PALEONTOLOGICAL RESOURCES TECHNICAL REPORT

FOR THE

I-25 (US 36 to 104th Avenue) Environmental Assessment

Prepared for:

Colorado Department of Transportation
Region 1
2829 W. Howard Place
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January 2020

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List of Acronyms and Abbreviations

ARPA	Archaeological Resources Protection Act
BLM	Bureau of Land Management
BOR	Bureau of Reclamation
CatEx	Categorical Exclusion
CDOT	Colorado Department of Transportation
CHPA	Colorado Historical, Prehistorical and Archaeological Resources Act
DMNS	Denver Museum of Nature and Science
EA	Environmental Assessment
EIS	Environmental Impact Statement
FHU	Felsburg Holt & Ullevig
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
FWS	Fish and Wildlife Service
GIS	Geographic Information System
I-25	Interstate 25
LORS	Laws, Ordinances, Regulations and Standards
NEPA	National Environmental Policy Act
NPS	National Park Service
PBDB	Paleobiology Database
PEL	Planning and Environmental Linkages
PFYC	Potential Fossil Yield Classification
PLSS	Public Land Survey System
PRPA	Paleontological Resources Preservation Act
ROD	Record of Decision
SVP	Society of Vertebrate Paleontology
UCM	University of Colorado Museum
US 36	United States Highway 36
USDA	United States Department of Agriculture
USDI	United States Department of Interior
USFS	United States Forest Service

1.0 Project Description

A paleontological evaluation was completed for the Interstate 25 (I-25) North, United States Highway 36 (US 36) to 104th Avenue project.. Colorado Department of Transportation (CDOT), in cooperation with the Federal Highway Administration (FHWA), is preparing a template Environmental Assessment for the I-25 North, US 36 to 104th Avenue project. The Regional Transportation District (RTD) is a cooperating agency.

The I-25 North, US 36 to 104th Avenue project includes improvements to relieve congestion and improve safety on I-25 from US 36 to 104th Avenue in Adams County and the City of Thornton, Colorado (**Figure 1** and **Figure 2**). The project will provide improvements to an approximately 4-mile segment of I-25 between US 36 and 104th Avenue. The current cross-section of I-25 between US 36 and 104th Avenue generally includes three general-purpose lanes and one Express Lane along the inside shoulder with an auxiliary lane between 84th Avenue and Thornton Parkway. The inside shoulder varies in size between 2 and 12 feet, and the outside shoulder varies between 10 and 12 feet. There is a 2-foot inside shoulder and a 2-foot buffer between the Express Lane and the nearest general-purpose lane.

Proposed improvements associated with this project are as follows:

- Adding a fourth general-purpose lane in each direction from 84th Avenue to Thornton Parkway with the northbound general-purpose lane extending to 104th Avenue,
- Constructing continuous acceleration and deceleration lanes between the I-25/84th Avenue interchange, and the I-25/Thornton Parkway interchange,
- Widening the inside and outside shoulder to a consistent 12-foot width,
- Accommodating a proposed median transit station and pedestrian bridge for the Thornton Park-n-Ride just south of 88th Avenue, and
- Replacing the 88th Avenue bridge.

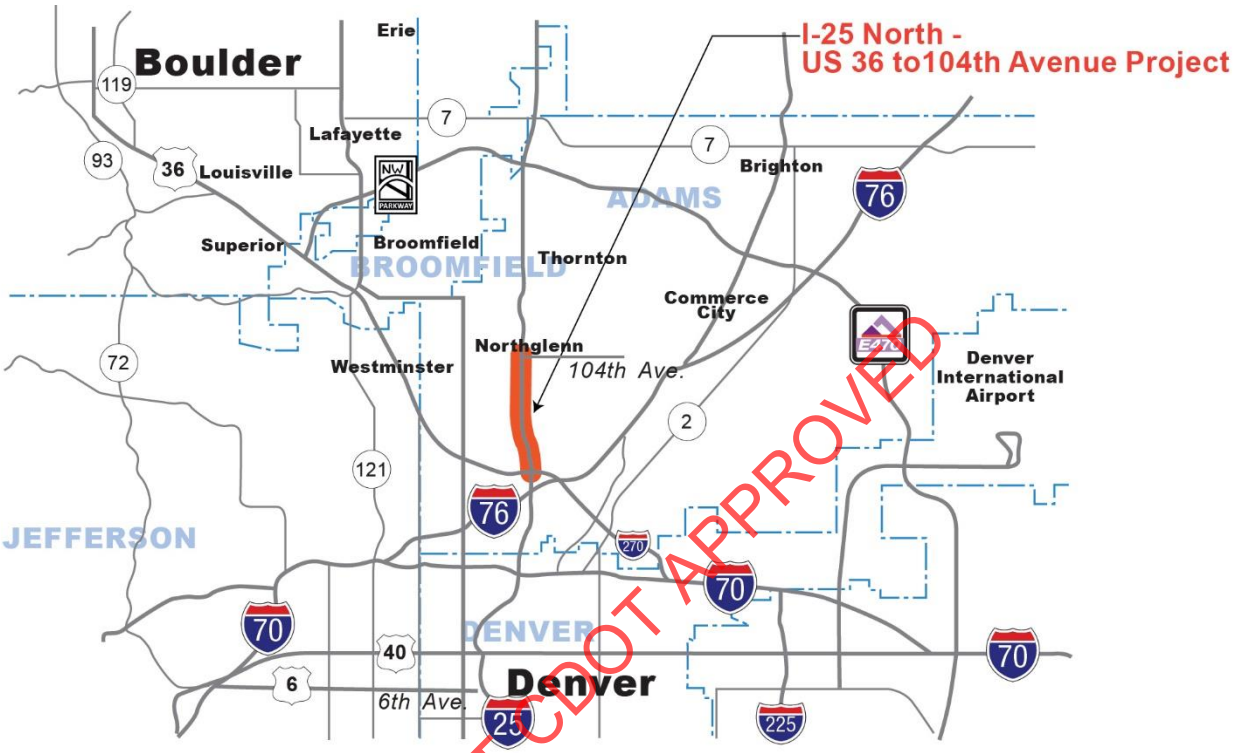
The proposed typical section on I-25 will consist of four 12-ft general-purpose lanes, a 12-ft Express Lane along the inside travelled way, and a 12-ft outside auxiliary lane between each interchange. Additionally, the inside and outside shoulders will be widened to 12 feet and the Express Lane buffer will be widened to 4 feet, and a 2-foot barrier will separate the northbound and southbound lanes of I-25. Surrounding the median station will be a 2-foot concrete barrier separating the Express Lanes from the bus station and bus lanes.

2.0 Paleontological Resources Assessment

This technical report presents the results of an analysis of existing paleontological data and field survey completed for the I-25 North, US 36 to 104th Avenue project **(Figure 1** and **Figure 2**). According to geologic mapping (Lindvall, 1980), the project area is underlain by one mapped bedrock sedimentary unit, consisting of the Denver Formation (TKda). In addition, the project area is underlain by four mapped surficial sedimentary deposits, consisting of Pleistocene Rocky Flats Alluvium (Qrf), Pleistocene and Holocene Colluvium (Qco), Pleistocene and Holocene loess (Ql), and Holocene Piney Creek Alluvium (Qp).

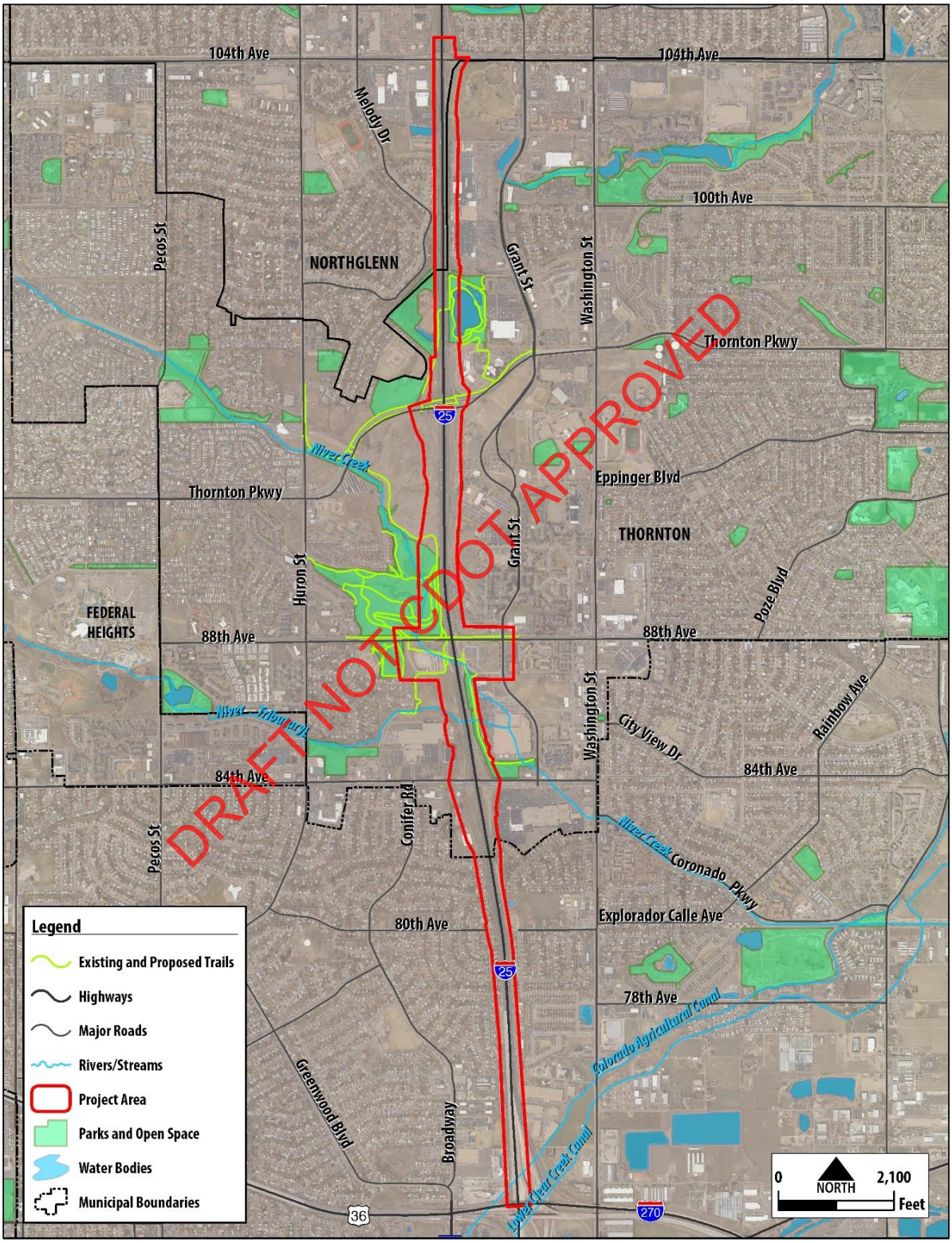
According to the Potential Fossil Yield Classification (PFYC) System, the Denver Formation has very high paleontological potential (PFYC 5). Surficial deposits mapped within the project area of Pleistocene age have moderate paleontological potential (PFYC 3), while surficial deposits of Holocene age have low paleontological potential (PFYC 2). The purpose of this analysis, summarized in **Table 1**, is to evaluate the potential for adverse impacts on previously recorded, currently undiscovered, and scientifically important paleontological resources within the project area.

Figure 1. Project Vicinity



Source: FHU, 2019

Figure 2. Project Area



Source: FHU, 2019

Table 1. Project Summary

Project Name	I-25 North, US 36 to 104th Avenue Environmental Assessment				
Project Description	Conducted a paleontological resources analysis of existing data to evaluate the potential for adverse impacts on subsurface fossils during project construction. The construction will involve adding a fourth general-purpose lane in each direction from 84th Avenue to Thornton Parkway, constructing continuous acceleration and deceleration lanes between the I-25/84th Avenue interchange and the I-25/Thornton Parkway interchange, widening the inside and outside shoulder to a consistent 12-foot length, accommodating a proposed median transit station and pedestrian bridge for the Thornton park-n-Ride, and replacing the 88th Avenue bridge. The proposed improvements will have a typical cross-section with four 12-ft general-purpose lanes, a 12-ft Express Lane along the inside shoulder, and a 12-ft auxiliary lane between each interchange. Additionally, the inside and outside shoulders will be widened to 12 feet, and the Express Lane buffer will be extended to 4 feet.				
Total Acreage	292.48 acres				
Location (Public Land Survey System [PLSS]) and Landowner/Managing Agency	**Quarter-Quarter**	**Section**	**Township**	**Range**	**Land Agency/ Private Landowner**
	SESW, SWSE	10	T2S	R68W	Private/CDOT ROW
	SESW, SWSE, NESW, NWSE, SENW, SWNE, NENW, NWNE	15	T2S	R68W	Private/CDOT ROW
	NENW, NWNE, SENW, SWNE, NESW, NWSE, SESW, SWSE	22	T2S	R68W	Private/CDOT ROW
	NENW, NWNE, SENW, SWNE, NWSE, SWSE	27	T2S	R68W	Private/CDOT ROW
	NWNE, SWNE, NWSE, SESE, SWSE	34	T2S	R68W	Private/CDOT ROW
Geologic Map(s)	Lindvall, R.M., 1980, Geologic map of the Commerce City quadrangle, Adams and Denver Counties, Colorado: U.S. Geological Survey, Geologic Quadrangle Map GQ-1541, scale 1:24,000.				
Topographic Quad(s)	Commerce City, CO USGS 7.5' Quadrangle				
Geology	Denver Formation (TKda), Rocky Flats Alluvium (Qrf), Colluvium (Qco), Loess (Ql), Piney Creek Alluvium (Qp)				
Surveyors	Kate D. Zubin-Stathopoulos, M.S.				
Survey Dates	2/02/2017 and 2/06/2017				
Previously Documented Fossil Localities within the Same County	7 previously documented fossil localities from the Denver Formation within Adams County				
Fossil Localities Discovered During Survey	Non-significant Fossil Occurrences: 0 Significant Fossil Localities: 0				

3.0 Definition and Significance of Paleontological Resources

Paleontology is a multidisciplinary science combining geology, biology, chemistry, and physics elements to understand the history of life on earth. Paleontological resources, or fossils, are the remains, imprints, or traces of once living organisms that have been 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 but also 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 (Murphey and Daitch, 2007). Fossils are important scientific and educational resources and can be used to:

- Study the phylogenetic relationships among 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, 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 (Murphey and Daitch, 2007).

According to Bureau of Land Management (BLM) IM 2009-011 (BLM, 2008), 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 scientifically important because 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 identified educational or recreational value. Paleontological resources that may be considered to not have paleontological significance include those that lack provenience or context, lack physical integrity because of 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.

4.0 Laws, Ordinances, Regulations, and Standards

Fossils are classified as non-renewable scientific resources protected by various laws, ordinances, regulations, and standards (LORS) across the country. The Society of Vertebrate Paleontology (SVO) established professional procedures for assessing and mitigating adverse impacts on paleontological resources (2010). This paleontological study was conducted in accordance with the LORS that are applicable to paleontological resources within the project area, as well as established best practices in mitigation paleontology (Murphey, et al.,

2014). Pertinent federal, state, county, and city LORS are summarized below.

4.1 Federal

The National Environmental Policy Act (NEPA) of 1969, as amended (Public Law 91-190, 42 U.S.C. 4321-4347, January 1, 1970, as amended by Public Law 94-52, July 3, 1975, Public Law 94-83, August 9, 1975, and Public Law 97-258 § 4(b), Sept. 13, 1982), 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 about 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 affect the environment.

With the Paleontological Resources Preservation, Title VI, Subtitle D in the Omnibus Public Lands Act of 2009, Public Law 111-011, 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 (United States Department of Interior [USDI], United States Department of Agriculture [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, National Park Service (NPS), United States Forest Service (USFS), Bureau of Reclamation (BOR), and Fish and Wildlife Service (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 the illegal sale and transport, and the theft and vandalism of fossils from federal lands;
- Uniform requirements for the curation of federal fossils in approved repositories; and
- Federal protections for scientifically significant paleontological resources that 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 project area.

4.2 State

The Colorado Historical, Prehistorical and Archaeological Resources Act of 1973 (CHPA) (CRS 24-80-401 to 411, and 24-80-1301 to 1305) defines permitting requirements and procedures for collecting prehistoric resources, including paleontological resources on state lands, and actions that should be taken if those resources are discovered in the course of state-funded projects and on state-owned/ administered lands. Based on this legislation, 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. CDOT will review this study and must fulfill FHWA's NEPA requirements under the CHPA.

4.3 County

Adams County has no LORS that specifically address potential adverse impacts on paleontological resources. Therefore, no county-level protections of paleontological resources pertain to the project.

4.4 City

There are no City of Thornton LORS that pertain to the project.

4.5 Private Lands

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

5.0 Methods

This study will evaluate the paleontological sensitivity of the geologic units within the project area by researching their known fossil potential and paleontological significance and by determining the number and significance of previously recorded fossil localities within the project area and elsewhere in the same geologic units. This study was undertaken at the request of Felsburg Holt & Ullevig (FHU) and CDOT.

5.1 Personnel

The field survey was conducted by Paleo Solutions' paleontologist Kate D. Zubin-Stathopoulos, M.S., under the direction of Principal Investigator Dr. Paul C. Murphey. The data analysis was completed, and this report was prepared by Kate D. Zubin-Stathopoulos, M.S., and Dr. Paul C. Murphey. Geographic Information System (GIS) support was provided by Paleo Solutions' GIS specialist Barbara Webster, M.S.

5.2 Analysis of Existing Data Methods

The analysis of existing paleontological data included the following elements:

- A museum record search to determine the presence of previously recorded fossil localities within the project area from the University of Colorado Museum (UCM) and the Denver Museum of Nature and Science (DMNS). An additional records search used the public online Paleobiology Database (PBDB);
- A geologic map review to determine the distribution of geologic units within the project area; and
- A literature search to evaluate the paleontological sensitivity of the project area and the same geologic units near the project area.

The geologic units within the project area were classified according to the PFYC system. The record search area included only the same geologic units that occur within the project area. The geologic map used was prepared by Lindvall (1980). The literature search emphasized publications on paleontological resources from the same geologic units present within the project area and the same units elsewhere in Colorado.

5.3 Field Survey Methods

The analysis of existing data was followed by a pedestrian field survey. The field survey included a pedestrian examination of the entire project area. Only areas for which permission to enter had been granted and that were safely accessible were surveyed. The survey was completed in two sessions, one on February 2 and 6, 2017, and a second on July 20, 2018, at the request of FHU after the project area was enlarged. Five survey areas were determined by the PLSS section that the project passes through using the following format: Section-Township-Range. Defined survey areas include:

- 10-2-68,
- 15-2-68,
- 22-2-68,
- 27-2-68, and
- 34-2-68.

5.4 Distribution of Data

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

6.0 Literature Research Results

The project area is in the city of Thornton, Adams County, Colorado (see **Figure 1**). This section summarizes the geology and paleontology of the mapped geologic units within the project area. The literature search was based on the same geologic units that are mapped within the project area in geologically pertinent parts of the Denver Basin and adjacent areas of Colorado.

6.1 Geology and Paleontology

The I-25 North, US 36 to 104th Avenue project area is directly underlain by one mapped sedimentary bedrock unit consisting of the Denver Formation (TKda). In addition, the project area is underlain by four mapped surficial sedimentary deposits, consisting of the Pleistocene Rocky Flats Alluvium (Qrf), Holocene-Pleistocene Colluvium (Qco), Holocene-Pleistocene Loess (Ql), and Holocene Piney Creek Alluvium (Qp) (see **Table 2**). **Figure 3** and **Figure 4** show the distribution of these units within the project area.

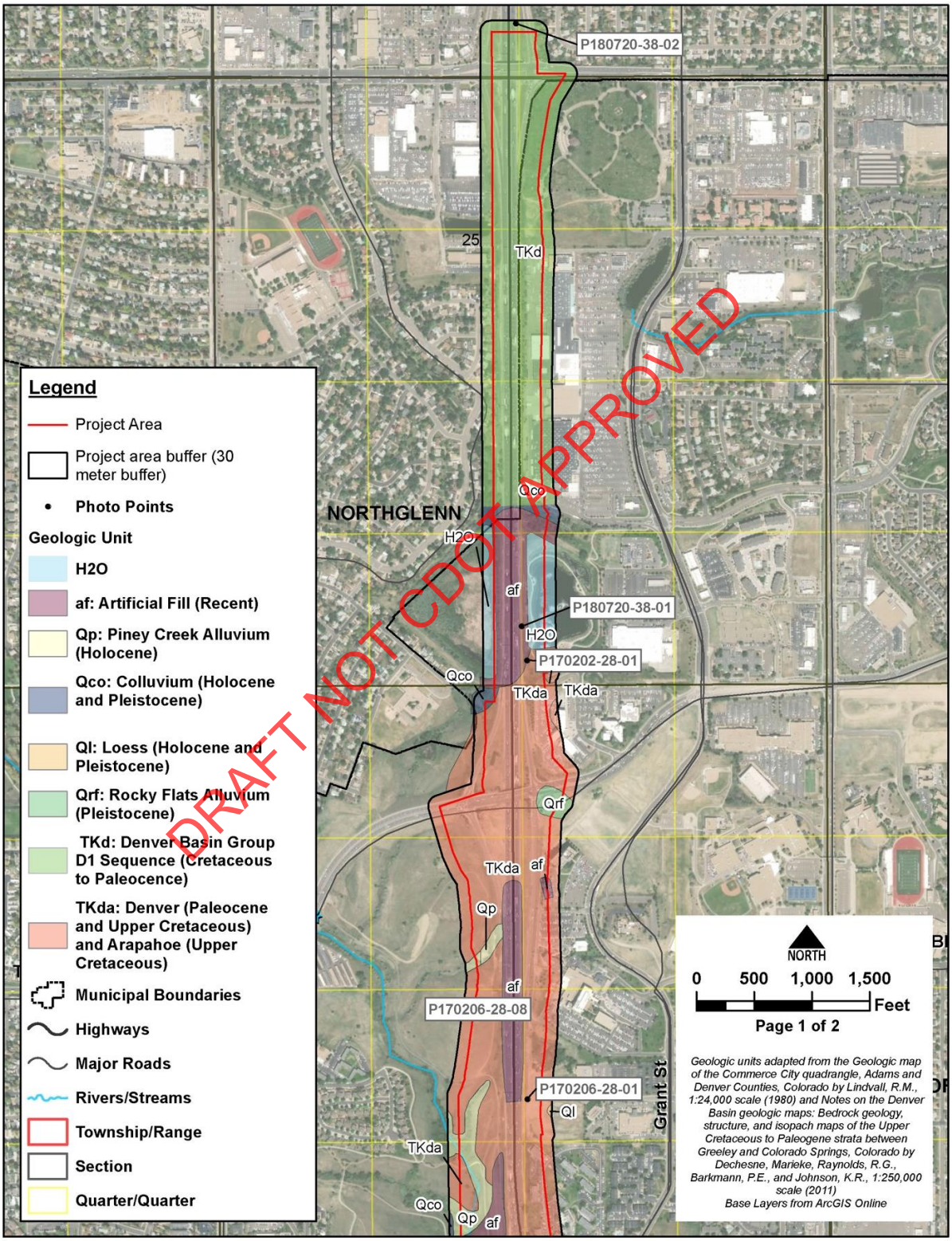
The Denver Formation was deposited in the Denver Basin—an asymmetrical Laramide-aged structural basin that contains sedimentary bedrock of Pennsylvanian through Pliocene age, unconformably overlain by Pleistocene and Holocene surficial deposits. The geology of the strata deposited within the Denver Basin is scientifically important because it records, among other events, the erosion of the ancestral Rocky Mountains, the development of a vast interior seaway that covered much of central North America, and the uplift of the Front Range of the Rocky Mountains during the Laramide Orogeny. Significant paleontologic events recorded within Denver Basin units include the extinction of the dinosaurs at the end of the Cretaceous Period, the development of tropical rainforest ecosystems and evolutionary radiation of mammals during the Paleocene Period, and the environments and animals that lived in the region during the Pleistocene ice ages.

Table 2. Geologic Units within the Project Area

Geologic Unit Name	Map Unit Abbreviation	Common Fossils	Age	PFYC
Piney Creek Alluvium	Qp	Contains the remains of modern, extant species of animals and plants. Too young to contain *in-situ* fossils.	Holocene	2
Loess	Ql	Mammoth, horse, bison, camel, and small mammals	Holocene and Pleistocene	2-3
Colluvium	Qco	Mammoth, horse, bison, camel, and small mammals	Holocene and Pleistocene	2-3
Rocky Flats Alluvium	Qrf	*Stegomastodon elegans* (Proboscidean), Horse *(Dolichohippus* sp.), prairie dog	Pleistocene	3
Denver Formation	TKda	Well-preserved abundant plants; rare vertebrates including dinosaurs and mammals	U. Cretaceous and L. Paleocene	5

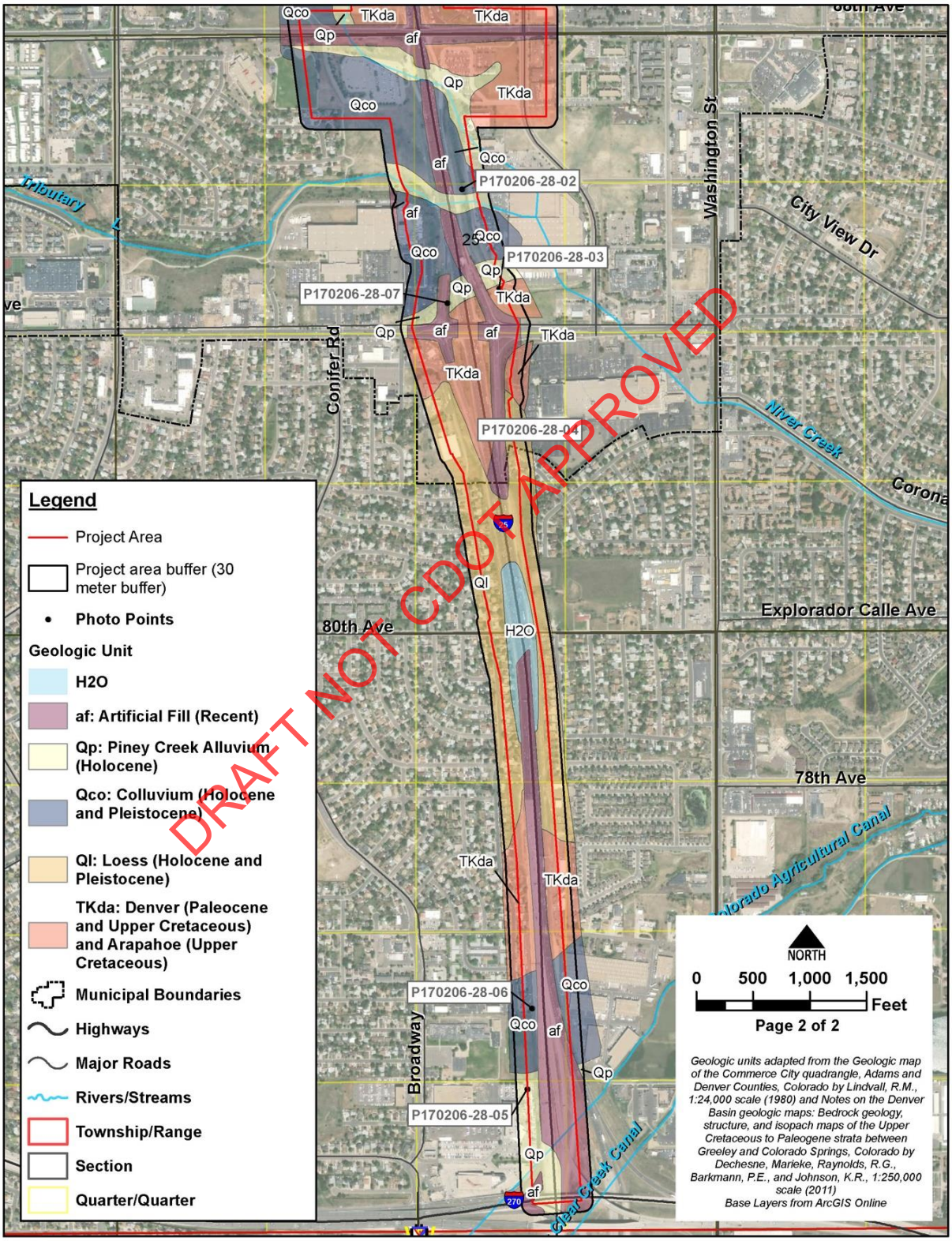
Source: Lindvall, 1980

Figure 3. Geologic Map of the Northern Half of the Project Area



Source: Paleo Solutions, 2018.

Figure 4. Geologic Map of the Southern Half of the Project Area



Source: Paleo Solutions, 2018.

6.1.1 Denver Formation (TKda)

In 1888, Cross named the Late Cretaceous Denver Formation for its exposures in the Denver-Julesburg Basin near Denver, Colorado. This formation unconformably overlies the Laramie and Arapahoe Formations and unconformably underlies widely distributed Pleistocene- and Holocene-age surficial sedimentary deposits to the east of the Front Range foothills in the basin. The unit is stratigraphically equivalent to the Raton, Poison Canyon, Dawson, and Fort Union formations and, in part, to the San Jose Formation. To the north, the unit is equivalent with the upper portions of the Lance Formation in Wyoming and the Hell Creek Formation in Montana and the Dakotas. The unit is geographically isolated to Colorado and was originally divided into the Golden and Pleasant View Members (LeRoy, 1946), stratigraphic terminology that is no longer recognized. The formation is reported to be as much as 565 feet thick (Colton, 1978). It consists of dark-brown, yellowish-brown, and grayish-olive tuffaceous claystone, mudstone, and sandstone beds interbedded with scattered conglomerate (Bryant, et al., 1981; Colton, 1978; Soister, 1978; Trimble and Machette, 1979).

The Denver Formation, largely composed of altered andesitic (volcanic) debris, was deposited during the Laramide uplift of the Rocky Mountains in rivers and on alluvial floodplains in a tropical forest environment. Spanning from the latest Cretaceous (Maastrichtian) to the Paleocene (Puercan), D1 deposits of the Denver Formation preserve the Cretaceous-Tertiary boundary (dinosaur mass extinction event), which is reflected by the presence of dinosaur fossils below the boundary and early Paleocene-age mammal fossils above the boundary. D1 Denver Formation strata unconformably underlie “D2” strata, which are dated to the early Eocene based on scant fossil evidence (a single tooth of the early Eocene mammal *Coryphodon*). The boundary between D1 and D2 strata consists of a widely distributed paleosol deposit (Johnson and Raynolds, 1999; Raynolds and Johnson, 2003).

The Denver Formation preserves locally abundant and scientifically significant plant fossils (Brown, 1943; 1962; Ellis, et al., 2003; Johnson and Ellis, 2002; Knowlton, 1930) and a less abundant but scientifically important vertebrate fossil fauna (Eberle, 2003; Middleton, 1983). The flora is highly diverse and has been documented from 149 stratigraphically controlled localities, including the well-publicized Castle Rock Rainforest site along I-25 south of Denver (Johnson, et al., 2003). Vertebrate fossils include diverse Cretaceous-age dinosaurs and early Paleocene-age mammals (Carpenter and Young, 2002; Eberle, 2003). Both the DMNS and UCM have recorded several Denver Formation localities around the Denver Basin.

The geology and paleontology of the Denver Formation remains the subject of research by scientists and students at the DMNS and the UCM. This work has added considerably to the scientific understanding of the geologic and biologic history of the Denver Basin and surrounding areas during the late Cretaceous Period and Paleocene Epoch (Eberle, 2003; Ellis. et al., 2003; Johnson and Ellis, 2002; Johnson and Raynolds, 1999). Future fossil finds from the Denver Formation will add to this ongoing research effort. Because the Denver Formation contains locally abundant and well-preserved plant fossils, as well as less common but locally well-preserved and scientifically important vertebrate fossils, the unit has very high paleontological potential (PFYC 5).

6.1.2 Quaternary Surficial Deposits (Qrf, Qco, Qp, Ql)

Mapped geologic units of Pleistocene and Holocene age within the project area include, from oldest to youngest, Rocky Flats Alluvium (Qrf), which is Pleistocene in age; Colluvium (Qco), which is Pleistocene and Holocene in age; Loess (Ql), which is Pleistocene and Holocene in age; and Piney Creek Alluvium (Qp), which is Holocene in age. Quaternary surficial deposits are described in general below, and the details of the specific units are in the following sections.

Many Pleistocene fossils provide important paleobiologic, paleobiogeographic, and paleoenvironmental information and are, therefore, scientifically important. In Colorado and the Rocky Mountain region, in general, the most common Pleistocene vertebrate fossils are

mammoth, horse, bison, deer, and camel. However, several 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, 1999b; Graham and Lundelius, 1994; Heaton, 1999; Hunt, 1954; Lewis, 1970; Scott, 1963; 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, 1998). 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, dominated by mastodon remains, also includes the remains of mammoth, ground sloth, the giant *Bison latifrons*, camel, deer, various small mammals, tiger salamander, and several 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.

In Colorado, construction excavations commonly unearth Pleistocene fossils within alluvium, and several examples of such reports exist for the Denver area. For example, C.B. Hunt reported that more than 100 "collections" of Pleistocene and Holocene mammal remains were made during the fieldwork for his 1954 study, with an additional 32 previously curated "collections" housed at the DMNS. These specimens were found in alluvium (Hunt, 1954, p. 118): practically all of them consist of "single bones, and a large proportion of them are fragmentary." Hunt's report attests to the mostly isolated nature of Pleistocene skeletal remains in the Denver area. Others report more complete skeletal remains found at construction sites of gravel pits from alluvial deposits, including 18 individuals of *Stegomastodon*, a horse, an antelope-sized artiodactyl, a camel, a bison, a small rodent, and a vulture-sized bird from the Weis gravel pit near Holyoke (DMNS, unpublished paleontological data; Richard Stucky, personal communication, 2015). Hunt (1954, p. 107) lists other fossils discovered in Pleistocene alluvial sediments in the general vicinity of central Denver in deposits of Piney Creek Alluvium that were later recognized and mapped as Broadway Alluvium and Louviers Alluvium (e.g., Scott, 1962). Paleontologist C.L. Gazin of the National Museum of Natural History identified these fossils, which include camel bones, bison teeth, and antelope bones.

Quaternary deposits of Pleistocene age have been assigned moderate paleontological potential (PFYC 3) by the BLM, whereas younger Holocene sediments have low potential (PFYC 2).

Rocky Flats Alluvium (Qrf)

The Rocky Flats Alluvium is mapped within the project area in the northern portion along Thornton Parkway (see **Figure 3**), and according to Lindvall (1980), is composed of reddish-brown to light brown, poorly sorted coarse grained sand and gravel that contains lenses of silt and clay. Cobbles and scattered boulders are also present. It contains a strongly developed calcium carbonate zone that occurs near the top of this unit. It is commonly 3 to 6 meters thick (Lindvall, 1980).

Several vertebrate taxa are reported from the Rocky Flats Alluvium. These taxa include *Stegomastodon elegans* (Proboscidean) and *Dolichohippus* sp. (Horse), indicating that the Rocky Flats Alluvium is early Pleistocene in age (Late Blancan) (Scott, 1982). The BLM has assigned the Rocky Flats Alluvium moderate paleontological potential (PFYC 3).

Colluvium and Loess (Qco, Ql)

Colluvium is mapped primarily in the central portion of the project area, and Loess is mapped in the southern half of the project area (see **Figure 3 and Figure 4**). Colluvium consists of rock and soil that has moved under the influence of gravity and, within the project area, is composed of gray, dark gray and brown to light brown sandy silt and clay. Rare pebbles and cobbles occur and it has developed on steep to gentle slopes. It is commonly less than 1.5 meters thick (Lindvall, 1980). Loess consists of yellowish-brown to light grayish-brown sandy silt with the upper 2 feet containing more clay and silty clay. It is slightly calcareous, is sticky when wet, and has columnar structure. It is usually less than 3 meters thick but can be up to 8 meters (Lindvall, 1980).

Generally, colluvium is much less likely to contain well-preserved fossils than intact native sediments. Colluvium is often subjected to increased groundwater percolation, which tends to have a negative effect on the preservation of fossils, and gravitationally induced movements of sediment can also destroy fossil remains through abrasion and breakage. Loess deposits, which consist of windblown silt and sand, do preserve fossils but only rarely and typically as isolated specimens or in small assemblages.

Hunt (1954) reported fossils of mammoth and camel that were collected from Pleistocene-age eolian deposits at five localities in the Denver area. Additional fossil discoveries include horse and camel bones from south of Littleton (Scott, 1963) and badger, cottontail, jackrabbit, black-tailed prairie dog, the extinct white-tailed prairie dog, Richardson's ground squirrel, pocket gopher, vole, sagebrush vole, field mouse, pocket mouse, and possibly bison recorded by now retired CDOT Staff Paleontologist Steve Wallace in eastern Colorado (S. Wallace, written communication, 2000).

Pleistocene-aged Colluvium and Loess have moderate paleontological potential (PFYC 3), while Holocene-aged Colluvium and Loess have low paleontological potential (PFYC 2).

Piney Creek Alluvium (Qp)

Piney Creek Alluvium is primarily mapped within the central portion of the project area (see **Figure 3** and **Figure 4**). It is composed of brown, light brown, and light to dark gray interbedded sand silt and clay. It is generally well-stratified with common humic material in the upper 0.6 meter. Gravel occurs in the lower portion of this unit and grades upward to finer grained sediment. It occurs in the bottoms of almost every valley and has a thickness of 1.5 to 3.0 meters (Lindvall, 1980). Piney Creek Alluvium is Holocene in age and, therefore, is too young to contain *in-situ* fossils. It has been assigned a low paleontological potential (PFYC 2).

7.0 Records Search Results

Table 3 summarizes the fossil localities identified using the PBDB cross referenced with DMNS locality data and the published literature on fossil localities in the Denver Formation in Adams County. The University of Colorado Natural History Museum and the DMNS have no records of previously recorded fossil localities within the same township as the project area.

The localities listed in **Table 3** confirm the high paleontological potential of the Denver Formation in the Denver Basin and confirm a late Cretaceous age for this formation in Adams County. The field survey for the I-25 North Corridor EIS did not yield any fossil localities between US 36 and Thornton Parkway and to the best of our knowledge, no other paleontological surveys of the project area have been completed.

Table 3. Previously Recorded Fossil Localities within Adams County

Locality Number	Data Provided By	Data Collected By	Fossils	Age	Formation
DMNS 82031	Carpenter and Young, 2002	Carpenter and Young, 2002	*Ornithomimus cf. velox*, *Dromaeosauridae* indet., *Edmontonia* sp., Ceratopsidae indet.	Maastrichtian	Denver
PBDB 49541	PaleoBiology Database	Carpenter and Young, 2002	Ceratopsidae indet.	Maastrichtian	Denver
DMNS 1738	Carpenter and Young, 2002	Carpenter and Young, 2002	*Ornithomimus cf. velox*, Ceratopsidae indet.	Maastrichtian	Denver
DMNS 2366-2371	PaleoBiology Database	Carpenter and Young, 2002	Ceratopsidae indet.	Maastrichtian	Denver
PBDB 49555	PaleoBiology Database	Carpenter and Young, 2002	Ceratopsidae indet.	Maastrichtian	Denver
PBDB 49556	PaleoBiology Database	Carpenter and Young, 2002	Ceratopsidae indet.	Maastrichtian	Denver
DMNS 2843	DMNS	Carpenter, 2007	*Triceratops* sp.	Maastrichtian	Denver

Source: Paleobiology Database at www.paleobiodb.org

8.0 Field Survey Results

The surface of the project area is almost entirely vegetated or previously disturbed by roads and existing construction. Approximately 1 percent of the project area consists of exposed Denver Formation (Tkda). The only exposed bedrock is located near Russell Boulevard on the east side of I-25. There are no exposures of Quaternary surficial sediments within the project area. No new fossil localities were documented during the field survey.

Table 4 through **Table 8** summarize the survey results and provide representative project area photographs. **Figure 3** and **Figure 4** show photo point locations. Survey area names are based on the PLSS section using the following format: Section-Township-Range.

Table 4. Overview of 34-2-68 Survey Area

Survey Area Name	10-2-68
Survey Date(s)	7/20/2018
Formation(s)	Denver Formation (TKda), Colluvium (Qco)
Topography	Highway, ditches, entrance and exit ramps on north end, parts of parking lots and businesses on edges of survey area.
% Bedrock and Exposure Location	0%, no bedrock or surficial sediment exposure
Lithology(s)	N/A
Photo Points	P180720-38-02; see Figure 4 for photo point location
NFO's	N/A, no new fossil localities
SFL's	N/A, no new fossil localities
Land Ownership	Private/CDOT ROW
Topographic Quad	Commerce City, CO USGS 7.5' Quadrangle
Geologic Map	Lindvall, 1980

Photo 1. Overview from photo point P180720-38-02 facing north

Photo 2. Overview from photo point P180720-38-02 facing east

Photo 3. Overview from photo point P180720-38-02 facing south

Photo 4. Overview from photo point P180720-38-02 facing west

Table 5. Overview of 15-2-68 Survey Area

Survey Area Name	15-2-68
Survey Date(s)	2/03/2017, 7/20/2018
Formation(s)	Denver Formation (TKda)
Topography	Flat to rolling hills, almost completely previously disturbed along I-25
% Bedrock and Exposure Location	0%, no bedrock or surficial sediment exposure
Lithology(s)	N/A
Photo Points	P170202-28-01, P180720-38-01; see Figure 3 for photo point locations
NFO's	N/A, no new fossil localities
SFL's	N/A, no new fossil localities
Land Ownership	Private/CDOT ROW
Topographic Quad	Commerce City, CO USGS 7.5' Quadrangle
Geologic Map	Lindvall, 1980

Photo 1. Overview from photo point P170202-28-01 facing north

Photo 2. Overview from photo point P170202-28-01 facing west

Photo 3. Overview from photo point P170202-28-01 facing south

Photo 4. Overview from photo point P170202-28-01 facing southeast

Table 6. Overview of 22-2-68 Survey Area

Survey Area Name	22-2-68
Survey Date(s)	2/03/2017, 2/06/2017
Formation(s)	Denver Formation (TKda), Rocky Flats Alluvium (Qrf), Colluvium (Qco) and Piney Creek Allvium (Qp)
Topography	Flat to rolling hills, almost completely previously disturbed along I-25
% Bedrock and Exposure Location	5%, exposure of the Denver Formation on the east side of I-25 near Russell Blvd.
Lithology(s)	Lenticular sandstone, pale blueish-gray weathering to moderate orange brown, fine to medium grained, well sorted, subrounded, moderately lithified, 0.3 m thick, bottom contact not exposed.
Photo Points	P170206-28-01, P170202-28-02, P170206-28-08; see Figure 3 for photo point locations
NFO's	N/A, no new fossil localities
SFL's	N/A, no new fossil localities
Land Ownership	Private/CDOT ROW
Topographic Quad	Commerce City, CO USGS 7.5' Quadrangle
Geologic Map	Lindvall, 1980

Photo 1. Exposure of the Denver Formation from photo point P170206-28-01 facing east

Photo 2. Close up of exposure of the Denver Formation from photo point P170206-28-01

Photo 3. Overview of survey area from photo point P170202-28-02 facing west

Photo 4. Overview of survey area from photo point P170202-28-02 facing north

Table 7. Overview of 27-2-68 Survey Area

Survey Area Name	27-2-68
Survey Date(s)	2/06/2017
Formation(s)	Denver Formation (TKda), Colluvium (Qco), Loess (Ql), and Piney Creek Allvium (Qp)
Topography	Flat rolling hills on the shoulder and side of I-25, stream on the east side. Southern portion in SWSE residential, developed and not accessible.
% Bedrock and Exposure Location	0%, no bedrock or surficial sediment exposure
Lithology(s)	N/A
Photo Points	P170206-28-02, P170206-28-3, P170206-28-4, P170206-28-7; see Figures 3 and 4 for photo point location
NFO's	N/A, no new fossil localities
SFL's	N/A, no new fossil localities
Land Ownership	Private/CDOT ROW
Topographic Quad	Commerce City, CO USGS 7.5' Quadrangle
Geologic Map	Lindvall, 1980

Photo 1. Overview from photo point P170206-28-03 facing north

Photo 2. Overview from photo point P170206-28-07 facing south

Photo 3. Overview from photo point P170206-28-02 facing south 0762

Photo 4. Overview from photo point P170206-28-02 facing north

Table 8. Overview of 34-2-68 Survey Area

Survey Area Name	34-2-68
Survey Date(s)	2/06/2017
Formation(s)	Denver Formation (TKda), Colluvium (Qco), Loess (Ql), and Piney Creek Allvium (Qp)
Topography	Completely developed road shoulder, residential and commercial properties.
% Bedrock and Exposure Location	0%, no bedrock or surficial sediment exposure
Lithology(s)	N/A
Photo Points	P170206-28-05, P170206-28-06; see Figure 4 for photo point location
NFO's	N/A, no new fossil localities
SFL's	N/A, no new fossil localities
Land Ownership	Private/CDOT ROW
Topographic Quad	Commerce City, CO USGS 7.5' Quadrangle
Geologic Map	Lindvall, 1980

Photo 1. Overview from photo point P170206-28-05 facing north

Photo 2. Overview from photo point P170206-28-05 facing south

Photo 3. Overview from photo point P170206-28-06 facing north

Photo 4. Overview from photo point P170206-28-06 facing south

9.0 Recommendations

1. There are seven previously recorded fossil localities in the Denver Formation within Adams County. The fossil rich Denver Formation is mapped at the surface throughout the project area (see **Figure 3** and **Figure 4**). During the field survey, it was found to be exposed at one location near Russell Boulevard on the east side of I-25. No fossils were observed during the field survey. Since the Denver Formation is mapped and locally exposed within the project area, it is likely that it occurs at a shallow depth throughout the entire project area. When the project design plans are finalized, the CDOT Staff Paleontologist should examine them and determine the amount (lateral extent and depth) of impact to the Denver Formation, and the amount of construction monitoring, if any, that is required to reduce potential adverse impacts on scientifically important paleontological resources to a less than substantial level.
2. If any subsurface bones or other potential fossils are found during construction and a paleontological monitor is not present, work in the immediate vicinity (20-foot radius) should be halted, and the CDOT Staff Paleontologist should be notified to inspect the discovery to make further recommendations.

Table 9 and **Table 10** identify the impacts and mitigation strategies for paleontological resources.

Table 9. Impacts on Paleontological Resources

Context	No Action Alternative	Proposed Action
The project area is directly underlain by one mapped sedimentary bedrock unit consisting of the Denver Formation (TKda), which has a very high paleontological potential to encounter fossils. In addition, the project area is underlain by four mapped surficial sedimentary deposits, consisting of the Pleistocene Rocky Flats Alluvium (Qrf), Holocene-Pleistocene Colluvium (Qco), Holocene-Pleistocene Loess (Ql), and Holocene Piney Creek Alluvium (Qp). The Pleistocene age surficial-sedimentary deposits have a moderate paleontological potential to encounter, which the Holocene age surficial-sedimentary deposits have a low paleontological potential to encounter fossils.	**Permanent Impacts** Would not affect paleontological resources.	**Permanent Impacts** No permanent impacts are anticipated. **Temporary Impacts** Fossils could possibly be unearthed during construction, with the most likely being from the Denver Formation.

Table 10. Mitigation Commitments for Paleontological Resources

Impact	Mitigation Commitment	Responsible Branch	Timing/Phase That Mitigation Will Be Implemented
The potential to impact previously unknown resources.	If any subsurface bones or other potential fossils are found during construction and a paleontological monitor is not present, work in the immediate vicinity (20-foot radius) should be halted, and the CDOT Staff Paleontologist should be notified to inspect the discovery to make further recommendations. When the project design plans are finalized, the CDOT Staff Paleontologist should examine them to determine the amount (lateral extent and depth) of impact to the Denver Formation, and the amount of construction monitoring, if any, that is required to reduce potential adverse impacts on scientifically important paleontological resources to a less than substantial level.	CDOT	Construction

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APPENDIX A. COPY OF COLORADO PALEONTOLOGICAL RESOURCES USE PERMIT

HISTORY Colorado

No. 2016–61

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 *(Principal Investigator[s])* and same plus Kate D. Zubin-Stathopoulos *(Project Paleontologists)*,

of: 1216 E. 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 & Science-Denver, CO

Other condition(s):

Issued this 1 day of March, 2016.

The Permit is valid through February 28, 2017.

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

State Archaeologist of Colorado

Rev. 4/10

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.