SEEKING BALANCE

A Climate-Responsive Water Management System for Southern Manitoba's Provincial Waterways with Shannon Creek as an Exemplar

Alex Boss

Seeking Balance: A Climate-Responsive Water Management System for Southern Manitoba's Provincial Waterways with Shannon Creek as an Exemplar

by

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Abstract

This practicum answers the research question, "how to create a climate-responsive water management system within a working agricultural landscape." Through literature review of the natural and human history, GIS mapping, careful site analysis, and extensive site visits, the landscape's inherent way of being began to emerge as a path forward for climate resilient provincial waterways. Policy, land use, and crop inventory analysis make the current state clear and existing watershed district / landowner partnerships offer a platform for broader scale interventions. This practicum proposes to use Manitoba's GROW program as a mechanism to incentivize farmers to adopt the intervention.

Provincial waterways were once natural creeks and rivers that have been channelized to assist spring runoff from agricultural fields. These ecologically poor waterways are dozens, if not hundreds, of kilometres long and are maintained by a variety of groups: the province, the rural municipality, or the adjacent landowner. Therefore, an intervention in a waterway must be easy enough to be adopted by this variety of groups but also means the capacity for having a substantial impact on water across the province is markedly increased when compared with a small, single site, intervention.

Knowledge gained through background research and on-the-ground site analysis led to a relatively simple intervention that employs three design elements already found in the region: shelterbelts, wetlands, and prairie grasslands. These three elements combine to capture snow and eventual spring melt, create habitat, clean agricultural pollutants from the waterway, and hold water in place, ultimately increasing the water storage capacity of provincial waterways by a significant 70%. This practicum leans on vernacular practice, embraces the inherent extremes of the prairie ecoregion, and offers a way to maintain a productive agricultural landscape while responding to the increasing challenges of the climate crisis.

Key Words: Climate-responsive, Water Management, Shelterbelt, Wetland, Prairie Grass

ACKNOWLEDGEMENTS

I recently heard it takes a village to get a student through their Master's degree, and this is surely the case here. There are not enough words to thank my primary advisor Frits Van Loon. He taught me a design process I will build on for the rest of my career. Without his time, enthusiasm, and grace I would have taken a lot longer to get here.

Thank you to my far flung friends and family for listening to hours of delirium and their unwavering faith in my ability to complete this degree.

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Thank you to the various donors to scholarships, fellowships, and awards through the Department of Landscape Architecture. During this degree I worked between one and three jobs at all times and the financial aid I received through these donations is immensely appreciated.

Never known for my modesty, I want to thank myself. I worked so hard to get into this program, then worked even harder than I thought possible while in this Faculty. I know now that I have a deep well of endurance and strength within me and I am so proud of myself for persevering.

It's been a privilege to learn and serve in the Faculty of Architecture and I am looking forward to what comes next.

Dedication

This practicum is dedicated to the resilient woman who have come before me: Kate Rogers, Billie Johnson, Pat Stephen, and Wendy Ross.

Wendy is without a doubt the most vibrant being in this world, I am so grateful to be her daughter.

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1.0 INTRODUCTION

Southern Manitoba has a flat, repetitive landscape. Southern Manitoba is a rich, woven tapestry of grasslands, wetlands, and migrating creatures. Southern Manitoba is rural. Southern Manitoba is a hotbed of industry. Every landscape has juxtaposing elements. The same area can have drought and flooding within weeks of each other. This project brings together seemingly disparate values in agriculture, ecology, and water management to create a landscape that allows for all to work together.

I was drawn to landscape architecture for its twinned nature as both a science and an art. I feel strongly about responding to the climate crisis and believe this field can contribute to a positive future. When looking for a local climate problem to 'solve' for this project, Morris, a small town in Southern Manitoba, was recommended to me as a place that is frequently impacted by flooding. My advisor, Frits Van Loon, a landscape architect and professor from the Netherlands, and I went down in early May 2023 to get a feel for the area. It was a dark, blustery day and I was immediately entranced. We were there two days after the Red River's peak flow and the water was lapping just under the bridge into town. I later learned that this swollen body of water was being impacted from two avenues. Flow from the western highlands along both Shannon Creek and the Morris River met the rising Red to create a impromptu lake at their confluence. I realized I would not be able to solve flooding, particularly along the Red, but perhaps I could help hold some of the westerly water in place to give the Red some space to breathe. Therefore, Shannon Creek became my focus.

During subsequent site visits, I was surprised again and again by this landscape's beauty, fortitude, and intelligence. What began as an investigation into flooding and drought, conditions only perceived as negative post-colonization, has resulted in a strong affection and admiration for this landscape. In the pages that follow, I detail the natural and human history of the area as they pertain to the background to the problem of water imbalance. The research framework is outlined before landscape features like shelterbelts and wetlands are explained further. After my first visit I chose eight locations to visit weekly for two months, and these observations are briefly summarized with photos detailing what was learned. Further site analysis through GIS mapping as well as policy analysis of Manitoba's existing water, drought, and climate strategy documents impacted the design decisions. Manitoba has programs in place to improve watershed health and sustainability through partnerships with farmers. The design is a masterplan that can be enacted gradually as more landowners sign on. Shannon Creek is shown as the exemplar design site for what any provincial waterway in Southern Manitoba could become. Combining the agricultural vernacular technique of shelterbelt tree plantings, with the reintroduction of wetlands, and use of prairie grass species for hay creates a multi-faceted design that addresses the, at times, competing interests of agriculture, ecology, and surface water management through a climate resiliency lens.

2.0 BACKGROUND TO PROBLEM

Figure 1. Glacial history showing Laurentide Ice Sheet and Lake Agassiz maximum extents.

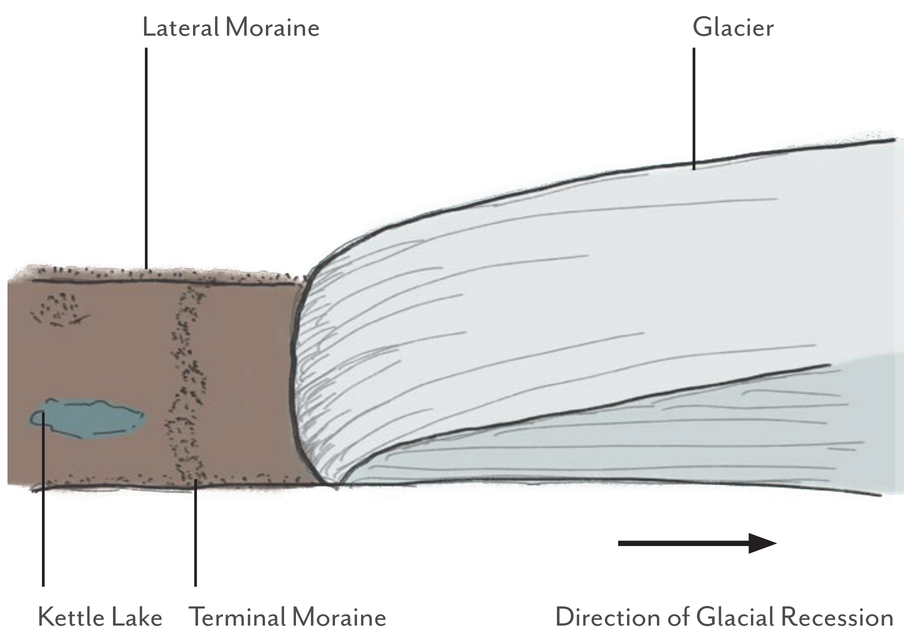


Figure 2. Glacial Landforms.

NATURAL HISTORY

This project gleans lessons from the land's natural history to propose a different way to cultivate water harmony in the Morris area of Southern Manitoba. To understand today's landscape, the geomorphology of the area must be studied first. Geomorphology is the study of the origins of topography and bathymetry; it investigates the processes that led to the form and function of the Earth as we know it today. Subfields of geomorphology yield further, more nuanced, clues and are explored here. Hydromorphology, the development of waterways; biogeomorphology, the relationships between flora, fauna, and geomorphic processes; and sociogeomorphology, the human impact on waterways, come together to refine our understanding of what has taken place thus far.[1] Beginning with the Wisconsin Glaciation, 70,000 to 10,000 years ago, the glacial effects on Manitoba are marked. The Laurentide Ice Sheet melted, leading to the creation of Lake Agassiz, which set processes in motion that ultimately shaped the modern-day Red River Valley. After reviewing this natural geomorphological history, the sociogeomorphological history of humans draining and diking the landscape is detailed to explain why the region experiences such surface water imbalance today.

Glacial Action

For millennia, Manitoba, along with most of Canada, was covered by the Laurentide Ice Sheet during the Wisconsin Glaciation in Earth's last ice age.[2] Glaciers carve new terrain, creating both elevations and depressions in the landscape. From glaciers spring new waterways, habitats, and entire climates. As a glacier grows and shrinks it moves sand, rock, and whatever else it has consumed during its lifetime. In glacial terms, the debris they leave behind are known as moraines and are identified by their position in relation to the glacier.[3] Terminal moraines occur at the nose of the glacier, while lateral moraines are deposited parallel to the glacier's walls. After thousands of years of weathering, this debris becomes covered in sediment, creating rolling hills and other landforms. Just as glacial

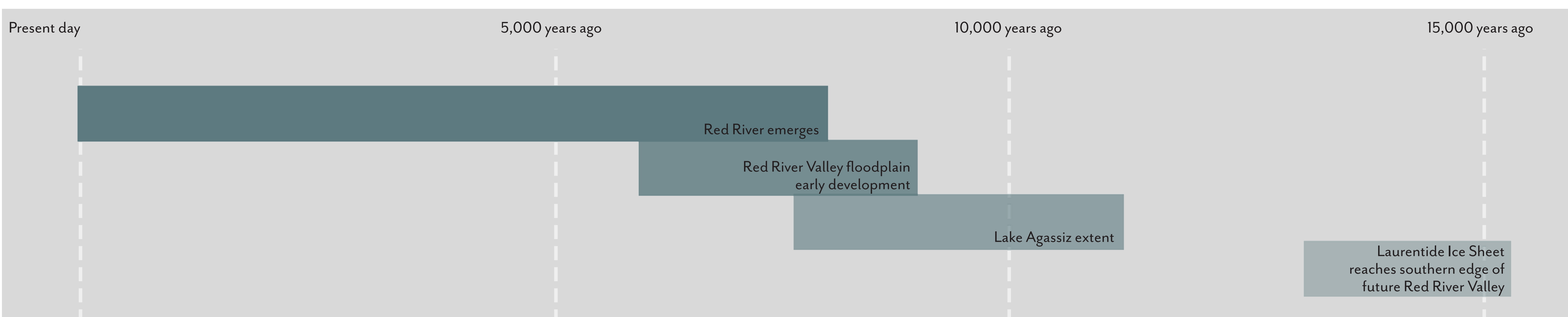


Figure 3. Glacial Timeline.

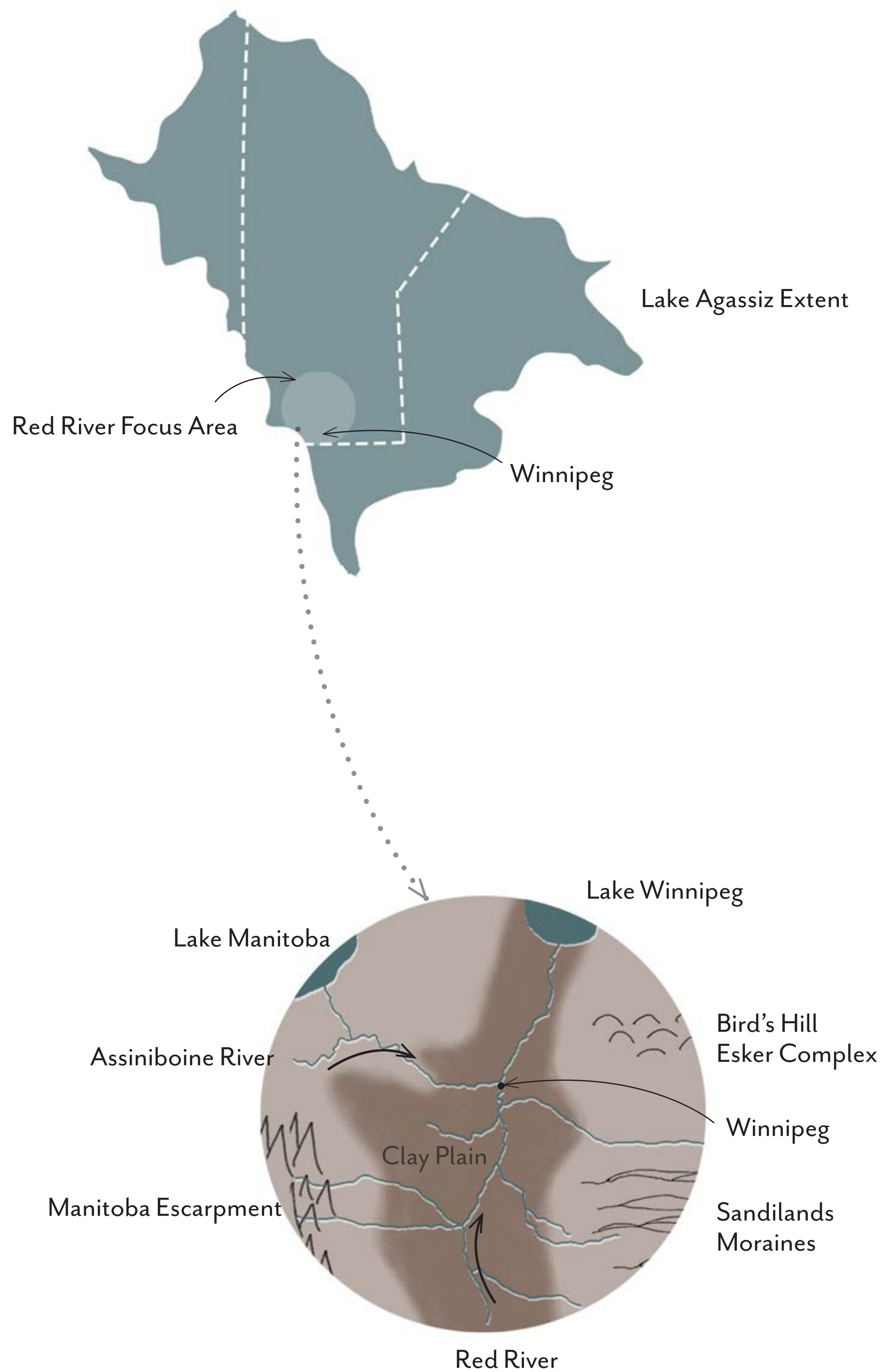


Figure 4. Geomorphological features of the Red River Valley.

deposition of sediment load has created highs in the landscape, it has also created lows. Kettle lakes, more commonly known in the prairie provinces as potholes, are small lakes or temporary wetlands created by large chunks of ice that broke off from the main glacier. The weight and volume of these ice blocks causes a divot, and the eventual melt creates a lasting depression in the land. As Figures 1 through 4 show, evidence of Manitoba's glacial history can be seen widely across the landscape.

Lake Agassiz's Impact

The Laurentide Ice Sheet advanced and retreated multiple times over the course of its 60,000 year presence in North America. Near the end of its life, it retreated north towards the area now known as Hudson Bay. Manitoba is at a lower elevation than its neighbouring American states, partially due to the crushing weight of the glacier that spent more time here than farther south. As the glacier melted and retreated, a large lake formed between the remaining ice in the north and the elevated land of the south. This glacial lake, Lake Agassiz, swelled in size and was the largest to ever hold space on the continent. It was present 11,500 to 7,700 years ago and left an indelible mark on the North American Prairies, but especially Manitoba.[4]

In its later years, Lake Agassiz's southern extent through Manitoba was confined by the topography of the region. The Manitoba Escarpment in the west of the province is a raised pre-glacial landform, its shale cap providing protection from the eroding powers of the ice sheet.[5] The moraines and Canadian Shield to the east are also at a higher elevation than the southern centre of the province, though to a much lesser degree. Therefore, Lake Agassiz formed the Red River Valley; a wide, stunningly flat, a 0.0014% average slope, glaciolacustrine silt and clay plain running from North Dakota and Minnesota in the USA, north to Lake Winnipeg in Manitoba.[6] Cutting through this valley now is the Red River, 880 km by channel length but only 496 km long as the crow flies due to its wide meanders, decreasing just 70 m across this distance as it reaches Lake Winnipeg.[7] The channel is founded on alluvial soil (stream deposits) rather than the more clay heavy soil of the surrounding plain. Lake bottom vegetation in Lake Agassiz grew, died, and decomposed for 3000 years, contributing to rich sedimentary layers of organic material. When the lake dried up, this deposition of material resulted in fertile, silty clay soil that supported the evolution of the tallgrass prairie ecosystem.

Prairie: Wetlands, Grasslands, Climate

Characterized by its glaciolacustrine history, the Prairies Ecozone is predominated by wetlands, grasslands, and a continental climate. Prairies are known for their expansive, flat, fields of grasses with minimal trees and fluctuating water levels. Created by the glacial activity previously described, prairie pothole lakes and wetlands provide important water sources for migrating fauna ranging from bison to birds. Ephemeral wetlands seasonally fill with snow and subsequent melt, drying out in the summer months. Alongside these wetlands are the prairie grasses, generally categorized as short, mid, tall or mixed grass. Tallgrass prairie species were once the most common in the study area and are therefore in focus here. They can survive where others cannot, a landscape that is too dry for forests to thrive, yet too wet to be considered arid. The roots of these grasses are exceptionally long and sturdy, making them resilient to foraging, trampling, and even fire. They are natural carbon sinks due to three quarters of their biomass being below the surface, trapping carbon. These deep roots also greatly reduce soil erosion caused by wind and water. However, settlers did not recognize the important role these grasslands played and converted most into farmland. Formerly the largest ecosystem in North America, only 1% of tallgrass prairie remains in Manitoba.[8] Losing these grasses has opened the land to erosion and significant habitat degradation. Non-native crops do not hold water and soil in place as effectively and settler agricultural practices have increased the impact of flood events.

In addition to the palimpsest of ice sheet movement and glacial lake flows, it is the continental climate which continues to underpin the way in which these ecosystems function together. As the geographical heart of Canada and with its only sea access, the Hudson Bay, being frozen for half the year, Manitoba can be considered mostly landlocked. This breeds a climate of extreme annual temperatures with regular winters reaching below -40 C and summers climbing over +30 C. While this type of climate is typically dry; warm, moist air received from the Gulf of Mexico makes Manitoba wetter than other prairie provinces. Additionally, Colorado Lows are a common low pressure system that develop southwest of the province, bringing precipitation year-round. Despite heavy snow cover in winter, the bulk of the year's precipitation falls in the spring and summer months. Summer thunderstorms are frequent and can replenish wetlands in between dry spells.

TRANSITIONAL CONCLUSIONS

When the hydromorphological and biogeomorphological history of the Red River Valley is considered, the region's challenges with surface water management are easy to understand. The vast flatness of the Red River Valley makes it clear that should a flood occur; it would be far reaching.[9] The heavy clay causes minimal infiltration of water, making fast runoff inevitable. This heightens the incidence of both flood and drought as the land cannot hold onto water easily, except in the wetlands and lakes. Prairie grasslands also reduce erosion and slow runoff. Wetlands and grasslands are able to work with the inherent extremes of the continental climate's temperature and precipitation fluctuations. However, as the upcoming Human History section describes, colonial policies dating back to the late 19th century and into the 20th century restricted the land's ability to accommodate water and exacerbated early settlers' struggles to work the land.

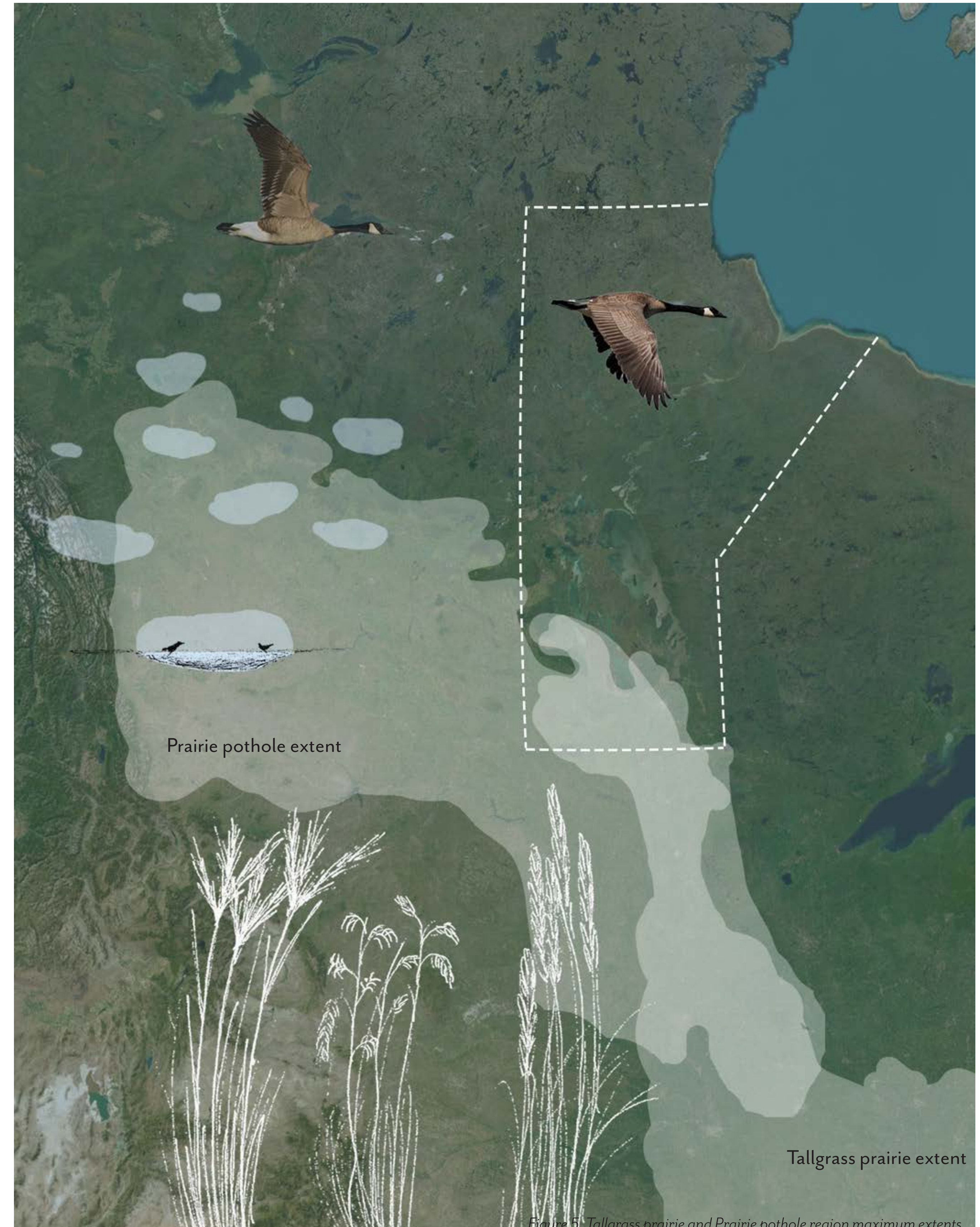


Figure 5: Tallgrass prairie and Prairie pothole region maximum extents.

Figure 6. Reworked original Manitoban drainage districts map overlaid on a photo by author of drainage ditch maintenance in 2023.

HUMAN HISTORY

Indigenous

Archaeological work at the Forks in Winnipeg show that trade among Indigenous people along the Red River has been ongoing for at least 6000 years. Due to the lack of written records, genocide, and assimilation of surviving Indigenous people, it is hard to completely understand how the Morris area was pre-European contact. It is believed that many Indigenous people led a seasonal life that involved returning to the same sites at the same time each year. This lifestyle involved hunting as well as "low-impact plant cultivation" including the harvest of "berries, root vegetables, and wetland plants, through management processes that included controlled fires, digging, and sowing of wild seeds."[10] Indigenous people certainly left an imprint on the land but lived harmoniously with what was available and knew when to move to more suitable land when the time came. Numerous plant species and their ecosystems benefited from Indigenous fire management pre-colonization. While we may not have extensive historical records of Indigenous people's land practices, it would be incorrect to view the landscape pre-European settlement as wild and unmanaged.

Settler

Drainage Policies

Past

The province of Manitoba was created in 1870 and with it came the rush to settle the area. A clerk, Molyneux St. John, was sent to survey the southern reaches of this new province to determine if there were any factors that might impede agricultural success.[11] An astute surveyor, St. John recommended that parcel division should be dependent on presence of arable land, wet prairie, and other watercourses. He saw that wet prairie, grassland with streams and wetlands interspersed, was beneficial for water retention but not for high crop production. Nevertheless, the familiar mile-to-mile grid system was overlaid per what had been done in other areas of North America, without regard for ecosystems, waterways, or ground cover. In fact, Manitoba is the starting point of the grid system with the first Prime Meridian established by the Dominion Land Survey just west of Winnipeg.[12] Almost immediately, Red River Valley settlers had drainage problems with standing water and began ad-hoc efforts to create surface drainage ditches. In 1895, the Land Drainage Act was passed and kicked these efforts into high gear.[13] Drainage districts were created across Manitoba, see above Figure 6, covering over 800,000 ha. They were dug mostly along the agricultural grid to drain spring melt off the fields, as well as along natural creeks and rivers to canalize and straighten them. While much of the land was able to be seeded and worked, drainage and flooding continued to be such an issue that within 20 years of the Act being passed, two reports were commissioned to solve the mounting water control problems.[14] Despite both these reports supporting a watershed based drainage approach, the human landscape had already been etched onto the physical, and for the majority of farmers, there was no going back after their perceived investments into the land.[15] The deliberation over naturalized vs. engineered responses continued for decades, with one 1940s report even suggesting that watersheds be remade in the image of the drainage districts. In 1959, a nature-based approach finally gained more credence and led to the development of the first conservation districts, though most were only enacted under the 1976 Conservation Districts Act.[16] However, these districts were still along existing administrative boundaries. Just recently, in 2020, these 18 conservation districts were consolidated into 14 watershed districts under the Watershed Districts Act.[17]

Present

The Watershed Districts Program is a land and water conservation program now accepted as one of the most successful water management programs in Canada.[18] One of the keys to this success is the GROW (Growing Outcomes in Watersheds) protocol which focuses on watershed resiliency to climate change and improvement of water quality. Through this, a variety of farmer / watershed district programs have been developed that pay farmers to enact more environmentally beneficial practices on their land, like riparian restoration, cover crops, shelterbelt planting, and wetland rehabilitation. Funded mostly by the province, GROW is a voluntary partnership between watershed districts and municipalities. Uptake of the watershed district program has been generally good, surprisingly though, some of the most flood-affected municipalities are still non-members. The Redboine watershed district covers over 500,000 ha of southwestern Manitoba, but only about half of the municipalities in the watershed are members.[19] The Rural Municipality (RM) of Morris was one of the holdouts and so landowners are unable to take advantage of the numerous ecological goods and services offered through GROW programs.[20] This will be changing though, as during the May 2023 RM council meeting a resolution to join the watershed districts was carried. [21] As watershed districts adhere to watershed rather than municipal boundaries, the RM of Morris falls across three watersheds, however the bulk of it is in the Redboine watershed.

Water Infrastructure

Urban (Floodway, Diversion, Dam)

The drainage ditch era of approximately 1880-1950 was the result of colonial policies, invested settlers, and a momentary lull in severe flooding. The last major flood to occur in the 19th century in the Red River Valley was 1861 and there wasn't another flood of the same intensity until 1950.[22] It seems a baton of sorts was handed off at this point. The focus shifted from drainage ditches as the main water management strategy to a grander, more urban-centric solution. The resulting Red River Floodway was one of the largest earthworks projects of its time, second only to the Panama Canal. It was completed in 1968 and has been expanded multiple times to ensure watertight protection for the City of Winnipeg, which is now safeguarded against a 1-in-700-year flood event.[23] The 48 km long Red River Floodway was constructed south and east of the city to re-route excess water from the Red River and is used frequently to maintain regular flows through the city. Two additional feats of engineering protect the city from the westerly flows of the Assiniboine River, the Red River's largest tributary. The Portage Diversion and the Shellmouth Reservoir reduce flows on the Assiniboine by funneling water into Lake Manitoba or the Reservoir, respectively, thereby

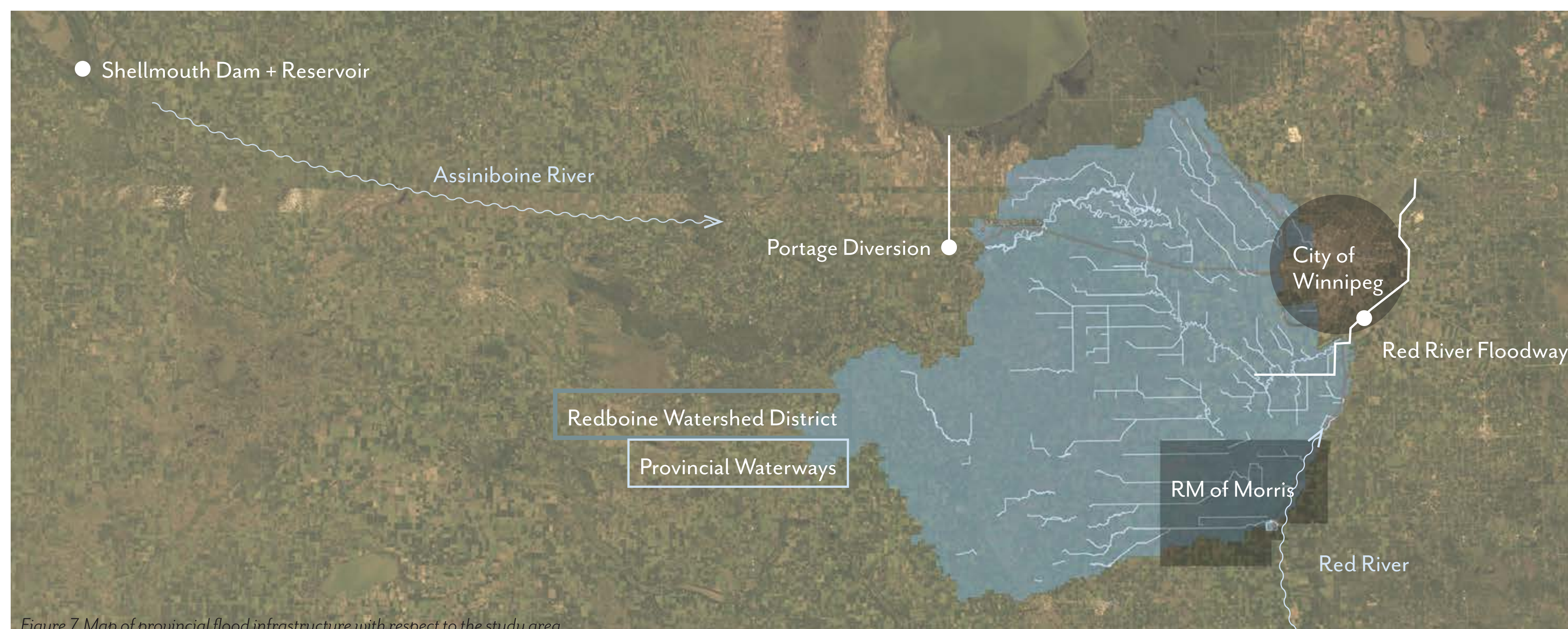


Figure 7. Map of provincial flood infrastructure with respect to the study area.

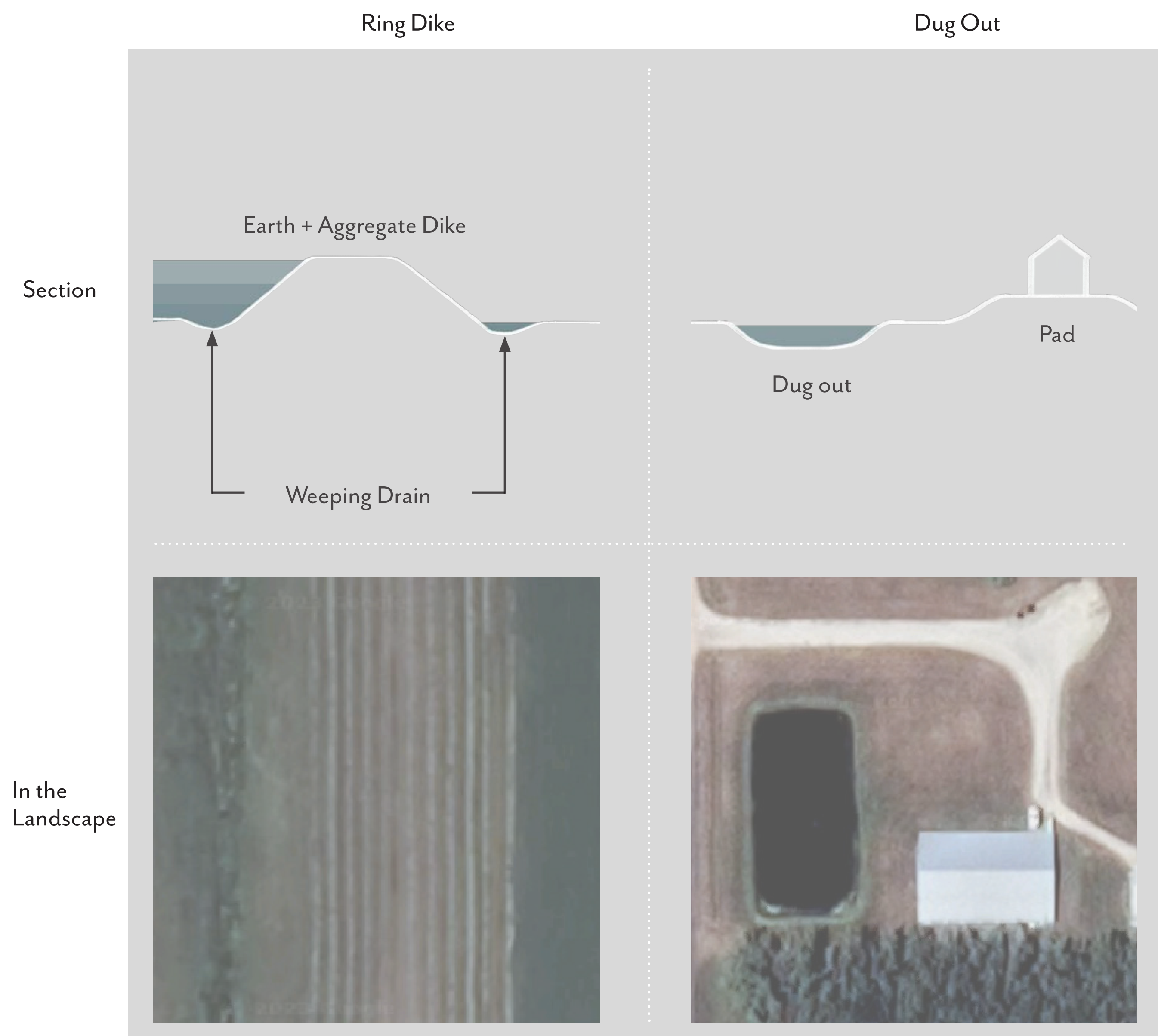


Figure 8. Ring dike and dug out in section and in the landscape.

reducing the load on the Red River's flood infrastructure. The Portage Diversion is a 29 km long channel, named for its location west of Portage La Prairie, and was completed in 1970.[24] The Shellmouth Dam and Reservoir, close to the Saskatchewan border, were completed the following year.[25] These major flooding infrastructure projects have effectively secured Winnipeg against future Red River floods but have not solved any of the surface water management issues for Southern Manitoban communities.

Rural Community (Dikes, Drainage Ditches)

Due to the Red River's shallow valley and low population base, ring dikes rather than diking along the entire riverbank was deemed more feasible for smaller community protection. A ring dike is an earthen wall around a community or individual property to defend against floodwaters. The RM of Morris constructed a ring dike in 1966, with several expansions and maintenance over the years. During the 1997 Red River flood that devastated cities in North Dakota and Minnesota, Winnipeg remained safe while smaller Manitoban communities outside the Floodway protection were inundated by floodwaters. Some had existing ring dikes that were successful, like Morris, while others failed against the later named, Flood of the Century. There are 18 communities that fall outside the Floodway's protection zone, south of the City, that are now protected by ring dikes from a 1997 flood plus 0.6m freeboard.[26] There are also many individual properties that have been raised on earth pads or built ring dikes around to the same level. During a flood event, ring dikes protect the community within its walls, but the agricultural land outside is still overcome by water which generally results in fields polluted with debris and seeding.

Rural Individual (Shelterbelts, Dug Outs)

Following the droughts of the early 1930s, the federal government established the Prairie Farm Rehabilitation Administration (PFRA) to assist farmers with the physical challenges they were facing. The PFRA set up programs to help farmers create dugout water reservoirs for livestock and plant shelterbelts of trees to reduce soil erosion due to wind and a general lack of moisture.[27] Dugouts are small ditches or ponds near farmsteads that are still used today by prairie farmers. The earth excavated for dugouts is usually the same earth used to create the raised mounds or pads that farmhouses sit upon for flood prevention. They are often built in conjunction with a grouping of trees, known as a shelterbelt, to collect snow in one place. Shelterbelts are purposeful plantings of trees and shrubs designed to protect buildings, crops, and livestock from wind. They are also used to direct snow to prevent unwanted drifting. Shelterbelt design will be discussed more in Section 5: Key Landscape Features but as a brief note here, shelterbelts planted 20-50m from the dugout, species-dependent, can trap large amounts of snow in a small area, creating a reservoir for future

drought.[28] Coupling shelterbelts with dugouts is a nature-based approach to local surface water management that provides habitat, reduces wind-related erosion, keeps water on site, and gives a landowner more autonomy over their resources. This small-scale strategy could have a stronger positive impact if developed into an overarching plan of multiple shelterbelts linked to resurrected or new ephemeral wetlands.

TRANSITIONAL CONCLUSIONS

Humans are part of nature; our presence should not imply a destabilizing influence. Indigenous people in the Prairies were positive, contributing members of a functioning ecosystem for millennia. Europeans knew little of the environment they were entering and made poor choices when trying to force the land to fit their preferred vision of a productive, agricultural landscape. Understanding what has and hasn't worked over the years is integral to navigating successful future dealings with the land.

This land floods. That was a fact a thousand years ago and is still a fact today. This project does not intend to 'solve' flooding. If the land has always flooded, surely that means flooding is not an inherent negative. It must also be acknowledged that there is no going back to an idealized pre-settler time of endless grasslands and roaming bison. It is the 21st Century, there are thousands of people who rely on the food and products produced in this landscape. Looking forward, the climate is changing, and the current practices are not sustainable with intensified flooding and drought. The following section on Future Climate outlines the projected prairie-specific impacts of the climate crisis. This project aims to take the lessons of the past and meld those with the predictions for the future, so that our present decisions reflect our collective best practice knowledge.

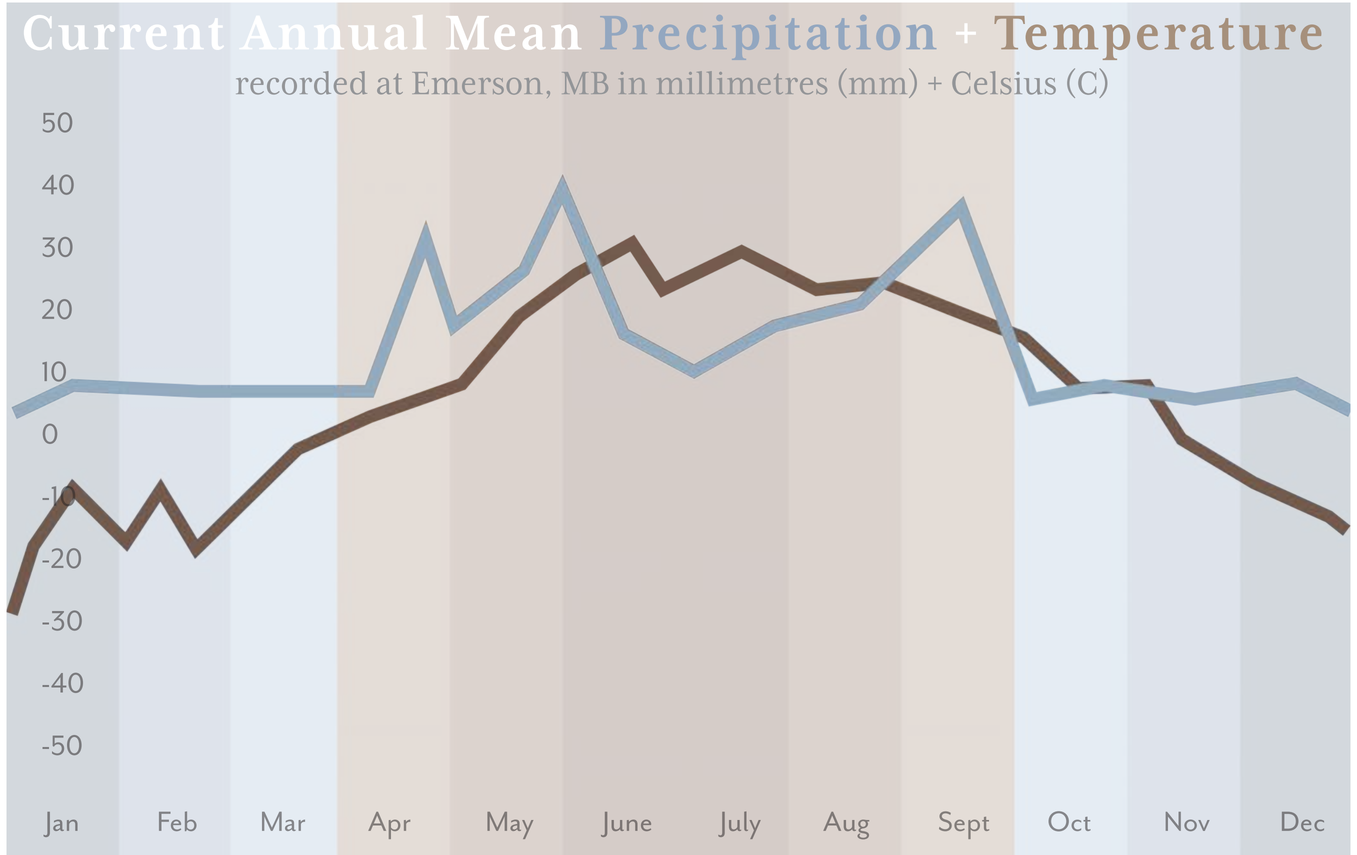


Figure 9. Graph of 2022 annual mean precipitation and temperature reorded at Emerson, MB (approx. 45km from the study area).

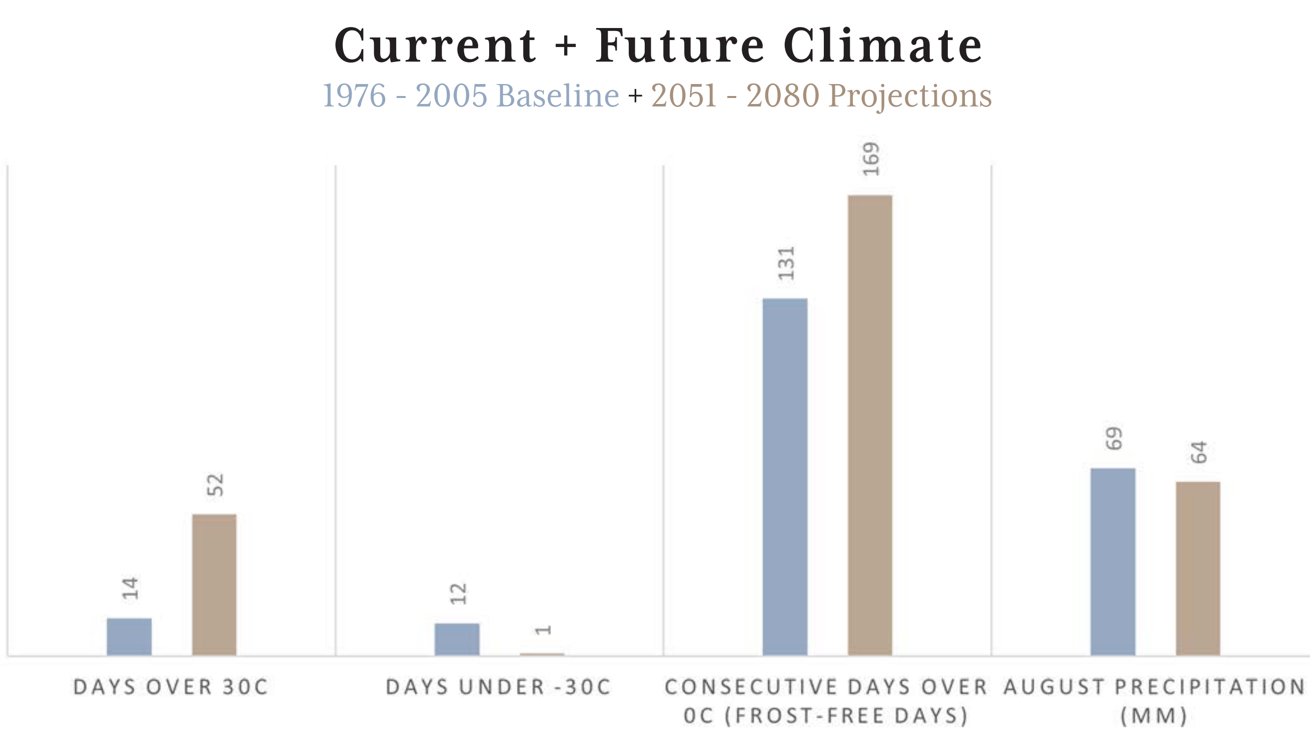


Figure 10. Graph of baseline and climate projections using data from "A Snapshot of the Changing Prairie Climate." *ClimateWest.* 2022.

FUTURE CLIMATE

The Prairies account for over 80% of Canada's farmland, therefore, the findings from think tanks like the Prairie Climate Centre, Climate West, and the Prairie Adaptation Research Collaborative will be instrumental in recalibrating agricultural practices for a changing prairie climate. The International Institute for Sustainable Development is headquartered in Winnipeg and in their 2021 publication *Farming the Future: Agriculture and Climate Change on the Canadian Prairies stated that* "Canada is warming almost twice as fast as the rest of the world, and the Prairies are warming more quickly than any other Canadian region except the Arctic."[29] The Climate Atlas and the Prairie Climate Centre agree that Manitoba's climate is projected to become wetter in the spring, drier in the summer, and hotter overall. Between 2050 and 2080, spring precipitation is expected to increase over 25% while summer precipitation is expected to decrease 7%.[30 31] Rainfall will be sporadic across summer, with more severe storm events and downpours. Over the same time period, if greenhouse gas emissions stay the same, average hottest days will increase by 5C and the annual number of below 0C days will plummet from 189 to 149.[32] Continuing to raise ring dikes will do nothing to prevent fields being flooded in the spring, delayed seeding, and drying out in the summer, leading to loss of crops and income. Going forward, the rigid, highly engineered flood infrastructure projects will become more costly, inflexible, and less reliable as climate change worsens.

Most, if not all, farms in the study area currently do not need to irrigate, however this will not be the case in the future. Projected droughts across the Prairies within the next 30 years will diminish the availability of ground and river water. Already the agricultural sector is the biggest user of freshwater when compared across industries, responsible for 67% of the world's total freshwater usage.[33] Drier fields will also be more affected by the strong Prairie winds and will undoubtedly suffer from soil loss due to wind erosion.[34] Agriculture and Agri-Food Canada (AAFC) recommends the use of vegetated buffer strips, shelterbelts, and grassed waterways to reduce erosion by wind and water.[35] Without interventions that increase the land's water-holding capacity farmers will face multi-faceted challenges to feed Canadians.

When comparing crops traditionally found in southern Manitoba, forage crops, or those used to feed livestock and create hay, are best suited to withstand periods of drought.[36] In particular, warm season grasses like millet and sorghum are being favoured as farmers adapt to drier summers. However, native prairie grasses are as effective as a hay crop and are more climate resilient. Many of their roots reach over 2m deep, holding the soil together, reducing erosion and water loss, and giving them access to ground water stores traditional crops do not have.

CONCLUSIONS + DESIGN IMPLICATIONS

When examining the land, it is impossible to silo the relationships and processes that contribute to its form and function. Geomorphology impacts soil and hydrology, which impacts and is impacted by climate, which impacts and is impacted by human activity. This Background to Problem Section has explained how glacial action including the presence of a glacial lake created the conditions for a fertile yet flood prone river valley. Manitoba's continental climate implies extreme annual temperatures, but natural wetlands and tallgrass species allowed the Prairies to be a cohesive, functioning ecosystem for millennia. As settlers arrived and colonial drainage policies were instituted in the late 19th century, wholesale changes across watersheds increased surface water management issues rather than alleviated them. When the 1950 flood occurred, attention shifted to a larger scale response that prioritized the City of Winnipeg, resulting in a series of enormous flood infrastructure projects built later that century. Provincial programs for farmers have recently become watershed based and are incentivizing landowners to leave wetlands in place rather than draining them. If the past 150 years can teach us anything, it's that working with what the land and hydrological system naturally want to do will always be the most cost-effective, resilient, and sustainable option.

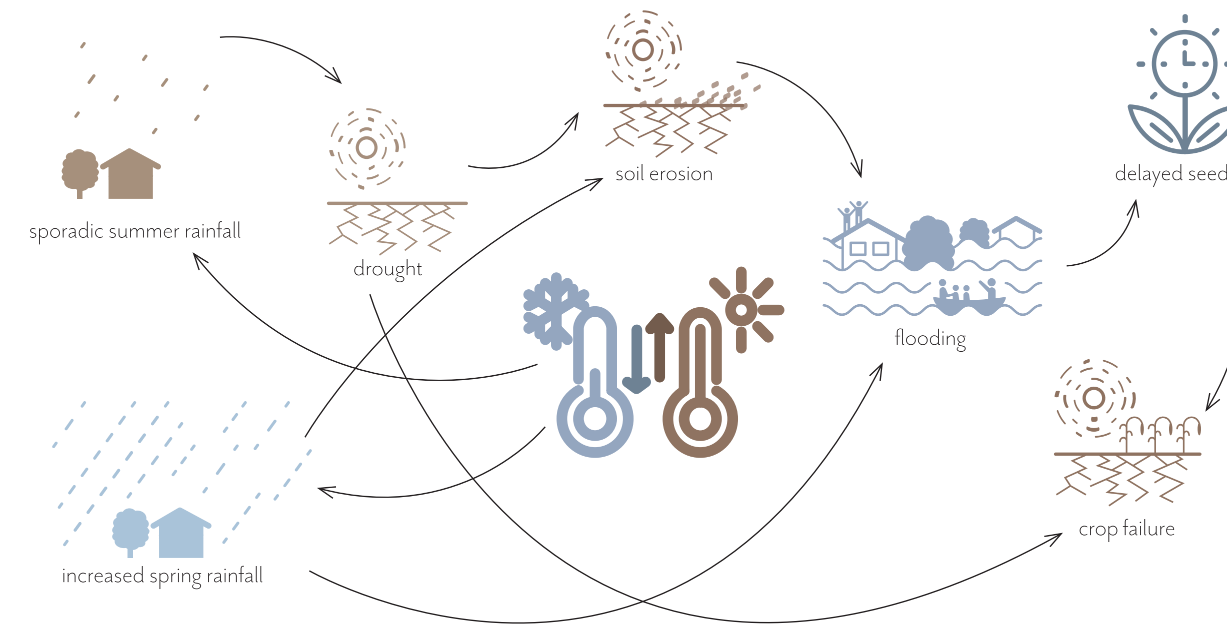


Figure 11. Infographic of climate change impacts in the Prairies.

3.0
RESEARCH FRAMEWORK

RESEARCH QUESTIONS

How do we develop a healthy, working landscape that more effectively balances water across the seasons now and into the future?

Sub Question 1:

How do we renaturalize heavily modified hydrology (drainage districts) and still allow for productive agriculture?

Sub Question 2:

How do we create a permanent wetland in a regularly flooded area that acts as both spring sponge and summer reservoir?

These research questions were derived during the initial research and following the first site visit. They helped guide both the research process and the design process.

DESIGN OBJECTIVES

Shannon Creek is dozens of kilometres long and requires a multi-faceted approach in order to respond adequately to the research questions posed. First, the design for Shannon Creek must be viewed as an exemplar masterplan that could be used on any of the canalized provincial waterways. Therefore, there are design objectives for the overarching **system**. Second, there are always unique areas that offer opportunities to demonstrate the design principles in a more tangible way. Therefore, there are design objectives that can be referenced when looking to create a unique, smaller **site** intervention.

System:

- Create an effective, healthy water management system;
  - By adapting the vernacular technique of pairing dugouts and shelterbelts to re-integrate a range of wetlands that are fed, in part, by captured snow;
  - Re-integrate ephemeral wetlands and intermittent streams to hold freshet (spring melt) in place to reduce load on wider hydrological system and keep water available into summer months.

Site:

- Effective, innovative flood and drought mitigation at a regularly flooded area that impacts the people who live in the area.
- Establish a permanent wetland that can be part habitat, part water management strategy, part agriculture, and even part recreation.

THEORETICAL FRAMEWORK

The theory of Landscape Ecology only developed once aerial photos became more widespread and humans could view the land from above.[37] Seeing our world from a bird's eye view helped evolve our understanding of how habitats, animals, and ecosystems interact. Drumstad, Olson, and Forman wrote the seminal book, *Landscape Ecology Principles in Landscape Architecture and Land-Use Planning,* which lays out the principles of patches, edges, mosaics, and corridors in the landscape. Patches are patches of habitat; edges can be man-made like a highway or natural like a river; mosaics are a combination of features like patches and edges; corridors are similar to edges in that they can be man-made, like a hydro power-line grassy stretch, or natural like a stream. I applied this theory to find the patches, edges, and corridors in the study area landscape and used the design as a means to connect them.

METHODOLOGY

A variety of methods have been used in the development of this document. *Research on Design* through case study analysis; *Research for Design* through policy analysis, landscape biography, and observation through photography and walking; and *Research through Design*.[38]

Prior to this project, I completed an independent study that helped develop my thinking on how natural processes can, and should, be integral to a landscape design. It was a case study analysis of three projects that each hinged on the successful integration of a natural process (ie. wind, water flow). This Research on Design provided an idea of how other landscape architects have worked with natural processes to create successful projects.

A landscape biography is a collation of natural and human history as well as site analysis, which can be seen in this document in the previous Section 2: Background to Problem, and the upcoming Section 4: Landscape Analysis and Section 6: Field Observations. Site visits involved photography, walking, and exploration. These consecutive and extended visits gave me a truer understanding of how the landscape works; ecologically, socially, and seasonally. Being out there, in the elements, sharpened my vision for the phenomenological output of the design. These steps formed my Research for Design.

Finally, Research Through Design has been a constant method in the design process. Early on I made sketches with the goal of a design that could hold water, which would evolve into a sketch that could hold water and still be productive agricultural land, which evolved to sketches of designs that could hold water, allow agriculture, and be a system that could be scaled up. Every time a sketch was made it was tested against the real world constraints and the results informed next steps and design decisions.

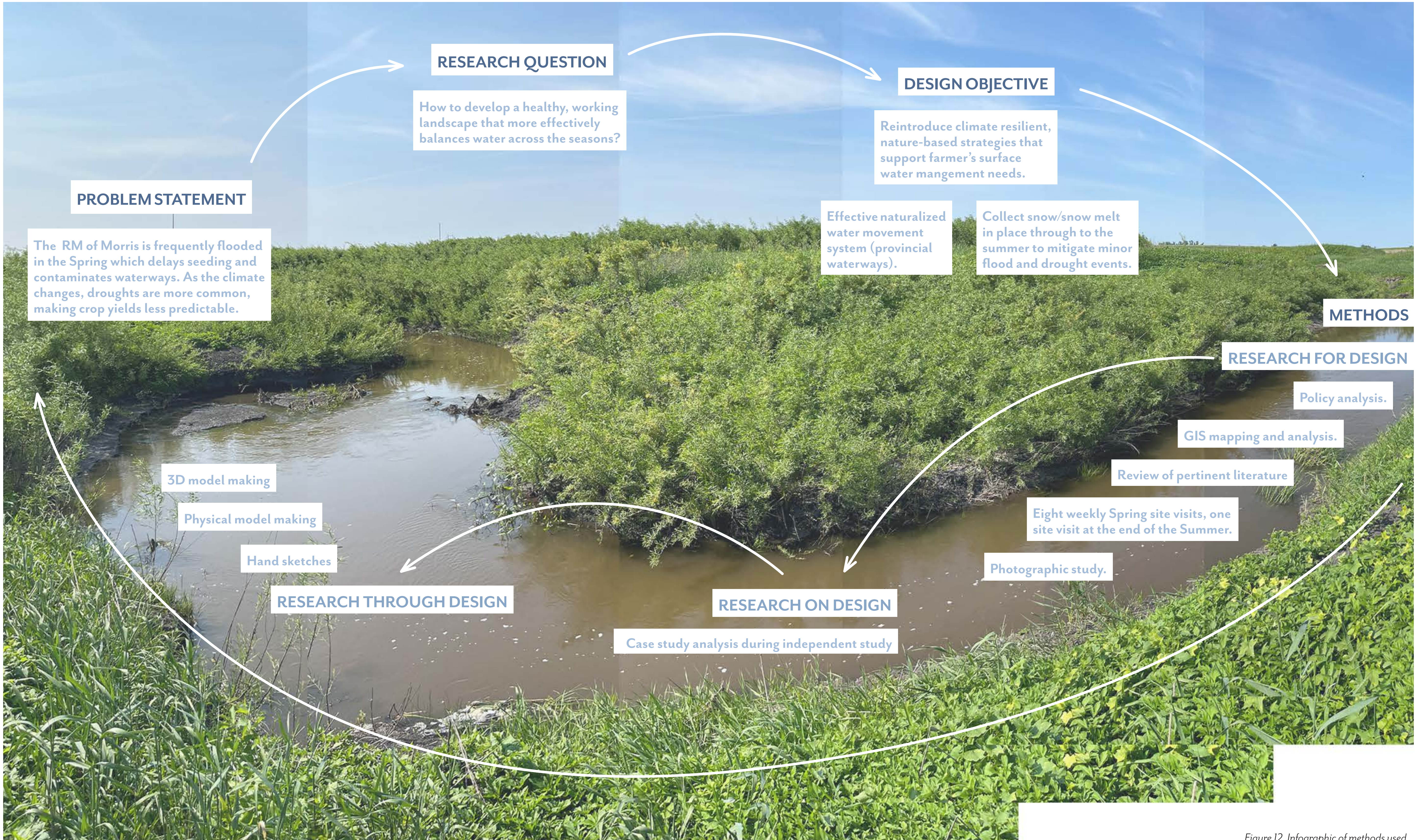


Figure 12. Infographic of methods used.

4.0
LANDSCAPE ANALYSIS

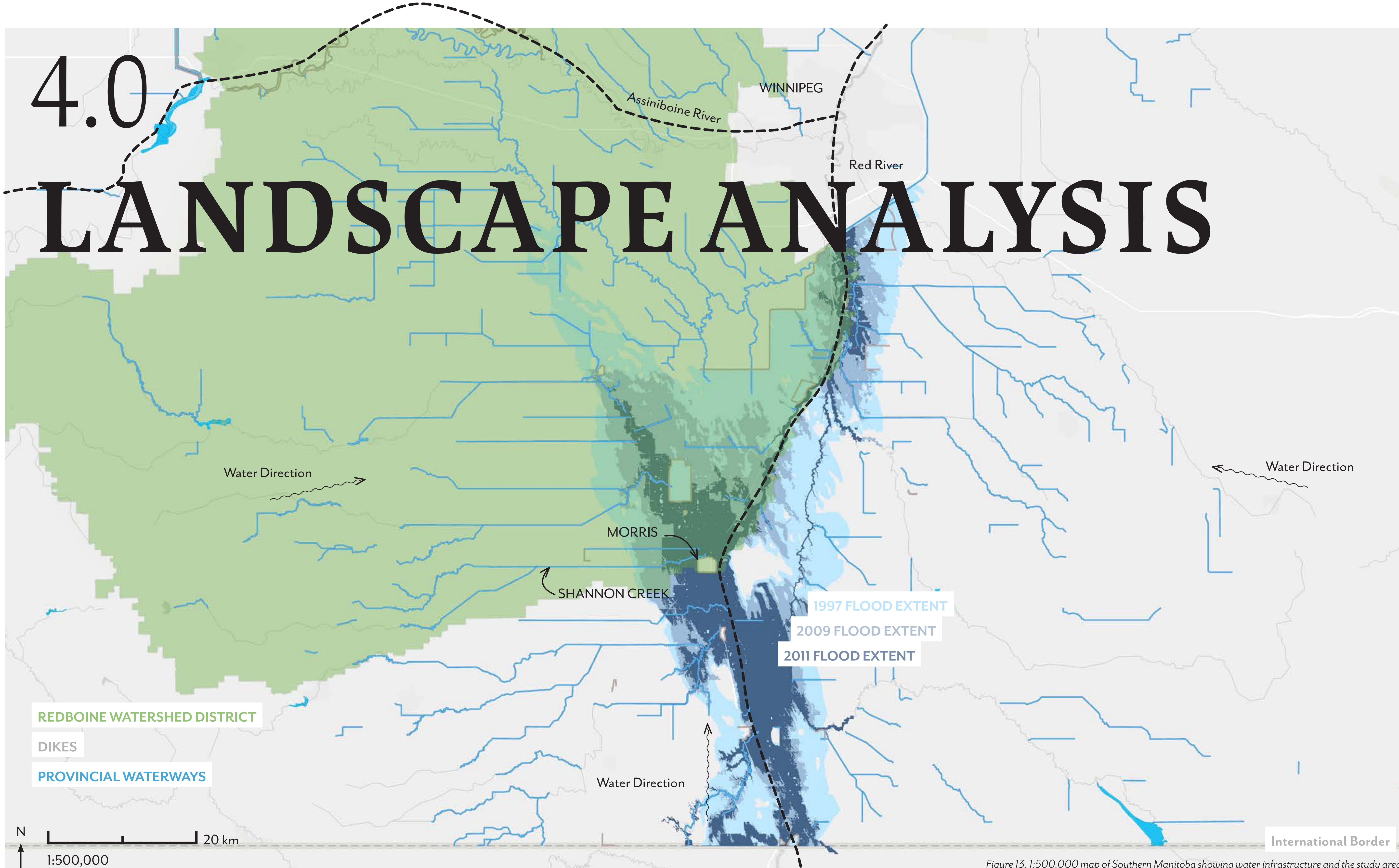


Figure 13. 1:500,000 map of Southern Manitoba showing water infrastructure and the study area.

To help answer Sub Research Question 1 of *How do we renaturalize heavily modified hydrology (drainage districts) and still allow for productive agriculture?* I used GIS mapping to investigate the area's current land cover, types of flooding and hydrology infrastructure present, and historical flood events. Section 7: Policy Analysis is on a provincial level, therefore, I started with mapping on a 1:500,000 scale to understand how the flooding in Morris is being impacted by other areas in the province. Figure 13 outlines the linear provincial waterways, carrying water from the west and east highlands to the Red River Valley. As mentioned in Section 2: Background to Problem, the Red River is already being fed by the southern highlands, making the Red River Valley somewhat of a bowl as it gently slopes toward Lake Winnipeg.

Seeing the uniformity and high level impact of the provincial waterway system at this scale made it clear that changing the borders of Conservation Districts to Watershed Districts on paper would not be enough for a meaningful intervention into the way water moves across Southern Manitoba. Subsequent mapping exercises zoomed into Shannon Creek at the 1:100,000 scale, then 1:15,000, then continuing to 1:200 until a fuller picture began to emerge. Section 6: Field Observations will go into the human scale as experienced on the ground in more detail.

During the process of site visits, two sites were chosen for closer investigation. The following maps were originally drawn at 1:15,000 and 1:5,000 in order to see the undulations in the apparently blanket of "agricultural field" as Figure 15 shows. The decision behind selecting the two sites will be explained in later in Section 10: Further Explorations. For now, analysis mapping uses these two sites to understand the existing hydrology and land cover of land adjacent to Shannon Creek at a more tangible scale.

Figure 14. Map of Shannon Creek study area with proposed sites.

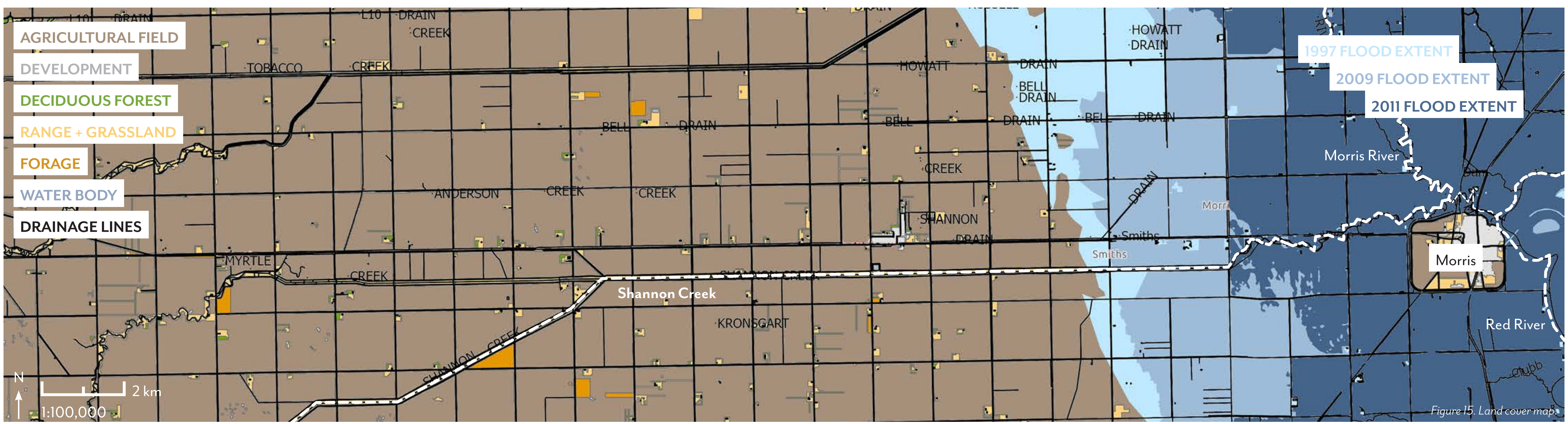


Figure 15. Land cover map.

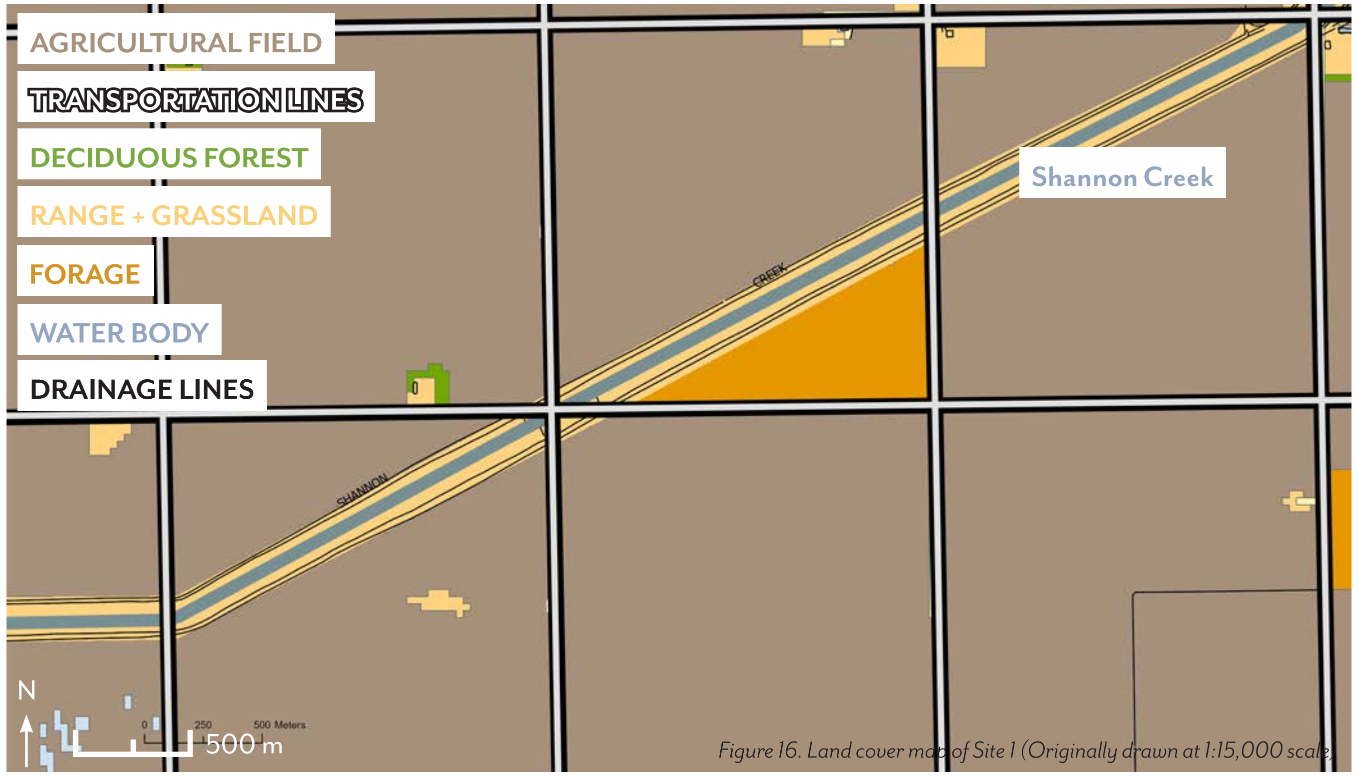


Figure 16. Land cover map of Site 1 (Originally drawn at 1:15,000 scale)

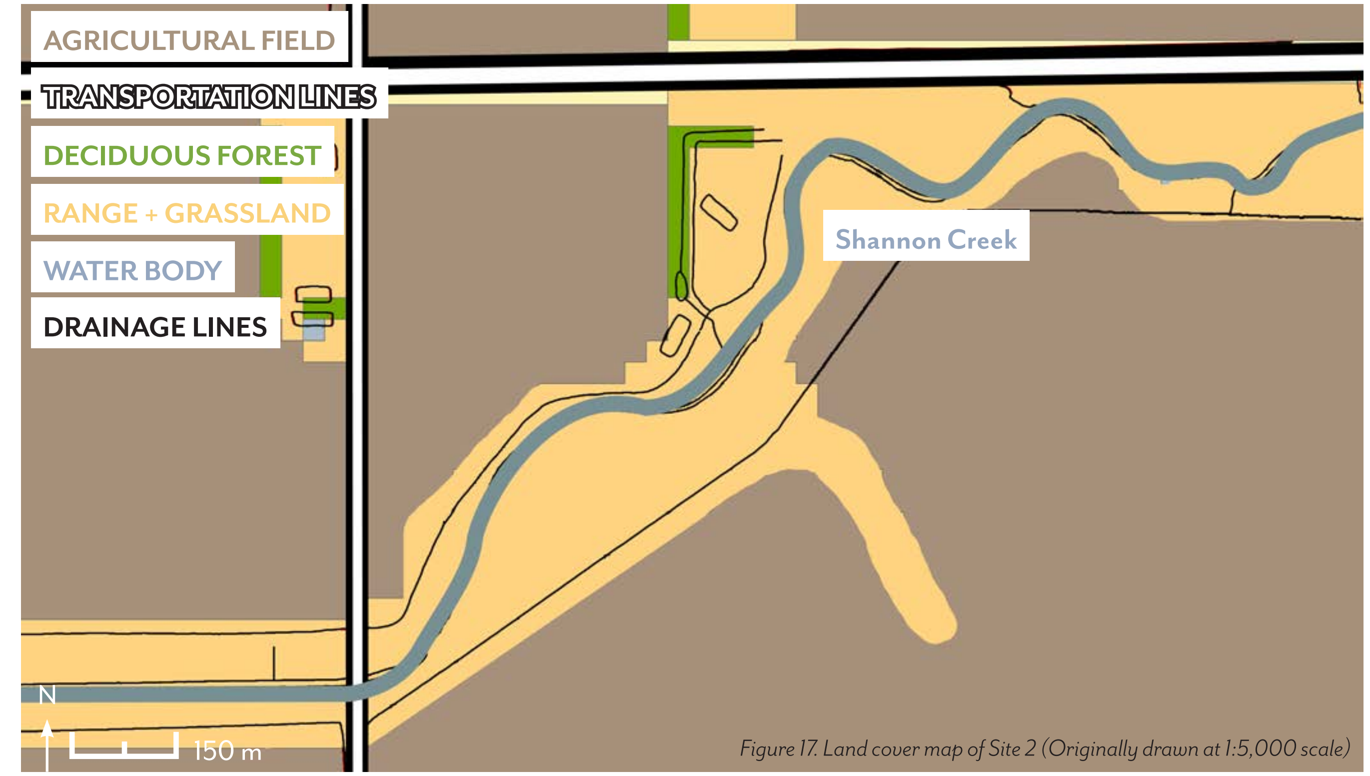


Figure 17. Land cover map of Site 2 (Originally drawn at 1:5,000 scale)

Site 1

Site 2

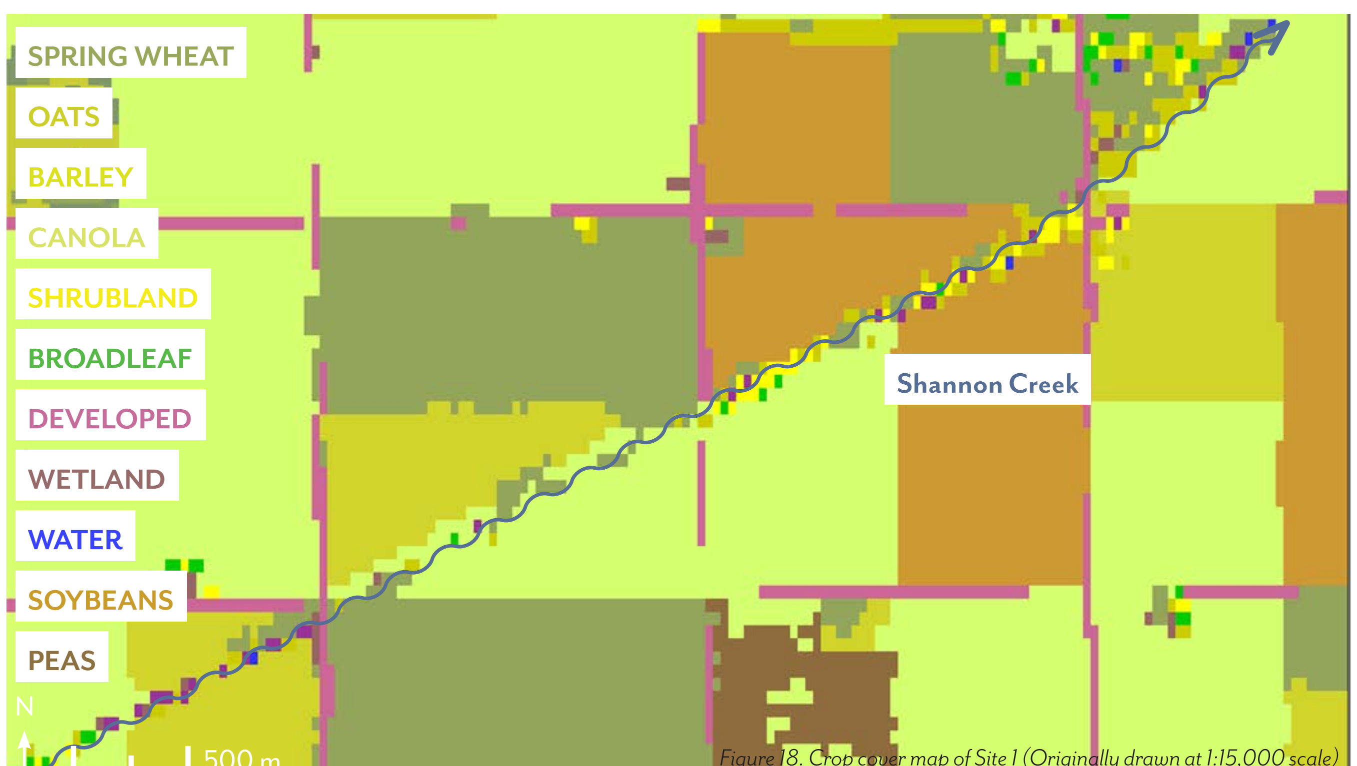


Figure 18. Crop cover map of Site 1 (Originally drawn at 1:15,000 scale)

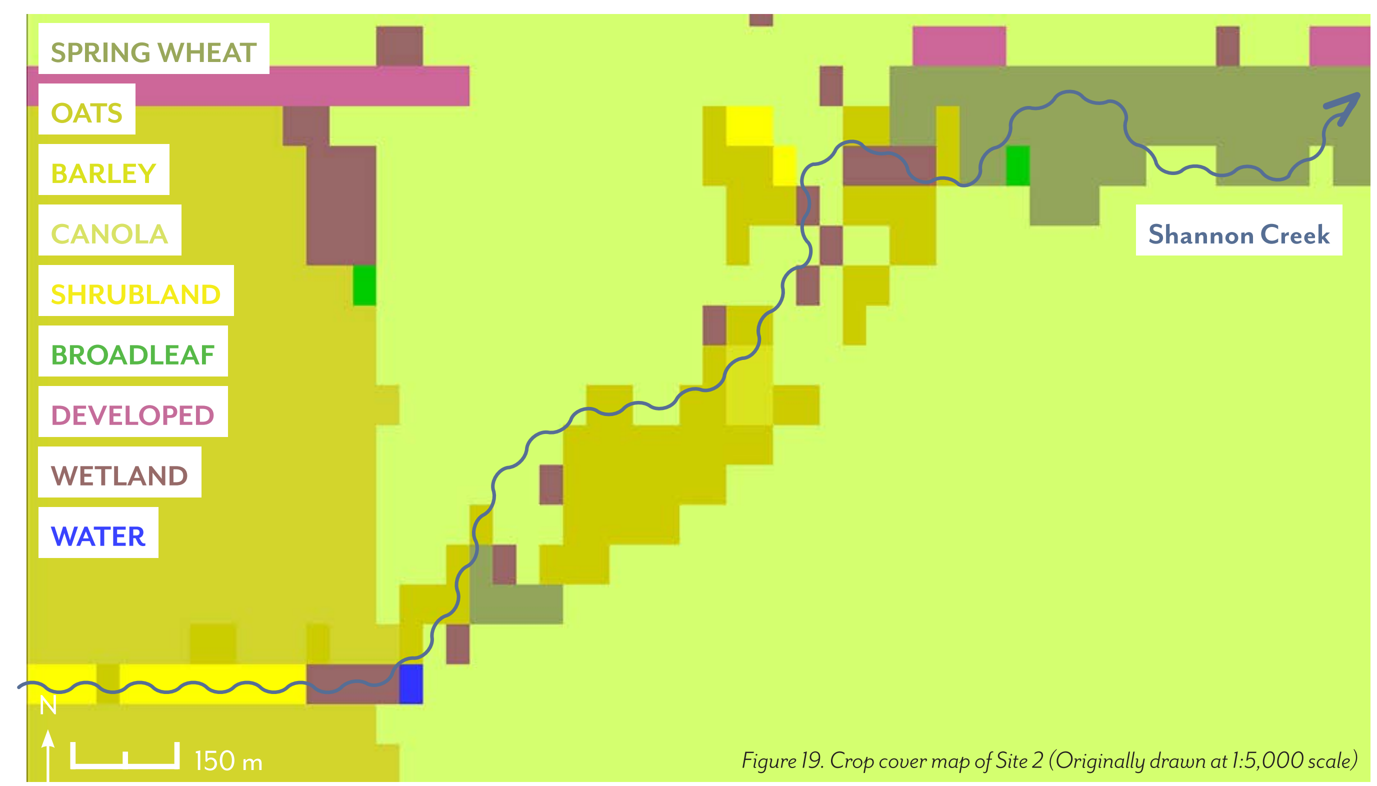


Figure 19. Crop cover map of Site 2 (Originally drawn at 1:5,000 scale)

LAND COVER MAPS (TOP)

These maps use content from the Manitoba Land Initiative (MLI) to broadly deliniate land cover. They demonstrate the vast nature of the agricultural landscape - mostly regular with only some deviation. The deviation present from crop land is the vernacular technique of shelterbelts (classed as Deciduous Forest but likely includes conifers), grass and rangeland, and waterbodies in the form of drainage lines and dug outs.

CROP COVER MAPS (BOTTOM)

Focusing on the large swathes of agricultural land identified in the previous maps, the information in these maps come from Agriculture and Agri-Food Canada's (AAFC) annual crop inventory (2022 data set) which sheds light on the specific crops being grown in the area. Crops are rotated so will likely change year to year, but this gives a glimpse into favoured crops. Most obvious being canola, oats, spring wheat, and soy beans.

TRANSITIONAL CONCLUSIONS

Land cover maps demonstrate shelterbelts and dugouts already present in the landscape, and that shelterbelts are generally planted on the north/west side of the dugouts. The more detailed crop cover maps confirm the information received from the land cover maps; that waterbodies and wetlands (in the form of provincial waterways) are found side-by-side grasslands and forage crops. This provincial and federal data validates that shelterbelts and dugouts are common features in Southern Manitoba and necessitated the further exploration of how shelterbelts could work with wetlands, provincial waterways, and prairie grass. The coming Section 5: Key Landscape Features elaborates on the mechanics of shelterbelts, types of wetlands, and benefits of prairie grass.

5.0 KEY LANDSCAPE FEATURES

Shelterbelts and dugouts have been referenced as rural, vernacular interventions that could be adapted to suit this project's goals. Following my site visits and literature research I viewed these post-settler additions to the landscape as a potential way to reintegrate wetlands and tall grass prairie habitat back into the landscape. To understand how they work and the opportunities they present, different types of shelterbelts, classes of wetlands, and prairie grass species are discussed and diagrammed here as key components of the landscape before moving into a more specific site analysis.

SHELTERBELTS

Shelterbelts are an agroforestry technique used commonly in rural areas to protect crops and livestock from strong prairie winds.[39] They disrupt wind patterns to slow or redirect wind which can reduce erosion and physical damage to plants and property.[40] Now frequently used along highways for their snow control abilities, when set back an adequate distance they can slow windspeed to a point that forces the bulk of snow being transported to drop before reaching the area to be protected.[41 42] Traditionally, shelterbelts have mostly been used to redirect unwanted snow, but this project focuses on the intentional collection of snow to create reservoirs of meltwater in the spring.

Porosity, height, length, and orientation are the main factors influencing shelterbelt effectiveness.[43] Figure 20 indicates the difference in porosity on the dispersal of snow. While solid windbreaks, like very dense shelterbelts or non-porous wind fences, are more effective at slowing wind quickly they increase turbulence and amplify the wind's cooling effects. [44] Shelterbelts of approximately 50% porosity are most preferred as they slow wind and reduce unhelpful turbulence.[45] Additionally, the gap between the ground and the bottom of the windbreak also needs to be considered. H refers to the height of the shelterbelt and is used in equations to determine snow fence efficacy.[46] Generally, a gap of 0.15 to 0.2H is recommended, however this also depends on if the shelterbelt is at the top of a ridge, bottom of a ditch, or on a flat plain.[47]

Variables for successful shelterbelts include species of plant and number of rows planted. Coniferous plants have a stronger impact on wind speed than deciduous do and have much less leaf drop in the fall.[48] However, Ogdahl's Shrubby Willow study demonstrated 4 rows of shrubby willows to be effective after only 2 years of growth, and that a variety of *Salix* (Willow) species would be good choices for shelterbelts.[49] A windward row of shrubs in front of taller trees is most effective at reducing both wind speed and turbulence. Shelterbelts are versatile, functional, and should be viewed as green infrastructure. They

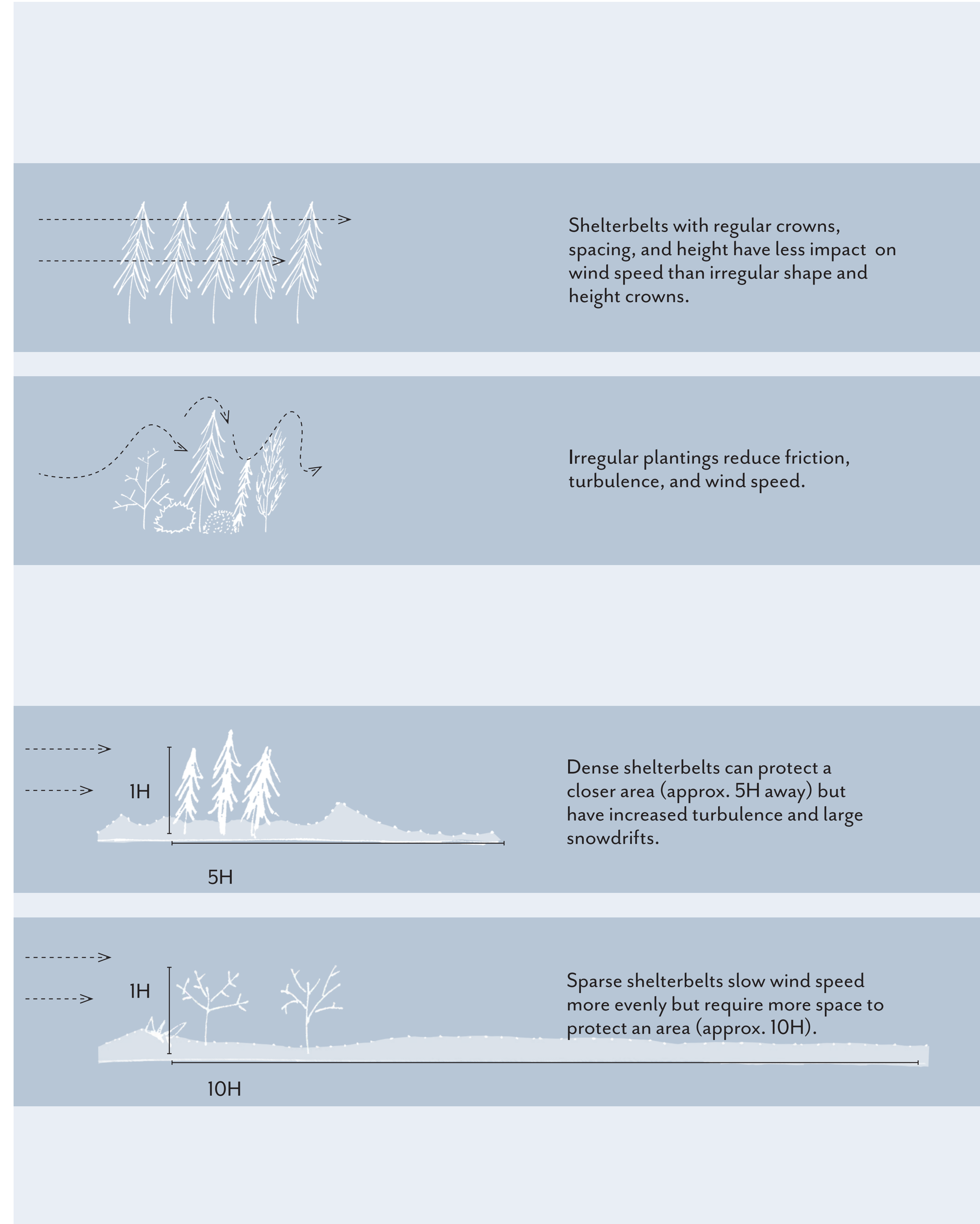


Figure 20. Shelterbelt and snowdrift dynamics.

perform the same wind and snow stopping functions as constructed snow fences while providing extensive ecological goods and services, requiring minimal maintenance, and having a longer life span.

AAFC defines several categories of shelterbelts, like farmyard, field, and highway. Farmyard shelterbelts are used to reduce snow buildup on driveways and around farm buildings. AAFC recommends five rows of plantings a minimum of 30 m from the area to be protected, with the outer planting being a shrub and inner plantings (closer to the protected area) being longer-life trees.[50] This technique aids in the design strategy as it allows for a protected area, like a recreational trail, and an anticipated snow dump site, like the deepest part of the wetland. Field shelterbelts are usually a single line of trees that only slow wind enough to drop snow more evenly across a field. Both farmyard and field shelterbelt techniques are used in the design strategy, with denser plantings to collect snow in wetlands and more sparse plantings along the creek to ensure crops still get snow cover. Figure 23 shows both farmyard and field shelterbelts in the study area.

Figure 21. May 14, 2023 photo of dugout in study area.

Figure 22. May 14, 2023 photo of shelterbelt in study area.

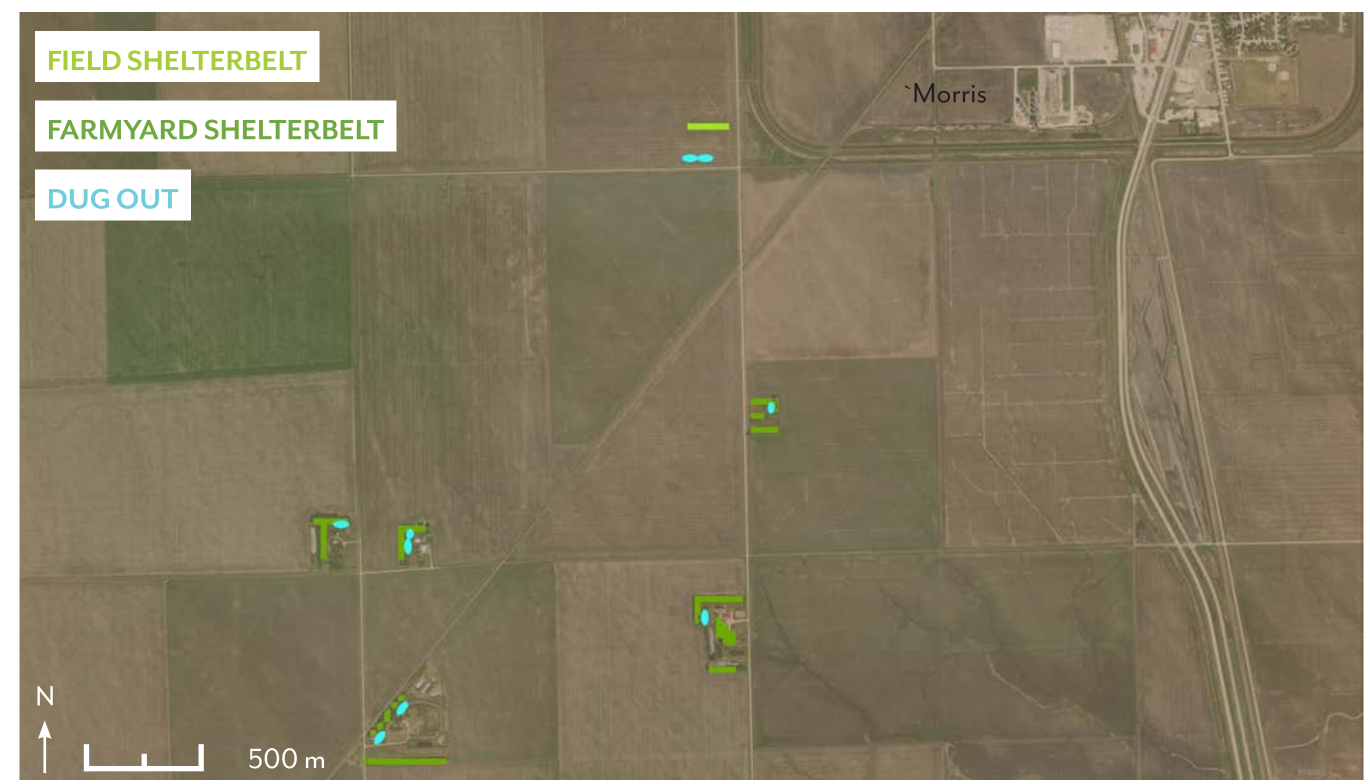


Figure 23. Map of dugouts and shelterbelts in study area.

WETLANDS

In general, "a wetland is defined as land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, vegetation, and other biological activity adapted to a wet environment."[51] The wetlands in the study area can be defined as marshy wetlands, as opposed to swamps, bogs, fens. Wetlands can be identified by water depth, soil, and vegetation type. Manitoba uses a class system for its wetlands based on longevity of their water levels. A guide has been developed by Ducks Unlimited to assist Manitoban landowners with identifying their wetlands for the purpose of applying to programs like GROW.[52] Class 1 Ephemeral Wetlands typically only retain water 1-3 weeks into early spring and are associated with low prairie vegetation. Class 2 Temporary Wetlands hold water 2-6 weeks into spring and have wet meadow vegetation. Class 1 and Class 2 wetlands do not have hydric soil. Hydric soil is flooded or submerged long enough that they develop anaerobic conditions. Class 3 Seasonal Wetlands begin to show hydric indicators as they retain water into mid summer and have shallow marsh vegetation. Class 4 Semi-Permanent Wetlands generally keep water through September with hydric soil zones in the deeper areas with deep marsh vegetation. Class 5 Permanent Wetlands / Open Water maintain water year-round with hydric soil and an open water zone that is too deep for common wetland plants like cattails to be found.

Wetlands act as a sponge in extreme rain and flood events and a reservoir in times of drought. They are also a critical factor in water quality. A lack of natural buffers like wetlands and riparian ecosystems, along with increased pesticide and herbicide usage on farms, has led to increase nutrient loading in Lake Winnipeg. This severely effects the health of native flora and fauna in the area as well as downstream.

PRAIRIE GRASS HAY

While shelterbelts and wetlands were easy to find in the site area, the final key landscape feature of native prairie grass was harder to come by. As mentioned, tallgrass prairie was converted to farmland when settlers arrived and few intact patches remain today. However, reintroducing prairie grasses to the agricultural landscape of Southern Manitoba would have cascading benefits financially, ecologically, and resiliency. Canola is the most commonly grown crop in the study area as it is currently one of the highest paying crops. However, it is susceptible to lack of "adequate and timely rainfall."[53] A recent report states that rising summer temperatures will result in heat stress for canola, "particularly at

Figure 24. Photo of Class I Wetland.

Figure 25. Photo of Class 2 Wetland.

Figure 26. Photo of Class 3 Wetland.

Figure 27. Photo of Class 4 Wetland.

Figure 28. Photo of Class 5 Wetland.

crucial plant germination stages" which could decimate a farmer's entire season.[54] While increased food prices have helped crop prices to remain steady, production inputs have risen drastically in the years post-COVID. Canola fertilizer, pesticide, and gas prices have doubled since 2018. This has increased investment risk and reliance on a good growing season.[55] Many producers are now turning to growing native prairie as they are drought tolerant, hardly need fertilizers or herbicides due to their resistance to and suppresssion of weedy species, and can produce good quality hay. It is important to note that native prairie grasses could not immediately be substituted in place of traditional cash crops like canola, but reintroducing them in interstitial spaces like provincial waterways would help producers see their benefits and allow transition time to get used to the slightly altered requirements for these species. Native prairie grasses could be substituted more quickly for traditional forage crops like alfafa.

TRANSITIONAL CONCLUSIONS

Shelterbelts, wetlands, and grasslands are integral features of the design strategy that follows. They already exist, in part, in the landscape and contribute to habitat creation, water quality correction, water collection, and healthy ecosystems. It is possible to immerse them more fully into the agricultural landscape with minimal disruption to conventional working of the fields. Using their impressive functionality alongside striking species and location selection can create a cohesive surface water management system.

Figure 29. Spring (invasive Reed Canary Grass, Phalaris arundinacea, shown here).

Figure 30. Fall (native Purple Prairie Clover, Dalea purpurea, shown here).

Figure 31. Winter (invasive Common Reed, Phragmites australis, shown here).

6.0
FIELD OBSERVATIONS

Figure 32. Context map showing locations of the eight field observation sites.

I went to site eight times in eight weeks to capture the dramatic changes that come with spring in the Prairies. Once summer got into full swing and water levels were more consistent I went again in September to see how fall was impacting the sites I had begun to know. Without continued site visits this project would be far removed from reality.

Morris is approximately one hour south of Central Winnipeg, with the drive my field trips would last four hours on a short day, six on a long one. It was easy to get lost in the landscape, not literally, but time slipped by as I made my way through fields of tall grass, squishy clay wetlands, and clamoured up and down the sides of the ring dike. These visits filled in the contextual and visceral gaps that the GIS site analysis maps could never provide.

The regular early spring visits didn't just highlight the rapidly dropping water levels, they showed me all the things I never knew existed, and would have never thought to look for... The scrunched up reeds left behind from the floodwaters that now housed small mammals, the snakes waking up in the new sun, the owl that lives in an abandoned shelterbelt, the deer tracks that showed the way to the creek... There is a whole world on the ground that cannot be understood from the sky, making these field observations critical to next steps in the design process.

Figure 33. May 26, 2023 photo taken on the north side of Morris' ring dike looking north at the bridge/Highway 75 into the Town of Morris.

LOCATION 1 / 49.358932, -97.363911 / DIKE + RIVER

PHYSICAL CHARACTERISTICS:

- Morris River on the north side of the dike, meets the Red River just east of the bridge.
  - The water overtops the bridge in spring every few years due to the Red River breaching its banks.
  - Can be considered a class 5 wetland.
- Once floodwaters recede, evidence of ATV and bike trails.
- Dike is regularly mown, typical Kentucky Bluegrass *Poa pratensis*.
- Some wildflowers in spring lower on the dike. Large, old Cottonwood trees *Populus deltoides* at the water's edge.

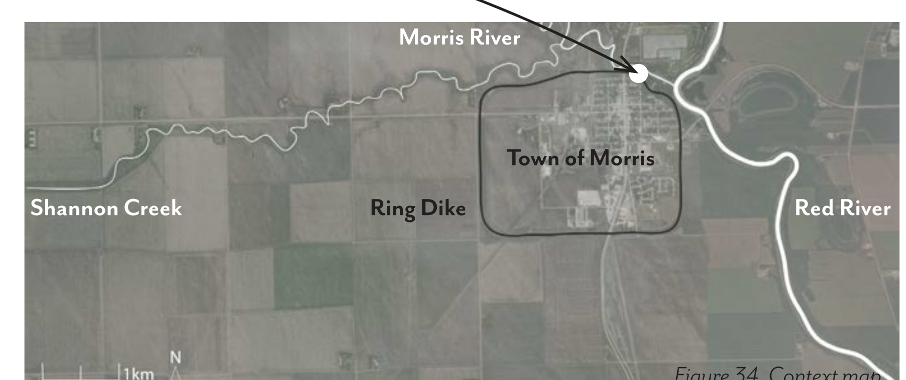


Figure 34. Context map.

Figure 35. May 7, 2023 photo taken on the bridge/Highway 75 into the Town of Morris looking south at the ring dike (left).

PHENOMENOLOGICAL CHARACTERISTICS:

— Very noisy due to Highway 75 through traffic.

— Feels windswept at the top of the dike, exciting.

— The dike is the best place for views across the river, though, even at this height the view is still obscured by trees.

— Hard to cross the road safely, however, when water is very low in late summer the bike trails continue under the bridge.

WHY CHOSEN / WHAT LEARNED:

— This was going to be the initial study site due to it being recommended as an area routinely impacted by flooding.
  - Realized flooding needs to be addressed upstream, rather than at the pressure point.

— Learned the dike is used as a means of transportation as well as flood defense.

— Could be a good way to get a sense of elevation + increase viewscapes in the landscape, but wind buffers required to improve the human experience.

Figure 36. May 7, 2023 photo of Morris' ring dike looking southeast.

Figure 37. June 24, 2023 photo of Morris' ring dike looking southeast.

Figure 38. Sept 3 2023 photo of Morris' ring dike looking southeast.

Figure 39. May 14, 2023 photo of agricultural drainage ditches at a rural road intersection.

LOCATION 2 / 49.325246, -97.391230 / DITCH

PHYSICAL CHARACTERISTICS:

- Drainage ditch maintenance was underway during the first site visit which allowed me to see how full the ditches can become with vegetation, and the culverts with garbage.
  - This maintenance clears out ecosystems that appear healthy (see Figure 41) but is required to remove built up sediment.
- Water levels varied between ditches, some holding their water weeks longer than others, likely due to blocked culverts and varying levels of ditch maintenance.
- Cattails found in some of the deeper areas, usually at road intersections. Range from Class 2 - 4 wetlands.

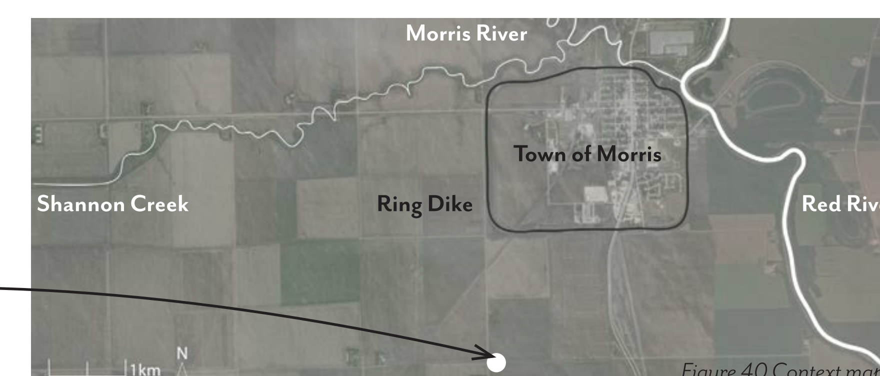


Figure 40 Context map.

PHENOMENOLOGICAL CHARACTERISTICS:

— Red-winged blackbirds *Agelaius phoeniceus* abound in the vegetated ditches along with many other birds, creating a whimsical feeling even within the agricultural grid.
  - An ensemble of song.
  - The blackbirds were innumerable in the spring but noticeably absent in September.

— On the ground you can start to see the slight dips in terrain that are only shadows on the satellite image.
  - The hint of a feeling of rolling pastures.

Figure 41. June 17, 2023 photo of wetlands in agricultural drainage ditch.

WHY CHOSEN / WHAT LEARNED:

— Ditches are a human intervention to drain fields, therefore I wanted to understand the impact of this change in topography in an agricultural setting.

— I learned they essentially become linear wetlands when left alone and certainly have the capacity to hold, clean, and direct water while maintaining a productive landscape.

Figure 42. May 7, 2023 photo of agricultural drainage ditch looking north.

Figure 43. June 24, 2023 photo of agricultural drainage ditch looking north.

Figure 44. Sept 3, 2023 photo of agricultural drainage ditch looking north.

Figure 45. May 14, 2023 photo of unmaintained shelterbelt looking west.

PHYSICAL CHARACTERISTICS:

- Some distinct shelterbelt plantings, some clumped groupings of trees.
- Appears to be an abandoned homestead, two grain silos remain on the site.
- The most frequently seen terrestrial wildlife in the eight locations:
  - Herd of deer seen twice.
  - One horned owl seen three times, see Figure 47.
- Long grass, unknown species, mown only once or twice, unsure by who. Very few wildflowers.
- Dugout beside one of the shelterbelts, see Figure 45. Class 1-3 wetlands present.

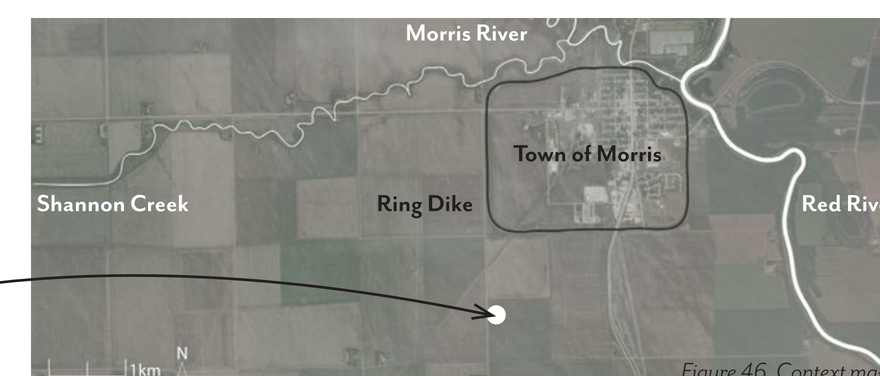


Figure 46. Context map.

LOCATION 3 / 49.330107, -97.391316 / SHELTERBELT

Figure 47. June 4, 2023 photo of Great Horned Owl, Bubo virginianus.

PHENOMENOLOGICAL CHARACTERISTICS:

— The numerous animals and sense of enclosure created by the groupings of trees created a feeling of discovery and prospect/refuge compared with the agricultural ditches visited moments before.

— Felt more damp and lush than surrounding areas.

WHY CHOSEN / WHAT LEARNED:

— This site offered the opportunity to see what a previously human-centred space might return to with minimal disturbance. Drainage maintenance crews looked to be dumping excess soil there but otherwise looked mostly unused. The wildlife present and their tracks found appear to confirm this.

— The site provides insight into the benefits of trees being integrated into the landscape, for both habitat and creation of temporary wetlands due to snow trapping.

Figure 48. May 7, 2023 photo of unmaintained shelterbelt looking east.

Figure 49. June 24, 2023 photo of unmaintained shelterbelt looking east.

Figure 50. Sept 3, 2023 photo of unmaintained shelterbelt looking east.

Figure 51. May 14, 2023 photo of three row Golden Willow, Salix alba 'Vitellina' shelterbelt looking west.

PHYSICAL CHARACTERISTICS:

— A typical three row shelterbelt planting of Golden Willow, *Salix alba 'Vitellina'*.

— Soybeans are being grown in the adjacent fields.

— Strong snow-trapping, snow remained in place for weeks later than surrounding, non-sheltered areas. As can be seen in Figure 51, a linear depression parallel to the shelterbelt drains this melt away from the field and into the adjoining field drainage ditch.

— Trees are planted on a mound only noticable once in the plantings.

LOCATION 4 / 49.341499, -97.392190 / SHELTERBELT

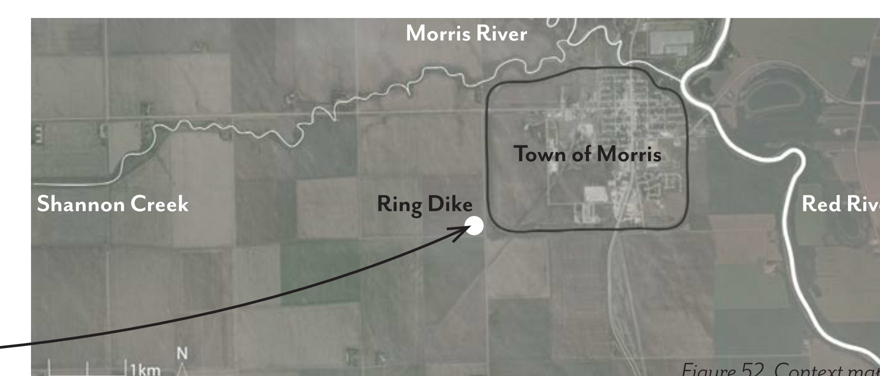


Figure 52. Context map.

PHENOMENOLOGICAL CHARACTERISTICS:

- The monoculture of the plantings did not inspire the same feelings of intrigue and forest bathing as Location 3.
- The long grass that came up in the spring hid scurrying rodents and large broken branches which made walking through unsafe and undesirable.

Figure 53. June 11, 2023 photo of raised mound inside Willow shelterbelt.

WHY CHOSEN / WHAT LEARNED:

- An intact field shelterbelt was an ideal opportunity to see how the plantings impacted snow trapping, crop development, and overall moisture on the site.
- I was surprised both by how long the snow took to melt, and conversely by how quickly the soil cracked following the meltwater drying up, however this is common for clay soil
- The trees do assist with moisture retention and habitat creation, however alternative groupings and species could create a much more dynamic and enjoyable place.

Figure 54. May 7, 2023 photo of three row Willow shelterbelt looking north.

Figure 55. June 24, 2023 photo of three row Willow shelterbelt looking north.

Figure 56. Sept 3, 2023 photo of three row Willow shelterbelt looking north.

Figure 57. May 26, 2023 photo taken on the southwest side of Morris' ring dike looking southwest.

PHYSICAL CHARACTERISTICS:

- A single row planting of Willow, *Salix alba* at the outer base of the dike.
- The weeping drain of the dike has created a Class 3-4 wetland. Numerous birds and plant species.
- No snow present in May like the other shelterbelt sites, likely due to less dense plantings and southwest aspect.
- As the weather warmed the wetland quickly vegetated, but did not retain water into the summer as well as I expected.

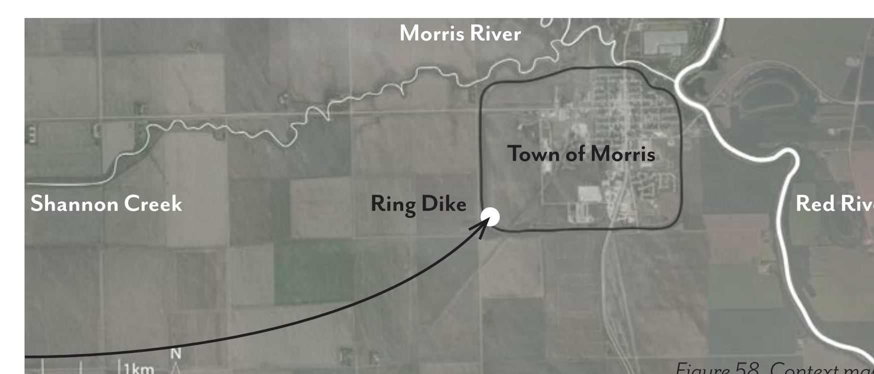


Figure 58. Context map.

LOCATION 5 / 49.343231, -97.390696 / DIKE + WETLAND

PHENOMENOLOGICAL CHARACTERISTICS:

— Location 5 was one of my least favourite to visit. Visually, it is one of the most interesting, but being physically halfway between two places (the dike and the road) made me also feel like I was on the edge of an environment rather than being fully immersed. It felt narrow and exposed.

Figure 59. June 11, 2023 photo of wetland grasses pushed up both by water levels and mammals using them for shelter.

WHY CHOSEN / WHAT LEARNED:

— A planting of trees beside both a wetland and a dike provided a unique setting for some of the design concepts I wanted to test/learn from.

— The dried reeds and grasses weren't just decomposing layers on the ground, they moved upwards into hollow mounds, taking the shape of burrows. On two occasions at Location 6 I saw a White-Tailed Jackrabbit (or Prairie Hare) *Lepus townsendii* and a smaller rodent dart out of these reed burrows, confirming animals' use of these plant materials in making their homes.

Figure 60. May 7, 2023 photo of southwest side of Morris' ring dike looking south at weeping drain wetland.

Figure 61. June 24, 2023 photo of southwest side of Morris' ring dike looking south at weeping drain wetland.

Figure 62. Sept 3, 2023 photo of southwest side of Morris' ring dike looking north at weeping drain wetland.

Figure 63. June 4, 2023 photo taken in Shannon Creek.

LOCATION 6 / 49.357721, -97.391422 / CREEK

PHYSICAL CHARACTERISTICS:

- Shannon Creek is wide and narrow, expansive and shrinking. It can be clearly seen from the road and the dike, but on the ground the grasses grow so high you have to follow deer tracks to find the water.
- Formally, it is a relatively small provincial waterway that retains its natural meanders near Morris and is then canalized for approximately 40 km west before meandering again north of Winkler.
- Mostly Class 4 to Class 5 wetlands in the creek proper, with Class 3 wetlands just south between the creek and the north edge of the ring dike, see context map Figure 64.

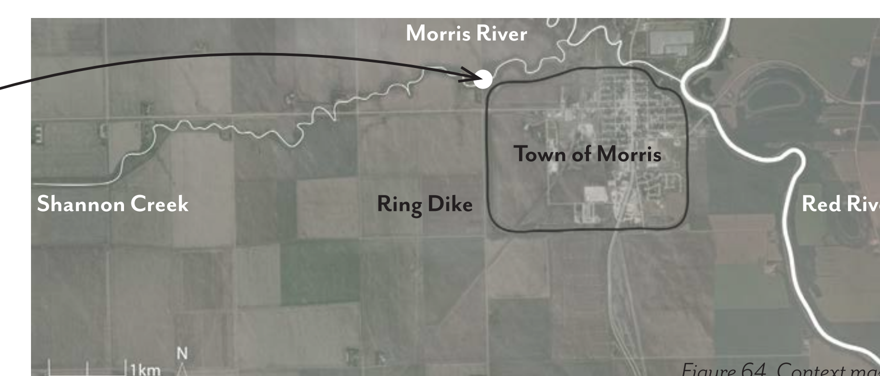


Figure 64. Context map.

PHENOMENOLOGICAL CHARACTERISTICS:

- I've lost hours at Shannon Creek. It is a muddy adventure with all kinds of wildlife, wild flowers, undulating topography, and hidden wetlands.
- This location was the closest I could get to feeling encapsulated by the floodwaters.
- Every time I went there the water levels had changed, the plants had grown, and I got to see a little more of how the creek functions. Most of the banks aren't sloping, they're cut levels, and the flow was quite fast in some areas. Being able to wade through the creek at various points helped me understand soil, water temperature, flora, and fauna.
- It felt wild and unkempt compared to the manicured fields, but much more alive, healthy, and cohesive.

Figure 65. June 4, 2023 photo of previously flooded soil.

WHY CHOSEN / WHAT LEARNED:

- When looking at the site on Google Maps, I couldn't believe it was the same place, it felt like a massive lake when I first saw it in May but it was a tiny line on a map that I knew I needed to see change as the seasons went by.
- I was shocked this area was farmed as it was underwater at least a month longer than surrounding areas. The undulating, elongated pockmarks created additional seeding difficulties and demonstrates that this soil is often underwater, Figure 65. This helped me understand Class 1-2 wetland areas can be easily farmed, but areas flooded for longer should be left alone.

Figure 66. May 7, 2023 photo of Shannon Creek looking north.

Figure 67. June 24, 2023 photo of Shannon Creek looking north.

Figure 68. Sept 3, 2023 photo of Shannon Creek looking north

Figure 69. May 14, 2023 photo taken on northwest side of Morris' ring dike looking west.

PHYSICAL CHARACTERISTICS:

- The ring dike is the highest topography in the area at 4 m above prairie level ('normal' ground level). It has steep sloped sides with a weeping channel on the outer bank.
- Like Location 5, the weeping channel has formed an extensive wetland habitat that feeds into Shannon Creek, particularly during flood events.
- The top of the dike is compacted limestone gravel, wide enough for vehicle access and is used as a service route for commerical vehicles, and as a recreational route for joggers, dog walkers, and ATVers.

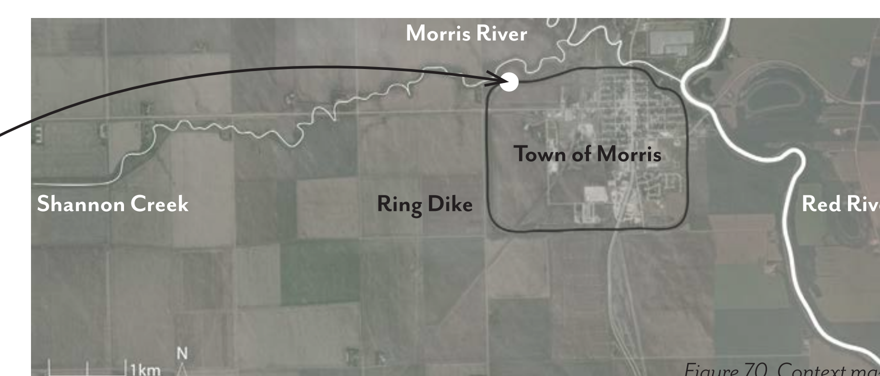


Figure 70. Context map.

LOCATION 7 / 49.357634, -97.388567 / DIKE + CREEK

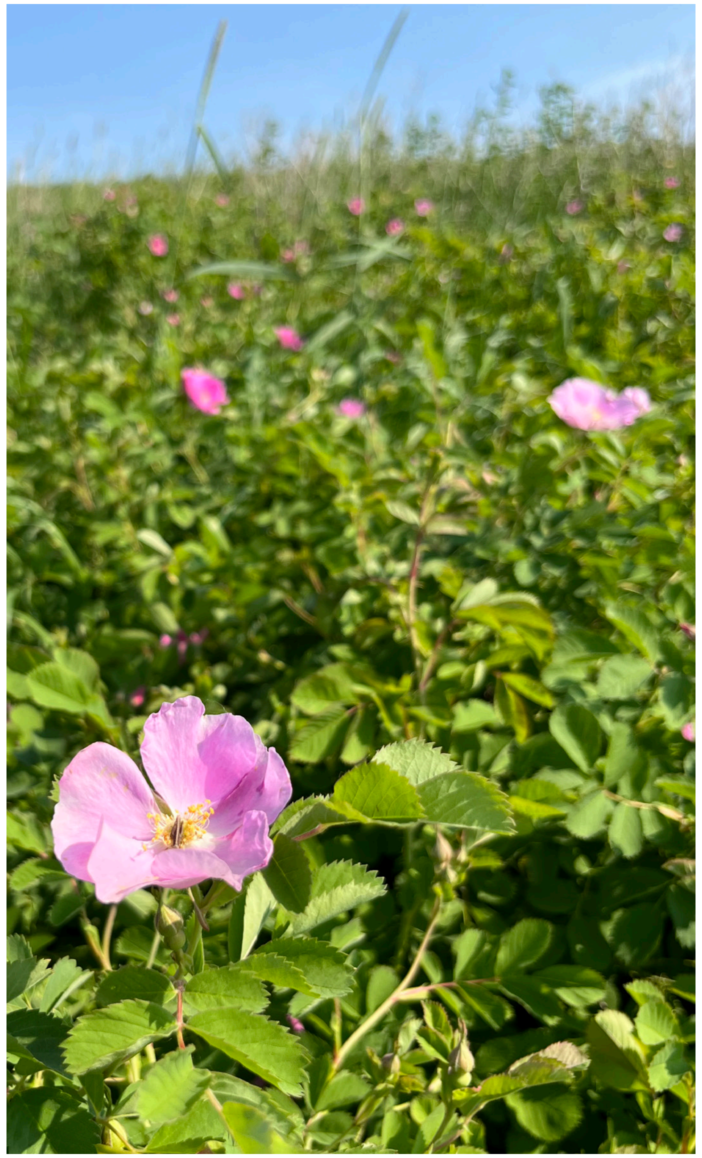


Figure 71. June 11, 2023 photo of Prickly Wild Rose, Rosa acicularis.

PHENOMENOLOGICAL CHARACTERISTICS:

— The top of the dike is windswept but still retains hardy plants. Many times I visited was in the midst of a summer thunderstorm, it was the definition of a sublime landscape. It invoked awe, beauty, and fear as I saw the dark clouds roll across the landscape, lightning light up the sky, and forceful raindrops whip through the air.

— Climbing the dike and walking along its spine is really the only way to see the vastness of the prairie, it gave me a much greater appreciation for how native grasslands can create a rich visual tapestry (compared with the monotony of monoculture fields).

WHY CHOSEN / WHAT LEARNED:

— This location became a selected site only during my second field visit to Morris. I needed to get a better view of the flooding related to Shannon Creek.

— The wetland at the base of the dike was teeming with life, like tadpoles and small fish, not to mention birds and many wildflowers up the banks. This extended marshy area from the dike to the creek was one large wetland at the beginning of the spring and prompted the idea to allow for graduating levels of wetlands radiating off the skirt of the dike.

Figure 72. May 14, 2023 photo taken on northwest side of Morris' ring dike looking northwest.

Figure 73. June 24, 2023 photo taken on northwest side of Morris' ring dike looking northwest.

Figure 74. Sept 3, 2023 photo taken on northwest side of Morris' ring dike looking northwest.

Figure 75. May 14, 2023 photo of Shannon Creek looking south.

LOCATION 8 / 49.347200, -97.458993 / CREEK

PHYSICAL CHARACTERISTICS:

- This was the most active site with regard to agricultural industry. I could only visit on the weekends otherwise there was a high likelihood of not being able to access the site.
- The first time I went it was a rushing creek, a week later I saw there was actually a submerged bridge, another week later the bridge was above water, and a month after that initial visit the bridge had been repaired and was being used to cross the creek. This series of events indicated that the current conditions for Shannon Creek are not adequate for farmers' year round use of the site.
- The clear cut flood lines in the banks indicate slumping, which occurs when vegetation is not present to hold the bank together. This suggests this stretch of creek is active and may suffer from soil loss and structural degradation during the next flood.

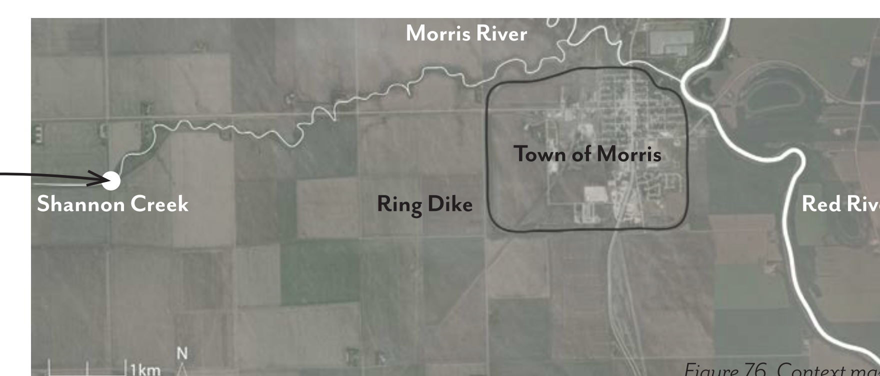


Figure 76. Context map.

Figure 77. September 3, 2023 photo of deceased Grey Fox, Urocyon cinereoargenteus.

PHENOMENOLOGICAL CHARACTERISTICS:

- Every field observation site located on or by water was filled with signs of animals. However in this part of Shannon Creek, lacking in trees and other riparian vegetation, I usually only found dead animals. There were noticeably less birds as well. I had assumed a meandering site would automatically be better, but without the accompanying vegetation the site was quite sterile, the dead animals indicating a lack of scavengers as well.
- The openess of the site was not inviting and I usually did not linger, the nestled feeling of enclosure present at other sites was distinctly missing here.

WHY CHOSEN / WHAT LEARNED:

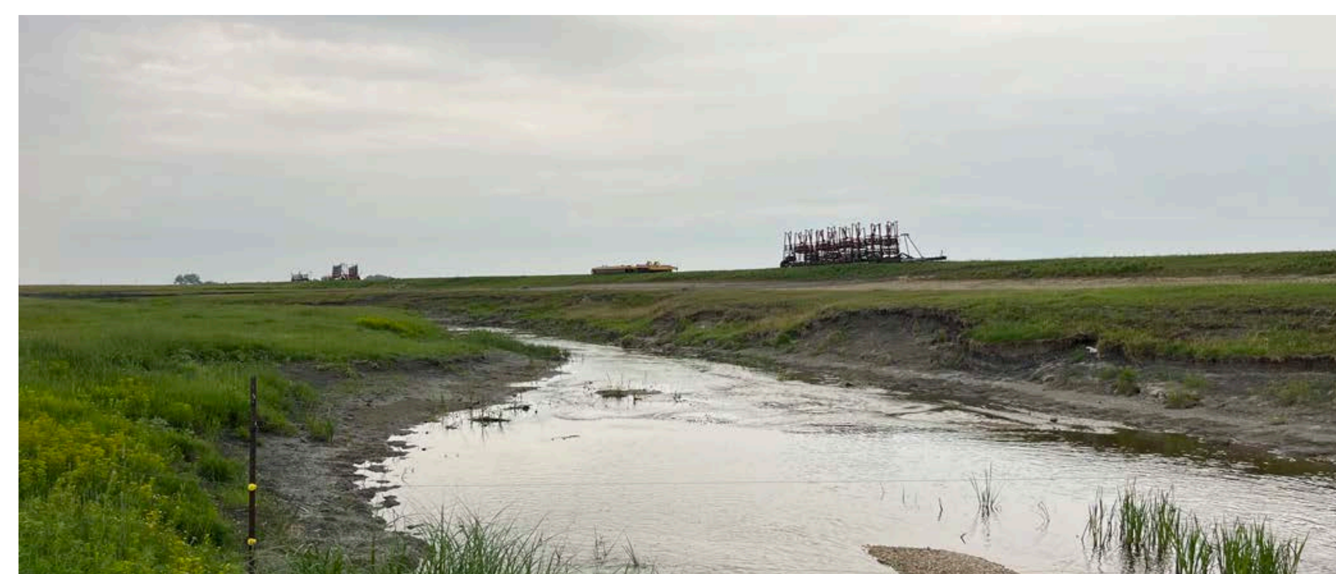
- Shannon Creek changes from being canalized to meandering at this site which is why I initially went, I wanted to see what that edge condition looked like.
- I learned that riparian vegetation was required for both ecological health and an enjoyable environment to be in.

Figure 78. May 14, 2023 photo of Shannon Creek looking southeast.

Figure 79. June 24, 2023 photo of Shannon Creek looking southeast.

Figure 80. September 3, 2023 photo of Shannon Creek looking southeast.

7.0 POLICY ANALYSIS



Manitoba is fortunate to have 900 trillion litres of surface water in the form of 100,000 lakes and many rivers.[56] However, 70% of the water in Manitoba originates outside the province which leaves it susceptible to other provincial and state regulations.[57] The Red River drainage basin covers three US states before it meets Canada. Only 20,000 km^2 of the drainage basin's 122,000 km^2 contributing area is in Canada.[58] There are some transboundary commissions that oversee water in Alberta, Saskatchewan, Manitoba, Ontario, and North Dakota and Minnesota south of the international border.[59] However, according to Manitoba's 2016 Drought Management Strategy, there is no intergovernmental water agreement between Canada and the USA for the apportionment or sharing of flows in Red River basin.[60] At the time of writing, July 2023, the newly formed Canada Water Agency was just announced and is in the process of becoming a full federal agency to coordinate management of the country's freshwater resources. Two months previous, the RM of Morris' council approved joining the Redboine Watershed District, more than two years after the passing of the Watershed District Act, thereby allowing their farmers to be eligible for the GROW program. As climate change effects are felt with greater severity, policies are changing rapidly. This brief overview of the current, pertinent provincial policy documents (2022 Water Management Strategy, 2017 A Made-In-Manitoba Climate and Green Action Plan, and the 2016 Manitoba Drought Management Strategy) will highlight key goals within the documents that this project responds to and incorporates into the design strategy. This project's design intervention is an exemplar for how a large-scale design strategy can encompass multiple landowners to provide individual and collective benefits, and therefore must be aware and responsive to current policies.

WATER MANAGEMENT STRATEGY

Published in November 2022, Manitoba's updated Water Management Strategy includes eight guiding principles, 11 focus areas, and 47 strategic objectives to help fulfill its mission of ensuring "the stewardship and protection of Manitoba's waters to meet environmental, social, and economic needs, today and tomorrow."[61] The Strategy is intended to be both a long-term framework for future decision making and an iterative short-term water action plan that outlines specific, measurable goals and actions. The 11 key focus areas are:[62]

1. Make every drop count through conservation and efficient water use.
2. Protect biodiversity and aquatic ecosystem health.
3. Build our preparedness and resilience to a variable and changing climate.
4. Address our water infrastructure challenges and opportunities.
5. Meet the water supply needs of current and future generations sustainably.
6. Protect the quality and quantity of groundwater.
7. Protect and improve surface water quality.
8. Advance Indigenous inclusion in water management.
9. Improve coordination of water management and governance across watersheds, basins and aquifers.
10. Improve data, information, and knowledge available on water.
11. Enhance engagement and participation of Manitobans in water stewardship.

The design strategy aligns with many of these focus areas and strategic objectives, specifically:

3. Build our preparedness and resilience to a variable and changing climate.
   - Improve surface water management at the watershed scale, including retention and drainage.[63]
4. Address our water infrastructure challenges and opportunities.
   - Prioritize incorporating natural infrastructure and nature-based solutions to water management challenges.[64]
7. Protect and improve surface water quality.
   - Reduce excess nutrient loading to Manitoba's waterways.[65]

DROUGHT MANAGEMENT STRATEGY

Southern Manitoba is more known for its flooding than drought troubles but as the Drought Management Strategy outlines, the province has been struck by drought in the 19th century, the 1930s, the early 1960s, the late 1980s, the early 2000s, and most recently about a decade ago.[66] Manitoba follows the Western Water Stewardship Council's definitions of the different types of drought: *meteorological drought*, which "only refers to the reduction in precipitation amount"; *agricultural drought*, occurs when there is insufficient water for a certain crop, it "depends on the amount of rainfall, prevailing soil moisture conditions, evaporation, and transpiration"; *hydrological drought*, "the effect of low rainfall on water levels in rivers, reservoirs, lakes, and aquifers," these droughts are only recognizable some time after meteorological droughts; and finally *socioeconomic drought*, "when the supply fails to meet the demand for an economic good such as domestic water supply."[67] The Strategy goes on to outline action items for identifying and managing drought. Relevant to this project are three of the 13 proposed drought management strategies:[68]

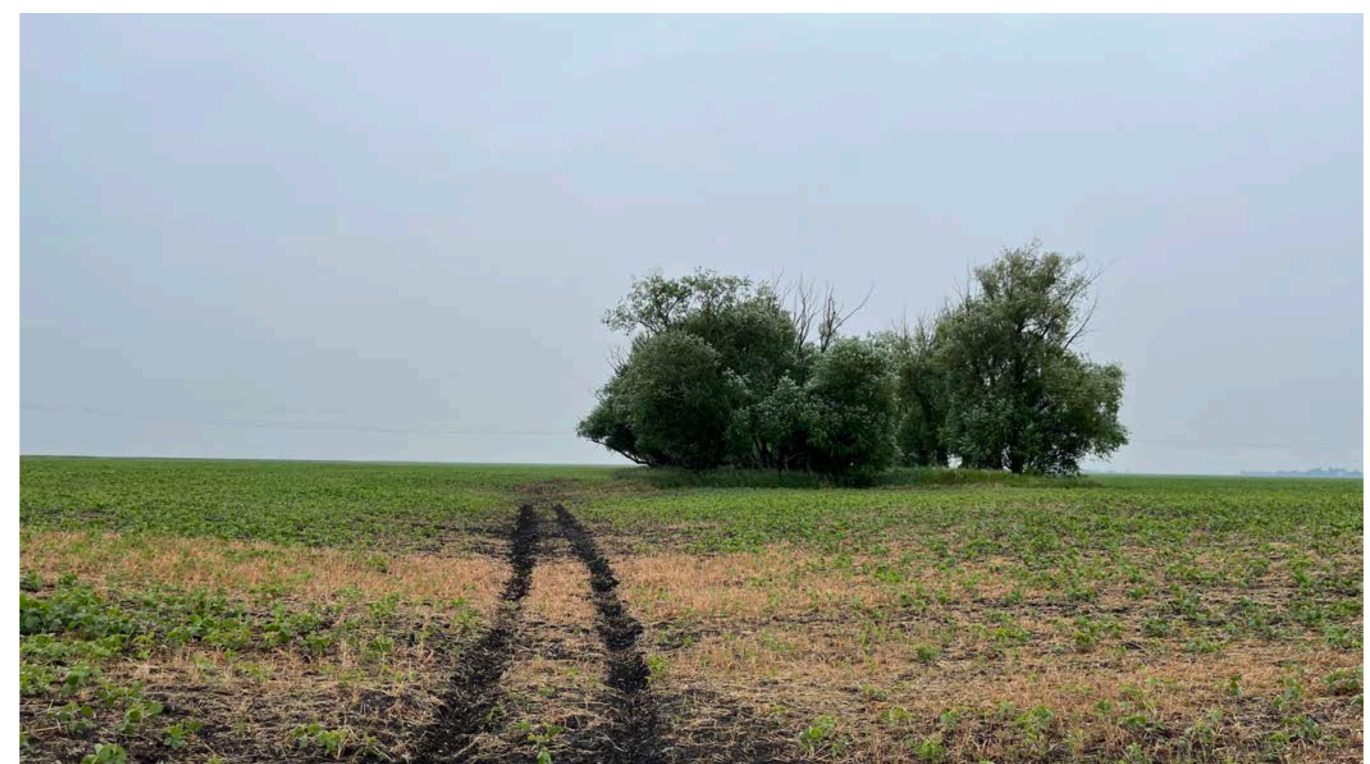
5. Drought tolerant agriculture
6. Restoration of wetlands
9. Demand management – Water efficiency and reduced consumption.

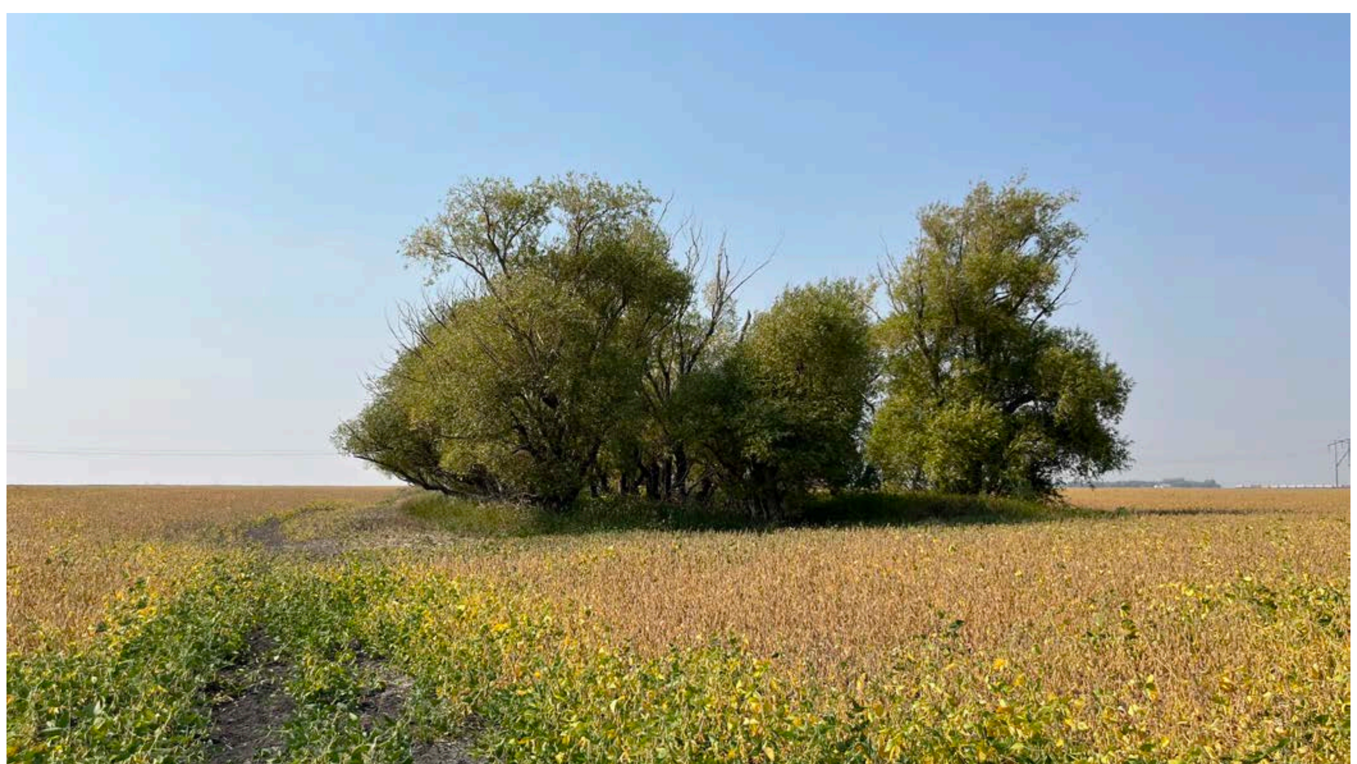
The design adapts the agricultural landscape to better withstand drought through the reintroduction of prairie grass hay and creation of wetlands in Shannon Creek which provides landowners with additional water reservoirs, thereby decreasing demand on the main water supply.

CLIMATE AND GREEN PLAN

The Made-in-Manitoba Climate and Green Plan, hereafter referred to as the Climate Plan, was released in 2017 with the intention of making Manitoba "Canada's cleanest, greenest, and most climate resilient province."[69] The Climate Plan defines a climate-resilient society as one that "is able to withstand, respond, and recover quickly from the impacts of a changing climate."[70] The Plan is a strategic framework with four pillars: climate, jobs, water, and nature. The climate pillar focuses on reducing greenhouse gas emissions and investing in renewable energy sources. The jobs pillar builds on this by creating jobs in the renewable energy, green infrastructure, and green technology sectors. The nature pillar focuses mainly on conservation of existing wilderness areas and building upon the provincial park system. I have focused on the water pillar as the four keystones under it are the most related to this project: agriculture and land use, flood and drought, wetlands and watersheds, and water quality.[71] An overarching commitment to note is the provincial government declaring a "no net loss principle of water retention," meaning that the overall water storage capacity within a watershed will not be reduced due to human activities.[72] This implies a commitment to retain existing wetlands, but rather, necessitates the creation of new ones should a 'need' to fill some in arise. Within the four keystones this project specifically responds to almost all the recommendations directly:[73]

1. Wetlands and watersheds
   - Watershed planning
   - Wetlands
2. Agriculture and land use
   - GROW
   - Drainage and water retention
3. Flood and drought
   - No net loss
   - Drought defense
4. Water quality
   - Managing excess nutrients





WATERSHED DISTRICT GROW PROGRAMS

GROW (Growing Outcomes in Watersheds) was established under the province's Climate Plan in 2019 with an initial investment of $52 million from the provincial government to improve watershed climate resiliency and water quality.[74] The program is delivered through the Watershed Districts with support from the Winnipeg Foundation and the Manitoba Habitat Heritage Corporation. It supports initiatives that:

— Retain water.

— Conserve, restore, and/or enhance wetlands, riparian areas, and upland areas.

— Establish shelterbelts.

An additional Wetlands GROW Trust was established to protect Class 1 and Class 2 ephemeral and temporary wetlands, which the design strategy ties into well.[75] Through GROW, 1,295 ha of wetlands have been conserved and 140 ha of drained wetlands have been restored.[76] The difference between GROW and this project is that GROW is geared towards individual property owners and their specific project(s), and this project proposes to use GROW as the mechanism to deliver a wider ranging intervention. This project proposes a large-scale project across provincial waterways that impacts multiple landowners. By using an existing program like GROW, these landowners can be financially incentivized to join the project, thereby exponentially increasing the ecological goods and services for themselves, their neighbours, and the watershed district as a whole.

TRANSITIONAL CONCLUSIONS

Manitoba has some progressive policy and strategy documents that provide an aspirational, if at times, vague, roadmap to climate resiliency. The design strategy responds to many of the province's existing strategy points, demonstrating a plan that is rooted in reality and possibility. It also goes further by suggesting system-scale interventions that have a larger impact than the individual projects GROW currently allows for.

8.0
ANALYSIS IMPLICATIONS

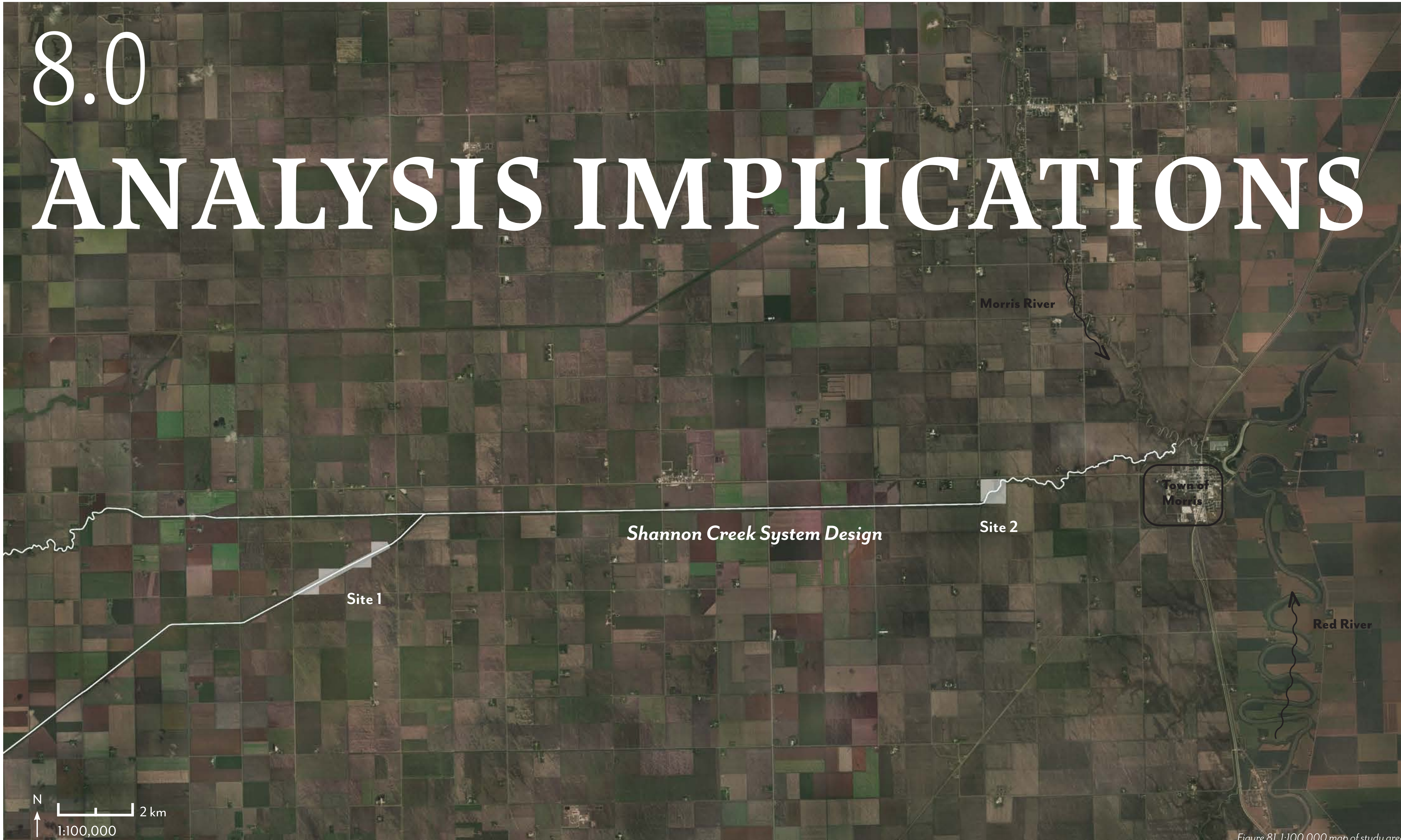


Figure 81. 1:100,000 map of study area.

NATURAL HISTORY + LANDSCAPE ANALYSIS

Literature research, site analysis through GIS mapping, field observations, and policy analysis all informed the decisions that follow. The complex geomorphology of the Red River Valley and ongoing human impacts, learned through peer-reviewed articles, books, and government and news websites, necessitated using GIS to understand the current soils, ecoregions, and water levels in relation to the historic record. Knowing about the incredible flatness of the valley; pervading clay soil; the projected increase in spring rainfall and reduction in summer rainfall means I know I cannot attempt to prevent large-scale overland flooding. However, knowing clay soil is amenable to holding water led to the idea of creating wetland reservoirs filled by spring flooding, allowing farmers use the water in these reservoirs into the summer.

HUMAN HISTORY

Reading about the human impacts on the region, especially in the last 150 years made it clear that the natural hydrology had been massively reworked, creating a functionally and aesthetically very different landscape. Perhaps most importantly, emphasized by the 20th century drainage ditch conflict, there is a strong cultural landscape. Southern Manitoba is the heartland of farming in this province. Additionally, this farmland is critically important to the economic health of Manitoba. To completely rewrite the grid in Southern Manitoba is unrealistic and unfeasible, both logistically and culturally.

KEY LANDSCAPE FEATURES

The cultural landscape reveals the vernacular use of shelterbelts and dugouts. Farmers are already making individal interventions to work with the Prairie climate. This also reflects the void left by wetlands and grasslands and their ability to regulate water levels. Researching shelterbelts, wetlands, and prairie grass hay, in conjunction with site visits, demonstrated their effectiveness in the landscape, making them the key landscape features used in the design.

POLICY ANALYSIS + FIELD OBSERVATIONS

Programs like GROW help rehabilitate and establish shelterbelts and wetlands in the agricultural landscape through financial incentives. The government does seem committed to funding climate-resilient schemes, however the design still hinges on public participation and must therefore have a low threshold to enrollment. Pragmatically, the design only applies to the land *within* the existing diked provincial waterways. The provincial waterways are maintained by the province, the Rural Municipality (RM), or the owner of the adjacent field. From field observations, the maintenance regime appears to be the same; a mown, grassy ditch. Altering this easy-to-maintain landscape will require some convincing, in response, the design is repeating, simple, and can be navigated with standard farm equipment.

EVERYTHING TOGETHER

As Sub Research Question 1: *How do we renaturalize heavily modified hydrology (drainage districts) and still allow for productive agriculture?* indicates, I began this project with the intent of creating an overarching design with wide-ranging impacts. Through research and large-scale mapping I saw how this could be achieved. Shannon Creek is an example site for what an intervention across provincial waterways could look like. However this research did not always translate to what I saw on the ground during field observations. Field observations at eight locations gave me insight into agricultural plants, drainage ditches, wetlands, shelterbelts, and the dike system that situated the GIS maps in the landscape context. Two sites were chosen for site analysis mapping to investigate the possibility of smaller site-specific interventions. Researching these sites further gave me a better idea of scale but ultimately reinforced the necessity of an overarching design in order to achieve my main Research Question of: *How do we develop a healthy, working landscape that more effectively balances water across the seasons now and into the future?*. Therefore, Sub Research Question 2: *How do we create a permanent wetland in a regularly flooded area that acts as both spring sponge and summer reservoir?* is answered by the design of Shannon Creek itself.

EXPLORATIONS + ITERATIONS

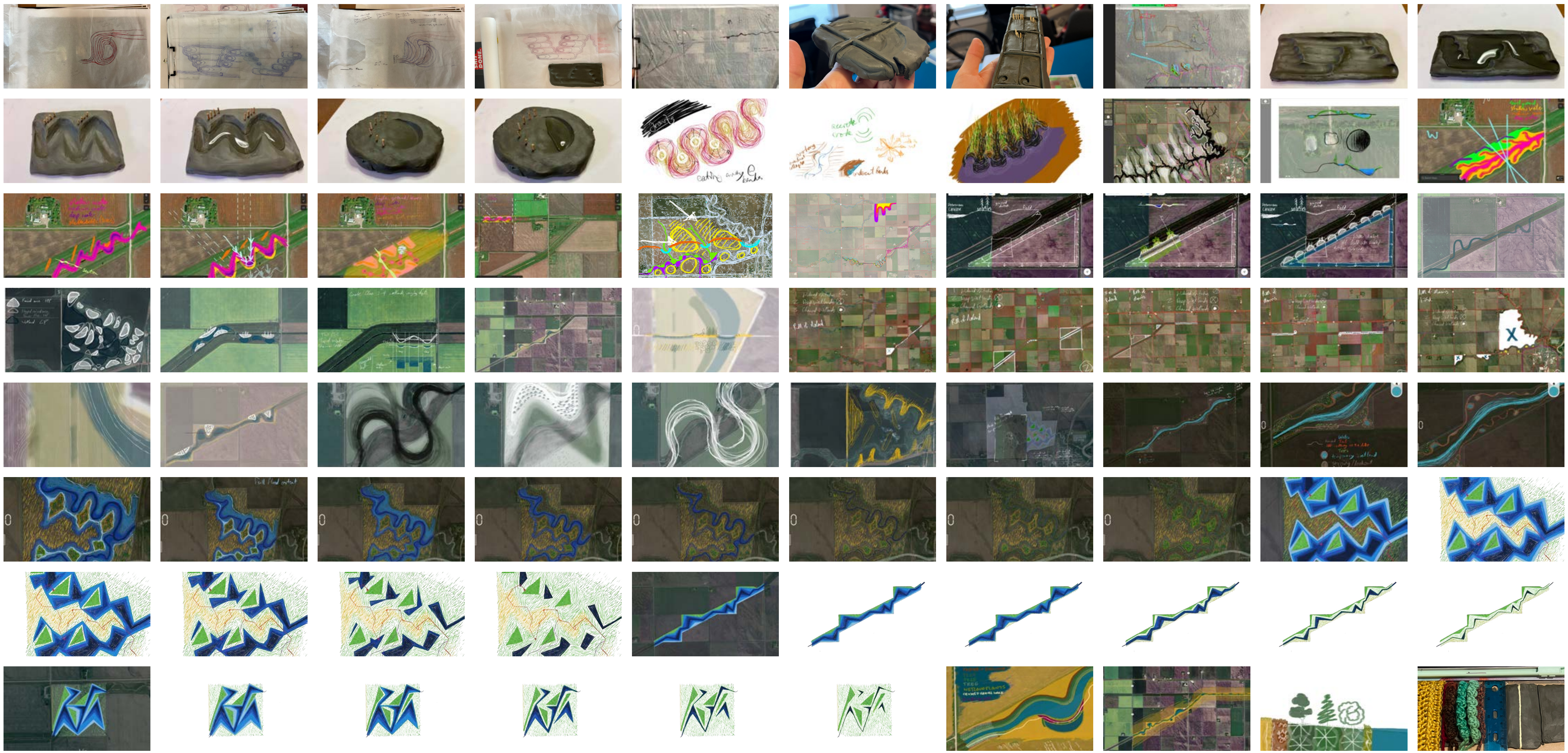


Figure 82. Compilation of design iterations.

Figure 83. Satellite image of natural drainage lines in the study area.

Figure 84. Photo of natural drainage lines near Location 4.

MOVING FROM ANALYSIS TO DESIGN

Figure 82 demonstrates just some of the iterations from the past six months. The final design is a quiet combination of them all, intended to be a conversation between the issues of agriculture, water management, and climate that seemingly compete, but in truth can be aligned. The proposed function has been made clear, to collect water and support agriculture, in a sustainable way. The form reflects this function. Since the first site visit I have seen small divots in the landscape where the grass grows greener and taller, perceptible both on the ground and via satellite, seen in Figures 83 and 84.

Green lines in the landscape indicate water and this project is all about the presence of water.

— Natural lines of trees - riparian - a stream
— Planted lines of trees - shelterbelt - a dugout, a pond - a landmark

The design is marked by dense shelterbelts coupled with deep wetlands, a meandering Shannon Creek home to many shallow wetlands, prairie grass dikes, and a continuous, sparse line of trees along the northern dike. This line performs the function of a field shelterbelt, aiding in even snow coverage across the site, as well as creating a form perceptible on the ground and via satellite. A signal visible from far across the flat landscape - there is water here, there is life here.

Figure 85. Perspective drawing of the proposed sparse, continuous shelterbelt.

9.0

DESIGN STRATEGY

Figure 86. 1:100,000 map of proposed intervention across provincial waterways.

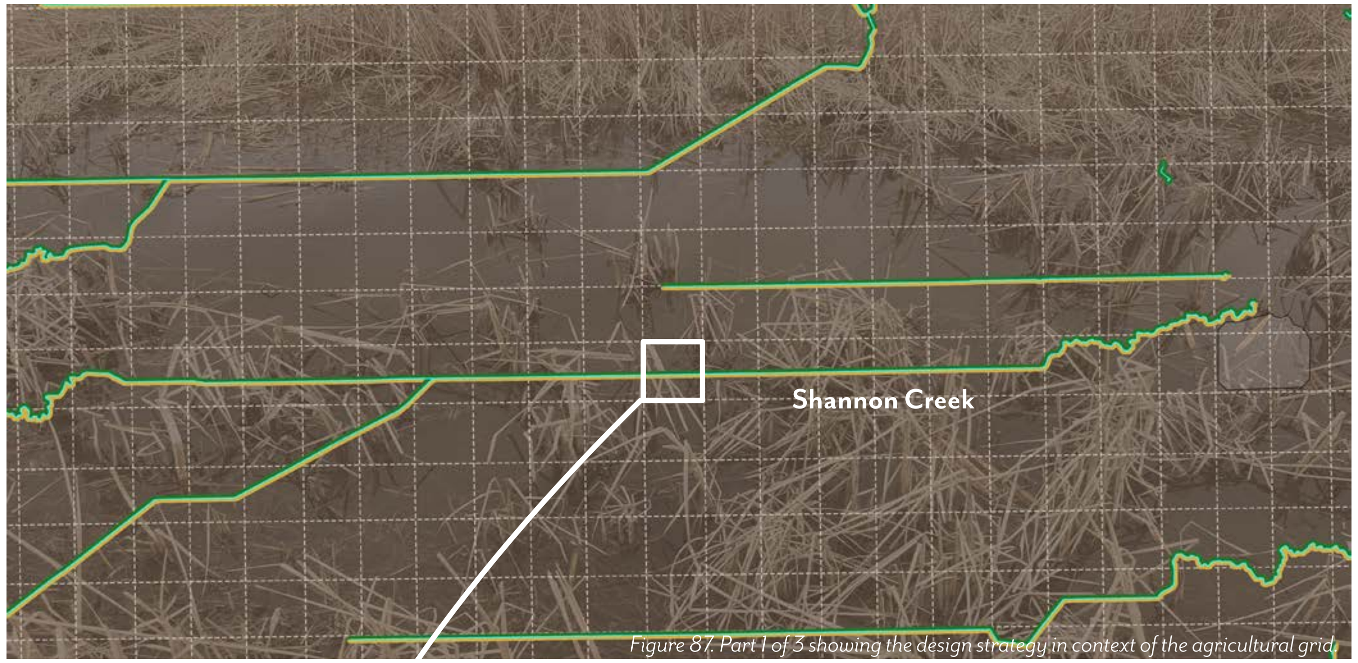


Figure 87. Part 1 of 3 showing the design strategy in context of the agricultural grid.

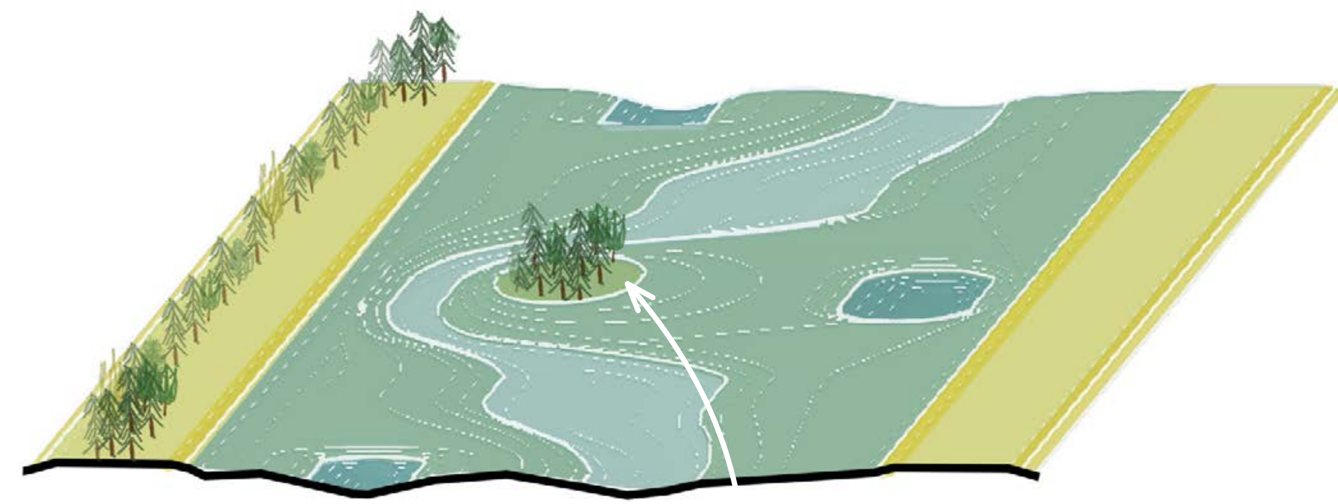


Figure 89. Part 3 of 3 showing the detailed design strategy.

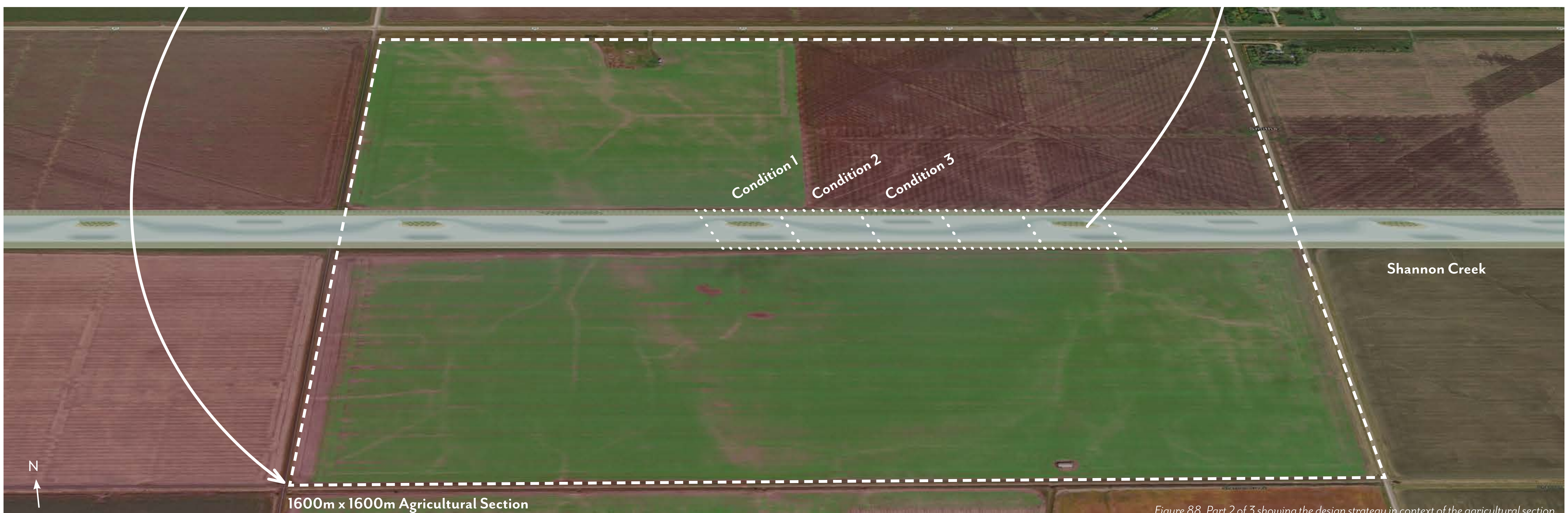


Figure 88. Part 2 of 3 showing the design strategy in context of the agricultural section.

SYSTEM DESIGN PRINCIPLES

This design uses provincial waterways as an entry point to creating a climate-resilient, agricultural landscape. It achieves this by:

— Increasing water storage capacity through the addition of ***shelterbelts***, ***wetlands***, ***and prairie grasslands***.
  - Eases seasonal spring flooding caused by rain and snow melt.
  - Eases seasonal summer droughts caused by lack of reliable rainfall.
  - Watershed becomes more climate resilient.

— Working with farmers.
  - Reduces unwanted flooding by creating conditions for planned flooding in controlled areas (provincial waterways with enhanced water storage capacity).
  - GROW program compensates property owners for initial start-up costs, like planting and regrading.
  - Harvestable hay spans the site, increasing the economic viability of this project.
  - Water is available later into the summer in the wetland reservoirs.
  - Farmers choose from a selection of shelterbelt, wetland, and prairie grass species to allow for individuality and a sense of autonomy, while ensuring the design's functionality remains intact.

— Looking to the past to prepare for the future.
  - Understanding the historic, ecological condition of the Prairie: wetlands, grasslands, intense climate.
  - Bringing these elements that work so well together, back, in a way that works with agriculture, and can brace for current and future climate change.
  - Aligning shelterbelt locations with downwind wetlands to ensure maximum snow capture, learning from vernacular practice.
    - Collecting snow in place, replicating the creation of natural ephemeral wetlands that spring from snow melt.
    - Shelterbelt trees provide many ecological goods and services (EGS) such as habitat creation, carbon storage, and improve air and water quality.
  - Native prairie grasses in place of traditional hay crops to adapt to future climate.

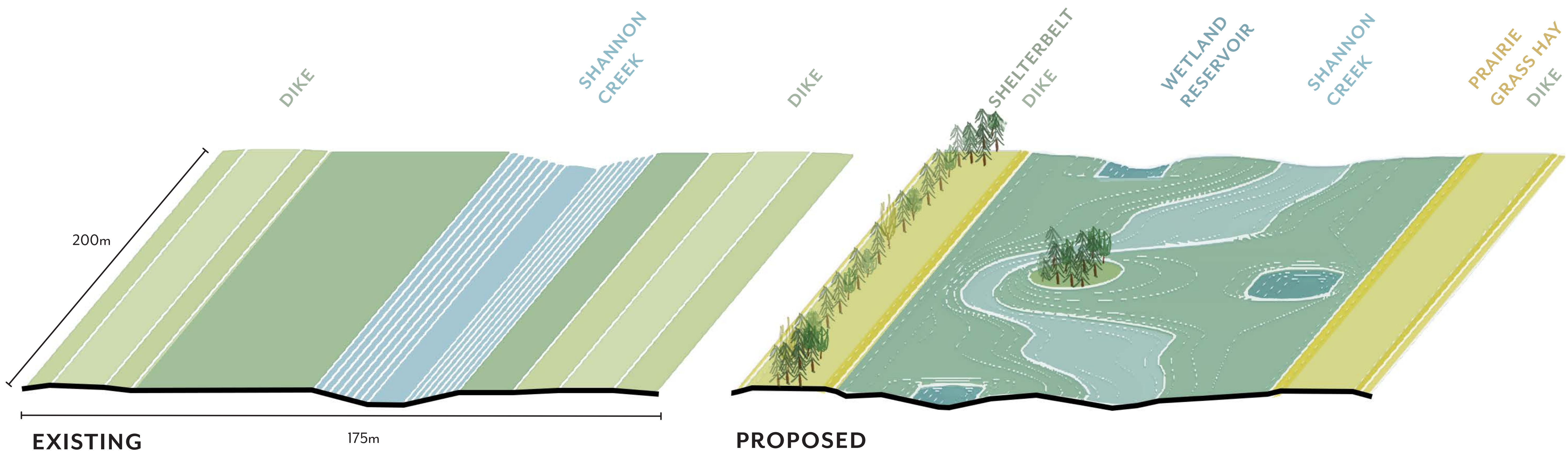


Figure 90. Axonometric views of existing Shannon Creek (left) and proposed Shannon Creek (right).

CHANNEL DESIGN OVERVIEW

This intervention has been designed to fit into an existing provincial waterway's footprint, specifically Shannon Creek. Keeping it along agricultural section lines and within the existing dike system minimizes disruption to farmers. Agricultural "sections" are approximately 1600m x 1600m, based on the original mile-to-mile grid. This intervention allows farmers on quarter (800m x 800m), half (800m x 1600m), and full (1600m x 1600m) sections access to at least one reservoir. The design repeats from west to east along the waterway. There are three proposed conditions that are each approximately 200m wide and bound by the existing north and south dikes. These dikes are raised 0.5m to increase the system's water capacity. Moving from north to south, each condition can be distilled to:

— **Condition 1:** Dense shelterbelt *to* wetland reservoir *to* Shannon Creek
— **Condition 2:** Sparse shelterbelt *to* Shannon Creek
— **Condition 3:** Shannon Creek *to* dense shelterbelt *to* wetland reservoir

Site analysis has shown that shelterbelts planted on the windward (north, northwest) side of dugouts (small ponds) are a common practice throughout rural Manitoba. The prevailing winter winds are from the north and northwest and from the south and southwest in the summer. Placing a shelterbelt on the windward side of a depression slows the wind, causing it to drop the snow in that depression. This combination collects snow and snow melt in place for use later in the year. Natural wetlands used to be common place in this landscape and are a larger, more ecologically-sound version of a dugout. This design elevates and amplifies the vernacular practice of shelterbelts and dugouts by planting elevated shelterbelts on the north/northwest side of deepened portions of the provincial waterway bed to collect snow within a controlled area to increase water storage and reduce unwanted drifting snow.

The southern summer winds are interrupted by planting tall prairie grasses on the southern dike of the provincial waterway. Both the elevation and vegetation slow wind, reduce soil erosion, and combined with the shelterbelts on the northern side, keep much of the moisture in this small riparian valley. Prairie grasses planted in lower elevations of the dike can tolerate short-term standing water and account for some of the Class 1 - 2 wetland plantings. Here they clean provincial waterway water as it moves through the system, reducing nutrient load in Lake Winnipeg and providing a cleaner habitat for numerous species. The grasses are harvested in the fall, which provides income for the farmer, and cleans out the wetland, preventing build-up of nutrients. Shelterbelts, wetlands, and prairie grasses create a provincial waterway water management system that collects, retains, and cleans.

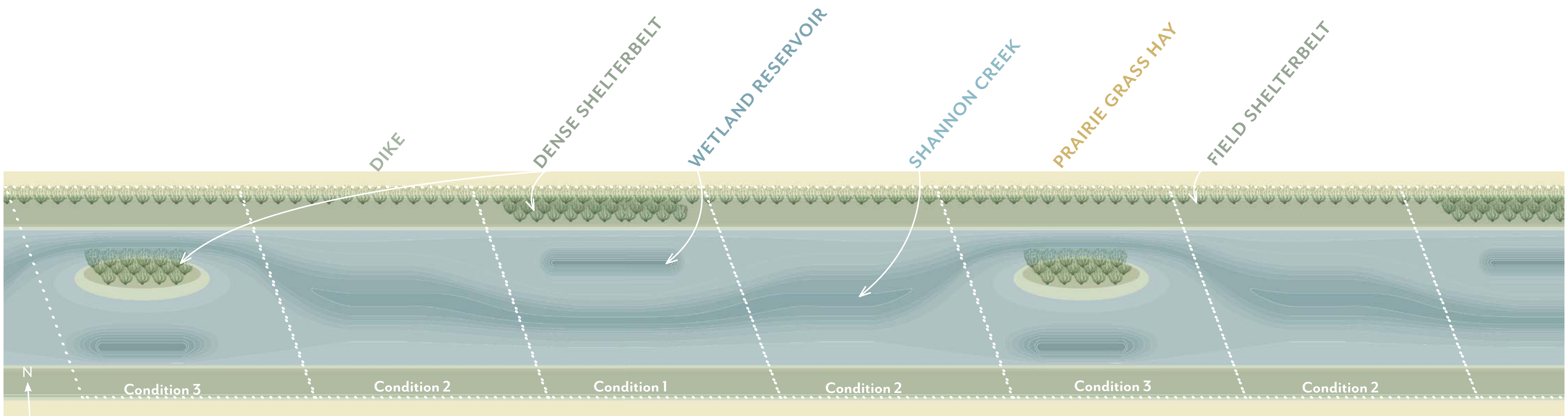


Figure 91. Channel design overview in plan perspective showing system design elements.

CHANNEL DESIGN ELEMENTS

PRAIRIE GRASS HAY

— Prairie grass hay is more cost-efficient than traditional crops since its adapted to this environment. It can be sold for the same price as other forage crops. It is more climate resilient to drought and flood than other forage crops.

DIKE

— Dike is raised 0.5m for a total 1m above Prairie Level to increase flood resiliency. Soil excavated from the wetland reservoirs and deepening Shannon Creek is used to build up the dikes.

— Slope is never more than 15 degrees across the site to ensure farm equipment access.

SHELTERBELT

— Three row shelterbelt to collect snow in reservoir. Minimal number of rows to allow some snow through and avoid widening dike further. Planted on the dike will increase their snow catching efficacy.

— Deciduous must be on windward side to reduce chance of leaf matter buildup in reservoir. Avoid fruit bearing and sparse branching patterns.

— Minimum two coniferous for appropriate density.

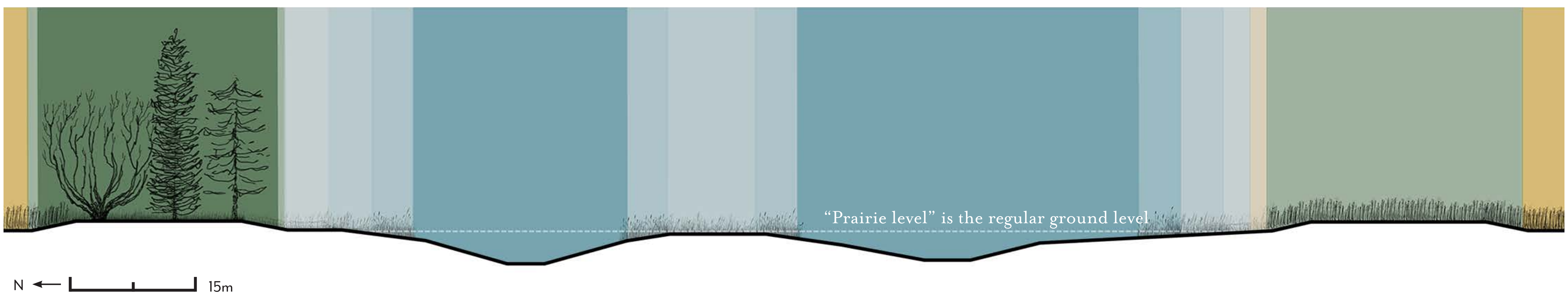


Figure 92. Condition I section demonstrating channel design elements, originally drawn at 1:200 scale.

WETLANDS

— Differing slopes and depths to allow for the full range of wetland classes.

— Provides habitat for a wide variety of flora and fauna.

— Helps reduce nutrient load, filtering water before it joins the Red River.

RESERVOIRS + SHANNON CREEK

— Spring floods and snow melt fill reservoir

— Deep enough to hold water year round most years.

— Slope allows for annual mowing to clean out sediment and organic matter that traps nutrients.

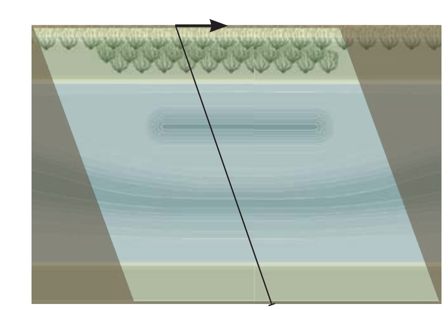


Figure 93. Condition I section line in plan.

DESIGN CONDITION 1

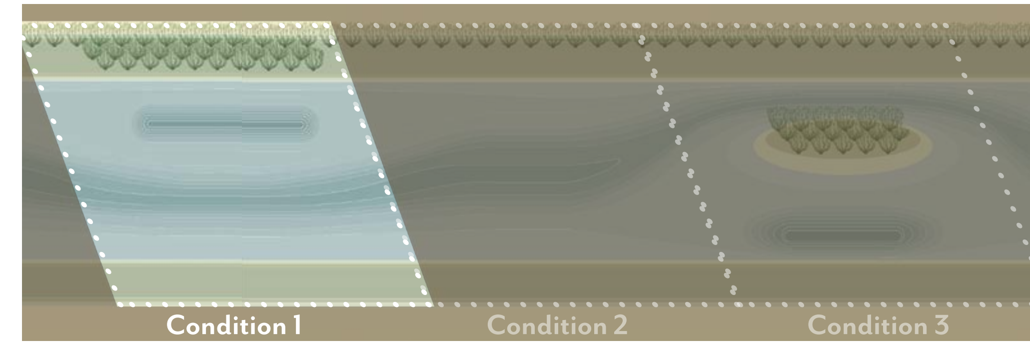


Figure 94. Condition 1 in plan.

Figure 95. Condition 1 tapestry section.

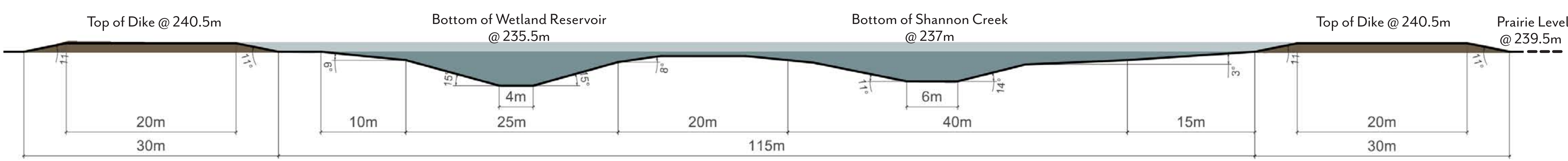


Figure 96. Condition 1 section showing high and low points. Light blue indicates seasonal water changes (Class 1-3 wetlands). Dark blue indicates Class 4 - 5 wetlands which are predicted to hold water year-round, most years.

DESIGN CONDITION 2

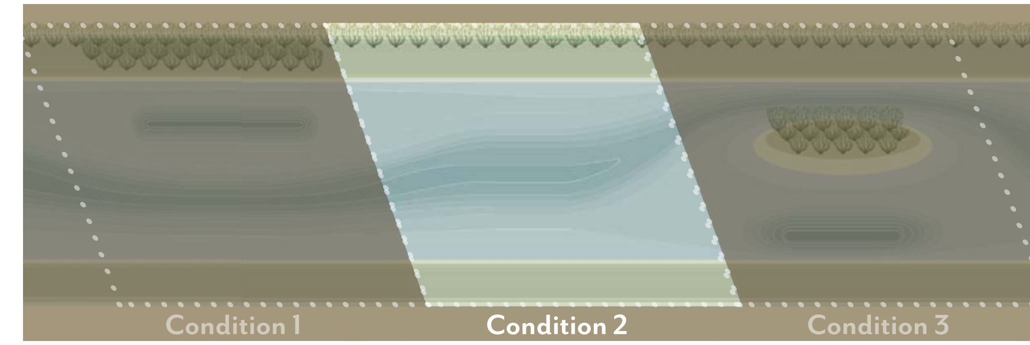


Figure 97. Condition 2 in plan.

Figure 98. Condition 2 tapestry section.

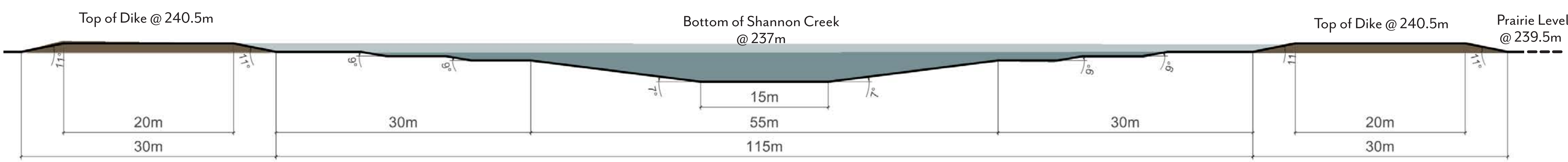


Figure 99. Condition 2 section showing high and low points. Light blue indicates seasonal water changes (Class 1-3 wetlands). Dark blue indicates Class 4 - 5 wetlands which are predicted to hold water year-round, most years.

DESIGN CONDITION 3

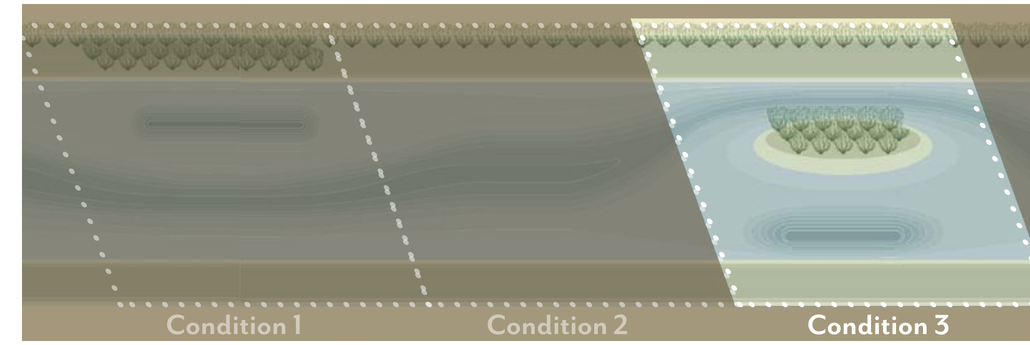


Figure 100. Condition 3 in plan.

Figure 101. Condition 3 tapestry section.

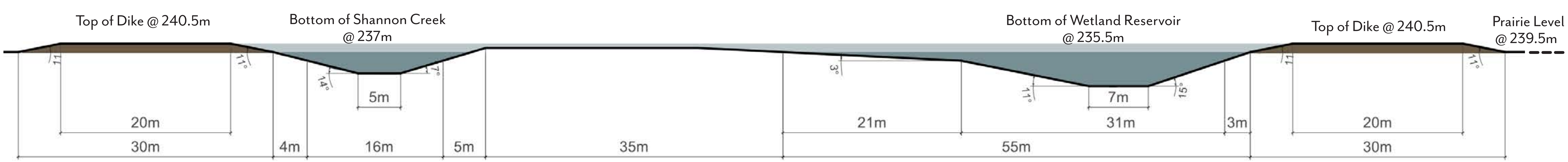
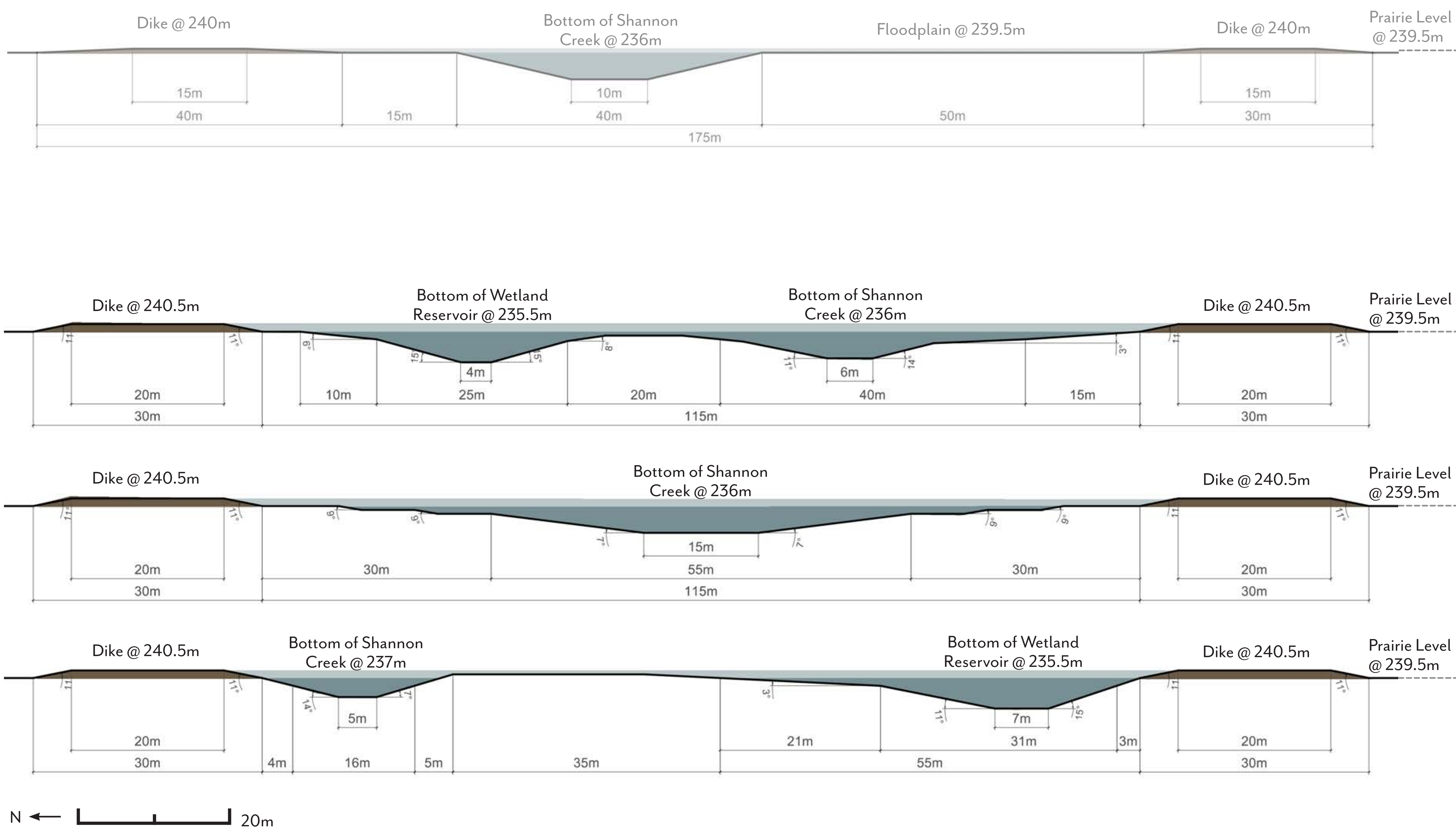


Figure 102. Condition 3 section showing high and low points. Light blue indicates seasonal water changes (Class 1-3 wetlands). Dark blue indicates Class 4 - 5 wetlands which are predicted to hold water year-round, most years.

WATER VOLUME CAPACITY

Perimeter: 1600m x 175m
Total Area: 280,000m²
Total Surface Area: 281,374m²

TOTAL **EXISTING** WATER VOLUME CAPACITY: 180,000M³



Perimeter: 1600m x 175m
Total Area: 280,000m²
Total Surface Area: 281,733m²

TOTAL **PROPOSED** WATER VOLUME CAPACITY: 311,935M³

INCREASES WATERWAY CAPACITY BY 70%

Figure 103. Sections of existing and proposed Shannon Creek demonstrating increased water volume capacity.

DESIGN ELEMENT 1: SHELTERBELTS

Shelterbelts are the backbone of the design strategy as they collect snow in the winter which produces spring melt, their roots stabilize the dike, and they create habitat year-round for birds, insects, and mammals. The farmers who live here and will be involved in making this design a reality can select from a species list for the shelterbelts, wetlands, and prairie grasses. Proposed species for the design's shelterbelts have been chosen based on a number of factors:

— Most are native to Manitoba which demonstrates their hardiness.

— Non-natives have been included as a way to introduce future-climate species, trees that may be better suited to a warming Prairie climate.

— A range of sizes, foliage and bark colour, seasonal colour change, texture and density of branches, and shrub clumping patterns have been included to create a vibrant tapestry of colour and texture across the horizon.

- This diversity allows for a greater range of habitat, a much more interesting composition, pest and disease resilience, and a sense of ownership for farmers choosing their preferred plantings.

— To reduce the amount of leaf drop in the wetland reservoirs, only coniferous are suggested on the water's edge. This will help minimize contamination of the water supply and improve water quality on site and throughout the system.

Figure 104. Photo of model showing snow trap and low water (ice) level.

Figure 105. Photo of model showing spring melt and high water level.

Suggested Shelterbelt Species

Sources include the Trans-Canada Highway Shelterbelt Project by Manitoba Habitat Heritage Corporation, the Province of Manitoba, and HTFC Planning and Design; as well as *Woody Plants in the Prairie Landscape* by Bill Remphrey and University of Manitoba Landscape Architecture professor, Philip Ronald.[77]

Coniferous Trees **(planted inside and/or leeward edge of shelterbelt)**

Picea glauca – White Spruce
Pinus strobus – Eastern White Pine
Pinus ponderosa – Ponderosa Pine
Pinus sylvestris – Scots Pine
Larix siberica – Siberian Larch
Juniperus scopulorum – Rocky Mountain Juniper

Deciduous Trees **(planted on windward edge of shelterbelt)**

Acer saccharum – Sugar Maple
Celtis occidentalis – Delta Hackberry
Populus deltoides 'Jefcot' – Cottonwood
Tilia americana – American Linden
Quercus macrocarpa – Bur Oak
Populus tremuloides – Trembling Aspen
Salix alba 'Vitellina' – Golden Willow
Salix alba 'Sericea' – Silver Willow

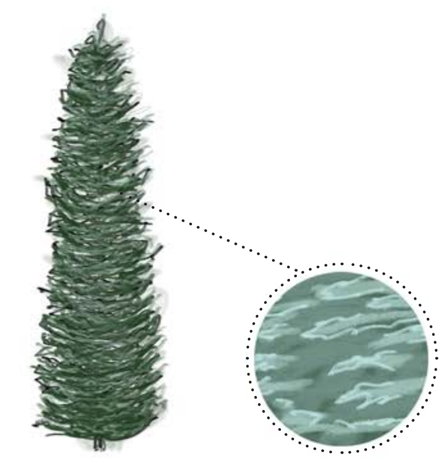
Deciduous Shrubs **(planted on edges of shelterbelt)**

Amelanchier alnifolia – Saskatoon
Syringa vulgaris – Common Lilac
Cornus sericea – Red Osier Dogwood
Corylus cornuta – Beaked Hazelnut
Prunus tromentosa – Nanking Cherry
Rhus typhina – Staghorn Sumac
Crataegus x mordensis – Hawthorn
Viburnum lentago – Nannyberry
Viburnum trilobum – Highbush Cranberry

Salix alba 'Vitellina' – Golden Willow

Golden Willow has a dense branching habit which makes it a preferred decidious tree for catching snow. Its yellow branch tips are one of the few deciduous plants that provide colour into the winter. It tolerates dryness and short-term flooding.

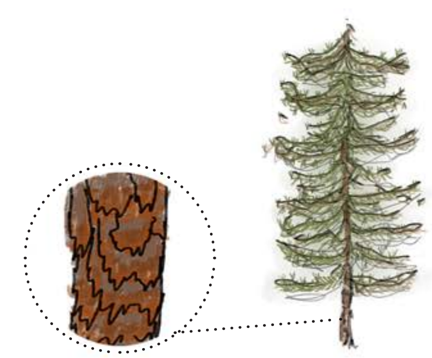
— Native to Euroasia
— Hardiness zone 2a



Picea glauca – White Spruce

White Spruce is a dense conifer with beautiful blue-green, smooth needles. Its branching begins low to the ground, increasing its impact on wind speed. It is tolerant of a variety of soil conditions and is effective solo or within a group.

— Native to Prairie provinces
— Hardiness zone 1b



Pinus ponderosa – Ponderosa Pine

Ponderosa Pine has an interesting, somewhat sparse, branching structure. It has long bunches of green needles and craggy, rust-brown bark. It is tolerant of most soils as well as hot, dry conditions.

— Native to western North America, not the Prairie provinces
— Hardiness zone 2b - 3a

Figure 106. Illustrations of example species highlighting foliage and bark characteristics.



Winter **Spring** **Fall**



Figure 107. Shelterbelts. Top row: site photos, bottom row: model photos.

DESIGN ELEMENT 2: WETLANDS

Wetlands provide essential water purifying services and can make a significant impact on reducing nutrient loads for downstream water bodies. This leads to needing to mow or burn back these wetlands on occasion to clear out the nutrients they have been trapping. Therefore, the design strategy has slopes that allow for haying and easy maintenance. The design strategy targets all classes of wetlands, with certain areas focusing on Class 1-2, Class 3, and Class 4 wetlands.

Suggested Wetlands Species

Sources include Ducks Unlimited and Prairie Originals.[78]

Class 1 – Low Prairie

Solidago – Goldenrod
Aster sp. – Aster
Symphyotrichum sp. – Aster
Symphyoricarpos sp. – Snowberry
Poa palustris - Blue Fowl Grass
Low Prairie Grasses

Class 2 – Wet Meadow

Carex sp. – Sedge
Juncus sp. – Rush
Spartina pectinata – Prairie Cordgrass
Rosaceae potentilla - Cinquefoil

Class 3 – Shallow Marsh

Alisma triviale – Water Plantain
Sparganium eurycarpum – Giant Bur Reed
Beckmannia syzigachne – Sloughgrass
Schoenoplectus tabernaemontani - Softstem Bulrush
Sium suave - Water Parsnip
Peltandra virginica - Arrow-Leaf Arum

Class 4 to 5 – Deep Marsh to Open Water

Typha latifolia – Broadleaf Cattail
Schoenoplectus acutus – Hardstem Bulrush
Lemna sp. – Duckweed

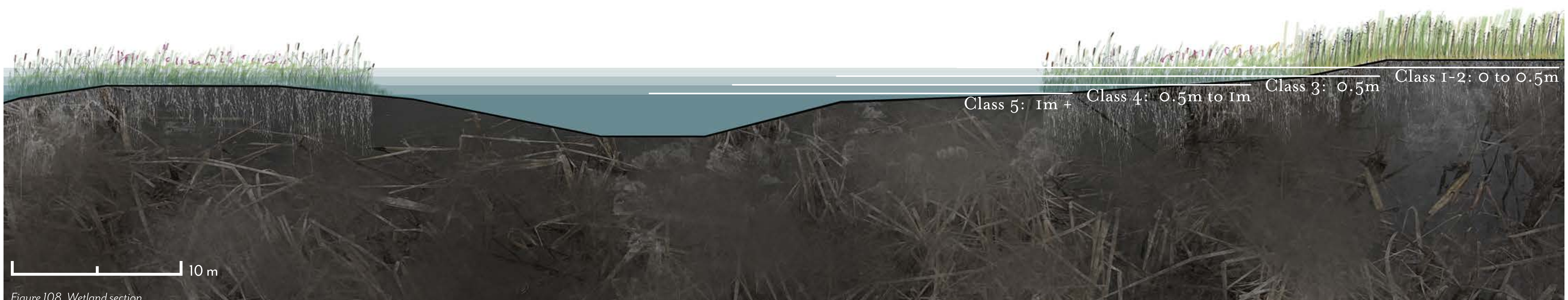


Figure 108. Wetland section.

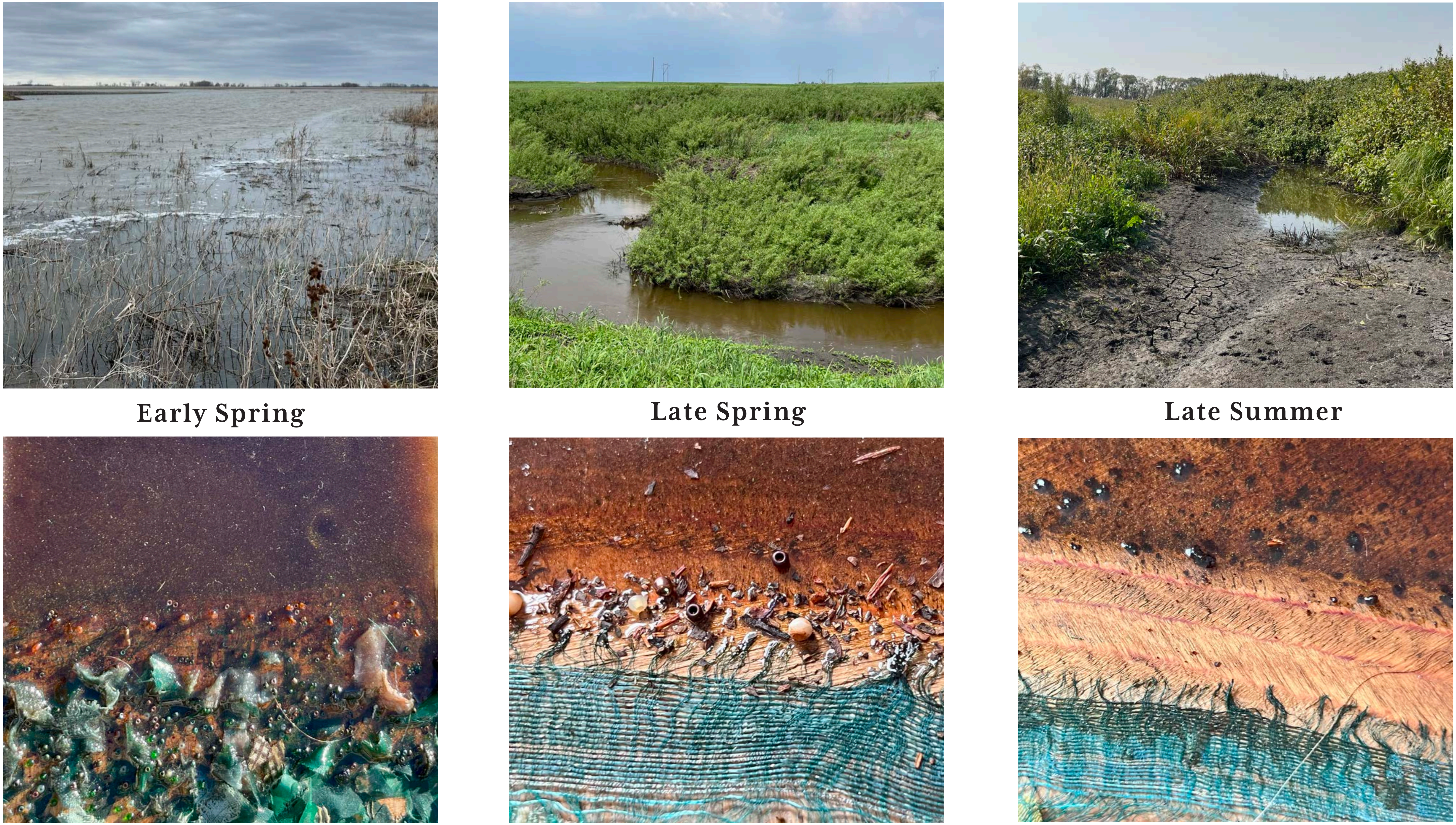


Figure 109. Wetlands. Top row: site photos, bottom row: model photos.

DESIGN ELEMENT 3:PRAIRIE HAY GRASSES

Prairie hay grasses as an alternative crop is the final driving element of the design. Using native grasses traps carbon and increases climate resiliency through their resistance to flood, fire, and forage. These benefits are largely due to their root stock being significantly more long and dense than their above-ground plant material. They provide ecological goods and services as well as an important economic component to the strategy. Although farmers get financial incentives through the GROW program, this masterplan strategy needs to provide a route to financial viability if it is to be self-sustaining. Switching to prairie hay grasses allows for a comparable sale of crops now and increased climate resiliency into the future.

Suggested Prairie Grass Species

Sources include Ducks Unlimited, Agriculture and Agri-Food Canada, and Native Plant Solutions.[79]

Pascopyrum smithii - Western Wheatgrass
Agropyron cristatum - Northern Wheatgrass
Nassella viridula - Green Needlegrass
Schizachyrium scoparium - Little Bluestem
Elymus caninus - Awned Wheatgrass
Elymus trachycaulus - Slender Wheatgrass
Panicum virgatum - Switchgrass
Andropogon gerardi - Big Bluestem
Dalea purpurea - Purple Prairie Clover
Bouteloua curtipendula - Sideoats Grama
Sorghastrum nutans - Sorghastrum
Sporobolus heterolepis - Prairie Dropseed
Panicum virgatum - Switch Grass

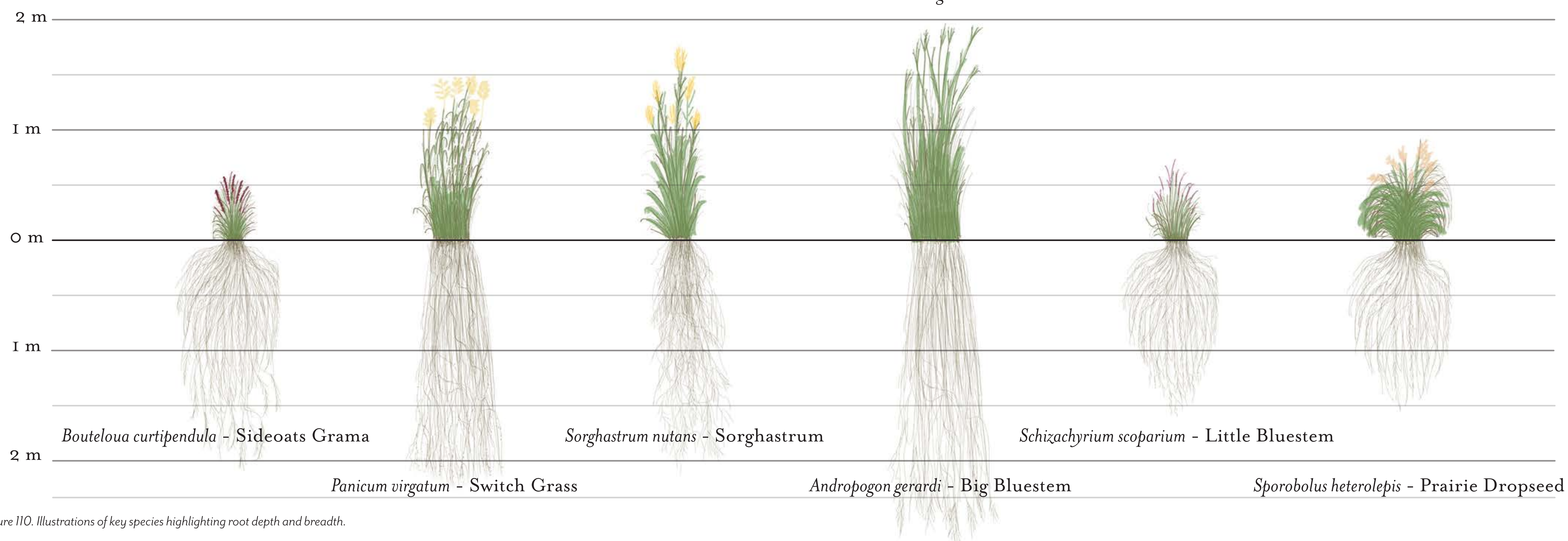


Figure 110. Illustrations of key species highlighting root depth and breadth.



Late Winter | **Late Spring** | **Late Summer**

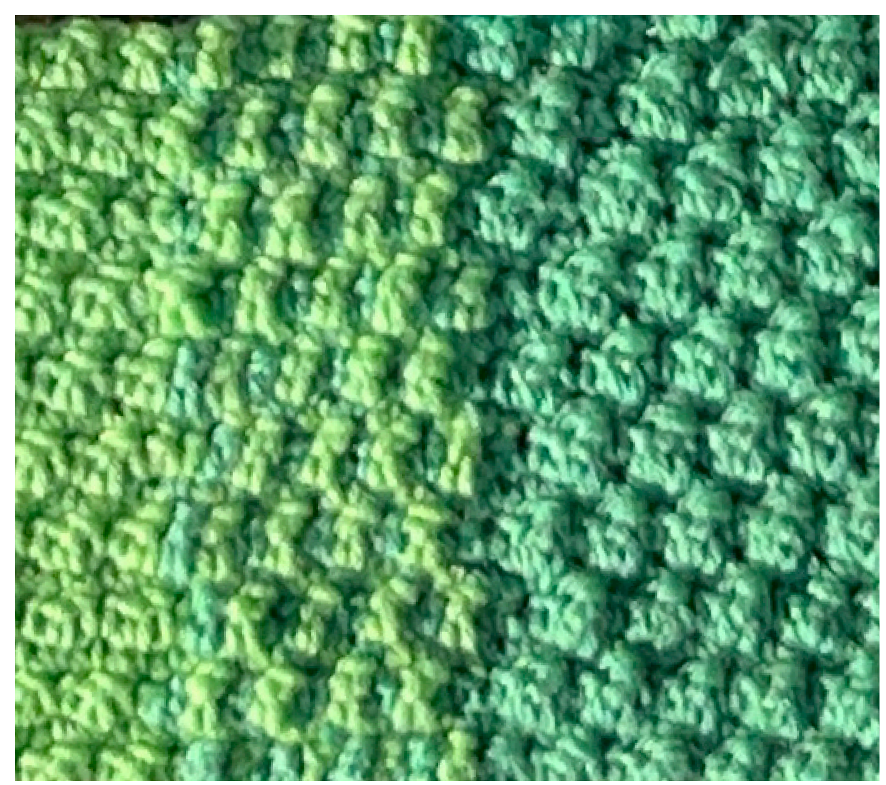
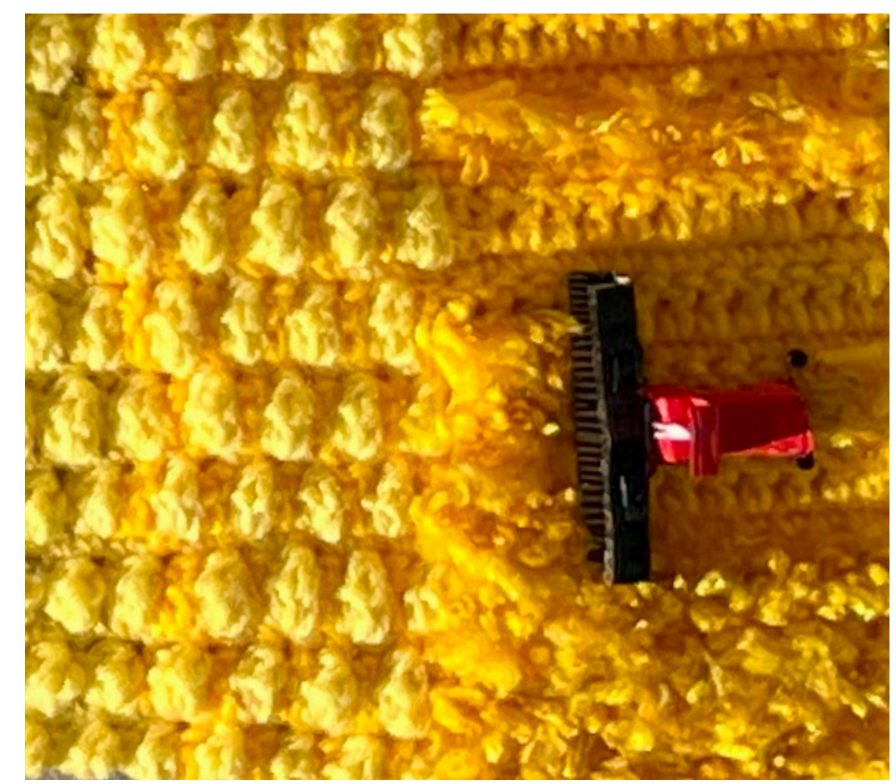




Figure 111. Grasses. Top row: site photos, bottom row: model photos.

10.0 FURTHER EXPLORATIONS

POTENTIAL FUTURE SITES

The crux of the design strategy is large-scale change across provincial waterways. However, this does not negate the benefit of focusing on a few smaller, individual sites alongside a waterway that highlight the design principles at a more human scale. The flexibility of the system design allows for site-specific interventions when unique areas are identified and there is a desire to expand on the original design goals. Therefore, in addition to detailing the system masterplan, a brief overview of how two unique sites along Shannon Creek were chosen provides a road map for selecting special sites in other waterways.

Site 1

— Affordable, neighbouring slivers of farmland that abut each other and Shannon Creek connect patch habitat and provide more room for meanders to roam.

- Chosen after reviewing the property assessment parcel map and finding four sequential triangle pieces of land that are priced significantly lower than neighbouring sections and front onto Shannon Creek.
- If purchased from landowners by the Rural Municipality (RM) or the Province, could provide a significant sized wetland and riparian habitat, greatly contributing to ecosystem health and biodiversity in the region. More importantly for the design goals, there is significant space for water collection and detention. For comparison, the area of Site 1 is roughly the same area (2.5km^2) as Fort Whyte Alive, a reclaimed urban nature park in Winnipeg.

Figure 112. Context Map

Figure 113. Site 1 with property assessment parcel values.

Figure 114. Fort Whyte for size comparison to Site 1.

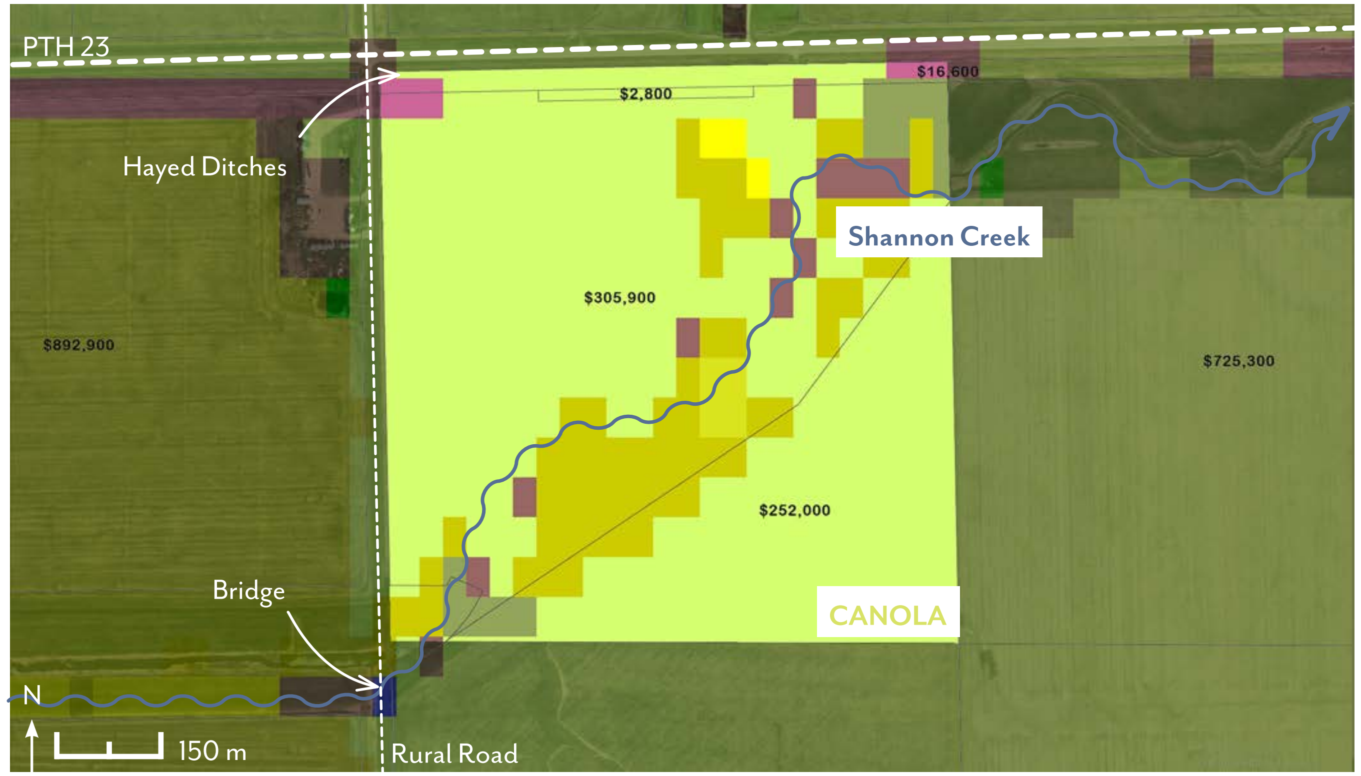


Figure 115. Site 2 context.

Site 2

- This is Field Observation Location 8 and was initially chosen to observe as its where Shannon Creek changes from canalized to meandering. During the monitoring period I learned the bridge that divides the channelized portion from the meandering portion of Shannon Creek is flooded every Spring and requires annual rebuilding, yet the streambed on the meandering (east) side of the bridge is dry by the end of the summer.
    - Chosen for further exploration after reviewing the crop cover inventory map and noticing that the 75% of the land cover at this site is Canola, a climate-insecure crop, making it an ideal location to trial native prairie grass haying.
    - The north side is bound by Provincial Trunk Highway 23 (PTH 23) and due to highway setback requirements, has much wider drainage ditches than along the rural roads. This wide ditch is currently being hayed, already demonstrating the ability to integrate wetlands and haying.
- Overall, this site is a great representative site to tackle the design issues of agriculture and water management.

At the time of applying the system design to a provincial waterway, the RMs and/or Province should be doing a site analysis and can identify unique opportunities at that time. Those land parcels can then be earmarked for further exploration and protected at the outset if funds are not available to develop them right away.

Figure 116. Bridge at Site 2 on May 14, 2023.

Figure 117. Bridge at Site 2 on September 3, 2023.

11.0 CONCLUSIONS

LIMITATIONS

On a scale this large, for the scope of a Masters practicum, some limitations and extrapolations are expected and must be acknowledged. The available contour data does not extend across the entire study site. However, the agricultural grid continues largely unchanged and Shannon Creek's profile is consistent in the canalized portions. Using a one section sized site (1600m x 1600m) that intersects the canalized portion of Shannon Creek (175m wide), an approximation was made for the volume of water that can be held in the creek in any one section. As the agricultural grid is prominent over much of the province, this sized site (the size of an agricultural section) and accompanying calculations can be used as a basis for other provincial waterways once the regular depth and profile of the waterway is known.

A longer monitoring period could have given more dimension to the understanding of winter in the agricultural landscape. Additionally, more intensive hydrological analysis would have provided more specific predictions for water holding capacity and flow rates. As with most research projects, now knowing what I know at the end of the project there are many things I would have done differently at the outset, but on the whole I am glad I went to site nine times and that I visited a variety of locations.

CONCLUSIONS

Southern Manitoba is evidence of everyone and everything that has come before. This project responds to the realities of the past and the challenges of the future. There are present day programs that enable positive change in our watersheds that impact our farmers, and by extension, our province. While this project has taken many twists and turns, the original plan for an overarching system that could have wide-ranging impacts, while allowing for site-specific adaptations, has been achieved. Renaturalizing provincial waterways can happen across the province through scaled up versions of GROW.

Background to Problem

Research into the natural history of Southern Manitoba brought to light the immense glaciolacustrine impact on topography, soil, and climatic conditions. The human history of the region, with particular emphasis on the last 150 years, demonstrated that enormous feats of engineering along the Assiniboine and Red Rivers had protected the City of Winnipeg from floods but did little to assist farmers upstream, nor work with the natural hydrological system. Understanding the combination of a flat, clay basin with a grid of drainage ditches meant I moved forward with developing a design that could to these pre-existing conditions.

Research Questions

The main Research Question of *How do we develop a healthy, working landscape that more effectively balances water across the seasons now and into the future?* was answered by the masterplan system design for provincial waterways, attacking the head of the drainage snake. Background research led me to the decision to design within the provincial waterway system as this grid is so heavily embedded into the physical and social landscape and would allow for a much easier adoption by landowners. The design brings the elements of shelterbelts, wetlands, and grasslands together to create a healthy water management system that still prioritizes agriculture. Using climate resilient techniques ensures that this landscape will more effectively balance water across the season now, and into the future.

Theoretical Framework

Due to referencing the theory of Landscape Ecology, I was aware that keeping the design within the bounds of the existing dike system meant the design adheres to an unnaturally straight corridor and edge which can reduce ecological diversity. However, streams and waterways "are corridors of exceptional significance in a landscape. Maintaining their ecological integrity in the face of intense human use is both a challenge and an opportunity to landscape designers and land-use planners."[80] Additionally, it can be argued that the installation of shelterbelts and grasses softens the edge-effect that is currently present in provincial waterways. Therefore, the decision to give precedence to both ecology and agriculture still offers many opportunities to positively impact the ecological health of the area through patch and corridor enhancements. Connecting patches of habitat in the form of wetlands and shelterbelts encourages flora and fauna recolonization of intermediate areas and reduces agricultural pollutants travelling downstream.[81]

Landscape Analysis

Becoming intimately familiar with common and repeating elements in the landscape allows the use of touchpoints in the design that will succeed climatically and will be received more positively by landowners. Already aware of shelterbelts from previous research, I sought these out both on the ground and via GIS satellite imagery, from there I found dugouts paired with many of these shelterbelts, dotted across the landscape. Building upon the background research which stated that marshy wetlands used to be commonplace led to the development of the design idea to pair shelterbelts with wetlands to build on the positive aspects of the natural and human history of the region. Prairie grasses were the final piece that added to the climate resiliency and future financial viability of the design.

Field Observations

Visiting the site in May shaped my viewpoint for the research and design to come. Following the initial field visit, eight locations were chosen for a two-month long monitoring period with weekly check-ins. These field observations filled in the gaps left by GIS and literature review and formed the backbone of the design intent. Synthesizing the information received on the ground and behind the computer screen felt at times to be a conflicting endeavour but ultimately meant a much richer design that acknowledged the competing interests in the landscape.

Policy Analysis

Research into existing policies led to opportunities to weave the design into existing infrastructure like GROW, making the whole system design more plausible. Understanding what options are available to landowners and how they could be inclined to change their section of waterway is integral to rooting the design in reality.

Design Strategy

Policy and literature research, GIS analysis, and field observations informed the design strategy by advocating for a re-introduction of ephemeral and permanent wetlands to hold snow and spring melt in place to both reduce spring flooding and keep water available for longer into the summer. Shelterbelts of grasses, shrubs, and trees work in tandem with the wetlands to provide more water collection and retention along the tributaries before they meet the Red River, establish habitat for flora and fauna, prevent erosion during freshet (spring melt), and create capacity for when the Red River swells. Prairie grasses reintroduced to the landscape in these relatively unused waterways offer the opportunity to reestablish this native ecosystem and lead to financial viability through haying.

At the 1:100,000 scale (Figure 86) the proposed system appears as long green lines following the existing canalized provincial waterways. In some areas where waterways are closer to each other, lines of trees on either side create a new, distinct framing of the previously wide open Prairie horizon. In other locations, just one waterway will be in view,

creating a closed horizon on one side, and in other areas the waterways are so far apart that the expansive Prairie view is still a reality. The visual, spatial, and functional impact of this design on the region would grow as the trees grow and take on a more dominating presence on the skyline. While it sounds bold, there are already numerous dense strips of plantings that are part of the familiar landscape. These existing shelterbelt plantings denote a homestead, water, life. The proposed shelterbelt plantings echo this message.

Conclusion

Bringing together regional geomorphology, agriculture, ecology, water management, and government policies with landscape architecture rooted in the Prairies resulted in a truly local design response. Learning from the land and its inhabitants meant the agricultural vernacular technique of shelterbelt tree plantings was paired with the reintroduction of wetlands. Using prairie grass species for hay creates a design integrated with the cultural context. Through it all, the desire to address the climate crisis, while ensuring the land can still be worked, is evident. The result is a much healthier, ecologically, landscape that has the capacity to hold 70% more water in times of flood, and due to integrated reservoirs, means times of drought are also less severe. This project has sought to balance many seemingly competing interests. Its success is made possible through the use of the beautiful, resilient, and intelligent ecosystems and natural processes already present in the landscape.

REFLECTIONS

This project speaks… shouts! to the future of landscape architecture. Landscape architects must wade further into agriculture, ecological restoration, and politics. The benefits of programs like GROW can be significantly scaled up with the design and planning skills of landscape architects. Facts and figures are critical for functional interventions, but the feeling of being in the landscape will be what changes hearts and minds. Landscapes are not machines to be engineered, but rather a tapestry of lives, soft breezes, and pouring rain to be woven together. Landscape architecture has always been transdisciplinary and the expansive general knowledge landscape architects have is a strength that multifaceted projects like this require. By the same token, farmers have much to teach academics, therefore only a reciprocal and respectful dialogue between experts will bring about beneficial change to the working landscape of Southern Manitoba.

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Software programs used:
ArcGIS Pro, Photoshop, InDesign, Illustrator, Vectorworks, Excel