GeoStrata 14425 S. Center Point Way, Bluffdale, Utah 84065
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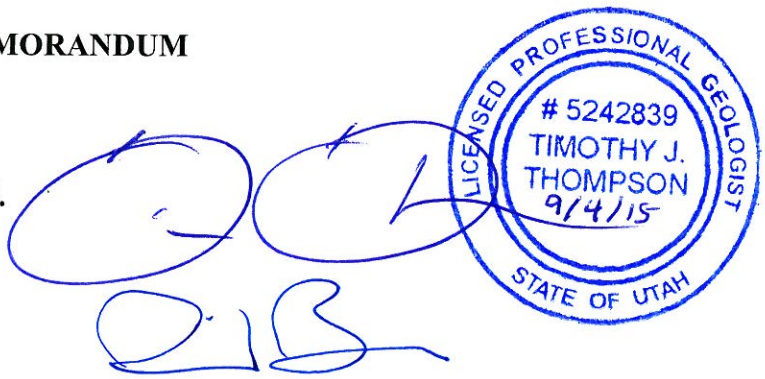
MEMORANDUM



To: **Matt Rasmussen**

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

Date: **September 4, 2015**

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. David B. Simon, P.G. of Simon Associates LLC (SA) prepared a review of our report. This memorandum was prepared in response to a series of review questions presented in a letter prepared by Mr. Simon and dated May 27, 2015.

SA Recommendations

The May 27, 2015, SA review letter contained ten items for which SA recommended Weber County request additional data and/or clarification. It is our opinion that the July 9, 2015, GeoStrata memorandum adequately responds to eight of the items in the May 27, 2015 SA geologic review letter. SA recommends Weber County not consider the geologic submittals complete from a geologic perspective until GeoStrata adequately addresses the following items:

1. *Item 5 from May 27, 2015, SA Geologic Review Letter:*

   a. *In their July 9, 2015 memorandum, GeoStrata states (first paragraph on page 5) "As stated in GeoStrata's response to SA Recommendation 2 above, the updated log of Trench 2 has been included in this response to extend our trench coverage on the east side of Lot 1R the requested 25 feet setback distance."*

   GeoStrata Trench T-2 is located about 275 feet to the south of Lot 1R. It is SA's opinion T-2 is located too far to the south to be representative of geologic conditions at Lot 1R, particularly in regards to evaluating surface-fault-rupture potential.

   Geologic mapping and paleoseismic trenching 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 (trend) of the fault.

While a single trench provides data at a specific fault location, multiple trenches are often required to characterize variability of the fault, to provide a more comprehensive understanding of faulting at a particular site, and/or to adequately document the absence of faulting.

For that reason, it is standard practice that subsurface data generally not be extrapolated more that about 300 feet (100± meters) without additional subsurface information. Accordingly, SA recommends:

i. Excavation of a trench near Lot 1R, of adequate length to explore the proposed building site(s) plus any potential setback to the east of the building envelope (Salt Lake County 2002; Christensen and others, 2003; Morgan County, 2010; Draper City, 2010).

GeoStrata Response:

As per instructions of Dana Q. Shuler P.E., CFM in an email dated August 19, 2015 this review comment is not to be addressed at this time.

ii. At least 25 feet be utilized as the potential setback distance.

GeoStrata Response:

As per instructions of Dana Q. Shuler P.E., CFM in an email dated August 19, 2015 this review comment is not to be addressed at this time.

iii. A scoping meeting prior to commencement of field work to allow Weber County to evaluate the geologist's investigative approach. At the scoping meeting, the consultant should present the purpose of the field work and the location of the proposed trench(es), which meet the minimum standard of practice. To expedite the process and due to Weber County's familiarity with the proposed development, the site plan could be emailed to Weber County and the scoping meeting completed via telephone.

GeoStrata Response:

As per instructions of Dana Q. Shuler P.E., CFM in an email dated August 19, 2015 this review comment is not to be addressed at this time.

iv. A field review by Weber County of the trench(es) to allow Weber County the opportunity to evaluate subsurface data (i.e., age and type of sediments; presence/absence of faulting, etc.) with the consultant, and verify the investigation is adequate.

GeoStrata Response:

As per instructions of Dana Q. Shuler P.E., CFM in an email dated August 19, 2015 this review comment is not to be addressed at this time.

b. The descriptions of Unit 4, Trench T-2 (page 6) and Unit 5 (page 7), in the July 9, 2015, GeoStrata memorandum appear to reference incorrect geologic units. SA recommends Weber County request GeoStrata clarify the apparent discrepancies.

GeoStrata Response:

The two unit descriptions noted in the SA review comment have a typo that incorrectly referred to Unit 3 instead of Units 4 and 5 in one sentence in each unit description. The corrected sentence from each unit description should read "Unit 4 was interpreted as Pleistocene-aged lacustrine gravel deposits" for Unit 4 and "Unit 5 was interpreted as Pleistocene-aged lacustrine gravel deposits" for Unit 5.

2. *Item 6b from May 27, 2015 SA GeoLogic Review Letter:*

Response "b" on page 11 of the July 9, 2015, GeoStrata memorandum states: "GeoStrata has attached the Site Geologic Map (Plate A-5) and the Site Geologic Setback Map (Plate A-6) to the end of this letter. The Site Geologic Map (Plate A-5) is intended to delineate the alluvial fan sediments on the site and the Site Geologic Setback Map (Plate A-6) is intended to show the active channel setback based on the hydrology report prepared by HydroPlot titled "Drainage Evaluation for Dauphine'-Savoy-Piedmont Subdivision, Lot #2, Ogden, UT" and dated September 4, 2014 and shown on the Grading/Drainage Plan prepared by Silverpeak Engineering and stamped by Joshua R. Jensen P.E. This report and Grading/Drainage Plan are included in Appendix D of this letter."

There appears to be an inconsistency between the calculated drainage setback as shown on GeoStrata Plate A-6, Site Geologic Setback Map (attached), and site geologic conditions as shown on GeoStrata Plate A-5, Site Geologic Map (attached). Plate A-6 depicts the drainage setback coinciding with the proposed building foot print, northwest of the drainage setback line. SA recommends Weber County request GeoStrata clarify the apparent discrepancy.

GeoStrata Response:

GeoStrata has revised the Site Geologic Setback Map to more accurately reflect the location of the drainage easement delineated in the Grading/Drainage Plan prepared by Silverpeak Engineering. The updated map is attached as Plate 1.

3. *Item 6d from May 27, 2015, SA Geologic Review Letter:*

Response "d" on page 12 of the July 9, 2015, GeoStrata memorandum states: " The drainage easement is labeled on the Grading/Drainage Plan as an existing 50 ' drainage easement but actually measures 75 feet according to the reported scale. The Modified Channel Cross Section detail on the Grading/Drainage Plan shows a minimum channel width of 20 feet and a minimum depth of 3 feet."

SA recommends Weber County request GeoStrata clarify whether the existing drainage easement is 50 feet of 75 feet wide.

GeoStrata Response:

The existing drainage easement is 50 feet wide. The discrepancy for the easement width came as a result of the scale being incorrect on the Grading / Drainage Plan by Silverpeak Engineering. It is labeled on their drawing as being 1 inch equal to 30 feet, when it should be 1 inch equal to 20 feet. This mistake was verified with Joshua Jensen, P.E. of Silverpeak Engineering.

4. *Item 6e(ii) from May 27, 2015, SA Geologic Review Letter:*

On page 13 of the July 9, 2015, GeoStrata memorandum, GeoStrata states:

Fire-related debris flow volumes for the subject property were predicted using the Western USA regression model (Gartner and others, 2008; Giraud and Castleton, 2009; Cannon and others 2010). The model estimates debris flow volumes as:

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

Giraud and Castleton, 2009, utilize the Western U.S. regression model of Gartner and others (2008) for fire related debris flows:

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

It is noteworthy that the regression model in Gartner and others (2008) and Giraud and Castleton (2009) is not the same as the regression equation in Cannon and others (2010) for fire related debris flows:

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

SA recommends Weber County request GeoStrata evaluate the fire related debris volume using the regression models from Giraud and Castleton (2009) and Cannon and others (2010); the most conservative results should be used at the subject site (hand calculations should be provided).

GeoStrata Response:

GeoStrata has evaluated the fire related debris volume using the regression model from Cannon and others (2010). A printout of our calculations, showing inputs and outputs for the regression model is included as Plate 2. 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.

5. *The July 9, 2015, GeoStrata memorandum provides debris flow analysis only for fire-related debris flows. SA recommends Weber County request GeoStrata provide an analysis of debris flows that could result from rapid snowmelt/rainfall. That analysis should:*

   a. Include hand calculations.

   b. Include derivation of all variables, including sediment bulking, and;

   c. Account for all processes that trigger snowmelt/rainfall debris flows.

GeoStrata Response:

GeoStrata has completed an analysis of debris flows that could result from rapid snowmelt/rainfall. Our analysis included a field observation of the existing channel, the measurement of cross sections in the field, plotting the measured cross section using both field data and sub-meter Wasatch Front LiDAR elevation data obtained from the State of Utah AGRC, and determining the total volume of bulked sediment in the existing channel.

A field investigation was conducted to observe the conditions of the existing channel and to measure cross sections of the channel bottom at selected representative points along the length of the channel. Photographs from various points along the length of the channel, including the locations of the measured cross sections, are included as Plate 4 to Plate 10. Cross sections of the channel were measured in the field at 3 representative points along the length of the channel. A map showing the locations of each of the cross sections is included as Plate 11. During our field investigation, we observed that the channel is heavily vegetated with scrub oak, grasses, and some small cacti. Soils observed consisted mainly of a silty gravel with sand. The high fines content of the observed soil suggests that erosion of the existing stream channel is occurring at a very slow rate, which is a function of the presence of heavy vegetation.

Within the canyon, occasional angular boulders of up to approximately 18 inches in diameter were observed and appeared to have been deposited as a result of the rock fall processes within the canyon. Boulders were not observed within the channel below the mouth of the canyon. Two test pits were excavated for the 2013 GeoStrata geotechnical report for the subject property within the channel. Maximum observed particle diameter within the test pits consisted of cobbles up to 10” in diameter in test pit TP-1 and cobbles up to 6” in diameter in test pit TP-2. The test pit logs are attached as Plate 12 and Plate 13.

Plots of each of the cross sections that were analyzed for this investigation are included as Plate 14 through Plate 17. Total stored sediment was estimated using the geometry of each of the cross sections. The table below summarizes the results of our investigation.

Cross Section	Channel Segment Length (ft)	Stored Sediment (ft^3/ft)	Stored Sediment (ft^3)	Debris Flow Volume (ac-ft)
1	882.4	28	24707.2	0.6
2	614.5	8	4916	0.1
3	1010.1	18	18181.8	0.4
4	1558.0	86	133988	3.1
				4.2

Based on these calculations, a debris flow event resulting from rapid snowmelt/rainfall should have a total volume of 4.2 ac-ft. This value is based on breaking the channel into four segments and assuming that stored sediment in each of the segments is represented in the cross sections that are presented.

In order be conservative, we have elected to estimate the total stored sediment for the entire length of the channel to be 86 ft^3/ft, the maximum observed stored sediment, and that 100% of the stored sediment is mobilized in a debris flow event with a 50% bulking rate (debris flows consisting of 50% sediment and 50% water). Using these assumptions, the maximum potential debris flow event is estimated to be 16.1 ac-ft.

Applying this volume to a unit rational hydrograph, peak debris flow for the subject property is estimated to be 193.6 cfs. Based on the Silverpeak Engineering Grading /Drainage Plan, they propose improving the existing stream channel and show a cross section of the improved stream channel on page C1.0. The gradient of the stream channel as shown on their Grading /Drainage Plan will be approximately 14.5%. Velocity of the debris flow at peak flows will be 13.0 feet per second.

Based on equations from Prochaska and others (2008) mentioned in the July 9, 2015 GeoStrata review response document, the superelevation height around the bends in the channel across the property will be 0.26 ft, and the berm height or channel depth should be at least 6.0 feet.

Based on the depth to width ratio given by Hungr and others (1984), the slope and grade of the property, and estimated debris flow volumes and peak flows, we recommend that the channel be modified to consist of a trapezoidal channel with a base width of 1 foot and depth of at least 6.0 feet with the sides of the channel sloped at a 2H:1V (horizontal to vertical) gradient. Given these channel dimensions, the depth of flow for an anticipated debris flow would be approximately 2.5 feet, the width of the channel at the top of the flow would be approximately 11.0 feet resulting in a depth-to-width ratio for the modified channel of 0.23. This ratio complies with the recommendation of Hunger and others, (1984) of a minimum depth-to-width ratio of 0.2. These channel cross section dimensions should be consistent across the entire site to prevent deposition of debris flows within the channel. A cross section drawing of the channel cross section is included as Plate 3.

6. Item 6e(ii) from May 27, 2015, SA Geologic Review Letter; On page 13 of the July 9, 2015, GeoStrata memorandum it states:

"Total basin area and the percent of the basin with slopes greater than 30% were given in the 2014 HydroPlot hydrology report (Appendix D)."

The water shed area is shown on Figure 1 of the September 4, 2014, HydroPlot report. SA recommends Weber County request GeoStrata submit HydroPlot Figure 1 ("Broad Hollow Drainage Location & Topography") with bar Scale.

GeoStrata Response:

As per instructions of Dana Q. Shuler P.E., CFM in an email dated August 19, 2015 this review comment is not to be addressed at this time.

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.

Christenson, G.E., and Shaw, L.M., 2008, Geographic Information System database showing geologic-hazard special study areas, Wasatch Front, Utah; Utah Geological Survey Circular 106, j7 P., GIS data, scale 1:24,000.

Gartner, J.E., Cannon, S.H., Santi, P.M. and Dewolfe, V.G., 2008, Empirical Models to Predict the Volumes of Debris Flows Generated by Recent Burned Basins in the Western U.S., Geomorphology 96 (2008) 339-354.

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.

Yonkee, A., Lowe, M., 2003, Geologic Map of the Ogden 7.5' Quadrangle, Weber and Davis Counties, Utah, Utah Geological Survey Map 200.

Trench 1

Trench 2

Trench 3

Trench 4

Legend

- 25ft Fault Setback Zone
- Site Boundary
- Fault (Yonkee & Lowe 2004)
- Fault Trench
- Drainage Setback
- Buildable Area
- Non-Buildable Area
- Proposed Buildable Area
- Proposed Building Footprint

0 25 50 100 150 200 Feet

1:1,200

Base Map: 2012 HRO 6 inch Orthophotography obtained from the State of Utah AGRC.

All Locations are Approximate

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South Weber, Utah
Project Number: 910-001

Site Geologic Setback Map

Plate 1

Intermountain Western US Post Wildfire Debris Flow Volume Regression Model
Cannon and others (2010)

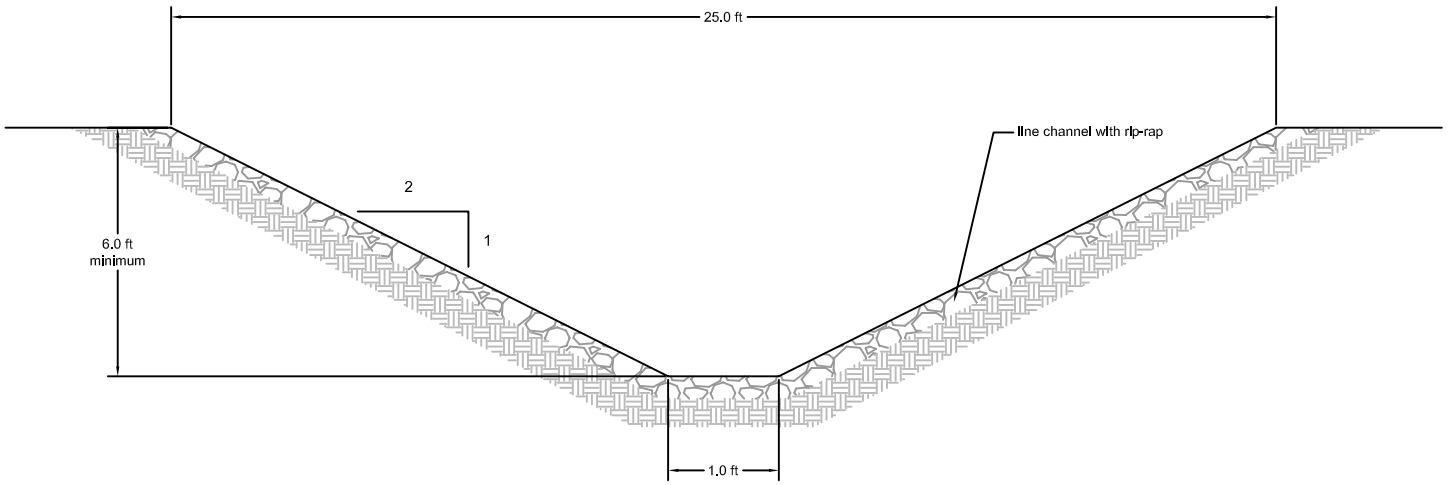
ln V = 7.2+ 0.6(ln A) + 0.7(B)^(1/2) + 0.2(T)^(1/2) + 0.3

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**

Channel Cross Section



NOT TO SCALE

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Plate
3

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Cross Section 1 – Upstream View

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Plate 4

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Cross Section 1 – Cross-Stream View

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Plate 5

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Cross Section 2 – Upstream View

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Plate 6

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Between Cross Section 1 and Cross Section 2 – Upstream View

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Plate 7

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Cross Section 3 – Upstream View

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Plate 8

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Cross Section 3 – Upstream View

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Plate 9

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Cross Section 3 – Downstream View

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South Weber, UT
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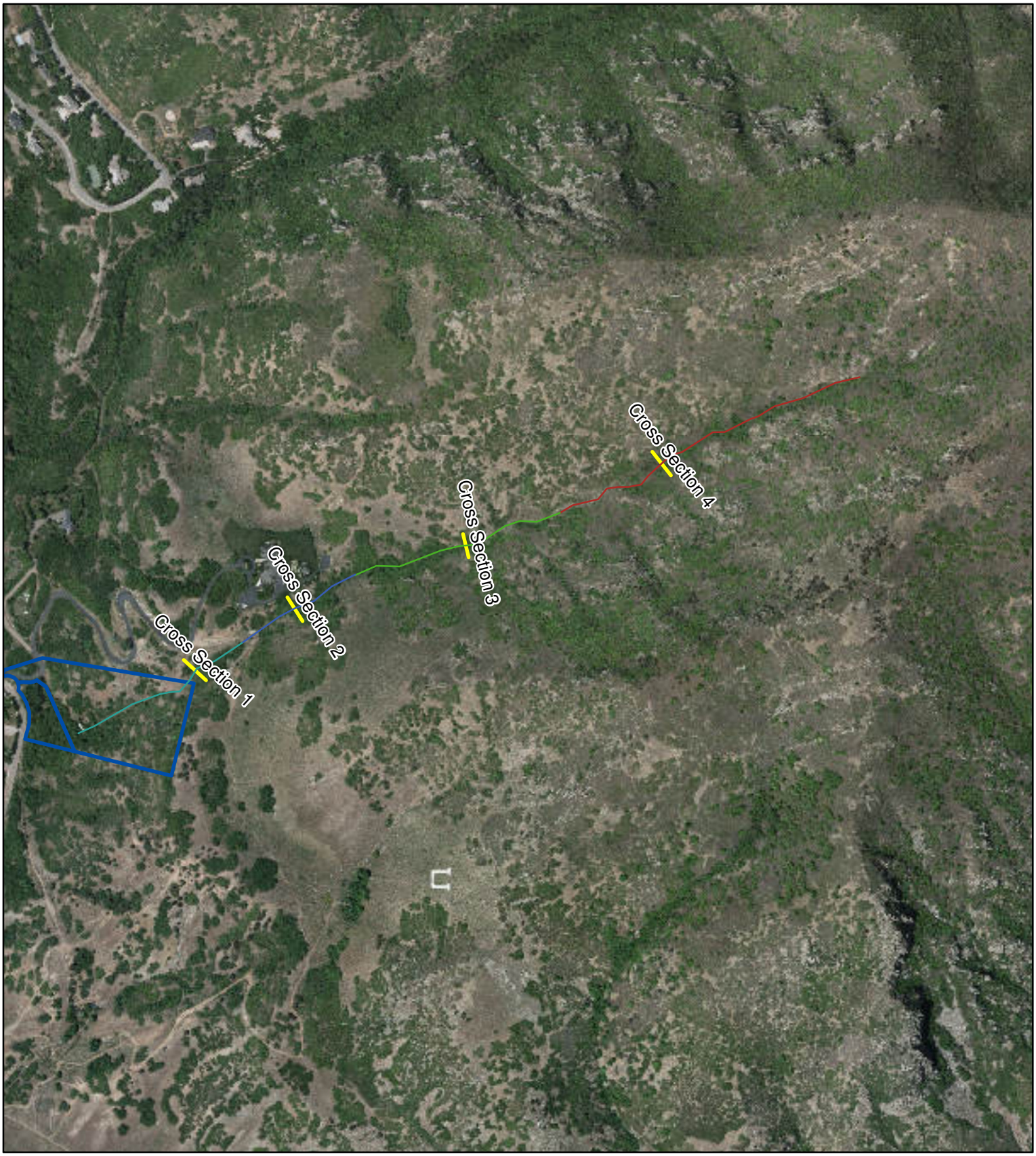
Plate 10



0 250 500 1,000 1,500 2,000 Feet

1:7,200

Base Map: Utah AGRC Imagery BaseMap

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Legend

- Channel Segment 1
- Channel Segment 2
- Channel Segment 3
- Channel Segment 4
- Cross Section
- Site Boundary

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Cross Section Location Map

Plate 11

DATE
STARTED: 10/22/13
COMPLETED: 10/22/13
BACKFILLED: 10/22/13

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Weber County, UT
Project Number 910-001

GeoStrata Rep: S. Seal
Rig Type: Trackhoe

TEST PIT NO:
TP-1
Sheet 1 of 1

DEPTH
METERS | FEET

SAMPLES | WATER LEVEL | GRAPHICAL LOG | UNIFIED SOIL CLASSIFICATION

LOCATION
NORTHING EASTING ELEVATION

MATERIAL DESCRIPTION

Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
	3.2	12.3	NP	NP
	0.8	7.9	NP	NP

Moisture Content and Atterberg Limits
Plastic Limit | Moisture Content | Liquid Limit
10 20 30 40 50 60 70 80 90

0 m / 0 ft
TOPSOIL; Clayey SAND with gravel, cobbles, and boulders - with roots and pinholes throughout

SM
Silty SAND with gravel and cobbles - dense, brown, moist to slightly moist, gravel is subrounded, cobbles observed up to 10" in diameter

1 m / 5 ft
2 m

GP-GM
Poorly Graded GRAVEL with silt and sand - dense, brown, moist to slightly moist, gravels are subrounded, gravel observed up to 3" in diameter

@ 9.5 ft - material is angular, gravel observed up to 6" in diameter

3 m / 10 ft

Bottom of Test Pit @ 11 Feet

4 m

LOG_OF_TEST_PITS_PLATE TEST PIT LOGS - GEOTECH.GPJ IGES.GDT 9/3/15

GeoStrata

SAMPLE TYPE
- GRAB SAMPLE
- 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
- MEASURED
- ESTIMATED

NOTES:

Plate
12

DATE
STARTED: 10/22/13
COMPLETED: 10/22/13
BACKFILLED: 10/22/13

Matt Rassmusen
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Weber County, UT
Project Number 910-001

GeoStrata Rep: S. Seal
Rig Type: Trackhoe

TEST PIT NO:
TP-2
Sheet 1 of 1

LOCATION
NORTHING EASTING ELEVATION

DEPTH METERS	DEPTH FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0	0					TOPSOIL; Silty SAND with gravel, cobble, and boulders - with roots and pinholes throughout					
					SP-SM	Poorly Graded SAND with silt, gravel, and cobbles - dense, brown, moist to slightly moist, gravel is subrounded to subangular, cobbles observed up to 6" in diameter		2.0	10.9	NP	NP
3	10				GP	Poorly Graded GRAVEL with sand and cobbles - dense, brown, moist to slightly moist, gravel is subangular, gravel observed up to 6" in diameter		0.8	3.8	NP	NP
						Bottom of Test Pit @ 11 Feet					

Moisture Content and Atterberg Limits
Plastic Limit — Moisture Content — Liquid Limit
10 20 30 40 50 60 70 80 90

GeoStrata

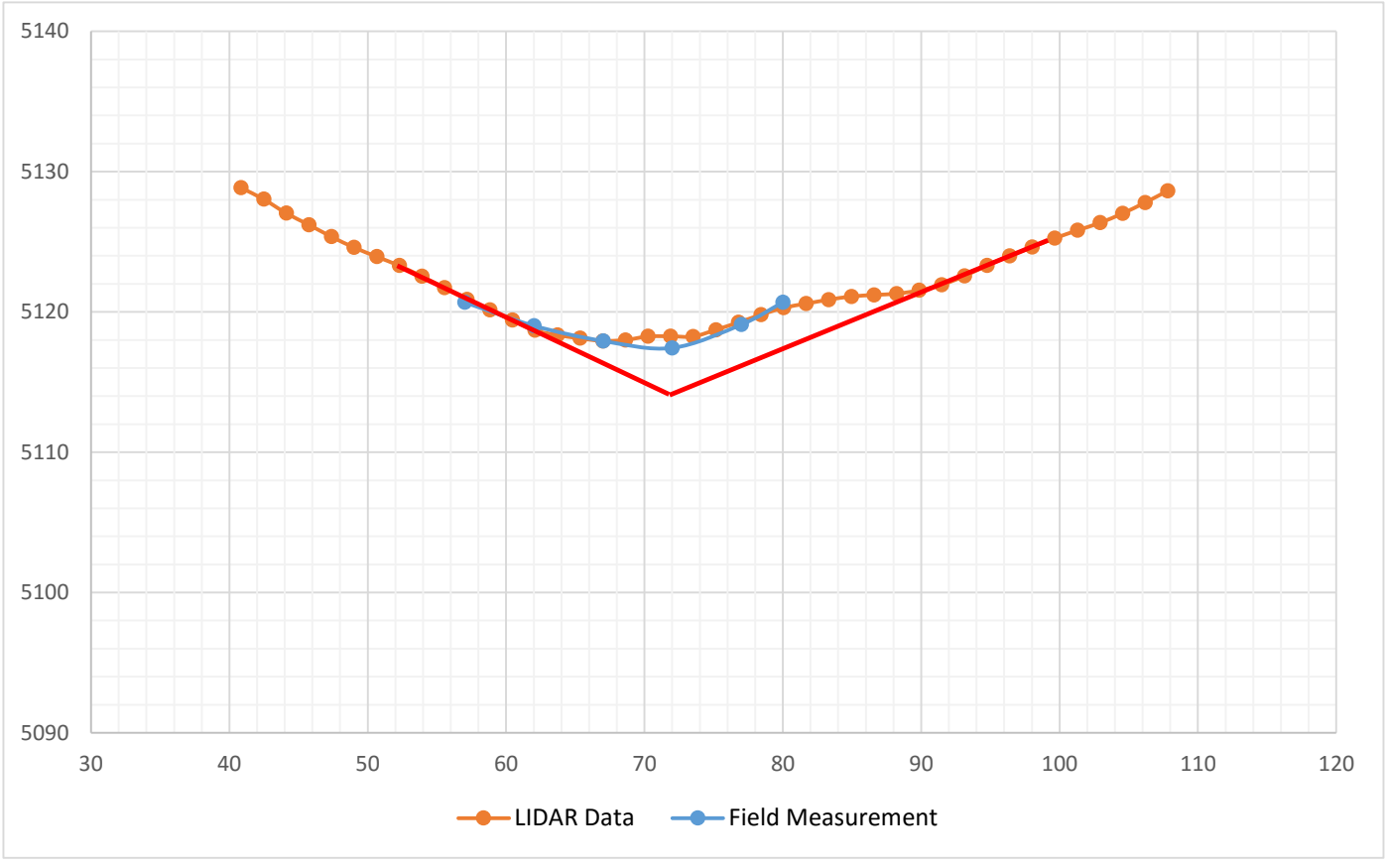
SAMPLE TYPE
- GRAB SAMPLE
- 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
- MEASURED
- ESTIMATED

NOTES:

Plate
13

LOG_OF_TEST_PITS_PLATE TEST PIT LOGS - GEOTECH.GPJ IGES.GDT 9/3/15



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Cross Section 1

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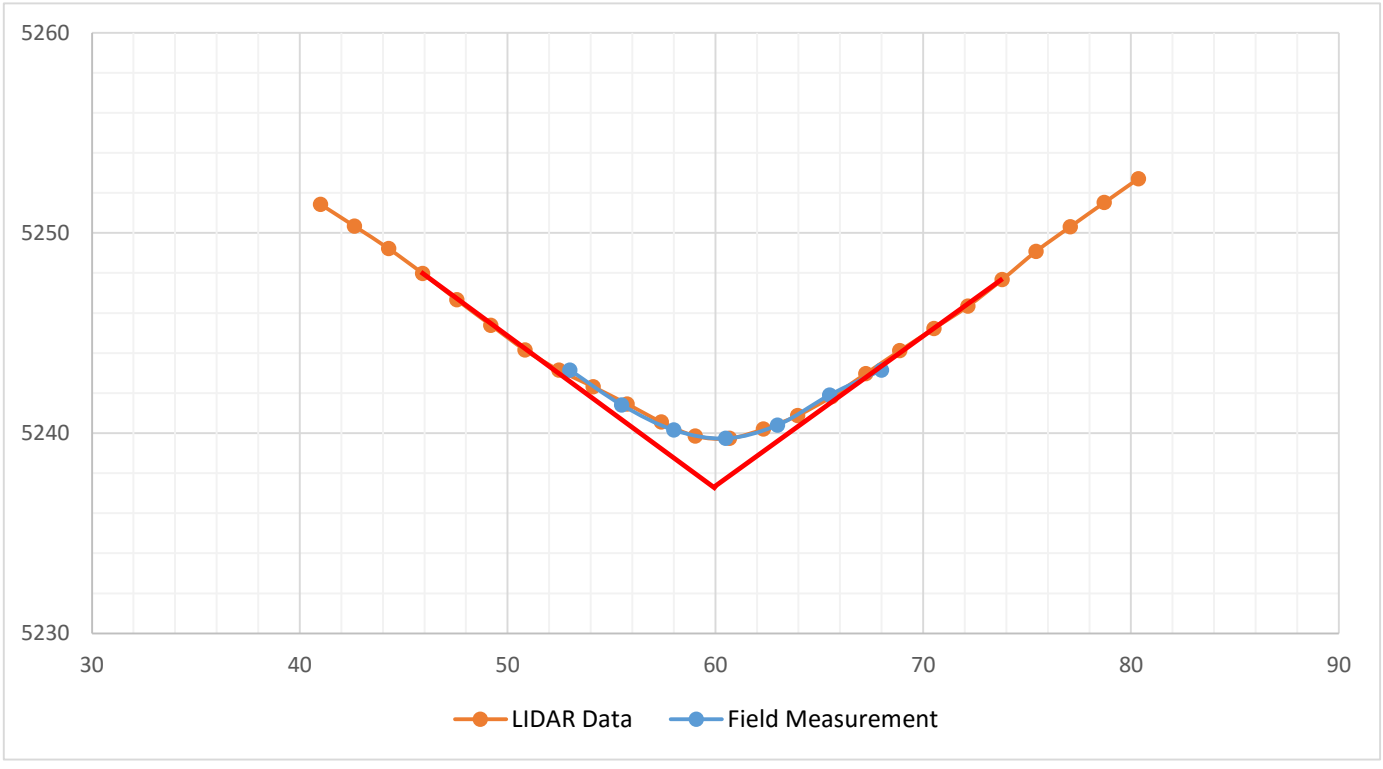
Plate 14



Cross Section 2

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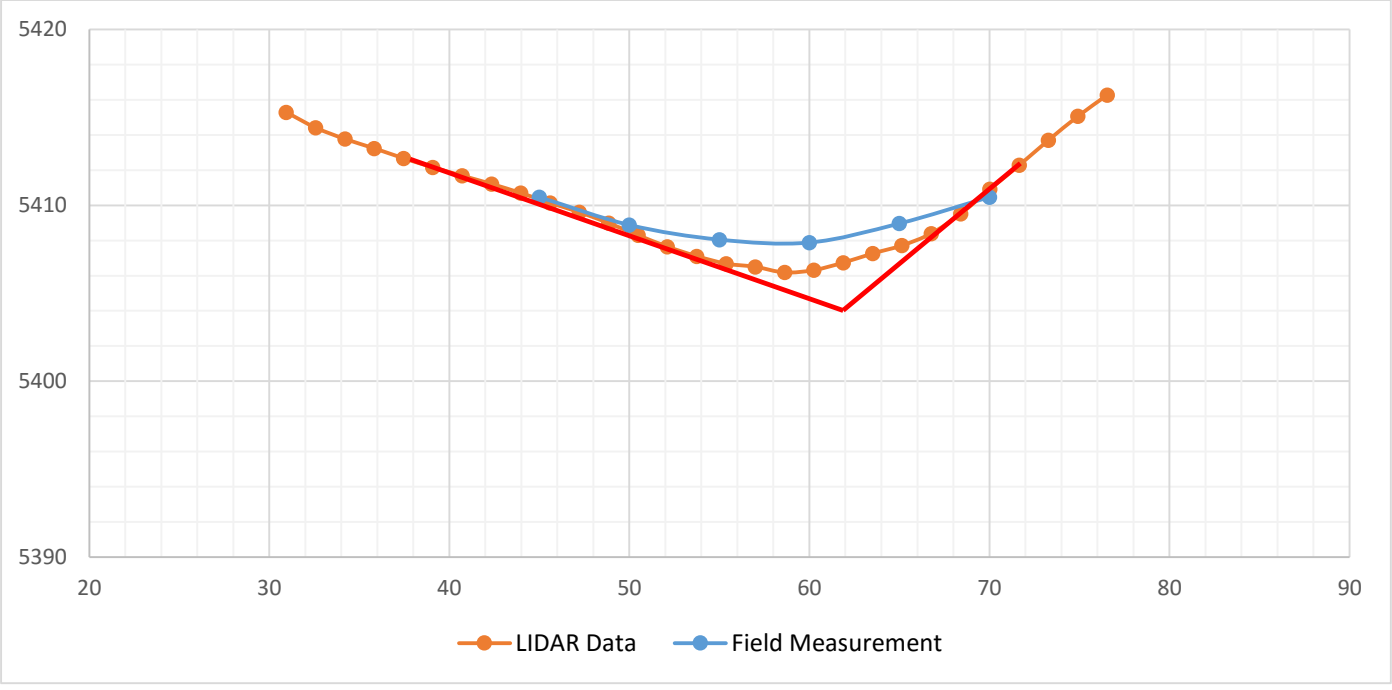
Project Number: 910-001

Plate 15



Cross Section 3

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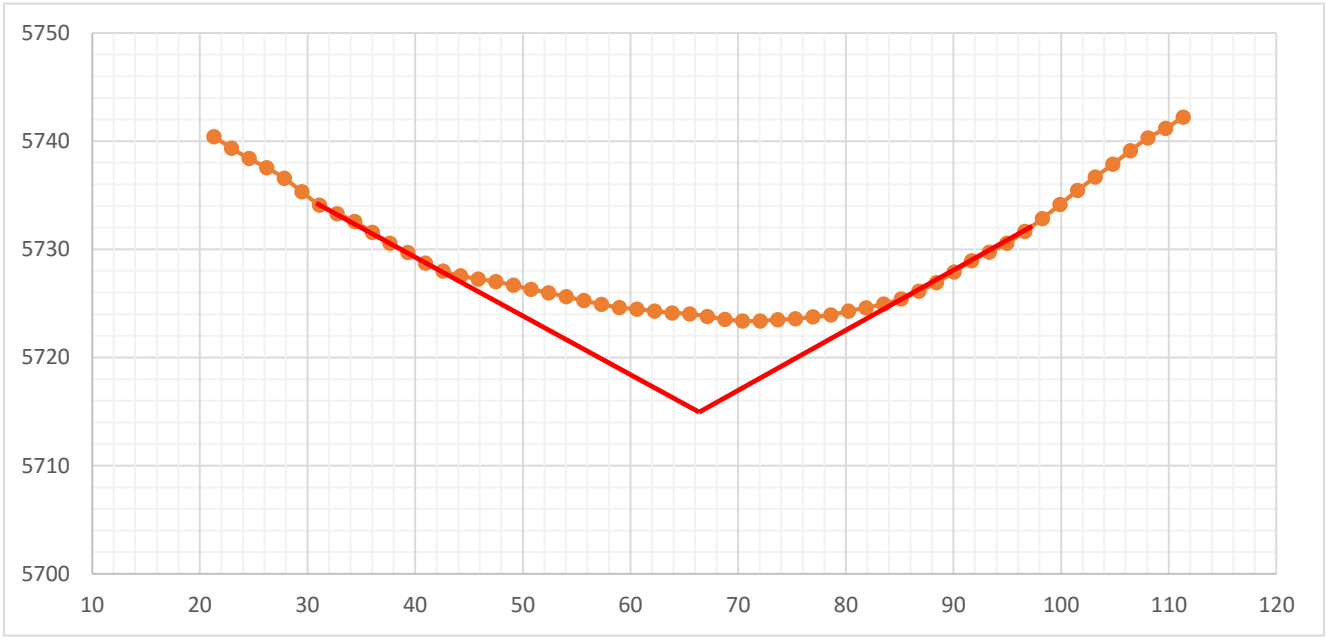
Project Number: 910-001

Plate 16



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Cross Section 4

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Project Number: 910-001

Plate 17