Syilx Okanagan Flood and Debris Flow Risk Assessment

Report 1 of 4: Synthesis and Recommendations

31 December 2019

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

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Cover Photo: View downstream (southeast) along a dike on the Similkameen River near Cawston, October 2018. Ebbwater Consulting Inc. image.

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This Assessment is a testament to the power of collaboration and partnership between *Syilx* and non-*Syilx* organizations, including the project team at Ebbwater Consulting Inc. (Ebbwater), and exhibits a shared concern for how water is managed and recognized in the territory.

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List of Acronyms and Abbreviations

AFN	Assembly of First Nations
AIDR	Australian Institute for Disaster Resilience
BC	British Columbia
CEPF	Community Emergency Preparedness Fund
DMAF	Disaster Mitigation Adaptation Fund
ONA	Okanagan Nation Alliance
EMBC	Emergency Management British Columbia
EPA	Emergency Program Act
FLNRORD	Ministry of Forests, Lands, Natural Resource Operations and Rural Development
FNFC	First Nations Fisheries Council
GIS	Geospatial Information System
HRVA	Hazard, Risk, and Vulnerability Assessment
LiDAR	Light Detection and Ranging
LSIB	Lower Similkameen Indian Band
NDMP	National Disaster Mitigation Program
NRCan	Natural Resources Canada
OBWB	Okanagan Basin Water Board
OCAP	Ownership, Control, Access and Possession
OCCP	Okanagan Collaborative Conservation Program
OKIB	Okanagan Indian Band
ONA	Okanagan Nation Alliance
PECG	Palmer Environmental Consulting Group
PIB	Penticton Indian Band
PSC	Public Safety Canada
QGIS	Quantum Geographic Information System
RAAD	Remote Access Archaeology Database
RDCO	Regional District of Okanagan-Similkameen
RDNO	Regional District of North Okanagan
RDOS	Regional District of Okanagan-Similkameen
Sendai	Sendai Framework for Disaster Risk Reduction
SHIFT	SHIFT Collaborative
TEK	Traditional Ecological Knowledge
TRC	Truth and Reconciliation Commission
UBCO	University of British Columbia Okanagan
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples
UNDRR	United Nations Office for Disaster Risk Reduction
USIB	Upper Similkameen Indian Band
WFN	Westbank First Nation
WSA	Water Sustainability Act

1 Introduction

In recent years, flood and debris flows have become an increasing concern across *Syilx* Okanagan territory. Viewed from the perspective of water and land, these phenomena can play a positive role within ecosystems. However, they also negatively affect the Okanagan Nation Alliance's (ONA) member communities, and the wider region. Negative impacts range from flooded septic systems, to erosion of fish-bearing creeks, and potential spilling of abandoned mine tailings water. Roads closed due to active slides affect access to services and lands valued for food gathering and other cultural and recreational activities. The events have caused environmental, social, and economic impacts—all of which affect human livelihoods.

Climate change was identified as a key driver for recent flooding in BC[1]. Furthermore, research indicates that, in addition to climate change, other cumulative pressures are making disasters, including flood and debris flows, worse. These pressures include ecological disturbance (e.g., wildfires), urban development, and industrial activities. It is well known, but perhaps not readily acknowledged, that cumulative pressures are strongly linked to human activities. In the Okanagan-Similkameen region, these human-related pressures did not exist, as we understand them today, prior to European settlement.

The Sendai Framework for Disaster Risk Reduction (Sendai) addresses these critical issues; it is the global blueprint to help communities become more resilient to changes in natural phenomena such as flood and debris flows. Sendai's first priority is understanding risk, and this includes integrating Indigenous knowledge and scientific best practice to inform adaptation actions. The approach is supported by global and regional directives (e.g., United Nations Declaration on the Rights of Indigenous Peoples [UNDRIP], Truth and Reconciliation Commission, *Abbott/Chapman Report* recommendations, etc.).

> *"When we take care of the land and water, the land and water take care of us."*
>
> *Syilx siwɬkʷ (water) Declaration*

It is within this context that this risk assessment project was initiated by the Okanagan Nation Alliance. The project was funded by the National Disaster Mitigation Program (NDMP) and completed from September 2018 to December 2019. It is the initial phase of a multi-year flood and debris flow adaptation initiative. **The goal of this project phase is to understand the risk due to flood and debris flows within the Okanagan-Similkameen region to support priority-setting of future work**. This report synthesizes the project drivers, methods, and results; it also provides background on best practice and concrete recommendations.

The project is unique in that it sees risk through the lens of Indigenous People. Indeed, all leaders in the region have much to learn from those who lived on the land prior to the time when the problems arose. Furthermore, leaders in the region have a responsibility to help those who have been disproportionately impacted by recent events, particularly First Nations, as documented in the *Abbott/Chapman Report*.

[1] Addressing the New Normal: 21st Century Disaster Management in British Columbia. (EMBC 2019 and referred to herein as the Abbott/Chapman Report). Weblink: https://www.preventionweb.net/publications/view/58245.

In addition to this project, the Okanagan Nation Alliance is working on water and ecosystem-based management more broadly and is exploring different approaches to risk assessment that can draw from and emphasize *Syilx* Okanagan perspectives. In line with best practice, the ONA is focusing on risk reduction by applying a planning process based on community values considering a range of hazard levels, including the effects of climate change. The project outputs will be a resource for everyone in the region to achieve mutual objectives.

1.1 *Syilx* Okanagan Nation

The *Syilx* Okanagan people are a distinct and sovereign Nation inhabiting the interior plateau and applying knowledge systems here since the beginning of time, sharing the same land, *nsyilxcən* language, culture, and customs. The *Syilx* Okanagan Nation has never signed treaties with European settlers and holds Title and Rights to the lands and waters within the territory. The *Syilx* Okanagan people have always governed these lands according to principles that are embedded in *captík*^{w}*ɬ* (oral stories) that derive from these diverse ecosystems, landscapes, and water. These principles carry a sacred, inherent responsibility to care for *tmix*^{w} (all life forms), *tmx*^{w}*ulax*^{w} (land), and *siwɬk*^{w} (water).

The *Syilx* Okanagan way of life was dramatically disrupted with first European contact in 1811. The subsequent influx of immigrants upset the equilibrium in the region, resulting in the social marginalization of the *Syilx* Okanagan people and ongoing impacts on their sovereign territory including ecosystem degradation, severe water quality deterioration, and extreme stress on local ecologies and species loss at a scale and rate that is unprecedented.

The *Syilx* Okanagan Nation knows that in order to effectively plan for flooding events and mitigation, it is necessary to consider the health of the *tmix*^{w} (all life forms), *tmx*^{w}*ulax*^{w} (land), and *siwɬk*^{w} (water) just as much as the health of human beings. *tmix*^{w} *is t*he *nsyilxcən* word that most closely translates as “ecology”. The *Syilx* Okanagan understanding is that *siwɬk*^{w} (water), *tmx*^{w}*ulax*^{w} (land), and all living things are all part of *tmix*^{w} and are intricately connected. What we do to one of them, we do to them all. *Syilx* Okanagan responsibilities extend beyond fellow human beings to include everything within the ecosystem: water, plants, animals, land. With the word *tmix*^{w}, the Syilx Okanagan responsibility to honour the natural laws of that which gives us life is embedded within the *nsyilxcən* language itself.

As is stated in the *Syilx siwɬk*^{w} (Water) Declaration: “The Okanagan Nation has accepted the unique responsibility bestowed upon us by the Creator to serve for all time as protectors of the lands and waters in our territories, so that all living things return to us regenerated. When we take care of the land and water, the land and water takes care of us. This is our law.”

The Okanagan Nation is confident that by incorporating *Syilx* Okanagan values, perspectives, and processes into regional planning efforts, a new way of working with nature will emerge that is to the benefit of everyone, inclusive of the *tmix*^{w}.

1.2 Project Objectives

The goal of this project—to support priority-setting of future work—is multi-faceted. Best practice dictates that adaptation to natural phenomena such as flood and debris flows be achieved through a thoughtful, risk-based planning process based on community values. Considerable effort for this project was focussed on process—it was important to embrace a diversity of perspectives and to build relationships across organizations in the region; this process-focus enabled the development of community resilience by increasing knowledge and capacity and by supporting the development of networks.

> *"I'm glad to see people at the table who are here to work together. Not in a tokenism way, but real working together."*
>
> *Syilx* Okanagan participant, Workshop 1, February 13, 2019.

The project's objectives were as follows:

1. Better understand flood and debris flows and how they impact the region.
2. Apply diverse perspectives in assessing the risk from these natural phenomena.
3. Collaborate with local governments to strengthen and align risk assessment initiatives.
4. Provide supporting information for future funding and to prioritize adaptation actions.

1.3 Project Area

The project area includes the Okanagan River watershed including *kɬúsx̌nítkw* (Okanagan Lake) and the *nməlqaytkw* (Similkameen River tributary) watershed (Figure 2). The region's climate and landscape is diverse, and ranges from semi-arid grasslands to open pine forests. The region is one of the most biodiverse in Canada, and is a geographic link between more northern and southern ecosystems for many animals. The *Syilx* people have inhabited the interior plateau since time immemorial, and the project area is located on unceded territory (see Figure 1 inset). Today, the project area exceeds 360,000 people who live in six *Syilx* communities (italicized in Figure 1) and over 15 primarily non-*Syilx* communities.

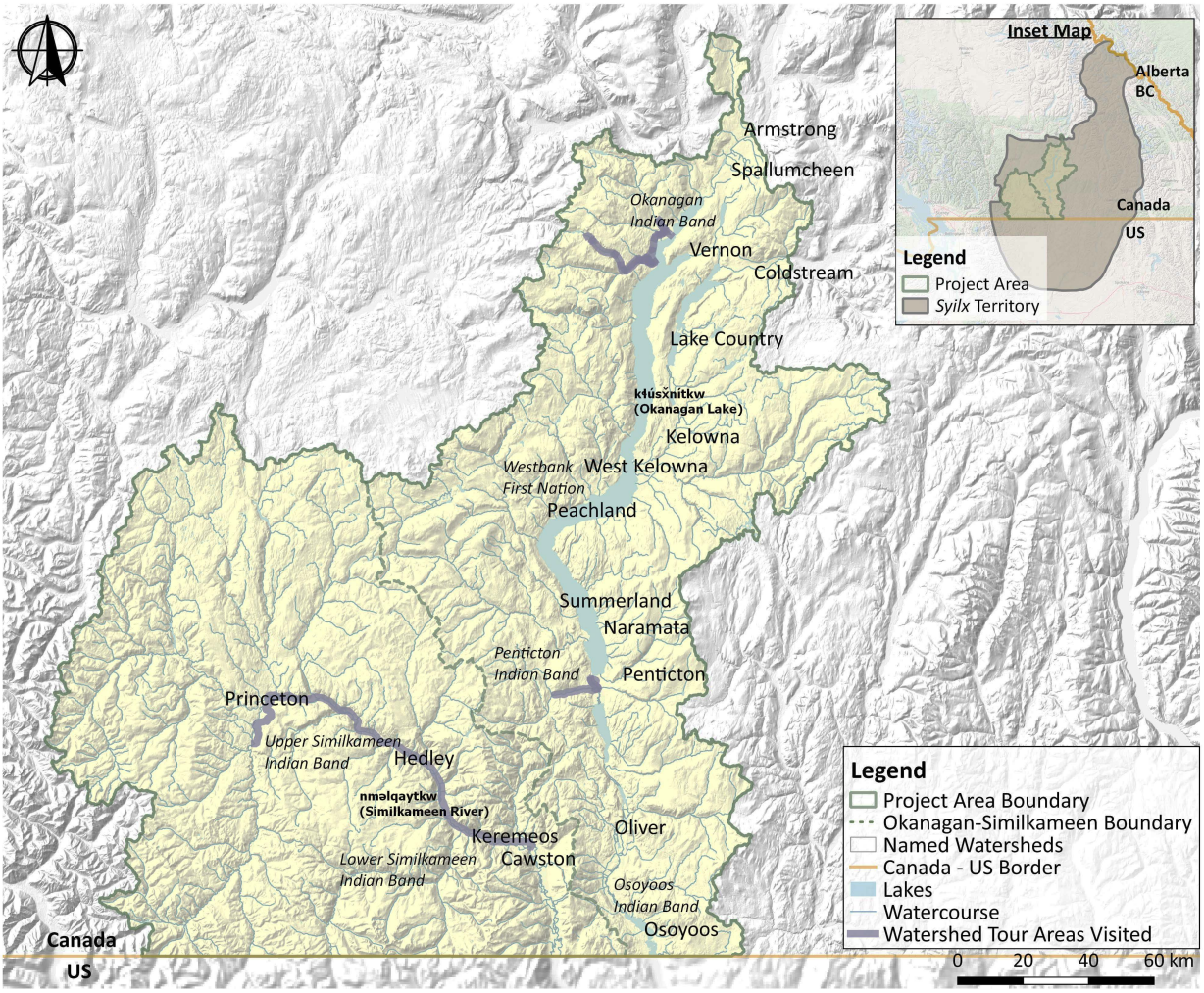

Figure 1: Project Area (approximately 15,400 km²).

1.4 Project Background

Flood and debris flow risk is part of a larger water and land related *wicked problem*[2]; it is difficult to solve because of complex, inter-jurisdictional, multi-disciplinary, incomplete, and contradictory requirements that are hard to recognize and articulate. This project plays an important role in better understanding the problem by linking and informing efforts across spatial scales and viewpoints.

In terms of flood and debris flows, the project area is increasingly affected by global-scale climate change, which is changing water movement on the landscape. Projections are for recent trends of increasing temperature and more extreme precipitation to worsen in BC. This is very likely to lead to continued shifts in hydrologic regimes, resulting in larger and more frequent flood events (Bush and Lemmen, 2019).

[2] The phrase was originally used in social planning and in 1967 was used by C. West Churchman in the journal of Management Science. Weblink: https://en.wikipedia.org/wiki/Wicked_problem. Accessed September 24, 2019.

The longer-term initiative of this project focuses on adapting to the effects of climate change, which can be achieved primarily through policy and planning with, and among, local government and other groups in the region. The project area is also affected by decision-making at local levels that impacts water and land, through cumulative pressures, in ways that exacerbate flood and debris flows. However, local government jurisdictions are not currently set up to think on a watershed basis, which is necessary when addressing flood and debris flow phenomena. This project is building cross-jurisdictional and government relationships by breaking down "silos" of thinking. By helping organizations to think collectively "like a watershed", organizations can align adaptation efforts.

Risk assessment is a tool that can be used to prioritise adaptation efforts that benefit humans over the long-term. The components of risk are complex, multi-layered, and typically based on western scientific practice. As a result, risk assessments are usually narrowly-focused, and are based primarily on quantitative information sources. This risk assessment is based on a new template that is more holistic and ecosystem-based. It emphasizes or places equal weighting on qualitative components and focusses on the *Syilx* perspective that values water and land—primarily through place-based experiences.

This new template is applied in the spirit of opportunity. In addition to the drivers for inclusive integration of Indigenous People in land-based decisions, Indigenous people have a unique perspective that can help solve the wicked problem addressed in this risk assessment, as well as others.

1.5 Activities and Reporting

To achieve the project objectives, activities supporting the risk assessment ranged across the spectrum of qualitative and quantitative to widen the sources of information and interpretation (see top portion of Figure 2). Some example project activities and their purpose are explained below:

- **Watershed tours (mostly qualitative):** Provided participants with an opportunity to experience the land from the perspective of *Syilx* Elders in specific areas.
- **Impacts mapping (mix of qualitative and quantitative):** Enabled participants to share their knowledge and experiences by marking-up maps with flood and debris flow areas.
- **Workshops (mix of qualitative and quantitative):** Focused on building relationships among people and organizations in the region while sharing relevant information.
- **Risk matrices (quantitative):** Compared the risk from flood and debris flows in the Okanagan and Similkameen watersheds in terms of the magnitude and the consequences of the event.

Project reporting mirrors the activities shown in Figure 2, and is summarized in Figure 3. The reporting documents consist of the Basis of Study, which provides background information including geographic scope, project framework, and a risk assessment primer. The Qualitative Study documents the engagement events and their outputs. The Quantitative Study focusses on numerical analyses completed to obtain risk scores across the project area. The Map Book integrates the spatial outputs from the Qualitative and Quantitative studies; it is easily navigable and is meant to be a quick reference tool. The synthesis process (see right hand side of Figure 2 and Figure 3) is captured within this Synthesis and Recommendations report and integrates information from the risk assessment supporting documents

mentioned above. The report numbers in Figure 3 reflect the order in which the reports are generally intended to be read.

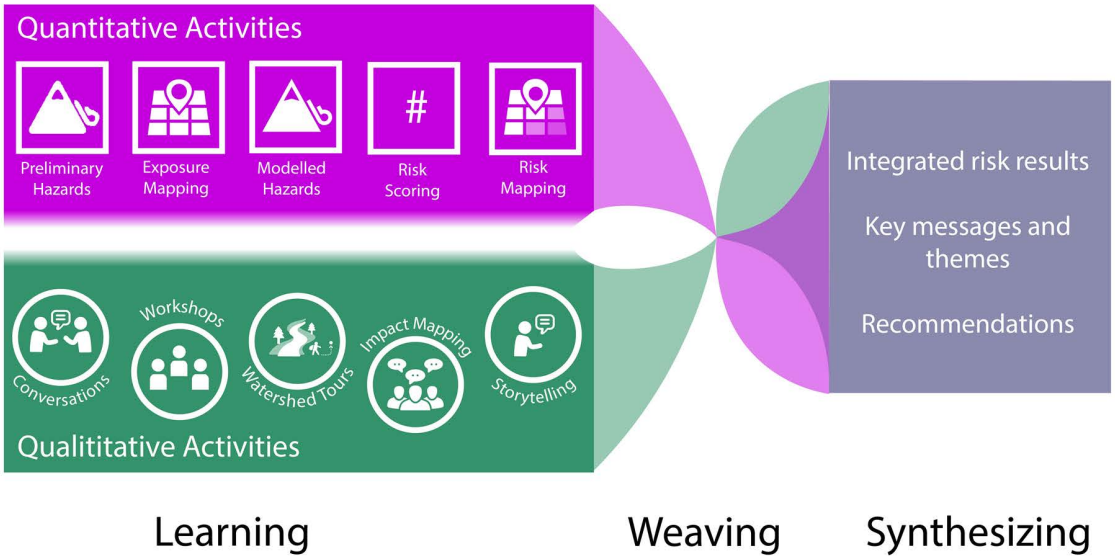

Figure 2: The spectrum of qualitative and quantitative risk assessment supporting activities (left) were woven to synthesize outputs and achieve the project goal.

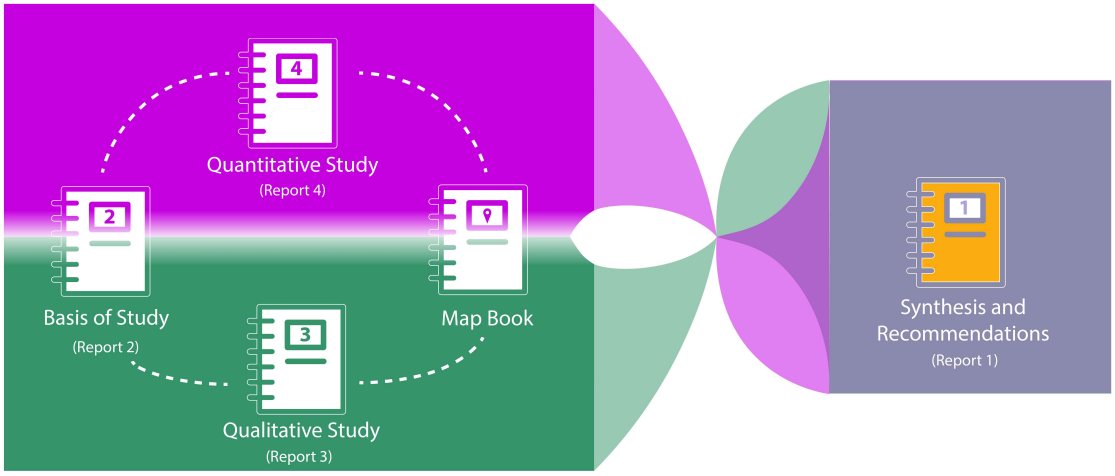

Figure 3: Project reporting documents with this report highlighted.

In this Synthesis and Recommendations report, Chapters 2 to 6 summarize the project drivers, activities, and results, as follows:

- **Chapter 2 Flood and Debris Flow Phenomena:** What are they and how do they occur?
- **Chapter 3 Weaving Perspectives:** Importance of ecosystem benefits, learning activities, building relationships, and developing ideas to guide adaptation.
- **Chapter 4 Risk Assessment Process at a Glance:** How it was completed, including mapping impacts and consequences, and scoring risk on a watershed scale.
- **Chapter 5 Results Summary:** Integrated qualitative and quantitative analyses of impacts and consequences, and risk, as well as study limitations.
- **Chapter 6 Looking Forward:** Building resilience, linking *siwɬkʷ* (water) and adaptation, and reducing risk.

Chapters 7 to 9 of this report contain information for project next steps, as follows:

- **Chapter 7 Best Practice for Risk Reduction:** Sendai priorities, strategic flood risk management, and governance and decision-making.
- **Chapter 8 Recommendations:** Quick-wins and concrete actions organized by Sendai priorities.
- **Chapter 9 Conclusion:** Project outcomes are linked with the project objectives.

1.5.1 Constraints

Knowledge-sharing within *Syilx* traditions and culture is passed on using all sensory abilities through storytelling and spiritual practices, listening, smelling, and seeing the land, etc. While the activities conducted as part of this project included these traditions, the dissemination of the learnings through the documents produced do not do them justice. With this in mind, readers are encouraged to share this report with colleagues, friends, and family with consideration and respect for oral traditions. Talk about this report; share your thoughts as well as your feelings; and let your emotions and intellect work in tandem to guide your subsequent actions.

2 Flood and Debris Flow Phenomena

Flood and debris flow phenomena are part of a range of natural earth processes (geohazards) that include rockfalls, landslides, clear-water floods, etc. Flood and debris flows are distinguished scientifically based on the proportions of water and material that are transported, and the speed at which they moved, during an event (see the Basis of Study for details). This project focused on assessing flood and debris flow phenomena (e.g., Figure 4 and Figure 5) specifically. However, the intent was to also consider other geohazards more broadly, which were included in qualitative discussions.

From a risk assessment perspective, flood and debris flows can differ in many ways, including: how quickly they can occur (i.e., time of onset), how long they last (duration), where they occur (distribution), how destructive they are (impacts/consequence), and how often they occur (likelihood). Some of these more technical terms are discussed in Chapter 4.

Figure 4: Flood at McDougall Creek in Westbank First Nation, 2017 (Source: WFN).

Figure 5: Flood and debris flow on Highway 3 at Yellow Lake and Fairview Golf Course, 2018 (Source: RDOS).

Quantitative comparisons are made throughout this study between flood and debris flow phenomena. However, due to their differences, the comparisons are considered high-level and are in *relative* terms to inform discussions on prioritization of adaptation efforts.

2.1 What is a Flood?

Floods occur when surface water reaches higher-than-normal levels. They are driven by climate processes that have influence on the watershed scale. Floods are caused by natural and human influences, but increasingly, human influences are at play. Flood types include pluvial, riverine, dam and dike breach, and high water table. The main mechanisms causing flooding in the project area are heavy rain, snowmelt, and rain-on-snow. The careful control of reservoir outflows to manage water supply and ecosystem needs can also play a role in flooding. Flood events can affect the landscape and cause other natural phenomena such as landslides and debris flows.

> ***ṫiḱt* (flood)**
> *ṫiḱt is the word for flood. There are also words for flood land... but ṫiḱt talks about the water… it almost sounds* like *t'ik'ʷt, which is the word for lake. ṫiḱt is shallower and not still like the lake…*
>
> Richard Armstrong, *Syilx* Okanagan Elder, Traditional Ecological Knowledge Keeper and *Syilx* language instructor. Personal communication, February 14, 2019.

2.2 What is a Debris Flow?

Debris flows are rapid mass movements of saturated surface materials that move rapidly through channels to their outlets (debris flow fans). The high-water content of debris flows allows them to flow downhill as slurry that often resembles wet concrete. Channelized debris flows commonly grow larger as they move downstream, picking up material within the channel. Debris flows can also be initiated by rockslides, which subsequently disintegrate and release internal water or pick up other material. Debris flows are controlled by an intricate balance of geomorphic and climatic factors and are commonly triggered by a mechanism such as a heavy rainfall event. A complex interplay exists between factors driving debris flow initiation, and unlike floods, continuous debris flow activity is not monitored for most debris flow basins.

3 Weaving Perspectives

There is growing recognition of the importance of reconciling the use of western methods with Indigenous knowledge in order to realize the beneficial outcomes that are possible when multiple perspectives are considered. The *Syilx* Okanagan worldview is rich with ideas relevant to flood and debris flow management. This project departs from previous regional planning in that it directly includes and empowers *Syilx* Okanagan people in line with Sendai, UNDRIP, and other directives to obtain "full and meaningful" participation of affected parties[3].

In the *Syilx* Okanagan worldview, the *nʕawqnwixʷ* process offers a means of incorporating Indigenous and western knowledge and ways of knowing into dialogue and decision-making. This uniquely *Syilx* decision-making model was applied in this project.

nʕawqnwixʷ considers principles and knowledge that are contained within the *captikwɬ* "How Food Was Given," which is also known as the story of the Four Food Chiefs who came together in order to make a plan to feed *st'lsqilxʷ* (the people to be). They are able to resolve this central question through the coming together of the different perspectives of each the Four Chiefs: *skmxist* (Black Bear), *siya* (Saskatoon Berry), *spiƛ̓əm* (Bitter Root), and *ntityix* (King Salmon). In the *nʕawqnwixʷ* approach, all perspectives must be included when making decisions. Within the framework of *nʕawqnwixʷ*, collective input helps build a broader perspective. Collective dialogue helps to clarify the question and reveals information, actions, and solutions to move forward, all based on the dynamic inputs of multiple perspectives.

> ***Respect for Syilx Knowledge***
> *It was against the law to talk about the Indigenous worldview and my dad almost went to jail because of that.*
>
> Richard Armstrong, *Syilx* Okanagan representative. Workshop 2, April 25, 2019.

The *nʕawqnwixʷ* process teaches that:

- With complex issues, it is important to step out of our comfort zone and truly listen to other perspectives.
- It's important to allow space for the diverse perspectives from all participants to be voiced and understood from all angles and different worldviews.
- There are voices beyond the human kind that also need a space to be heard and recognized, such as species, species habitats, and spiritual locations/landforms.
- There is a collective approach that includes all different perspectives and will only occur after fair dialogue in which all voices are heard.
- Solutions will be multi-faceted and holistic and consider social, cultural, scientific, economic, and governance values.

Weaving perspectives together in this way facilitates taking complex and interdependent concepts and presenting them in a more simplified form. This weaving process was applied to many dimensions of the

[3] The United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) was tabled in the BC Legislature on October 24, 2019.

project in answer to the wicked problem defined in Section 1.4. At its core, the process of bringing diverse perspectives together was used as a driver to disrupt the *path dependency* (Parsons et al., 2019) of flood and debris flow management in the Okanagan-Similkameen region. Management approaches in recent history reflect an entrenched view that hazards should generally be managed by fighting nature through structural mitigation. There is now growing interest in exploring alternative approaches.

The *nʕawqnwixʷ* manner of weaving diverse voices was an effective way to integrate qualitative and quantitative information sources, as well as the *Syilx* Okanagan perspective and multi-disciplinary western science. Practical outcomes of the process included articulating ecosystem benefits, learning through diversity, building relationships, and finally, developing ecosystem-based adaptation ideas.

3.1 Articulating Ecosystem Benefits

> ***Recognizing Nature's Work***
> *Flooding is a natural process and the land requires it.*
>
> Tyrone Kruger, *Syilx* representative.

Flood and debris flow phenomena are typically viewed negatively in society; they destroy infrastructure and other assets that humans value. In typical risk assessment terminology, the term "hazard" describes this view. However, flood and debris flows are part of an ever-changing landscape and contribute to ecosystem function and diversity. This is supported by multi-disciplinary western science (see Basis of Study), which seems to be catching up with the *Syilx* Okanagan perspective in this respect. A review of the science indicates that these phenomena can play a positive role in enriching soils with nutrients that feed the landscape including riparian and aquatic ecosystems (Geertsema et al., 2009). Furthermore, the sediment, vegetation, and woody debris that end up in these ecosystems play a role in sculpting diverse habitats (Fetherston et al., 1995). The diverse habitats support plants, macroinvertebrates, and fish during their various lifecycle stages (Trush et al., 2002). In turn, healthy ecosystems provide services such as clean drinking water, carbon sequestration, food supply, cultural and recreational opportunities, etc. (de Groot et al., 2012).

Balancing the consideration of positive ecosystem-based benefits of flood and debris flow phenomena with the negative impacts felt by humans is tricky[4]. It's one of the factors contributing to the "wicked problem" in the project area. Since European settlement, water and land have been utilized with little consideration for the ecosystems (and people) that depend on them. This has been manifested by the lack of consideration for flood and debris flows, as natural and necessary phenomena, within prevalent natural resource management practices. Enabling *Syilx* Okanagan people, knowledge and practices lead watershed planning and governance can help the region find a better balance.

[4] In this project, flood and debris flows are referred to as "phenomena" where possible, to convey the idea that their impacts may be positive or negative. However, within the quantitative risk assessment, flood and debris flows are referred to as "hazards" to align with common risk assessment terminology.

3.2 Learning through Diversity

Engagement activities were important opportunities to invigorate ecosystem-based ideas and practices by learning about them. The activities were led in large part by *Syilx* Okanagan Elders, or Traditional Ecological Knowledge Keepers (TEK). During these events, ideas common to the *Syilx* Okanagan and multi-disciplinary western science perspectives were identified to obtain a more holistic understanding of flood and debris flow management. The engagement activities consisted of 3 watershed tours and 2 workshops. These were venues for people to share ideas who otherwise would not have such opportunities (i.e., *Syilx* and non-*Syilx*, but also from one organization or jurisdiction to another). Participants from *Syilx* Okanagan communities, various levels of government, and other agencies explored and co-learned based on their diversity of perspectives, knowledge, and experience.

The 23 organizations represented throughout the engagement events were as follows:

- Ebbwater Consulting Inc. (Ebbwater)
- Emergency Management BC
- En'owkin Centre
- Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD)
- City of Kelowna
- Village of Keremeos
- District of Lake Country
- Lower Similkameen Indian Band (LSIB)
- Okanagan Basin Water Board (OBWB)
- Okanagan Indian Band (OKIB)
- Okanagan Nation Alliance (ONA)
- Town of Osoyoos
- Osoyoos Indian Band (OIB)
- Palmer Environmental Consulting Group (PECG)
- City of Penticton
- Penticton Indian Band (PIB)
- Regional District of Central Okanagan (RDCO)
- Regional District of North Okanagan (RDNO)
- Regional District of Okanagan-Similkameen (RDOS)
- SHIFT Collaborative (SHIFT)
- Upper Similkameen Indian Band (USIB)
- District of Summerland
- Westbank First Nation (WFN)
- City of West Kelowna

During the watershed tours, participants directly observed recent and localized changes and discussed these in terms of historical contexts and regional patterns (Figure 6 and Figure 7). The insights gained were constructive for sharing ideas about the history, nature, causes, and solutions to flood and debris flow management.

Figure 6: Participants visit an abandoned mine waste dump site located 30 m from the Similkameen River near Hedley. Flood conditions could cause toxic contaminants to be released to the receiving environment. Watershed Tour 2: *nməlqaytkw* (Similkameen River).

Figure 7: Participants listen to Elders talk about the history of the Penticton Channel and plans for nearby locatee lands. Watershed Tour 1: *snpintktn* (Penticton).

Figure 8: Participants marking up impacts on large-size hardcopy maps. Workshop 1: *t̓ik̓t* (Flood) in the Syilx Okanagan Territory.

Figure 9: Participants sharing their ideas through one-on-one discussions. Workshop 2: Moving from *t̓ik̓t* (Flood) Risk to Adaptation.

Workshop activities focused on sharing ideas and gathering information, such as presenting and marking up maps (Figure 8), while considering the project area as a whole. Participants heard *Syilx* Okanagan *captikʷɬ* stories such as the "Stripes on the Turtle's Neck", and the "Origin of the Four Food Chiefs". Participants also explored ways to adapt to flood and debris flows through discussions about resilience (Figure 9).

Committees internal and external to the ONA were struck to guide the project throughout its progress. The external committee consisted of technical staff, as well as political representatives, from local governments. The intent is for these committees to continue working over the longer-term adaptation initiative in the region.

3.3 Building Relationships

The *Syilx* Okanagan perspective extends beyond the worldview, ethics, and relationships that *Syilx* Okanagan people have with their natural world. In this project, the perspective also includes the lived *experience* of the *Syilx* Okanagan in the Okanagan-Similkameen region. The effects of colonization, including injustice and marginalization of *Syilx* Okanagan people, must be acknowledged to build relationships between *Syilx* Okanagan and non-*Syilx* peole and organizations. This is increasingly supported by systemic forces at various levels of governance, including UNDRIP[6].

Long-term actions will require relationships to be strengthened to build trust among people and organizations that have not typically worked together. This requires "breaking down silos" between, and even within, larger organizations in the public and private sectors.

Working Together

Water is a vehicle for re-establishing a common vision and closing the gap between our communities… We are in the midst of an emergency, and we must now work together. People of the Earth are coming together because of the challenges we are facing. When there's a crisis, we come together.

ʔaʔsiwɬ, Grand Chief Stewart Phillip, Chair of the Okanagan Nation Alliance. Environmental Flow Needs Conference, October 17, 2018[5].

[5] Proceedings and Outcomes. *siwɬkʷ* (Water) for All—Our Responsibility. Environmental Flow Needs Conference 2018: Science, Policy & Practice. October 17-18, 2018. *Syilx* Okanagan Nation Territory, Kelowna, BC.

[6] United Nations Declaration on the Rights of Indigenous Peoples. Weblink: https://www.un.org/development/desa/indigenouspeoples/declaration-on-the-rights-of-indigenous-peoples.html. Accessed March 15, 2019.

In terms of flood and debris flow risk assessment, building relationships is important to establish a common understanding of the environmental setting (Figure 10) of this project. This provides a foundation to understand the process being followed to obtain results for priority-setting of adaptation actions. With diverse views and strong relationships, valuable ideas can emerge.

Figure 10: Observing natural processes occurring at the mouth of Equesis Creek at Okanagan Lake. Watershed Tour 3: *nk'mapəpəlqs* (Head of the Lake).

> ***Open Knowledge Sharing***
> *Industrial operators need to be open and transparent about the science that has been done. If you believe so much in science, why not share it?*
>
> Wendy Hawkes, *Syilx* representative. Watershed Tour 2, March 4, 2019.

3.4 Developing Ecosystem-Based Ideas to Guide Adaptation

Important ideas emerged through the process of sharing information and finding commonalities between the *Syilx* Okanagan and western science perspectives. Ideas that directly related to flood and debris flow phenomena were:

- The need to respect water
- The need to recognize cumulative pressures

3.4.1 Respect Water

Participants acknowledged that water must be respected. It commands respect as it is powerful, it is life, and it is connected (Table 1). The Basis of Study and the Qualitative Study contain additional information supporting the reasons to respect water, including the *Syilx siwɬkʷ* (Water) Declaration[7], and the "10 golden rules" for strategic flood management (Sayers et al., 2014)[8]. These documents respectively represented the *Syilx* Okanagan and multi-disciplinary western science perspectives.

> ***Respecting Water***
> *Water is half of our existence… we need to speak about it and feel it from our heart, not our mouth and our mind.*
>
> Arnie Baptiste, *Syilx* representative. Workshop 1, February 13, 2019.

[7] Syilx siwɬkʷ (Water) Declaration. Weblink: https://www.Syilx.org/about-us/Syilx-nation/water-declaration/. Accessed October 4, 2019.

[8] The paper with the 10 golden rules was co-authored by representatives of diverse perspectives including academic and government officials, engineers and planners, as well as recognized leaders in the field of flood risk management. Details on the paper are found in Section 7.2.

Table 1: Common water-based threads identified by weaving *Syilx* perspective and western science ideas.

Reasons to Respect Water	Consideration
1. Water is powerful	It will always find a way around obstructions. It is a source of power in many dimensions (e.g., political, social, spiritual, electrical, environmental).
2. Water is life	It is a part of, and sustains, humans and all life; it feeds and regenerates ecosystems in water and on land.
3. Water is connected	It connects living and non-living things in the past, present, and future. Water is affected by cumulative pressures.

3.4.2 Recognize Cumulative Pressures

There are tangible connections between the need to respect water and activities occurring on the *tmx*^{w}*ulax*^{w} (land). Based on project feedback (see Qualitative Study) and a literature review of scientific research (see Basis of Study), watershed-scale cumulative pressures on flood and debris flows were identified. These include climate change, land-use change, ecological disturbances, industrial activity, flood defence structures, urban development, and surface-subsurface interactions (Figure 11).

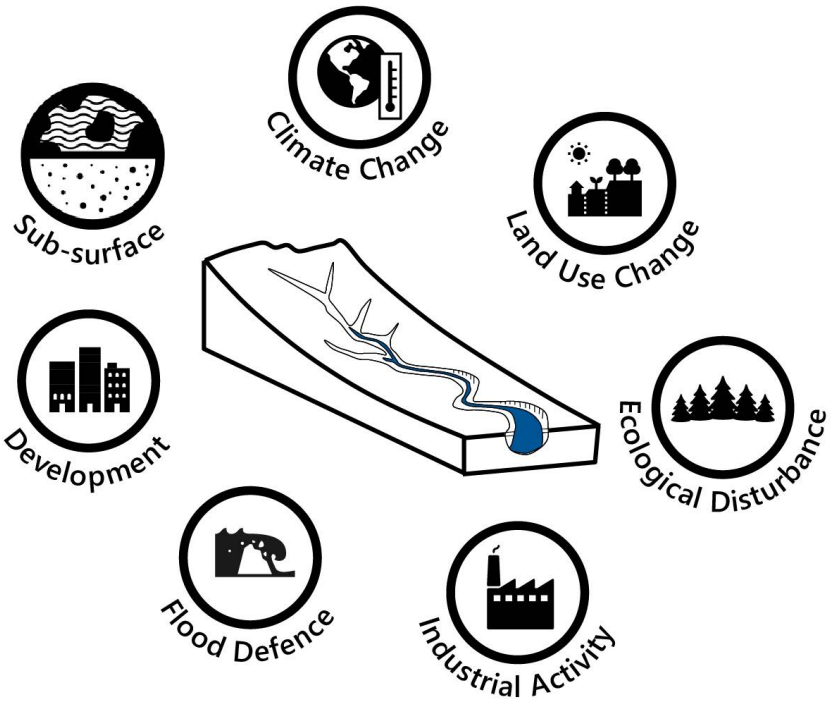

Figure 11: Watershed-scale human-induced cumulative pressures that worsen flood and debris flows.

4 Risk Assessment Approach at a Glance

Compared to typical risk assessments focused on western science methods, the approach for this project needed to evolve to incorporate *Syilx* Okanagan perspectives throughout the process. The Syilx *nʔawqnwixʷ* process of weaving diverse perspectives together discussed in the previous Chapter are an important evolution, and they represent a unique outer layer to this assessment approach (Figure 12). Looking toward the inner layer of the risk assessment approach, *mapping* is critical to the risk assessment process as it provides a mix of qualitative and quantitative information in a spatial context. To be clear, this project distinguishes *impacts* as stemming from qualitative information, whereas *consequences* stem from quantitative information.

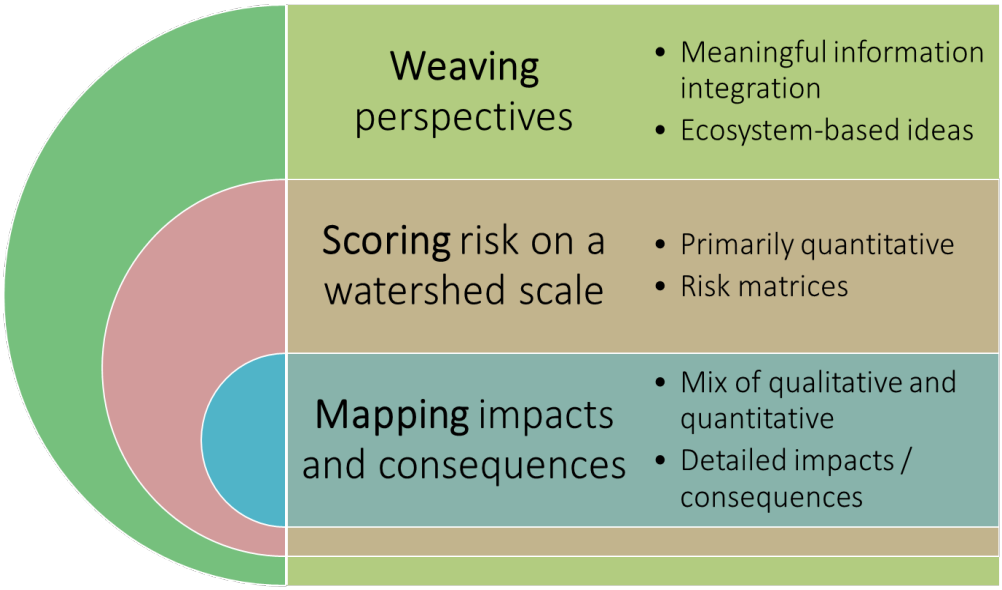

Figure 12: Evolved risk assessment approach; all the layers incorporate *Syilx* perspectives, and the outer layer is unique to this project.

The mapping of quantitative consequences, which is part of the innermost layer of the approach, is the basis of scoring risk. This is achieved by aggregating results on a watershed scale and is helpful for prioritization purposes. The inner two layers of the risk assessment approach are discussed respectively in more detail in later sections. However, the building blocks of risk are first discussed below—these building blocks apply to both the inner layers of the evolved risk assessment approach.

4.1 Building Blocks

Simply put, risk is a function of both the likelihood of an event occurring, and the consequence if that event occurs. However, these basic components of risk include nuances that can be challenging to understand because they often vary in time and place. Additionally, it is difficult to articulate and make sense of the impacts/consequences.

These challenges are addressed by using a mapping technique that represents likelihood in terms of *hazard scenarios*, and impacts/consequence in terms of *exposure indicators* (Figure 13). Hazard scenarios and exposure indicators are further explained below in terms of how they were used qualitatively and quantitatively.

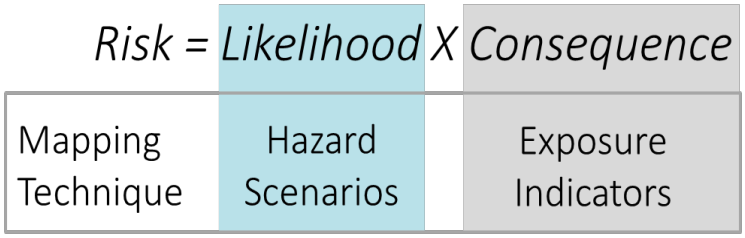

Figure 13: Quantitative risk assessment components.

4.1.1 Hazard Scenarios

In risk terminology, a natural hazard is a physical event or phenomenon that may cause harm. (However, as discussed in Chapter 2, these phenomena can also benefit ecosystems). As explained in Chapter 2, hazards such as flood and debris flows are characterized by their time of onset, duration, distribution, frequency, etc. Multiple hazard scenarios can be defined by associating events of different approximate likelihoods with the estimated size of areas that these events cover (i.e., magnitude). For example, a flood that is less likely to occur typically covers a larger area—and has a higher magnitude. At the end of this hazard scenario definition process, a range of hazard extents are mapped, each having different associated approximate likelihoods.

For simplicity and due to the timing of hazard scenario development relative to the occurrence of the engagement events, the Qualitative Study is based on preliminary flood and debris flow hazard areas. Therefore, there is no qualitative consideration for the range of likelihood of hazard events. However, for the Quantitative Study, multiple flood hazard scenarios are determined and mapped, and debris flow hazard areas are mapped in more detail[9]. The hazard delineation process is highly technical and is detailed in the Quantitative Study.

4.1.2 Exposure Indicators

Exposure represents the things we care about that are located in hazard areas such as the environment, people, culture, and economic assets like infrastructure. Exposure indicators capture information about these assets and how they vary based on location. For example, urban areas usually have fewer natural spaces and larger human populations compared to rural areas.

The exposure indicators used in this assessment are broadly based on Sendai and are currently used by federal agencies in Canada. The six indicators are: environment, culture, mortality, affected people, economy, and disruption. The indicators are meant to capture a wide set of impacts/consequences while keeping in mind what can, and cannot, be measured. In the Qualitative Study, the indicator information is obtained directly from participant input. In the Quantitative Study, the indicator information is obtained using various spatial data sources as proxies (Table 2).

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[9] The processes governing flood and debris flows are different; accordingly, different numerical techniques were used to represent each hazard. Based on the effort allocated in the project, 3 flood hazard magnitude scenarios were defined (i.e., low, moderate, high). Conversely, a single hazard magnitude scenario (i.e., moderate) was defined for debris flow.

Table 2: Exposure indicators and summary of supporting qualitative prompts for participants and quantitative data sources.

Exposure Indicator	(Qualitative) Impacts – Example Guiding Question(s)	(Quantitative) Consequences – Proxy Data Sources
Environment 	Where and how were ecosystems negatively or positively affected?	Contamination sources Environmental receptors
Culture 	Were sensitive archaeological, fisheries, or other sites affected?	Cultural buildings *Syilx* and non-*Syilx* archaeological sites
Mortality 	Not applicable	Census dissemination areas Building footprints
Affected People 	Were people hurt, displaced, suffer emotional trauma, or affected in other ways (e.g. spiritually)?	Census dissemination areas Building footprints
Economy 	What property was damaged, and/or which businesses were affected? How much did the response effort cost?	Land parcels Building footprints
Disruption 	What was the critical infrastructure that was disrupted as a result of the event?	Major and minor roads, rail, gas, electricity infrastructure, and telecommunications

4.2 Mapping Impacts and Consequences

Impacts and consequences describe what happens when a hazard gets in the way of the things that matter. While both qualitative impacts and quantitative consequences were mapped, this was done using two different means, as explained in the following sections.

4.2.1 Impacts

Mapping cannot be restricted to what can be measured—lived experience shared through qualitative sources can provide key insights into a hazard or its impacts. For example, this type of information sharing can identify changes on the landscape such as new flow pathways, which are otherwise not documented. information sharing can also lead to important connections between issues (e.g., management of wildfires, invasive species, and beaver habitat). It can also provide a voice to people such as the *Syilx*

Okanagan who have been marginalized in the past and whose views are not captured in datasets stemming from western science.

For the Qualitative Study, comments on impacts were obtained from map markups as well as other discussions, including during watershed tours and workshops. These were subsequently interpreted and categorized. The information was input to QGIS (an open-source geographic information system software package) and used to create hotspot maps for each indicator (Figure 14). Hotspot maps are used to obtain a sense of the spatial distribution of impacts within and across watersheds.

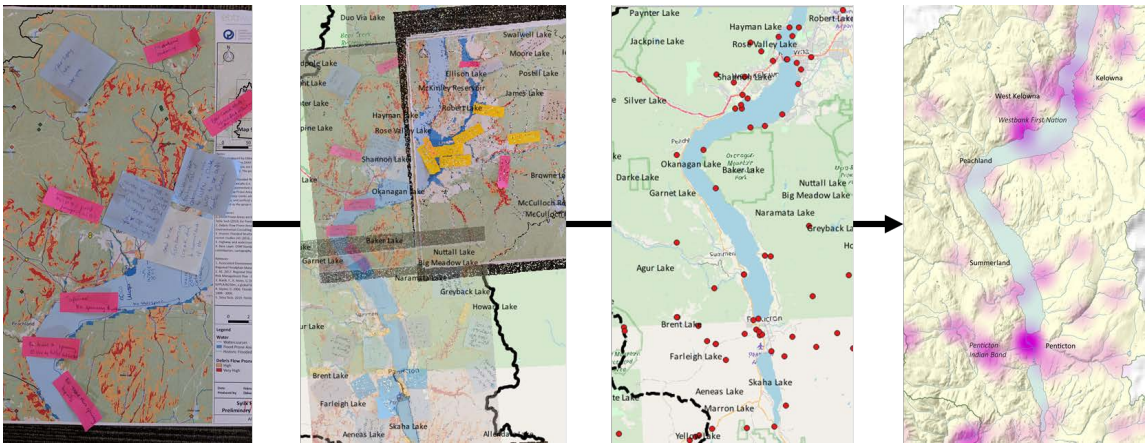


Figure 14: Process of transforming qualitative impacts information into hotspot maps for each indicator.

4.2.2 Consequences

For the Quantitative Study, the various hazard scenarios and exposure indicator information were overlaid, as shown in Figure 15, using QGIS. Therefore, for a particular hazard scenario and exposure indicator, the consequence is represented spatially based on the overlapping areas.

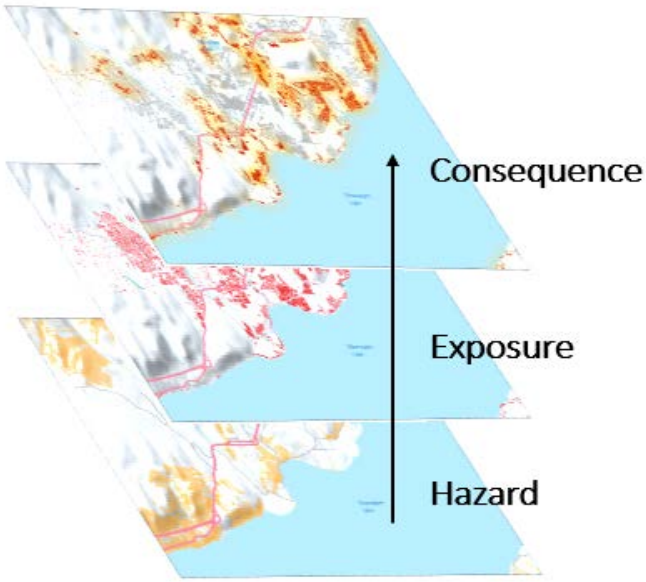


Figure 15: Quantitative overlay of hazard scenarios and exposure indicators to obtain consequence.

Figure 16 shows example results of the overlay process for the three flood hazard magnitude scenarios. (i.e., high, moderate, and low), for a sub-area in the Similkameen watershed. In the example, the exposure data are land parcels and building footprints that were used as proxies for the economy indicator. The consequences of the economy indicator are determined by aggregating the land value flooded, for each hazard scenario, and for each watershed.

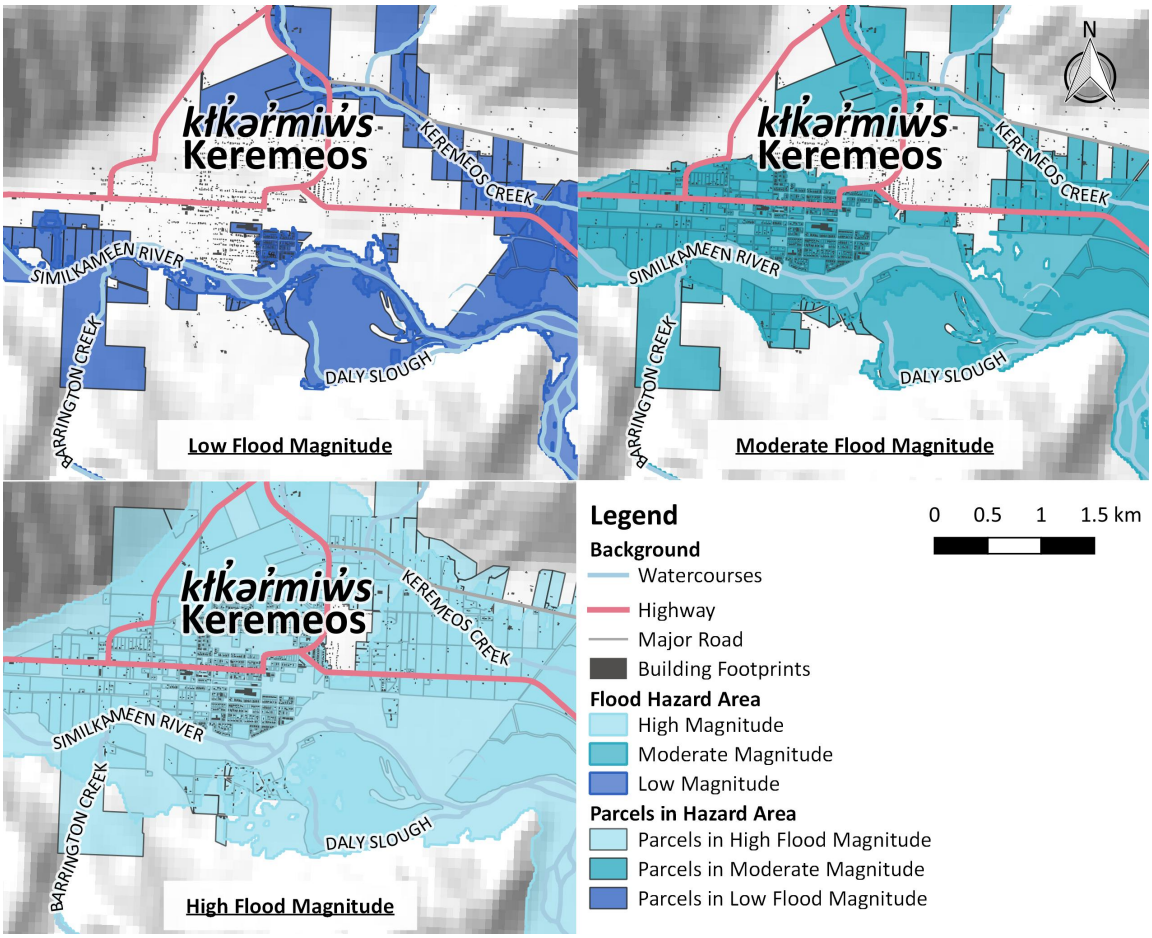


Figure 16: Example spatial data processing showing land parcels and building footprints in each of the three flood hazard scenarios for a sub-area in the Similkameen watershed. Darker colours show areas of overlap.

4.2.3 Integration

Mapping and analysis of impacts and consequences provides a rich base of information. This knowledge is integrated to obtain a more comprehensive understanding of how the region is affected by flood and debris flows, and can help answer key questions such as "What do project participants think are the most important impacts?"; "Are the important impacts consistent with the consequences?"; and "Do things need to be measured, or measured differently, to better capture what matters to people in the region?".

Impacts and consequences across the project area can be visualized in the Map Book, which is a standalone project output (see Section 1.5). It contains all the mapping information from large scale (i.e., Okanagan-Similkameen area) to more local scale (i.e., sub-watershed, city, or village). In the Map Book,

impacts and consequences are organized together by indicator for easy reference. However, the two types of information are deliberately shown on different maps to avoid confounding the two sources of information.

Figure 17 shows an example clarifying how the sources of information differ when considering the culture indicator. In Figure 17 the mapped consequences are based on three sets of digitally-sourced data that are considered to be consistent over the project area: cultural amenities (orange), *Syilx* Okanagan archaeology sites (purple), non-*Syilx* archaeology sites (pink), and recreational trails. In contrast to the mapped culture impacts (yellow), the mapped consequences are more numerous. The reason for the difference in the amount of quantitative versus qualitative data is important.

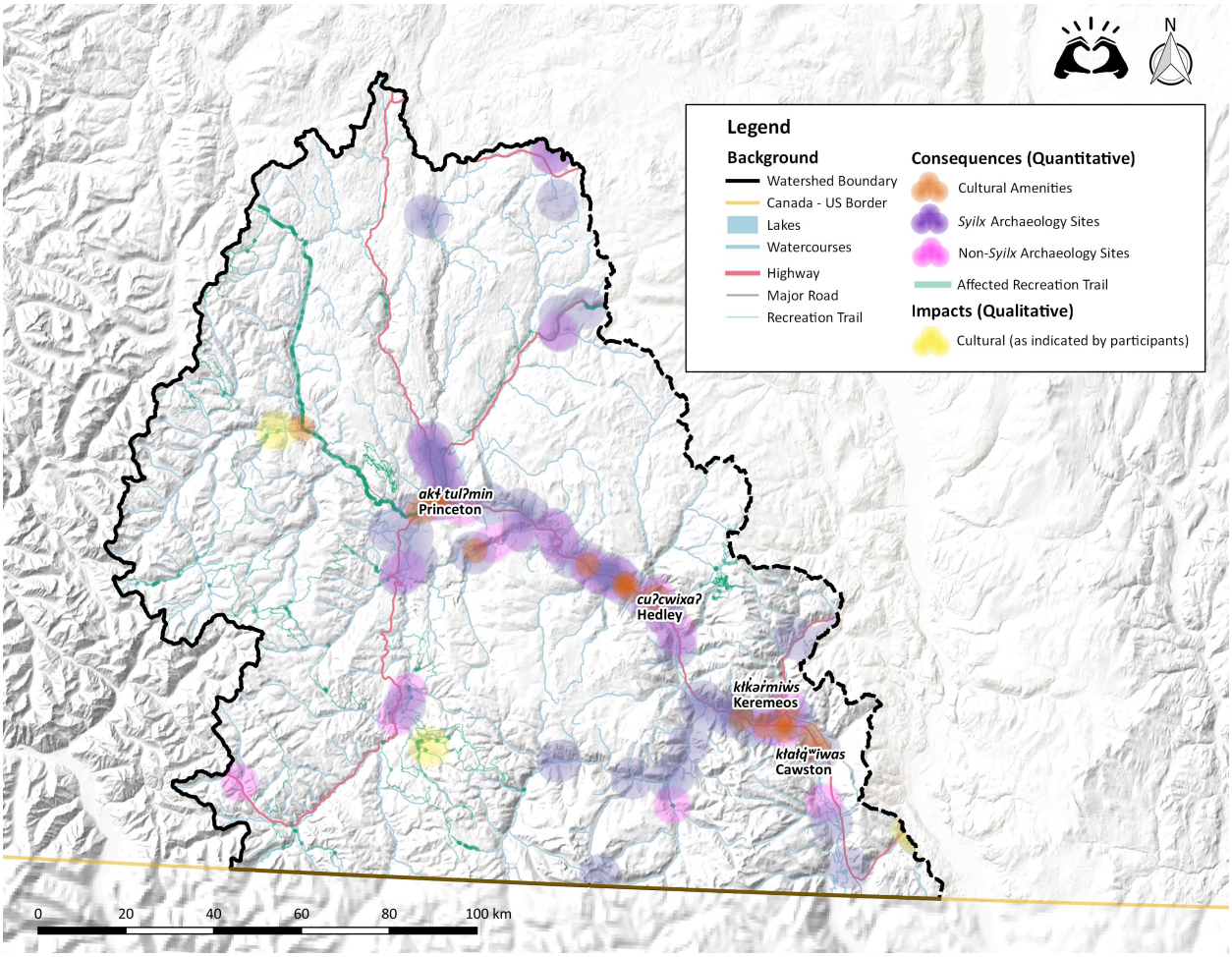


Figure 17: Example map of quantitative consequences and qualitative impacts for the culture indicator, for the Similkameen watershed.

Through the process of gathering the qualitative information, it was expressed that *Syilx* Okanagan community members were not comfortable sharing the locations of culturally significant areas. *Syilx* Okanagan people have a responsibility to past and future generations to respect and protect such sites; past negative experiences related to open sharing of site locations now dissuade community members toward this practice. Trust needs to be rebuilt among those providing information and those who use it.

Impacts and consequences information is important to this risk assessment as it provides insights that are spatial, and that include qualitative and quantitative information sources that can be integrated. Quantitatively, the result of overlaying the hazard and exposure to obtain consequences forms the basis of the risk scoring.

4.3 Scoring Risk on a Watershed Scale

Scoring is primarily a quantitative exercise to obtain relative comparisons that are based on consistent information. To do this, the consequence data are aggregated on a watershed basis (i.e., Okanagan and Similkameen) for each exposure indicator through classification. The benefit of this process is that it allows risk to be scored on a larger scale of interest, and consequences to be assessed over time. These processes are explained below.

4.3.1 Classification

Likelihood and consequence scores are determined based on risk assessment guidance classification tables from national and federal best practice sources (e.g., AIDR, 2015; Stantec Consulting Ltd. & Ebbwater Consulting Inc., 2017). The risk is then calculated as the product of the likelihood and consequence scores. For example, the resultant risk for the affected people indicator in a watershed from a "low" hazard scenario (i.e., score of 4, see left-hand table in Figure 18), which has an associated consequence level of "major" (i.e., score of 4, see right-hand table in Figure 18) is 16. This risk level, according to Table 3, is extreme.

Likelihood Scoring – Flood Hazard

Scenario	Level	Score
-	Almost certain	5.0
Low	More Likely	4.0
Moderate	Unlikely	3.0
High	Less Likely	2.5
-	Rare	2.0
-	Very rare	1.0

Consequence Scoring – Affected People Indicator

Measure	Level	Score
1 in 10 people	Catastrophic	5
> 1 in 100, but < 1 in 10	Major	4
> 1 in 1,000, but < 1 in 100	Moderate	3
> 1 in 10,000, but < 1 in 1,000	Minor	2
< 1 in 10,000	Limited	1

Note: The measures in the table are based on the number of people who would be *potentially* affected.

Figure 18: Example likelihood and consequence scoring tables.

Table 3: Risk scoring levels.

Risk Score	Levels
1–2	Very Low
3–4	Low
5–9	Medium
10–15	High
>15	Extreme

4.3.2 Likelihood and Consequence

Results from classification and multiplication are plotted on a risk matrix. The matrix can help answer key questions including "What are the risks of one hazard compared to another in a watershed?" and "Should we care about large or small events, if we think about the long-term?" For example, a more minor hazard (e.g., lower magnitude flood) that is more likely to occur may have an equal risk compared to a more catastrophic hazard (e.g., debris flow or high magnitude flood) that is less likely to occur (Figure 19). The risk from flood and debris flows is plotted for each exposure indicator, and for the Okanagan and Similkameen watersheds. This is key information to identify and prioritize adaptation efforts.

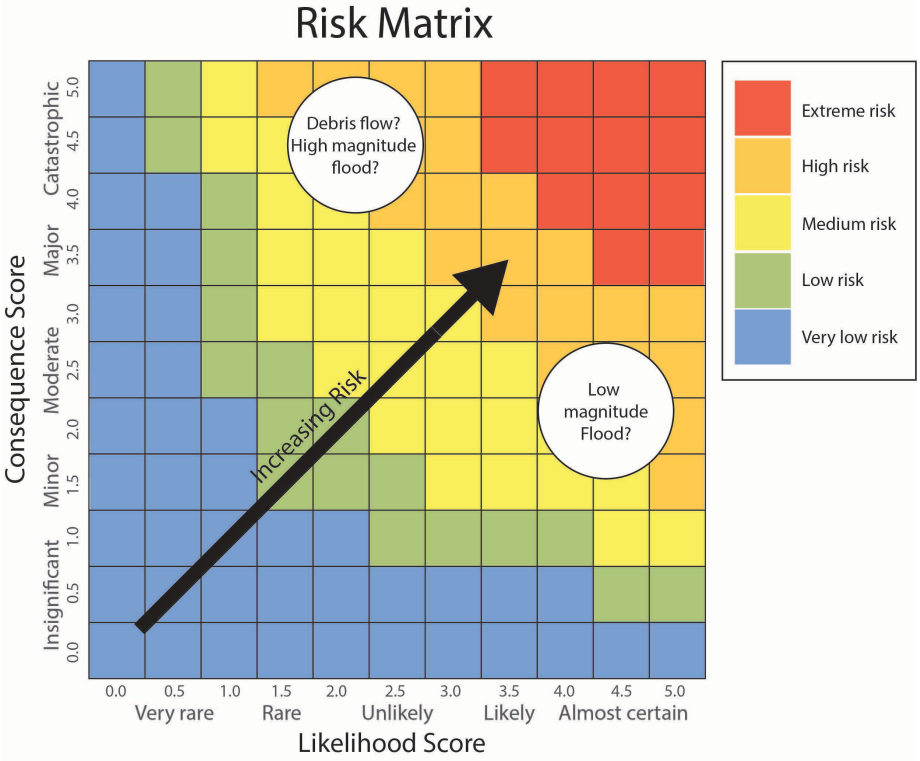


Figure 19: Example risk matrix with events having different combinations of likelihood and consequence. A low magnitude flood has a higher likelihood score, and a high magnitude flood has a lower likelihood score.

From the perspective of guiding adaptation, the mapping and scoring information is helpful when viewed holistically. This more quantitative information can provide a valuable "backdrop" for the more qualitative-based views that also need consideration when analyzing results. Therefore, the results in the next section continue to integrate the qualitative and quantitative analyses explained in this section.

5 Results Summary

In this section, results for the two inner layers of the risk assessment approach, as shown in Figure 12 (i.e., mapping impacts and consequences, and scoring risk on a watershed scale) are discussed. Each of these sets of analyses provide advantages and disadvantages in terms of their consideration of qualitative and quantitative information, as well as their spatial detail and ability to integrate results over time. The analysis characteristics are summarized in Table 4.

Table 4: Summary of the ability of the impacts and consequences, and risk analyses to integrate information.

Analysis	Exposure Indicators	Information Type	Spatial Detail	Time Consideration
Impacts and Consequences	All included	Mix of qualitative and quantitative	Higher; as detailed as data allow	Limited to qualitative comments (e.g., "recent floods have been high")
Risk	All included	Primarily quantitative	Lower; data aggregated to watersheds	Likelihood incorporated by way of defining and associating hazard magnitudes

Both the impacts and consequences, and risk analyses present results in terms of exposure indicators. The impacts and consequences analyses are useful for considering a mix of qualitative and quantitative information, and for visualizing more detailed spatial data. The detailed spatial information, however, is not used to assess impacts and consequences over time. Rather, that consideration is included within the risk analyses. To achieve that objective, the quantitative data is summarized at the watershed level.

The mixed approach for the analyses provides a robust way of using different information types to present results that are meaningful. Throughout the presentation of results in this section, slider icons are included to indicate the relative use of qualitative and quantitative (i.e., "qual." and "quant".) information in the analysis. Furthermore, the results draw on the spatial and time-based information in a way that is easily understandable for leaders in the region. Following the results analyses, the main limitations are presented.

5.1 Impacts and Consequences

Impacts and consequences are detailed in the Qualitative and Quantitative studies, respectively. They are also shown spatially within the Map Book. Figure 20 is an example that shows the impacts for the environment indicator from flood and debris flow hazard in the project area. The result allows a visual comparison of the impacts, which are widespread across the project area and are near large rivers and lakes. Figure 21 is an example that shows the consequences for the environment indicator. The distribution of impacts/consequences generally follows the same pattern in both maps. However, compared to the impacts map, the consequence map contains additional spatial detail and hazard specificity—the information in Figure 21 is focused on the Okanagan watershed and on the debris flow hazard scenario.

The consequence map for the environment indicator shown in Figure 21 was developed by applying the mapping technique (Section 4.2), as well as the source-pathway-receptor model[10]. This model links sources of contamination (e.g., septic systems, potential mine waste, industrial storage facilities) with nearby assets that could be negatively affected through contaminant transport (i.e., drinking water wells, fish and fish habitat, and high biodiversity areas). The zoom-in maps show where sources overlap with hazards and were within 2 km of a specific receptor point or area. The Map Book contains higher-resolution maps. The spatial information as a whole can be used to target further analyses.

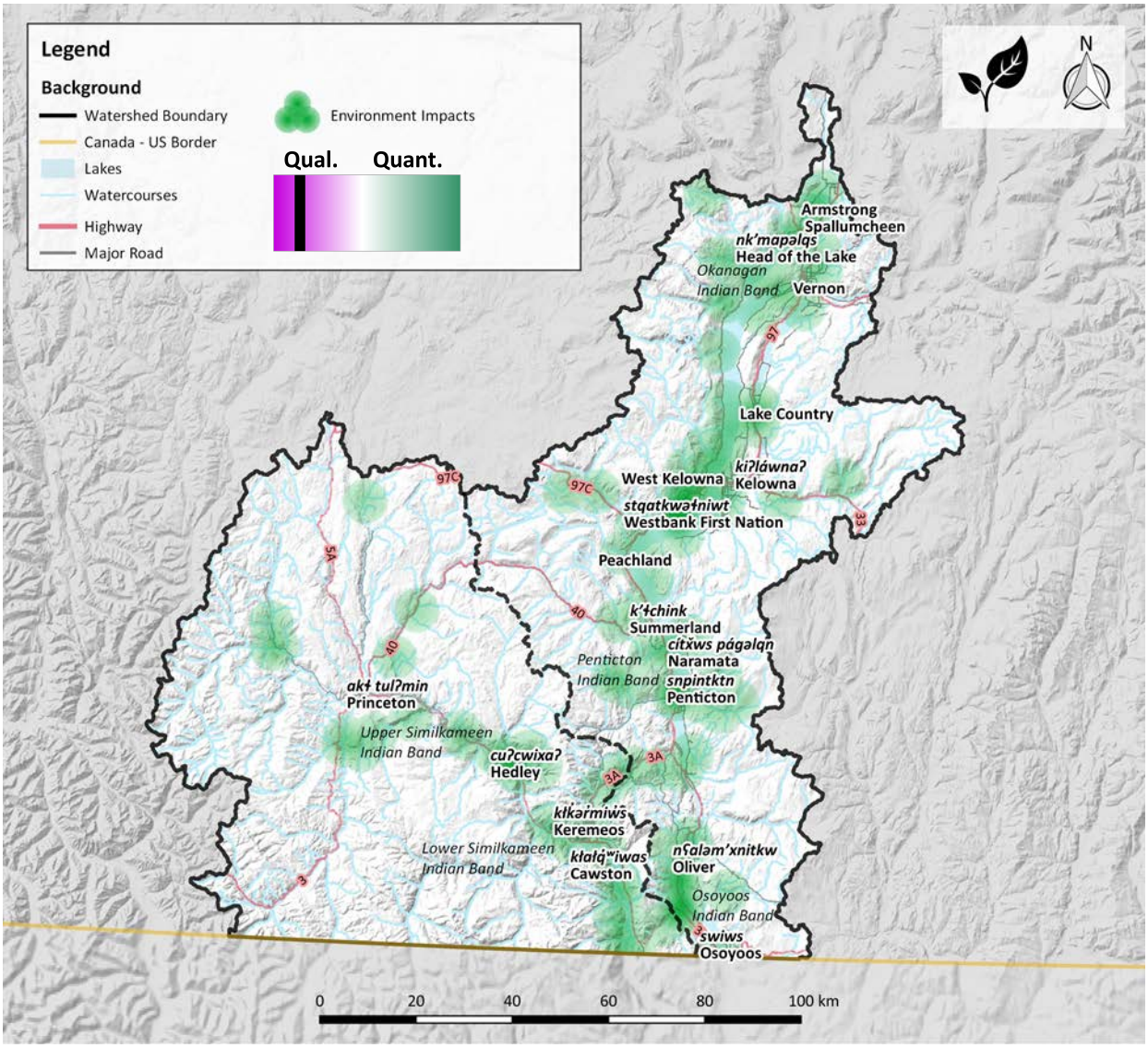


Figure 20: Environment indicator (qualitative) impacts from flood and debris flow hazards in the project area.

[10] The model has been applied widely in environmental science investigations and two examples are shown in the following examples 1) Weblink: https://www.ceaa-acee.gc.ca/default.asp?lang=en&n=B82352FF-1&offset=11&toc=hide, accessed September 15, 2019, and 2) Weblink: http://www.floodsite.net/html/faq2.htm, accessed September 15, 2019.

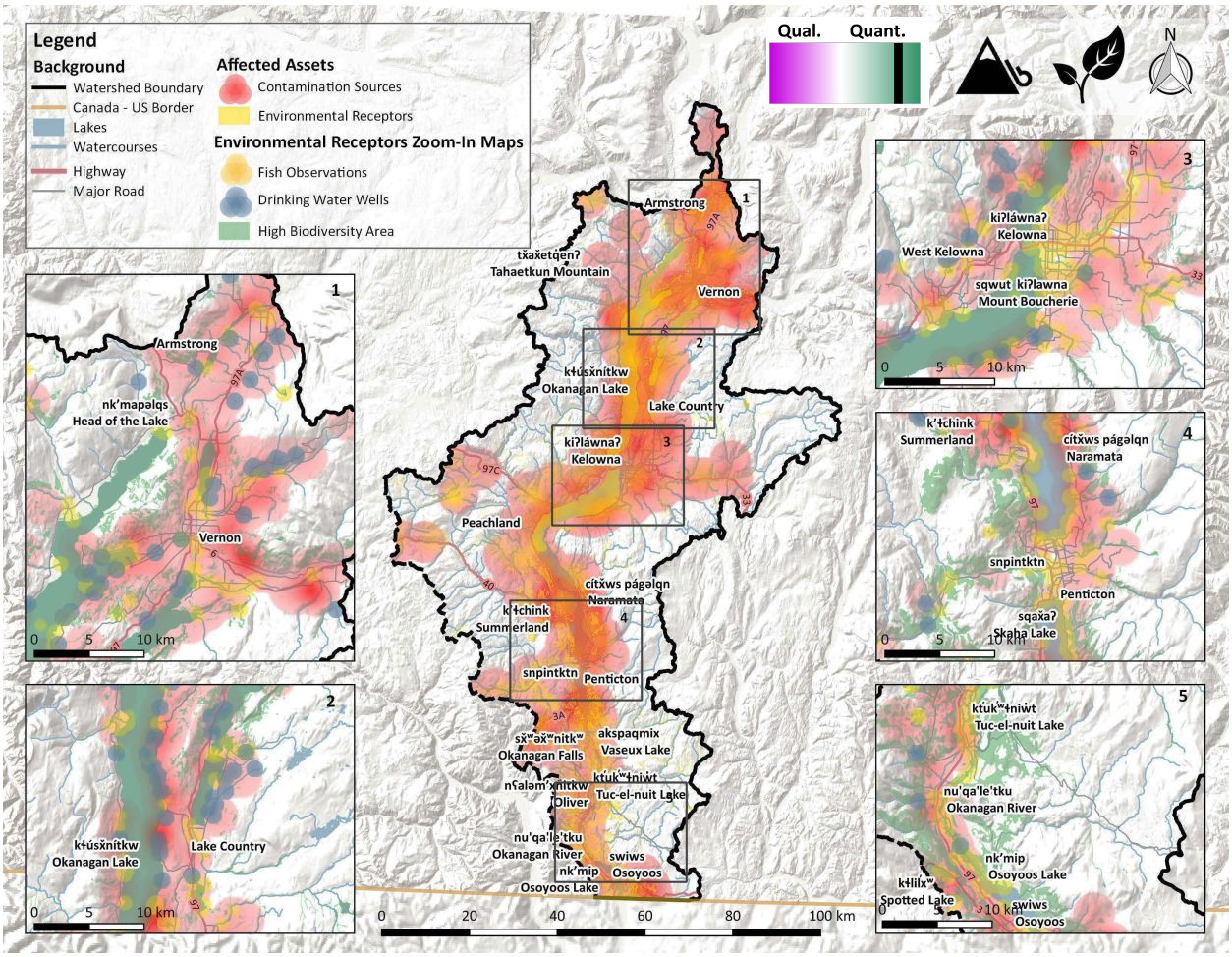


Figure 21: Environment indicator (quantitative) consequences from debris flow hazard in the Okanagan.

5.1.1 Main Issues Raised

> *This is a learning process! We wouldn't know what we know now if we didn't come [to the engagement events].*
>
> Participant, Workshop 2, April 25, 2019.

Identifying and articulating impacts is complex and messy—there are multiple connections between issues, and they interact based on historical and present contexts. This messiness contributes to the *wicked problem* (Section 1.4). This project is a first step in gathering and making sense of information to this end. Figure 22 illustrates the many impacts and issues of concern that were raised during the engagement events. Generally, the larger a word appears, the more frequently it was mentioned within mark-ups or conversations. The messiness of issues captured within the word-cloud illustrates the need for complementary qualitative and quantitative studies. While some of the issues within the word cloud can be quantitatively measured, others cannot be so easily. Despite this, all

the issues need consideration, which was made more possible within the holistic risk assessment approach.

Figure 22: Issues and topics raised related to flood and debris flow impacts during the engagement events.

5.1.2 Integrated Summaries

The impacts and consequences are integrated and summarized in Table 5 to obtain a high-level understanding of how these affect the different indicators. This analysis format takes advantage of the different types of information gathered, including the positive and negative implications of how flood and debris flow phenomena interact with the indicators. The indicators are by no means a perfect way of representing impacts and consequences based on the things that matter to people in the Okanagan-Similkameen region (As described in the table, the information gathered often spans more than one indicator). However, the indicators provide a way of organizing and making sense of the complex information gathered.

The consequence classification qualifiers used for each indicator are based on a 5-point scale (e.g., 1-insignificant, 2-minor, 3-moderate, 4-major, and 5-catastrophic). It should be noted that none of the consequences to any indicator are found to be insignificant. In addition to the qualifiers, the discussion includes numerical ranges of results. Quantitative comparisons are made between flood and debris flow phenomena. However, recognizing that the two are distinct natural processes, the comparisons are considered high-level and are presented in *relative* terms.

Table 5: Summary of impacts and consequences by indicator.

Indicator / Information Weighting	Impacts and Consequences Comments
Environment  Qual. Quant. 	The largest number of impacts recorded related to this indicator with a focus on fish and fish habitat, and water quality. There were numerous mentions of recent changes to flow paths as a result of cumulative pressures such as climate change, ecological disturbance (i.e., wildfire), and urban development. There was an emphasis on the negative impacts of flood defence infrastructure on riparian ecosystems such as cottonwoods; these are ecosystems that depend on flooding and they can provide natural flood storage. Their destruction has impacted cultural use of such ecosystems. Human encroachment on wildlife habitat or animal removal (i.e., beavers) was cited as a problem for flood and ecosystem management. Concern was also expressed over the mismanagement of industrial waste (e.g., mine tailings), and contamination sources such as pleasure boat fuel tanks stored on lakeshore docks, and the disposal of sandbags used for flood protection. For consequences, the source-pathway-receptor model was applied, and there is a high potential for septic systems to contaminate drinking water wells and high biodiversity areas. Consequence scores were assigned qualitatively and ranged from moderate to catastrophic (i.e., minor to permanent or severe destruction of ecosystems).
Culture  Qual. Quant. 	There are numerous overlaps between the impacts for this indicator and the environment indicator. An important link is due to the high value placed primarily by *Syilx* Okanagan people on fish and fish habitat. Mapped impacts relate to *Syilx* landmarks, harvesting sites, and places of cultural and spiritual significance. Many places of cultural significance to the *Syilx* were pointed out in general terms, but there was hesitation in identifying specific areas. Respect for these areas and lack of communication between responsible organizations were widely cited as key issues that have led to their destruction. For consequences, there are high proportions of *Syilx* Okanagan and non-*Syilx* archaeology sites (i.e., approximately 30%-60% [11]), and cultural buildings (i.e., approximately 40%-60%) that overlap the hazard areas. Consequence scores were assigned qualitatively and range from minor to catastrophic (i.e., widespread permanent loss, to damage to objects of identified cultural significance).

[11] The ranges provided are approximate and rounded to provide readers with a context of the general proportion of consequences.

Indicator / Information Weighting	Impacts and Consequences Comments
Mortality  Qual. Quant. 	There were no mortality impacts gathered, but there was mention of an elderly *Syilx* Okanagan person having to cross a creek after a bridge had been destroyed by recent flooding. For flood hazard, consequences were not considered; due to their longer time of onset, they do not tend to result in mortalities. For debris flows, the consequences are major in the Okanagan watershed (i.e., greater than 1 in 100 but less than 1 in 10 people living in residential buildings, compared to the total project area, are located in debris flow hazard paths). For the Similkameen watershed, consequences are moderate (i.e., greater than 1 in 1000 but less than 1 in 100 people in the project area).
Affected People  Qual. Quant. 	Impacts recorded for this indicator were the second largest after environment. They related to potential loss in services such as clean drinking water or private assets such as homes. Affected road infrastructure was noted due to the disruption this causes for people's mobility and access to services. This was noted more in rural areas. Potential and plausible impacts to human health (e.g., from leaching of mine waste into recreational and drinking water systems) were also mentioned. Consequence is based on census information using population density in hazard areas. In the Okanagan, consequence is generally catastrophic (i.e., more than 1 in 10 people, compared to the project area population, are estimated to live in hazard zones). In the Similkameen, the consequence is generally moderate (i.e., greater than 1 in 100 but less than 1 in 10 people live in hazard zones).
Economy  Qual. Quant. 	There were significant overlaps noted between impacts to the economy, environment, and culture as these all relate to ecosystem services and livelihoods. Impacts were concentrated in populated areas. Consequences are catastrophic in the Okanagan watershed (i.e., direct economic exposure of 4% to 40% of estimated GDP for the project area) and moderate or major in the Similkameen watershed. For example, the moderate flood scenario translates to approximately $15B and $750M in exposed properties in the Okanagan and Similkameen, respectively. For debris flow, the total exposed building and land value is approximately $23B in the Okanagan and $800M in the Similkameen[12].

[12] As of June 27, 2019, the costs that the Government of BC expended through EMBC associated with the 2017 and 2018 flood events in the project area were $2.7M and $15.6M for private and public sectors, respectively (see Basis of Study). The damages estimated in this project are conservatively high, as they assume that natural hazard events would occur across the project area simultaneously.

Indicator / Information Weighting	Impacts and Consequences Comments
Disruption  Qual. Quant. 	The majority of impacts described related to those occurring along major and minor roads. This is expected as most of the area's infrastructure is linear and follows these rights-of-way. Washed-out roads were most commonly mentioned, including impacts to culverts. Concern was expressed over the impacts of not being able to access services or sites of cultural significance without proper roads. There were mentions of bridges being affected by both flood and debris flows, and worry associated with the impacts from dam failures. In terms of consequences, consequences were considered moderate to catastrophic in the Okanagan watershed, and major to catastrophic in the Similkameen watershed. The percentage of roads, rail and gas and electric utilities were assessed. Over the project area, approximately 1% to 30% of roads are exposed. Approximately 5% to 30% of aggregated gas and electric utility infrastructure is exposed.

5.1.3 Spatial Patterns

The spatially consistent consequence results are summarized and compared in Table 6. The summary presents general patterns by watershed, and compares consequences from flood and debris flow hazards in relative terms.

Table 6: Consequence summary by watershed and hazard.

Qual. Quant. 	**Consequences Summary – Watersheds and Hazards**
General Remarks	• Consequences across all indicators for flood and debris flow hazards generally range from moderate to catastrophic. • For flood, the consequences are largest for the high magnitude scenario, as expected.
Okanagan 	• Higher within 10-20 km of shorelines and major population centres. • More widespread for culture and disruption indicators. • Higher compared to Similkameen watershed in absolute terms.
Similkameen 	• Higher near population centres and along river and main highways. • Per capita consequences are as high or higher than Okanagan.
Flood 	• Affects highly populated areas near large river and lakes. • Compared to debris flows, floods affect more buildings since they tend to be closer to water.

Qual. Quant. 	**Consequences Summary – Watersheds and Hazards**
Debris Flow 	• Consequences are typically between the moderate and high flood scenario. • More widely distributed including hillslope areas, and affects indicators that are more prevalent in rural areas (e.g., culture, disruption).

The general patterns indicate that, in any given year, consequences from floods and debris flow should be of concern in both watersheds. Both the impacts and consequences are shown in the Map Book, with details shown at scales as small as 1:50 000 for consequences.

5.2 Risk

Risk scores were calculated for each indicator, by aggregating the information for each hazard scenario on a watershed basis and multiplying their likelihood and consequence scores (see Section 4.2). Compared to the consequence summary shown in Table 6, the risk analysis enables the consideration of consequences over time—this information stems from hazards of different magnitudes.

5.2.1 Matrices

The results were plotted on risk matrices, which allow the risk for each indicator to be compared between the Okanagan and Similkameen watersheds. Figure 23 is an example risk matrix for the environment indicator, for flood hazard. The figure shows that the low magnitude flood scenario represents an extreme risk in the Okanagan watershed (see the Okanagan watershed icon located in the red area of the matrix). Figure 23 also indicates that the risk is high for the other flood magnitudes across the Okanagan and the Similkameen watersheds (the other icons are located in the orange area of the matrix). In total, 24 risk matrices were produced, and they are in the Quantitative Study.

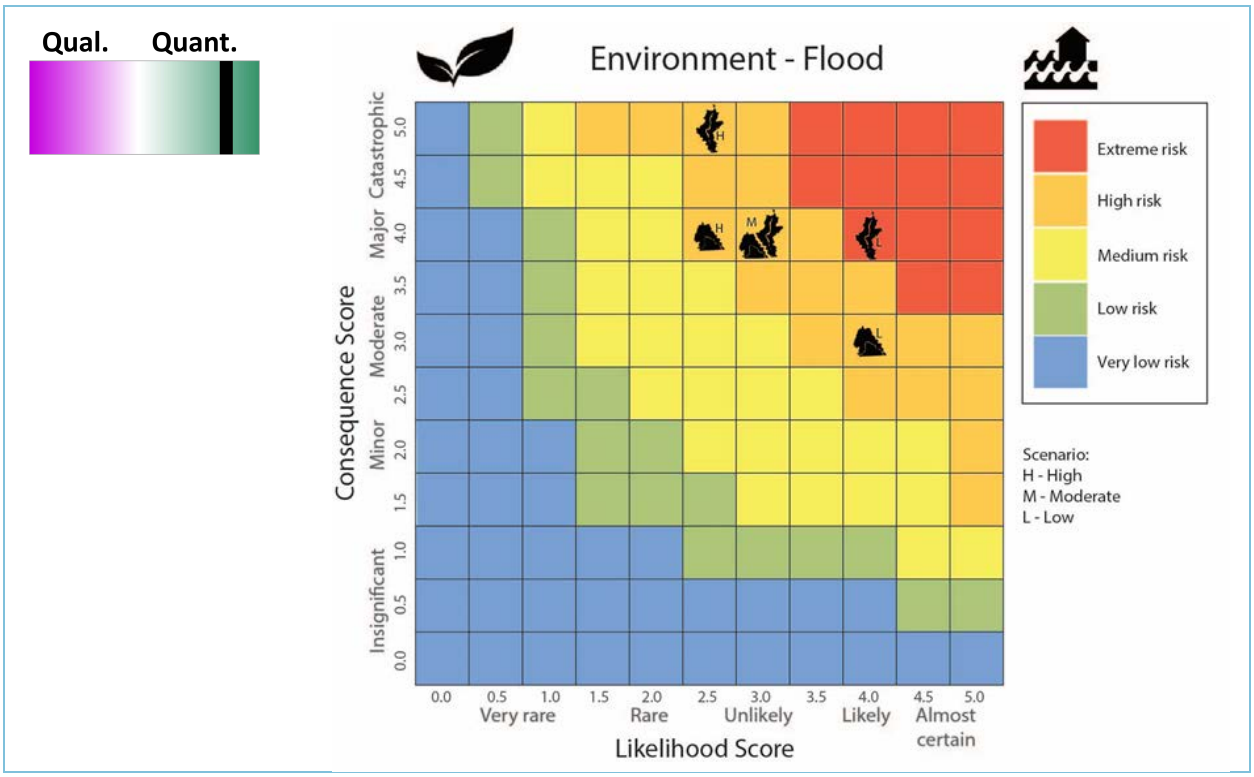


Figure 23: Example risk matrix for the environment indicator, for the 3 magnitude flood hazard scenarios (i.e., high, moderate, low). Icons show risk for the Okanagan and Similkameen watersheds, separately.

5.2.2 Risk Summaries

When considering results from all the risk matrices, the risk from flood and debris flow hazards, in both the Okanagan and Similkameen watersheds, ranges from medium to extreme across all indicators (i.e., there are no indicators with low, or very low risk). This is shown in the risk summaries in Figure 24 and Figure 25 for flood and debris flow, respectively.

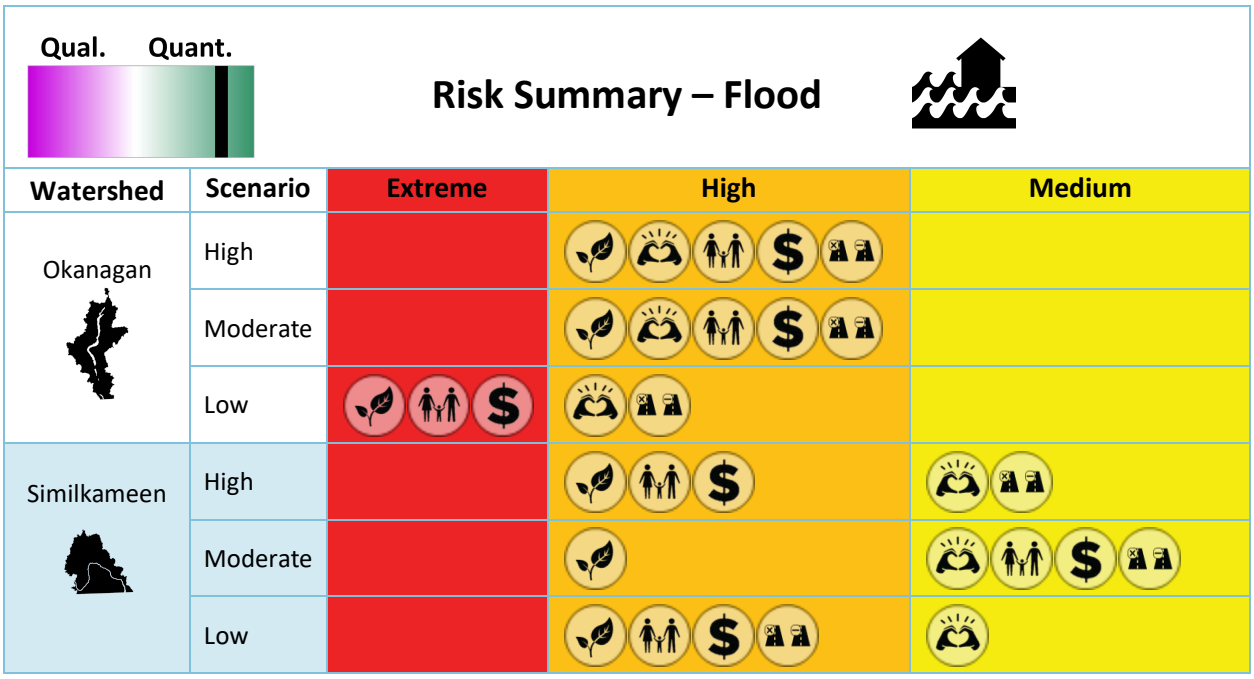


Figure 24: Summary of flood risk for all indicators.

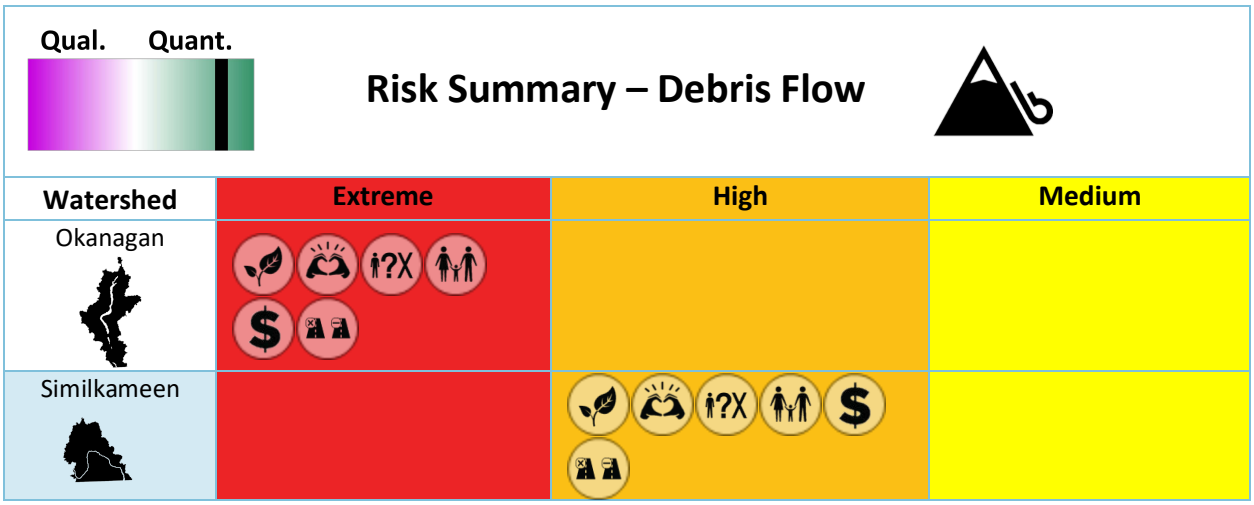


Figure 25: Summary of debris flow risk for all indicators.

The risk summaries for flood and debris flow reveal important insights as follows:

- **Flood Risk:**
  - **Extreme** in the Okanagan watershed for the low scenario for the environment, affected people, and economy indicators.
  - High for many indicators including environment, affected people, and economy in both watersheds.
  - Medium for indicators such as culture and disruption in the Similkameen watershed.
  - Generally higher in the Okanagan compared to the Similkameen watershed.
- **Debris Flow Risk:**
  - **Extreme** in the Okanagan watershed for all indicators.

- High in the Similkameen watershed for all indicators.

The risk findings counter typical assumptions about natural hazards in the project area, and among practitioners in general. For example, a review of recent flood and debris flow projects conducted within the project area (see Appendix D of the Basis of Study) found that the majority of effort in the project area has been directed toward better understanding the consequences of *large flood events*. However, the results from this study clearly indicate that **more effort is required to understand *low magnitude (i.e., higher likelihood), flood events*.** Furthermore, the results show that **more attention should be directed at understanding and managing *debris flows*.** Lastly, while the majority of project area population resides in the Okanagan watershed, **populations in the Similkameen are disproportionately impacted and *rural areas* thus need greater consideration.**

5.2.3 Cumulative Risk

The quantitatively-based risk determined and analyzed in the previous sections needs to be considered within the context of the ecosystem-based ideas presented in Section 3.4 to guide adaptation. First, cumulative pressures need to be considered in the context of risk. As a first step, Table 7 summarizes the results of the grey and peer-reviewed literature that links the cumulative pressures to flood and debris flows.

Table 7: Examples of how each cumulative pressure is projected to affect flood and debris flows, all else remaining equal.

Qual. Quant.  **Linking Cumulative Pressures to Changes in Flood and Debris Flows**	
Cumulative Pressure	**Projection**
Climate change 	Increasing temperature and changes in precipitation patterns in BC are affecting flood and debris flows through factors such as hydrologic regime shifts and increases in precipitation intensity and frequency. This means that the low magnitude flood hazard events will have a higher likelihood of occurrence, and that the higher magnitude flood hazards will increase in magnitude (Bush & Lemmen, 2019).
Landuse change 	Landuse change is likely to continue, which will affect floodwater storage as forests, wetlands, riparian areas and floodplains, are removed or changed (Tollan, 2002). Vegetation change/removal also reduces carbon storage, which increases climate change potential.
Ecological disturbance 	Ecological disturbance, such as wildfires, infestations and invasive species, animal and habitat removal (e.g., beaver dams) are likely to continue due to climate change and human activities. Burning forests release carbon, increasing the potential for climate change. Burned surfaces and dry soils result in higher runoff (Gimbel et al., 2016) and increase the likelihood of debris flows (Nyman et al., 2019). Recreational land use is likely to continue to decrease natural water storage and water quality, and to fragment ecosystems.

Qual. Quant. 	**Linking Cumulative Pressures to Changes in Flood and Debris Flows**
Industrial activity 	Effects on hydrology resulting from non-renewable resource extraction and logging are likely to continue from industrial activity. E.g., clearcut areas can increase runoff (Winkler et al., 2010), and in some areas of BC, is linked to an increased likelihood of landslides (Guthrie, 2002).
Flood defence structures 	The persistence of flood defence structures such as dikes will continue to transfer floodwaters downstream (Pinter et al., 2008, Entwistle et al., 2018). Reservoir management is likely to be less effective in the face of extreme precipitation and increasing environmental constraints such as instream flow needs.
Urban development 	Continued urban development, especially in the Okanagan watershed due to population growth, is likely to increase impermeable surfaces, resulting in increased runoff[13].
Sub-surface interactions 	The changing interaction of natural and human-made sub-surface conditions could affect groundwater flooding (British Geological Survey, 2010). This pressure is highly connected to many of the other pressures including climate change, land use change, urban development, industrial activity, and flood defence structures.

While it was out of the scope of this project to quantify the likelihood and consequences of the individual cumulative pressures, the research evidence points strongly to their likely cumulative effect on risk. Unless the other risk components (e.g., exposure) decrease to offset the increasing hazard from cumulative pressures, the risk from flood and debris flows is likely to increase in the project area. This concept is illustrated in Figure 26.

[13] United States Geological Survey. Impervious Surfaces and Flooding. Weblink: https://www.usgs.gov/special-topic/water-science-school/science/impervious-surfaces-and-flooding?qt-science_center_objects=0#qt-science_center_objects. Accessed March 15, 2019.

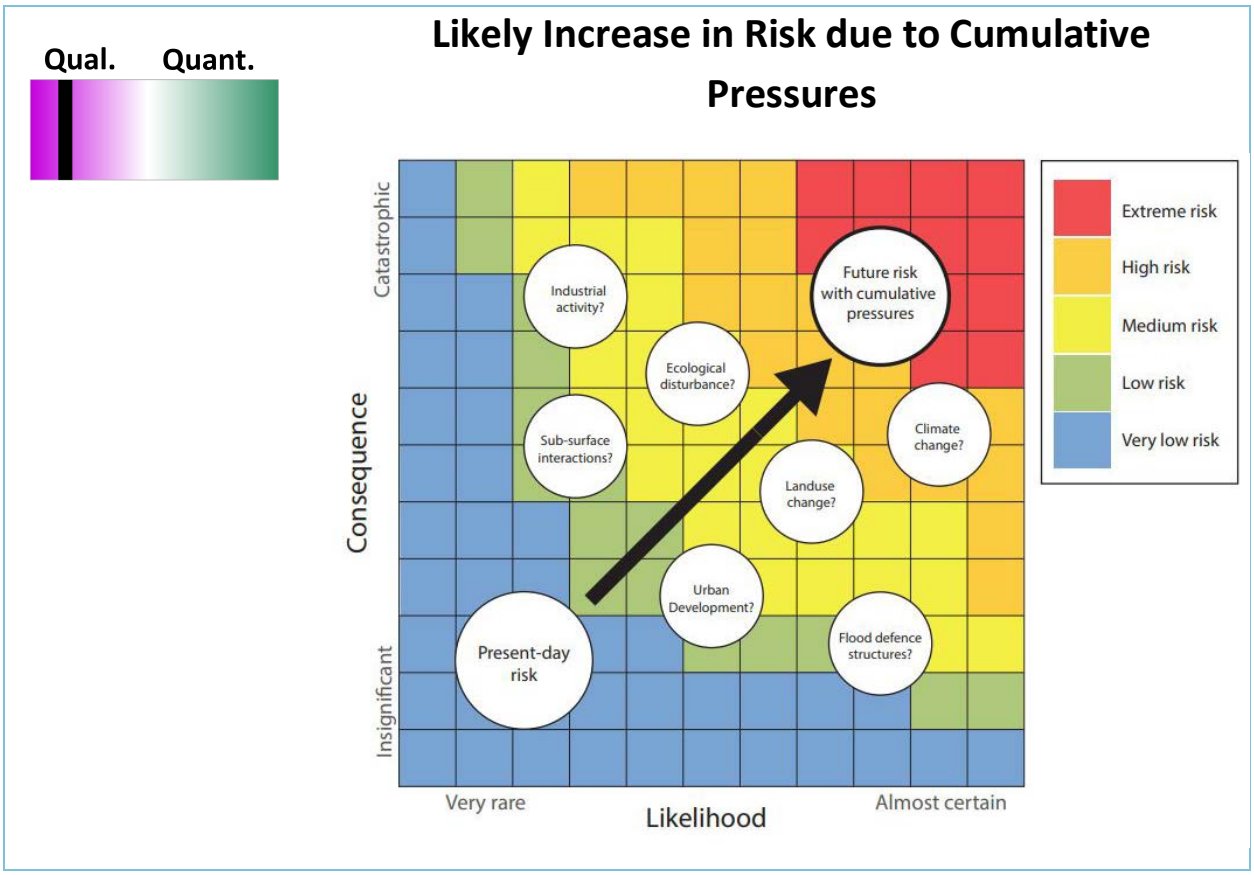


Figure 26: The likely effect of cumulative pressures on flood and debris flow risk in the project area. The figure is illustrative only. Per the results of this project, the present-day risk is high to extreme. Therefore, future risk is likely to be more extreme.

The next step in linking the impacts and consequences, and risk, results with adaptation actions lies in making connections with ecosystem-based ideas. Those links follow a description of the main study limitations.

5.3 Study Limitations

The limitations in the results discussed in the previous sections can be traced to the limitations in the Qualitative and Quantitative studies. They are discussed in greater detail in the respective Qualitative and Quantitative study reports, and a summary for each follow:

1. **Qualitative Study.** The study is limited by the people who provided input, and their interests including the locations with which they were familiar. Therefore, there are gaps in this study's findings on a local basis. Different findings would potentially arise if the same process were followed with different participants. Also, past experiences, data sensitivity, and trust need to be addressed to obtain a more comprehensive understanding of specific indicators, such as culture.
2. **Quantitative Study.** The study is limited by the quality and quantity of hazard and exposure data, the proxies developed to represent exposure indicators, the quantitative measures applied to determine consequence, and the tables used for likelihood and consequence scoring. In terms of the delineation of hazard magnitudes, for example, there is low confidence in the definition of the low magnitude flood scenario. This is due to a lack of flood mapping in the project area to calibrate this hazard magnitude.

Given the limitations outlined above, the consulting team applied significant judgment. This judgment was influential in the resulting interpretations of impacts, as well as likelihood and consequence scoring, and could have been different if alternate decisions had been made throughout the process. In terms of impacts, the consulting team attempted to represent what was heard and recorded through the engagement events as accurately and consistently as possible. In terms of scoring methods, the consulting team used spatially consistent quantitative data and applied methods based on international best practice. From this perspective, the risk assessment is considered robust for the purposes of this project.

6 Looking Forward

This risk assessment project is part of a longer-term *Syilx* Okanagan *ɬiḱt* (flood) adaptation initiative. The initiative is driven by *Syilx* perspectives, which include understanding the lived experience of the *Syilx* people through colonization. The *Syilx* Okanagan Nation fully believes that Indigenous knowledge is the way forward for climate change adaptation and complex water and land issues. This starts with treating *siwɬkʷ* (water) with honour, respect, and reciprocity to ensure that water is healthy for the *tmixʷ* (all living things). For these reasons, *Syilx* leadership needs to be at the forefront of planning, protection, and operational processes including the next steps of this risk assessment.

The first of the next three sections discusses output from Workshop 2 based on participant ideas to build resilience now and in the future. The second section links the project's findings with adaptation actions. These findings are organized in terms of respect for *siwɬkʷ* (water). The third section shows the evolution of risk reduction. Risk assessment can provide the tools and knowledge to reduce risk and achieve outcomes similar to those achieved by the *Syilx* Okanagan people prior to colonization.

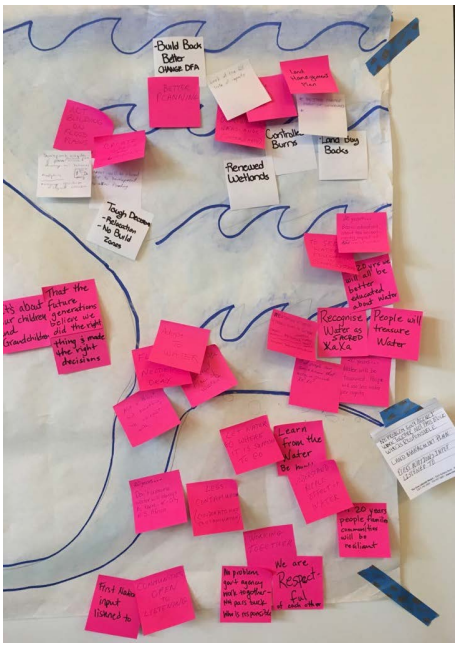
6.1 Building Resilience

The project participants engaged in a water-based visioning exercise to think about how to address key issues to adapt by becoming more resilient. This is an important example of relationship building, and in the exercise, participants considered the present (a lake), the future (the ocean), and the actions/issues required to connect the two (the river). The key status and actions related to each water feature / time period are in Table 8. Figure 27 shows the output from the exercise.

Table 8: Key actions/issues to build resilience in the region through time.

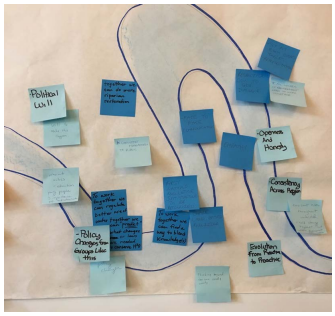
Water Feature (Time Scale) and question addressed	Status and Actions
The lake (present) Where are we now in our relationships to water, flood and debris flow?	• We are reactive, not proactive, and approaches are siloed. • There is a lack of awareness of where our water comes from and our impacts on it. • We lack cross-culturally inclusive water ceremony. • Non-*Syilx* peoples lack the values, policies and systems to coexist in a healthy way with water and land. • We lack resources and coordination across levels of government. • We are in the planning stage – consultation, engagement, communication, and consideration of title and rights is necessary. • We are in the beginning stages of working together, sharing knowledge, and developing shared values.

Water Feature (Time Scale) and question addressed	Status and Actions
The ocean (future) How do we envision our relationships to water, flood and debris flow in the future?	• Water is recognized as sacred (X*aXa).* • The needs of water are respected, including listening to where it wants to move, getting out of its way – we adapt to, and coexist with, water. • Land management and planning takes account of the whole interconnected system, restores natural function and makes wiser decisions in consideration of the whole. • We've made tough decisions to reduce risk and more wisely manage our interactions with water such as building back better, and relocating out of floodplains. • We work together and are respectful of one another. First Nations and the experience of communities are listened to. • Future generations look back and see that we did the right thing and made the right decisions. This is for our children and grandchildren.
The river (connecting the present with the future) How can we work together to move from here (the lake) to the envisioned future (the ocean)? What values and principles can guide us?	• Make policy and regulatory changes. • Draw on multiple sources and types of knowledge, including traditional and land-based knowledge. • Respectful government-to-government dialogue, and working together. • Equity, social justice. • Openness, honesty, respect and empathy. • Take a consistent approach across the watershed. • Move from reactive to proactive decisions. • To look to the future, we need to look to the past. • Move beyond our own wants and desires. • Realign our values. • Education and consistent messaging.



The Ocean (future conditions)

The Lake (present conditions)



The river (connecting present and future conditions)

Figure 27: Output from the visioning exercise.

The status and actions associated with the different time periods in the resilience visioning exercise are examples of how people and organizations in the region must work together to adapt and reduce risk over time.

6.2 Linking *siwɬkʷ* (Water) and Adaptation

Chapter 3 explained that, through this project's engagement events, ecosystem-based ideas to guide adaptation actions emerged from a process of weaving together *Syilx* Okanagan perspectives and multi-disciplinary western science. These ideas related to respect for water and recognition of cumulative pressures. Cumulative pressures were addressed qualitatively in terms of risk in the previous section. Respect for water is addressed in Table 9. With the objective of providing leaders in the region with guidance for adaptation that is ecosystem-based, the project's key findings are presented in terms of respecting water's power, its ability to sustain life, and its connectivity.

Table 9: Project key messages to guide adaptation action, in terms of respecting water.

Findings		Adaptation Guidance
Water is Powerful		
Over time, water exerts its power in small and large storm and flood events.	Manage all flood and debris flow hazard magnitude events.	
Water finds a way around obstacles. Flood defence structures do not protect over time.	Favour nature-based solutions over fighting nature.	
Events are likely to increase in magnitude and frequency.	Address uncertainty through community resilience.	
Water is Life		
Flood and debris flow phenomena are part of natural processes that bring ecosystem benefits.	Land managers need to consult with Syilx Okanagan TEK and multi-disciplinary scientists to consider ecosystem implications.	
Contaminant release to land and water systems leads to widespread negative impacts.	Regulate and monitor contaminant production and disposal.	
Water is Connected		
People in the region are connected by shared recent history, values, and watersheds.	Work together to pool resources and take whole- of-society approach.	
Water is affected by human-induced cumulative pressures.	Prioritize reversing or modifying human activities.	
Water is linked to other natural hazards.	Adopt an all-hazards approach to risk reduction.	

6.3 Reducing Risk

Risk reduction in flood management is a relatively new concept that requires detailed site-specific information while keeping the big picture in sight. To better understand how risk reduction can inform adaptation actions in the Okanagan-Similkameen, it is useful to think about how flood management has evolved in recent history. Sayers et al. (2013) describes this evolution in terms of six generalized stages, which apply to the project area (Table 10). Table 10 also indicates generally if the actions in each stage contribute to increasing or decreasing flood risk levels.

Table 10: The evolution of flood management and the general change in flood risk (adapted from Sayers et al. [2013]).

Icon	Stage / Description of Actions	General effect on flood risk levels
	A willingness to live with floods • Individual and small communities adapt to nature's rhythm.	Reduces ↓
	A desire to use the floodplain • Fertile land in the floodplain is drained. • Permanent communities are established. • Local uncoordinated dikes are constructed	Increases ↑
	A desire to control flood flows and defend against flooding • Large-scale structural approaches (dikes, dams and other controls) are planned and implemented.	Increases ↑
	A desire to reduce flood damages • A recognition that engineering alone has limitations. • Effort is devoted to increasing resilience of communities.	Decreases ↓
	A desire to manage risks effectively • A recognition that budgets are limited and not all problems are equal. • Risk management is seen as a means to target limited resources.	Decreases ↓
	A desire to promote opportunities and manage risks adaptively • Adaptive management used to work with uncertainties in future climate change, demographics and funding.	Decreases ↓

As the region moves through the later stages of flood management evolution, adaptation efforts to reduce risk are going to be challenging due to the increasing cumulative pressures, and governance and decision-making frameworks. Keeping sight of the big picture will be critical. The objective should be to **reduce risk in the Okanagan-Similkameen region *as a whole*, over the long-term**. However, it should be understood that, in the transition toward this objective, risk may be redistributed and increased in local areas, especially over the short-term.

Reducing Exposure

If we really care about addressing flooding, shouldn't we be moving houses out of the flood plain?

Brody Eneas, *Syilx* Okanagan representative. Watershed Tour 1, February 22, 2019.

The previous sections summarized ways of thinking about resilience that should "flow" from the present to the future. This was followed by describing the project's key findings as they relate to *siwɬkʷ* (water) and adaptation actions. Finally, a summary of the evolution of flood risk management was presented. The following sections describe risk reduction best practice, which is then followed-up by concrete actions that can be considered or implemented at the present time.

7 Best Practice for Risk Reduction

Many jurisdictions around the world are in the process of transitioning toward a risk-based approach to flood management[14]. The following sections summarize a series of frameworks on disaster risk reduction, flood risk management, and on governance and decision making. Together they provide one view of what is required to help communities adapt to flood and debris flows in the region.

7.1 Sendai Framework for Disaster Risk Reduction

The Sendai Framework for Disaster Risk Reduction (Sendai) [15] is the global blueprint for reducing disaster risk and increasing community resilience. The goal of Sendai is to "prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures… to strengthen resilience". The framework is thus multi-disciplinary and follows four priorities (Figure 28). Loosely, this project's activities fit within Priorities 1 and 2.

Figure 28: Four priorities of the Sendai Framework for Disaster Risk Reduction.

Sendai recognizes that humans are at the centre of disasters. I.e., not only are humans responsible for increasing hazards (Section 3.4), hazards themselves are not problematic unless they interact with humans. The framework thus places human decisions at the centre of disaster risk reduction, and advocates for a risk-based approach to managing multiple hazards (i.e., all-hazards approach). Sendai also encourages whole-of-society engagement actions, such as "To empower local authorities, as appropriate, through regulatory and financial means to work and coordinate with civil society, communities and Indigenous peoples and migrants in disaster risk management at the local level."

Canada, and more recently BC, are signatories to Sendai. The BC Government is actively taking steps to incorporate Sendai into its activities. For example, the *BC Government Action Plan* (Emergency

[14] This best practice section generally focuses on flood hazard, but it is emphasized that best practices discussed are also relevant to debris flow hazard.

[15] Sendai Framework for Disaster Risk Reduction 2015-2030. United Nations. Weblink: https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf, accessed May 24, 2019.

Management BC, 2018), developed to answer the *Abbott/Chapman Report* following the 2017-2018 floods and wildfires in BC, outlines a plan for an Integrated Disaster Recovery Framework. The multi-disciplinary framework is currently under development by various agencies and is focused on activities related to Sendai Priority 4 (Figure 28).

Importantly, according to the *BC Government Action Plan*, the framework for BC will "reflect the important roles of First Nations and other recovery partners". This aligns with other initiatives at the International, Federal and Provincial levels (e.g., United Nations Declaration on the Rights of Indigenous Peoples, Tsilqot-in decision, Truth and Reconciliation Commission Calls to Action and BC draft principles).

Recently, the BC Government also announced that it will be modernizing the *Emergency Program Act* (EPA) [1996][16]. The goal of the process is to legislate a new Act in 2020 that formally recognizes Sendai, and works toward making the province more resilient by recognizing that the environment is changing in ways that will challenge everyone.

With the completion of this risk assessment project, the ONA is well-placed to inform future risk-based decisions. Furthermore, framing future work on flood and debris flow risk in the region in terms of Sendai will help the ONA and its partners to leverage funding that will be available through provincial programs.

7.2 Strategic Flood Risk Management

The consensus in global peer-reviewed literature is that implementing a holistic, risk-based approach to flood management reduces negative impacts while promoting other aspects of societal well-being over the long-term. In this section we draw on an internationally recognised paper by Sayers et al. (2014), which captures guiding approaches and rules for sound strategic flood management. This paper and framework have been cited upwards of 50 times in peer-reviewed journals in the five years since publication. Further, this paper and the 'golden rules' also map well with Sendai.

The Sayers et al. (2014) paper was co-authored by representatives of diverse perspectives (academic and government officials, engineers and planners) as well as recognized leaders in the field of flood risk management. The authors suggest that strategic flood risk management provides a means of working towards sustainable development, and associated social, environmental and economic goals. However, they also acknowledge that resources to achieve this are limited, and that pragmatic trade-offs must be made between reducing flood risk and investing resources towards achieving other societal goals. In this respect, they emphasise the importance of investing resources effectively and efficiently.

Therefore, the primary goals of strategic flood management are to efficiently use limited resources to:

- Reduce risk to people and communities from flood sources;
- Promote ecosystem goods and services; and

[16] Modernizing BC's Emergency Management Legislation. Weblink: https://www2.gov.bc.ca/assets/gov/public-safety-and-emergency-services/emergency-preparedness-response-recovery/modernizing_bcs_emergencymanagement_legislation.pdf. Accessed October 28, 2019.

- Reduce risk to, and promote, economies;
- Promote social well-being.

The authors note that these are lofty goals; however, programs aren't expected to reach these goals at the outset. Rather, the goals are intended to guide an iterative, adaptive strategic planning process. The authors go on to outline several common characteristics of successful, strategic plans including:

- They will be based on understanding of the whole-system behaviour and societal goals (i.e., consideration of cumulative pressures and associated values);
- Decision-making will be informed by knowledge of risk and uncertainty over time;
- A portfolio of measures and instruments will be used to manage risk; and

7.2.1 10 Golden Rules

In addition to these characteristics, the authors present ten 'golden rules' for sound strategic flood management. The authors state that these 'golden rules' are necessary, but not necessarily sufficient, components of successful flood management.

Rule	Description
1. Accept that absolute protection is not possible and plan for exceedance.	There will always be a bigger flood. Residual risk always exists and resilience to future, inevitable, flood events can be built through the planning process.
2. Promote some flooding as desirable.	The natural connection between land and water is critical. Flood plains provide fertile land and other ecosystem services in addition to accommodating flood waters.
3. Base decisions on understanding risk and uncertainty	Managers should not delay decision-making and action on the basis of uncertainty. Rather, managers should draw on the available knowledge, explicitly account for uncertainty, and then monitor and adapt management plans with time.
4. Recognize that the future will be different from the past	Climate and flood risk are changing. Managers need to move beyond planning processes that focus on historic flood records and information, and account for future changes in flood risk.
5. Do not rely on a single measure; implement a portfolio of responses	Flood risk has multiple components. Management tools can be used to reduce hazard, exposure, and consequence while also working towards other environmental, economic, and social goals.
6. Utilize limited resources efficiently and fairly to reduce risk	A management plan should be tailored to the specific context, with consideration of not only the cost-efficiency of risk reduction outcomes, but also the fairness of these outcomes and the associated ecosystem enhancement opportunities.
7. Be clear on responsibilities for governance and action	Funding and decision-making should reflect shared responsibility. Collaboration on a watershed scale is critical to achieve shared outcomes and to avoid conflicts.

Rule	Description
8. Communicate risk and uncertainty effectively and widely	The public does not often understand the degree of flood risk they face. Significant and targeted awareness programs are required to obtain greater public and political support for progressive management initiatives.
9. Promote stakeholder participation in the decision-making process	All interested and affected people play an important role in developing and delivering management activities. This should be done in a way that promotes "living with floods" rather than "fighting against them".
10. Reflect local context and integrate with other planning processes	There is a need for locally relevant and specific management planning, as opposed to focusing on compliance with a one-size-fits-all engineering standard.

The golden rules should be considered throughout the process of adapting to flood and debris flows. Sayers et al. (2014) mentions that plans themselves should be adaptive and underpinned by a continuous process of monitoring and review in order to be flexible shifting priorities and governance structures.

7.3 Governance and Decision-Making

As discussed in Section 1.4, flood and debris flow risk is part of a larger water-based "wicked problem"; it is difficult to solve because of complex, inter-jurisdictional, multi-disciplinary, incomplete, and contradictory requirements that are difficult to recognize and articulate. Furthermore, cumulative pressures are being felt at local scales, but require addressing at regional and global scales, spanning short to longer-term time horizons.

Water is at the centre of this wicked problem. Therefore, one possible way to better address the issues is to adopt a watershed-based governance model. Implementing such a model in the Okanagan-Similkameen region will not be without challenges. These include working through the complex government-to-government relationship between the Crown and the *Syilx* Okanagan Nation, and developing processes that can support Indigenous and non-Indigenous interests through collaborative decision making. This aligns with recommendation 28 from the *Abbott/Chapman Report* (i.e., "local governments and First Nations are empowered to enter into agreements with their neighbouring jurisdictions").

The Polis Project on Ecological Governance's *Handbook for Water Champions*[17] (Polis Project on Ecological Governance, 2019) provides essential components to water governance, which are as follows:

- Champions and commitment
- Projects and pooling knowledge
- Shared visioning and setting priorities

[17] Handbook for Water Champions: Strengthening Decision-Making and Collaboration for Healthy Watersheds. Polis Project on Ecological Governance. April 2019. Weblink: https://poliswaterproject.org/polis-research-publication/handbook-water-champions/. Accessed 15 May, 2019.

- Use local resources and authorities
- Formalize an advising role and exert influence
- Collaborative watershed planning
- Shared authorities

In BC, Water Sustainability Plans (WSPs) can assist communities with water and land governance issues. They are an example of the ongoing changes to the regulatory landscape (in this case under the *Water Sustainability Act* [2016]), as they will be required to be completed by watershed communities and incorporate Indigenous perspectives. Taking a whole-of-watershed approach is central to the completion of WSPs[18]. "Thinking like a watershed" can help organizations within that watershed recognize the benefits of ecosystem-based management and to consider cumulative pressures

8 Recommendations

The goal of this project is to understand the risk due to flood and debris flows within the Okanagan-Similkameen region to support priority-setting of future work. Based on the scale of this project, the recommendations are meant to align local and regional initiatives. Recommendations are equally directed toward urban and rural areas.

The recommendations are presented in the form of quick wins, followed by a list of actions that are organized according to the Sendai Priorities. The Sendai priorities provide a good best practice framework and is now policy in Canada and BC; therefore, the actions should align well with funding applications moving forward. The intended lead of the recommendations is the ONA and its various partners in the region. In many cases, the Province is referenced due to its current greater capacity to address regional issues. In those cases, there is a general recommendation that this report be shared with the ONA's partners in the region, including the Province. However, it should be made clear that, like with other First Nations in BC, the *Syilx* Okanagan Nation is free to determine a path forward in order to work with provincial and federal agencies and other partners—or not—on its own terms (FNFC, 2018).

8.1 Quick Wins

Many seemingly simple risk reduction targets, measures, and actions take time and/or money to implement. There are, however, some no-regrets actions that can be taken by the ONA and its regional partners immediately. These actions are in line with Sendai and the objectives of regional partners and/or recommendations from the *Abbott/Chapman Report*; therefore, partners should already be thinking about, and ready to embrace, them. This will serve to reduce risk and ensure that momentum built throughout this process is not lost. Quick wins that were identified are as follows:

[18] Water Sustainability Plans: Potential, Options, and Essential Components. Deborah Curran and Oliver M. Brandes. 2019. Polis Project on Ecological Governance, Environmental Law Centre, and University of Victoria Centre for Global Studies. Weblink: https://poliswaterproject.org/files/2019/10/POLIS-WSP2019-6e1-web.pdf. Accessed October 22, 2019.

- **Continue to strengthen relationships with local governments and agencies in the region.** Working with regional partners will be key to maintain consistency and alignment on risk reduction objectives. If the region can have agreed-upon goals, this will make it easier for individual local governments to develop and implement context-specific actions to meet them. This is in line with recommendations 4-7 of the *Abbott/Chapman Report*. This could potentially be done by expanding this project's Flood Steering Committee, or integrating it into, and influencing, an existing committee/group (i.e., the floodplain mapping initiatives). Specific examples where the ONA and its member communities have worked collaboratively with regional partners on water issues include monitoring for environmental flood needs with the OBWB and working to train staff to deploy Tiger dams in collaboration with the RDOS.
- **Present findings to decision-makers, and promote education and awareness.** At the local government level, the ONA can present the findings at regional board meetings. The ONA and its regional partners should continue to provide updates to interested and affected parties on their efforts to reduce risk from flood and debris flows. Consistency in communication is important as there are many related recent and ongoing projects in the region that address risk in different ways. There are advantages to engaging the public and seeking input to ground any future policy within local communities. This action is in line with recommendation 31 of the *Abbott/Chapman Report.*
- **Support local-scale risk assessment projects by integrating the holistic knowledge and detailed information from this project, and vice versa.** Regional partners can benefit from this project by using the outputs provided or applying a similar template to replicate the approach. Specific qualitative findings that were reported for this project should not be transferred to other projects, as qualitative information is context-specific (see Section 4.2 of the Basis of Study). However, high-level qualitative statements related to ecosystem-based ideas to guide adaptation apply throughout the region. The quantitative exposure data that was compiled and processed can also be used at more local scales. Alignment of projects across the region is a two-way street. Therefore, the results from local-scale projects should be communicated to the ONA to strengthen understanding at the basin scale within the territory.
- **Foster connections with private interests.** Local governments and agencies should nurture connections with forestry and other industry companies, land developers, etc., in line with recommendation 29 of the *Abbott/Chapman Report*. This will help make the implementation of future policies smoother. These groups have an effect on hazard risk through cumulative pressures.

8.2 Sendai Priority Actions

The remaining actions have been grouped according to the four Sendai Priorities (see Section 7.1) as follows:

- Priority 1: Understanding Disaster Risk
- Priority 2: Strengthening Disaster Risk Governance
- Priority 3: Investing in Disaster Risk Reduction for Resilience
- Priority 4: Enhancing Preparedness for Response

Under each Sendai Priority, actions have been grouped by theme within a table. Each action has been assigned a relative priority and cost, but in no specific order or rank. Development details to provide context for next steps have also been provided.

8.2.1 Understanding Disaster Risk

Understanding disaster risk includes obtaining better knowledge on hazards, exposure, vulnerability (i.e., the characteristics of people and assets that make them more susceptible to impacts), and the capacity of communities to adapt to changing risk. Actions under this priority are presented below in terms of detailed mapping, and research and knowledge, and communications and outreach.

Detailed Mapping

At the federal level, Natural Resources Canada is developing a Federal Flood Mapping Guideline Series, which captures recommended common practices for flood mapping (Natural Resources Canada & Public Safety Canada, 2017). The series will include methods on analysing the effects of climate change on flood modelling (Natural Resources Canada, 2018), including considering uncertainties involved in climate scenario analysis, and the subsequent effects on flood plain mapping. While guidelines are focused on flood hazards, the National Disaster Mitigation Strategy[19] supports an all-hazards approach. Therefore, other hazards such as debris flows and erosion, should be considered.

The Okanagan-Similkameen region needs to improve flood mapping approaches in line with these federal strategic directions. Modelling of the Okanagan lake tributaries and lakeshore areas is currently being developed using detailed Light Detection and Ranging (LiDAR) data[20], and a similar project is underway in the Similkameen watershed (see Appendix D of the Basis of Study for a list of recent and current flood management-related studies in the region). This *Syilx* Okanagan flood and debris flow risk assessment project is fulfilling a need to align the various smaller-scale initiatives to provide a region-wide assessment. The results from this assessment can be used to prioritize local-scale efforts such as detailed mapping. Specific actions related to detailed mapping are in Table 11.

[19] Canada's National Disaster Mitigation Strategy. Public Safety Canada. Weblink: https://www.publicsafety.gc.ca/cnt/mrgnc-mngmnt/dsstr-prvntn-mtgtn/ntnl-dsstr-mtgtn-strtg-en.aspx. Accessed June 15, 2019.

[20] Okanagan Valley receives $1.45 million for floodplain mapping. Penticton Western News. April 10, 2018. Weblink: https://www.pentictonwesternnews.com/news/okanagan-valley-receives-1-45-million-for-floodplain-mapping/. Accessed September 15, 2019.

Table 11: Actions related to detailed mapping.

High-level estimates of priority and cost (primarily dollar cost, but also in some instances human resources and skills) are provided in this table as **H**igh (red), **M**edium (yellow) and **L**ow (green).

Action #	Description	Development Details
1. Priority: H Cost: L	Develop modern flood and other natural hazard maps and include them within land use plans. LiDAR has been collected and flood maps are being developed for many areas of the Okanagan and Similkameen.	Natural hazard maps are the foundational tool to support good decision making, such as the development and application of zoning or providing development guidance for areas that are deemed to be in recognized hazard areas. Maps may also be integrated into broader land use-based decision making such as forestry and other industrial activity to address cumulative effects on hazards. It is important to note that maps have to be implemented through policy or regulation in order for them to serve their purpose (this is discussed in Action #1 in Table 15).
2. Priority: H Cost: M	Ensure that the mapping of natural phenomena such as flood and debris flow in the Okanagan-Similkameen region is presented within an ecosystem-based perspective, and that they are risk-based.	A memorandum of understanding between GIS departments of various partners could outline (with details to be defined at a later date) that flood and debris flow hazard maps include a note indicating that the impacts of these phenomena can be positive for ecosystems. Mapping should also be based on scenarios for risk analyses, which incorporate projections of future climate change and other cumulative pressures.
3. Priority: H Cost: M	Support local governments to collect local exposure and vulnerability information to undertake detailed natural hazard risk assessments.	The ONA and regional partners could provide guidance on what data to collect, as well as tools to support data collection. Financial support from provincial and federal governments would also be highly beneficial. NRCan is currently working on several projects that may support this effort, including the social vulnerability index (SOVI)[21].

[21] Murray Journeay. Research Scientist, Natural Resources Canada. Personal Communication, August 12, 2019.

Action #	Description	Development Details
4. Priority: H Cost: M	Develop and maintain analysis tools to support mapping studies. Various datasets are required to input into region-wide risk assessments (e.g., hydrological, climate, exposure, vulnerability).	In lieu of more accurate and detailed local information, collaboration among regional partners is required to house region-wide datasets that can provide the minimal information required to conduct local risk mapping studies. Standard hydrological, geospatial, and risk mapping tools should be made available by agencies in the region.
5. Priority: H Cost: L	Establish and maintain a central repository to house local flood and debris flow maps and associated metadata.	A central repository would ensure the ongoing storage and accessibility of maps in the region. Such a repository may be hosted by a regional, provincial, or federal agency. GeoBC and EMBC are working to support this effort in BC for practitioners. The OBWB is working on a portal for general public use that would consist of "storymaps" that show historical flood extents and related information[22].
6. Priority: M Cost: M	Work with the Province and regional partners to continue to collect information during events, to support robust event mapping.	During a natural hazard event it is common to focus on emergency response. However, the collection of event data (e.g., high water marks and flow measurements) is invaluable and should be seen as a priority. The data can be used for model calibration and validation, facilitating the development of studies to project future events with more accuracy. Drone technology can be deployed effectively for this purpose.

Research and Training

Sound decision-making in the Okanagan-Similkameen region should be underpinned by *Syilx* and scientific knowledge. It is important that the ONA and its regional partners have a good understanding of their priority knowledge needs, how to address these through effective partnerships and investments, and how to translate this new knowledge into policy and practice change. Continuous weaving of *Syilx* and western science knowledge is critical, as well as recognizing the advantages of qualitative and quantitative information sources. Some local-level research partnerships and regional initiatives already exist within the Okanagan-Similkameen region. For example, the En'owkin Centre, the University of British Columbia – Okanagan (UBCO), the Pacific Climate Impacts Consortium, as well as provincial and federal research agencies. Actions related to research and knowledge are in Table 12.

[22] Anna Warwick-Sears. Executive Director, Okanagan Basin Water Board. Personal communication, November 13, 2019.

Table 12: Actions related to research and training.

Action #	Description	Development Details
1. Priority: H Cost: L	Develop a catalogue of current flood management studies, identify and prioritize knowledge gaps, and develop a strategic plan to inform future investments in scientific monitoring and research.	A preliminary list of the various flood management studies that have been commissioned within the region has been started (see Appendix D, Basis of Study). This catalogue could be updated and be made available on-line, serving as a tool to create awareness regarding flood studies.
2. Priority: M Cost: M	Strengthen partnerships with research organizations, NGOs, and industry to facilitate collaborative research and the integration of new science into policy and practice.	Long-term investments and proactive efforts are required to strengthen relationships between *Syilx* and non-*Syilx* policy-makers, practitioners, and researchers. These relationships will be pivotal to integrating new knowledge, when it becomes available, into practice. Watershed tours, led by local experts such as *Syilx* Okanagan Elders, should be included by default within future studies.
3. Priority: M Cost: L	Continue to support and undertake desktop and field research to improve ecosystem management modelling, flood modelling, climate modelling, risk analysis and the development of management strategies.	Scientific research could be progressed through externally-commissioned projects or internal projects. This would require both financial investment and in-kind resources.
4. Priority: M Cost: L	Address data gaps in quantitative risk assessment for the region. Comments on data gaps are included in the Quantitative Study in the context of "limitations and opportunities for future improvement".	Some key data gaps include: • Developing land valuation that reflects ecosystem services through natural capital inventories. • Updating and improving the provincial Remote Access to Archaeological Data (RAAD) system. • Creating datasets that describe where people spend the majority of their time, instead of where they officially live (i.e., include hunting or fishing camp locations and number of residents). • Conduct comprehensive mapping of a wide range of sources of contamination. • Better understand how fisheries resources are impacted positively and negatively by flood and debris flow phenomena.

Action #	Description	Development Details
5. Priority: H Cost: M	Enhance capacity and capability amongst provincial, regional, and local flood management agencies to undertake holistic risk-based planning.	To enable the successful role out of risk-based planning, a capability and capacity building program will be required across all levels of Government. Potential program initiatives could include: • Promotion of natural hazard risk assessment through the showcasing of best practice. • Support of online and in-person courses on flood risk analysis and planning. • Support of in-person networking opportunities for risk assessment professionals. • Development of an online portal to facilitate information and resource-sharing. Examples that are in development include the GeoBC Flood Application, and the City of Kelowna Model City.

Communication and Outreach

Understanding disaster risk includes better communicating knowledge across government agencies and to the public. Community outreach initiatives help people to understand the role of flooding in their landscape, the potential consequences, opportunities, and risks of floods, and the actions they can take to reduce this risk. There is an opportunity for the ONA and regional partners to take a more active role in increasing public awareness regarding flood and debris flow phenomena, by launching region-wide initiatives and providing support for local initiatives. There are many actions that could be undertaken to improve communication and outreach in the region; a few examples are inTable 13.

Table 13: Actions related to communication and outreach.

Action #	Description	Development Details
1. Priority: H Cost: M	Work together to develop and implement public awareness initiatives.	Develop locally-led public awareness initiatives, such as watershed tours, and resources and education materials for use by local governments. Learnings and materials should be shared across the region.
2. Priority: H Cost: L	Adopt transparency in the region to inform the local population and visitors of the consequences resulting from flooding.	An example is to conduct water quality testing of polluted waters following flooding. Post public advisories when water quality is found to be below guidelines in recreational areas.

Action #	Description	Development Details
3. Priority: H Cost: M	Produce a region-wide interactive, online flood map that shows current and projected flood risk under climate change.	The Okanagan Lakeshore Mapping project could be expanded in spatial extent and scope to include the Similkameen region, as well as include debris flow phenomena. Natural hazard maps are an important tool to communicate information about risk. Such an initiative may also be completed at the provincial scale (e.g., the National Oceanic Atmospheric Science Agency's Sea Level Rise viewer).
4. Priority: H Cost: L	Require that BC Assessment property information and rental agreements disclose current and projected flood risk levels.	Mandatory and early disclosures of flood risk information would ensure prospective property buyers and renters are aware of the risks associated with a given property. Studies of coastal sea level rise have also shown this helps to reorient real estate demand to areas with reduced risk (Votsis & Perrels, 2016).

8.2.2 Strengthening Disaster Risk Governance

Sendai Priority 2 promotes disaster risk governance through collaboration and partnership. One of the objectives of this project is to lay the foundation and build relationships to implement a governance arrangement that embraces the *Syilx* perspective and works toward risk reduction in the region as a whole. Existing tools and regulations that apply at the local government level can be useful measures to coordinate efforts in the shorter term. However, it should be understood that for First Nations in BC, establishing a new governance approach is one step along a larger path to self-determination (FNFC, 2019). This section thus contains actions on self-determination, collaborative decision-making, and regulatory tools.

Self-Determination

Under the current governance arrangements, there are key barriers to self-determination for the *Syilx*. For example, the *Syilx* People have limited financial, human, and infrastructure resources to work within current demands. Further, as the economy becomes increasingly based on knowledge and data, self-determination is dependent on data sovereignty. More work is required to ensure that the *Syilx* have ownership over the information that is gathered on their land. Table 14 outlines recommendations related to self-determination.

Table 14: Actions related to self-determination.

Action #	Description	Development Details
1. Priority: H Cost: M	Conduct a scan of opportunities to identify how governments can streamline funding arrangements to help increase the capacity of the *Syilx* Okanagan Nation to implement a new governance model.	An example of this process is the Emergency Management Services Funding Agreement between the Federal and Provincial governments [23], from 2017. The agreement establishes a constructive working relationship between the Crown and the BC First Nations Leadership Council, "through a joint high-level dialogue process, that focuses on a mutually developed agenda related to issues of common interest…".
2. Priority: M Cost: M	Increase awareness in the region on Indigenous sovereignty issues.	The provincial Community Emergency Preparedness Fund (CEPF) includes an "Indigenous cultural safety and cultural humility training" stream to offer "emergency management in a way that respects Indigenous Peoples as the decision-makers in their own care"[24].
3. Priority: H Cost: L	Promote Indigenous data sovereignty as a means of "decolonizing" data and supporting a governance model that empowers the *Syilx* Okanagan Nation.	Organizations in the Okanagan-Similkameen region should strive to abide by the First Nations principles of Ownership, Control, Access and Possession (OCAP), which are becoming standard for how to conduct research with First Nations[25]. As programs such as the OCAP certification process are rolled out, the ONA should seek to work with partners who have demonstrated awareness of these principles[26].

[23] Emergency Management Services Funding Agreement. Weblink: https://engage.gov.bc.ca/app/uploads/sites/121/2017/03/INAC-EMBC-Emergency-Services-Funding-Agreement-Boilerplate-Feb-2017-Web-Copy.pdf. Accessed August 15, 2018.

[24] Community Emergency Preparedness Fund. Indigenous Cultural Safety and Cultural Humility Training. Weblink: https://www.ubcm.ca/assets/Funding~Programs/LGPS/CEPF/CEPF-2019-Indigenous-Cultural-Safety-Program-Guide.pdf. Accessed September 27, 2019.

[25] The First Nations Principles of OCAP®. First Nations Information Governance Centre. Weblink: https://fnigc.ca/ocap. Accessed July 15, 2019.

[26] During this project, Ebbwater inquired with OCAP about obtaining training and certification. However, at this time neither the ONA nor Ebbwater have completed training.

Collaborative Decision-Making

The engagement activities and information produced through this project have established a foundation for collaborative decision-making in the region. The next steps along this path are outlined in Table 15.

Table 15: Actions related to collaborative decision-making.

Action #	Description	Development Details
1. Priority: H Cost: M	Consider developing an adaptation planning framework that is in line with a governance model for the Okanagan-Similkameen region.	The adaptation planning framework will establish how modern and detailed flood and debris flow maps could be implemented through policy and used to support governance in the region.
2. Priority: M Cost: M	Develop guidance materials, templates and decision tools to support the uptake of the framework by the ONA and local governments.	Resources will be required to support the uptake of the framework. These resources should be flexible in nature, supporting both simple and more complex holistic risk analysis and planning processes. This will enable application of the planning framework by the broad range of partners in the region.
3. Priority: M Cost: M	Establish a collaborative innovation network in the region to organize information that supports a new governance model. Collaborative innovation is rooted in business but can be applied to develop new products, services, and policies to better serve communities.	Collaborative innovation leverages tools such as web-based platforms to promote internal transparency and direct communicati[27]. Technology can be used to create networks using "cyberteams" of motivated individuals who can work together to effect the required change[28].
4. Priority: M Cost: M	Use a transparent and open approach to explore the trade-offs associated with risk reducing decisions that are required to be made in the region.	The next phase of work should build on the relationships that have been built in this initial phase and employ a process such as structured decision making. Structured Decision Making[29] is an effective process that can help interested and affected parties navigate the wicked problem of flood and debris flow management.

[27] Collaborative Innovation Network. Weblink: https://en.wikipedia.org/wiki/Collaborative_innovation_network. Accessed September 15, 2019.

[28] Collaborative Innovation Networks: Building Adaptive and Resilient Organizations. Weblink: https://www.springer.com/gp/book/9783319742946. Accessed September 15, 2019.

[29] Structured Decision Making. Weblink: http://www.structureddecisionmaking.org/how-to-use/. Accessed May 15, 2019.

Regulatory Tools

While no statutes in Canada or BC definitively recognize First Nations' jurisdiction and authorities, many have the potential to impact Aboriginal and Treaty Rights, especially related to water. Also, local governments within ONA territory have developed statutes that provide a regulatory framework for the management of flood and debris flows. These include the *Community Charter* [2003] and *Local Government Act* [2004] (e.g., development permit areas, flood bylaws, zoning bylaws, etc.). Official community plans (OCP)s and regional growth strategies (RGS)s provide higher-level guidance. Although these regulations do not apply to the *Syilx* Okanagan Nation, they may be used to reduce disaster risk on *Syilx* territory.

Provincially, legislation may be leveraged, particularly to strengthen the application of Indigenous perspectives and to address flood and debris flows more holistically. Further, on October 24, 2019, the Province tabled *Bill 41 – 2019: Declaration on the Rights of Indigenous Peoples Act* to implement UNDRIP. Table 16 lists actions related to regulatory tools.

Table 16: Actions related to regulatory tools.

Action #	Description	Development Details
1. Priority: H Cost: M	Use Crown tools to strategically advance water-based priorities.	BC's *Water Sustainability Act* (WSA) [2016] contains several potentially useful provisions that the *Syilx* Okanagan Nation can use to protect their waters, including protection of water for fish through adequate environmental flows. There is also potential to ensure that the development and implementation of new WSA regulations and tools is co-led with First Nations. For example, the potential to connect the concept of "protecting water" in the WSA with "making room for water" could be explored.
2. Priority: H Cost: M	Consider how the *Environmental Management Act* [2003] can be leveraged to progress holistic thinking and elevate the importance of ecosystem-based management within flood and debris flow management.	The *Act* includes the provision of environmental management plan preparation for planning, research, and investigation; planning, design, and construction, operation, and maintenance of works; providing information to the public about quality of the environment; and publishing policies, strategies, objectives, guidelines and standards; for the protection, enhancement, management, and use of the environment. Management plans can relate to flood control, flood hazard management and development of land that is subject to flooding; drainage; water resource management; and fisheries and aquatic life management among others.

Action #	Description	Development Details
3. Priority: H Cost: M	Support local governments to strengthen natural hazard regulations and zoning bylaws in areas prone to frequent flooding.	Regulations could be tightened to reduce exposure in these flood plains by: • Limiting density of new developments. • Requiring that there are no subdivisions or major redevelopments. • Reducing the number of exceptions that enable development. • Prohibiting development of new critical public infrastructure. • Prohibiting new hazardous land uses.
4. Priority: M Cost: L	Work with the Province and the National Research Council, which is currently leading a project to update the National Building Code, to ensure that climate change is considered in the design of buildings at risk from flooding. This is a long-term, resource-intensive project, which will ultimately inform updates to provincial building codes.	The Province can facilitate and encourage local planning authorities to strengthen their building codes above and beyond provincial requirements. This could include, for example: • Requiring a high level of floodproofing for new developments or existing developments that are substantially renovated. Future flood hazard (i.e., incorporating climate change) should be used to define buildings at risk. • Requiring that developers provide flood risk assessments as part of planning applications.
5. Priority: M Cost: M	Strengthen monitoring and enforcement activities to increase adherence to existing regulations.	The Province should consider options to build local capability and capacity to conduct monitoring and enforcement through training and resource investment.
6. Priority: H Cost: M	The Province and regional partners should undertake an investigation of the various planning options that local governments could implement to reverse human activities, restore ecosystems, and adapt, to changing flood and debris flow risk.	All levels of government and regional partners need to investigate these options to understand their relative benefits and challenges, and the legal mechanisms for implementing them. Specific planning options could be investigated primarily for existing development include, for example: • Property buy back. • Life rights. • Transfer of development rights. • Incentives to relocate. • Assumption of risk by property owner. • Establish and protect green infrastructure.

8.2.3 Investing in Disaster Risk Reduction for Resilience

Sendai Priority 3 focusses on public and private investments in disaster risk prevention through structural and non-structural measures. According to a recent report released by the Insurance Bureau of Canada and the Federation of Canadian Municipalities, adaptation to flood risk is one of the areas that requires the greatest investment in adaptation[30]. This requires helping professionals prioritize and define non-structural mitigation measures, such as policy and planning that is leveraged by regulatory tools (discussed in Section 8.2.2. Prioritizing such non-structural measures will avoid continued dependence on structural mitigation as an exclusive solution to manage flood and debris flows.

Actions in this section focus on property level resilience measures that are not meant to permanently fight water (like large-scale structural mitigation does). Soft-path mitigation aims to reduce residual risk through property level protections. However, any comprehensive plan requires consideration of structural mitigation, for which recommendations are also included.

Property-Level Resilience

In areas where risk cannot be reduced through larger-scale planning and policy approaches (see Table 16), there are a number of property-level resilience measures that can be taken to protect assets at smaller scales. These are actions that a variety of people including homeowners, farm owners, and boat operators can take. Some of the actions involve structures, but they are not meant to permanently fight water and are thus referred to as soft-path mitigation actions.

Property-level risk can also be managed through insurance. Property owners can increase their resilience by transferring financial risk to insurance providers. Residential insurance for overland (pluvial and fluvial) flooding became available in Canada during mid-2015. In 2016, the Insurance Bureau of Canada (IBC) reported that around 7% of homes were ineligible for flood insurance due to prohibitively high levels of flood risk. As the flood insurance market matures, insurance options may become available to these high-risk homes (Sigma Risk Management, 2017).

For Indigenous communities, three companies in Canada offer “municipal-type” flood insurance; however, coverage is contingent on whether the area has been designated as a flood zone. There may be opportunities for local governments and *Syilx* communities to work with the insurance market to make flood insurance more available to people living in the region. Table 17 provides actions related to property-level resilience measures.

[30] Investing in Canada’s Future: The Cost of Climate Adaptation. Weblink: http://assets.ibc.ca/Documents/Disaster/The-Cost-of-Climate-Adaptation-infographic-EN.pdf. Accessed September 30, 2019.

Table 17: Actions related to property-level resilience measures.

Action #	Description	Development Details
1. Priority: M Cost: L	Move valuables from buildings/homes out of basements and into upper floors. In the case of assets located in the debris flow areas, move bedrooms to the other side of the house.	At the property level, in the event of a flood or debris flow, the primary objective should be life safety. For the things that remain in a building/house, the objective is to reduce damage to the most valuable items. This strategy can be integrated within the communication and outreach actions in Table 13, as well as action #1 related to enhancing early warning systems (Table 19).
2. Priority: H Cost: M	Remove watercraft fuel barrels from docks when a flood is imminent.	Alternative storage areas may be identified to temporarily remove these contamination sources out of the flood area to avoid spills into the receiving environment. This is dependent upon strong communications (Table 13) and early warning systems (Table 19), as well as education around trade-offs associated with fuel-powered pleasure-boating.
3. Priority: H Cost: M	Work with partners who are working on concepts, communications, and sourcing of materials for various measures, to ensure that on-reserve building types are included.	Examples of specific property-level measures that are being developed include: • Install seals or shields to make windows and doorways watertight. • Install sump pumps to remove water in order to reduce the amount of time standing water remains inside a structure. • In industrial areas, move heavy equipment temporarily to high ground. If this is not possible, consider moving equipment temporarily off-site. • Protect wells and water supply lines by maintaining a gradient away from the well head to ensure water runoff does not pool near the well head. • Improve site drainage to expedite the flow of water out of, and away from, buildings and sources of contamination. • Modify septic systems to avoid sewage release in flood prone areas (e.g., install above-ground septic treatment tank).
4. Priority: M Cost: L	Install sand-filled bags, or purpose-built and reusable plastic, as barriers forming a wall against rising floodwaters.	These should be considered as a tool of last resort. The bags must be strong enough to hold the sand and withstand contact with water indefinitely (usually burlap or strong plastic bags). Note that flooded sandbags are considered hazardous material.

Action #	Description	Development Details
5. Priority: M Cost: L	Work with the insurance industry to support the development of a certification program that enables homeowners to access reduced flood insurance premiums based on property-level flood-proofing.	Certification schemes could conceivably play a role in incentivising homeowners to improve the resilience of their property to flooding through flood proofing measures. Such a scheme could also facilitate the move towards risk-reflective insurance premiums.
6. Priority: H Cost: M	Investigate options to support homeowners to transition into the flood insurance market.	In coordination with the Province, local governments and the *Syilx* Okanagan Nation could initiate a targeted public awareness and engagement program to alert homeowners to their need for flood insurance. Producing standardized flood risk maps for insurance providers is one piece of this puzzle.

Structural Mitigation

While the focus of this project is on understanding risk for the purpose of adaptation planning, best practice indicates that part of this process includes a consideration for structural flood mitigation. However, structural measures should not be considered in isolation—the focus needs to be on long-term risk reduction, which can be achieved primarily through non-structural mitigation outlined in the previous sections. Within this context, high-level considerations for structural mitigation are listed in Table 18 for future projects in the region to consider.

Table 18: Actions related to structural mitigation.

Action #	Description	Development Details
1. Priority: H Cost: L	Work with local governments to re-frame the evaluation of engineering options within an ecosystem-based perspective. Emphasis should be placed on reversing human activities and restoring ecosystems. Nature-based green infrastructure should be considered a priority.	Low-carbon green infrastructure projects (wetland restoration, permeable pavements, green roofs, swales etc.) are increasingly being adopted due to their co-benefits: while offsetting high costs of traditional (grey) engineering designs, they improve biodiversity and human wellness.
2. Priority: H Cost: M	Leverage funding available through the Canadian Disaster Mitigation Adaptation Fund (DMAF), and Structural Flood Mitigation stream of the provincially-led Community Emergency Preparedness Fund (CEPF).	The DMAF is a $2B fund for projects with a minimum cost of $20M. Projects are evaluated on criteria such as innovation in managing hazards and strengthening resilience. The CEPF has a grant maximum of $750,000. Regional partners and the Province should identify opportunities to apply for funding for infrastructure projects.

8.2.4 Enhancing Preparedness for Response

Sendai Priority 4 recognizes the need for preparedness, response, and recovery at all levels. Disasters represent an opportunity to "build back better". This is an opportunity to reduce "path-dependency" (see Basis of Study) by disrupting common views around flood management and seeing the problem through diverse perspectives (e.g., Indigenous communities, vulnerable people, future generations represented by youth, etc.).

Building back better requires thoughtful consideration in the early phases of the emergency management cycle of flood prevention, mitigation, preparedness, response and recovery. To facilitate this process, the Province is currently undergoing an update to the Hazards, Risk, Vulnerability Assessment Analysis (HRVA) Tool for local authorities and First Nations (Emergency Management BC, 2019). When it is ready, the tool will provide a step-by-step process to develop an HRVA at the community level. The methodology will include working directly with First Nations Elders, and will include recommendations and best practices on engaging the community, identifying hazards, assessing resilience and consequences, and identifying risk reduction strategies.

The HRVA process is thus an important tool to empower communities and will form a part of the longer-term adaptation initiative building on this project. In the short-term, the HRVA is also a functional tool to build emergency management capacity.

Emergency Management

Emergency Management BC is the focal point for all aspects of the emergency management cycle in the province. Table 19 lists a few related actions.

Table 19: Actions related to emergency management.

Action #	Description	Development Details
1. Priority: M Cost: L	Continue to support local governments to enhance early warning systems.	This action would help to facilitate increases in awareness about flood and debris flow hazard and to reduce exposure in the lead up to, and during, flood events. This is a critical step for property-level resilience measures (Table 17) to be executed effectively.
2. Priority: H Cost: M	Investigate options to integrate emergency management planning with long-term flood risk management planning. Investigate options to integrate emergency management planning with long-term flood risk management planning.	It is important that adaptive flood management planning and emergency management planning are integrated as part of a cohesive approach to flood prevention, mitigation, preparedness, response and recovery. The HRVA Tool will play a role in this process.

Action #	Description	Development Details
3. Priority: H Cost: M	Work with EMBC to build points of connection between UNDRIP, Sendai, and the Truth and Reconciliation Commission (TRC).	EMBC is currently modernizing the *Emergency Program Act* (EPA) [1996][31], to integrate UNDRIP, SENDAI, and the TRC. The modernization process also calls for responsible ministries to include risk mitigation and recovery within their hazard-specific planning (FLNRORD is responsible for flood and debris flows).

[31] Modernizing BC's Emergency Management Legislation. Weblink: https://engage.gov.bc.ca/app/uploads/sites/121/2019/10/modernizing_bcs_emergencymanagement_legislation.pdf. Accessed October 28, 2019.

9 Conclusion

The Okanagan-Similkameen region has recently experienced and will continue to face significant impacts from flood and debris flows. The goal of this project phase is to understand the risk from these natural phenomena within the region to support priority-setting of future work. Process was a significant component of this project, which included watershed tours and workshop engagement events consisting of a diverse team of *Syilx* Okanagan and non-*Syilx* people representing 22 communities, local governments, and partner organizations in the region.

For this risk assessment, four specific project objectives were evolved to support the region's needs. These have been addressed as summarized below.

Better understand flood and debris flows and how they impact the region. Qualitative and spatially consistent quantitative information sources were used to obtain a rich database of knowledge. Both types of information were mapped. The impacts from flood and debris flows, which are distinct natural phenomena, are complex and vary across the region.

Apply *Syilx* Okanagan perspectives to assess the risk from these natural phenomena. Throughout the process, discussions were led by *Syilx* Okanagan Elders. These perspectives were woven with multi-disciplinary western science to establish ecosystem-based guiding principles for adaptation actions. A range of technical and non-technical analyses were completed. Flood and debris flows provide ecosystem benefits, which need to be considered in discussions about risk.

Collaborate with local governments to strengthen and align risk assessment initiatives. By applying a consistent approach across the region, this project's findings can be used to inform initiatives occurring in more local contexts. One of the project's findings is that the recurrence of small flood events over time may be a greater risk compared to large flood events. However, this will depend on how the assets are valued from one community to another. The connections made with regional partners provide a means to share this project's information and vice versa.

Provide supporting information for future funding and to prioritize adaptation actions. The regulatory context is changing rapidly in BC related to Sendai, UNDRIP, Emergency Program Act, etc. The results from this risk assessment enable the ONA and regional partners to target more detailed information gathering, to align with Provincial and Federal programs, and to prioritize efforts within the Okanagan-Similkameen region. A long list of recommended actions has been provided.

The ONA is committed to doing things better for everyone in the region over the long-term by taking a collaborative, risk-based approach to understanding natural phenomena. This approach has required evolving the typical risk assessment method and has provided an opportunity to disrupt the path-dependency that has created the flood and debris flow issues experienced in the region today.

This project has established a foundation with the information and tools necessary for leaders to reduce risk from flood and debris flows in the region. Now it is time for leaders to collectively answer the call to action.

References

AIDR. (2015). Handbook 10: National Emergency Risk Assessment Guidelines. 2nd Edition. Australian Institute for Disaster Resilience, Australian Government Attorney-General's Department.

British Geological Survey. (2010). *Groundwater Flooding*.

Bush, E., & Lemmen, D. S. (2019). *Canada's Changing Climate Report*. Government of Canada, Ottawa, Ontario.

Emergency Management BC. (2018). *Government's action plan: Responding to wildfire and flood risks*. Retrieved from https://www2.gov.bc.ca/assets/gov/public-safety-and-emergency-services/emergency-preparedness-response-recovery/embc/action_plan.pdf

Emergency Management BC. (2019). Hazard, Risk, and Vulnerability Analysis Tool for Local Authorities and First Nations (Draft Edition 3.2+, January 2019).

Entwistle, N., Heritage, G., & Milan, D. (2018). Flood energy dissipation in anabranching channels. *River Research and Applications*, *34*(7), 709–720. Retrieved from https://onlinelibrary.wiley.com/doi/pdf/10.1002/rra.3299

FNFC. (2018). *Protecting Water Our Way: First Nations Freshwater Governance in British Columbia*.

Geertsema, M., Highland, L., & Vaugeouis, L. (2009). Environmental Impacts of Landslides. *Landslides - Disaster Risk Reduction*, 589–607.

Gimbel, K. F., Puhlmann, H., & Weiler, M. (2016). Does drought alter hydrological functions in forest soils? *Hydrology and Earth System Sciences*, *20*(3), 1301–1317. https://doi.org/10.5194/hess-20-1301-2016

de Groot, R., Brander, L., van der Ploeg, S., Costanza, R., Bernard, F., Braat, L., et al. (2012). Global estimates of the value of ecosystems and their services in monetary units. *Ecosystem Services*, *1*(1), 50–61. https://doi.org/10.1016/j.ecoser.2012.07.005

Guthrie, R. H. (2002). The effects of logging on frequency and distribution of landslides in three watersheds on Vancouver Island, British Columbia. *Geomorphology*, *43*(3–4), 273–292.

Natural Resources Canada. (2018). Federal Floodplain Mapping Guideline Series. Natural Resources Canada. Floodplain Mapping Knowledge Transfer Workshop, Vahghan, Canada.

Natural Resources Canada, & Public Safety Canada. (2017). *Federal Floodplain Mapping Framework: Version 1.0*. Ottawa, Canada. https://doi.org/10.4095/299806

Parsons, M., Nalau, J., Fisher, K., & Brown, C. (2019). Disrupting path dependency: Making room for Indigenous knowledge in river management. *Global Environmental Change*, *56*(September 2018), 95–113. https://doi.org/10.1016/j.gloenvcha.2019.03.008

Polis Project on Ecological Governance. (2019). *Strengthening Decision-Making and Collaboration for Healthy Watersheds*.

Sayers, P., Li, Y., Galloway, G. G. G., Penning-rowsell, E. E., Shen, F., Kang, W., et al. (2013). Flood Risk

Management: A Strategic Approach. Paris, UNESCO. Retrieved from http://www.sayersandpartners.co.uk/uploads/6/2/0/9/6209349/flood-risk-management-web.pdf

Sayers, P., Galloway, G., Penning-Rowsell, E., Yuanyuan, L., Fuxin, S., Yiwei, C., et al. (2014). Strategic flood management: ten 'golden rules' to guide a sound approach. *International Journal of River Basin Management*, (June), 1–15. https://doi.org/10.1080/15715124.2014.902378

Sigma Risk Management. (2017). *Review of Residential Insurance Development in Canada and Implications for GoC DFAA Payments: DRAFT*.

Stantec Consulting Ltd., & Ebbwater Consulting Inc. (2017). DRAFT National Risk and Resilience Aggregation and Return on Investment Tools. Vancouver, Canada: Prepared for Public Safety Canada.

Tollan, A. (2002). Land-use change and floods: what do we need most, research or management? *Water Science and Technology*, *45*(8), 183–90.

Votsis, A., & Perrels, A. (2016). Housing Prices and the Public Disclosure of Flood Risk: A Difference-in-Differences Analysis in Finland. *The Journal of Real Estate Finance and Economics*, 450–471. https://doi.org/10.1007/s11146-015-9530-3

Winkler, R. D., Moore, R. D., Redding, T. E., Spittlehouse, D. L., Smerdon, B. D., & Carlyle-Moses, D. E. (2010). Chapter 7 - The effects of forest disturbance on hydrologic processes and watershed response. In *Compendium of Forest Hydrology and Geomorphology in British Columbia* (pp. 179–212).