PLANNING COMMISSION - TITLE 49 COMMITTEE AGENDA

April 20, 2023 at 12:00 PM

Zoom Webinar

https://juneau.zoom.us/j/84887480299 or 1-669-444-9171 Webinar ID: 848 8748 0299

A. LAND ACKNOWLEDGEMENT

B. ROLL CALL

C. REQUEST FOR AGENDA CHANGES AND APPROVAL OF AGENDA

D. REGULAR AGENDA

1. AME2021 0008- Hazard Mapping: Moderate and Severe Avalanche Area Map, Severe Landslide Area Map, and Draft Ordinance

    -Staff Memo

    -Draft Ordinance

    -Ordinance Notes from Comm. Cole

    -Tetra Tech, Technical Memo #4

    -Public Comments

E. COMMITTEE COMMENTS AND QUESTIONS

F. ADJOURNMENT

ADA accommodations available upon request: Please contact the Clerk's office 36 hours prior to any meeting so arrangements can be made for closed captioning or sign language interpreter services depending on the meeting format. The Clerk's office telephone number is 586-5278, TDD 586-5351, e-mail: city.clerk@juneau.org.

CITY AND BOROUGH OF JUNEAU
ALASKA'S CAPITAL CITY
COMMUNITY DEVELOPMENT

(907) 586-0715
CDD_Admin@juneau.org
www.juneau.org/community-development
155 S. Seward Street • Juneau, AK 99801

MEMORANDUM

DATE: April 17, 2023

TO: **Travis Arndt, Chair, Title 49 Committee**

FROM: Scott Ciambor, Planning Manager

SUBJECT: **Moderate and Severe Avalanche Area Map, Severe Landslide Area Map, and Draft Ordinance**

At the April 11, 2023 Planning Commission Committee of the Whole meeting, the Commission decided to continue the discussion on the Moderate and Severe Avalanche Area Map, Severe Landslide Area Map, and Draft Ordinance at the next Title 49 Committee meeting.

The Title 49 Committee packet includes:

- Staff memo;
- Draft ordinance to amend the code related to avalanche and landslide areas; and
- Tetra Tech Technical Memo #4 that provides definitions used for the landslide and avalanche assessment.

Other useful background information is available on the CDD Landslide and Avalanche Assessment page.

If changes to the draft ordinance are minimal, the goal would be to return the ordinance to the May 23, 2023 Planning Commission meeting for public hearing.

Presented by: The Manager
Presented: 2023
Drafted by:

ORDINANCE OF THE CITY AND BOROUGH OF JUNEAU, ALASKA

Serial No. 2023 XX

An Ordinance Amending the code related to avalanche and landslide areas and replacing the avalanche and landslide areas maps

WHEREAS, and…

BE IT ENACTED BY THE ASSEMBLY OF THE CITY AND BOROUGH OF JUNEAU, ALASKA:

Section 1. Classification. This ordinance is of a general and permanent nature and shall become a part of the City and Borough of Juneau Municipal Code.

Section 2. Amendment of Section. CBJC49.70.300 **Avalanche and landslide areas** is amended to read:

(a) *Generally.*

(1) Development in mapped moderate and severe avalanche and severe landslide areas shall minimize the risk of loss of life or property due to landslides and avalanches.

(2) Boundaries of severe avalanche areas will be as shown on the avalanche area maps dated April 27, 2022, as the same may be amended from time to time by the assembly by ordinance.

(3) Boundaries of severe landslide areas will be as shown on the landslide area maps dated April 27, 2022, as the same may be amended from time to time by the assembly by ordinance.

(4) Owners and developers should provide written notice to potential buyers or renters that the property is located in a moderate or severe avalanche area, or a severe landslide area, or both.

(b) *Moderate and Severe avalanche areas.*

(1) Notwithstanding any other provision, subdivision other than a boundary line relocation, a lot line adjustment, or a lot consolidation, or development greater than a single-family dwelling within severe avalanche areas shall require a conditional use permit.

(2) Notwithstanding any other provision, development greater than a single-family dwelling, within the moderate or severe avalanche areas shall require a conditional use permit with site specific engineering for the following: peak drainage, special foundation or high back wall engineering, and debris flow diversion mechanisms. For the purposes of this section, accessory dwelling units are considered development greater than a single-family dwelling.

(3) A subdivision must create lots that have a sufficient buildable site, without the need for a variance, in the moderate and severe avalanche areas, unless the lot is platted as a Public Use Lot (49.15.422).

(4) If a developer disagrees with the boundaries shown on the severe avalanche map, the developer may seek departmental relocation of the boundaries by submitting a site specific study prepared and stamped by a civil engineer licensed in the State of Alaska. Such studies shall include detailed analyses of topography, vegetation, potential snow accumulation, and other factors. The results should indicate actual hazard area

boundaries and potential debris flow direction, time, distance and mass. If, in the opinion of the Director of Engineering & Public Works, the studies clearly establish that the map boundaries are inaccurate and the proposed development is outside a moderate or severe avalanche area, the department shall proceed accordingly.

(5) The commission may require mitigating measures certified as effective by a civil engineer licensed in the State of Alaska for development in moderate or severe avalanche areas. Such measures may include dissipating structures or dams, special structural engineering, or other techniques designed for the site. Mitigating measures may also include reduction in the proposed density, occupancy, or development.

(c) *Severe landslide areas.*

(1) Notwithstanding any other provision, no subdivision other than a boundary line relocation, a lot line adjustment, or a lot consolidation, shall be approved in a severe landslide area. Applications for all other subdivision types shall not be accepted for filing or shall be rejected by the director.

(2) Notwithstanding any other provision, no development or any part of a development, which is within a severe landslide area shall, by the addition of bedrooms, , conversions of buildings, or otherwise increase the density of the lot or increase the occupancy of the building; provided, that a single-family dwelling may be constructed on a vacant lot. Accessory dwelling units are not permissible on lots located in a severe landslide area.

(3) Notwithstanding any other provision, development including a single-family dwelling within the severe landslide areas shall require a conditional use permit with site specific

engineering for the following: peak drainage, special foundation or high back wall engineering, and debris flow diversion mechanisms. .

(4) The commission may require mitigating measures certified as effective by a civil engineer licensed in the State of Alaska for development in severe landslide areas. Such measures may include dissipating structures or dams, special structural engineering, or other techniques designed for the site. Mitigating measures may also include reduction in the proposed density, occupancy, or development.

(5) If a developer disagrees with the boundaries shown on the severe landslide map, the developer may seek departmental relocation of the boundaries by submitting a site specific study prepared and stamped by a civil engineer licensed in the State of Alaska. Such studies shall include detailed analyses of topography, vegetation, potential snow accumulation, and other factors. The results should indicate actual hazard area boundaries and potential debris flow direction, time, distance and mass. If, in the opinion of the Director of Engineering & Public Works, the studies clearly establish that the map boundaries are inaccurate and the proposed development is outside a severe landslide area, the department shall proceed accordingly.

(d) *Warning and disclaimer of liability*. Avalanches and landslides may occur outside hazard areas in excess of engineering expectations. The location and severity of the event may be increased by manmade or natural causes. This article does not imply that land outside of designated hazard areas, or uses permitted within such areas, will be free from danger or damage. This article shall not create liability on the part of the City and Borough of Juneau

or any officer or employee thereof for any damages that result from reliance of this article or any administrative decision lawfully made under this article.

Section 4. Amendment of Section. CBJC 19.04.R301.9 Geophysical hazards is amended to read:

"*301.9 Geophysical hazards*. In Severe geophysical hazard zones as shown in "Downtown Juneau Landslide and Avalanche Hazard Assessment" dated April 27, 2022, and on the "Moderate and Severe Avalanche Maps and Severe Landslide Area Map", ~~both adopted by ordinance serial no. 87-49,~~ adopted _____ 2023 or when the building official determines that development is proposed in an area similar in nature to those studied in the above referenced documents, and is located outside of the study area, an engineered structural analysis shall be submitted with the permit application. The building official may waive this requirement upon presentation of more specific studies prepared and stamped by a civil engineer licensed in the State of Alaska showing the proposed site is not likely to be affected by geophysical hazards."

Section 5. Amendment of Section. Hillside Development CBJ 49.70.210(a)(4) is amended to read:

Any hazard area identified on the avalanche and landslide area maps dated ~~September 9, 1987,~~ April 27, 2022 ~~consisting of sheets 1 – 8~~, as the same may be amended from time to time by the assembly by ordinance or any other areas determined to be susceptible to geophysical hazards.

Section 6. Amendment of Section. Definitions CBJ 49.80.120 is amended to read:

Accessory dwelling unit (ADU) means a subordinate dwelling unit added to, created within, or detached from a single-family residence, which provides basic requirements for living, sleeping, cooking, and sanitation. The unit may have a separate exterior entrance or an entrance to an internal common area accessible to the outside. ADUs are not included in the density calculation for a site.

Density means the amount of development per acre permissible on a parcel under the applicable zoning, measured as dwelling units per acre (du/ac).

Section 7. Effective Date. This ordinance shall be effective 30 days after its adoption.

Adopted this _____ day of _____, 2023.

_____
Beth A. Weldon, Mayor

Attest:

_____
Elizabeth J. McEwen, Municipal Clerk

Hazard Maps Ordinance- COW notes from PC Mtg. 4/11/23- notes from MOC

Overarching concerns:

1. No clear evidence that avalanche risk is easier to predict vs. landslide risk- PC is not convinced that development must be differentially managed (ie. development greater than SF home in avalanche zone with CUP vs no development greater than SF home in landslide zone). Possible solution- Draft Section 2(c)1 to mirror Section 2(b)1. If we leave development options more restricted in severe landslide, see Line change 3 below.

2. No consensus that moderate avalanche zones must also be regulated- PC preferred the original draft which only addressed severe landslide and avalanche zones. Possible solution- eliminate "moderate" references from draft.

3. No distinction between "landslide" and "debris fall", which appear to be different issues. Debris fall appears to be mitigated by man-made structures. Allow for CUP application with "site specific engineering" in severe landslide zone. Possible solution- draft Section 2(c)3 to mirror Section 2(b)2.

4. Need additional clarity- any portion of the lot in hazard zone means entire lot is in the zone…why? Can lots remain buildable if the structure portion is not in the hazard zone?

Line Changes:

1. Section 2(a)1: Development in mapped severe avalanche and severe landslide areas shall be managed per this section to minimize the risk of loss of life or property due to landslides and avalanches.

2. Section 2(a)4, line 1: change "should" to "shall"

3. Section 2(c)2, line 18, delete "or any part of a development"

Line 19, delete "by the addition of bedrooms, conversions of buildings, or otherwise"

Line 19, now reads: …increase the "housing unit count".

Delete "density of the lot or increase the occupancy of the building"

TETRA TECH

TECHNICAL MEMO

ISSUED FOR USE

To:	Teri Camery (CBJ)	**Date:**	April 27, 2022
c:	Scott Ciambor (CBJ)	**Memo No.:**	4
From:	Rita Kors-Olthof, Alan Jones, Vladislav Roujanski	**File:**	704-ENG.EARC03168-02A
Subject:	Guide to Avalanche and Landslide Hazard Designations 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.

Tetra Tech has provided a series of technical memos to respond to comments and questions that arose from the from the report and the public meetings. All the completed memos will be appended to the Final Draft Report.

This Technical Memo #4 provides a "Guide to Avalanche and Landslide Hazard Designations." More in-depth explanations for landslides are also provided to respond to questions and concerns from the public, and in recognition of the larger number of variables and challenges in predicting behavior for landslides compared to avalanches. The primary objective of this memo is to help Juneau residents and CBJ better understand the meanings of the avalanche and landslide hazard designations. The secondary objective is to provide some additional background to help understand the limitations of those hazard designations. A quick-reference table for the contents of this memo is presented in Table 1.

Table 1: Quick-Reference Table for the Contents of the Guide

Tetra Tech Canada Inc.
14940 - 123 Avenue
Edmonton, AB T5V 1B4 CANADA
Tel 780.451.2121 Fax 780.454.5688

2.0 AVALANCHE HAZARD DESIGNATIONS AND DESCRIPTIONS

2.1 General

This section will provide information on avalanches, including:

- The definition of an avalanche;
- Definitions of the avalanche hazard designations;
- Excerpts from the mapping to show examples of each designation;
- Photos with examples of the terrain in each of the hazard designations; and
- An explanation of the limitations of a hazards-only assessment.

2.2 What is an Avalanche?

An avalanche means a snow avalanche, unless otherwise specified, and is it usually just called an “avalanche.” A snow avalanche is a volume of snow moved by gravity, that is visibly moving downslope. Snow avalanches can contain rock, broken trees, soil, ice, or other material in addition to snow (after CAA 2016).

2.3 How are Avalanche Hazards Designated?

Avalanche hazard designations are based on review of snow climate data, previous reports and studies, historic avalanche occurrence records, magnitude-frequency analyses, air photos, satellite imagery, LiDAR data, field investigation, meetings and data provided by local experts, and dynamic and statistical avalanche modelling.

The Downtown Juneau Study Area was divided into areas with *Low, Moderate,* and *Severe* avalanche hazard designations, according to the results of the analysis for each of the avalanche areas. The *Low, Moderate,* and *Severe* zones are often called White, Blue, and Red hazard zones in other jurisdictions (as they are in several of the references used for this project), and those are the colors assigned to them in the mapping shown on Figures 2.3a, 2.3b, and 2.4a through 2.4j. This system is based on a combination of magnitude (impact pressure) and frequency, with CBJ designations consistent with those used in Europe and Canada. Avalanche paths were mapped to delineate a 300-year hazard boundary for destructive flow (dense and/or powder avalanches). Table 2 shows the avalanche hazard designation system. This table is the same as Table 2.3 in the main report.

Table 2: Avalanche Hazard Designation System

Hazard Designation	Symbol	Hazard Attribute Description
Low	L	▪ Return period greater than 300 years; OR ▪ Impact pressures less than 20 lbs/ft^2 (1 kPa) with a return period greater than 30 years.
Moderate	M	▪ Return period between 30 and 300 years; AND ▪ Impact pressure less than 600 lbs/ft^2 (30 kPa).
Severe	S	▪ Return period less than 30 years; AND/OR ▪ Impact pressure greater than or equal to 600 lbs/ft^2 (30 kPa).

There are some important differences between the new hazard designation mapping and the adopted 1987 hazard designation mapping:

- The 1987 mapping and the current mapping have slightly different boundaries due to different project areas. These differences resulted in some areas being flagged as concerns, when the differences were in fact due to new areas being mapped that had not been mapped before (additional Study Area northwest and southeast, and to reach the top-of-slope or ridge crest), or areas being omitted in the new mapping because they were beyond the top-of-slope boundary line of the new Study Area. Different modelling methods also led to differences in estimated runouts, which were particularly prominent where they extended into Gastineau Channel.

- The 1987 mapping combined avalanche and landslide hazard designations into one map. As it turns out, avalanche hazard designations and landslide hazard designations tend to be very different, and they should not be grouped together into the same maps. The new maps show landslide and avalanche hazard designations on different maps, so that they can be managed independent of each other.

- The 1987 mapping follows property lines, resulting in numerous right-angle corners in the hazard boundaries. Avalanches do *not* respect property lines, instead running right over them, and forming boundaries that relate only to the conditions that create avalanches, such as slope gradients, topography, snow conditions, wind, winter storms, rain-on-snow events, and rapid spring melt conditions, among other factors. The new avalanche hazard mapping does not follow property boundaries, but rather reflects observed and modelled avalanche behavior combined with historical observations.

- Structures located in avalanche paths do not provide protection, and thus the avalanche hazard lines are “agnostic” to the structures.

- Due to these limitations, arbitrary hazard boundaries that follow property lines should be removed as not reflecting the true threat to the public safety, i.e., hazard designations based on property lines do **not** adequately describe the hazards.

The level of assessment prepared for this project is suitable for determining whether land areas could be affected by avalanches. A more detailed site-specific investigation and evaluation would be required to determine appropriate mitigations for specific properties.

2.4 Avalanche Hazard Designation - *Low*

An avalanche hazard designation of *Low* is used for avalanches that have a return period of more than 300 years, OR avalanches with impact pressures of less than 20 lbs/ft^2 (1 kPa) with a return period of more than 30 years. Allowing a low impact pressure means that non-destructive powder avalanches can enter *Low* hazard areas, which is common in Juneau (e.g., Snowslide Creek path on Thane Road) and should be considered acceptable. For reference, 20 lb/ft^2 or 1 kPa could be capable of breaking windows or snapping tree branches but, for the most part, is not considered harmful to people or structures, which is why it is used as part of the *Low* hazard designation.

An estimate of the return period of 300 years or 30 years for an avalanche is the same as calling it a 1 in 300-year event or a 1 in 30-year event. Note that the return period of an avalanche does *not* mean that an event of a specified size or severity will return *every* X number of years. It just means that, on average, one could expect an avalanche of about that size or severity about that often, but the actual return period could be shorter or longer. For a 30-year return period, for example, the typical range in the return period is 20 years to 50 years, as shown in Table 2.1 in the main report. However, if one observes consistently longer or shorter return intervals than the average, the avalanche experts might eventually decide to assign a different return period to that size of avalanche. A change in return period could occur due to a number of reasons, including climate change, changes in forest cover, or terrain modification by natural (e.g., landslides) or human-induced (e.g., mining) causes.

On the avalanche hazard designation mapping, a *Low* avalanche hazard zone is considered to be the same as the White zone, which means there is no extra color added to the map. The *Low* avalanche hazard zones are located anywhere that is not colored blue or red on the accompanying avalanche hazard maps.

Residents who suddenly find their property assigned a *Low* hazard designation, after never being in a named zone before, might wonder what that means. Including a *Low* hazard designation makes the mapping system consistent with numerous internationally-accepted hazard mapping systems. This does not mean that the hazard has changed for properties that are now designated as being in a *Low* hazard zone. It just means that it has been given a name that recognizes that a hazard is never “zero,” but the hazard is low enough that owners of properties within the *Low* hazard zone generally should not have to do anything extra to protect their properties from avalanches, except for being attentive, i.e., observing and recording anything unusual at or around their properties, such as avalanche debris coming closer to the house than usual etc. The caveat to that logic could be if something changes around your property, like a structure being removed, or if the debris from an avalanche wasn’t recorded before it was removed, making it difficult to detect where it occurred. See Question #9 on Tech Memo #3 for more information.

One example of terrain with an avalanche hazard designation of *Low* is most of the Starr Hill subdivision, as shown in Figure 1. Figure 2 shows a view of Starr Hill from the helicopter.

Figure 1: Excerpt from Figures 2.4c and 2.4h in the main report, showing the northeast end of the Starr Hill subdivision. Almost all of the lots are mapped with an avalanche hazard designation of *Low (i.e., not colored as red or blue)*, with the only encroachment being the G000 (Park) avalanche path on the right (marked *Severe*, with *Moderate* terrain below). All the existing houses are currently located in areas designated as *Low*.

Figure 2: Looking southeast at the Starr Hill subdivision. Nelson Street is near the top left of the photo, East Street is near the photo center, Gold St. is near the photo right edge. 6th Street is in the foreground left, and the next road to the southeast is 5th Street.

2.5 Avalanche Hazard Designation - *Moderate*

An avalanche hazard designation of *Moderate* is used for areas that have a return period between 30 and 300 years AND have an impact pressure of less than 600 lbs/ft^2 (30 kPa). To compare, Table 2.2 in the main report describes some typical avalanche sizes, and what an avalanche of a specified size might be expected to do.

For example, a Size D2 avalanche that could produce a typical impact pressure on the order of 200 lbs/ft^2 (10 kPa) could bury, injure, or kill a person (e.g., a person outside of a house in their back yard). On the other hand, a Size D3 avalanche [typical impact pressure on the order of 2,000 lbs/ft^2 (100 kPa)] could bury and destroy a car, damage a truck, destroy a wood frame house, or break a few trees. An impact pressure of 600 lbs/ft^2 is typically used as a threshold between the *Severe* and *Moderate* hazard designations because it is close to the threshold that destructive avalanches (i.e., Size D3 or larger) typically can destroy wood-frame structures and thus kill people within them, whereas below this threshold they typically just damage rather than destroy the structures (and thus

are less likely to kill the occupants). It's important to point out that avalanches with impact pressures less than 600 lbs/ft^2 (30 kPa) can still cause considerable damage to residences and kill people, but would be expected to do so less frequently (or, alternatively, less severely) than in areas designated as red (*Severe*) hazard zones. Table 3 provides a summary of impact pressures associated with various types or extent of damage.

Table 3: Impact Pressures Associated with Damage (modified from CAA 2018)

Potential Damage	Impact Pressure	
	lbs/ft^2	kPa
Break windows	21	1
Push in doors, damage walls, roofs	62-125	3-6
Severely damage wood frame	209	10
Destroy wood frame structures, break trees	418-626	20-30
Destroy mature forests	1,044-2,090	50-100
Uproot mature spruce	2,090	100
Move large boulders	6,262	300
Move reinforced concrete structures	20,900	1,000

Avalanche areas mapped with a hazard designation of *Moderate* are shown in blue on the mapping. Typically, the *Moderate* zone on the larger mountain slopes forms a fringe downslope and alongside the main avalanche paths (mapped in red) that is less likely to experience an avalanche, and if an avalanche does reach *Moderate* terrain, the impact pressures are expected to be lower, and are impacted less frequently. Figure 3 is an example of this type of avalanche terrain adjacent to the southern section of Gastineau Avenue and upslope of South Franklin Street.

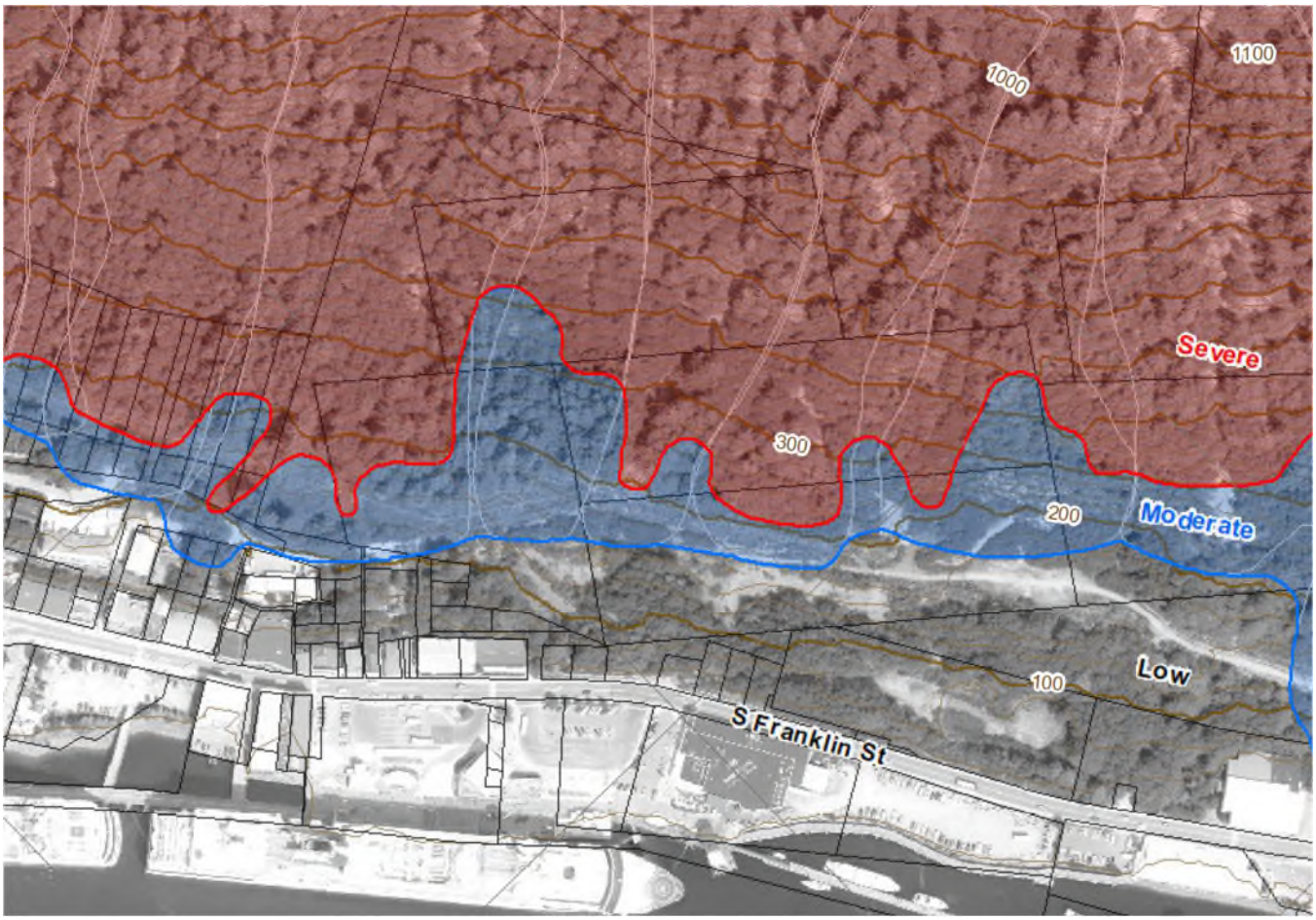

Figure 3: Excerpt from Figure 2.4d in the main report, showing avalanche paths G003 to G009 and T000 (from left to right). The blue fringe shows terrain designated as having *Moderate* avalanche hazard along the toe of Mt. Roberts. In this area, the *Moderate* hazard does not reach South Franklin Street, but it does reach Gastineau Avenue in several locations. Further southeast (off the right-hand side of this map excerpt), the slopes of Mt. Roberts become higher and are affected by unforested alpine terrain, and the Moderate avalanche terrain reaches further downslope, past Thane Road, and sometimes into Gastineau Channel.

Figure 4a below shows the slope from the helicopter, which is vegetated with a relatively dense forest cover in this area. Avalanche hazards are present within the gullied parts of the slopes, and have historically affected areas close to Gastineau Avenue. Figure 4b provides a view from Google Earth that shows distinct avalanche paths and start zones within the gullies that are easily seen on the winter imagery, which highlights the differences in coniferous versus deciduous forests.

Figure 4a: View of Mt. Roberts from the helicopter showing part of the slope mapped in Figure 3. Note the increasing height of slope from left to right (northwest to southeast). The slope is fairly well-treed but is still prone to avalanching. Gullies tend to increase avalanche runouts. See also Figure 4b.

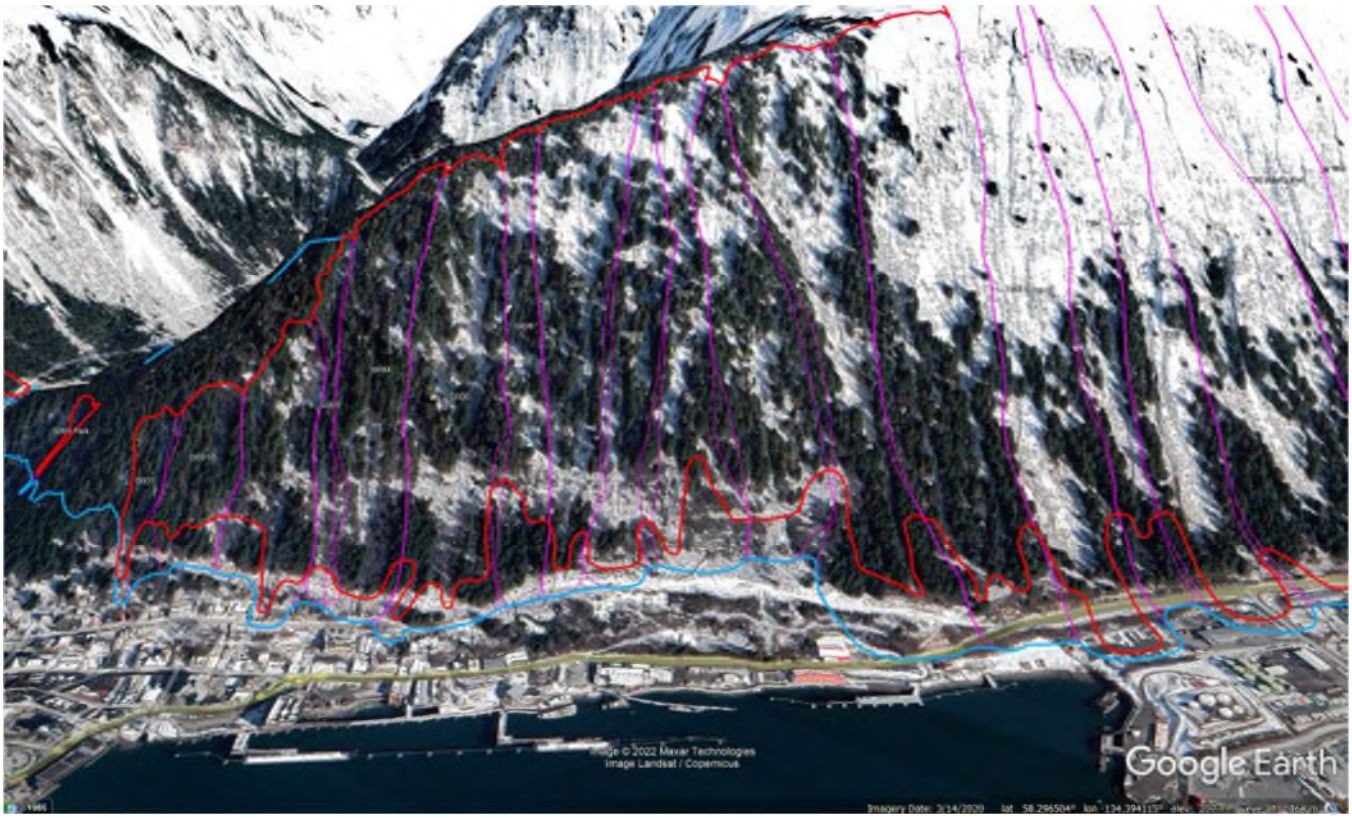

Figure 4b: View of the northern part of Mount Roberts along Gastineau Avenue and South Franklin Street, with avalanche paths and *Moderate/Severe* hazard boundaries shown. Note the increasing height (and length) of slope from left to right (northwest to southeast), which increases the runout distance and hazard to lower elevation areas towards the industrial park. Although the Gastineau Avenue area is forested, distinct avalanche paths and start zones within the gullies can be observed on the winter imagery, which highlights the forest cover differences (coniferous versus deciduous forests). (Image credit: Google Earth 2022.)

2.6 Avalanche Hazard Designation - *Severe*

An avalanche hazard designation of *Severe* is used for avalanches that have a return period of less than 30 years AND/OR have an impact pressure greater than or equal to 600 lbs/ft^2 (30 kPa). Severe hazard areas could include areas that are affected by frequent, but lower impact pressure avalanche hazards, for example, an area that is affected on average every 5 to 10 years by avalanches with 200 lb/ft^2 to 400 lb/ft^2 (10 kPa to 20 kPa) impact pressures that could damage, but not destroy a wood-frame structure – this would be the case for some residential areas within the White Subdivision. Or it could include areas that, on average, are not affected by avalanches more frequently than at 30-year intervals but, should they be affected, would be impacted by large destructive avalanches with impact pressures well in excess of 600 lbs/ft^2 (30 kPa). This scenario applies to areas within the Behrends Subdivision. Although some parts of the subdivision have not been impacted since the large avalanche event of 1962 (e.g., some residences on Behrends Avenue), should a similar event occur within a 30- to 300-year return period, it would be expected to be large with impact pressures greatly exceeding 600 lbs/ft^2 (30 kPa). Areas that are affected by avalanches that are both frequent and destructive (i.e., less than a 30-year return period and with more than 600 lb/ft^2 of impact pressure) are clearly within the *Severe* hazard designation.

Avalanche areas mapped with a hazard designation of *Severe* are shown in red on the mapping. Typically, the *Severe* zone on the larger mountain slopes incorporates the main avalanche paths (mapped in red) that are the

most likely to experience an avalanche (i.e., higher frequency), and experience the highest impact pressures. In many cases within the Juneau area, this occurs within distinct gullies. Figure 5 is an example of this type of avalanche terrain in the Behrends avalanche path and subdivision. Figure 6 shows the slope from the helicopter. Figure 7 shows the lower part of the slope after a very large avalanche in 1985.

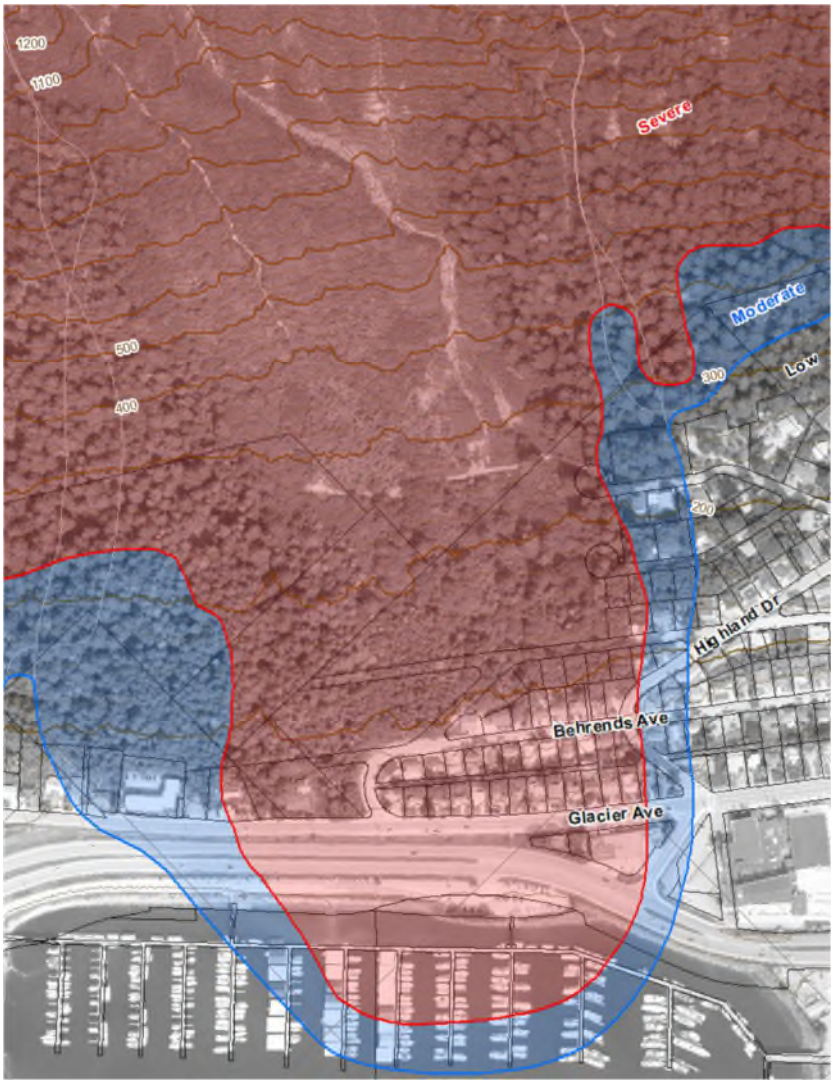

Figure 5: Excerpt from Figure 2.4b showing the major avalanche path at J010 Behrends. Note the distinct trimlines that define the edges of this path, indicating regular avalanche activity within the central part of the path and less frequent avalanche activity on the outside (lateral boundaries) of the path.

Figure 6: Looking north-northeast at the lower end of the J010 Behrends Avenue avalanche path. Note the differences in vegetation within the path, beside the path, and below it, mostly due to regular and destructive avalanche activity. The large building in the lower right corner of the photo is the high school at the corner of Glacier Avenue and Highlands Drive. The school is located just outside of the *Moderate* hazard zone. Most of the other areas (with the exception of the densely forested upper right part of the photo) are within either *Severe* or *Moderate* hazard zones.

Figure 7: The aftermath of 1985 avalanche, looking north from just south of Behrends Avenue and Highland Drive. This event was the longest running avalanche in the Behrends Subdivision since the destructive 1962 event. The photo clearly shows the destructive potential of this avalanche and the way it came right into the community and was close to damaging/destroying many structures. However, it only damaged one house on Troy Avenue, the one on the right. (Photo credit: Dan Bishop 1985.)

Figure 8 shows another avalanche event that occurred in 2012 further to the east of the Behrends Subdivision, at the Bathe Creek avalanche path.

Figure 8: This photo illustrates a Size D3 avalanche within a *Severe* (red) hazard zone. The avalanche occurred in 2012 in the Bathe Creek avalanche path. This highlights a hazard area that is both frequent (more frequent than a 30-year return period) and destructive, with an impact pressure greater than 600 lbs/ft2 (30 kPa), capable of both burying/destroying a car and destroying a wood frame residence. (Photo credit: Mike Janes (AELP).)

3.0 LANDSLIDE HAZARD DESIGNATIONS AND DESCRIPTIONS

3.1 General

This section will provide:

- Definitions of the landslide hazard designations;
- Excerpts from the mapping to show examples of each designation;
- Photos with examples of the terrain in each of the hazard designations;
- Information on the difference in potential hazards from landslides above or below a property; and

- An explanation of the limitations of a hazards-only assessment.

3.2 What is a Landslide?

A landslide is a gravity-induced mass movement of upslope materials, including rockfall, rockslide, debris slide, debris flow, and creep. In general, landslide types include falls, topples, slides, spreads, flows, and slope deformations. Landslides can also contain broken trees, structures (whole or crushed), vehicles, or other materials, as well as water, in addition to soil and rock debris.

3.3 How are Landslide Hazards Designated?

Landslide hazard designations are determined based on collecting and reviewing previous mapping and reporting; historic landslide occurrence records including newspaper reports; air photos, satellite imagery, LiDAR data; mapping of surficial geology, historical slope movement activity, historical gully erosion activity; and fieldwork to confirm or correct the mapping.

The Downtown Juneau Study Area has been divided into areas with *Low, Moderate, High*, and *Severe* landslide hazard designations, according to the results of the historical air photo record analysis, mapping and the field investigation, as well as a semi-quantitative analysis to help sort out which terrain types belong to which landslide hazard designation. Areas mapped with *Low, Moderate, High*, and *Severe* landslide hazard designations are shown with green, yellow, orange, and red colours, respectively, in the mapping on Figures 1.6a through 1.6j, as well as Figure B.6 in Appendix B in the main report, and in the mapping excerpts shown in this memo. Table 4 provides a description of each hazard designation. Sections 3.4, 3.5, 3.6, and 3.7 provide some examples of the mapping for each hazard designation, and photos of the areas shown in the map excerpts. Table 4 in this memo is the same as Table 1.4 in the main report. This table includes some additional explanations of the typical sizes and event probabilities that would be anticipated for each of the landslide hazard designations. These same explanations are provided in the following sections for each level of hazard. These explanations are *not* based on a magnitude-frequency analysis for the slopes, because this type of analysis has not been completed for Juneau yet, as discussed in Section 5.0 of this Memo. Instead of a magnitude-frequency analysis, proxies based on slope activity identified on air photos were used to help determine the appropriate divisions between the different landslide hazard designations. The only landslide information considered reasonably reliable or predictable in attempting to determine typical return periods for each of the designations is the historical landslide information that has been reviewed, as listed at the beginning of this section. When results of a magnitude/frequency analysis are available, the return periods should be reviewed and adjusted as needed to more reliably reflect the frequency of landslides of particular sizes.

Note that sometimes the hazard is not related to what is happening right around your house, but what is happening higher on the slope or around your neighbour's house. That is especially true for hazards related to debris flows, because where the debris will end up is not always predictable. See also Technical Memo #2, Question #8 (Appendix C of the main report; Tetra Tech 2022b) for more information. Also, residents might not always know what happened to their lot or house before they moved there.

Table 4: Refined Landslide Hazard Designation System

Hazard Designation[1]	Symbol	Hazard Attribute Description
Low	L	▪ Gentle to moderate slopes (0° to 26°) ▪ No signs of historical landslide activity on the air photos ▪ No written record of property damage or loss of life ▪ Surficial geology and texture for Classes I, II, and III as shown in Table 1.2 in the main report ▪ Estimated event probability is "Unlikely to Very Unlikely," with a return period of more than 100 years. Class I, II, and III terrain is generally not prone to active slope processes, and no landslide events were observed or reported, so it is unlikely that landslide events would happen in the future[2]
Moderate	M	▪ Moderate to Moderately steep slopes (27° to 35°) ▪ May be signs of historical activity (scars on trees, vegetated debris lobes or scarps, historical activity visible on the air photos) ▪ Can include low-lying areas within the runout zones of slides from nearby slopes ▪ No apparent written record of property damage or loss of life ▪ Surficial geology and texture for Class IV as shown in Table 1.2 in the main report ▪ Estimated event probability is "Possible," with a return period of 10 to 100 years. This is the return period estimated for Class IV terrain where slopes are susceptible to landslides, and where there might already be signs of landslide events. Therefore, landslide events could happen in the future[2]
High	H	▪ Steep slopes (>35°) ▪ Areas where rockfall activity impacts individual trees but does not knock them over or destroy them[3] ▪ May have written record of property damage or loss of life ▪ Surficial geology and texture for Class IV as shown in Table 1.2 in the main report ▪ At least two of the following criteria are met: – Thin layer of colluvium (Cv) present – A maximum polygon slope of 70° to 80° – A mean polygon slope of 40° to 50° ▪ Estimated event probability is "Likely," with a return period of 5 to 30 years. This is the return period estimated for Class IV terrain where slopes are known to be susceptible to landslides, and where there are signs of recent and/or historical landslide events. Therefore, landslide events are likely to keep happening in the future[2]
Severe	S	▪ Steep to vertical slopes (>35°) ▪ Signs of recent activity either in aerial photographs or from field inspection (rockfall tracks, debris slide activity, debris flow paths etc.) ▪ May have written record of property damage or loss of life ▪ Signs of repeated historical activity ▪ Surficial geology and texture for Class V as shown in Table 1.2 in the main report ▪ Estimated event probability is "Very Likely to Almost Certain," with a return period of 1 to 20 years. This is the return period estimated for Class V terrain, where the slopes are highly susceptible to landslides, and where there are signs of recent landslide activity as well as repeated historical landslide activity. Therefore, landslide events are very likely to almost certain to keep happening in the future[2]

Notes:

1. Landslide hazard designations (*Low*/*Moderate*/*High*/*Severe*) correspond to green/yellow/orange/red on Figures 1.6a through 1.6j of the main report, and Figure B.6 in Appendix B of the main report.
2. Estimated event probability based on observed and recorded slope movement activity level. Note that this is not an indication of consequence (potential for damage), nor is it a magnitude/frequency study, which can determine return periods with more accuracy.
3. This type of rockfall can be highly active but has a small enough impact not to be readily visible on the air photos or satellite imagery.

Although the landslide hazard designations as shown in Table 4 do include a numerical figure to distinguish the estimated event probabilities of each of the landslide hazard designations, these very high-level approximations are based *only* on the observed slope movement activity levels from air photo analysis and observations made by Tetra Tech's geotechnical engineer in the field. In view of the information that is currently available, even more important are the other hazard attributes that help to better identify the types of terrain described by each hazard designation. For example, *Severe* hazard designations are assigned to the areas subject to rockfall, debris slides, and debris flows, as shown on the surficial geology maps. Areas with a *High* hazard rating were assigned based on the results of the semi-quantitative analysis. These areas are expected to experience rockfall that damages but does not always knock out trees, and as such are a less severe hazard than a debris flow or debris slide that removes everything in its path. Evidence of this type of rockfall activity was identified during the field investigation. See Sections 3.6 and 3.7 for more information about *High* and *Severe* hazard designations.

It should also be noted that the frequency or return period of an event (or the mapping proxy of visual evidence of repeated slide activity) does *not* mean that an event of a specified size or severity will return every X number of years. For example, a debris flow of a certain size typically depends on two events coinciding: a storm event large enough to mobilize debris in a gully, and enough debris accumulated in the gully from previous events to mobilize the debris. So, when a return period of 30 years is estimated for a rainstorm or a landslide, that means that a rainstorm or a landslide could happen at any time in a 30-year period, *not* that it will always happen every 30 years like clockwork. It could happen this year, and it could happen again next year. But if that rainstorm or landslide starts happening consistently more often (or less often) than predicted, so that the average is no longer 30 years, it might be time to reassess the return period for those events.

There are some important differences between the new hazard designation mapping and the adopted 1987 hazard designation mapping (CBJ 2021):

- The 1987 mapping and the current mapping have slightly different boundaries due to different project areas. These differences resulted in some areas being flagged as concerns, when the differences were in fact due to new areas being mapped that had not been mapped before (additional Study Area northwest and southeast, and to reach top-of-slope), or areas being omitted in the new mapping because they were beyond the top-of-slope boundary line of the new Study Area. Some areas were also inadvertently flagged as concerns, due to confusion resulting from the colour scheme used in the comparison, with the salmon pink being mistaken for red.

- The 1987 mapping combined avalanche and landslide hazard designations into one map. As it turns out, avalanche hazard designations and landslide hazard designations tend to be very different, and they should not be lumped together. The new maps show landslide and avalanche hazard designations on different maps, so that they can be managed independent of each other.

- The 1987 mapping follows property lines, resulting in numerous right-angle corners in the hazard boundaries. Landslides do *not* respect property lines, instead running right over them, and forming boundaries that relate only to the conditions that create landslides, such as slope gradients, topography, surficial geology, large storms (usually with record precipitation), rapid spring melt conditions, among other factors. The new landslide hazard designation mapping does not follow property boundaries, but rather reflects historical observations of landslide behaviour.

- *Due to these limitations, arbitrary hazard boundaries along property lines should be removed as not reflecting the true threat to the public safety, i.e., hazard designations based on property lines do* ***not*** *adequately describe the hazards*.

The level of assessment prepared for this project is suitable for determining whether land areas could be affected by landslides. A more detailed site-specific investigation and evaluation would be required to determine appropriate mitigations for specific properties.

3.4 Landslide Hazard Designation - *Low*

A landslide hazard designation of *Low* is assigned to terrain that has the following characteristics:

- Gentle to moderate slopes (0° to 26°);
- No signs of historical landslide activity on the air photos;
- No written record of property damage or loss of life;
- Surficial geology and texture for Classes I, II, and III as shown in Table 1.2 of the main report; and
- Estimated event probability is "Unlikely to Very Unlikely," with a return period of more than 100 years. Class I, II, and III terrain is generally not prone to active slope processes, and no landslide events were observed or reported, so it is unlikely that landslide events would happen in the future.

Residents whose property is assigned a *Low* hazard designation, after never being in a named zone before, might wonder what that means. Including a *Low* hazard designation makes the mapping system consistent with numerous internationally accepted hazard mapping systems. This does not mean that the hazard has changed for properties that are now designated as being in a *Low* hazard zone. It just means that it has been given a name that recognizes that a hazard is never "zero," but the hazard is low enough that owners of properties within the *Low* hazard zone generally should not have to do anything extra to protect their properties from landslides, except for being attentive, i.e., observing and recording anything unusual at or around their properties, such as ground settlement, cracking etc. The caveat to that logic could be if something changes around the property, like a structure being removed, or if the debris from a landslide was not recorded before it was cleaned up, making it difficult to detect where it occurred. Ideally, the mapping would be supported by good historical records, including property owner reporting, if applicable and available. See Question #9 on Tech Memo #3 for more information.

Figure 9 shows the surficial geology and the landslide hazard mapping for two areas of Downtown Juneau that are designated as having a *Low* landslide hazard. Figure 10 shows a photo for each of those areas.

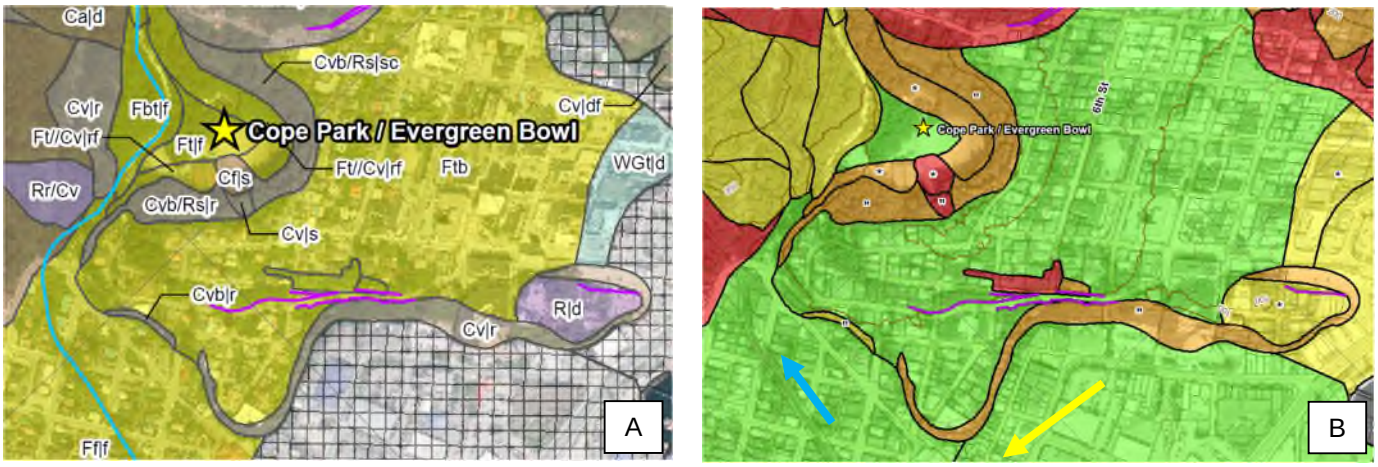

Figure 9: These two map excerpts are from the mapping across the approximate middle of the downtown area. Figure 79A shows the surficial geology, and Figure 9B shows the landslide hazard mapping. Gold Creek is marked as a blue stream along the left side of Figure 9A. Willoughby Avenue is in the cross-hatched area on Figure 9A, where fill was placed to extend the land area of the city. The yellow arrow on Figure 9B shows the direction of look in Figure 10A. The blue arrow on Figure 9B shows the direction of look in Figure 10B.

Figure 10: Views of Juneau in terrain mapped with landslide hazard designation of *Low*. Figure 10A: Looking west from Telephone Hill at the east-west leg of Willowby Avenue. Figure 10B: Looking upstream at the Gold Creek flume, with terrain mapped in *Low* on both sides of the creek. (Photo credits: Figure 10A: Alaska State Library – Historical Collections, ASL-P417-040, Caroline Jensen 1948. ASL 2022a. Figure 10B: CBJ December 4, 2020.)

3.5 Landslide Hazard Designation - *Moderate*

A landslide hazard designation of *Moderate* is assigned to terrain that has the following characteristics:

- Moderate to Moderately steep slopes (27° to 35°);
- May be signs of historical activity (scars on trees, vegetated debris lobes or scarps, historical activity visible on the air photos);
- Can include low-lying areas within the runout zones of slides from nearby slopes;
- No apparent written record of property damage or loss of life;
- Surficial geology and texture for Class IV as shown in Table 1.2 of the main report; and
- Estimated event probability is “Possible,” with a return period of 10 to 100 years. This is the return period estimated for Class IV terrain where slopes are susceptible to landslides, and where there might already be signs of landslide events or deposits from slides upslope. Therefore, landslide events could happen in the future.

Two sets of examples are provided for terrain designated with a *Moderate* landslide hazard: downslope of the Behrends Subdivision (Figures 11 and 13A), and downslope of South Franklin Street (Figures 12 and 13B).

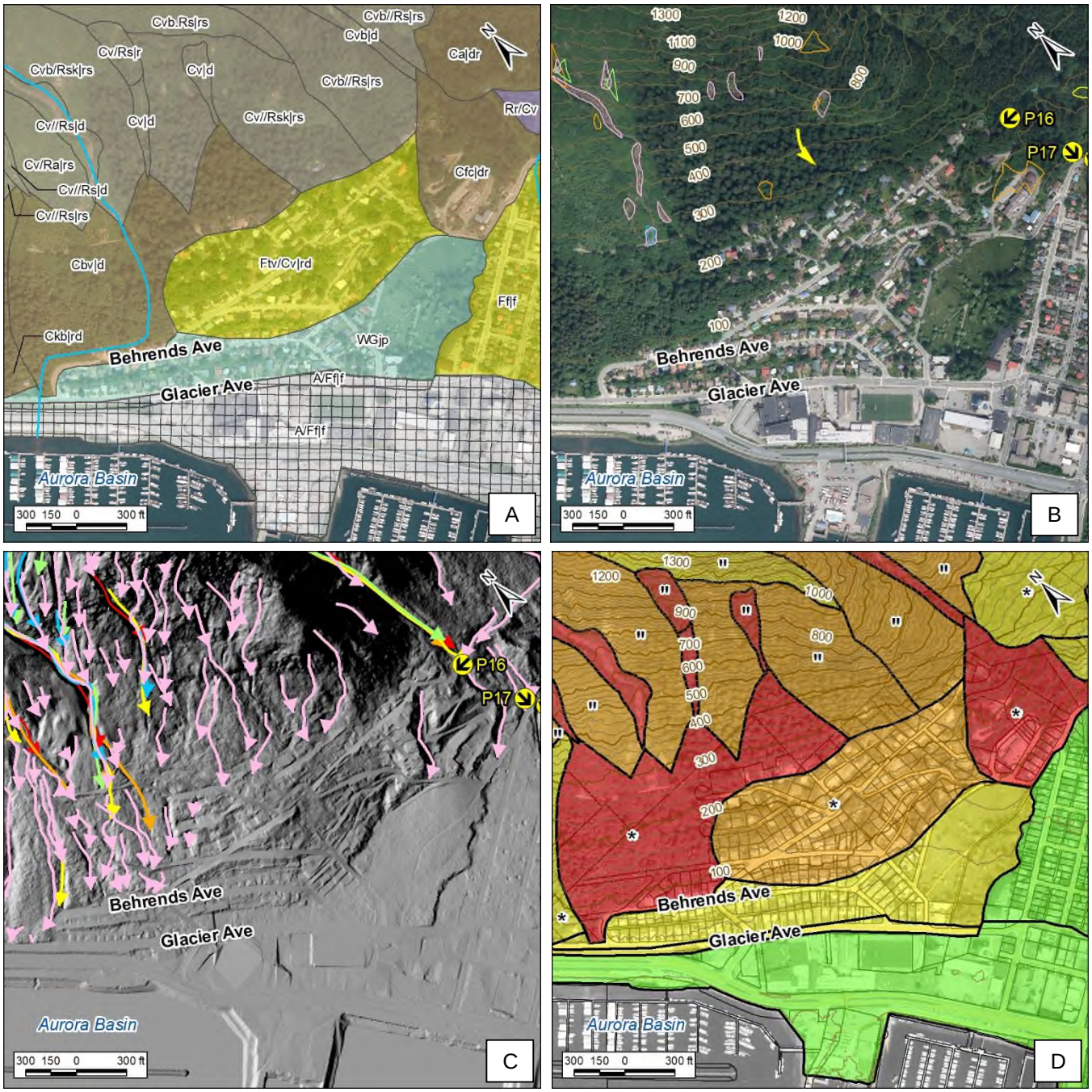

Figure 11: These mapping excerpts show *Moderate* hazard terrain from part of the Juneau Study Area. Figures 11A through 11D. The terrain mapped as glaciomarine (WG) in Figure 11A reveals no slope movement features in Figure 11B, and no gully erosion features in Figure 11C. That results in a landslide hazard designation of *Moderate*, as shown on Figure 11D. See also Figure 13 for examples of *Moderate* terrain. Events that affect mainly roads (e.g., Figure 13A) tend to be cleaned up promptly and are generally not seen on the air photos.

As shown on Figure 11D, Glacier Avenue at Ross Way is just below the *Severe* landslide designation zone at the Behrends Subdivision, at the northwest end of Behrends Avenue (left side of figure). That means Glacier Avenue could receive some smaller water-borne debris and muddy water that runs down the road, but it should not experience the more serious impacts generally seen further upslope. However, because some effects are still

possible, such as erosion (red arrow on Figure 13A), the landslide hazard designation here cannot be considered *Low*. As shown on Figure 11B, no other historical slope movement features were observed on the imagery, and on Figure 11C, the gullies appear not to extend across Behrends Avenue or Glacier Avenue, although the debris may flow onto them. Therefore, a landslide hazard designation of *Moderate* is considered appropriate.

Similar conditions apply downslope of South Franklin Street. The runouts of the several landslides on this slope are represented by surficial geology shown in Figure 12A and the *Severe* landslide hazard designations shown in Figure 12B.

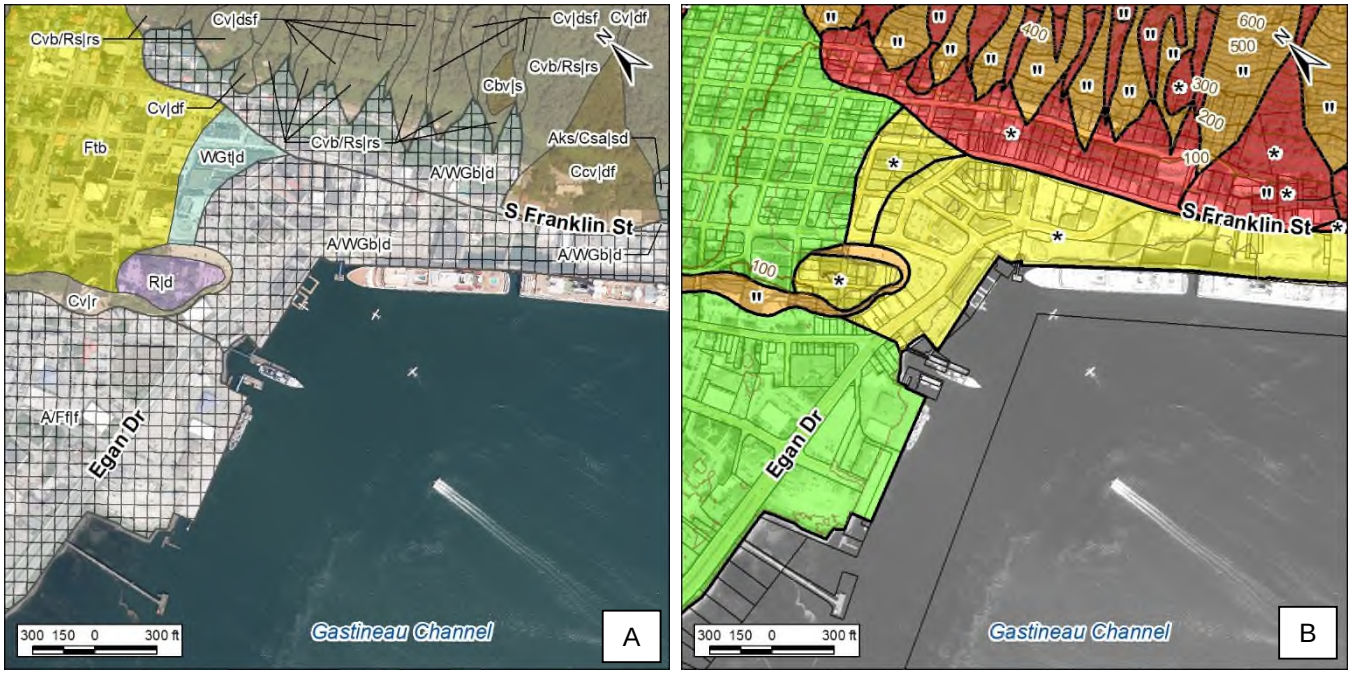

Figure 12: These mapping excerpts show *Moderate* hazard terrain from another part of the Downtown Juneau Study Area. Figures 12A and 12B are from the Downtown Historic District, the east leg of Tidelands, and the top of Telephone Hill. At center-left of Figure 12A, there is glaciomarine terrain (WG), and a rock outcrop (R) at Telephone Hill. Southeast of these two upslope areas, the terrain has been extensively human-modified (A). In this case, new ground was made from fill to create more space for the townsite development. These three areas together (except for the steep colluvial sideslopes of Telephone Hill) result in a *Moderate* hazard designation along the shoreline. In this case, a large landslide originating from the *Severe* terrain upslope of South Franklin Street (including the apparently mining-related events of 1920 and 1936) could have the potential to affect the *Moderate* terrain, but no obvious signs remain below South Franklin Street.

No mass movement events appear to have crossed South Franklin Street recently, and it is possible that the drainage and retaining structures erected along Gastineau Avenue could mitigate the extent of future landslides, at least at the 1920 landslide location. Nevertheless, the lower edge of the *Severe* terrain has been adjusted to be located downslope of South Franklin Street to account for the possibility of debris having been cleaned up and not seen on the imagery (Figure 12B). See Technical Memos #3, #6, and #7 (Appendix C in the main report; Tetra Tech 2022c, 2022f, 2022g) for more information about the slopes on Mt. Roberts.

Figure 13: These photos are of *Moderate* terrain. Figure 13A is looking southeast along Glacier Avenue on December 4, 2020, where Ross Way enters. Ross Way carried debris and water from Behrends Avenue to Glacier Avenue. Debris can also run southeast on Behrends Avenue. Note the apparently eroded and failed section of the sidewalk (at red arrow) where a section of concrete slab was missing. Figure 13B is looking downslope towards South Franklin Street (formerly Front Street) on January 2, 1920, after a major landslide from upslope of Gastineau Avenue. The red circle shows possible landslide debris across the street. (Photo credits: Figure 13A: CBJ December 4, 2020. Figure 13B: Alaska State Library – Historical Collections, ASL-P109-42, Katherine Shaw 1920. ASL 2022b.)

On South Franklin Street (formerly Front Street), debris has sometimes crossed the road, for example, during the November 22, 1936 major landslide when debris reached the Juneau Cold Storage building, or as seems to have happened during the January 2, 1920 landslide, based on the photo in Figure 3B. However, these appear to be relatively rare events and, in the case of the 1920 landslide, seem to have been aggravated by a leaky flume from the Alaska Juneau Gold Mining Company (AJGMC) and, in 1936, was possibly aggravated by an oversteepened fill/spoil slope, also mining-related. The October 1, 1952 landslide resulted in debris blocking South Franklin Street.

Another major landslide on November 7, 1900 caused damage to a flume and the Juneau Iron Works building on the upslope side of South Franklin Street (Front Street), immediately southeast of where a later landslide on October 16, 1936 damaged the back of the Alaskan Hotel and destroyed several houses, and about 350 feet southeast of a landslide on September 25, 1918 that damaged the back of the Gastineau Hotel (now the New Cain Hotel) and destroyed several other buildings (Bayers 2022; Sanborn 1904, 1914; Swanston 1972; The Alaska Daily Empire 1918a).

Bayers also reported a “land & mud slide in the usual place back of the Manhattan Hotel, McMillan Bros. Grocery and Solomon the Tailor on S. Franklin St.” on November 7, 1918 (Bayers 2022; The Alaska Daily Empire 1918b, 1918c; Sanborn 1914). Those structures appear to have been located about where the Nor’Westerly, Frontier Gifts, and Tanzanite International are currently located, upslope of South Franklin Street.

3.6 Landslide Hazard Designation - *High*

A landslide hazard designation of *High* is assigned to terrain that has the following characteristics:

- Steep slopes (>35°);
- Areas where rockfall activity impacts individual trees but does not knock them over or destroy them, resulting in an impact small enough not to be easily noticed on the air photos or satellite imagery;

- May have written record of property damage or loss of life;
- Surficial geology and texture for Class IV as shown in Table 1.2 of the main report;
- At least two of the following criteria are met:
  - Thin layer of colluvium (Cv) present;
  - A maximum polygon slope of 70° to 80°; and
  - A mean polygon slope of 40° to 50°.
- Estimated event probability is “Likely,” with a return period of 5 to 30 years. This is the return period estimated for Class IV terrain where slopes are known to be susceptible to landslides, and where there are also signs of recent and/or historical landslide events. Therefore, landslide events are likely to keep happening in the future.

Two example areas are provided for terrain designated with a *High* landslide hazard in the vicinity of Evergreen Avenue and around the slopes of Cope Park (Figures 14, 15, and 16).

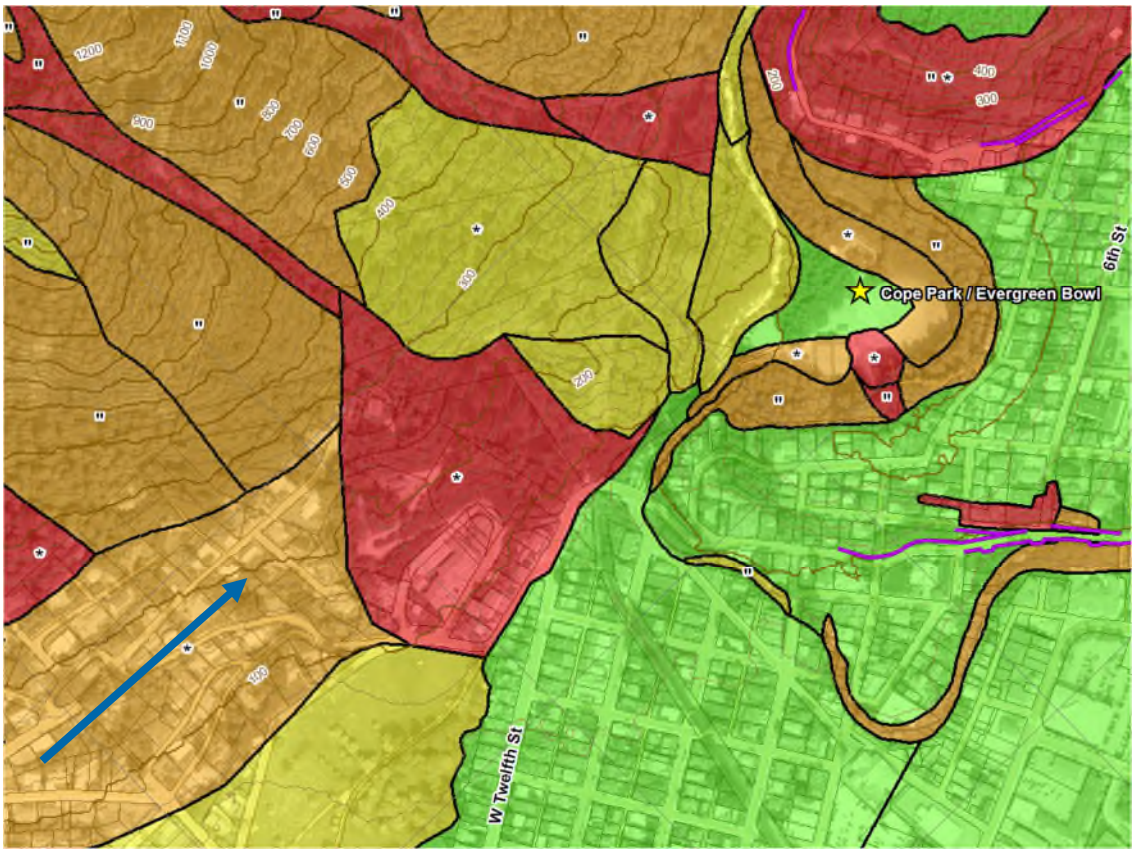

Figure 14: Excerpt from the landslide hazard mapping. Blue arrow on Figure 14 is direction of look on Figure 15, and back end of arrow is lower edge of photo in Figure 15. (See also Figures 9 and 11 for connecting map areas.)

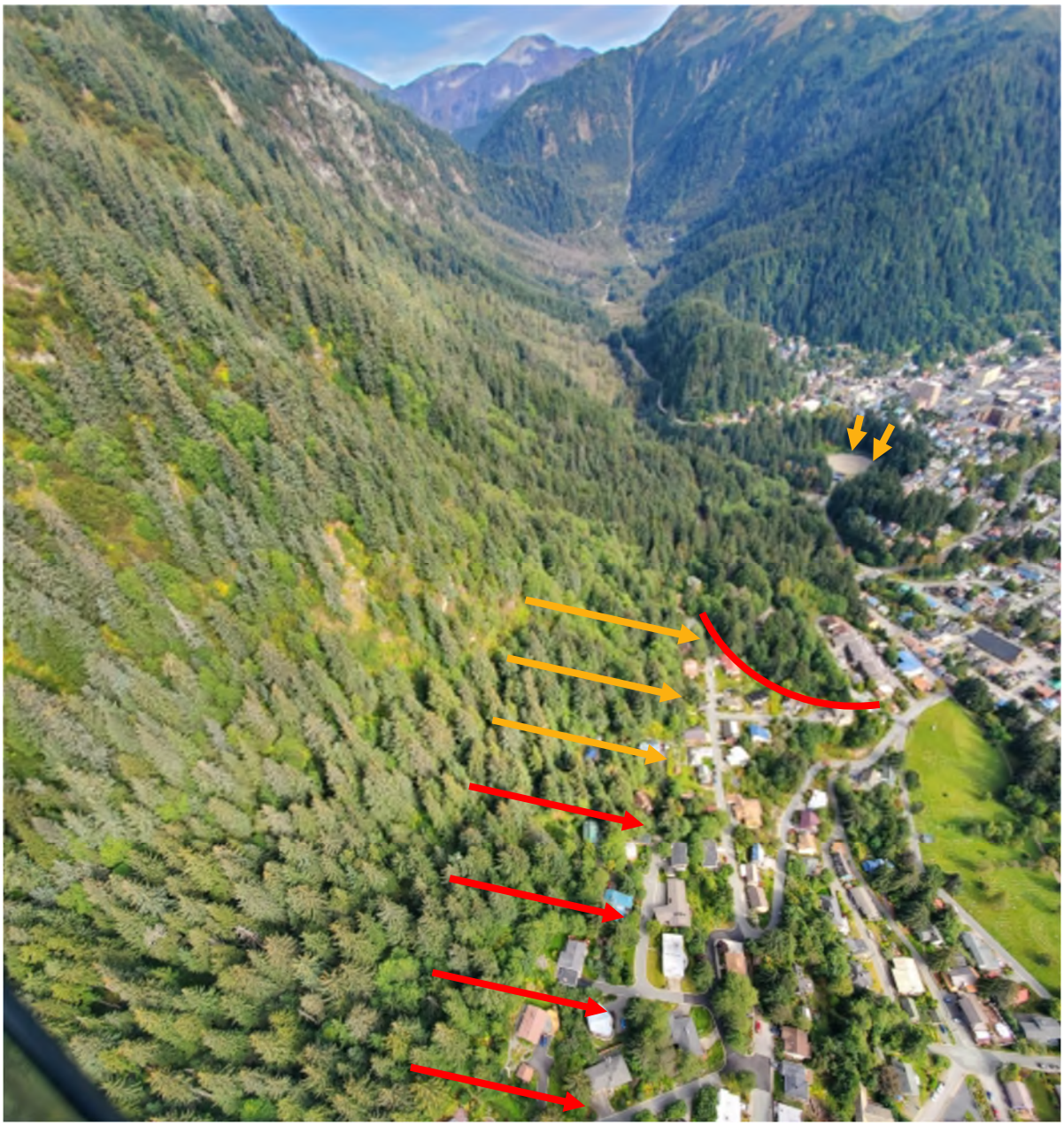

Figure 15: View from the helicopter looking east towards Last Chance Basin (see direction of look on Figure 14). Upper Evergreen Avenue is approximately in line with direction of look.

Most of the residential area in the foreground of Figure 15 is in *High* hazard zone. The upper ends of the road stubs in the foreground are mapped as *Severe* hazard (red arrows). Moving further east of the hairpin turn of Evergreen Avenue (further away from the camera), the upslope terrain is in *High* hazard zone (orange arrows) until the Bathe Creek fan/cone, where trees obscure the east end of Evergreen Avenue along the west edge of a large gully (near side outlined in red). The cemetery, which is the verdant green space at the lower right edge of the photo, is in *Moderate* hazard zone. The orange arrows at Cope Park (in the middle distance) show that most of the slope around the park is mapped as *High* hazard. See Figure 14 for more hazard mapping details. See Figure 16 for a close-up view of the slopes at Cope Park. See Technical Memo #2 (Appendix C in the main report; Tetra Tech 2022b) for more information about the Bathe Creek area.

Figure 16: Looking southeast at the steep slopes around Cope Park at the ball diamond. Note the retaining wall at the toe of slope here, which is mapped as having a *High* hazard. (Photo credit: CBJ Parks & Recreation 2022.)

3.7 Landslide Hazard Designation - *Severe*

A landslide hazard designation of *Severe* is assigned to terrain that has the following characteristics:

- Steep to vertical slopes (>35°);
- Signs of recent activity either in aerial photographs or from field inspection (rockfall tracks, debris slide activity, debris flow paths etc.);
- May have written record of property damage or loss of life;
- Signs of repeated historical activity;
- Surficial geology and texture for Class V as shown in Table 1.2 of the main report; and
- Estimated event probability is “Very Likely to Almost Certain,” with a return period of 1 to 20 years. This is the return period estimated for Class V terrain, where the slopes are highly susceptible to landslides, and where

there are signs of recent landslide activity as well as repeated historical landslide activity. Therefore, landslide events are very likely to almost certain to keep happening in the future.

Two sets of examples are provided for terrain designated with a *Severe* landslide hazard: at the northeast end of the Starr Hill subdivision, above Nelson Street (Figures 17 and 18), and at the northwest end of the White Subdivision (Figures 19 and 20). As these examples show, *Severe* landslide hazards can occur on relatively short slopes or on very long slopes.

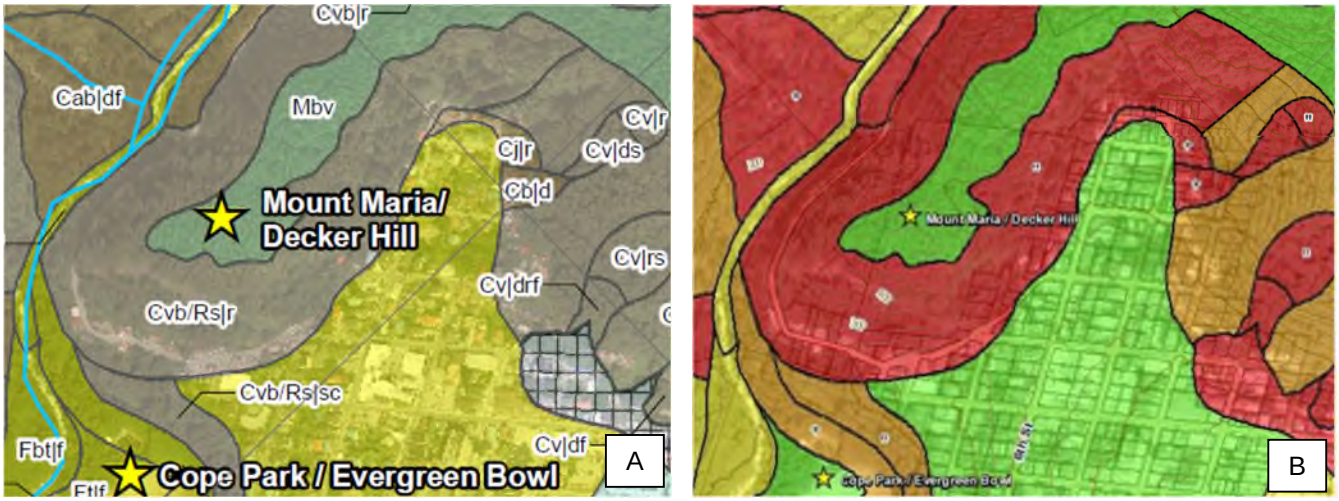

Figure 17: These two map excerpts are from the mapping slopes above Starr Hill. Figure 17A shows the surficial geology, and Figure 17B shows the landslide hazard designation mapping. Around Starr Hill, the green signifies *Low* hazard, the orange is *High* hazard, and the red is *Severe* hazard. See Figure 18 for the landslide seen in the *Severe* hazard area above Nelson Street. More information about this area is available in Technical Memo #3.

Figures 17B and 19D are hazard maps, which indicate areas that are potentially hazardous. If there was a lot of potentially hazardous geomorphic process activity on a slope, or if new activity was identified in the field, that area was mapped as having a *Severe* hazard. For instance, debris could be building up on the slope directly above a house (Figure 18), or in a location where debris can potentially run towards a house, and where it could become a more serious hazard in the future (Figures 20B and 20D). Smaller debris slides and debris flows tend to accumulate debris material in wedges within gullies. Eventually, when a critical level of debris accumulation is reached, or a significant precipitation event occurs, all that stored debris is scoured out of the gully, potentially resulting in a very large debris flow event. Similar events can occur on open slopes where slide debris piles up in lobes over days, months, or years, sometimes separated by channels of faster-flowing loose material. These debris lobes can slowly be creeping downslope, until the critical moment when there is enough mass and enough water to trigger the debris flow rapidly downslope. See also Technical Memo #2 for more mapping examples (Appendix C in the main report; Tetra Tech 2022b).

Figure 18: Compares Tetra Tech's photo from September 10, 2019 (Figure 18A) with residents' photo from August 1, 2021 (Figure 18B) at the same location. Slope instabilities appear to be ongoing in the historical slide paths located above Nelson Street on a slope with a landslide hazard designation of *Severe*. See Technical Memo #3 for more information about the slopes around Starr Hill.

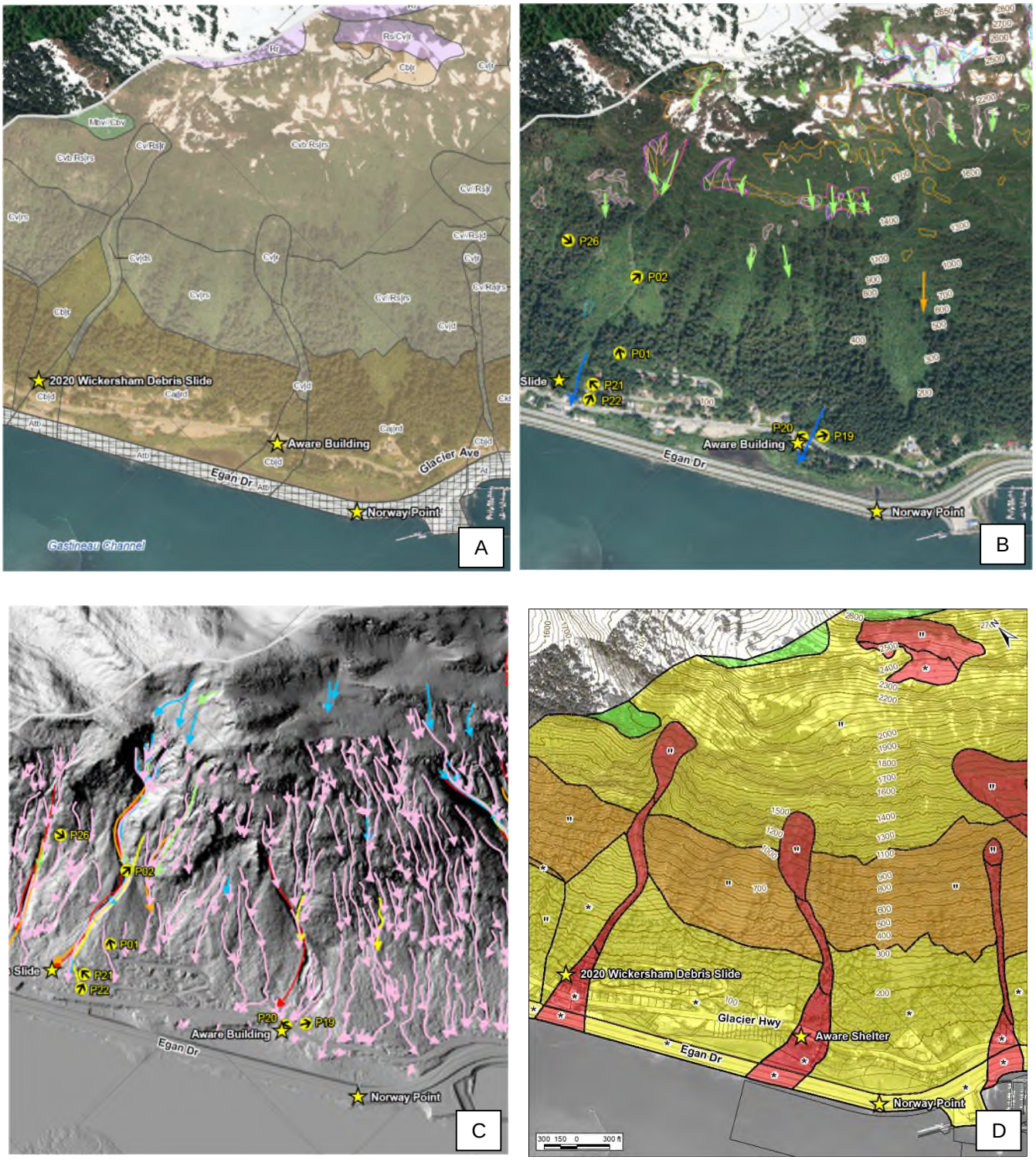

Figure 19: These excerpts are from the mapping at the slopes at the White Subdivision. Figure 19A shows the surficial geology, Figure 19B shows the slope movement features, Figure 19C shows the gully erosion features, and Figure 19D shows the landslide hazard mapping. The Wickersham slide (Figure 20) is related to a very active gully erosion feature in *Severe* hazard.

Figure 20: The Wickersham debris slide in the White Subdivision is an example of a landslide in terrain with a *Severe* landslide hazard designation. Figure 20A: Part of the debris deposit at the northwest end of Wickersham Avenue on the uphill side; Figure 20B: Debris on the downhill side of Wickersham Avenue; Figure 20C: Debris running down along the swale between Wickersham and Glacier Highway; Figure 20D: Debris deposit at Glacier Highway, filling a concrete sump behind the railing. (Photo credits: CBJ December 4, 2020.)

Figure 20 shows the aftermath of a large debris slide, after the roads had been mostly cleared. The debris was up to 8 feet thick at Wickersham Avenue, crossing Wickersham to impact a residence, filling a drainage path to Glacier Avenue, filling a drainage sump, and flowing out onto Glacier Avenue. By the time the photo in Figure 20C was taken, the water was running clear again. More debris is visible on the right, where it ran down to Glacier Highway.

4.0 HAZARD FROM ABOVE OR HAZARD FROM BELOW

Landslide hazards can affect properties from both upslope and downslope. Landslide hazards that affect properties from upslope are landslides that have the potential to run down a slope and impact a property, overrun it, damage it, or destroy it. Landslide hazards that affect properties from downslope are landslides that have the potential to remove part of a property when the ground falls downslope away from the property. For example, part of the backyard falls down the hill, or so much ground falls away that the foundation of the building is endangered. The

worst case would be if so much ground falls away that the building can no longer be supported, and it too will topple or slide downhill.

A few examples of areas of Juneau where landslide hazards from above can potentially affect property include Tidelands, Starr Hill, Gastineau Avenue, Behrends, Highlands, and the White Subdivision. A few examples of areas where landslide hazards from below can potentially affect property include Chicken Ridge, Telephone Hill, and the northwest corner of Juneau Townsite (as shown on the Historical Neighborhoods website (CBJ 2022)). Chicken Ridge is also the main area where landslides can affect property from both above and below, for example, along Basin Road, and in a few places along Goldbelt Avenue.

5.0 LIMITATIONS OF A HAZARDS-ONLY ASSESSMENT

A detailed risk assessment would generally include the following basic steps:

- Hazard assessment;
- Magnitude/frequency analysis;
- Consequence assessment; and
- Risk assessment.

Depending on the requirements of the project, more data is acquired to satisfy each of the steps. The Downtown Juneau Landslide and Avalanche Hazard Assessment project has completed the first step – the hazard assessment. The other three steps were not part of the scope for this project. The thorough hazard assessment completed by Tetra Tech (Tetra Tech 2021, 2022) provides important information on where the past, present, and future slope instability areas are located in Downtown Juneau. This information can be used to progress to the other three steps.

Future phases of the project would allow more information to be collected and analysed, but each task also requires considerably more work and funding to acquire the necessary data before each subsequent task can be completed. See Technical Memo #1 for more information (Appendix C of the main report; Tetra Tech 2022a).

For example, the magnitude/frequency analysis would allow the slope activity data to be refined so that it could be used to help predict return periods for landslides of a specific type and size for a particular site, like a debris flow gully. Consequences could then be evaluated. For instance, if a specific gully experiences debris flows, i.e., acts as a conduit for conveying debris downslope, what happens downslope if it is only a small debris flow? What happens if it is a very large debris flow? Maybe nothing happens, because there are no buildings below, or maybe several buildings are destroyed when the debris runs into them.

Finally, a risk assessment can be done with a combination of all the data gathered in the previous steps. Land management decisions can then be made based on what is considered to be a tolerable risk, such as having to occasionally clean debris off the road; or what is considered to be an intolerable risk, such as a debris slide overrunning a house with someone in it.

The main challenge for CBJ at present is managing questions that require a risk assessment to be answered satisfactorily when the only data available so far are the results of the hazard assessment (Tetra Tech 2021).

6.0 REQUESTS FOR ADDITIONAL INFORMATION

A few specific questions were asked and are addressed specifically in this section. With the background information provided in the previous sections, the reader will understand the context of the answers. With limited data, it is not always possible to find a complete answer, but it will also help to understand what the landslide hazard designations mean when describing what could happen.

- **Question:** Does a *Severe* landslide hazard designation mean it would be a catastrophic failure?

  Answer: A *Severe* landslide hazard designation only describes the hazard. A description of the hazard can include information like the type of landslide (debris slide, debris flow, rockfall etc.), the size, and the location. If there is lots of data, such as many years of air photos, satellite imagery, cleanup reports, damage reports, that helps to give an idea of landslide activity and size. That is, out of 10 historical air photos of a particular slope taken over 70 years, does a landslide scar appear only once? Twice? Every year that is checked? How large is the area affected? How much debris needs to be cleaned up? Which structures are damaged and where are they located?

  A *Severe* landslide hazard designation does *not* specifically mean a catastrophic failure. In the case of this study, there are two main criteria that are used to decide whether an area needs to be designated as *Severe*:

  - Evidence of slope instability within the same feature in more than one air photo or LiDAR year and/or field investigation year; and/or
  - A cone or fan of colluvium is present at the base of a slope, no matter how old it is, because the hazard is still present.

  Numerous gullies in Juneau show evidence of slope instabilities in several years (sometimes every year) of imagery, incident report data, or field observation data that was reviewed.

  More steps are needed to determine whether a landslide in an area designated *Severe* would be catastrophic or not. One of the most important steps would be a consequence assessment, summarized in Section 6.0. See Question #1 in Technical Memo #2 for more information on how a *Severe* landslide hazard designation is determined (Appendix C of the main report; Tetra Tech 2022b).

- **Question:** What about the *Moderate* areas of the Highlands and Downtown Juneau – are they low probability, high consequence? Wouldn't any landslide damage be catastrophic?

  Answer: A *Moderate* landslide hazard designation only describes the hazard; it does not describe the consequence. Estimating the probability of a landslide requires a magnitude/frequency analysis. Evaluating the consequence of a landslide requires a consequence analysis. Neither of those tasks was in the scope and they not been done.

  However, let's compare the different landslide hazard designations shown in Table 1.4 in Section 3.0 above. The description for a *Moderate* landslide hazard might be somewhat reassuring compared to the description for *High* or *Severe* landslide hazards. Since there is insufficient data to determine a return period for a possible landslide of a particular size, the only basis for comparison is to consider the other characteristics of the designation. To summarize, landslides are possible, and there might (or might not) be signs of past landslides, but there is no apparent record of damage or loss of life.

  Although the natural terrain in some parts of Juneau has been obscured by construction-related earthworks, very large events in the past have left traces, like the very large prehistoric landslides mapped along the valley

slopes (Swanston 1972). In contrast, the large suspected deep-seated bedrock failure southeast of Snowslide Creek is rated *Severe*, even though it has not yet happened. Despite these exceptions, even if a landslide happens only rarely, it does not necessarily mean that a rare event is always going to be the "big one." Conceivably, land managers could decide to avoid all areas in which a landslide could occur, including those with a designation of *Moderate*, but the priority should be to avoid the *Severe* and *High* designated areas first, because those areas will usually be affected more often and more seriously than the *Moderate* ones.

See also Section 3.5 for examples of *Moderate* terrain and mapping.

- **Question:** Can you provide additional explanatory terms that reference a general timeframe for a specific landslide hazard designation, e.g., *Low* – geologic time, *Moderate* – 100 to 1,000 years etc.?

  Answer: Without a magnitude/frequency analysis, it is not possible to definitively tie the landslide hazard designation to a specific timeframe. The activity level observed during the historical air photo record analysis and the fieldwork, as well as occasional reported events, provide the only information about frequency that is currently available. The activity level does have some correlation to frequency (i.e., more active landslide areas experience landslides more frequently), but that is not the same as having the results of a more rigorous magnitude/frequency analysis. Based on the activity levels, it is only possible to tie the landslide hazard designations to a much shorter timeframe, as described in Section 3.0.

- **Question:** Can you tell me more about the proxies that are being used instead of a magnitude/frequency analysis?

  Answer: A useful proxy for magnitude is the size of the unvegetated slope area (or range of sizes), based on the typical sizes of the events seen on the available air photos, satellite images, and evidence seen during the field work. Another proxy for magnitude is whether any damage or loss of life was reported for a specific landslide event. (In risk studies – *not* part of the current scope – reports of size, damage or loss of life would also contribute to an understanding of consequence.)

  The proxy for frequency is activity: the proportion of air photo or satellite images (or field observations) that show a lack of vegetation on a slope that would ordinarily be vegetated. The more often a slope section or gully has no vegetation on it, the higher the rating it will receive. Areas showing activity in two or more air photo years were identified and given a hazard designation of *Severe* on the hazard designation maps due to their higher activity levels. In fact, many of the areas designated as *High* or *Severe* in the mapping turned out to have several instances of lack of vegetation, with numerous gullies showing evidence of slope instabilities for all, or almost all, observation dates. See Section 3.3 in this memo, and additional discussion in the answer to Question #1 in Technical Memo #2 (Appendix C of the main report; Tetra Tech 2022b).

7.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the City and Borough of Juneau and its 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 the City and Borough of Juneau and its 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.

8.0 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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/jf

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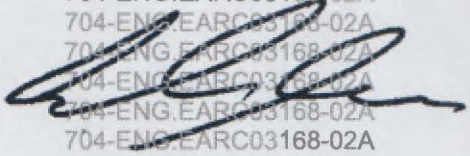

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The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. 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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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.

From: Brianna Ackley <wolfsongwellnessboutique@gmail.com>
Sent: Saturday, April 8, 2023 1:08 PM
To: PC_Comments; PC_Comments
Subject: Fwd: Fw: Downtown Landslide Assessment Concerns

Hi there! I know that the public comments window closed yesterday, but I originally sent this email on Thursday, and I just got a notice that it wasn't delivered, so I'm resending it from my work email.
Thank you for your time and consideration!
Brianna Ackley

---------- Forwarded message ---------
From: **Brianna Ackley** <brie_ackley@hotmail.com>
Date: Sat, Apr 8, 2023 at 1:01 PM
Subject: Fw: Downtown Landslide Assessment Concerns
To: wolfsongwellnessboutique@gmail.com <wolfsongwellnessboutique@gmail.com>

From: Brianna Ackley
Sent: Thursday, April 6, 2023 2:11 PM
To: PC_Comments@juneau.org <PC_Comments@juneau.org>; PC_Comments@juneau.gov <PC_Comments@juneau.gov>
Subject: Downtown Landslide Assessment Concerns

Hello!
I know that you aren't currently taking public testimony about this issue, but I fear that if you don't hear about how these changes will affect the real people that are living on downtown hillsides, this issue could just get lost in bureaucracy. I live on Starr Hill downtown, and the risk assessment of my home will be changing from 'moderate' to 'severe' if the planned maps are adopted. While I acknowledge the risk of living on a steep hillside, there are some concerns I have about the way the city is going about adopting these new maps.

If the new risk maps are adopted, it could make entire neighborhoods unsellable. If a home can't be insured, it can't be sold. But the city just reassessed our entire neighborhood at about 20% higher than last year's market value. So we're paying 20% more taxes on houses that the city is about to deem unsellable? The city can't have it both ways. Either these houses are valuable or worthless, but you can't collect extra taxes on properties that can't be sold. If these houses can't be insured, has the city thought about creating some kind of private insurance pool for affected houses? Hundreds of houses are going to be affected by this new designation, and it would be irresponsible of the city to adopt it without putting measures into place to insure the continued value of the properties affected.

Also, it's my understanding that the proposed maps don't take into account the difference between the risk of earth movement and that of debris fall. While these are definitely both risks to the properties in our area, they are different types of risks, and should be designated differently. Earth movement could take an entire house off of its foundation, while debris fall mostly just causes cosmetic and structural damage.

Lastly, I hope the city will make a plan to mitigate some of the future risk to the area, because it's their land that poses the risk to our properties. For example, if I owned the hillside behind my house, I could go up there and cut down trees that are starting to lean and I could plant smaller trees and bushes whose roots could help stabilize the hillside and prevent further erosion. But I can't do that because the city owns the hillside behind my house. The city is saying that our properties are at more of a risk than was previously assessed, but it's the city's land that is posing that risk, so I think that it would be remiss of the city to adopt these new maps without concurrently adopting a risk management plan for areas where erosion could potentially be mitigated.

Some of my neighbors have probably already emailed you about their concerns for your upcoming meeting on the 11th, and I hope you'll take into account the fact that the proposed change will have very real effects on hundreds of Juneau residents. I understand the risks of living in a slide zone, and I'm honestly not even against the changes in the maps, but what bothers me is the seeming lack of forethought on how these changes will affect people and the lack of responsibility being taken by the city to mitigate future damage.

Thank you so much for taking the time to hear my thoughts on this!
Brianna Ackley
433 Nelson Street

From: Frankie Pillifant <frankiepillifant@gmail.com>
Sent: Sunday, April 9, 2023 3:50 PM
To: PC_Comments
Subject: Questions to ask

Follow Up Flag: Follow up
Flag Status: Flagged

My apologies, this is being sent after close of business Friday and may not make it into the packet. I worked as a geotechnical geologist with geotechnical engineers in an open pit mine on assessing open rock faces and the forces at work as they were being mined. I have technical questions about the ability to predict risk in the manner CBJ seems to be pursuing. But as important, has there been any outreach to professionals for economic questions about how assesment, insurance or lending would be impacted? I think assembly members may have asked that question, but if I remember right it was answered by a staff opinion and not questioned further. Please direct me to that specifically if it's available.

Many thanks for everyone's time and considerations on this weighty matter.

Frankie Pillifant, Juneau, AK.

"In the end, the love you take is equal to the love you make"- The Beatles

From: Ke Mell <kemell@alaskan.com>
Sent: Sunday, April 16, 2023 1:34 PM
To: PC_Comments
Subject: Comment on Severe Avalanche and Severe Landslide Area Maps and Draft Ordinance
Attachments: Hazard vs. Risk - Wirehouse Employer Services.pdf; 22 10-03 Predicting Landslides - NPR Short Wave.pdf; David A. Kent - January 19, 1972 Mr. Juneau Avalanche.pdf

Friends and neighbors,

I've attended the past two Planning Commission Committee of the Whole work sessions on the Avalanche & Landslide Hazard Maps Draft Ordinance. I've watched with considerable frustration as the Commission appeared unaware of or struggled to address fundamental issues. Those include:

Avalanches and landslides are different. Snow melts. In Juneau there is **NO** avalanche hazard in July. For six months of the year there is no avalanche hazard. That means for six months of the year avalanche hazard areas can be used for anything—including seasonal housing, tourist business, and recreation. Juneau—and downtown in particular—suffer from a severe shortage of seasonal (summer) housing for visitors and seasonal workers, among others.

Hazards covered by the proposed ordinance come in two flavors: upslope and downslope. Upslope (the ground comes down on you from above) and downslope (the ground falls out from underneath you) are fundamentally different and are addressed in different ways. In Juneau there is no construction in the on mountaintop cornices, so avalanches always come down from above (upslope), never out from under one's feet. Landslide hazard can be either, but CBJ's current ordinance does not differentiate. It appears to be concerned only with upslope hazard. Downslope hazard is addressable through CBJ's current Hillside Endorsement for development on slopes exceeding 18%. ***This ordinance should clearly state whether it is concerned with downslope risk or with upslope only.*** Tetra Tech distinguishes between upslope and downslope landslide hazard on its maps (+/-), but on the resulting areas that are subject to both it is unclear whether the hazard color would change if, for example, only upslope hazard were considered.

Hazard is not risk. According to Wirehouse Employer Services, https://wirehouse-es.com/health-and-safety/whats-the-difference-between-hazard-and-risk-a-complete-guide/, which has a very concise definition:

- Hazard: something that could potentially cause harm.
- Risk: the degree of likelihood that harm will be caused.

Let's not confuse the two. Tetra Tech provided hazard maps. As City Manager Rorie Watt noted of Tetra Tech's study in his November 3, 2022 memo to the Assembly, "disclaimers in the study that indicate that the maps are not to be used for site specific decisions". Tetra Tech's maps provide a 10,000 foot view of the terrain. Iin their report, Sec. 1.5.2 Limitations, Tetra Tech states, "Geologic conditions are known to be variable, and the amount of information available from mapping using remote sensing data plus limited

field-checking means that there are bound to be some areas with conditions than those anticipated from the air photo interpretation and mapping work done to date."

Tetra Tech's maps establish hazard: something that could potentially cause harm. They do not establish risk, the determination of which will require additional information, both with regard to site particulars, and with regard to site uses. TetraTech themselves consider their work to date a first step. From page 8 of their report: "The hazard designations assigned do not account for current or future positioning of infrastructure or people, as this is considered ***risk mapping,*** which ***is beyond the scope of this study****.* Similarly, ***analysis of magnitude/frequency, runout, and risk assessment are not part of this study***." (emphasis added)

In his November 3 memo, Rorie continues, "At a high cost, the consultant has indicated that additional site specific analysis could cost between $250K and $1M per hazard path." This further analysis is essential to the development of reasonable regulations. (for comparison with regard to flood hazard and risk CBJ's website: https://fema.maps.arcgis.com/apps/StorytellingSwipe/index.html?appid=48beaefc7ca447f895978686b8e6bd1d# , at the bottom of the upper portion of the left sidebar, just above the Legend, states *"Please note, data is for informational purposes only.* Effective regulatory flood hazard data is available through the FEMA Map Service Center website." *Emphasis added*.)

Tetra Tech's study has provided the City and Borough of Juneau and its residents with significantly more information that was available previously, but not with adequate information to establish risk, much less to establish the degree of harm that might potentially be caused. As such ***Tetra Tech's study is not ready for adoption as the basis for regulation of development***. ***The study is ready for adoption—and should be immediately adopted—on an informational basis.***

Adopted on an informational basis, the study would support language in the proposed ordinance stating that "Owners shall provide written notice to potential buyers or renters that the property is located in a severe avalanche (or landslide) **hazard** area prior to sale or rental of the property." This is essential. Everyone should know what their getting into, and then be allowed to judge for themselves the risks they are willing to take on. The ordinance must explain or refer to an explanation of the difference between hazard and risk, as this may not be common knowledge.

The regulation of development should be addressed separately; this is—as Rorie noted—considerably more complicated. ***Regulation of development should be underpinned by a community-wide consensus as to risk, what sorts of risk, assumed by which parties, and to what levels of risk.*** Tetra Tech has explicitly declined to address risk, except in future work at considerable cost.

The draft ordinance Sec. 2. (a), (2), states, "Development in mapped … areas shall minimize the risk of loss of life or property ...." (Complete quote: "Development in mapped moderate and severe avalanche and severe landslide areas shall minimize the risk of loss of life or property due to landslides and avalanches.") Life and property are different. Life is generally more important than property. Life can move out of harm's way; property generally can't.

Risk to life can be minimized through attention to weather conditions and site particulars. CBJ invests resources in avalanche prediction, issuing Urban Avalanche Advisory daily during the avalanche season. In the wake of the 2015 Kramer Avenue landslide, Sitka established a community-based early warning system for landslides—somewhat analogous to Juneau's Urban Avalanche Advisories. On October 3, 2022 National Public Radio's Short Wave published the attached story of Sitka's experience. Despite differences in soil types between Juneau and Sitka, Juneau could benefit from discussions with

Sitka's community and municipal government. I draw several lessons from S[illegible] landslides are predictable; 2) risk can be estimated; 3) public notice can be provided; 4) what Sitka is doing with landslides is similar to what CBJ does with avalanches.

Risk to private property can be addressed through personal choice as to where to live, through insurance, and through site specific mitigation. Sec. 2 (b), (2) of the proposed ordinance requires "site specific engineering for the following: peak drainage, special foundation or high back wall engineering, and debris flow diversion mechanisms." Such engineering requires quantification of risk in a particular location. ***Assertion of hazard is not a substitute for quantification of risk, and the proposed ordinance provides no mechanism for quantification of risk.***

Sec. 2 (b), (4) allows for relocation of mapped hazard area boundaries. ***Relocation of hazard area boundaries depends on quantification of risk, and the ordinance provides no mechanism for quantification of risk.***

Sec. 2 (b), (5) and Sec. (c), (4) mention "mitigating measures certified as effective by a civil engineer licensed in the State of Alaska". "Such measures may include dissipating structures or dams, special structural engineering, or other techniques designed for the site." Certifying as effective"—to what standard? Design professionals regularly certify construction as in compliance with locally adopted codes; to what national model codes or well-developed State or local codes would they be certifying? "Certified as effective" is unreasonable as there are no codes or standards to which to certify, and the ensuing professional liability is more than any licensed professional, firm, or professional liability insurer is willing to assume. "***In the absence of quantification of risk, allowing mitigation is meaningless.***

Site specific analysis is required to quantify risk. Such analysis is only available for a very few properties, and most such analyses were done by Bill Baxandall, P.E. (now deceased) decades ago. In September 2021 I contacted Tetra Tech to ask if they could provide a site-specific assessment for my property, as having done the initial mapping and being acquainted with the area, they were obviously most suited. They declined, citing their work with CBJ. I inquired elsewhere; despite considerable research, I was unable to find engineers or firms willing to provide such analysis. Reasons cited include: In the course of working with Tetra Tech CBJ consulted most, if not all, of the individuals and firms with local civil and geotechnical expertise. They were asked to review Tetra Tech's work and provide comments to CBJ. I have talked to several (there are not many in Juneau). They were unwilling to speak on the record or be identified, but they felt that ***having reviewed and commented on Tetra Tech's work for CBJ, they could not openly criticize it, or work for someone who took issue with the work.***

With considerable difficulty I found an expert outside Juneau, an Alaska licensed civil engineer with decades of experience in civil engineering, who owns a civil and geotechnical engineering firm with dozens of employees and offices in several western states as well as Alaska. He stated that, despite having no professional or other connections to CBJ or Tetra Tech, given that Tetra Tech mapped hazard only, and that the maps were vague and arbitrary, ***the professional liability***--on account of the lack of quantification of risk or professional standards to guide work--***was so great that he and his firm could not become involved.*** Local engineers with whom I spoke had the same concerns, in addition to their direct involvement with CBJ.

As Rorie noted in his November 3, 2022 memo, "private engineers and geologists who have expertise in hazard zones have little to gain by participating in individual site selections on reduced budgets. The liability is simply too great and the applicant's ability to pay for a detailed analysis is very limited. Private engineers with economic resources to protect are going to be naturally conservative." … "The new landslide mapping is not linked to event probabilities. Some discussion of probability was included in the draft report and

deleted by the consultant in the final report; the consultant was unwilling to [illegible] to event probability estimates." *(emphasis added)*

Who is to "prepare site specific studies" if no one will so?

I live at 850 Basin Road; I care about my neighborhood, and the risks to myself and my neighbors. I also care about property values—mine and theirs—and my ability—and theirs—to maintain and prudently develop our properties. My neighborhood is upper Basin Road, a flat section before the road turns abruptly north into Last Chance Basin. I have lived here since 2002, having bought the property from my JDHS guidance counselors, who had lived there since 1969.

Near my neighborhood are a couple of extremely risky areas, with active landslide chutes that discharge rocks and debris annually if not more often. Tetra Tech lumps those areas in with my neighbor at 883 Basin Road, whose house is on a knob of rock at very little to no risk, as there are no cliffs above to shed rocks and any debris flow would be deflected by topography before reaching the house. My neighborhood of perhaps ten houses has seven or eight distinct topographic conditions that would directly affect landslide risk; Tetra Tech's work colors the entire neighborhood the same. This is not helpful. Of those seven or eight areas, the potential risk at two of those areas results from past CBJ work in the neighborhood. Aside from the known chutes with annual rock and debris flow, there has been no landslide activity (with one exception, below) in the neighborhood at least since the early 60s, when they moved in, according to my neighbor at 883 Basin Road.

As TetraTech says on page 6 of their report, C. Criteria for Slope Stability Interpretations, under Slope Morphology, "Slopes with irregular or benched topography controlled by bedrock are relatively stable;" In my neighborhood (upper Basin Road) that describes the ground largely upslope of the road, and the near-surface bedrock downslope of the road throughout the neighborhood. There are a series of bedrock terraces parallel to the road, which do not shed rocks or debris, and tend to retain loose material. By contrast, on both sides of our neighborhood, where Basin Road wraps to the east and north, those terraces become active chutes. Tetra Tech's maps are too coarse-grained to capture this critical distinction.

The exception noted above was a landslide, approximately 4' deep and 30' wide, which collapsed an unoccupied portion of my parking area in November 2005 during very heavy rains. I took no action and the area has since revegetated. On January 19, 1972 a large avalanche came down Mt. Juneau, dammed Gold Creek, and buried the adjacent stretch of Basin Road, see attached webpage by David A. Kent. The following spring CBJ Streets Dept. approached Richard and Anne Meeker, then property owners of 850 Basin Road, asked, and obtained permission to dump "many truckloads"—in Richard's words—of debris from the landslide onto the slope at 850 Basin Road. For 53 years this debris expanded the parking area at 850 from two cars parallel to the road to four (compact) cars perpendicular to the road. This area collapsed in 2005, restoring the parking area and hillside to the pre-1972 profile. There had been minor sloughing before, and given its history I knew the slope to be unstable. No vehicles were parked there when it collapsed. This collapse was the direct and inevitable outcome of actions by CBJ personnel decades before and did not represent a naturally occurring slope condition. Since 2005, the slope has been quite stable. In later correspondence with Tetra Tech with regard to their mapping through CBJ Planner Teri Camry, Tetra Tech noted the area of collapse as a "slide path", but did not appear aware of the source. I offer this example to illustrate the variability within neighborhoods, the necessity for site specific analysis, and the risk of relying on hazard maps, which are **NOT** risk assessments.

To summarize:
1) Snow melts
2) Upslope vs. downslope
3) Hazard vs. risk
4) Sitka forecasts
5) Site specific analysis
6) An example: my neighborhood

I'd like to thank the Planning Commission for their work—to date and future--on the Avalanche & Landslide Hazard Maps Draft Ordinance. Gunalch鼸span>esh (Without you, it would not be possible.)

Ke Mell
850 Basin Road

What's the Difference Between Hazard and Risk? A Complete Guide

July 08, 2019 | By: Victoria Owings

The statistics are shocking. The Health and Safety Executive reports that 1.4 million people in the UK are currently suffering from a work-related illness or injury. 555,000 injuries occur every single year at work. A staggering 144 people were killed at work in the year 2017/18. It is critical for employers to actively assess and implement strategies to avoid harm to their employees. As the numbers show, numerous employers still don't take this responsibility seriously. When asked: "what's the difference between hazard and risk ?", many people are unable to give you an answer.

This guide will help you to understand fully what's the difference between hazard and risk, and how you use the two together to ensure your workplace is the safest place it could be.

Let's begin with a definition.

When it comes to amateur health and safety efforts, the words 'hazard' and 'risk' are often used interchangeably. However, these terms have both totally different meanings and totally different functions. Let's take a look at definitions for both words:

- Hazard: something that could potentially cause harm.
- Risk: the degree of likelihood that harm will be caused.

In short, a hazard can cause harm. A risk is how likely it is to do so. The two terms work together to enable employers fully assess their working environment for potential dangers and prioritise them effectively. Let's look more in-depth at hazards and how they can be identified and categorised.

What Exactly Is A Hazard?

Many accidents are entirely avoidable, and the key to doing so is in minimising all possible hazards. Some items are naturally hazardous; while others harbour potential dangers if used incorrectly or inappropriately.

Hazards can be broken down into two basic categories:

- 1. Acute Hazard – these are hazards that pose obvious issues and would impact instantly. An example of this would be a liquid spillage, causing an immediate danger of somebody slipping over and hurting themselves.
- 2. Chronic Hazard – these hazards are not immediately apparent, and can have more of a hidden issue, sometimes only arising after long periods. An example of this would be the build-up of workplace stress or the gradual decline of a piece of machinery.

All hazards, whether acute or chronic fall into six core categories.

- 1. Physical – It refers to the stereotypical workplace hazard most of us would think of, for example, lighting issues, objects obstructing walkways, unsafe machinery, spillages on floors.
- 2. Chemical – This includes any form of liquid, vapour, dust, fumes or gases that could be spilt, leaked or misused.
- 3. Ergonomic – Usually stems from ill-thought-out design or spatial awareness. This can include workstations that aren't fit for healthy usage. However, this category can also include hazards associated with lack of training (e.g. manual handling) or unsafe working conditions leading to injury (e.g. repetitive movement).
- 4. Radiation – This may be more prevalent in a clinical setting and covers x-rays, gamma rays, UV and microwaves.
- 5. Psychological – This applies heavily across all industries in many forms. Examples of psychological risk include stress, working shifts, problems dealing with the public, internal harassment and lack of empowerment.
- 6. Biological – Not to be confused with chemical, biological risks involve viruses, bacteria and fungi. This can happen through bites, cuts, or contamination through contact with an infected person.

How To Identify A Hazard

Before the start of a shift or new procedure, equipment should be checked, and surroundings should be reviewed for potential hazards, especially around high-risk areas. When designing the workflow, consider the potential hazards involved, e.g. installing a new office kitchen consists of a myriad of dangers. If you are installing new machinery, consider its features and its impact on the immediate environment.

During Work

While tasks are being completed, ensure staff are aware of any changes. If something abnormal happens, whether that is a new smell, an unusual sound or simply an intuitive feeling, it should be clear to whom and how they should report it.

After Accidents

All accidents or injuries should be reported to Management and recorded in the accident book, including details of the full circumstances so that risks from hazards can be identified and minimised or removed.

Health and Safety Inspections

Informal and formal inspections should take place regularly, with full focus on hazard identification. A Health and Safety Supervisor or, in bigger companies, a Health and Safety Committee should take charge, planning and reviewing the results of inspections.

To make sure that no hazards are missed:

- Remember all stages of the working day, not just the main tasks. Include non-routine activities such as maintenance and repairs or cleaning.
- Look at all components of each process; all equipment and materials involved, as they may not be stored together during inspection.
- Make sure you speak to individual workers. They may have vital information that is not obvious from simple observation alone.
- Read records from previous accidents and injuries – what happened and has it all been fixed?
- There will also be risks to visitors or the public, take these into account.

To be completely thorough, it is important to imagine yourself in various scenarios. Ask yourself the following questions:

- 1. Which materials could I come into contact with?
- 2. What materials or equipment is being used?
- 3. What could I hit myself on or get myself stuck in?

- 4. What could I fall from or off?
- 5. What could I slip on or trip over?
- 6. How could I overexert myself?

Try to be imaginative and think about all of the possible things that could happen, even if the chances are minimal. Think about what would happen if violence happened in your workplace, and staff members behaved in a more erratic way than usual? What would happen if unauthorised visitors entered the building? What if a staff member was working alone and there was a fire?

How Do I Determine Risk Level?

We know from the earlier definition that a risk is a 'degree of likelihood'. But how do we work this out?

Firstly, look at the people involved. If you are working in a school and there are hundreds of children running around, there is a higher chance of them not noticing a hazard. Older, frail people may have problems with mobility or eyesight and may also miss a hazard. Young, inexperienced workers may not yet have adequate health and safety knowledge. Think also of other vulnerable groups: pregnant women, foreign workers with experience of different regulations and disabled staff or visitors.

Secondly, look at the time. How long has the risk been there and how long will it stay there? Is this a busy time of day, or is there a particularly significant event coming up?

Finally, keeping the above people and time in mind, look at the place. How many people will come near the hazard, and how often? What other hazards may be nearby?

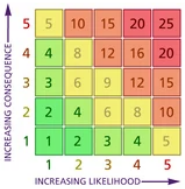
Introducing Risk Assessments

You have now been introduced to the concepts of hazard and risk, and should now understand what's the difference between hazard and risk. However, the chances are, you will find that your workplace is riddled with hazards, all posing different levels of risk. So how do you put everything into an effective prioritised list? The answer is with a Risk Assessment.

To identify and prioritise potential risks, they must be assessed and acted on accordingly. The best way to do this is to ask yourself the following two questions:

- 1. How severe will the consequences (or harm) be?
- 2. How likely is it to happen?

There are different methods you can use to carry out a Risk Assessment. This blog looks at the 5 x 5 matrix method. To use this method, the person carrying out the Risk Assessment would issue a numerical value between 1 and 5 for likelihood of the hazard causing harm and also give the consequence a numerical value rating between 1 and 5. Then multiple the two numerical values together to work out the risk rating (Likelihood x Consequence = Risk Rating).



Download Our Risk Assessment Template

Our 5x5 Risk Assessment template helps you quickly identify any risks via our risk rating calculator

What's the Difference Between Hazard and Risk : Real Life Scenarios

Here are two scenarios that could happen in real life, featuring different forms of hazard and risk, then we have provided an example of the Risk Assessment for each.

- Example 1: An Office Spillage

Jane cleans the office of a busy law firm every evening between 10 pm and midnight. Part of this job is mopping the lobby floor. One night, while doing so, Jane kicks the mop bucket and knocks the water and cleaning agent mix onto the floor. Jane needs more water to finish the job, so takes the empty mop and bucket upstairs to refill before she can finish the job and clean up the spillage. She displays a caution wet floor sign to warn others of the spill.
Where is the hazard? In this case, this is the liquid spillage on the floor.
Who can be harmed? Cleaner, lawyers working late, security guards.
What is the likelihood of harm? The lobby is at its busiest during the day and has minimal footfall at night. There are occasionally lawyers working late, and security work in the buildings 24 hours a day. Therefore, there is a risk, but it would be lower than a comparative time of 10am-12pm. Within 15 minutes, Jane will have cleaned the spillage. The likelihood would, therefore, be a 2 (unlikely).
What is the potential consequence of harm? A member of staff could slip and injure themselves. Most of the law firm employees are young and physically able. A fall is likely to result in bruising or possibly a sprain. The severity would, therefore, be at a 3 (moderate risk).
Risk Assessment score: 2 x 3 = 6 (adequate).

- Example 2: Care Home Carpet

A carpet tile has come loose in the middle of a corridor in a busy care home, with a corner sticking up an inch in the central walkway. The walkway provides access to the resident rooms, living area and the staff kitchen.
Where is the hazard? The hazard is the defective, loose carpet tile.
Who can be harmed? Elderly residents, employees and anyone visiting the care home.
What is the potential consequence of harm?
A fall for an older person can cause severe injuries, including broken bones and the need for extended hospital time. A fall for a busy care home staff member could result in moderate injuries and potential loss of earnings. This is severe, so 4 (major).
What is the likelihood of harm? Being a care home, there is an unusually high level of people with restricted mobility and of fragile health. Further, care home staff are often very overworked and may be rushing to complete their work, increasing the risk even more. Older people with poor eyesight or spatial awareness have less of a chance of seeing the problem and avoiding it. An accident is very likely, so 5 (very likely).
Risk Assessment score: 4 x 5 = 20 (unacceptable)
As you can see, a risk rating of 20 is unacceptable in terms of risk. Control measures such as fixing the carpet needs to be implemented to reduce the risk.

What Are The Next Steps?

So, now we know what's the difference between hazard and risk, and how we use the two together to assess potential danger. But how do we ensure we are utilising this information properly to stay within the law?
The Management of Health & Safety at Work Regulations 1999 stipulates that employers must carry out Risk Assessments to be legally compliant. The five steps to a Risk Assessment are:

- 1. Identify potential hazards associated with work activities
- 2. Identify those at risk from those hazards
- 3. Implement control measures (how are you managing the risks now, what more could you do)
- 4. Record the findings of the Risk Assessment
- 5. Review the Risk Assessment regularly

Incorporating these five steps into your routine will ensure you stay on a clear path to excellent health and safety. So now, you can answer the question: "what's the difference between hazard and risk ?" and answer confidently. Follow the lessons learnt in this guide, and you will be one big step closer to keeping your workplace and those within it happy, healthy and safe.

SHORT WAVE

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October 3, 2022 · 12:10 AM ET

14-Minute Listen

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EMILY KWONG, HOST:

You're listening to SHORT WAVE from NPR.

OK, Aaron, I want to tell you a little bit about Sitka. So this is the town in Alaska where I used to live and report. And there was one day that honestly changed people's relationship to the weather.

AARON SCOTT, BYLINE: Emily, I love your Sitka stories, so I'm all ears.

KWONG: Yeah. Sitka's on an island on the edge of the Pacific Ocean in the Tongass National Forest. It's beautiful there, and it rains a lot - over 100 inches a year.

LISA BUSCH: We have beautiful rivers with salmon, and the salmon need rain. Our ecosystems need a lot of rain.

KWONG: This is Lisa Busch, executive director of the Sitka Sound Science Center.

BUSCH: You know, all of this is like, this is - we are rain people. We are people of the rain.

KWONG: And Lisa never feared the rain before. But the morning of August 18, 2015, was different.

BUSCH: I remember my pants getting wet, like, all the way up to my knees, just walking from my car to the airport. So I remember thinking, this is a lot of rain, a lot of rain.

KWONG: Rivers in town began to rise, and the land started to slide. Forty landslides were documented on Baranof and Chichagof Islands that day. A slope above a subdivision of new homes under construction gave way.

This landslide, the Kramer Avenue landslide, demolished a building and took the lives of three Sitkans - brothers Elmer and Ulises Diaz and Sitka's building inspector, William Stortz. I heard the news at the radio station. Lisa heard it on the plane.

BUSCH: I mean, I knew all the people who died. I knew all the people who were affected. I knew lots of people who were searching for these people. It's hard to get your head around.

KWONG: And the feeling in town that day was just one of precarity. The sky was so gray. There were these thick clouds that were almost pressing down. And the mountains - you don't think about mountains moving, right? But looking around, the geology suddenly didn't feel so static. For days, Sitkans were shoveling debris, cooking casseroles, keeping vigil with the families of those lost and coordinating shelters for those evacuated.

UNIDENTIFIED PERSON #1: I can stay with a friend, so my whole house is open.

UNIDENTIFIED PERSON #2: Chartereis (ph) has room.

KWONG: These are locals reading Facebook posts written at the time.

UNIDENTIFIED PERSON #3: My home is very small. But I can offer food, blankets.

UNIDENTIFIED PERSON #4: (Speaking Spanish).

KWONG: Keith Perkins of Sitka wrote this the day the last missing person was recovered.

KEITH PERKINS: (Reading) The sun set tonight in Sitka. Seven days from a horrific moment, a day of warm sun, the day Sitkans helped bring out our third friend home to his family, the day that marks closure, the day that begins a healing process for the community.

SCOTT: Emily, no matter how much you read or hear about natural disasters in other communities, nothing prepares you for when it happens to your own community.

KWONG: Absolutely. And I wanted to take you back to this moment so you could understand everything that happened after because the thing for Lisa, the Sitka Sound Science Center to do was to get answers. Why did this happen? Why did this rain tip the scale the way it did? Why Kramer Avenue? And how do you stop a tragedy like this from ever happening again?

SCOTT: Yeah. I mean, those are huge questions. Who do you call for something like that?

KWONG: You call scientists.

SCOTT: Of course you do.

KWONG: You know, my boss at the time, news director Rob Woolsey, said the answer is literally a puzzle, and everyone's holding a different piece. And Lisa dialed everyone - NASA, the National Forest Service, the National Park Service, the U.S. Geological Survey.

BUSCH: They responded so quickly. Yes, how can we help? All these scientists said, yes, we can help you with our expertise.

KWONG: With the goal of creating something Sitka and, really, the United States had never seen before - a community-based early warning system for landslides. This is the story of how scientists and locals found common ground to protect a community from disaster.

I'm Emily Kwong.

SCOTT: I'm Aaron Scott. And you're listening to SHORT WAVE, the daily science podcast from NPR.

(SOUNDBITE OF MUSIC)

SCOTT: So, Emily, introduce us to Sitka's landslide early warning system.

KWONG: I am going to do you one better, Aaron. It just launched last month, so can I show it to you?

SCOTT: Yes, please. Website? App? What should I look at?

KWONG: It's a website. It's like a digital dashboard. So take out your phone or your laptop. Type in sitkalandslide.org. Tell me what you see.

SCOTT: OK. So I'm looking at a clean page. There's a green checkmark that says the current risk of landslide is low, and the 24-hour forecast is also low. So this is great. This is reassuring.

KWONG: Mmm hmm. It kind of works like a traffic light system.

SCOTT: Right, right, right.

KWONG: And you saw for yourself it's really simple to look at. But developing a system that's both science-backed and user-friendly took seven years, a $2.1 million grant from the National Science Foundation and the involvement of an entire town.

SCOTT: Yeah, and a town that had just gone through a massive tragedy.

KWONG: Yeah. I mean, parents, a year after the landslide, were still calling the school district when it rained, asking, is it safe to send my kid to school?

SCOTT: Wow.

KWONG: And the superintendent - she was used to determining a snow day based on road conditions, but she had no frame of reference for when to call a rain day.

SCOTT: So if you're surrounded by these hillsides, how do you know which ones are at risk of sliding?

KWONG: Yeah, this is the where piece of the puzzle. Where do landslides happen?

I'm going to let Jacyn Schmidt, a local geologist, show us that.

JACYN SCHMIDT: Hey, Emily. Here in the field.

KWONG: Jacyn is the geoscience coordinator at the Sitka Sound Science Center, heavily involved in this project. I asked her to hike us to the origin point of an old landslide.

SCHMIDT: A debris flow happened here couple of years ago. And I'm at the head scarp, so it's the place where it all started.

KWONG: A debris flow - that's the type of landslide we're talking about here.

SCOTT: OK.

KWONG: It happens when you get a lot of water in the system, water that travels down through gravity and transforms layers of earth into a slurry of mud, water and other debris, taking on the consistency of wet cement. It can move up to 25 miles per hour, giving you very little time to get out of the way. It almost looks like the mountain has liquefied and has turned into a river coming towards you.

SCOTT: And so this is what happened on Kramer Avenue in 2015?

KWONG: It is. And Jacyn says a part of what makes Sikta landslide-prone is that the land is young. It hasn't had a lot of time to pack together and consolidate.

SCHMIDT: And you can see the layers that are making up the geology of slopes here.

KWONG: If you read the layers, you learn the story of how Sitka came to be. So the top layer is the Tongass Forest, the pretty stuff.

SCHMIDT: Where there's grasses and mosses and berries. Blueberries are ripe.

KWONG: Underneath that is the volcanic ash, which is called tephra.

SCHMIDT: It's a little bit orange in color. And when I rub it between my fingers, it's superfine material.

KWONG: And this tephra settled out of the air from blankets of ash spewed up by Mount Edgecumbe, the local volcano, about 10,000 years ago.

SCHMIDT: Then underneath the tephra, there's some glacial till. It's this gray, unconsolidated. When you run your hand over the rock, it just falls off.

KWONG: And it's only below all that that you finally reach the bedrock. So the layers of land - they're just not packed together super tight. It's more like a loose lasagna.

SCOTT: Emily, the fact that she can rub the tephra between her fingers and that the glacial till, like, breaks off when she just brushes against it with her hand...

KWONG: Yeah, I know.

SCOTT: ...Like, it's scary how unstable that sounds.

KWONG: It is typically very stable, by the way. It's just when it rains.

SCOTT: OK.

KWONG: But the soil - it does contain a clue. There are scars of old landslides all around Sitka. And geology tells us that new landslides are likely to form in the footprint of these old landslides, which is telling. So when Sitka's geo task force started discussing that, the Forest Service, Lisa says, was like, hold on.

BUSCH: Well, we have a landslide inventory that we've been keeping track of for the last 50 years in the area. Would that be helpful? And we were all like, what?

KWONG: Historical data? Yes.

BUSCH: Hello? We didn't even know that they were doing that.

SCOTT: I love it when discovering a database is like discovering hidden treasure.

KWONG: Yes. And that trove of data wound up in the hands of Annette Patton, a post-doc at the University of Oregon and now lead geologist on this project. So with a sense of how slopes have failed before, the ridge above Kramer Avenue being one of them, Annette, along with Josh Roering at the University of Oregon, wanted to know what amount of rain tips the balance.

SCOTT: So, like, do certain amount of rainfall predictably lead to landslide risk?

KWONG: Something like that, yeah.

ANNETTE PATTON: Like, if it rains really hard for a day, is that what triggers a landslide? If it rains really hard for an hour? So we didn't know for sure exactly what timescale of heavy rainfall would trigger a landslide. So that's where we wanted to start.

KWONG: So Annette combined this landslide inventory that the Forest Service happened to have with Sitka's rain record - 20 years of data gathered at the airport. And after a lot of number crunching and statistics, she started to see a pattern. Five of the most catastrophic landslides in the last decade, ones that blocked roads, destroyed human life and property - they all saw a certain amount of rain in a three-hour interval.

SCOTT: Ooh, this is like a rain mystery. So how much? How much rain?

KWONG: It's not an absolute because the model is more designed to calculate probability. So a high-risk probability warning is triggered around 1.3 inches of rain in a three-hour interval. Before the Kramer Avenue landslide, 1.7 inches fell between 6 and 9 a.m., so it was like a whole day's worth of rain happened in that three-hour time period.

SCOTT: That's a hard rain. So what's great about this, though, is that it's taking this unpredictable thing - rainfall and landslides - and then putting some order on it. And we can then start to decode what might lead to these disasters, right?

KWONG: That's the question. And the pieces started coming together. We had where. We had why. Annette built an algorithm that pulled all of that information into one place. And that's the basis of Sitka's early warning system. The Science Center - they also installed soil sensors in the three slopes most at risk - Gavan Harbor and Verstovia - and 10 of these tipping buckets in people's backyards. These are just designed to measure local rainfall totals.

SCOTT: And so they're building up infrastructure on the ground to gather even more data in the years to come and kind of move into the future of this.

KWONG: Yeah, it's very Alaskan. You know, if you give people the chance to get involved, they will get involved. So the Science Center - they consulted the community as much as possible. Sitka Tribe of Alaska got involved. They contributed traditional knowledge about landslides and human movement. That's on the dashboard. And to make sure the warning system actually reaches everyone in town, the Science Center

decided to map the social networks. Robert Lempert led this part. He's a senior scientist at the RAND Corporation and did all these co-design workshops.

ROBERT LEMPERT: We ran a game, an exercise where we asked everybody in the room - and there's about 20 people or so - to fill out a little form and say, whom in the room would they take shopping for clothes to get good advice on, you know, what to buy?

SCOTT: I love this, Emily. So the people we trust most are the people we know will give us honest feedback on what we're wearing.

KWONG: (Laughter). Yeah. And certain names kept coming up again and again. Social network mapping identified 50 super connectors in Sitka, 50 people who should know about the landslide early warning system.

LEMPERT: And this idea that you've got individuals who have worked through the process who now, you know, trust this body of information, trust each other.

KWONG: Basically, any innovation in geo hazard science is meaningless if there aren't innovations in human preparedness and scientists taking the time to do this work thoughtfully and people willing to show up for that. This kind of collaboration - it's only becoming more important, right? I mean, these landslides - they're connected to climate change. Southeast Alaska is going to see more extreme rainfall.

SCOTT: Yeah. I mean, a lot of places are going to see more rainfall, which raises the question, are other communities taking note of this project?

KWONG: Yes. Yes, communities who also worry about landslides and other things. Which is why the Science Center hopes to bring this predictive modeling to six other rural and tribal communities in southeast Alaska.

SCOTT: Oh, great.

KWONG: The NSF-funded project, which is called Kuti, which is the Tlingit word for weather, helps to create a regional system for warning people about flooding, avalanches and landslides. These natural hazards can't be stopped, at least not yet. But Lisa Busch says people can learn to live with them.

BUSCH: To me, it's heartening to see a community adapt and move on. Yes, we have to live among landslides. We have to live in a changed world, and that's not easy. But it's heartening when people do it.

KWONG: Especially, Aaron, I think, at the local level to keep people safe. I can't think of a better use for science.

SCOTT: Emily, thank you for bringing us this story from Sitka.

KWONG: My pleasure, Aaron.

SCOTT: This episode was produced by Chloee Weiner and edited and fact-checked by Gabriel Spitzer. The audio engineer was Ko Takasugi-Czernowin.

KWONG: Special thanks to KCAW Sitka, especially Robert Woolsey and Katherine Rose. And to the following Sitkans - Megan Pasternak, Brooke Schafer, Paul Norwood,

Keith Perkins and Jason Schmidt (ph). Beth Donovan is our senior director, and Anya Grundmann is our senior vice president of programming. I'm Emily Kwong.

SCOTT: I'm Aaron Scott. Thanks, as always, for listening to SHORT WAVE from NPR.

(SOUNDBITE OF MUSIC)

SCIENCE
Tweeting directly from your brain (and what's next)

Wednesday, January 19, 1972, 32 years ago, A Clear, Eventful, EXTREMELY WINDY, Very Cold day with Taku Winds.

Mt. Juneau, 3,576 feet, Juneau, Alaska. The avalanche originated at the top of the streak of white running down the mountain right of center. Mt. Maria is the foothill to the right. Picture taken February 4, 2005 by O. Richard Kent.

11:07 A.M. PST (Juneau was on Pacific Time then):

KINY Radio's tower (reported to be 500' tall) on the A.J. Rock Dump blew over, putting 1 of the only 2 radio stations in town at the time off the air. Gusts were to some 100 m.p.h.; chill factor -60 degrees below zero.

2:15 PM PST (Approximately):

A HUGE Snowslide on Mt. Juneau at the main waterfall-drainage visible from downtown Juneau on the Last Chance Basin side of the mountain.

Speed of the air blast is estimated at 180 m.p.h.

Downtown Juneau including the Federal Building is engulfed in the tremendous billowing cloud of snow, snow reaches Douglas Island and our house. To this date (January 19, 2004) there has not been an avalanche since in any way equivalent to the 1972 avalanche.

RESULTING IN:

Gold Creek is dammed by the slide and Basin Road along the NW side of Mt. Maria is buried under the snow.

The Municipal Water System of Juneau is put out of commission for 2 days because of the destruction of the Spring Line where it crosses Gold Creek and the electric power lines in Last Chance Basin that supplied power to the well pumps were damaged. A check valve at the 8th Street Reservoir then malfunctioned because of a block of wood, allowing the water to drain out of the reservoir. Because of the 40" - 45" of snow in the front yard of 3270 Nowell Avenue (then numbered 240) there was plenty of snow to melt for water..the bathtub was filled with snow so it could melt and be an in-house reservoir.

One of the pictures of the slide as it happened, taken by Juneau resident Jonathan "Skip" Gray from the A.J. Rock Dump was featured in the September 1982 issue of "National Geographic" on pages 292-293 in the article "Avalanche! Battling the Juggernaut" pages 290-305.

MEANWHILE ON DOUGLAS ISLAND:

Mrs. Marie Kent in the morning was holding a "Sarah Circle" women's church group meeting at the house and wondering if the large windows in the Living Room were going to blow out from the wind. When the avalanche occurred and the snow reached 240, Mrs. Kent did not know immediately what was happening.

David the author, was in Gastineau Elementary School on 3rd Street in

Douglas in the 4th grade classroom of Mrs. Kreuzenstein listening to the Taku winds whistling through the gaps in the aluminum window frames. He was totally unaware of what else was going on in town; school was let out when the water system failed.

AND DOWNTOWN:

Mr. O. Richard (Dick) Kent Contracting Officer for the U.S.D.A. Forest Service in Room 527 on the 5th floor (SE side of building...the side opposite Mt. Juneau) of the Federal Building came home at +/- 4:00 P.M. after the Juneau water system failed and the 8th Street reservoir had run dry (no water at 240 Nowell by 3:45 P.M.). Earlier in the afternoon Mr. Kent had come home to tie down the tarps over our 22' Sabre Craft cabin cruiser boat stored in the front yard, which were being torn off by the winds.
