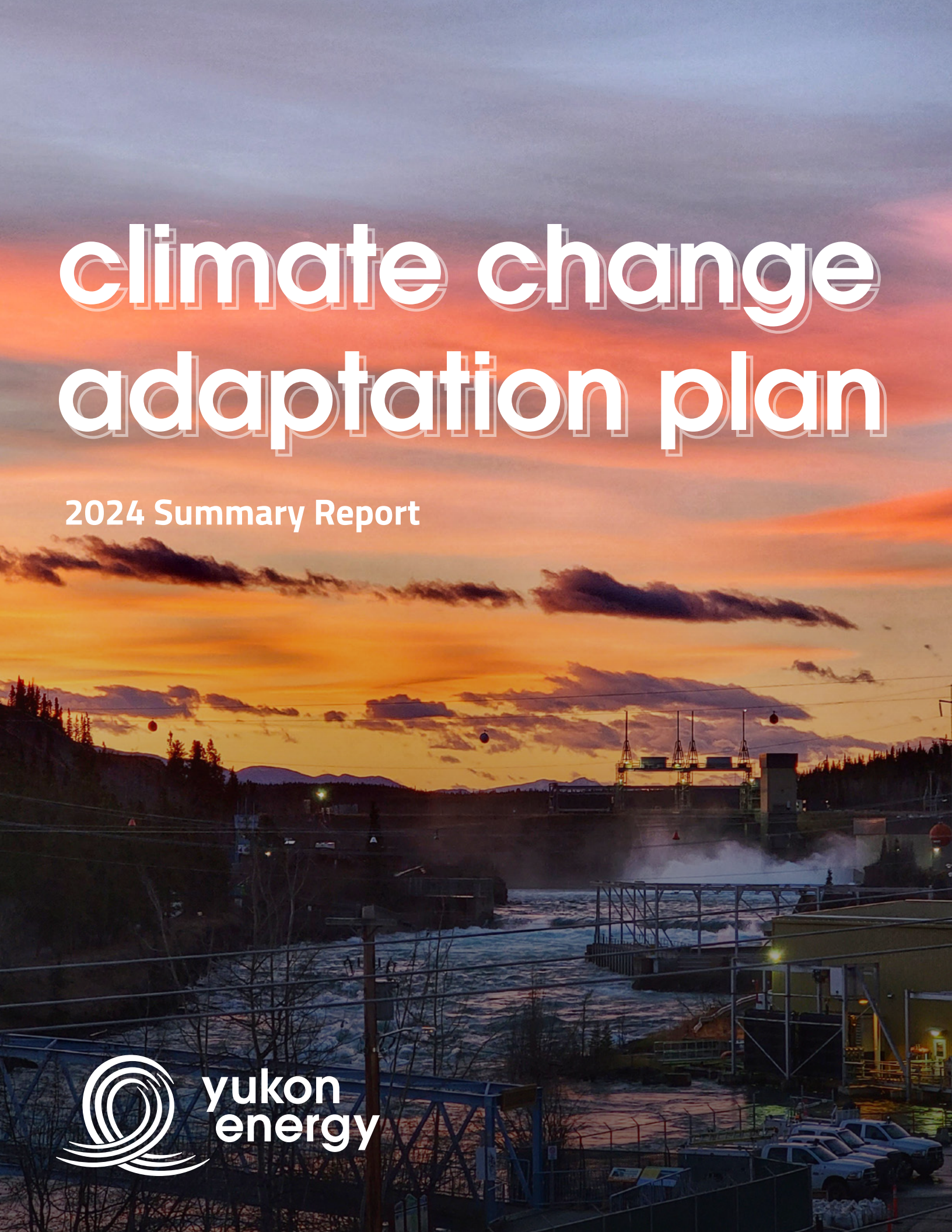


climate change adaptation plan

2024 Summary Report

yukon energy

contents

Cover: Myles O'Brien

1

climate change is impacting Yukon Energy

Yukon's climate is changing. In the last 50 years, Yukon's average temperatures and rainfall have both increased, and climate change events are becoming more frequent and intense, particularly in the North.

Electricity Canada warns that Canadian utilities face unavoidable, adverse climate change impacts on infrastructure. Yukon Energy has noticed impacts of climate change in the following ways:

- Changes in timing of the spring freshet into our watersheds have caused flooding impacts;
- Warmer weather and rain in autumn has caused flooding impacts;
- Fluctuating temperatures leading to difficulty setting ice downstream of hydro plants. This has created flooding risks and generation restrictions;
- Increased vegetation growth rates along power lines has caused greater need for brushing; and
- Dangerous slope conditions at the Mayo hydro facility forced a plant shutdown causing significant loss of revenue.

We are committed to understanding the impacts of climate change on our ability to supply power to Yukoners. We have reviewed first-hand accounts and observations, historical knowledge, and recommendations by staff to understand how climate change increases risk to the Yukon's electricity supply.

Climate change has serious potential consequences for Yukon Energy and its mission: *to enable Yukon's prosperity with sustainable, cost-effective and reliable electricity*. To continue delivering on our mission, we must adapt our business to withstand the climate change impacts on our infrastructure, processes and activities. We are being proactive in monitoring and planning for climate change and extreme weather. We are implementing a strategic approach to manage this risk.

Mayo A hydro facility is impacted by erosion, leading to ground instability. Dangerous slope conditions make it difficult to access the plant for regular maintenance or operational emergencies.

2

what is climate change adaptation?

Climate change adaptation is the act of protecting people, places and systems from the impacts of climate change by making them less vulnerable.

A climate change adaption plan is a strategic approach that considers climate science and impacts and develops a plan to manage the risks of climate change. Yukon Energy has developed this Climate Change Adaptation Plan to improve our utility's resilience to key risks from climate change and extreme weather. The plan identifies key climate change risks and specific adaptations we can implement to better cope with, or recover more quickly from, those climate change risks. Our Climate Change Adaptation Plan is necessary to continue delivering reliable, safe and affordable electricity to Yukoners.

Our planning approach is aligned with industry best practices and will allow us to plan for improved resiliency now and in the future. It builds on information and direction from local researchers, governing bodies and academia.

1. We followed methodology from Electricity Canada's *Climate Change and Extreme Weather: A Guide to Adaptation Planning for Electricity Companies in Canada.*
2. We formed an internal team to provide climate observations and asset information
3. We consulted local climate change experts, reviewed available climate projections, and utilized leading risk assessment methodologies.
4. We conducted a comprehensive risk assessment of the impacts of climate change on our assets and operations.

This plan is intended to be a living document and will be updated as adaptation actions are implemented, new risks identified, and climate science evolves.

3

what major climate changes will affect Yukon Energy?

Climate change scientists have identified that our climate is warming rapidly and is projected to continue. We can say with near certainty that infrastructure built without the future climate in mind will be more vulnerable.

Yukon Energy uses climate change models developed by leading Canadian climate scientists to understand impacts of climate change on Yukon Energy. Temperature and precipitation are the two weather parameters showing the greatest amount of change and projected change with the most certainty.

temperature

▲0.7 to 3.7 °C
over the next 50 years

Over the last 50 years, temperature in the territory has increased by 2 °C with winter temperatures warming more significantly than summer temperatures. Climate models predict continued temperature increase over the next 50 years with estimates of temperature increases between 0.7 and 3.7 °C. Most of this temperature increase is predicted to occur in winter months.

precipitation

▲ 4 to 17%
over the next 50 years

Over the past 50 years, precipitation has increased around 3 to 12%, mostly in summer months, and this trend is continuing. Climate models predict precipitation will increase by 4 to 17% over the next 50 years. The degree to which precipitation is changing in the territory depends on the geographic region. For example, less annual precipitation is expected in the Whitehorse region, whereas more precipitation is expected in the Mayo region.

Both temperature and precipitation impact many of Yukon Energy's assets. Higher temperatures and changes in precipitation impact the water reservoirs that we manage for power production. In addition to this, our facilities, operations and staff will also be impacted in ways that can affect our ability to deliver power to Yukoners.

Extreme events are projected to become more frequent and intense due to climate change. Multiple climate parameters were assessed to understand what could happen when multiple events occurred at once. For example, if above average winter precipitation, above average temperatures from August to October, and above average precipitation from July to October occurred in the same year, this could cause severe flooding in the Southern Lakes region. Future trends for forest fires, flooding, extreme wind and ice storms were analyzed.

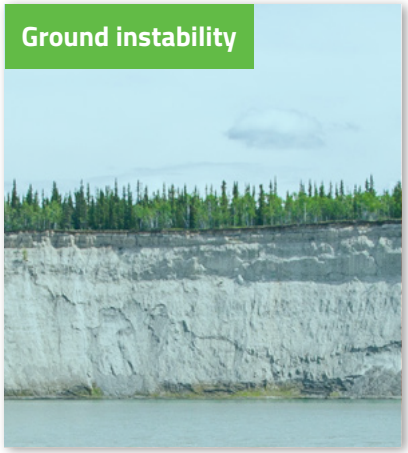
The data available in the Yukon is focused on temperature and precipitation; however, there are other climate changes that impact our assets that we considered.

Here is the list of climate changes that were considered in the risk assessment as potential **impacts** to our assets and operations. This list was selected by reviewing work by local researchers, governing bodies and other Canadian utilities.

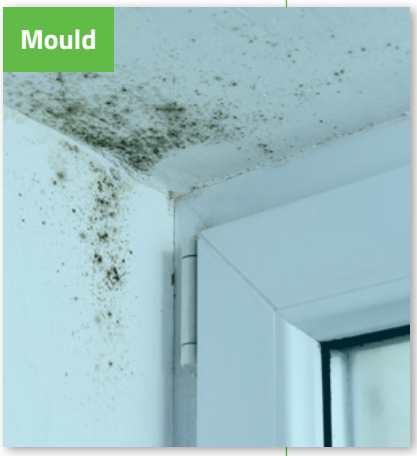
Impacts:

- Snow variability
- Heavy snow
- High snowpack
- Increased precipitation
- Extremely hot days
- Windy days
- Major precipitation events
- High water levels

Ground instability



Mould



Floods and flash flooding

Impacts:

- Ice storms and freezing rain
- Climate variability and uncertainty

Road ice

Impacts:

- Extremely hot days
- Increased temperature
- Windy days
- Wind events

Wildfires
Lightning
Evapotranspiration

Permafrost melt

Increased growth rates

4

how has Yukon Energy adapted to climate change?

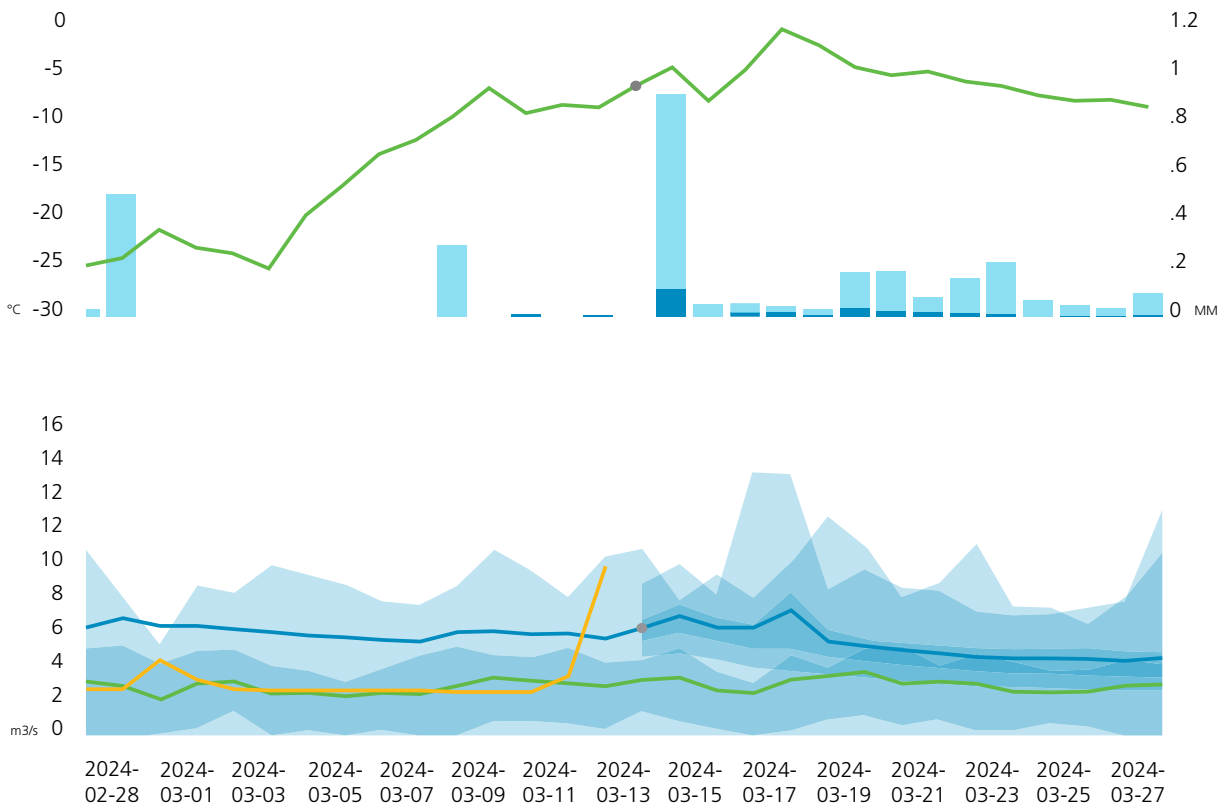
Yukon Energy has been gradually adapting to climate change over the years, altering our operations and how we manage our assets throughout the territory.

In the past, staff have identified changes in operations and safety risks related to weather through on-the-job observations. These observations allow us to make better decisions to reduce risk-to-asset lifespan, operational efficiency and safety. They have proposed adaptation measures to reduce those risks and prolong life of assets, enhance efficiency, provide a better understanding of the issue for decision making, or reduce safety risks.

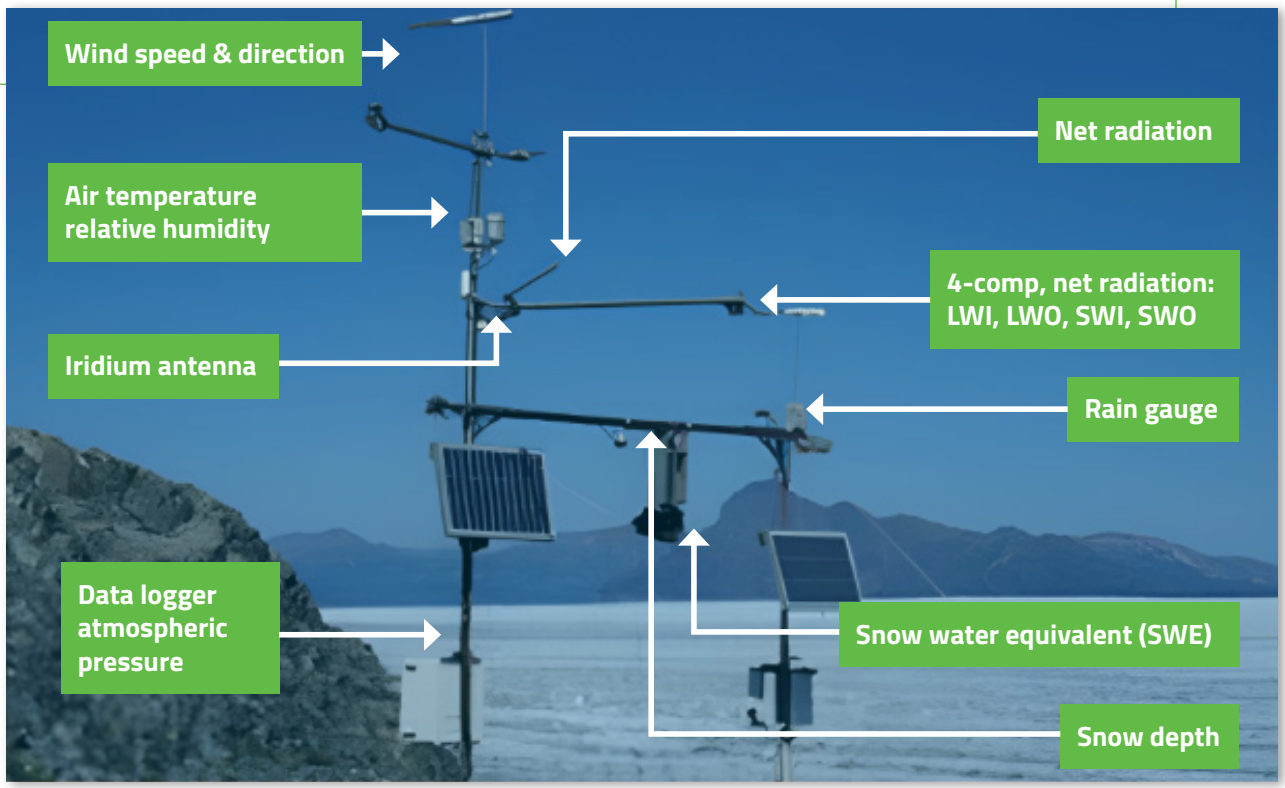
Here are some examples of work we are currently doing to build climate resilience.

1. Developing an inflow forecast for short- and medium-term water forecasting on Aishihik Lake, Mayo Lake and the Yukon River. Inflow forecasting allows us to better understand water inflows such that we can more efficiently manage hydro generation and reduce impacts of downstream flood events.

figure 1 **example of Mayo short-term inflows forecast**



2. Maintaining meteorological stations to better understand inflows into the Mayo, Aishihik and Yukon River basins. Improved meteorological data allows us to calibrate and improve our water forecasting models.



Anatomy of the Yukon River meterological station

3. Repairing the Lewes River boat lock (near Marsh Lake Bridge) after damage caused by flooding in 2021. The repair will improve system resilience in two ways:

    i. The structure itself will be more resilient to impacts of flooding; and

    ii. The structure is designed to allow more water to pass in the event of a flood to reduce upstream flooding in the Southern Lakes.

Repairing the Lewes River boat lock

4. Conducting slope remediation above the Mayo Generating Station to prevent further slope destabilization from future high precipitation events.

Slope remediation

5. Operationally reducing Aishihik hydro generation and store water at Aishihik Lake to prevent flooding at the Aishihik dam and/or Canyon Lake Control Structure.

6. Conducting a flood assessment of Aishihik Lake to be able to reduce the impacts of flooding.

7. Changing our operational procedures during weather events, such as increasing the number of inspections we conduct, and the number of staff required on-site at all generating facilities during anticipated flood events, so that we will be able to detect issues earlier and react more quickly.

Looking at the work we have done already, and the impacts that are expected, this plan presents a systematic and robust process to identify risks, prioritize responses and stay current with climate science.

5

which Yukon Energy assets are vulnerable to climate change?

Yukon Energy maintains power generation and transmission assets located across a large geographical area, often in remote areas, over varied terrain and climates. The Yukon grid is isolated and requires local generation, which means resilience to impacts of climate change is critical to ensuring reliable power supply.

Yukon Energy generates most of the power on Yukon's isolated grid. Most of the electricity we produce is renewable, produced primarily from hydro resources at our Whitehorse, Mayo and Aishihik hydroelectric facilities. We also generate a limited amount of electricity from liquefied natural gas (LNG) and diesel plants to supplement our hydro generation during the winter months and in case of outages.

Yukon Energy maintains 1,100 km of transmission power lines, 400 km of distribution power lines and 17 substations, and conducts a variety of operations critical to delivering electricity.

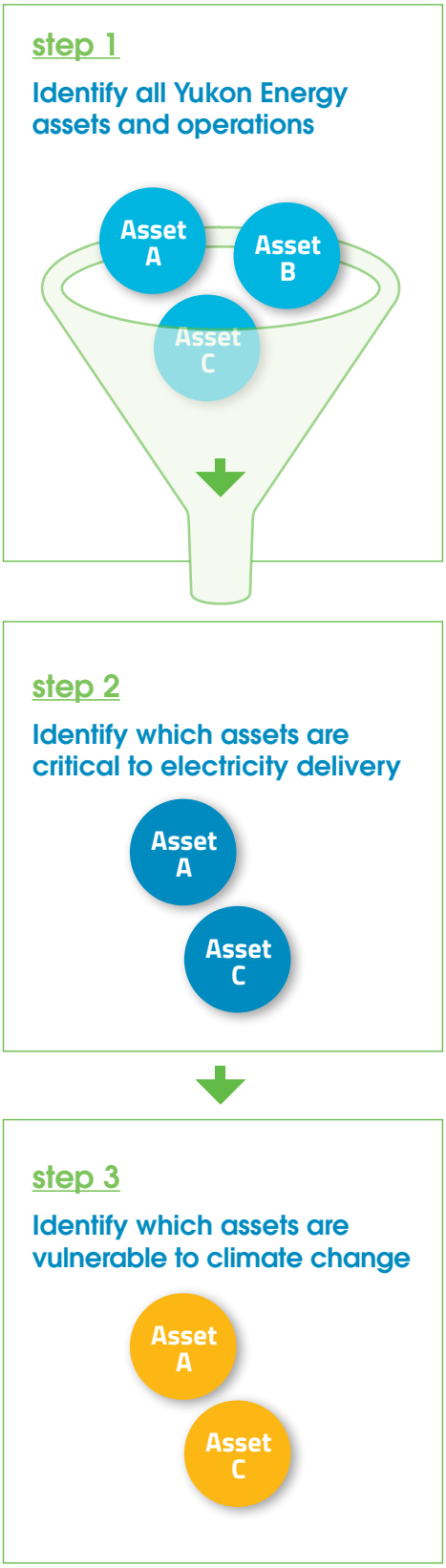
Through Yukon Energy staff interviews, review of external utility documents and workshops with key experts, we identified some Yukon Energy assets and operations that are critical to meeting Yukon's electrical demand. Understanding of our assets' functionality, interdependencies, remoteness and sensitivity to downtime is critical in order to properly assess these assets and operations for future risk ranking.

For example, Asset A could be Aishihik Hydro Generating Station. This is a critical asset because it provides critical electricity as our largest winter generating asset, when demand is the highest. It is vulnerable because of its geographic location at the end of a long transmission line without redundancy. This asset is also more vulnerable to forest fire.

Asset B might be a Yukon Energy pickup truck. While it is needed for many important operational tasks, it is not critical to the delivery of electricity, as another truck could be procured to fill its role. However, a pickup truck is generally not vulnerable to increased precipitation or to the projected increased temperatures in the Yukon.

Asset C could be Whitehorse hydro power turbines and equipment. These are vulnerable to floods inside the Whitehorse hydro plant. If the hydro plant was flooded, it would significantly impact this equipment and its ability to generate power. This would result in a major medium-term loss in power.

On the following page is an overview of identified assets and operations that are vulnerable to climate change impacts. Some assets have relatively low, or lower, vulnerability to climate change, and thus are not on the vulnerability assets list. For example, diesel fueled generators currently have relatively low climate change vulnerability.



How we identify assets that are both critical and vulnerable

Assets and operations identified as relatively more vulnerable to climate change:

operations

- energy generation
- First Nations and stakeholder engagement
- project success
- supply chain
- health and safety
- outage response
- organizational reputation
- operations and maintenance

assets

- power lines and power poles
- roadways and right of ways
- hydro power turbines and equipment
- dam infrastructure
- LNG piping
- substation assets
- buildings and property
- information technology hardware

See figure 2 for locations.

figure 2 **location of Yukon Energy's assets that are vulnerable to climate change**

6

how does Yukon Energy assess its risk to climate change?

Once we understand likely climate changes, we identify the risks to our critical and vulnerable assets and operations by using the knowledge of those most familiar with our assets – Yukon Energy staff and other utilities in our industry. We assess the exposure and likelihood of a future climate hazard and the consequence to our assets, operations or organization.

How do we measure risk?

Risk is a formula of three factors: exposure, likelihood and consequence. Climate projections are used to determine exposure and likelihood scores. Internal staff knowledge is used to determine a consequence score from minor to worst case. Exposure, likelihood and consequence scores are determined based on the methodology described below.

R = E x L x C

risk

A numerical score. A higher score means a higher impact risk. These scores are categorized into worst-case, severe, major, moderate and minor categories.

exposure

Yes (1) there is exposure or No (0) there is no exposure, to determine whether an asset is exposed to a climate hazard or not.

likelihood

Scores range from 1–Remote to 5–Virtually Certain, and are given the ranking based on percentage of future change from current conditions.

consequence

Scores from 1–Minor to 5–Worst Case are used to indicate the severity of the consequence.

The scores applied to exposure, likelihood and consequence are multiplied to calculate a final risk score.

The highest-ranked risks are prioritized for adaptation projects.

Currently, we have identified 114 climate risks to Yukon Energy critical assets and operations. Nineteen risks are considered highest priority and are chosen for priority adaptation.

These highest risks are associated with flood events and impacts to hydro generation, hydro equipment and dam infrastructure. Considering that many of Yukon Energy's assets are located in or near water, it is not surprising that out of the 19 highest risks, 14 were related to flood-related climate hazards. Most of these risks affect the Southern Lakes, Whitehorse Rapids Generating Station and Aishihik Generating Station, and less so Mayo Generating Station. Other high-priority risks identified include ground instability, flash flooding, snow variability and wildfire.

The following shows the distribution of climate hazards creating the most critical risks.

floods

- Loss of energy impacts at Whitehorse Rapids Generating Station (three instances)
- Flooding of hydro turbines and equipment at Whitehorse Rapids Generating Station causing full replacement of equipment
- Loss of energy generation at all hydro plants (two instances)
- Damage to shorelines and soils around Lewes River Control Structure
- Slumping of soil in and around at Lewes substation
- Erosion around Whitehorse Rapids Generating Station hydro dam infrastructure
- Erosion around Mayo Generating Station hydro dam infrastructure
- Erosion around Aishihik Generating Station hydro dam infrastructure
- Erosion around Canyon Lake Control Structure (two instances)
- Difficulty meeting water licensing conditions impacting regulatory and permitting for the Aishihik Generating Station water licence
- Shoreline erosion downstream of the Aishihik Generating Station could damage Yukon Energy's organizational reputation with First Nations

ground instability

- Impact to Aishihik Generating Station hydro dam infrastructure
- Impact to buildings near water courses

snow variability

- Impacts on planning for and acquiring liquid natural gas (LNG) for generation. Water inflows from a variable snowpack for electricity generation can cause fluctuations of LNG need

icing

- Impacts to energy generation with the inability to set ice cover downstream of all hydro plants

wildfire

- Impacts to power lines, power poles and transmission line equipment from wildfires

7

how does Yukon Energy plan to respond to these risks?

Yukon Energy has developed adaptation actions to address the highest risks for implementation in 2024. These adaptation actions will either eliminate, reduce, prepare for, or allow us to better understand the greatest risks to our assets and operations.

We determined adaptation actions for each risk considering the following:

- **Eliminate the risk**
  Example of eliminating: Install a physical barrier to prevent flood water from entering a power plant.

- **Reduce the risk**
  Example of reducing: Remove brush and trees with higher frequency on power line right of ways to reduce wildfire risk to power lines.

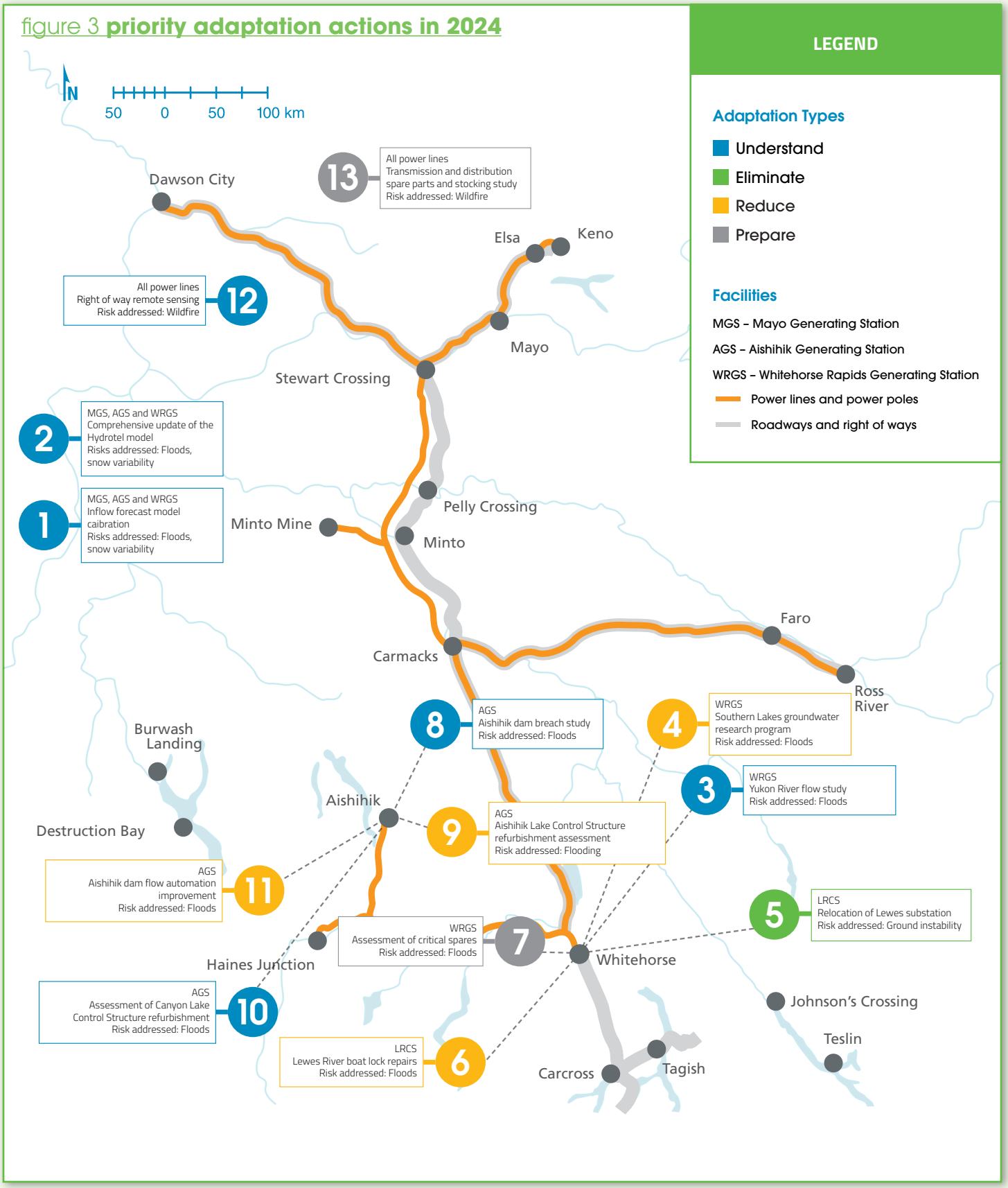
- **Prepare for the risk**
  Example of preparing: Have spare equipment on hand in the event a power line burns down during a wildfire.

- **Better understand the risk**
  Example of understanding: Update Yukon Energy's inflow forecasting model with new and additional meteorological data for more accurate water level forecasts.

This adaptation plan and its actions will be updated regularly as our understanding of climate change increases and Yukon Energy completes adaptation actions.

Yukon Energy identified 19 priority adaptation actions to be included in the 2024 capital plan and budget. Figure 3 shows adaptation actions are predominantly in areas where higher flood risk is present in southern Yukon. The risk assessment determined that our hydro assets are at greatest risk to climate change, so the majority of the adaptation actions focus on these assets.

figure 3 **priority adaptation actions in 2024**



These actions have been proposed and received budgetary approval to begin implementation in 2024.

table 1 **priority adaptation items**

LOCATION	ACTION TITLE	DESCRIPTION	REASON FOR ACTION	ASSOCIATED ASSET	CATEGORY OF ADAPTATION
All hydro generating locations 1	Inflow forecast model calibration	Calibrate model outputs to current meterological data for greater accuracy	Improve predictions of water flowing into the hydroelectric basins for hydro generation efficiency and flood management	Generating station infrastructure, hydro turbines and equipment and energy generation	**Understand**
All hydro generating locations 2	Comprehensive update of the Hydrotel model	Combine Hydrotel and precipitation modelling and do an integrated study that looks at groundwater, precipitation and ocean temperatures and inflow	Improve predictions of water flowing into the hydroelectric basins for hydro generation efficiency and flood management	Generating station infrastructure, hydro turbines and equipment and energy generation	**Understand**
Whitehorse Rapids Generating Station (WRGS) 3	Yukon River flow study	Model Yukon River flows at different lake levels to further assess the impact of: 1. The Lewes River Control Structure 2. Lowering Schwatka Lake during freshet	By understanding the Yukon River flows at different lake levels, we can find ways to reduce impact and cost of floods	WRGS dam infrastructure, hydro turbines and equipment and energy generation	**Understand**
Whitehorse Rapids Generating Station (WRGS) 4	Southern Lakes groundwater research program (2024 to 2027)	Study climate impacts to groundwater collaboratively with government and university partners – 2024 to 2027	Improve predictions of groundwater flowing into the hydroelectric basins for hydro generation efficiency and flood management	WRGS dam infrastructure, hydro turbines and equipment and energy generation	**Reduce**
Lewes River Control Structure (LRCS) 5	Lewes substation service relocation	Conduct a siting assessment for a new substation location and relocate the existing substation	This substation is already seeing impacts of ground instability and flooding. It is important to move the asset before another flood event to avoid risk of further movement or a prolonged outage	Lewes substation	**Eliminate**

LOCATION	ACTION TITLE	DESCRIPTION	REASON FOR ACTION	ASSOCIATED ASSET	CATEGORY OF ADAPTATION
Lewes River Control Structure (LRCS) 6	Lewes River boat lock repairs	Repairs of the Lewes River boat lock that was damaged during the 2021 flood event	To allow more water to pass the boat lock during flood events and to prevent further erosion	Lewes River Control Structure, WRGS dam infrastructure, hydro turbines and equipment and energy generation	**Reduce**
Whitehorse Rapids Generating Station (WRGS) 7	WRGS critical spare requirements assessment	Desktop study to identify critical spare equipment and how many to keep in stock in the event of a major flooding event	During a major flood, equipment would need to be replaced. If critical spares are not on hand, there would be an increase in delays in restoration	WRGS hydro turbines and equipment and energy generation	**Prepare**
Aishihik Generating Station (AGS) 8	Aishihik dam breach study	An updated dam breach study to be completed for the AGS (Aishihik Lake, Canyon Lake and Power Canal). This would identify flood inundation extents and denote hazard in terms of flow depth, velocity and timing of downstream impacts	It is important to understand the downstream hazard associated with a breach event	Dam infrastructure and downstream environment	**Understand**
Aishihik Generating Station (AGS) 9	Aishihik Lake Control Structure refurbishment options assessment	Conduct an assessment to determine which projects are feasible to mitigate the impacts of flooding	Flooding downstream of the Aishihik Lake Control Structure has been identified with high likelihood. Therefore, it is important to study the options to refurbish the Aishihik dam considering flooding impacts along with regular maintenance and end-of-life of certain dam components	Aishihik Lake Control Structure	**Reduce**

LOCATION	ACTION TITLE	DESCRIPTION	REASON FOR ACTION	ASSOCIATED ASSET	CATEGORY OF ADAPTATION
Aishihik Generating Station (AGS) 10	Canyon Lake Control Structure refurbishment options assessment	Desktop assessment of the possible options to refurbish the Canyon Lake Control Structure at Aishihik to mitigate flooding and improve asset condition	Flooding at Aishihik Lake has the potential to impact and cause damage to the Canyon Control Structure. There are components of the Canyon Control Structure that need refurbishment and with higher flood potential elevate the importance of this project.	Aishihik Lake or generating station infrastructure, energy generation, organizational reputation, regulatory and permitting	**Understand**
Aishihik Generating Station (AGS) 11	Improve water level control at Aishihik Lake Control Structure	Upgrade control structure openings to release water more efficiently	Improving the openings at the control structure could provide additional ability to pass water during flood events. This would minimize vulnerability of the structure to high water and erosion around the dam	Aishihik Lake Control Structure infrastructure, hydro turbines and equipment and energy generation, organizational reputation, regulatory and permitting	**Reduce**
All power poles locations 12	Right of way (ROW) remote sensing (Vegetation/clearing assessment)	Assessment of remote sensing use on ROWs for vegetation management	The outcome of this study is a business case on the use of remote sensing for brushing management. Remote sensing can aid in locating areas with wildfire criticality	Power lines/ Power poles	**Understand**
All power poles locations 13	Transmission and distribution spare parts and stocking study	Having more critical equipment on hand to repair a power line that would be burned down. This would reduce the potential outages due to a wildfire	Having more critical equipment on hand to repair a power line that could be burned down. This would reduce the potential outages due to a wildfire	Power lines/ Power poles	**Prepare**

8

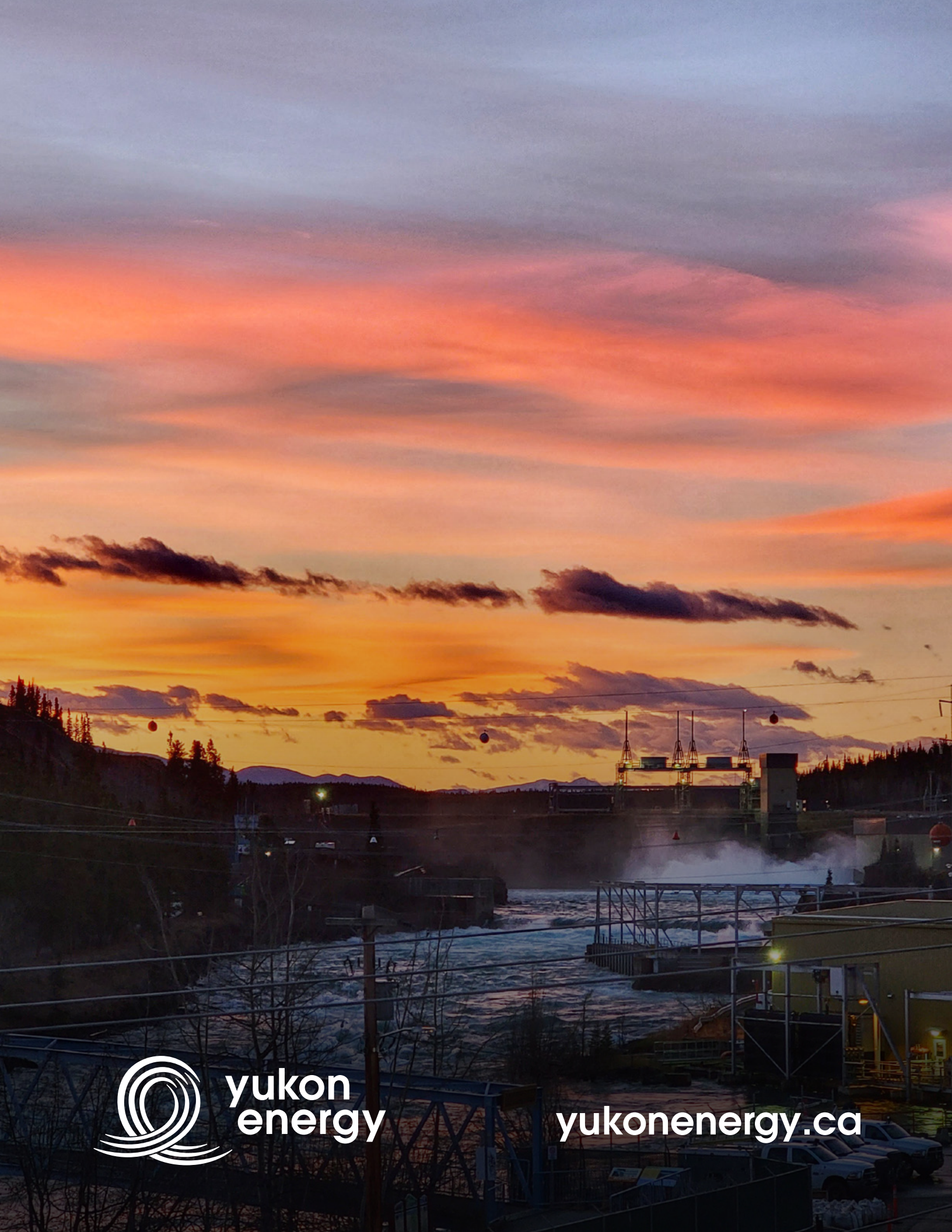
how will Yukon Energy adapt as climate continues to change?

Predicting the future is difficult. However, we will continue to assess risks as new information becomes available. We are committed to reviewing, updating and improving the plan regularly. The information and actions identified in this plan are intended to evolve as we learn more and complete adaptation projects.

Yukon Energy is committed to this plan, the process and keeping Yukoners informed of progress to manage risks.

Others have insights to help us better understand a changing climate. We intend to learn from individuals, experts, organizations and governments. We will strive to incorporate these insights and knowledge into future planning as well as observations from Yukon Energy staff as they work in these environments daily.

Ultimately, we see the effects of climate change, and changes are happening fast in the North. This plan is Yukon Energy's way of prioritizing actions to ensure we can continue to provide Yukoners with the electricity they need when they need it and improve the overall resiliency of our electricity grid to climate risks.


yukon
energy
yukonenergy.ca