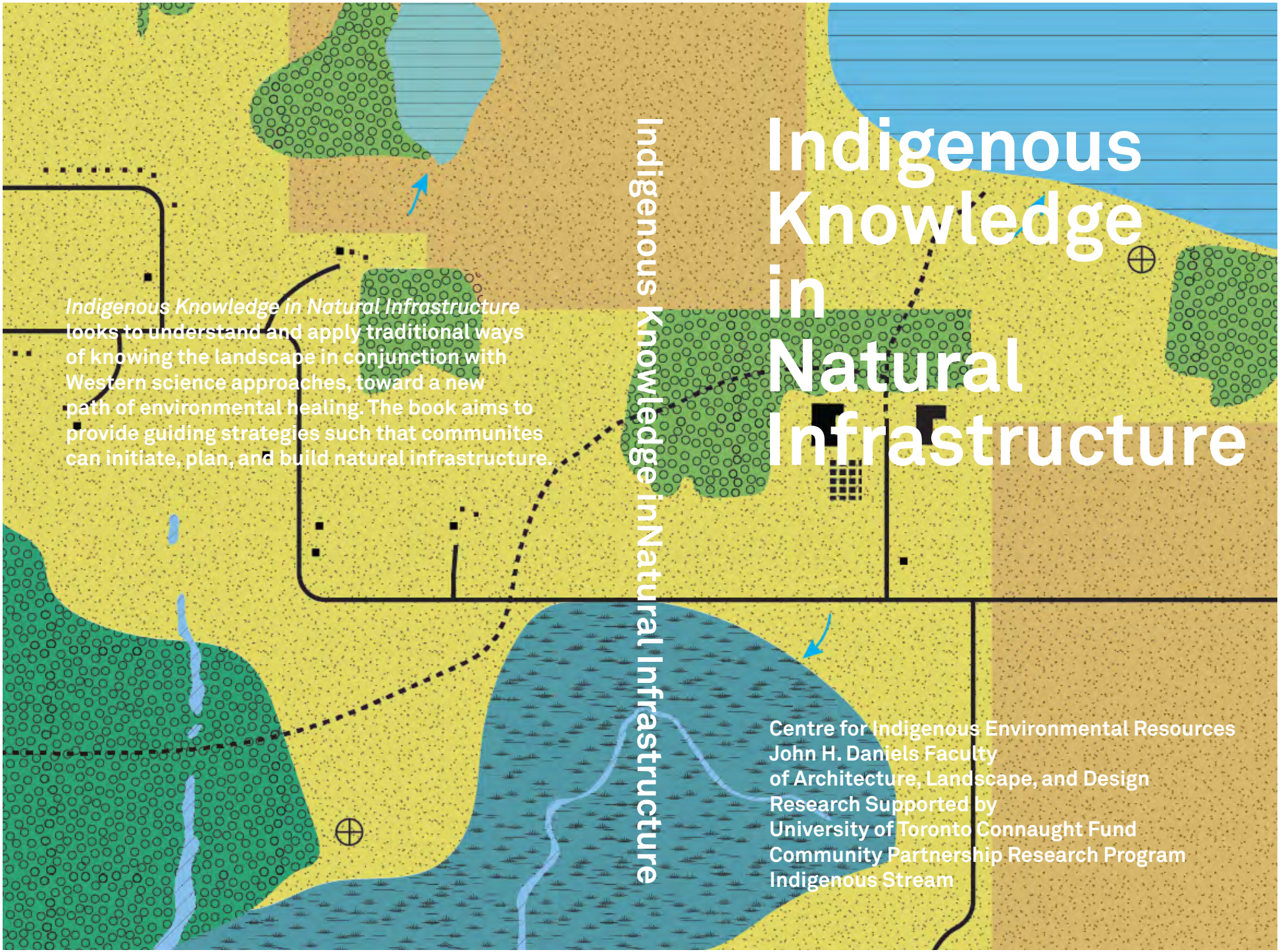

Indigenous Knowledge in Natural Infrastructure

Indigenous Knowledge in Natural Infrastructure looks to understand and apply traditional ways of knowing the landscape in conjunction with Western science approaches, toward a new path of environmental healing. The book aims to provide guiding strategies such that communites can initiate, plan, and build natural infrastructure.

Indigenous Knowledge in Natural Infrastructure

Centre for Indigenous Environmental Resources
John H. Daniels Faculty
of Architecture, Landscape, and Design
Research Supported by
University of Toronto Connaught Fund
Community Partnership Research Program
Indigenous Stream

Indigenous Knowledge in Natural Infrastructure

A Community-Based Water Quality
Improvement Guidebook
for the South Lake Winnipeg Basin
Integrating Traditional Ecological Knowledge
and Western Science Approaches
in the Design and Construction
of Natural Infrastructure Networks
Toward a New Path for Environmental Healing

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John H. Daniels Faculty
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Indigenous Knowledge in Natural Infrastructure

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University of Toronto

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To the Elders and knowledge keepers who steward the lands and waters, and whose guidance helped make this book possible.

To the next seven generations—this work is for you.

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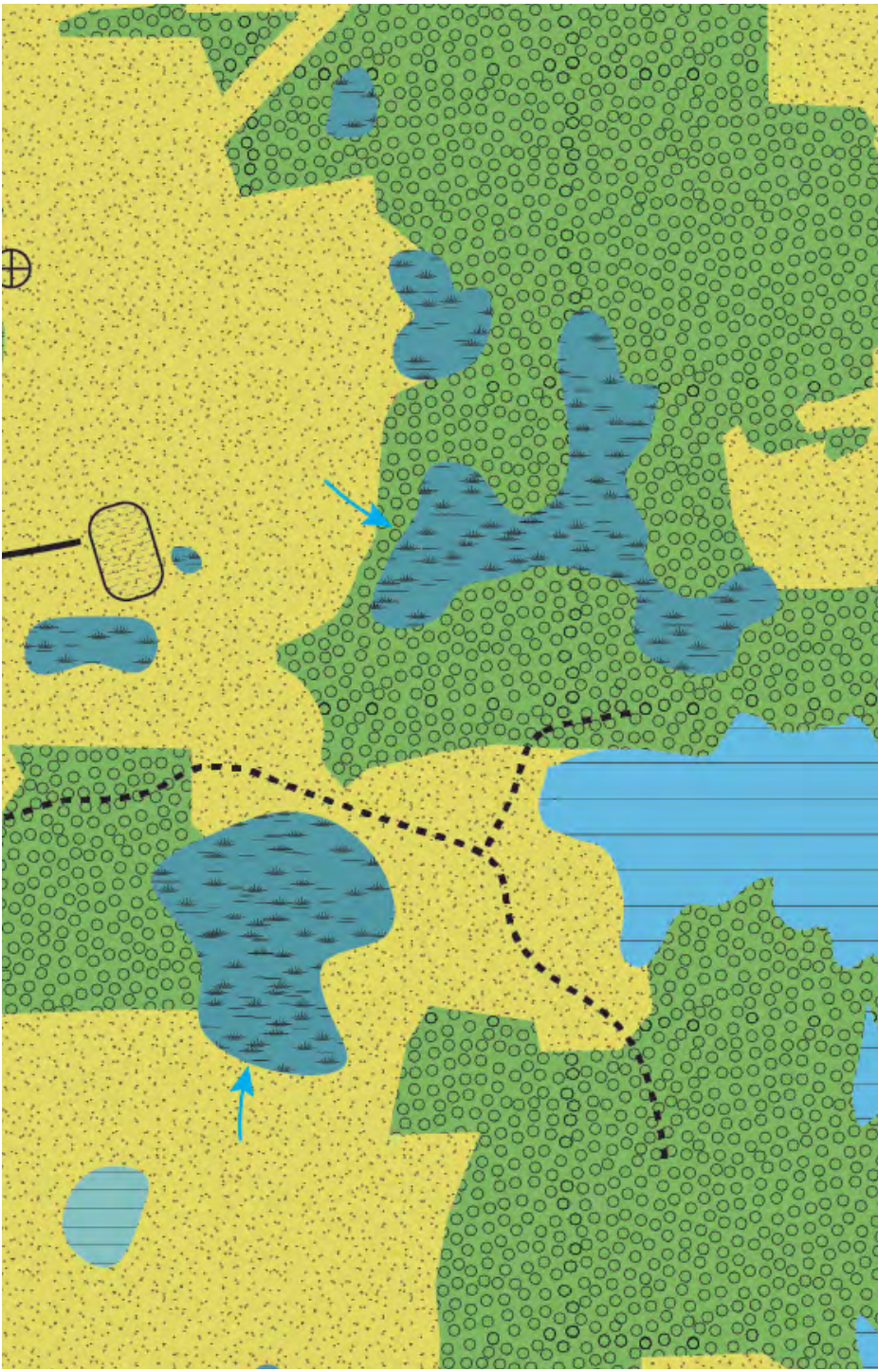


Introduction

Introduction

Indigenous Knowledge in Natural Infrastructure
The Centre for Indigenous Environmental Resources (CIER) has partnered with the Landscape Architecture Program at the University of Toronto, to promote the integration of Indigenous Knowledge (IK) in the design and construction of a natural infrastructure network for the south Lake Winnipeg Basin.

Our team is looking to understand and apply traditional ways of knowing the landscape in conjunction with Western science approaches, toward a new path of environmental healing.

In promotion of natural infrastructure ideals, we sought participation from Indigenous communities in the south Lake Winnipeg region, which took place at Knowledge Circles (workshops)—for the twenty communities in the western and eastern Collaborative Leadership Initiative (CLI) region—to exchange ideas, as well as through a survey, which has informed and shaped the information in this guidebook and the natural infrastructure approaches.

This project is one component of a long-term initiative, led by the Collaborative Leadership Initiative (CLI), to rebuild regional environmental health and community well-being. This component project can serve as a model for co-operative community-driven environmental improvement initiatives across Canada.

Indigenous Knowledge
The United Nations Educations, Scientifi , and Cultural Organization (UNESCO), defines th t "Local and indigenous knowledge refers to the understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings. For rural and indigenous peoples, local knowledge informs decision-making about fundamental aspects of day-to-day life." As CIER has outlined in their Mission and Vision statement, such unique ways of knowing position "Indigenous people and communities to be leaders of positive environmental change, using the best of Western and Indigenous knowledge to create a world that is in balance and supports the well-being of all living things.

Natural Infrastructure
Natural infrastructure, as defined y the Canadian Council of Ministers of the Environment, refers to the use of "existing, restored, or enhanced combinations of vegetation and associated biology, land, and water, and their naturally occurring ecological processes "to meet targeted infrastructure outcomes."

Indigenous Knowledge (IK) has served Indigenous communities in living sustainably for millennia. It is increasingly recognized, especially predominantly in the discipline of landscape architecture, that conventional gray infrastructure projects have not served our communities well, while natural

infrastructure is proving to provide the necessary resiliency against the realities of environmental degradation and resultant climate change. The opportunity to collaborate and integrate the long lineage of IK alongside Western natural infrastructure (increasingly used by landscape architects), provides this great opportunity to corroborate our shared ideals toward environmental restoration.

The design and construction of a natural infrastructure network in the south Lake Winnipeg Basin, already initiated by CLI, with its established Indigenous and municipal communities, provides the site and constituents in which to share knowledge and ideas, and develop collaborative approaches. The opportunity to initiate pilot projects, based on the community consensus, will serve to validate the approach.
Lake Winnipeg is the tenth largest freshwater lake in the world and a source of immense natural, economic, social, and cultural value. Yet it is also severely degraded. The most harmful and intractable challenge facing Lake Winnipeg is eutrophication, a condition caused by an over-abundance of nutrients, particularly phosphorus, in the water.

Centre for Indigenous Environmental Resources
The Centre for Indigenous Environmental Resources (CIER) is an Indigenous-directed non-profit organization that works in partnership with Indigenous Nations across Canada to support their community and environmental wellbeing. Since being created in 1994 by 10 Indigenous Chiefs, CIER has delivered research, advisory, education, and training services to over 400 Indigenous communities, governments, and private companies, with measurable impact through more than 450 projects. CIER created and is leading the Collaborative Leadership Initiative (CLI) in partnership with two other organizations: the Winnipeg Metropolitan Region (WMR) and the Southern Chiefs' Organization (SCO).

The Collaborative Leadership Initiative
The Collaborative Leadership Initiative (CLI) is a ground-breaking regional governance partnership between 28 Mayors, Reeves, and Chiefs representing 16 municipalities and 11 First Nations governments in southern Manitoba. The CLI Leaders sit at a shared governance table, guided by an Intergovernmental MOU, and work together on three critical common interests: economic development, water and land health, and infrastructure resiliency.

For more information on the Collaborative Leadership Initiative, please visit:
www.collaborativeleaders.ca

For more information, or to connect, please visit:
www.yourcier.org

Additional print copies of this publication are available at blurb.ca. For those needing to read this document at a larger text size, this document can also be downloaded from CIER at https://yourcier.org/resources/document-library/, and read on an electronic device with a zoom feature, or the downloaded publication can be printed out to fill 11”x17” pages in landscape format, which will increase the size of the text by almost double the size of the font in this publication.

Acknowledgements

We acknowledge this project involves the ancestral and treaty territories of Indigenous Nations, who have worked and raised families here since time immemorial. As outlined in the United Nations Declaration on the Rights of Indigenous Peoples, we recognize Indigenous Knowledge as contributing to proper management of the environment and the right of Indigenous Peoples to participate in decision-making matters affecting their rights. We strive to center the principle of reconciliation by advancing meaningful collaboration and cooperation with Indigenous Peoples. We also acknowledge the Treaty relationships that provide a foundation for reconciliation across the territory of the First Nations who were invited to participate in the creation of this guidebook, specifical y Treaties 1, 2, 4, and 5.

This work has been supported by a grant from the University of Toronto, Connaught Fund, Community Partnership Research Program, Indigenous Stream, and the University of Toronto Work Study Program, and in-kind donations from CIER and the Daniels Faculty.

The research that went into this guidebook was a collaborative team effort, which included: Richard Farthing-Nichol, Project Manager at CIER; Shianne McKay, Pine Creek First Nation, Treaty 1 Territory, Senior Project Manager at CIER, and from the University of Toronto: Alissa North, Associate Professor of Landscape Architecture; with Emiley Switzer-Martell and Benson Yuhao Zou, Master of Landscape Architecture Research Assistants.

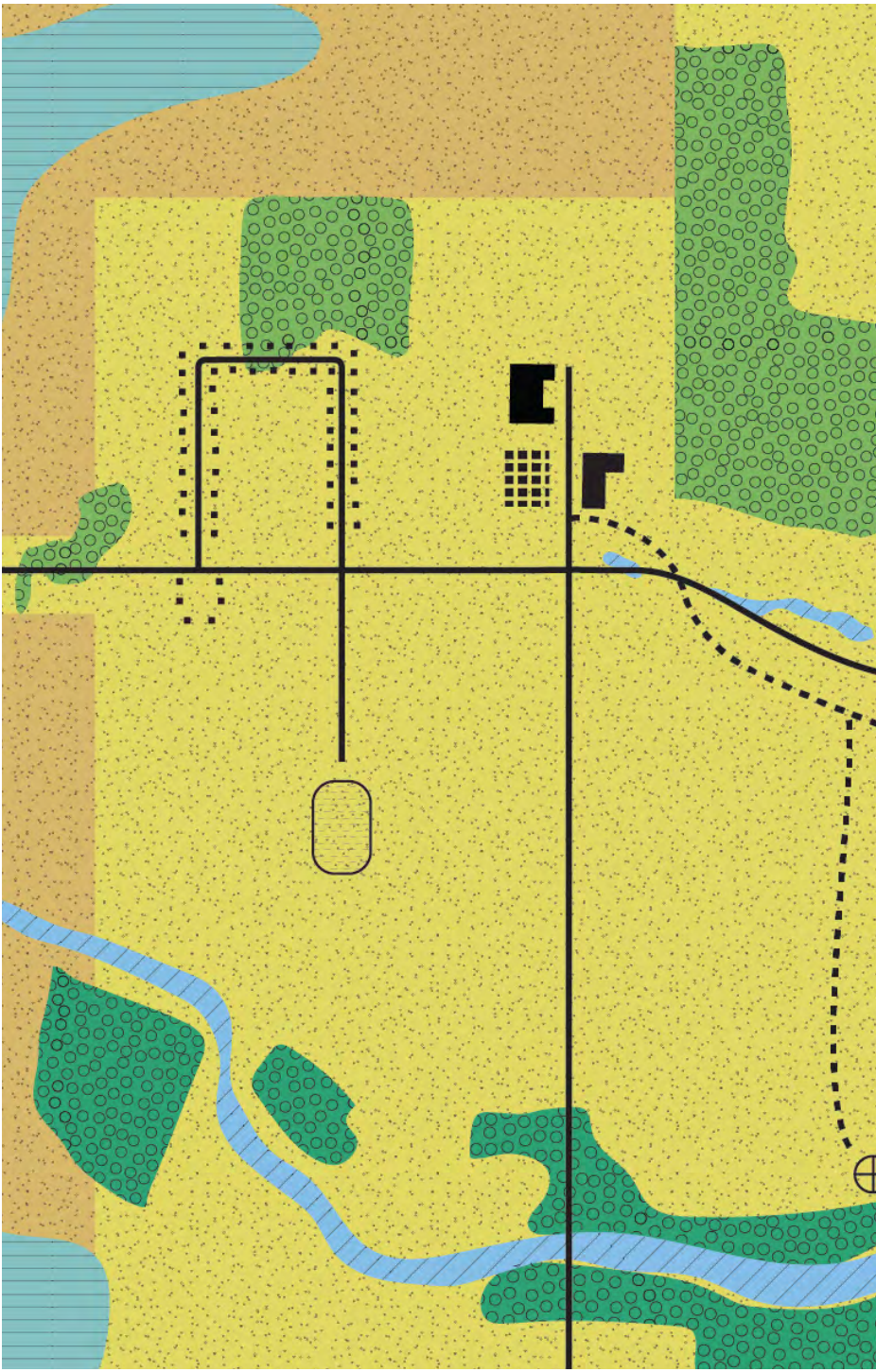
Thank you to Merrell-Ann Phare, Michael Miltenberger, and Glenn Tssessaze, who provided early valuable guidance as we headed into this project. Gratitude toward those at the Daniels Faculty of Architecture, Landscape, and Design for support and technical assistance, which includes: Professor Rob Wright, Nene Brode, Manager, External Relations and Outreach, and Steve Kupferman, former Digital Content Coordinator, and Temira Bruce for editing.

Thank you to the First Nations who were invited to participate, and who engaged in the process, particularly during the extraordinary times of the pandemic and widespread forest fi es. These communities were:

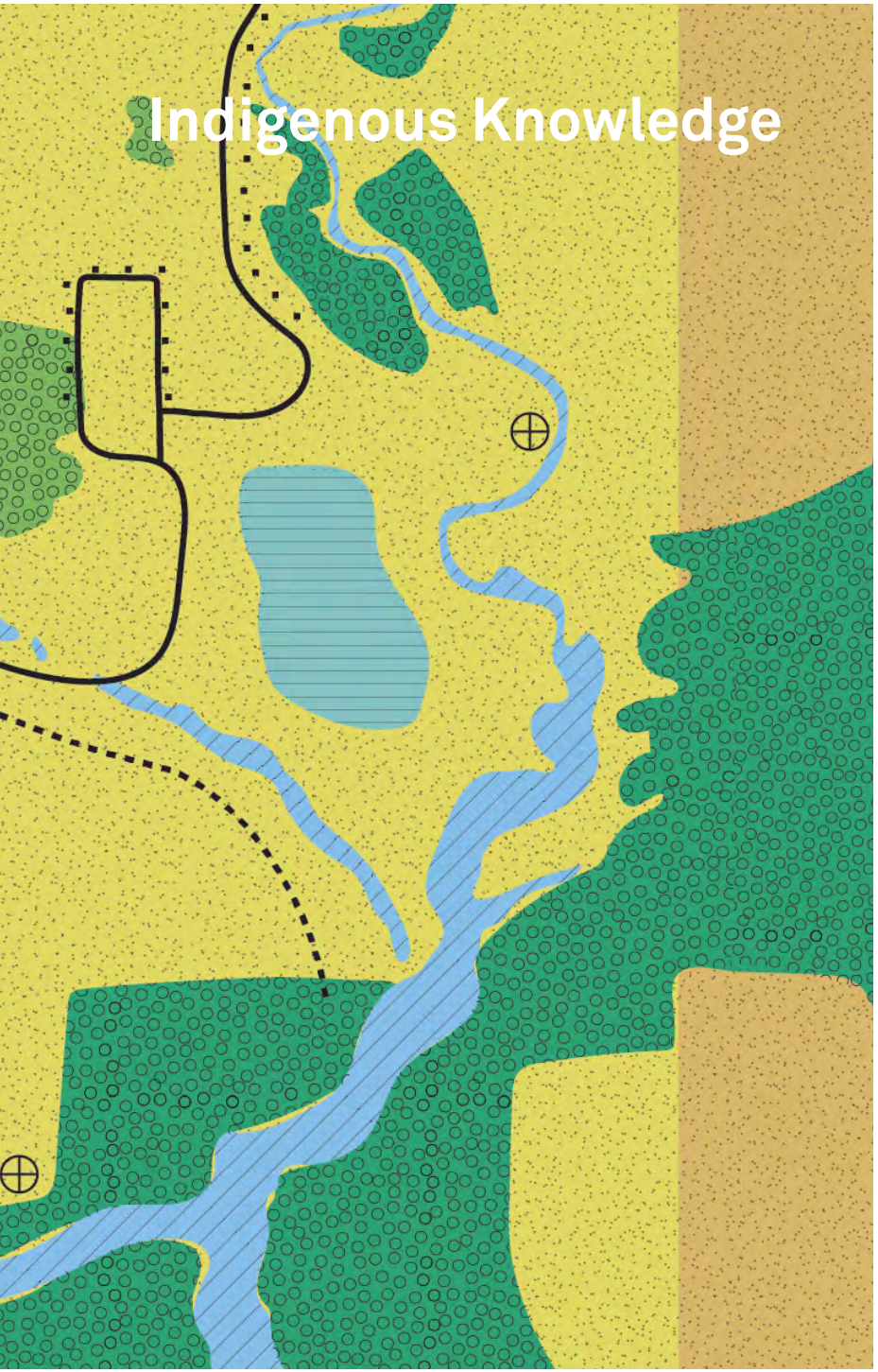
— Black River First Nation
— Brokenhead Ojibway Nation
— Canupawakpa Dakota Nation
— Dakota Plains Wahpeton First Nation
— Dakota Tipi First Nation
— Ebb and Flow First Nation
— Fisher River Cree Nation

— Gambler First Nation
— Hollow Water First Nation
— Keeseekoowenin Ojibway First Nation
— Lake Manitoba First Nation
— Long Plain First Nation
— Peguis First Nation
— Pine Creek First Nation
— Rolling River First Nation
— Roseau River Anishinaabe First Nation
— Sagkeeng First Nation
— Sandy Bay Ojibway First Nation
— Skownan First Nation
— Swan Lake First Nation

A very big thank you to the following people who provided deep and heartfelt insights in sharing their knowledge found on the pages of this book, and includes thanks to those who shared, but wish to remain anonymous. This grateful thanks goes to: Elders Clarence and Barbara Nepinak, David Beaulieu, Devon (James) Bird, Elizabeth Bird, Bradley Burns, Eric Cameron, Marie Gregory, Miranda Pashe, Irvin Sayer, and Mike Sutherland — Chi miigwetch!



Indigenous Knowledge



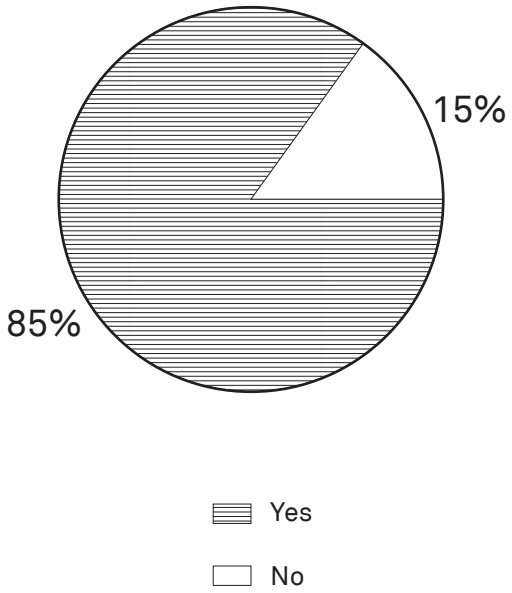
Indigenous Knowledge

This section outlines Indigenous Knowledge that was voluntarily shared through Knowledge Circle sessions, as well as an online survey to ensure that the gathered information accurately reflected the values of the communities.

The data from the online survey was aggregated so that participants remained anonymous. The valuable information from the survey will help inform natural infrastructure approaches in the south Lake Winnipeg Basin. The survey was conducted online, held in the summer of 2021, and had 18 participants. Understanding and applying traditional ways of knowing in the landscape in conjunction with Western science approaches, can provide a new path of environmental healing. The data is displayed on the following pages as pie charts, bar graphs, and as lists.

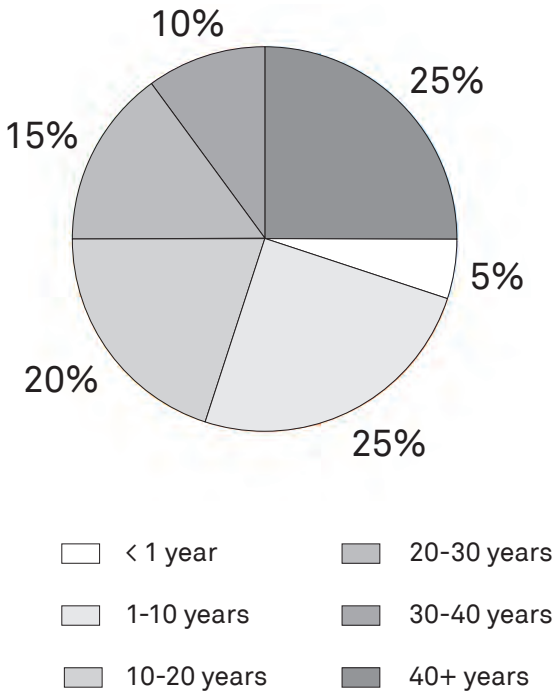
The Knowledge Circles included a brief introduction to natural infrastructure, which was followed by discussion questions, interactive surveys, and group discussion. The sessions were held online in the spring of 2021, and there were 14 participants. This incredible shared knowledge has been paraphrased and grouped under the same thematic headings as the data, to provide detailed insights.

Do you currently reside in a First Nations community?

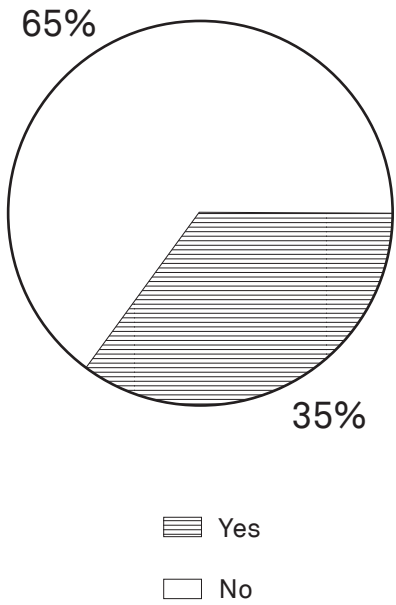


Community Characteristics

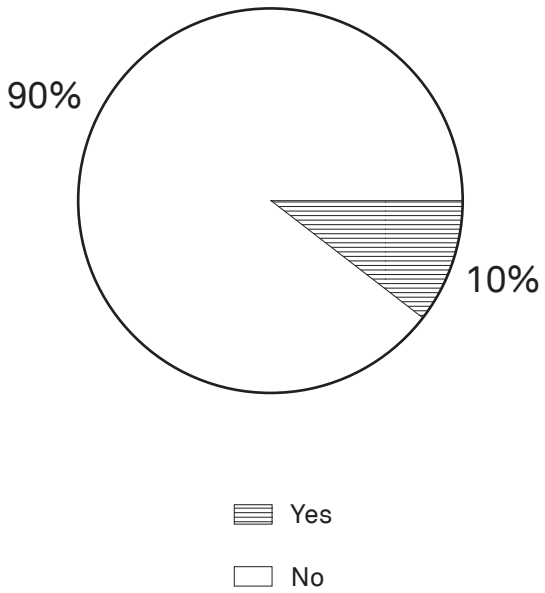
How many years have you lived in your community?



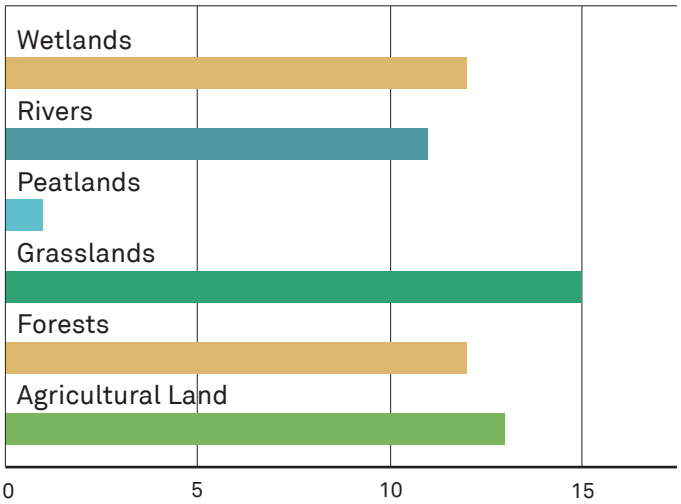
Do you identify as an Elder in your community?



Do you identify as a Youth (ages 18-30) in your community?

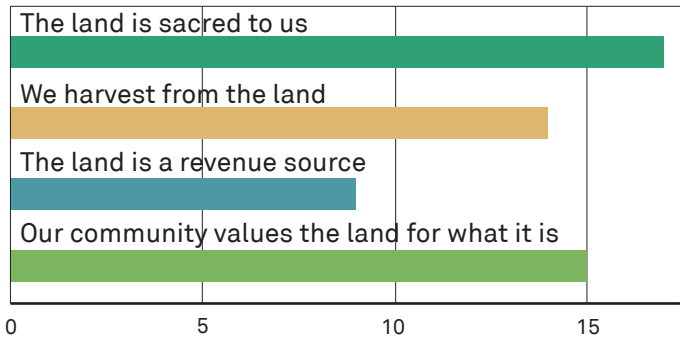


What do you think are the most important natural areas for your community? Check all that apply:



Important Natural Areas in the Community

Why are these areas important? Check all that apply:



— Our precious Lake Winnipeg and its tributaries and everything that surrounds it.

— The river. It is a way to get from here to there, transportation, and it gives us recreation uses. It's really peaceful. For us, it's the natural way to get water, food, all types of medicines that grow alongside the river.

— In Keeseekoownin, Riding Mountain National Park is very significant o us. For those that don't know our history, at the time of the treaty signing, we were given lands on the shore of Dauphin Lake. That's where we were supposed to have established our community. It does hold significanc , and it has a huge fish popul tion, that even to this day our people still annually harvest, but as time went on, the community at Dauphin Lake was scrapped. Two communities were then established—one where we are today, in the valley on highway 45, but our community was originally living on the western shore of Clear Lake in Riding Mountain National Park.

— Riding Mountain National Park has many different areas of cultural significance o us. There are several spiritual sites, a lot of medicine picking we still utilize, hunting, and fishin . Back in 1939 when Riding Mountain National Park was established, government decision dictated that nobody could live there. Parks Canada came in and burned out the homes and cottages of the Keeseekoownin people, and we were

displaced from the Park, so half of our people located to Clear Lake, and half to where we are today. We didn't get the land back for about 60 years. We have grave sites up there, it is a very spiritual place for us, and not just where we lived but all of the Park. The Elders remember. My grandfather tells me stories of hunting on horseback through the Park with his dad.

— The Park has many spiritual sites located throughout that we haven't even identified with arks Canada, in trying to keep that knowledge safe. Our community is in the process of doing a cultural study on the Park and the areas we utilized, such as where the fish mig ate in the spring, meadows where there are medicines. Where we are now was also another place of significance o our people in the past, and there are stopping places along the way from here to Clear Lake which are also significant o us.

— As an Anishinaabe I follow my traditions and know and understand our own laws. We follow the laws of nature as well as the laws of the great spirit. We understand that many things have already been taken from the earth, which are not replaced, causing the slow shifting of the earth. This causes the weather to change, being a major factor of global warming. Many trees are being cut by Hydro, and they refuse to put in fil ering systems that will clean our water. What is wrong with reforesting the trees and plants? Stopping the pipeline is not our priority, it's what it carries and how these things affect life—the life of

everything, as well as everyone. Safety and survival are most important. Money will never be able to buy life, and every life matters! Money could help with improvements so we can harvest cleaner energy, if the energy such as water is kept clean. The great spirit created the land on top of the turtle and life upon, and within her our mother, the earth, she is alive. In order for her to care for the life we need to help her. Everything in creation relies on each other. We need all these things in order to live. This is for everything and everyone not just Indigenous People! We only borrow the land, the water, and all of life that is upon our mother from our children. We think of the future, not just the here and now—seven generations we need to take care of!

— One of the most important natural areas for every community that's around lake Winnipeg is the Washow Peninsula, where it goes from Hecla Island all the way out to Matheson Island, and what's happening out there right now is a long-term harvesting of peat. At Washow Peninsula, 50% of it is water, and in order to harvest the peat, you need to drain the water. There is probably about four or fi e companies that are harvesting right now, and were fig ting tooth and nail to get them out. They have 60-70 year plans of peat harvesting in up to 70% of the peninsula. If we allow the government to continue to give permits to these harvesting companies like Sun Gro, Sunterra, and so on, the peninsula will be destroyed. Once the peninsula is destroyed, the life of lake Winnipeg

will be very limited. The peninsula is the kidney, it fil ers everything that comes into Lake Winnipeg, from the Rockies down to the Dakotas, east into the Lake of the Woods, through to the Winnipeg River system—everything comes here. Lake Winnipeg is the final basin or everything that comes in and goes out to James Bay. If legislation continues to permit harvesting in there, it will be destroyed. For our community, that is one of the most sensitive areas in and around that whole Lake Winnipeg Basin.

— The area is used a lot for harvesting and hunting as well. It hosted the highest moose population in the world prior to peat mining, which started with a few companies in the late 80s, and now, the moose populations are very limited. First Nations have been blamed for over harvesting, but we've been fig ting with the Province, who is issuing permits. We have moose closures in our area, and they tell us we can't hunt moose because there are low numbers, but this is hypocritical. We are told not to hunt moose, but then the Province allows the habitat to be destroyed. Last year there was a fi e that destroyed over a thousand hectares of land, and it was one of the peat companies that started it!

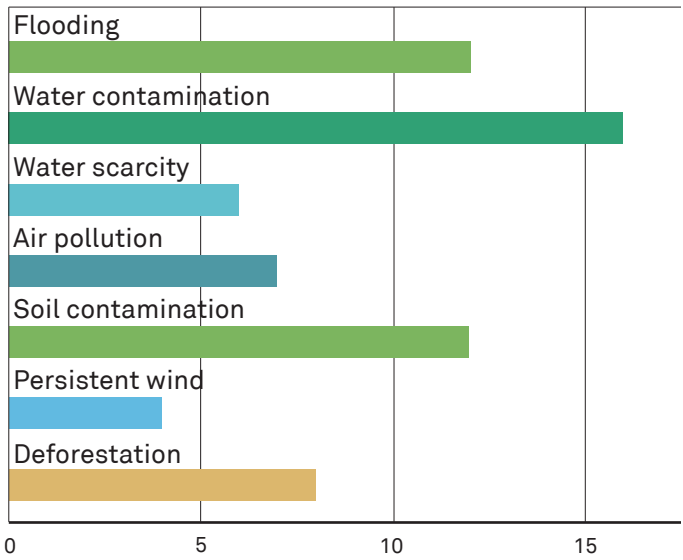
— There are a lot of medicines in there. I trap muskrats and beavers in that area, and I will be trapping till the end of this month. I do beaver control, trapper, and land-based education. We collect the castor for medicines, for bait, for making incense,

and they are used for perfume. We teach this to the youth. I am meeting a group of youth out there tonight actually.

— It is a heavily used area for our people, and we have done medicine walkthroughs of that area, and found that there is mountain ash, which is a very heavily used medicine, but it's found only in very few places in Manitoba, with Washow Peninsula being one of them.

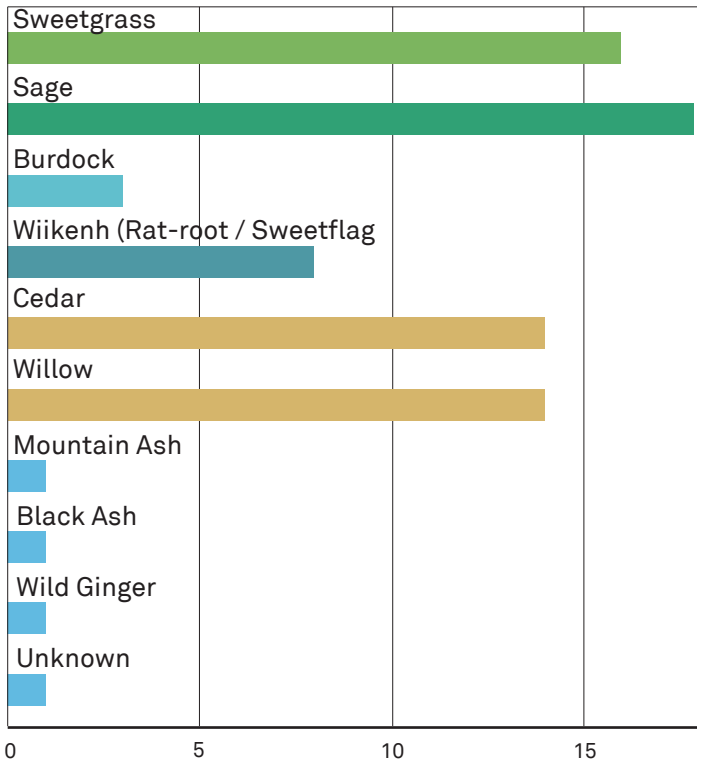
— About fi e years ago we initiated a huge protest, where several First Nations bussed in groups of people. There were over 200 people on the roadway protesting the peat harvesting. Some of the local communities believe it's beneficial or the local communities, but the companies—Sun Gro, Sunterra—are very big and have their own extensive resources, equipment, and trucks. They are not employing hundreds of locals hauling the peat out of there, they are all coming from the States, so there are limited benefits or local truck drivers. The sustainability is not there. The destruction of the land is immense. The destruction is unfathomable—the long-term effects it will have on the life of Lake Winnipeg.

Which of the following issues affect your community? Check all that apply:

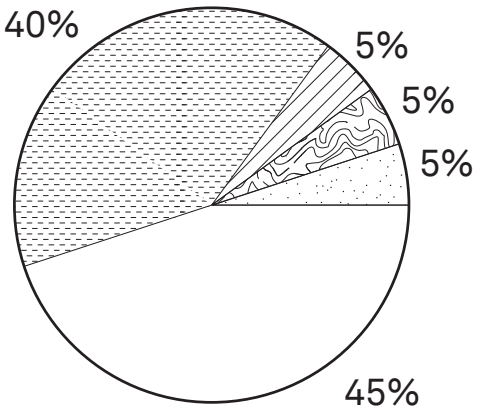


Plants

What kinds of plants do you harvest from the land? Check all that apply:



Why are these plants important to you?



Our people have been using them for years, for ceremonies, blessing, etc.

Spiritual meaning

Traditional value

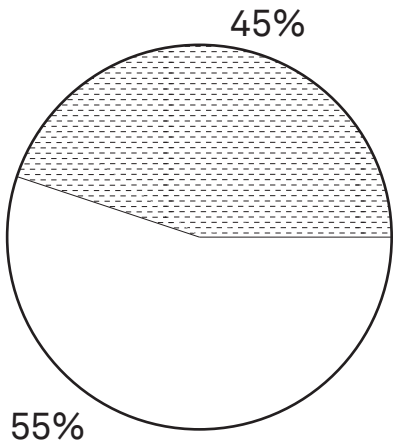
Prefer not to say

Medicines

Are there plants that you need to harvest in your community that are now gone or harder to find

— Berries of all kinds
— Birch bark
— Cattail
— Sage
— Senecca root
— Sweet grass
— White willow
— Wiikenh (wild ginger)

What changes to plants and plant communities have you observed, and why do you think these changes are happening?

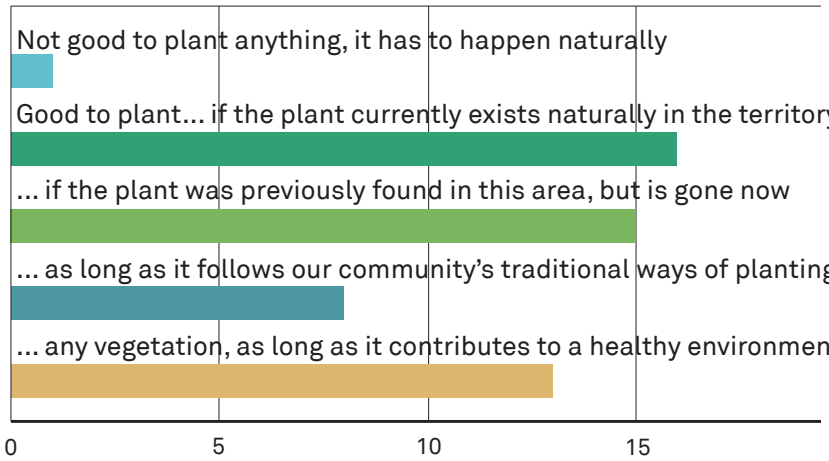


I have not observed or heard of changes in the plant community

I have observed or heard of changes in the plant community

— Loss of wiikenh (wild ginger), which used to be plentiful in watery areas, but there is not much water around anymore
— Because of pesticides, certain plants will not grow anymore in areas around water
— Scarce and not as lush as they were in the past, they seem to be shrinking
— Invasive plants, and deforestation
— Various Developments
— Climate change
— Agriculture
— Wild fruits

For a natural infrastructure project, what are your thoughts on planting vegetation. Check all that apply:



— We pick a lot of medicines in the area, which we use to help boost the immune system. There still is a good abundance of balsam and juniper. But, a lot of the medicine that we would pick along the river, we don't anymore because of the agricultural practices, and the river is too contaminated. North of us is all forestry and swamp, so we are able to access from there our medicinal plants, as much as we need.

— When I medicine pick with my mom, we can never find weetgrass nearby. We have to travel far to find i . The patches are very minimal, and sage is now in small patches as well.

— There is critical damage to the trees at Sandy Bay, due to the flood, trees are dying. Tree planting would be very beneficia . I have never seen any flowers, but I think that would be another suggestion I would make to the Chief and Council. There was sage, there was sweetgrass, there was mint, but since the flood in 2011, these have disappeared. It will take time for them to regrow. Hopefully they will. People who live in Lake Road South have said there are some medicines growing in that area. There is poplar around the area, and there is still birch, but no cedar. Talking to the cultural practitioners, they noted that wiikenh was prominent in the marsh area, but is not now. If you want to pick sage, you have to go miles out of the community. I noticed one person collecting sage, but he has to travel four miles west of the community, and

even then, it is patchy. We have to go to Peguis in order to collect Sweetgrass now. For a lot of medicines, we have to go outside the community, travel for maybe a couple of hours in order to access the medicines.

— One community has built very successful community gardens. In my time, when I lived on the reserve, we always had community gardens. My parents had their own garden, but my mom would plant an extra row of vegetables for a single mom that lived across the road. To build a healthy community is to be able to support each other, and to be sure that we strive for the same thing.

— We use a wide variety of plants, but we have seen less and less cedar throughout our communities. Mostly because of forestry operations and agriculture, so we have to travel very far to harvest cedar. But our people do it. We harvest sage, and used to do a lot of wiikenh harvesting along the river, as well as lily pads, bullrush roots, and so on, but because of all the agricultural practices, the river is too contaminated and a lot of our people won't harvest there anymore, so again, we have to travel far, or search some of the small lakes, tributaries, and swamps.

— We have a good community garden farming program. We were always a farming community, but because of climate change, it has really had an impact on our agricultural practices. There are now very

few farmers, however, there is a lot of community gardening at homes. Raising chickens is now a big thing at Peguis, and we have two huge community gardens that are looked after by a single champion who leads a team. It works really well, because if people don't have their own garden plot, they can come and get a section, to be able to garden.

— We have a woman who has a medicine program. She shares her knowledge with locals on reserve, as well as those seeking plant knowledge beyond our community.

— A couple years ago we planted wiikenh and sweet grass, but it was out of the reserve, because there is nowhere to plant in our community. These plants seem to grow better away from people anyway, and they are growing well. We also planted cedar. I asked our Elders where we should plant, because they are the knowledge keepers of our community, and they said where best it could be planted. This planting came about through a workshop with the Health Center, and we also connected with the Turtle Lodge from Sagkeeng, they were the ones that gave us the seedlings. Each community that participated got seedlings to bring back to their communities, to then transplant into the ground. It was a good initiative, and the majority of it is growing really well. The sage not so much, it didn't really take, but each community that participated got seeds and seedlings, even vegetables and potatoes.

— There used to be many areas where there was lots of wiikenh and bullrush roots growing—we could always go to one spot to pick, but then with the water level being so low, it got dry rot and a whole section of it died. There are other areas, but I can only get to these spots by boat or by canoe now. It's really hard for me to go out and pick the medicines I usually go and get. We use burdock as a system cleanse—it's a natural flushing a ent for your body—but we can barely find th t around our community anymore.

— Our Keeseekoownin medicine woman passed away last year. She and another woman ran a medicine camp here, and they educated people from all over. This still continues. Even university students come for classes. Our medicine women are very familiar with all of the plants, all the medicinal uses—silver willow and a lot of plants found on the planes, annex root, burdock, hyssop, and rabbit root. During the pandemic they have handed out a lot of flu type medic tion. Hundreds of bags of it have gone out.

— We pick a lot of muscatel tea. One benefit th t we have here, is our traditional territory—Riding Mountain National Park. They have a whole staff committed to looking after the place, really. We have a relationship with Parks Canada, we try not to interfere with each other. We have to get recognition that this was our homeland, not to be treated as a partner, that they have displaced us. Not just to be treated as a stakeholder. Our medicines that are in the Park, are

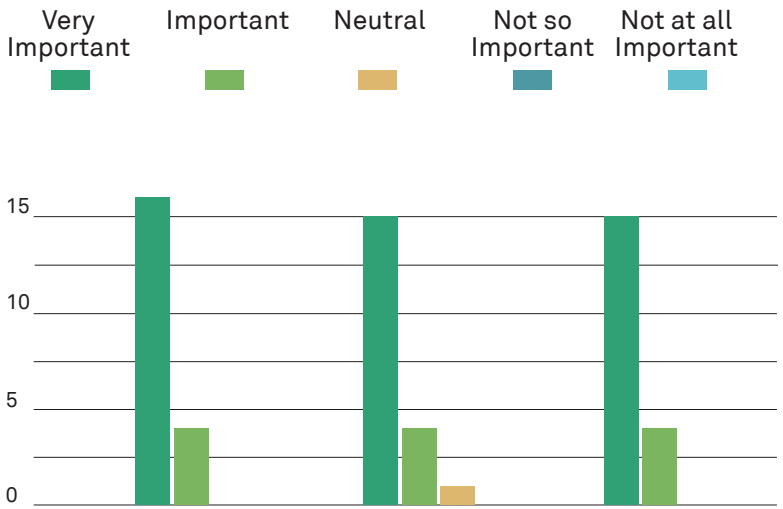
at the buffalo pasture, up by Lake Audy. We have a recognized medicine society and harvesting society. The Park recognizes this, with our people, so, our situation is pretty good. The issue for us in our area is that we are surrounded by so much farmland. One of the jokes that we have is that the cows have more access to the land then we do—have more right to the land then we do. There is a lot of unfair treaty business in all of that. Within our community, we use what grows here naturally.

— One of the things that doesn't grow in our area is cedar. We have to travel about six hours for it. We could certainly plant it, but from a traditional standpoint, if it's meant to be here it will be here. That's the way we look at things. I have heard of places where wild rice was introduced to lakes, and forgotten, and it grew and maintained itself, but in other areas, in other times they have tried to introduce it, but it never took.

— In our community, we are going to plant 575 trees within the next three weeks as a shelter belt. We have houses in the middle of fie ds where there are no trees at all. We need these trees—we need them for the environment. We need it for the air and for us. The majority of the trees will be hybrid poplar, because they grow about six feet a year. We have willows and lilac that the Elders suggested. We have someone to transport all these trees for us. In our area, we

have wind 95 percent of the year, summer, winter, and fall, so we need this windbreak. We have a high wind ratio all the time. This will provide a little bit of wind break for our houses. Especially in the winter time, it is really cold here, so we are doing this for our environment, and for our community.

When building a natural infrastructure project in your community, how important is/are:

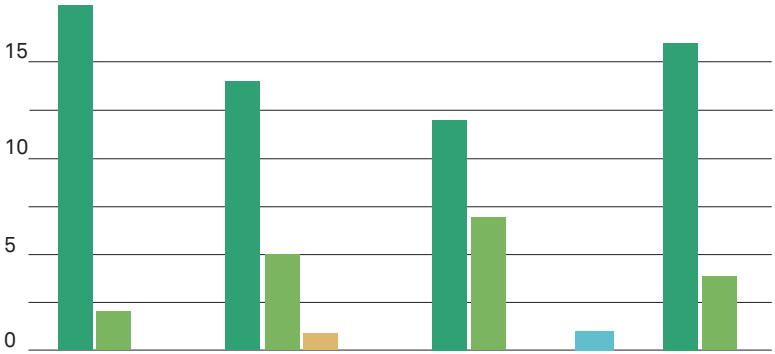


Engagement
—
Bringing people together, and ensuring the project is organized and spearheaded collectively by the community

Management
—
Be fully managed by the community

Access
—
Accessible and centrally located in the community

Building Natural Infrastructure in the Community



Cultural Sites
—
Avoid culturally important sites

Plant Selection
—
Only use plants that exist naturally in the area

Rare Plants
—
Increase and make use of plants that are currently hard to fin

Plant Value
—
Ensure careful selection of plants that correspond with community values and traditional practices

— There is concern regarding the shores of Lake Manitoba where marshes have been damaged. There are no more frogs, and hardly any pintails. Ice overflowed into the marsh, which brought in another species of fish o Lake Manitoba, damaging the natural habitat of the original fish We are really concerned with the lake level, and the shoreline damage. Now the First Nations have to go several miles out in order to get the proper fish th t they need for sustenance to feed their families, and to make an adequate living. Natural infrastructure does not exist in my community. They built dikes here, causing large pits by the marsh, and they just left them, they did not refill them There was no shoreline stabilization, naturalization, filt ation trenches, nothing. It is just open damage. Now Manitoba Infrastructure is attempting to build another channel which will probably fail, which will probably infest Lake Manitoba from Lake Winnipeg. Grassy Narrows has mercury poisoning from Dryden. They all flow into Lake Winnipeg through the Winnipeg River system. And if that fails, it all goes into Lake Manitoba, which is going to be a disaster.

— There are so many projects that are underway right now that are detrimental to Lake Winnipeg. We were working with the Lake Winnipeg Foundation for the Red River Basin Commission on the marsh rehabilitation. Their proposal was to open the channel by dredging, and to put the dredge material into the marsh. The Netley-Libau Marsh is a cut that was made

in the early 1900s, which is about a half kilometre in length, and it changed the outflow of the Red River, and how it moves to Lake Winnipeg. Putting that whole state back to the way it was before, is a project with a bigger scope beyond dredging the river into the Netley Marsh. As long as that channel is there, the water flow is always going to the marsh, and the marsh is dead because of all of the contaminants coming down the Red River from the United States, so, this small initiative actually needs a bigger contextual scope.

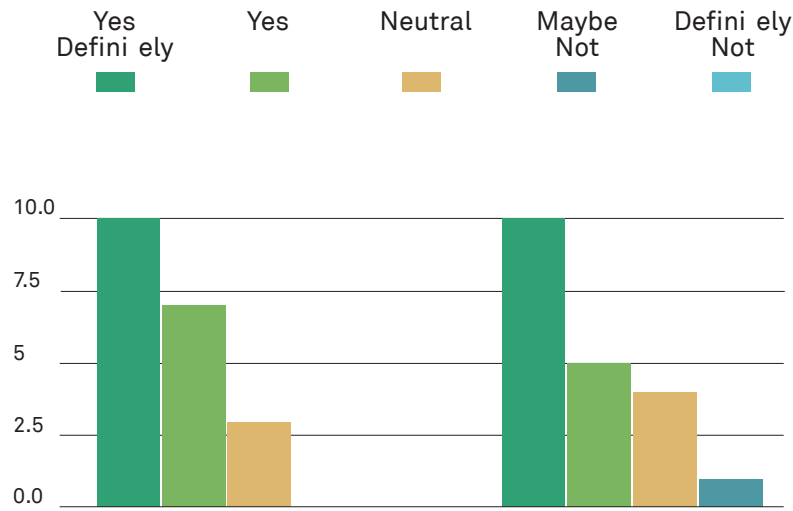
— At Swan Lake First Nation in south central Manitoba, two miles from the border, we are currently doing a drainage study. We built a dam and retention pond to fil er all the phosphorus and stuff that comes off the fie ds, into the creeks, the aquifer we have on our land.

— The channels project, the silica sand mines, the Province approves all of this without considering the life of Lake Winnipeg. Let's consider what's coming down through the Assiniboine River, the watershed coming down from Saskatoon to Regina, that's all potash mining. Water is recycled back to the land, if it comes down here. If you go south of Regina, into the Dakotas, the Souris River system is all fracking operations. Again, that water is recycled back onto the land once it comes this way. Natural infrastructure projects will help Lake Winnipeg—I think is a good idea—but fi st we need to get to the root of the problem, and stop the Province from

passing detrimental agricultural practice legislation that destroys our environment, which will kill Lake Winnipeg.

— There is a line of water that comes down to Sandy Bay. For years and years, the water table was so high. I live on a ridge that was flooded. The ridge is higher than the lake. The water came from Riding Mountain. They opened up a channel, which flooded everything along that river system. There is a creek where garbage is dumped, which stops the flow of water, and flooded everything along the way. Water came up from the ground. The flow has been so disrupted—something has to be done. No wonder we have boil water advisories in our First Nations. All that waterflow coming from the west side, the east side, and the south side is not helping much with any community near the lake. Our systems are damaged and spoiled. Natural infrastructures might save a lot of this damage that had been happening.

— If successful, going to the supreme court to stop and prevent the channel being built at Lake St. Martin, will help any First Nations along the shoreline of Lake Manitoba, including Lake Winnipeg, the lake system, and the Wabigoon river system. People will start realizing that water is important, water is life. Anything living out there needs water. Infrastructure, flood mitigation, and natural infrastructure is very critical at this juncture. I hope to see something in my life time for the next generation.

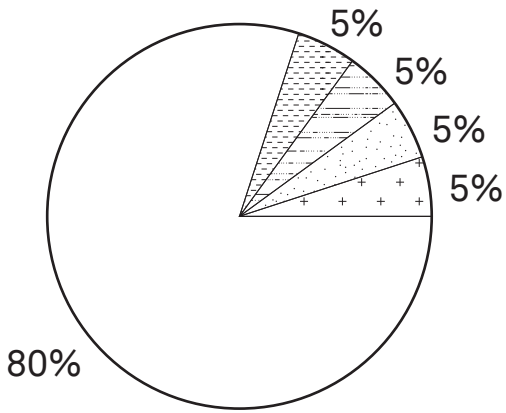


Is natural infrastructure for flood reduction something your community needs?

Can you imagine that your community would support building it?

Flooding

Can you think of any important considerations around natural infrastructure for flood reduction in your community?

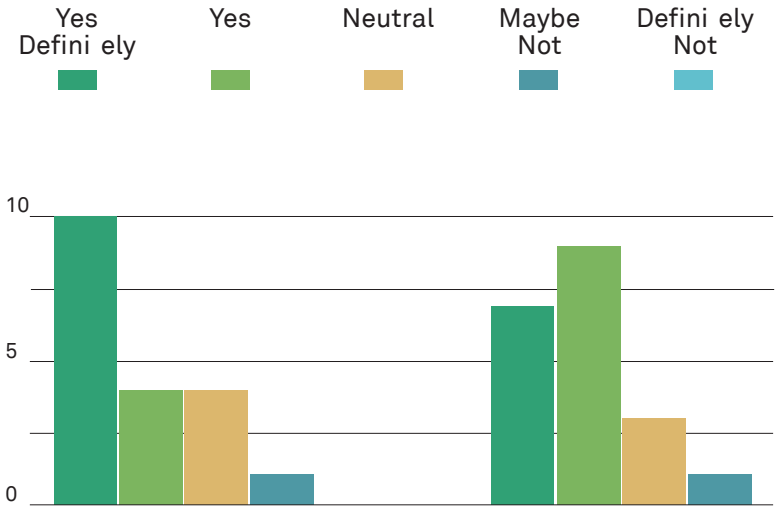


- Dam and retention pond drainage study
- Flood reduction study
- We are surrounded by water—even underground
- Rebuild and renew pre-flood infrastructure
- No

— Our beach used to be a beautiful beach with trees and change houses, you name it, it was all there. Now the beach is only maybe eight feet in length, when it used to be twenty, with shoreline hills. A lot of sand, a lot of trees, now they are all gone. You can see the lake from where I live, about fi e miles from the lake. But I could see the shoreline. Considering Sandy Bay, we don't have bioswales, infilt ation trenches, buffers, wetlands, constructed wetlands, or floating wetlands. Our wetlands are damaged, because of the flooding, the backflow from the Lake St. Martin area. When they opened the channel at Hoop and Holler, it went to Lake St. Martin, then it came back. It flooded and damaged our burial grounds.

— The banks of our land near Lake Catherine are eroding. Within our community at Rolling River, we have Perch Lake, and those banks are getting smaller every year too. Our community is studying this. Our ancestors named Rolling River, but now every year it is non-existent by the end of June. It's now May, and it's already a trickle. But, during flood season, a lot of our houses are flooded. Last year we had rain for three days. I had a foot and half of water in my basement, and I am on top of the valley. You wouldn't think I would get flooded, but that was the second time in ten years my basement has been flooded with water a foot and half deep.

— At Dakota Tipi, we are a very small First Nation near the southern basin of the Assiniboine. Originally, we were across the river on the other side of the Assiniboine River, but then there was flooding, and they moved us here. Now we are starting to get floods here. Many of our basements are flooded, and our roads are cracking because of the water. We do not have a large land base—just a mile wide each way. Everything else is crown land around us. The City of Portage is also around us, and owned as personal property. The land that was ours across the river has now been built with complexes, high-rises, and big homes. Our community recently flooded again, and we are working with the Indigenous services on flood mitigation.

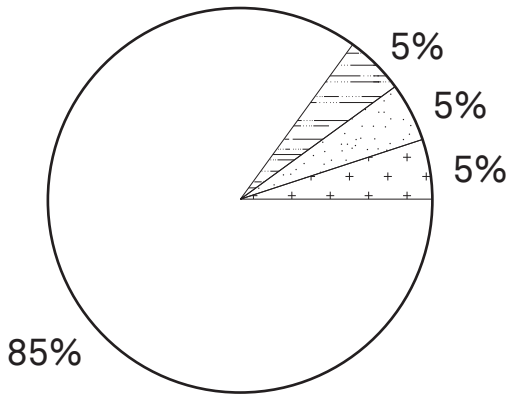


Is natural infrastructure for erosion control something your community needs?

Can you imagine that your community would support building it?

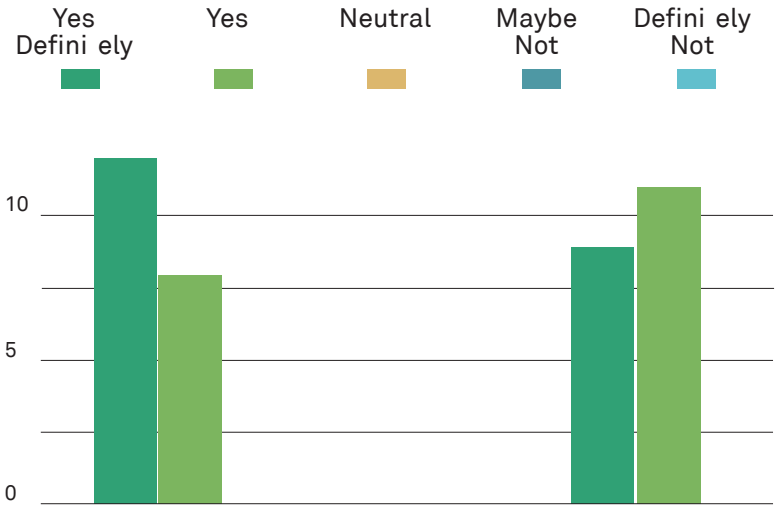
Erosion Control

Can you think of any important considerations around natural infrastructure for erosion control in your community?



— We have some areas where we are having gutter erosion. We are planting another 200 trees to stabilize the erosion. There are areas where we need shelter belts, and we have been planting trees to provide protection and privacy for the houses. We had a dam here in the 80s, we had a potato farm. We built the dam for irrigation, but it started to erode. Our dam structure was lowered, and we've also had to deal with erosion in the valley, caused by an underground stream. We have to get engineers to fi ure out how to stabilize that. In certain areas, like the retention pond, we have been asking the Elders to let us know what we should be growing there—they have suggested plants such as willow, which is also useful as medicine.

— At Sandy Bay, they dug out the land and built dikes. The dikes themselves are weak according to the people on lakeshore and on the south side of the lake. When another flood happens, the dike will be gone. Water will wash it away because it is made of clay. Clay floats, clay washes away. They didn't even clean up after what they dug out. There are rusted culverts all over the place and wood scrap. There are children playing around those things. That's dangerous.

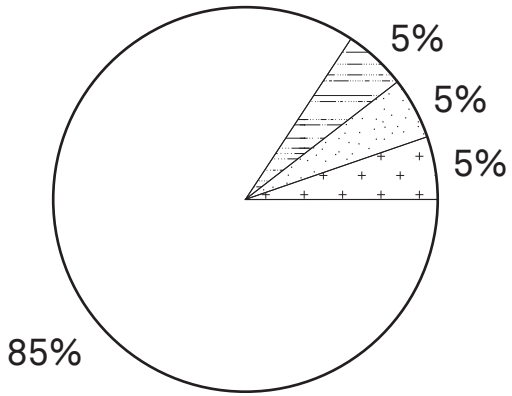


Is natural infrastructure for water cleansing something your community needs?

Can you imagine that your community would support building it?

Clean Water

Can you think of any important considerations around natural infrastructure for water cleansing in your community?



- Planting vegetation, trees, etc.
- Consultation with elders on how water was naturally preserved in the past
- Cisterns require deep cleaning and/or replacement
- No

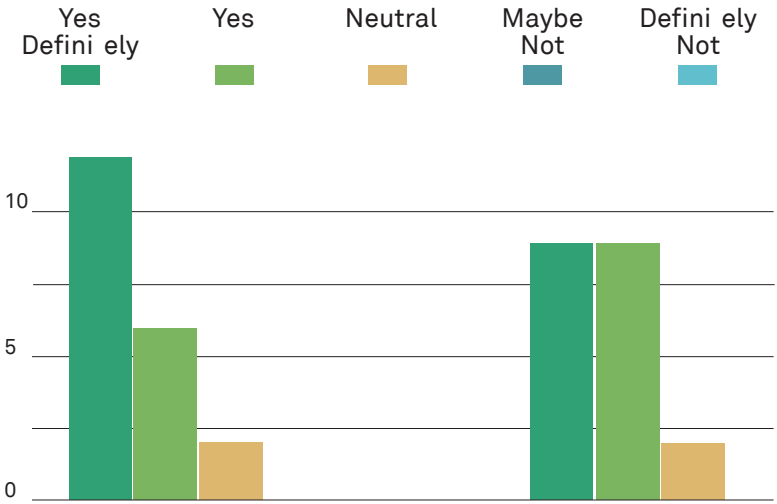
— We have two aquifers under our land, Swan Lake in the south, and we also connect to the Assiniboine River, so we work with three different watersheds. We started a drainage study to determine what chemicals are used by the farmers, and what is draining into our lake. We built water retention ponds, and a little dam to fil er whatever comes down the stream. We have an abandoned mill road that goes through our land. We have been in mitigation on that. It's causing selenium in one of our creeks, where our train station used to be. We are also dealing with the pipeline. There are some major spills going back 50 years that were never cleaned up. We are final y getting them to clean that up. We are trying to control all the phosphorus and algae in our lake. We are trying to protect our water resources.

— The deepest part of our lake is about three meters. The rest is one to two meters all around, so it freezes almost to the bottom every year. We hardly have any fish In the late 1960s they built a dam in Rock Lake, which flows from Badger Creek in the United States. In the late 1990s they built a dam at Pelican Lake, and the chief and council at that time were worried about our water situation based on those two dams, and now we are running short of water here. We have done a feasibility study to build a weir dam to raise our lake to at least two to three meters. That's our challenge right now.

— At Rolling River First Nation, located right by Riding Mountain and north of Brandon, our community now has bodies of water that were not there 10 – 15 years ago. We would like to find out whe e they came from, where they originated from. We have two houses within our community that are winter road accessible.

— We are trying to get back more water around here in Black River. There used to be medicines and wild rice that grew alongside the river. Now the water is so low, we can't get to certain places that do have water. Animals can't get as far upstream as they used to be able to. There could be a way to reserve the water that we do have.

— The silica sand mine is in one of our traditional use areas, it's a migratory route for Peguis First Nation, through Sandilands Provincial Forest. There are further silica mine proposals that plan to extract the silica sand from 100-150 feet below the surface, suggesting that this is safe, but the silica sand is part of the whole ecosystem below the ground—the artesian wells, bedrock, and so on. Hydrologists are working with our communities to determine impact, and once thousands of metric tonnes of silica sands are removed from below the surface, there will be a void, and how is that void going to be fil ed? So not only is air quality affected, but it's going to have even more impact below the surface, where many of our sources of drinking water come from.

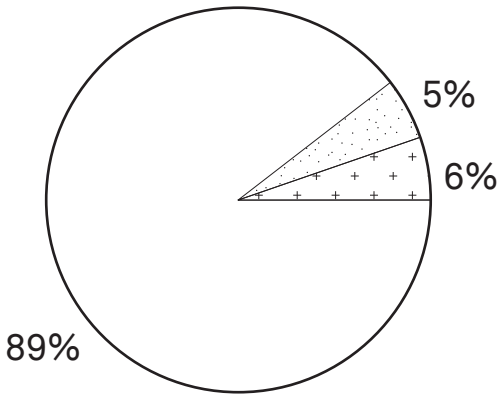


Is natural infrastructure for contaminant removal in soil something your community needs?

Can you imagine that your community would support building it?

Contamination

Can you think of any important considerations around natural infrastructure for removing contaminants from soils in your community?



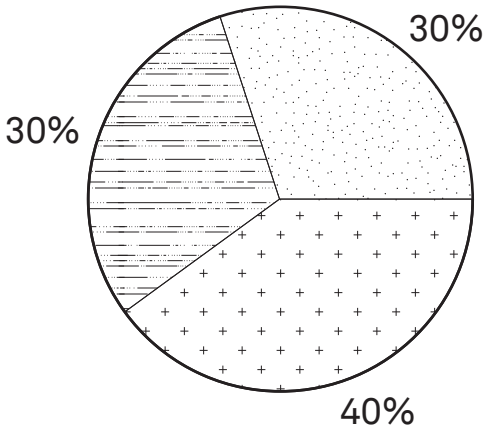
— In the west bound Lake Winnipeg area, we need to stop legislation that allow extensive agriculture use. In November 2017, an omnibus bill was passed in Manitoba, which included the hog operations. In 2007 the NDP government placed a moratorium on hog operation expansion and in spreading manure. In 2017, the omnibus bill opened that moratorium up, it did away with it. Companies can again expand operations. They want to spread manure on the lands in the winter, and we are fig ting to prevent that.

— Within our community, we used to have a lot of moose, but those are all gone. We need to keep our two fishing a eas pure. The majority of our land that's not being used for housing is being used for hay and grazing for cows and horses, and the rest is agriculture. There is a lot of use of fertilizers. We have to look at the impact of those fertilizers on our air and water, and how it is affecting us. Some of our kids now have allergies, and we don't know what's all in those fertilizers that are affecting the air quality. Many of our houses are close to the agricultural areas. We are meeting with our Elders to discuss our issues. Our community is quite small, so we don't have a lot of Elders living within the community. That means all that knowledge is leaving us. We need to learn what to do with the land and water, it would be interesting to see what they have to say.

— There is a lot of knowledge with our Elders of our traditional areas, and the places we harvested. Where we are located right now is in a valley, which is a natural corridor for animal traffic th t comes and goes. One of the major issues that we deal with here, because we are in western Manitoba, is a lot of farmland. A lot of chemicals enter the waterways down river from us, where an artificial dam has formed a lake, which effects everything. We deal with a lot of farmers, and the spraying of chemicals which enter the waterway. Our community does not have a water treatment facility, so every home gets huge water bottles for drinking, with the water that comes into our homes left untreated. We're working on this, but we're told that it will be two years before the government will even consider doing anything. The chemicals in the water affects the insect life, the bees and so forth, and our Elders are telling us how it never used to be this way.

— The silica sand mine toward the Manigotagan area, is having a detrimental impact on the communities surrounding it, such as the constant transportation of material on roads and barges that damages animal habitat, and the fine pa ticles becoming airborne, which is linked to causing cancer.

If a natural infrastructure project was being guided by your community's knowledge and people, it would most likely happen through:



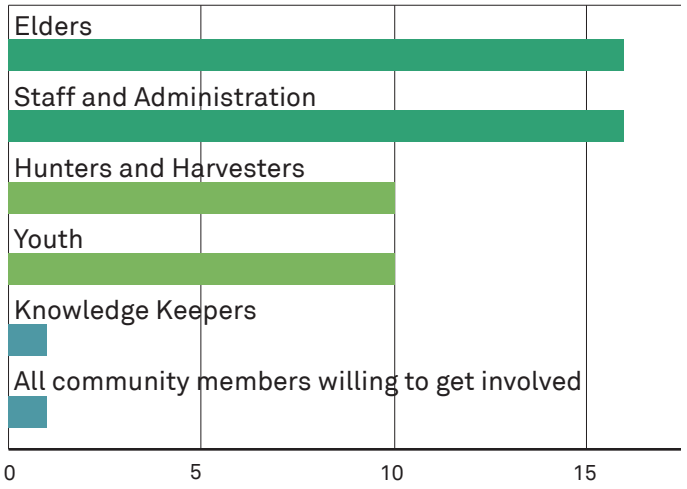
Community Consultation — Meeting with the Elders, youth and all members of the community to coordinate and implement the project

Working Group — Interested members of the community work together with the community to organize and build the group

Community Champion — A knowledgeable member of the community gathers information and spearheads the project, serving as a liaison between the community and those outside the community working on the project

Community Engagement

Who would be the most important people that outsiders should talk to in your community about a natural infrastructure project? Check all that apply:



— We have found that during our focus group sessions with the community members, you have to go to the people rather than making it political. I have always stated to the politicians, "go to the people, never leave out the people, always go to your people!" Any bylaw or law that needs to be passed is 50 percent plus 1. That hasn't occurred in my community for as far back as I can remember.

— There has to be a community champion that can lead the proposals, so that they have a good understanding—we are always willing to sit down with people and suggest things if we understand it. A lot of us are here for our people.

— We need the people's knowledge. We have been having a hard time communicating with a lot of them who don't have wi-fi or compu ers. It is harder to get information to those people. So, we have to hand deliver most of the time.

— Some of these projects are federally regulated. The channels project is regulated by the Impact Assessment Agency of Canada. The pipe line project that happened here recently was regulated by the Canada Energy Regulator; it used to be the National Energy Board. Same with the Manitoba-Minnesota transmission line. These massive projects have negative impacts on the environment, and one of our biggest problems is adequate Section 35 consultations by the Province of Manitoba. The Manitoba Government doesn't

really want to consult, and they actually changed their consultation policy, such that as of December 2019, the Province has the authority to pass down the consultation process to their units. So now, Manitoba Infrastructure is consulting Peguis, and we fought tooth and nail to ensure that Manitoba Infrastructure staff aid the process. They brought on representatives from the Board of Indigenous Relations, and they lead the consultation. Manitoba Infrastructure also put a call out for a facilitator to help groups. We understand Section 35 of the consultation is supposed to be nation to nation, Peguis to the Federal Government. Sometimes the Federal Government will hand that authority down to the Province, and now the Province passed a policy two years ago that gives them the authority to pass that consultation process down to a consultation group. Now, when you talk about supreme court rulings, and being fair and meaningful, that's gone out the window. Now, a First Nation is consulting with a consulting fi m—that's a watered-down process that has to change. We have to start pressuring the regulatory bodies that oversee these projects at the federal level to make sure that the Province does their consultation process—Manitoba Hydro, Enbridge, DC Energy, TransCanada Pipe Lines—the Section 35 process accordingly and properly, ensuring that we are consulted, and not only consulted, but accommodated. The federal regulatory bodies have to have a good understanding about what that means. In discussions, they have openly stated that they don't have the staff to review Section 35 reports of traditional lands studies. If the federal regulatory bodies don't have

the capacity to review studies that we put forth, then we're in dire straits, we're in a lot of trouble, because how can they develop a report, which represents First Nations concerns, and send them to federal ministers for approval? We have a lot of work to do when it comes to legislation, the approval process, and challenging this province in regard to how they conduct major projects.

— Another omnibus bill was recently passed again, with a lot of changes to the environment that affect us. It's not just the project themselves, but the process that displays a lack of federal responsibility—that has to change. We have to hold the Premier's feet to the fi e, as well as the Prime Minister. That's where the approvals and major projects start, which will affect the environment. This is not about cottage owners, or the sport fishing indu try. We live out here, we live on the land next to the lake, we see the effects. We're not fig ting so that we can have a beautiful day at our cottage along the lake. We're fig ting for good drinking water for our families. If you have that authority to reach up to federal ministers, that is what we need to do.

— Collaboration is the way to do things, the way to accomplish things, to do things together as a community. What you're doing, is hearing what the people are asking for. You are hearing what the young people are living through, and you are hearing from the Elders that are seeing the frustrations—the deterioration of the land and the loss of communication links.

— We have had presentations from Parks Canada. We sit at the table in Treaty 2 and the Province shows us their moose management numbers for the area. One of the comments was that there are no moose south of Highway 45, which is right along Keesee, so they're implying that they have been killed off everywhere by us. We do deal with racism. In the past two years our hunters have taken about ten moose, which really has no impact, since the numbers of moose in the Park is about 2,500.

— One of the things that several of us are involved in is the climate change processes. We are part of a whole team of Indigenous People forming an advisory council, where we review proposals that come from communities. The greatest thing that any community can do, is to consult with the Elders and with the youth, together or separately. The youth can gather online, but with Elders it should be face to face. It doesn't need to be a whole bunch of people at once, but what needs to be done is community needs assessments, where individuals can speak freely about what they want to talk about, and their words should be taken down. Don't make any promises. With the council that we are on, there have been a lot of good projects that have been funded—through collaboration, by direction from the Elders, and also giving direction to the young people as well. It works! I've seen proposals that were given permission, or given resources, that have come to flourish, which is a good thing.

— A person with Natural Infrastructure expertise could come to the community, and review the area and the situation with the community. The community could outline their key issues. Some areas might be flooding, or some areas might have excessive agricultural nutrients. The expert could make several suggestions for the best areas to put natural infrastructure. That would be a presentation to the community, then the community could look at the suggestions and discuss what would work best for them. CIER could be a resource to help fi ure out what sort of government grants and programs, including through their own programming, can assist each community.

— Only twenty years ago, everybody still knew everybody. Everybody knew where everybody lived, and at any given time you could hear, "oh, this is where my cousin lives or where my aunt lives." Its not like that anymore, people no longer know one another, because nobody is talking to one another. That's sad, because then there is no community. When you reach that level, there is no community. The the key thing for us to do, in order for us to survive as Indigenous People, is to support each other and empower each other. As long as Elders are there, reach out to Elders, maybe some are more respected than others, but a lot of people have a lot of things to share. People need to listen.

— In our climate change process work, our communities who collaborate with the young people, or the people who are middle age, they work together collectively, and

they put their thoughts and words together and put in a proposal, and it works! As a peer assessment reviewer, I can see the way the proposal is worded, that there was clear collaboration with Elders, it is clean and concise, what they want to see happen in their communities, and ultimately everyone wants a healthy community. That's what this is all about—creating a healthy environment. Not just the environment, but the living conditions, the water accessibility, and on and on. But, somebody has to start somewhere, somebody has to be that community champion, and it's up to the communities to be able to identify those individuals.

— There are resources available for communities to access. There has to be collaboration with the Elders and youth, as the most successful proposals are the ones submitted in that way. The best chances of getting approval is through consultation and collaboration. It is working together and identifying something that affects the community specifical y, because each community has different needs. It's a collaboration with Health Canada and Environment and Agriculture. Depending on how your community proposal is laid out, it could fit either one f those. It makes a big difference if you contact those program managers, because they can get you directions of how to proceed with your proposals, and how to identify the process of what to do. Communities can access this on their own, you don't have to go to every community and say "can we work together." It should just come from within the community, identified y the community members.

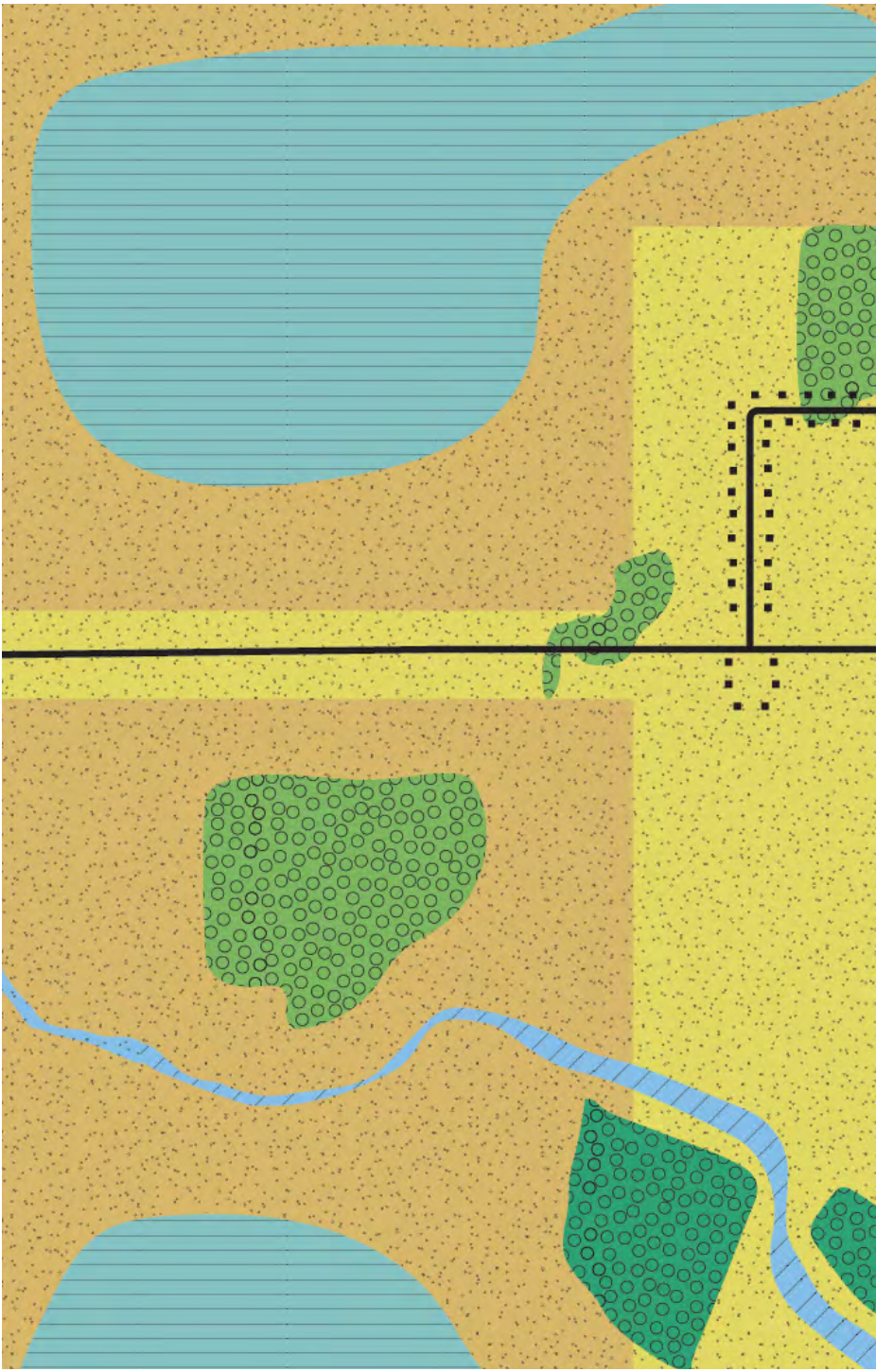
Consultants are not necessary if you have a community champion to lead the project. It's just a matter of educating yourself and asking questions. There are no such things as dumb questions. People can ask simple questions, and they are answered too, because they have impact on the end result.

— We are a caring society, but now, with so many interruptions and lack of services, people tend to isolate themselves. It shouldn't be like that because then its not a healthy community anymore. Who suffers in the end? Children do. Those are the true victims. Even now, you look at your environment, you look at your community, who is suffering the most there? We have to start caring. We have to start supporting our people. Not so much financial y, but emotional support. That's a good way to start, because in the end you want wellness in your community. And that's what we want for our children and grandchildren—to be able to set the foundation for them and to guide other people. To be able to provide that to their grandchildren and the future generations to come. Because if we don't take care of that, nobody else will.

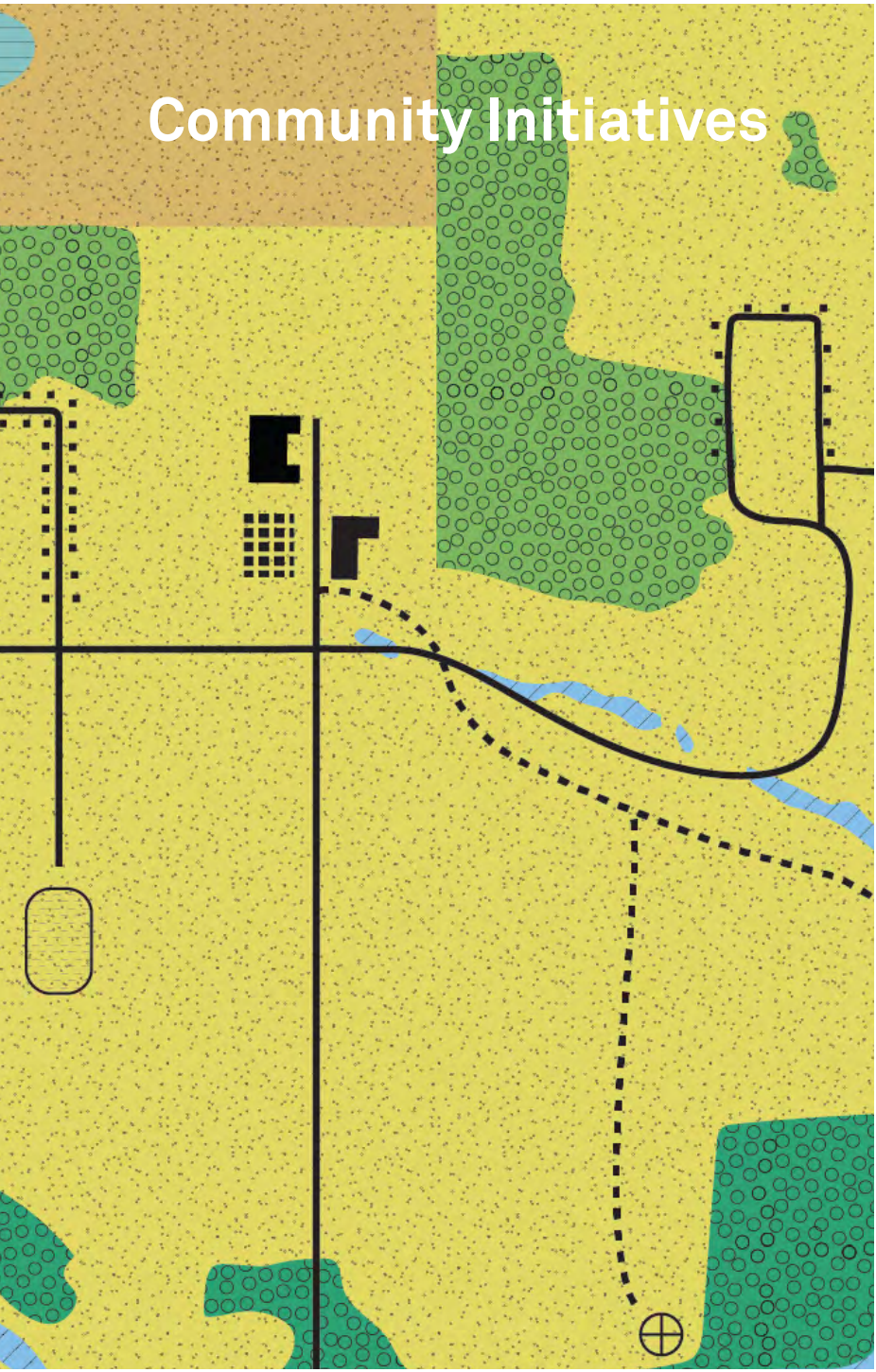
— Peguis First Nation does all of their own Section 35 consultation of Clean Environment hearings, Canada Energy Regulators, and all federal regulator hearings. Its all done through our offic . We don't use consultants anymore, and unless it's part of the process we don't use lawyers either.

— Language is important, because we understand the Ojibway language more than English. Speaking Ojibway is very important. We speak and understand our people, understand our community, understand our problems, the issues that have risen over the years, including climate change. I noticed that a lot of people speak English rather than Ojibway. Explaining something in Ojibway is critical. It has more meaning for an Indigenous person. It has more meaning and provides clarity in terms of how to explain a situation of climate change, food sovereignty, flood mitigations, natural infrastructures that were broken down throughout the ages. The lead person would have to fully understand what has happened throughout the years in their community, and explain it to the community. If things aren't fully explained, you can't fully understand what's happening.

— You have to go to the people, you have to work with the people, you have to include the people. Inclusion has to be a priority, and the language is critical. I speak fluent y. My grandparents spoke the language every day, and that's how I learned. I think our language is very important in terms of having discussions with community and people.



Community Initiatives



Community Initiatives

Planning a Project
The following pages outline the steps for how a First Nations Community can Plan a Project:

— *With the Community*
> *Steps 1 – 6* to be organized and completed by the community.

— *With Consultants*
> *Steps 1 – 6* would be organized and guided by a consultant, such as CIER, landscape architects, ecologists, environmental engineers, etc., who would be responsible for holding community meetings, gathering community information, and formulating a community reviewed project on behalf of the community.

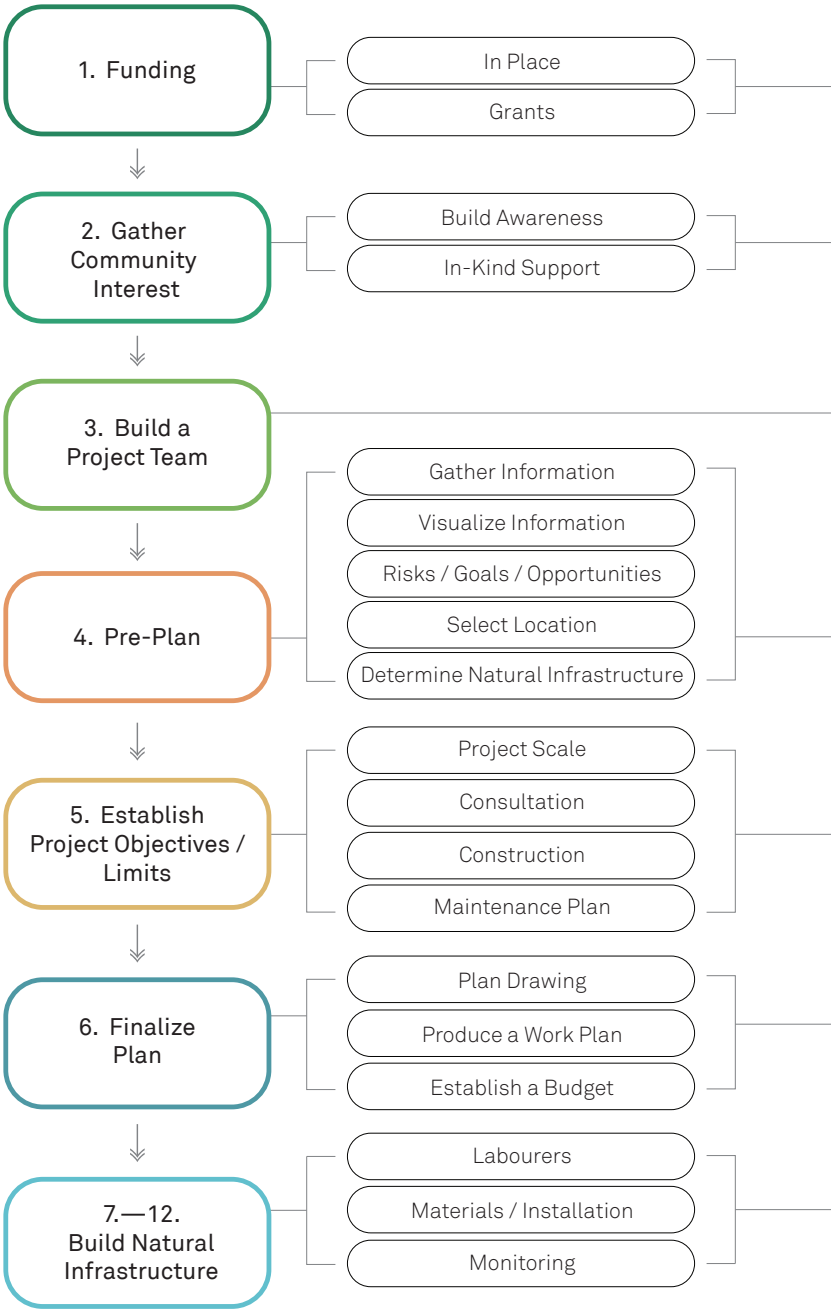
Building a Project
The following pages outline the steps for how a First Nations Community can Build a Project:

— *With the Community*
> *Steps 7 – 9* only, with building done by the community.

— *With a Contractor*
> Jump to *Steps 10 – 12* where building is done by a construction company, landscape contractor, etc., and where the community, or a consultant manages the work of the contractor.

Summary — **Planning a Project with the Community / with Consultants**

1. **Funding**
    - *a. Private Grants*
    - *b. Government Grants*
        - *i. Partnering with an NGO or Academic Institution*
2. **Gather Community Interest**
    - *a. Build Awareness*
    - *b. Record In-Kind Support*
3. **Build a Project Team**
4. **Pre-Plan**
    - *a. Gather Information*
    - *b. Visualize Information / Existing Conditions*
    - *c. Assess Risks*
    - *d. Establish Goals*
    - *e. Distinguish Opportunities*
    - *f. Choose the Location(s)*
    - *g. Select a Natural Infrastructure Project*
        - *i. Recall Goals*
        - *ii. Site Visit*
        - *iii. Determine Suitable Natural Infrastructure(s)*
5. **Establish Project Objectives / Limits**
    - *a. Project Scale*
    - *b. How much are you willing to do?*
    - *c. Consult Local Land Authorities*
    - *d. Contractor vs. Self-Built*
    - *e. Maintenance Plan*
6. **Finalize Plan**
    - *a. Create a Plan Drawing*
    - *b. Produce a Work Plan*
        - *i. Timeline Estimate*
        - *ii. Task Breakdown*
        - *iii. Labour Estimates*
        - *iv. Materials Required*
        - *v. Source Materials*


1. Funding
In Place
Grants
2. Gather Community Interest
Build Awareness
In-Kind Support
3. Build a Project Team
4. Pre-Plan
Gather Information
Visualize Information
Risks / Goals / Opportunities
Select Location
Determine Natural Infrastructure
5. Establish Project Objectives / Limits
Project Scale
Consultation
Construction
Maintenance Plan
6. Finalize Plan
Plan Drawing
Produce a Work Plan
Establish a Budget
7.—12. Build Natural Infrastructure
Labourers
Materials / Installation
Monitoring

If funding is already secured, the following steps can be used to conduct feasibility. If funding is not yet secured, the following steps can be undertaken to produce a comprehensive funding proposal.

It is important to gain attention in the community by building awareness. You might meet people that offer to help, be sure to note down who they are and how to get in contact with them, they will be valuable later.

A project team will organize the project and keep it on track. Team members should be familiar with similar projects and passionate about the outcomes.

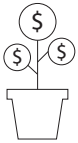
Gather information, and list the important resources on the land, ones that are at risk or lost, and would benefit from re-introduction. Visualize existing conditions on maps, to establish what you know, and asses risks, devise goals, and distinguish opportunities. Determine what areas will benefit from a natural infrastructure project, and what type of natural infrastructure would be best suited to reach your goals.

It is important to outline the desired scale of impact by deciding on the geographical scale. Be realistic about how much time and resources you and your team have for your project. If your desired project is larger than the time and hands you have, consultants and/or a contractor may be necessary. Be sure to establish a maintenance strategy early in the process to determine who will be responsible for the project once it is installed.

Create a plan drawing that will clearly outline what you want to build. Produce a work plan that considers the project size, the materials and people needed, and a timeline to determine a project budget.

Building Natural Infrastructure will include preparing for work, and building it with the community, or hiring a contractor. This step involves organizing the physical components of the project, such as volunteers and workers, scheduling machinery rentals, and sourcing and purchasing materials, or obtaining them in-kind, and then installing them. Each project will require monitoring after construction to ensure ongoing functioning.

1. Funding



2. Gather Community Interest

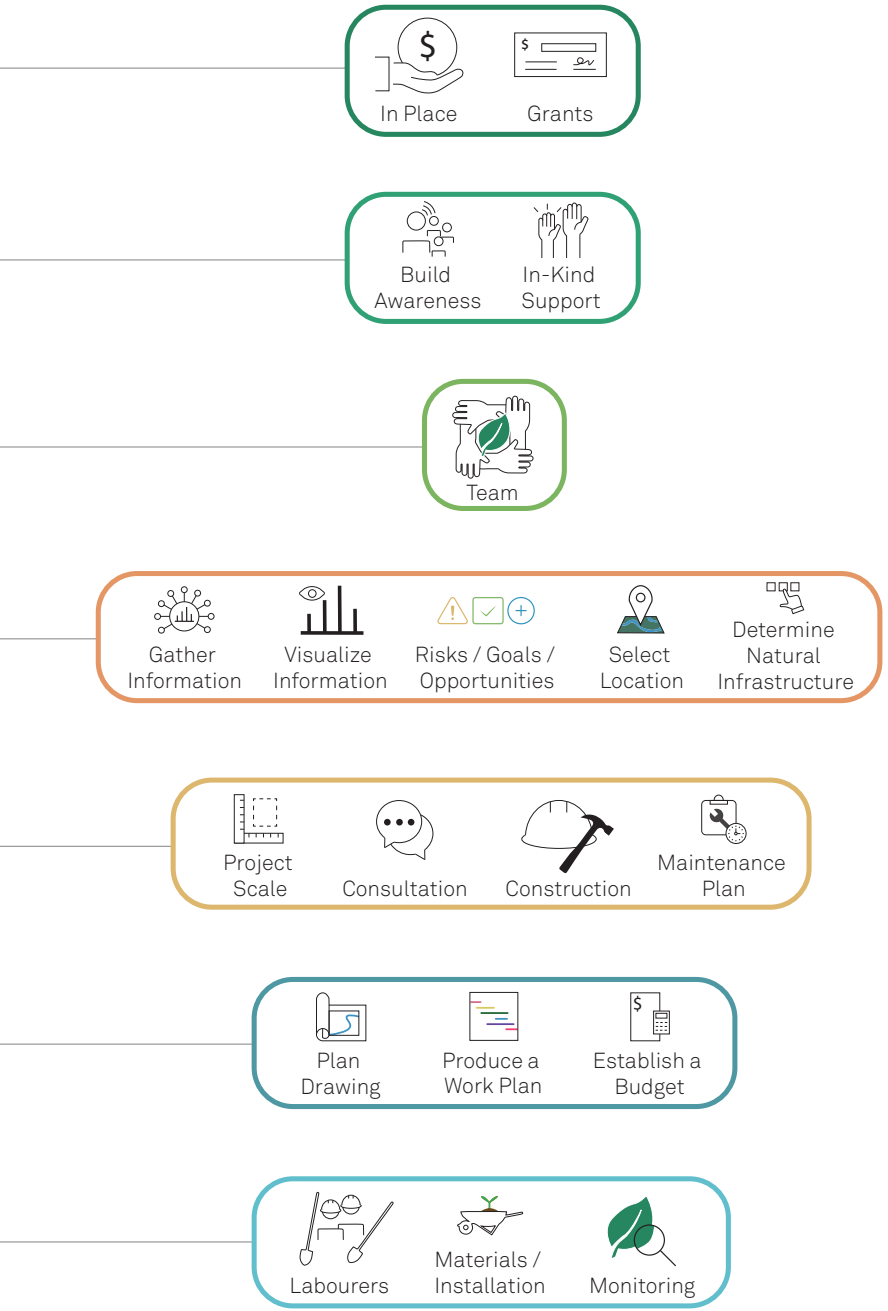
3. Build a Project Team

4. Pre-Plan

5. Establish Project Objectives / Limits

6. Finalize Plan

7.—12. Build Natural Infrastructure


In Place
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Consultation
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Plan Drawing
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Labourers
Materials / Installation
Monitoring

Planning a Project with the Community / with Consultants

1. Funding

If funding has already been secured for the project, steps 2 – 6 can be followed to produce a feasibility study to ensure that project goals can be met with the secured budget. Alternately, if funding has not been secured, steps 2 – 6 can be followed to produce a comprehensive funding proposal. The following outline a few funding options.

a. Private Grants

There are many private organizations that are interested in supporting environmental and Indigenous led projects. See the Potential Grants section of this booklet for possible grants your community can apply for. These grants are often fairly straight forward, which generally makes them easier to apply for. Some grants offer lump sums intended to cover the full cost of the project. Others have limitations, such as not paying for salaries, or will only match money or in-kind resources that have already been committed to the project.

b. Government Grants

There are many grants, provincially and nationally for which Natural Infrastructure projects are eligible. See the Potential Grants section of this booklet. Applications for grants can be lengthy, so it is important to have a good sense of the project budget, to be able to pursue the right grants. Government grants may also offer full, partial, or matching funding.

i. Partnering with an NGO or Academic Institution

Partnering with a NPO (not-for-profit o ganization) like CIER, or an Academic Institution (colleges and

universities) will open up even more funding options, providing Natural Infrastructure projects with more eligibility for grants. Keep in mind that the NGO or Academic Institution will need to share a portion of the grant money to cover their involvement in the project, with amounts to be discussed and determined by the parties involved.

2. Gather Community Interest
Building Natural Infrastructure has benefits or increasing the health of the land and for the community that lives on it, but constructing these projects is no small feat. It is important to gain attention in the community, for building knowledge, constructing a team and selecting the right project.

a. Build Awareness
Building awareness in the community can be done through various activities, such as contacting Elders, holding town hall meetings, going door to door, through social media, etc. Usually, the best strategy is a multi-pronged approach that then spreads the idea through word of mouth. However, different engagement strategies will be effective depending on the community

b. Record In-Kind Support
In-kind support refers to resources other than money. In the early planning stages, members of the community might offer machinery, land from which to harvest materials, or volunteer labour. When this happens, note down who they are and how to get in contact with them, as they will be valuable later.

3. Build a Project Team
Building a Team will help to organize the project and give it direction. Designating a Project Lead or Champion can also be helpful to keep the project on

track. In most communities this will likely be someone from the lands department, economic development, or other body familiar with similar projects.

4. Pre-Plan
This phase is probably the most important part of implementing a Natural Infrastructure project.

a. Gather Information
Working with the Team or the entire community, the group needs to fi st discuss existing land conditions. This information can be gathered in a list, which includes your land or watershed's most valued natural features, such as forests, wetlands, watershed, ecological inventories, habitat for wildlife or wildlife corridors, fish habit t, clean water, contaminated water, recreational routes, agricultural lands, traditionally used landscapes, or culturally important trails, to name a few.

b. Visualize Information / Existing Conditions
In order to create a plan drawing that will ultimately serve to illustrate what the community wants to build, It is useful to locate/visualize the existing conditions discussed above on a map for everyone to see and to agree on how it has been represented. If participants are not comfortable drawing on maps, this information can also be written on sticky notes and attached to a map, or a sticker dot system can be devised where participants put dots on a map to indicate areas of various importance. It will be important to also include any approved future development to ensure this change will be taken into consideration.

c. Assess Risks
Once the land conditions are visualized or listed, it may not be readily apparent, but it will be easier to assess what lands are at the highest risk of being lost if no action is taken.

d. Establish Goals

The team or community needs to come up with a set of goals to create the wide vision for the project. Perhaps this is a list of how important land resources could be enhanced: ones that have been lost and would benefit from re-introduction, protecting habitats at risk, or restoring environmentally degraded areas.

e. Distinguish Opportunities

The community, or project team can determine exactly what could be restored, or improved, or needs attention the soonest. By visualizing or listing the areas and understanding which portions are most important to the community, and what is currently at the highest risk, the group can pin-point which area of the land will benefit f om a Natural Infrastructure project.

f. Choose the Location(s)

Once the opportunities are known and prioritized, the team can pinpoint the exact location(s) to implement the project.

g. Select a Natural Infrastructure Project

Selecting the proper Natural Infrastructure project for the desired outcome is dependent on a few things.

i. Recall Goals

Recall what exact impact you are seeking to make. Do you want to improve habitat? Minimize stormwater runoff? Cleanse water?

ii. Site Visit

On the ground you will need to evaluate slopes of the ground, types of vegetation occurring naturally, water levels, land ownership, as well as surrounding context. Understanding the area of land will also help define which Natural Infrastructure approach will work best to heal the land.

iii. Determine Suitable Natural Infrastructure(s)

The Natural Infrastructure drawings in this book can help set you on track to determining a Natural Infrastructure that might be applicable for your project. Keep in mind that these drawings are for general education, but are not construction drawings, so much more research on a particular Natural Infrastructure will be required for your community to reach a solution that can be built. If the community is unsure about this step, you may want additional consultation to determine a Natural Infrastructure solution that is right for your situation.

5. Establish Project Objectives / Limits

At this time it is easy to feel overwhelmed with the needs of a project. Now that you have a general idea for the potential of the project, it is important to outline the scope and scale of impact that you want to see. The team or community needs to come up with the specific obje tives—the concrete deliverables—that will be achieved through the project. This will ensure that the project can be reasonably accomplished, and that it does not spiral out of control and become too big (scope creep), and therefore, unmanageable. The next steps help structure and establish the project objectives.

a. Project Scale

Using the existing land conditions map or list, you can start to visualize a plan drawing that will indicate the scope of your project. No matter what project you implement, it will have an impact somewhere else in the area. Decide how large you want your project to be. Is it just one project to prevent erosion on a small stream section, or will it be multiple projects across the region to combat pollution from surface runoff? Consider who else should be consulted. All projects will benefit f om consulting with Elders, those in the

community that know the larger landscape very well, or perhaps even an environmental consultant in the area who may have access to land data for the area. For very large projects it is highly recommended that you consult broadly.

b. How much are you willing to do?

If you have other projects on the go, it is important to be realistic about how much time and resources you and your team have for this project as a whole, and your ambitions should reflect this.

c. Consult Local Land Authorities

Local land authorities will require consulting to ensure that any necessary protocols are being followed and/or permits required for the project are being applied for and obtained in time for projected project construction.

d. Contractor vs. Self-Built

It might be feasible to build this project on your own, or with the help of the community. However, if the desired project is larger than the time and hands you have to complete it, hiring a contractor will ensure the proper skills are on site as well.

e. Maintenance Plan

It is important to clearly establish a maintenance strategy early in the planning process to determine who will be responsible for the crucial up-keep of the project once the project is built.

6. Finalize Plan

Solidifying a plan helps everyone involved be on the same page, keep the project moving forward.

a. Create a Plan Drawing

It is very useful to have a plan drawing (or several drawings which include details), of what you want to build. These drawings should be drawn to scale and accurately annotated, so that their exact size, materials, and vegetation specific tions are clear. This way you will have a visual to help explain the scope and details of your project for permitting purposes, and to share with the team that is building the project, or with a contractor. A landscape architect or an engineer can be obtained for this step, if the task of creating such drawings is not in the community's skill set. Some professionals may be willing to contribute this type of work pro-bono, or at a reduced rate.

b. Produce a Work Plan

A work plan considers the Natural Infrastructure projects, their size, the materials and people needed, and ultimately a timeline that produces an overall project budget.

i. Timeline Estimate

Take time to estimate how long finalizing plans and constructing the Natural Infrastructure project will take.

ii. Task Breakdown

Understanding the entire project in smaller steps will help to comprehend how these projects can come to life.

iii. Labour Estimates

Once the tasks have been broken down, you can determine how many people will be needed and for how long.

iv. Materials Required

The amount of materials needed, and what type, will be determined by the type of Natural Infrastructure, as well as the scale of Natural Infrastructure that is intended to be built.

v. Source Materials

Once it is known how much and which type of materials are necessary, you can begin to locate where you can harvest, purchase them, or from where they might be donated.

c. Establish a Budget

With the work plan quantified you can estimate the project costs for labour and materials.

i. Tasks and Associated Costs

Work out all tasks that will be necessary to complete the project. Try to think through every detail, which might include things such as running errands, and the time/distance to do so. Determine the associated costs for each task.

ii. In-Kind Support

Volunteer materials or labour that were offered earlier in the planning of this project can be recalled and considered. This may affect your calculations from the step above.

iii. Volunteer vs. Paid Labour

There is also the opportunity to seek volunteers to help construct the project, although a few salaried workers are always good to maintain consistency and commitment. This step is an incredible opportunity to get youth involved and demonstrate and share important skills.

iv. Equipment

Machinery is recommended for the construction of some Natural Infrastructure projects, and renting or borrowing are good options if needed.

Evergreen. School Ground Greening: a policy and planning guidebook. https://www.evergreen.ca/downloads/pdfs/School-Ground-Greening-Policy-Planning.pdf. Ontario Streams. Ontario's Stream Rehabilitation Manual, last modified Ma , 2002. https://cdn.website-editor.net/a46ec8be333642209835c758be53898c/files/uploaded Ontario%2520Streams%2520Rehabilitation%2520Manual.pdf.
United States Department of Agriculture: Forest Service. Erosion Control Treatment Selection Guide, last modified December 2006 https://www.fs.fed.us.

Building a Project with the Community

7. Preparing for the Work

a. Volunteers

Gather volunteers and ensure everyone is aware of the schedule, appropriate attire and location for the project.

b. Machinery Rentals

Renting machinery may not be necessary if the intended Natural Infrastructure project is small. If machinery is rented, you should ensure you have the right insurance coverage in case it is damaged.

c. Sourcing Materials

Sustainable harvesting is recommended if personally harvesting materials such as plants or root wads. In other cases materials may need to be purchased from a plant nursery, lumber yard, hardware store, etc.,

8. On the Site

Having workers on the job site is a big responsibility, especially if located in a remote location. Ensure proper safety protocols.

a. Permits

In the planning stages you should contact the municipality for building permits, these permits should be on the job site.

b. Facilities

Washrooms, food, and water must be available for workers on the job site.

c. Construction and Installation

The best approach will involve the community, and provide opportunities for participants to learn about native plants and habitats that their efforts will support.

i. Project Management

Includes coordinating volunteers, organizing deliveries, and collecting tools and equipment.

ii. Preparation

Arranging security fencing, removing unwanted vegetation and root material, staking, marking utilities, stockpiling topsoil, soil amendments, etc.

iii. Construction

The installation of non-living materials like logs, laying stones, layering fil , etc.

iv. Planting

Planting and watering of ground cover, trees, and shrubs can take place after the majority of construction. Consider a community event to obtain enthusiastic participation.

v. Clean Up

Clean up remaining debris left from the above steps.

9. After Project Completion

Although most projects don't require much maintenance, some maintenance and monitoring is necessary to ensure the long term success of Natural Infrastructure. The maintenance plan should have been considered during the overall planning phase. The Natural Infrastructure project descriptions in this booklet can help provide a general indication of maintenance needs.

a. Monitoring and Maintenance 0 to 3 years

Visits to the new Natural Infrastructure project should be done regularly, perhaps twice a season (less in winter), or after heavy rainfall events or prolonged droughts. Stream stabilization infrastructure should be checked in high and low water levels.

b. Monitoring and Maintenance 3+ years

Visits to the Natural Infrastructure should be done periodically based on project needs, with twice a year being a good minimum, and ideally in spring and fall.

Building a Project with a Contractor

10. Preparing for the Work

a. Contractor Solely Responsible

When a contractor is solely responsible for the construction of a project, the contractor will coordinate all parts of construction and installation, including any sub-trades, and is usually also responsible for permits and applications. The community would hold a contract with the contractor, with the community's responsibility being to ensure that the contractor completes the work as outlined in the contract. If the community is working with a consultant, such as a landscape architect or engineer, it is the professional that will manage the work of the contractor on behalf of the client (the community), which can further ensure that the work is being constructed properly.

b. Sub-Contracting

The community may wish to serve as the overall coordinator of several sub-contractors. If there is expertise in this type of management in the community, this can sometimes be more cost effective, and can also allow for some parts of the project to be constructed by the community.

11. On the Site

The contractor will be fully responsible for all aspects of safety and construction protocols.

a. Permits

When a contractor takes full responsibility for construction, it is usually in the contract that the contractor will also be responsible for all permits and applications. Ensure that this role is clear between the community and the contractor you are working with. If the community decides to make use of sub-contractors, it is less likely that they will take

responsibility for permitting, so the community may need to do this.

b. Insurance

If the community's insurance does not cover contractors, they should ensure that all contractors are aware that they are responsible for obtaining their own insurance coverage.

12. After Project Completion

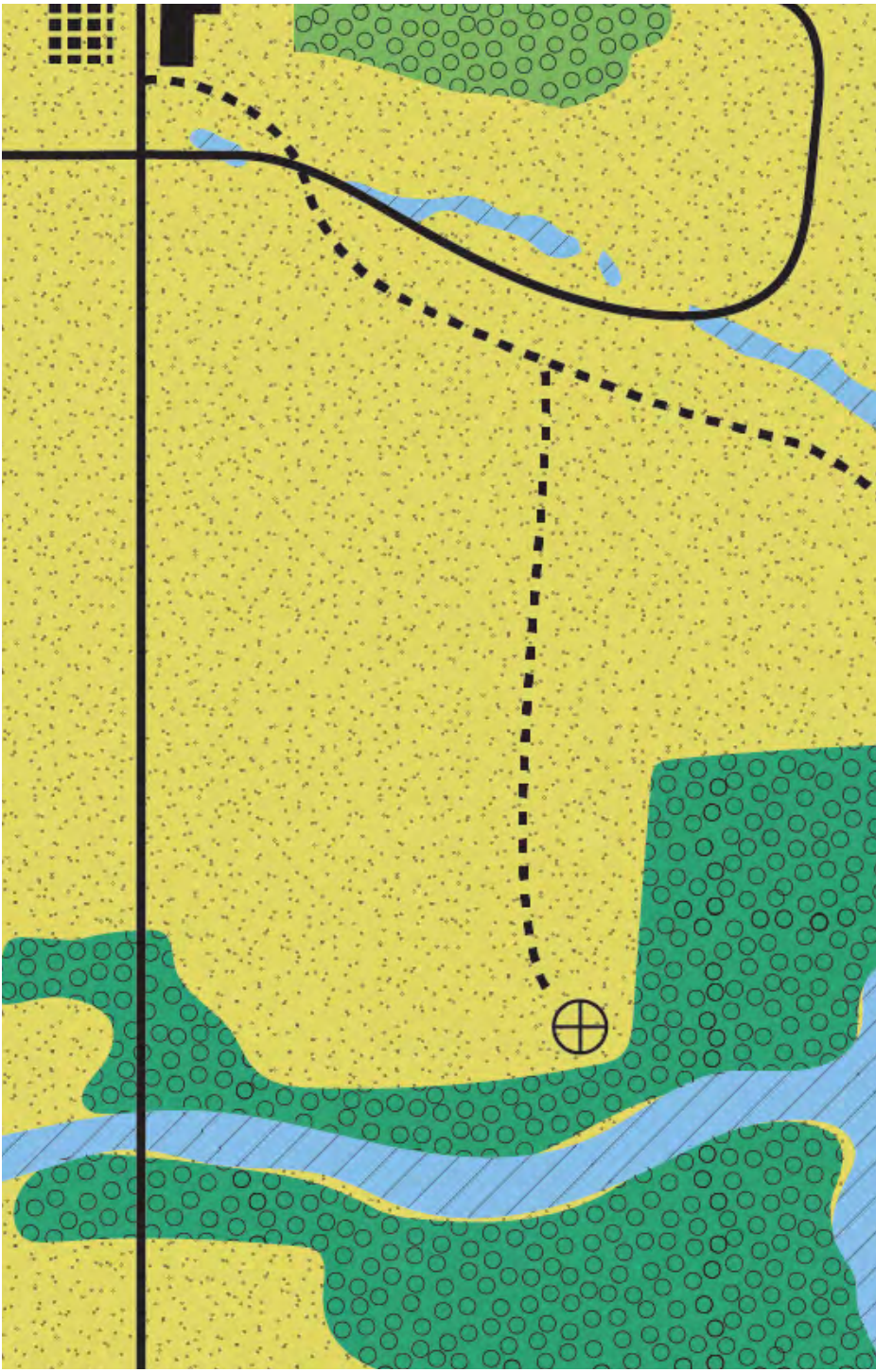
The contractor will provide notice that the project is complete, and the community will be responsible to verify accurate construction. If outlined in the contract, there may be an opportunity to take a final walk through the site and make a deficiencies li t, which the contractor will be responsible to fix b fore the project is declared official y completed. If the community is working with a consultant, such as a landscape architect or engineer, it is the professional that will manage the deficiencie , and ensure that the work is properly and fully completed, prior to final approval.

a. Monitoring and Maintenance 0 to 3 years

Some contracts stipulate that the contractor is responsible for a warranty period (usually 1 to 2 years), to ensure that everything in the project lives up to expectations—materials are holding up, and vegetation is alive and growing. However, the community will be responsible for the general and regular monitoring and maintenance (unless stipulated otherwise).

b. Monitoring and Maintenance 3+ years

The community will now be fully responsible for the project, with any necessary repairs or adjustments up to the community. Visits to the site should be done periodically based on project needs, with twice a year in the spring and fall, being a good minimum ideal.



Resources

PRIVATE GRANTS			
Grant	**Deadline**	**Objectives**	**Application**
Friends of the Environment Foundation Grant TD Canada Trust	January 15 and July 15	Green projects that engage communities, and promote education	Online
Community Grant Program Shell Canada	Ongoing	Social investment themes: environment	https://forms.benevity.org/982bc866-1553-4830-bc10-f83e3d3d946e?lang=en-us

ACCESS MANITOBA GOVERNMENT GRANTS			
Grant	**Deadline**	**Objectives**	**Application**
Assurance: Ecological Goods and Services	/	Watershed districts working with farmers to implement sustainable environmental practices	Must work with a farmer, with Statement of Completion for an Environmental Farm Plan (EFP)
Assurance: Beneficial Management Practices	February 15, 2021	Farmers implementing and adopting beneficial management practices (BMP)	Must own, rent, lease, manage, or control agricultural land
Fish and Wildlife Enhancement Fund	March 1 and September 1	Benefit or improve wildlife through habitat restoration, monitoring, research, stewardship, etc.	Summary /background https://gov.mb.ca/fish-wildlife/pubs/fish_wildlife/fish/fwef/final_report_guidelines.pdf
Conservation and Climate Fund	July 31, 2020	Climate change projects that impact water, nature, and a resilient landscape	https://www.gov.mb.ca/grants/pdf/ccf_fund_guide.pdf
Heritage Grants Program	January 31 and June 1	Identifying, protecting, and interpreting the Province's human and natural heritage	Application Form https://www.gov.mb.ca/chc/grants/pdf/heritage/hgp_application_form.pdf

Potential Grants

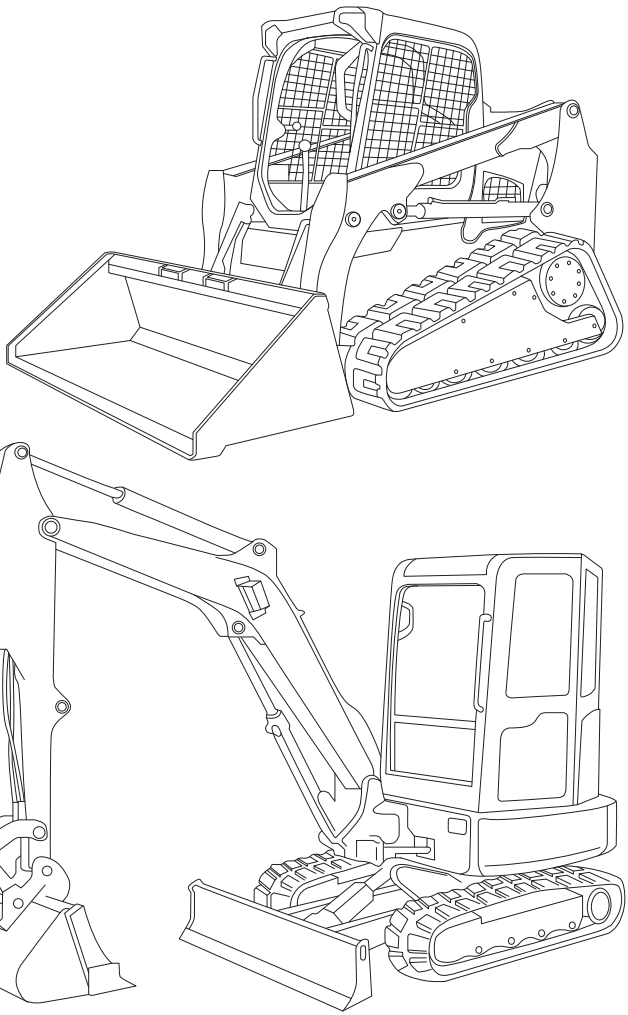
The following grants can serve as a starting point for grant application and for further grant searches. They were valid as of date of publication of this guidebook.

Notes	Duration	$	Website
Must be in Canada	Can reapply	~$2,000 to ~$8,000	https://www.td.com/ca/en/about-td/ready-commitment/funding/fef-grant/
Anyone can apply for general grant	Can reapply	$5,000	https://www.shell.ca/en_ca/sustainabil ity/communities/community-grant.html

Notes	Duration	$	Website
Projects involving water retention and runoff, wetland restoration, soil improvement, riparian edge enhancement, etc.	1 year	$100,000 max. $300,000 max. per watershed	https://www.gov.mb.ca/agriculture/env ironment/ecological-goods-and-services/watershed-egs.html
Applicable BMPs: farmyard runoff control, managing livestock access to riparian areas	N/A	$10,000 to $50,000	https://www.gov.mb.ca/agriculture/environment/environmental-farm-plan/ag-action-manitoba-assurance-beneficial-management-practices.html
Individuals can apply	N/A	N/A	https://gov.mb.ca/fish-wildlife/fish-and-wildlife-enhancement-fund/index.html
/	1 year	$200,000 max.	https://www.gov.mb.ca/grants/grant-department.html (last one in the list)
Encourages community, culture, and natural landscapes	Non - recurring	up to 50% eligible expenses	https://www.gov.mb.ca/chc/grants/hgp.html

GOVERNMENT OF CANADA ENVIRONMENTAL GRANTS			
Grant	**Deadline**	**Objectives**	**Application**
Aboriginal Fund for Species at Risk (AFSAR)	January 19, 2021 - March 2, 2021	Conservation, protection, and recovery of species on Indigenous lands and community engagement	Grants and Contributions Enterprise Management System (GCEMS)
EcoAction Community Funding Program	/	Projects that involve communities, which lead to real environmental results for freshwater	https://www.canada.ca/en/environment-climate-change/services/environmental-funding/ecoaction-community-program/applicant-guide.html
Environmental Damages Fund	Ongoing	Restore the environment and conserve wildlife in a scientifically sound, cost-effective way	GCEMS, partnership may benefit application
Habitat Stewardship Program for Terrestrial Species at Risk	January 19, 2021 - March 2, 2021	Benefit species at risk, engage Canadians, and improve stewardship as a conservation tool	More collaboration may mean higher chance of success
Habitat Stewardship Program for Aquatic Species at Risk	January 19, 2021 - March 2, 2021	Promote and support the conservation and recovery of aquatic species	https://www.dfo-mpo.gc.ca/species-especes/documents/sara-lep/hsp-pih/hsp-application-pih-formulaire-en.pdf
Funding for Lake Winnipeg Basin Projects	February 5, 2021	Reduce nutrients entering the watershed, encourage collaboration with governments, and engage Indigenous communities	Letter of intent (LOI), Project proposal submission
Nature Smart Climate Solutions Fund	Fall 2021	Sequester carbon by restoring ecosystems, and improving management practices	Available Fall 2021
Indigenous Guardians Pilot	November 30, 2020	Protecting and conserving ecosystems, sustainable economies, and connections between Indigenous culture and the Canadian landscape	N/A

Notes	Duration	$	Website
Must highlight an engaged, threatened, or species of special concern	2 year max.	$10,000 to $50,000 0.20:1 matching contributions	https://www.canada.ca/en/environment-climate-change/services/environmental-funding/programs/aboriginal-fund-species-risk.html
Must contribute to improvement of freshwater management by involving natural infrastructure	3 year max.	$25,000 to $100,000 50% must come from elsewhere	https://www.canada.ca/en/environment-climate-change/services/environmental-funding/ecoaction-community-program.html
Directs funds from fines and court orders to projects that benefit Canada's environment	N/A	varies depending on number of fines	https://www.canada.ca/en/environment-climate-change/services/environmental-funding/programs/environmental-damages-fund.html
Must have applicable species	2 year max.	$25,000 to $100,000 0.20:1 matching contributions	https://www.canada.ca/en/environment-climate-change/services/environmental-funding/programs/habitat-stewardship-species-at-risk.html
For Indigenous groups a minimum of 20% contributions is required, and 1:1 for non	multi-year	$25,000 to $100,000	https://www.dfo-mpo.gc.ca/species-especes/sara-lep/hsp-pih/about-sur/index-eng.html
⅓ -⅔ of total project costs may be funded, and projects must be completed by March 31, 2021	1-4 years	$15,000 to $400,000	https://www.canada.ca/en/environment-climate-change/services/water-overview/comprehensive-approach-clean/lake-winnipeg/funding.html
Projects under three streams of work: Indigenous Partnerships, Place-based Actions, Sector-based Policy	N/A	N/A	https://www.canada.ca/en/environment-climate-change/services/environmental-funding/programs/nature-smart-climate-solutions-fund.html
Funding for this program has completed, but there may be other similar programs	N/A	N/A	https://www.canada.ca/en/environment-climate-change/services/environmental-funding/indigenous-guardians-pilot.html



Common Landscaping Equipment

Landscaping work can be done by the community if there is interest and skill. Heavy equipment and power tools commonly used in landscape construction can be rented, if not already owned, or several communities can decide to purchase new or used equipment.

Heavy Equipment
Skid Steers, Compact Track Loaders — grading, digging, loading carrying materials (top left)
Mini Excavators — digging, trenching (bottom left)
Trucks, Trailers — hauling materials and equipment

Power Tools
Tillers — soil loosening for planting
Chain Saw — log related work

Hand Tools
Long-handled Pruning Shears
Shovels, Spades, Scoops
Spading Fork
Hand Trowels
Saws
Wheelbarrows, Carts, Buckets, Tarps
Water Pumps, Hose

Safety Equipment
Hard Hats
Safety Vests
Steel-toed boots
Eye/Ear Protection
Work Gloves
First Aid Kits

Definition

Aggradation
The process by which a stream bed is raised in elevation by deposition of sediment (opposite of degradation).

Alluvial
Term used to describe material deposited by running water.

Aquifer
One or more geologic formations containing sufficient saturated porous and permeable material to transmit water at a rate sufficient o feed a spring or for economic extraction by a well.

Artificial echarge
The deliberate act of adding water to a groundwater aquifer by means of a recharge project; also, the water so added. Artificial echarge can be accomplished via injection wells, spreading basins, or in stream projects. See also incidental recharge, natural recharge, and recharge.

Bank Shaping and Planting
Smoothing the streambank to a stable slope while integrating topsoil and planting with riparian species, ground cover, shrubs and trees.

Base Flow
Streamflow derived from groundwater seepage into the stream.

Basin
The total area of land that drains water to a central stream, river or other water body. Also called Drainage Basin.

Bioengineering
In soil applications, refers to the use of live plants and plant parts to reinforce soil, serve as water drains, act as erosion prevention barriers, and promote dewatering of water laden soils.

Biodiversity
Refers to the variety of life in a particular habitat or ecosystem.

Bioswale
A natural infrastructure that has a gently sloping depression planted with dense vegetation that cleans stormwater runoff from the surrounding area.

Biotechnical
In slope stability engineering refers to the use of both live plant material and inert structures to stabilize and reinforce slopes.

BMPs / Best Management Practices
Managerial techniques that are recognized to be the most effective and practical means to control pollutants yet are compatible with the productive use of the resource to which they are applied. BMPs are used in both urban and agricultural areas. BMPs include:
reducing paving areas and increasing plant cover, using gray water for irrigation, fil er beds, subsurface infilt ation basins, green trellises for shade, cisterns for roofs and playgrounds, permeable parking areas, regarding for onsite infilt ation, green roofs, cistern walls, green planning, green screens, vegetated creeks/drainage channels, parking orchards.

In agriculture, BMPs using multiple natural infrastructural projects coordinated across an agricultural land will alleviate non-point source pollution (NPS).

Brush Mattresses
A layered mat of branch cuttings bundles are held in place by live stakes and twine to stabilize the rivers edge.

Branch Packing
Holes in steep streambanks are fil ed with layers of live branches and compacted fill o stabilize the rivers edge.

Capillary Fringe
The unsaturated zone immediately above the water table containing water in direct contact with the water table.

Carrying Capacity
The number or mass of organisms of a species that can live in a given area.

Channel
A waterway with obvious banks that contains moving water at least part of the year.

Channel Route
Channel Route must take into consideration surrounding land uses and topographic constraints.

Constructed Wetlands
An artificial y created wetland used for treating wastewater and stormwater runoff. The plants in constructed wetlands can remove a wide range of pollutants.

Consumptive Use
A use that makes water unavailable for other uses, usually by permanently removing it from local surface or groundwater storage as the result of evaporation and/or transpiration. Does not include evaporative losses from bodies of water. See non-consumptive use.

Contaminant Plume
A zone of polluted groundwater down-gradient from a point source of pollution.

Cover
Any object in the stream that provides protection to fish and ther animals. Fish use cover to hide, rest, escape and feed.

Dams / Weirs
Used for ponding water in a river. Often used to prevent sediment flow downstream.

Degradation
The process by which a stream bed is lowered in elevation by removal or scouring of sediment (opposite of aggradation). This term is also used to refer to a damaged condition of habitat.

Deposition
The process of sediment falling out of the water onto the stream bed in areas of lower flow and energy

Detention Ponds
Controls flooding by diverting water during peak flow times. Usually placed out of channel. Hold water temporarily, as opposed to Retention Pond (see below). Detention facilities are dry ponds which become completely dry within 24 hours of a storm event. Extended detention facilities store the fi st flush

(normally the first ½" of runoff) of stormwater runoff for a period of time between 24 hours and 72 hours. After 72 hours, the bottom of the facility will be dry until the next storm event. Detention of stormwater runoff provides water quality benefits by allowing some pollutants to precipitate from the water before being discharged to receiving streams.

Diversion Channels
Channels made to provide an alternative route for excessive water to mitigate the effect of flooding.

Discharge
The volume of water that flows past a given place during a certain amount of time.

DO / Dissolved Oxygen
The amount of oxygen that is dissolved in water. It also refers to a measure of the amount of oxygen available for biochemical activity in water body, and as indicator of the quality of that water.

Dormant Post Planting
A bank stabilization method where posts of dormant, deep-rooting woody species are inserted vertically into a streambank to slow currents.

Eddy
A circular current of water usually formed at a bend or obstruction in the stream.

Effluent
Treated wastewater discharged from sewage treatment plants. See tertiary treatment.

Embankment
A wall or a bank made of stone or earth to protect the land from flooding.

Enclosure
A protective measure is an area that is sealed off with a barrier to ensure the infrastructure can establish successfully.

Erosion
The wearing away of rock or soil and the movement of the resulting particles by wind, water, ice, or gravity.

Estuary
The area where fresh and salt water mix at the mouth of a river. Estuaries are important areas that are used as rearing habitat by many fish species and ther animals.

Evaporation
The process of liquid water becoming water vapor, including vaporization from water surfaces, land surfaces, and snow fie ds, but not from leaf surfaces. Compare with transpiration.

Evapotranspiration
The sum of evaporation and transpiration.

Floating Wetlands
Small platforms that are constructed to allow water-liking plants to grow in water that is too deep for them; allowing plant roots to trap pollutants that are floating in the water.

Floodplain
The low area along a stream into which water spreads during a flood.

100 Year Floodplain
Those lands that are subject to a one percent or greater chance of flooding in any year.

Floodway
Those portions of the floodplain adjoining and including the channel of a river or stream which discharges the flood water and flow of that water or stream. It is any place where the water is moving with velocity and a defini e current, but does not include other portions of the floodplain where the water is just standing.

Flow Resistance
Channel material can either increase of decrease friction, thus slowing down or speeding up the water. Factors that contribute to flow resistance include: sediment and grain size, bed forms including ripples, dunes, bars, pools and riffles, river sinuosity, water depth to grain size, sediment transport, and vegetation. As more objects and obstructions are introduced into the channel it becomes hard to predict channel flow and water turbulence.

Freshet
A rapid rise in stream flow due to runoff from rain or snowmelt.

Gabions
Used in a variety of forms to stabilize slopes. Durable and porous. May be used with plants.

Gaging Station
A site on a stream, lake, reservoir or other body of water where direct systematic observations of hydrologic data are obtained.

Gradient
The amount that a stream drops in elevation over a distance; the stream's steepness.

Grassed Swale
A natural infrastructure composed of a shallow open channel planted with vegetation that allows rainwater to be slowly absorbed into the soil.

Green Slope Stabilizers
There are a variety of slope stabilizing methods that involve the use of grass and vegetation.

Groundwater
Subsurface water body in the zone of saturation or more commonly, available groundwater is defined as That portion of the water beneath the surface of the earth that can be collected with wells, tunnels, or drainage galleries, or that flows naturally to the earth's surface via seeps or springs.

Hydraulic Continuity
The term refers to the natural interconnection between ground and surface water.

Hydrologic Cycle
The cyclic transfer of water vapor from the earth's surface via evapotranspiration into the atmosphere, from the atmosphere via precipitation back to earth, and through runoff into bodies of water.

Incidental Recharge
Water incidentally added to a groundwater aquifer due to human activities, such as excess irrigation water applied to fie ds or water discharged as waste after a use. See also recharge, artificial echarge, and natural recharge.

Infilt ation Ponds
Infilt ation allows the water to seep into the ground and recharge the groundwater. The infilt ation rate or how quickly the water enters the ground depends on the type of soil. Sandy soils infilt ate more quickly

than gravelly soils. The practicability of infilt ation depends on groundwater elevations, the depth to bedrock and the infilt ation rate.

Infilt ation Trenches
Ditches that collect rainwater from the surrounding surfaces and allow water to quickly seep into the ground.

Instream Flow
The amount of water remaining in a stream without diversion that is required to maintain a particular aquatic environment or water use.

Instream Flow
The amount of water remaining in a stream without diversion that is required to maintain a particular aquatic environment or water use.

Intragravel Flow
Water that moves between gravel or other particles in the stream bed; important for fish eggs and oung fish in the gravel.

Inundation
Refers to the situation where land is covered by water.

Joint Plantings
A bank stabilization method where live cuttings are tapped into holes arranged in a streambank laid with rocks.

Live Cribwalls
A structure built from interlocking logs, bottomed with fil , and topped with live cuttings embedded into the rivers edge.

Live Cuttings
Branches cut from sections of some woody species that will grow new plants when planted into moist soil.

Live Fascines
Cylindrical bundles of live cuttings are staked perpendicular to the edge of the stream to control erosion.

Live Stakes
Sections of branches without leaves or twigs that are thick enough to be tapped into very soft soil.

Livestock Exclusion or Management
A system of permanent fencing to prevent livestock from approaching the stream.

Log / Brush Shelter
Structures made of brush, logs and rocks are installed along the edge of the river to sloe water currents, create shade and enhance fish habit t.

Log / Rootwad / Boulder Revetments
The placement of logs, rootwads and boulders in and on the streambank to mitigate erosion and build habitat.

Mainstream
The principle stream or river of a particular basin.

Meander
A turn or winding of a stream.

Natural Infrastructure
Using natural materials existing in nature to meet targeted infrastructural outcome, ultimately achieving healthy nature.

Natural Recharge
Naturally occurring water added to an aquifer. Natural recharge generally comes from snowmelt and storm runoff. See also recharge, artificial echarge, incidental recharge.

Naturalization
The process by which a stream bed is raised in elevation by deposition of sediment (opposite of degradation).

Naturalized Wastewater Lagoon
A combination of naturalization and floating wetlands to fil er contaminants in existing water bodies.

Non-Consumptive Use
A use that leaves the water available for other uses. Examples are power generation and recreational uses. See consumptive use.

NPS / Nonpoint Source Pollution
Occurs when water runs off land or through the ground, picks up pollutants, and deposits them in surface waters or introduces them into groundwater. Pollution that does not come from a single source, such as a pipe
or ditch.

Off-Channel Habitat Ponds
Channels or wetlands that are connected to the main channel of a stream.

Outlets / Inlets
Used to bring water into, or take water away from a waterbody.

Overgrazing
A phenomenon which occurs when the vegetation in an area of land is consumed intensively by animals without having the chance for regrowth.

Phytoremediation
Plants and soil contain, or remove, toxic environmental contaminants.

Planted Buffers
Strips of gently sloped densely planted land. The various trees, shrubs, and plants, store and clean water.

Point Source
A source of water pollution that originates from a single point, such as an outflow pipe from a factory. See NPS.

Pool
A part of the stream that is usually deeper than the surrounding water and has slower current. Pools are often formed by scouring under or around an obstacle, by plunging over logs or rocks, or by side channels.

Pool-Riffle Ratio
The total area of pools compared to the total area of riffles in a stream. In habitat restoration it is beneficial to increase the number of pools by adding large woody debris. Most healthy streams in forested areas have a high pool-riffle ratio.

Potable Water
Water of a quality suitable for drinking.

Primary Treatment
A physical process in which the sewage flow is slowed down in settling tanks or lagoons. The thicker part of the wastewater, the sludge, is then removed from the

bottom and disposed of in a variety of ways. Floating solids, oil and grease are usually skimmed off the surface before the remaining effluent is dis harged into a water body.

Rain Garden
A natural infrastructure composed of a small depression, planted with trees shrubs and flowers. Its purpose is to temporarily hold and absorb rainwater and runoff, while also removing unwanted chemicals and dirt.

Rapids
Steep section of stream with swift current and lots of surface agitation and some waves.

Recharge
To add water to an aquifer; also, the water added to an aquifer. See also artificial echarge, incidental recharge, and natural recharge.

Retention Ponds
Retention facilities or wet ponds permanently pond water. Wet ponds also provide water quality benefits by allowing pollutants to precipitate from the water before discharging into receiving streams. Wet ponds increase the temperature of the water stored in the pond. These increased temperatures can adversely impact the cool waters required for trout.

Revetment
The structure installed on the slope of the coast or bank to protect the land from erosion caused by water.

Riffle
Shallow rapids with surface agitation, but no waves.

Rill
A tiny drainage channel cut in a slope by the flow of water. Can develop into a gully with continuing erosion.

Riparian
Anything associated with the banks of a stream, river or other water body. Often used to describe the vegetation along a stream.

Riparian Habitat
Natural home for plants and animals occurring on the land bordering a stream or river.

Rip-Rap
Used for lining banks and as an apron for outlet pipes. May be washed away in high flow times if not properly used. Grouted rip-rap is an option to add stability to the material. Rip-rap is porous and may be used with plants.

Rock Job
Bank stabilization achieved by lining the stream side with rocks or rip rap.

Rootwad
The mass of roots of a tree. Rootwads of fallen trees in the stream can form large pools and provide excellent cover.

Run
Swiftly flowing part of a stream with little surface agitation and no major obstructions.

Runoff
That part of rain and snowmelt that runs over the ground and into a stream or other water body.

Scour
Removal of sediment from the stream bed by flowing water.

Secondary Treatment
Also known as biological treatment, further reduces the amount of solids by helping bacteria and other microorganisms consume the organic material in the sewage. Oxygen is critical to this treatment stage. Air activated sludge and biological fil ers are two of many methods of secondary treatment.

Sediment
The silt, sand, rocks, wood and other solid material that gets washed out from some places and deposited in others.

Sediment Basin
A excavated basin connected to a main water channel designed to trap debris carried by water.

Sediment Traps
Temporary settling basins usually constructed on a construction site to capture eroded soil washed off by storm water.

Shoreline Stabilization
A natural infrastructure that combats erosion on streambanks by using naturally occurring materials like plants, rocks, or brush.

Soil
Particles are categorized into sand, silt, and clay based on their size. They are particles of minerals that make up the soil.

Storm Water Runoff
Precipitation that cannot be absorbed directly by ground and water bodies and flows on the surface across the land.

Stream Bed
The stream bottom.

Streamflow
The discharge that occurs in a natural channel. A more general term than runoff, streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

Streamflow Temperature Management
Planting groundcover, shrubs and trees along the stream to increase shade and manage water temperatures.

Subcritical Flow
Subcritical flow is classified acco ding to the flows Froude number which is a speed to length ratio. Subcritical flow is less than one. Subcritical flow causes less erosion problems.

Subsurface Flow
The flow of water beneath earth's surface as part of the hydrological cycle.

Supercritical Flow
Classified acco ding to a Froude number which is a speed to length ratio. Supercritical flow is more than one. Supercritical flow is purposefully engineered to help speed up flow, under low bridges. In a case like this it is cheaper to create baffles which cause supercritical flow, than to make the bridge higher.

Surface Permeability
The extent to which water can penetrate through earth's surface to reach the groundwater.

Tailout
The shallow area where water flows out of a pool.

Thalweg
The deepest area running along the stream bed. Usually where the fastest water runs.

Tributary
A stream that feeds into a larger stream. Also called a "feeder stream."

Turbidity
An optical characteristic used to measure the clarity of water. High turbidity in water can be caused by increased sedimentation and affect the water quality.

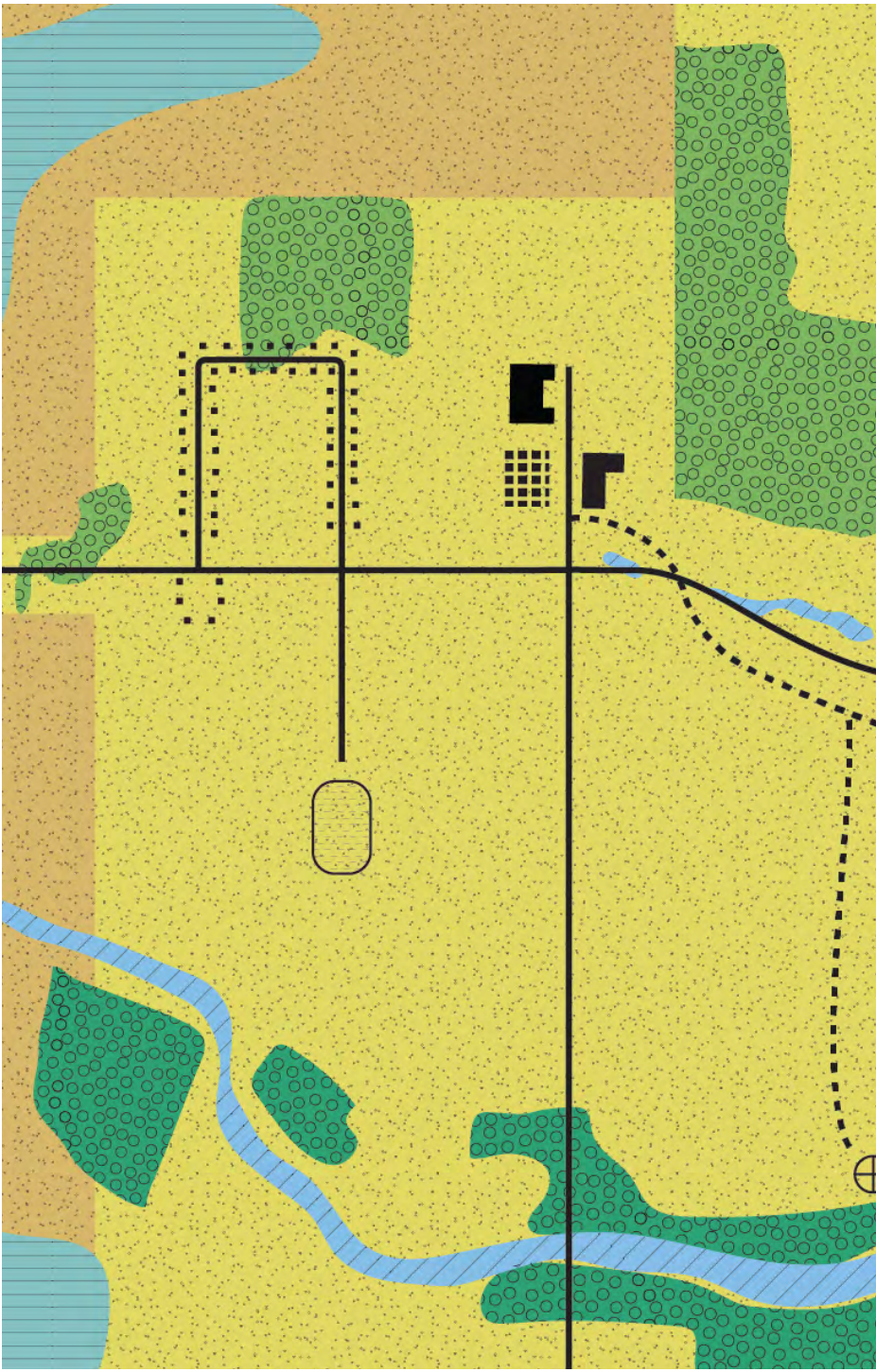
Upstream
The area of water in the opposite direction to which a river or stream flows.

Water Table
The upper boundary of a free groundwater body, at atmospheric pressure.

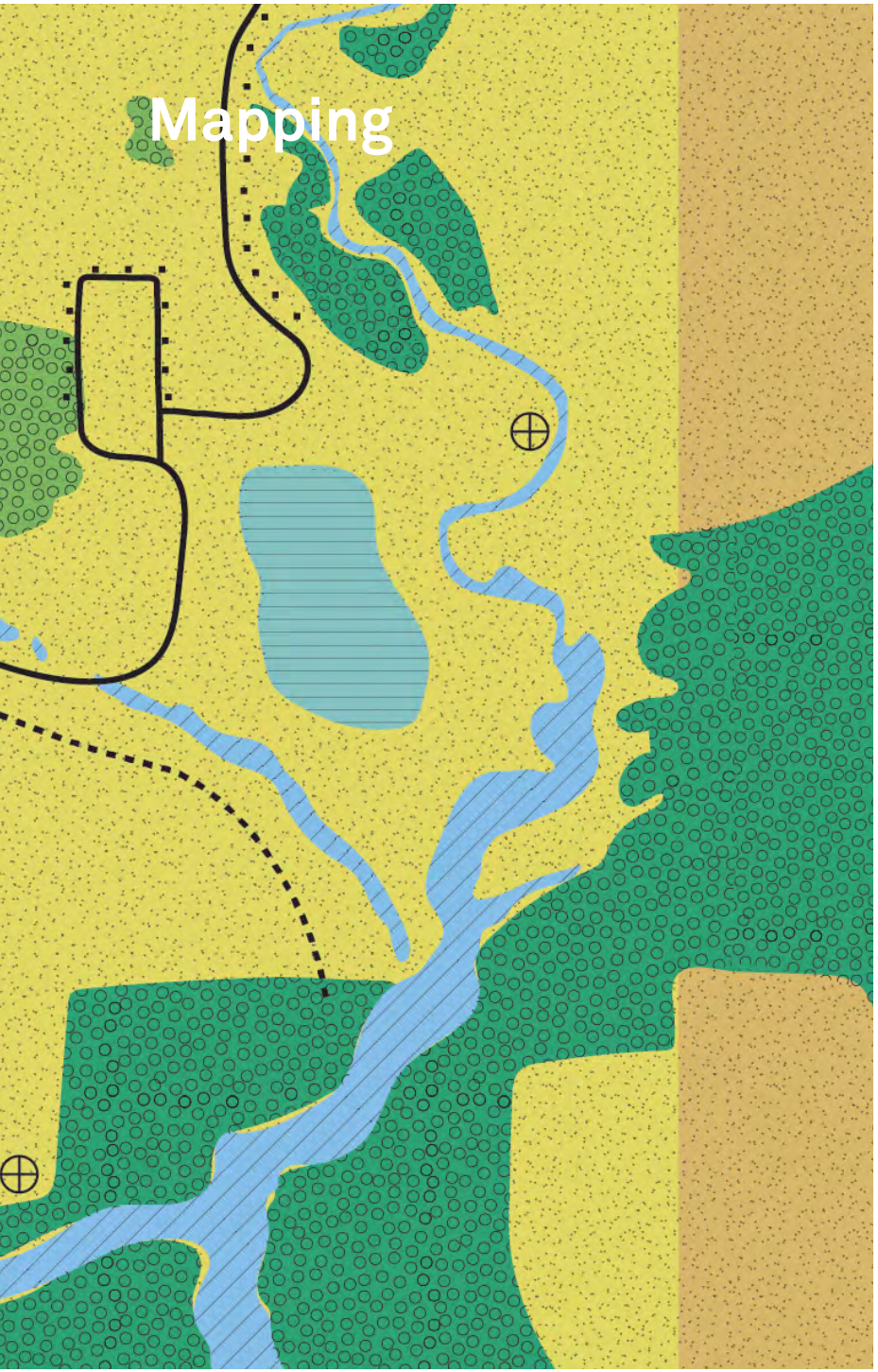
Watershed
The area drained by a river or stream, including the area drained by its tributaries. Natural watershed boundaries are ridges that divide one drainage area from another.

Wetland
Land with a wet, spongy soil, where the water table is at or above the land surface for at least part of the year. There are a number of different wetlands indicators (soil type, plants, etc.), that determine whether a piece of land is legally considered a wetland.

Hargreaves, George, Annie Gilson, and Alissa [Puhm] North. LA River Studio Book. Cambridge: Harvard Graduate School of Design, 2002.



Mapping



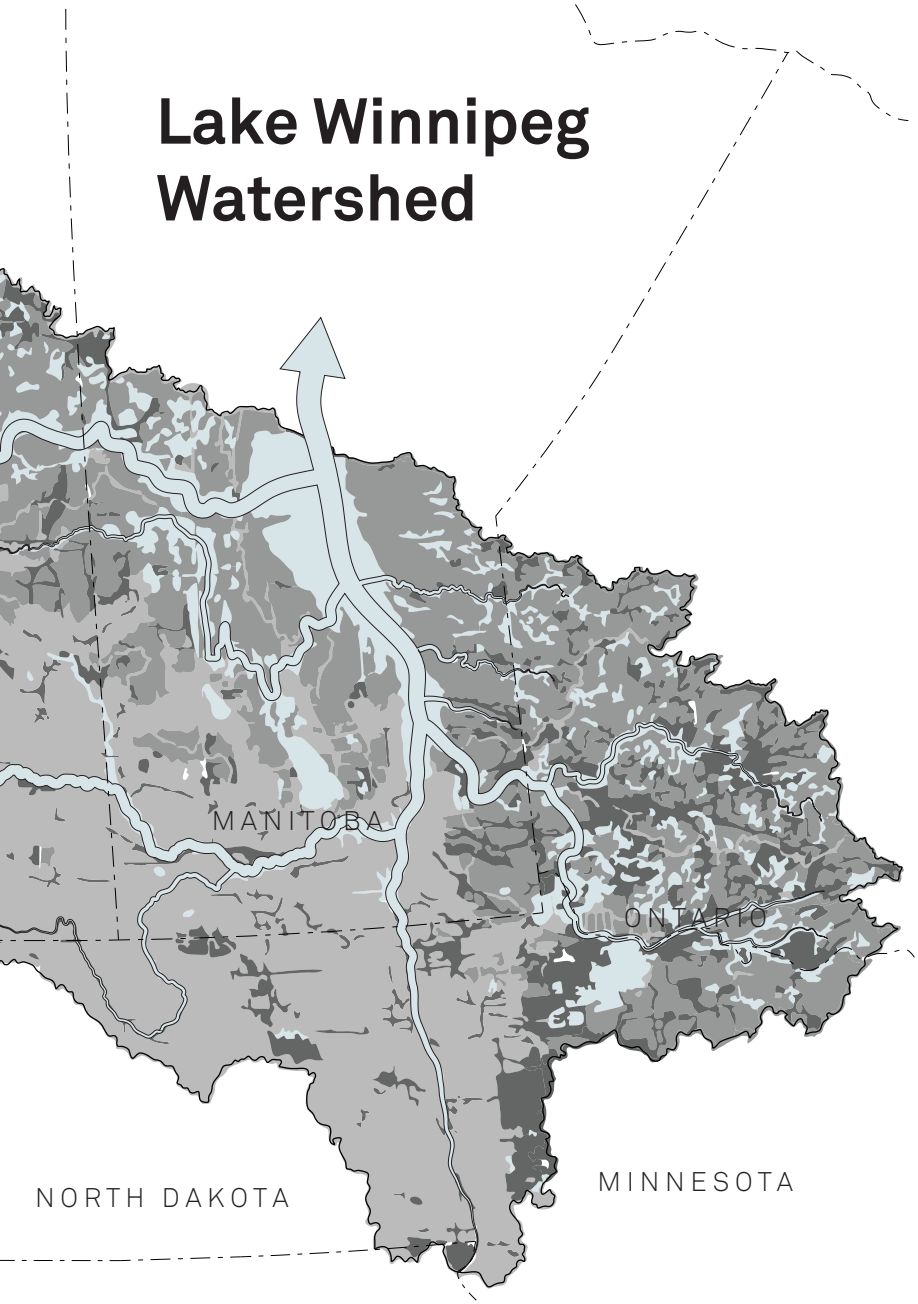
Mapping

Maps can be useful resources in understanding the context of proposed projects. Watersheds, environmental issues, political jurisdictions, land use, and future initiatives are some of the topics that can be researched and understood visually through maps.

The following maps, while certainly not exhaustive, are examples of large-scale mappings that can help situate initiatives and guide work at the local scale.


ALBERTA
SASKATCHEWAN
MONTANA
Cropland
Forest
Bare Rock

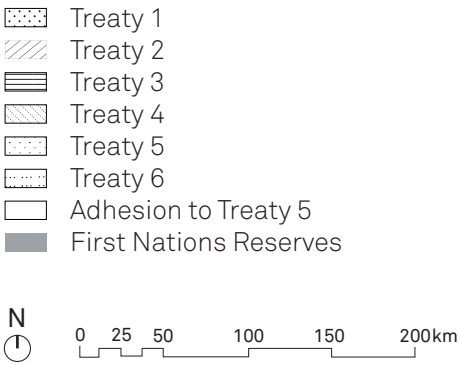
Lake Winnipeg Watershed



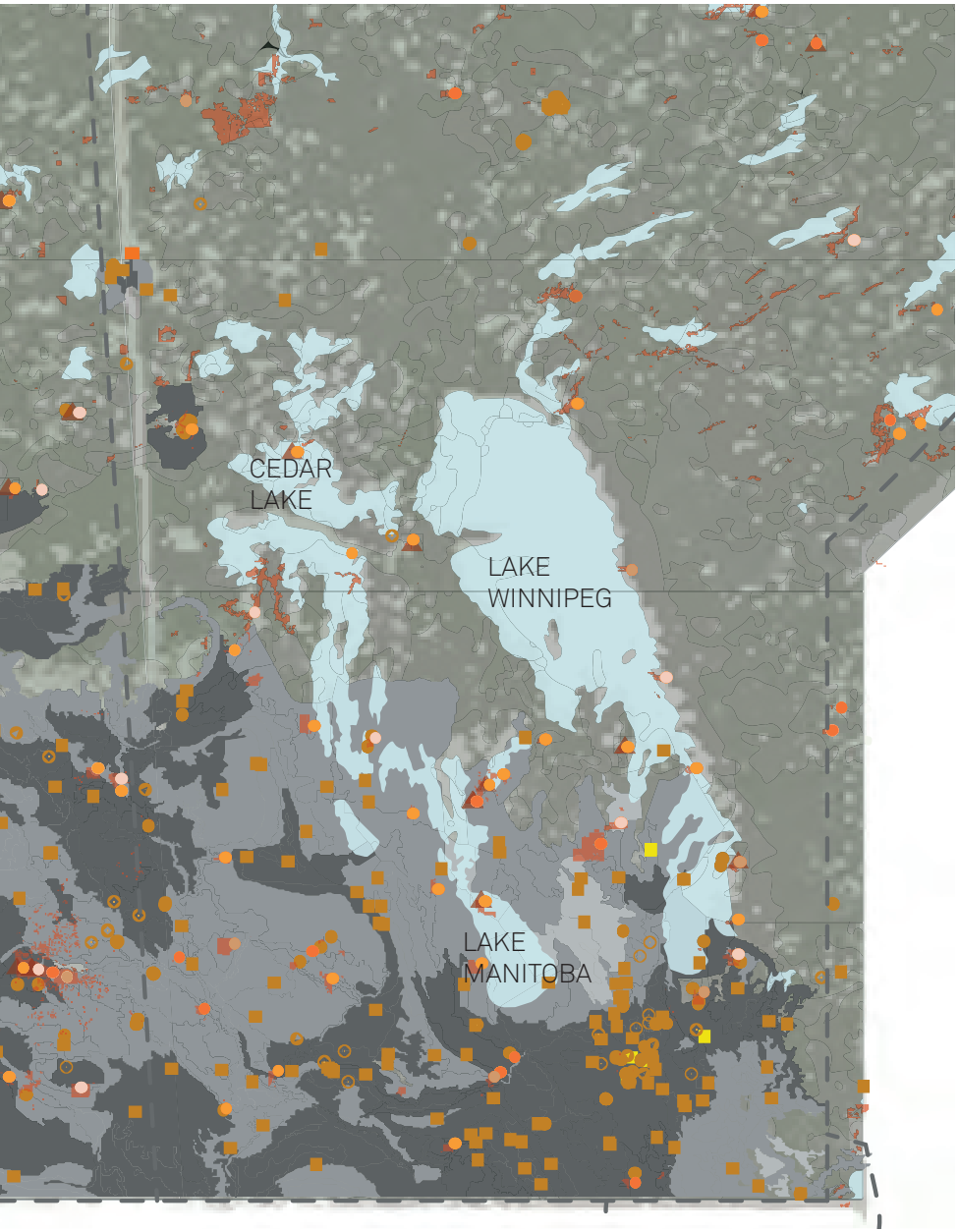
"Lake Winnipeg Watershed ." Map. Lake Winnipeg Foundation . Accessed August 12, 2021. https://lakewinnipegfoundation.org/news/mapping-out-new-watershed-connections.


Bunibonibee
Manto Sipi
Cross Lake
God's Lake
Red Sucker Lake
Opaskwayak
Norway House
Wasagamack
Mosakahiken
Garden Hill
St. Theresa Point
Misipawistik
CEDAR LAKE
Chemawawin
Poplar River
Sapotaweyak
LAKE WINNIPEG
Wuskwi Sipihk
Berens River
Pauingassi
Pine Creek
Dauphin River
Skownan
Kinonjeoshtegon
Little Grand Rapids
Lake St. Martin
Little Saskatchewan
Bloodvein
Pinaymootang
O-Chi-Chak-Ko-Sipi
Tootinaowaziibeeng
Peguis
Fisher River
Hollow Water
Ebb and Flow
Waywayseecappo
Lake Manitoba
Black River
Keeseekoowenin
Gamblers
Sandy Bay
Sagkeeng
Rolling River
LAKE MANITOBA
Birdtail Sioux
Broakenhead
Sioux Valley
Dakota Tipi
Winnipeg
Long Plain
Canupawakpa
Dakota Plains
Swan Lake
Roseau River
Buffalo Point

First Nations Reserves / Territories



Locations of First Nations in Manitoba. Map. Indigenous and Northern Affairs Canada. Government of Canada, 2017.
First Nations and Treaty Areas in Manitoba. Map. Indigenous and Northern Affairs Canada. Government of Canada, 2017.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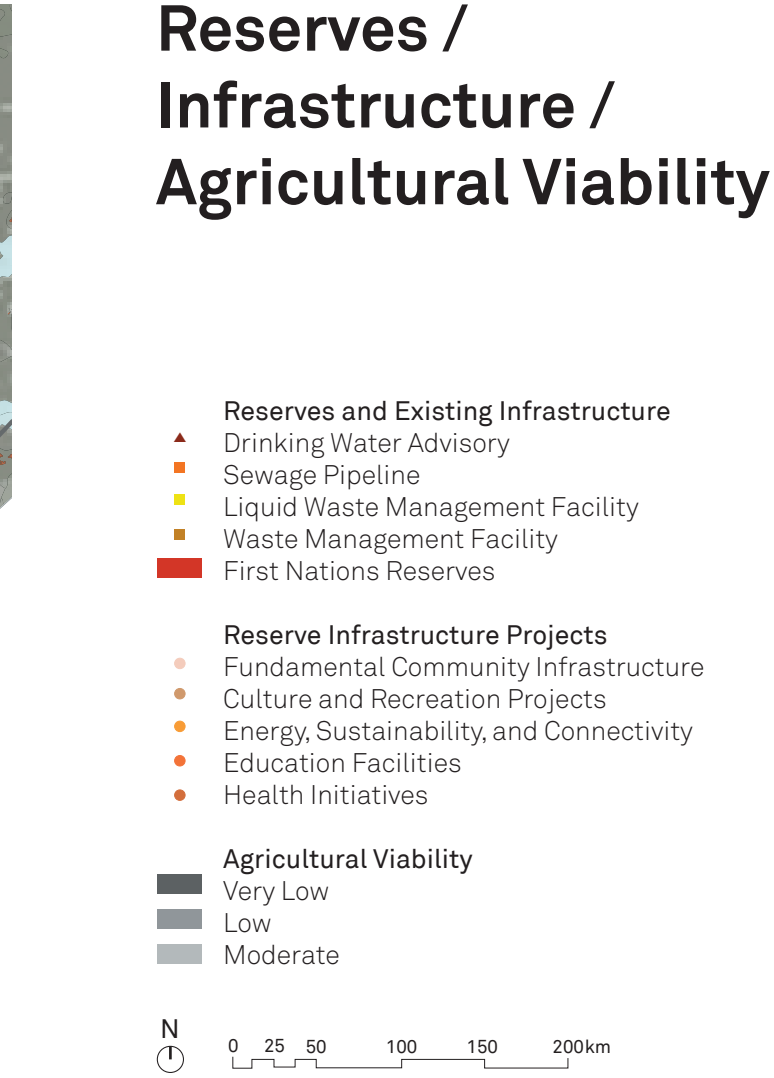
Reserves / Infrastructure / Agricultural Viability



Government of Canada. Oil and Mining. Dataset. https://open.canada.ca/data/en/dataset/000183ed-8864-42f0-ae43-c4313a860720.
Government of Canada. Prairie Agriculture, Landscapes. Dataset. https://open.canada.ca/data/en/dataset/0b2303be-ef05-49a8-8082-44a3eabcfa57.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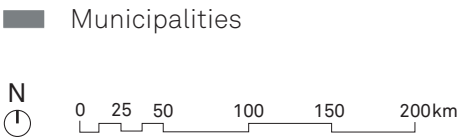
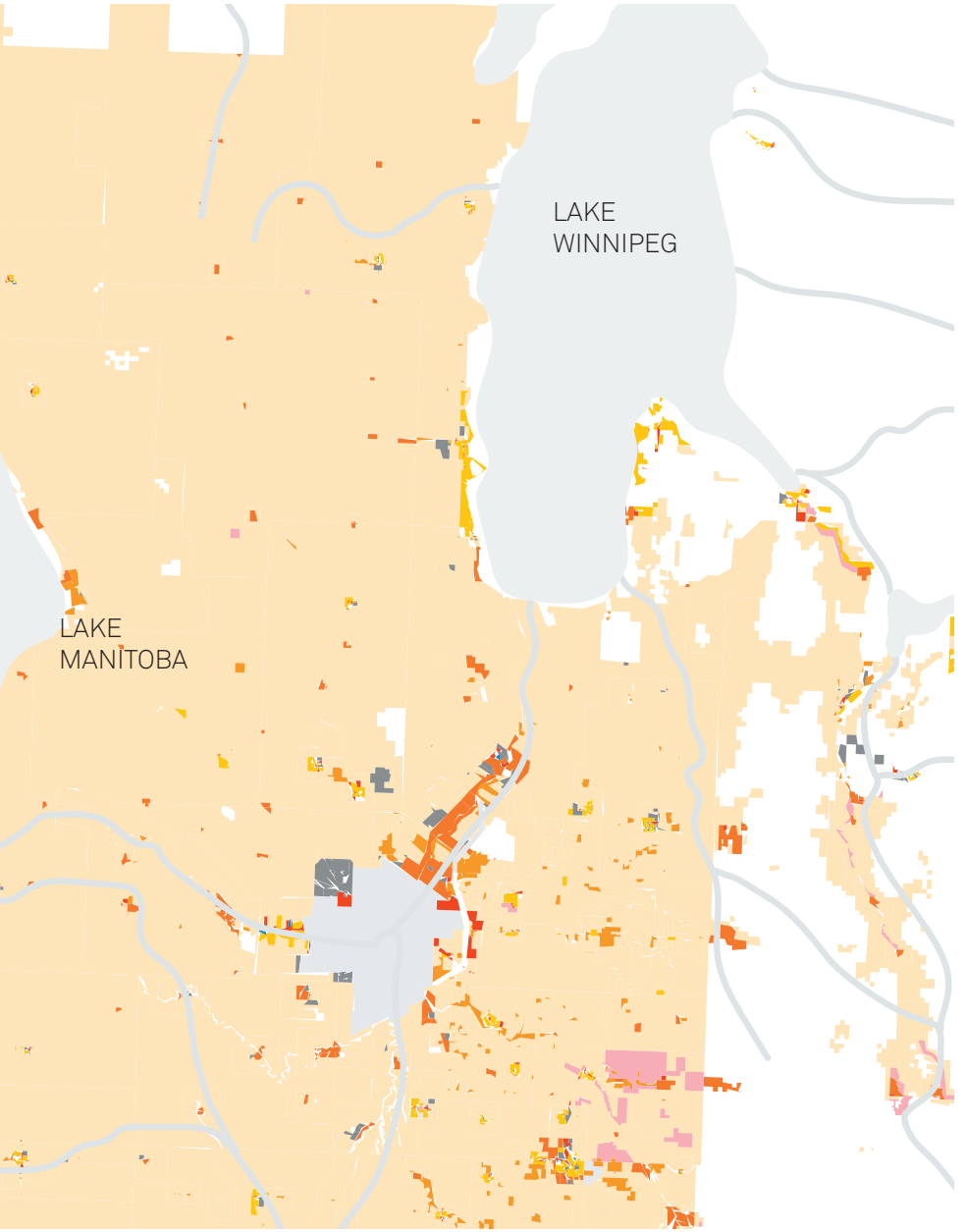
MANITOBA

Municipalities



Manitoba government. Manitoba Municipal Boundaries. Shape file. Last modified August 5, 2021. https://geoportal.gov.mb.ca/datasets/manitoba::manitoba-municipal-boundaries/about.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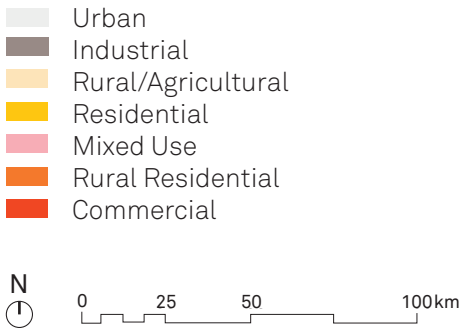
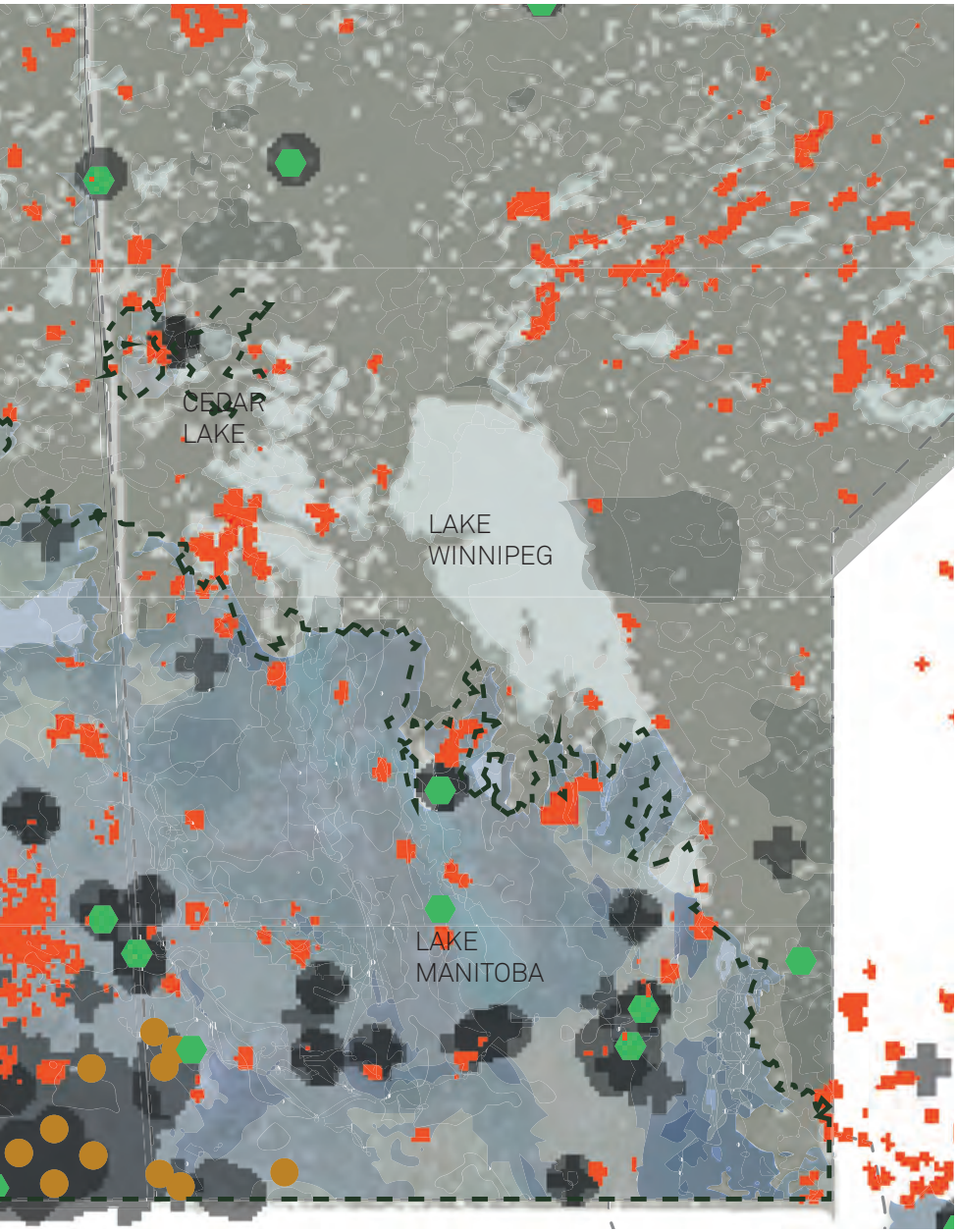
Land / Agriculture



Manitoba Government. Manitoba Development Plan Designations. Shape file. Last modified August 12, 2021. https://www.arcgis.com/home/item.html?id=6fe6107e957d-4a9e98d11f71fd13089a.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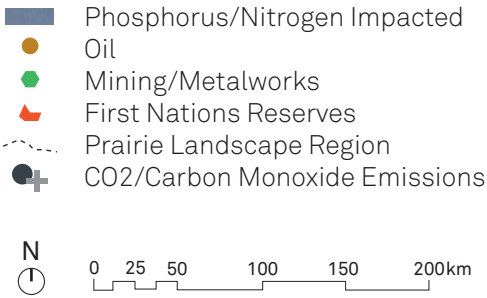
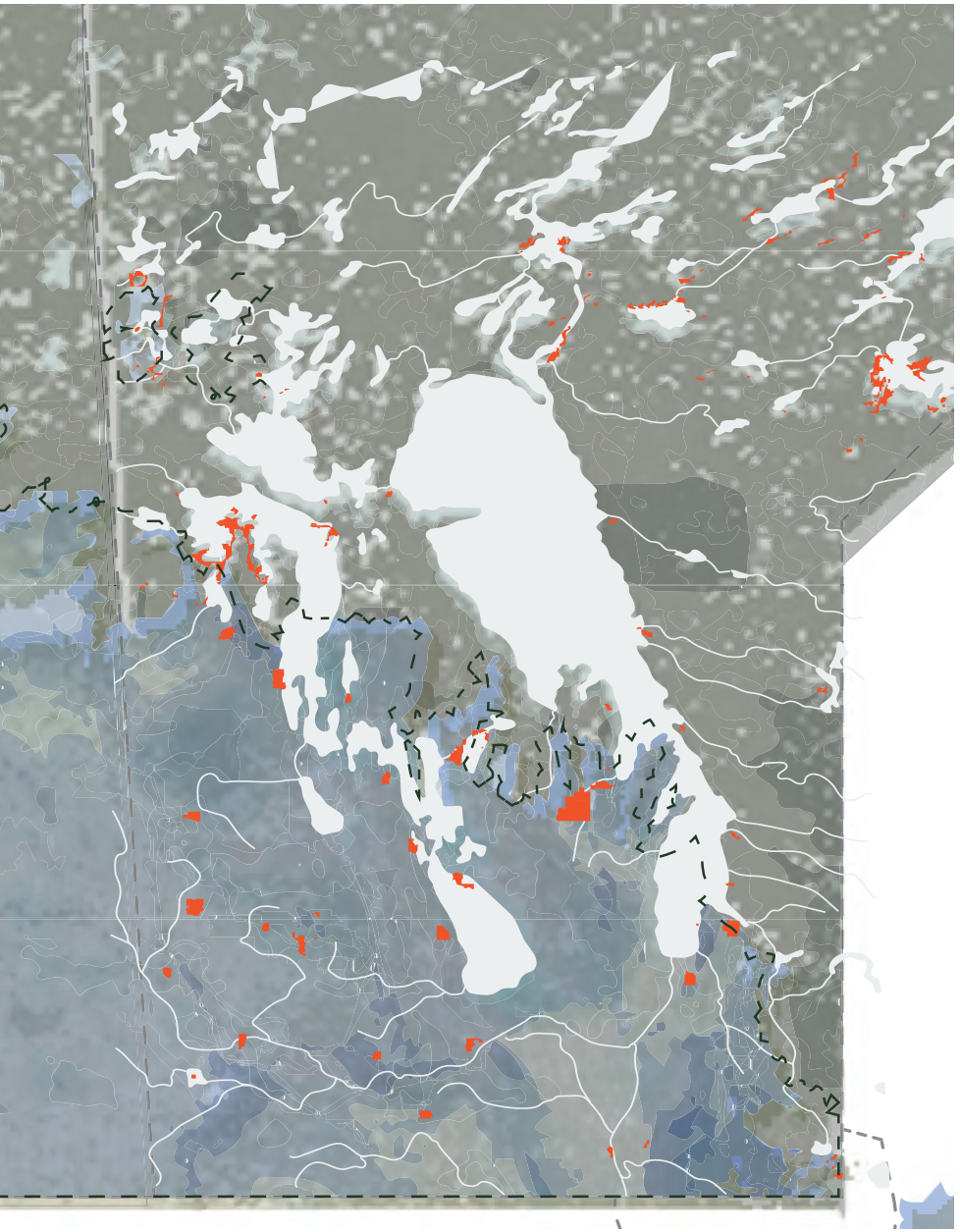
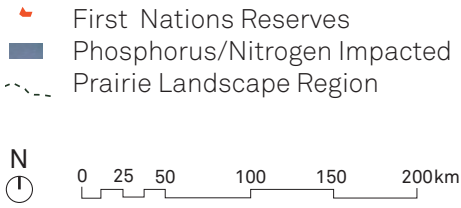
Agriculture/ Resource Extraction



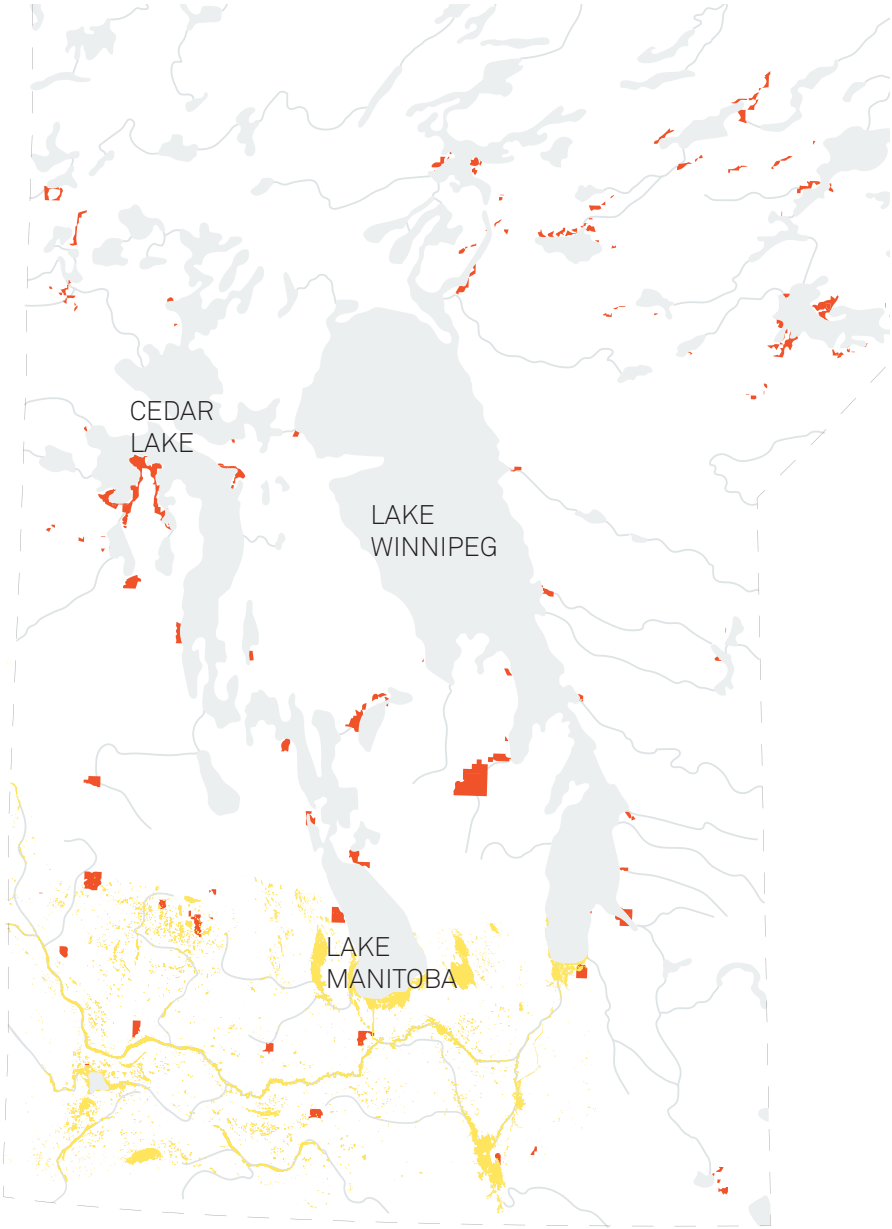
Government of Canada. Oil and Mining. Dataset. https://open.canada.ca/data/en/dataset/000183ed-8864-42f0-ae43-c4313a860720.
Government of Canada. Prairie Zones. Dataset. https://open.canada.ca/data/en/dataset/ac6a1e51-9c70-43ab-889f-106838410473.
Government of Canada. Prairie Agriculture, Landscapes. Dataset. https://open.canada.ca/data/en/dataset/0b2303be-ef05-49a8-8082-44a3eabcfa57.



Phosphorous / Nitrogen



Government of Canada. Nitrogen, Phosphorus. Dataset. https://open.canada.ca/data/en/dataset/3f5acb7c-78e6-4127-8867-ddd70e396476.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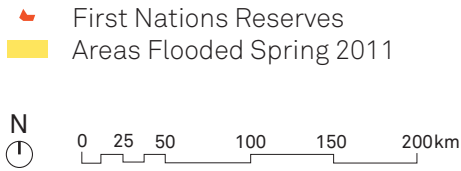
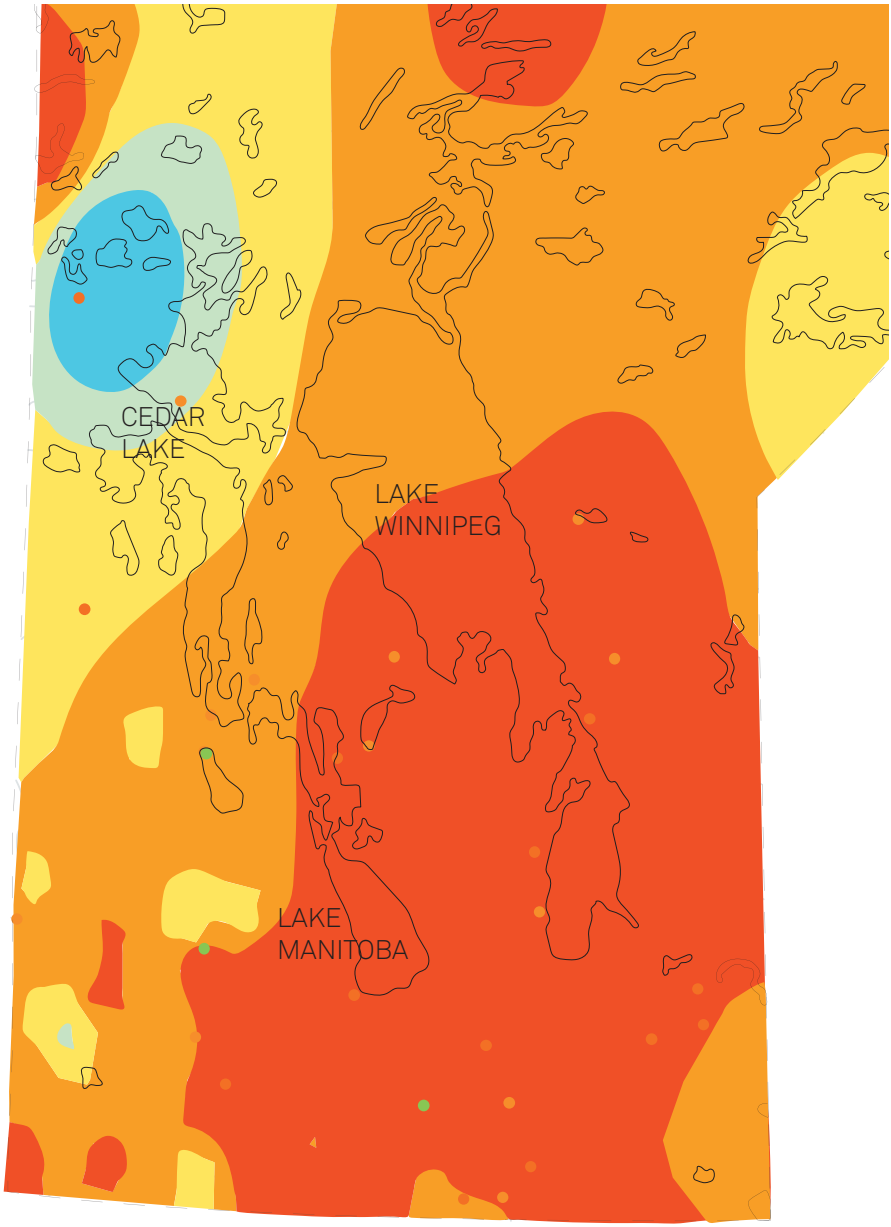
Flooding

This map depicts flooding in one season of one year, which was the spring of 2011. Flooding varies greatly by season and by year, and is attibutable to both natural and human-caused factors.



Hannah Cole. Southern Lake Manitoba April to May 2011_WFL1. Shape file. Last modified Dec 11, 2019. https://www.arcgis.com/home/item.html?id=2a19cccd-d7c3465a832131414d6ef521.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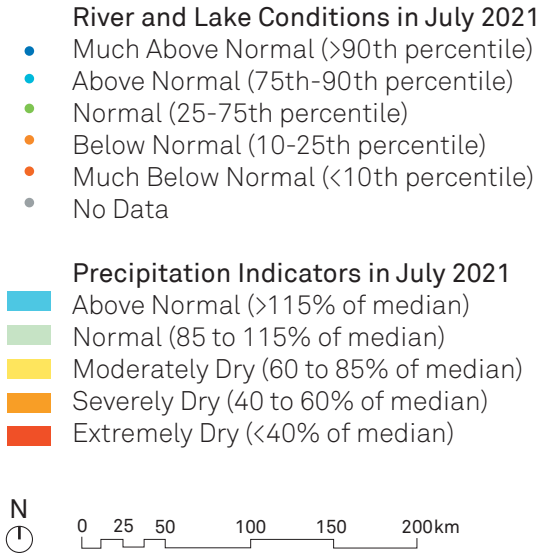
Drought



Manitoba Government. Manitoba Drought Monitoring : River and Lake Conditions. Shape file. Last modified Aug 6, 2021. https://www.arcgis.com/home/item.html?id=1dc30790d3004d1b-956daa69f85268de.
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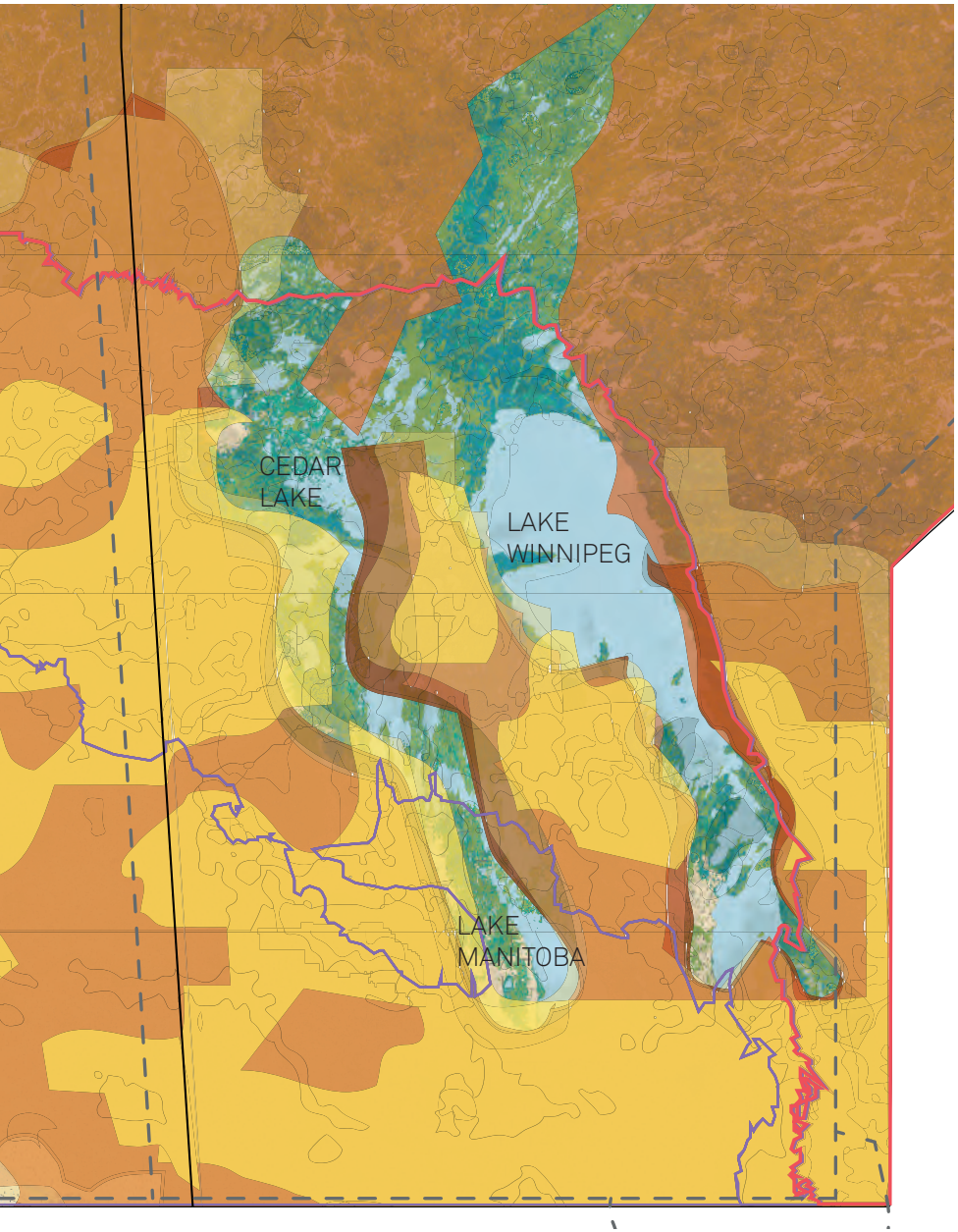
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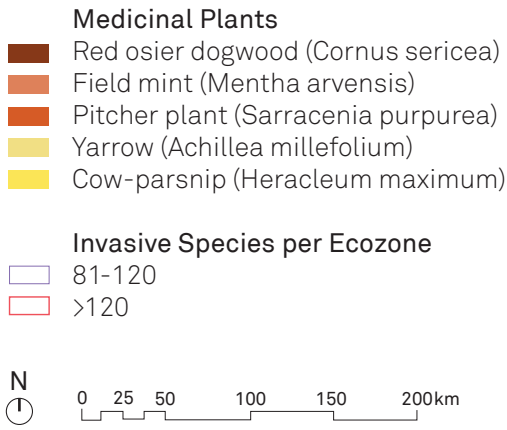
Select Medicinal Plants / Invasive Species



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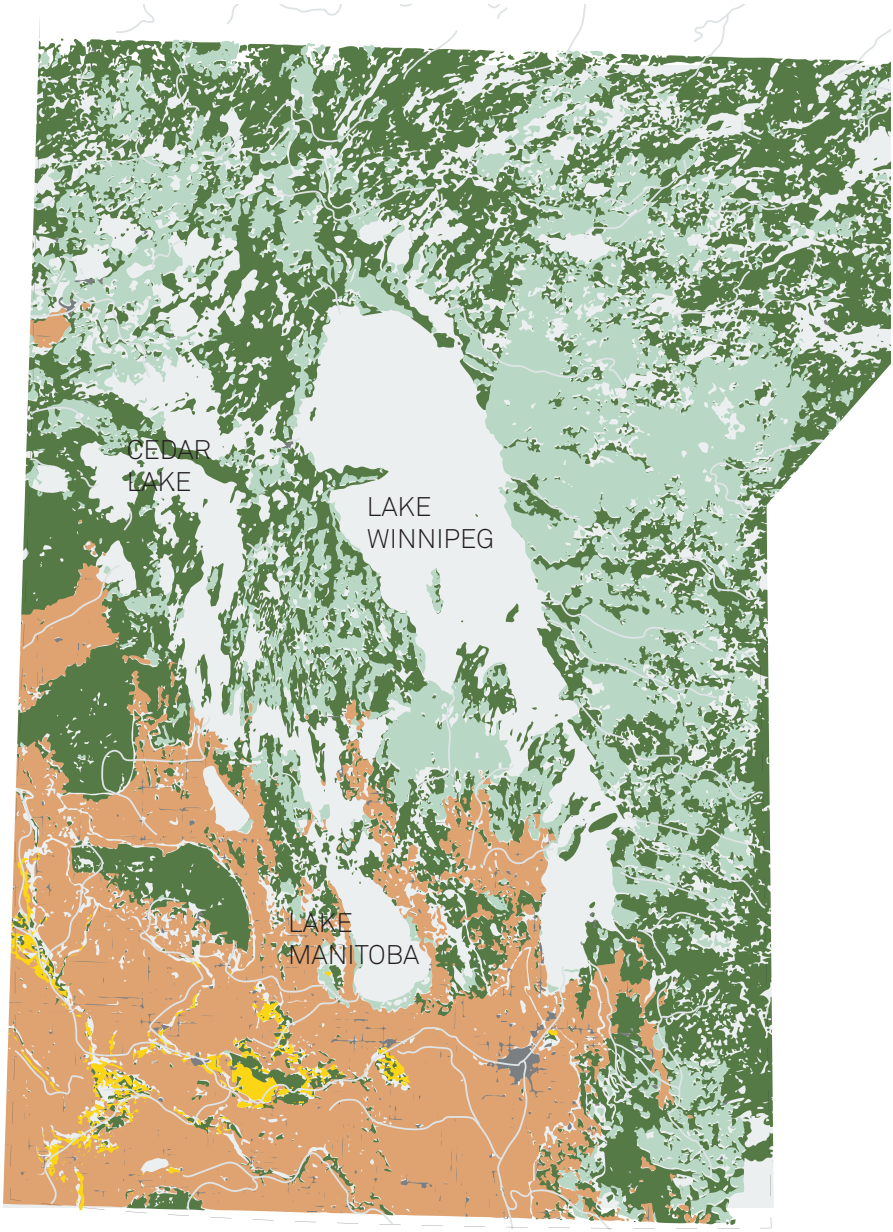
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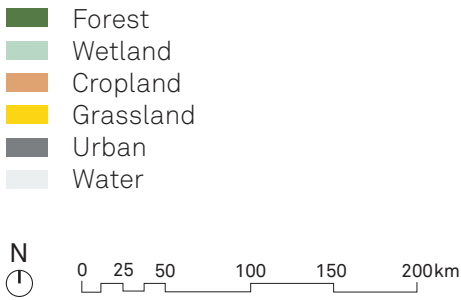
Ecotypes



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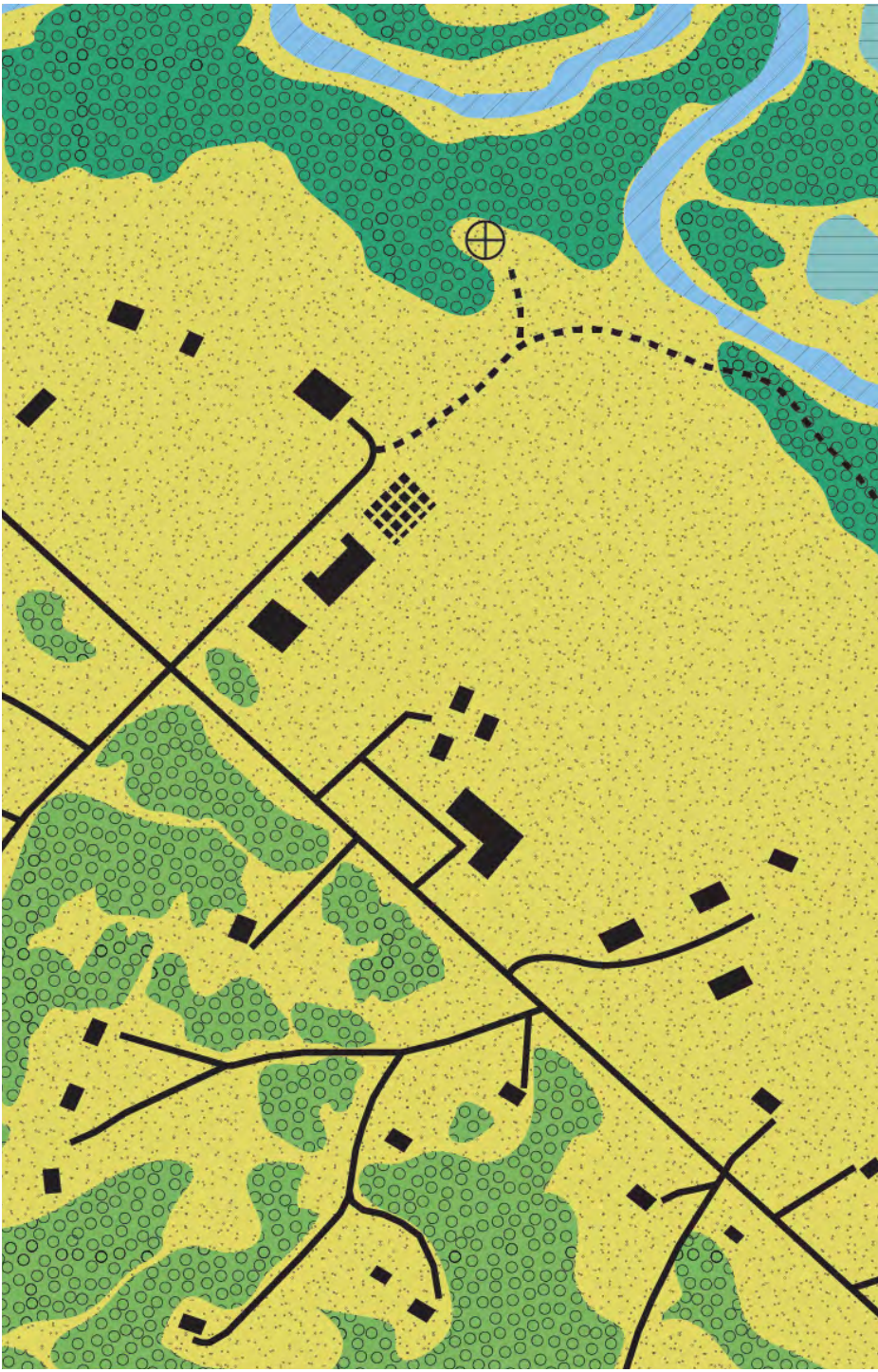
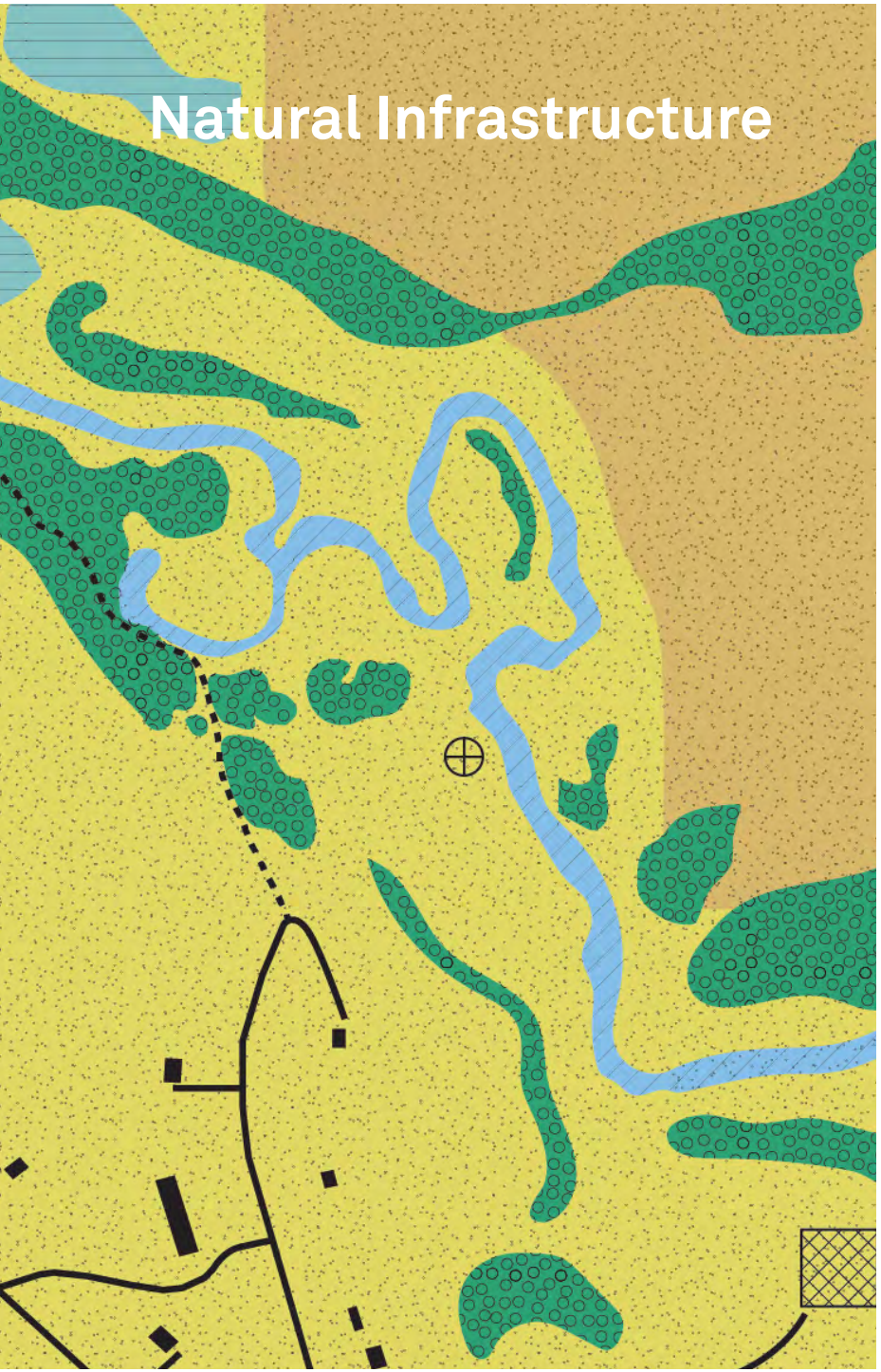
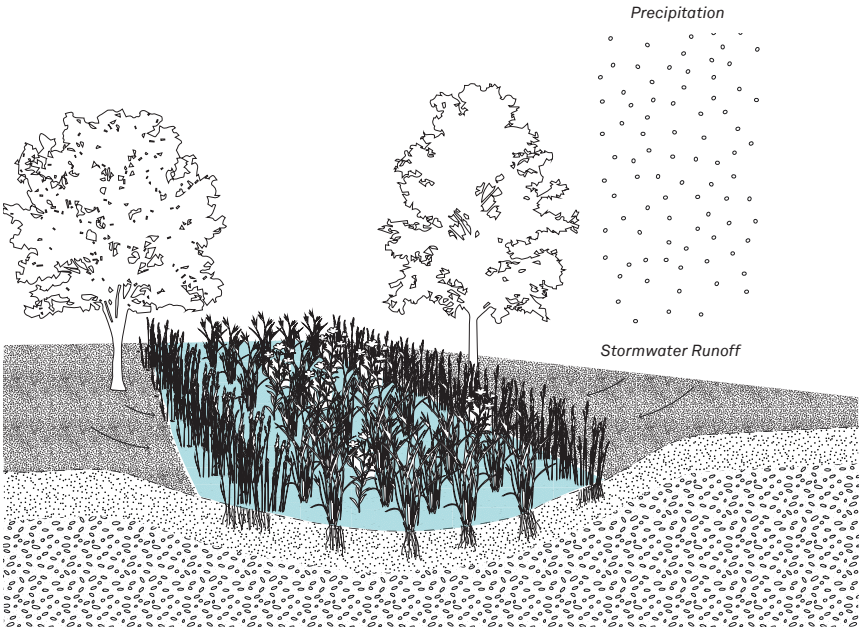


Natural Infrastructure





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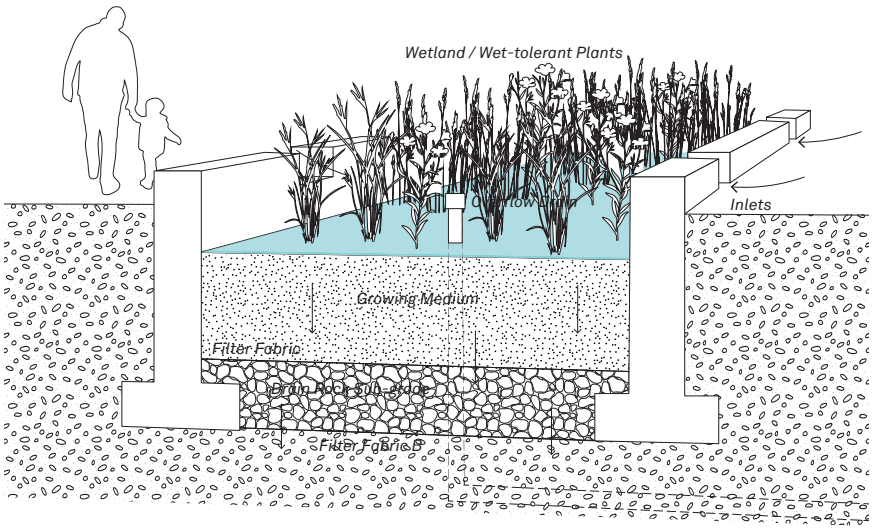
Bioswale

Stormwater Filter
Temporary Stormwater Pond

Description
Bioswales are landscape depressions that are designed to retain and absorb stormwater runoff from the surrounding area.

Function
Bioswales provide an alternative to stormwater treatment by removing contaminants from the stormwater as it flows through and infilt ates into the ground. They are typically used at the edge of impervious surfaces such as roadsides and parking lots, as well as the edge of agricultural fie ds.

Components
Vegetation — Plants should be selected based on their ability to tolerate water and drought. The bottom of the swale should be planted with species that can tolerate periodic inundation.
Alternatives — Bioretention planters, rain gardens, infilt ation planters can be implemented at different scales.
Management — Inspect swales periodically especially after storms to ensure the proper function.
Maintenance — Water irrigation should be applied for the fi st two years after construction to ensure the success of settlement of plants. Remove trash and sediment, maintain the side slope to prevent erosion.



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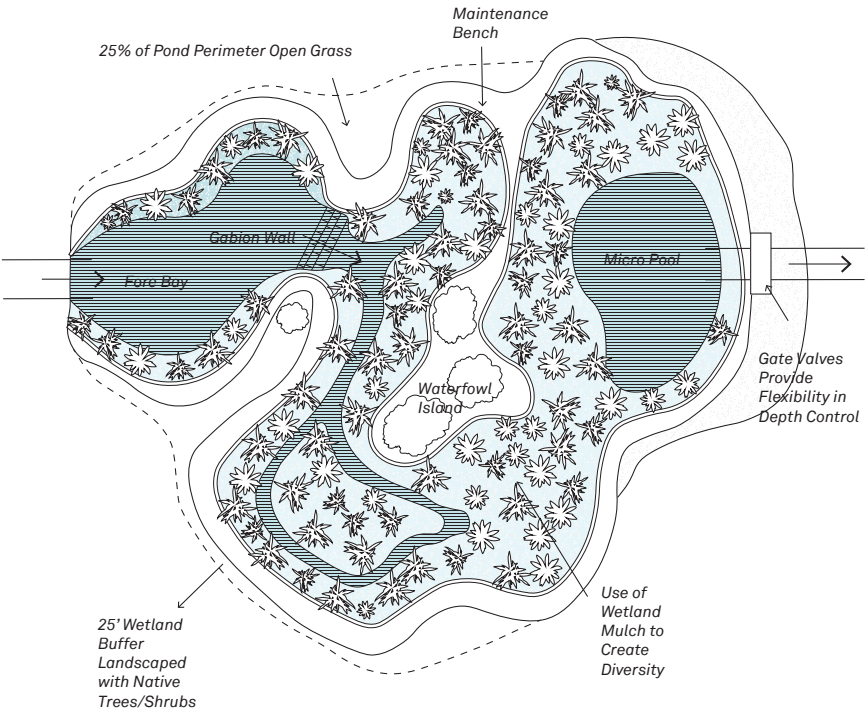
Bioretention Planter

Rain Garden
Bioretention Curb / Cell
Infilt ation Planter
Retention Cell

Description
Bioretention planters are ideal for small urban sites. They are planters designed to form shallow basins with moist-liking plants.

Function
Bioretention planters are designed to retain and absorb stormwater while fil ering out pollutants as the runoff seeps into the soil.

Components
Vegetation — Plants that are suitable for wet-to-moist soil including rushes, sedges, perennials, ferns, and shrubs. All plants should be planted densely and evenly to ensure proper hydrological function.
Alternatives — Rain gardens, bioretention curb, Infilt ation planter, and retention cell can be implemented at different scales as alternatives.
Management — Measures of Insects and rodent control should be taken when necessary. After major storm events, water needs to be drained through the planter within 24 hours.
Maintenance — Irrigation is required for the fi st two years to ensure the success of plants establishment. Replacement of dead plants should be applied while invasive plants should be removed.



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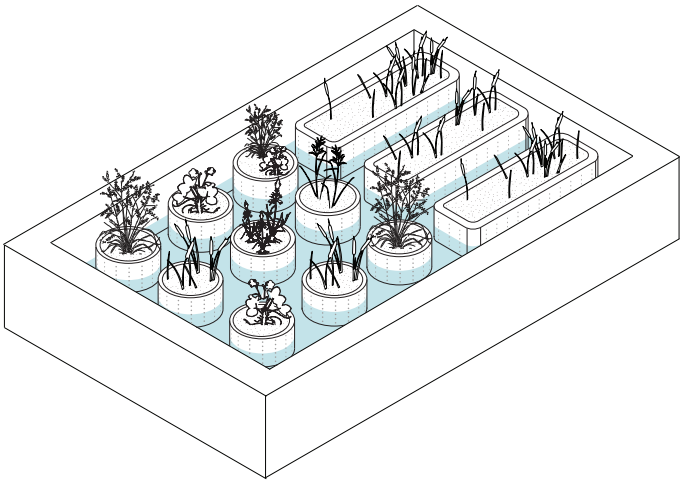
Constructed Wetland

Constructed Marsh
Stormwater Marshland

Description
A shallow surface flow wetland, where storm water runoff enters the wetland system designed to purify and temporarily store water before being released into the watershed.

Function
Constructed wetlands are designed to catch and hold runoff long enough for peak storm flows to be dampened, for sediment to drop out, and for physical and biochemical processes to reduce other contaminants before the water is discharged.

Components
Vegetation — **Planting should achieve dense and diverse vegetation and be selected based on the land's proximity and susceptibility to water.**
Alternatives — Other design options incorporate toe revetments, marsh sills, marsh with groins, and offshore breakwater systems. The incorporation of multiple habitat elements increases ecosystem complexity.
Management — A sediment fore bay is placed before the wetland to slow the influent torm water and reduce sediment loads before storm water enters. As much area as possible should be allocated to very shallow depth (1"-6") to maximize surface area.
Maintenance — Requirements are low, but long-term plans should include inspections for damage and depth of sediment accumulation as well as supplemental water source options during plant establishment.



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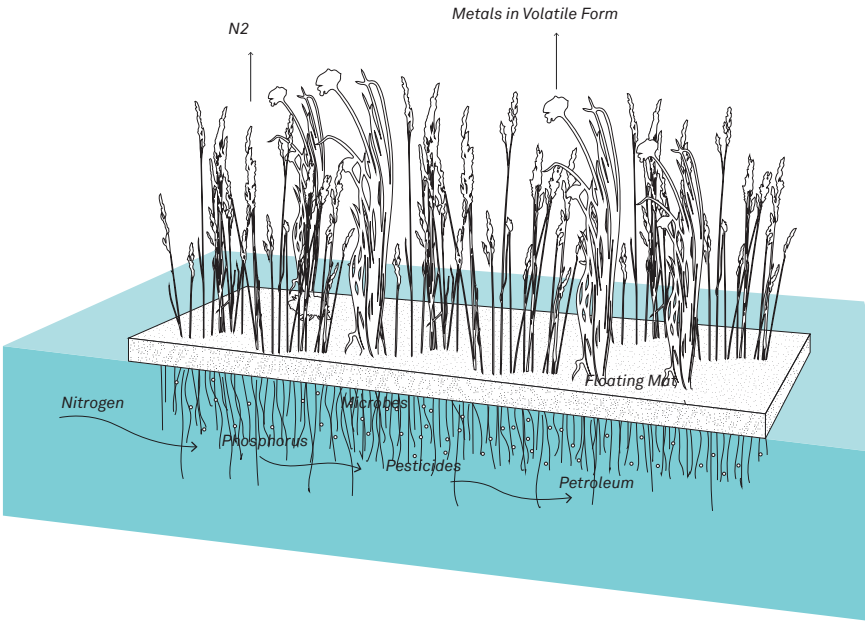
Managed Constructed Wetland

Waste Treatment Lagoon

Description
An artificial etland where individual permeable tanks that contain wetland plant species and soil are distributed through an area of stagnant or slowly moving water.

Function
The permeable tanks allow polluted water to pass through slowly allowing the contained microorganisms and plants to purify the water.

Components
Vegetation — Wetland plants are the fundamental component of managed constructed wetlands. Individual species is determined by water depth which should be monitored and regulated.
Alternatives — Bioretention planter, constructed wetland, bioswale.
Management —Wetlands must be managed if they are to perform well, this includes monitoring water levels, presence of burrowing animals.
Maintenance — Systems should see routine cleaning of inlet and outlet structures and throughout to ensure even distribution, dikes should be mowed regularly and entire system should be monitored often.



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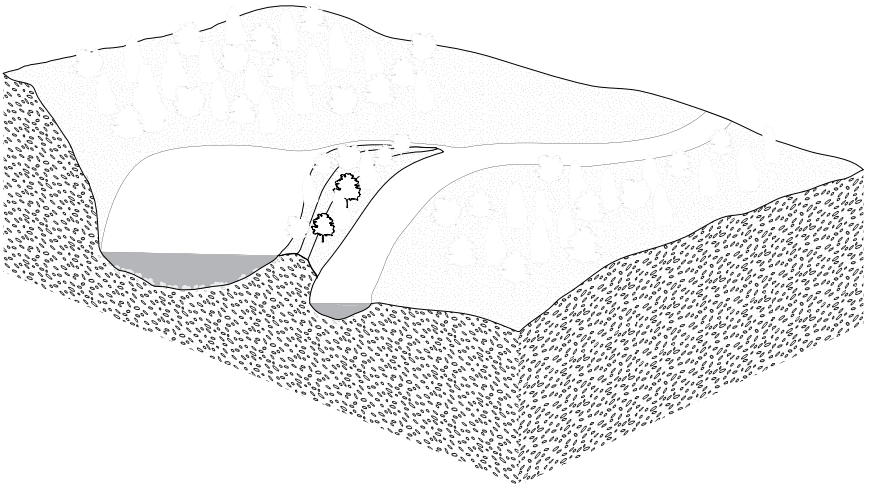
Floating Wetland

Floating Treatment Wetlands
Natural Floating Wetlands
Managed Constructed Wetlands

Description
Floating wetlands comprise planting over the surface of existing water bodies. Unlike other traditional wetlands, floating wetlands are installed on artificial floating structures while the plant roots extend into the water.

Function
Floating wetlands are often used to treat contaminated water of both organic and inorganic pollutants. They can be applied to urban rivers, canals, ponds, and water bodies adjacent to agricultural fie ds.

Components
Vegetation — Plants should be selected based on the specific pollutant , their growing habits, and the level of maintenance. For organic contaminants, selecting plants with highest biomass can help achieve the ideal outcome.
Maintenance — Harvesting and replanting is required to remove nutrients like nitrogen and phosphorous. Floating wetlands may need to be removed completely to eliminate the inorganic contaminants that are absorbed into the plant roots.



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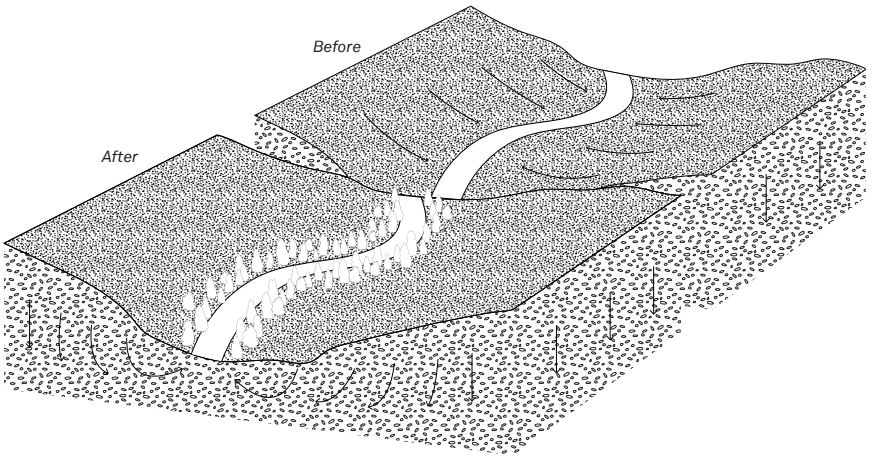
Sediment Basin

Sediment Traps and Basins

Description
Sediment basins are ponds created by excavation or embankment to contain sediment and debris carried by runoff. They are usually connected to the stream by a diversion channel.

Function
As a form of water management, sediment basins can reduce sediment load in the stream when the upstream encounters severe erosion. It can also separate particles of different sizes, allowing finer particles to pass through while containing larger particles like sand and gravel.

Components
Alternatives — Sediment basin traps can be implemented on a small scale to achieve a similar outcome.
Management — A high level of analysis is necessary in the implementation of sediment basins.
Maintenance — Will need frequent inspection especially after heavy storm events. Sediment needs to be removed periodically to remain the proper function. When spotting damage, a repair would need to be made immediately.



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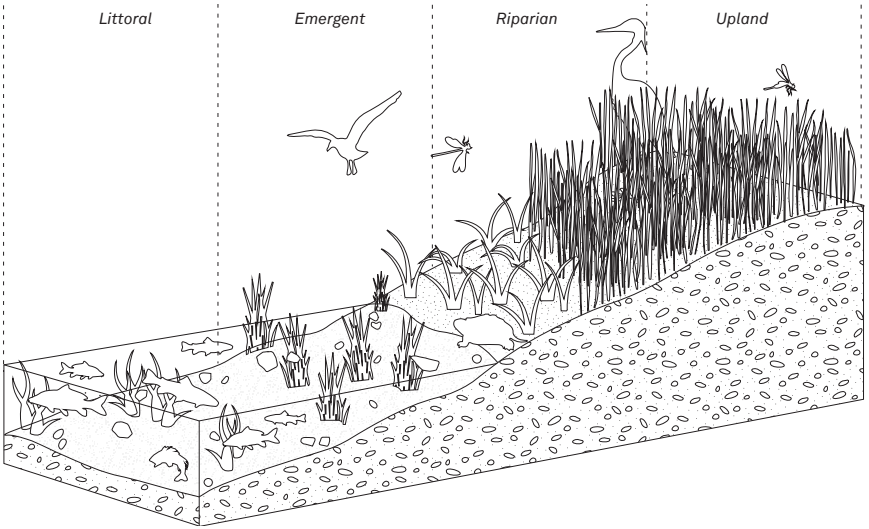
Stream Temperature Management

Streamfl w Temperature Management

Description
Streamflow temperature management refers to the practices implemented on both streamside and upland areas to manage the temperature of streamflow. These include riparian restoration, streambank stabilization, and upland practices that manage storm water runoff.

Function
Improved streamside vegetation cover can protect the stream from excessive solar radiation, and enhance subsurface water flow by facilitating surface permeability. Practices that provide erosion control can reduce water turbidity and therefore decrease the solar radiation absorbed into the stream.

Components
Vegetation — Will vary depending on the type of practice. In general, native tree and shrub species that naturally occur along rivers and streams.
Alternatives — Various practices that deal with storm water runoff, stream bank erosion, habitat restoration, and livestock management can be combined as an overall scheme to reduce the impact on water temperature caused by climate change.
Management — Will vary depending on the type of practice.
Maintenance — Varies depending on practice.



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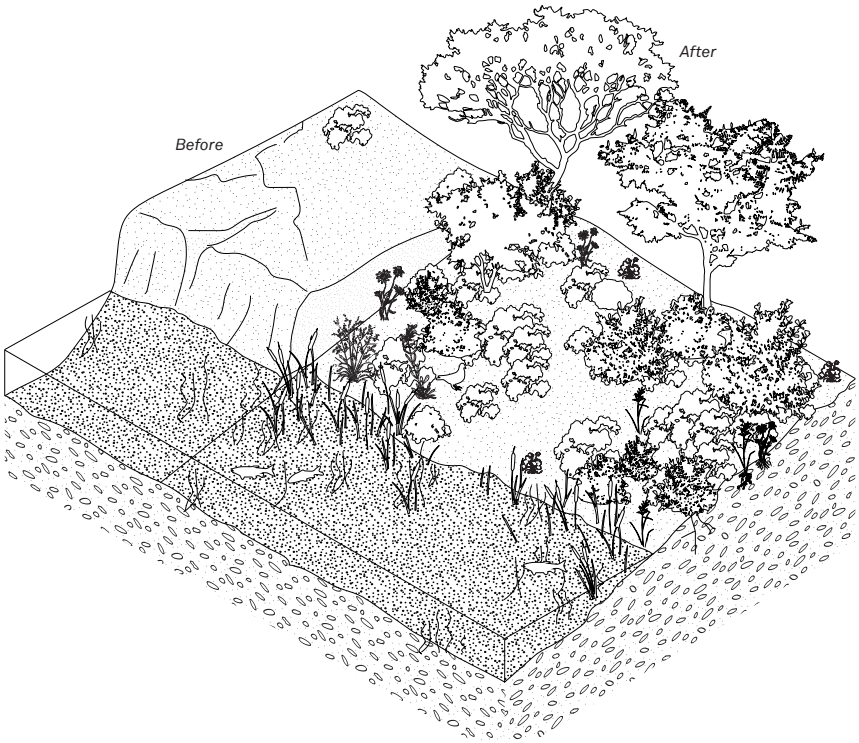
Living Shoreline

Bank Stabilization

Description
A plan of techniques for shoreline restoration and rehabilitation that combines riparian habitat and natural or engineered means of restoring the lake's edge.

Function
Living shorelines reduce energy on site and allow for important natural processes that maintain the health of the broader watershed ecosystem. By virtue of their position in the landscape, near shore habitats serve as a last line of defense in protecting estuarine water quality from watershed derived pollutants.

Components
Vegetation — Plants suitable for a littoral zone are selected based on their individual tolerance to water depth.
Alternatives — Other design options incorporate toe revetments, marsh sills, marsh with groins, and offshore breakwater systems. The incorporation of multiple habitat elements increases ecosystem complexity.
Management — Beach nourishment, dune restoration, tidal marsh creation or enhancement, bank grading, and instillation of natural fiber ogs.
Maintenance — Designs may include strategies of long-term vegetation management (e.g., trimming overhang trees, enhancing plant cover and diversity).



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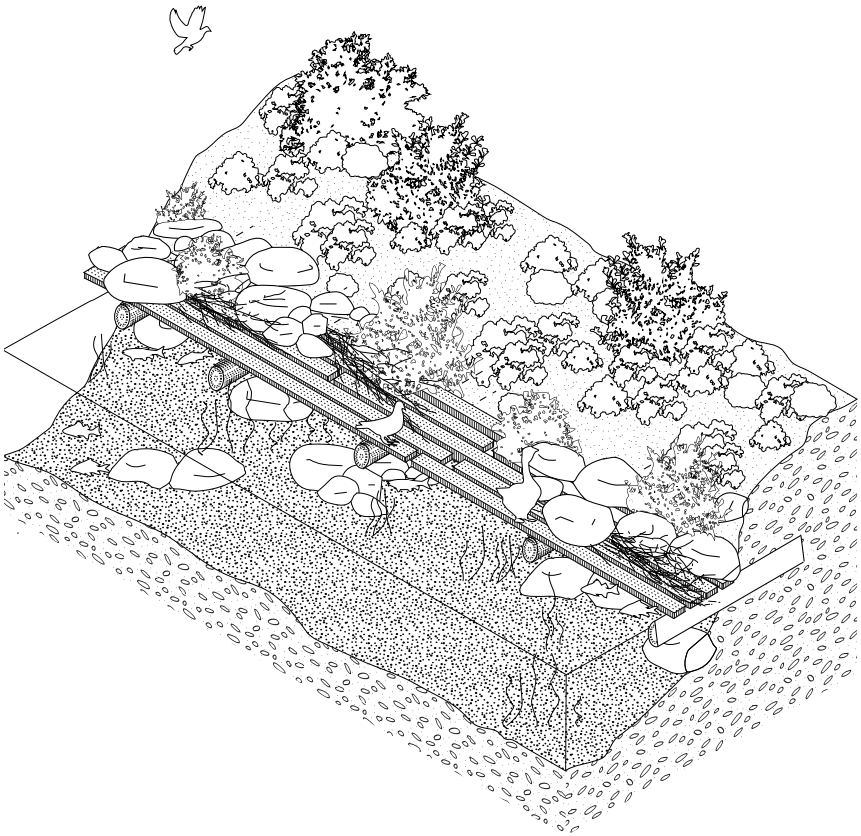
Bank Shaping and Planting

Bank Regrading and Naturalization
Bank Re-Naturalization

Description
Smoothing streambank to a stable slope and placing materials like topsoil and plants to provide a foundation for natural ongoing plant growth.

Function
Bank shaping levels the slope for stability and modifies the surface to control runoff, making it better suited for planting native riparian species, encouraging establishment of native species and preventing erosion.

Components
Vegetation — Aquatic plants, grasses, shrubs, and trees can be used. However, deep-rooting, fast-growing and water-loving plants are recommended.
Alternatives — Alternatives for gentle slopes include live steaks, dormant post plantings or brush mattresses. Other projects should be used when seasonal water flow and velocity exceeds the tolerances of selected plants, or the initial slope is too steep.
Management — This project is suitable for stream banks that have a gentle slope and occur in slow currants. So, reinforcements are often needed at the toe of the embankment, while other practices like soil stabilization or added mulch may be needed prior to planting.
Maintenance — Periodic analyses of slope stability is recommended to ensure long-term success of erosion prevention, while additional planting may be needed depending on growth in fi st two years.



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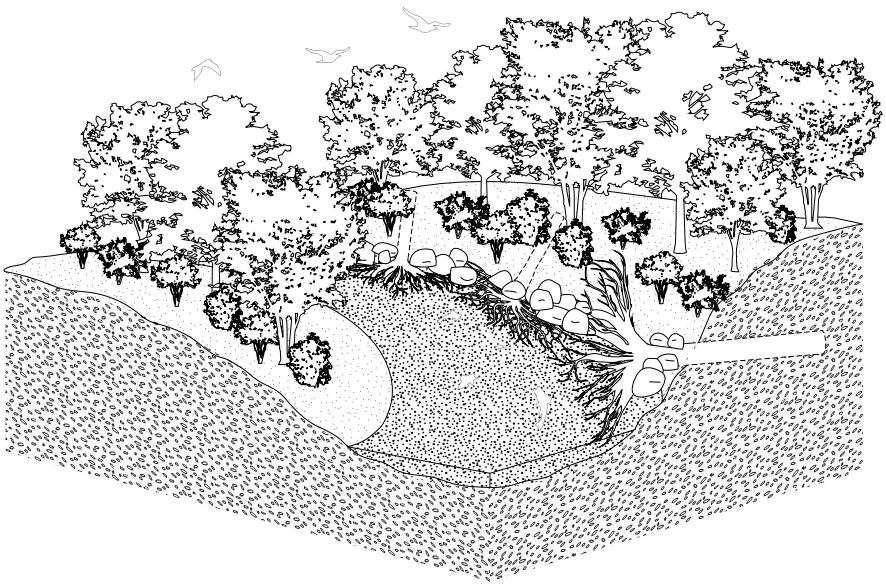
Log / Brush Shelter

Log / Brush Bank Stabilization

Description
Structures made of brush, logs and rocks are installed along the edge of the river to slow water currents, create shade and enhance fish habit t.

Function
Shelters are effective in areas with shallow stream banks where overhead cover is needed for aquatic plants and animals. By providing habitat for insects and fish a ong the edge of the river, the shelter supports healthy riparian food web dynamics while also stabilizing the rivers edge.

Components
Vegetation — Brush from fast-rooting and water-loving species like willow, dogwood and alder work well.
Alternatives — Other natural infrastructure that can enhance shoreline habitat by working in combination or as an alternative includes bank shaping/planting, living shorelines, and brush mattress.
Management — Shelters are better suited for the outside of bend ways and in streams where aquatic habitat is scarce. Not useful for streams with severe bank erosion unless used in combination with other natural infrastructure projects.
Maintenance — The shelter should be inspected in low water levels and monitoring of adjacent shorelines, above and below the sheltered area should be preformed to identify any possible neighbouring impacts.



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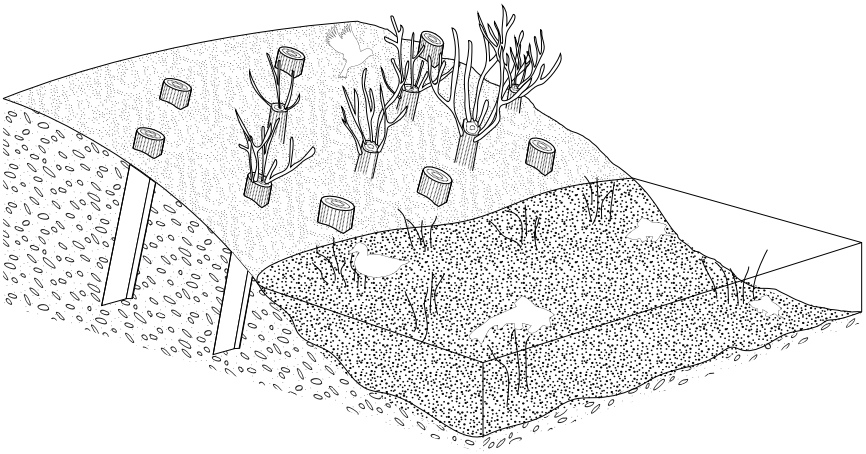
Log / Rootwad / Boulder Revetment

Natural Bank Stabilization

Description
Log, rootwad, and boulder revetments refer to systems that involve the placement of logs, rootwads, and boulders to stabilize the soil on stream banks while creating habitat for insects and other organisms.

Function
Can be used to stabilize the stream banks, prevent erosion, and improve biodiversity. They are suitable for streams where there is a lack of fish habit t.

Components
Vegetation — The lifespan of revetments will depend on the tree species and climate. Species like Cottonwood or Willow can help expedite the process of establishment.
Alternatives — Other techniques such as Tree Revetments can achieve a similar result.
Management — Planting in the upper bank area should be combined to enhance the overall stability of the streambank.



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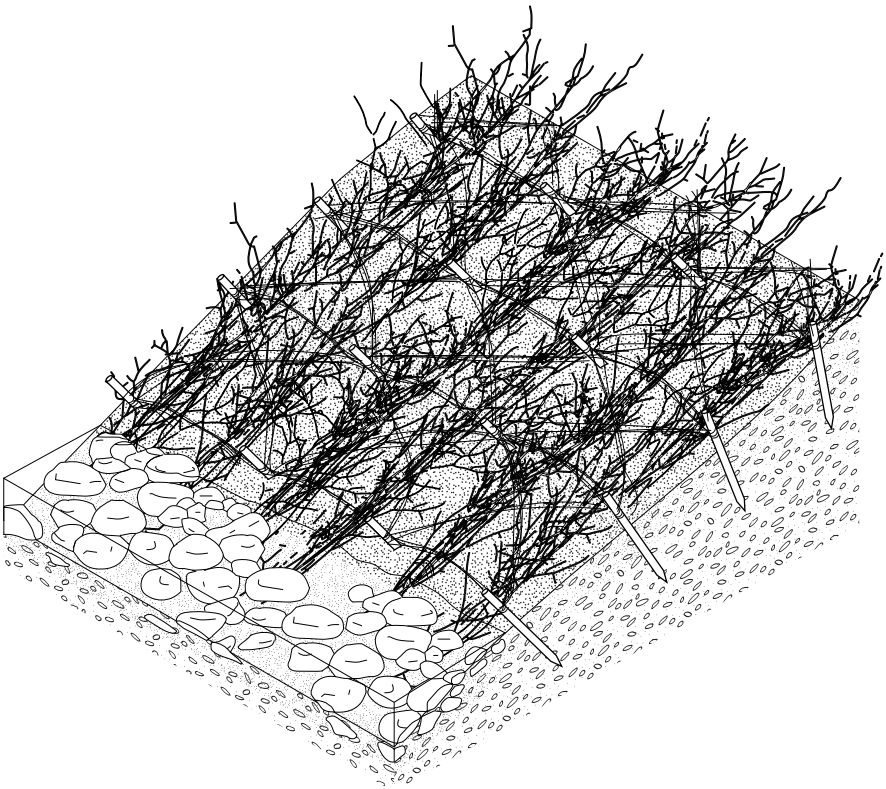
Live Stakes

Live Staking

Description
Live stakes refer to a system that consists of planting woody cuttings into the soil where these live stakes will establish their roots and eventually grow into trees.

Function
The live stakes can be harvested during their dormant season from the stems of trees and planted directly into the soil. In the process, the live stakes will develop their root system and form into a root mat. By stabilizing the soil particles, the root mat can prevent erosion and improve conditions for the establishment of nearby plant communities.

Components
Vegetation — Stems from trees that grow naturally along stream banks such as Black Willow and Red Osier Dogwood.
Alternatives — Implementation can be combined with other soil bioengineering techniques and vegetative plantings.
Management — Irrigation might be applied in the fi st two years during summer. Pulling the stakes lightly in fall can help determine the success of planting. Replanting can be applied to replace the stakes that fail to survive.
Maintenance — Weeding might be required to help the stakes establish themselves and prevent other vegetation from taking over.



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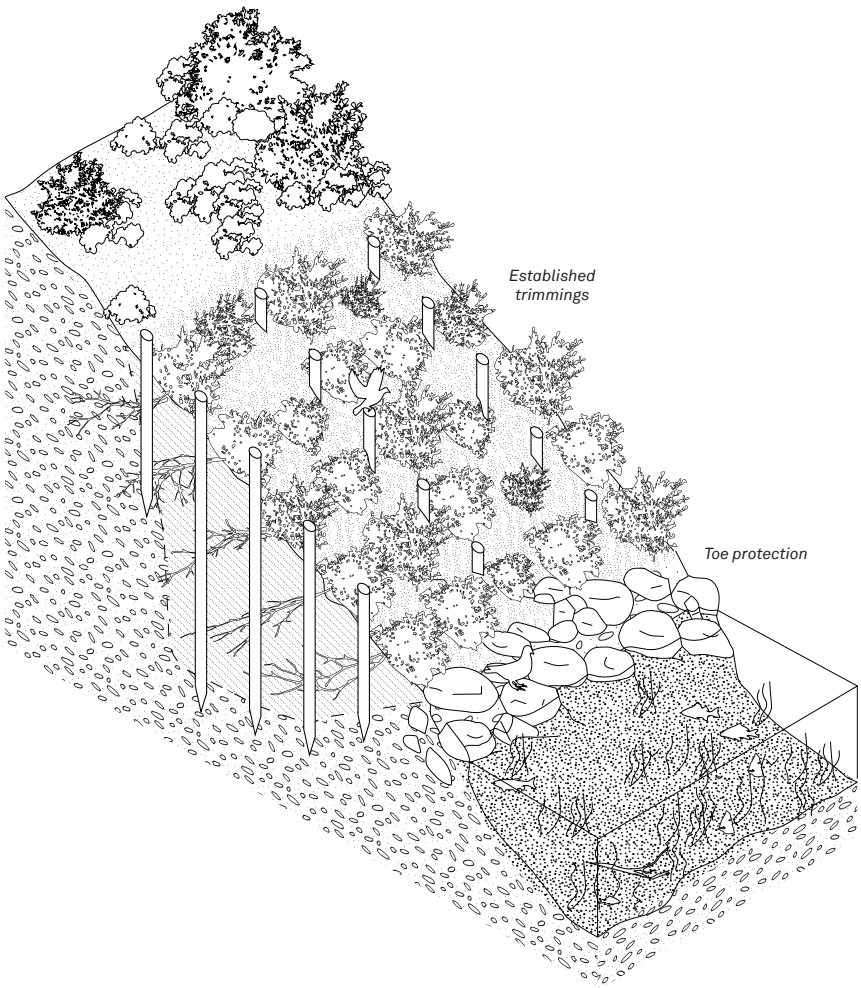
Brush Mattress

Willow Brush Mattress and Stakes
Branch Cuttings for Streambank Erosion Control

Description
A layered mat of branch cuttings bunches, buried at one end, covering the streambank. Bundles are held in place by live stakes and twine; and eventually reclaim the area as cuttings sprout and native species naturally reestablish the river's edge.

Function
Brush mattresses are a quick and cost-effective method of restoring moderately eroded and medium sloped rivers edge. The natural infrastructure immediately protects banks, sprouts quickly, and provide long term protection as the cuttings take root.

Components
Vegetation — Fresh and mature dormant cuttings with diameters over 2cm work best. Water-loving woody species like dogwood or viburnum are suggested.
Alternatives — Alternate erosion control projects for moderate bank steepness include live plantings, joint plantings, and live fascines.
Management — Banks should be graded before installation, while toe protection at stream edge may be needed in areas with stronger currents. Additionally, steaks at the top of the bush mattress should be plentiful as a failure here could be detrimental.
Maintenance — Maintenance of established bush layers are minimal, live cuttings should survive long enough to stabilize soils and promote native growth.



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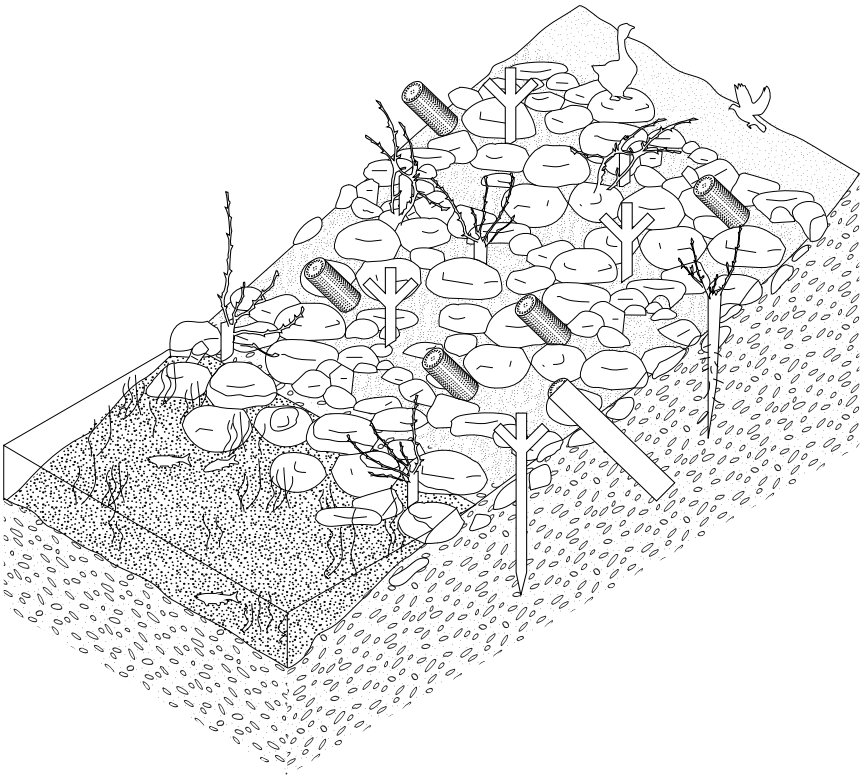
Branch Packing

Streambank Bioengineering
Bank Stabilization

Description
Holes and slumps in steep stream banks are fil ed with layers of branches cut from live, woody plants and fil ed with compacted fill o secure stems and stabilize the river's edge.

Function
Branch packing provides immediate soil reinforcement for holes in steep stream banks while quickly establishing vegetation. Developing roots reinforce the soil while stems reduces runoff, prevent surface erosion, and enhances the bank for naturalization.

Components
Vegetation — Live branches or trimmings of water-loving woody species of willow, alder or dogwood.
Alternatives — This technique should be used in areas that are already hollow. An alternative project for long sections of steep, unstable stream edge is live cribwalls.
Management — Branch packing works best when combined with geofabrics to prevent erosion prior to cuttings taking root. Ensure when planting, 75 - 80% of the dormant stems are buried, with the tips left exposed.
Maintenance — As a site already impacted by erosion the project should be monitored to ensure long-term success, as well as monitoring for any up or downstream changes in currents or erosion. Additional planting may be needed depending on growth in fi st two years.



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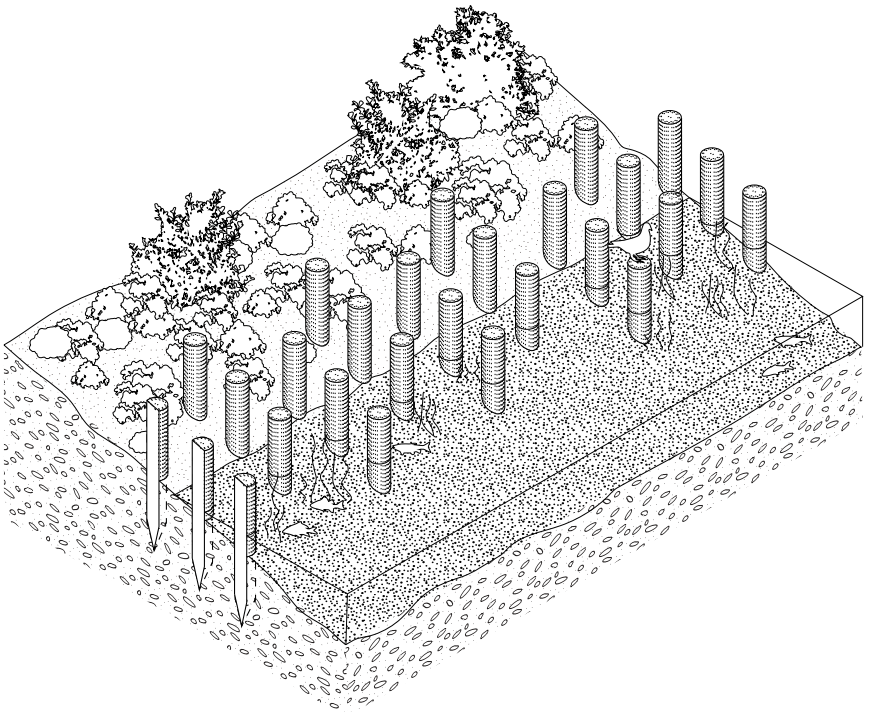
Joint Planting

Live Cuttings and Rip Rap Bank Stabilization

Description
Live cuttings are tapped into holes arranged in a streambank laid with rocks or rip rap. The rocks hold the cuttings in place until the roots grow which then holds the rocks in place, stabilizing the site.

Function
Joint plantings are an effective means of repairing erosion in areas with high water velocities, wave action and steep banks. This method quickly stabilizes a rivers edge, establishes cuttings and collect sediment.

Components
Vegetation — Live branches or trimmings of water-loving woody species that are hearty and root easily like willow, cottonwood, or poplar are recommended.
Alternatives — erosion control projects for similar or steep banks that are moderately stable include branch packing or live crib walls.
Management — The site needs to be free of debris as the rocks and live steaks will need full contact with the ground. Constructing the project works best when the rocks and stakes are done together to ensure adequate holes for post, and proper securing from the stones.
Maintenance — Maintenance of an established joint planting site is minimal. Additional planting may be needed depending on the growth of plants within the first two years. Long-term monitoring is needed to ensure the rocky bed does not become a smooth surface, increasing river velocities and potential for erosion downstream.



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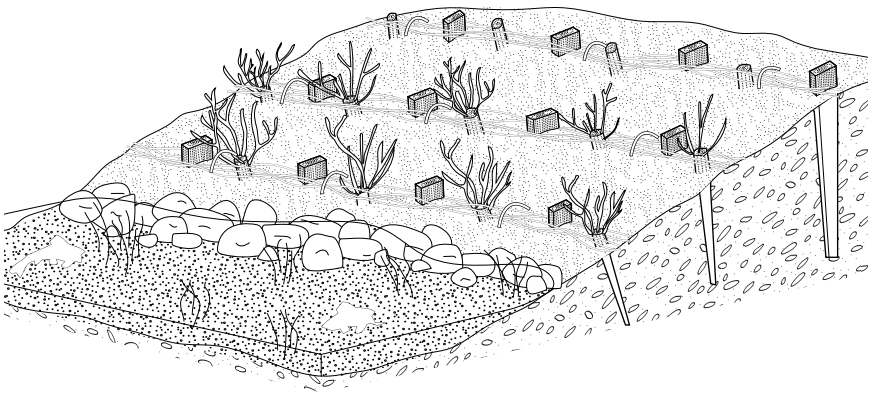
Dormant Post Planting

Pole Planting
Dormant Post Bioengineering

Description
Posts of dormant, deep-rooting woody species are inserted vertically in a square or triangular arrangements, deep into a shallow streambank with slow to medium currents.

Function
Dormant posts immediately disrupt and slow stream currents, trapping sediments, reducing erosion and quickly establishing a riparian edge.

Components
Vegetation — Trimmings of water-loving woody species like willow, cottonwood, or poplar are recommended.
Alternatives — Should be used in small streams with living shorelines that encourage native plant establishment. Alternative projects include live fascines, live steaks, or grading and planting.
Management — Try to harvest posts from sites that are expecting to be cleared or thinned, or from dense stands as attaining posts can be disruptive. Avoid using in area with gravel or rock or are prone to freezing.
Maintenance — Maintenance is limited as self-repairing system should re-sprout if affected by livestock or beavers. Additionally, unsuccessfully rooted posts can provide some benefits li e trapping additional sediment.



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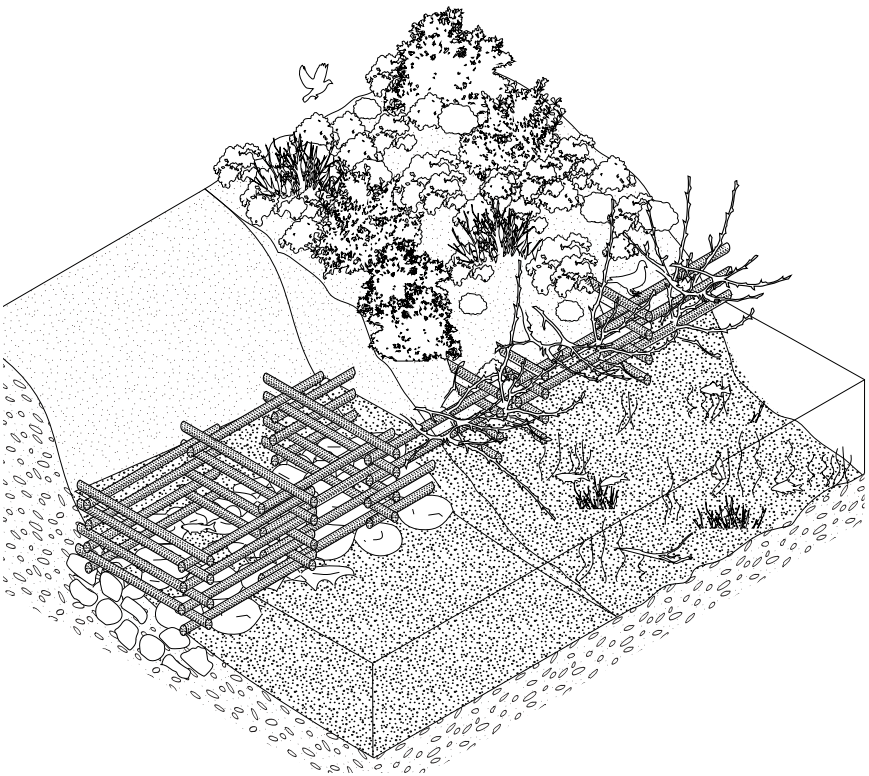
Live Fascines

Live Bundle

Description
Live fascines are long cylindrical bundles created by dormant branch cuttings, usually implemented on the slopes or in shallow trenches near a stream.

Function
Live fascines can effectively retain soil on the streambank by dividing the streambank into multiple shorter slopes. They are often implemented at the edge of streams for erosion control, filt ation of pollutants, and improvement of fisheries habit t.

Components
Vegetation — The branches used for fascines commonly include dormant branches of Willow, Red-osier Dogwood, and Snowberry.
Alternatives — Implementation should be combined with other soil bioengineering techniques and vegetative plantings.
Management — Measures for protection such as enclosures may be taken to ensure the fascines establish successfully.
Maintenance — Inspection will be required after each flood for a minimum of twice a year in the fi st year, and no less than once a year afterwards. The fascines should not be inundated for too long. During drought seasons, ensure the fascines have sufficient access o water.



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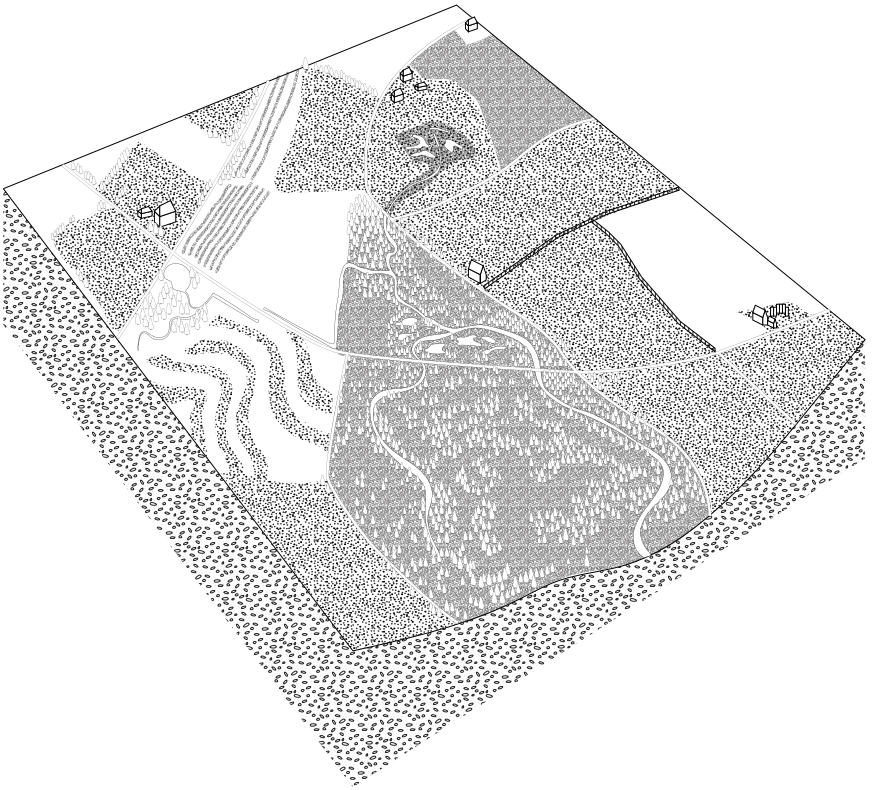
Live Cribwall

Live Log Wall / Structure

Description
A three-dimensional structure built from interlocking logs, bottomed with fill and opped with live cuttings embedded in the rives edge.

Function
In steep areas and or areas of strong current with limited opportunity for sloping options, live cribwalls are a great toe-protection, a natural option to replace structures like concrete walls, that immediately protect the streambank and create a natural appearance by housing quick-growing woody species.

Components
Vegetation — Logs should be cedar, red pine, jack pine, fir or sp uce. Whiles cuttings could include willow, dogwoods, or poplar for larger streams.
Alternatives — Erosion control projects for similar grades are joint plantings. Cribwalls could be used in combination with brush mattress, live stakes, or living shorelines to stabilize upper banks.
Management — Live cribwalls require the use of heavy equipment, as a 3-foot foundation will need to be excavated and fill will be needed o secure walls below water.
Maintenance — Constructing live cribwalls is the most taxing part of this project, once the live cribwalls are growing it will require little to no ongoing maintenance. Frequent monitoring of structure should be prioritized during the fi st months following instalation.



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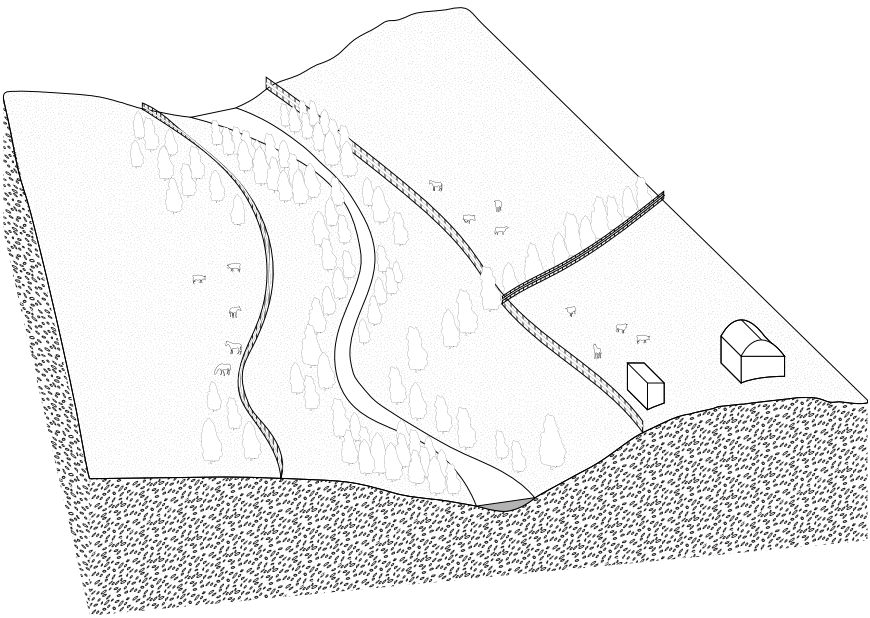
Agricultural Best Management

Best Management Practices for Agriculture
Agricultural BMPs

Description
Best management practices: agriculture refers to a single or a collective approach implemented in farmland for pollution alleviation. The common BMPs include: contour farming, strip cropping, vegetative strips, conservation tillage, terracing, integrated pest management, and nutrient management.

Function
There are three general types of BMPs. Minimizing pollution input at the source by implementing nutrient management in fertilizers and manures, and Integrated pest management in herbicides and insecticides. Erosion prevention and runoff management can be achieved through practices like strip-cropping which can restrict the movement of nutrients and pesticides on the land. Practices like vegetative strips can function as buffers between farmland and natural streams by trapping the contaminants in the runoff.

Components
Vegetation — Will vary depending on the type of practice. In general, native plant species with the ability to uptake pollutants will be the best.
Alternatives — Within the same type of BMPs, different practices can be applied to achieve the same outcome. The optimal result can be reached by a combination of BMPs.
Management — Will vary depending on the type of practice.
Maintenance — Varies depending on practice.



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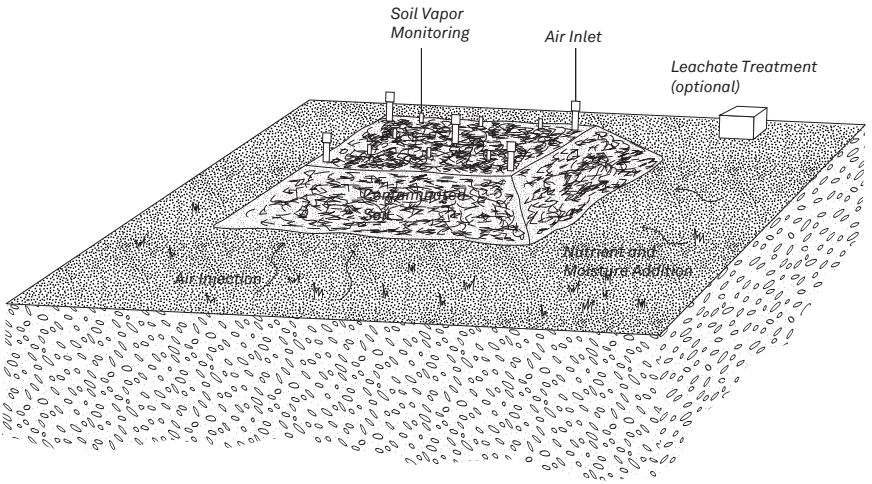
Livestock Exclusion

Livestock Management

Description
Livestock exclusion or management refers to the system that aims to improve water quality by restricting the access of livestock to the stream. It may include different sources of water and sheltering, streamside fencing, managed grazing, and buffer strips.

Function
Livestock exclusion or management can minimize the environmental impact caused by livestock, improve water quality, and enhance the health of the ecosystem as a whole. Limiting livestock access to the stream can effectively protect the woody vegetation along the stream from overgrazing and prevent erosion. It can also reduce water pollution caused by livestock manure.

Components
Alternatives — An overall management plan can be created by combining different strategies of livestock exclusion, but it must be integrated with an overall grazing plan.
Management — Will vary depending on the specific type of practice.
Maintenance — Will vary depending on the specific type of plan. Fencing, for example, will require periodic inspections. When spotting damage, a repair will be necessary immediately.



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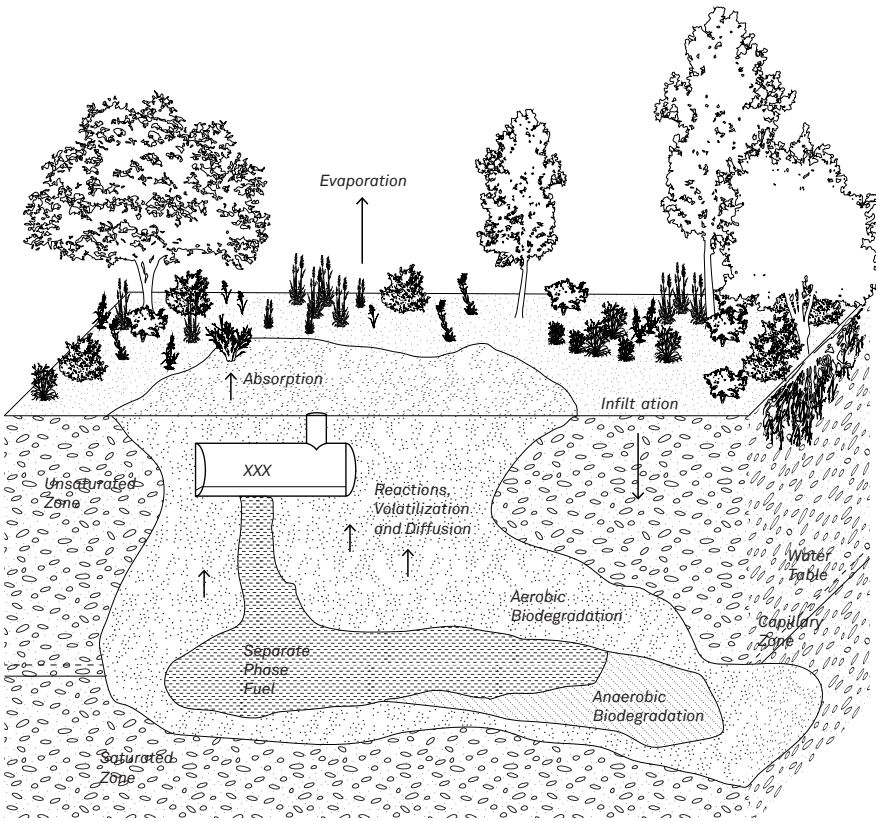
Biopile

Biocell / Heaps / Mounds
Compost Piles

Description
Biopiles utilize biodegradation to treat excavated soil by alleviating petroleum substances. The contaminated soil is stored in piles where aeration and added nutrients and moisture can help increase aerobic microbial activity.

Function
Biopiles are effective in treating the concentration of almost all petroleum substances. Lighter petroleum substances like gasoline can evaporate during the process of aeration, while heavier petroleum substances like diesel fuel and heating oil can be broken down through biodegradation.

Components
Alternatives — Landfarming can aerate the soil and by plowing and tilling.
Management — Control of moisture, heat, nutrients, oxygen, and PH is required to achieve optimal biodegradation.
Maintenance — The emitted volatile organic compounds may need to be contained and treated before releasing into the atmosphere.



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Mulligan, Catherine, and Raymond Yong. 2003. Natural attenuation of contaminated soils. Environment International. https://www.sciencedirect.com/science/article/pii/S0160412003002332.

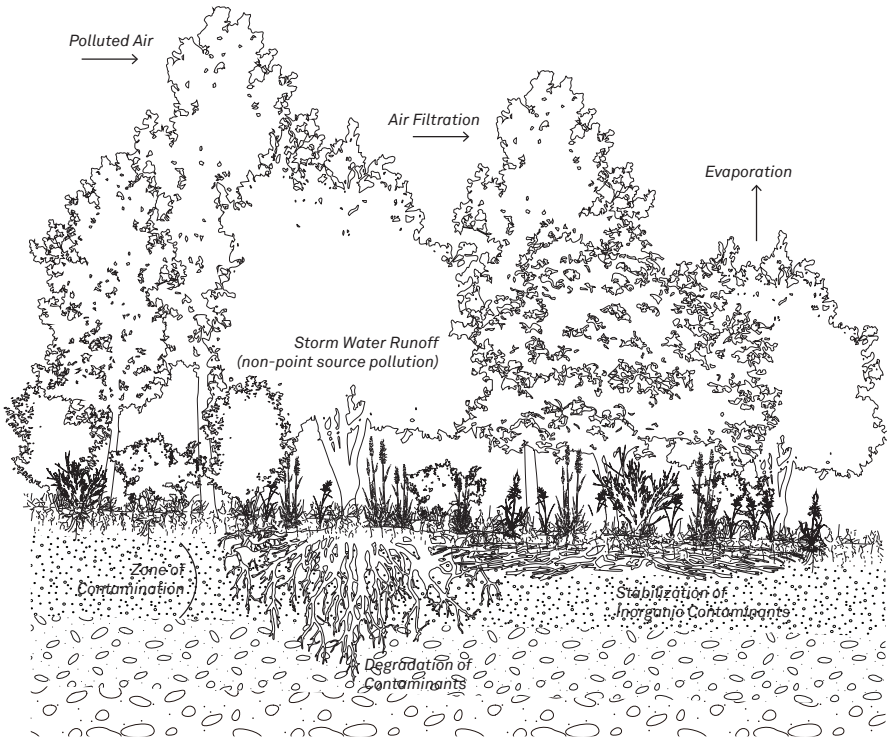
Natural Attenuation

Monitored Natural Attenuation

Description
Natural attenuation describes a range of physical and biological processes that reduce the concentration, mobility, or toxicity of chemical contaminants unaided by human intervention. Long term monitoring is necessary to demonstrate that contaminant concentrations continue to decrease to ensure that the plume is not expanding.

Function
It is a favorable remediation option for contaminated areas with dissolved petroleum hydrocarbons. It may be a favorable option for chlorinated-solvent ground-water plumes discharging to wetland sediments, because the organic-rich nature of wetland sediments and their typically high population diversity and density of microorganisms can enhance biodegradation.

Components
Vegetation — Several plants are applicable, however plants that can tolerate pollution, produce a large amount of biomass, and grow fast can speed up the process.
Management — Some monitoring of the system will be needed to confi m proper processes are taking place, mainly soil testing to confi m the contaminants on site are decreasing.
Maintenance — At some sites natural attenuation alone may not be enough and might benefit f om being combined with engineered processes like soil removal.



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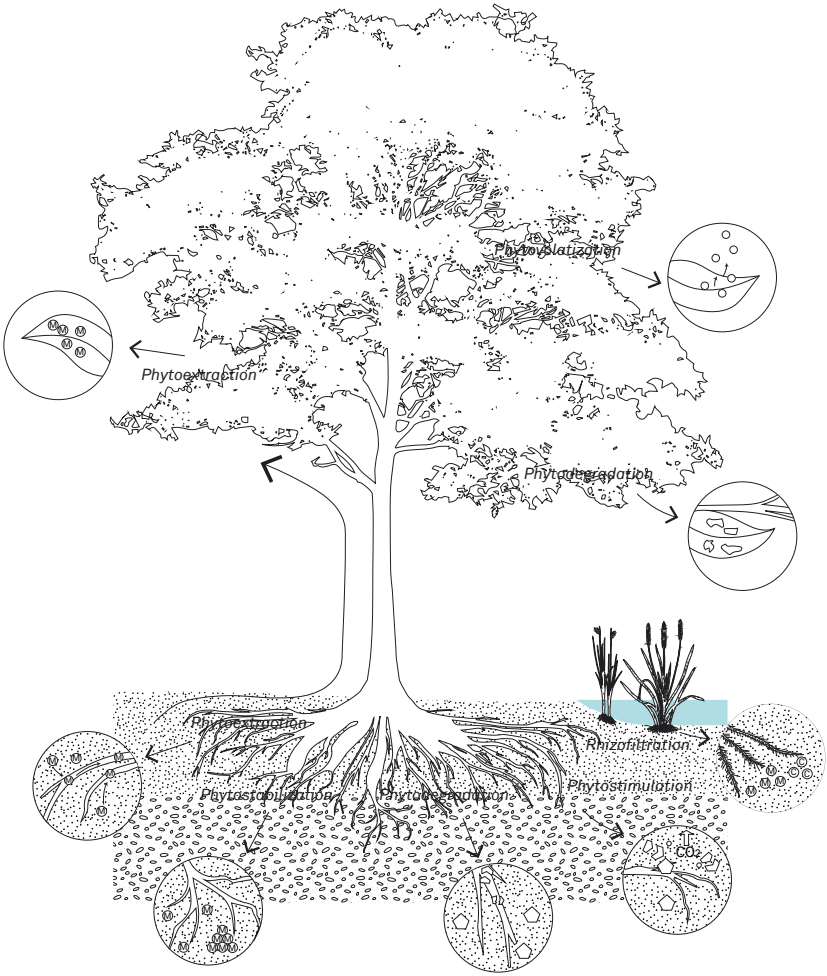
Planted Buffer

Multi-Mechanism Buffer
Buffer Strip

Description
Strips of gently sloped and heavily vegetated land borders a non-point pollution source. A vegetated buffer usually has a rough surface and typically contains a heterogeneous mix of ground cover including herbaceous and woody species of vegetation.

Function
The plants store and purify water running from one site to the next, becoming a versatile method of storm water retention and treatment, ensuring they're applicable to many sites; riparian zones, road sides, etc.

Components
Vegetation — Vegetation is determined on the location of the buffer and contaminants being targeted on site.
Alternatives — A vegetated buffer also provides ecosystem services like erosion prevention, habitat for wildlife, carbon sequestration and even increased property value. In populated areas these buffer areas are well-suited to provide snow storage capacity as they have excellent filt ation qualities.
Management — Can be placed between lanes of pedestrian and or vehicular traffic o produce a scenic street or be used and doubled as a visual buffer for perimeters.
Maintenance — Ideally no plant material would need to be harvested so very little maintenance is needed.



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Phytoremediation Work Team. 1999. Decision Tree: Phytoremediation. Interstate Technology and Regulatory Cooperation Work Group.

Phytoremediation

Vegetative Remediation

Description
Phytoremediation is a technology which utilizes plants to remediate contaminated soil, water, and air. It consists of several techniques that use the enzymes and other processes in vegetation. Both organic pollutants like pesticides and inorganic pollutants such as metals and macro-nutrients can be removed through specific types f phytoremediation (see following pages).

Function
Phytoremediation has been applied mainly at hazardous waste sites for point and non-point source contamination control. The diversity of pollutants can be treated by phytoremediation makes this technology increasingly popular for both academic research and businesses.

Components
Vegetation — Several plants are known to have phytoremediation capabilities (see following pages).
Management — Some plants require periodic harvesting to achieve the optimal outcome. Some plants, or parts of the plant, require safe disposal to remove contaminants completely out of the system.
Maintenance — Removal of invasive species. Irrigation might be required to ensure the success of planting.

Phytoextraction
The process of plant roots translocating metal contaminants from the soil into the portions of plants aboveground. Phytoextraction is also referred to as phytoaccumulation. Plants are harvested after weeks or months of growth. The planting and harvesting can be repeated to achieve the desired outcome.

Function
Key contaminants treated include nickel, zinc, lead, chromium, cadmium, selenium, other heavy metals, radionuclides.

Components
Vegetation — Plants uptake metals and organic chemicals with water, or by cation pumps, sorption, and other mechanisms.

Environmental Careers Organization. 2005. The Use and Effectiveness of Phytoremediation to Treat Persistent Organic Pollutants. Washington DC: U.S. Environmental Protection Agency.
Phytoremediation Work Team. 1999. Decision Tree: Phytoremediation. Interstate Technology and Regulatory Cooperation Work Group.

Phytovolatization
The process of plant uptake, transforming contaminant into a different form then releasing it into the atmosphere. Some contaminants can volatilize into the atmosphere through leaves at low concentrations.

Function
Key contaminants treated include chlorinated solvents, organic VOSs, BTEX, MTBE, Mercury and selenium.

Components
Vegetation — Plants uptake and transpire volatile metals and organic compounds while some organic compounds are easier to be degraded in the atmosphere through photodegradation.

Phytodegradation / Phytotransformation
The metabolic process by which contaminants are broken down and incorporated as nutrients into plant tissues.

Function
Key contaminants treated include munitions, atrazine, halogenated compounds, DDT, and other chlorine and phosphorus based pesticides, phenols, and nitrites.

Components
Vegetation — Plants absorb, store, and degrade organic compounds to harmless byproducts, products, and use them to create new biomass.

Phytostabilization
A technique which utilizes the roots of certain plant species to immobilize contaminants in soil and groundwater while stabilizing the soil. Metal-tolerant species may be planted to re-vegetate sites and reduce the migration of contamination both on the surface of the soil and leaching to groundwater.

Function
Key contaminants treated include phenols, chlorinated solvents, and hydrophobic organic compounds. Heavy metals in mine tailing ponds.

Components
Vegetation — Plants establish controls of PH, soil gases, and redox conditions to immobilize contaminants in soil. Humific tion of some organic compounds is expected.

Environmental Careers Organization. 2005. The Use and Effectiveness of Phytoremediation to Treat Persistent Organic Pollutants. Washington DC: U.S. Environmental Protection Agency.
Phytoremediation Work Team. 1999. Decision Tree: Phytoremediation. Interstate Technology and Regulatory Cooperation Work Group.

Rhizofilt ation
The absorption of contaminants onto plant roots or into the plant roots when they are in solution surrounding the root zone. Plants for rhizofilt ation are raised in greenhouses in water. Once they establish a large root system, plants are moved and floated in the contaminated water. Harvesting is required to remove the contaminants out of the system.

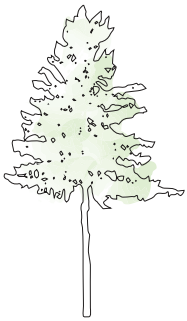
Function
Key contaminants treated include hydrophobic organic chemicals, heavy metals, and radionuclides.

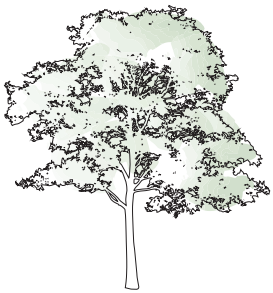
Components
Vegetation — Plant roots uptake or absorb compounds from contaminated water.

Phytostimulation
The microbial activity that breaks down contaminants in the plant rhizosphere, where microorganisms transform organic matters into nutrients. Phytostimulation, also called rhizodegradation, or rhizosphere biodegradation, is facilitated by the way plants loosen the soil and transport water and oxygen to the area.

Function
Key contaminants treated include polyaromatic hydrocarbons, BTEX, and other petroleum hydrocarbons, perchlorate, atrazine, alachlor, polychlorinated biphenyl, and other organic compounds.

Components
Vegetation — Plant exudates, root necrosis, and other processes provide organic carbon and nutrients to enhance soil bacteria growth. Live roots supply oxygen to aerobes and dead roots support anaerobes.





Ojibwe Name —	Okikaandag mutug	Aamoo ziixibaajwad mitig
Latin Name —	*Pinus banksiana*	*Gleditsia triacanthos*
Common Name —	Jack Pine	Honey Locust
USDA Zone —	3—8	3—9
Native to —	N. America	N. America
Contaminants Remediated —	BTEX	BTEX

Best Practices and Resources on Climate Resilient Natural Infrastructure. Canadian Council of Ministers of the Environment, 2018. Accessed 2020.
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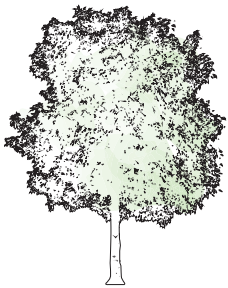
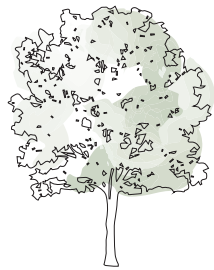
Trees for Phytoremediation

Lower Manitoba Basin Suitability



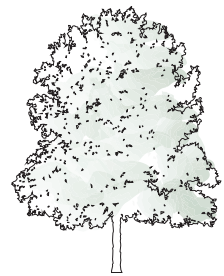
-
Celtis occidentalis
Hackberry
2—9
N. America

BTEX, TPH, PAH



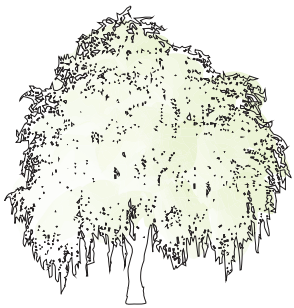
Wiigob
Tilia americana
Basswood
2—8
N. America

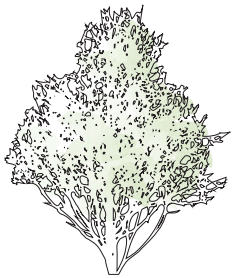
Nitrogen
Phosphorus



Mutugomish -
Quercus macrocarpa
Bur Oak
3—8
N. America

BTEX





Ojibwe Name —	Oziisigobiminzh -	Oziisigobiminzh -
Latin Name —	*Salix alba*	*Salix alaxensis*
Common Name —	White willow	Felt-Leaf Willow
USDA Zone —	2—6	2—8
Native to —	Europe, Central Asia, Northern Africa	Alaska, Canada
Contaminants Remediated —	Nitrogen Phosphorus	TPH

Chapin, F. Stuart, Keith Van Cleve, and Peter R. Tryon. "Relationship of Ion Absorption to Growth Rate in Taiga Trees." Oecologia 69, no. 2 (1986): 238-42. Accessed July 2, 2021. http://www.jstor.org/stable/4217935.

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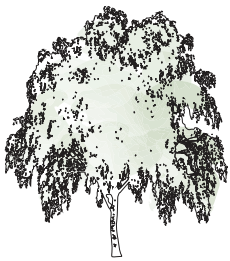
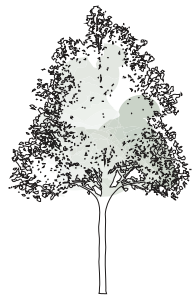


Wiigwaasaatig
Betula papyrifera
Paper birch
2—6
N. America

Nitrogen
Phosphorus

Maanazaadi
Populus balsamifera L.
Balsam poplar
1—8
N. America

Nitrogen
Phosphorus



Azaadi/Azaadiinsag
Populus tremuloides
Quaking aspen
1—6
N. America

Nitrogen
Phosphorus

Ojibwe Name —	-	-
Latin Name —	*Bouteloua dactyloides*	*Bouteloua gracilis*
Common Name —	Buffalo Grass	Blue Grama
USDA Zone —	3—9	3—9
Native to —	N. America	N. America
Contaminants Remediated —	TPH PAH	PAH

Chen, Yan, Regina P Bracy, Allen D Owings, and Donald J Merhaut. "Nitrogen and Phosphorous Removal by Ornamental and Wetland Plants in a Greenhouse Recirculation Research System." HortScience 44, no. 6 (2009): 1704–1711.
Kennen, Kate, and Niall Kirkwood. 2015. Phyto: principles and resources for site remediation and landscape design. Abingdon: Routledge.

Grasses for Phytoremediation

Lower Manitoba Basin Suitability

-
Elymus canadensis
Canada Wild Rye
3—9
N. America

TPH
PAH

-
Panicum virgatum
Switchgrass
2—9
N. America

Anthracene
PAH
Pyrene
TPH

-
Sorghastrum nutans
Indiangrass
2—9
N. America

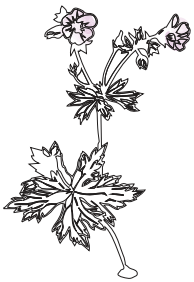
TPH
PAH

Ojibwe Name —
Latin Name —
Common Name —
USDA Zone —
Native to —
Contaminants Remediated —

Chen, Yan, Regina P. Bracy, Allen D Owings, and Donald J. Merhaut. "Nitrogen and Phosphorous Removal by Ornamental and Wetland Plants in a Greenhouse Recirculation Research System." HortScience 44, no. 6 (2009): 1704–1711.
Kennen, Kate, and Niall Kirkwood. 2015. Phyto: principles and resources for site remediation and landscape design. Abingdon: Routledge.

Herbaceous Plants for Phytoremediation

Lower Manitoba Basin Suitability

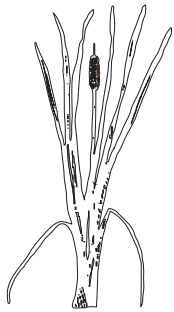


-
Geranium viscosissimum
Sticky Geranium
2—10
Western N. America

PAH

-
Helianthus
Sunflower
4—9
N./S. America

PAH

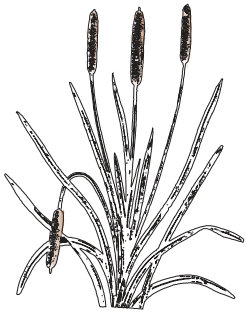


Ojibwe Name —	-	Apakweshkway
Latin Name —	*Pontederia cordata**	*Typha angustifolia**
Common Name —	Pickerel weed	Narrowleaf cattail
USDA Zone —	3—8	2—11
Native to —	N. America	Worldwide
Contaminants Remediated —	Nitrogen Phosphorus	DRO Oil Gasoline Phenol Nitrogen Phosphorus

Grosshans, Richard E. "Cattail(Typha spp.) Biomass Harvesting for Nutrient Capture and Sustainable Bioenergy for Integrated Watershed Management." PHD diss., University of Manitoba, 2014.
Burke, Mary C. "An assessment of carbon, nitrogen, and phosphorus storage and the carbon sequestration potential in Arcata's constructed wetlands for wastewater treatment." Master thesis., Humboldt state university, 2011.
Wang, Chih-Yu, David J Sample, Susan D Day, and Thomas J Grizzard. "Floating Treatment Wetland Nutrient Removal through Vegetation Harvest and Observations from a Field Study." Ecological engineering 78 (2015): 15–26.

Wetland Plants for Phytoremediation

Lower Manitoba Basin Suitability

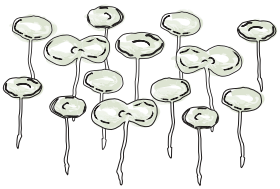


Apakweshkway
*Typha latifolia**
Broadleaf cattail
3—10
Americas, Africa, Western Eurasia
DRO
Oil
Gasoline
Phenol
Nitrogen
Phosphorus

Anaakanashk
*Schoenoplectus tabernaemontani**
Soft stem bullrush
4—9
N. America

Phenol
Oil
Gasoline
Nitrogen
Phosphorus

* Harvesting Required



Ojibwe Name —	Maawidekwegozidiwashk
Latin Name —	*Lemna minor**
Common Name —	Common duckweed
USDA Zone —	4—10
Native to —	Worldwide
Contaminants Remediated —	Nitrogen Phosphorus

Iqbal, Jamshaid, Atif Javed, and Muhammad Anwar Baig. "Growth and Nutrient Removal Efficiency of Duckweed (lemna Minor) from Synthetic and Dumpsite Leachate Under Artificial and Natural Conditions." PloS One 14, no. 8 (2019): e0221755–e0221755. https://doi.org/10.1371/journal.pone.0221755.

Yu, Shuai, Chunping Miao, Hong Song, Yanqing Huang, Wei Chen, and Xingyuan He. "Efficiency of Nitrogen and Phosphorus Removal by Six Macrophytes from Eutrophic Water." International Journal of Phytoremediation 21, no. 7 (2019): 643–51. https://doi.org/10.1080/15226514.2018.1556582.

Xiang, Wu, Yang Xiao-e, and Zed Rengel. "Phytoremediation Facilitates Removal of Nitrogen and Phosphorus from Eutrophicated Water and Release from Sediment." Environmental Monitoring and Assessment 157, no. 1-4 (10, 2009): 277-85. doi:http://dx.doi.org/10.1007/s10661-008-0534-9. http://myaccess.library.utoronto.ca/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fscholarly-journals%2Fphytoremediation-facilitates-removal-nitrogen%2Fdocview%2F222040545%2Fse-2%3Faccountid%3D14771.

-
*Elodea canadensis**
Canadian waterweed
4—10
N. America

Nitrogen
Phosphorus

-
*Iris sanguinea**
Japanese iris
3—10
Asia, N. America

Nitrogen
Phosphorus

* Harvesting Required