IISD | Natural Infrastructure for Water Solutions

POLICY BRIEF

Natural Infrastructure Essentials

A focus on water retention

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The Decline of Water Storage in Prairie Watersheds

On the Canadian Prairies and around the world, the need for water storage to cope with extremes associated with climate change is increasing. Nature provides over 99% of freshwater storage globally (McCartney et al., 2022), but unfortunately, this storage—a natural buffering capacity—is on the decline.

Historical and ongoing drainage, as well as altered landscapes, across the Canadian Prairies have significantly reduced the water storage capacity in many watersheds. In Alberta, for example, the loss of approximately 133,000 hectares of wetlands over the past 40 to 60 years has resulted in a loss of roughly 379 million m^3 of water storage capacity, equivalent to about 21 times the volume stored in Calgary's Glenmore Reservoir (Canadian Climate Institute and Smart Prosperity Institute, 2021). This is a risky situation, considering how **extreme weather events, resulting in droughts and floods, are anticipated to become more frequent and severe**. Water from snowmelt and rainfall replenishes rivers, wetlands, and lakes, but this can fluctuate from too little water (drought conditions) to too much water (flood conditions). Climate change may alter the way precipitation falls on the prairies, with increased rainfall instead of snow during winter, resulting in decreased snowpack and lower infiltration. As water demand increases due to a growing population and greater industry usage (e.g., irrigation, manufacturing) and water supply is less reliable, there is a **greater risk of water scarcity, where supply no longer meets demand** (Sauchyn et al., 2020).

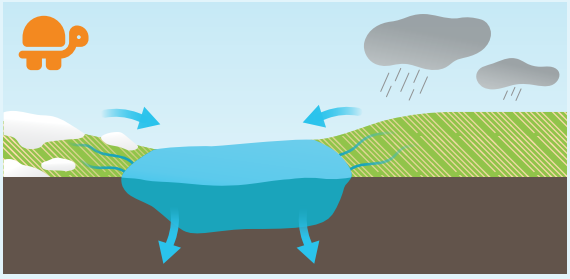
The Canadian Prairies need natural infrastructure that provides **water retention** and offers multiple benefits, such as flood protection and restored water storage capacity. Water retention supports water security for **healthy communities and a prosperous economy** (Burke et al., 2023).

The Turtle and the Hare: Slowing the flow of water to win the water storage race

The flood and drought benefits of water retention projects are primarily achieved via storage, which slows water, like the slow and steady turtle , as compared to degraded or drained landscapes, where the storage function is lost and runoff increases, like the speedy hare .

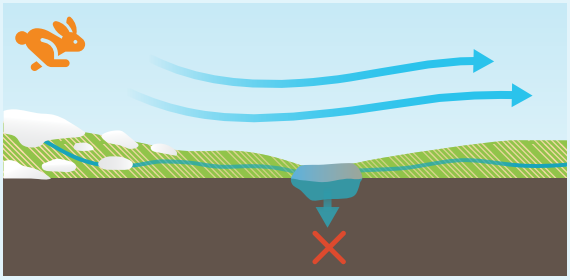
Storage refers to the ability to capture and store precipitation and runoff, either permanently (retention) or temporarily (detention) in a basin. Storage can attenuate peak floods, enhance water infiltration, and promote soil moisture, particularly when water is retained or stored for longer periods, providing even more benefits like water quality improvements and habitat creation.

For example, think of annual cropland and compare an intact wetland to a drained wetland.



A wetland basin is a low-lying area that collects and stores snowmelt and rainfall, slowing the velocity of runoff and promoting infiltration, plus other benefits like reducing nutrients.

← Water moves slowly, like a turtle, and is stored in the wetland.



Surface ditches drain the wetland and remove the storage capacity. Instead of being held, water moves quickly downstream, causing erosion, higher sedimentation, and reduced infiltration.

← Water moves quickly, like a hare, contributing to issues downstream.

What is Water Retention?

Water retention refers to the ability of a landscape to capture, store, and gradually release snowmelt and rainfall. Water retention measures involve a range of approaches, from more "natural" measures like conserving and restoring landscapes like floodplains, grasslands, riparian areas, and wetlands (i.e., conserved and restored water retention), to more technical solutions, such as constructing small reservoirs (i.e., constructed water retention). These options all fall under the broader category of natural water retention measures, which aim to store water by

mimicking or enhancing natural processes to retain and slow the flow of water. The water retention approach to natural infrastructure stands in sharp contrast to grey infrastructure solutions for flood mitigation, such as dry dams, which are designed solely for short-term water detention. Unlike natural water retention measures, these grey infrastructure solutions do not provide the broad co-benefits provided by long-term water storage.

Water retention basins hold water permanently, unlike water detention sites (or dry dams), which only store water temporarily. Retention time is a key factor in site performance and should be considered in design and management of constructed sites, with higher retention time resulting in more benefits, like wildlife habitat and nutrient removal (Simoes et al., 2023).

Natural water retention measures are defined as measures that aim to safeguard and enhance the water storage potential of landscapes, soils, and aquifers by restoring ecosystems, natural features, and characteristics of water courses and using natural processes (European Commission, 2014).

Boosting Water Retention Across the Prairies

Conservation Should Be Prioritized

There is a strong body of evidence that shows conserving natural features like wetlands is important for overall water retention and the resilience of ecosystems (Canadian Climate Institute and Smart Prosperity Institute, 2021). Conserving the remaining intact ecosystems remains a priority to support nature and human needs. Restoring wetlands and constructing water retention sites are also necessary to regain the storage capacity lost to drainage and land conversion, but this can still result in a net loss of storage capacity and benefits if wetlands are not conserved and drainage continues.

Constructing New Water Retention Projects Adds More Capacity

As people and sectors across the prairies seek to increase water retention and restore lost storage capacity, constructed water retention options are growing in popularity. Constructed water retention typically involves engineering design and heavy equipment to recontour basins, install berms, culverts, and control structures. It also involves planting vegetation and restoring or enhancing previously drained wetlands.

In practice, both conserved and restored or constructed water retention projects typically

- aim to protect and manage water resources, with a focus on retention, recovery, and re-use of water, nutrients, and sediments;

- yield multiple benefits, including reducing the severity of floods and drought, increasing water supply, improving water quality, sequestering carbon, and supporting wildlife and the economy;
- vary in size, but usually have smaller footprints, and multiple water retention sites can be implemented for greater impact over a large area or across a watershed;
- are designed pragmatically for technical implementation by local groups.

Constructed Water Retention: A closer look

There is growing momentum for constructed water retention projects across the Prairies, and some already exist across Alberta, Saskatchewan, and Manitoba, as shown in these examples (note: areas and volumes are estimates only).

In **Alberta**, Ducks Unlimited Canada (personal communication, December 9, 2024) manages 1,690 water retention basins, comprising of steel weirs, dams, ditches, and ditch plugs, holding an estimated 1.6 billion m^3 of water—that would fill Calgary's Glenmore Reservoir 90 times!

Source: Ducks Unlimited Canada.

Between 2018 and 2023, **Manitoba**'s watershed districts constructed 257 water retention projects throughout the province, providing 6.7 million m^3 of storage (Manitoba Association of Watersheds, personal communication, November 11, 2024)—that would fill 2,678 Olympic swimming pools!

Source: East Interlake Watershed District.

In **Saskatchewan**, Ducks Unlimited Canada (personal communication, November 29, 2024) worked with farmers and ranchers to restore drained wetlands across 3,842 acres. Using small dams, called "ditch plugs," these wetlands range from small, ephemeral basins to large, permanent basins.

Source: Ducks Unlimited Canada.

What are the benefits of implementing water retention projects across the Canadian Prairies?

As floods and droughts are anticipated to become more frequent and severe with climate change, water retention is an important approach to buffer against both extremes by storing water to alleviate the wide fluctuations in the quantity and quality of water resources, while providing additional benefits (Simoes et al., 2023). The exact benefits of any water retention practice will depend on factors such as site characteristics, operation and maintenance, and surrounding land use.

Source: Jane Elliott.

Reduced flood risk by slowing and retaining water closer to upland sources of runoff.

For example, 8 years of monitoring at a constructed retention project with a small dam in southern Manitoba demonstrated that, on average, the Steppler Dam reduced annual peak flows from snowmelt by 72% and from summer rainfall by 48% (Tiessen et al., 2011).

Increased water supply and reduced drought risk by buffering flow, increasing groundwater recharge, and providing surface water storage capacity for agriculture or municipal use.

For example, Pelly's Lake is a controlled retention project in south-central Manitoba that provides water storage which is released downstream to Stephenfield Reservoir, a water supply source for nine towns and rural municipalities. During drought conditions in 2021, water levels in Pelly's Lake were managed to maintain the water supply for Stephenfield Reservoir (International Institute for Sustainable Development, 2024).

Source: IISD.

Source: Agriculture and Agri-Food Canada.

Removal of sediment and nutrients for improved water quality by physical, chemical, and biological processes.

At an Agriculture and Agri-Food Canada site near Morden, Manitoba, researchers built a berm and water control structure at a location in the field that often had standing water or saturated soils, delaying seeding or producing poor yields. As shown here, the research site was at full capacity in the spring of 2017. Results from 2016 to 2019 showed average reductions of ~65% for peak flow, ~80% for total dissolved phosphorus, ~78% for total phosphorus, and ~82% for total suspended solids (International Institute for Sustainable Development, 2022).

While water retention can contribute to carbon sequestration, there can be naturally occurring emissions like methane too, and more work is required to fully understand if they act as net greenhouse gas sinks or sources (Simoes et al., 2023).

Carbon sequestration and storage, as vegetation absorbs carbon dioxide during photosynthesis to store in its leaves, branches, and roots. As plant material dies and falls, bacteria and fungi metabolize it into organic carbon, which is stored in the soil.

For example, the Smith Creek Basin in Saskatchewan is representative of a prairie pothole region, where about 25% of wetlands are drained. Models show that wetlands in the prairie pothole region store an average of 205 t/ha of carbon and that 89 t/ha would be released if drained. Conserving intact basins is critical to avoid carbon release, and while restoration can reduce carbon too, it takes many years before they become carbon sinks (Pattison-Williams et al., 2018).

Source: iStock.

Source: iStock.

Habitat provision and improved biodiversity by providing the conditions (e.g., food, water, energy, space, and shelter) that plants, animals, and other species need to live.

For example, about 10 years post-restoration, wetlands in agricultural land in Saskatchewan had similar water chemistry and an abundance of macroinvertebrates, and submersed aquatic plants as natural wetlands (Bortolotti et al., 2016). Restoring previously drained wetlands is an effective tool to restore lost storage capacity and biodiversity, but intact wetlands must still be conserved, otherwise risking a net loss of benefits.

Economic benefits by supporting agricultural production, municipal services, and more.

For example, a review of 10 water retention projects in Southern Manitoba showed that every dollar invested provided CAD 3.16 in co-benefits to livestock producers, in addition to preventing damage to local infrastructure from floods (Puzyreva et al., 2022).

Source: IISD.

What is next for water retention?

Water retention is typically designed for flood mitigation, but there is growing momentum in Manitoba to focus on its other benefits, like reducing phosphorus and increasing water supply (Government of Manitoba, 2022). To improve and expand water retention across the Canadian Prairies, the following steps are essential (Simoes et al., 2023):

- **prioritize wetland conservation**: Protecting existing wetlands should be a cornerstone of water security and storage strategies across the prairies, helping to retain current storage capacity and contributing to flood mitigation.
- **clarify and assess approaches**: Identify strategies for improving water retention in each prairie province, including policy and funding mechanisms. For effective outcomes, wetland conservation must remain a priority, complemented by strategic water retention initiatives through restoration and/or constructed water retention projects.
- **evaluate cumulative storage needs**: Assess each province's water storage needs and identify non-point source nutrient hot spots to guide the placement and design of retention projects.
- **expand benefits**: Develop water storage solutions that provide a bundle of benefits in terms of flood risk, water availability, water quality, habitat, carbon sequestration, and more. Ongoing research and monitoring are crucial to understanding how benefits can vary across time and space.
- **increase funding**: Expand funding for retention projects, ensuring support for technical expertise in project design and location selection.

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