sale.

2. FLIGHT INSTRUCTION AND/OR AIRCRAFT RENTAL

- a. *Instructors:* The ~~FBO or~~ SASO shall provide at least one FAA certified flight instructor to cover the type of training offered and at least one properly certified ground school instructor to enable students to pass the FAA written examination for at least a sport pilots license.
- b. *Aircraft:* If flight instruction is provided, the ~~FBO or~~ SASO shall own or have access to rent or lease at least one properly certified and maintained aircraft equipped for flight instruction. If aircraft rentals are provided, the SASO shall own or lease at least one properly certified and maintained aircraft equipped for aircraft rental. If both services are offered, these can be the same aircraft, provided they are properly equipped and certificated for both instruction and rental.

~~c. —~~ *Building:* The ~~FBO or~~ SASO shall provide adequate facilities for storing, parking, serving and repairing aircraft used for flight instruction or aircraft rental. The ~~FBO or~~ SASO shall provide, ~~or lease at least 140 square feet of office space lease, or sublease~~ adequate office required to conduct their services, as determined by

the Airport Manager. Operator shall also make arrangement for the use of additional adequate space in the same facility for classroom training activities and restroom facilities. This additional space may be common with other users at the airport. ~~in the facility.~~

~~d. *Hours of Operation:* The FBO or SASO shall provide services at least eight hours per day, Monday through Friday to best serve the public. The hours of operation shall be conspicuously posted.~~

~~e.c.~~ *Insurance Coverage:* Insurance shall be carried meeting the minimum requirements outlined in Section VI.

e. *Part Time Flight Instruction:* An entity may provide "part time" or "guest instructor" flight training not to exceed ten (10) hours a month, without the office and aircraft requirements, provided that such an entity ~~satisfy's~~satisfies the requirements for insurance coverage and indemnification for ~~the City of Hurricane~~the City, ~~and maintains an appropriate operators agreement with the Airport.~~

3. AIR CHARTER-AIR TAXI SERVICE

a. *Aircraft and registration:* The ~~FBO or~~ SASO shall provide on-demand air charter and air taxi service with at least one aircraft ~~equipped for flight in IFR conditions,~~ in accordance with Federal Aviation Regulation 14 CFR Part 135. If required, the ~~FBO or~~ SASO shall be properly registered with the Utah Aeronautics Commission.

b. *Personnel:* The ~~FBO or~~ SASO shall employ or contract with at least one appropriately rated pilot available to operate such air charter and air taxi aircraft.

4. AERIAL APPLICATION AND SEEDING OPERATIONS

~~An FBO or A~~ SASO desiring to engage in aerial application operations must hold an appropriate operator's certificate issued by the FAA, comply with the requirements of the State of Utah and the Airport's Storm water Pollution Prevention Plan, and provide as a minimum the following:

a. *Personnel:* The ~~FBO or~~ SASO shall provide at least one person holding a current FAA commercial pilots license, properly rated for the aircraft to be used and meeting the requirements of Federal Aviation Regulation 14 CFR Part 137 and applicable regulations of the State of Utah. Any pilot involved with any aerial application must hold the appropriate certificates from the State of Utah Department of Agriculture and Food.

- b. *Aircraft:* The ~~FBO or~~ SASO shall own or lease at least one aircraft meeting all requirements of Federal Aviation Regulation 14CFR Part 137 and applicable regulations of the State of Utah.
- c. *Storage:* The ~~FBO or~~ SASO shall provide a segregated chemical storage area protected from public access and meeting all applicable Federal and State environmental regulations and Occupational Health and Safety Administration (OHSA) requirements.
- d. *Cleaning:* The ~~FBO or~~ SASO shall provide a DEQ/EPA approved washing area if the washing involves an aircraft that has been exposed to chemicals.
- e. *Building:* The ~~FBO or~~ SASO shall provide or lease at a minimum, 140 square feet to conduct operations. The SASO shall provide a segregated chemical storage area protected from public access and meeting all applicable Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OHSA) requirements.
- f. *Insurance:* Insurance shall be carried meeting the minimum requirements outlined in Section VI.

5. SPECIALIZED AIRCRAFT REPAIR SERVICE (~~i.e. airframe, powerplant,~~ avionics, instrument or propeller)

- a. *Building:* The SASO shall construct or lease a building to provide office space, public restrooms, and sufficient space to work indoors on aircraft, avionics, instruments, propellers, or other repairs or services.
- b. *Performance of Services:* The services provided hereunder shall be performed within or with immediate access to the required building, except for such services as must be performed outside for safety or emergency reasons, such as accidents, or aircraft run-ups, or if the aircraft is too large to be placed within the building.
- a.c. ~~*Personnel:* The FBO or SASO shall provide at least one FAA certified employee qualified in accordance with the terms of the repair service offered, on duty at least eight hours per day, five days per week. At least one properly FAA certified employee shall be on duty during posted business hours. An FAA certified IA mechanic shall be~~

available as necessary.

b.d. EquipmentBuilding: The ~~FBO or~~ SASO shall maintain adequate space, tools and equipment, as determined by the Airport Manager, to perform the services offered.

e.e. Spare parts: The ~~FBO or~~ SASO shall have access to adequate spare parts and accessories necessary to provide the servicess offered.

6. AIR CHARTER-AIR TOUR FLIGHTS

A ~~FBO or~~ SASO desiring to provide air charter and/or scenic flight services greater than 25 statute miles from the Airport under Federal Aviation Regulation 14CFR Part 135 must hold an FAA Air Taxi-Commercial Operator Certificate with ratings appropriate to the functions to be accomplished, be properly registered with the Utah Aeronautics Commission, if required by state law or regulation, and provide as a minimum the following services and facilities:

a. *Building*: The ~~FBO or~~ SASO shall provide or lease at least 140 square feet of office space. The SASO shall also make arrangement for the use of additional adequate space in the same facility for reception and passenger waiting areas and restroom facilities. This additional space may be common with other users in the facility.

b. *Personnel*: The ~~FBO or~~ SASO shall employ or contract for at least one FAA certified commercial pilot, appropriately rated to conduct the operations performed.

c. *Aircraft*: The ~~FBO or~~ SASO shall own or lease at least one properly certified and maintained single engine aircraft, equipped for VFR operations.

~~d. *Hours of Operation*: The FBO or SASO shall provide services at least eight hours per day, Monday through Friday to best serve the public. Extended or "on-call" hours are encouraged. The hours of operation shall be conspicuously posted.~~

e.d. Insurance Coverage: Insurance shall be carried meeting the minimum requirements outlined in Section VI.

7. COMMERCIAL HANGAR LEASING

Any ~~FBO or~~ SASO desiring to provide hangars for the sole intent of leasing to other aircraft owners or lessees shall provide as a minimum the following services and facilities:

a. Land: Leasehold shall contain adequate land area to

accommodate all building structures and parking areas.

- b. *Building:* Construct or lease a hangar or building of at least 2,500 contiguous square feet which meets the City's approval.
- c. *Parking:*
Lessee shall lease from the city a minimum of two parking spaces or more as appropriate for a proposed hangar unit. Other parking accommodations may be appropriate with the approval of the airport manager.
- d. *Insurance Coverage:* Insurance shall be carried meeting the minimum requirements outlined in Section VI.
- e. *Restrooms:* - Lessee shall provide at least one restroom per hangar development as approved by the airport manager.

~~8. AIRFRAME OR POWERPLANT/SPECIALIZED AIRCRAFT REPAIR SERVICES~~

~~A SASO desiring to engage in airframe or powerplant repair service must provide as a minimum the following services and facilities:~~

- a. ~~*Land:* The leasehold lessee or sub shall ~~lessee shall have~~ contain at least 3,500 contiguous square feet for an adequate building and required setbacks.~~
- b. ~~*Building:* Construct or lease a building of at least 3,000 contiguous square feet to provide office space, public restrooms and sufficient space to work indoors on aircraft, avionics, instruments or propellers.~~
- c. ~~*Personnel:* At least one properly FAA certified employee shall be on duty during posted business hours. An FAA certified IA mechanic shall be available as necessary~~
- d. ~~*Hours of Operation:* The SASO shall provide services at least eight hours each day, Monday through Friday to best serve the public. The hours of operation shall be conspicuously posted.~~
- e. ~~*Performance of Services:* The services provided hereunder shall be performed within or with immediate access to the required building, except for such services as must be performed outside for safety or emergency reasons, such as accidents, or aircraft run-ups, or if the aircraft is too large to be placed within the building.~~
- f. ~~*Insurance Coverage:* Insurance shall be carried meeting the~~

9.8. SPECIALIZED COMMERCIAL ACTIVITIES

- a. *Parachute Jumping:* No commercial parachute jumping clubs or organizations desiring to engage in parachute jumping above or onto the Airport will be allowed without the special permission of the Airport Management. In the event that permission is granted. Then the operator must as a minimum provide the following:
 - i. Obtain the written permission of the Airport Manager.
 - ii. Specify the hours and areas for the drop and issue a Notice to Airmen as appropriate.
 - 111. Provide the Airport with a general liability insurance policy that names the City as an additional insured party, in an amount to be determined by the City. If the organization is a member of the United States Parachute Association, the coverage provided by membership in that organization is acceptable.
- b. *Flying Clubs:* An entity organized for the express purpose of providing its members with aircraft for their personal use only, must provide the following as a minimum:
 - i. Documentation of the clubs corporate status, a list of all members and a list of all Club-owned or - leased aircraft. The Club shall be an entity organized for the express purpose of providing its members with an aircraft for their personal use and enjoyment. The ownership of the aircraft must be vesting in the name of the Club. The Club may not derive greater revenue from the use of its aircraft than the amount necessary for the operations, maintenance and replacement of its aircraft. Financial records shall be provided to the Airport Manager no less than annually or as requested.
 - ii. Provide the Airport Manager with proof of insurance coverage meeting the requirements outlined in Section VI.
- c. *Other Commercial Aeronautical Activities:*

Other commercial aeronautical activities not specifically addressed in this part shall be approved on a case-by-case basis by the City. Examples may include, but are not limited

to, commercial banner towing, aircraft paint, aircraft restoration, avionics, instrument or propeller repair facilities. Other commercial aeronautical activities may also include an amateur-built aircraft manufacturer or sport pilot/light-sport aircraft service provider.

Applications for activities not specifically addressed under these standards must contain all information requested in Section II of these standards. Minimum standards for other aeronautical activities will be created and adopted into these Standards as determined to be necessary by the City Council of ~~Hurricane City~~the City.

SECTION VI - MINIMUM INSURANCE REQUIREMENTS

Dependent upon the type of activity or activities conducted, the Operator will be required throughout the term of its lease or agreement under standards to obtain insurance of the types and amounts set forth by the City. All insurance must meet the following requirements:

- A. Prior to commencement of operations, the Operator will be required to provide the Airport Manager with proper evidence of insurance covering its operations on the Airport as specified in this section.
- B. Such evidence of insurance must name ~~the City of Hurricane~~the City as an additional insured.
- C. Evidence of insurance must also provide ~~the City of Hurricane~~the City with at least 30 days notice of any policy change, cancellation or termination.
- D. The Operator must also provide a waiver of subrogation to the benefit of ~~the City of Hurricane~~the City.

Section VII - LEASE TERMS and CONDITIONS

It shall be the policy of ~~the City of Hurricane~~the City to negotiate such lease terms and conditions as may be appropriate to the type of business operation being proposed, scale and scope of proposed investment into the Airport, and appropriate term length not to exceed a base term length of 20 years, with a single five year extension option, subject to the approval of ~~the City of Hurricane~~the City.

Section VIII - NON COMMERCIAL ACTIVITIES

A Non-Commercial Hangar Operator (Operator) is an Entity that develops/constructs and owns one or more hangar structures used for Non-Commercial storage of aircraft.

No Commercial Aeronautical Activity of any kind shall be permitted on or from the leased premises.

Non Commercial Hanger space is limited to aircraft storage only. *If an aircraft is stored in a hangar and there is excess space for additional property owned solely by the hangar owner, this additional property may be stored with the approval of the aAirport mManager as long as it meets all storage and safety requirements in this document and in the Hurricane City Rules and Regulations document.* ~~Vehicles, trailers, motorhomes, or any other items not associated with aeronautical activities are prohibited. However, a hangar owner may park his/her personal vehicle (car/truck) being utilized for transportation to and from the hangar inside that structure while utilizing their aircraft. This section is intended to prevent the routine or term storage of non-aeronautical vehicles or property in an airport hangar, not to prevent an owner from parking his/her incidental transportation inside the hangar while utilizing their aircraft.~~

Operator shall not be permitted to sublease any land or Improvements on the leased premises for any purpose.

Public Facilities — The City is permitted to store and maintain equipment at the Hurricane City Airport. The City, as the owner of the Airport, is permitted to store and maintain equipment and supplies at the Airport, including equipment and supplies related to airport maintenance and responding to emergencies.

Hurricane City Municipal Airport Hurricane, Utah

Rules and Regulations

Adopted and Approved
[date of approval]
Hurricane City Council

Table of Contents

Table of Contents	2
Purpose	4
Definitions	5
Airport Manager	8
Permission to Use Airport Conditional	8
Approval of Aviation Operations	8
Rules and Regulations	10
A. Compliance w/ State and Other Regulations	10
B. Vehicle Operations	10
C. Security	11
D. Aircraft Operations	11
E. Aircraft Parking	13
F. Hangar Use	13
G. Safety Prohibitions	14
H. Accidents / Incidents	15
I. Nuisances	16
J. Pedestrians	16
K. Operators to keep the Rules and Regulations	16
L. Refuse	17
M. Construction	17
N. Special Events	17
O. Noise Sensitive Areas	17
P. Self-Services	19

Q. Storage and Maintenance	19
R. Structure Design	20
S. Commercial Standards	20
T. Enforcement / Appeal	20

PURPOSE

These Rules and Regulations, hereafter referred to as “regulations”, have been adopted by the Hurricane City Council and approved through *resolution* by this council. These regulations are designed to establish the structure necessary to ensure the continued viability and safety of the airport for its users and for the citizens of Hurricane.

These Standards are intended to be reasonable, non-arbitrary and non-discriminatory. These standards apply equally to everyone using the airport and shall be observed, abided by, and obeyed.

All aeronautical activities, operations, piloting of aircraft, business, and other activities at the airport shall be conducted in accordance with these rules and regulations, Hurricane City’s Minimum Standards for Commercial Aeronautical Activities, other Hurricane City Codes, Federal Aviation Administration, Utah Department of Transportation, and National Fire Prevention Association standards as appropriate.

DEFINITIONS

As used in this chapter, the following words and terms shall have the meanings ascribed to them in this section:

ACCIDENT - An occurrence associated with the operation of an aircraft which any person suffers death or serious injury or in which the aircraft receives substantial damage.

AERIAL APPLICATIONS - The business of making aerial applications of fire retardants, fertilizers, pesticides, seeding or other dusts or sprays.

AGL – refers to actual altitude above average elevation of terrain or “above ground level”.

AIR SALES OPERATOR - A person, firm or corporation engaged in the business of buying, selling and exchanging new or used aircraft.

AIR TAXI OPERATOR - A person, firm or corporation engaged directly in air transportation of passengers and/or property subject to the provisions of FAR Part 119 and FAR part 135 of the federal aviation regulations and holding any required certification from the Federal Aviation Administration the state of Utah.

AIRCRAFT - Any device used or intended to be used for flight in the air, including, but not limited to, airplanes, ultralights, balloons, and gliders of all types.

AIRCRAFT HANGAR – A building on the airport with the primary purpose of storing an aircraft.

AIRCRAFT RADIO - Instrument, Propeller and Accessories Shop - A person, firm or corporation engaged in FAA approved aircraft, radio, and instrumentation or propeller business, including sales, service, repair, exchange and installation of new and/or used aircraft radio equipment, instruments or propellers and parts.

AIRPORT - All City owned or leased real or personal property comprising the Hurricane City Municipal Airport as now existing or as the same may hereafter be expanded and developed.

AIRPORT BUILDING STANDARDS – The Hurricane City Airport Minimum Building Standards as adopted and amended from time to time.

AIRPORT MANAGER - The duly appointed manager of the Hurricane City Airport or his/her designee.

AIRPORT MINIMUM STANDARDS – The Hurricane City Airport Minimum Standards for Commercial Aeronautical Services, as adopted and amended from time to time.

AOA - Airport Operations Area

BASED AIRCRAFT – Any aircraft habitually parked or stored on the airport, whether in a hangar or without. This also includes any aircraft or similar vehicle transported onto the airport and assembled and flown from the airport.

CITY – Hurricane City.

CITY COUNCIL – The governing body of the municipality which owns the Airport and is the final authority in all matters of policy.

COMMERCIAL ACTIVITY - The conduct of any aspect of a business or concession on the airport for revenue, whether intended to be profit producing or nonprofit.

CONTROLLED ACCESS AREA - All areas of the airport enclosed by fence or other barrier and to which vehicular access may be obtained only through electronically activated gates.

FAA – The Federal Aviation Administration or duly designated representative thereof.

FIXED BASE OPERATOR (FBO) - A person, firm or corporation subject to the provisions of a lease engaging in the delivery of fuel and oil products into aircraft, in addition to at least two of the following services:

- The sales, service, exchange, renting or leasing of new and used aircraft, and/or aircraft parts, accessories and hardware;
- The repair, overhaul, maintenance and modification of general aviation aircraft and/or aircraft equipment using FAA certified mechanic(s) or under the provisions of an FAA approved Part 145 repair station;
- The conduct of FAA approved pilot flight and ground school training under the provisions of FAR Part 61 or FAR Part 141;
- Charter flight services which may include aerial photography, advertising, map making and aerial application services.

FLIGHT SCHOOL OPERATOR - A person, firm or corporation engaged in an FAA approved pilot flight training school under the provisions of FAR Part 61 or FAR Part 141, limited to dual and solo flight training in fixed and/or rotary wing aircraft and such related ground school instruction as is necessary to prepare a student pilot to take a written examination and practical test for pilot certificate or appropriate aircraft rating from the FAA.

FUEL HANDLING - The transportation, delivery, fueling and draining of fuel or fuel waste products.

FUEL STORAGE AREA - Any portion of the airport designated temporarily or permanently by the Airport Manager as areas in which AvGas or any type of fuel may be stored or loaded.

GENERAL AVIATION SPECIALTY SHOPS - Aircraft Maintenance: A person, firm or corporation engaged in the business of providing FAA approved routine, normal and preventive maintenance of general aviation aircraft.

LAW ENFORCEMENT OFFICER (LEO) – Any sworn peace officer, City Police, County Sherriff, UHP, or similar law enforcement personnel that may be on the Airport in the line of assigned duty.

MOVEMENT AREA - The runways, taxiways and other areas of an airport which are used for taxiing or hover taxiing, air taxiing, takeoff and landing of aircraft, exclusive of loading ramps and aircraft parking areas.

OPERATIONAL AREA - Any place on the airport not leased or designated to anyone for occupancy.

PARK OR PARKING - The standing of an aircraft or vehicle, whether occupied or not.

PUBLIC AREA - Those areas normally used by the general public, including structures and facilities such as roadways, sidewalks and terminal buildings that are maintained and kept at the airport for use by the general public.

SASO – A specialized aeronautical service provider performing less than full FBO services.

SELF-SERVICE – The fueling, washing, servicing, repair, touch-up painting or maintenance of an aircraft performed by the owner or operator of the aircraft by themselves, and using his or her own tools and equipment. Self-Service cannot be contracted out to another party. Maintenance, preventive maintenance, repair, alterations, is authorized under Self-Service provided the Self-Service is performed in accordance with FAR Parts 43, 65, 91, or 103 as, appropriate to the aircraft.

SIDA - Security Identification Display Area

THROUGH-the-FENCE OPERATIONS – “Through-the-fence” are those activities permitted by an airport sponsor through an agreement that permits access to the public landing area by independent entities or operators offering an aeronautical activity or to owners of aircraft based on land adjacent to, but not part of, the airport property.

Recreational, light sport and glider aircraft that are designed to be transported by a trailer shall not be considered through-the-fence operations as long as NO commercial activity takes place.

AIRPORT MANAGER

The City Council may employ a qualified individual to manage, direct, and coordinate the operations and maintenance of the airport in order to ensure compliance with all federal, state and city regulations. The Airport Manager is authorized to take all reasonable actions necessary to protect and safeguard the public while present at the airport and to oversee all airport operations consistent with these standards. The Airport Manager shall coordinate airport affairs with the Federal Aviation Administration, Utah Department of Transportation Aeronautical Division and other applicable agencies to ensure that the ongoing needs of the airport are met.

PERMISSION TO USE AIRPORT CONDITIONAL

Any permission granted by the City, directly or indirectly, expressed or by implication, to enter upon or use the airport or any part thereof, including, but not limited to, operators, crew members and passengers, spectators, sightseers, pleasure and commercial vehicles, officers and employees of airlines, lessees and other persons occupying space at the airport, persons doing business with the airport, its lessee, sub lessee and permit tees, and all other persons whatsoever whether or not of the type indicated, is conditioned upon compliance with this chapter and any rules, regulations or procedures promulgated hereunder; entry upon or into the airport by any person shall be deemed to constitute an agreement by such person to comply with this chapter and such rules, regulations and procedures. The City reserves the right to deny any or all usage of the airport to any person or persons for cause.

APPROVAL OF AVIATION OPERATIONS

Any person wishing to commence commercial activities or operations at the airport shall submit all information and material in accordance with Section II of the Airports Minimum Standards for Commercial Aeronautical Activities as well as a City business license application to the Airport Manager. If the application is complete, the Airport Manager will forward the complete materials to the business licensing officer. If the application is incomplete, the Airport Manager will advise the applicant in writing of the deficiencies within ten (10) business days.

The business licensing officer will collect payment from the applicant upon receipt of a complete application. The application will then be reviewed to ensure that all licensing requirements are met including but not limited to the following:

1. Verification of professional license (if applicable).
2. Business name registered with the Department of Commerce.
3. A passed fire inspection is completed.

4. An active sales tax number for the City is provided (if applicable).
5. For any new construction a certificate of occupancy must be issued first.

RULES AND REGULATIONS

The following rules and regulations will govern the conduct of all persons at the airport, whether engaged in aeronautical activities or otherwise:

A. Compliance with State and Other Regulations

1. No person shall navigate, land aircraft upon, or conduct any aircraft operations on or from the airport other than in conformity with FAA rules and regulations.
2. All vehicles operated on airport property within the controlled access area shall be maintained in a safe operating condition in accordance with the Utah Department of Transportation (UDOT) codes and standards. All fuel trucks operating on the airport must meet UDOT standards and adhere to the Uniform Fire Code (UFC), National Fire Protection Agency (NFPA) or any City Fire regulations.

B. Vehicle Operations

1. Only bona fide emergency vehicles, airport maintenance vehicles, and those vehicles belonging to aircraft owners, and/or operators, and hangar owners may be operated on the ramp, taxiway, runway portions of the airport. With the operations of ground vehicles on the taxiway or runway being further restricted to those situations necessary to respond to an emergency, airport maintenance, or to the positioning of or retrieval of gliders or ultralight aircraft. In all cases the operator of a ground vehicle will give the right of way to all pedestrians and all aircraft taxiing, taking off or landing.
2. No vehicles shall ever be parked unattended on the runway, nor shall any vehicle ever be parked unattended on any portion of any taxiway or ramp such as to deny or restrict the free passage of any aircraft to/from any hangar, tiedown or parking spot.
3. No motor home, travel trailer, boat trailer, horse trailer, utility trailer, any other type of powered or unpowered vehicle, shall be stored at the airport; provided, however, that the following are permitted: 1. Trailers specially designed and constructed to store/transport gliders and ultralight aircraft; 2. Mobile refueling equipment used for refueling aircraft by an authorized fuel provider; 3. Trailers and equipment used by airport personnel for airport maintenance activities; 4. Operational automobiles parked in long term parking; 5. City Public Facilities storage. If stored in public view, these items may only be stored in those areas that have been designated by the Airport Manager.
4. No bicycles, motorbikes, motorcycles, or all-terrain vehicles shall be

operated on any portion of the runway, taxiway, or ramp except where such operation is approved by the Airport Manager and is conducted by the owner/operator of any aircraft or lessee of any hangar at the airport.

5. Except for emergency response vehicles and aircraft in the act of taking off or landing, no person may operate a motor vehicle on any portion of the airport at a speed greater than 15 MPH, nor may any person operate any vehicle in a careless or reckless fashion.
6. General vehicle parking on the airport will only be in those locations designated by the Airport Manager. Lease holders may park in areas adjacent to their leased facilities, when in the opinion of the Airport Manager, such parking will not create a hazard or conflict with any airport operation or activity. The Airport Manager will have the authority to move, or have moved, at the vehicle owner's expense, any vehicle parked in an inappropriate location.

C. Security:

1. The Airport Manager as well as hangar owners should be aware of those people who are on the airport as visitors. Visitors should be questioned as to the reason for their presence at the airport. The Hurricane City Police Department should be immediately notified of any suspicious person/s or activities.

D. Aircraft Operation:

1. Every person operating an aircraft shall comply with and operate such aircraft in accordance with these Rules and Regulations, and all pertinent rules and regulations of the Federal Aviation Administration (FAA), UDOT/Aero and any other appropriate governmental agencies. Every person operating an aircraft is responsible for the safety of his/her operation and for the safety of others exposed to such operation, and therefore shall exercise good operating procedures at all times. Aircraft shall not be operated carelessly or negligently nor in disregard of the rights and safety of others.
2. The City Airport is a non-towered airport. Even though radio communications are not required, it is highly recommended that pilots have radio equipment permitting two-way communication to monitor the airport common traffic advisory frequency (CTAF) while in the vicinity of the airport.
3. All aircraft shall comply with the FAA Federal Aviation Regulations (FAR) and follow the appropriate taxiway and runway guidance markings and

lighting when operating on the airport.

4. Any aircraft weighing more than 12,500 lbs. aircraft gross weight is prohibited on the runway, taxiways or apron, unless approved by the Airport Manager.
5. Under no circumstances shall any person approach any aircraft, other than a pilot or certified aircraft mechanic, whether it is fixed wing or rotorcraft, until all blades or propellers have come to a complete stop. The only exception will be hot fueling in compliance with the operators hot fueling safety procedures.
6. Except in an emergency, rotorcraft are not permitted to perform autorotations to a running or skidding landing, or any other type of running or skidding landing, on any taxiway, runway, or other paved surface at the airport.
7. Lighter than air or hot air balloons are not permitted to land or take off from the airport without prior approval from the Airport Manager.
8. Parachuting activity over or onto the airport shall be conducted in accordance with all relevant requirements of FAR Part 105.
9. Ultralight operations at the Hurricane Airport shall be conducted in accordance with all relevant requirements of FAR Part 103, except for such deviations from that part as may be authorized by an FAA issued Grant of Exception.
10. The traffic pattern and rules for operating in that traffic pattern for the Hurricane Airport are as follows:
 - a. The recommended primary runway shall be runway 19. The traffic pattern shall be a right-hand pattern and shall be flown by the powered aircraft (other than ultralights and similar aircraft) at an altitude of at least 800 to 1,000 feet above the published field elevation.
 - b. The traffic pattern for runway 1 shall be a standard left hand pattern and shall be flown by powered aircraft (other than ultralights and similar aircraft) at an altitude of at least 800 to 1,000 feet above the published field elevation.
 - c. The traffic pattern for ultralights, powered parachutes, and similar aircraft shall be the same as for other powered aircraft except it shall be flown at an altitude of at least 500 feet above the published field elevation.
 - d. When departing south on runway 19 turn a right crosswind prior to the gravel pit (located left of runway centerline) to avoid a traffic conflict with any traffic from Sky Ranch.

Hurricane Airport is an uncontrolled airport, therefore pilots shall adhere to the “see and avoid ” concept. The CTAF for radio equipped aircraft is currently 123.05 mhz.

11. Use of an aviation transceiver to broadcast intentions is encouraged.
12. Aircraft are prohibited from taking off or landing anywhere on the Airport property other than the paved runway. Two exceptions to this rule are: 1. Helicopters may sidestep onto a paved taxiway provided the helicopter does not interfere with the normal movement of aircraft on the taxiway, and 2. Aircraft in an emergency situation. 3. Powered parachutes in approved taxiway by manager.

E. Aircraft Parking

1. All aircraft will be parked in areas designated by the Airport Manager. Each aircraft owner or operator occupying a hangar or tie down is responsible for adequately securing his/her own aircraft.
2. Helicopter operations shall be limited to areas designated by the Airport Manager.
3. Major repairs to aircraft or engines in a private hangar *shall not* be made unless it's in accordance with FAR Parts 43, 65, 91, or 103.
4. Minor general maintenance or repairs to personal aircraft such as oil changes is permitted as applicable in FAA Part 43, appendix A(C)
5. No derelict, non flyable or un-airworthy aircraft will be permitted to tie down anywhere within at the airport for longer than a 30 day period without the permission of the Airport Manager. Aircraft in violation of this paragraph may be removed by the Airport Manager at the owner's expense.
6. The city assumes no responsibility for damages by a third party or theft to aircraft or vehicles operated or parked at the airport. Transient and long term aircraft parking fees are set from time to time by the Airport Manager and the City Council.

F. Hangar Use

1. The primary purpose of an aircraft hangar is the storage of aircraft. An office, restroom, or similar facility may be contained within a hangar, but not to such extent that an aircraft cannot then be stored within the hangar.
2. Residential occupancy of a hangar of any length of time by any person(s) is prohibited with the exception of the Airport Manager.

G. Safety Prohibitions

1. All persons using the Airport or the facilities of the Airport in any way must exercise the utmost care to guard against fire and injuries to persons and property. The following are not authorized on the City Airport:
 - a. Smoking within fifty feet (50') of any aircraft, fuel truck or fuel storage tank of any kind.
 - b. Refueling or defueling of any aircraft is prohibited in any hangar.
 - c. Refueling during an electrical storm is prohibited.
 - d. While fueling aircraft, electronic devices such as cell phones, two way radio's, pagers, etc., shall not be worn or used until all fueling operations have been completed.
 - e. Hot fueling aircraft while the propellers or blades are in motion is permitted if the operator complies with the provisions of the FAA's operators hot fueling safety procedures.
 - f. Fueling shall be done in strict accordance with NFPA 407 requirements, City fire codes, and/or other applicable fire or hazardous materials regulations.
 - g. Self-fueling one's own aircraft from drums, small containers, or fuel systems is not permitted at the Airport unless verification has been completed by the Airport Manager that the following items have been received; appropriate insurance coverage has been obtained for conducting self-fueling operations including adding the City as an additional insured on such insurance coverage and completing an indemnification agreement with the City.
 - h. Fuel services shall be administered only by an authorized fuel provider that adheres to the Airport Minimum Commercial Aeronautical Standards. All fuel for aircraft must be purchased from an authorized fuel provider on the airport unless approved by the Airport Manager and the requirements of G.1.g. are complied with.
 - i. "Flagging" and/or "Hawking" is prohibited at the Airport. For the purposes of these regulations, this is defined as: Any method or means used from any location to attract incoming aircraft for the purposes of selling fuel or providing other services (except the use of fixed signs, such signage to be approved by the Airport Manager.)
 - j. Flying any type of drone or model aircraft at the airport is prohibited unless prior approval is given by the Airport Manager. Each drone or model aircraft operator must have in his/her possession a remote pilot certificate issued by the FAA, as applicable, and must adhere to the provisions of FAR Part 107 or Part 101 depending on the type of operation being conducted.

- k. No parachutes, powered or otherwise, shall depart from or land at the Hurricane City American Legion Equestrian Park located adjacent to the Airport.
2. The following is prohibited in aircraft storage hangars:
- a. Starting or taxiing an aircraft
 - b. Refueling of any aircraft
 - c. . Major aircraft repairs and alterations as defined by the FAA may be completed by individuals (SASO operations or aircraft owners) that hold the Proper FAA credentials and/or certifications to do so. Hangar owners may construct a homebuilt aircraft in their hangar with the approval of the Airport Manager. Self-serve minor maintenance is limited to preventative maintenance as outlined in FAR Parts 43, 65, 91, or 103 as applicable. All safety rules and regulations as described in this document as well as the City's Minimum Standards for the Airport, shall be complied with.
 - d. Painting is prohibited. Self-service touch-up painting may be authorized with prior approval from the Airport Manager.
 - e. Welding is prohibited.
 - f. Open flame tools are prohibited.
 - g. Storage of any Hazardous Materials other than oily waste rags is prohibited. Suitable small metal receptacles with self closing covers shall be provided by tenants for the storage of such items.
 - h. Open storage of flammable materials is prohibited. One (1) suitable fire safe container, no larger than four (4) feet in width, and eight (8) feet in height, and complies with OSHA, UL, or NFPA Standards, may be used to store limited amounts of flammable materials such as small spray paint cans, that may be needed to support self-service maintenance requirements.
3. The City is authorized to conduct inspections of all areas leased to hangar tenants, including inspections of the interiors of hangars. A tenant's refusal to allow such inspections shall constitute a violation of these Rules and Regulations.

H. Accidents/Incidents

Persons involved in an aircraft accident affecting airport operations or damaging city property shall make a full verbal report to the Airport Manager or his/her designee within one hour after the accident. The report must include names and addresses, time, place, cause, injuries and other information requested by the Airport Manager. When a written report of an accident is required by the FAA or NTSB, a copy of such report shall be submitted to the Airport Manager. At accident

scenes, aircraft owners (and) the pilots or agents will promptly remove disabled aircraft, parts and accident debris unless directed by the Airport Manager, FAA, NTSB, or local authorities to delay such action pending an accident investigation. Damage sustained to the airport facility, grounds or buildings will be assessed as a claim against the responsible party.

I. Nuisances

1. Dismantled aircraft, aircraft parts, dismantled or inoperative aircraft or any other unsafe, un-kept, unsightly miscellaneous item or items in disrepair shall not be left over a period of 30 days in open view. This includes all movement areas as well as non-movement areas. If the Airport Manager determines that a violation has occurred, he shall so advise the owner. If not corrected within thirty (30) days, the Airport Manager may remove such items and bill the owner or operator for associated costs. Conditions involving safety issues shall be corrected within twenty-four (24) hours.
2. Any person, including the operators of an aircraft, causing overflowing of fuel and / or spilling of excess oil or grease on any apron will notify the Airport Manager immediately. The involved person shall be responsible for cleaning such areas and repair any damage thereto.
3. At no time shall engines be "run up" when other aircraft, hangars, shops, buildings or persons are in the path of the propulsion stream. Any person operating any vehicle or aircraft (including fixed wing and rotor) shall be responsible for damage or cleanup caused by such operations (i.e., scattering of debris from prop blast or rotor down wash).

J. Pedestrians

1. Hangar owners and aircraft operators may walk on any runway or taxiway when necessary to gain access to an aircraft, glider, or ultralight. This also applies to pilots and ground crew when involved in the launch or recovery of such aircraft; and for airport maintenance and debris removal, and to emergency personnel in the performance of their duties. Anyone walking on the runway shall remain alert for any aircraft operating in the traffic pattern.
2. On all areas of the airport, pedestrians will give way to all moving aircraft.

K. Operators to keep the Rules and Regulations Availability

All commercial operators with valid leases to perform aeronautical business on the airport shall keep a current copy of these rules and regulations prominently posted in their place of business and available for viewing to all who enter the facilities. It is the responsibility of all owners of aircraft based at the airport and pilots who regularly use the airport to be familiar with the contents of this document. The operators bear the responsibility for compliance and ignorance is not an excuse

for violation of any part of these rules and regulations.

L. Refuse

No person shall throw, dump or deposit any waste, refuse or garbage on the airport. All waste, refuse or garbage from airport operators or construction crews shall be placed and kept in closed garbage containers and all operating areas shall be kept in a safe, neat, clean and orderly manner at all times and in such manner as to minimize any hazards. Garbage containers and temporary restroom facilities must be in place before any construction starts.

M. Construction

In addition to the requirements of this paragraph, all construction at the Airport shall comply with the City's generally applicable ordinances, standards, and regulations governing such construction. Before any construction project begins on the airport, the contractor or his/her designated project supervisor will be required to attend a one hour training class on Airport Familiarization and Safety. The contractor is required to have in place one port a potty and one enclosed refuse dumpster prior to the start of construction per City Building Ordinance. The Airport Manager or his designee will attend the pre-inspection meeting to discuss the operations at the Airport. Attendance at the post inspection by the Airport designee will also be required before any final inspection is approved.

N. Special Events

Special events include but are not limited to the following:

Air shows	War bird shows
Balloon festivals	Fly-in meets or open house
Air races	Parachute team demonstrations

These special events require written permission and approval from the Airport Manager.

O. Noise Sensitive Areas

- a. In addition to complying with FAR Part 91.119 for maintaining minimum altitudes over congested areas such as the residential areas of the City, pilots are expected to use good judgment and flight procedures that result in minimum noise over noise-sensitive areas. Compliance with the City's noise policy is strongly encouraged.
- b. Noise abatement procedures.

The following voluntary procedures are defined to abate excessive noise at the airport:

- a. Runway 19 should be used whenever wind conditions allow for safe landing and takeoff operations. If departing to the north using Runway

- 1, a left crosswind turn should be executed as soon as safely practical to avoid unnecessary overflight of residential areas.
- b. All aircraft shall make a practical effort to reach pattern altitude (1000' AGL) before turning downwind. All aircraft departing the airport pattern area are to make a reasonable effort to climb to a minimum altitude of 1000' AGL before doing so utilizing the standard pattern legs as defined in Section 4-3-3 of the Aeronautical Information Manual (AIM).
 - c. All arriving aircraft utilizing the traffic pattern are to maintain a minimum of 1000' AGL until established in the pattern per guidelines found in the AIM.
 - d. Helicopters shall make a practical effort to vary the downwind distance from the runway when performing repetitive pattern work in order to reduce sustained ground noise under a particular flight path. See AIM 4-3-3(b).
 - e. Simulated forced landings and/or auto-rotations should not initiate until the aircraft reaches the typical pattern altitude of 1000' AGL.
 - f. Unless otherwise approved by the Airport Manager or a Memorandum of Understanding agreement between the City and the applicable entity, repetitive aircraft training operations should be limited to (2) 30 minute sessions within a 24 hour period Monday through Saturday for helicopters and/or aircraft that exceed 80 (eighty) decibel levels per noise measurement levels determined and defined in FAA Circular AC 36-1H. Repetitive pattern work for these aircraft is not to be flown on Sundays. This restriction shall not apply in emergencies, where necessitated by safety considerations, or when required by the Federal Aviation Administration.
 - g. Aircraft are not to be started, run-up, or depart the Airport between sunset and sunrise other than to make an immediate departure from the airport area.
 - h. All aircraft arriving between sunset and sunrise to be limited to one (1) full stop approach and landing sequence.
 - i. Repetitive pattern work, touch and go's, stop and go's, low approaches, or practice autorotations are not to be conducted between sunset and sunrise. 2.

EXCEPTIONS

The following categories of aircraft are exempt from airport noise abatement guidelines:

- a. Aircraft operated by or under contract of the United States of America, any State, county, city, subdivision or special district of a state including military, firefighting, search & rescue, disaster relief, and medical evacuation flights;
- b. Aircraft used for emergency purposes during an emergency officially

proclaimed by competent authority pursuant to the laws of the United States, the State of Utah, Washington County, or Hurricane City;

- c. Civil Air Patrol aircraft when engaged in actual search and rescue missions;
- d. Aircraft which have declared an inflight emergency;
- e. Aircraft operating as air ambulance for medical purposes.
- f. Aircraft engaged in take-offs or landings while conducting tests under the direction of the Airport Director.

P. SELF-SERVICES

The owner of an aircraft located on the airport is permitted to wash and to perform minor repairs and alterations to his/her own aircraft, provided there is no attempt to perform such services for others.

Commercial Activities

- a. **No person shall operate a Commercial Activity of any nature that is based at or operated from the Airport unless the conduct of that activity has been approved by the City. A business not directly involved in any form of Aeronautical activity may be allowed only if such business would serve and support the airport and the flying community (e.g. an airport restaurant).**
- b. **Any Commercial Activity based out of the airport shall require a business license from the City in addition to a commercial lease signed for the facility from which the Commercial Activity or business will be conducted.**
- c. **All Commercial Activity must comply with all Federal, State and local regulations and with the City's Minimum Standards for Commercial Aeronautical Activities.**

Q. STORAGE AND MAINTENANCE

Aircraft storage hangars shall be used primarily for aircraft storage. No uncovered trash containers shall be maintained in any outside area, and areas to be used for trash or garbage containers shall be only those areas designated by the Airport Manager. All hangars and other premises including an area five (5) feet from the outside hangar wall on the airport shall be maintained by the lessee in a condition as to repair, cleanliness and general maintenance that is equal to the level of maintenance maintained by the City in comparable areas. Fuel and oil storage facilities must be approved by and in a location designated by the Airport Manager. Such storage shall comply with any regulations adopted pursuant to the Airports Commercial Standards, Rules and Regulations, as well as applicable federal, state and local fire codes pertaining to fire safety, including, but not limited to, the City Building Code, and the Uniform Fire Code.

R. STRUCTURE DESIGN

In order to assure an aesthetic appearance and harmonious design of airport improvements, new construction and remodeling or repainting of existing structures shall comply with the Airport Building Standards.

S. COMMERCIAL STANDARDS

In addition to compliance with the regulations set forth herein, the City Council has adopted Minimum Standards for Commercial Aeronautical Activities at the Airport to carry out the purposes of this chapter and serve the best interests of the City. Such standards shall be made available to all members of the public, both at the city recorder's office and from the Airport Manager. Failure to comply with such standards shall be considered a violation of this chapter, and the Airport Manager may deny the use and privileges of the airport to any such violator, subject to the appeal rights contained in the Enforcement; Appeal section of this chapter.

T. ENFORCEMENT; APPEAL

The primary concern of Airport Management is the safe and efficient operations of the Airport.

A. Citations

The City may issue citations for violations of this chapter, including the rules and regulations contained in this chapter, and/or promulgated pursuant to the Commercial Standards of this Chapter. The city may take enforcement action as set forth herein or it may initiate legal action as it may deem appropriate.

B. Appeal

Any person, who feels aggrieved by staff enforcement of this chapter, rules and regulations promulgated hereunder, or the Minimum Standards for Commercial Aeronautical Activities promulgated hereunder, may Appeal any decision. Appeals shall be made in writing to the City Manager, who after due consideration, shall rule on the matter. Final appeal may be made to the Mayor and City Council. The sole exception to the appeal process herein provided shall apply to criminal citations under state or city traffic law and emergency or safety issues.

Hurricane Municipal Airport

Minimum Standards For Commercial Aeronautical Activities

Adopted and Approved
[date of approval]
Hurricane City Council

TABLE OF CONTENTS

Table of Contents	2
Introduction/General	3
Section I. Definitions	5
Section II. Application Requirements	9
Section III. General Conditions and Requirements	11
Section IV. Action upon Application	17
Section V. Minimum Standards	18
A. Fixed Base Operators	18
B. Specialized Aviation Service Operators	23
1. New and/or used aircraft sales	24
2. Flight Instruction and/or aircraft rental	24
3. Air Charter and Air Taxi service	25
4. Aerial applications and seeding operations	25
5. Specialized aircraft repair service	26
6. Air Charter and Air tour flights	26
7. Commercial hangar leasing	27
8. Specialized commercial activities	28
Section VI. Minimum Insurance Requirements	30
Section VII. Lease Terms and Conditions	30
Section VIII. Non Commercial Activities	31

INTRODUCTION

The Hurricane Municipal Airport ("Airport") is the primary general aviation air transportation facility for Hurricane City. The Airport is owned by Hurricane City and daily operations of the Airport are overseen by the Airport Manager, who is appointed by the City.

These Minimum Standards for Commercial Aeronautical Activities ("Standards") have been developed and adopted to protect and promote in a reasonable manner the best interests of the public by requiring a minimum level and quality of facilities and services required of commercial aeronautical businesses at the Airport. These Standards are designed to provide reasonable opportunity, without discrimination, for the non-exclusive conduct of aeronautical activities at the Airport.

The City reserves the right to review and amend these Standards from time to time and may promulgate revisions deemed necessary to address proposed activities or to protect or improve the Airport or the quality of service provided to the public.

It should be emphasized that this document specifies the Minimum Standards that must be met to conduct commercial aeronautical activities at the Airport. Applicants and operators are encouraged to exceed these minimums whenever possible.

GENERAL

- A. No entity, including those under sublease, shall engage in any commercial aeronautical activity or business of any nature whatsoever on Airport property, except with the prior written approval of the City.
- B. Such written approval by the City is issued through either a signed lease agreement with the City if land and/or facilities are leased from the City, or a written Lease Agreement under the Minimum Standards if the activity will be operating under a sublease from an existing Airport tenant.
- C. In the event these Minimum Standards, as they now exist or are hereafter amended, conflict with applicable Federal Aviation Regulations, the latter shall be deemed to control. If one or more clauses, sections or provisions of these Standards shall be held to be unlawful, invalid or unenforceable by final judgement of any court of competent jurisdiction, the invalidity of such clauses,

sections or provisions shall in no way affect any other clauses, sections or provisions of these Standards.

- D. These Standards do not pertain to military operations.
- E. All activities at the Hurricane Municipal Airport are subject to and must comply with all existing and future applicable laws, ordinances, rules and regulations of the Airport, the City, the State of Utah, the Federal government and all other governmental bodies having jurisdiction.

SECTION I - DEFINITIONS

As used in these Standards, the following definitions apply:

Aeronautical Activity - Any activity that involves, makes possible, or is required for the operation of aircraft or that contributes to or is required for the safety of such operations. Activities within this definition, commonly conducted on airports, include, but are not limited to, the following: general and corporate aviation, air taxi and charter operations, scheduled and nonscheduled air carrier operations, pilot training, aircraft rental and sightseeing, aerial photography, crop dusting, aerial advertising and surveying, aircraft sales and services, aircraft storage, sale of aviation petroleum products, repair and maintenance of aircraft, sale of aircraft parts, parachute or ultralight activities, and any other activities that, because of their direct relationship to the operation of aircraft, can appropriately be regarded as aeronautical activities. Activities, such as model aircraft and model rocket operations, are not aeronautical activities.

Agreement - A written contract, executed by both parties, and enforceable by law between the City and an Entity granting a concession, transferring rights or interest in land and/or improvements, and/or prohibiting the conduct of certain activities.

Aircraft Maintenance - The repair, adjustment, maintenance, alteration, preservation, and/or inspection of aircraft airframe or power plant, including the replacement of parts. Major repairs include major alterations to the airframe, power plant, or propeller, as defined in 14 CFR Part 43. Minor repairs include normal, routine annual inspection with attendant maintenance, repair, calibration, or adjustment of aircraft airframe or power plant and associated accessories. Preventive maintenance means simple or minor preservation operations and the replacement of small standard parts not involving complex assembly operations, as defined by 14 CFR Part 43.

Airframe and Power Plant Mechanic - A person who holds an Aircraft mechanic certificate with both the airframe and power plant ratings issued by the FAA under the provisions of 14 CFR Part 65.

Airport Layout Plan - The currently approved, scaled dimensional layout diagram of the entire Airport property, indicating current proposed usage for each identifiable segment as approved by the Federal Aviation Administration and the City.

Hurricane City - Referred to as the "City", means Hurricane City, the fee simple owner and operator of the property that comprises the Airport.

Commercial Operator - An Entity engaging in a Commercial Aeronautical Activity.

Commercial Aeronautical Activity - Any aeronautical activity which involves or makes possible the operation of aircraft, the purpose of such activity being to secure income, earnings, compensation or profit, whether or not such objectives are accomplished.

Entity - A person, persons, firm, partnership, limited liability company, unincorporated proprietorship, association, group or corporation.

Exclusive Right - A power, privilege, or other right excluding or preventing another from enjoying or exercising a like power, privilege, or right. An Exclusive Right may be conferred either by express agreement, by imposition of unreasonable standards or requirements, or by any other means. Such a right conferred on one or more Entities, but excluding others from enjoying or exercising a similar right or rights, would be an Exclusive Right.

Federal Aviation Administration (FAA) - All branches, offices and officers of the United States Department of Transportation, Federal Aviation Administration

Fixed Base Operator (FBO) - A commercial tenant which provides for aircraft services as outlined in Section V.

General Aviation - All aviation with exception of air carriers (including cargo) and government. General aviation aircraft are utilized for commercial and noncommercial purposes including business, corporate, recreational/pleasure, charter/air taxi, industrial/special purpose, and instructional.

Manager - The Airport Manager of the Hurricane Municipal Airport as appointed by the City.

Master Plan - The current Master Plan report, which is an assembly of appropriate documents and drawings covering the development of the Airport from a physical, economical, social, and political jurisdictional perspective and adopted by the City and any amendments, modifications, revisions, or substitutions thereof. The Airport Layout Plan (ALP) is a part of the Master Plan.

Minimum Standards - Qualifications, standards and criteria, established by the City as the minimum requirements to be met as a condition for the right to conduct a commercial aeronautical activity on the Airport.

National Fire Protection Association (NFPA) - All codes, standards, rules and regulations contained in the standards of the National Fire Protection Association, as may be amended from time to time.

Non-Commercial Flying Club - Any combination in which three or more persons are associated (directly or indirectly) as individuals or as any association or legal entity to provide such persons the privilege of piloting club-owned aircraft based on the Airport. The flying club shall be operated on a non-profit basis so that it does not receive greater revenue than the amount necessary for the operation, maintenance, acquisition and replacement of its aircraft. The non-profit status shall be substantiated by documentary proof from the Internal Revenue Service.

Non-Commercial Operator - An Entity that either owns or leases and operates aircraft for personal or recreational purposes. In the case of a business, the operation of aircraft must be an ancillary activity to support the business's purposes by providing transportation for the exclusive use of its employees, agents, and/or customers. Notwithstanding the foregoing, the Non-Commercial Operator shall neither offer nor engage in Commercial Aeronautical Activities. For purposes of these Minimum Standards, all government agencies shall be considered Non-Commercial Operators.

Operator - The entity responsible for the operations of a commercial aeronautical activity.

Repairman - A person who holds an aircraft repairman certificate, with appropriate ratings, issued by the FAA under the provisions of 14 CFR Part 65.

Repair Station - A certificated aircraft maintenance facility approved by the FAA to perform specific maintenance functions. These facilities are certificated under 14 CFR Part 145.

Rules and Regulations - The rules and regulations as may be promulgated and adopted from time to time by the City to protect the public health, safety, interest and welfare of the Airport.

Specialized Aviation Service Operator (SASO) - A commercial aeronautical activity that provides one or more commercial services as outlined in section V.

Hurricane Municipal Airport - Referred to as the "Airport", means the property allocated for the operation of the Hurricane Municipal Airport in Hurricane City, State of Utah, as depicted on the current Airport Layout Plan.

Through the Fence Operations - "Through-the-fence" are those activities permitted by an airport sponsor through an agreement that permits access to the public landing area by independent entities or operators offering an aeronautical activity or to owners of aircraft based on land adjacent to, but not part of, the airport property.

Recreational, light sport, and glider aircraft that are designed to be transported by a trailer shall not be considered through the fence operations as long as NO commercial activity takes place.

SECTION II - APPLICATION REQUIREMENTS

Applications for permission to conduct any commercial aeronautical activity or for a land or facility lease to conduct such activity at the Airport shall be made in writing to the Airport Manager. Applicants are strongly encouraged to visit with the Airport Manager to discuss the applicant's proposed activity prior to the preparation and submission of a detailed application.

The applicant shall submit all information and material necessary or requested by the City to establish to the City's satisfaction that the applicant will qualify and comply with these Standards. Failure by the applicant to submit any of the requested information may be grounds for denial of the application. All such applications must include all that are applicable to the applicant of the following:

1. Name, mailing address and phone number of applicant(s).
2. Type and structure of the organization; if incorporated, the names of the officers; if a partnership, the names of the partners.
3. Individual or business name and mailing address to appear on the lease or agreement.
4. A statement of past experience in the specified aviation business or commercial activity for which the application is being made.
5. A list of any applicable federal, state or local certifications and licenses currently held or to be obtained. Include copies of currently held licenses or certificates.
6. A description of the amount of land, number of buildings, building space, etc. the applicant desires to lease. If the activity will be conducted under a sublease from an existing leaseholder, a copy of the proposed sublease must be provided.
7. A description of the services to be offered, including all of the intended services upon completion or the installation of the facility.
8. Proposed commencement date of the proposed construction or site improvements, proposed completion date and proposed date of commencement of operations.
9. A description of the building space to be constructed, including square footages, building types and intended use of each. For buildings proposed to be constructed, the applicant shall provide certification that it will comply with all building standards as adopted by the City as they apply to the Airport.

10. The estimated total cost of construction and improvements.
11. A site plan drawing depicting construction intended for the lease area (must be compatible with the Airport's current Airport Layout Plan).
12. The hours of operations and number of employees.
13. The number and type of aircraft to be based upon the leasehold to be leased or subleased by the Operator.
14. A certificate of insurance or other satisfactory evidence of the ability to obtain insurance coverage as required in Section VI.

SECTION III - GENERAL CONDITIONS AND REQUIREMENTS

The following general conditions and requirements shall apply to all commercial aeronautical activities and will be included in all commercial aeronautical activity leases or any written agreement. These are basic clauses only and more specific clauses, covenants and language, dependent upon the particular activity authorized by the City, may be included in the lease or agreement:

If an Operator desires to sublease space to another Operator, the Operator must obtain the written approval from the City to sublease the space. The sub lessee must apply for and obtain a permit to operate at the Airport, and must satisfy the applicable Minimum Standards to provide sub lessee's proposed Commercial Aeronautical Activity.

A. NON DISCRIMINATION:

Premises are to be operated for the use and benefit of the public. Non-discrimination means:

1. To furnish good, prompt and efficient services adequate to meet the demands for its service at the Airport;
2. To furnish said service on an equal and non-discriminatory basis to all users thereof;
3. To charge reasonable and non-discriminatory prices for each unit of sale or service, provided that the Operator may be allowed to make reasonable and non-discriminatory discounts, rebates or other similar types of price reductions to volume purchasers;
4. The Operator, his agents and employees will not discriminate against any person or class of persons by reason of race, color, creed or national origin in providing any services or in the use of any of its facilities provided for the public in any manner. The Operator further agrees to comply with enforcement procedures as the United States might demand that the City take in order to comply with the Airport's Federal Assurances.

B. AIRCRAFT SERVICE BY OWNERS OR OPERATORS OF AIRCRAFT

It is to be clearly understood by all Operators under these Standards that no right or privilege has been granted which would serve to prevent other aircraft owners or Operators (commercial or non-commercial) on the Airport from performing any service on their own aircraft. This does not

preclude the Operator under these Standards from restricting the activities of others on its own leasehold.

C. NON-EXCLUSIVE RIGHT

The granting of rights and privileges to engage in Aeronautical Activities shall not be construed in any manner as affording the Operator any exclusive right of use of the premises and/or facilities at the Airport, other than those premises and/or facilities which may be assigned exclusively to the Operator, and then only to the extent provided in a written agreement.

D. RIGHTS RESERVED

The City further reserves the right to designate specific Airport areas for activities in accordance with the Airport Layout Plan (ALP) as may be amended from time to time. Such designation shall give consideration to the nature and extent of current and/or future activities and the land and/or improvements that may be available and/or used for specific activities and shall be consistent with the safe, orderly, and efficient use of the Airport.

The City reserves the right to take any action it considers necessary to protect the navigable airspace and aerial approaches of the airport against obstruction, together with the right to prevent Operators from erecting, or permitting to be erected, any building or other structure on or adjacent to the airport which, in the opinion of the City, would limit the usefulness of the Airport or constitute a hazard to aircraft.

The City reserves the right to prohibit any Entity from using the Airport or engaging in activities at the Airport (and/or revoke or suspend any privileges granted to any Entity) upon determination by the City that such Operator has not complied with these Minimum Standards, the Rules and Regulations, applicable regulatory measures, directives issued by the City, or has otherwise jeopardized the safety of Entities utilizing the Airport or the land and/or improvements located at the Airport.

If the City determines there are more qualified applicants seeking to provide a particular Commercial Aeronautical Activity than there is space or demand at the airport for such service, the City may select the Commercial Aeronautical Activity provider through a competitive solicitation or request for proposals.

E. GROUNDS FOR DENIAL

The City may reject any proposal or application for any one (1) or more reasons including, but not limited to, the following:

The Entity, for any reason, does not fully meet the qualifications, standards, and requirements established by the City.

The Entity's proposed activities and/or improvements will create a safety hazard at or on the Airport.

The City would be required to expend funds and/or supply labor and/or materials in connection with the proposed activities and/or Improvements that the City is unwilling and/or unable to spend and/or will result in a financial loss or hardship to the City.

No appropriate, adequate, or available land and/or improvement exists at the Airport to accommodate the proposed activity of the Entity (at the time the proposal or application are submitted), nor is such availability contemplated within a reasonable time frame.

The proposed activities and/or improvements do not comply with the Master Plan of the Airport or the ALP then in effect or anticipated to be in effect within the time frame proposed by the Entity.

The development or use of the land requested by the Entity will result in a congestion of Aircraft and/or the improvements will, in the sole discretion of the City, unduly interfere with activities of any existing Operator on the Airport and/or prevent adequate access to the leased premises of any existing Operator.

The Entity has intentionally or unintentionally misrepresented or omitted material fact in the proposal, on the application, and/or in supporting documentation.

The Entity has failed to make full disclosure in the proposal, on the application, and/or in supporting documentation.

The Entity or an officer, director, agent, representative, shareholder, or employee of the Entity has a record of violating or is in violation of City regulatory measures (or any other airport sponsor), the FAA, or any other regulatory measure applicable to the Airport and/or the Entity's proposed Activity.

The Entity or an officer, director, agent, representative, or shareholder of the Entity has defaulted in the performance of any lease, sublease, agreement, or permit at the Airport or at any other airport.

The Entity does not exhibit adequate financial responsibility or capability to undertake the proposed activity.

F. AIRPORT DEVELOPMENT

The City reserves the right to further develop Airport property or improve the

landing areas of the Airport as it sees fit, regardless of the desires or views of the Operator and without interference or hindrance.

Location. FBOs and SASOs may be situated only in those areas of the Airport specified for such use in the Airport Layout Plan (ALP) and the Airport Master Plan or otherwise approved by the Airport Board.

G. MAINTENANCE OF LANDING AREA AND ALL PUBLICLY OWNED FACILITIES

The City reserves the right, but shall not be obligated to the Operator, to maintain and keep in repair the landing areas of the Airport and all publicly owned facilities of the Airport, together with the right to direct and control all activities of the Operator in this regard.

H. NATIONAL EMERGENCY

During time of war or national emergency, the City shall have right to lease the landing area or any part thereof to the United States Government for military use, and if such lease is executed, the provisions of this instrument insofar as they are inconsistent with the provisions of the lease to the U.S. Government, shall be suspended.

I. AIRPORT OBSTRUCTIONS

The City reserves the right to take any action it considers necessary to protect the aerial approaches of the Airport against obstructions, together with the right to prevent the Operator from erecting or permitting to be erected, any building or other structure on or adjacent to the Airport, which, in the opinion of the City, would limit the usefulness of the Airport or constitute a hazard to aircraft. FAA Part 77 regulations also apply.

J. SUBORDINATION

These minimum standards shall be subordinate to the provisions of any existing or future agreement between the City and the United States, relative to the operation and maintenance of the Airport, the execution of which has been or may be required as a condition precedent to the expenditure of Federal funds for the development of the Airport.

K. HAZARDOUS MATERIALS AND WASTE

The Operator shall not discharge, deposit or store any waste or hazardous materials on the Airport. The Operator's operating area shall be kept in a safe, neat, clean and orderly manner at all times and in such a manner to minimize any hazards. The operator must comply with the Airport's Stormwater Pollution Prevention Plan as appropriate. Examples of hazardous materials and waste include, but are not limited to, garbage; used fluids such as oil, chemicals, or fuel; scrap materials or other debris.

L. OPERATION AREA

The Operator shall not conduct any of its business or activities on any area except those specified in the lease or agreements under these Minimum Standards.

M. COMPLIANCE WITH APPLICABLE RULES AND REGULATIONS

The Operator shall comply with all federal, state and local rules and regulations which may pertain to its operation on the Airport and all future revisions thereto.

N. APPROVAL OF CONSTRUCTION

No buildings, structures, tiedowns, ramps, paving, taxi area, drains, earthwork or any other improvements or additions to the Airport shall be placed or constructed, or altered or removed at the Airport without the prior written approval of the City. Applicable City permits must be obtained by the Operator prior to any such work. The Operator must conform to all requirements in the Airport Building Standards.

A pre-construction meeting must take place with the Airport Manager or designee before any work can begin. A post inspection meeting must take place before final approval of the project can be awarded.

O. CHANGE IN SERVICES OFFERED

Once a lease or agreement is entered into, the Operator may not add or delete services offered without the prior consent of the City. Any additional services contemplated must meet the requirements outlined in these standards. A change in services offered may require a change in leased area. Any such modification may be subject to a modification of rates and charges.

P. RIGHT OF RELOCATION

The City shall have the right to relocate the Operator's Premises when necessary to accommodate the Airport development. The need for such relocation shall be solely determined by the City. If relocation becomes necessary, the City shall provide the Operator with a replacement area substantially equivalent in size and amenities. Should Operator disagree with the replacement location, Operator shall have the right, within ten (10) calendar days of receipt of the cities written notice of impending relocation, to provide written notice to the Airport Manager that Operator disagrees with the replacement location. Upon such notice by Operator, the parties shall, for a period not to exceed thirty (30) days from the date of such notice, negotiate in good faith in an attempt to resolve the matter to the satisfaction of both parties; however if for any reason the disagreement is not resolved within thirty (30) days, the City shall have the right to unilaterally decide the matter, and Operator agrees to and shall abide by the cities decision, subject to such rights of termination as Operator may have under its Lease or Permit. If the City requires the Operator to relocate its facilities during the term of its Agreement, the City will reimburse the Operator for its documented actual and reasonable out- of-pocket relocation expenses, if any, but the City shall have no liability for increased overhead or operating costs, or lost profits or revenue of Operator, if any, arising out of such relocation.

Q. THROUGH THE FENCE ACTIVITIES

"Through the fence" Activities are prohibited at the Hurricane Municipal Airport.

Recreational, light sport and glider aircraft that are designed to be transported by a trailer shall not be considered through the fence Operations as long as NO commercial activity takes place.

SECTION IV - ACTION UPON APPLICATION

Upon receipt of an application to conduct a commercial general aviation activity under these standards, the Airport Manager will review the application to ensure its completeness and compliance with the requirements of Section II, Application Requirements.

- A. Applicant shall submit all information and material in accordance with Section II as well as a City business license application to the Airport Manager. If the application is complete, the Airport Manager will turn the packet over to the business licensing officer. If the application is incomplete, the Airport Manager will advise the applicant in writing of the deficiencies.
- B. The business licensing officer will collect payment from the applicant once they have a complete application. The application will then be reviewed to ensure that all licensing requirements are met including but not limited to the following:
 - 1. Verification of professional license (if applicable).
 - 2. Business name registered with the Department of Commerce.
 - 3. A passed fire inspection is completed.
 - 4. An active sales tax number for the City is provided (if applicable).
 - 5. For any new construction a certificate of occupancy must be issued first.

SECTION V - MINIMUM STANDARDS

A. FIXED BASE OPERATOR

A Fixed Base Operator (FBO) is any entity who shall have entered into a written agreement with the City to provide on the Airport and serve the public with the following:

1. Sale of aviation jet fuel, aviation gasoline and oil
2. Ramp services, aircraft loading, unloading and towing
3. Aircraft repair and maintenance
4. Commercial aircraft storage

In addition to the general requirements of the Minimum Standards, each Fixed Based Operator at the Airport shall comply with the following minimum standards set forth in this section.

NOTE: Only FBOs will be authorized to offer retail sales and/or delivery into- plane of aircraft fuels. City also retains its right to offer retail sales and/or delivery into- plane of aircraft fuels.

Such services may be provided by the FBO or under contract with another Operator. If such service requirements are to be provided by another Operator, that Operator shall separately apply for approval under these standards and shall be responsible for payment of all fees, rates or charges established by the City. Fixed Base Operators must meet the following general minimum standards and requirements as well as those for the specific services they provide:

SCOPE OF ACTIVITY

Unless otherwise stated in these Minimum Standards, FBO's employees using FBO's vehicles and equipment must provide all required products and services.

FBO's products and services shall include the following:

1. Aviation Fuels and Lubricants (Jet Fuel, Avgas, and Aircraft Lubricants):
 - a. FBO shall deliver and dispense jet fuel, avgas, and aircraft lubricants into all General Aviation Aircraft normally frequenting the Airport.
 - b. FBO shall provide a response time of no more than 30 minutes during required hours of activity (excepting situations beyond the control of the FBO).

- c. FBO shall provide fueling services after hours, 24 hours per day, by means of on-call personnel. A 30 minute response time from notification shall be achieved (excepting situations beyond the control of the FBO).

2. Passenger, Crew, and Aircraft Ground Services, Support, and Amenities

- a. FBO shall meet, direct, and park all aircraft arriving on Operator's leased premises.
- b. FBO shall provide a lounge for pilots and their crew members.
- c. FBO shall provide arrival and departure services for aircraft using Operator's leased premises including crew and passenger baggage handling.
- d. FBO shall provide parking and tie-down of aircraft upon the Operator's leased premises.
- e. FBO shall provide for hangar storage of aircraft.
- f. FBO shall provide oxygen, nitrogen, and compressed air services.
- g. FBO shall provide lavatory services and aircraft cleaning services.
- h. FBO shall make available aircraft ground power units.
- i. FBO shall provide courtesy transportation, utilizing Operator's vehicles, for passengers, crew, and baggage, as necessary and/or appropriate.
- j. FBO shall make available crew and passenger ground transportation arrangements (limousine, shuttle, and rental car).
- k. FBO shall make available aircraft catering arrangements.

3. Aircraft Maintenance

- a. FBO shall provide aircraft maintenance on the airframe, power plants, and associated systems of general aviation aircraft up to turboprop aircraft normally frequenting the airport. In addition, FBO shall be properly certified as an FAA Aircraft Repair facility and have available a certified A & P mechanic during normal business hours.
- b. FBO can meet these Minimum Standards for the provision of Aircraft Maintenance by and through authorized sub-lessee(s) who meet the minimum standards for Aircraft Maintenance Operator and operates from the FBO's leased premises.

LEASED PREMISES

FBO shall have adequate land, apron, paved tie-down, facilities (hangars, terminal, maintenance, and fuel storage), and vehicle parking to accommodate all activities of FBO and all approved sub-lessees. A comprehensive site plan for all activities must be approved by the City and may require a Development Agreement approved by the City.

(1) Vehicle Parking - All landside vehicle parking belonging to the lessee shall comply with the City zoning ordinance requirements. Storage of trailers, motorhomes, un-operational vehicles, etc., in the landside or airside parking areas of a leased facility or business is not allowed. Areas other than leased site parking may be subject to time limited parking regulations as posted. Items left over fifteen (15) days may be towed at the owner's expense unless approved by the Airport Manager.

FUEL STORAGE

FBO shall construct or install and maintain an on-Airport aboveground fuel storage facility at the Airport with appropriate leak containment provisions, unless otherwise authorized or required, in a location consistent with the Airport Master Plan and approved by the City.

Fuel storage facility shall have a total capacity for three (3) days peak supply of fuel for aircraft being serviced by an FBO.

FBO shall, at its sole expense, maintain the fuel storage facility, all improvements thereon, and all appurtenances thereto, in a presentable condition consistent with good business practice and equal or better than in appearance and character to other similar improvements on the Airport. Security fencing surrounding the Operators fuel storage facility must be in place at all times.

FBO shall demonstrate that satisfactory arrangements have been made with a reputable aviation petroleum supplier/distributor for the delivery of aviation fuels in the quantities that are necessary to meet the requirements set forth herein.

FUELING EQUIPMENT

All equipment necessary to adequately support all required activities shall be provided and maintained in accordance with good maintenance practices and all applicable FAA, NFPA, EPA and/or UDOT regulations.

FUELING INSPECTIONS

Hurricane Municipal Airport, Airport Operations Department, under FAA Part 139.321 regulations, are required to inspect an FBO's fueling equipment and employee training records every 90 days for compliance. Findings of non compliance issues may violate the operating lease of the Operator. A Letter of Correction or violation must be repaired no later than 30 days from the inspection date.

GENERAL EQUIPMENT

FBO shall have the following equipment:

1. Adequate equipment for providing sufficient ground power units for aircraft normally frequenting the Airport.
2. One (1) courtesy vehicle (capable of accommodating four (4) passengers) to provide transportation of passengers, crews, and baggage to and from destinations on the Airport and local area hotels and restaurants in close proximity.
3. One (1) aircraft tug (and tow bar) with at least a rating capacity sufficient to meet the towing requirement of the heaviest general aviation aircraft normally frequenting the Airport.
4. One (1) fuel spill kit
5. Adequate number of approved and regularly inspected dry chemical fire extinguisher units shall be maintained within all hangars, on apron areas, at fuel storage facilities, and on all ground handling and refueling vehicles.

6. All equipment reasonably necessary for the proper performance of Aircraft Maintenance in accordance with applicable FAA regulations and manufacturers' specifications.
7. All vehicles shall display proper company identification placards and a rotating beacon as required by the current FAA FAR Part 139 regulations for access into all Airport Operation Areas.

PERSONNEL

Provide qualified employees to perform all required activities. Where required, the Operator shall provide the City with copies of all necessary personnel training certificates and licenses. All personnel must attend an Airport Familiarization class upon hire and attend a refresher course once annually.

COMMUNICATIONS

The FBO shall at all times maintain an active telephone service with current telephone numbers that can be accessed by the public during required business hours. Each FBO is required to monitor the local CTAF during business hours.

AIRPORT SECURITY

The Operator, its employees, agents, customers, and contractors, shall comply fully with The Airport Security Plan. Transportation Security Administration Part 1542 and 1544 applies.

The Operator shall designate a responsible person for the coordination of all security communications and procedures with the Airports Security Coordinator.

The Operator shall develop and maintain a Security Plan. Operator's Security Plan shall be submitted to the Airports Security Coordinator no later than 7 days before Operator commences activities at the Airport. The Operator is solely responsible for implementation of and compliance with The Operator's security plan.

HOURS OF OPERATION

The FBO shall provide service hours that best serve the public requirements. Hours of operation shall not be less than eight hours per day, seven days per week. Hours of operation may be seasonally adjusted with prior approval of the Airport Manager and shall be conspicuously posted. The FBO shall provide a 24 hour fueling capability (including "on call" service) to the customer or provide a self serve fueling system that will accept alternative payment.

AIRCRAFT REMOVAL

Recognizing that aircraft removal is the responsibility of the aircraft owner/operator, the FBO shall be prepared to lend assistance within 30 minutes upon request, or as soon as practical, in order to maintain the operational readiness of the Airport. The FBO shall prepare an Aircraft Removal Plan and have the equipment readily

available that is necessary to remove the general aviation aircraft normally frequenting the Airport.

INSURANCE

Except as otherwise provided for herein, the FBO shall maintain, at a minimum, the coverage and limits of insurance set forth by the City as outlined in Section VI.

RAMP SERVICES, REPAIR AND MAINTENANCE

- a. *Maintenance:* The FBO shall provide, at least eight hours per day, six days per week, adequate equipment, facilities and appropriately certificated personnel for performing at least preventive aircraft airframe and powerplant repair and maintenance as outlined in Federal Aviation Regulation 14CFR Part 43, appendix A.
- b. *Ramp Services:* The FBO shall provide adequate equipment and trained personnel during posted business hours to meet public requirements for all ramp services including but not limited to aircraft marshalling and towing, ground power service and lavatory service.

AIRCRAFT LOADING, UNLOADING AND TOWING

The FBO shall provide adequate loading, unloading and towing equipment and trained operators to accommodate the based and transient general aviation aircraft generally utilizing the airport.

B. SPECIALIZED AVIATION SERVICE OPERATOR (SASO)

A Specialized Aviation Service Operator (SASO) is any entity who shall have entered into a written agreement with the City to provide on the Airport and serve the public with *one or more* of the following activities or services:

- 1. Airframe or powerplant repair
- 2. Aircraft Inspection & Avionics Certification
- 3. Aircraft flight instruction
- 4. Aircraft rental
- 5. Aerial application
- 6. Air charter-air taxi service
- 7. Air charter-air tours
- 8. Commercial Hangar Leasing
- 9. Specialized Commercial Activities

Facilities shall include appropriate customer and administrative areas.

SERVICES AND STANDARDS

Specialized Aviation Service Operators must meet the following minimum standards and requirements according to the service(s) provided:

1. NEW AND/OR USED AIRCRAFT SALES

- a. *Building:* For businesses involved in aircraft sales, the SASO shall provide suitable office space, as determined by the Airport Manager, for conducting sales and keeping proper records in connection herewith.
- b. *Records:* The SASO shall provide records of all sales of aircraft to the Airport Manager. The FBO shall remit any and all applicable fees and/or taxes as established by City, State of Utah, and/or Airport.
- c. *Personnel:* The SASO shall provide, (or contract for) during posted business hours, at least one person having a current pilot certificate with appropriate ratings for the types of aircraft being demonstrated for sale.

2. FLIGHT INSTRUCTION AND/OR AIRCRAFT RENTAL

- a. *Instructors:* The SASO shall provide at least one FAA certified flight instructor to cover the type of training offered and at least one properly certified ground school instructor to enable students to pass the FAA written examination for at least a sport pilots license.
- b. *Aircraft:* If flight instruction is provided, the SASO shall own or have access to rent or lease at least one properly certified and maintained aircraft equipped for flight instruction. If aircraft rentals are provided, the SASO shall own or lease at least one properly certified and maintained aircraft equipped for aircraft rental. If both services are offered, these can be the same aircraft, provided they are properly equipped and certificated for both instruction and rental.

Building: The SASO shall provide adequate facilities for storing, parking, serving and repairing aircraft used for flight instruction or aircraft rental. The SASO shall provide, lease, or sublease adequate office required to conduct their services, as determined by the Airport Manager. Operator shall also make arrangement for the use of additional adequate space in the same facility for classroom training activities and restroom facilities. This additional space may be common with other users at the airport.

- c. *Insurance Coverage:* Insurance shall be carried meeting the minimum requirements outlined in Section VI.
- d. *Part Time Flight Instruction:* An Entity may provide "part time" or "guest instructor" flight training not to exceed ten (10) hours a month, without the office and aircraft requirements, provided that such an Entity satisfies the requirements for insurance coverage and indemnification for the City.

3. AIR CHARTER AND AIR TAXI SERVICE

- a. *Aircraft and registration:* The SASO shall provide on-demand air charter and air taxi service with at least one aircraft in accordance with Federal Aviation Regulation 14 CFR Part 135. If required, the SASO shall be properly registered with the Utah Aeronautics Commission.
- b. *Personnel:* The SASO shall employ or contract with at least one appropriately rated pilot available to operate such air charter and air taxi aircraft.

4. AERIAL APPLICATION AND SEEDING OPERATIONS

A SASO desiring to engage in aerial application operations must hold an appropriate operator's certificate issued by the FAA, comply with the requirements of the State of Utah and the Airport's Storm Water Pollution Prevention Plan, and provide as a minimum the following:

- a. *Personnel:* The SASO shall provide at least one person holding a current FAA commercial pilots license, properly rated for the aircraft to be used and meeting the requirements of Federal Aviation Regulation 14CFR Part 137 and applicable regulations of the State of Utah. Any pilot involved with any aerial application must hold the appropriate certificates from the State of Utah Department of Agriculture and Food.
- b. *Aircraft:* The SASO shall own or lease at least one aircraft meeting all requirements of Federal Aviation Regulation 14CFR Part 137 and applicable regulations of the State of Utah.
- c. *Storage:* The SASO shall provide a segregated chemical storage area protected from public access and meeting all applicable Federal and State environmental regulations and Occupational Health and Safety Administration (OHSA) requirements.

- d. *Cleaning:* The SASO shall provide a DEQ/EPA approved washing area if the washing involves an aircraft that has been exposed to chemicals.
- e. *Building:* The r SASO shall provide or lease at a minimum, 140 square feet to conduct operations. The SASO shall provide a segregated chemical storage area protected from public access and meeting all applicable Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OHSA) requirements.
- f. *Insurance:* Insurance shall be carried meeting the minimum requirements outlined in Section VI.

5. SPECIALIZED AIRCRAFT REPAIR SERVICE (airframe, powerplant, avionics, instrument or propeller)

- a. *Building:* The SASO shall construct or lease a building to provide office space, public restrooms, and sufficient space to work indoors on aircraft, avionics, instruments, propellers, or other repairs or services.
- b. *Performance of Services:* The services provided hereunder shall be performed within or with immediate access to the required building, except for such services as must be performed outside for safety or emergency reasons, such as accidents, or aircraft run-ups, or if the aircraft is too large to be placed within the building.
- c. *Personnel:* At least one properly FAA certified employee shall be on duty during posted business hours. An FAA certified IA mechanic shall be available as necessary.
- d. *Equipment:* The SASO shall maintain adequate space, tools and equipment, as determined by the Airport Manager, to perform the services offered.
- e. *Spare parts:* The SASO shall have access to adequate spare parts and accessories necessary to provide the services offered.

6. AIR CHARTER AND AIR TOUR FLIGHTS

A SASO desiring to provide air charter and/or scenic flight services greater than 25 statute miles from the Airport under Federal Aviation Regulation 14CFR Part 135 must hold an FAA Air Taxi-Commercial Operator Certificate with ratings appropriate to the functions to be accomplished, be properly registered with the Utah Aeronautics

Commission, if required by state law or regulation, and provide as a minimum the following services and facilities:

- a. *Building:* The SASO shall provide or lease at least 140 square feet of office space. The SASO shall also make arrangement for the use of additional adequate space in the same facility for reception and passenger waiting areas and restroom facilities. This additional space may be common with other users in the facility.
- b. *Personnel:* The r SASO shall employ or contract for at least one FAA certified commercial pilot, appropriately rated to conduct the operations performed.
- c. *Aircraft:* The r SASO shall own or lease at least one properly certified and maintained single engine aircraft.
- d. *Insurance Coverage:* Insurance shall be carried meeting the minimum requirements outlined in Section VI.

7. COMMERCIAL HANGAR LEASING

Any SASO desiring to provide hangars for the sole intent of leasing to other aircraft owners or lessees shall provide as a minimum the following services and facilities:

- a. *Land:* Leasehold shall contain adequate land area to accommodate all building structures and parking areas.
- b. *Building:* Construct or lease a hangar or building of at least 2,500 contiguous square feet which meets the City's approval.
- c. *Parking:* Lessee shall lease from the city a minimum of two parking spaces or more as appropriate for a proposed hangar unit. Other parking accommodations may be appropriate with the approval of the airport manager.
- d. *Insurance Coverage:* Insurance shall be carried meeting the minimum requirements outlined in Section VI.
- e. *Restrooms:* - Lessee shall provide at least one restroom per hangar development as approved by the Airport Manager.

8. SPECIALIZED COMMERCIAL ACTIVITIES

- a. *Parachute Jumping:* No commercial parachute jumping clubs or organizations desiring to engage in parachute jumping above or onto the Airport will be allowed without the special permission of the Airport Manager. In the event that permission is granted then the operator must as a minimum provide the following:
 - i. Obtain the written permission of the Airport Manager.
 - ii. Specify the hours and areas for the drop and issue a Notice to Airmen as appropriate.
 - 111. Provide the Airport with a general liability insurance policy that names the City as an additional insured party, in an amount to be determined by the City. If the organization is a member of the United States Parachute Association, the coverage provided by membership in that organization is acceptable.
- b. *Flying Clubs:* An entity organized for the express purpose of providing its members with aircraft for their personal use only, must provide the following as a minimum:
 - i. Documentation of the clubs corporate status, a list of all members and a list of all Club-owned or Club-leased aircraft. The Club shall be an Entity organized for the express purpose of providing its members with an aircraft for their personal use and enjoyment. The ownership of the aircraft must be vesting in the name of the Club. The Club may not derive greater revenue from the use of its aircraft than the amount necessary for the operations, maintenance and replacement of its aircraft. Financial records shall be provided to the Airport Manager no less than annually or as requested.
 - ii. Provide the Airport Manager with proof of insurance coverage meeting the requirements outlined in Section VI.
- c. *Other Commercial Aeronautical Activities:*
 - i. Other commercial aeronautical activities not specifically addressed in this part shall be approved on a case-by-case basis by the City. Examples may include, but are not limited to, commercial banner towing, aircraft paint, aircraft restoration, avionics,

instrument or propeller repair facilities. Other commercial aeronautical activities may also include an amateur-built aircraft manufacturer or sport pilot/light-sport aircraft service provider.

- ii. Applications for activities not specifically addressed under these standards must contain all information requested in Section II of these standards. Minimum standards for other aeronautical activities will be created and adopted into these Standards as determined to be necessary by the City Council of the City.

SECTION VI - MINIMUM INSURANCE REQUIREMENTS

Dependent upon the type of activity or activities conducted, the Operator will be required throughout the term of its lease or agreement under standards to obtain insurance of the types and amounts set forth by the City. All insurance must meet the following requirements:

- A. Prior to commencement of operations, the Operator will be required to provide the Airport Manager with proper evidence of insurance covering its operations on the Airport as specified in this section.
- B. Such evidence of insurance must name the City as an additional insured.
- C. Evidence of insurance must also provide the City with at least 30 days notice of any policy change, cancellation or termination.
- D. The Operator must also provide a waiver of subrogation to the benefit of the City.

Section VII - LEASE TERMS and CONDITIONS

It shall be the policy of the City to negotiate such lease terms and conditions as may be appropriate to the type of business operation being proposed, scale and scope of proposed investment into the Airport, and appropriate term length not to exceed a base term length of 20 years, with a single five-year extension option, subject to the approval of the City.

Section VIII - NON COMMERCIAL ACTIVITIES

- A. Non-Commercial Hangar Operator (Operator) is an Entity that develops/constructs and owns one or more hangar structures used for Non-Commercial storage of aircraft.
- B. No Commercial Aeronautical Activity of any kind shall be permitted on or from the leased premises.
- C. Non-Commercial Hanger space is limited to aircraft storage *only* .*If an aircraft is stored in a hangar and there is excess space for additional property owned solely by the hangar owner, this additional property may be stored with the approval of the Airport Manager as long as it meets all storage and safety requirements in this document and in the Hurricane City Rules and Regulations document.*
- D. Operator shall not be permitted to sublease any land or Improvements on the leased premises for any purpose.
- E. The City, as the owner of the Airport, is permitted to store and maintain equipment and supplies at the Airport, including equipment and supplies related to airport maintenance and responding to emergencies.



STAFF COMMENTS

Item: Consideration and possible approval of Resolution 2025-14 approving the Interlocal Agreement for Election Services with Washington County - Cindy Beteag.

Discussion: In preparation for the 2025 municipal elections, Washington County has provided the cities and towns within the County with two alternative contracts for election services. One is for full election services, and the other is for limited election services.

The full service agreement is consistent with how the County has conducted elections in the past. The County will assume responsibility for the election, with the City Council acting as the Board of Canvassers. The County's expenses will be passed on to the City.

The limited service agreement is substantially different from the procedures that have been followed in the past, with the City taking possession of the ballots after signature verification and removing the ballots from the County's property. The County would not assist or have any involvement from the time the City takes possession of the ballots, so the City would be solely responsible to transport, secure, tally, and store the ballots in the manner and following the process required by the Utah Code. Also, under this agreement, voters at the County voting locations will have to vote by provisional ballots to ensure those municipal ballots are not inserted into the County's tabulating machine. The City would still reimburse the County for its costs to print, mail, and process the ballots for signature verification.

Staff has the same concerns and reservations with the limited service agreement as were expressed when these discussions occurred in the last municipal election. Assuming possession of the ballots and responsibility for the election midway through the process will increase the risk of legal claims against the City that the ballot transition or vote counting was flawed. Allowing the County to assume the responsibility and liability of the election process from the beginning to the end is the legally prudent method to handle the municipal election. Also, the limited-service agreement will require a substantial investment of time by the City Attorney and the City Recorder to become experts in election law and to ensure that all of the legal and technical requirements of the election process are met.

Staff recommends that the Council approve the full service agreement with the County for election services. -Dayton Hall, City Attorney.

Findings:

Recommendation:

INTERLOCAL COOPERATION AGREEMENT REGARDING FULL ELECTION SERVICES

This INTERLOCAL COOPERATION AGREEMENT (the “Agreement”) is between Washington County, Utah (the “County”) and _____ City (the “Municipality”) located within the geographic boundary of the County (collectively the “Parties”).

RECITALS

WHEREAS, under the Utah Election Code (Utah Code Ann. § 20A-1-101, *et. seq.*) the Washington County Clerk-Auditor is charged with many duties pertaining to conducting accurate, fair, and impartial elections in Washington County;

WHEREAS, due to those duties, the County regularly conducts county-wide elections and has the equipment, experience, and applicable contracts in place to efficiently conduct elections within the County;

WHEREAS, Municipalities within Washington County are responsible for conducting municipal elections within their own jurisdictions;

WHEREAS, in accordance with Utah law, the County adopted a vote by mail system for elections beginning in 2018, and secured contracts for printing, mailing, distributing, and returning mail-in ballots;

WHEREAS, under the Utah Code, local political subdivisions may enter into interlocal agreements with the County for services that are more efficiently provided by the County;

WHEREAS, the County and the Municipality acknowledge the mutual benefit and efficiency of having the County assist in the Municipality’s elections;

WHEREAS, for the purpose of conducting more efficient municipal elections, the County is willing to assist municipalities located within the County in their responsibilities to conduct elections;

WHEREAS, it is in the best interest of the citizens of Washington County that the County assist in conducting the Municipality’s elections;

WHEREAS, under Utah Code § 20A-1-102(23)(c), the Municipal Clerk is the election officer for the municipal election cycle; the County is an election vendor and will contract to provide election support services, including technical, prior election experience, and statutory support; and

WHEREAS, the County and the Municipality desire to revoke all Interlocal Cooperation Agreements Regarding Election Services dated prior to the date of this Agreement.

AGREEMENT

NOW, THEREFORE, in consideration of the mutual promises, the covenants contained herein, and pursuant to the Interlocal Cooperation Act, the Parties agree as follows.

A. SPECIFIC TERMS

Section 1. County.

(a) The County agrees to assist and support the Municipality in conducting vote by mail municipal elections; however, the County does not have the equipment or software to provide support for Ranked Choice Voting. If the Municipality chooses to use Ranked Choice Voting, the County can direct the Municipality to an election vendor that can administer the election in this format.

(b) In accordance with the County's contract with a selected printer, the County will order ballots and envelopes for the Municipality based on the number of registered voters within the Municipality, and the outgoing and return by-mail ballot envelope packets will be addressed to the Washington County Clerk. The state and the County will conduct by-mail elections utilizing paper ballots, with additional voting methods like casting in-person paper ballots at approved vote center locations.

(c) The County may, at its discretion, provide election equipment for municipalities where it is providing election support if the Municipality has 4,000 or more active registered voters. The County also may provide election equipment to municipalities with fewer than 4,000 active registered voters based on the availability of equipment. All approved vote center locations will have poll workers trained and assigned by the County for use by the voters of the Municipality. The Municipality is responsible for posting the required election notices.

(d) The County shall recruit, hire, and train poll workers and provide all voting equipment, training, and support for approved vote center locations.

(e) The County shall use its available tabulation machines to count ballots for the Municipality; the County will not manually count or hand count ballots. Any municipal race that requires a recount will be machine tabulated.

(f) The County shall provide the Municipality with the date, time, and location of the required meeting described in Utah Code § 20A-4-104, and the required automatic tabulating equipment test. The Municipality is responsible for providing the public with notice by publishing it as a class A notice as required by law and posting it on the Utah Public Notice website.

(g) The County shall provide the Municipality with the date, time and location of the required meeting described in the Lieutenant Governor's Post Election Audit Policy. The Municipality is responsible for posting this notice as required by law and on the Utah Public Notice website, and complying with rules promulgated by the Lieutenant Governor.

(h) The County shall continue to conduct all statutorily required obligations, including signature verification using signature verification equipment and the State voter database, in accordance with applicable state and local codes.

(i) The County shall provide the Municipality with a cost estimate for upcoming election services by February 1st preceding the municipal election if requested.

(j) The County Clerk, shall provide the Municipality the summary report required under Utah Code § 20A-4-303 by noon on the day of the scheduled canvass and if requested, may attend the Board of Canvassers scheduled canvass to support the Municipality's Election Official in presenting the results summary report.

Section 2. Municipality.

(a) The Municipality agrees to reimburse the County for all costs and expenses related to the Municipality's election, including all printing and mailing expenses incurred under the County's contract with the printer, within 30 days of receiving an invoice from the County.

(b) The Municipality shall collect its election items from the County Clerk-Auditor's Office by the first work day in January after the municipal election.

(c) The Municipality shall notify the County in writing by February 15th of the election year if the Municipality does not accept the county-provided cost estimate and therefore does not desire to receive the County's election services as outlined in this Agreement.

(d) The Municipality shall designate one or more qualified staff members to attend scheduled public meetings, process ballots, adjudicate ballots, and assist the County to re-make ballots on a regular basis. Failure to fulfill the duties in this subparagraph will not delay or prevent the County's ballot processing. The qualified staff member(s) shall attend required trainings.

(e) The Municipality's Board of Canvassers is encouraged to and may attend ballot processing, post-election audits and post recount audits conducted pursuant to State law as part of the canvassing process.

Section 3. Term. This Agreement shall become effective on the date it is duly executed and shall expire December 31, 2025. This Agreement shall automatically renew for additional one-year periods not to exceed 10 years, unless written notice of intent to terminate it is given by either Party on or before November 30th of the current year at issue. All prior interlocal agreements regarding election services between the Parties are revoked.

B. GENERAL TERMS

Section 1. Purpose. The purpose of this Agreement is to allow the Parties to comply with State law to accomplish the intentions and purposes referred to in the recitals above.

Section 2. Termination. Other than as set forth in A(3), above, either Party may terminate this Agreement by timely notifying the other Party in writing of its intent to terminate the Agreement, for instance, when a Municipality cancels a local election pursuant to Utah Code Ann. § 20A-1-206. Any costs incurred by County shall be reimbursed by the Municipality upon termination.

Section 2. No Waiver of Governmental Immunity. The Parties are governmental entities under the Governmental Immunity Act of Utah. Utah Code Ann. § 63G-7-101, *et. seq.* None of the Parties waive any defenses otherwise available under the Governmental Immunity Act of Utah.

Section 3. Indemnity.

(a) The Municipality shall hold harmless and indemnify County, and its elected officials, officers, employees, and agents, against any and all loss, liability, damage, claim, cost, charge, demand, or expense (including reasonable attorney's fees and costs) arising out of or resulting from the services in, or performance of, this Agreement if caused by any negligent act or omission, or any intentional misconduct, of the Municipality or any of its elected officials, officers, employees, or agents. The County is not responsible for, and does not assume any liability for, the actions of the Municipality or its elected officials, officers, employees, or agents.

(b) The County shall hold harmless and indemnify the Municipality, and its elected officials, officers, employees, and agents against any and all loss, liability, damage, claim, cost, charge, demand, or expense (including reasonable attorney's fees and costs) arising out of or resulting from the services in, or performance of, this Agreement if caused by any negligent act or omission, or any intentional misconduct, of the County or any of its elected officials, officers, employees, or agents. The Municipality is not responsible for, and does not assume any liability for, the actions of the County or its elected officials, officers, employees, or agents.

Section 4. Interlocal Cooperation Act Requirements. In satisfaction of the requirements of the Interlocal Cooperation Act in connection with this Agreement, the Parties agree as follows:

(a) This Agreement shall be authorized and adopted by resolution of the legislative body of each Party pursuant to and in accordance with Utah Code Ann. § 11-13-202.5.

(b) This Agreement shall be reviewed as to proper form and compliance with applicable law by a duly authorized attorney on behalf of each Party pursuant to and in accordance with Utah Code Ann. § 11-13-202.5(3).

(c) A duly executed original counterpart of this Agreement shall be filed immediately with the keeper of records of each Party pursuant to and in accordance with Utah Code Ann. § 11-13-209.

(d) No separate legal entity is created by the terms of this Agreement. The Parties designate the Chair of the County Commission as the Administrator responsible to administer this Agreement and the accomplishment of the purposes of the cooperative action contemplated hereby and specified herein pursuant to Utah Code Ann. § 11-13-207.

(e) The effective date of this Agreement shall be the date that each of the Parties has signed it, adopted a resolution to approve it, and filed the Agreement with the keeper of records.

(f) The term of this Agreement shall commence on the date of full execution of this Agreement by all Parties.

(g) No real or personal property shall be acquired jointly by the Parties as a result of this Agreement.

(h) Following the execution of this Agreement by the Parties, either Party may cause a notice regarding this Agreement to be published on behalf of the Parties in accordance with Utah Code Ann. § 11-13-219.

Section 5. Notices. All notices, requests, demands and other communications under this Agreement shall be in writing and shall either be hand delivered or sent by first-class mail, postage prepaid, and properly addressed to the Parties at the following addresses:

Municipality
Attn: Clerk
ADDRESS

Washington County
Attn: Commission Chair
111 East Tabernacle Street
St. George, UT 84770

Section 6. Entire Agreement; Modification; Waiver. This Agreement constitutes the entire agreement between the Parties pertaining to the subject matter and supersedes all prior and contemporaneous agreements, negotiations, representations, promises, or understandings of the Parties whether oral or written. No supplement, modification, amendment, or waiver of any obligation of this Agreement shall be binding unless executed in writing by all the Parties. No waiver of any of the provisions in this Agreement shall be deemed or shall constitute a waiver of any other provision, whether or not similar, nor shall any waiver constitute a continuing waiver.

Section 7. No Third-Party Beneficiaries. This Agreement is not intended to confer upon any person other than the Parties any rights or remedies.

Section 8. Governing Law. This Agreement shall be governed by the laws of the State of Utah. The Parties agree that venue for all legal actions, unless they involve a cause of action with mandatory federal jurisdiction, shall be the Fifth District Court for the State of Utah. The Parties further agree that the Federal District Court for the District of Utah shall be the venue for any cause of action with mandatory federal jurisdiction.

Section 9. Counterparts; Filing. This Agreement may be executed in one or more counterparts, each of which shall be deemed an original, but all of which together shall constitute one and the same instrument.

DATED this ____ day of _____, 2025.

WASHINGTON COUNTY

Victor Iverson
Washington County Commission Chair

Attest:

Ryan Sullivan
Washington County Clerk-Auditor

Date: _____

Approved as to Form:

Deputy Washington County Attorney

City

Mayor

Attest:

City Recorder

Date: _____

Approved as to Form:

City Attorney

INTERLOCAL COOPERATION AGREEMENT REGARDING LIMITED ELECTION SERVICES

This INTERLOCAL COOPERATION AGREEMENT (the “Agreement”) is between Washington County, Utah (“the County”) and _____ (the “Municipality” or the “Municipal”) located within the geographic boundary of the County (collectively “the Parties”).

RECITALS

WHEREAS, under the Utah Election Code (Utah Code Ann. § 20A-1-101, *et. seq.*) the Washington County Clerk-Auditor is charged with many duties pertaining to conducting accurate, fair, and impartial elections in Washington County;

WHEREAS, due to those duties, the County regularly conducts county-wide elections and has the equipment, experience, and applicable contracts in place to efficiently conduct elections within the County;

WHEREAS, Municipalities within Washington County are responsible for conducting municipal elections within their own jurisdictions;

WHEREAS, in accordance with Utah law, the County adopted a vote by mail system for elections beginning in 2018, and secured contracts for printing, mailing, distributing, and returning mail-in ballots;

WHEREAS, under Utah Code, local political subdivisions may enter into interlocal agreements with the County for services that are more efficiently provided by the County;

WHEREAS, the County and the Municipality acknowledge the mutual benefit and efficiency of having the County assist in the Municipality’s elections to the extent set forth herein;

WHEREAS, the Municipality has determined that it can provide many election services itself that the County has provided in the past, and can do so in what it determines is a safe, secure, and efficient manner;

WHEREAS, the County and the Municipality acknowledge that the County will assist only in the duties required in Utah Code, and as set forth herein, and the Municipality will accept all other duties related to its elections;

WHEREAS, under Utah Code Ann. § 20A-1-102(23)(c), the Municipal Clerk is the election officer for the municipal election cycle; the County is an election vendor and will contract to provide election support services, including technical, prior election experience, and statutory support; and

WHEREAS, the County and the Municipality desire to revoke all Interlocal Cooperation Agreements Regarding Election Services dated prior to the date of this Agreement.

AGREEMENT

NOW, THEREFORE, in consideration of the mutual promises, the covenants contained herein, and pursuant to the Interlocal Cooperation Act, the Parties agree as follows:

A. SPECIFIC TERMS

Section 1. County.

(a) The County agrees to assist and support the Municipality in conducting vote by mail municipal elections; however, the County does not have the equipment or software to provide support for Ranked Choice Voting. If the Municipality chooses to use Ranked Choice Voting, the County can direct you to an election vendor that can administer the election in this format.

(b) In accordance with the County's contract with a selected printer, the County will order ballots and envelopes for the Municipality based on the number of registered voters within the Municipality, and the outgoing and return by-mail ballot envelope packets addressed to the Washington County Clerk. The state and the County conduct by-mail elections utilizing paper ballots, with additional voting methods like casting in-person paper ballots at approved vote center locations.

(c) The County may provide election equipment in each Municipality with 4,000 or more active registered voters in County's discretion. The County also may provide election equipment to additional Municipalities with fewer than 4000 active registered voters based on the availability of equipment in County's discretion. All approved vote center locations will have poll workers trained and assigned by the County for use by the voters of the Municipality. The Municipality is responsible for posting the required election notices.

(d) The County will provide voting equipment and support for the County-approved vote center location(s). If a voter from the Municipality votes at an approved vote center location, they will be required to vote by Provisional Ballot to ensure that no Municipal ballots are inserted into the County tabulating equipment. The County will segregate Municipal ballots it receives by mail, drop box, or approved vote center location, and maintain them for turn over to the Municipality in accordance with chain-of-custody procedures. The Municipality is responsible for posting the required election notices.

(e) The County will maintain custody of all approved vote center voting equipment, and remove it and all ballots at the end of election day. No ballots or envelopes will be turned over to the Municipality until after the processes outlined in subparagraph (i), below

(f) The County will not manually count or hand count Municipal ballots. For consistency in procedures, and security reasons, the County will not add a different counting process. The County is partnering with many other municipalities, and the County uses its available tabulating equipment for counting ballots.

(g) The County will provide the Municipality with the date, time and location of the required meeting described in Utah Code § 20A-4-104, and the required automatic tabulating

equipment test. The Municipality is responsible for providing the public with notice by publishing it as a class A notice as required by law and posting it on the Utah Public Notice website.

(h) The County will continue to conduct all statutorily required obligations, including provisional ballot verification, signature verification using verification equipment and the State voter database, and ballot cure procedures, in accordance with applicable state and local codes.

(i) The County will assist the Municipality through provisional ballot verification, signature verification, and ballot cure procedures, and thereafter turn over custody of verified Envelopes and Provisional Ballots (Envelopes and Ballots) to two Municipal staff members authorized to take custody at the County facility and take them to a Municipal facility. This will be accomplished at predetermined times specified by the County during business hours. The last Envelope and Ballot pick up by the Municipality will be no later than noon on the day of the Municipal canvass meeting. The authorized Municipal staff members will take custody of the Envelopes and Ballots by signing County's chain-of-custody documentation and removing them from the County facility. Thereafter, the County will no longer have possession of, or any responsibility for, the Envelopes and Ballots.

Section 2. Municipality.

(a) The Municipality agrees to reimburse the County for all costs and expenses related to the Municipality's election, including all printing and mailing expenses incurred under the County's contract with the printer, within 30 days of receiving an invoice from the County.

(b) The Municipality shall be responsible for all vote tabulation procedures and processes by whatever means it selects, and the procedures and processes shall be conducted at Municipal facilities only. The Municipality shall perform all other duties and responsibilities found in the Utah Election Code unless specifically enumerated herein as being a County responsibility.

(c) The Municipality shall be responsible for all audits, post-election audits, recounts, and post-recount audits for its election. If there is an election challenge, the Municipality is solely responsible for it.

(d) The Municipality agrees to collect all of its remaining election items from the County Clerk-Auditor's Office by noon on the day of the Municipality's canvass date.

(e) The Municipality agrees to notify the County in writing by April 30th of the election year if the Municipality does not accept the county-provided cost estimate and therefore does not desire to receive the County's election services as outlined in this Agreement.

Section 3. Term. This Agreement shall become effective on the date it is duly executed and shall expire December 31, 2025. All prior interlocal agreements regarding election services between the Parties are revoked.

B. GENERAL TERMS

Section 1. Purpose. The purpose of this Agreement is to allow the Parties to comply with State law to accomplish the intentions and purposes referred to in the recitals above.

Section 2. Termination. Other than as set forth in A(3), above, either Party may terminate this Agreement by timely notifying the other Party in writing of its intent to terminate the Agreement, for instance, when a Municipality cancels a local election pursuant to Utah Code Ann. § 20A-1-206. Any costs incurred by County shall be reimbursed by the Municipality upon termination.

Section 3. No Waiver of Governmental Immunity. The Parties are governmental entities under the Governmental Immunity Act of Utah. Utah Code Ann. § 63G-7-101, *et. seq.* None of the Parties waive any defenses otherwise available under the Governmental Immunity Act of Utah.

Section 4. Indemnity.

(a) The Municipality shall hold harmless and indemnify County, and its elected officials, officers, employees, and agents, against any and all loss, liability, damage, claim, cost, charge, demand, or expense (including reasonable attorney's fees and costs) arising out of or resulting from the services in, or performance of, this Agreement if caused by any negligent act or omission, any intentional misconduct, or criminal act of the Municipality or any of its elected officials, officers, employees, or agents. Manual counting or hand counting ballots poses risks related to the chain of custody of Envelopes and Ballots, and errors and omissions in tabulation, and the Municipality fully accepts all risks related thereto whether known or unknown, enumerated or not enumerated. The County is not responsible for, and does not assume any liability for, the actions of the Municipality or its elected officials, officers, employees, or agents.

(b) The County shall hold harmless and indemnify the Municipality, and its elected officials, officers, employees, and agents against any and all loss, liability, damage, claim, cost, charge, demand, or expense (including reasonable attorney's fees and costs) arising out of or resulting from the services in, or performance of, this Agreement if caused by any intentional misconduct or criminal act of the County or any of its elected officials, officers, employees, or agents.

Section 5. Interlocal Cooperation Act Requirements. In satisfaction of the requirements of the Interlocal Cooperation Act in connection with this Agreement, the Parties agree as follows:

(a) This Agreement shall be authorized and adopted by resolution of the legislative body of each Party pursuant to and in accordance with the provisions of Utah Code Ann. § 11-13-202.5.

(b) This Agreement shall be reviewed as to proper form and compliance with applicable law by a duly authorized attorney on behalf of each Party pursuant to and in accordance with the Utah Code Ann. § 11-13-202.5(3).

(c) A duly executed original counterpart of this Agreement shall be filed immediately with the keeper of records of each Party pursuant to and in accordance with Utah Code Ann. § 11-13-209.

(d) No separate legal entity is created by the terms of this Agreement. The Parties designate the Chair of the County Commission as the Administrator responsible to administer this Agreement and the accomplishment of the purposes of the cooperative action contemplated hereby and specified herein pursuant to Utah Code Ann. § 11-13-207.

(e) The effective date of this Agreement shall be the date that each of the Parties has signed it, adopted a resolution to approve it, and filed the Agreement with the keeper of records.

(f) The term of this Agreement shall commence on the date of full execution of this Agreement by all Parties.

(g) No real or personal property shall be acquired jointly by the Parties as a result of this Agreement.

(h) Following the execution of this Agreement by the Parties, either Party may cause a notice regarding this Agreement to be published on behalf of the Parties in accordance with Utah Code Ann. § 11-13-219.

Section 6. Notices. All notices, requests, demands and other communications under this Agreement shall be in writing and shall either be hand delivered or sent by first-class mail, postage prepaid, and properly addressed to the Parties at the following addresses:

Municipality
Attn: Clerk/Recorder
ADDRESS

Washington County
Attn: Commission Chair
111 East Tabernacle Street
St. George, UT 84770

Section 7. Entire Agreement; Modification; Waiver. This Agreement constitutes the entire agreement between the Parties pertaining to the subject matter and supersedes all prior and contemporaneous agreements, negotiations, representations, promises, or understandings of the Parties whether oral or written. No supplement, modification, amendment, or waiver of any obligation of this Agreement shall be binding unless executed in writing by all the Parties. No waiver of any of the provisions of this Agreement shall be deemed or shall constitute a waiver of any other provision, whether or not similar, nor shall any waiver constitute a continuing waiver.

Section 8. No Third-Party Beneficiaries. This Agreement is not intended to confer upon any person other than the Parties any rights or remedies.

Section 9. Governing Law. This Agreement shall be governed by the laws of the State of Utah. The Parties agree that venue for all legal actions, unless they involve a cause of action with mandatory federal jurisdiction, shall be the Fifth District Court for the State of Utah. The Parties further agree that the Federal District Court for the District of Utah shall be the venue for any cause of action with mandatory federal jurisdiction.

Section 10. Counterparts; Filing. This Agreement may be executed in one or more counterparts, each of which shall be deemed an original, but all of which together shall constitute one and the same instrument.

DATED this ____ day of _____, 2025.

WASHINGTON COUNTY

Gil Almquist
Washington County Commission Chair

Attest:

Ryan Sullivan
Washington County Clerk-Auditor

Date: _____

Approved as to Form:

Deputy Washington County Attorney

_____ City

Mayor

Attest:

City Recorder

Date: _____

Approved as to Form:

_____ City Attorney



STAFF COMMENTS

Item: Consideration and possible approval of Ordinance ZC24-06 and PSP24-09 a **Zone Change Amendment and a Preliminary Site Plan** request located approximately 5210 W 2250 S from A-5 (Agricultural, one unit per 5 acres) to RR (Recreation Resort). Parcel numbers H-4138-A, H-4138-G, and H-4-2-15-112.

Discussion: The applicant requests approval to rezone and add approximately 3.37 acres to the existing Pecan Valley Resort. The current zoning of the 3.37 acres is Agricultural A-5 and it is proposed they be rezoned to Recreation Resort. The request includes a site plan with additional parking spaces to support nearby clubhouses and amenities, the construction of pickleball courts, and the construction of 17 housing units. The Planning Commission heard this item on January 23, 2025, and unanimously recommended approval upon condition that it will not increase the current number of already approved Recreation Resort units within the overall Pecan Valley development, and that the development agreement for Pecan Valley Resort be updated to include the additional acreage. The applicant has agreed that the 17 proposed units will be a density transfer to the new site and will not increase the existing unit count for the overall resort. --Gary Cupp

Findings:

- The application meets the standards of the General Plan Map in that the action would bring the zoning of the subject property into consistency with the general plan, but it does not meet policies in the Moderate Income Housing Plan.
- Generally, the proposal is harmonious with the surrounding uses to the north, south, and east.
- The proposed amendment will have an impact on the area; however, the impact could be considered minimal in light of the overall Recreation Resort development that has already been approved around the subject property.
- Services are currently adequate to serve the property.
- The application does not meet some of the requirements of rezoning a property to Recreation Resort; specifically, the overall development will be larger than the recommended 20 acres and the property is not located adjacent to a master planned road.
- The Preliminary Site Plan provided is acceptable for the zone change application.

Recommendation: Staff recommends approval. While the zone change may not meet all the considerations for rezoning to the Recreation Resort designation, the proposal does establish consistency with the general plan by eliminating a small island of

inconsistent zoning. And even though the Pecan Valley Resort has already exceeded the 20-acre maximum area recommended by City ordinance for a Recreation Resort zone, the addition of 3.37 acres to the Pecan Valley Resort would be a negligible increase that would eliminate a small portion of agriculturally zoned land that would likely never be used for agricultural purposes and align the site with the general plan. The property is almost an island of agriculturally zoned land bounded on three sides by the Pecan Valley Resort; therefore, staff recommends approval of the requested zone change subject to the condition that it will not increase the current number of already approved Recreation Resort units within the overall Pecan Valley development, and that the development agreement also be updated to include the additional acreage.

Alternatively, the City Council could reasonably deny the application, since the zone change does not meet all the conditions for rezoning to the Recreation Resort designation in that it:

- exceeds the recommended 20 acres for Recreation Resort developments;
- is not consistent with the existing development agreement;
- is not located adjacent to major collectors, minor arterials, or major arterial roads;
- does not add significant commercial viability to the area nor does it provide commercial amenities; and
- would result in the loss of agricultural lands.

AN ORDINANCE OF THE CITY COUNCIL OF HURRICANE APPROVING THE REZONE
FOR PARCELS H-4138-A, H-4138-G, AND H-4-2-15-112 FROM AGRICULTURAL 5 (A-5)
TO RECREATION RESORT (RR)

WHEREAS, Utah Code 10-9a allows Cities to regulate land use within their boundaries; and

WHEREAS, the proposed amendment is generally compatible with the current General Plan;
and

WHEREAS, the proposed amendment is generally in harmony with the overall character of
the proposed surrounding development; and

WHEREAS, the proposal will not have an adverse impact on the surrounding area; and

WHEREAS, there are adequate facilities to support the proposed zone change; and

WHEREAS, the Planning Commission gave a positive recommendation on the proposed
zone change.

BE IT FURTHER ORDAINED BY THE CITY COUNCIL OF HURRICANE CITY THAT:

That parcels H-4138-A, H-4138-G, and H-4-2-15-112 are rezoned from Agricultural 5 (A-5) to
Recreation Resort (RR).

PASSED AND APPROVED on this 6th day of February 2025.

Hurricane City

Nanette Billings, Mayor

Attest:

Cindy Beteag, City Recorder

The foregoing Ordinance was presented at a regular meeting of the Hurricane City Council held at the Hurricane City Office Building on the 6th day of February 2025. Whereupon a motion to adopt and approve said Ordinance was made by _____ and seconded by _____. A roll call vote was then taken with the following results:

	Yea	Nay	Abstain	Absent
David Hirschi	_____	_____	_____	_____
Kevin Thomas	_____	_____	_____	_____
Clark Fawcett	_____	_____	_____	_____
Drew Ellerman	_____	_____	_____	_____
Joseph Prete	_____	_____	_____	_____

Cindy Beteag, City Recorder

EXHIBIT A
ZONING MAP



Application

Application Accepted Date: 04/26/2024				
Type of Improvement: <u>Zone Change Application</u>				
Description: <u>Wylar & Stratton area Zone Change</u>				
Tenant / Project Name: <u>Pecan Valley Development ZC</u>				
Bldg. Address: <u>5210 West 2250 South</u>				
City: <u>Hurricane City</u>		State: <u>UT</u>		Zip: <u>84737</u>
Subdivision: <u>Pecan Valley Resort</u>		Phase: <u>TBD</u>		
Block: <u></u>	Lot #: <u></u>	Parcel #: <u>H-4138-A, H-4138-G, H-4138-F</u>		
Zone: <u>A-5</u>				
Property Owner: <u>Chris Wylar</u>				
Permit Contact: <u>Brandee Walker</u>			P:(435) 668-4023	
Email: <u>bwalker@civilsience.com</u>				
CONTACT INFORMATION				
Engineer of Record: <u>Civil Science</u>				
Email: <u>bwalker@civilsience.com</u>			P: (435) 668-4023	
General Contractor: <u>Pecan Valley Development LLC</u>				
License #:		P: (435) 467-2216		
Address: <u>5202 W 2250 S</u>				
City: <u>Hurricane</u>		State: <u>UT</u>		Zip: <u>84737</u>
Email: <u>wyltile@gmail.com</u>				
APPLICATION DETAILS				
DRAFT				

Valuation		\$	0.00
PERMIT FEES			
Planning Fee	\$	500.00	
Planning Fee	\$	500.00	
Sub Total:	\$	500.00	
Permit Total:	\$	500.00	
Amount Paid:	\$	500.00	
Remaining Due:	\$	0.00	

APPROVALS	DATE	INFO

Setbacks	Front:	Rear:	Left:	Right:
Min.				
Actual:				

APPLICATION NUMBER: PLANZC24-06

This permit becomes null and void if work or construction authorized is not commenced within 180 days, or if construction or work is suspended or abandoned for a period of 180 days at any time after work is commenced. I here-by certify that I have read and examined this application and know the same to be true and correct. All provisions of laws and ordinances governing this type of work will be complied with whether specified herein or not the granting of a permit does not presume to give authority to violate or cancel the provisions of any other state or local law regulating construction or the performance of construction and that I make this statement under penalty of perjury. Maintenance Deposit is refundable after final inspection if: 1) site is kept clean 2) building is NOT occupied prior to final inspection and issuance of Certificate of Occupancy.

Applicant Name: Brandee Walker

Signature of Applicant/Authorized Agent or Owner: _____ **Date:** _____

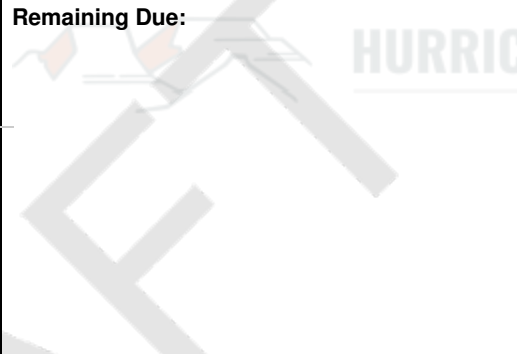
Application Approved By: _____ **Date:** _____

Application Issued By: _____ **Date:** _____

Receipt #: 8.178280-04/26/24



Application

Application Accepted Date: 04/26/2024		Valuation		\$	0.00															
Type of Improvement: Site Plan (Preliminary)		PERMIT FEES																		
Description: Site Plan for RR zoning		Planning Fee		\$	200.00															
Tenant / Project Name: Pecan Valley Development		Planning Fee		\$	200.00															
Bldg. Address: 5210 West 2250 South		Sub Total:		\$	200.00															
City: Hurricane City State: UT Zip: 84737		Permit Total:		\$	200.00															
Subdivision: Pecan Valley Resort Phase: TBD		Amount Paid:		\$	200.00															
Block: Lot #: Parcel #: H-4138-A, H-4138-G		Remaining Due:		\$	0.00															
Zone: A-5 (RR)																				
Property Owner: Chris Wyler																				
Permit Contact: Brandee Walker P:(435) 668-4023																				
Email: bwalker@civilsience.com																				
CONTACT INFORMATION																				
Engineer of Record: Civil Science																				
Email: bwalker@civilsience.com P: (435) 668-4023																				
General Contractor: Pecan Valley Development LLC																				
License #: P: (435) 467-2216																				
Address: 5202 W 2250 S																				
City: Hurricane State: UT Zip: 84737																				
Email: wyltile@gmail.com																				
APPLICATION DETAILS																				
																				
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 15%;">Setbacks</th> <th style="width: 15%;">Front:</th> <th style="width: 15%;">Rear:</th> <th style="width: 15%;">Left:</th> <th style="width: 15%;">Right:</th> </tr> <tr> <td>Min.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Actual:</td> <td></td> <td></td> <td></td> <td></td> </tr> </table>						Setbacks	Front:	Rear:	Left:	Right:	Min.					Actual:				
Setbacks	Front:	Rear:	Left:	Right:																
Min.																				
Actual:																				
APPLICATION NUMBER: PLANPSP24-09																				
This permit becomes null and void if work or construction authorized is not commenced within 180 days, or if construction or work is suspended or abandoned for a period of 180 days at any time after work is commenced. I hereby certify that I have read and examined this application and know the same to be true and correct. All provisions of laws and ordinances governing this type of work will be complied with whether specified herein or not the granting of a permit does not presume to give authority to violate or cancel the provisions of any other state or local law regulating construction or the performance of construction and that I make this statement under penalty of perjury. Maintenance Deposit is refundable after final inspection if: 1) site is kept clean 2) building is NOT occupied prior to final inspection and issuance of Certificate of Occupancy.																				
Applicant Name: Brandee Walker																				
Signature of Applicant/Authorized Agent or Owner: Date:																				
Application Approved By: Date:																				
Application Issued By: Date:																				
Receipt #: 8.178297-04/26/24																				

Pecan Valley Development – Zone Change

Narrative

The proposed zone change amendment is for a combined 2.925 acres within the Pecan Valley area located at approximately 2250 South 5210 West. The existing zoning is A-5 with the proposed zoning to be RR (recreation resort). The applicant has developed the RR lots due north, Pecan Valley Phase 3, as well as the RR multifamily property south, Pecan Valley Resort. The existing zoning to the west is RR which is also part of the master planned Pecan Valley development.

This zone change would help correct the agriculture 5 acre minimum as the parcels requesting the zone change together are less than the 5 acre minimum. The adjacent Stratton land to the east is currently seeking a zone change from the A-5.

Pecan Valley Development

Preliminary Site Plan

The applicant is seeking preliminary site plan approval for 3.37 acres of RR (proposed recreational resort) adjacent to the existing Pecan Valley and Pecan Valley Resort developments. This application proposes the amenities of pickle ball, parking, and 17 townhome units. With the PV Resort clubhouse and large pool & waterpark amenity being approximately 350 south of this parcel, the applicant feels the additional parking will offer both support for the pickle ball courts, clubhouse, pool & waterpark, as well as the existing RR large homes to the north of 2250 South.

This application proposes a density of 5.0 units per acre. All town home units have a 2-car garage and the large units on the end have increased driveways. This application provides an additional 92 surface stalls within the parking lot area, 38 stalls in the town home driveways, with 34 garage spaces totaling 164 parking spaces to compliment the existing resort community.

The 3.37 acres will be a part of the existing master planned Pecan Valley community and help provide the connectivity from the northern single family RR lots to the southern multifamily and resort amenities.

13
Return To:
City of Hurricane
Attention: Cindy Beteag
147 N 870 W
Hurricane, UT 84737

DOC # 20230000908

Agreement. Page 1 of 13
Gary Christensen Washington County Recorder
01/11/2023 11:38:04 AM Fee \$ 0.00
By HURRICANE CITY



**DEVELOPMENT AGREEMENT
FOR
PECAN VALLEY ZONE CHANGE**

THIS DEVELOPMENT AGREEMENT ("Agreement") is made and entered into as of the 11 day of January, 2023 (the "Effective Date"), by and between HURRICANE CITY, a Utah municipal corporation, hereinafter referred to as "City," and PVH LLC, a Utah LLC, hereinafter referred to as "Developer." The City and Developer are hereinafter collectively referred to as "Parties."

RECITALS

A. Developer is the owner of approximately 18.09± acres of land located within Hurricane City as is more particularly described on EXHIBIT A, attached hereto and incorporated herein by reference (the "Property").

B. On November 17, 2022, the City Council approved a zone change as shown on the zoning map attached hereto as EXHIBIT B, subject to and conditioned upon the terms and conditions of this Agreement.

C. Developer has proposed, and City has approved, a Preliminary Site Plan attached hereto and incorporated herein as EXHIBIT B. The Preliminary Site Plan grants no vested entitlements and shall be subject to changes as listed within this agreement.

D. Developer is willing to design and construct the Project in accordance with the Preliminary Site Plan and in a manner that is in harmony with and intended to promote the long-range policies, goals, and objectives of the City's general plan, zoning and development regulations in order to receive the benefit of vesting for certain uses and zoning designations under the terms of this Agreement as more fully set forth below.

E. The City Council have further authorized the Mayor of the City to execute and deliver this Agreement on behalf of the City.

F. The City has the authority to enter into this Agreement pursuant to Utah Code Section 10-9a-102(2) and relevant municipal ordinances, and desires to enter into this Agreement with the Developer for the purpose of guiding the development of the Property in accordance with the terms and conditions of this Agreement and in accordance with applicable City Ordinances.

G. This Agreement is generally consistent with, and all preliminary and final plats within the Property are subject to and shall conform with, the City's General Plan, Zoning

Ordinances, and Subdivision Ordinances, and any permits issued by the City pursuant to City Ordinances and regulations.

H. The Parties desire to enter into this Agreement to specify the rights and responsibilities of the Developer to develop the Property as expressed in this Agreement and the rights and responsibilities of the City to allow and regulate such development pursuant to the requirements of this Agreement.

I. The Parties understand and intend that this Agreement is a "development agreement" within the meaning of, and entered into pursuant to, the terms of Utah Code Ann., §10-9a-102.

J. The Parties intend to be bound by the terms of this Agreement as set forth herein.

AGREEMENT

NOW, THEREFORE, in consideration of the mutual covenants contained herein, and other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the City and the Developer hereby agree as follows:

1. Incorporation of Recitals. The foregoing Recitals are hereby incorporated into this Agreement as a substantive part hereof.

2. General Terms: The City approves the zoning boundaries shown in EXHIBIT B with the following terms and conditions.

a. Planned Development Overlay. The area labeled as PDO in EXHIBIT B is approved but shall be limited to no more than 77 total units. These units shall only be used for long-term residential uses. Prior to any development, Developer shall file a new preliminary site plan that complies with Hurricane City Code and standards and obtain approval from the Hurricane City Planning Commission.

b. Recreation Resort. The area labeled as Pecan Valley Resort within EXHIBIT B is approved but shall contain no more than 236 units. Prior to any development, Developer shall file a new site plan that complies with Hurricane City Code 10-26 for review and obtain approval from the Planning Commission. The Developer shall provide new outdoor amenities within the southern section of the resort according to Hurricane standards or as otherwise approved by the Planning Commission. The Planning Commission may, but is not required to, consider amenities in other areas of the resort to offset required amenities.

c. Clubhouse and Amenity Center. In the first phase of any development within the Pecan Valley Resort, Developer shall develop a Clubhouse in the northeast of the development as shown in EXHIBIT B. The applicant shall follow all Hurricane City approval procedures, including a preliminary site plan, construction drawings, subdivision plans, final site plan, and building permits.

3. Nothing in this Agreement shall amend or replace any requirements by City, State, Federal, Fire, other local development agreements or restrictions, or other applicable regulations.

4. Notices. Any notices, requests and demands required or desired to be given hereunder shall be in writing and shall be served personally upon the party for whom intended, or if mailed, by certified mail, return receipt requested, postage prepaid, to such party at its address shown below:

To the Developer: Pecan Valley Holdings LLC
Attention: Chris Wyler
5183 W 2040 S
Hurricane, UT 84737

To the City: City of Hurricane
Attention: Dayton Hall, City Attorney
147 N 870 W
Hurricane, UT 84737

5. Adequate Public Facilities.

a. This subsection 5 applies to any portion of the Property for which development has not already been approved by the City.

b. Developer understands, acknowledges and specifically agrees that: (a) power, water, and other utility services to the Property may not be currently available in sufficient capacity to serve some or all of the Property, and may not have been extended to the Property; (b) the granting of this zone change, approval of a preliminary plat, and review of construction drawings, does not in any way guarantee or warrant the availability and extension of power, water, or other utility services to the Property; (c) no application for any building or grading permit requiring the availability and extension of power, water, or other utility service for the specific property identified in the permit application, shall be filed, made, or approved until such time that such utilities or services are available and have been extended to the applicable property, as determined by City staff; and (d) Developer assumes all risk and liability associated with any development activity on the Property, including but not limited to all costs incurred for engineering, feasibility studies, etc., in the event that such services do not become available and are not extended to the Property.

c. The City may deny any application for preliminary plat(s), final plat(s), site plans, and/or building permit(s) if the City finds that (1) utilities, roadways, or other public facilities or infrastructure are inadequate to support the Property that is the subject of that application or (2) services are not in the vicinity of the Property that is the subject of that application. Notwithstanding the foregoing, the City may consider an application if the applicant can show that current utility systems, roadway systems, and other public facilities and infrastructure are adequate to meet the demand for the Property that is the subject of that application and the applicant can provide a plan on how to reasonably

connect the systems, facilities, and infrastructure to the property that is the subject of that application.

6. General Term and Conditions.

a. Headings. The headings contained in this Agreement are intended for convenience only and are in no way to be used to construe or limit the text herein.

b. Binding Effect. This Agreement shall inure to the benefit of, and be binding upon, the parties hereto and their respective heirs, representatives, officers, agents, employees, members, successors and assigns (to the extent that assignment is permitted). Without limiting the generality of the foregoing, a "successor" includes a party that succeeds to the rights and interests of the Developer as evidenced by, among other things, such party's submission of land use applications to the City relating to the Property or the Project.

c. Non Liability of City Officials and Employees. No officer, representative, consultant, attorney, agent or employee of the City shall be personally liable to the Developer, or any successor in interest or assignee of the Developer, for any default or breach by the City, or for any amount which may become due to the Developer, or its successors or assignees, or for any obligation arising under the terms of this Agreement. Nothing herein will release any person from personal liability for their own individual acts or omissions.

d. Third Party Rights. Except for the Developer, the City and other parties that may succeed the Developer on title to any portion of the Property, all of whom are express intended beneficiaries of this Agreement, this Agreement shall not create any rights in and/or obligations to any other persons or parties. The Parties acknowledge that this Agreement refers to a private development and that the City has no interest in, responsibility for, or duty to any third parties concerning any improvements to the Property unless the City has accepted the dedication of such improvements

e. Further Documentation. This Agreement is entered into by the Parties with the recognition and anticipation that subsequent agreements, plans, profiles, engineering and other documentation implementing and carrying out the provisions of this Agreement may be necessary. The Parties agree to negotiate and act in good faith with respect to all such future items.

f. Relationship of Parties. This Agreement does not create any joint venture, partnership, undertaking, business arrangement or fiduciary relationship between the City and the Developer.

g. Agreement to Run With the Land. This Agreement shall be recorded in the Office of the Washington County Recorder against the Property and is intended to and shall be deemed to run with the land, and shall be binding on and shall benefit all successors in the ownership of any portion of the Property.

h. Performance. Each party, person and/or entity governed by this Agreement shall perform its respective obligations under this Agreement in a manner that will not unreasonably or materially delay, disrupt or inconvenience any other party, person and/or entity governed by this Agreement, the development of any portion of the Property or the issuance of final plats, certificates of occupancy or other approvals associated therewith.

i. Applicable Law. This Agreement is entered into under and pursuant to, and is to be construed and enforceable in accordance with, the laws of the State of Utah.

j. Construction. This Agreement has been reviewed and revised by legal counsel for both the City and the Developer, and no presumption or rule that ambiguities shall be construed against the drafting party shall apply to the interpretation or enforcement of this Agreement.

k. Consents and Approvals. Except as expressly stated in this Agreement, the consent, approval, permit, license or other authorization of any party under this Agreement shall be given in a prompt and timely manner and shall not be unreasonably withheld, conditioned or delayed. Any consent, approval, permit, license or other authorization required hereunder from the City shall be given or withheld by the City in compliance with this Agreement and the City Ordinances.

l. Approval and Authority to Execute. Each of the Parties represents and warrants as of the Effective Date this Agreement, it/he/she has all requisite power and authority to execute and deliver this Agreement, being fully authorized so to do and that this Agreement constitutes a valid and binding agreement.

7. Amendment. This Agreement may be amended only in writing signed by the Parties hereto.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement by and through their respective, duly authorized representatives as of the day and year first hereinabove written.



ATTEST:

By: _____

City Recorder

CITY:

CITY OF HURRICANE

By: _____

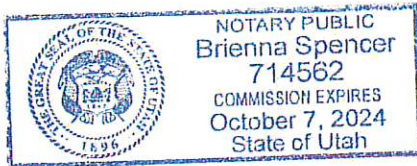
Mayor

DEVELOPER:

By: [Signature]
Name: Chris Wyler
Title: Member

STATE OF UTAH)
 :SS
COUNTY OF UTAH)

On the 11 day of January, 2023, personally appeared before me Chris Wyler, who being by me duly sworn, did say that he is the Member of PVH, a Utah limited liability company, and that the within and foregoing instrument was signed on behalf of said limited liability company with proper authority and duly acknowledged to me that he executed the same.



Brienna Spencer
Notary Public
Residing at: Hurricane UT 84737

EXHIBIT A
Legal Description Parcel

PARCEL H-4138-E & H-4138-L
COMBINED LEGAL DESCRIPTION

BEGINNING AT A POINT N 88°41'43" W 645.27 FEET ALONG THE CENTER SECTION LINE OF SECTION 15, TOWNSHIP 42 SOUTH, RANGE 14 WEST, SALT LAKE BASE AND MERIDIAN, FROM THE EAST QUARTER CORNER OF SAID SECTION 15, POINT BEING ON THE WEST LINE OF A PARCEL MORE PARTICULARLY DESCRIBED IN DOCUMENT NO. 20210017450, RECORDED AND ON FILE IN THE OFFICE OF THE RECORDER, WASHINGTON COUNTY, STATE OF UTAH, AND RUNNING THENCE S 1°07'49" W 624.69 FEET ALONG SAID LINE, TO THE NORTHEAST CORNER OF A PARCEL MORE PARTICULARLY DESCRIBED IN DOCUMENT NO. 20220015183, RECORDED AND ON FILE IN THE OFFICE OF SAID RECORDER; THENCE ALONG SAID PARCEL THE FOLLOWING TWO (2) COURSES, (1) S 47°49'50" W 237.76 FEET, (2) THENCE S 76°32'06" W 317.12 FEET, TO A POINT ON THE EAST 1/16TH LINE OF SAID SECTION 15, THENCE N 1°07'49" E 225.96 FEET ALONG SAID LINE, TO THE SOUTHWEST CORNER OF A PARCEL MORE PARTICULARLY DESCRIBED IN DOCUMENT NO. 20170050011, RECORDED AND ON FILE IN THE OFFICE OF SAID RECORDER; THENCE ALONG SAID PARCEL THE FOLLOWING THREE (3) COURSES, (1) S 88°52'21" E 226.17 FEET, (2) THENCE N 0°33'28" W 191.12 FEET, (3) THENCE N 66°45'54" W 220.69 FEET, TO A POINT ON THE SAID EAST 1/16TH LINE, THENCE N 1°07'48" E 444.19 FEET ALONG SAID LINE, TO THE CENTER EAST 1/16TH CORNER, THENCE N 1°05'38" E 947.24 FEET ALONG THE EAST 1/16TH LINE OF SAID SECTION 15, TO THE SOUTHWEST CORNER OF A PARCEL MORE PARTICULARLY DESCRIBED IN DOCUMENT NO. 20140011171, RECORDED AND ON FILE IN THE OFFICE OF SAID RECORDER, THENCE S 88°55'08" E 479.95 FEET ALONG THE SOUTH LINE OF SAID PARCEL, TO A POINT ON THE WEST LINE OF SAID PARCEL MORE PARTICULARLY DESCRIBED IN DOCUMENT NO. 20210017450, THENCE S 1°05'47" W 949.11 FEET ALONG SAID LINE TO THE POINT OF BEGINNING

CONTAINS 18.09 ACRES MORE OR LESS

EXHIBIT B
Zoning Amendment Preliminary Site Plan Map

EXHIBIT C
City Council Approval Minutes

Mr. Nelson. Councilman Hirschi confirmed there are five hundred units and expressed concern with the density. Mr. Brown noted that he discussed this with Mr. Nelson and felt this area is a good location for this type of development. Councilman Thomas noted that there is infrastructure in the area, and this is near other commercial uses.

Mayor Billings asked how the applicant intends to make this an affordable housing product. Mr. Brown reiterated that the applicant is willing to provide ten percent as affordable housing with a development agreement. Councilman Prete likes the project. It is time to proceed forward with the moderate-income housing plan. He confirmed that the applicant agrees to not exceed three stories and designate ten percent as affordable housing. He explained that these details must be worked out in a development agreement. He suggested continuing the item until the development agreement has been reviewed. He noted that this is the first applicant that has committed to deed-restricted affordable housing.

Joseph Prete motioned to continue the Zone Change Amendment request for Steward Land Holdings located at approx. 3112 West State Street from HC to PC to the next meeting to consider the request with a development agreement. Seconded by Kevin Thomas. Dave Sanders, Kevin Thomas, and Joseph Prete voting, aye. David Hirschi and Doug Heideman nay. Motion carried.

5. Consideration and possible approval of **allocating funds to the Tourism Board** - April Gates/Doug Heideman

April Gates stated that the Tri-State Jamboree donated money to help veterans. The Tourism Alliance is taking over the Tri-State Jamboree moving forward. Ms. Gates reported that the Tourism Board is requesting \$3,000 to help boost their website.

Kevin Thomas motioned to approve allocating \$3,000 to the Tourism Board. Seconded by Dave Sanders. Joseph Prete, Doug Heideman, David Hirschi, Kevin Thomas, and Dave Sanders voting aye. Motion carried unanimously.

6. Ordinance 2022-60: Consideration and possible approval of a proposed **Zone Change Amendment request located at approx. 5200 West and 2500 South from A-5, agriculture one unit per 5 acres, to RM-1/PDO, multifamily 6 units per acre with a Planned Development Overlay, and RR, recreation resort**. Parcel numbers: H-4138-B, H-4138-L, H-4138-E. Chris Wyler Applicant. Brandee Walker-Civil Science Agent.

Stephen Nelson explained that this is part of the Pecan Valley project. The applicant previously asked to expand the resort use and add a PDO. The Planning Commission recommended denial. After discussions with the applicant, the City Council felt a development agreement could be implemented to cap the density. He explained that the presented development agreement will require amenities in certain areas, an additional clubhouse in the southern area, and limits the

number of units. Mayor Billings asked when the clubhouse will be built. Mr. Nelson reported that the clubhouse will be built in the first phase. Councilman Thomas feels this is a good change that benefits the community. Councilman Sanders asked how the excavation process will affect the neighbors. Chris Wyler feels it will help the neighbors with the flood water. They have a four-foot storm drain going to the river, which will help with future flooding. Mr. Nelson explained that the Planning Commission recommended denial due to concerns regarding infrastructure in the area, the main sewer line, and the expansion of the resort area. He noted that the development agreement contains adequate public facilities language.

Kevin Thomas motioned to approve the Zone Change Amendment request located at approx. 5200 West and 2500 South from A-5, agriculture one unit per 5 acres, to RM-1/PDO, multifamily 6 units per acre with a Planned Development Overlay, and RR, recreation resort subject to a development agreement and staff and JUC comments; 1. Power: Dixie Power area. Still waiting on off-site improvements. Probably will have enough capacity when they get to this part. 2. Water: Need an updated water model. Water is in the area but could be limited with this increase. 3. Streets: Second access needed to handle high density traffic flow. 4. Sewer: A lot of off-site sewer will be needed for this property. May need a regional lift station. 5. Engineering: 5200 W is 5350 W. The property should be acquired to connect 5350 W through. The Hunter and Lowell Frei parcels should be accessible from a public street. 6. Fire: Water supply and access. 7. Gas: No concerns. 8. Cable: No comments. 9. Density: The applicant is proposing 4.2 units per acre, RM-1 zoning allows up to six units per acre. The applicant is proposing 71 long-term townhome units and 228 resort townhome units. 10. The applicant is proposing that the already approved parking lot and clubhouse area on the north end of Pecan Valley Resort be zoned RM-1 PDO. The applicant has indicated to staff that this would be a recreation/community center open to the public. 11. Amenities: The total Pecan Valley Resort area has 473 units. Per HCC 10-26-4: Two clubhouses with 2,000 sq ft of nonoffice space and four pools of at least 2,000 sq ft are required. Two clubhouses are shown and the Planning Commission has approved a larger pool amenity with enhanced features in the phase 1 amenity area. a. The Planning Commission may approve an alternative amenity package. Staff would be broadly supportive of some level of alternative compliance on this overall plan due to the fact that the code requiring amenities was passed during the design and construction of the overall resort area. The relevant codes are: i. Alternative compliance, such as splash pads, sports courts, and open space amenities may be considered by the Planning Commission to offset other amenities requirements. ii. Pools: Pools may be combined for an enhanced amenity area with the approval of the Planning Commission. b. Staff has serious concerns with counting the proposed recreation/community center as an amenity for the resort when it is not zoned Recreation Resort and instead zoned RM-1 PDO. Other resorts in the city have been required to provide all of their amenities within the recreation resort zoning and have not been allowed to count amenities in other zones. c. Another consideration is that HCC 10-26-4 states that: "These amenities should be centrally located and have walking trails or sidewalks for access. Where applicable, multiple amenities should be placed throughout the property to ensure equitable access." With this addition the amenities are clustered around the northern end of the property.

Some sort of amenity should be placed on the southern end of the property. 12. Parking: A full parking plan will be needed for the preliminary plat approval. Most units will have garages sized enough to meet the requirements of, "two parking spaces per unit or one space per bedroom, whichever is higher" (HCC 10-26-6 E) a. Previous submissions have indicated that 100 RV parking spaces are provided within the recreation resort zone. 94 spaces are required for the entire resort area. 13. While staff has no issues with long-term residential in this area staff has serious concerns with the plan as presented with regards to the integration of the two uses on the site plan. Staff has had problems in the already built portions of Pecan Valley where there is an approved resort on one street and long-term residential on another where people have bought in the long-term area thinking it was the short-term, which causes confusion for property owners and noise and parking issues for residents. This plan mitigates this from the previous plan by not having long-term and short-term units sharing a building but where they share a street and where the units will theoretically be identical looking the problems that exist in other phases of Pecan Valley will persist. 14. The applicant is proposing that 3.737 acres of resort zoning be removed from the northern property and 3.370 acres be added to the southern property. This change increases the number of approved resort units within Pecan Valley by 23 additional units. 15. Planned Development Overlays (PDO) are required to be a minimum of 5 acres. The proposed resort is a total of 3.737 acres. This zoning is attached to the resort and the other PDO. Generally speaking, the applicant is seeking to exchange property from Resort to PDO without changing the use and justifying an expansion of resort zoning. Because of this, staff would generally recommend that the clubhouse/fitness area remains in the same zone and that the Planning Commission consider the southern zone change independently. 16. Hurricane City Code 10-37-4 states: a. Land shall be developed only where existing infrastructure is in place or will be timely provided to service proposed development. The City may require an analysis to be completed to determine whether adequate public facilities are available to service a development and whether such development will change existing levels of service or will create a demand which exceeds acceptable levels of service for roadways, intersections, bridges, storm drainage facilities, water lines, water pressure, sewer lines, fire and emergency response times, and other similar public services. The City may disapprove a proposed development if demand for public services exceeds accepted levels of service. No subsequent approval of such development shall be given until either the developer or the City installs improvements calculated to raise service levels to the standard adopted by the City. b. The City has generally interpreted this code to mean that developments should not be approved without an adequate, approved, and bonded for plan to install facilities and infrastructure to the property. The Sewer District has expressed concerns about sewer capacity. Also, the Fire District has serious concerns about increasing units and density along Turf Sod Road, which does not have a second access, and there are plans for an improved second access to the property to Dixie Springs Drive once connected to 5140 West. These plans have been signed, but the improvements have not been installed. Seconded by David Hirschi. Doug Heideman, Dave Sanders, David Hirschi, and Kevin Thomas voting aye. Joseph Prete, nay. Motion carried.

EXISTING ZONE: R1-10

LOT 60

LOT 59

LOT 58

LOT 57

LOT 56

EXISTING ZONE: RR

2250 SOUTH (52' PUBLIC STREET)

BEGINNING AT A POINT BEING WHICH IS N 88°27'52" W 330.00 FEET ALONG THE NORTH LINE OF SECTION 15, TOWNSHIP 42 SOUTH, RANGE 14 WEST, SALT LAKE BASE AND MERIDIAN, FROM THE NORTHEAST CORNER OF SAID SECTION 15, POINT ALSO BEING THE NORTHEAST CORNER OF A PARCEL MORE PARTICULARLY DESCRIBED IN ENTRY NO. 641595, RECORDED AND ON FILE IN THE OFFICE OF SAID RECORDER, THENCE S 88°27'52" W 137.48 FEET TO A POINT ON THE NORTH LINE OF SAID SECTION 15, THE EAST LINE OF SAID PARCEL AND THE EXTENSION THEREOF, THENCE S 88°27'52" E 137.48 FEET TO A POINT ON THE EXTENSION OF THE EAST LINE OF A PARCEL MORE PARTICULARLY DESCRIBED IN DOCUMENT NO. 20220002045, RECORDED AND ON FILE IN THE OFFICE OF SAID RECORDER, THENCE S 1°07'30" W 232.00 FEET, TO A POINT ON THE NORTH LINE OF A PARCEL MORE PARTICULARLY DESCRIBED IN DOCUMENT NO. 20300203476, RECORDED AND ON FILE IN THE OFFICE OF SAID RECORDER, THENCE S 88°27'52" W 137.48 FEET TO A POINT ON THE NORTH LINE OF SAID SECTION 15, THE EAST LINE OF SAID PARCEL AND THE EXTENSION THEREOF, THENCE S 88°28'33" E 264.02 FEET THE NORTH LINE OF SAID PARCEL AND THE EXTENSION THEREOF, TO THE POINT OF BEGINNING.

CONTAINS 148,066 SQ FT OR 3.399 ACRES MORE OF LESS

EXISTING ZONE: PF

EXISTING ZONE: RR

5210 WEST
(52' PUBLIC STREET)

EXISTING ZONE: RR

PECAN VALLEY DEVELOPMENT LLC,
PARCEL NO.
H-4-2-15-112

SUBJECT PARCEL
3.399 ACRES

EXISTING ZONE: A-5
PROPOSED ZONE: RR

EXISTING ZONE: A-5

EXISTING ZONE: RA-1

LAW HOLDINGS LLC,
PARCEL NO.
H-4138-A

PECAN VALLEY HOLDINGS LLC,
PARCEL NO.
H-4138-G

EXISTING ZONE: RR

APPLICANT
PECAN VALLEY DEVELOPMENT LLC
CHRIS WYLER
5202 W 2250 S
HURRICANE, UT 84737

LOCATED IN
NORTHEAST 1/4 OF SECTION 15, TOWNSHIP 42 SOUTH, RANGE 14 WEST, AND THE
SALT LAKE BASE AND MERIDIAN

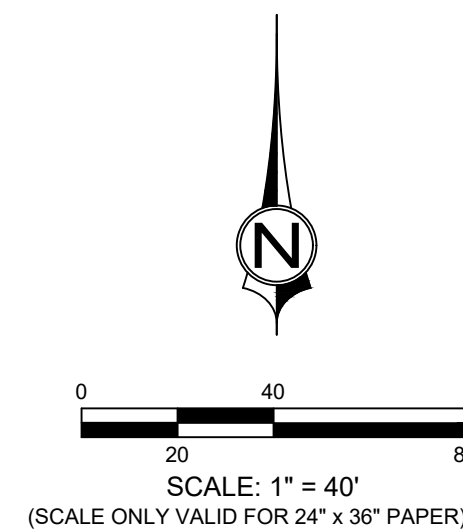
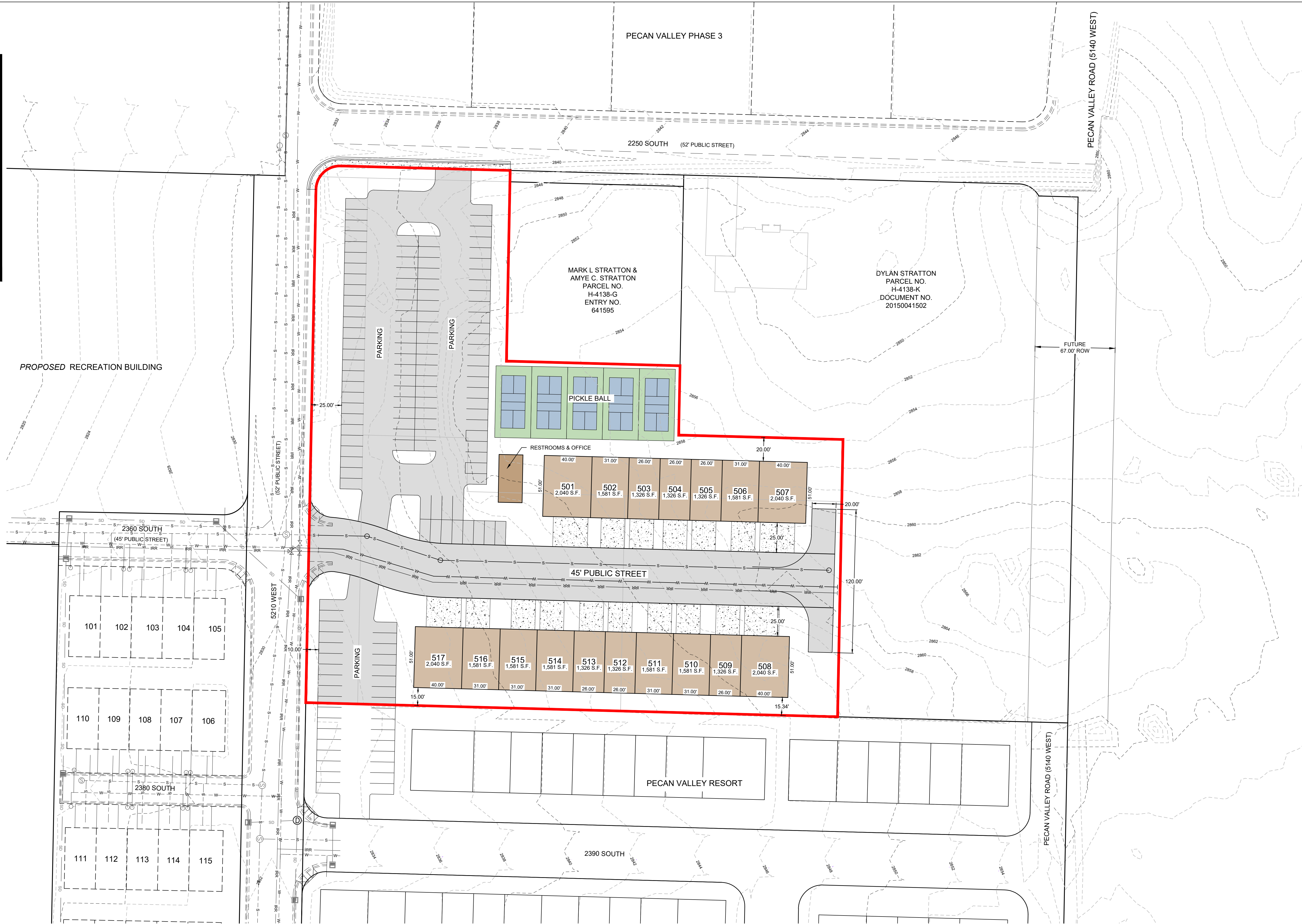
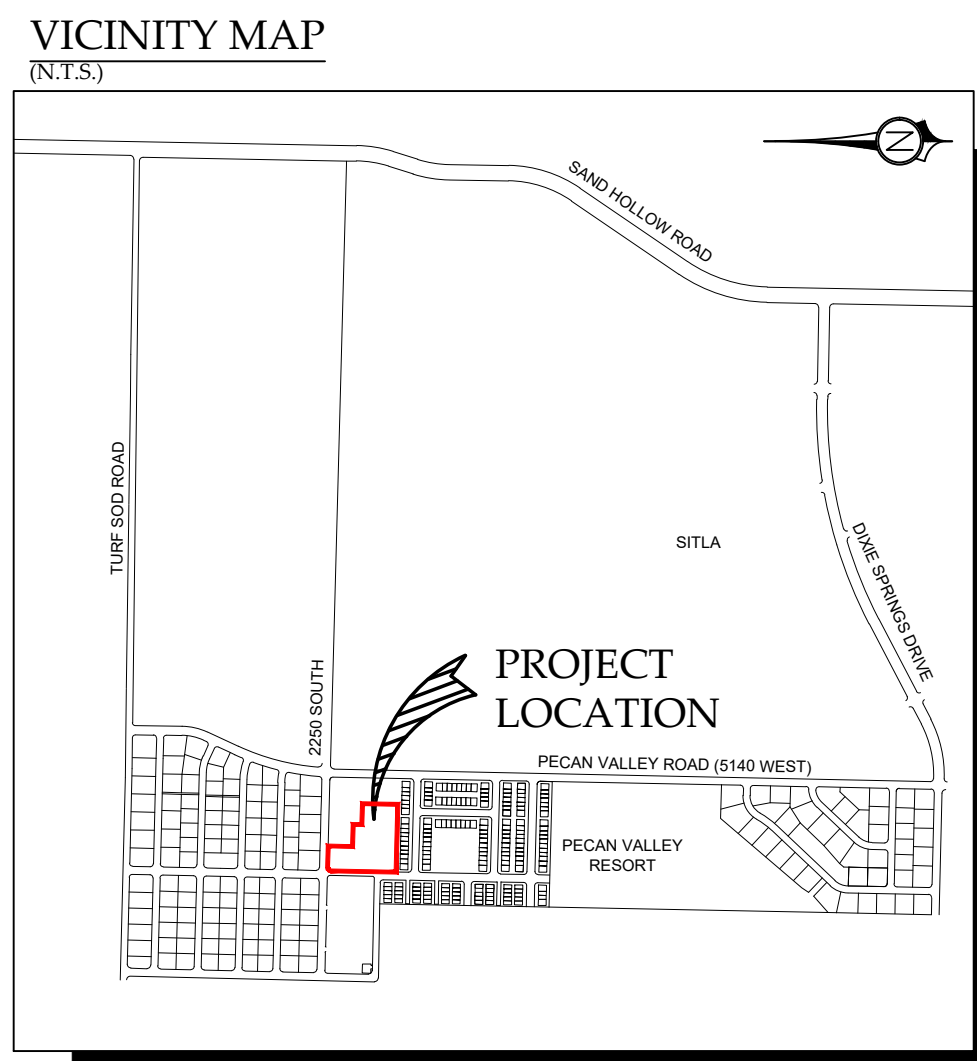
ST. GEORGE, UT 84770
435.986.0100



PECAN VALLEY DEVELOPMENT I
ZONE CHANGE
LOCATED IN HURRICANE, UTAH

DJ. #: FF23159
 DRAWN BY: BLW
 DATED: 5/07/2024
 CHECKED BY: TWS
 SCALE OF SHEET
 R SCALE: 1" = 40'

1
OF
1



PROJECT INFORMATION
TOTAL AREA: 3.37 ACRES
PROPOSED RR ZONING
UNITS: 17 TOWN HOMES
DENSITY: 5.0 DU/AC
AMENITY AREA: 0.81 ACRES
PARKING AREA: 0.66 ACRES

PARKING
PARKING STALLS: 138 SURFACE STALLS
TOWN HOME DRIVEWAYS: 38 STALLS
TOWN HOME 2-CAR GARAGES: 34 GARAGE SPACE

PECAN VALLEY DEVELOPMENT
PRELIMINARY SITE PLAN
(RECREATIONAL RESORT)

PECAN VALLEY DEVELOPMENT
LOCATED IN
NE 1/4 OF SECTION 15, TOWNSHIP 42 SOUTH,
RANGE 14 WEST, SALT LAKE BASE & MERIDIAN

PROJ. #: FF23159
DRAWN BY: BLW
DATE: 12/02/2024
SCALE OF SHEET
HOR SCALE: 1" = 40'

SHEET
1
OF
1



STAFF COMMENTS

Agenda Date:	02/06/2025 – City Council
Application Number:	ZC24-06; PSP24-09
Type of Application:	Zone Change
Action Type:	Legislative
Applicant:	Chris Wyler
Agent:	CivilScience
Request:	Zone Change from A-5 to Recreation Resort.
Location:	5210 W 2250 S
Zoning:	Agricultural A-5
General Plan Map:	Planned Community
Recommendation:	Approve with conditions.
Report Prepared by:	Gary Cupp

Discussion:

The applicant requests approval to rezone and add approximately 3.37 acres to the existing Pecan Valley Resort. The current zoning of the 3.37 acres is Agricultural A-5 and it is proposed they be rezoned to Recreation Resort. The request includes a site plan with additional parking spaces to support nearby clubhouses and amenities, the construction of pickleball courts, and the construction of 17 housing units. The Planning Commission heard this item on January 23, 2025, and unanimously recommended approval upon condition that it will not increase the current number of already approved Recreation Resort units within the overall Pecan Valley development, and that the development agreement for Pecan Valley Resort be updated to include the additional acreage. The applicant has agreed that the 17 proposed units will be a density transfer to the new site and will not increase the existing unit count for the overall resort.

2. *Whether the proposed amendment is harmonious with the overall character of existing development in the vicinity of the subject property;*

3. *The extent to which the proposed amendment may adversely affect adjacent property;*
and

4. *The adequacy of facilities and services intended to serve the subject property, including, but not limited to, roadways, parks and recreation facilities, police and fire protection, schools, stormwater drainage systems, water supplies, and wastewater and refuse collection.*

1. Is the proposed amendment consistent with the City's General Plan's goals, objectives, and policies?

Response: The General Plan Map shows this area as “Planned Community” and recommends that, *Master planned communities should be complete communities that offer a mixture of housing types and supporting uses such as neighborhood and supporting commercial uses, offices, churches, schools, and parks. Development in this designation should take into account the character of existing surrounding development.*

Historically, when the City has approved Recreation Resort zones, these zones have been limited to the Planned Community portions of the Future Land Use Map. The project area is surrounded by existing and ongoing resort development.

This area is currently zoned A-5, agricultural one unit per 5 acres, which does not conform to the general plan, but there are many agricultural uses and larger homesteads in the area. The General Plan says: *1.1. Hurricane encourages the preservation of farms and open pastures that recall the agricultural heritage of Hurricane and help provide a sustainable local food source.* A buffer area between agriculture and resort use would be desirable, but one is not provided by this plan and is likely not feasible since the zone-change area is bounded on three sides by Recreation Resort zones.

The Moderate Income Housing Plan, most recently updated in 2024, recommends limiting the expansion of Recreation Resort zoning except in special circumstances. Ultimately, the proposed zone change would be practical since the property is essentially a small island of agriculturally zoned land surrounded by Recreation Resort.

2. Is the proposed amendment harmonious with the overall character of existing development in the subject property's vicinity?

Response: Most of the area is agriculture, undeveloped, or other phases of Pecan Valley Resort. The proposed development plan would be harmonious with the adjacent phases of Pecan Valley Resort.

3. Will the proposed amendment adversely affect the adjacent property?

Response: Any adverse impacts on the surrounding property resulting from the zone change could be considered negligible in light of the overall Recreation Resort development that has already been approved around the subject property. Furthermore, bringing the zoning into conformance with the

Planned Community general plan designation for the site could justify the zone change. But the loss of agricultural area could be seen as an adverse impact.

4. Are public facilities and services adequate to serve the subject property?

Response: Services should be adequate for the additional development. See JUC comments below.

Other Considerations:

Per Hurricane City Code Recreation Resorts 10-26-5:

B. In addition to the items required by 10-7-7, the City shall consider the following criteria in assessing any zone change application.

1. *General Plan Map: Recreation Resort Zoning shall be located in Commercial, Planned Community, Mixed Use, or Multi-Family areas as labeled by the General Plan Map.*

Response: The property is located in the Planned Community portion of the General Plan Map and the zone change would bring consistency between the general plan and zoning at the site.

2. *Recreation Resort Zoning shall avoid clustering in a single location, and should be limited in size relative to the commercial or multi-family zoned area. Only in rare cases should a recreation resort zone exceed 20 acres.*

Response: Even without this addition, the Pecan Valley Resort already exceeds 20 acres and is the largest development in the area.

3. *Recreation Resort Zoning shall only be located adjacent to Major Collectors, Minor Arterials, or Major Arterial Roads.*

Response: There are no master planned roadways adjacent to this property. The nearest master planned roadway is 5140 W which is a minor collector.

4. *Recreation Resort Zoning should help add to the commercial viability of an area within commercial areas listed in the General Plan Map. It may do this by adding commercial amenities, tourism, or renewed development of an area.*

Response: The proposed zone change does not enhance this objective.

5. *Recreation Resort Zoning should not conflict with long term housing and moderate income housing needs of an area. Recreation Resort Zoning should not be located in places where multi-family housing could be built that would have easy access to public amenities and services, such as schools, parks, and utilities.*

Response: This area does not have easy access to existing public amenities that would benefit multifamily uses; this site would probably not be ideal for multifamily housing due to the existing surrounding resort uses.

Vacation Rentals

The City has approved 5,250 recreation resort units, the vast majority of which have not been constructed. There is a development agreement currently in place for Pecan Valley Resort that limits the total number of new resort units the developer is allowed to construct to 236 units (not counting previously approved units in Pecan Valley Phase 3 and Pecan Valley Resort Phase 1-4). Staff would recommend that this development agreement be amended to encompass this area and that the number of units permitted not be increased. This allows the City to maintain the current number of approved recreation resort units to 5,250 but allow for the thoughtful development of this parcel.

Preliminary Site Plan Review

Applicant has submitted a site plan for the proposed zone-change site.

JUC Comments:

Public Works: No comment.

Power: Dixie Power area. No comment.

Water: Okay.

Streets: No comment.

Sewer: No exception to the additional seventeen units.

Engineering: The preliminary site plan should indicate how the historic access to the neighboring parcel H-4138-G will be preserved or replaced (HCC 10-7-10(D)(2)). A portion of the area in this zone change exhibit was subdivided from a neighboring parcel without a plat or staff's approval (HCC 10-39-4(A)). Applicant needs to review our on-street parking ordinance (HCC 10-34-8(J)). Public street should be extended to property lines (HCS 2.1(bullet 2)) & turnaround can be protected by easement. The preliminary site plan shall include a preliminary storm drain plan (HCC 10-7-10(D)(2)(A)(5)). A brief summary of the amenities being provided in other portions of the resort, a ratio of units per amenity, a comparison of entitled units to proposed units could go a long way.

Fire: Okay.

Gas: No concerns.

Fiber: No comment.

WCWCD: Washington County Water Conservancy District hereby acknowledges that based on the information provided, the zone change adequately mitigates interference with district facilities and property interests. The District reserves the right to rescind this acknowledgement if additional information becomes available. The district has not determined whether water will be available for this development and does not hereby make any guarantee of water availability. In addition, the development must conform with applicable district requirements, including but not limited to payment of fees.

Staff Comments:

1. **Density:** The density is about 5 units per acre for the zone change area. Density cap is 15 units per acre in RR zoning. As stated above, staff recommends the existing development agreement be extended to include this property so this could be considered a “density transfer” from the area to the south.

2. **Parking:** Per HCC 10-26-6:

E. Off street parking: Parking shall comply with the following standards.

- 1. Within recreational resorts, an application shall provide two parking spaces per unit or one space per bedroom, whichever is higher. Tandem parking spaces are permitted only if approved as part of the preliminary site plan by the Planning Commission.*
 - 2. RV and Trailer Parking: An applicant shall provide sufficient parking areas for RV's and trailers. A minimum of one RV/trailer parking space shall be provided for every 5 units.*
 - a. More information is required but one would presume all of these units will have garages to fulfill part 1's requirements.
 - b. No RV/trailer parking is shown in this site plan and none is existing or planned in approved future phases of Pecan Valley Resort (this development predates that requirement). Some of the parking stalls appear to be pull-through which the Planning Commission has allowed for RV parking in the past.
 - c. On street parking needs to meet HCC 10-34-8.
3. **Amenities:** The applicant is requesting that amenities being provided in other phases of the resort be counted towards the amenity requirements. Otherwise, one clubhouse and pool would be required.

Findings:

Staff makes the following findings:

1. The application meets the standards of the General Plan Map in that the action would bring the zoning into consistency with the general plan, but it does not meet policies in the Moderate Income Housing Plan.
2. Generally, the proposal is harmonious with the surrounding uses to the north, south, and east.
3. The proposed amendment will have an impact on the area; however, the impact could be considered minimal in light of the overall Recreation Resort development that has already been approved around the subject property.
4. Services are currently adequate to serve the property.
5. The application does not meet some of the requirements of rezoning a property to Recreation Resort; specifically, the overall development will be larger than the recommended 20 acres and the property is not located adjacent to a master planned road.
6. The Preliminary Site Plan provided is acceptable for the zone change application.

Recommendation: Staff recommends approval. While the zone change may not meet all the considerations for rezoning to the Recreation Resort designation, the proposal does establish consistency with the general plan by eliminating a small island of inconsistent zoning. And even though the Pecan Valley Resort has already exceeded the 20-acre maximum area recommended by City ordinance for a Recreation Resort zone, the addition of 3.37 acres to the Pecan Valley Resort would be a negligible increase that would eliminate a small portion of agriculturally zoned land that would likely never be used for agricultural purposes and align the site with the general plan. The property is almost an island of agriculturally zoned land bounded on three sides by the Pecan Valley Resort; therefore, staff recommends approval of the requested zone change subject to the condition that it will not increase the current number of already approved Recreation Resort units within the overall Pecan Valley development, and that the development agreement also be updated to include the additional acreage.

Alternatively, the City Council could reasonably deny the application, since the zone change does not meet all the conditions for rezoning to the Recreation Resort designation in that it:

- exceeds the recommended 20 acres for Recreation Resort developments;
- is not consistent with the existing development agreement;
- is not located adjacent to major collectors, minor arterials, or major arterial roads;
- does not add significant commercial viability to the area nor does it provide commercial amenities; and
- would result in the loss of agricultural lands.



STAFF COMMENTS

Item: Consideration and possible approval of **Resolution 2025-16 amending the rental fee** for the Fine Arts Building.

Discussion: The current rate for use of the Theater is \$100 per hour with a cap of \$400. We have not had any written hours of rental times and would like to get those defined. We currently require a \$100 cleaning deposit for rentals that happen outside our regular business hours at the Community Center. So all weekend rentals we take a deposit for but we have not been doing the same for the FA building. I am asking for the following changes

1. That the rental rate for the Fine Arts building be updated to **\$100 per hour**, with **no cap** on the number of hours requested for rental, and the hourly rate will apply for all hours of use.
2. That a **\$100 cleaning deposit** will be required for all rentals of the Fine Arts building. This deposit will be fully refundable upon the satisfactory inspection of the facility after the rental.
3. That the Fine Arts building will be available for rental between the hours of **8:00 AM and 10:00 PM**.
4. That this new rate structure shall take effect July 1, 2025. - Tiffani Wright

Findings:

Recommendation:

A RESOLUTION OF THE CITY COUNCIL OF HURRICANE, UTAH, AMENDING FEES AND ADOPTING HOURS OF OPERATION ASSOCIATED WITH THE FINE ARTS BUILDING.

WHEREAS the Hurricane City Council is authorized by Section 10-3-717 of the Utah Code and Section 1-5-6 G.1. of the Hurricane City Code to establish fees for municipal services; and

WHEREAS the City Council desires to amend the follow fees; and

WHEREAS the Hurricane City Council finds that it is necessary and desirable for the preservation and protection of the health, safety, and welfare of the residents of Hurricane,

BE IT HEREBY RESOLVED by the City Council that the following provisions and fee schedule is hereby amended and adopted for implementation:

RENTAL HOURS	8:00 AM TO 10:00 PM
---------------------	---------------------

The rental rate is \$100 per hour. The hourly rate will apply for all hours of use.
A \$100 cleaning deposit is required for all rentals. This deposit will be fully refundable upon the satisfactory inspection of the facility after the rental period.

BE IT FURTHER RESOLVED that this Resolution shall take effect on July 1, 2025.

DATED this 6th day of February 2025.

Nanette Billings, Mayor

Attest:

Cindy Beteag, Hurricane City Recorder

The foregoing Resolution was presented at a regular meeting of the Hurricane City Council held at the Hurricane City Office Building on the 6th day of February 2025. Whereupon a motion to adopt and approve said Resolution was made by _____ and seconded by _____. A roll call vote was then taken with the following results:

	Yea	Nay	Abstain	Absent
David Hirschi	_____	_____	_____	_____
Kevin Thomas	_____	_____	_____	_____
Clark Fawcett	_____	_____	_____	_____
Drew Ellerman	_____	_____	_____	_____
Joseph Prete	_____	_____	_____	_____

Cindy Beteag, Recorder



STAFF COMMENTS

Item: Consideration and possible approval of **Ordinance 2025-02 amending Title 7, Chapter 5** regarding regulations of the Hurricane City Cemetery.

Discussion: In 2017, the City Council adopted a resolution limiting the number of cemetery plots a resident could purchase at the residential rate. Staff has now proposed incorporating this limitation into the ordinance to make it more accessible and easier to locate. Last year, the Council also discussed how to define a "resident," and a clear definition has been added to the ordinance for clarity.

While updating the chapter, staff reviewed it for other necessary revisions. All changes are highlighted in red. Key updates include:

1. Changing the term "lot" to "plot" for consistency.
2. Updating the authorized signers of certificates to align with current practices.
3. Revising the allowable materials for vault construction.
4. Removing the section that allows a portion of the cemetery to be contracted with religious and fraternal organizations. This section was removed because the term "reasonable portion" was not clearly defined. However, if the Council wishes to retain this section, it will need to define what constitutes a "reasonable portion," as a group has expressed interest in purchasing approximately 50 plots.
5. Updating regulations on monument sizes.

These changes aim to clarify and modernize the ordinance for better implementation and understanding. - Cindy Beteag

Findings:

Recommendation:

**AN ORDINANCE OF THE CITY COUNCIL OF HURRICANE, UTAH AMENDING
TITLE 7, CHAPTER 5 OF THE HURRICANE CITY CODE GOVERNING THE CITY
CEMETERY**

WHEREAS, the City Council of Hurricane, Utah desires to amend Title 7, Chapter 5 of the Hurricane City Code governing the City Cemetery; and

WHEREAS, the City Council deems this amendment necessary and desirable for the preservation of the general health, safety, and welfare of the residents of Hurricane,

BE IT HEREBY ORDAINED that Title 7, Chapter 5 of the Hurricane City Code shall be, and is hereby, amended as follows:

CHAPTER 5 - CEMETERIES

Sec. 7-5-1. City cemetery.

The burial ground of this City shall be known and designated by the name of Hurricane City Cemetery.

(1998 Code § 8-202; Ord. No. 2022-51, 10-3-2022)

Sec. 7-5-2. Definitions.

The following words or phrases shall have the following meanings, unless the context otherwise clearly requires:

~~Lot~~Plot means the partial ~~lot~~lots or single graves in the City cemetery.

~~Lot~~Plot owner or *~~lot~~plot* purchaser and grave owner or grave purchaser means the owner or purchaser of burial privileges or the collateral right of use of any burial ~~lot~~plot evidenced by a deed or burial right for a described ~~lot~~plot or by proved and recognized descent or devise from the original owner.

Resident means a person who is registered to vote in Hurricane City or who has a government issued identification with a valid Hurricane address.

Rules and regulations means the rules and regulations that are included in this chapter or that are otherwise adopted by the City Council to govern the City cemetery.

(1998 Code § 8-201; Ord. 2005-20, 9-1-2005; Ord. No. 2022-51, 10-3-2022)

Sec. 7-5-3. Applicability.

All cemeteries owned and/or maintained by the City, wherever situated, are hereby declared subject to the provisions of this chapter.

(1998 Code § 8-203; Ord. No. 2022-51, 10-3-2022)

Sec. 7-5-4. Cemetery superintendent.

- A. *Created.* There is hereby created the position of Cemetery Superintendent, as designated by the City Council.
- B. *Duties.* The Cemetery Superintendent shall have the general supervision and administration of the City cemetery, including, but not limited to:
1. Recommending to the City Council such additional rules and regulations as may be necessary for the operation, maintenance, use and protection of the cemetery.
 2. Subdividing the cemetery into ~~lot~~plots and grave sites.
 3. Overseeing the maintenance of a record of the location of the graves and preventing any ~~lot~~plot from being used beyond its capacity.
 4. Keeping in proper repair the enclosure around the cemetery and preventing its being entered by animals and, so far as practical, preventing the destruction or defacing of any tablet or marker placed or erected therein.
 5. Overseeing the keeping of a duplicate plat of the cemetery and, at the request of any person wishing to purchase any of the ~~lot~~plots or parts of ~~lot~~plots, pointing out any of the ~~lot~~plots or parts of ~~lot~~plots for sale; and upon disposal of any ~~lot~~plots or parts thereof, notifying the City Recorder or Cemetery Clerk of such fact. The Cemetery Clerk shall, after payment of the ~~lot~~plot price has been received in the treasury, issue a certificate of burial rights which shall describe the ~~lot~~plot or grave to which the right to burial is granted. The certificate shall be signed by ~~the Mayor and~~ the City Treasurer, and shall be attested by the City Recorder.
 6. Opening any graves in the cemetery upon application to him being made by the Cemetery Clerk or by any person having the right to make such application and being responsible for closing all graves.
 7. Removing floral pieces or displays left on any grave that are in violation of the rules and regulations or as deemed necessary to the appearance of the cemetery, but such floral pieces or displays shall not be removed sooner than five days after original placement, except in emergencies.
 8. Keeping the streets, alleys, walks and avenues in the cemetery in good order and unobstructed.
 9. All work in the cemetery, including, but not limited to, interments, disinterments, planting, landscaping, grading, record keeping, placement of grave markers, groundskeeping, construction, and all maintenance, improvement and beautifying of the grounds, shall be done under the supervision of the Cemetery Superintendent.

(1998 Code §§ 8-211, 8-212; Ord. 2005-20, 9-1-2005; Ord. No. 2022-51, 10-3-2022)

Sec. 7-5-5. Burials.

- A. *Registration.* Before any deceased person may be buried in the City cemetery, the relatives or person having charge of the deceased shall provide the City Recorder/Clerk with ~~a~~a

~~statistic form~~written statement which shall be filed by the City Recorder/Clerk, which ~~statement~~ shall contain, if known, information about the deceased regarding his or her name, when and where born, the date ~~and cause~~ of death, ~~the name of the attending physician~~, date of burial, name of cemetery and the description of the location of the grave.

B. *Burials and disinterment; unlawful acts.*

1. It is an infraction, subject to penalty as provided in section 1-4-1 of this Code, for any person to:
 - a. Disinter any body buried in any cemetery, except under the direction of the Cemetery Superintendent who shall, before disinterment, require written permission from both the health officer and the owner of the ~~lot~~plot or his or her heirs, which written authorization shall be filed and preserved in a record kept for such purposes. Payment of fees in advance. No grave shall be opened for interment or disinterment in the City cemetery until:
 - (1) The applicable fee or charge as specified by resolution set from time to time by the City Council shall have first been paid to the City Recorder/Clerk or such other person as the City Council may from time to time designate; and
 - (2) Evidence, in the form of a receipt issued by the City Recorder/Clerk or such other person as the City Council may from time to time designate, of payment of the applicable fees and charges shall have been first presented to the Cemetery Superintendent.
 - b. Disinter or remove the body of a person who has died from a contagious disease within two years after the date of burial, unless the body was buried in a hermetically sealed casket or vault and is found to be so encased at the time of disinterment.
2. It is an infraction, subject to penalty as provided in section 1-4-1 of this Code, to inter anything other than the remains of human bodies in City cemeteries.
3. It is an infraction, subject to penalty as provided in section 1-4-1 of this Code, to bury the body of any person within the City, except in the City cemetery or a private cemetery, unless by special permission of the City Council under such rules and regulations that it may prescribe.

C. *Vaults required.*

1. ~~It shall be unlawful for any person to be buried in the cemetery unless the casket shall be placed in a vault made of concrete, fiberglass, steel or brick lined or of such other material approved by the City Council, substantially constructed and covered with a similar durable material. Before a casket is accepted for burial, it must be housed within an approved vault having fixed top and side panel edge restraints incorporated into the construction and having a strength capable of uniformly withstanding a stress of seven and one-half (7-1/2) pounds per square inch. If a particular type or construction of a vault is rejected by the sexton, the mortician or party utilizing the vault shall bear the burden of proving compliance with the strength requirements of this section.~~
2. No wood shall be used as a permanent part of the construction of any part of the vault.

(Ord. 2005-20, 9-1-2005; Ord. No. 2022-51, 10-3-2022)

Sec. 7-5-6. Fees and charges.

- A. *Established; authority.* The City Council shall, from time to time by resolution, fix ~~the size of lots,~~ the price at which burial rights shall be sold and the fees which shall be charged for the various cemetery services to be provided.
- B. **Quantity Restrictions: Residents may purchase up to six plots at the residential rate. Additional plots may be purchased at the non-resident rate.**
- C. *Opening grave.*
 - 1. *Fee payment required.* No grave shall be opened in the City cemetery until payment of a fee as set from time to time by resolution of the City Council shall be paid.
 - 2. *Receipt authority to open.* The presentation of a receipt from the city recorder or person designated by the City Council when presented to the cemetery superintendent, shall be authority to open a grave for the burial of a deceased person. However, upon a contract being entered into between any mortician and the City wherein the mortician agrees to be responsible and liable for fees for the opening of a grave, and wherein that mortician will be personally liable for such fees and for perpetual care payments, the City Recorder or authorized person may give the Cemetery Superintendent authority to open graves without the presentation of a receipt from the City Recorder or authorized person.
 - 3. *Ordering grave opening.* Arrangements for a grave opening can be made by the funeral director or a responsible party. The required permits need to be filled out and fees paid. The information required is the name of the deceased, the place of interment (obtained from the cemetery master file, unless new purchase), the location, date and time of the funeral services, and the name of the funeral director or mortician. It shall be unlawful for any person to bury the body of a deceased person in the cemetery without first obtaining a certificate of burial right for the ~~lot~~plot used or producing satisfactory evidence of a right to burial based on a properly acquired certificate of burial right. Information received by telephone concerning burial location will be the responsibility of the caller.
 - 4. *Amount of fees and charges.* The fees for the opening and closing of graves and other services in connection therewith, including, but not limited to, proper interment or disinterment of bodies, proper restoration of the earth and cemetery grounds and recordation of burial information, shall be set from time to time by resolution.
 - 5. *Hours for burials.* Requests for burials are accepted during normal business hours at the City offices. No interment or graveside service will be held in the City cemetery on Sunday, on any holiday recognized by the City, or on any day that a holiday is observed by the City. An overtime fee in an amount determined by the City Council is assessed for burials after 4:00 p.m. and for burials on Saturdays.
- D. *Collection.* The City Recorder, and such other persons as the City Council may designate, are hereby authorized to collect in advance, prices and fees for the opening and closing of graves or other services which shall include, but not be limited to, properly disinterring

bodies and properly restoring the earth and grounds, recording each burial, disinterment or removal and raised monument privileges. The fees shall be such amounts as are determined by the City Council from time to time by resolution.

(1998 Code § 8-243; Ord. 2005-20, 9-1-2005; Ord. No. 2022-51, 10-3-2022)

Sec. 7-5-7. LotPlot sales.

- A. *Authority; records.* The City Recorder, and such other person as the City Council may designate, are hereby authorized to sell the use of lotplots in the City cemetery for burial purposes only and to collect all sums arising from the sale. The City Recorder shall keep a complete record of all sales, which record shall describe the location of the lotplot purchased and the price paid therefor.
- B. *Burial rights.* The City cemetery is a public park and will remain so as long as the City exists. Only permissive burial rights are sold. The City retains title to the cemetery property. A certificate of burial rights will be issued to each purchaser after fees are paid in full. The City Recorder/Clerk or designated person shall deliver to each purchaser a certificate of burial rights for each lotplot purchased, which certificate shall, among other things, describe the location of the lotplot, the purchase price and the type of maintenance services which are to be provided, e.g. perpetual care, prepaid continued maintenance or currently paid services. The cemetery master file is considered to be the correct record. Any discrepancy between the master file and the certificate of burial rights will be considered a clerical error. The City reserves the right to recall, correct and reissue the correct certificate.
- C. *Fee schedule.* The fee schedule in connection with the purchase and perpetual care of cemetery lotplots shall be set from time to time by resolution.
- D. *Purchase price; scope of.* A certificate and rights to burial shall be exempt from execution, taxation or assessment for care and maintenance from and after full payment of the purchase price. Payments made pursuant to this section shall not be construed to be in payment for cemetery services other than perpetual care.
- E. *Unused lotplots.* LotPlots that have been unused for or have no written notice of claim or interest on for over 60 years can be reclaimed by the cemetery. Every effort, practically and legally, will be made to find the owner or legal heirs before the lotplots, by lawful means, will be reverted. Should a certificate of title or right to a lotplot that has been reverted to the City be presented, the legal holder is entitled to be compensated in the amount of the original purchase price. All proceeds of the resale of the reverted property shall be placed in the perpetual care fund.
- F. *Improvements, changes and services.* No other improvements, changes or services, except perpetual care or prepaid continued maintenance, shall be made on any lotplot without the certificate holder or his heirs first submitting to and receiving from the cemetery superintendent written approval for such improvements, changes or services, which improvements, changes or services shall be subject to the rules and regulations promulgated by the City Council.
- G. *Resale restrictions.*

1. From and after January 1, 1978, the ~~lot~~plots sold by the City shall not be further sold, transferred, conveyed or assigned to any person except the City. The City hereby agrees to buy back any City cemetery grave ~~lot~~plot which it may hereafter sell. The repurchase price of such ~~lot~~plots shall be the same as the original purchase price.
2. Whenever a certificate to burial rights or ~~lot~~plots reverts to the City, as provided for in this subsection, or becomes vested in the City for any reason, before new certificates are issued, the original certificate shall be canceled or an assignment given and the record shall be so changed.
3. The certificates shall be issued and signed by the ~~Mayer and~~ City Treasurer and shall be attested by the City Recorder. All ~~lot~~plots or parts of ~~lot~~plots, as provided in this subsection, together with all improvements, shall be exempt from execution and from taxation and assessment for care and maintenance charges from and after said payment.

(1998 Code § 8-251; Ord. 2005-20, 9-1-2005; Ord. No. 2022-51, 10-3-2022)

Sec. 7-5-8. Perpetual care ~~lot~~plots.

- A. *Scope of care.* The essential perpetual care that the City agrees to give shall consist of care of the cemetery generally, and shall include, but is not limited to, mowing of all ~~lot~~plots and graves at reasonable intervals, resodding, seeding and filling in sunken graves, resurfacing the surface of the graves to ~~lot~~plot level, removing dead flowers and trimming trees and shrubbery when necessary, raking and cleaning the ~~lot~~plots and straightening of tilting stones or markers, but shall not include repairing or replacing markers or memorial structures of any nature, except when the need for repair or replacement is directly caused by the City.
- B. *Contracting for care.*
 1. No grave shall be hereafter opened in the cemetery of this City until perpetual care upon the ~~lot~~plot where the grave is to be opened shall have been contracted for with the City, or perpetual care thereon paid. Should it be the desire of any person to have a grave opened and the body interred therein and perpetual care shall not have been previously contracted for or paid in full for the ~~lot~~plot therein, the person may either pay the full purchase price for perpetual care or enter into a contract wherein payment shall be agreed upon.
 2. Perpetual care or prepaid continued maintenance shall be deemed to include the filling of the grave, the placing of topsoil upon the grave, seeding the grave with grass, and watering and cutting the grass. This fee is collected and kept in a special endowment fund, the interest of which may be used for the general care, maintenance and improvement of the cemetery. This fund aids in the maintenance of the cemetery after it is sold out or finally filled up. Perpetual care fees are included in the charges for certificates of burial rights. Voluntary contributions for the perpetual care fund will be graciously accepted.
- C. *Perpetual care fund.*
 1. *Created.*

- a. There hereby is established a perpetual care fund according to the laws of the state and this chapter. All funds received from the sale of perpetual care services shall be placed in a special perpetual care fund, invested in compliance with the laws of the state and used for the purposes herein provided.
 - b. The income from the perpetual care fund shall be used to pay the upkeep and development of the cemetery. The City may borrow from the fund from time to time, but any funds borrowed shall be repaid to the fund with interest thereon at the prevailing rate paid by the City to borrow funds from commercial lenders.
 - c. If the City borrows from the fund, it shall pay into a fund for the operation of the cemetery the interest accrued upon money annually. Should it be found that the interest returned upon the perpetual care fund shall be more than is required to pay for the operation and upkeep of the City cemetery, then the surplus shall be added to the principal amount of the perpetual care fund herein created, and shall be handled until changed by resolution to provide for the use of such accumulated interest.
2. *Duties of Treasurer.* It shall be the duty of the City Treasurer to keep an accurate record of the perpetual care trust fund account, including investments, to see that the principal portion thereof is properly invested in accordance with resolutions of the City Council and the laws of the state, and to advise the Mayor when funds are available for investment in the amount of \$1,000.00 or more. The Mayor shall advise the City Council of the availability of such funds.
 3. *Duty of City Council.* It shall be the duty of the City Council when funds are available for investment to direct by resolution all purchases of securities for the perpetual care fund or to name a suitable trustee for such investment.
 4. *Income.* All income from investments held in the perpetual care fund shall be quarterly credited to the cemetery maintenance fund for use in providing the perpetual care as required herein.

(1998 Code §§ 8-261, 8-271—8-274; Ord. 2005-20, 9-1-2005; Ord. No. 2022-51, 10-3-2022)

Sec. 7-5-9. Indigents.

- A. The City Council may by resolution designate a portion of the City cemetery to the burial of indigents. Whenever it is made to appear to the City manager by proof submitted to him by the Cemetery Clerk that any person who has died does not have an estate sufficient to pay the purchase price of a ~~lot~~plot in the cemetery, and that the nearest relative or representative of such deceased person desires to have the body of such deceased interred in the cemetery, the City Manager may grant burial space for such deceased person at the request made to him by the Cemetery Clerk.
- B. The City Manager shall communicate his decision to both the Cemetery Clerk and the Cemetery Superintendent. The City Manager shall give report of his decision, whether affirmative or negative, to the City Council at its next regular meeting. All strangers without funds or other persons who may die in the City may be granted the privilege granted herein.

(Ord. 2005-20, 9-1-2005; Ord. No. 2022-51, 10-3-2022)

Sec. 7-5-10. Rules and regulations.

A. *Authority to regulate; procedure.*

1. The City Council may promulgate by resolution such additional rules and regulations concerning the care, use, operation and maintenance of the cemetery as it shall deem necessary.
2. The Cemetery Superintendent may, from time to time as the City Council deems necessary, direct and publish the rules and regulations for the convenience of the purchasers of ~~lotplots~~ in the City cemetery. Such rules and regulations shall constitute a part of the terms and conditions under which owners and users may utilize the cemetery and shall form a supplement to this chapter after they have been adopted as official by resolution of the City Council.
3. Any changes in the rules and regulations shall be adopted by the City Council before such changes shall be official.

B. *~~LotPlots sold.~~* Every ~~lotplot or single grave~~ sold is subject to rules and regulations that have been or may be adopted. The rules and regulations shall be subject to such changes as are found necessary for the protection of ~~lotplot~~ and/or burial right owners, the remains of the dead and the preservation of the cemetery.

C. *Traffic control.*

1. The provisions of the City traffic ordinances relative to the operation of vehicles and conduct of pedestrians shall be in effect in the cemetery, except as herein otherwise modified by this chapter.
2. It shall be unlawful for any person to ride or drive within the City cemetery at a speed greater than five miles per hour.

D. *Children.* Children under the age of 16 years shall not be allowed in cemeteries unless accompanied by their parents or other adults, except for the purposes of attending authorized funerals or, in the company of adults, placing flowers on the grave of a deceased relative or friend, or performing any other customary evidence of respect in accordance with their religious principles.

E. *Animals.* No animal shall be allowed in any cemetery, except in the confines of a vehicle and must be at all times retained within the confines of said vehicle while the vehicle remains in the cemetery.

F. *Decorum.* Cemetery grounds are sacredly devoted to the interment and repose of the dead. Strict observance of decorum due such a place shall be required of all persons.

G. *Errors in opening graves.* Under no circumstances will the City assume responsibilities for errors in opening graves when orders are given by telephone.

~~H. *Religious and fraternal organizations.*~~ ~~The City may contract with religious and fraternal organizations to designate a reasonable portion of the cemetery in which burials may be restricted to members of such religious and fraternal organizations and their families.~~

HI. *Records research*. Copies of cemetery records for research, historical or genealogical purposes will be made available upon payment of copy fees, which are set by resolution of the City Council.

IJ. *Glass containers*. Except for Memorial Day Weekend, glass containers of any kind are not permitted in the City cemetery.

JK. *Decorations; flowers*.

1. *Flowers on new graves*. Decorations or flowers on new graves will be removed by the cemetery crew after five days. Special flower mementos should be removed at the conclusion of services by those interested. After the grave is closed, the casket spray is placed at the center of the grave, other flower containers and wreaths are laid down in an orderly fashion around the spray with the containers extending outward. Only the last row of containers is visible, the other being covered by each succeeding row of flowers. Flowers are laid down to prevent them from being blown around the cemetery by the local winds.
2. *Flower policy*. Flowers properly displayed add to the beauty and character of the cemetery. Flowers are allowed throughout the year. The City and the cemetery staff will not be responsible for flowers or other personal property left in the cemetery.
3. *General cleanup*. All flowers and decorations not in permanent containers and those that are wilted or damaged in permanent containers will be removed from the cemetery during spring cleanup. All flowers and decorations picked up are taken to the county landfill for disposal. Those who bring in decoration intended for use during the entire year are encouraged to wait until after the cleanup following the Memorial Day weekend.

KL. *Memorial Day*. Cemetery crews begin preparation for Memorial Day the Monday prior to the holiday. Preparations, including mowing, trimming and weeding, take the whole week to accomplish. The sprinkling of the grass is stopped on Friday afternoon through the end of Memorial Day to allow for the placement of decorations. Flower regulations as listed above will be strictly enforced. The cleanup of the cemetery will begin the Monday morning following Memorial Day. Anyone desirous of picking up the wreaths or decorations should do so prior to Monday. All decorations are disposed of at the county landfill.

LM. *Burials per grave*. One burial is permitted per ~~lot~~plot. If desired, specific areas of the cemetery are designated for infant and cremation burials.

MN. *Orientation of graves*. By convention, burial spaces are laid out in rows with the head of the grave to the west and the foot to the east. Individual grave tracts usually measure four feet wide by ten feet long. Traditional burial custom had the wife placed to the left side of the husband; however, placement is a matter of choice. The Cemetery Superintendent will assist in the decision as needed.

NO. *Items of monetary value*. Those placing decorations or other items in the cemetery are encouraged not to leave items of monetary value in the cemetery. The City is not responsible for loss, damage, or theft that may occur in relation to items placed in the cemetery.

(1998 Code §§ 8-226, 8-229, 8-230, 8-232, 8-233, 8-300; Ord. 2005-20, 9-1-2005; Ord. No. 2022-51, 10-3-2022)

Sec. 7-5-11. Care and maintenance; right to enter.

The City reserves the right to enter upon any grave and to perform all work necessary for the care and upkeep of all ~~lot~~plots and graves in its cemeteries.

(1998 Code § 8-228; Ord. No. 2022-51, 10-3-2022)

Sec. 7-5-12. Unlawful acts.

A. Injury to property.

1. It is a class B misdemeanor, subject to penalty as provided in section 1-4-1 of this Code, for any person to tie or attempt to tie any horse, animal or motor vehicle to any monument, gravestone, tablet, marker, tree, shrub, fence or enclosure on the premises of the cemetery for the purpose of injuring, defacing or attempting the removal of same.
2. It shall be an infraction, subject to penalty as provided in section 1-4-1 of this Code, for any person to injure, deface, break, destroy or remove any headstone, tombstone, monument, tree, shrub or any other property in the cemetery.

B. Landscaping by private persons. Except as provided by the rules and regulations of the City Council, it shall be unlawful for any person to erect or maintain any fence, corner post, coping or boundary of any kind, to plant any vegetation upon any ~~lot~~plot or ~~lot~~plots, street, alley or walk in the cemetery or to grade the ground or land thereof. The Cemetery Superintendent shall, whenever required, furnish the true lines of any ~~lot~~plots according to official survey, shall prevent and prohibit any markings of the same except by official landmarks, and shall prevent and prohibit any grading thereof that might destroy or interfere with the general slope of the land.

(1998 Code §§ 8-234, 8-235; 2000 Code; Ord. No. 2022-51, 10-3-2022)

Sec. 7-5-13. Placement of markers.

It shall be unlawful for any person to erect, place or cause to be placed any marker or monument on any ~~lot~~plot in the cemetery in violation of the rules and regulations promulgated by the City Council regarding the placement, construction and design of all such markers.

- ##### *A. Ownership and responsibility.* Headstones are personal property. All monuments within the cemetery are the property of ~~lot~~plot owners, their heirs or the responsible party that ordered and placed them. All care and upkeep of the monuments is the responsibility of the owner. The cemetery is maintained by City crews who exercise great care in keeping the grounds groomed. The City will not be responsible for inadvertent scratches and chips that occur from routine maintenance. Such happenings are a condition that go with the privilege of placing markers in the cemetery.

- B. *Size limitations and requirements.* All headstones or markers must be placed on a concrete pad or footing that provides a six-inch border around the base of the headstone or marker. The top of the concrete pad or footing must be flush with the surface of the ~~-groundlawn~~. Monuments and concrete borders must be placed within the boundary of the grave or graves of the owner in conformity with established rows. Monuments for single graves may not exceed 36 inches in width, not counting the concrete border. Monuments for double graves sharing a monument may not exceed 72 inches in width, not counting the concrete border. No monument may exceed a depth of ~~28~~6 inches, including the concrete border. No raised monument may exceed a height of 42 inches above the concrete border. Monuments in the specific areas of the cemetery designated for infant and cremation burials shall be flat monuments with the top of monuments flush with the surface of the ~~groundlawn~~ and shall have maximum widths of ~~36~~28 inches and maximum depths of ~~28~~16 inches. Bench monuments are permitted and are required to maintain the same maximum dimensions as traditional monuments. All permanent vases must be attached to the monument, stone, base or cast into the concrete border. No vases separate from the memorial will be permitted. Memorials will be placed in an orderly manner in predesignated rows as directed by the Cemetery Superintendent. Flat markers, level with the ground, with approval of the Cemetery Superintendent may be installed between established rows. No flower vases or containers, permanent or otherwise, will be permitted on the markers. Only one raised marker is permitted per grave. Family monuments must comply with this section. If a monument is determined by the Cemetery Superintendent to be oversized, interferes with the sprinkler irrigation system, or is otherwise in violation of this chapter, the owner shall pay for the necessary modifications.
- C. *Interference with excavation.* The owner or responsible party is responsible for the removal and replacement of a marker that must be moved for the excavation of a grave, or for the expenses of such service if contracted. If the owner or responsible party wishes, the City will make arrangements for the service with a local monument dealer at the owner's expense.
- D. *Recommendations.* Consult with a monument manufacturer on monument materials suitable to handle conditions at the cemetery. Markers are subject to temperature extremes, snow, ice, sprinkler irrigation water and occasional nicks and chips from mowing equipment. It is recommended that raised markers have a rough nosed base or edge rather than a polished smooth surface.
- E. *Obstructions.* No fences, foot markers or other obstructions or installations except a headstone or monument will be permitted in the cemetery.

(1998 Code § 8-236; 2000 Code; Ord. 2005-20, 9-1-2005; Ord. No. 2022-51, 10-3-2022; Ord. No. 2023-06, 4-20-2023; Ord. No. 2024-10, 8-15-2024)

NOW THEREFORE, BE IT ORDAINED BY THE HURRICANE CITY COUNCIL OF HURRICANE CITY, UTAH THAT:

All ordinances, resolutions, and policies of the City, or parts thereof, inconsistent herewith, are hereby repealed, but only to the extent of such inconsistency. This repealer shall not be construed as reviving any law, order, resolution, or ordinance, or part thereof.

Should any provision, clause, or paragraph of this ordinance or the application thereof to any person or circumstance be declared by a court of competent jurisdiction to be invalid, in whole or in part, such invalidity shall not affect the other provisions or applications of this ordinance or the Hurricane City Municipal Code to which these amendments apply. The valid part of any provision, clause, or paragraph of this ordinance shall be given independence from the invalid provisions or applications, and to this end the parts, sections, and subsections of this ordinance, together with the regulations contained therein, are hereby declared to be severable.

BE IT FURTHER ORDAINED that this Ordinance shall, after adoption and approval, take effect immediately upon publication or posted as required by law.

PASSED AND APPROVED this 6th day of February 2025

Hurricane City

Nanette Billings, Mayor

Attest:

Cindy Beteag, City Recorder

The foregoing Ordinance was presented at a regular meeting of the Hurricane City Council held at the Hurricane City Office Building on the 6th day of February, 2025. Whereupon a motion to adopt and approve said Resolution was made by _____ and seconded by _____. A roll call vote was then taken with the following results:

	Yea	Nay	Abstain	Absent
David Hirschi	_____	_____	_____	_____
Kevin Thomas	_____	_____	_____	_____
Clark Fawcett	_____	_____	_____	_____
Drew Ellerman	_____	_____	_____	_____
Joseph Prete	_____	_____	_____	_____

Cindy Beteag, Recorder



STAFF COMMENTS

Item: Consideration and possible approval of Resolution 2025-15 approving a **Memorandum of Understanding (MOU) for the construction of SR-7 Exit 19 Interchange** and Sand Hollow State Park Entrance.

Discussion: Hurricane City has partnered with Utah State Parks, UDOT, and WCWCD to construct an entry into Sand Hollow State Park at the 3200 West interchange on SR-7. At the request of Utah State Parks, Hurricane City has agreed to manage the design and construction of this project, which will include the design and construction of the exit and entrance ramps for westbound traffic on SR-7, 3200 West Street, a new State Park entrance station and parking area, and associated utilities. A memorandum of understanding has been drafted by the Hurricane City Attorney and circulated amongst the stakeholders for review, and is now ready for approval by each respective board. – Arthur LeBaron

Findings: The proposed MOU has been proposed by Hurricane City and all edits are acceptable to staff.

Recommendation: It is recommended for approval.

MEMORANDUM OF UNDERSTANDING
Construction of SR-7 Exit 19 Interchange and Sand Hollow State Park Entrance

Effective _____, 2025, this Memorandum of Understanding (“MOU”) is made between Utah Division of State Parks, a division of the Utah Department of Natural Resources (“State Parks”); Utah Department of Transportation (“UDOT”); Hurricane City, a Utah municipal corporation (the “City”); and Washington County Water Conservancy District, a Utah water conservancy district (the “District”) (State Parks, UDOT, City, and District are collectively referred to as the “Parties,” or separately as “Party”).

I. AUTHORITY

The statutes authorizing the Parties to enter into this MOU and engage in the activities described herein include, but are not limited to, Utah Code Sections 11-13-101 *et seq.* (Interlocal Cooperation Act, 10-8-1 *et seq.* (Municipal General Powers), 17B-1-1 *et seq.* (Local District Powers), and 17B-2a-1001 *et seq.* (Water Conservation District Act).

II. BACKGROUND

The Parties are cooperating to create a second public access into the Sand Hollow State Park (the “Park”). Presently, Exit 19 on SR-7 is limited to eastbound exit and entrance ramps, and the interchange does not provide public access to the Park. The project will include the construction of westbound exit and entrance ramps, the construction of 3200 West to connect Exit 19 to the Park, and the construction of Park entrance station buildings and associated utilities (the “Project”). The Project is intended to relieve vehicular pressures on the Park’s west entrance and provide a route for off-highway vehicles to access the Park besides the existing tunnel underneath SR-7.

The District owns the property where the Park is located, including where the entrance station buildings will be located. State Parks manages the Park. UDOT has jurisdiction over SR-7 and has already acquired the property where the westbound ramps will be constructed. The Project is located entirely within City limits.

III. COORDINATION OF PARTIES

As more specifically described below in Section IV., State Parks will provide all of the funding for the Project, with the exception of the City’s contribution of a \$2 million grant obtained from the Utah Division of Outdoor Recreation. The City will act as the Project manager and coordinator. The District will authorize access to the Park from Exit 19 and the construction of

Park entrance stations buildings on its property. Each Party will participate in Project team meetings.

IV. RESPONSIBILITY OF THE PARTIES

To accomplish the purposes of the proposed Project described above, the Parties respectively agree to pursue in good faith the following:

A. Utah Division of State Parks

1. Provide all funding for the Project, except for City's contribution of a \$2 million grant obtained from the Utah Division of Outdoor Recreation.
2. Pay approved invoices promptly as they are received.
3. Secure permission or right to construct Project roadways and improvements.
4. Provide design review, and construction management of Park entrance buildings, roads, and other improvements.
5. Participate with the City in the procurement needs of the Project, including the selection of consultants, contractors, and the awarding of bids.
6. Attend all Project team meetings.

B. Utah Department of Transportation

1. Provide design review, of proposed improvements within the UDOT right-of-way.
2. Allow approved construction within the UDOT right-of-way.
4. Attend Project team meetings as necessary.

C. Hurricane City

1. Act as lead in project management.
2. Utilize the City's procurement procedures to secure design and construction services, with input from the other Parties.
3. Receive and forward invoices to State Parks to ensure prompt payment of approved invoices.
4. Host regular Project team meetings.

D. Washington County Water Conservancy District

1. Provide design review of improvements located in District property.
2. Grant permission or right to construct Project roadways and improvements on District property.
3. Attend Project team meetings as necessary.

V. GENERAL

A. Amendment. This MOU may be amended through written agreement of all Parties.

B. Termination. This MOU will end when all of the Parties have fulfilled their respective commitments described above or December 31, 2027, whichever occurs first.

C. Other agreements. Nothing in this MOU limits any Party from entering into other agreements with one another or with third parties.

D. Release. The Parties agree to release one another from any and all loss, injury, damages, debts, obligations, claims, demands, encumbrances, deficiencies, costs, penalties, suits, proceedings, expenses whether accrued, absolute, contingent or otherwise, including, without limitation, attorney's fees and costs (whether or not suit is brought) and other liabilities of every kind, nature and description arising out of performance under this MOU. This release shall survive any termination of this MOU. However, if a third party were to challenge anything arising out of the performance under this MOU, each Party will bear its own costs and incur any liabilities imposed by the third-party action.

E. No third-party beneficiaries. Nothing in this MOU is intended to create any rights, duties, or obligations by the Parties to any person or entity not a party, and this MOU shall not be deemed to give rise to any right by any person or entity not a party against any Party to this MOU. Nothing in this MOU is intended to nor shall be deemed to relieve or discharge the obligation or liability of any person or entity not a party to this MOU.

F. Authorities not altered. Nothing in this MOU alters, limits, or supersedes the authorities and responsibilities of any Party on any matter within their respective jurisdictions. Nothing in this MOU shall require any of the Parties to perform beyond its respective authority.

G. Financial obligations. Nothing in this MOU shall require any of the Parties to assume any obligation or expend any sum in excess of authorization and appropriations available.

H. Immunity and defenses retained. Each Party retains all immunities and defenses provided by law with respect to any action based on or occurring as a result of this MOU.

I. Enforceability. The Parties agree that this MOU does not create any contractual, or any other legal obligation, meant to be enforceable by operation of law.

J. Counterparts. This MOU may be executed in counterparts.

K. Paragraph headings. The paragraph and subparagraph headings used herein are for convenience only and shall not be considered in the interpretation of this MOU.

L. Laws and regulations. Any and all actions performed pursuant to this MOU will comply fully with all applicable Federal, State, and local laws and regulations.

M. Points of contact. Each Party designates below a primary point of contact ("POC") to coordinate all matters concerning the carrying out of activities under this MOU. Any modifications to the POC will be provided in writing to the other parties. The contacts for work related to the project are:

Party	Point of Contact	Address	Telephone	e-mail
State Parks	Chase Prince	646 North Main Cedar City, UT 84721	435-680-1624	chaseprince@utah.gov
UDOT	Tracy Munson	5340 W. 200 S. Hurricane, UT 84737	(435) 590-0252	tmunson@utah.gov
City	Arthur LeBaron	187 N. 870 W. Hurricane, UT 84737	(435) 632-3462	arthur@hurricane.utah.gov
District	Trevor Brown	533 East Waterworks Drive, St. George, UT 84770	(435) 218-9848	trevor@wcwcd.gov

Entered into and effective on the date first written above:

Utah Division of State Parks

By:

Its:

Utah Department of Transportation

By:

Its:

Hurricane City

By: Nanette Billings

Its: Mayor

Washington County Water Conservancy District

By:

Its:

APPROVED AS TO FORM:

Counsel for Utah Division of State Parks

Counsel for Utah Department of State Parks

Counsel for Hurricane City

Counsel for Washington County Water Conservancy District



STAFF COMMENTS

Item: Consideration and possible approval of awarding a contract for the 1100 West Widening Project.

Discussion: The Hurricane City Council directed staff to acquire the road right-of-way and associated public utility easement on the west side of 1100 West from 1300 South to 3000 South to accommodate a transmission powerline. During the acquisition process, many of the property owners requested the City make some improvements on 1100 West which include relocation of utilities along with some safety improvements. The right-of-way acquisition is complete and the City is obligated to fulfill promises made in purchase agreements to relocate irrigation services, etc. by April 1, 2025. The City has completed improvement plans that include all of the obligatory relocations and safety measures, and put it out to bid, with bids being due on February 5, 2025. A bid tabulation and recommendation for award will be sent to the Council as soon as possible after the bid opening.— Arthur LeBaron

Findings: Staff will review the bids and send a recommendation to the Council as soon as possible after the bid opening on February 5.

Recommendation: To be determined.



STAFF COMMENTS

Item: Consideration and possible approval of **Resolution 2025-17 Appointing a representative and alternates to the UAMPS** Board of Directors.

Discussion: Our UAMPS Representative is already set up with Scott Hughes as the representative and Brian Anderson as the alternate. This Resolution will just add Michael Ramirez as an additional available alternate. – Crystal Wright

Findings:

Recommendation:

A RESOLUTION OF THE CITY COUNCIL OF HURRICANE, UTAH, APPOINTING A REPRESENTATIVE TO SERVE ON UAMPS

WHEREAS, Hurricane City is a member of Utah Associated Municipal Power Systems (UAMPS); and

WHEREAS, Hurricane City wishes to appoint a representative of Hurricane City to serve on the UAMPS Board of Directors;

BE IT HEREBY RESOLVED by the City Council of Hurricane City, Utah;

1. That Scott Hughes is hereby appointed as its Representative to Utah Associated Municipal Power Systems (UAMPS) Board of Directors effective immediately, together with such alternate or alternates as the Mayor shall appoint.
2. That the Mayor hereby appoints Brian Anderson and Michael Ramirez as its alternates.
3. That this resolution shall remain in effect until repealed by another resolution appointing a different Representative to UAMPS.

PASSED AND APPROVED this 6th day of February 2025.

Nanette Billings, Mayor

ATTEST:

Cindy Beteag, Recorder

The foregoing Resolution was presented at a regular meeting of the Hurricane City Council held at the Hurricane City Office Building on the 6th day of February 2025. Whereupon a motion to

adopt and approve said Resolution was made by _____ and seconded
by _____. A roll call vote was then taken with the following results:

	Yea	Nay	Abstain	Absent
David Hirschi	_____	_____	_____	_____
Kevin Thomas	_____	_____	_____	_____
Clark Fawcett	_____	_____	_____	_____
Drew Ellerman	_____	_____	_____	_____
Joseph Prete	_____	_____	_____	_____

Cindy Beteag, Recorder



STAFF COMMENTS

Item: Consideration and possible approval of a Declaration of Covenants, Conditions and Restrictions between Hurricane City, Western Mortgage & Realty Company, and the Gateway at Sand Hollow Master Association.

Discussion: To provide for the maintenance and upkeep of landscaping along roadways within the Gateway PID area and within roundabouts, a set of CC&Rs for the Gateway at Sand Hollow Master Association have been drafted. The CC&Rs provide that the Association will provide the maintenance of the landscaping, even though most of the area to be maintained has been dedicated to the City. The intent is to ensure that the roundabouts and roadways, including the privately owned areas between the sidewalks and the privacy walls, are maintained. The City's signature is required on the CC&Rs because the City will grant the Association access and permission to maintain landscaping within the public right-of-way. There are also indemnify provisions between the Association and the City. The proposed CC&Rs are the product of coordination and negotiation between Western Mortgage, the Association's attorneys, and the City. The City Attorney approves the contract as to form. -Dayton Hall, City Attorney.

Findings:

Recommendation:

WHEN RECORDED MAIL TO:
Ruesch Reeve Werrett & Jones, PLLC
86 N 3400 W
Hurricane, UT 84737

**DECLARATION
OF
COVENANTS, CONDITIONS AND RESTRICTIONS**

This Declaration of Covenants, Conditions and Restrictions (“Declaration”), is made and entered into this January 21, 2025, by and between Gateway at Sand Hollow Master Association, a Utah non-profit corporation (“Association”), Western Mortgage & Realty Company, a Washington corporation (“Declarant”) and Hurricane City, a Utah Municipal corporation (“City”). Association, Declarant and City are referred to collectively in this Declaration as the “Parties” or individually as a “Party.”

WHEREAS, Declarant is the owner (or previous owner) of certain real property in Hurricane City, Utah, hereafter referred to in this agreement as the “Property,” which is more fully described in Exhibit A, attached hereto.

WHEREAS, the Property is located within the GATEWAY AT SAND HOLLOW PUBLIC INFRASTRUCTURE DISTRICT 1-3 (“PID”). As such, the Property is subject to the following matters of public record relating to the PID:

1. Resolution No. 2021-10, of the City Council of Hurricane, Utah providing for the creation of Gateway at Sand Hollow Public Infrastructure District No. 1 and as more particularly described in document recorded July 26, 2021, as Entry No. 20210049928, of Official Washington County Records.
2. Resolution No. 2021-10, of the City Council of Hurricane, Utah providing for the creation of Gateway at Sand Hollow Public Infrastructure District No. 1 and as more particularly described in document recorded August 10, 2021, as Entry No. 20210053501, of Official Washington County Records.
3. Notice of Public Infrastructure District Creation Gateway at Sand Hollow Public Infrastructure District No.1 and as more particularly described in document recorded August 10, 2021, as Entry No. 20210053502, of Official Washington County Records.
4. Resolution No. 2021-10, creation of Gateway at Sand Hollow Public Infrastructure District #1, located in Washington County, as more particularly described in document recorded October 22, 2021, as Entry No. 20210068431, of Official Washington County Records.
5. Corrected Local Entity Final Plat, as more particularly described in document recorded November 5, 2021, as Entry No. 20210071482, of Official Washington County Records.
6. Map, as more particularly described in document recorded November 18, 2022 as Entry No. 20220050366, of Official Washington County Records.

7. Certificate of Creation, the GATEWAY AT SAND HOLLOW PUBLIC INFRASTRUCTURE DISTRICT NO. 2, as more particularly described in document recorded November 18, 2022 as Entry No. 20220050367, of Official Washington County Records.
8. Map, as more particularly described in document recorded November 18, 2022 as Entry No. 20220050369, of Official Washington County Records.
9. Certificate of Creation, the GATEWAY AT SAND HOLLOW PUBLIC INFRASTRUCTURE DISTRICT NO. 3, as more particularly described in document recorded November 18, 2022 as Entry No. 20220050370, of Official Washington County Records.

NOW, THEREFORE, Declarant hereby declares that the Declaration for the property shall provide as follows:

ARTICLE ONE PURPOSE AND INTENT

Declarant desires and intends to protect the value and desirability of the Property as a harmonious and attractive commercial, residential, and resort community for the purpose of development. Therefore, Declarant declares that the Property is subject to the covenants, conditions, restrictions, and easements, which along with the governing documents of the Association (“Governing Documents”), provides for a governance structure and a system of standards and procedures for the development, expansion, maintenance, and preservation of the Property as a master planned commercial, residential, and resort community. The Property may also encompass recreational areas, open space, and other areas deemed by Declarant.

Therefore, to effectuate its intent, the Property is subject to the following covenants, conditions, restrictions, and easements, which, along with the Governing Documents, provides for a governance structure and a system of standards and procedures for the development, expansion, maintenance, and preservation of the Property as a master planned community.

The City requires that maintenance of the park strips and certain other landscape improvements or in other words, areas to be maintained by the Association, located within the PID area, adjacent (or in the general vicinity) to the Property (the “Park Strip(s)”) be implemented. The upkeep and maintenance of these Park Strips are essential to ensure a clean, safe, and aesthetically pleasing urban environment while preserving green spaces that contribute to air quality, drainage, and overall community well-being.

ARTICLE TWO DECLARATION

Declarant hereby declares that all of the Property, and such other property that may hereafter be subjected to this Agreement shall be held, sold, conveyed and occupied subject to the following covenants, conditions, restrictions, easements, assessments, charges and liens, and to any applicable Subdivision Plat, and other Governing Documents as set forth herein. This Declaration and applicable Subdivision Plats shall be construed as covenants of equitable

servitude; shall run with the Property and be binding on all parties having any right, title or interest in the Property or any part thereof, their heirs, successors and assigns; and shall inure to the benefit of each Owner thereof.

ARTICLE THREE DEFINITIONS AND CONCEPTS

The following definitions and concepts shall control in this Declaration. Any term not defined in this Declaration shall have its plain and ordinary meaning.

3.1. “Articles” means and refers to the Articles of Incorporation of the Gateway at Sand Hollow Master Association, which are filed with the Utah Division of Corporations and Commercial Code, and includes any amendments or supplements thereto. The purpose of the Articles is to establish the Association as a non-profit corporation under Utah law.

3.2. “Association” means the Gateway at Sand Hollow Master Association, a Utah non-profit corporation, its successors and assigns.

3.3. “Bylaws” means and refers to the Bylaws of the Gateway at Sand Hollow Master Association. The purpose of the Bylaws is to govern the Association’s internal affairs, such as (for purposes of example but not limitation) voting, elections, and meetings. A true and complete copy of the Bylaws in effect as of the date hereof are attached hereto as Exhibit B.

3.4. “City” means and refers to Hurricane City, a Utah municipal corporation.

3.5. “Common Area” means and refers to all real property, which the Association owns, leases, manages or otherwise holds possessory rights in, at any given time, for the common use and enjoyment of the Owners.

3.6. “Common Expenses” means the actual and estimated expenses incurred, or anticipated to be incurred, by the Association for the general benefit of the Owners, including any reasonable reserve, as the Board may find necessary and appropriate pursuant to the Governing Documents.

3.7. “Cost Sharing Covenants” means and refers to any declaration of easements and/or covenants between the Association, the Declarant, and/or any third-parties to share in the cost, maintenance, and use of the Park Strips and/or to provide reciprocal easements to and for such things as roadways, parking areas, common areas, recreational facilities, etc.

3.8. “Declarant” means Western Mortgage & Realty Company, a Washington corporation, and its successors or assigns.

3.9. “Declaration” means this instrument and any amendments, restatements, supplements, or annexations thereto, which are recorded in the office of the Washington County Recorder.

3.10. “Directors”, “Board of Directors”, or “Board” means the governing body of the Association.

3.11. “Governing Documents” means, collectively, this Declaration, the Articles, the Bylaws, the Design Code, and any amendments or supplements thereto, and includes any rules and regulations established pursuant to the Declaration, Articles, Bylaws, or Design Code. Where the context requires, the term Governing Documents shall include any other documents relevant to those Governing Documents heretofore described.

3.12. “Lot” means and refers to: (a) a separately numbered and individually described plot of land shown on any Subdivision Plat designated as a Lot for private ownership (and where the context requires includes and refers to the dwelling structure

located on a Lot), but specifically excludes the Common Area; and (b) a condominium unit established under the Utah Condominium Ownership Act, Title 57, Chapter 8 of the Utah Code.

3.13. “Maintenance Area” means and refers to the area extending from the curb and including (a) the Park Strip, (b) the asphalt sidewalk or trail, (c) the public utility easement beyond the sidewalk or trail, and (d) any additional space up to and abutting the privacy wall of the [Subdivision name], and (e) any roundabouts within the PID. The Maintenance Area, excluding any roundabout, is bounded (a) on the street side by the outer edge of the curb, (b) on the opposite side by the base of the privacy wall, and (c) by the established boundaries of a Subdivision or Parcel.

3.14. “Member” means every person or entity with membership in the Association. Membership in the Association is appurtenant to and may not be separated from Lot ownership. The term “Member” is synonymous with the term “Owner.”

3.15. “Mortgagee” shall mean and refer to any institutional holder, insurer, or guarantor of a first Mortgage.

3.16. “Owner” means the entity person, or group of persons owning fee simple title to any Lot (or other Parcel) within the Property. Regardless of the number of parties participating in ownership of each Lot (or other Parcel), the group of those parties shall be treated as one “Owner.” The term “Owner” includes contract purchasers but does not include persons or entities who hold an interest merely as security for the performance of an obligation (such as a Mortgagee) unless and until title is acquired by foreclosure or similar proceedings.

3.17. “Parcel” shall mean any real property that is not a Lot.

3.18. “Park Strip(s)” means and refers to the landscaped area located between the curb and the sidewalk or trail adjacent to any subdivision within the PID. The Park Strip may include, but is not limited to, grass, trees, shrubs, flowers, ground cover, and any irrigation systems, decorative materials, or other landscaping features installed therein. The Park Strip shall be maintained by the Association, and shall be subject to all applicable landscaping and maintenance standards set forth herein or as otherwise required by law or local ordinances.

3.19. “Public Utility Easement” means and refers to the area beginning at the edge of the asphalt sidewalk or trail (or concrete sidewalk, where applicable) furthest from the street, extending from this edge to the base of the privacy wall, and running parallel to the asphalt sidewalk or trail for the entire length of the Maintenance Area. The area includes all underground and above-ground utility installations within this defined space, such as but not limited to water lines, sewer lines, electrical conduits, telecommunication lines, natural gas lines, utility boxes, meters, and access points.

3.20. “Subdivision” means to that certain parcel or parcels of real property that have been divided into two or more lots, parcels, sites, units, or interests for the purpose of sale, lease, development, or improvement, whether shown on a recorded plat, described by metes and bounds, or otherwise legally created under applicable laws and ordinances. The Subdivision shall include all lots, common areas, easements, and other portions of the property subject to this Declaration, as well as any subsequent phases, additions, or annexations made pursuant to the terms of this Declaration.

3.21. “Subdivision Plat” means any subdivision plat, survey, or plan that describes any portion of the Property or phase thereof and has been approved by the City and recorded in the office of the Washington County Recorder, and includes any replacements thereof, or

supplements, alterations, amendments, or additions thereto. For purposes of this Declaration, the term "Subdivision Plat" includes a condominium plat as defined by the Utah Condominium Ownership Act.

ARTICLE FOUR

LAND USE DESIGNATIONS AND CLASSIFICATIONS; RULES

4.1 Owner's Acknowledgment; Notice to Purchasers. All Owners are given notice that the use and development of their Lots, as the case maybe, and use of the Common Area is limited by the covenants, conditions, restrictions, easements, and other provisions of this Declaration, the other Governing Documents, and Cost Sharing Covenants, as each such document may be amended, expanded, or modified from time to time. Each Owner, by acceptance of a deed (or similar ownership interest) to a Lot, acknowledges and agrees that the use and enjoyment and marketability of its Lot can be affected by said documents. All Lot purchasers are on notice that the Declarant or the Association may have adopted changes to the Governing Documents which might differ from those any purchaser might receive from or have disclosed by the Owner from whom the purchaser is purchasing a Lot. Copies of current Governing Documents may be obtained from the Association.

4.2 Lots; Activities upon Lots. Each Lot is owned in fee simple by the Owner, subject to the covenants, conditions, restrictions, and easements in this Declaration, the provisions of the other Governing Documents, any Cost Sharing Covenants, the Subdivision Plat, and other applicable covenants, conditions, restrictions, and/or easements that may be recorded against the Lot, and any laws and ordinances applicable to the Property.

4.3 Management Agreement; Property Manager. The Board may engage for the Association the services of one or more property managers to perform such duties and services as the Board shall authorize. The Board may delegate to and otherwise authorize the property manager to perform those services to which the Board itself may perform under the Governing Documents or the Utah Community Association Act, and those services to which the Utah Community Association Act otherwise authorizes a manager to perform. Fees, costs, and other charges of the property manager shall be Common Expenses.

4.4 Promulgation of Rules.

(a) Rulemaking Authority. The Board may, from time to time, subject to the provisions of the Governing Documents, adopt, amend, and repeal rules and regulations governing, among other things, use of any Common Area and restrictions on other activities or improvements on the Property which, in the opinion of the Board, create a hazard, nuisance, unsightly appearance, excessive noise, offensive smell, or are otherwise necessary to protect, enhance, or preserve the Property or to address any other matter for which the Governing Documents or Community Association Act expressly or impliedly give the Board the right to regulate.

(b) Rulemaking Procedure. The adoption, amendment, or repeal of any rules shall be performed in compliance with the provisions and requirements of the Community Association Act, Utah Code§ 57-8a-217.

4.5 Design Guidelines. To preserve the aesthetic integrity, architectural harmony, and overall value of the Property, all construction, improvements, modifications, and alterations to any Lot, including but not limited to dwellings, accessory structures,

fencing, landscaping, exterior color schemes, and signage, shall be subject to the design guidelines established by the Declarant attached hereto as Exhibit C. These guidelines may include, without limitation, requirements for architectural style, materials, height restrictions, setbacks, rooflines, exterior finishes, and landscaping standards. No construction, installation, or modification shall commence until the plans and specifications have been submitted to and approved in writing by the Board [or such other entity or person(s)] designated by the Declarant or the Association. The design guidelines may be amended from time to time by the Declarant or the Association, in accordance with the provisions of this Declaration, to ensure the continued quality and desirability of the Subdivision.

ARTICLE FIVE

MEMBERSHIP AND VOTING RIGHTS

5.1. Membership. Every Owner is a Member of the Association. Membership in the Association automatically transfers upon transfer of title to any Lot by the record Owner to another person or entity.

5.2. Voting Rights; Classes. The Association has one class of voting membership, Class A. Class A Members are all Members. Class A Members are entitled to one vote for each Lot owned. When more than one person holds an interest in any Lot, the group of such persons shall be a Member. The vote for such Lot shall be exercised as they among themselves determine, but in no event shall more than one vote be cast with respect to any Lot. A vote cast at any Association meeting by any of such co-Owners, whether in person or by proxy, is conclusively presumed to be the vote attributable to the Lot concerned unless written objection is made prior to that meeting, or verbal objection is made at that meeting, by another co-Owner of the same Lot. In the event an objection is made, the vote involved shall not be counted for any purpose except to determine whether a quorum exists.

5.3. Change of Corporate Status. The Association has been set up and established as a non-profit corporation under Utah law. The continuing existence and viability of the Association, however, is not vested in its corporate status. During any period in which the Association is not incorporated or otherwise has a change of corporate status (e.g., involuntary dissolution under the Utah Nonprofit Corporation Act for failure to file for corporate renewal), the Governing Documents shall nevertheless continue to be effective as the Governing Documents of the Association, and the Board and all officers and committees operating under the authority of the Governing Documents shall have all rights, power, and authority granted therein, and no Lot Owner may escape or avoid any assessment, charge, lien, rule or other matter contained in the Governing Documents by virtue of such change of corporate status. In the case of non-incorporation, the Board is authorized, to the extent it deems necessary, and without approval of the Members, to reincorporate under a same or similar name and such corporation shall be deemed the successor to the Association. In the event the Board does not reincorporate, the Association shall continue to operate and function under the Governing Documents as an unincorporated association.

5.4. Voting Members. Until such time as the Board designates the matters for which the Voting Members will vote, Class A Members who are eligible to vote shall be entitled personally to cast the votes attributable to their respective Lots on any issue on which the Governing Documents requires a vote of Class A Members.

ARTICLE SIX
MEMBERSHIP AND VOTING RIGHTS

6.1 Assessments: Authority. The Association is hereby authorized to levy assessments against the Owners as provided for in the Governing Documents. The following are the types of assessments that may be levied by the Association, which are more particularly described below: (1) annual assessments and charges; (2) special assessments; (3) specific assessments; (4) emergency assessments; (5) any other amount or assessment levied or charged by the Board pursuant to this Declaration; and (6) interest, costs of collection and reasonable attorney fees, as hereinafter provided.

6.2 Creation of Lien and Personal Obligation of Assessments. Each Owner of any Lot by acceptance of a deed therefor, whether or not it shall be so expressed in any such deed or other conveyance, covenants and agrees to pay to the Association all assessments and charges authorized in the Governing Documents. All such amounts shall be a charge on the Lot and shall be a continuing lien upon the Lot against which each such assessment or amount is charged. Such assessments and other amounts shall also be the personal obligation of the person who was the Owner of such Lot at the time when the assessment became due. No Owner may exempt himself from liability for assessments or other charges by non-use of Common Area, abandonment of his Lot, or any other means. The obligation to pay assessments is a separate and independent covenant on the part of each Owner. No diminution or abatement of assessments or set-off shall be claimed or allowed for any alleged failure of the Association, the Board, or Declarant to take some action or perform some function required of it, or for inconvenience or discomfort arising from the making or repairs or improvements, or from any other action they might take.

6.3 Purpose of Assessments. The assessments levied by the Association shall be used to advance the purposes for which the Association was formed, as set forth and articulated in the Governing Documents. The assessments may provide for, but are not limited to, the payment of taxes on Association property; the payment of insurance maintained by the Association; the payment of the cost of repairing, replacing, maintaining the Maintenance Areas; the payment of administrative expenses of the Association; the establishment of capital and operational reserve accounts; the payment of any professional services deemed necessary and desirable by the Board; the payment of expenses pursuant to any Cost Sharing Covenants; and other amounts required or authorized by this Declaration or the Board shall determine to be necessary to meet the primary purposes of the Association. The assessments may provide, at the discretion of the Board, for the payment of other charges including (without limitation) maintenance, management, and utility charges.

6.4 Initial Annual Assessments. The Board shall initially establish the amount of the annual assessments. Thereafter, the establishment of annual assessments shall be according to the procedures and requirements of Section 6.5.

6.5 Annual Assessments: Budgeting.

(a) Adoption of Budget. At least sixty (60) days before the beginning of each fiscal year, the Board shall prepare a budget of the estimated Common Expenses for that year for the purpose of calculating and establishing the annual assessments for the subsequent fiscal year. Annual assessments for Common Expenses shall be based upon the estimated net cash flow requirements of the Association to cover items including, without limitation: the cost of routine maintenance and operation of the Common Area; expenses of management; premiums for insurance coverage maintained by the Association; landscaping expenses; common lighting within the Common Area; routine renovations within the Common Area; wages; common water and utility charges; security services; legal and accounting fees; expenses and liabilities from a previous assessment period; the supplementing of the reserve fund for general, routine maintenance, repairs, and replacement of the Common Area on a periodic basis; the payment of expenses pursuant to any Cost Sharing Covenants; the payment of any telecommunications services; and any other expense authorized or contemplated by this Declaration to be charged to Owners as a Common Expense.

(b) Notice of Budget and Assessment. The Board shall send a copy of the final budget, together with notice of the amount of the annual assessment to be levied pursuant to such budget, to each Owner at least thirty (30) days prior to the effective date of such budget. The budget shall automatically become effective unless disapproved by Members representing at least sixty-seven percent (67%) of the Entire Membership. There shall be no obligation to call a meeting for the purpose of considering the budget except on petition of the Members as provided for special meetings pursuant to the Bylaws. Any such petition must be presented to the Board within fourteen (14) days after delivery of the final budget and notice of the amount of the annual assessment.

(c) Failure or Delay in Adopting Budget. If any proposed budget is disapproved or the Board fails, for any reason to determine the budget for any year, then the budget most recently in effect, and the annual assessments based thereon, shall continue in effect until a new budget and corresponding annual assessment is determined.

(d) Automatic Budget Approval. Notwithstanding the foregoing, if the budget proposed by the Board will increase the annual assessment by no more than 3% of the previous annual assessment, then such budget and corresponding annual assessment shall be automatically approved and effective upon thirty days' notice and the Members shall not have the opportunity to disapprove of the budget and annual assessment.

(e) Adjustment of Budget and Assessment. The Board may revise the budget and adjust the annual assessment from time to time during the year, subject to the notice requirements and the right of the Members to disapprove the revised budget as set forth in Section 4.5(b), provided, however, that such an adjustment is exempt from the requirements of Section 4.5(b) if the adjustment would either decrease the annual assessment or increase the annual assessment by no greater than three percent (3%).

6.6 Special Assessments. In addition to the annual assessments, the Board may levy, in any assessment year, a special assessment, applicable to that year only to cover

unbudgeted expenses or expenses in excess of those budgeted, including but not limited to defraying, in whole or in part, the cost of any construction, reconstruction, repair or replacement of the Park Strips and any structures, fixtures and personal property related thereto. Any such special assessment may be levied against the Entire Membership (excluding Declarant) if such special assessment is for Common Expenses. Except as otherwise provided in this Declaration, any special assessment shall require the affirmative vote or written consent of a majority of the Entire Membership, if a Common Expense. Special assessments shall be payable in such manner and at such times as determined by the Board, and may be payable in installments extending beyond the fiscal years in which the special assessment is approved.

6.7 Specific Assessments. The Association shall have the power to levy Specific Assessments against a particular Lot as follows: to cover the costs, including overhead and administrative costs, of providing services to Lots upon request of an Owner pursuant to any menu of special services which may be offered by the Association. Specific assessments for special services may be levied in advance of the provision of the requested service.

6.8 Emergency Assessments. Notwithstanding anything contained in this Declaration, the Board, without Member approval, may levy emergency assessments in response to an emergency situation. Prior to the imposition or collection of any assessment due to an emergency situation, the Board shall pass a resolution containing the written findings as to the necessity of such expenditure and why the expenditure was not or could not have been reasonably foreseen or accurately predicted in the budgeting process and the resolution shall be distributed to the Members with the notice of the emergency assessment. If such expenditure was created by an unbudgeted utility maintenance or similar expense or increase, the assessment created thereby shall be discontinued by the Board by a similar resolution, if such expense is subsequently reduced, or to the extent the next succeeding annual budget incorporates said increase into the annual assessment. An emergency situation is one in which the Board finds: (a) an expenditure, in its discretion, required by an order of a court, to defend the Association in litigation, or to settle litigation; (b) an expenditure necessary to repair or maintain the Property or any part of it for which the Association is responsible where a threat to personal safety on the Property is discovered; (c) an expenditure necessary to repair, maintain, or cover actual Association expenses for the Property or any part of it that could not have been reasonably foreseen by the Board in preparing and distributing the proforma operating budget (for example: increases in utility rates, landscape or maintenance contract services, attorney fees incurred in the defense of litigation, etc.); or (d) such other situations in which the Board finds that immediate action is necessary and in the best interests of the Association.

6.9 Payment; Due Dates.

(a) The assessments provided for herein shall commence to accrue against a Lot upon conveyance of the Lot to a bona fide purchaser, adjusting the amount of such assessment according to the number of months remaining in the fiscal year.

(b) Assessment due dates shall be established by the Board. The Board may provide for the payment of assessments in equal installments throughout the assessment year on a monthly or quarterly basis.

(c) The Board may require advance payment of assessments at closing of the transfer of title to a Lot.

(d) Payment of assessments shall be applied first to any accrued interest, then to any accrued costs, charges, and fees, and then to the principal amount of the assessment. No Owner shall have the right to direct the Association or its agents or employees to apply payments in any other manner or method and any such attempt to do so will not be recognized.

6.10 Effect of Non-Payment of Assessment; Remedies of the Association. Any assessment or installment thereof not paid within thirty (30) days after the due date therefor shall be delinquent and shall bear interest from the due date at the rate of eighteen percent (18%) per annum (or such lesser rate as the Directors shall determine appropriate) until paid. In addition, the Directors may assess a late fee for each delinquent installment that shall not exceed ten percent (10%) of the installment.

6.10.1 Remedies. To enforce this Article, the Board may, in the name of the Association, and to the extent not prohibited by law:

6.10.1.1 Bring an action at law against the Owner personally obligated to pay any such delinquent assessment without waiving the Association's lien for the assessment;

6.10.1.2 foreclose the lien against the Lot in accordance with the laws of the State of Utah applicable to the exercise of powers of sale in deeds of trust or to the foreclosure of mortgages. or in any other manner permitted by law;

6.10.1.3 restrict, limit, or totally terminate any or all services performed by the Association on behalf of the delinquent Owner; terminate, in accordance with the Utah Community Association Act, Utah Code Ann. § 57-5a-204, the Owner's right to receive utility services paid as a Common Expense and/or terminate the Owner's right of access and use of any recreational facilities, including any Resort Facilities;

6.10.1.4 if the Owner is leasing or renting his Lot, the Board may, in accordance with the Utah Community Association Act, Utah Code Ann. § 57-8a-205, demand that the Owner's tenant pay to the Association all future lease payments due from the Owner, beginning with the next monthly or other periodic payment, until the amount due to the Association is paid;

6.10.1.5 suspend the voting rights of the Owner for any period during which any assessment or portion thereof against the Owner's Lot remains unpaid; and/or

6.10.1.6 accelerate all assessment installments that will become due within the subsequent twelve (12) months so that all such assessments for that period become due and payable at once. This acceleration provision may only be invoked against an Owner who has

been delinquent in paying any assessment or installment two (2) or more times within a twelve (12) month period.

6.10.2 Attorney Fees and Costs. There shall be added to the amount of any delinquent assessment the costs and expenses of any action, sale or foreclosure, and reasonable attorney fees incurred by the Association, together with, where applicable, an account for the reasonable rental for the Lot from time to time of commencement of the foreclosure. The Association shall be entitled to the appointment of a receiver to collect the rental income or the reasonable rental without regard to the value of the other security.

6.10.3 Power of Sale. A power of sale is hereby conferred upon the Association that it may exercise. Under this power of sale, the Association may sell Lots as an enforcement remedy under Section 6.10 in the manner provided by Utah law pertaining to deeds of trust as if said Association were beneficiary under a deed of trust. The Association may designate any person or entity qualified by law to serve as Trustee for purposes of power of sale foreclosure.

6.10.4 Condominium Units. The remedies for nonpayment of assessments for condominium units within the Property shall be made with reference to and in compliance with condominium declarations applicable to such condominium units and the Utah Condominium Ownership Act, Title 57, Chapter 8 of the Utah Code.

6.11 Exempt Property. The following property subject to this Declaration is exempt from the assessments created herein: (a) all property dedicated to and accepted by the City or any other public authority; (b) all Common Area;; and (d) any other property declared exempt from assessments as set forth in this Declaration or within any Subdivision Plat.

6.12 Subordination of Lien to Mortgages. The lien of the assessments provided for herein shall be subordinate to the lien of any first Mortgage held by an institutional lender if the Mortgage was recorded prior to the date the assessment became due. Sale or transfer of any Lot shall not affect the assessment lien. However, the sale or transfer of any Lot pursuant to foreclosure of a first mortgage or any proceeding in lieu thereof, shall extinguish the assessment lien as to payments which became due prior to such sale or transfer. No sale or transfer, however, shall relieve a Lot or Owner from liability for assessments coming due after the Owner takes title or from the lien of such later assessments.

6.13 Books. Records. and Audit.

6.13.1 The Association shall maintain current copies of the Declaration, Articles, Bylaws, rules and other similar documents, as well as its own books, records and financial statements which shall all be available for inspection by Owners and insurers as well as by holders, insurers and guarantors of first mortgages during normal business hours upon reasonable notice. Charges shall be made for copying, researching or extracting from such documents. An Owner or holder, insurer or guarantor of a first Mortgage may obtain an audit of Association records at its own expense so long as the results of the audit are provided to the Association.

6.13.2 The Association shall prepare a roster of Owners in the Property and the assessments applicable thereto at the same time that it shall fix the amount of the annual assessment, which roster shall be kept by the Treasurer of the Association, who shall

record payments of assessments and shall allow inspection of the roster by any Member at reasonable times.

6.13.3 The Association shall, upon demand, and for a reasonable charge, furnish a certificate signed by an officer of the Association setting forth whether the assessment on a specified Lot has been paid. Such certificates, when properly issued, shall be conclusive evidence of the payment of any assessment or fractional part thereof which is therein shown to have been paid.

ARTICLE SEVEN MAINTENANCE COVENANT

Unless otherwise agreed by the City, the Association shall be responsible for all maintenance and repair of the Maintenance Area, including landscaping, irrigation, and other necessary improvements. Accordingly, in connection with the Owner's development of the Property, the City requires, and Association agrees to maintain, the following measures in accordance with the maintenance covenant contained herein. City approval must be obtained prior to any modification or removal of this covenant. Maintenance and repair of the Maintenance Area includes, but is not limited to:

1. Lawn mowing
2. Weed control
3. Tree and shrub trimming
4. Irrigation system maintenance
5. Planting and replacement of vegetation and related landscape improvements as necessary

For purposes of this covenant, the Maintenance Area DOES NOT include the asphalt sidewalk or trail located between the Park Strip and the Public Utility Easement. The City will be responsible for the repair and maintenance of the asphalt sidewalk or trail (or the concrete sidewalk, where applicable).

ARTICLE EIGHT ACCESS EASEMENT

8.1. Access Easement. The City hereby grants and conveys to Association, its successors, assigns, agents, contractors, and employees, a perpetual, non-exclusive access easement (the "Easement") on, over, and across the Park Strips located within the boundaries of the PID, for the sole purpose of accessing, maintaining, and improving the Park Strips. The Easement shall be used by Association solely for the purpose of maintaining and improving the Park Strips, including, but not limited to, performing landscaping, irrigation, planting, and general upkeep. The Easement shall not be used for any other purpose unless otherwise agreed upon in writing by the City. The Easement is granted subject to the right of the public to use and enjoy the Park Strips for any lawful purpose, provided that such use does not unreasonably interfere with Association's rights under this Agreement. Association shall not unreasonably interfere with the public's use of the Park Strips. City agrees to indemnify, defend, and hold harmless Association,

its officers, employees, and agents, from and against any and all claims, damages, losses, liabilities, or expenses (including reasonable attorney's fees) arising out of or related to Association's use of the Easement, including any injury to persons or damage to property, except to the extent caused by the Association's negligence or willful misconduct.

8.2 Indemnification. The Association agrees to indemnify, defend, and hold harmless the City from any claims, damages, or losses arising directly from the Association's maintenance activities within the Maintenance Area, including but not limited to: (a) injuries resulting from negligent maintenance practices (b) property damage caused by Association maintenance equipment or personnel, and (c) environmental damage resulting from improper use of chemicals or landscaping materials within the Maintenance Area. The City agrees to indemnify, defend, and hold harmless the Association from any claims, damages, or losses arising from (a) defects in design or construction of any City-owned infrastructure within the Maintenance Area, (b) the City's actions or omissions in the Maintenance Area, excluding actions or omissions for which Associations has assumed responsibility pursuant to the Maintenance Covenant of this Declaration or for which one or more Owners is responsible. In the event of any claim, damage, or loss arising from a combination of factors for which both parties bear some responsibility, the parties agree to share liability proportionately based on their respective degrees of fault as determined by a court of competent jurisdiction or as mutually agreed upon.

ARTICLE NINE AMENDMENT

9.1 By Class A Members. Except as otherwise specifically provided herein, this Declaration may be amended, modified, extended, or revoked, in whole or in part, by the affirmative vote or written consent, obtained by written ballot or otherwise, or any combination thereof, of Owners representing at least sixty-seven percent (67%) of the total votes in the Association. Notwithstanding the above, the percentage of votes necessary to amend a specific clause shall not be less than the prescribed percentage of affirmative votes required for action to be taken under that clause.

9.2 By Board. The Board has the right to unilaterally amend this Declaration if such amendment is necessary (a) to bring any provision into compliance with any applicable governmental statute, rule, regulation, or judicial determination; (b) to enable any reputable title insurance company to issue title insurance coverage on any Lot; (c) to enable any institutional or governmental lender, purchaser, insurer, or guarantor of mortgage loans to make, purchase, insure, or guarantee mortgage loans on any Lot; (d) to satisfy the requirements of any local, state, or federal governmental agency; or (e) to correct any scrivener's error.

9.3 Validity. Any procedural challenge to an amendment must be made within six months of its recordation or such amendment shall be presumed to have been validly adopted. In no event shall a change of conditions or circumstances operate to amend any provisions of this Declaration.

9.4 Effective Date. Unless a later effective date is specified in the amendment, any amendment shall be immediately effective upon recording in the office of the Washington County Recorder a copy of such amendment accompanied by a verified certificate of the Secretary of the Association stating that the required number of votes or consents was obtained

and that a record of such votes or originals of the consents will be placed on file in the Association's office. In the case of amendment by Declarant as provided for herein, such amendment shall be immediately effective upon recording in the office of the Washington County Recorder with a copy of such amendment signed and verified by the Declarant.

ARTICLE TEN LENDER PROTECTIONS

10.1 Notices. A Mortgagee that provides a written request to the Association, stating the Mortgagee's name and address and the Lot address to which its Mortgage relates, will be entitled to timely written notice of:

- (a) Any condemnation loss or any casualty loss that affects a material portion of the Property or which affects any Lot securing its Mortgage;
- (b) Any 60-day delinquency in the payment of assessments or charges owed by the Owner of any Lot on which it holds a Mortgage;
- (c) Any lapse, cancellation, or material modification of any insurance policy maintained by the Association; and
- (d) Any other matter in this Declaration which authorizes or requires notice to a Mortgagee.

10.2 Failure to Provide Notice. Notwithstanding anything to the contrary in this Declaration, in the event a Mortgagee fails to provide the notice as stated in Section 10.1, the Mortgagee shall be deemed to have waived its right to provide any consent or to receive any notice required to be sent to Mortgagees by the provisions of this Declaration.

10.3 Notice of Objections; Implied Approval. Unless a Mortgagee provides the Secretary of the Association with written notice of its objection, if any, on any matter that requires Mortgagee approval within thirty (30) days following the receipt of notice delivered by certified or registered mail, return receipt requested, of such proposed amendment or action, the Mortgagee shall be deemed conclusively to have approved the proposed amendment or action.

ARTICLE ELEVEN GENERAL PROVISIONS

11.1 Construction and Severability. All of said conditions, covenants, and restrictions contained in this Declaration shall be construed together, but if any one of said conditions, covenants, or restrictions, or any part thereof, shall at any time be held invalid, or for any reason become unenforceable, no other condition, covenant, or restriction, or any part thereof, shall be thereby affected or impaired; and the Declarant, Association and Owners, their successors, heirs and assigns shall be bound by each article, section, subsection, paragraph, sentence, clause and phrase of this Declaration, irrespective of the invalidity or unenforceability of any other article, section, subsection, paragraph, sentence, clause or phrase.

11.2 Implied Rights: Board Authority. The Association may exercise any right or privilege given to it expressly by the Governing Documents, or reasonably implied from or reasonably necessary to effectuate any such right or privilege. All rights and powers of the Association may be exercised by the Board without a vote of the membership except where applicable law or the Governing Documents specifically require a vote of the membership.

11.3 More Restrictive Terms: Conflicts in Further Restrictions. Nothing in this Declaration shall preclude any supplemental declaration or other recorded covenants applicable to any portion of the Property from containing additional restrictions or provisions which are more restrictive than the provisions of this Declaration and, in such case, the more restrictive shall control.

11.4 Duration. The covenants, conditions, restrictions, terms, and easements of this Declaration shall run with and bind the Property, and shall inure to the benefit of and be enforceable by the Association, its respective legal representatives, heirs, successors, and assigns for a term of twenty (20) years from the date this Declaration is recorded, after which time said covenants shall be automatically extended for successive periods of ten (10) years.

11.5 Interpretive Conflicts. In the event of any conflict between the provisions of any of the Governing Documents, the documents shall control in the following order of authority: (1) the Declaration; (2) the Articles; (3) the Bylaws; and (5) any rule, regulation, or resolution passed pursuant to the authority of the foregoing documents. In the event of any conflict between the Declaration and any subsidiary declaration, the provisions of the Declaration shall control. Notwithstanding the above, in the event of any conflict between the provisions of the Declaration and any condominium declaration establishing a condominium regime of unit ownership under the Utah Condominium Ownership Act, the provisions of the condominium declaration shall control.

11.6 Notices. Any notice required to be sent under the provisions of this Declaration shall be deemed to have been properly sent when deposited in the U.S. Mail, postpaid, to the last known address of the person who is entitled to receive it. Members are required to keep the Association informed as to their current mailing address. Notwithstanding the above, the Declarant or the Board may adopt a policy for notification via electronic communication to Members in lieu of notice by mail.

11.7 Gender and Grammar. The singular, wherever used herein, shall be construed to mean the plural when applicable, and the necessary grammatical changes required to make the provisions hereof apply either to corporations or individuals, men or women, shall in all cases be assumed as though in each case fully expressed.

11.8 Waivers. No provision contained in this Declaration shall be deemed to have been waived by reason of any failure to enforce it, irrespective of the number of violations which may occur.

11.9 Topical Headings. The topical headings contained in any article, section, or subsection of this Declaration are for convenience only and do not define, limit, or construe the contents of this Declaration or any provision hereof.

IN WITNESS WHEREOF, the Parties have executed this Declaration as of the day and year first above written.

SIGNATURES ON FOLLOWING PAGE

DECLARANT:

Western Mortgage & Realty Company

By: Tim Tippet
Its: Vice-President

STATE OF UTAH)
)
 : ss.
COUNTY OF WASHINGTON)

On this ____ day of _____ 20____, appeared before me _____ the _____ of _____, Declarant herein, who, his/her identity and position having been satisfactorily established to me, affirmed to me upon oath that the governing body of _____ has authorized her to execute the foregoing document, and did duly acknowledge in my presence having executed the same for the purpose stated therein.

Notary Public

ASSOCIATION:

Gateway at Sand Hollow Master Association

By: Tim Tippet
Its: Director

STATE OF UTAH)
 : ss.
COUNTY OF WASHINGTON)

On this ____ day of _____ 20____, appeared before me _____ the _____ of Gateway at Sand Hollow Master Association, who, his identity and position having been satisfactorily established to me, affirmed to me upon oath that the governing body of Gateway at Sand Hollow Master Association, has authorized him to execute the foregoing document, and did duly acknowledge in my presence having executed the same for the purpose stated therein.

Notary Public

Hurricane City,
a Utah municipal corporation

_____, Recorder

, Recorder

STATE OF UTAH)
 : ss.
COUNTY OF WASHINGTON)

On the _____ day of _____ 20____, personally appeared before me Nanette Billings and _____, who duly acknowledged before me that they are respectively the Mayor and City Recorder of Hurricane City, a Utah municipal corporation, and that they signed the foregoing document on behalf of said city, pursuant to authority granted them by the Hurricane City Council, and for the uses and purposes stated therein.

Notary Public

EXHIBIT A
LEGAL DESCRIPTION

EXHIBIT B
BYLAWS

EXHIBIT C

ARCHITECTURAL AND DESIGN GUIDELINES

ARCHITECTURAL and DESIGN GUIDELINES for “STANDARD RESIDENTIAL” Summary of Architectural Guidelines for the Association’s Standard RESIDENTIAL Neighborhoods.

These Guidelines are recommendations only and are not to be read as mandates. The Guidelines are established to encourage harmony of design and quality construction throughout the Property as defined in the Declaration. Wherever city codes and these Architectural and Design Guidelines may be in conflict, the State, County, or City codes shall prevail.

General Conditions:

Exterior architecture and materials tending to European styling.
Natural color palette to match the local geography.
Timeless styling and long-term quality products on exteriors.
Inset windows wherever possible.
Garages set back at or behind the front elevation plane wherever possible.
Toybox or barndominium homes allowed only on pre-approved lots.

Home exterior walls:

Smooth trowel acrylic finish recommended where stucco is used.
Stone, cultured stone, stucco, brick, cementitious, or batten board finishes with limited tin or lumber accents.
Treated or synthetic exposed wood (to resist weathering).

Roofs:

5:12 pitch or greater at main roof preferred
Flat roofing to be aesthetically completed for benefit of elevated down-views.
HVAC and utilities screened from street views and elevated property views.
Slate or similar composite roof material. Flat shape preferred.
Satellite dishes and antennas screened from street view.
Traditional solar box-panels hidden or screened from street view.

Doors and Windows:

Weather resistant doors and windows preferred
Exterior Door and Garage Door designs to enhance the home appearance.
Shutters, if any, sized to the opening.
Gridded windows preferred.
Inset windows preferred.

Landscape:

Pavers and pervious materials wherever possible.
Masonry yard walls (see appendix for detail)
Metal or wrought iron fencing (see appendix for detail)
Abundance of tree planting.
Down-lighting encouraged.
A green theming with real or artificial grass as the major landscape, with rock and desert theming

as the minor landscape.

ARCHITECTURAL and DESIGN GUIDELINES for “CUSTOM LOT” RESIDENTIAL Summary of Architectural Guidelines for Association Custom Lot RESIDENTIAL Neighborhoods.

These Guidelines are recommendations only and are not to be read as mandates. The Guidelines are established to encourage harmony of design and quality construction throughout the Property as defined in the Declaration. Wherever city codes and these Architectural and Design Guidelines may be in conflict, the State, County, or City codes shall prevail.

General Conditions:

- Exterior architecture and materials tending to European styling.
- Natural color palette to match the local geography.
- Timeless styling and long-term quality products on exteriors.
- Inset windows recommended on all exterior walls.
- Garages set back at or behind the front elevation plane wherever possible.
- Toybox or barndominium homes allowed only on pre-approved lots.

Home exterior walls:

- Smooth trowel acrylic finish where stucco is used.
- Stone, cultured stone, stucco brick, cementitious, or batten board finishes with limited tin or lumber accents.
- Treated or synthetic exposed wood (to resist weathering).

Roofs:

- 5:12 or greater pitch at main roof preferred
- Flat roofing to be aesthetically completed for benefit of elevated down-views.
- HVAC and utilities screened from street views and elevated property views.
- Slate or similar composite roof material. Flat shape preferred.
- Satellite dishes and antennas screened from street view.
- Traditional solar box-panels hidden or screened from street view.

Doors and Windows:

- Weather resistant doors and windows preferred
- Exterior Door and Garage Door designs to enhance the home appearance.
- Shutters, if any, sized to the opening.
- Gridded windows preferred.
- Inset windows preferred.

Landscape:

- Pavers and pervious materials wherever possible.
- Masonry yard walls (see appendix for detail)
- Metal or wrought iron fencing (see appendix for detail)
- Abundance of tree planting.
- Down-lighting encouraged.

A green theming with real or artificial grass as the major landscape, with rock and desert theming as the minor landscape.

ARCHITECTURAL and DESIGN GUIDELINES for “COMMERCIAL”
Summary of Architectural Guidelines for Association COMMERCIAL Neighborhoods.

These Guidelines are recommendations only and are not to be read as mandates. The Guidelines are established to encourage harmony of design and quality construction throughout the Property as defined in the Declaration. Wherever city codes and these Architectural and Design Guidelines may be in conflict, the State, County, or City codes shall prevail.

General Conditions:

Exterior architecture and materials tending to European styling.

Natural color palette to match local geography.

Timeless styling and long-term quality products on exteriors.

Inset windows recommended on exterior walls.

Trees (direct-plant or pots) in landscape.

Storage units allowed only on pre-approved lots.

Building's exterior walls:

Smooth trowel acrylic finish recommended where stucco is used.

Stone, cultured stone, stucco, brick, cementitious, or batten board finishes with limited tin or lumber accents.

Treated or synthetic exposed wood (to resist weathering).

Roofs:

5:12 or greater pitch at main roof preferred

Flat roofing to be aesthetically completed for benefit of elevated down-views.

HVAC and utilities screened from street and elevated property views.

Slate or similar composite material. Flat shape preferred. Tin and other materials approved on a case-by-case basis.

Satellite dishes and antennas screened from street view.

Traditional box solar panels hidden or screened from street view.

Doors and Windows:

Weather resistant doors and windows preferred

Exterior doors (retail, shop or garage style) to enhance building's styling.

Shutters, if any, sized to the opening.

Gridded windows preferred.

Inset windows preferred.

Landscape and parking lots:

A green theming with real or artificial grass as the major landscape, with rock and desert theming as the minor landscape.

Pavers, asphalt, cement, and pervious materials.

Masonry yard walls (see appendix for detail).

Metal or wrought iron fencing recommended. (see appendix for detail).

Down-lighting.

Potted plants and tree wells.

Shading (trees and awnings) over sidewalks and benches.

Traditional box solar panels hidden or screened from street views.

Signage:

LED limited to 14' in height to reduce light pollution. Exceptions considered on a case-by-case basis.

Excessively bright lighted signage discouraged.

Billboards discouraged to minimize visual pollution.

Attached signage on buildings as per city codes.

Monument signage whenever possible.

Pole signage not to exceed 30 feet in height to preserve view corridors. Exceptions considered on a case-by-case basis.

Signage to be maintained to a fresh appearance standard.