PALEONTOLOGICAL TECHNICAL REPORT: CDOT PROJECT *STA 050A-022*, US HIGHWAY 50 PURCELL TO WILLS, PUEBLO COUNTY, COLORADO

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Prepared under State of Colorado Paleontological Permit 2013-69

September 8, 2013

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1.0 SUMMARY

The Colorado Department of Transportation (CDOT) is proposing improvements to a 3.37-mile long segment of US Highway (US) 50 between highway mileposts (MP) 309.78 and 313.15 in Pueblo County (see Figure 1). This study is an evaluation of potential impacts to non-renewable scientifically significant paleontological resources that could result from ground disturbance within the Area of Potential Effect (APE) for the US 50 Purcell to Wills Project (CDOT Project STA 050A-022), hereafter referred to as the US 50 Project, or survey corridor. The survey corridor is located on the USGS Northwest Pueblo 7.5-minute Topographic Quadrangle. The west end of the corridor (MP 309.78) lies at a point in the SW¼ SE¼ SE¼ NE of Section 7 T. 20 S., R. 65 W. The east end (MP 313.15) lies at a point in the SW¼ NE¼ SW¼ NW¼ of Section 14, T. 20 S., R. 65 W. The scope of the proposed construction includes widening of the eastbound lanes. Potential impacts to both surface and subsurface paleontological resources in the Project area are evaluated in this report.

Prior to the field survey, the paleontological sensitivity of the geologic units within the survey corridor was evaluated by reviewing scientific literature, geologic mapping, and museum records. According to Scott (1969), the survey corridor traverses five geologic units (see Figure 2). From oldest to youngest, and in approximate ascending stratigraphic sequence, these include the Smoky Hill Shale Member of the Upper Cretaceous Niobrara Formation (middle shale unit, middle chalk unit, upper chalky shale unit, and upper chalk unit of Scott, 1969), and Quaternary surficial deposits including Slocum Alluvium, Broadway Alluvium, Piney Creek Alluvium, and colluvium. In Colorado, the Niobrara Formation contains locally abundant, diverse and well preserved fossil invertebrates and less common fossil vertebrates, and has moderate paleontological potential (PFYC Class 3a). Fossils are uncommon but often scientifically important in older Quaternary (Pleistocene) sedimentary deposits in Colorado, and these deposits have low to moderate paleontological sensitivity (PFYC Class 2 to 3a). Holocene deposits are too young to contain in-situ fossils, and have low paleontological sensitivity (PFYC Class 2).

No previously recorded fossil localities occur within the survey corridor. However, numerous localities have been documented in the Niobrara Formation in the Pueblo area, and two (USGS D3503, D3504) are located adjacent to the survey corridor (see Figure 2). Additionally, the CDOT staff paleontologist has compiled a database of USGS fossil localities in the area based on Scott (1969) and Scott and Cobban (1964) that documents the well sampled molluscan fauna. The collections of fossil marine mollusks from the USGS localities were used to analyze the biostratigraphy of the Niobrara Formation and other Cretaceous marine rock units in the area, and facilitated correlation with other fossiliferous sequences elsewhere in the region, resulting in numerous scientific publications.

Two fossil localities were recorded during the field survey reported herein, and both are stratigraphically positioned within the middle shale unit of the Smoky Hill Shale Member of the Niobrara Formation. Locality PCM28Aug13-01 (5PE7923) is located on the eastbound side of US 50 at MP 312.0, and preserves fragmentary but large inoceramid clams. Locality PCM28Aug13-02 (5PE7024) is located on the westbound side of US 50 at MP 312.3, and preserves fragmentary inoceramid clams and oysters, and an external mold of a scaphitid ammonite was also observed. Based on the taxa observed and the quality of preservation, neither of these fossil localities is considered scientifically significant. In particular, no vertebrate fossils were observed during the survey, and although it is likely that more complete and better preserved marine mollusk specimens occur subsurface at both localities, the marine invertebrate fossil record of the Niobrara Formation has been well documented in the Pueblo area. Unlike fossil vertebrates, additional invertebrate specimens would likely be redundant with existing specimens in scientific collections. If any sub-surface bones or other potentially significant fossils are found anywhere within the US 50 Project area during construction, work in the immediate vicinity should be temporarily suspended, and the CDOT staff paleontologist should be notified immediately in order to assess the significance of the find and make further recommendations.

2.0 INTRODUCTION

The Colorado Department of Transportation (CDOT) is proposing improvements to a 3.37-mile long segment of US Highway (US) 50 between highway mileposts (MP) 309.78 and 313.15 in Pueblo County (see Figure 1). This study is an evaluation of potential impacts to non-renewable scientifically significant paleontological resources that could result from ground disturbance within the Area of Potential Effect (APE) for the US 50 Purcell to Wills Project (CDOT Project STA 050A-022), hereafter referred to as the US 50 Project, or survey corridor. The scope of the proposed construction includes widening of the eastbound lanes. Potential impacts to both surface and subsurface paleontological resources in the Project area are evaluated in this report. Potential impacts to both surface and subsurface paleontological resources in the Project area are evaluated in this report. The survey corridor traverses five geologic units. These include the Upper Cretaceous Niobrara Formation and Quaternary surficial deposits of Slocum Alluvium, Broadway Alluvium, Piney Creek Alluvium, and Colluvium.

2.1 Definition and Importance of Paleontological Resources

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. In accordance with CDOT policy, 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 (Murphey and Daitch, 2007). 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.
- Identify past and potential future human-caused effects to global environments and climates (Murphey and Daitch, 2007).

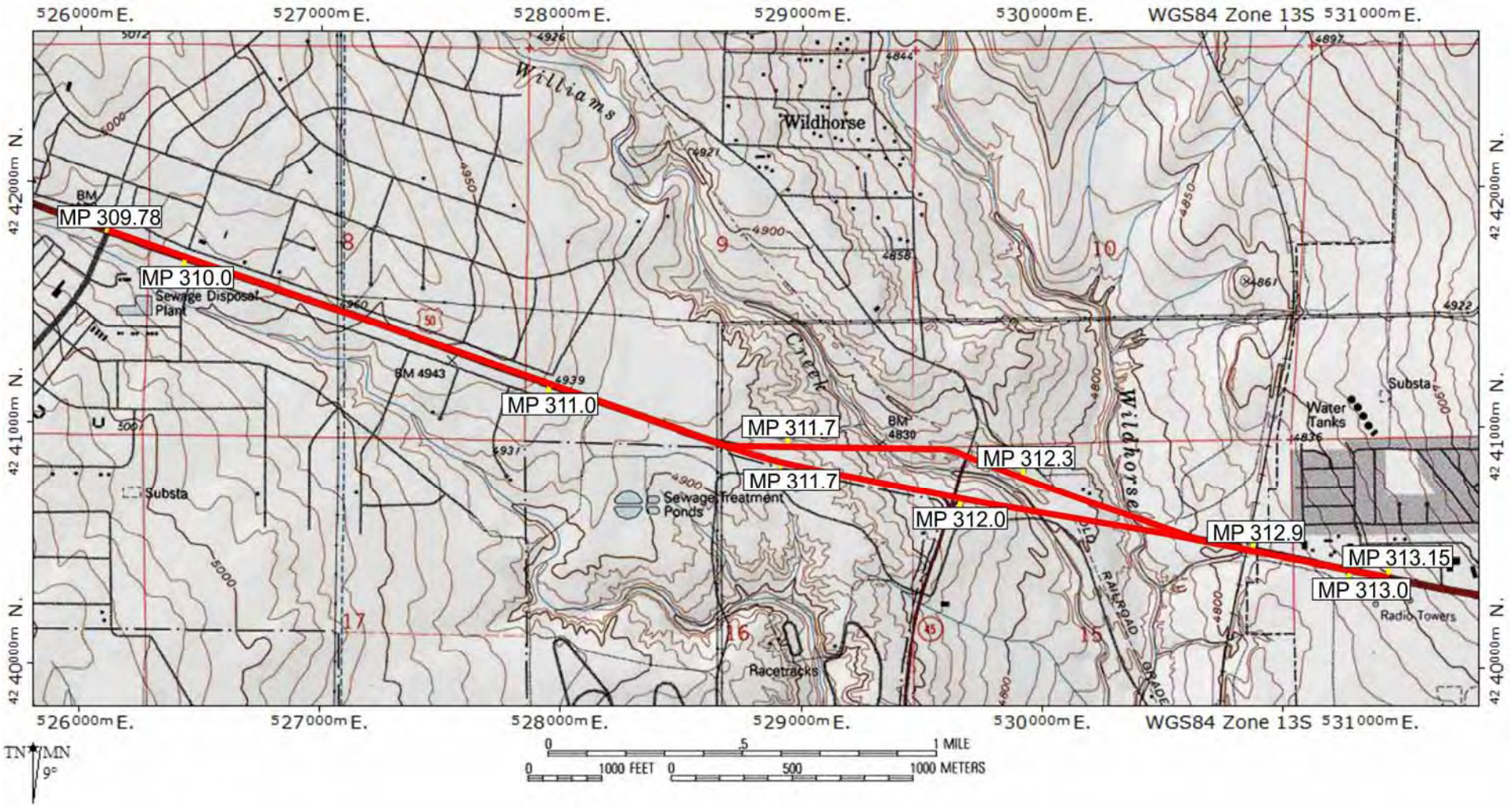

Figure 1. Location map showing the survey corridor for the US 50 Purcell to Wills Project in red, along with the locations of highway mileposts discussed in Section 9.0. Fossil localities were recorded at MP 312.0 and 312.3.

3.0 METHODS

The purpose of this study is to evaluate the paleontological sensitivity of the geologic units within the survey corridor by researching their known fossil potential and paleontological significance, and by determining the number and significance of fossil localities within the study area and elsewhere in the same geologic units. The scope of the study included a review of pertinent scientific literature, geologic maps, museum records, and completion of a pedestrian field survey. The museums included in the record search were the Denver Museum of Nature and Science (DMNS) and the University of Colorado Natural History Museum (UCM). The paleontological evaluation procedures for this study were conducted in accordance with established professional standards by a qualified and permitted paleontologist (State of Colorado Paleontological Permit 2013-69). This study was undertaken at the request of Centennial Archaeology and CDOT.

The SH 50 survey corridor extends between highway mileposts (MP) 309.78 and 313.15 in Pueblo County (see Figure 1). The corridor is located on the USGS Northwest Pueblo 7.5-minute Topographic Quadrangle. The west end of the corridor (MP 309.78) lies at a point in the SW¼ SE¼ SE¼ NE of Section 7 T. 20 S., R. 65 W. The east end (MP 313.15) lies at a point in the SW¼ NE¼ SW¼ NW¼ of Section 14, T. 20 S., R. 65 W.

The field survey for this study was conducted on August 27 and 28, 2013, and consisted of an inspection of the survey corridor for 1) surface fossils, 2) exposures of potentially fossiliferous rock, and 3) areas in which fossiliferous rock or younger potentially fossiliferous surficial deposits could be exposed or otherwise impacted during construction-related ground disturbance. As standard operating procedure, only areas within the Project area that were safely accessible were surveyed, and all fossils observed during the field survey were documented.

For CDOT paleontological surveys in general, safely accessible areas where geologic units of moderate, high and very high paleontological sensitivity are exposed are subject to a 100-percent pedestrian inspection; areas with exposures of low sensitivity deposits are spot-checked; and areas with no paleontological sensitivity are not inspected. If the geology of an area is uncertain, or the paleontological sensitivity of an area is unknown, the area is subject to a 100-percent pedestrian inspection. For this study, a complete pedestrian survey was completed because of the abundant fragments of bedrock mixed with alluvial gravels at the surface and apparent shallow bedrock in some areas.

4.0 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 survey corridor (see Table 1). Pertinent federal, state, county, and city LORS are summarized below:

4.1 Federal

The National Environmental Policy Act 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:

a) all Federal agencies consider the environmental impacts of proposed actions;
b) the public be informed of the potential environmental impacts of proposed actions; and
c) that the public be involved in planning and analysis relevant to actions that impact the environment.

Federal Land Policy and Management Act of 1976 (43 U.S.C. 1712[c], 1732[b]); sec. 2, Federal Land Management and Policy Act of 1962 [30 U.S.C. 611]; Subpart 3631.0 et seq.), Federal Register Vol. 47, No. 159, 1982. The FLPMA does not refer specifically to fossils. However, "significant fossils" are understood and recognized in policy as scientific resources. Permits which authorize the collection of significant fossils for scientific purposes are issued under the authority of FLPMA.

Under FLPMA, Federal agencies are charged to:

a) manage public lands in a manner that protects the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, archaeological, and water resources, and, where appropriate, preserve and protect certain public lands in their natural condition (Section 102 (a)(8) (11));

b) periodically inventory public lands so that the data can be used to make informed land-use decisions (Section 102(a)(2); and

c) regulate the use and development of public lands and resources through easements, licenses, and permits (Section 302(b)).

CFR Title 43

Under the Code of Federal Regulations (CFR) Title 43, Section 8365.1-5, the collection of scientific resources, including vertebrate fossils, is prohibited without a permit. Except where prohibited, individuals are also authorized to collect some fossils for their personal use. The use of fossils found on Federal lands for commercial purposes is also prohibited.

DOI Report – Fossils on Federal & Indian Lands

In 2000, the Secretary of the Interior submitted a report to Congress entitled "Assessment of Fossil Management on Federal and Indian Lands." This report was prepared with the assistance of nine federal agencies, including the Bureau of Indian Affairs, the Bureau of Land Management, the Bureau of Reclamation, the United States Fish and Wildlife Service, the United States Forest Service, the National Park Service, the United States Geological Survey, and the Smithsonian Institution. The consulting agencies concluded that administrative and Congressional actions with respect to fossils should be governed by these seven basic principles:

a) Fossils on Federal land are a part of America's heritage.
b) Most vertebrate fossils are rare.
c) Some invertebrate and plant fossils are rare.
d) Penalties for fossil theft should be strengthened.
e) Effective stewardship requires accurate information.
f) Federal fossil collections should be preserved and available for research and public education.
g) Federal fossil management should emphasize opportunities for public involvement.

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.

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 Project area.

4.2 State

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 even that resources are discovered in the course of state-funded projects and on state-owned/administered lands. Based on this legislation, the Colorado Department of Transportation (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. The CDOT must fulfill FHWA's NEPA requirements under the Colorado Historical, Prehistorical and Archaeological Resources Act (CHPA).

4.3 County

There are no Huerfano County 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 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.

Table 1. Summary of paleontological laws, ordinances, regulations, and standards applicable to the Project.

Agency/Owner	Pertinent Paleontological LORS
Federal	Assessment required by FHWA under NEPA
State	Assessment required by CDOT under CHPA
County	None
City	None
Private	None

4.6 Permits and Approvals

A State of Colorado Paleontological Permit is required to collect fossils on state owned or administered lands in Colorado. A Bureau of Land Management Paleontological Resources Use Permit is required to collect significant fossils on BLM land. If paleontological mitigation is requested by CDOT or another state agency, the Project Paleontologist and other paleontological personnel would be required to possess a State of Colorado paleontological permit, and a BLM permit and USFS permit if lands managed by these agencies are involved. The paleontological mitigation program would need approval by the CDOT Staff Paleontologist and the BLM/USFS (if BLM/USFS lands are involved), including review and approval of the final mitigation report. All scientifically significant fossils collected during mitigation would be required to be prepared, identified, and curated at an approved repository, such as the DMNS or UCM, where they would be curated and permanently stored. This would ensure their availability for future scientific research, education, and display.

5.0 RESOURCE ASSESSMENT CRITERIA

The paleontological sensitivity of each geologic unit within the survey corridor was evaluated using the Potential Fossil Yield Classification system (PFYC). The PFYC system was originally developed by the Forest Service's Paleontology Center of Excellence and the Region 2 Paleontology Initiative in 1996. Modifications have been made by the BLM's Paleontological Resources staff in subsequent years. The PFYC version used for this analysis was approved as policy by the BLM in 2007 (BLM, 2007). This classification system is summarized below:

5.1 Potential Fossil Yield Classification

Occurrences of paleontological resources are closely tied to the geologic units (i.e., formations, members, or beds) that contain them. The probability for finding paleontological resources can be broadly predicted from the geologic units present at or near the surface. Therefore, geologic mapping can be used for assessing the potential for the occurrence of paleontological resources.

Using the PFYC system, geologic units are classified based on the relative abundance of vertebrate fossils or scientifically significant invertebrate or plant fossils and their sensitivity to adverse impacts, with a higher class number indicating a higher potential. This classification is applied to the geologic formation, member, or other distinguishable unit, preferably at the most detailed mappable level. It is not intended to be applied to specific paleontological localities or small areas within units. Although significant localities may occasionally occur in a geologic unit, a few widely scattered important fossils or localities do not necessarily indicate a higher class; instead, the relative abundance of significant localities is intended to be the major determinant for the class assignment.

The PFYC system is meant to provide baseline guidance for predicting, assessing, and mitigating paleontological resources. The classification should be considered at an intermediate point in the analysis, and should be used to assist in determining the need for further mitigation assessment or actions.

The descriptions for the classes below are written to serve as guidelines rather than as strict definitions. Knowledge of the geology and the paleontological potential for individual units or preservational conditions should be considered when determining the appropriate class assignment. Assignments are best made by collaboration between land managers and knowledgeable researchers.

Class 1 – **Very Low**. Geologic units that are not likely to contain recognizable fossil remains.

- Units that are igneous or metamorphic, excluding reworked volcanic ash units.
- Units that are Precambrian in age or older.

(1) Management concern for paleontological resources in Class 1 units is usually negligible or not applicable.

(2) Assessment or mitigation is usually unnecessary except in very rare or isolated circumstances.

The probability for impacting any fossils is negligible. Assessment or mitigation of paleontological resources is usually unnecessary. The occurrence of significant fossils is non-existent or extremely rare.

Class 2 – **Low**. Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils.

- Vertebrate or significant invertebrate or plant fossils not present or very rare.
- Units that are generally younger than 10,000 years before present.

• Recent aeolian deposits.

• Sediments that exhibit significant physical and chemical changes (i.e., diagenetic alteration).

(1) Management concern for paleontological resources is generally low.

(2) Assessment or mitigation is usually unnecessary except in rare or isolated circumstances.

The probability for impacting vertebrate fossils or scientifically significant invertebrate or plant fossils is low. Assessment or mitigation of paleontological resources is not likely to be necessary. Localities containing important resources may exist, but would be rare and would not influence the classification. These important localities would be managed on a case-by-case basis.

Class 3 – **Moderate** or **Unknown**. Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence; or sedimentary units of unknown fossil potential.

• Often marine in origin with sporadic known occurrences of vertebrate fossils.

• Vertebrate fossils and scientifically significant invertebrate or plant fossils known to occur intermittently; predictability known to be low.

(or)

• Poorly studied and/or poorly documented. Potential yield cannot be assigned without ground reconnaissance.

***Class 3a* – Moderate Potential.** Units that are known to contain vertebrate fossils or scientifically significant nonvertebrate fossils, but these occurrences are widely scattered. Common invertebrate or plant fossils may be found in the area, and opportunities may exist for hobby collecting. The potential for a project to be sited on or impact a significant fossil locality is low, but is somewhat higher for common fossils.

***Class 3b* – Unknown Potential.** Units exhibit geologic features and preservational conditions that suggest significant fossils could be present, but little information about the paleontological resources of the unit or the area is known. This may indicate the unit or area is poorly studied, and field surveys may uncover significant finds. The units in this class may eventually be placed in another class when sufficient survey and research is performed. The unknown potential of the units in this class should be carefully considered when developing any mitigation or management actions.

(1) Management concern for paleontological resources is moderate; or cannot be determined from existing data.

(2) Surface-disturbing activities may require field assessment to determine appropriate course of action.

This classification includes a broad range of paleontological potential. It includes geologic units of unknown potential, as well as units of moderate or infrequent occurrence of significant fossils. Management considerations cover a broad range of options as well, and could include pre-disturbance surveys, monitoring, or avoidance. Surface-disturbing activities will require sufficient assessment to determine whether significant paleontological resources occur in the area of a proposed action, and whether the action could affect the paleontological resources. These units may contain areas that would be appropriate to designate as hobby collection areas due to the higher occurrence of common fossils and a lower concern about affecting significant paleontological resources.

Class 4 – **High**. Geologic units containing a high occurrence of significant fossils. Vertebrate fossils or scientifically significant invertebrate or plant fossils are known to occur and have been documented, but may vary in occurrence and predictability. Surface disturbing activities may adversely affect paleontological resources in many cases.

Class 4a – Unit is exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than two acres. Paleontological resources may be susceptible to adverse impacts from surface disturbing actions. Illegal collecting activities may impact some areas.

Class 4b – These are areas underlain by geologic units with high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances. The bedrock unit has high potential, but a protective layer of soil, thin alluvial material, or other conditions may lessen or prevent potential impacts to the bedrock resulting from the activity.

- Extensive soil or vegetative cover; bedrock exposures are limited or not expected to be impacted.
- Areas of exposed outcrop are smaller than two contiguous acres.
- Outcrops form cliffs of sufficient height and slope so that impacts are minimized by topographic conditions.
- Other characteristics are present that lower the vulnerability of both known and unidentified paleontological resources.

(1) Management concern for paleontological resources in Class 4 is moderate to high, depending on the proposed action.

(2) A field survey by a qualified paleontologist is often needed to assess local conditions.

(3) Management prescriptions for resource preservation and conservation through controlled access or special management designation should be considered.

(4) Class 4 and Class 5 units may be combined as Class 5 for broad applications, such as planning efforts or preliminary assessments, when geologic mapping at an appropriate scale is not available. Resource assessment, mitigation, and other management considerations are similar at this level of analysis, and impacts and alternatives can be addressed at a level appropriate to the application.

The probability for impacting significant paleontological resources is moderate to high, and is dependent on the proposed action. Mitigation considerations must include assessment of the disturbance, such as removal or penetration of protective surface alluvium or soils, potential for future accelerated erosion, or increased ease of access resulting in greater looting potential. If impacts to significant fossils can be anticipated, on-the-ground surveys prior to authorizing the surface disturbing action will usually be necessary. On-site monitoring or spot-checking may be necessary during construction activities.

Class 5 – **Very High**. Highly fossiliferous geologic units that consistently and predictably produce vertebrate fossils or scientifically significant invertebrate or plant fossils, and that are at risk of human-caused adverse impacts or natural degradation.

Class 5a – Unit is exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than two contiguous acres. Paleontological resources are highly susceptible to adverse impacts from surface disturbing actions. Unit is frequently the focus of illegal collecting activities.

Class 5b – These are areas underlain by geologic units with very high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances. The bedrock unit has very high potential, but a protective layer of soil, thin alluvial material, or other conditions may lessen or prevent potential impacts to the bedrock resulting from the activity.

- Extensive soil or vegetative cover; bedrock exposures are limited or not expected to be impacted.

- Areas of exposed outcrop are smaller than two contiguous acres.
- Outcrops form cliffs of sufficient height and slope so that impacts are minimized by topographic conditions.
- Other characteristics are present that lower the vulnerability of both known and unidentified paleontological resources.

(1) Management concern for paleontological resources in Class 5 areas is high to very high.

(2) A field survey by a qualified paleontologist is usually necessary prior to surface disturbing activities or land tenure adjustments. Mitigation will often be necessary before and/or during these actions.

(3) Official designation of areas of avoidance, special interest, and concern may be appropriate.

The probability for impacting significant fossils is high. Vertebrate fossils or scientifically significant invertebrate fossils are known or can reasonably be expected to occur in the impacted area. On-the-ground surveys prior to authorizing any surface disturbing activities will usually be necessary. On-site monitoring may be necessary during construction activities.

6.0 PALEONTOLOGICAL RESOURCE ASSESSMENT

The paleontological sensitivity of the geologic units within the Project area was evaluated by reviewing scientific literature, geologic mapping, and museum records. According to Scott (1969), the survey corridor traverses five geologic units (see Figure 2). From oldest to youngest, and in approximate ascending stratigraphic sequence, these include the Smoky Hill Shale Member of the Upper Cretaceous Niobrara Formation (middle shale unit, middle chalk unit, upper chalky shale unit, and upper chalk unit of Scott, 1969), and Quaternary surficial deposits including Slocum Alluvium, Broadway Alluvium, Piney Creek Alluvium, and colluvium. In Colorado, the Niobrara Formation contains locally abundant, diverse and well preserved fossil invertebrates and less common fossil vertebrates, and has moderate paleontological potential (PFYC Class 3a). Fossils are uncommon but often scientifically important in older Quaternary (Pleistocene) sedimentary deposits in Colorado, and these deposits have low to moderate paleontological sensitivity (PFYC Class 2 to 3a). Holocene deposits are too young to contain in-situ fossils, and have low paleontological sensitivity (PFYC Class 2).

Table 2. Summarized paleontological potential of geologic units within the survey corridor. Geologic unit abbreviations are from Scott (1969).

Geologic Unit	Map Abbreviation	Age	Typical Fossils	PFYC
Colluvium	Qc	Holocene	Too young to contain in-situ fossils	*Class 2* (low)
Piney Creek Alluvium	Qp	Holocene	Too young to contain in-situ fossils	*Class 2* (low)
Broadway Alluvium	Qb	Pleistocene	Mostly scattered and disarticulated but scientifically important mammal fossils	*Class 2 to 3a* (low to moderate)
Slocum Alluvium	Qs	Pleistocene	Sparse but scientifically important mammal fossils	*Class 2* (low)
Niobrara Formation Smoky Hill Shale Member	Ksms, Ksmc, Ksus, Ksuc	Upper Cretaceous	Locally abundant marine invertebrates (mostly mollusks) and trace fossils, less common vertebrates	*Class 3a* (moderate)

7.0 GEOLOGY AND PALEONTOLOGY

Scott (1969) mapped five geologic units within the survey corridor. These include the Upper Cretaceous Niobrara Formation and Quaternary surficial deposits of Slocum Alluvium, Broadway Alluvium, Piney Creek Alluvium, and Colluvium (Figure 2). This section of the report summarizes the geology and paleontology of these units, from oldest to youngest.

7.1 Niobrara Formation

The upper Cretaceous (Turonian, Coniacian, Santonian, Campanian) Niobrara Formation is a thick and widely distributed near-shore marine unit that includes two members: the Fort Hays Limestone and the overlying and thicker Smoky Hill Shale Member. The Niobrara is widely distributed, and was deposited mostly in nearshore marine settings during the second late Cretaceous transgressive-regressive cycle. The type locality for the Niobrara Formation, also called the "Niobrara chalk," is located in Knox County, northeastern Nebraska. The skeletal remains of marine organisms make up a large portion of the chalk in the formation, with beds composed of bentonite and limestone as well (Diffendal and Voorhies, 1994). The Smoky Hill Shale Member is made up of primarily foraminifera tests and coccoliths (fecal pellets) (Diffendal, 1995; Diffendal et al., 2002). Darton (1899) noted that the chalky deposits at the top of the Niobrara Formation were characterized by thin hard beds containing the oyster *Ostrea congesta*. It is equivalent with the Smoky Hill Shale Member of the Great Plains. It is partially stratigraphically equivalent with the Mancos Shale which occurs further to the west.

In the Pueblo area, the late Turonian and early Coniacian Fort Hays Limestone Member is about 40-feet thick, consists of about 82% limestone and 18% shale. The Coniacian, Santonian and early Campanian Smoky Hill Shale Member is far thicker at about 700 feet, and consists of shale, chalk and some limestone. The member has been divided into seven lithologically distinct units (Scott, 1969; Scott and Cobban, 1964).

Fossil marine mollusks, cephalopods and foraminifers are locally abundant within the Niobrara Formation throughout its distribution. Most fossils have been discovered in the Smoky Hill Shale Member in Kansas, although other geographic areas have produced less abundant and less well-preserved vertebrate remains. Among the most well known Niobrara Formation fossils from Kansas are articulated skeletons of pterosaurs, fishes (including rare sharks), birds, and numerous plesiosaurs, mosasaurs and turtles. Although rare, dinosaurs including a hadrosaur and an ankylosaur have been recovered (Diffendal et al., 2002). Marine fossils of the Smoky Hill Shale Member include ammonites and inoceramid bivalves (Scott, 1969; Scott and Cobban, 1964; Scott et al., 1986; Walaszczyk and Cobban, 2007). Free swimming crinoids (sea lilies) have also been reported (Cobban, 1995). Mosasaurs, plesiosaurs, and fishes have been discovered within the Smoky Hill Shale Member of the Niobrara Formation in Colorado (Anthony and Smith, 1992, Feager and Smidt, 1992; Martz, 1996). In an unpublished CDOT technical report, Wallace (2011) summarized the paleontologic content of the Niobrara Formation, including fossil localities in the Pueblo area. Although fossil invertebrates are relatively common in the Niobrara Formation, including the Smoky Hill Shale Member, vertebrate fossils are comparatively rare, and both the Fort Hays Limestone and Smoky Hill Shale members have moderate paleontological sensitivity in Colorado (PFYC Class 3a). The distribution of the Niobrara Formation within the survey corridor is shown in Figure 2.

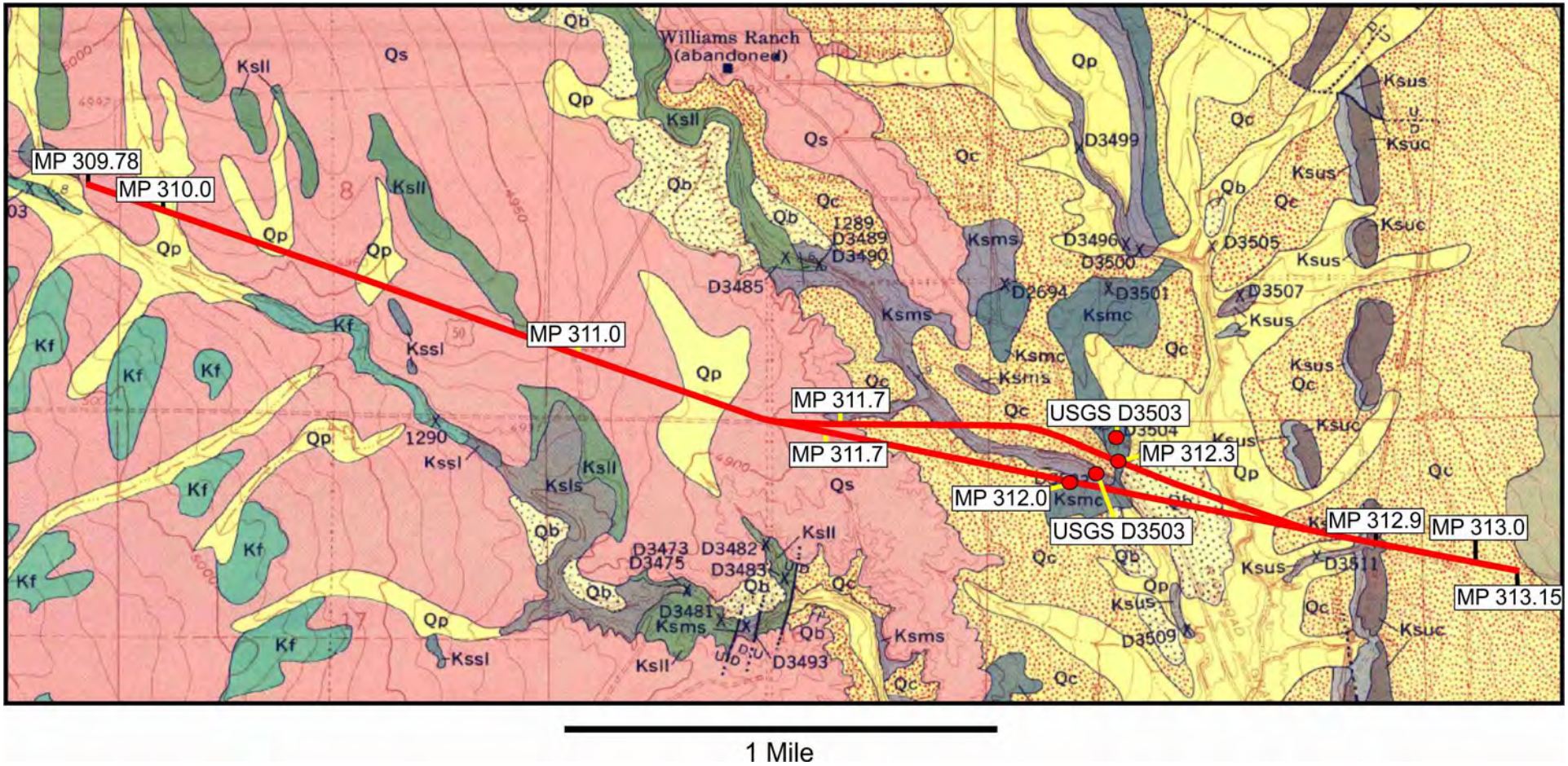

Figure 2. Geologic map showing the US 50 Purcell to Wills survey corridor, along with the locations of highway mileposts discussed in Section 9.0 (after Scott, 1969). USGS fossil localities D3503 and D3504, situated adjacent to the survey corridor, are also shown. Newly recorded fossil localities were documented at MP 312.0 and 312.3 (see Section 9.0). Pertinent abbreviations: Ksms, middle shale unit of the Niobrara Formation Smoky Hill Shale Member; Ksmc, middle chalk unit of the Niobrara Formation Smoky Hill Shale Member; Ksus, upper chalky shale unit of the Niobrara Formation Smoky Hill Shale Member; Ksuc, upper chalk unit of the Niobrara Formation Smoky Hill Shale Member; Qs, Slocum Alluvium, Qb, Broadway Alluvium; Qp, Piney Creek Alluvium; Qc, colluvium.

7.2 Quaternary Surficial Deposits

Generally, Pleistocene surficial deposits, especially alluvium, may contain mineralized or partially mineralized animal bones, invertebrates, and plant remains of paleontological significance. With the exception of some caves, hot springs, and tar deposits, these fossils typically occur in low density and usually consist of scattered and poorly preserved remains. Nevertheless, many Pleistocene fossils provide important paleobiologic, paleobiogeographic, and paleoenvironmental information and are therefore scientifically important. The most common Pleistocene vertebrate fossils include the bones of mammoth, bison, deer, and small mammals; but other taxa including horse, lion, cheetah, wolf, camel, antelope, peccary, mastodon, and giant ground sloth, have been reported from the Rocky Mountain region (Cook, 1930, 1931; Emslie, 1986; Graham and Lundelius, 1994; Gillette and Miller, 1999; Gillette et al., 1999a, 1999b; Heaton, 1999; Hunt, 1954; Lewis, 1970; Scott, 1963; Smith et al., 1999; unpublished paleontological data, Denver Museum of Nature and Science and University of Colorado Museum). A recent noteworthy discovery in Colorado yielded a large collection of middle to late Pleistocene fossils recovered from Ziegler Reservoir near Snowmass Village from November of 2010 to July of 2011. This locality was named the "Snowmastodon" site by DMNS crews (Johnson et al., 2011). The locality yielded over 4,000 well preserved vertebrate specimens. The fauna is dominated by mastodon remains, but also includes mammoth, ground sloth, the giant *Bison latifrons*, camel, deer, a variety of small mammals, tiger salamander, and other taxa. Numerous exquisitely preserved plant fossils were also salvaged (Johnson, K., personal communication, 2011).

Pleistocene deposits have the potential to contain typically scattered but often scientifically important fossil remains, and have low to moderate paleontological sensitivity (PFYC Class 2 to 3a). Holocene surficial deposits of are too young to preserve in-situ fossils, and contain the unfossilized remains of modern species of animals and plants. As such, they have low paleontological sensitivity (PFYC Class 2).

7.2.1 Slocum Alluvium

The Pleistocene (Illinoian Glaciation or Sangamon Interglaciation) Slocum Alluvium is composed of calcareous silt containing small pieces of limestone and coarse sand deposited by local streams (Scott, 1969). Typically the unit contains larger clasts including more abundant boulders closer to the mountains (Lindvall, 1979; Scott, 1972). Clasts within the unit are typically altered by weathering and coated with calcium carbonate (Scott, 1972). It contains a well developed calcium carbonate enriched zone (relict soil) in its upper part. It averages 25 feet thick in the Pueblo area (Scott, 1969).

Although the remains of bison, horse, prairie dog, gopher Richardson's ground squirrel, and mollusks have been found in this unit (Scott, 1963; 1972), fossils are generally uncommon and poorly preserved. Therefore, the Slocum Alluvium has low paleontological sensitivity (PFYC Class 2). The distribution of this unit within the survey corridor is shown in Figure 2.

7.2.2 Broadway Alluvium

The Pleistocene (Wisconsinian) Broadway Alluvium is composed of grayish brown coarse sand along Fountain Creek, and yellowish-gray calcareous silt containing pieces of limestone along Dry Creek and other creeks. It is about 10-25 feet thick, and its surface lies at about 40 feet above modern streams (Scott, 1969).

The Broadway Alluvium is known to contain rare and mostly isolated fossil remains including mammoth, horse, bison, camel, and small mammals (Hunt, 1954; unpublished UCM and DMNS paleontological data). Although commonly scattered and disarticulated, a moderate number of taxonomically diverse fossils have been discovered in the Broadway Alluvium, and it has low to

moderate paleontological sensitivity (PFYC Class 2-3a). The distribution of the Broadway Alluvium within the survey corridor is shown in Figure 2.

7.2.3 Piney Creek Alluvium

The Piney Creek Alluvium consists of yellowish gray silt and clay that occurs along most valleys, and contains lenses of sand and pebbles in its lower part. It is locally 25-feet thick, and its surface lies about 20 feet above modern streams. It also contains a calcium carbonate enriched late Holocene brown soil weakly developed in its upper part (Scott, 1969).

The Piney Creek alluvium it too young to contain in-situ fossils, and has low paleontological sensitivity (PFYC Class 2). The distribution of Piney Creek Alluvium within the survey corridor is shown in Figure 2.

7.2.4 Colluvium

Colluvium consists of rock and soil that has moved under the influence of gravity. Lithologies vary locally and are dependent upon the type of source rock. However, within the survey corridor it consists of yellowish-gray silt and clay containing pebbles, angular blocks of limestone, and sandstone derived from underlying bedrock and surficial sediments (Scott, 1969). Colluvium forms on unstable slopes and on older colluvial deposits, and generally is much less likely to contain well-preserved fossils than intact native sediments. Like landslides, colluvial sediments are commonly subjected to increased groundwater percolation, which tends to have a negative effect on the preservation of fossils. Gravitationally-induced movements of sediment can also destroy fossil remains through abrasion and breakage. Additionally, when the original stratigraphic position of the sediments is disturbed, there are varying degrees of information loss with the severity of changes to the slide mass.

Intact fossils are rare in Pleistocene colluvium, but they could have scientific importance despite the lack of precise stratigraphic control. Overall, colluvium of either Pleistocene or Holocene age has low paleontological sensitivity (PFYC Class 2). The distribution of colluvium within the survey corridor is shown in Figure 2.

8.0 MUSEUM RECORD SEARCH

Because paleontological locality data are confidential and are exempt from the Freedom of Information Act, precise geographic coordinates for fossil localities, if applicable, are provided only with agency copies of paleontological reports.

No previously recorded fossil localities occur within the survey corridor. However, numerous localities have been documented in the Niobrara Formation in the Pueblo area, and two (USGS D3503, D3504) are located adjacent to the survey corridor (see Figure 2). Additionally, the CDOT staff paleontologist has compiled a database of USGS fossil localities in the area based on Scott (1969) and Scott and Cobban's (1964) publications that documents the well sampled molluscan fauna of the area. The collections of fossil marine mollusks from the USGS localities were used to analyze the biostratigraphy of the Niobrara Formation and other Cretaceous marine rock units in the area, and facilitated correlation with other fossiliferous sequences elsewhere in the region, resulting in numerous scientific publications.

9.0 FIELD SURVEY

As mapped by Scott (1969), the 3.37-mile long survey corridor (MP 309.78-313.5) crosses Piney Creek Alluvium, Slocum Alluvium, Broadway Alluvium, Colluvium, Niobrara Formation Smoky Hill Shale Member (upper chalk unit, upper chalky shale unit, middle chalk unit, middle shale unit) (figures 3-20). Vegetation within the mostly topographically flat corridor is somewhat sparse, and therefore surficial sediments are well exposed, and are often locally difficult to distinguish from weathered bedrock (figures 3-8). Exposures of bedrock are limited to the vicinity of MP 312.0-312.5, and 312.8-312.9, in the eastern portion of the survey corridor (figures 9, 11, 19). Project design plans were not available for the field survey, so the survey area included all safely accessible areas within the right-of-way fence and an approximate similar survey corridor width where no right-of-way fence is present.

Two fossil localities were recorded during the field survey, and both are stratigraphically positioned within the middle shale unit of the Smoky Hill Shale Member of the Niobrara Formation. Locality PCM28Aug13-01 (5PE7923) is located on the eastbound side of US 50 at MP 312.0 (figures 9-14). This locality preserves fragmentary but large inoceramid clams as internal and external molds and some specimens retain some original shell. Locality PCM28Aug13-02 (5PE7024) is located on the westbound side of US 50 at MP 312.3 (figures 15-18). This locality preserves fragmentary inoceramid clams and oysters, and an external mold of a tentatively identified scaphitid ammonite was also observed.

Based on the taxa observed and the quality of preservation, neither of these fossil localities is considered scientifically significant. However, it is noteworthy that an external mold of an ammonite was found at locality PCM28Aug13-02, since the taxonomic diversity of the invertebrates of both members of the Niobrara Formation is low despite the local abundance of fossils.

Figure 3. MP 309.78. View east southeast along US 50 from western terminus of survey corridor in area mapped as Slocum and Piney Creek Alluvium. Photo view UTM 13S, 526168 mE, 4241760 mN (NAD83).

Figure 4. MP 310. View west northwest along US 50 towards western terminus of survey corridor in area mapped as Piney Creek Alluvium. Photo view UTM 13S, 526429 mE, 4241702 mN. (NAD 83).

Figure 5. MP 311.0. View west northwest along westbound lanes of US 50 in area mapped as Slocum Alluvium. Lower limestone unit of Smoky Hill Shale Member was mapped just to the west of this area by Scott (1969), but was not observed in the field and may be located outside of the corridor . Photo view UTM 13S, 527921 mE, 4241192 mN (NAD83).

Figure 6. MP 311.7. View east along US 50 at gentle slope consisting of arkosic sand and gravel with fragments of calcareous shale and limestone, and mapped as Slocum Alluvium. Photo view UTM 13S, 528906 mE, 4240825 mN (NAD83).

Figure 7. MP 311.7. View from same location as Figure 6 towards the north side of the highway along the westbound lanes (UTM 13S, 529000 mE, 4240931 mN, NAD83). At this location there is an outcrop (visible in photo) of middle shale unit of Smoky Hill Shale Member. No fossils observed, but bedrock unit was not well exposed within CDOT ROW.

Figure 8. MP 311.7. Fragment of weathered limey sandstone in Slocum Alluvium at same location as Figure 6. Photo shows a poorly preserved burrow of the trace fossil *Ophiomorpha* (interpreted as callianassid shrimp burrow). This fossil locality was not recorded since the fossil lacks provenance and is therefore non-significant.

Figure 9. MP 312.0. View east looking at eastbound entrance ramp from SH 45 at exposures of middle shale unit of Smoky Hill Shale Member of Niobrara Formation. This is an overview of locality PCM 28Aug13-01 (5PE7923). Photo view UTM 529683 mE, 4240688 mN (NAD83).

Figure 10. MP 312.0. Fragment of large inoceramid clam shell impression at PCM 28Aug13-01 (5PE7923).

Figure 11. MP 312.0. View east along US 50 at most productive area of locality PCM 28Aug13-01 (5PE7923).

Figure 12. MP 312.0. Fragment of large inoceramid clam shell impression at PCM 28Aug13-01 (5PE7923).

Figure 13. MP 312.0. Fragment of large inoceramid clam shell impression with original shell at PCM 28Aug13-01 (5PE7923).

Figure 14. MP 312.0. Fragment of large inoceramid clam shell impression with original shell at PCM 28Aug13-01 (5PE7923).

Figure 15. MP 312.3. Inoceramid clam fossils (original shell fragment and shell impression) at locality PCM28Aug13-02 (5PE7924) in middle shale unit of Smoky Hill Shale Member (Scott, 1969). No panoramic photograph was taken of his locality. Photo location UTM 13S, 529911 mE, 4240803 mN (Photo location NAD83).

Figure 16. MP 312.3. Oyster shale valves and fragments in oxidized concretion; middle shale unit of Smoky Hill Shale Member (Scott, 1969). Lithology: medium-gray calcareous shale and light grayish-white chalky limestone. Locality PCM28Aug13-02 (5PE7924).

Figure 17. MP 312.3. Fragment of large inoceramid shell impression at locality PCM28Aug13-02 (5PE7924).

Figure 18. MP 312.3. Impression of scaphitid ammonite phragmocone at locality PCM28Aug13-02 (5PE7924).

Figure 19. MP 312.9. View west along westbound lanes of US 50 at exposures of upper chalk unit of Niobrara Formation upper chalk unit of Scott (1969). Unit is well exposed in numerous gullies in this area, but no fossils were observed. UTM 13S, 530895 mE, 4240517 mN (NAD 83).

Figure 20. MP 313.0. No bedrock is present within survey corridor from this point east to eastern terminus of survey corridor. Photo view UTM 13S, 530895 mE, 4240517 mN (NAD83).

10.0 RECOMMENDATIONS

1) Based on the taxa observed and the quality of preservation, the two localities recorded during the field survey (5PE7923 and 5PE7924) are not considered scientifically significant. In particular, no vertebrate fossils were observed during the survey, and although it is likely that more complete and better preserved marine mollusk specimens occur subsurface at both localities, the marine invertebrate fossil record of the Niobrara Formation has been well documented in the Pueblo area. Unlike fossil vertebrates, additional invertebrate specimens would likely be redundant with existing specimens in scientific collections.

2) If any sub-surface bones or other potentially significant fossils are found anywhere within the US 50 Project area during construction, work in the immediate vicinity should be temporarily suspended, and the CDOT staff paleontologist should be notified immediately in order to assess the significance of the find and make further recommendations.

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APPENDIX A

FOSSIL LOCALITY FORMS AND MAPS