TECHNICAL MEMO

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To:	Teri Camery (CBJ)	**Date:**	April 27, 2022
c:	Scott Ciambor (CBJ)	**Memo No.:**	5
From:	Rita Kors-Olthof, Vladislav Roujanski	**File:**	704-ENG.EARC03168-02A
Subject:	Landslide Hazard Designations at Telephone 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 of the main report; Tetra Tech 2022a, 2022b, 2022c).

CBJ has now requested a further series of memos to address additional landslide hazard-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 appended to the Final Draft Report.

This Technical Memo #5 provides some additional explanation for anticipated future slope instabilities within the landslide hazard designations mapped as *High* or *Severe* on the slopes of Telephone Hill (Figures 1 and 2) compared to the areas mapped as *High* or *Severe* on the slopes along and above Gastineau Avenue.

2.0 SCOPE AND METHODS

The primary objective of this memo is to address the question, "The area of Telephone Hill and the bluffs below is mapped as a *High* hazard. What is the difference between Telephone Hill and the steep slopes on Gastineau in terms of hazard and potential for damage?" Specific tasks included the following:

- Review landslide hazard designation mapping completed by Tetra Tech;
- 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
- Prepare Technical Memo, providing descriptions and/or comparisons, as needed.

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The surficial geology mapping shows that the colluvial terrain at Telephone Hill is connected to the northwest leg of the Juneau townsite, which is in turn connected to the northwest leg of Chicken Ridge on the southwest side of Cope Park. Therefore, it is logical to consider these areas together in addressing this question.

3.0 TELEPHONE HILL, JUNEAU TOWNSITE, AND CHICKEN RIDGE

3.1 Summary of Historical Landslides in Areas Mapped *High* or *Severe*

It is useful to first consider a view of Telephone Hill from Mt. Maria in the historical photo taken in about 1896, prior to the Juneau development that has gradually obscured the slopes (Figure 1). The prominent bedrock ridge seen in this photo was mapped by Miller (1975) as undifferentiated Tertiary or upper Mesozoic rock with an unconformity, suggesting that some material was scoured off at some point in geological history, and the bottom of the upper layers does not match the top of the lower layers. Although the top of the ridge is gently sloped, the sides of the ridge are quite steep. In locations where a thin veneer of colluvium covers the bedrock, this material could be more prone to mass movement than other materials such as a blanket of colluvium or glacial till (Tetra Tech 2021a).

Figure 1: Looking south towards Telephone Hill and Gastineau Channel from Mt. Maria, circa 1896, early in the development of Juneau, when structures along the toe of slope at Willoughby Avenue were supported on wharfs, and before fill began to be placed along the shoreline to extend the useable land area. (Photo credit: Excerpted from Alaska State Library – Historical Collections, ASL-P87-0753, Winter & Pond, ca. 1896.)

Adjacent to the Main Street Garage (a multi-level parkade) at the southeast end of Telephone Hill, on the northeast side of the bedrock ridge, the bedrock slope was cut to make room for the structure, with some rock-bolting also done to protect a residence on top of the ridge. The bedrock face at that location is regularly inspected and scaled if/as needed. The State Archives and Records Center, on the Willoughby Avenue side, is built into the ridge, with an adjacent retaining structure just southeast of the back of the building. The State Office Building appears to have been built alongside and across the top of the ridge. Several other residences remain on top of the ridge. Numerous bedrock outcrops are present along Dixon Street in this area. Heading northwest along Dixon Street, Calhoun Avenue, Goldbelt Avenue, and Main Street into the Juneau Townsite and Chicken Ridge areas, retaining walls and buildings set into the slope are common, as well as bedrock outcrops.

Only a few historical landslides have been documented in this part of Juneau. These landslides are plotted on Figure 2 for information and comparison.

On September 7, 1923, the Juneau Daily Empire reported that a landslide "of about 100 feet occurred on the hill between Calhoun Avenue and Willoughby Avenue, at the foot of Dixon Street." The slide had occurred early that morning due to the heavy rainfall of the preceding few days. The slide pushed a large unoccupied two-storey frame house off its foundations, moving it several feet. No damage was reported to the house, except that its "underpinnings" had been torn out. In addition, the slide also destroyed "part of the stairway leading from Calhoun Ave. to the Indian village" (The Alaska Daily Empire 1923). This landslide occurred in colluvium and appears to have been directly downslope of the fork at Dixon Street and Calhoun Avenue, in an area that still experiences periodic landslides, at the northwest corner of the Juneau Townsite in CBJ's Historic Neighborhoods mapping.

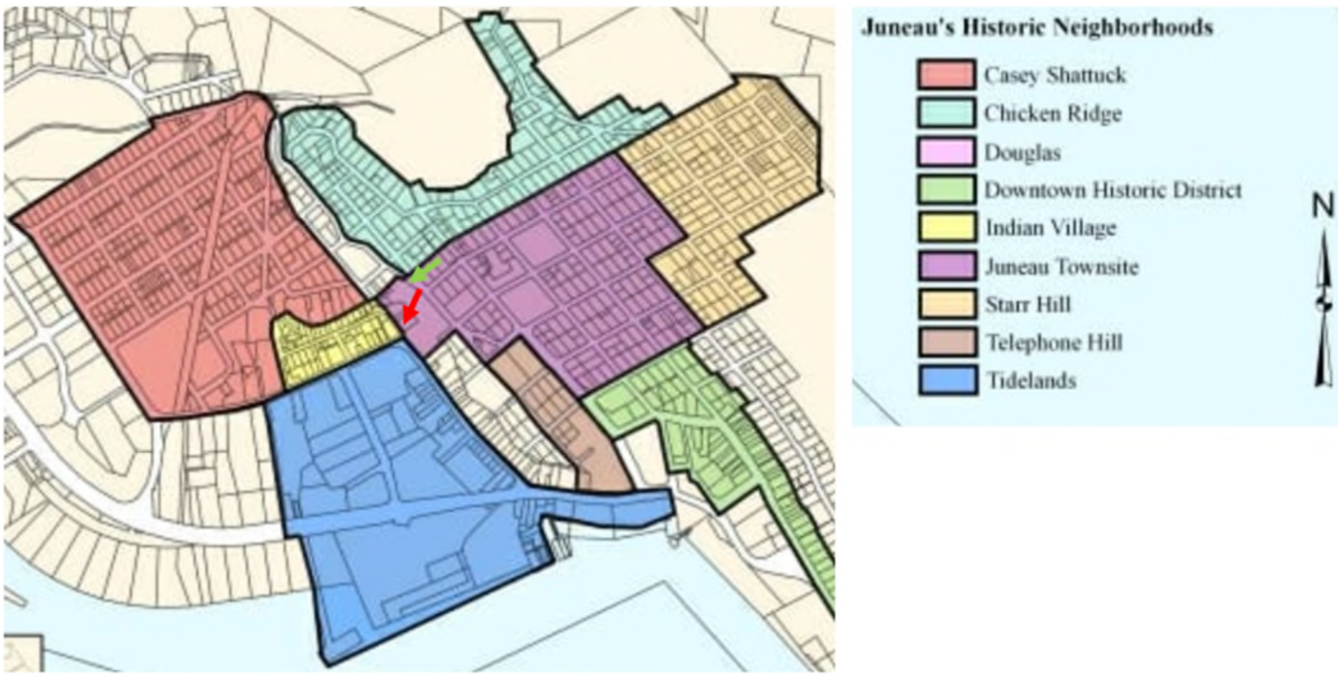

Figure 2 Excerpt of map of Downtown Juneau's Historic Neighborhoods (CBJ 2022), showing selected historical landslide locations. The 1923 landslide is shown running downslope from Calhoun Avenue and the southeast end of Dixon Street to a little above the present-day Willoughby Avenue (red arrow). Landslides still occur at Calhoun Avenue, originating upslope of Dixon Street (green arrow).

CBJ has reported that debris slides occur regularly at the fork between Dixon Street and Calhoun Avenue, between the northwest end of the retaining wall on Calhoun, and just downslope of the West 6th Street cul-de-sac. This location overlaps the southwest corner of Chicken Ridge, and the northwest corner of the Juneau Townsite in CBJ's Historic Neighborhoods (CBJ 2022) mapping, and its location is shown in Figure 2. Rocks on the road have been reported after large storm events in at least the past two years. Trees or pieces of large woody debris are less frequent, occurring at roughly five-year intervals (email communications: July 20, 2021; A. Pierce, T. Camery, Q. Tracy, V. Roujanski, and R. Kors-Olthof). Google Street View suggests that debris appears to originate at a bedrock bluff partway upslope towards West 6th Street, and could consist of soil, rocks, trees, or other large woody debris, and other organic debris that typically lands on Dixon Street, requiring cleanup to restore road access, as seen in Figure 3. Part of the slope, between Dixon Street and Main Street upslope, is occupied by a building, but some debris seems to originate from the lower slope below the building too.

Figure 3: Typical debris slide deposit at the fork between Dixon Street and Calhoun Avenue. In the left-hand photo, note the fork in the road at center-right, and the northwest end of the retaining wall at the right edge of the photo. The downslope edge of Calhoun at the railing is supported by another retaining wall. In the right-hand photo, note the presence of a steep cutslope into apparent weathered bedrock, with a thin veneer of colluvium. The debris from this landslide event extends an estimated 40 feet northwest of the end of the metal railing. The distance along the toe of slope along Dixon/Calhoun is about 110 feet between the northwest edge of the debris and the northwest corner of the upslope retaining wall. (Photo credits: CBJ, provided July 16, 2021.)

There are a great many retaining walls visible on Dixon Street, Calhoun Avenue, Goldbelt Avenue, parts of Main Street, and connecting streets. Some of these retaining walls were apparently used to construct houses and associated landscaping to make more efficient use of the slope, but numerous retaining walls along roads appear to be necessary to create or maintain access to properties, or to reduce landsliding along steep slopes. In adjacent locations that lack retaining walls, many slope sections have either deciduous trees or grasses, suggesting that shallow debris slides might be fairly common. However, the specific location shown in Figure 3, and the landslide downslope in 1923 at almost this exact location, do suggest that there is something particular about this site that causes it to be exceptionally prone to slope failure. An excerpt of the LiDAR in this area provides a possible explanation (Figure 4).

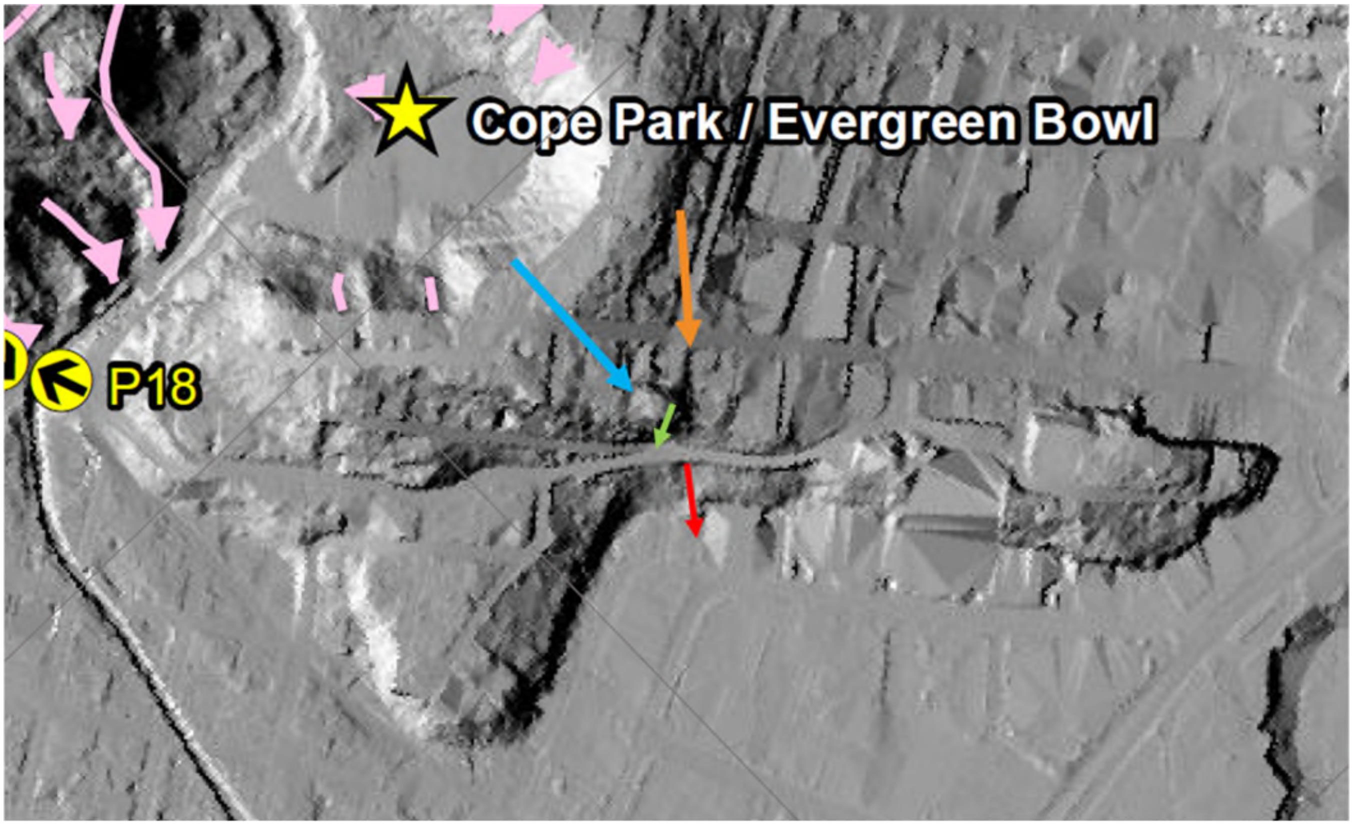

Figure 4: Just off the southwest end of West 6th Street, there is a prominent bedrock knoll (blue arrow), and an adjacent gully (downslope of the orange arrow) that both potentially contribute to repeated debris slides at this location that regularly run out onto Dixon Street (green arrow). The gully is also directly in line with what appears to be a scar from the 1923 landslide that moved from Calhoun Avenue down to Willoughby Avenue (red arrow). See also Figure 2.

3.2 Comparison of Map Excerpts

A summary of Tetra Tech's mapping along Telephone Hill, Juneau Townsite, and Chicken Ridge is shown in Figure 5, with surficial geology on the left and landslide hazard designation mapping on the right. There is a clear correlation between the types and shapes of the surficial geology units and the landslide hazard designations at that location. In Figure 6, the colluvial areas are distinguished by the vegetation visible along slopes where it is difficult to construct housing or other structures.

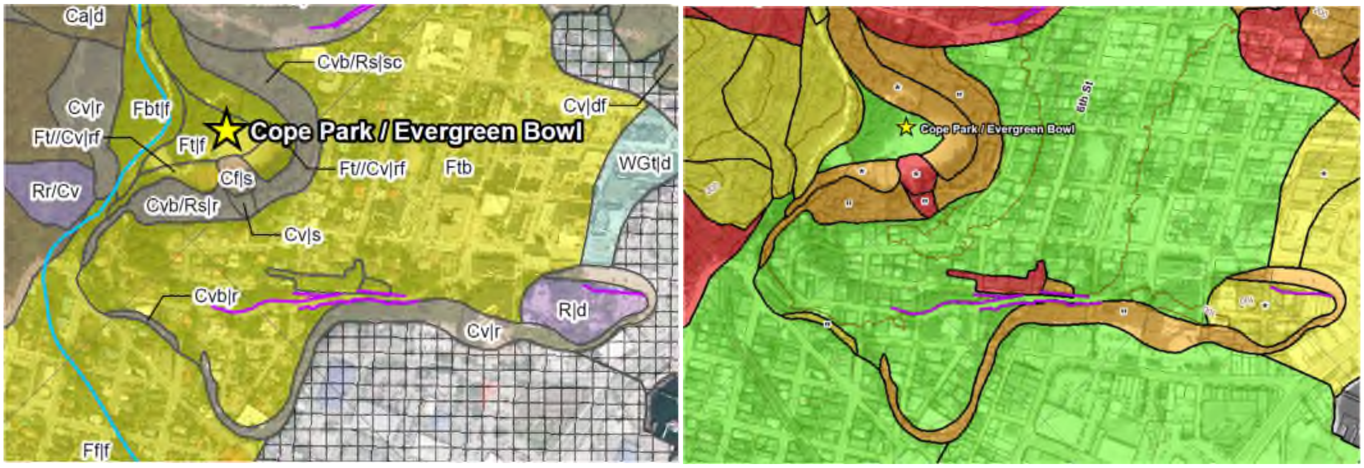

Figure 5: Excerpts from Figure 1.3b Surficial Geology (left) and Figures 1.6c Landslide Hazard Designation Mapping (right). Surficial geology corresponds closely to landslide hazard designations.

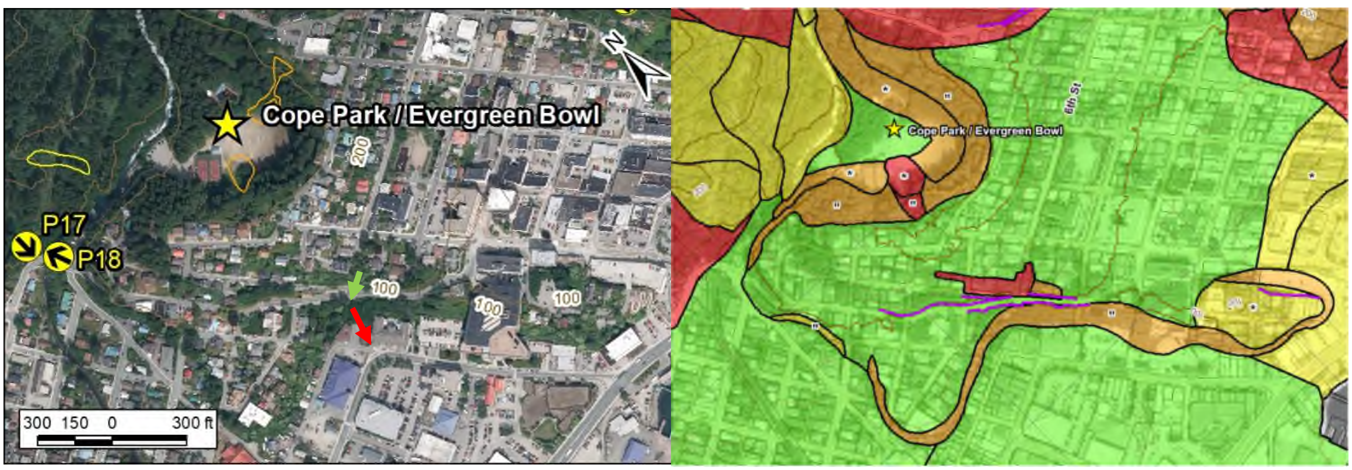

Figure 6: Excerpts from Figure 1.4b Slope Movement Features and Figure 1.6c Landslide Hazard Designation Mapping. On the left-hand image, the 1923 landslide is shown running downslope from Calhoun Avenue and the southeast end of Dixon Street to a little above the present-day Willoughby Avenue (red arrow). Landslides still occur at Calhoun Avenue, originating upslope of Dixon Street (green arrow). On the right-hand image, the hazard mapping from 1987 has been restored and updated above Calhoun Avenue, based on the debris slides reported by CBJ.

Depending on the date of construction of the Calhoun Avenue upslope retaining wall, the area currently shown as *High* in Figure 6 could be downgraded to *Moderate*, but the area shown as *Severe* should remain as is due to the high frequency of debris slides at that location.

4.0 GASTINEAU AVENUE (SLOPES OF MT. ROBERTS)

4.1 Summary of Historical Landslides in Areas Mapped *High* or *Severe*

Much of the slope along Gastineau Avenue and South Franklin Street has a landslide hazard designation of *Severe*, due to being in the runout zone of numerous major debris flow paths. For debris slides that initiate within *Severe* zones upslope, the likelihood is very high that they will also run out in *Severe* zones downslope. As for debris slides in areas designated as *High* that occur between those *Severe* zones upslope, e.g., on open slopes between debris flow gullies, these slides can be small enough that they will initiate and run out all within the same *High* zone. Depending on the location; however, some slides that initiate in the *High* zones could run out into the *Severe* zones.

It would be useful to determine whether any of the well-documented major landslides on the slopes of Mt. Roberts that initiated in a *High* zone, and ended up in *Severe*, also reaching structures along Gastineau Avenue or further downslope. For comparisons of less well-known landslides, side-by-side comparisons can help in this task, as further discussed in Section 4.2. Technical Memos #3, #6, and #7 provide additional information on specific findings on Mt. Roberts (Appendix C of the main report; Tetra Tech 2022c, 2022f, 2022g). Figures 7, 8, and 9 provide some side-by-side mapping comparisons for surficial geology, mass movement features, and gully erosion features compared to landslide hazard designations near the northwest end of Mt. Roberts. Figures 10, 11, and 12 provide the same side-by-side comparisons at the southeast end of the Study Area at Snowslide Creek. Details for two major landslides near the northwest end of Mt. Roberts are discussed below.

Landslide of January 2, 1920: Most of this landslide area is mapped in *Severe*, including the two houses that were destroyed above Gastineau Avenue (see Tetra Tech 2021a, Figure 1.6c, the first complete debris flow path from the right). Consider the report of overflowing water from the Alaska Juneau Gold Mining Company (AJGMC) flume in the time leading up to the landslide (The Alaska Daily Empire 1921). If that water came from Portal #1 (Figures 1a,1b in Technical Memo #7), does that mean it poured down the northwest side of the fill/spoil slope, triggering a slope failure in *High*? (See Figure 5 in Technical Memo #7.) It seems possible, mainly because AJGMC lost a court case in 1921 that contested whether or not AJGMC's leaky flume had contributed to that slide. On the other hand, AJGMC won three other court cases about the exact same landslide. A debris slide was not visible on the 1948 air photos on the southeast side of the 1920 gully; however, it is plausible that the scar from that event must have been fully revegetated by 1948, when the earliest set of air photos used in this project were taken (Figure 1.4b in the main report). In contrast, debris slide activity *was* mapped to the northwest of the 1920 debris flow gully on the 1977 air photos (suggesting that it occurred sometime after 1962, but before 1977). That debris slide area was located partly in *High* and partly in *Severe*, crossing several narrow hazard designation zones across its width (Figures 7 and 8). The toe of the debris slide area was about 100 feet in elevation above the cutline for the powerline above Gastineau Avenue.

Landslides of November 22, 1936: The tension crack reported below the AJGMC tramline (presumably within the fill/spoil slope) seems suspicious, suggesting initiation of the slope failure in *High*. However, the slide seems to have entered the runout in *Severe* along the southeast edge of the runout cone encompassing the former AJGMC office (for 1936B), and the adjacent slide (1936A) seems to have been entirely within *Severe* (Figures 1a, 1b in Technical Memo #7). Several debris slides were mapped in this area thereafter, apparently on the fill/spoil slope, in 1962, 1977 (confirming the 1971 air photo mosaic map from the State of Alaska, Department of Highways (ASL 2022)), and in 2013 and 2019 (Figure 8; Tetra Tech 2021a, Figure 1.4b). All but one of these later debris slides ran out to approximately the upper edge of the cleared powerline right-of-way, and the 2019 debris slide ran out to the lower edge of the right-of-way (Figure 8). Another debris slide or flow was mapped on the 1977 air photos, originating from upslope of the tramline, apparently flowing along the northwestern edge of the 1936B debris slide path, but running out well above the powerline right-of-way (Figure 8).

Landslide events that reach the lower slopes of Mt. Roberts tend to consist of debris flows or debris slides, and runouts are typically mapped in *Severe* on this slope. Those debris flows or debris slides could incorporate debris originating from areas mapped as *High* within the colluvium on the mid- to lower slopes, as noted above. The length of the slopes on Mt. Roberts means that there could be a few different types of landslide events between the top and bottom of the slope (Figures 7, 8, and 9 at the northwest end of Mt. Roberts; Figures 10, 11, and 12 at Snowslide Creek). Just as for Telephone Hill, and the adjacent Juneau Townsite and Chicken Ridge in terrain representing the same geological feature as Telephone Hill, wherever debris slide or debris flow processes are occurring now, these are the kinds of mass movement processes that have been ongoing for decades and centuries, and they are expected to continue.

The processes described for Telephone Hill and the adjacent Juneau Townsite and Chicken Ridge are the same as those occurring on the slopes of Mt. Roberts, though the slope length is greater on Mt. Roberts, and although debris slides on open slopes can be similar in size to those above Telephone Hill and the adjacent areas, larger-scale events are possible, particularly for debris flows or debris slides within gullies (Figures 7, 8, 9, 11, and 12 below; Figures 1.4b, 1.5b, 1.4c, and 1.5c in Tetra Tech 2021a). However, many of the debris slides in *High* zones on Mt. Roberts terminate well above residential or commercial areas, and it is mainly where the debris slides coincide with *Severe* zones that they become more concerning.

4.2 Comparison of Map Excerpts

A summary of Tetra Tech's mapping near the northwest end of Mt. Roberts is shown in Figure 7, with surficial geology on the left and landslide hazard designation mapping on the right. There is a clear correlation between the types and shapes of the surficial geology units and the landslide hazard designations at that location. The same correlations can be seen in the side-by-side comparisons of slope movement features (Figure 9) and gully erosion features (Figure 10).

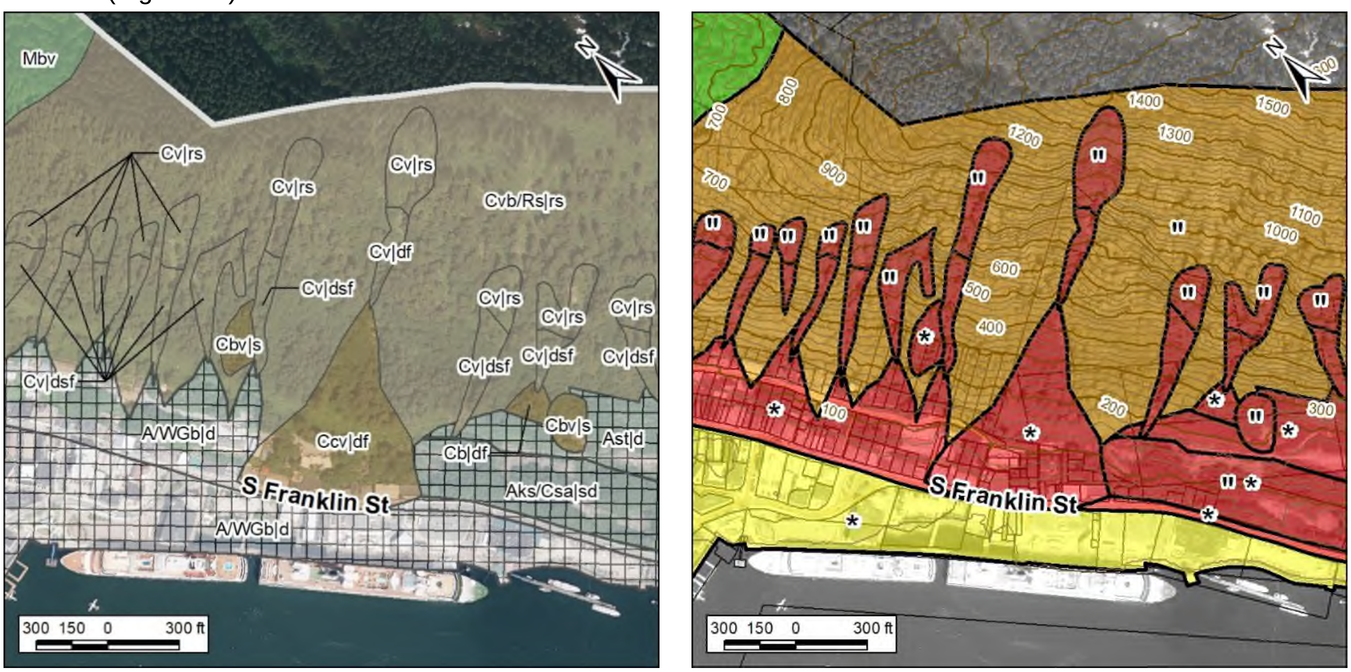

Figure 7: Excerpts from Figure 1.3b Surficial Geology (left) and Figures 1.6c and 1.6h Landslide Hazard Designation Mapping (right) near the northwest end of Mt. Roberts. Surficial geology corresponds closely to landslide hazard designations.

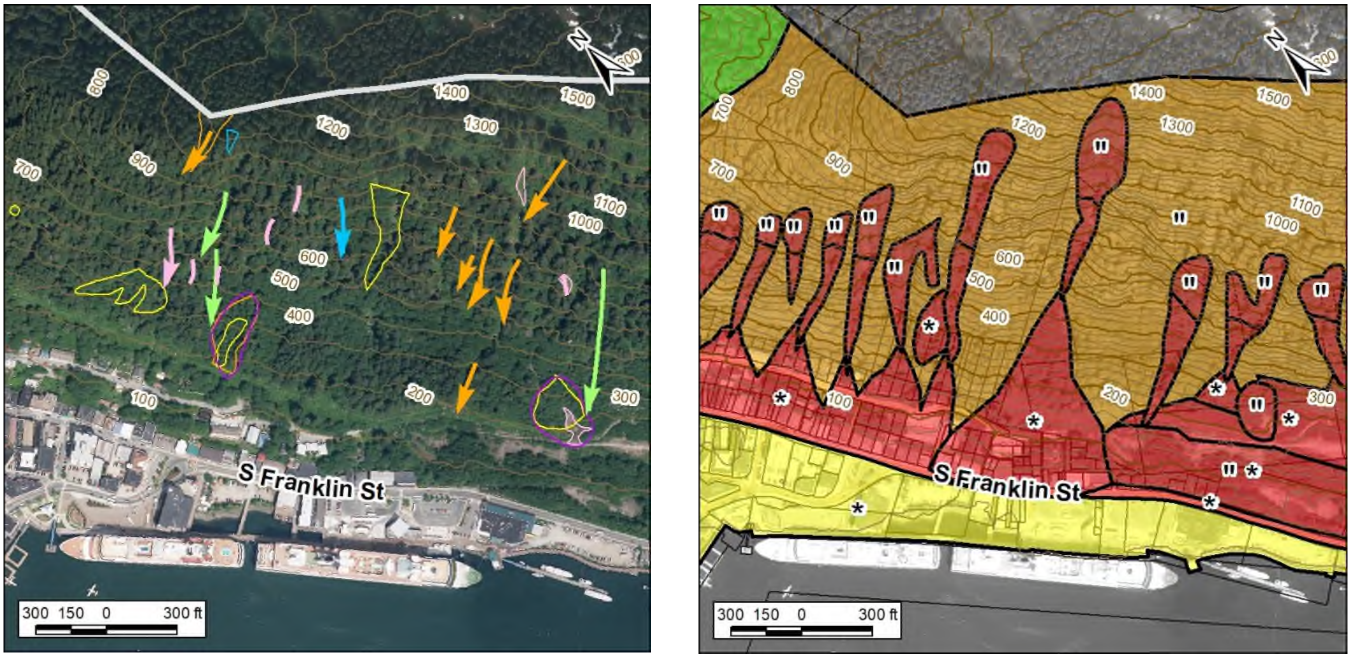

Figure 8: Excerpts from Figure 1.4b Slope Movement Features (left) and Figures 1.6c and 1.6h Landslide Hazard Designation Mapping (right) near the northwest end of Mt. Roberts. Note outlines of several colours at center-left, indicating several years of landslide events at the same location, just upslope of the powerline right-of-way.

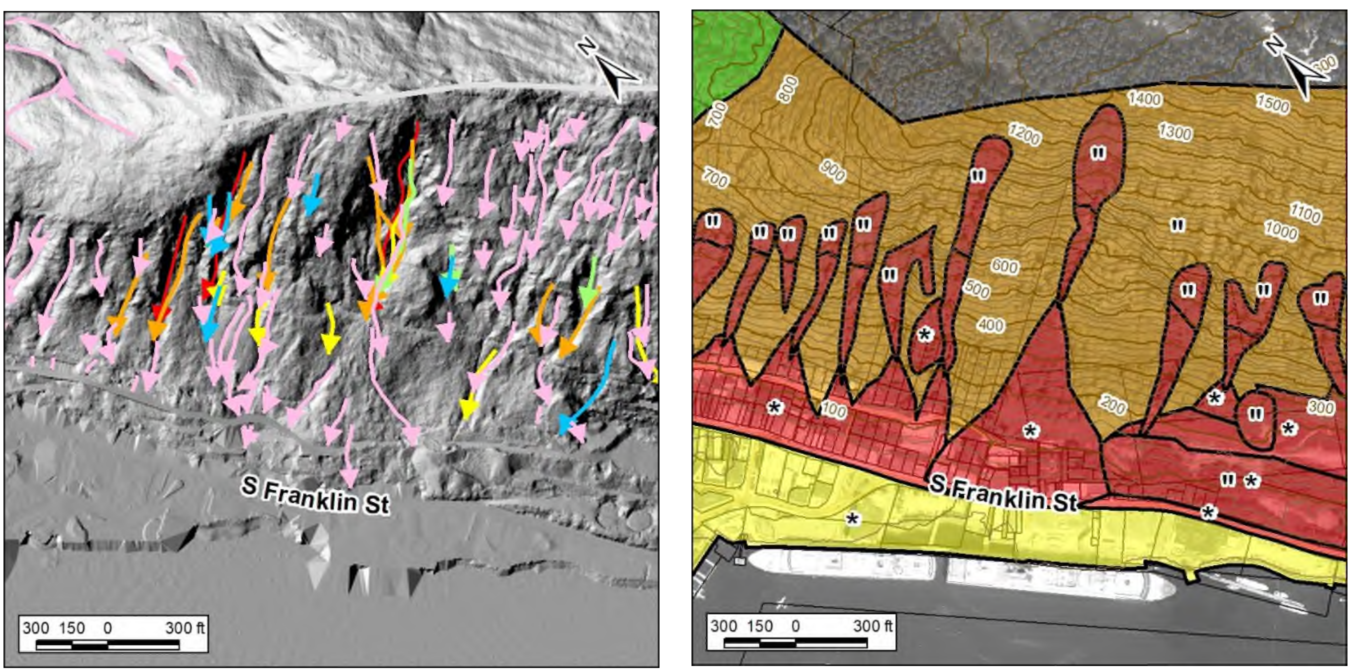

Figure 9: Excerpts from Figure 1.5b Gully Erosion Features (left) and Figures 1.6c and 1.6h Landslide Hazard Designation Mapping (right) near the northwest end of Mt. Roberts. Multiple colours in gullies mean more activity than gullies that only have one colour.

The same comparisons can be made further southeast along the slope, for example, for the terrain at Snowslide Creek, with surficial geology on the left and landslide hazard designation mapping on the right (Figure 10). Once again, there is a clear correlation between the shapes of the surficial geology units and the associated landslide hazard designations, as well as the type of geology and the resulting hazard designation. The same correlations can be seen in the side-by-side comparisons of slope movement features (Figure 11) and gully erosion features (Figure 12).

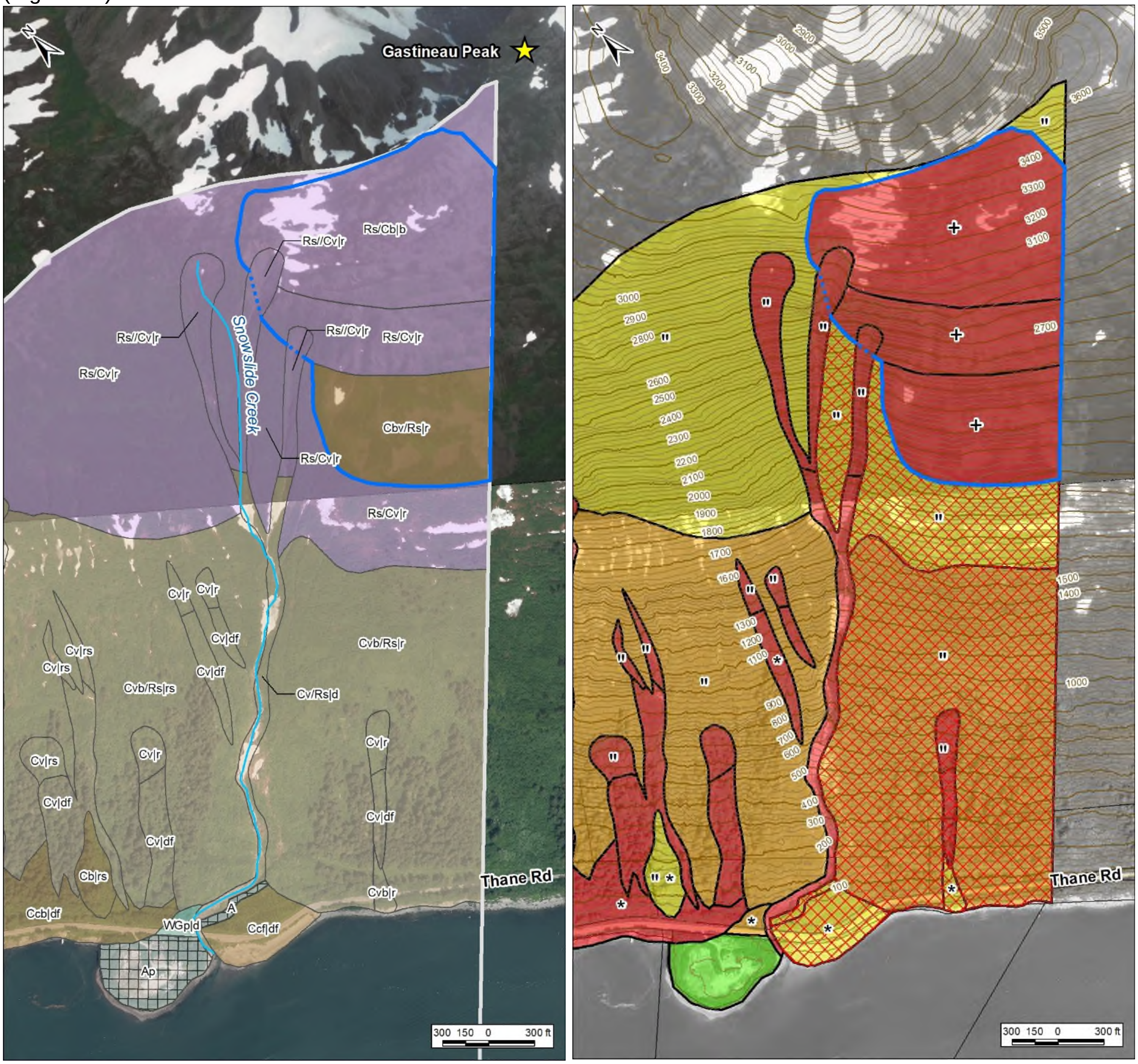

Figure 10: Excerpts from Figure 1.3c Surficial Geology (left) and Figures 1.6e and 1.6f Landslide Hazard Designation Mapping (right) at Snowslide Creek at the southeast end of the Study Area. Again, surficial geology corresponds closely to landslide hazard designations.

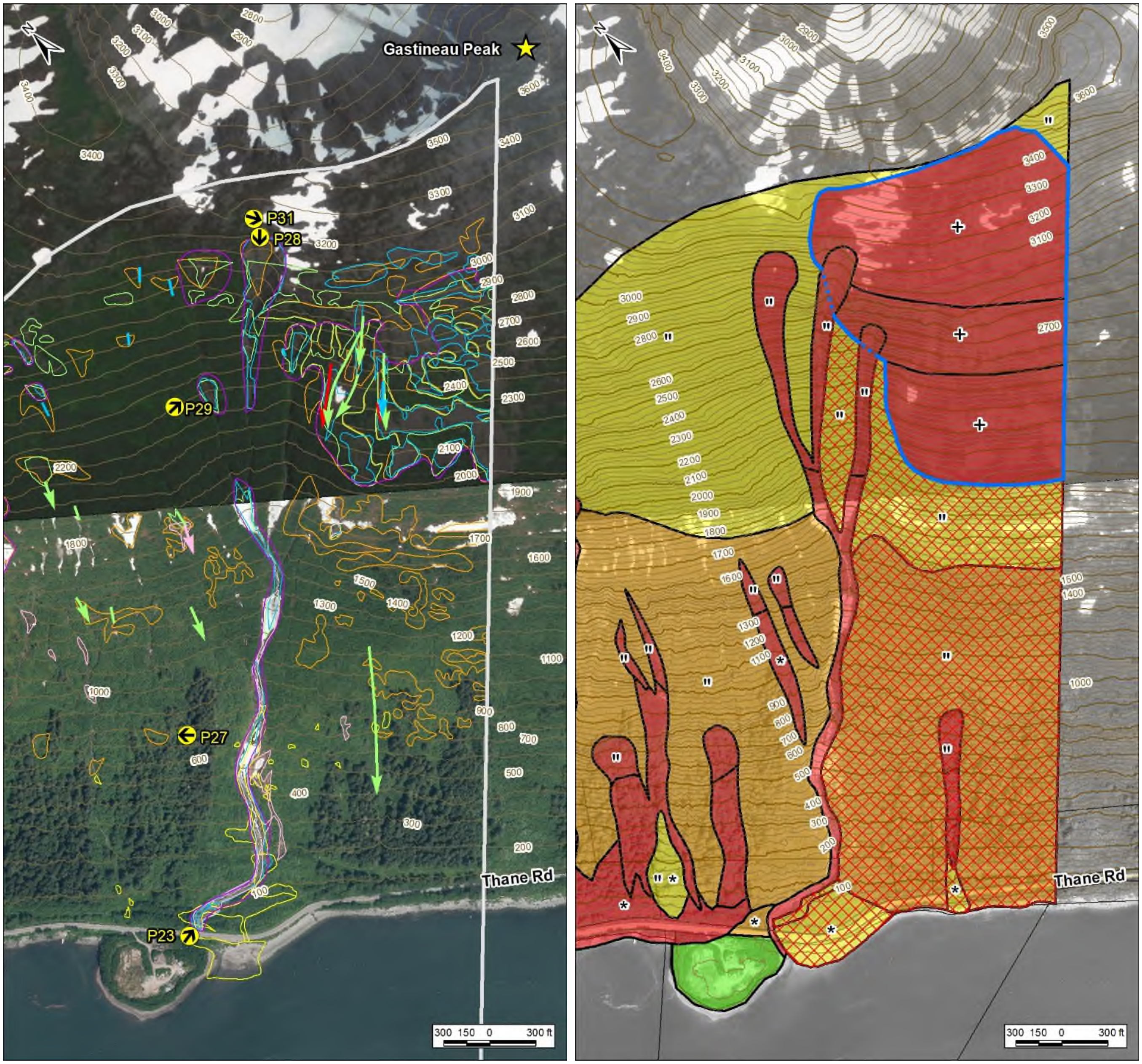

Figure 11: Excerpts from Figure 1.4c Slope Movement Features (left) and Figures 1.6e and 1.6f Landslide Hazard Designation Mapping (right) at Snowslide Creek at the southeast end of the Study Area. This comparison shows that many slope movement features, such as debris slides, are located on open slopes that typically have a *Moderate* or *High* landslide hazard designation. The exception in this part of the Study Area is the suspected deep-seated bedrock slide on the open slope at the top right of each image, with lots of slope movement features and a *Severe* landslide hazard designation. Slope movement features that take place within gullies contribute to a *Severe* landslide hazard designation, shown dramatically here at Snowslide Creek.

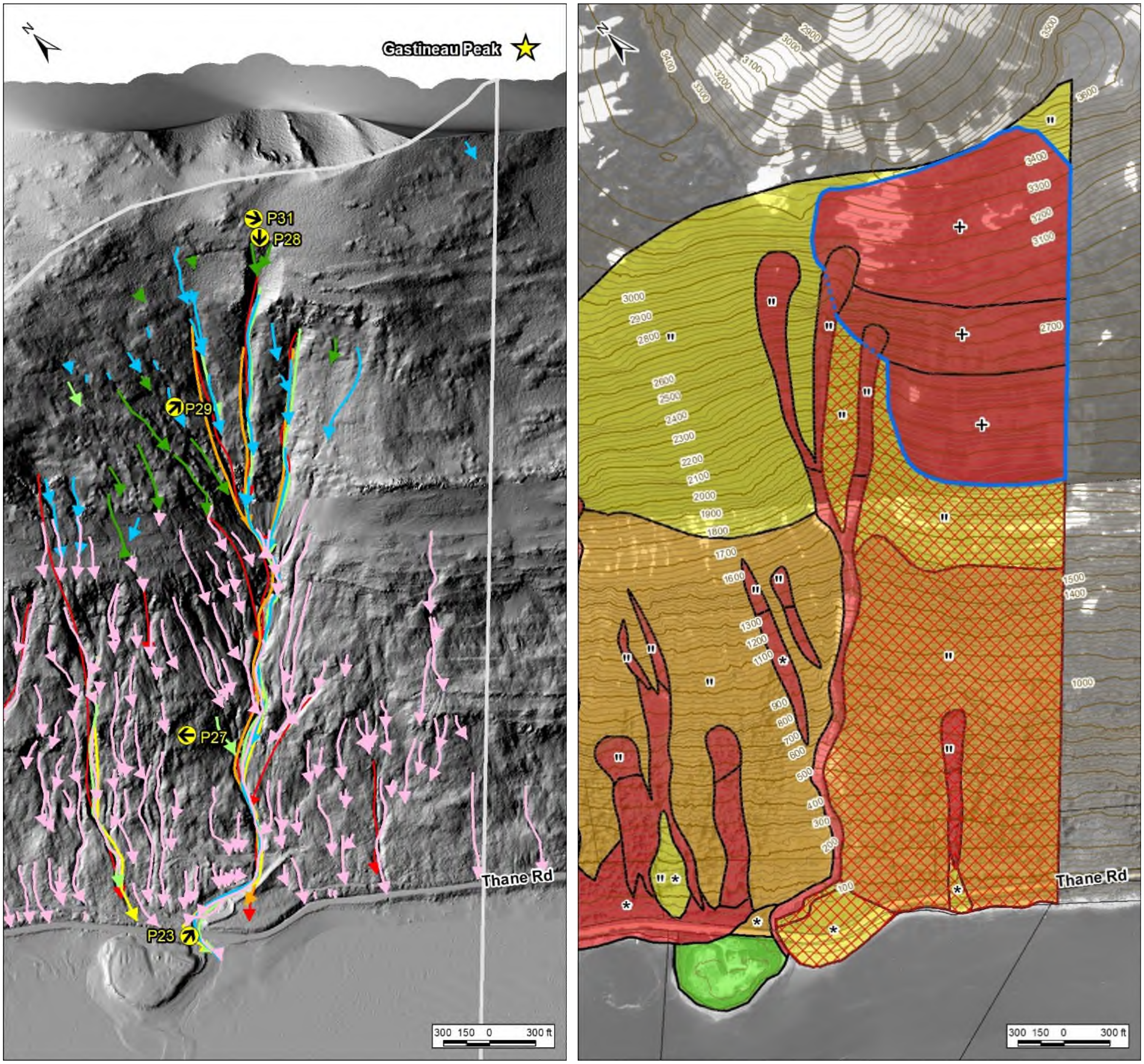

Figure 12: Excerpts from Figure 1.5c Gully Erosion Features (left) and Figures 1.6e and 1.6f Landslide Hazard Designation Mapping (right) at Snowslide Creek at the southeast end of the Study Area. In this comparison, the reason for the *Severe* landslide hazard designation at highly active gullies becomes clear. The more colours of arrows (representing different years of air photos in which erosion was observed), the more likely that a *Severe* rating is required. Note that minor gullies on otherwise open slopes do not elevate the rating for the open slopes, which are generally rated *High* for the lower slopes and *Moderate* for the upper slopes.

The presence of major active gullies on Mt. Roberts shows the main difference between Mt. Roberts and Telephone Hill, where gullies are not so prevalent (or obvious). As shown by the landslide hazard designation mapping, Telephone Hill and nearby neighborhoods to the northwest generally have lower hazard ratings than Mt. Roberts.

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

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Tetra Tech. (2022g). Technical Memo #7. Considerations for Anthropogenic Terrain at Starr Hill and Gastineau Avenue, Downtown Juneau Landslide and Avalanche Hazard Assessment. Prepared for CBJ. Tetra Tech File: 704-ENG.EARC03168-02A. April 27, 2022.

The Alaska Daily Empire, 1921. News article: "$18,275 Verdict Given Goldstein in Damage Case." The Alaska Daily Empire, p.1. Image provided by Alaska State Library Historical Collections and reproduced at the Library of Congress. The Alaska daily empire. [volume], April 05, 1921, Image 1. Access date: April 1, 2022.

The Alaska Daily Empire, 1923. News article: "Landslide Takes Out Stairway Leading to Local Indian Village." The Alaska Daily Empire, p.2. Image provided by Alaska State Library Historical Collections and reproduced at the Library of Congress. The Alaska daily empire. [volume], September 07, 1923, Page 2, Image 2. Access date: April 1, 2022.

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1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

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.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by persons other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

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.