AQUA ENGINEERING

INNOVATIVE ENGINEERING SOLUTIONS

Submittal Review

September 24, 2024

Company Name
Industrial Pipe and Welding
PO Box 1110
Clearfield, Ut 84075

Project: 002703.C | Green Hills WTF
Equipment/Material/Spec: GeoHazard Assessment

Subject Submittal has been reviewed and review action is as shown below. Corrections or comments made relative to submittals during this review do not relieve the Contractor from compliance with the requirements of the drawings and specifications. This check is only for review of general conformance with the design concept of the project and general compliance with the information given in the Contract Documents. The Contractor is responsible for confirming and correlating all quantities and dimensions; selecting fabrication processes and techniques of construction; coordinating his work with that of other trades and performing his work in a safe and satisfactory manner.

Submittal No.	Subject of Shop Submittal	No Exceptions Noted	Exceptions Noted	Exceptions Noted Submit Data	Receipt Acknowledged	Return for Correction
011	GeoHazard Assessment				X	

Additional Comments:

1. No Comments

Reviewed By: Brady Lister

Sincerely,

Brady Lister

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Reconnaissance- Level Geologic Hazards Assessment
Green Hills Sewer and Water - Maple Hills WTP
922 N. Maple Street Huntsville, Utah 84317

GeoStrata Job No. 1929-001

September 13, 2024

Prepared for:

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Reconnaissance-Level Geologic Hazards Assessment
Green Hills Sewer and Water - Maple Hills WTP
922 N. Maple Street
Huntsville, Utah 84317
Parcel # 21-079-0003 Common Area "L" plus a portion of Parcel # 21-083-0006

GeoStrata Job No. 1929-001

Prepared by:

Charles Memmott, G.I.T.
Project Geologist

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September 13, 2024

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APPENDICES

1.0 EXECUTIVE SUMMARY

This report presents the results of a reconnaissance-level geologic hazard assessment conducted for the Green Hills Water and Sewer District proposed Maple Well Water Treatment Facility treatment building to be located at 922 North Maple Street in Huntsville, Utah, (Parcel #: 21-079-003 Common Area “L” plus a portion of Parcel # 21-083-0006). Our reconnaissance-level geologic hazards assessment is intended to adequately address the geologic hazards at the site consistent with reasonable standards of practice. Information concerning the nature of the project was provided by the Client as well as in a bidding document prepared by Ardurra titled “Bidding Documents for Green Hills Water and Sewer District Water Treatment Facility Huntsville Utah” and dates July 2024. GeoStrata conducted an office investigation and geologic reconnaissance site visit to the subject property to assess whether any identified potential geologic hazards could impact the cost and feasibility of the proposed construction. The work performed for this report was performed in accordance with our proposal, dated September 10, 2024.

Based on our review of the project description provided in the Bidding Documents for the Green Hills Water and Sewer District Water Treatment Facility prepared by Ardurra and dated July 2024, as well as on the topographic information provided on Grading Plan (Sheet C4.0) contained within the Bidding Documents, it is our understanding that the subject property is currently sloped at an approximate 2.5H:1V grade within the area of the proposed water treatment building. Based on this information, we understand that the subject property is currently an undeveloped Common Area “L” within the Green Hills Estates development. It is our understanding that the proposed water treatment building is to be constructed by excavating into the approximate 2.5H:1V grade hillside such that the rear of the structure will largely be buried. We additionally understand that the eastern wall (upslope wall) of the structure will be reinforced in order to serve as a retaining feature against the cut slope. Finally, it is our understanding that a relatively small portion of the proposed excavation will be completed in order to accommodate a concrete pad that will be utilized to support generator equipment. In this area, the excavated cut slope will be unretained and is planned to be graded to a maximum approximate 1.6H:1V grade.

The reported geologic unit underlying the subject site is identified as Holocene to Middle Pleistocene? undivided mass-movement and colluvial deposits (Qmc) which is described as consisting of poorly sorted to unsorted, mostly clay, silt, sand, gravel, cobbles, and boulders; angular to rounded clasts; non-bedded; mapped on slopes where individual landslides, slumps, slopewash, and soil creep are difficult to distinguish from one another; often characterized by hummocky slopes composed of numerous slumps of various sizes and ages; includes soil creep, talus, slopewash, and debris-flow deposits but lacks clear landslide scarps and lateral margins to allow separate mapping; typically forms on slopes overlying clay-bearing, landslide-prone bedrock units; 0 to 40 feet (0–12 m) thick. Surrounding the subject site, Undivided alluvial and colluvial deposits (Qac), Colluvial deposits (Qc) and Landslide deposits (Qms) have been identified.

Ground shaking, surface fault rupture, tectonic deformation, rock fall and topple, landslide, slump, creep, avalanche, debris flow, hyperconcentrated flow, stream flow/ sheet flooding, stream flooding, canal flooding, and karst and sink hole hazards were assessed as part of this reconnaissance-level geologic hazards assessment. It is our opinion that the hazard for ground shaking is considered high for the proposed construction, the hazard for soil creep is considered moderate, the hazard for canal flooding and dam failure is not applicable to the proposed construction and all other hazards assessed are considered low for the proposed construction of the addition to the existing single-family residential structure.

Liquefaction, shallow groundwater, problem soils, and radon hazards were not assessed as part of this reconnaissance-level geologic hazards assessment and no inference is made as to the presence or absence of these hazards at the site.

IMPORTANT INFORMATION ABOUT THIS GEOTECHNICAL ENGIEERING REPORT:

This executive summary is not intended to replace the report of which it is part and should not be used separately from the report. The executive summary is provided solely for the purpose of overview. The executive summary omits a number of details, any one of which could be crucial to the proper application of this report. Do not rely on this report if this report was prepared for a different client, different project, different purpose, different site, and/or before important events occurred at the site or adjacent to it. All recommendations in this report are confirmation dependent.

2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE OF WORK

This report presents the results of a reconnaissance-level geologic hazard assessment conducted for the Green Hills Water and Sewer District proposed Maple Well Water Treatment Facility treatment building to be located at 922 North Maple Street in Huntsville, Utah, (Parcel #: 21-079-003 Common Area “L” plus a portion of Parcel # 21-083-0006) (Plate A-1 *Site Vicinity Aerial Imagery Map*, Plate A-2 *Site Vicinity USGS Topographic Map*;). The purpose of our reconnaissance-level geologic hazard assessment is to assess the subject property for geologic hazards that may impact the cost and feasibility of the proposed construction.

Our reconnaissance-level geologic hazards assessment is intended to adequately address the geologic hazards at the site consistent with reasonable standards of practice. Information concerning the nature of the project was provided by the Client as well as in a bidding document prepared by Ardurra titled “Bidding Documents for Green Hills Water and Sewer District Water Treatment Facility Huntsville Utah” and dates July 2024. GeoStrata conducted an office investigation and geologic reconnaissance site visit to the subject property to assess whether any identified potential geologic hazards could impact the cost and feasibility of the proposed construction. The work performed for this report was performed in accordance with our proposal, dated September 10, 2024. Our scope of services included the following:

- Review of available geologic references and maps of the area.
- Stereographic aerial photograph interpretation of aerial photographs covering the site area
- Review of Digital Elevation Models obtained from the State of Utah UGRC
- Geologic reconnaissance site visit
- Preparation of this report

The recommendations contained in this report are subject to the limitations presented in the Limitations section of this report.

2.2 PROJECT DESCRIPTION

The proposed Maple Well Water Treatment Facility treatment building will be located at 922 North Maple Street in Huntsville, Utah (Parcel #: 21-079-003 Common Area “L” plus a portion of Parcel # 21-083-0006) (Plate A-1 *Site Vicinity Map*, Plate A-2 *Site Vicinity USGS Topographic Map*). Our understanding of the project was provided by the Client as well as in a bidding document prepared by Ardurra titled “Bidding Documents for Green Hills Water and Sewer District Water Treatment Facility Huntsville Utah” and dates July 2024.

Based on our review of the project description provided in the Bidding Documents for the Green Hills Water and Sewer District Water Treatment Facility prepared by Ardurra and dated July 2024, as well as on the topographic information provided on Grading Plan (Sheet C4.0) contained within the Bidding Documents, it is our understanding that the subject property is currently sloped at an approximate 2.5H:1V grade within the area of the proposed water treatment building. Based on this information, we understand that the subject property is currently an undeveloped Common Area "L" within the Green Hills Estates development. It is our understanding that the proposed water treatment building is to be constructed by excavating into the approximate 2.5H:1V grade hillside such that the rear of the structure will largely be buried. We additionally understand that the eastern wall (upslope wall) of the structure will be reinforced in order to serve as a retaining feature against the cut slope. Finally, it is our understanding that a relatively small portion of the proposed excavation will be completed in order to accommodate a concrete pad that will be utilized to support generator equipment. In this area, the excavated cut slope will be unretained and is planned to be graded to a maximum approximate 1.6H:1V grade.

The geologic unit underlying the subject site is identified by Anderson and others (2023) as Holocene to Middle Pleistocene? undivided mass-movement and colluvial deposits (Qmc). Additionally, Undivided alluvial and colluvial deposits (Qac), Colluvial deposits (Qc) and Landslide deposits (Qms) have been identified surrounding the subject site. It should be noted that these units are used to delineate areas of potential landslide hazards and alluvial fan flooding and debris flow hazards. This report addresses potential geologic hazards that could impact the proposed construction including landslide hazards and alluvial fan flooding and debris flow hazards.

3.0 METHOD OF STUDY

3.1 OFFICE INVESTIGATION

As part of our office investigation, GeoStrata reviewed pertinent literature and maps listed in the references section of this report, which provided background information on the local geologic history of the area and the locations of suspected or known geologic hazards (Coogan and King, 2016; Anderson and Others, 2024; Elliot and Hardy, 2010; Black and others, 2003; Hecker, 2003; Crittenden and Sorensen, 1979; U.S. Geological Survey and Utah Geological Survey, 2016;). A stereographic aerial photograph interpretation was performed for the subject site using a set of stereo aerial photographs obtained from the UGS as shown below in Table 1.

Source	Photo Number	Scale	Date
USFS	1963 EMD 13-73	15840	1963
USFS	1963 EMD 13-74	15840	1963

Table 1: Aerial Stereosets.

GeoStrata also conducted a review of 2016 .5-meter lidar provided by the State of Utah UGRC to assess the subject site for visible geomorphology related to landslide deposits, alluvial fan deposits and/or other geologic hazards related geomorphology. The lidar elevation data was used to create hillshade and slope imagery that could be reviewed for assessment of geomorphic features related to geologic hazards (Plate 5 *Hillshade Map;* Plate 6 *Slopeshade Map*, Plate 7 *Percent Slope Map*, Plate 8 *Topographic Map;*).

3.2 FIELD INVESTIGATION

As part of this reconnaissance-level geologic hazards assessment, a GeoStrata engineering geologist visited the subject site on September 12, 2024, to investigate the geologic conditions within the general site area and to assess existing geomorphology for surficial evidence of geologic hazards. During our fieldwork we conducted site observations to assess geologic hazards that might impact the cost and feasibility of the proposed construction. We used our field observations to confirm the observations made during our office research and to observe any evidence of geologic hazards that were not evident in our office research, but which could be observed in the field.

4.0 GEOLOGIC CONDITIONS

4.1 REGIONAL GEOLOGIC SETTING

The site is located along the southeastern margin of Ogden Valley along the southwest side of Maple Canyon in Huntsville, Utah at an elevation of approximately 5,280 to 5,300 feet above sea level. The geologic unit underlying the subject site is identified as Holocene to Middle Pleistocene? undivided mass-movement and colluvial deposits (Qmc) (Anderson and others, 2023). Surrounding the subject site, Undivided alluvial and colluvial deposits (Qac), Colluvial deposits (Qc) and Landslide deposits (Qms) have been identified.

The geology of Ogden valley is dominated by the Willard Thrust faulting event, which occurred during the Sevier Orogeny. The Willard Thrust fault, one of the largest faults in the Sevier Mountain belt, bounds the western side of Ogden Valley. The Ogden Valley is a northwest trending deep, lacustrine sediment-filled structural basin of Cenozoic age bounded on the northeast and southwest by two normal faults that dip towards the center of the valley. The Ogden Valley is a fault graben flanked by two uplifted blocks, the Wasatch Range on the west and unnamed flat-topped mountains to the east (King and others 2008). The Wasatch Range is the easternmost expression of pronounced Basin and Range extension in north-central Utah (Stokes, 1986).

The near-surface geology of Ogden Valley is dominated by sediments which were deposited within the last 30,000 years by Lake Bonneville and streams draining into Lake Bonneville during the high stand of the Lake Bonneville Cycle when water inundated Ogden Canyon and formed a small lake in Ogden Valley up to an approximate altitude of 4,900 feet (Scott and others, 1983; Hintze, 1980; Hintze, 1993; Leggette and Taylor, 1937; Coogan and King, 2016;). Lake Bonneville shoreline deposits are mapped in the canyons extending out of Ogden Valley. As the lake receded, streams began to incise large deltas that had formed at the mouths of major canyons along the Wasatch Range and the unnamed flat- topped mountains bounding the eastern margins of Ogden Valley. The eroded material was then deposited in shallow lakes and marshes in the basin and at the base of nearby canyons and in a series of recessional deltas and alluvial fans that extended into the Ogden Valley and nearby canyons. Sediments toward the center of the valley are predominately deep-water deposits of clay, silt and fine sand whereas sediments closer to the mountain fronts are shallow-water deposits of coarse sand and gravel. However, these deep-water deposits are in places covered by a thin post-Bonneville alluvial cover. Tertiary age volcanics and mass wasting deposits associated with the Tertiary age volcanics are prevalent throughout the foothills and knolls along the margins of Morgan Valley.

4.2 REPORTED SITE GEOLOGY

As shown on Plate A-3 *Site Vicinity 7.5-minute Geologic Map*, Anderson and others (2023) identify the unit underlying the subject site as Holocene to Middle Pleistocene? undivided mass-movement and colluvial deposits (Qmc) which is described as consisting of poorly sorted to unsorted, mostly clay, silt, sand, gravel, cobbles, and boulders; angular to rounded clasts; non-bedded; mapped on slopes where individual landslides, slumps, slopewash, and soil creep are difficult to distinguish from one another; often characterized by hummocky slopes composed of numerous slumps of various sizes and ages; includes soil creep, talus, slopewash, and debris-flow deposits but lacks clear landslide scarps and lateral margins to allow separate mapping; typically forms on slopes overlying clay-bearing, landslide-prone bedrock units; 0 to 40 feet (0–12 m) thick. Surrounding the subject site, Undivided alluvial and colluvial deposits (Qac), Colluvial deposits (Qc) and Landslide deposits (Qms) have been identified.

4.3 SITE SPECIFIC GEOMORPHOLOGY

The subject site is located near the mouth of Maple Canyon on the west dipping and moderately sloping east side of the Maple Canyon drainage within the western foothills of the mountains along the central-eastern margin of Ogden Valley. The subject site generally slopes to the southwest. The area to the north and northeast of the subject site has been heavily modified by previous grading activities associated with the construction of Maple Street, local utilities, and the development of the homes built in the area. A minor perennial stream was observed running northeast to southwest through parcel # 21-083-0006 east of the area of the proposed development and just east of the existing graded fenced off area. Further to the southeast, just past the eastern boundary of parcel # 21-083-0006, an ephemeral stream was observed (Plate A-4 *Site Specific Geologic Map*).

5.0 GENERALIZED SITE CONDITIONS

5.1 SURFACE CONDITIONS

The subject site for the proposed development is approximately 0.1 acres in size, comprised of a portion of Parcel #: 21-079-003 Common Area “L” plus a portion of Parcel # 21-083-0006. The subject site is moderately sloping to the east-northeast from the road up to an existing graded fenced off area with a small shed-sized building, electrical meter, and large concrete manhole. Two access roads were observed leading to the existing structures, one leading from Maple Drive to the north side of the fenced area, and one leading from the driveway in Parcel # 21-083-0006 to the southern side of the fenced area. The area of the proposed development is moderately vegetated with grasses, sparse trees, and bushes surrounding the north access road. The area surrounding the subject site was observed to be moderately sloping to the southwest. This area was observed to be generally open space with a few surrounding single-family residential structures. This area was observed to be moderately to heavily vegetated with grasses and sagebrush, and a few bushes. The area within the perennial stream channel was observed to be heavily vegetated with grasses, milkweed, and other shrubs and a few trees. Soils surrounding the subject site were observed to be comprised of clayey soils with sand and gravel. Gravel clasts observed across the subject site were ranged from approximately 1-inch to l½-foot in diameter and were observed to be generally platy to spherical and angular to subrounded. Throughout the subject site mudcracks were observed in the soils with an aperture up to ¾-inch. North of the subject site long fractures in the soil were observed extending 4- to 5- feet with an aperture of up to approximately 1-inch and extending 1- to 2-inches below the surface. The orientation of these fractures was observed to be approximately northwest to southeast, generally perpendicular to the slope of the ground surface, and the apertures of these fractures appeared to be opening from northeast to southwest.

6.0 GEOLOGIC HAZARDS ANALYSIS AND RECOMMENDATIONS

Geologic hazards are defined as naturally occurring geologic conditions or processes that could present a danger to human life and property. These hazards must be considered before development of the site. There are several hazards that if present at the site should be considered in the design of habitable structures and other critical infrastructure. The hazards considered for this site are presented in Table 2 and discussed in the following sections of this report.

Hazard	Hazard Rating*					Further Study Recommended
	Not Applicable	Not Assessed	Low	Moderate	High	
Ground Shaking					X	
Surface Fault Rupture			X			
Tectonic Deformation			X			
Liquefaction		X				E
Rock Fall and Topple			X			
Landslide			X			
Slump			X			
Creep				X		
Avalanche			X			
Debris Flow			X			
Hyperconcentrated Flow			X			
Stream Flow/Sheet Flooding			X			
Shallow Groundwater		X				E
Stream Flooding			X			
Canal Flooding	X					
Dam Failure	X					
Problem Soils		X				E
Radon		X				O
Karst and Sink Hole			X			

Table 2: Summary of Geologic Hazards.

Table 2 summarizes the geologic hazards assessed and those not assessed at the study area. The hazard rating as shown on Table 2 is intended to assess the probability that the hazard could have an impact on the site and not the severity of the hazard. A hazard rating of "Not Applicable" indicates that no evidence was found to indicate that the hazard is present, and it is our opinion that the hazard does not impact the site. A hazard rating of "Not Assessed" are hazards this report does not evaluate and no inference is made as to the presence or absence of the hazard at the site. A hazard rating of "Low" indicates that no evidence was found to indicate that the hazard is present and has a low probability of impacting the site, hazard not known or suspect to be present. A hazard rating of "Moderate" indicates that the hazard has a moderate probability of impacting the site, but the evidence is equivocal, based only on theoretical studies, or was not observed and further study is necessary as noted. A hazard rating of "High" indicates that that evidence is strong and suggests that there is a high probability of impacting the site and mitigation measures should be taken. If a hazard is assessed to potentially impact the site, then further studies may be recommended. The following are the recommended studies and the letter designation associated with those studies: “O” – other, “E” – geotechnical/engineering, “H” – hydrologic, “A” – avalanche, “G” – additional detailed geologic hazard study out of the scope of this study.

6.1 EARTHQUAKE GROUND SHAKING HAZARD

During the event of an earthquake, seismic waves radiate outward from the initial point of rupture and dissipate with distance. The ground shakes as the seismic waves displace the ground both vertically and horizontally. Ground shaking can cause significant damage to and potentially collapse structures and can also trigger landslides, avalanches and liquefaction. The type of soil a seismic wave travels through can amplify or dampen the effects of ground shaking (Petersen and others, 2008).

Spectral responses for the Risk-Targeted Maximum Considered Earthquake (MCE_R) are shown in the table below. These values generally correspond to a one percent probability of structure collapse in 50 years for a “firm rock” site. To account for site effects, site coefficients which vary with the magnitude of spectral acceleration are used. Based on our field exploration and the mapped geologic conditions of the surficial deposits within the subject site, it is our opinion that this location is best described as a Site Class D (default). The spectral accelerations are calculated based on the site’s approximate latitude and longitude of 41.2755° and -111.7315° respectively and the Seismic Design Maps web-based application at https://seismicmaps.org/.

Description	Value
Site Class	D (default)
S_s - MCE_R ground motion (period – 0.2s)	0.764
S_1 - MCE_R ground motion (period – 1.0s)	0.263
F_a - Site amplification factor at 1.0s	1.200
F_v - Site amplification factor at 1.0s	null
PGA - MCE_G peak ground acceleration	0.333
PGA_M – Site modified peak ground acceleration	0.422

It should be noted that our investigation did not include a site-specific ground motion hazard analysis, and a Site Class D (default) has been used to determine the seismic parameters presented above based on known geologic conditions at the site according to the Section 20.1 of ASCE 7. The seismic parameters presented herein may be used for design of the proposed structures provided that structural design allows for the ground motion hazard analysis exception in ASCE 7-16 Segment 11.4.8. The seismic data provided above should be used by the project geotechnical and structural engineers for proper site and structural design. GeoStrata recommends that a licensed structural engineer provide proper structural designs for the proposed residential structure which account for and mitigate this hazard. It is the opinion of GeoStrata that earthquake ground shaking hazard is considered high for the subject site but should not preclude development of the proposed water treatment facility assuming that the recommendations provided in this report are followed.

6.2 SURFACE FAULT RUPTURE HAZARD

Movement along faults within the crustal rocks beneath the ground surface generates earthquakes. During large magnitude earthquakes (generally Richter magnitude 5.0 or greater) along the normal faults in the intermountain region, fault ruptures can propagate to the ground surface resulting in a surface fault rupture (Smith and Arabasz, 1991). The fault scarp formed during a surface fault rupture event along a normal fault is generally nearly vertical. A surface rupture fault may be comprised of a larger single surface rupture or several smaller surface ruptures across a fault zone. For all structures designed for human occupancy, a surface rupturing fault is considered active if it has experienced movement in approximately the past 10,000 radiocarbon years before present [14C yr B.P.], or about 11,700 calibrated years before present [cal yr B.P.]) (Bowman and Lund, 2020).

The active fault most closely located to the subject site Weber segment of the Wasatch fault zone, approximately 11 miles to the west of the subject site (Black and others, 2003). The site is not mapped as being underlain or adjacent to any known active faults and is not in a surface fault rupture special study area and therefore does not require a surface-fault rupture hazard assessment. Based on our office investigation, it is the opinion of GeoStrata that the surface fault rupture hazard within the subject site is considered low and should not preclude development of the proposed water treatment facility.

6.3 TECTONIC DEFORMATION

Subsidence is a hazard associated with warping, lowering and tilting of a valley floor accompanying surface ruptures on normal faults (Hilley and others, 2001, Lund and others, 1991). Inundation along the shores of lakes and reservoirs and the rise of groundwater levels are the main hazards associated with subsidence. Structures that require gentle gradients or horizontal floors such as wastewater treatment plants and sewer lines may be adversely affected by tectonic subsidence. Because subsidence may occur over very large areas, it is not generally practical to avoid the use of potentially affected land except in narrow areas of hazard due to lakeshore inundation. Tectonic subsidence is not typically assessed for subdivision development unless the development is located within an area of potential lake flooding.

As summarized in Section 6.2 *Surface Fault Rupture Hazard* of this report, the subject site is most closely located to the Weber segment of the Wasatch fault zone, approximately 11 miles to the west of the subject property (Black and others, 2003). The site is not mapped as being underlain or adjacent to any known active faults and is not in a surface fault rupture special study area and therefore does not require a surface-fault rupture hazard assessment for tectonic deformation analysis. Based on our office investigation, it is the opinion of GeoStrata that the tectonic deformation hazard within the subject property is considered low and should not preclude development of the proposed water treatment facility.

6.4 LIQUEFACTION

Certain areas within the intermountain region possess a potential for liquefaction during seismic events. Liquefaction is a phenomenon whereby loose, saturated, granular soil deposits lose a significant portion of their shear strength due to excess pore water pressure buildup resulting from dynamic loading, such as that caused by an earthquake. Among other effects, liquefaction can result in densification of such deposits causing settlements of overlying layers after an earthquake as excess pore water pressures are dissipated. The primary factors affecting liquefaction potential of a soil deposit are: (1) level and duration of seismic ground motions; (2) soil type and consistency; and (3) depth to groundwater (Anderson and others, 1994; Christensen and Shaw, 2008;).

The liquefaction hazard assessment is outside the scope of this reconnaissance-level geologic hazards assessment, therefore no evaluation of the liquefaction hazard for the proposed water treatment building has been made. If the Client wishes to have a better understanding of the liquefaction potential of the soils located at the subject property, we recommend that a liquefaction analysis be completed.

6.5 ROCKFALL AND TOPPLE

Rockfalls are the fastest moving mass movement that predominantly occurs in mountains where a rock source exists along steep slopes and cliffs greater than 35 degrees. Rockfalls are a result of a loss of support from beneath the rock mass that can be caused by freeze/thaw action, rainfall, weathering and erosion, and/or strong ground shaking resulting from seismic activity. Rockfalls result in the collection of rock fall material, referred to as talus, at the base of the slope. The presence of talus indicates that a rockfall hazard has occurred and may still be present at the site.

Based on our review of .6-meter 2021 aerial imagery (Plate 1 *Site Vicinity Aerial Imagery Map*), and our review of hillshade and slope imagery derived from 2016 .5-meter lidar elevation data, no bedrock outcroppings that could be a rockfall and topple source were identified in the vicinity of the subject property and no rockfall talus was observed within or adjacent to the subject property. It is the opinion of GeoStrata that rockfall and topple hazard within the subject site is considered low and should not preclude development of the proposed water treatment facility.

6.6 LANDSLIDE, SLUMP, AND CREEP

There are several types of landslides that should be considered when evaluating geologic hazards at a site with moderately to steeply sloping terrain. These include shallow debris slides, deep-seated earth or rock slumps, and earth flows. Landslides, slumps, creep, and other mass movements can develop on moderate to steep slopes where the slope has been altered or disturbed. Movement can occur at the top of a slope that has been loaded by fill placement, at the base of a slope that has been undercut, or where local groundwater rises resulting in increased pore pressures within the slope. Slopes that exhibit prior failures and large landslide deposits are particularly susceptible to instability and reactivation.

Anderson and others (2023) identify the subject property being underlain by Holocene to Middle Pleistocene? undivided mass-movement and colluvial deposits (Qmc). Based on our review of aerial photographs, hillshade and slope images derived from 2016 .5-meter lidar elevation data, and our field reconnaissance conducted during our site visit, no landslide related geomorphology was identified within the subject property. However, during our site visit, we observed mud cracks throughout the subject site, and fractures were observed northeast of the subject site. These fractures were observed to extend 4- to 5- feet and to have an aperture of up to approximately 1-inch. The orientation of these fractures was observed to be approximately northwest to southeast, generally perpendicular to the slope of the ground surface, and the apertures of these fractures appeared to be opening from northeast to southwest. Based on these observations, it is our opinion that soil creep hazard is present at the site, and minor soil movement and sloughing of the proposed unretained slope is possible. We recommend mitigating the soil creep hazard at the subject site, the unretained cut slope be laid back as much as is practicable to accommodate a shallower cut slope, and that the unretained cut slope be stabilized with a native seed mix covered by erosion control blankets and wattles designed as part of the site erosion control plan by the project civil engineer. Based on our reconnaissance-level assessment, it is the opinion of GeoStrata that the landslide and slump hazard within the subject site is considered low and should not preclude development of the proposed water treatment facility. Based on our reconnaissance-level assessment, it is the opinion of GeoStrata that the soil creep hazard within the subject site is considered moderate and should not preclude development of the proposed water treatment facility if the recommendations contained in this report are followed.

6.7 AVALANCHE

An avalanche is a rapid flow of snow down a hill or mountainside. Several factors that influence a snow avalanche include weather, temperature, slope steepness, slope orientation, wind direction and wind loading, terrain, vegetation, and snowpack conditions. Snow avalanche hazard could affect access and snow removal on roads as well as the safety of habitable structures and critical facilities.

According to the National Avalanche Center (https://avalanche.org/avalanche-tutorial/avalanche-terrain.php) *"Avalanches are possible on any slope steeper than 30 degrees and occur most frequently on slopes 30 to 50 degrees."* According to Toby Weed, Forecaster with the Utah Avalanche Center (Blog: Steepness) (https://utahavalanchecenter.org/blog/16386), *"Jill Fredston and Doug Fesler discuss the importance of slope steepness in their bestselling classic, Snow Sense, "The underlying concept is that as the slope angle increases, so does the stress exerted on the snowpack." Avalanche experts agree that most avalanches occur on slopes with angles ranging between 30 and 45 degrees, but there is some discord regarding dangerous slab avalanche frequency as slope angles steepen."*

Based on our review of .6-meter 2021 aerial imagery, our review of hillshade and slope imagery derived from 2016 .5-meter lidar elevation data, and our field reconnaissance conducted during our site visit of the subject site the subject site has slopes generally between approximately 30 to 50 percent slope (17 to 27 degrees). These slopes were observed to generally slope away from the site of the proposed water treatment building. It is the opinion of GeoStrata that the avalanche hazard within the subject property is considered low and should not preclude development of the proposed water treatment plant.

6.8 DEBRIS, HYPERCONCENTRATED, AND STREAM FLOW/SHEET FLOODING

Alluvial fan flooding is a potential hazard that exists in areas containing Holocene alluvial fan deposits. This type of flooding typically occurs as debris flows, hypercontracted flows, and stream flow or sheet flooding consisting of a mixture of water, soil, organic material, and rock debris with variations in sediment-water concentrations transported by fast-moving water flows. Debris flows contain approximately 60% to 80% sediment by volume and hyperconcentrated flows contain 20% to 60% sediment by volume. Stream flows contain approximately less than 20% sediment by volume and involve sediment transport by entrained and suspended sediment load (Bowman and Lund, 2020). Unconfined stream flows are referred to as sheetfloods which are spread over and occur in the distal areas of the alluvial fan or within unchanneled, broad, relatively flat-bottomed portions of drainages.

Alluvial fan flooding can be a hazard on or below alluvial fans or in stream channels above alluvial fans. Precipitation (rainfall and snowmelt) is generally viewed as an alluvial fan flood “trigger”, but this represents only one of the many factors that contribute to alluvial fan flooding hazard. Vegetation, root depth, soil gradation, antecedent moisture conditions and long-term climatic cycles all contribute to the generation of debris and initiation of alluvial fan flooding. Events of relatively short duration, such as a fire, can significantly alter a basin’s absorption of storm water and snowmelt runoff and natural resistance to sediment mobilization for an extended period of time. These factors are difficult to quantify or predict and vary not only between different watersheds, but also within each sub-area of a drainage basin. In general, there are two methods by which alluvial fan flooding can be mobilized: 1) when shallow landslides from channel side-slopes are conveyed in existing channels when mixed with water and 2) channel scour where debris is initially mobilized by moving water in a channel and then the mobilized debris continues to assemble and transport downstream sediments.

Based on our review of .6-meter 2021 aerial imagery, our review of hillshade and slope imagery derived from 2016 .5-meter lidar elevation data, and our geologic reconnaissance observations, the subject property is located on a shallow to moderately sloping undivided mass wasting and colluvial deposits. A minor perennial stream was observed east to southeast of the subject site and draining away from the subject site. Additionally, a minor ephemeral drainage was observed farther east of the subject site. No evidence was observed during our site reconnaissance visit that debris flows or hyperconcentrated flows had occurred in the area of the subject site. It was observed during our site visit that the stream may experience increased flow in times of high runoff. It is our opinion that stream flow/sheet flooding is confined to the stream channel. It is the opinion of GeoStrata that debris flow, hyperconcentrated flow, and stream flow/sheet flooding hazard within the subject site is considered low and should not preclude development of the proposed water treatment facility.

6.9 SHALLOW GROUNDWATER

Shallow groundwater flooding is a hazard that can cause the flooding of excavated areas where the depth of excavation exceeds the minimum potential depth of the local water table. Shallow groundwater flooding should be considered when designing habitable structures that are planned to have basements or below-grade habitable space within areas of potential shallow groundwater. The IRC Section R405 Foundation Drainage recommends the construction of a foundation drain around any walls or portions thereof that retain earth and enclose spaces and floors below grade. Where a site located in well-drained gravel or sand/gravel mixture soils, a dedicated drainage system is not required.

The shallow groundwater hazard is outside the scope of the reconnaissance-level geologic hazards assessment, therefore no evaluation of the groundwater conditions within the subject site has been made. The groundwater elevation should be established prior to placing the footings. We recommend a minimum of 3 feet of separation between the lowest planned finished floor slab grade and groundwater elevation. Seasonal fluctuations in precipitation, surface runoff from adjacent properties, or other on or offsite sources may increase moisture conditions; groundwater conditions can be expected to rise several feet seasonally depending on the time of year.

If an approved foundation drainage system is planned for the proposed water treatment facility, we recommend that the foundation drain be designed in accordance with the International Residential Code Section R405 Foundation Drainage R405.1 Concrete or masonry foundations (IRC 2018), that dampproofing is done in accordance with IBC Section 1805 Dampproofing and Waterproofing (IBC, 2018), and that the sump, if needed, be installed in compliance with IRC Section R405.2.3 Drainage system (IRC, 2018). We recommend that the foundation drain construction be observed and documented in a subsequent observation letter. If an approved foundation drainage system is not planned for the proposed water treatment facility there will be an increased risk of below grade flooding.

6.10 STREAM FLOODING

Stream flooding can be caused by precipitation, snowmelt, or a combination of both. Throughout most of Utah, floods are most common in the spring during the snowmelt and during large seasonal rainstorm events. High flows in drainages can last for a few hours to several weeks. Factors that affect the potential for flooding at a site include surface water drainage patterns and hydrology, site grading and drainage design, and seasonal runoff.

Based on our review of the site topography, a minor perennial stream was observed east and southeast of the subject site. (Plate A-4 *Site Vicinity Geologic Map*). This stream and associated flood plain were observed to be incised in the surrounding topography. It is our opinion that due to the observed confinement of the incised stream channel; the stream has a low likelihood of overflowing the channel and affecting the proposed water treatment building. Review of current FEMA flood hazard maps (https://msc.fema.gov/portal/home) show that there is no FEMA flood hazard zone mapped in the area of the proposed development. It is the opinion of GeoStrata that stream flooding hazard is considered low and should not preclude development of the proposed water treatment plant.

6.11 CANAL FLOODING AND DAM FAILURE

High runoff in a short period of time can lead to canal water breaching their banks and flooding the surrounding area. Failure of the canal embankments or a blockage in the canal could also lead to flooding surrounding the canal. High runoff in a short period of time, landslides, or tectonic events can lead to dam failure leading to water retained by a dam breaching the dam and flooding the downstream area.

Based on our review of topography and current FEMA flood maps, no canal was observed in the vicinity of the subject site. It is the opinion of GeoStrata that the canal flooding hazard for the subject property is considered not applicable.

Based on our review of 2021 .6-meter aerial imagery, no dam was observed uphill of the subject site. It is the opinion of GeoStrata that the hazard from dam failure is considered not applicable.

6.12 PROBLEM SOILS

Problem soils include collapsible soils and expansive soils. Collapsible soils have a potential to collapse under increased loading and moisture conditions and are typically characterized by a pinhole structure and relatively low unit weights. In general, potentially collapsible soils are observed in fine-grained soils that include clay and silt, although collapsible soils may include sandy soils. This type of problem soil typically occurs in alluvial fan flooding deposits, dry loess or eolian deposits or unconsolidated colluvium deposits (Owens and Rollins, 1990). Expansive soils are soils that undergo an increase in volume upon wetting and typically include fine grained soils such as clay.

Problem soils hazard is outside the scope of the reconnaissance-level geologic hazards assessment, therefore no evaluation of the problem soils hazard for the proposed water treatment building has been made. If the Client wishes to have a better understanding of the problem soils hazard potential at the subject property, we recommend that a geotechnical study be completed for the proposed water treatment building.

6.13 RADON

Radon is a naturally occurring odorless, tasteless and colorless gas that is released during the breakdown of uranium in well drained permeable soils and uranium rich rocks which include granite, metamorphic rocks, black shales, and some volcanic rocks (Sprinkel and Solomon, 1990). Radon gas moves freely in the air and can also dissolve in water which can potentially migrate through cracks and open spaces in rock, soils, and foundations as well as utility pipes.

The radon gas hazard is out of the scope of this study. No published data related to radon gas hazard within the subject site is currently available. Based on our observations of the soils encountered during our September 12, 2024, reconnaissance site visit, it is our preliminary opinion that the soils underlying the subject property are comprised predominantly of clay with sand and gravel, and no well drained permeable soils or uranium rich rocks were encountered. Based on the surficial soils encountered on the subject property, it is our opinion that the hazard for radon gas is low, however, indoor testing following construction is recommended for determining radon gas levels and mitigation methods needed.

6.14 KARST AND SINK HOLE

Karst and sink hole hazard is a hazard resulting from the presence of soluble soil or rock. These soils or rocks contain soluble minerals such as calcium carbonate, dolomite, or gypsum. In the presence of water these soluble minerals will dissolve causing subsidence and the formation of sinkholes (Bowman and Lund 2020). Based on our review of available geologic maps, it is the opinion of GeoStrata that karst and sink hole hazard is considered low and should not preclude the development of the proposed water treatment building.

7.0 GEOLOGIC HAZARDS SUMMARY AND CONCLUSIONS

Below is a summary of the geologic hazards that were assessed in this study as well as a summary of the geologic hazards that were not assessed as a part of this study.

- Ground shaking, surface fault rupture, tectonic deformation, rock fall and topple, landslide, slump, creep, avalanche, debris flow, hyperconcentrated flow, stream flow/ sheet flooding, stream flooding, canal flooding, and karst and sink hole hazards were assessed as part of this reconnaissance-level geologic hazards assessment. It is our opinion that the hazard for ground shaking is considered high for the proposed construction, the hazard for soil creep is considered moderate, the hazard for canal flooding and dam failure is not applicable to the proposed construction and all other hazards assessed are considered low for the proposed construction of the addition to the existing single-family residential structure.
- Liquefaction, shallow groundwater, problem soils, and radon hazards were not assessed as part of this reconnaissance-level geologic hazards assessment and no inference is made as to the presence or absence of these hazards at the site.

If there are changes in the proposed development, we should be notified so that we can assess the planned changes and modify our recommendations if deemed necessary. It is the opinion of GeoStrata that the geologic hazards assessed in this study should not preclude the proposed development of the subject site, assuming that the recommendations provided in this report are followed.

8.0 CLOSURE

8.1 LIMITATIONS

The conclusions and recommendations contained in this report, which include professional opinions and judgments, are based on the information available to us at the time our reconnaissance-level geologic hazards assessment was conducted, the results of our assessment of available geological data, and our understanding of the proposed site development. If any conditions are encountered at this site that are different from those described in this report, our firm should be immediately notified so that we may make any necessary revisions to the recommendations contained in this report. In addition, if the scope of the proposed development changes from that described in this report, our firm should also be notified.

All services were completed in accordance with the current standard of care and generally accepted standard of practice at the time and in the place our services were completed. No other warranty, expressed or implied, is made. Development of property in the immediate vicinity of geologic hazards involves a certain level of inherent risk. It is impossible to predict where geologic hazards will occur. New geologic hazards may develop, and existing geologic hazards may expand beyond their current limits.

All services were performed for the exclusive use and benefit of the above addressee. No other person is entitled to rely on GeoStrata's services or use the information contained in this letter without the express written consent of GeoStrata. We are not responsible for the technical interpretations by others of the information described or documented in this report. The use of information contained in this report for bidding purposes should be done at the Contractor's option and risk.

8.0 REFERENCES CITED

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APPENDIX A

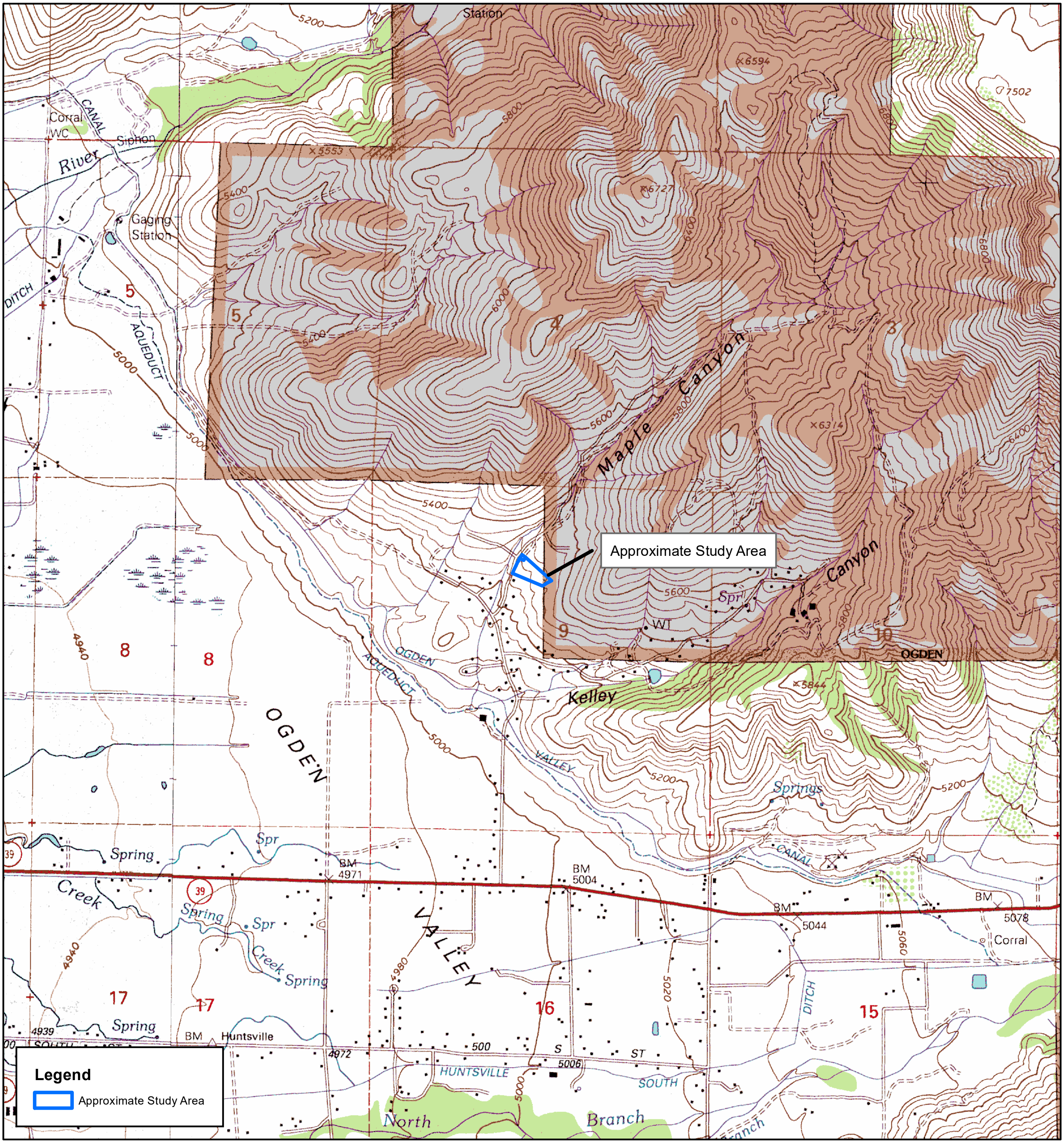
Base Map
.6 Meter 2021 NAIP Orthophotography
Weber County Mosaic
Provided by the State of Utah UGRC

GeoStrata

Reconnaissance-Level Geologic Hazards Assessment
Green Hills Sewer and Water - Maple Hills WTP
922 N Maple St.
Huntsville Utah 84317

Site Vicinity Aerial Imagery Map

Plate 1

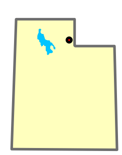


0 625 1,250 2,500 3,750 5,000 Feet

1 inch = 2,000 feet

Base Map
1:24,000 Scale 7.5-minute USGS Topographic Map
Weber County Mosaic
Provided by the State of Utah UGRC

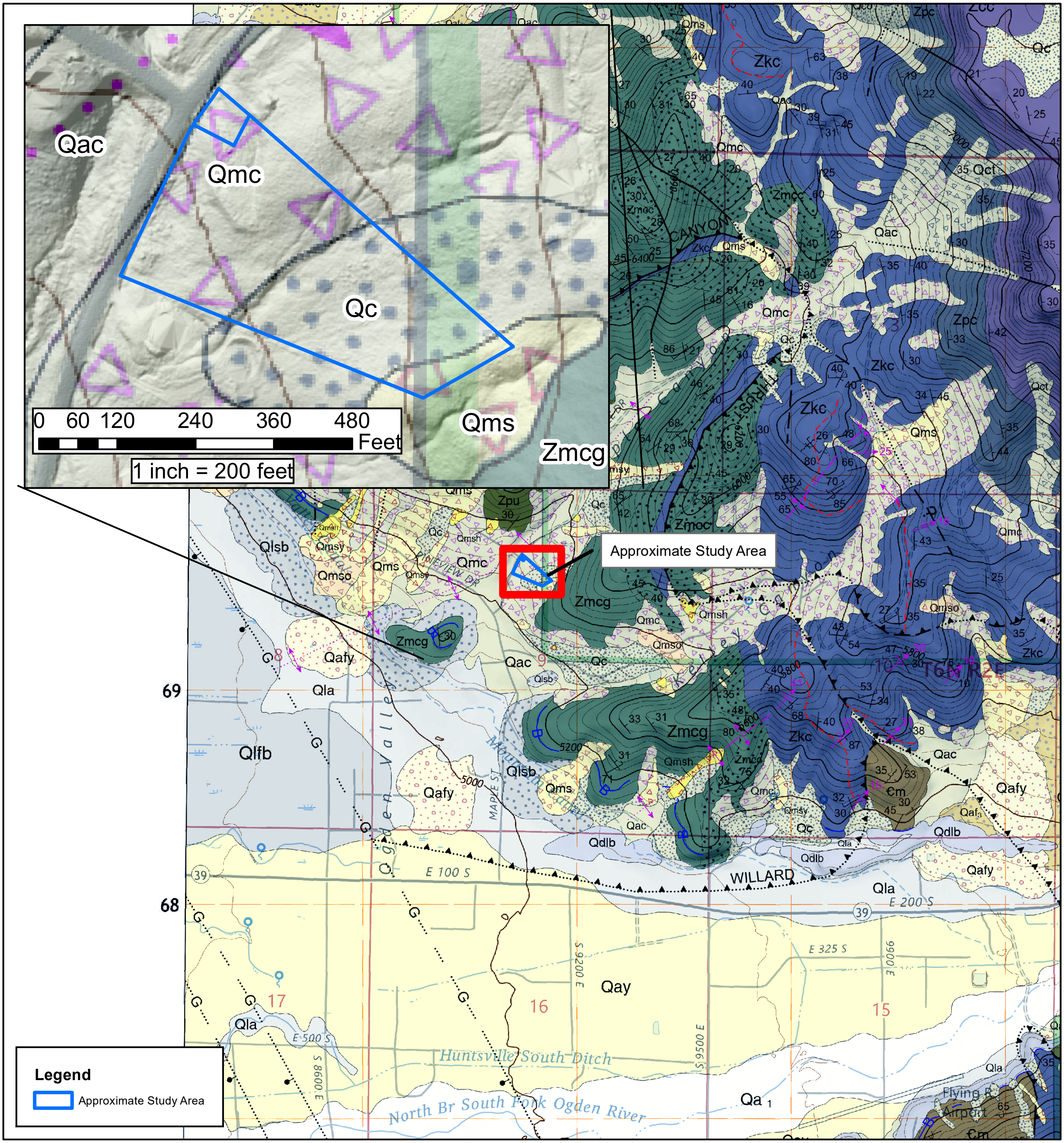
N



Reconnaissance-Level Geologic Hazards Assessment
Green Hills Sewer and Water - Maple Hills WTP
922 N Maple St.
Huntsville Utah 84317

Site Vicinity USGS Topographic Map

Plate 2



0 625 1,250 2,500 3,750 5,000 Feet

1 inch = 2,000 feet

Base Map
Interim Geologic Map of the Browns Hole Quadrangle,
Weber and Cache Counties, Utah
by Zachary W. Anderson, Greg N. McDonal, Elizabeth A. Balgord,
and W. Adolph Yonkee, 2023
Provided by the State of Utah UGS

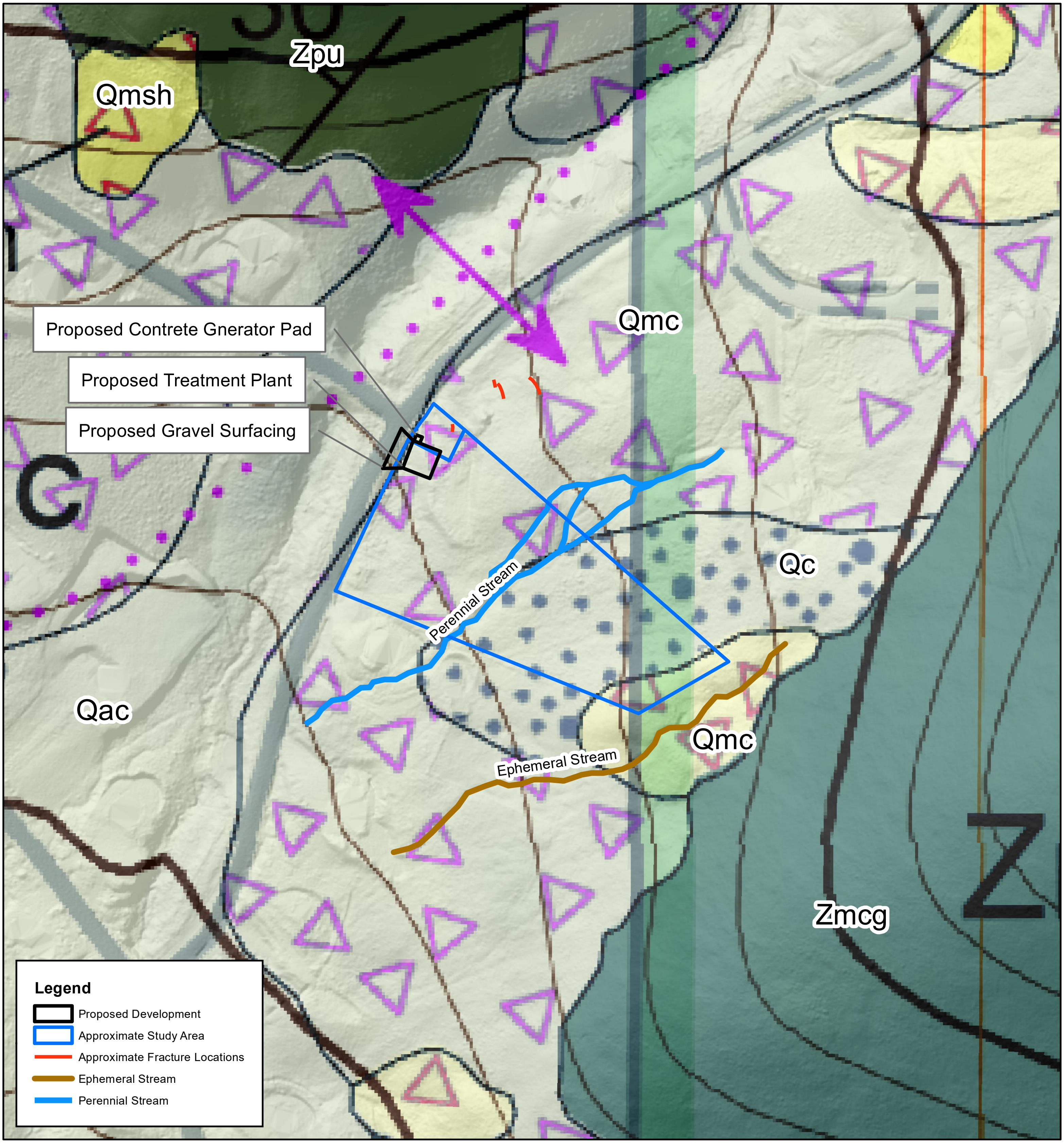
N

GeoStrata

Reconnaissance-Level Geologic Hazards Assessment
Green Hills Sewer and Water - Maple Hills WTP
922 N Maple St.
Huntsville Utah 84317

Site Vicinity 7.5-minute Geologic Map

Plate 3



0 62.5 125 250 375 500 Feet

1 inch = 200 feet

Base Map
Hillshade derived from 2016 .5 meter LiDAR
Provided by the State of Utah UGRC

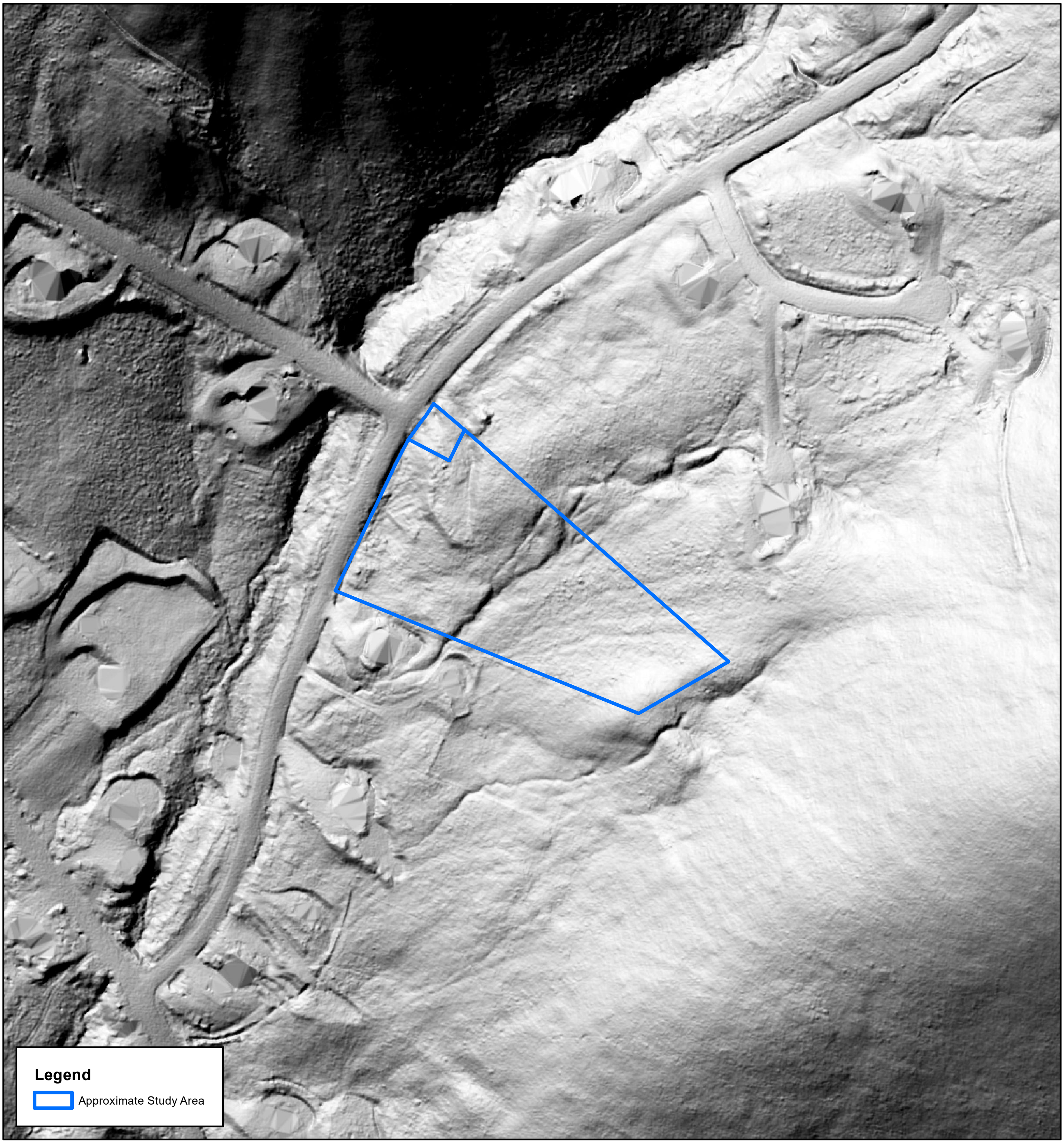
N

GeoStrata

Reconnaissance-Level Geologic Hazards Assessment
Green Hills Sewer and Water - Maple Hills WTP
922 N Maple St.
Huntsville Utah 84317

Site Specific Geologic Map

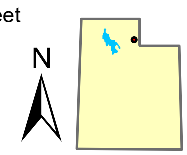
Plate 4



0 62.5 125 250 375 500 Feet

1 inch = 200 feet

Base Map
Hillshade derived from 2016 .5 meter LiDAR
Provided by the State of Utah UGRC

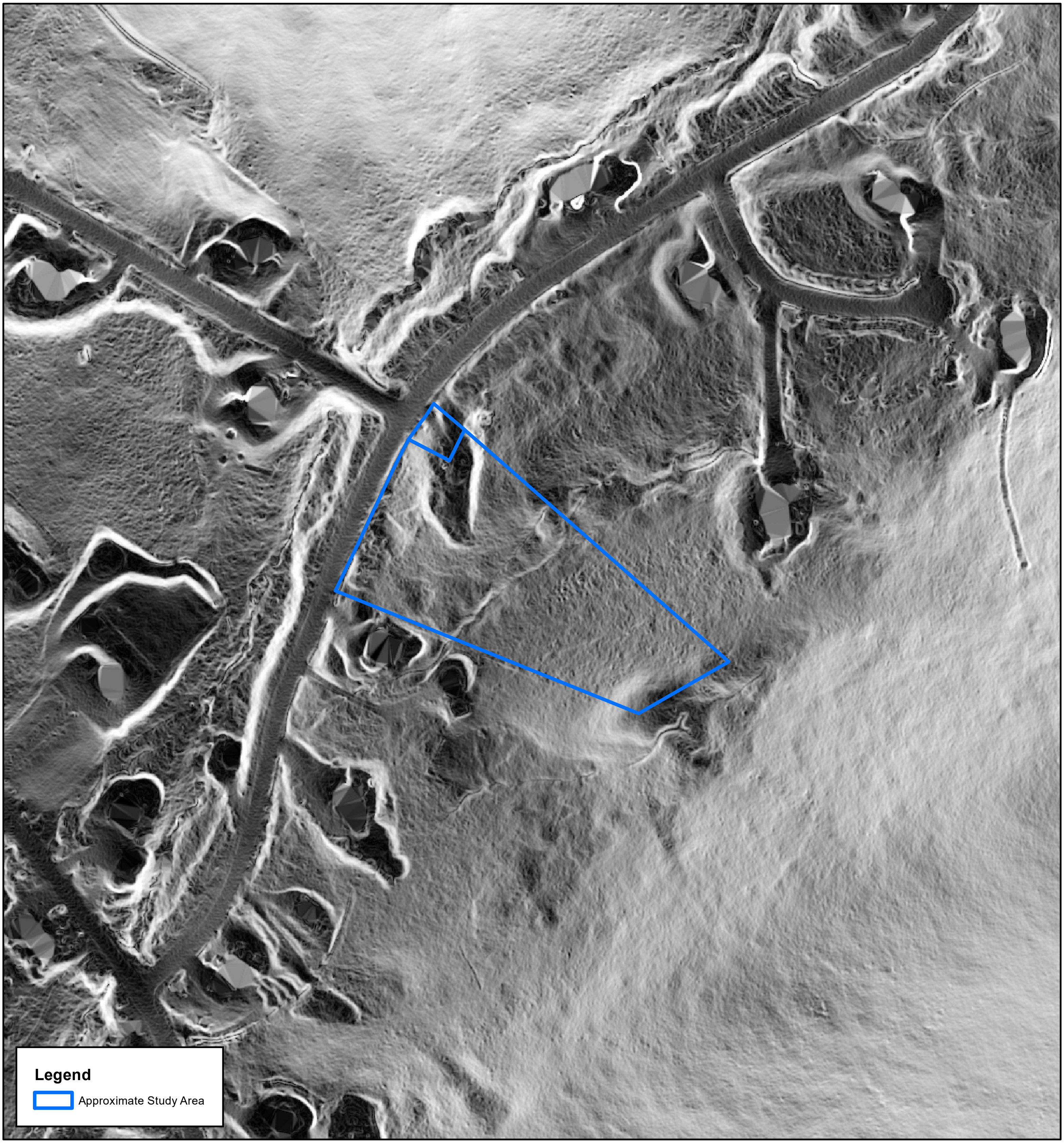


GeoStrata

Reconnaissance-Level Geologic Hazards Assessment
Green Hills Sewer and Water - Maple Hills WTP
922 N Maple St.
Huntsville Utah 84317

Hillshade Map

Plate 5



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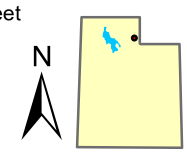
1 inch = 200 feet

Base Map
Slopeshade derived from
2016 .5 meter LiDAR
Provided by the State of Utah UGRC

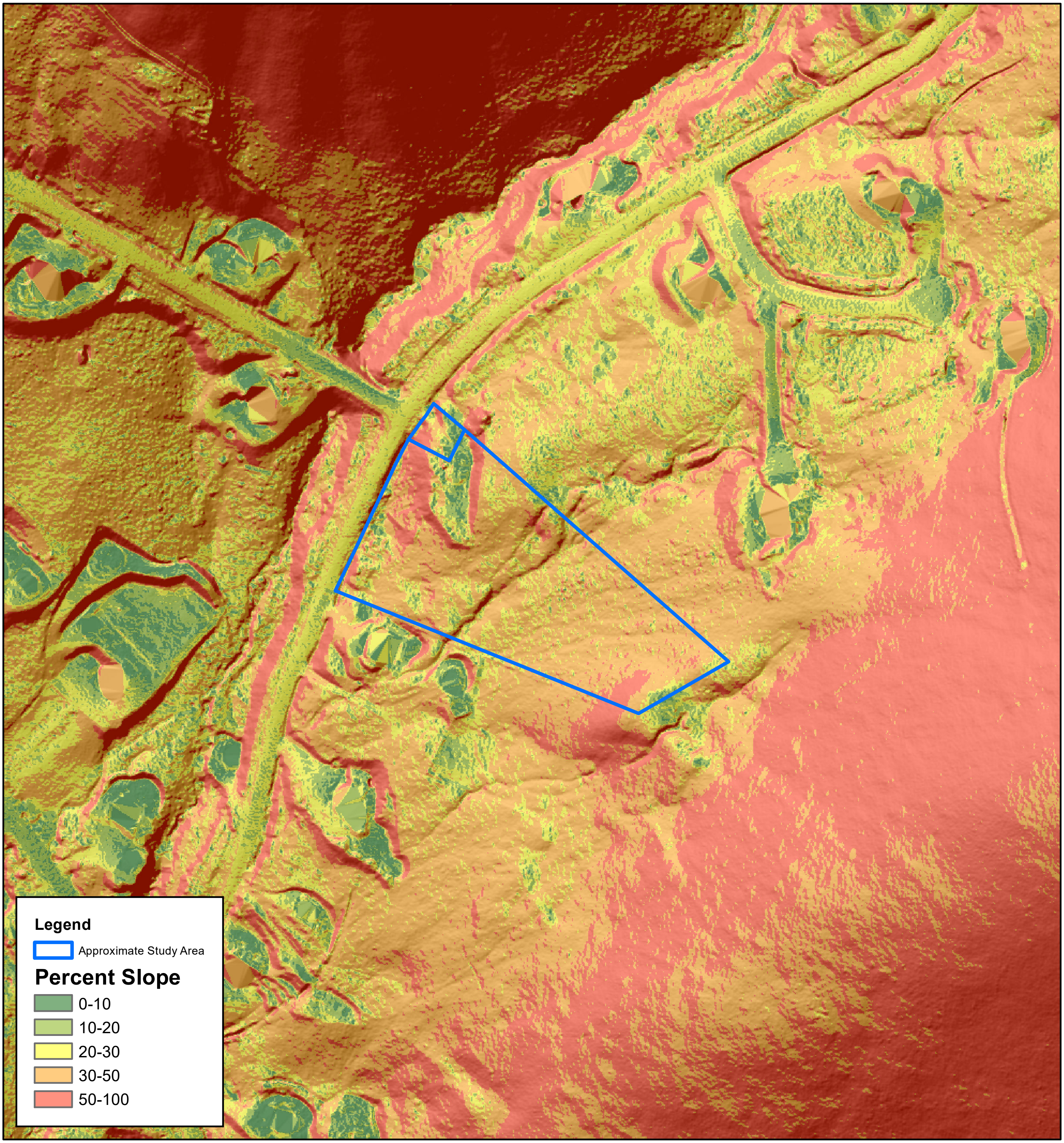


GeoStrata

Reconnaissance-Level Geologic Hazards Assessment
Green Hills Sewer and Water - Maple Hills WTP
922 N Maple St.
Huntsville Utah 84317

Slopeshade Map

Plate 6



0 62.5 125 250 375 500 Feet

1 inch = 200 feet

Base Map
Percent Slope derived from
2016 .5 meter LiDAR
Provided by the State of Utah UGRC

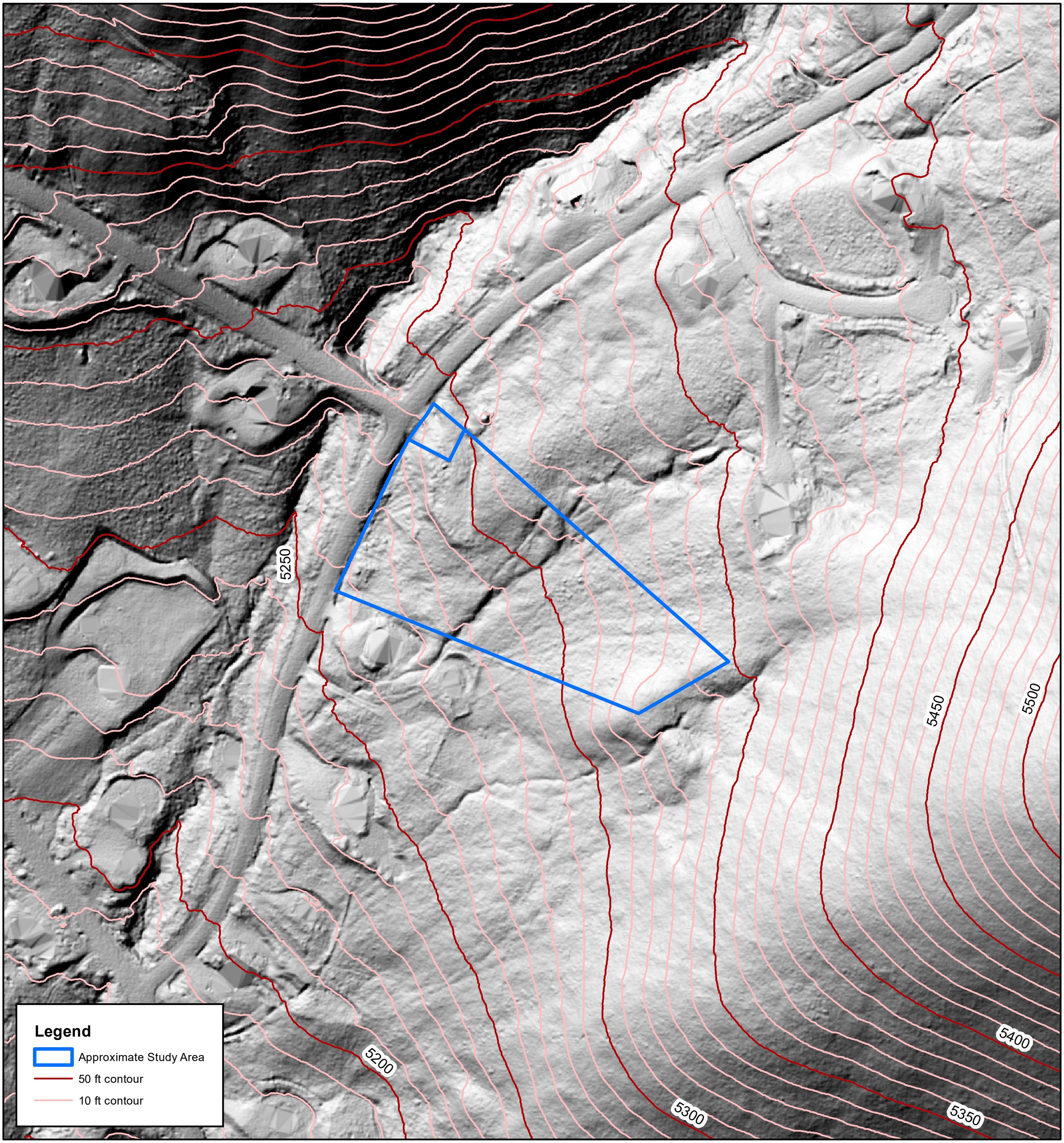
N

GeoStrata

Reconnaissance-Level Geologic Hazards Assessment
Green Hills Sewer and Water - Maple Hills WTP
922 N Maple St.
Huntsville Utah 84317

Percent Slope Map

Plate 7



0 62.5 125 250 375 500
Feet
1 inch = 200 feet

Base Map
Hillshade and Contours derived from
2016 .5 meter LiDAR
Provided by the State of Utah UGS

N

GeoStrata

Reconnaissance-Level Geologic Hazards Assessment
Green Hills Sewer and Water - Maple Hills WTP
922 N Maple St.
Huntsville Utah 84317

Topographic Map

Plate 8