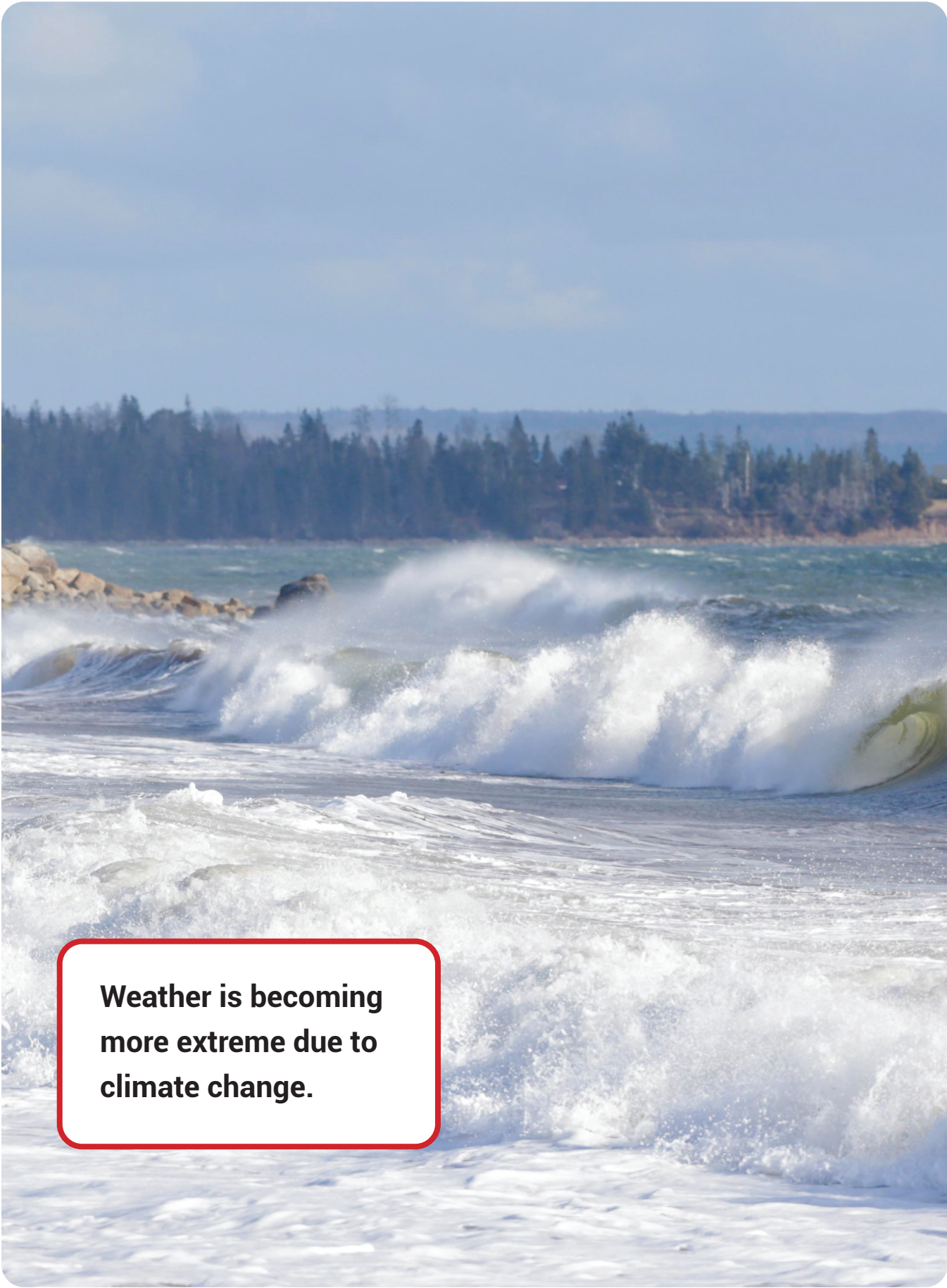


**ADAPTING TO CLIMATE CHANGE**

Flooding & Severe Weather Events:  
**Mitigating Risk to  
Aboveground Petroleum  
Storage Tanks**

2020





**Weather is becoming more extreme due to climate change.**

Nova Scotia is almost completely surrounded by the ocean and covered in rivers, lakes, and streams. Environmental issues naturally arise when leaks or spills from petroleum storage tanks and facilities have the opportunity to enter water resources. Climate change and extreme weather have real and continuing impacts on local infrastructure and residents, due to our settlement patterns, our geographical location, and geographical features in local areas.

**Settlement patterns:** Waterways were the original highways, so people tended to settle on natural floodplains and in coastal areas. The lushness of soil and often flat topography with easy access or attractive sightlines to water has led to extensive residential settlements and associated commercial development in these low-lying areas. Roads tend to follow water features, which means that service stations and bulk fuel plants are regularly located close to water. These areas are subject to tidal or wave surges during storms or spring weather events.

**Geographic location:** Nova Scotia lies near strong wind and water currents that tend to bring tropical storms and hurricanes up from the Caribbean. Since 2000, one hurricane makes landfall every other year in Canada with post-tropical storms common during hurricane season. Weather events are becoming more severe due to climate change.

**Geographical features:** Geographical features can induce storm force winds in local areas. Our best example is Les Suêtes winds on the west coast of Cape Breton. South-easterly winds from the east side of the island flow down from the Highlands plateau to sea level, regularly producing winds of over 100 km/hr. Gusts have measured over 200 km/hr.

To increase resiliency and mitigate against impacts to human health or the natural environment by releases of petroleum products during floods or groundwater surges, specific actions should be taken to improve the quality of infrastructure and adapt operating procedures to mitigate impacts.

**Disclaimer:** *The following information is intended for general guidance and education only. Since site requirements and equipment will vary widely, users are encouraged to consult a qualified professional to determine specific designs and actions best suited to reflect the environmental protection needs of the particular location and proposed service before designing, installing or operating any equipment or plans intended to diminish potential risks of climatic events.*

## Key risks for aboveground tanks

### Floating risk in flood waters

Tanks are buoyant, because both air and petroleum are lighter than water. Flood waters lift tanks off their prepared bases. They float away, becoming an impact risk for other structures. If punctured by ground-based structures like pumps or broken by uneven stresses on their shell, their contents contaminate the environment.

Water in motion is a powerful force, as engineers at the University of New South Wales have demonstrated:

- A small car can be floated in 15 cm of water moving at 1 m/s.
- Floodwater 2 m deep, 20 m wide, moving at 1 m/s has an impact equivalent to being hit by a 40 tonne semi-trailer every 15 seconds.

### Buckling risk when tanks under stress

Tank walls for even the largest storage tanks are relatively thin, generally 6 to 20 mm.

The relative strength of the tank comes from three features:

- the stiffness of the material
- the geometry of the shape where common stresses are shared
- the hydrostatic pressure of the contents pushing from the inside of the tank

If the tank is not completely full or if sudden stresses such as wind gusts or water or wave action pushes on a limited area of a tank, the point of stress may fail. This may cause the tank wall to buckle inward.

Damage may

- be localized
- spread along welded seams or across the tank
- lead to leakage or complete tank failure

### Impact risk from floating or blowing debris

Flood waters and high winds can break off and move objects. The wind or water carry them along until they meet an obstruction.

Heavy or sharp objects moving at high speed may damage or puncture storage tanks or related piping and equipment. A puncture, leak, or break may release tank contents into the environment.

## Product displacement risk when water enters tanks

Water is heavier than many petroleum products. If water can enter a storage tank — through a vent, leaking roof, other opening, or puncture — it can quickly fill the tank. Water sinks in the tank and pushes the petroleum product out through any unsealed openings.

## Tank failure risk when water accumulates on tank roof

A roof serves three functions on a petroleum storage tank:

- keeps water from contaminating products
- prevents fumes from creating local environmental and fire hazards
- keeps pressure equalized through vents or floating roof design

Because the volume of product within a tank changes constantly, pressure inside the tank needs to be constantly equalized. If pressure is not equalized, the shell can contract or bulge.

Roof features keep pressure equalized, which keeps the tank from bulging or contracting:

- Vents provide a conduit for air to leave the tank and enter the tank. This air flow allows the pressure to equalize. Vents must be regularly maintained to ensure they function properly.
- Floating roofs on large tanks eliminate the air space issue by moving up and down with inventory changes. Floating roofs must be regularly maintained to ensure they function properly.

Roof drains keep water from accumulating on a tank roof. They provide a conduit for rainwater and melting snow to drain off a roof, like rain gutters on a house. To be effective, roof drains must be

- sized to handle the current and projected precipitation rates in the local area (for projected precipitation rates, see <https://climatedata.ca/> )
- regularly maintained so they function effectively — kept free of debris

If water accumulates on a tank roof during heavy rainfall or snowfall, the weight of the water can cause roof failure in localized areas or over the entire structure. Product may be displaced, or the tank may rupture.

## Ways to mitigate risk

### Avoid flood zones

Avoid installing petroleum storage systems in flood zones, if possible, to prevent liability. Known flood zones are generally well mapped. Find information on potential exposures at municipal planning offices. Make sure to use an up-to-date flood map and wherever possible consider projected precipitation, sea level rise and storm surge. Information on climate change can be found on <https://climatedata.ca/> and on the Nova Scotia Climate Change website at [www.novascotia.ca/nse](http://www.novascotia.ca/nse).

### Avoid areas with strong winds

Avoid installing petroleum storage systems in areas where strong winds are common, if possible, to prevent liability. Find information on potential exposures at municipal planning offices. Historical weather data can also help you identify areas where strong winds are common and where wind events regularly occur.

### Anchor tanks securely

The National Fire Code of Canada (2015 edition) requires aboveground tanks installed in areas subject to flooding to be securely anchored: Section 4.3.3.3.

The design of aboveground tanks should

- be prepared and approved by a professional engineer
- consider the potential stresses involved for a particular tank and location when exposed to flooding or elevated winds
- distribute anchor points evenly to prevent uneven stresses from causing damage to the tank or attached piping

### Redesign or re-enforce systems with significant legal, financial, or social liability risks

Purchasing decisions should factor in potential legal, financial, and social liability risks – as well as ongoing operational and maintenance costs – for a more complete picture.

Focussing on initial capital outlay may seem logical in the short term. However, operational and liability concerns can increase costs over the life of the system. Leaks, spills, and injuries will ultimately affect both overall profitability and company goodwill and reputation. The cheapest option may not be the wisest option when all costs and risks are calculated.

Storage tanks and related equipment are designed, constructed, and installed to meet specific needs and operating parameters. Those involved in specifying, purchasing, and installing the equipment need to understand the conditions under which the

equipment will operate by examining local extreme weather and climate data. They also need the expertise to balance competing concerns and technical parameters. Information on climate change can be found on <https://climatedata.ca/> and on the Nova Scotia Climate Change website at [www.novascotia.ca/nse](http://www.novascotia.ca/nse).

- tanks with thicker walls or stiffening rings may cost more but are less prone to damage from the effects of winds
- increasing the diameter of the tank and decreasing height will lower wind stresses but can increase the negative effects of buoyancy

Standards and codes for storage tank systems incorporate detailed safety factors:

- variations in material type and quality
- operating pressures
- exposures and repetitive stresses
- environmental protection
- fire protection
- staff protection

When making decisions about new or updated storage facilities, consider the following in your cost-benefit analysis:

- how the capital cost of safety features protects against future liability claims and clean-up costs
- how the type of use has varied since initial installation, including the volume of product the system is designed to handle versus current volumes and anticipated future volumes
- how well the system adapts to changes in extreme weather events, both experienced locally and projected.

## **Manage risk operationally**

Create contingency management plans to manage operational-related risk:

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### **Risk**

Tanks exposed to high sustained winds, particularly on a single side, have a tendency to fold inwards if unsupported.

### **Mitigation measure**

Either keep the tanks relatively full of product, or, if empty, fill with water before the weather event.

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### **Risk**

Smaller tanks in exposed areas where additional protection is impractical are vulnerable to damage.

### **Mitigation measure**

Pump out smaller tanks before major weather events so that catastrophic losses are reduced to equipment only.

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### **Risk**

Tank use has changed since installation so that it no longer meets specific needs and operating parameters. For example storing a different type of petroleum product, such as changing from diesel to gasoline or increasing additives such as methanol, ethanol or biofuels. This can degrade the tank, its components or the operability of the tank system.

### **Mitigation measure**

Assess current needs against existing codes and standards and local conditions. Recommend upgrades. Consult with a qualified professional engineer or the manufacturer for recommended upgrades.

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### **Risk**

Spills can occur even when all precautions were taken to prevent a release of petroleum to the environment.

### **Mitigation measure**

Update contingency management plans regularly. Communicate with and train people responsible for responding to spills.

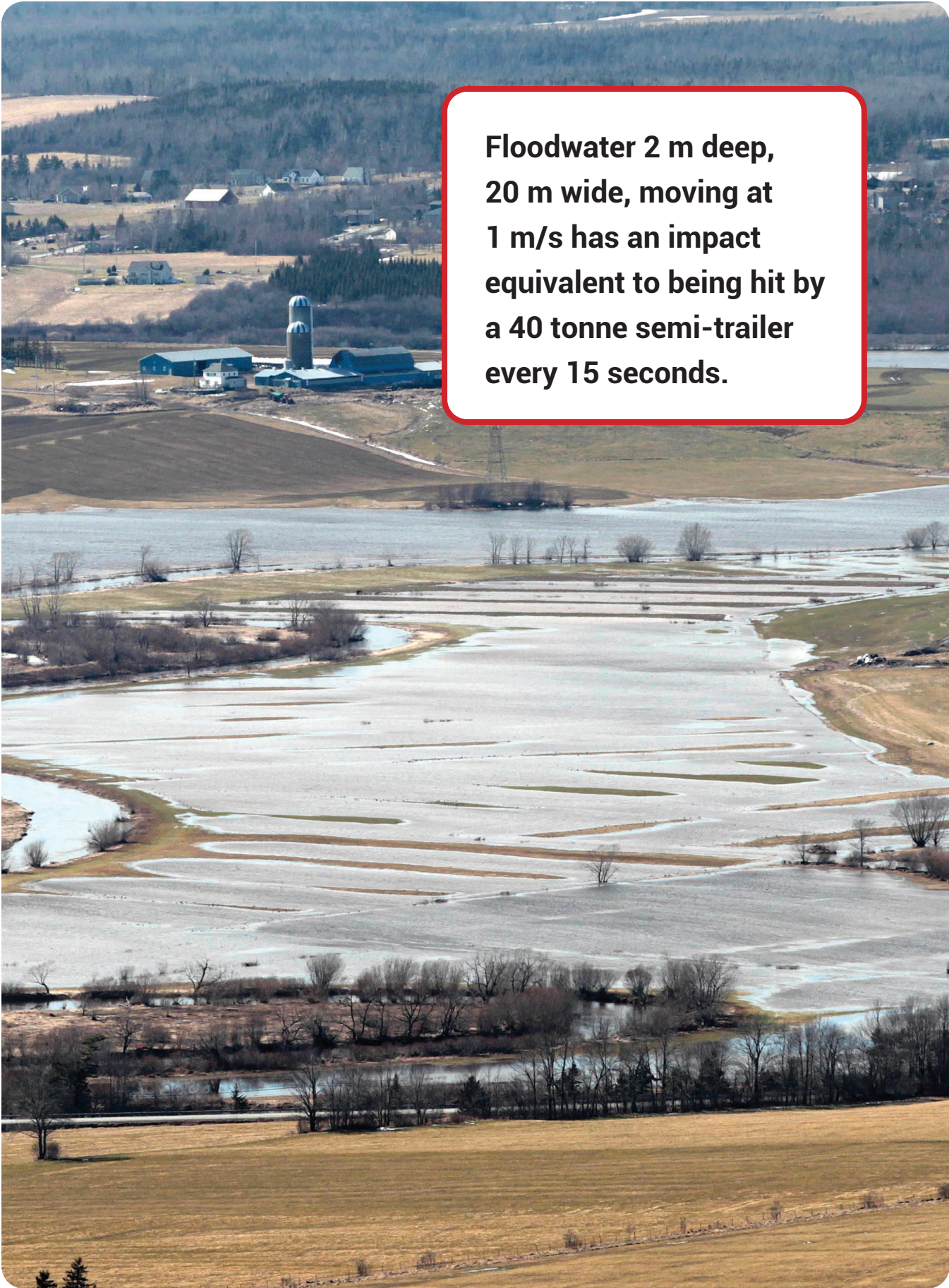
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## **Maintain systems regularly and strategically**

Schedule regular inspections of storage tank systems by persons trained to know applicable standards and codes and capable of recognizing signs of damage or potential failure before they impact operations or safety:

- Check roof vents, floating roof seals, and vacuum relief systems to ensure they are functioning properly.
- Clear debris from roof drains regularly to reduce or eliminate any ponding of precipitation on roofs.
- Service regularly and repair damage promptly to ensure safe operation during normal and adverse conditions.
- Keep detailed records of inspections and repairs to track trends for predictive maintenance and to cover liabilities.
- When issues arise with a tank system, assess all equipment of similar age, manufacture, or service.
- Assess overall system performance against current usage needs, current standards and codes, and changing climate conditions.





**Floodwater 2 m deep,  
20 m wide, moving at  
1 m/s has an impact  
equivalent to being hit by  
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every 15 seconds.**

## After flooding or severe weather

Inspect your storage tank systems to ensure that no damage has occurred and no product has been lost.

Copy the inspection checklist and use it to track completed actions and when follow-up action is needed.

### INSPECTION CHECKLIST

AREA	Action complete	ACTIONS	Follow-up required	FOLLOW UP ACTIONS	Follow-up complete
FACILITY	<input type="checkbox"/>	<b>INSPECT</b> for evidence of release of petroleum product; if spills or leaks are evident	<input type="checkbox"/>	<b>REPORT</b> spills or leaks to Nova Scotia Environment as required under the Environmental Emergency Regulations	<input type="checkbox"/>
TANKS & PIPING	<input type="checkbox"/>	<b>CHECK</b> for water contamination; if contaminated	<input type="checkbox"/>	<b>REMOVE WATER &amp; DISPOSE</b> of at a facility approved for that purpose	<input type="checkbox"/>
INTERSTITIAL SPACE in systems with intrinsic secondary containment	<input type="checkbox"/>	<b>CHECK</b> to ensure no leakage or ingress of water has occurred; if any evidence of leakage or intrusion	<input type="checkbox"/>	<b>REPAIR &amp; RESTORE</b> before reuse	<input type="checkbox"/>
ELECTRICAL SYSTEM	<input type="checkbox"/>	Have a <b>QUALIFIED ELECTRICIAN CHECK</b> for damage or presence of water	<input type="checkbox"/>	<b>CONDUCT NECESSARY REPAIRS</b> before restarting the power	<input type="checkbox"/>
TANK WALLS & ROOFS	<input type="checkbox"/>	<b>CHECK</b> for visible deflection or damage; if damage is apparent	<input type="checkbox"/>	<b>EMPTY TANK</b> contents as quickly as possible Arrange for detailed <b>ASSESSMENT &amp; REPAIR</b>	<input type="checkbox"/>
EQUIPMENT: • pumps • shear valves • fill pipes • vent lines	<input type="checkbox"/>	<b>CHECK</b> equipment for proper operation: • no water, debris, or silt intrusion • items open and close or turn on or off smoothly • no blockages	<input type="checkbox"/>	<b>CLEAN</b> any signs of corrosion, <b>LUBRICATE</b> moving parts, and <b>REPLACE</b> failed parts	<input type="checkbox"/>
DISPENSING FACILITY, if one	<input type="checkbox"/>	<b>INSPECT</b> for visible damage to the dispensing facility; if any evidence of tank or line movement or breakage	<input type="checkbox"/>	<b>CONDUCT</b> more extensive checks and <b>REPLACE</b> if needed	<input type="checkbox"/>
SPILL BUCKETS & SUMPS, if any	<input type="checkbox"/>	<b>CLEAN &amp; EMPTY</b> spill buckets and sumps, including those under dispensers and above the tanks	<input type="checkbox"/>	<b>DISPOSE</b> of any cleaned-out material at a facility approved for that purpose by the authority having jurisdiction	<input type="checkbox"/>
	<input type="checkbox"/>	<b>CHECK</b> dispenser filters and submersible check-valve screens	<input type="checkbox"/>	<b>REPLACE</b> any clogged filters and screens	<input type="checkbox"/>
	<input type="checkbox"/>	<b>INSPECT</b> for damage or possible leaks	<input type="checkbox"/>	<b>CONDUCT</b> a tightness test	<input type="checkbox"/>
	<input type="checkbox"/>	<b>FLUSH</b> the piping and dispensers	<input type="checkbox"/>	<b>DISPOSE</b> of any rinse product and water at a facility approved for that purpose	<input type="checkbox"/>

## Resources

National Fire Code of Canada 2015,  
National Research Council of Canada

American Petroleum Institute (API) Standard 650:  
Welded Steel Tanks for Oil Storage

Floodwater research, University of New South Wales:  
<https://www.engineering.unsw.edu.au/news/unsw-engineers-demonstrate-the-dangers-of-floodwaters>

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