# Flooding in Old Crow: Exposure analysis and risk reduction recommendations

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Photo credit: Government of Yukon

# Executive Summary

The YukonU Research Centre (YRC) is working with the Infrastructure Branch (IB) of the Department of Community Service (CS), Government of Yukon (YG), to assess the flood vulnerability and protection in Old Crow in the Traditional Territory of the Vuntut Gwitchin First Nation.

The objectives of this project are to assess key aspects of community exposure to flooding, focusing on critical buildings, assets, and infrastructure, and to document the effectiveness of current and proposed flood risk reduction strategies. The YukonU Research Centre conducted two main activities:

- Elevation survey of various buildings and assets, and assessment of flood protection infrastructure in Old Crow. This was completed using a digital elevation model.
- Water level frequency analyses based on available historical hydrometric records. This means that we established a water surface elevation (and longitudinal river gradient) corresponding to specific annual probabilities (in %/year) or return periods (in years).

Results are presented in this table:

| **Return period** | **2 years** | **20 years** | **200 years** |
|---|---|---|---|
| **Annual probability** | **50%** | **5%** | **0.5%** |
| Water level at downstream end of **Old Crow** | 244.2 m | 246.1 m | 247.5 m |
| Water level at upstream end of **Old Crow** | 244.4 m | 246.3 m | 247.3 m |

Flood extent results suggest that Old Crow is exposed to flood hazards, mainly associated with ice jams, with potential consequences (or damage) occurring as often as every 10 years, on average. Given the current flood protection infrastructure, a 200-year ice-jam flood event would be disastrous and given the proximity of the community with the Ch'oodeenjìk (Porcupine River), there are challenges in addressing this risk. An analysis of the impact of climate change based on both historical data and knowledge of hydrological processes forced by future weather conditions revealed no clear trend in the frequency and intensity of future floods.

Recommended flood reduction adaptation measures for Old Crow include:

- Assessment of the efficiency of the riprap erosion protection
- Removing culvert valves and improving urban drainage infrastructure
- Considering installing an ice fence
- Protecting the sewage lagoon
- Improving the resilience of WSC hydrometric station 09FD003
- Developing breakup timing and intensity forecast tools
- Improving access to the community during a significant flood event
- Sharing information about flooding processes and probabilities with the population
- Assessing the quantitative risk associated with critical community assets
- Updating flood emergency protocols
- Updating flood risk tools considering climate change and recent hydrological events

Old Crow has not been affected by a significant flood in recent years. This is not a sign that the flood risk is decreasing, it represents an adaptation opportunity before the next flood.

# Project Team


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Table of Contents

## List of Figures

# List of Tables

# 1. Context

## 1.1 General perspective

The Department of Community Services (CS), Infrastructure Branch (IB), of the Yukon Government (YG) is interested in understanding the risk of flooding and in developing flood risk reduction strategies for communities of Yukon. The YukonU Research Centre (YRC) has offered to produce a study that would meet these needs for the community of Old Crow, in the Traditional Territory of the Vuntut Gwitchin First Nation.

In addition to IB-CS financially supporting this project, the National Disaster Mitigation Program (NDMP) is providing significant support whereas the YRC provides in-kind contribution.

## 1.2 Project objectives

Old Crow has been flooded relatively frequently over the years, with the 1991 river-ice-breakup flood being associated with the highest water level in Water Survey of Canada (WSC) records. Quantifying the risk of flooding and updating flood response strategies is not only known to be beneficial from a financial point of view (each dollar invested in prevention saves six dollars in the future; UN Press Release, 2019), it also supports sustainable living in the North.

The objectives of this project are to 1. assess key aspects of community exposure to flooding, focusing on critical buildings, assets, and infrastructure, and to 2. document the effectiveness of current and proposed flood risk reduction strategies. While the approach could be applied in any Yukon community, it was identified that Old Crow is associated with one of the greatest flood risks in the Territory (the risk is a combination of hazard likelihood and hazard consequence).

Meeting the first objective of the project involved surveying the elevation of buildings, assets and infrastructure in the community (Section 2) and developing a flood frequency analysis (Section 3). Results of this analysis are presented in Section 4. After a discussion about the documented and expected impact of climate change (Section 5), the second objective of the project is met through a discussion of the expected performance of current and potential flood protection measures (Section 6). A conclusion is then presented in Section 7.

# 2. Asset Elevation Surveys

Surveys of key assets in Old Crow took place on September 2, 2021. These assets can be divided in four categories, with some overlap: 1. Important buildings and fixed infrastructure for critical community operations (e.g., water and electricity production), 2. Public service buildings (e.g., Government buildings, machinery warehouses, RCMP, school), 3. Flood protection and surface drainage-related infrastructure (e.g., culverts and culvert gates), and 4. Other valuable assets (e.g., fuel tanks, businesses). In most cases, the surveyed feature or component of each asset was:

- First floor (for buildings)
- Electric system (when lower than first floor, if visible and accessible)
- Lowest elevation (fuel tanks, storm drains, culverts, etc.)

The approach used for all the surveyed assets was to measure, on site, the differential elevation between the asset and an open, horizontal area that is far enough from any building using a high-accuracy pressure differential instrument (ZipLevel Pro-2000 from Technidea Corporation). Back in the office, the absolute elevation of each open area was obtained using a LiDAR-derived Digital Elevation Model (DEM). Then, the elevation of the surveyed asset was calculated back using the measured elevation differential and the absolute elevation.

A total of 68 assets were surveyed in Old Crow. The elevation of the surveyed features ranged from 242.4 m (bottom of stream culvert) to 251.2 m (first floor of school). Appendix A presents a table of the surveyed assets with their respective elevation and flood return period. Appendix B present similar information, with more detail regarding the location, and including a photo.

During the time of survey, the Ch'oodeenjìk (Porcupine River) water level was low, and despite not presenting conditions that resemble those associated with floods (such as an ice jam), the YRC team recorded observations about the shape of the channel, which contributed to the simulation of different flooding scenarios.

# 3. Flooding processes chronology and flood scenarios

## 3.1 General perspective on floods in Old Crow

Old Crow has historically been affected by high water levels from both open water and ice jam conditions. The cause of the highest water level mostly depends on the late-winter snowpack in the watershed, as well as on the sequence of weather events that lead to snowmelt and river ice breakup. In some years, ice jam peaks and freshet peaks occur only a few days apart (Janowicz, 2017). Overall, ice jams are consistently producing higher water levels year after year in Old Crow, as depicted in Figure 3.1.1 (Turcotte, 2021). The record at station 09FD003 (2006-present) contains several gaps, but this was addressed using complementary data from existing station 09FD002 (Porcupine River at the Alaska Border) and former station 09FD001 (1961-1995).

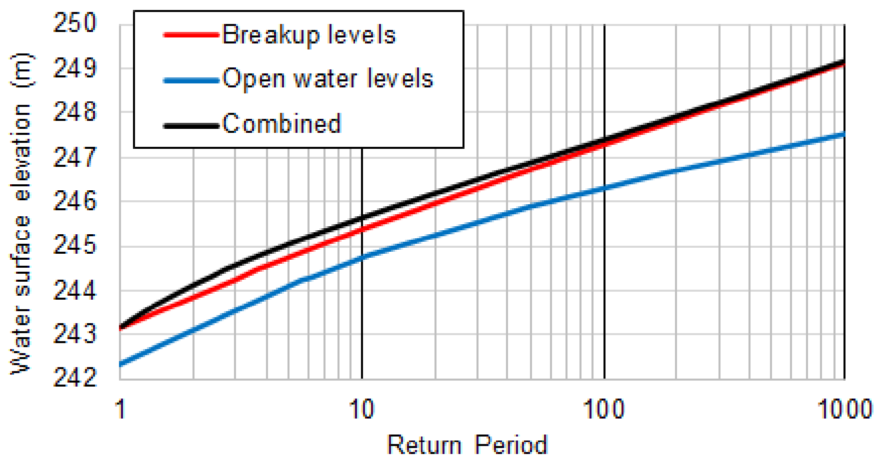


**FIGURE 3.1.1 RELATIONSHIP BETWEEN THE WATER SURFACE ELEVATION AND THE RETURN PERIOD OF BREAKUP AND OPEN WATER EVENTS (AS WELL AS COMBINED STATISTICS) AT STATION 09FD003 LOCATED ON THE PORCUPINE RIVER AT OLD CROW.**

Breakup in the multi-channel delta of the Chyàh Njìk (Old Crow River) is typically thermally driven and occurs after the Porcupine River breakup. As a result, it seems to represent a low flooding threat to the community. The following subsections present information about the behaviour of the Porcupine River, beginning with a description of the events leading to the most recent great flood in Old Crow.

## 3.2 Flood of 1991

A significant ice-jam flood affected Old Crow in 1973 (William Josie, Government of the Vuntut Gwitchin First Nation, personal communication, 2021) with water entering the town from downstream. This event was slightly worse, in terms of water levels, than the 1991 event, but little record or information has been collected so far about this event.

The 1991 ice-jam flood in Old Crow has been described in detail by Jasek (1997), who concluded that it resulted from a combination of warm weather in the headwaters (Miner and Whitestone Rivers) that generated significant runoff while Old Crow remained relatively cold and a dominant resisting point (icing accumulation) at the Sriinjìk (Bluefish River) confluence that stopped the ice run and initiated the jam, causing water to back up to Old Crow. Also, Jasek (1997) described that, when the water level reached its maximum, it was no longer the Bluefish River icing that was impeding ice passage, but another site located between the Bluefish River and Old Crow (the original toe of the ice jam has been mobilized). The ice jam finally released on May 8 at a discharge that has been estimated to 3500 $m^3/s$ by Jasek (1993). Note that this value does not seem to agree with the estimated discharge by the WSC at station 09FD002 located far downstream.

This ice jam created extensive flooding in Old Crow, as presented in the photograph in Figure 3.2.1 and as simulated in Figure 3.2.2, despite the fact that the head of the jam was not even visible from Old Crow. Jasek (1997) did not miss pointing out that the flood could have been even worse if the ice jam had extended all the way upstream to Old Crow, but luckily, the stationary ice in the Porcupine River stayed in place upstream of the Chiiveenjìk (Bell River) and Ch'izhìn Njìk (Eagle River) for a few days, which gave time to the Old Crow ice jam to melt in place and eventually release. Subsequent ice runs did not encounter any obstacle and the water level rise associated with their passage did not generate any flooding.

**FIGURE 3.2.1. OLD CROW FLOODED ON MAY 8, 1991, JUST BEFORE THE ICE JAM RELEASED. PART OF THE EMERGED AIR STRIP IS VISIBLE ON THE RIGHT. PHOTO FROM DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT, GOVERNMENT OF CANADA (DIAND).**

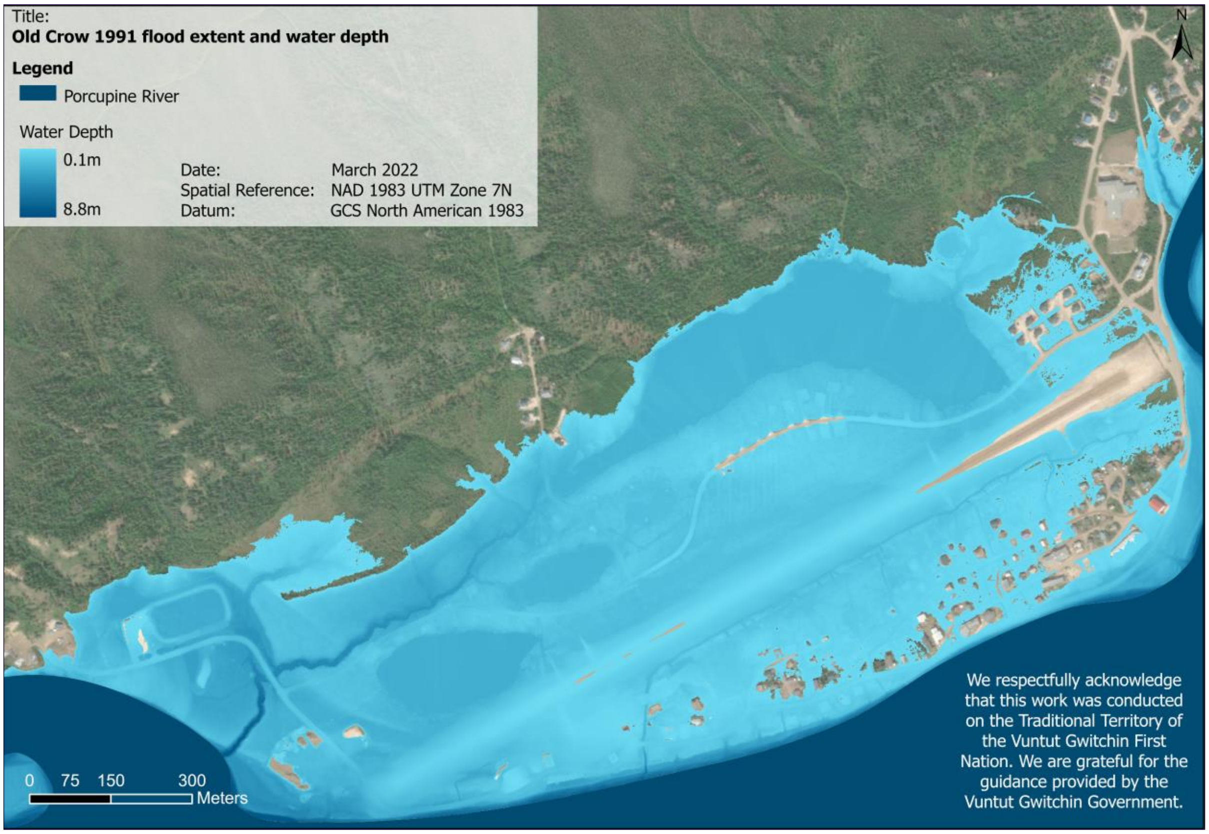


**FIGURE 3.2.2. APPROXIMATE MAXIMUM FLOOD EXTENT CAUSED BY THE 1991 ICE JAM.**

## 3.3 Likely flood scenarios

In years where the ice cover melts in place for several days under mild air temperatures, and when no significant ice jam forms, breakup water levels can be contained within the Porcupine River channel. When this happens, high open water flows may generate the highest water level of that year. However, most years, large ice jams form in the river at various locations, including immediately downstream and upstream of Old Crow.

The Bluefish River icing does not seem to consistently intercept ice runs or initiate ice jams. Indeed, the WSC, the agency that has been measuring and estimating the thickness of the icing accumulation at the Bluefish River mouth every spring prior to breakup for many years, has reported several instances where the icing was extensive and thick, yet no significant ice jam resulted at breakup. The Bluefish River icing may still play a role at breakup, but other overlooked factors are likely playing an important role during spring breakup sequences year after year (e.g., the river ice formation intensity in the Porcupine River, the Bluefish River delta sediment deposit). Besides, the Bluefish River mouth is located 42 km downstream of Old Crow, which represents a significant distance (and space, when considering the channel width) for ice to pile up before water levels start affecting the community.

A frequency analysis of high-water levels was performed by the YRC using historical hydrometric data collected since 1970 (Figure 3.2.1), including a partial river ice breakup data set (it is virtually impossible to transfer most ice-affected high water levels from former station 09FD001 to the current station 09FD003) and some notes left on hydrometric records. The return period of the 1991 ice-jam flood was estimated to be 50 years. The 2-year event (50% probability of higher water level on any given year) and the 20-year event (5% annual probability) were associated with an ice jam that forms downstream of Old Crow, but that does not extend up to the community, like in 1991 (Figure 3.2.2). On the other hand, the 200-year event (0.5% annual probability), a fairly rare occurrence, has to consider that a significant ice jam (in terms of total ice volume) could extend to, and even past, the community, like in 1989, and that this ice jam could form or remain in place at a high discharge (comparable to the 1991 event). This means that, unlike the flood of 1991, where the water surface profile had a slope of 0.005% (5 cm for every longitudinal river km, essentially flat water) and the maximum water level was 246.9 m at the WSC station, the water surface profile in this case would match that of the river channel at high discharge, which corresponds to 0.03% (30 cm per km) with a maximum water level of 248.0 m at the station (Figure 3.3.1). Because of the difference in water surface (and ice jam surface) slope, water levels downstream of Old Crow would only be slightly higher than in 1991, but water levels upstream of the community would be significantly higher, with possible ice floe intrusions in the streets, and impacts against buildings and structures.

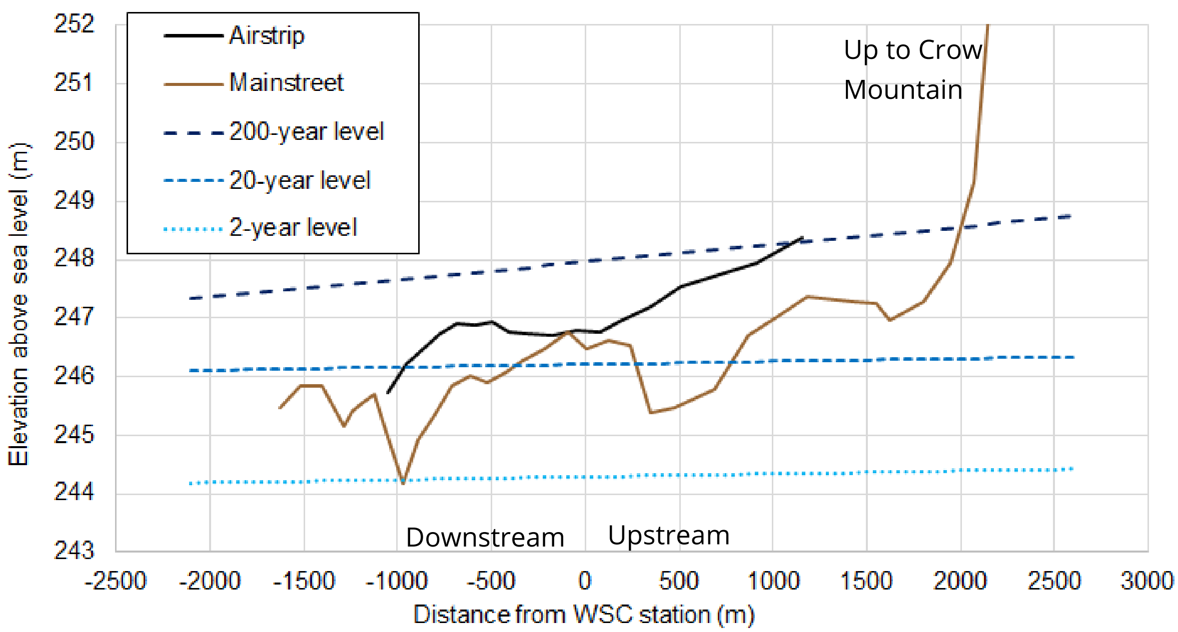


**FIGURE 3.3.1. WATER SURFACE ELEVATION PROFILE OF THE PORCUPINE RIVER AT OLD CROW FOR 2-YEAR, 20-YEAR, AND 200-YEAR HYDROLOGICAL EVENTS. THE AIR STRIP AND LONGEST STREET IN THE COMMUNITY IS ALSO PRESENTED FOR REFERENCE.**

The YRC understands that this flood elevation represents a concern for the people of Old Crow. It may be perceived that this scenario is too conservative and that it probably would have a return period well above 200 years. The YRC acknowledges the limits of the western science approach in this report and the dependency on a relatively short quantitative observation record. This is the reason why Vuntut Gwichin should be consulted before official flood scenarios are adopted. In the interim, it is important to note that:

- An ice-jam thickness and hydraulic calculation was performed for the proposed 200-year ice jam scenario using an approximate river channel bathymetry and resulting flow velocities were considered realistic (this scenario is not just a statistical artefact that Nature cannot generate).
- The breakup dynamics along the Porcupine River in recent springs has been investigated using satellite imagery and hydrological data, and it seems to differ from what is described by Jasek (1997). For example, it had been reported that the Bell and Eagle Rivers usually played a more important role at breakup compared with the Miner and Whitestone rivers. However, observations from recent years reveal that the southern portion of the watershed is often affected by warmer temperatures, and its impact on ice-induced water levels in Old Crow is therefore more significant than described 25 years ago.
- In 2020, a 25 km-long ice jam formed upstream of Old Crow, and it released when the ice cover downstream of Old Crow was largely intact. When the ice jam released, the wave of water and ice almost flooded the southern part of town even if the flow of ice did not stop. Had the ice run stopped at or upstream of the Bluefish River, significant flooding could have resulted, given the preliminary flow estimate of 4000 $m^3/s$.
- The ice jam of 1991 was associated with a discharge of about 3500 $m^3/s$ whereas the system has the potential to generate even higher flows at breakup (like in 2020). The higher the flow in the presence of an ice jam, the higher the backwater and water level.
- The floodplain on the riverbank opposite to Old Crow is higher than most of the community. This means that the south bank floodplain has limited evacuation capacity in the presence of an ice jam compared with the floodplain on which Old Crow sits. This morphological reality makes Old Crow vulnerable to ice-jam floods.

For the simulated 200-year water level to materialize, three conditions must be present:

- A thick ice cover must be in place prior to breakup (this could be the result of significant freeze-up ice jams in the fall, a very cold winter, or a thick icing accumulation at the Bluefish River).
- The snowpack must be above average (it must not represent a limitation to snowmelt runoff for a few consecutive days of warm weather).
- A cold winter and delayed spring must be followed by a sudden warming in the southern portion of the watershed (the snowpack must melt quickly and faster than the ice cover degrades).

Questions may also arise about the impact of climate change on flooding processes and flood frequency. This is discussed in Section 5.

# 4. Results summary

This section presents the results from two spatial perspectives: A side view of the community as if someone was going upriver in a boat and an aerial view, as if someone was flying above Old Crow. Tables are also provided to summarize flood return period statistics for some assets, and the detailed information for each asset is presented in Appendix A.

## 4.1 Spatial Flood Modelling

Table 4.1.1 presents water levels and channel gradients for each flood scenario. As proposed in Section 3, water surface slopes were assumed to be constant, a reasonable assumption considering that:

- Most gradients are low
- The community is short in the river direction relatively to the width of the river

This assumption is also justified by the typical hydraulic behaviour of rivers where the water surface tends to adopt the average long-distance gradient for ice jams affected by a relatively high discharge. In addition, this assumption allows for a significant and cost-saving simplification of the hydrodynamic approach, avoiding the collection of detailed bathymetric information and by-passing the development and calibration of a hydrodynamic model.

**TABLE 4.1.1. FLOOD LEVELS AND GRADIENTS FOR THE 2-YEAR, 20-YEAR, 1991, AND 200-YEAR FLOODS IN OLD CROW.**

| **Old Crow** | 2-year flood | 20-year flood | 1991 flood | 200-year flood |
|---|---|---|---|---|
| Water level at WCS station | 244.3m | 246.2m | 246.9m | 248.0m |
| Gradient | 0.005% | 0.005% | 0.005% | 0.03% |
| Water level at downstream end | 244.2 m | 246.1 m | 246.8 m | 247.5 m |
| Water level at upstream end | 244.4 m | 246.3 m | 246.9 m | 247.3 m |

To perform spatial flood analyses, digital elevation models (DEMs) were obtained from the Yukon Government's geodata base. The compatibility of the DEM with Water Survey of Canada (WSC) data was verified by comparing water surface elevations at the date and time of LiDAR (ground elevation data) acquisition and water levels measured by the WSC station. Then, high water levels were superposed to the DEM for each flood scenario: a gradient was applied at 100m increments up- and downstream of the WCS station in Old Crow. These distances were applied along a main-channel centerline, which is represented by the x axis in Figure 3.1.1. Cross sections at 90° angles to the river centerline were created, and equal water levels were applied along each cross section, extending sideways from the river. This created a point grid of 100m x 100m resolution. An Inverse distance weighted (IDW) interpolation was applied to the grid, resulting in water level DEMs for each flood scenario. Initial flood depths were retrieved by subtracting the DEM's of the communities from the corresponding water levels. Positive values display water depth, while negative values show areas that are not flooded and are hence removed from the flood extent. The result was essentially comparable to the output of a 1D hydrodynamic model on a 3D terrain.

When this was completed, there was a need to emulate a 2D flow in some areas for some flood scenarios, especially in shallow flooded sectors connected to the river channel by upstream or downstream low points. In Old Crow, a small ungauged creek drains the foot of the Crow Mountain and reaches the Porcupine River downstream of the community. This represents a low point through which water from the river can penetrate the inhabited area. The airstrip is also an interesting hydrodynamic factor in Old Crow, as it can act as a dike for areas behind it. For a 2-year event, the low-lying creek channel behind the air strip is the only part of the community affected by water, and it is filled like a bathtub (backwater from the Porcupine River) with a negligeable impact on the community.

For the 20-year ice-jam flood scenario, a significant amount of water is able to enter town at the same location (downstream tip of the airstrip), flooding a large area like a bathtub at an elevation of 246.2m (no gradient is applied since that water level is controlled by the Porcupine River at one location). On the other hand, water levels along the shoreline are based on the water surface gradient following the river (the airstrip acts as a dike, and most of the community is on the river side of that dike). Some buildings and assets are affected by this 20-year flood.

During the 1991 event, water from the Porcupine River crossed the airstrip up to an elevation of 246.9m. Water levels behind the airstrip were modeled to follow the low gradient of the river back to the main channel downstream of the community whereas upstream areas (behind the dry part of the airstrip, northeast corner) were considered affected by a consistent water elevation of 246.9m with no gradient. Along the shoreline, on the river side of the airstrip, water levels were simulated to follow the gradient of the river (water velocities were probably low, given the gradient of 0.005% imposed by the downstream ice jams [Jasek, 1997]).

In a 200-year scenario, given the higher water level in all areas of the community as well as high water surface gradient caused by a significant ice jam extending passed Old Crow, the river side of the airstrip, which includes most of the community, would become part of the channel (including fast moving water and ice slabs). On the other side of the airstrip, at the foot of Crow Mountain, given the shallow water depth across and upstream of the airstrip, a hybrid gradient was selected, replicating a 2D flow (faster velocities across the road and air strip, then slower velocities going downstream back into the Porcupine River channel at the west end of town). In the event of a more intense flood, most likely associated with an ice jam, the entire floodplain where Old Crow sits would become part of the Porcupine River and would be occupied by ice floes and fast flowing current.

The following sections present flood extents as well as potential impacts to the surveyed vulnerable assets.

## 4.2 Flood extent results

Figures 4.2.1 presents the lateral view of high-water event profiles including surveyed assets. It shows that the main street at the downstream tip of the airstrip is flooded, on average, every second year. On the other hand, the first floor of most buildings and assets is not affected by water more than once every 20 years, on average. The airstrip also starts to be affected by water from the Porcupine River at the same corresponding return period.

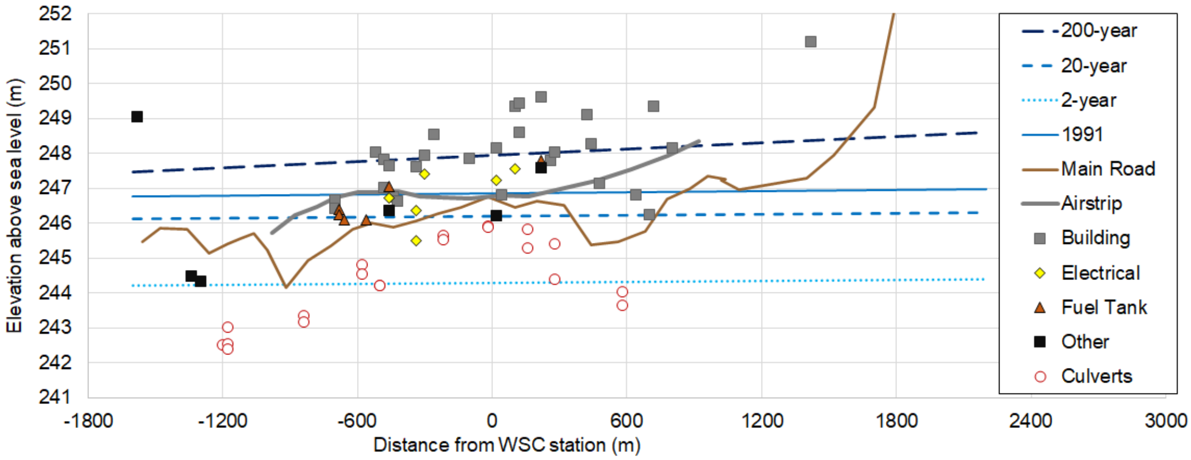


**FIGURE 4.2.1. SURVEYED ASSETS AND WATER SURFACE PROFILES OF THE PORCUPINE RIVER AT OLD CROW FOR 2-YEAR, 20-YEAR, AND 200-YEAR HYDROLOGICAL EVENTS.**

Figures 4.2.2 to 4.2.5 present flood extents for four different flood scenarios:

- 2-year flood event (mostly contained within the Porcupine River channel, with minor backwater behind and at the downstream tip of the airstrip)
- 20-year flood event (large area flooded behind airstrip and some areas of the community also affected by shallow water, sewage lagoon under water, some flood damage, and environmental concerns)
- 1991 flood extent: this event was associated with extreme flood damage
- 200-year flood event (community entirely flooded, school surrounded by water, extreme flood damage to be expected, potential life-threatening conditions imposed by moving ice)

The water depth on each figure is shown when the water level is higher than the DEM. Since no bathymetric information was used in this project (LiDAR data cannot be obtained under water), the Porcupine River is presented in dark blue, with an exact depth that is unknown. In addition to the flood extent and depth, the flood impact for each asset is categorized as not affected (green), first floor above water (orange), surrounded by water (yellow), and flooded (red).

As mentioned above, the portion of the community located behind the airstrip is drained by a creek that crosses the road to the sewage lagoon through two culverts (the main one is larger and lower). These culverts are equipped with valves that are meant to be closed manually when the Porcupine River water level is high. However, these valves, located on the river side of the road, may no longer be accessible for water levels above a 2-year flood elevation, and they may not be needed after all, as described in Section 6.

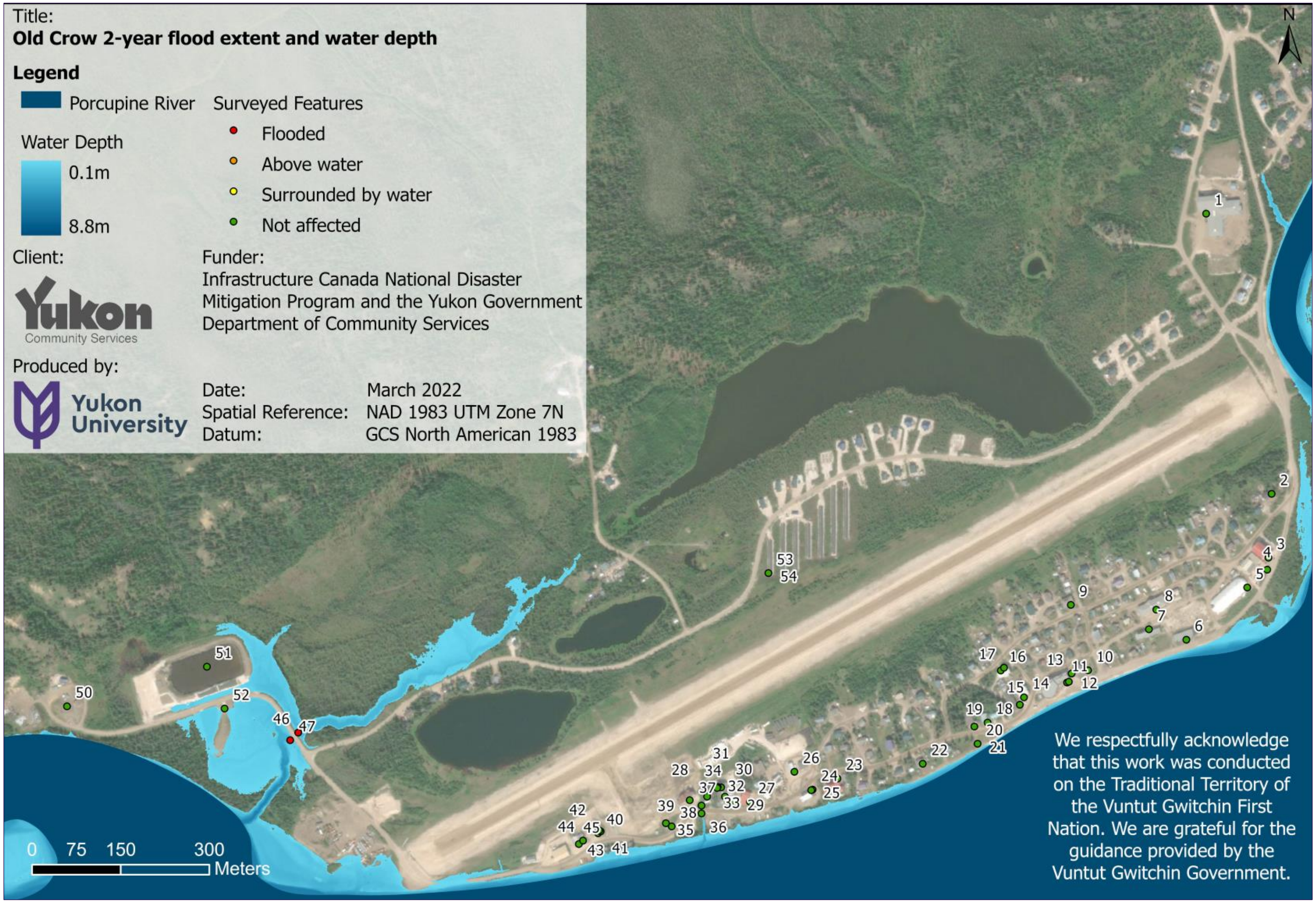


**FIGURE 4.2.2. 2-YEAR FLOOD EXTENT, WATER DEPTH, AND SURVEYED ASSETS CATEGORIZED BY FLOOD EXPOSURE. NO FLOOD DAMAGE TO REPORT, JUST MINOR FLOODING ON THE ROAD DOWNSTREAM OF THE COMMUNITY.**

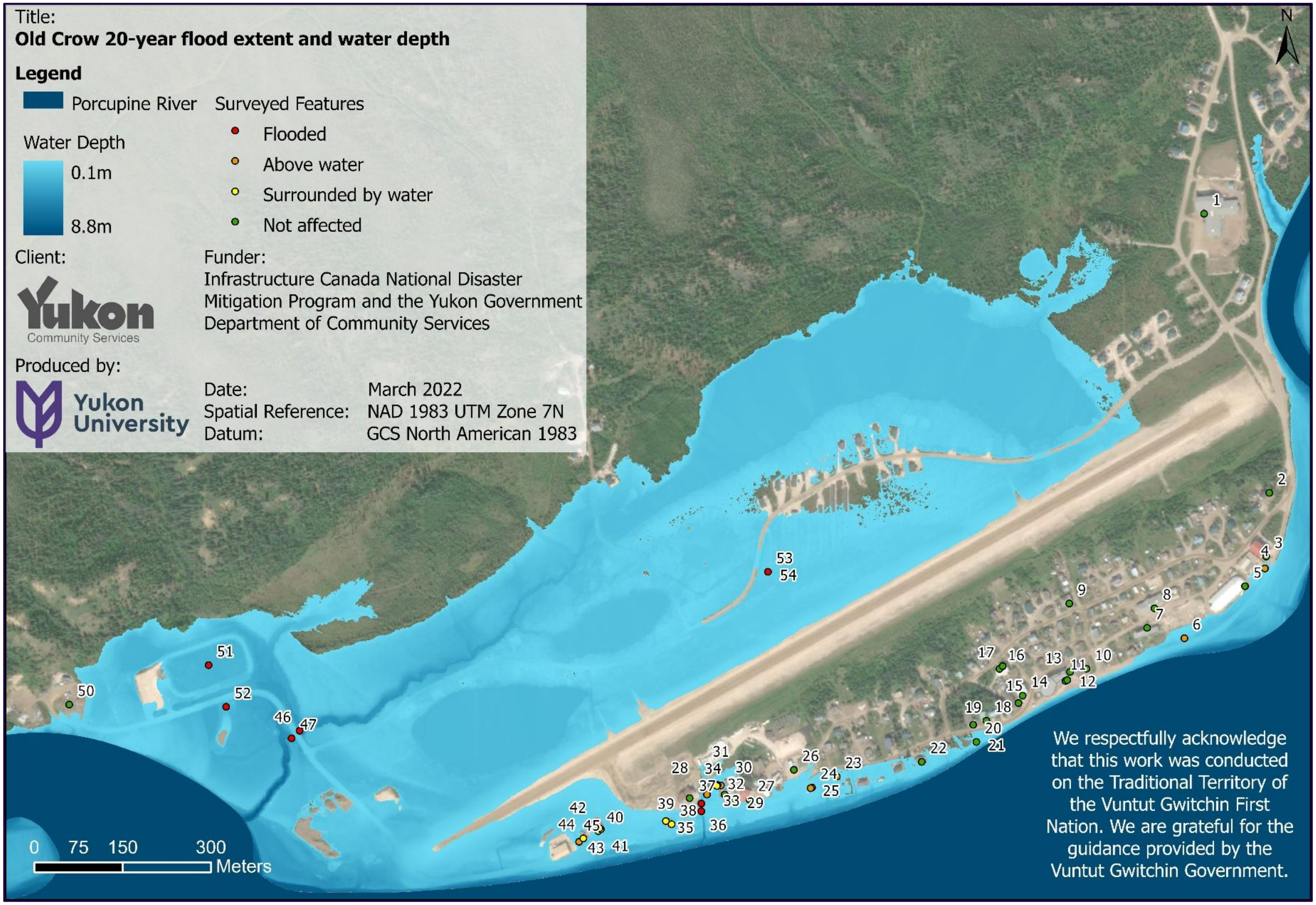


**FIGURE 4.2.3. 20-YEAR FLOOD EXTENT, WATER DEPTH, AND SURVEYED ASSETS CATEGORIZED BY FLOOD EXPOSURE. MAJOR FLOOD INCONVENIENT IS REPORTED, INCLUDING POTENTIAL DAMAGE AND WATER QUALITY ISSUES.**

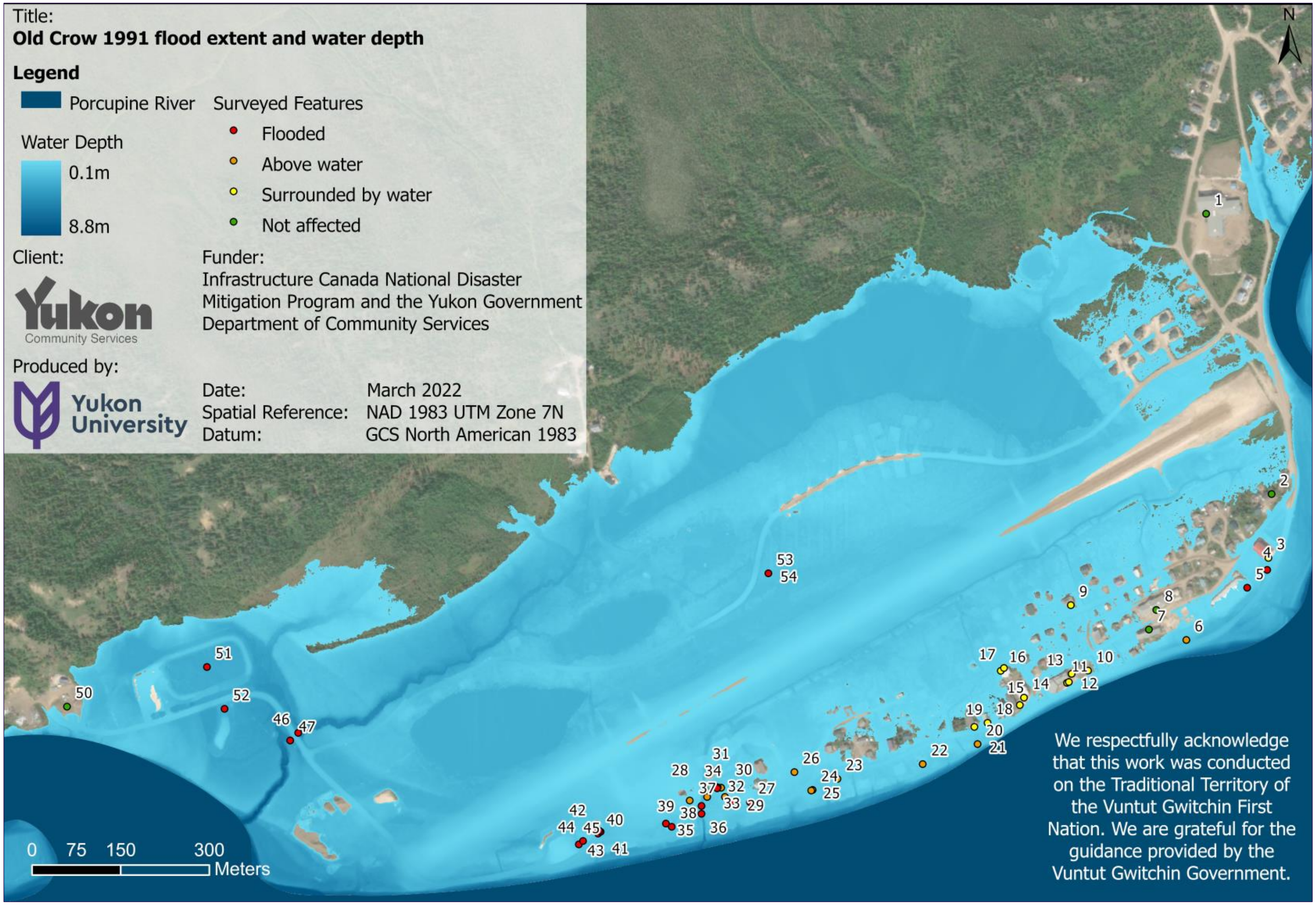


**FIGURE 4.2.4. ICE-JAM FLOOD OF 1991: FLOOD EXTENT, WATER DEPTH, AND SURVEYED ASSETS CATEGORIZED BY FLOOD EXPOSURE. EXTREME FLOOD DAMAGE WAS REPORTED.**

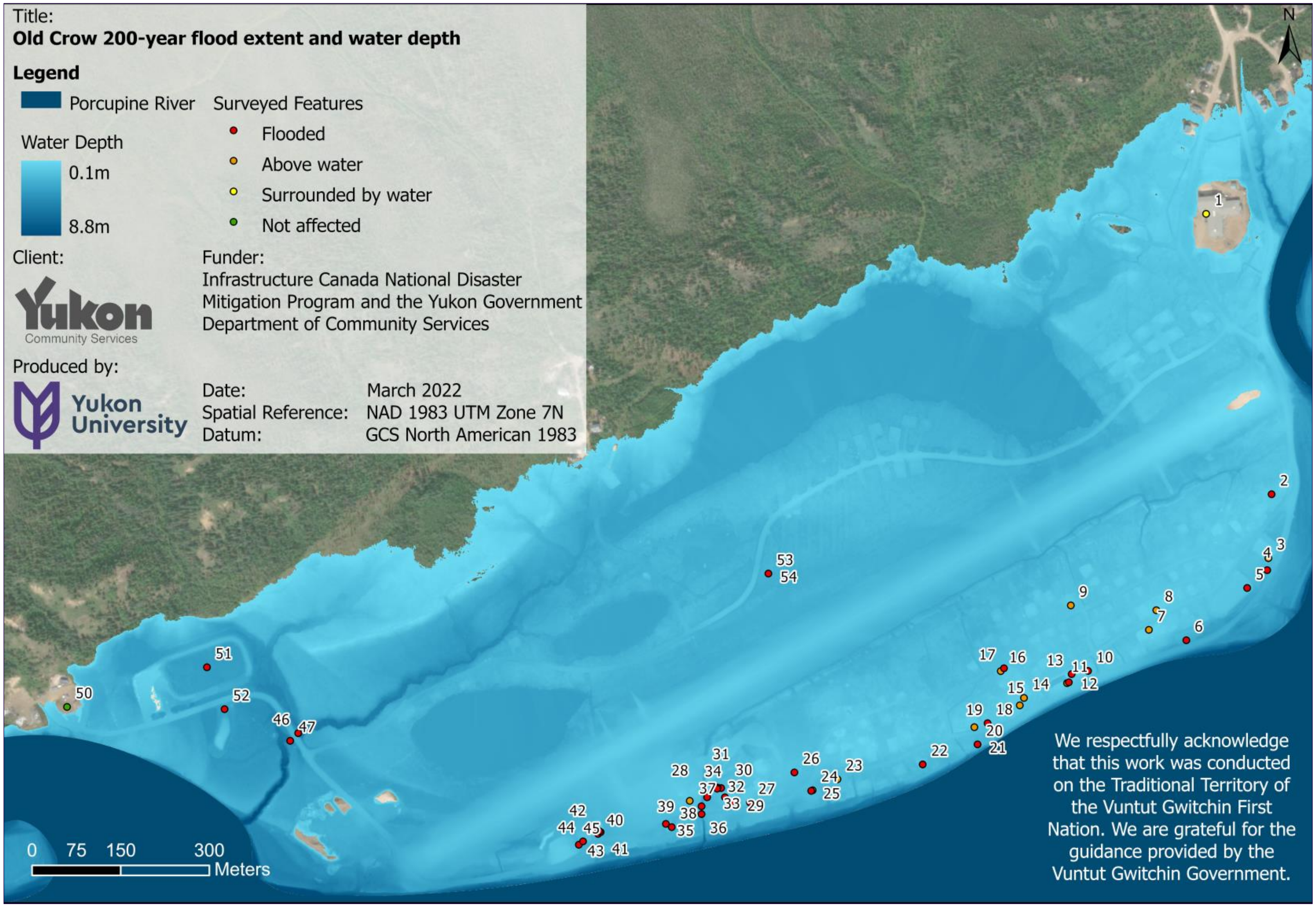


**FIGURE 4.2.5. 200-YEAR FLOOD EXTENT, WATER DEPTH, AND SURVEYED ASSETS CATEGORIZED BY FLOOD EXPOSURE. EXTREME FLOOD DAMAGE IS REPORTED, ALSO LIFE-THREATENING CONDITIONS IMPOSED BY MOVING ICE AND FAST FLOWING WATER.**

## 4.3 Flood exposure assessment for specific community assets

The following list of surveyed assets are associated with a range of flood return periods (the complete list, with corresponding numbers in Figures 4.2.2 to 4.2.5, is presented in Appendix A):

- Minor flooding, with a return period corresponding to less than 10 years, does not significantly affect the airstrip. However, for higher flood elevations, access to the terminal and fuel tanks may be impeded by water. For flood events with a return period of 25 years or higher, the airstrip would become flooded to a point where the Air North plane that carries supplies to the community could not safely land.
- ATCO Electric assets would be flooded once every 25 years (lowest solar panel on the North side of the airstrip and electric cables beside diesel turbines) to 160 years (newer diesel generators). The exact role and level of importance of each asset has not been determined, nor the weakest link in the electricity production and distribution system (as stated in Section 6.9).
- The sewage Lagoon could be flooded as often as once every 2.5 years. Since this infrastructure is located in the hydraulic shadow of the airstrip, contamination could disperse upstream and affect low areas behind the airstrip. In turn, it seems that the dump located at the western end of the road would not be flooded for an event with a return period of 200 years.
- The first floor of the current Old Crow Health Centre (Old Crow Alts'ik K'atr'anahtii Zheh) is out of reach of most floods, with an elevation that corresponds to a 500-year event. However, the Centre would be isolated by more than 0.3 m of water once every 30 years on average and could be damaged by ice once every 80 years or so. A new Health Centre is currently being built on the other side of the community, close to the school, where the 200-year water level is estimated to 248.2 m.
- RCMP assets, at least their first floor, are very high above the ground. These buildings (three were surveyed) would be surrounded by water during a 25-year event, and their electric system (crawl space level) could be affected once every 100 years (when there is about 1 m of water on the streets).
- Machinery parked at the downstream end of the airstrip would be affected by water once every 5 years, on average, whereas the first floor of the compounds located closer to the airport terminal would be inundated once every 25 to 40 years.
- The Water Survey of Canada real-time hydrometric station would be surrounded by water for a river surface elevation corresponding to a 20-year event. Since large ice blocks would also be push against the bank for that same event, the station could be severally damaged once every 20 years (this is discussed in Section 6).
- The first floor of the Sarah Abel Chitze Building would be flooded once every 250 years, but the building itself could suffer flood damage more frequently.

# 5 Climate change perspective

## 5.1 General concepts

The flood return periods presented so far in this report are based on hydrometric data for the 1970-2021 period. This data does not reveal what is going to happen in the future. It would be strangely amazing if a changing climate was not impacting the frequency and intensity of floods, as if the multiple effects of altered hydrometeorological conditions would cancel each other to generate statistically stable water levels in the long term. It is therefore not surprising that trends in both open-water and ice-jam floods have been identified for the Porcupine River (Janowicz, 2017; Turcotte, 2021). However, the climate change signal, as it relates to high water levels, is unclear and much uncertainty remains.

Three aspects of climate change may play a direct or indirect role in current and future runoff rates and flooding processes in Yukon:

- Changes in watershed scale precipitation patterns (both in winter and spring)
- Extreme watershed scale warm conditions (mainly in the spring, when snow melts)
- Extreme sub watershed scale (convective) precipitation (in the summer)

The consequences of these processes, combined with the influence of a progressive rise in average temperatures, may also trigger changes in other parameters affecting floods through morphological destabilization or hydrological cycle alteration:

- Altered river ice cover thickness (e.g., affecting the potential intensity of ice-jam floods)
- Increased forest fire hazards (e.g., impact on surface runoff rates and evaporation)
- Thawing permafrost (e.g., impact on surface runoff rates)
- Shrubification of tundra areas (e.g., impacts on evaporation and snow interception)
- Increased landslide hazards (e.g., impacts on channel bed elevation and channel width)

The following subsection explores the potential response of the Porcupine River to a changing climate.

## 5.2 Future floods in Old Crow

### 5.2.1 Ice-jam floods

The last great flood in Old Crow was caused by an ice jam and took place in 1991 (Section 3.2). It followed another ice-jam flood circa 1973. Does the Porcupine River have the capacity to generate ice jams of high intensity as the climate gets warmer? The spring breakup water level record contains too many gaps to provide a clear answer. From an <u>ice resistance point of view</u> (the higher the resistance, the more significant ice jams can be), three factors should be considered:

- The initial (freeze-up) ice cover thickness, largely controlled by the discharge when the ice cover forms
- The ice cover thickening during winter, largely controlled by air temperatures
- The ice cover degradation in the spring, largely controlled by the presence of new snow on the river, by sky conditions (sunny or cloudy) and by the rate at which air temperatures are increasing

Based on 59 years of data, Figure 5.2.1 suggests that flows in the Porcupine River prior to river ice formation have been increasing after 2000 (and this is probably associated with increased fall precipitation). This could generate thicker freeze-up jams at key points along the Porcupine River, therefore increasing resistance in the spring and consequently the affecting the risk associated with ice jams.

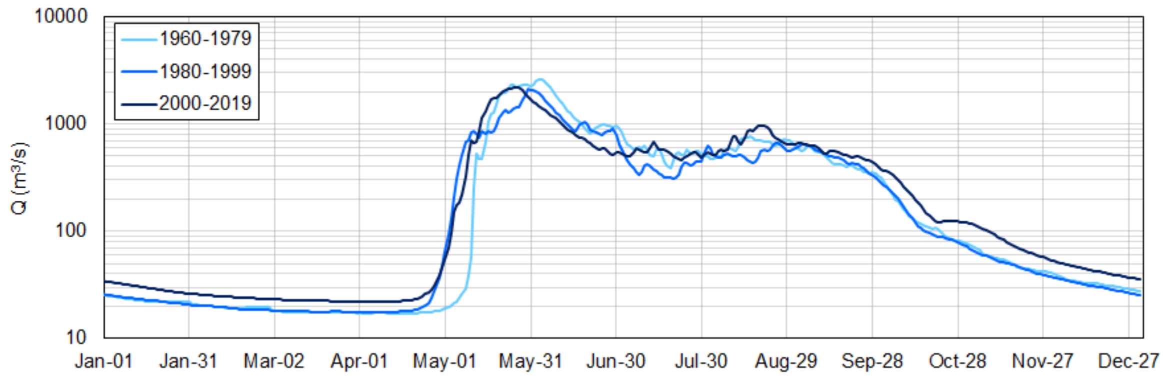


**FIGURE 5.2.1. AVERAGE CALCULATED AND ESTIMATED DISCHARGE AT THE PORCUPINE RIVER STATION 09FD002 (AND CONVERTED DISCHARGE FROM STATION 09FD001 PRIOR TO 1987) FOR THREE PERIODS OF 20 YEARS.**

In turn, through an investigation of maximum freezing degree-days in Old Crow, Figure 5.2.2 indicates that winters are becoming milder, which consequently suggests that the ice cover is becoming thinner over time, on average, by a few centimeters per decade. This is supported by measurements of the ice cover thickness performed by the Water Survey on the Porcupine River downstream at the Alaska border in recent winter and revealing an average reduction of 0.25 m in 20 years. Therefore, the ice cover could, on average, become weaker over the years.

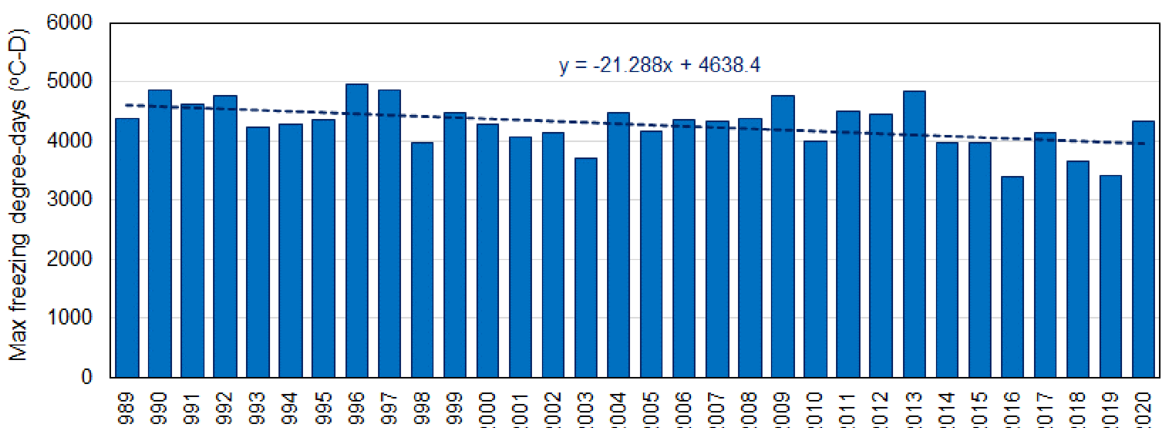


**FIGURE 5.2.2. MAXIMUM FREEZING DEGREE-DAYS AT OLD CROW SINCE 1989. THE TREND IS APPARENTLY DECREASING.**

In terms of parameters driving the mobilization of the ice cover, another aspect of breakup intensity (the more intense the drive is, the more likely ice jams are to form), Janowicz (2017) had suggested that snowmelt runoff events were becoming more conducive to severe ice jams. It has certainly been observed, in recent springs, that very warm temperatures early in the spring could cause a very dynamic mobilization of the ice cover over long distances of the Porcupine River (e.g., in May 2019 and May 2020). This is somewhat supported by Figure 5.2.1 revealing a freshet (snowmelt runoff period) that begins sooner post-1980. Climate projections presented by the Government of Canada (Zang et al., 2019) suggest that December to February precipitation will increase by 10% to 30% in the future. Although this does not include the entire Yukon winter period, it still suggests a higher potential for snowmelt runoff in the Spring.

However, recent climate observations suggest that the snowpack may become thinner over time in the Yukon's north (losing 2% to 5% of its snow water equivalent per decade, Mudryk et al., 2018), which would represent a limitation to high runoff rates (the snow cover had largely melted in the Porcupine River headwaters in May 2020 while breakup was underway).

From an ice jam initiation point of view, an observational study must be performed to document breakup patterns upstream and downstream of Old Crow. It would therefore be important to revisit what Jasek (1997) had judiciously described two decades ago. Conversations with VGFN citizens in recent years indicate that the riverbed is changing, another expected consequence of climate change. More local and satellite-derived information would need to be analyzed for an accurate assessment to be completed.

In summary, the impact of climate change on the multiple factors influencing the severity of river ice jams in the Old Crow reach of the Porcupine River remains largely uncertain, with factors potentially increasing the risk and others reducing the risk of floods.

### 5.2.2 Open-water floods

The highest water levels in Old Crow are generally caused by ice jams, but post-breakup intense snowmelt can also generate open-water floods (Figure 3.1.1). The minor flood level in Old Crow (approximately 244.5 m at the WSC station) is reached every 4 years in the presence of an ice jam and every 8 years once breakup is over (overbank flooding in Old Crow begins above 5500 $m^3/s$).

It is unclear how changing air temperatures, precipitation, vegetation coverage, and permafrost conditions will affect post-breakup high flows (open water conditions) in the Porcupine River at Old Crow. Very intense (local) rain events are not likely to significantly impact the discharge of the Porcupine River, given its large drainage area. Moreover, the increased variability in larger scale wet weather events that generate high flows after snowmelt (and this has had a low potential for flooding in recent decades) could be offset by permafrost thaw and increase evapotranspiration.

Therefore, an increase in the frequency of open-water floods in Old Crow would probably depend on snowpack and snowmelt rates, just like for ice-jam floods. Figure 5.2.3 reveals that, since 1968, annual maximum flows have remained relatively stable at about 4000 $m^3/s$, on average. This means that, despite the projected increased winter precipitation (Zang et al., 2019) that could lead to higher flows after breakup, this signal is still not visible in historical data.

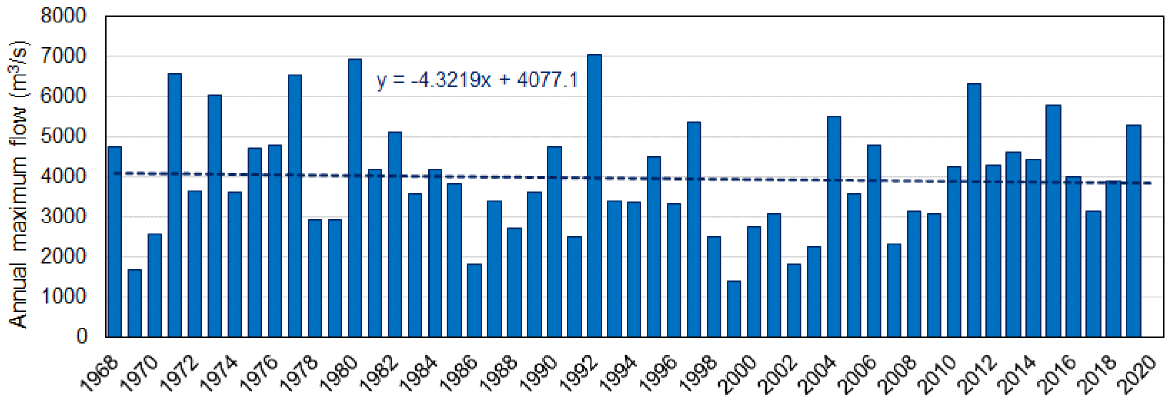


**FIGURE 5.2.3. MAXIMUM DISCHARGE IN THE PORCUPINE RIVER AT ALASKA BORDER FROM 1968 TO 2020 (WITH SOME DATA TRANSFERRED FROM THE FORMER STATION 09FD001). THE TREND IS APPARENTLY STABLE.**

### 5.2.3 Morphological considerations

Beyond ice and runoff driven flooding processes, the evolving alignment and shape of the Porcupine River channel is an important consideration. The tight meander bend in the Porcupine River just upstream of Old Crow is apparently becoming thinner (based on a comparison of satellite imagery, Figure 5.2.4). Regardless of a changing climate and melting permafrost, natural forces (ice jam overflow) could eventually cut this meander, a process that would result in a significant destabilization of the Porcupine River channel at Old Crow and a change in flooding probabilities for the community.


**FIGURE 5.2.4. SLOWLY EVOLVING PENINSULA ON THE INNER SIDE OF THE MEANDER BEND UPSTREAM OF OLD CROW BETWEEN 1986 AND 2020. (GOOGLE EARTH ENGINE)**

Other morphological processes related to floods include landslides suddenly blocking the Porcupine River or the Old Crow River (a natural process that has been observed in other rivers of the North) and generating high flow events upon blockage release. William Josie (personal communication, 2021) raised concerns from community members about lakes in Old Crow flats (Old Crow River watershed) that could suddenly empty into the drainage system and cause high water levels in Old Crow. Given the morphology and size of the Old Crow River (with a significant flood wave attenuation capacity), the risk associated with this process is probably low for Old Crow, but it needs to be further analyzed.

***

On one side, hydrological, ice, and morphological processes in the changing North are very complex. On the other side, historical hydrometric records are short and partial. A consultation with VGFN about the impact of climate change on high water levels in the Porcupine River has not happened yet. It is therefore recommended to consider that flood elevations based on the 1989-2021 stage record, as defined in this study, should be used until a more comprehensive climate change research assessment is completed, while keeping an eye on morphological processes, such as the stability of the meander bend located just upstream of the community.

# 6. Recommendations to improve flood protection and reduce flood vulnerability

Previous sections of the report demonstrate that ice jams represent the greatest flood hazard in Old Crow, also that the impacts of climate change are uncertain. The next large flood may hit next year or in 50 years, and depending on the level of adaptation, consequences could be limited or not. This section presents a series of recommendations to reduce the risk of flooding by limiting the exposure of vulnerable assets and infrastructure. Appendix B presents all surveyed assets with their level of exposure to floods.

## 6.1 Riprap

It has been observed, during the dynamic breakup of May 2020, that ice pieces from the Porcupine River easily push and move rocks (generally smaller than 200 mm) composing the erosion protection (riprap) layout on the upstream bank in Old Crow. Not only is the sizing of the rocks questionable (even without ice abrasion, see Figure 6.1.1), but the alignment and downstream extent of the erosion protection may not be optimal, especially as the channel orientation continues to evolve. It is recommended to obtain professional advice about potential improvements to erosion protection, especially in the context where new assets have been built along the riverbank.

**FIGURE 6.1.1. EROSION PROTECTION ALONG THE PORCUPINE RIVER IN OLD CROW LOOKING EAST**

## 6.2 Culverts

Several culverts in the community are equipped with valves, including two large culverts in the creek behind (north of) the airstrip and one large culvert draining the south side of the airstrip. At each site, these valves are supposed to be closed manually during high water events in order to prevent water from the Porcupine River from entering the community. However, our analyses reveal that a large majority of these valves do not reduce flood damage. For example, the largest culverts on the road towards the landfill may prevent water from entering the community for benign hydrological events with a return period of 5 years. In turn, these valves are bypassed (the road is overtopped by water) for more significant events that do cause damage. It is therefore recommended to remove these valves rather than to maintain or fix them, unless there would be a plan to build vulnerable assets at low elevation on that side of the airstrip.

In the community, various culverts are installed to drain low areas whereas other culverts are meant to connect road-side ditches in order to drain streets and properties. A large majority of these culverts are structurally damaged by vehicles, or half buried under gravel, soil and vegetation (Figure 6.2.1, Appendix B). Some ditches are also blocked by debris and vegetation. Beyond the irritation associated with water accumulations in the community, this poses an increased risk for permafrost thawing. In order to avoid snowmelt and rain runoff water accumulations in the community, it is recommended to maintain, fix, and replace these culverts and ditches, and to design a functional surface water management network.

**FIGURE 6.2.1. EXAMPLE OF A CULVERT THAT IS DAMAGED AND UNLIKELY TO SERVE AS DESIGNED.**

## 6.3 Ice fence or dike

In the occurrence of a major flood (return period greater than 50 years, an event worse than the 1991 flood), large ice floes and slabs could enter the community and may severely damage buildings and houses. A quantitative risk assessment, involving the determination of damage associated with ice jam events of different return periods, could help determine whether a flood protection infrastructure represents an affordable and socially acceptable risk reduction measure for Old Crow.

If ice-related damage is found to be a significant risk, an ice fence could be worthy of investigation. Such a fence could be comprised of set of robust piers sticking out of the ground that would keep the largest ice floes in the river channel, therefore reducing the damage caused by ice. The structure could be removed and reinstalled when needed, using heavy equipment. The cost of a permanent dike would be significant and would create a barrier between the people and the river, and it would only reduce the risk for a limited range of flood scenarios.

## 6.4 Sewage Lagoon

Based on the current analysis, the dike around the sewage lagoon could be overtopped for events with a return period just above 2 years. In such a scenario, contaminated water could flow in the upstream direction in the hydrodynamic shadow of the airstrip and mix with relatively stagnant water in the creek and in the series of ponds (e.g., Figure 4.2.3). It seems important to protect the population of Old Crow and the environment against the harmful effects of the sewage lagoon water, and it is recommended to consider the deployment of temporary dikes prior to a forecasted intense breakup event, or to increase the permanent dike protection around this infrastructure.

## 6.5 Resilience of WSC hydrometric station 09FD003

The Water Survey of Canada station located in Old Crow is installed on wood blocks and almost seems like a temporary asset (Figure 6.5.1). This station provides critical hydrometric information to flood forecasters and decision makers, and it represents the only source of quantitative data that can be used for statistical analyses from which flood risk assessments are derived. It is recommended to:

- Protect this station against ice impacts (it is exposed to ice pushed against the bank during moderate to intense river ice breakup events).
- Operate the station from mid-April to mid-November (there is a need to better document river ice formation events from a hydrological perspective, and this station must be operational at the onset of breakup).
- Use adapted technology (the bubbler technology that relies on air lines has proven to be unsuitable for this site). In May 2020 air lines were either frozen or pulled downstream by the first sustained ice movement. There is also a need for duplicate sensors.

**FIGURE 6.5.1. THE WATER SURVEY OF CANADA STATION 09FD003 SEEMS EXTREMELY VULNERABLE TO ICE JAM IMPACTS AND FLOODS, AND THIS IS WHEN THE DATA IS NEEDED.**

## 6.6 Breakup timing and intensity forecast tools

In recent years, freeze-up and breakup ice jams have formed in the meander bend located just east of Old Crow. These ice jams are not visible from the community and their release may translate into a flood event in Old Crow within a few hours. Such an event is difficult to predict.

Existing ice-observation practices by the Community and Yukon Government are important, but Old Crow could benefit from other flood forecasting tools. It is recommended to:

- Obtain regular visual updates or ice conditions just upstream of Old Crow. A drone could support the collection of such information, but the proximity of the airstrip (air space) may prevent drone flights as for Transport Canada regulation.
- Install a real-time water level sensor in a river bend upstream of Old Crow. The sensor and data logger would trigger an alarm if the water level varied suddenly, which would indicate that an ice run is coming. The data acquisition rate during breakup would be adjustable in order to save batteries and community members could be trained to operate and maintain it. It could also serve as a hydrometric backup in the case station 09FD003 fails.

In addition, it is recommended to update the studies performed by Jasek (1993, 1997), which would include consultation with community members. Quantitative and qualitative information has been collected since these studies were completed (e.g., historical ice maps collected by Yukon Government), but it has not been analyzed yet. This would inform future breakup monitoring strategies and could also inform the development of a breakup timing and intensity forecast model, in collaboration with the population. Such a model does not currently exist for Old Crow, and it represents a fundamental risk reduction tool.

## 6.7 Access during a flood event

The school is where the population of Old Crow should evacuate in the event of a major flood. Its elevation is deemed safe for a 200-year hydrological event as simulated by the YRC. However, Figure 4.2.5 shows that the school could become isolated (yellow dot), which means it would be surrounded by water with depths greater than 1 m in all directions. Beyond evacuation protocols and emergency supply management (discussed in Section 6.3), it is recommended to:

- Prepare an area next to the school where a heavy helicopter could safely land, or to
- Ensure that emergency supplies carried by a large helicopter could reach the school.

Rising the elevation (at least a portion) of the air strip could be considered as a measure to access the community when affected by an exceptional flood, but the cost of gravel in Old Crow may prevent this adaptation measure from being affordable. A new Health Centre is being built across the road from the school. The design elevation and access to this new critical infrastructure would need to consider the most recent flood probability assessment available.

## 6.8 Flood information diffusion within the population

Vuntut Gwitchin people have a close relationship with the Water and the Land. The 1973 and 1991 floods had a profound impact on the community, exposing its vulnerability, but also its resilience. Considering that Old Crow remains exposed to floods that could occur relatively suddenly, and with little lead time to react or evacuate, it would be appropriate to share knowledge about hydrological processes and floods. Flood information could be shared through meetings.

## 6.9 Critical community assets

Essential services in Old Crow include access to drinking water, water treatment, access to food, communication, and electricity. Several surveyed assets provide these services, but the lowest elevation of the weakest component of each asset could not be confirmed, and the real impact of its exposure to water could only be revealed through knowledge exchange with the various owners (Community Services, Vuntut Gwitchin First Nation, ATCO, YEC, etc.). This report, and the data presented in Appendices A and B, is meant to provide information about different flood levels at the location of each asset, to let owners and emergency managers measure the level of consequence that this represents, and to inform future adaptation, if needed.

For example, the lowest solar panel and electric cables connecting diesel turbines to other small buildings on the ATCO property in Old Crow could be affected by water every 25 years on average. However, it cannot be confirmed if this water level would result in damage to an entire system, an entire solar panel array, or just a few solar panels.

## 6.10 Updating flood emergency protocols

A review of emergency protocols for the management of a flood event and recovery falls outside the scope of this study. However, emergency protocols prepared by communities and by the Emergency Measure Organization (EMO), an entity of Community Services (CS), should be regularly reviewed and updated. It should be considered that:

- In the case of a major ice-jam flood, water level would start rising first downstream (as reported in 1973). Water level rise rates could be as high as several centimeters per minute, giving less than one hour between the first flood impact and severe flood damage. With adequate tools and models, an ice-jam flood could be forecasted a few days in advanced and detected with a lead time of a few hours.
- In the less likely situation of an open-water flood, water levels would rise by several centimeters per hour, providing a more reasonable lead time for flood response. Flooding would also likely begin downstream where the land elevation is lower.

If invited in meetings, the YRC would like to extend a standing offer to contribute relevant technical expertise when needed.

## 6.11 Updating flood risk tools regularly

The impact of climate change on the frequency of high water levels remains uncertain (Section 5). Continued observation of annual maximum water levels and changes in channel characteristics is crucial to determining the probability of a flood. It is recommended to update water level frequency analyses on an annual basis, and to update flood maps when deemed appropriate (if flood levels have sensibly changed, or once the impact of climate change is better defined). The current study could also be updated if and when needed.

# 7. Conclusions

This project, through elevation surveys and GIS analyses using LiDAR-derived digital elevation models, has documented the flood exposure of different assets in Old Crow. The current frequency of flooding, evaluated using historical stage data as well as information provided in reports, is relatively high: once every 10 years (10% of annual probability).

The impact of climate change on the frequency and severity of floods in Yukon is difficult to assess and to isolate from the natural variability of hydrological processes. In winter, air temperatures in Old Crow may be as high as -5ºC (even 0ºC with light rain, a new reality identified by Janowicz, 2010) and as low as -50ºC. This significant range, added to the overall sequence of atmospheric systems during the long sub-arctic winter, and influenced by increased carbon dioxide concentrations, dictate hydrological processes that lead to ice jam and snowmelt driven floods. The complexity of interacting factors that influence river water levels, the scarcity of historical data, and our embryonic ability to simulate dynamic winter hydrological processes represent significant limitations to foresee the future risk of flooding. Long periods without significant floods combined with other societal challenges, such as COVID19, also tend to slow flood adaptation efforts. However, at a larger scale, in neighbouring provinces and even in other watersheds of Yukon, significant floods continue to generate increasing damage.

Considering the location of the community, the presence of permafrost, the local channel morphology, and the hydrological regime of the Ch'oodeenjìk (Porcupine River), improving the level of flood protection is not trivial. Adaptation measures that are easier to implement include focusing on resilience, prevention, and recovery rather than flood-proofing the entire perimeter of the community. In a context of uncertainty in which the next flood will probably happen sooner than sought, the YRC has recommended a number of actions.

This report represents a scientific basis on which Government decision makers and expert consultants can confirm flood protection weaknesses, and design adapted flood protection assets in Old Crow. Improving the resilience to floods does not only imply construction, but also the development of computational tools and models, river monitoring strategies, as well as the dissemination of information related to this natural hazard, the second in importance after forest fires (Diarmuid O'Donavan, CS-EMO, personal communication, 2019).

As established by agencies around the world and synthesized in a UN Press Release (2019), every dollar invested in climate change resilience could save six dollars. It is never too early to adapt.

# 8. References


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# Appendix A: List of surveyed assets

| ID# | Surveyed assets | | Elev. (m) | Flood return Period |
|---|---|---|---|---|
| | Description | Surveyed feature | | |
| 1 | School | Door step, first floor | 251.2 | 7000 |
| 2 | Trinin Tsul Zheh, Family DayHome Old Crow | Door step, first floor | 248.2 | 185 |
| 3 | Coop, entrance | Door step, first floor | 249.3 | 750 |
| 4 | Wood and other storage yard | Ground elevation | 246.2 | 20 |
| 5 | Arena | Ground elevation, first floor | 246.8 | 40 |
| 6 | Old Crow Arctic Research Facility | First floor, top of ramp | 247.2 | 65 |
| 7 | John Tizya (community) Centre | Door step, first floor | 249.1 | 800 |
| 8 | Sarah Abel Chitze (Gov.) Building | Door step, first floor | 248.3 | 260 |
| 9 | Yukon College | Door step, first floor | 248.1 | 200 |
| 10 | Old Community Centre | Door step, first floor | 247.8 | 170 |
| 11 | New Community Centre | Door step, first floor | 249.6 | 1600 |
| 12 | Board walk around new Community Centre | Wood surface, low point | 247.6 | 125 |
| 13 | Fuel tank for new Community Centre | Foot of support | 247.8 | 160 |
| 14 | RCMP main building | Door step, first floor | 249.4 | 1250 |
| 15 | RCMP Ttemporary quarters | Door step, first floor | 248.6 | 420 |
| 16 | RCMP brown building, north | Door step, first floor | 249.4 | 1200 |
| 17 | RCMP brown building, north | Electric boxes on north side | 247.5 | 125 |
| 18 | Old Church | Door step, first floor | 246.8 | 45 |
| 19 | New Church, blue building | Door step, first floor | 248.2 | 265 |
| 20 | Water Survey Canada station | Bottom of structure | 246.2 | 20 |
| 21 | Water Survey Canada station | Bottom of box with instruments | 247.2 | 80 |
| 22 | Old Crow B&B | Door step, first floor | 247.9 | 200 |
| 23 | Health Centre (Old Crow Alts'ik K'atr'anahtii Zheh) | Door step, first floor | 248.5 | 500 |
| 24 | Water Treatment facility | Door step, first floor | 247.9 | 235 |
| 25 | Water Treatment facility | Elextric box visible from outside | 247.4 | 110 |
| 26 | Porcupine Enterprises, offices | Door step, first floor | 247.6 | 160 |
| 27 | Maintenance compound, brown building | Concrete slab, first floor, first door | 246.6 | 35 |
| 28 | Northwestel building | Door step, first floor | 247.0 | 60 |
| 29 | ATCO old diesel generator | Low point | 246.8 | 45 |
| 30 | ATCO diesel tanks 1 and 2 | Metal support, surface | 247.1 | 65 |
| 31 | ATCO new generator, blue roof | First floor, assumed | 247.7 | 160 |
| 32 | ATCO white battery | First floor, lowest elevation | 247.8 | 200 |
| 33 | ATCO transformer (green) Box | Concrete footing, surface | 246.7 | 40 |
| 34 | Metal track with electric cables | Surface of metal sheet | 246.4 | 25 |
| 35 | South airport culvert drainage, downstream | Bottom elevation | 244.2 | 2 |
| 36 | South airport culvert drainage, upstream | Bottom elevation | 244.2 | 2 |
| 37 | Airport terminal | Door step, first floor | 248.0 | 260 |

| # | Surveyed assets | | Elev. (m) | Flood return Period |
|---|---|---|---|---|
| | Description | Surveyed feature | | |
| 38 | Two grey fuel tanks, west of Airport terminal | Bottom of tanks | 246.1 | 18 |
| 39 | Dike around fuel tanks | Low point | 246.3 | 25 |
| 40 | Large fuel tank and smaller white ones #1202 | Bottow of support | 246.4 | 28 |
| 41 | Smaller white tank | Bottom, concrete slab | 246.1 | 18 |
| 42 | Tank at the back | Bottom, concrete slab | 246.3 | 23 |
| 43 | Dike around fuel tanks | Low point | 246.4 | 28 |
| 44 | Small compound, grey guilding / white annex | Door step, first floor | 246.4 | 25 |
| 45 | Large compound, blue building with pipes | Concrete slab, first floor | 246.7 | 40 |
| 46 | Large culvert draining north of airstrip, upstream | Bottom elevation | 242.4 | 0.3 |
| 47 | Large culvert draining north of airstrip, downstr. | Bottom elevation | 242.6 | 0.4 |
| 48 | Small culvert draining north of airstrip, upstream | Bottom elevation | 242.5 | 0.4 |
| 49 | Small culvert draining north of airstrip, downstr. | Bottom elevation | 243.0 | 0.6 |
| 50 | Household Waste Dump | Ground level | 249.1 | 1600 |
| 51 | Sewage Lagoon | Dike around lagoon / low point | 244.5 | 2.5 |
| 52 | Community Metal Dump | Ground level | 244.4 | 2.5 |
| 53 | Solar farm | Lowest point of lower panel | 246.4 | 25 |
| 54 | Solar farm | Lowest point lowest gravel pad | 245.5 | 8 |
| 55 | Culvert draining east of Old Crow, upstream | Bottom elevation | 243.7 | 1.0 |
| 56 | Culvert draining east of Old Crow, downstream | Bottom elevation | 244.0 | 1.5 |
| 57 | Culvert draining park and streets, upstream | Bottom elevation | 245.4 | 7 |
| 58 | Culvert draining park and streets, downstream | Bottom elevation | 244.4 | 2 |
| 59 | Culvert west of new C Center, upstream | Bottom elevation | 245.9 | 12 |
| 60 | Culvert west of new C Center, dowstream | Bottom elevation | 245.3 | 6 |
| 61 | Culvert along ditch close to Church, upstream | Bottom elevation | 245.9 | 13 |
| 62 | Culvert along ditch close to Church, downstr. | Bottom elevation | 245.9 | 13 |
| 63 | Culvert, East of Health Center, upstream | Bottom elevation | 245.6 | 10 |
| 64 | Culvert, East of Health Center, downstream | Bottom elevation | 245.5 | 9 |
| 65 | Small culvert west of airport, upstream | Bottom elevation | 244.8 | 4 |
| 66 | Small culvert west of airport, downstream | Bottom elevation | 244.5 | 2.6 |
| 67 | Small culvert west or airstrip, upstream | Bottom elevation | 243.4 | 0.8 |
| 68 | Small culvert west of airstrip, downstream | Bottom elevation | 243.2 | 0.7 |

# Appendix B. Detailed surveyed assets

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 1 |
| **Asset** | Chief Zzheh Gittlit School |
| **Location** | Northeastern tip of community / North of airstrip |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Doorstep / First floor / Top of stairs | | |
| **Elevation** | 251.2 m | **Flood return period** | 7000 years* |
| | | **Annual overflow probability** | 0.01%* |

* Isolated by a flood (surrounded by water) every 200 years, approximately.

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 2 |
| **Asset** | Trinin Tsul Zheh, Family Day Home Old Crow |
| **Location** | Eastern end of community / Street corner |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Doorstep / First floor / Top of stairs | | |
| **Elevation** | 248.2 m | **Flood return period** | 185 years* |
| | | **Annual overflow probability** | 0.5%* |

* Isolated by a flood (surrounded by water) every 80 years, approximately.

<table>
<tr><td>Community</td><td colspan="3">Old Crow</td></tr>
<tr><td>ID #</td><td colspan="3">3</td></tr>
<tr><td>Asset</td><td colspan="3">Coop (Super Market and accommodation)</td></tr>
<tr><td>Location</td><td colspan="3">Eastern end of the community, in front of the Porcupine River</td></tr>
<tr><td colspan="4">
</td></tr>
<tr><td>Surveyed feature</td><td colspan="3">First floor / Main floor</td></tr>
<tr><td>Elevation</td><td>249.3 m</td><td>Flood return period</td><td>750 years</td></tr>
<tr><td colspan="2"></td><td>Annual flood probability</td><td>0.1%</td></tr>
</table>

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 4 |
| **Asset** | Wood yard / Construction material storage |
| **Location** | Eastern end of the community, besides Coop |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Ground level / Yard entrance | | |
| **Elevation** | 246.2 m | **Flood return period** | 20 years |
| | | **Annual flood probability** | 5 % |

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 5 | | |
| **Asset** | Old Crow Arena | | |
| **Location** | Eastern end of the community | | |
|  | | | |
| **Surveyed feature** | Ground level / Floor level | | |
| **Elevation** | 246.8 m | **Flood return period** | 40 years |
| | | **Annual flood probability** | 2.5 % |

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 6 | | |
| **Asset** | Old Crow Arctic Research Facility | | |
| **Location** | Waterfront / East of John Tizya Community Centre | | |
|  | | | |
| **Surveyed feature** | Floor level, doorstep / Top of ramp | | |
| **Elevation** | 247.2 m | **Flood return period** | 65 years |
| | | **Annual flood probability** | 1.5 % |

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 7 | | |
| **Asset** | John Tizya (community) Centre | | |
| **Location** | One street away from waterfront / West of Old Crow Research Facility | | |
|  | | | |
| **Surveyed feature** | Doorstep / First floor / Top of stairs | | |
| **Elevation** | 249.1 m | **Flood return period** | 800 years* |
| | | **Annual overflow probability** | 0.1%* |

* Isolated by a flood (surrounded by water) every 180 years, approximately.

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 8 | | |
| **Asset** | Sarah Abel Chitze (VG Government) Building | | |
| **Location** | One street away from waterfront / North of John Tizya Centre | | |
|  | | | |
| **Surveyed feature** | Doorstep / First floor / Top of stairs | | |
| **Elevation** | 248.3 m | **Flood return period** | 260 years* |
| | | **Annual overflow probability** | 0.4%* |



* Isolated by a flood (surrounded by water) every 80 years, approximately.

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 9 | | |
| **Asset** | Yukon University / Old Crow Campus | | |
| **Location** | Middle of community, airstrip side street | | |


| | | | |
|---|---|---|---|
| **Surveyed feature** | Doorstep / First floor / Top of stairs | | |
| **Elevation** | 248.1 m | **Flood return period** | 200 years* |
| | | **Annual overflow probability** | 0.5%* |

* Isolated by a flood (surrounded by water) every 50 years, approximately.

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 10 |
| **Asset** | Old Community Centre |
| **Location** | Waterfront / next to New Community Centre |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Doorstep / First floor | | |
| **Elevation** | 247.8 m | **Flood return period** | 170 years |
| | | **Annual flood probability** | 0.6 % |

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 11 |
| **Asset** | New Community Centre |
| **Location** | Waterfront / next to Old Community Centre |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Doorstep / First floor (top of outside stairs and ramps) | | |
| **Elevation** | 249.6 m | **Flood return period** | 1600 years* |
| | | **Annual flood probability** | 0.06 % |

* Outdoor stairs and ramps could be damaged by ice once every 100 to 200 years.

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 12 | | |
| **Asset** | **Boardwalk** – New Community Centre | | |
| **Location** | Waterfront / next to Old Community Centre | | |
|  | | | |
| **Surveyed feature** | Flood level / Surface of boardwalk / Lowest point | | |
| **Elevation** | 247.6 m | **Flood return period** | 125 years |
| | | **Annual flood probability** | 0.8 % |

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 13 | | |
| **Asset** | **Fuel Tank (White)** – New Community Centre | | |
| **Location** | Between New and Old Community Centre | | |
|  | | | |
| **Surveyed feature** | Concrete pad / Ground level | | |
| **Elevation** | 247.8 m | **Flood return period** | 160 years |
| | | **Annual flood probability** | 0.6 % |

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 14 |
| **Asset** | RCMP main building |
| **Location** | West side of New Community Centre / Waterfront / Brown building |


| | | | |
|---|---|---|---|
| **Surveyed feature** | Doorstep / First floor / Top of outdoor stairs | | |
| **Elevation** | 249.4 m | **Flood return period** | 1250 years* |
| | | **Annual flood probability** | 0.08 %* |

* Some electric and ventilation assets as well as storage below first floor may be exposed to floods on a more frequent basis.

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 15 |
| **Asset** | RCMP Temporary Quarters |
| **Location** | West of RCMP main building / Waterfront / Red building |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Doorstep / First floor / Top of outdoor stairs | | |
| **Elevation** | 248.6 m | **Flood return period** | 420 years* |
| | | **Annual flood probability** | 0.25 %* |

* Some electric and ventilation assets as well as storage below first floor may be exposed to floods on a more frequent basis.

<table>
<tr><td>Community</td><td colspan="3">Old Crow</td></tr>
<tr><td>ID #</td><td colspan="3">16-17</td></tr>
<tr><td>Asset</td><td colspan="3">RCMP large building (two story building)</td></tr>
<tr><td>Location</td><td colspan="3">At the back of the yard between two RCMP buildings (back view below)</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Surveyed feature</td><td colspan="3">Doorstep / First floor / Top of stairs (electric boxes)</td></tr>
<tr><td>Elevation</td><td>249.4 m (247.5)</td><td>Flood return period</td><td>1200 years (125 years)*</td></tr>
<tr><td colspan="2"></td><td>Annual overflow probability</td><td>0.1 (0.8%)*</td></tr>
</table>

* Some vulnerable components of the building may be located at lower elevations and therefore could be affected more frequently by water.

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 18 |
| **Asset** | Old Church |
| **Location** | Waterfront / Next to New Church (St. Luke's Anglican Church) |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Doorstep / First floor | | |
| **Elevation** | 246.8 m | **Flood return period** | 45 years |
| | | **Annual flood probability** | 2.3 % |

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 19 | | |
| **Asset** | St. Luke's Anglican Church | | |
| **Location** | Waterfront / next to old Church | | |
|  | | | |
| **Surveyed feature** | Doorstep / First floor | | |
| **Elevation** | 248.2 m | **Flood return period** | 265 years |
| | | **Annual flood probability** | 0.4% |

<table>
<tr><td>Community</td><td colspan="3">Old Crow</td></tr>
<tr><td>ID #</td><td colspan="3">20-21</td></tr>
<tr><td>Asset</td><td colspan="3">Water Survey of Canada Hydrometric station 09FD003</td></tr>
<tr><td>Location</td><td colspan="3">Water edge / Front of St. Luke's Anglican Church</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Surveyed feature</td><td colspan="3">Wood structure and support (& Electronic box)</td></tr>
<tr><td>Elevation</td><td>246.2 m (247.2 m)</td><td>Flood return period</td><td>20 years (80 years*)</td></tr>
<tr><td colspan="2"></td><td>Annual flood probability</td><td>5% (1.2%*)</td></tr>
</table>

* The station could be severely damaged more frequently (ice could be pushed on the station every 20 to 50 years) and debris and ice could affect stage measurements even more often (cables are exposed).

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 22 | | |
| **Asset** | Porcupine B&B | | |
| **Location** | Waterfront / Access from main street | | |
|  | | | |
| **Surveyed feature** | Doorstep / First floor / Top of outdoor stairs | | |
| **Elevation** | 247.9 m | **Flood return period** | 200 years* |
| | | **Annual flood probability** | 0.5 %* |

* Given its location on the waterfront, this building could be damaged by ice more often.

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 23 |
| **Asset** | Old Crow Health Centre / Nursing station (Alts’ik K’atr’anahtii Zheh) |
| **Location** | Waterfront / Main street (Blue two story building / red roof) |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Doorstep / First floor / Top of outdoor stairs | | |
| **Elevation** | 248.5 m | **Flood return period** | 500 years* |
| | | **Annual flood probability** | 0.2 %* |

* Isolated by a flood (surrounded by water) and crawl space flooded every 30 years.

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 24-25 |
| **Asset** | Water treatment facility |
| **Location** | Waterfront / East of Airport terminal |


| | | | |
|---|---|---|---|
| **Surveyed feature** | Doorstep / First floor / Top of outdoor stairs (electric box / meter) | | |
| **Elevation** | 247.9 m (247.4 m) | **Flood return period** | 230 years (110 years)* |
| | | **Annual flood probability** | 0.4 % (0.9%)* |

* Water would reach the concrete pad (groundwater surface and ground water wells) every 20 years.

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 26 |
| **Asset** | Porcupine Enterprises / Offices |
| **Location** | Across Water Treatment Facility |


| | | | |
|---|---|---|---|
| **Surveyed feature** | Doorstep / First floor / Top of stairs | | |
| **Elevation** | 247.6 m | **Flood return period** | 160 years |
| | | **Annual overflow probability** | 0.6% |

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 27 |
| **Asset** | Maintenance Compound / Highways and Public Works garage |
| **Location** | Main street / Airstrip side / East of Airport terminal |


| | | | |
|---|---|---|---|
| **Surveyed feature** | Concrete pad / Doorstep | | |
| **Elevation** | 246.6 m | **Flood return period** | 35 years |
| | | **Annual flood probability** | 3% |

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 28 |
| **Asset** | Northwestel Building / below antenna |
| **Location** | Between HPW Garage and Airport terminal |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Doorstep / First floor | | |
| **Elevation** | 247.0 m | **Flood return period** | 60 years |
| | | **Annual flood probability** | 1.6% |

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 29 |
| **Asset** | ATCO old diesel generator |
| **Location** | Northeastern tip of community / North of airstrip |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Bottom of building / ground level | | |
| **Elevation** | 246.8 m | **Flood return period** | 45 years* |
| | | **Annual overflow probability** | 2%* |

* The elevation of critical components of the generating system and the impact of contact with water are unknown.

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 30 |
| **Asset** | ATCO Fuel tanks |
| **Location** | Northeastern tip of community / North of airstrip |


| | | | |
|---|---|---|---|
| **Surveyed feature** | Foot of tank | | |
| **Elevation** | 247.1 m | **Flood return period** | 65 years* |
| | | **Annual overflow probability** | 2%* |

* Access would be affected by water from the Porcupine River at that frequency

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 31 | | |
| **Asset** | ATCO (new) diesel generators | | |
| **Location** | Northeastern tip of community / North of airstrip | | |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Foot of tank | | |
| **Elevation** | 247.7 m | **Flood return period** | 160 years* |
| | | **Annual overflow probability** | 0.6%* |

* The elevation of critical components of the generating system and the impact of contact with water are unknown.

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 32 |
| **Asset** | ATCO (assumed) battery |
| **Location** | Northeastern tip of community / North of airstrip |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Bottom of building / Top of stairs / First floor | | |
| **Elevation** | 247.8 m | **Flood return period** | 200 years* |
| | | **Annual overflow probability** | 0.5%* |

* The elevation of critical components of the generating system and the impact of contact with water are unknown.

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 33 | | |
| **Asset** | ATCO (assumed) transformer (green metal box on concrete footing) | | |
| **Location** | Northeastern tip of community / North of airstrip | | |
|  | | | |
| **Surveyed feature** | Concrete surface / Foot box | | |
| **Elevation** | 246.7 m | **Flood return period** | 40 years* |
| | | **Annual overflow probability** | 2.5%* |

* The elevation of critical components of the generating system and the impact of contact with water are unknown.

<table>
<tr><td>Community</td><td colspan="3">Old Crow</td></tr>
<tr><td>ID #</td><td colspan="3">34</td></tr>
<tr><td>Asset</td><td colspan="3">ATCO electric cables in metal track</td></tr>
<tr><td>Location</td><td colspan="3">Northeastern tip of community / North of airstrip</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Surveyed feature</td><td colspan="3">Top of metal track on floor</td></tr>
<tr><td>Elevation</td><td>246.4 m</td><td>Flood return period</td><td>25 years*</td></tr>
<tr><td colspan="2"></td><td>Annual overflow probability</td><td>4%*</td></tr>
</table>

* The elevation of critical components of the generating system and the impact of contact with water are unknown.

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 35-36 | | |
| **Asset** | Large culvert (Community stream drainage / South of airstrip) | | |
| **Location** | Front of airport terminal | | |
|  | | | |
| **Surveyed feature** | Upstream side (with gate) / Bottom of culvert | | |
| **Elevation** | 244.2 m | **Flood return period*** | 2 years |
| | | **Annual overflow probability*** | 50 % |

* Porcupine River backwater upstream of street

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 37 | | |
| **Asset** | Airport Terminal | | |
| **Location** | West of airport runway | | |
|  | | | |
| **Surveyed feature** | Doorstep / First floor / Top of outdoor stairs | | |
| **Elevation** | 248.0 m | **Flood return period** | 260 years* |
| | | **Annual flood probability** | 0.4%* |

* Water from the Porcupine River would start affecting airport operations every 20 years, on average.

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 38-39 |
| **Asset** | Silver fuel tanks 1203 and 1863 (and dike around tanks) |
| **Location** | West of airport terminal |


| | | | |
|---|---|---|---|
| **Surveyed feature** | Foot of tanks (and low point in the dike around the tanks*) | | |
| **Elevation** | 246.1 m (246.3 m) | **Flood return period** | 18 years (25 years) |
| | | **Annual overflow probability** | 6 % (4%) |

* It is assumed that the dike around the tank represents a spill control structure and not a flood protection structure.

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 40-41-42-43 |
| **Asset** | Silver and white fuel tanks (dike around tanks) |
| **Location** | West of airport / close to machinery compounds |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Foot of lowest tank (and low point in the dike around the tanks*) | | |
| **Elevation** | 246.1 m (246.4 m) | **Flood return period** | 18 years (28 years) |
| | | **Annual overflow probability** | 6 % (4%) |

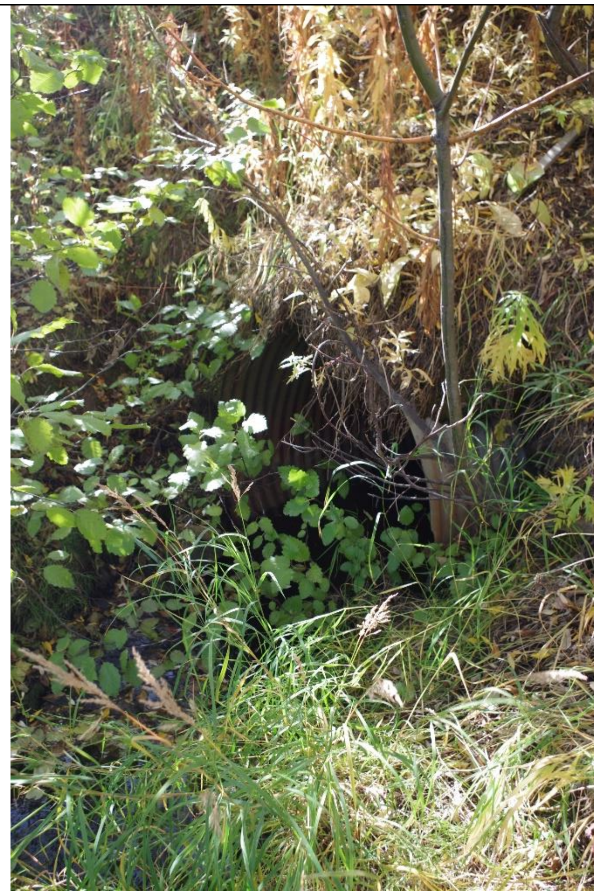
* It is assumed that the dike around the tank represents a spill control structure and not a flood protection structure.

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 44 |
| **Asset** | Old compound for machinery (silver metal sheet buildings) |
| **Location** | West of airport / Western tip of Old Crow / East of large compound |


| | | | |
|---|---|---|---|
| **Surveyed feature** | Concrete pad / Doorstep / First floor | | |
| **Elevation** | 246.4 m | **Flood return period** | 25 years |
| | | **Annual overflow probability** | 4% |

<table>
<tr><td>Community</td><td colspan="3">Old Crow</td></tr>
<tr><td>ID #</td><td colspan="3">45</td></tr>
<tr><td>Asset</td><td colspan="3">New (larger) compound for machinery (blue metal sheet buildings)</td></tr>
<tr><td>Location</td><td colspan="3">West of airport / Western tip of Old Crow / West of small compound</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Surveyed feature</td><td colspan="3">Concrete pad / Doorstep / First floor</td></tr>
<tr><td>Elevation</td><td>246.7 m</td><td>Flood return period</td><td>40 years</td></tr>
<tr><td colspan="2"></td><td>Annual overflow probability</td><td>2.5%</td></tr>
</table>

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 46-47 | | |
| **Asset** | Large culvert (Creek / drainage of the north side of airstrip) | | |
| **Location** | Western tip of Old Crow / Road towards the sewage lagoon and dump | | |



| | | | |
|---|---|---|---|
| **Surveyed feature** | Upstream side (picture on the right) / Bottom of culvert | | |
| **Elevation** | 242.6 m | **Flood return period*** | 0.4 years** |
| | | **Annual overflow probability*** | 260 %** |

* Porcupine River backwater upstream of road into the creek

** It is difficult / dangerous to attempt closing the gate for a water elevation of 244.6 m, which corresponds to a return period of 3 years, or an annual probability of 33%.

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 48-49 |
| **Asset** | Secondary culvert (Creek / drainage of the north side of airstrip) |
| **Location** | Western tip of Old Crow / Road towards the sewage lagoon and dump |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Upstream side (picture on the right) / Bottom of culvert | | |
| **Elevation** | 243.0 m | **Flood return period*** | 0.6 years** |
| | | **Annual overflow probability*** | 170 %** |

* Porcupine River backwater upstream of road into the creek

** It is difficult / dangerous to attempt closing the gate for a water elevation of 244.6 m, which corresponds to a return period of 3 years, or an annual probability of 33%.

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 50 | | |
| **Asset** | Household Waste Dump | | |
| **Location** | West of the community / End of main road | | |
|  | | | |
| **Surveyed feature** | Ground level / Low point (from DEM information, photo from Google Earth) | | |
| **Elevation** | 249.1 m | **Flood return period** | 1600 years* |
| | | **Annual overflow probability** | 0.06%* |

* The dump would not be accessible for a flood return period of approximately 2 years because of water on the road.

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 51 |
| **Asset** | Sewage Lagoon |
| **Location** | Right side of main road when going to the community dump |


| | | | |
|---|---|---|---|
| **Surveyed feature** | Top of dike around lagoon (from DEM, photo from Google Earth) | | |
| **Elevation** | 244.5 m | **Flood return period** | 2.5 years |
| | | **Annual overflow probability** | 40% |

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 52 |
| **Asset** | Metal dump |
| **Location** | Left side of main road when going to the community dump / across Lagoon |


| | | | |
|---|---|---|---|
| **Surveyed feature** | Ground level / Low point (from DEM information, photo from Google Earth) | | |
| **Elevation** | 244.4 m | **Flood return period** | 2.5 years |
| | | **Annual overflow probability** | 40% |

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 53-54 | | |
| **Asset** | Solar farm / Solar panel array A (lowest elevation) | | |
| **Location** | North or airstrip | | |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Lowest panel (lowest gravel pad corner) | | |
| **Elevation** | 246.4 m (245.5 m) | **Flood return period*** | 25 years (8 years) |
| | | **Annual overflow probability*** | 4% (12%) |

* The impact of flooding the lowest component of a solar panel is unknown

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 55-56 |
| **Asset** | Culvert (community drainage / storm drain) |
| **Location** | Eastern end of the community / across Old Crow Arena |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Upstream side (picture at the top) / Bottom of culvert | | |
| **Elevation** | 244.0 m | **Flood return period*** | 1.5 years |
| | | **Annual overflow probability*** | 70 % |

* Porcupine River backwater upstream of street

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 57-58 | | |
| **Asset** | Culvert (community drainage / storm drain) | | |
| **Location** | In front of Old Community Centre / kids park area / Waterfront | | |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Upstream side (picture at the top) / Bottom of culvert | | |
| **Elevation** | 245.4 m | **Flood return period*** | 7 years |
| | | **Annual overflow probability*** | 14 % |

* Porcupine River backwater upstream of street

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 59-60 |
| **Asset** | Culvert (community drainage / storm drain) |
| **Location** | West end of New Community Centre / Waterfront |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Upstream side (picture at the top) / Bottom of culvert | | |
| **Elevation** | 245.9 m | **Flood return period*** | 12 years |
| | | **Annual overflow probability*** | 8 % |

* Porcupine River backwater upstream of street

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 61-62 |
| **Asset** | Culvert (community drainage / storm drain) |
| **Location** | Road crossing (T) / West of St. Luke's Anglican Church |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Upstream side (picture at the top) / Bottom of culvert | | |
| **Elevation** | 245.9 m | **Flood return period*** | 13 years |
| | | **Annual overflow probability*** | 7 % |

* Porcupine River backwater upstream of street

<table>
<tr><td>Community</td><td colspan="3">Old Crow</td></tr>
<tr><td>ID #</td><td colspan="3">63-64</td></tr>
<tr><td>Asset</td><td colspan="3">Culvert (community drainage / storm drain)</td></tr>
<tr><td>Location</td><td colspan="3">Main street / East of Nursing Station / Old Crow Health Centre</td></tr>
<tr><td colspan="4">
</td></tr>
<tr><td>Surveyed feature</td><td colspan="3">Upstream side (picture at the top) / Bottom of culvert</td></tr>
<tr><td>Elevation</td><td>245.6 m</td><td>Flood return period*</td><td>10 years</td></tr>
<tr><td colspan="2"></td><td>Annual overflow probability*</td><td>10 %</td></tr>
</table>

* Porcupine River backwater upstream of street

| | |
|---|---|
| **Community** | Old Crow |
| **ID #** | 65-66 |
| **Asset** | Culvert (community drainage / storm drain) |
| **Location** | Western of Airport terminal / East of machinery compounds |

| | | | |
|---|---|---|---|
| **Surveyed feature** | Upstream side (picture at the top) / Bottom of culvert | | |
| **Elevation** | 244.8 m | **Flood return period*** | 4 years |
| | | **Annual overflow probability*** | 25 % |

* Porcupine River backwater upstream of street

| | | | |
|---|---|---|---|
| **Community** | Old Crow | | |
| **ID #** | 67-68 | | |
| **Asset** | Culvert (community drainage / storm drain) | | |
| **Location** | Western end of airstrip / West of machinery compound | | |
|  |  | | |
| **Surveyed feature** | Upstream side (picture on the right) / Bottom of culvert | | |
| **Elevation** | 243.4 m | **Flood return period*** | 0.8 years |
| | | **Annual overflow probability*** | 120 % |

* Porcupine River backwater upstream of street