PALEONTOLOGICAL TECHNICAL REPORT

WESTBOUND I-70 PEAK PERIOD SHOULDER LANE, CLEAR CREEK COUNTY, COLORADO

Colorado Department of Transportation

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1.0 INTRODUCTION

This document presents the results of an analysis of existing paleontological data and field survey completed for the I-70 WB PPSL Project (Figure 1). The purpose of this analysis, summarized in Table 1, is to document the occurrence of Pleistocene aged surficial deposits within the study area, and thus evaluate the potential for adverse impacts on previously recorded, and currently undiscovered, scientifically important paleontological resources within the study area. Paleo Solutions completed this study at the request of HDR and the Colorado Department of Transportation (CDOT). According to geologic mapping (Sims, 1964; Braddock 1967; Sheridan and Marsh, 1976; Widmann, Kirkham and Beach, 2000; Widmann and Miersemann, 2002; Taylor, 1976), the study area is underlain by eight mapped surficial sedimentary units, consisting of Older Alluvium (Pleistocene), Older Terrace Alluvium (Pleistocene), Younger Terrace Alluvium (Late Pleistocene), Colluvium (Pleistocene and Holocene), Piney Creek Alluvium and/or Older Alluvium (Pleistocene and Holocene), Alluvium (Holocene), Post-Piney Creek Alluvium (Late Holocene), and Debris Fan and Fanglomerate deposits (Holocene). According to the Potential Fossil Yield Classification System (PFYC) (BLM, 2016), Pleistocene deposits have moderate paleontological potential (PFYC 3), whereas Holocene deposits have low paleontological potential (PFYC 2). The study area is also underlain by 16 igneous and metamorphic rock units of Precambrian or Cretaceous age. These units have low paleontological potential (PFYC 1).

The WB PPSL project adds an approximate 12-mile tolled Peak Period Shoulder Lane (PPSL) between the Veterans Memorial Tunnels and US 40/I-70 interchange, in the westbound direction only. Improvements include:

Peak Period Shoulder Lane. Extending from the western side of the Veterans Memorial Tunnels to just west of the US 40 interchange with I-70, the inside shoulder of westbound I-70 is open for vehicles to use during peak periods. The toll system uses transponders and license plate tolling. Pricing is planned to achieve the desired lane use and keep the lane operating at a reliable speed of approximately 45 miles per hour.

I-70 Modifications. Westbound I-70 is resurfaced between MP 243 and MP 232, and widened in select areas to effectively create three travel lanes during peak periods. Emergency pull-outs are added to be used for emergencies and enforcement. The two general purpose lanes remain open and free to all travelers at all times. Drainage enhancements include a storm system for minor and major storm events and water quality facilities. At SH 103, I-70 is realigned to enhance safety and improve drainage.

SH 103 Interchange Improvements. Ramp improvements address sight distance problems. The pedestrian sidewalk is improved by adding lighting and a decorative paving buffer adjacent to the existing sidewalk on the SH 103 bridge over I-70. This sidewalk connects to a new sidewalk buffered from 13th Avenue between the interchange ramp and Idaho Street in Idaho Springs.

Safety Turn-Outs. A total of seven new safety pull-outs are built—five along WB I-70 and two along EB I 70. One existing safety pull-out on EB I-70 is improved. The intention of these is to provide a space for vehicles to use if they experience a break down and for law enforcement to use.

Rockfall Mitigation. Rockfall mitigation measures are added at four locations to prevent rocks or other debris from falling on travel lanes or shoulders and reduce the potential for crashes and travel disruptions. Rockfall mitigation measures are included at MP 239, MP 238.4, MP 237.1, and MP 236.4.

Active Traffic Management. Dynamic signage informs drivers so the peak period shoulder lane is appropriately used to reduce congestion. This innovative design reduces safety risk and improves mobility.

Fiber Optic Upgrades. Fiber optics are specifically designed and located to accommodate future emerging technologies for autonomous and connected vehicles, improving driver information and emergency response capabilities.

Dumont Port-of-Entry Interchange. The project includes merge area improvements to the Dumont interchange acceleration lane.

Table 1. Project Summary

Project Name	WB I-70 Peak Period Shoulder Lane				
Project Description	The WB I-70 PPSL project adds a westbound peak period shoulder lane from about the Veterans Memorial Tunnels to the US 40/I-70 interchange, or mileposts 243 to 230. The project entails minimal widening throughout the corridor with potential minor structure widening, potential retaining/sound walls, design of tolling and ITS infrastructure, rockfall mitigation, and improvements to the SH 103 interchange in Idaho Springs.				
Total Acreage	Study Area: 178.49 acres				
Location (PLSS)	**Quarter-Quarter**	**Section**	**Township**	**Range**	**Land Agency/Private Land Owner**
	L2, NESE, NESW, NWSE, SESW	31	3S	72W	Private/CDOT ROW
	NES, NES, NWS, NWS, SEN, SEN, SWN, NWS, SWNW	32	3S	72W	Private/CDOT ROW
	L2, L3, SES, SESW, SWSE, SWSW	24	3S	74W	Private/CDOT ROW
	L1, L2, L3, L5	25	3S	74W	Private/CDOT ROW
	L1, L10, L20, L22, L24, L30, L5	26	3S	74W	Private/CDOT ROW
	L33, L38, L39, L40, L41, L42, L44, L45, L47, L48, L54, L55, L56, L63, L64, NESE, NESW NWSE, SENE, SESW, SWNE, SWSE	27	3S	74W	Private/CDOT ROW
	L1, L10, L11, L12, L17, L18, NWSW	33	3S	74W	Private/CDOT ROW
	L7, L8, L9, L10, L11, L12, L13, L14, L15, NENW, NWNW, SWNW	34	3S	74W	Private/CDOT ROW
Topographic Map(s)	Squaw Pass, Idaho Springs, Central City, Empire, and Georgetown, CO USGS 7.5' Topographic Quadrangles				
Geologic Map(s)	Sims, 1964, Geology of the Central City quadrangle, Colorado: U.S. Geological Survey, Geologic Quadrangle Map GQ-267 scale 1:24,000. Beach, S.T., 2000, Geologic Map of the Idaho Springs Quadrangle, Clear Creek County, Colorado. Colorado Geological Survey , Open-File Report OF00-02, 1:24,000 Braddock, 1969, Geology of the Empire quadrangle, Grand, Gilpin, and Clear Creek Counties, Colorado: U.S. Geological Survey, Professional Paper 616 scale 1:24,000. Sheridan and Marsh, 1975, Geologic map of the Squaw Pass quadrangle, Clear Creek, Jefferson, and Gilpin Counties, Colorado: U.S. Geological Survey, Geologic Quadrangle Map GQ-1337 scale 1:24,000.				

Table 1. Project Summary

	Widmann, Kirkham and Beach, 2000, Geologic map of the Idaho Springs quadrangle, Clear Creek County, Colorado: Colorado Geological Survey, Open-File Report OF-00-2SR scale 1:24,000. Widmann and Miersemann, 2002, Geologic Map of the Georgetown 7.5 Minute Quadrangle, Clear Creek County, Colorado: Colorado Geological Survey, Open-File Report OF01-05 scale 1:24,000.
Geologic Units	Older Alluvium (Qoal) (PFYC 3), Older and Younger Terrace Alluvium (Qto, Qty) (PFYC 3), Colluvium (Qc) (PFYC 2-3), Piney Creek Alluvium and/or Older Alluvium (Qpo) (PFYC 2-3), Alluvium (Qa) (PFYC 2), Post-Piney Creek Alluvium (Qpp) (PFYC 2), Debris Fan and Fanglomerate deposits (Qf), and sixteen Igneous and Metamorphic units (PFYC 1).
Surveyor(s)	Kate D. Zubin-Stathopoulos, M.S. and Chris J. Ward, M.S.
Survey Date(s)	August 30, and September 01, 2017
Previously Documented Fossil Localities within the study area	No previously recorded fossil localities occur within or adjacent to the study area
Newly Documented Fossil Localities	Non-significant Fossil Occurrences: 0 Significant Fossil Localities: 0

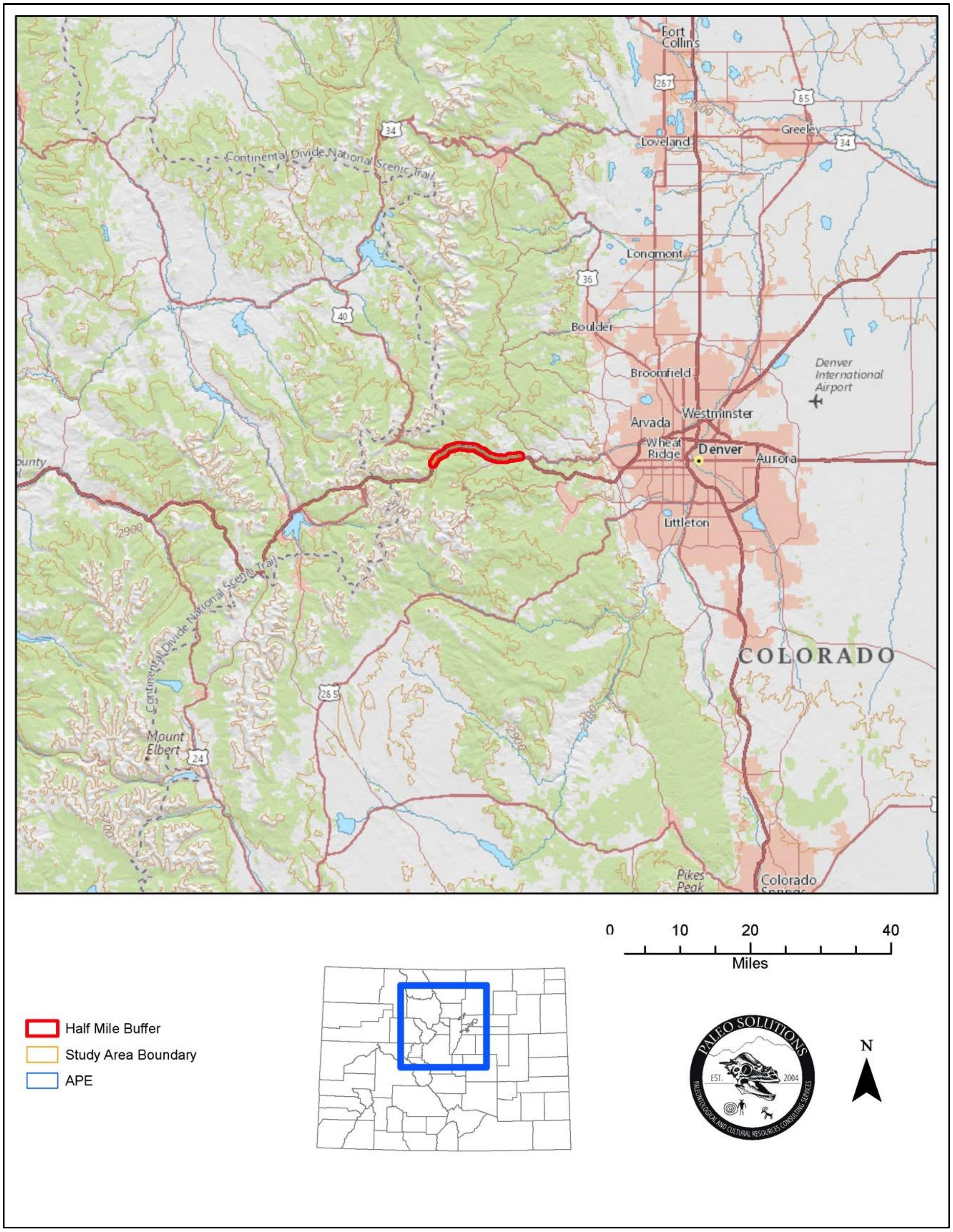

Figure 1. Overview Map of the I-70 WB PPSL Study Area.

2.0 DEFINITION AND SIGNIFICANCE OF PALEONTOLOGICAL RESOURCES

As defined by Murphey and Daitch (2007): "Paleontology is a multidisciplinary science that combines elements of geology, biology, chemistry, and physics in an effort to understand the history of life on earth. Paleontological resources, or fossils, are the remains, imprints, or traces of once-living organisms preserved in rocks and sediments. These include mineralized, partially mineralized, or unmineralized bones and teeth, soft tissues, shells, wood, leaf impressions, footprints, burrows, and microscopic remains. Paleontological resources include not only fossils themselves, but also the associated rocks or organic matter and the physical characteristics of the fossils' associated sedimentary matrix.

The fossil record is the only evidence that life on earth has existed for more than 3.6 billion years. Fossils are considered non-renewable resources because the organisms they represent no longer exist. Thus, once destroyed, a fossil can never be replaced. Fossils are important scientific and educational resources because they are used to:

- Study the phylogenetic relationships amongst extinct organisms, as well as their relationships to modern groups;
- Elucidate the taphonomic, behavioral, temporal, and diagenetic pathways responsible for fossil preservation, including the biases inherent in the fossil record;
- Reconstruct ancient environments, climate change, and paleoecological relationships;
- Provide a measure of relative geologic dating that forms the basis for biochronology and biostratigraphy, and which is an independent and corroborating line of evidence for isotopic dating;
- Study the geographic distribution of organisms and tectonic movements of land masses and ocean basins through time;
- Study patterns and processes of evolution, extinction, and speciation; and
- Identify past and potential future human-caused effects to global environments and climates."

Fossil resources vary widely in their relative abundance and distribution and not all are regarded as significant. According to Bureau of Land Management (BLM) Instructional Memorandum (IM) 2009-011, a "Significant Paleontological Resource" is defined as:

> "Any paleontological resource that is considered to be of scientific interest, including most vertebrate fossil remains and traces, and certain rare or unusual invertebrate and plant fossils. A significant paleontological resource is considered to be of scientific interest if it is a rare or previously unknown species, it is of high quality and well-preserved, it preserves a previously unknown anatomical or other characteristic, provides new information about the history of life on earth, or has an identified educational or recreational value. Paleontological resources that may be considered not to have scientific significance include those that lack provenience or context, lack physical integrity due to decay or natural erosion, or that are overly redundant or are otherwise not useful for research. Vertebrate fossil remains and traces include bone, scales, scutes, skin impressions, burrows, tracks, tail drag marks, vertebrate

coprolites (feces), gastroliths (stomach stones), or other physical evidence of past vertebrate life or activities" (BLM, 2008).

3.0 LAWS, ORDINANCES, REGULATIONS, AND STANDARDS

Fossils are classified as non-renewable scientific resources, and are protected by various laws, ordinances, regulations, and standards (LORS) across the country. Professional procedures for the assessment and mitigation of adverse impacts to paleontological resources have been established by the Society of Vertebrate Paleontology (SVP) (2010). This paleontological study was conducted in accordance with the LORS that are applicable to paleontological resources within the study area, as well as established best practices in mitigation paleontology (Murphey et al., 2014). Pertinent federal, state, county, and city LORS are summarized below.

This section of the report presents the state and local regulatory requirements pertaining to paleontological resources that apply to this Project.

3.1 FEDERAL REGULATORY SETTING

The National Environmental Policy Act (NEPA) of 1969, as amended (Pub. L. 91-190, 42 U.S.C. 4321-4347, January 1, 1970, as amended by Pub. L. 94-52, July 3, 1975, Pub. L. 94-83, August 9, 1975, and Pub. L. 97-258 § 4(b), Sept. 13, 1982). NEPA recognizes the continuing responsibility of the Federal Government to "preserve important historic, cultural, and natural aspects of our national heritage..." (Sec. 101 [42 USC § 4321]) (#382).

The goal of the NEPA process is to make informed, publicly supported decisions regarding environmental issues. Under NEPA, the Federal government requires that:

- All Federal agencies consider the environmental impacts of proposed actions;
- The public be informed of the potential environmental impacts of proposed actions; and
- The public be involved in planning and analysis relevant to actions that impact the environment.

Paleontological Resources Preservation, Title VI, Subtitle D in the Omnibus Public Lands Act of 2009, Public Law 111-011. Purpose: The Secretary (Interior and Agriculture) shall manage and protect paleontological resources on Federal land using scientific principles and expertise.

The Paleontological Resources Preservation Act (PRPA) is modeled after the Archaeological Resources Protection Act (ARPA) and incorporates the recommendations of the May 2000 Report of the Secretary of the Interior, "Assessment of Fossil Management on Federal and Indian Lands," regarding future actions to formulate a consistent paleontological resources management framework. With the passage of the PRPA, Congress officially recognizes the importance of paleontological resources on federal lands (USDI, USDA excluding Tribal lands) by declaring that fossils from federal lands are federal property that must be preserved and protected using scientific principles and expertise. The PRPA essentially codifies existing policies of the BLM, NPS, USFS, BOR, and FWS. The PRPA provides:

- Uniform definitions for "paleontological resources" and "casual collecting;
- Uniform minimum requirements for paleontological resource use permit issuance (terms, conditions, and qualifications of applicants);

- Uniform criminal and civil penalties for illegal sale and transport, and theft and vandalism of fossils from Federal lands;
- Uniform requirements for curation of federal fossils in approved repositories; and

Federal protections for scientifically significant paleontological resources apply to projects if any construction or other related project impacts occur on federally owned or managed lands, involve the crossing of state lines, or are federally funded. Because this project has FHWA involvement, federal protections under NEPA apply to paleontological resources within the study area.

3.2 STATE REGULATORY SETTING

The Colorado Historical, Prehistorical and Archaeological Resources Act of 1973 (CRS 24-80-401 to 411, and 24-80-1301 to 1305), defines permitting requirements and procedures for the collection of prehistoric resources, including paleontological resources on state lands, and actions that should be taken in the event that resources are discovered in the course of state-funded projects and on state-owned/administered lands. Based on this legislation, the CDOT requests assessments on state-owned and/or administered lands that have the potential to contain significant paleontological resources, and mitigation monitoring during ground disturbance in these areas. This study will be reviewed by CDOT. CDOT must fulfill FHWA's NEPA requirements under the Colorado Historical, Prehistorical and Archaeological Resources Act (CHPA).

3.3 LOCAL REGULATORY SETTING

3.3.1 County

There are no Clear Creek County LORS that specifically address potential adverse impacts on paleontological resources. Therefore, no county-level protections of paleontological resources pertain to the Project.

3.3.2 City

There are no City of Idaho Springs, or Downieville-Lawson-Dumont census-designated place LORS that pertain to the Project.

3.3.3 Private Lands

There are no LORS applicable to paleontological resources that occur on privately owned lands in the state of Colorado.

4.0 METHODS

The purpose of this study is to evaluate the paleontological sensitivity of the geologic units within the study area by researching their known fossil potential and paleontological significance, and by determining the number and significance of previously recorded and newly discovered fossil localities within the study area and elsewhere in the same geologic units. This study was undertaken at the request of HDR and CDOT.

4.1 ANALYSIS OF EXISTING DATA

The analysis of existing paleontological data included the following elements: 1) a museum record search to determine the presence of previously recorded fossil localities within the study area from the University of Colorado Museum (UCM) and the Denver Museum of Nature and Science

(DMNS). An additional records search using the public online Paleobiology Database (PBDB) was also completed; 2) a geologic map review to determine the distribution of geologic units within the study area; and 3) a literature search to evaluate the paleontological sensitivity of the study area and the same geologic units in the vicinity of the study area. The geologic units within the study area were classified according to the Potential Fossil Yield Classification system (PFYC). The record search area included the same geologic units that are mapped within the study area. The geologic maps used were prepared by Sims (1964), Braddock (1969); Sheridan and Marsh (1975); Widmann, Kirkham and Beach (2000), and Widmann and Miersemann (2002). The literature search emphasized publications on paleontological resources from the same geologic units that are present within the study area and these same units elsewhere in Colorado. The study area was subject to a pedestrian field survey (Section 4.3) except for the SH 103 Interchange Improvements. This feature was not included in the field survey because it had not been defined at the time that the survey was completed. A desktop review of this feature was performed as part of the analysis of existing data.

4.2 PERSONNEL

The data analysis and field survey were conducted by Paleo Solutions paleontologist Kate D. Zubin-Stathopoulos, M.S., and Chris J. Ward, M.S. under the direction of Principal Investigator Dr. Paul C. Murphey. The data analysis was completed and this document was prepared by Chris J. Ward, M.S. and Kate D. Zubin-Stathopoulos, M.S., and Dr. Paul C. Murphey. GIS support was provided by Paleo Solutions' GIS specialist Nathan Dickey, M.S.

4.3 FIELD SURVEY METHODS

The analysis of existing data was followed by a pedestrian field survey. The field survey included a pedestrian examination of the study area to look for exposure of Pleistocene-aged surficial deposits both in areas where these units are mapped and where they could occur in places but are unmapped. Only areas for which permission to enter had been granted and that were safely accessible were surveyed. The fieldwork was completed on August 30 and September 1, 2017.

4.4 DISTRIBUTION OF DATA

Electronic copies of this document will be submitted to HDR. An electronic copy will be retained by Paleo Solutions.

5.0 LITERATURE SEARCH RESULTS

The study area is located in the city of Idaho Springs and the Downieville-Lawson-Dumont census-designated place, Clear Creek County, Colorado (see Figure 1). This section summarizes the geology and paleontology of the mapped geologic units within the study area. The literature search was based on the same geologic units that are mapped within the study area in geologically pertinent areas of Colorado.

5.1 GEOLOGIC MAP REVIEW

According to Sims (1964), Braddock (1969); Sheridan and Marsh (1976); Widmann, Kirkham and Beach (2000), and Widmann and Miersemann (2002), the WB I-70 PPSL study area is directly underlain by eight mapped sedimentary surficial units, consisting of Older Alluvium, Older and Younger Terrace Alluvium, Colluvium, Piney Creek Alluvium and/or Older Alluvium, Alluvium, Post-Piney Creek Alluvium, and Debris and Fanglomerate deposits and sixteen Igneous and

Metamorphic units detailed below. These units are summarized in Table 2, and the distribution of these units within and adjacent to the study area is shown in Figures 2-12, ordered from east to west.

5.2 GEOLOGY AND PALEONTOLOGY

The study area is located in Clear Creek County in the Front Range Mineral belt, a northeast-trending region that extends approximately 50 miles from Jamestown to Breckenridge, Colorado. This zone mostly consists of Precambrian igneous bedrock, intrusive rocks, and early Tertiary hydrothermal veins of ore deposits that have been shaped in part by Clear Creek which runs west to east within the study area, as well as glaciation (Soule, 1999). Basement rock in this region is mostly composed of gneissic rocks and smaller bodies of pegmatitic and granitic rocks. In the early Tertiary, Precambrian rocks were invaded by several types of porphyritic intrusive rock as a result of the Laramide orogeny (Harrison and Wells, 1959; Moench and Drake, 1966). Holocene and Pleistocene aged surficial deposits are found along modern and extant river channels and banks, directly overlying basement rock. These surficial deposits can provide insight into the environments and animals which lived in the region during the Pleistocene ice ages.

Table 2. Geologic Units Within The Study Area (Maberry and Lindvall, 1977)

Geologic Unit Name	Map Unit Abbreviation	Common Fossils	Age	PFYC
Debris Fan and Fanglomerate deposits	Qf	Too young to contain *in-situ* fossils	Holocene	2
Post-Piney Creek Alluvium	Qpp	Too young to contain *in-situ* fossils	Holocene	2
Alluvium	Qa	Too young to contain *in-situ* fossils	Holocene	2
Piney Creek Alluvium and/or Older Alluvium	Qpo	Holocene: Too young to contain *in-situ* fossils Pleistocene: Mammoth, mastodon, bison, deer, and small mammals	Pleistocene to Late Holocene	2 to 3
Colluvium	Qc	Holocene: Too young to contain *in-situ* fossils Pleistocene: Mammoth, mastodon, bison, deer, and small mammals	Pleistocene to Late Holocene	2 to 3
Younger Terrace Alluvium	Qty	Mammoth, mastodon, bison, deer, and small mammals	Late Pleistocene	3
Older Terrace Alluvium	Qto	Mammoth, mastodon, bison, deer, and small mammals	Middle Pleistocene	3
Older Alluvium	Qoal	Mammoth, mastodon, bison, deer, and small mammals	Pleistocene	3
Quartz Monzonite Porphyry and Granodiorite Porphyry	Kqm	No paleontological resource potential	Late Cretaceous	1
Bostonite Porphyry and Related Rocks	Kb	No paleontological resource potential	Late Cretaceous	1

Table 2. Geologic Units Within The Study Area (Maberry and Lindvall, 1977)

Geologic Unit Name	Map Unit Abbreviation	Common Fossils	Age	PFYC
Bostonite Group	Tb	No paleontological resource potential	Tertiary (Late Cretaceous?)	1
Quartz Monzonite Group	Tqm	No paleontological resource potential	Tertiary (Late Cretaceous?)	1
Pegmatite	Yxp	No paleontological resource potential	Precambrian	1
Biotite Gneiss	Xb	No paleontological resource potential	Precambrian	1
Feldspar-rich Gneiss Interlayered with Hornblende Gneiss, Amphibolite, and Other Gneisses	Xfhi	No paleontological resource potential	Precambrian	1
Feldspar-rich Gneiss	Xf	No paleontological resource potential	Precambrian	1
Granite Pegmatite	Grp	No paleontological resource potential	Precambrian	1
Biotite Gneiss	gnb	No paleontological resource potential	Precambrian	1
Microcline-quartz-plagioclase-biotite Gneiss	gnm	No paleontological resource potential	Precambrian	1
Quartz Diorite and Hornblendite	qdh	No paleontological resource potential	Precambrian	1
Biotite-muscovite Quartz Monzonite	qmb	No paleontological resource potential	Precambrian	1
Hornblende Gneiss and Amphibolite	gnh	No paleontological resource potential	Precambrian	1
Boulder Creek Granite	bcg	No paleontological resource potential	Precambrian	1
Silver Plume Granite	spg	No paleontological resource potential	Precambrian	1
Granodiorite of the Mount Evans batholith	Ygd	No paleontological resource potential	Middle Proterozoic	1
Silver Plume Granite	Ysp	No paleontological resource potential	Middle Proterozoic	1

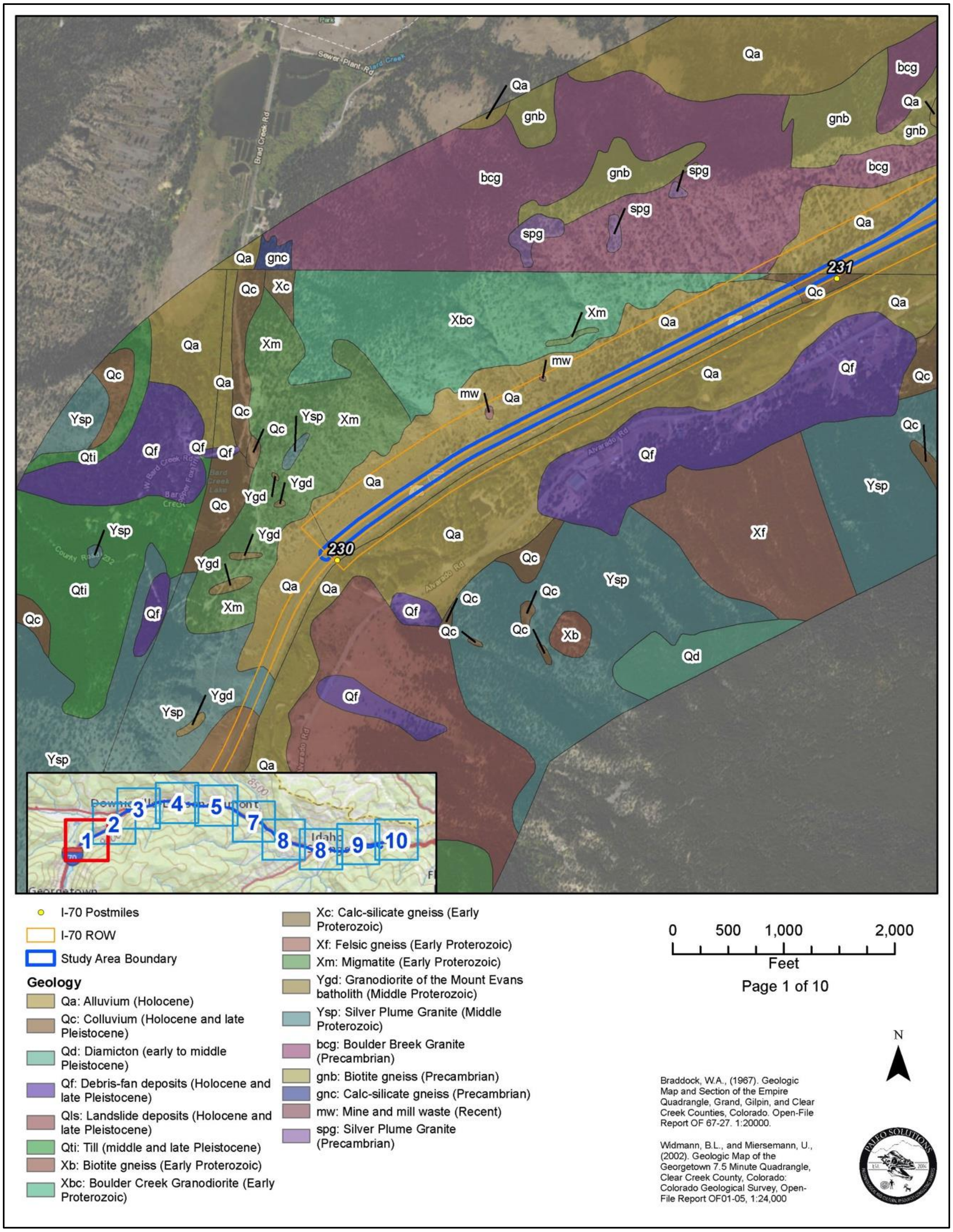

Figure 2. Geologic Map of the Study Area.

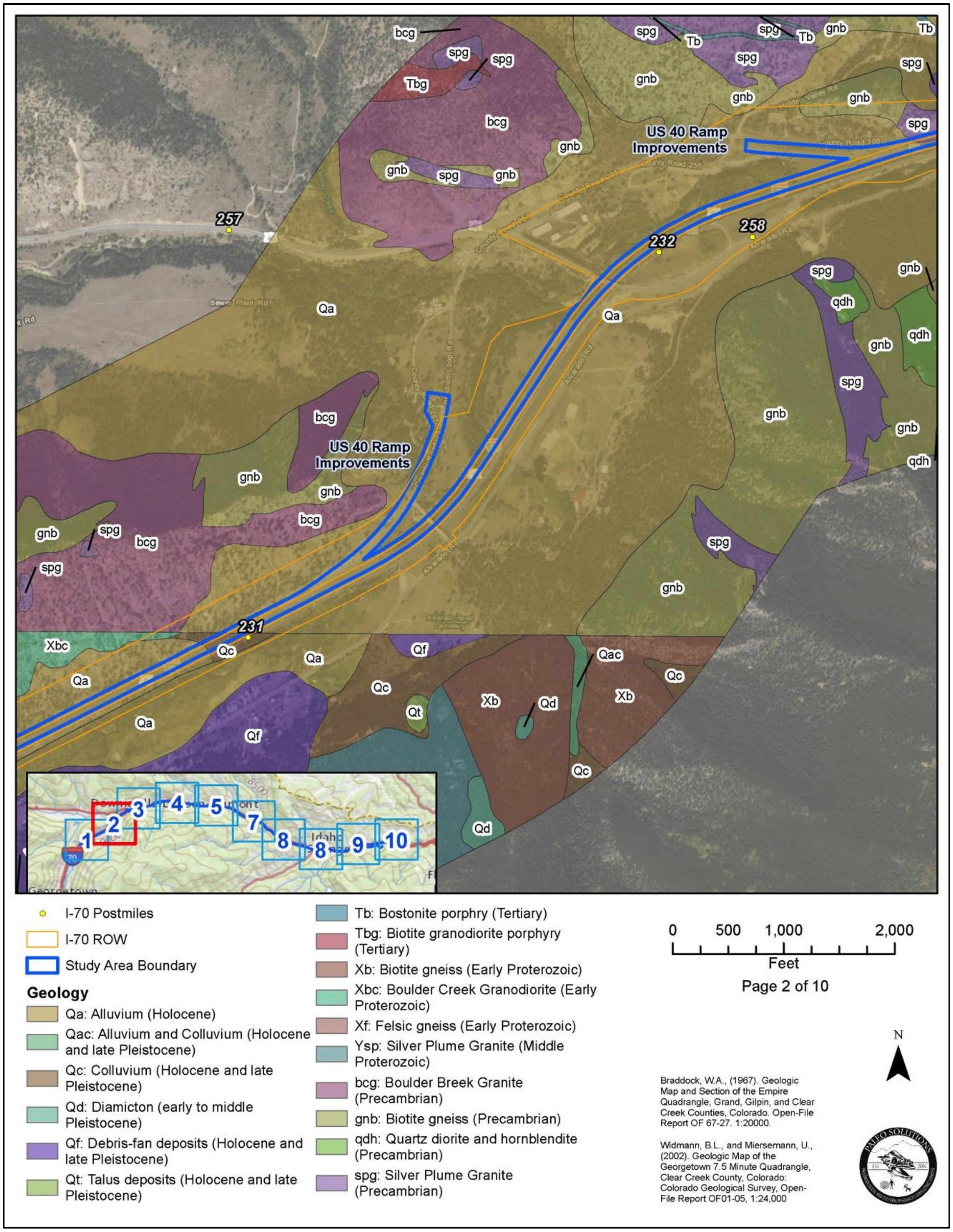

Figure 3. Geologic Map of the Study Area.

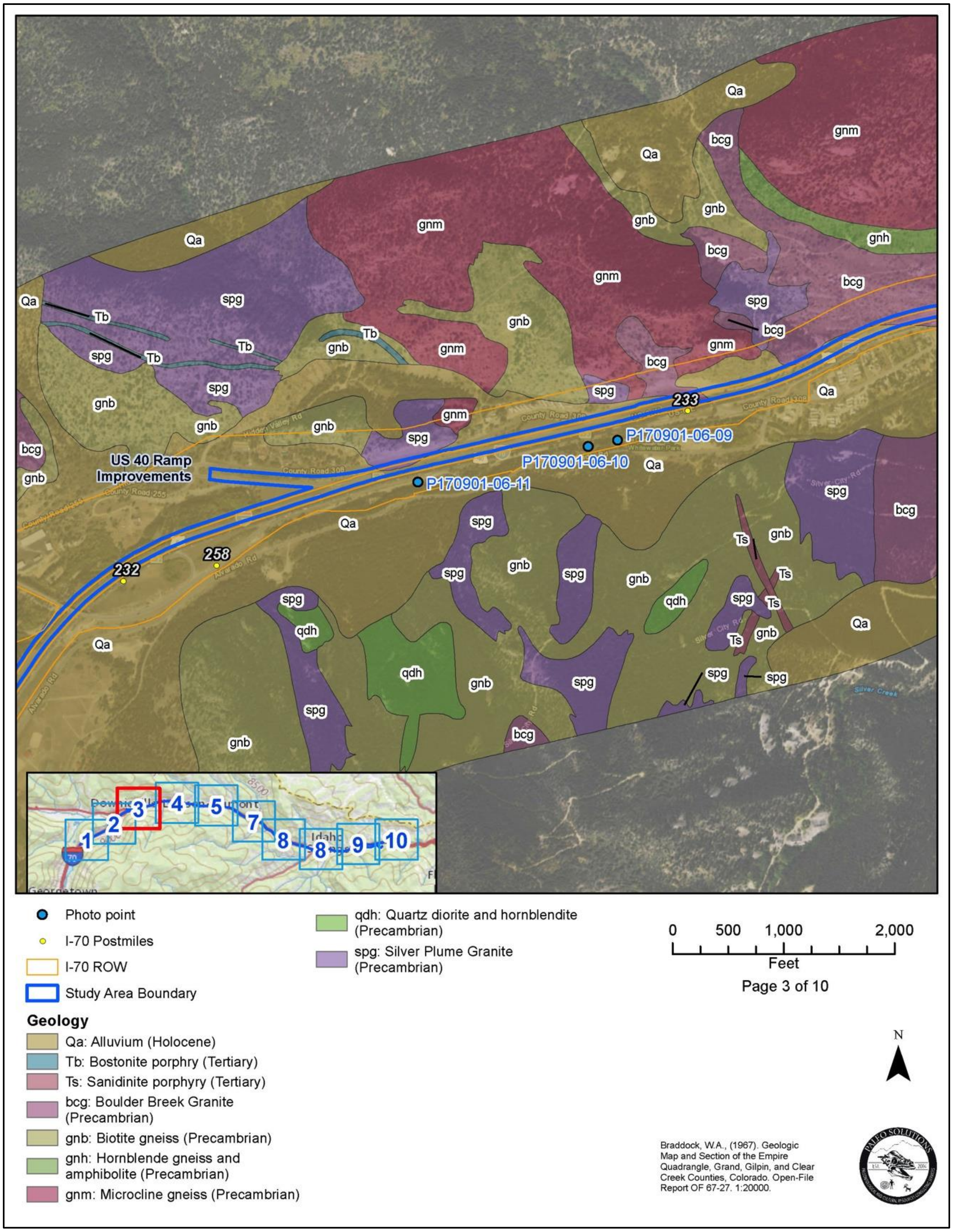

Figure 4. Geologic Map of the Study Area.

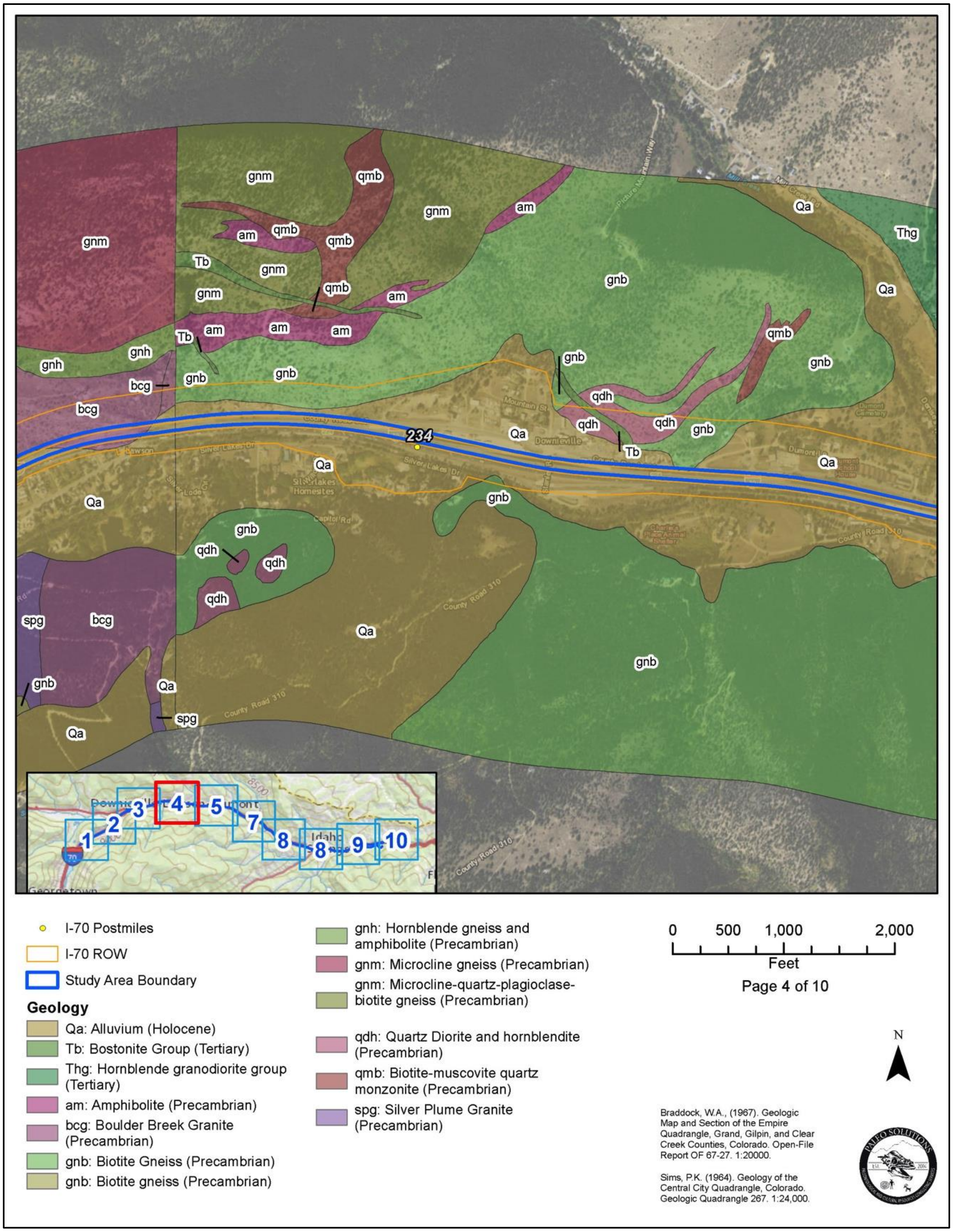

Figure 5. Geologic Map of the Study Area.

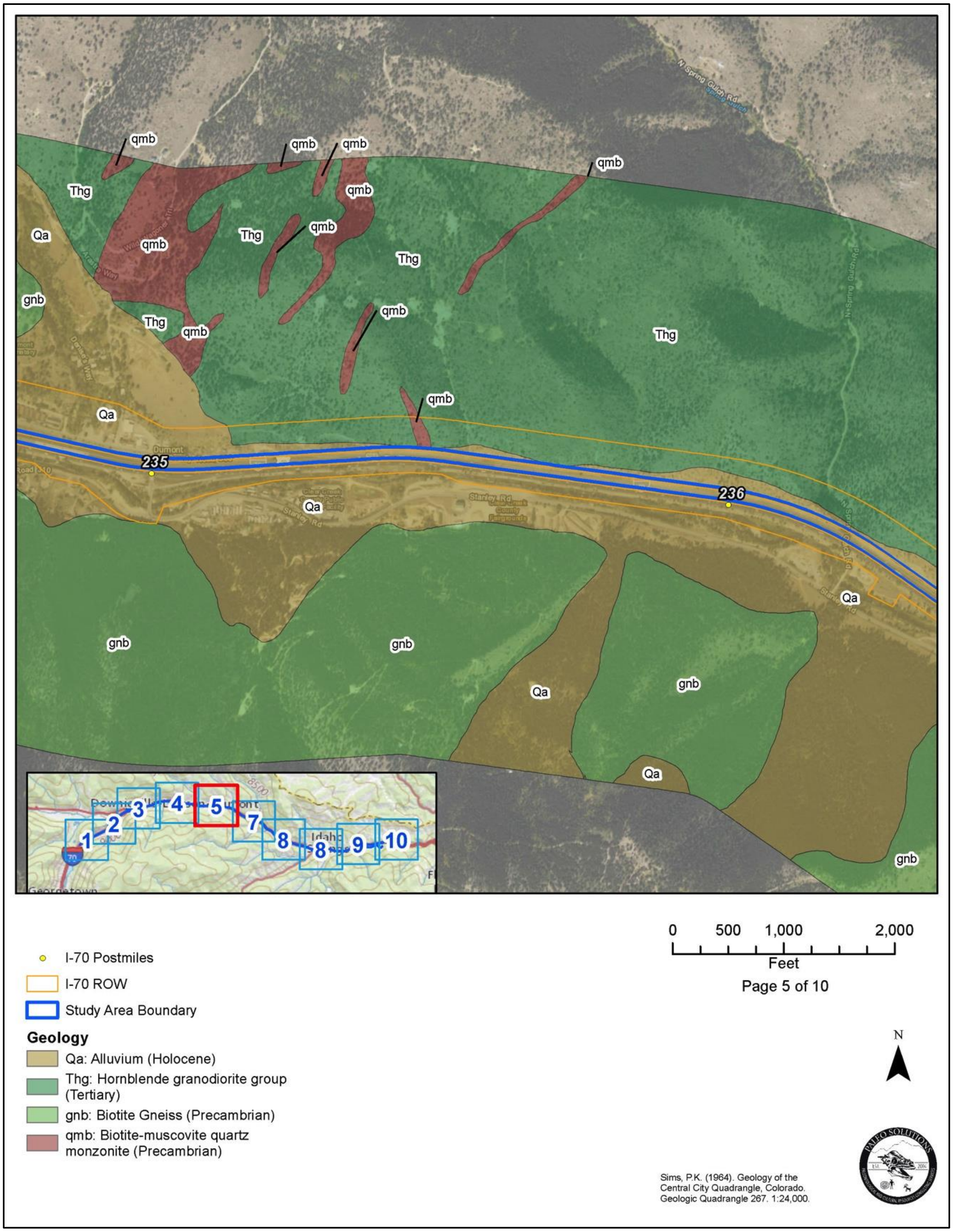

Figure 6. Geologic Map of the Study Area.

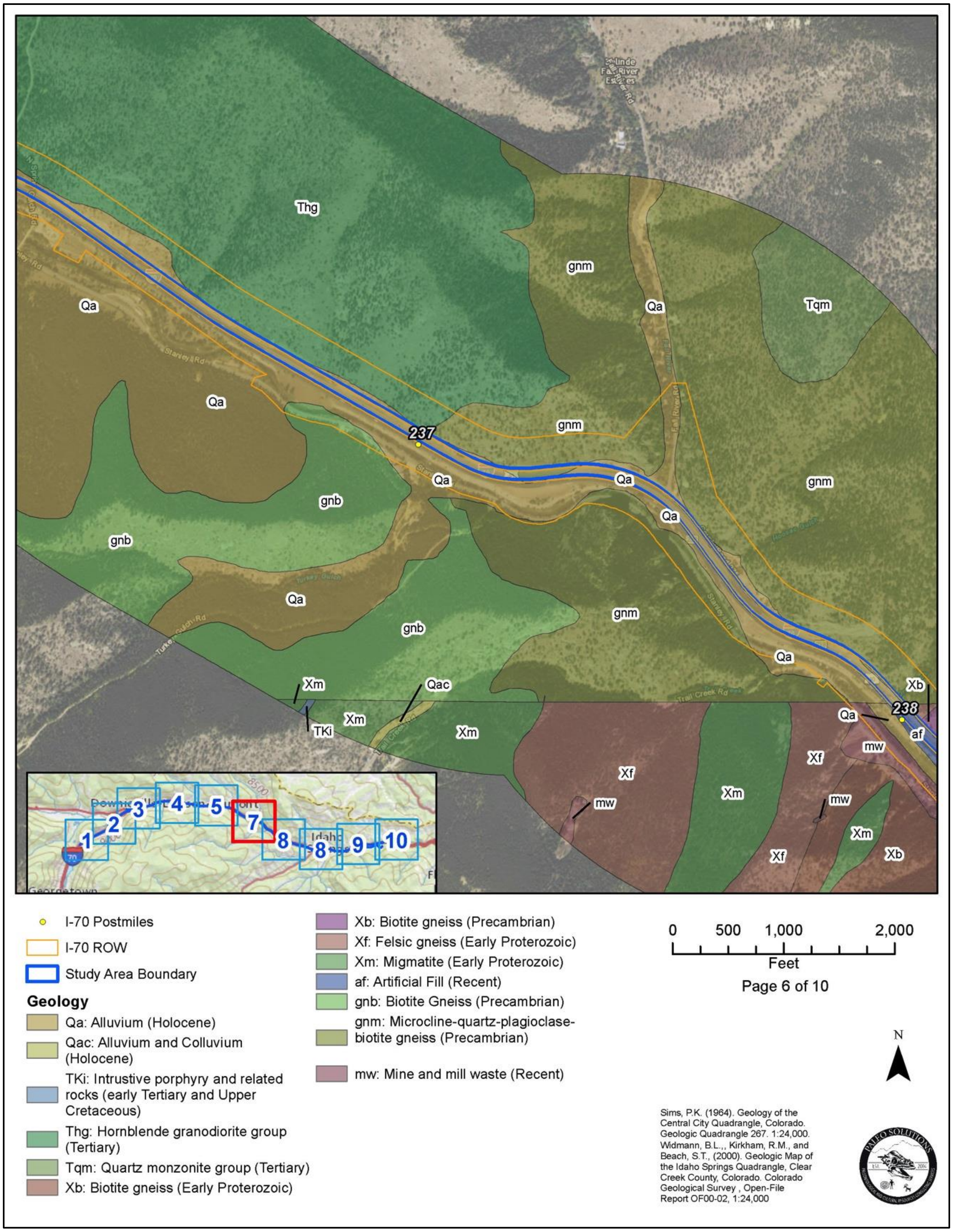

Figure 7. Geologic Map of the Study Area.

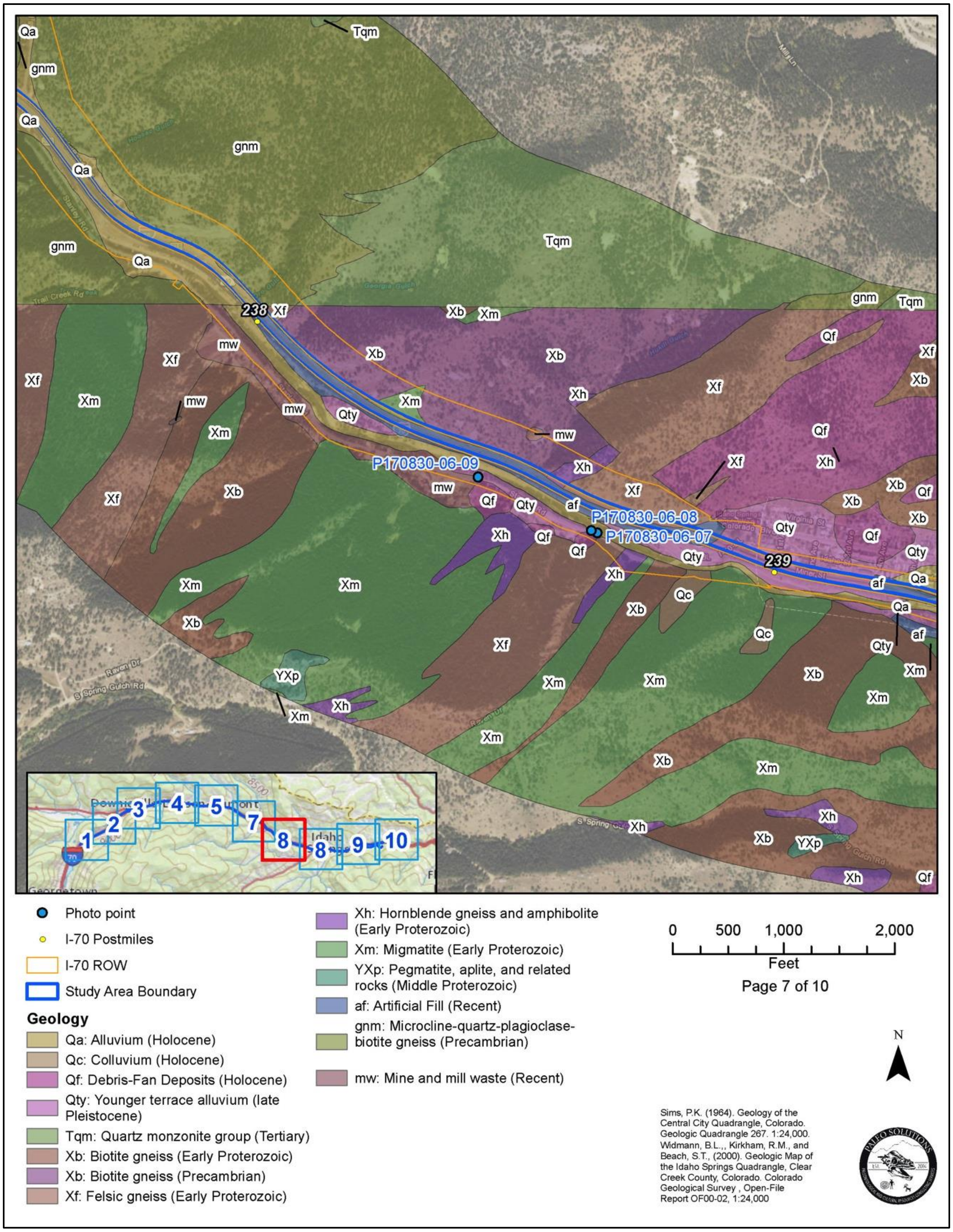

Figure 8. Geologic Map of the Study Area.

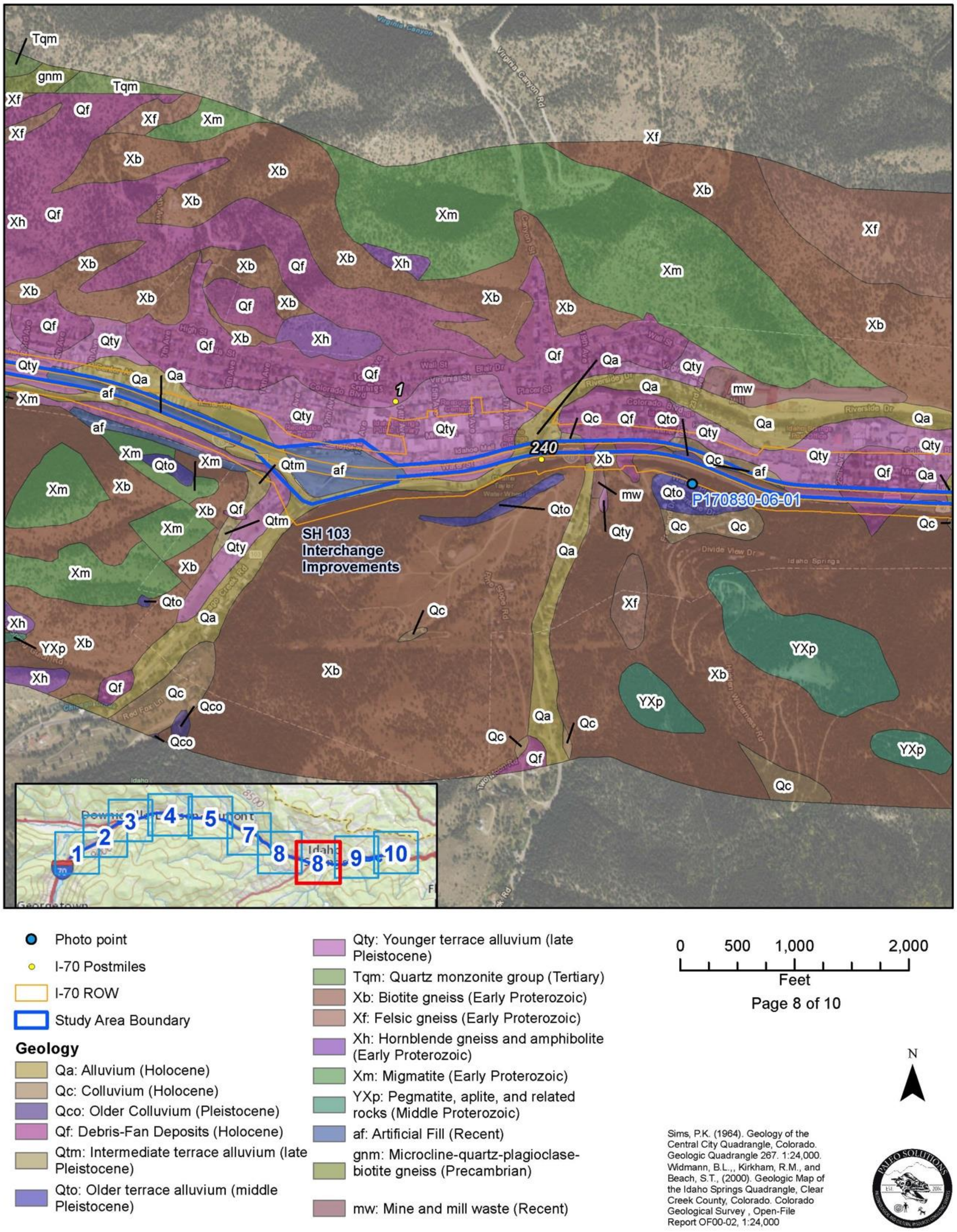

Figure 9. Geologic Map of the Study Area.

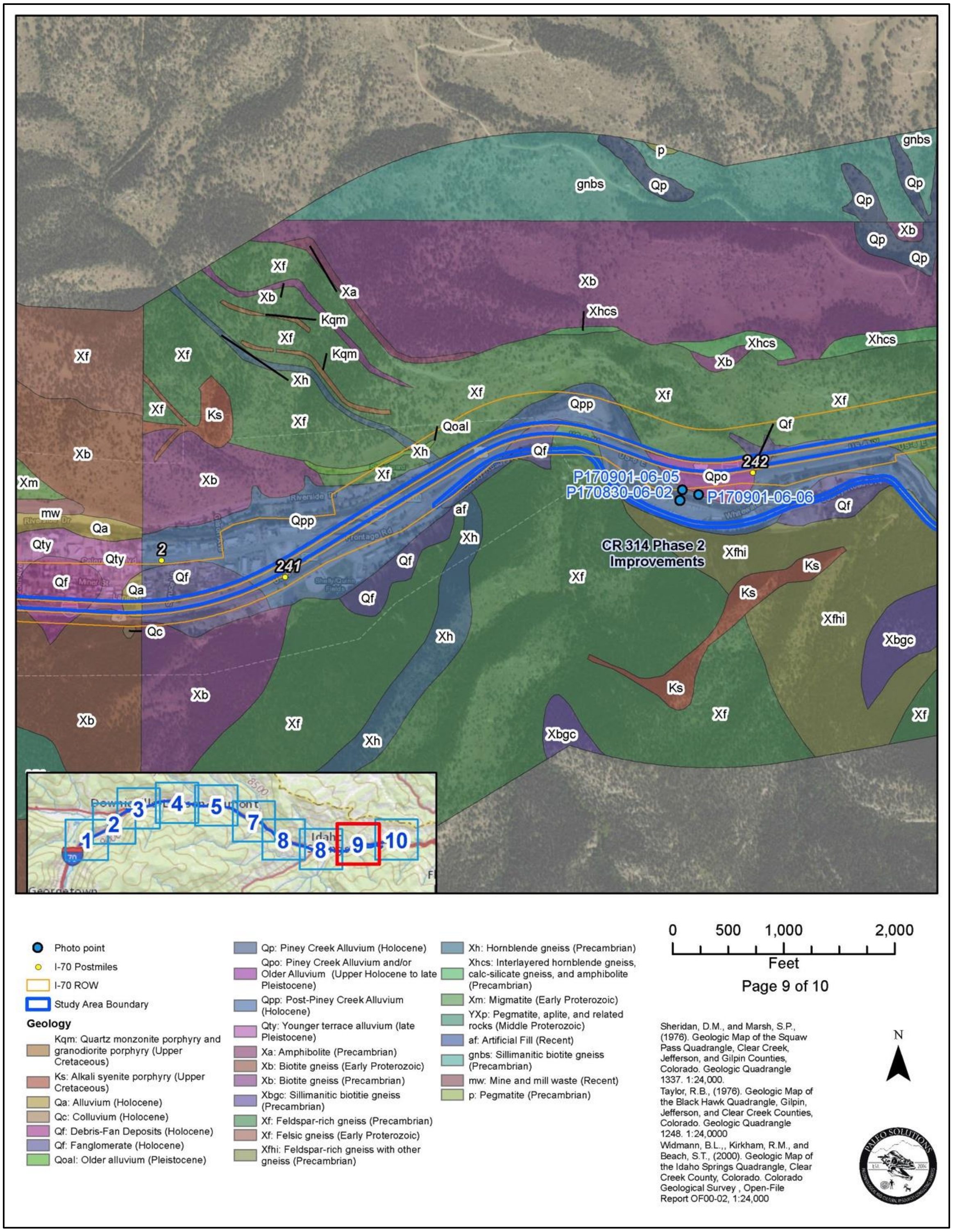

Figure 10. Geologic Map of the Study Area.

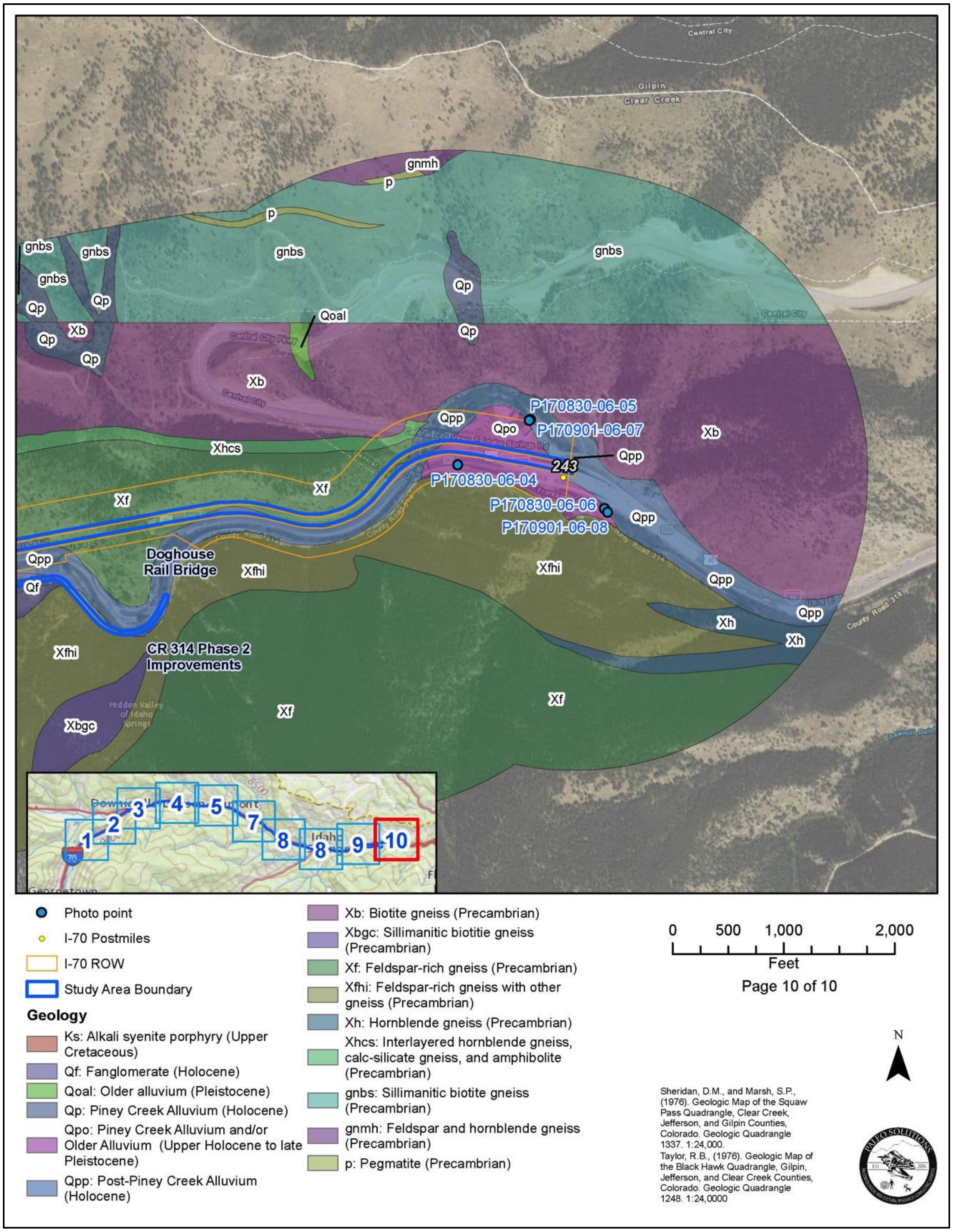

Figure 11. Geologic Map of the Study Area.

5.2.1 Igneous and Metamorphic Rock Units

The study area is underlain by sixteen igneous and metamorphic rock units (Table 3), all of which have very low potential to produce scientifically important paleontological resources (PFYC 1).

Igneous rocks are crystalline or non-crystalline rocks that form through the cooling and subsequent solidification of lava or magma. Intrusive (plutonic) igneous rocks form below the earth's surface, and extrusive (volcanic) rocks form on the earth's surface. Lava and magma are formed by the melting of pre-existing plutonic rocks in the earth's crust or mantle due to increases in temperature, changes in pressure, or changes in geochemical composition. Extreme temperatures in the environments in which intrusive igneous rocks form prevent the preservation of fossils. The formation of extrusive igneous rocks as a result of volcanic processes is associated with extremely high temperatures that also prevent the preservation of fossils. The following igneous rocks are present within the study area (Bastin and Hill, 1917; Sims, 1964; Braddock 1969; Sheridan and Marsh, 1976; Widmann, Kirkham and Beach, 2000; Widmann and Miersemann, 2002):

- Quartz diorite and hornblendite (qdh), which consists of mottled black-and-white or black, medium to coarse grained rocks.
- Boulder Creek granite (bcg), which is gray, medium-grained, nearly equigranular rock, dominantly foliated, with some pegmatite present.
- Granite pegmatite (grp, Yxp), which is coarse-grained to variably grained white, pink, or light-gray granite, occurring as dikes and irregularly shaped bodies.
- Biotite-muscovite quartz monzonite (qmb), which is grey or pink, fine- to medium-grained, weakly foliated intrusive rock. Includes some pegmatite.
- Silver Plume Granite (spg, Ysp), which is pink to pinkish-gray, consisting primarily of microcline, plagioclase and quartz, with minor to moderate amounts of biotite and muscovite. Abundant microcline phenocrysts are tabular and locally weakly aligned.
- Granodiorite of the Mount Evans batholith (Ygd), which is weakly to moderately foliated, mottled black and white rock composed of plagioclase, microcline, quartz, biotite, and accessory hornblende, magnetite, and sphene.
- Bostonite porphyry (Tb, Kb), which is composed of pinkish to medium gray dikes, the pinkish gray type being higher in feldspar phenocrysts and the medium gray variety containing few phenocrysts.
- Quartz monzonite porphyry and Granodiorite porphyry (Tqm, Kqm), which is light to medium-gray, pale violet, and pinkish-gray rock exposed in numerous dikes.

Metamorphic rocks result from the transformation of other rocks due to high temperature and high pressure. The parent rock can be igneous, sedimentary, or a pre-existing metamorphic rock. Metamorphic rocks comprise a large portion of the earth's crust and are classified on the basis of their chemistry and mineralogy. Most do not preserve fossils due to the conditions under which they were formed. However, metasedimentary rocks are formed from common sedimentary rock types such as limestone, shale, mudstone, siltstone, sandstone, and conglomerate. These types of metamorphic rocks do sometimes preserve fossils, but rarely fossils of scientific importance. Examples of fossils in metasedimentary rock include mollusks preserved in marble and echinoderms and graptolites preserved in slate. The following metamorphic rocks are present within the study area (Sims, 1964; Braddock 1969; Sheridan and Marsh, 1976):

- Felsic gneiss (Xf), which is composed of light-gray to white or tan, fine to medium grained, moderately well-foliated microcline-quartz-plagioclase-biotite gneiss; it is dark to light gray where biotite content is lesser, and tan where biotite content is higher. Garnet, hornblende, or magnetite are present at some localities.
- Hornblende gneiss and amphibolite (gnh, Xh) which is composed of dark to medium gray, massive or well banded, fine grained hornblende gneiss, and black to dark green, fine to medium grained amphibolite. Hornblende gneiss is mostly comprised of plagioclase and hornblende, and lesser amounts of biotite, quartz, and pyroxene; amphibolite is made up almost entirely of plagioclase and hornblende with almost no biotite, quartz, or pyroxene.
- Biotite gneiss (Xb), which is medium to light gray, fine grained gneiss, mostly composed of plagioclase, quartz, and biotite with small amounts of magnetite, garnet, sillimanite, and cordierite; it is typically "salt and pepper" in appearance and is usually equigranular.
- Biotite gneiss (gnb), which is composed of gray, medium-grained migmatitic biotite gneiss, interlayered biotite-quartz-plagioclase gneiss; this category includes sillimanite-biotite-quartz-plagioclase-microcline-muscovite gneiss, biotite-quartz-plagioclase-microcline gneiss, garnetiferous varieties, and much pegmatite as thin layers and discrete bodies.
- Microcline gneiss (gnm), which is composed of light- or yellowish-gray microcline-quartz-plagioclase-biotite gneiss that has a granitic appearance and well-defined layering.
- Feldspar rich gneiss with hornblende (Xfhi), which consists of approximately equal amounts of rocks identical to hornblende gneiss and amphibolite (Xh) and feldspar-rich gneiss (Xf) interlayered at intervals of a few centimeters to at least 10 meters, with small amounts of interlayered biotite-quartz-plagioclase gneiss, and layers of calc-silicate gneiss and lenses of impure marble and quartz gneiss present locally.

The distribution of igneous and metamorphic rocks in the study area is shown in Figures 2-12.

5.2.2 Quaternary Surficial Deposits

There are eight mapped surficial sedimentary units of Holocene and Pleistocene age within the study area. Pleistocene age deposits are described together below, and Holocene aged deposits are described separately in the following paragraph.

Pleistocene-aged Deposits

Pleistocene-aged deposits mapped within the study area consist of older alluvium, older and younger terrace alluvium, colluvium, and Piney Creek Alluvium and/or Older Alluvium. Alluvium is composed of light-gray, grayish-brown, and rusty-brown sand and silt containing lenses and layers of pebble, cobble, and boulder gravel. Colluvium is composed of poorly sorted boulder to sandy silt and clay (Sheridan and Marsh, 1976). Terrace alluvium is composed of poorly sorted and clast supported, boulder pebble and cobble gravel in a sandy matrix.

Pleistocene-aged deposits in Colorado contain many fossils that provide important paleobiologic, paleobiogeographic, and paleoenvironmental information. In particular, varying types of alluvium are reported to contain well-preserved Pleistocene-aged fossils.

In Colorado and the Rocky Mountain region in general, the most common Pleistocene vertebrate fossils are mammoth, horse, bison, deer, and camel. However, numerous other taxa, including diverse small vertebrate, invertebrate, and plant assemblages, have been reported (Anderson, 1965; Barnosky, 2004; Cook, 1930, 1931; Emslie, 1986; Gillette and Miller, 1999; Gillette et al., 1999a, b;

Graham and Lundelius, 1994; Heaton, 1999; Hunt, 1954; Lewis, 1970; Scott, 1963a,b; Smith et al., 1999; unpublished paleontological data, DMNS). Many other Pleistocene fossils have been reported in other areas of Colorado, including mammoth and horse remains from south of Florissant, as well as the scientifically well-known Porcupine cave site south of Hartsel that yielded amphibians, reptiles, 19 species of birds, and more than 75 species of mammals including camel, sloth, wolf, coatimundi, peccary, and cheetah (Cockerell, 1907; Barnosky, 2004; Barnosky and Rasmussen, 1988). An unusually well-preserved Pleistocene locality was recently discovered at the Ziegler Reservoir near Snowmass, and has been the subject of continuous research since its discovery (Pigati et al., 2014; Miller et al, 2014; Sertich et al., 2014). The locality, discovered in 2010, yielded more than 4,000 well-preserved vertebrate specimens. The assemblage is dominated by mastodon remains, but also includes those of mammoth, ground sloth, the giant *Bison latifrons*, camel, deer, a variety of small mammals, tiger salamander, and numerous other taxa. Exquisitely preserved plant fossils were also salvaged and provide an unprecedented nearly continuous record of alpine plant communities between approximately 140,000 and 55,000 years BP (Johnson et al., 2011; Johnson and Miller, 2012; Miller et al, 2014). These sites demonstrate the paleontological potential of similar sediments in the Rocky Mountains, the vast majority of which are rarely disturbed and hence provide few opportunities to sample and study their fossil record. Pleistocene-aged deposits, particularly alluvium, have been assigned moderate paleontological potential (PFYC 3).

Holocene-aged Deposits

Holocene-aged surficial deposits within the study area consist of Alluvium, Post Piney Creek Alluvium, and Debris Fan and Fanglomerate deposits. Holocene aged alluvial deposits are composed of dark-grey humic silt and sand with lenses of sand and gravel near the base, or bouldery alluvium with a matrix of gravel, sand or silt. Debris Fan and Fanglomerate deposits are composed of pebbles, cobbles, and boulders interbedded with sand and silt (Sheridan and Marsh, 1976). Holocene deposits are too young to contain *in-situ* fossils, therefore any Holocene-aged surficial deposits have low paleontological potential (PFYC 2).

6.0 RECORD SEARCH RESULTS

Neither the UCM nor DMNS have any records of previously recorded fossil localities within the study area. However, numerous other fossil localities have been recorded in surficial sedimentary deposits elsewhere in montane environments in Colorado.

7.0 FIELD SURVEY RESULTS

The surface of the study area is mostly vegetated, previously disturbed or with residential and commercial buildings and roads, or consists of igneous and metamorphic bedrock exposures. Areas underlain by metamorphic and igneous rocks, whether exposed or not, were not subject to pedestrian survey because they have very low paleontological potential. These areas were first identified using geologic maps and then were cleared visually in the field to confirm the accuracy of the mapped geology, and specifically to check for any unmapped Quaternary Surficial Deposits. Areas identified before the field survey as containing mapped Quaternary surficial deposits were subject to a thorough pedestrian survey, the purpose of which was to inspect the study area for locations of potentially fossiliferous Pleistocene sedimentary deposits and document their locations. Exposures of surficial sedimentary deposits occur locally throughout the study area and are located adjacent to streams. One area at Milepost 238.4 to 238.6 is interpreted to have Pleistocene aged deposits (Table 3). No new fossil localities were documented during the field survey.

The survey results are summarized in Table 3. Representative study area photographs are provided in Figure 13, and photo point locations are shown in Figures 2-12, which are in order from east to west.

Table 3. Field Survey Summary Results Showing Locations of Observed Surficial Deposits

Mapped Surficial Unit	Age	Field Survey Results and Age Interpretation	Milepost	Interpreted Pleistocene Deposits?
Debris Fan and Fanglomerate deposits (Qf)	Holocene	No observed exposures within the study area.	N/A	No
Post-Piney Creek Alluvium (Qp)	Holocene	No observed exposures within the study area.	N/A	No
Alluvium (Qa)	Holocene	Exposed at the surface at two places within the study area and is confirmed to be only Holocene in age.	232.5, and 235.2	No
Piney Creek Alluvium and/or Older Alluvium (Qpo)	Pleistocene to Late Holocene	Located at the base of the slope leading down to clear creek. Approximately 1-2 meters thick. It is likely that these deposits are only Holocene in age based on how close they are to the water level.	241.9 to 242	No
Colluvium (Qc)	Pleistocene to Late Holocene	Exposure found in one area, though the field observations indicate that it does not contain any Pleistocene aged sediments.	230	No
Younger Terrace Alluvium (Qty)	Late Pleistocene	One exposure within the study area close to and extending above Hukill Gulch. At the east end of the exposure, the lower bank of the river is composed of faintly graded and well-compacted angular rusty orange granite boulders and some possibly in-place granite. The upper 10 feet of the bank is pebbly sand. At the east end, the top 5 feet is heavily vegetated pebbly humic sand, while the lower 10 feet is well compacted and fainly graded bouldery and pebbly coarse sand.	238.4 to 238.6	Yes
Older Terrace Alluvium (Qto)	Middle Pleistocene	No observed exposures within the study area; all areas where this unit is mapped have been developed.	N/A	No
Older Alluvium (Qoal)	Pleistocene	No observed exposures within the study area; all areas where this unit is mapped have been developed.	N/A	No

Photo 1. Overview of Colluvium at MP 230, photo point P170901-06-04, facing northeast.

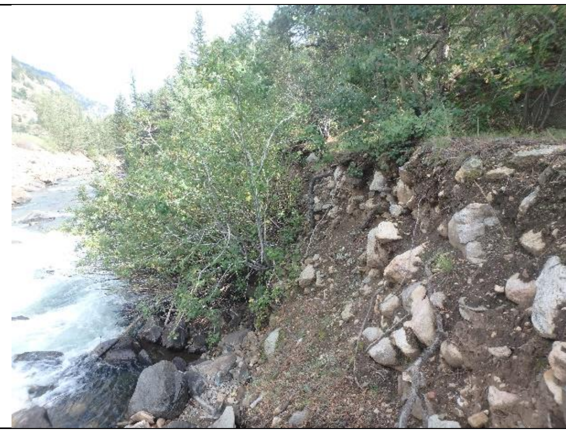

Photo 2. Overview of Alluvium at MP 232.5 at photo point P170901-06-11, facing east.

Photo 3. Overview of Alluvium at MP 235.2 at photo point P170901-06-03, facing west.

Photo 4. Overview of the west end of exposure at MP 238.4, photo point P170830-06-09, facing east.

Photo 5. Close-up view of the Younger Terrace Alluvium at MP 238.6, photo point P170830-06-08, facing south.

Photo 6. View from the east end of the exposure at MP 242, photo point P170901-06-06, facing west.

Figure 12. Overview Photographs of Exposed Quaternary Surficial Deposits.

8.0 RECOMMENDATIONS

The study area contains geologic units with very low, low and moderate paleontological potential (PFYC 1 to 3). During the field inspection, it was found that there is one area between mileposts 238.4 to 238.6 that is mapped both as containing Pleistocene aged deposits consisting of Younger Terrace Deposits, and as having exposure of deposits that are likely Pleistocene in age. All other areas that are mapped as containing Pleistocene aged deposits contained artificial fill or are developed. No previously recorded fossil localities are located within the study area based on the record searches completed for this study, and no new fossil localities were discovered during the survey. Given the absence of Pleistocene aged surficial deposits except in one area directly adjacent to a creek bed, in combination with the minimal surface disturbance required for Project construction, immediate paleontological clearance is recommended.

If any subsurface bones or other potential fossils are unearthed during project construction, work in the immediate area (20-foot diameter) should be temporarily halted and the CDOT Staff Paleontologist should be contacted immediately to evaluate the discovery and make further recommendations.

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APPENDIX A. COPY OF STATE OF COLORADO PALEONTOLOGICAL RESOURCES USE PERMIT

HISTORY Colorado

No. 2017-36

STATE OF COLORADO PALEONTOLOGICAL PERMIT

Issued under the authority of the Colorado Historical, Prehistorical, and Archaeological Resources Act, CRS 1973 24-80-401 *et seq.*, and under the procedures of the State Administrative Procedures Act, CRS 1973 24-4-101 *et seq.*

THIS IS TO CERTIFY that: Paul C. Murphey and
(Principal Investigator[s])

Same plus Kate D. Zubin-Stathopoulos, Courtney Richards, and Geraldine Aron ,
(Project Paleontologists)

of: 1216 East 10th Ave, Denver CO 80218

representing: Rocky Mountain Paleo Solutions

has/have been found to be qualified for the conduct of Paleontological studies and is/are hereby authorized to conduct paleontological investigations as described below, subject to: (a) the terms and conditions listed below, and (b) the Rules and Procedures published by the Colorado State Archaeologist.

Nature of investigation and location: Paleontological Survey and Testing—Statewide

Disposition of materials collected (subject, however, to such reservation as the State Archaeologist may impose under CRS 1973 24-80-406d):

Denver Museum of Nature and Science

Other condition(s): ______

Issued this 24 day of February, 2017.

The Permit is valid through February 28, 2018.

NOTE: Keep a copy of this Permit
in your field possession.

Holly Kathryn Norton
State Archaeologist of Colorado

Rev. 4/10

History Colorado, 1200 Broadway, Denver, CO 80203 HistoryColorado.org

C.R.S. 24-80-406. Permits. (2) Stipulations:

(a) The investigations, excavations, gatherings, and removals shall be undertaken only for the benefit of reputable museums, universities, colleges, or other recognized scientific or educational institutions, with a view to increasing the knowledge of such resources; and such activities shall be conducted for permanent preservation, either on the site or in museums, open to the public and available to qualified students.

(b) All permit holders shall provide the state archaeologist, within one year after the start of the investigation, excavation, gathering, or removal, with a preliminary report of progress. If such activity continues for more than one year, an annual progress report shall be made. The permit holder shall furnish a final report of the activity undertaken within three years after termination of the field work.

(c) An inventory of all materials recovered during the course of the investigation, excavation, gathering, or removal shall be supplied to the state archaeologist.

(d) Upon receipt of the final report of the activity undertaken by a permit holder, the state archaeologist may require that a representative collection of the materials recovered be delivered to the state of Colorado and shall determine a repository for the same.

(e) Any permit issued by the society may be revoked by the society, pursuant to article 4 of this title, at any time if there is evidence that the activity authorized by the permit is being unlawfully or improperly conducted or if the permit holder does not honor the conditions of the permit. When a permit is revoked, all recovered materials, catalogues, maps, field notes, and other records necessary to identify the same shall be surrendered immediately to the society.