Mountain Land Development Services (801) 550-0611 dbatatian@gmail.com

May 9, 2017

Mike Gladbach, P.E.
Public Works Director
Sandy City
8775 South 700 West
Sandy, UT 84070

RE: Review of Surface Fault Rupture Hazard Evaluations for Pepperwood Hills Subdivision, 11000 South Wasatch Blvd., Sandy City- Reports prepared by Simon-Bymaster Inc., (December 30, 2009) *and* Western GeoLogic (January 23, 2015)

Dear Mr. Gladbach,

At your request, and on behalf of Sandy City, I have completed third-party reviews of the above-referenced surface-fault rupture hazard investigations. This work is performed under a contract with Sandy City and Mountain Land Development Services, LLC ("Reviewer" or "the Reviewer") for Third Party Geologic Hazard Reviews. The scope of these reviews included the following:

- Review of a *"Proposed Work Plan – Fault Investigation"* dated May 9, 2007 prepared by Simon-Bymaster Inc. (SBI);
- Field reviews of fault hazard investigation trenches during excavation and logging by SBI in 2007 and 2008;
- Review of proposed site development plans provided in 2007;
- Review of report, *"Fault Investigations, Pepperwood Hills Subdivision, 70+ Acre Residential Parcel, 11000 South Wasatch Boulevard, Sandy, Utah"* prepared by SBI for Mr. David Bromley, Horman and Johnson Enterprises; report dated December 30, 2009 (two volumes: V.1, Fault Investigation; V. 2, Trench Logs).
- Proposed site development plan showing fault setbacks for Pepperwood Hills P.U.D. 11200 S. Wasatch Blvd., Sandy City *("Site Exhibit", "Sheet C-1)* prepared by Stantec Consulting Services, Inc. for Terramerica Corp., plan dated April 8, 2016; and,
- Review of report, *"Surface Fault Rupture Hazard Evaluation, Pepperwood Hills Development, 11000 South Wasatch Boulevard, Sandy, Utah, prepared for Chris Howells, Terramerica Corporation"*, report prepared by Western GeoLogic, LLC, report dated January 23, 2015.

A. Guidance for Third-Party Regulatory Reviews. This review was conducted following published surface fault rupture hazard evaluation guidelines that were in effect at the time of performance. The initial SBI trench logging and field reviews were performed following Utah Geological Survey (UGS) *"Guidelines for evaluating surface-fault-rupture hazards in Utah"* (Christianson, G.E., Batatian, L.D., and Nelson, C.V., UGS Miscellaneous Publication 03-06 (referred to herein as *"UGS Guidelines, 2003")*. In 2016, the UGS updated those guidelines, publishing *"Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah* (Lund, W.R., Christenson, G.E., Batatian, L.D., and Nelson, C.V., 2016 (referred to herein as *"UGS Guidelines, 2016)* as part of a larger volume, *"Guidelines for Investigating Geologic Hazards and Preparing Engineering-Geology Reports, with a Suggested Approach to Geologic Hazards Ordinances in Utah" edited by Bowman, Steve D., and Lund, William R.,* Utah Geological Survey Circular 122. The Reviewer is a co-author of these surface-fault rupture hazard guidelines.

Per the *UGS Guidelines (2016)*, "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... 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."

B. Chronology of Review of Surface Fault Rupture Hazard Investigations for the Proposed Pepperwood Hills Subdivision/P.U.D. Mountain Land Development Services performed the field reviews of SBI's fault hazard investigation trenches in 2007 and 2008 under a contract with Sandy City. Although the final reports were prepared by SBI in late 2009, no formal review of the report was completed, economic conditions not being favorable; and in 2013, the Reviewer accepted full-time employment with a consulting firm. Performance of third-party reviews was deferred until Reviewer's primary employer granted permission for the reviewer to perform work as an independent entity. Subsequently, a new contract was negotiated between the Reviewer and Sandy City. In the interim, the UGS began the process of reviewing and updating their *UGS Guidelines, 2003.* The Reviewer maintained on-going discussions with the City and the project developer, Terramerica Corp., to keep them informed of discussions regarding the guidelines update. The developer engaged Western GeoLogic LLC to conduct an additional surface fault rupture hazard investigation to fill data gaps and further constrain certain faulting parameters, which included excavation and observation of an additional trench WG-T1. This study was completed in January 2015. The contract between the Reviewer and Sandy City was signed November 3, 2015. Terramerica submitted to Sandy City in April, 2016 an updated site plan for Pepperwood Hills P.U.D. *("Site Exhibit", "Sheet C-1)* prepared by Stantec Consulting Services, Inc. which included the fault setbacks as delineated by Western GeoLogic.

This review did not include a field review of the trench excavated by Western GeoLogic in 2015. As noted above, this Reviewer was not under a contract with Sandy City during the field portion of the Western GeoLogic's investigation. However, a representative of the UGS Geologic Hazards Program observed Western GeoLogic's trench, at the time it was excavated and logged. Sandy City has provided the Reviewer with a copy of the Western GeoLogic 2015 report, which (excepting the field review) is part of this review.

C. Review Checklists. As per the *UGS Guidelines (2016),* this Reviewer has completed a *"Surface-Fault-Rupture-Hazard Report Review Checklist"* for both of the consultants' reports. These "Checklists" are attached to this letter, and are incorporated into this review.

- **SBI, 2009.** Refer to attached "Surface-Fault-Rupture-Hazard Report Review Checklist- SBI"
- **Western GeoLogic, 2015.** Refer to attached "Surface-Fault-Rupture-Hazard Report Review Checklist- Western GeoLogic"

Both investigations were performed by highly qualified paleoseismologists with considerable experience conducting surface-fault rupture investigations along the Wasatch fault in Utah. Debris flow deposits observed in fault trench investigations at the site include non-stratified, chaotic deposits that lacked marker horizons, included massive boulders, and were challenging to excavate, log and interpret. The commitment of both investigators to accurately log and interpret faulting relationships within these deposits is notable.

Both reports meet or exceed the requirements of the *UGS Guidelines (2016)*. The two surface fault rupture hazard reports adequately and appropriately identify surface fault rupture hazards to proposed development at the site. "Active" faults are identified through detailed fault trenching studies, supported by lineament and aerial photography analysis, and constrained by both inferred stratigraphic and radiometric age-dating techniques. Faults determined to be "active" are mapped through the site, and non-buildable setbacks from these active faults were established based on the fault dips, presumed basement depth, and criticality factor for the type of proposed residential construction per the *UGS Guidelines (2003 and 2016)*. Within the fault setbacks, residential construction of habitable structures is not permitted, as described below.

D. Recommendations for Mitigation of Surface Fault Rupture Hazard and Considerations for Approval. From the *UGS Guidelines (2016)*: "... 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."

Construction in areas of active faulting is a developing science, The UGS *Guidelines (2016)* reflect the current standard of care for over a decade, and are generally accepted by the geologic hazards community in Utah to be reasonably prudent. However, it is important to note that there has not been a significant normal-faulting earthquake event in the Basin & Range where the effects of surface fault rupture on a highly developed urban area have been observed. These investigations and proposed mitigation reflect the standard of care, but it should be noted they are untested.

The reviewer suggests the City carefully consider the risks in evaluating approval for the proposed development. Even with the proposed setbacks, life safety and property may be at risk. And, like many areas along the Wasatch Fault, this community is likely to experience failure of infrastructure, including utility lifelines, due to a significant earthquake. Every effort should be made to design and construct the planned development with best-available methods for earthquake resilience.

At a minimum, the following recommendations of the Reviewer should be implemented, along with all recommendations provided in the reports by SBI, 2009 (pgs. 16-17) and Western GeoLogic, 2015 (pgs. 10-11). These reports must be carefully read, referenced, and implemented as part of any proposed development planning and approval, design and construction.

1) **Fault Setbacks.** Both reports recommend avoidance of the hazard, using setbacks from the faults as mitigation of the hazard. The fault setback areas are delineated on Western GeoLogic's 2015 report *"Supplemental Figure 5"* (attached). No structures for human habitation, or residential or commercial occupation, shall be permitted within the fault setback areas. The fault setbacks show on Western GeoLogic's *Supplemental Figure 5* must be identified and strictly observed during all site development planning, design/engineering, and construction, including all preliminary and final recorded plat(s), and on any subsequent building and/or zoning plans submitted for development approval, whether for the entire development or for individual parcels.

Per Western GeoLogic's recommendations, areas between closely spaced faults should also be avoided. It should be noted that the plan prepared by Stantec for Pepperwood Hills PUD did not correctly include several fault setback areas between closely-spaced faults as shown on Western GeoLogic's *Supplemental Figure 5*. This should be corrected as part of any future submittal. Roads and streets are generally acceptable within fault setback areas.

2) **IBC Risk Category and Criticality Factor in Setback Area.** The fault setback areas are calculated using a 'criticality' factor derived from the IBC Risk Category of the proposed development. The criticality of the proposed structures is not affected by the change in the proposed development from single family to multi-family residential townhomes shown on the Stantec Site Plan; both development types are within the IBC Risk Category II(a). However should the proposed development be modified to any other type of construction other than IBC Risk Category II(a), or if the IBC standards are modified prior to development, the setbacks will need to be recalculated by Western GeoLogic, Inc. and re-mapped to adjust for any increased criticality factor.

3) **Vulnerability of Utilities and Infrastructure.** Utilities and infrastructure that cross the faults are likely to experience severe ground deformation and disturbance. It is possible that utilities will be so severely affected by surface-fault rupture that service will be interrupted. Every effort should be made to design and construct this planned development with earthquake resilience. Best-available methods should be used during the design and construction of utilities and infrastructure- both above-ground and underground- to ensure post-earthquake integrity and performance, to minimize disruption to the residences and ensure emergency response access. Consultation with a civil engineer regarding redundancy and resiliency is encouraged.

4) **Debris Flow Hazard Evaluation Required.** A debris flow hazard evaluation is required due to the presence of mapped and observed voluminous late-Holocene debris flow deposits deposited across the site. Debris flow hazard analysis and proposed mitigation, if required, should follow Giraud, R.E., 2016, *Guidelines for the geologic investigation of debris-flow hazards on alluvial fans in Utah,* 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:* Utah Geological Survey Circular 122, p. 75–91. A third-party review of the report should be conducted by a qualified, licensed reviewer. Any recommendations for debris flow mitigation must be incorporated into the site development planning, design/engineering, permitting and construction.

5) **Disclosure of Hazard, Recording of Restrictive Covenant.** Disclosure and recording a restrictive covenant is required. Per the *UGS (2016) Guidelines:* "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." See Recommendation 1.

6) Additional Recommendations Provided in SBI and Western GeoLogic Reports. The recommendations provided in the reports by SBI, 2009 (pgs. 16-17) and Western GeoLogic, 2015 (pgs. 10-11) must also be incorporated into any submittals and approvals. These reports must be carefully read, referenced, and implemented as part of any proposed development.

E. Qualifications of the Regulatory Reviewer. This review was prepared by Mountain Land Development Services, LLC, by its principal geologist, L. Darlene Batatian, P.G. Ms. Batatian is a Utah-licensed Professional Geologist with over 30 years of applied geologic experience, including experience and qualifications applicable to the review of surface-fault rupture hazards reports:

- As a geologic field technician for a consulting company, she performed surface-fault rupture investigations in Alquist-Priolo Special Study Areas in California, between 1986-1988.
- In her role as the Salt Lake County Geologist (1998-2006), she reviewed hundreds of land-use applications and specifically was tasked with the review and approval of engineering geology reports prepared and submitted as part of land use applications in geologic hazard areas. Her reviews included surface-fault rupture hazard investigations along the Wasatch fault, involving field reviews of dozens of fault trench excavations performed by consultants, as well as reviewing those reports and preparing recommendations for final land use approvals.
- Ms. Batatian was responsible for the preparation, approval and implementation of *"Salt Lake County Ordinance 19.75 Natural Hazards"*, including *Appendix A: "Minimum Standards for Conducting Surface Fault Rupture Hazard Studies" (2002).* She engaged with both the consulting community and the UGS to develop a standard of care for these studies. In addition to establishing minimum standards for landslide, debris flow, rockfall and avalanche hazard reports in the Ordinance, *Appendix A* described the surface-fault rupture hazard setback calculation methodology that would be subsequently adopted Statewide, for which publications she is also a co-author (*UGS Guidelines, 2003* and *UGS Guidelines, 2016).*
- In the interest of protection of the public, Ms. Batatian was instrumental in a successful 2003 Statewide legislative bill requiring professional licensure for geologists in the State of Utah.
- She has authored and co-authored numerous publications and presentations, and is a former Chair, Association of Engineering Geologists (AEG), Intermountain Chapter.

Thank you very much for the opportunity to provide this review on behalf of Sandy City. If you have any questions, please do not hesitate to contact me.

Sincerely,



Mountain Land Development Services, LLC

L. Darlene Batatian, P.G.

Attachments:

Review Checklist - SBI (2009) Surface-Fault Rupture Hazard Report

Review Checklist - Western GeoLogic (2015) Surface-Fault Rupture Hazard Report

"Supplemental Figure 5" - Western Geologic (2015)

SURFACE-FAULT-RUPTURE-HAZARD REPORT REVIEW CHECKLIST

For additional information, see chapters 2 and 3 of: Bowman, S.D., and Lund, W.R., editors, 2016, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah: Utah Geological Survey Circular 122, p. 15–58.

Report and Review Information

Report Title:Fault Investigation- Pepperwood Hills Subdivsion, December 30, 2009			
Report Type: _ Reconnaissance _ Preliminary _X Final _ Combined Engineering Geology/Geotechnical _ Other			
Author: SBI Simon Bymaster Inc.	Project #: 2-07-359	Adequately Documented	Additional Information Needed
Location: 11000 South Wasatch Blvd Sandy, Utah	County: Salt Lake County		
Reviewing Organization: Mountain Land Development Services LLC	File #:		
Reviewed By: Darlene Batatian	Utah PG License #: 5242877-2250		
First Review: November 17, 2016 Review # _1__	Final Approval: March 23, 2017		

1. Investigation/Report Purpose and Scope

Are the purpose and scope of the surface-faulting investigation appropriate and adequate for the proposed project?	X	
Review Comments:		

2. Project Description and Location

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.	X	
Review Comments: Residential; IBC Occupancy Class R-3; basements to 10 ft; see pg 11		

3. Literature Review

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?	X	
Review Comments:		

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.	X	
Review Comments:		

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.	X	
Review Comments: Personius & Scott, 1992; Black and others, 1996		

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	X	
Review Comments: Figures 2-6		

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.	X	
Review Comments: Trench logs are detailed, accurate representation of trench exposures per my field trench reviews. See note in Western GeoLogic (2015) pg. 8, regarding minor discrepancies on SBI's trench logs (reversed trench end labels, depth of fault survey locations, etc. Western GeoLogic's report & maps supercede SBI's trench fault locations.		

8. ~~Borehole and CPT Logs~~ Radiocarbon Age Data (Appendix C)

Are boreholes and CPT soundings appropriately located and interpreted for the proposed project? NA 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.	Age Dating X	
Review Comments: Appendix C, Radiocarbon Age Data (Trench T-3) summarizes AMS radiocarbon age results derived from bulk samples, that constrain maximum age of faulting along fault f-1 in Trench 3 to post 6,555 RC years BP.		

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.	NA	
Review Comments:		

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.	X	
Review Comments: SBI's conclusions define active faults at the site, and provide setback calculations from each fault based on Christenson & others (2003)- similar to current *UGS Guidelines for Evaluating SFR Hazards in Utah, 2016.*		

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.	X	
Review Comments: SBI's conclusions define active faults at the site, and provide setback calculations from each fault based on Christenson & others (2003)- similar to current *UGS Guidelines for Evaluating SFR Hazards in Utah, 2016.* Fault setbacks are detailed in Appendix F, and shown on Drawing 1.		

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/.	X	
Review Comments:		

Review Summary, Notes, and Reviewer Professional Geologist (PG) Stamp *Review Comments:*

SBI's trenching study was thorough and exhaustive, yielding detailed trench observations accurately reflected in the trench log drawings. SBI's commitment to completing a detailed fault rupture exploration endured in spite of very difficult trenching conditions including chaotic debris flow materials that lacked marker horizons, often encountering very large boulders. An excellent and detailed report. A follow-up report at this site by Western GeoLogic, 2015 addressed a data gap and corrected some minor discrepancies in SBI's report; Western GeoLogic's report and map should be referenced for final fault setback locations. Refer to Reviewer's letter for final recommendations for approval. A debris flow analysis should also be completed. - Mountain Land Development Services, LLC.	3-21-2017 LICENSED PROFESSIONAL GEOLOGIST L. DARLENE BATATIAN 5242877-2250 STATE OF UTAH Reviewer's Utah PG Stamp

SURFACE-FAULT-RUPTURE-HAZARD REPORT REVIEW CHECKLIST

For additional information, see chapters 2 and 3 of: Bowman, S.D., and Lund, W.R., editors, 2016, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah: Utah Geological Survey Circular 122, p. 15–58.

Report and Review Information

Report Title: Surface Fault Rupture Hazard Evaluation- Pepperwood Hills Development, January 23, 2015			
Report Type: _ Reconnaissance _ Preliminary _X Final _ Combined Engineering Geology/Geotechnical _ Other			
Author: Western GeoLogic, LLC	Project #: NA	Adequately Documented	Additional Information Needed
Location: 11000 South Wasatch Blvd Sandy, Utah	County: Salt Lake County		
Reviewing Organization: Mountain Land Development Services LLC	File #:		
Reviewed By: Darlene Batatian	Utah PG License #: 5242877-2250		
First Review: November 20, 2016 Review # _1__	Final Approval: March 23, 2017		

1. Investigation/Report Purpose and Scope

Are the purpose and scope of the surface-faulting investigation appropriate and adequate for the proposed project?	X	
Review Comments: The purpose was to evaluate the hazard, based on data from prior studies (SBI, 2009) which includes data from Black and others (1996); and including supplemental trenching to address a data gap.		

2. Project Description and Location

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.	X	
Review Comments: see pg. 9: IBC Class R residential structures; basements to 10 ft		

3. Literature Review

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?	X	
Review Comments: The author of this report is Bill Black, main author of Black and others (1996)- references are appropriately incorporated into conclusions, and appropriately cited.		

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.	NA	
Review Comments: NA- summary report; aerial photograph analysis not necessary,		

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.	X	
Review Comments: Figure 2, per Personius & Scott, 1992		

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	X	
Review Comments: Figure 2, per Personius & Scott, 1992; setback map Figure 5		

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.	X	
Review Comments: Trench log is detailed. Note that this reviewer was not able to field-review this trench, but Mr. Black is a highly qualified paleo-seismologist; the trench log details are consistent w/ SBI's trench observations.		

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8. Borehole and CPT Logs Radiocarbon Age Data (Appendix C) 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.	NA	
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.	NA	
Review Comments:		

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.	X	
Review Comments: Western GeoLogic's conclusions corroborate the presence of active faults at the site, and provide setback calculations from each fault based on current *UGS Guidelines for Evaluating SFR Hazards in Utah, 2016.*		

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.	X	
Review Comments: Western GeoLogic's recommendations corroborate the presence of active faults at the site, and provide setback calculations based on current *UGS Guidelines for Evaluating SFR Hazards in Utah, 2016.* Fault setbacks are detailed in Tables 1, 2, and shown on Figure 5*.		

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/.	X	
Review Comments:		

Review Summary, Notes, and Reviewer Professional Geologist (PG) Stamp *Review Comments:*

A thorough report by an experienced paleo-seismologist very familiar with the site and faulting history. Western GeoLogic's SFR Hazard Evaluation addresses a data gap and corrected minor discrepancies in SBI's (2009) report.

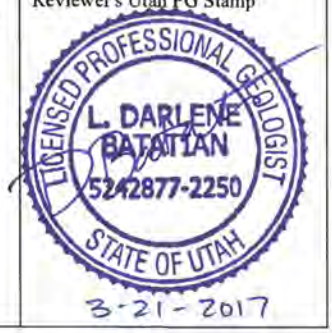
*Western GeoLogic's report and map (Figure 5) should be referenced for final fault setback locations.

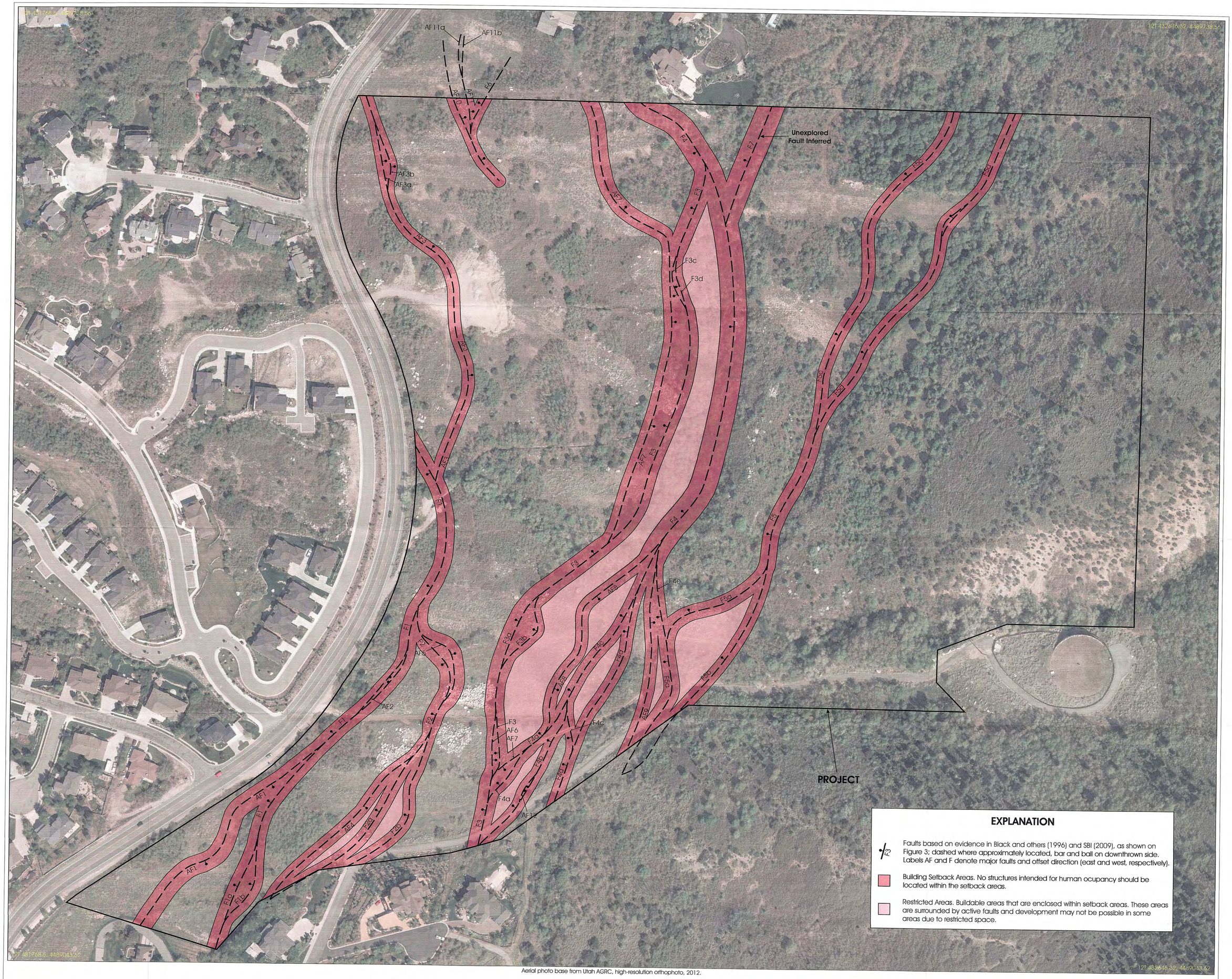
Refer to Reviewer's letter for final recommendations for approval.

Note: A debris flow analysis should also be completed.

- Mountain Land Development Services, LLC.

Reviewer's Utah PG Stamp





Aerial photo base from Utah AGRC, high-resolution orthophoto, 2012.

N
W E
S

0 50 100 feet

Scale 1:1,200
(1 inch = 100 feet)

WESTERN GEOLOGIC

SETBACK MAP

SURFACE FAULT RUPTURE HAZARD EVALUATION
Pepperwood Hills Development
Approximately 11000 South Wasatch Boulevard
Sandy, Utah

FIGURE 5