Appendix F.

GEOLOGIC REPORT

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GEOLOGIC HAZARD ASSESSMENT

Santa Fe Drive - I-25 to C-470

DENVER AND JEFFERSON COUNTIES, COLORADO

SHANNON & WILSON

October 2020

Shannon & Wilson No: 104536-001

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Submitted To: HDR Engineering, Inc.
1670 Broadway, Suite 3400
Denver, CO 80202
Attn: Mr. Jason Longsdorf, AICP

Subject: GEOLOGIC HAZARD ASSESSMENT, SANTA FE DRIVE - I-25 TO C-470, DENVER AND JEFFERSON COUNTIES, COLORADO

Shannon & Wilson prepared this report based on a desktop study and a field reconnaissance to document existing geologic conditions to evaluate potential geologic hazards for the Planning and Environmental Linkage (PEL) study for the Santa Fe Drive - I-25 to C-470 project. Our review of geologic maps and geologic/geotechnical reports, and our field reconnaissance along the alignment within the CDOT right-of-way is summarized herein.

We appreciate the opportunity to be of service to you on this project. If you have questions concerning this report, or we may be of further service, please contact us.

Sincerely,

SHANNON & WILSON

David Varathungarajan, PE
Senior Associate

SKN:DKM:DAV/mzc

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ACRONYMS

US-85	United States Highway 85
I-25	Interstate 25
C-470	Colorado Highway 470
CDOT	Colorado Department of Transportation
USGS	United States Geological Survey
USDA	United States Department of Agriculture
NRCS	Natural Resources Conservations Service
USLE	Universal Soil Loss Equation
RUSLE	Revised Universal Soil Loss Equation

1 INTRODUCTION

This report presents a summary of geologic conditions, a review of existing geotechnical data, and an evaluation of potential geologic hazards for the Planning and Environmental Linkage (PEL) study for Santa Fe Drive (US-85) between Interstate 25 (I-25) and Colorado State Highway 470 (C-470). The project alignment and study area considered in this study are shown in Figure 1.

2 EXISTING CONDITIONS

The project alignment extends north to south approximately 10 miles from C-470 to I-25. The South Platte River, which flows to the north, is located about 100 to 2,500 feet west of the existing roadway, depending on location, and generally parallels the alignment. Burlington Northern Santa Fe Railway (BNSF) and Regional Transportation District (RTD) rail tracks are located just east of the existing roadway and generally parallel the alignment.

South of Bowles Avenue, the existing alignment consists of two travel lanes in each direction. North of Bowles Avenue, the alignment generally consists of three travel lanes in each direction. Major interchanges, which include C-470, Belleview Avenue, US Highway 285 (US-285), Evans Avenue, and I-25, are grade separated. There are numerous at-grade intersections along the alignment.

Most of the corridor is developed, consisting of a mixture of light industrial and commercial properties. Some residential properties are also located along the alignment, particularly the southern portion. A more detailed description of conditions along the alignment is provided in Section 6.

3 GEOLOGIC OVERVIEW

3.1 Surficial Geology

A surficial geologic map of the project area is shown in Figure 2, and a summary of the geologic units within the extent of the geologic map is provided in Exhibit 1. As shown in Figure 2, the surficial geology along the alignment is dominated by Quaternary alluvium. Review of 1:24,000 scale geologic maps within the project area (Shroba, 1980; Lindvall, 1978, and Scott, 1962) shows that Santa Fe Drive traverses through multiple unconsolidated geologic units which create a relatively thin crust (30 feet to 40 feet) of sediments overlying bedrock of the Denver and Arapahoe Formations. Piney Creek Alluvium (Holocene), eolian sands and silts (Holocene to Pleistocene), Broadway Alluvium (Pleistocene) and Slocum Alluvium (Pleistocene) largely underlie the alignment. The alluvial soils along the project alignment predominantly consist of sands and gravels with interbedded fine-grained layers, while eolian deposits mapped just east and west of the alignment consist of wind-blown fine sand, silt, and clay.

3.2 Bedrock Geology

The bedrock mapped along the project alignment includes sedimentary rocks from Tertiary Denver and Arapahoe Formations. The maps we reviewed suggest that bedrock is generally on the order of 30 to 40 feet below ground surface, which is consistent with subsurface explorations we reviewed. Near the southern end of the project alignment (C-470 to West Ridge Road), surficial bedrock of the Dawson Formation is mapped just east of the alignment. A summary of the sedimentary bedrock stratigraphy is provided in Exhibit 1.

3.3 Groundwater

Due to the proximity of the project alignment to the South Platte River, groundwater levels can be anticipated to correspond closely to the level of water in the river. Fluctuations in the river and groundwater levels due to seasonal variation, flooding, operations of the upstream Chatfield Dam, and precipitation are likely.

Exhibit 1. Stratigraphy of the Geologic Units

Geologic Time	Type	Geologic Unit	Unit Description
Quaternary	Unconsolidated sediments	Alluvium (Qa)	Modern alluvium. Includes Piney Creek Alluvium and younger deposits.
		Alluvium (Qg)	Includes Broadway and Louviers Alluvium.
		Alluvium (Qgo)	Older alluvium. Includes Slocum, Verdos, Rocky Flats, and Nussbaum Alluviums in east, and Florida, Bridgetimber, and Bayfield Gravels in southwest.
		Eolian sand and silt (Qe)	Dune sand, silt and Peoria loess.
Tertiary	Sedimentary bedrock	Dawson Arkose and Green Mountain Conglomerate (Tdu)	Arkosic sandstone, conglomerate, and shale.
Tertiary-Cretaceous		Denver and Arapahoe Formations (TKda)	Sandstone, mudstone, claystone, and conglomerate; Denver Formation is characterized by andesitic materials.
		Denver Formation and/ lower part of Dawson Arkose (TKdl)	Arkosic sandstone, shale, mudstone, conglomerate, and local coal beds.
Cretaceous		Laramie Formation and Fox Hills Sandstone (Klf)	Sandstone, mudstone and coal beds.
		Pierre Shale - Upper unit (Kpu)	Shale
		Pierre Shale - Middle unit (Kpm)	Sandstone and shale
		Pierre Shale - Lower unit (Kpl)	Sharon Springs Member (organic-rich shale and numerous bentonite beds) in lower part
		Colorado Group (Kc)	Shale and limestone. Consists of Niobrara Formation (Kn) and either Benton Shale or Carlile, Greenhorn, and Graneros Formation (Kcg)

Note: Only geologic units shown in Figure 2 (Geologic Map) are described in Exhibit 1. Any absence of geologic units does not represent an unconformity.

4 PREVIOUS GEOTECHNICAL STUDIES

We reviewed existing geotechnical documents that were in the archive of the Colorado Department of Transportation (CDOT) Soils and Geotechnical Program. Selected documents that contained relevant information for subsurface characterization completed in our study are provided in Appendix A. The locations of the previous study areas are shown in Figure 3. Generalized subsurface conditions based on these reports are described below. Refer to the reports provided in Appendix A for subsurface explorations. During final design, we recommend obtaining and reviewing pertinent geotechnical reports and data from other agencies located along the alignment (e.g. City and County of Denver, City of Englewood, City of Littleton).

4.1 C-470 to Bowles Avenue

Based on the existing data, subsurface conditions along the southern end of the project alignment from C-470 to Bowles Avenue consist of approximately 10 to 60 feet of overburden. Fill materials apparently related to existing roadway embankments and rail embankments just east of Santa Fe Drive were encountered in several locations and consisted of soft to medium stiff, sandy clay and loose to medium dense, clayey sand with varying amounts of gravel. Where encountered, fill had a maximum thickness of about 10 feet. Beneath the fill (where present), soil consisting of medium stiff to very stiff, sandy clay and loose to medium dense, clayey sand, which were described as eolian in several boring logs, was encountered.

Bedrock consisted of interbedded claystone, siltstone, and sandstone. Standard penetration test (SPT) N-values in the bedrock generally increased from about 50 at the top of rock to greater than 100 at a depth about 10 feet below the top of rock.

Where encountered in the explorations, groundwater ranged from approximately elevation 5,360 to 5,420 feet (generally decreasing to the north), depending on location, which is about 10 to 20 feet below the roadway grade of Santa Fe Drive.

4.2 Bowles Avenue to Dartmouth Avenue

Subsurface conditions from Bowles Avenue to Dartmouth Avenue consisted of approximately 15 to 40 feet of overburden. Fill materials apparently related to existing roadway and rail embankments were encountered in several locations and had a maximum thickness of about 20 feet. The fill consisted of loose to medium dense, slightly clayey, gravelly sand. Explorations completed west of Santa Fe Drive near Oxford Avenue encountered up to 25 feet of landfill materials. Beneath the fill (where present), soil generally consisted of loose to medium dense, silty to clayey, gravelly sand and medium stiff, sandy clay. Layers of soft clay a few feet thick were encountered in borings near Quincy Avenue.

Bedrock encountered in the explorations consisted of claystone, siltstone, and sandstone. SPT N-values in the bedrock were generally greater than 100.

Where encountered in the explorations, groundwater ranged from approximately elevation 5,285 to 5,340 feet (generally decreasing to the north), depending on the location, which is about 10 to 25 feet below the roadway grade of Santa Fe Drive.

4.3 Dartmouth Avenue to I-25

Borings completed between Dartmouth Avenue and I-25 encountered about 10 to 45 feet of overburden. Several explorations encountered fill material up to 15 feet in thickness. The fill consisted of medium dense, clayey sand and soft to stiff, sandy clay. The fill reportedly contained organic material and cinders. Fill materials encountered west of Santa Fe Drive, near Dartmouth Avenue, contained trash and debris. Soil underlaying the fill (where encountered) consisted of medium dense sand with variable gravel and fines content. At the Evans Avenue interchange, soft to medium stiff clay with a maximum thickness of about 10 feet was encountered.

Bedrock consisted of claystone and sandstone. N-values in the bedrock ranged from about 50 to over 100 and generally increased with depth.

Where encountered in the explorations, groundwater ranged from approximately elevation 5,250 to 5,235 (generally decreasing to the north), depending on the location, which is about 5 to 15 feet below the roadway grade of Santa Fe Drive.

5 POTENTIAL GEOLOGIC HAZARDS

Based on our desktop review of geologic maps and reports, we have compiled a summary of potential geologic hazards that should be considered during the design and construction phase of the project.

5.1 Swell and Collapse Potential

Expansive and collapse-prone materials (soils and rock that experience volume change upon wetting) are common along the Front Range of Colorado. To assist us in determining the swell and collapse potential along the alignment, we reviewed a published geologic map of potentially swelling soil and rock along the Front Range urban corridor developed by Hart (1974), which is shown in Figure 4. The map generally indicates low swell and collapse potential, which is consistent with subsurface conditions indicated by the available explorations. The map indicates wind-blow (eolian) soils east and west of the alignment. Such materials may be susceptible to collapse. Additionally, the map indicates high swell potential along the southern portion of the alignment (C-470 to West Ridge Road), where the roadway skirts the margin of near-surface Dawson Formation bedrock.

In general, we do not anticipate that significant areas of the project alignment will require swell/collapse mitigation. However, mitigation may be required in some areas, particularly in the southern portion of the alignment. Potential swell and collapse mitigation techniques in this area are discussed below (similar techniques can be implemented to mitigate both mechanisms of ground movement).

5.1.1 Pavements

Over-excavation can be completed beneath the pavement section to reduce the likelihood of swell- and collapse-related distress. Swell mitigation should be in accordance with the requirements of the current version of the CDOT Pavement Design Manual. The necessary over-excavation depth could be on the order of several feet. It may be necessary to lime treat over-excavated soil to reuse the material as backfill in the over-excavated zone. Bedrock removed from the over-excavation will be difficult to process for reuse as fill and will likely need to be disposed off-site. Even with over-excavation, some swell-related movement could still occur.

5.1.2 Retaining Structures

Flexible retaining structures, such as mechanically stabilized earth (MSE) walls, are preferable in areas of swelling/collapse-prone soil/rock because of their ability to tolerate differential movement. However, even with flexible wall systems, some over-excavation still is likely to be required to reduce the likelihood of swell/collapse-related distress. Comparatively rigid retaining structures, such as cast-in-place concrete (CIPC) walls are more susceptible to damage if movement occurs. CIPC walls may require over-excavation.

5.1.3 Bridges

In general, the use of deep foundations to support bridges is adequate for swell mitigation, even at sites with relatively high swell/collapse potential. Dead loads are generally sufficient to resist swell-related uplift on deep foundation elements. However, drilled shafts may be preferable to driven piles due to their ability to more easily achieve penetration into the bedrock. Shallow foundations, including geosynthetic reinforced soil-integrated bridge systems (GRS-IBS), are generally not feasible for sites with relatively high swell/collapse potential.

5.2 Slope Stability

The existing alignment is relatively flat, with the exception of the existing roadway and railroad embankments. The largest natural slopes along the alignment occur at the northern end of the alignment, where the northbound and southbound lanes of Santa Fe Drive are split by the South Platte River. The riverbanks in this area are about 10- to 20-feet high and appear to be stable based on our site reconnaissance (see Section 6). As such, instability of natural slopes along the alignment is not anticipated to pose a significant hazard.

5.3 Erosion

Erosion potential for the study area has been reviewed in terms of the T-factor (soil loss tolerance) and the K-factor (the soil erodibility factor) of the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to model the predictive average annual rate of soil loss by sheet and rill erosion per ton per acre per year (see Figures 5 and 6) using the USDA NRCS web tool (USDA NRCS, 2020).

Sinkholes have been reported near the intersection of Santa Fe Drive and Oxford Avenue in June 2015, July 2018, and July 2019 (Butzer, 2019). These sinkholes appear to have formed due to damaged stormwater infrastructure that resulted in soil erosion and, therefore, are not anticipated to pose a hazard for a well-constructed project.

5.4 Seismicity

The Front Range of Colorado is an area of low potential for damaging earthquakes. Unfortunately, it is not possible to accurately estimate the timing or location of future earthquakes, because the occurrence of earthquakes is relatively infrequent and the historical earthquake record in Colorado is short (about 130 years). Based on a recent geologic map by the U.S. Geological Survey (USGS), the nearest fault to the proposed project is the Golden Fault, approximately 10 miles to the west (Rogers and others, 1998). However, there is only disputed evidence that this fault has been active in the Quaternary Period, or last 1.6 million years. Therefore, in our opinion, the potential for ground surface fault rupture is low.

We also reviewed ground motion parameters for the alignment using the USGS U.S. Seismic Design Map Web Application (USGS, 2018). The mapped seismic acceleration for the alignment is relatively low. The soft rock peak ground acceleration (PGA_B) is about 0.06g for the ground motion with a 7% probability of exceedance in 75 years. Based on the relatively low peak ground acceleration for this area, it is our opinion that the potential for seismic hazards (e.g. liquefaction, seismic slope instability, seismic settlement) to significantly affect design of the project is low.

5.5 Historical Fill Areas

Historically, gravel mining occurred along the South Platte River. The mined-out areas would often then be utilized as uncontrolled landfills. Such materials, which could include poorly compacted debris and refuse, present geotechnical challenges related to settlement and stability, as well as environmental concerns. To evaluate the potential for historic fill areas to exist along the alignment, we reviewed a compilation of data prepared by Pinyon Environmental Engineering Resources, Inc. (Pinyon) for the City and County of Denver. In addition to showing landfill areas, the Pinyon (1997) data also show areas of fill associated with site grading (e.g. embankment construction). Data from the Pinyon (1997) study are shown in Figure 7.

As shown in Figure 7, several historical fill areas are present along the alignment. These include an abandoned gravel mine that was subsequently used as a landfill on the west side of Santa Fe Drive between US-285 and Oxford Avenue. The Riverpoint shopping development and a golf course now occupy this area. It is unclear if the landfill materials were mitigated as part of those developments. The mapping of the landfill at Oxford Avenue is consistent with the available subsurface explorations (see Appendix B), which suggest that landfill materials are located outside of the existing Santa Fe Drive roadway.

A second area of widespread gravel mining that was subsequently utilized as a landfill is shown along Santa Fe Drive from approximately Louisiana Avenue to I-25. This includes the area of the Santa Fe Drive/I-25 interchange that was reconstructed in the last 10 years. Several other fill areas are shown along the alignment in Figure 7, but the Pinyon (1997) data indicates that these are areas of general fill placement for site grading and are not associated with gravel mining or landfill usage.

West of historic downtown Littleton (north of Bowles Avenue and West of Santa Fe Drive), there is reportedly another historical landfill. Aerial images and USGS topographic maps from 1942 and 1957 document a gravel pit at this location (Figure 7), which was subsequently used as a landfill, based on discussions with the City of Littleton.

Additionally, the South Platte River was relocated to the west of its former location during the construction of Santa Fe Drive in the vicinity of Bowles Avenue. There are likely other relocations of the South Platte River that occurred during original construction of the roadway alignment. Therefore, a mix of embankment fill and alluvial materials are possible in these areas where the river channel was relocated, along with potentially irregular subsurface drainage patterns. The City of Littleton has indicated that underdrains have been used to manage these issues in some of these areas.

Additional evaluation of existing uncontrolled fill materials along the alignment will be necessary. Borings should be completed in the mapped fill areas to evaluate the presence and characteristics of any uncontrolled fill materials. Depending on the extent and thickness of such materials, mitigation may be required. Mitigation techniques could include removal and replacement, surcharging, grouting, or installation of aggregate columns. However, the applicability of different ground improvement techniques will depend on the characteristics of the landfill material.

5.6 Soft Clays

Soft to medium stiff clay with a maximum thickness of about 10 feet were reported at the Evans Avenue interchange (see Appendix A, Report 16). Due to concerns with the stability and settlement of concrete walls constructed on the clay materials at the interchange, the ramp bridges were reportedly extended to decrease the maximum wall height.

Additional characterization of clays at the interchange should be completed during design. Depending on the strength and compressibility characteristics of the clays, mitigation may be required for retaining structures at this location due settlement and stability concerns. In general, MSE walls are flexible and can accommodate relatively large settlements. As such, MSE walls may be preferable at this location. Additionally, staged construction may be necessary to provide adequate global stability of retaining walls constructed at this location. This could be accomplished by building the wall to a portion of its full height, monitoring and allowing pore water pressures in the clay to dissipate, then continuing with placement of the remaining fill height. Ground improvement (e.g. stone columns) could also be utilized to mitigate potential stability concerns.

6 FIELD RECONNAISANCE

A field reconnaissance was performed on May 20, 2020 and May 21, 2020 by a Shannon & Wilson geologist. On May 20, the field representative drove the project alignment (from I-25 in the north to C-470 in the south and then back north to I-25 along Santa Fe Drive) looking for settlement, heaving, sinkholes, and other distress in the roadway that could be indicative of geologic hazards. On May 21, the field representative looked at major structures along the alignment such as bridges, walls, and embankments at major intersections. In general, we did not observe any features that were indicative of substantial distress related to the aforementioned geologic hazards. However, we did observe some structural and pavement distress as noted below. See Appendix B for photographs of selected site features and observations.

6.1 C-470 To South Prince Street

Representative photos of this reach are shown in Figures B-1 and B-2. The pavement consists of asphalt and is in good condition. Noise walls and jersey barriers also appear to be in good condition. The concrete curb in the median is disintegrating just north of the intersection of Bowles Avenue. Bridges, embankments, and retaining structures at the C-470/Santa Fe Drive interchange all appear to be in good condition.

6.2 South Prince Street to West Florida Avenue

Representative photos from this reach are shown in Figures B-3 through B-8. The pavement surfacing is concrete and is in fair condition. Transverse expansion joints create an uneven driving surface and ride. Longitudinal joints are separated up to approximately three inches in some locations. Concrete curbs are sporadically damaged along this stretch of the alignment and in poor condition.

At Oxford Avenue, where sinkholes related to damaged stormwater infrastructure previously occurred, we did not observe any indications of recent distress. This area is also located in a historical fill area (Figure B-5). We did not observe indications of settlement or distress that could be related to the potential presence of landfill materials.

At the Santa Fe Drive/US-285 (Hampden Avenue) interchange, we observed cracking near the bridge abutments (see Figure B-6). At the bridge carrying Santa Fe Drive over Big Dry Creek, there was cracking observed at each abutment (one crack on south abutment and three in northern abutment). The cracks are vertical and run the full height of the abutment wall (Figure B-4).

6.3 West Florida Avenue to I-25

Representative photos from this reach are shown in Figures B-9 through B-12. The pavement on Santa Fe Drive in this reach consists of asphalt and appears to be in fair to good condition. Some of the pavement in the two far-right lanes of the southbound roadway have been patched, repaved, and exhibit more pavement distress than the other lanes. Longitudinal cracking was observed in this stretch of the alignment.

Within a historic fill area near West Tennessee Avenue, on the east side of Santa Fe Drive, there is a railroad tie retaining wall next to the South Platte River Trail. The wall ranges from 4 to 5 feet tall, runs approximately 500 feet north and 300 feet south of the intersection at West Tennessee Avenue, and is in poor condition. The wall is tilting toward the bike trail, the railroad ties are disintegrating, and individual segments of the wall are wavy (Figure B-10, Sheet 1). Minor erosion was observed in fill by the railroad ties. An erosion feature was observed approximately 3 feet in diameter and 3 feet off the pavement near this retaining wall (Figure B-10, Sheet 2). About 300 feet south of the West Tennessee Avenue intersection, a newer sheet pile wall was installed and is in good condition (Figure B-10, Sheet 3). Approximately 500 feet north of the intersection, the retaining wall shortens and transitions to an embankment that does not present any visual indications of distress (e.g. cracking or erosion).

7 CONCLUSIONS

Based on our review of existing geotechnical and geologic data, we do not anticipate that subsurface conditions along the project alignment will pose a significant hazard (i.e., one that could not be mitigated using typical design and construction techniques) to the project. However, three hazards will require further evaluation and may require some mitigation during design: 1) landfill areas and undocumented fills, 2) swelling/collapse prone soils, and 3) soft clays at the Evans Avenue interchange.

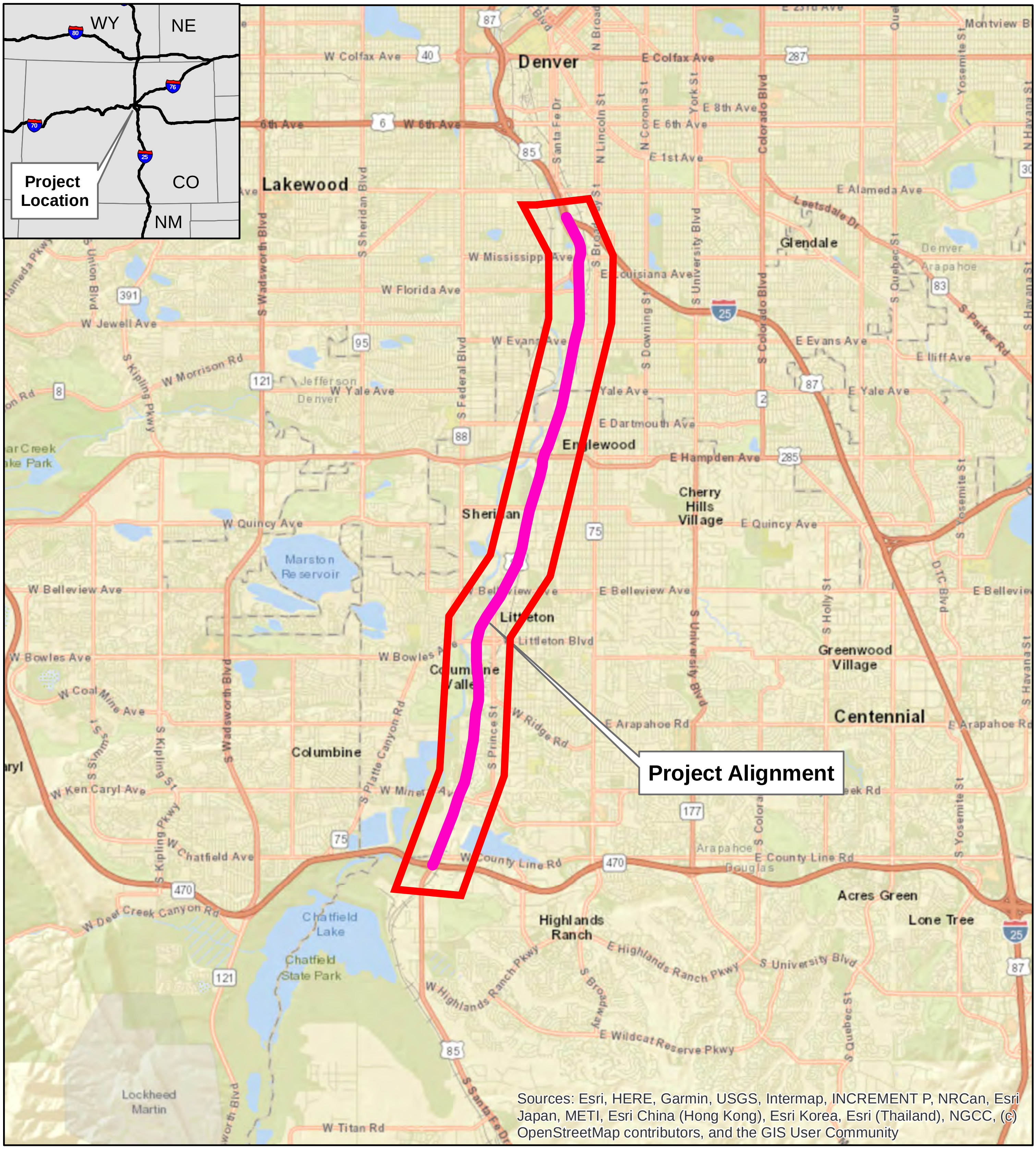
Landfill areas reportedly occur near Oxford Avenue, Dartmouth Avenue, and the I-25 interchange. With the exception of the I-25 interchange, these landfill areas appear to occur adjacent to the existing roadway and do not appear to extend a significant distance beneath the roadway. Nonetheless, further exploration and evaluation of these landfill areas will be required during design to characterize the locations of these materials relative to the proposed improvements and to develop mitigation solutions.

Eolian soils are mapped along the alignment and were encountered in explorations completed in the southern portion of the alignment. These soils are sometimes prone to collapse when wetted. Surficial bedrock, which may be susceptible to swell, may also be encountered near the southern portion of the alignment. However, surficial bedrock was not encountered in the explorations we reviewed. Additionally, isolated zones of swell-susceptible clay could be encountered throughout the alignment. Mitigation may be required to protect retaining structures and pavements from swell/collapse-related movement in some areas of the alignment. Over-excavation is likely the most suitable technique to mitigate these hazards.

Soft to medium stiff clays with a maximum thickness of about 10 feet were encountered at the Evans Avenue interchange. Due to previous concerns with stability and settlement of concrete walls constructed on such soils, the existing ramp bridges were reportedly extended to decrease the heights of concrete retaining walls (see Appendix A, Report 16). A similar approach could be utilized to mitigate settlement of future construction. Alternatively, relatively flexible MSE walls could be utilized. Additional mitigation, such as staged construction or ground improvement, may also be required to provide adequate stability of walls at this location.

8 LIMITATIONS

The preliminary evaluation of geologic hazards presented in this report is based on the results of our desktop study, review of existing geotechnical data, and our reconnaissance. This report was prepared for the exclusive use of CDOT, HDR Engineering, Inc., and the project team members for use in the PEL study for the Santa Fe Drive - C-470 to I-25 project. It is not suitable for final design or construction.



LEGEND

Project Alignment - Santa Fe Drive

Study area

0 0.75 1.5 3 Miles

N

Santa Fe Drive I-25 to C-470
Denver and Jefferson Counties, Colorado

VICINITY MAP

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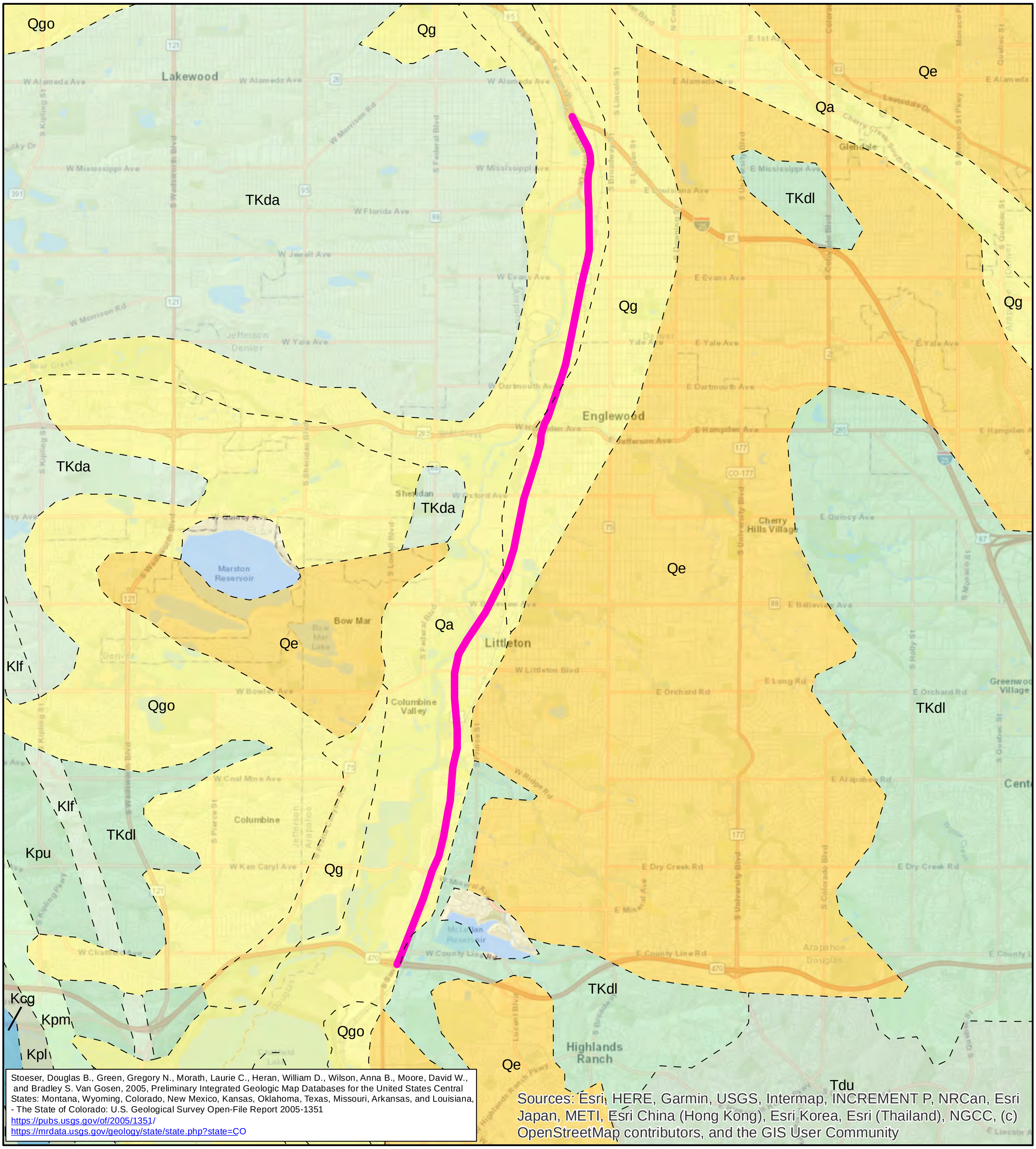
FIG. 1



Stoeser, Douglas B., Green, Gregory N., Morath, Laurie C., Heran, William D., Wilson, Anna B., Moore, David W., and Bradley S. Van Gosen, 2005, Preliminary Integrated Geologic Map Databases for the United States Central States: Montana, Wyoming, Colorado, New Mexico, Kansas, Oklahoma, Texas, Missouri, Arkansas, and Louisiana, - The State of Colorado: U.S. Geological Survey Open-File Report 2005-1351
https://pubs.usgs.gov/of/2005/1351/
https://mrdata.usgs.gov/geology/state/state.php?state=CO

LEGEND

Surficial bedrock and soil

- Quaternary alluvium (Qa, Qg, Qgo)
- Quaternary eolian sand and silt (Qe)
- Tertiary Dawson Arkose and Green Mountain Conglomerate (Tdu)
- Tertiary-Cretaceous Denver and Arapahoe Fms (TKda)
- Tertiary-Cretaceous Denver Fm and/ lower part of Dawson Arkose (TKdl)
- Cretaceous Laramie Fm and Fox Hills Sandstone (Klf)
- Cretaceous Pierre Shale - Upper unit (Kpu)
- Cretaceous Pierre Shale - Middle unit (Kpm)
- Cretaceous Pierre Shale - Lower unit (Kpl)
- Cretaceous Colorado Group (Kcg)

Project Alignment - Santa Fe Drive

0 0.5 1 2 Miles

N

Santa Fe Drive I-25 to C-470
Denver and Jefferson Counties, Colorado

SURFICIAL GEOLOGIC MAP

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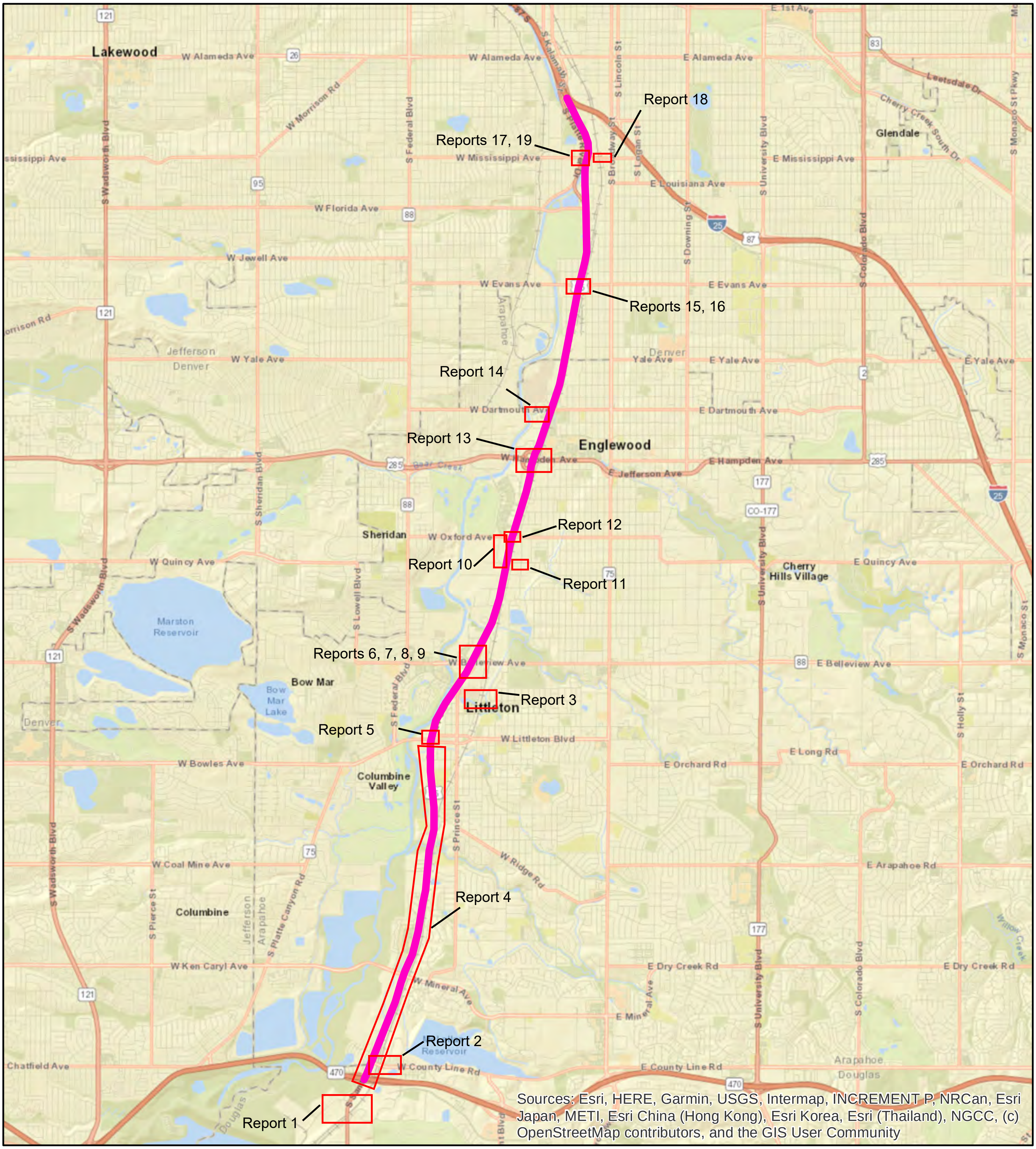
FIG. 2



LEGEND

Project Alignment- Santa Fe Drive

Geotechnical Study Areas (Reports)

Note: Study areas shown in figure are referenced as reports in Appendix A.

0 0.5 1 2 Miles

N

Santa Fe Drive I-25 to C-470
Denver and Jefferson Counties, Colorado

PREVIOUS CDOT GEOTECHNICAL STUDY AREAS

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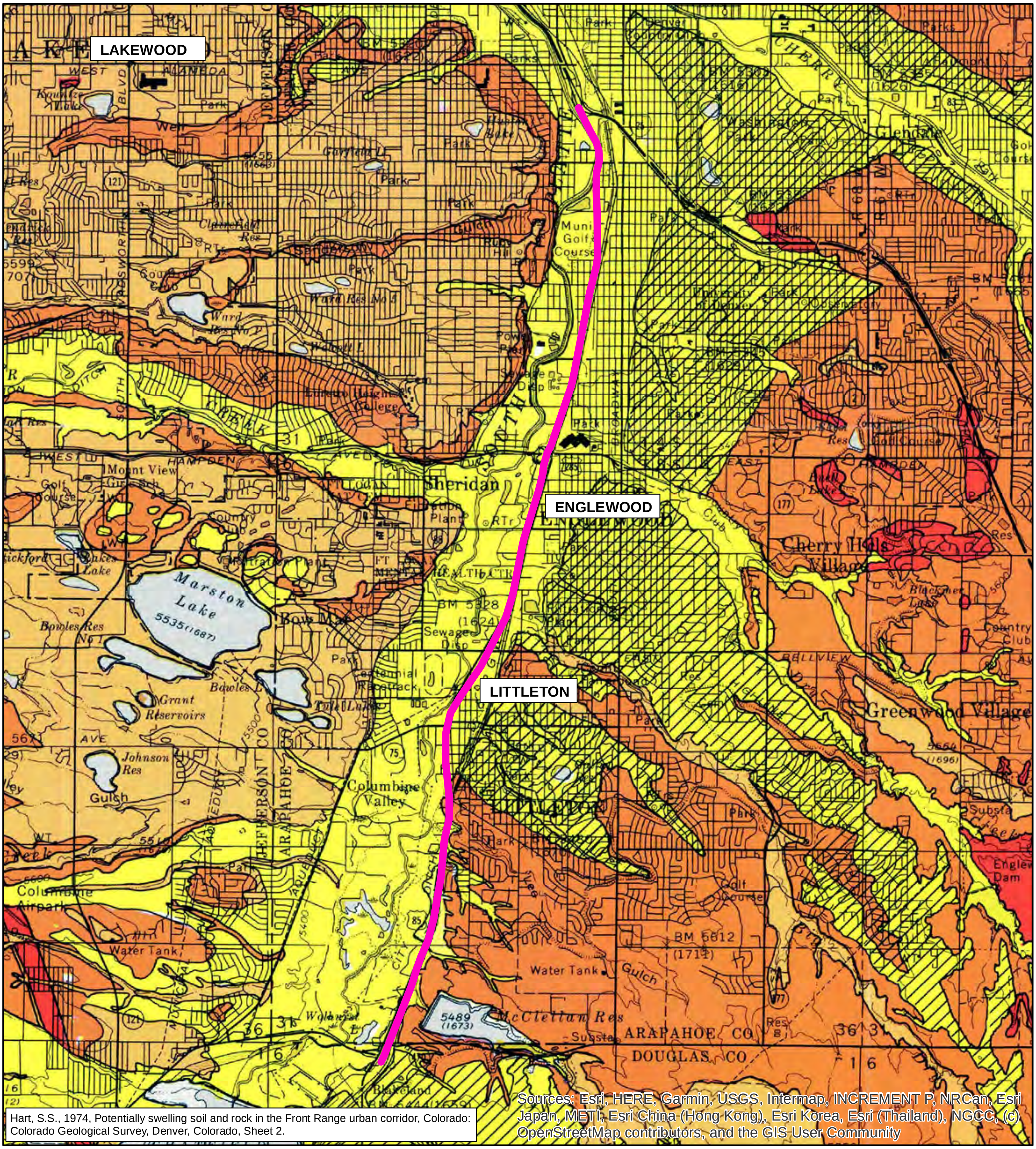
FIG. 3



LEGEND

- Very High Swell Potential
- High Swell Potential
- Moderate Swell Potential
- Low Swell Potential
- Wind Blown Sand/Silt
- Project Alignment - Santa Fe Drive

N

0 0.5 1 2 Miles

Santa Fe Drive I-25 to C-470
Denver and Jefferson Counties, Colorado

SOIL AND ROCK SWELL POTENTIAL

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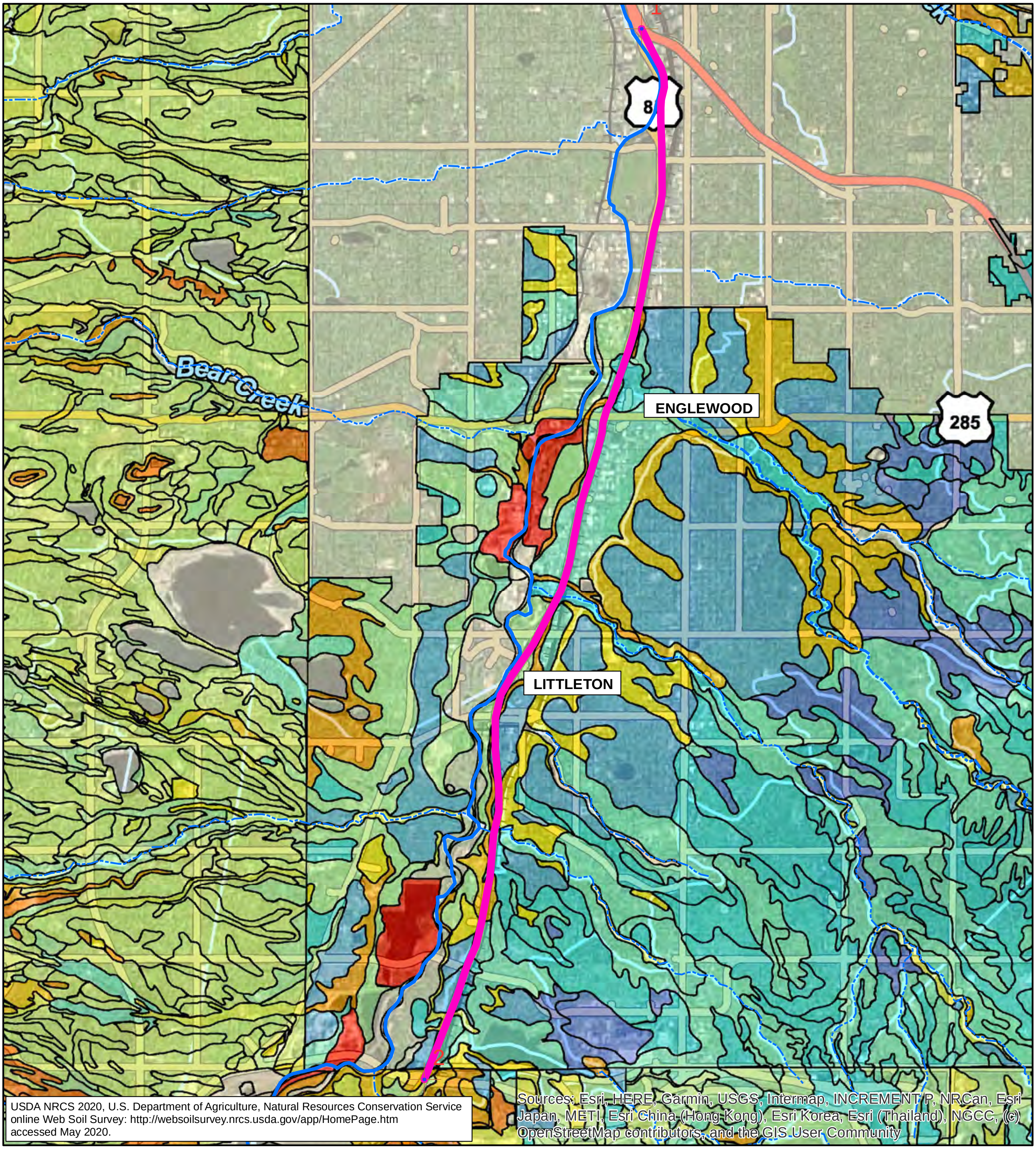
FIG. 4



LEGEND

Erosion Rating (K- factor)

0.02	0.24	0.55
0.05	0.28	0.64
0.10	0.32	Not rated
0.15	0.37	
0.17	0.43	
0.20	0.49	

- 1st / 2nd Order Streams
- 3rd / 4th Order Streams
- 5th - 7th Order Streams
- Project Alignment - Santa Fe Drive

0 0.5 1 2 Miles

N

NOTE Soil polygons are based on soil surveys mapped at scales ranging from 1:20,000 to 1:24,000 and compiled by the USDA - NRCS.

Santa Fe Drive I-25 to C-470
Denver and Jefferson Counties, Colorado

POTENIAL SOIL EROSION K-FACTOR

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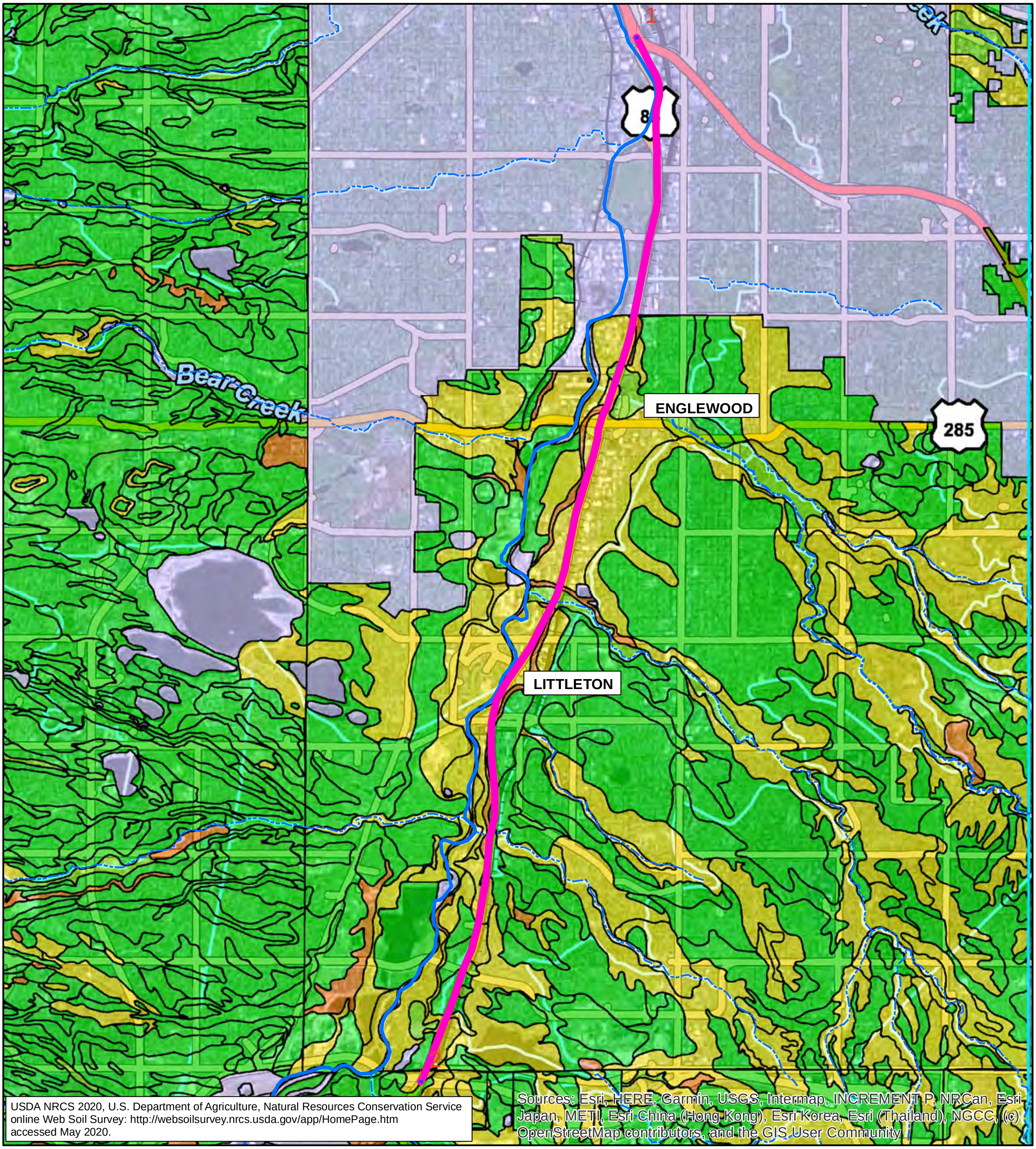
FIG. 5



LEGEND

Erosion Rating (T- factor) in Tons/Acre/Year

- 1
- 2
- 3
- 4
- 5
- Not rated/ available

- 1st / 2nd Order Streams
- 3rd / 4th Order Streams
- 5th - 7th Order Streams
- Project Alignment - Santa Fe Drive

N

0 0.5 1 2 Miles

NOTE

Soil polygons are based on soil surveys mapped at scales ranging from 1:20,000 to 1:24,000 and compiled by the USDA - NRCS.

Santa Fe Drive I-25 to C-470
Denver and Jefferson Counties, Colorado

POTENIAL SOIL EROSION T-FACTOR

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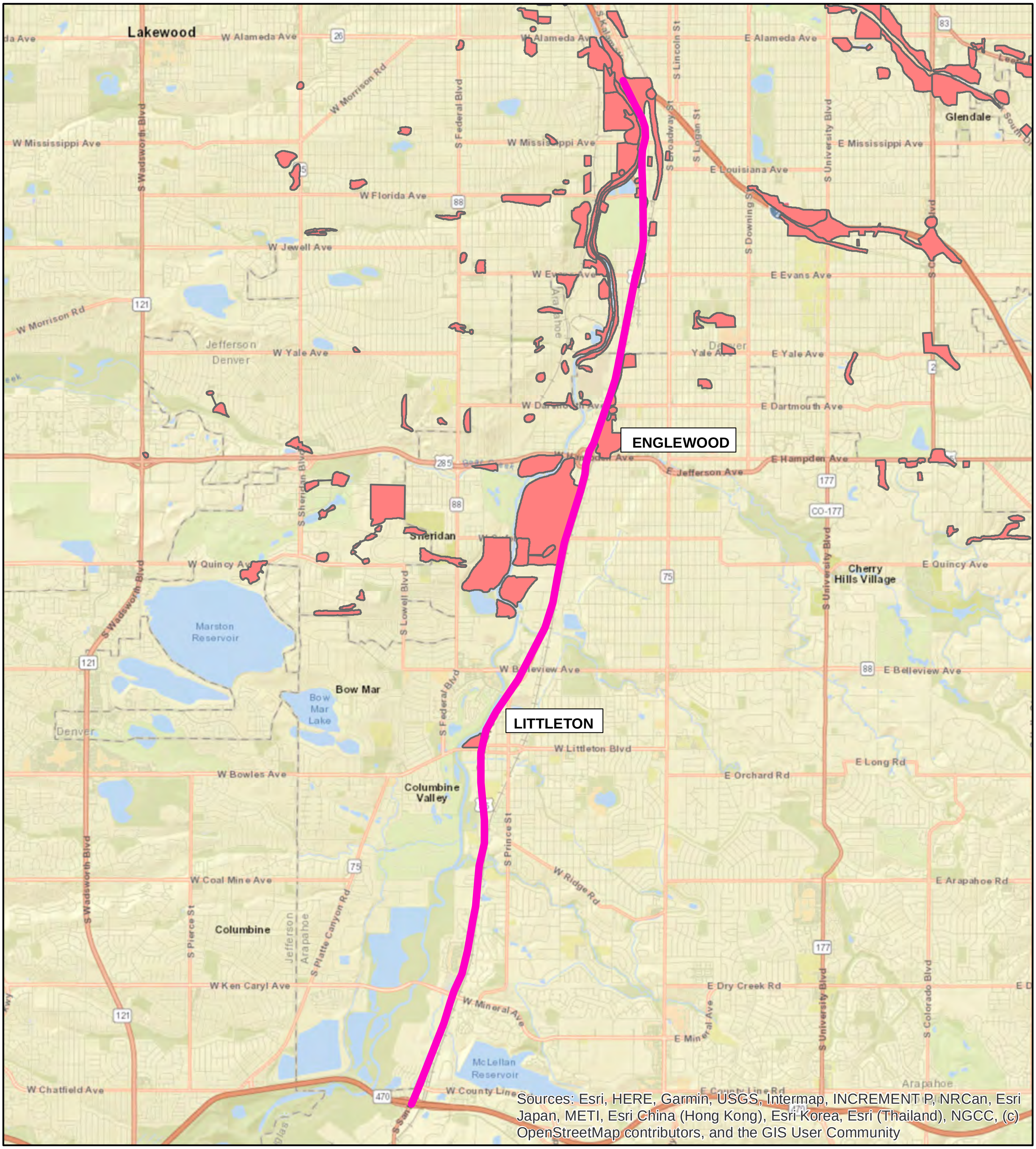
FIG. 6



LEGEND

Project Alignment- Santa Fe Drive

Historical Fill Areas

Note:

Location of historical landfill location near Bolwes and Santa Fe was mapped from USGS 1957 topographic map.

0 0.5 1 2 Miles

N

Santa Fe Drive I-25 to C-470
Denver and Jefferson Counties, Colorado

HISTORICAL FILL AREAS

October 2020 104536

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 7

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