TETRA TECH

TECHNICAL MEMO

ISSUED FOR USE

To:	Teri Camery (CBJ)	**Date:**	April 27, 2022
c:	Scott Ciambor (CBJ)	**Memo No.:**	7
From:	Rita Kors-Olthof, Vladislav Roujanski	**File:**	704-ENG.EARC03168-02A
Subject:	Considerations for Anthropogenic Terrain at Starr Hill and Gastineau Avenue Downtown Juneau Landslide and Avalanche Hazard Assessment		

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) has prepared an Issued-for-Review (3rd Draft) Report, Downtown Juneau Landslide and Avalanche Assessment for the City and Borough of Juneau (CBJ), dated May 28, 2021 (Tetra Tech 2021); and participated in three Landslide and Avalanche Hazard Public Meetings that took place on July 21, August 10, and September 20, 2021.

Following CBJ's initial email request of July 27, 2021, Tetra Tech responded to comments and questions that arose from the July 21, 2021, Public Meeting with a series of three technical memos. These memos were Issued-for-Review to CBJ, along with an email providing supplemental information, and have since been updated (Appendix C in the main report; Tetra Tech 2022a, 2022b, 2022c).

CBJ has now requested a further series of memos to address additional landslide-related questions, as well as a review of historical avalanche data, to address further questions that arose following the August 10 and September 20, 2021, Public Meetings; as well as some follow-up questions from CBJ. The scope is as described in Tetra Tech's proposal of December 9, 2021, with a few modifications as discussed during the kick-off meeting with CBJ on February 8, 2022. All the completed memos will be included in an appendix of the Final Draft Report.

This Technical Memo #7 provides some additional discussion about past and anticipated future slope instabilities potentially related to the past human activities, which shaped anthropogenic, i.e., human-modified terrain within the landslide hazard designations mapped as *Severe* on the slopes above Starr Hill and Gastineau Avenue.

2.0 SCOPE AND METHODS

The primary objective of this memo is to provide some additional background for responding to Question #14 in Technical Memo #3 (Appendix C in the main report; Tetra Tech 2022c). Since the potential influences of anthropogenic (human-modified) terrain can also affect the performance of these slopes, some additional interpretation and evaluation of these types of influences has also been considered. Specific tasks included the following:

- Review landslide hazard mapping;
- Locate suitable photographs illustrating landslide hazards in the above-noted map areas, if/as needed;
- Prepare map excerpts, if/as needed;
- Refer to information presented previously in other technical memos, as applicable; and

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- Prepare Technical Memo, providing descriptions and/or comparisons, as needed.

3.0 STARR HILL

3.1 General Considerations

The slope conditions around the Starr Hill subdivision were discussed in detail in Technical Memo #3 (Appendix C in the main report; Tetra Tech 2022c). Portions of these slopes are potentially affected by anthropogenic changes (human-made modifications). Above Starr Hill, such modifications mostly include the presence of trails, some of which are related to recreational hiking and access to the views from Mt. Roberts, and some of which are related to powerline alignments and/or possible former mining-related trails.

3.2 Effects of Human-Modified Terrain

Technical Memo #3 provides an overview of the overall slope conditions above the Starr Hill subdivision, along with numerous photos and map excerpts. The main influence of human-modified terrain on the slopes around Starr Hill is the likelihood that earthworks along trails (and possibly the powerline alignments) might have blocked some of the natural swales and gullies that would ordinarily carry surface water runoff. Oversteepened cutslopes, or oversteepened or sidecast fillslopes, if present, also have the potential to result in, or contribute to, slope failures. The presence of human modifications on slopes also has implications for anticipating which slopes or slope sections might be more susceptible to landslides in the future, particularly if surface water drainage modifications or cuts and fills have disrupted the natural slope conditions. Figures 1 through 3 below present a few examples of former and/or active trails and other linear infrastructure on the slopes above Starr Hill. Conceivably, there could be still more trails not yet discovered on the imagery or historical photos.

As noted in Technical Memo #3, Question #12, surface water drainage along trails and other linear infrastructure, whether abandoned or actively in use, should be purposefully managed, so that the original natural drainage paths across these human-made features can be preserved or restored. For a detailed evaluation and recommendations for possible mitigations in human-modified terrain, a purpose-specific field investigation would be needed and is not part of the current scope. Recommendations for future investigation and evaluation are provided below in Section 5.0.

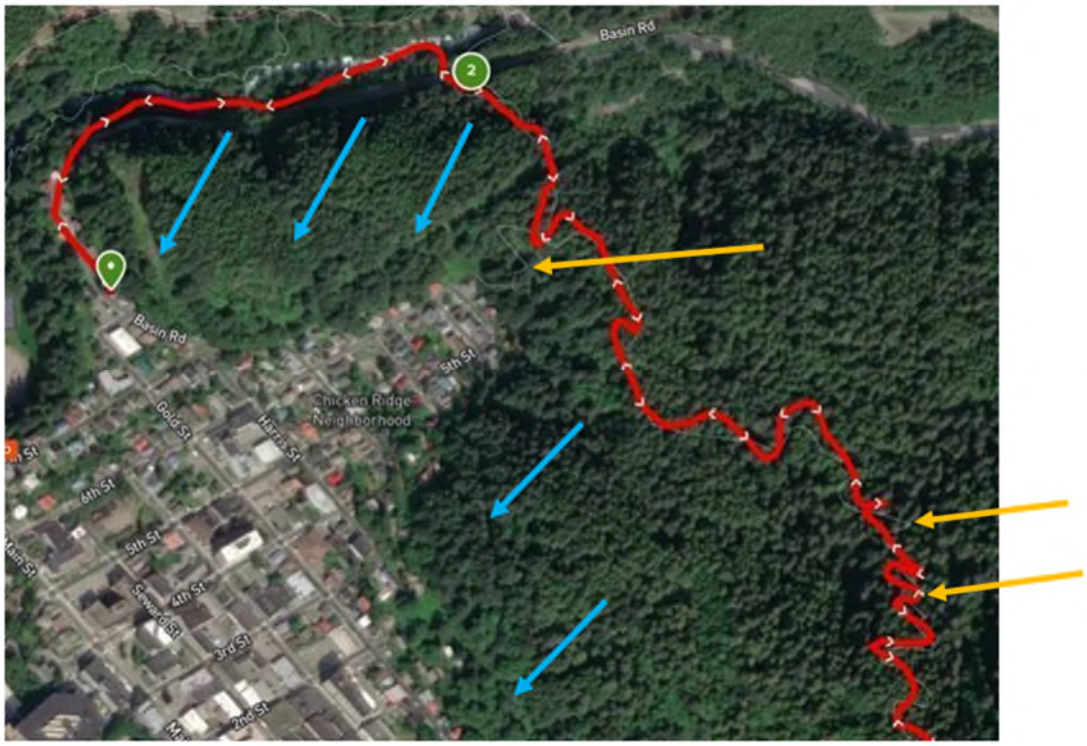

Figure 1: Current Mt. Roberts hiking trail (red) and former hiking trail (pale gray). Switchbacks along new and old trails (orange arrows). Powerline cutlines are also visible (blue arrows). (Image credit: AllTrails 2021.)

Figure 2: Topographic map, showing the same trail alignments as the pale gray lines on Figure 1. Dotted trail above Nelson Street is the trail section officially no longer used. Note switchbacks. (Image credit: AllTrails 2022).

Figure 3: View of Mt. Maria and Mt. Roberts from Mt. Juneau, circa 1935. Note possible old forestry trail on the slopes above Starr Hill (red arrow) and the former Alaska Juneau Gold Mining Company (AJGMC) tramway (blue arrow). (Photo credit: Alaska State Library – Historical Collections, ASL-P87-0542, Winter & Pond. ASL 2022a.)

4.0 GASTINEAU AVENUE (SLOPES OF MT. ROBERTS)

4.1 General Considerations

Several past landslides on the slopes above Gastineau Avenue and South Franklin Avenue on Mt. Roberts were considered in Technical Memo #3, Question #14 (Tetra Tech 2021d). Of particular interest in that question was whether past landslides, such as those on deforested slopes in the vicinity of the siteworks of the former Alaska Juneau Gold Mining Company (AJGMC), should be considered representative of the potential for future landslides. The implication was that, because the logged slopes had revegetated, and mining-related blasting and water discharge were no longer taking place, landslides might not be as common as they once were on this slope. The answer to that question in Technical Memo #3 was that some of the landslides appeared to have been directly attributable to the mining-related siteworks or operations (e.g., the leaky flume apparently contributing to the January 2, 1920 landslide), or possibly suspicious (e.g., the tension crack seen below the flume in the November 22, 1936 landslide), but on the other hand, the cause of some of the landslides (e.g., the 1952 landslide) could *not* be directly attributed to the former mining infrastructure or operations.

What has not yet been directly considered for the Mt. Roberts slope is the possibility that the remnants of the tramway/railway grade, as well as roads, trails, or powerlines on Mt. Roberts might *still* potentially affect slope

stability on a large portion of the lower slope of Mt. Roberts, between the north flank at Starr Hill to at least as far south as the northwest end of Thane Road (Figure 1a, 1b), even though the mine has not been operating for decades (since 1944). The premise for the slopes on Mt. Roberts is the same as that for the slopes above Starr Hill. It is important to account for the following:

- Past and probable future natural slope instabilities originating on natural terrain, not specifically modified or influenced by human activities, addressed in Technical Memos #3 and #6 for this slope (Appendix C in the main report; Tetra Tech 2022c, 2022f); and
- Past and potential future slope instabilities in anthropogenic (human-modified) terrain, including areas of previous logging, old roads, trails, powerlines, and tramway/railway grades (this memo).

The evaluation of natural slope instabilities is based on the slope observations made during the mapping project and is applicable to the entire slope of Mt. Roberts within the Study Area (see main report).

At this time, only a preliminary evaluation of the effects of human-modified terrain is possible, based on the slope observations made during the mapping project, a subsequent LiDAR data review and air photo 3D-analysis in PurVIEW, and a review of historical photos and records from the Alaska State Archives – Historical Collections (2022a through 2022e), documenting a range of mass movement events on this slope. For a detailed evaluation and recommendations for possible mitigations in human-modified terrain, a purpose-specific field investigation would be needed and is not part of the current scope. Recommendations for future investigation and evaluation are provided below in Section 5.0. Some of the observed effects of human-induced terrain disturbance are described in Section 4.2.

4.2 Effects of Human-Modified Terrain

Some of the potential and documented human-induced slope instabilities were discussed in Technical Memo #3 (Appendix C in the main report; Tetra Tech 2022c). Subsequent desktop evaluation on the slope along Gastineau Avenue has revealed some additional useful information, which has been used to update Question/Comment #14 in Technical Memo #3, and is discussed in detail here.

Tetra Tech used numerous historical photos from the Alaska State Archives – Historical Collections (2022a through 2022e), maps, plans, and the LiDAR mapping for the landmarking of several major landslides that took place on the southeast (Gastineau Channel) side of Mt. Roberts, and previously described in Technical Memo #3, Question #14 (Appendix C in the main report; Tetra Tech 2022c). In one case, for the January 2, 1920 landslide, it was possible to directly compare a documented “before-and-after” set of photos (Figures 4 and 5), with confirmation of most of the structures available from the 1914 survey plans. In other cases, such as the November 22, 1936, landslide, for which photos of the slope had uncertain dates, a timeline of photos and maps was developed based on structures or slope features that were present or absent.

Figures 4 through 7 below present a few examples of former and/or active linear infrastructure, such as old roads, trails, powerlines, and tramway/railway grades, on the slopes above Gastineau Avenue on Mt. Roberts where landslides have occurred. Figure 1a, 1b, attached, provides some additional interpretation of the current slope conditions, the locations of some of the old mining infrastructure, and the locations of a few of the major slides over the past century. Conceivably, there could be more such features on the slope that have not yet been discovered on the imagery or historical photos. To reduce the likelihood of unexpected contributions from infrastructure to landslide occurrences or severity, more information could be collected on those features, and a decision-making process implemented to decide what to do about them, if anything.

Figure 4: This "before" photo is from after 1914 but before 1920, and possibly from the summer of 1919. The stairway at center-right is Bulger Way. The pier-like structure is Gastineau Avenue. Decker Way (a stairway) is located just beyond the left edge of the photo. Note the numerous structures between Decker Way and Bulger Way before the landslide. Just up and left of the smoking-chimney building is the tenement building that tipped and rotated clockwise during the landslide (see Figure 5). Top right is the former Alaska Juneau Gold Mining Company (AJGMC) office building. (Photo credit: Alaska State Library – Historical Collections, PCA0154-295, Snow Family Photograph Collection. ASL 2022b.)

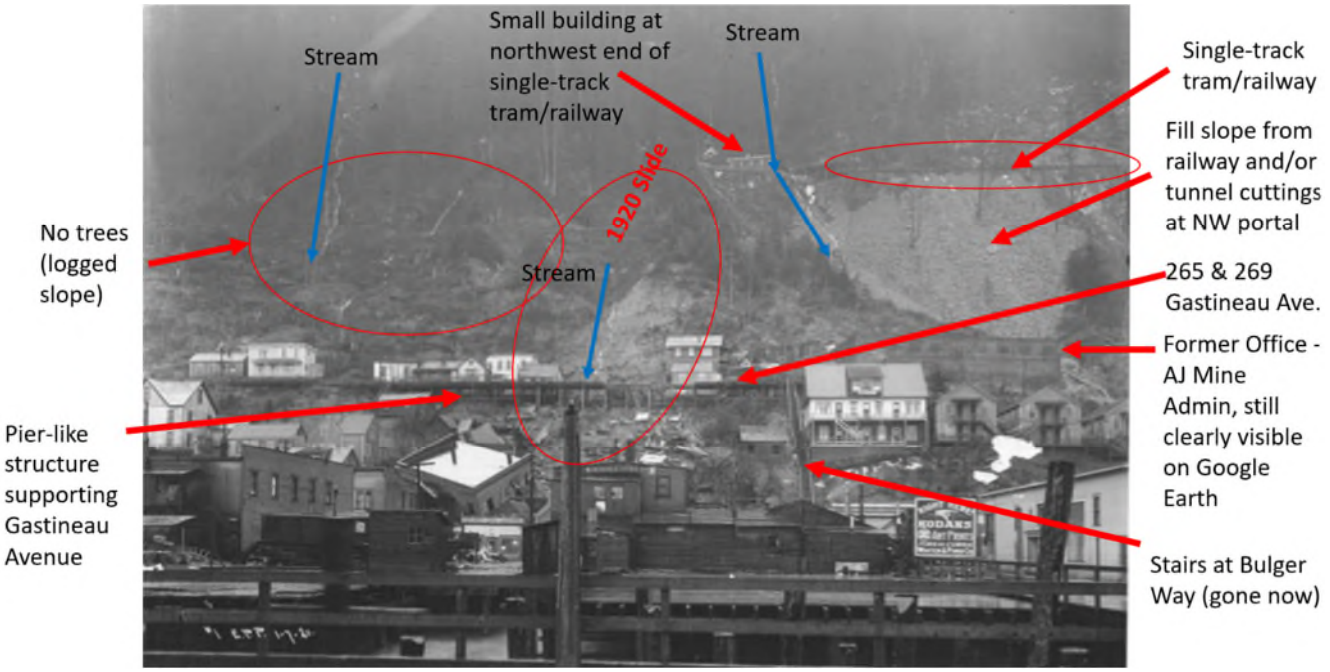

Figure 5: Compare to Figure 4 and note numerous missing, destroyed and/or shifted structures. Slope right of small building failed in November 22, 1936 landslide. (Photo credit: Alaska State Library – Historical Collections, ASL-P87-1223, Winter & Pond, January 7, 1920; cropped to fit page, markups from CBJ and Tetra Tech. ASL 2022c.)

Figure 6: Two apparent debris paths from November 22, 1936, landslide (red arrows, see also Figure 1a, 1b attached). Structure at center-left was the Juneau Cold Storage Company building, later replaced. Debris ran up against the S. Franklin St. side of Juneau Cold Storage, moved the Madsen Building downslope, destroyed several buildings, and killed 15 people. (Photo credit: Alaska State Library – Historical Collections, ASL-P134-312-4, date uncertain, cropped to fit. ASL 2022d.)

Figure 7: Excerpt from 1971 air photo mosaic showing a reactivated slope failure at the site of the 1936 landslide (red arrow). Since the 1968 air photo mosaic showed little exposed soil at this location, this slope might continue to slough and ravel periodically over time, confirmed by Tetra Tech's mapping of mass movement features (Tetra Tech 2021a). (Image credit: Alaska State Library – Historical Collections, ASL-_Map_Case_Juneau_1971, ALS 2022e.)

5.0 RECOMMENDATIONS FOR FUTURE WORK

A forestry road-deactivation format for slope review and the preparation of recommendations for proposed mitigations could be considered for future work.

The intent of the work would be to mitigate or reduce the potential for damage resulting from slope instabilities that are attributable to abandoned or active infrastructure on the slope, especially linear infrastructure that tends to alter surface water drainage. It might not be possible to prevent all infrastructure-related slope instabilities but could reduce the likelihood that the infrastructure triggers slope instabilities or that it makes the effects of natural slope instabilities worse.

6.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of City and Borough of Juneau and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than City and Borough of Juneau and their agents, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

7.0 CLOSURE

We trust this technical memo meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

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Enclosure: Limitations on Use of this Document
Figures 1a, 1b

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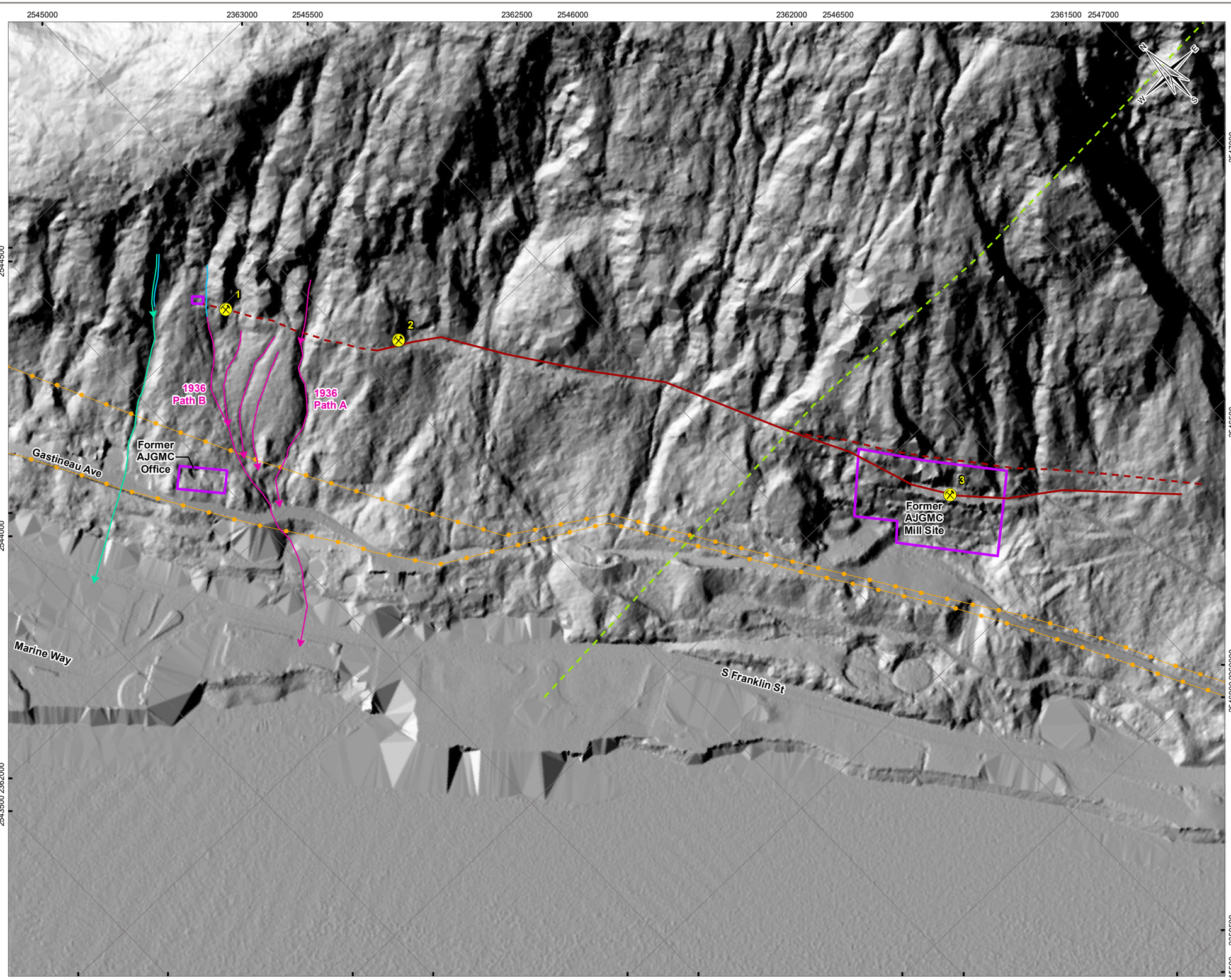

LEGEND

- Mine Portal
- 1 — Interpreted from the 1948 air photos and 1916 drawing from Alaska-Juneau Gold Mining Co. (see References)
- 2 — Interpreted from the 1948 air photos and 1916 drawing from Alaska-Juneau Gold Mining Co. (see References), and confirmed by Tetra Tech in the field
- 3 — Interpreted from Juneau historical photos (Alaska State Library) and confirmed by Tetra Tech in the field
- 1920 Landslide - Interpreted from the 1948 air photos, historical photos (Collections from Alaska State Library), news reports, summary from Swanston (1972), and geologic mapping from Miller (1975)
- 1936 Landslide - Interpreted from the 1948 air photos, historical photos (Collections from Alaska State Library), summary from Swanston (1972), and geologic mapping from Miller (1975)
- Tramway/Railway Grade - Interpreted from the 1948 air photos and confirmed by Tetra Tech in the field
- Tramway/Railway Grade - Interpreted from the 1948 air photos and Juneau historical photos (Alaska State Library)
- Stream
- Gondola
- Power Line
- Building Footprint

NOTES
Base data source:
Hillshade derived from 2013 LiDAR data provided by CBJ.

STATUS
ISSUED FOR USE

JUNEAU LANDSLIDE AND AVALANCHE ASSESSMENT

Locations of Infrastructure and Landslides on Mt. Roberts (LiDAR)

PROJECTION State Plane Alaska Zone 1 5001	**DATUM** NAD83			**CLIENT** CITY AND BOROUGH OF JUNEAU
Scale: 1:3,000 — 200 100 0 200 Feet				TETRA TECH
FILE NO. EARC03168-01_FIG1a_MtRoberts_Hillshade.mxd				
OFFICE Tt-EDM	**DWN** SL	**CKD** BB	**APVD** SM/VER	**REV** 0
DATE April 27, 2022	**PROJECT NO.** ENG.EARC03168-01			**Figure 1a**

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LEGEND

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- Stream
- Gondola
- Power Line
- Building Footprint

NOTES
Base data source:
Primary imagery provided by CBJ, 2013.

STATUS
ISSUED FOR USE

JUNEAU LANDSLIDE AND AVALANCHE ASSESSMENT

Locations of Infrastructure and Landslides on Mt. Roberts (Air Photos)

PROJECTION State Plane Alaska Zone 1 5001	**DATUM** NAD83	**CLIENT** CITY AND BOROUGH OF JUNEAU	
Scale: 1:3,000 — 200 100 0 200 Feet			
FILE NO. EARC03168-01_FIG1b_MtRoberts_Imagery.mxd		TETRA TECH	
OFFICE Tt-EDM	**DWN** SL / **CKD** BB / **APVD** SM/VER / **REV** 0		**Figure 1b**
DATE April 27, 2022	**PROJECT NO.** ENG.EARC03168-01		

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GEOTECHNICAL

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If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

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1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary investigation and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.8 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.9 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.10 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

1.11 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.12 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.13 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

1.14 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.15 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

1.16 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

1.17 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.