ClimateWest, a central hub for climate services in Manitoba, Saskatchewan, and Alberta, is proud to host Alberta's Adaptation Resilience Training module recordings and resources.

Check out climatewest.ca for all training material available through ART and other initiatives.

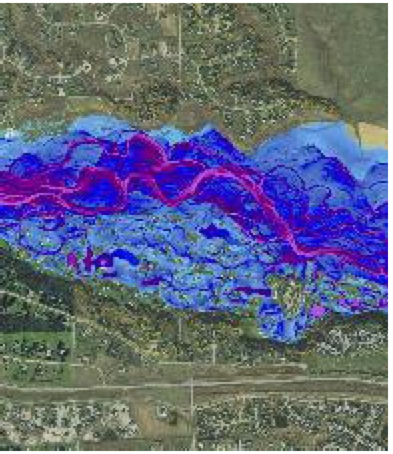
ClimateWest
Building Prairie Resilience

The aim of the Adaptation Resilience Program (ART) is to build the capacity of professionals in Alberta to adapt to climate change. This module was recorded in September, 2021.

Professionals across the Prairie region may find this training useful.

Supported by the Natural Resources Canada's Building Regional Adaptation Capacity and Expertise (BRACE) Program and the Government of Alberta

Natural Resources Canada
Ressources naturelles Canada
Canada
Alberta



Stream-Specific Module: Watershed Management

Water: Too Much or Too Little to Manage

John van der Eerden, M.Eng., P.Eng., Vice President Water Resource
Kristen Andersen, P.Biol., Senior Environmental Scientist
September 13, 2021

Module Overview/Outline

- Session 1: Watershed Hazards (in a Changing Climate) - *John*
- Session 2: Understanding Risks - *John*
- Session 3: Managing Risk through Adaptation – *John/Kristen*
- Session 4: Assessing Value of Adaptation Strategies - *John*
- Session 5: Effective Communication: Achieving Resilience - *Kristen*

Session 1: Watershed Hazards (In a Changing Climate)

- River Floods

- Extreme Precipitation

Coastal
Surge, tides, waves
Sea Level Rise

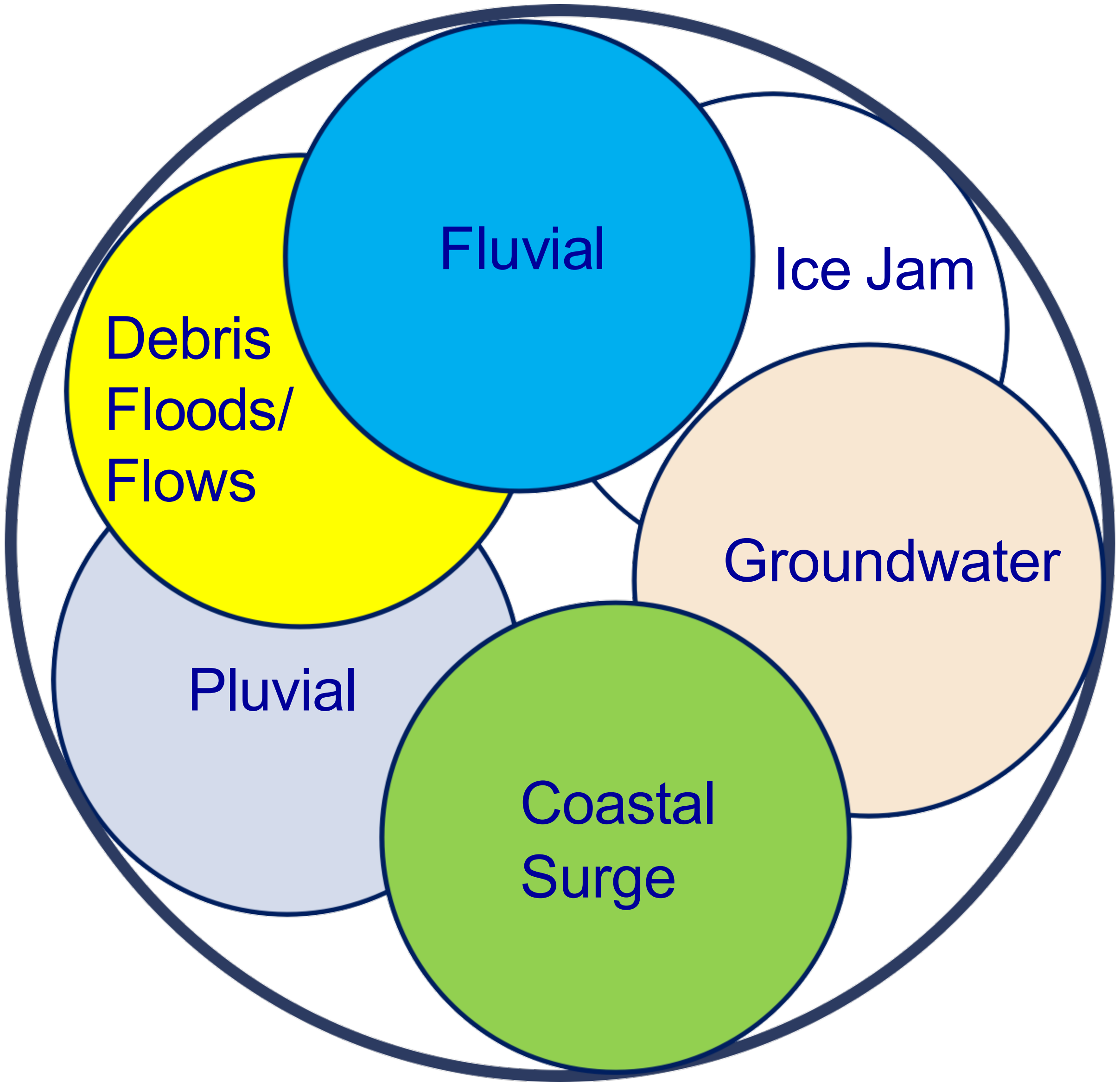
Ice Jam
Freeze up/break up

Dry Spell, E_t

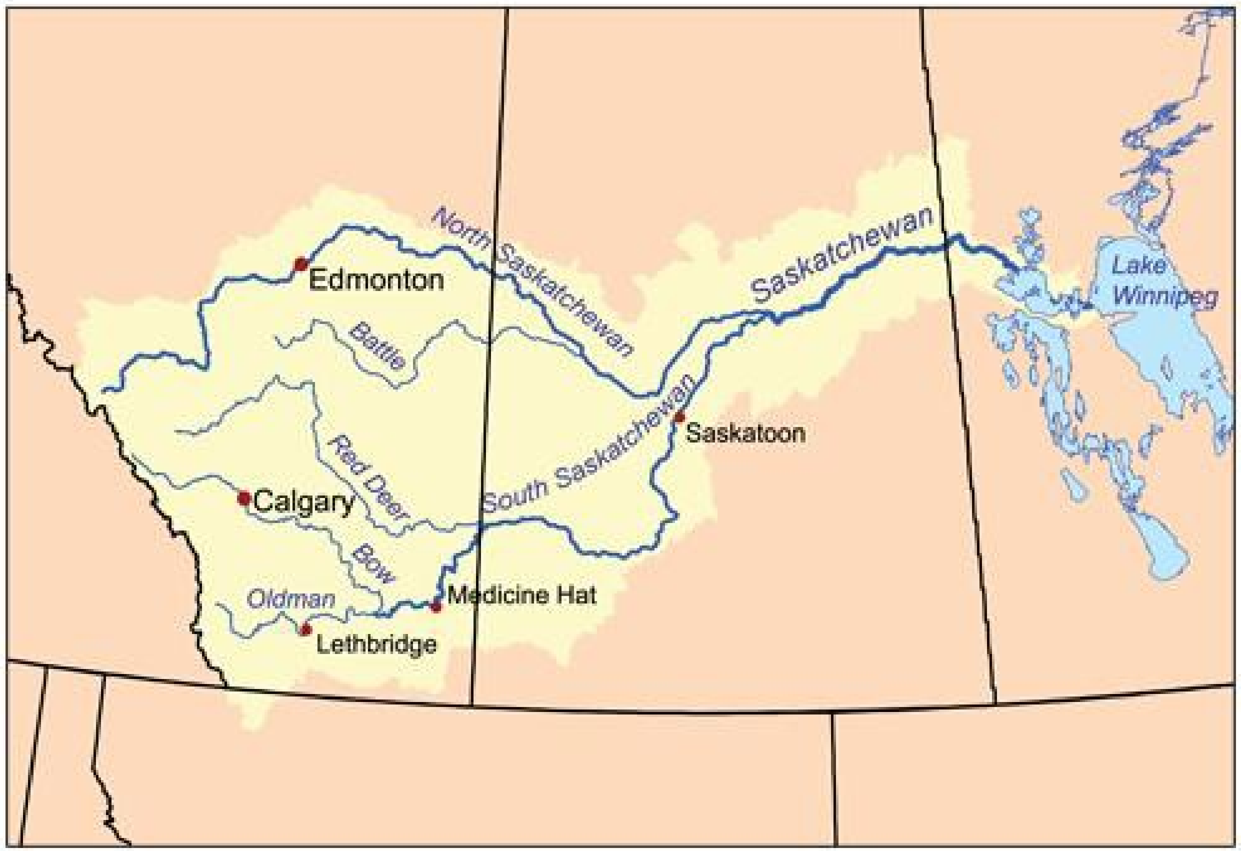
Drought hazards

“There is no reservoir large enough to hold all the water that nature provides for free in the form of snow and ice” (Robert Sandford quote).

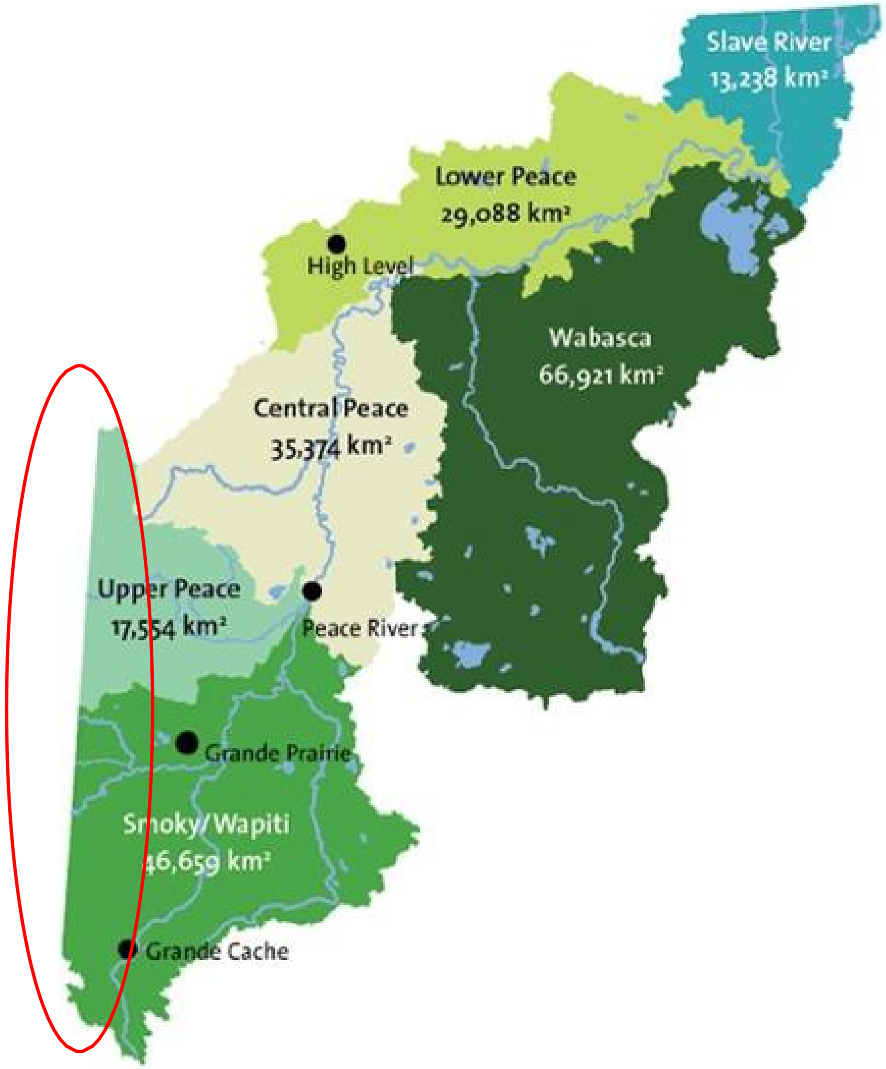
Compound Events



What is a Watershed?



Source: Karl Musser/Wikimedia
https://commons.wikimedia.org/wiki/File:Saskatchewanrivermap.png



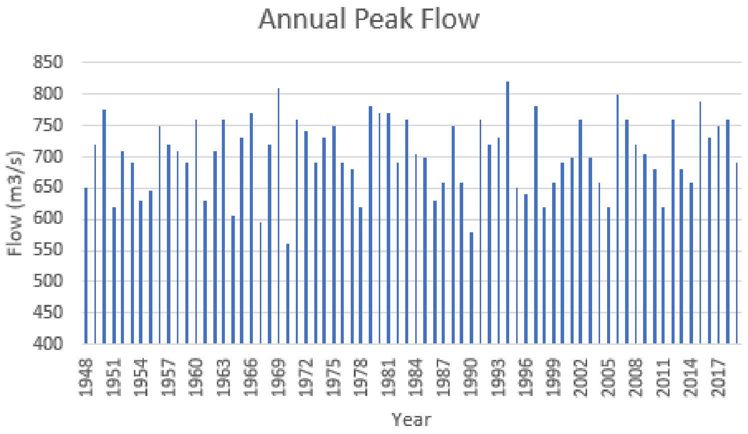
https://www.mightypeacewatershedalliance.org/about-1/the-watershed/

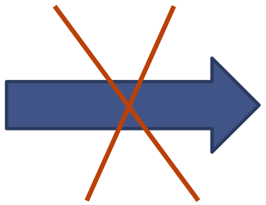
How is C.C. affecting watershed hazards?

<u>Non-stationarity:</u>

- The mechanisms that caused hazards are fundamentally changing (e.g. atmospheric rivers, loss of glaciers, phase of winter precipitation)

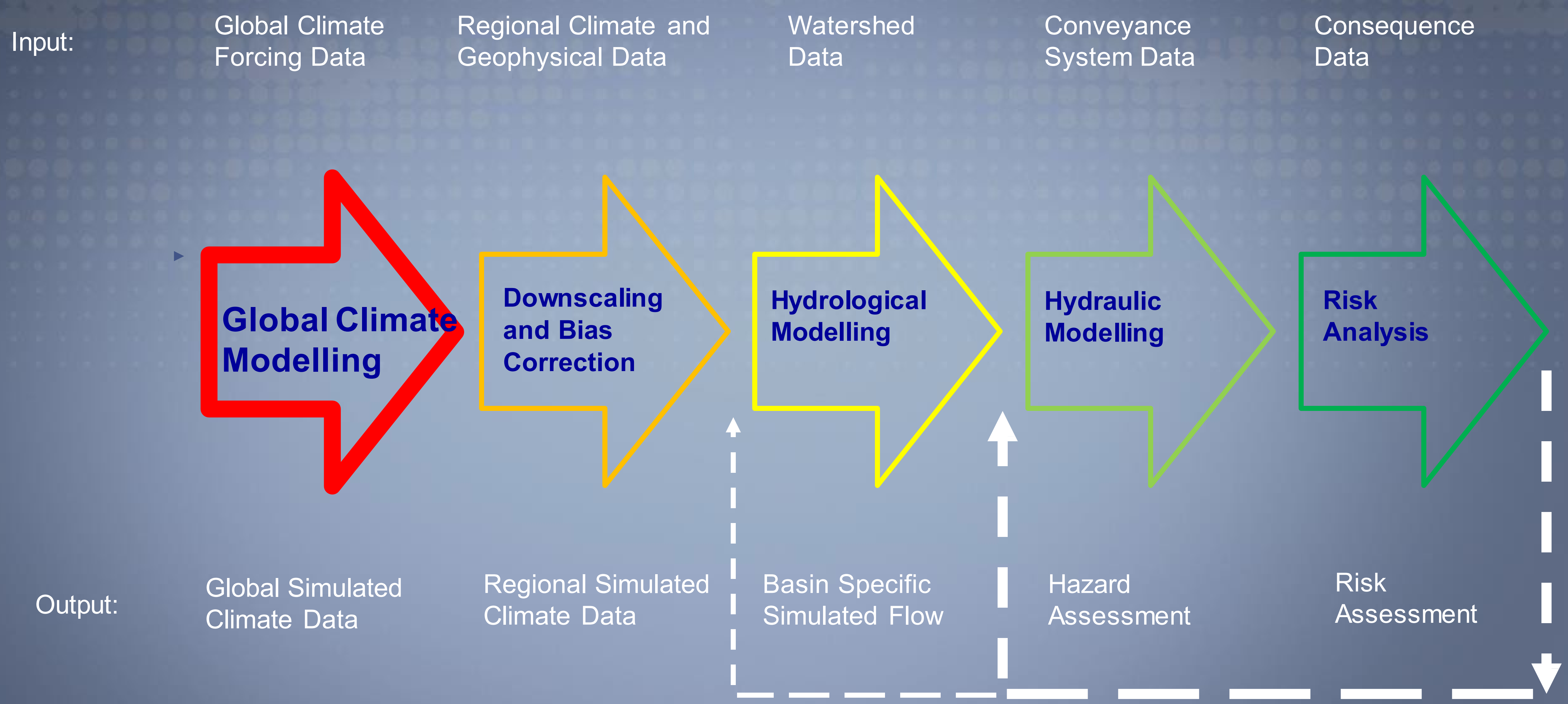
- Historical records are no longer valid to predict future events.





Annual Exceedance Probability
(aka Return Period)

- **Must rely on predictive models to estimate future conditions.**


Input:
Global Climate Forcing Data
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Downscaling and Bias Correction
Hydrological Modelling
Hydraulic Modelling
Risk Analysis
Output:
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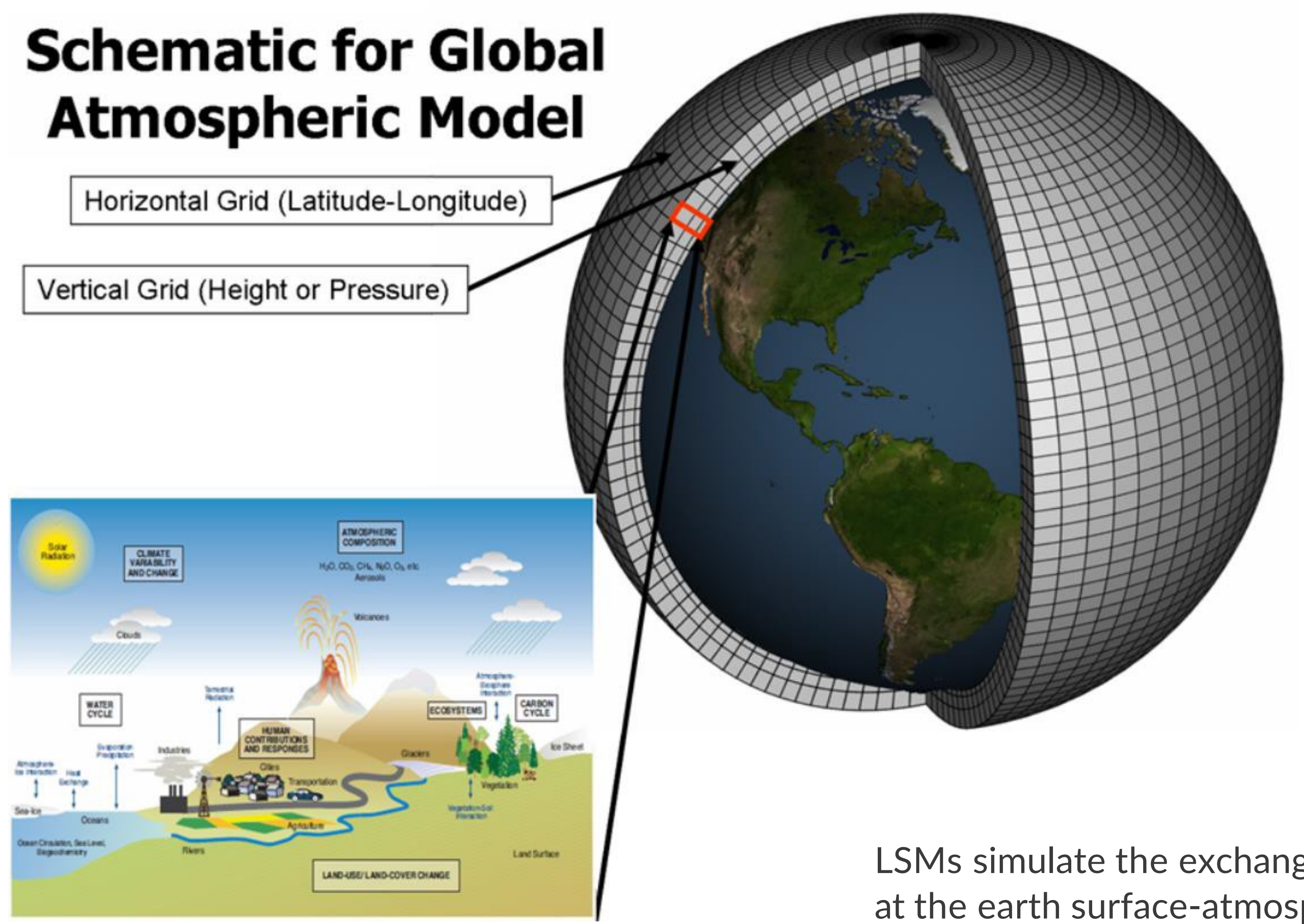
Regional Simulated Climate Data
Basin Specific Simulated Flow
Hazard Assessment
Risk Assessment

Global Climate Model (GCM)

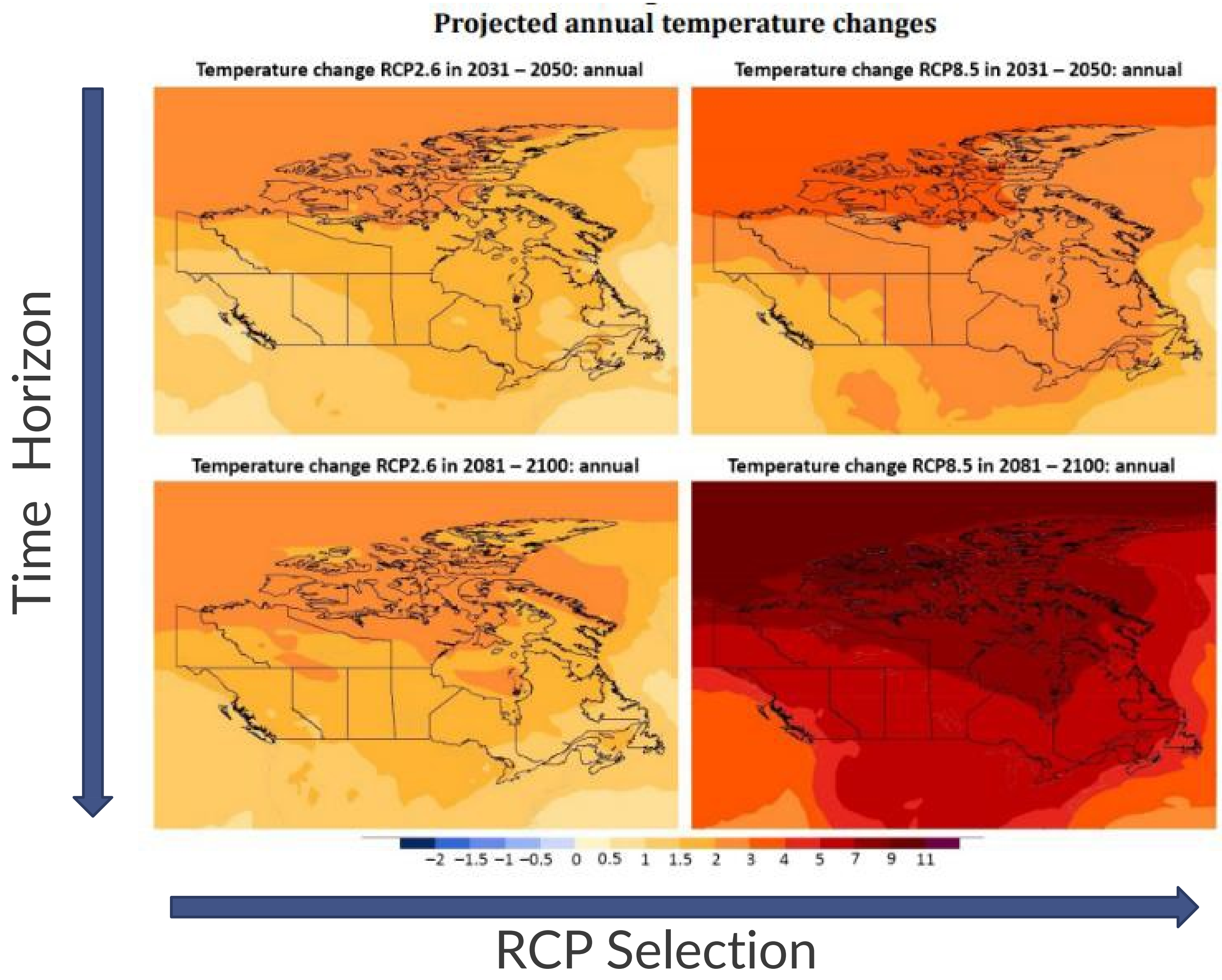


Land surface models (LSM)

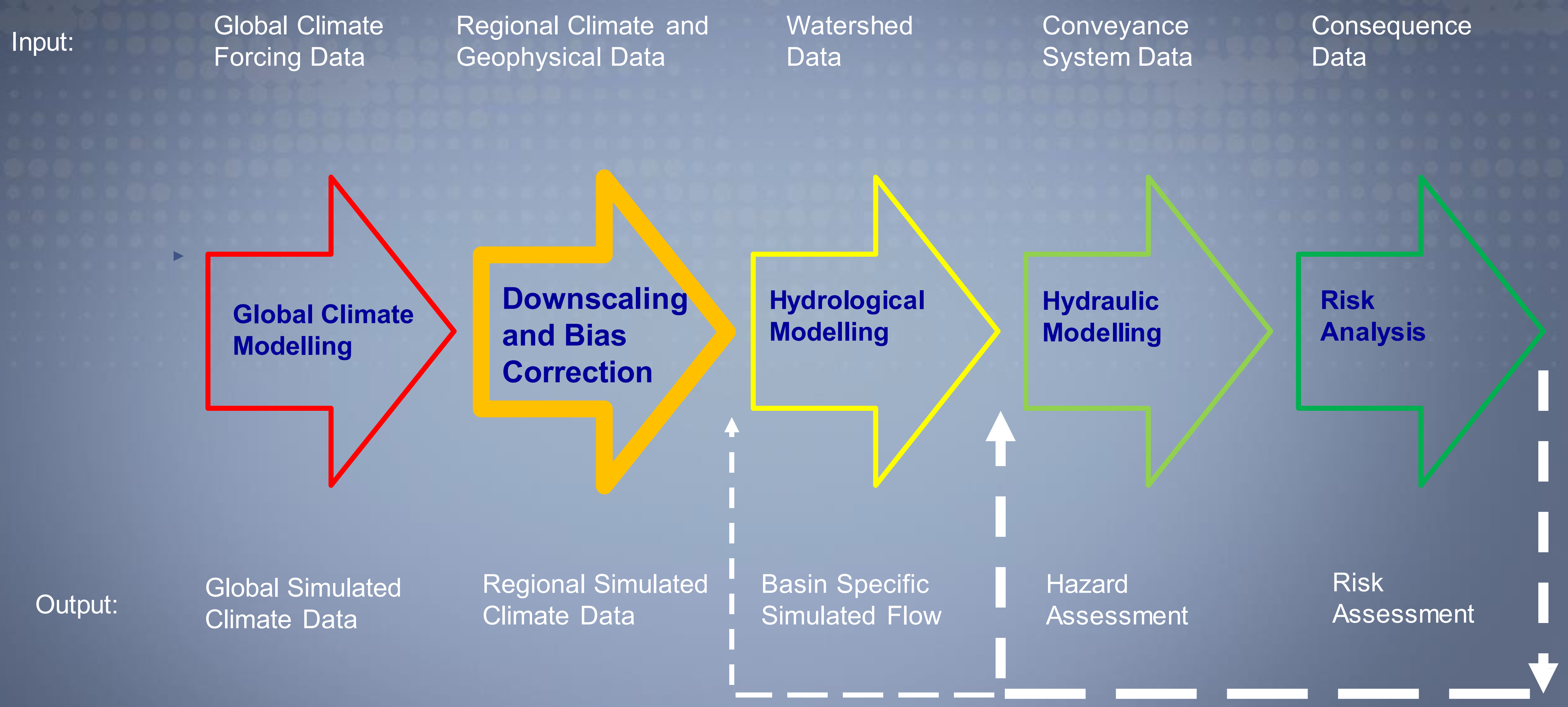
LSMs simulate the exchange of water and energy fluxes at the earth surface-atmosphere interface.

Source: U.S. National Oceanic and Atmospheric Administration

Impact of RCP Selection and Time Horizon - Temperature



Source: PLUS 4013:19, Technical guide: Development, interpretation and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resources practitioners.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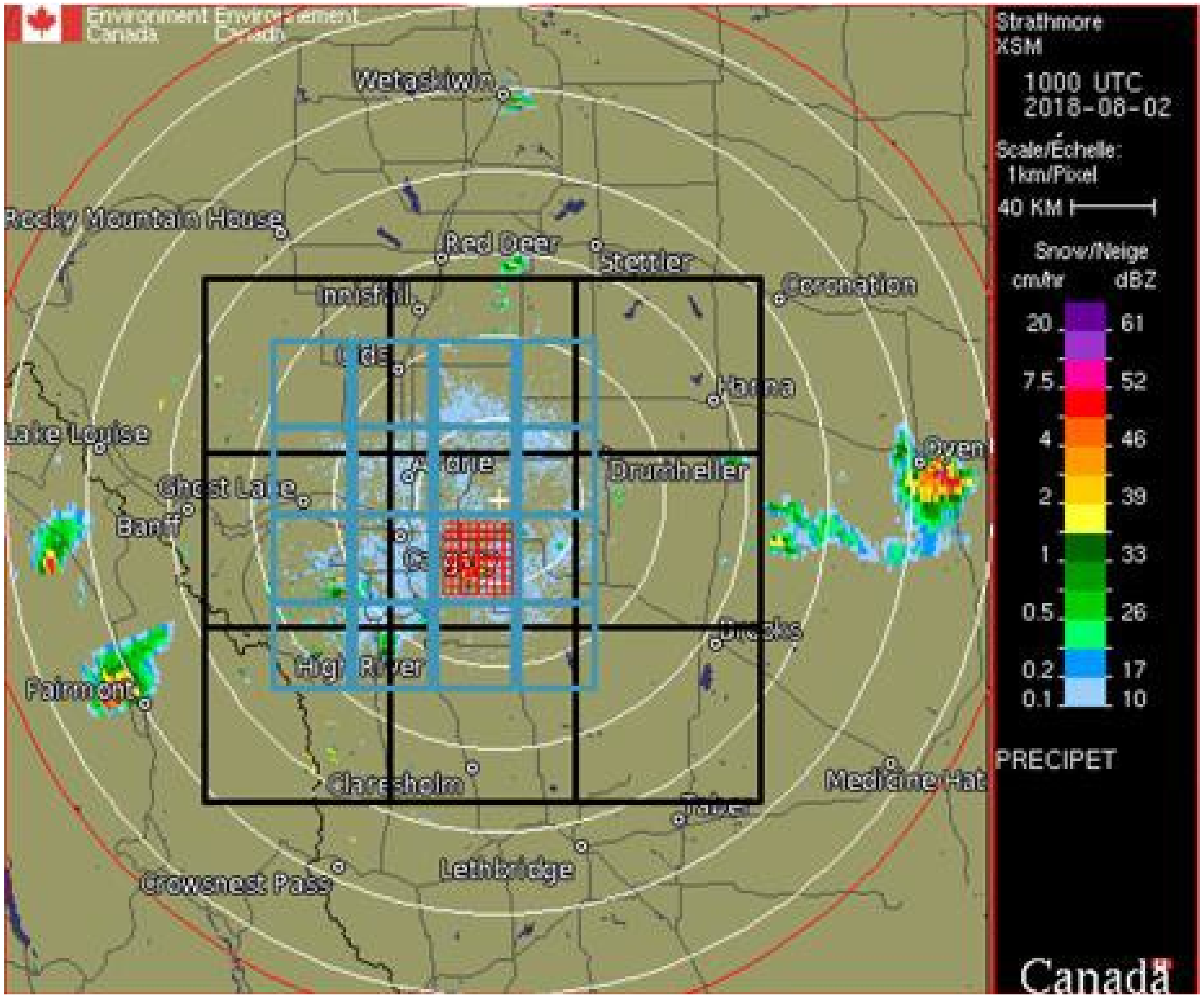
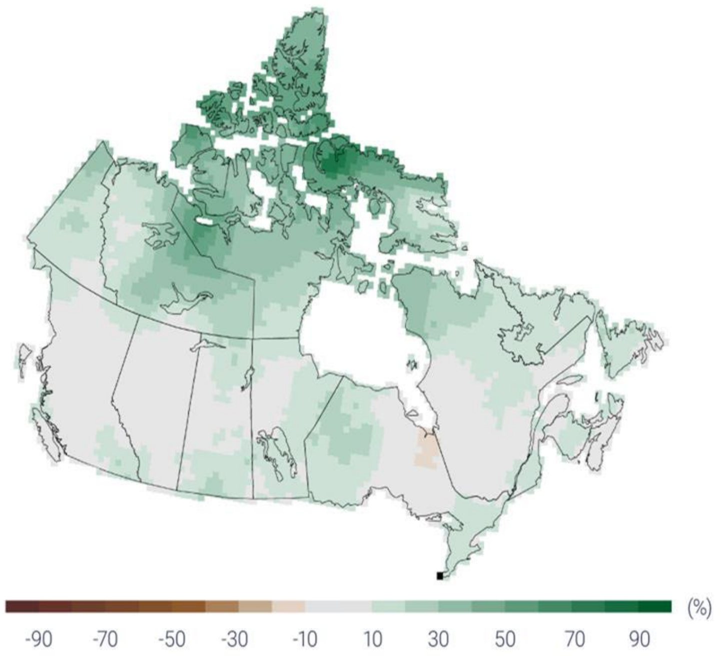
Spatial downscaling to create RCMs

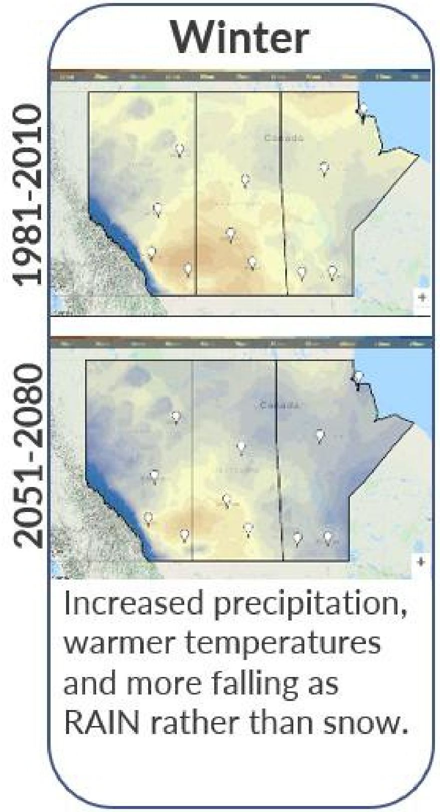


Courtesy of Environment Canada and Climate Change

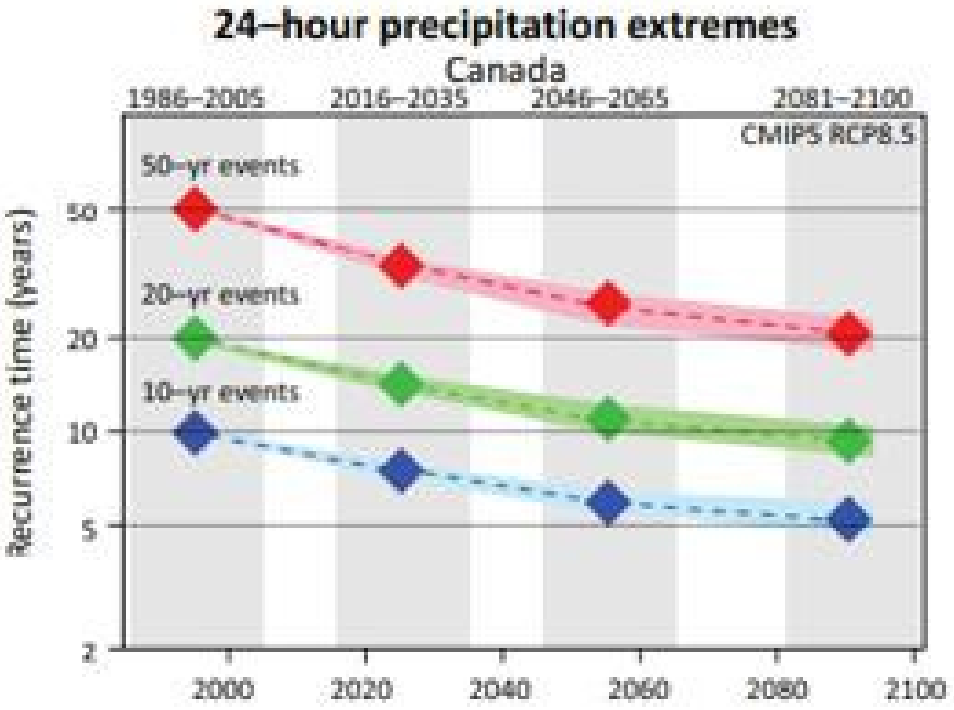
Temporal scale examples of Annual, Seasonal and Daily Rainfall



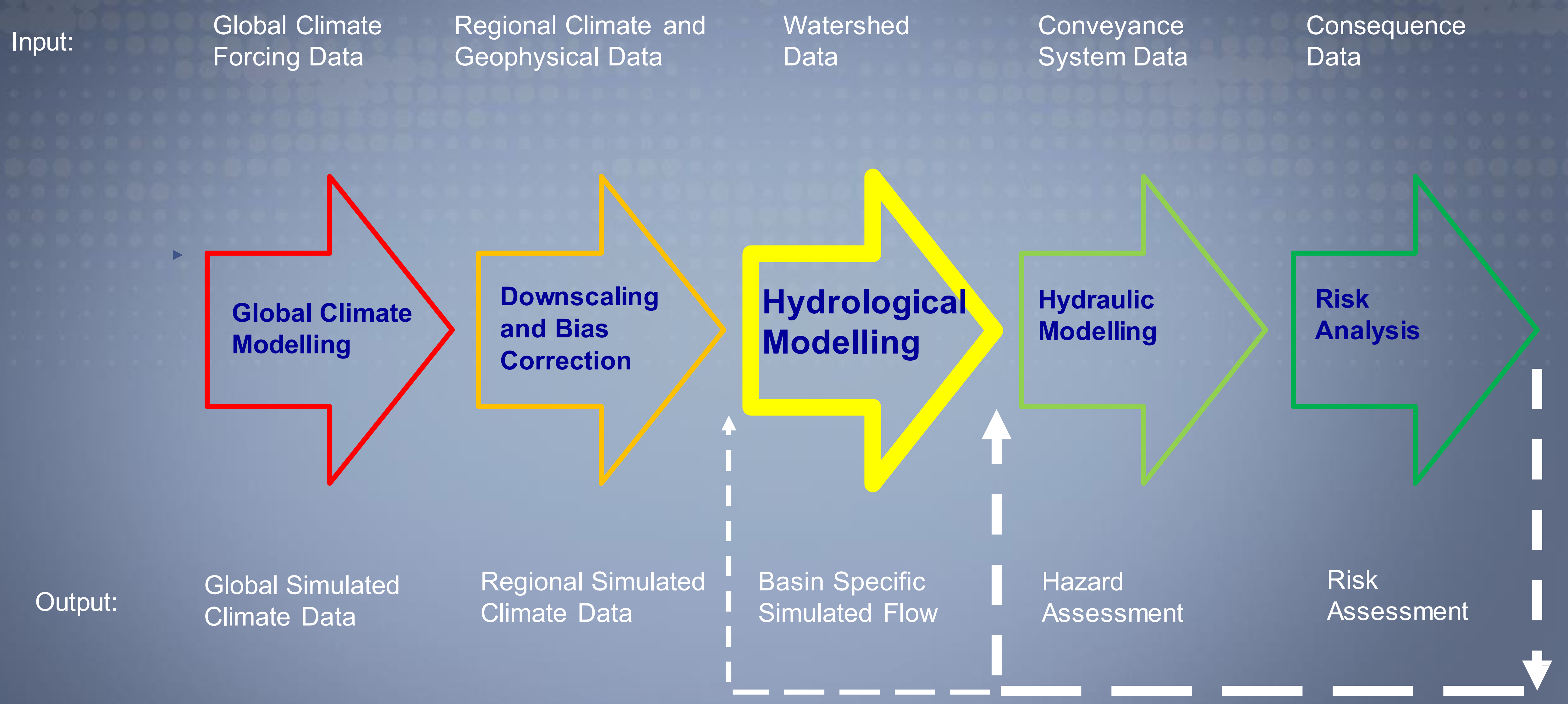
Historical National Precipitation Trends (1948-2016)



Constructed from images from Prairie Climate Atlas.



Source: PLUS 4013:19, Technical guide: Development, interpretation and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resources practitioners. © 2019 Canadian Standards Association. Please visit store.csagroup.org



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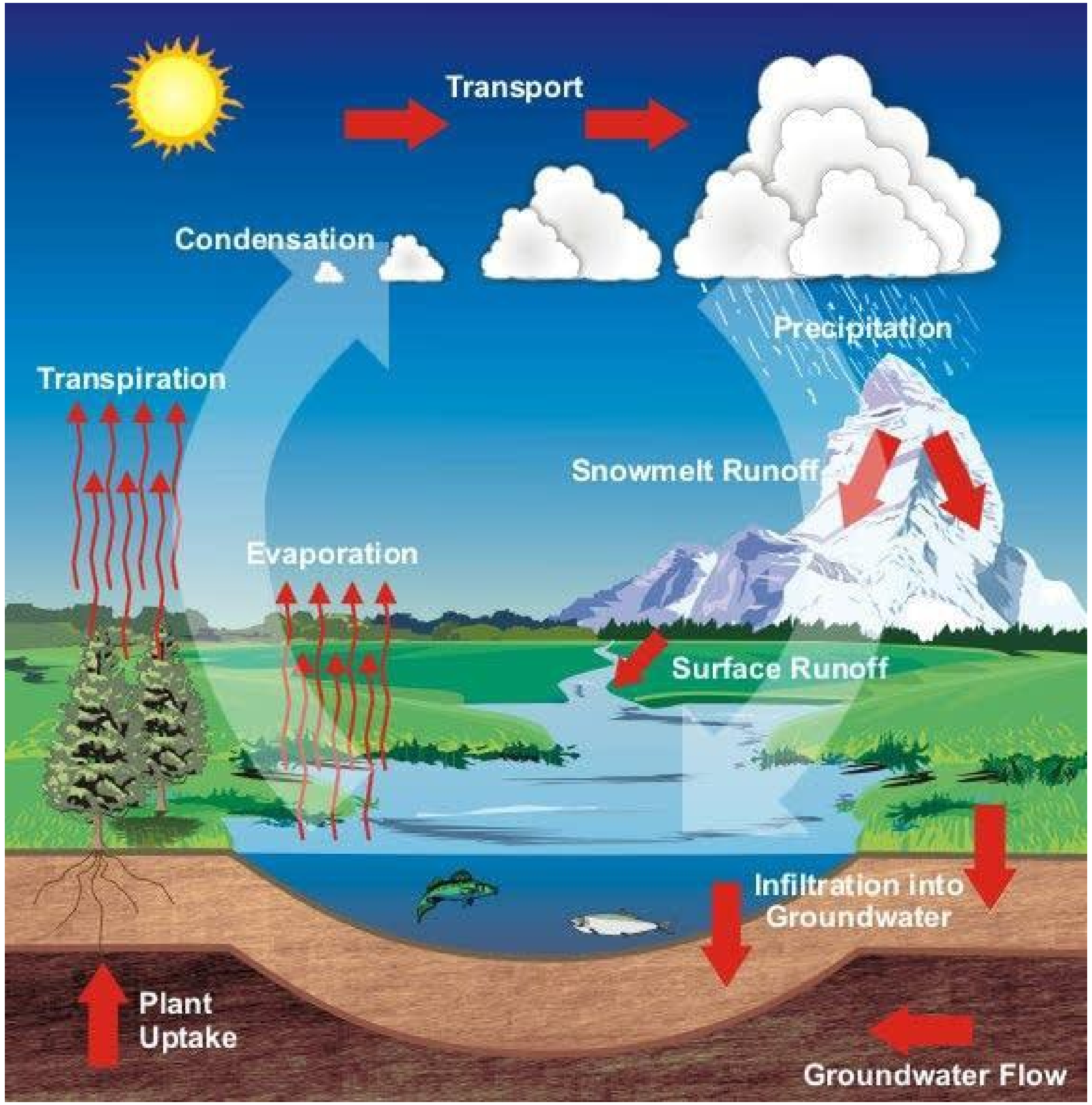
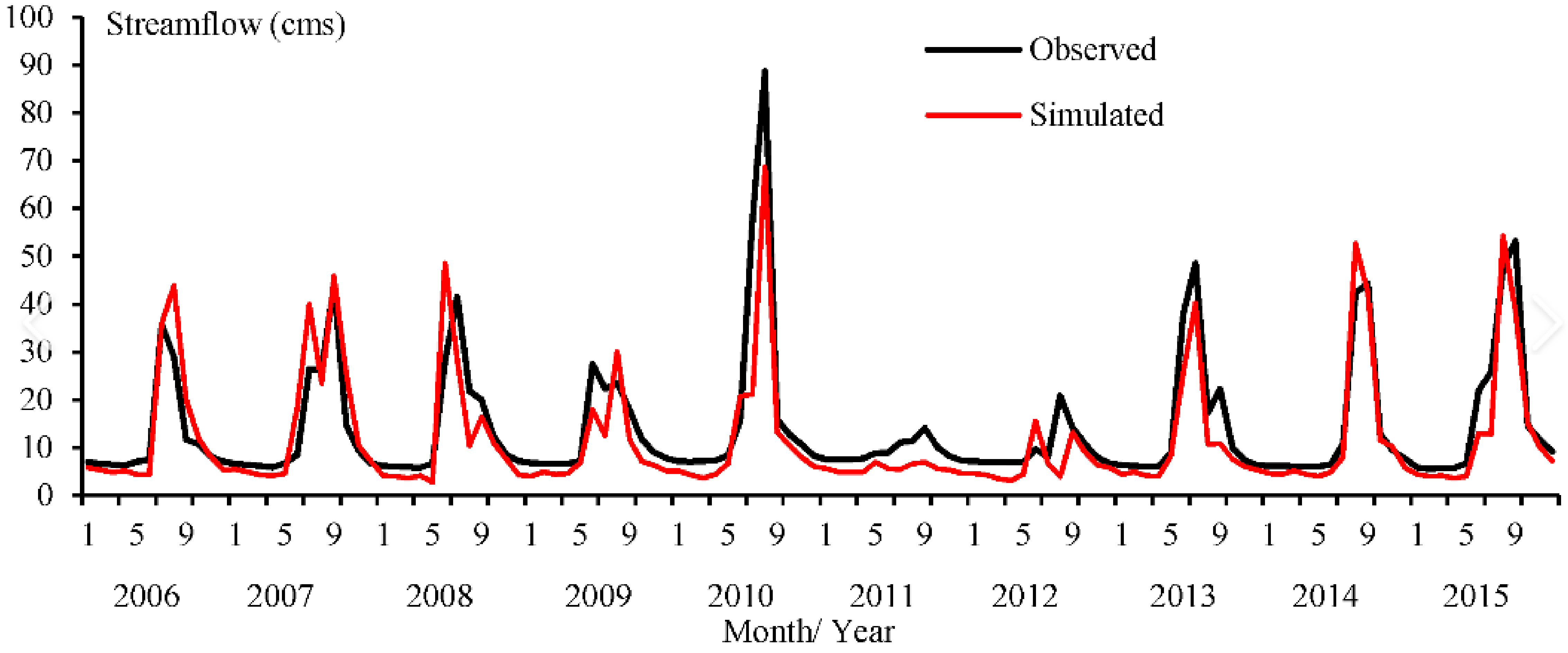
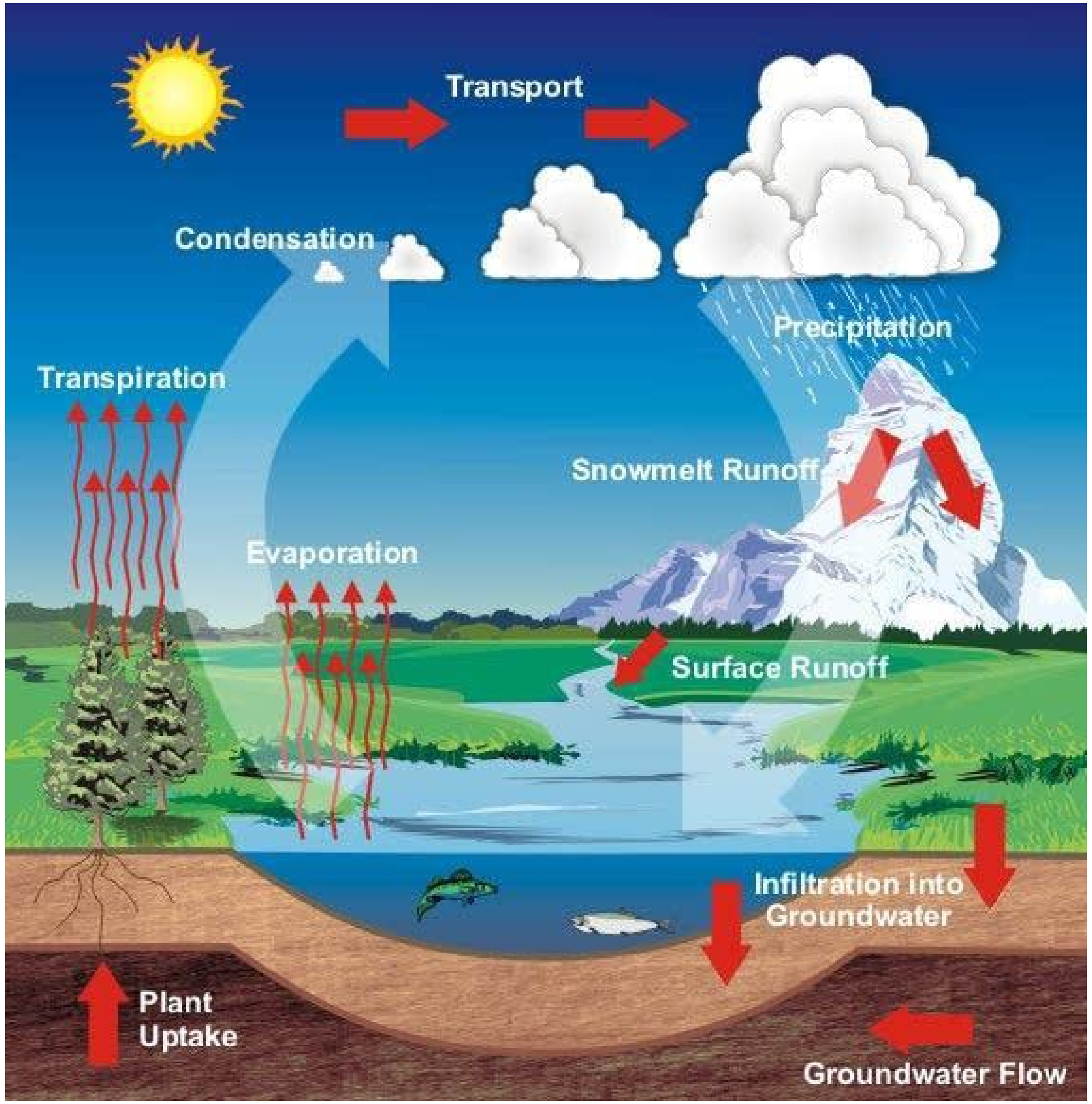
Hydrologic Modelling – Existing Conditions



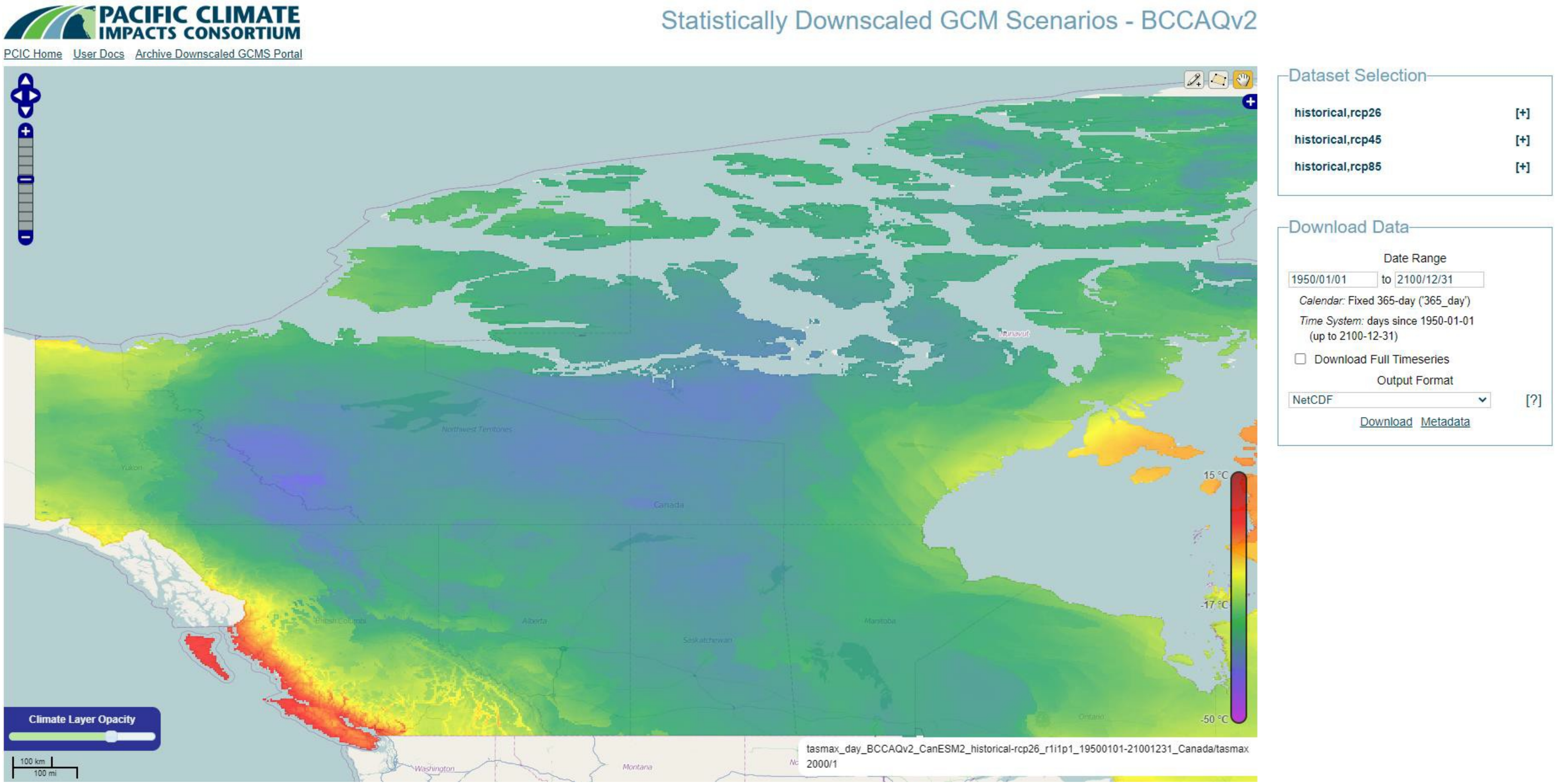
Model Calibration/Verification



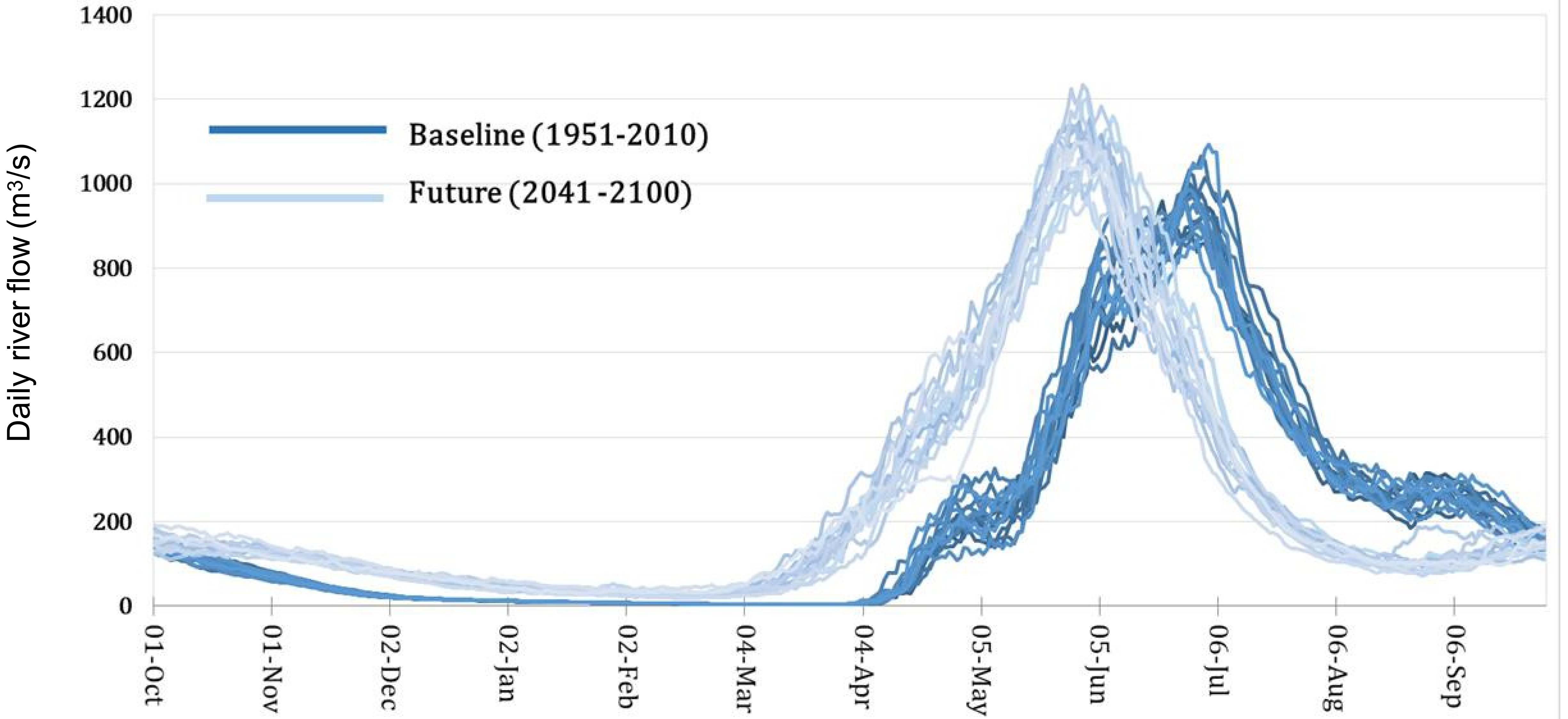
Hydrologic Modelling with Climate Change



Sample Gridded Hydrological Data



Past and Future Water Year Hydrographs, NSR at Edmonton



Anis and Sauchyn, 2021

Session 1: Key Messages

- Climate change is affecting the magnitude, timing and frequency of hazards.

- Fundamental mechanisms driving hazard events can be changing, therefore historical records are not valid to predict future events; must rely on modelling.

- Hazards can be increasing, decreasing or staying the same. Must evaluate potential changes at an appropriate spatial and temporal scale.

Polling Questions - Assessing Impacts of Climate Change on Flood and Drought

Session 2: Understanding Risk

What is Risk?

Risk = Likelihood of Event x Consequences of it Occurring

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Severe
Frequent					
Likely					
Possible					
Unlikely					
Rare					

Domain:

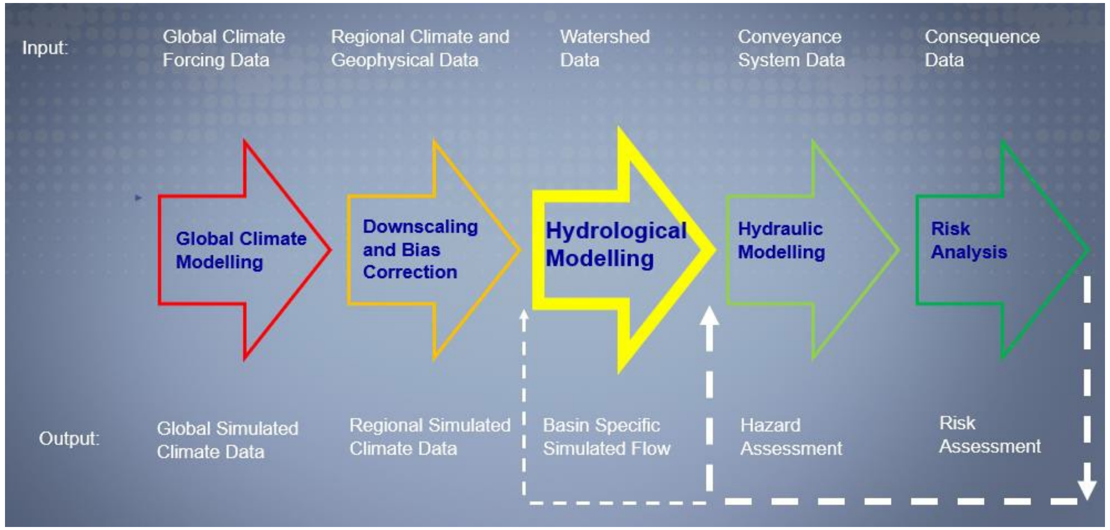
- What hazard(s)?
- Where?

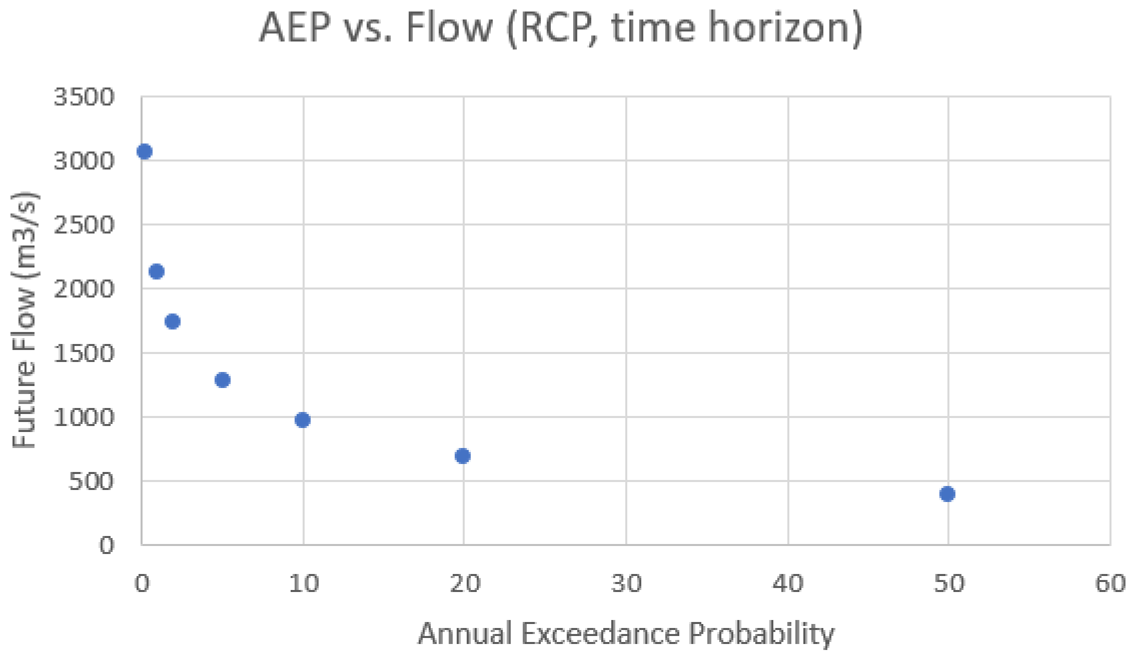
….How do we quantify risk?

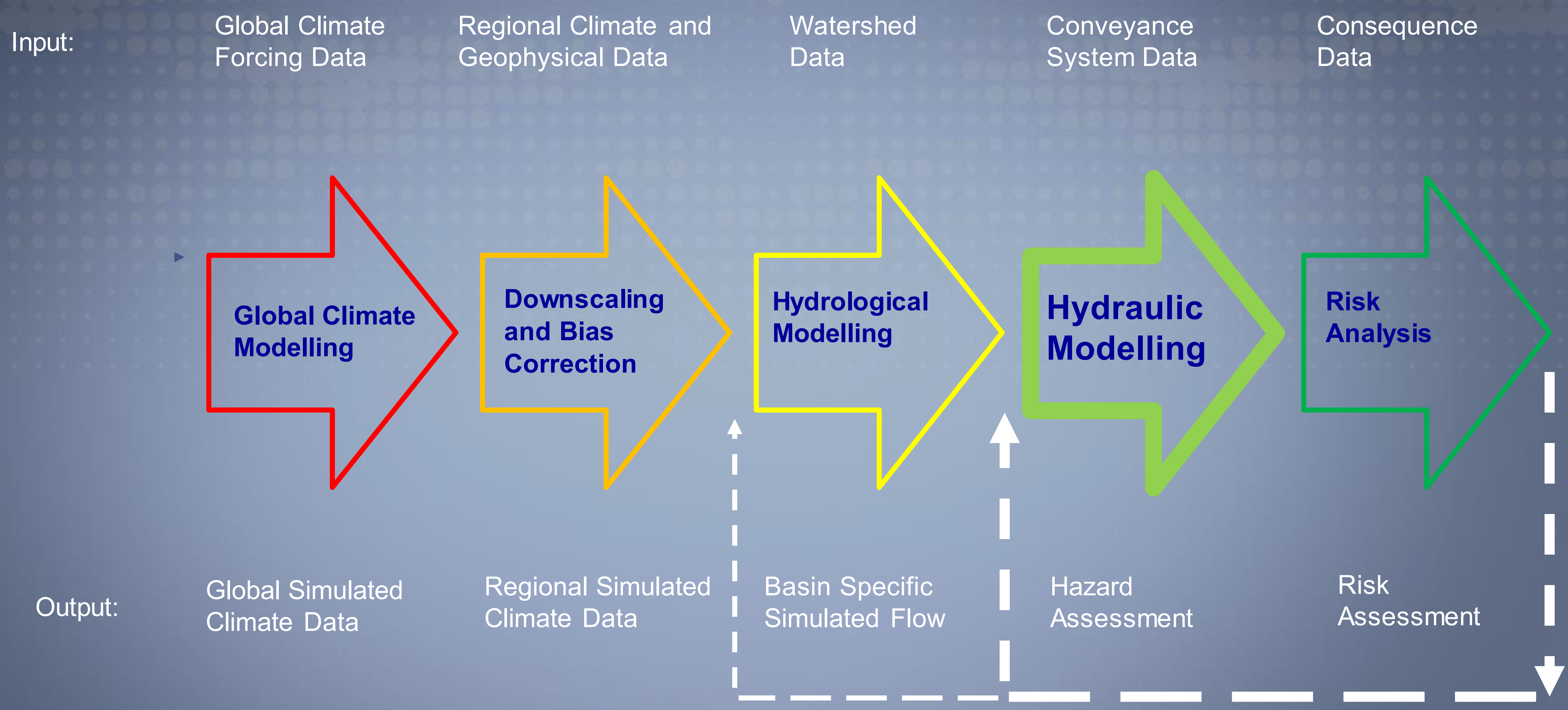
Adapted from PIEVC Risk Table, Engineers Canada

Likelihood – Flooding Example

- For each hazard, we need to estimate:
  - Annual Exceedance Probability (aka likelihood or 1/Return Period)



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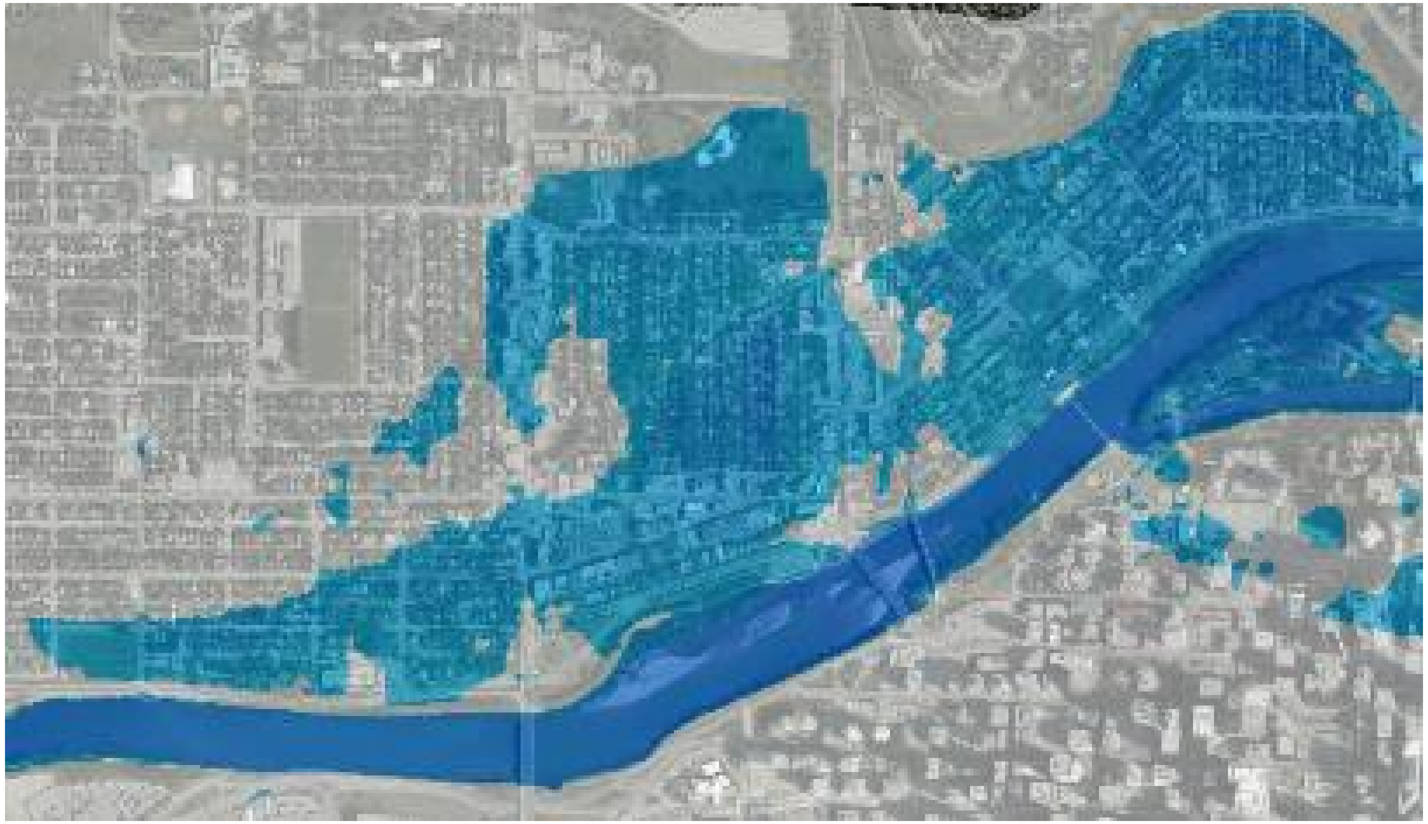
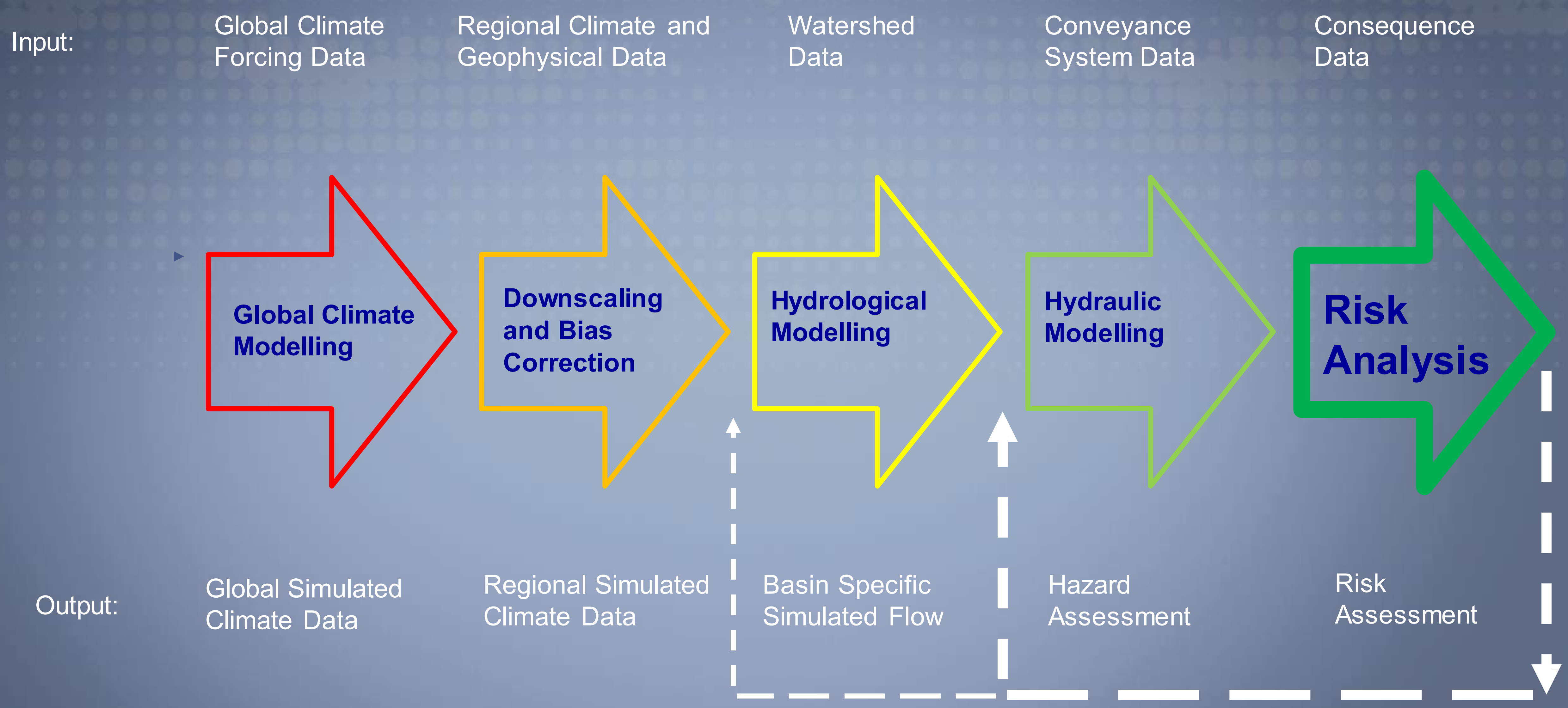
Flood Inundation Mapping, Bow River, Calgary



To understand consequence, we need to understand what is exposed, its vulnerability, and its value.

For illustrative purposes only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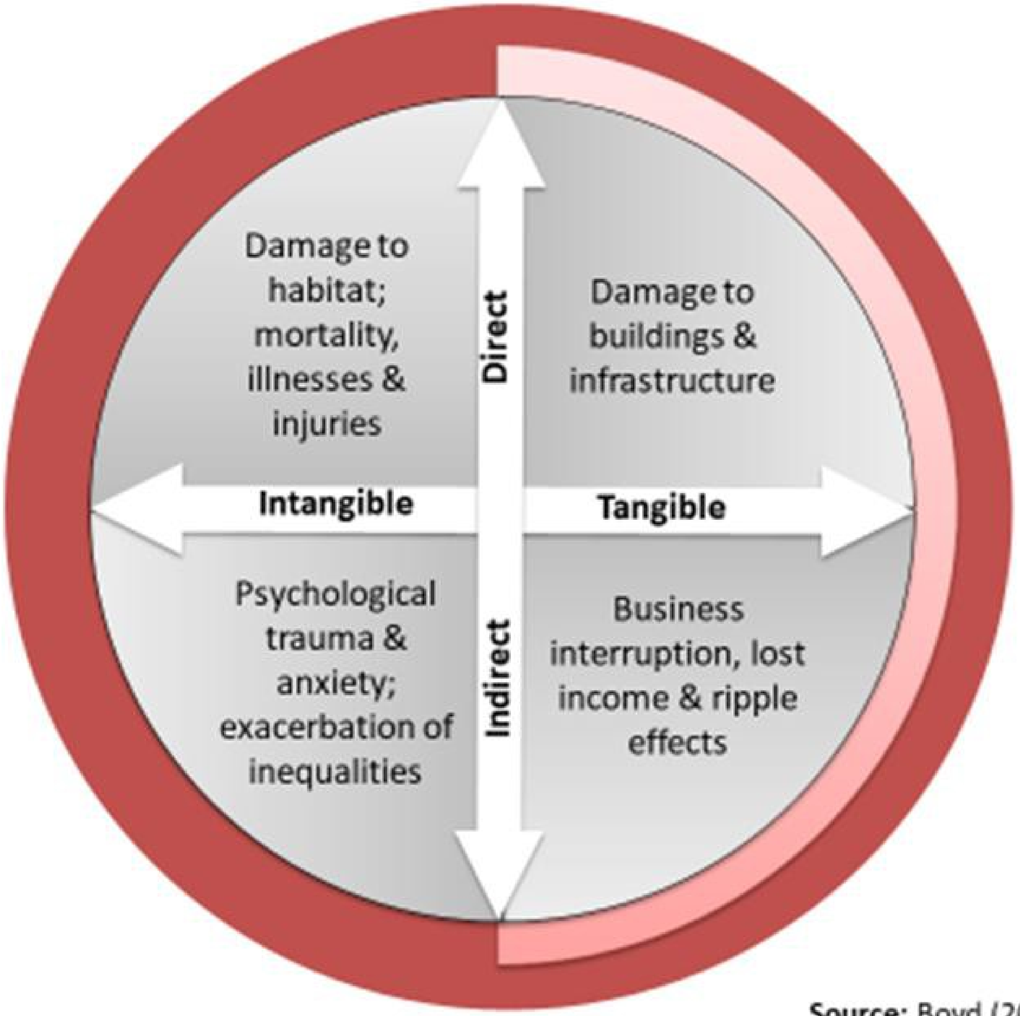
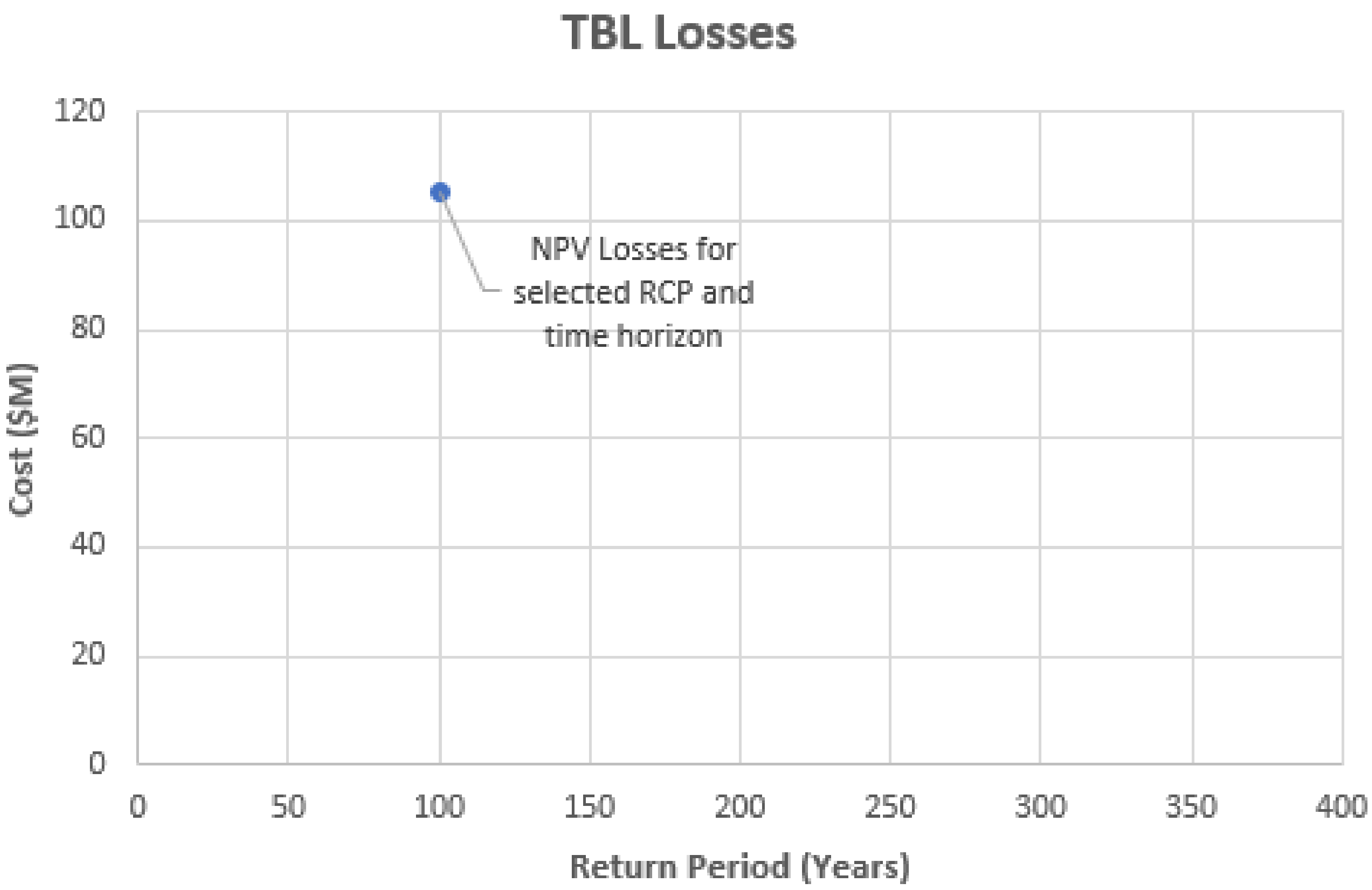
Consequences

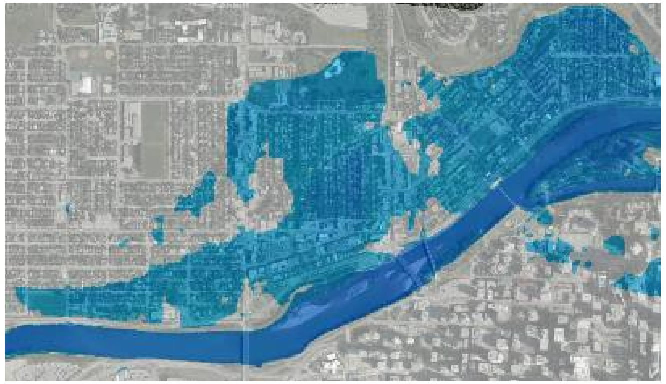
- Economic
- Social
- Environmental

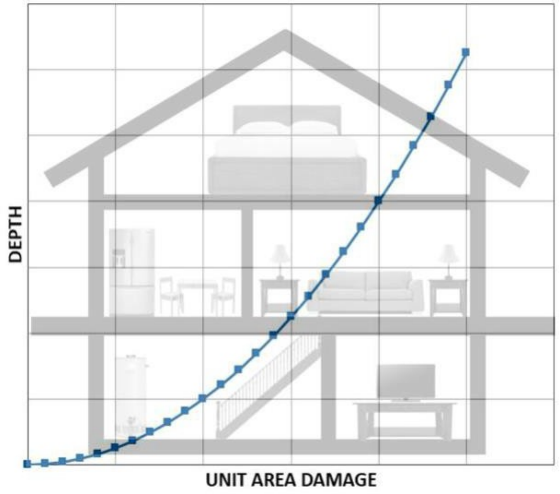


Source: Boyd (2018)

Standards-Based Flood Risk Assessment







Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Severe
Frequent					
Likely					
Possible					
Unlikely					
Rare					

For illustrative purposes only

Session 2: Key Messages

- Risk = Likelihood x Consequences
- Modelling is required to assess likelihood of an event under future climate.
- Consequences include direct and indirect losses, and tangible and intangible elements, but level of inclusion can vary.
- Risk can be quantified for a particular magnitude event.

Q&A (10 mins) and Break (5mins)

Session 3: Managing Risk through Adaptation

Why Adapt?

- Current infrastructure is generally designed based on historical records
- This assumes that the climate (and other factors) are stationary
- The climate is changing as are the likelihood and magnitude of events
- Leads to insufficient resiliency against some hazards
- Need to re-evaluate acceptable risk

Flood Risk Example

7		Catastrophic 0.800	0	7	14	21	28	35	42	49
6		Hazardous 0.400	0	6	12	18	24	30	36	42
5		Serious 0.200	0	5	10	15	20	25	30	35
4		Major 0.100	0	4	8	12	16	20	24	28
3	SEVERITY	Moderate 0.050	0	3	6	9	12	15	18	21
2		Minor 0.025	0	2	4	6	8	10	12	14
1		Measurable 0.0125	0	1	2	3	4	5	6	7
0		No Effect	0	0	0	0	0	0	0	0
			negligible or not applicable	improbable 1:10 000	remote 1:1 000	occasional 1:500	moderate 1:100	probable 1:25	frequent 1:5	continuous 1:1
			PROBABILITY							
			0	1	2	3	4	5	6	7

Climate Change

Adaptation

Adapted from PIEVC Risk Table, Engineers Canada

Adaptation Examples: Flood and Drought Resilience

	Flood	Drought
Structural	• Dyking (flood boxes and pump stations) • Diversion • Storage	Supply Management • Storage • Diversion • Irrigation network
Non-Structural	• Floodplain Development Bylaws • Managed Retreat • Wetland protection	Demand Management • Agricultural practices • Low volume fixtures • Water use restrictions

Adaptation

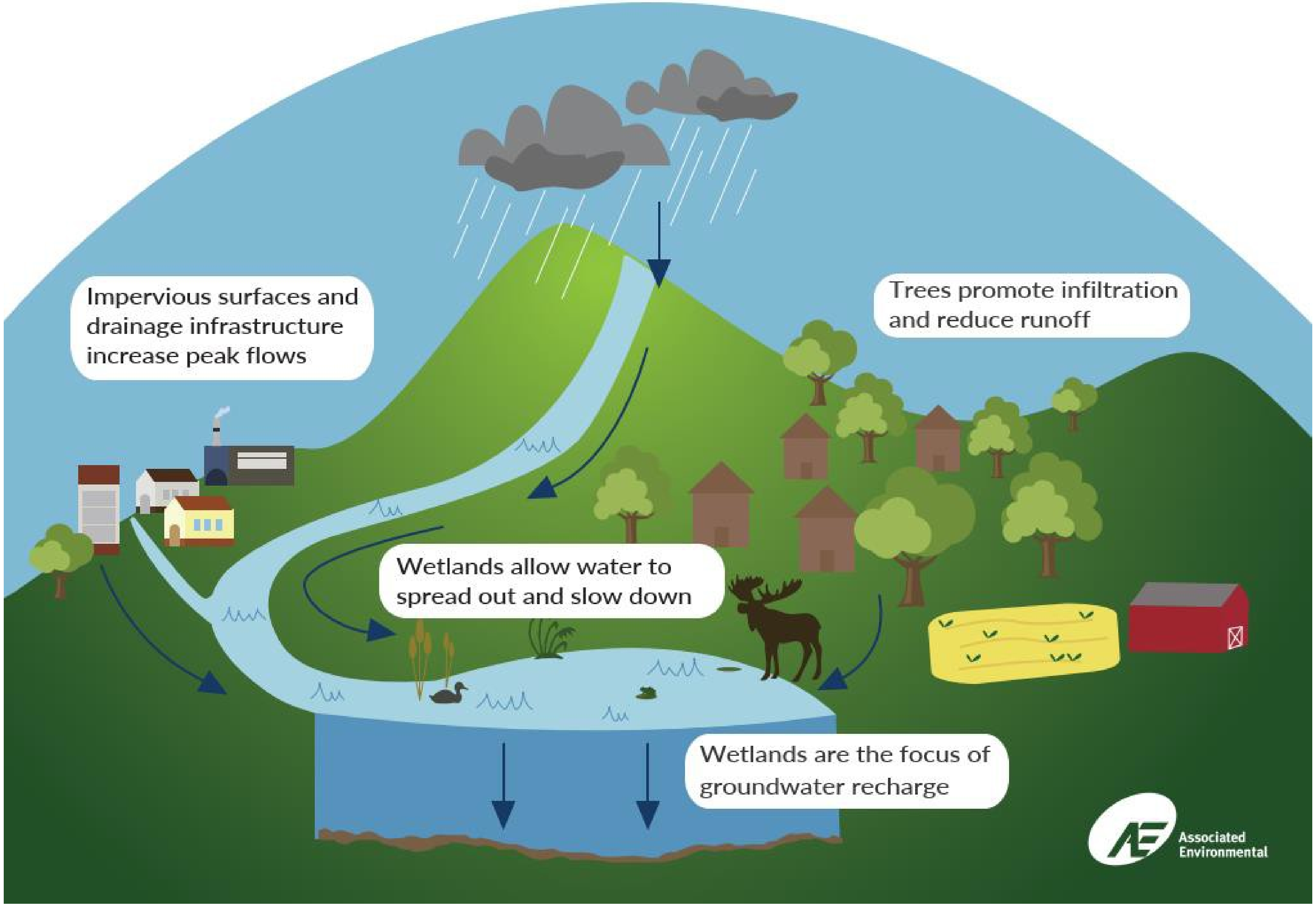
Structural solutions are sometimes necessary to provide resilient systems. Policy and Soft Engineering Solutions typically provide superior value.

As a general rule, in order of preference, the most cost-effective means to mitigate flood and drought hazard is as follows:

1. Retain what you have
2. Restore what you've lost and
3. Build what you must.

Watershed Management and Non-structural “Nature Based” Solutions

Watershed Health, Flooding, and Drought



Adaptation Key Components

Adaptive Capacity

- Flexibility in the face of unexpected and predicted hazards

Mitigation

- An adaptive act to reduce root causes

Resilience

- A kind of adaptation that secures desired function in the face of change

Riparian Ecosystems and Floodplains

Filters to Recovery – Over-Steepened Slopes

Filters to Recovery – Soil Compaction

Filters to Recovery – Dense Weed Growth

Simple Choices: a) View or b) Stable lake shore

Nature-Based Solutions: Soil Bioengineering

- Resilient ecosystems are ones that can absorb an impact and maintain function
- Sensitive areas where trees were removed are susceptible to erosion and slumping during major precipitation events
- Restoring native woody vegetation creates resilience to flooding

Soil Bioengineering

- Use of plants to perform an engineering function
- Root systems provide root strength and root zone diversity
- Dense woody vegetation reduces flow velocities
- Self healing and self sustaining
- Lower cost and typically installed by hand
- Other benefits include biodiversity, carbon sequestration, habitat

Slope at Reservoir– May 15, 2018

Slope at Reservoir– April 24, 2018

Live Staking with Balsam Poplar

Slope at Reservoir– July 16, 2018

Slope at Reservoir– July 19, 2019

RMWB Post Wildfire Erosion/Drainage Control

RMWB Post Wildfire Erosion/Drainage Control

RMWB Post Wildfire Erosion/Drainage Control

Dense Live Toe Staking

Dense Live Toe Staking

Wattle Fence

Wattle Fence

Wattle Fence

Silt Fence

Live Silt Fence

Live Silt Fence

Wetland Restoration to Build Resilience

- Wetlands store water reducing downstream flooding
- Wetlands allow water to spread out reducing erosion risk
- Biological and chemical process improve water quality
- Wetlands function to replenish groundwater
- Source of hay during drought

Restoring Floodplain Wetlands

Restoring wetlands by Disabling Ditches

October 10, 2019

July 12, 2020

Restoring Wetlands by Disabling Ditches

Restoring Wetlands by Disabling Ditches

Weeds replaced with native wetland plants after hydrology is restored

Restoring Wetlands for Source Water Protection

September 9, 2020

August 9, 2021

Creating Wetlands at Stormwater Facilities

Creating Wetlands Around Dugouts

Creating Wetlands by Establishing Basins

Land Use Policy

Policy limiting development and removal of natural assets

- Wetland Policy
- Fisheries Act
- Floodplain Development
- Riparian Buffers

Session 3: Key Messages

Nature-based and Policy-based adaptation solutions provide good value. Therefore, we re-iterate:

1. Wetlands and riparian vegetation are natural assets that improve watershed resilience and mitigate flooding and drought.

2. Degraded ecosystems are highly susceptible to impacts.

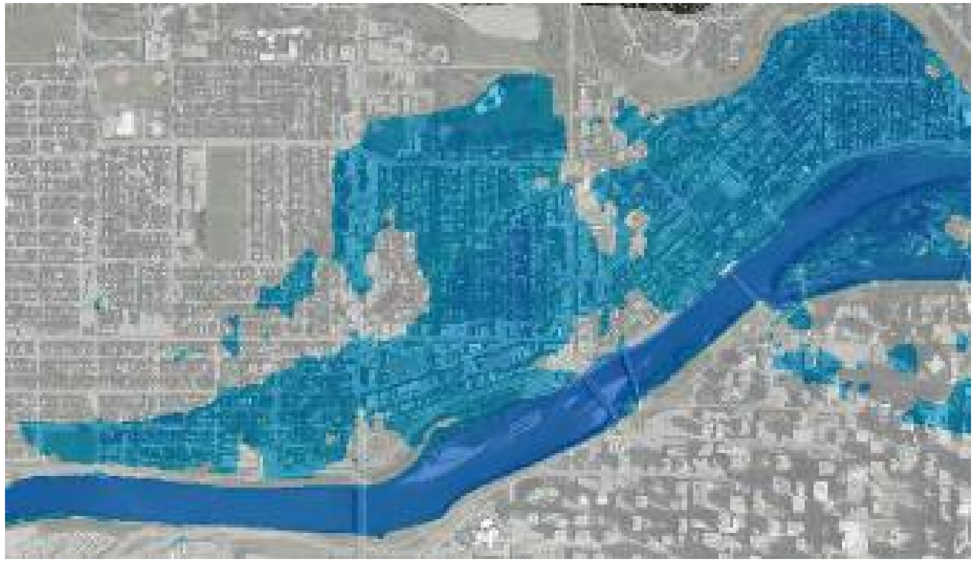
3. Retain what you have, restore what you've lost and build what you must.

Q&A/Polling Question (10 min) and Break (5min)

Session 4: Assessing Value of Adaptation Strategies

Cost and Benefit Assessment Example - Flood

Adaptation Options



Structural

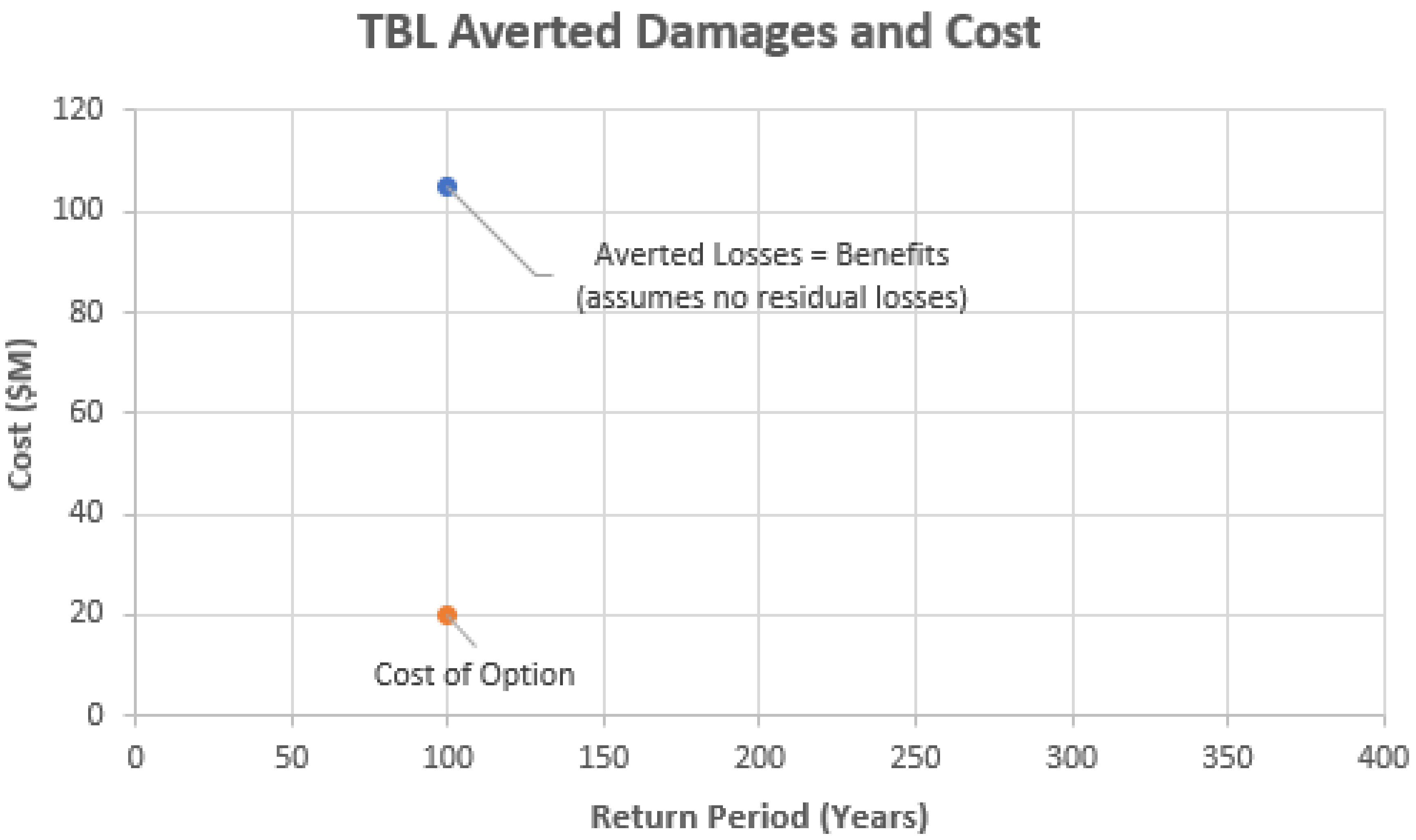
- Option 1: Dyke alignment 1
- Option 2: Dyke alignment 2
- Option x….

Non-Structural

- Option 1: Do nothing (= Cost of Inaction)
- Option 2: Managed Retreat
- Option x….

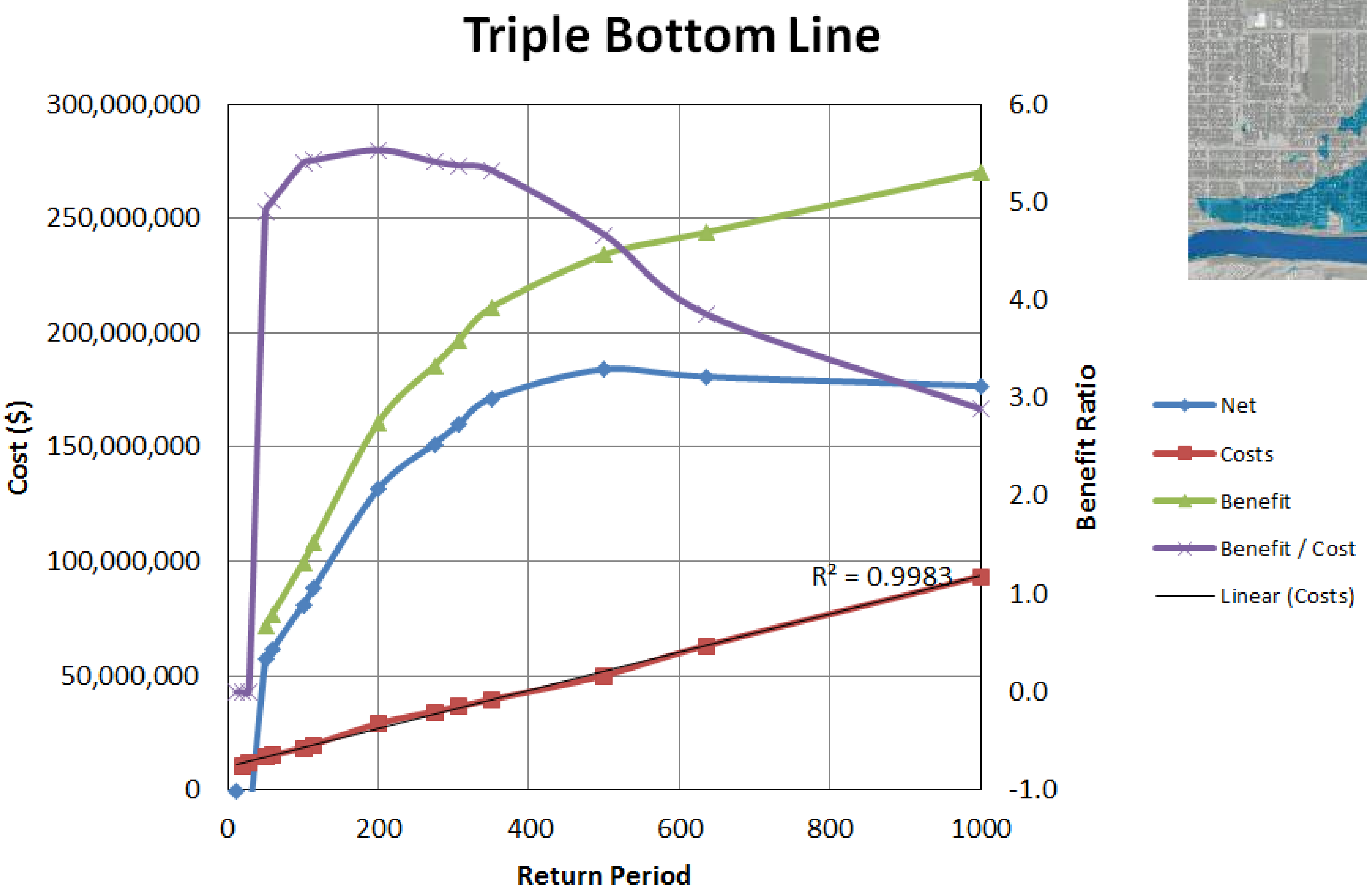
For illustrative purposes only

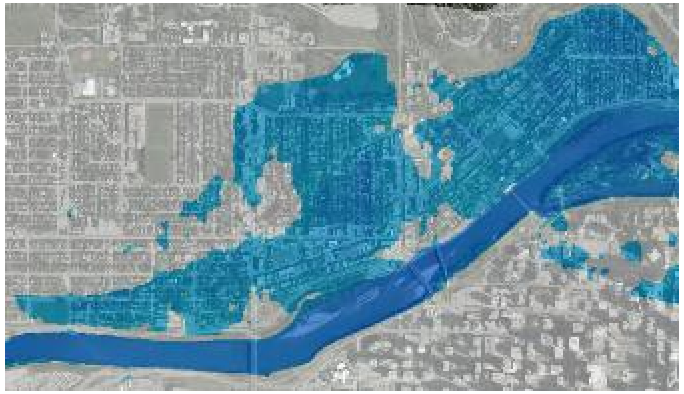
Standards-Based: Structural Option 1



For illustrative purposes only

Risk Based Flexible Design – Structural Option 1





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Risk-Based Flexible Design

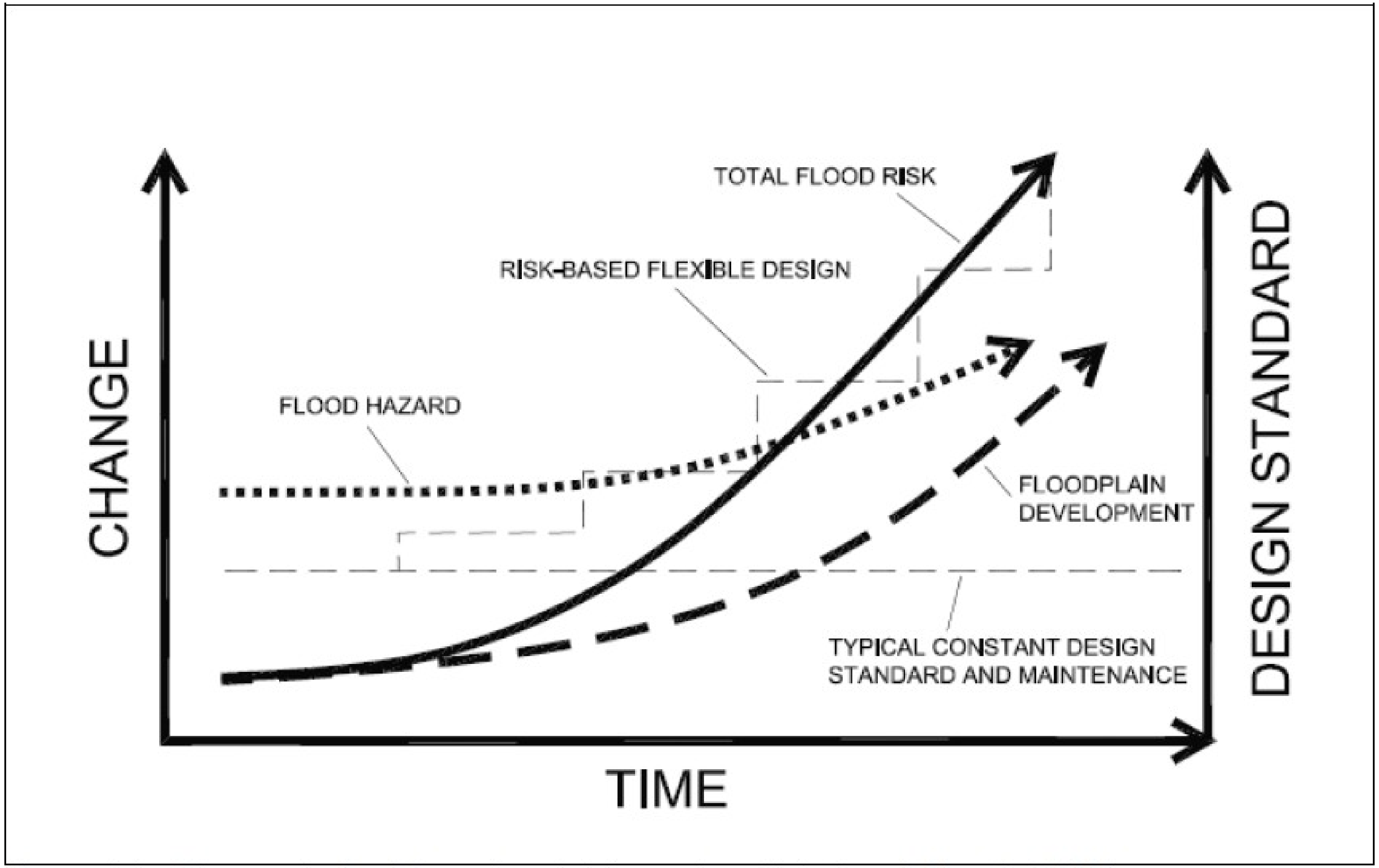
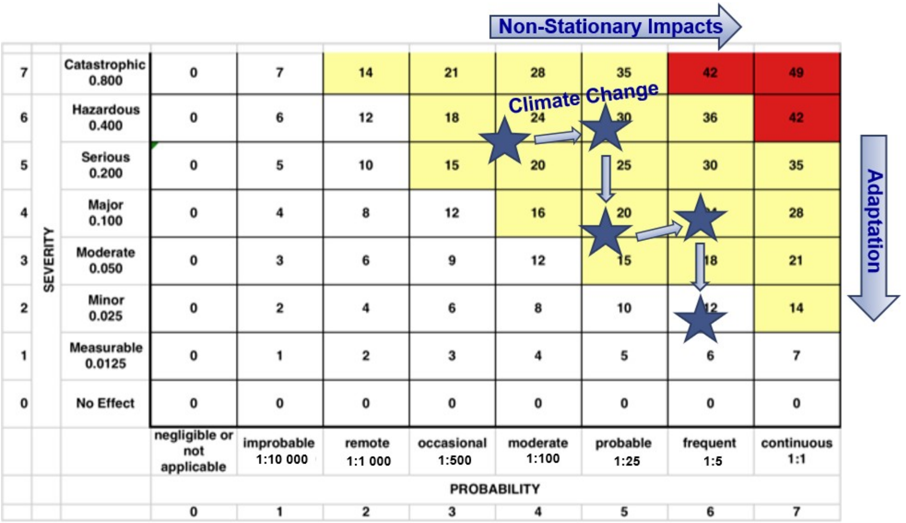


Figure 1-1: Changes in *flood hazard* and *risk* over time (Jakob and Church, 2012).



	SEVERITY									
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4		Major 0.100	0	4	8	12	16	20	[illegible]	28
3		Moderate 0.050	0	3	6	9	12	15	18	21
2		Minor 0.025	0	2	4	6	8	10	12	14
1		Measurable 0.0125	0	1	2	3	4	5	6	7
0		No Effect	0	0	0	0	0	0	0	0
			negligible or not applicable	improbable 1:10 000	remote 1:1 000	occasional 1:500	moderate 1:100	probable 1:25	frequent 1:5	continuous 1:1
			PROBABILITY							
			0	1	2	3	4	5	6	7

Adapted from PIEVC Risk Table, Engineers Canada

Session 4: Key Messages

- Assessing value of an adaptation option to improve resilience can be based on a fixed standard.
- The level of service of a fixed design standard will change over time due to non-stationary factors, including climate change.
- Enhanced value can be derived by allowing a flexible level of service (i.e. annual exceedance probability).
- A risk-based flexible design can maintain an appropriate level of service for best value.

Session 5: Effective Communication: Achieving Resilience

Effective Communication: Achieving Resilience for Watershed Management

Socio-Ecological Systems Framework

- System of people and nature
- Linkage between ecological system and management practice is based on knowledge
- Resilient systems are those that have capacity for social learning and self organization

Social Learning

- A property of social collectives
- Capacity and processes through which new values, ideas and practices are disseminated, popularized and become dominant in society
- Has a role in transitional and transformational adaptation

Self Organization

- The propensity for social collectives to form without direction from higher level institutions or actors
- Includes formal and informal groups (neighbours, NGO's)
- Supportive of innovation and rich in trust
- Creates a realm for learning, novel values and practices to emerge

Role of Social Learning and Self Organization

- Individuals and organization can work to transfer information
- Addressing climate change not only as technical but also the social and political agenda
- Promote conversations between science and policy
- Relating vulnerability and subsequent adaptation to wider social processes
- Akin to the distinction between treating the symptoms and causes

Polling Questions – Examples of Effective Communication

Take 2 minutes and enter suggestions for effective communication – Word Art

Session 5: Key Messages

- Communication occurs through several dynamic processes
- Range of knowledge, politics and underlying values shapes how information is received
- Communication with other people plays a significant role in how people come to understand and act on climate change

DISCLAIMER

THANK YOU!

If you have any questions, please contact info@climatewest.ca

To download this presentation and additional resources please visit: climatewest.ca

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Building Prairie Resilience