GEOLOGY AND SOILS
IDYLWILDE HYDROELECTRIC PROJECT

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Contents

Figures

Geology and Soils
Idylwilde Hydroelectric Project

Introduction

The City of Loveland, Colorado (City) is proposing to relicense Federal Energy Regulatory Commission (FERC) Project No. 2829, Idylwilde Hydroelectric Project (the Project). The Project is owned and operated by the City. Water Consult retained ERO Resources Corporation (ERO) to prepare preapplication materials associated with geologic and soil resources for the proposed relicensing. This report addresses the requirements for a preapplication document described in FERC's Integrated License Application Process (18 CFR 5.6).

Idylwilde Project Description

The Project is on the Big Thompson River along U.S. Highway 34 (U.S. 34), 14 miles west of the City (Figure 1). The dam is on National Forest lands managed by the Arapaho-Roosevelt National Forest. A hydroelectric plant was built on municipally owned property, allowing generation and distribution of energy from the Project to begin in 1925. The original dam and hydroelectric plant were destroyed in the Big Thompson River flood on July 31, 1976, and were subsequently rebuilt and returned to full service in 1981.

The dam is 50.5 feet high and has a total length of 239.1 feet. The reservoir has a surface area of 3.67 acres at spillway elevation, and impounds about 45 acre-feet of water. A minimum bypass flow of 7 cubic feet per second (cfs) is maintained through the dam to provide suitable habitat in the stream reach below. The penstock, 9,534 feet in length, originates at the dam and delivers water to two 450-kilowatt turbine-generator units in Loveland's Viestenz-Smith Mountain Park. The penstock crosses Forest Service and privately owned lands, and U.S. 34. Two taps along the penstock provide access to water for fire protection and 15 irrigation services are tapped into the line. The power generated is connected to the City's distribution system through a 22-kilovolt transmission line 1,153 feet in length.

Existing Environment

The Project is in the Front Range of the Southern Rocky Mountain physiographic region. The region is characterized by a gently rolling upland block of Proterozoic (older than 542 million years ago (Ma)) crystalline rocks where summits decline gently eastward but canyons are steep, narrow, and deeply incised (Cole and Braddock 2009). The Project area consists of the narrow valley of the Big Thompson River in which the reservoir, dam, portions of the pipeline, and the hydroelectric plant and outfall are located; and

steep rocky hillsides vegetated with grasses, ponderosa pine, and Douglas fir through which the majority of the pipeline passes.

GEOLOGY

Regional Geology

The geology in the Project area consists of Precambrian metamorphic and igneous bedrock (Figure 2). The majority of the Project area is underlain by metasedimentary rocks, primarily schist, biotite gneiss, and migmatite, which were formed from marine sediments and volcanic materials during regional deformation about 1,750 Ma. Palisade Mountain, adjacent to the north of the reservoir and dam site, is comprised of trondhjemite, an igneous rock that intruded into the metasedimentary bedrock about 1,726 Ma. The metasedimentary rocks underwent further metamorphism during the intrusion of the Boulder Creek Granodiorite to the south about 1,715 Ma (Braddock et al. 1970; Cole and Braddock 2009). Subsequent mountain building events (the latest being the Laramide orogeny, which started in the Late Cretaceous 70 to 80 Ma and ended in the early Tertiary 35 to 55 Ma) have folded, faulted, and upturned the bedrock into a complex landform.

The eastern portion of the pipeline passes through a fault zone of the Thompson Canyon fault, a major northwest-southeast structure that roughly follows the Big Thompson River and North Fork of the Big Thompson River for nearly 25 miles from the mouth of the Big Thompson Canyon to Icefield Pass in Rocky Mountain National Park. The Colorado Geological Survey (CGS) created a database of faults and folds that are known or suspected to have moved during the late Cenozoic (about the last 23.7 million years) (i.e., that cut Miocene or younger rocks). The current tectonic environment of Colorado initiated near the beginning of the Miocene Epoch. According to the CGS database, the Thompson Canyon fault is not listed and, therefore, is not known to have been active during this time period (Kirkham et al. 2004-2007).

Geologic Resources

The Project area is in a region with limited geologic resources. Because the bedrock is composed of Precambrian metamorphic or igneous rock, there is no potential for oil and gas, coal, or paleontological resources. Metallic minerals, primarily beryl, have been mined in pegmatites to the west of the Project area, but these rock formations do not occur in the Project area. The Big Thompson River valley has only minor sand and gravel deposits; however, the metamorphic and granitic rocks in the area could be used as a source of aggregate for construction materials (Cappa et al. 2001).

SOILS

The Project area crosses four soil map units described below and depicted on Figure 3 (Natural Resources Conservation Service 2010).

- **Map Unit 2703B** – Cypher-Ratake families complex, 5 to 40 percent slopes
- **Map Unit 2717B** – Cypher-Wetmore-Ratake families complex, 5 to 40 percent slopes
- **Map Unit 4703B** – Bullwark-Catamount families-Rock outcrop complex, 40 to 150 percent slopes

These soils are on mountain slopes. The parent materials consist of colluvium (sediment at the bottom of slopes transported by gravity), residuum (weathered bedrock), and/or slope alluvium, all derived from igneous and metamorphic rock. The soils are somewhat excessively drained and have a rapid permeability and a very low available water capacity. The shrink-swell potential for these soils is low. The erodibility of these soils is dependent on slope steepness; however, because these soils are shallow, well–drained, and composed of rock fragments, the potential for mass soil movement is minimized.

- **Map Unit 5101A** – Pachic Argiustolls-Aquic Argiudolls complex, 0 to 15 percent slopes

These soils are on stream terraces or alluvial flats. The parent materials consist of alluvium derived from igneous, metamorphic, and sedimentary rocks and deposited by the Big Thompson River. The soils on stream terraces are well drained, have a moderately high permeability, a moderate available water capacity, and a low potential for erosion and mass soil movement. The soils on alluvial flats are poorly drained; have a moderately high permeability; have a low available water capacity except during occasional flooding from snowmelt runoff in May, June, and July; and have a moderate potential for erosion and mass soil movement because of their location in the river channel. Both types of soil have a low shrink-swell potential.

PROJECT AREA CONDITIONS

The reservoir, dam, and a portion of the pipeline are in the river channel where steep slopes of cobbles, boulders, and bedrock predominate and the potential hazards of rockfall and slope instability are high (Soule et al. 1976). Above the south bank of the reservoir are near-vertical rock outcrops and steep hillsides that show evidence of erosion and landslides. This erosion may have initially been caused by the July 1976 Big Thompson flood and may be exacerbated by significant spring flows during snowmelt runoff. The variation of the reservoir level of 3 to 4 feet during winter operations is not likely to increase erosion of the hillsides. The north shore is lined with rock riprap and boulders likely installed during construction of the parking area above the reservoir.

U.S. 34 separates the reservoir and dam from vertical rock outcrops and steep hillsides of unconsolidated rocks and boulders.

The pipeline segment from the dam to about 1 mile downstream (where a residential community is present) runs just below the ground surface along a terrace above the river made up of alluvial deposits of gravel, cobbles, and boulders. To the east of the community, the pipeline climbs up and through the steep hillsides to the south, thereby avoiding areas of rockfall and slope instability in this area. The pipeline crosses six drainages high up above the river on trestles, five of which are metal and one of which is wood, before descending below grade down a steep hillside to the hydroelectric plant and outfall, which are on Quaternary-age alluvial deposits. One area of erosion along the pipeline currently exists west of the residential community where surface flow from a steep drainage is undermining the pipeline. No other evidence of erosion, mass soil movement, slumping, or other forms of instability is known along the pipeline.

Potential Impacts

Direct and Indirect Impacts

Relicensing and continued operation of the existing Project facilities would not affect geologic or soil resources.

Cumulative Impacts

The implementation of the Windy Gap Firming Project would slightly increase flows in the river in the Project area during some months (by up to 18 cfs during July) (Bureau of Reclamation 2007). These small increases in flow would not be significant enough to increase erosion, mass soil movement, or other forms of instability in the project area.

Mitigation Measures

No mitigation measures are recommended for geologic or soil resources.

Preliminary Issues and Recommended Studies

Preliminary Issues

No preliminary issues related to geologic and soil resources were identified.

Recommended Studies

No additional studies are recommended for geologic and soil resources.

Agencies Contacted

The agencies contacted for this report were City staff.

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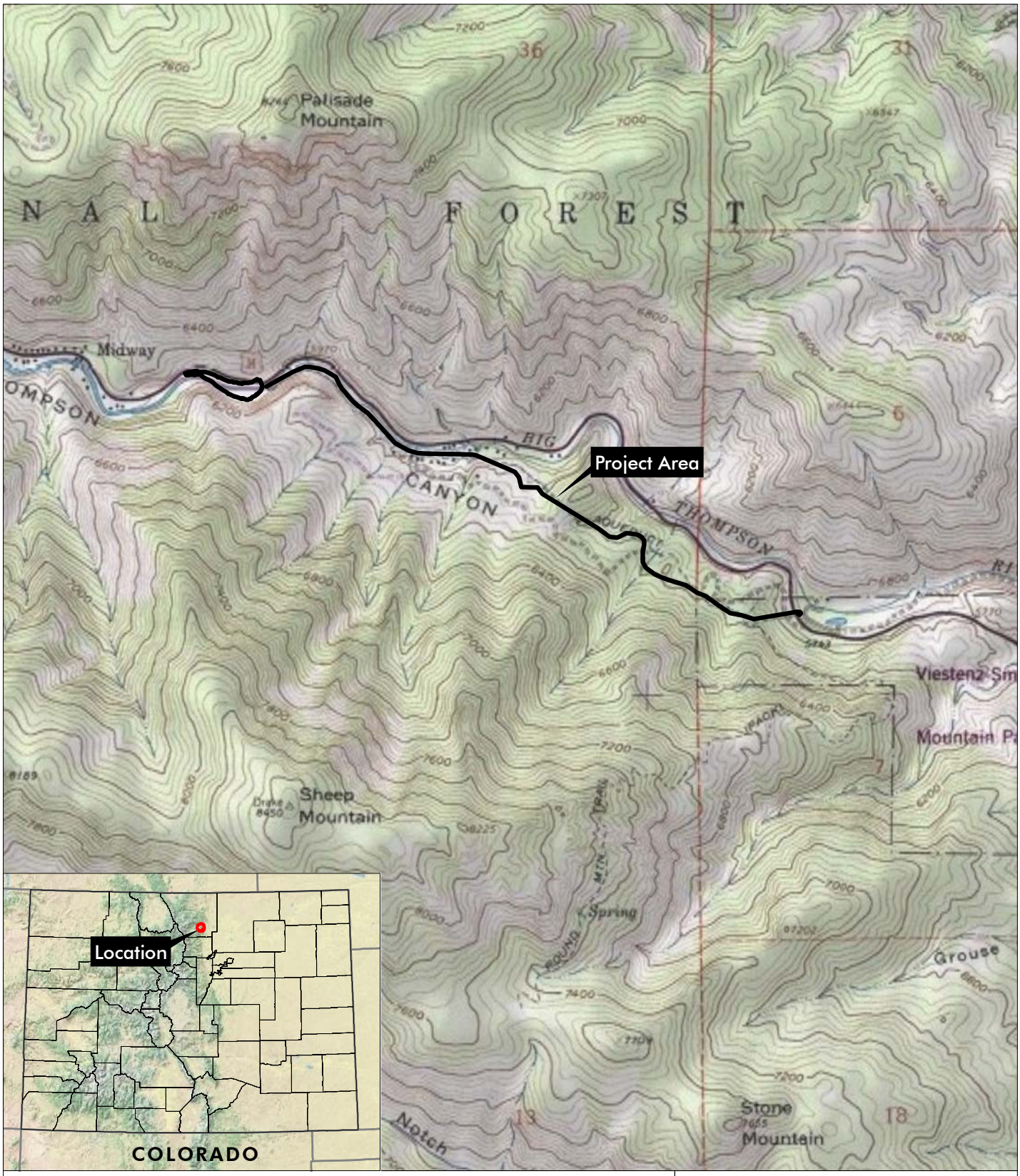

Idylwilde Hydroelectric Project

Sections 1 and 2, T5N, R71W; Section 7, T5N, R70W; 6th PM
UTM NAD 83: Zone 13N; 474730mE, 4474958mN
Latitude, Longitude: 40.424874°N, 105.297895°W
USGS Drake, CO Quadrangle
Larimer County, Colorado

Figure 1
Site Location

Prepared for: Water Consult
File: 4872 figure 1.mxd [WH]
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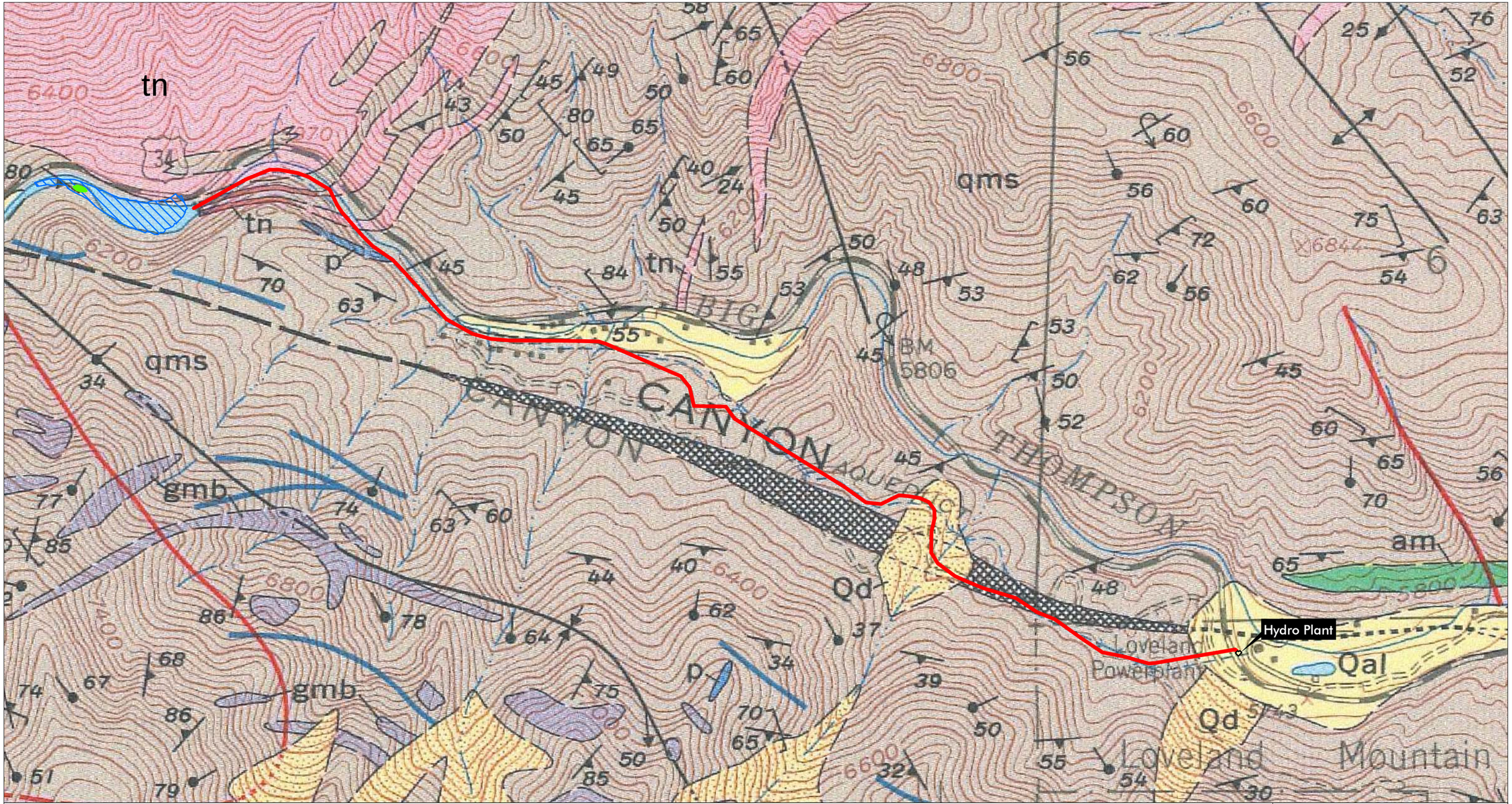

Idylwilde Hydroelectric Project

- Idylwilde Pipeline
- Hydro Plant
- Island
- Reservoir

Qd — Undivided deposits
Includes alluvial fan deposits, talus, and solifluction debris

Qal — Alluvium

Qg — Terrace gravel

Tb — Boulder deposits
Consists of large boulders of pegmatite and biotite. The body in the southeast corner of the quadrangle also contains boulders derived from the Lyons Sandstone (Permian) and Fountain Formation

p — Pegmatite
Irregularly d… veined. Most p… biotite-muscov… Boulder Creek…

tn — Trondhjemite
Light-gray, coarse-grained and equigranular to very fine grained and porphyritic; typically nonfoliated; may be discordant or concordant

tnm — Mixed tonalite and metamorphic rock
Consists of breccia produced by magmatic stoping, of thin sills in metamorphic rock exciting little effect of reaction, or of migmatite in which there has been much reaction

bcg — Boulder Creek Granodiorite
Light- to dark-gray medium-grained granodiorite commonly forming foliated roof-pendants

am — Amphibolite
Dark-gray to black well to poorly foliated rock composed of hornblende, quartz, and plagioclase

gmb — Biotite-muscovite granite
Gray or pink fine-grained granite that is typically discordant

pgb — Mixed biotite-muscovite granite and pegmatite

79 — Fault or fracture zone, showing dip
Arrow where approximately located or inferred; dotted where concealed

qms, mks, bsc — Metasedimentary rocks
Mineralogy varies with metamorphic grade: muscovite, quartz, plagioclase, and biotite are ubiquitous; chlorite, tourmaline, garnet, staurolite, andalusite, and sillimanite may be present
qms, interbedded quartzofeldspathic schist and gneiss and mica schist and gneiss. Contains thin beds of knotted mica schist and granule to pebble metaconglomerate
mks, knotted mica schist characterized by porphyroblasts of staurolite and/or andalusite or by knots of sillimanite. May contain thin beds of granule to pebble metaconglomerate and quartzofeldspathic schist
bsc, porphyroblastic biotite schist characterized by abundant porphyroblasts of coarse biotite

Data Source: Braddock et al., 1970

0 350 700 feet

N

Figure 2
Geology

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File: 4872 - figure 2 geology.mxd (WH)
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Idylwilde Hydroelectric Project

Larimer County Area
- 43 - Haploborolls-Rock outcrop complex, steep
- 93 - Rock outcrop
- 117 - Wetmore-Boyle-Rock outcrop complex, 5 to 60 percent slopes

Arapahoe-Roosevelt National Forest Area
- 2703B - Cypher-Ratake families complex, 5 to 40 percent slopes
- 2704D - Typic Haplustolls-Cathedral family-Rock outcrop complex, 40 to 150 percent slopes
- 2705D - Ratake-Cathedral families-Rock outcrop complex, 40 to 150 percent slopes
- 2706D - Cypher family-Rock outcrop complex, 40 to 150 percent slopes
- 2717B - Cypher-Wetmore-Ratake families complex, 5 to 40 percent slopes
- 4703D - Bullwark-Catamount families-Rock outcrop complex, 40 to 150 percent slopes
- 5101A - Pachic Argiustolls-Aquic Argiudolls complex, 0 to 15 percent slopes

- Idylwilde Pipeline
- Trestles
- Hydro Plant
- Island
- Reservoir

Image Source: USDA NAIP, 2009
Data Source: NRCS

0 350 700 feet

N

Figure 3
Soils

Prepared for: Water Consult
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