Intermountain GeoEnvironmental Services, Inc.
12429 South 300 East, Suite 100, Draper, Utah 84020
Phone (801) 748-4044 | Fax (801) 748-4045
www.igesinc.com

RECONNAISSANCE-LEVEL GEOLOGIC HAZARDS INVESTIGATION
Bloomington Well Pump Station
Summit Powder Mountain Resort
Weber County, Utah

IGES Project No. 01628-029

February 11, 2019

Prepared for:

Summit Mountain Holding Group

Intermountain GeoEnvironmental Services, Inc.
12429 South 300 East, Suite 100, Draper, Utah 84020 ~ T: (801) 748-4044 ~ F: (801) 748-4045

Prepared for:

Summit Mountain Holding Group
3632 North Wolf Creek Drive
Eden, Utah 84310
Attn: Mr. Rick Everson

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Prepared by:

Peter E. Doumit, P.G., C.P.G.
Senior Geologist

Reviewed by:

David A. Glass, P.E.
Senior Geotechnical Engineer

IGES, Inc.
12429 South 300 East, Suite 100
Draper, Utah 84020
(801) 748-4044

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1.0 EXECUTIVE SUMMARY

This report presents the results of a reconnaissance-level geologic hazard investigation performed for the proposed Bloomington Well Pump Station, part of the greater Summit at Powder Mountain Resort Expansion Project in Weber County, Utah. Based on the literature reviewed and surficial conditions encountered across the property, **it is our opinion that the proposed development is not anticipated to be adversely impacted by geologic hazards, provided that the recommendations presented in this report are incorporated into the design and construction of the project**.

- In general, the property is covered by weathered Wasatch Formation conglomeratic bedrock, with outcrops of Nounan Formation or St. Charles Formation dolomite observed to the south in the Powder Ridge Road roadcut.

- The weathered Wasatch Formation exposed at the surface consists of a clayey sand with gravel, containing subrounded to subangular cobbles and boulders of quartzite and conglomeratic quartzite up to 5 feet in diameter.

- Due to the presence of a few large boulders immediately upslope of the proposed pump house, the rockfall hazard risk is considered to be *low to moderate*. These are considered to be potentially susceptible to downslope movement in a seismic event, and it is recommended that these boulders be scaled (removed from) the slope preceding development to reduce the rockfall hazard risk to *low*.

- Landslide, debris-flow, flooding, surface-fault-rupture, liquefaction, and shallow groundwater hazards are considered to be low for the property.

NOTE: The scope of services provided within this report are limited to the assessment of the surface conditions at the subject site. The executive summary is provided solely for purposes of overview and is not intended to replace the report of which it is part and should not be used separately from the report.

2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE OF WORK

This report presents the results of a reconnaissance-level geologic hazard investigation performed for the proposed Bloomington Well Pump Station, part of the greater Summit at Powder Mountain Resort Expansion Project in Weber County, Utah (see Figure A-1, *Site Vicinity Map*, in Appendix A). This study was performed as a reconnaissance-level geologic hazards assessment to identify any surficial or subsurface geologic hazards that may be extant on the property or have the capability to adversely impact the property. Specifically, this study was conducted to:

- Analyze the existing geologic conditions present on the property and relevant adjacent areas;
- Assess the geologic hazards that pose a risk to development across the property, and determine an associated risk for each hazard; and
- Identify the most significant geologic hazard risks and provide recommendations for appropriate additional studies and/or mitigation practices, if necessary.

The scope of work completed for this study included a literature and aerial imagery review, site reconnaissance, and the preparation of this report. The recommendations contained in this report are subject to the limitations presented in the *Limitations* section of this report (Section 7.1). Our services were performed in accordance with our proposal dated November 14, 2018 and your signed authorization.

2.2 PROJECT DESCRIPTION

The subject property is located within the greater Powder Mountain Resort area in the southeast quarter of Section 6, Township 7 North, Range 2 East, near the northern margin of Weber County (Figure A-1). The Bloomington pump station is to be built adjacent to the existing Hidden Lake pump station, approximately 140 feet south of the existing reservoir and 130 feet north of Powder Ridge Road.

Our understanding of the project is based on information and drawings provided by the Client. We understand that the proposed development will consist of the construction of a single pump station, with tied-in utilities to the Hidden Lake pump station and the nearby existing water tank. The pump station will be a wood-framed structure founded on conventional spread footings.

3.0 METHODS OF STUDY

3.1 LITERATURE REVIEW

A number of pertinent publications were reviewed as part of this assessment. Sorensen and Crittenden, Jr. (1979) provides 1:24,000 scale geologic mapping of the Huntsville Quadrangle (Figure A-2, *Regional Geology Map 1*). Coogan and King (2001) provide more recent geologic mapping of the area, but at a 1:100,000 scale. Western Geologic (2012) conducted a reconnaissance-level geologic hazard study for the greater 200-acre Powder Mountain expansion project, including the subject area (Figure A-3, *Regional Geology Map 2*). The Western Geologic (2012) study modified some of the potential landslide hazard boundaries that had previously been mapped at a regional scale (1:100,000) by Coogan and King (2001) and Elliott and Harty (2010). An updated Coogan and King (2016) regional geologic map (1:62,500 scale) provides the most recent published geologic mapping that covers the project area (Figure A-4, *Regional Geology Map 3*). The corresponding United States Geological Survey (USGS) topographic map for the Huntsville Quadrangle (2017) provides physiographic and hydrologic data for the project area. Regional-scale geologic hazard maps pertaining to landslides (Christenson and Shaw, 2008a; Elliott and Harty, 2010; Colton, 1991), faults (Christenson and Shaw, 2008a; USGS and Utah Geological Survey (UGS), 2006), debris-flows (Christenson and Shaw, 2008b), and liquefaction (Christenson and Shaw, 2008c; Anderson et al., 1994) that cover the project area were also reviewed. The Quaternary Fault and Fold Database (USGS and UGS, 2006) was reviewed to identify the location of proximal faults that have had associated Quaternary-aged displacement.

More site-specific, a geotechnical investigation performed by Raba Kistner Infrastructure, Inc. (RKI, 2013) for the nearby water tank was reviewed, along with an IGES (2017) geotechnical and geologic hazard investigation for the nearby Horizon Neighborhood.

Aerial photographs of the property were examined stereoscopically for the presence of large-scale geomorphologic features indicative of landslide deposits and headscarps, as well as lineaments which might suggest the presence of a fault. Additional aerial imagery for the property, including current and historic Google Earth images, were also reviewed to help assess the presence of geologic hazards. The aerial photographs reviewed are documented in the *References* section of this report.

3.2 SITE RECONNAISSANCE

A licensed IGES geologist conducted site reconnaissance of the project site and immediately adjacent areas on November 14, 2018. The site reconnaissance entailed the mapping of the surficial geology and the characterization of potentially suspect geologic hazard areas, with specific interest in those areas identified in the geologic literature and aerial imagery reviews as potential geologic hazard areas (if identified). Additionally, the site reconnaissance provided the opportunity to geologically map the surficial geology of the area (Figure A-5, *Local Geology Map*).

4.0 GEOLOGIC CONDITIONS

4.1 GENERAL GEOLOGIC SETTING

4.1.1 Regional Geology

The Bloomington Well Pump Station site is situated in the western portion of the northern Wasatch Mountains, approximately 5 miles northeast of Ogden Valley. The Wasatch Mountains contain a broad depositional history of thick Precambrian and Paleozoic sediments that have been subsequently modified by various tectonic episodes that have included thrusting, folding, intrusion, and volcanic activity, as well as scouring by glacial and fluvial processes (Stokes, 1987). The uplift of the Wasatch Mountains occurred relatively recently during the Late Tertiary Period (Miocene Epoch) between 12 and 17 million years ago (Milligan, 2000). Since uplift, the Wasatch Front has seen substantial modification due to such occurrences as movement along the Wasatch Fault and associated spurs, the development of the numerous canyons that empty into the current Salt Lake Valley and Utah Valley and their associated alluvial fans, erosion and deposition from Lake Bonneville, and localized mass-movement events (Hintze, 1988).

The Wasatch Mountains, as part of the Middle Rocky Mountains Province (Milligan, 2000), were uplifted as a fault block along the Wasatch Fault (Hintze, 1988). Ogden Valley itself is a fault bounded trough that was occupied by Lake Bonneville (Sorensen and Crittenden, Jr, 1979) before being cut through by the Ogden River and subsequently dammed to form the Pineview Reservoir.

4.1.2 Seismotectonic Setting

The Wasatch Fault and its associated segments are part of an approximately 230-mile long zone of active normal faulting referred to as the Wasatch Fault Zone (WFZ), which has well-documented evidence of late Pleistocene and Holocene (though not historic) movement (Lund, 1990; Hintze, 1988). The faults associated with the WFZ are all normal faults, exhibiting block movement down to the west of the fault and up to the east. The WFZ is contained within a greater area of active seismic activity known as the Intermountain Seismic Belt (ISB), which runs approximately north-south from northwestern Montana, along the Wasatch Front of Utah, through southern Nevada, and into northern Arizona. In terms of earthquake risk and potential associated damage, the ISB ranks only second in North America to the San Andreas Fault Zone in California (Stokes, 1987).

The WFZ consists of a series of ten segments of the Wasatch Fault that each display different characteristics and past movement, and are believed to have movement independent of one another (UGS, 1996). The subject property is located approximately 9.6 miles northeast of the Weber Segment of the WFZ, which represents the closest mapped Holocene-aged (active) fault to the property (USGS and UGS, 2006).

4.2 HYDROLOGY

The USGS topographic map for the Huntsville Quadrangle (2017) shows that project site is situated near the top of a topographic high, with the topographic gradient down to the south toward the Lefty's Canyon drainage (see Figure A-1). No active or ephemeral stream drainages were observed on the property during the site reconnaissance. No springs are known to occur on the project site and springs are not anticipated to occur on the property, even during peak spring runoff times.

Baseline groundwater depths for the property are currently unknown but are anticipated to be deep and fluctuate both seasonally and annually. No groundwater was encountered in the 60-foot boring drilled for the nearby water tank (RKI, 2013). The annual high groundwater level is likely to be attained following peak spring runoff.

4.3 SITE GEOLOGY FROM LITERATURE

According to Sorensen and Crittenden, Jr. (1979; Figure A-2), the project site is entirely underlain by the undivided Tertiary/Cretaceous Wasatch and Evanston Formations (unit TKwe), described as "unconsolidated pale-red to greenish-red pebble, cobble, and boulder conglomerate. Forms boulder-covered slopes but does not crop out anywhere. Clasts are mainly Precambrian quartzite and are tan, gray, or purple; matrix is mainly poorly consolidated sand and silt."

Coogan and King (2001) produced a regional-scale geologic map that covered the property; this map shows the property to be entirely underlain by the Wasatch Formation. Coogan and King (2016) updated their 2001 map, but did not change the interpretation of the property to be situated entirely upon a ridge of Wasatch Formation bedrock (unit Tw), though landslide (unit Qms) and mixed landslide and colluvial deposits (unit Qmc) are mapped within 500 feet to the west, south, and northeast of the property (Figure A-4).

RKI (2013) drilled a single boring with an ODEX rig to perform a geotechnical evaluation of site soils for the nearby water tank. The boring SPT blow counts and drill cuttings indicated that the "subsurface materials consist of dense, silty gravel with cobbles and boulders," which was interpreted to mean that the Wasatch Formation conglomerate bedrock was present to the total depth of the boring (60 feet below existing grade). No groundwater was encountered in the boring.

4.4 GEOLOGIC HAZARDS FROM LITERATURE

Based upon the available geologic literature, regional-scale geologic hazard maps that cover the subject property have been produced for landslide, fault, debris-flow, and liquefaction hazards. The following is a summary of the data presented in these regional geologic hazard maps.

4.4.1 Landslides

Two regional-scale landslide hazard maps have been produced that cover the project area. Neither Colton (1991) nor Elliott and Harty (2010) show the site to be located in an area that is underlain by landslide deposits. Elliott and Harty (2010) show the project area to be located between downslope areas classified as "Landslide undifferentiated from talus and/or colluvial deposits."

Western Geologic (2012) identified a number of landslide deposits contained within the Powder Mountain Resort expansion area, though none of these underlie the subject area (Figure A-3). Older (Pleistocene-aged) and younger (Holocene-aged) landslide deposits have been mapped within approximately 1,000 and 750 feet of the property, respectively. Additional deposits noted as "mixed slope colluvium, shallow landslides, and talus" are mapped within 600 feet of the property.

4.4.2 Faults

Neither Christenson and Shaw (2008a) nor the Quaternary Fault and Fold Database of the United States (USGS and UGS, 2006) show any Quaternary-aged (~2.6 million years ago to the present) faults to be present on or projecting towards the subject area. The closest Quaternary-aged fault to the area is the Ogden Valley Northeastern Margin Fault, which trends northwest to southeast approximately 3 miles southwest of the property (USGS and UGS, 2006). The Weber County Natural Hazards Overlay Districts defines an active fault to be "a fault displaying evidence of greater than four inches of displacement along one or more of its traces during Holocene time (about 11,000 years ago to the present)" (Weber County, 2015). The closest mapped active fault to the property is the Weber Segment of the Wasatch Fault Zone, located approximately 9.6 miles southwest of the site (USGS and UGS, 2006).

4.4.3 Debris-Flows

Christenson and Shaw (2008b) does not show the project area to be located within a debris-flow/alluvial fan special study area.

4.4.4 Liquefaction

Anderson, et al. (1994) and Christenson and Shaw (2008c) both show the project area to be located in an area designated as having a very low potential for liquefaction.

4.5 SITE GEOLOGY FROM AERIAL IMAGERY

A series of aerial photographs that cover project area were taken from the UGS Aerial Imagery Collection (UGS, 2019) and analyzed stereoscopically for the presence of adverse geologic conditions across the property. This included a review of photos collected from the years 1952 and 1963 which were all taken prior to recent Powder Mountain development. A table displaying the details of the aerial photographs reviewed can be found in the *References* section at the end of this report. No geologic lineaments, fault scarps, landslide headscarps, or landslide deposits were observed in the aerial photography on the subject property.

Google Earth imagery of the property from between the years of 1993 and 2018 were also reviewed. No landslide or other geological hazard features were noted in the imagery. The property was observed to remain largely in a natural state until 2009 before significant surface disturbance occurred. The nearby water tank and Hidden Lank pump station were installed by October of 2014, and increased surficial disturbance across the proposed Bloomington Pump Station site is present in all subsequent imagery.

4.6 LOCAL GEOLOGY FROM SITE RECONNAISSANCE

Mr. Peter E. Doumit, P.G., C.P.G., of IGES conducted reconnaissance of the site and the immediate adjacent properties on November 14, 2018. The local geology was observed to be largely consistent with that as-mapped and described by Coogan and King (2016); Figure A-5 is a site-specific *Local Geology Map*.

At the time of the site reconnaissance, the project site was found to be situated just below the local topographic high, with no natural drainages and significant human disturbance. A cut into the hillslope upslope (north) of the Hidden Lake pump station was observed to expose all weathered Wasatch Formation, which was present as a moderate reddish orange to dark reddish brown clayey sand with subrounded to subangular quartzite gravel, cobbles, and boulders up to 5 feet in diameter. Discontinuous pockets of dark reddish brown sandy fat clay with gravel were observed within the uppermost four feet of the cut, but no slickensides or evidence of shear were observed.

The site of the proposed Bloomington Well Pump Station was observed to be highly irregular and disturbed by human activity, including a rip-rap lined small drainages to the east and south of the site, and a small detention pond to the west (dry at the time of the reconnaissance). On the slope and sitting at the top of the slope immediately above the proposed pump station location were several large clasts of Wasatch Formation conglomerate and Nounan Dolomite up to four feet in diameter, believed to have been removed from the subsurface during the water tank excavation. As such, these were sitting unburied on the existing ground surface, and were not partially buried like most of the other native boulders observed on the surface.

Road cuts to the south of the project area along Powder Ridge Road exposed approximately 6 feet of Wasatch Formation conglomerate overlying dark gray Nounan Dolomite. An elevation change of approximately 35 feet between Powder Ridge Road and the water tank located uphill of the road, combined with the RKI (2013) boring extending to a depth of 60 feet below existing grade from the water tank location and encountering all Wasatch Formation, indicate a significant thickening of the Wasatch Formation deposits to the north. As such, it is anticipated that the subgrade for the Bloomington Pump Station will be entirely Wasatch Formation conglomerate bedrock.

5.0 GEOLOGIC HAZARD ASSESSMENT

Geologic hazard assessments are necessary to determine the potential risk associated with particular geologic hazards that are capable of adversely affecting a proposed development area. As such, they are essential in evaluating the suitability of an area for development and provide critical data in both the planning and design stages of a proposed development. The geologic hazard assessment discussion below is based upon a qualitative assessment of the risk associated with a particular geologic hazard, based upon the data reviewed and collected as part of this investigation.

A "low" hazard rating is an indication that the hazard is either absent, is present in such a remote possibility so as to pose limited or little risk, or is not anticipated to impact the project in an adverse way. Areas with a low-risk determination for a particular geologic hazard do not require additional site-specific studies or associated mitigation practices with regard to the geologic hazard in question.

A "moderate" hazard rating is an indication that the hazard has the capability of adversely affecting the project at least in part, and that the conditions necessary for the geologic hazard are present in a significant, though not abundant, manner. Areas with a moderate-risk determination for a particular geologic hazard may require additional site-specific studies, depending on location and construction specifics, as well as associated mitigation practices in the areas that have been identified as the most prone to susceptibility to the particular geologic hazard.

A "high" hazard rating is an indication that the hazard is very capable of adversely affecting or currently does adversely affect the project, that the geologic conditions pertaining to the particular hazard are present in abundance, and/or that there is geologic evidence of the hazard having occurred at the area in the historic or geologic past. Areas with a high-risk determination always require additional site-specific hazard investigations and associated mitigation practices where the location and construction specifics are directly impacted by the hazard. For areas with a high-risk geologic hazard, simple avoidance is often considered.

The following is a summary of the geologic hazard assessment for the proposed Bloomington Well Pump Station.

5.1 LANDSLIDES

Neither the most recent geologic map covering the property (Coogan and King, 2016) nor the regional landslide maps (Elliott and Harty, 2010; Western Geologic, 2012) show the property to be underlain by landslide deposits. Additionally, landslide deposits or headscarps were not observed on the property in the aerial imagery review or during the site reconnaissance. Given this data, the landslide and mass-movement hazards associated with the property are considered to be low.

5.2 ROCKFALL

No bedrock outcrop is exposed upslope of the property. However, several larger boulders of the Wasatch Formation and Nounan Dolomite possibly dug out from the water tank excavation were observed upslope of the project area sitting on the surface of the slope or at the edge of the top of the slope. It is considered possible that these boulders could potentially travel downslope and adversely impact the pump station during a seismic event. As such, the rockfall hazard associated with the property is considered to be *low to moderate*.

5.3 DEBRIS-FLOWS AND FLOODING

Debris-flows typically deposit on existing alluvial fans located at the mouth of active canyons, while flooding typically occurs in drainage channels and lowland areas within a drainage basin. The site is located on a slope just below a topographic high, and no drainages or alluvial fan deposits have been mapped on the property. Given this information, the risk associated with debris-flows and flooding hazards on the property is considered to be low.

5.4 SURFACE FAULT RUPTURE

No faults are known to be present on or projecting towards the property, and the closest mapped active fault to the property is the Weber Segment of the Wasatch Fault Zone, located approximately 9.6 miles to the southwest of the property (USGS and UGS, 2006). Given this information, the risk associated with surface-fault-rupture on the property is considered low.

The entire property is subject to earthquake-related ground shaking from a large earthquake generated along the active Wasatch Fault. Given the distance from the Wasatch Fault, the hazard associated with ground shaking is considered to be moderate. Proper building design according to appropriate building code and design parameters can assist in mitigating the hazard associated with earthquake ground shaking.

5.5 LIQUEFACTION

Liquefaction occurs in loose, saturated sand and some silts, whereas bedrock does not liquefy. The site is largely underlain by unconsolidated Wasatch Formation conglomerate and possibly Nounan Dolomite. Additionally, groundwater is not anticipated to be near-surface. Given this data, and consistent with the existing geologic literature for the area, the risk associated with earthquake-induced liquefaction is considered to be low.

5.6 SHALLOW GROUNDWATER

Groundwater was not encountered in the RKI (2013) boring to a depth of 60 feet below existing grade. The boring was drilled in June, hence the groundwater level was likely beginning to decline from its annual high level. The groundwater level is anticipated to fluctuate both seasonally and annually, but given this data, the shallow groundwater hazard is considered to be low.

6.0 GEOLOGIC CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Based upon the data collected and reviewed as part of this assessment, IGES makes the following conclusions regarding the geologic hazards present at the proposed Bloomington Well Pump Station property:

- **From a reconnaissance-level perspective, the Bloomington Well Pump Station project area does not appear to have geological hazards that would adversely affect the development as currently proposed. As such, no subsurface geologic hazards investigative methods are considered to be necessary for the property preceding development, and the property is considered buildable from a geologic hazard perspective.**

- In general, the property is covered by weathered Wasatch Formation conglomeratic bedrock, with outcrops of Nounan Formation or St. Charles Formation dolomite observed to the south in the Powder Ridge Road roadcut.

- The weathered Wasatch Formation exposed at the surface consists of a clayey sand with gravel, containing subrounded to subangular cobbles and boulders of quartzite and conglomeratic quartzite up to 5 feet in diameter.

- Due to the presence of a few large boulders immediately upslope of the proposed pump house, the rockfall hazard risk is considered to be low to moderate. These boulders are considered to be potentially susceptible to downslope movement during a seismic event.

- Landslide, debris-flow, flooding, surface-fault-rupture, liquefaction, and shallow groundwater hazards are considered to be low for the property.

6.2 RECOMMENDATIONS

Given the findings of this geologic hazards assessment, IGES recommends the following:

- To reduce the rockfall hazard risk, the boulders immediately upslope of and sitting at the edge of the top of the slope that are considered as being potentially susceptible to seismically-induced rockfall events should be scaled (removed from) the hillslope prior to development. These boulders can be moved with the same equipment that will be used to excavate the pump station foundation, and can either be removed from the hillslope altogether or moved downslope and positioned such that they are not likely to have the capacity to be naturally mobilized by seismicity or erosion.

- The foundations for the pump station may be founded directly upon undisturbed native subgrade (Wasatch Formation bedrock). If soft, loose, or otherwise deleterious earth materials are exposed at the foundation subgrade, the subgrade should be over-excavated a minimum of 2 feet and replaced with structural fill (as defined in IGES, 2012), such that all foundations are underlain by a relatively uniform fill blanket. Constructing the pump house on a native/fill transition zone is not recommended.

- Shallow spread or continuous wall footings constructed entirely on competent native subgrade or entirely on a minimum of two feet of structural fill may be proportioned utilizing a maximum net allowable bearing pressure of 2,500 psf. This bearing value is for dead load plus live load conditions. A 1/3 increase may be allowed for wind or seismic loading.

- All other geotechnical engineering recommendations presented in the Design Geotechnical Investigation report by IGES (2012) should be followed, except where superseded herein.

7.0 CLOSURE

7.1 LIMITATIONS

The concept of risk is a significant consideration of geotechnical and geologic hazard analyses. The analytical means and methods used in performing geotechnical and geologic hazard analyses and development of resulting recommendations do not constitute an exact science. Analytical tools used by geotechnical engineers and engineering geologists are based on limited data, empirical correlations, engineering judgment and experience. As such, the solutions and resulting recommendations presented in this report cannot be considered risk-free and constitute IGES's best professional opinions and recommendations based on the available data and other design information available at the time they were developed. IGES has developed the preceding analyses, recommendations and designs, at a minimum, in accordance with generally accepted professional geotechnical engineering and engineering geology practices and care being exercised in the project area at the time our services were performed. No warrantees, guarantees or other representations are made.

The information contained in this report is based on limited field reconnaissance and understanding of the project. The subsurface data used in the preparation of this report were obtained largely from the boring drilled as part of the geotechnical investigation for the nearby water tank (RKI, 2013) and hillslope and road cuts. It is very likely that variations in the soil, rock, and groundwater conditions exist between and beyond the points explored. The nature and extent of the variations may not be evident until construction occurs and additional explorations are completed. If any conditions are encountered at this site that are different from those described in this report, IGES must be immediately notified so that we may make any necessary revisions to recommendations presented in this report. In addition, if the scope of the proposed construction or grading changes from those described in this report, our firm must also be notified.

This report was prepared for our client's exclusive use on the project identified in the foregoing. Use of the data, recommendations or design information contained herein for any other project or development of the site not as specifically described in this report is at the user's sole risk and without the approval of IGES, Inc. It is the client's responsibility to see that all parties to the project including the designer, contractor, subcontractors, etc. are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the contractor's option and risk.

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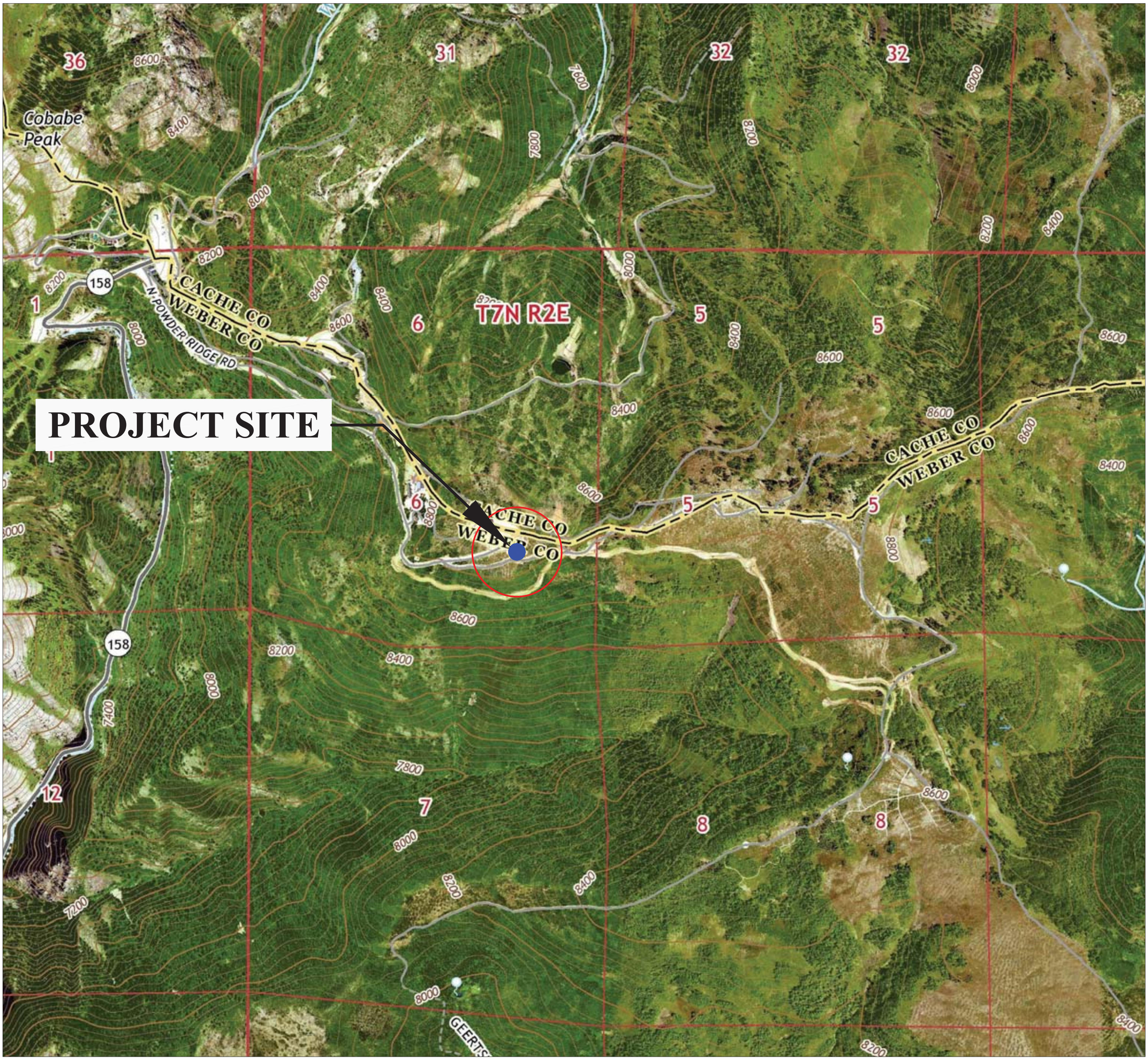
AERIAL PHOTOGRAPHS

Data Set	Date	Flight	Photographs	Scale
1953 AAI	September 14, 1952	4K	35,36	1:20,000
1963 ELK	June 25, 1963	3	58,59	1:15,840

*https://geodata.geology.utah.gov/imagery/

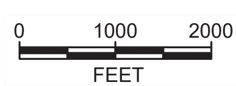
Weber County, 2015, Natural Hazards Overlay Districts, Chapter 27 of Title 104 of the Weber County Code of Ordinances, adopted on December 22, 2015.

APPENDIX A



Base Maps:

-USGS *Brown's Hole, Huntsville, James Peak* and *Sharp Mountain* 7.5-Minute Quadrangles (2017)



1" = 2000'

QUADRANGLE LOCATION

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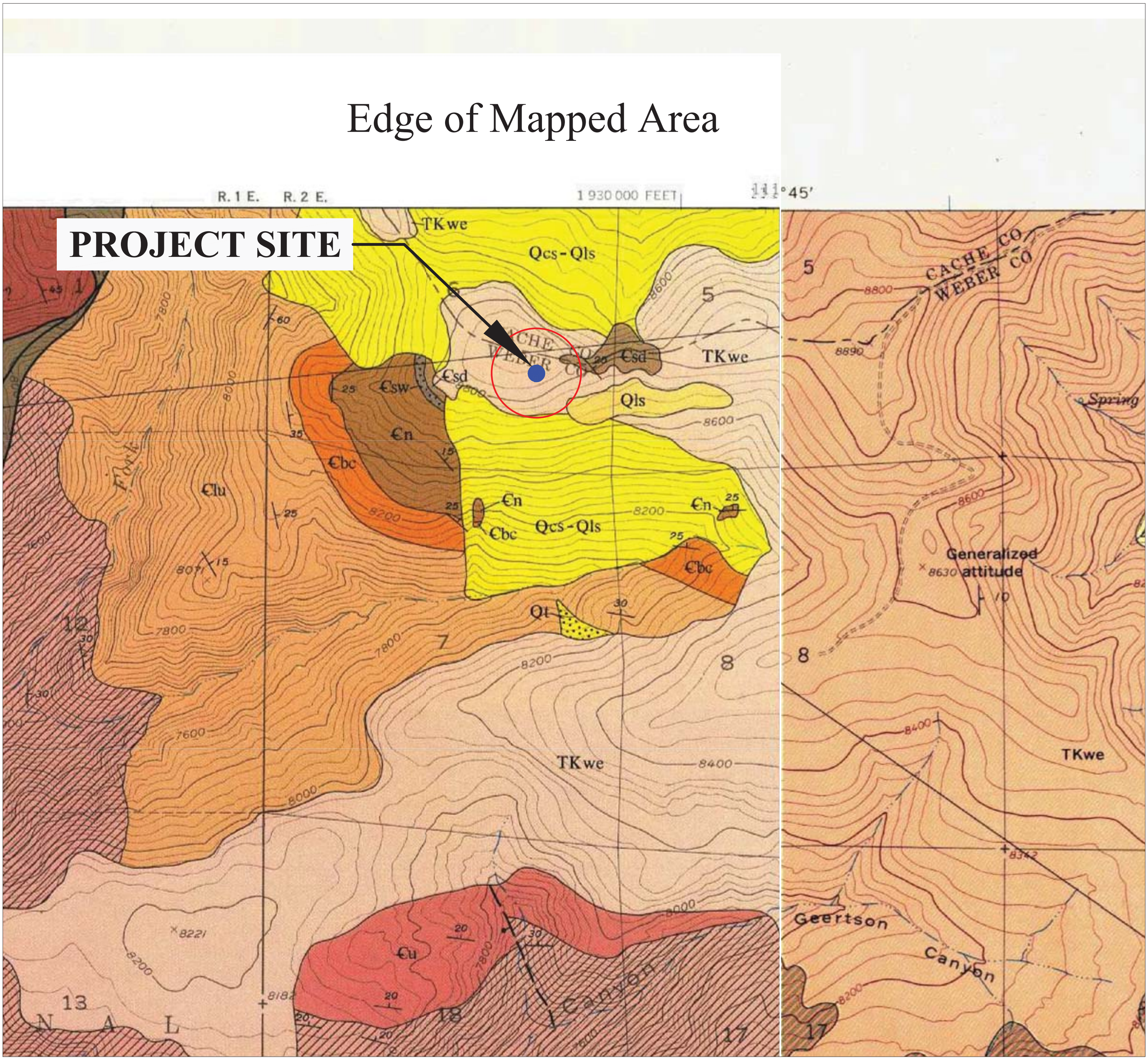
Reconnaissance-Level Geologic Hazard Assessment
Bloomington Well Pump Station
Summit Powder Mountain Resort
Weber County, Utah

Site Vicinity Map

Figure

A-1



Base Maps:

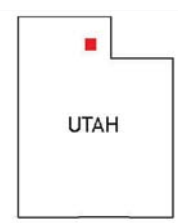
-USGS *Huntsville Quadrangle,* 1:24,000 scale, map GQ-1503, Sorensen and Crittenden (1979)

-USGS *Brown's Hole Quadrangle,* 1:24,000 scale, map GQ-968, Crittenden (1979)

N

0 1000 2000
FEET

1" = 2000'



QUADRANGLE LOCATION

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Regional Geology Map 1

Figure

A-2a

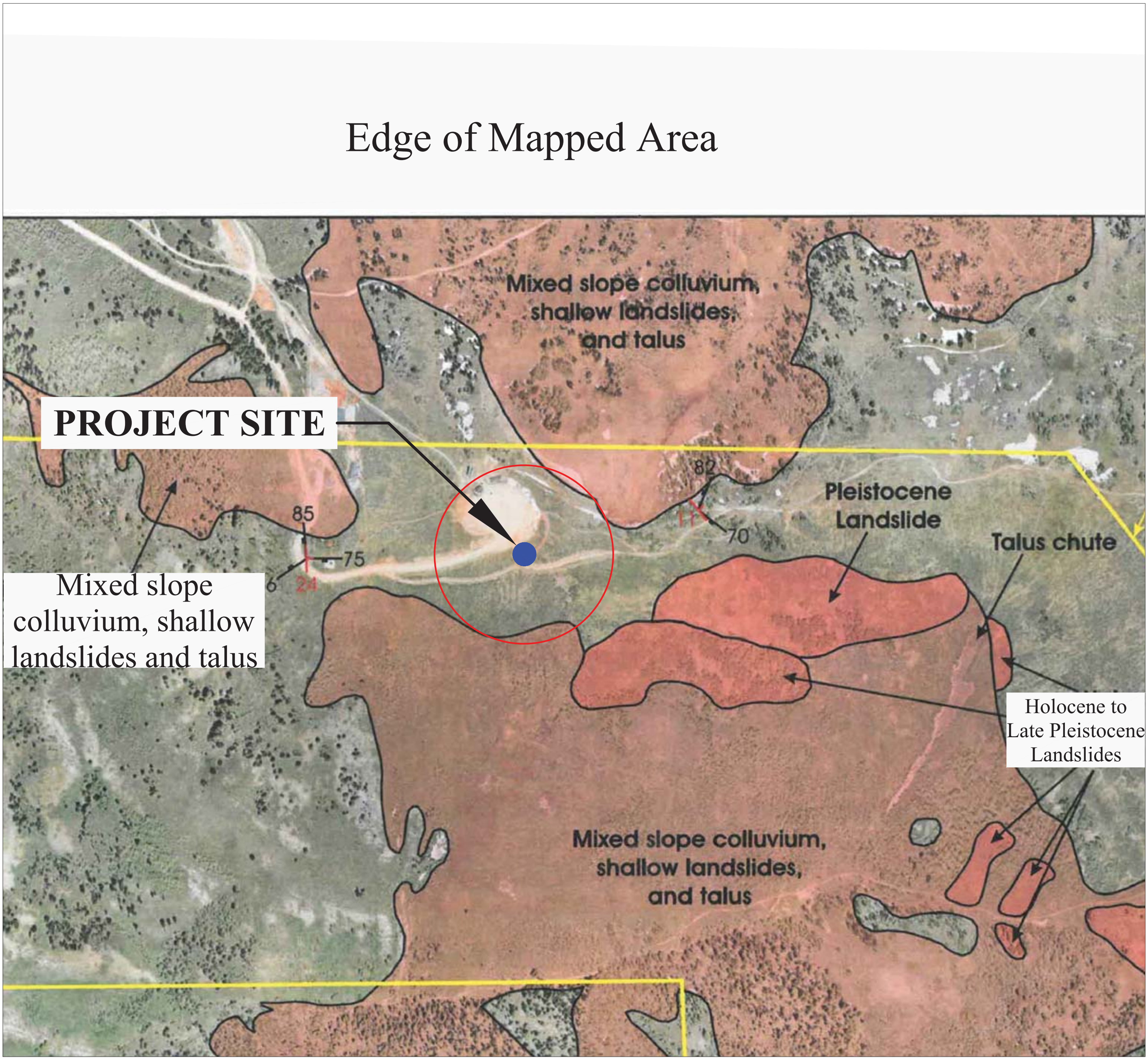
MAP LEGEND

Qcs	**COLLUVIUM AND SLOPEWASH (Holocene)** – Bouldery colluvium and slopewash chiefly along eastern margin of Ogden Valley; in part, lag from Tertiary units; thickness 0-30 m
Qls	**LANDSLIDE DEPOSITS (Holocene)** – thickness 0-6 m
TKwe	**WASATCH AND EVANSTON(?) FORMATIONS, UNDIVIDED** (Eocene, Paleocene, and Upper Cretaceous?) – Unconsolidated pale-reddish-brown pebble, cobble, and boulder conglomerate; forms boulder-covered slopes. Clasts are mainly Precambrian quartzite and are tan, gray, or purple; matrix is mainly poorly consolidated sand and silt; thickness 0-150 m
	St. Charles Limestone (Upper Cambrian) Includes:
€sd	Dolomite member – Thin- to thick-bedded, finely to medium crystalline, light- to medium-gray, white- to light-gray-weathering, cliff-forming dolomite; linguloid brachiopods common in basal 15 m; thickness 150-245 m
€sw	Worm Creek Quartzite Member – Thin-bedded, fine- to medium-grained, medium- to dark-gray, tan- to brown-weathering calcareous quartzitic sandstone; detrital grains well-sorted and well-rounded; thickness 6 m
€n	**NOUNAN DOLOMITE (Upper and Middle Cambrian)** – Thin- to thick-bedded, finely crystalline, medium-gray, light- to medium-gray-weathering, cliff-forming dolomite; white twiggy structures common throughout unit; thickness 150-230 m
€bc	**CALLS FORT SHALE MEMBER OF BLOOMINGTON FORMATION** (Middle Cambrian) – Olive-drab to light-brown shale and light- to dark-blue-gray limestone with intercalated orange to rusty-brown silty limestone; intraformational conglomerate common throughout unit; thickness 23-90 m
€lu	**CAMBRIAN LIMESTONES, UNDIVIDED (Middle Cambrian)** – Includes limestone and Hodges Shale Members of Bloomington Formation, and Blacksmith and Ute Limestones

Recently active normal fault – Dashed where inferred. Ticks on downthrown side

Pre-Tertiary normal fault – Dotted where concealed. Bar and ball on downthrown side

Thrust fault – Dashed where inferred. Sawteeth on upper plate



Base Map:

-Western GeoLogic (2012) Geologic Hazards Reconnaissance Report, Figure 3

N

0 500 1000

FEET

1" = 1000'

QUADRANGLE LOCATION

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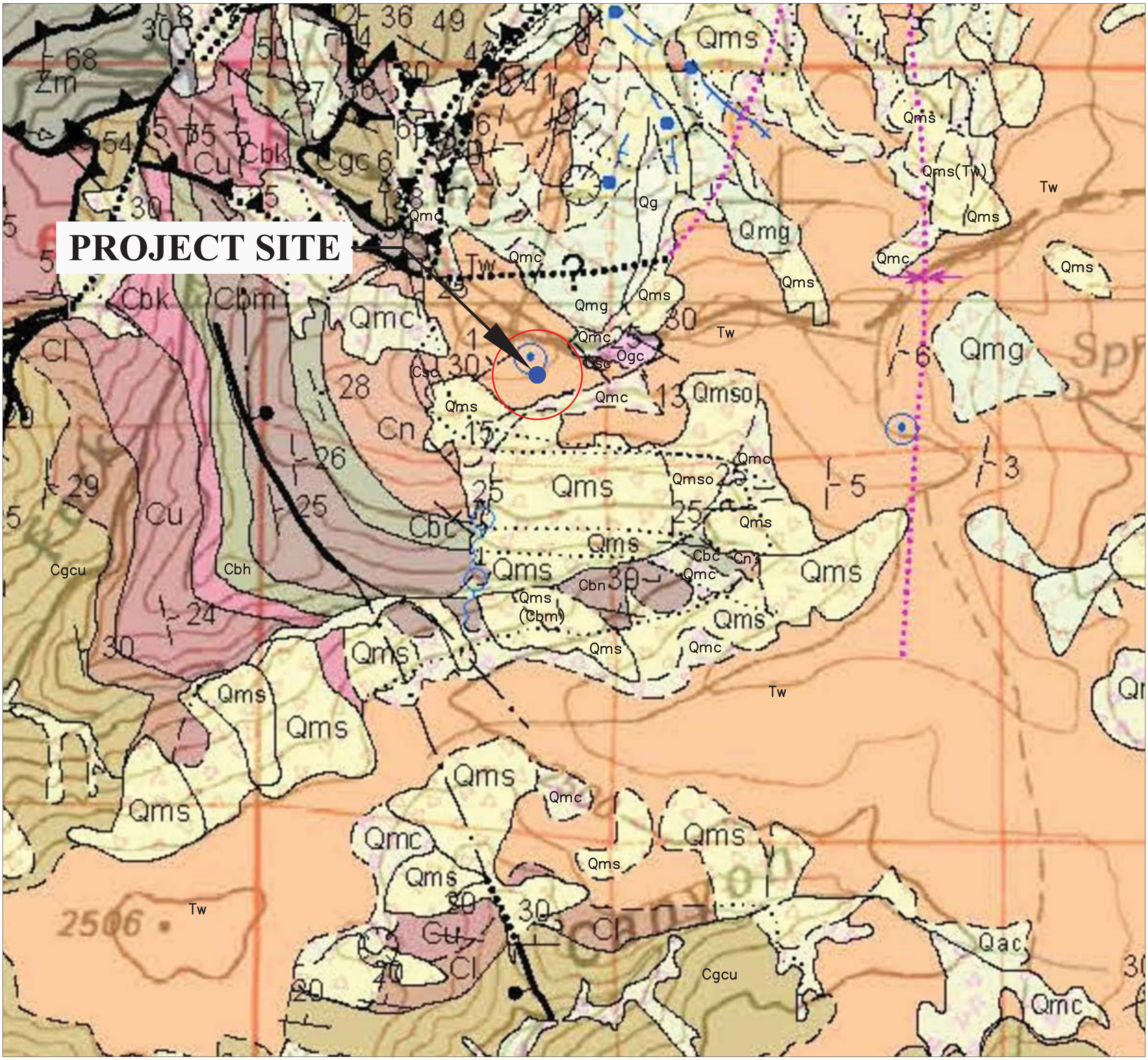
Bloomington Well Pump Station
Summit Powder Mountain Resort
Weber County, Utah

Regional Geology Map 2

Figure

A-3



Base Map:

-UGS *Ogden 30' x 60' Geologic Quadrangle*, 1:62,500 scale, map OFR-635DM, Coogan and King (2016)

N

0 1000 2000
FEET

1" = 2000'

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Reconnaissance-Level Geologic Hazard Assessment
Bloomington Well Pump Station
Summit Powder Mountain Resort
Weber County, Utah

Regional Geology Map 3

Figure

A-4a

MAP LEGEND

Qms, Qms?, Qmsy, Qmsy?, Qmso, Qmso?

Landslide deposits (Holocene and upper and middle? Pleistocene) – Poorly sorted clay- to boulder-sized material; includes slides, slumps, and locally flows and floods; generally characterized by hummocky topography, main and internal scarps, and chaotic bedding in displaced blocks; composition depends on local sources; morphology becomes more subdued with time and amount of water in material during emplacement; Qms may be in contact with Qms when landslides are different/distinct; thickness highly variable, up to about 20 to 30 feet (6-9 m) for small slides, and 80 to 100 feet (25-30 m) thick for larger landslides. Qmsy and Qmso queried where relative age uncertain; Qms queried where classification uncertain. Numerous landslides are too small to show at map scale and more detailed maps shown in the index to geologic mapping should be examined.

Qms without a suffix is mapped where the age is uncertain (though likely Holocene and/or late Pleistocene), where portions of slide complexes have different ages but cannot be shown separately at map scale, or where boundaries between slides of different ages are not distinct. Estimated time of emplacement is indicated by relative-age letter suffixes with: Qmsy mapped where landslides deflect streams or failures are in Lake Bonneville deposits, and scarps are variably vegetated; Qmso typically mapped where deposits are "perched" above present drainages, rumpled morphology typical of mass movements has been diminished, and/or younger surficial deposits cover or cut Qmso. Lower perched Qmso deposits are at Qao heights above drainages (95 ka and older) and the higher perched deposits may correlate with high level alluvium (QTa_) (likely older than 780 ka) (see table 1). Suffixes y and o indicate probable Holocene and Pleistocene ages, respectively, with all Qmso likely emplaced before Lake Bonneville transgression. These older deposits are as unstable as other slides, and are easily reactivated with the addition of water, be it irrigation or septic tank drain fields.

Qmso?(Qafoe), Qmso?(QTcg?), Qmso?(Ts), Qmso?(Tcg), Qmso?(Tn), Qmso?(Tf), Qmso?(Xfc)

Block landslide and possible block landslide deposits (Holocene and upper and middle? Pleistocene) – Mapped where nearly intact block is visible in landslide (mostly block slide) with stratal strikes and dips that are different from nearby in-place bedrock; unit involved in landslide shown in parentheses, for example Qms(Tw) and composition depends bedrock unit; rx shown where bedrock unit in block not known or multiple units are in the block, with Zrx shown where the units are Neoproterozoic; see surficial deposits or rock unit in parentheses for descriptions of blocks; thickness highly variable, up to about 20 to 30 feet (6-9 m) for small slides, and cross sections show larger blocks are about 150 feet (45 m) thick. Relative ages are like those for other landslide deposits (Qms, Qmso).

Qms and Qmso queried (Qms?, Qmso?) where bedrock block may be in place, that is stratal strikes and dips in queried block are about the same as nearby in-place bedrock.

Qmc **Landslide and colluvial deposits, undivided (Holocene and Pleistocene)** – Poorly sorted to unsorted clay- to boulder-sized material; mapped where landslide deposits are difficult to distinguish from colluvium (slopewash and soil creep) and where mapping separate, small, intermingled areas of landslide and colluvial deposits is not possible at map scale; locally includes talus and debris flow and flood deposits; typically mapped where landslides are thin ("shallow"); also mapped where the blocky or rumpled morphology that is characteristic of landslides has been diminished ("smoothed") by slopewash and soil creep; composition depends on local sources; 6 to 40 feet (2-12 m) thick. These deposits are as unstable as other landslide units (Qms, Qmsy, Qmso).

Qmg, Qmg?

Mass-movement and glacial deposits, undivided (Holocene and Pleistocene) – Unsorted and unstratified clay, silt, sand, and gravel; mapped where glacial deposits lack typical moraine morphology, and appear to have failed or moved down slope; also mapped in upper Strawberry Bowl (Snow Basin quadrangle) where glacial deposits have lost their distinct morphology and the contacts between them and colluvium and talus in the cirques cannot be mapped; likely less than 30 feet (9 m) thick, but may be thicker in Mantua, James Peak, North Ogden, Huntsville, and Peterson quadrangles.

MAP LEGEND

Tw, Tw?

Wasatch Formation (Eocene and upper Paleocene) – Typically red to brownish-red sandstone, siltstone, mudstone, and conglomerate with minor gray limestone and marlstone locally (see Twl); lighter shades of red, yellow, tan, and light gray present locally and more common in uppermost part, complicating mapping of contacts with overlying similarly colored Norwood and Fowkes Formations; clasts typically rounded Neoproterozoic and Paleozoic sedimentary rocks, mainly Neoproterozoic and Cambrian quartzite; basal conglomerate more gray and less likely to be red, and containing more locally derived angular clasts of limestone, dolomite and sandstone, typically from Paleozoic strata, for example in northern Causey Dam quadrangle; sinkholes indicate karstification of limestone beds; thicknesses on Willard thrust sheet likely up to about 400 to 600 feet (120-180 m) in Sharp Mountain, Dairy Ridge, and Horse Ridge quadrangles (Coogan, 2006a-b), about 1300 feet (400 m) in Monte Cristo Peak quadrangle, about 1100 feet (335 m) in northeast Browns Hole quadrangle, about 2200 feet (670 m) in southwest Causey Dam quadrangle, about 2600 feet (800 m) at Herd Mountain in Bybee Knoll quadrangle, and about 1300 feet (400 m) in northwest Lost Creek Dam quadrangle, estimated by elevation differences between pre-Wasatch rocks exposed in drainages and the crests of gently dipping Wasatch Formation on adjacent ridges (King); thickness varies locally due to considerable relief on basal erosional surface, for example along Right Fork South Fork Ogden River, and along leading edge of Willard thrust; much thicker, about 5000 to 6000 feet (1500-1800 m), south of Willard thrust sheet near Morgan. Wasatch Formation is queried (Tw?) where poor exposures may actually be surficial deposits. The Wasatch Formation is prone to slope failures. Other information on the Wasatch Formation is in Tw descriptions under the heading "Sub-Willard Thrust - Ogden Canyon Area" since Tw strata are extensive near Morgan Valley and cover the Willard thrust, Ogden Canyon, and Durst Mountain areas.

Ogc, Ogc?

Garden City Formation (Lower Ordovician) – Gray to tan weathering, dark-gray to gray, thin- to medium-bedded, silty limestone; contains tan to yellowish-weathering, less resistant, wavy, silty to argillaceous laminae to inch-scale layers that are more abundant in lower part; intraformational, flat-pebble conglomerate present in lower half; ledge forming; chert near the top of unit (black nodules and stringers) and in lowermost part; at least locally fossiliferous (see Mullens, 1969); 500 to 1200 feet (150-365 m) thick in our map area.

Csc, Csc?

St. Charles Formation (Lower Ordovician and Upper Cambrian) – Mostly dark-gray, medium- to thick-bedded dolomite; contains subordinate medium-gray dolomite and limestone; all with tan-weathering mottling and recesses of crude laminae to inch-scale layers of sandstone and siltstone; overall gray to tan weathering and ledge forming; uppermost part contains light-colored, typically pink, chert; lower part is less resistant, light-gray, tannish-gray weathering, thin-bedded, silty and sandy limestone and dolomite, and silty shale, with tannish-gray, medium-bedded, cross-bedded Worm Creek Quartzite Member (Upper Cambrian) that is locally present; total thickness about 500 to 1000 feet (150-300 m) and may thin to south and east over Tooele arch (see Hintze, 1959).

Cn, Cn? **Nounan Formation (Upper Cambrian)** – Medium-gray to dark-gray, very thick to thick-bedded, light to medium gray and tan-weathering, typically cliff forming, variably sandy and silty dolomite and lesser limestone, with crude laminae to partings and mottling of sandstone and siltstone that weather tan or reddish; little sandstone and siltstone in more resistant lower part; about 600 to 1150 feet (180-350 m) thick.

Cbc, Cbc?

Calls Fort Shale Member (Middle Cambrian) – Brown-weathering, slope-forming, olive-gray to tan-gray, thin bedded, shale and micaceous argillite with minor, thin-bedded, dark-gray, silty limestone; *Bolaspidella* sp. trilobite fossils reported by Rigo (1968, USGS No. 5965-CO) in the Causey Dam quadrangle; 75 to 125 feet (23-40 m) thick on the leading edge of the Willard thrust sheet (Coogan, 2006a-b; see Rigo, 1968, aided by Mullens), 100 to 120 feet (30-35 m) thick in Causey Dam quadrangle (King this report), and about 400 feet (120 m) thick in Huntsville quadrangle (King this report).

Contact, approximately located
Contact, scratch, used where map units combined
Bedding, strike & dip, upright, photogrammetric (3-point)
Contact, concealed, queried
Thrust fault, concealed
Moraine crest, asymmetrical
Contact, concealed
Contact, well located
Water well
Sinkhole
Select spring

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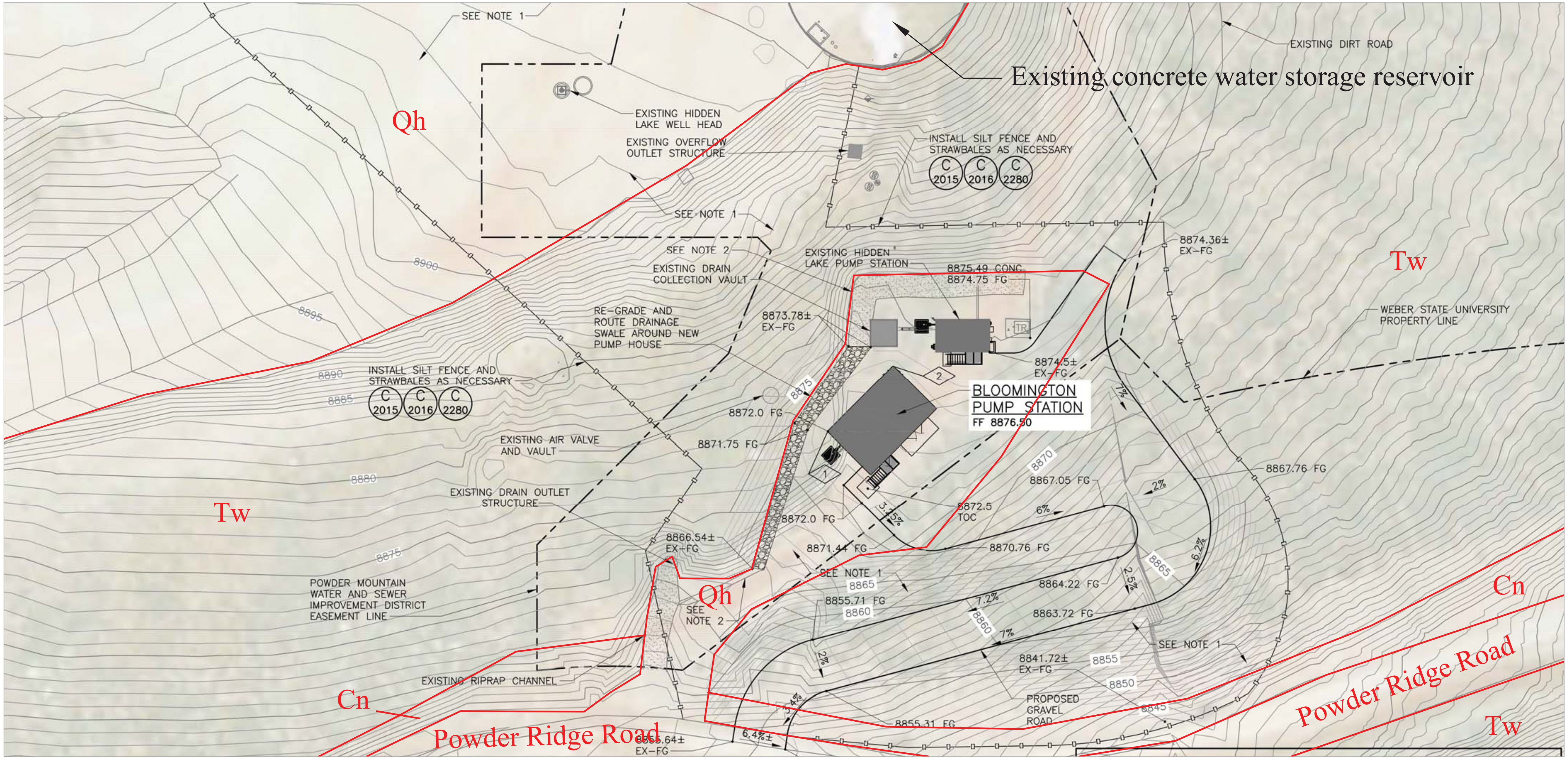
Regional Geology Map 3

Figure

A-4c



LEGEND

Base Map From:

-Bloomington Well Project Grading Plan from Bowen Collins & Associates. Dated 8-22-2018

Contour Interval: 1'

*All Geologic Contacts Approximately Located

Qh: Human Disturbed

Tw: Wasatch Formation

Cn: Nounan Formation

Geologic Contacts

N

0 40 80

FEET

1" = 40'

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Local Geology Map

Figure

A-5