NOTICE OF MEETING
HILLSIDE REVIEW BOARD
CITY OF ST. GEORGE
WASHINGTON COUNTY, UTAH

Public Notice

Notice is hereby given that the Hillside Review Board of the City of St. George, Washington County, Utah, will hold meetings at the referenced site on **Wednesday, September 23, 2020** commencing on-site at 8:30 a.m.

The estimated site times are in bold.
The agenda for the meetings are as follows:

1. Consider a request for a Hillside Development Permit to allow development of a residential subdivision to be called "**Summit Estates**." The property is generally located at the intersection of Hillrise Drive and Ft. Pierce Drive. The property is currently zoned PD-R (Planned Development – Residential). The owner is V.E. MGMT & Investment Company LC, the representative is Ben Willits, Horrocks Engineers. Case No. 2020-HS-008. (*See 'Meeting Place' exhibit below*). **Meeting time 8:30 am**
2. Consider a request for a Hillside Development Permit to allow development of a restaurant/multi-tenant commercial building to be called "**Commerce Point North**." The property is generally located at 1276 S Black Ridge Drive and 1190 S Bluff. The property is currently zoned C-2 (Highway Commercial). The owner is Commerce Point, LLC, the representative is Austin Atkin. Case No. 2020-HS-012. (*See 'Meeting Place' exhibit below*). **Meeting time approx. 9:30 am**
3. Consider approval of the meeting minutes from August 26, 2020

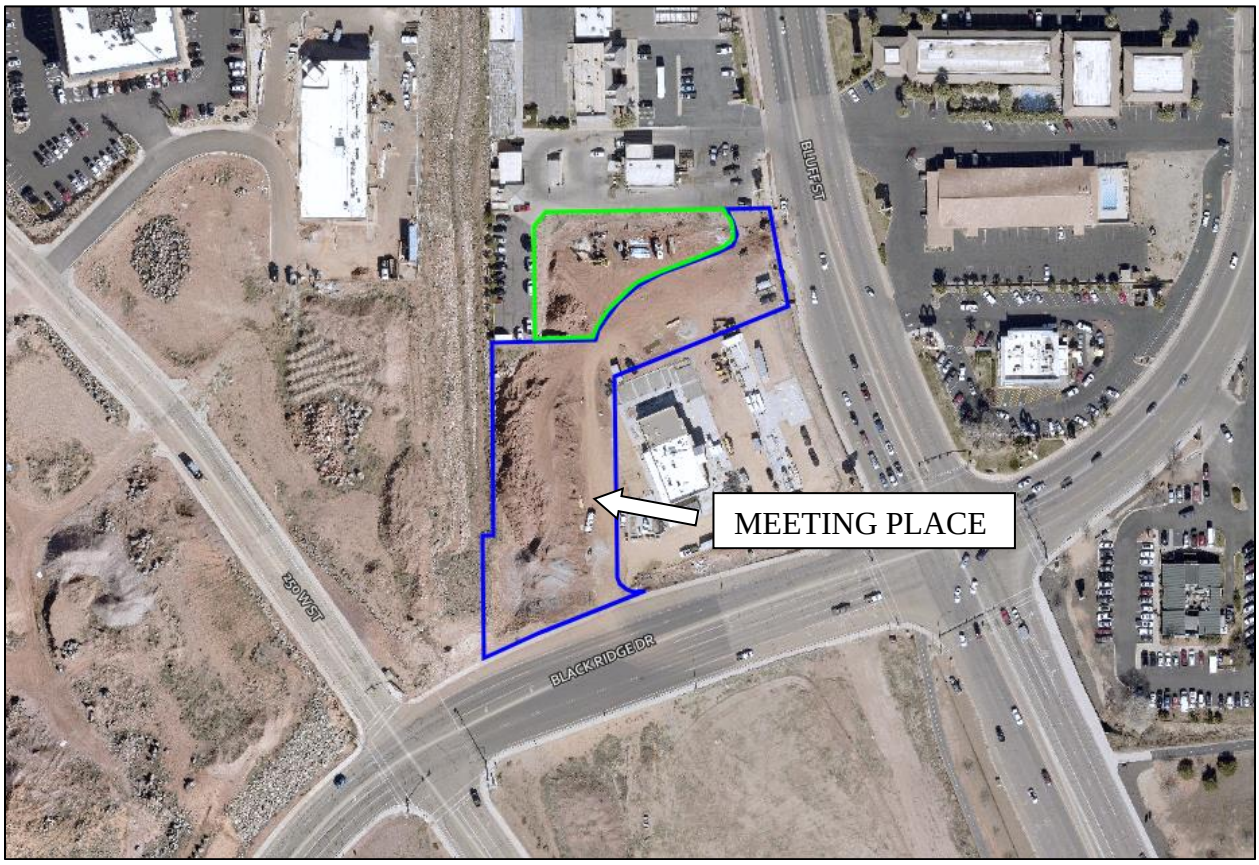
Dan Boles, AICP
Senior Planner
Development Services

Reasonable Accommodation: The City of St. George will make efforts to provide reasonable accommodations to disabled members of the public in accessing City programs. Please contact the City Human Resources Office at (435) 627-4674 at least 24 hours in advance if you have special needs.

Meeting Place Summit Estates



Meeting Place Commerce Point North



St.George
Community Development

ITEM 1
Hillside Permit

HILLSIDE REVIEW BOARD AGENDA REPORT: **09/23/2020**

HILLSIDE DEVELOPMENT PERMIT
Commerce Point North
Case No. 2020-HS-012

Request:	This is a request for a Hillside Development Permit to allow development a Restaurant/Multi-Tenant Commercial Building
Stability Report:	Project No. 18535
Owner:	Commerce Point, LLC
Applicant:	Austin Atkin
APN:	SG-COMP-1-1, SG-COMP-1-3
Location:	Approx. 1276 S Black Ridge Drive/1190 S Bluff Street
Acreage:	Approx. 2.13 acres (Lot 1 = 0.54 acres) (Lot 2 = 1.59 acres)
Zoning:	C-2
Adjacent zones:	C-2 & PD-C
Powers & Duties:	Section 10-13A(9) of the St. George City Code, "Hillside Review Board Powers and Duties" states that the Hillside Board can make recommendations for approval, conditional approval, and denial to the Planning Commission (PC) and City Council (CC).
Permit required:	Section 10-13A(7) requires that all major development (i.e., cut greater than 4', etc.) on slopes above 20% requires a 'hillside development permit' granted by the City Council upon recommendation from the Hillside Review Board and the Planning Commission.

COMMENTS

Hazards:	The item of concern for the proposed site is potential for landslide movement. Soils will be reviewed with at the time building permit is reviewed.

Site: The site sits at the bottom of the hillside and, if approved, is proposed to have two buildings, one close to Black Ridge Drive and one adjacent to Bluff Street. The key question is how the applicant plans to deal with the tow of the slope being in the landslide area. For the boards consideration is attached a slope stability analysis and a grading plan.

Landslide: The ancient landslide is reported to not be moving currently, but factors of safety against future movement have to meet industry standards. If the site is to be developed, the developer should be aware of this condition and accept risk of future movement if the landslide reactivates.

MOTION (HSRB)

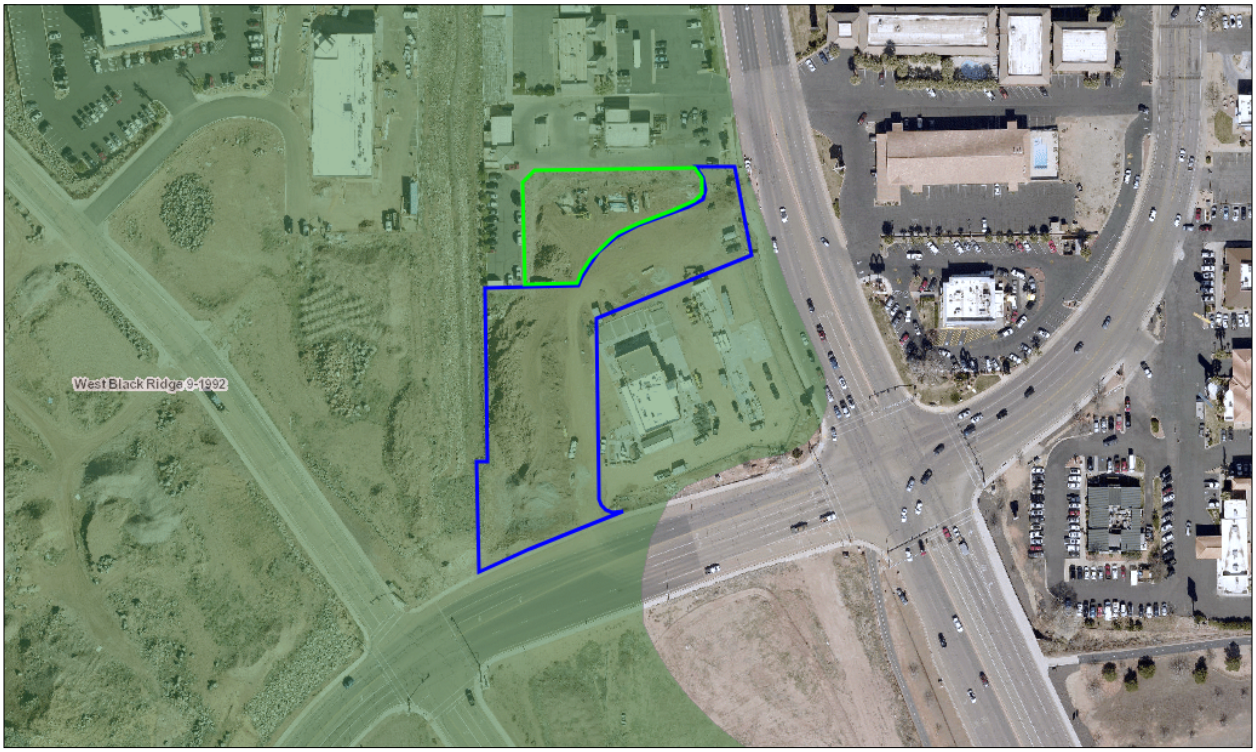
HSRB Motion Options: The hillside board can recommend several different options to the Planning Commission and the City Council:

1. Denial
2. Approval as presented
3. Approval with specific conditions and comments added as required.

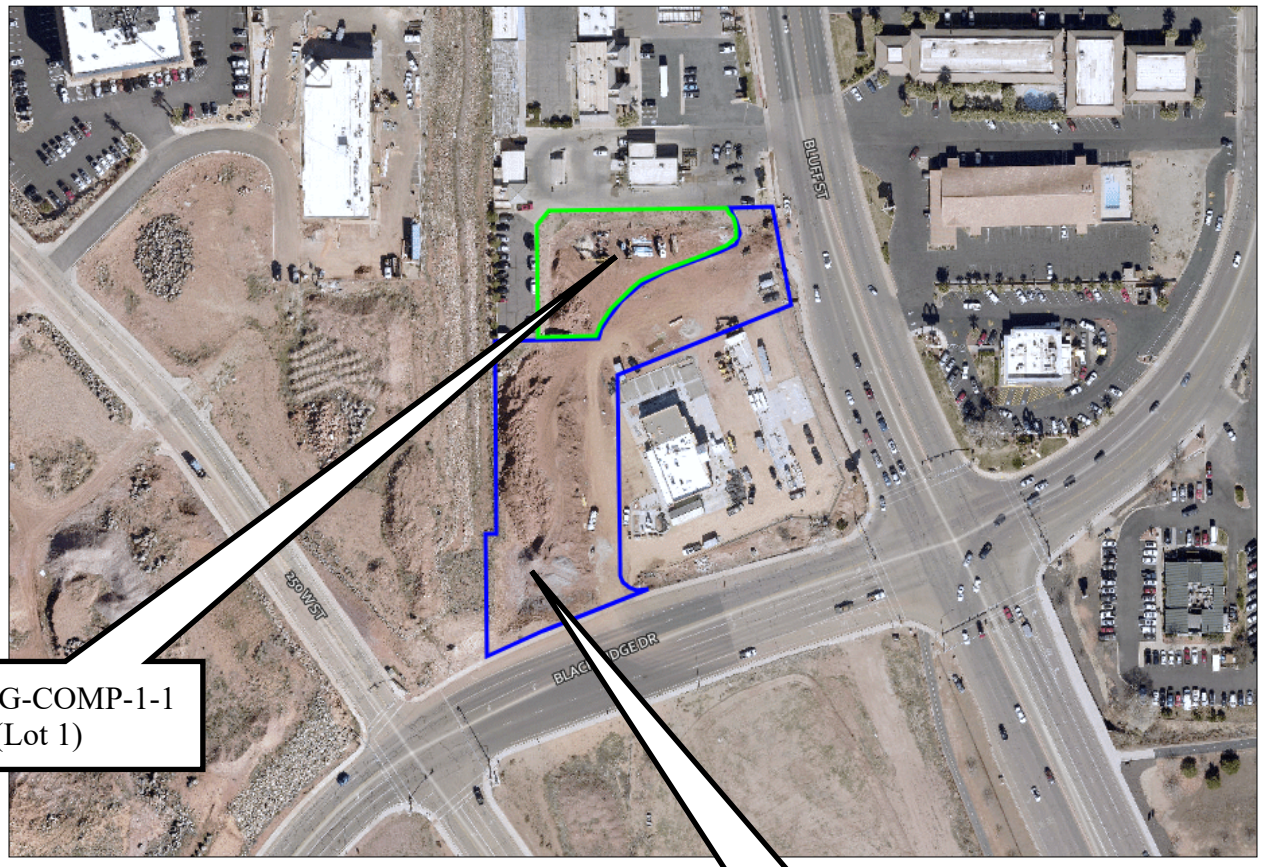
Example Motion: The hillside board recommends _____ of the request for a Hillside Development Permit to allow development of restaurant and retail building with comments and conditions.

1. Drainage _____
2. Landslide _____
3. _____
4. _____

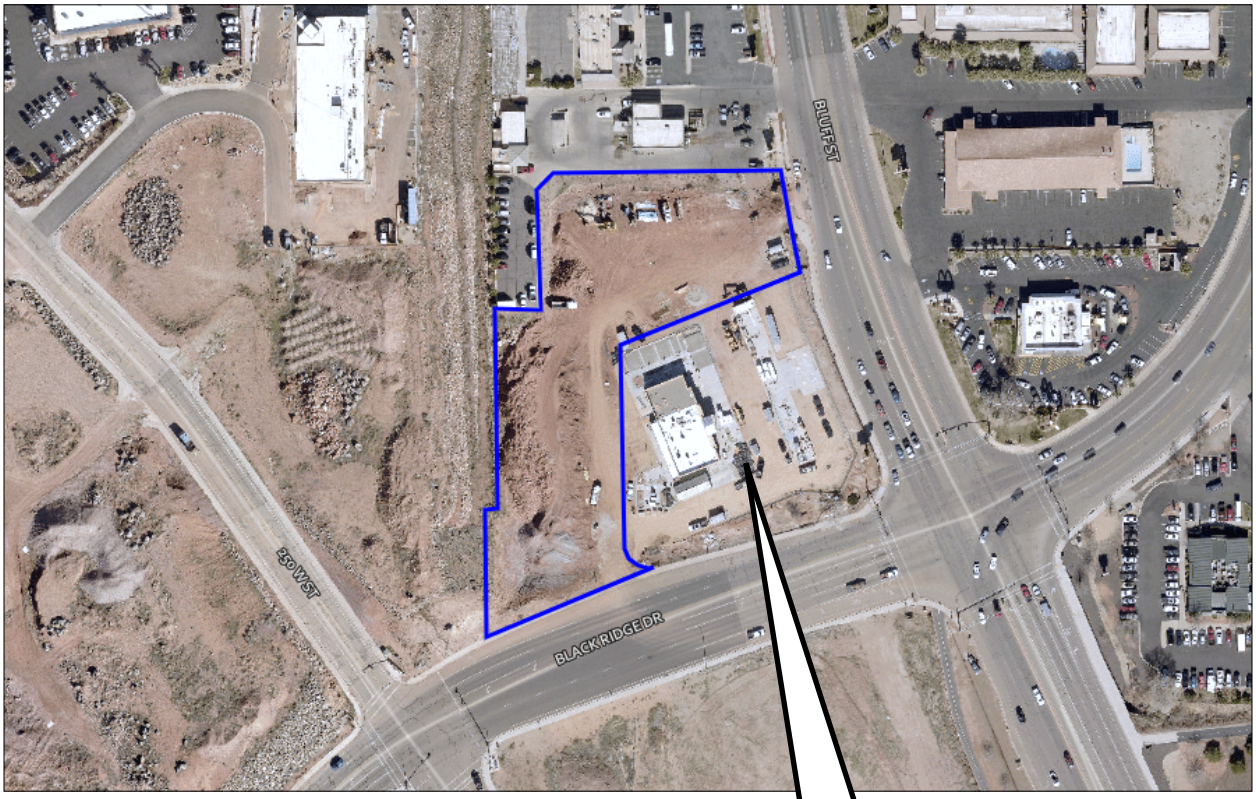
Hillside Overlay Map



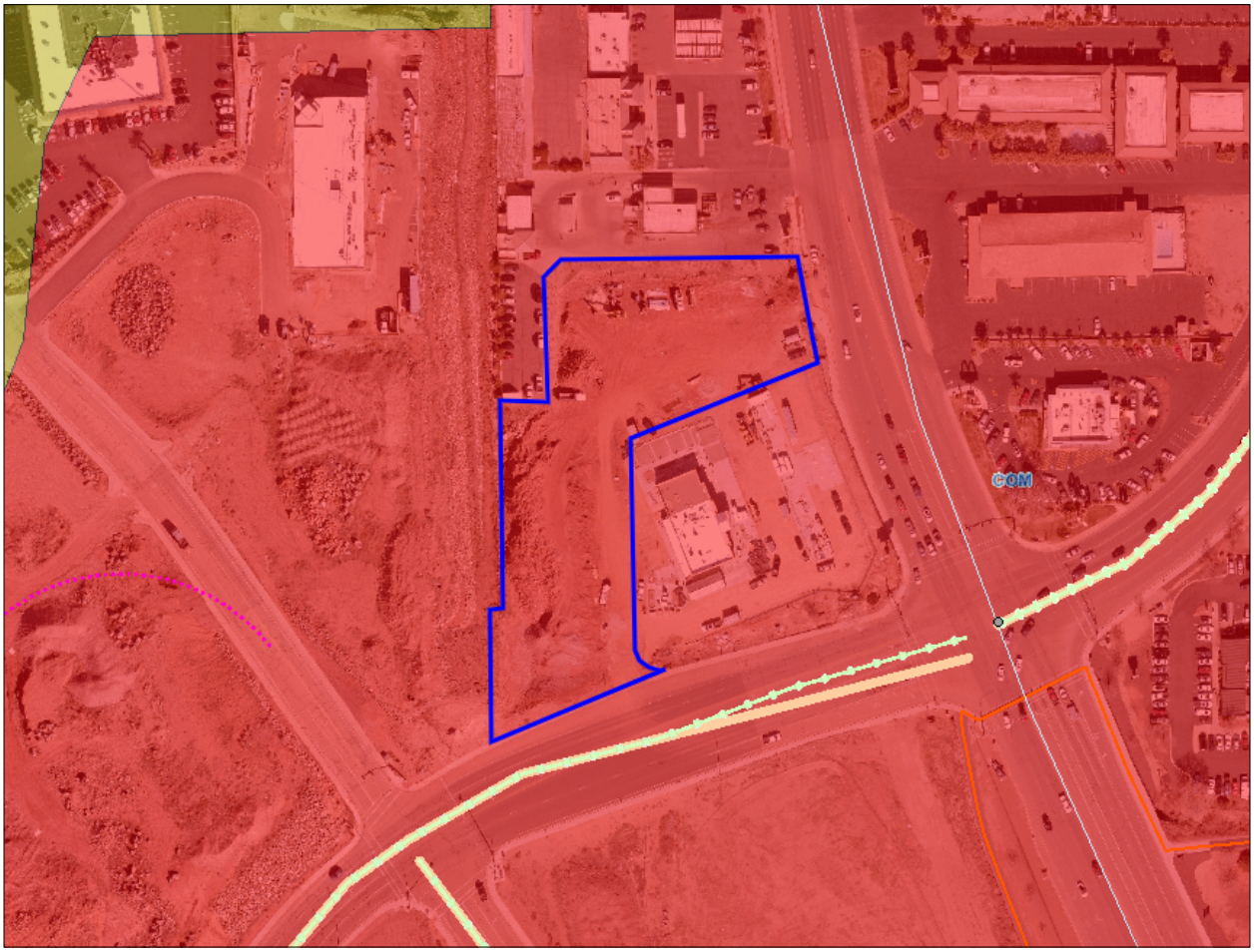
Vicinity Map



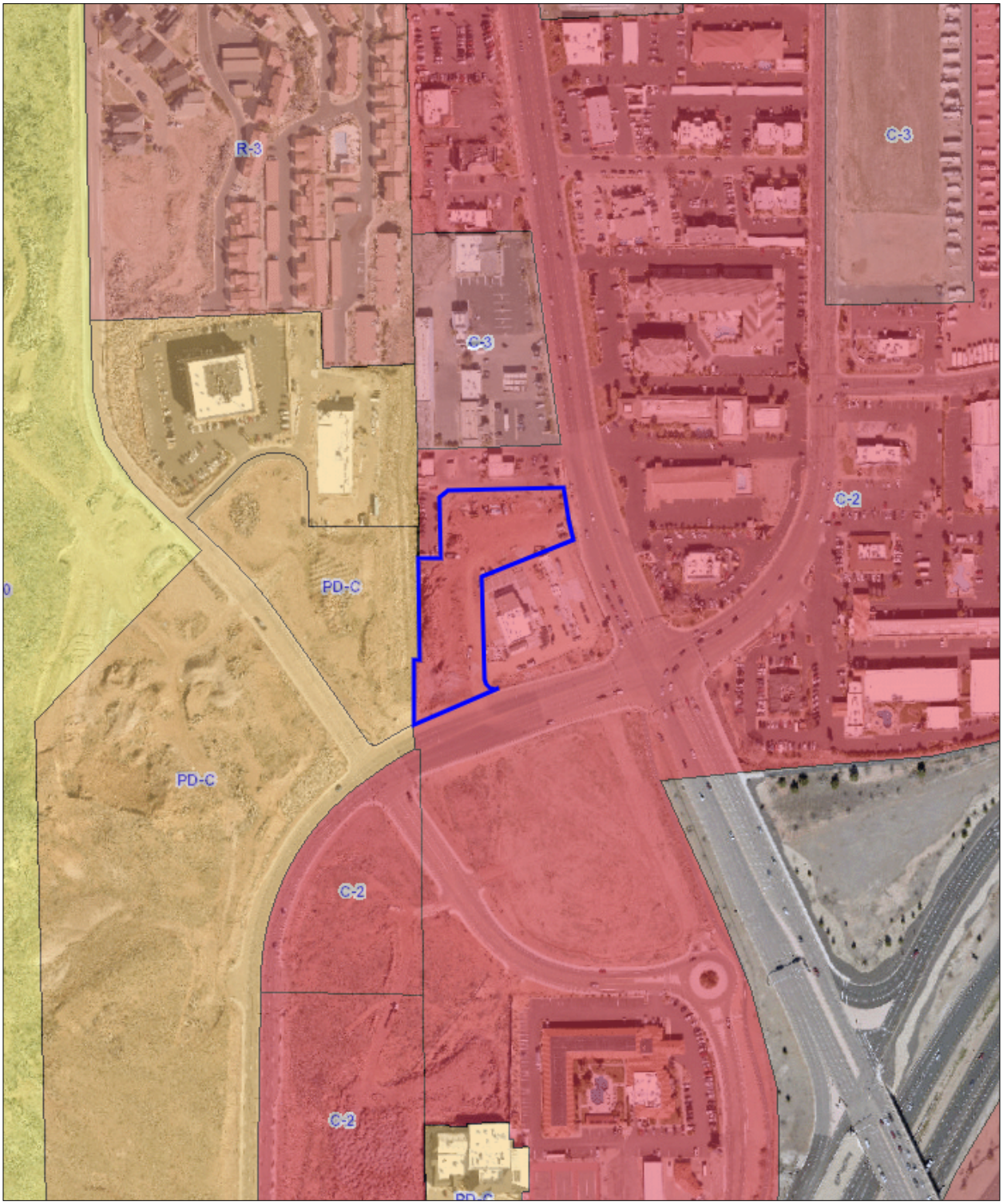
Site – Aerial



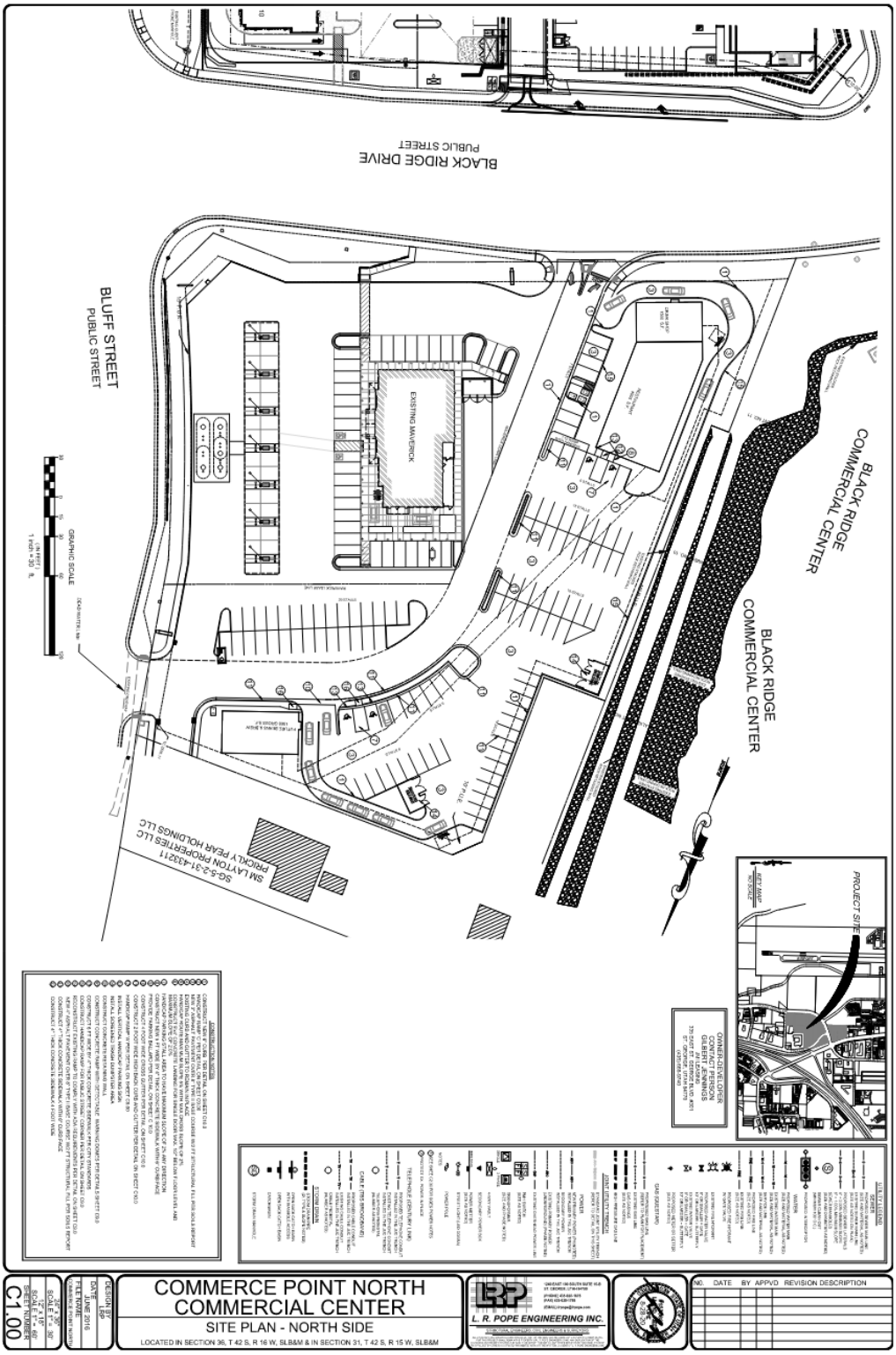
General Plan = COM *(Commercial)*



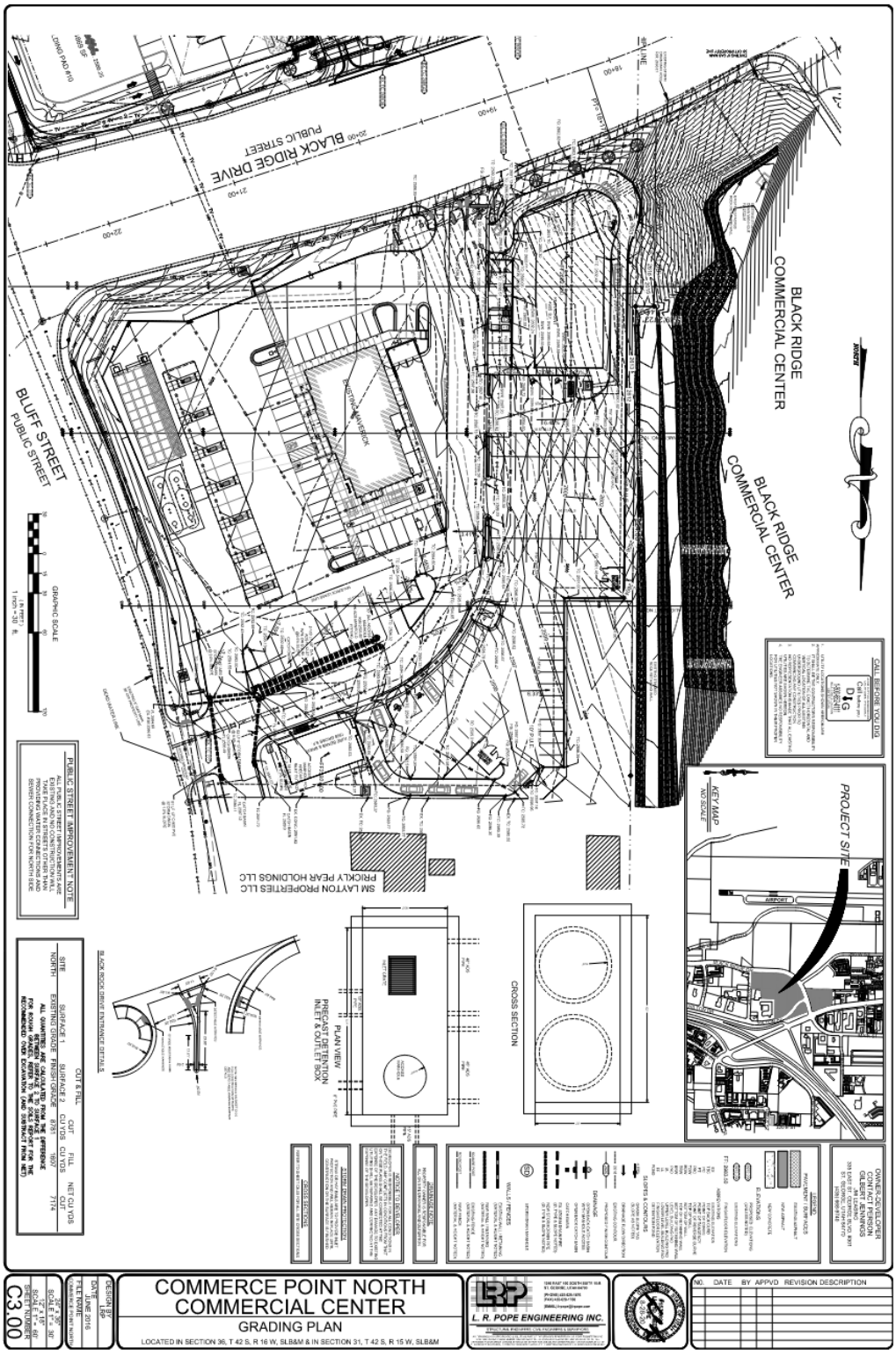
Zoning = PD-C



Concept Site Plan



Grading Plan



Slope Stability Analysis

GEOTECHNICAL TESTING SERVICES, INC.
1509 South 270 East, Suite 8, St. George, UT 84790
(435) 628-9536 (435) 628-9589 – fax

May 24, 2018

Mr. Steve Jennings
Jennings Management, Inc.
335 East St. George Blvd., Suite 301
St. George, UT 84770

Subject: Slope Stability Analysis
Proposed Commerce Point Shopping Center - North Phase
Northwest Corner of Black Ridge Drive and
Bluff Street
St. George, Utah
GTS Project Number 18535

Dear Mr. Jennings:

We have completed our stability analysis of the proposed cut slope that is to be located along the west side of the above noted development. At the current time, the exact geometry of the slope is not known, but for this analysis, we have assumed that a retaining wall will be constructed near the property line as outlined in Table 1. It is our understanding that the property owners located west of the subject property are concerned that if the toe of the slope is cut away on the subject property that it will affect the slope stability of their properties. The approximate property lines are shown on Figure 1.

Table 1
Summary of Proposed Retaining Wall Location

Section Number	Distance Between Property Line and Retaining Wall (ft)
10	21
11	35
12	4
13	20

Subsurface soils information was obtained from our Geotechnical Investigation performed for this property, GTS Project Number 18535, dated July 28, 2017. To investigate the subsurface soils, three 21.5- to 30.5-foot deep test holes were drilled and two 13.0- to 16-foot deep test pits were excavated across the western portions of the property. The subsurface soils encountered

generally consisted of stiff to very stiff, low to high plastic clay (CL and CH) encountered to the maximum depth of exploration, 30.5 feet. Groundwater was not encountered in our test holes and test pits at the time of our investigation.

We performed unconfined compression tests on samples recovered from our test holes. The unconfined compression tests were run as part of this study, however they were originally sampled for our Geotechnical Investigation. The test holes were drilled and sampled on June 12, 2017 and the unconfined compression testing was performed on December 27 and 28, 2017. In order to perform the unconfined compression tests, the samples were extracted from their liners. The extraction process caused some sample disturbance which can be observed in the reduction in the average dry densities of the samples when compared to the dry densities reported in our Geotechnical Investigation. The unconfined compressions ranged from 1,829 psf to 7,311 psf. Due to the sample disturbance, we feel that these numbers are lower than if they were compared to "fresh" samples that had less disturbance. The samples contained gravel and coarse sand sized particles that caused most of the disturbances. A summary of the test results can be found in Table 2.

TABLE 2
Summary of Laboratory Work

Test Hole Number	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)	Unconfined Compression (psf)
TH-1*****	3.67	14.0	100.4	
TH-1*****	6.17	15.2		
TH-1*****	8.67	15.8	99.4	
TH-1*****	21.0	10.3	101.4	
TH-2*****	6.17	12.5	108.0	
TH-2*****	8.67	17.7	97.7	
TH-2	11.17	18.8	85.4	1829
TH-2*****	15.8	15.8	89.7	
TH-2*****	16.17	15.7	93.0	
TH-2	20.67	12.9	96.5	2973*
TH-2	25.67	11.6	102.0	4191**
TH-3	5.83	11.7	91.1	2733***
TH-3	6.17	12.9	93.4	2733***

Test Hole Number	Sample Depth (ft.)	Moisture Content (%)	Dry Density (pcf)	Unconfined Compression (psf)
TH-3*****	8.67	12.2	118.2	
TH-3	10.8	8.6	104.5	7311***
TH-3	11.17	11.8		7311****
TH-3	15.67	9.3	104.0	3363***
TH-3	20.83	21.1	90.3	2172
Average Results for Geotechnical Investigation		16.4	101.0	
Average Results for Geotechnical Investigation Minus High and Low Density Readings			100.0	
Average Results for Unconfined Compression Testing		13.2	95.9	

* Top portion (about 1/4) of sample broke away upon loading into the testing apparatus.
** About 1/4- to ½- inch deep crumbled gravel located in the side of the sample.
*** Samples were dry and crumbling, did not hold together well.
**** Bottom corner of sample broke away upon loading.
***** Moisture content and dry density information obtained during laboratory testing performed during the original Geotechnical Investigation, GTS Project Number 18535, dated July 28, 2017. Densities were measured while sample was still in the sample liner. All other densities measured during unconfined compression testing were measured after the samples were extracted from the liners.

For this study, the hillside was assumed to consist entirely of the clays encountered during our Geotechnical Investigation. A cohesion value of 2,700 psf and a friction angle of 0 was assumed for the clay. The cohesion value, based upon our observations of the test samples, is expected to be very conservative. The Modified Bishop Method was used for the analysis of the slope both in the existing state and in the proposed configuration. Four different sections were analyzed across the development as shown in Figure 1. Table 3 summarizes the results of the analysis. We analyzed the slope both in a global sense (see Figure 2 for an example of the global analysis) and locally (see Figure 3 for an example of the local analysis).

TABLE 3
Summary of the Slope
Stability Analysis

Section	Factor of Saftey					
	Existing Geometry Global Analysis	Existing Geometry Local Analysis	Proposed Geometry Global Analysis	Proposed Geometry Local Analysis	Change In Factor of Safety - Global Analysis	Change in Factor of Safety - Local Analysis
10	2.900	3.056	2.746	2.746	0.154	0.310
11	3.143	3.701	3.018	3.184	0.125	0.517
12	2.683	2.803	2.596	2.674	0.087	0.129
13	3.546	3.681	3.447	3.378	0.099	0.303

It appears that the maximum reduction in the factor of safety due to the slope cuts is 0.517 which is along Section 11. Section 11 is the location of the maximum cut in the slope and it would be expected to have the greatest reduction in the factor of safety. All other reductions in the factor of safety are under 0.310.

It appears that the proposed cuts in the slope will not affect the stability of the slope to the point as to cause failure of the slope. Changes in the soil or loading conditions above the slope could affect the stability of the hill. The following factors are a partial list of conditions that might affect the stability of the slope at some point in the future. All property owners and managers, both located on the Commerce Point Development and the up slope properties should be made aware of these issues.

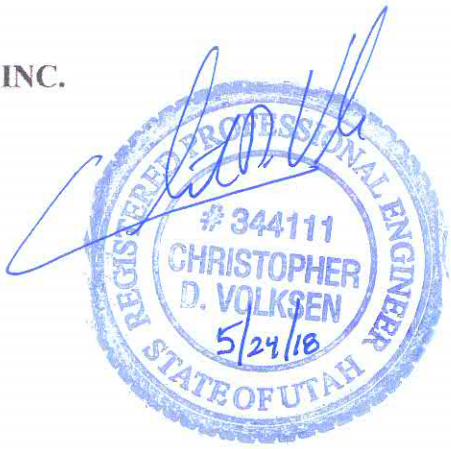
- Saturation of the down, mid, and/or up slope soils will cause the soils to weaken and could cause movement of the slope. Saturation of the soils also causes an increase in the weight of the soils which will increase the loading conditions of the slope. Care should be given to the landscaping of all properties, desert type landscaping is recommended. Storm water of the up slope properties should be carefully controlled and monitored and not be allowed to saturate into the subsurface soils. Water should not be allowed to flow over the slope.
- Over steeping of the existing slope will increase the loading conditions of the slope. Any changes of the exiting slope that are required for future development should be analyzed for their impact of the stability of the slope.
- Future development of the up slope properties could cause an increase in the loading conditions of the slope. Adding fill material or any type of building will increase loading and it should be analyzed for its impact on the stability of the slope. Removing material from the up slope properties should decrease the loading conditions and may increase the stability of the slope.

It is the responsibility of the current and future landowners of the property to the west to demonstrate that any proposed development will not impact the Commerce Point Commercial Center property. The over-steeping of the slope and construction of the rock wall/slope that was

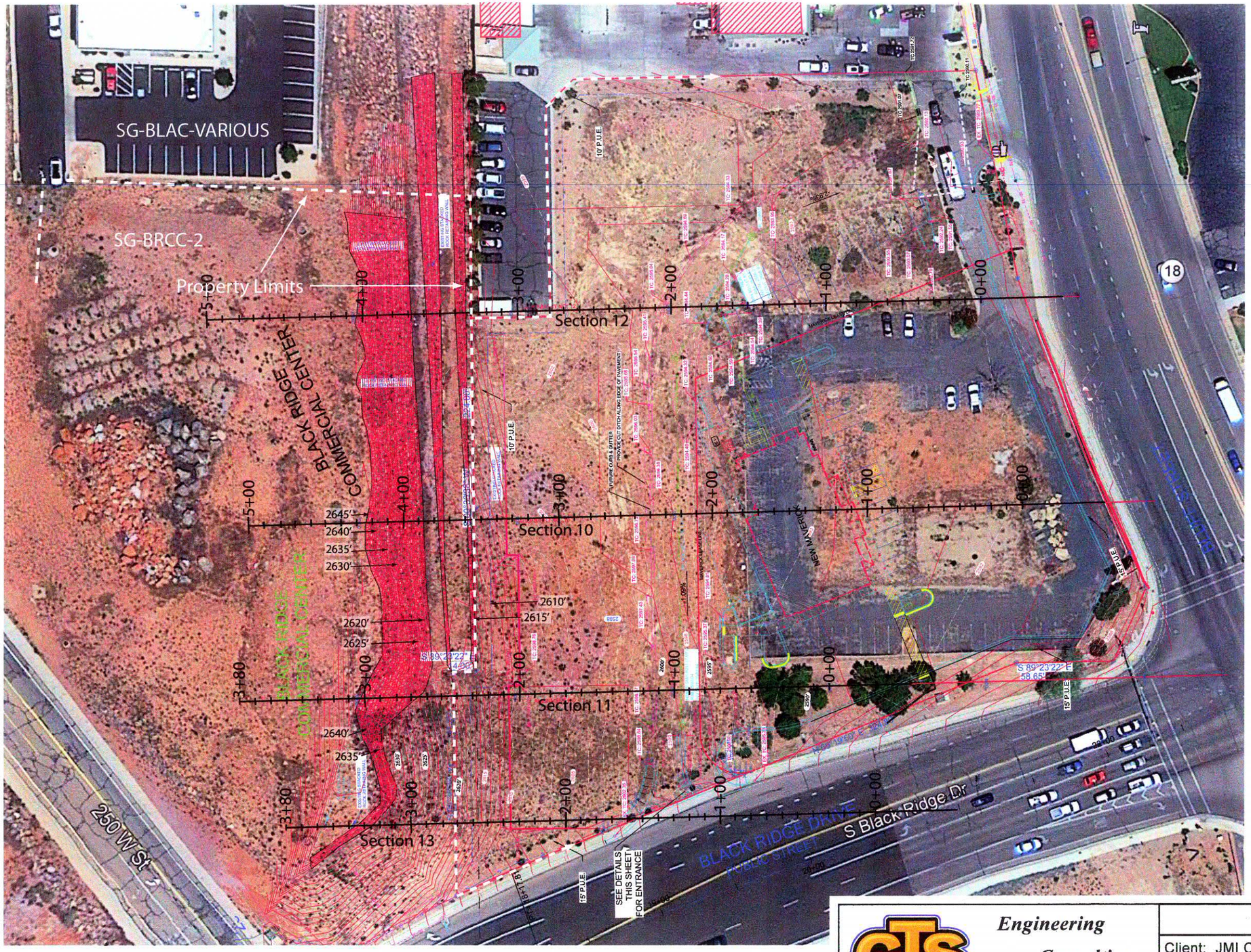
performed in the early 2000's is providing a large load to the slope. This load will most likely be the key to the driving force of the slide.

We appreciate the opportunity to be of service to you on this project. Please call us if you have any questions or need additional information.

Very truly yours,
GEOTECHNICAL TESTING SERVICES, INC.



CHRISTOPHER D. VOLKSEN, P.E.
President
CDV/c



GTS Geotechnical Testing Services Inc.

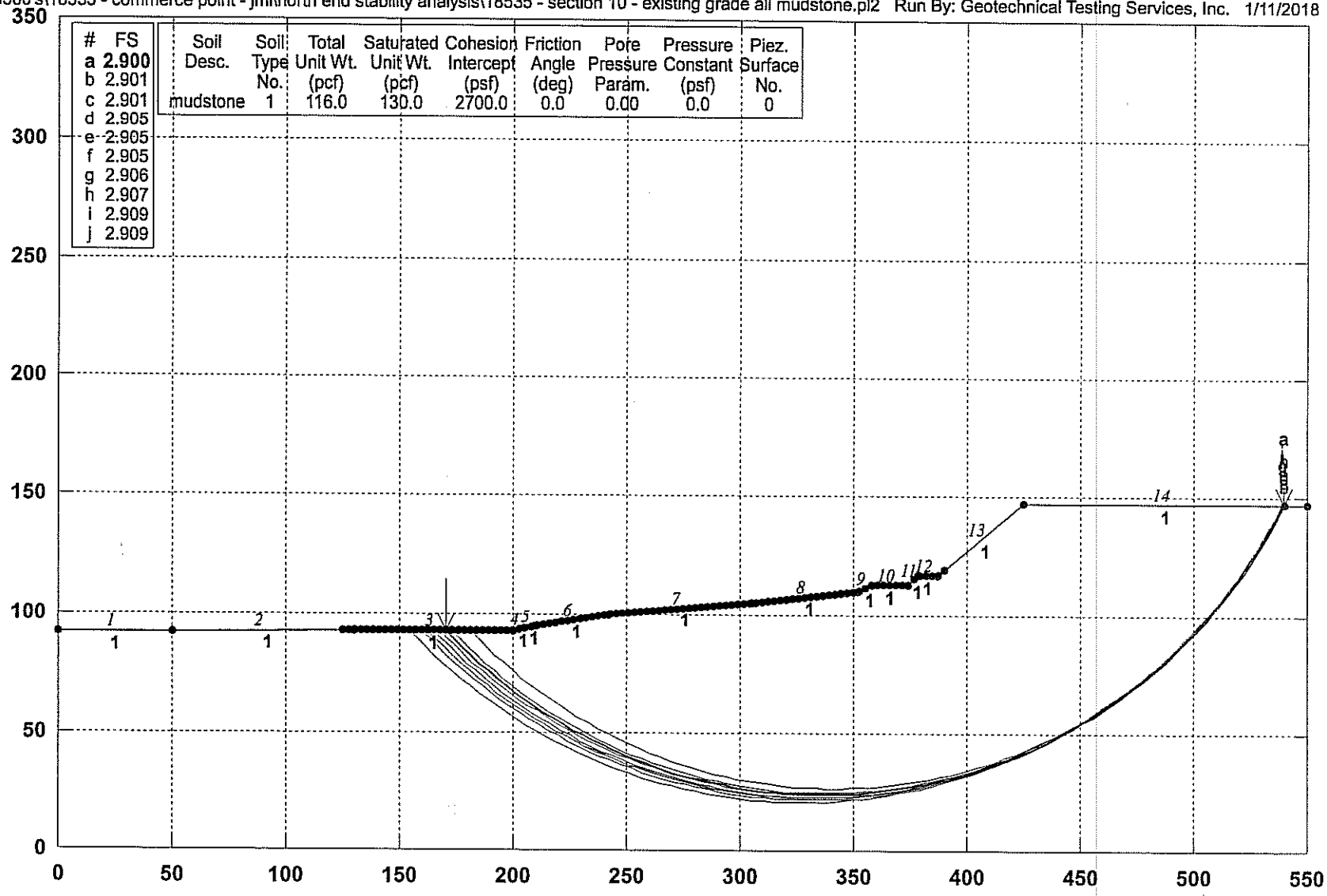
Engineering
Consulting
Testing

SITE PLAN

Client: JMI Constructors
Project: Commerce Point Commercial Center - North Phase
Location: Northwest Corner Bluff St. and Blackridge Dr.
Number: 18535 **Figure 1**

18535 - Commerce Point - N Phase Section10 - Existing Grades

z:\18500's\18535 - commerce point - jmi\north end stability analysis\18535 - section 10 - existing grade all mudstone.pl2 Run By: Geotechnical Testing Services, Inc. 1/11/2018 09:43PM



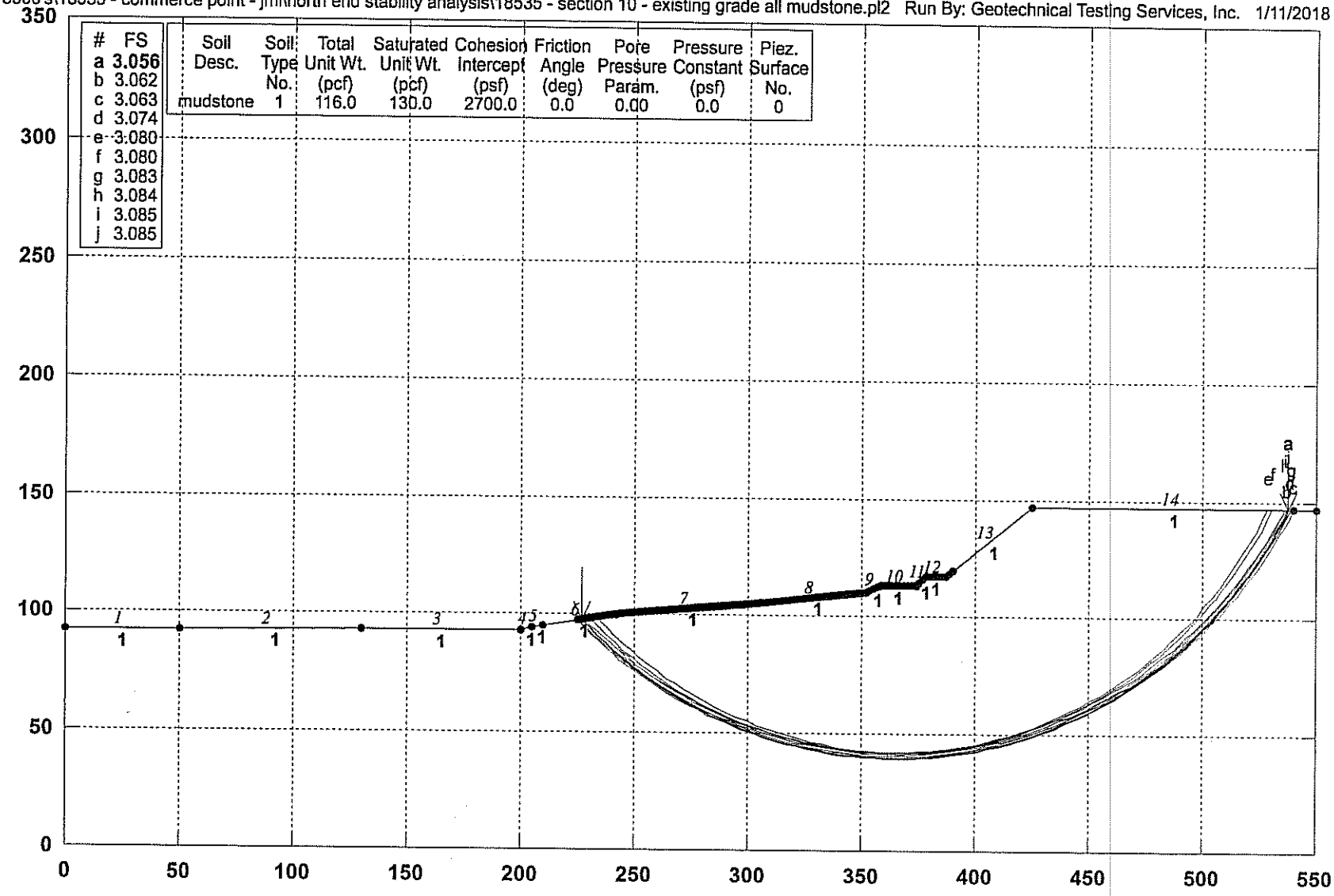
GSTABL7 v.2 FSmin=2.900

Safety Factors Are Calculated By The Modified Bishop Method

Figure 2

18535 - Commerce Point - N Phase Section10 - Existing Grades

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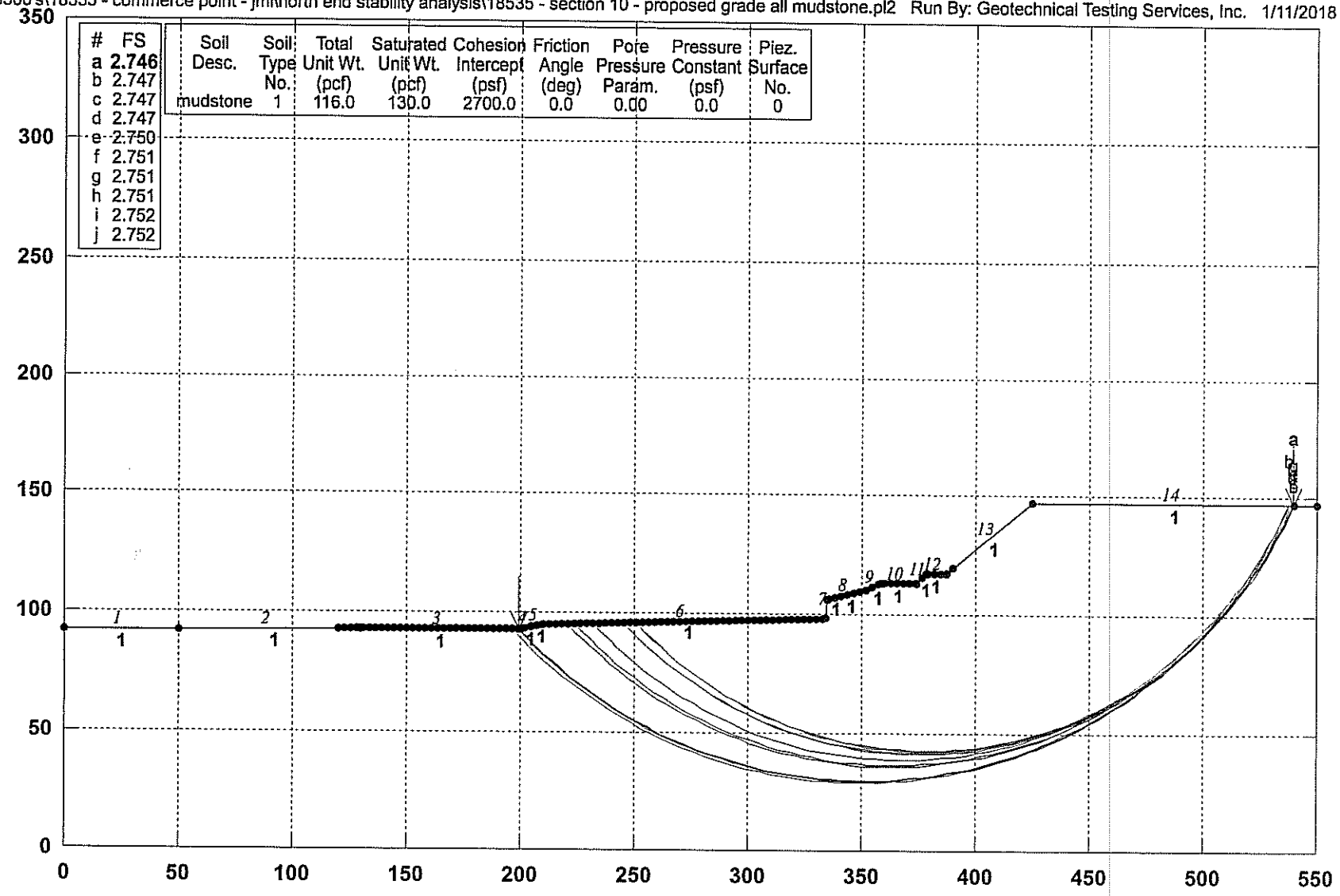
GSTABL7 v.2 FSmin=3.056

Safety Factors Are Calculated By The Modified Bishop Method

Figure 3

18535 - Commerce Point - N Phase Section10 - Proposed Grades

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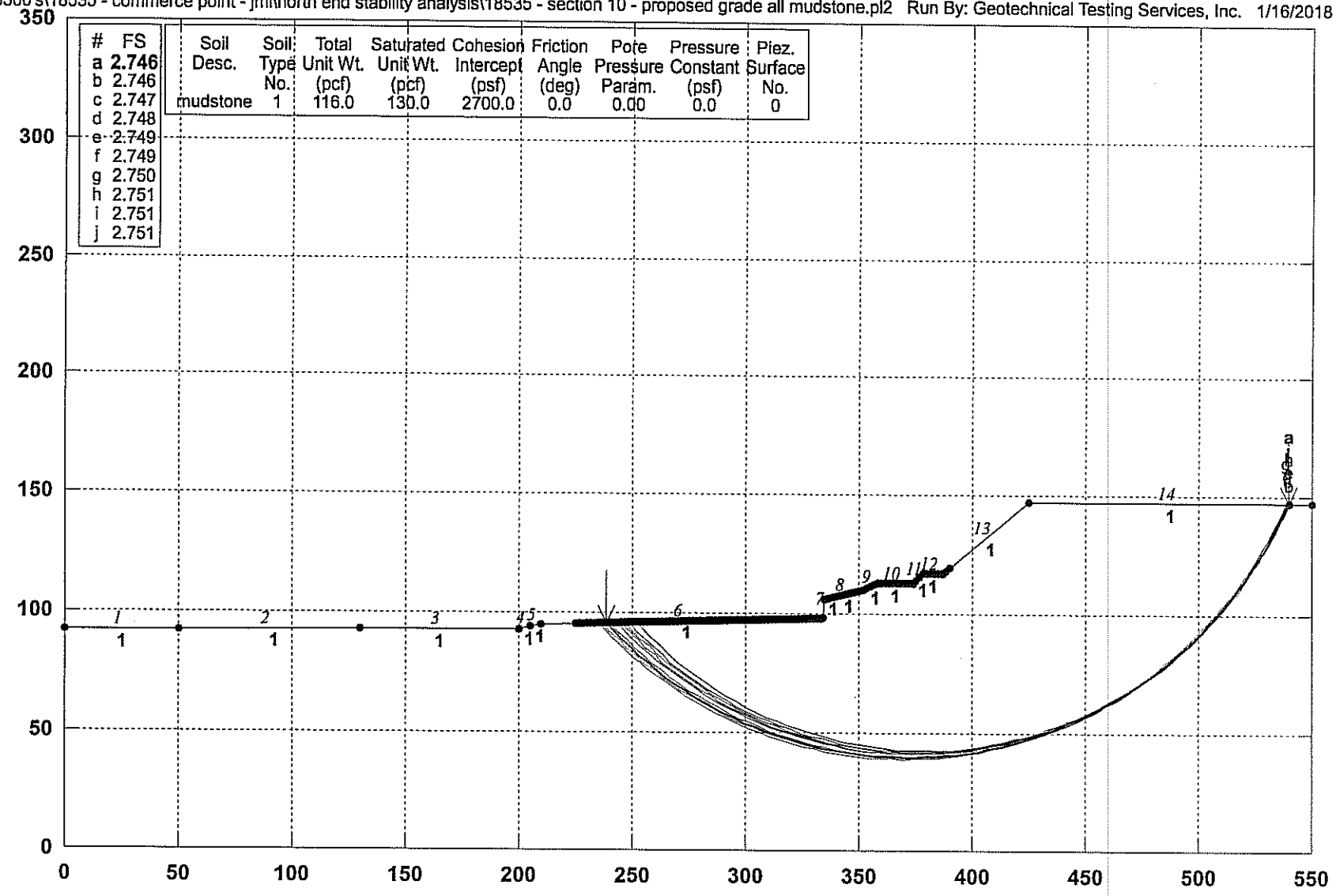
GSTABL7 v.2 FSmin=2.746

Safety Factors Are Calculated By The Modified Bishop Method

Figure 4

18535 - Commerce Point - N Phase Section10 - Proposed Grades

z:\18500's\18535 - commerce point - jmi\north end stability analysis\18535 - section 10 - proposed grade all mudstone.pl2 Run By: Geotechnical Testing Services, Inc. 1/16/2018 06:37PM



#	FS
a	2.746
b	2.746
c	2.747
d	2.748
e	2.749
f	2.749
g	2.750
h	2.751
i	2.751
j	2.751

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
mudstone	1	116.0	130.0	2700.0	0.0	0.00	0.0	0

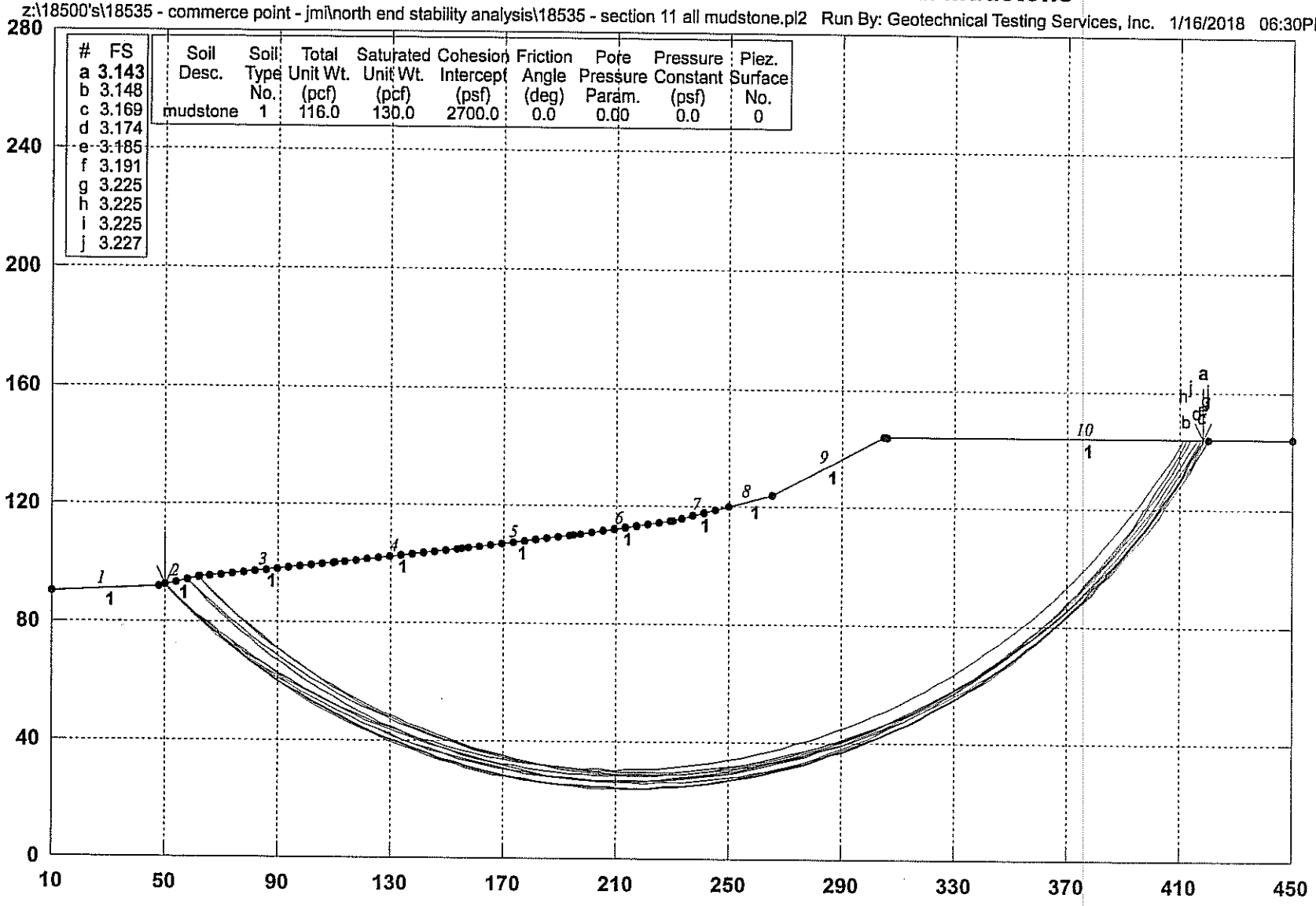
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Safety Factors Are Calculated By The Modified Bishop Method

Figure 5

18535 - Commerce Point North End Section 11 - All Mudstone

z:\18500's\18535 - commerce point - jmi\north end stability analysis\18535 - section 11 all mudstone.pl2 Run By: Geotechnical Testing Services, Inc. 1/16/2018 06:30PM



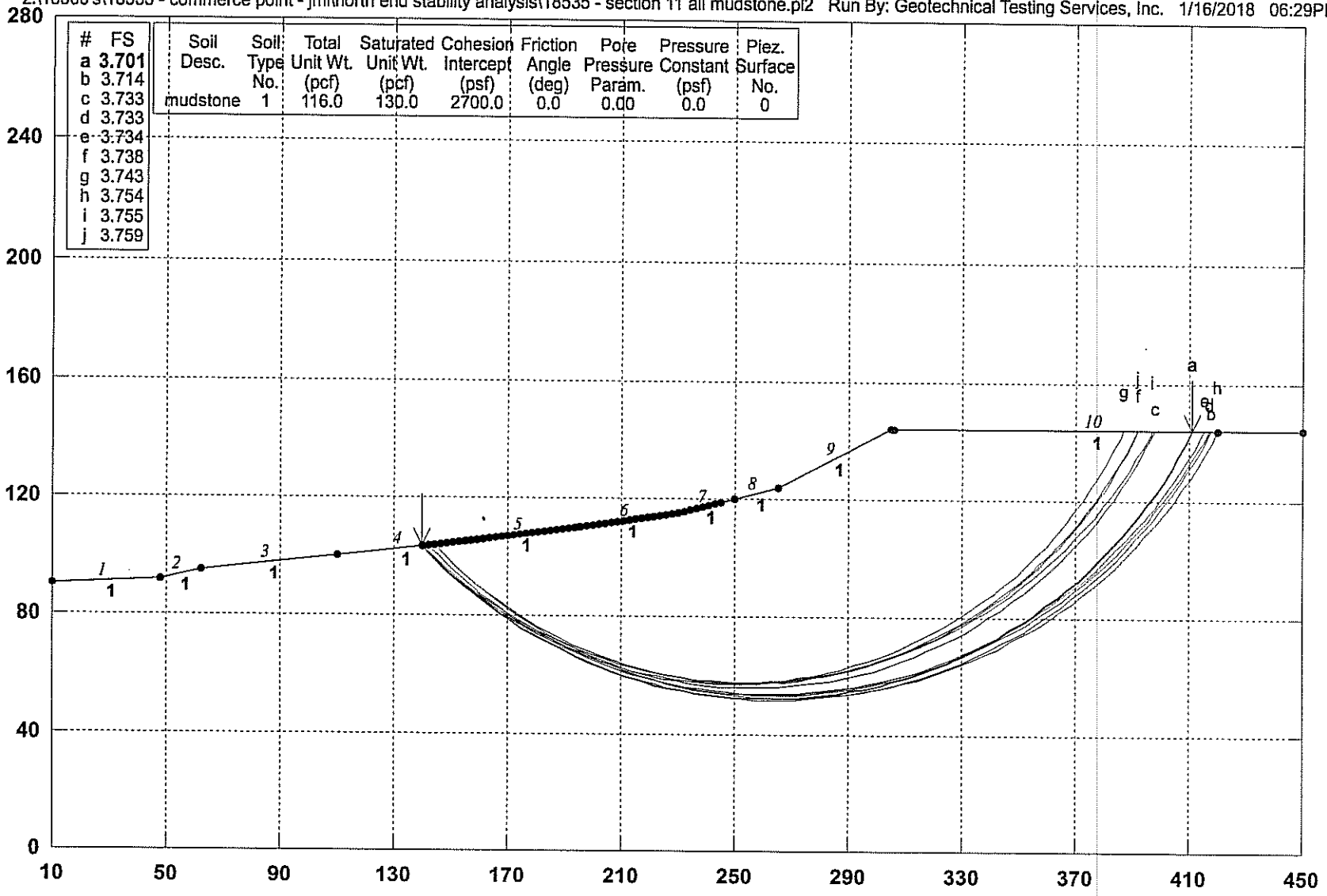
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Safety Factors Are Calculated By The Modified Bishop Method

Figure 6

18535 - Commerce Point North End Section 11 - All Mudstone

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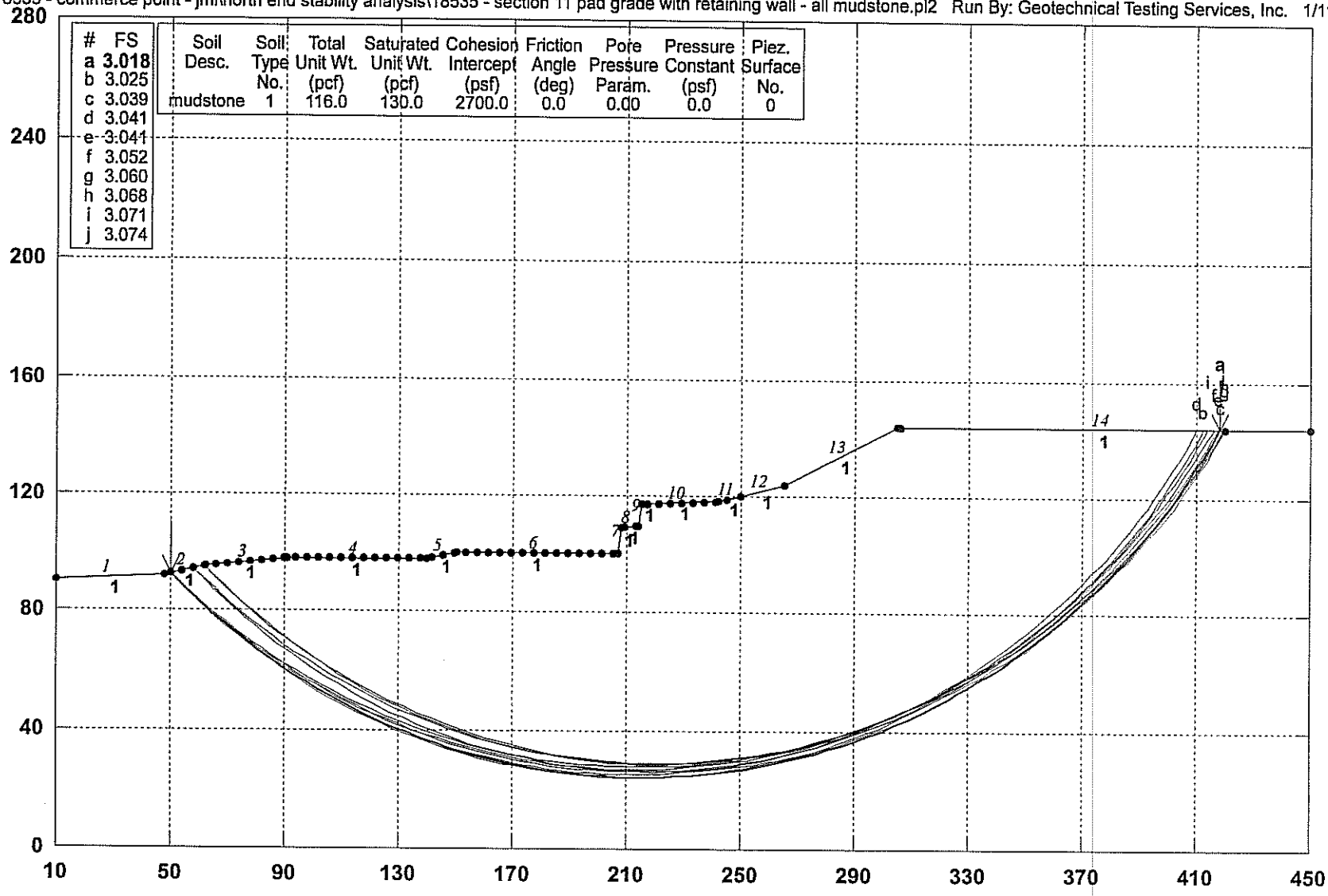
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Safety Factors Are Calculated By The Modified Bishop Method

Figure 7

18535 - Commerce Point - Section 11 +1' to Pad Grade - 2 R-w's

z:\18500's\18535 - commerce point - jmi\north end stability analysis\18535 - section 11 pad grade with retaining wall - all mudstone.pl2 Run By: Geotechnical Testing Services, Inc. 1/11/2018 09:30



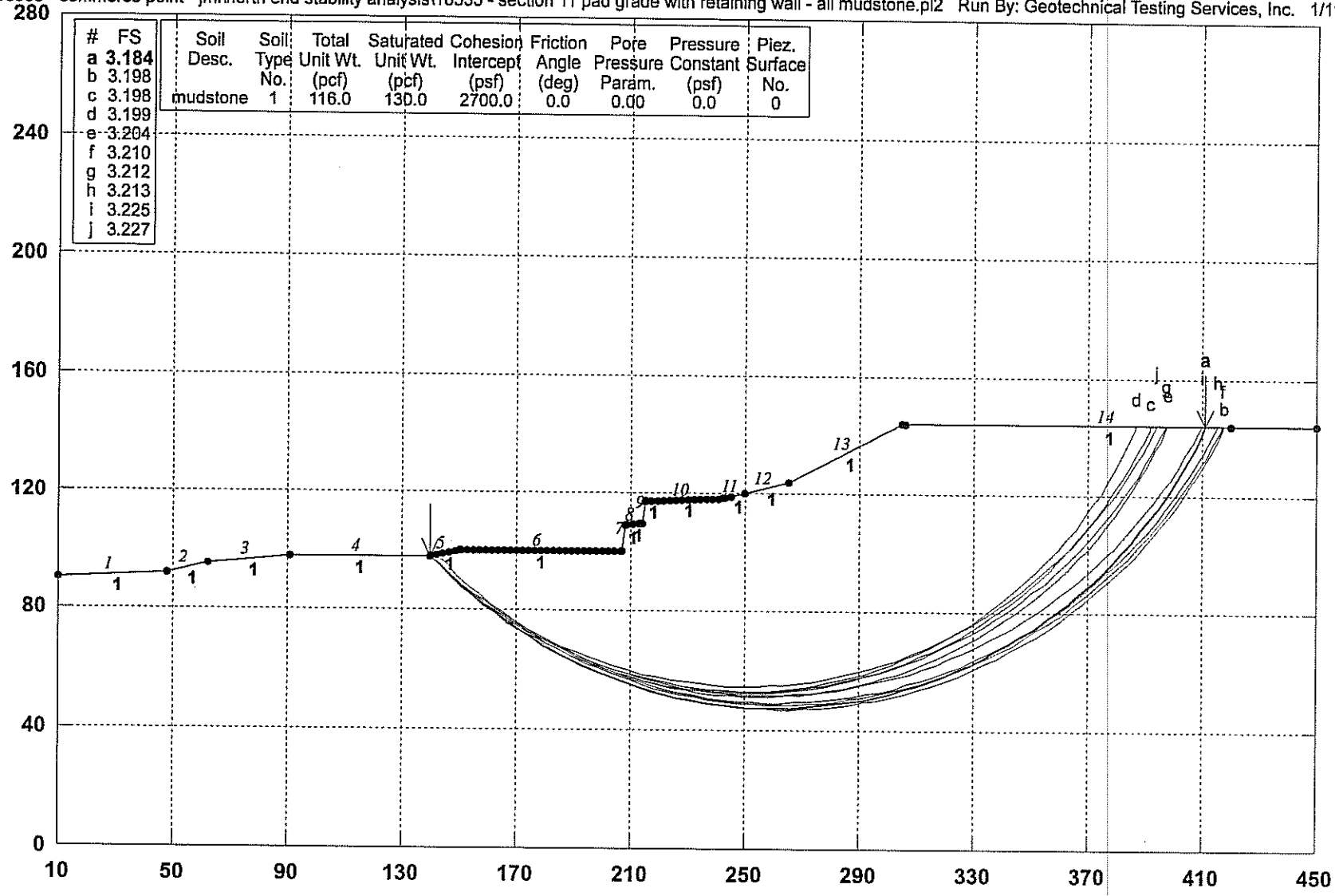
GSTABL7 v.2 FSmin=3.018

Safety Factors Are Calculated By The Modified Bishop Method

Figure 8

18535 - Commerce Point - Section 11 +1' to Pad Grade - 2 R-w's

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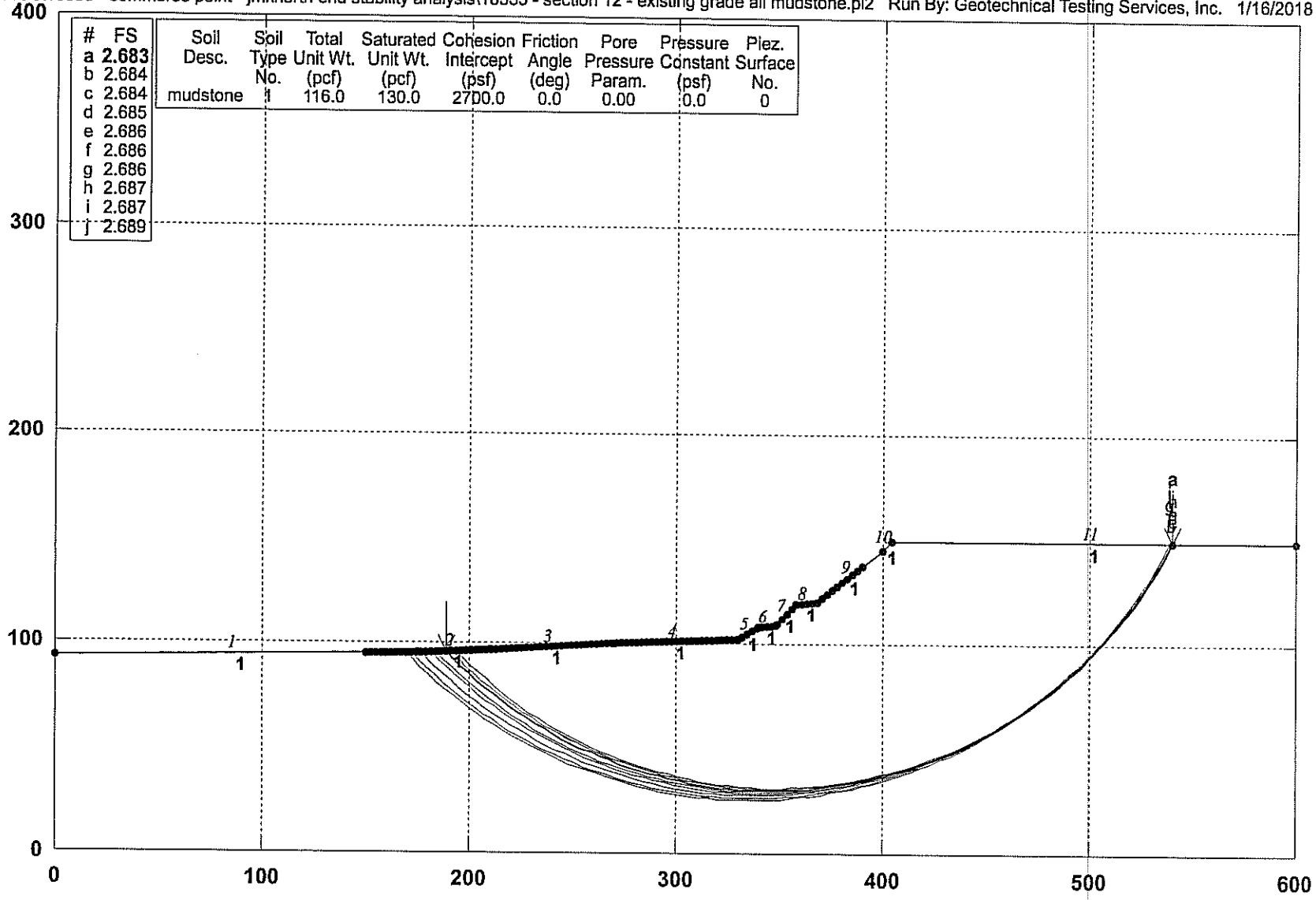
GSTABL7 v.2 FSmin=3.184

Safety Factors Are Calculated By The Modified Bishop Method

Figure 9

18535 - Commerce Point - N Phase Section12 - existing grades

z:\18500's\18535 - commerce point - jmi\north end stability analysis\18535 - section 12 - existing grade all mudstone.pl2 Run By: Geotechnical Testing Services, Inc. 1/16/2018 06:59PM



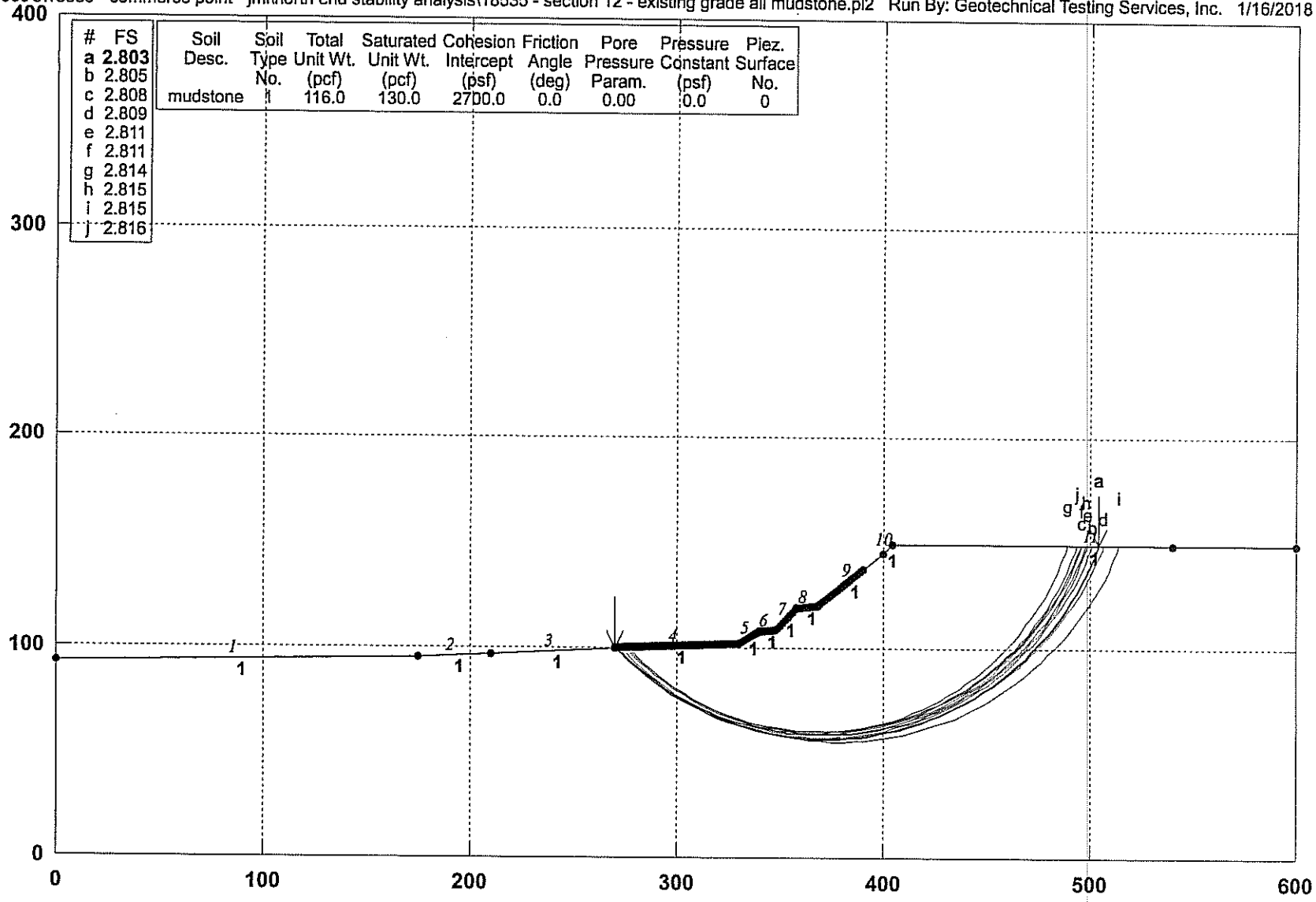
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Safety Factors Are Calculated By The Modified Bishop Method

Figure 10

18535 - Commerce Point - N Phase Section12 - existing grades

z:\18500's\18535 - commerce point - jm\north end stability analysis\18535 - section 12 - existing grade all mudstone.pl2 Run By: Geotechnical Testing Services, Inc. 1/16/2018 06:58PM



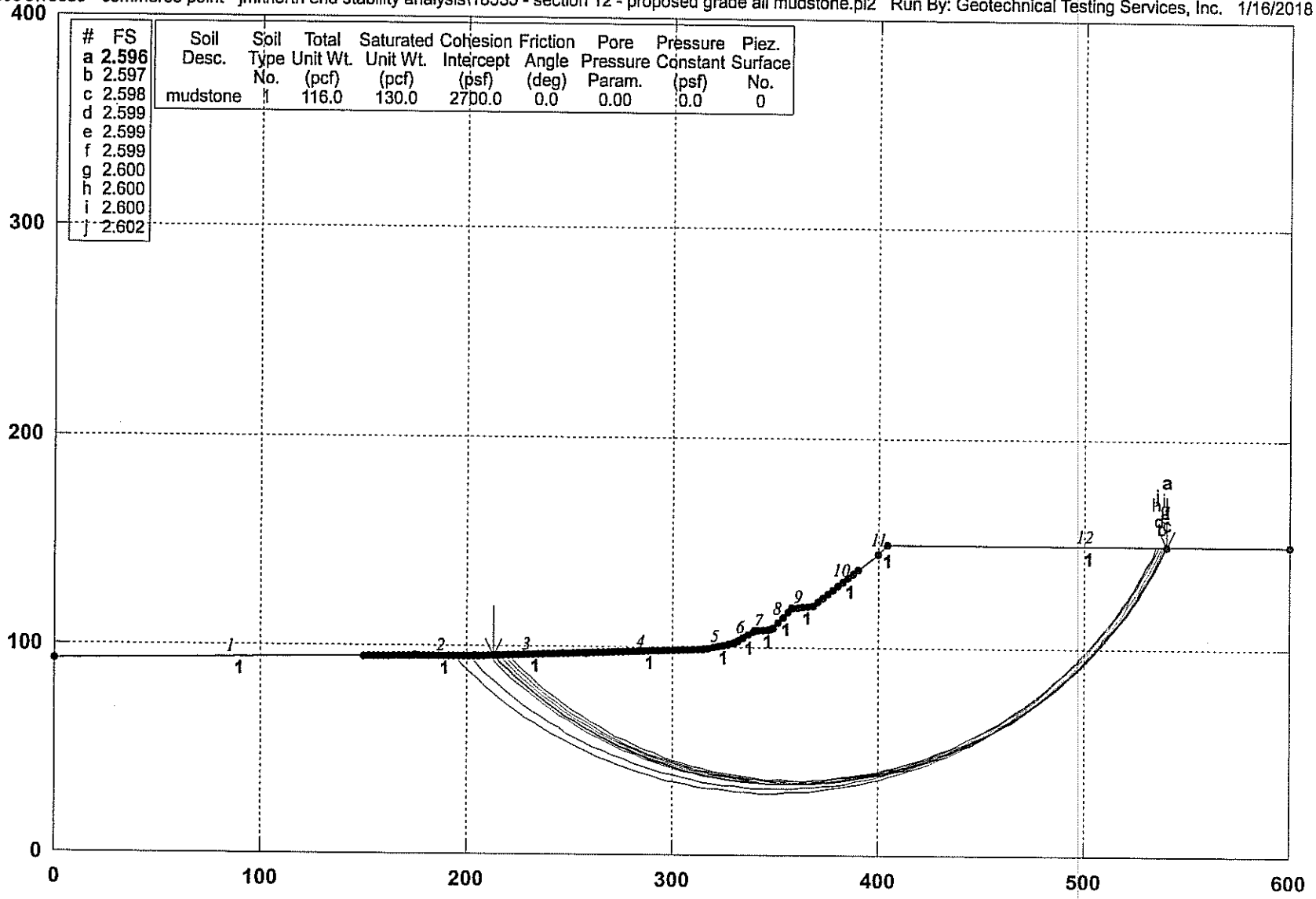
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Safety Factors Are Calculated By The Modified Bishop Method

Figure 11

18535 - Commerce Point - N Phase Section12 - existing grades Proposed Grades

z:\18500's\18535 - commerce point - jmi\north end stability analysis\18535 - section 12 - proposed grade all mudstone.pl2 Run By: Geotechnical Testing Services, Inc. 1/16/2018 06:47PM



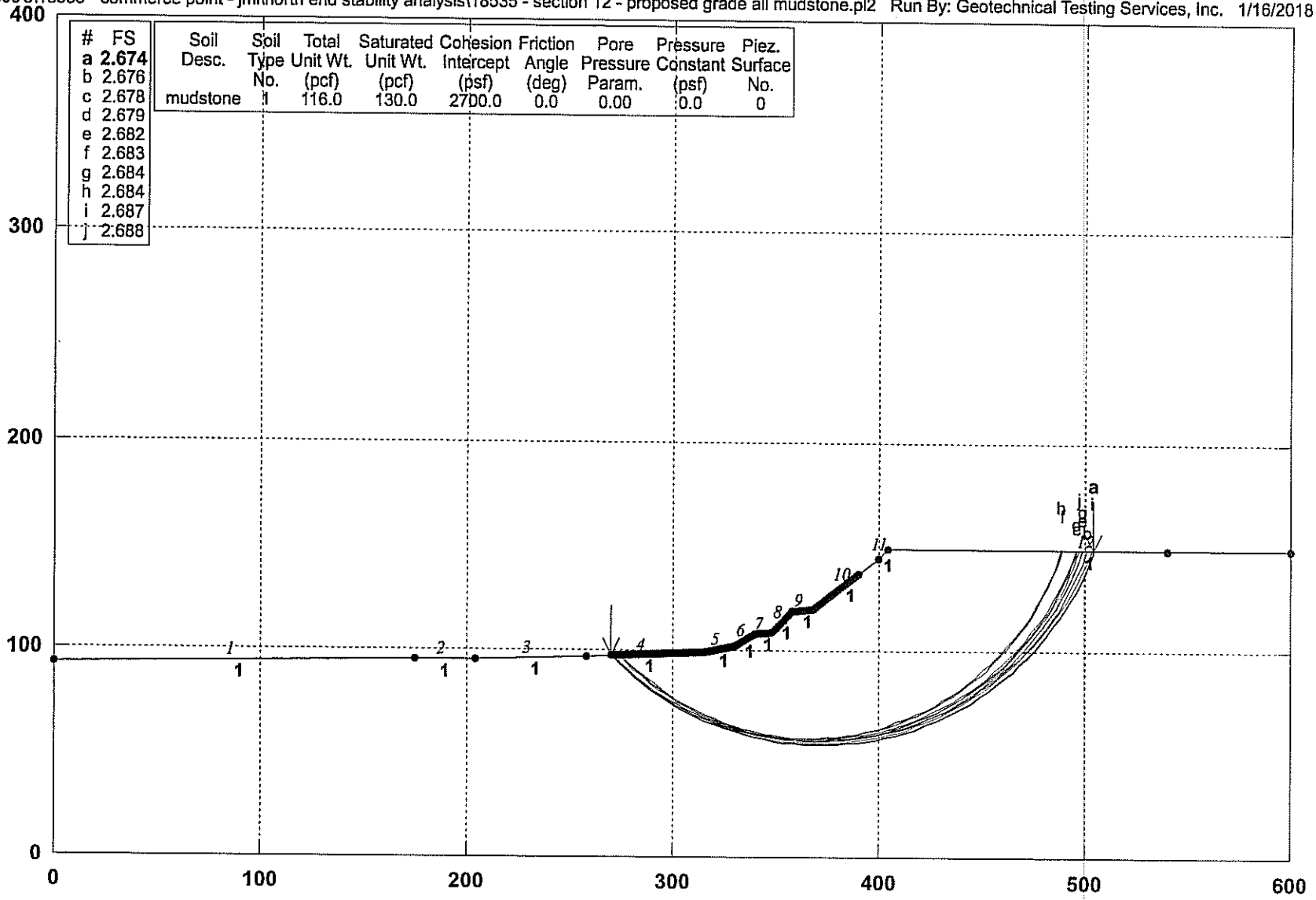
GSTABL7 v.2 FSmin=2.596

Safety Factors Are Calculated By The Modified Bishop Method

Figure 12

18535 - Commerce Point - N Phase Section12 - existing grades Proposed Grades

z:\18500's\18535 - commerce point - jmi\north end stability analysis\18535 - section 12 - proposed grade all mudstone.pl2 Run By: Geotechnical Testing Services, Inc. 1/16/2018 06:49PM



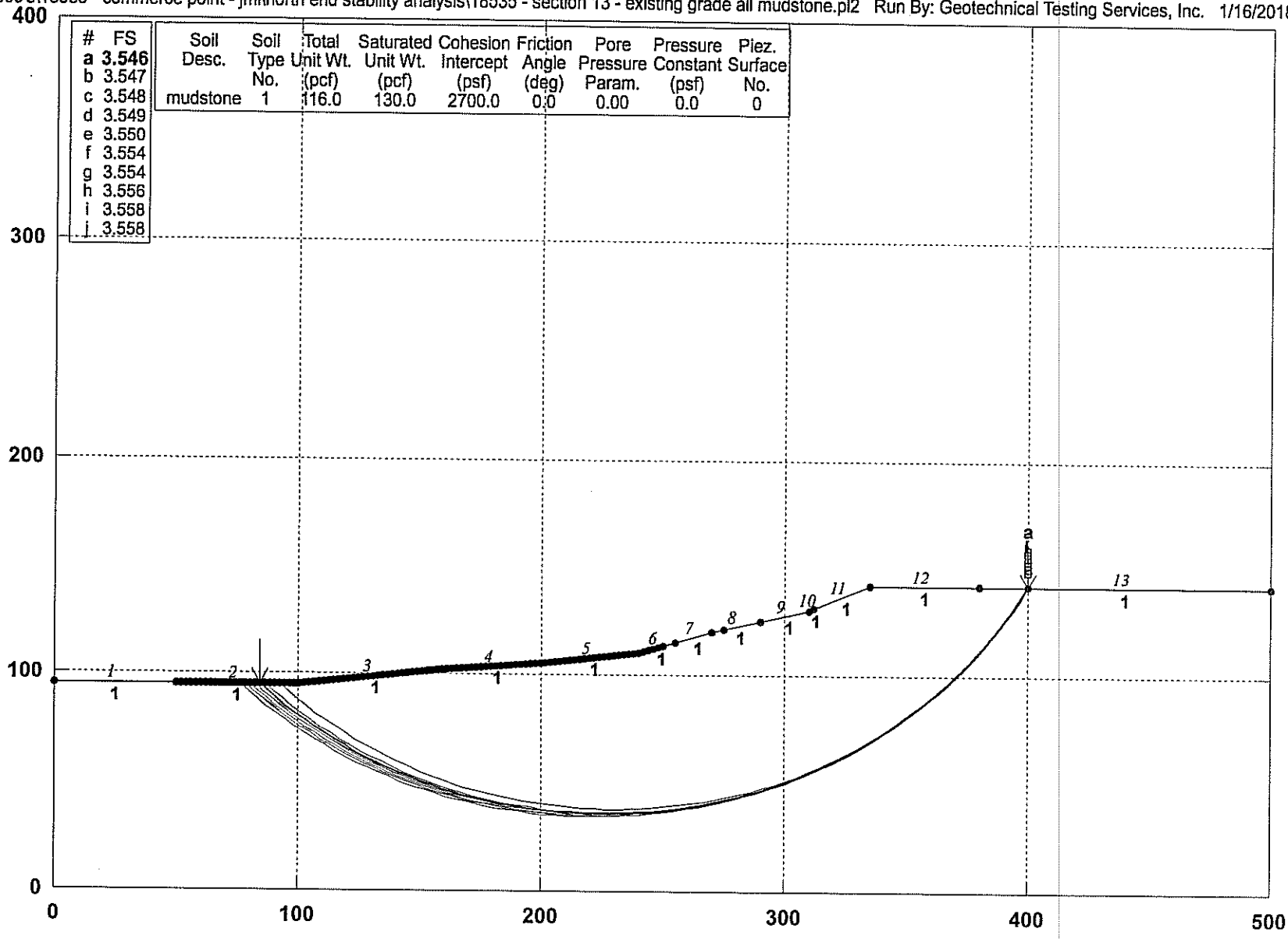
GSTABL7 v.2 FSmin=2.674

Safety Factors Are Calculated By The Modified Bishop Method

Figure 13

18535 - Commerce Point - N Phase Section 13 - existing grades

z:\18500's\18535 - commerce point - jmi\north end stability analysis\18535 - section 13 - existing grade all mudstone.pl2 Run By: Geotechnical Testing Services, Inc. 1/16/2018 07:15PM



#	FS
a	**3.546**
b	3.547
c	3.548
d	3.549
e	3.550
f	3.554
g	3.554
h	3.556
i	3.558
j	3.558

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
mudstone	1	116.0	130.0	2700.0	0.0	0.00	0.0	0

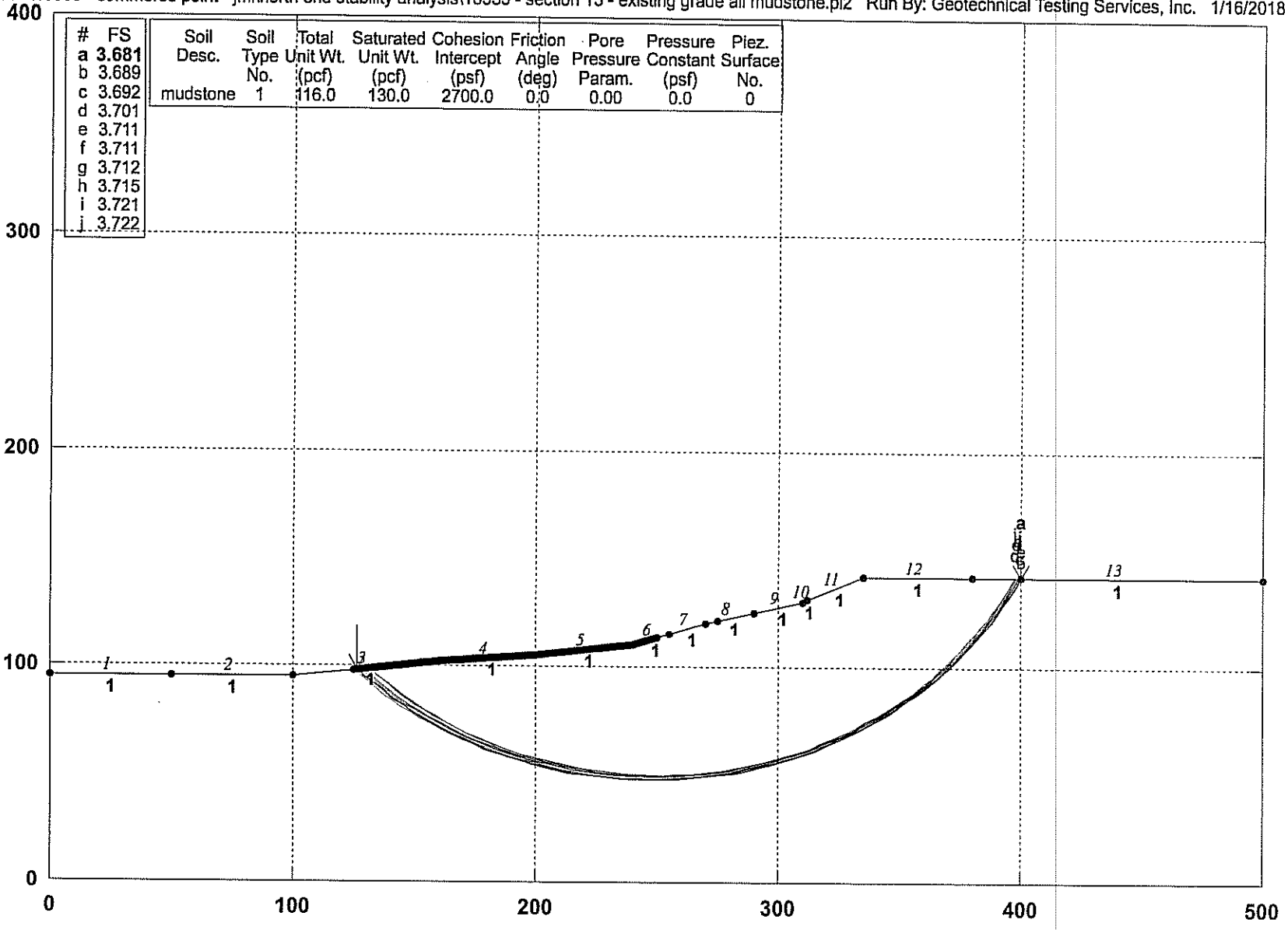
GSTABL7 v.2 FSmin=3.546

Safety Factors Are Calculated By The Modified Bishop Method

Figure 14

18535 - Commerce Point - N Phase Section 13 - existing grades

z:\18500's\18535 - commerce point - jmi\north end stability analysis\18535 - section 13 - existing grade all mudstone.pl2 Run By: Geotechnical Testing Services, Inc. 1/16/2018 07:14PM



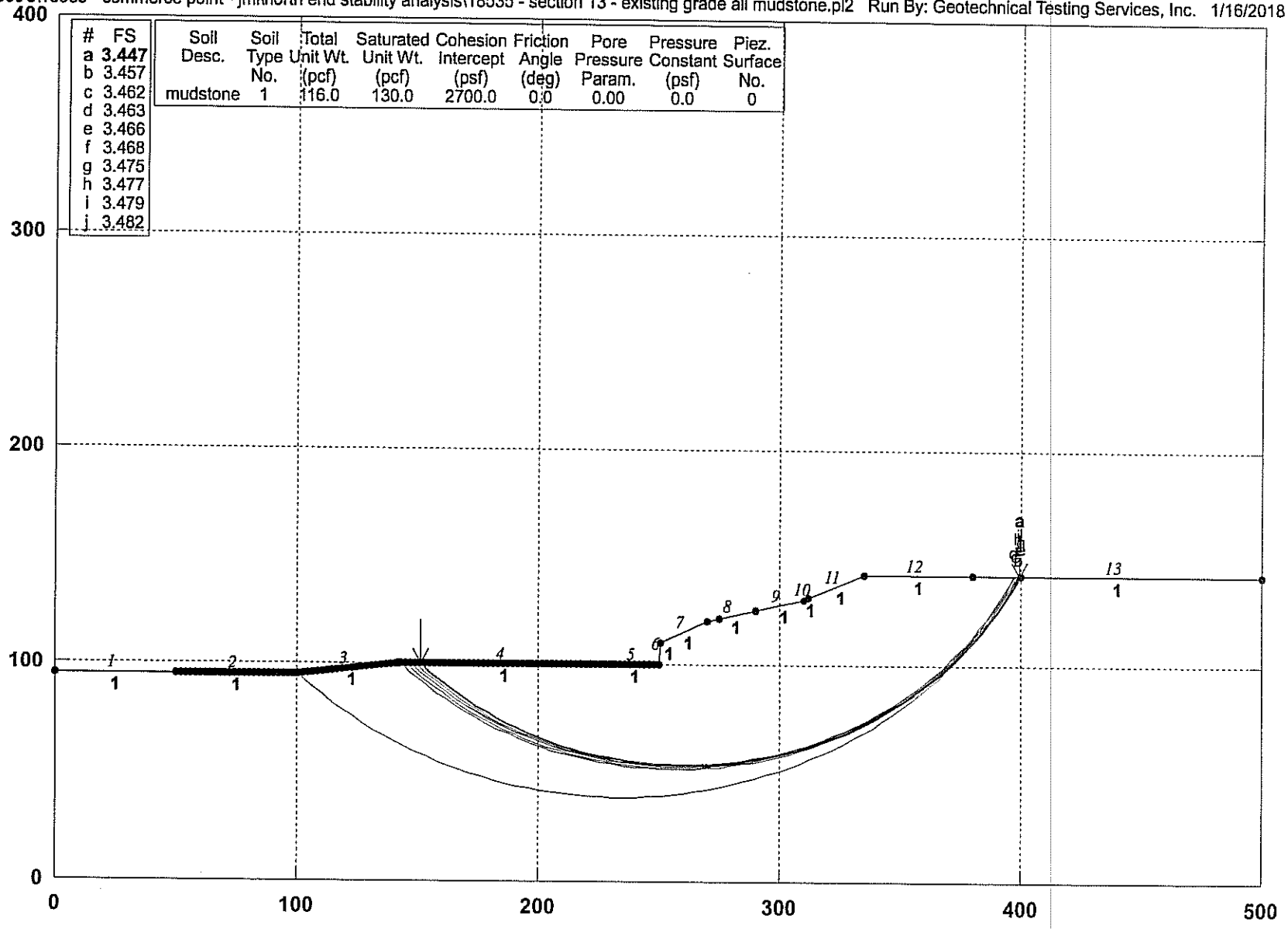
GSTABL7 v.2 FSmin=3.681

Safety Factors Are Calculated By The Modified Bishop Method

Figure15

18535 - Commerce Point - N Phase Section13 - Proposed grades

z:\18500's\18535 - commerce point - jmi\north end stability analysis\18535 - section 13 - existing grade all mudstone.pl2 Run By: Geotechnical Testing Services, Inc. 1/16/2018 07:22PM



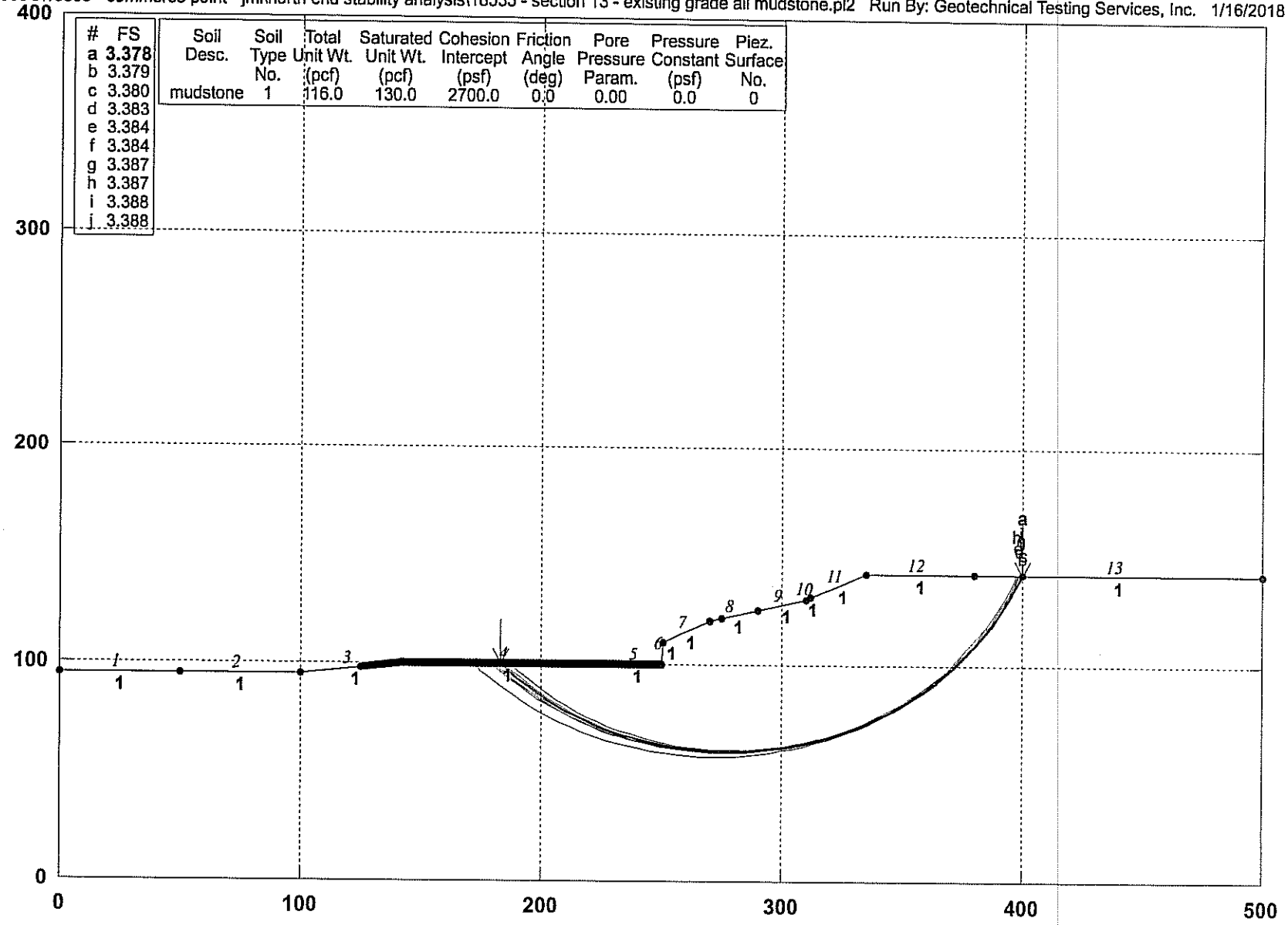
GSTABL7 v.2 FSmin=3.447

Safety Factors Are Calculated By The Modified Bishop Method

Figure 16

18535 - Commerce Point - N Phase Section13 - Proposed grades

z:\18500's\18535 - commerce point - jmi\north end stability analysis\18535 - section 13 - existing grade all mudstone.pl2 Run By: Geotechnical Testing Services, Inc. 1/16/2018 07:23PM



GSTABL7 v.2 FSmin=3.378

Safety Factors Are Calculated By The Modified Bishop Method

Figure 17

St.George
Community Development

ITEM 1

Hillside Permit

HILLSIDE REVIEW BOARD AGENDA REPORT: **11/20/2019 (Tabled)**
HILLSIDE REVIEW BOARD AGENDA REPORT: **09/16/2020**

HILLSIDE DEVELOPMENT PERMIT
Summit Estates
Case No. 2019-HS-008

Background: On November 20, 2019, the Hillside Review Board met on the site to discuss the project and the request of the applicant. At the meeting, the board discussed several items that they would like to see. The applicant has revised their drawings and those revised drawings are attached to this staff report. Additionally, for your reference, we have attached the minutes from the previous meeting.

Request: This is a request for a Hillside Development Permit allowing development of 'Summit Estates' a residential subdivision.

References: Sienna Canyon Master Plan and the Webb Hill land exchange development agreement (1998)

Project: Summit Estates would be a residential subdivision with parcels ranging in size from 0.41 acres up to 6.2 acres in size. The lots would each have the homes placed to minimize cuts and fills.

Owner: V.E. MGMT & Investment Company, LC

Engineer: Horrocks

Representative: Ben Willits, Project Manager

APN: SG-5-3-5-32001

Location: Intersection of Hillrise Drive & Ft Pierce Drive

Acreage: Parcel size = 70.83 acres
Developable area = 41.88 acres
Private open space = 28.95 acres

Current Use: This area is currently undeveloped with a City R.O.W. used for an access road up to the Webb Hill communication towers and also to the 'Kentucky Lucky Chicken Trail' (*a city trail*).

General Plan: OS (Open Space) & VLDR (Very Low Density Residential)

Zone: Currently PD-R (*Part of the original Sienna Canyon Master Plan & per the Webb Hill land exchange development agreement, July 1998*).

Open Space: Over 45% of the project site would be left in open space (due to terrain, hillsides, etc.).

Density: 0.6 du / ac

Note: This parcel is entitled to 54 lots per the Webb Hill land exchange development agreement, July 1998. However, no variances to this are being requested or anticipated at this time.

Units: A total of 43 units (0.5 – 6.3 acres) is anticipated to be submitted for with the platting process portion of this projects development.

HSRB
(Hillside Review Board)

Powers & Duties: Section 10-13A-12.B.1 of the "Hillside Review Board Powers and Duties" states that the Hillside Review Board can make recommendations for approval, conditional approval, and denial to the Planning Commission (PC) and City Council (CC).

Permit required: Section 10-13A-6:A requires that all major development (i.e., cut greater than 4', etc.) on slopes above 20% requires a 'hillside development permit' granted by the City Council upon recommendation from the Hillside Review Board and the Planning Commission.

Applicable Ordinance(s):

10-13A-1: Purpose
The city finds that the health, safety and the general public welfare of the residents of the city will be promoted by establishing standards for the development and excavation of hillside and slope areas located in the city so as to minimize soil and slope instability and erosion, to minimize the adverse effects of grading, cut and fill operations, to preserve the character of the city's hillsides, and to otherwise supplement and amplify the city subdivision and zoning ordinances. The provisions herein are designated to accomplish the following:

A. Prohibit development of uses which would likely result in a hazardous situation due to slope instability, rock falls or excessive soil erosion.

B. Provide for safe vehicular circulation and access.

C. Encourage the location, design and development of building sites in a manner that will minimize the scarring and erosion effects of cutting, filling and grading of hillsides.

% Natural Slope	Dwelling Units (DU) / Acre
0-19	See underlying zone
20-29	2 DU/acre, provided the units are clustered on 30 percent (30%) or less of the land area within this slope category. 70 percent of this slope category shall remain undisturbed. The 70 percent area is based upon the overall area/development rather than per lot. Also see subsections A1, A2, and A3 of this section.
30-39	1 DU/10 acres, provided no more than 5 percent (5%) of the site is disturbed, and 95 percent of the site remains undisturbed. If the cumulative area is at least 1 acre but less than 10 acres, the cumulative area shall be allowed 1 DU.
40	Development is not permitted (0%), **except** as provided for in subsection A4 of this section.

D. Encourage preservation of open space by encouraging clusters or other design techniques to preserve the natural terrain.
E. Where hillside excavation does occur, require that buildings be located in the cut area to minimize the visual effects of scarring. (1998 Document § 10A-1)

Section 10-13A-4: Density and Disturbance Standards

A. Schedule: In furtherance of the purposes set forth above, density and site disturbance within the hillside development overlay zone shall comply with the following schedule. Any portion of a development parcel having a slope greater than forty percent (40%) shall not be included in the calculation of the area of such parcel for the purposes of determining conformity with the density requirements below:

A.4. The city council, after considering the recommendation from the hillside review board, and from the planning commission may approve the removal of small hills which contain slopes forty percent (40%) or greater subject to determining the application conforms to all of the following requirements:

a. The hill is not contiguous to nor part of a major hillside formation, and
b. The removal of such landform will not create a negative aesthetic impact in the opinion of the city council, and
c. The land area is zoned for residential, commercial, or industrial development. (Ord. 2013-01-001, 1-3-2013)

Section 10-13A-5: Slope and Slope Areas Determined

B. Procedure: The location of the natural twenty percent (20%), thirty percent (30%) and forty percent (40%) slopes for the purposes of this article shall be determined using the following procedure: (Ord. 2005-07-007, 7-21-2005)

3. Determination of Slope Areas for Density Calculations: Using the contour maps, slopes shall be calculated in intervals no greater than forty feet (40') along profile lines. Points identified as slopes of twenty percent (20%), thirty percent (30%), and forty percent (40%) shall be located on the contour map and connected by a continuous line. That area bounded by said lines and intersecting property lines shall be used for determining dwelling unit density. Small washes or rock outcrops which have slopes distinctly different from surrounding property and not part of the contiguous topography may be excluded from slope determination if, in the opinion of the hillside review board, the exclusion of such small areas from slope determination will not be contrary to the overall purpose of this article. For the purpose of determining developable areas and allowable densities, previously disturbed hillside areas shall be considered on a pre-disturbance natural slope basis, where feasible, as proposed by the applicant's engineer and approved by the hillside review board. Where a property owner restores a previously disturbed area to a natural or near natural condition, the area may be included within a required no disturbance area. (Ord. 2005-07-007, 7-21-2005)

HSRB Motion Options: The Hillside Board can recommend several options to the Planning Commission & City Council:

1. Denial
2. Approval as presented
3. Approval with specific conditions and comments

Example Motion: The Hillside Review Board recommends approval of a Hillside Development Permit for Case No. 2019-HS-008; allowing future development of 'Summit Estates' a proposed residential subdivision

The applicant shall adhere to the recommendations and conditions recommended in the:

A. Rock Fall Report *(Note: There is not a rock fall report, but rockfall is mentioned several times in the geotech report – particularly Figure 3B "Rock Fall Hazard Map*).

B. Drainage Report (*Horrocks Project No. UT-1507-1901 dated November 13, 2019),*

C. Geotechnical Report (*AGEC Project No. 2182014 dated October 23, 2019*).

Narrative / Summary

To: St. George Hillside Committee

From: Ben Willits, Project Manager

Date: October 30, 2019

Subject: **Summit Estates Hillside analysis summary**

HORROCKS ENGINEERS
555 South Bluff Street | Suite 101
St. George, Utah 84770 | 435.986.7888

Attached is the Hillside Development package on the Summit Estates (Webb Hill) project.

Site Statistics:

Parcel Size: 70.83 ac *Assessor's Parcel ID*: SG-5-3-5-32001

Location: Intersection of Hillrise & Ft. Pierce Dr. St. George, UT

Existing Site Use: Undeveloped with a City ROW access road to the Webb Hill Comm. Towers and Kentucky Lucky Chicken Trail (City trail).

Zoning and Entitlements:

Currently the site is zoned PD-R as part of the original Sienna Canyon Master Plan and per the Webb Hill Land Exchange Development Agreement, July 1998. The parcel is entitled for 54 lots per said agreement. No variances to this are being requested at this time.

Proposed Project Parcel Planning:

The developers are proposing a low impact, high-end custom residential parcels ranging from 0.5 ac. To over 6.2 ac. in size. Over 45% of the site will be left in open space with the lot and home placement carefully selected so as to minimize cuts and fills to the site. Very strict design guidelines and CC&R's will be placed on the plat and will deed restrict the manner in which the homes will be built.

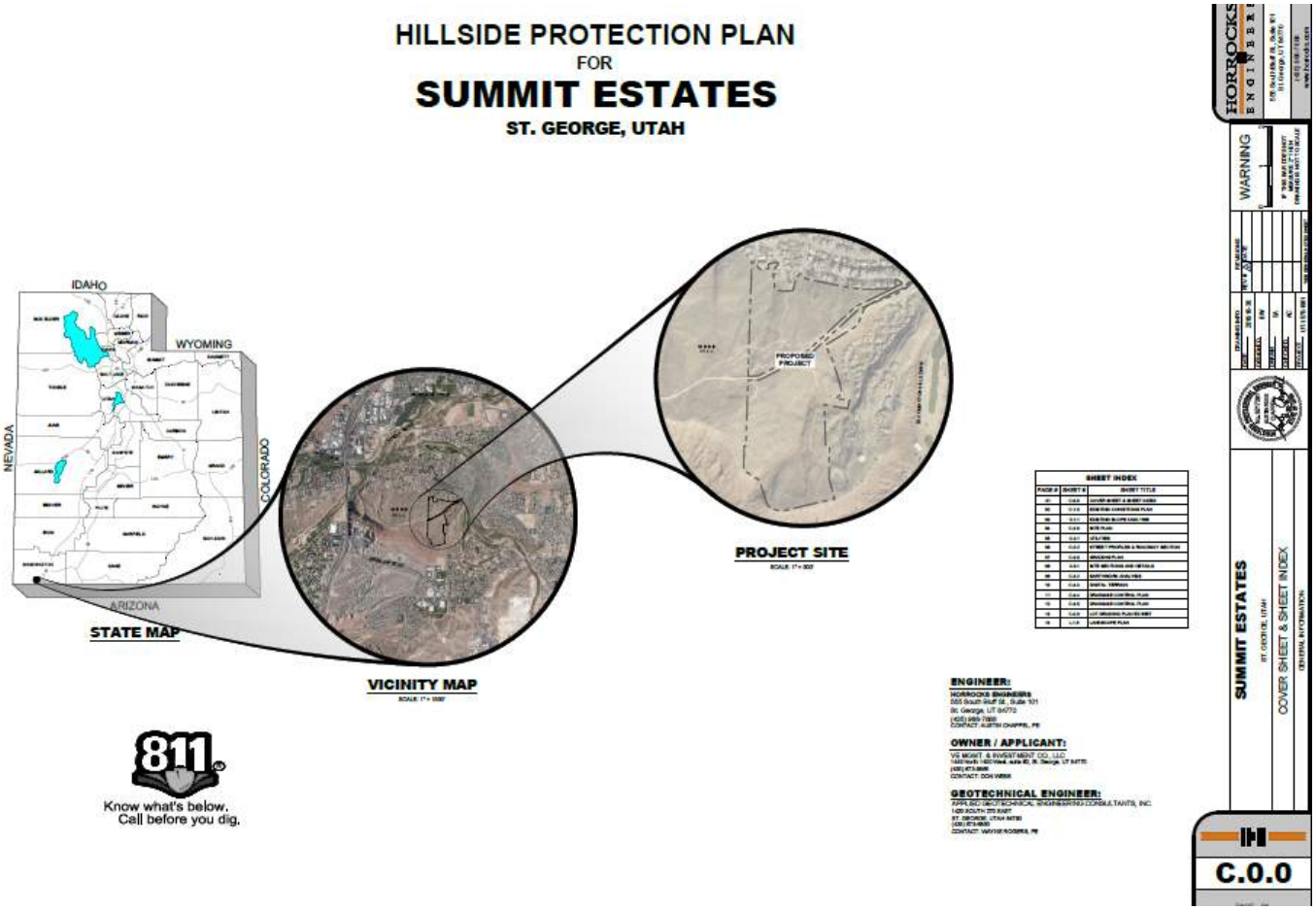
Earth Moving and Grading Plans:

Working in conjunction with our Geotechnical Engineer, AGEC, the site is found to have three primary rock types throughout including: Shale, Sandstone and Siltstone Bedrocks. The onsite bedrock will be used as site grading fill. It will require processing such that the maximum particle size is 4" and at least 60% of the material passes the no.4 sieve. This may require some crushing of the sandstone material. It is anticipated that a rock hammer and/or trencher will be used for utility trenching with the mass grading being ripped with a dozer and hammer. A staging area will be utilized in the lower portion of the site (in ph.2) where a detention basin is designed. This will provide an area away from the higher slopes on site and will keep dust and noise to a minimum to the existing residents. The upper 4-6' of material, depending on the rock hardness, is suitable to be processed in use for backfill of trenches and fill alike. The larger material will be used in natural rock retaining walls per the design. It is anticipated that all of the material will be used on site with only select fill being imported as necessary.

No blasting will occur on site as to minimize the impacts of potential rock fall to the existing Sienna Canyon development below and to the south-east of the project. All home sites will have individual tests and foundation recommendations from AGEC prior to platting and will be graded at time of home construction. They will adhere to the attached strict grading guidelines and plat design criteria.

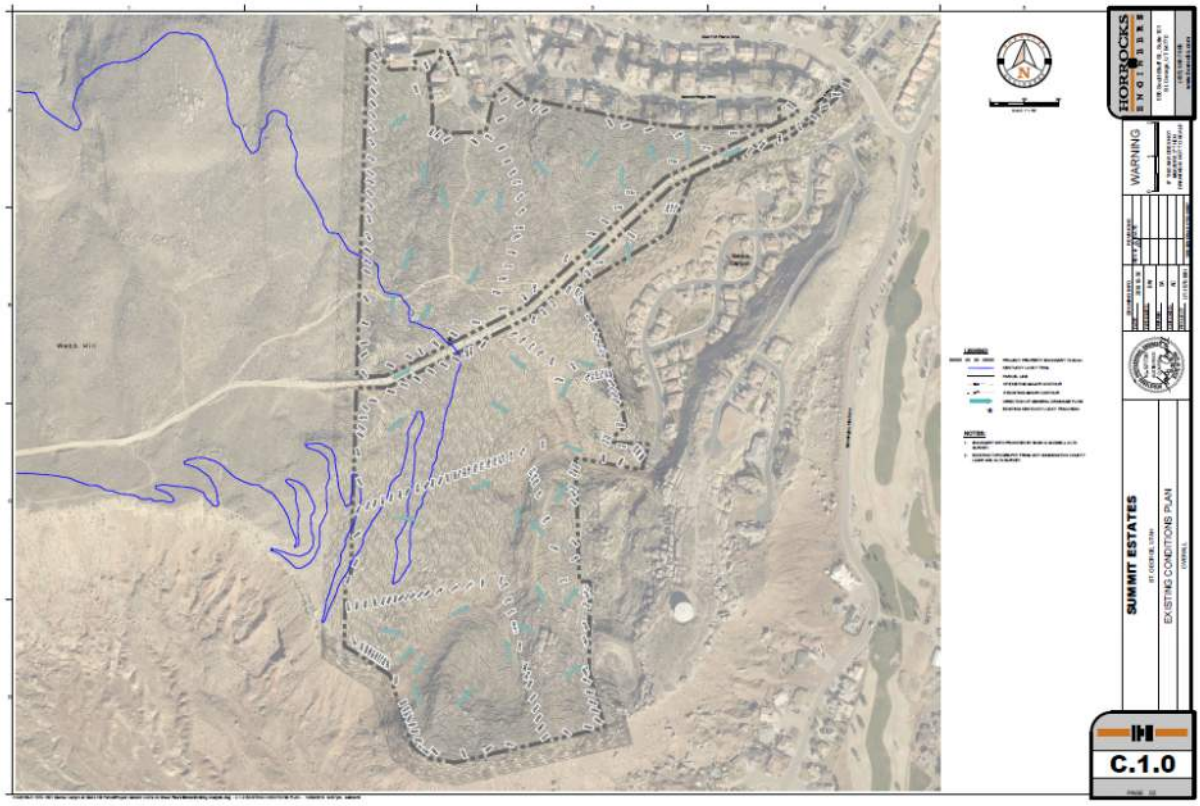
Proposed Project Schedule:

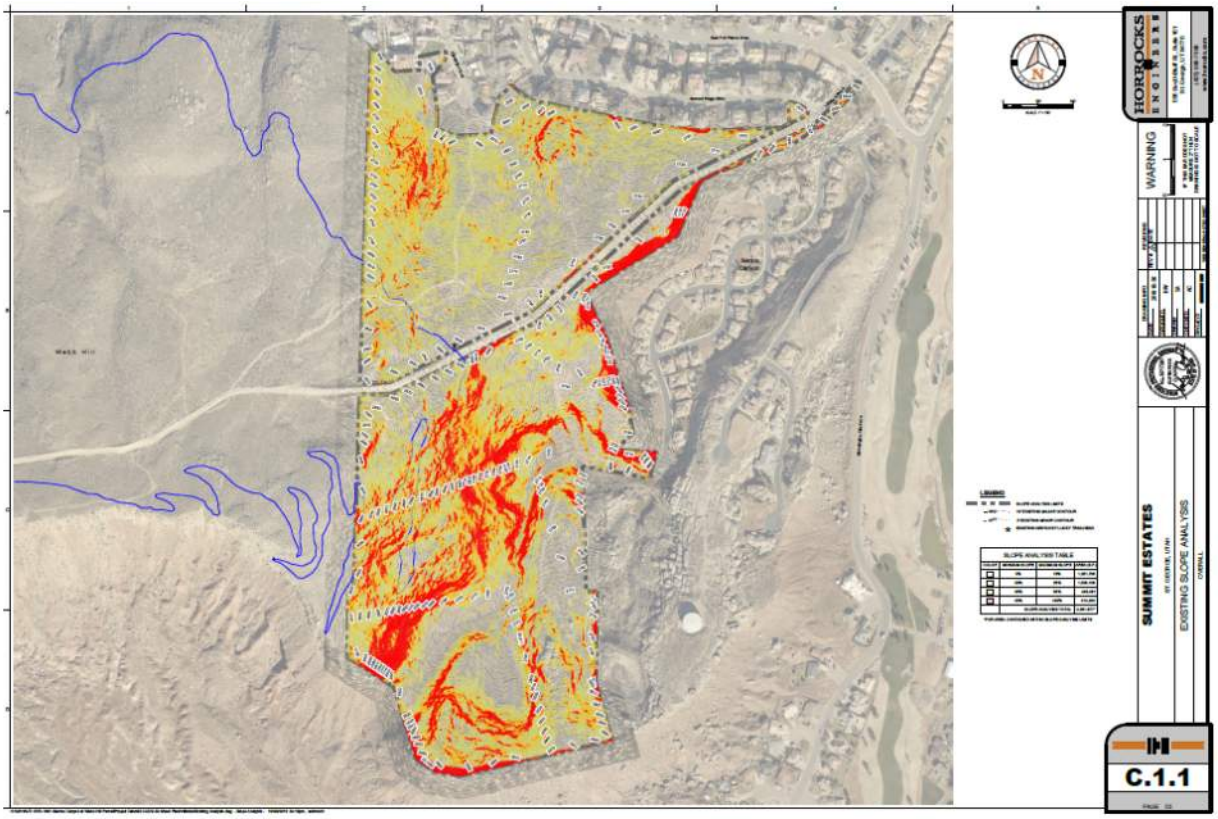
It is anticipated that the project will be built in two phases with the first phase of improvements beginning in Feb. 2020. The first phase of land development (lots 1-22), which will include a new water tank, is anticipated to take approximately 6 months to complete with a completion date of Aug. 2020. The second phase (lots 23-43) will begin in approximately 2023 and will depend largely on the absorption rate of phase one and the health of the economy.



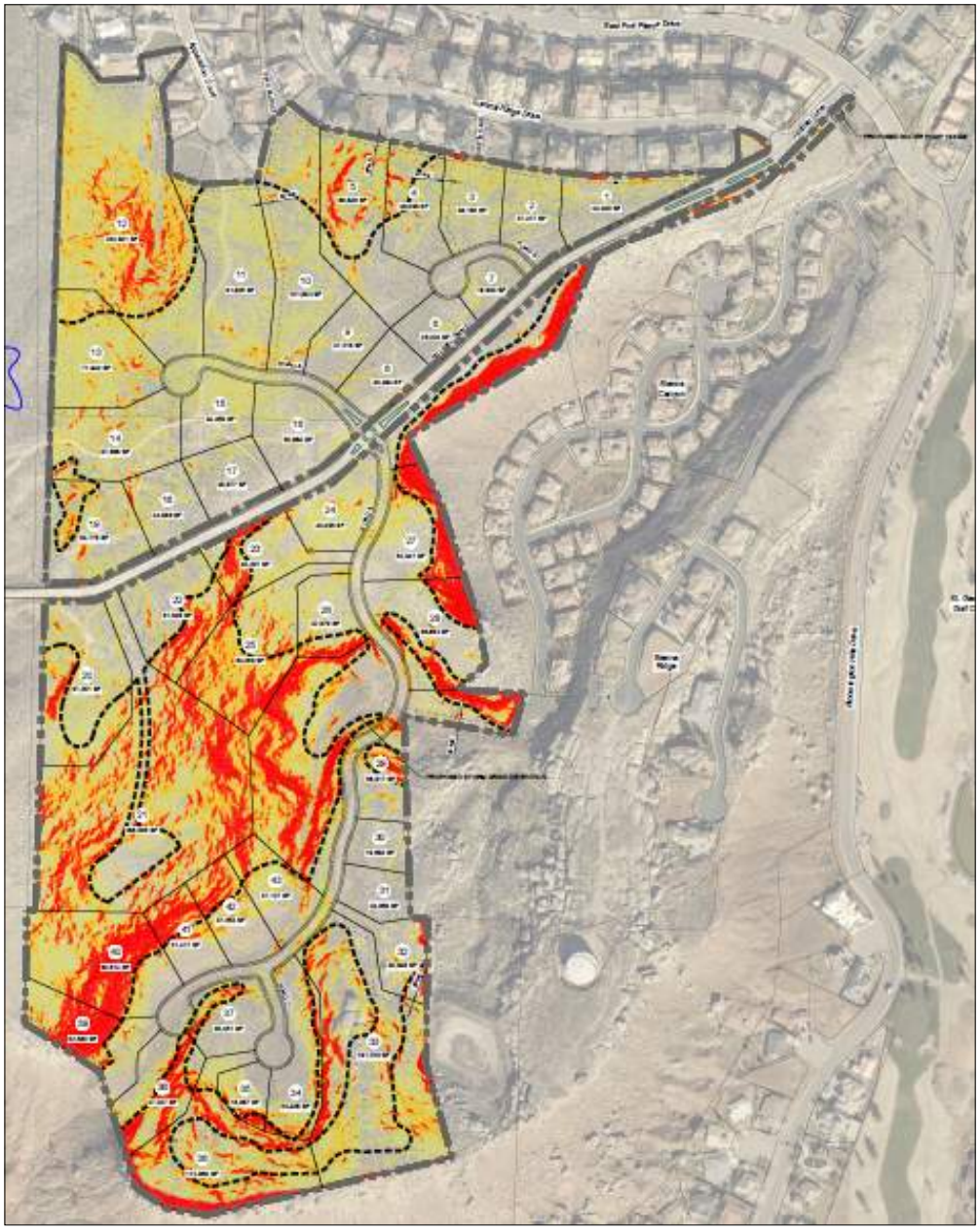
Vicinity Map



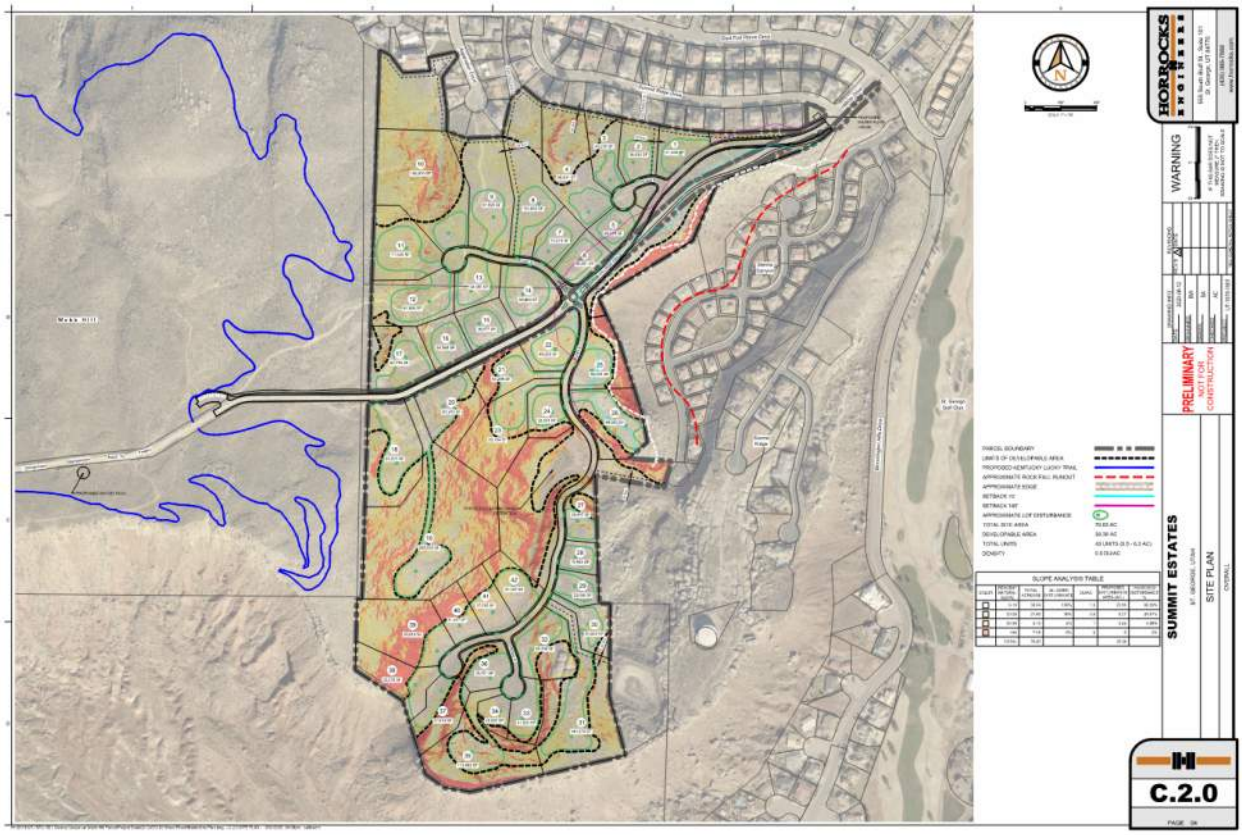

HORROCKS ENGINEERS
WARNING
SUMMIT ESTATES
EXISTING CONDITIONS PLAN
C.1.0


HORROCKS ENGINEERS
WARNING
SUMMIT ESTATES
EXISTING SLOPE ANALYSIS
C.1.1

Original Site Plan

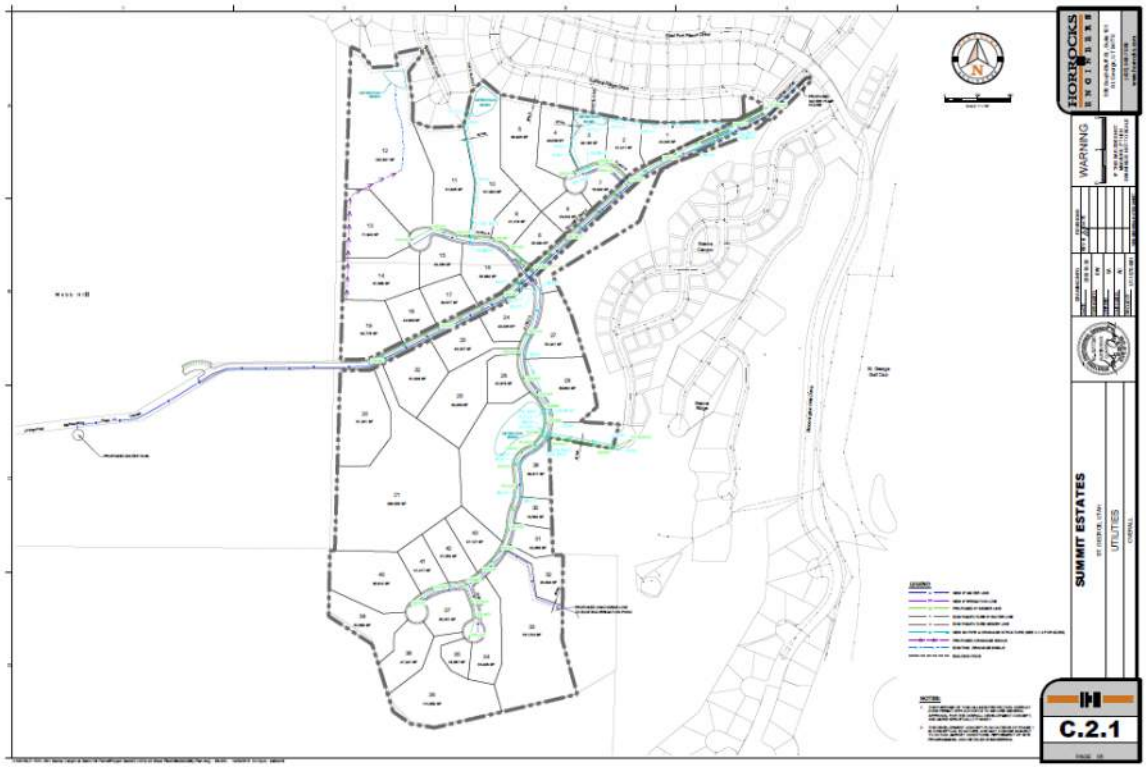


Revised Site Plan

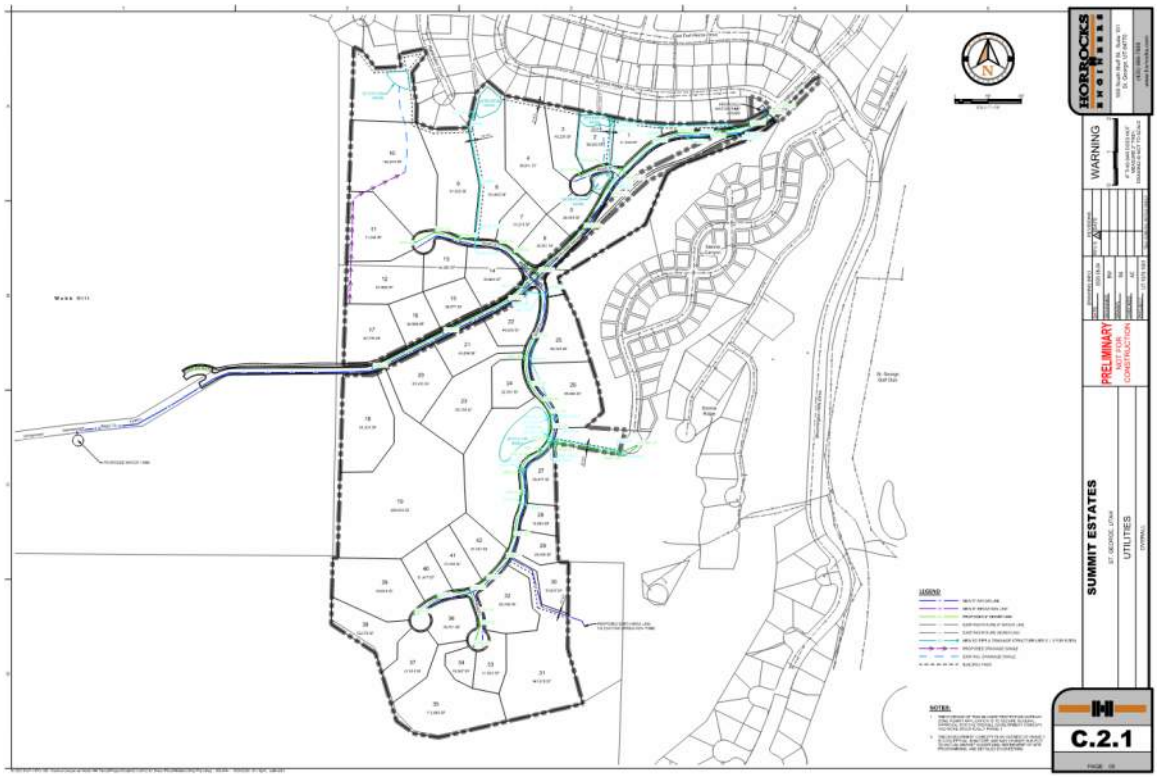


SLOPE ANALYSIS TABLE						
COLOR	PERCENT NATURAL SLOPE	TOTAL ACREAGE	ALLOWED DISTURBANCE	DU/AC	PROPOSED DISTURBANCE AREA (AC.)	PROPOSED DISTURBANCE %
	0-19	30.64	100%	1.6	20.86	68.09%
	20-29	27.60	30%	0.9	8.27	29.97%
	30-39	5.10	5%	1	0.25	4.88%
	>40	7.49	0%	0	0	0%
	TOTAL	70.83			29.38	

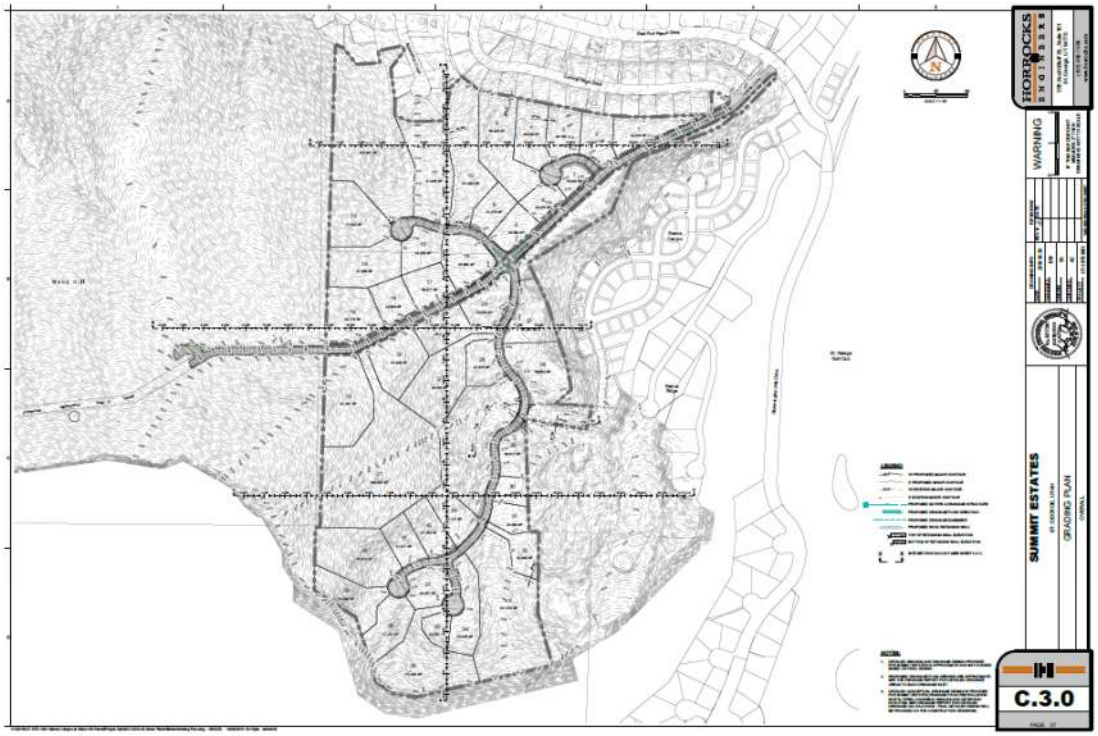
Original Utilities Drawings



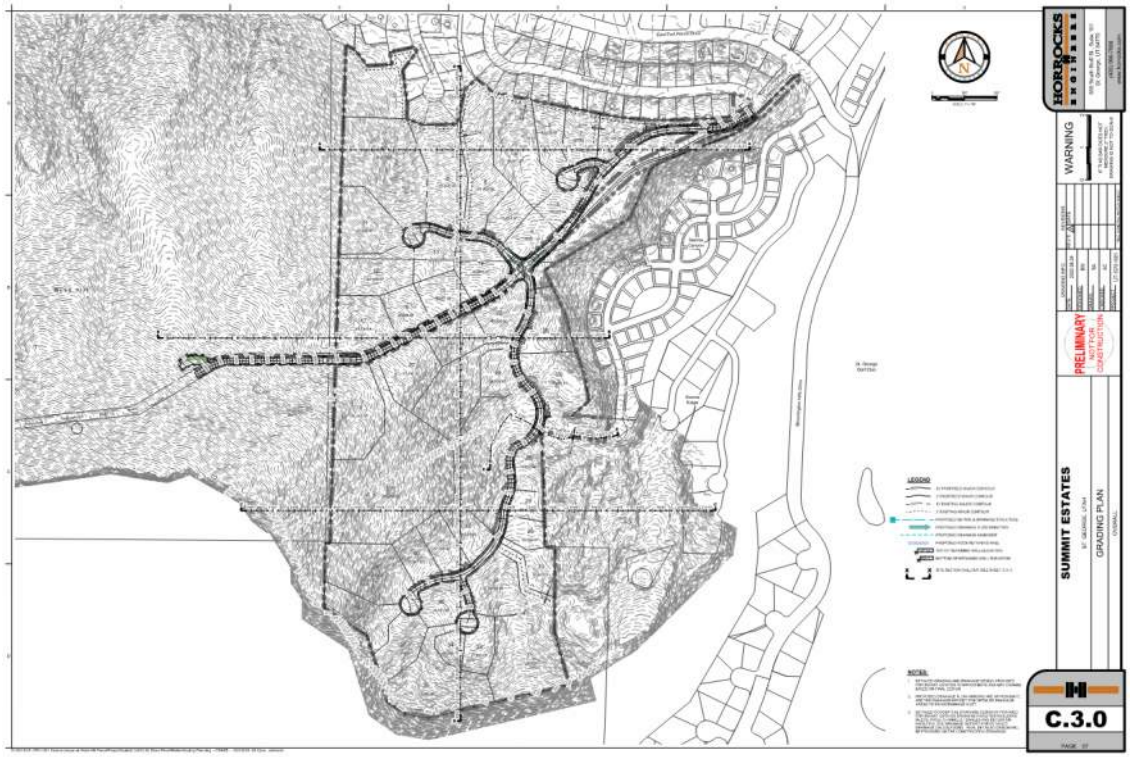
Revised Utilities Drawings



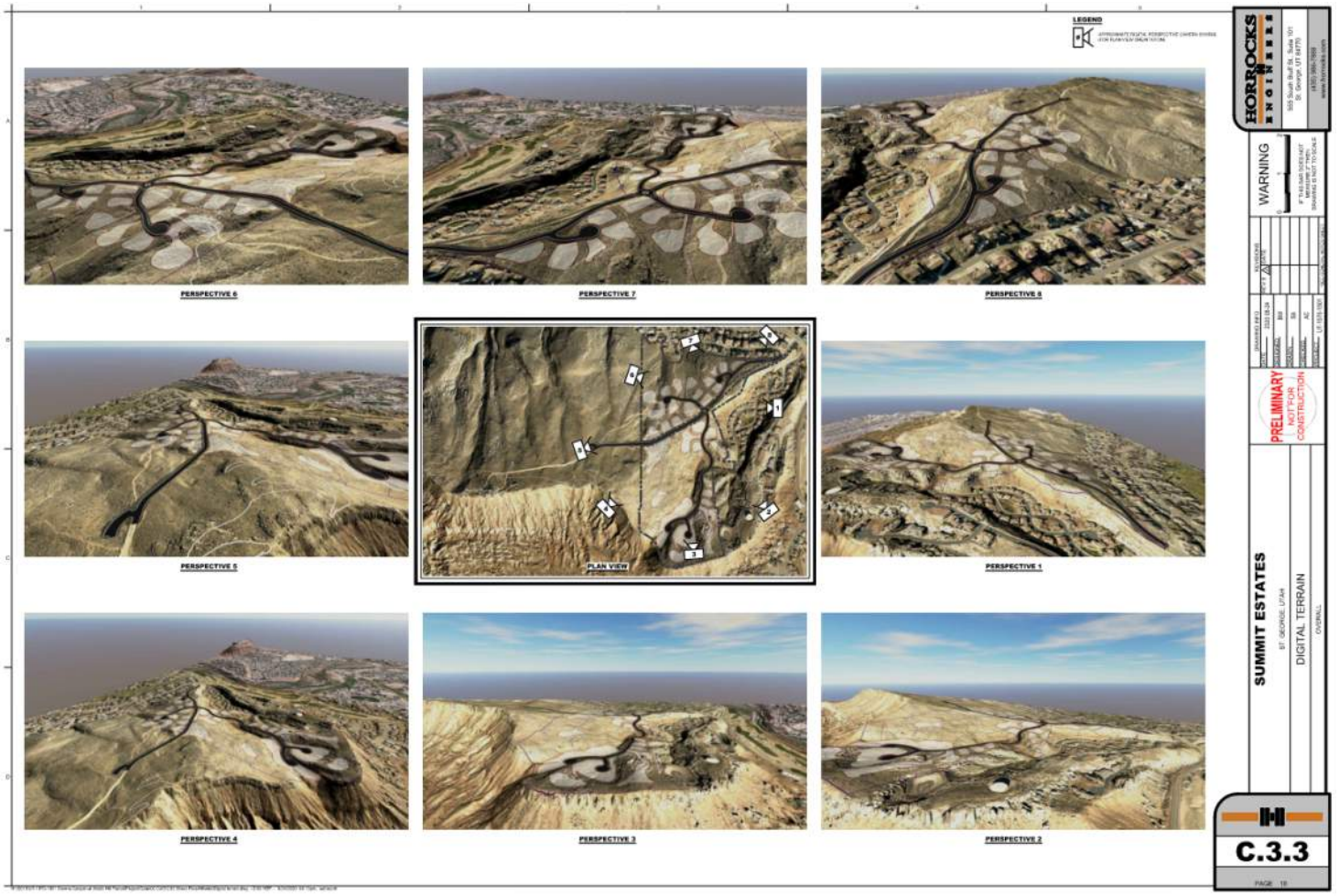
Original Grading Drawings



Revised Grading

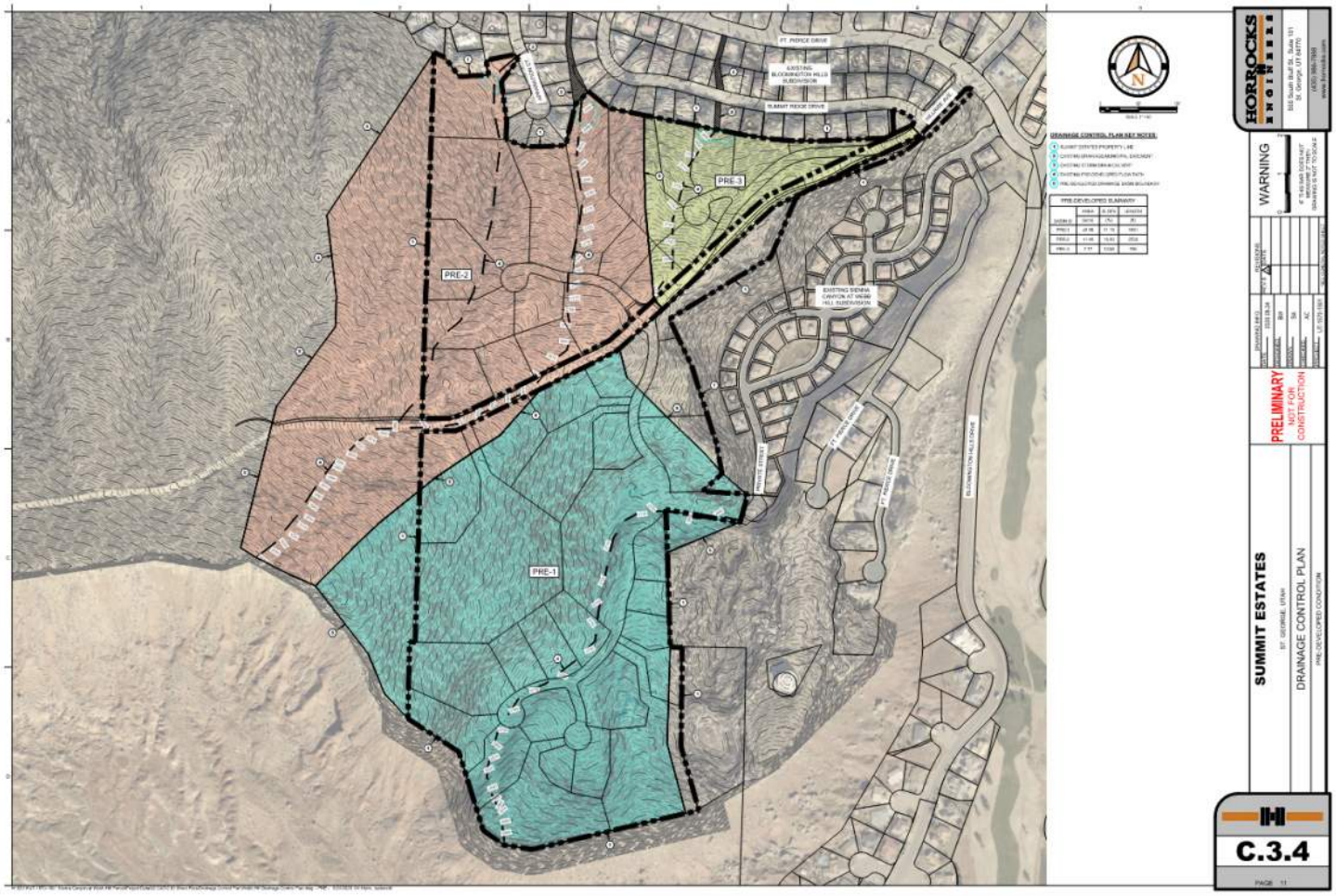


Updated Digital Terrain



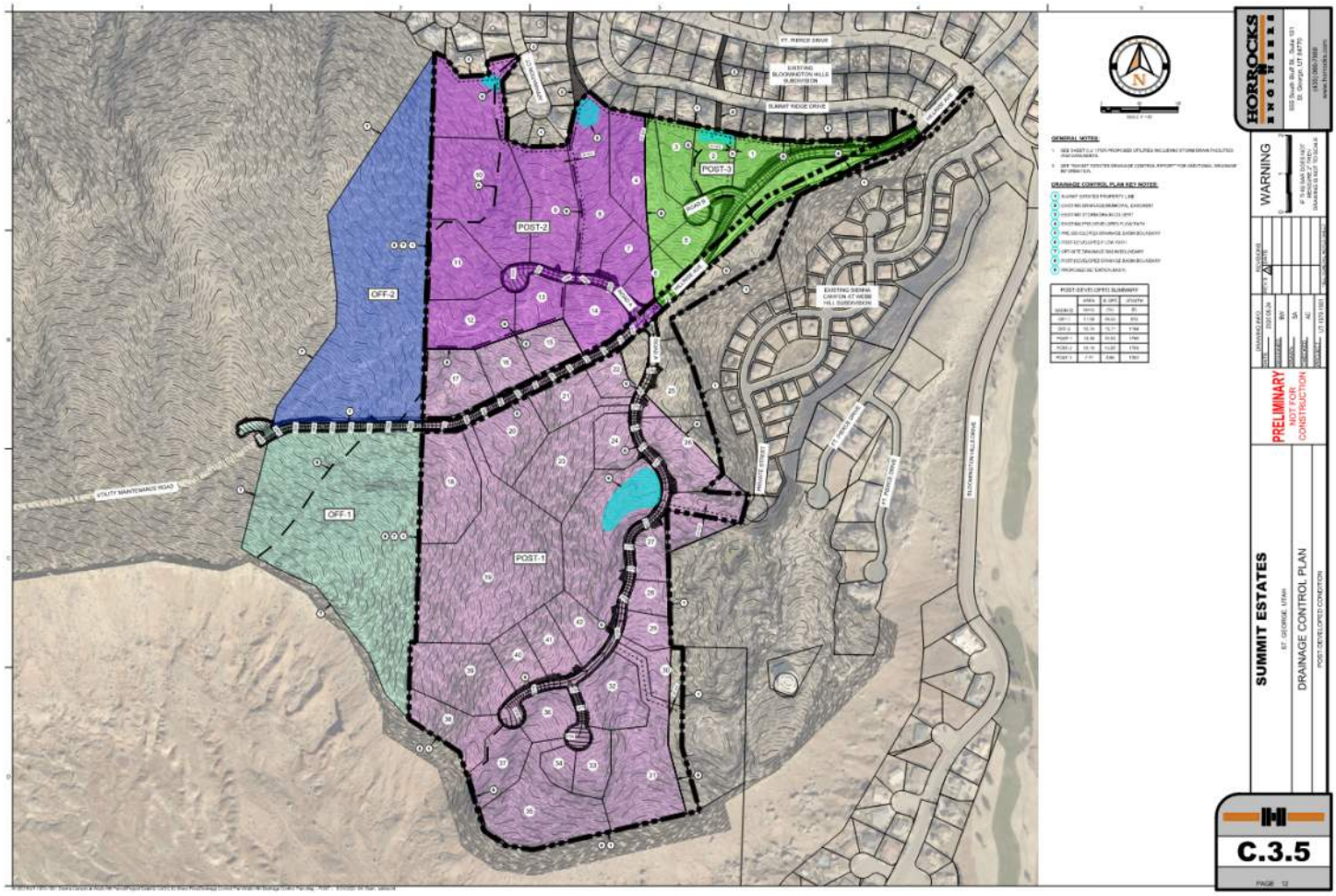
Updated Drainage Control Plan

Pre-Developed Conditions

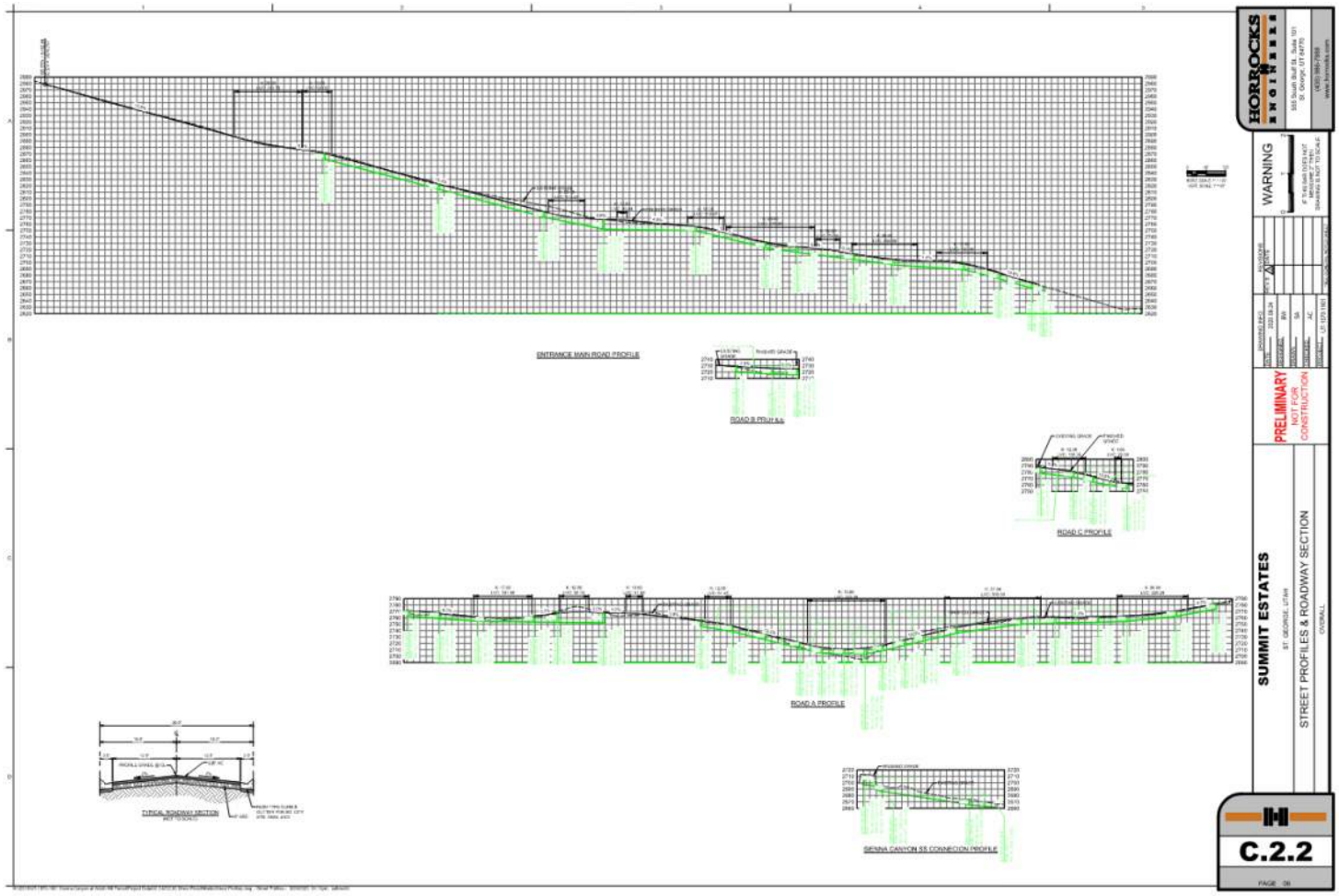


Updated Drainage Control Plan

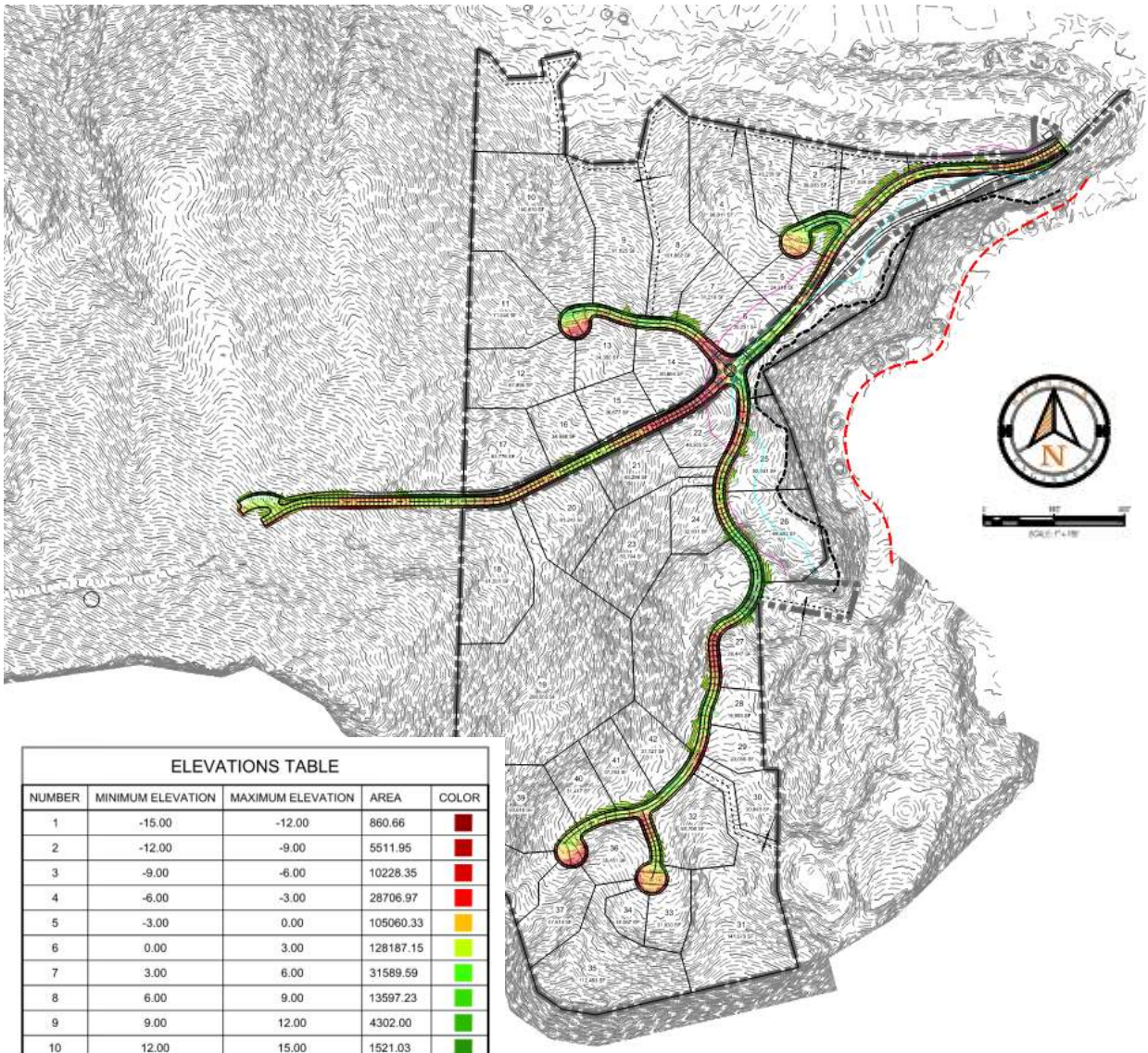
Post-Developed Conditions



Street Profiles & Roadway Section



Earthwork Analysis



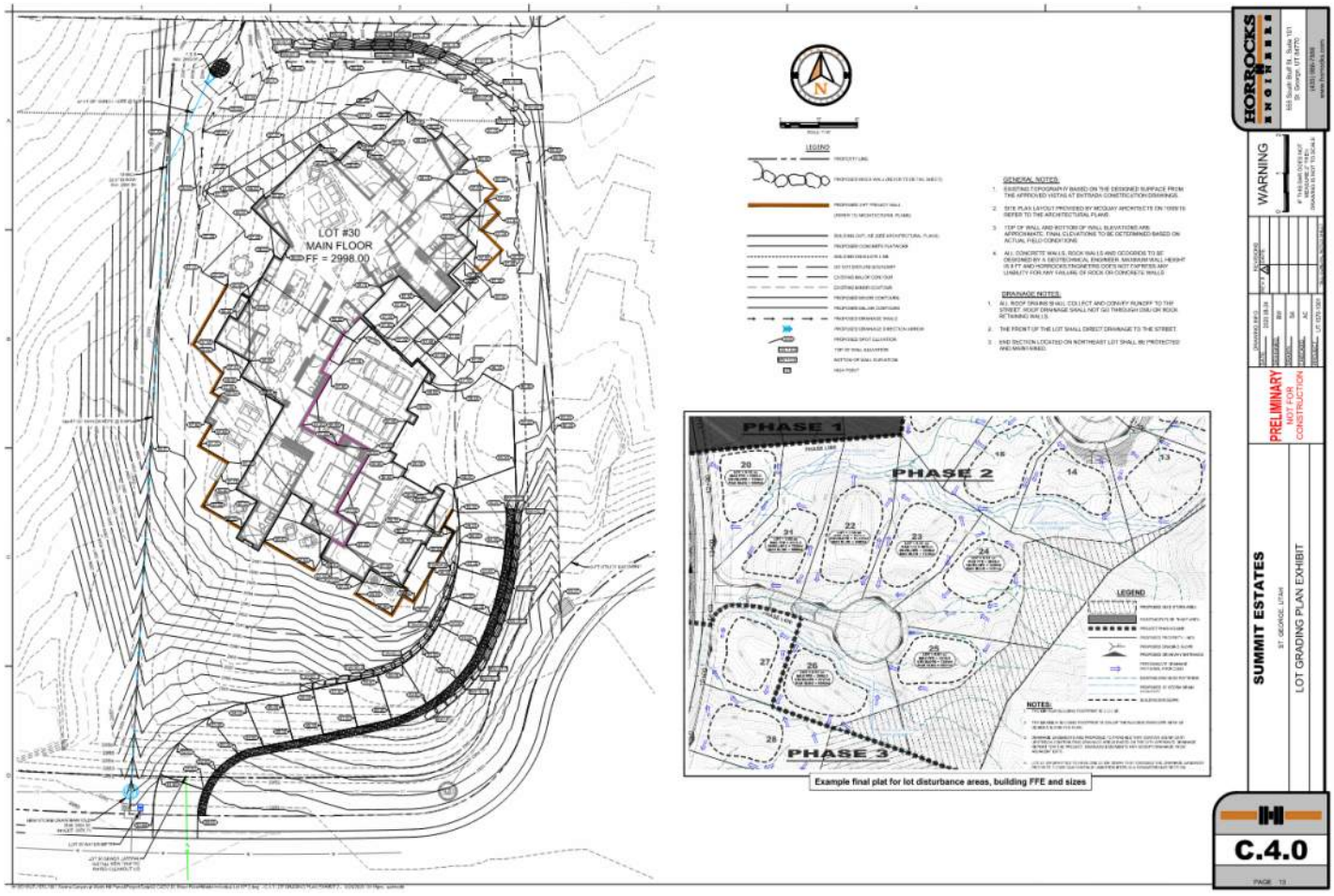
ELEVATIONS TABLE				
NUMBER	MINIMUM ELEVATION	MAXIMUM ELEVATION	AREA	COLOR
1	-15.00	-12.00	860.66	
2	-12.00	-9.00	5511.95	
3	-9.00	-6.00	10228.35	
4	-6.00	-3.00	28706.97	
5	-3.00	0.00	105060.33	
6	0.00	3.00	128187.15	
7	3.00	6.00	31589.59	
8	6.00	9.00	13597.23	
9	9.00	12.00	4302.00	
10	12.00	15.00	1521.03	
11	15.00	18.00	1435.12	

CUT / FILL SUMMARY						
NAME	CUT FACTOR	FILL FACTOR	2D AREA (FT^2)	CUT (YD^3)	FILL (YD^3)	NET (YD^3)
SUMMIT ESTATES ROADWAY DESIGN VS. FLOWN EXISTING GROUND	1.00	1.00	331,000	14,726	17,673	2,947

LOT GRADING NOTE:

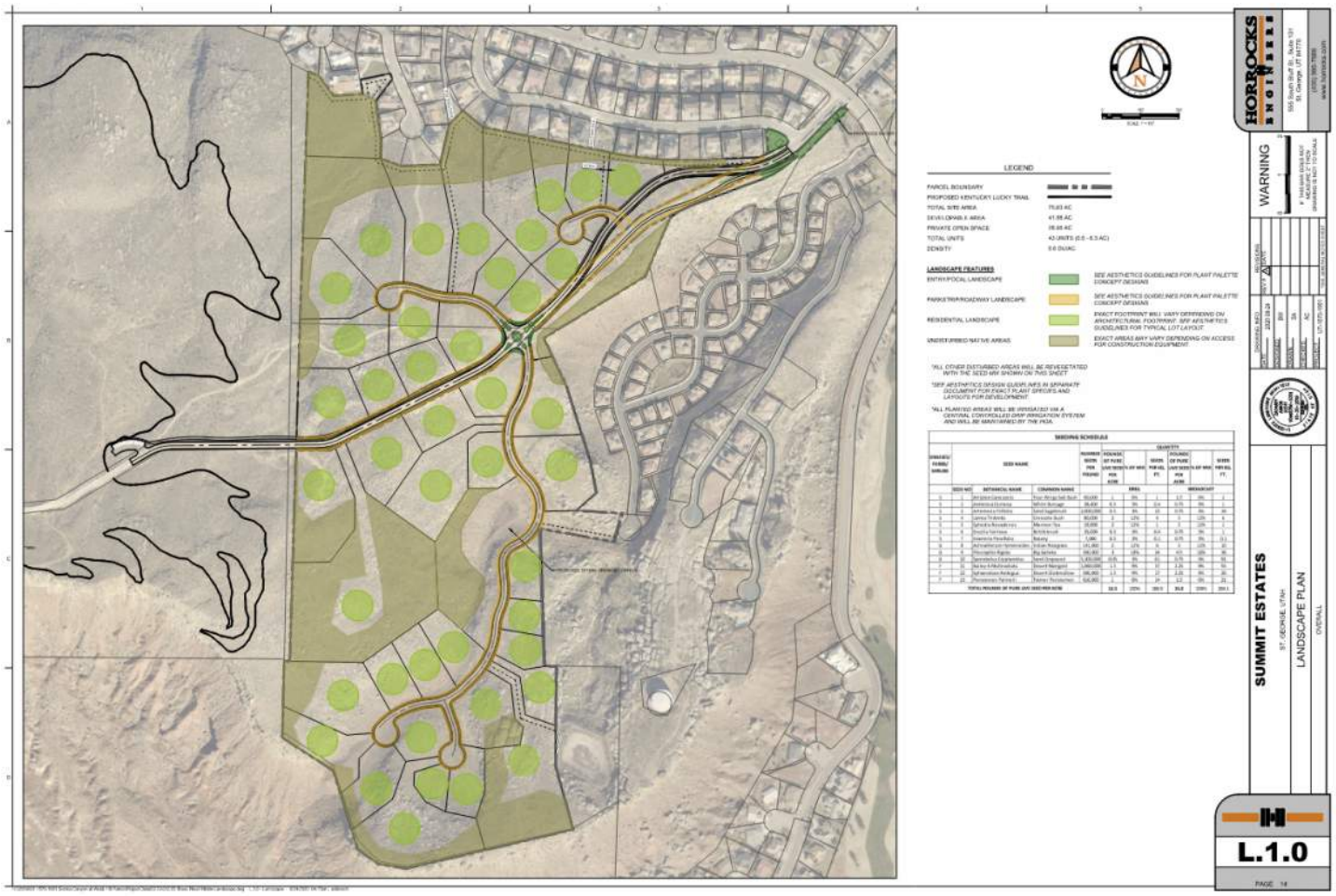
1. EACH LOT WILL SUBMIT A LOT SPECIFIC GRADING PLAN AT TIME OF CUSTOM HOME BUILD PLAN SUBMITTAL. THESE PLANS WILL ADHERE TO THE LIMITS OF DISTURBANCE FOUND ON THE SITE PLAN AND WILL INCLUDE STRICT CC&R'S AND DESIGN GUIDELINES FOR GRADING AND BUILDING IN THE DEVELOPMENT. SEE SHEET C.4.0 FOR EXAMPLES OF LOT SPECIFIC GRADING PLAN.

Lot Grading Plan Exhibit



Example final plat for lot disturbance areas, building FFE and sizes

Updated Conceptual Landscape Areas



SEE AESTHETICS GUIDELINES FOR PLANT PALETTE CONCEPT DESIGNS

SEE AESTHETICS GUIDELINES FOR PLANT PALETTE CONCEPT DESIGNS

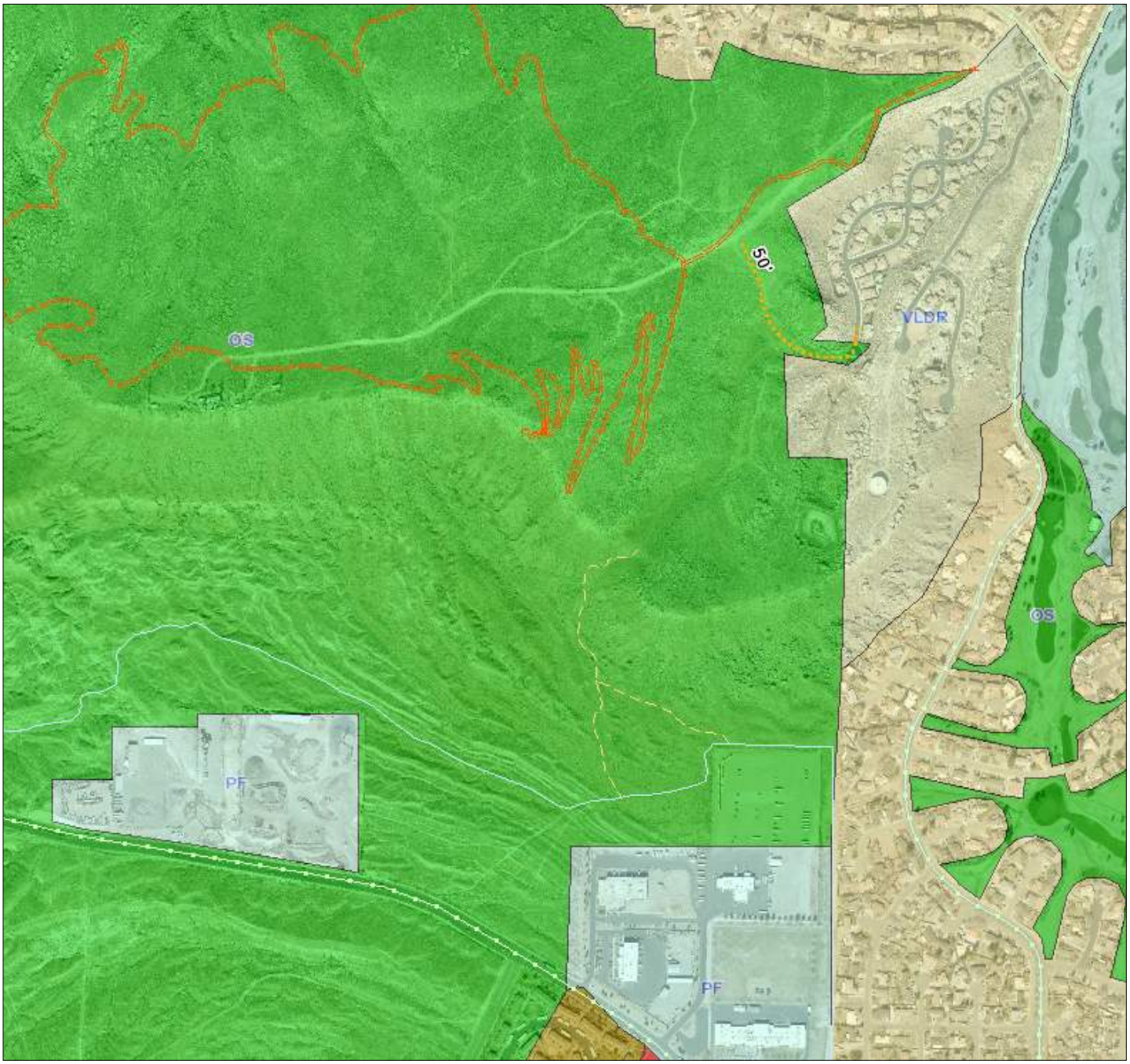
EXACT FOOTPRINT WILL VARY DEPENDING ON ARCHITECTURAL FOOTPRINT. SEE AESTHETICS GUIDELINES FOR TYPICAL LOT LAYOUT.

EXACT AREAS MAY VARY DEPENDING ON ACCESS FOR CONSTRUCTION EQUIPMENT.

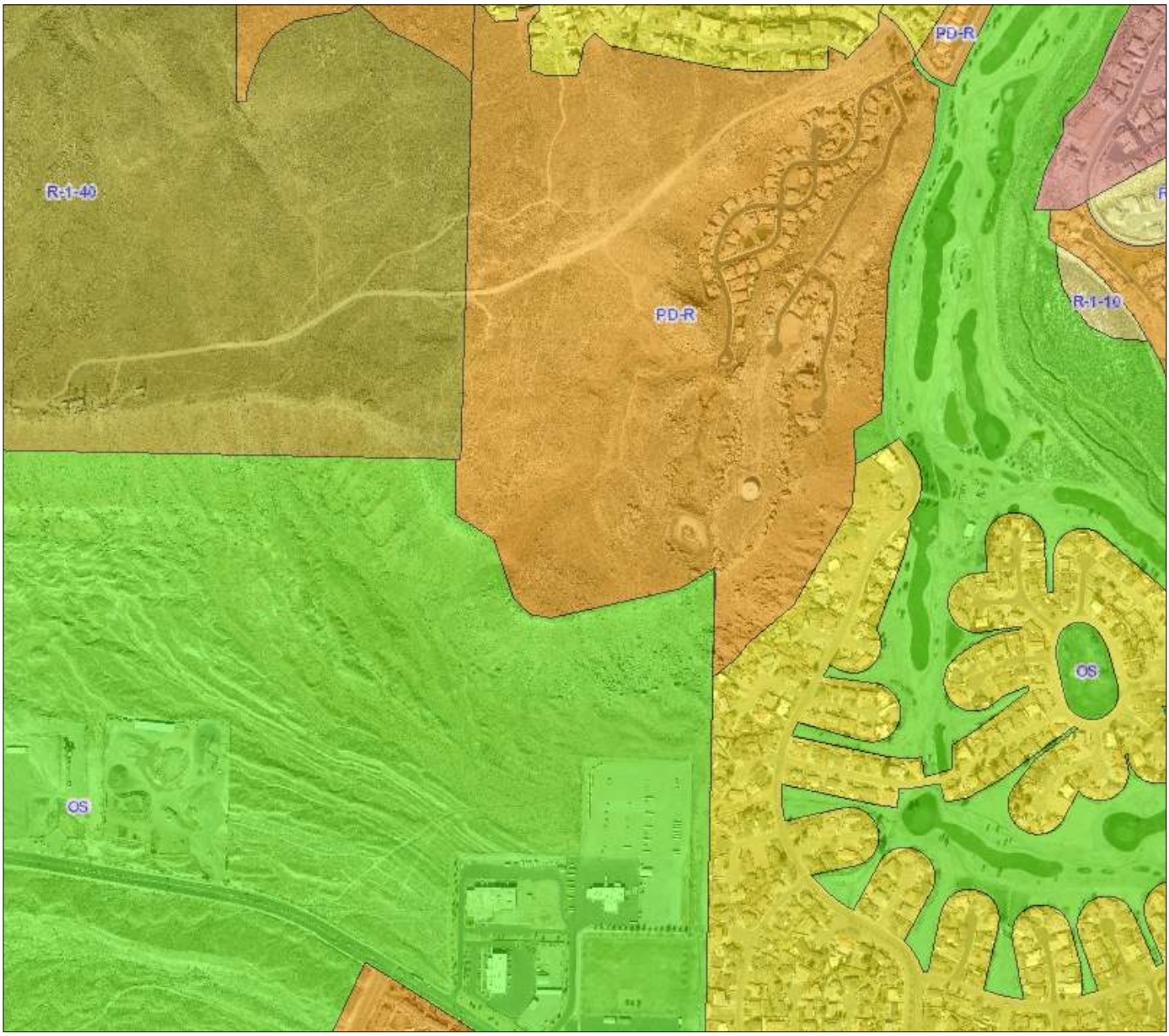
SEEDING SCHEDULE

GRASSES/ FORBS/ SHRUBS	SEED NAME			NUMBER SEEDS PER POUND	QUANTITY					
					POUNDS OF PURE LIVE SEED PER ACRE	% OF MIX	SEEDS PER SQ. FT.	POUNDS OF PURE LIVE SEED PER ACRE	% OF MIX	SEEDS PER SQ. FT.
	SEED NO	BOTANICAL NAME	COMMON NAME		DRILL			BROADCAST		
S	1	Atriplex Canescens	Four Wings Salt Bush	60,000	1	6%	1	1.5	6%	2
S	2	Ambrosia Dumosa	White Bursage	38,400	0.5	3%	0.4	0.75	3%	1
S	3	Artemesia Filifolia	Sand Sagebrush	2,000,000	0.5	3%	23	0.75	3%	34
S	4	Larrea Tridenta	Creosote Bush	80,000	2	12%	4	3	12%	6
S	5	Ephedra Nevadensis	Mormon Tea	19,900	2	12%	1	3	12%	1
S	6	Encelia Farinosa	Brittlebrush	35,000	0.5	3%	0.4	0.75	3%	1
S	7	Krameria Parvifolia	Ratany	7,000	0.5	3%	0.1	0.75	3%	0.1
G	8	Achnatherum Hymenoides	Indian Ricegrass	141,000	2	12%	6	3	12%	10
G	9	Pleuraphis Rigida	Big Galleta	350,000	3	18%	24	4.5	18%	36
G	10	Sporobolus Cryptandrus	Sand Dropseed	5,300,000	0.05	3%	61	0.75	3%	91
F	11	Bailey A Multiradiata	Desert Marigold	1,060,000	1.5	9%	37	2.25	9%	55
F	12	Sphaeralcea Ambigua	Desert Globmallow	500,000	1.5	9%	17	2.25	9%	26
F	13	Penstemon Palmerii	Palmer Penstemon	610,000	1	6%	14	1.5	6%	21
TOTAL POUNDS OF PURE LIVE SEED PER ACRE					**16.5**	100%	188.9	**24.8**	100%	284.1

General Plan



Zoning Map



Drainage Study

Drainage Report

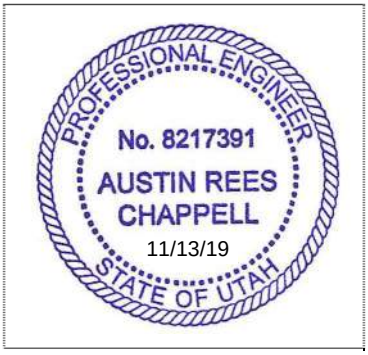
Summit Estates at Webb Hill

November 13, 2019

Horrocks Project Number
UT-1507-1901

Owner:
V.E. Management & Investment Co., LC
1240 E. 100 S. Suite 12
St. George, UT 84790

Prepared By: Austin Chappell, P.E. of
HORROCKS ENGINEERS
555 South Bluff Street, Suite 101
St. George, UT 84770
435.986.7888



Engineer's Seal

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SECTION 1: DESCRIPTION OF PROPERTY

1.1 Location & Existing Conditions:

The proposed Sienna Canyon at Webb Hill subdivision is located south of Hillrise Avenue, southwest of the Hillrise Avenue and Summit Ridge intersection. The developed site will include parcel SG-5-3-5-32001, which is located in Sections 5 and 8, Township 43 South, and Range 15 West SLBM.

The existing site is currently undeveloped consisting of primarily natural desert landscape with boulders. There is an existing dirt road that extends from the end of Hillside Avenue to the west side of the project site and continues west.



Figure 1: Project Vicinity Map

SECTION 2: OFF-SITE DRAINAGE

2.1 Off-Site Drainage

The upstream offsite basins generally drain from the southwest to the northeast. The offsite drainage basins remain in the existing condition in the pre and post development conditions. There are two off-site drainage basins identified as OFF-1 and OFF-2 located on the western boundary of the project site. See Figure C.3.5, Post Development Drainage Control Plan in Appendix A for basin boundaries, areas

and flow patterns. The two basins are both undeveloped areas and are also comprised of existing natural desert landscape and boulders. Runoff from Basin OFF-1 drains from the southwest of the basin to the northwest where it impacts the project site. Runoff from Basin OFF-2 drains from the southwest of the basin to the northwest where it impacts the project site.

All runoff generated by these off-site drainage areas is included in the Siena Canyon site's hydrologic and hydraulic analysis provided in this report.

SECTION 3: ON-SITE DRAINAGE

On-site drainage is separated into two categories, existing (pre-development conditions) and proposed (Post development conditions). See Figures C.3.4 and C.3.5 in Appendix A for basin delineations, flow patterns, and basin areas. Each category is described as follows:

- Existing on-site drainage generally originates from southwest and flows towards northeast. Runoff from existing on-site drainage Basin PRE-1 generally drains from the west and is conveyed to the east where it discharges from the project site near the southwest end of the Sienna Canyon at Webb Hill existing development. The runoff from basin PRE-2 drains from the southwest to the north where it discharges from the project site at a drainage easement that connects to Apparation Court and at the drainage easement that connects to Summit Ridge Drive. Runoff generated from existing on-site drainage Basin PRE-3 drainage from the south to the north where it discharges through a drainage easement the connects to Summit Ridge Drive. The project site includes natural washes created from natural storm events.

- This study proposes to improve existing earthen Hillrise Avenue into (XXX) pavement. The avenue exists from the northeast corner of the project site and extends towards southwest direction. Additionally, two roadways are proposed; Road A and Road B. Road A extends towards northwest and southwest directions from centerline of Hillrise Avenue. Road B extends only towards northwest direction from the centerline of Hillrise Avenue.

  The proposed flow patterns generally match the existing flow patterns. Proposed on-site drainage Basin POST-1 drains to the low point in Road A south of Hillrise Avenue. There is a proposed detention basin, DB1, which reduces flows to pre-developed conditions. The runoff from onsite Basin POST-2A drains north to the onsite, local Detention Basin DB-2A discharges through the drainage easement and into Apparation Court. Runoff from onsite basin POST-2B is conveyed north through the developed site to the onsite, local Detention Basin DB-2B and reduces the developed peak runoff to below the pre-development peak runoff. Runoff from onsite basin POST-3 is conveyed north through the developed site to the onsite, local Detention Basin DB-3 and reduces the developed peak runoff to below the pre-development peak runoff. The runoff from DB-3 discharges through the existing drainage easement and into Summit Ridge Drive. See Section 10 of this report for details of the proposed drainage improvements

SECTION 4: MASTER PLANNED DRAINAGE

A review of the City of St. George Storm Drain Maser Plan indicates the engineer is not aware of proposed drainage improvements within the project area.

SECTION 5: FEMA FLOODPLAIN

Sienna Canyon is located within Area of Minimum Flood Hazard as indicated by the FEMA flood map included in Appendix D of this report.

SECTION 6: OTHER DRAINAGE STUDIES

Other than the City of St. George Storm Drain Master Plan, the engineer is not aware of other drainage studies applicable to this site.

SECTION 7: PROPOSED DRAINAGE FACILITIES

7.1 Grading:

The overall grading plan consists of typical residential grading; draining lot runoff into adjacent streets or drainage easements until it is intercepted by curb and gutter or catch basins. The project site generally drains to four (4) discharge locations. The first is at the southeast area near the low-point in the proposed Road B. Runoff is discharged from detention basin DB-1 and into the existing wash to match existing condition flow patterns. The second is at the northwest corner of the site, just south of Apparation Court and discharges runoff from DB-2A into Apparation Court. The third discharge location is located at the norther of the site, just south of the drainage easement that drains into DB-2B and then through the drainage easement to Summit Ridge Drive. The fourth discharge location is located at the norther of the site, just south of the drainage easement that drains into DB-3 and then through the drainage easement to Summit Ridge Drive.

7.2 Roadway Improvements:

Roadway improvements will include asphalt residential driveways, Hillrise Avenue, Road A and Road B. Hillrise Avenue will be a 30’ wide street with normal crown, curb and gutter and sidewalks on either side of the street. Road A and Road B will also be 30’ wide roadways with curb and gutter and sidewalks on either side of the street. Road A and Road B include cul-de-sac where they terminate.

7.3 Conveyance Improvements:

The overall storm water management approach for this project is based on conveying the 10-year storm through inlets and pipes and the 100-year storm flows in streets. Inlets will be placed at strategic locations as shown in the Drainage Control Plans and pipes will be used to convey both on-site and off-site storm drain runoff.

7.4 Detention Facilities:

It is proposed that onsite, local detention basin facilities will be required to reduce the post-developed discharge rate to less than or equal to the pre-developed discharge or 0.20 cfs per acre, whichever is greater. This report includes a hydrologic analysis, which is used to compare the pre and post developed peak runoff. The post-development HEC-1 models include the minimum detention basin volumes and discharge pipe sizes that meet the criteria per the City of St. George Drainage Manual (Hereinafter referred to as “The Manual”). However, the final grading of the proposed detention basins may vary while providing the minimum capacity and volumes as shown in the report. The locations as shown on Figure C.3.5 and as described in the report above.

SECTION 8: COMPLIANCE WITH FEMA REQUIREMENTS

Not applicable, there are no FEMA mapped floodplains within the project boundary.

SECTION 9: DESIGN RUNOFF COMPUTATIONS

9.1 Selection of Hydrological Model:

The hydrological analysis completed for this project is based on the SCS curve number method and is modeled using HEC-1. Similar to HEC-HMS, HEC-1 is commonly used for hydrologic analysis of both simple and complex drainage basins and can be used to model runoff from various design storm events including detention basin routing. The design storm frequency and distribution used in this analysis is based on the City of St. George Drainage Manual and summarized below

- 10-year, 24-hour (Type II)
- 100-year, 24-hour (Type II)
- 100-year, 3-hour (Farmer Fletcher)

Both pre and post developed site conditions were modeled using the design storm noted. See Figures C.3.4 and C.3.5 in Appendix A and Appendix C for HEC-1 Summary Tables. Complete HEC-1 reports for each site condition and design storm are provided in Appendix C.

9.2 Hydrological Model Input Parameters:

HEC-1 requires the following inputs and parameters to model and compute peak flows for each drainage basin/sub-area.

- Drainage Area (acre)
- SCS Curve Number (weighted)
- Time of Concentration (min)
- Rainfall Depth (inches)
- Storm Distribution

Hydrological model inputs noted above are described in more detail under Sections 9.3 to 9.7 below.

9.3 Watershed Area:

Watershed areas for both pre and post-developed conditions are shown in Appendix A and summarized in Tables 9.4.1 and 9.4.2 below.

9.4 Curve Number:

Soil data obtained from USDA Web Soil Survey shows the site consists of primarily Hobog-Rock Land Association (HG) soils with Hydrologic Soil Group (HSG) “D”. Refer to Appendix D for additional Web Soil Survey figures and data.

SCS runoff curve numbers obtained from TR-55 Table 2-2a and 2-2d based on soil type, hydrologic soil group and land cover. The resulting curve numbers for both pre and post developed site conditions are provide in Tables 9.4.1 and 9.4.2 respectively.

Table 9.4.1: Pre-Developed Runoff Curve Number					
Basin	**Soil Type**	**HSG**	**Cover Description**	**CN**	**Area (acre)**
PRE-1	HG (Hobog-Rock)	D	Desert shrub-Fair	86	42.38
PRE-2	HG (Hobog-Rock)	D	Desert shrub-Fair	86	41.40
PRE-3	HG (Hobog-Rock)	D	Desert shrub-Fair	86	7.77

Table 9.4.2: Post-Developed Runoff Curve Number					
Basin	**Soil Type**	**HSG**	**Cover Description**	**CN**	**Area (acre)**
OFF-1	HG (Hobog-Rock)	D	Desert shrub-Fair	86	11.59
OFF-2	HG (Hobog-Rock)	D	Desert shrub-Fair	86	10.74
POST-1	HG (Hobog-Rock)	D	Western desert urban area	88	43.46
POST-2A	HG (Hobog-Rock)	D	Western desert urban area	88	8.50
POST-2B	HG (Hobog-Rock)	D	Western desert urban area	88	9.70
Post-3	HG (Hobog-Rock)	D	Western desert urban area	88	7.77

9.5 Lag Time:

For drainage areas less than 2,000 acres, the lag time can be calculated using the following equation:

$$L = \frac{l^{0.8}\left(\frac{1000}{CN} - 9\right)^{0.7}}{1900(S)^{0.5}}$$

Where:

L = Lag Time (hour)
l = longest length of subarea (ft.)
CN = SCS Curve Number
S = average slope along longest length (%)

Resulting lag times for both pre and post-developed site conditions are summarized in Table 9.5.1 and 9.5.2 respectively.

Table 9.5.1: Pre-Developed Watershed Inputs				
Basin ID	**CN**	**Length (ft)**	**Slope (%)**	**Lag Time (hrs)**
PRE-1	86	1931	11.19%	0.132
PRE-2	86	2538	16.00%	0.137
PRE-3	86	705	13.88%	0.053

Table 9.5.2: Post-Developed Watershed Inputs				
Basin ID	**CN**	**Length (ft)**	**Slope (%)**	**Lag Time (hrs)**
OFF-1	86	870	19.43%	0.053
OFF-2	86	1855	16.2%	0.106
POST-1	88	1785	10.03%	0.121
POST-2A	88	1250	14.4%	0.076
POST-2B	88	1184	15.71%	0.07
POST-3	88	1083	8.86%	0.086

9.6 Rainfall Depth:

Rainfall depths used in the hydrological model were obtained from the NOAA Atlas 14 and are summarized in Table 9.6.1.

Table 9.6.1: NOAA Rainfall Data		
Storm Event	**3-Hour (in)**	**24-Hour (in)**
10-Year	0.99	1.57
100-Year	1.64	2.31

9.7 Hydrological Model Output

The worst-case results of the HEC-1 are summarized in Table 9.7.1. Complete hydrograph output reports can be reviewed in Appendix C.

Table 9.7.1: Hydrograph Results - Worse Case					
Design Storm	**Storm Distribution**	**Pre-Developed**	**Post-Developed**	**Peak Discharge**	**Discharge Location**
		Peak Flow (cfs)	**Peak Flow (cfs)**	**Increase (cfs)**	
100-Year, 3-Hour	Farmer-Fletcher	42	69	27	DB-1 or CD2
10-Year, 24-Hour	Type II	7.8	6	-1.8	DB-2A
100-Year, 3-Hour	Farmer-Fletcher	25P	26	1	DB-2B or CD1
100-Year, 3-Hour	Farmer-Fletcher	9	10	1	DB-3

As previously discussed under Section 7.4, the project will need to include a detention facility capable of reducing the post-developed peak discharge by at least amounts shown in table 9.7.1 in order to be less than or equal to the pre-developed peak discharge.

SECTION 10: DRAINAGE FACILITY DESIGN

In accordance with the City of St. George Drainage Manual, the HEC-1 peak flows are prorated and used to design drainage collection facilities for the 10-year flood. The methodology for the HEC-1 models is described above. The prorate calculations are performed by calculating the cfs/acre for the basin calculated using the HEC-1 models, then using the prorate areas of the basins to determine the peak flows at points of interest. The prorated subbasins are delineated and the resulting peak flows calculations are summarized on Figure C.3.5 in Appendix A.

10.1 Summary Tables

Basin Peak Flowrates Summary				
PRE-DEVELOPED CONDITION 24 HOUR EVENT				
Basin	**Area (acres)**	**Q_{10} (cfs)**	**Q_{100} (cfs)**	**Discharge location**
PRE-1	42.38	21	43	DB-1
PRE-2	41.40	12.2	25	DB-2B
		7.8	16	DB-2A
PRE-3	7.77	4	9	DB-3
PRE-DEVELOPED CONDITION 3 HOUR EVENT				
PRE-1	42.38	13	42	DB-1
PRE-2	41.40	7.3	25	DB-2B
		4.7	16	DB-2A
PRE-3	7.77	3	9	DB-3

Basin Peak Flowrates Summary			
POST-DEVELOPED CONDITION 24 HOUR EVENT			
Basin	**Area (acres)**	**Q_{10} (cfs)**	**Q_{100} (cfs)**
CD1[1]	-	12	23
CD2[2]	-	32	62
OFF-1	11.59	7	13
OFF-2	10.74	6	12
POST-1	43.45	26	50
POST-2A	8.48	6	12
POST-2B	9.70	6	10
POST-3	7.77	5	9

[1]CD1 = POST-2B + OFF-2

[2]CD2 = POST-1 + OFF-1

POST-DEVELOPED CONDITION 3 HOUR EVENT			
CD1	-	8	26
CD2	-	22	69
OFF-1	11.59	4	14
OFF-2	10.74	4	14
POST-1	43.45	18	55
POST-2A	8.48	5	13
POST-2B	9.70	4	12
POST-3	7.77	4	10

[1]CD1 = POST-2B + OFF-2

[2]CD2 = POST-1 + OFF-1

10.2 Prorate Summary Tables

PRORATE FLOW SUMMARY FOR POST DEVELOPED CONDITION FARMER-FLETCHER-100YR			
Basin	**Area (acres)**	**Q_{100} (cfs)**	**CFS/AC**
OFF-1	11.6	14	1.21
POST-1	43.4	55	1.27
POST2A-(a)	8.5	13	1.53
POST-3	7.8	10	1.28
Sub-basin ID	Area (Acres)	Q100 (cfs)	100-yr unit flow (cfs/acre)
OFF-1(a)	7.3	8.8	1.21
OFF-1(b)	3.2	3.9	1.21
OFF-1(c)	1.1	1.3	1.21
Total	11.6	14	
Sub-basin ID	Area (Acres)	Q100 (cfs)	100-yr unit flow (cfs/acre)
POST-1(a)	5.2	6.6	1.27
POST-1(b)	2.7	3.4	1.27
POST-1(c)	3.4	4.3	1.27
POST-1(d)	20.4	25.9	1.27
POST-1(e)	5.5	7.0	1.27
POST-1(f)	0.6	0.8	1.27
Other	5.6	7.1	1.27
Total	43.5	55	
Sub-basin ID	Area (Acres)	Q100 (cfs)	100-yr unit flow (cfs/acre)
POST-2A(a)	3.3	5	1.53
Other	5.2	8	1.53

Total	8.5	13	
Sub-basin ID	Area (Acres)	Q100 (cfs)	100-yr unit flow (cfs/acre)
POST-3(a)	2.4	3	1.28
POST-3(b)	0.8	1	1.28
POST-3(b)	0.2	0.3	1.28
Other	4.4	5.7	1.28
Total	7.8	10	

SECTION 11: DRAINAGE EASEMENTS

All proposed storm drain improvements are contained within the individual lots and drain to proposed roadways or to proposed and/or existing easements. See the proposed drainage easements on Figure C.3.5 in Appendix A.

SECTION 12: FEMA FLOODPLAIN CALCULCATIONS

Not applicable, there are no FEMA mapped floodplains within the project boundary.

SECTION 13: CONCLUSIONS

13.1 Concluding Statement:

The proposed storm drain improvements presented herein, and on the accompanying Drainage Control Plans, are designed to comply with all City of St. George drainage requirements. It is determined by Horrocks Engineers that the proposed drainage infrastructure proposed for the Summit Estates at Webb Hill will effectively convey storm water runoff through the site, and reduce developed flows to or below peak flows in the pre-developed condition. All hydraulic and hydrologic computations used to develop this drainage study were performed using the current standard of care and engineering best management practices.

Upon approval of the hillside, and other necessary entitlements/permits, detailed construction plans will be completed and supplemental revisions to this original report, if any, will be submitted to the City for final review.

APPENDICES

A. FIGURES AND DRAWINGS

A.1 Figure C.3.4 - Pre-Developed Drainage Basins
A.2 Figure C.3.5 - Post-Developed Drainage Basins

B. HYDRAULIC COMPUTATIONS

B.1 Street Normal Depth Calculations
B.2 Drop Inlet Calculations
B.3 Storm Drain Normal Depth Calculations

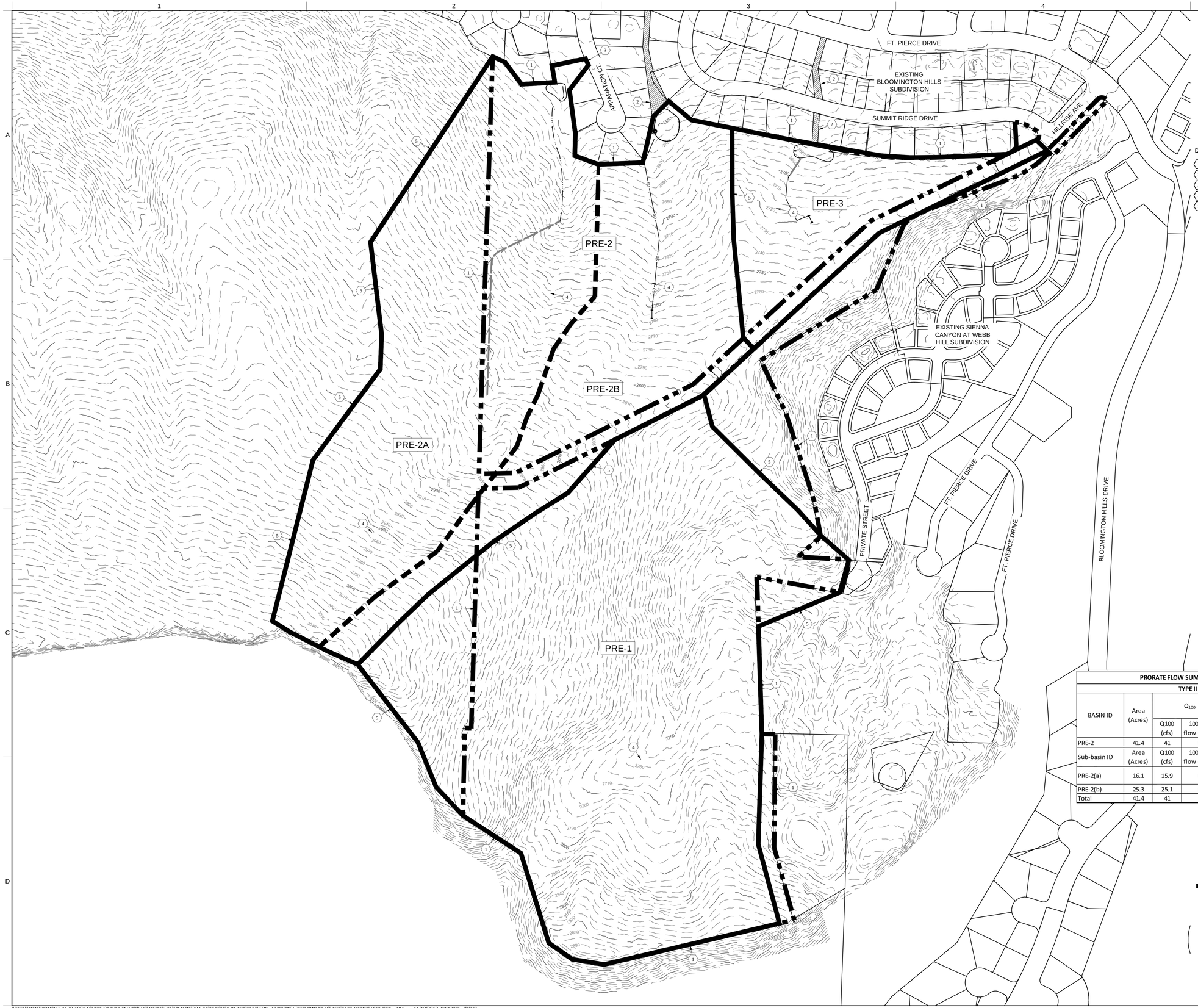
C. HYDROLOGIC COMPUTATIONS

C.1 HEC-1 Parameters Summary
C.2 HEC-1 - Pre-Developed Farmer-Fletcher
C.3 HEC-1 - Pre-Developed Type II
C.4 HEC-1 - Post-Developed Farmer-Fletcher
C.5 HEC-1 - Post-Developed Type II

D. REFERENCES/RESOURCES

D.1 NOAA Atlas 14 Rainfall Data
D.2 USDA Web Soil Map
D.3 USDA Hydrologic Soil Group
D.4 FEMA Floodplain Boundary Map

APPENDIX A: FIGURES AND DRAWINGS



DRAINAGE CONTROL PLAN KEY NOTES:

1. SUMMIT ESTATES PROPERTY LINE
2. EXISTING DRAINAGE/MUNICIPAL EASEMENT
3. EXISTING STORM DRAIN CULVERT
4. EXISTING PRE-DEVELOPED FLOW PATH
5. PRE-DEVELOPED DRAINAGE BASIN BOUNDARY

0 60' 120'
SCALE: 1" = 60'

Basin Peak Flowrates Summary

PRE-DEVELOPED CONDITION 24 HOUR EVENT				
Basin	Area (acres)	Q_{10} (cfs)	Q_{100} (cfs)	Discharge location
PRE-1	42.38	21	43	DB-1
PRE-2	41.40	12.2	25	DB-2B
		7.8	16	DB-2A
PRE-3	7.77	4	9	DB-3
PRE-DEVELOPED CONDITION 3 HOUR EVENT				
PRE-1	42.38	13	42	DB-1
PRE-2	41.40	7.3	25	DB-2B
		4.7	16	DB-2A
PRE-3	7.77	3	9	DB-3

PRORATE FLOW SUMMARY FOR PRE-DEVELOPED CONDITION

	TYPE II					FARMER-FLETCHER	
BASIN ID	Area (Acres)	Q_{100}		Q_{10}		Q_{10}	
		Q100 (cfs)	100-yr unit flow (cfs/acre)	Q10 (cfs)	10-yr unit flow (cfs/acre)	Q100 (cfs)	100-yr unit flow (cfs/acre)
PRE-2	41.4	41	0.99	20	0.48	41	0.99
Sub-basin ID	Area (Acres)	Q100 (cfs)	100-yr unit flow (cfs/acre)	Q10 (cfs)	10-yr unit flow (cfs/acre)	Q100 (cfs)	100-yr unit flow (cfs/acre)
PRE-2(a)	16.1	15.9	0.99	7.8	0.48	15.9	0.99
PRE-2(b)	25.3	25.1	0.99	12.2	0.48	25.1	0.99
Total	41.4	41		20		41	

KEY:

- POST-1 — BASIN NAME
- BASIN BOUNDARY
- PRORATE BASIN BOUNDARY

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SUMMIT ESTATES
ST. GEORGE, UTAH
DRAINAGE CONTROL PLAN
PRE-DEVELOPED CONDITION

C.3.4

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POST DEVELOPED SUMMARY			
Basin	**Area (acre)**	**Length (ft)**	**Slope (%)**
OFF-1	11.59	870	19.43%
OFF-2	10.74	1855	16.20%
POST-1	43.46	1785	10.03%
POST-2A	8.5	1250	14.40%
POST-2B	9.7	1184	15.71%
POST-3	7.77	1083	8.86%

0 60' 120'
SCALE: 1" = 60'

GENERAL NOTES:

1. SEE SHEET C.2.1 FOR PROPOSED UTILITIES INCLUDING STORM DRAIN FACILITIES AND EASEMENTS.
2. SEE "SUMMIT ESTATES DRAINAGE CONTROL REPORT" FOR ADDITIONAL DRAINAGE INFORMATION.

DRAINAGE CONTROL PLAN KEY NOTES:

1. SUMMIT ESTATES PROPERTY LINE
2. EXISTING DRAINAGE/MUNICIPAL EASEMENT
3. EXISTING STORM DRAIN CULVERT
4. EXISTING PRE-DEVELOPED FLOW PATH
5. PRE-DEVELOPED DRAINAGE BASIN BOUNDARY
6. POST-DEVELOPED FLOW PATH
7. OFF-SITE DRAINAGE BASIN BOUNDARY
8. POST-DEVELOPED DRAINGE BASIN BOUNDARY
9. PROPOSED DETENTION BASIN

POST DEVELOPED CONDITION CROSS SECTION SUMMARY						
Cross Section	**Description**	**Q (cfs)**	**Slope (%)**	**Depth (ft)**	**Velocity (ft/s)**	**DxV**
Section-1 3-Hour 100-YR	CI1	15.4	12.00	0.27	7.37	1.99
Section-3 3-Hour 100-YR	CI1	14.1	6.25	0.29	5.61	1.63
Section-4 3-Hour 100-YR	CI1	13.5	11.40	0.26	7.04	1.83
Section-5 3-Hour 100-YR	CI1	29.7	4.00	0.39	5.86	2.29
Section-6 3-Hour 100-YR	CI2-19	31	11.20	0.34	8.43	2.87
Section-7 3-Hour 100-YR	CI2-35	26.3	11.20	0.33	8.13	2.68
Section-8 3-Hour 100-YR	CI2-19	5	2.80	0.25	3.27	0.82
Section-9 3-Hour 100-YR	CI2-35	3	5.60	0.19	3.92	0.74
Section-10 3-Hour 100-YR	CI3	1	7.30	0.12	4.58	0.55
Section-11 3-Hour 100-YR	ON-D3	0.3	12.00	0.07	4.08	0.29

Basin Peak Flowrates Summary

POST-DEVELOPED CONDITION 24 HOUR EVENT

Basin	Area (acres)	Q_{10} (cfs)	Q_{100} (cfs)
CD1[1]	-	12	23
CD2[2]	-	32	62
OFF-1	11.59	7	13
OFF-2	10.74	6	12
POST-1	43.45	26	50
POST-2A	8.48	6	12
POST-2B	9.70	6	10
POST-3	7.77	5	9

[1]CD1 = POST-2B + OFF-2
[2]CD2 = POST-1 + OFF-1

POST-DEVELOPED CONDITION 3 HOUR EVENT

CD1	-	8	26
CD2	-	22	69
OFF-1	11.59	4	14
OFF-2	10.74	4	14
POST-1	43.45	18	55
POST-2A	8.48	5	13
POST-2B	9.70	4	12
POST-3	7.77	4	10

[1]CD1 = POST-2B + OFF-2
[2]CD2 = POST-1 + OFF-1

PRORATE FLOW SUMMARY FOR POST DEVELOPED CONDITION FARMER-FLETCHER-100YR

Basin	Area (acres)	Q_{100} (cfs)	CFS/AC
OFF-1	11.6	14	1.21
POST-1	43.4	55	1.27
POST2A-(a)	8.5	13	1.53
POST-3	7.8	10	1.28

Sub-basin ID	Area (Acres)	Q100 (cfs)	100-yr unit flow
OFF-1(a)	7.3	8.8	1.21
OFF-1(b)	3.2	3.9	1.21
OFF-1(c)	1.1	1.3	1.21
Total	11.6	14	

Sub-basin ID	Area (Acres)	Q100 (cfs)	100-yr unit flow
POST-1(a)	5.2	6.6	1.27
POST-1(b)	2.7	3.4	1.27
POST-1(c)	3.4	4.3	1.27
POST-1(d)	20.4	25.9	1.27
POST-1(e)	5.5	7.0	1.27
POST-1(f)	0.6	0.8	1.27
Other	5.6	7.1	1.27
Total	43.5	55	

Sub-basin ID	Area (Acres)	Q100 (cfs)	100-yr unit flow
POST-2A(a)	3.3	5	1.53
Other	5.2	8	1.53
Total	8.5	13	

Sub-basin ID	Area (Acres)	Q100 (cfs)	100-yr unit flow
POST-3(a)	2.4	3	1.28
POST-3(b)	0.8	1	1.28
POST-3(b)	0.2	0.3	1.28
Other	4.4	5.7	1.28
Total	7.8	10	

KEY:

- POST-1 — BASIN NAME
- 4—4 — CROSS SECTION
- BASIN BOUNDARY
- PRORATE BASIN BOUNDARY

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DRAINAGE CONTROL PLAN
POST-DEVELOPED CONDITION

C.3.5

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APPENDIX B: HYDRAULIC COMPUTATIONS

Section-1 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	12.000 %
Discharge	15.40 cfs

Section Definitions

Station (ft)	Elevation (ft)
0+00	0.50
0+04	0.41
0+05	0.41
0+06	0.00
0+07	0.12
0+20	0.37
0+33	0.12
0+34	0.00
0+35	0.41
0+36	0.41
0+40	0.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 0.50)	(0+07, 0.12)	0.013
(0+07, 0.12)	(0+33, 0.12)	0.016
(0+33, 0.12)	(0+40, 0.50)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	0.28 ft
Elevation Range	0.0 to 0.5 ft
Flow Area	2.1 ft²
Wetted Perimeter	20.14 ft
Hydraulic Radius	0.10 ft
Top Width	19.92 ft
Normal Depth	0.28 ft
Critical Depth	0.43 ft
Critical Slope	0.610 %

Results	
Velocity	7.37 ft/s
Velocity Head	0.84 ft
Specific Energy	1.12 ft
Froude Number	4.013
Flow Type	Supercritical

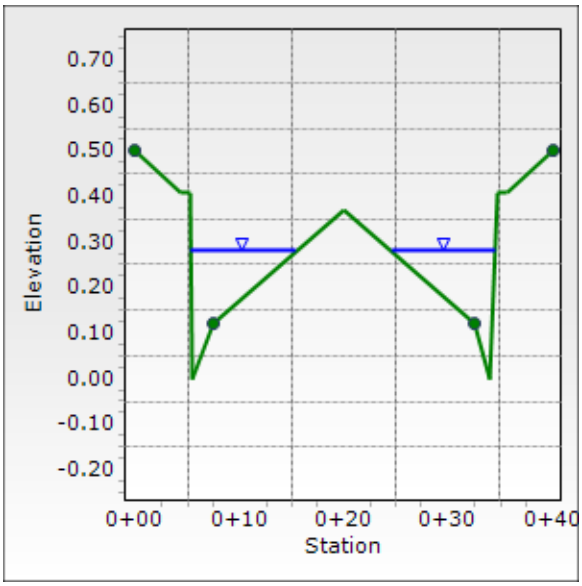
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Number Of Steps	0

GVF Output Data	
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Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.28 ft
Critical Depth	0.43 ft
Channel Slope	12.000 %
Critical Slope	0.610 %

Cross Section for Section-1 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	12.000 %
Normal Depth	0.28 ft
Discharge	15.40 cfs



Section-3 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	6.250 %
Discharge	14.10 cfs

Section Definitions

Station (ft)	Elevation (ft)
0+00	0.50
0+04	0.41
0+05	0.41
0+06	0.00
0+07	0.12
0+20	0.37
0+33	0.12
0+34	0.00
0+35	0.41
0+36	0.41
0+40	0.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 0.50)	(0+07, 0.12)	0.013
(0+07, 0.12)	(0+33, 0.12)	0.016
(0+33, 0.12)	(0+40, 0.50)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	0.30 ft
Elevation Range	0.0 to 0.5 ft
Flow Area	2.5 ft²
Wetted Perimeter	22.22 ft
Hydraulic Radius	0.11 ft
Top Width	21.99 ft
Normal Depth	0.30 ft
Critical Depth	0.42 ft
Critical Slope	0.621 %

Results	
Velocity	5.61 ft/s
Velocity Head	0.49 ft
Specific Energy	0.79 ft
Froude Number	2.929
Flow Type	Supercritical

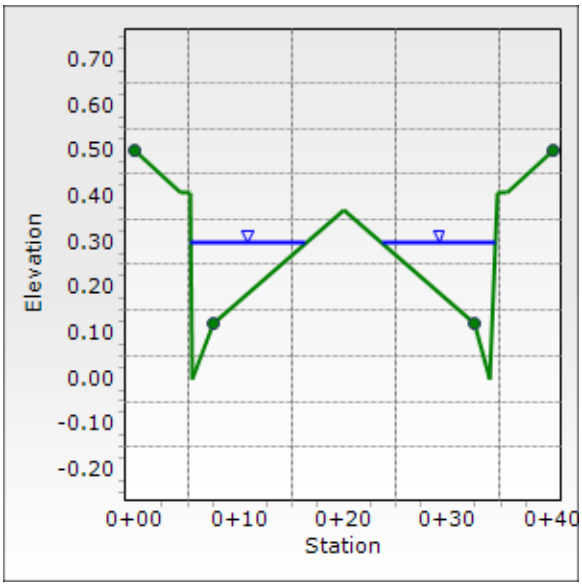
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GVF Output Data	
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Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.30 ft
Critical Depth	0.42 ft
Channel Slope	6.250 %
Critical Slope	0.621 %

Cross Section for Section-3 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	6.250 %
Normal Depth	0.30 ft
Discharge	14.10 cfs



Section-5 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	4.000 %
Discharge	29.70 cfs

Section Definitions

Station (ft)	Elevation (ft)
0+00	0.50
0+04	0.41
0+05	0.41
0+06	0.00
0+07	0.12
0+20	0.37
0+33	0.12
0+34	0.00
0+35	0.41
0+36	0.41
0+40	0.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 0.50)	(0+07, 0.12)	0.013
(0+07, 0.12)	(0+33, 0.12)	0.016
(0+33, 0.12)	(0+40, 0.50)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	0.39 ft
Elevation Range	0.0 to 0.5 ft
Flow Area	5.1 ft²
Wetted Perimeter	29.86 ft
Hydraulic Radius	0.17 ft
Top Width	29.55 ft
Normal Depth	0.39 ft
Critical Depth	0.54 ft
Critical Slope	0.561 %

Results	
Velocity	5.86 ft/s
Velocity Head	0.53 ft
Specific Energy	0.93 ft
Froude Number	2.495
Flow Type	Supercritical

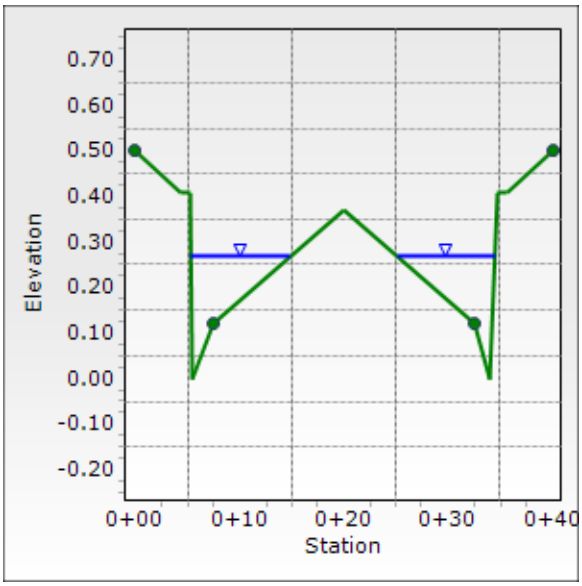
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Length	0.00 ft
Number Of Steps	0

GVF Output Data	
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Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.39 ft
Critical Depth	0.54 ft
Channel Slope	4.000 %
Critical Slope	0.561 %

Cross Section for Section-4 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	11.400 %
Normal Depth	0.27 ft
Discharge	13.50 cfs



Section-6 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	11.200 %
Discharge	31.00 cfs

Section Definitions

Station (ft)	Elevation (ft)
0+00	0.50
0+04	0.41
0+05	0.41
0+06	0.00
0+07	0.12
0+20	0.37
0+33	0.12
0+34	0.00
0+35	0.41
0+36	0.41
0+40	0.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 0.50)	(0+07, 0.12)	0.013
(0+07, 0.12)	(0+33, 0.12)	0.016
(0+33, 0.12)	(0+40, 0.50)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	0.34 ft
Elevation Range	0.0 to 0.5 ft
Flow Area	3.7 ft²
Wetted Perimeter	27.17 ft
Hydraulic Radius	0.14 ft
Top Width	26.89 ft
Normal Depth	0.34 ft
Critical Depth	0.55 ft
Critical Slope	0.554 %

Results	
Velocity	8.43 ft/s
Velocity Head	1.10 ft
Specific Energy	1.45 ft
Froude Number	4.017
Flow Type	Supercritical

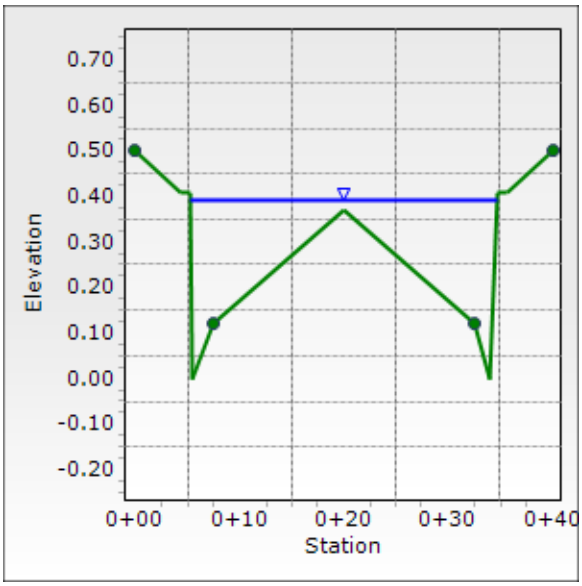
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Length	0.00 ft
Number Of Steps	0

GVF Output Data	
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Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.34 ft
Critical Depth	0.55 ft
Channel Slope	11.200 %
Critical Slope	0.554 %

Cross Section for Section-5 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	4.000 %
Normal Depth	0.39 ft
Discharge	29.70 cfs



Section-7 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	11.200 %
Discharge	26.30 cfs

Section Definitions

Station (ft)	Elevation (ft)
0+00	0.50
0+04	0.41
0+05	0.41
0+06	0.00
0+07	0.12
0+20	0.37
0+33	0.12
0+34	0.00
0+35	0.41
0+36	0.41
0+40	0.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 0.50)	(0+07, 0.12)	0.013
(0+07, 0.12)	(0+33, 0.12)	0.016
(0+33, 0.12)	(0+40, 0.50)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	0.33 ft
Elevation Range	0.0 to 0.5 ft
Flow Area	3.2 ft²
Wetted Perimeter	25.40 ft
Hydraulic Radius	0.13 ft
Top Width	25.14 ft
Normal Depth	0.33 ft
Critical Depth	0.52 ft
Critical Slope	0.572 %

Results	
Velocity	8.13 ft/s
Velocity Head	1.03 ft
Specific Energy	1.36 ft
Froude Number	3.998
Flow Type	Supercritical

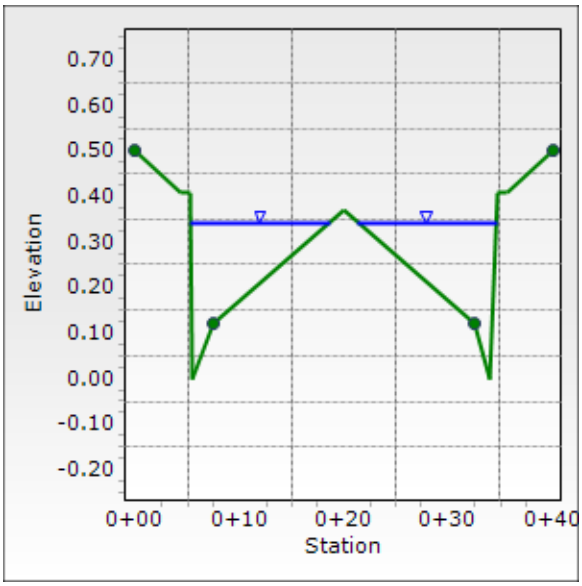
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Length	0.00 ft
Number Of Steps	0

GVF Output Data	
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Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.33 ft
Critical Depth	0.52 ft
Channel Slope	11.200 %
Critical Slope	0.572 %

Cross Section for Section-6 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	11.200 %
Normal Depth	0.34 ft
Discharge	31.00 cfs



Section-8 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	2.800 %
Discharge	5.00 cfs

Section Definitions

Station (ft)	Elevation (ft)
0+00	0.50
0+04	0.41
0+05	0.41
0+06	0.00
0+07	0.12
0+20	0.37
0+33	0.12
0+34	0.00
0+35	0.41
0+36	0.41
0+40	0.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 0.50)	(0+07, 0.12)	0.013
(0+07, 0.12)	(0+33, 0.12)	0.016
(0+33, 0.12)	(0+40, 0.50)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	0.25 ft
Elevation Range	0.0 to 0.5 ft
Flow Area	1.5 ft²
Wetted Perimeter	16.97 ft
Hydraulic Radius	0.09 ft
Top Width	16.77 ft
Normal Depth	0.25 ft
Critical Depth	0.30 ft
Critical Slope	0.708 %

Results	
Velocity	3.27 ft/s
Velocity Head	0.17 ft
Specific Energy	0.41 ft
Froude Number	1.913
Flow Type	Supercritical

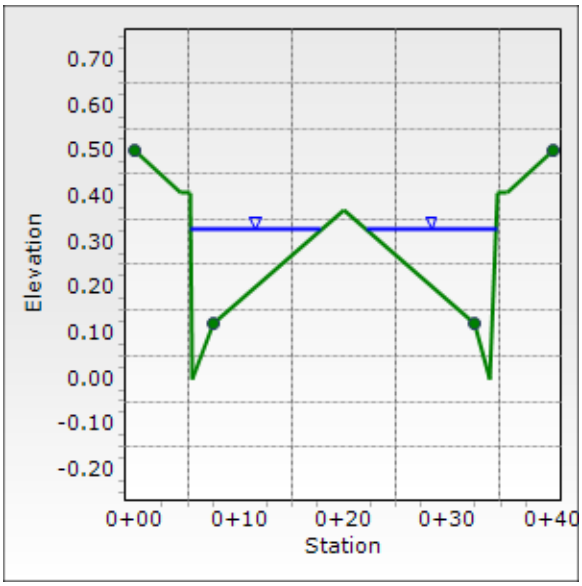
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Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.25 ft
Critical Depth	0.30 ft
Channel Slope	2.800 %
Critical Slope	0.708 %

Cross Section for Section-7 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	11.200 %
Normal Depth	0.33 ft
Discharge	26.30 cfs



Section-9 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	5.600 %
Discharge	3.00 cfs

Section Definitions

Station (ft)	Elevation (ft)
0+00	0.50
0+04	0.41
0+05	0.41
0+06	0.00
0+07	0.12
0+20	0.37
0+33	0.12
0+34	0.00
0+35	0.41
0+36	0.41
0+40	0.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 0.50)	(0+07, 0.12)	0.013
(0+07, 0.12)	(0+33, 0.12)	0.016
(0+33, 0.12)	(0+40, 0.50)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	0.19 ft
Elevation Range	0.0 to 0.5 ft
Flow Area	0.8 ft²
Wetted Perimeter	11.33 ft
Hydraulic Radius	0.07 ft
Top Width	11.18 ft
Normal Depth	0.19 ft
Critical Depth	0.26 ft
Critical Slope	0.725 %

Results	
Velocity	3.92 ft/s
Velocity Head	0.24 ft
Specific Energy	0.43 ft
Froude Number	2.637
Flow Type	Supercritical

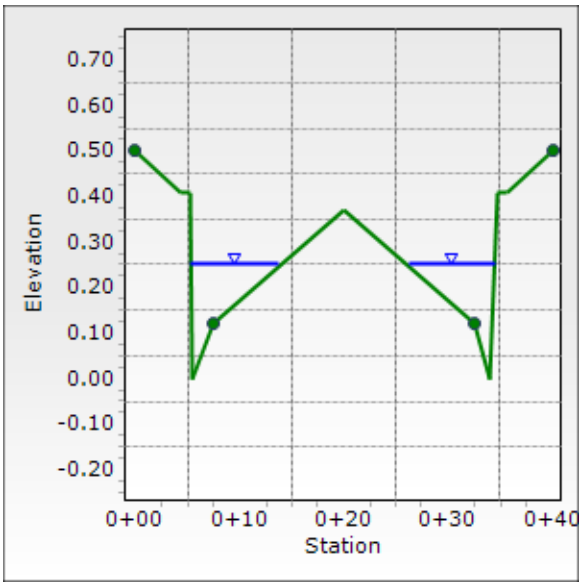
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Length	0.00 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.00 ft
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.19 ft
Critical Depth	0.26 ft
Channel Slope	5.600 %
Critical Slope	0.725 %

Cross Section for Section-8 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	2.800 %
Normal Depth	0.25 ft
Discharge	5.00 cfs



Section-10 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	7.300 %
Discharge	1.00 cfs

Section Definitions

Station (ft)	Elevation (ft)
0+00	0.50
0+04	0.41
0+05	0.41
0+06	0.00
0+07	0.12
0+20	0.37
0+33	0.12
0+34	0.00
0+35	0.41
0+36	0.41
0+40	0.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 0.50)	(0+07, 0.12)	0.013
(0+07, 0.12)	(0+33, 0.12)	0.016
(0+33, 0.12)	(0+40, 0.50)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	0.12 ft
Elevation Range	0.0 to 0.5 ft
Flow Area	0.2 ft²
Wetted Perimeter	3.82 ft
Hydraulic Radius	0.06 ft
Top Width	3.72 ft
Normal Depth	0.12 ft
Critical Depth	0.18 ft
Critical Slope	0.621 %

Results	
Velocity	4.58 ft/s
Velocity Head	0.33 ft
Specific Energy	0.44 ft
Froude Number	3.337
Flow Type	Supercritical

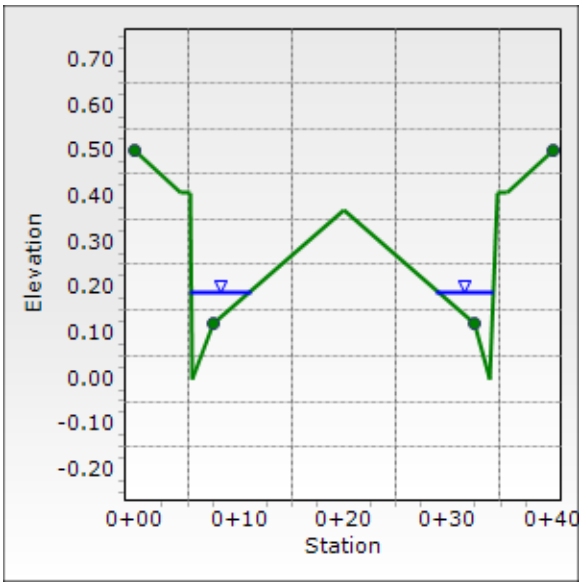
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Length	0.00 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.00 ft
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.12 ft
Critical Depth	0.18 ft
Channel Slope	7.300 %
Critical Slope	0.621 %

Cross Section for Section-9 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	5.600 %
Normal Depth	0.19 ft
Discharge	3.00 cfs



Section-11 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	12.000 %
Discharge	0.30 cfs

Section Definitions

Station (ft)	Elevation (ft)
0+00	0.50
0+04	0.41
0+05	0.41
0+06	0.00
0+07	0.12
0+20	0.37
0+33	0.12
0+34	0.00
0+35	0.41
0+36	0.41
0+40	0.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 0.50)	(0+07, 0.12)	0.013
(0+07, 0.12)	(0+33, 0.12)	0.016
(0+33, 0.12)	(0+40, 0.50)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	0.07 ft
Elevation Range	0.0 to 0.5 ft
Flow Area	0.1 ft²
Wetted Perimeter	2.22 ft
Hydraulic Radius	0.03 ft
Top Width	2.16 ft
Normal Depth	0.07 ft
Critical Depth	0.12 ft
Critical Slope	0.656 %

Results	
Velocity	4.08 ft/s
Velocity Head	0.26 ft
Specific Energy	0.33 ft
Froude Number	3.901
Flow Type	Supercritical

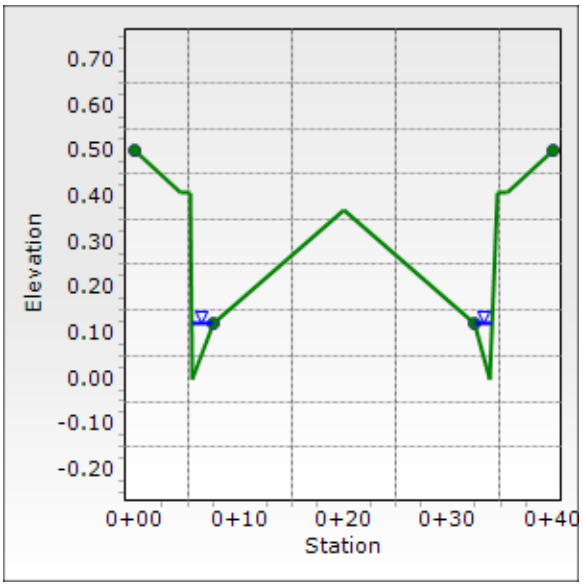
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Length	0.00 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.00 ft
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.07 ft
Critical Depth	0.12 ft
Channel Slope	12.000 %
Critical Slope	0.656 %

Cross Section for Section-10 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	7.300 %
Normal Depth	0.12 ft
Discharge	1.00 cfs



Section-4 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	11.400 %
Discharge	13.50 cfs

Section Definitions

Station (ft)	Elevation (ft)
0+00	0.50
0+04	0.41
0+05	0.41
0+06	0.00
0+07	0.12
0+20	0.37
0+33	0.12
0+34	0.00
0+35	0.41
0+36	0.41
0+40	0.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 0.50)	(0+07, 0.12)	0.013
(0+07, 0.12)	(0+33, 0.12)	0.016
(0+33, 0.12)	(0+40, 0.50)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	0.27 ft
Elevation Range	0.0 to 0.5 ft
Flow Area	1.9 ft²
Wetted Perimeter	19.23 ft
Hydraulic Radius	0.10 ft
Top Width	19.02 ft
Normal Depth	0.27 ft
Critical Depth	0.41 ft
Critical Slope	0.611 %

Results	
Velocity	7.04 ft/s
Velocity Head	0.77 ft
Specific Energy	1.04 ft
Froude Number	3.907
Flow Type	Supercritical

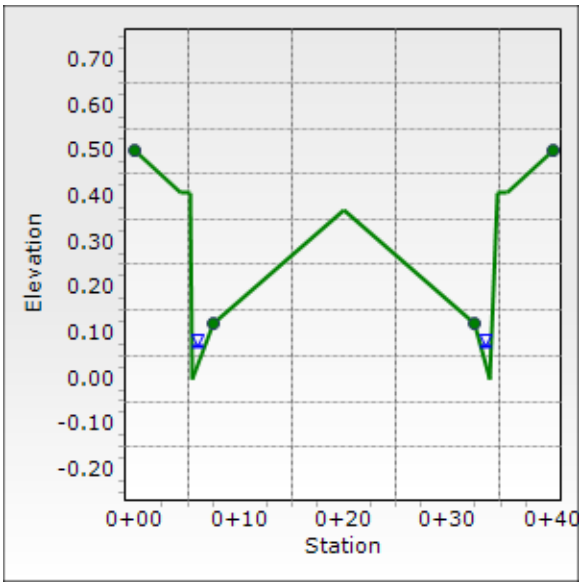
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Downstream Depth	0.00 ft
Length	0.00 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.00 ft
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.27 ft
Critical Depth	0.41 ft
Channel Slope	11.400 %
Critical Slope	0.611 %

Cross Section for Section-11 3-Hour 100-YR

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	12.000 %
Normal Depth	0.07 ft
Discharge	0.30 cfs



DI#1_5'_3-Hour 100-YR

Project Description

Solve For	Efficiency

Input Data

Discharge	15.40 cfs
Slope	12.000 %
Gutter Width	1.50 ft
Gutter Cross Slope	8.330 %
Road Cross Slope	2.000 %
Roughness Coefficient	0.016
Local Depression	2.0 in
Local Depression Width	18.0 in
Grate Width	1.50 ft
Grate Length	1.25 ft
Grate Type	P-50 mm (P-1 -7/8")
Clogging	0.0 %
Curb Opening Length	2.50 ft

Options

Calculation Option	Use Both
Grate Flow Option	Exclude None

Results

Efficiency	28.94 %
Intercepted Flow	4.46 cfs
Bypass Flow	10.94 cfs
Spread	12.13 ft
Depth	0.34 ft
Flow Area	1.5 ft²
Gutter Depression	1.1 in
Total Depression	3.1 in
Velocity	9.98 ft/s
Splash Over Velocity	6.35 ft/s
Frontal Flow Factor	0.674
Side Flow Factor	0.004
Grate Flow Ratio	0.368
Equivalent Cross Slope	8.426 %
Active Grate Length	1.25 ft
Length Factor	0.024
Total Interception Length	52.82 ft

Messages

Messages		
Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).	

DI#3_5'_3-Hour 100-YR

Project Description

Solve For	Efficiency

Input Data

Discharge	14.10 cfs
Slope	6.250 %
Gutter Width	1.50 ft
Gutter Cross Slope	8.330 %
Road Cross Slope	2.000 %
Roughness Coefficient	0.016
Local Depression	2.0 in
Local Depression Width	18.0 in
Grate Width	1.50 ft
Grate Length	1.25 ft
Grate Type	P-50 mm (P-1 -7/8")
Clogging	0.0 %
Curb Opening Length	2.50 ft

Options

Calculation Option	Use Both
Grate Flow Option	Exclude None

Results

Efficiency	34.49 %
Intercepted Flow	4.86 cfs
Bypass Flow	9.24 cfs
Spread	13.36 ft
Depth	0.36 ft
Flow Area	1.9 ft²
Gutter Depression	1.1 in
Total Depression	3.1 in
Velocity	7.60 ft/s
Splash Over Velocity	6.35 ft/s
Frontal Flow Factor	0.888
Side Flow Factor	0.006
Grate Flow Ratio	0.334
Equivalent Cross Slope	7.831 %
Active Grate Length	1.25 ft
Length Factor	0.029
Total Interception Length	43.74 ft

Messages

Messages		
Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).	

DI#5_5'_3-Hour 100-YR

Project Description

Solve For	Efficiency

Input Data

Discharge	29.70 cfs
Slope	4.000 %
Gutter Width	1.50 ft
Gutter Cross Slope	8.330 %
Road Cross Slope	2.000 %
Roughness Coefficient	0.016
Local Depression	2.0 in
Local Depression Width	18.0 in
Grate Width	1.50 ft
Grate Length	1.25 ft
Grate Type	P-50 mm (P-1 -7/8")
Clogging	0.0 %
Curb Opening Length	2.50 ft

Options

Calculation Option	Use Both
Grate Flow Option	Exclude None

Results

Efficiency	23.65 %
Intercepted Flow	7.02 cfs
Bypass Flow	22.68 cfs
Spread	19.54 ft
Depth	0.49 ft
Flow Area	3.9 ft²
Gutter Depression	1.1 in
Total Depression	3.1 in
Velocity	7.64 ft/s
Splash Over Velocity	6.35 ft/s
Frontal Flow Factor	0.884
Side Flow Factor	0.006
Grate Flow Ratio	0.225
Equivalent Cross Slope	5.927 %
Active Grate Length	1.25 ft
Length Factor	0.020
Total Interception Length	61.82 ft

Messages

Messages		
Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).	

DI#6_5'_3-Hour 100-YR

Project Description

Solve For	Efficiency

Input Data

Discharge	31.00 cfs
Slope	11.200 %
Gutter Width	1.50 ft
Gutter Cross Slope	8.330 %
Road Cross Slope	2.000 %
Roughness Coefficient	0.016
Local Depression	2.0 in
Local Depression Width	18.0 in
Grate Width	1.50 ft
Grate Length	1.25 ft
Grate Type	P-50 mm (P-1 -7/8")
Clogging	0.0 %
Curb Opening Length	2.50 ft

Options

Calculation Option	Use Both
Grate Flow Option	Exclude None

Results

Efficiency	17.80 %
Intercepted Flow	5.52 cfs
Bypass Flow	25.48 cfs
Spread	16.26 ft
Depth	0.42 ft
Flow Area	2.7 ft²
Gutter Depression	1.1 in
Total Depression	3.1 in
Velocity	11.42 ft/s
Splash Over Velocity	6.35 ft/s
Frontal Flow Factor	0.544
Side Flow Factor	0.003
Grate Flow Ratio	0.273
Equivalent Cross Slope	6.760 %
Active Grate Length	1.25 ft
Length Factor	0.016
Total Interception Length	79.22 ft

Messages

Messages		
Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).	

DI#8_5'_3-Hour 100-YR

Project Description

Solve For	Efficiency

Input Data

Discharge	5.00 cfs
Slope	2.800 %
Gutter Width	1.50 ft
Gutter Cross Slope	8.330 %
Road Cross Slope	2.000 %
Roughness Coefficient	0.016
Local Depression	2.0 in
Local Depression Width	18.0 in
Grate Width	1.50 ft
Grate Length	1.25 ft
Grate Type	P-50 mm (P-1 -7/8")
Clogging	0.0 %
Curb Opening Length	2.50 ft

Options

Calculation Option	Use Both
Grate Flow Option	Exclude None

Results

Efficiency	52.25 %
Intercepted Flow	2.61 cfs
Bypass Flow	2.39 cfs
Spread	10.30 ft
Depth	0.30 ft
Flow Area	1.1 ft²
Gutter Depression	1.1 in
Total Depression	3.1 in
Velocity	4.42 ft/s
Splash Over Velocity	6.35 ft/s
Frontal Flow Factor	1.000
Side Flow Factor	0.015
Grate Flow Ratio	0.433
Equivalent Cross Slope	9.553 %
Active Grate Length	1.25 ft
Length Factor	0.063
Total Interception Length	19.74 ft

Messages

Messages		
Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).	

DI#9_5'_3-Hour 100-YR

Project Description

Solve For	Efficiency

Input Data

Discharge	3.00	cfs
Slope	5.600	%
Gutter Width	1.50	ft
Gutter Cross Slope	8.330	%
Road Cross Slope	2.000	%
Roughness Coefficient	0.016	
Local Depression	2.0	in
Local Depression Width	18.0	in
Grate Width	1.50	ft
Grate Length	1.25	ft
Grate Type	P-50 mm (P-1 -7/8")	
Clogging	0.0	%
Curb Opening Length	2.50	ft

Options

Calculation Option	Use Both
Grate Flow Option	Exclude None

Results

Efficiency	69.18	%
Intercepted Flow	2.08	cfs
Bypass Flow	0.92	cfs
Spread	7.06	ft
Depth	0.24	ft
Flow Area	0.6	ft²
Gutter Depression	1.1	in
Total Depression	3.1	in
Velocity	5.27	ft/s
Splash Over Velocity	6.35	ft/s
Frontal Flow Factor	1.000	
Side Flow Factor	0.011	
Grate Flow Ratio	0.608	
Equivalent Cross Slope	12.601	%
Active Grate Length	1.25	ft
Length Factor	0.075	
Total Interception Length	16.61	ft

Messages

Messages		
Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).	

DI#10_5'_3-Hour 100-YR

Project Description

Solve For	Efficiency

Input Data

Discharge	1.00 cfs
Slope	7.300 %
Gutter Width	1.50 ft
Gutter Cross Slope	8.330 %
Road Cross Slope	2.000 %
Roughness Coefficient	0.016
Local Depression	2.0 in
Local Depression Width	18.0 in
Grate Width	1.50 ft
Grate Length	1.25 ft
Grate Type	P-50 mm (P-1 -7/8")
Clogging	0.0 %
Curb Opening Length	2.50 ft

Options

Calculation Option	Use Both
Grate Flow Option	Exclude None

Results

Efficiency	96.88 %
Intercepted Flow	0.97 cfs
Bypass Flow	0.03 cfs
Spread	3.53 ft
Depth	0.17 ft
Flow Area	0.2 ft²
Gutter Depression	1.1 in
Total Depression	3.1 in
Velocity	5.11 ft/s
Splash Over Velocity	6.35 ft/s
Frontal Flow Factor	1.000
Side Flow Factor	0.012
Grate Flow Ratio	0.909
Equivalent Cross Slope	17.854 %
Active Grate Length	1.25 ft
Length Factor	0.136
Total Interception Length	9.20 ft

Messages

Messages		
Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).	

DI#11_5'_3-Hour 100-YR

Project Description

Solve For	Efficiency

Input Data

Discharge	0.30 cfs
Slope	12.000 %
Gutter Width	1.50 ft
Gutter Cross Slope	8.330 %
Road Cross Slope	2.000 %
Roughness Coefficient	0.016
Local Depression	2.0 in
Local Depression Width	18.0 in
Grate Width	1.50 ft
Grate Length	1.25 ft
Grate Type	P-50 mm (P-1 -7/8")
Clogging	0.0 %
Curb Opening Length	2.50 ft

Options

Calculation Option	Use Both
Grate Flow Option	Exclude None

Results

Efficiency	100.00 %
Intercepted Flow	0.30 cfs
Bypass Flow	0.00 cfs
Spread	1.18 ft
Depth	0.10 ft
Flow Area	0.1 ft²
Gutter Depression	1.1 in
Total Depression	3.1 in
Velocity	5.14 ft/s
Splash Over Velocity	6.35 ft/s
Frontal Flow Factor	1.000
Side Flow Factor	0.012
Grate Flow Ratio	1.000
Equivalent Cross Slope	19.441 %
Active Grate Length	1.25 ft
Length Factor	0.204
Total Interception Length	6.12 ft

Messages

Messages		
Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).	

SD1 Section1

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data		
Roughness Coefficient	0.016	
Channel Slope	6.900	%
Diameter	18.0	in
Discharge	4.50	cfs

Results		
Normal Depth	0.46	ft
Flow Area	0.5	ft²
Wetted Perimeter	1.75	ft
Hydraulic Radius	0.26	ft
Top Width	1.38	ft
Critical Depth	0.81	ft
Percent Full	30.4	%
Critical Slope	0.846	%
Velocity	9.92	ft/s
Velocity Head	1.53	ft
Specific Energy	1.98	ft
Froude Number	3.048	
Maximum Discharge	24.11	cfs
Discharge Full	22.42	cfs
Slope Full	0.278	%
Flow Type	Supercritical	

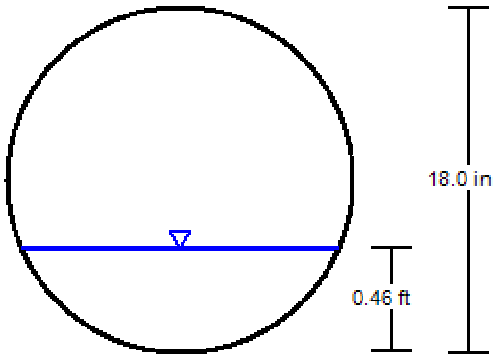
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Length	0.00	ft
Number Of Steps	0	

GVF Output Data		
Upstream Depth	0.00	ft
Profile Description	N/A	
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.0	%
Normal Depth Over Rise	30.4	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.46	ft
Critical Depth	0.81	ft
Channel Slope	6.900	%
Critical Slope	0.846	%

Cross Section for SD1 Section1

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.016
Channel Slope	6.900 %
Normal Depth	0.46 ft
Diameter	18.0 in
Discharge	4.50 cfs



V: 1
H: 1

SD2 Section2

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data		
Roughness Coefficient	0.016	
Channel Slope	6.100	%
Diameter	18.0	in
Discharge	4.50	cfs

Results		
Normal Depth	0.47	ft
Flow Area	0.5	ft²
Wetted Perimeter	1.78	ft
Hydraulic Radius	0.27	ft
Top Width	1.39	ft
Critical Depth	0.81	ft
Percent Full	31.4	%
Critical Slope	0.845	%
Velocity	9.49	ft/s
Velocity Head	1.40	ft
Specific Energy	1.87	ft
Froude Number	2.865	
Maximum Discharge	22.67	cfs
Discharge Full	21.08	cfs
Slope Full	0.278	%
Flow Type	Supercritical	

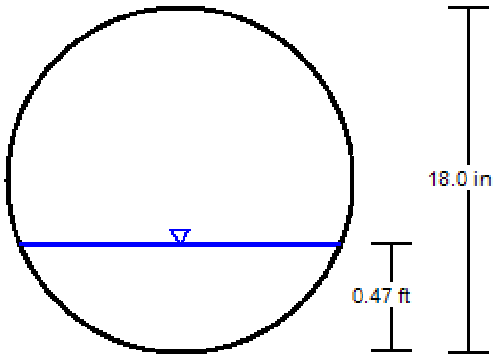
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Length	0.00	ft
Number Of Steps	0	

GVF Output Data		
Upstream Depth	0.00	ft
Profile Description	N/A	
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.0	%
Normal Depth Over Rise	31.4	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.47	ft
Critical Depth	0.81	ft
Channel Slope	6.100	%
Critical Slope	0.845	%

Cross Section for SD2 Section2

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.016
Channel Slope	6.100 %
Normal Depth	0.47 ft
Diameter	18.0 in
Discharge	4.50 cfs



V: 1
H: 1

SD3 Section3

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data		
Roughness Coefficient	0.016	
Channel Slope	12.100	%
Diameter	18.0	in
Discharge	9.40	cfs

Results		
Normal Depth	0.58	ft
Flow Area	0.6	ft^2
Wetted Perimeter	2.01	ft
Hydraulic Radius	0.31	ft
Top Width	1.46	ft
Critical Depth	1.18	ft
Percent Full	38.7	%
Critical Slope	1.303	%
Velocity	14.90	ft/s
Velocity Head	3.45	ft
Specific Energy	4.03	ft
Froude Number	3.998	
Maximum Discharge	31.93	cfs
Discharge Full	29.69	cfs
Slope Full	1.213	%
Flow Type	Supercritical	

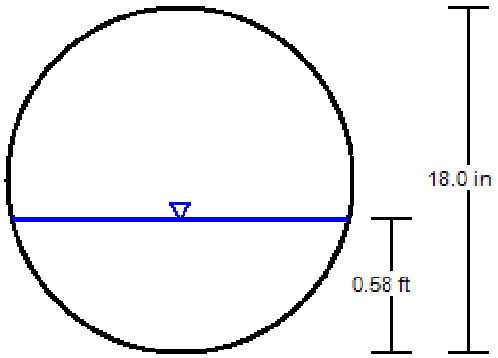
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Length	0.00	ft
Number Of Steps	0	

GVF Output Data		
Upstream Depth	0.00	ft
Profile Description	N/A	
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.0	%
Normal Depth Over Rise	38.7	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.58	ft
Critical Depth	1.18	ft
Channel Slope	12.100	%
Critical Slope	1.303	%

Cross Section for SD3 Section3

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data		
Roughness Coefficient	0.016	
Channel Slope	12.100	%
Normal Depth	0.58	ft
Diameter	18.0	in
Discharge	9.40	cfs



V: 1
H: 1

Worksheet for SD4 Section4

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.016
Channel Slope	2.000 %
Diameter	24.0 in
Discharge	22.90 cfs

Results	
Normal Depth	1.46 ft
Flow Area	2.5 ft²
Wetted Perimeter	4.09 ft
Hydraulic Radius	0.60 ft
Top Width	1.78 ft
Critical Depth	1.70 ft
Percent Full	72.9 %
Critical Slope	1.458 %
Velocity	9.34 ft/s
Velocity Head	1.35 ft
Specific Energy	2.81 ft
Froude Number	1.402
Maximum Discharge	27.96 cfs
Discharge Full	25.99 cfs
Slope Full	1.552 %
Flow Type	Supercritical

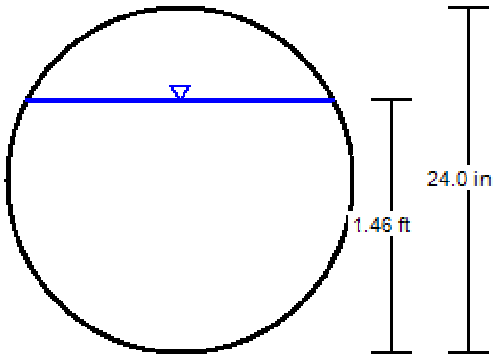
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Length	0.00 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.00 ft
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	72.9 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	1.46 ft
Critical Depth	1.70 ft
Channel Slope	2.000 %
Critical Slope	1.458 %

Cross Section for SD4 Section4

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.016
Channel Slope	2.000 %
Normal Depth	1.46 ft
Diameter	24.0 in
Discharge	22.90 cfs



V: 1
H: 1

SD5 Section5

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data		
Roughness Coefficient	0.016	
Channel Slope	10.700	%
Diameter	18.0	in
Discharge	7.00	cfs

Results		
Normal Depth	0.51	ft
Flow Area	0.5	ft²
Wetted Perimeter	1.87	ft
Hydraulic Radius	0.28	ft
Top Width	1.42	ft
Critical Depth	1.02	ft
Percent Full	34.1	%
Critical Slope	1.024	%
Velocity	13.14	ft/s
Velocity Head	2.68	ft
Specific Energy	3.20	ft
Froude Number	3.786	
Maximum Discharge	30.03	cfs
Discharge Full	27.92	cfs
Slope Full	0.673	%
Flow Type	Supercritical	

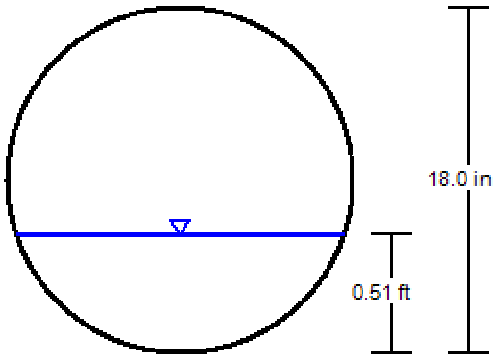
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Length	0.00	ft
Number Of Steps	0	

GVF Output Data		
Upstream Depth	0.00	ft
Profile Description	N/A	
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.0	%
Normal Depth Over Rise	34.1	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.51	ft
Critical Depth	1.02	ft
Channel Slope	10.700	%
Critical Slope	1.024	%

Cross Section for SD5 Section5

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data		
Roughness Coefficient	0.016	
Channel Slope	10.700	%
Normal Depth	0.51	ft
Diameter	18.0	in
Discharge	7.00	cfs



V: 1
H: 1

SD6 Section6

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data		
Roughness Coefficient	0.016	
Channel Slope	10.500	%
Diameter	18.0	in
Discharge	12.50	cfs

Results		
Normal Depth	0.71	ft
Flow Area	0.8	ft^2
Wetted Perimeter	2.27	ft
Hydraulic Radius	0.36	ft
Top Width	1.50	ft
Critical Depth	1.33	ft
Percent Full	47.1	%
Critical Slope	1.909	%
Velocity	15.26	ft/s
Velocity Head	3.62	ft
Specific Energy	4.32	ft
Froude Number	3.636	
Maximum Discharge	29.75	cfs
Discharge Full	27.65	cfs
Slope Full	2.145	%
Flow Type	Supercritical	

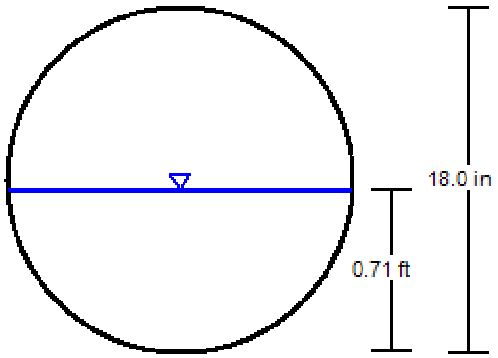
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Length	0.00	ft
Number Of Steps	0	

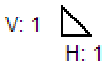
GVF Output Data		
Upstream Depth	0.00	ft
Profile Description	N/A	
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.0	%
Normal Depth Over Rise	47.1	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.71	ft
Critical Depth	1.33	ft
Channel Slope	10.500	%
Critical Slope	1.909	%

Cross Section for SD6 Section6

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data		
Roughness Coefficient	0.016	
Channel Slope	10.500	%
Normal Depth	0.71	ft
Diameter	18.0	in
Discharge	12.50	cfs





Worksheet for SD7 Section7

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data		
Roughness Coefficient	0.016	
Channel Slope	2.000	%
Diameter	30.0	in
Discharge	38.80	cfs

Results		
Normal Depth	1.73	ft
Flow Area	3.6	ft²
Wetted Perimeter	4.91	ft
Hydraulic Radius	0.74	ft
Top Width	2.31	ft
Critical Depth	2.10	ft
Percent Full	69.1	%
Critical Slope	1.298	%
Velocity	10.72	ft/s
Velocity Head	1.79	ft
Specific Energy	3.51	ft
Froude Number	1.510	
Maximum Discharge	50.70	cfs
Discharge Full	47.13	cfs
Slope Full	1.356	%
Flow Type	Supercritical	

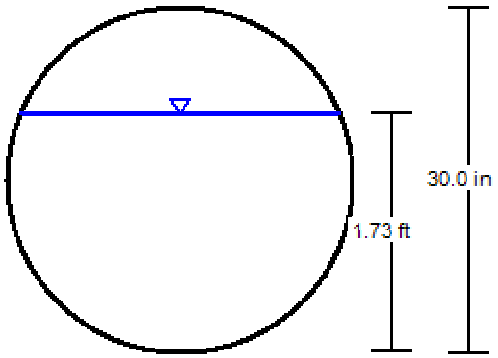
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Length	0.00	ft
Number Of Steps	0	

GVF Output Data		
Upstream Depth	0.00	ft
Profile Description	N/A	
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.0	%
Normal Depth Over Rise	69.1	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.73	ft
Critical Depth	2.10	ft
Channel Slope	2.000	%
Critical Slope	1.298	%

Cross Section for SD7 Section7

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.016
Channel Slope	2.000 %
Normal Depth	1.73 ft
Diameter	30.0 in
Discharge	38.80 cfs



V: 1
H: 1

SD8 Section 8

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data		
Roughness Coefficient	0.016	
Channel Slope	17.500	%
Diameter	18.0	in
Discharge	2.60	cfs

Results		
Normal Depth	0.27	ft
Flow Area	0.2	ft^2
Wetted Perimeter	1.32	ft
Hydraulic Radius	0.17	ft
Top Width	1.16	ft
Critical Depth	0.61	ft
Percent Full	18.3	%
Critical Slope	0.763	%
Velocity	11.77	ft/s
Velocity Head	2.15	ft
Specific Energy	2.43	ft
Froude Number	4.754	
Maximum Discharge	38.40	cfs
Discharge Full	35.70	cfs
Slope Full	0.093	%
Flow Type	Supercritical	

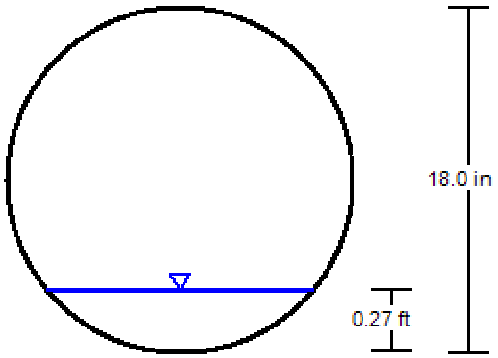
GVF Input Data		
Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

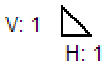
GVF Output Data		
Upstream Depth	0.00	ft
Profile Description	N/A	
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.0	%
Normal Depth Over Rise	18.3	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.27	ft
Critical Depth	0.61	ft
Channel Slope	17.500	%
Critical Slope	0.763	%

Cross Section for SD8 Section 8

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.016
Channel Slope	17.500 %
Normal Depth	0.27 ft
Diameter	18.0 in
Discharge	2.60 cfs





SD9 Section 9

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data		
Roughness Coefficient	0.016	
Channel Slope	12.300	%
Diameter	18.0	in
Discharge	2.10	cfs

Results		
Normal Depth	0.27	ft
Flow Area	0.2	ft^2
Wetted Perimeter	1.31	ft
Hydraulic Radius	0.16	ft
Top Width	1.15	ft
Critical Depth	0.55	ft
Percent Full	17.9	%
Critical Slope	0.750	%
Velocity	9.76	ft/s
Velocity Head	1.48	ft
Specific Energy	1.75	ft
Froude Number	3.980	
Maximum Discharge	32.20	cfs
Discharge Full	29.93	cfs
Slope Full	0.061	%
Flow Type	Supercritical	

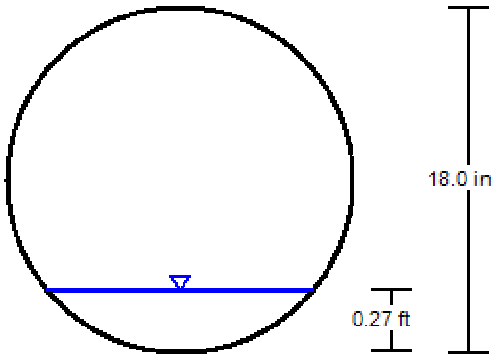
GVF Input Data		
Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

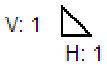
GVF Output Data		
Upstream Depth	0.00	ft
Profile Description	N/A	
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.0	%
Normal Depth Over Rise	17.9	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.27	ft
Critical Depth	0.55	ft
Channel Slope	12.300	%
Critical Slope	0.750	%

Cross Section for SD9 Section 9

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.016
Channel Slope	12.300 %
Normal Depth	0.27 ft
Diameter	18.0 in
Discharge	2.10 cfs





SD10 Section 10

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.016
Channel Slope	13.200 %
Diameter	18.0 in
Discharge	1.00 cfs

Results	
Normal Depth	0.18 ft
Flow Area	0.1 ft²
Wetted Perimeter	1.07 ft
Hydraulic Radius	0.12 ft
Top Width	0.99 ft
Critical Depth	0.37 ft
Percent Full	12.3 %
Critical Slope	0.746 %
Velocity	8.04 ft/s
Velocity Head	1.00 ft
Specific Energy	1.19 ft
Froude Number	3.987
Maximum Discharge	33.35 cfs
Discharge Full	31.01 cfs
Slope Full	0.014 %
Flow Type	Supercritical

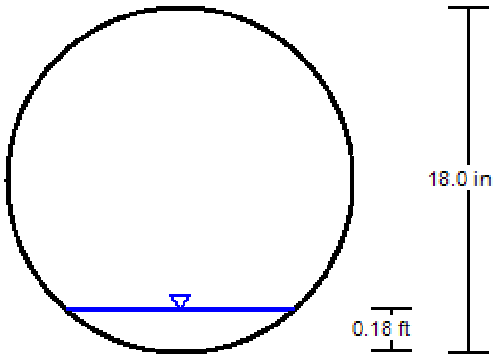
GVF Input Data	
Downstream Depth	0.00 ft
Length	0.00 ft
Number Of Steps	0

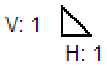
GVF Output Data	
Upstream Depth	0.00 ft
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	12.3 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.18 ft
Critical Depth	0.37 ft
Channel Slope	13.200 %
Critical Slope	0.746 %

Cross Section for SD10 Section 10

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.016
Channel Slope	13.200 %
Normal Depth	0.18 ft
Diameter	18.0 in
Discharge	1.00 cfs





SD11 Section 11

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data		
Roughness Coefficient	0.016	
Channel Slope	0.640	%
Diameter	18.0	in
Discharge	1.30	cfs

Results		
Normal Depth	0.44	ft
Flow Area	0.4	ft^2
Wetted Perimeter	1.72	ft
Hydraulic Radius	0.25	ft
Top Width	1.37	ft
Critical Depth	0.43	ft
Percent Full	29.6	%
Critical Slope	0.742	%
Velocity	2.97	ft/s
Velocity Head	0.14	ft
Specific Energy	0.58	ft
Froude Number	0.928	
Maximum Discharge	7.34	cfs
Discharge Full	6.83	cfs
Slope Full	0.023	%
Flow Type	Subcritical	

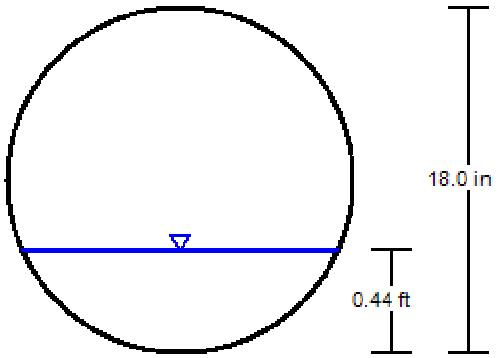
GVF Input Data		
Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

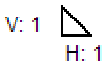
GVF Output Data		
Upstream Depth	0.00	ft
Profile Description	N/A	
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.0	%
Normal Depth Over Rise	14.0	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.44	ft
Critical Depth	0.43	ft
Channel Slope	0.640	%
Critical Slope	0.742	%

Cross Section for SD11 Section 11

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.016
Channel Slope	0.640 %
Normal Depth	0.44 ft
Diameter	18.0 in
Discharge	1.30 cfs





APPENDIX C: HYDROLOGIC COMPUTATIONS

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JUN  1998                *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   11NOV19  TIME  11:27:29   *
*                                       *
*****************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
*   HYDROLOGIC ENGINEERING CENTER   *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*          (916) 756-1104           *
*                                   *
*************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X              X
XXXXXXX  XXXX     X        XXXXX  X
X     X  X        X              X
X     X  X        X     X        X
X     X  XXXXXXX   XXXXX         XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.....1.......2.......3.......4.......5.......6.......7.......8.......9......10

              *DIAGRAM
    1         ID
    2         ID      <><><><><><><><><><><><><><><><><><><><><><><><>
    3         ID        SIENNA CANYON AT WEBB HILL
    4         ID        HYDROLOGIC MODEL
    5         ID        ----------------------------
    6         ID
    7         ID        PRE AND POST DEVELOPMENT
    8         ID        10 AND 100-YR STORM EVENT
    9         ID        TYPE II DISTRICTUBTION
   10         ID
   11         ID        ----------------------------
   12         ID        HORROCKS ENGINEERING
   13         ID        PRE-DEVELOPED CONDITION
   14         ID        FILE: Sienna_Pre_Post.DAT
   15         ID        PROJECT No: UT-1570-1901
   16         ID        DATE:  NOV 2019
   17         ID      <><><><><><><><><><><><><><><><><><><><><><><><>
   18         ID
   19         ID       ---> 24-HOUR / TYPE II <---
   20         ID
   21         IT        5       0       0     330
   22         IO        5
   23         IN       30
   24         JR     PREC    0.68    1.00
              *
   25         KK    PRE-1
   26         BA    .0662
   27         PB     2.31
   28         PC     .000    .005    .011    .016    .022    .028    .035    .041    .048    .055
   29         PC     .063    .071    .079    .088    .098    .108    .120    .132    .146    .162
   30         PC     .181    .204    .235    .283    .664    .735    .773    .800    .820    .839
   31         PC     .855    .868    .881    .892    .902    .912    .921    .929    .937    .945
   32         PC     .952    .959    .965    .972    .978    .984    .989    .995   1.000
   33         LS        0      86
   34         UD     .132
              *
   35         KK    PRE-2
   36         BA    .0647
   37         LS        0      86
   38         UD    0.137
              *
   39         KK    PRE-3
   40         BA    .0121
   41         LS        0      86
   42         UD     .053
              *
   43         ZZ
```

1 SCHEMATIC DIAGRAM OF STREAM NETWORK

```
 INPUT
  LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

   NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

    25       PRE-1
                .
                .
    35          .       PRE-2
                .          .
                .          .
    39          .          .       PRE-3

  (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*               JUN   1998              *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   11NOV19  TIME  11:27:29   *
*                                       *
*****************************************

*************************************
*                                   *
*    U.S. ARMY CORPS OF ENGINEERS   *
*    HYDROLOGIC ENGINEERING CENTER  *
*          609 SECOND STREET        *
*       DAVIS, CALIFORNIA 95616     *
*           (916) 756-1104          *
*                                   *
*************************************

                          <><><><><><><><><><><><><><><><><><><><>
                            SIENNA CANYON AT WEBB HILL
                            HYDROLOGIC MODEL
                            ---------------------------

                            PRE AND POST DEVELOPMENT
                            10 AND 100-YR STORM EVENT
                            TYPE II DISTRICTUBTION

                            ---------------------------
                            HORROCKS ENGINEERING
                            PRE-DEVELOPED CONDITION
                            FILE: Sienna_Pre_Post.DAT
                            PROJECT No: UT-1570-1901
                            DATE:  NOV 2019
                          <><><><><><><><><><><><><><><><><><><><>

                           ---> 24-HOUR / TYPE II <---

   22 IO          OUTPUT CONTROL VARIABLES
                       IPRNT          5  PRINT CONTROL
                       IPLOT          0  PLOT CONTROL
                       QSCAL          0.  HYDROGRAPH PLOT SCALE

      IT          HYDROGRAPH TIME DATA
                        NMIN          5  MINUTES IN COMPUTATION INTERVAL
                       IDATE      1   0  STARTING DATE
                       ITIME       0000  STARTING TIME
                          NQ        330  NUMBER OF HYDROGRAPH ORDINATES
                      NDDATE      2   0  ENDING DATE
                      NDTIME       0325  ENDING TIME
                       ICENT         19  CENTURY MARK

                    COMPUTATION INTERVAL     .08 HOURS
                         TOTAL TIME BASE   27.42 HOURS

           ENGLISH UNITS
                DRAINAGE AREA         SQUARE MILES
                PRECIPITATION DEPTH   INCHES
                LENGTH, ELEVATION     FEET
                FLOW                  CUBIC FEET PER SECOND
                STORAGE VOLUME        ACRE-FEET
                SURFACE AREA          ACRES
                TEMPERATURE           DEGREES FAHRENHEIT

      JP          MULTI-PLAN OPTION
                       NPLAN          1  NUMBER OF PLANS

      JR          MULTI-RATIO OPTION
                     RATIOS OF PRECIPITATION
                     .68      1.00
1

                PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                              FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                          TIME TO PEAK IN HOURS


                                                                RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION      AREA     PLAN            RATIO 1  RATIO 2
                                                          .68     1.00
```

```
 HYDROGRAPH AT
+                 PRE-1       .07     1   FLOW          21.      43.
                                           TIME        12.00    12.00

 HYDROGRAPH AT
+                 PRE-2       .06     1   FLOW          20.      41.
                                           TIME        12.00    12.00

 HYDROGRAPH AT
+                 PRE-3       .01     1   FLOW           4.       9.
                                           TIME        12.00    12.00


 *** NORMAL END OF HEC-1 ***
```

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*             JUN  1998                 *
*           VERSION 4.1                 *
*                                       *
*  RUN DATE   12NOV19  TIME  12:11:52   *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*    HYDROLOGIC ENGINEERING CENTER      *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*           (916) 756-1104              *
*                                       *
*****************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X              X
XXXXXXX  XXXX     X        XXXXX  X
X     X  X        X              X
X     X  X        X     X        X
X     X  XXXXXXX   XXXXX         XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


```
LINE      ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

          *DIAGRAM
    1     ID
    2     ID      <><><><><><><><><><><><><><><><><><><><>
    3     ID        SIENNA CANYON AT WEBB HILL
    4     ID        HYDROLOGIC MODEL
    5     ID        ---------------------------
    6     ID
    7     ID        PRE AND POST DEVELOPMENT
    8     ID        10 AND 100-YR STORM EVENT
    9     ID        TYPE II DISTRICTUBTION
   10     ID
   11     ID        ---------------------------
   12     ID        HORROCKS ENGINEERING
   13     ID        POST-DEVELOPED CONDITION
   14     ID        FILE: Sienna_Post.DAT
   15     ID        PROJECT No: UT-1570-1901
   16     ID        DATE:  NOV 2019
   17     ID      <><><><><><><><><><><><><><><><><><><><>
   18     ID
   19     ID       ---> 24-HOUR / TYPE II <---
   20     ID
   21     IT       5       0       0     660
   22     IO       5
   23     IN      30
   24     JR    PREC    0.68    1.00
          *

   25     KK  POST-3
   26     BA   .0121
   27     PB    2.31
   28     PC    .000    .005    .011    .016    .022    .028    .035    .041    .048    .055
   29     PC    .063    .071    .079    .088    .098    .108    .120    .132    .146    .162
   30     PC    .181    .204    .235    .283    .664    .735    .773    .800    .820    .839
   31     PC    .855    .868    .881    .892    .902    .912    .921    .929    .937    .945
   32     PC    .952    .959    .965    .972    .978    .984    .989    .995   1.000
   33     LS       0      88
   34     UD    .086
          *

   35     KK    DB-3
   36     KM   LOCAL DETNETION BASIN FOR DISCHARGE AT BASIN POST3
   37     RS       1
   38     SA     0.0    0.06    0.08    0.10    0.12
   39     SE      10   10.01      11      12      13
   40     SL      10    1.77    0.62     0.5
   41     SS   12.99      25       3     1.5
          *

   42     KK  POST2A
   43     BA   .0152
   44     LS       0      88
   45     UD   0.076
          *
```

```
LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

  46          KK   DB-2A
  47          KM   LOCAL DETNETION BASIN FOR DISCHARGE AT BASIN POST2A
  48          RS      1
  49          SA    0.0    0.11    0.13    0.15    0.17
  50          SE     10   10.01      11      12      13
  51          SL     10    1.77    0.62     0.5
  52          SS  12.99      25       3     1.5
              *
  53          KK  POST2B
  54          BA   .0133
  55          LS      0      88
  56          UD    .070
              *
  57          KK   OFF-2
  58          BA   .0168
  59          LS      0      86
  60          UD   .0106
              *
  61          KK    CD1
  62          KM   COMBINES POST2B AND OFF-2
  63          HC      2
              *
  64          KK   DB-2B
  65          KM   LOCAL DETNETION BASIN FOR DISCHARGE AT BASIN POST2B AND OFF-2
  66          RS      1
  67          SA    0.0    0.04    0.05    0.07    0.08
  68          SE     10   10.01      11      12      13
  69          SL     10    3.14    0.62     0.5
  70          SS  12.99      25       3     1.5
              *
  71          KK   POST1
  72          BA   .0679
  73          LS      0      88
  74          UD    .121
              *
  75          KK   OFF-1
  76          BA   .0181
  77          LS      0      86
  78          UD    .053
              *
  79          KK    RTE1
  80          KM   ROUTE OFF-1 THROUGH ROAD SIDE DRAIN
  81          RD   1670    .005    .013           TRAP
              *
```



```
LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

  82          KK    CD2
  83          KM   COMBINES POST 1 AND OFF-1
  84          HC      2
              *
  85          KK    DB-1
  86          KM   LOCAL DETNETION BASIN FOR DISCHARGE AT BASIN POST1 AND OFF-1
  87          RS      1
  88          SA    0.0    0.55    0.57    0.64    0.69
  89          SE     10   10.01      11      12      13
  90          SL     10    4.91    0.62     0.5
  91          SS  12.99      25       3     1.5
              *
  92          ZZ
```

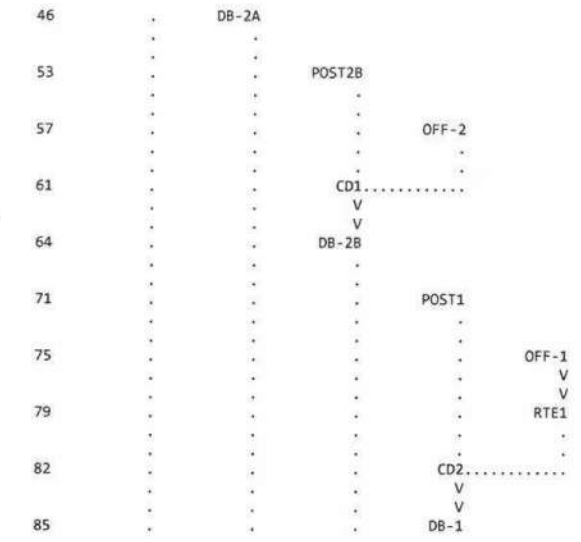
1

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
INPUT
 LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

  NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

   25      POST-3
             V
             V
   35       DB-3
              .
              .
   42         .      POST2A
              .         V
              .         V
```



(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*               JUN   1998              *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   12NOV19  TIME  12:11:52   *
*                                       *
*****************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
*   HYDROLOGIC ENGINEERING CENTER   *
*         609 SECOND STREET         *
*       DAVIS, CALIFORNIA 95616     *
*           (916) 756-1104          *
*                                   *
*************************************
```

```
<><><><><><><><><><><><><><><><><><><><><><><><>
  SIENNA CANYON AT WEBB HILL
  HYDROLOGIC MODEL
  ---------------------------

  PRE AND POST DEVELOPMENT
  10 AND 100-YR STORM EVENT
  TYPE II DISTRICTUBTION

  ---------------------------
  HORROCKS ENGINEERING
  POST-DEVELOPED CONDITION
  FILE: Sienna_Post.DAT
  PROJECT No: UT-1570-1901
  DATE:  NOV 2019
<><><><><><><><><><><><><><><><><><><><><><><><>

 ---> 24-HOUR / TYPE II <---
```

```
 22 IO          OUTPUT CONTROL VARIABLES
                     IPRNT          5  PRINT CONTROL
                     IPLOT          0  PLOT CONTROL
                     QSCAL         0.  HYDROGRAPH PLOT SCALE

    IT          HYDROGRAPH TIME DATA
                      NMIN          5  MINUTES IN COMPUTATION INTERVAL
                     IDATE      1    0  STARTING DATE
                     ITIME        0000  STARTING TIME
                        NQ         660  NUMBER OF HYDROGRAPH ORDINATES
                    NDDATE      3    0  ENDING DATE
                    NDTIME        0655  ENDING TIME
                     ICENT          19  CENTURY MARK

                  COMPUTATION INTERVAL      .08 HOURS
                      TOTAL TIME BASE   54.92 HOURS

        ENGLISH UNITS
             DRAINAGE AREA         SQUARE MILES
             PRECIPITATION DEPTH   INCHES
             LENGTH, ELEVATION     FEET
             FLOW                  CUBIC FEET PER SECOND
             STORAGE VOLUME        ACRE-FEET
             SURFACE AREA          ACRES
             TEMPERATURE           DEGREES FAHRENHEIT
```

```
      JP          MULTI-PLAN OPTION
                      NPLAN           1  NUMBER OF PLANS

      JR          MULTI-RATIO OPTION
                  RATIOS OF PRECIPITATION
                  .68      1.00
1

                PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                              FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                          TIME TO PEAK IN HOURS

                                                                  RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN                    RATIO 1  RATIO 2
                                                                .68     1.00

 HYDROGRAPH AT
+                 POST-3       .01     1   FLOW                  5.       9.
                                            TIME                12.00    12.00

 ROUTED TO
+                   DB-3       .01     1   FLOW                  4.       8.
                                            TIME                12.00    12.00

                                        ** PEAK STAGES IN FEET **
                                        1   STAGE               10.38    10.84
                                            TIME                12.00    12.00

 HYDROGRAPH AT
+                 POST2A       .02     1   FLOW                  6.      12.
                                            TIME                12.00    12.00

 ROUTED TO
+                  DB-2A       .02     1   FLOW                  5.       9.
                                            TIME                12.08    12.08

                                        ** PEAK STAGES IN FEET **
                                        1   STAGE               10.46    11.05
                                            TIME                12.08    12.08

 HYDROGRAPH AT
+                 POST2B       .01     1   FLOW                  6.      10.
                                            TIME                12.00    12.00

 HYDROGRAPH AT
+                  OFF-2       .02     1   FLOW                  6.      12.
                                            TIME                12.00    12.00

  2 COMBINED AT
+                    CD1       .03     1   FLOW                 12.      23.
                                            TIME                12.00    12.00

 ROUTED TO
+                   DB-2B      .03     1   FLOW                 11.      20.
                                            TIME                12.00    12.00

                                        ** PEAK STAGES IN FEET **
                                        1   STAGE               10.67    11.72
                                            TIME                12.00    12.00

 HYDROGRAPH AT
+                  POST1       .07     1   FLOW                 26.      50.
                                            TIME                12.00    12.00

 HYDROGRAPH AT
+                  OFF-1       .02     1   FLOW                  7.      13.
                                            TIME                12.00    12.00

 ROUTED TO
+                   RTE1       .02     1   FLOW                  6.      12.
                                            TIME                12.08    12.00

  2 COMBINED AT
+                    CD2       .09     1   FLOW                 32.      62.
                                            TIME                12.00    12.00

 ROUTED TO
+                   DB-1       .09     1   FLOW                 21.      34.
                                            TIME                12.17    12.17

                                        ** PEAK STAGES IN FEET **
                                        1   STAGE               10.87    11.99
                                            TIME                12.17    12.17
1
                                    SUMMARY OF KINEMATIC WAVE - MUSKINGUM-CUNGE ROUTING
                                        (FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)
                                                                                 INTERPOLATED TO
                                                                                COMPUTATION INTERVAL
          ISTAQ    ELEMENT      DT       PEAK    TIME TO      VOLUME      DT       PEAK    TIME TO     VOLUME
                                                    PEAK                                      PEAK
```

		(MIN)	(CFS)	(MIN)	(IN)	(MIN)	(CFS)	(MIN)	(IN)
FOR PLAN = 1 RATIO= .00									
	RTE1 MANE	4.50	6.20	724.50	.54	5.00	6.03	725.00	.54

CONTINUITY SUMMARY (AC-FT) - INFLOW= .5227E+00 EXCESS= .0000E+00 OUTFLOW= .5228E+00 BASIN STORAGE= .5850E-03 PERCENT ERROR= -.1

		(MIN)	(CFS)	(MIN)	(IN)	(MIN)	(CFS)	(MIN)	(IN)
FOR PLAN = 1 RATIO= .00									
	RTE1 MANE	4.57	12.12	722.34	1.09	5.00	11.96	720.00	1.09

CONTINUITY SUMMARY (AC-FT) - INFLOW= .1051E+01 EXCESS= .0000E+00 OUTFLOW= .1052E+01 BASIN STORAGE= .7754E-03 PERCENT ERROR= -.1

*** NORMAL END OF HEC-1 ***

```
1*****************************************
 *                                       *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
 *              JUN  1998                *
 *            VERSION 4.1                *
 *                                       *
 *  RUN DATE   11NOV19  TIME  11:27:34   *
 *                                       *
 *****************************************
```

```
**************************************
*                                    *
*   U.S. ARMY CORPS OF ENGINEERS     *
*   HYDROLOGIC ENGINEERING CENTER    *
*        609 SECOND STREET           *
*      DAVIS, CALIFORNIA 95616       *
*          (916) 756-1104            *
*                                    *
**************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X              X
XXXXXXX  XXXX     X        XXXXX  X
X     X  X        X              X
X     X  X        X     X        X
X     X  XXXXXXX   XXXXX         XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

              *DIAGRAM
    1         ID
    2         ID      <><><><><><><><><><><><><><><><><><><><>
    3         ID        SIENNA CANYON AT WEBB HILL
    4         ID        HYDROLOGIC MODEL
    5         ID        ---------------------------
    6         ID
    7         ID        PRE AND POST DEVELOPMENT
    8         ID        10 AND 100-YR STORM EVENT
    9         ID        TYPE II DISTRICTUBTION
   10         ID
   11         ID        ---------------------------
   12         ID        HORROCKS ENGINEERING
   13         ID        PRE-DEVELOPED CONDITION
   14         ID        FILE: Sienna_Pre_Post.DAT
   15         ID        PROJECT No: UT-1570-1901
   16         ID        DATE:  NOV 2019
   17         ID      <><><><><><><><><><><><><><><><><><><><>
   18         ID
   19         ID       ---> 03-HOUR / Farmer-Fletcher <---
   20         ID
   21         IT       5       0       0      330
   22         IO       5
   23         IN       5
   24         JR    PREC    0.60    1.00
              *
   25         KK   PRE-1
   26         BA   .0662
   27         PB    1.64
   28         PC    .000    .003    .007    .010    .013    .016    .020    .282    .489    .634
   29         PC    .726    .781    .824    .855    .879    .897    .914    .929    .941    .944
   30         PC    .947    .951    .954    .957    .960    .964    .967    .970    .974    .977
   31         PC    .980    .984    .987    .990    .993    .997   1.000
   32         LS       0      86
   33         UD    .132
              *
   34         KK   PRE-2
   35         BA   .0647
   36         LS       0      86
   37         UD  0.137
              *
   38         KK   PRE-3
   39         BA   .0121
   40         LS       0      86
   41         UD    .053
              *
   42         ZZ
```

1 SCHEMATIC DIAGRAM OF STREAM NETWORK

INPUT

```
 LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

  NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

   25       PRE-1
                .
                .
   34           .       PRE-2
                .          .
                .          .
   38           .          .       PRE-3

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*               JUN  1998              *
*            VERSION 4.1               *
*                                      *
*  RUN DATE   11NOV19  TIME  11:27:34  *
*                                      *
****************************************

                                                  ************************************
                                                  *                                  *
                                                  *   U.S. ARMY CORPS OF ENGINEERS   *
                                                  *   HYDROLOGIC ENGINEERING CENTER  *
                                                  *        609 SECOND STREET         *
                                                  *      DAVIS, CALIFORNIA 95616     *
                                                  *          (916) 756-1104          *
                                                  *                                  *
                                                  ************************************

                          <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
                           SIENNA CANYON AT WEBB HILL
                           HYDROLOGIC MODEL
                           ---------------------------

                           PRE AND POST DEVELOPMENT
                           10 AND 100-YR STORM EVENT
                           TYPE II DISTRICTUBTION

                           ---------------------------
                           HORROCKS ENGINEERING
                           PRE-DEVELOPED CONDITION
                           FILE: Sienna_Pre_Post.DAT
                           PROJECT No: UT-1570-1901
                           DATE:  NOV 2019
                          <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>

                           ---> 03-HOUR / Farmer-Fletcher <---

  22 IO          OUTPUT CONTROL VARIABLES
                      IPRNT          5  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE

     IT          HYDROGRAPH TIME DATA
                      NMIN          5  MINUTES IN COMPUTATION INTERVAL
                     IDATE      1    0  STARTING DATE
                     ITIME        0000  STARTING TIME
                        NQ          33  NUMBER OF HYDROGRAPH ORDINATES
                    NDDATE      1    0  ENDING DATE
                    NDTIME        0240  ENDING TIME
                    ICENT          19  CENTURY MARK

                  COMPUTATION INTERVAL     .08 HOURS
                      TOTAL TIME BASE    2.67 HOURS

          ENGLISH UNITS
               DRAINAGE AREA         SQUARE MILES
               PRECIPITATION DEPTH   INCHES
               LENGTH, ELEVATION     FEET
               FLOW                  CUBIC FEET PER SECOND
               STORAGE VOLUME        ACRE-FEET
               SURFACE AREA          ACRES
               TEMPERATURE           DEGREES FAHRENHEIT

     JP          MULTI-PLAN OPTION
                      NPLAN          1  NUMBER OF PLANS

     JR          MULTI-RATIO OPTION
                     RATIOS OF PRECIPITATION
                     .60      1.00
1

               PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                          TIME TO PEAK IN HOURS


                                                                 RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN           RATIO 1  RATIO 2
                                                       .60     1.00
```

```
 HYDROGRAPH AT
+                PRE-1       .07     1   FLOW          13.      42.
                                         TIME          .92      .83

 HYDROGRAPH AT
+                PRE-2       .06     1   FLOW          12.      41.
                                         TIME          .92      .92

 HYDROGRAPH AT
+                PRE-3       .01     1   FLOW           3.       9.
                                         TIME          .83      .75


 *** NORMAL END OF HEC-1 ***
```

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JUN   1998               *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   11NOV19  TIME  16:32:07   *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*   U.S. ARMY CORPS OF ENGINEERS        *
*   HYDROLOGIC ENGINEERING CENTER       *
*         609 SECOND STREET             *
*       DAVIS, CALIFORNIA 95616         *
*           (916) 756-1104              *
*                                       *
*****************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X              X
XXXXXXX  XXXX     X        XXXXX  X
X     X  X        X              X
X     X  X        X     X        X
X     X  XXXXXXX   XXXXX         XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


```
LINE          ID.....1.......2.......3.......4.......5.......6.......7.......8.......9......10

              *DIAGRAM
    1         ID
    2         ID      <><><><><><><><><><><><><><><><><><><><>
    3         ID        SIENNA CANYON AT WEBB HILL
    4         ID        HYDROLOGIC MODEL
    5         ID        ----------------------------
    6         ID
    7         ID        PRE AND POST DEVELOPMENT
    8         ID        10 AND 100-YR STORM EVENT
    9         ID        TYPE II DISTRICTUBTION
   10         ID
   11         ID        ----------------------------
   12         ID        HORROCKS ENGINEERING
   13         ID        POST-DEVELOPED CONDITION
   14         ID        FILE: Sienna_Pre_Post.DAT
   15         ID        PROJECT No: UT-1570-1901
   16         ID        DATE:  NOV 2019
   17         ID      <><><><><><><><><><><><><><><><><><><><>
   18         ID
   19         ID       ---> 03-HOUR / Farmer-Fletcher <---
   20         ID
   21         IT       5       0       0      300
   22         IO       5
   23         IN       5
   24         JR    PREC    0.60    1.00
              *
   25         KK  POST-3
   26         BA   .0121
   27         PB    1.64
   28         PC    .000    .003    .007    .010    .013    .016    .020    .282    .489    .634
   29         PC    .726    .781    .824    .855    .879    .897    .914    .929    .941    .944
   30         PC    .947    .951    .954    .957    .960    .964    .967    .970    .974    .977
   31         PC    .980    .984    .987    .990    .993    .997   1.000
   32         LS       0      88
   33         UD    .086
              *
   34         KK    DB-3
   35         KM   LOCAL DETNETION BASIN FOR DISCHARGE AT BASIN POST3
   36         RS       1
   37         SA     0.0    0.06    0.08    0.10    0.12
   38         SE      10   10.01      11      12      13
   39         SL      10    1.77    0.62     0.5
   40         SS   12.99      25       3     1.5
              *
   41         KK  POST2A
   42         BA   .0152
   43         LS       0      88
   44         UD   0.076
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  45          KK   DB-2A
  46          KM   LOCAL DETNETION BASIN FOR DISCHARGE AT BASIN POST2A
  47          RS       1
  48          SA     0.0    0.11    0.13    0.15    0.17
  49          SE      10   10.01      11      12      13
  50          SL      10    1.77    0.62     0.5
  51          SS   12.99      25       3     1.5
              *

  52          KK  POST2B
  53          BA   .0133
  54          LS       0      88
  55          UD    .070
              *

  56          KK   OFF-2
  57          BA   .0168
  58          LS       0      86
  59          UD    .0106
              *

  60          KK     CD1
  61          KM   COMBINES POST2B AND OFF-2
  62          HC       2
              *

  63          KK   DB-2B
  64          KM   LOCAL DETNETION BASIN FOR DISCHARGE AT BASIN POST2B AND OFF-2
  65          RS       1
  66          SA     0.0    0.04    0.05    0.07    0.08
  67          SE      10   10.01      11      12      13
  68          SL      10    3.14    0.62     0.5
  69          SS   12.99      25       3     1.5
              *

  70          KK   POST1
  71          BA   .0679
  72          LS       0      88
  73          UD    .121
              *

  74          KK   OFF-1
  75          BA   .0181
  76          LS       0      86
  77          UD    .053
              *

  78          KK    RTE1
  79          KM   ROUTE OFF-1 THROUGH ROAD SIDE DRAIN
  80          RD    1670    .005    .013            TRAP
              *
1                                        HEC-1 INPUT                                    PAGE  3

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  81          KK     CD2
  82          KM   COMBINES POST 1 AND OFF-1
  83          HC       2
              *

  84          KK    DB-1
  85          KM   LOCAL DETNETION BASIN FOR DISCHARGE AT BASIN POST1 AND OFF-1
  86          RS       1
  87          SA     0.0    0.55    0.57    0.64    0.69
  88          SE      10   10.01      11      12      13
  89          SL      10    4.91    0.62     0.5
  90          SS   12.99      25       3     1.5
              *
  91          ZZ
1
          SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
  LINE    (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

   NO.    (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

    25    POST-3
            V
            V
    34     DB-3
            .
            .
    41      .      POST2A
            .         V
            .         V
    45      .       DB-2A
```

```
                .          .
                .          .
   52           .          .      POST2B
                .          .          .
                .          .          .
   56           .          .          .       OFF-2
                .          .          .          .
                .          .          .          .
   60           .          .        CD1.....     .
                .          .          V          .
                .          .          V          .
   63           .          .       DB-2B         .
                .          .          .          .
                .          .          .          .
   70           .          .          .       POST1
                .          .          .          .
                .          .          .          .
   74           .          .          .          .       OFF-1
                .          .          .          .         V
                .          .          .          .         V
   78           .          .          .          .        RTE1
                .          .          .          .          .
                .          .          .          .          .
   81           .          .          .        CD2.....     .
                .          .          .          V          .
                .          .          .          V          .
   84           .          .          .        DB-1
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JUN   1998               *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   11NOV19  TIME  16:32:07   *
*                                       *
*****************************************
```

```
*************************************
*                                   *
*    U.S. ARMY CORPS OF ENGINEERS   *
*    HYDROLOGIC ENGINEERING CENTER  *
*          609 SECOND STREET        *
*       DAVIS, CALIFORNIA 95616     *
*           (916) 756-1104          *
*                                   *
*************************************
```

```
                        <><><><><><><><><><><><><><><><><><><><>
                          SIENNA CANYON AT WEBB HILL
                          HYDROLOGIC MODEL
                          ---------------------------

                          PRE AND POST DEVELOPMENT
                          10 AND 100-YR STORM EVENT
                          TYPE II DISTRICTUBTION

                          ---------------------------
                          HORROCKS ENGINEERING
                          POST-DEVELOPED CONDITION
                          FILE: Sienna_Pre_Post.DAT
                          PROJECT No: UT-1570-1901
                          DATE:  NOV 2019
                        <><><><><><><><><><><><><><><><><><><><>

                         ---> 03-HOUR / Farmer-Fletcher <---

  22 IO         OUTPUT CONTROL VARIABLES
                      IPRNT          5  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE

    IT          HYDROGRAPH TIME DATA
                       NMIN          5  MINUTES IN COMPUTATION INTERVAL
                      IDATE      1    0  STARTING DATE
                      ITIME        0000  STARTING TIME
                         NQ          30  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE      1    0  ENDING DATE
                     NDTIME        0225  ENDING TIME
                     ICENT          19  CENTURY MARK

                  COMPUTATION INTERVAL      .08 HOURS
                      TOTAL TIME BASE    2.42 HOURS

        ENGLISH UNITS
             DRAINAGE AREA         SQUARE MILES
             PRECIPITATION DEPTH   INCHES
             LENGTH, ELEVATION     FEET
             FLOW                  CUBIC FEET PER SECOND
             STORAGE VOLUME        ACRE-FEET
             SURFACE AREA          ACRES
             TEMPERATURE           DEGREES FAHRENHEIT

    JP          MULTI-PLAN OPTION
```

NPLAN 1 NUMBER OF PLANS

JR MULTI-RATIO OPTION
RATIOS OF PRECIPITATION
.60 1.00
1

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES
TIME TO PEAK IN HOURS

OPERATION	STATION	AREA	PLAN		RATIOS APPLIED TO PRECIPITATION RATIO 1 .60	RATIO 2 1.00
HYDROGRAPH AT						
+	POST-3	.01	1	FLOW	4.	10.
				TIME	.83	.83
ROUTED TO						
+	DB-3	.01	1	FLOW	3.	9.
				TIME	.92	.92
			** PEAK STAGES IN FEET **			
			1	STAGE	10.25	10.95
				TIME	.92	.92
HYDROGRAPH AT						
+	POST2A	.02	1	FLOW	5.	13.
				TIME	.83	.75
ROUTED TO						
+	DB-2A	.02	1	FLOW	3.	9.
				TIME	1.00	.92
			** PEAK STAGES IN FEET **			
			1	STAGE	10.28	11.05
				TIME	1.00	.92
HYDROGRAPH AT						
+	POST2B	.01	1	FLOW	4.	12.
				TIME	.83	.75
HYDROGRAPH AT						
+	OFF-2	.02	1	FLOW	4.	14.
				TIME	.83	.75
2 COMBINED AT						
+	CD1	.03	1	FLOW	8.	26.
				TIME	.83	.75
ROUTED TO						
+	DB-2B	.03	1	FLOW	8.	22.
				TIME	.83	.83
			** PEAK STAGES IN FEET **			
			1	STAGE	10.43	11.97
				TIME	.83	.83
HYDROGRAPH AT						
+	POST1	.07	1	FLOW	18.	55.
				TIME	.92	.83
HYDROGRAPH AT						
+	OFF-1	.02	1	FLOW	4.	14.
				TIME	.83	.75
ROUTED TO						
+	RTE1	.02	1	FLOW	4.	14.
				TIME	.92	.83
2 COMBINED AT						
+	CD2	.09	1	FLOW	22.	69.
				TIME	.92	.83
ROUTED TO						
+	DB-1	.09	1	FLOW	14.	33.
				TIME	1.17	1.17
			** PEAK STAGES IN FEET **			
			1	STAGE	10.52	11.86
				TIME	1.17	1.17

1

SUMMARY OF KINEMATIC WAVE - MUSKINGUM-CUNGE ROUTING
(FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)

ISTAQ	ELEMENT	DT	PEAK	TIME TO PEAK	VOLUME	INTERPOLATED TO COMPUTATION INTERVAL DT	PEAK	TIME TO PEAK	VOLUME

```
                          (MIN)     (CFS)      (MIN)     (IN)     (MIN)     (CFS)     (MIN)       (IN)

          FOR PLAN = 1  RATIO=  .00
              RTE1  MANE          .75      4.10     54.75       .18      5.00      4.10     55.00         .18

CONTINUITY SUMMARY (AC-FT) - INFLOW= .1816E+00 EXCESS= .0000E+00 OUTFLOW= .1777E+00 BASIN STORAGE= .4513E-02 PERCENT ERROR=   -.3

          FOR PLAN = 1  RATIO=  .00
              RTE1  MANE          .75     14.07     49.50       .58      5.00     14.03     50.00         .57

CONTINUITY SUMMARY (AC-FT) - INFLOW= .5635E+00 EXCESS= .0000E+00 OUTFLOW= .5565E+00 BASIN STORAGE= .8689E-02 PERCENT ERROR=   -.3



*** NORMAL END OF HEC-1 ***
```

Basin Peak Flowrates Summary				
PRE-DEVELOPED CONDITION 24 HOUR EVENT				
Basin	**Area (acres)**	**Q_{10} (cfs)**	**Q_{100} (cfs)**	**Discharge location**
PRE-1	42.38	21	43	DB-1
PRE-2	41.40	12.2	25	DB-2B
		7.8	16	DB-2A
PRE-3	7.77	4	9	DB-3
PRE-DEVELOPED CONDITION 3 HOUR EVENT				
PRE-1	42.38	13	42	DB-1
PRE-2	41.40	7.3	25	DB-2B
		4.7	16	DB-2A
PRE-3	7.77	3	9	DB-3

Basin Peak Flowrates Summary			
POST-DEVELOPED CONDITION 24 HOUR EVENT			
Basin	**Area (acres)**	**Q_{10} (cfs)**	**Q_{100} (cfs)**
CD1[1]	-	12	23
CD2[2]	-	32	62
OFF-1	11.59	7	13
OFF-2	10.74	6	12
POST-1	43.45	26	50
POST-2A	8.48	6	12
POST-2B	9.70	6	10
POST-3	7.77	5	9

[1]CD1 = POST-2B + OFF-2

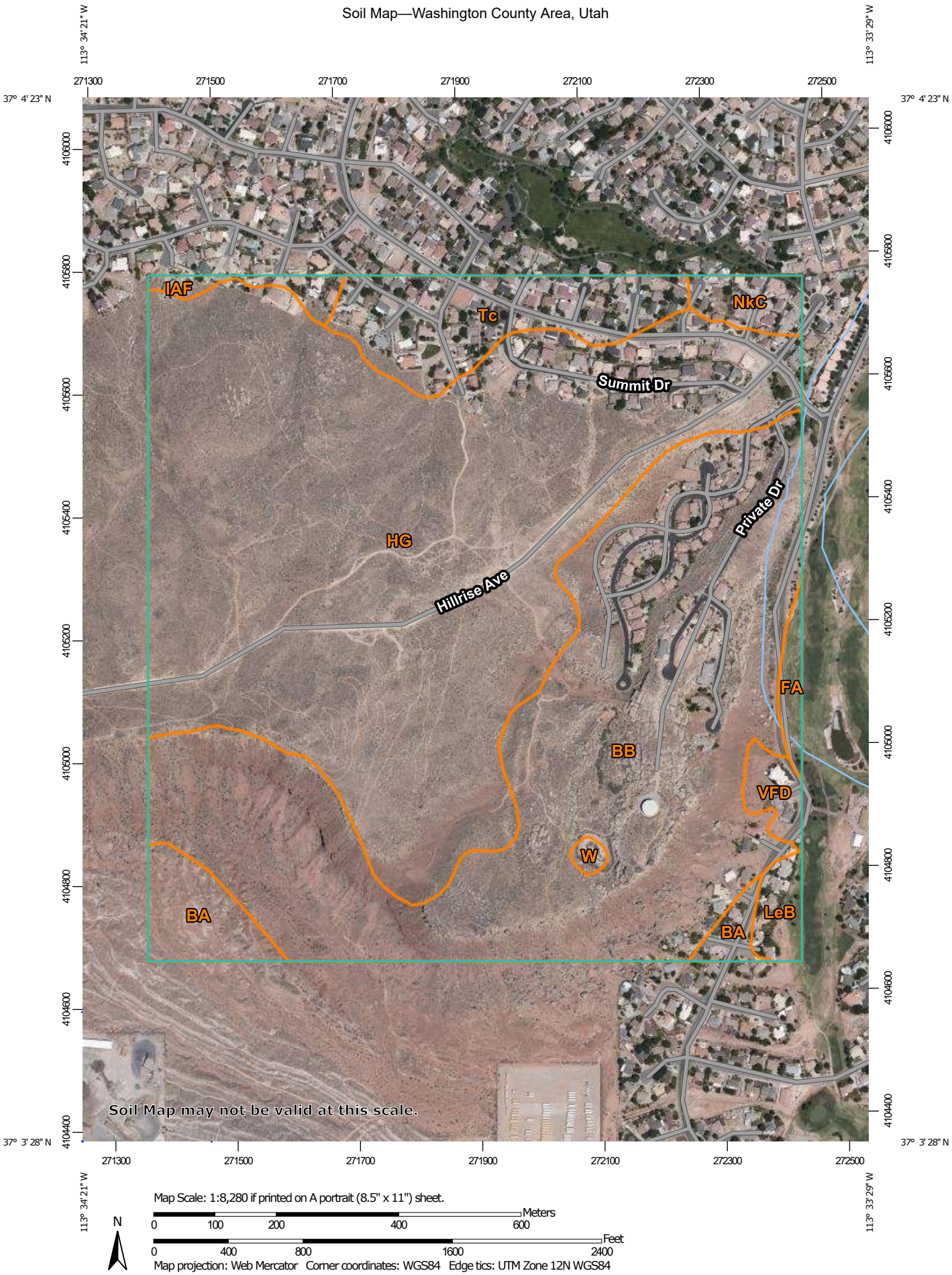
[2]CD2 = POST-1 + OFF-1

POST-DEVELOPED CONDITION 3 HOUR EVENT			
CD1	-	8	26
CD2	-	22	69
OFF-1	11.59	4	14
OFF-2	10.74	4	14
POST-1	43.45	18	55
POST-2A	8.48	5	13
POST-2B	9.70	4	12
POST-3	7.77	4	10

[1]CD1 = POST-2B + OFF-2

[2]CD2 = POST-1 + OFF-1

APPENDIX D: REFERENCES/RESOURCES


113° 34' 21" W
113° 33' 29" W
37° 4' 23" N
37° 3' 28" N
271300
271500
271700
271900
272100
272300
272500
4106000
4105800
4105600
4105400
4105200
4105000
4104800
4104600
4104400
IAF
Tc
NkC
Summit Dr
HG
Hillrise Ave
Private Dr
FA
BB
VFD
W
BA
LeB
BA
Soil Map may not be valid at this scale.
Map Scale: 1:8,280 if printed on A portrait (8.5" x 11") sheet.
N
Meters
0 100 200 400 600
Feet
0 400 800 1600 2400
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Washington County Area, Utah
Survey Area Data: Version 13, Sep 16, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 1, 2018—Aug 1, 2018

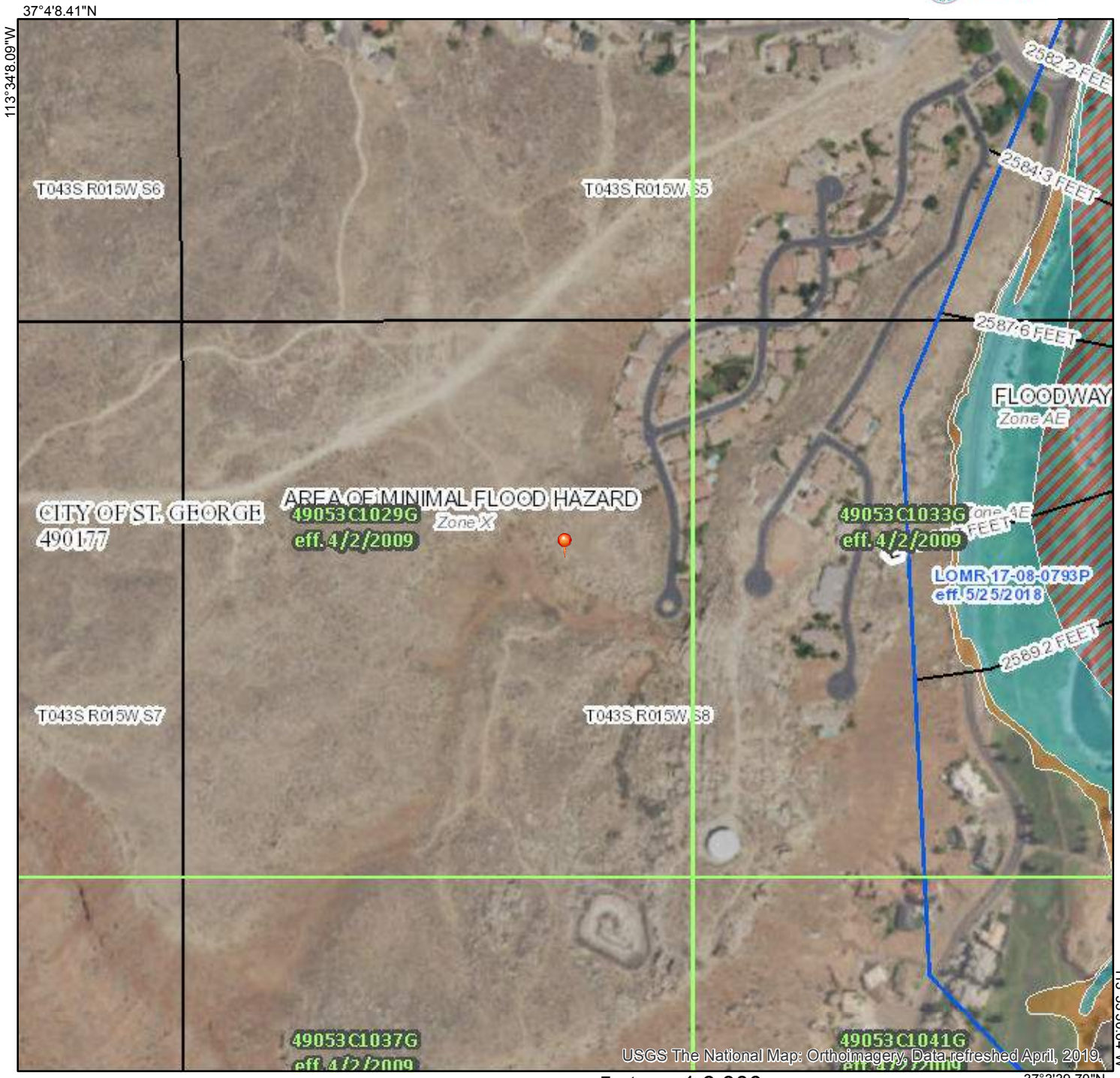
The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BA	Badland	8.8	3.0%
BB	Badland, very steep	108.7	36.7%
FA	Fluvaquents and torrifluvents, sandy	2.1	0.7%
HG	Hobog-Rock land association	146.4	49.5%
IAF	Isom cobbly sandy loam, 3 to 30 percent slopes	2.4	0.8%
LeB	Leeds silty clay loam, 1 to 2 percent slopes	3.0	1.0%
NkC	Nikey sandy loam, 1 to 3 percent slopes	3.8	1.3%
Tc	Tobler fine sandy loam	17.3	5.9%
VFD	Vekol sandy loam, 2 to 10 percent slopes	2.8	0.9%
W	Water	0.6	0.2%
Totals for Area of Interest		**295.9**	**100.0%**

National Flood Hazard Layer FIRMette

FEMA



Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 10/30/2019 at 5:05:31 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

NOAA Atlas 14, Volume 1, Version 5
Location name: Saint George, Utah, USA*
Latitude: 37.067°, Longitude: -113.5651°
Elevation: 2758.09 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.123** (0.106-0.144)	**0.158** (0.137-0.185)	**0.213** (0.184-0.249)	**0.262** (0.225-0.307)	**0.338** (0.285-0.394)	**0.404** (0.336-0.472)	**0.481** (0.390-0.565)	**0.566** (0.446-0.668)	**0.698** (0.529-0.839)	**0.812** (0.598-0.983)
10-min	**0.187** (0.161-0.219)	**0.240** (0.209-0.281)	**0.324** (0.279-0.378)	**0.399** (0.341-0.468)	**0.515** (0.434-0.600)	**0.615** (0.511-0.719)	**0.732** (0.594-0.860)	**0.862** (0.680-1.02)	**1.06** (0.805-1.28)	**1.24** (0.909-1.50)
15-min	**0.231** (0.200-0.271)	**0.297** (0.259-0.349)	**0.402** (0.346-0.469)	**0.494** (0.423-0.579)	**0.639** (0.538-0.744)	**0.763** (0.634-0.891)	**0.908** (0.736-1.07)	**1.07** (0.843-1.26)	**1.32** (0.998-1.58)	**1.53** (1.13-1.86)
30-min	**0.312** (0.269-0.365)	**0.401** (0.348-0.470)	**0.542** (0.467-0.632)	**0.666** (0.570-0.780)	**0.860** (0.725-1.00)	**1.03** (0.853-1.20)	**1.22** (0.991-1.44)	**1.44** (1.14-1.70)	**1.77** (1.34-2.13)	**2.06** (1.52-2.50)
60-min	**0.386** (0.333-0.452)	**0.496** (0.431-0.582)	**0.670** (0.578-0.782)	**0.824** (0.706-0.966)	**1.06** (0.897-1.24)	**1.27** (1.06-1.49)	**1.51** (1.23-1.78)	**1.78** (1.41-2.10)	**2.19** (1.66-2.64)	**2.55** (1.88-3.09)
2-hr	**0.468** (0.414-0.537)	**0.582** (0.517-0.671)	**0.761** (0.674-0.872)	**0.920** (0.809-1.06)	**1.17** (1.01-1.33)	**1.37** (1.17-1.57)	**1.61** (1.34-1.85)	**1.87** (1.52-2.18)	**2.27** (1.78-2.68)	**2.62** (1.99-3.12)
3-hr	**0.519** (0.464-0.587)	**0.646** (0.581-0.735)	**0.830** (0.745-0.942)	**0.987** (0.880-1.11)	**1.22** (1.08-1.38)	**1.42** (1.23-1.61)	**1.64** (1.39-1.87)	**1.88** (1.57-2.20)	**2.29** (1.83-2.71)	**2.64** (2.06-3.15)
6-hr	**0.644** (0.579-0.724)	**0.805** (0.729-0.907)	**1.02** (0.922-1.15)	**1.21** (1.08-1.36)	**1.47** (1.30-1.65)	**1.69** (1.47-1.91)	**1.93** (1.65-2.19)	**2.19** (1.84-2.52)	**2.59** (2.11-3.03)	**2.93** (2.33-3.46)
12-hr	**0.771** (0.699-0.858)	**0.968** (0.874-1.08)	**1.22** (1.09-1.35)	**1.42** (1.27-1.58)	**1.70** (1.51-1.89)	**1.91** (1.68-2.14)	**2.14** (1.86-2.41)	**2.38** (2.04-2.70)	**2.71** (2.27-3.11)	**3.00** (2.47-3.49)
24-hr	**0.874** (0.813-0.935)	**1.09** (1.02-1.17)	**1.36** (1.27-1.45)	**1.57** (1.47-1.67)	**1.86** (1.73-1.98)	**2.08** (1.93-2.22)	**2.31** (2.13-2.46)	**2.54** (2.33-2.72)	**2.84** (2.58-3.14)	**3.08** (2.78-3.52)
2-day	**0.946** (0.893-1.01)	**1.18** (1.11-1.26)	**1.46** (1.38-1.55)	**1.68** (1.59-1.78)	**1.98** (1.86-2.10)	**2.20** (2.07-2.34)	**2.43** (2.27-2.58)	**2.66** (2.47-2.83)	**2.96** (2.73-3.18)	**3.19** (2.92-3.56)
3-day	**1.00** (0.947-1.06)	**1.25** (1.18-1.32)	**1.54** (1.46-1.63)	**1.77** (1.67-1.86)	**2.07** (1.96-2.18)	**2.31** (2.17-2.43)	**2.54** (2.38-2.68)	**2.78** (2.59-2.93)	**3.08** (2.86-3.28)	**3.32** (3.05-3.60)
4-day	**1.06** (1.00-1.12)	**1.31** (1.24-1.39)	**1.62** (1.53-1.70)	**1.85** (1.76-1.94)	**2.17** (2.06-2.26)	**2.41** (2.28-2.52)	**2.65** (2.50-2.78)	**2.89** (2.71-3.03)	**3.20** (2.98-3.38)	**3.44** (3.18-3.64)
7-day	**1.20** (1.13-1.27)	**1.48** (1.40-1.57)	**1.82** (1.73-1.92)	**2.08** (1.97-2.18)	**2.41** (2.29-2.53)	**2.66** (2.52-2.78)	**2.90** (2.74-3.03)	**3.13** (2.95-3.28)	**3.42** (3.22-3.60)	**3.62** (3.39-3.82)
10-day	**1.32** (1.24-1.40)	**1.64** (1.55-1.75)	**2.02** (1.92-2.14)	**2.31** (2.19-2.44)	**2.69** (2.55-2.83)	**2.97** (2.81-3.12)	**3.24** (3.05-3.41)	**3.49** (3.29-3.69)	**3.82** (3.58-4.04)	**4.05** (3.78-4.30)
20-day	**1.63** (1.53-1.73)	**2.03** (1.91-2.16)	**2.48** (2.35-2.64)	**2.81** (2.66-2.97)	**3.22** (3.04-3.39)	**3.49** (3.30-3.69)	**3.75** (3.54-3.96)	**3.99** (3.75-4.21)	**4.26** (4.00-4.51)	**4.42** (4.16-4.69)
30-day	**1.92** (1.80-2.05)	**2.39** (2.25-2.54)	**2.93** (2.76-3.11)	**3.32** (3.13-3.51)	**3.81** (3.59-4.02)	**4.14** (3.90-4.37)	**4.46** (4.20-4.71)	**4.75** (4.46-5.03)	**5.09** (4.77-5.39)	**5.32** (4.97-5.65)
45-day	**2.30** (2.14-2.46)	**2.86** (2.67-3.07)	**3.53** (3.31-3.76)	**4.01** (3.76-4.26)	**4.60** (4.32-4.87)	**5.02** (4.71-5.30)	**5.40** (5.07-5.71)	**5.74** (5.39-6.08)	**6.12** (5.76-6.48)	**6.34** (5.98-6.73)
60-day	**2.59** (2.41-2.77)	**3.23** (3.01-3.46)	**3.97** (3.70-4.24)	**4.51** (4.21-4.80)	**5.18** (4.83-5.50)	**5.64** (5.26-5.99)	**6.07** (5.66-6.45)	**6.45** (6.01-6.86)	**6.89** (6.42-7.35)	**7.15** (6.66-7.65)

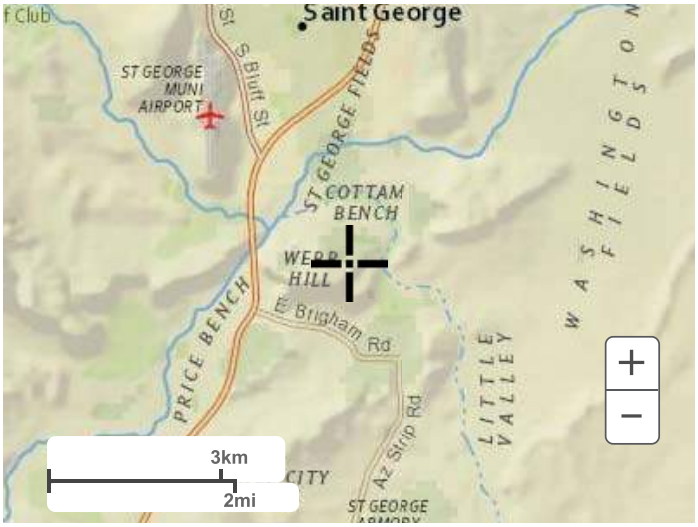
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

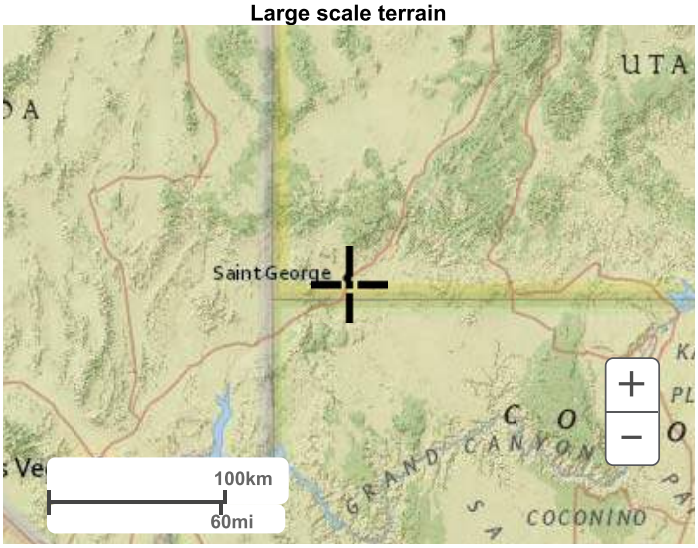
Please refer to NOAA Atlas 14 document for more information.

Back to Top

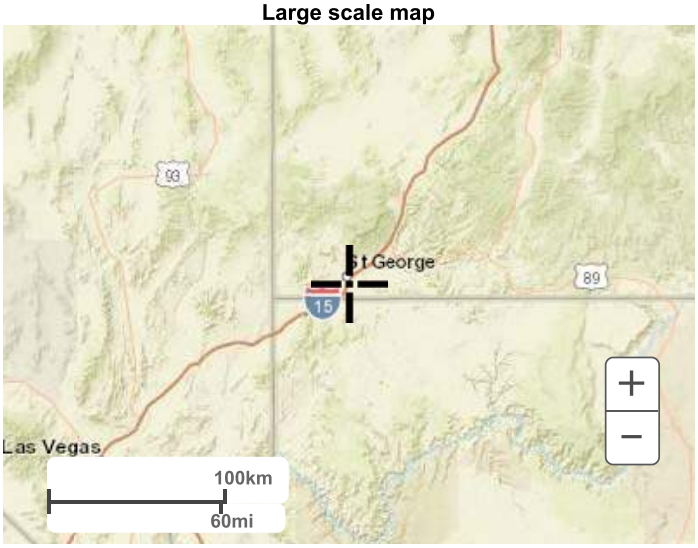
PF graphical



Large scale terrain



Large scale map



Large scale aerial

Geotechnical Report

AGEC

Applied GeoTech

GEOTECHNICAL INVESTIGATION
& HILLSIDE EVALUATION
SUMMIT ESTATES

ST. GEORGE, UTAH

PREPARED FOR:

V.E. MANAGEMENT
1240 EAST 100 SOUTH #12
S. GEORGE, UTAH 84790

ATTENTION: JOBE VENUTI

PROJECT NO. 2182014

OCTOBER 23, 2019

1420 South 270 East • St. George, Utah 84790 • (435) 673-6850 • FAX (435) 673-1044

SUMMARY

1. AGEC has conducted a Geologic Hillside Evaluation and a preliminary geotechnical study for the property shown on Figures 1 and 2. The study included a geologic review of available literature, a site reconnaissance, field exploration of the subsurface conditions, and preparation of this report.

2. The study has concluded the following:

    a. The geologic hazards identified as a potential risk and were evaluated include:

        - Expansive Soil/Rock
        - Hard Rock

    b. Of lesser concern, the following items were identified through literature review and further evaluated during the site study and exploration:

        - Drainage or Erosion (civil engineer will provide a drainage study and plan)
        - Rock Fall (site has a low rock fall concern)
        - Landslide

    c. AGEC observed the drilling of 11 borings at the approximate locations shown on Figure 2.

3. The proposed development will be a single family residential development with relatively large lots. The development will include grading and development of roadways and individual lots will be graded during construction of the residences. The proposed grading for the roadways is shown on Figure 2A. Cuts and fills are anticipated to be less than 10 feet with the majority of cuts and fill less than 5 feet.

4. The bedrock on the site varies from shale from the Upper Red Member of the Moenkopi Formation to siltstone and sandstone from the Shinarump Member of the Chinle Formation. The shale and siltstone were found to have zones that were slightly plastic and may exhibit low expansion characteristics. Due to the slight potential, we recommend each lot be evaluated on an individual basis. The geologic map and hazard maps are shown on Figures 3, 3A, 3B, 3C and 3D. The boring logs are shown on Figures 4 and 5 with the legend shown on Figure 6. Photos of the core samples from the borings are shown in Appendix A.

5. Groundwater was not encountered in the borings drilled to the maximum depth investigated approximately 24 feet. Fluctuations in groundwater may occur over time. An evaluation of such fluctuations was beyond the scope of this report. Springs or seepages were not observed on the site. We do not anticipate excavations or grading will expose groundwater concerns.

6. The topography of the site consists of a moderately sloping hillside with a ridge along the south and northeast portions of the site. Rock fall was not found to affect the lots on this site. During the grading of the roadway along the north end of the site, care should be taken to avoid creating rock fall on the development below the site.

7. Slopes should be graded along the roadways within the fill zone no steeper than 2:1 (Horizontal:Vertical). Cut slopes in the bedrock may be graded as steep as ½:1.

8. We anticipate that the proposed residences may be supported on conventional spread footings bearing on bedrock or properly compacted structural fill. Each lot should be verified with additional exploration prior to design and construction.

9. Grading recommendations for site grading and roadway/public improvements are included in the report.

10. We anticipate that portions of the bedrock will require blasting and heavy duty excavation equipment. Portions of the sandstone rock are anticipated to be suitable for use for rock stacked walls, rip rap or processed for granular fill.

SCOPE

This report presents the results of a geotechnical investigation and hillside evaluation for the proposed Summit Estates subdivision to be located in St. George, Utah, as shown in Figure 1. This report presents the subsurface conditions encountered and recommendations for the project.

Field exploration was conducted to obtain information on the subsurface conditions and to obtain samples for laboratory testing. Information obtained from the field and laboratory was used to define conditions at the site and to develop recommendations for the proposed development. The laboratory testing is currently in progress and will be used to assist in individual lot evaluation.

This report has been prepared to summarize the data obtained during the study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. The report has been prepared to provide a geologic hazard and preliminary design. Grading recommendations for the development including public improvements are included within the report.

SITE CONDITIONS

The subject site is south of the Bloomington Hill North Residential Development and southwest of the Sienna Canyon Development in St. George, Utah as shown on Figure 1. The majority of the site is covered with sparse vegetation consisting of desert brush and weeds. Bedrock is exposed through the majority of the property. The site slopes down moderately from the south to the north with a rim along the center of the site and a bowl or valley area within the eastern portion of the site. This area slopes down generally to the north and northeast. There is vacant property to the west with a water tank at the top of the ridge/hillside to the southwest. The Sienna Canyon development is located adjacent and generally below the property to the east along the northern portion of the site. There is an additional water tank and pond adjacent to the east to southeast portion of the site. At the

south end of the property is the crest of the hillside and a steep slope down towards the adjacent the property to the south.

FIELD STUDY

On January 10,11 and 14, 2019 an engineer from AGEC visited the site and observed the drilling of 11 borings. The location of the explorations are shown on Figure 2. The borings were drilled utilizing a truck mount drilled rig equipped with 8-inch hollow stem augers. The borings were advanced into bedrock using a 2½ inch HQ core barrel with a diamond bit using compressed air to remove cuttings. The subsurface soil profile was logged and soil samples were obtained at this time for laboratory testing. Continuous samples were obtained during coring.

GEOLOGIC AND SEISMOTECTONIC SETTING

A. Regional Geology

This area is part of the St. George Basin which is bound on the north by the Pine Valley Mountains, on the east by the Hurricane Cliffs, on the west by the Beaver Dam Mountains, and on the south by the Mount Trumball area.

Bedrock in the St. George basin mainly consists of Upper Permian and Lower Jurassic sandstone, shale, siltstone, limestone, gypsum, and conglomerate. These beds are folded to the southeast into the northeast trending Virgin anticline. Several north-trending faults are present within the St. George Basin, the most prominent of which is the Washington Fault (Christensen and Deen, 1983).

The St. George Basin is characterized by basalt capped buttes and cuestas that were once stream channels along which lava flowed. Erosion of the surrounding softer sedimentary rocks over time has resulted in an inverted topography of old stream channel becoming resistant basalt ridges such as the Middleton Black Ridge and the West Black Ridge (Christenson and Deen, 1983).

The geologic structure within the basin is dominated by the Virgin anticline which trends northeast south and east of the site. The Virgin anticline is a broad, generally symmetrical fold with maximum flank dips of 25 to 30 degrees to the northwest and southeast (Christenson and Deen, 1983).

The geologic conditions at the site were evaluated based on a review of geologic literature, test pit exploration and a reconnaissance of the site. Figure 3 indicates the most recent geologic mapping for the site.

B. Tectonic Setting

The site is located on the north side of the flank of the Virgin River Anticline as shown on Figure 3 (Higgins and Willis, 2011). Several north/south trending faults can be found in the vicinity, including the Washington Fault and the Hurricane Fault. Also, the St. George Fault is located north and east of the property.

The Washington Fault is located approximately 4.4 miles west of the site. The sense of displacement on this high angle normal fault is down to the west (Higgins, 1998). The Washington Fault is thought to bifurcate into several smaller faults creating a wide fault zone north of the city of Washington (Christenson and Deen, 1983; Willis and Higgins, 1995). The Washington Fault is considered to be active due to evidence for late Quaternary offset of both the Washington basalt flow and late Pleistocene sediments (Willis and Higgins, 1995; Higgins, 1998).

The Hurricane Fault is located approximately 14 miles east of the site. The sense of displacement on this high angle normal fault is down to the west (Biek, 2003b). The Hurricane Fault is considered to be active due to evidence for displacement of Quaternary basaltic flows, fault scarps in alluvium, as well as recent seismic activity, including the 1992 St. George earthquake (Christenson, 1995; Black et al., 2003; Biek, 2003a).

Based on previous work by Christenson and Deen (1983), Lund and others (2008), the mapped location of the St. George fault extends in a north-south direction approximately ½ mile to the east of the property. Based on previous conversations with Lund and others, the St. George Fault is not considered and active fault.

C. Stratigraphy

The stratigraphy of the area consists of Jurassic-aged bedrock of the Chinle and Moenkopi Formations. Quaternary-aged alluvial deposit cover the gently sloping area on the west (Figure 3).

Upper Red Member of the Moenkopi Formation ($T_R$mu) (Triassic aged): This bedrock consists of moderate reddish-brown, thin bedded siltstone and sandstone with some gypsum beds and abundant discordant gypsum stringers; locally contains a few thick to massive bedded, ledge forming, channel sandstones; 500 feet thick.

Shinarump Conglomerate Member of the Chile Formation ($T_R$cs) (Jurassic aged): This bedrock varies from grayish-orange to moderate-yellowish-brown, medium to course-grained sandstone with locally well-developed limonite bands to a moderate to dark-reddish-brown, chert pebble conglomerate. It forms a very resistant cuesta ledge; deposited in stream channels and locally has hummocky surface where involved in gravity slumping. It ranges from 50 to 200 feet thick.

The geologic conditions of the site and vicinity are shown on Figure 3.

GEOLOGIC HAZARDS

Based on review of geologic literature and site reconnaissance, the following hazards were reviewed as a part of the evaluation.

- Landslide Hazard (Figure 3A)
- Rockfall Hazard (Figure 3B)
- Expansive Soil and Rock Susceptibility (Figure 3C)
- Shallow Bedrock Susceptibility (Figure 3D)

AGEC has reviewed the Geologic Hazard Study for the St. George-Hurricane Metropolitan Area, Washington County, Utah, UGS Special Study 127, 2007 by Lund etal. Maps of the site that identify each of the items above are included as noted.

Based on our review of these maps and further site evaluation, the following geologic hazards were identified:

A. Expansive Soil/Bedrock

The presence of potentially low to moderate expansive layers of bedrock is identified by the geologic mapping hazard by Lund and others, 2008 as shown on Figure 3C. The expansive bedrock is mapped as Chinle Formation and the Moenkopi Formation. Our subsurface investigation (11 borings) and laboratory testing (in progress) by AGEC and our experience in the area also indicate that there is a potential for low expansion within the siltstone and shale bedrock within the area. We recommend that each lot be verified during the design and construction phases.

B. Shallow Bedrock

The majority of the site contains a moderate amount of hard sandstone bedrock. In addition, the shale bedrock was soft to moderately hard (see Figure 3D). The hard bedrock consists of sandstone and will likely result in the need for blasting. The recommendations for grading these materials is address in the grading section of this report.

There were several other hazards that the literature identified and were evaluated by AGEC and found not to be of concern. These include the Rockfall (Figure 3B), and the rockfall (Figure 3B, and the landslide (Figure 3A).

SUBSURFACE CONDITIONS

Following our geologic review, the site was evaluated by drilling 11 borings at the locations shown on Figure 2. The locations and elevations of the borings were measured by a hand held GPS and correlated to the existing topography map provided by Horrocks Engineering.

The subsurface conditions vary at the site with sandstone and siltstone along the majority of the site with a zone of shale bedrock through the center of the site.

Shale Bedrock: The shale bedrock was encountered within Borings B-6, B-7, B-9, B-10 and B-11. The shale is part of the Upper Red Member of the Moenkopi Formation and is low plastic, moderately weathered, dry to slightly moist and light brown to red in color.

Sandstone Bedrock: The sandstone bedrock was encountered through the majority of the property in the remaining borings. The sandstone is part of the Shinarump Member of the Chinle Formation and consists of fine to coarse/gravel material. Portions of the Shinarump consist of a conglomerate type material of highly cemented sand and gravel. The sandstone was generally slightly fractured and contains layers of siltstone. The sandstone is moderately hard to hard, dry and light brown to yellow in color.

Siltstone Bedrock: - The siltstone bedrock was encountered within the sandstone as layers or zones. The siltstone varied from non to low to medium plastic. The material is weathered, blocky and moderately hard. The bedrock is dry and grey with yellow streaks.

The Logs of Exploratory Borings are shown on Figures 4-5. The Legend and Notes of Exploratory Borings are shown on Figure 6.

PROPOSED CONSTRUCTION

The property is proposed to be developed into 43 lots varying in size as shown on Figure 2. The roadways will be graded as a part of the development and individual lots will be graded at the time of the residential construction. A cut and fill map for the roadways is shown on Figure 2A.

For design purposes, we have utilized a Traffic Indexes (TI) of 5 for the roadways according to St. George City Standards.

Details of proposed residences are not known at this time. Once those details are known, AGEC should be requested to provide detailed recommendations for the proposed construction.

RECOMMENDATIONS

Based on our experience in the area, the subsurface conditions encountered, our engineering analysis, the proposed construction, and the proposed grading provided by Horrocks Engineering the following recommendations are provided:

A. Site Grading

1. Subgrade Preparation

Prior to placing fill, the site should be grubbed to remove vegetation and soil containing roots and organics. Generally the surface is bedrock and the vegetation is sparse.

Prior to placing fill over bedrock, if soil exists, the soil should be scarified, moisture conditioned and properly compacted. In bedrock areas, the scarification process is not necessary.

2. Excavation/Slopes

Permanent cut slopes excavated into the bedrock may be cut as steep as ½ :1 (horizontal to vertical).

Fill slopes constructed with on-site granular soils should be constructed no steeper than 2:1. Fill slopes should be constructed by overbuilding the slope and then cutting back the slope face to the desired grade to provide a properly compacted slope face. Fill placed on existing slopes steeper than 3:1 should be keyed into the existing slope using a benching procedure. Benches should be of sufficient width to allow for operation of compaction equipment.

Water should be directed around slopes using drainage swales to reduce potential erosion in accordance with a site specific drainage plan. Soil slopes may also be protected from erosion with an appropriate geotextile or riprap underlain with filter fabric. More detailed recommendations for riprap erosion control can be provided if requested. A lot specific drainage study should be conducted on lots adjacent to the hillside.

Utility trenches excavated in the on-site soils should be excavated in accordance with OSHA requirements using a Soil Class A (½:1) for trenches excavated into the bedrock. Steeper trenches may require the use of shoring or a trench box to provide as safe work environment. Safe trench excavation is the responsibility of the contractor.

3. Materials

Import materials should be non-expansive, non-gypsiferous, granular soil. Listed below are the materials recommended for imported fill.

Area	Fill Type	Recommendations
Roadways	Site grading/ structural fill	**-200** <50%, **LL** <30% Maximum size: 4 inches Solubility < 1%
Roadways	Base course	CBR>50%, **200** <12% Maximum size: ¾ inch

-200 = Percent Passing the No. 200 Sieve
LL = Liquid Limit

The onsite bedrock may be used as site grading fill. It will require processing such that the maximum particle size is 4 inches and at least 60 percent of the material passes the No. 4 sieve. This may require crushing of the sandstone materials.

4. Compaction

Compaction of fill materials placed at the site should equal or exceed the following percentages when compared to the maximum dry density as determined by ASTM D-1557:

Area	Percent Compaction ASTM D-1557
Subgrade	90
Utility trench backfill (Structural Areas)	95

Fill should be placed in lifts which do not exceed the capability of the equipment used. Generally 6 to 8 inch lifts are adequate for heavy rubber tire equipment. Lift thicknesses should be reduced to 4 inches for hand compaction equipment. Fill placed at the site should be properly moisture conditioned prior to placement and should be tested to verify proper compaction. The fill should be moisture conditioned to within 2 percentage points of the optimum moisture content as determined by ASTM D-1557.

5. Drainage

The following drainage recommendations should be implemented:

- Positive site drainage should be maintained during the course of construction

B. Soil Corrosion

Our experience has shown that portions of the on-site soil/bedrock or imported soils may contain sulfates in sufficient concentration to be corrosive to concrete. Therefore, we recommend concrete elements that will be exposed to the on-site soils be designed in accordance with provisions provided in the American Concrete Institute Manual of Concrete Practice (ACI) 318-14. Tables 19.3.1.1 and 19.3.2.1 of ACI 318-14 should be referenced for design of concrete elements utilizing a Sulfate Exposure Class of S2.

Consideration should also be given to cathodic protection of buried metal pipes. We recommend utilizing PVC pipes where local building codes allow.

C. Pavement

Based on the subsoil conditions encountered and the laboratory test results, the following recommendations are given:

1. Analysis

Asphaltic Concrete: The flexible pavement analysis is based on UDOT and AASHTO design methods and a 20 year design life. The following parameters were considered for our analysis:

- Base course that meets specifications which would correspond to a Structural Coefficient (a_2) of at least 0.12. Asphalt that provides a Structural Coefficient (a_1) of at least 0.40.
- Drainage Coefficient = 1.0.
- The subgrade support soils will consist of processed sandstone, siltstone, and shale bedrock. A M_R value of 15,000 pounds per square inch (psi) was used for the subgrade based upon an estimated CBR value of 10 percent and the relationship between CBR and Resilient Modulus (M_R).
- Serviceability Index: $P_o = 4.2$, $P_t = 2.5$.
- Reliability of 90 percent.
- Standard Deviation (S_o) = 0.45.

2. Subgrade Support

We anticipate the subgrade materials will consist of compacted on-site bedrock or processed bedrock. Our design assumes a properly compacted subgrade. Prior to placing base course or pavement area grading fill, the subgrade should be prepared as recommended in the Subgrade Preparation section of this report.

3. Pavement Thickness

Based on the anticipated traffic, a 20 year design life, PCC and AASHTO design methods, the following pavement sections are recommended.

	Flexible Pavement	
Area	Asphaltic concrete (inches)	Base Course (inches)
Interior roadways	2½	6

4. Pavement Materials

The pavement materials should meet AASHTO and St. George City Specifications for gradation and quality. The pavement thicknesses indicated above assume that the base course is high quality material with a CBR of at least 60 percent. Asphalt material should have a Marshall stability of at least 1,800 pounds.

5. Drainage

The collection and diversion of drainage away from the pavement surface is extremely important to the satisfactory performance of the pavement section. Proper drainage should be provided. We further recommend a yearly maintenance program including crack sealing and a surface treatment such as a slurry seal to extend the pavement life and reduce water infiltration into the subsurface soils.

D. Construction Testing and Observations

We recommend testing fill, concrete, and asphalt materials at a frequency which meets or exceeds St. George City minimum testing frequency requirements for city improvements. We also recommend the following testing and observations be done as a minimum:

1. Verify the subgrade is properly prepared/compacted in accordance with the recommendations provided in the Subgrade Preparation section of this report.

2. Conduct compaction testing on fill placed in roadways. We recommend testing each foot of fill placed.

3. Conduct construction materials testing of soils, concrete and asphalt materials required for the proposed construction by St. George City.

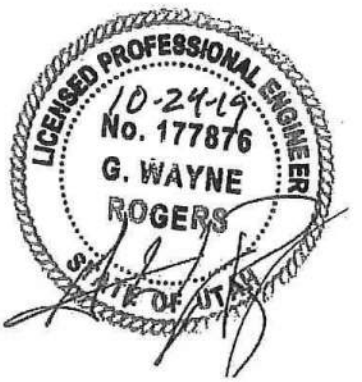
E. Geotechnical Recommendation Review

The client should familiarize themselves with the information contained in this report. If specific questions arise or if the client does not fully understand the conclusions/recommendations provided, AGEC should be contacted to provide clarification.

LIMITATIONS

This report has been prepared in accordance with generally accepted soil and foundation engineering practices in the area for the use of the client for design purposes. The conclusions and recommendations included within the report are based on the information obtained from the borings, and our experience in the area. Variations in the subsurface conditions may not become evident until excavation is conducted. If the subsurface conditions or groundwater level are found to be significantly different from those described above, we should be notified to reevaluate our recommendations.

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.



G. Wayne Rogers, P.E.

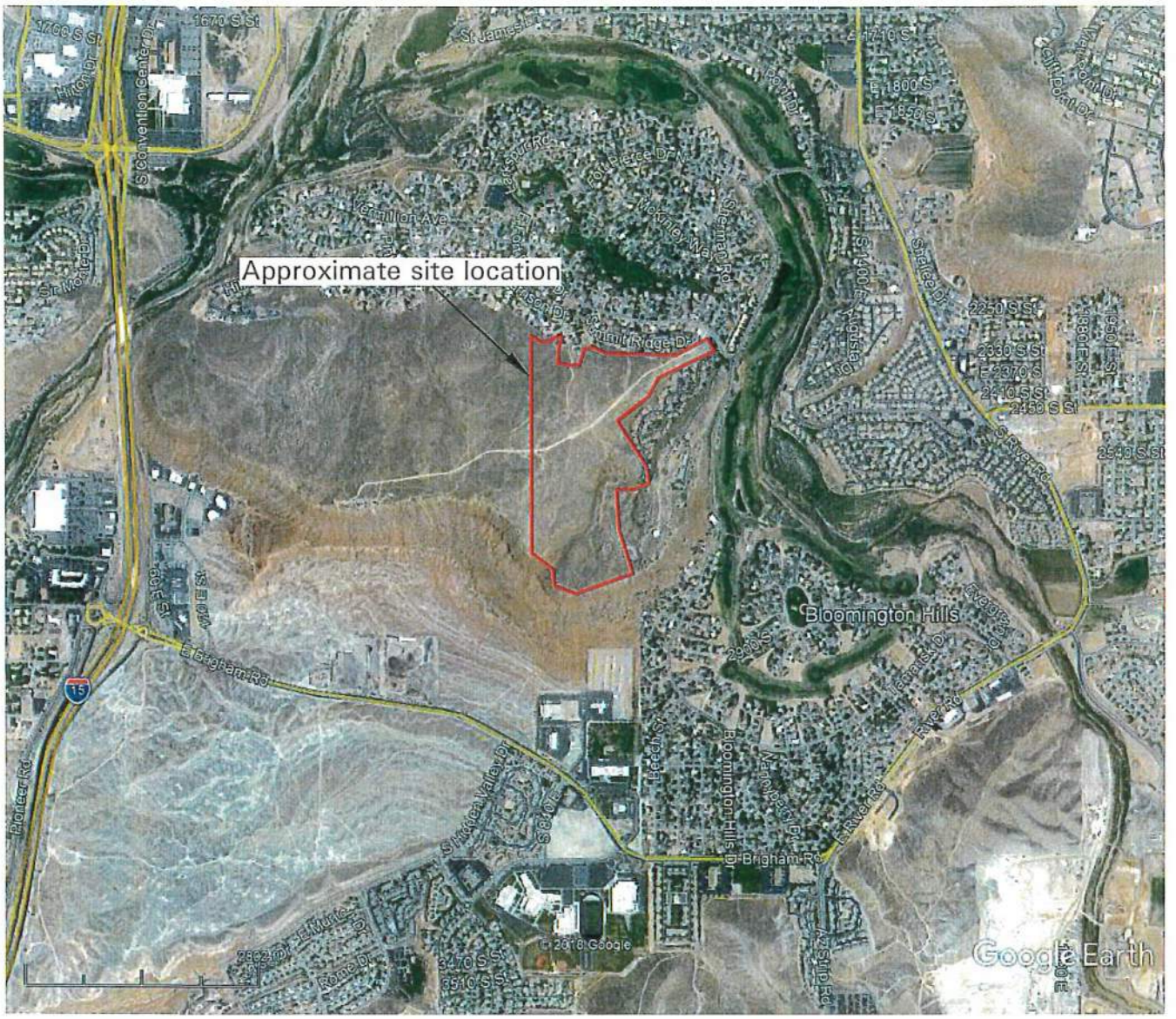
Reviewed by: Jon Russell Hanson, P.E.

P:\2018 Project Files\2182000\2182014 - Webb Hill 70 Acres\Geologic Hillside Report.wpd

REFERENCES:

Christenson, G.E. and Deen, R.D., 1983, Engineering Geology of the St. George area Washington County, Utah: Utah Geological and Mineral Survey Special Studies 58, 32 p., scale 1:24,000.

Lund, W.R., Knudsen, T.R., Vice, G.S., and Shaw, L.M., 2008, Geologic hazards and adverse construction conditions, St. George-Hurricane Metropolitan Area, Washington County, Utah, Utah Geological Survey Special Study 127, 14 plates, scale 1:24,000.



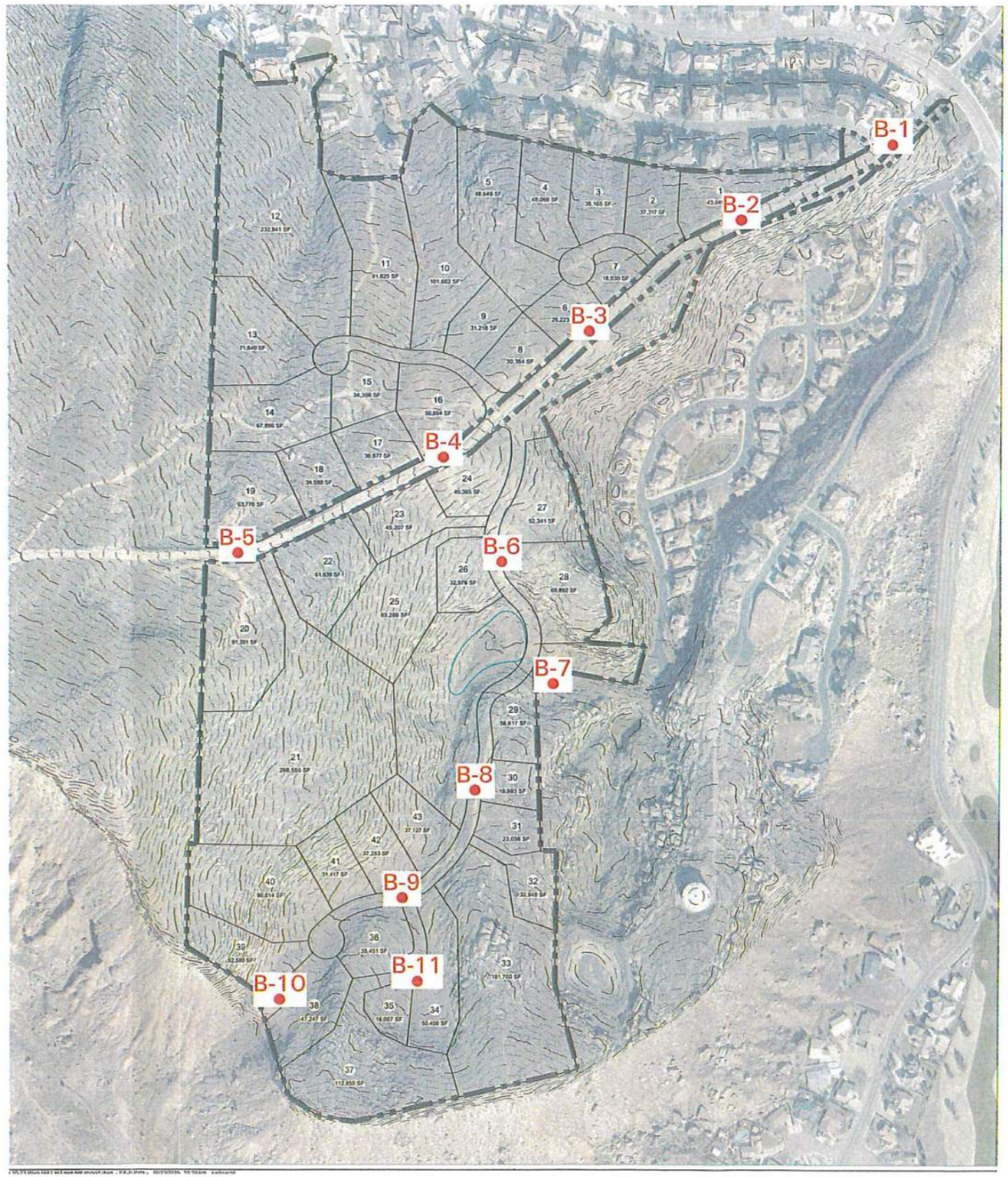
SUMMIT ESTATES
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2182014	AGEC	Vicinity Map	Figure 1

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● Approximate boring location

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0 400 800 feet

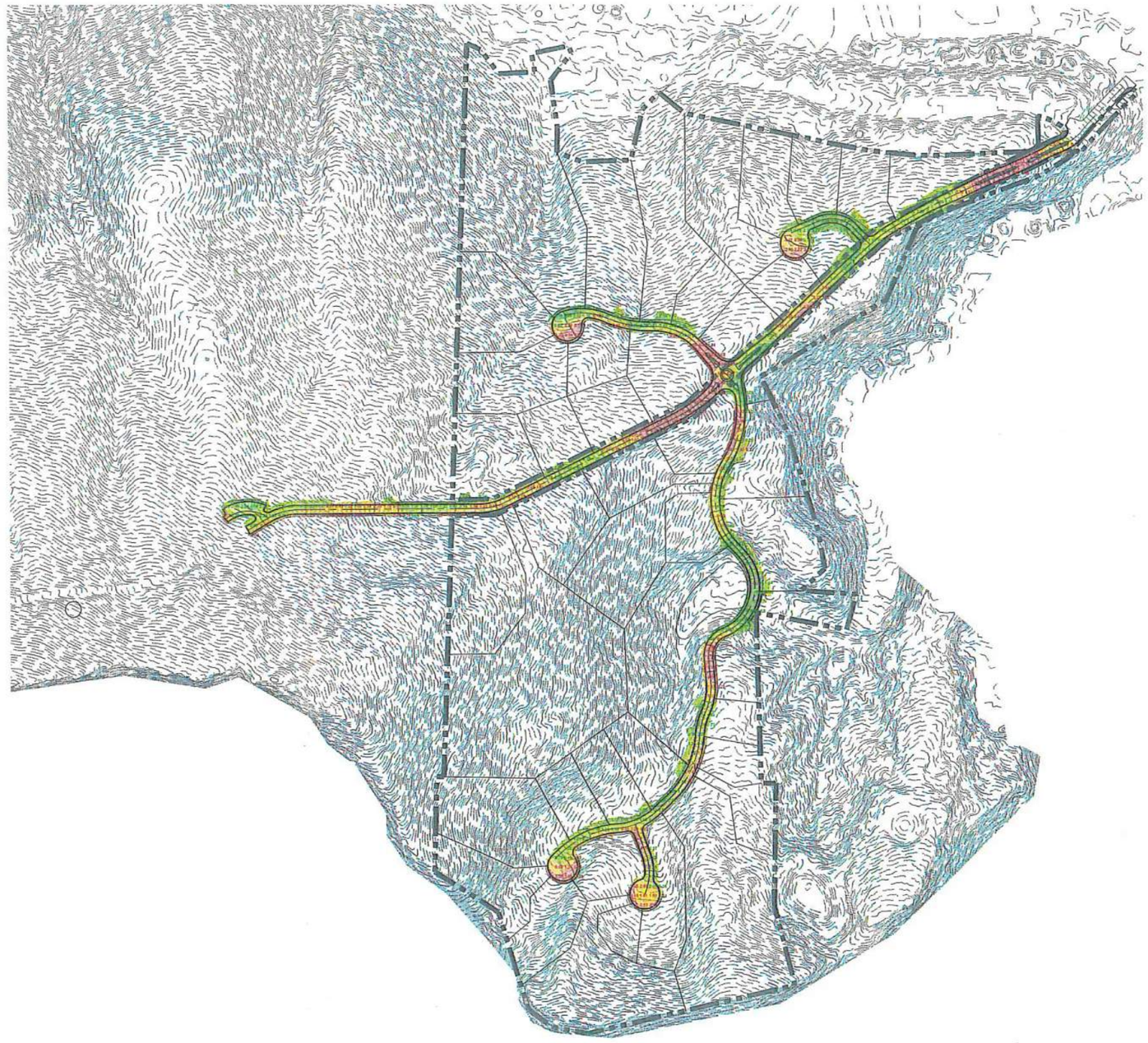
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2182014	AGEC	Site Plan	Figure 2

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ELEVATIONS TABLE				
NUMBER	MINIMUM ELEVATION	MAXIMUM ELEVATION	AREA	COLOR
1	-15.00	-12.00	860.66	
2	-12.00	-9.00	5511.95	
3	-9.00	-6.00	10509.26	
4	-6.00	-3.00	40484.69	
5	-3.00	0.00	97038.11	
6	0.00	3.00	121002.75	
7	3.00	6.00	34949.71	
8	6.00	9.00	14797.00	
9	9.00	12.00	5254.56	
10	12.00	15.00	1852.62	
11	15.00	18.00	1421.73	

CUT / FILL SUMMARY						
NAME	CUT FACTOR	FILL FACTOR	2D AREA (FT^2)	CUT (YD^3)	FILL (YD^3)	NET (YD^3)
SUMMIT ESTATES ROADWAY DESIGN VS. FLOWN EXISTING GROUND	1.00	1.00	333,683	16,804	18,987	2,183

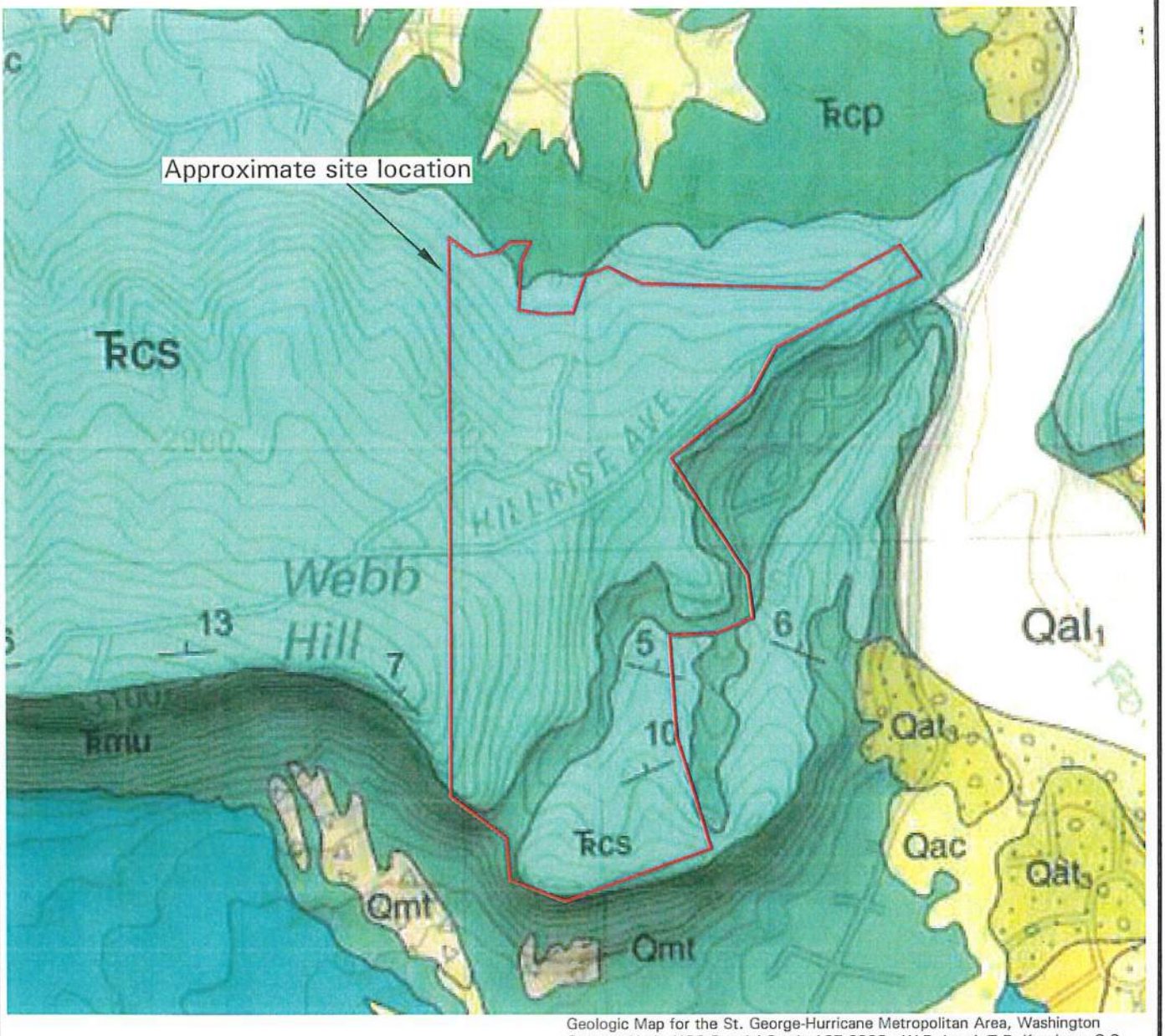


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0 400 800 feet

Approximate Scale

2182014	AGEC	Earthwork Analysis	Figure 2A



Geologic Map for the St. George-Hurricane Metropolitan Area, Washington County, Utah, UGS Special Study 127 2008, W.R. Lund, T.R. Knudson, G.S. Vice and L.M. Shaw

TRmu: Upper red member of Moenkopi Formation
Moderate-reddish-brown to moderate-reddish-orange, thin- to medium-bedded siltstone and very fine grained sandstone with some thin gypsum beds and abundant discordant gypsum stringers; ripple marks common in the siltstone; locally includes 20-foot-thick (6 m) fine-grained, resistant sandstone near base; where the basal sandstone is thickened, the weathering and slope retreat of overlying units is slowed, creating resistant points on the cuestas that form Webb and Bloomington Hills

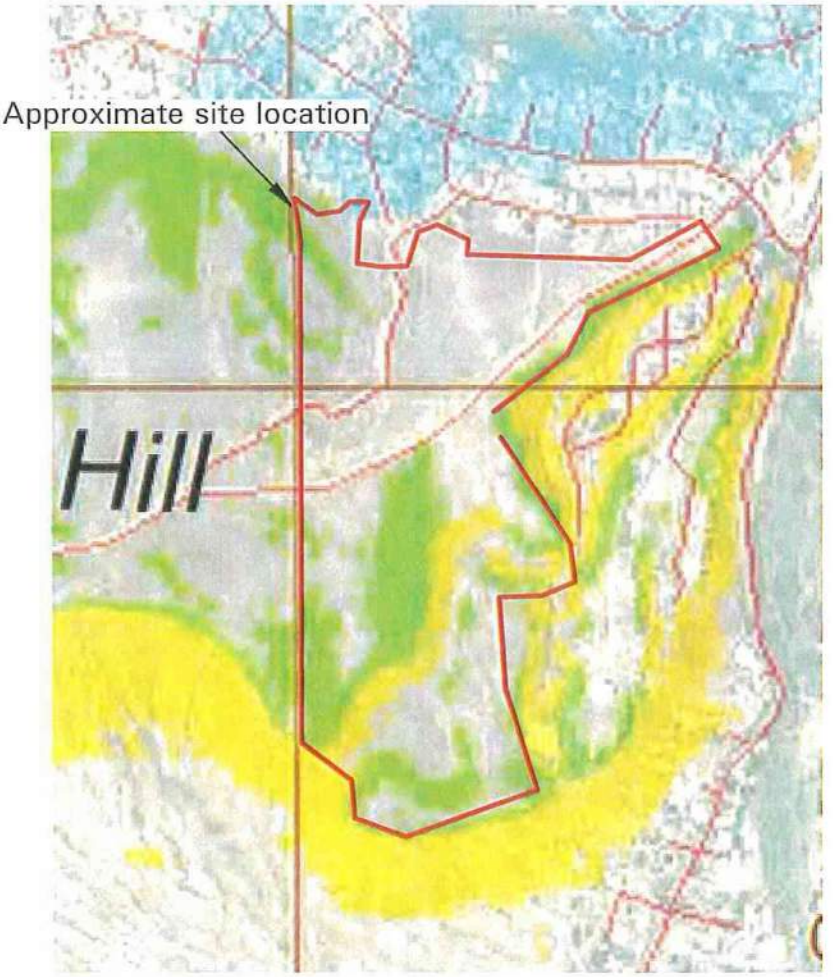
TRcs: Shinarump Conglomerate Member of Chinle Formation
Grayish-orange to moderate-yellowish-brown, medium- to coarse-grained sandstone with locally well-developed limonite bands ("picture stone" or "landscape rock"), grading to moderate-brown, pebbly conglomerate with subrounded clasts of quartz, quartzite, and chert; conglomerate well developed in the southeast corner of the quadrangle;

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2182014	AGEC	Geologic Map	Figure 3



Landslide-Hazard Map for the St. George-Hurricane Metropolitan Area, Washington County, Utah, UGS Special Study 127 2008, W.R. Lund, T.R. Knudson, G.S. Vice and L.M. Shaw

EXPLANATION

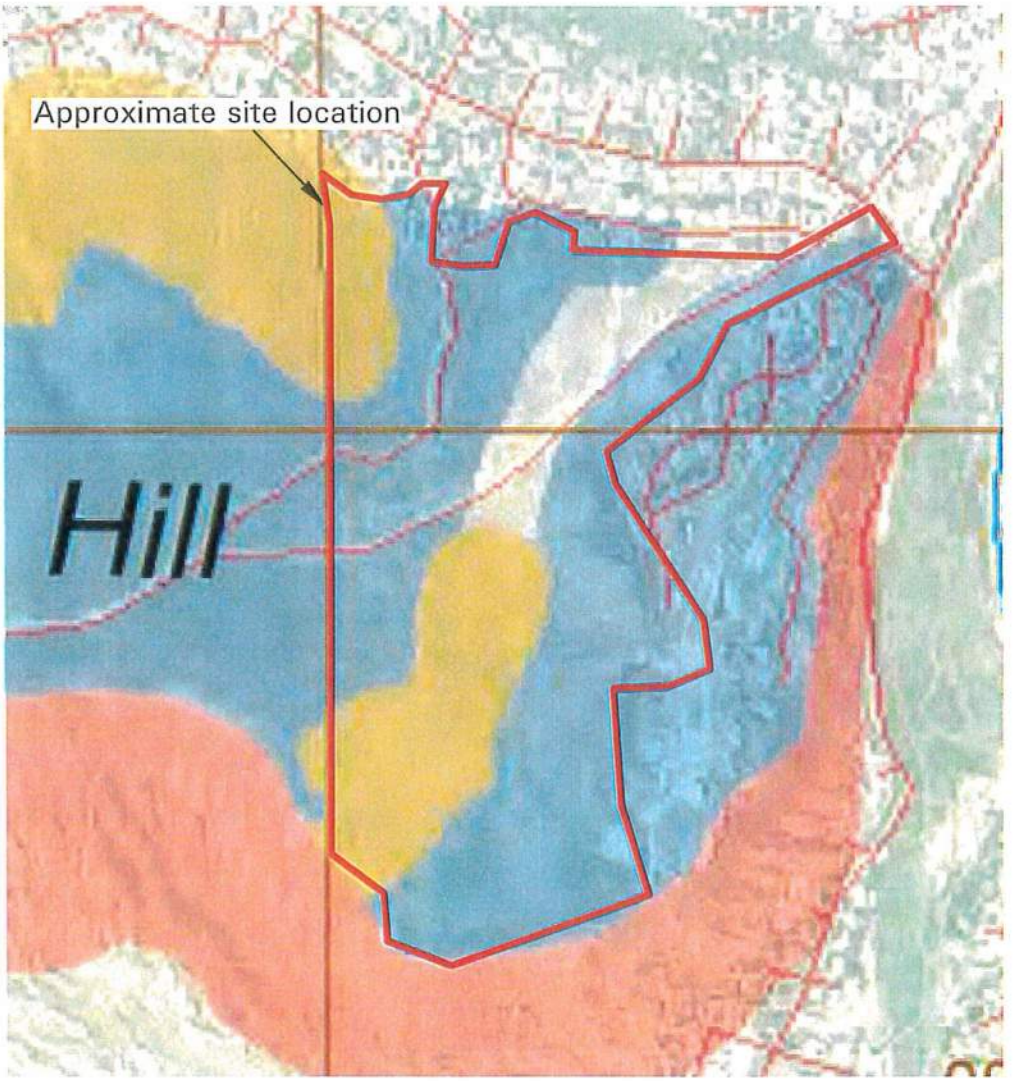
VH	Very High: Existing landslides (Category A).
H	High: Areas where Category B geologic units crop out on slopes greater than 15 percent (8.5°).
M_C	Moderate C: Areas where Category C geologic units crop out on slopes greater than 20 percent (11.3°).
M_B	Moderate B: Areas where Category B geologic units crop out on slopes less than 15 percent (8.5°).
L	Low: Areas where Category D geologic units crop out on slopes greater than 30 percent (16.7°).

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2182014	AGEC	Landslide Hazard Map	Figure 3A



Rock-Fall-Hazard Map for the St. George-Hurricane Metropolitan Area, Washington County, Utah, UGS Special Study 127 2008, W.R. Lund, T.R. Knudson, G.S. Vice and L.M. Shaw

EXPLANATION

H — High rock-fall-hazard areas include steep slopes below resistant cliff-forming units where the acceleration and runout zones are littered with abundant rock-fall boulders greater than 1.5 feet in diameter. Such large boulders can do significant damage to property and threaten lives. Rock units in high rock-fall-hazard areas chiefly include the Shinarump Member of the Chinle Formation, upper Kayenta Formation, Springdale Sandstone Member of the Kayenta Formation, Navajo Sandstone, Virgin Limestone Member of the Moenkopi Formation, Kaibab Formation, Toroweap Formation, and Tertiary–Quaternary basalt flows. Where jointed or fractured, outcrops of these rock units can produce large, angular boulders.

M — Moderate rock-fall-hazard areas are present where slopes provide sufficient relief to create an acceleration zone, but where only sparse rock-fall debris is present on slopes or in the runout zone at the base of the slope. Typically rock units in moderate-hazard areas crop out in the slope instead of forming a capping unit, or where a capping unit is present, the resulting rock-fall debris is typically less then 1.5 feet in diameter. Rock units in moderate rock-fall-hazard areas include the Kayenta Formation, Moenave Formation, and portions of the Kaibab Formation and Navajo Sandstone.

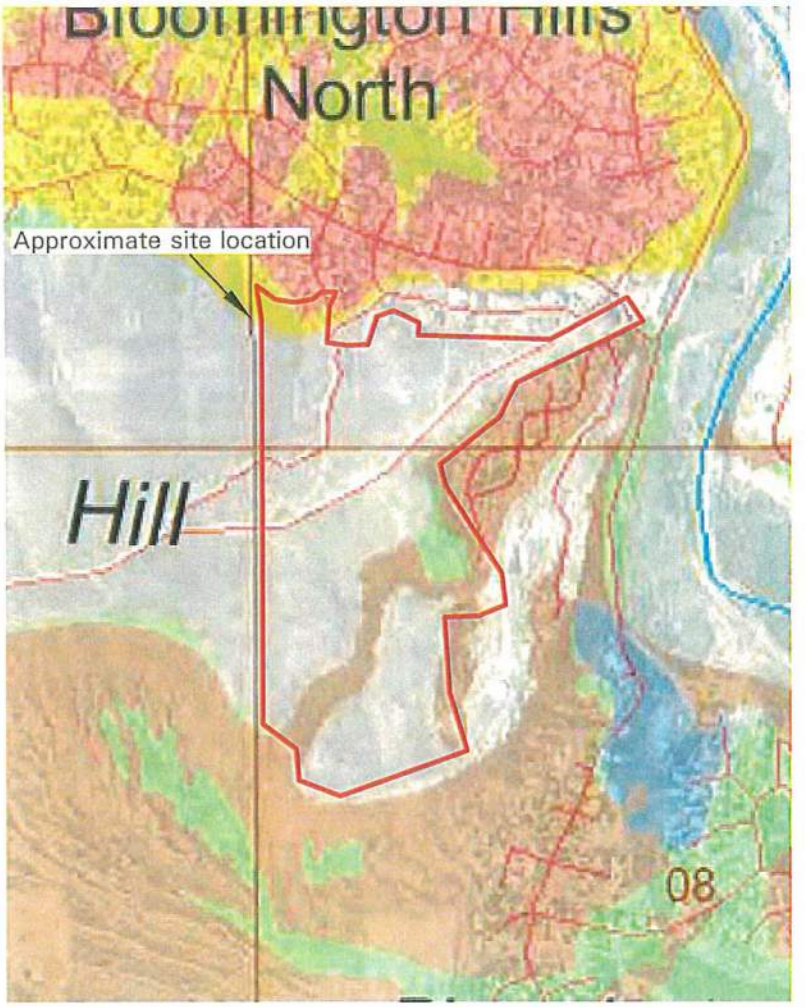
L — Low rock-fall-hazard areas are present where fine-grained, comparatively soft rock units such as mudstone and shale crop out on steep slopes, or where rock units typical of moderate- or high-hazard categories crop out in areas of low to moderate relief. Low rock-fall-hazard areas typically contain sparse rock sources of limited extent. Low rock-fall hazard is most common adjacent to low relief outcrops of Navajo Sandstone and basalt.

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Not to Scale

2182014	AGEC	Rock-Fall-Hazard Map	Figure 3B



Expansve-Soil- and Rock-Susceptibility Map for the St. George-Hurricane Metropolitan Area, Washington County, Utah, UGS Special Study 127 2008, W.R. Lund, T.R. Knudson, G.S. Vice and L.M. Shaw

EXPLANATION

SOIL

ESH — Soils with high susceptibility for volumetric change are typically clay rich and have a liquid limit (LL) >45, a plasticity index (PI) >20, and/or a swell/collapse test (SCT) value of ≥3 percent swell. Soils with these characteristics are of limited areal extent at the surface in the study area, but are frequently found at depth as shown by the geotechnical database (see GEOTECHNICAL DATA EVALUATION section in accompanying text). This phenomenon reflects the fact that most of the geotechnical data available for the study area come from the municipalities of St. George, Santa Clara, Ivins, and Washington, portions of which are underlain at shallow depth (typically <20 feet) by bedrock with high or moderate susceptibility for volumetric change. The influence of this shallow, often clay-rich source rock on overlying soils is apparent in the geotechnical data collected from below a depth of 60 inches.

ESM — Soils classified by the Natural Resources Conservation Service (NRCS) as having moderate susceptibility for volumetric change (LL from 20 to 50, and PI from nonplastic (NP) to 30). These values overlap at their upper ends with soils in the high susceptibility category. Chen (1988) recognized that while PI is an indicator of expansive potential, other factors also exert an influence, and therefore reported a range of PI values when categorizing soil's capacity to shrink or swell.

ESL — Soils classified by the NRCS as having low susceptibility for volumetric change (LL from 0-30, and PI from NP-15). These values overlap at their upper ends with soils in the moderate susceptibility category. However, the low category includes soils with highly variable potential for volumetric change that do not fit easily into the moderate or high categories.

ROCK

ERH — Bedrock units with high shrink/swell susceptibility include claystone horizons in the Virgin Limestone Member of the Moenkopi Formation; the Petrified Forest Member of the Chinle Formation, known locally as the "Blue Clay," the lower red beds of the Dinosaur Canyon Member and the Whitmore Point Member of the Moenave Formation; the Iron Springs Formation, which contains abundant clay-rich strata in its lower part; and a thin interval (maximum thickness 90 feet) of montmorillonitic clay that lies between the Carmel Formation and the overlying Iron Springs Formation. Landslides mapped within these rock units were also included in the high-susceptibility category. These bedrock units contain an abundance of expansive clay minerals and are commonly associated with expansive rock problems in the study area.

ERM — Bedrock units with moderate shrink/swell susceptibility include the Shinarump and lower, middle, and upper red members of the Moenkopi Formation; the Co-op Creek and Crystal Creek Members of the Carmel Formation; and the Temple Cap Formation. These rock units are chiefly fine grained and contain alternating strata of shale, claystone, mudstone, siltstone, sandstone, and limestone. Not all or necessarily the majority of these strata contain expansive clay minerals, but past experience in the study area has shown that a sufficiently high percentage of strata do contain expansive clays that foundation problems are often associated with these rock units. Where mapped as undivided, we assigned a moderate susceptibility to the Moenkopi Formation, Carmel Formation, and grouped Triassic, Triassic/Jurassic, and Jurassic/Cretaceous rocks. Landslides mapped within moderate-susceptibility units are also included in this category.

ERL — Bedrock units with low shrink/swell susceptibility include the Timpowasp Member of the Moenkopi Formation and the the Kayenta Formation. Although we consider these units to have a low susceptibility relative to the bedrock units identified above, they contain some fine-grained, clay-rich strata that may cause shrink/swell problems locally.

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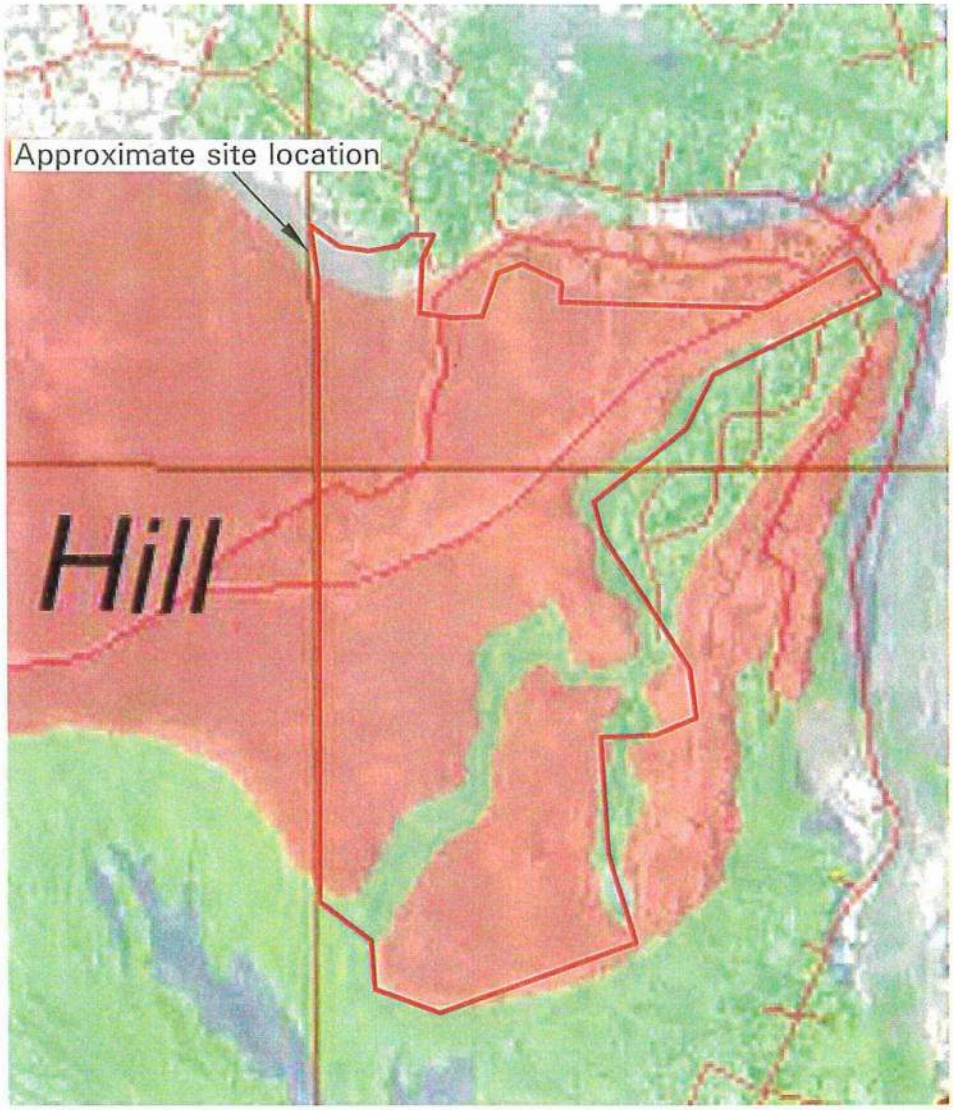
CHESR — Area of highly expansive soil or rock (≥5 percent swell) in the shallow subsurface (<20 feet), but with little or no evidence of such material at the ground surface. Based on past engineering experience, such highly expansive soil or rock can cause differential displacements at the ground surface even when overlain by as much as 20 feet of nonexpansive material, and these areas are considered to have a high potential for expansive soil and rock problems.

SUMMIT ESTATES
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Not to Scale

2182014	AGEC	Expansive-Soil and Rock-Susceptibility Map	Figure 3C



Shallow-Bedrock-Susceptibility Map for the St. George-Hurricane Metropolitan Area, Washington County, Utah, UGS Special Study 127 2008, W.R. Lund, T.R. Knudson, G.S. Vice and L.M. Shaw

EXPLANATION

BR_H Hard: Areas where generally hard and resistant bedrock crops out at the ground surface. These bedrock units typically require blasting to excavate.

BR_S Soft: Areas where less resistant bedrock crops out at the ground surface. Even when fresh, these bedrock units typically can be excavated without blasting, although some blasting may be required locally. Some rock units may contain expansive clay minerals and may be deeply weathered.

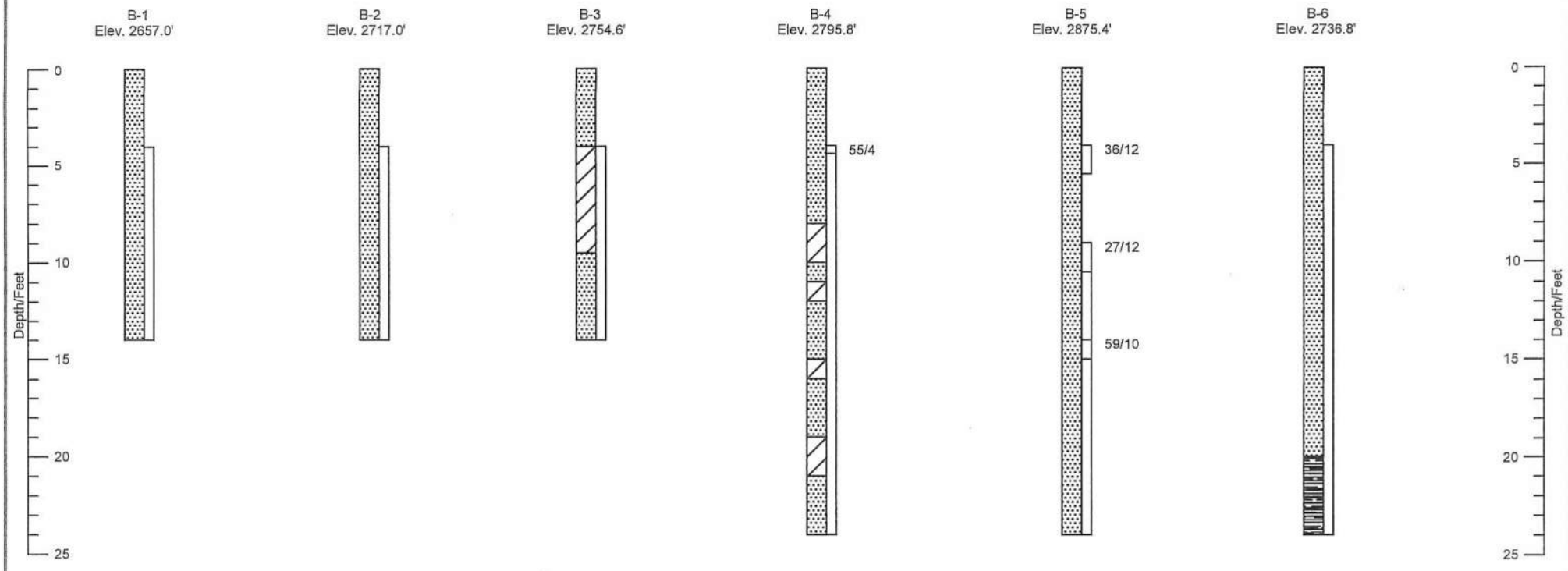
BR_B Buried: Areas where depth to bedrock is ≤10 feet beneath soil cover. In most areas the identity and degree of weathering of the underlying bedrock is unknown. However, many basalt flows in the study area, which consist of very hard and durable rock, are covered with a thin veneer of soil and fall into this category.

SUMMIT ESTATES
ST. GEORGE, UTAH

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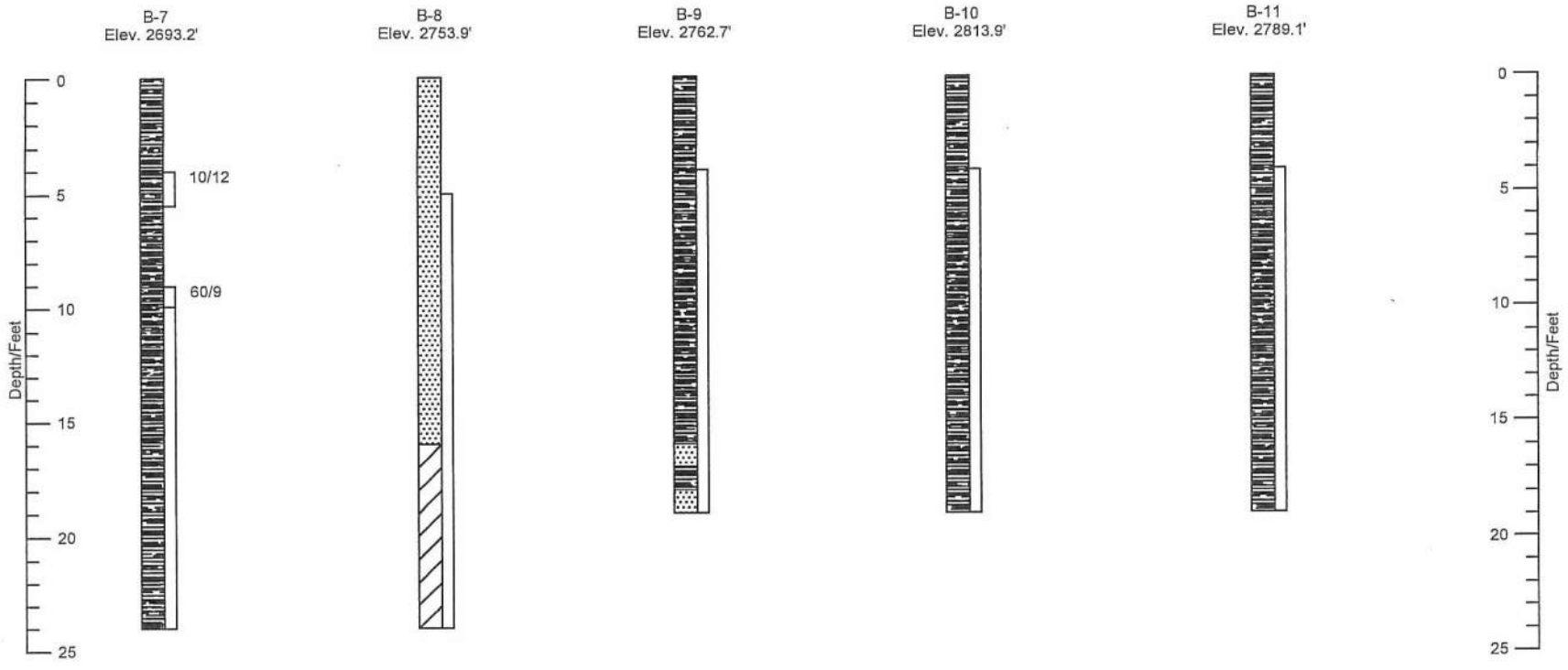
Not to Scale

2182014	AGEC	Shallow-Bedrock-Susceptibility Map	Figure 3D



See Figure 6 for Legend and Notes

2182014	AGEC	Logs of Exploratory Borings	Figure 4



See Figure 6 for Legend and Notes

2182014	AGEC	Logs of Exploratory Borings	Figure 5

LEGEND:



Sandstone Bedrock; moderately hard to hard, some coarse pebbles, conglomerate, yellow light brown



Shale Bedrock; soft to moderately hard, weathered, dry to slightly moist, low to medium plastic, red to light brown.



Siltstone Bedrock; weathered, highly fractured in upper zone, low to medium plastic, light brown to grey to brown.



California drive sample taken. The symbol 10/12 indicates that 10 blows from a 140 pound hammer falling 30 inches were required to drive the sampler 12 inches.



Indicates core sample taken.

NOTES:

1. The borings were drilled on January 10, 11, and 14, 2019 with a truck mounted drill rig equipped with 8-inch hollow-stem augers. The bedrock was cored using an HQ 2½" core barrel with a diamond bit using air to remove cuttings.
2. The location of the borings were measured by a hand held GPS as shown on Figure 2.
3. The elevation of the borings were determined by Horrocks Engineering using the hand held GPS data.
4. The boring locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between the materials shown on the boring logs represent the approximate boundaries between material types and the transitions may be gradual.
6. Free water was not encountered in the borings at the time of drilling.

Appendix A

Core Sample Photos

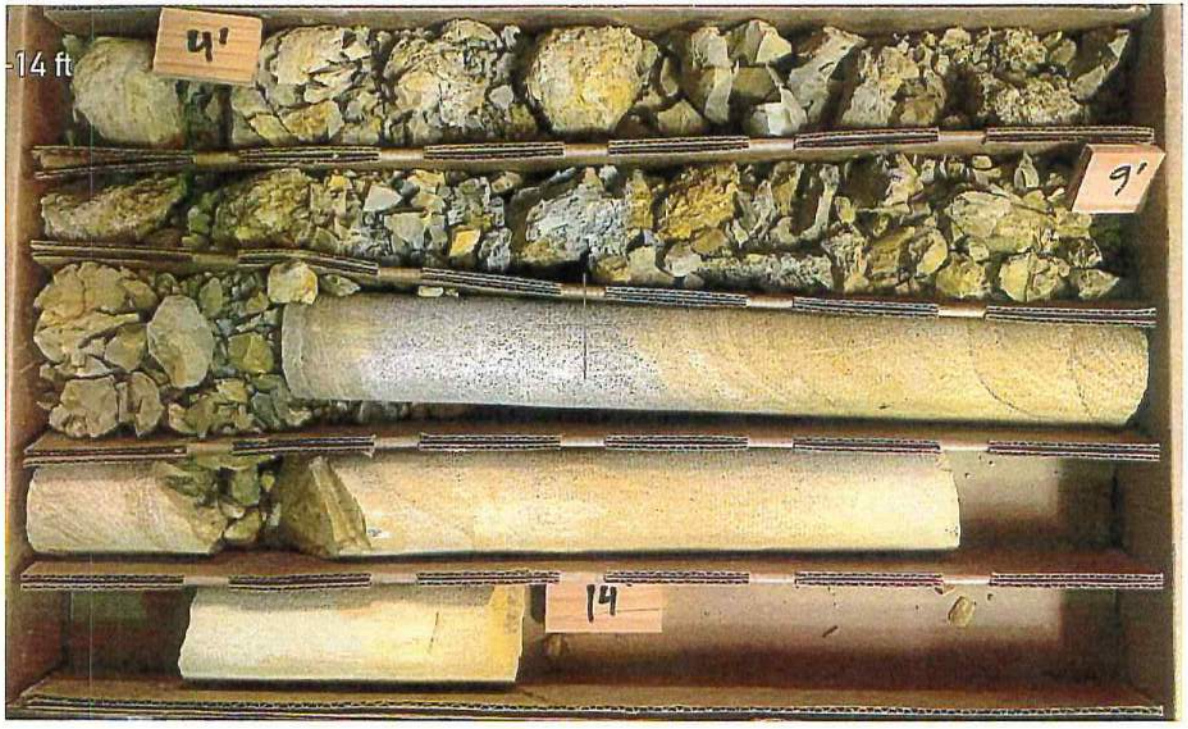
Borings B-1 to B-11



Boring B-1@ 4-14 ft.



Boring B-2@ 4-14 ft.



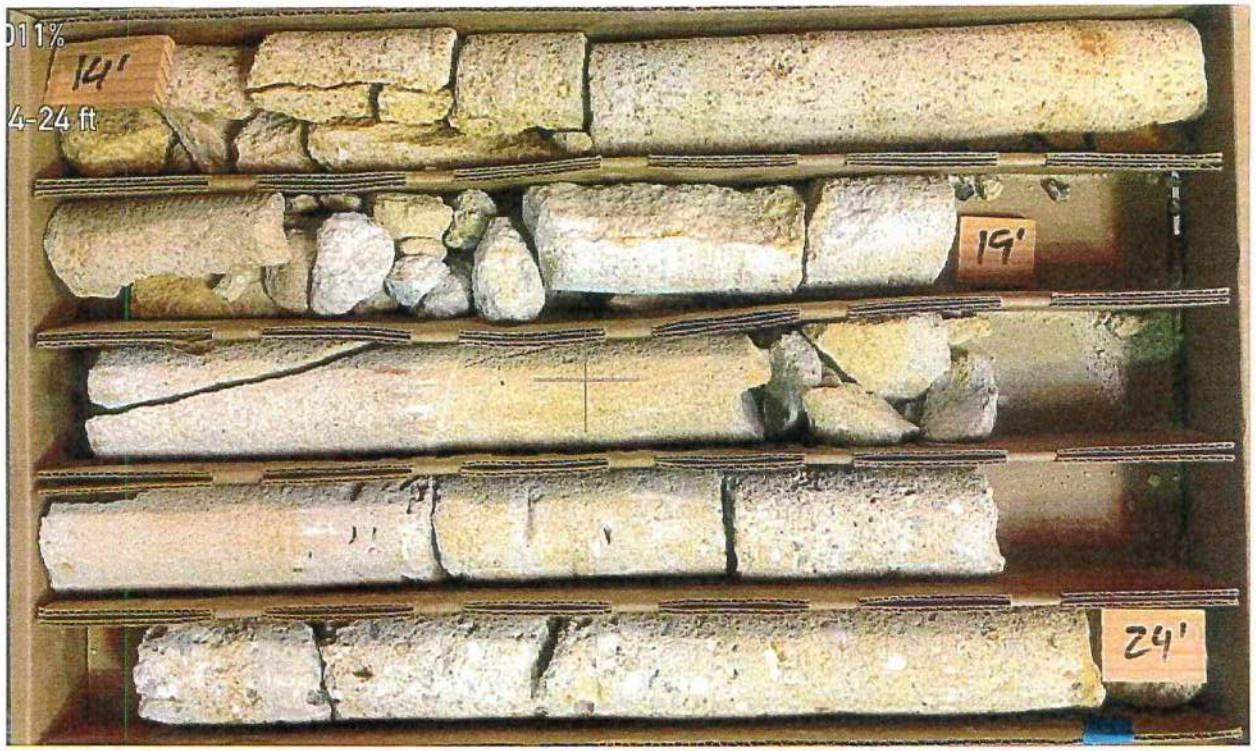
Boring B-3@ 4-14 ft.



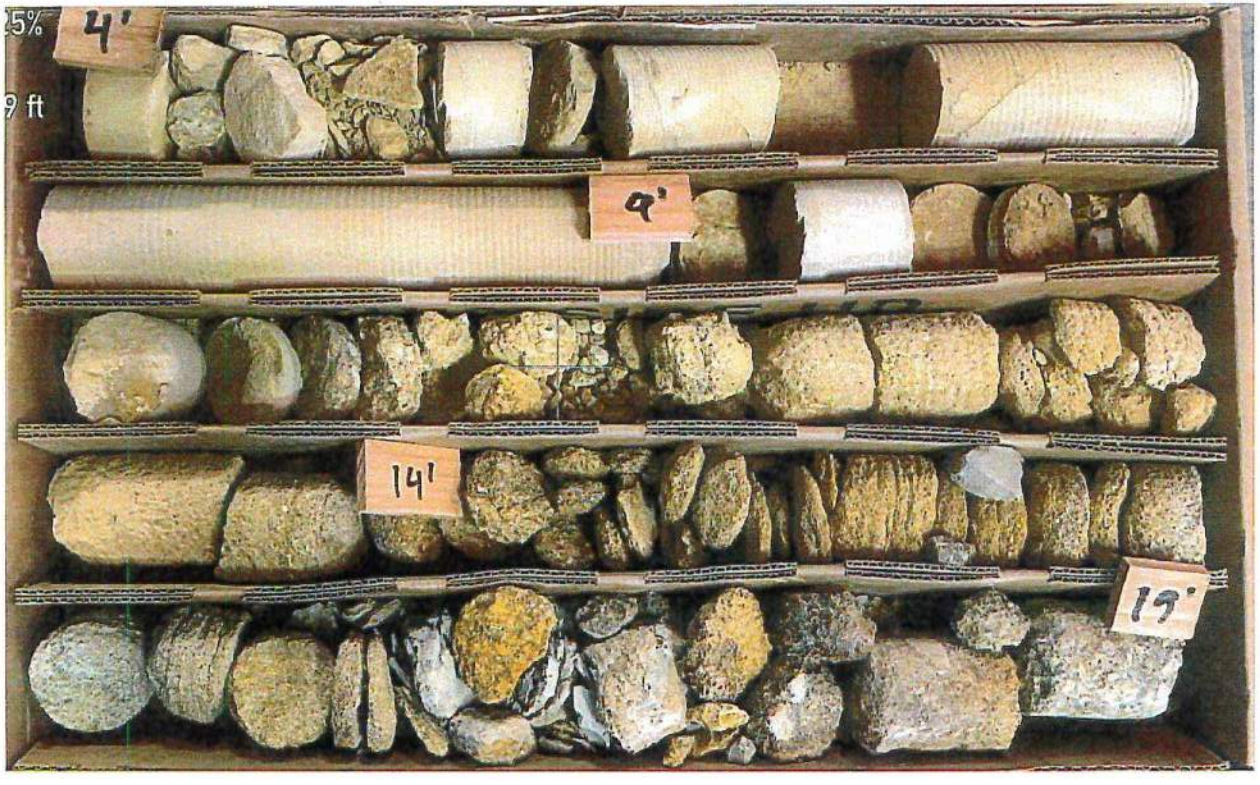
Boring B-4@ 4-16 ft.



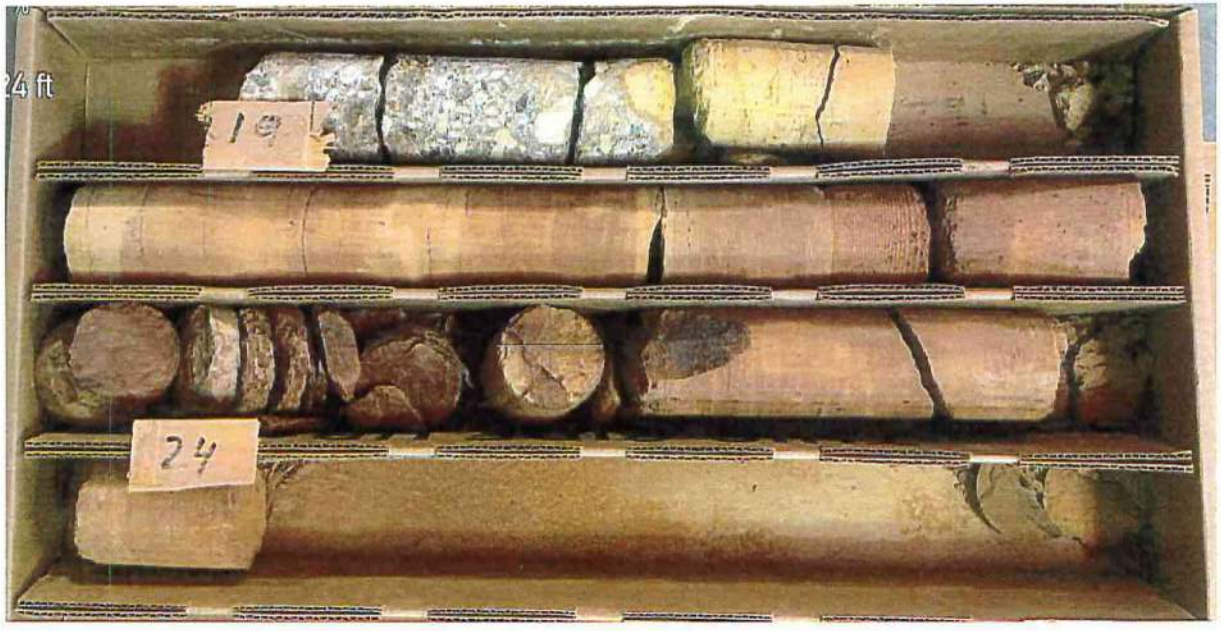
Boring B-4@ 16-24 ft.



Boring B-5@ 14-24 ft.



Boring B-6@ 4-19 ft.



Boring B-6@ 19-24 ft.



Boring B-7@ 9-23 ft.



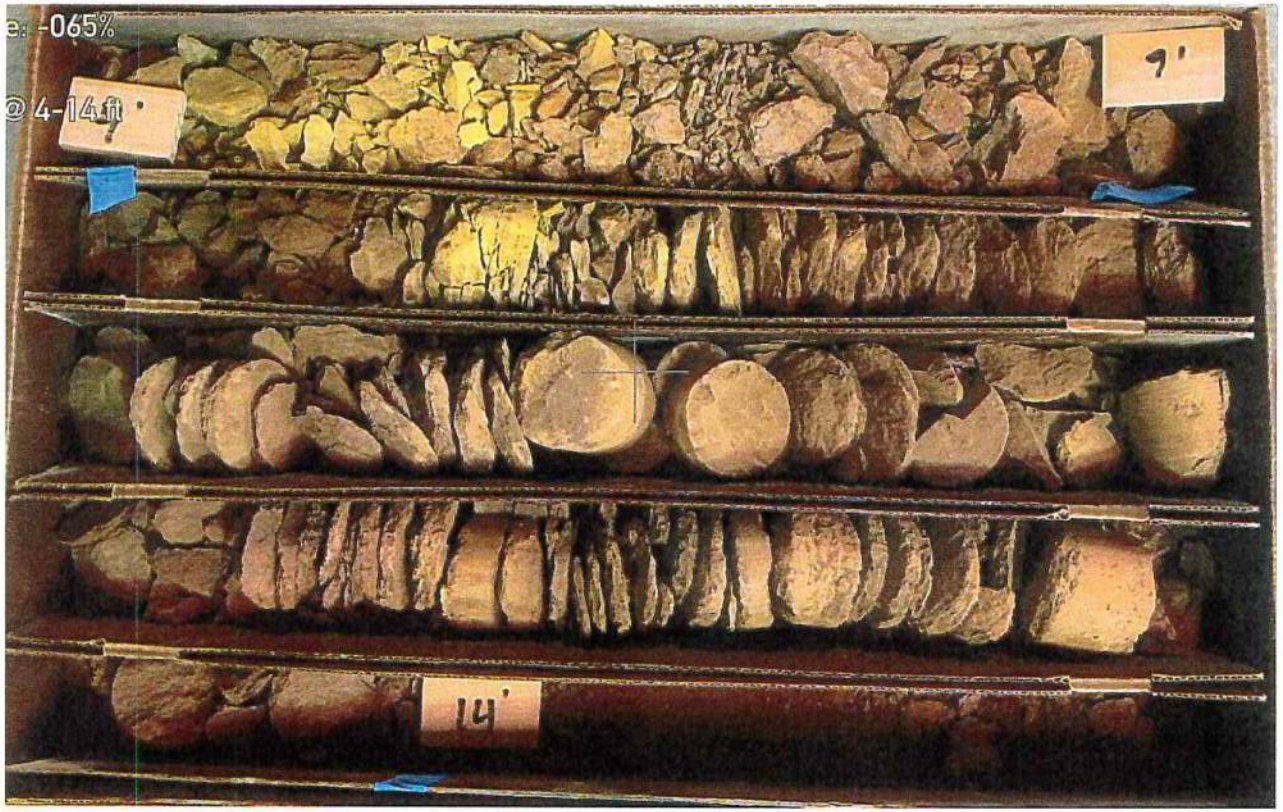
Boring B-7@ 23-24 ft



Boring B-8@ 5-19 ft.



Boring B-8@ 19-24 ft.



Boring B-9@ 4-14 ft.



Boring B-9@ 14-19 ft.



Boring B-10@ 4-19 ft.



Boring B-11@ 4-16.5 ft.



Boring B-11@ 16.5-19 ft.

Vibration Report

AGEC
Applied GeoTech

July 14, 2020

VE Management and Investment Co., L.C.
1240 East 100 South $12
St. George, Utah 84790

Attention: Joby Venuti
EMAIL: joby@netutah.com

Subject: Summit Estates
Hillrise Circle
St George, Utah
Project No. 2182014

Gentlemen:

Applied Geotechnical Engineering Consultants, Inc. (AGEC) was requested to provide our professional opinion on ways to reduce the risk of rock falling on existing improvements within the Sienna Canyon Development during construction of the proposed subdivision on Webb Hill in St George, Utah.

AGEC previously conducted a rockfall run-out evaluation for the Sienna Canyon Development, specifically along the property boundary between Sienna Canyon Development and Webb Hill. We presented our findings in a report dated February 10, 2020 under Project No. 2182014.

FINDINGS

Based on the investigation conducted, it is our professional opinion that:

- There are a number of locations along the hill located along the west side of the Sienna Canyon subdivision where large rock could roll off of the slope and damage and possibly result in loss of life or injury to the residents below the hill.
- Should hydraulic driven rock breakers be needed to excavate below the existing ground surface for utility and/or roadway construction, we recommend that the magnitude of vibration be limited by size of equipment and that the distance away from potential rockfall be kept as large as possible.
- Based on our current evaluation, it appears that hydraulic rock breakers should be no closer than160 feet from the rock on the slope and that rock trenchers be operated no closer than 75 feet from the slope.

- We recommend that these distances be verified once the actual equipment has been identified by on-site evaluation at the time of construction.
- We recommend that the vibrations generated during construction, that is performed close to the slope, be monitored.

LITERATURE STUDY

A review of available literature was conducted in order to determine the findings from earlier studies on the potential adverse impact of vibration. From our research we were able to find levels of ground shaking that could be considered to reduce potential damage. We were also able to find typical distances and their associated ground vibration that could be induced by various types of construction equipment.

Based on the information obtained, we suggest that a peak particle velocity be limited to a maximum value of less than 0.08 inches per second. This is the criteria used for "ruins and ancient monuments" as presented in "A Survey of Traffic-induced Vibrations" by Whiffin and Leonard, Transport and Research Laboratory, RRL Report LR418, Crowthorne, Berkshire, England, 1971.

ON-SITE INVESTIGATION

Our field investigation included three steps. The first step was to visit the rock slope and assess the potential for rock to move and/or become dislodged from the slope, which could then roll down and adversely impact the improvements below.

The second step of the field investigation included measuring actual ground motions resulting from impact at various distances away from a vibration measuring device.

The third step of the field investigation included measuring actual ground motions resulting from vibration generated in the ground from two potential pieces of construction equipment, a CAT H140E hydraulic breaker, and a Vermeer T855 trencher.

A. Rock Slope Evaluation

Based on our observations, the following rockfall related conditions were observed:

1. Ground slopes were measured to range from 26 to 40 degrees.

2. Specific rock surfaces that were sloping downslope were found to be as steep as 65 degrees to near vertical.
3. Rocks were observed to be in a condition that could result in future movement by:

a. sliding down slope
b. becoming dislodged from an overhang
c. dislodge from a wedge
d. fall from a precarious stack

4. It appears that many rocks could be loosened and/or freed from their current position by very small efforts of ground shaking, erosion or impact.

5. The rocks were found to be predominantly sandstone and could be considered a weak rock.

B. Vibration

We were able to measure the velocity and acceleration at distances varying from 2 to 160 feet using a falling weight that imposed an energy of approximately 100-foot pounds to the rock. From this information we were able to plot the measured vibration versus distance.

Based on the energy imposed and the response, it appears that the on-site ground motions were larger than what the literature would indicate.

With this condition, we conducted on-site testing to further define the site response of the energy imposed by potential construction equipment to excavate the rock.

On April 28, 2020 a hydraulic breaker (CAT H140E) and a trencher (Vemeer T855) were operated on site to measure the induced vibration on the ground surface at a number of distances away from the equipment. The measurements obtained are presented on Figure 2.

LABORATORY TESTING

Samples of the rock were taken to the laboratory to determine the approximate strength and sliding resistance that the rock may have. Based on our testing, the friction angle between rocks was measured to vary from 30 degrees to 61 degrees. Similar results were obtained when the rock was wet.

From this study we anticipate that the larger friction values are a result of the asperities of the rock and therefore have not been incorporated in our analysis. The average value of the interface friction angle is 39 degrees.

ANALYSIS AND FINDINGS

Based on the existing condition of the hillside along with the relatively weak strength of the rock, it is our professional opinion that the rockfall hazard for the improvements at the bottom of the slope should be considered significant even without construction on the neighboring site. From our evaluation, it is apparent that a number of rocks are in a position that could dislodge with very small amounts of ground motion, erosion of supporting materials and/or wetting.

Ideally, the development should have followed the recommendations presented in the original geotechnical report for the proposed Webb Canyon Development (currently known as the Sienna Canyon Subdivision) provided by Black, Miller & Associates, Inc. dated May 8, 1996 under Project No. 96-1191-01.

Using the information obtained from our on-site measurements, a plot of ground vibration resulting from use of the equipment at various distances has been plotted. These measurements are presented on Figure 2.

The literature indicates that vibration inducted by equipment typically follows a linear relationship in a log-log scale. This linear approximation has been applied to the vibrations measured by the T855 trencher and the H140E hydraulic hammer. These results are presented on Figure 2.

Also presented on Figure 2 is what historically been measured as vibration from truck traffic.

Assuming that trucks have traveled on the existing road, that closely parallels the steep slope, some of the rockfall hazard areas may have experienced ground shaking higher than we are recommending to be considered as the threshold for future activities.

The proposed road alignment and grading plan prepared by Horrocks Engineers, dated June 12, 2020, incorporates many of the recommendations that were previously provided to the developer for consideration and development of the area.

The following conditions pertaining to the vibration hazard have been incorporated in the design.

a. The entrance roadway has been located west of and farther away from the area of rockfall hazard.

b. The proposed alignment of the entry roadway results in cuts of 3 feet or less in the first 200 feet of the roadway. We understand that deeper cuts would have been considered if the existing road alignment was used to access the development.

c. It appears that the buildable areas have been restricted to be west of the entry road until after the intersection of Hillside Drive and "Road A." Lots 25 and 26 are the only two buildable areas that are on the east side of the road. We understand that the grading plan (prepared by Horrocks Engineers) indicates that fill will be placed on Lots 25 and 26 to achieve the desired grade. This effort would result in less vibration than if the final grade required cuts.

d. The grading plan indicates that water that is collected west of the roadway will drain towards the north away from the slope of concern. This is also an improvement compared to the existing drainage condition.

RECOMMENDATIONS

1. With these conditions, we recommend that positive measures be taken in order to reduce the potential of unacceptable performance of the rocks during construction on Webb Hill. This can be accomplished by:

   a. using equipment that would minimize vibration in the ground.

   b. maintaining sufficient distances away from the slope of concern with vibration inducing equipment.

2. The minimum distance away from the slope for equipment should be considered based on a criteria that is included in the literature to prevent damage to "ruins and ancient monuments". This criteria (maximum particle velocity of 0.08 inches per second) was obtained from, "A Survey of Traffic-Induced Vibrations" by Whiffin and Leonard, Transport and Research Laboratory, RRL Report LR418 Crow thorn Berkshire, England, 1971.

3. Human beings have the capability of becoming aware of vibration well below the level when damage may occur. In fact, there will likely be concern long before there is a potential for vibration induced hazard. With this condition, we recommend that contractors consider using equipment that induces vibration in the ground use as little vibration that will still accomplish the task at hand. Vibrations on the order of 0.006 to 0.019 inches/second within the literature can be perceived. Keeping the energy of the equipment and/or operating farther away from the slope will help to limit the perception by others.

4. Based on the field measurements of the hydraulic hammer and trencher, and using the criteria of 0.08 inches per second peak particle velocity, the hydraulic hammer should be operated no closer than 160 feet and the trencher no closer than 75 feet of the area of concern. These setbacks are presented on Figure 1.

5. The induced vibration of the equipment proposed for excavation into rock should be measured before proceeding. Any modification to the criteria developed by this study could then be made if needed. These evaluations would help reduce the potential for rockfall to occur.

6. Ground motions should be measured during construction to verify that the threshold selected is not being exceeded.

7. The criteria presented in this letter should be followed by contractors working on site.

8. Blasting should not be allowed on site.

9. The improvements on the building lots within the 160-foot setback should follow the same criteria indicated within this letter. If vibrations, larger than the ones generated for this study, are contemplated, beyond the 160 feet setback, we should be consulted in order to establish energy limits and/or the appropriate set back to reduce the potential for potentially damaging vibration.

LIMITATIONS

This letter has been prepared in accordance with generally accepted geotechnical engineering practices in the area for the use of the client. The conclusions and recommendations included in the letter are based on conditions observed during our field study. If conditions are significantly different from those described in this letter, we should be notified to reevaluate our conclusions and recommendations.

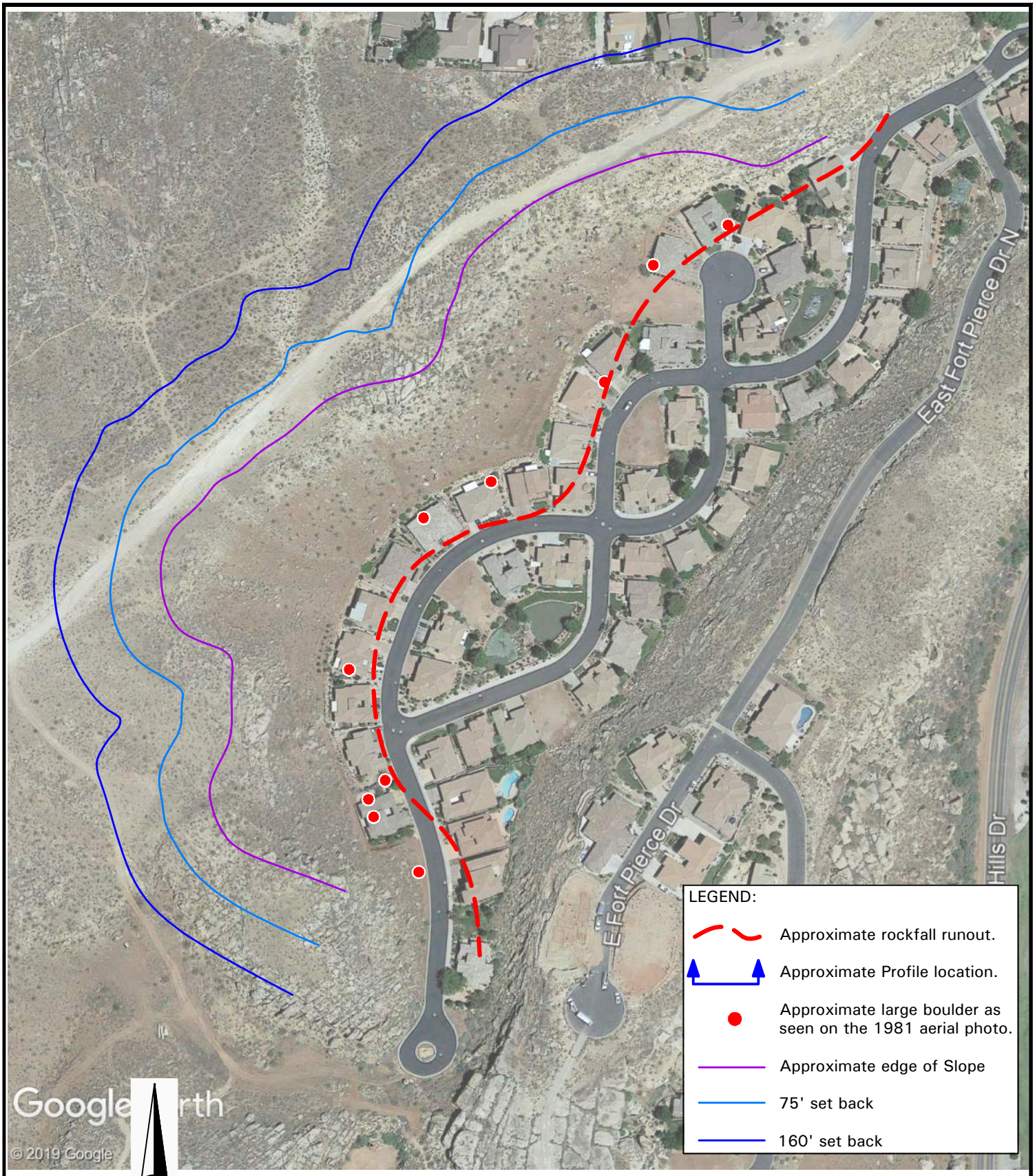
If you have questions or if we can be of further service, please call.

Sincerely,

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

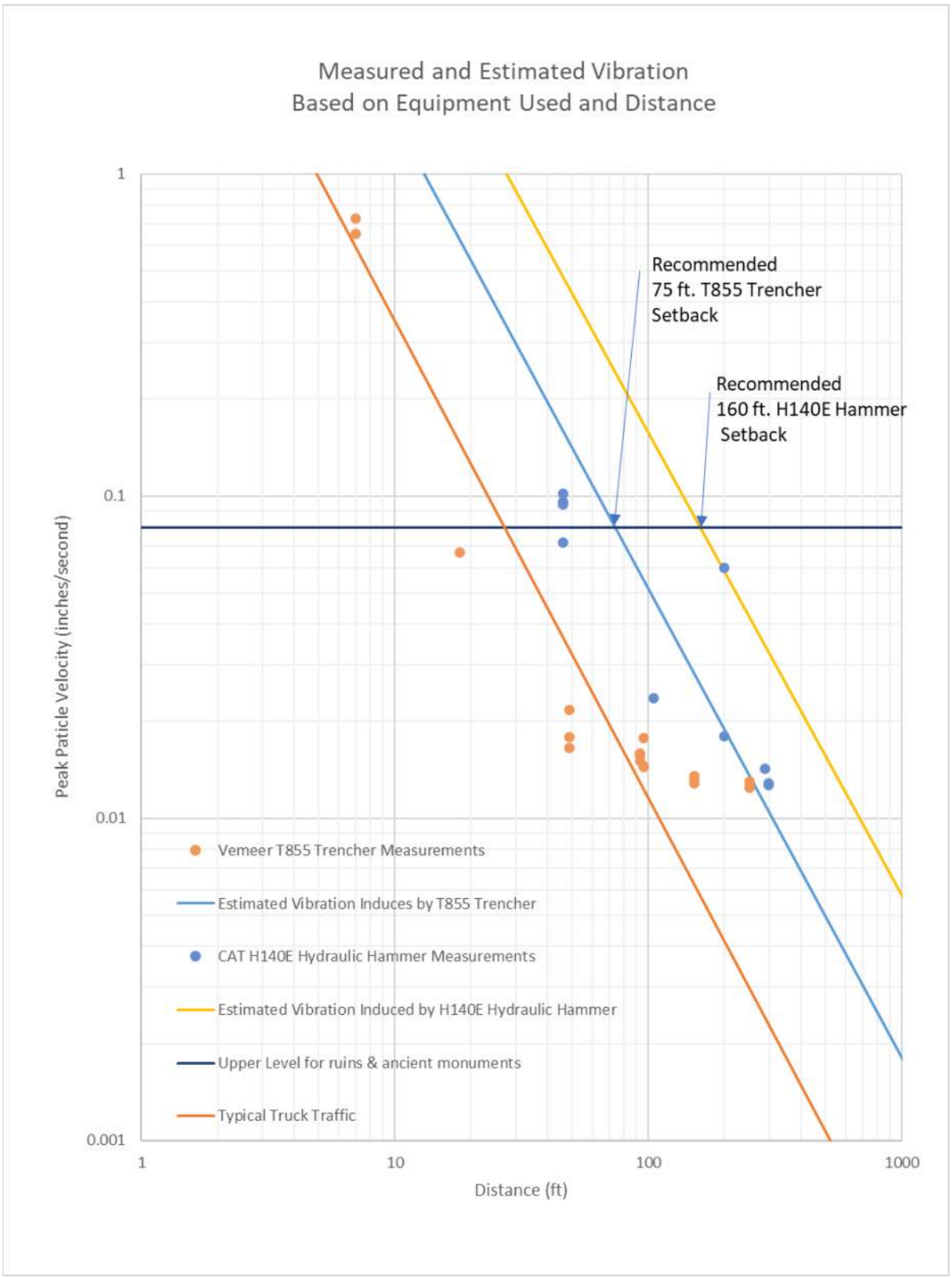


James E. Nordquist, P.E., D.G.E.
JEN/rs



ROCKFALL HAZARD ASSESSMENT
SUMMIT ESTATES
HILLSIDE CIRCLE
ST. GEORGE, UTAH

2182014	AGEC	Rockfall Hazard and Profile Locations	Figure 1


Measured and Estimated Vibration
Based on Equipment Used and Distance
Peak Paticle Velocity (inches/second)
1
0.1
0.01
0.001
1
10
100
1000
Distance (ft)
Recommended
75 ft. T855 Trencher
Setback
Recommended
160 ft. H140E Hammer
Setback
Vemeer T855 Trencher Measurements
Estimated Vibration Induces by T855 Trencher
CAT H140E Hydraulic Hammer Measurements
Estimated Vibration Induced by H140E Hydraulic Hammer
Upper Level for ruins & ancient monuments
Typical Truck Traffic

Minutes from November 20, 2019

MINUTES OF THE
HILLSIDE REVIEW BOARD (HSRB) MEETING
CITY OF ST GEORGE, UTAH
WEDNESDAY, November 20, 2019

Note: These minutes are not verbatim (*Note: an audio recording was taken and is on file)*

ATTENDANCE:

HSRB Committee	Council	Staff	Representative(s)
Present 1. (DB) Dave Black (Chairman) 2. (TE) Todd Edwards 3. (TH) Tyler Hoskins 4. (SP) Shawn Patten 5. (JS) James Sullivan *Absent* 1. (JD) James Dotson *(Note: a minimum quorum of 4 is required)*	Present 1. (EB) Ed Baca	Present 1. (WJ) Wes Jenkins, 2. (JW) John Willis 3. (DB) Dan Boles 4. (RS) Ray Snyder 5. (MG) Mark Goble 6. (JP) Jeff Peay Absent 1. -0-	**Item # 1** 1. (BW) Ben Willits 2.(AC) Austin Chappell 3.(WR) Wayne Rogers – AGEC 4. (JV) Joby Venuti – owner representative

ITEM #1: Consider a request to develop "Summit Estates" a proposed residential subdivision. Case No. 2019-HS-008.

1.	-0-	Note: It was raining this day and a pop up canopy was set up and used to cover a table to layout the plans on.
2.	BW	• Introduced the "Summit Estates" project. • This is a remnant of the Sienna Canyon development. On approx. 70 acres. • Ben explained the history; 'Webb Hill' land was traded for property by the replacement airport, but this portion was approved to be developed for residential. • This will not be a part of the Sienna Canyon HOA; it will be a stand alone development. • The roadway up to the 'towers' (Webb Hill) is an easement that divides the project in half. • Originally this site was envisioned for 54 lots, but will now be less. • It will be a 'best fit' high end development. • Lots will vary in size from ½ acre up to 6 acres. • The hillside analysis has been done with a drone. • Pointed out the 'isolated and non-significant' areas over 40% that are requested to be removed – explained most are rocks that show up on aerial analysis. • Pointed out "No Build areas" • Explained that a new water tank is required. • New water tank once constructed will be deeded to the City. • There will be a pump station at the base of the development (pumps water up to tank and then gravity pressure to feed homes). • The existing 'irrigation water tank' (for golf course) will be removed as a part

		of this project. A new tank is to be in a relocated location and will be underground. We are working with the Water Department on this. • Developer will pay for the water tank. It is a million gallon tank. • Only about 4 ft. of the tank will be visible above the ground. • Discussed existing trail (Kentucky Lucky). • The trail head will be relocated further up the road and a new parking area will be provided. • Ben pointed out the small cyan dots on the plan which represent the developable pad areas. • During the platting process will show the no disturb areas. • Will minimize the disturbance area. • These will not be typical graded lot pads, they will each be customized. • The CC&R's will contain strict design guidelines.
3.	EB	Will there be one or two HOA's?
4.	BW	There will be just one.
5.	EB	Will you show the largest lot proposed?
6.	BW	Pointed out the 6 acre lot.
7.	JW	Are the no disturb areas in the lots?
8.	BW	Yes
9.	TE	Why is the no disturb areas a part of the lots?
10.	BW	The buyers like it more, they feel they have a bigger lot.
11.	DB	What about fencing?
12.	BW	We were at PSR (Planning Staff Review) meeting yesterday with staff and we discussed fencing. We will propose something like a 42 inch high fence – possibly wrought iron or split rail.
13.	JW	How can this be enforced?
14.	BW	Ben showed examples of lots in Entrada and how they have added fence for no disturb areas. They will have to be surveyed in. We see this as a step after hillside. A survey will set the buildable area.
15.	JW	May have to do similar
16.	JV	Will establish footprint of house, can't grade a flat lot, C&R's will be very restrictive. Custom lots. Harder for contractor to develop. The boulders and rocks are a selling point. Preserve as many as is possible.
17.	JP	Designate the wash out areas
18.	(HSRB)	Discussion of roadway and R.O.W.
19.	BW	• A 50 ft. R.O.W. with a 30 ft. asphalt roadway. • Discussed the round-a-bout • Use for 'traffic calming.' • It is a point where the slopes 'come together.' • There will be a trail along the edge.
20.	JW	Discussed percent of grades
21.	BW	Showed the 'cuts & fills' map. Will not be above 15%, The red = cuts & green = fills.
22.	JW	What about the lot 'staffs'?

23.	JV	They are very 'flat'
24.	TH	Discussed sight distances on road at roun-a-bout
25.	JW	The City has to agree with the development of a round-a-bout (discussed other possible options).
26.	BW	The owners like the look and feel of a round-a-bout
27.	TE	Can mountable curves be used?
28.	BW	Yes they will be used. We want to have the round-a-bout as a 'traffic calming.'
29.	JP	Discussed the idea of the City installing a future 'Viewing Area."
30.	JW	The open space with the original plan. Discussed the rock outcroppings.
31.	BW	• Pointed out on the plan the isolated areas • Lot 33 & 26 discussed • Dual driveway for Lot 32 & 33
32.	TE	Discussed technology (used to create contour map) Discussed how every little dtail is picked up (referring to the non-contiguous and insignificant areas)
33.	EB	Will there be sidewalks? Will there be street lights?
34.	BW	On one side sidewalks are proposed. Low level lighting will be proposed.
35.	JW	The public roads, note that the HOA cannot regulate parking on a public road.
36.	BW	Discussed treatments; there will be no exposed hillside cuts.
37.	JW	The HSRB can specify the type of rocks and colors used to mitigate.
38.	DB	• It will need to blend in naturally • A discussion of how to ensure mitigations occur (in the event if another owner occurs)
39.	JW	The HSRB can recommend conditions that will control that.
40.	DB	I have some concerns; there is no rock fall hazard within this project, but yet adjacent to it, the hillside above Sienna Canyons does have the threat of rock fall. I have safety concerns. How is it mitigated that development will not trigger a rock fall in the adjacent development?
41.	JV	I have to agree 100% This is a concern that needs to be mitigated.
42.	WR	• There is a high hazard of rock fall (into Sienna Canyons) • We've met with a potential excavator • Looking at options (eg. Low impact blast, trench, etc.) • Researching seismology
43.	JW	Staff and HSRB will want to see that mitigation plan.
44.	WR	• May have to crane and pick-up boulders to mitigate • We did not do a 'rock fall study' (nothing on the project side)
45.	DB	Have you considered other locations to bring up the utilities?
46.	BW	We are looking at all options
47.	TH	Pointed out areas on map that can be considered
48.	DB	Note: Dave Had to leave the meeting (prior commitments)
49.	WJ	Discussed a 30 ft. ridgeline setback.
50.	BW	Yes, understood
51.	JW	Staff will want to walk and look at the ridgeline setback and verify it.

52.	TE	Have you considered 'swing the road' more and losing a lot to move further away from the rock fall area?
53.	EB	Note: Ed Baca left
54.	SP	Asked several questions about the proposed wall heights.
55.	BW	It will be seen during final approval (platting); civil plans. A maximum tier is 8 ft. Have to follow City code.
56.	JW	The city ordinance does dictate what can be done.
57.	JV	The owners do not want the stacked rock look. (pointed out in distance other homes and there stacked walls).
58.	JW	The developer needs to accommodate for drainage in the pad. Do not put it into the no-disturb zone.
59.	WJ	Provide a setback area for a drainage area to control
60.	BW	Disturbed area, but reserve for drainage
61.	TH	Discussed the issues that have occurred in 'Paradise Canyon.'
62.	BW	Each lot will have a drainage plan
63.	HSRB	Several discussions about drainage. A rough sketch was drawn of concept.
64.	MG	Discussed the trail
65.	BW	Explained the concept for a trail. It will be 10 ft. wide. It will be meandering and some areas will go out of R.O.W., but will work with the City to formalize how it will work.
66.	HSRB	Discussion of trail L/O
67.	BW	Discussed common areas
68.	AC	Discussed drainage L/O's
69.	JW	Discussed how this site was a 3-way trade and as a result the City allowed a longer staff distance on the subdivision.
70.	TE	I would like to see the "Design Guidelines"; to see the walls, heights, colors, etc. Seeing this will make it easier to determine what approval can be recommended. This proposal should come back again. Especially with the final proposal of how to handle rock fall.
71.	TE	**MOTION**: I make a motion that we 'table' this hillside permit request at this time and await submission of the items we have talked about.
72.	JW	Show the pad areas.
73.	WJ	Remember, we will want to run together at the PC (Planning Commission) meeting and CC (City Council) meeting the hillside permit, preliminary plat, and ZCA (zone change amendment). So, we will have to address al of these issues.
74.	JW	The hillside board has the purvey to review drainage.
75.	HSRB	Brief discussion again about pedestrian safe crossing and how that needs to be mitigated and presented.
76.	JS	**I SECOND the MOTON**
77.	TE	We don't have to meet on site again, we can meet at the City.
78.	JW	The HSRB will need to meet again, but after staff again meets with the reprsentatives and is comfortable with what will be presented.
79.	HSRB	**VOTE** – 4:0 (to table item)

HSRB Motion:

The Hillside Review Board voted to "Table" this request (4:0).

END OF MEETING

(Approx. 10 am)

HILLSIDE REVIEW BOARD
CITY OF ST GEORGE
WASHIHNGTON COUNTY, UTAH
AUGUST 26, 2020

PRESENT: Chairman Dave Black
James Dotson
James Sullivan

CITY STAFF:
Assistant Public Works Director Wes Jenkins
Senior Planner Dan Boles
Development Office Supervisor Brenda Hatch

EXCUSED: Shawn Patten

1. Consider a request for a Hillside Development Permit to allow development of a multi-family housing subdivision to be called "**The Cove**." The property is generally located west of Bluff Street at approximately 300 West and 900 South. The property is currently zoned C-2 (Highway Commercial). The owner is Cove Towers LLC, the applicant is Brent Holdaway, and the representative is Bush & Gudgell, Inc. Case No. 2020-HS-007. (*See 'Meeting Place' exhibit below*).

   Item Representatives Present: Wayne Rogers, Rick Myer, Reed Scow and Brent Holdaway.

   Dan Boles presented the following:

   Dan Boles – We were here last month, can someone from the developer's side explain where we are at?

   Rick Myer – The big thing that changed was the cut of the hill. Instead of doing those crazy walls, we came up with a cross section with Wayne Rogers for how to catch that slope up the hillside quicker. We came out and staked along up the hillside where that daylight line would be.

   Wayne Rogers – Basically the cuts will be 15 to 30 feet max at the toe of that, then we will put an 8-foot rock wall at the bottom. It will have an exposed bedrock face for a short 10- or 15-foot max distance with a short wall at the top with a catch behind it for drainage. The only place drainage really gets heavy is just right here where you can see, we will have a catch up there to get it down into the parking and drain system. The way the buildings are designed through there most of the cuts behind the building, the exposed bedrock will be hidden behind the building.

Wes Jenkins – So you'll have an 8-foot rock wall and then a bedrock slope?

Wayne Rogers – Yes. That's stable its rock, it's not superficial stuff or blue clay. Our landslide deposit right there was superficial, more of a surface material came off and we've already addressed that.

Wes Jenkins – Remind me how you addressed that?

Wayne Rogers – Just that it wasn't a concern. That was the conclusion. You can see where the stakes start and go up, they don't even exceed the disturbed zone. Basically, catch the disturb zone all the way through and then just a little above the disturb zone on the left. Matching where are test pits are, it's bedrock everywhere but right in the drainage which is the flatter zone right there. That's where we will catch, our upper wall right through there may end up being about an 8-foot wall to just to make that stable. We will just have to follow that bedrock surface as we come around.

Dave Black – I think when we met last time, we had given them the direction that we hoped they could limit their cuts to the disturbed area and I think they have done that.

Wayne Rogers – The way we did it before I would estimate we were going about 30 feet up the slope last time. This time it is a lot less. That was the direction we got last time.

James Sullivan – From the tests you've done then you'll be in bedrock most of the time?

Wayne Rogers – Yes, we did 4 along that face up there and we hit bedrock at 3 feet, 1 foot, 7 feet and 3 feet. The 7 feet is right back in there where the drainage is. As you can see the cuts are anticipated, there shouldn't be a whole lot of surprises with that. Stability wise it should be good because it is bedrock.

Dave Black – On your wall detail, you show some gunite on the upper wall. But I wonder if you want to incorporate something like that on the lower one. It's facing on rock.

Wayne Rogers – The reason we didn't, and I don't disagree with you on that, is because the area of the influence of water from that is just right here. There is not a lot of water that's going to get through that one, where this one here has the whole slope coming down to it.

Dave Black – I wonder if we have a 30-foot wall if we need some type of a safety fence or something behind it? I don't know if you envision anyone getting behind it. Maybe T posts with wire stretched through, see through not visible like in Horseman Park.

Wayne Rogers – If there was a trail behind it, I think it would be a must.

Rick Meyer – One of the big differences between this one and the one at Horseman's Park is that it's kind of flattish up on top, right, so if you have someone riding a 4-wheeler, then you might not see it until they are right on it.

James Dotson - It would take some effort to get down to this one.

Rick Meyer – I think when we get it constructed up there and it looks like there is a hazard, we will try to be safe. I would just put that as a note, something to look at during construction. If we get up there and it looks like there is a place for people to walk or hike behind it then let's address it.

Dave Black – Maybe something along the power pole area where the stakes are.

Wes Jenkins – So that's not even part of your project?

Wayne Rogers – No I don't think so, maybe where that road comes across, we could put a little fence right there.

James Dotson – Do you anticipate that cut slope in that section, in the best-case scenario, what happens when you get to these changes in grade across there? That bedrock is going to change the depth. What if you get there and there is not bedrock? But now we've got a big cut. How are you going to deal with that? Does the top wall just get taller?

Wayne Rogers – Yes, that is why this says varies on top. I don't see us having to do a two tier at the bottom because we will be down into the cut so far that we know we will be at bedrock down at the bottom. The top is why it says varies. And again, we had the one test that said 7 feet. So it may go up to 7 feet, the others were all 1 to 3 feet so we will pick them up really shallow. We would just modify the height of the wall if needed.

James Dotson – And fill behind it?

Wayne Rogers – Yes.

Wes Jenkins – So you don't see yourself ever needing to go above the non-disturb line?

Wayne Rogers – That's the goal. If the wall changes it's going to go lower, the zone in the middle is going to get less. The top is set, the slope of that is such that we are probably a little bit flatter than a wall, so it won't go up in slope anymore.

James Dotson – So you won't see a clean-cut line, that wall is going to get shorter and then it may come across there?

Wayne Rogers – Yes you will have the bottom one that comes around the base of it and it's going to change as the slope changes. It's not the straight square thing that I always like.

Dave Black – Are you using boulders or stacked block?

Wayne Rogers – Rock.

James Dotson - And you can go 8 feet with those?

Wayne Rogers – Yes.

Wes Jenkins – So you don't have any geo grid behind that.

Wayne Rogers – On the bottom piece? Because it will be facing bedrock.

Wes Jenkins – So you are saying it's really more of a facing of the bedrock?

Wayne Rogers – Yes it keeps the stability higher than if we stepped that out and put a wall in there. We are trying to keep that slope stable with the natural strength.

Dave Black – I think that since it's limited to the disturbed area it makes a justification for approval. I think you've done a good job.

Wes Jenkins – We do this with all projects, with that exposed face we will require a letter from Wayne at the end indicating that it is a stable slope. We're going steeper than the 2:1, so a letter is required.

Dave Black – The other thing we talked about is some type of statement that the rock fall hazard mitigation is dealt with in the parking area and the set back of the building because it was in the rock fall hazard area.

Wayne Rogers – It runs into the parking lot barely. By the time it comes over that edge and hits.

MOTION: James Sullivan made a motion to recommend approval to Planning Commission and City Council of a Hillside Development Permit for The Cove with the understanding that there will be a letter from AGEC that the slope has been stabilized and mitigated and that the rock fall hazards have been mitigated and taken care of.
SECOND: James Dotson
VOTE:
AYES (3)
Dave Black
James Dotson

James Sullivan
NAYS (0)
Motion Carries unanimous recommend approval

2. Consider a request to amend a Hillside Development Permit for Hillside Professional. Case No. 2020-HS-010.

   Item Representatives Present: Wayne Rodgers and Brandee Walker

   Brandee Walker – Wes asked us to redefine the 30-39%

   Wes Jenkins – Indicated on the map where the areas were that they are considering man made cuts.

   Brandee Walker – Between the two of them if you take off the part that is the natural slope, we are only disturbing 2% that is not the man-made portion.

   Dave Black – So in order to get your site distance what will you need to do?

   Brandee Walker – We curved the parking lot out and pushed the parking back in. It will be nice and flat then we will have the rock wall at the edge of the parking there.

   Wes Jenkins – Her request is that this part of the slope man made and should be counted towards the 30-39%.

MOTION: James Dotson made a motion to recommend approval to Planning Commission and City Council for a Hillside Development Permit for Hillside Professional recognizing that the man made slope should not be counted in the 30-39% and are not part of the continuous topography out there, to allow an increasing in disturbing a little more than the 40%.
SECOND: James Sullivan
VOTE:
AYES (3)
Dave Black
James Dotson
James Sullivan
NAYS (0)
Motion Carries unanimous recommend approval

3. Consider approval of the meeting minutes from July 15, 2020.

MOTION: James Sullivan made a motion to approve the meeting minutes from July 15,

2020.
SECOND: James Dotson
VOTE:
AYES (3)
Dave Black
James Dotson
James Sullivan
NAYS (0)
Motion Carries unanimous recommend