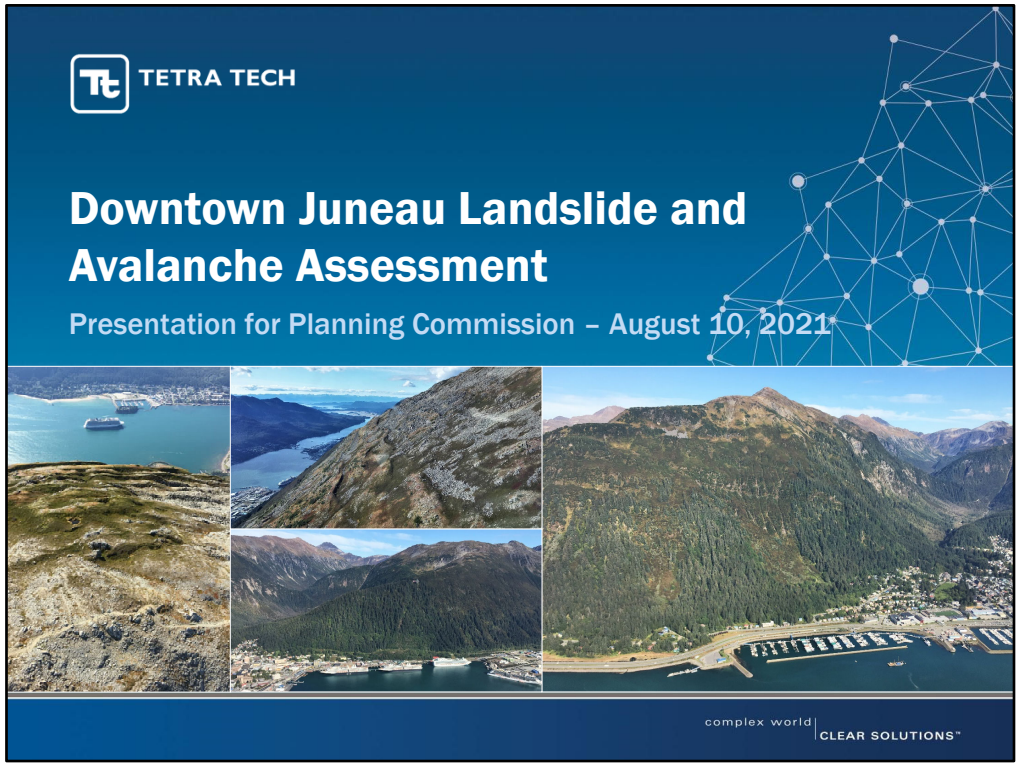
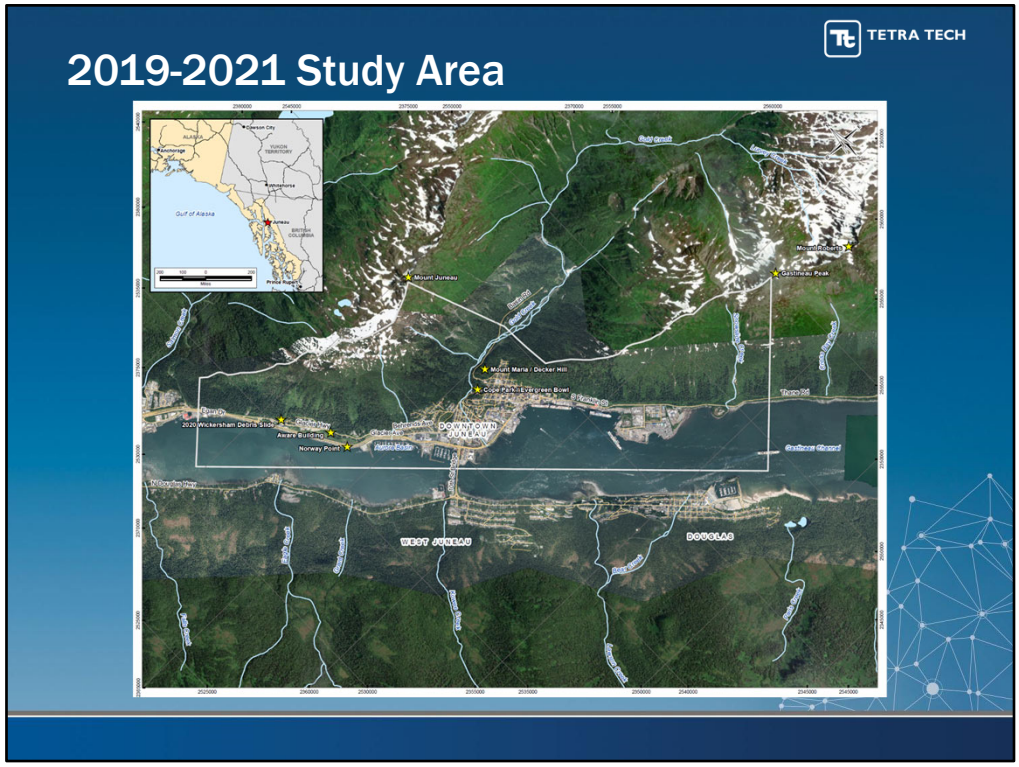


Good evening, everyone. It's a real pleasure for us to join you online tonight. We'll be summarizing the findings from the Landslide and Avalanche Assessment, and we'll have some time for answering your questions at the end of the presentation.

Thanks for your introductions, Teri. I'm Alan Jones from Dynamic Avalanche Consulting and I'll start us off with a summary of the avalanche mapping. Then Rita Kors-Olthof from Tetra Tech will continue with a summary on the landslide mapping and a bit of landslide history in Juneau. Vlad Roujanski can explain more about the mapping procedures if anyone would like more information about that later on.



Here's the project mapping area. You'll notice that we've tipped the image so that northwest is to the left and southeast is to the right along Gastineau Channel. That's so that we can fit more on the page for each of the maps. The mapping extends northwest almost to the Macaulay Salmon Hatchery, and southeast to just past Snowslide Creek.

TETRA TECH

Snow Avalanche Hazard - Study Objectives

- Identify (map) avalanche paths within the Study Area, including initiation, track and runout zones
- Field investigations
- Technical analyses
- Prepare avalanche hazard designation mapping with *Low*, *Moderate* and **Severe** hazard designations

TETRA TECH

Tasks completed and methods

- **Reviewed and analyzed:**
  - Snow climate data
  - Previous reports and studies
  - Historic avalanche occurrence records, magnitude-frequency analyses
  - Air photos, satellite imagery, LiDAR data
- **Field investigation to observe terrain, vegetation, evidence**
- **Meetings with Juneau-based avalanche experts**
- **Dynamic and statistical avalanche modelling**

TETRA TECH

Avalanche Hazard Designation System

- Reviewed US, Canadian, European systems
- No US national guidelines or standards, determined by town/county
- Most systems based on combination of magnitude (e.g., impact pressure) and frequency, 3 or 4 categories
- CBJ designations equivalent to White/Blue/Red zones (Eur., Can.)

Table 2.3: 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/ft² (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/ft² (30 kPa).
Severe	S	▪ Return period less than 30 years; AND/OR ▪ Impact pressure greater than or equal to 600 lbs/ft² (30 kPa).

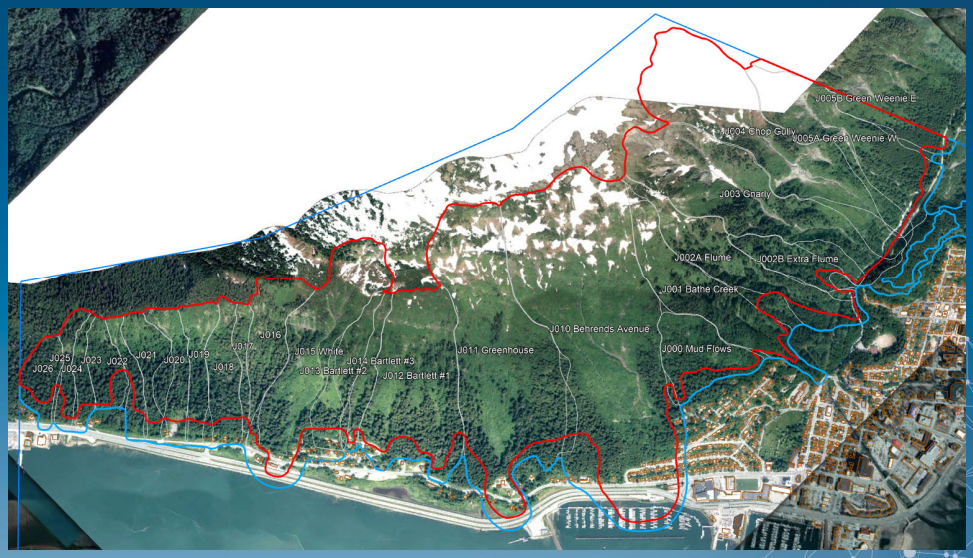
TETRA TECH

Avalanche Mapping Results

- Identified 52 unique avalanche paths, each was assigned *Severe*, *Moderate* and *Low* hazard areas.
- Paths identified in 3 areas: Mt. Juneau (25 paths), Gastineau Ave. (11 paths), Thane Road (16 paths).
- Paths mapped to delineate a 300-year hazard boundary for destructive flow (dense and/or powder)

TETRA TECH

Example: Avalanche Mapping Results – Mt. Juneau



TETRA TECH

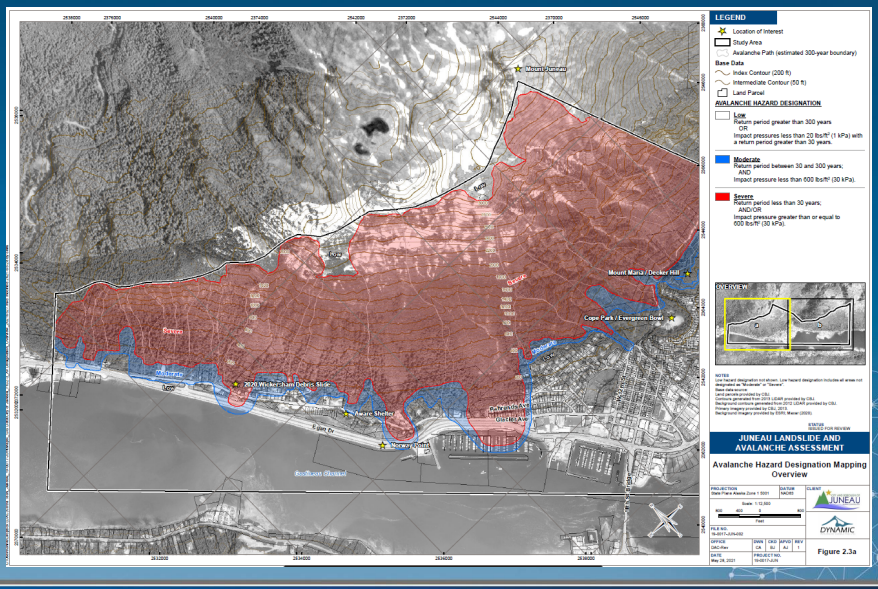
Avalanche Hazard Designation Mapping

- Designates areas in Study area as Low, Moderate or Severe

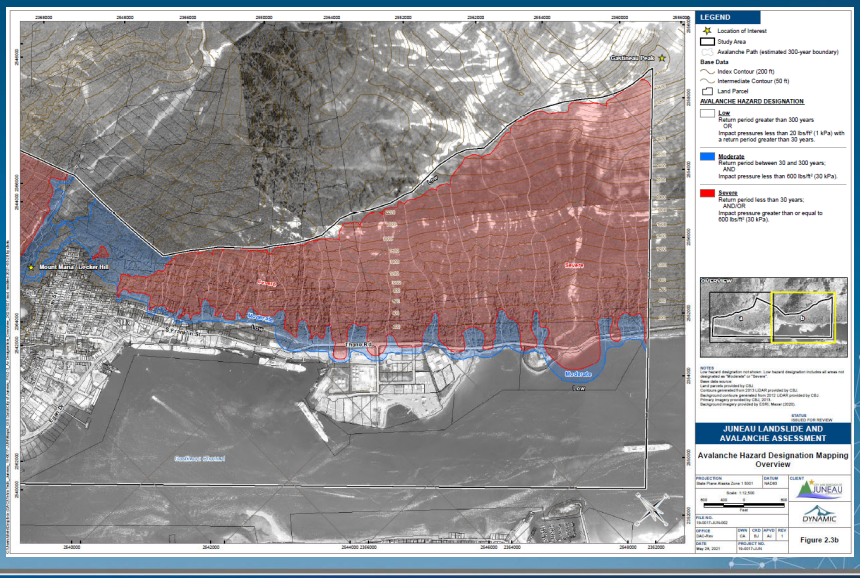
- ***Severe*** hazard: typically includes initiation zone and track, lower return period (< 30 years) AND/OR higher impact pressure (>= 600 lbs/ft^2)
- ***Moderate*** hazard: longer return period (30-300 years) AND lower impact pressures (< 600 lbs/ft^2)
- ***Low*** hazard: long return period (> 300 years) OR low impact pressure (< 20 lbs/ft^2) (typically powder impacts)

TETRA TECH

Avalanche Hazard Designation Mapping – Mt. Juneau



Avalanche Hazard Designation Mapping – Gastineau Ave. and Thane Road



TETRA TECH

Conclusions

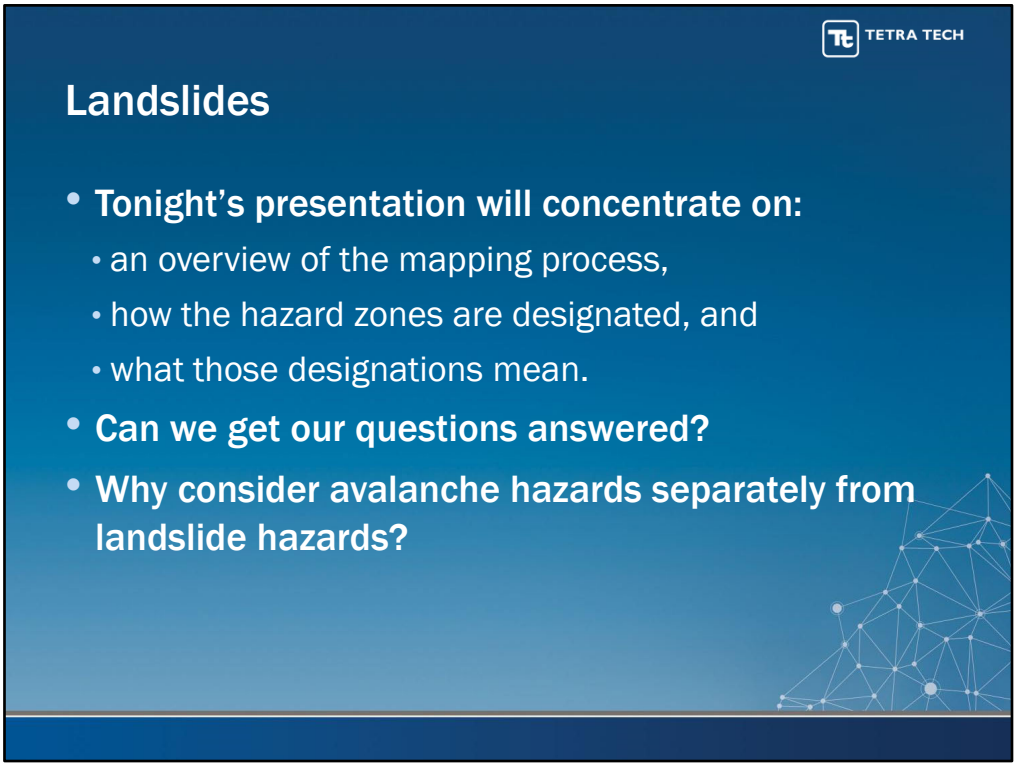
- Identified 52 avalanche paths, each with Severe and *Moderate* hazard areas. Areas beyond path boundaries are *Low* hazard.
- Paths divided into 3 areas: Mt. Juneau (25), Gastineau Ave. (11), and Thane Road (16).
- Level of assessment is suitable for CBJ to determine whether or not land areas could be affected by avalanches
- Continued use of 3-level hazard designation is recommended (Low, Moderate, Severe) with four modifications (see report)
- UAS is completing studies into effects of climate change on the avalanche regime – results will be considered as they become available.

TETRA TECH

Limitations

- Avalanches are complex, uncertainty in the estimates of frequency and magnitude. Uncertainty reduced by combining and weighting results using various methods.
- Boundaries between *Low*, *Moderate*, *Severe* areas are not hard lines, but rather as transition zones – they do not follow property lines or other development lines (e.g. roads)
- Hazard designation maps use data provided by CBJ. Changes in property boundaries and terrain could change boundaries.
- Assessment not completed to a level suitable for determining specific hazard mitigation for properties. Mitigation measures should be determined with additional, site-specific investigation(s).
- Change in forest cover (e.g. fire, disease, pests, landslides, climate change) could change hazard (or create new paths).

Hi everyone, I'm Rita Kors-Olthof. Vlad Roujanski and Shirley McCuaig are here with us tonight too, and they can explain more about the landslide mapping procedures if anyone would like more information about that later on.



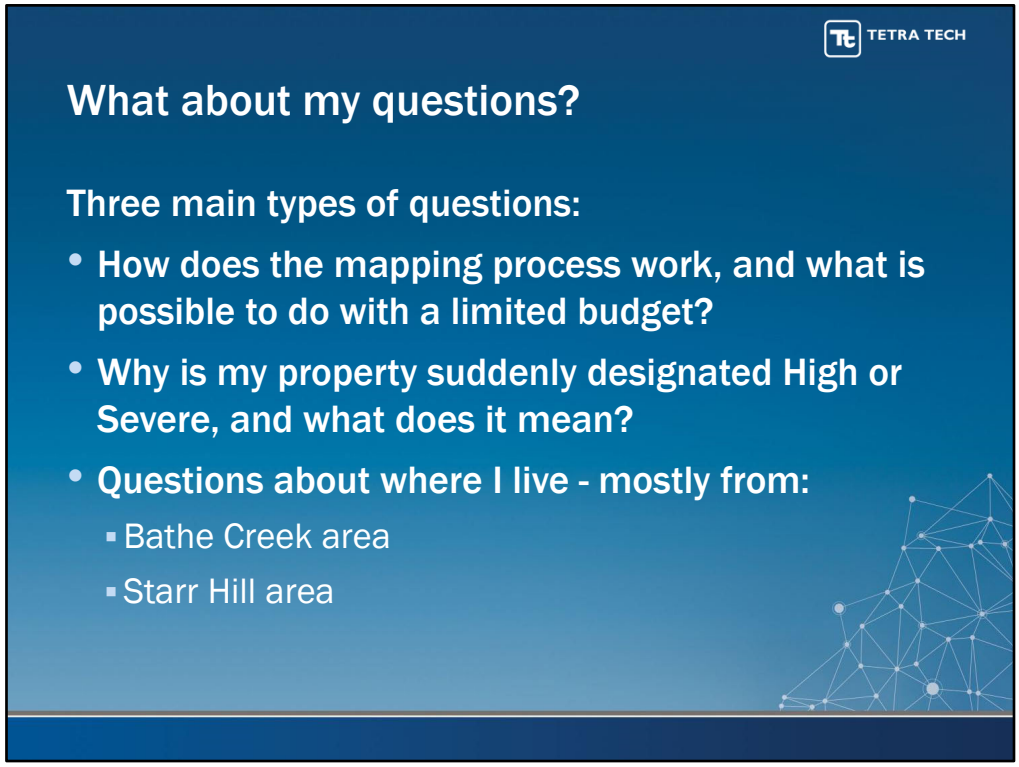
Tonight, our landslides presentation will concentrate on:

- an overview of the mapping process,
- how the hazard zones are designated, and
- what those designations mean.

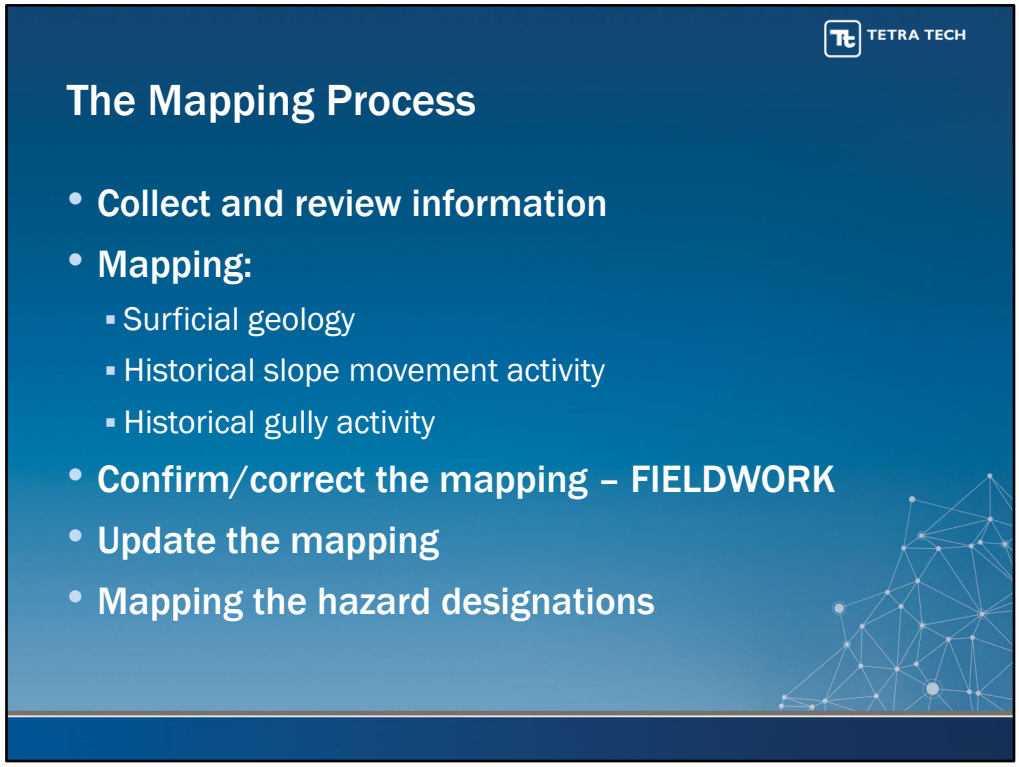
We will review the three main types of questions that have come up since the July 21 presentation and try to provide you with some answers.

Finally, we will discuss why it is important to consider avalanche hazards separately from landslide hazards.

We've also been working on some written summaries for CBJ that will cover questions from the public in more detail.

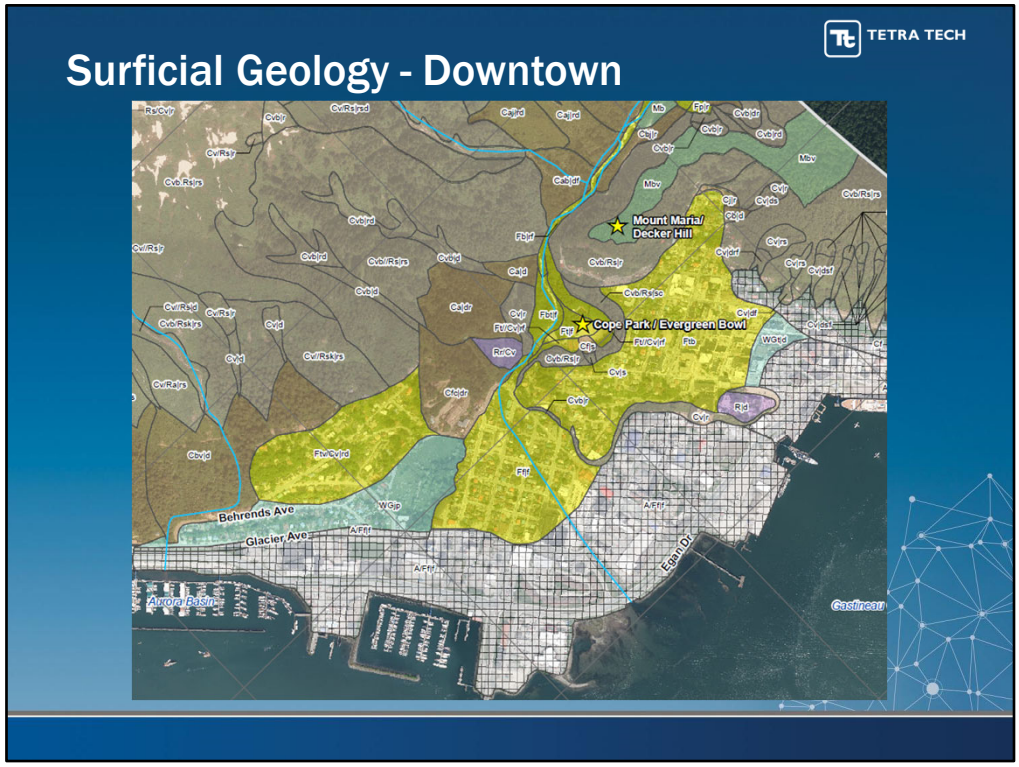


So, what about those questions? Some of these questions relate to the mapping process and what is feasible to do on a limited budget; lots of questions are from people who suddenly find themselves in a High or Severe zone; and there are a lot of questions specific to Bathe Creek and the surrounding residential areas, and to Starr Hill and the surrounding steep slopes. We've also been busy writing detailed summaries to answer these kinds of questions, and tonight we'll show you some maps and some photos to hopefully help in understanding the hazards a little better.



Here's a summary of the mapping process: [READ SLIDE]

Since we covered most of this during the July 21 meeting, and we don't have very much time allotted to us tonight, I'm going to let you review that previous presentation for the details, and just skim through the parts that were already covered. Then, I'll concentrate on the parts that people have the most questions about.

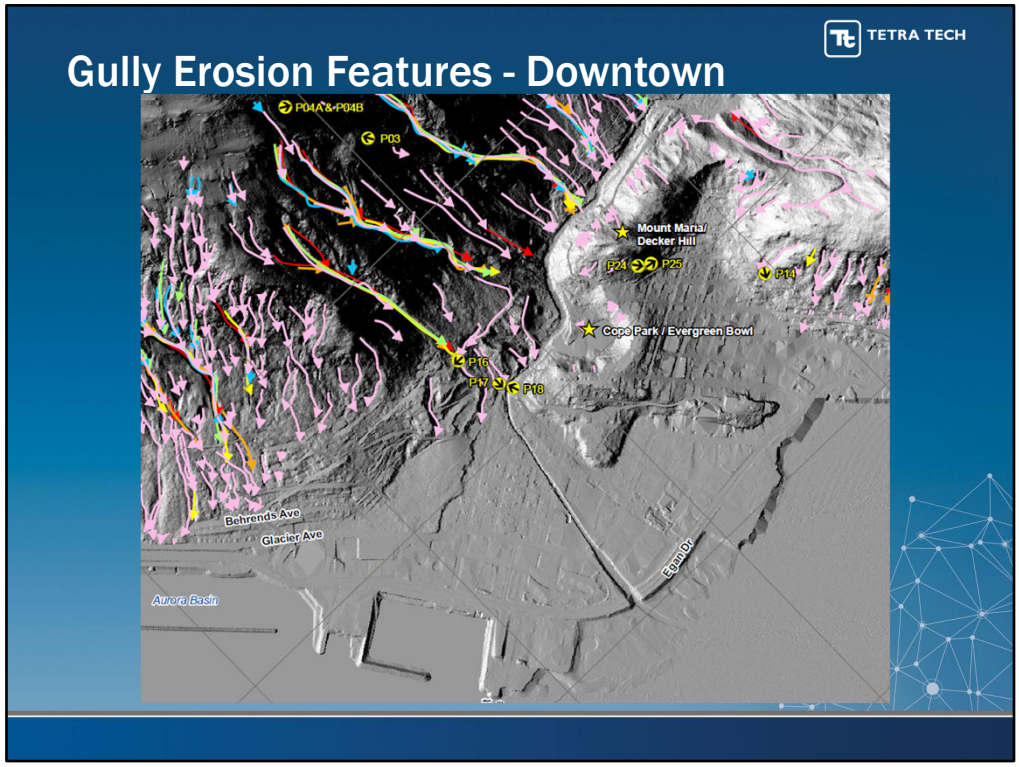


This is an excerpt from the surficial geology map for the area between Behrends and Mt. Roberts. This map was created using an ArcGIS add-on called PurView that lets us zoom in to take a really close look at different features. That means we were able to map at about 10 times the scale of the 1975 geology mapping – at 1:2000 and 1:4000 scale instead of 1:24,000 scale.

Notice the different shapes and colours that represent the different soil and rock features that were identified on the air photos. There are a lot of similar shapes in some of the later maps. This tells us that the different soil and rock features have a big influence on how the slopes behave. Remember these long narrow up-and-down strips that look a bit like the handles on a straw broom.

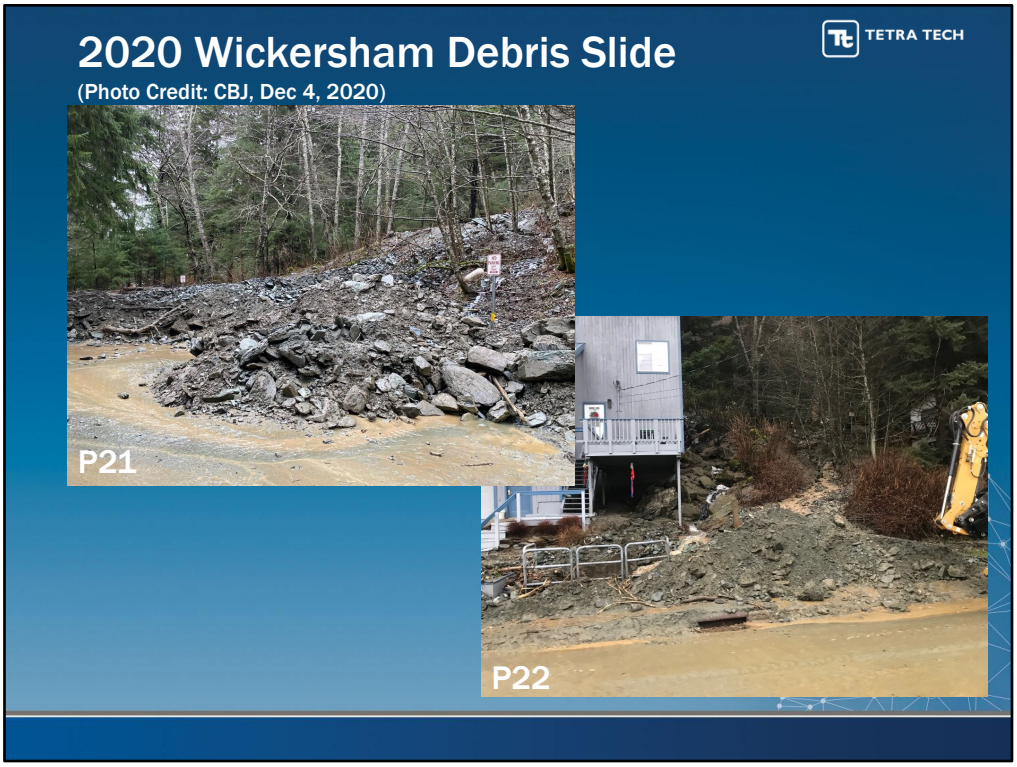
Also notice that there is a lot of colluvium on this map, and that means soil and rock that has in some way moved downhill, as a debris slide, a debris flow, a rockfall or a rockslide. Some examples of colluvium are all those cone-shaped features above Behrends and Highlands, at Bathe Creek and Gold Creek, and along Mt. Roberts too. The side slopes of Cope Park are another example, and so is Mt. Maria, where the colluvium continues around the Starr Hill subdivision.

Next, let's see what the historical records can tell us about where the slope has been moving, with evidence from the air photos, satellite imagery, site investigations, and the incident reports. The arrows and outlines that represent debris slides or rockslides are coded by colour to show which air photo year they were identified on. Now let's look at the gullies.



Here we have all the gullies that were mapped from the imagery. You might ask, why map the gullies in such detail? That's because they're another major way of moving debris downslope, like flushing water, dirt and rocks down half-pipes, and there are a lot of them! Different colours of arrows mean the gullies were mapped from different years of imagery. The pink ones are from the LiDAR, so they were easier to see.

Remember those long narrow up-and-down strips from the geology map? They show up here as major active gullies. The red arrows show gullies that were already clearly visible in 1948. Gullies with several colours tend to be a lot more active than the ones that only have one or two colours. Many of the gullies lead down to the Behrends Subdivision, alongside the Hermit/Rheinhardt Subdivision at Bathe Creek to the Irwin Street bridge, and there are even some gullies above Starr Hill.



Well, those maps look pretty interesting, but how do we check that they're accurate? One of the main ways to do that is to go into the field and inspect a lot of the features that were identified on the maps, like gullies, debris flows, debris slides, rockfalls... We did some helicopter flights, both for an overview and to reach hard-to-access areas. We did a foot traverse, covering a lot of ground in Juneau. We also spent a whole lot of time on the slopes around the residential areas. We took measurements, photos, and recorded GPS data for landslide initiation and runout zones.

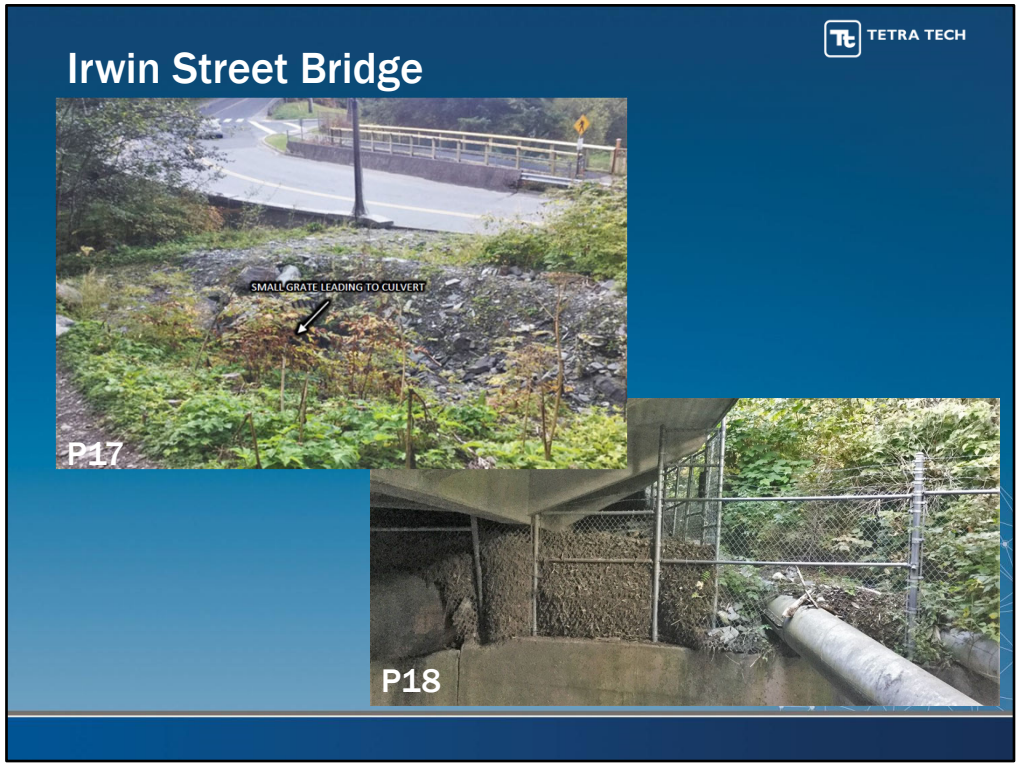
Here's an example of what gullies can do – dump a lot of debris and water where nobody wants it. CBJ told us about this one and sent us their photos.

Sometimes, we discover exactly what we expected from the maps. Other times, especially where there is a lot of thick forest, we discover that there are even *more* landslide features that couldn't be seen on the air photos, like rockfall that doesn't destroy the trees, or very narrow gullies or slide paths that hidden by the trees, such as the slopes above parts of Starr Hill. In the field, we try to collect enough information to confirm or correct the mapping. Sometimes information is also available from incident reports, or news reports.

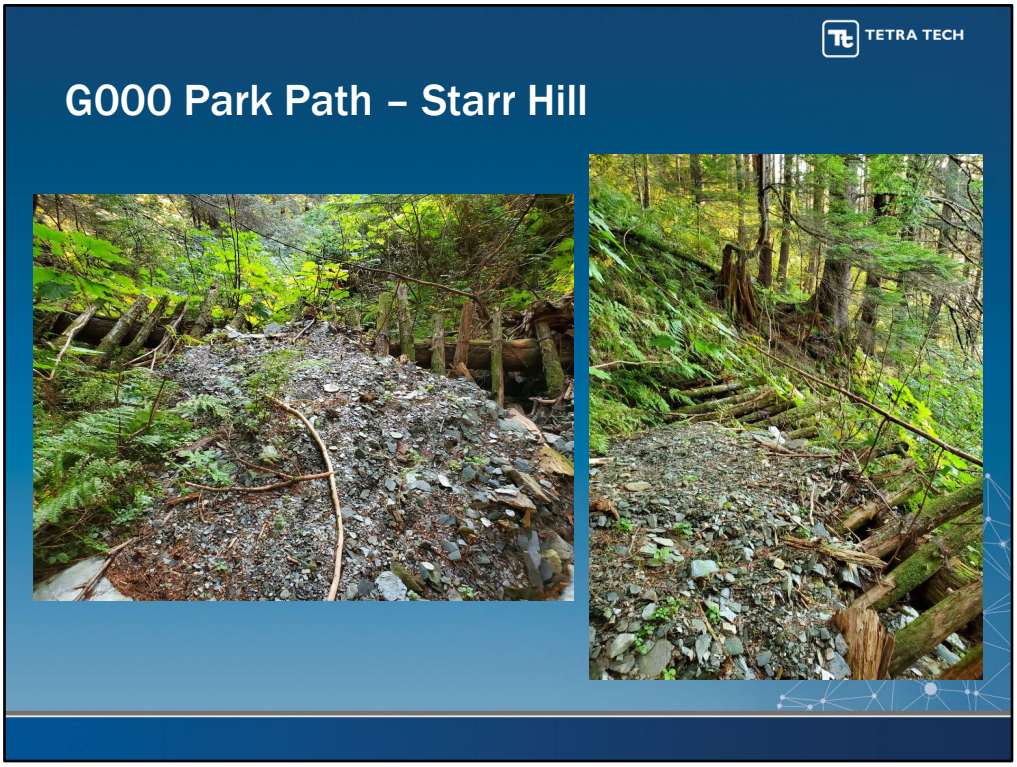
Some people have asked if landslide modelling would help to be able to get a better idea of where the trouble spots are. It might, but it would cost a whole lot more money to get better information than what we already have, based on the detailed air photo study. Landslide modelling wasn't in the scope and neither was geotechnical drilling.

2019 Gold Creek Flume Trail

Here's another gully – this photo is looking down towards the Gold Creek Flume Trail from the Bathe Creek debris flow gully. Notice the large amount of debris in and alongside the gully, as well as the scarring on the tree beside the road that extends to at least 6 feet above ground surface. This gully is very active, and the debris that is deposited at the road crossing, and that plugs the culvert, is regularly cleaned up. This road crossing has the potential to divert debris flows into the residential community downslope and to the west, especially if more than one surge of debris happens before the debris can be cleaned up. The LiDAR shows two major gullies alongside the subdivision that are otherwise hidden by trees on the air photos.

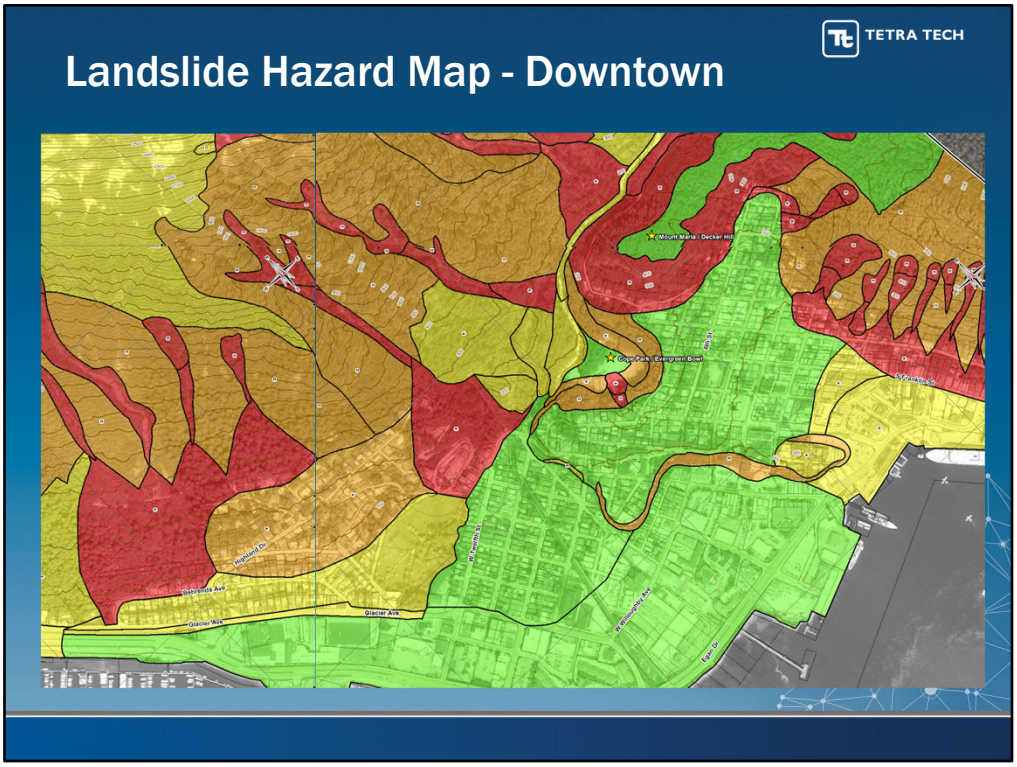


Debris flow deposits are seen at the Irwin Street bridge over Gold Creek, which receives a lot of that debris from the Bathe Creek feature. Here are a couple of photos, one looking south at the debris deposited near the bridge, and the other looking north at the debris deposited under the bridge. The debris flow gully at Bathe Creek has created two big gullies on either of the residential area, with the east end of Evergreen Avenue at the top, and Irwin Street at the bottom. Smaller gullies are also visible above Hermit Street. Any diversion of the debris at Evergreen or the Gold Creek Flume Trailhead could result in debris flowing through the subdivision.



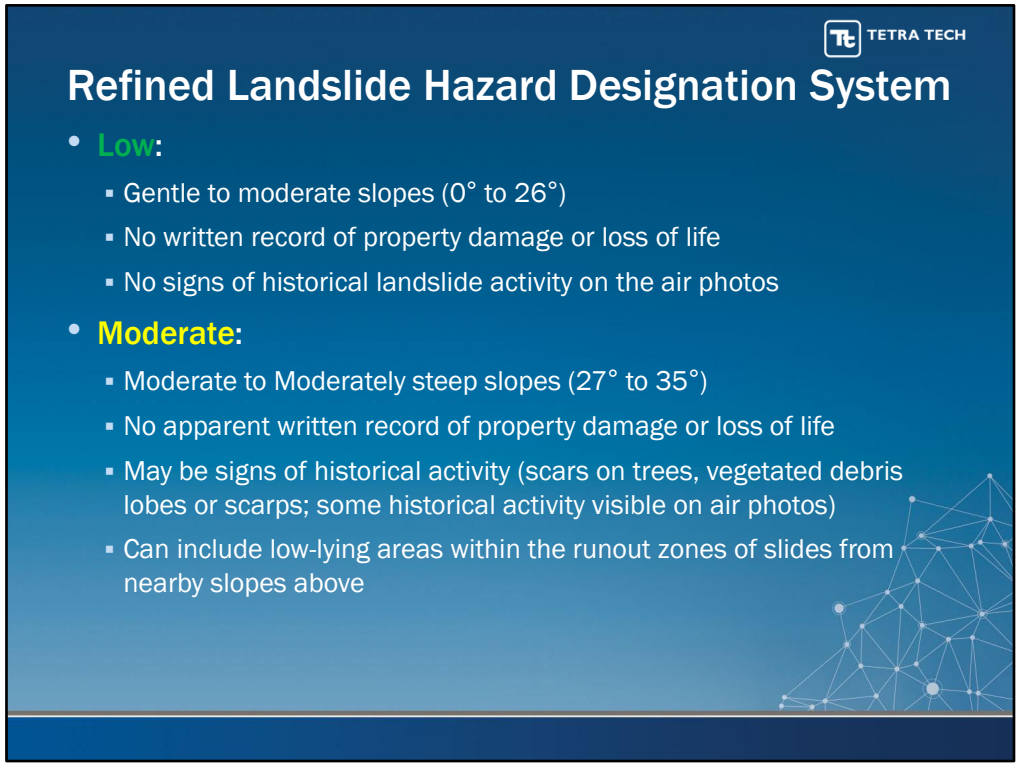
Here are a couple of different views of one of the debris-flow mitigation structures that were built by homeowners living below the G000 Park debris flow path above Starr Hill. This structure has captured debris material from one or possibly two events. Depending on the size of the next debris flow, maybe it'll retain a little more debris, or collapse, or be overrun by debris, or even be completely scoured out by a larger debris flow originating further up the gully. The homeowners currently living below this debris flow path report that some of the structures need repair or replacement.

This debris flow, and the rockfall and rock bluffs that we saw a couple of slides ago, aren't the only issue around the perimeter of Starr Hill, which is surrounded by very steep slopes. Above Nelson Street and especially at the southeast corner of Nelson and 5th Streets, there is a lot of open untreed slope that is subject to debris slides. This is most easily seen in the winter when the leaves are off, but can be discerned in summer by a variation in the colour of the vegetation. The field team spent a lot of time in this area, looking at the slopes above every house.



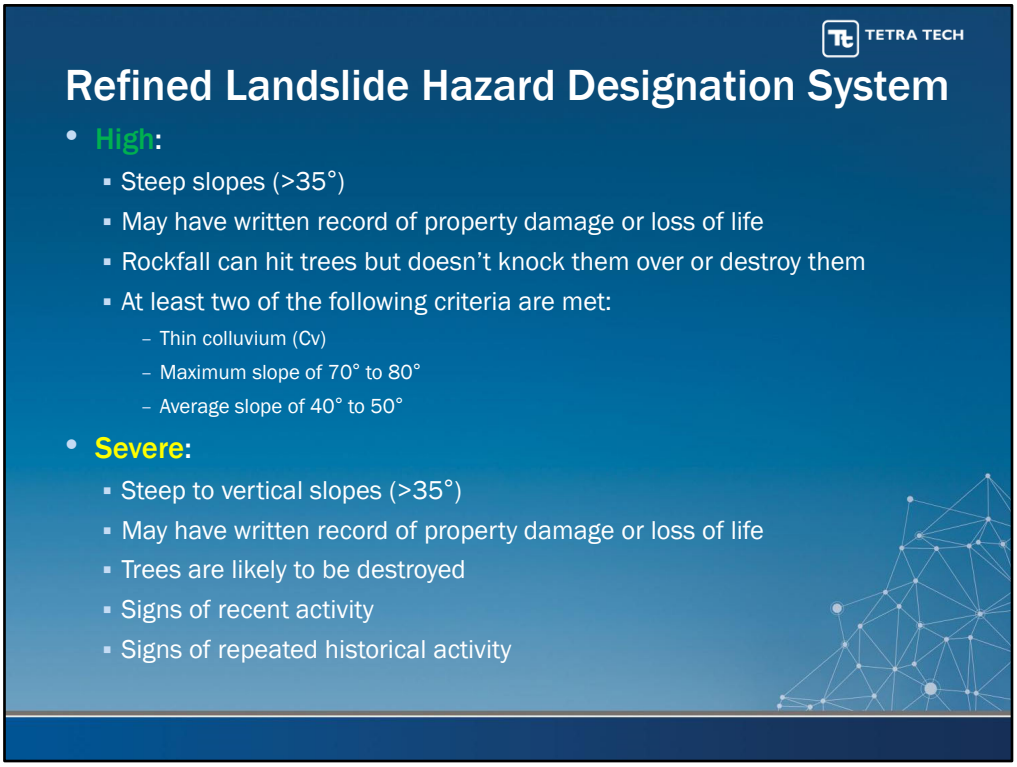
All those different kinds of maps that were created, plus the recent field observations, and resulting mapping updates, lead us to yet another kind of map – the Landslide Hazard Designation Map. All the shapes from the surficial geology map are now classified with different landslide hazard designations, including those long up-and-down strips that turned out to be gullies.

Zooming in a little bit from the previous maps, here are the landslide hazard designations for the downtown and surroundings. Red areas mark Severe hazard, for example, the area along Behrends Avenue and upslope of Highland Drive, the far ends of Gruening Avenue, Coleman Street and Judy Lane, uphill portions of the lots above Willow Street, the east end of Evergreen Avenue and the Gold Creek Flume Trailhead down to Hermit and Rheinhardt Streets, above and below Basin Road, around a large part of Starr Hill, and a lot of property along the toe of Mt. Roberts. It's important to recognize that it's not always what's happening on the lower slope that determines your hazard, it's what happening high on the slope above you.



Now, let's have a closer look at what we mean by Low, Moderate, High, and Severe hazard designations. For Low and Moderate, the slopes are not as steep as for High and Severe. There should be no written record of property damage or loss of life for either Low or Moderate. For Low, there are no signs of historical landslide activity on the air photos. For Moderate, there might be signs like scars on trees, or debris lobes or scarps that are vegetated, and some historical activity seen on the air photos. Moderate can also include low-lying areas that receive debris from slopes above.

Note that "Low" is everywhere that doesn't have a Moderate, High, or Severe designation for landslides.



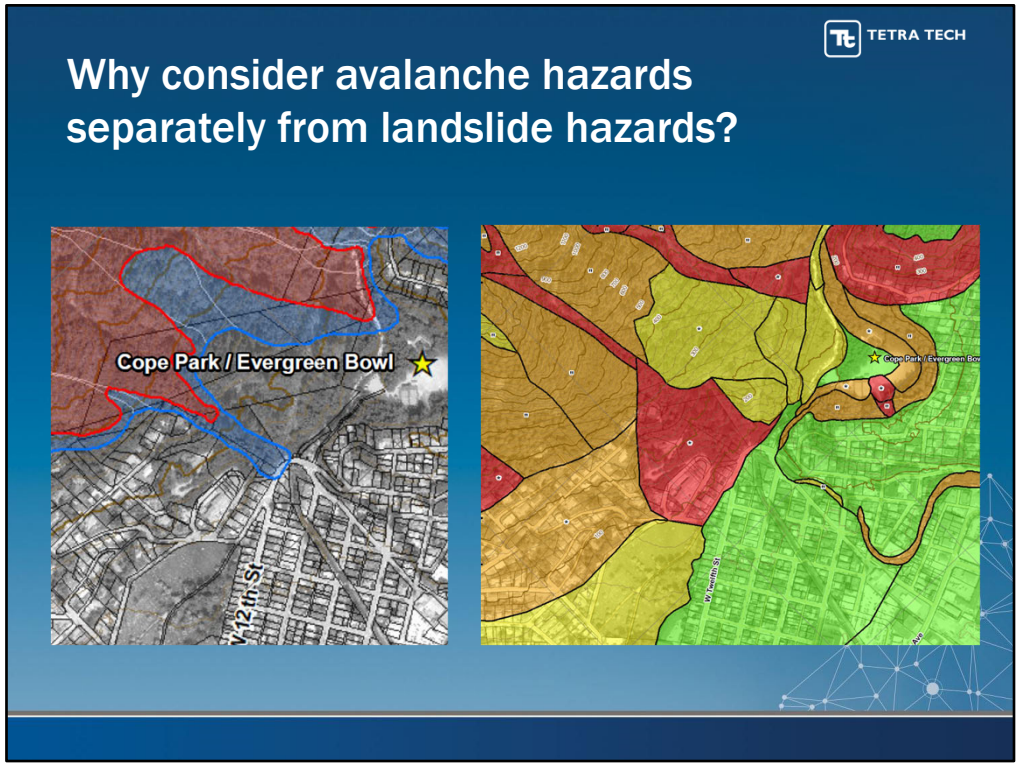
For High and Severe hazard designations, slopes are steeper than 35 degrees, and both can have written reports of property damage or loss of life.

Now we come to the differences between the two:

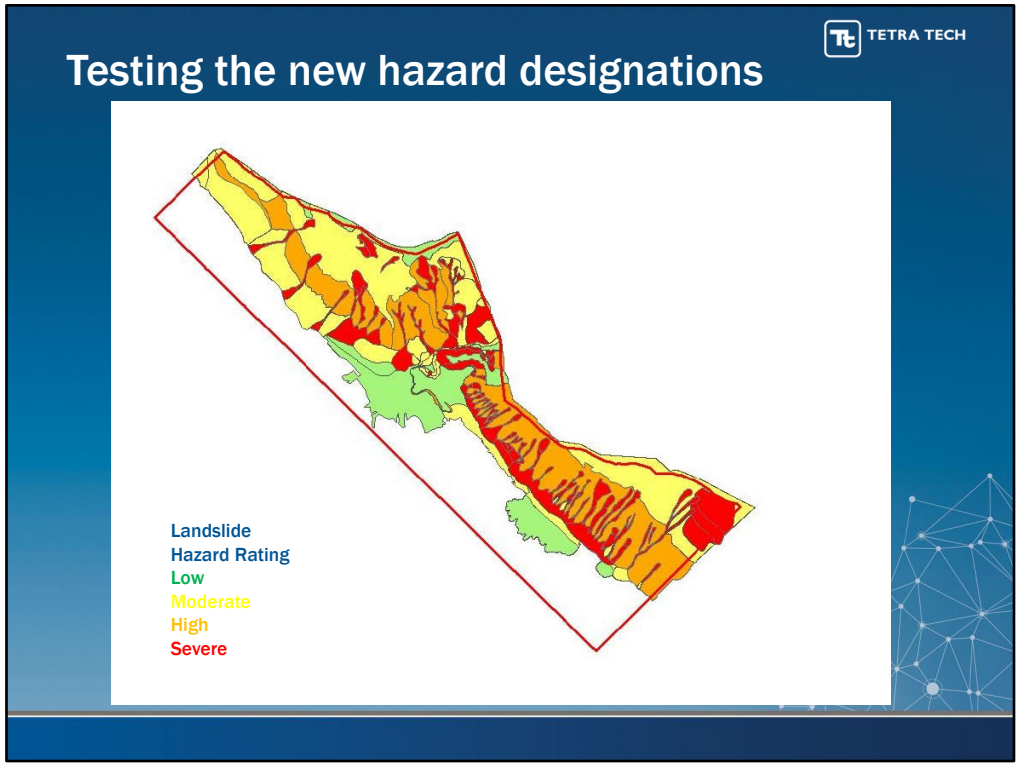
For High, there can be rockfall that hits trees but doesn't knock them over or destroy them. For Severe, trees are likely to be destroyed. For High, you might not be able to see from the air photos that rockfall is happening, but for Severe, there will be signs of recent activity on air photos or from field inspection (like rockfall tracks, debris slide tracks, debris flow paths) and, usually, evidence of repeated historical activity, like when we saw a bunch of different coloured arrows at the same place on the maps for slides and gullies.

Slopes that aren't bad enough to be considered Severe, but are iffy for Moderate, can be considered High if they meet at least 2 of these 3 criteria: thin colluvium, maximum slope of 70 to 80 degrees, average slope of 40 to 50 degrees.

A few people have asked about using frequency to help define which hazard designation should be applied. That can be useful, but a magnitude-frequency analysis would be required to develop a suitable decision-making tool. In some cases, events can be equally frequent in Severe or High, but there is a significant difference in damage with Severe compared to High, for example, where rockfall destroys trees or just tumbles down between them or scuffs them up a bit. There are a lot of variables to consider with the different types of landslides.

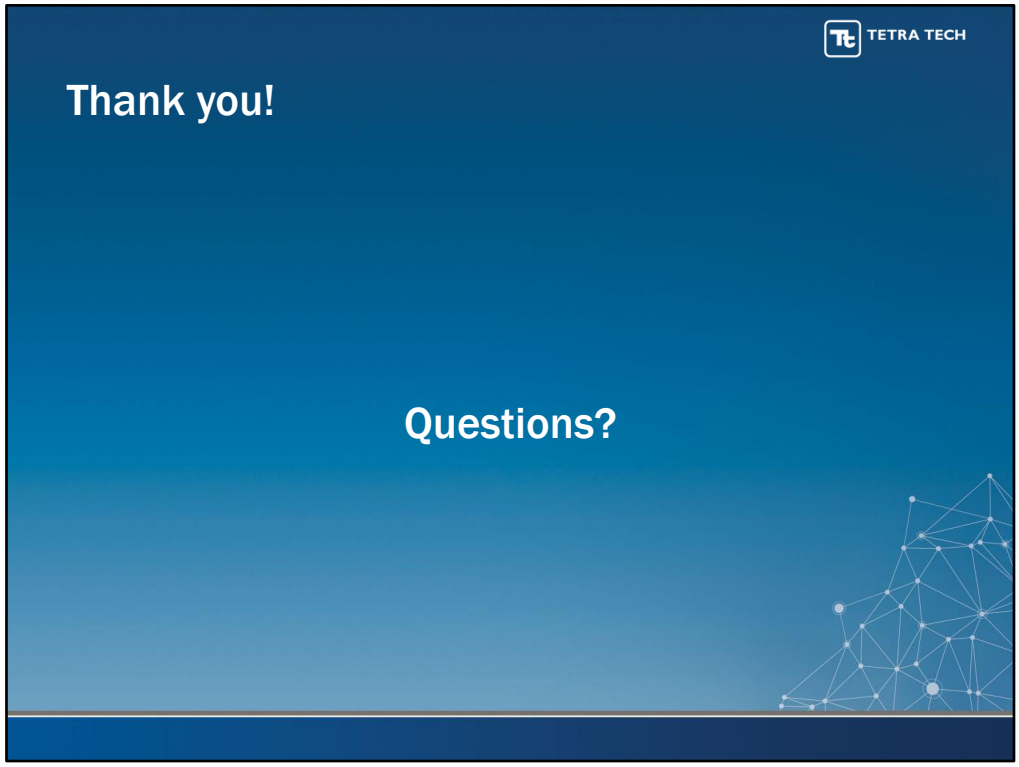


Why consider avalanche hazards separately from landslide hazards? On the left we have the hazard designation mapping for avalanches in a portion of the Study Area and, on the right, we have the same area with the hazard designation mapping for landslides. Even though avalanches and landslides can occur in some of the same locations, and understanding the terrain and vegetation can be useful in evaluating both types of hazard, there are some important differences. Avalanche hazard is related to topography but not to geology. Landslide hazard is strongly related to both topography and geology. You can see how different the resulting hazard areas are and, for that reason, they should be considered and managed differently.



When we look at the overall Study Area, we also notice a few more differences between the avalanche hazard mapping that Alan showed you earlier: Most of the Severe avalanche zoning extends right to the top of slope, but that isn't the case for landslide hazard zoning. We can also see that there is a significant difference in the mapping by virtue of separating High from Severe. If the two were combined, all of the orange areas would also be red or Severe.

[From July 21, 2021 presentation, for the slide comparing old to new mapping systems:] You can see that with the addition of the new High hazard designation, we can pin down a lot more information about the slope. We can clearly see now that the mid-slope on Mt. Juneau has more stability issues than the upper and lower slopes, and we also know that a lot of those issues are due to rockfall. Something similar happens on Mt. Roberts, where we see that most of the upper slope and the very bottom of the slope looks pretty good – only rated Moderate. But most of the lower slope is kind of a mess – rated either High or Severe. Having the High rating really helps us to key in on the differences between those slope areas.



That brings us to the end of our presentations. Thank you so much for coming. We have a few minutes now for questions.