Wrangell - St. Elias National Park & Preserve

Strategic Transportation Study for the Nabesna District

Phase 1 – Gravel Material Source Assessment

Prepared for:
National Park Service
Wrangell-St. Elias National Park &

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Executive Summary

Off-road vehicle (ORV) use in the Nabesna District predates the establishment of Wrangell-St. Elias National Park and Preserve (WRST). Over time, a network of ORV trails formed as locals used them to access private property and hunting grounds. These sporting, recreational, and subsistence activities continued after the area was designated as a National Park and Preserve. With increased use, the ORV trails in the Nabesna District have substantially degraded, resulting in extensive damage to the tundra habitat. In 2006, several conservation groups filed a lawsuit against the National Park Service (NPS), challenging the method used by the NPS to issue recreational ORV permits for the nine trails within the Nabesna District. As a result of this legal action, the NPS prepared an ORV Management Plan and Environmental Impact Statement (EIS) in 2011, which sought to resolve issues surrounding ORV trails and their management in the Nabesna Road area.

Need for the Study

Since the 2011 EIS and Record of Decision, WRST has implemented various treatments to several of the nine ORV trails in accordance with the direction set forth in the Nabesna ORV Management Plan. However, some of these actions failed or proved unsustainable or unfeasible. Additional strategic planning is needed to better understand ORV trail conditions, gravel resource availability, and financial sustainability considerations for providing year-round trail access along the Nabesna Road corridor in WRST. In 2021, the NPS requested technical planning assistance from the Federal Highway Administration (FHWA) Western Federal Lands Highway Division (WFLHD) to evaluate gravel source potential along the Nabesna corridor and begin defining baseline ORV trail conditions through preliminary landform mapping. The analysis and findings contained in this *Strategic Transportation Study Phase 1 Gravel Materials Source Assessment* provide WRST with a foundational understanding of relative aggregate potential and set the stage for a Phase 2 effort that identifies specific ORV trail maintenance best practices, mutually beneficial projects, and implementation strategies for maintaining trails and minor roads year-round.

Copper Lake Trail, photo taken during July 2022 Site Visit

Phase 1 Study Process

The *Strategic Transportation Study Phase 1 Gravel Materials Source Assessment* was organized around the following tasks:

- **Data Collection** – The NPS Alaska Region acquired Light Detection and Ranging (LiDAR) remote sensing data in 2021 to analyze topography within the Nabesna District for use in assessing trail conditions and potential gravel sources.

- **Preliminary Engineering Assessment** – Using available data sources, including LiDAR, a Preliminary Engineering Assessment of the Nabesna District ORV Trails and Minor Roads was completed.
    - **Landform Mapping** – This subtask focused on landform (geomorphic) interpretation and mapping. Nine landform types and eleven subtypes were mapped.
    - **Field Verification** – After preliminary desktop landform mapping was completed, a site visit was conducted in Summer 2022 by WFLHD and WRST staff to review field conditions and validate desktop landform mapping in the field. Selected sites were visited to confirm the interpretation and accuracy of the landform mapping, and test pits were dug to investigate subsurface conditions of select landforms.
    - **Relative Aggregate Potential Analysis** – Each landform type was assigned a relative potential for aggregate suitability. The analysis completed by WFLHD was compared against previous geotechnical investigations completed by the Alaska Department of Transportation and Public Facilities (AKDOT&PF) in 1994.
- **Multi-Agency Coordination** – WFLHD hosted an on-site technical review meeting with key staff from the NPS and AKDOT&PF to present initial findings from the Preliminary Engineering Assessment and discuss next steps for the Strategic Transportation Study. In addition to the on-site technical review, WFLHD engineers also engaged with the Alaska Transportation Working (inspiration) Group at their annual project coordination meeting to present on the landform mapping and relative aggregate potential analysis methodology.

Next Steps

Using the relative aggregate potential findings from the *Phase 1 - Gravel Material Source Assessment*, the NPS and its partners can move forward with the next phase of the Strategic Transportation Study (STS). The Phase 2 effort will focus on developing planning-level cost estimates and ORV standard trail designs in alignment with the 2011 ORV Management Plan actions. Additional considerations for the next phase of the STS include:

- A cost-benefit analysis of maintaining the Nabesna District ORV trails in year-round accessible conditions;
- Best management practices for sustainable ORV trail management;
- Further investigation of high aggregate potential sites to understand the "downstream impacts" of harvesting material within WRST (e.g., environmental impacts, hydrological impacts, etc.) and other sensitivities around material extraction/processing within a National Park;
- Revisiting the 2011 Record of Decision and data collected to determine trail maintenance feasibility and if updates to the planning document are needed; and
- Coordination with AKDOT&PF on corridor-wide gravel needs.

The WRST Nabesna District is characterized by three discrete but related challenges: addressing ORV trail maintenance and access priorities per the EIS Record of Decision, maintaining Nabesna Road as a primary corridor within the National Park and Preserve, and anticipating impacts from the Nabesna Mine Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cleanup. The gravel materials source analysis and findings from this Phase 1 STS will be an important data-driven resource for the NPS as it plans for the future of the Nabesna District.

INTRODUCTION

Purpose & Background

Off-road vehicle (ORV) use in the Nabesna District predates the establishment of Wrangell-St. Elias National Park and Preserve (WRST). Over time, a network of ORV trails formed as locals used them to access hunting grounds and private property. These sporting and subsistence uses continued after the area was designated as a National Park and Preserve.

The enabling legislation for WRST provides that the unit shall be managed "to maintain unimpaired the scenic beauty and quality of high mountain peaks, foothills, glacial systems, lakes and streams, valleys and coastal landscapes in their natural state… and to provide continued opportunities, including reasonable access… for wilderness recreational activities." This directive requires a balance of providing access to opportunities for park visitors and residents while protecting park resources and values.

Over the years, the ORV trails in the Nabesna District have substantially degraded, resulting in extensive damage to the tundra habitat. In 2006, several conservation groups filed a lawsuit against the National Park Service (NPS), challenging the method used by the NPS to issue recreational ORV permits for the nine trails within the Nabesna District. As a result of this legal action, the NPS prepared an ORV Management Plan and Environmental Impact Statement (EIS) in 2011, which sought to resolve issues surrounding ORV trails and their management in the Nabesna Road area.

The findings of the 2011 EIS included a range of alternatives and an analysis of the environmental consequences of each. In 2012, the U.S. Department of the Interior issued a Record of Decision (ROD) and selected "Alternative 6 – Improve Trails, Permit Recreational Use on Improved Trails in the Preserve" as the preferred alternative. Specifically, the ROD states:

> "All nine trails would be improved to at least a maintainable condition through trail hardening, tread improvement, or constructed re-routes. After improvements are completed, recreational ORV use would be permitted on trails in the National Preserve but not on trails in the National Park. Until improvements are completed, recreational ORV use would only be permitted on trails in fair or better condition (Lost Creek and Trail Creek trails). Subsistence ORV use would continue but would be subject to monitoring and management action if resource impacts increased. On the trails in the designated wilderness, subsistence ORV users would be required to stay on designated trails, with allowance for game retrieval. In designated wilderness subsistence user restrictions would be accomplished by closures pursuant to 36 CFR 13.460."

However, some of the actions that the ORV Management Plan and EIS directed the park to undertake have failed or proven unsustainable or unfeasible. Additional strategic planning is needed to better understand gravel resource availability, maintenance best management practices, and financial sustainability considerations for providing year-round trail access along the Nabesna Road corridor in WRST. As such, the purpose of this Phase 1 Strategic Transportation Study is to evaluate gravel source potential along the Nabesna Road corridor to inform future planning and management decisions for maintaining ORV access into WRST.

Study Area Location and Description

At 13 million acres, WRST is the largest unit of the United States National Park System and includes nine of the country's 16 highest mountain peaks. There are two gravel roads that exist within WRST: McCarthy Road, which provides access to the small mining towns of Kennecott and McCarthy, and Nabesna Road, which connects the Nabesna Mine Site to the Alaska state highway system (Figure 1).

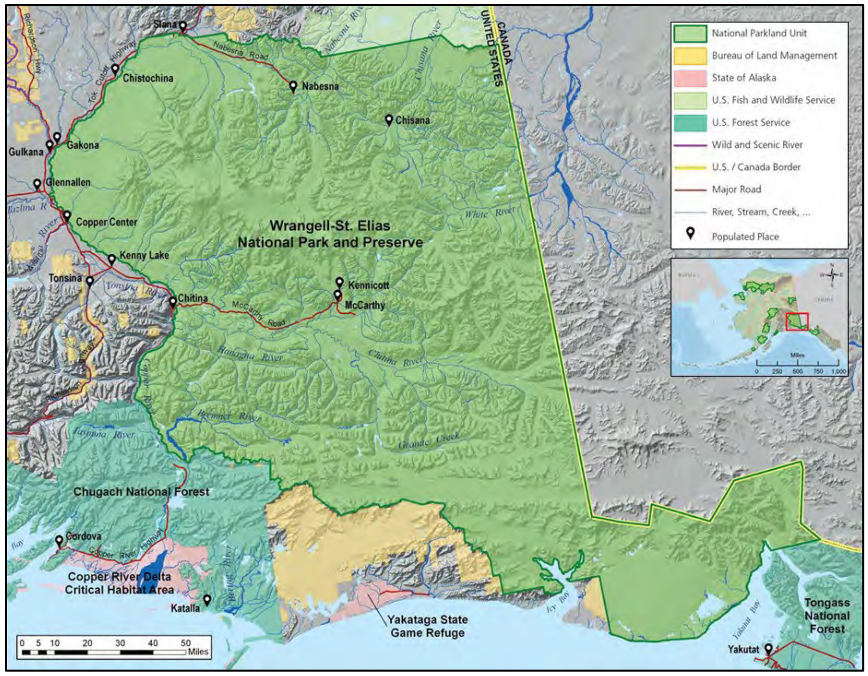


Figure 1: Wrangell-St. Elias National Park and Preserve Location (Source: NPS)

The northern reaches of the Park and Preserve can be explored by driving Nabesna Road, a 42-mile unpaved road that begins at Mile 60 of the Tok Cutoff Highway in Slana, AK (shown in Figure 2 on the following page). Originally built for a gold mine, the Nabesna Road corridor is now characterized by additional recreation and subsistence uses. The north side of the road is designated a National Preserve, while the south side of the road is designated a National Park. The primary difference between these designations involves hunting regulations. Within the National Preserve only, sport hunting is allowed. Within both the National Park and the National Preserve, subsistence hunting is allowed. Many rural and native Alaskans live off of the land, relying on fish, animals, and other natural resources for personal consumption. The Nabesna Road corridor and the many ORV trails that connect to it are critical transportation assets for both the National Park and Preserve and the local community.

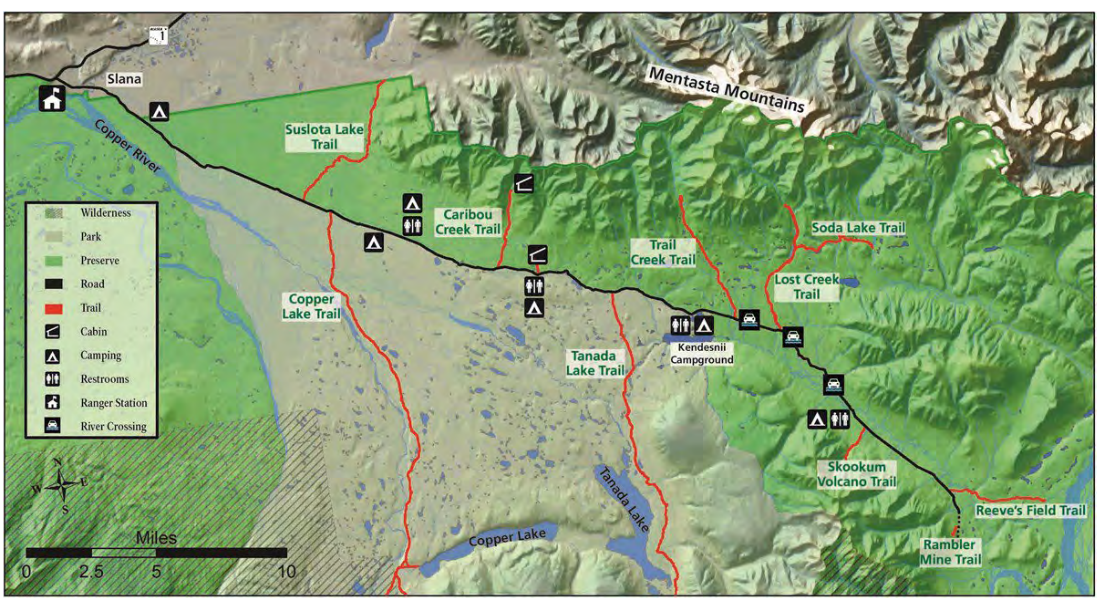


Figure 2: WRST Nabesna Road Corridor (Source: NPS)

Nabesna Mine and CERCLA Cleanup

WRST contains several private inholdings, including the historic Nabesna Mine site which is entirely on private land. Between 1925 and 1940, approximately 53,400 ounces of gold was extracted from the Nabesna Mine. The mine has been inactive for many decades, but the presence of mill tailings at the site prompted the NPS to implement various environmental and geochemical studies to better understand potential risks to human health and environmental resources. Currently, the Nabesna Mine is the focus of an NPS-led Engineering Evaluation/Cost Analysis (EE/CA), which is being carried out under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

In an EE/CA, multiple cleanup actions are evaluated and the NPS will recommend a final "removal action" to ensure that future site conditions are protective of human health and the environment. This evaluation process and overall CERCLA investigation framework takes many years to complete. At the time of this report, the NPS is working through the cleanup action selection phase, which includes fieldwork, site analyses, and cleanup action vetting. The final recommended cleanup action and its implementation will likely have significant impacts to the Nabesna Road.

Nabesna Mine, photo taken during July 2022 Site Visit

Planning Context

A number of plans and studies have been completed that relate to the WRST Strategic Transportation Plan Study Area. These documents set the stage for the existing and anticipated conditions within WRST and the Nabesna Road corridor, and offer important context for the consideration of ORV trails and minor road improvements. Some of these plans are referenced throughout the report, and a comprehensive list of previous plans and studies can be found in **Appendix A – Summary of Previous Plans and Studies**.

History of ORV Management Decisions

ORV Use Prior to 2006 Legal Action

Off-road vehicle use in the Nabesna District began shortly after World War II when surplus military vehicles were available to hunters, miners, and other locals for personal use in accessing remote areas along the corridor. In the late 1970s, all-terrain vehicles emerged as a new and more affordable mode of cross-country travel in rural Alaska. By the time WRST was established as a National Park and Preserve in 1980, there was a well-established trail network in the Nabesna District.

In 1983, WRST began issuing permits for recreational ORV use on nine established trails under 43 CFR 36.11(g)(2). This regulation provides superintendents authority to issue permits allowing ORV use on existing trails in areas that are not designated wilderness— if ORV use would be compatible with the purposes and values for which the area was established. The permits require users to stay on existing trails and adhere to certain conditions. The number of permits issued for recreational ORV use has fluctuated over time, shown in Figure 3.

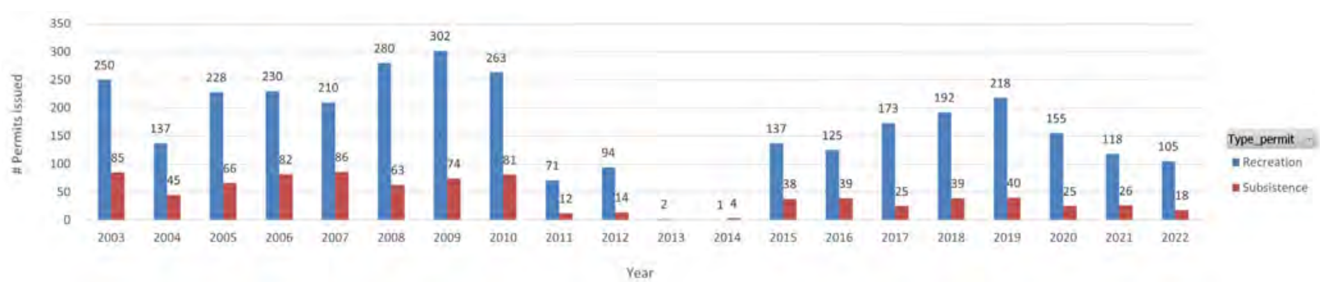


Figure 3: Number of Permits Issued for Subsistence and Recreational ORV Use, 2003 – 2022 (Source: NPS)

Two major studies (Happe et al. 1998, Connery 1987) of ORV impacts and mitigation and a detailed survey and inventory of physical conditions along the existing trails in the Nabesna District (Meyer and Anderson 2007) demonstrated that ORV use in certain areas was causing resource degradation. In particular, ORV use over wet areas led to trail braiding and widening and, as this vegetation does not recover quickly, soils erode, permafrost depth changes, and impacts to surface hydrology occur. Where this occurs, trails can become impassable, resulting in the formation of multiple alignments or braiding.

2006 Legal Action and Settlement

On June 29, 2006, the National Parks Conservation Association, Alaska Center for the Environment, and the Wilderness Society filed a lawsuit against NPS in the United States District Court for the District of Alaska. The plaintiffs challenged NPS's method of issuing recreational ORV permits for the nine trails within the Nabesna District. They asserted that when issuing recreational ORV permits, NPS failed to make the compatibility finding required by 43 CFR 36.11(g)(2) and failed to prepare an environmental analysis of recreational ORV use as required by the National Environmental Policy Act of 1969 (NEPA). The plaintiffs did not challenge the use of ORVs for subsistence uses.

In a settlement agreement announced on May 15, 2007, the NPS agreed to suspend issuing recreational ORV permits for three specific trails (Suslota, Caribou Creek, Reeves Field) unless the ground is frozen. NPS also agreed to prepare an Environmental Impact Statement (EIS) in accordance with NEPA and issue a Record of Decision.

2011 Nabesna Off-Road Vehicle Management Plan/Environmental Impact Statement

In the months following the settlement agreement, the NPS published a Notice of Intent to prepare an EIS in the Federal Register. The initial planning process included extensive public involvement, agency consultation, and Tribal consultation. The Nabesna Off-Road Vehicle Management Plan/Draft Environmental Impact Statement (DEIS) was released to the public on August 11, 2010.

The purpose of the Off-Road Vehicle (ORV) Management Plan/Environmental Impact Statement (Plan/EIS) is to describe a strategy to provide continued opportunities for appropriate and reasonable access to wilderness and backcountry recreational activities that also accommodates subsistence use and access to inholdings while protecting scenic quality, fish and wildlife habitat, and other park resource values. The Plan/EIS describes a reasonable range of alternatives, characterizes the affected environment, and presents a detailed analysis of environmental consequences of the alternatives.

The EIS includes a no-action alternative and five action alternatives for managing ORV use on nine trails in the Nabesna District of WRST. Each action alternative presents a different means of meeting the purpose and needs through various combinations of trail improvement, trail administration, and identification of other trail opportunities. The alternatives and impacts are summarized below:

- Alternative 1 (No Action): Significant environmental issues include moderate, adverse impacts to soil, wetlands, vegetation, fish habitat, and wilderness. Socioeconomic effects would be beneficial.
- Alternative 2 (Permit Recreational ORV Use): Environmental issues include major impacts to soil, wetlands, and vegetation, and moderate impacts to fish habitat and wilderness. Socioeconomic effects would be beneficial.
- Alternative 3 (No Recreational ORV Use): Impacts to soils, wetlands, vegetation, fish habitat, and wilderness would be moderate, and impacts to recreational ORV users would be moderate to major. Effects to non-motorized users, socioeconomics, and natural soundscape would be beneficial.
- Alternative 4 (Improve Trails, Permit Recreational ORV Use in Preserve): Environmental issues include moderate impacts to wildlife and subsistence, and major impacts to wilderness character. Effects to trail condition, visitor opportunities, and socioeconomics would be beneficial.
- Alternative 5 (Improve Trails, Permit Recreational ORV Use on Improved Trails – **Preferred Alternative**): Environmental issues include moderate effects to wildlife, subsistence, and wilderness character. Effects to trail condition, visitor opportunities, and socioeconomics would be beneficial.

The Plan/EIS considers the environmental consequences of each of the five alternatives, evaluating the direct, indirect, and cumulative impacts and comparing them to existing conditions. The cumulative impact assessment outlines overall impacts resulting from past, current, proposed, and reasonably foreseeable management and other actions. The analysis intends to guide the decision-maker in choosing a management action based on an objective understanding of environmental consequences. NPS analyzed potential effects to the following environment areas and impact topics:

- Physical Environment: Soils and trail condition;
- Biological Environment: Wetlands, vegetation, water quality and fish habitat, and wildlife; and
- Human Environment: Scenic quality, cultural resources, subsistence, wilderness, visitor opportunities/access, socioeconomics, and natural soundscapes.

Following this analysis, the EIS directed the Park to take action on the preferred Alternative 5 (Improve Trails, Permit Recreational ORV Use on Improved Trails).

During the 90-day public comment period on the DEIS, which included public meetings and briefings, NPS received 153 comment letters. NPS responses to public comments were included in the Final Environmental Impact Statement Nabesna Off-Road Vehicle Management Plan (FEIS) published in August 2011. The FEIS describes major impacts to soils, wetlands, and vegetation associated with ORV use on unimproved trails. It also describes moderate to major impacts to wilderness character associated with subsistence ORV use in designated wilderness.

The FEIS proposed an additional Alternative 6, which responded to public comment on the DEIS and combines Alternatives 4 and 5. Under Alternative 6, all nine trails would be improved to at least a maintainable condition through trail hardening, tread improvement, or constructed re-routes.

Alternative 6 proposed that until improvements were completed, recreational ORV use would only be permitted on trails in fair or better condition (see Figure 4). Subsistence ORV use would continue but would be subject to monitoring and management action if resource impacts increase. On the trails in the designated wilderness, subsistence ORV users would be required to stay on designated trails with allowance for game retrieval. In designated wilderness, subsistence user restrictions would be accomplished by closures pursuant to 36 CFR 13.46. Following those improvements, recreational ORV use would be permitted on trails in the National Preserve (Suslota, Caribou Creek, Lost Creek, Trail Creek, and Reeve Field trails), but not those in the National Park (Tanada Lake, Copper Lake, and Boomerang trails).

2011 Record of Decision

On December 14, 2011, the Regional Director signed a Record of Decision (ROD) which identified a preferred alternative (Alternative 6) in the FEIS as the selected action. The ROD closed the damaged trails to recreational ORV use until the trails could be rebuilt and the impacts from ORV use could be mitigated. The ROD followed a four-year planning process, including extensive public involvement in which NPS held and attended public meetings with stakeholders to discuss the ORV Management Plan/EIS. They met with other federal agencies, state agencies, Native corporations, Tribal councils, environmental organizations, citizens groups, and subsistence advisory bodies.

The selected action provides continued opportunities for appropriate and reasonable access to backcountry recreation. It also accommodates subsistence use, maintains access to private inholdings, enhances non-motorized opportunities, and protects scenic views, fish and wildlife habitat, and other resources and values of WRST. Under the selected action, NPS sought to improve the most degraded segments of ORV trails in the Nabesna District through trail re-routing or reconstruction to a design-sustainable or maintainable condition (as defined in the FEIS). A design-sustainable or maintainable condition ensures that ORV users can stay on one trail alignment and that damage to soils, watersheds, vegetation, and other resources are minimized while providing reasonable access.

The selected action identified in the ROD included actions for the improvement of 64.6 miles of motorized trail with a combination of re-routes and reconstruction, as shown in Figure 4 on the following page. The FEIS estimates that each of the improved trails in the National Preserve will have between 50 and 180 ORV round trips per year, most of these occurring during hunting season. The ROD also included actions to construct six new trails that were to be used by non-motorized users and to apply impact standards to unimproved trails or trail segments to ensure resource impacts do not expand and resource impacts associated with off-trail motorized use are minimized. In all, the non-motorized additions would add 62.2 miles of new trails to the park. Once improvements are in place, recreational ORV use would be permitted on trails in the National Preserve but not trails in the National Park (Tanada Lake, Copper Lake, and Boomerang). Subsistence ORV use would continue on improved and unimproved trails in the National Park and National Preserve, subject to monitoring/management actions described in the ROD.

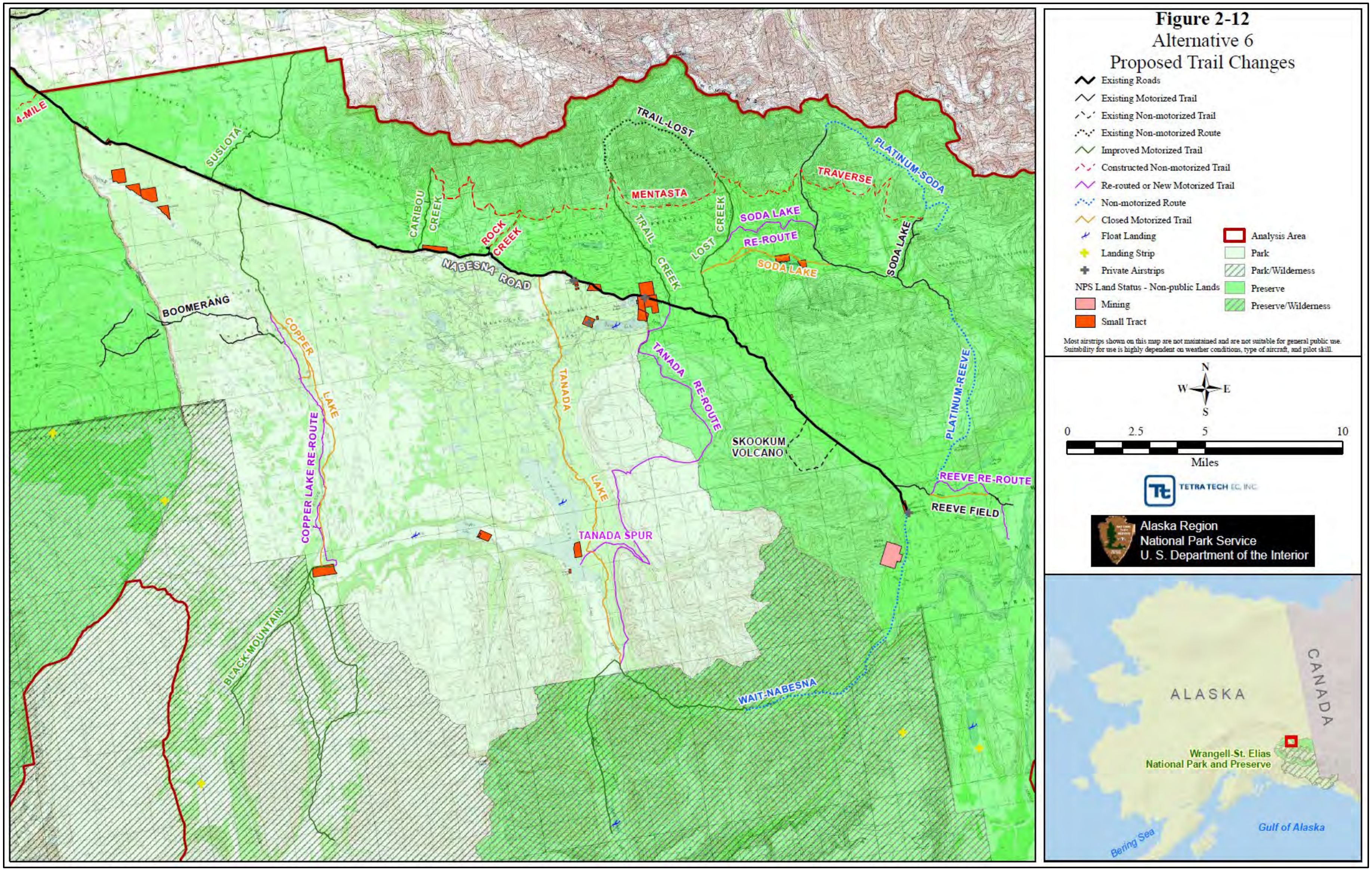


Figure 4: Alternative 6 Proposed Trail Changes (Source: NPS)

The ROD notes that the establishment of an ORV Management Plan for WRST is a necessary step to address transportation and access issues according to the General Management Plan, as well as to address the impacts to park resources that are occurring due to ORV use in the Nabesna District. A successful Management Plan would address and mitigate resource impacts while still providing access for motorized and nonmotorized users of Park and Preserve lands. All practical means to avoid or minimize environmental harm have been adopted. The actions described in the ROD will not impair park resources or values, and in fact will enhance the ability of all users to enjoy park resources in a manageable and sustainable manner.

2014 Final Rule

NPS published the proposed rule for the management of ORV use in the Nabesna District of WRST at 79 FR 2608 (January 15, 2014). Comments were accepted through March 17, 2014, and NPS received nine comments. A summary of comments and NPS responses is provided in the final rule. Several comments supported the proposed rule and did not request any change. After considering the public comments and after additional review, NPS did not make any substantive changes in the final rule. The rule amends the special regulations for WRST at 36 CFR Part 13 Subpart V, to implement the selected action in the ROD. The final rule is supported by the Nabesna Off-Road Vehicle Management Plan/Environmental Impact Statement and Record of Decision.

Pursuant to 36 CFR 4.10(b), the rule designates six trails in the National Preserve for recreational ORV use. Recreational ORV users are required to obtain a permit to use the designated trails. Permits are issued only for frozen trails or trails in a design-sustainable or maintainable condition, as determined by the Superintendent. The rule requires that subsistence ORV users stay on trails or within trail corridors in the FEIS Wilderness Area. It also establishes vehicle weight and size limits to protect park resources.

ORV Trail Work Completed Since 2014

In response to the 2014 Final Rule and in accordance with the direction set forth in the Nabesna Off-Road Vehicle Management Plan/Environmental Impact Statement and Record of Decision, WRST has advanced a variety of trail construction and maintenance techniques to improve ORV access within the Park and Preserve. Many of the trail construction and management methods profiled in the following sections are described in more detail in the USDA Forest Service's publication *Designing Sustainable Off-Highway Vehicle Trails – An Alaska Trail Manager's Perspective.* **Appendix B - Nabesna District ORV Trail Status** provides additional information on use, condition, and work completed for each ORV trail.

Trail Construction Methods

Gravel

WRST prefers to use gravel, where feasible, for trail maintenance as it is highly effective with limited environmental impacts. Before and after pictures showing gravel use in trail construction for the Caribou Creek Trail are shown in Figure 5. WRST spent over $400,000 between 2011 and 2019 on contracting gravel deliveries from private-sector vendors. The NPS must either mine gravel from limited sources within the park boundaries or import from outside sources. Importing gravel poses additional challenges due to the high cost ($70/yard for pit run, including delivery), significant environmental impact from long-distance transporting, potential risk of invasives (both natural and archaeological) and damage to roads and trails from heavy dump trucks making multiple delivery trips.

Figure 5: Gravel Use in Trail Construction for Caribou Creek Trail before (left) and after (right). Source: NPS

Please note that this trail is located on the north side of the Nabesna Road, where soils are generally better for trail building and WRST can often use gravel as the sole construction materials without combining it with other materials or methods.

DuraDeck

DuraDeck is a synthetic-surface matting material that WRST used on Copper Creek Trail. Before and after photos showing DuraDeck applications for Copper Creek Trail are depicted in Figure 6. This maintenance technique is expensive and heavy, and therefore difficult to transport into backcountry areas. It works well for straightaways, but custom-cut DuraDeck or layering is required for horizontal curves. Additionally, light-colored DuraDeck must be used to prevent permafrost melting, but due to associated visual impacts, a combination of materials methods, such as gravel, GeoFabric, etc., must be used. Lastly, ORV hitches often bump against the DuraDeck surface, causing water and mud to seep through DuraDeck joints and pool on the surface. Recurring maintenance is expensive and burdensome; maintenance over 20 years would cost the same as re-installation.

Figure 6: DuraDeck used in trail construction for the Copper Lake Trail before (left) and after (right). Source: NPS

Unfilled GeoBlock

GeoBlock is a type of geosynthetic material that is commonly used for trail construction and erosion control. It is made of a high-density polyethylene and is designed to be a durable, lightweight, and flexible material that can withstand heavy use and harsh environmental conditions. GeoBlock typically comes in the form of interlocking panels that can be easily assembled into a "GeoTrack" configuration (shown in Figure 7) or a "full width" path configuration (shown in Figure 8).

This treatment is used in wet/soft soil conditions and vegetation disturbance is minimal. The open, elevated geo-block grid allows vegetation to grow through and provides cross drainage.

Figure 7: Example of a "GeoTrack" used in trail maintenance on Kodiak Island. Source: GeoChem, Inc.

GeoBlock with Gravel

GeoBlock with gravel was used for approximately 600 feet of the Copper Lake Trail as part of a volunteer project in 2012. By 2019, the treated portion of the trail was showing signs of failure, as shown in Figure 8. As of 2023, this segment is in fair to poor condition. Fill material has migrated/been lost over time, especially on turns and corners. There are a few panels that are starting to deform/deflect. GeoBlock with gravel was also used for approximately 1,500 feet of the Soda Lake Trail in 2012. Since then, the majority of filled GeoBlock has failed on the Soda Lake Trail and crews have replaced approximately 1,100 feet. GeoTrack is not recommended. Cheaper methods of using geofabric and gravel fill for tread hardening are more preferable than GeoBlock (filled or unfilled). GeoBlock makes subsequent repair/rehab very costly and difficult. This method uses solid GeoBlock grids topped with four to six inches of gravel, which reduces wear and tear on the GeoBlock material but also reduces cross-drainage.

Figure 8: GeoBlock infilled with gravel used in trail construction for the Copper Lake Trail during construction (left) and after (right) (Source: NPS)

Please note that this trail is located on the south side of the Nabesna Road, where the terrain is generally boggier and WRST must often use gravel as one of several construction materials combined with a number of other materials / methods. This 600-foot section of the trail was completed in 2012 and was began to show signs of failure in 2019.

Geotextiles

Geotextiles are a type of fabric material commonly used in trail construction and maintenance to improve the durability and longevity of the trail. They are typically made from synthetic materials and are designed to have high resistance to environmental factors like moisture, UV rays, and temperature fluctuations. Geotextile has been used on Copper Lake Trail, Soda Lake Re-Route, and Caribou Creek Trail, underneath a top layer of gravel, to improve the condition of the trail and prevent erosion. It is also permeable, so there are minimal drainage impacts. This treatment has been moderately successful. Geotextiles used to elevate and confine fill material have proven more cost effective and maintainable than geoblock segments. Success is variable in very wet/sensitive environments due to highly variable permafrost melt and high volumes of fill necessary to maintain tread geometry to shed water.

Bench Cuts

Bench cuts are a common technique used to create a level and stable walking surface on a sloping hillside. It involves cutting into the side of a hill at a slight angle, creating a level "bench" or platform on which the trail can be constructed. Bench cuts have been used on Soda Lake Re-Route, Copper Lake Trail, and Caribou Creek Trail. An example for the Copper Lake Trail is shown in Figure 9. Heavy brushing and tree removal are required before construction can begin. Cuts consist of full bench cuts, sidecast, and compacting the outside of the trail sub-base. Exposed tread is then compacted. The outside compacted vegetated edge provides for runoff filtering of exposed tread and cutslopes. Bench cuts are challenging with permafrost and are dangerous with very unstable, steep slopes, and can result in erosion.

Figure 9: Bench cut used in trail construction for the Copper Lake Trail during construction (left) and after (right) (Source: NPS)

Ditch and Elevate

In the "ditch and elevate" method, vegetation is removed and an excavator "ditches" native soil on either side of the trail and "elevates" the tread by placing the native soil on the existing trail area to allow for drainage. Excavated material is spread along the trail, and once the native soil has drained sufficiently, the trail is compacted to support vehicle use. Drainage is provided off the trail tread via the parallel ditches. Ditch and elevate was used for a 1,300-foot section of the Caribou Creek Trail in order to install a vegetated parallel drain and an elevated tread surface in preparation for a synthetic tread treatment. This method works in some locations, but can cause cross-drainage impacts and trail erosion.

Bridges

For major water crossings, bridge installation should be a consideration. Determining whether a bridge is needed will depend on various factors, including cost and environmental impact. A 70-foot fiberglass bridge was installed over Tanada Creek on the Copper Lake Trail in 2012. The Tanada Creek bridge is in good condition as of 2023. There is a braid of Tanada Creek that has become increasingly problematic, however. The braid separates from the main channel of Tanada Creek approximately 1.5 miles above the current bridge and segment of trail that it crosses approximately .4 miles north of the bridge, often becoming impassable during high water. Another bridge may be necessary to address this hazard.

Drainage Structures

Drainage structures have been used on Soda Lake Re-Route, Copper Lake Trail, and Caribou Creek Trail. They are used in spot or lateral application where mud or muck holes exist, generally in flat areas where there is limited or no drainage and reduces ORV impacts to the trail tread. The structure is sized accordingly to remove or store water from most rain events away from the trail tread. The average size is approximately six feet wide, 16 feet long, and four feet deep on either side of the trail. Material from the excavation is utilized to raise the trail tread to direct water flow. Drainage structures require minor vegetation removal, excavation, and displacement of soils, which results in the alteration of drainage patterns.

Arched Culverts

Arched culverts have been installed on Copper Lake Trail and the Caribou Creek Trail. They are utilized in areas where water is flowing and drainage is required. They are made of lightweight polymers in 7.5-foot segmented sections. A 6-foot cap of native surface would be covered with a tensor grid for added strength and an overcap of four to six inches of gravel. Arched culverts are less affected by freeze-thaw conditions than other methods. Vegetation disturbance is limited to material excavation needed to cover the culverts, but there is no disturbance of the water course and it allows for cross-drainage.

"Do Nothing"

WRST has not repaired or rehabilitated the following trails: Trail Creek Trail, Lost Creek Trail, Suslota Lake Trail, Reeves Field Trail, and Tanada Lake Trail. The "do nothing" method is appropriate where the existing trail tread is durable and allows adequate drainage.

Elevated Trail

WRST does not currently have any elevated ORV trails, but has considered various options. The park considered elevated trails on helical piles, like Potters Marsh in Anchorage, as shown in Figure 10, and these typically last 20 to 40 years, depending on climate change impacts. However, the park eliminated this option due to its high ongoing maintenance costs and the inability for hunters to exit the trail to retrieve their hunting game. The park has also considered a trail on pylons with rigid foam insulation for Suslota Trail, but this would pose a significant cost barrier.

Figure 10: Elevated trail on helical piles from [Potter's Marsh, Anchorage Coastal Wildlife Refuge](). (Source: NPS)

Additional Construction Challenges

The transport of materials and crew to work sites often causes more damage to the trail than the users themselves. Materials staging, or the process of gathering and storing necessary materials prior to construction, also poses challenges due to limited space available, weather condition risks, and environmental impacts. Lastly, staff capacity and housing availability is a significant barrier to trail construction. The construction of Copper Lake Trail used two rotating crews of six seasonal staff, which was insufficient staff to complete all expected work. The extent of cyclic maintenance work would be sufficient work for 30 seasonal employees, but current housing facilities can only support a maximum of approximately 16 seasonal staff. Alternatively, ongoing trail maintenance could potentially be contracted out.

Preliminary Engineering Assessment of Gravel Source Potential

The most critical task of the Phase 1 Strategic Transportation Study was a Preliminary Engineering Assessment of the Nabesna District ORV trails and minor roads to identify and verify potential sources of gravel material. The following section offers a high-level summary of the relative aggregate potential analysis and findings. For a more detailed discussion on the Preliminary Engineering Assessment methodology and results of the desktop landform mapping, interpretation, and analysis, see **Appendix C - Preliminary Engineering Technical Memorandum**.

Determining Relative Aggregate Potential

Utilizing several existing geospatial datasets, a relative aggregate potential (RAP) model was developed that assigned qualitative rankings for potential of each landform type of to contain quality aggregate for use in the construction and maintenance of roads and off-road vehicle (ORV) trails within the park. Laboratory testing data from aggregate samples taken by the Alaska Department of Transportation and Public Facilities (AKDOT&PF) during a 1994 subsurface geotechnical investigation provided an invaluable opportunity to test RAP assumptions by comparing actual aggregate quality to mapped RAP.

Corridor	Total Area Mapped[1] (acre)	Percentage Area by RAP[1,2,3]				
		High	Mod. High	Mod.	Mod. Low	Low
Nabesna Road	---	---	---	---	---	---
Sec.1 MP 0.5-6.95	3,587	15%	**49%**	18%	15%	3%
Sec.2 MP 6.95-17.5	8,570	1%	2%	6%	**91%**	0%
Sec.3 MP 17.5-28.0	8,618	6%	0%	**72%**	22%	0%
Sec.4 MP 28.0-43.0	13,446	**68%**	3%	5%	21%	4%
Caribou Creek Trail	3,260	31%	1%	**41%**	23%	4%
Trail Creek Trail	6,118	**42%**	8%	11%	32%	8%
Lost Creek Trail	5,556	34%	1%	18%	**41%**	6%
Soda Lake Trail	8,578	15%	5%	16%	**61%**	4%
Reeves Field Trail	4,089	27%	0%	1%	**65%**	6%
Copper Lake Trail	29,682	**42%**	9%	4%	38%	8%
Tanada Lake Trail	9,891	14%	2%	22%	**60%**	1%

[1]Area calculated where 1.243-mile road and trail mapping buffer overlaps area of lidar coverage within Wrangel St. Elias National Park and Preserve boundaries and excludes areas of standing water.

[2]Relative aggregate potential (RAP) ranking categories: High = 3, Moderately high = 2.5, Moderate = 2, Moderately low = 1, and Low = < 1.

[3]**Bold** number indicates highest ranked percentage of RAP for each corridor.

Table 1: Relative Aggregate Potential (RAP) by percentage of area mapped within specified road or trail corridors in Wrangell-St. Elias National Park and Preserve

Overall, the RAP model generally correlated well with aggregate quality testing from AKDOT&PF's 1994 subsurface investigation. There were instances where the RAP model appeared to both over- and under- estimate aggregate potential. However, the model appears to reasonably represent aggregate potential in mapped areas. Table 1 and Figure 11 provide an overview of the percentage of mapped RAP, by area, of selected corridors. For a more detailed discussion on methodology and results of the desktop mapping and analysis, see **Appendix C**. Assuming highest quality aggregate sources are comprised of landforms with moderate to high RAP, corridors can be ranked by summing percentages of those areas to determine which sources should be prioritized for additional investigation. As shown in Table 2, the Nabesna Road corridor has the highest probability of producing quality aggregate for use in road and trail construction and maintenance.

Rank	Corridor	Percentage[1]
1	Nabesna Road Section 1	82
2	Nabesna Road Section 3	78
3	Nabesna Road Section 4	76
4	Caribou Creek Trail	73
5	Trail Creek Trail	61
6	Copper Lake Trail	55
7	Lost Creek Trail	53
8	Tanada Lake Trail	38
9	Soda Lake Trail	36
10	Reeves Field Trail	28
11	Nabesna Road Section 2	9

[1]Sum of areas of moderate to high RAP

Table 2: Corridors ranked by the sum of percentage of area mapped as moderate to high Relative Aggregate Potential (RAP)

A 2002 memo from AKDOT&PF indicated a need for 520,000 yds^3 of aggregate (safety factor of 1.2 for 650,000 yds^3) and 20,000 yds^3 of riprap (safety factor of 2.0 for 40,000 yds^3) to reconstruct and maintain Nabesna Road. To provide a sense of scale for WRST aggregate needs and potential resource volumes available, an estimate of potential aggregate volume was made for a landform located three-quarters of a mile east of the Caribou Creek trailhead near MP 12.5, which was mapped as having high RAP. The landform contains an estimated volume of 5.3 million yds^3 (for further information, see **Attachment H – Example Landform Aggregate Volume** in **Appendix C**). This single landform could provide nearly ten times the volume required for Nabesna Road alone. Although results suggest sufficient potential and volumes for quality aggregate along Nabesna Road, they also indicate significantly lower potential along trails. This may indicate substantial haul distances would be required to move material from Nabesna Road to surrounding trails within WRST.

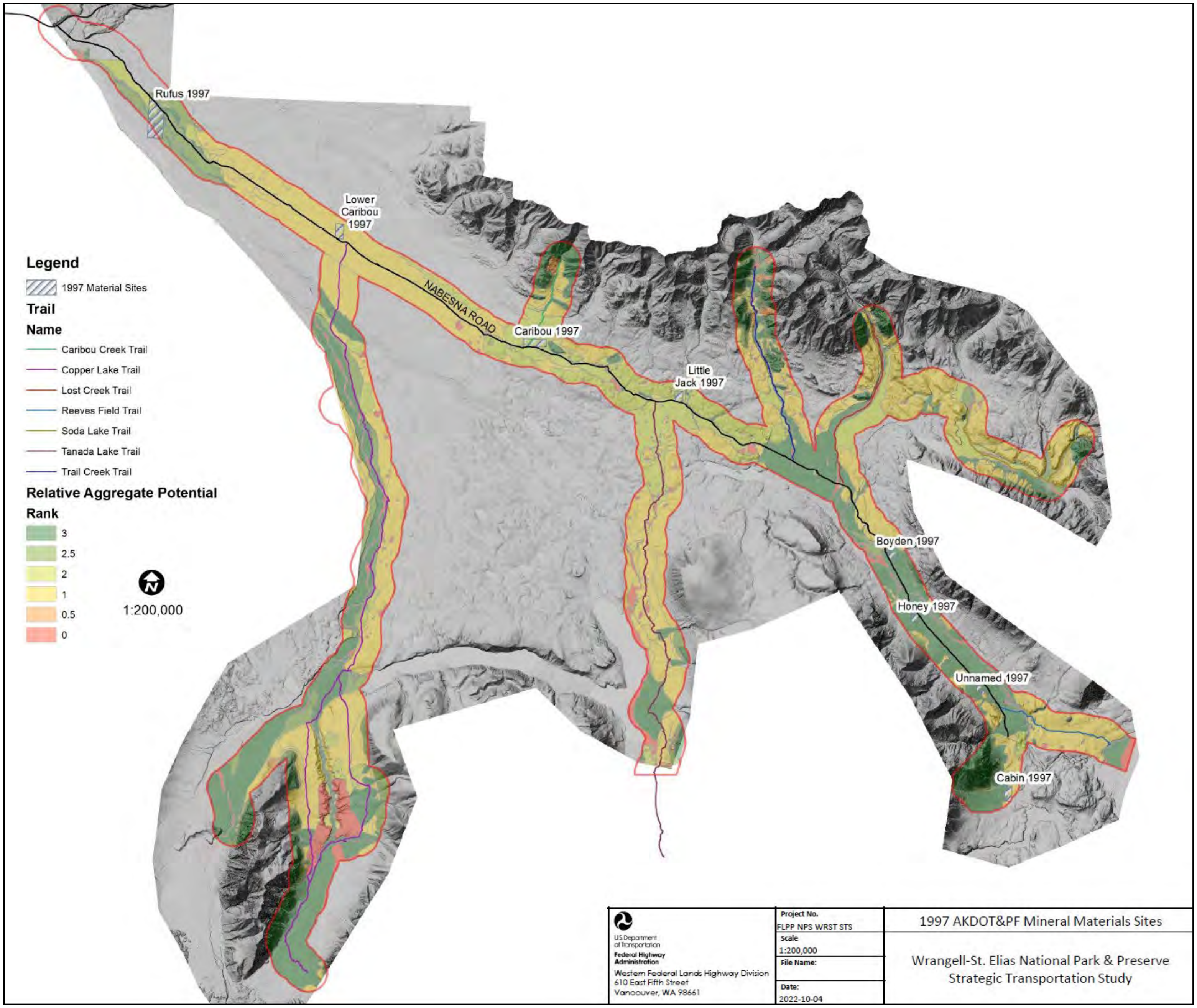


Figure 11: Relative Aggregate Potential Overview

Given significant quantities of readily replenished material available along the approximately 3.5-mile-wide coalescing alluvial fan deposited by Trail and Lost Creeks, vicinity to area roads and trails, and potential ease of excavation, it is recommended that further testing of aggregates occurs at this location to determine suitability for use in building and maintain roads and trails in WRST. WFLHD also recommends testing of alluvial fan deposits located along Jack Creek, as these could also be an important source of material for reconstruction of the Nabesna Haul Road and for proposed future CERCLA cleanup of the Nabesna Mine.

In subsequent efforts related to aggregate source planning, existing landform mapping could be used to develop relative geologic risk maps (based on geohazards, existing stability concerns, permafrost, high groundwater conditions, poor soils, etc.) for maintaining existing alignments or constructing proposed realignments. Additional mapping would be required as part of any effort to determine the geologic risks described above. Relative geologic risk mapping can be used to highlight areas that present lower or higher risk to proposed or existing transportation infrastructure. Further, a relative geologic risk map could be used for planning purposes by comparing relative geologic risk and associated costs of various alignment options. Typical road and trail design sections can be developed to reduce risk to infrastructure from specific geological risk areas. For example, when alignments (existing or proposed) cross different mapped relative geological risk areas, the most resilient typical design section could be applied/used. For estimating purposes, a road or trail section cost per lineal foot and the approximate construction quantities for each design section could be determined, as well as anticipated maintenance costs. Under this approach and methodology, comparisons of options can then be more easily understood and made to inform decision-makers on road and trail maintenance within WRST.

It was communicated to WFLHD that the Tanada Lake trail is under consideration for realignment. Its current location is within low-elevation muskeg terrain, which is incredibly challenging for a hardened trail to be maintained. As such, a higher-elevation option is being considered. Additional RAP geologic risk mapping/modelling could be used to consider potential aggregate sources and their relative quality during preliminary realignment planning.

Multi-Agency Coordination

Maintaining vehicular and ORV access within the Nabesna District is a complex undertaking. Effective coordination between the Park Service, AKDOT&PF, and impacted community members is critical to ensure successful planning and implementation of any improvements to the transportation system. Multi-agency coordination occurred throughout the STS Phase 1 effort to leverage expertise, resources, and knowledge on gravel materials sourcing. The following sections describe the primary coordination activities that took place.

Project Site Visit and Technical Review Meeting – July 2022

The NPS, WFLHD, and USDOT Volpe Center conducted a project site visit in the Nabesna District to observe and document the existing characteristics of the corridor. The site visit also included a technical review meeting where WFLHD engineers presented initial findings from the desktop landform mapping analysis and field verification. Discussion and follow-ups from the project site visit are included as **Appendix D – July 2022 WRST Site Visit Summary**.

Alaska Project Coordination Meeting – November 2022

The WFLHD project delivery team presented on the STS Phase 1 methodology at the 2022 Alaska Transportation Working Group (AK TWiG) Project Coordination meeting. The AK TWiG brings together federal land management agencies (FLMAs) in Alaska to share and collect data, coordinate on project programming and delivery, and support new research and planning efforts. The AK TWiG includes representative from:

- the Federal Highway Administration,
- US Fish and Wildlife Service,
- National Park Service,
- US Forest Service,
- Bureau of Land Management,
- Alaska Department of Transportation & Public Facilities,
- Alaska Municipal League,
- Bureau of Indian Affairs,
- Denali Commission,
- Fairbanks Area Surface Transportation Metropolitan Planning Organization (MPO), and
- Anchorage Metropolitan Area Transportation Solutions MPO.

Once a year, the AK TWiG hosts a Project Coordination Meeting to discuss planned projects for the Working Group and identify areas of potential collaboration.

Gravel material sourcing is a challenge for the FLMAs, AKDOT&PF, and local governments, and it was featured as a “hot topic” for discussion during the 2022 Project Coordination Meeting. The session began with a discussion of AKDOT&PF’s gravel needs and ended with a presentation by the WRST Strategic Transportation Study project team. The following sections summarize the multi-agency discussions that took place during the Project Coordination Meeting.

Gravel Sourcing Discussion

A representative from AKDOT&PF provided an overview of how the agency currently sources gravel for capital and maintenance projects. If a gravel need is identified, a materials engineer will review a geologic map to see where material potential may be located. Ideally, a gravel pit is available every 20 miles across the state highway system. The general cost estimate for procuring and transporting gravel is $1 per ton of material per mile. There are three tiers of gravel needs for AKDOT&PF:

1) **Large Capital Projects**, or any projects greater than $1 million;
2) **Small Capital Projects**, or any project between $500,000 and $1 million (from maintenance and operations); and
3) **Low Tier Maintenance**, or pothole fixes, winter sand, and post-winter ditch graveling. Field crews will source this one dump truck at a time.

Once a potential source location has been identified on the geologic map, AKDOT&PF considers the landowner. The easiest alternative is when the land is owned by the Alaska Department of Natural Resources (DNR). In this situation, DNR has to designate a site as a materials source and complete a public review of the site. Once approved by DNR, the site can be used for gravel sourcing. Materials sourcing is more complicated when the land is owned by a Native corporation or a federal land management agency.

AKDOT&PF is responsible for the maintenance of Nabesna Road within WRST and would like to identify two materials sites along the corridor. The most promising locations are at MP 4.5, 12, and 34.5. In Summer 2023, AKDOT&PF intends to take a crew out to do more testing at those sites and will need to coordinate with the NPS.

In addition to gravel, AKDOT&PF noted that it would be beneficial to identify a local rock source. A couple of potential source sites had a thin overburden with bedrock closer to the surface. One option to improve the ORV trails is to use a “low water” rock, or riprap, and build on top of that. The town of Alyeska has successfully used this technique. The rocks help to keep the permafrost intact. If there is a rock source within a practical distance, it could be a viable option. The closest option at present is a quarry at MP 49 on the Tok cutoff.

Conclusion and Next Steps

Using the relative aggregate potential findings from the *Phase 1 - Gravel Material Source Assessment*, the NPS and its partners can move forward with the next phase of the Strategic Transportation Study (STS). The Phase 2 effort will focus on developing planning-level cost estimates and ORV standard trail designs in alignment with the 2011 ORV Management Plan actions. Additional considerations for the next phase of the STS include:

- A cost-benefit analysis of maintaining the Nabesna District ORV trails in year-round accessible conditions to determine trail maintenance feasibility and update planning and compliance documents accordingly;
- Best management practices for sustainable ORV trail management;
- Further investigation of high aggregate potential sites to understand the "downstream impacts" of harvesting material within WRST (e.g., environmental impacts, hydrological impacts, etc.) and other sensitivities around material extraction/processing within a National Park; and
- Coordination with AKDOT&PF on corridor-wide gravel needs.

The WRST Nabesna District is characterized by three discrete but related challenges: addressing ORV trail maintenance and access priorities per the EIS Record of Decision, maintaining Nabesna Road as a primary corridor within the National Park and Preserve, and anticipating impacts from the Nabesna Mine Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) clean-up. The gravel materials source analysis and findings from this Phase 1 STS will be an important data-driven resource for the NPS as it plans for the future of the Nabesna District.

APPENDIX A – SUMMARY OF PREVIOUS PLANS AND STUDIES

A number of plans and studies have been completed that relate to the WRST Strategic Transportation Study Area. These documents set the stage for the existing and anticipated conditions within WRST and the Nabesna Road corridor, and offer important context for the consideration of ORV trails and minor road improvements. Bolded documents are summarized in detail on the following pages.

State-Level

- **2023 - Alaska NPS Region Drop-Down LRTP**
- **2022 - Alaska Department of Transportation & Public Facilities (AKDOT&PF) LRTP**
- **2019 - Alaska Federal Lands Collaborative Long-Range Transportation Plan, 2020-2040**

Unit-Level

- 2023 – WRST Fire Management Plan
- **2019 - GravelFest**
- 2017 - WRST Foundation Document
- 2016 - WRST State of the Park
- 2016 - WRST Park Atlas
- 2014 - Climate Change Scenario Planning for Central Alaska Parks (NPS)
- 2014 - WRST Wilderness Character Narrative
- 2011 - WRST Natural Resource Condition Assessment
- 2010 - WRST Fire Management Plan
- 2008 - Field Validation Report: WRST ORV Vegetation Mapping
- 2003 - Delineation and Attribution of Wrangell Saint Elias Park and Preserve Off-Road Vehicle Trails and Vegetation
- **2002 - WRST Nabesna Road Scenic Corridor Plan**
- **1998 - AKDOT&PF Nabesna Road Location Study – Material Site Locations Study and Associated Memo**
- 1986 - WRST General Management Plan, Land Protection Plan, and Wilderness Suitability Review

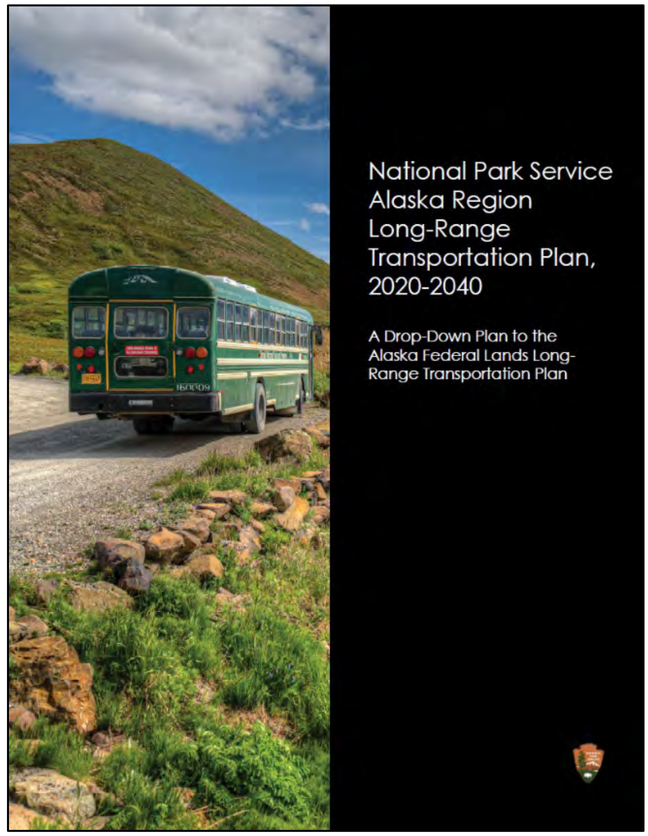
National Environmental Protection Act (NEPA) Documents

WRST NEPA reviews and findings include:

- **2017 - Copper Lake Trail Improvements and Private Land Bypass Re-Route Finding of No Significant Impact (EA and FONSI)**
- **2012 - Nabesna Off-Road Vehicle Management Plan Final Environmental Impact Statement and Record of Decision (FEIS and ROD)**
    - 2011 - WRST Wilderness Eligibility Reclassification, Nabesna ORV
- 2000 - Donated Property Along the Nabesna Road Finding of No Significant Impact (EA and FONSI)
- 1983 - Natural and Cultural Resource Management Plan and Environmental Assessment (EA and FONSI)

State-Level Plans and Studies

National Park Service Alaska Region Long-Range Transportation Plan, 2020-2040 (tent. 2023)



The NPS Alaska Region LRTP provides NPS-specific strategic priorities and strategies to achieve the mission, goals, and objectives established in the CLRTP. It includes existing baseline conditions, identified transportation deficiencies and system needs, projections for strategic desired improvements, and a summary of possible funding sources. This information allows other Federal land management agencies (FLMA) participating in the Alaska Federal Lands LRTP to identify gaps in the statewide transportation network that serves Federal public lands and to develop better interagency coordination in leveraging project funds and addressing high-level priorities.

The LRTP outlines strategic priorities that align CLRTP goals and objectives to NPS AKR's progress and needs. This includes **developing a road preservation program to ensure that paved and unpaved road surfaces are preserved through regular preventative maintenance measures**. Additionally, the LRTP establishes strategies to achieve objectives for each CLRTP goal area. Regarding gravel, the LRTP recommends continuing to **consider gravel roads as high priority assets**, collaborating with partners to **identify opportunities for local gravel sources**, and using the results from the 2019 FLH Road Inventory Program to **identify roads vulnerable to extreme weather and establish a plan to address these vulnerabilities**. With respect to ORVs, the LRTP notes the negative impacts of ORVs on park resources and recommends continuing to **study, document, and invest in managing ORV and snow machine use**.

Alaska Department of Transportation and Public Facilities Long-Range Transportation Plan (2022)

The Alaska Department of Transportation and Public Facilities (DOT&PF) Long-Range Transportation Plan (LRTP) outlines goals, policies, and measurable actions to inform investment strategies for an adaptable and resilient transportation system. The LRTP presents a transportation for the state that is intended to filter down to other transportation plans in the state, some of which are already in place and others are still in development. The LRTP does not provide any gravel- or ORV-specific existing conditions or recommendations, and instead focuses on state-wide goals that apply to all modes and users and identifying partners, programs, and practices to achieve those goals.

Alaska Federal Lands Collaborative Long-Range Transportation Plan (2019)

Alaska's multimodal transportation system provides critical links to connect local residents and visitors with their Federal lands and, in many cases, allows for inter-village travel and subsistence use. Understanding the connection between transportation and conservation, the Alaska Federal Land Management Agencies (FLMAs) have established mission, goals, and objectives to serve as benchmarks for evaluating improvements to the transportation system as part of the Alaska Federal Lands Collaborative Long Range Transportation Plan (CLRTP). Together with an understanding of existing transportation infrastructure deficiencies in the state of Alaska, this plan enables FLMAs, individually and collectively, to make better decisions regarding the most critical needs.

The CLRTP includes a range of high-priority implementation actions to improve transportation coordination and decision-making among the Alaska FLMA partners. With respect to ORV and minor roads, the CLRTP recommends that the FLMAs **complete gravel roads condition assessments to improve condition and contribute to performance management**. The findings from this study will support the goals, objectives, and implementation of the Alaska Federal Lands CLRTP.

Wrangell-St. Elias National Park and Preserve Plans & Studies

WRST Nabesna Road Scenic Corridor Plan (2002)

In 2002, an interagency planning team composed of the NPS, AKDOT&PF, and Alaska Department of Natural Resources prepared a Scenic Corridor Plan for Nabesna Road. The purpose of this Corridor Plan was to identify future road improvements and accommodate future visitors' needs respective to the scenic, cultural, and natural resources in the area. Recommendations from the plan include gravel material and disposal site selection to improve annual maintenance repairs. Nine (9) existing and ten (10) proposed material and disposal sites were evaluated. Additionally, the plan described material site selection criteria to inform future decision-making. Site selection criteria for new material sites include:

- Must meet AKDOT&PF material specifications;
- Must be separated from the road and visually screened by natural vegetation, topography, and/or other accepted means;
- Must be gated and secured from unauthorized access and use;
- Must be aligned to prevent direct views into the materials site from the roadway;
- Preferably should be spaced no more than 10 miles along the road;
- Must complete Section 4(f) analysis if using Federal Highway funds for mining within parks and a determination must be made that there is no feasible and prudent alternative and the action includes all possible planning to minimize harm to the property resulting from such use; and
- A Site Mining Plan must meet environmental requirements and conditions as stipulated by NEPA, NPS, or other requirements;

AKDOT&PF Nabesna Road Location Study – Material Site Locations Study and Associated Memo (1998)

The purpose of Nabesna Road Material Site Locations memo is to summarize discussions between AKDOT&PF and NPS staff in October 1997. The group was "responsible for evaluating proposed material sites along Nabesna Road using geologic features, and assessing possible impacts of developing proposed sites including wetland impacts, hydraulic effects of mining, and possible impacts on cultural resources" for maintenance activities and capital improvement projects for AKDOT&PF and NPS. The memo summarizes types of material required for different maintenance and project needs and establishes material source development criteria:

- Material sites should be located within ½ mile of road.
- Sites should be screened from the road, preferable on the backside of a knob.
- Construction pits must contain Select material, Type A.
- DOT&PF would like the spacing between material sites to be no more than 10 miles with the NPS prefers a greater than 10-mile spacing where feasible.
- Materials sites used for construction and long-term maintenance must meet quality specifications for crushed products.

The memo summarizes material potential at the following sites:

- Rufus Creek, Mile 4
- Lower Caribou Creek, Mile 12

- Caribou Creek, Mile 20.3
- Little Jack Creek, Mile 25.1
- Trail Creek, Mile 29.7
- Lost Creek, Mile 31.4
- Chalk Creek, Mile 32
- Boyden Creek, Mile 34.6
- Unnamed Creek, Mile 37 (formally Honey Creek)
- Unnamed Creek, Mile 40.3
- Skookum Creek, Mile 42
- Cabin Creek, Mile 44

It concludes by noting both agencies should continue material source location discussions, including reconnaissance level drilling and laboratory testing prior to final selections, and an in-depth geotechnical investigation once material sources are selected.

Wrangell-St. Elias National Park and Preserve NEPA Documents

Copper Lake Trail Improvements and Private Land Bypass Re-Route Finding of No Significant Impact (FONSI) (2017)

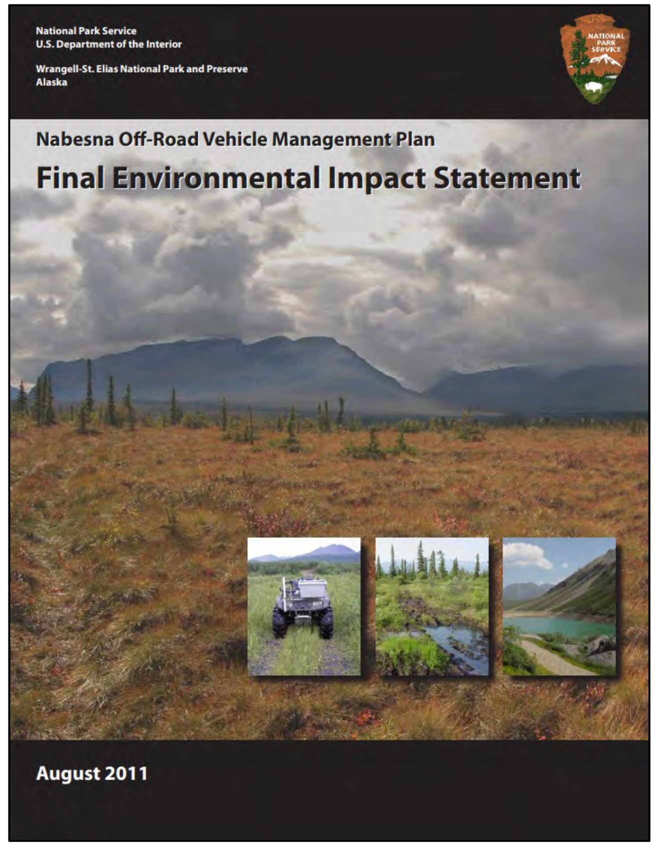
The Copper Lake Trail Improvements and Private Land Bypass Re-Route Finding of No Significant Impact (FONSI) summarizes the proposed improvements to Copper Lake Trail and environmental impacts associated with those alternative actions. In the Record of Decision for the Nabesna Off Road Vehicle Management Plan/Environmental Impact Statement, NPS proposed re-routing the existing Copper Lake trail alignment to bypass a private property that crosses through the trail. NPS considered two alternatives: (A) no action alternative, and (B) the proposed action (NPS preferred alternative) in which NPS re-routes a section of the trail to bypass the private property.

NPS prepared an Environmental Analysis (EA) and selected Alternative B (the NPS preferred alternative) because it maintains access for subsistence users, minimizes impacts over time, reduces the amount of trail braiding due to poor trail conditions, protects park resources, and resolves the issue of private property trespassing by subsistence users. The EA found Alternative B has the potential for impacts on soils, wetlands, vegetation, and scenic quality; however, no potential for significant adverse impacts were identified and an EIS was not required and would not be prepared.

Nabesna Off-Road Vehicle (ORV) Management Plan Final Environmental Impact Statement and Record of Decision (FEIS and ROD) (2011)

The purpose of the Nabesna ORV Management Plan EIS is to "describe a strategy to provide continued opportunities for appropriate and reasonable access to wilderness and backcountry recreational activities, that also accommodate subsistence use and access to inholdings, while protecting scenic quality, fish and wildlife habitat, and other park resource values". There were three reasons for completing an ORV Management Plan:

1. The General Management Plan (GMP) for WRST recognized the need to conduct future planning to address transportation and access issues. Specifically, the GMP recognized that the Alaska National Interest Lands Conservation Act (ANILCA) authorized ORV use for subsistence purpose and access to inholdings within the park under certain circumstances.
2. There is a need to address the impacts to park resources that are occurring because of ORV use in the Nabesna District. Prior studies completed by the park demonstrated that ORV use over wet areas leads to trail braiding and widening, and vegetation does not recover quickly, soils erode, permafrost depth changes, and impacts to surface hydrology occur.
3. There is a need to consider other recreational opportunities and address user conflicts. Because some of the trails where ORV use are degraded, other non-motorized uses (e.g., hiking, horseback riding, and mountain biking) may be discouraged by conditions.



As part of the EIS, the NPS considered five action alternatives and a No Action alternative for managing ORV use on nine trails in the Nabesna District of WRST. The FEIS proposed an additional alternative, Alternative 6, which combined actions from Alternatives 4 and 5. Each action presented a different means of meeting the purpose and need through various combinations of trail improvement, administration, and identification of other trail opportunities.

The FEIS proposed an additional alternative, Alternative 6, which responded to public comment on the DEIS and combines Alternatives 4 and 5. Under Alternative 6, all nine trails would be improved to at least a maintainable condition through trail hardening, tread improvement, or constructed re-routes.

Appendix B – Nabesna District ORV Trail Status

The tables below summarize FEIS actions, existing conditions, and other relevant information for ORV trails in WRST National Preserve and Park.

*Table 3: Summary of FEIS Actions and Existing Conditions for **Suslota ORV Trail** - Located in WRST National Preserve at MP 11 on Nabesna Road*

Actions Identified in 2011 FEIS/ROD	Condition	Use	Trail Work Since ROD
• Trail will be improved utilizing gravel from local sources, GeoBlock installation, and tread improvement. • Improvements will include bridge and puncheon installation at creek crossing SLT-3, and re-routing to a naturally hardened crossing at SLT-1. Improvements will result in a maintainable trail.	• Conditions are generally poor and wet, but can vary with seasonal rains and amount of use. • Travel is difficult due to muskeg, mud bogs, standing water and tussocks.	• Currently closed to recreational ORVs and open to subsistence ORV use. Given conditions, this trail is less desirable for recreational ORV use. Heaviest use is mid-August through mid-September. • Not recommended for hiking. The trail crosses out of the National Preserve and on to State of Alaska land after approximately 8 miles. Suslota Lake is outside WRST boundary and has several privately owned cabins around the lake.	• Work to improve this trail has not been initiated. Improving and maintaining this trail does not seem feasible knowing the challenges of improving Copper Lake Trail.

*Table 4: Summary of FEIS Actions and Existing Conditions for **Caribou Creek ORV Trail** - Located in WRST National Preserve at MP 19.1 on Nabesna Road*

Actions Identified in 2011 FEIS/ROD	Trail Condition	Trail Use	Trail Work Since ROD
• Improvements will consist of major trail hardening utilizing local gravel sources and/or other trail-hardening methods, re-alignment of creek crossings, re-alignment of a sidehill traverse, and re-grading of the upper portion of the trail. These improvements will result in a maintainable trail.	• Trail is generally in good condition, but varies with seasonal rains and amount of use. • Trail surface is dirt and rocky streambeds. Creek crossings can be hazardous when water levels are high. The first portion of the trail is easy but becomes more difficult due to several stream crossings and elevation gain.	• Caribou Creek Trail is currently closed to recreational ORVs and open to subsistence ORVs. • Recommended for hiking. Caribou Creek trail offers outstanding views of the Wrangell Mountains and the Copper River Valley as well as access to hiking in the Mentasta Mountains. There is a public use cabin at the end of the trail.	• In 2014 and 2015, crews installed a vegetated parallel drain and an elevated tread surface to 1300′ heavily degraded wetland segment; later installed Geo-Fabric and full-width GeoBlock onto segment and infilled with imported gravel, and completed “spot” repairs to entrenched mud holes along lower portion of trail • 2014 – 2016 – Several small projects were completed to ditch & elevate, install geoblock and other synthetic

Actions Identified in 2011 FEIS/ROD	Trail Condition	Trail Use	Trail Work Since ROD
			trail hardening, as well as installing gravel for a total of 2,600 ft of trail improvements. • 2019 – WRST Trail Crews re-graded and hardened the remaining segments. Utilizing mechanized equipment, the crew installed 750 cy of imported purchased pit-run gravel to harden degraded segments of travel, adding culverts and integrated water-control features where necessary. The first 0.5 miles of trail has yet to be hardened (the existing tread is of poor quality material installed in 2008) because plans for a better connector trail from the trailhead parking lot to the trail itself, which will likely circumvent around this segment, have yet to be finalized. • 2023 – The Caribou Creek Trail is waiting for plans to be finalized for a connector trail to connect the trailhead parking lot to the trail itself before opening to Recreational ORVs (via permit). • There are a few locations along the trail which may be suitable for small-scale gravel acquisition.

*Table 5: Summary of FEIS Actions and Existing Conditions for **Trail Creek ORV Trail** - Located in WRST National Preserve at MP 29.8 on Nabesna Road*

Actions Identified in 2011 FEIS/ROD	Trail Condition	Trail Use	Trail Work Since ROD
• A single trail alignment will be located, cleared, or marked along or adjacent to the existing gravel route to consolidate travel and minimize stream crossings. Improvements would result in a maintainable trail.	• Generally good over a gravel stream bed. Rain and snow melt can cause dramatic increases in water levels. High water in Trail Creek can make travel hazardous. Users are advised to stay alert for changing weather conditions.	• Trail Creek trail is currently open to recreational ORVs (via permit) and open to subsistence ORV use. • Appropriate for hikers or ORVs. Hikers can continue north up Trail Creek to a pass and cross over to the Lost Creek drainage. It is possible to follow Lost Creek back to Nabesna Road creating a loop trip.	No trail work as described in the ROD has been undertaken on this trail

*Table 6: Summary of FEIS Actions and Existing Conditions for **Lost Creek ORV Trail** - Located in WRST National Preserve at MP 31.2 on Nabesna Road*

Actions Identified in 2011 FEIS/ROD	Trail Condition	Trail Use	Trail Work Since ROD
• A single trail alignment will be located, cleared, or marked along or adjacent to the existing gravel route to consolidate travel and minimize stream crossings. Improvements would result in a maintainable trail.	• Generally good over gravel stream bed and packed dirt. • Follows the Lost Creek stream bed but sometimes enters through the forest adjacent to the creek. Rain and snowmelt can cause dramatic increases in water levels. High water in Lost Creek can make travel hazardous.	• The Lost Creek trail is currently open to recreational ORVs (via permit) and open to subsistence ORV use. • Hikers can reverse the Trail Creek-Lost Creek loop and start at Lost Creek. The recreational ORV trail ends where the stream exits the narrow canyon.	No trail work as described in the ROD has been undertaken on this trail

*Table 7: Summary of FEIS Actions and Existing Conditions for **Soda Lake ORV Trail** - Located in WRST National Preserve at Mile 3 on the Lost Creek Trail*

Actions Identified in 2011 FEIS/ROD	Trail Condition	Trail Use	Trail Work Since ROD
• A re-route will be constructed from Lost Creek to Platinum Creek to avoid private property. This re-route will bypass most of the trail segments currently classed as degraded or very degraded. • These improvements will result in a new 7-mile segment of sustainable trail in uplands and 5 miles of maintainable trail	• Trail conditions are generally fair to good, but varies with seasonal rains and amount of use. • First 3 miles are over hard packed ground.	• Suitable for hiking and ORV use. • The Soda Lake trail was completed in 2012. It is open to recreational ORVs with a permit and open to subsistence ORV use • Recreational ORV trail ends at a campsite on Soda Creek and is marked with a sign. Users can continue on foot to the mineral spring and to Soda Lake.	• In 2012, WRST Trail crews in cooperation with a regional consultant (K.Meyer) and a contractor (USFS – Trails Unlimited) completed the proposed work on the Soda Lake Re-route using a variety of methods including bridging, timber puncheon, GeoBlock in both full-width and

Actions Identified in 2011 FEIS/ROD	Trail Condition	Trail Use	Trail Work Since ROD
along floodplain portions for the balance of the alignment. • Once the re-route is completed, the old trail will be seasonally closed to all motorized uses (except those accessing private land) to allow for vegetation and soils recovery.		• There is private land located on the old trail to Big Grayling Lake.	"GeoTrack" configurations, ditch & elevate, bench construction, & gravel hardening. Later in 2012, the previous Soda Lake Trail alignment was closed to use for all but private in-holder access and the Soda Lake Re-Route was opened for use, including recreational OHV use via permit. • In 2016, WRST Trail crews completed a cyclic maintenance project leading to the replacement of the vast majority of the GeoTrack installations which had experienced widespread failure. The majority of bench construction completed by the contractor in 2012 resulted in too-narrow tread and over-steep back slopes resulting in both backslope and outslope sloughing over time. As a remedy, WRST Trail crews widened the bench and laid back backslopes, harvesting all the usable gravel from those excavations, utilizing it to harden and re-grade segments where GeoTrack had failed. • 2023 – Many segments of geoblock have failed and are being replaced with mineral soil tread hardening techniques. Repair of backslopes and outslopes on the prevalent bench cut segments is ongoing during cyclic maintenance. Highly variable permafrost melting has caused potholding and various small scale

Actions Identified in 2011 FEIS/ROD	Trail Condition	Trail Use	Trail Work Since ROD
			drainage problems along the trail that are also being addressed during cyclic maintenance.

Table 8: Summary of FEIS Actions and Existing Conditions for ***Reeves Field ORV Trail*** *- Located in WRST National Preserve at MP 40.2 on Nabesna Road*

Actions Identified in 2011 FEIS/ROD	Trail Condition	Trail Use	Trail Work Since ROD
• A re-route will be constructed utilizing an old road alignment. This alignment does not currently meet sustainable design guidelines. • Some areas of trail hardening will be required. This re-route will by-pass all trail segments currently classed from degraded to extremely degraded. • Bridges suitable for ORV passage will be constructed at both Jack Creek crossings. • To access the Nabesna River and dispersed camping opportunities, the proposed trail will be extended along the floodplain to the south. These improvements will result in a maintainable trail. • Once the re-route is completed, the old trail section will be seasonally closed to all motorized users to allow for vegetation and soils recovery.	• Travel is difficult due to mud bogs and tussocks. • Trail surface is dirt and corduroy improvements for the first 2 miles, with tussocks and mud bogs for most of the remainder of the trail. • There are two creek crossings that can be hazardous. Trail users should stay alert to changing conditions and rising water levels. • As of 2023, the trail is in fair to poor condition.	• Closed to recreational ORV use and open to subsistence ORV use. Once trail improvements are completed, this trail would be re-opened to recreational ORV use. • The first mile of the trail is an easy hike to Jack Creek. After this, users must cross Jack Creek twice. • The Recreational ORV trail ends at the Nabesna River, but hikers can continue up stream as far as the confluence with Jacksina Creek. • There are two private allotments located adjacent to the Reeve Field trail near Nabesna River. Private property begins shortly after the second Jack Creek crossing. A fifty-foot easement is provided for trail users.	• Improvement of this trail would be an "easier win" given environmental conditions in the area and the amount of work that has already been done to establish a good re-route. • There is a PMIS project developed for this (PMIS #162047) but the cost estimated in the current project will not be enough to finish the trail to meet design standards. The project will need to be re-written or edited and submitted with current planning, design standards, and cost estimates.

*Table 9: Summary of FEIS Actions and Existing Conditions for **Tanada Lake Trail** - Located in WRST National Park*

Actions Identified in 2011 FEIS/ROD	Trail Condition	Trail Use	Trail Work Since ROD
• The trail will be reconstructed to the wilderness boundary utilizing a constructed re-route to the east of the existing trail. • The construction of the re-route will use local gravel sources, construction of a bridge across Jack Creek, some spot hardening, and full-bench trail construction utilizing mechanized equipment. • These improvements will result in sections of sustainable design and maintainable trail. • Once the trail is reconstructed, old, degraded trail segments will be closed to all ORV use to allow vegetation and wetland recovery.	• Travel is generally extremely difficult due to deep mud bogs and tussocks. Drainage is poor and conditions are worsened after rain and heavy use.	• The Tanada Lake Trail is closed to recreational ORV use and open to subsistence ORV use. The EIS did not propose to open the trail to recreational ORV use. • Not recommended for hikers, however, some hikers do use this trail to access Sheep Lake and Grizzly Lake. Poor trail conditions make this a difficult hike. Hikers generally allow 5 to 7 days for this trip.	• Work to reroute this trail has not been initiated. Improving and maintaining this trail does not seem feasible knowing the challenges of improving Copper Lake Trail.

*Table 10: Summary of FEIS Actions and Existing Conditions for **Tanada Spur Trail** - Located in WRST National Park*

Actions Identified in 2011 FEIS/ROD	Trail Condition	Trail Use	Trail Work Since ROD
• This new trail will be constructed along the gravel floodplain from the reconstructed Tanada Lake trail to Tanada Lake.			

*Table 11: Summary of FEIS Actions and Existing Conditions for **Copper Lake Re-Route** – Located at MP12.2 along Nabesna Road within WRST National Park*

Actions Identified in 2011 FEIS/ROD	Trail Condition	Trail Use	Trail Work Since ROD
• The trail will be reconstructed in segments. • The trail will be widened in the first segment, using gravel capping, plank treads, ditch and cap work, and bench cuts. • The second segment will be re-re-routed along the Copper River floodplain, using gravel, bench cuts, well-drained soils, and hardened trail. • Improvements on the third segment will consist of minor re-routes, drainage structures, or spot hardening. • All improvements will result in a design-sustainable trail. • On all segments, once trail segments are reconstructed, old degraded trail segments will be closed to all ORV use to allow vegetation and wetland recovery. • An easement across the private property located west of Copper Lake is being pursued to address trespass issues associated with the existing trail alignment across private land.	• The trail is generally in fair condition, but varies with seasonal rains and amount of use. • The first 6 miles are generally over dry dirt. The remainder of the trail may be very wet with numerous mud bogs. Travel can be difficult.	• Trail is closed to recreational ORV use and open to subsistence ORV use. The EIS did not propose to open the trail to recreational ORV use. • The first 2.5 miles of the trail is suitable for day hikers. ORVs are the principal users of the trail.	• Surveyed easement across private lands that would allow public access across private lands on an alignment leading to Copper Creek Bridge site and final segment of Copper Lake Trail wilderness boundary. The easement was obtained in 2020. • Proposed spur trail on Park land on south end of trail to provide access to Copper Lake for recreation or a mode of transportation change to access other private inholdings. • Segments 1 and 2 of this trail are largely completed; Segment 3 is not yet complete. • WRST has sourced some gravel from bench cuts during construction. They are moving those materials to areas of more wetland topography to harden those areas, and have been able to reroute trails into better mineral soils near the Copper River bluffs. • Sockeye Salmon migrate up Tanada Creek to spawn in Tanada Lake. A bridge was installed in 2012 to mitigate impacts.

APPENDIX C – PRELIMINARY ENGINEERING TECHNICAL MEMORANDUM

U.S. Department
of Transportation
**Federal Highway
Administration**

M E M O R A N D U M

Western Federal Lands Highway Division
610 E. Fifth Street
Vancouver, WA 98661

DATE: December 20, 2022

TO: Jamie Lemon
Community Planner

FROM: Ryan Cole, RG, CEG (OR)
Engineering Geologist
Orion George, LG, LEG (WA)
Engineering Geologist

SUBJECT: **Geotechnical Memo 27-22**
Preliminary Engineering Assessment of
Nabesna District ORV Trails and Minor Roads
Wrangell St. Elias National Park ORV Study
FLPP AK WRST PLAN
Slana, Alaska

INTRODUCTION

This memorandum is provided to explain our workflow, data collected and used, and methodology utilized by Western Federal Lands Highway Division (WFLHD) to develop landform and relative aggregate potential (RAP) mapping in support of the Wrangell St. Elias National Park and Preserve's (WRST) implementation of the 2011 Nabesna Off-Road Vehicle Management Plan Environmental Impact Statement (EIS). The EIS (WRST, 2011) aims to provide continued opportunities for appropriate and reasonable access to wilderness and backcountry recreational activities through year-round use of off-road vehicle (ORV) trails.

The project is located in central Alaska, generally near the Wrangell Mountains' northern limits (see ATTACHMENT A – PROJECT LOCATION MAPS). The Nabesna Road leaves Tok Cutoff Highway at Slana Junction approximately 69 miles northeast of Gakona Junction. The Nabesna Road is approximately 43 miles long and provides the main access to the northern portion of WRST, as well as to the historic, privately owned, and abandoned Nabesna Mine. This site is identified as needing cleanup under authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

PROJECT DESCRIPTION

Use of ORVs in permafrost-affected areas of Alaska has increased significantly in recent decades. Environmental, socioeconomic, and accessibility impacts of ORVs on low-volume gravel roads and trails is evident in WRST, where both recreational and subsistence ORV activities occur. These impacts were assessed in the 2011 EIS, which identified a strategy to provide continued opportunities for appropriate and reasonable access to wilderness and backcountry recreational activities, that also accommodates subsistence use and access to private inholdings.

Findings of the 2011 EIS included a range of alternatives and an analysis of the environmental consequences of each. In 2012, the U.S. Department of Interior issued a Record of Decision (ROD) and selected “Alternative 6 – Improve Trails, Permit Recreational Use on Improved Trails in the Preserve” as the preferred alternative. Specifically, the ROD states:

> “[T]rails would be improved to at least a maintainable condition through trail hardening, tread improvement, or constructed re-routes”.

Additional strategic planning is needed to better understand baseline trail conditions, gravel resource availability, maintenance best management practices, and financial sustainability considerations for providing year-round trail access in WRST. In 2020, WFLHD and WRST entered into an agreement under the Alaska Region Long Range Transportation Program for the Wrangell-St. Elias National Park & Preserve Strategic Transportation Study (STS, May 2020). The purposes for the study include:

- Assessing baseline road/trail conditions within the Nabesna area of WRST,
- Determining best management practices for ORV trails and minor roads, and
- Identifying mutually beneficial projects and implementation strategies to maintain ORV trails and minor roads year-round.

Specifically, *this* memorandum presents results of the May 2020 STS under *Task 3: Preliminary Engineering Assessment of Nabesna District ORV Trails and Minor Roads*. This task included conducting a geomorphic desktop mapping analysis using all available data to complete a preliminary assessment of existing aggregate sources (quantity, quality, development feasibility, potential environmental constraints, etc.). The preliminary engineering assessment was informed by a desktop mapping analysis to identify potential material resource areas and geologic deposits conducive to aggregate production for future ORV/minor road maintenance.

This task is critical and is considered a “foundational requirement of understanding” for the WRST to plan for and address the two lower bulleted items listed under the STS above.

SCOPE OF WORK

1 - Review of existing information

Multiple geospatial datasets were consulted and incorporated for Geographic Information System (GIS)-based geomorphic (landform) mapping and ranking of RAP. These data sets are listed below. Landforms were interpreted from geospatial datasets and mapped by WFLHD, along a 1.243 mile-wide (two kilometer) road and trail buffer along Nabesna Road and adjacent ORV trails. The corridor width chosen is assumed to be the likely maximum proximity of developable aggregate material sites from existing road and trail locations.

In addition, test borings from a materials site investigation conducted by the Alaska Department of Transportation and Public Facilities (ADOT&PF, 1997), as well as vegetation mapping and our geomorphology mapping combined with trail condition surveys and reports and personal communication with WRST employees, allowed for a better understanding of geologic materials and their respective conditions on the ground within WRST boundaries.

Within boundaries of WRST, the following data sets were utilized for WFLHD GIS landform mapping:

- 1-meter, quality level 2 light detection and ranging (LiDAR) derived, bare earth digital elevation model (DEM) (Merrick and Company, 2021)
- 1:250,00 scale and 1:500,000 geologic mapping (Richter, 1976; Richter et al., 2006)
- 10-centimeter, 4-band orthorectified aerial imagery (Merrick and Company, 2021)
    - o Data gaps in coverage are being collected in summer 2023.
- Vegetation mapping (Saint Mary's University of Minnesota, 2008)
- Roads and trails geospatial data (NPS, 2016)
- Google Earth (2022)
- 1994 AKDOT&PF geotechnical investigation (AKDOT&PF, 1997/1998)
- Personal communication with NPS staff

2 - Receive, organize, and process existing data

Wrangel Saint Elias National Park and Preserve provided WFLHD with most datasets listed above. The LiDAR and orthorectified aerial imagery base data sets, were flown June 9-12, 2021, by Ahtna Merrick JV, LLC, and included approximately 503 square miles of WRST south of Slana, Alaska, mainly west of the Nabesna Road. Wrangel Saint Elias National Park and Preserve provided WFLHD with these data, which required substantial post-processing and organization. Non-geospatial data (e.g.: AKDOT&PF geotechnical data) were georeferenced for incorporation into the GIS spatial data.

3 - Desktop landform (geomorphic) interpretation and mapping

Once data were organized, processed, and incorporated into the GIS, landform interpretation and mapping began. Landform interpretation seeks to identify origin and evolution of topographic and bathymetric features created by physical, chemical or biological processes operating at or near Earth's surface. Landform interpretation attempts to determine why landscapes look the way they do. Through understanding landform development and terrains dynamic history, it allows for correlation of the types of materials reasonably expected to occur within each landform type. For example, talus, which forms fan-like deposits of material at the base of cliffs due to rockfall, can reasonably be expected to be composed of relatively large blocks of rock, whereas wide, low-gradient, near-mountain floodplain streams can reasonably be expected to be composed of well to poorly-graded sands and gravels with some thin, laterally discontinuous fine grained soil layers. Further, landform interpretation provides insight to relative surface ages, which can inform anticipated time for soil development and expected soil depths in the project area.

The advent of LiDAR has significantly contributed to the field of geomorphology due to its high resolution (in some cases sub-meter) elevation data combined with the ability to virtually "remove" vegetation and obstructions in order to see the “bare earth” underneath. The bare earth DEM provides the base data for landform interpretation. This high-resolution view of the earth’s surface, combined with geologic mapping and aerial imagery, assists in delineating landform extents and anticipated material types.

For this effort, nine landform types and eleven landform subtypes (a total of 16 individual landforms) were identified and mapped within the project boundaries, and are shown in Table 1. Descriptions of these landforms are given in further detail later in the ANALYSIS section of this memorandum. It is important to note landform units mapped in this exercise are not “true” geomorphologic units, but rather broad inclusive and undifferentiated units with similar morphologic earth processes and depositional environments informing anticipated landform materials, anticipated surface age, and anticipated overburden (e.g.: wind-blown soils (loess) cover).

Table 1. Landforms mapped for assessing relative aggregate potential (RAP), including the general geomorphic process forming them and their identified subtypes.

<table>
<tr><th>Geomorphic Process</th><th>Landform Type</th><th>Landform subtype</th></tr>
<tr><td rowspan="6">Hillslope</td><td rowspan="2">01 Alluvial fan</td><td>Relative age 1</td></tr>
<tr><td>Relative Age 2</td></tr>
<tr><td rowspan="3">02 Colluvium</td><td>Over shallow bedrock (5’-20’ depth)</td></tr>
<tr><td>Over deep bedrock (>20’ depth)</td></tr>
<tr><td>Over unconsolidated deposits</td></tr>
<tr><td>03 Landslide</td><td>N/A</td></tr>
<tr><td rowspan="5">Fluvial</td><td>04 Active stream channel</td><td>N/A</td></tr>
<tr><td rowspan="4">05 Alluvial Terrace</td><td>Relative age 1</td></tr>
<tr><td>Relative age 2</td></tr>
<tr><td>Relative age 3</td></tr>
<tr><td>Relative age 4</td></tr>
<tr><td rowspan="3">Glacial Drift</td><td rowspan="2">06</td><td>Kame</td></tr>
<tr><td>Subdued</td></tr>
<tr><td>07 Outwash</td><td>N/A</td></tr>
</table>

	08 Lacustrine	N/A
Igneous/tectonic	09 Bedrock outcrops	N/A

4 - Field verification and revision of mapping

After preliminary desktop landform mapping was complete, a site visit was conducted July 17-21, 2022, by WFLHD engineering geologists and WRST staff to review field conditions and validate desktop landform mapping in the field. Selected sites were visited to confirm the interpretation and accuracy of landform mapping, and test pits were dug to investigate subsurface conditions of select landforms. Several days of increased precipitation beginning on July 9, 2022 led to a cumulative rainfall total of 1.15 inches by July 17, 2022 (National Oceanic and Atmospheric Administration, 2022), which caused localized flooding of area streams and ultimately precluded access to much of the project area, including the Tanada Lake and Copper Lake trails. Where inconsistencies between desktop landform interpretation/mapping and field conditions were identified, mapping was revised to accurately reflect landform extents or types, as appropriate.

5 - Finalize mapping and correlate to relative aggregate potential (RAP)

Upon updates and revisions to mapping, each landform type and subtype was assigned a relative potential for aggregate suitability from zero to three. As discussed later in the ANALYSIS section, assignment of RAP was based on material source type and quality. Also considered were potential environmental or site conditions that have the potential to make development of material sources more difficult (i.e.: the potential for permafrost, high ground water tables, distance from road or trail corridors, development within active stream channels, overburden depth, etc.). Once rankings were assigned, landform rankings were displayed using a traditional stop-light color ramp symbology (red is lowest potential and green is highest potential) to display spatial distributions of RAP within the project area.

6 - Compare existing aggregate quality data to landform mapping and anticipated

relative aggregate potential (RAP)

Laboratory testing of aggregate samples taken from the 1994 AKDOT&PF geotechnical investigation provided an invaluable opportunity to test assumptions about anticipated aggregate quality, and our proposed RAP of the various mapped landforms. As discussed later in the ANALYSIS section, AKDOT&PF test data were used to validate or invalidate assumptions on potential of certain landforms to produce quality aggregate suitable for use in road and trail construction and maintenance.

GEOLOGY

The project is situated on the northwest edge of the Wrangell Mountains and the northeast edge of the Copper River Lowlands physiographic division of Alaska (Wahrthaftig, 1965). The Copper River Lowland physiographic division is noted for extensive permafrost, abundant ice thaw lakes, and having been widely influenced by glacial lake and riverine activity. The Wrangell

Mountains are a group of shield and composite volcanoes, some active, that rise above glaciated ridges in the project area. The mountains are composed of Cretaceous (approximately 65 million years old) volcanic rocks that rest on deformed Paleozoic (approximately 300 to 250 million years old) and Mesozoic (250 to 65 million years old) sedimentary and volcanic rocks. Cliff-forming limestone and slightly metamorphosed basalt, commonly known as the Nikolai greenstone, are found with these units. Some Paleozoic granitic units intrude the Mesozoic rocks (see ATTACHMENT B – GEOLGIC MAP).

Very little work has been done on active tectonics in this area. However, this region is in an active tectonic setting with oblique convergence of the Pacific plate pushing the Yakutat block into southern Alaska (Elliot, et al., 2013). This tectonic process is producing uplift in the project area but is also driving oblique right lateral (dextral) shearing of the Denali and Totschunda fault systems. Net uplift rates from these dynamic processes are uncertain for the project area.

The project area has also experienced numerous past glaciations. Glacial activity extended from the mountains covering lower portions of the project area with ice. During times of glacial advance, ice would transport materials from those mountains to lower elevations and erode areas being overridden by ice. During times of more extensive glacial periods the whole project area may have been covered by a thick ice cap (Nichols, 1989). In periods of lesser ice, glaciers extending out of the mountains would block drainages, allowing glacial lakes to form behind the ice. Glacial Lake Atna was the largest and most notable (Ferrians, 1989). In times of glacial retreat, ice would melt allowing for large riverine systems to form, which also transported material and caused erosion in the stream valleys as well. Deposits representing all these forms of glacial activity can be found within the project area.

An additional impact of having large volumes of ice over the landscape is deflection/loading of earth's crust. The sheer weight of large volumes of ice will depress the (earth's crustal) elevation of entire regions, but conversely, when the ice retreats and the ice loads are removed over an area the earth's crust, it will rebound in a process called isostacy. We liken this process to a finger applying pressure on an ice cube in a glass of water and then releasing the pressure. The ice cube can be thought of as the earth's crust in this example. This area is likely experiencing some isostatic rebound as well. This is a challenging metric to ascertain but is expected due to the fairly recent glaciations the project area has experienced.

Materials sites investigated by AKDOT&PF in 1994 are generally situated on alluvial fans formed by short, seasonally flowing creeks. The creeks eventually empty into the Copper River, the major drainage in the area. Soils generally consist of alluvial deposits and glacial drift. Most of the gravel is composed of soft, fine-grained sandstone, calcareous (containing calcium carbonate) siltstone, and basalt. Both, ground water and perennially frozen soils, have been noted during previous subsurface investigations by AKDOT&PF (1997).

SITE CONDITIONS

The project lies within the Continental Climatic Zone of Alaska, which is typified by large diurnal and annual variations in temperature, low annual precipitation amounts, and generally low humidity. Data presented below were taken from the Western Regional Climate Center (2022), and were recorded at Slana, Alaska at an elevation of 2,146 feet for the period from 1957 to 2005:

Mean annual precipitation (inches)	15.4
Mean annual snowfall (inches)	55.8
Mean annual temperature (degrees Fahrenheit)	27.2
Thawing Index, (Fahrenheit degree days)	1,603
Design thawing index, (1 year in 30) Fahrenheit degree days	1,891
Freezing index, (Fahrenheit degree days)	2,396
Design freezing index (1 year in 30) Fahrenheit degree days	3,123

The record high for the recording period is 93°F in June of 1969 and the record low is -57°F in January of 1975. Melting generally begins in April and freeze-up begins in late September or early October.

All descriptions given below are given as if driving from west to east along Nabesna Road from Slana to the Nabesna Mine. Mileposts were derived from Google Earth beginning at the intersection of Nabesna Road with the Tok Cutoff (Alaska Route 1, near MP 60). Nabesna Road begins at an elevation of approximately 2,230 feet, and is *generally* a two lane, 30-foot-wide asphalt and aggregate surfaced road, traveling generally southeast towards the Nabesna River and mine. Road grades are generally gently rolling while the road reaches a maximum elevation of 3,321 feet where it crosses the continental divide at Little Jack Creek near MP 24.7 and ends at 3,087 feet elevation at the Nabesna Mine near MP 43.2. The corridor is populated with black spruce, birch and willow shrubs, with a ground cover of moss, grass, sedges, and shrubs.

For the first approximately 17.5 miles Nabesna road slowly climbs about 600 feet over relatively flat terrain deposited by glacial Lake Atna and streams draining the western side of the continental divide. On the right near MP 0.2 is the turn off for WRST's Slana Ranger Station. Near MP 0.4 is a depleted AKDOT&PF materials pit that is currently used as a stockpile and staging site. At MP 1.53 a bridge crosses the Slana River. AKDOT&PF's Rufus Creek materials site is adjacent to the south side of the road beginning at MP 3.95. The road crosses Rufus Creek at MP 6.95. On the south at MP 7.45 is the 1998 uninvestigated WRST Rufus Creek materials site. The Suslota Lake trailhead is on the north side of the road at MP 11.2. To the north at MP 11.7 is the AKDOT&PF Lower Caribou Creek materials site, and the road crosses Caribou Creek at MP 11.9. The Copper Lake trailhead is to the south at MP 12.2.

From MP 17.5 to approximately MP 28 the road begins traversing more rolling, glaciated terrain, consisting of kame and kettle topography (see discussion on **kame** deposits in the ANALYSIS section). The road gains approximately 480 feet in this section, reaching a maximum elevation of 3,321 feet at the continental divide near Little Jack Creek. At MP 18.9, the AKDOT&PF Upper Caribou Creek materials site is to the north, and the Caribou Creek trailhead is also to the north at MP 19.2. The road crosses an approximately 1.2-mile-wide alluvial fan deposited along valley margins of Caribou Creek in this section. Sited just east on the north side at MP 19.8 is the 1998 uninvestigated WRST Caribou Creek materials site. The road crosses Rock Creek at MP 21.1 and passes the Rock Lake rest area on the south side at MP 21.7. To the north at MP 25.5

the road passes the AKDOT&PF Little Jack Creek materials site. The alluvial fan deposited by Little Jack Creek is approximately 2.5 miles-wide along this section of the road. Kendesnii campground is located on the south side at MP 27.7.

From MP 28 to the end of the Nabesna Road near MP 43.2 it generally traverses more deeply-rolling terrain created by alluvial fans deposited into the Jack Creek valley from several steep tributary streams draining the southern Mentasta Mountains and the northern Wrangell Mountains. On the south side near MP 28 is the Wrangell Mountain Wilderness Lodge. On the north, at approximately MP 28.9, the road crosses the active channel of Trail Creek and AKDOT&PF's 1998 uninvestigated Trail Creek materials site. The Trail Creek trailhead is also located here. The road crosses an approximately 3.5-mile-wide series of coalescing alluvial fans originating from both Trail and Lost Creeks in this section. The road crosses the active channel of Lost Creek near MP 30.7 and approaches the Lost Creek/Soda Lake trailhead to the northeast near MP 30.9. On the southwest side near MP 31.3 is AKDOT&PF's 1998 uninvestigated Chalk Creek materials site, and the road crosses Chalk Creek near MP 31.6. At MP 31.7 the road passes the AKDOT&PF Boyden Creek materials site to the northeast, and crosses Boyden Creek near MP 34.2. The alternate 1998 uninvestigated Boyden Creek materials site is located on the east side of Boyden Creek on an alluvial fan deposit. The road crosses a bridge over Jack Creek at MP 35.2. The Skookum Volcano Trail and AKDOT&PF Honey Creek materials site are to the southwest near MP 36. The road crosses through the AKDOT&PF Unnamed Creek materials site beginning near MP 39.1. The Reeves Field trailhead is on the northeast side near MP 40, and the Devils Mountain Lodge is located along the right-hand side of the road near MP 41. Beyond the Devils Mountain Lodge, beginning near MP 41.2, the road narrows considerably in both width and level of maintenance, and essentially transitions into a poorly maintained single lane ORV trail until it's end at the Nabesna Mine. The Rambler Mine trailhead is on the southwest side near MP 41.7. To the northeast near MP 42.7 is a trail that accesses the AKDOT&PF Cabin Creek materials site. On the southwest side near MP 43 is a lower access road leading to the Nabesna Mine. From here the road climbs uphill toward the end at MP 43.2, where Nabesna Mine and its associated outbuildings are located.

SUBSURFACE CONDITIONS

In 1994 AKDOT&PF conducted a reconnaissance investigation to identify potential aggregate material sites along the Nabesna Road for use in improving the entire length of the Nabesna Road. A subsurface geotechnical investigation was performed from September 7-17, 1994, at eight potential material sites along the Nabesna road. The investigation utilized a CME 45B drill mounted to a Bombardier Muskeg tracked carrier to drill 34 test holes that terminated at depths of 9.5 to 33.5 feet below ground surface (BGS). Locations of the materials sites are shown in ATTACHMENT C – MATERIAL SITE MAPS.

Results of the investigation determined that soils generally consisted of glacial drift or alluvial fan deposits overlying glacial drift or bedrock, with boulders and cobbles throughout. Surface soils were generally composed of gravel to silt as shown in Table 2, which provides a summary of generalized subsurface conditions encountered during the 1994 investigation.

Table 2. Summary of subsurface conditions encountered during the 1994 AKDOT&PF geotechnical subsurface investigation.

Material site	Milepost[1]	Boring depths[2]	Groundwater elevations[2]	Ice depths[2]	Material type[3]
Rufus Creek	4.5	18.4 - 33.1	1.6 – 2.0	1.0 – 18.4	Gr to SaSi
Lower Caribou Creek	12.0	18.0 - 33.5	14.1	1.0 – 28.5	Gr to Si
Upper Caribou Creek	20.0	23.0 - 28.5	1.6 – 3.9	1.6 – 28.5	SiSaGr to Si
Little Jack Creek	25.3	25.9 - 28.5	10.2 – 11.2	3.6 – 28.5	Gr to Si
Boyden Creek	34.6	9.5 – 33.1	N/A	1.0 – 26.9	Gr to SiGr
Honey Creek	37.0	21.0 - 33.1	7.5	2.6 – 21.0	Gr to SiGr
Unnamed Creek	40.3	12.5 – 28.5	1.3	2.6 – 19.4	SaGr to Si
Cabin Creek	44.0	18.4 – 25.9	6.6	N/A	

[1]Mileposts derived from AKDOT&PF 1997 report; these do not match those in the SITE CONDITIONS section, which were taken from Google Earth beginning at the intersection of Nabesna Road and Alaska Route 1.
[2]Feet below ground surface (BGS).
[3]Gr = Gravel, Sa = Sand, Si = Silt, Cl = Clay, when combined descriptors increase in percentage to the right (e.g.: SiSaGr is a silty, sandy gravel, where Si<Sa<Gr).

The 1997 report concluded that aggregate materials quality gradually decreases from Slana to the Nabesna Mine, and some deposits rest on fine-grained glacial drift that does not meet quality specifications because it contains high moisture content, requiring special handling and processing for use as an acceptable construction aggregate material. They also noted deposits containing limestone and marble generally did not meet quality specifications for crushed aggregate products due to high Los Angeles Abrasion test results. Lastly, use of the Cabin Creek site near the Nabesna Mine was discouraged due to the presence of hazardous material. Table D - 1 in ATTACHMENT D – TABLES provides a summary of the results of the 1994 materials testing performed by AKDOT&PF.

ANALYSIS

As previously shown in Table 1, 16 individual landform types were interpreted and mapped in the WFLHD desktop landform interpretation and mapping. This section discusses the geologic processes responsible for formation of each landform, key geomorphic signatures for identification and interpretation, as well as anticipated material source type and quality. Aerial imagery and LiDAR derived products illustrate examples of each landform are shown in ATTACHMENT E - FIGURES. Also considered are potential environmental or site conditions that may make development of material sources more difficult. Based on these factors, which are discussed in further detail below, the rankings shown in Table 3 were assigned to each landform to give a RAP for aggregate source development for use on roads and trails within WRST. It is important to note these rankings are relative to each landform mapped within the project limits, and do not necessarily translate to areas outside of the study area boundaries, where different landforms are likely to be present.

Table 3. Relative ranking of landforms as potential aggregate sources. For rationale used in assigning landform ranks, see discussion for each landform below. Relative aggregate potential (RAP) descriptors are used in the following RESULTS section of this memorandum rather than numeric values.

Landform	Relative Aggregate Potential (RAP) Rating	RAP Descriptor
Alluvial fan (relative age 1)	3	High
Alluvial terrace (relative age 1)	3	High
Glacial drift (outwash)	3	High
Bedrock outcrop	3	High
Alluvial terrace (relative age 2)	2.5	Moderately High
Colluvium (over shallow bedrock)	2.5	Moderately High
Alluvial fan (relative age 2)	2	Moderate
Alluvial terrace (relative age 3)	2	Moderate
Glacial drift (kame)	2	Moderate
Alluvial terrace (relative age 4)	1	Moderately Low
Colluvium (over deep bedrock)	1	Moderately Low
Colluvium (over unconsolidated deposits)	1	Moderately Low
Glacial drift (subdued)	1	Moderately Low
Landslide	0.5	Low
Active channels	0	Low
Glacial drift (lacustrine)	0	Low

Alluvial fans are an accumulation of sediments that fan outward from a concentrated source of sediments, such as a narrow canyon emerging from a mountain range to an unconfined valley bottom. They are characteristic of mountainous terrain in arid to semiarid climates but are also found in more humid environments subject to intense rainfall and in areas of modern glaciation. Alluvial fans typically form a characteristic arcuate "fan" along their deposition zone, where stream flow emerges from a confined channel and is free to spread out and infiltrate the surface. This reduces carrying capacity of the flow and results in deposition of sediments. Deposition can be from infrequent debris flows, from more ephemeral flows, or perennial streams. These landforms are generally found at the outlets of high-gradient streams draining mountain fronts along the southern Mentasta Mountains and northern Wrangell Mountains. Specific areas include the upper watershed of the Copper River Drainage and Copper Lake, the headwaters of Tanada Creek and Tanada Lake, and along Jack Creek. Figure E - 1 shows a Google Earth aerial imagery example of coalescing alluvial fans found along the Nabesna Road at Trail and Lost Creeks, while Figure E - 2 shows the same alluvial fan landforms mapped on the LiDAR derived bare earth DEM.

During the mapping process multiple ages of alluvial fans were determined to be present. Steno's laws of stratigraphy, particularly the law of superposition, which states younger materials typically sit atop older materials, as well as the law of cross-cutting relationships, which states if one material has disturbed another then the disturbed material must be older, allowed for interpretation of different ages of alluvial fans. Instances when we interpreted different relative ages of alluvial fans include where we observed fans deposited atop other fans, or when (atop) elevated surfaces had been eroded into by active alluvial fans or active river channels. Aerial imagery was also used to determine vegetation growth to interpret relative age. We only interpreted two relative ages for alluvial fans in this work, denoted as relative age 1 (younger) and relative age 2 (older). It should be stressed no quantitative dating methods were used to date alluvial fan ages. Rather, qualitative methods of superposition and cross-cutting relationships were used to discern relative ages of alluvial fans.

Based on the depositional environment described above it is anticipated alluvial fans will have a wide range of clast sizes from silt to boulders. More granular material is expected closer to the apex of the fan, at the mouth of the constraining canyon. Additionally, clast sizes are expected to become smaller the further from the fan's apex, as less energy is available to transport the larger and typically heavier bedload. Smaller clasts will be transported farther because they require less energy. Given their relatively high permeability, steep gradients, and generally consistent gradations, alluvial fans are anticipated to be good sources of aggregate of varying quality. As these landforms are generally younger, we expect them to have minimum thicknesses of overburden to remove. Difficult excavation conditions including permafrost and high ground water tables are generally not anticipated in alluvial fans. Additionally, it is anticipated materials would replenish themselves over time in this type of landform.

During the site visit, maintenance staff indicated that they have removed several thousands of yards over the years along Trail and Lost Creeks. These deposits are generally widely distributed within close proximity of Nabesna Road within the project area. Notable sources include Caribou Creek, Trail and Lost Creeks, and the headwaters of Jack Creek.

Colluvium is a general term for loose, unconsolidated sediments that have been transported and deposited along, and at the base of hillslopes by either rainwash, sheetwash, slow continuous downslope creep, or a combination of these processes. Colluvium is typically composed of a heterogeneous range of rock types and sediments ranging from silt to rock fragments of various sizes. These landforms are generally found on steep hillslopes within high-gradient stream channels draining the southern Mentasta and northern Wrangell Mountains, generally just upslope of alluvial fan deposits. Key distinguishing features are breaks in slope along mountain fronts accompanied by a change in surface roughness between bedrock outcrops and colluvium deposits. Specifically, colluvium is found in the steep tributaries of the upper Copper River, Tanada Creek, and Trail Creek. Figure E - 3 shows a Google Earth aerial imagery example of various subtypes of colluvium deposited within the valley margins of Trail Creek, while Figure E - 4 shows the same alluvium landforms interpreted from the LiDAR derived bare earth DEM.

We mapped this landform into three individual map units: *colluvium overlying shallow bedrock*, *colluvium overlying deep bedrock*, and *colluvium overlying unconsolidated deposits*. The three individual colluvial units were broken out by reviewing surrounding mapped geology, surrounding landform units mapped by us, proximity to steep slopes, and aerial imagery. Based on the depositional character of colluvium described above, we made assumptions about colluvium material thickness over bedrock. We provide an educated guess on estimated depths for “shallow” or “deep” bedrock, and it should be noted that this distinction is offered at a qualitative level as an opportunity to consider overburden on top of bedrock and relative volumes of colluvium available, if considered for further investigation and development.

- *Colluvium over shallow bedrock*; was typically mapped closer to bedrock outcrops and interpreted as a younger and coarser grained subset of this landform. It is expected to be easier to excavate into underlying bedrock if desired. This landform unit was given a moderately high aggregate potential. Estimated thicknesses may range from 5 feet to 20 feet.
- *Colluvium over deep bedrock*; was typically mapped further from bedrock outcrops. This unit was interpreted as an older surface consisting of generally smaller clasts and fine-grained material. We anticipate challenging excavation conditions through these deposits into underlying bedrock. This unit was given a moderately low aggregate potential. Estimated thicknesses are anticipated to be greater than 20 feet.
- *Colluvium over unconsolidated deposits*; this unit was mapped further from bedrock outcrops as well. The unit was typically mapped at the base of steeper slopes of unconsolidated materials such as glacial or alluvial (river) deposits. Smaller clasts and fine-grained soil materials are expected in this unit and excavating through the landform into higher aggregate potential material was not deemed likely. This unit was given moderately low aggregate potential.

Given their wide variability in gradation and quality, these deposits are generally not anticipated to be good sources of aggregate. We rated *colluvium over shallow bedrock* higher with aggregate potential as an effort to capture our assumption that this material is coarser from proximity to bedrock and could possibly be excavated through to access bedrock below. Difficult excavation conditions such as high ground water tables are generally not anticipated in colluvium, however, steep slopes could prove to be problematic for excavation (stability), access, staging and processing, and haul. These deposits are generally not widely distributed at close proximity to the Nabesna Road within the project area but could provide distant sources of material at the termini of the Copper Lake, Tanada Lake, and Trail Creek Trails. This would minimize haul distances to trail termini if suitable material sites are verified.

Landslides are characterized by several forms of mass wasting that include a wide range of ground movements, such as rockfalls, deep-seated slope failures, mudflows, and debris flows. Landslides occur in a variety of environments, characterized by either steep or gentle slope gradients, from mountain ranges to coastal cliffs. Some forms of landslides, such as debris flows or debris avalanches have potential to move materials long distances, up to several tens of miles. Key distinguishing features are generally arcuate headscarps that form down dropped benches at the head of a landslide, an intermediate body where land movement occurs, and a depositional landslide toe zone. Depending on material transported and resultant stability of the deposit, landslides can be potential sources of aggregate. Given that gravity is generally a primary driving force for landslide occurrence, they are typically found in steeper terrains such as mountainous regions.

Within the project area, these landforms are generally found on steep hillslopes within high-gradient stream channels draining the southern Mentasta and northern Wrangell Mountains, generally adjacent to colluvium deposits. Figure E - 5 shows a Google Earth aerial imagery example of a large translational landslide in the southern Mentasta Mountains, east of Suslota Lake Trail, while Figure E - 6 shows the same feature interpreted from the LiDAR derived bare earth DEM.

Given their wide variability in material types, difficult access, and potential stability issues associated with excavation, these deposits are generally not anticipated to be good sources of aggregate. In addition to potential for destabilization, difficult excavation conditions such as high ground water tables or permafrost can reasonably be anticipated within landslide deposits. These deposits are also not typically distributed within close proximity to the Nabesna Road.

Active stream channels are defined here as the area of land that constrains rivers and streams to their banks during normal, non-flood (two-year storm) flows. This area does not include the wider floodplain, which experiences flooding during periods of high discharge, and is defined as an area of land adjacent to a river or stream which stretches from the banks of its channel to the base of the enclosing valley sidewalls (see discussion on alluvial terraces below). For example, the active channel of the Copper River near the outlet of Copper Lake is approximately 100-feet wide, while the larger floodplain, which includes younger alluvial terrace deposits, is approximately 2,500-feet wide. Figure E - 7 shows a Google Earth aerial imagery example of the active channel described above, while Figure E - 8 shows the same feature mapped from the LiDAR derived bare earth DEM.

It is generally anticipated that active channels will contain well-graded gravels with silt and sand. Difficult excavation conditions include flowing water, high ground water tables, and potential for shifting channels. Additionally, there may be significant environmental challenges in working in active channels (e.g.: adequate erosion control measures, floods during operations, and presence of endangered species). One exception to working in active channels is those that occur on steep alluvial fans. As discussed above, their relatively high permeability, ephemeral nature, and steep gradients would generally preclude difficult excavation conditions found in lower-gradient active channels.

Alluvial Terraces are elongated terraces that flank the sides of floodplains and river valleys. They consist of a relatively level strip of land, called a "tread", separated from either an adjacent floodplain, other alluvial terraces, or uplands by distinctly steeper strips of land called "risers". These terraces lie parallel to and above the river channel and its floodplain. Because of the way they form, alluvial terraces are underlain by river sediments of highly variable thickness. River terraces are the remnants of earlier floodplains that existed at a time when either a stream or river was flowing at a higher elevation before its channel downcut to create a new floodplain at a lower elevation. Stream incision can occur due to regional uplift caused by tectonic forces or crustal isostatic rebound (uplift) from reduction of glacial ice loading. Terraces can also be left behind when river flows decline, or bedload is reduced without a reduction of erosive energy; this is common when climate changes in areas of previous glaciation.

Because alluvial terraces form sequentially as a river system downcuts or experiences a reduction in flow, they are often significantly different ages (up to tens of thousands of years difference). Older alluvial terraces had more time to consolidate and experience the effects of weathering and erosion. They have also had more loess (windblown soils (silts in this case)) deposition, time to develop appreciable soil profiles, and considerably more vegetation growth and detritus build up. These processes can lead to relatively thick sequences of overburden. For this reason, four separate relatively aged alluvial terrace units were mapped within this layer, with *alluvial terrace relative age 1* being the youngest and *alluvial terrace relative age 4* being the oldest. Figure E - 9 shows a Google Earth aerial imagery example of the alluvial terraces described above, while Figure E - 10 shows the same features interpreted from the LiDAR derived bare earth DEM.

We mapped alluvial terrace relative age units by reviewing available geologic mapping, high resolution lidar derived topographic data, and aerial photographic imagery. Like mapping of alluvial fan units, Steno's laws of stratigraphy (superposition and cross-cutting relationships) were used to interpret relative ages of alluvial terraces. Typically, the *active channel* layer would be at the lowest elevation of the local hydrologic regime with successively older alluvial terraces being readily identified at higher elevations. It should be stressed no quantitative dating methods were used to discern ages of terraces, but rather qualitative relationships and observations described above were used to interpret units relative ages. Key observations and assumptions were used to assign relative ages for different alluvial terraces:

- *Alluvial terrace relative age 1* (AT1); is the youngest of the alluvial terrace units. They were mapped at very close elevation to active channel elevations. These terraces are often considered active/current floodplains with minimal to no vegetation growing on their surfaces. It is expected these units would have high aggregate potential because surfaces are young with minimal soil development, vegetation growth, and overburden.
- *Alluvial terrace relative age 2* (AT2); was mapped at higher elevations than AT1. These terraces are considered older than AT1, with successively more vegetation typically observed growing on their surfaces. It is expected these units would have moderate aggregate potential as their surfaces are old enough for deeper soil development, more loess deposition, and more subsequent overburden.
- *Alluvial terrace relative age 3* (AT3); was mapped at successively higher elevations than AT2. These terraces were observed to have well developed vegetation growing in aerial photographs. It was assumed these surfaces had well developed, deeper soil profiles (with a larger fine grained soil fraction) and significant loess deposition; yielding significantly more overburden to excavate. This deeper, finer grained overburden was also expected to be susceptible to permafrost conditions, which pose different challenges for aggregate development. It is expected these units have a moderate aggregate potential. While it is anticipated that surfaces are expected to be challenging for exploration and development, the risers (lateral edges) of these units were observed to be high enough to allow potentially easier access and may pose opportunities as an aggregate source.
- *Alluvial terrace relative age 4* (AT4); was mapped at successively higher elevations than AT3. These terraces are typically significantly higher, in larger drainages, and have smoother topographic surface roughness than other alluvial terrace units. These

terraces also have well developed vegetation growing on them. It is assumed these surfaces have more developed and deeper soil profiles than AT3, more loess deposition, more overburden to excavate, and are even more susceptible to permafrost conditions. Some areas exhibit thermokarst topographic features such as small hummocks, marshy areas, and polygonal ground surface patterns suggestive of permafrost. It is expected these units have a moderately low aggregate potential. As with AT3, these surfaces are expected to be challenging to explore and develop, but AT4 riser lateral edges could be high enough to allow for easier access and pose opportunities for aggregate development.

We assume alluvial terraces generally have higher aggregate potential as they contain materials like those found in active channels (well-graded gravels with silt and sand). Because alluvial terraces are composed of flood deposits, these can reasonably be assumed to contain some percentage of boulder and cobble as well. One potential issue with siting materials sources in alluvial terraces is floods have potential to jump out of their active channels and into a materials source within an active floodplain (e.g.: AT1 or AT2). Relative age 1 and 2 alluvial terraces will also likely be closer to local groundwater elevations (i.e.: active channel) and could encounter difficult excavation conditions. Alluvial terraces relative ages 3 and 4 may have had more time to consolidate or develop thicker sequences of overburden and vegetation and would likely be more difficult to excavate if permafrost is present. As noted above, these older alluvial terrace units (AT3 and AT4) have a higher risk of permafrost due to the deeper overburden and general length of time for permafrost to form and be insulated. Typically, in areas of permafrost groundwater is also perched on frozen soils due to reductions in infiltration rates.

Alluvial terraces have been observed to be good sources of aggregate for trail maintenance and construction, particularly younger terraces. Personal communication from Jesse Heinbaugh, WRST Backcountry Maintenance Trails Supervisor, indicated trail crews consistently searched for, developed, and utilized aggregate borrow locations on AT1 surfaces because those areas have less vegetation, soil development, loess depth, and surface water allowing for easier extraction. Further, he indicated risers of older terraces could be utilized to for aggregate extraction because these areas are readily exposed but posed more challenging access than the flatter, older stream terrace surfaces.

Glacial drift is the name for all material of glacial origin. For this reason, and because drift can form from different processes and conditions leading to varying materials deposits, we divided drift into four different glacial landform types: *glacial drift (kame)*, *glacial drift (subdued)*, *outwash*, and *lacustrine* deposits.

Glacial drift (kame) is an irregularly shaped hill or mound composed of sand, gravel and drift (well-graded glacial deposit) that accumulates in a depression on a retreating glacier and is deposited on the land surface with further glacier melting. Kames are often associated with kettles (blocks of ice that become buried with sediment from retreating glaciers, subsequently melt, and leave behind small lakes), which is referred to as kame and kettle topography. Kame and kettle topography is generally found within the project area east of the Copper River, to the continental divide near Jack Lake at approximately milepost 28, and south of the Nabesna Road to both Copper and Tanada Lakes. Figure E - 11 shows a Google Earth aerial imagery example of the kame and kettle topography described above, while Figure E - 12 shows the same features interpreted from the LiDAR derived bare earth DEM.

Given kame deposits are anticipated to have variable gradations, material sources may require additional processing and development. Kame units are anticipated to be aggregate sources of varying quality. Variable thicknesses of overburden are anticipated. Difficult excavation conditions including permafrost and perched groundwater tables may be present in kame deposits. High groundwater tables, however, may be avoided in higher-relief deposits. These characteristics led us to assume kame deposits have a moderate relative aggregate potential. These deposits are generally distributed within close proximity to Nabesna Road between Caribou Creek and Jack Lake. These sources could provide close proximity sources of material for the Caribou Creek, Tanada Lake, and Trail Creek Trails.

Glacial drift (subdued) is well-graded, overconsolidated, glacial sediment that is derived from the erosion and entrainment of material by the moving ice of a glacier. It can be deposited significant distances "down-ice" to form terminal, lateral, and medial ground moraines, and can be either primary, deposits laid directly by glacier action, or secondary, deposits reworked by fluvial (river) action from melting glaciers. Glacial readvances over glacial drift, coupled with more loess deposition generally causes more subtle topography that we differentiated into *subdued glacial drift*. The subdued glacial drift unit is used in this case to capture suspected glacial deposits that are somewhat subdued and do not clearly identify to other landform units. This unit likely represents more secondary drift deposits than primary drift deposits as hummock surfaces of this unit are typically smoother than the more abrupt hummocks of kame units. The subdued nature of the terrain of these units may be representative of the surface being older and with thicker, overlying loess deposition. This unit is typically eroded into by alluvial terrace units, overlain by alluvial fan units, or are in a transitional contact with kame units. Subdued glacial drift deposits are found throughout the project area along the valley margins of every major stream, including the Copper River, Tanada Creek, Jack Creek, and their tributaries. These deposits, however, are notably mostly absent along the Nabesna Road from Slana to Caribou Creek. Figure E - 13 shows a Google Earth aerial imagery example of subdued glacial topography near Twin Lakes, while Figure E - 14 shows the same features interpreted from the LiDAR derived bare earth DEM.

It is anticipated subdued glacial drift will consist predominantly of clay, silt, and sand, with gravel, cobble, and boulder scattered throughout. More clay and silt are anticipated in these units than kame units because the drift may have been reworked in a lower energy environment and the surface may have significant amounts of loess deposited on it. Due to minimal, or no, sorting (well-graded) these deposits are not expected to produce high quality aggregates, because of anticipated high-fines content.

Outwash deposits are formed from the flow of meltwater in front of (outwash plains) or beneath (eskers) glaciers. They are typically composed of poorly-graded sands and gravels that have been reworked by flowing water. Outwash plains are generally expansive, flat areas that contain braided river channels. Outwash plains can extend for miles beyond the glacier margins. Glacial outwash deposits within the project area are sparse, but were mapped near the Caribou Creek trailhead at milepost 24, and the headwaters of Trail Creek. Figure E - 15 shows a Google Earth aerial imagery example of glacial outwash near the Caribou Creek trailhead, while Figure E - 16 shows the same features interpreted from the LiDAR derived bare earth DEM.

It is generally anticipated glacial outwash will contain materials like those found in active channels (well-graded gravels with silt and sand). Because outwash deposits were likely deposited during periodic high-flow events, they can reasonably be assumed to contain a significant percentage of boulder and cobble as well. Because outwash deposits in the project area form mounds of material that are generally higher in elevation than surrounding topography, it is not anticipated they would contain high groundwater tables and would be potentially less likely to be affected by permafrost. These unconsolidated deposits should be easily excavated, although overburden thicknesses are expected to be variable. As such we feel glacial outwash deposits have high relative aggregate potential. Although not distributed widely geographically, outwash deposits should produce high quality mineral aggregate sources. The potential source near the Caribou Creek trailhead could provide a substantial quantity of aggregate for maintenance of nearby roads and trails.

Lacustrine deposits are sedimentary deposits that form on the bottom of a lake, through a variety of processes. A common characteristic of lacustrine deposits are a river or stream channel has carried sediment into a closed basin and are typically very poorly-graded (well sorted sediment) with highly laminated beds of silts and clays. They typically form flat surfaces and commonly leave behind concentric stand lines that form from wave action along the shoreline (indicating lowering lake levels over time). Glaciers can dam rivers and create lakes behind the ice mass. Lakes may also develop in front of a glacier as the climate warms and the glacier recedes up valley over time. The glacial melt water is trapped behind a terminal moraine formed from material that was shoved out in front of the glacier as it advanced, creating an earthen dam of sorts, or a glacier may simply drain into a rock-confined basin. Glacial lacustrine deposits were mapped along the Copper River Trail south of Copper Lake, presumably when a glacier advanced from Mt. Sanford, damming a tributary of the Copper River, and created a temporary lake. Figure E - 17 shows a Google Earth aerial imagery example of the glacial lacustrine deposit described above, while Figure E - 18 shows the same features interpreted from the LiDAR derived bare earth DEM.

Because lacustrine deposits are primarily composed of silts and clays, they are not expected to be good sources of aggregate. This landform unit was assigned a low relative aggregate potential ranking.

Bedrock outcrops are exposures of basement rock that are not covered by water, soil, plants, or anthropogenic structures. They are indicative of the regional geology and represent the least weathered and eroded landforms. Bedrock outcrops most frequently occur where erosion is rapid and exceeds the weathering rate of the rock, such as steep hillsides, mountain ridgelines, riverbanks, or are prevalent in tectonically active areas. Depending on type and quality of rock in the exposure, bedrock outcrops can be good sources of quality aggregate. They often require quarrying and processing of the mineral rock materials, which can involve drilling, blasting, crushing, stockpiling, and haul for use as aggregate. Within the project area bedrock outcrops are primarily found along the mountain fronts of the southern Mentasta and northern Wrangell Mountains. Bedrock exposures within the project area were mapped by Richter (1976) primarily as Tetelna Volcanics in the southern Mentasta Mountains, and as Wrangell Lavas in the northern Wrangell Mountains. For this work the *bedrock* unit was mapped as predominantly outcrops, but also included minor areas of colluvium over shallow bedrock. Figure E - 19 shows a Google Earth aerial imagery example of a bedrock outcrop near the end of the Nabesna Road, close to the Nabesna Mine, while Figure E - 20 shows the same features interpreted from the LiDAR derived bare earth DEM.

It is generally anticipated mapped *bedrock* units will contain basalts and andesite rock in the northern Wrangell Mountains, and volcaniclastic rocks (mudflows, breccias, conglomerates) in the southern Mentasta Mountains. Bedrock outcrops are not anticipated to contain high groundwater tables or deep permafrost. Bedrock outcrops are not expected to be easily excavated, and may require drilling, blasting, and crushing to produce quality aggregate. However, talus below bedrock outcrops may be present and could be used as another potential source of material for aggregate and possibly riprap. Since most of these exposures exist in steep, mountainous topography at relatively long distances from the Nabesna Road, they are not expected to be reasonably developable. Additionally, any quarrying of bedrock outcrops can be expected to present visual challenges to the viewshed as observed from the Nabesna Road corridor or other locations.

RESULTS

Table 4 provides an overview of mapped RAP for trails and four sections of Nabesna Road within WRST. For the following discussion on results of desktop mapping we will refer back to information contained in Table 4, as well as ATTACHMENT F – LANDFORM MAPS and ATTACHMENT G – RELATIVE AGGREGATE POTENTIAL (RAP) MAPS for spatial distributions of mapped landforms and RAP descriptions for each corridor given below.

Table 4. Relative aggregate potential (RAP) by percentage of area mapped within specified road or trail corridors.

Corridor	Total Area Mapped[1] (acre)	Percentage Area by RAP[1,2,3]				
		High	Mod. High	Mod.	Mod. Low	Low
Nabesna Road	---	---	---	---	---	---
Sec.1 MP 0.5-6.95	3,587	15%	**49%**	18%	15%	3%
Sec.2 MP 6.95-17.5	8,570	1%	2%	6%	**91%**	0%
Sec.3 MP 17.5-28.0	8,618	6%	0%	**72%**	22%	0%
Sec.4 MP 28.0-43.0	13,446	**68%**	3%	5%	21%	4%
Caribou Creek Trail	3,260	31%	1%	**41%**	23%	4%
Trail Creek Trail	6,118	**42%**	8%	11%	32%	8%
Lost Creek Trail	5,556	34%	1%	18%	**41%**	6%
Soda Lake Trail	8,578	15%	5%	16%	**61%**	4%
Reeves Field Trail	4,089	27%	0%	1%	**65%**	6%
Copper Lake Trail	29,682	**42%**	9%	4%	38%	8%
Tanada Lake Trail	9,891	14%	2%	22%	**60%**	1%

[1]Area calculated where 1.243-mile road and trail mapping buffer overlaps area of lidar coverage within Wrangel St. Elias National Park and Preserve boundaries and excludes areas of standing water.

[2]Relative aggregate potential (RAP) ranking categories: High = 3, Moderate high = 2.5, Moderate = 2, Moderate low = 1, and Low = < 1.

[3]**Bold** number indicates highest ranked percentage of RAP for each corridor.

Table D - 1 in ATTACHMENT D – TABLES provides an overview of material types found at each material site investigated by AKDOT&PF in 1994, as well as results of laboratory testing to determine suitability of aggregate for use as various road construction materials. Descriptions of material specifications referred to in the table and text corridor descriptions below can be found in the AKDOT&PF Standard Specifications for Highway Construction (AKDOT, 2020) and they generally agree with minimum standards outlined in the FP-14 Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects.

Nabesna Road Corridor

Landforms along the Nabesna Road Corridor can be broken down into four generalized landform sections. ***Section one*** includes the lower portion of the road along the Ahtell Creek floodplain at MP 0.5, to the bridge over Rufus Creek at MP 6.95. This section consists mainly of young to moderately old alluvial terraces (relative ages 1-3) deposited within the Copper River floodplain. These landforms are mapped as having a moderate to high RAP (15% high, 49% moderately high, 18% moderate, 15% moderately low, and 3% low). The 1997 AKDOT&PF Rufus Creek material site, located at MP 4.5, produced material that was found to be suitable for use in every aggregate type category, and validates our model assumptions that younger alluvial terraces have high potential to produce quality aggregate.

Section two begins at the bridge over Rufus Creek at MP 6.95 and extends to approximately MP 17.5. This section generally consists of older alluvial terrace deposits (relative ages 3-4) with minor deposits of subdued glacial drift in the first two miles of the section. These landforms are mapped as having moderately low RAP (1% high, 2% moderately high, 6% moderate, 91% moderately low, and 0% low). The 1997 AKDOT&PF Lower Caribou Creek material site, located at MP 12.0, produced material was found to be suitable for use in every aggregate type category (except for Selected Material, Type A), and challenges model assumptions that older alluvial terraces have only a moderately low to moderate potential to produce quality aggregate. However, the 1997 AKDOT&PF report indicated site materials contained a significant fraction of fines that could complicate compaction efforts, validating model assumptions that older terraces may have had more loess deposition and/or additional time to develop thicker overburden profiles.

Section three begins at approximately MP 17.5 and extends to the Wrangell Mountain Wilderness Lodge near MP 28.0. This section generally consists of older alluvial terrace deposits (relative ages 3-4) with deposits of kame and subdued glacial drift. One notable exception occurs from approximately MP 18.3 to 20.0, where the Nabesna Road crosses an alluvial fan (relative age 2) deposited by Caribou Creek. Landforms in this section are generally mapped as having a moderately low to moderate RAP (6% high, 0% moderately high, 72% moderate, 22% moderately low, and 0% low). The 1997 AKDOT&PF Upper Caribou Creek and Little Jack Creek materials sites, located at MPs 20.0 and 25.3, respectively, produced high quality aggregate found to be suitable for use in every aggregate type category (except for Selected Material, Type A). This challenges model assumptions that older alluvial fans (relative age 2) have only moderate RAP to produce high quality aggregate. The 1997 AKDOT&PF report also indicated the west side of the Upper Caribou Creek site contains thick layers of silty sand and sandy silt that will require selective mining.

Section four begins at the Wrangell Mountain Wilderness Lodge near MP 28.0 and extends to the road's end at the Nabesna Mine near MP 43.0. This section consists mostly of alluvial fan (relative age 1) deposits along the valley margins of Jack Creek, with one exception from Chalk Creek near MP 31.0 to the vicinity of the Boyden Creek material site near MP 32.0, which consists mainly of subdued glacial drift. These deposits are mapped as moderately low to high RAP (68% high, 3% moderately high, 5% moderate, 21% moderately low, and 4% low). This section contains the 1997 AKDOT&PF Boyden, Honey, Unnamed, and Cabin Creeks material sites, located at MPs 34.6, 37.0, 40.3, and 44.0, respectively. These sites generally produced low to high quality aggregate. Aggregate quality generally decreases from the Boyden Creek material site to the Unnamed Creek material site. The 1997 report noted Honey Creek contained variable quality aggregate requiring selective mining and Unnamed Creek contained low quality aggregate not meeting requirements for any crushed products. Additionally, samples taken from the Cabin Creek site did not receive a full suite of testing, presumably because they contained hazardous materials (from the Nabesna Mine). These results do not agree with model assumptions that younger alluvial fans (relative age 1) consistently have a high RAP for producing high quality aggregate.

Caribou Creek Trail Corridor

Caribou Creek trail begins at MP 19.2 at the southern boundary of the 1997 AKDOT&PF Upper Caribou Creek materials site. It begins ascending a broad alluvial fan (relative age 2) for the first 1.15 miles. For the next mile the trail begins following a tributary stream and traverses an alluvial terrace (relative age 1) deposited at the valley margins. The stream cuts through subdued glacial drift deposits. For the last mile the trail encounters colluvium deposited along the valley margins that was eroded from bedrock ridges on either side of the trail. Additionally, the last 0.6 miles of the trail encounters a large landslide to the West. The Caribou Creek corridor is generally mapped as moderately low to high RAP (31% high, 1% moderately high, 41% moderate, 23% moderately low, and 4% low). As discussed in the Nabesna Road Corridor section above, the Upper Caribou Creek materials site produced high quality aggregate that was found to be suitable for use in every aggregate type category (except for Selected Material, Type A). Bedrock in the corridor is mapped as high RAP, but distant sources may be challenging to access and develop, and development would be visible throughout the project area. Bedrock outcrop sources occurring along the mountain front could provide an opportunity to “screen” materials development from the viewshed due to their geometry and relief.

Trail Creek Trail Corridor

Trail Creek trail begins at MP 28.9 on the Nabesna Road, and for the first 1.1 miles, climbs a broad coalescing alluvial fan (relative age 1) developed from the confluence of Trail and Lost Creeks. The trail also follows the Trail Creek active channel for its entire length, which appears to constantly shift the trail centerline after significant streamflow events. For the next two miles the trail is within close proximity of alluvial terraces (relative age 3) that were deposited during past flood events. For the next 1.5 miles the trail encounters small deposits of alluvial terrace (relative age 1) deposited adjacent to the active channel, while large deposits of subdued glacial drift occur to the west, with bedrock and associated colluvium to the east. In the last three miles, the trail encounters an alternating series of colluvium, alluvial fans (relative ages 1 and 2), and landslides that eroded from adjacent bedrock ridges. The Trail Creek corridor is generally mapped as low to high RAP (42% high, 8% moderately high, 11% moderate, 32% moderately low, and 8% low). There were no aggregate testing data available to test model assumptions along this corridor, but geologic mapping indicates limestone bedrock near this trail, which may not meet road building quality standard specifications for crushed aggregate products may not be an issue for ORV trail improvements and maintenance. There is also a significant quantity of readily available and often replenished aggregate materials along the approximately 3.5-mile-wide alluvial fan on the Nabesna Road. This source may be suitable for ORV trail construction and maintenance near the trail head.

Lost Creek Trail Corridor

Lost Creek trail begins at MP 30.9, and for the first 3.5 miles, climbs a broad coalescing alluvial fan (relative age 1 to the west and relative age 2 to the east) deposited by Lost Creek. The trail also follows the Lost Creek active channel for its entire length, which appears to constantly shift the trail centerline after significant streamflow events. For the next 2.3 miles the trail generally ascends through adjacent subdued glacial drift, which Trail Creek has incised through. For the last mile the trail encounters minor deposits of colluvium and landslides, but the valley generally contains subdued glacial drift deposited by alpine glaciers. Bedrock is mapped along adjacent ridgelines, but steep terrain would largely challenge material site development and reasonable access in these locations. The Lost Creek corridor is generally mapped as low to moderate RAP (34% high, 1% moderately high, 18% moderate, 41% moderately low, and 6% low), but much like the lower portion of Trail Creek, contains a significant quantity of readily available and often replenished material along the 3.5-mile-wide alluvial fan on the Nabesna Road, which may be suitable for ORV trail construction and maintenance. There were no aggregate testing data available to test model assumptions along this corridor, but geologic mapping indicates limestone bedrock in the upper drainage may not meet road building quality specifications for a crushed product, although this may be a non-issue for ORV trails.

Soda Lake Trail Corridor

Soda Lake trail begins at approximately MP 3.2 of the Lost Creek trail, where it heads east towards the Nabesna River. For the first 1.1 miles, it traverses an alluvial terrace (relative age 2) before it climbs over subdued glacial drift for the next three miles. Over the next six miles the trail drops into Platinum Creek and follows the active channel down valley before turning northeast to ascend Soda Creek. In this six miles the trail generally encounters alluvial terraces (relative ages 1-4), subdued glacial drift, and alluvial fans (relative age 1). In the last quarter mile, the trail is within close proximity of bedrock outcrops. The Soda Lake corridor is generally mapped as low to moderate RAP (15% high, 5% moderately high, 16% moderate, 61% moderately low, and 4% low), but the Platinum Creek and Soda Creek portions of the trail encounter generally moderate to high RAP deposits. There were no aggregate testing data available to test model assumptions along this corridor, but geologic mapping indicates that limestone bedrock, which may not meet quality specifications for crushed product used in road building, although this may be a non-issue for ORV trails. Much like the lower portion of Trail Creek and Lost Creeks, the 5.5-mile-long section of the corridor that follows Platinum Creek and Soda Creek contains a significant quantity of readily available and often replenished material, which may be suitable for ORV trail construction and maintenance.

Reeves Field Trail Corridor

The Reeves Field trail begins at approximately MP 40 of the Nabesna Road, where it heads east towards the Nabesna River and traverses alluvial fan (relative age 1) deposits for the first 0.6 miles before crossing alluvial terraces (relative age 1) adjacent to the active channel of Jack Creek for the next 0.4 miles. In the next three miles it climbs over subdued glacial drift, encountering small bedrock outcrops, until it reaches the active channel and alluvial terraces (relative age 1) of the Nabesna River. The Reeves Field corridor is mapped as moderately low to high RAP (27% high, 0% moderately high, 1% moderate, 65% moderately low, and 6% low). There were no aggregate testing data available to test model assumptions along this corridor, but alluvial fans mapped in the first mile of the trail are assumed to be derived from the same source areas as the Honey Creek materials site and may be suitable for ORV trail construction and maintenance.

Copper Lake Trail Corridor

Copper Lake trail begins at MP 12.2 of the Nabesna Road and heads south toward Copper Lake, generally along alluvial terraces deposited by the Copper River. The first 2.25 miles of the trail travels over older alluvial terrace (relative age 4) deposit that was presumably formed by the confluence of the Copper River with other streams draining the western side of the continental divide. For the next five miles the trail traverses an alternating sequence of younger alluvial terraces (relative age 1-2) interspersed with kame and subdued glacial drift deposits. At approximately MP 7.25 the trail is located on an approximately six-mile-long deposit of subdued glacial drift on the east side of the Copper River. The trail briefly drops down into younger alluvial terraces at the outlet of Copper Lake before ascending onto subdued glacial drift again. The last eight miles of trail traverses alluvial fans (relative age 1) shedding from adjacent mountains. One notable landform is an approximately 1,800-acre lacustrine deposit that was presumably formed when a glacier blocked the outlet of the Copper River, creating a temporary glacial lake. This deposit not only has low RAP but may also represent an increased zone of risk for potential trail realignments. There were no aggregate testing data available to validate model assumptions along this corridor but based on materials testing of similar deposits found downstream at Rufus Creek, it is presumed that younger alluvial terraces adjacent to the Copper River contain a significant quantity of readily available and often replenished material, which are most likely suitable for ORV trail construction and maintenance. These deposits are also in close proximity of the first 15 trail miles and were mapped with a moderately high to high RAP. Overall, the corridor is generally mapped as low to high RAP (42% high, 9% moderately high, 4% moderate, 38% moderately low, and 8% low).

Tanada Lake Trail Corridor

Tanada Lake trail begins at MP 12.2 of the Nabesna Road and heads south toward Tanada Lake along alluvial terrace (relative age 3) deposits with sporadic deposits of subdued glacial drift for the first 4.5 miles. The trail then traverses alternating deposits of subdued glacial drift and colluvium for the next 5.5 miles, where it then encounters an approximately 2.25-mile-wide alluvial fan (relative age 1) before terminating in colluvium that contains landslides for the last 1.5 mile of the mapped portion of the corridor. The Tanda Lake trail was generally mapped with a moderate RAP for the first 4.5 miles, and a moderately low RAP for the remainder of the trail. The only exception to this generalization is an alluvial fan deposited on the east side of Tanada Lake, which was mapped with high RAP. It was observed that trail conditions in this corridor have a positive correlation with RAP (i.e.: the trail tends to become more braided in low RAP deposits, and is a single strand in high RAP deposits). It is assumed that this is because the alluvial fan deposits are better drained, contain coarser aggregates, and may not be as affected by permafrost. Overall, the corridor is generally mapped as moderately low to high RAP (14% high, 2% moderately high, 22% moderate, 60% moderately low, and 1% low). There were no aggregate testing data available to test model assumptions along this corridor, but Little Jack Creek materials site situated on the same alluvial terrace (relative age 3) deposited along the first 4.5 miles of the trail was found to produce high quality aggregate suitable for road construction.

As shown above in Table 4, each road and trail corridor has at least some potential to produce quality aggregate for use in road and trail maintenance. Figure E - 21 in ATTACHMENT E - FIGURES provides a visual representation of the same data and is used to rank corridors in terms of overall RAP. Assuming highest quality aggregate sources are comprised of landforms with moderate to high RAP, corridors can be ranked by summing percentages of those areas to determine which sources should be prioritized for additional investigation (shown below in Table 5). As indicated by Table 5, Nabesna Road has the highest potential for producing quality aggregate, while trail corridors generally show decreasing levels of RAP.

Table 5. Corridors ranked by the sum of percentage of area mapped as moderate to high RAP.

Rank	Corridor	Percentage[1]
1	Nabesna Road Section 1	82
2	Nabesna Road Section 3	78
3	Nabesna Road Section 4	76
4	Caribou Creek Trail	73
5	Trail Creek Trail	61
6	Copper Lake Trail	55
7	Lost Creek Trail	53
8	Tanada Lake Trail	38
9	Soda Lake Trail	36
10	Reeves Field Trail	28
11	Nabesna Road Section 2	9

[1]Sum of areas of moderate to high RAP

Example Landform Aggregate Volume

To provide a sense of scale for WRST aggregate needs and potential resource volumes available, we estimated potential aggregate volume for a landform identified as having high RAP. The landform, located three-quarters of a mile east of the Caribou Creek trailhead near MP 12.5, was mapped as a glacial outwash deposit and was discussed and reviewed in the field by WRST and WFLHD staff during the site visit. To calculate landform volume, we first utilized a bare-earth DEM to create a surface terrain model in Open Roads Designer (ORD). We then created a flat "cut" model that used an assumed quarry floor base elevation, as well as an area around the base of the landform where it intersected the quarry floor elevation. Volume was calculated by subtracting cut model elevations from surface terrain model elevations and multiplying by landform base area. This calculation estimated a volume of 5.3 million cubic yards (MCUYD) as shown in ATTACHMENT H – EXAMPLE LANDFORM AGGREGATE VOLUME. Additionally, the same methodology was utilized via Google Earth to verify model results. Estimated volumes calculated by two independent WFLHD designers were within five percent of that calculated by ORD.

CONCLUSIONS AND RECOMMENDATIONS

Overall, our RAP model generally correlated well to aggregate quality testing from AKDOT&PF's 1994 subsurface investigation. There were instances where the RAP model appeared to over-estimate aggregate potential. Conversely, there were also instances where the model underestimated aggregate potential. Overall, we feel the model reasonably represents aggregate potential in mapped areas. We feel this model can be used as a tool to focus maintenance efforts and to assist maintenance crews in identifying potential aggregate resource areas. It should be noted any potential materials sources should be properly investigated and tested prior to development. Overall, we feel this model can be used as a planning tool to assess aggregate potential along existing roads and trails, and the methodology could be applied to future road and trail alignments.

In a 1998 memo AKDOT&PF indicated 506,905 yds^3 was needed to maintain Nabesna Road from MP 4-42. An update in a 2002 memo indicated a need for 520,000 yds^3 of aggregate (safety factor of 1.2 for 650,000 yds^3) and 20,000 yds^3 of riprap (safety factor of 2.0 for 40,000 yds^3). As discussed above, a single landform near MP 12.5 could provide nearly ten times the volume required for Nabesna Road alone. Although results suggest sufficient potential and volumes for quality aggregate along Nabesna Road, they also indicate significantly lower potential along trails. This may indicate substantial haul distances would be required to move material from Nabesna Road to surrounding trails within WRST.

Given significant quantities of readily replenished material available along the approximately 3.5-mile-wide coalescing alluvial fan deposited by Trail and Lost Creeks, vicinity to area roads and trails, and potential ease of excavation, we recommend testing of aggregates here to determine suitability for use in building and maintain roads and trails in WRST. We also recommend testing of alluvial fan deposits located along Jack Creek as these could also be an important source of material for reconstruction of the Nabesna Haul Road for proposed future cleanup of the Nabesna Mine.

In subsequent efforts, and possibly next steps related to aggregate source planning, existing landform mapping could be used to develop relative geologic risk maps (based on geohazards, existing stability concerns, permafrost, high groundwater conditions, poor soils, etc.) for maintaining existing alignments or constructing proposed realignments. Additional mapping would be required as part of any effort to determine the geologic risks described above. Relative geologic risk mapping can be used to highlight areas that present lower or higher risk to proposed or existing transportation infrastructure. Further, a relative geologic risk map could be used for planning purposes by comparing relative geologic risk and associated costs of various alignment options. Typical road and trail design sections can be developed to reduce risk to infrastructure from specific geological risk areas. For example, when alignments (existing or proposed) cross the different mapped relative geological risk areas, the most resilient typical design section could be applied/used. For estimating purposes, a road or trail section cost per lineal foot and the approximate construction quantities for each design section could be determined as well as anticipated maintenance costs. Under this approach and methodology, comparisons of options can then be more easily understood and made to inform decision-makers on road and trail maintenance within WRST.

It was communicated to WFLHD that the Tanada Lake trail is under consideration for realignment. Its current location is within low elevation muskeg terrain, which is incredibly challenging for a hardened trail to be maintained. As such, a higher elevation option is being considered. Additional RAP geologic risk mapping/modelling could be used to consider potential aggregate sources and their relative quality during preliminary realignment planning.

LIMITATIONS

This assessment was intended to inform potential aggregate material sourcing for planning purposes with regard to road and trail construction and maintenance and does not guarantee high- or low-quality aggregate quality sources based on RAP alone. Interpretation and assumptions related to landform mapping are generalized and may not be representative of an entire mapped landform. Site-specific investigation and testing are recommended prior to any proposed aggregate material site development. As stated herein, field verification of landform interpretation was limited to Nabesna Road during the site visit due to a flooding event.

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CLOSING

Please contact Ryan Cole (360) 619-7571 Ryan.Cole@dot.gov, or Orion George (360) 619-763, Orion.George@dot.gov with any questions regarding this memorandum.

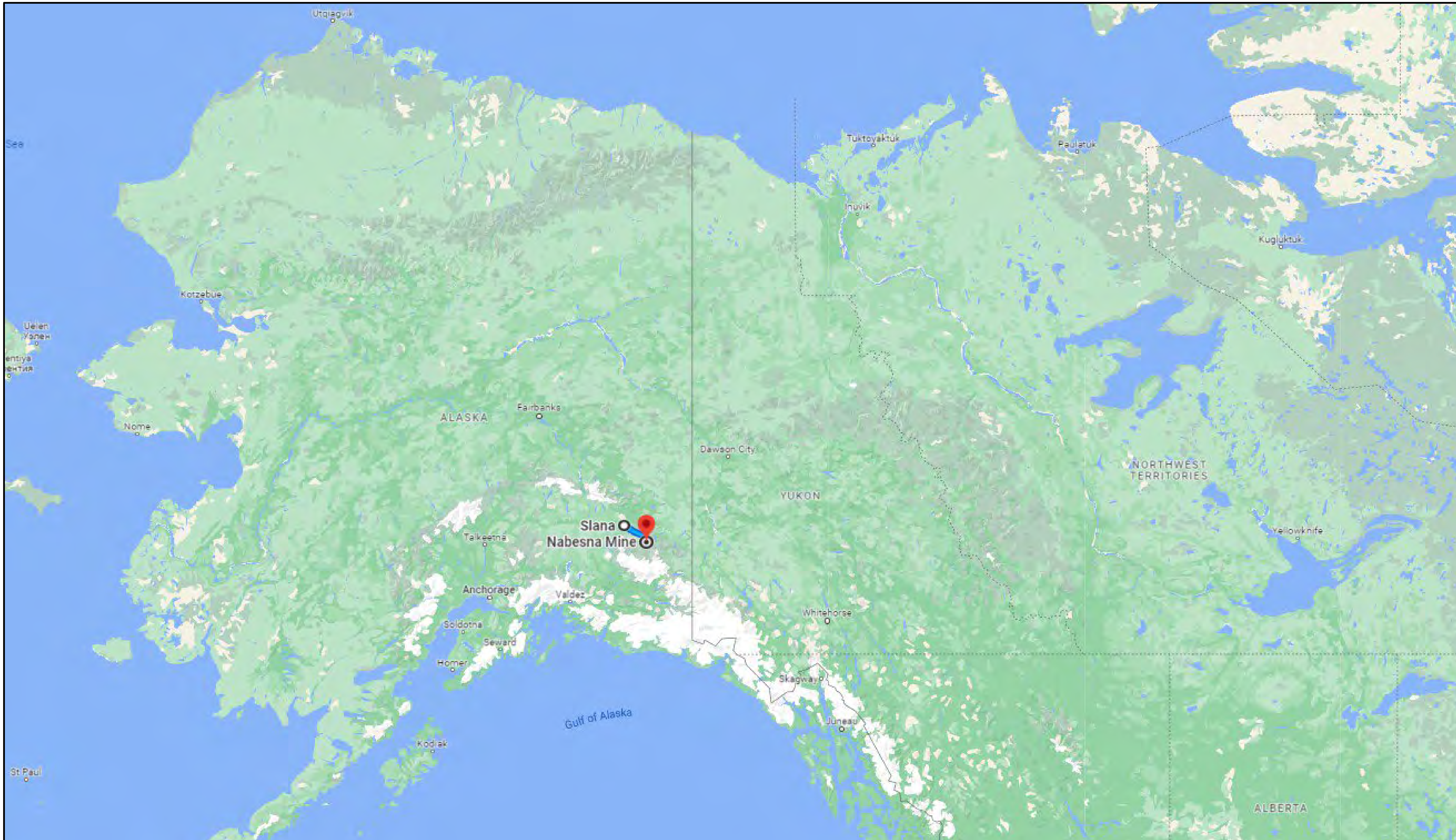
INITIALS

CC: Doug Anderson, Geo Team Functional Manager
Geotechnical File

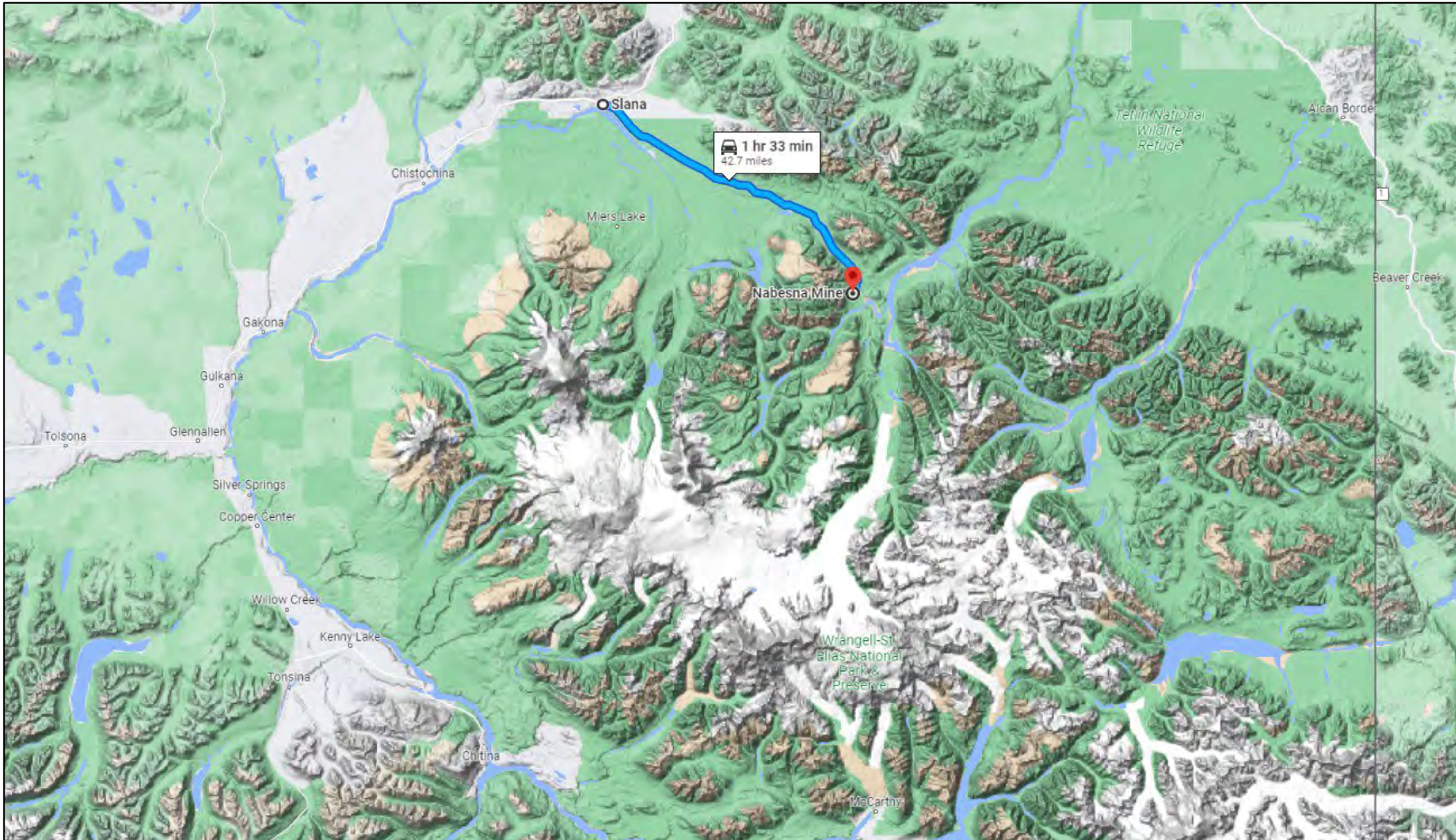
Attachments:

ATTACHMENT A – PROJECT LOCATION MAPS
ATTACHMENT B – GEOLGIC MAP
ATTACHMENT C – MATERIAL SITE MAPS
ATTACHMENT D – TABLES
ATTACHMENT E - FIGURES
ATTACHMENT F – LANDFORM MAPS
ATTACHMENT G – RELATIVE AGGREGATE POTENTIAL (RAP) MAPS
ATTACHMENT H – EXAMPLE LANDFORM AGGREGATE VOLUME

ATTACHMENT A – PROJECT LOCATION MAPS



U.S. Department of Transportation Federal Highway Administration Western Federal Lands Highway Division 610 East Fifth Street Vancouver, WA 98661	**Project No.** FLPP NPS WRST STS **Scale** NTS **File Name:** **Date:** 2022-09-20	Regional Project Location Wrangell-St. Elias National Park & Preserve Strategic Transportation Study	Figure A1



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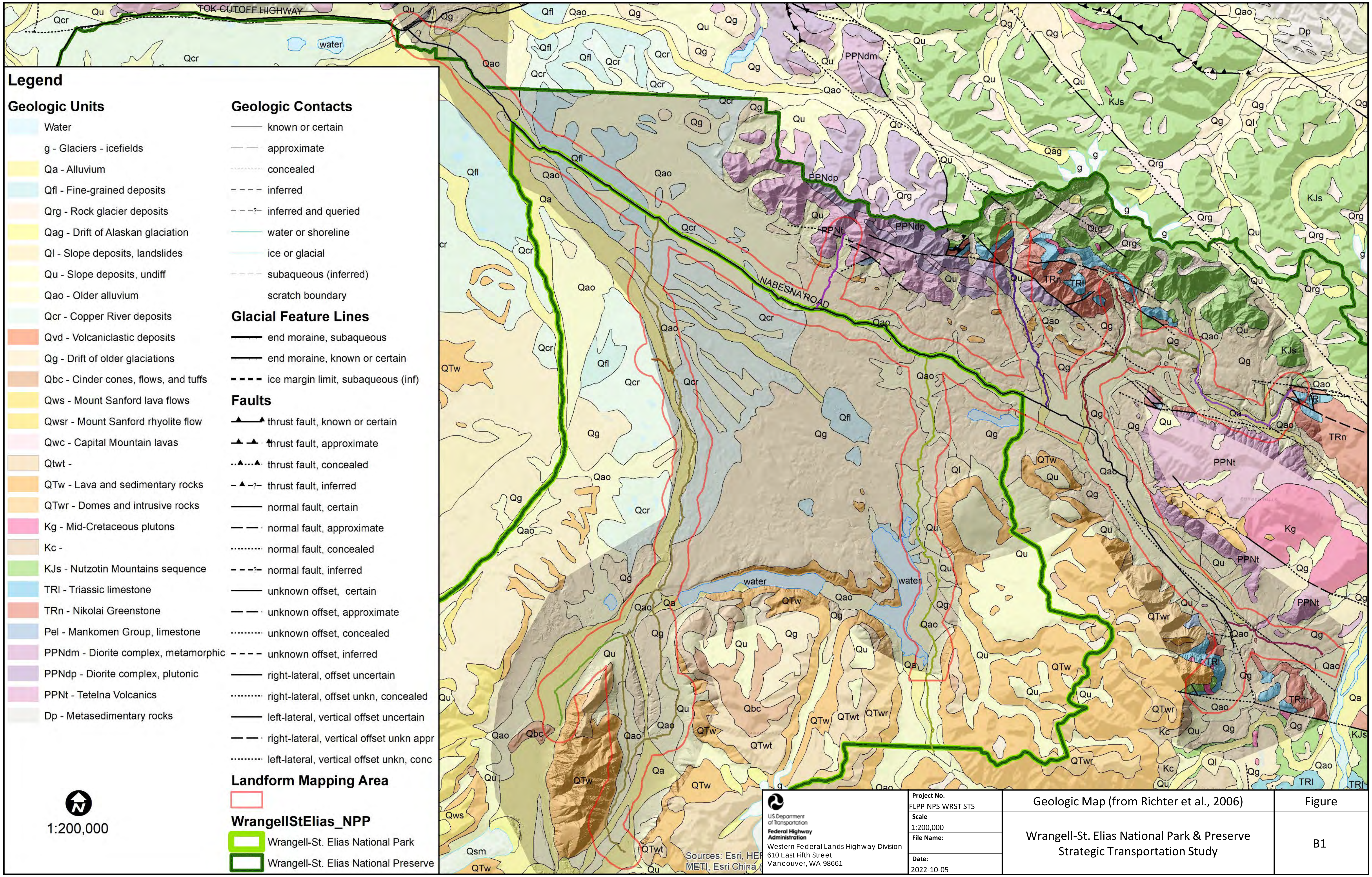
ATTACHMENT B – GEOLGIC MAP



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Project No.	Geologic Map (from Richter et al., 2006)	Figure
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Scale	Wrangell-St. Elias National Park & Preserve Strategic Transportation Study	B1
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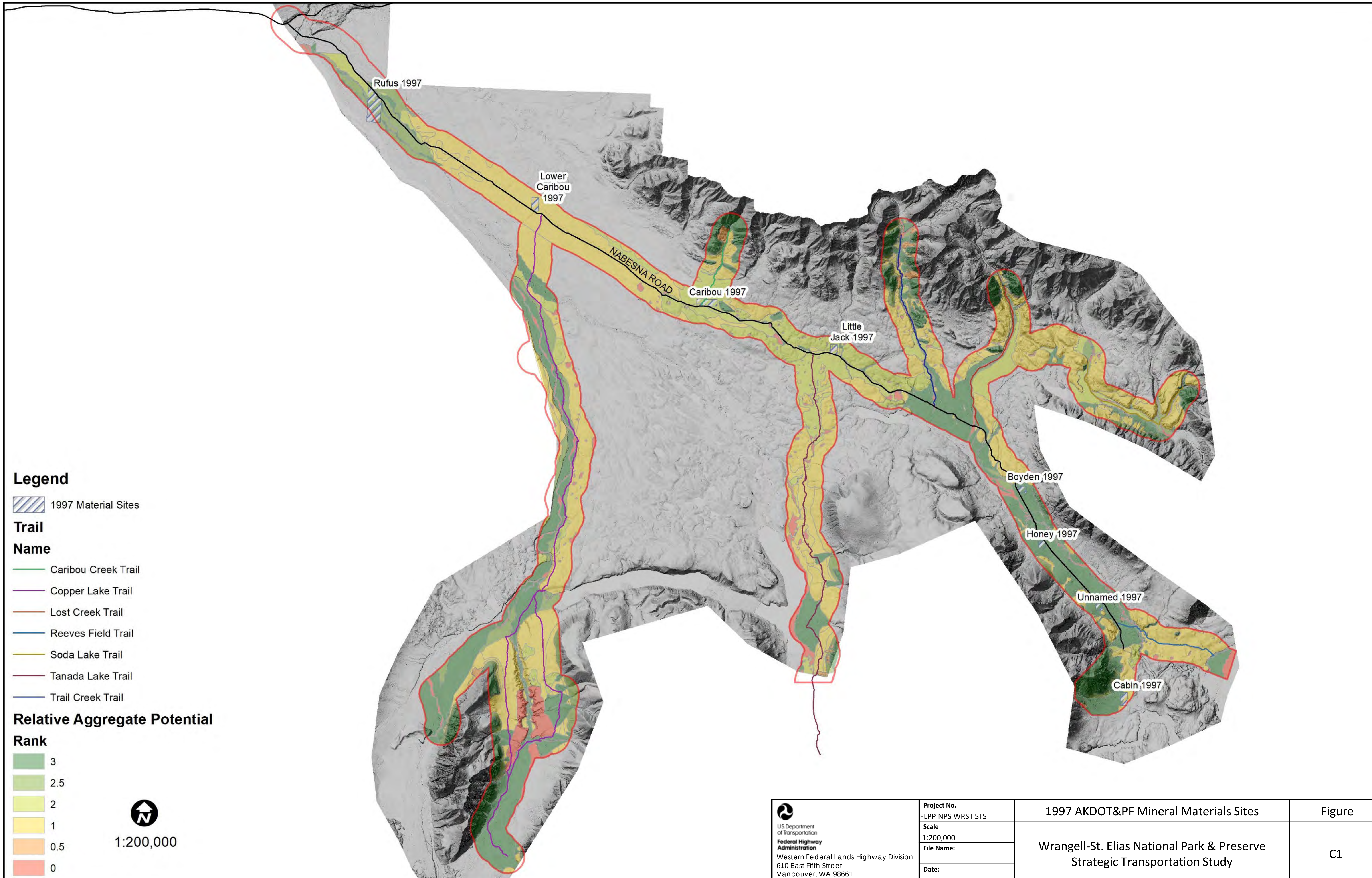
Date:		
2022-10-05		

ATTACHMENT C – MATERIAL SITE MAPS



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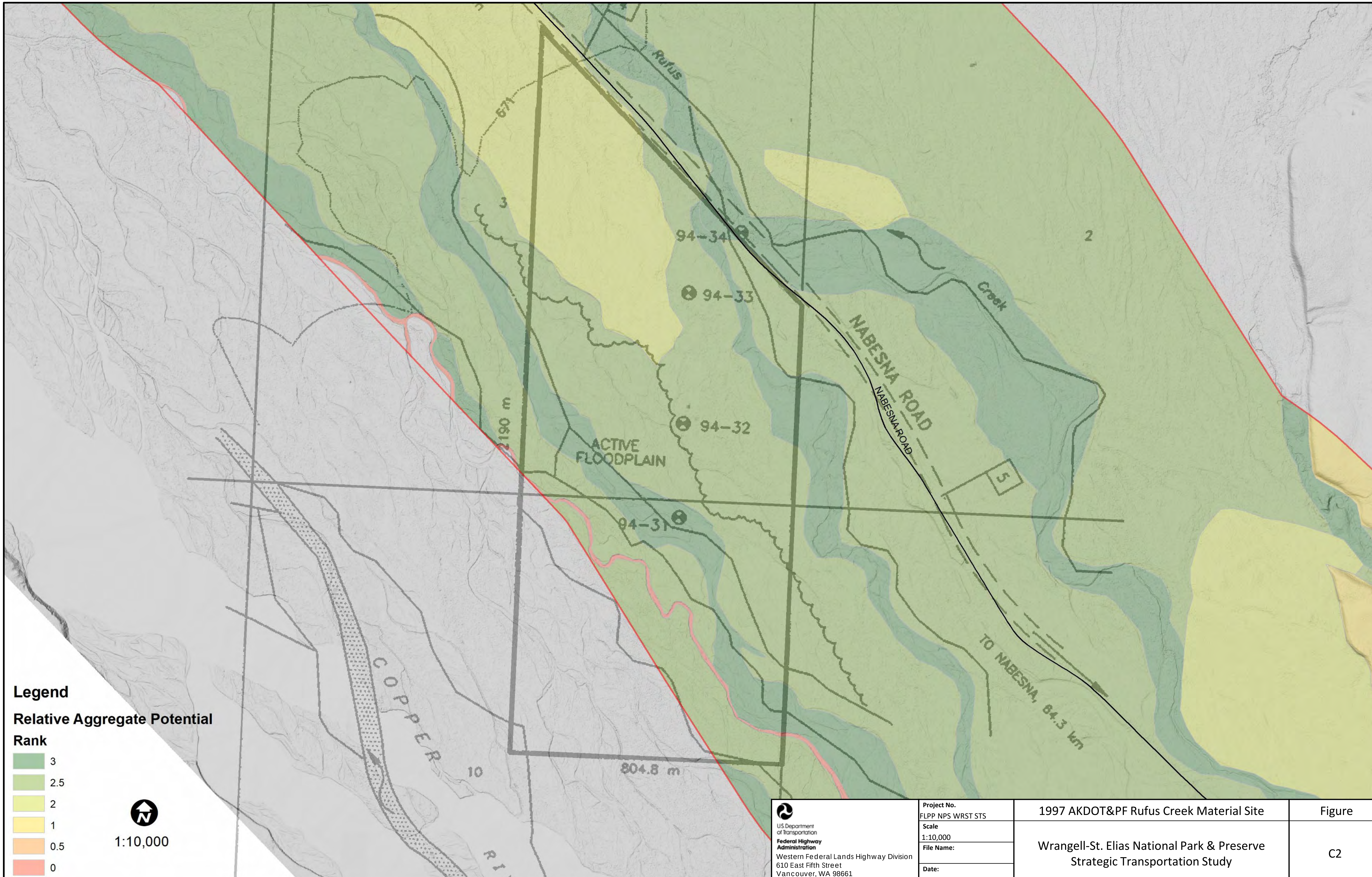

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Project No. FLPP NPS WRST STS
Scale 1:10,000
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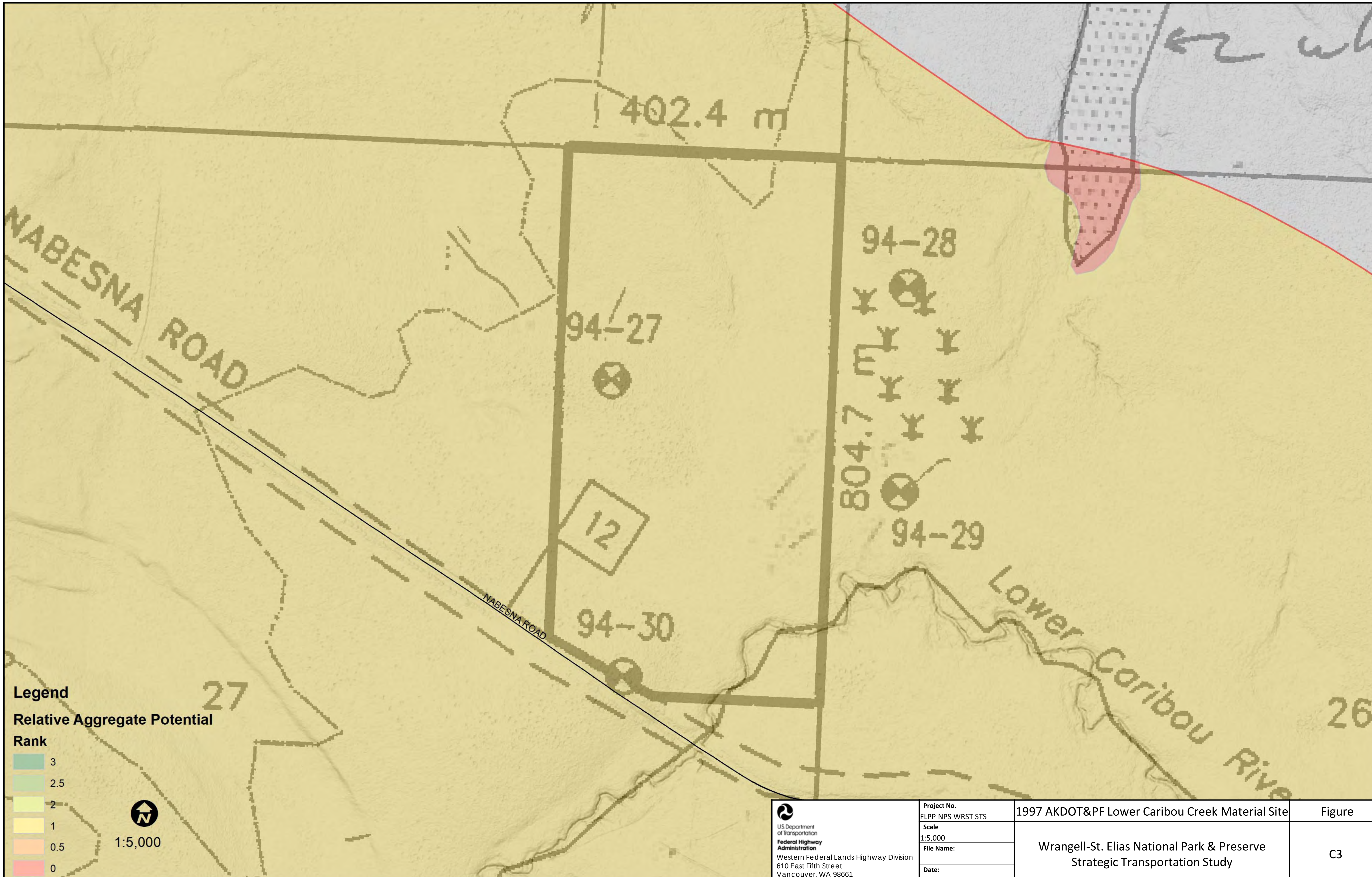
Date: 2022-10-04

1997 AKDOT&PF Rufus Creek Material Site

Wrangell-St. Elias National Park & Preserve Strategic Transportation Study

Figure C2



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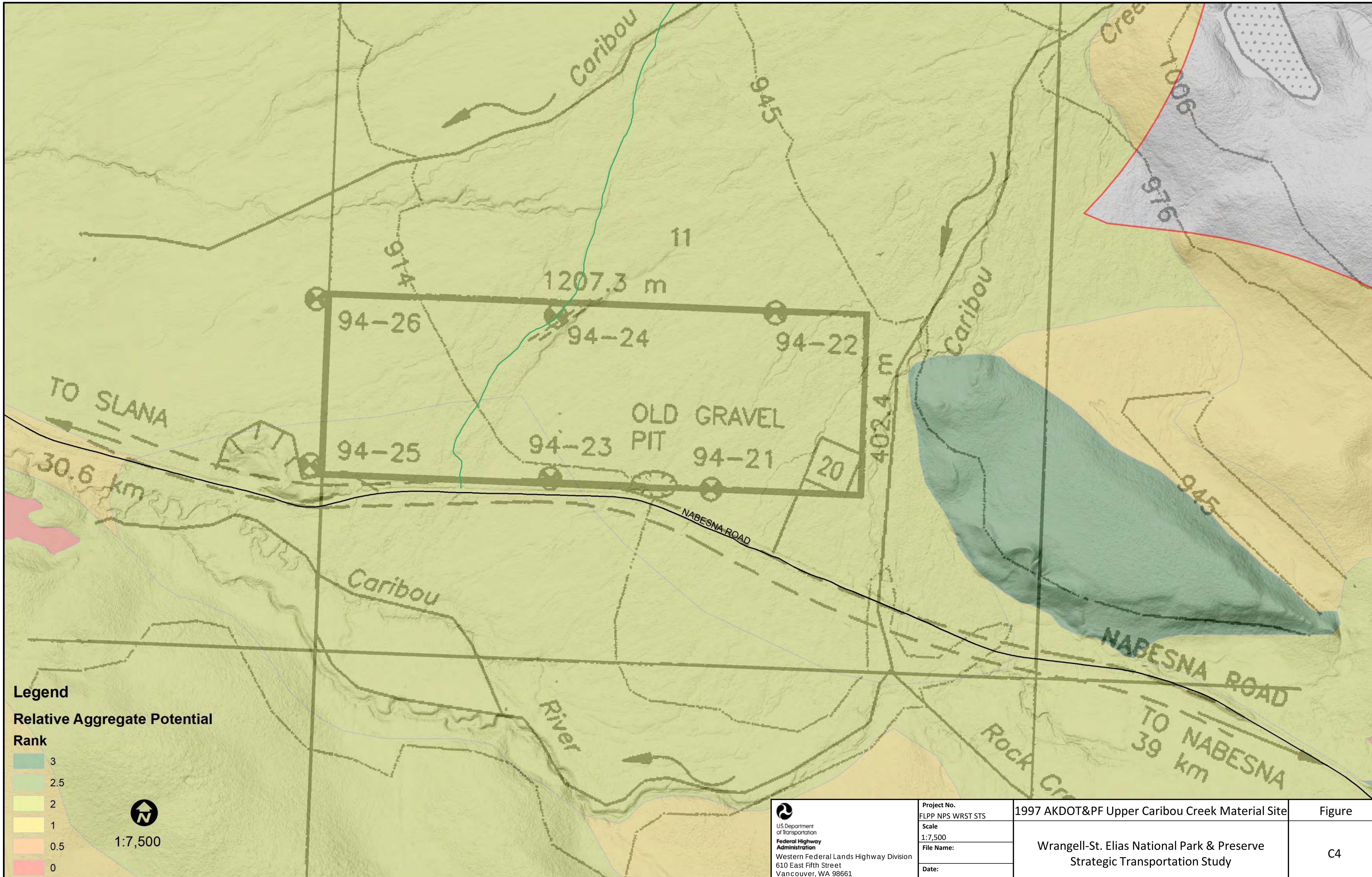

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Project No. FLPP NPS WRST STS	1997 AKDOT&PF Upper Caribou Creek Material Site	Figure
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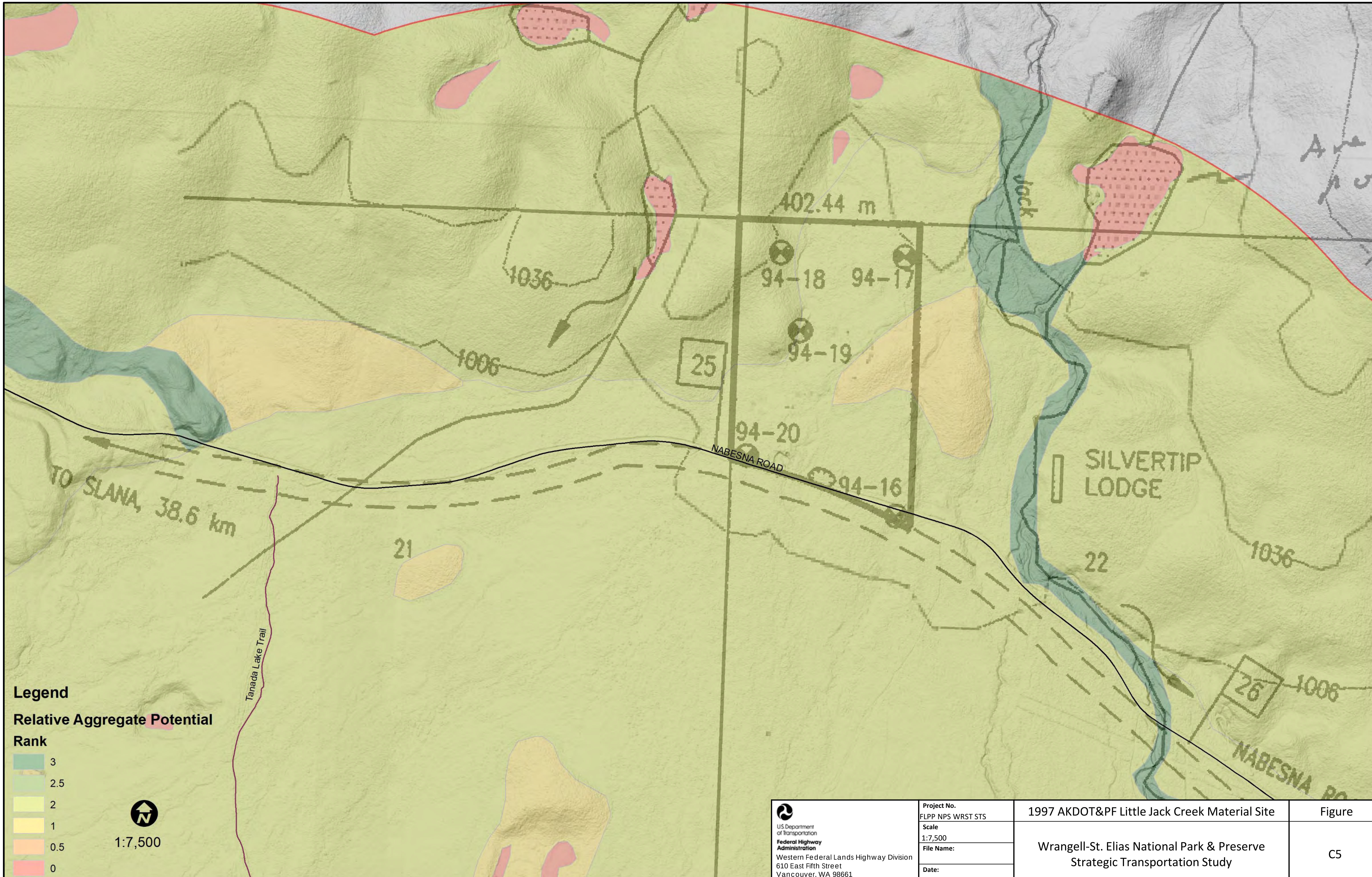

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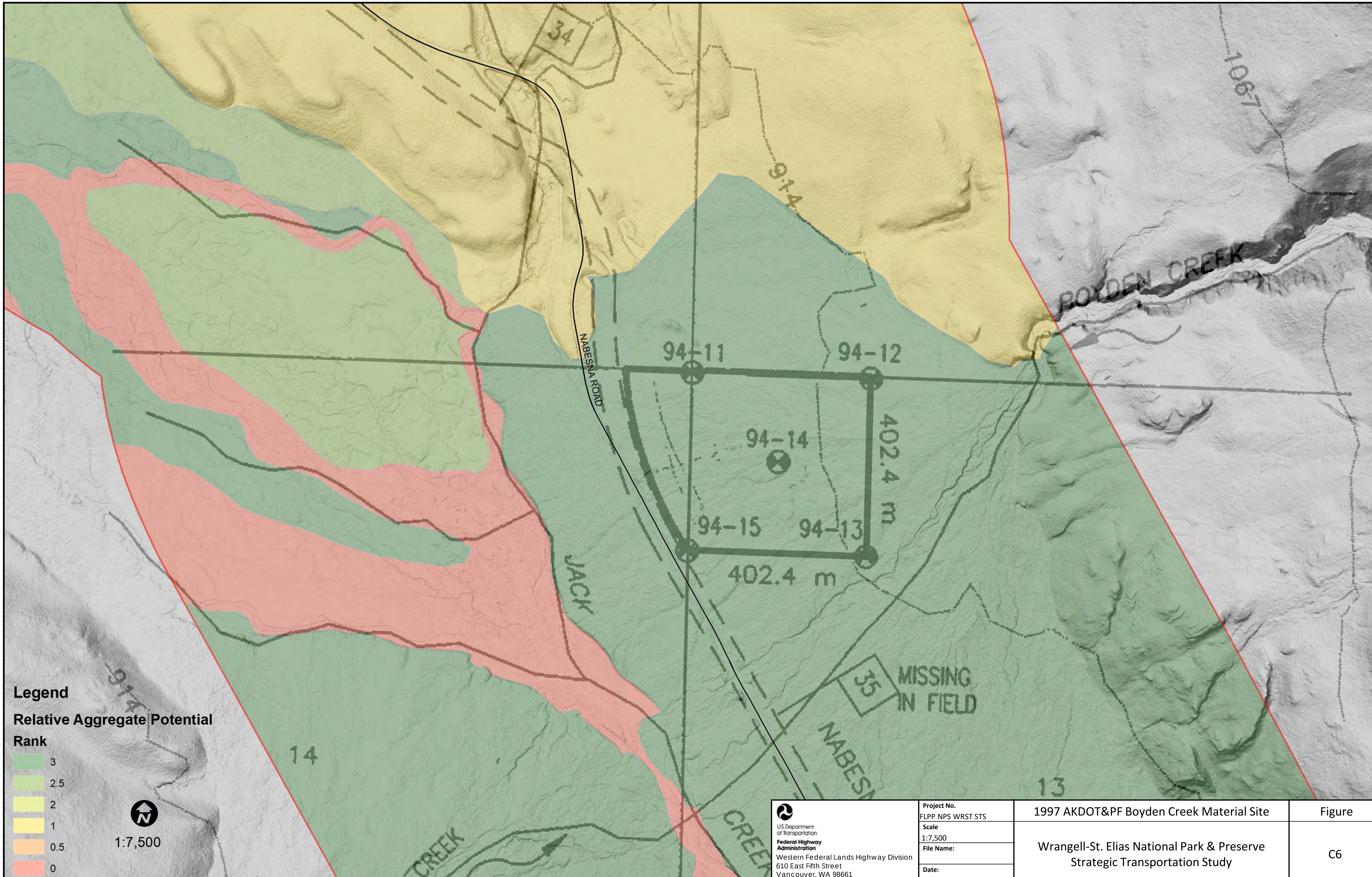

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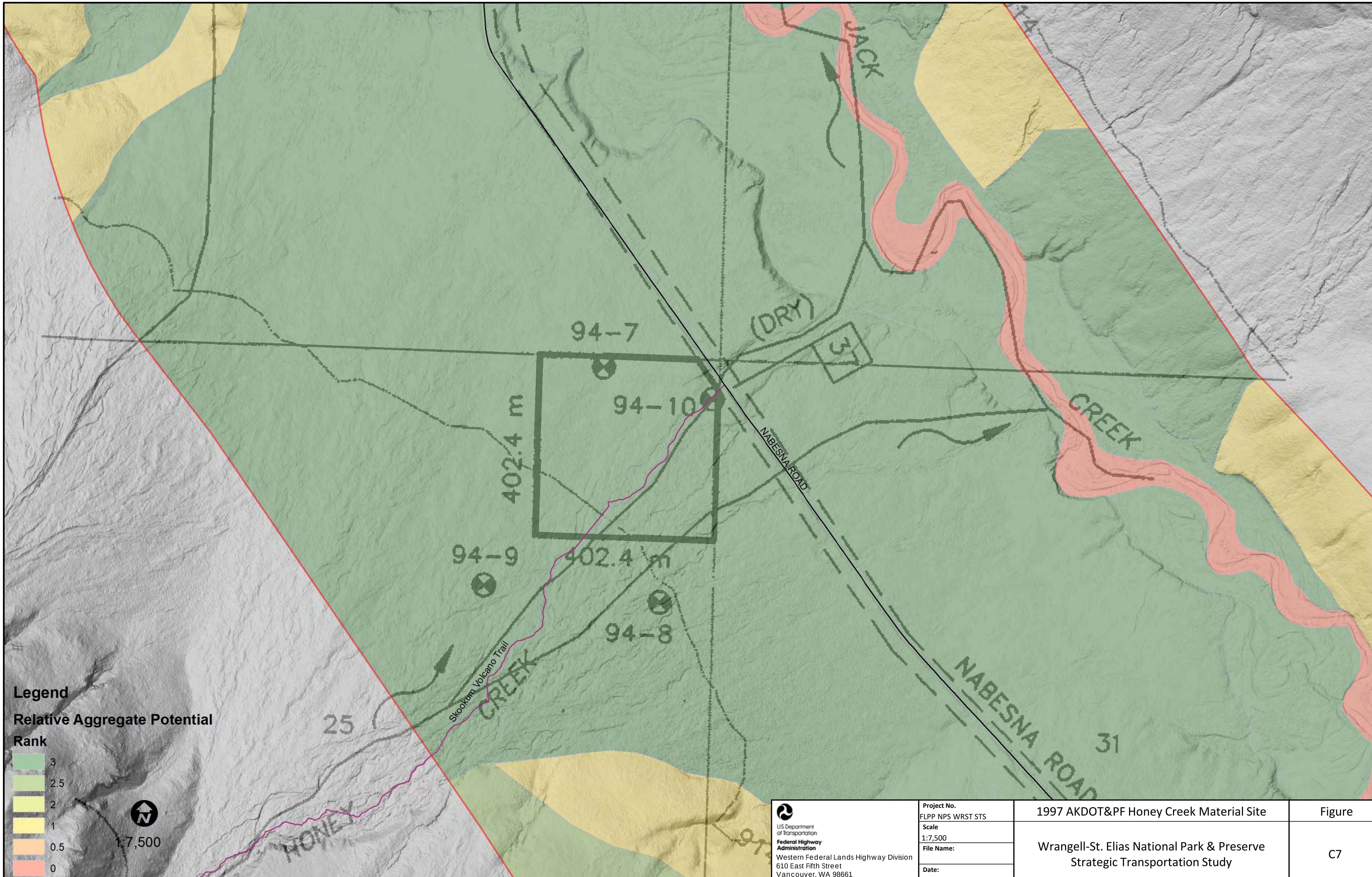

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Project No. FLPP NPS WRST STS	1997 AKDOT&PF Honey Creek Material Site	Figure
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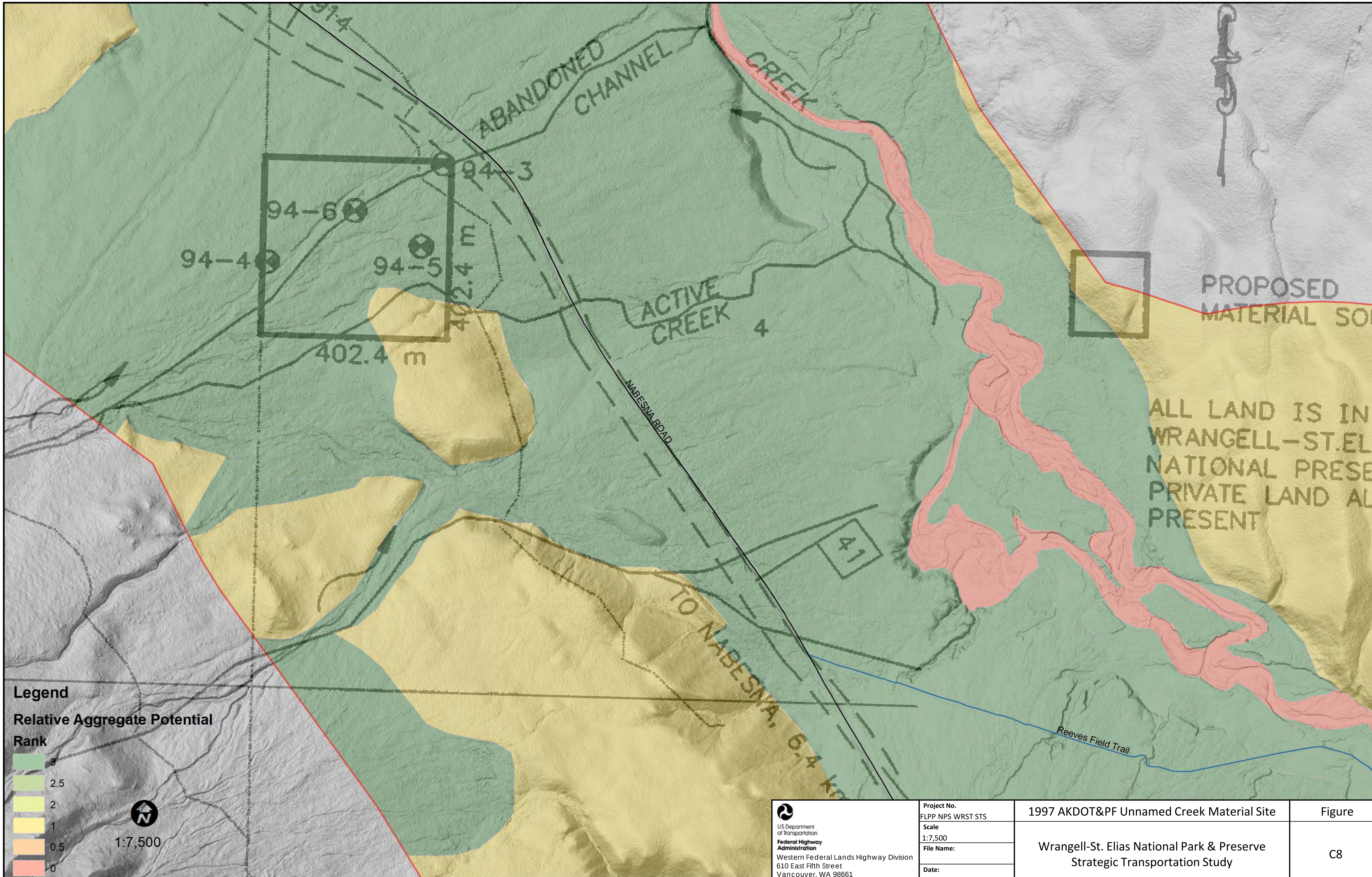
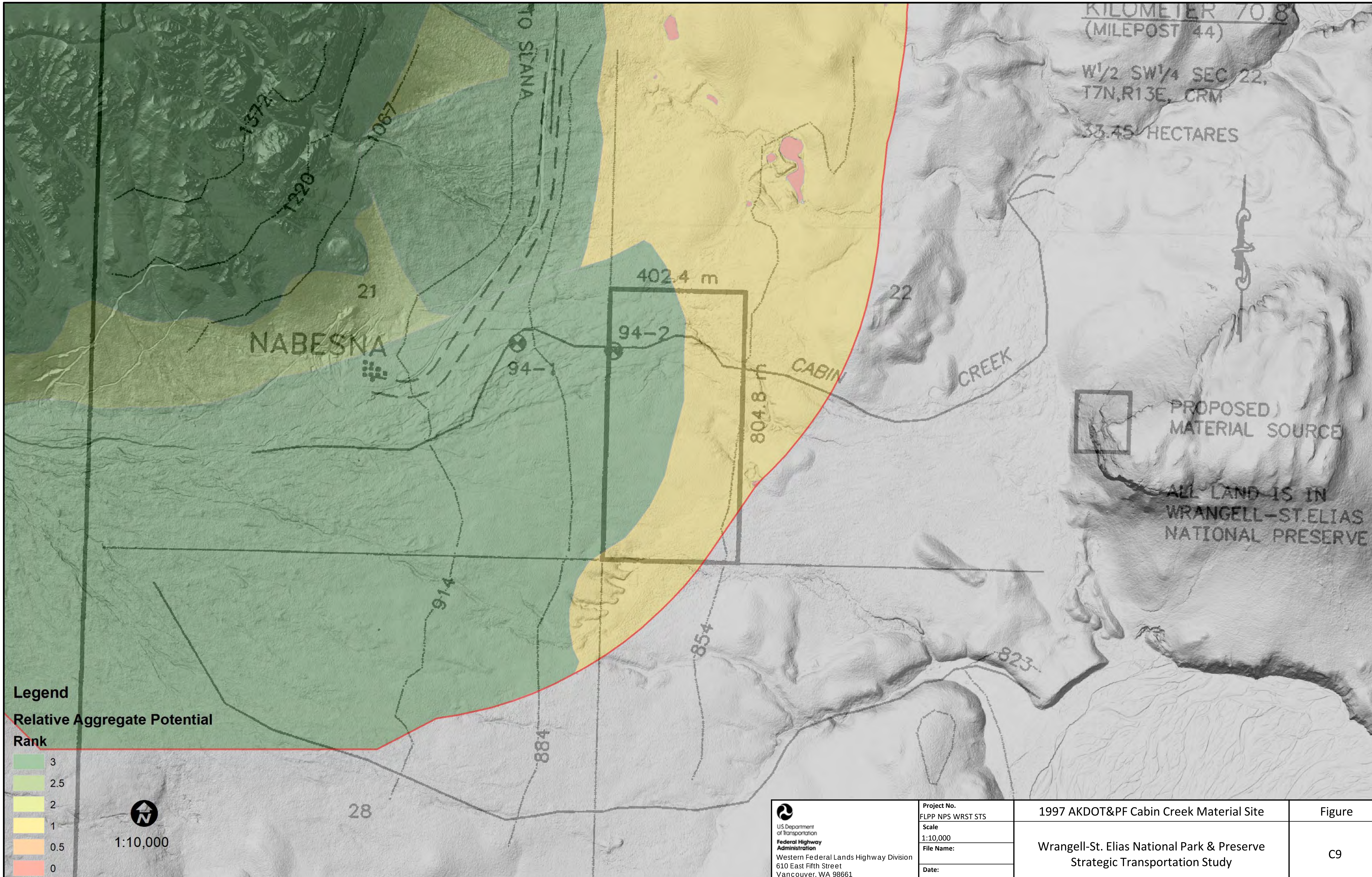


U.S. Department of Transportation Federal Highway Administration Western Federal Lands Highway Division 610 East Fifth Street Vancouver, WA 98661	Project No. FLPP NPS WRST STS Scale 1:7,500 File Name: Date: 2022-10-04	1997 AKDOT&PF Unnamed Creek Material Site Wrangell-St. Elias National Park & Preserve Strategic Transportation Study	Figure C8



U.S. Department of Transportation
Federal Highway Administration
Western Federal Lands Highway Division
610 East Fifth Street
Vancouver, WA 98661

Project No.	1997 AKDOT&PF Cabin Creek Material Site	Figure
FLPP NPS WRST STS		
Scale: 1:10,000	Wrangell-St. Elias National Park & Preserve Strategic Transportation Study	C9
File Name:		
Date: 2022-10-04		

ATTACHMENT D – TABLES

Table D - 1. Summary of Nabesna Road material sites (modified from AKDOT&PF, 1997). For descriptions of material type specifications, see the Standard Specifications for Highway Construction (AKDOT&PF, 2020).

Site	Milepost	Degradation	L.A. Abrasion	Sodium Sulfate Soundness	Base Course?	Subbase?	Subbase Wearing Course?	Asphalt Aggregate?	Cover Coat?	Aggregate Type	Landform	Relative Aggregate Potential (RAP)	Comments
Rufus Creek	4.5	77, 78	22	0.4, 0.8	Yes	Yes	Yes	Yes	Yes	A, B, C	Active Channel, Alluvial Terrace 1-3	Moderate to High	High quality, low silt, large quantity available, best overall source, not centrally located, 1st choice
Lower Caribou Creek	12.0	54, 67	16	0.6, 2.8	Yes	Yes	Yes	Yes	Yes	B, C	Alluvial Terrace 4	Moderate	High quality, Proctor plot close to Z.A.V line, may be very difficult to compact during rainy periods or if high moisture conditions occur.
Upper Caribou Creek	20.0	74	Lost	Lost	Yes	Yes	Yes	Yes	Yes	B, C	Alluvial Fan 1, Alluvial Terrace 3	Moderate to High	High quality, central location between 1st and 2nd choice, west side of site contains thick layers of silty sand and sandy silt, selective mining required
Little Jack Creek	25.3	51	17	1.5, 1.4	Yes	Yes	Yes	Yes	Yes	B, C	Alluvial Terrace 3, Glacial Drift Kame, Glacial Drift Subdued	Moderate to High	High quality gravelly-silty-sand, and sandy-silt, had LL of 17&19 and a PI of 3&4, quantities may be limited
Boyden Creek	34.6	55	14, 15	0.8, 1.5	Yes	Yes	Yes	Yes	Yes	A, B, C	Alluvial Fan 1	High	High quality, low silt, 2nd choice
Honey Creek	37.0	51	27	6.8, 6.9	No/yes	No/yes	No/yes	No/yes	No/yes	A, B, C	Alluvial Fan 1	High	Variable quality, low silt, selective mining required for crushed aggregate products, additional quality tests required
Unnamed Creek	40.3	13, 27	13, 27	4.6, 3.3	No	no	no	no	no	A, B, C	Alluvial Fan 1, Glacial Drift Subdued	Moderate to High	Low quality, low silt, does not meet requirements for crushed aggregate products, bedrock noted in creek with natural fracture pattern for potential riprap quarry
Cabin Creek	44.0	53	53	-	-	-	-	-	-	A	Alluvial Fan 1, Glacial Drift Subdued	Moderate to High	Probable hazardous waste site, do not consider

ATTACHMENT E - FIGURES

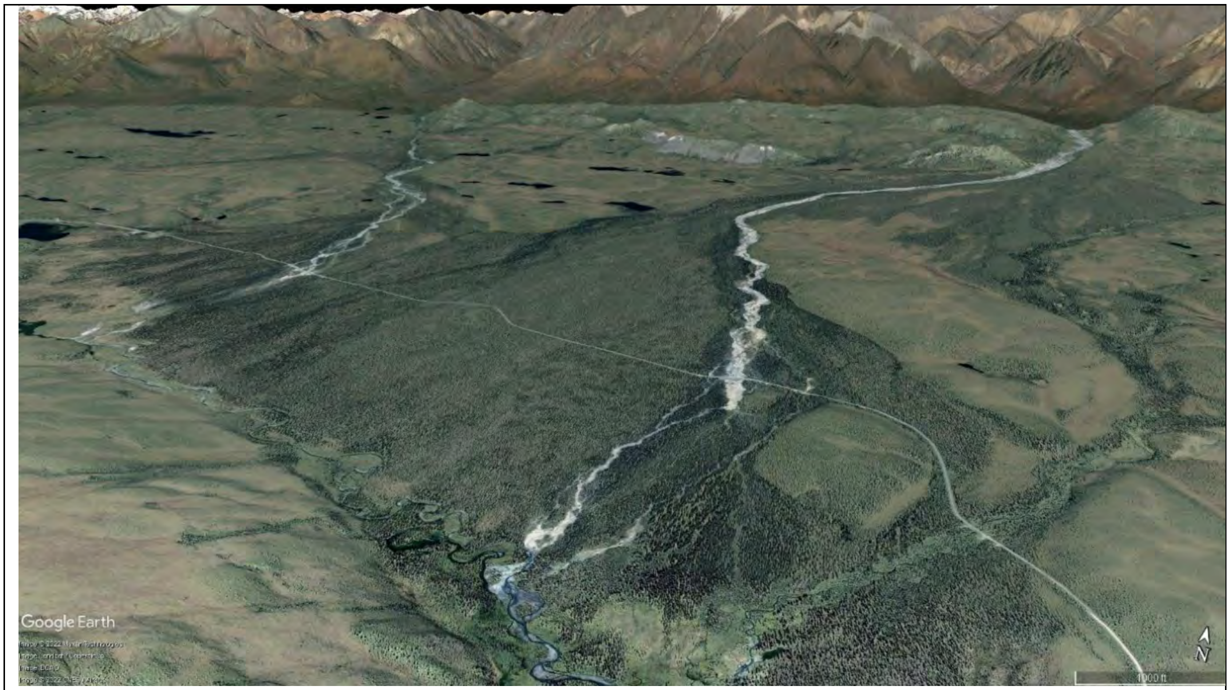


Figure E - 1. Oblique aerial imagery from Google Earth showing coalescing alluvial fans from Trail and Lost Creeks along the Nabesna Road.

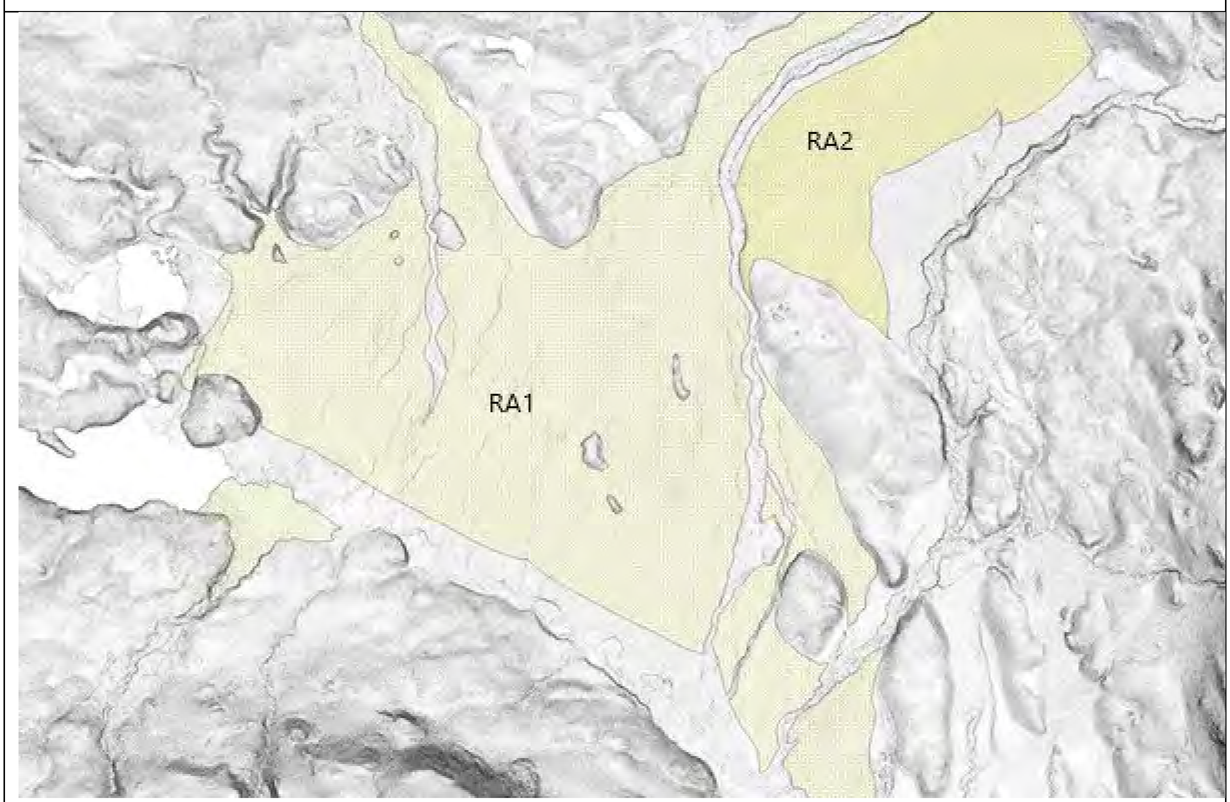


Figure E - 2. LiDAR DEM of coalescing alluvial fans (relative age 1 and 2) at Trail and Lost Creeks, interpreted and delineated in shades of yellow. Relative age 1 unit (RA1) is interpreted as younger than relative age 2 unit (RA2) because RA2 is on an elevated surface that has been eroded into by the active fan surface of RA1.

Figure E - 3. Oblique aerial imagery from Google Earth showing colluvium deposited in the valley margins of Trail Creek.

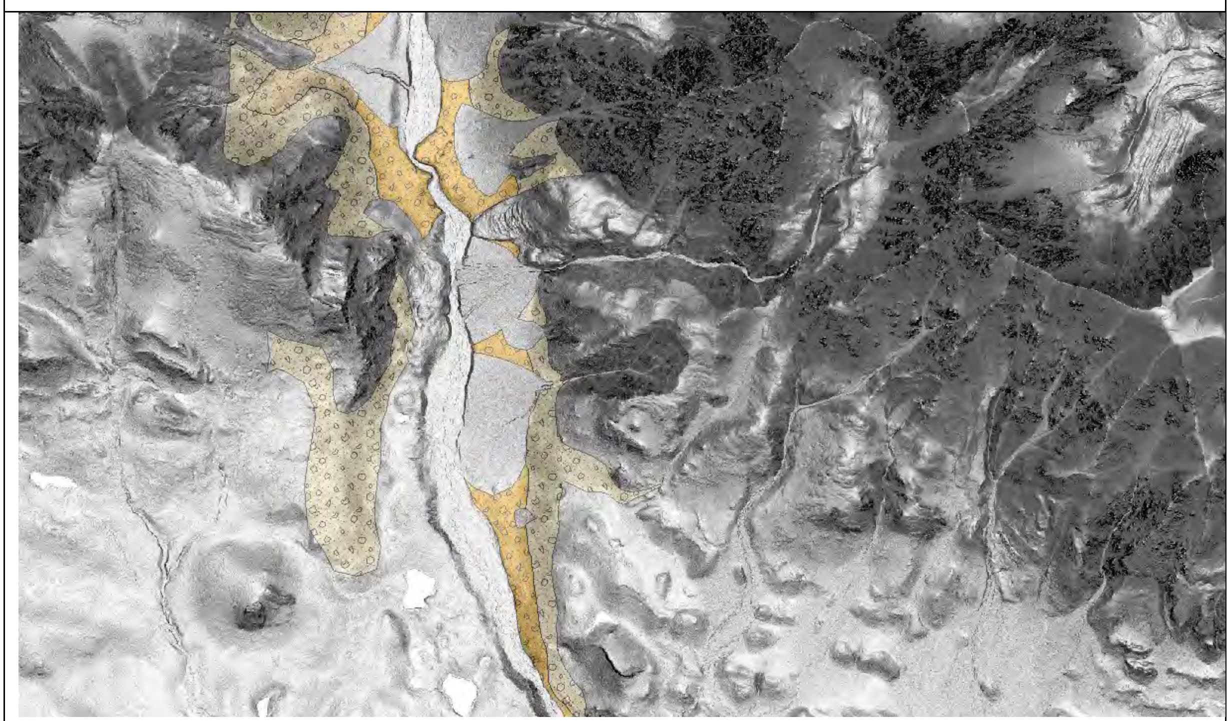


Figure E - 4. LiDAR DEM of colluvium deposits over shallow bedrock (light yellow texture), deep bedrock (light orange texture), and unconsolidated deposits (dark orange texture) in the valley margins of Trail Creek.

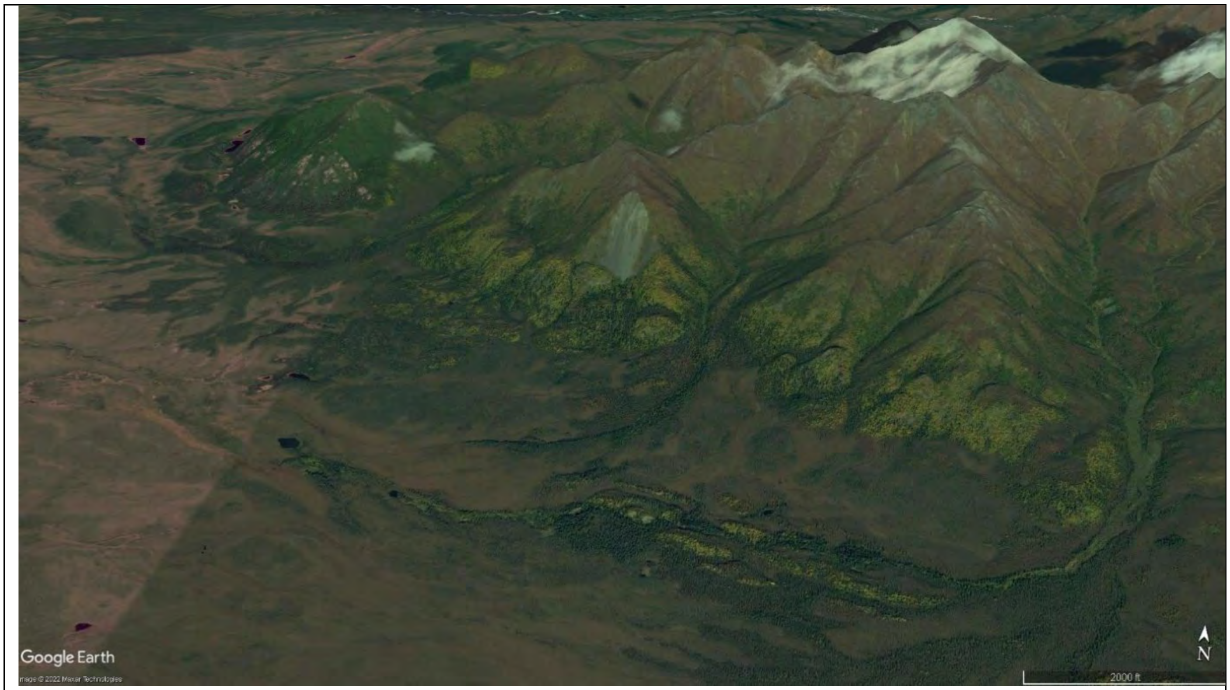


Figure E - 5. Oblique aerial imagery from Google Earth showing a large translational landslide in the southern Mentasta Mountains, east of the Suslota Lake Trail.

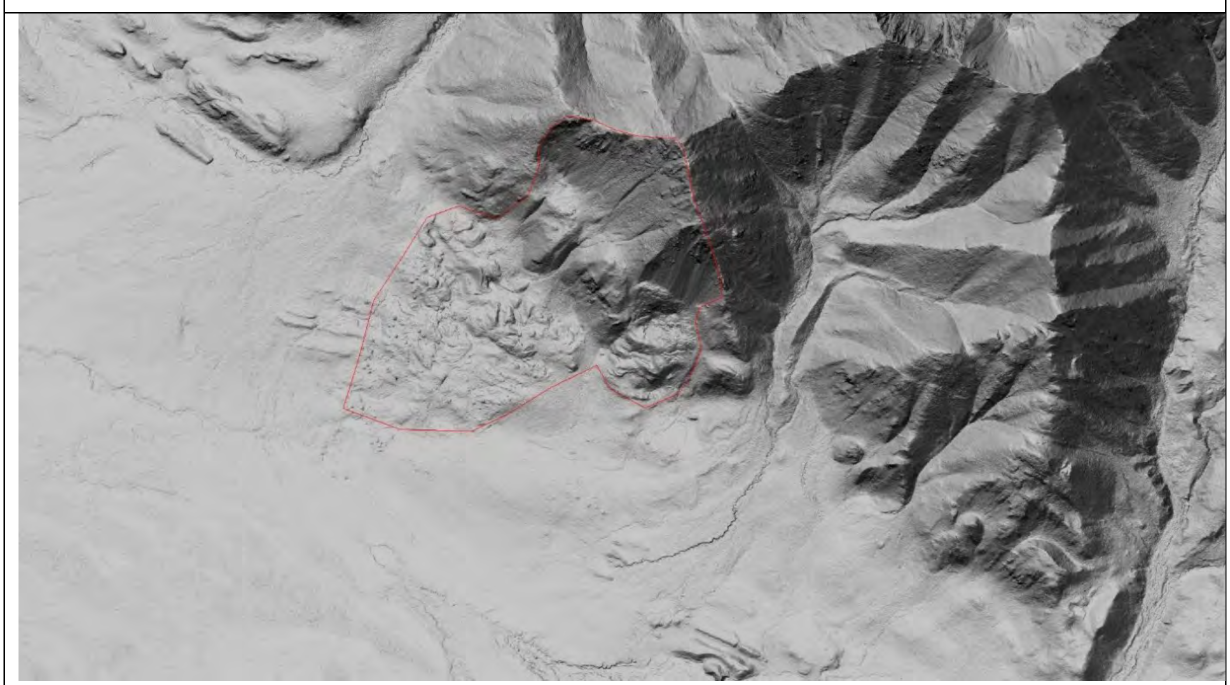


Figure E - 6. LiDAR DEM of a large translational landslide, outlined in red, in the southern Mentasta Mountains, east of the Suslota Lake Trail.

Figure E - 7. Oblique aerial imagery from Google Earth showing the active channel (lighter colored, non-vegetated area) at the outlet of Copper Lake.

Figure E - 8. LiDAR DEM showing the active channel (outlined in blue) at the outlet of Copper Lake. Note that the active channel does not include the wider floodplain of the Copper River.

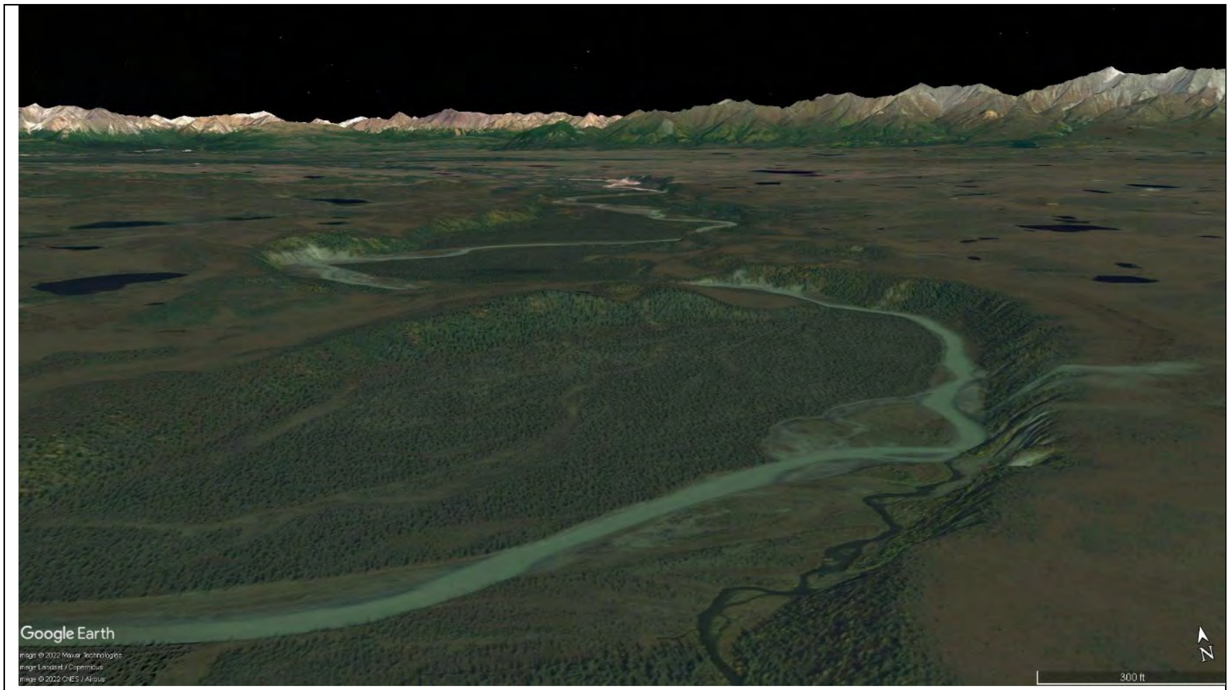


Figure E - 9. Oblique aerial imagery from Google Earth showing alluvial terraces (benches at successively higher elevations from the active channel) along the Copper River near the outlet of Copper Lake.

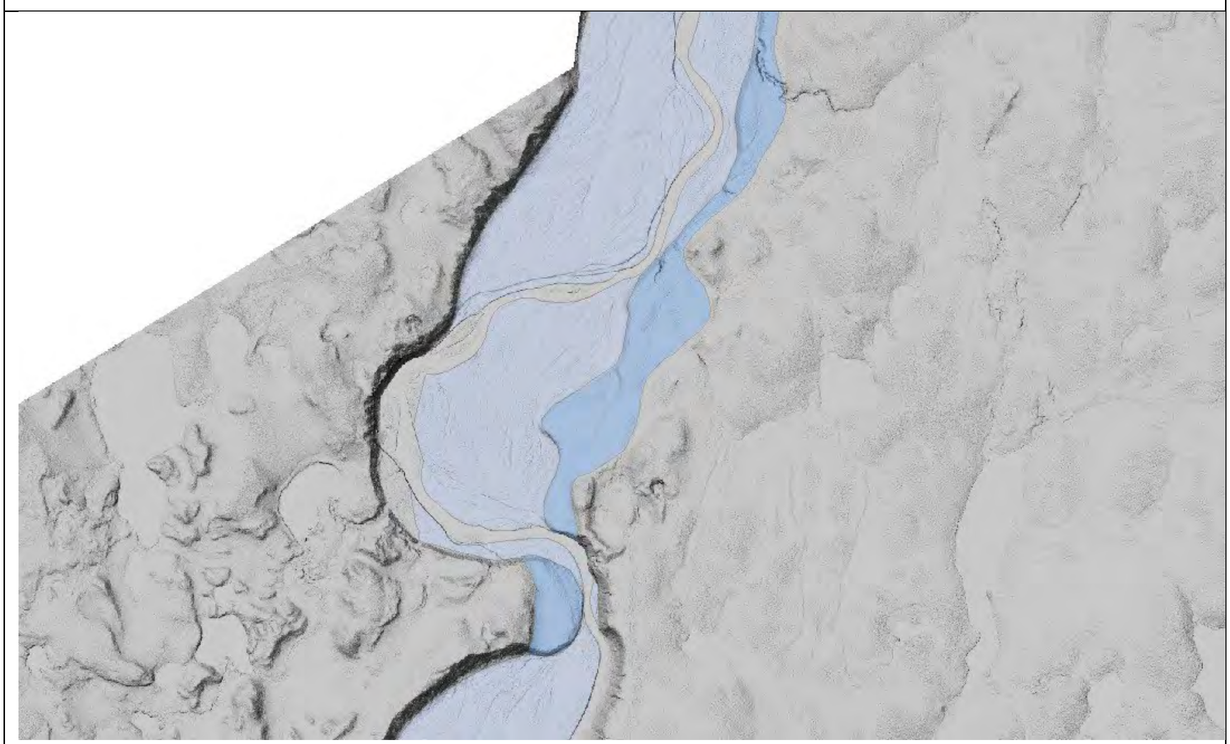


Figure E - 10. LiDAR DEM showing alluvial terraces (relative ages 1 (light blue) and 2 (medium blue) along the Copper River near the outlet of Copper Lake.

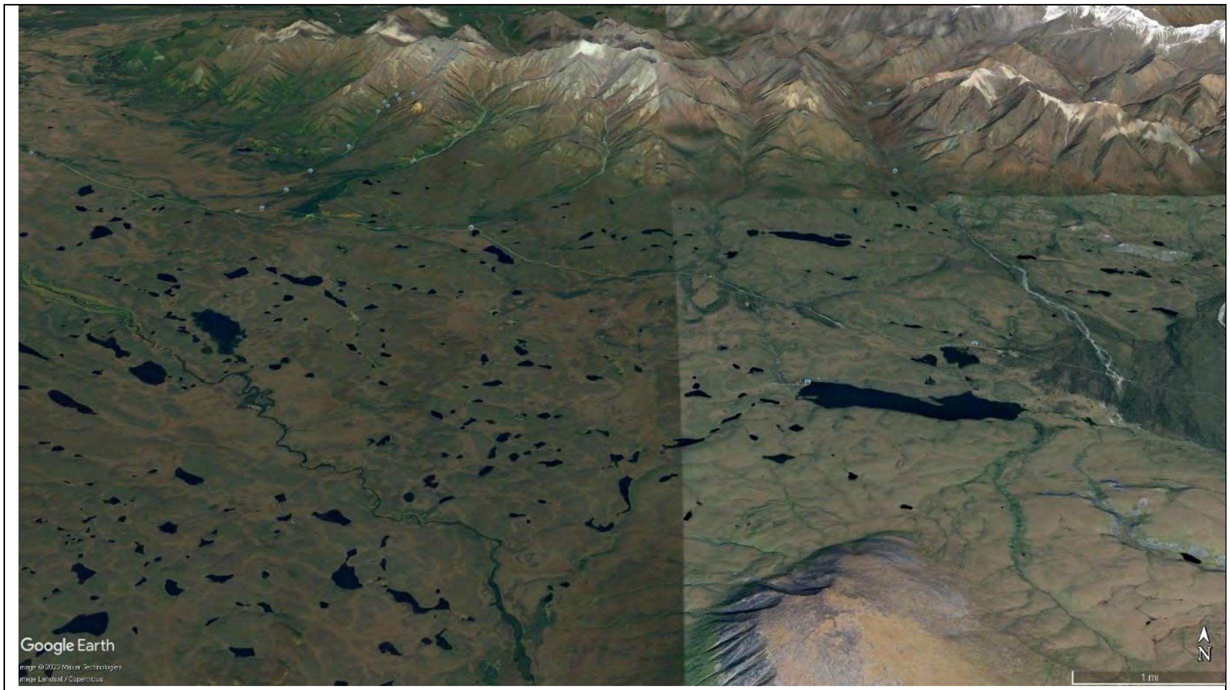


Figure E - 11. Oblique aerial imagery from Google Earth showing kame and kettle topography south of the Mentasta Mountains between the Copper River and the continental divide near Jack Lake.

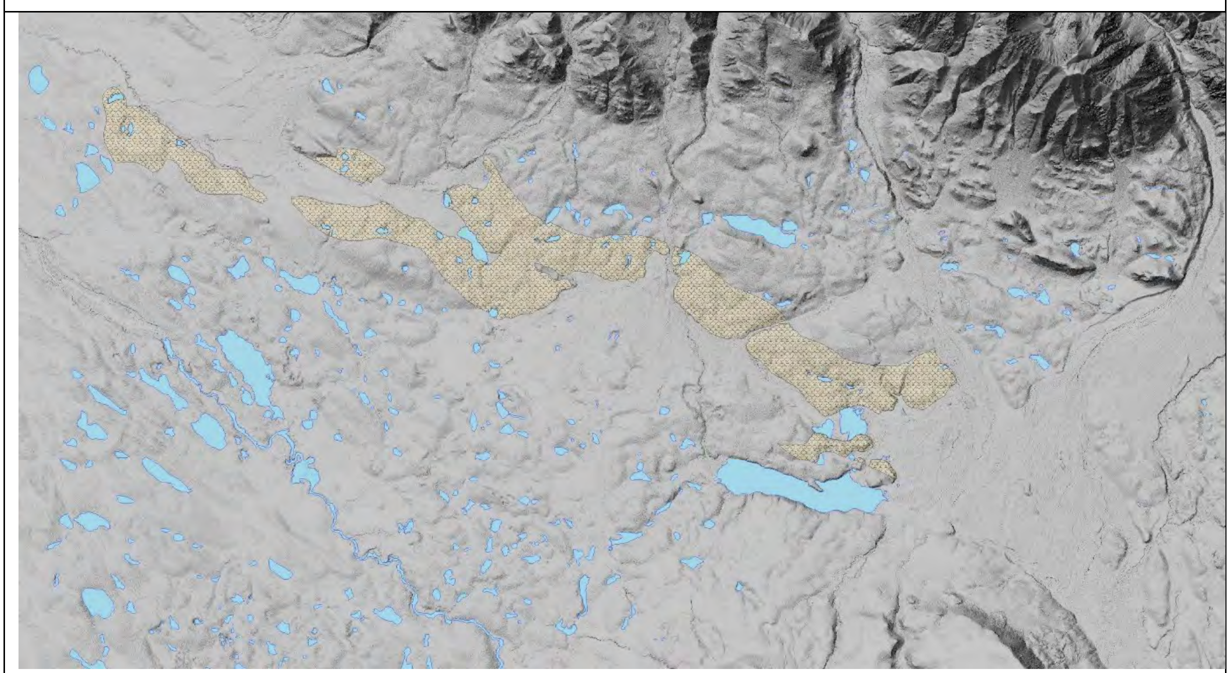


Figure E - 12. LiDAR derived bare earth DEM showing kame deposits (light yellow texture) mapped south of the Mentasta Mountains between the Copper River and the continental divide near Jack Lake.

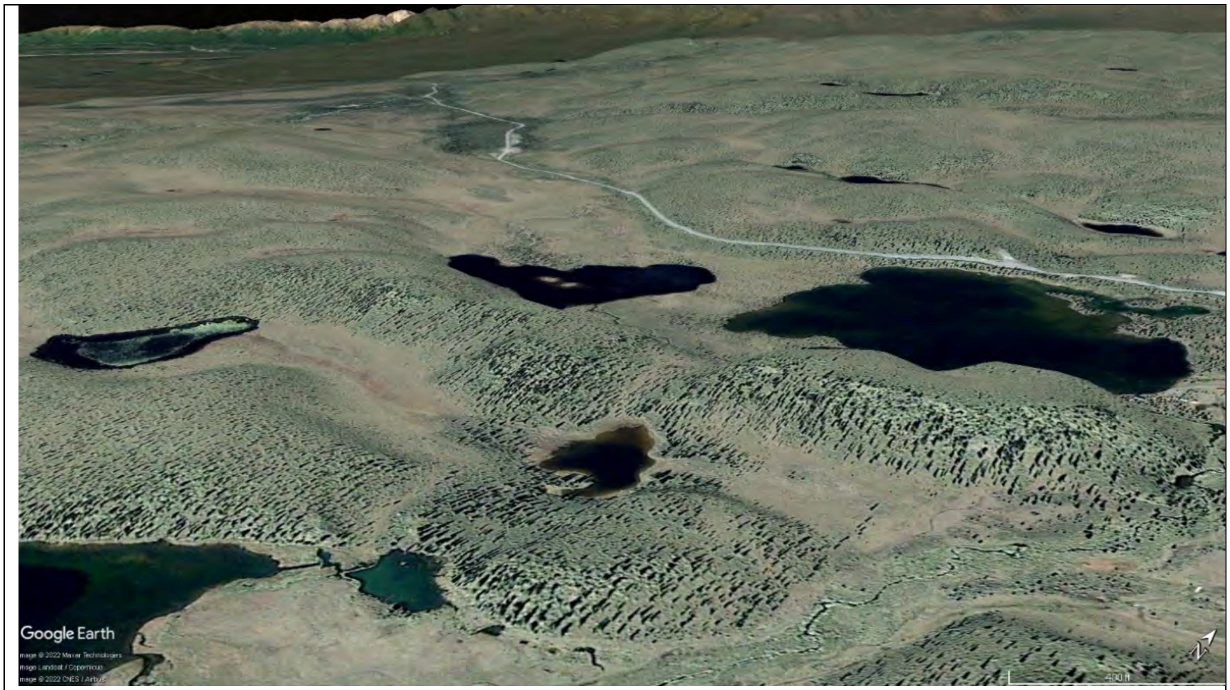


Figure E - 13. Oblique aerial imagery from Google Earth showing subdued glacial drift topography along the Nabesna Road near Twin Lakes at approximately milepost 27.2.

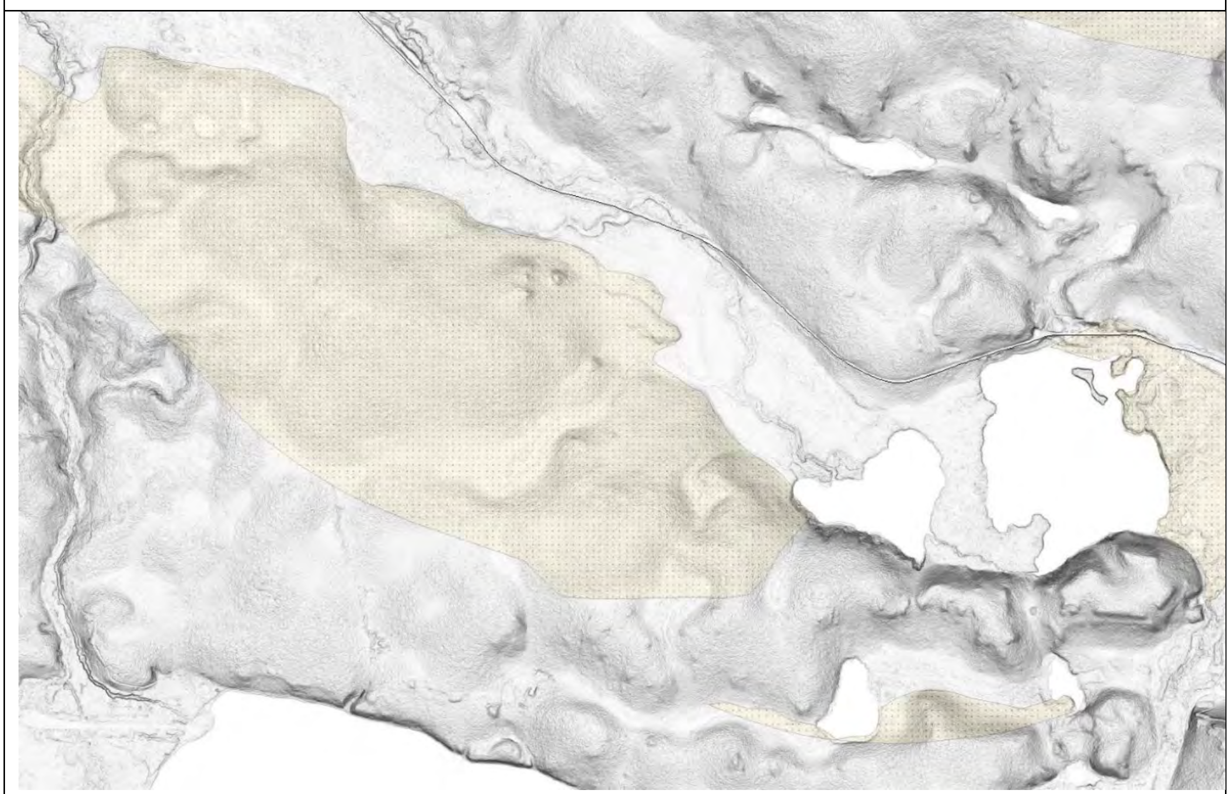


Figure E - 14. LiDAR DEM showing subdued glacial drift topography (light tan with dots) along the Nabesna Road near Twin Lakes at approximately milepost 27.2.

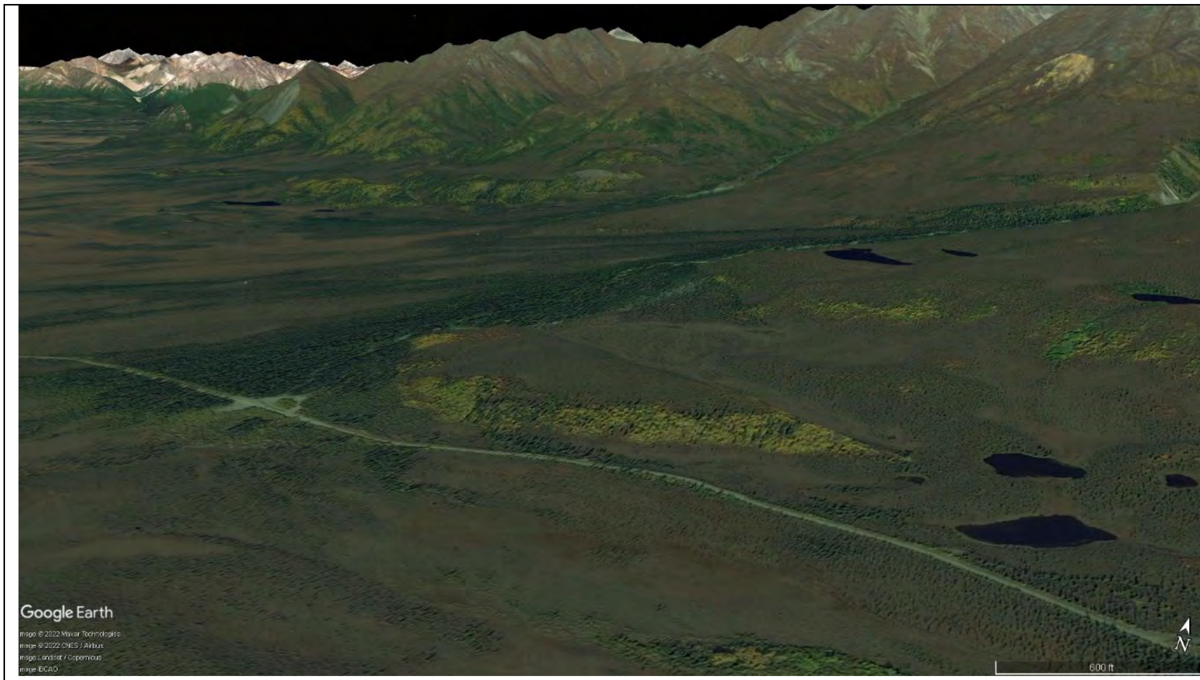


Figure E - 15. Oblique aerial imagery from Google Earth showing a glacial outwash deposit along the Nabesna Road at the Caribou Creek trailhead.

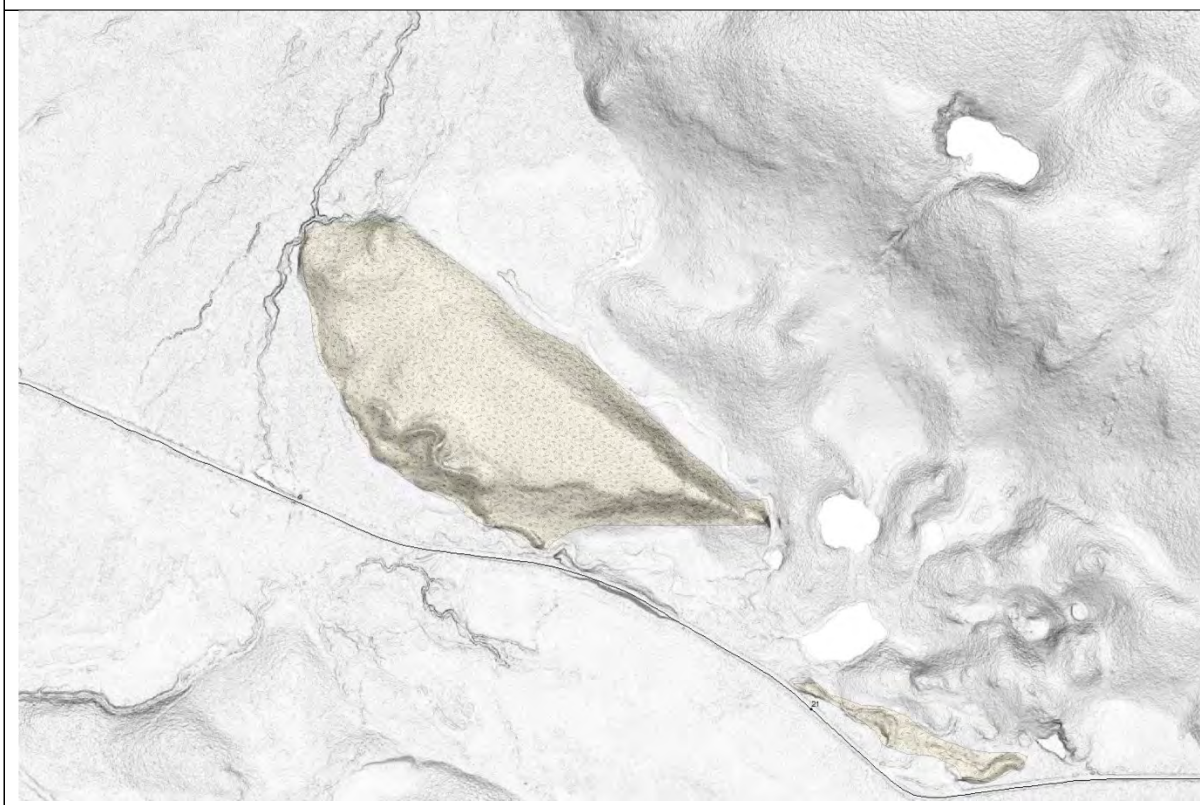


Figure E - 16. LiDAR DEM showing a glacial outwash deposit (medium tan with dots) along the Nabesna Road the Caribou Creek trailhead.

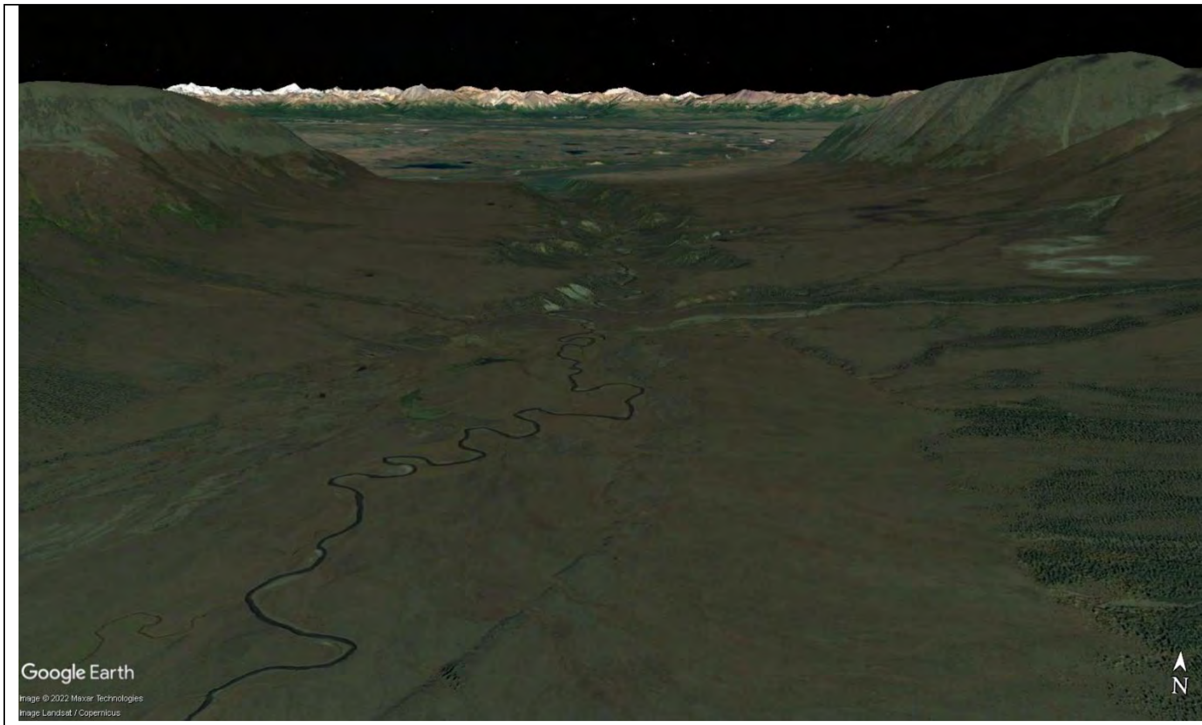


Figure E - 17. Oblique aerial imagery from Google Earth showing a glacial lacustrine deposit along the Copper River Trail south of Copper Lake.

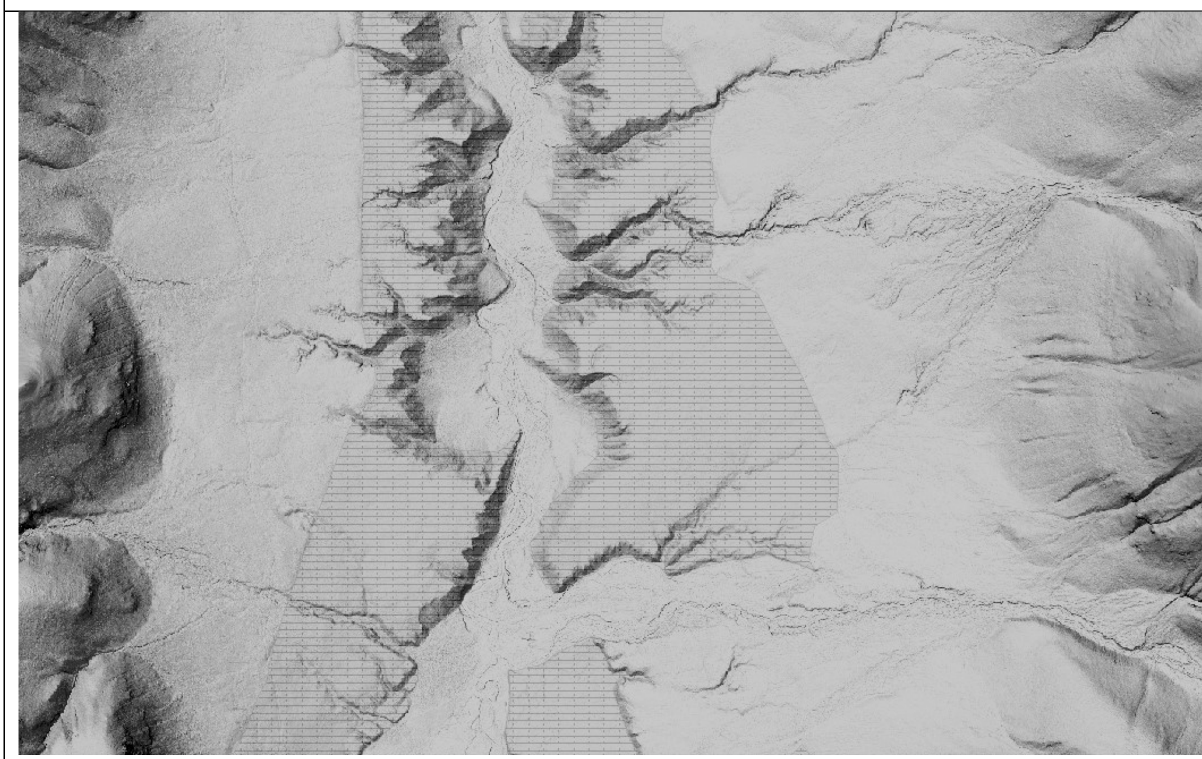


Figure E - 18. LiDAR DEM showing a glacial lacustrine deposit (gray with cross-hatching) along the Copper River Trail south of Copper Lake.

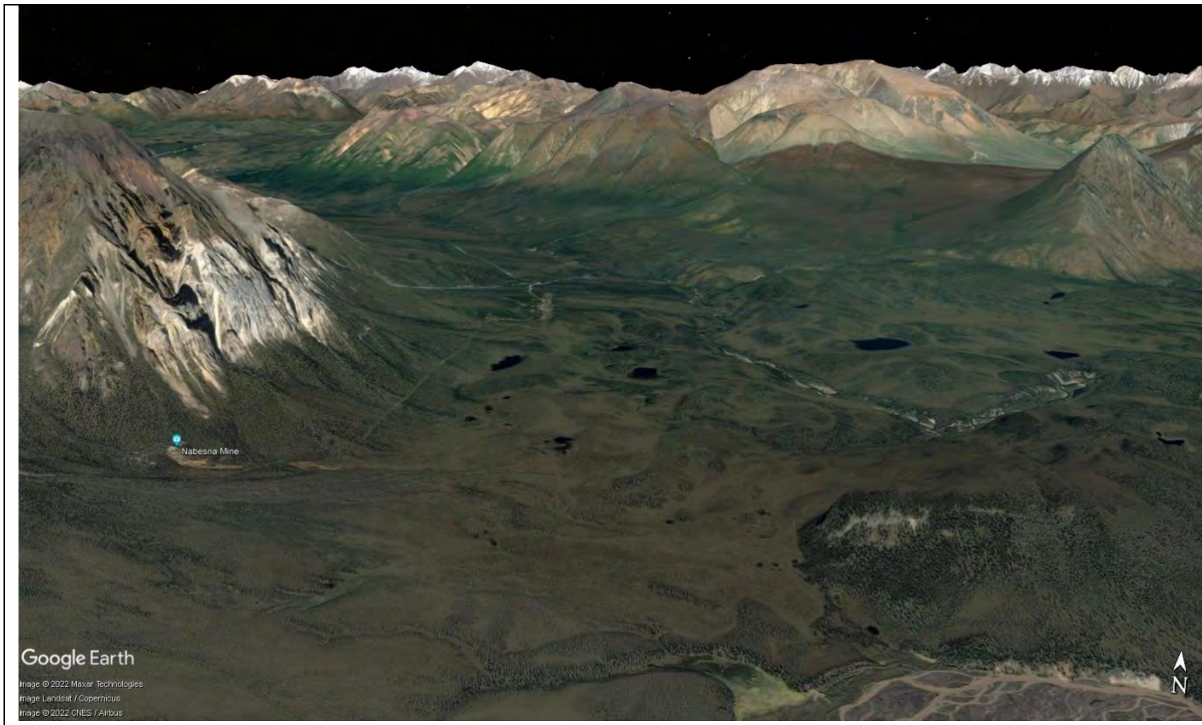


Figure E - 19. Oblique aerial imagery from Google Earth showing bedrock outcrops near the end of the Nabesna Road near the Nabesna Mine.

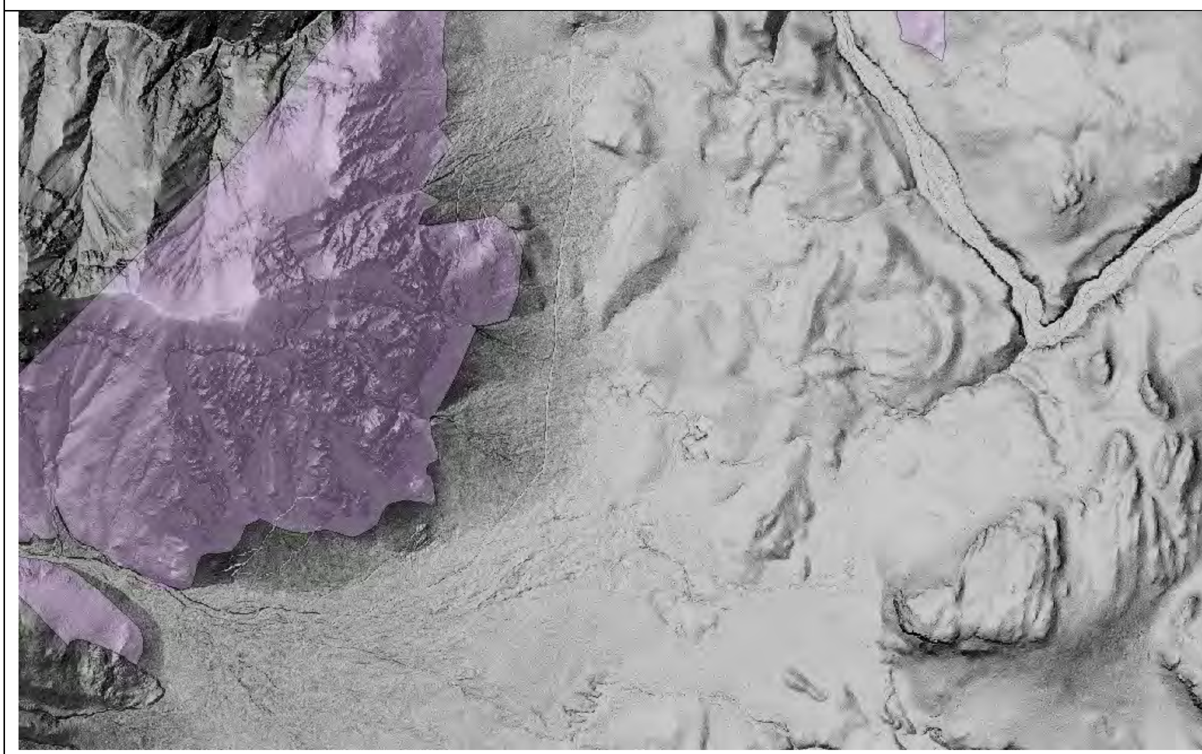


Figure E - 20. LiDAR DEM showing bedrock outcrops (purple) near the end of the Nabesna Road close to the Nabesna Mine.

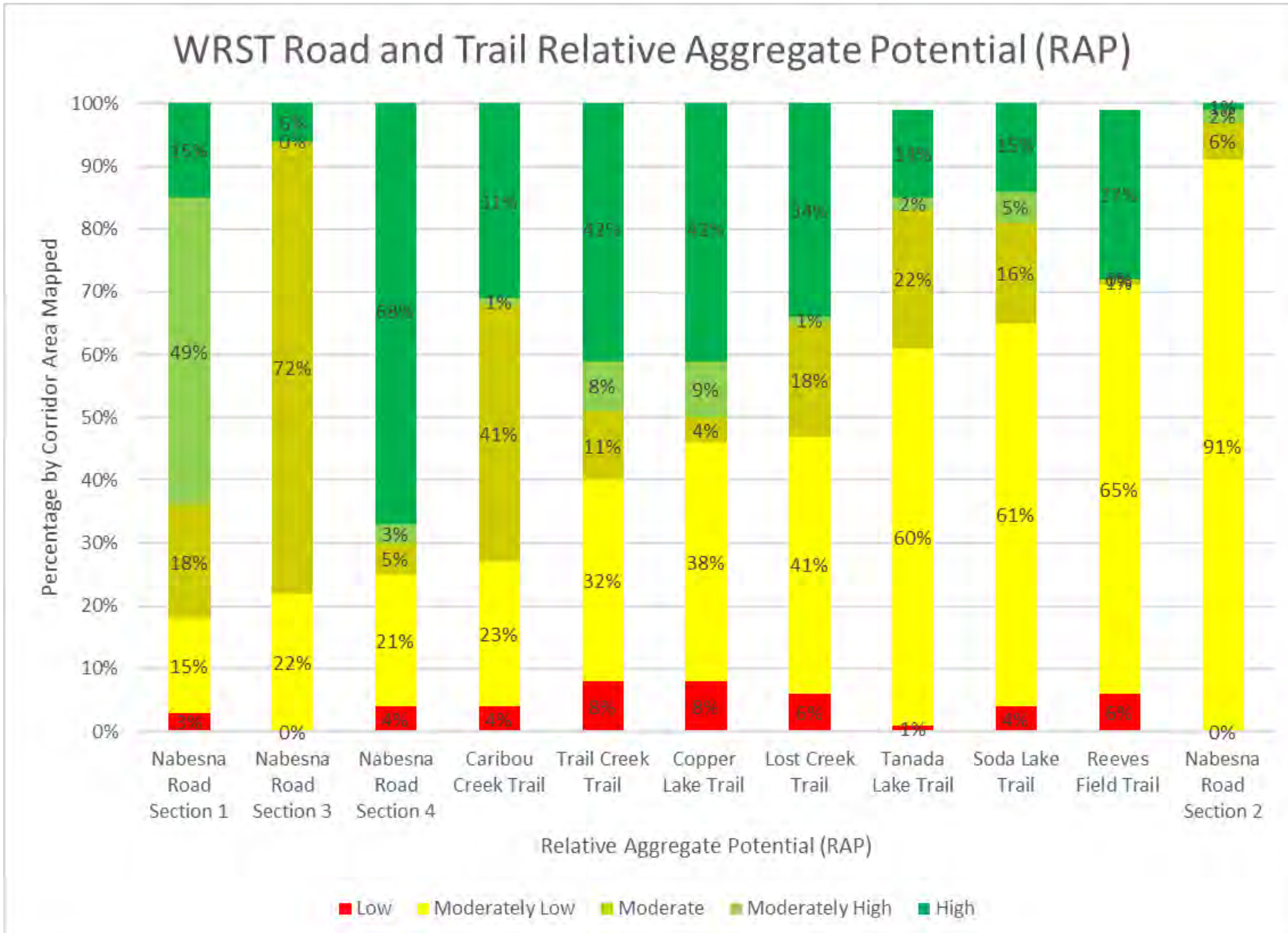
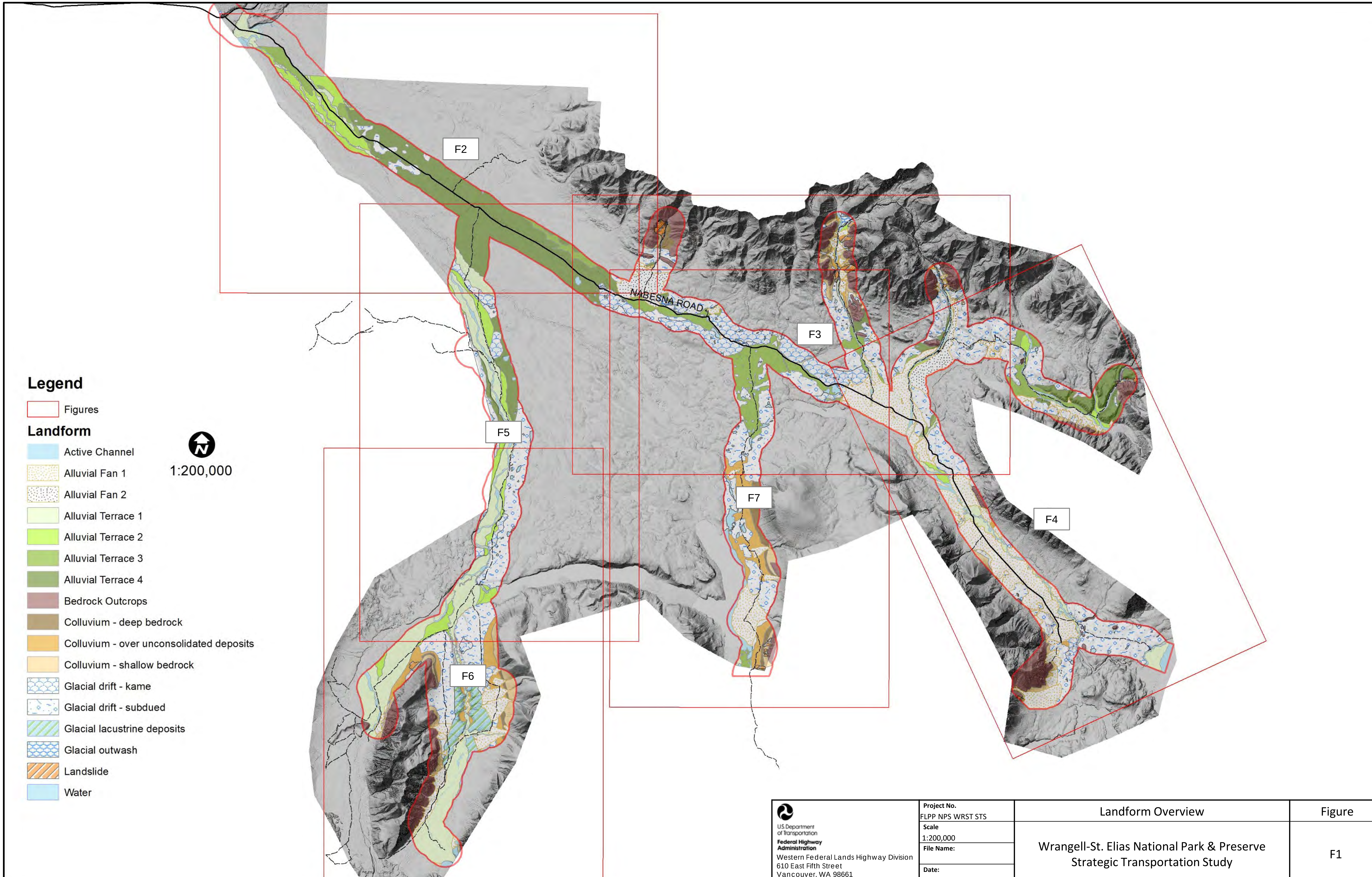
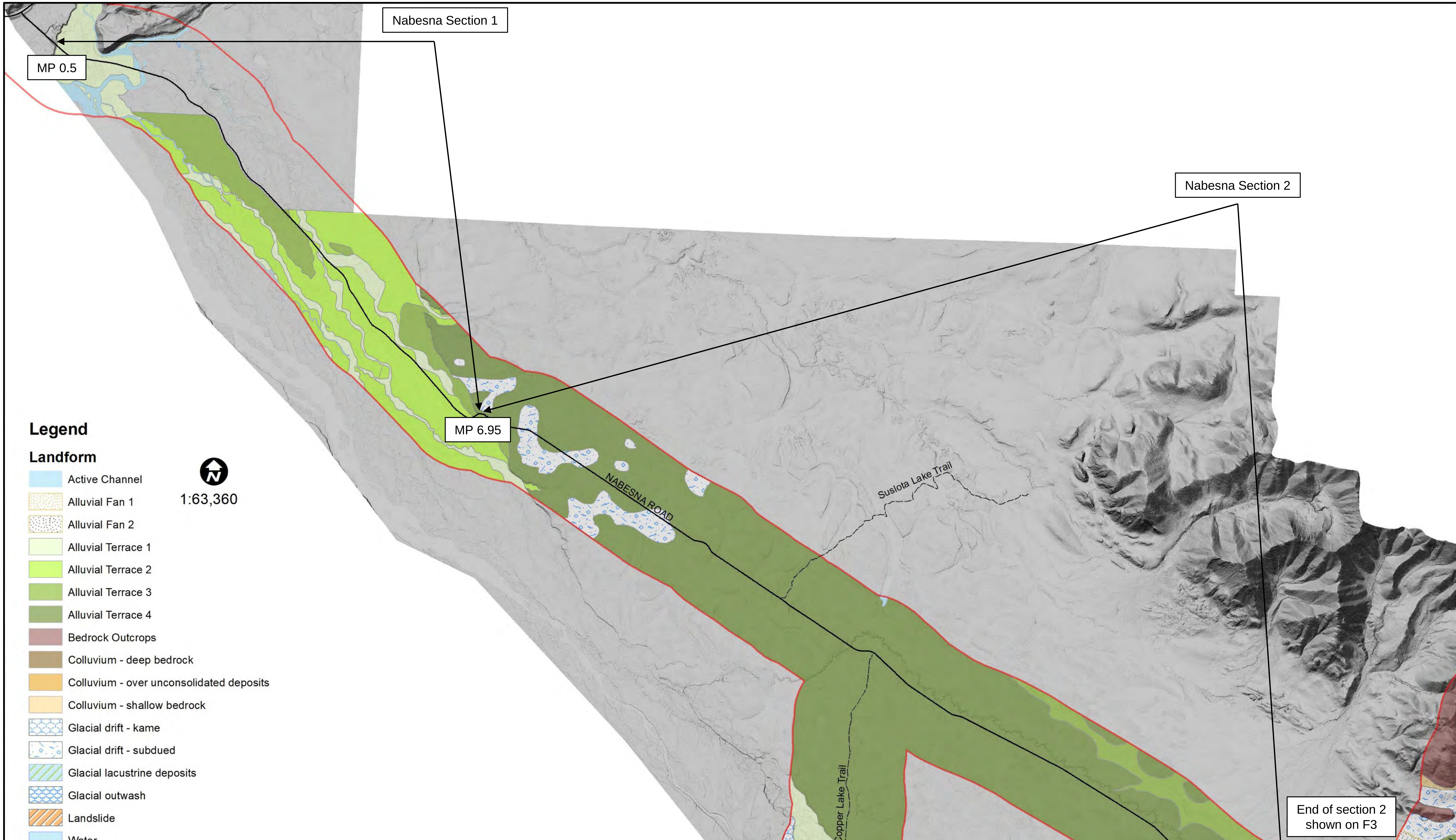


Figure E - 21. Relative Aggregate Potential (RAP) for each road/trail corridor by percentage of corridor area mapped. Corridors are displayed in increasing order of sum of areas of RAP from moderate to high, indicating likely best corridors for aggregate potential.

ATTACHMENT F – LANDFORM MAPS



U.S. Department of Transportation Federal Highway Administration Western Federal Lands Highway Division 610 East Fifth Street Vancouver, WA 98661	**Project No.** FLPP NPS WRST STS **Scale** 1:200,000 **File Name:** **Date:** 2022-10-05	Landform Overview Wrangell-St. Elias National Park & Preserve Strategic Transportation Study	Figure F1



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Western Federal Lands Highway Division
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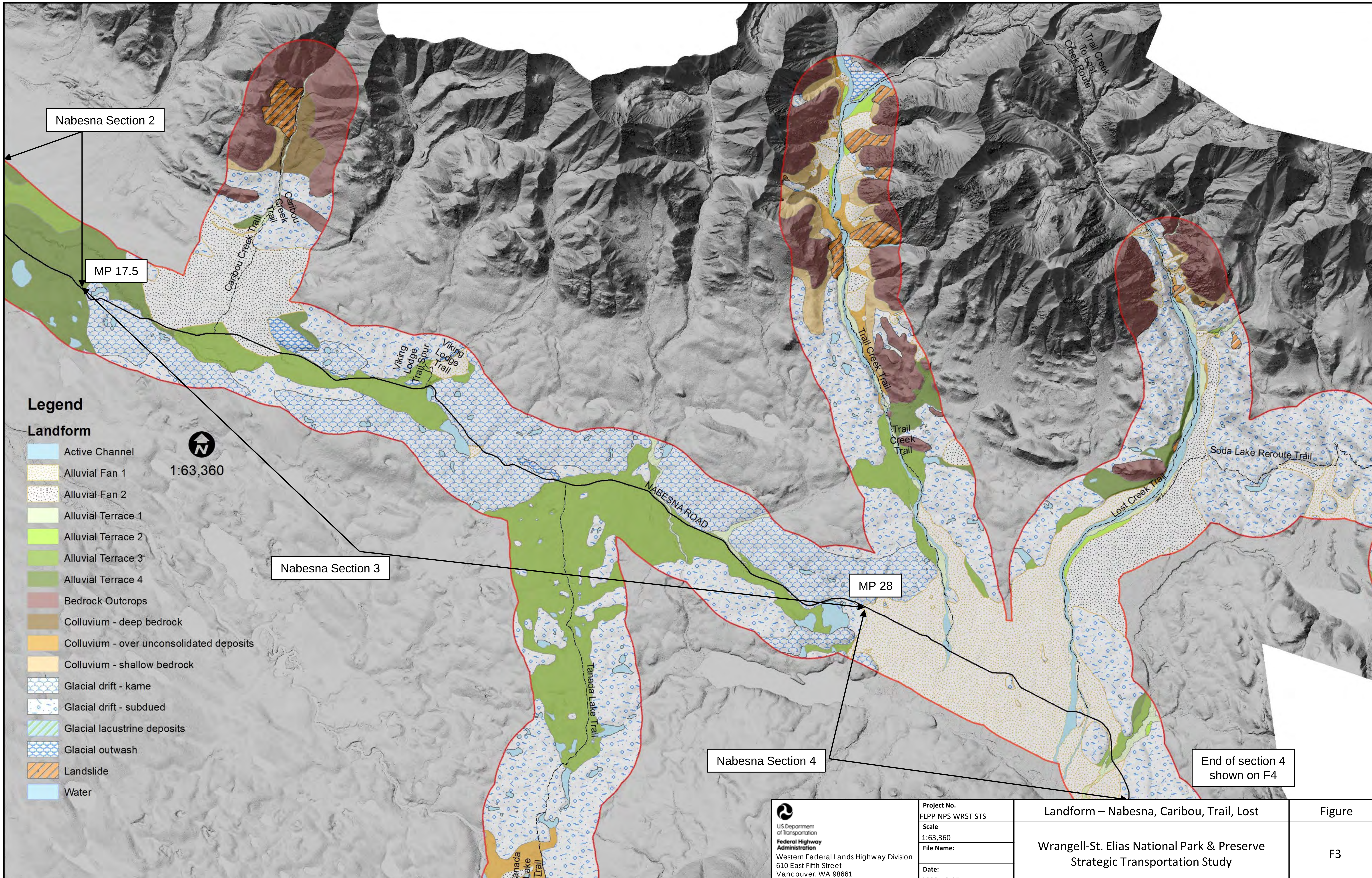
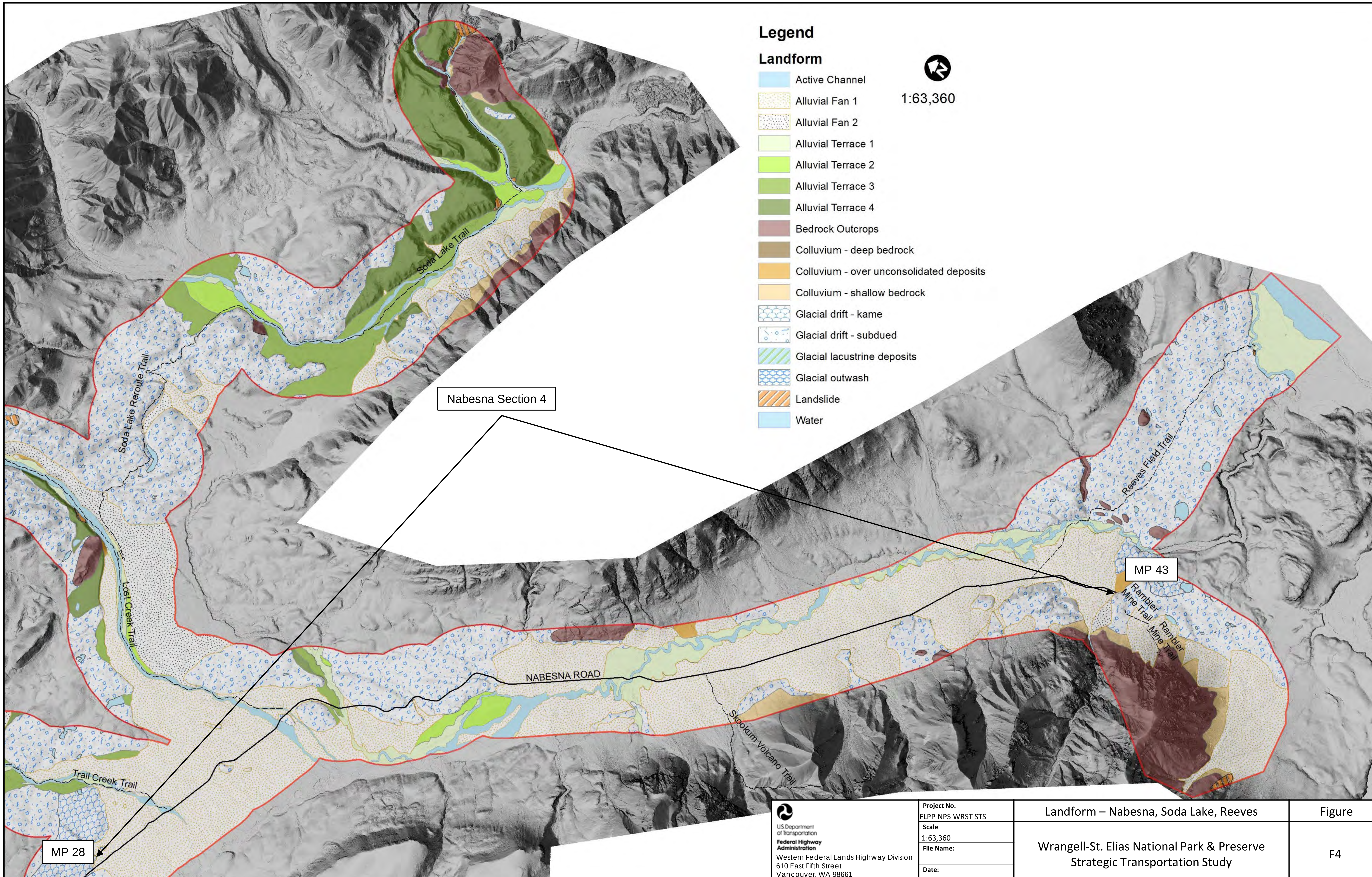
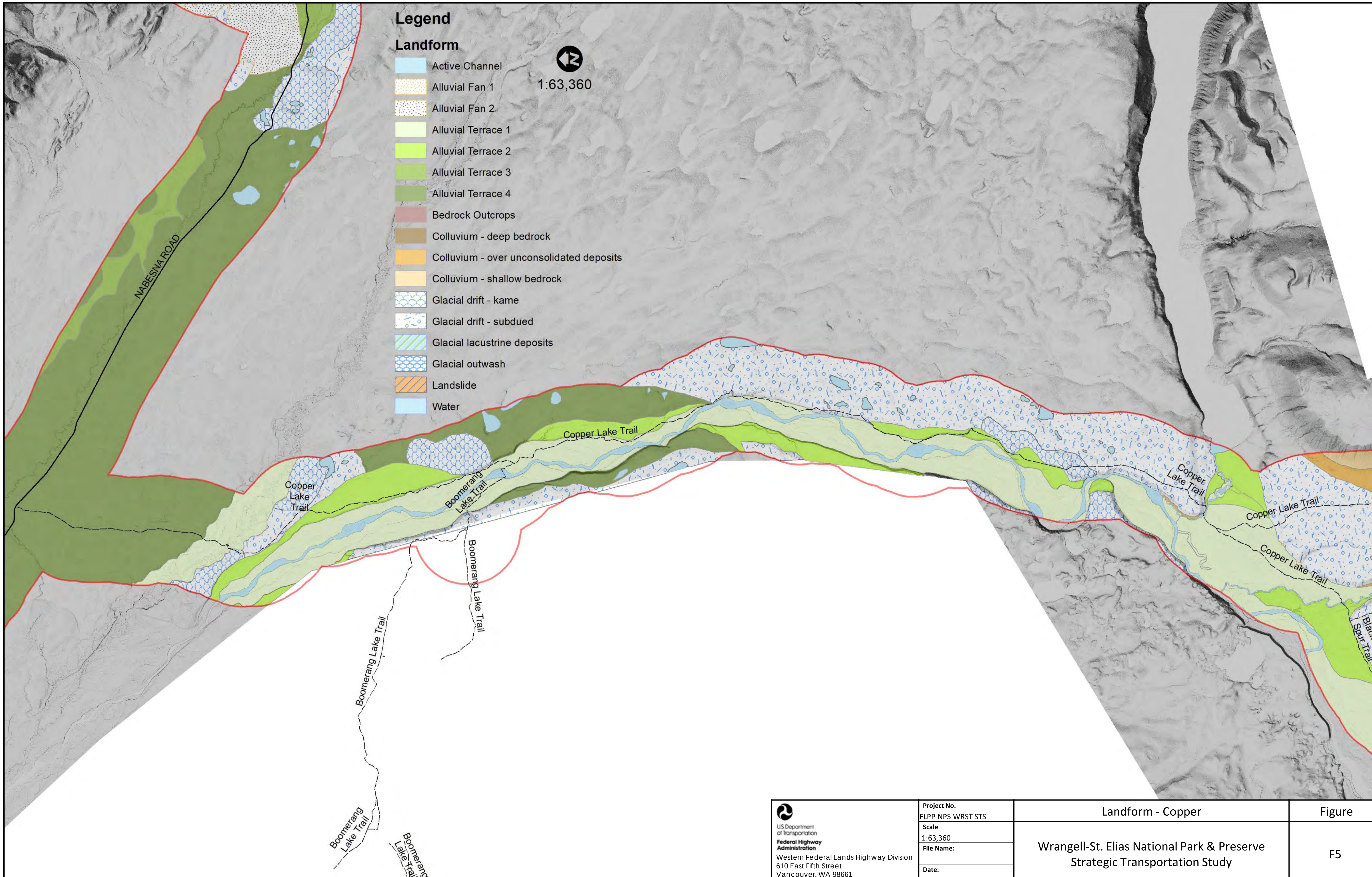
Vancouver, WA 98661

Project No. FLPP NPS WRST STS	Landform - Nabesna		Figure
Scale 1:63,360	Wrangell-St. Elias National Park & Preserve Strategic Transportation Study		F2
File Name:			
Date: 2022-10-05			


Nabesna Section 2
MP 17.5
Caribou Creek Trail
Caribou Creek Trail
Viking Lodge Trail Spur
Viking Lodge Trail
Trail Creek To Lost Creek Route
Trail Creek Trail
Trail Creek Trail
Soda Lake Reroute Trail
Lost Creek Trail
NABESNA ROAD
Nabesna Section 3
MP 28
Tanada Lake Trail
Tanada Lake Trail
Nabesna Section 4
End of section 4 shown on F4
1:63,360
Legend
Landform
Active Channel
Alluvial Fan 1
Alluvial Fan 2
Alluvial Terrace 1
Alluvial Terrace 2
Alluvial Terrace 3
Alluvial Terrace 4
Bedrock Outcrops
Colluvium - deep bedrock
Colluvium - over unconsolidated deposits
Colluvium - shallow bedrock
Glacial drift - kame
Glacial drift - subdued
Glacial lacustrine deposits
Glacial outwash
Landslide
Water
U.S. Department of Transportation
Federal Highway Administration
Western Federal Lands Highway Division
610 East Fifth Street
Vancouver, WA 98661
Project No.
FLPP NPS WRST STS
Scale
1:63,360
File Name:
Date:
2022-10-05
Landform – Nabesna, Caribou, Trail, Lost
Wrangell-St. Elias National Park & Preserve
Strategic Transportation Study
Figure
F3



U.S. Department of Transportation Federal Highway Administration Western Federal Lands Highway Division 610 East Fifth Street Vancouver, WA 98661	Project No. FLPP NPS WRST STS Scale 1:63,360 File Name: Date: 2022-10-05	Landform – Nabesna, Soda Lake, Reeves Wrangell-St. Elias National Park & Preserve Strategic Transportation Study	Figure F4



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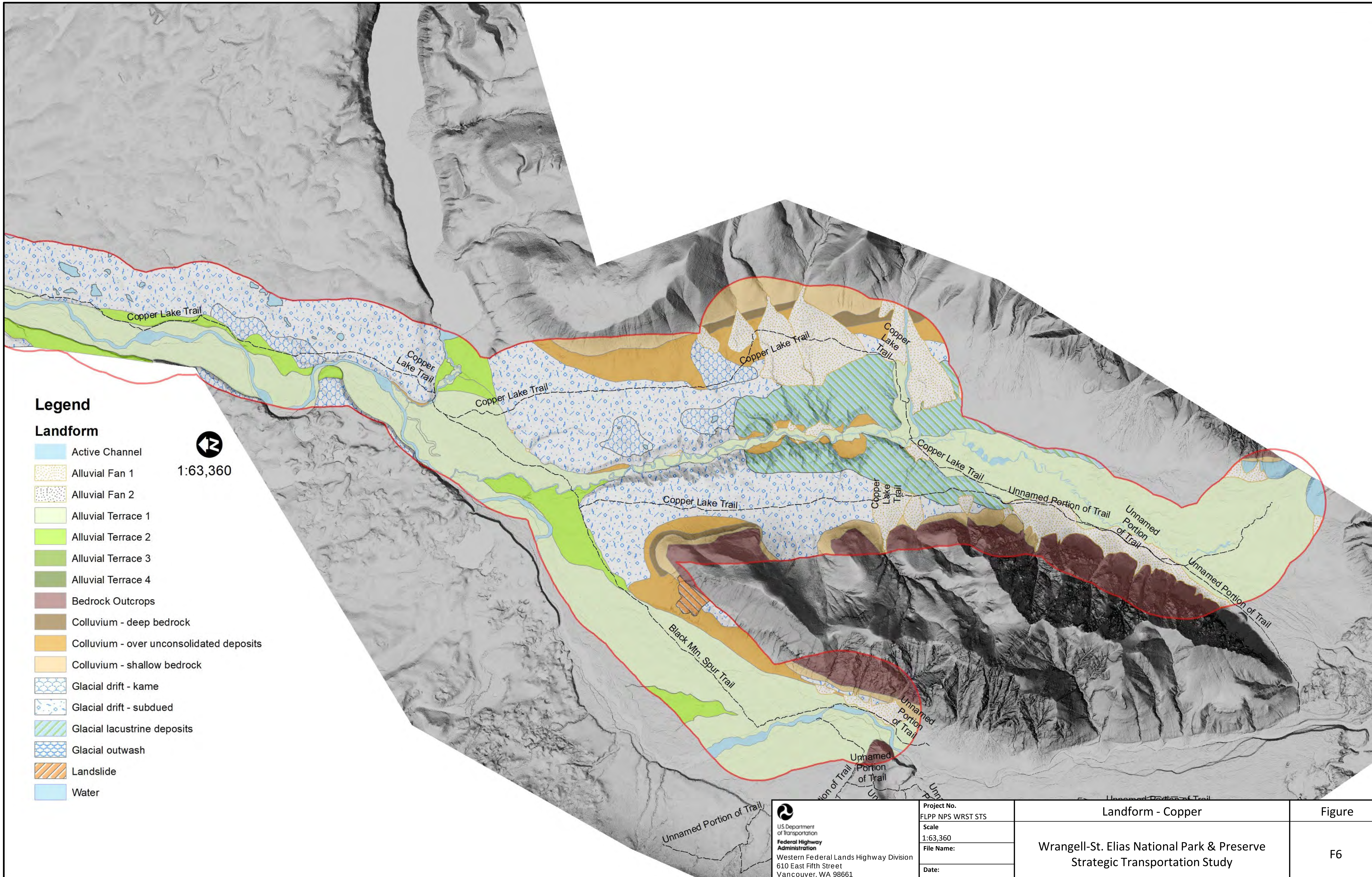
Project No.	FLPP NPS WRST STS
Scale	1:63,360
File Name:	
Date:	2022-10-05

Landform - Copper

Wrangell-St. Elias National Park & Preserve
Strategic Transportation Study

Figure F5



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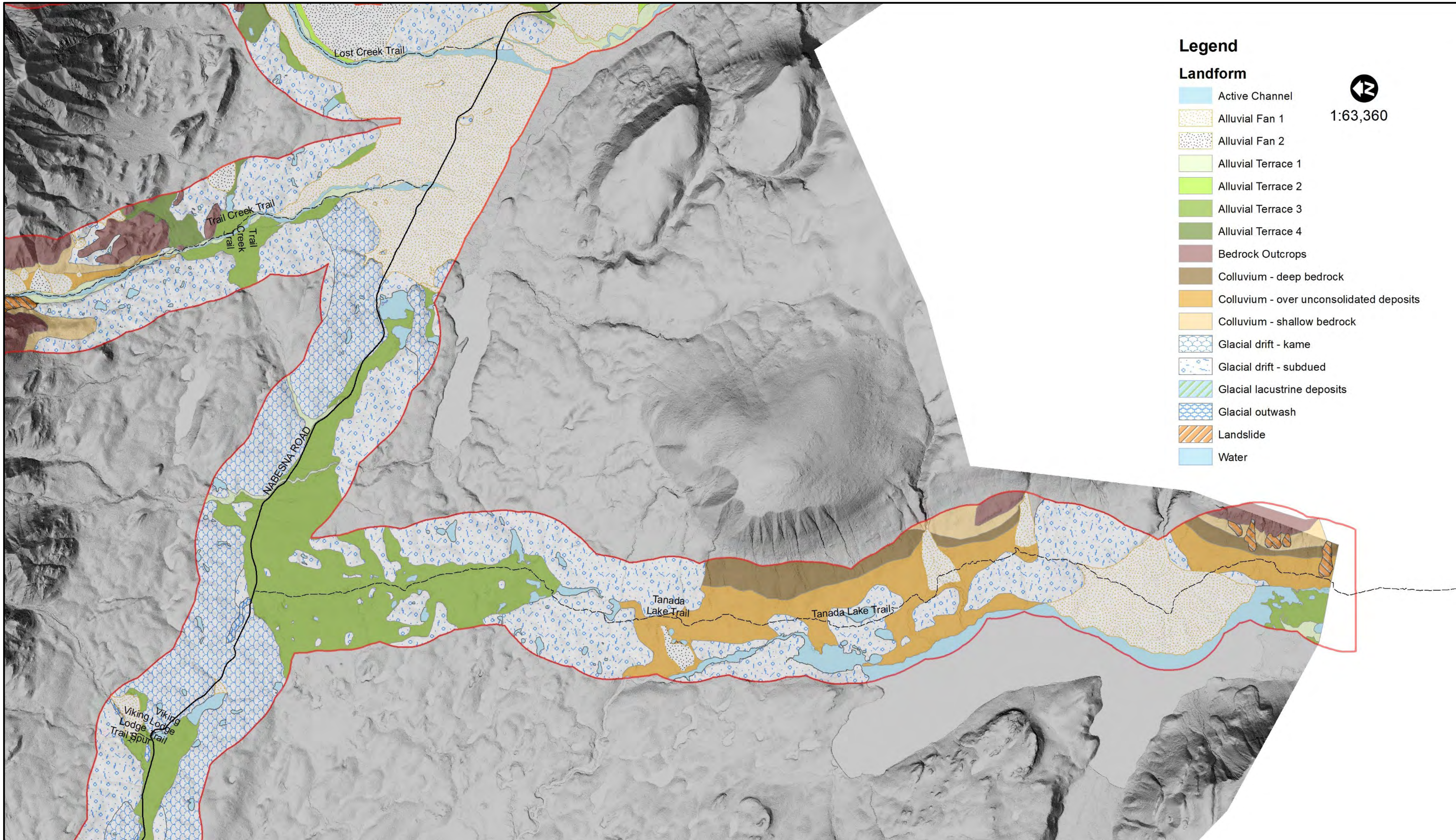
Project No.	FLPP NPS WRST STS
Scale	1:63,360
File Name:	
Date:	2022-10-05

Landform - Copper

Wrangell-St. Elias National Park & Preserve
Strategic Transportation Study

Figure
F6



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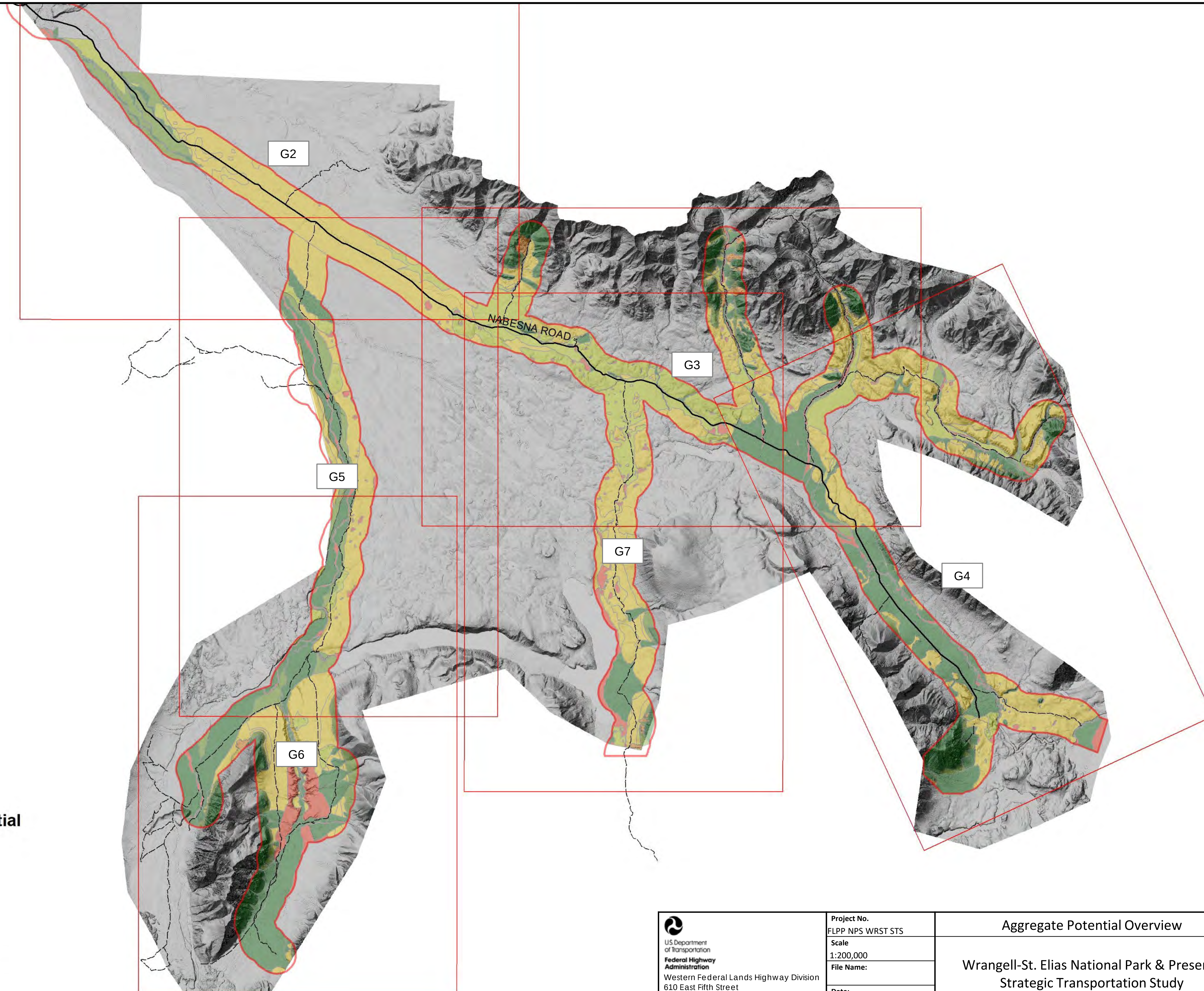
Project No.	Landform - Tanada	Figure
FLPP NPS WRST STS		
Scale	Wrangell-St. Elias National Park & Preserve Strategic Transportation Study	F7
1:63,360		
File Name:		
Date:		
2022-10-05		

ATTACHMENT G – RELATIVE AGGREGATE POTENTIAL (RAP) MAPS



Legend

Figures

Relative Aggregate Potential

Rank

- 3
- 2.5
- 2
- 1
- 0.5
- 0

N

1:200,000

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Vancouver, WA 98661

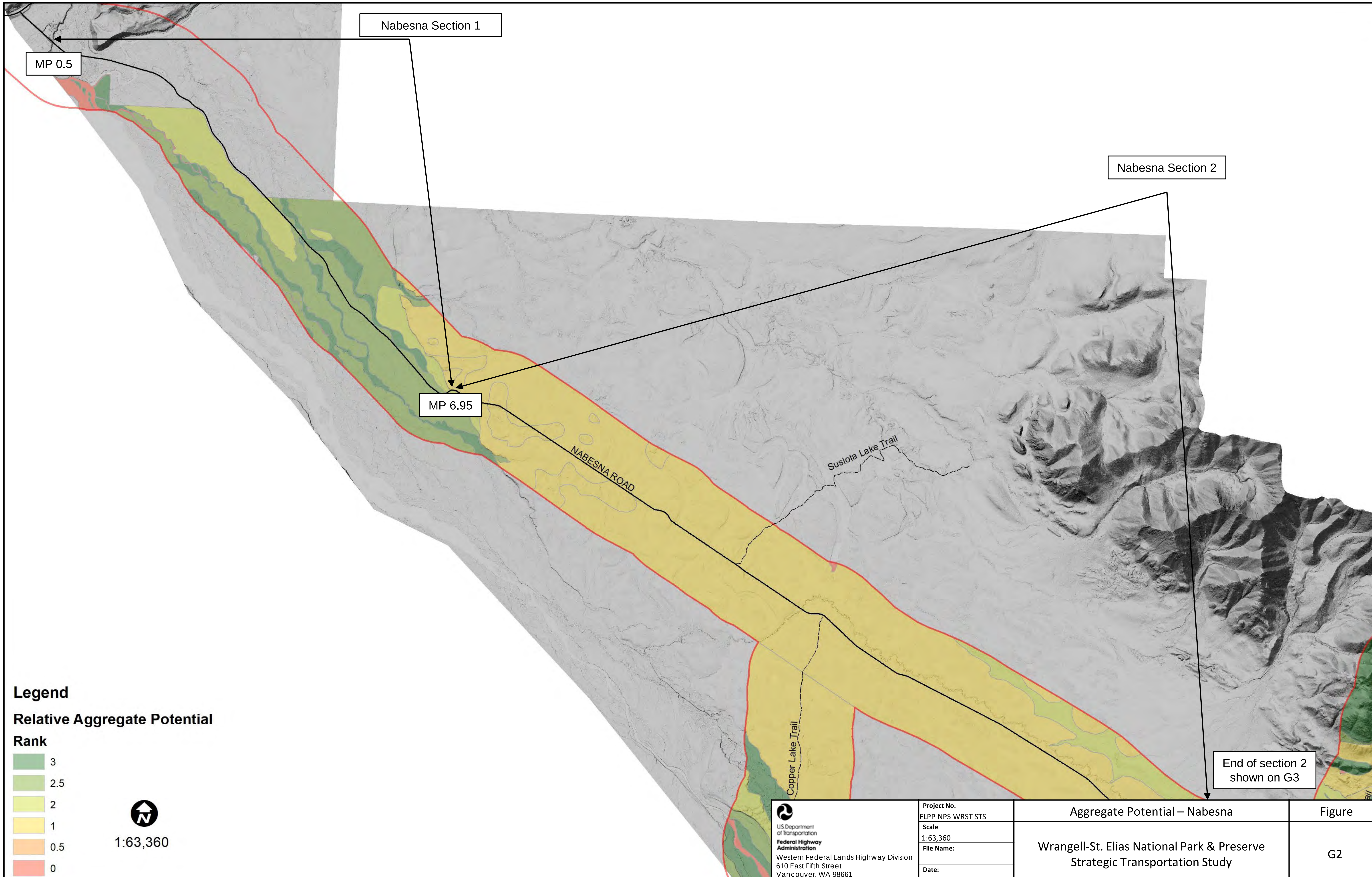
Project No.	FLPP NPS WRST STS
Scale	1:200,000
File Name:	
Date:	2022-10-05

Aggregate Potential Overview

Wrangell-St. Elias National Park & Preserve
Strategic Transportation Study

Figure

G1



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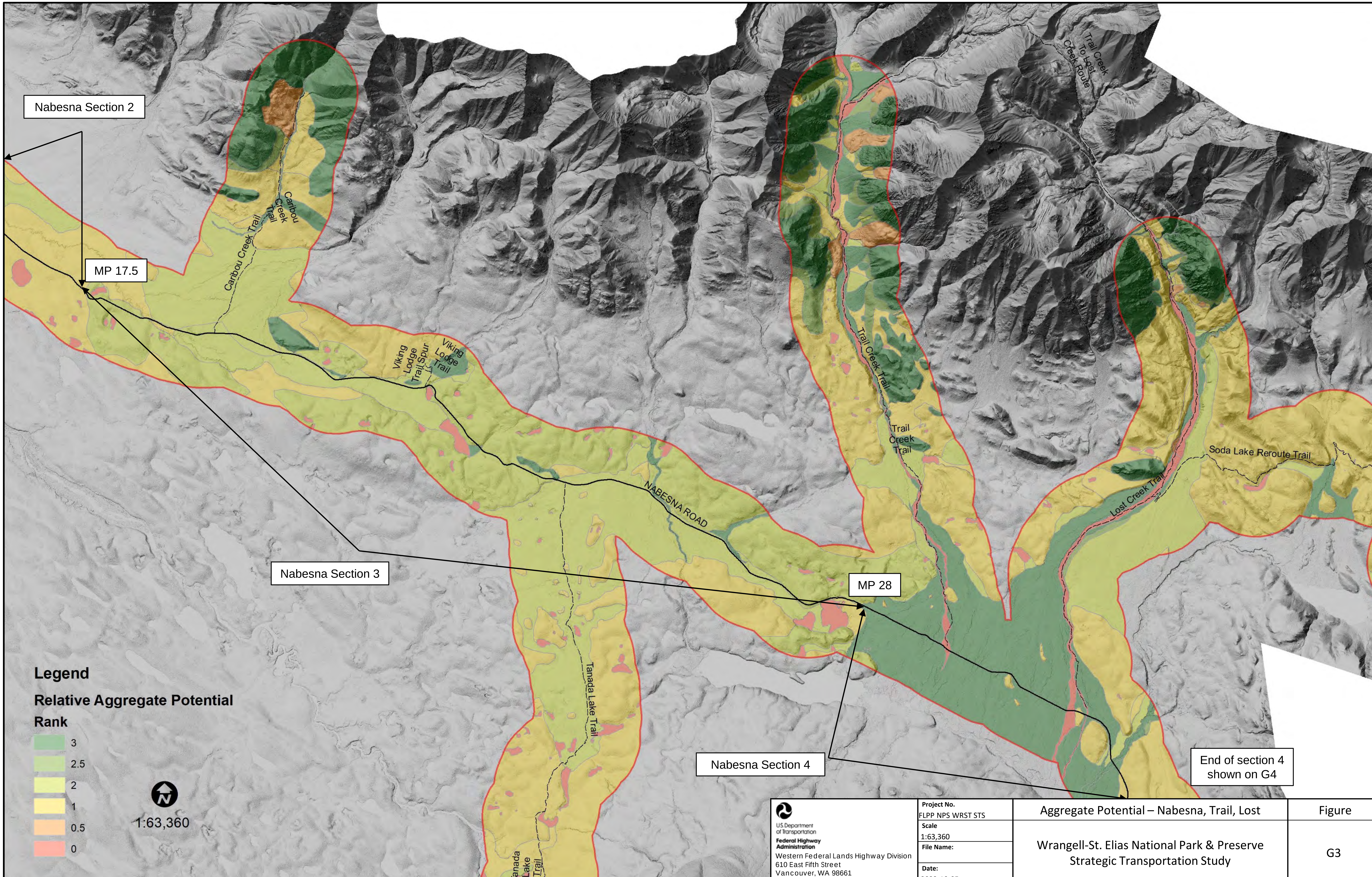
Project No.	FLPP NPS WRST STS
Scale	1:63,360
File Name:	
Date:	2022-10-05

Aggregate Potential – Nabesna

Wrangell-St. Elias National Park & Preserve
Strategic Transportation Study

Figure
G2



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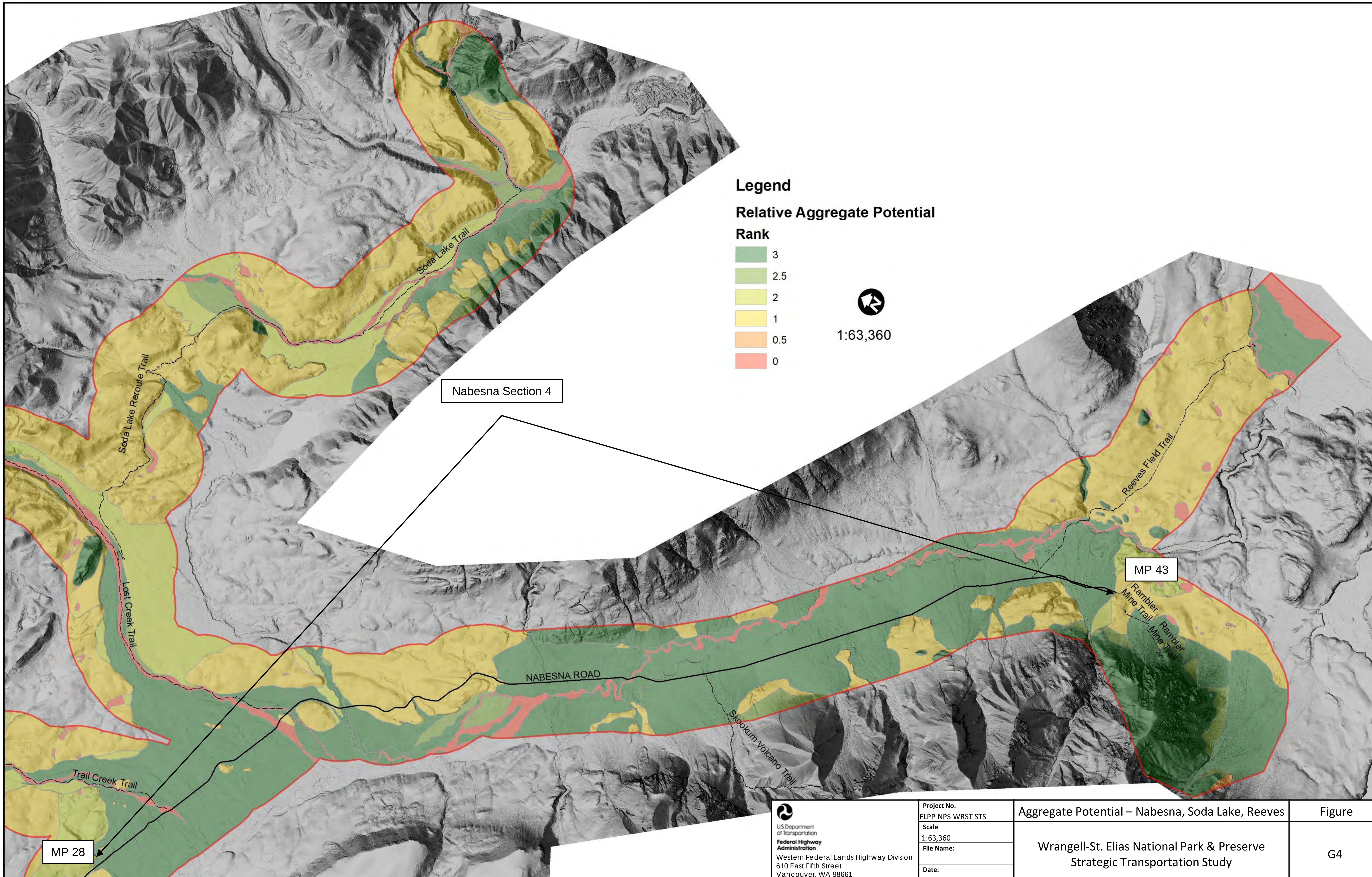
Project No.	Aggregate Potential – Nabesna, Trail, Lost	Figure
FLPP NPS WRST STS		
Scale: 1:63,360	Wrangell-St. Elias National Park & Preserve Strategic Transportation Study	G3
File Name:		
Date: 2022-10-05		



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Federal Highway Administration
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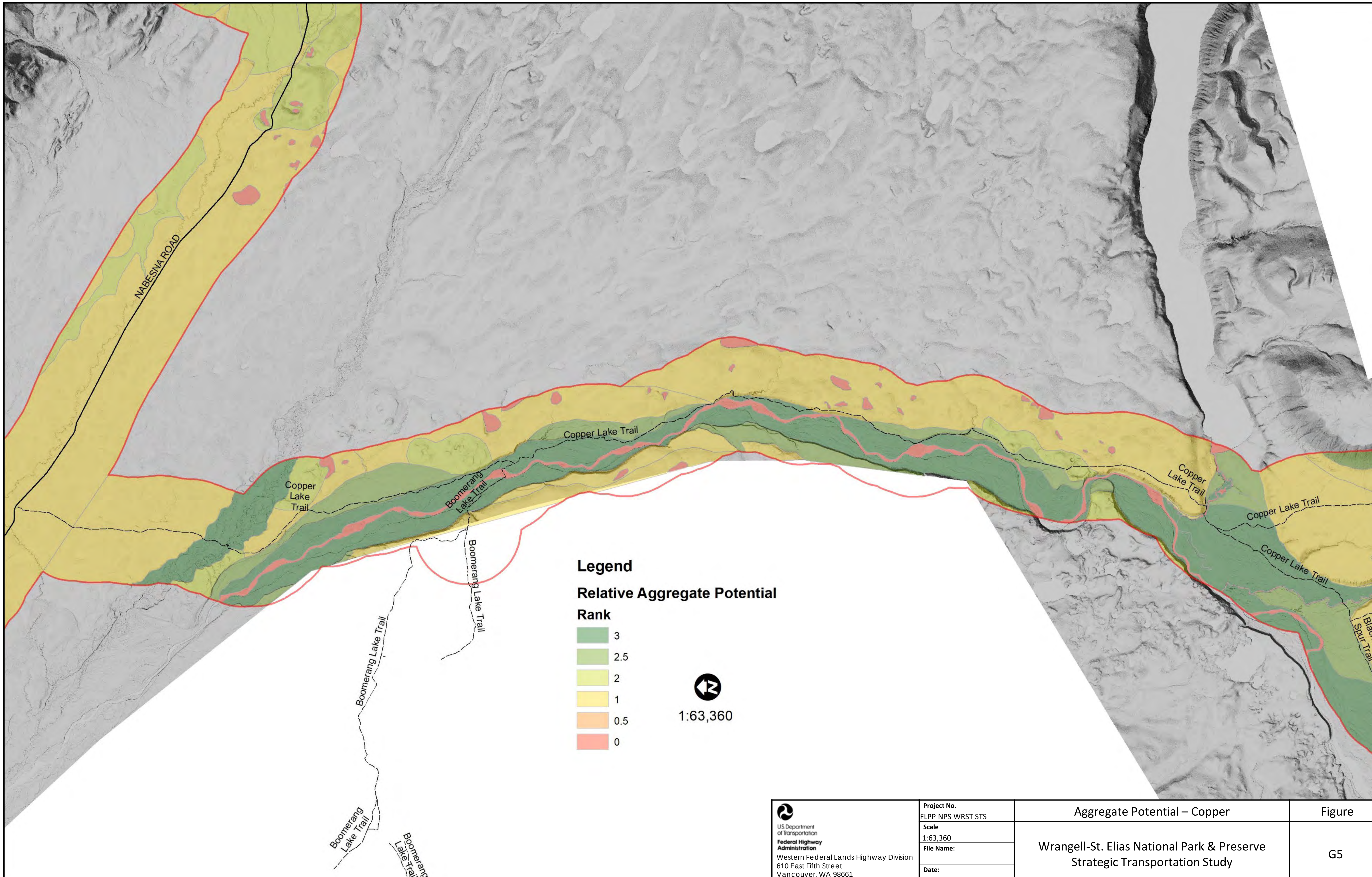
Vancouver, WA 98661

Project No.	Aggregate Potential – Nabesna, Soda Lake, Reeves	Figure
FLPP NPS WRST STS		
Scale: 1:63,360	Wrangell-St. Elias National Park & Preserve Strategic Transportation Study	G4
File Name:		
Date: 2022-10-05		



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Federal Highway Administration
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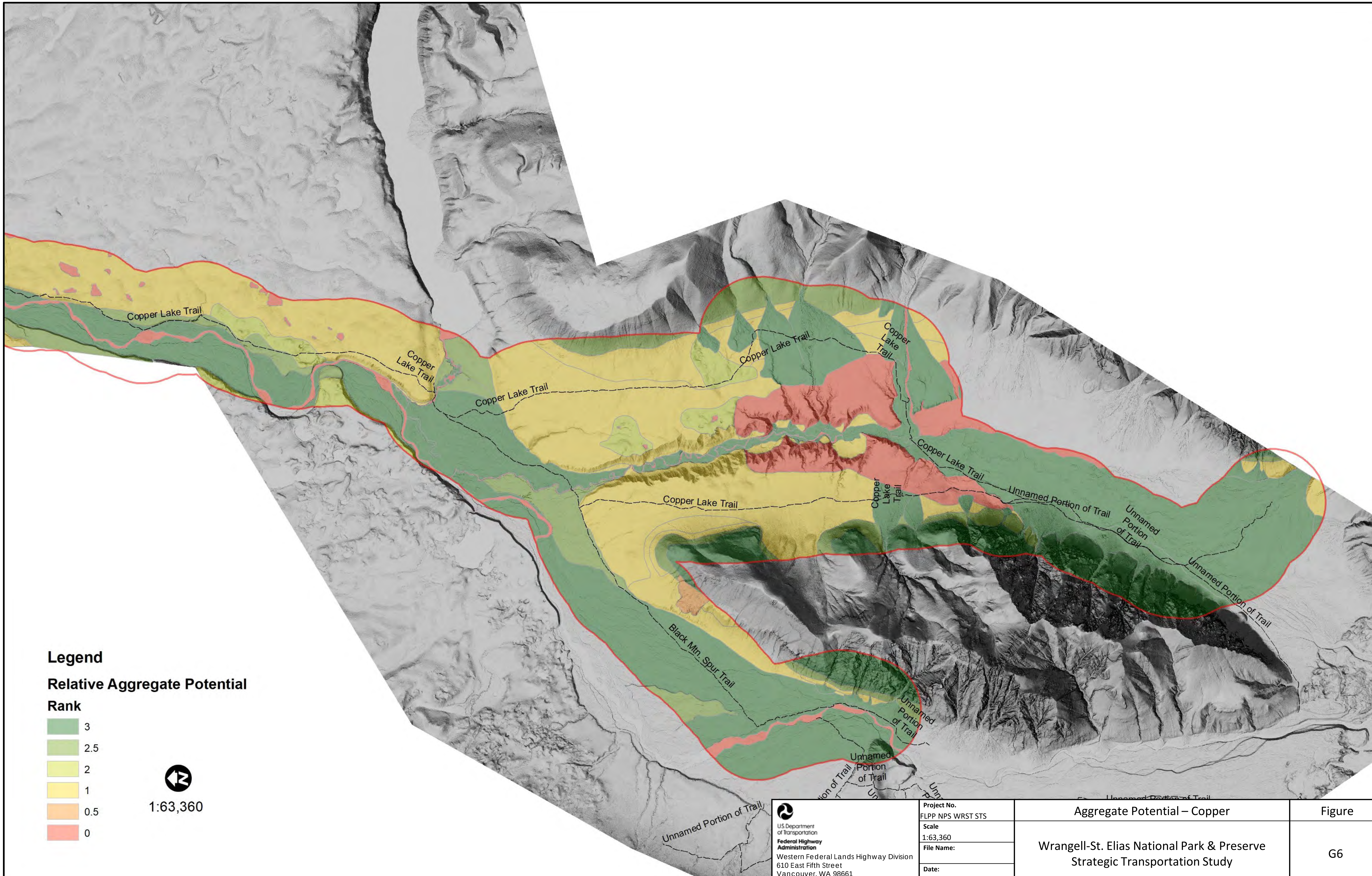
Vancouver, WA 98661

Project No.	FLPP NPS WRST STS
Scale	1:63,360
File Name:	
Date:	2022-10-05

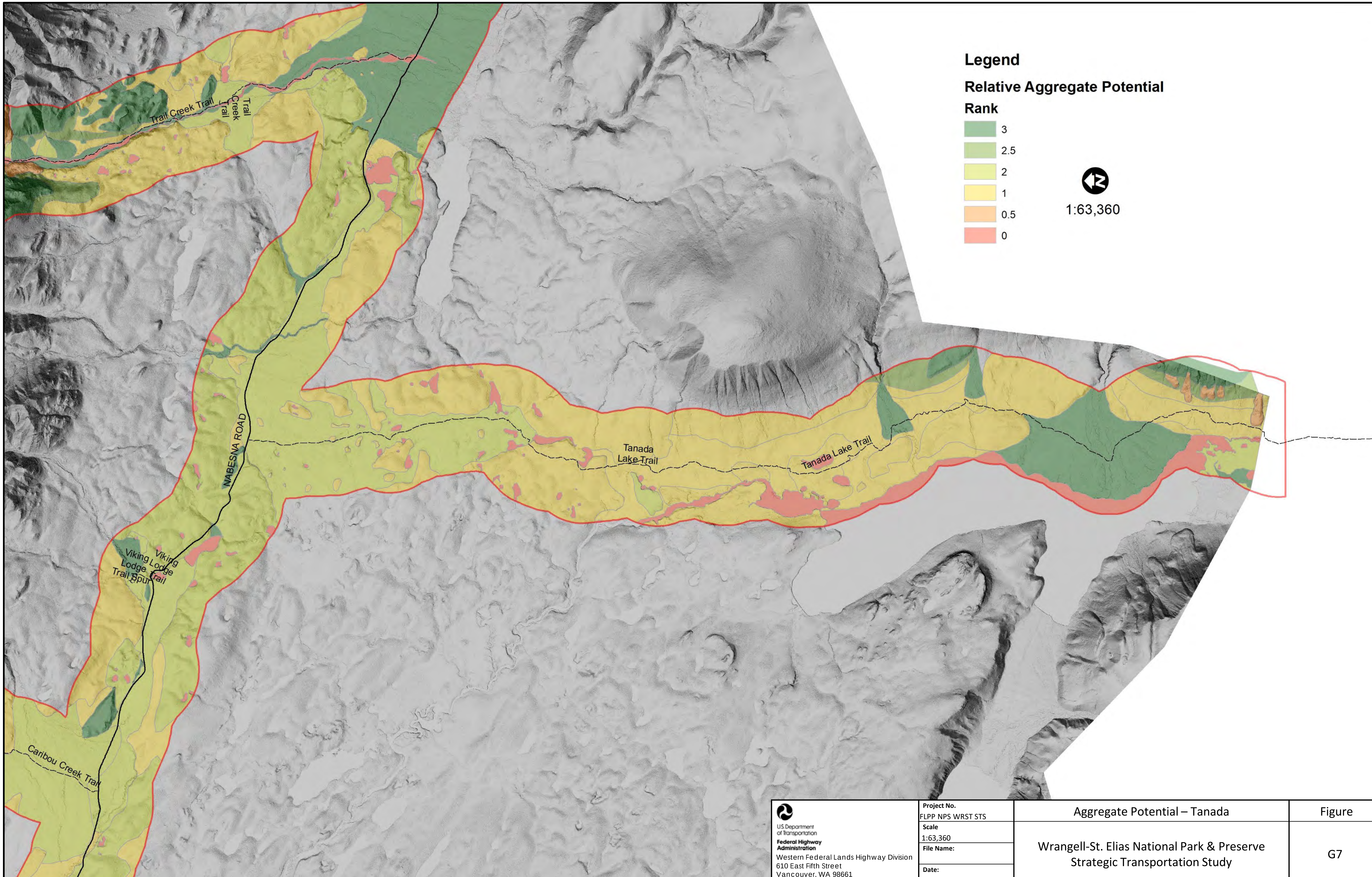
Aggregate Potential – Copper

Wrangell-St. Elias National Park & Preserve
Strategic Transportation Study

Figure G5



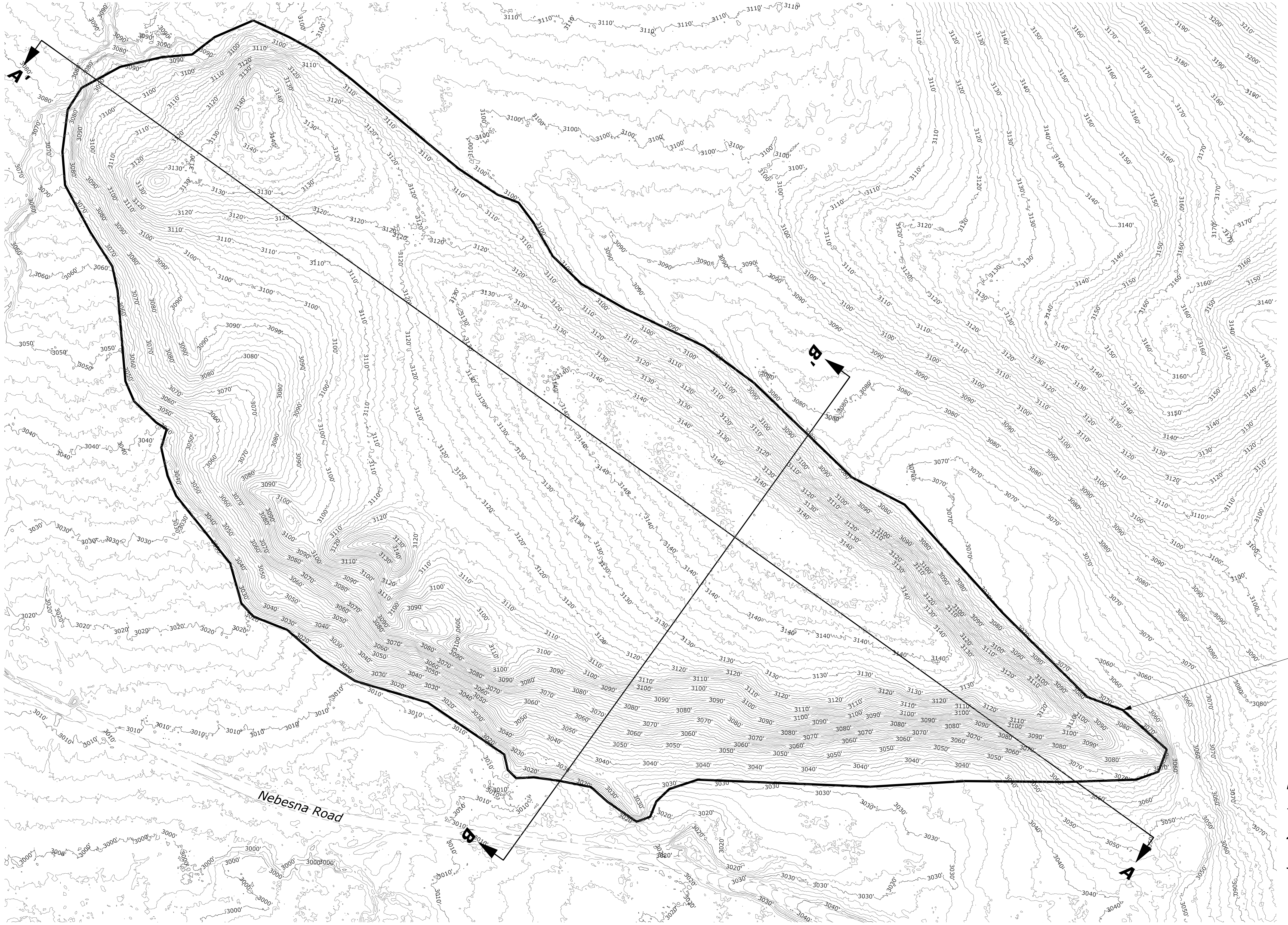
U.S. Department of Transportation Federal Highway Administration Western Federal Lands Highway Division 610 East Fifth Street Vancouver, WA 98661	Project No. FLPP NPS WRST STS Scale 1:63,360 File Name: Date: 2022-10-05	Aggregate Potential – Copper Wrangell-St. Elias National Park & Preserve Strategic Transportation Study	Figure G6



U.S. Department of Transportation Federal Highway Administration Western Federal Lands Highway Division 610 East Fifth Street Vancouver, WA 98661	Project No. FLPP NPS WRST STS Scale 1:63,360 File Name: Date: 2022-10-05	Aggregate Potential – Tanada Wrangell-St. Elias National Park & Preserve Strategic Transportation Study	Figure G7

ATTACHMENT H – EXAMPLE LANDFORM AGGREGATE VOLUME

PROJECT	SHEET NUMBER
FLPP AK WRST PLAN	PLN-01



NOTES:

1. *Gravel volume quantity calculated using OpenRoads Designer software.*
2. *Existing terrain model created using LiDAR data.*
3. *Assumed 4 feet of overbuden on top of gravel source.*

Scale in feet

250 0 250 500 750 1000

CARIBOU CREEK GRAVEL SOURCE PLAN VIEW

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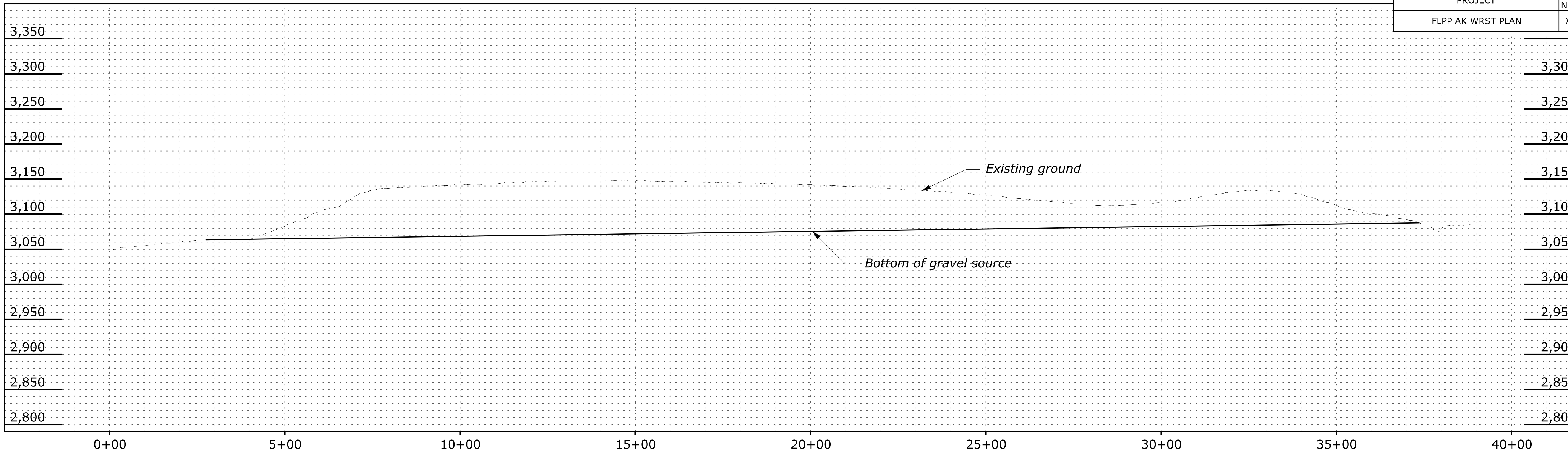
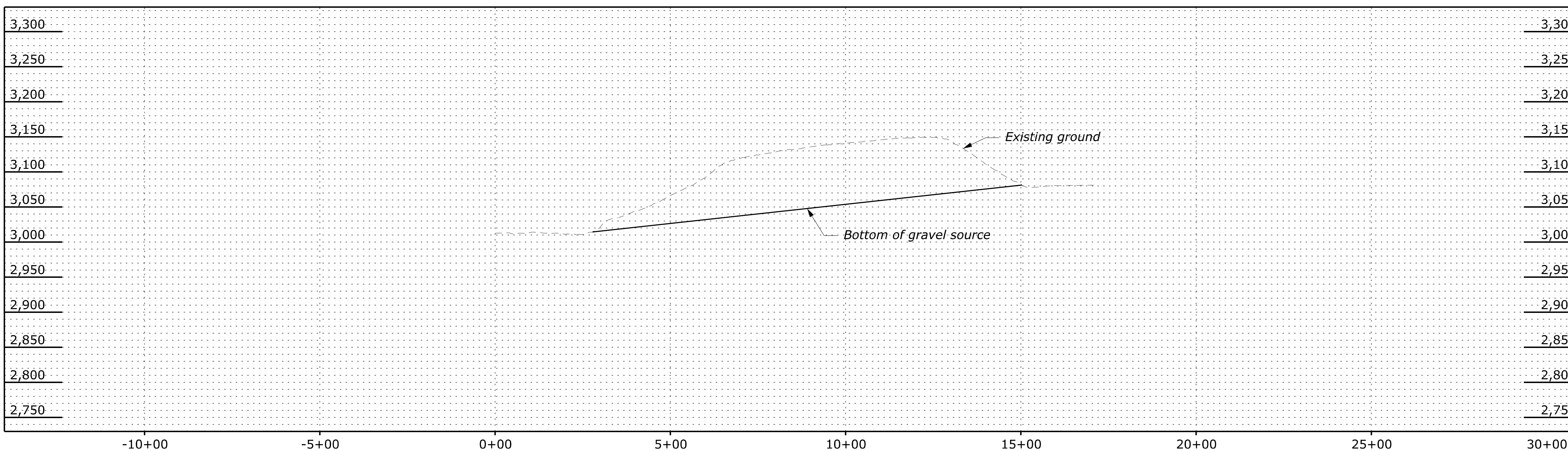
29 November 2022 4:18 PM

PROJECT	SHEET NUMBER
FLPP AK WRST PLAN	XS-01



A-A' SECTION



B-B' SECTION

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29 November 2022 4:18 PM

CARIBOU CREEK GRAVEL SOURCE ORTHOGONAL CROSS SECTIONS

Appendix D – July 2022 WRST Site Visit Summary

Wednesday, July 20: Day 1

9:30 – 9:35 am	**Greetings and Logistics**
9:35 – 10:00 am	**Introductions and Review Workshop Goals**
10:00 – 11:00 am	**Discussion of WRST Management Needs** • Nabesna Road corridor, ORV roads and trails • CERCLA process for Nabesna mine cleanup; heavy traffic needs • Opportunities for collaboration with local partners • Gravel sourcing sites and management
11:00 – 4 pm	**Site Visit** • Road-based tour o Show what is indicative of different area trails o Stop locations determined by geology / engineering team o Get a sense of gravel harvesting – what is happening, opportunities for future management • Understanding of what trails look like • Discuss gravel sourcing and management

Thursday, July 21: Day 2

9:00 – 9:35 am	**Greetings and Logistics**
9:30 – 11:00 am	**Review Engineering Assessment Findings** • Mapping and data analysis • Site observations • Initial engineering findings and recommendations
11:00 am – 12:30 pm	**Discussion of Next Steps** • Review follow-ups from site visit • Phase 2 high-level scoping • October Project Coordination Meeting & multiagency coordination on gravel resources

Day 1 - July 20, 2022

Project Briefing before Corridor Tour | Slana Community Corporation Building

Discussion Summary

The NPS WRST staff provided an overview of existing conditions and trends occurring within both the Park and the Nabesna Area, including:

- Only two roads provide access into WRST (Nabesna and McCarthy) and both areas are experiencing an increase in visitation.
- There is a long history of people using park land for subsistence.
- Years ago, WRST was involved in a lawsuit over trail management in the Nabesna Area and the resulting EIS ORV Management Plan needs to be revisited.
- With respect to gravel sourcing and ORV trail conditions:
  - The DOT pit at the beginning of Nabesna Road is almost tapped, the park has to spend more to import gravel from farther away. Hauling gravel from outside sources costs $100-$150/yard and risks bringing in invasive species and artifacts.
  - Trail Creek and Lost Creek trails are dynamic and the alluvial fan they cross over moves a lot of sediment as it drains. Braiding and shifting occurs along the channels and it's difficult to plan for where the stream will cross. This area could be a source for gravel.
  - There is a cemetery located at the Lost Creek Trail.
- AKDOT&PF manages drainages above the road and NPS provides DOT with authorization to do what they need to do to manage the road.
- A wilderness area is located south of the Nabesna Road. Because of the ORV trail network, it should not be wilderness-eligible. But areas beyond trails designated in EIS, area designated as wilderness-eligible; which is an issue with trails not listed in EIS.
- Is there potential to reroute Nabesna Road farther north? It would be expensive and probably not something the Park would entertain.
- Park is interested in identifying potential local gravel sources, with caveats (e.g., not visible from roads or trails). Option for land swap with AKDOT&PF for gravel sites.
- The mine at the end of Nabesna Road is a CERCLA site and remediation will bring heavy traffic on the road, further degrading the condition and increasing the need for more gravel.
- Building and maintaining trails in the Park is incredibly expensive and serves few users (~50 people/day). However, subsistence users have a right to access.
- Various treatments have been used on Copper Lake Trail since the EIS ROD with mixed results:
  - Bench construction on gravelly soil (~6 miles of trail) has been successful in lower level floodplains. Muskeg bluffs are challenging for trail maintenance. The most successful solution so far has been Duradec, but it's expensive, labor intensive, doesn't work well for some vehicle types, and has aesthetic issues.
  - Other synthetic materials have been tested (Geoblock, Geogrid, Corduroy, and mixed) but none were successful. Geoblock was too brittle to survive winter conditions. There has been some success containing gravel with Geofabrics and proposals to insulate with Geofoam board. The issue is the Park didn't have good data to make decisions.

    - This trail was built up to accommodate vehicle use and is not a good hiking trail. Building a true multi-use trail is possible but would cost a lot more. Copper Lake Trail also does not access the lake.
- Argo ATVs with tracks are best for road use but exceeds current weight limits. Consideration of vehicle restriction in the EIS: move to PSI restrictions instead of weight.
- Climate change is impacting the landscape of WRST; some lakes are forming while others are disappearing. Rapid changes are occurring and the ORV trails can accelerate the process. Small changes to the trails (drainage, widening, etc.) can have big impacts to resources.
- Has the Park been measuring permafrost along the trails? Joshua will look into the thermistor study. Park may want to consider putting in thermistors as part of trail work. Building trails will contribute to permafrost degradation. Insulating trails could be an option but it would be very expensive. WRST estimates it costs $300,000/mile in trail building.
- The Copper Lake Trail easement is currently out of compliance.
- Discussion on the ideal outcomes of the July site visit and overall study:
    - Technical specifications for trail treatments with cost estimates – what would it cost to improve trails to a sustainable level and what would it cost to operate and maintain them?
    - A better understanding of what is feasible to inform an EIS revision, with defensible information to improve decision making.
    - Assessment of different alternatives to make sure subsistence users' needs are met.
    - Biggest priorities for users are 1) Copper Lake 2) Tanada Lake and 3) Reeves Field (doable with minimal investment if the Park can get gravel resources out to the end of the road).
    - Consideration of bridges – basic bridges that meet federal requirements and look like something a homesteader would have built. Bridges could help address drainage problem areas.
    - Consider partnerships with user groups – RTCA as potential partner in trail maintenance (were involved in earlier Copper Lake work).
    - Provide information and resources for users on how to minimize impacts.
    - There is a need for good planning and not ad hoc efforts. A long-range plan (pre-NEPA) would spell out actions that would then require NEPA (e.g., Denali National Park LRTP and Risk Assessment). For WRST, this could be a Transportation Plan, Gravel Extraction Plan, and future visitor services planning.

Day 2 - July 21, 2022

Meeting to Review Engineering Assessment Findings | Copper Center Visitor Center

Discussion Summary

Preliminary Engineering Assessment

Ryan Cole and Orion George (FHWA WFLHD) presented analysis and initial preliminary engineering assessment findings.

- Attendees reviewed potential gravel source locations.
- There is also a need to identify locations for material processing. These areas take up space and would require protection so gravel piles don't wash away. Old gravel pits could be used for processing (e.g., the old Caribou site).
- The gravel potential maps are high level and individual sites would require additional screening.
- Overall, the gravel resource sites align with the 1992 DOT recommendations, with some exceptions.
- Potential sites farther down Nabesna Road would need to be analyzed for mining contaminants and cooked carbonates. Hazmat sites near the mine need to be avoided.
- There are hydrology and hydrogeology data gaps, as well as subsurface information on the preferred deposit sites. The WFL engineers also were not able to observe conditions on Copper Lake and Tanada Lake trails due to flooding.
- WFL developed a novel model that is based off of risk mapping done for Gates of the Arctic National Park and Preserve.
- What is the difference between the alluvial fan environment in Wrangell versus the braided stream environment in Toklat?
  - In Toklat, there is continuous material replenishment.
  - With an alluvial fan, the gravel can be extracted in one place, but the stream channel meanders elsewhere and the deposits are not replenished.
  - The creek could be controlled more if the alignment were farther upstream, the channel is more static.
  - Nabesna Road traverses the alluvial fan and it's not really constructed. Could the road be hardened to accommodate heavy hauling traffic associated with the CERCLA project?

WRST Perspective

- Superintendent's concern is that there hasn't been a strategic plan to drive implementation efforts. There is a need to develop a data-driven plan to support stakeholder discussions and inform what is feasible and not feasible.
  - Ben is a scientist and will point out capricious decision making. He will be supportive of a gravel pit within the Park if the data and analysis supports that decision.
- Ideally, WRST would have a broad Long Range Transportation Plan that includes all of the related plans and studies (McCarthy PEL, Copper River access study, Nabesna Road gravel study, etc.). However, the Park has limited planning staff to assist with all of these planning efforts. Option to request a NPS Transportation Scholar to work on-site and coordinate all of the different planning activities?

- The Park would benefit from a formal understanding of gravel needs, both recurring (maintenance) and future needs (projects).

Next Steps for Phase 1

- Draft report will be prepared by October 2022. Additional considerations for the report:
  - Specifications for gravel pits, rock crushing and processing areas – WFL materials engineers can generate high-level estimates and specs on processing sites.
  - Information on comparable pits in other parks (Denali, Katmai, etc.)
  - Information from the US Forest Service and other land management agencies on their gravel issues
  - Addressing sensitivities of material extraction and processing within a National Park (minimizing footprints and impacts)
  - Articulating why importing gravel is not the preferred option (higher risk for invasive species and artifacts, higher costs) and describing gravel costs of recent projects.
- WFL project delivery team will focus on original scope. Other "nice to have" items will be documented in the report as work to be completed as part of Phase 2.
- Future work could include additional mapping, comparing alternate alignments, best management practices for building resilient trails through saturated wet areas in WRST, and detailed specifications for rock crushing areas.
- The Task 5 – Multi-Agency Workshop will be moved to October and added to the Alaska TWiG Project Coordination meeting agenda. Jamie will work with Cole Grisham to modify the agenda and add Ryan, Orion, and Joshua to the invitee list.

Phase 2 Scoping

Attendees discussed what a Phase 2 Wrangell-St. Elias Strategic Transportation Study scope should address.

- There are three discrete but related projects: 1) ORV Trails related to the EIS; 2) Nabesna Road maintenance and gravel needs; 3) CERCLA projects and road needs/impacts during clean-up project.
- The next iteration of the study should address all actions included in the ORV EIS. Specifically, a cost-benefit analysis of maintaining the ORV trails in a year-round accessible condition (cost of materials, maintenance, etc.). Also understanding the cost and gravel quantities needed to rehabilitee trails as described in the EIS (e.g., $X million per mile of trail).
- Cost-benefit analysis – the Park has a lot of information on costs, but what about benefits? Analysis of visitor and user data. Potential data inputs:
  - Visitation – recreational ATV permits
  - Subsistence use – including area population trends, hunting reports and permit data
  - Trail count data, where available
  - Nabesna Road traffic counts
  - Consideration of where the Park wants to design for subsistence use, recreational use, or both. Trail design standards vary significantly depending on trail type.

- Include best management practices, design standards, and specifications for sustainable ORV trails. Reference other park and federal land management agencies that have related practices and experience completing this type of work in sensitive environments.
- Assessment of different access options prescribed in the EIS (e.g., vehicle weight restrictions, seasonal use, etc.)
- Close data gaps from Phase 1 (hydrology, materials evaluation, etc.) and further investigate high potential sites and the "downstream" impacts of material extraction.
- Include more coordination with AKDOT&PF.
- Once preferred source sites have been identified, integrate that into a corridor-wide plan for gravel maintenance that includes Nabesna Road and the ORV trails.
- Include specific practices for controlling the Trail Creek alluvial fan. Oregon DOT is managing a pit plan on an alluvial fan site, Ryan to contact ODOT about sharing information.
- Include other recommendations (viewshed planning, vegetation assessments, etc.)