GORDON GEOTECHNICAL ENGINEERING, INC.

REPORT
GEOTECHNICAL STUDY
PROPOSED CREEKSIDE ESTATES
515 CARI LANE
MIDWAY, UTAH

February 27, 2020

Job No. 609-004-20

Prepared for:
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Construction Services Consulting
PO Box 571363
Murray, Utah 84157

Attention: Mr. Pete Skolmoski

Ladies and Gentlemen:

Re: Report
Geotechnical Study
Proposed Creekside Estates
515 Cari Lane
Midway, Utah

1. INTRODUCTION

1.1 GENERAL

This report presents the results of our geotechnical study performed at the site of the proposed Creekside Estates which is located at 515 Cari Lane in Midway, Utah. The general location of the site with respect to major topographic features and existing facilities, as of 1998 and 1999, is presented on Figure 1, Vicinity Map. A detailed location of the site showing existing roadways and surrounding facilities, on an air photograph base, is presented on Figure 2, Area Map. The locations and alignments of photographs taken of the site during the field portion of study are also shown on Figure 2. A more detailed layout of the site showing the proposed lot boundaries and building footprints is presented on Figure 3, Site Plan. The locations of the test pits excavated in conjunction with this study are also presented on Figure 3.

1.2 OBJECTIVES AND SCOPE

The objectives and scope of our study were planned in discussions between Mr. Pete Skolmoski of Construction Services Consulting and Mr. Patrick Emery of Gordon Geotechnical Engineering, Inc. (G^2).

In general, the objectives of this study were to:

1. Accurately define and evaluate the subsurface soil and groundwater conditions across the site.

2. Provide appropriate foundation, earthwork, pavement, and geoseismic recommendations to be utilized in the design and construction of the proposed development.

In accomplishing these objectives, our scope has included the following:

1. A field program consisting of the excavating, logging, and sampling of five test pits at the site.

2. A laboratory testing program.

3. An office program consisting of the correlation of available data, engineering analyses, and the preparation of this summary report.

1.3 AUTHORIZATION

Authorization was provided by returning a signed copy of our professional services agreement No. 20-0102 dated January 2, 2020.

1.4 PROFESSIONAL STATEMENTS

Supporting data upon which our recommendations are based are presented in subsequent sections of this report. Recommendations presented herein are governed by the physical properties of the soils encountered in the exploration test pits, measured and projected groundwater conditions, and the layout and design data discussed in Section 2., Proposed Construction, of this report. If subsurface conditions other than those described in this report are encountered and/or if design and layout changes are implemented, G^2 must be informed so that our recommendations can be reviewed and amended, if necessary.

Our professional services have been performed, our findings developed, and our recommendations prepared in accordance with generally accepted engineering principles and practices in this area at this time.

2. PROPOSED CONSTRUCTION

A seven-lot single-family residential subdivision is planned for the three and one-half-acre site. The proposed structures are anticipated to be two to three levels above grade with a partial- to full-depth basement level. Construction will be of reinforced concrete below grade and woodframe construction above grade. Maximum column and wall loads are projected to be on the order of 40 to 60 kips and 2 to 3 kips per lineal foot, respectively.

Site development will require a minor amount of earthwork in the form of site grading. It is estimated that maximum cuts and fills to achieve design grades will be on the order of three to four feet.

A 435-foot long at-grade roadway terminating in a cul-de-sac will provide access to the lots. Traffic over the pavement will consist of a light to moderate volume of automobiles and light trucks, and some medium-weight trucks.

3. INVESTIGATIONS

3.1 FIELD PROGRAM

In order to define and evaluate the subsurface soil and groundwater conditions across the site, five test pits were excavated to a depths ranging from two to eight and one-half feet below existing grade. It should be noted that excavation refusal was encountered on hard hot spring deposits (tufa) at all test pits except for Test Pit TP-5. The limited depth of Test Pit TP-5 was due to saturated granular soils flowing into the test pit. Locations of the test pits are presented on Figure 3.

The field portion of our study was under the direct control and continual supervision of an experienced member of our geotechnical staff. During the course of the excavation operations, a continuous log of the subsurface conditions encountered was maintained. In addition, relatively undisturbed and small disturbed samples of the typical soils encountered were obtained for subsequent laboratory testing and examination. The soils were classified in the field based upon visual and textural examination. These classifications have been supplemented by subsequent inspection and testing in our laboratory. Detailed graphical representation of the subsurface conditions encountered is presented on Figures 4A through 4E, Log of Test Pits. Soils were classified in accordance with the nomenclature described on Figure 5, Unified Soil Classification System.

Disturbed bag samples were collected from the soils brought up by the backhoe bucket. Additionally, relatively undisturbed samples were obtained utilizing thin-walled hand sampling equipment.

Following completion of excavating and logging, each test pit was backfilled. The backfill was not placed in uniform lifts and compacted to a specific density. Consequently, settlement of the backfill with time is likely to occur.

3.2 LABORATORY TESTING

3.2.1 General

In order to provide data necessary for our engineering analyses, a laboratory testing program was performed. The program included collapse-consolidation tests, partial gradation, and chemical tests. The following paragraphs describe the tests and summarize the test data.

3.2.2 Collapse-Consolidation Tests

In order to assess moisture sensitivity and load deformation characteristics, two collapse-consolidation tests were performed on representative samples of the relatively fine-grained silty sand and sandy silt soil encountered in Test Pits TP-1 and TP-2. The collapse test was performed as follows:

1. Load sample at in-situ moisture content to specific axial pressure.
2. Measure and record axial deflection.
3. Saturate sample.
4. Measure and record resulting collapse.

The test results are tabulated below:

Test Pit No.	Depth (feet)	Soil Classification	Natural Dry Density (pcf)	Natural Moisture Content (percent)	Axial Load When Saturated (psf)	Collapse (percent)
TP-1	3.0	SM	95	10.8	800	0.54*
TP-2	2.5	ML	96	8.2	1,600	1.38*

* Some of the measured collapse is due to sample disturbance.

The results of the tests indicate that the silty sand and sandy silt soils encountered at the site to depths of two to six and one-half feet are slightly moisture sensitive and exhibit a slight collapse potential when saturated or nearly saturated. Some of the measured collapse is attributable to disturbance of the soil during the sampling process.

Following the collapse portion of the test, normal consolidation loading was applied. The results of the test indicate that the silty sand and sandy silt soils encountered are moderately overconsolidated and exhibit moderately low compressibility and moderate strength characteristics when loaded below the preconsolidation pressure. Results of the test are maintained within our files and can be provided upon request.

3.2.3 Partial Gradation Tests

To aid in classifying the soils and to provide general index parameters, a partial gradation test was performed upon four representative samples of the soils encountered in the exploration test pits. The results of the test are tabulated below:

Test Pit No.	Depth (feet)	Sieve Percent Passing		Soil Classification
		No. 4	No. 200	
TP-1	5.0	58.6	4.0	SP/GP
TP-2	2.5	--	63.6	ML
TP-4	6.0	--	31.6	SM
TP-5	7.0	44.8	2.5	SP/GP

3.2.4 Chemical Tests

To determine if the site soils will react detrimentally with concrete, chemical tests were performed on a representative sample of the near-surface fine-grained soils encountered. The results of the chemical tests are tabulated below:

Test Pit No.	Depth (feet)	Soil Classification	pH	Total Water-Soluble Sulfate (mg/kg-dry)
TP-3	3.0	CL	8.31	< 5.35

4. SITE CONDITIONS

4.1 SURFACE

The overall site is irregular in shape and contains one existing single-family residential structure established slab-on-grade. The remainder of the site consists of vacant/undeveloped land. The site was covered with four to six inches of snow at the time of our field work. Topography across the site slopes gently down to the south with up to approximately 20 feet of overall relief. Snake Creek flows to the south on the southwestern portion of the site. A stacked rock retaining wall and numerous piles of end-dumped fill material were observed to be raising the grade of the southern portion of the site. The observed fills have not been properly placed and compacted and are considered non-engineered.

The site is bordered by Cari Lane to the north, and single-family residential structures to the east, south, and west.

Representative photographs of the site area are shown on Figure 6, Photographs.

4.2 SUBSURFACE SOIL

The soil conditions encountered in each of the test pits, to the depths penetrated were relatively similar. At the surface in Test Pits TP-4 and TP-5, clayey fine to coarse sand and gravel fill was encountered extending to depths of one and one-half to two and one-half feet below the ground surface. The fill was observed to be loosely end-dumped and without documentation and compaction testing results, the fill must be considered non-engineered. Non-engineered fills will exhibit variable and most likely poor engineering characteristics. This non-engineered fill may be re-utilized as structural fill; however, due to the clay content, the on-site non-engineered fill will require close moisture control and will be difficult during wet and cold periods of the year.

Below the fill Test Pits TP-4 and TP-5, and from the ground surface in the remainder of the test pits, natural soils were encountered to the maximum explored depths, two to eighth and one-half feet below existing grade. The natural soils consist of silty fine sand (SM), fine sandy silt (ML), and fine to coarse sand and gravel with trace silt (SP/GP). Collapse-consolidation tests indicate that the silty sand (SM) and sandy silt (ML) soils are slightly moisture sensitive and exhibit a slight collapse potential when saturated or nearly saturated.

The natural sands and gravels (SP/GP) are slightly moist to saturated, loose to medium dense, and are projected to exhibit high strength and low compressibility characteristics under the anticipated loading range.

Excavation refusal was encountered on hard rock comprised of hot spring deposits calcareous tufa. The tufa is white to light brown in color, moderately closely fractured, porous, hard, and relatively unweathered.

The upper three inches of the soil profile contains major roots and is classified as topsoil.

The lines designating the interface between soil types on the test pit logs generally represent approximate boundaries. In-situ, the transition between soil types may be gradual.

4.3 GROUNDWATER

Groundwater was encountered in Test Pit TP-5, at the lowest portion of the site, at a depth of three feet below existing grade. Very moist soils were encountered in Test Pit TP-4 at a depth of eight feet below existing grade, possibly due to infiltration of water from the nearby creek. Seasonal fluctuations of the groundwater table on the order of one to two feet are expected, with the highest levels occurring during the late spring and early summer months.

5. DISCUSSIONS AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

The proposed structures may be supported upon conventional spread and continuous wall foundations over suitable natural soils or tufa and/or structural fill extending to suitable natural soils or tufa.

The most significant geotechnical aspects of the site are:

1. The non-engineered fill encountered to depths of one and one-half to two and one-half feet at Test Pits TP-4 and TP-5 as well as end-dumped fills observed on the southern portion of the site. Non-engineered fills must be completely removed from beneath the building footprint and rigid pavement areas. Due to the variable nature of the non-engineered fills encountered, a qualified geotechnical engineer from our staff must aid in verifying that all non-engineered fills have been completely removed prior to the placement of structural site grading fills, footings, or foundations.

2. Excavation on refusal on hard tufa at depths of two to eight and one-half feet below existing grade. Deeper excavations into the tufa will be difficult in confined areas. However, in our experience, mass excavations for building footprints are typically feasible with standard excavation equipment. There have been instances in Midway where rock trenching machines were required for utility installation. Due to the porosity of the tufa, rock breakers are typically ineffective.

3. The relatively shallow groundwater encountered at a depth of three feet at Test Pit TP-5. For design groundwater recommendations see Section 5.9, Design Water Table. Groundwater was encountered in Test Pit TP-5 at a depth of three feet below the ground surface at the lowest area of the site. However, it is projected that site grading fill will be utilized to raise the overall grade of the southern portion of the site, where the numerous end-dumped fill piles are currently positioned. For design groundwater recommendations see Section 5.9, Design Water Table.

4. Slightly collapsible soils encountered to depths of two to six and one-half feet at Test Pits TP-1 through TP-4. The silty sand and sandy silt soils encountered at the site are slightly moisture sensitive and exhibit a slight collapse potential when saturated or nearly saturated. Ideally, potentially collapsible soils should be completely removed from below foundations where feasible. However, due to the limited thickness of the slightly collapsible soils encountered, and the relatively low collapse potential, additional settlement upon saturation of the subgrade soils will be within the tolerable range for structures of this type. Therefore, footings may be established directly on undisturbed natural soils utilizing a reduced bearing pressure. See Section 5.3.1, Design Data for details.

5. Potential for "perched" groundwater conditions. Due to the potential for "perched" groundwater conditions, foundation subdrains are recommended around below-grade portions of structures.

Detailed discussions pertaining to earthwork, foundations, floor slabs, lateral resistance, pavement, and the geoseismic setting of the site are discussed in the following sections.

5.2 EARTHWORK

5.2.1 Site Preparation

Preparation of the site must consist of the removal of all non-engineered fills, vegetation, loose surficial soils, topsoil, debris, and other deleterious materials from beneath an area extending at least three feet beyond the perimeter of the proposed building, rigid pavement, and exterior flatwork areas.

Non-engineered fills may remain in flexible pavement areas as long as they are properly prepared. Proper preparation will consist of scarifying and moisture conditioning the upper eight inches and recompacting to the requirements of structural fill. However, it should be noted that compaction of fine-grained soils (clays and silts) as structural site grading fill <u>will be very difficult, if not impossible</u>, during wet and cold periods of the year. As an option for proper preparation and recompaction, the upper eight inches of the non-engineered fills may be removed and replaced with granular subbase over proofrolled subgrade. Even with proper preparation, flexible pavements established on non-engineered fills may experience some long-term movements. If the possibility of these movements is not acceptable, these non-engineered fills must be completely removed.

Subsequent to the above operations and prior to the placement of footings, structural site grading fill, or floor slabs, the exposed natural subgrade must be proofrolled by passing moderate-weight rubber tire-mounted construction equipment over the surface at least twice. If any loose, soft, or disturbed zones are encountered, they must be completely removed in footing and floor slab areas and replaced with granular structural fill. If removal depth required is greater than two feet, G^2 must be notified to provide further recommendations. In pavement areas, unsuitable soils encountered during recompaction and proofrolling must be removed to a maximum depth of two feet and replaced with compacted granular structural fill.

5.2.2 Excavations

Groundwater is anticipated to be encountered only in the lowest area of the site at a depth of three feet below existing grade. Temporary construction excavations not exceeding four feet in depth may be constructed with near-vertical sideslopes. If cohesionless granular soils and groundwater are encountered, flatter sideslopes may be required. This condition is anticipated in the area of Test Pit TP-5. Deeper excavations are not anticipated at the site.

Utility trench excavations must be constructed in accordance with OSHA trench safety guidelines.

All excavations must be inspected periodically by qualified personnel. If any signs of instability or excessive sloughing are noted, immediate remedial action must be initiated.

5.2.3 Structural Fill

Structural fill is defined as all fill which will ultimately be subjected to structural loadings, such as imposed by footings, floor slabs, pavements, etc. Structural fill will be required as backfill over foundations and utilities, as site grading fill, and in some areas, as replacement fill below footings. All structural fill must be free of sod, rubbish, topsoil, frozen soil, and other deleterious materials. Structural site grading fill is defined as fill placed over fairly large open areas to raise the overall site grade. For structural site grading fill, the maximum particle size should generally not exceed four inches; although, occasional larger particles, not exceeding six inches in diameter may be incorporated if placed randomly in a manner such that “honeycombing” does not occur and the desired degree of compaction can be achieved. The maximum particle size within structural fill placed within confined areas should generally be restricted to two inches.

The on-site natural silty sand, sandy silt, and non-engineered fill soils may be utilized as structural site grading fill. However, it should be noted that compaction of silty and clayey soils will require close moisture control and will be very difficult if not impossible during wet and cold periods of the year.

To stabilize soft subgrade conditions or where structural fill is required to be placed below a level one foot above the water table at the time of construction, a mixture of coarse gravels and cobbles and/or one and one-half- to two-inch gravel (stabilizing fill) should be utilized. Stabilizing fill may be required in the lowest area of the site.

Non-structural site grading fill is defined as all fill material not designated as structural fill and may consist of any cohesive or granular soils not containing excessive amounts of degradable material.

5.2.4 Fill Placement and Compaction

Structural fill shall be placed in lifts not exceeding eight inches in loose thickness. Structural fills shall be compacted in accordance with the percent of the maximum dry density as determined by the AASHTO[1] T-180 (ASTM[2] D-1557) compaction criteria in accordance with the table below:

Location	Total Fill Thickness (feet)	Minimum Percentage of Maximum Dry Density
Beneath an area extending at least 3 feet beyond the perimeter of the structures	0 to 8	95
Outside area defined above	0 to 6	90
Outside area defined above	6 to 8	92
Road base	-	96

Structural fills greater than eight feet thick are not anticipated at the site.

Subsequent to stripping and prior to the placement of structural site grading fill, the subgrade must be prepared as discussed in Section 5.2.1, Site Preparation, of this report. In confined areas, subgrade preparation should consist of the removal of all loose or disturbed soils.

Non-structural fill may be placed in lifts not exceeding 12 inches in loose thickness and compacted by passing construction, spreading, or hauling equipment over the surface at least twice.

Coarse gravel and cobble mixtures (stabilizing fill), if utilized, shall be end-dumped, spread to a maximum loose lift thickness of 15 inches, and compacted by dropping a backhoe bucket onto the surface continuously at least twice. As an alternative, the fill may be compacted by passing moderately heavy construction equipment or large self-propelled compaction equipment over the surface at least twice. Subsequent fill material placed over the coarse gravels and cobbles shall be adequately placed so that the “fines” are “worked into” the voids in the underlying coarser gravels and cobbles.

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1 American Association of State Highway and Transportation Officials
2 American Society for Testing and Materials

5.2.5 Utility Trenches

All utility trench backfill material below structurally loaded facilities (flatwork, floor slabs, roads, etc.) should be placed at the same density requirements established for structural fill. If the surface of the backfill becomes disturbed during the course of construction, the backfill should be proofrolled and/or properly compacted prior to the construction of any exterior flatwork over a backfilled trench. Proofrolling may be performed by passing moderately loaded rubber tire-mounted construction equipment uniformly over the surface at least twice. If excessively loose or soft areas are encountered during proofrolling, they should be removed to a maximum depth of two feet below design finish grade and replaced with structural fill.

Most utility companies and City-County governments are now requiring that Type A-1 or A-1-a (AASHTO Designation – basically granular soils with limited fines) soils be used as backfill over utilities. These organizations are also requiring that in public roadways the backfill over major utilities be compacted over the full depth of fill to at least 96 percent of the maximum dry density as determined by the AASHTO T-180 (ASTM D-1557) method of compaction. We recommend that as the major utilities continue onto the site that these compaction specifications are followed.

The on-site silty sand and sandy silt soils are not recommended for use as utility trench backfill. Some of the non-engineered fill may be utilized for utility trench backfill provided it meets the requirements stated above.

5.3 SPREAD AND CONTINUOUS WALL FOUNDATIONS

5.3.1 Design Data

The proposed structures may be supported upon conventional spread and continuous wall foundations established upon suitable natural soils or tufa and/or structural fill extending to suitable natural soils or tufa. Under no circumstances shall footings be placed overlying non-engineered fills.

For design, the following parameters are provided with respect to the projected loading discussed in Section 2., Proposed Construction, of this report:

Minimum Recommended Depth of Embedment for Frost Protection	- 42 inches
Minimum Recommended Depth of Embedment for Non-frost Conditions	- 15 inches
Recommended Minimum Width for Continuous Wall Footings	- 18 inches
Minimum Recommended Width for Isolated Spread Footings	- 24 inches
Recommended Net Bearing Pressure for Real Load Conditions	
For footings on suitable natural soils and/or structural fill extending to suitable natural soils	- 1,500 pounds per square foot
For footings established entirely on tufa and/or Structural fill extending to tufa	- 2,500 pounds per square foot
Bearing Pressure Increase for Seismic Loading	- 50 percent*

* Not applicable for edge bearing pressure when the footings are established upon granular soil. Use 25 percent for overturning or other inclined loading.

The term “net bearing pressure” refers to the pressure imposed by the portion of the structure located above lowest adjacent final grade. Therefore, the weight of the footing and backfill to the lowest adjacent final grade need not be considered. Real loads are defined as the total of all dead plus frequently applied live loads. Total load includes all dead and live loads, including seismic and wind.

5.3.2 Installation

Under no circumstances shall the footings be established upon non-engineered fills, loose or disturbed soils, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water. If unsuitable soils are encountered, they must be completely removed and replaced with compacted structural fill.

The width of structural replacement fill below footings should be equal to the width of the footing plus one foot for each foot of fill thickness.

5.3.3 Settlements

Settlements of foundations designed and installed in accordance with the above recommendations and supporting maximum projected structural loads are anticipated to be on the order of one-half of an inch or less. Settlements are expected to occur rapidly with approximately 60 to 70 percent of the settlements occurring during construction.

5.4 FOUNDATION SUBDRAINS

Due to the potential for “perched” groundwater conditions, and to provide additional protection, we recommend the installation of foundation subdrains around footings in partial- and full-depth basement areas.

Foundation subdrains should consist of a four-inch diameter perforated or slotted plastic or PVC pipe enclosed in clean gravel. The invert of a subdrain should be at least two feet below the top of the lowest adjacent floor slab. The gravel portion of the drain should extend two inches laterally and below the perforated pipe and at least one foot above the top of the lowest adjacent floor slab. The gravel zone must be installed immediately adjacent to the perimeter footings and the foundation walls. To reduce the possibility of plugging, the gravel must be wrapped with a geotextile, such as Mirafi 140N or equivalent. Above the subdrain, a minimum four-inch-wide zone of “free-draining” sand and gravel should be placed adjacent to the foundation walls and extend to within two feet of final grade. The upper two feet of soils should consist of a compacted clayey cap to reduce surface water infiltration into the drain. As an alternative to the zone of permeable sand and a prefabricated “drainage board,” such as Miradrain or equivalent, may be placed adjacent to the exterior below grade walls. Prior to the installation of the footing subdrain, the below-grade walls should be dampproofed. The slope of the subdrain should be at least 0.3 percent. The gravel placed around the drain pipe should be clean three-quarters to one-inch minus gap-graded gravel and/or “pea” gravel. The foundation subdrains can be discharged into the area subdrains, storm drains, or other suitable down-gradient location.

5.5 LATERAL RESISTANCE

Lateral loads imposed upon foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the footings and the supporting soils. In determining frictional resistance on fine-grained soils, a coefficient of 0.40 should be utilized. In determining frictional resistance on granular soils, a coefficient of 0.45 should be utilized. Passive resistance provided by properly placed and compacted granular structural fill above the water table may be considered equivalent to a fluid with a density of

300 pounds per cubic foot. Below the water table, this granular soil should be considered equivalent to a fluid with a density of 150 pounds per cubic foot.

A combination of passive earth resistance and friction may be utilized provided that the friction component of the total is divided by 1.5.

5.6 FLOOR SLABS

Floor slabs may be established upon suitable undisturbed natural soils, and/or upon structural fill extending to suitable natural soils. Non-engineered fills and topsoil are not considered suitable. To provide a capillary break, it is recommended that floor slabs be directly underlain by at least four inches of “free-draining” fill, such as “pea” gravel or three-quarters- to one-inch minus clean gap-graded gravel. Settlements of lightly to moderately loaded floor slabs are anticipated to be minor.

5.7 PAVEMENTS

The properly prepared non-engineered fills will exhibit poor engineering characteristics when saturated or nearly saturated. Non-engineered fills and collapsible soils may remain in flexible pavement areas if properly prepared, as stated previously in this report. Rigid pavements shall not be placed overlying non-engineered fills, even if properly prepared. Considering the existing non-engineered fill and sandy silt as the pavement subgrade and the projected traffic, the following pavement sections are recommended:

<u>Primary Roadway Area</u>

(Moderate Volume of Automobiles and Light Trucks,
Light Volume of Medium-Weight Trucks,
and Occasional Heavy-Weight Trucks)
[5 equivalent 18-kip axle loads per day]

<u>Flexible:</u>

3.0 inches	Asphalt concrete
8.0 inches	Aggregate base
Over	Properly prepared natural soils, properly prepared non-engineered fills, and/or structural site grading fill extending to suitable stabilized natural soils.

<u>Rigid:</u>

5.5 inches	Portland cement concrete (non-reinforced)
5.0 inches	Aggregate base
Over	Properly prepared natural soils, and/or structural site grading fill extending to suitable stabilized natural soils.*

* Rigid pavements shall not be placed over non-engineered fills, even if properly prepared.

For dumpster pads, we recommend a pavement section consisting of six and one-half inches of Portland cement concrete, four inches of aggregate base, over properly prepared natural stabilized subgrade or site grading structural fills.

These above rigid pavement sections are for non-reinforced Portland cement concrete. Concrete should be designed in accordance with the American Concrete Institute (ACI) and joint details should conform to the Portland Cement Association (PCA) guidelines. The concrete should have a minimum 28-day unconfined compressive strength of 4,000 pounds per square inch and contain 6 percent ±1 percent air-entrainment.

5.8 GEOSEISMIC SETTING

5.8.1 General

In July 2019, the State of Utah adopted the International Building Code (IBC) 2018 but is still using the International Residential Code (IRC) 2015. The IRC 2015 code includes provisions for seismic design under the IBC 2015 code. The IBC 2015 code determines the seismic hazard for a site based upon 2008 mapping of bedrock accelerations prepared by the United States Geologic Survey (USGS) and the soil site class. The USGS values are presented on maps incorporated into the IBC code and are also available based on latitude and longitude coordinates (grid points).

The structures must be designed in accordance with the procedure presented in Section 1613, Earthquake Loads, of the IBC 2015 edition.

5.8.2 Faulting

Based on our review of available literature, no active faults pass through or immediately adjacent to the site.

5.8.3 Soil Class

Based on our experience in the area, for dynamic structural analysis, the Site Class D - Stiff Soil Profile as defined in Table 20.3-1, Site Classification, of ASCE 7-10 can be utilized.

5.8.4 Ground Motions

The IBC 2015 code is based on 2008 USGS mapping, which provides values of short and long period accelerations for the Site Class B boundary for the Maximum Considered Earthquake (MCE). This Site Class B boundary represents a hypothetical sandstone bedrock surface and must be corrected for local soil conditions. The following table summarizes the peak ground and short and long period accelerations for a MCE event and incorporates a soil amplification factor for a Site Class D soil profile in the second column. Based on the site latitude and longitude (40.5292 degrees north and -111.4830 degrees west, respectively), the values for this site are tabulated below:

Spectral Acceleration Value, T Seconds	Site Class B-C Boundary [mapped values] (% g)	Site Class D [adjusted for site class effects] (% g)
Peak Ground Acceleration (Geo-Mean)	25.7	33.1
0.2 Seconds (Short Period Acceleration)	S_S = 64.2	S_{MS} = 82.6
1.0 Seconds (Long Period Acceleration)	S_1 = 21.4	S_{M1} = 42.2

The IBC 2015 code design accelerations (S_{DS} and S_{D1}) are based on multiplying the above accelerations (S_{MS} and S_{M1}) for the MCE event by two-thirds (⅔).

5.8.5 Liquefaction

The site is located in an area that has been identified by the Utah Geological Survey as having “very low” liquefaction potential. Liquefaction is defined as the condition when saturated, loose, finer-grained sand-type soils lose their support capabilities because of excessive pore water pressure which develops during a seismic event.

Due to the non-liquefiable tufa encountered at the test pit locations, and the coarse nature of the saturated granular soils encountered at Test Pit TP-5, the likelihood of liquefaction at the site during the design seismic event is very low.

5.9 CEMENT TYPES

Laboratory tests indicate that the site soils contain negligible amounts of water-soluble sulfates. Therefore, all concrete which will be in contact with the site soils may be prepared using Type I or IA cement.

5.10 SITE OBSERVATIONS

As stated previously, due to the variable nature of the non-engineered fills encountered, a qualified geotechnical engineer from our staff must aid in verifying that all non-engineered fills have been completely removed prior to the placement of structural site grading fills, footings, or foundations.

5.11 DESIGN INFILTRATION RATE

A conservative design infiltration rate of 30 minutes per inch is recommended for retention basins terminating in the natural silty sand and sandy silt soils encountered. A higher rate may potentially be utilized if infiltration testing is performed in the proposed basin location.

5.12 DESIGN WATER TABLE

The water table of our study was measured at a depth of three feet below existing grade at the lowest portion of the site (Test Pit TP-5). Considering seasonal and long-term groundwater fluctuations, we recommend that a design groundwater table of one foot below existing grade at Test Pit TP-5 be utilized in the design for the structures. Based on the provided topographic survey, this design water table corresponds to an elevation of approximately 5,683 feet. We recommend that all habitable floor slabs be established a minimum of two feet above the design water table.

GORDON GEOTECHNICAL ENGINEERING, INC.

We appreciate the opportunity of providing this service for you. If you have any questions or require additional information, please do not hesitate to contact us.

Respectfully submitted,

Gordon Geotechnical Engineering, Inc.

Jordan K. Culp, State of Utah No. 10975604
Professional Engineer

Reviewed By:

Patrick R. Emery, State of Utah No. 7941710
Professional Engineer

JKC/PRE:sn

Encl.	Figure	1,	Vicinity Map
	Figure	2,	Area Map
	Figure	3,	Site Plan
	Figures	4A	through 4E, Log of Test Pits
	Figure	5,	Unified Soil Classification System
	Figure	6,	Photographs

Addressee (3 + email)

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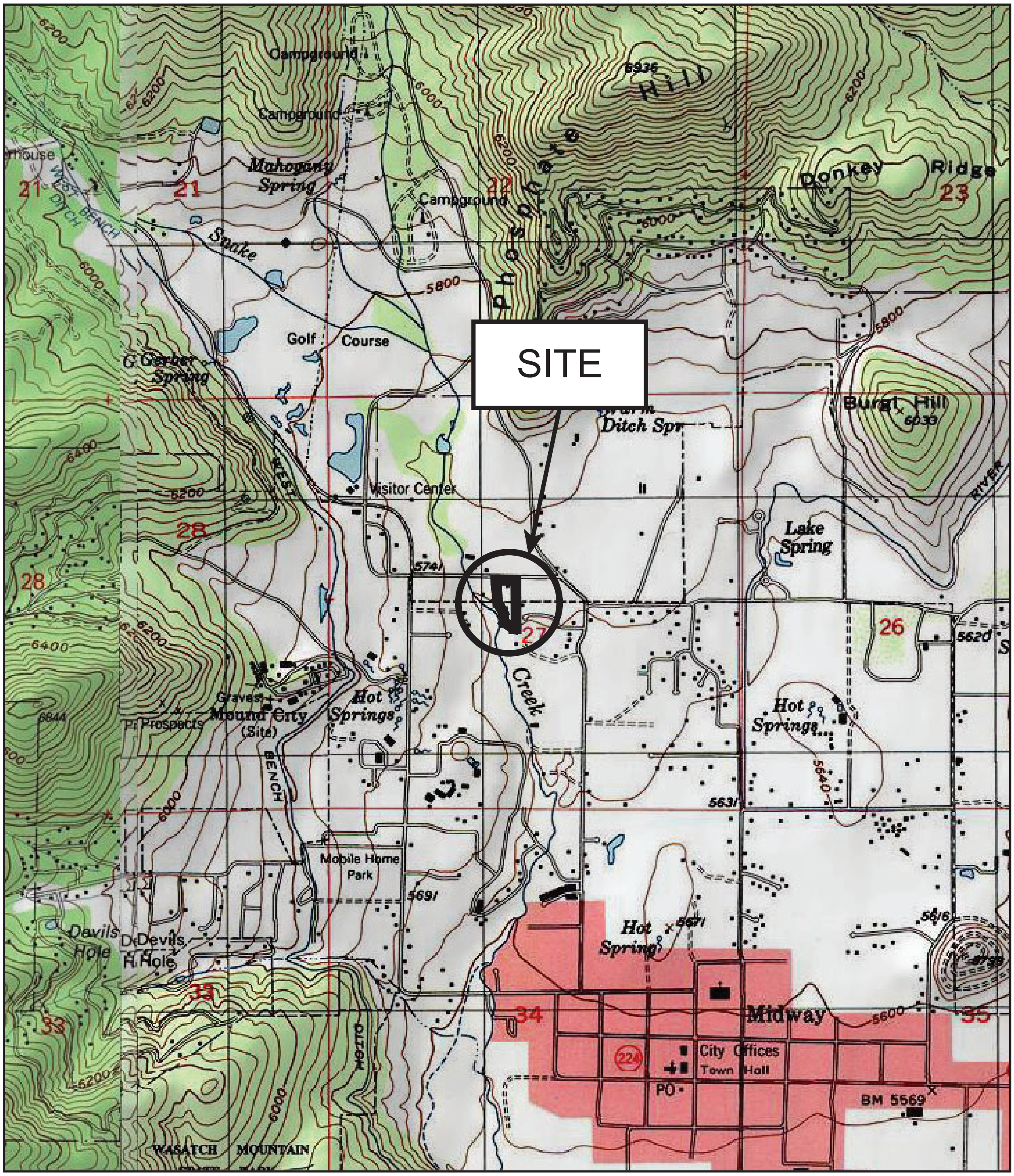
STATE OF UTAH

CONSTRUCTION SERVICES CONSULTING
JOB NO. 609-004-20

GORDON
GEOTECHNICAL
ENGINEERING, INC.



SCALE IN FEET

1000 0 1000 2000

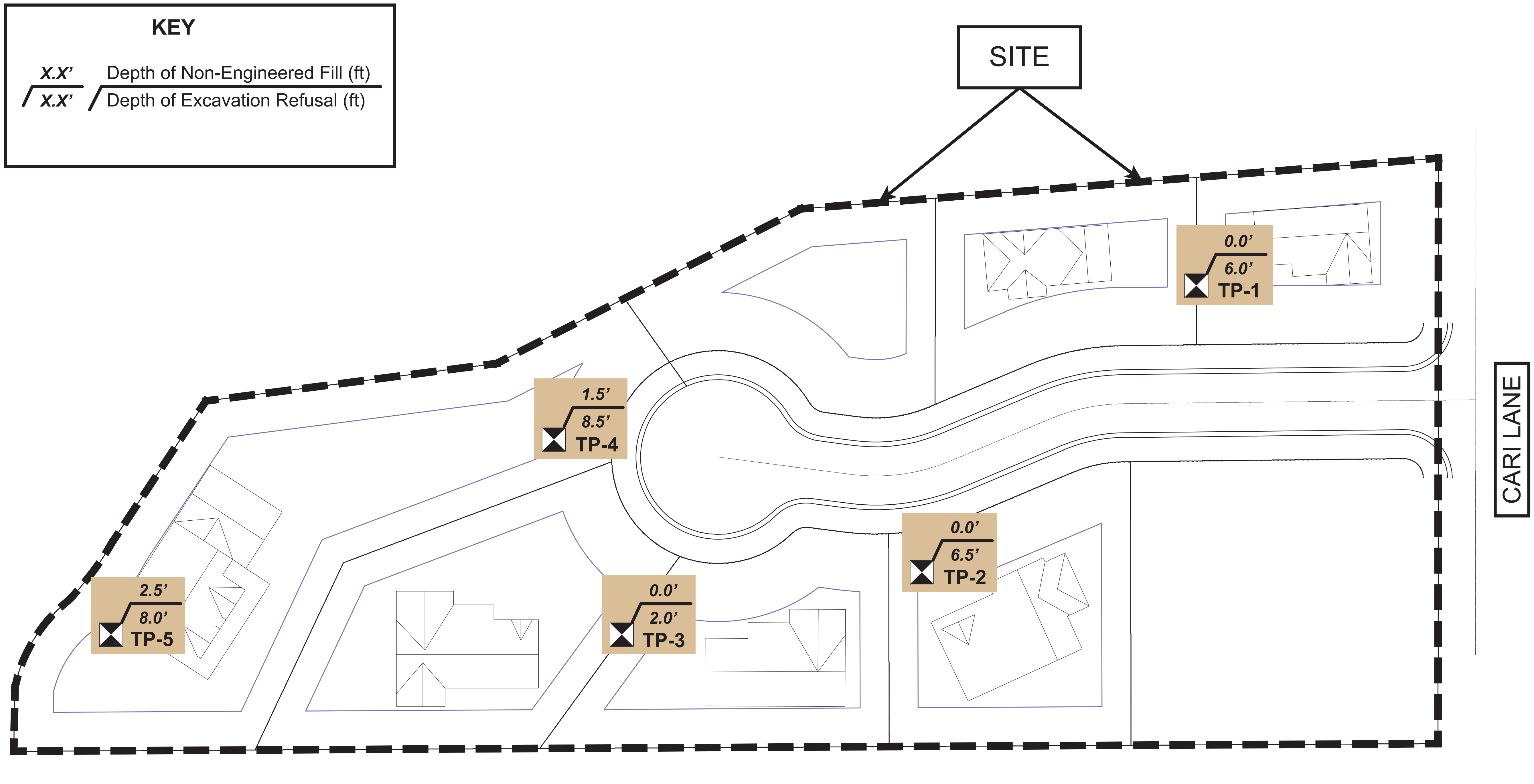
REFERENCE:
USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE MAPS
TITLED “HEBER CITY, UTAH”, DATED 1999 AND
“BRIGHTON, UTAH”, DATED 1998

FIGURE 1
VICINITY MAP

FIGURE 2
AREA MAP

CONSTRUCTION SERVICES CONSULTING
JOB NO. 609-004-20

GORDON GEOTECHNICAL ENGINEERING, INC.



NOT TO SCALE

FIGURE 3
SITE PLAN

REFERENCE:
ADAPTED FROM DRAWING PROVIDED
BY CLIENT, NOT DATED

Gordon Geotechnical Engineering, Inc.
4426 South Century Drive, Suite 100
Salt Lake City, Utah 84123

TEST PIT TP-1

Project Name: Proposed Creekside Estates
Project No.: 609-004-20
Location: 515 Cari Lane, Midway, Utah
Client: Construction Services Consulting
Excavating Method: Kubota KX057
Date Excavated: 01-28-20
Elevation: ---
Water Level: No groundwater encountered.
Remarks:

DESCRIPTION	GRAPHIC LOG	WATER LEVEL	DEPTH (FT.)	SAMPLE SYMBOL	SAMPLE TYPE	BLOWS/FT.	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	REMARKS
SILTY FINE SAND major roots (topsoil) to 3"; light brown (SM)												slightly moist "medium dense"
					TW		10.8	95				
FINE TO COARSE SAND AND FINE AND COARSE GRAVEL with trace silt; light brown (SP/GP)			5		B				4.0			slgithly moist "medium dense"
			10									
			15									
			20									
			25									

Excavation refusal at 6.0' on hard tufa.

Stopped sampling at 5.5'.

No groundwater encountered at time of excavating.

No significant sidewall caving.

The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary for a proper understanding of the nature of the subsurface material.

FIGURE 4A

Gordon Geotechnical Engineering, Inc.
4426 South Century Drive, Suite 100
Salt Lake City, Utah 84123

TEST PIT TP-2

Project Name: Proposed Creekside Estates
Project No.: 609-004-20
Location: 515 Cari Lane, Midway, Utah
Client: Construction Services Consulting
Excavating Method: Kubota KX057
Date Excavated: 01-28-20
Elevation: ---
Water Level: No groundwater encountered.
Remarks:

DESCRIPTION	GRAPHIC LOG	WATER LEVEL	DEPTH (FT.)	SAMPLE SYMBOL	SAMPLE TYPE	BLOWS/FT.	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	REMARKS
FINE SANDY SILT major roots (topsoil) to 3"; light brown (ML)				■	TW		8.3	96	63.6			slightly moist "stiff"/"medium dense"
			5									
Excavation refusal at 6.5' on hard tufa. Stopped sampling at 3.0'. No groundwater encountered at time of excavating. No significant sidewall caving.			10									
			15									
			20									
			25									

The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary for a proper understanding of the nature of the subsurface material.

FIGURE 4B

Gordon Geotechnical Engineering, Inc.
4426 South Century Drive, Suite 100
Salt Lake City, Utah 84123

TEST PIT TP-3

Project Name: Proposed Creekside Estates
Project No.: 609-004-20
Location: 515 Cari Lane, Midway, Utah
Client: Construction Services Consulting
Excavating Method: Kubota KX057
Date Excavated: 01-28-20
Elevation: ---
Water Level: No groundwater encountered.
Remarks:

DESCRIPTION	GRAPHIC LOG	WATER LEVEL	DEPTH (FT.)	SAMPLE SYMBOL	SAMPLE TYPE	BLOWS/FT.	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	REMARKS
SILTY FINE SAND with chunks of tufa; major roots (topsoil) to 3"; brown (SM)					B							
Excavation refusal at 2.0' on hard tufa. Stopped sampling at 1.5'. No groundwater encountered at time of excavating. No significant sidewall caving.			5									
			10									
			15									
			20									
			25									

The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary for a proper understanding of the nature of the subsurface material.

FIGURE 4C

Gordon Geotechnical Engineering, Inc.
4426 South Century Drive, Suite 100
Salt Lake City, Utah 84123

TEST PIT TP-4

Project Name: Proposed Creekside Estates
Project No.: 609-004-20
Location: 515 Cari Lane, Midway, Utah
Client: Construction Services Consulting
Excavating Method: Kubota KX057
Date Excavated: 01-28-20
Elevation: ---
Water Level: No groundwater encountered.
Remarks:

DESCRIPTION	GRAPHIC LOG	WATER LEVEL	DEPTH (FT.)	SAMPLE SYMBOL	SAMPLE TYPE	BLOWS/FT.	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	REMARKS
CLAYEY FINE TO COARSE SAND AND FINE AND COARSE GRAVEL, FILL dark brown (SC/GC-FILL)			0–1.5	◣	B							slightly moist "loose"
SILTY FINE SAND brown (SM)			1.5–8.5									moist "medium dense"
			~6.5	◣	B				31.6			
			~7									very moist

Excavation refusal at 8.5' on hard tufa. Very moist soils possibly due to infiltration from adjacent creek.

Stopped sampling at 6.5'.

No groundwater encountered at time of excavating.

No significant sidewall caving.

Depth scale: 5, 10, 15, 20, 25

The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary for a proper understanding of the nature of the subsurface material.

FIGURE 4D

Gordon Geotechnical Engineering, Inc.
4426 South Century Drive, Suite 100
Salt Lake City, Utah 84123

TEST PIT TP-5

Project Name: Proposed Creekside Estates
Location: 515 Cari Lane, Midway, Utah
Excavating Method: Kubota KX057
Elevation: ---
Remarks:

Project No.: 609-004-20
Client: Construction Services Consulting
Date Excavated: 01-28-20
Water Level: 3.0' (01-28-20)

DESCRIPTION	GRAPHIC LOG	WATER LEVEL	DEPTH (FT.)	SAMPLE SYMBOL	SAMPLE TYPE	BLOWS/FT.	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	REMARKS
CLAYEY FINE TO COARSE SAND AND FINE AND COARSE GRAVEL, FILL dark brown (SC/GC-FILL)												moist "loose"
FINE TO COARSE SAND AND FINE AND COARSE GRAVEL with trace silt; light brown (SP/GP)		▼ (3.0')										saturated "loose"
				◢	B				2.5			

Excavation refusal at 8.0' due to saturated cohesionless granular soil flowing into test pit.

Stopped sampling at 7.5'.

Major sidewall caving.

The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary for a proper understanding of the nature of the subsurface material.

FIGURE 4E

GORDON GEOTECHNICAL ENGINEERING, INC.

UNIFIED SOIL CLASSIFICATION SYSTEM

FIELD IDENTIFICATION PROCEDURES				GRAPH SYMBOL	LETTER SYMBOL [1]	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS More than half of material is larger than No. 200 sieve size. [2] (The No. 200 sieve size is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than No. 4 sieve size. (For visual classifications, the 1/4" size may be used as equivalent to the No. 4 sieve size.)	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.		GW	Well graded gravels, gravel-sand mixtures, little or no fines.
			Predominantly one size or a range of sizes with some intermediate sizes missing.		GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
		GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).		GM	Silty gravels, poorly graded gravel-sand-silt mixtures.
			Plastic fines (for identification procedures see CL below).		GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction is smaller than No. 4 sieve size. (For visual classifications, the 1/4" size may be used as equivalent to the No. 4 sieve size.)	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.		SW	Well graded sands, gravelly sands, little or no fines.
			Predominantly one size or a range of sizes with some intermediate sizes missing.		SP	Poorly graded sands, gravelly sands, little or no fines.
		SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).		SM	Silty sands, poorly graded sand-silt mixtures.
			Plastic fines (for identification procedures see CL below).		SC	Clayey sands, poorly graded sand-clay mixtures.

IDENTIFICATION PROCEDURES ON FRACTION SMALLER THAN No. 40 SIEVE SIZE

		DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)	GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
FINE GRAINED SOILS More than half of material is smaller than No. 200 sieve size. (The No. 200 sieve size is about the smallest particle visible to the naked eye)	SILTS AND CLAYS Liquid limit less than 50	None to slight	Quick to slow	None		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sand with slight plasticity.
		Medium to high	None to very slow	Medium		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		Slight to medium	Slow	Slight		OL	Organic silts and organic silt-clays of low plasticity.
	SILTS AND CLAYS Liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		High to very high	None	High		CH	Inorganic clays of high plasticity, fat clays.
		Medium to high	None to very slow	Slight to medium		OH	Organic clays of medium to high plasticity.
HIGHLY ORGANIC SOILS		Readily identified by color, odor, spongy feel and frequently by fibrous texture.				Pt	Peat and other highly organic soils.

[1] Boundary classifications: —Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW—GC, well graded gravel—sand mixture with clay binder.
[2] All sieve sizes on this chart are U.S. standard.

GENERAL NOTES

1. In general, Unified Soil Classification Designations presented on the logs were evaluated by visual methods only. There rore, actual designations (based on laboratory testing) may differ.

2. Lines seperating strata on the logs represent approximate boundaries only Actual transitions may be gradual.

3. Logs represent general soil conditions observed at teh point of exploration onthe date indicated.

4. No warranty is provided as to the continuity of soil conditions between individual sample locations.

FINE - GRAINED SOIL

CONSISTENCY	SPT (blows/ft)	TORVANE UNDRAINED SHEAR STRENGTH (tsf)	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH (tsf)	FIELD TEST
Very Soft	<2	<0.125	<0.25	Easily penetrated several inches by Thumb. Squeezes through fingers.
Soft	2 - 4	0.125 - 0.25	0.25 - 0.5	Easily penetrated 1 " by Thumb . Molded by light finger pressure.
Medium Stiff	4 - 8	0.25 - 0.5	0.5 - 1.0	Penetrated over 1/2 " by Thumb with moerate effort. Molded by strong finger pressure.
Stiff	8 - 15	0.5 - 1.0	1.0 - 2.0	Indented about 1/2 " by Thumb but penetrated only with great effort
Very Stiff	15 - 30	1.0 - 2.0	2.0 - 4.0	Readily indented by Thumbnail
Hard	>30	>2.0	>4.0	Indented with difficulty by Thumbnail

LOG KEY SYMBOLS

- Bulk / Bag Sample
- Standard Penetration Split Spoon Sampler
- Rock Core
- Water Level
- Thin Wall
- No Recovery
- 3-3/4" ID D&M Sampler
- 3" ID D&M Sampler
- California Sampler

COARSE -GRAINDE SOIL

APPERENT DENSITY	SPT (blows/ft)	RELATIVE DENSITY (%)	FIELD TEST
Very Loose	<4	0 - 15	Easily penetrated with 1/2 " reinforcing rod pushed by hand
Loose	4 - 10	15 - 35	Difficult to penetrated with 1/2 " reinforcing rod pushed by hand
Medium Dense	10 - 30	35 - 65	Easily penetrated a foot with 1/2 " reinforcing rod driven with 5-lb hammer
Dense	30 - 50	65 - 85	Difficult to penetrated a foot with 1/2 " reinforcing rod driven with 5-lb hammer
Very Dense	>50	85 - 100	Penetrated only a few inches with 1/2 " reinforcing rod driven with 5-lb hammer

STRATIFICATION

DESCRIPTION	THICKNESS
SEAM	1/16 - 1/2 "
LAYER	1/2 - 12 "

DESCRIPTION	THICKNESS
Occasional	One or less per foot of thickness
Frequent	More than on per foot of thichness

CEMENTATION

DESCRIPTION	DESCRIPTION
Weakely	Crumbles or breaks with handling of slight finger pressure
Moderately	Crumbles or breaks with considerable finger pressure
Strongly	Will not crumbles or breaks with finger pressure

MODIFIERS

DESCRIPTION	%
Trace	<5
Some	5 - 12
With	>12

MOISTURE CONTENT

DESCRIPTION	FIELD TEST
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible water, usually soil below Water Table

FIGURE 5

GORDON GEOTECHNICAL ENGINEERING, INC.

#1 Looking south along stream.

#2 Looking west.

#3 Looking southeast.

#4 Looking south.

FIGURE 6
PHOTOGRAPHS

Locations and direction, see Figure 2, Area Map

RIMROCK ENGINEERING & DEVELOPMENT

December 12, 2023

To: Midway City Planning Department

Attn: Michael Henke, Floodplain Manager

From: Devin Earl – Rimrock Engineering & Development

RE: Clark Subdivision – Floodplain Development Analysis

Mr. Henke

This memo is regarding the floodplain along Snake Creek for the proposed bridge that will provide a driveway access across Snake Creek for a future residential lot located on current Wasatch County Parcel 00-0006-1817 with a physical address of approximately 535 Cari Lane, Midway, Utah. I have worked with Mr. Clark to complete a site visit and topographic survey of his property, to determine where the additional cross sections should be created to analyze the effects of the proposed bridge.

I received a copy of the FEMA current effective hydraulic model and used that model in HEC-RAS 6.2 software to add the new cross sections necessary to analyze the addition of the bridge. In the current effective model, the river stations for the area we are analyzing ranged from river station 23856.43 to 25040.43 with 23856.43 being the downstream end of the analysis, which is section AP on FEMA FIRM Map 49051C0113E, and section 25040.43 being the upstream end of the analysis which is located just below Cari Lane as section AS shown on the previously referenced FIRM map. The section of river that was analyzed is also shown on FEMA FIS #49051CV000A on panel 40P effective March 15, 2012.

In order to analyze the impact of the new bridge, four new cross sections were added to the model that was previously updated in May of 2023 for the pedestrian bridge located near river station 24620 to create the corrected effective model. The previous model added cross sections being located at river station 24499, 24611, 24626, and 24884 which were unchanged in this analysis. The four new cross sections added to analyze the proposed driveway bridge were added at sections 24239, 24294, 24331, and 24467. The new cross sections were created using a combination of field survey and USGS available LiDAR data. The survey was completed in the North American Vertical Datum of 1988 (NAVD88) and was spatially referenced in the North American Datum of 1983 (NAD83). The LiDAR data used was the USGS one-meter x45y449 UT FEMAHQ B2 QL1 2018 with a publication date of 2020-03-30 which was available within the RAS-Mapper feature of HEC-RAS 6.2. The elevation data within this model are bare earth elevation values referenced to the North American Vertical Datum of 1988 (NAVD88) and are spatially referenced in North American Datum of 1983 (NAD83) which lines up with the survey data.

Three different models were completed and were as follows:

1. Current Effective Model with no changes
2. Corrected Effective Model (adding 8 new cross sections & upstream pedestrian bridge)
3. Proposed Project Model (adding the proposed bridge to the Corrected Effective Model)

The Current Effective Model was run to check the model against the FIRM panel base flood elevations and to make sure the model was working. This model did not have any changes done to it and as such does not have elevations listed for the new cross sections in the area that we are analyzing.

The corrected effective model resulted in the addition of eight cross sections, one structure, and shifted two of the existing cross sections from the current effective model as those two sections improperly had an overlap. The first 4 sections and structure added were from the previous “Completed Project Model” from May of 2023 which analyzed the recently constructed pedestrian bridge. Those cross sections were located at river stations 24884, 24626, 24611, and 24499 with the bridge located at 24620. To analyze any effects from the proposed driveway bridge four additional cross sections were added at river stations 24239, 24294, 24331, and 24467 to create a baseline to see if the proposed structure would cause a rise in the floodplain. When adding the new cross sections there were two existing downstream cross sections located at station 24098.27 and 24181.7 that already overlapped improperly and made it difficult to add the new cross sections as the east side of the creek is on the inside of a bend where the cross sections converge as they are to be perpendicular to the flow path of the flood plain. In order to correct the existing overlap and allow enough room for the new cross sections to not overlap the sections were slightly shifted and cross section 24098.27 became section 24103 and cross section 24181.7 became 24158. When the cross sections were adjusted, the elevations were also updated to match the recent survey so that the information would be as current as possible for the model. When corrected effective model was completed, it showed some changes to the current effective water surface elevations which was to be expected as additional data is being added to the model therefore making it more detailed and is the purpose for creating the corrected effective model. The Corrected Effective model with the new cross sections was used as the new baseline to check for a rise with the proposed project.

The Proposed Project Model was then created using the Corrected Effective Model and adding the proposed driveway bridge at river station 24326 which is to have a clear span of 35-feet and be 24-feet wide. The bridge will not have any negative disturbances in the flood plain as it is proposed to completely span the primary creek channel, and the bottom of the girders are to sit at a minimum of 1-foot above the water surface elevation of the 100-year flood. The abutment on the west side of the creek will be located near the outer edge of the floodplain and the abutment on the east side of the creek will be approximately 25-feet within the floodplain where the flood waters would be expected to be moving slow due to shallow depth and thick existing vegetative cover. The initial modeling resulted in a very slight increase in water surface elevation immediately upstream of the bridge which can be offset by removing small amounts of material within the existing high-water mark in the main channel to create more of a trapezoidal channel with a flat bottom to allow for slightly greater capacity. When the model was updated to account for the minor improvements/removal of material from the channel the result was a slight drop in the floodplain elevations as seen in the Table 1 below. The slight drop in water surface elevation is due to a decrease in the wetted perimeter and the Manning’s roughness coefficients would improve along the bridge abutments which results in an overall slight improvement in flow. It is recommended that the channel grading modifications begin approximately 10-feet upstream from river station 24331 and carry a constant grade to the proposed elevations at river station 24294 for a total length of 47-feet. The cross sections in Appendix C show the proposed grading changes.

Table 1 – Summary of HEC-RAS Results for the 100-Year Flood Event (610 cfs)

River Station	Current Effective Model W.S.E.	Corrected Effective Model W.S.E.	Completed Project Model W.S.E.	Delta W.S.E.
25057.10 CARI LANE	N/A	N/A	N/A	N/A
25040.43	5697.55	5697.54	5697.54	0.00
24971.71	5695.24	5695.37	5695.37	0.00
24884.00	N/A	5694.90	5694.90	0.00
24626.00	N/A	5692.83	5692.83	0.00
24620.00 BRIDGE	N/A	N/A	N/A	N/A
24611.00	N/A	5692.55	5692.55	0.00
24499.00	N/A	5691.58	5691.58	0.00
24467.00	N/A	5691.22	5691.22	0.00
24331.00	N/A	5689.35	5689.34	-0.01
24326.00 DRIVEWAY	N/A	N/A	N/A	N/A
24294.00	N/A	5688.83	5688.82	-0.01
24239.00	N/A	5687.32	5687.32	0.00
24181.70/24158.00	5686.24	5686.90	5686.90	0.00
24098.27/24103.00	5685.76	5686.30	5686.30	0.00
24058.81	5685.32	5685.28	5685.28	0.00
24047.94	5685.05	5685.05	5685.05	0.00
23998.78	5684.64	5684.64	5684.64	0.00
23856.43	5683.16	5683.17	5683.17	0.00

In summary the proposed bridge along with minor grading in the channel will result in **zero rise** to the base flood elevation at any point upstream or downstream of the project. The HEC-RAS result tables & profiles, proposed grading profiles, and the FEMA Firmette & FIS profile have been attached as appendices to this report. Copies of the HEC-RAS model may be obtained upon request. A state stream alteration permit will need to be obtained prior to work beginning within the stream banks.

It should also be noted that development outside the designated floodway, but within the floodway fringe, is acceptable if it does not increase the base flood elevation by more than one foot. Please see the FEMA *Guidance for Flood Risk Analysis and Mapping*, *November 2021* section 2.1 for additional information. Furthermore, it should be noted that the model is completed assuming that the stream channel both upstream and downstream of the project are free of debris or other blockages.

If any additional information is needed or for any questions, please feel free to reach me by phone at 801-664-2947 or by email at dearl@re-n-d.com.

Thank you,

Devin Earl, P.E.

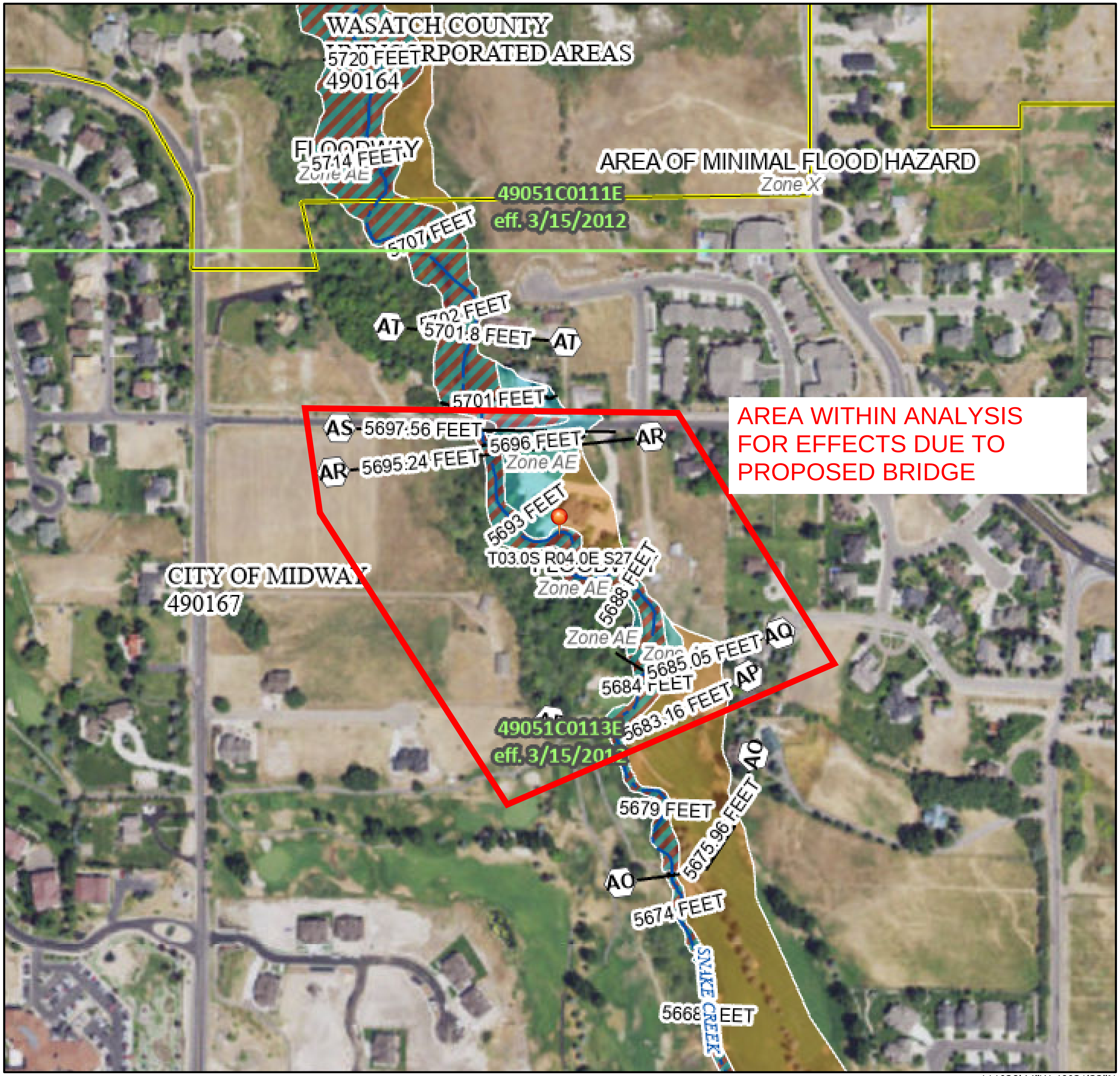
PROFESSIONAL ENGINEER
11623310
DEVIN SCOTT EARL
12/12/23
STATE OF UTAH

Appendix A - FEMA DATA

National Flood Hazard Layer FIRMette

FEMA

111°29'22"W 40°31'59"N



111°28'44"W 40°31'32"N

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

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

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
- B 20.2 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- 8 Coastal Transect
- 513 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

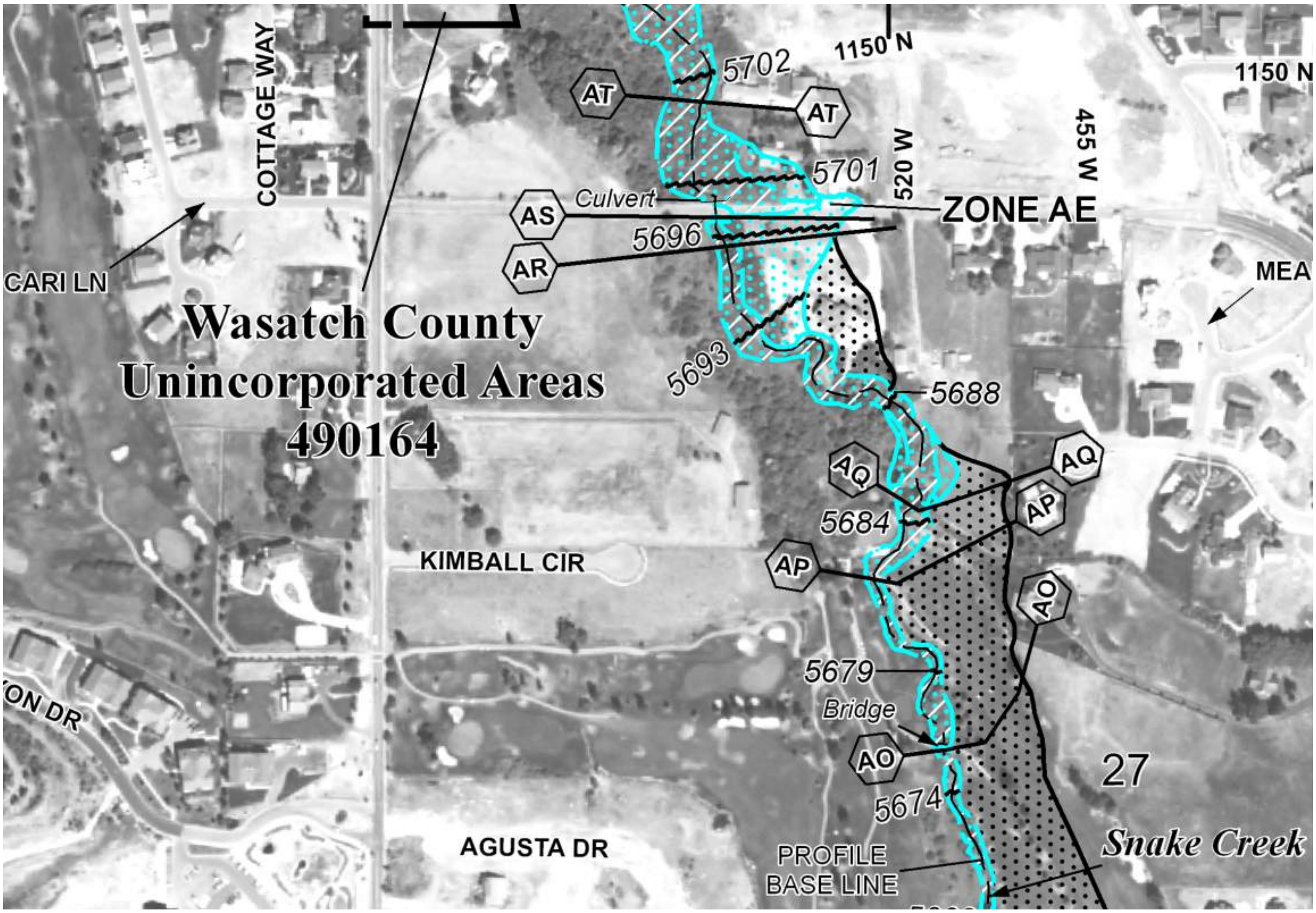
N

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 5/11/2023 at 2:45 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.



SCREENSHOT OF FIRM PANEL 49051C0113E FOR PROJECT AREA

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Snake Creek								
AA	14,449	26	81	7.7	5,548.0	5,548.0	5,548.0	0.0
AB	15,672	95	124	5.1	5,566.1	5,566.1	5,566.2	0.1
AC	16,460	123	173	3.6	5,576.9	5,576.9	5,577.7	0.8
AD	17,023	47	77	8.1	5,585.5	5,585.5	5,585.5	0.0
AE	17,378	25	110	6.1	5,588.3	5,588.3	5,588.6	0.3
AF	17,925	49	128	4.8	5,596.4	5,596.4	5,597.2	0.8
AG	18,388	58	77	10.3	5,603.7	5,603.7	5,603.7	0.0
AH	18,476	88	124	5.8	5,606.7	5,606.7	5,606.8	0.1
AI	19,574	121	134	5.1	5,615.5	5,615.5	5,615.5	0.0
AJ	19,698	55	117	5.5	5,616.3	5,616.3	5,616.6	0.3
AK	20,648	23	63	10.0	5,625.8	5,625.8	5,625.9	0.1
AL	21,630	18	66	9.3	5,637.3	5,637.3	5,637.5	0.2
AM	22,183	86	110	5.6	5,654.4	5,654.4	5,654.5	0.1
AN	22,495	42	85	7.2	5,657.7	5,657.7	5,657.8	0.1
AO	23,382	26	72	8.5	5,676.0	5,676.0	5,676.1	0.1
AP	23,856	34	91	6.7	5,683.2	5,683.2	5,683.2	0.0
AQ	24,048	79	158	4.7	5,685.1	5,685.1	5,685.1	0.0
AR	24,972	44	104	5.9	5,695.2	5,695.2	5,695.9	0.7
AS	25,040	12	59	10.4	5,697.6	5,697.6	5,697.6	0.0
AT	25,324	88	171	3.6	5,701.8	5,701.8	5,701.8	0.0
AU	26,877	54	88	6.9	5,731.5	5,731.5	5,731.5	0.0
AV	28,232	82	85	9.4	5,753.8	5,753.8	5,753.8	0.0
AW	28,369	35	84	10.6	5,756.3	5,756.3	5,756.3	0.0
AX	28,466	63	192	3.2	5,760.6	5,760.6	5,761.0	0.4

[1] Feet above Confluence with Middle Provo River

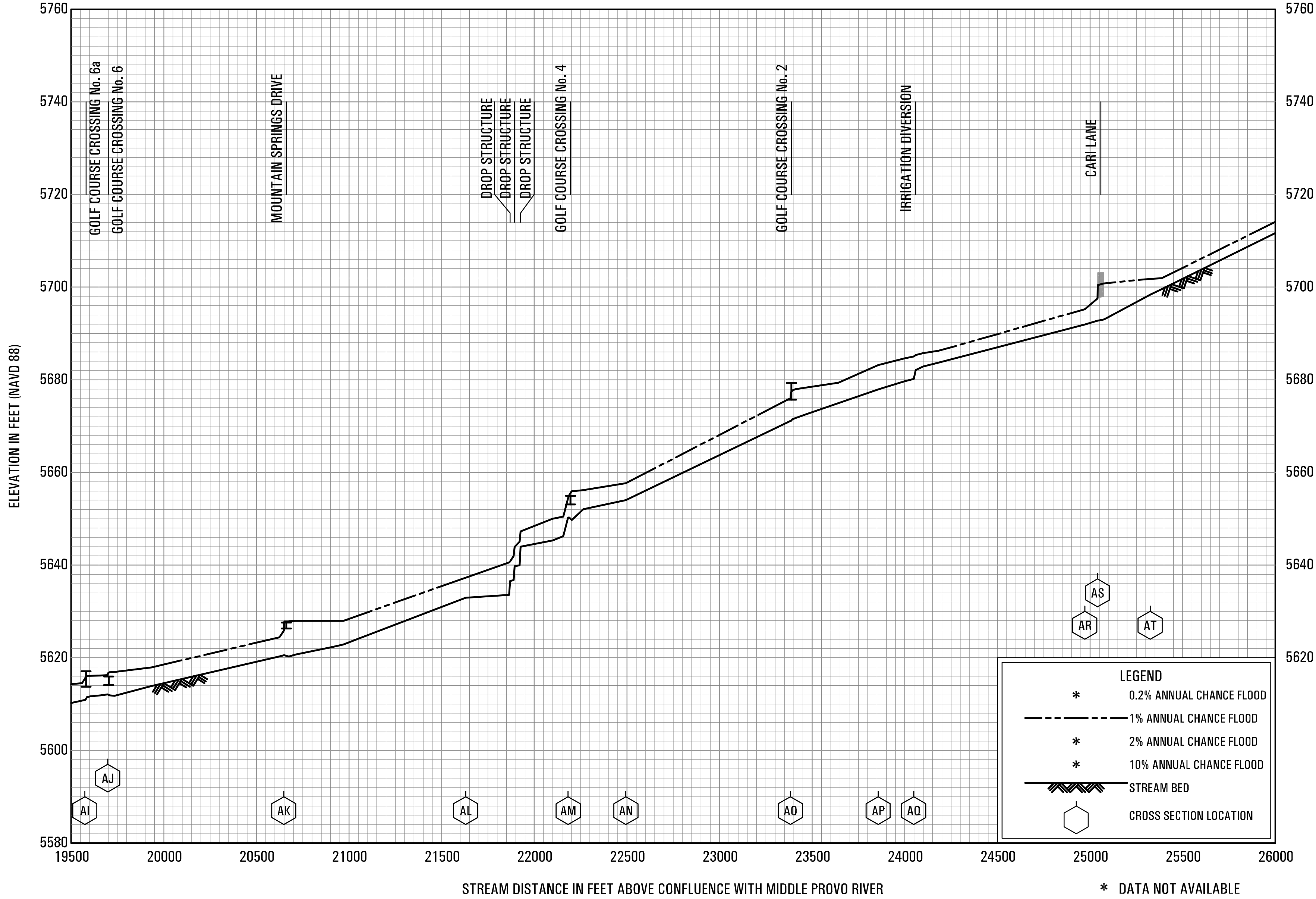
TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

WASATCH COUNTY AND INCORPORATED AREAS

FLOODWAY DATA

SNAKE CREEK



FLOOD PROFILES

SNAKE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

WASATCH COUNTY, UT

AND INCORPORATED AREAS

Appendix B - HEC-RAS Results

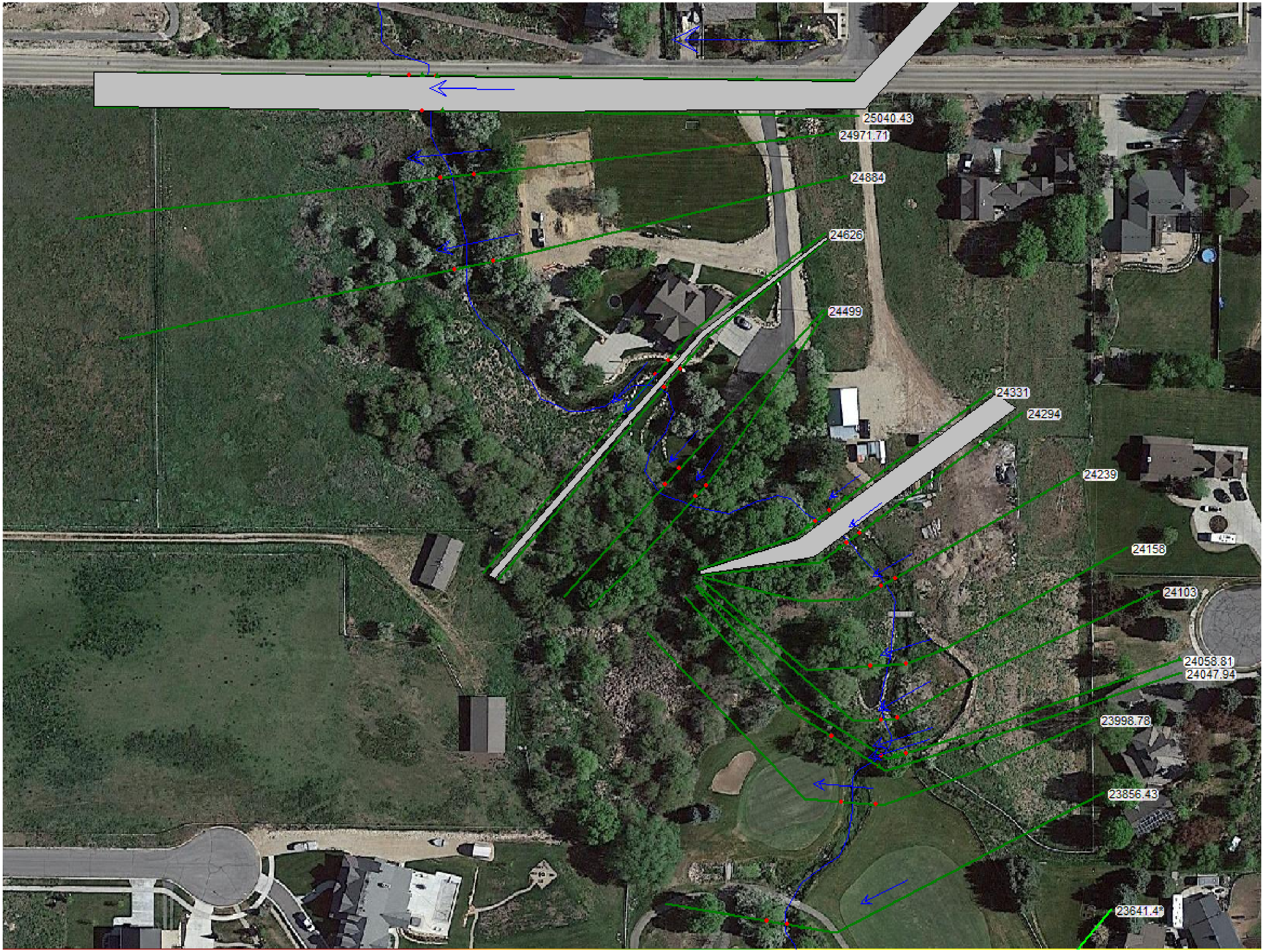
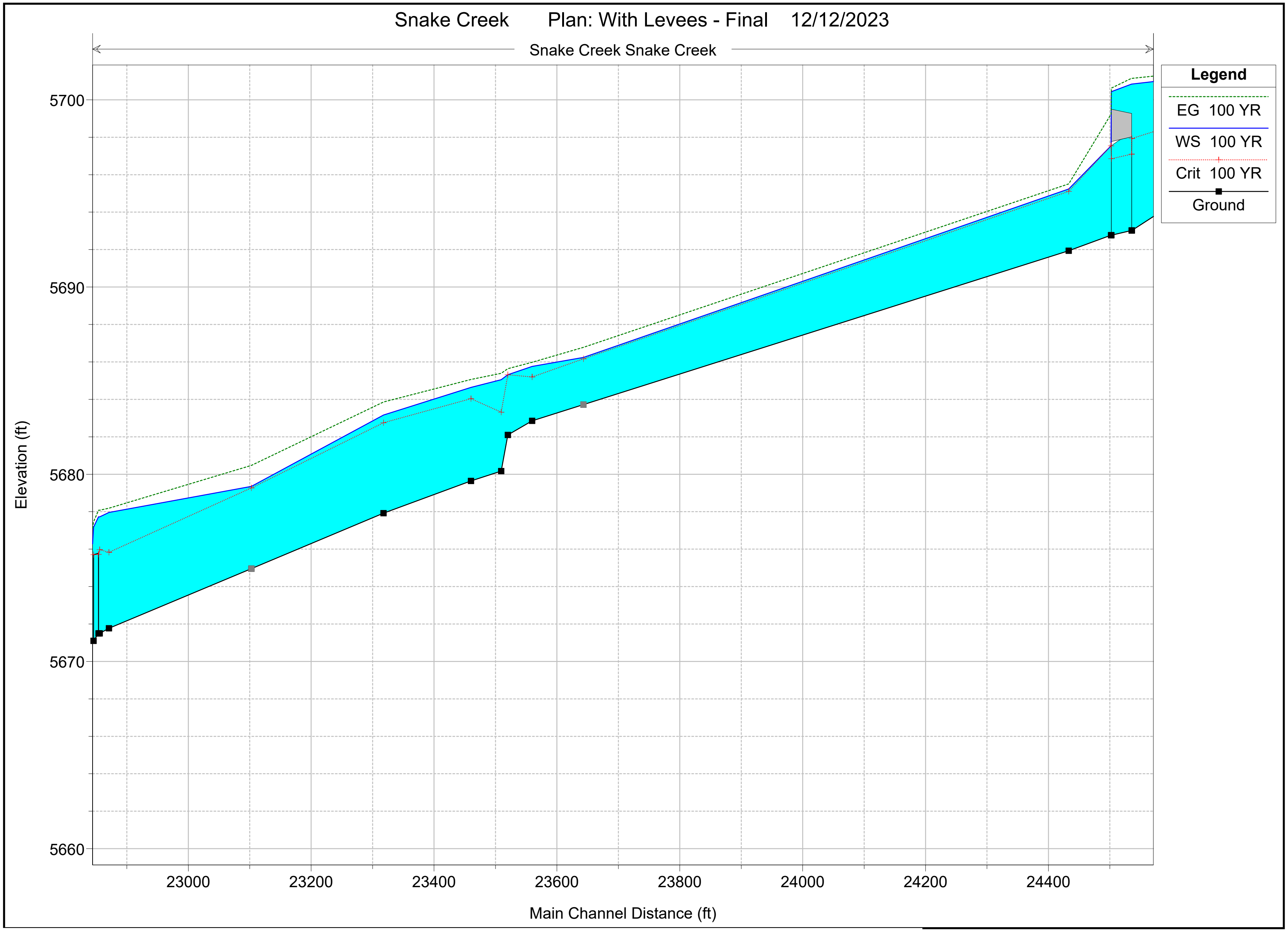


IMAGE 1 - FLOOD ANALYSIS AREA OVERVIEW

HEC-RAS Plan: WLevee Final Locations: User Defined Profile: 100 YR

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Snake Creek	Snake Creek	25040.43	100 YR	610.00	5692.77	5697.55	5697.55	5699.24	0.025786	10.43	58.49	17.49	1.01
Snake Creek	Snake Creek	24971.71	100 YR	610.00	5691.94	5695.24	5695.11	5695.51	0.008277	5.14	214.00	253.53	0.60
Snake Creek	Snake Creek	24181.7*	100 YR	610.00	5683.72	5686.24	5686.16	5686.78	0.015447	6.24	122.80	124.15	0.80
Snake Creek	Snake Creek	24098.27	100 YR	610.00	5682.85	5685.76	5685.20	5685.98	0.005305	4.19	195.32	166.79	0.49
Snake Creek	Snake Creek	24058.81	100 YR	610.00	5682.10	5685.32	5685.32	5685.64	0.020207	5.14	171.52	275.84	0.70
Snake Creek	Snake Creek	24047.94	100 YR	610.00	5680.17	5685.05	5683.31	5685.39	0.006096	4.72	129.27	248.24	0.52
Snake Creek	Snake Creek	23998.78	100 YR	610.00	5679.64	5684.64	5684.04	5685.07	0.006940	5.51	128.95	247.41	0.56
Snake Creek	Snake Creek	23856.43	100 YR	610.00	5677.92	5683.16	5682.75	5683.86	0.009931	6.95	93.12	334.02	0.62

MODEL 1 - CURRENT EFFECTIVE MODEL SIMULATION RESULTS TABLE

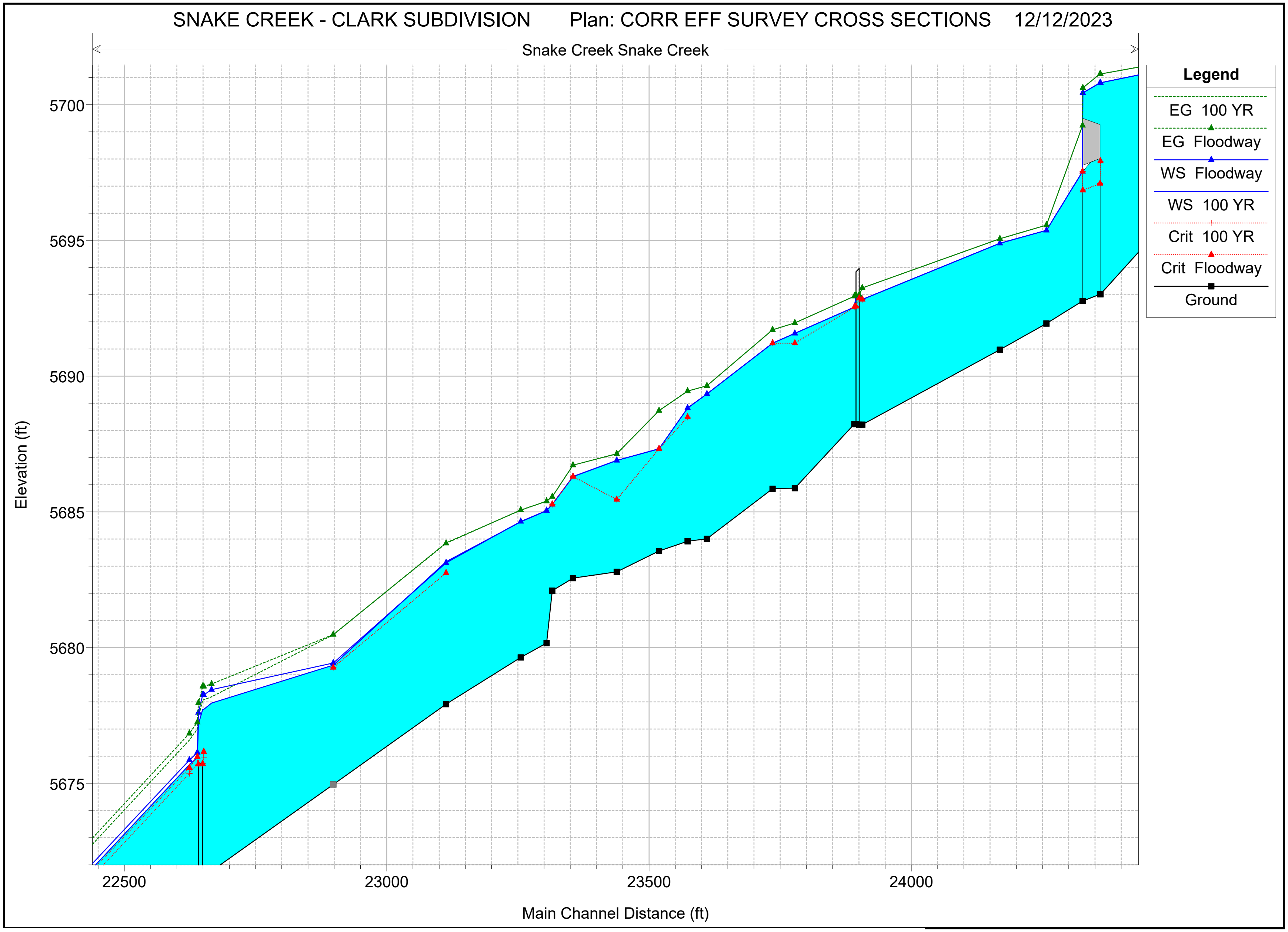


MODEL 1 - CURRENT EFFECTIVE MODEL STREAM PROFILE

HEC-RAS Plan: 12-12 CORR EFF Locations: User Defined Profile: 100 YR

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Snake Creek	Snake Creek	25040.43	100 YR	610.00	5692.77	5697.54	5697.54	5699.24	0.025807	10.43	58.47	17.49	1.01
Snake Creek	Snake Creek	24971.71	100 YR	610.00	5691.94	5695.37		5695.57	0.005732	4.44	248.88	263.49	0.51
Snake Creek	Snake Creek	24884	100 YR	610.00	5690.97	5694.90		5695.07	0.005338	3.94	209.43	252.03	0.47
Snake Creek	Snake Creek	24626	100 YR	610.00	5688.22	5692.83	5692.83	5693.25	0.009041	6.31	180.00	190.43	0.60
Snake Creek	Snake Creek	24620		Bridge									
Snake Creek	Snake Creek	24611	100 YR	610.00	5688.24	5692.55	5692.55	5692.95	0.008841	6.06	174.20	194.66	0.62
Snake Creek	Snake Creek	24499	100 YR	610.00	5685.87	5691.58	5691.22	5691.96	0.005270	5.68	212.89	190.74	0.51
Snake Creek	Snake Creek	24467	100 YR	610.00	5685.86	5691.22	5691.22	5691.71	0.006412	6.77	236.47	254.77	0.58
Snake Creek	Snake Creek	24331	100 YR	610.00	5684.01	5689.35		5689.65	0.002989	4.70	168.98	93.21	0.39
Snake Creek	Snake Creek	24294	100 YR	610.00	5683.92	5688.83	5688.49	5689.45	0.007526	7.15	135.95	96.73	0.62
Snake Creek	Snake Creek	24239	100 YR	610.00	5683.56	5687.32	5687.32	5688.73	0.020983	10.17	71.50	37.58	0.99
Snake Creek	Snake Creek	24158	100 YR	610.00	5682.79	5686.90	5685.46	5687.14	0.003091	4.25	193.37	135.07	0.40
Snake Creek	Snake Creek	24103	100 YR	610.00	5682.56	5686.30	5686.30	5686.72	0.008347	6.44	168.75	173.06	0.62
Snake Creek	Snake Creek	24058.81	100 YR	610.00	5682.10	5685.28	5685.28	5685.56	0.024208	5.53	160.78	274.22	0.76
Snake Creek	Snake Creek	24047.94	100 YR	610.00	5680.17	5685.05		5685.39	0.006096	4.72	129.27	248.24	0.52
Snake Creek	Snake Creek	23998.78	100 YR	610.00	5679.64	5684.64		5685.06	0.006945	5.51	128.92	247.39	0.56
Snake Creek	Snake Creek	23856.43	100 YR	610.00	5677.92	5683.17	5682.75	5683.86	0.009902	6.94	93.21	334.12	0.62

MODEL 2 - CORRECTED EFFECTIVE MODEL SIMULATION RESULTS TABLE

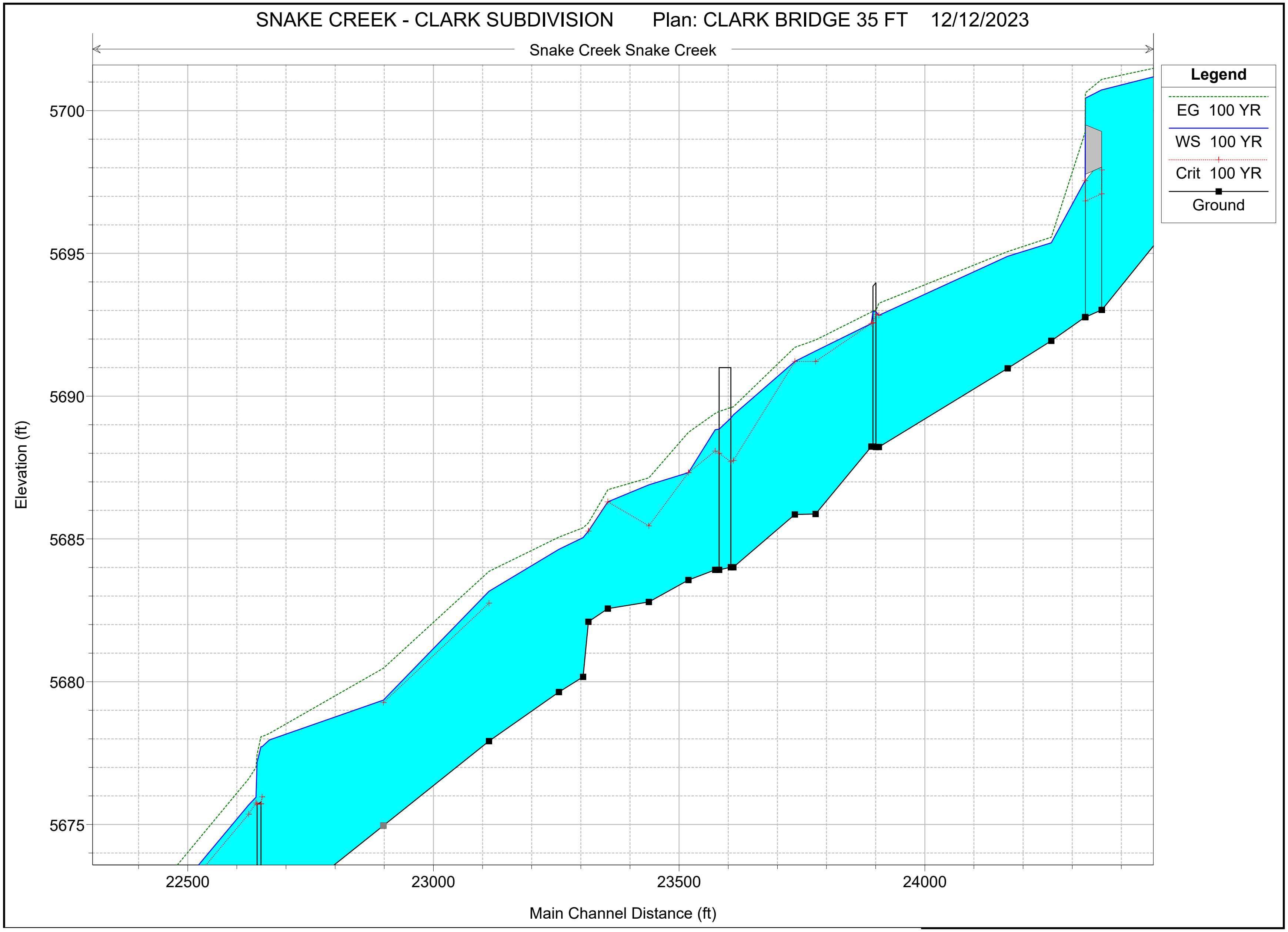


MODEL 2 - CORRECTED EFFECTIVE MODEL STREAM PROFILE

HEC-RAS Plan: CLARK BRIDGE 35FT Locations: User Defined Profile: 100 YR

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Snake Creek	Snake Creek	25040.43	100 YR	610.00	5692.77	5697.54	5697.54	5699.24	0.025807	10.43	58.47	17.49	1.01
Snake Creek	Snake Creek	24971.71	100 YR	610.00	5691.94	5695.37		5695.57	0.005732	4.44	248.88	263.49	0.51
Snake Creek	Snake Creek	24884	100 YR	610.00	5690.97	5694.90		5695.07	0.005338	3.94	209.43	252.03	0.47
Snake Creek	Snake Creek	24626	100 YR	610.00	5688.22	5692.83	5692.83	5693.25	0.009041	6.31	180.00	190.43	0.60
Snake Creek	Snake Creek	24620		Bridge									
Snake Creek	Snake Creek	24611	100 YR	610.00	5688.24	5692.55	5692.55	5692.95	0.008841	6.06	174.20	194.66	0.62
Snake Creek	Snake Creek	24499	100 YR	610.00	5685.87	5691.58	5691.22	5691.97	0.005246	5.67	213.45	190.86	0.50
Snake Creek	Snake Creek	24467	100 YR	610.00	5685.86	5691.22	5691.22	5691.71	0.006412	6.77	236.47	254.77	0.58
Snake Creek	Snake Creek	24331	100 YR	610.00	5684.01	5689.34	5687.74	5689.63	0.002446	4.44	149.35	92.97	0.35
Snake Creek	Snake Creek	24326		Bridge									
Snake Creek	Snake Creek	24294	100 YR	610.00	5683.92	5688.82	5688.08	5689.40	0.006499	6.53	107.12	96.67	0.55
Snake Creek	Snake Creek	24239	100 YR	610.00	5683.56	5687.32	5687.32	5688.73	0.020983	10.17	71.50	37.58	0.99
Snake Creek	Snake Creek	24158	100 YR	610.00	5682.79	5686.90	5685.46	5687.14	0.003091	4.25	193.37	135.07	0.40
Snake Creek	Snake Creek	24103	100 YR	610.00	5682.56	5686.30	5686.30	5686.72	0.008347	6.44	168.75	173.06	0.62
Snake Creek	Snake Creek	24058.81	100 YR	610.00	5682.10	5685.28	5685.28	5685.56	0.024208	5.53	160.78	274.22	0.76
Snake Creek	Snake Creek	24047.94	100 YR	610.00	5680.17	5685.05		5685.39	0.006096	4.72	129.27	248.24	0.52
Snake Creek	Snake Creek	23998.78	100 YR	610.00	5679.64	5684.64		5685.06	0.006945	5.51	128.92	247.39	0.56
Snake Creek	Snake Creek	23856.43	100 YR	610.00	5677.92	5683.17	5682.75	5683.86	0.009902	6.94	93.21	334.12	0.62

MODEL 3 - PROPOSED CONDITIONS MODEL SIMULATION RESULTS TABLE



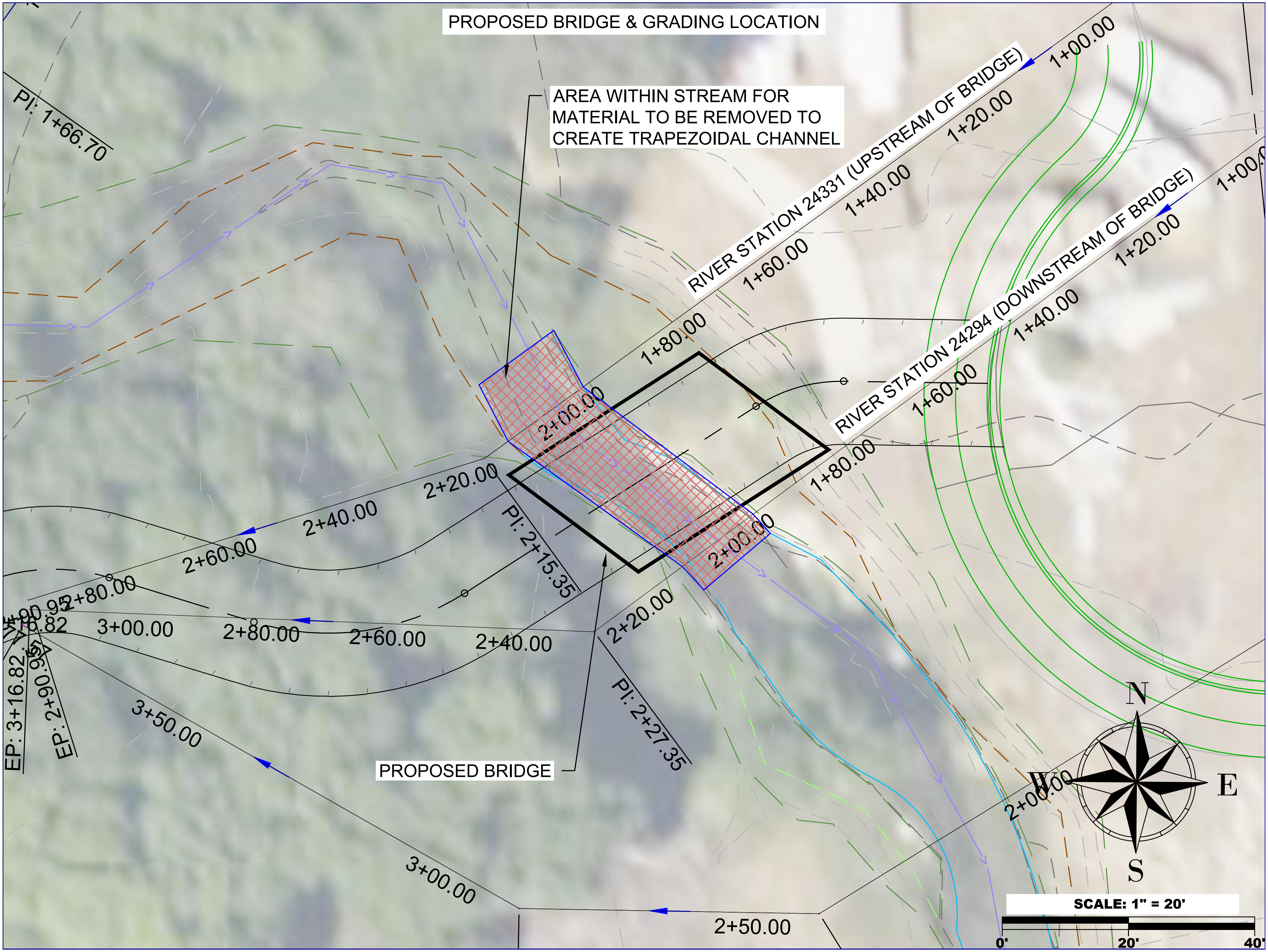
MODEL 3 - PROPOSED CONDITIONS STREAM PROFILE

HEC-RAS Locations: User Defined   Profile: 100 YR

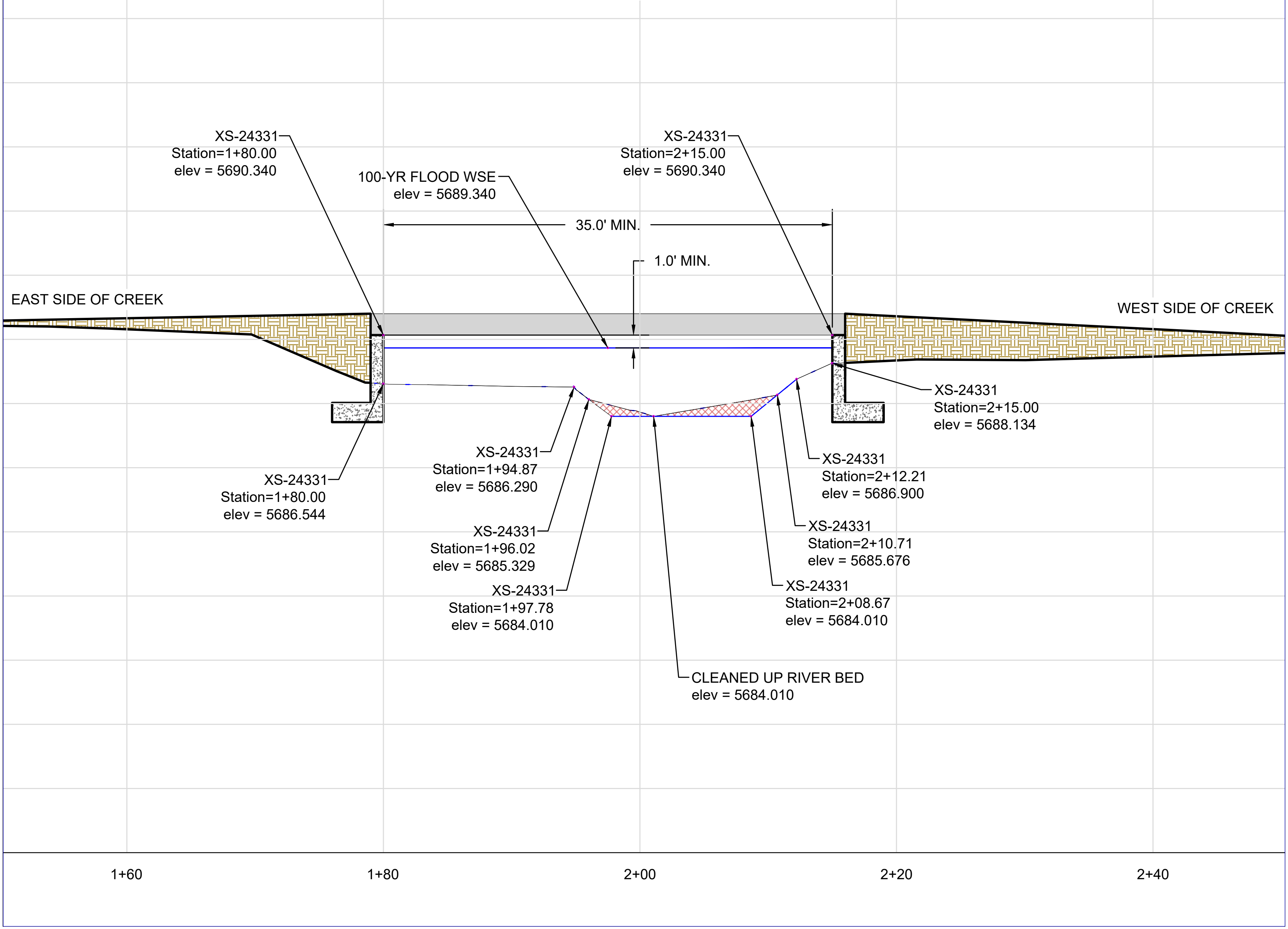
River	Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
					(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Snake Creek	Snake Creek	25040.43	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5692.77	5697.54	5697.54	5699.24	0.025807	10.43	58.47	17.49	1.01
Snake Creek	Snake Creek	25040.43	100 YR	CLARK BRIDGE 35FT	610.00	5692.77	5697.54	5697.54	5699.24	0.025807	10.43	58.47	17.49	1.01
Snake Creek	Snake Creek	24971.71	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5691.94	5695.37		5695.57	0.005732	4.44	248.88	263.49	0.51
Snake Creek	Snake Creek	24971.71	100 YR	CLARK BRIDGE 35FT	610.00	5691.94	5695.37		5695.57	0.005732	4.44	248.88	263.49	0.51
Snake Creek	Snake Creek	24884	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5690.97	5694.90		5695.07	0.005338	3.94	209.43	252.03	0.47
Snake Creek	Snake Creek	24884	100 YR	CLARK BRIDGE 35FT	610.00	5690.97	5694.90		5695.07	0.005338	3.94	209.43	252.03	0.47
Snake Creek	Snake Creek	24626	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5688.22	5692.83	5692.83	5693.25	0.009041	6.31	180.00	190.43	0.60
Snake Creek	Snake Creek	24626	100 YR	CLARK BRIDGE 35FT	610.00	5688.22	5692.83	5692.83	5693.25	0.009041	6.31	180.00	190.43	0.60
Snake Creek	Snake Creek	24620			Bridge									
Snake Creek	Snake Creek	24611	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5688.24	5692.55	5692.55	5692.95	0.008841	6.06	174.20	194.66	0.62
Snake Creek	Snake Creek	24611	100 YR	CLARK BRIDGE 35FT	610.00	5688.24	5692.55	5692.55	5692.95	0.008841	6.06	174.20	194.66	0.62
Snake Creek	Snake Creek	24499	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5685.87	5691.58	5691.22	5691.96	0.005270	5.68	212.89	190.74	0.51
Snake Creek	Snake Creek	24499	100 YR	CLARK BRIDGE 35FT	610.00	5685.87	5691.58	5691.22	5691.97	0.005246	5.67	213.45	190.86	0.50
Snake Creek	Snake Creek	24467	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5685.86	5691.22	5691.22	5691.71	0.006412	6.77	236.47	254.77	0.58
Snake Creek	Snake Creek	24467	100 YR	CLARK BRIDGE 35FT	610.00	5685.86	5691.22	5691.22	5691.71	0.006412	6.77	236.47	254.77	0.58
Snake Creek	Snake Creek	24331	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5684.01	5689.35		5689.65	0.002989	4.70	168.98	93.21	0.39
Snake Creek	Snake Creek	24331	100 YR	CLARK BRIDGE 35FT	610.00	5684.01	5689.34	5687.74	5689.63	0.002446	4.44	149.35	92.97	0.35
		24326		Proposed Bridge										
Snake Creek	Snake Creek	24294	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5683.92	5688.83	5688.49	5689.45	0.007526	7.15	135.95	96.73	0.62
Snake Creek	Snake Creek	24294	100 YR	CLARK BRIDGE 35FT	610.00	5683.92	5688.82	5688.08	5689.40	0.006499	6.53	107.12	96.67	0.55
Snake Creek	Snake Creek	24239	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5683.56	5687.32	5687.32	5688.73	0.020983	10.17	71.50	37.58	0.99
Snake Creek	Snake Creek	24239	100 YR	CLARK BRIDGE 35FT	610.00	5683.56	5687.32	5687.32	5688.73	0.020983	10.17	71.50	37.58	0.99
Snake Creek	Snake Creek	24158	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5682.79	5686.90	5685.46	5687.14	0.003091	4.25	193.37	135.07	0.40
Snake Creek	Snake Creek	24158	100 YR	CLARK BRIDGE 35FT	610.00	5682.79	5686.90	5685.46	5687.14	0.003091	4.25	193.37	135.07	0.40
Snake Creek	Snake Creek	24103	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5682.56	5686.30	5686.30	5686.72	0.008347	6.44	168.75	173.06	0.62
Snake Creek	Snake Creek	24103	100 YR	CLARK BRIDGE 35FT	610.00	5682.56	5686.30	5686.30	5686.72	0.008347	6.44	168.75	173.06	0.62
Snake Creek	Snake Creek	24058.81	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5682.10	5685.28	5685.28	5685.56	0.024208	5.53	160.78	274.22	0.76
Snake Creek	Snake Creek	24058.81	100 YR	CLARK BRIDGE 35FT	610.00	5682.10	5685.28	5685.28	5685.56	0.024208	5.53	160.78	274.22	0.76
Snake Creek	Snake Creek	24047.94	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5680.17	5685.05		5685.39	0.006096	4.72	129.27	248.24	0.52
Snake Creek	Snake Creek	24047.94	100 YR	CLARK BRIDGE 35FT	610.00	5680.17	5685.05		5685.39	0.006096	4.72	129.27	248.24	0.52
Snake Creek	Snake Creek	23998.78	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5679.64	5684.64		5685.06	0.006945	5.51	128.92	247.39	0.56
Snake Creek	Snake Creek	23998.78	100 YR	CLARK BRIDGE 35FT	610.00	5679.64	5684.64		5685.06	0.006945	5.51	128.92	247.39	0.56
Snake Creek	Snake Creek	23856.43	100 YR	CLARK SUB CORRECTED EFFECTIVE	610.00	5677.92	5683.17	5682.75	5683.86	0.009902	6.94	93.21	334.12	0.62
Snake Creek	Snake Creek	23856.43	100 YR	CLARK BRIDGE 35FT	610.00	5677.92	5683.17	5682.75	5683.86	0.009902	6.94	93.21	334.12	0.62

MODEL 2 VS MODEL 3 - CURRENT EFFECTIVE MODEL VS PROPOSED CONDITIONS SIMULATION RESULTS TABLE

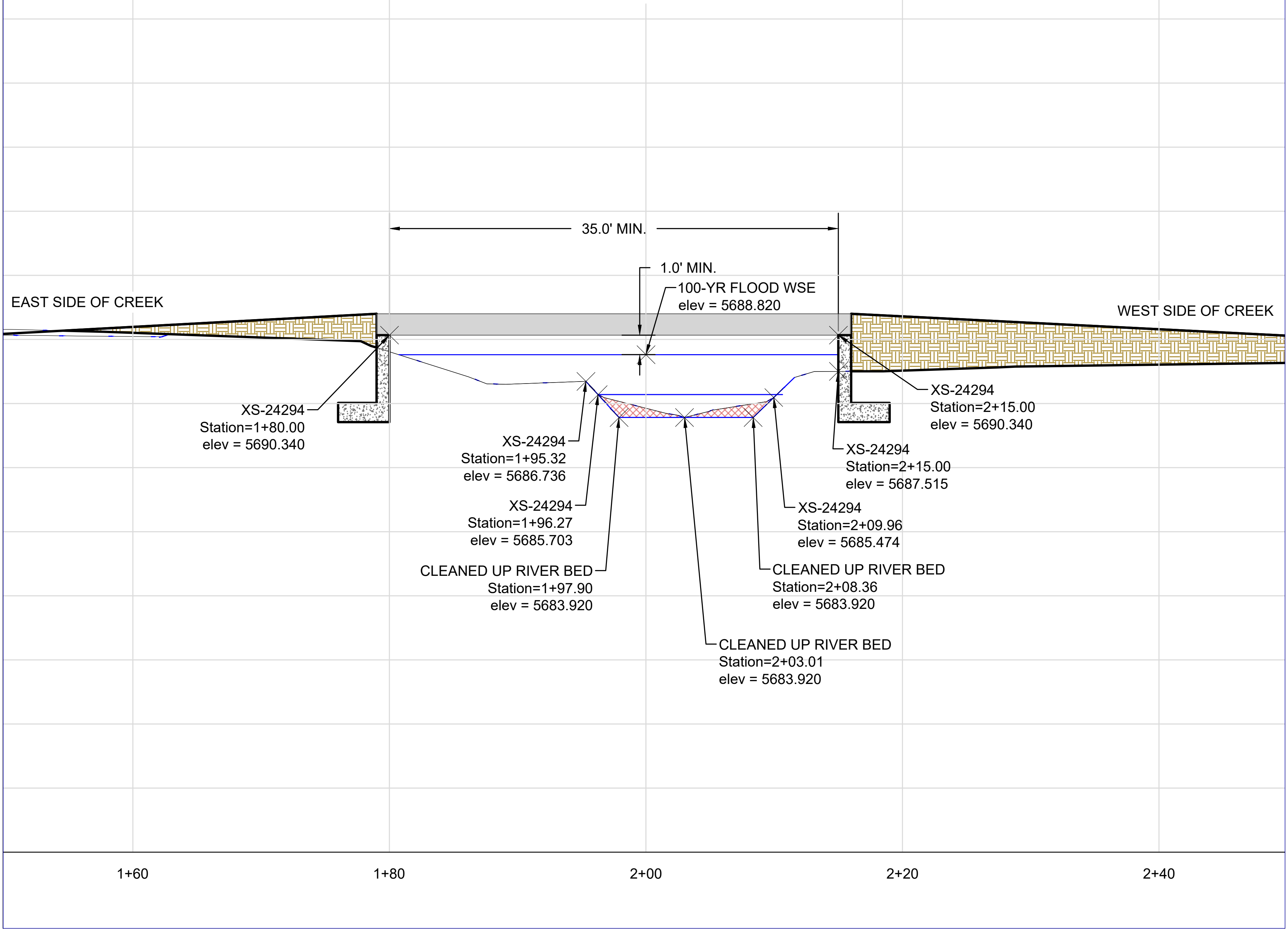
Appendix C - Proposed Cross Sections


PROPOSED BRIDGE & GRADING LOCATION
AREA WITHIN STREAM FOR MATERIAL TO BE REMOVED TO CREATE TRAPEZOIDAL CHANNEL
RIVER STATION 24331 (UPSTREAM OF BRIDGE)
RIVER STATION 24294 (DOWNSTREAM OF BRIDGE)
PROPOSED BRIDGE
PI: 1+66.70
PI: 2+15.35
PI: 2+27.35
EP: 3+16.82
EP: 2+90.95
1+00.00
1+20.00
1+40.00
1+60.00
1+80.00
2+00.00
2+20.00
2+40.00
2+60.00
2+80.00
3+00.00
3+50.00
2+50.00
N
E
S
W
SCALE: 1" = 20'
0'
20'
40'

RIVER STATION 24331 (UPSTREAM OF BRIDGE)



RIVER STATION 24294 (DOWNSTREAM OF BRIDGE)



Appendix D - Manning's N Values

Manning's n Values

Reference tables for Manning's n values for Channels, Closed Conduits Flowing Partially Full, and Corrugated Metal Pipes.

Manning's n for Channels (Chow, 1959).

Type of Channel and Description	Minimum	Normal	Maximum
Natural streams - minor streams (top width at floodstage < 100 ft)			
1. Main Channels			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. same as above, but more stones and weeds	0.030	0.035	0.040
c. clean, winding, some pools and shoals	0.033	0.040	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.050
e. same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. same as "d" with more stones	0.045	0.050	0.060
g. sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. bottom: cobbles with large boulders	0.040	0.050	0.070
3. Floodplains			
a. Pasture, no brush			
1.short grass	0.025	0.030	0.035
2. high grass	0.030	0.035	0.050
b. Cultivated areas			
1. no crop	0.020	0.030	0.040
2. mature row crops	0.025	0.035	0.045
3. mature field crops	0.030	0.040	0.050
c. Brush			
1. scattered brush, heavy weeds	0.035	0.050	0.070
2. light brush and trees, in winter	0.035	0.050	0.060
3. light brush and trees, in summer	0.040	0.060	0.080
4. medium to dense brush, in winter	0.045	0.070	0.110
5. medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. dense willows, summer, straight	0.110	0.150	0.200
2. cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. same as above, but with heavy growth of sprouts	0.050	0.060	0.080

4. heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. same as 4. with flood stage reaching branches	0.100	0.120	0.160
4. Excavated or Dredged Channels			
a. Earth, straight, and uniform			
1. clean, recently completed	0.016	0.018	0.020
2. clean, after weathering	0.018	0.022	0.025
3. gravel, uniform section, clean	0.022	0.025	0.030
4. with short grass, few weeds	0.022	0.027	0.033
b. Earth winding and sluggish			
1. no vegetation	0.023	0.025	0.030
2. grass, some weeds	0.025	0.030	0.033
3. dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. earth bottom and rubble sides	0.028	0.030	0.035
5. stony bottom and weedy banks	0.025	0.035	0.040
6. cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. no vegetation	0.025	0.028	0.033
2. light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. smooth and uniform	0.025	0.035	0.040
2. jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. dense weeds, high as flow depth	0.050	0.080	0.120
2. clean bottom, brush on sides	0.040	0.050	0.080
3. same as above, highest stage of flow	0.045	0.070	0.110
4. dense brush, high stage	0.080	0.100	0.140
5. Lined or Constructed Channels			
a. Cement			
1. neat surface	0.010	0.011	0.013
2. mortar	0.011	0.013	0.015
b. Wood			
1. planed, untreated	0.010	0.012	0.014
2. planed, creosoted	0.011	0.012	0.015
3. unplaned	0.011	0.013	0.015
4. plank with battens	0.012	0.015	0.018
5. lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. trowel finish	0.011	0.013	0.015
2. float finish	0.013	0.015	0.016
3. finished, with gravel on bottom	0.015	0.017	0.020
4. unfinished	0.014	0.017	0.020
5. gunite, good section	0.016	0.019	0.023
6. gunite, wavy section	0.018	0.022	0.025

7. on good excavated rock	0.017	0.020	
8. on irregular excavated rock	0.022	0.027	
d. Concrete bottom float finish with sides of:			
1. dressed stone in mortar	0.015	0.017	0.020
2. random stone in mortar	0.017	0.020	0.024
3. cement rubble masonry, plastered	0.016	0.020	0.024
4. cement rubble masonry	0.020	0.025	0.030
5. dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of:			
1. formed concrete	0.017	0.020	0.025
2. random stone mortar	0.020	0.023	0.026
3. dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. glazed	0.011	0.013	0.015
2. in cement mortar	0.012	0.015	0.018
g. Masonry			
1. cemented rubble	0.017	0.025	0.030
2. dry rubble	0.023	0.032	0.035
h. Dressed ashlar/stone paving	0.013	0.015	0.017
i. Asphalt			
1. smooth	0.013	0.013	
2. rough	0.016	0.016	
j. Vegetal lining	0.030		0.500

Manning's n for Closed Conduits Flowing Partly Full (Chow, 1959).

Type of Conduit and Description	**Minimum**	**Normal**	**Maximum**
1. Brass, smooth:	0.009	0.010	0.013
2. Steel:			
Lockbar and welded	0.010	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
3. Cast Iron:			
Coated	0.010	0.013	0.014
Uncoated	0.011	0.014	0.016
4. Wrought Iron:			
Black	0.012	0.014	0.015
Galvanized	0.013	0.016	0.017
5. Corrugated Metal:			
Subdrain	0.017	0.019	0.021
Stormdrain	0.021	0.024	0.030
6. Cement:			
Neat Surface	0.010	0.011	0.013
Mortar	0.011	0.013	0.015
7. Concrete:			
Culvert, straight and free of debris	0.010	0.011	0.013
Culvert with bends, connections, and some debris	0.011	0.013	0.014
Finished	0.011	0.012	0.014
Sewer with manholes, inlet, etc., straight	0.013	0.015	0.017

Unfinished, steel form	0.012	0.013	0.014
Unfinished, smooth wood form	0.012	0.014	0.016
Unfinished, rough wood form	0.015	0.017	0.020
8. Wood:			
Stave	0.010	0.012	0.014
Laminated, treated	0.015	0.017	0.020
9. Clay:			
Common drainage tile	0.011	0.013	0.017
Vitrified sewer	0.011	0.014	0.017
Vitrified sewer with manholes, inlet, etc.	0.013	0.015	0.017
Vitrified Subdrain with open joint	0.014	0.016	0.018
10. Brickwork:			
Glazed	0.011	0.013	0.015
Lined with cement mortar	0.012	0.015	0.017
Sanitary sewers coated with sewage slime with bends and connections	0.012	0.013	0.016
Paved invert, sewer, smooth bottom	0.016	0.019	0.020
Rubble masonry, cemented	0.018	0.025	0.030

Manning's n for Corrugated Metal Pipe (AISI, 1980).

Type of Pipe, Diameter and Corrugation Dimension	n
1. Annular 2.67 x 1/2 inch (all diameters)	0.024
2. Helical 1.50 x 1/4 inch	
8" diameter	0.012
10" diameter	0.014
3. Helical 2.67 x 1/2 inch	
12" diameter	0.011
18" diameter	0.014
24" diameter	0.016
36" diameter	0.019
48" diameter	0.020
60" diameter	0.021
4. Annular 3x1 inch (all diameters)	0.027
5. Helical 3x1 inch	
48" diameter	0.023
54" diameter	0.023
60" diameter	0.024
66" diameter	0.025
72" diameter	0.026
78" diameter and larger	0.027
6. Corrugations 6x2 inches	
60" diameter	0.033
72" diameter	0.032
120" diameter	0.030
180" diameter	0.028

State of Utah
DEPARTMENT OF NATURAL RESOURCES
JOEL FERRY
Executive Director
Division of Water Rights
TERESA WILHELMSEN
State Engineer/Division Director

SPENCER J. COX
Governor
DEIDRE M. HENDERSON
Lieutenant Governor

October 11, 2023

RIMROCK, LLC
12731 NORTH 4400 WEST
CORNISH, UT 84308

RE: (State Only) Stream Channel Alteration Permit Number **20-55-08SA** to construct a new pedestrian and vehicular bridge associated with Snake Creek in Wasatch County.
EXPIRATION DATE: **August 4, 2025**

Permit to Alter a Natural Stream Channel Number **20-55-08SA** is hereby extended pursuant to the requirements of Section 73-3-29 of the Utah Code Annotated, 1953.

Work Performed under this permit is subject to the conditions of the original permit.

This decision is subject to the provisions of Rule R655-6-17 of the Division of Water Rights and to Sections 63G-4-302 and 73-3-14 of the Utah Code Annotated, 1953 as amended, which provide for filing either a Request for Reconsideration with the State Engineer, or an appeal with the appropriate District Court. A Request for Reconsideration must be filed with the State Engineer within 20 days of this decision. A court appeal must be filed within 30 days after the date of this decision, or if a Request for Reconsideration has been filed, within 30 days after the Request for Reconsideration has been denied. A Request for Reconsideration is considered denied when no action is taken 20 days after the Request is filed.

If you have any questions or comments, please contact Chuck Williamson at 801-538-7404.

Sincerely,

E.W. Taylor

Everett W. Taylor, P.E.
Assistant State Engineer

EWT/tg

1594 West North Temple, Suite 220, PO Box 146300, Salt Lake City, UT 84114-6300
telephone (801) 538-7240 • facsimile (801) 538-7467 • TTY (801) 538-7458 • *www.waterrights.utah.gov*

This permit was mailed on ___________________________ to the addressee and the following:

Chase McDonald - Regional Engineer, chasemcdonald@utah.gov
Nolan Hahn - EPA, Hahn.Nolan@epa.gov
Mark Farmer - Division of Wildlife Resources, markfarmer@utah.gov
Tracie J. Harrison - Division of Emergency Management, tjharrison@utah.gov
Josh Call - Epic Engineering, jcall@re-n-d.com

By: ________________________________
Tiffany Gonzales, Executive Secretary

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO CA 95814-2922

September 17, 2024

Regulatory Division (SPK-2020-00404)

Cari Lane LLC
Attn: Mr. Jeremy Clark
280 North Red Ledges Boulevard
Heber City, Utah 84032-4740
clarkj1229@gmail.com

Dear Mr. Clark:

We are responding to your request for verification of an Aquatic Resource delineation for the Whispering Creek Estates site. The 6.74-acre project site is located on the south side of 535 Cari Lane, approximately 1.3 miles northwest of Midway City (Latitude 40.52891°, Longitude -111.48426°), Wasatch County, Utah (Enclosure 1).

Based on available information, we concur with your aquatic resources delineation for the site, which consists of approximately 0.36 acres of palustrine emergent wetland, 784 linear feet (0.19 acre) of perennial channel, and 54 linear feet (0.01 acre) of irrigation ditch, as depicted on the enclosed "Whispering Creek Wetland Exhibit", dated September 3, 2024, prepared by Berg Engineering (Enclosure 2). This letter verifies that the location and boundaries of wetlands were delineated consistent with the wetland definition at 33 CFR §328.3(c)(16), the 1987 *Corps of Engineers Wetlands Delineation Manual* (Wetlands Research Program Technical Report Y-87-1) and the applicable regional supplements; and the location and boundaries of non-tidal waters conform with the ordinary high water mark definition at 33 CFR §328.3(c)(7), Regulatory Guidance Letter 05-05, and any applicable regional guide.

This verification letter does not constitute a jurisdictional determination (JD). A JD is not required to process an application for a Department of the Army permit. If you do not require a JD for the site, your permit application may be processed sooner. You may request a JD for this site at any time prior to starting work in aquatic resources, including after a permit decision is made. To request a JD for this site, complete the attached *Request for Aquatic Resources Delineation or Jurisdictional Determination Form* (Enclosure 3) and return it to this office at the address listed below.

The delineation included herein has been conducted to identify the location and extent of the aquatic resource boundaries for the particular site identified in this request. This delineation may not be valid for the Wetland Conservation Provisions of the Food Security Act of 1985, as amended. If you or your tenant are USDA program participants, or anticipate participation in USDA programs, you should discuss the applicability of a certified wetland determination with the local USDA service center, prior to starting work.

Please refer to identification number SPK-2020-00404 in any correspondence concerning this project. If you have any questions, please contact me at the Utah Regulatory Office, 533 West 2600 South, Suite 150, Bountiful, Utah 84010, by email at Hollis.G.Jencks@usace.army.mil, or telephone at (801) 295-8380 ext. 8318.

Sincerely,

Hollis Jencks
Regulatory Project Manager
Utah Section

Enclosures

cc:
Dennis Wenger, Frontier Corporation USA, dwenger@frontiercorp.net

RIMROCK ENGINEERING & DEVELOPMENT

March 12, 2024

To: Midway City Planning Department

Attn: Michael Henke, Floodplain Manager

From: Devin Earl – Rimrock Engineering & Development

RE: Clark Subdivision – Floodplain Restoration Analysis

Mr. Henke

This memo is regarding the wetland/floodplain restoration work that Mr. Clark has completed on his property along Snake Creek located on current Wasatch County Parcel 00-0006-1817 with a physical address of approximately 535 Cari Lane, Midway, Utah.

In order to compare the restored conditions to previous conditions before the area was disturbed, we have gathered contour data available from the Utah AGRC from 2006 similar to that used in the FEMA FIS Report #49051CV000A as stated in section 1.2 on page 1. Rimrock Engineering & Development completed a topographic survey of the current conditions on March 11, 2024 and created a surface to compare to the surface available on the Utah AGRC website from 2006. Please see the attached exhibit which shows elevation differences of the current ground in comparison to the topo data from 2006. The exhibit has been color coded to quickly identify areas that are higher or lower than the surface data from 2006. The blue shaded areas represent values that are 3.51 feet lower to 0.5 feet lower than the 2006 surface, the light green shaded areas are anywhere from 0.5 feet lower to 0 feet lower. The yellow areas represent ground that is 0 feet to 0.5 feet higher, and the red is from 0.5 feet to 4.28 feet higher than the said surface data from 2006. Overall, the comparison of the two surfaces shows that the majority of the surface within the FEMA floodplain is at or below the previous surface data from 2006 which makes sense as some of the soils were stripped down during the initial grading of the area. Please note that there are a few areas within the floodplain that are slightly higher than the original 2006 data and that seems to follow along the rock wall that was created to protect the bank from erosion during the restoration work. It is our professional opinion that the areas within the floodway that are showing to be higher than the previous surface will have no effect on the base flood elevation. Furthermore, the actual field surveyed data is likely to better capture the actual ground in the areas near vegetation. It should also be noted that the data used in the FEMA FIS study was 1 meter data and may have some variations in elevations compared to the topographic survey due to the detail level of the data.

In summary the data shows that the current ground elevation is mostly at or below the same elevation within the floodplain as it was during at the time elevation data was gathered for the FIS report in 2006.

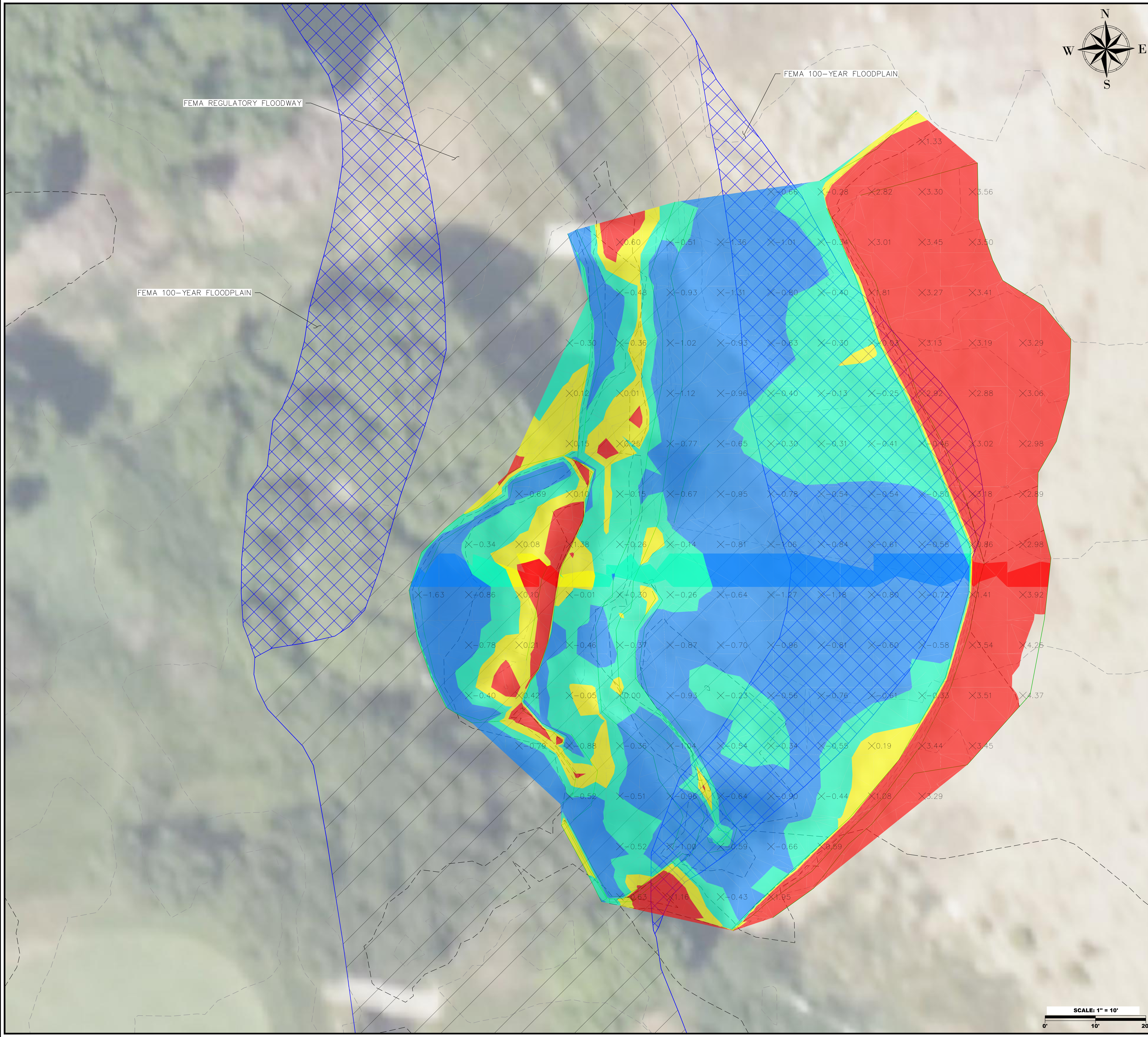
If any additional information is needed or for any questions, please feel free to reach me by phone at 801-664-2947 or by email at dearl@re-n-d.com.

Thank you,

Devin Earl, P.E.

PROFESSIONAL ENGINEER
11623310
DEVIN SCOTT EARL
03-12-24
STATE OF UTAH

5513 W 11000 N #435
Highland, UT 84003



Elevations Table				
Number	Minimum Elevation	Maximum Elevation	Area	Color
1	−3.51	−0.50	8437.13	
2	−0.50	0.00	1912.13	
3	0.00	0.50	1068.15	
4	0.50	4.28	3585.95	

SHEET NOTES

SHEET LEGEND

PLAN REVISIONS

A.

ENGINEER: DEVIN EARL
EMAIL: DEARL@RE-N-D.COM
PHONE: 801-664-2947

RIMROCK ENGINEERING & DEVELOPMENT

CAD TECH: DSE
DESIGNER: DSE
Q&A: ---

CALL BLUE STAKES PRIOR TO DIGGING

PROJECT NAME

JEREMY CLARK

SHEET NAME

RESTORATION GRADING

PLAN SUBMITTAL: PERMIT

SCALE:	11"x17"	24"x36"
VERT.	N/A	N/A
HORIZ.	1"=20'	1"=10'

DATE
3/12/24

SHEET NUMBER