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MEMORANDUM

To: **Matt Rasmussen**

From: **Timothy J. Thompson, P.G.**
Hiram Alba, P.E., P.G.
Daniel J. Brown, E.I.T.

Date: **September 8, 2015**

REGISTERED PROFESSIONAL ENGINEER 09/08/15 HIRAM ALBA 175774 STATE OF UTAH

LICENSED PROFESSIONAL GEOLOGIST # 5242839 TIMOTHY J. THOMPSON 9/8/15 STATE OF UTAH

Subject: **Review Response for Third Geological Review Matt Rasmussen Hillside Review 6472 South Bybee Drive, Ogden, Utah, 84403 SA Project No. 15-140**

GeoStrata has received review questions of our report titled **Review Response for Geological Review – 6472 and 6498 South Bybee Drive, Weber County Parcel Numbers: 07-753-0001 and 07-753-0002 Uintah, Weber County, Utah, SA Project Number 15-140**, GeoStrata Job Number 910-001 and dated July 9, 2015. This report was prepared for Mr. Matt Rasmussen and submitted to Weber County for review. Mr. Alan Taylor of Taylor Geotechnical (TG) prepared a review of our report. This memorandum was prepared in response to a series of review questions prepared by Mr. Taylor and dated August 5, 2015.

TG Review Comments

1. *Respond to geological comments in the Simon Associates, LLC (SA) third geologic review letter by SA dated August 4, 2015.*

GeoStrata Response: A response to review comments from Simon Associates, LLC (SA) has been prepared and submitted.

2. *Specify all variables used in calculating debris flow volume for the property in the July 9, 2015, GeoStrata Memorandum, such as:*

    a. *S (basin area with slopes greater than or equal to 30%, sq km);*

    b. *B (basin area burned at moderate and high severity, sq km); and,*

    c. *Rainfall data obtained from the NOAA Atlas 14, Volume 1, Version 5 Point Precipitation Frequency Estimates for the subject drainage basin (i.e. R, total storm rainfall, mm) (i.e., presumably "... a rainstorm event with a 10-year recurrence interval and 60 minute duration).*

GeoStrata Response: As per review comment 4 of the SA August 4, 2015 geologic review, for calculation of fire related debris flow volume, the more conservative result from the different equations from Giraud and Castleton (2009) and Cannon and others (2010) should be used at the subject site. For reference, the Giraud and Castleton (2009) regression model for the Western U.S. is:

$$\ln V = 0.59(\ln S) + 0.65(B)^{1/2} + 0.18(R)^{1/2} + 7.21$$

where:
V = volume (cubic meters)
S = basin area with slopes greater than or equal to 30% (square kilometers)
B = basin area burned at moderate and high severity (square kilometers)
R = total storm rainfall (millimeters)

The regression model from Cannon and others (2010) is:

$$\ln V = 7.2+0.6(\ln A) + 0.7(B)^{1/2} + 0.2(T)^{1/2}+0.3$$

where:
V = volume (cubic meters)
A = basin area with slopes greater than or equal to 30% (square kilometers)
B = basin area burned at moderate and high severity (square kilometers)
T = total storm rainfall (millimeters)

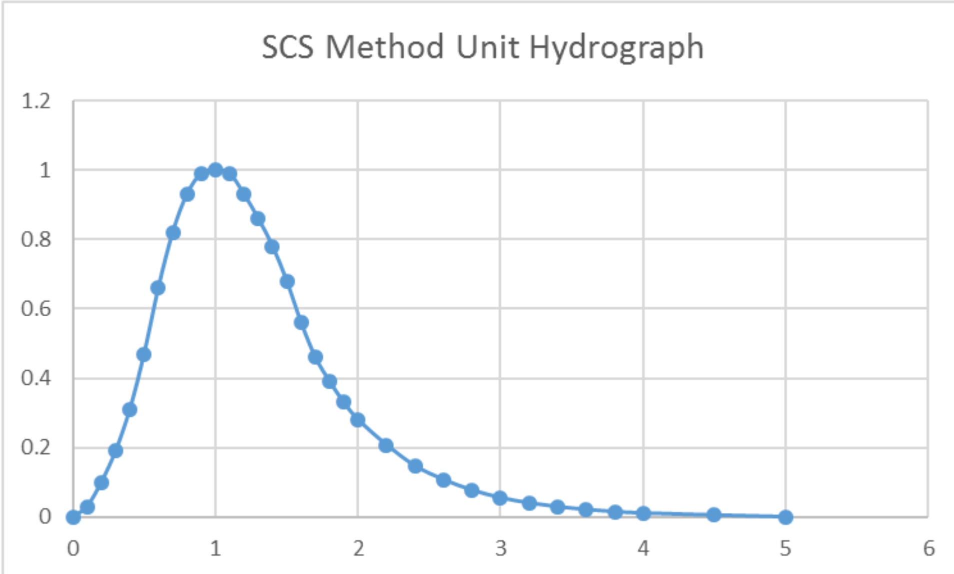
A printout of our calculations, showing inputs and outputs for the regression model is included as Plate 1. Based on our calculations, the fire related debris flow volume predicted by the Cannon and others (2010) intermountain western United States post-wildfire debris flow regression model for a maximum rainstorm event with a 10-year recurrence interval and a 60 minute duration is 6.2 acre-feet.

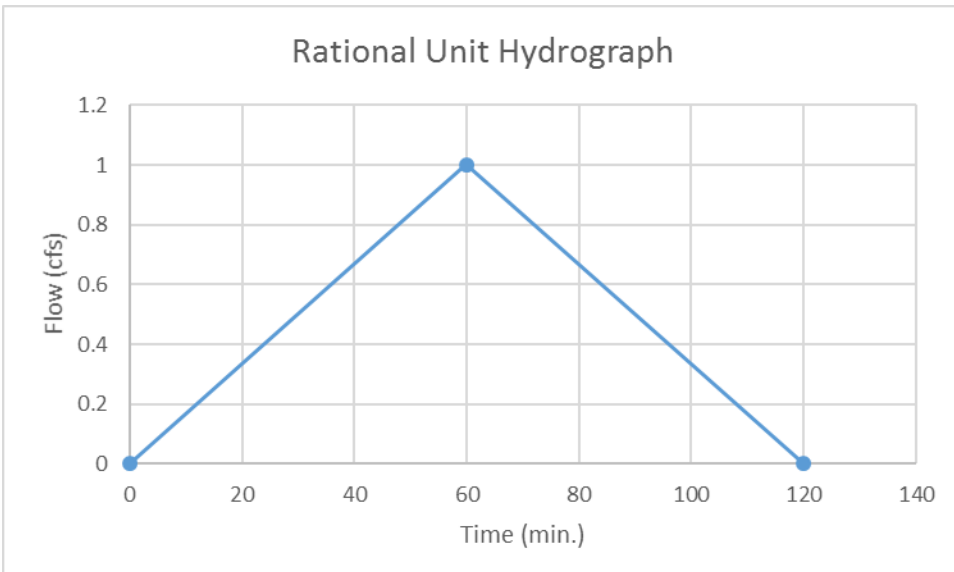
3. Provide hand calculations to support the estimated debris flow volume of 4-acre feet (i.e., associated with "... a rainstorm event with a 10-year recurrence interval and 60 minute duration).

GeoStrata Response: A printout of our calculations, showing inputs and outputs for the Cannon and others (2010) regression model is included as Plate 1.

4. Provide a copy of the "...unit rational hydrograph..." used to estimate a peak debris flow volume of 48.9 cfs for the property and provide hand calculations and data to validate a peak debris flow volume of 48.9 cfs.

GeoStrata Response: Unit hydrographs from the SCS method and the rational method of hydrological analysis are presented below.





It is assumed that when the reviewer asks for data relating to "peak debris flow volume of 48.9 cfs" that it does not refer to the volume of a debris flow, but to the rate of flow.

Our analysis shows that the peak flow calculated from the rational unit hydrograph gives a more conservative result; therefore, this method was used in the design of the channel cross section.

As per review comment 5 of the SA August 4, 2015 geologic review, debris flows that could result from rapid snowmelt/rainfall were analyzed. According to our analysis, the maximum potential debris flow volume is estimated to be 16.1 ac-ft. With this modified debris flow volume, our calculation for the maximum flow rate has also been modified to 193.6 cfs. Hand calculations are attached as Plate 2.

5. Provide hand calculations that substantiate "Velocity of the debris flow at peak flows will be 12.7 feet per second."

GeoStrata Response: As the debris flow volume and flow rates have changed, so has the calculated debris flow velocity at peak flows. The updated calculation for debris flow velocity at peak flow is 13.0 feet per second. Calculations are attached as Plate 3.

6. Provide hand calculations, including derivation of all variables, for the channel depth and run-up height based on the equations in Prochaska and others, 2008. Additionally, GeoStrata should clarify why equation (10) and not equation (3) in Prochaska and others, 2008 was utilized in the run-up height analysis.

GeoStrata Response: It is assumed that the reviewer is referring to equation (4) from Prochaska and others (2008) and not equation (3) as equation (3) is a formula developed by Gartner and others (2007) for the prediction of debris flow volumes from recently burned drainage basins in the western United States. Equation (4) from Prochaska and others (2008) is a model to predict the runup height on a berm within a debris basin where the debris flow is perpendicular to the berm. Equation (10) calculates the superelevation height of a debris flow within a channel and was used in our analysis because it applies to the subject property.

The following table presents the inputs and outputs utilized in our calculations for superelevation height and the height of the debris flow deflection berm.

Velocity (v)	13.0	**ft/sec**
Flow width (b)	11.0	**ft**
Radius of curvature (Rc)	221.8	**ft**
Acceleration of gravity (g)	32.2	**ft/s^2**
Superelevation height (Δh)	0.26	**ft**
Depth of flow (h)	2.5	**ft**
Height of debris flow deflection berm (hB)	5.7	**ft**

7. Provide cross sections and velocity of the channel upslope and down slope of the property along with the channel gradient. It should be noted that the regression model used by GeoStrata to calculate the height of the debris flow deflection berm is based on the following assumptions (Prochaska and others, 2008), i) The cross sectional area of flow behind the deflection berm is at least as large as the cross sectional area of flow in the natural channel upstream of the berm, and; ii) Flow velocity behind the berm is similar to flow velocity in the channel upstream of the berm.

GeoStrata Response: A cross section of the natural channel upstream of the property is attached as Plate 4. The channel downstream of the subject property has been modified by various developments, including Bybee Drive and several residences, and any analysis of the channel downstream of the subject property is outside of the scope of this study. The velocity of the peak debris flow in the natural channel upstream of the subject property is estimated to be 13.6 feet per second. Cross sectional area of the flow upstream of the subject property is 14.3 square feet, and cross sectional area of flow within the modified channel is 14.9 feet squared.

8. Provide an explanation of how a debris flow would impact the property at the storm drain inlet structure located on the Silverpeak site grading plan.

GeoStrata Response: If the storm drain inlet structure is built as designed in the October 2014 Silverpeak Engineering Grading / Drainage Plan, a maximum debris flow event would likely fill the pipe with sediment and then jump the channel.

9. Provide recommendations substantiated with hand calculations related to the debris flow and the storm drain structures so that they can be clearly depicted on the site grading plan.

GeoStrata Response: GeoStrata recommends that either the pavement for the firetruck turn around be redesigned so that it does not encroach on the channel, or that a culvert designed by a civil engineer be constructed to the dimensions specified in our channel cross section.

10. Provide the elevation(s) of the top of the diversion structure/retaining wall.

GeoStrata Response: The elevation of the bottom of the retaining wall drawn on the Silverpeak Grading / Drainage Plan is 4951 ft. At that point in the channel, the top of the deflection berm should be constructed at or below this elevation.

11. Provide the minimum height of the reinforced concrete foundation for the proposed residential structure (it is important that the wood frame of the structure is not compromised by potential debris flow.

GeoStrata Response: The design of the channel is intended to divert debris flow from impacting the proposed residence. Our analysis indicates that all debris flows will be contained within the designed channel, therefore, no additional height of foundation walls is being recommended for the structure.

12. Provide structural mitigation for reducing impacts of potential debris flow on the proposed structure (i.e., restriction of basement windows on the uphill (east) side of the home, etc.).

GeoStrata Response: See GeoStrata response to comment 11.

13. Provide the debris flow setback from the drainage for the proposed structure, including all supporting calculations.

GeoStrata Response: The easement designed in the hydrology report as presented on the Grading / Drainage Plan by Silverpeak Engineering is 50 feet wide and centered on the drainage. The width of the top of the channel as designed is 26 feet. It is the opinion of GeoStrata that the designed setback of 50 feet, along the drainage, with the designed channel cross section of 26 feet is sufficient to mitigate the debris flow hazard.

14. Provide hand calculation to corroborate the statement: "At this capacity the depth of flow within the channel would be approximately 1.5 feet.

GeoStrata Response: The calculation of the depth of flow within the channel is an iterative process where the depth is iterated until the output velocity and cross sectional area of the flow in the channel match the predicted peak flow. This was done using the inputs and outputs presented on Plate 3.

15. Substantiate that the proposed changes to the drainage channel do not increase the debris flow risk to downslope (west) properties.

GeoStrata Response: The drainage channel has been a conveyance structure for water, alluvial sediment, and debris flow sediment that have been transported from the canyon east of the subject site to the alluvial fan which is located west of the subject site on the valley floor. The proposed changes to the channel are intended to reduce the hazard associated with avulsion of water and sediment flow from the channel as flows transport through the channel and across the subject property. The proposed changes to the drainage channel do not increase the amount of water and sediment that may enter the channel from the canyon up-gradient of the subject site to the east, nor do the proposed changes change the release point of the existing channel on the downstream side of the subject site. The purpose of our investigation is to provide for safe conveyance of the debris flows across the subject property. Our design accomplishes this goal. The property owner cannot be held responsible to damage to other properties that have not been appropriately mitigated for this hazard.

Impacts to properties downstream from the subject property were not assessed for this study as this is outside of the scope. It is the opinion of GeoStrata that these properties will be negatively impacted by a debris flow event. The channel has been significantly modified by the construction of Bybee Drive and several residential properties west of the subject site. Future flow of water and sediment west of the subject property is not predictable in our opinion and we recommend that Weber County assess the debris flow hazard associated with these properties in order to provide hazard mitigation.

16. Stipulate who will be responsible for maintaining the storm drain structures shown on the Silverpeak grading plan.

GeoStrata Response: It is assumed that the property owner will be responsible for maintenance of the private storm drain structures on the subject property. This should be stipulated by the property owner.

17. Provide a recommended maintenance program and schedule for maintaining the storm drain structures shown on the Silverpeak grading plan.

GeoStrata Response: Maintenance of storm drain structures is outside of the scope of this study.

18. GeoStrata should provide a gradation for the rip-rap recommended in the channel in accordance with Prochaska 2008.

GeoStrata Response: In accordance with Prochaska and others (2008), the recommended riprap size for the channel is 24 inches.

19. Show all applicable recommendations on the civil engineering site grading plan and structural plans for the proposed residential structure.

GeoStrata Response: GeoStrata recommends that all applicable debris flow hazard mitigation recommendations be incorporated into the final civil engineering site grading plan and structural plans for the proposed structure.

Closure

The conclusions and recommendations contained in this memorandum which include professional opinions and judgments, are based on the information available to us at the time of our evaluation, the results of our field observations, our limited subsurface exploration and our understanding of the proposed site development. This memorandum was prepared in accordance with the generally accepted standard of practice at the time the report was written. No other warranty, expressed or implied, is made. Development of property in the immediate vicinity of active faults involves a certain level of inherent risk.

This memorandum was written for the exclusive use of Matt Rasmussen and only for the proposed project described herein. It is the Client's responsibility to see that all parties to the project including the Designer, Contractor, Subcontractors, etc. are made aware of this memorandum in its entirety. We are not responsible for the technical interpretations by others of the information described or documented in this memorandum. The use of information contained in this memorandum for bidding purposes should be done at the Contractor's option and risk.

References

Cannon, S. H., Gartner, J.E., Rupert, M.G., Michael, J.A., Rea, A.H., and Parrett, C., 2010, Predicting the Probability and Volume of Postwildfire Debris Flows in the Intermountain Western United States, Geological Society of America GSA Bulletin; January/February 2010; v. 122; no. 1/2; p. 127-144.

Giraud, R.E. and Castleton, J.J., 2009, Estimation of Potential Debris-Flow Volumes for Centerville Canyon, Davis County, Utah, Utah Geological Survey Report of Investigation 267, 33 p.

HydroPlot, September 4, 2014, Drainage Evaluation for the Dauphine'-Savoy-Piedmont Subdivision, Lot #2, Ogden, UT, p 3., unpublished consultant report.

Hungr, O., Morgan, G.C., and Kellerhals, R., 1984, Quantitative analysis of debris torrent hazards for design of remedial measures, Canadian Geotechnical Journal, v. 21, p. 663-677.

Silverpeak Engineering, 10-17-2014, Rasmussen Residence Weber Canyon Uinta County, Utah, Wash Grading Plan, Grading/Drainage Plan, p C1.0 - C2.0., Unpublished consultant plan set.

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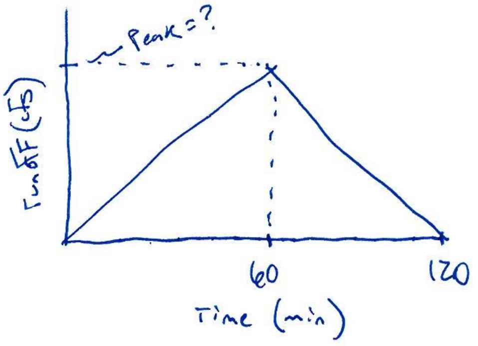
$\ln V = 7.2 + 0.6(\ln A) + 0.7(B)^{(1/2)} + 0.2(T)^{(1/2)} + 0.3$

V	Volume
A	Area with slopes greater than 30%
B	Area burned at moderate to high severity
T	Total storm rainfall

Broad Hollow WS

B	0.60	**sq km**		
A	0.56	**sq km**		
T-2 year	16.7	**mm**		
T-5 year	22.6	**mm**		
T-10 year	27.9	**mm**		
T-100 year	53.6	**mm**		
V-2 year	6042.183	**m^3**	4.9	**ac-ft**
V-5 year	6907.303	**m^3**	5.6	**ac-ft**
V-10 year	7677.514	**m^3**	6.2	**ac-ft**
V-100 year	11533.87	**m^3**	9.4	**ac-ft**



A - area
V - volume
h - height (peak runoff)
b - base (storm duration x2)

$V = 16.1$ ac-ft
$= 701{,}316$ ft^3

$A = \frac{1}{2} b h$

$V = \frac{1}{2} b h$

$h = V / \frac{1}{2} b$

$h = 701{,}316\ ft^3 / \frac{1}{2}(120\ min)\left(\frac{60\ sec}{min}\right)$

$= 193.6$ cfs

GeoStrata

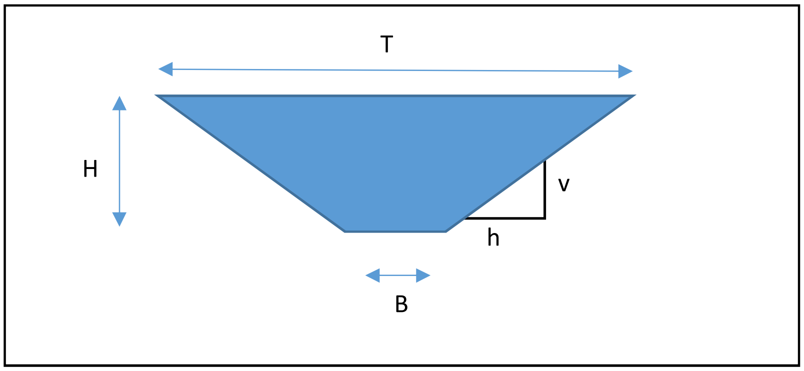
Hand Calculations – Flow Rate

Matt Rassmusen
Dauphine-Savory Piedmont Subdivision
South Weber, UT
Project Number: 910-001

Plate 2

Trapezoidal channel

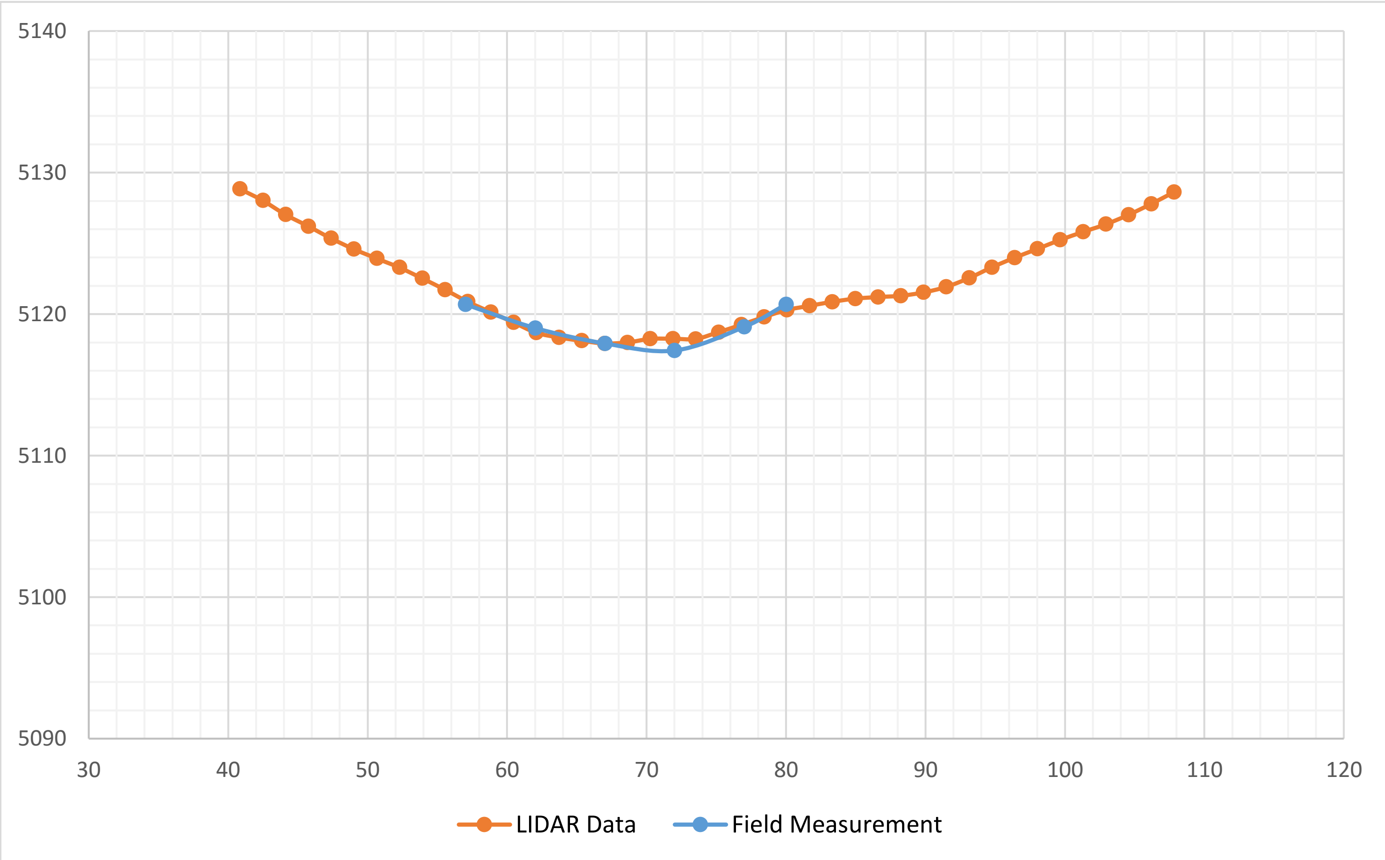
H	2.490
B	1
T	10.96
A	14.89
P	12.14
h	2
v	1



k	1.49
n	0.050
A	14.9
P	12.1
S	0.144718

$$V = \frac{k}{n} \times \frac{A}{P}^{2/3} \times S^{1/2}$$

V **13.0 ft/s**



GeoStrata

Natural Upstream Channel Cross Section

Matt Rassmusen
Dauphine-Savory Piedmont Subdivision
South Weber, UT
Project Number: 910-001

Plate 4