

Saskatchewan's Natural Hazards Risk Assessment



V. Wittrock¹, R.A. Halliday², D.R. Corkal³, M. Johnston¹, E. Wheaton⁴

¹Saskatchewan Research Council

²R. Halliday & Associates

³Walker Projects Consulting Engineers

⁴EWheaton Consulting

Invited Presentation to Prairie Provinces Water Board
Committees on Flow Forecasting & Hydrology Workshop
Edmonton, AB
November 27-28, 2019



SRC Publication No. 13749-3D19

Copyright © SRC 2019

Saskatchewan Flood and Natural Hazard Risk Assessment

Between January 2016 and December 2018, we (*V. Wittrock, R.A. Halliday, D.R. Corkal, M. Johnston, E. Wheaton, J. Lettvenuk, I. Stewart, B. Bonsal and M. Geremia*), under the guidance of *Saskatchewan Ministry of Government Relations*, completed a 250+ page comprehensive report.

Note: Community consultation was a major portion of this work

<https://www.saskatchewan.ca/government/news-and-media/2018/december/17/natural-hazards-risk-assessment-report>



Saskatchewan Flood and Natural Hazard Risk Assessment

Prepared for Saskatchewan Ministry of Government Relations

By V. Wittrock¹, R.A. Halliday², D.R. Corkal³, M. Johnston¹, E. Wheaton⁴, J. Lettvenuk¹, I. Stewart⁵, B. Bonsal⁶ and M. Geremia³



SRC Publication No. 14113-2E18
May 2018
Revised Dec 2018

R. Halliday
& ASSOCIATES
CONSULTING ENGINEERS
MANAGEMENT

WALKER PROJECTS
Consulting Engineers - Project Managers

EWheaton
Consulting



Copyright © SRC 2019

Summary

Saskatchewan's economy, citizens and environment are vulnerable to natural disasters, ranked in severity as follows:

Drought > Severe Weather > Forest Fires > Floods



- Risks were determined on a provincial scale
- Current adaptations reduce impact severity
- Resilience can be increased by enhancing adaptations for the projected greater risks:
 - Drought planning
 - Expanded emergency preparedness planning and response
 - Hydrological analysis and topographic mapping (lidar)
 - Stakeholders desire engagement, government leadership, improved inter-agency coordination, strengthened resilience

Risk Matrix Developed for Saskatchewan

Impact Categories (Emergency Management Ontario 2012, Public Safety Canada 2012, White 2016, Australian Government Attorney-General's Department 2015, consultations with various provincial government ministries 2017)					Likelihood Categories																				
Human Health and Safety	Social	Public Administration	Economic	Environment	Percent chance of occurrence in any given year	Less than 1%	One to <10%	10 to <50%	50 to <100%	100% chance of occurrence															
					Qualitative Description (Standard for all levels)	The event/condition may occur only in exceptional circumstances	The event/condition could happen at some time	The event/condition should occur at some time	The event/condition will probably occur in most circumstances	The event/condition is expected to occur in all circumstances															
Deaths, Injuries, Illness, Psychosocial Stress	Communities, Culture, Relationships	Provincial Scale	Direct and Indirect Economic Implications (including Infrastructure)	Air/Land water Biodiversity	Likelihood Descriptions Impact Descriptions	Rare	Unlikely	Possible	Likely	Almost Certain															
<ul style="list-style-type: none"> Multiple public facilities (DSE and/or critical facilities) with long term or permanent impairment (DSE) Extreme and ongoing consequences of regional health-related standards (e.g., CCME Selection Guidelines or Canadian Incident Air Quality Standard) Community evacuations of 250,000 people 	<ul style="list-style-type: none"> Permanent reduction in quality of life of impacted and nearby communities Permanent degradation of surrounding values and natural resources Extreme and ongoing consequences of regional health-related standards (e.g., CCME Selection Guidelines or Canadian Incident Air Quality Standard) Impacts related to development or decisions result in long and visible campaigns of civil disobedience Widespread permanent loss to culturally significant places 	<ul style="list-style-type: none"> Multi-municipal, provincial, national and international, specialized response Provincial government is unable to deliver their core functions, partially or wholly Violation of international and national treaties or agreements Severe, permanent loss of stakeholder and public trust in the provincial government 	<ul style="list-style-type: none"> Failure of a significant industry or sector in the jurisdiction as a direct result of the natural hazard event Economic decline and / or loss of asset value greater than 1% of the provincial GDP (2016) Closure of an entire tourism sector Permanent loss of investment in the province Existing markets for Saskatchewan's natural resources in jeopardy Ability for efficient and leading companies to break even Reduction of both critical infrastructure and high value property 	<ul style="list-style-type: none"> Significant regional or national damage incapable of restoration Extensive tourism permanently disrupted or specific attraction closed 	Catastrophic					Extreme Risk															
					<ul style="list-style-type: none"> Multiple public facilities (DSE and/or critical facilities) with long term or permanent impairment (DSE) and/or human impacts (DSE) Ongoing consequences of regional health-related standards (e.g., CCME Selection Guidelines or Canadian Incident Air Quality Standard) Community evacuations of 10,000 people 	<ul style="list-style-type: none"> Quality of life for communities and surrounding area impacted for more than 10 years – major community social problems Values are degraded but partially recoverable over the long term Extensive consequences of communities Irreparable damage to high value structures or items of cultural and historical significance Impacts related to development or decisions result in long and visible campaigns of civil disobedience and are generally disruptive to the general public. Significant regionally widespread psychosocial impacts 	<ul style="list-style-type: none"> Provincial government bodies encounter severe reduction in the delivery of core functions Multi-municipal, provincial and national specialized response Abandonment of key provincial government objectives in the near-term and some not met Major loss of stakeholder and public trust over years, although recoverable with time Municipal governments unable to deliver core services 	<ul style="list-style-type: none"> Significant structural adjustment required by identified industry or business to respond to and recover from the natural hazard event Major damage and impact on critical infrastructure Economic decline and / or loss of asset value greater than 0.5% of the provincial GDP (2016) Major portions of a tourism sector impacted or suffer serious decline Major loss of investment in the province, recoverable over time Existing market access for Saskatchewan natural resources is threatened / new market access not achieved Ability for various business sectors to break even 	<ul style="list-style-type: none"> Significant regional damage not entirely capable of restoration Extensive disruption or reduced service to critical services Severe effects on environmental values 	Major					High Risk										
										<ul style="list-style-type: none"> Single facility and / or critical impacts with long term or permanent impairment (DSE) and / or serious impacts (DSE) Minor impacts, partial consequences of regional health-related standards (e.g., CCME Selection Guidelines or Canadian Incident Air Quality Standard) Community evacuations of 500 people 	<ul style="list-style-type: none"> Quality of life of affected region and surrounding area moderately impacted for up to 10 years Short term setbacks require no action or minor action Values are degraded but fully recoverable within 10 years Impacts related to development or decisions result in regional disruption to some and not consistently Significant localized psychosocial impacts including panic, self-transcending, hoarding Some damage or localized widespread damage of culturally significant objects 	<ul style="list-style-type: none"> Provincial government bodies encounter significant reduction in the delivery of core functions Abandonment of key provincial government objectives (partial significant) Reduction of stakeholder or public trust, short term duration (less than 1 month) Regional government bodies encounter severe reduction in the delivery of core functions Multi-municipal and provincial specialized response 	<ul style="list-style-type: none"> No adjustment or business sector is significantly impacted by the natural hazard, resulting in medium term (i.e., less than one year) profit reductions directly attributable to the event Minor portions of investment levels in the province Economic decline and / or loss of asset value greater than 0.05% of the provincial GDP (2016) Operation of 3-4 critical community infrastructure services 	<ul style="list-style-type: none"> Regional damage capable of restoration over time Disrupts but over years values affected tend to be moderate 	Moderate					Moderate Risk					
															<ul style="list-style-type: none"> One serious injury requiring medical care and hospitalization Advisable limits of regional health-related standards (e.g., CCME Selection Guidelines or Canadian Incident Air Quality Standard) 	<ul style="list-style-type: none"> Minor effects on quality of life Short term setbacks require no action or minor action Disrupts related to development or decisions result in limited acts of civil disobedience with minor disruptions to the public. Some localized psychosocial impacts including disruption to media and some anxiety Some damage to localized culturally significant objects 	<ul style="list-style-type: none"> Provincial government encounters limited reduction in delivery of core functions Abandonment of key government objectives may be impacted Minor management specialized response Regional government encounter a reduction in the delivery of core functions 	<ul style="list-style-type: none"> Significant impact on localized industry or business sector resulting in short term (i.e., less than one year) profit reduction directly attributable to the event Minor portions of investment levels in the province Economic decline and / or loss of asset value greater than 0.01% of the provincial GDP (2016) Operation of 3 critical infrastructure services for short time 	<ul style="list-style-type: none"> Localized damage capable of restoration Disrupts but over years values affected tend to be minor 	Minor					Low Risk
																				<ul style="list-style-type: none"> First aid injury with no professional care required (minor, non-life threatening) No impact on public health and safety 	<ul style="list-style-type: none"> No obvious impact on quality of life Minor delay in public cultural event 	<ul style="list-style-type: none"> Provincial government's delivery of core functions is unaffected and normal Municipal or multi-municipal general response (medical and apprehensions) Municipal government encounters limited reduction in delivery of core functions 	<ul style="list-style-type: none"> Insignificant economic impact Minimal disruption and / or loss of asset value greater than 0.0005% of the provincial GDP (2016) Operation of 1-2 critical infrastructure services 	<ul style="list-style-type: none"> Localized, reversible and temporary damage Minor impact on local environmental values 	Insignificant

Comparison of Plausible Worst-Case Scenarios

Natural Hazard	Case Study Location	Likelihood of Occurrence	Impact Categories					Aggregate Risk
			Human Health & Safety	Social	Public Administration	Economic	Environment	
Drought All Types	Agricultural region of Saskatchewan	Unlikely	Major to Catastrophic	Major to Catastrophic	Catastrophic	Catastrophic	Moderate to Major	High
Convective Summer Storms	Regina and area	Unlikely	Catastrophic	Major to Catastrophic	Major	Major to Catastrophic	Major to Catastrophic	High
Forest Fire	Human-caused forest fires close to communities; forested zone of province	Unlikely	Major	Moderate to Major	Major	Moderate	Minor to Moderate	Moderate to High
Winter Storms	Southern Saskatchewan	Unlikely	Major	Minor to Moderate	Moderate to Major	Major	Moderate	Moderate to High
Overland Flooding	Agricultural region of Saskatchewan	Unlikely	Minor	Minor to Moderate	Minor	Major	Moderate	Moderate
Plains Runoff Flooding	Regina	Unlikely	Moderate	Minor to Moderate	Major	Major	Moderate	Moderate
Lake Flooding	Fishing Lakes Last Mountain Lake	Unlikely	Moderate	Minor	Minor	Minor	Moderate to Major	Moderate
Grass Fire	Grass fire > 1,000 ha; agricultural region of Saskatchewan	Unlikely	Major	Moderate to Major	Minor	Minor to Moderate	Minor	Moderate
Mountain Runoff Flooding	Prince Albert	Rare	Moderate	Minor	Moderate to Major	Minor	Minor	Low to Moderate
Groundwater Flooding	Highly localized	Unlikely	Insignificant to Minor	Insignificant to Minor	Insignificant to Minor	Insignificant to Minor	Insignificant to Minor	Low
Earthquake	Highly localized along the Saskatchewan and Montana border	Unlikely	Insignificant	Insignificant	Moderate	Moderate	Insignificant	Low

Worst-case scenarios

Drought – based on 1961 driest year on record but lasting for 10 years as in the 1930s.

Convective summer storms – similar storm as what occurred in 1912 (the Regina Cyclone) but with a larger population; more hazardous industrial sites;

Forest Fire - Major human-caused fire; Grows rapidly due to severe burning conditions; Multiple communities evacuated; Community infrastructure lost; Possibility of multiple fatalities.

Winter Storms – similar storm as the February 1978 but with the added dimension of freezing rain

Flooding (all scenarios) – similar to the 2010-2016 period

Grass Fires - Major human-caused fire; Grows rapidly due to severe burning conditions; Multiple communities evacuated; Community infrastructure lost; Possibility of multiple fatalities.

Earthquake – One strong enough to destroy the Morrison Dam on the East Poplar River near Coronach

Province-wide Risk Levels – Current Climate based on Historic Events

- **High Risk** – Drought and Convective Summer Storms
- **Moderate to High Risk** – Forest Fires and Winter Storms
- **Moderate Risk** – Overland Flooding, Plains Runoff Flooding, Lake Flooding and Grass Fires
- **Low to Moderate Risk** – Mountain Runoff Flooding
- **Low Risk** – Groundwater Flooding and Earthquakes.

By the 2050s, the **Risk Levels** of most of the hazards will **increase**



Copyright © SRC 2019

Worst-case scenarios

Drought – based on 1961 driest year on record but lasting for 10 years as in the 1930s.
Convective summer storms – similar storm as what occurred in 1912 (the Regina Cyclone) but with a larger population; more hazardous industrial sites;
Forest Fire - Major human-caused fire; Grows rapidly due to severe burning conditions; Multiple communities evacuated; Community infrastructure lost; Possibility of multiple fatalities.
Winter Storms – similar storm as the February 1978 but with the added dimension of freezing rain
Flooding (all scenarios) – overland flooding similar to 2010-2016 period, plains and lake flooding similar to mid-1970s, mountain runoff similar to late 1800s
Grass Fires - Major human-caused fire; Grows rapidly due to severe burning conditions; Multiple communities evacuated; Community infrastructure lost; Possibility of multiple fatalities.

Drought

- Droughts pose severe threats to the economy, environment, health and communities and can pose a challenge for public administration
- For example:
 - The 1999-2005 Canada-wide drought resulted in an estimated drop of \$5.8 billion in Canada's GDP and more than an estimated loss of 41,000 jobs (Wheaton et al. 2008).
 - In SK the 2001-2002 drought resulted in an estimated \$1.6 billion loss in Agricultural production (Wheaton et al. 2008).
- We used the severity of the drought of 1961 but with the long period of the 1930s and applied to today's living standards as the case study

Photo: E. Wheaton 2003

Convective Summer Storms

- Convective storms can result in heavy rain, hail, strong winds and tornadoes
- Majority of these storms are relatively local and can produce minor to moderate impacts on a relatively localized scale
- These storms may result in cumulative impacts due to their complex nature.

1912 Regina Tornado Map

[See Regina in 1912](#) [See Regina in 2012](#)



Image Source CBC 2018

(Credit for 1912 Regina map: Storm of the Century, Sandra Bingaman, 2011)

Convective Summer Storms

- Used the 1912 Regina cyclone (F4 tornado) as the case study and applied it to current day situation
- Approximately 150 people would now die with more than 1,000 people injured.
- Irreparable damage of at least \$82 million to high-value structures
- Major damage and impact on critical infrastructure
- Potential for secondary impacts is high....e.g., toxic substances are now carried by trains



Photo: Sherratt 2016

Forest Fires

- Fires are a natural occurrence in Saskatchewan. They occur every year.
- Only a hazard if they threaten values at risk: life, infrastructure, valuable timber, etc.
- SK has one of the highest rates of fire in Canada
- Highly variable: area burned ranges 3,885 to 1.7 million ha (1990-2015)
- 50% human-caused but burn less than 10% of area
- Areas south of the Churchill River are greater concern

Photo: Gov't of SK

Winter Storms

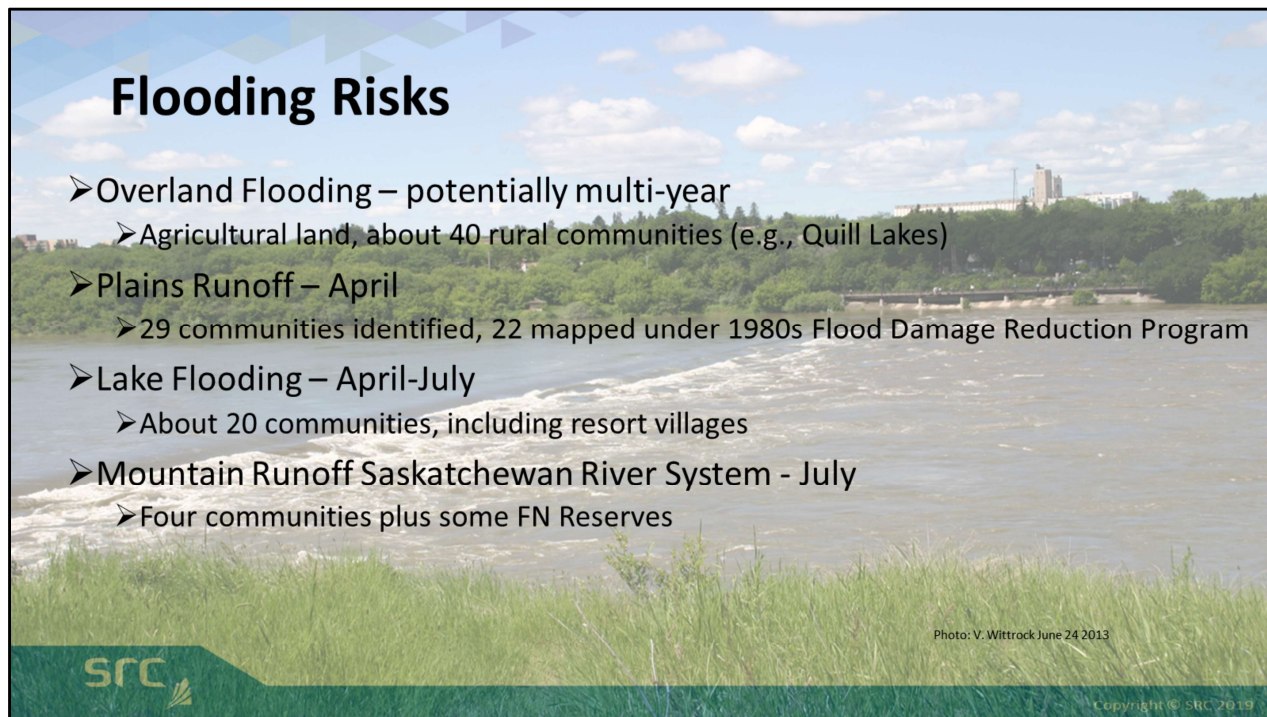
- Severe winter weather includes blizzards (snow and/or blowing snow with reduced visibility), snowstorms, freezing rain etc and can incorporate all of the events into one
- Worst case scenario was the blizzard of 1978 that lasted at least 60 hours and was applied to current conditions.
- Would result in:
 - Dangerous road conditions – likely closed to traffic
 - Potential for multiple fatalities: e.g., vehicular traffic, lack of heat in rural areas, carbon monoxide poisoning
 - Disruption in critical infrastructure e.g., power lines
 - Damage to buildings due to snow loads
 - Negative impacts on livestock and poultry producers
 - Delayed negative impacts with spring snow melt conditions



Photo: J. Wheaton March 2013



Photo: V. Wittrock December 2018



Wittrock et al. 2018

Overland Flooding: Saskatchewan has sustained considerable flood losses because of overland flooding in recent years. These losses relate to both rural and urban settings. Overland flooding may accompany spring runoff or may occur on account of heavy summer rains. In rural areas, overland flooding may lead to loss of vulnerable community infrastructure and to agricultural losses. In urban areas intense runoff events may overwhelm the capacity of municipal drainage systems, leading to flooding of municipal infrastructure and of private property.

Plains Runoff - Flooding in this area can take place in several different ways. These include urban riverine flooding from established streams, urban lake flooding, and overland flow, both rural and urban. Floods have been associated with the spring snowmelt. The severity of the flood relates to autumn precipitation, winter precipitation and snow redistribution, frost penetration, melt rate, and precipitation during the melt. In recent years, however, southern Saskatchewan has experienced very significant summer rains that have led to riverine flooding.

Lake flooding - may be due simply to high water levels, but damage can occur as well due to ice shove when strong winds, ice cover and high water combine to cause damage.

Mountain Runoff – North and South Saskatchewan Rivers and the Saskatchewan mainstem may experience flooding due to runoff from the eastern slopes of the Rocky Mountains

Grass Fires

- Grass fires have long been a part of southern Saskatchewan
- Spread extremely fast if grass/cropland is dry and winds are high (early spring before green-up and fall)
- Can result in injuries, death, loss of community infrastructure, road closures, pressure put on hospital infrastructure (moving of seniors and patients out of harms way), challenge of accessing water supplies and equipment.



Potential Adaptation Strategies

Transition from Province-wide Analysis to Community Level

- Comprehensive community response plans – natural and industrial hazards
- Proactive measures – drought planning, floodplain mapping and zoning, flood forecasting, FireSmart, insurance, improved urban infrastructure
- Reactive measures – evacuation, snow clearing, emergency dykes, water pumping, first responders, forest & grass fire suppression, Provincial disaster Assistance Programs.

Asset Management

- Build a community-level risk matrix
 - Data collection and analysis
 - Value/condition of assets
- Identify effects on Infrastructure
 - Water and Wastewater
 - Roads and other structures
- Training and workshops
- Post event analysis
- Share knowledge and lessons learned



General Recommendations

- Every province and territory in Canada should undertake a Hazard Risk Assessment that includes Natural Hazards and also includes projected future climate scenarios.
- Risk assessment should be reviewed and updated regularly.
- Important to include as many stakeholders / interested parties as possible.

Questions?

Wittrock, V., R.A. Halliday, D.R. Corkal, M. Johnston, E. Wheaton, J. Lettvenuk, I. Stewart, B. Bonsal and M. Geremia. Dec 2018. Saskatchewan Flood and Natural Hazard Risk Assessment. Report prepared for Saskatchewan Ministry of Government Relations. Web site: <https://www.saskatchewan.ca/government/news-and-media/2018/december/17/natural-hazards-risk-assessment-report>



Saskatchewan Flood and Natural Hazard Risk Assessment

Prepared for Saskatchewan Ministry of Government Relations

By V. Wittrock¹, R.A. Halliday², D.R. Corkal³, M. Johnston⁴, E. Wheaton⁵, J. Lettvenuk⁶, I. Stewart⁷, B. Bonsal⁸ and M. Geremia⁹



SRC Publication No. 14113-2E18
May 2018
Revised Dec 2018



Select References

Association of Insurance and Risk Managers (AIRMIC), The Public Risk Management Association (Alarm), and Institute of Risk Management (IRM). 2010. A Structured Approach to Enterprise Risk Management (ERM) and the Requirements of ISO 31000. AIRMIC, Alarm and IRM. Web site: https://www.theirm.org/media/886062/ISO3100_doc.pdf. Accessed Dec 2016

Australian Government Attorney-General's Department. 2015. National Emergency Risk Assessment Guidelines. Handbook 10. Australian Government Attorney-General's Department. Commonwealth of Australia. Web site: <https://www.aidr.org.au/publications/handbook-collection/handbook-10/> Accessed January 2017

National Emergency Management Committee. 2010. National Emergency Risk Assessment Guidelines. Tasmanian State Emergency Service. Hobart Australia. Web site: <http://coastaladaptationresources.org/PDF-files/1438-National-Emergency-Risk-Assessment-Guidelines-Oct-2010>. PDF Access 2016.

Ontario Centre for Climate Impacts and Adaptation Resources. No Date (ND). Risk Management Process in Climate Change Adaptation. Web Page: <http://climateontario.ca/doc/factsheets/RiskManagementProcess-Final.pdf>. Accessed March 2017.

Wheaton, E., S. Kulshreshtha, V. Wittrock, G. Koshida. 2008. Dry times: hard lessons from the Canadian drought of 2001 and 2002. The Canadian Geographer. 52(2): 241-262. DOI: <https://doi.org/10.1111/j.1541-0064.2008.00211.x>

Photos:

Flooded road – Government of Saskatchewan
Forest fire – Government of Saskatchewan
Winter drought – V.Wittrock January 2009
Snow banks along roadway – J.Wheaton March 2013
Oil well surrounded by water – I. Radchenko May 2015
Participants at Stakeholder Meetings June 2017 – D.Corkal June 2017
Kneeling farmer on cracked soil – istock photo
Tornado by Last Mountain Lake – D.Sherratt Summer 2016
#1 Highway east of Regina - Government of Saskatchewan
South SK River Saskatoon June 24 2013 - V. Wittrock
Fire fighter – Government of Saskatchewan
Soil dunes – E. Wheaton
Air plane with fire retardant – Government of Saskatchewan
Heavy Frost – V. Wittrock Dec 2018