Southern Lakes flood hazard mapping

What are flood maps and why are they useful?

Flood maps are prepared by engineers and show an area that may be covered by water or where water reached during a past flood event. These maps describe the level of flood hazard in different areas of a community.

The information produced through flood mapping studies can be used in the design of mitigation measures, emergency preparation, and community development planning. Final flood maps are publicly available for use by community members and all levels of government.

Mandate & funding

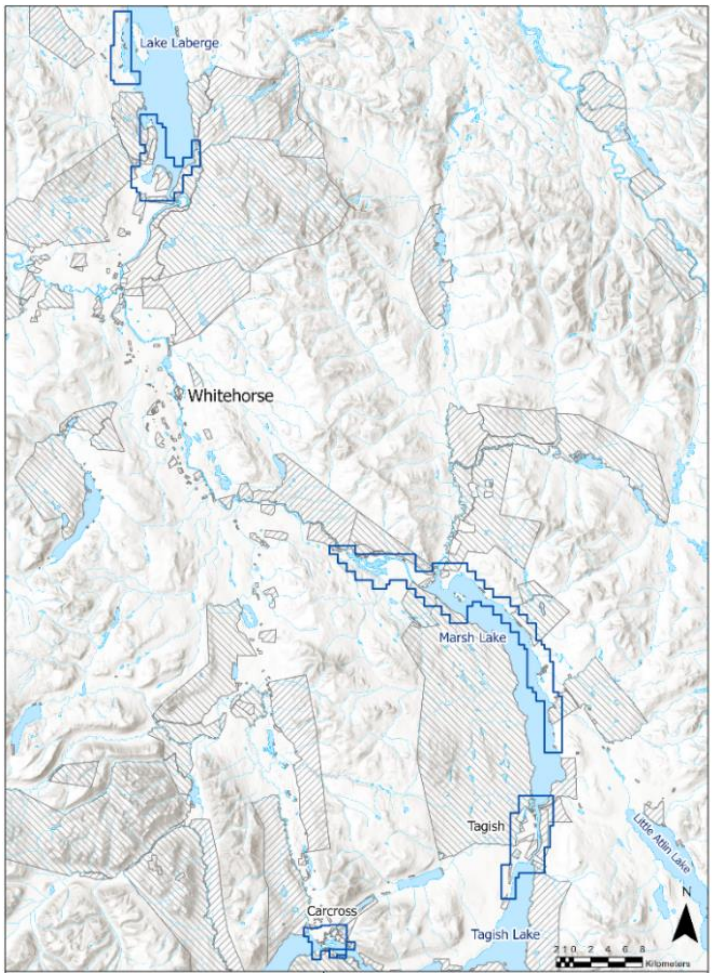
Mapping for communities at risk of flooding was established as an action in *Our Clean Future: A Yukon strategy for climate change, energy and a green economy*.
Natural Resources Canada is supporting this work through the *Flood Hazard Identification and Mapping Program*.

Mapping study overview

The Southern Lakes flood mapping study included key areas of interest around Carcross, Tagish, Marsh Lake, and Lake Laberge. Planning for the study began in winter 2021. The study was completed by a consultant hired by the Government of Yukon, KGS Group, and with input from the Ta'an Kwäch'än Council, Kwanlin Dün First Nation, Carcross/Tagish First Nation, Natural Resources Canada, and Environment and Climate Change Canada.

Here's how the work was completed:

- Understanding the main drivers of flooding;
- Field surveys of lake bottoms, the shoreline at key locations, and high water marks where available;
- Preparation of a digital model of ground elevations;
- Estimation of flood levels; and
- Mapping the flood levels onto the ground surface.



Areas of Interest Mapped
(outlined in blue)

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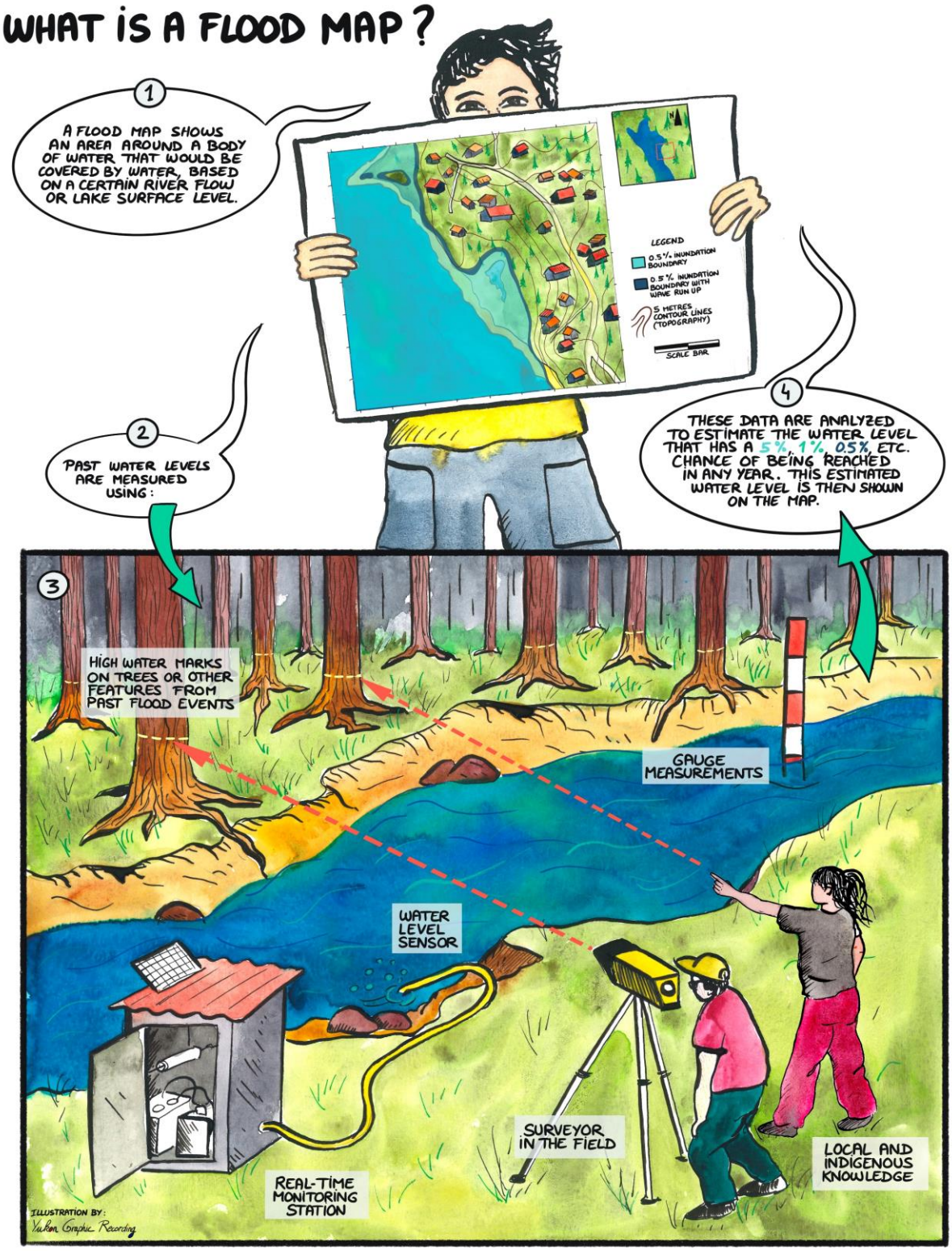
FloodMapping@yukon.ca / https://flood-atlas.service.yukon.ca/

WHAT IS A FLOOD MAP?



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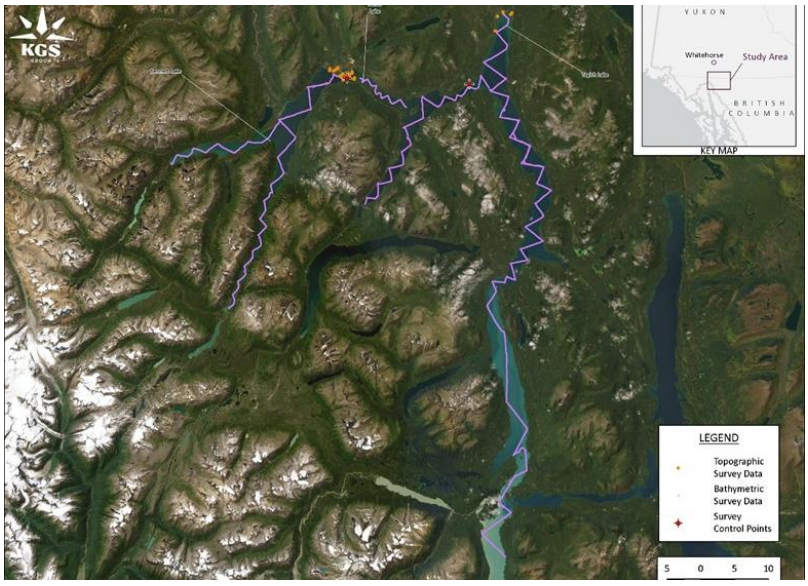
Site visits

Representatives from the Government of Yukon, KGS Group, Kwanlin Dün First Nation, and Carcross/Tagish First Nation visited areas of interest during spring 2023. This visit provided the opportunity for the project team to become familiar with the study area, areas that were flooded or at risk of flooding during the 2021 flood and the flood response. The visit also allowed the attendees to highlight any high-water marks from recent flood events.

Site Visit Areas with High Water Marks



Example Lake Bottom and Shoreline Survey

Field surveys

Field surveys were completed during summer 2023. The field surveys included the collection of lake bottom elevations on Bennett Lake, Nares Lake, Tagish Lake, Marsh Lake, and Lake Laberge by boat. Shoreline geometry was surveyed at 38 locations throughout the study area, as well as high water marks from past floods.

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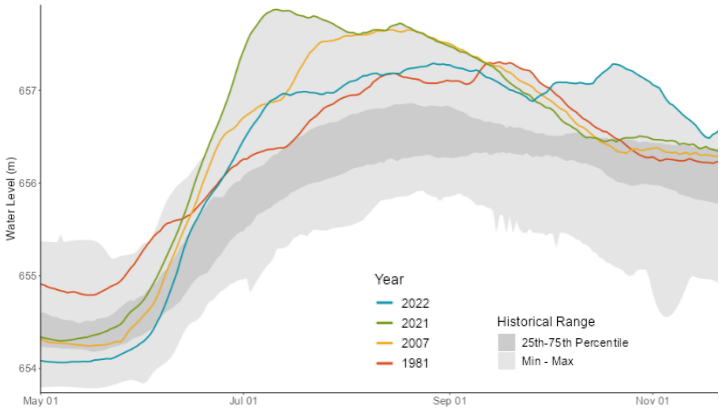
Flooding Processes

Flooding on the Southern Lakes is caused by high river inflows to lakes. This can be due to high snowpack levels, high temperatures that result in rapid snowmelt and glacial melt, and precipitation during both the spring snowmelt and summer glacial melt periods. Historical floods were found to occur between July 11 and September 31, although the 2022 peak water level occurred later in October. Flooding can also be worsened by wind setup and wave runup, both of which were considered in the estimation of flood levels.



Historical lake levels for Marsh Lake (1950 to 2022)

Wind Setup occurs when sustained winds blow along the long direction of a lake, and push water towards the downwind side of the lake.

Wave Runup occurs when waves generated by the wind travel up the shoreline slope as they break.

Understanding AEPs & return periods

An **annual exceedance probability** (AEP) describes how likely a given lake level is to occur or be exceeded within a single year. A return period is a different way of expressing the same thing. For example, the 1% AEP has a 1-in-100 chance of occurring or being exceeded in any given year – the same as a 1:100-year event.

The process for determining the levels associated with the AEPs for each lake is described in the following pages.

Estimation of flood levels

Flood levels were calculated on Bennett Lake, Nares Lake, Tagish Lake, Marsh Lake, and Lake Laberge based on the results of a type of statistical analysis known as a frequency analysis, used in combination with a Monte Carlo method.

Frequency analyses estimate the relationship between recorded historical events and the likelihood of specified future events. Frequency analyses were completed for peak water levels that were recorded on the Southern Lakes, as well as peak wind speeds in each direction that were recorded at nearby climate stations.

The Monte Carlo method is a computational process that relies on repeated random sampling from statistical relationships to generate a large range of possible outcomes. A Monte Carlo method was used to generate a large, artificial set of possible water levels on each lake, with sets of possible wind speeds and directions. This was used to calculate the wind setup and wave runup at each lake for each flood level, wind speed, and wind direction. These data sets were then evaluated to define a number of AEP flood levels.

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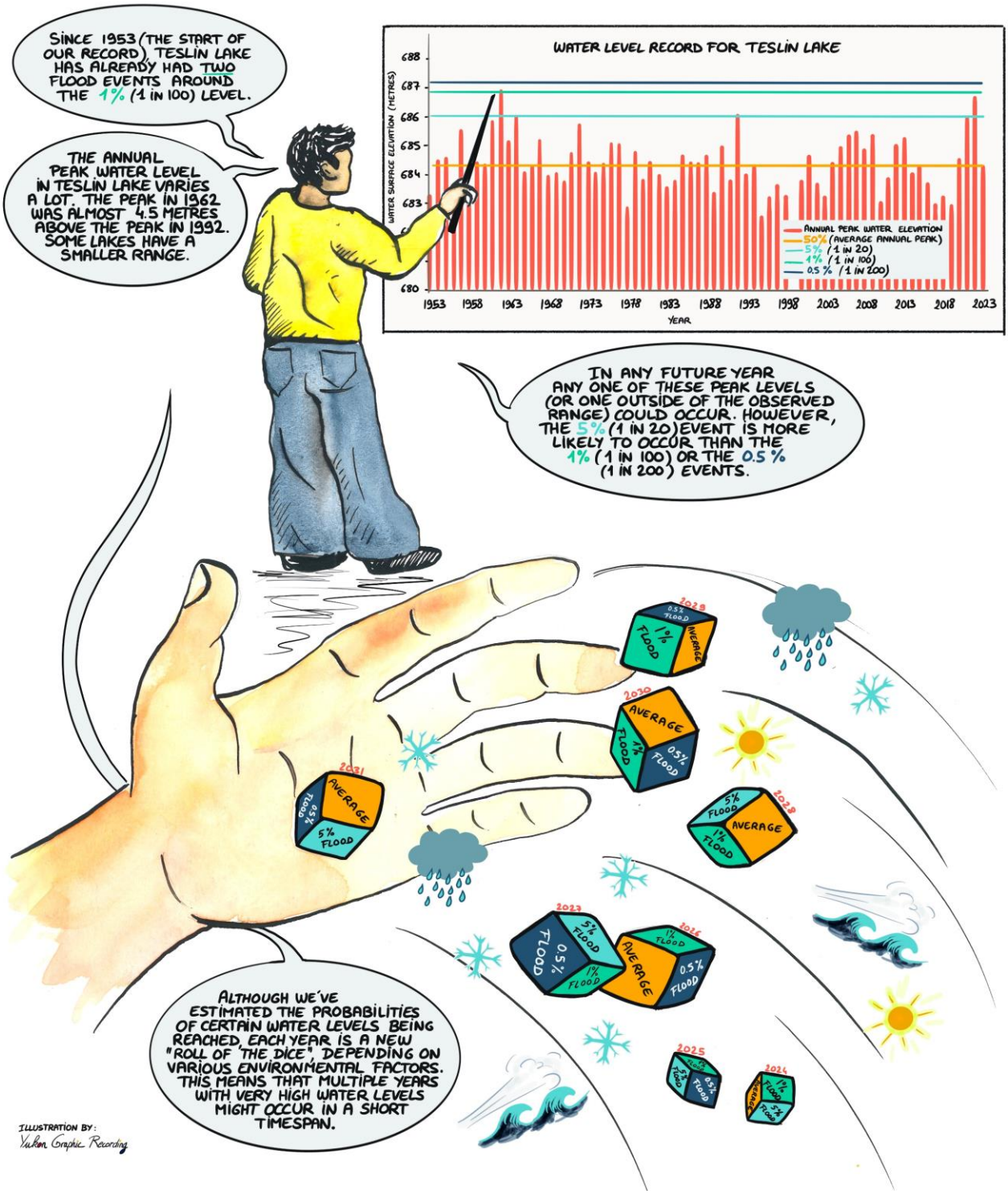
UNDERSTANDING FLOOD PROBABILITIES

THE LIKELIHOOD OF THE WATER REACHING OR EXCEEDING A CERTAIN LEVEL IN ANY YEAR CAN BE DESCRIBED AS A PERCENT PROBABILITY. THESE PROBABILITIES ARE CALCULATED BASED ON RECORDS OF THE PEAK LEVEL REACHED IN PAST YEARS. LEARN MORE ABOUT FLOOD PROBABILITIES BELOW THROUGH THE EXAMPLE OF PAST FLOODING IN TESLIN.



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Climate change

A review of climate change research was completed to understand potential impacts that climate change could have on flooding in the Southern Lakes area. Key climate change impacts that were identified included warmer winter and summer temperatures, increased precipitation, a greater portion of the precipitation falling as rain, and increased wind speeds. Changes to glacial melt were also noted, as warmer temperatures will result in more glacier melt, until a tipping point is reached where the glaciers have shrunk to the point that flows due to melt are reduced. However, the timing and magnitude of the changes to glacial melt are highly uncertain.

Climate impacts were considered and included in the development of climate change flood hazard maps. A review of the flood history on the lakes found the severity of flood levels has been increasing, and those trends were assumed to continue. Similarly, climate modelling completed by the Government of Canada found that wind speeds are projected to increase. These trends were integrated into the Monte Carlo method to generate a set of artificial flood events affected by climate change, which were then used to define climate change AEP flood levels for flood hazard mapping. One key finding of the climate change assessment was that flood events, both minor and severe, would be more common under climate change conditions.

What is LiDAR?

LiDAR stands for **Li**ght **D**etection **a**nd **R**anging and is a method for measuring three-dimensional information about the ground surface. LiDAR data is collected by airplane, and is processed to remove vegetation and structures, resulting in a representation of the bare earth surface.

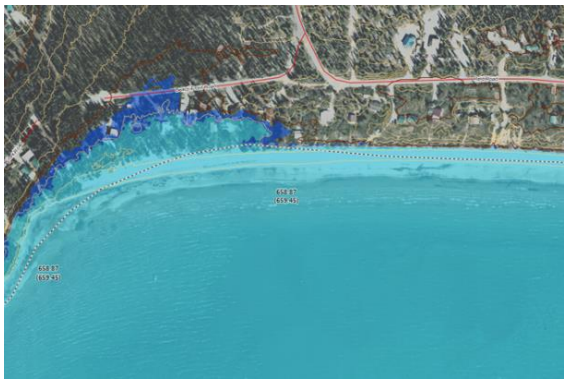
Map preparation

Flood maps were prepared by projecting the flood levels onto a LiDAR-based ground surface model for each area of interest. The Flood Inundation Boundary, which includes the effects of wind setup, shows where the flood levels are higher than the ground surface, and would be flooded for each AEP flood event. Additional areas that could potentially be flooded by wave runup are shown on the flood maps in a darker shade.

Engagement & final products

Draft flood maps were reviewed with community members in January and February 2024, with feedback being considered and integrated into the final maps. Feedback received also identified ways to make the maps easier to interpret and use.

Final flood maps, the technical report, and a What We Heard report are available from the Government of Yukon online via the Yukon Flood Atlas: https://flood-atlas.service.yukon.ca/



Example of Mapped Flood Hazard Extents

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