

Rethinking Water Drainage in a Prairie Landscape

Seine River Diversion

by
Kartik Kumar

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in partial fulfillment of the requirements of the degree of

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Department of Landscape Architecture
University of Manitoba
Winnipeg

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Dedicated to Lost Nature.

Abstract

This practicum focuses on improving the ecological conditions of the Seine River Diversion located near the city of Winnipeg. The Diversion is one of Manitoba's many engineered drainage infrastructures with poor water quality, lacking in biodiversity and habitat. The main objectives of the practicum are improving the water quality in the Diversion, habitat and biodiversity restoration, and providing recreational opportunities to create a new public space adjacent to the Diversion.

After conducting a detailed investigation of the existing conditions, historical context and the Diversion's impact on the large-scale landscape that emerged from under the glaciers, sites parallel to the Diversion that possess a potential for meeting the practicum's objectives are identified.

One site is distilled from the many potential sites, and a prototype design proposal that meets the goals and objectives of the practicum is developed in detail. An examination of the projects that can act as precedents for the prototype design is carried out to determine a sustainable and resilient design strategy.

The prototype design utilizes green infrastructure to propose a self-sustainable system that satisfies the practicum's objectives. Wetlands are proposed to collect, retain and treat the impure water from many sources of pollution before its release into the Diversion. The proposal improves the ecological conditions of the Seine River Diversion and tackles the issues of loss of habitats and biodiversity that are present globally.

Acknowledgements

To my committee chair, professor Dietmar Straub. Thank you for supporting me through this journey. I've learned a lot from you. At the onset of the graduate program, my belief in Landscape Architecture's engineering side was shaken. Thank you for restoring it and helping me to recognize that Landscape Architecture is not just aesthetics, sociology, ecology or engineering. It encompasses all of these fields and many others.

To my internal examiner, professor Anna Thurmayr. I have benefitted the most from the constructive criticisms provided by you. Thank you.

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Contents

Abstract

iv

Acknowledgement

v

List of Figures

viii-xi

0.1 Introduction (1 - 4)
0.11 Narrative Map

0.2 The Ghost - Lake Agassiz (5 - 10)
0.21 Introduction
0.22 Water History
0.23 Glacial Deposits
0.24 Vegetation

0.3 The Remnant - Lake Winnipeg (11 - 18)
0.31 Lake Winnipeg Watershed
0.32 Eutrophication
0.33 Sources of Nutrients
0.34 Carriers of Nutrients
0.35 Lake Winnipeg Usage
0.36 Netley - Libau Marsh

0.4 The Energetic Red River (19 - 24)
0.41 Introduction
0.42 Red River Watershed
0.43 Soils
0.44 Flooding

0.5 The Grid - Wet Prairie History (25 - 32)
0.51 Loss of Wet Prairie
0.52 Drainage Disputes
0.53 Watershed Approach

0.6 The Waning Seine River (33 - 38)
0.61 Seine River Watershed
0.62 Present Usage
0.63 The Obstacles

0.7 The Seine River Diversion (39 - 42)
0.71 Seine River Diversion
Watershed
0.72 Sources of Pollution

0.8 Selecting Water Pockets (43 - 48)
0.81 Existing Land Use
0.82 Topography

0.9 Precedents (49 - 62)
0.91 Introduction
0.92 Oak Hammock Marsh
0.93 Orongo Station Conservation
0.94 Renaturalizing River Aire

1.0 Design (63 - 120)
1.01 Existing Conditions
1.02 Design Strategy
1.03 Habitats and Biodiversity
1.04 Masterplan
1.05 Calculations
1.06 Claybars, Potholes and Meanders
1.07 Sewage Treatment Area
1.08 Proposed Water Levels
1.09 The Experience

1.1 Conclusion (121)

List of Figures

0.1 Introduction

Figure 0.11 - Location of Seine River Diversion in the Seine River Watershed

Figure 0.12 - Organization of Chapters

0.2 The Ghost - Lake Agassiz

Figure 0.21- Laurentide Ice Sheet and Lake Agassiz

Figure 0.22 - Extent of Lake Agassiz 11300 Years Ago

Figure 0.23 - Extent of Lake Agassiz 10400 Years Ago

Figure 0.24 - Extent of Lake Agassiz 9300 Years Ago

Figure 0.25 - Extent of Lake Agassiz 7700 Years Ago

Figure 0.26 - Ecoprovinces of Manitoba

0.3 The Remnant - Lake Winnipeg

Figure 0.31- Nutrient Load Distribution in Lake Winnipeg

Figure 0.32 - Lake Winnipeg Sub-watersheds and Major Tributaries

Figure 0.33- Blue-green Algae in Lake Winnipeg's Northern End

Figure 0.34 - Netley Libau Marsh on Lake Winnipeg's Southern End

0.4 The Energetic Red River

Figure 0.41 - The Energetic Red River

Figure 0.42 - Major Cities in the Red River Watershed

Figure 0.43 - Soils of Red River Watershed

0.5 The Grid - Wet Prairie History

Figure 0.51 - Checkered Landscape

Figure 0.52 - First Nature

Figure 0.53 - Loss of First Nature

Figure 0.54 - Current Land Use

0.6 The Waning - Seine River

Figure 0.61 - The Waning Seine River

Figure 0.62 - Rural Municipalities of Seine River Watershed

Figure 0.63 - Phosphorus Export to Lake Winnipeg from Seine River Sub-watersheds

0.7 The Seine River Diversion

Figure 0.71 - Seine River Diversion's Sources of Pollution

Figure 0.72 - Point and Non-point Sources of Pollution

0.8 Selecting Water Pockets

Figure 0.81 - Conceptual Sketch of Water Pockets

Figure 0.82 - Selecting Water Pockets

Figure 0.83 - Prairie Topography along the Diversion

0.9 Precedents

Figure 0.91 - Precedents

Figure 0.92 - Oak Hammock Marsh Location Plan

Figure 0.93 - Oak Hammock Marsh Plan

Figure 0.94 - Oak Hammock Marsh Sewage Treatment Area

Figure 0.95 - View from the Roof of the Interpretive Center

Figure 0.96 - Orongo Station Conservation Masterplan

Figure 0.97 - River Aire Conceptual Sketch

Figure 0.98 - Canal Garden and the River Aire

1.0 Design

Figure 1.01 - Location of Site for Detailed Design Intervention

Figure 1.02 - A Straight Line

Figure 1.03 - Existing Landscape Surrounding the Site

Figure 1.04 - On the Levee

Figure 1.05 - Meat Farming

Figure 1.06 - Kayaking

Figure 1.07- Fishing on the Diversion

Figure 1.08 - Spill into the Red

Figure 1.09 - Detailed Topography

Figure 1.10 - Section across the Seine River Diversion

Figure 1.11 -Proposed Prototype Design

Figure 1.12 - Kayaking on the Seine River Diversion

Figure 1.13 - Oxbow Lake of a Meandering River
Figure 1.14 - Oxbow Lake of an Engineered Diversion
Figure 1.15 - Principal Landforms
Figure 1.16 - Deep Marsh
Figure 1.17 - Shallow Marsh
Figure 1.18 - Wet Meadow
Figure 1.19 - Uplands
Figure 1.20 - Proposed Masterplan
Figure 1.21 - Area of Non-sloping Portion of the Ridges
Figure 1.22 - Area of Sloping Portion of the Ridges
Figure 1.23 - Area between Ground Level and -400mm
Figure 1.24 - Area between -400mm and -800mm
Figure 1.25 - Area between -800mm and -1200mm
Figure 1.26 - Area at -1200mm
Figure 1.27 - Location of Ritchot Landfill
Figure 1.28 - Northern Wetland's Emergent Vegetation Area on the Slopes of the Ridges
Figure 1.29 - Northern Wetland's Emergent Vegetation Area between Ground Level and

-400mm
Figure 1.30 - Northern Wetland's Emergent Vegetation Area between -400mm and -800mm
Figure 1.31 - Southern Wetland's Emergent Vegetation Area on the Slopes of the Ridges.
Figure 1.32 - Southern Wetland's Emergent Vegetation Area between Ground level and -400mm
Figure 1.33 - Southern Wetland's Emergent Vegetation Area between -400mm and -800mm
Figure 1.34 - Existing Sewage Lagoons
Figure 1.35 - Surface Area between Ground Level and -400mm
Figure 1.36 - Surface Area between -400mm and -800mm
Figure 1.37 - Surface Area between -800mm and -1200mm
Figure 1.38 - Surface Area at -1200mm
Figure 1.39 - Precise Design Intervention
Figure 1.40 - Site Plan after 20 - 30 Years
Figure 1.41 - Sewage Treatment Area
Figure 1.42 - Section - 01, Summer Season
Figure 1.43 - Section - 02, Fall Season
Figure 1.44 - Section - 03, Winter Season

Figure 1.45 - Seine River Diversion Control Structure
Figure 1.46 - Seine River Diversion Water Levels
Figure 1.47 - Sections Collage
Figure 1.48 - Windpump Perspective
Figure 1.49 - View from the Windpump
Figure 1.50 - View from the Deck
Figure 1.51 - Limestone Plaza Perspective

0.1 Introduction

The Seine River Diversion is located in the Canadian province of Manitoba near the city of Winnipeg. It was constructed in 1960 to reduce the impacts of flooding on the Seine River downstream of the town of St. Anne. The Diversion originates at St. Anne and stretches approximately 36km west to its junction with the Red River.

The Diversion is surrounded by numerous sources of water pollution, including sewage lagoons, large-scale livestock operations, agricultural runoff, and drains that degrade its water quality. The design model proposed in the practicum focuses on improving the Seine River Diversion's ecological conditions.

The objectives of the practicum are to improve the Diversion's water quality, reintroduce lost habitats, restore biodiversity and provide recreational opportunities for creating a new public space adjacent to the Seine River Diversion.

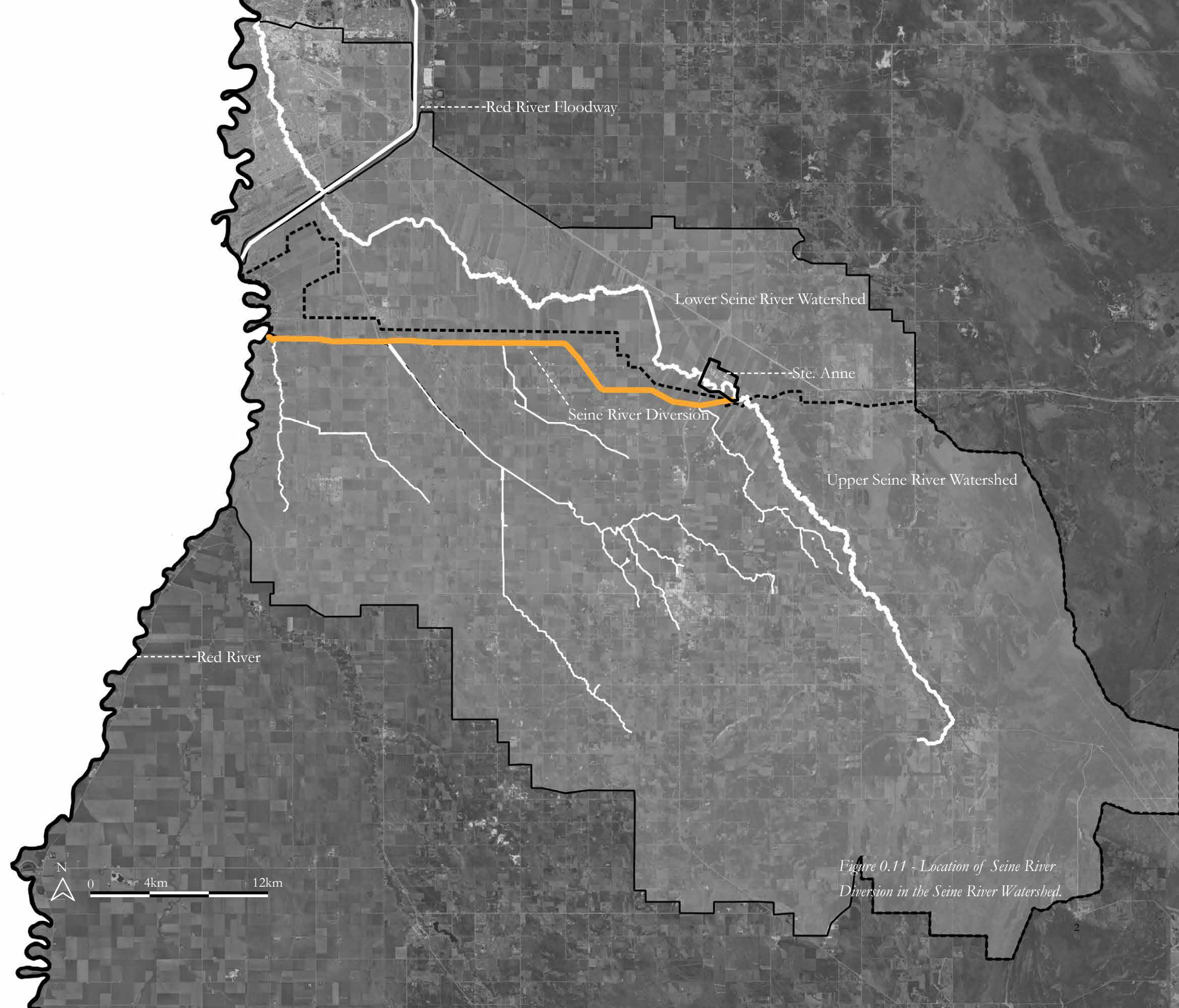
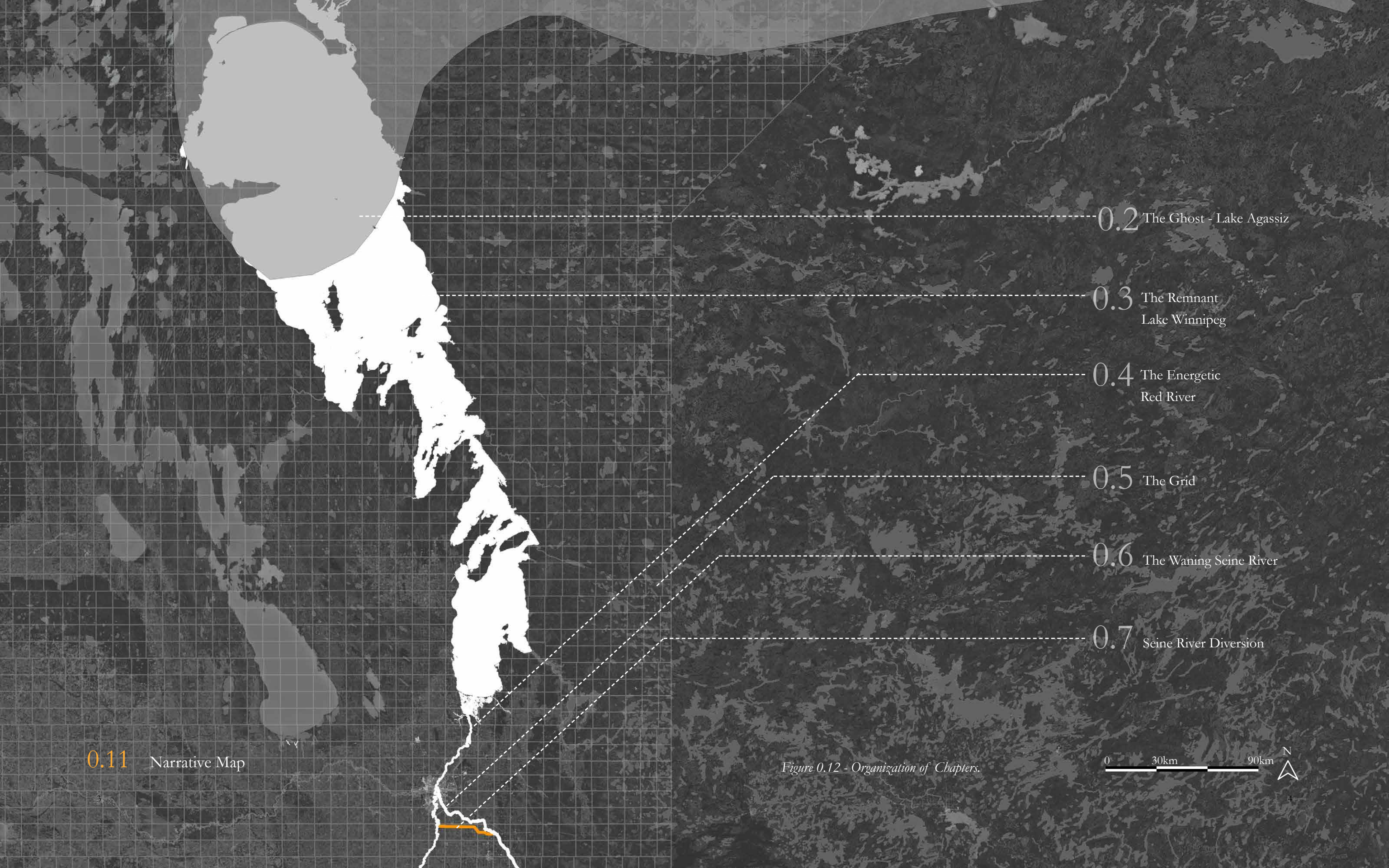


Figure 0.11 - Location of Seine River Diversion in the Seine River Watershed.



0.11 Narrative Map

0.2 The Ghost - Lake Agassiz

0.3 The Remnant
Lake Winnipeg

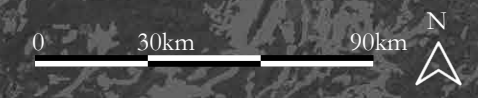
0.4 The Energetic
Red River

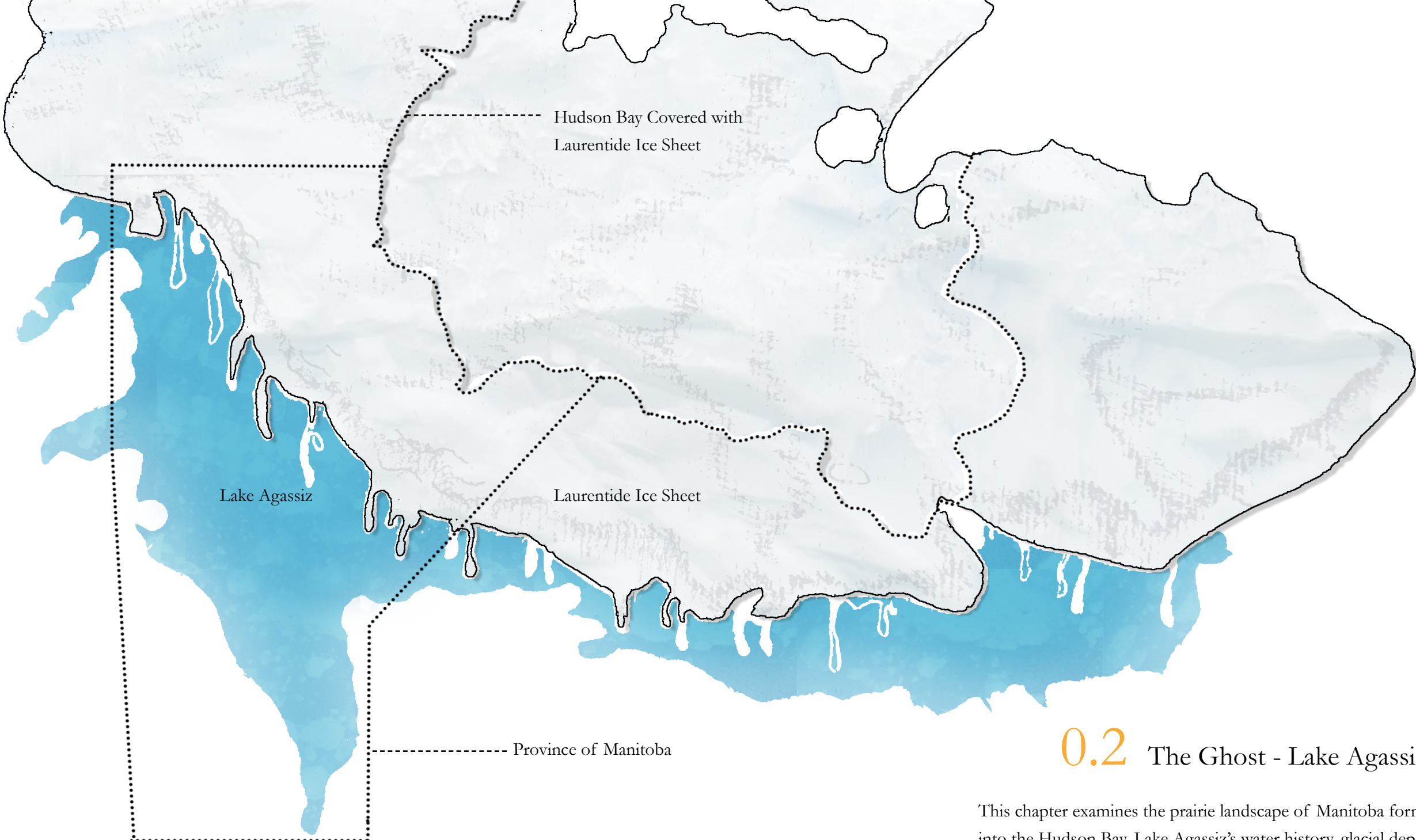
0.5 The Grid

0.6 The Waning Seine River

0.7 Seine River Diversion

Figure 0.12 - Organization of Chapters.





0.2 The Ghost - Lake Agassiz

This chapter examines the prairie landscape of Manitoba formed by Lake Agassiz's retreat into the Hudson Bay. Lake Agassiz's water history, glacial deposits and ecoprovinces of Manitoba are studied to understand the ecological conditions created by the receding Lake Agassiz. The watersheds of Manitoba, topography, soils, agriculture, flooding and drainage challenges are all legacy of Lake Agassiz. This chapter has helped to understand Manitoba's prairie landscape, in which the Seine River Diversion is situated.

Figure 0.21- Laurentide Ice Sheet and Lake Agassiz.



0.21 Introduction

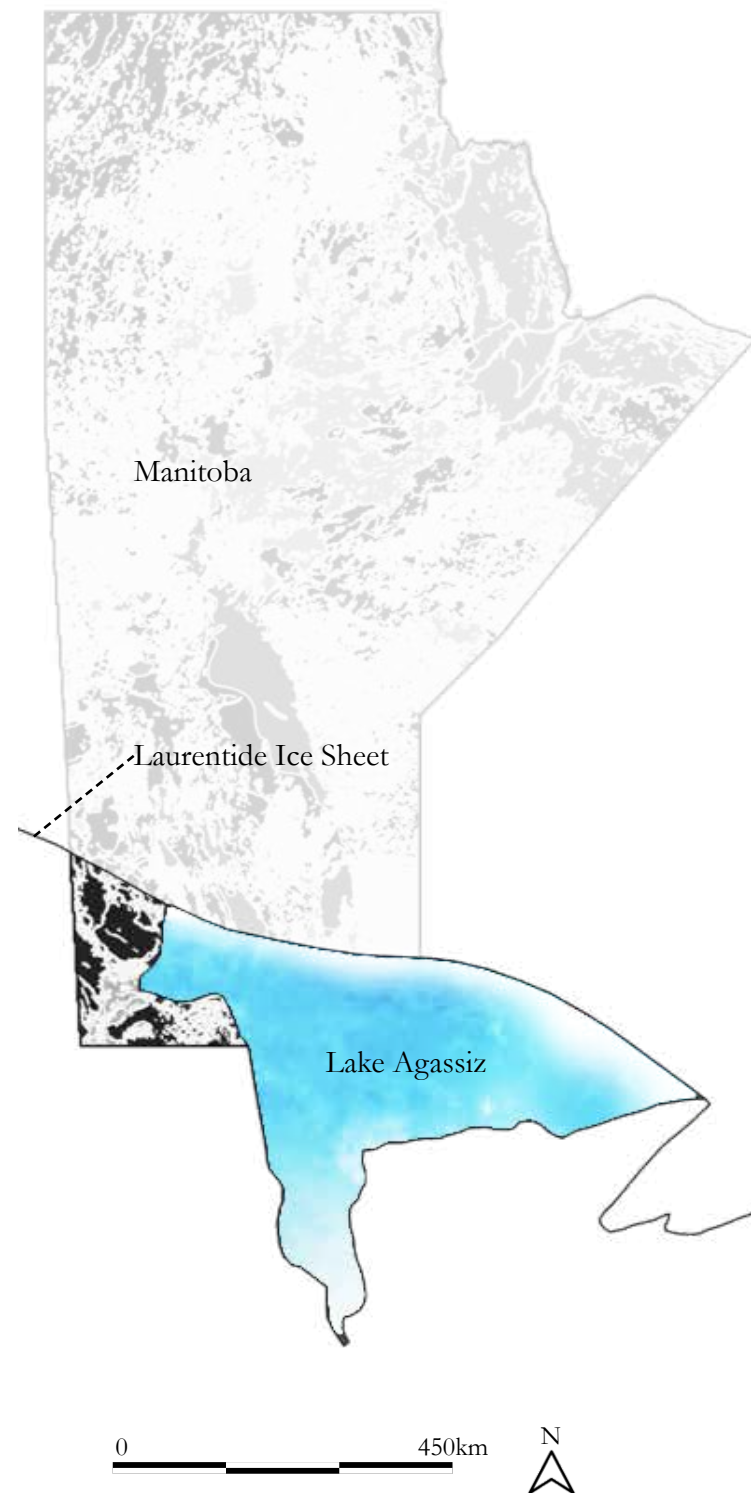
The receding Laurentide Ice Sheet created Lake Agassiz, the largest freshwater lake in the world. Covering Canada east of the Rocky Mountains, the Laurentide Ice Sheet depressed the underlying landscape and had a maximum thickness of approximately 5km near Hudson Bay (Perkins, 2002, p. 283). The meltwater from the Ice Sheet flowed into the Gulf of Mexico through tributaries of the Mississippi River (Perkins, 2002, p. 283). As the Ice Sheet retreated, crossing the divide between the Mississippi watershed and area draining northwards, the meltwater started to pool against it (Perkins, 2002, p. 283).

0.22 Water History

The overflow spillways of Lake Agassiz opened and closed following a fluctuating process of retreat and advance of the Ice Sheet (Teller and Leverington, 2004, p. 729).

About 8400 years ago, the Laurentide

Figure 0.22 - Extent of Lake Agassiz 11300 Years Ago.



Ice Sheet collapsed over Hudson Bay. Lake Agassiz, having an area of 841,000 km² at the time, drained into the North Atlantic Ocean (Perkins, 2002, p. 283).

Erosive wave action followed the retreating Lake Agassiz's shallow southern shoreline. As a result of erosion, well-defined beach ridges of

gravel and sand were formed, and a flat topography was produced, which is observable in the landscape today (Michalek, 2013, pp. 17-18).

The melting of ice chunks buried in soil resulted in the formation of depressions or prairie potholes (Candace, 2011, p. 53).

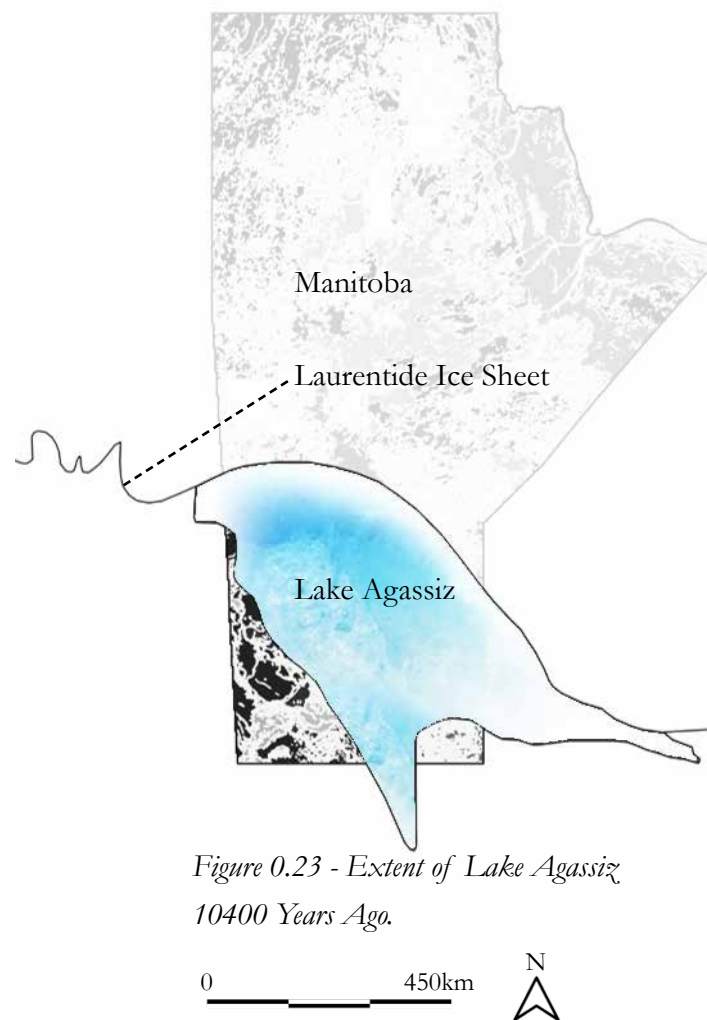


Figure 0.23 - Extent of Lake Agassiz 10400 Years Ago.

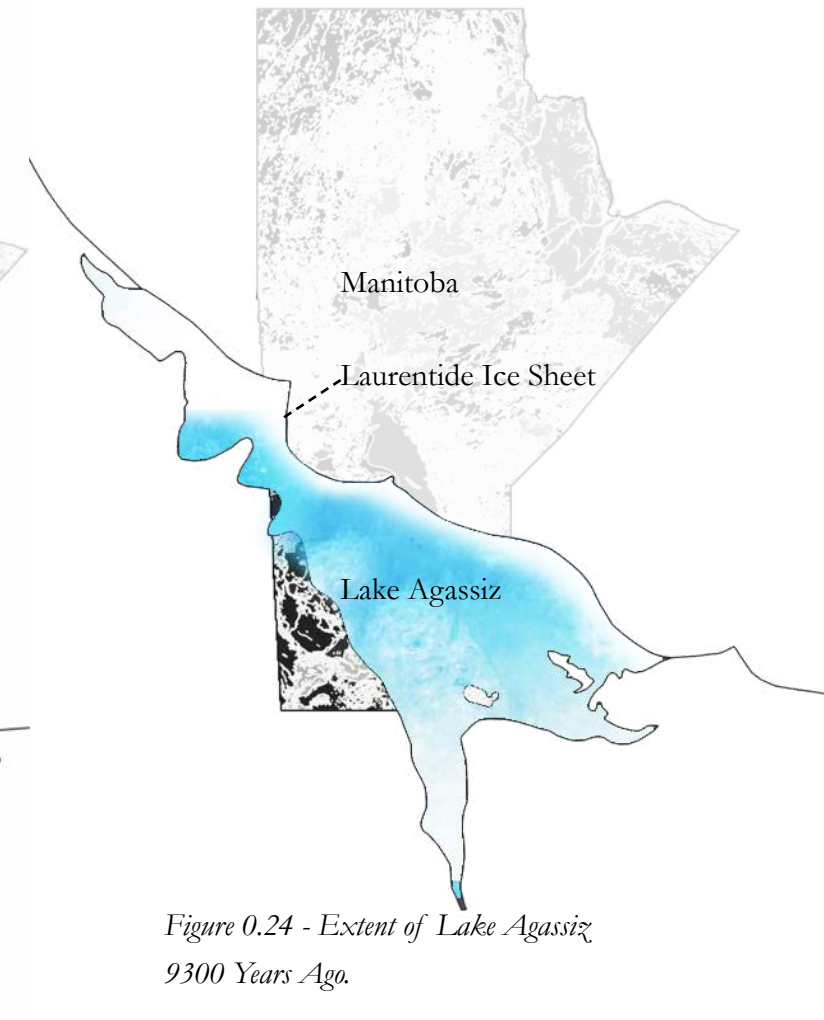


Figure 0.24 - Extent of Lake Agassiz 9300 Years Ago.

0.23 Glacial Deposits

The intermixture of sandy clay, gravel and occasional boulders formed the soils of nearly the entire prairie region. (Upham, 1895, p. 583).

“Surface sediments in the Red River valley are composed mainly of silty-clay soil known as Gumbo” (Teller et al., 1996, p. 1) which makes it ideal for cultivation. The rich alluvial clayey silt is present on both sides of the Red River up to 5 to 10 miles (Upham, 1895, p. 583).

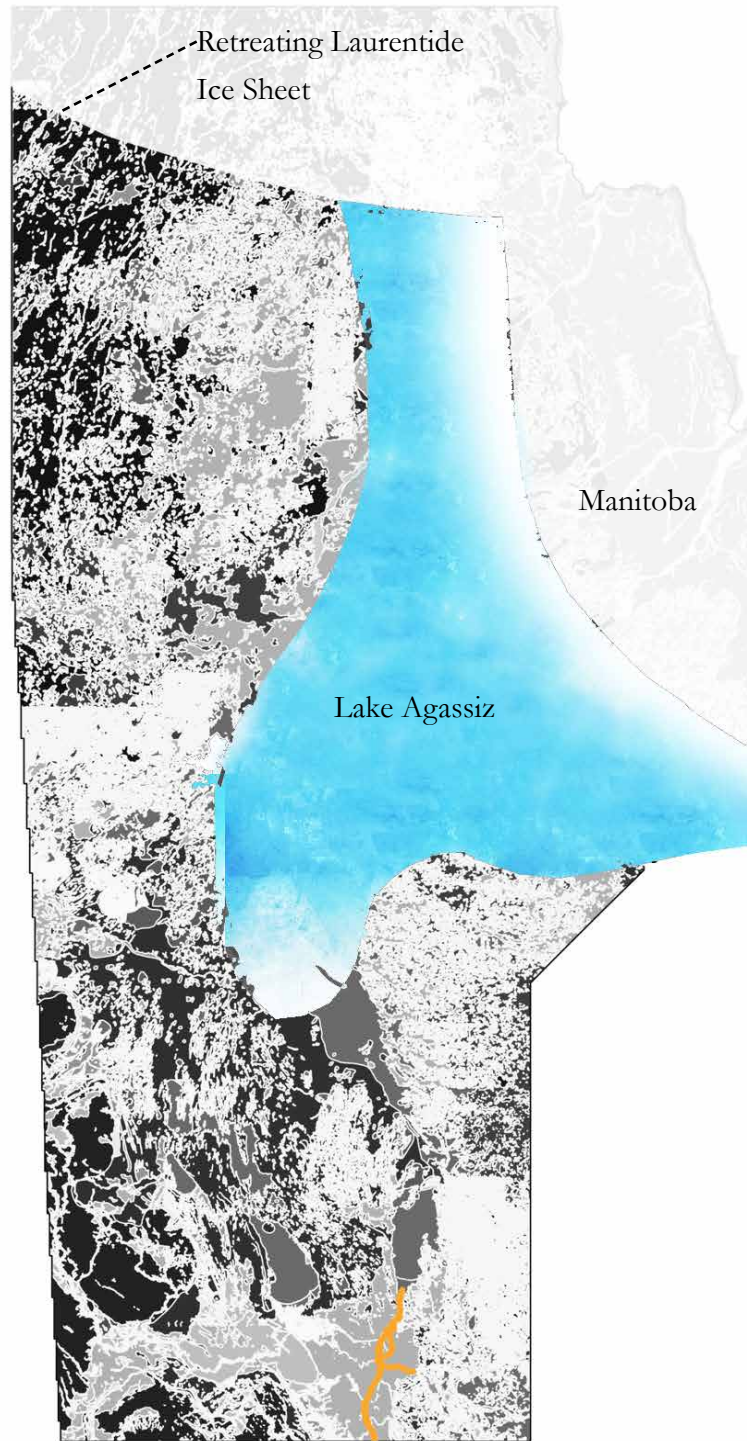


Figure 0.25 - Extent of Lake Agassiz 7700 Years Ago.

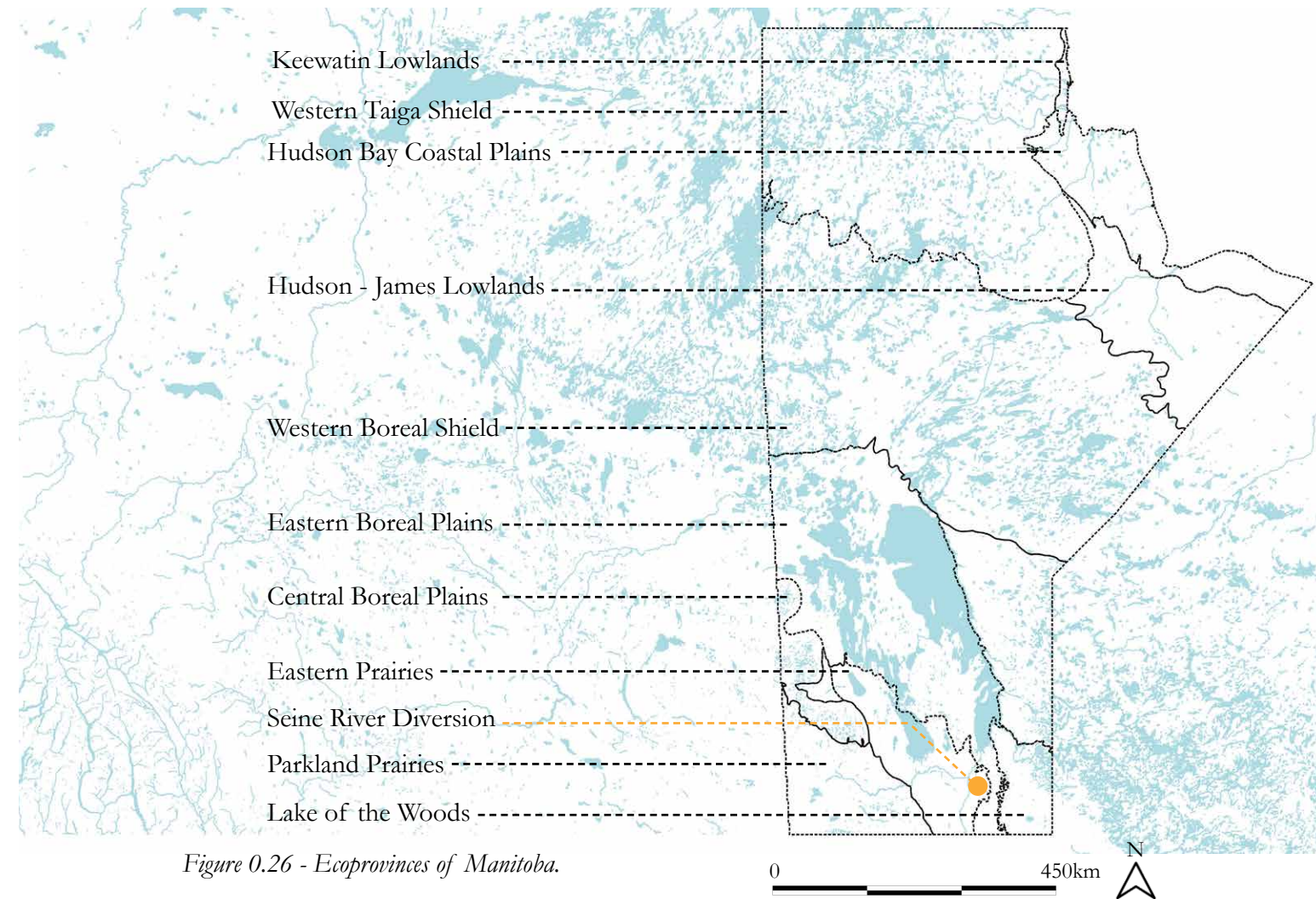


Figure 0.26 - Ecoprovinces of Manitoba.

0.24 Vegetation

Between 13000 and 11000 years ago, Earth’s climate changed dramatically. A rebound to a warmer climate followed the cold spell. These climatic fluctuations significantly altered the vegetation patterns on the North American plains. Pushed by warm and

dry weather, pines replaced the spruce forest, and they gave way to mixed woodlands in some places (Candace, 2011, p. 53). The grasses followed the mixed woodlands and stretched across the plains, forming the prairie landscape (Candace, 2011, p. 53).

0.3 The Remnant - Lake Winnipeg

This chapter focuses on studying Lake Winnipeg and the causes of its deteriorating health. Lake Winnipeg is a remnant of Lake Agassiz. The subchapters provide an understanding of Lake Winnipeg's watershed extent, its major tributaries, eutrophication of the lake and sources and carriers of nutrients that contribute towards the lake's deteriorating health. In addition, the importance of the lake and the current state of the Netley Libau Marsh situated on the southern shores of Lake Winnipeg is also explained. Low-quality water from the Seine River Diversion drains into the Red River, which subsequently drains into Lake Winnipeg. This chapter helps in recognizing the role of Seine River Diversion in an overarching landscape network.



Figure 0.31- Nutrient Load Distribution in Lake Winnipeg.



Figure 0.33 - Blue Green Algae in Lake Winnipeg's Northern End.

0.32 Eutrophication

The overfertilization of the aquatic systems, known as eutrophication (Lake Winnipeg Foundation, 2019, p. 3), results in excessive growth of algae which negatively impacts the health of Lake Winnipeg. Enrichment of Lake Winnipeg by nitrogen and phosphorus leads to an increase in the severity of

nuisance algal blooms. The ecosystem of Lake Winnipeg is impacted by the growth of blue-green forms of algae known as Cyanobacteria (Sandford, W, R., 2013, p. 16). High-density Cyanobacteria can form surface mats in late summer or autumn that may replace other phytoplankton by limiting the available light (Bryan, G., M., 2013, p. 1). When the algal

bloom dies, it sinks to the lake bottom and is decomposed by the bacteria that consume oxygen. The anoxic conditions created are fatal to fish and other aquatic species that constitute the food web (Lake Winnipeg Stewardship Board, 2006, p. 23). Cyanobacteria produce Microcystin, a toxin that is harmful to aquatic life, livestock, pets, wildlife and people

(Sandford, W, R., 2013, p. 80). This significantly impacts the recreational usage and tourism on Lake Winnipeg. Algae degraded the water quality on Lake Winnipeg's Victoria Beach in July 2019 (Stackelberg, V. M., 2019). Residents and vacationers were asked to not consume water from the lake because of excess amounts of toxins.

0.33 Sources of Nutrients

The agricultural lands in Manitoba contribute nearly 5 per cent of the total nitrogen load and 15 per cent of the total phosphorus load in Lake Winnipeg (Partners for the Saskatchewan River Basin Board, 2009, p. 144). The total excrement load (both animals and humans) to Lake Winnipeg is estimated to be equivalent to a population of approximately 50 million people even though its basin has a scattered human population (Sandford, W. R., 2013, p. 78).

The streams in southern Manitoba are the recipients of effluent and discharge from treatment facilities and industrial operations. The contaminated water from these streams eventually ends up in Lake Winnipeg. Over 400 licensed wastewater facilities and 76 industries are contributing to high nutrient concentration in Lake Winnipeg (Bourne, A., Armstrong, N. & Jones, G. 2002, p. 4).

0.34 Carriers of Nutrients

Annual averages of phosphorus and nitrogen contribution to Lake Winnipeg from 1994 to 2016 are given below (Environment and Climate Change

Canada, 2020, p. 6).

Red River - 34% (31,370 tonnes) nitrogen and 69% (5,070 tonnes) phosphorus.

Winnipeg River - 22% (20,530 tonnes) nitrogen and 14% (1,050 tonnes) phosphorus.

Saskatchewan River – 12% nitrogen (10,730 tonnes) and 5% (400 tonnes) phosphorus.

The remaining phosphorus and nitrogen load is contributed to the Lake Winnipeg by atmospheric deposition, nitrogen fixation and smaller tributaries.

0.35 Lake Winnipeg Usage

Lake Winnipeg contributes to the provincial economy by attracting visitors to its easily accessible beaches, commercial fishing and production of hydroelectricity through regulation of its outflow. Lake Winnipeg is a valuable resource also known for its importance to the traditional livelihood of Metis and First Nations communities (Environment and Climate Change Canada, 2020, p. 1).



Figure 0.34 - Netley Libau Marsh on Lake Winnipeg's Southern End.

0.36 Netley Libau Marsh

The Lake Winnipeg watershed once consisted of several wetlands which supported terrestrial and aquatic life. Netley-Libau Marsh, which is present on the southern edge of the southern basin of Lake Winnipeg, is a freshwater coastal wetland nationally designated as an important bird area.

Grosshans et al. (2004) compared the Netley Libau Marsh vegetation communities between 1979 and 2001. The researchers concluded that the

emergent vegetation communities were significantly reduced and smaller water bodies culminated to form large lakes and ponds. As a result, Netley Libau Marsh resembles a shallow lake, and its ability to support biodiversity and remove nutrients is degraded.

The practicum's objectives can be met by proposing a marshland near the Seine River Diversion's sources of pollution. Such a proposal's implications will be reduced nutrient inflow to the Red River, Netley Libau Marsh and Lake Winnipeg.

0.4 The Energetic Red River

This chapter investigates the Red River and its watershed, contributing the maximum amount of nutrients to Lake Winnipeg compared to its other tributaries. Detailed soil classification of the Red River's watershed and the flood extents of the Red River in different years is explained. In addition, the land morphology of the Red River valley consisting of soils ideal for cultivation is described. The Red River watershed encompasses the smaller watersheds of many rivers and streams, including the Seine River Diversion. The Diversion drains into the Red River and is situated within the Red River Valley.

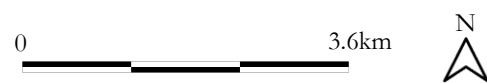
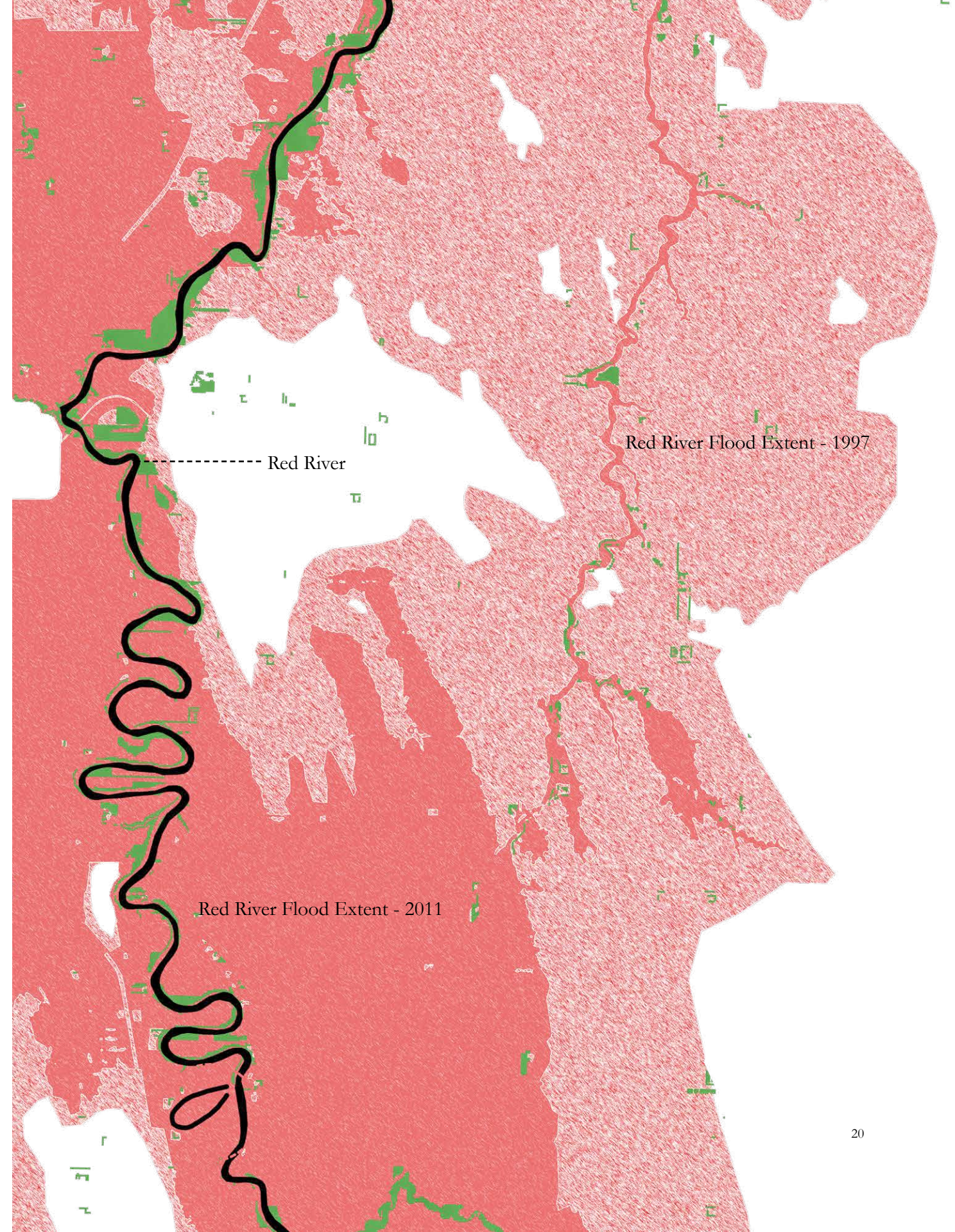


Figure 0.41 - The Energetic Red River.



0.41 Introduction

The Red River originates at the confluence of the Bois de Sioux and Otter Tail rivers at Wahpeton, North Dakota and drains into Lake Winnipeg in Manitoba.

The river cuts through the shallow plain and has a depth varying between 20 to 50 feet. (Upham, W., 1895, pp. 20-21). The Red River has seven main tributaries in Canada, including the Assiniboine River. The tributaries pass through the land dominated by agriculture and act as carriers of agricultural runoff. During floods, the Red River and its tributaries sweep over the agricultural land, taking the nutrients along with their flow.

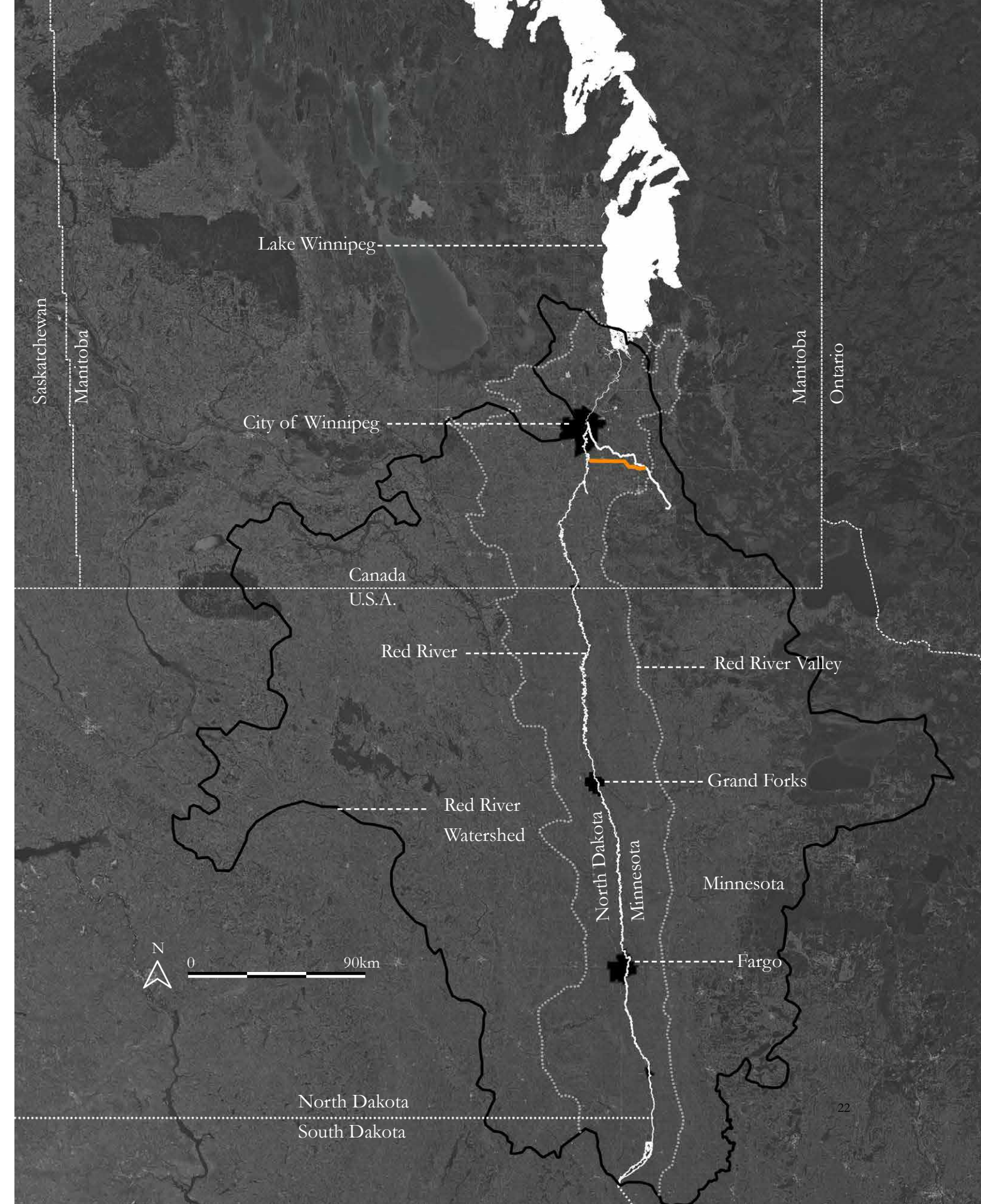
0.42 Red River Watershed

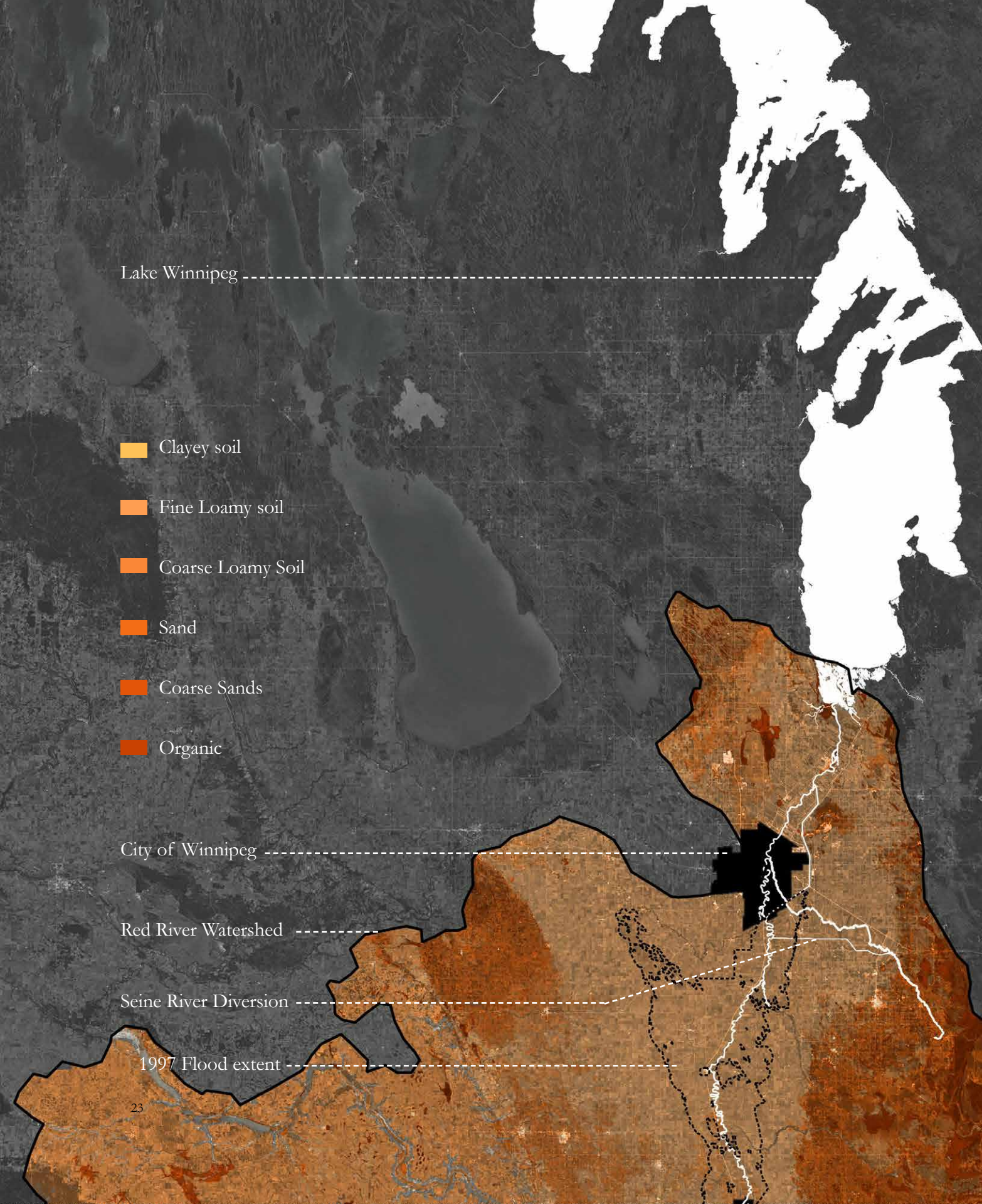
The Red River watershed covers an area of approximately 290,000 sq. km, of which 163,000 sq. km. is contributed by the drainage basin of the Assiniboine River (Brooks, R., G., 2017, p. 146). Winnipeg is the largest urban center located in the Red River valley, with a population of approximately 750,000 people.

The Red River valley covers an area of 68,000 sq. km. and is confined to the basin of the Red River (Brooks, R., G., 2017, p. 143). Agriculture in the valley contributes significantly to the economy of the region. There are 25 million acres of land within the basin, out of which approximately 75 per cent is agricultural land (Red River Basin Commission, 2011, p. 10).

The valley is 40 to 50 miles wide and more than 300 miles long. It slopes downwards in the north direction with an average slope of less than 1 foot per mile and upwards in the east and west direction with an average slope of 2 or 3 feet per mile for 10 to 15 miles from the River (Upham, W., 1895, p. 20).

Figure 0.42 - Major Cities in the Red River Watershed.





0.43 Soils

The valley plain is formed by the glaciolacustrine silt and clay deposits that formerly accumulated on the beds of Lake Agassiz. The soil is ideally suited for agriculture, and the Red River valley is considered an important agricultural area in the eastern prairies. Wheat, soybean, canola and to a lesser extent, corn, barley, and dry beans are the major crops grown in the valley in Manitoba (Brooks, R., G., 2017, p. 146).

0.44 Flooding

“The valley of the Red River is structurally and geomorphologically predisposed to flooding.” (Carlyle, J. W., 1984, p. 331) Early records show that the Red River basin was flooded in 1826, 1852, 1861, 1950, 1966, 1979, 1996 and 1997 (Simonovic, S., P. and Carson, R., W., 2003, p. 346).

The severity of the flood in 1950 led to a recommendation in 1958 by the Royal Commission for the construction of Red River Floodway, Portage Diversion and Shellmouth Reservoir (Simonovic, S., P. and

Carson, R., W., 2003, p. 347). The flood in 1997 carrying nearly the same amount of water as the 1950 flood, reached its peak in a comparatively shorter duration. The damages amounted to approximately \$300 million (Simonovic, S., P. and Carson, R., W., 2003, p. 349).

Flooding on the Red River was further exacerbated by the drainage of wetlands for increasing agricultural productivity. Historically, a grid pattern for the land division was imposed on Manitoba. This imposition created a disconnect between surface drainage patterns and land division and is explained in the next chapter.

Figure 0.43 - Soils of Red River Watershed.



0.5 The Grid - Wet Prairie History

The grid refers to the land management system established by the dominion government in Manitoba. The grid consists of 6-mile by 6-mile square sections known as townships subdivided into 36 smaller, mile by mile square sections (Warkentin, 1959). The grid was superimposed on Manitoba to increase agricultural productivity. This chapter explains the land and water divide created by superimposing the grid management system. It also highlights the struggles of landowners, organizations, and leaders in adopting a watershed approach for drainage. Finally, this chapter explains the socioeconomic realities tied to the agricultural landscape of Manitoba, which cannot be overlooked when proposing a design intervention for the Seine River Diversion.

■ Lowest Contour Elevation
■ Highest Contour Elevation

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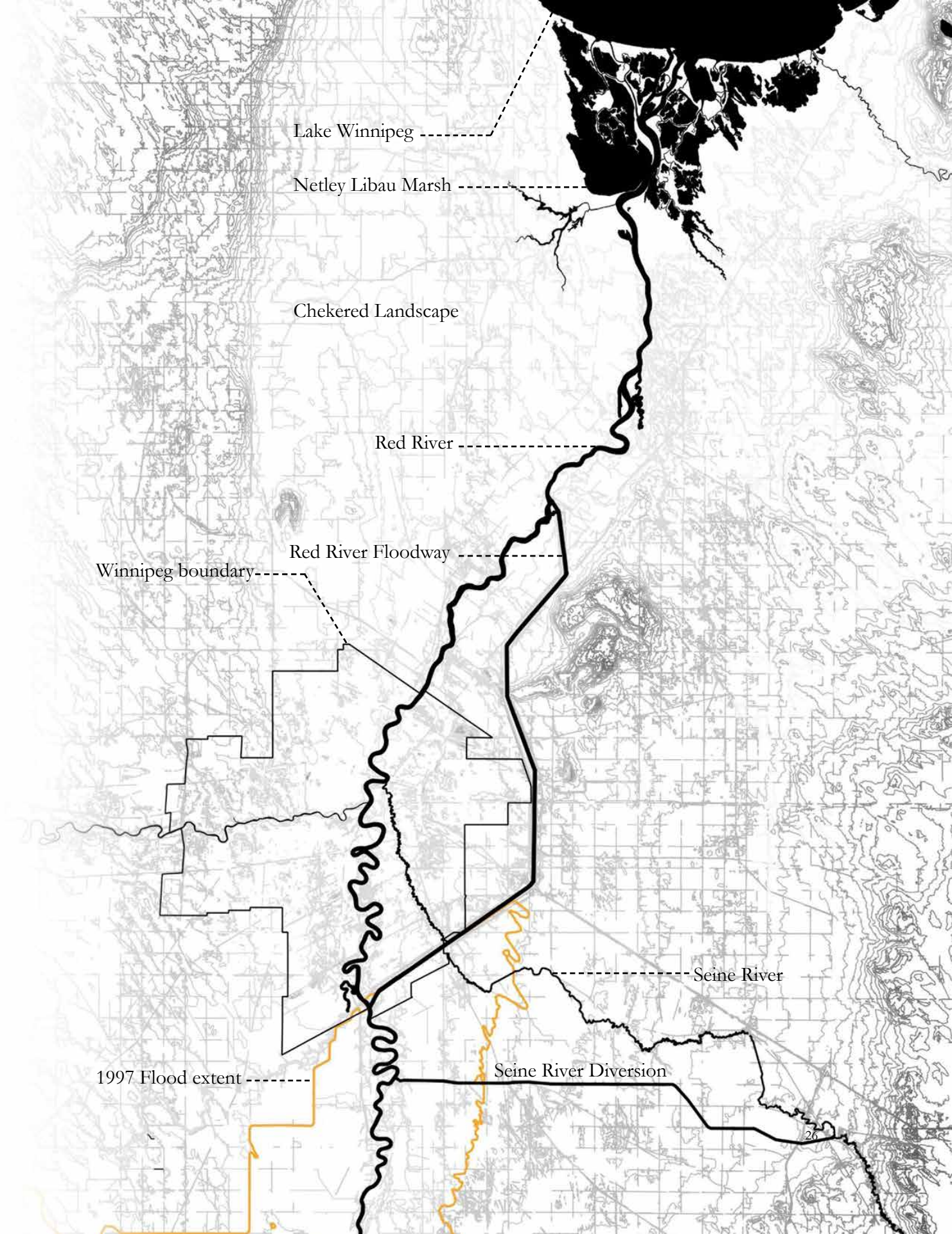


Figure 0.51 - Checkered Landscape.

0.51 Loss of Wet Prairie

The dynamic forces like prairie fires and bison grazing helped in maintaining the prairie grasslands. With the arrival of settlers, the prairie ecosystem encountered a regime shift that changed the ecology of the prairie grasslands. The advent of intensive agriculture in Manitoba altered the landscape and its hydrological characteristics. Amidst the pressures to drive the economy and encourage settlement, the environmental realities of the regions were changed by the federal and provincial governments.

Historically, the severance of land and water issues accompanied Manitoba's entry into the confederation (International Institute of Sustainable Development, 2010, p. 34).

In the late 1850s, Henry Youle Hind explored the northwestern land covered with marshes, bogs, and ridges, which in 1870 came to be known as the province of Manitoba (Bower, S.S., 2012, p. 19). The early settlers joined the Aboriginal and Metis groups and exploited the wetlands, which were a valuable source

of water, plants, ducks, and migrating geese on the prairie land (Bower, S.S., 2012, p. 21).

Colonel C.J. Dennis recommended a grid-based plan to the federal government on September 23, 1869. In 1872, the dominion government established a grid-based land management system for administration (Bower, S.S., 2012, p. 21).

The railway brought expansion opportunities for the province of Manitoba by increasing the influx of goods and settlers. The Canadian Pacific Railway reached Manitoba in 1882 (International Institute of Sustainable Development, 2010, p. 39). Settlers started draining the wet prairie and emerged as the dominant ecological component in the landscape (Hanuta, 2006, p. 49).

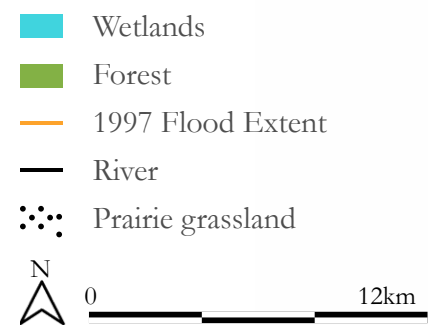
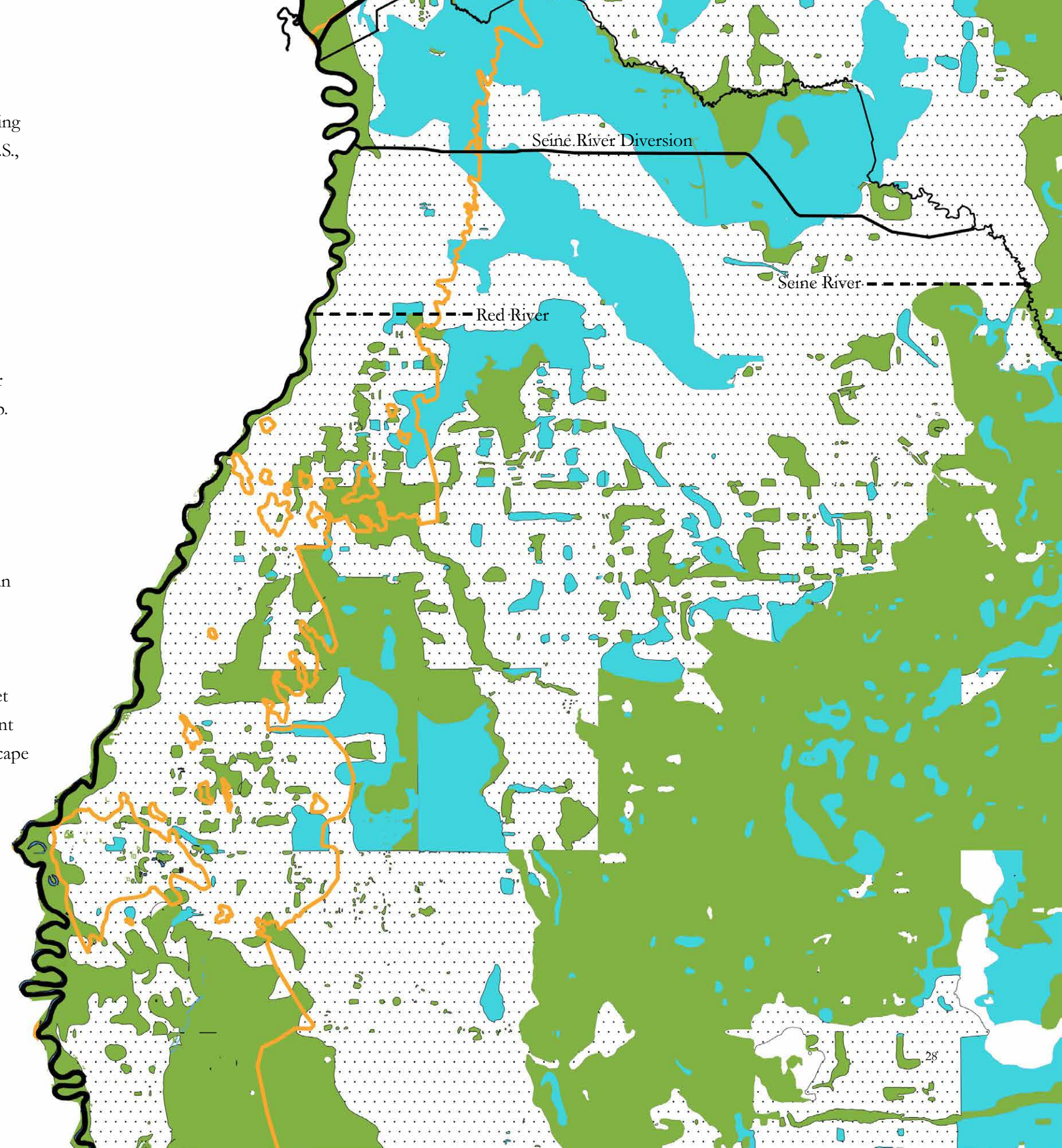


Figure 0.52 - First Nature.



0.52 Drainage Disputes

Early settlers overlooked the spatial and temporal variability of the environment, and they preferred to settle on dry land. Manitoba's 1895 land drainage act passed the creation of drainage districts related to the surface water conditions (Bower, S.S., 2012, p. 33). The drainage districts did not account for water coming from higher elevations and were limited to the lands that were prone to substantial and frequent flooding.

C.G. Elliot, an American drainage engineer and the Sullivan Commission recommended the adoption of a watershed approach (Bower, S.S., 2012, p. 85). The watershed approach included the flooded land as well as the water coming from the higher reaches of the land, which was defined as foreign water under the drainage districts approach.

This led to a dispute and segregation of landowners into highlanders and lowlanders based on the elevation of their land within the watershed (Bower, S.S., 2012, p. 90). The highlanders argued that they should

not pay for infrastructure, which is not beneficial for them. As the dispute continued, the adoption of the watershed approach was forestalled. Upon being appointed by the provincial government, M.A. Lyons recommended the use of double dyke drains to sever the major connection between highlands and lowlands (Bower, S.S., 2012, p. 103).

The resolution for the highlander and lowlander dispute was achieved through highlanders seeking remedies for soil erosion on their land. The fertile topsoil ended up in drains on lowlands reducing the drain capacity (Bower, S.S., 2012, p. 144). Solutions were derived by the cooperative working of highlanders and lowlanders on environmental management, preventing flooding on lowlands and erosion on highlands.

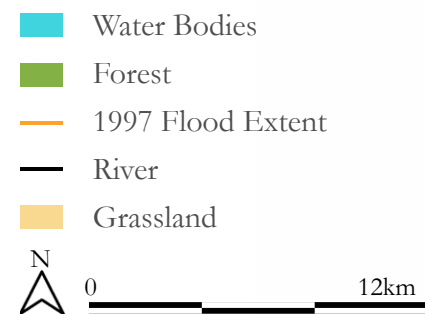


Figure 0.53 - Loss of First Nature.



0.53 Watershed Approach

The provincial government passed in 1959 the watershed conservation districts act, which created the local infrastructure to support the watershed idea (Bower, S.S., 2012, p. 154).

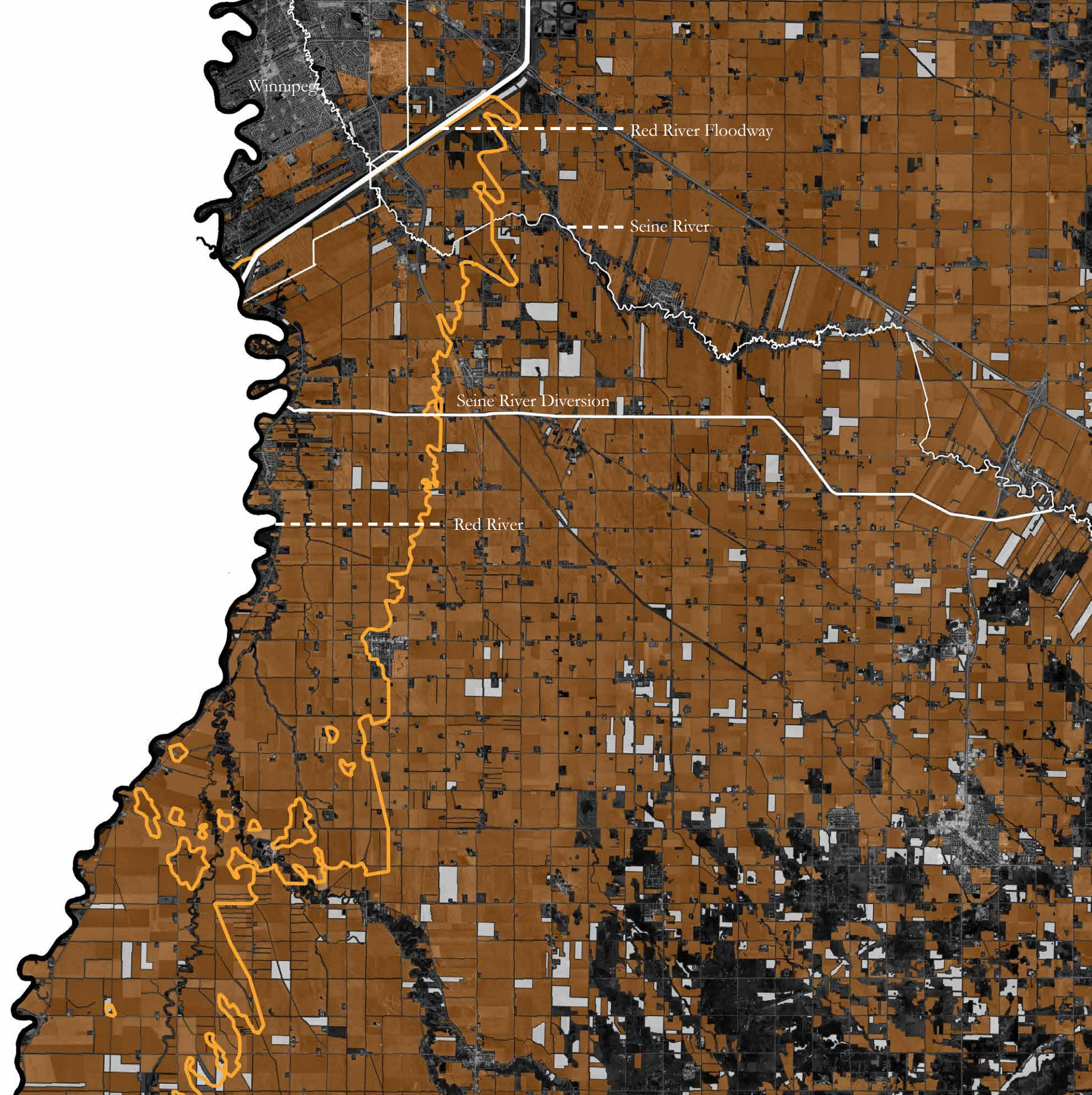
The 1976 conservation district act facilitated the creation of conservation districts through an order in the council (International Institute of Sustainable Development, 2010, p. 48).

By the early twenty-first century, 18 watershed conservation districts were covering 85 per cent of municipal Manitoba (Bower, S.S., 2012, p. 162).

- Agriculture land
- forage land
- 1997 Flood Extent



Figure 0.54 - Current Land Use.



0.6 The Waning Seine River

This chapter provides information about the Seine River, which is a tributary of the Red River. The subchapters explain the demographics, current land use, and phosphorus export to Lake Winnipeg from the sub-watersheds of the Seine River. Water from the Seine River is diverted into the Seine River Diversion to prevent flooding downstream. The Seine River Diversion's ecological conditions depend on the volume of water diverted from the Seine River.

Figure 0.61 - The Waning Seine River.

0 2.4km



0.61 Seine River Watershed

The Seine River originates at the Sandilands Provincial Forest and travels northwest where it converges with the Red River in the city of Winnipeg upon crossing under the Red River Floodway. Seine River watershed covers an area of approximately 210,748 hectares (Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration, 2005, p. 7).

Nine municipalities cover the watershed either fully or partially, along with a portion of the city of Winnipeg. The watershed population is estimated to be around 44,000, which does not contain a population residing in the portion of the city of Winnipeg that overlaps with the Seine River watershed. Nearly 11,000 people reside in the city of Steinbach, and one-third of the total population lives in urban centers (Seine-Rat River Conservation District, 2009, p. 6).

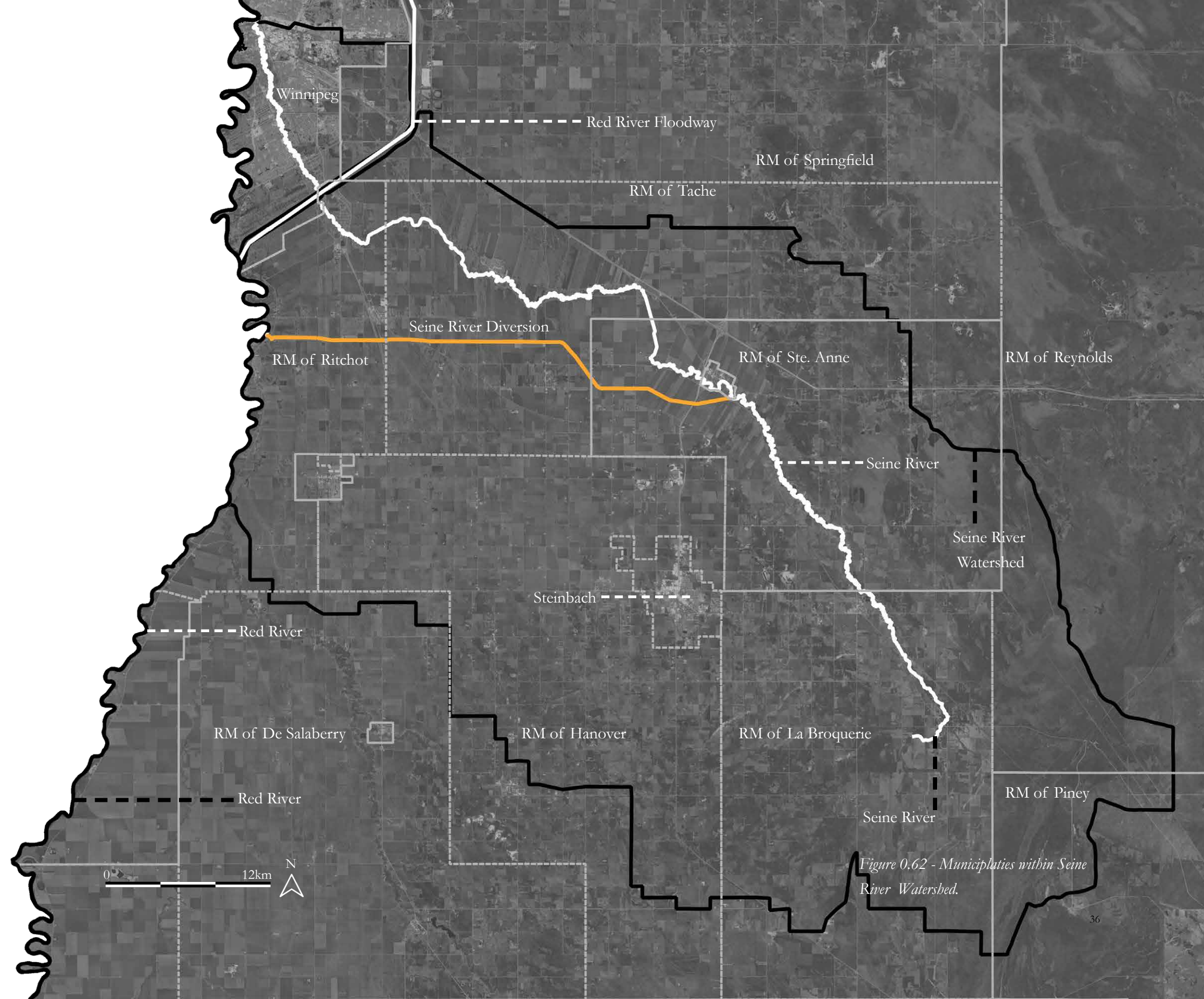


Figure 0.62 - Municipalities within Seine River Watershed.

0.62 Present Usage

Development in the Seine River watershed has increased along with a growth in the livestock production operations, primarily the hog production barns. Population increase due to development has put more pressure on the municipal sewage lagoons operating in the watershed. Land-based manure application practices have also increased. (Seine-Rat River Conservation District, 2005, p. 1). Traditional cereal, oilseed crops, selected speciality crops and haying operations are prevalent in the watershed (Seine-Rat River Conservation District, 2005, p. 11).

The Seine River watershed is composed of four sub-watershed units (Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration, 2005, p. 7).

Figure 0.71 shows the areas that contribute more than half of the total phosphorus export from the sub-watersheds of the Red River to Lake Winnipeg. (Lake Winnipeg Foundation, 2019, p. 5).

0.63 The Obstacles

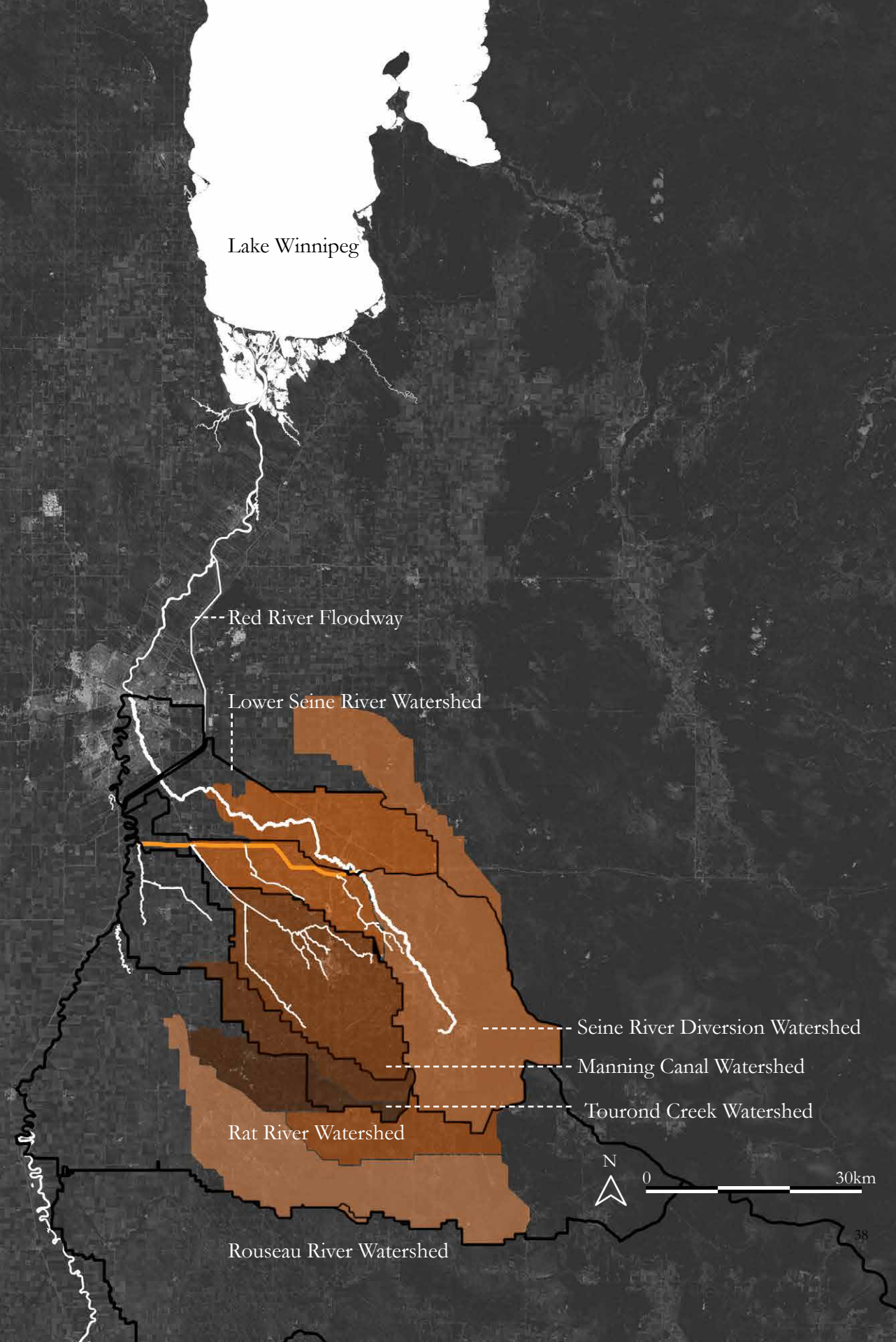
A control structure near St. Anne diverts water into the Seine River diversion, which has reduced the amount of flow in the Seine River. As a result, the downstream aquatic habitat and diversity are reduced (Seine-Rat River Conservation District, 2009, p.13).

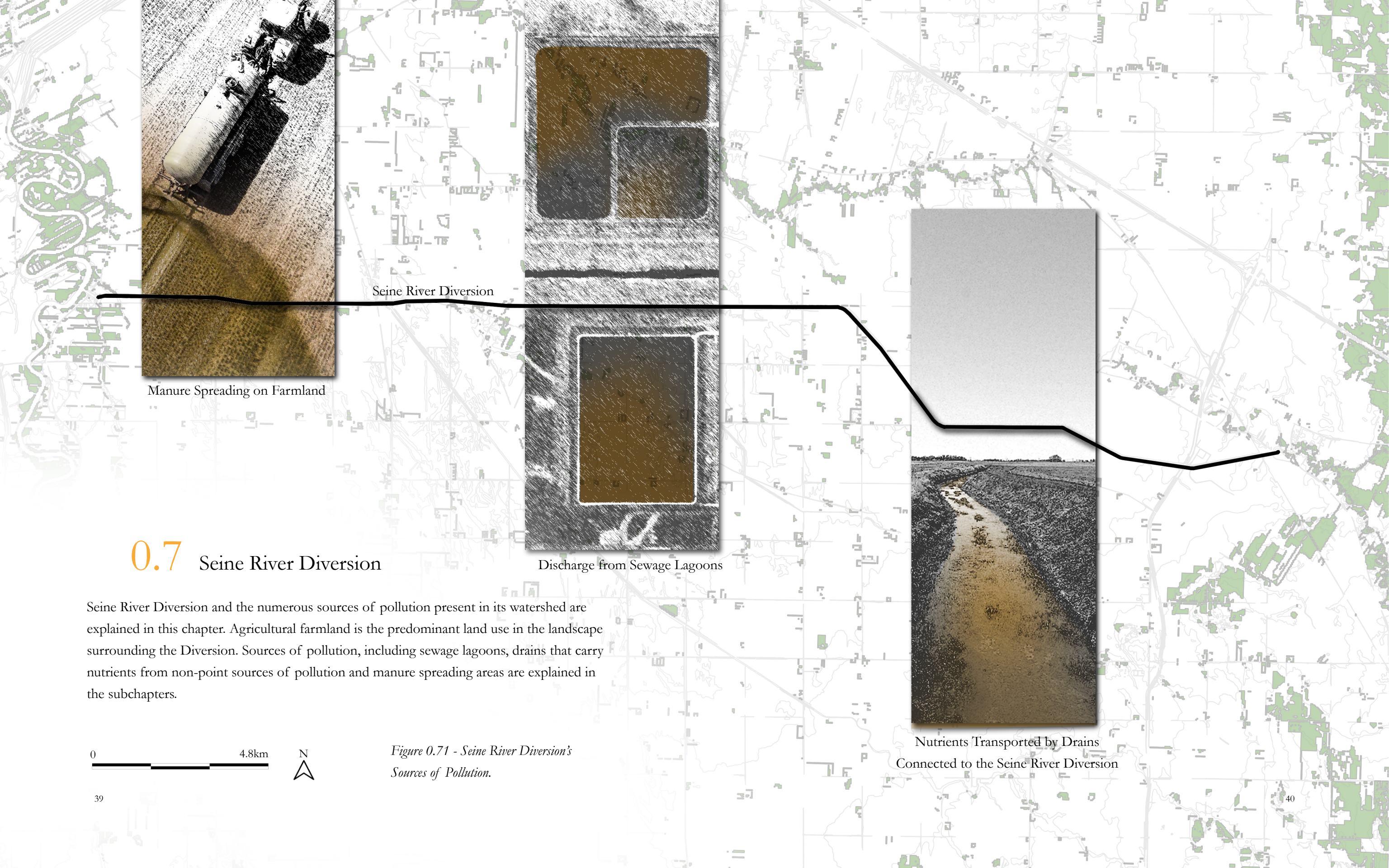
At the crossing of the Seine River and Red River Floodway, an inverted syphon is installed, which allows low river flows to cross the floodway. Higher flows are diverted by culverts into the floodway (Smith, M., J., 1992, p.4).

Phosphorus export to Lake Winnipeg

- 0.33 kg/ha/yr
- 0.50 kg/ha/yr
- 0.91 kg/ha/yr
- 1.14 kg/ha/yr
- 1.35 kg/ha/yr
- 1.49 kg/ha/yr
- 2.29 kg/ha/yr

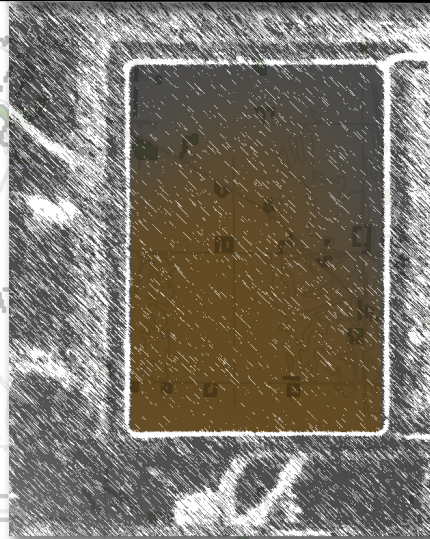
Figure 0.63 - Phosphorus Export to Lake Winnipeg from Seine River Sub-Watersheds.





Manure Spreading on Farmland

Seine River Diversion



Discharge from Sewage Lagoons



Nutrients Transported by Drains Connected to the Seine River Diversion

0.7 Seine River Diversion

Seine River Diversion and the numerous sources of pollution present in its watershed are explained in this chapter. Agricultural farmland is the predominant land use in the landscape surrounding the Diversion. Sources of pollution, including sewage lagoons, drains that carry nutrients from non-point sources of pollution and manure spreading areas are explained in the subchapters.



Figure 0.71 - Seine River Diversion's Sources of Pollution.

0.71 Seine River Diversion Watershed

The Seine River Diversion watershed encompasses approximately 1900 km² and has seen significant development in the past years.

Seine River Diversion had native vegetation consisting of tall and meadow grass communities, most of which have disappeared because of agriculture and development. (Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration, 2005, p. 11).

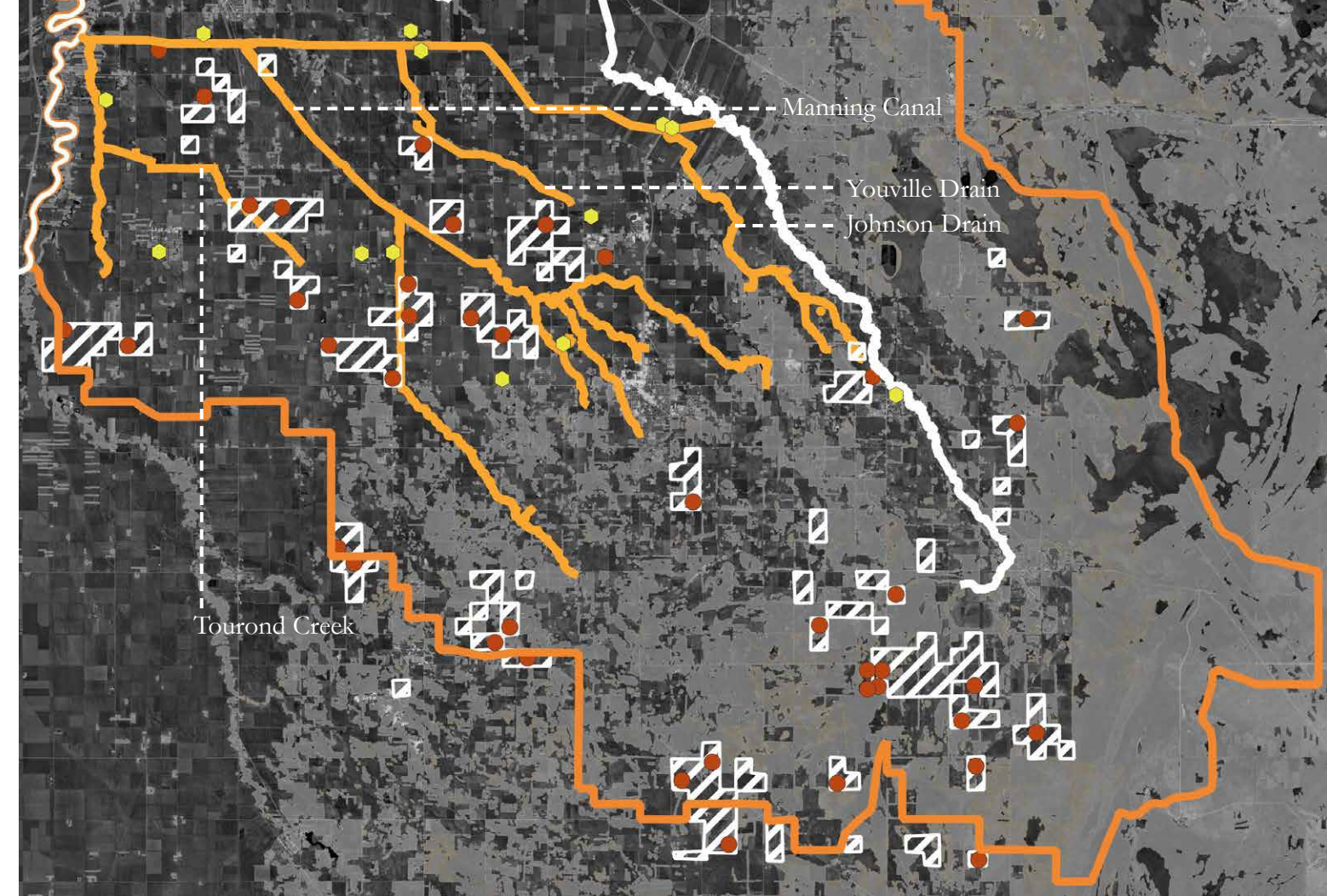
The Diversion is joined by many local drains from the south, such as Youville Drain, Johnson Drain, Manning Canal, and Tourond Creek (Manitoba Water Services Board, 2001, p. i).

0.72 Sources of Pollution

The water quality in the Diversion is impacted by point sources and non-point sources of pollution. The pollutants arrive directly or indirectly through drains and canals connected

to the Seine River Diversion. A total of 13-point discharges from licensed wastewater lagoons have been identified. The lagoons accept wastewater, septic tank waste, and weeping tile water from the communities. Due to excess hydraulic load, especially during wet years, the capacity of the lagoons often exceeds the threshold leading to an emergency discharge of lagoons after the winter storage season.

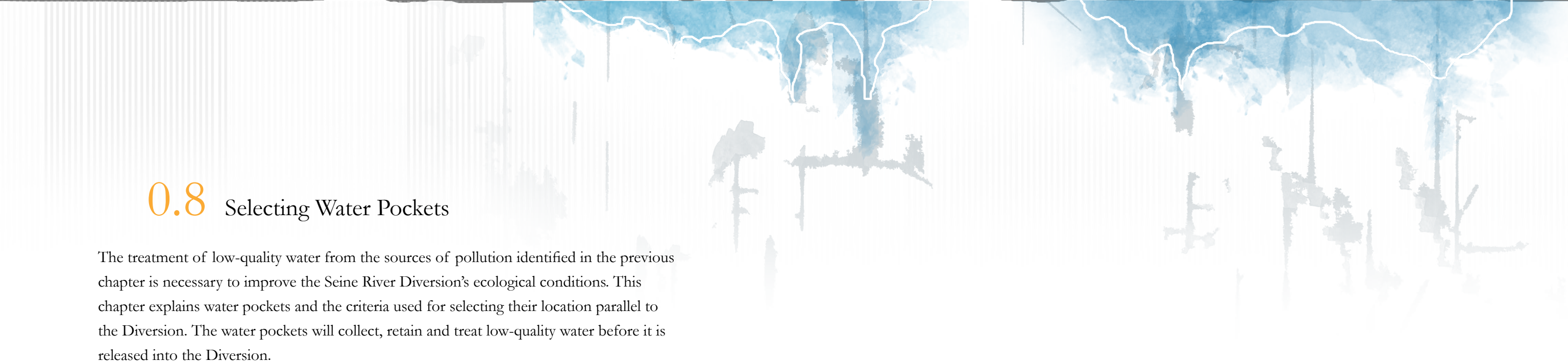
The primary source for non-point pollutant loading is large scale livestock operations within the watershed (Manitoba Water Services Board, 2001, p. 18). The manure collected from these large livestock operations is spread onto the agricultural land. The manure acts as a fertilizer source, rich in phosphorus. The point and non-point sources of pollution have increased the phosphorus concentration in the Seine River Diversion making the water unfit for potable or irrigation purposes (Manitoba Water Services Board, 2001, p. 58).



The next step of the practicum focuses on identifying sites along the Diversion that can help in nutrient reduction, improving Seine River Diversion's ecological condition, enhancing biodiversity and creating habitats.



Figure 0.72 - Point and non-point sources of pollution.



0.8 Selecting Water Pockets

The treatment of low-quality water from the sources of pollution identified in the previous chapter is necessary to improve the Seine River Diversion's ecological conditions. This chapter explains water pockets and the criteria used for selecting their location parallel to the Diversion. The water pockets will collect, retain and treat low-quality water before it is released into the Diversion.

Figure 0.81 - Conceptual Sketch of Water Pockets.

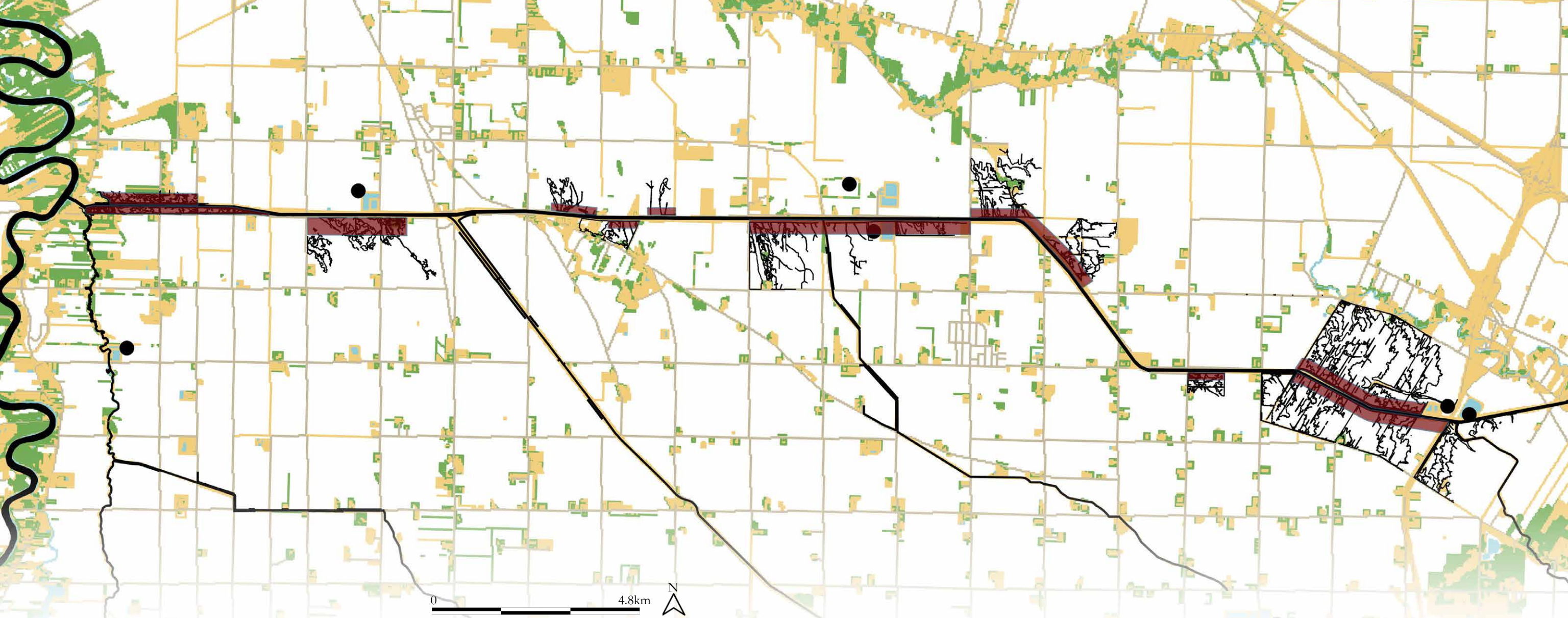


Figure 0.82 - Selecting Water Pockets.

Water Pockets
 Erosion Lines
 Range and Grassland
 Roads
 Sewage Lagoons
 Forest

0.81 Existing Land Use

A detailed investigation of topography, land use and vegetation helped in identifying several water pockets parallel to the Seine River Diversion. Water pockets were

identified in several farms to treat more agricultural runoff and to reduce the land area that will be lost to farmers. The linear water pockets are incorporated in farmland areas with existing wet conditions. The presence of erosion lines on

a portion of farmland makes it challenging to cultivate. The existing topography was studied in detail to identify farmlands that have a higher concentration of erosion lines near the Seine River Diversion. Proximity to existing habitats, towns and sources

of pollution were also considered in identifying the water pockets.



Figure 0.83 - Prairie topography along the Diversion.

Selected Sites

Site Selected for Prototype Design

Sewage Lagoons

Topography

Erosion Lines

0.82 Topography

Prairie landscape adjacent to the Diversion slopes towards the Red River and Lake Winnipeg. Wet conditions closer to the Seine River

Diversion's dike will be more prevalent as the land surrounding the Diversion slopes towards the Diversion's dikes.

The selected sites run through the farmland and parallel to the Diversion.

The length of a water pocket is decided based on the continuity of existing wet conditions parallel to the Diversion. Some water pockets cross multiple farmlands because of the presence of a continuous stretch

of wet conditions. The width of the water pockets vary between 200m and 300m and will finally be decided through discussions with farmland owners.

Oak Hammock Marsh - Canada



0.9 Precedents

The design process began by studying landscape projects with objectives and issues similar to those identified in the practicum. Precedent studies helped in understanding different problem-solving techniques used by the project's designers. The idea was to refer to and reinterpret the design strategies used in these projects to develop a design proposal.



Orongo Station Conservation
Masterplan - New Zealand



Renaturalizing River Aire - Switzerland

0.91 Introduction

The first precedent project identified is Oak Hammock Marsh, designed by the government of Manitoba and Ducks Unlimited Canada. Oak Hammock Marsh bears a resemblance to the historic prairie landscape and supports a wide range of biodiversity. The practicum's site and the marsh share a similar history and surrounding landscape characteristics. This precedent was selected as it provides an understanding of the native landscape of Manitoba.

Orongo Station Conservation project in New Zealand, designed by Nelson Byrd Woltz Landscape Architects, was selected as the second precedent project. The design for the Orongo Station satisfies the interests tied to the land of various people by proposing new productive farming operations, restoring ecology and cultural landscapes. The Orongo Station provides an example of how a design strategy can be used to meet multiple objectives.

The third precedent project is Renaturation of the River Aire,

designed by Atelier Descombes Rampini and Superpositions. The project's goal was to renaturalize an engineered canal. The Aire canal and the Seine River Diversion are surrounded by farmlands. They also share similarities in terms of their engineered linear form. The designer's ways of interpreting the existing infrastructure and the methods used for recreating the past state of the river has informed the design strategy for the practicum.



0.92 Oak Hammock Marsh

Oak Hammock Marsh is a man-made freshwater marsh situated approximately 30km north of the city of Winnipeg. It is the site of the national office of Ducks Unlimited Canada and Oak Hammock Marsh Interpretive Center.

The marsh is restored from a remnant of the St. Andrews Bog, the drainage of which began in 1897 to increase agricultural productivity. The restoration for the marsh started as a joint venture between the government of Manitoba, government of Canada, Ducks Unlimited Canada, wildlife conservation organizations and local landowners (Lindgren, C. J., 2001, p. 9).

Oak Hammock Marsh Interpretive Center is designed by Number Ten Architectural Group. The center exists at the intersection of the prairie edge and the marsh edge. The interpretive center hosts programs to spread awareness about the marsh ecology and demonstrates a need to preserve wetlands.

Figure 0.92 - Oak Hammock Marsh Location Plan.



The marsh is divided into a series of cells by constructing dikes for controlling the water (Ramsar, 1993, p. 1). The individual cells are drawn down and reflooded periodically to improve the productivity of the wetland (Ramsar, 1993, p.2). The artificial changes in the water volume in Oak Hammock Marsh mimics the wet-dry cycle of prairie wetlands. Spring snowmelt, rain, artesian wells, nearby springs and water from the Wavey Creek constitute the main water supply for the marsh (Lindgren, C. J., 2001, p. 9).

RAMSAR convention recognizes Oak Hammock Marsh as a wetland of international importance. The marsh is also listed as an Important Bird Area. Many nesting islands were constructed in the marsh for increasing the Waterfowl population.

0 1.6km

Figure 0.93 - Oak Hammock Marsh plan.

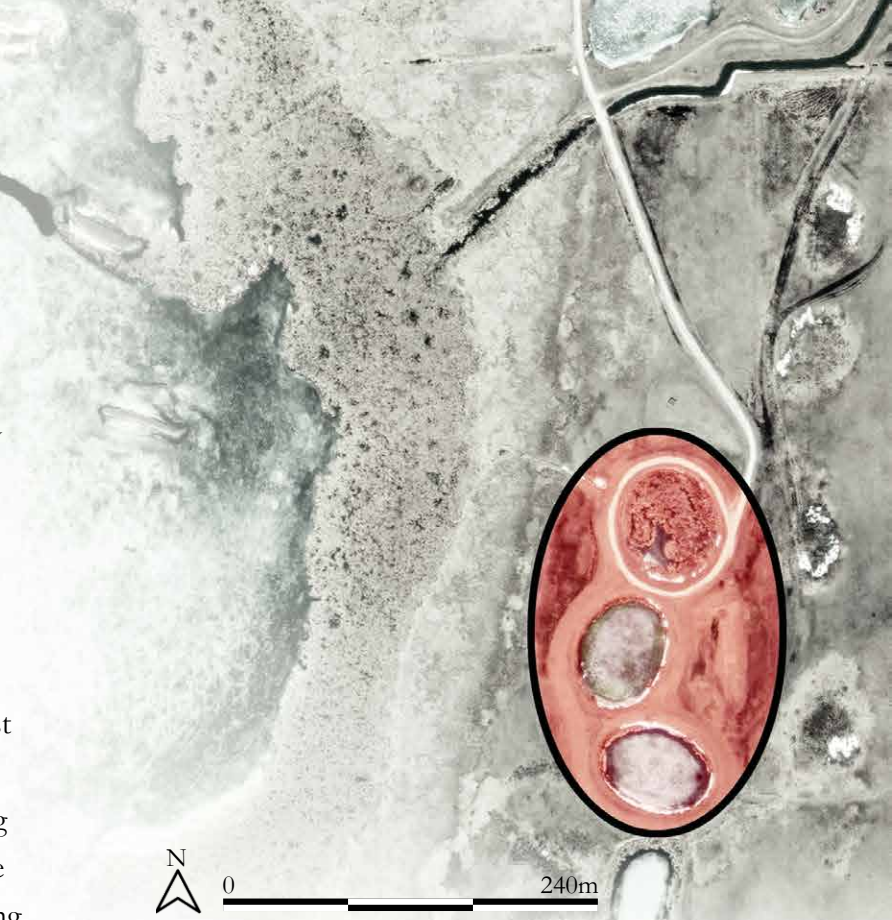
Figure 0.94 (right) - Oak Hammock Marsh Sewage Treatment Area.

The marsh is equally divided into wetlands and uplands. The majority of the uplands are sedges, grasses and remnants of the tallgrass prairie (Ramsar, 1993, p. 1). Willows, bur oaks, trembling aspens, among many other species, are present in the southeastern corner of the marsh (Lindgren, C. J., 2001, pp. 10-11).

Oak Hammock Marsh consists of over 30 kilometres of trail, with most of them located over the dikes. Six mounds or high points for observing the surrounding marsh landscape are present on the site. Waterfowl hunting is allowed in the private lands adjacent to the Oak Hammock Marsh Water Management Area only upon receiving permission from the landowner (Lindgren, C. J., 2001, p. 26).

Sewage Treatment Area

Oak Hammock Marsh uses constructed wetlands for treating wastewater produced on the site. The treatment system consists of three cells (Harris, G. F. D., 2010, p. 35). The primary cell separates the solids from the liquids. The secondary cell removes dissolved and



N 0 240m

suspended biological matter using microorganisms. Before its discharge into the tertiary cell, the water meets the provincial and federal lagoon effluent guidelines (Ducks Unlimited Canada, 2017). The tertiary cell further treats the water and makes sure that the water being discharged into a sensitive ecosystem contains a minimal amount of inorganic compounds and nutrients like nitrogen and phosphorus. The tertiary cell supports biodiversity and consists of vegetation that can treat the impure water by microbial, biological, physical and chemical processes (Anon, 2021).



Learnings

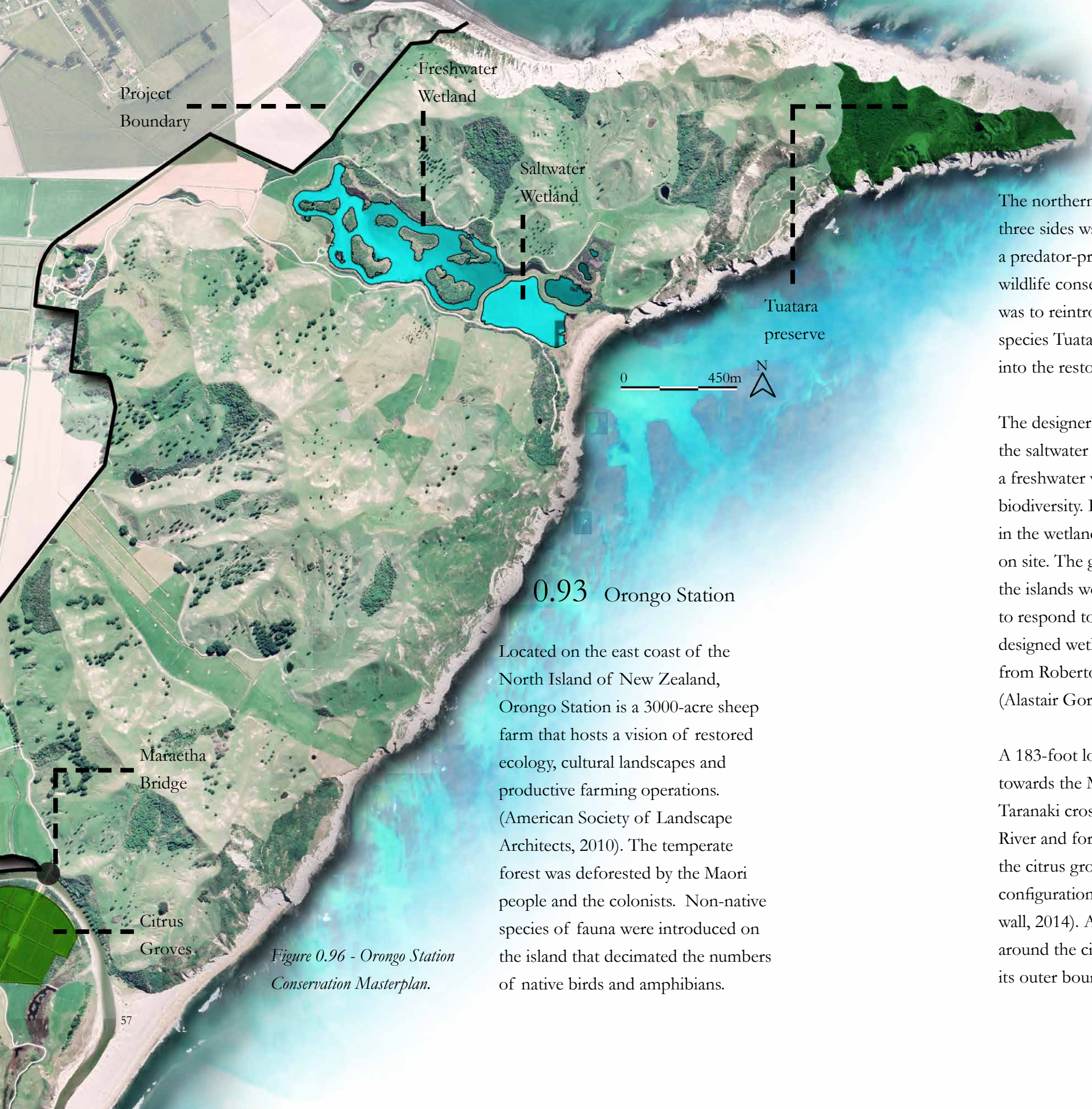
Oak Hammock Marsh provided information about the different vegetation communities and fauna species that inhabit the marsh.

Oak Hammock Marsh efficiently manages the wetland habitat to increase and sustain biodiversity by creating separate enclosures using dikes. These dikes host boardwalks which are used by visitors to navigate the marshland. The volume of water in the enclosures or cells are controlled to mimic the natural water fluctuation processes in a wetland. A similar strategy to create habitats and increase biodiversity by controlling the volume of water in different seasons and using topography to create enclosures or cells is implemented in the detailed design.

The sewage lagoon system of Oak Hammock Marsh utilizes the potential of constructed wetlands to treat sewage water. A similar strategy that comprises a wetland system to reduce the environmental impacts from emergency sewage discharge is used.



Figure 0.95 - View from the Roof of the Interpretive Center



0.93 Orongo Station

Located on the east coast of the North Island of New Zealand, Orongo Station is a 3000-acre sheep farm that hosts a vision of restored ecology, cultural landscapes and productive farming operations. (American Society of Landscape Architects, 2010). The temperate forest was deforested by the Maori people and the colonists. Non-native species of fauna were introduced on the island that decimated the numbers of native birds and amphibians.

Figure 0.96 - Orongo Station Conservation Masterplan.

The northern peninsula with cliffs on three sides was enclosed by installing a predator-proof fence to create a wildlife conservation area. The aim was to reintroduce the endangered species Tuatara, a prehistoric reptile, into the restored forest.

The designers proposed to restore the saltwater wetland and construct a freshwater wetland to improve biodiversity. Islands were constructed in the wetlands using soil excavated on site. The geometry and slopes of the islands were carefully calibrated to respond to different species. The designed wetlands take inspiration from Roberto Burle Marx's paintings (Alastair Gordon wall to wall, 2014).

A 183-foot long bridge oriented towards the Maori sacred hill of Taranaki crosses the Maraetaha River and forms the entrance to the citrus groves laid out in a linear configuration (Alastair Gordon wall to wall, 2014). A shelterbelt is introduced around the citrus groves, which marks its outer boundary.

Remnants of earthen defensive structures, fishing encampments, and the Kumara pits constructed by the Maori people to store the staple food were preserved and revealed through various design strategies.

The design integrates cultural and ecological restoration with agricultural operations and provides a national model for sustainable land management (Nelson Byrd Woltz Landscape Architects, n.d).

Learnings

The approach taken by the designers for creating the freshwater wetland and saltwater wetland is a source of inspiration for the detailed design intervention. Numerous islands were created using the soil excavated from the site. The ecological services of the wetlands were enhanced by calibrating the shapes and slopes of the geometries for creating different habitat conditions. A similar approach is applied to determine the sizes and shapes of the forms proposed in the detailed design for creating different habitat conditions.

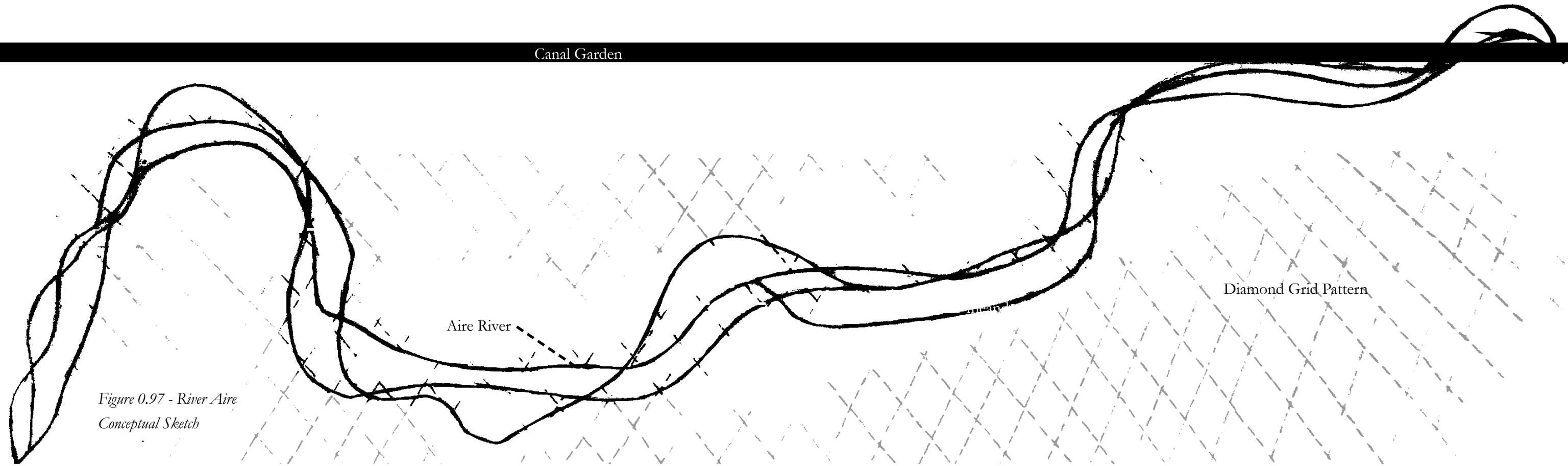


Figure 0.97 - River Aire
Conceptual Sketch

0.94 Renaturalizing River Aire

Aire river flows south of Geneva through farmland. From the late 19th century, the river was progressively canalized to control flooding. This led to the opening of a competition for renaturalizing the Aire River (Descombes, G., 2018a, p. 9).

The Aire River project opposed the requirements of the competition, which negated the history, culture and transformations of the river canal. Instead of attempting to redraw the course of the river and erase

the presence of the canal, the designers made a decision to retain the engineered canal and proposed a diamond grid pattern adjacent to it. The intention was to divert the river over the diamond pattern and render visibility to the invisible forces of the river. Deep trenches were dug for the preparation of the landscape over which the river traced its route (Besse, M. J., 2018, pp. 86-87). The diamond grid takes inspiration from a chocolate bar which reconfigures itself when milk is poured over it. Renaturalizing does not mean returning what is present to a past state but giving the history a new

sense through the project (Tiberghien, A. G., 2018, p. 147). The lozenges over which the river designed itself were constructed of silt, some of gravel and some a mixture (Kondolf, M. G., 2018, p. 177).

The canal alongside the meandering river is retained and converted into a garden questioning the water-based banal morphology of canals, ditches, hedgerows and wetlands, which are read as by-products of development. The presence of the canal alongside the river creates a dialogue between past and present forms.

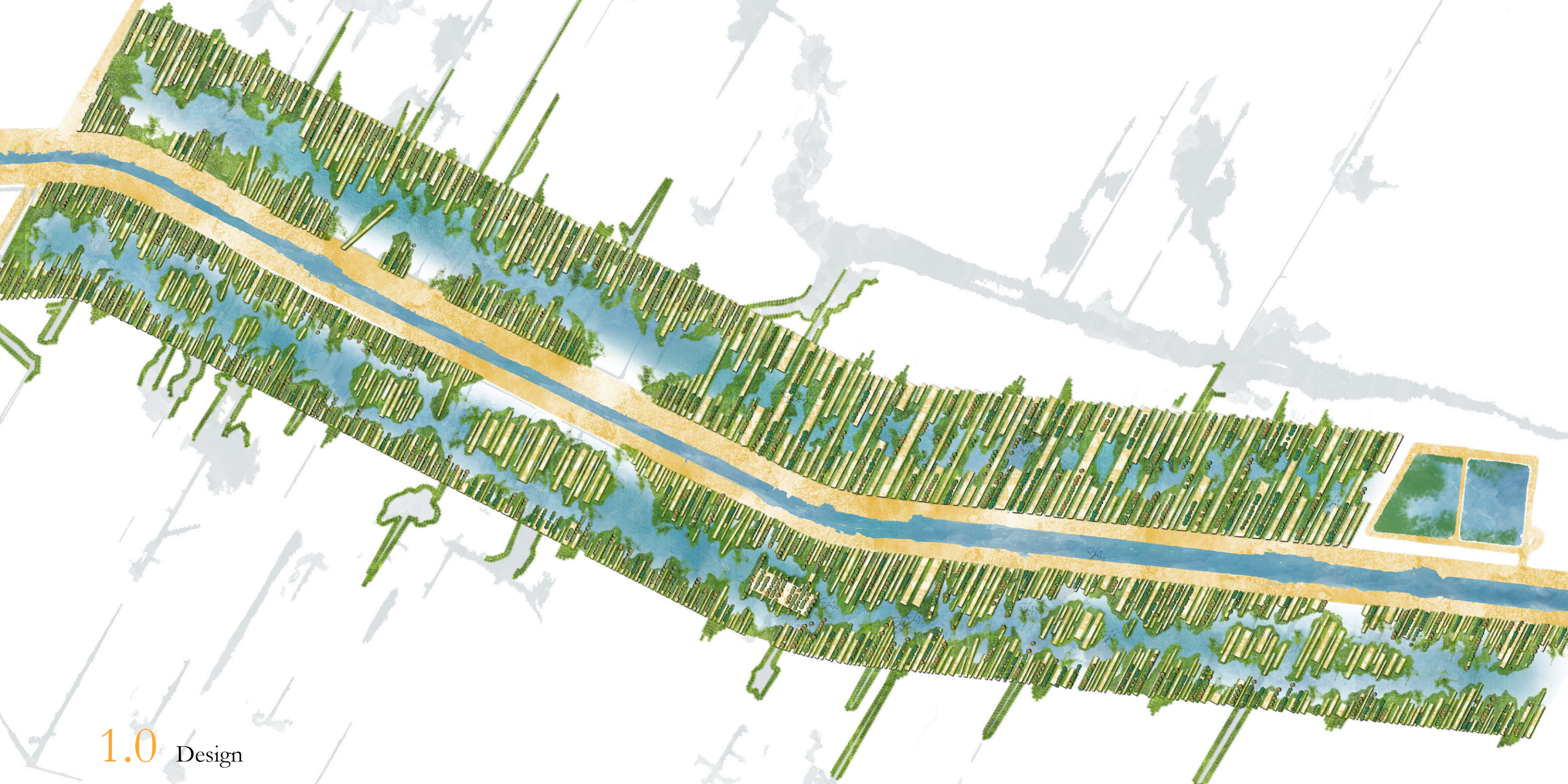
Diamond Grid Pattern

Learnings

The designers preserve the existing ecological conditions of the canal and propose a river habitat in parallel. The project's design strategy turns the existing canal infrastructure into a canal garden. The river modified the precise geometry of the diamond grid and created itself. The Renaturation of River Aire project informs the design thinking about how to interpret the existing infrastructure of the Seine River Diversion. The methodology used to create the river's form parallel to the canal using precise geometry is applied in the detailed design.



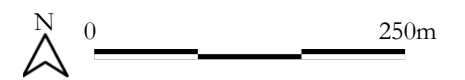
*Figure 0.98 - Canal Garden and
the River Aire.*



1.0 Design

This chapter describes the design proposal. The subchapters explain the site's existing conditions, design strategy, principal landforms, proposed habitats, masterplan, calculations, detailed design of different areas proposed and the overall experiential qualities of the project.

Figure 1.11 - Proposed Prototype Design.



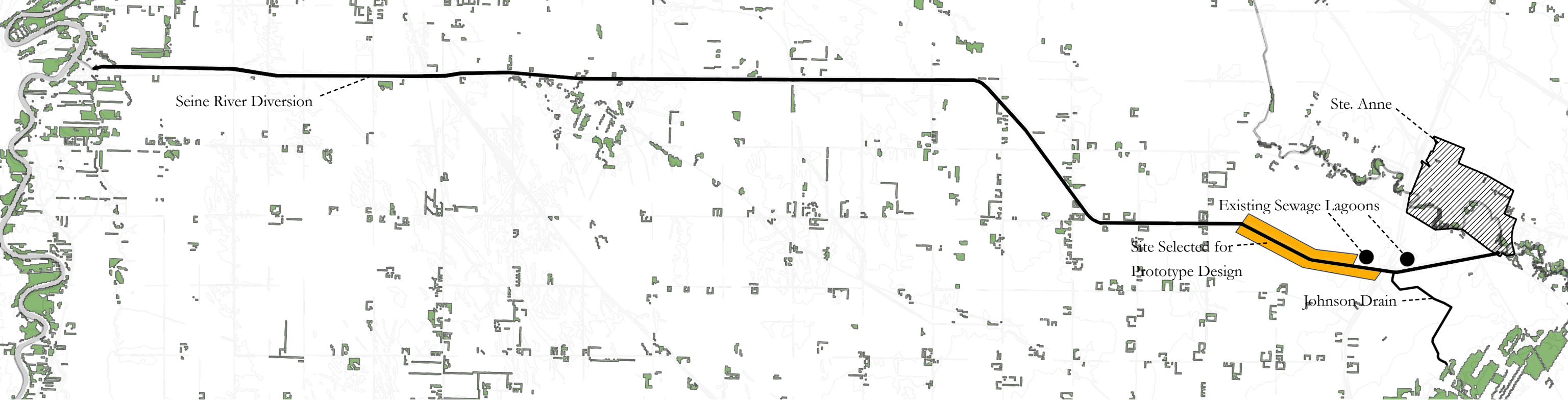


Figure 1.01 - Location of Site for Detailed Design Intervention.

1.01 Existing Conditions

The site selected for developing a prototype design is located near the town of Ste. Anne, two sewage lagoons and a drain that carries nutrients from non-point sources of pollution.

The Seine River Diversion has dry meadow habitat present near the

water's edge almost throughout its length. Trees are absent in the landscape surrounding the site.

Figure 1.02 - A Straight Line.



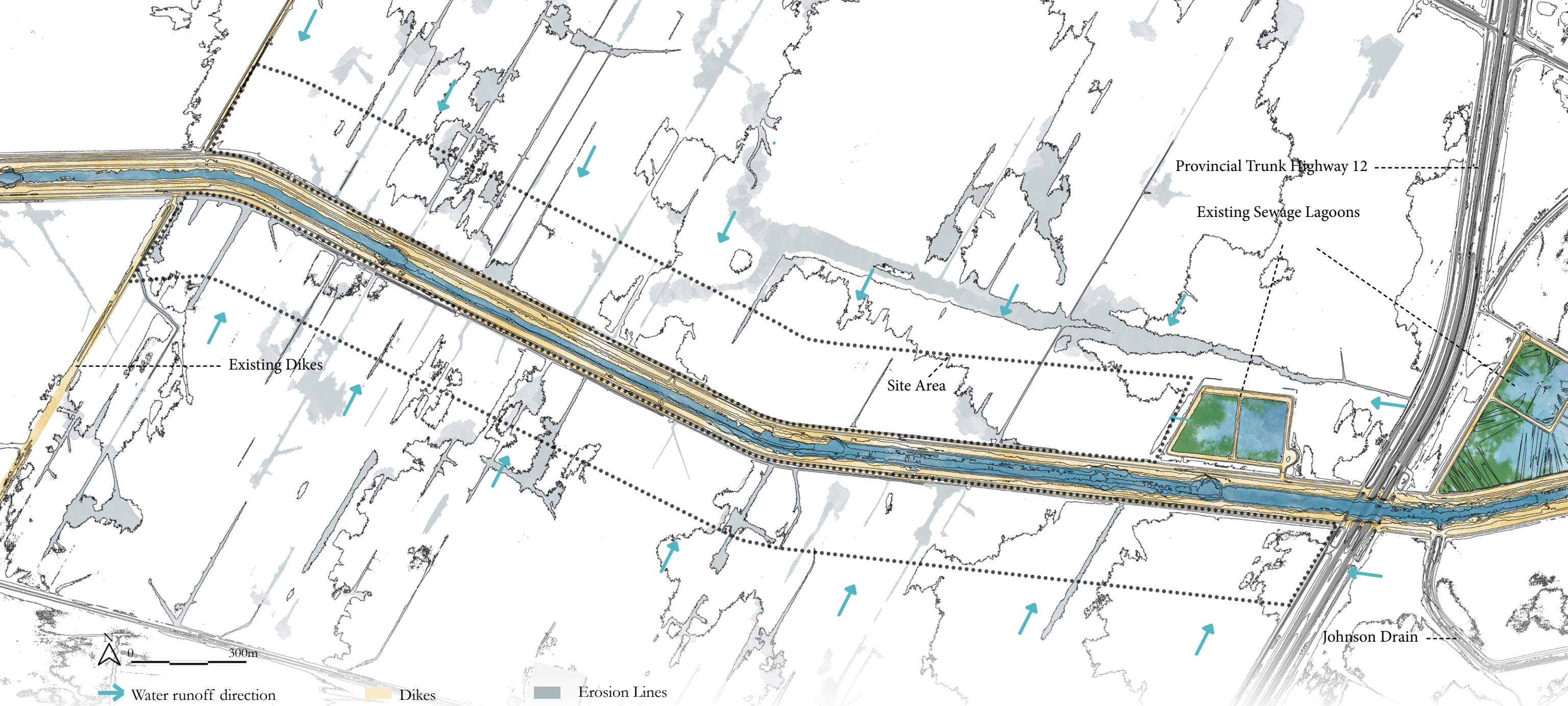


Figure 1.03 - Existing Landscape Surrounding the Site.

The site has a very low slope in the west direction towards the Red River. The western limit of the site is the existing dike, as shown in figure 1.01. The sewage lagoon and the Provincial

Trunk Highway 12 forms the eastern limit of the site. Many erosion lines are present in the farmlands in which the site for detailed design is present. Near the eastern limit of the site,

the Johnson Drain connects with the Seine River Diversion. The drain carries nutrients from non-point sources of pollution. Application of hog manure on the farmland is the

main non-point source of pollution. The town of Ste. Anne is located in the proximity of the site. Recreational activities such as kayaking and fishing are more prevalent.



Figure 1.04 - On the Levee.



Figure 1.06 - Kayaking.



Figure 1.07 - Fishing on the Diversion.



Figure 1.05 - Livestock Operation.



Figure 1.08 - Spill into the Red.

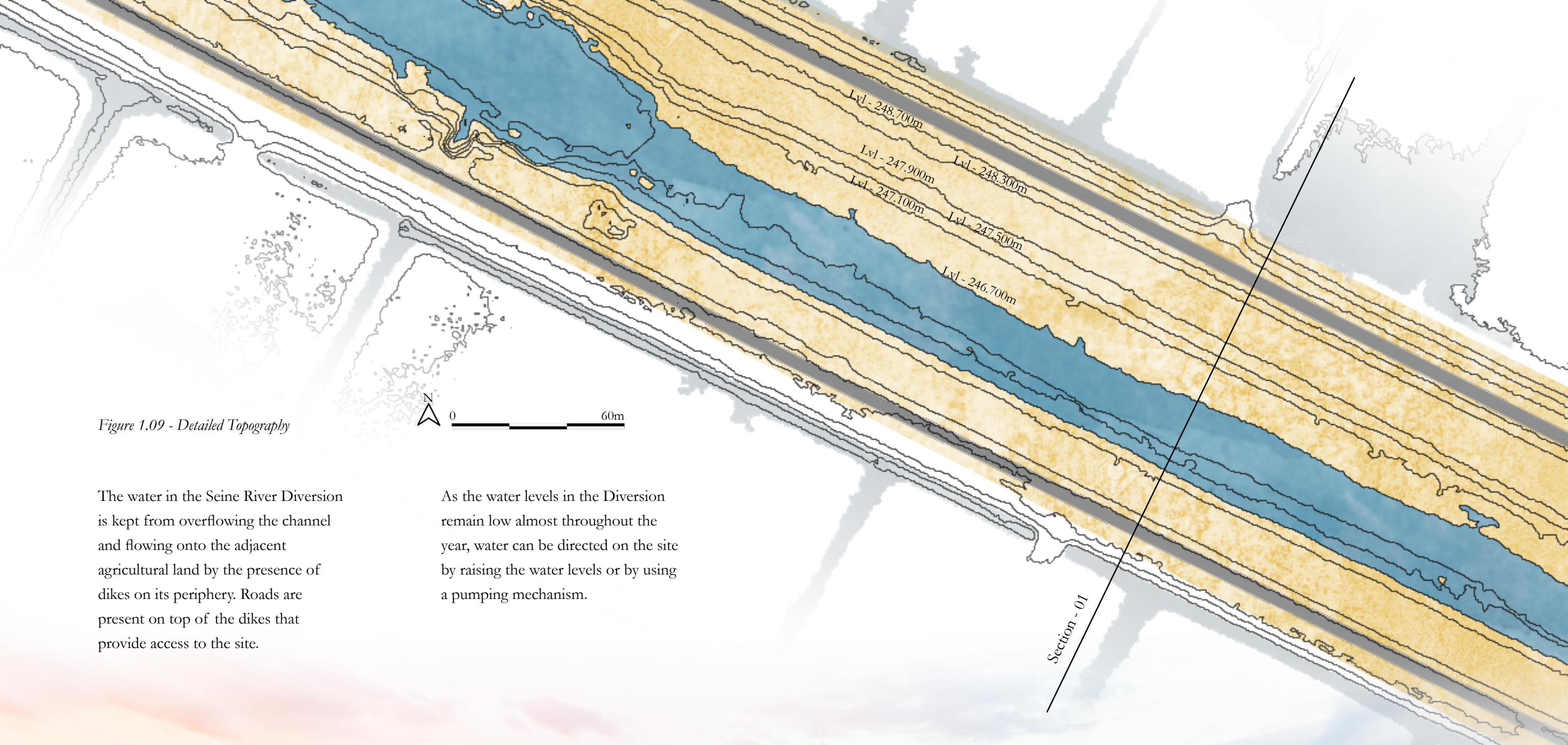


Figure 1.09 - Detailed Topography

The water in the Seine River Diversion is kept from overflowing the channel and flowing onto the adjacent agricultural land by the presence of dikes on its periphery. Roads are present on top of the dikes that provide access to the site.

As the water levels in the Diversion remain low almost throughout the year, water can be directed on the site by raising the water levels or by using a pumping mechanism.

Figure 1.10 - Section across the Seine River Diversion



1.02 Design Strategy

The design strategy aims to develop a proposal that can enhance biodiversity, recreational opportunities and ecologically improve the current state of the Seine River Diversion and its surroundings.

Water in the existing prairie landscape is dispersed quickly from the land, and the interconnected drainage networks function as highways for the water. Earlier, a large number of wetlands in the prairies captured, stored and treated the water runoff.

The design strategy focuses on providing room for the water parallel to the Seine River Diversion. Water from the surrounding landscape and infrastructure enters the Diversion and proceeds towards the Red River. The water retention corridors parallel to the Diversion will reduce the volume of water in the overall drainage system. The intention is to develop a wetland proposal that provides additional benefits of improving biodiversity and treating impure water.

The design strategy focuses on incorporating a landmark quality that can attract people from the surrounding towns and cities. The idea is to make the proposed wetland and the Seine River Diversion function as a public space.



Figure 1.12 - Kayaking on the Seine River Diversion



The site is envisioned to have a function similar to an oxbow lake of a meandering river. Oxbow lakes are of high ecological importance as they support a wide range of biodiversity. Impure water from different sources will be stored and treated on the site. A wetland habitat that supports biodiversity will be created through the collection of water.

The rows of crops used in farmland to maximize efficiency provided inspiration for developing forms of ridges and furrows to create different habitat conditions.

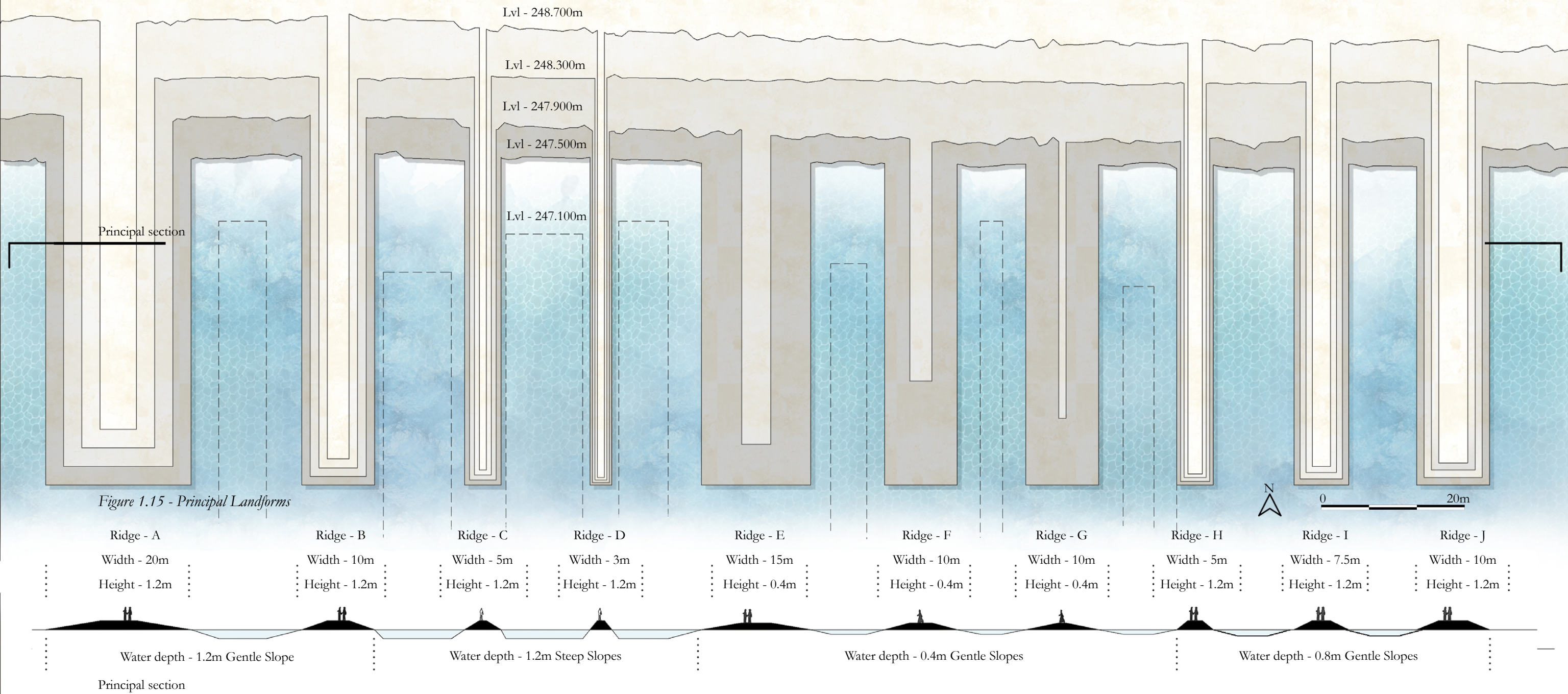
The aim was to develop a striking and unconventional topography that can function as an ecological water treatment plant and invite people,

flora and fauna. The rhythm and scale of the proposed topography will turn the landscape into a landmark.

Figure 1.13(left) - Oxbow Lake of a Meandering River

Figure 1.14(bottom) - Oxbow Lake of an Engineered Diversion





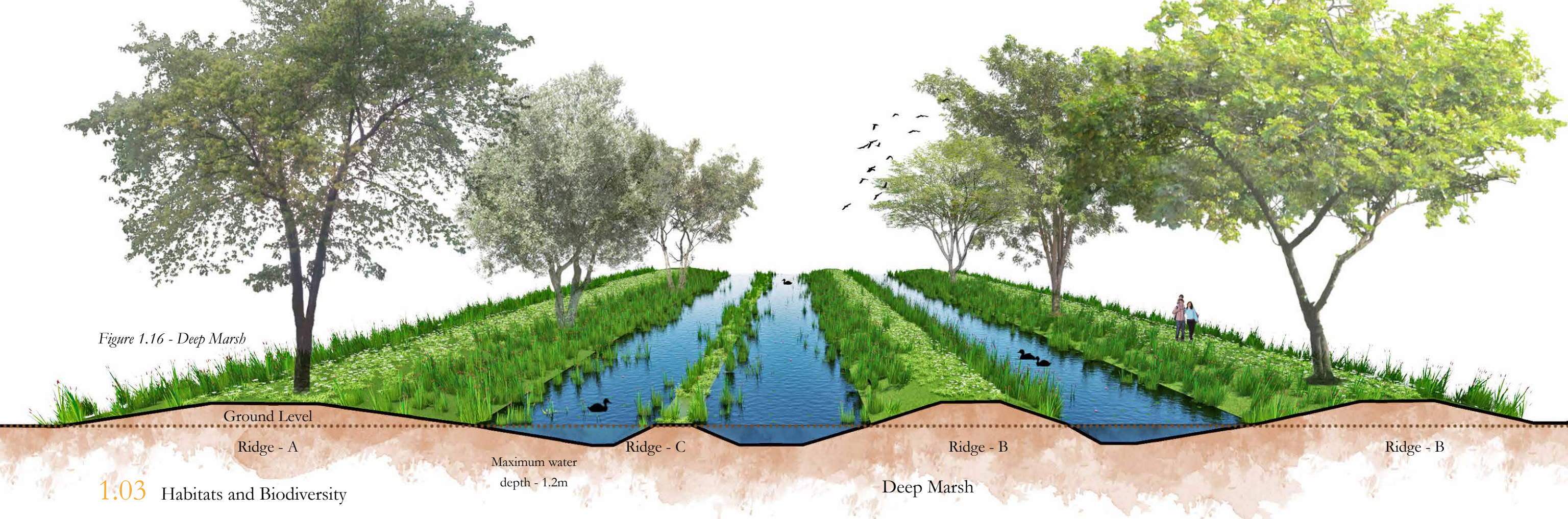
The height, width, slope, and shape of the ridges and furrows are calibrated to create suitable conditions for different flora and fauna species. The maximum level of the ridges from the finished

ground level is the same as the top level of the Seine River Diversion's dikes. Different combinations of the ridges and furrows are designed to create different habitat conditions. As the site evolves, the habitat on

the site will be a combination of the different habitats introduced in the subsequent pages. The ridges and furrows will be constructed using on-site cut and fill. A volume for water storage is provided amidst these linear

geometries to create microhabitats and incorporate the functional aspect of purifying water by emergent vegetation.

Figure 1.16 - Deep Marsh



1.03 Habitats and Biodiversity

Deep marsh, shallow marsh, wet meadow and upland habitats are developed using a combination of ridges and furrows explained earlier. The proposed habitats have varying landforms, water depth and duration of water presence. These variations cause the establishment of specific plant communities in different vegetation zones (Ducks Unlimited Canada, 2019, p. 2). The planting communities are designed to be self-sustainable and to evoke a connection to the landscape's past state. Variety in texture, colour and different blooming seasons were considered before selecting plants species.

Floating Vegetation Species



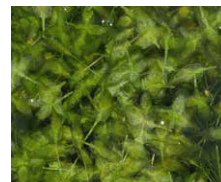
Nymphaea leibergii
Dwarf Water-Lily



Utricularia macrorhiza
Greater Bladderwort



Lemna minor
Lesser Duckweed



Lemna trisulca
Star Duckweed

This habitat consists of high, gently sloping ridges and deep water. In the deep marsh habitat, water will be present almost throughout the year, which may result in the creation of open water zones. Submerged vegetation and floating plants can establish successfully in deep waters (Ducks Unlimited Canada, 2019, p. 9). In the transition zone between deep water and shallow water, emergent vegetation will be grown by planting their rhizome shoots. Trees like willows, cottonwoods, and birch will be planted near the periphery of the landforms where the water level is low. In the deepwater zones, no trees will be planted.

Emergent Vegetation Species



Typha latifolia
Broadleaf Cattail

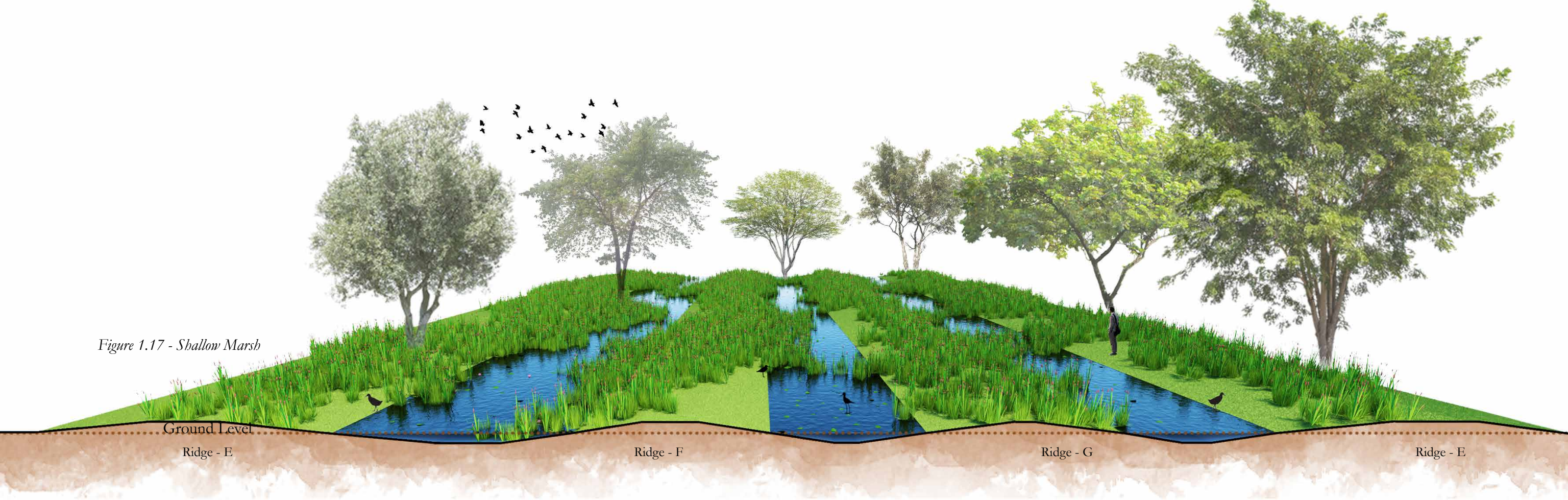


Bolboschoenus fluviatilis
River Bulrush



Schoenoplectus acutus
Hard Stem Bulrush

Figure 1.17 - Shallow Marsh



Shallow Marsh

This habitat is characterized by low, gently sloping ridges with shallow water conditions. In the shallow water zone near the edges of the landforms, the vegetation community includes non-persistent vegetation (Ducks Unlimited Canada, 2019, p. 7). Arrowheads that can purify water will be planted in this zone along with other species.

Tree species that can adapt to shallow water habitat conditions such as poplars, willows, cottonwoods and birch will be planted.

Shallow Marsh Vegetation



Beckmannia syzigachne
American Sloughgrass



Carex scirpoidea
Bulrush sedge



Juncus alpinoarticulatus
Northern Green Rush



Sparganium eurycarpum
Large Bur-reed



Schoenoplectus tabernaemontani
Soft Stem Bulrush



Alisma triviale
Water Plantain

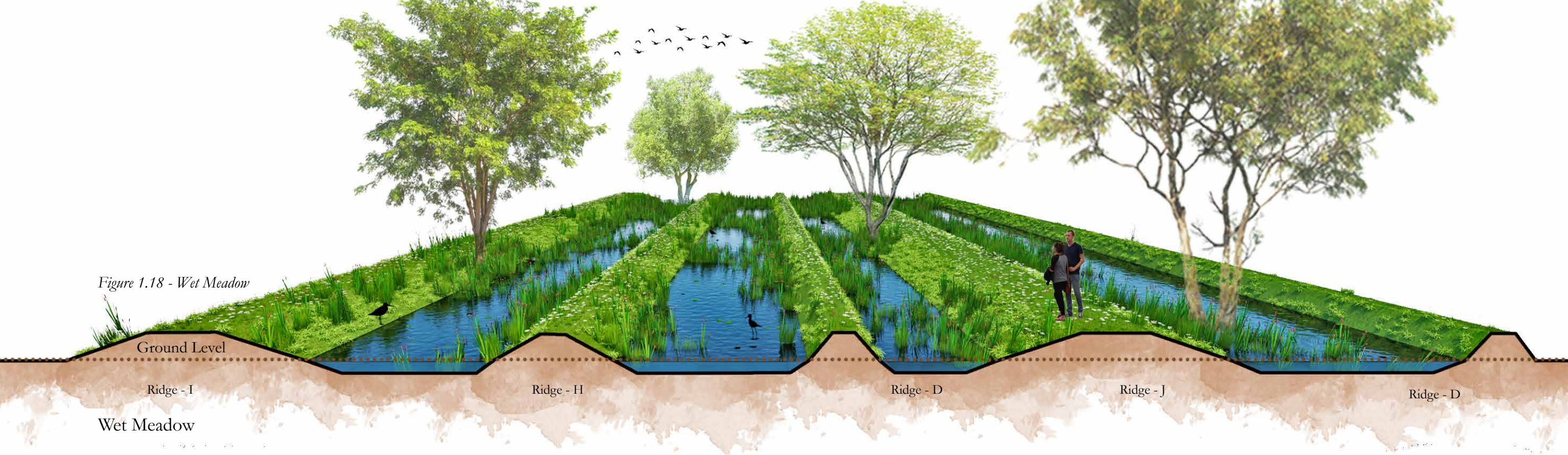


Persicaria amphibia
Water Smartweed



Sagittaria sagittifolia
Arrowhead

Figure 1.18 - Wet Meadow



This habitat is characterized by high, steeply sloping ridges with shallow water. In areas where the soil remains saturated, the vegetation zone comprises wet meadow communities. These meadow communities are designed based on their tolerance to shade and resemblance to historic meadows and grasslands. Wet sedge meadow communities dominated by sedges and including species such as Milkweeds, Smooth Camas, Ironweed, Asters, and Switchgrass will be planted near the water's edge (Ducks Unlimited Canada, 2019, p. 6).

Sedge Meadow Vegetation



Carex atherodes Awned Sedge *Juncus balticus* Baltic Rush *Rumex aquaticus* Western Dock *Spartina gracilis* Alkali Cordgrass *Hordeum jubatum* Foxtail Barley

Species of prairie meadows such as Purple Prairie Clover, Stiff Goldenrod, Culver's Root, Asters and Big Bluestem will be planted on the upper reaches of the ridges where the shade is absent. These species can support a wide variety of pollinators and birds along with other fauna. In shaded areas, meadow community including species of Golden Alexander, Giant Hyssop and Canada Wild Rye will be planted. Meadows will be grown through seeding with a minimum of 160 seeds per square foot to reduce the risk of weed invasion (The Nature Conservancy, 2017, p. 7).

The upper reaches of the ridges will be planted with Oaks, Maples, Basswood and Birch to provide shade and enrich biodiversity.

Prairie Meadow Vegetation



Agastache foeniculum Blue Giant Hyssop *Zizia aurea* Golden Alexander *Dalea purpurea* Purple Prairie Clover *Solidago canadensis* Canada Goldenrod *Symphotrichum ericoides* White Heath Aster

Figure 1.19 - Uplands



This habitat is characterized by high, gently sloping ridges with no water in between. The vegetation comprises upland trees and prairie meadow species. This area is integrated into the design with the intention of strengthening the recreational aspect of the project. In the upland area, the upper story of vegetation consists of native tree species planted linearly to strengthen the landforms.

Prairie Meadow Vegetation



Symphoricarpos albus Northern Snowberry
Poa pratensis Kentucky Bluegrass
Kochia scoparia Mexican Fireweed
Andropogon gerardii Big Bluestem
Bouteloua gracilis Blue Grama Grass



Panicum virgatum Switchgrass
Sorghastrum nutans Yellow Indiangrass
Populus deltoides Eastern Cottonwood
Quercus macrocarpa Bur Oak
Salix amygdaloides Peachleaf Willow

The trees are planted throughout the site in small linear clusters to create different sun and shade conditions. In the upland area, Oaks, Maples, Hackberry, Basswood and Birch trees are planted. The understory in the upland area consists of prairie meadow species.



Figure 1.20 - Proposed Masterplan

1.04 Masterplan

The ridges and furrows are arranged in parallel with the rows of crops to create an extension of the landforms used in existing farming practices. Wetlands are proposed adjacent to the Diversion that acts as a sponge by purifying the nutrient-rich water from

the surrounding agricultural landscape. The wetland to the north of the Diversion has a sewage treatment area closer to the two sewage lagoons, as shown in figure 1.19. This area further purifies the sewage water from the lagoons and stores their emergency discharge while supporting biodiversity.

Water in the wetland located south of the Diversion comes from the Johnson Drain, which is directed from under the highway through culverts. Two wind-powered pumps are installed in both wetlands to recharge wetlands during dry periods and purify as much water as possible. These windpumps can withdraw water from

the Diversion and operate when the water levels are low and to maintain biodiversity. The Diversion's dikes function as a walkway to explore the wetlands. High points are located at key locations to strengthen the recreational interest and to provide a view of the horizon.

1.05 Calculations

The landforms on the site are constructed using a cut and fill application. The intention was to reuse the fertile soil extracted from the site. The total volume of soil extracted and the total volume of soil reused is calculated for the design prototype. This step helped in making necessary improvements to the design in order to minimize the difference between cut and fill volume of soil and to reduce the energy consumption required for surplus soil transportation. The result of the calculation indicated that there is a surplus volume of soil that is not reused in design construction.

Calculation Method

The following abbreviations are used to explain the calculation method.

SA = Surface area of landforms obtained through Autocad.

DGL = depth of contour from ground level

CI = Contour Interval

H = Height of proposed landforms from ground level

Fill Calculation

Each landform proposed in the design is an addition of cuboid and triangular prism geometry.

The volume of cuboids and the triangular prisms are calculated separately and added to determine the total volume of fill.

$$\text{Volume of cuboid} = SA \times H$$

$$\text{Volume of triangular prism} = SA \times H \times 0.5$$

Cut Calculation

To determine the volume of cut between two contour levels, the following formula is used.

$$SA \times [DGL - (CI \times 0.5)]$$

The volume of cut for different contour levels are added to determine the total volume of cut.

Fill Calculation

Figure 1.21(■) - Area of Non-sloping portion of Ridges

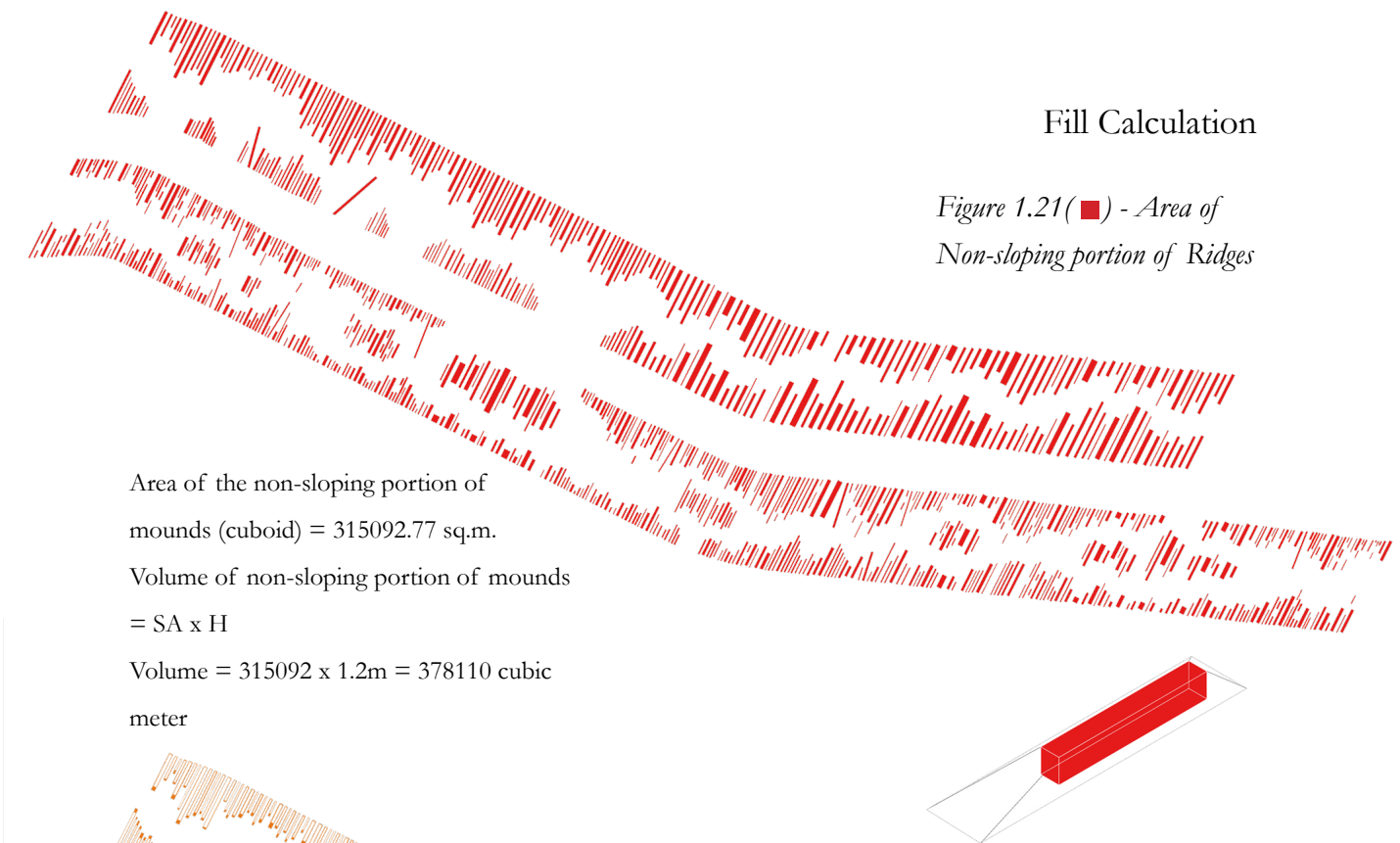
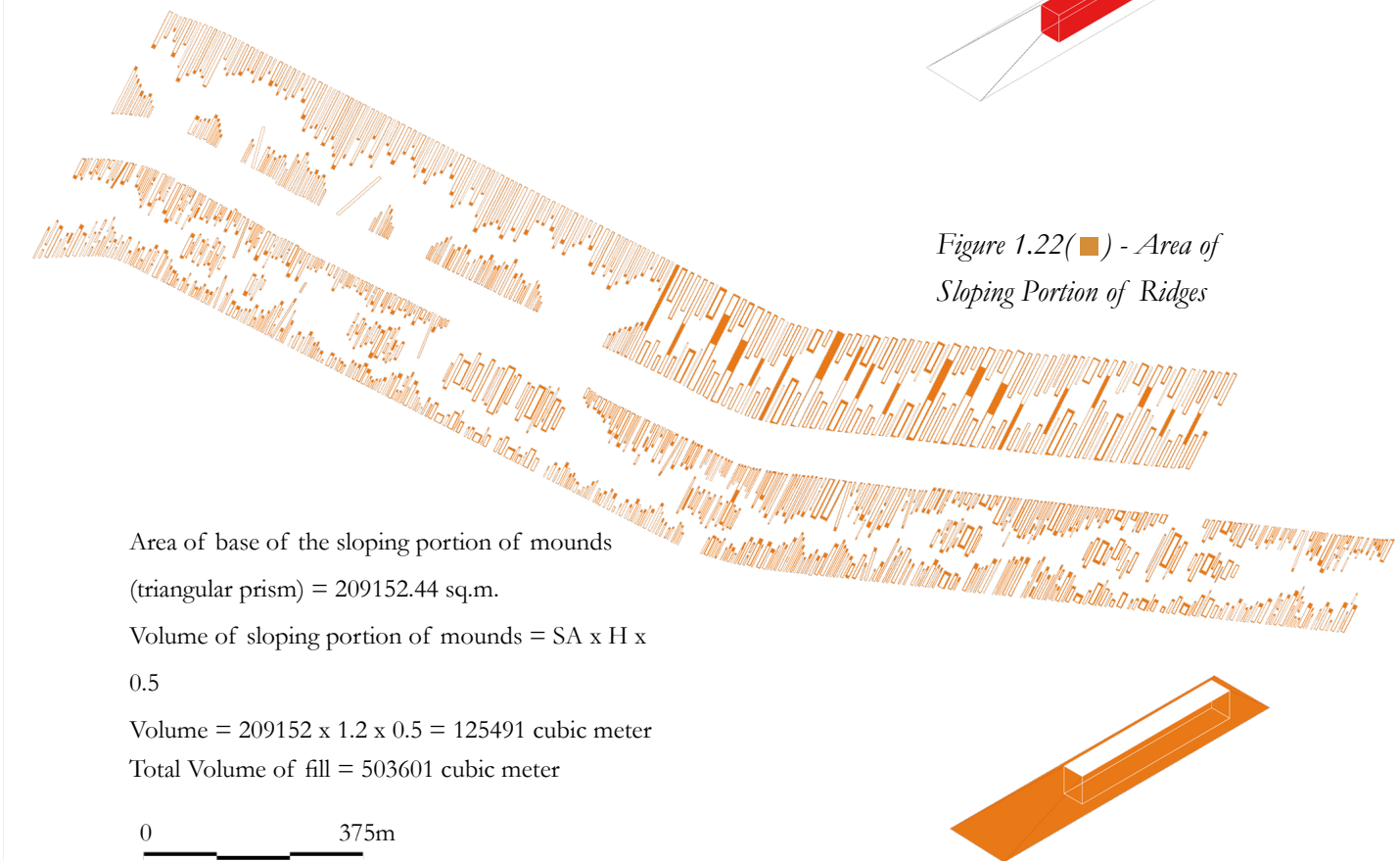
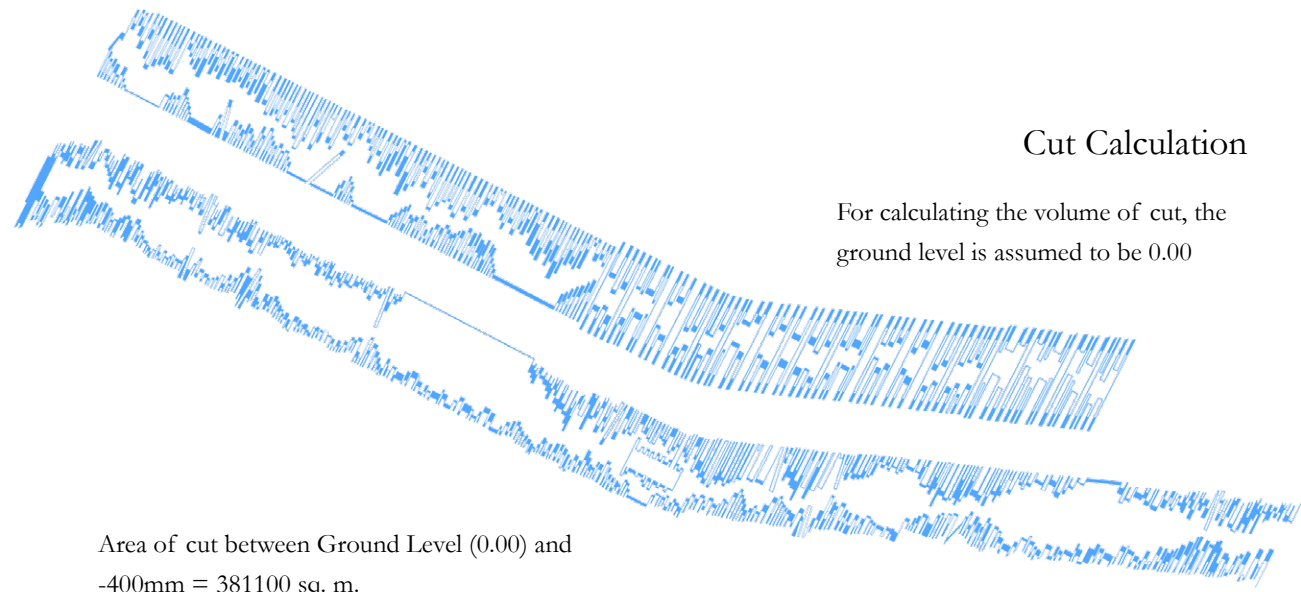


Figure 1.22(■) - Area of Sloping Portion of Ridges



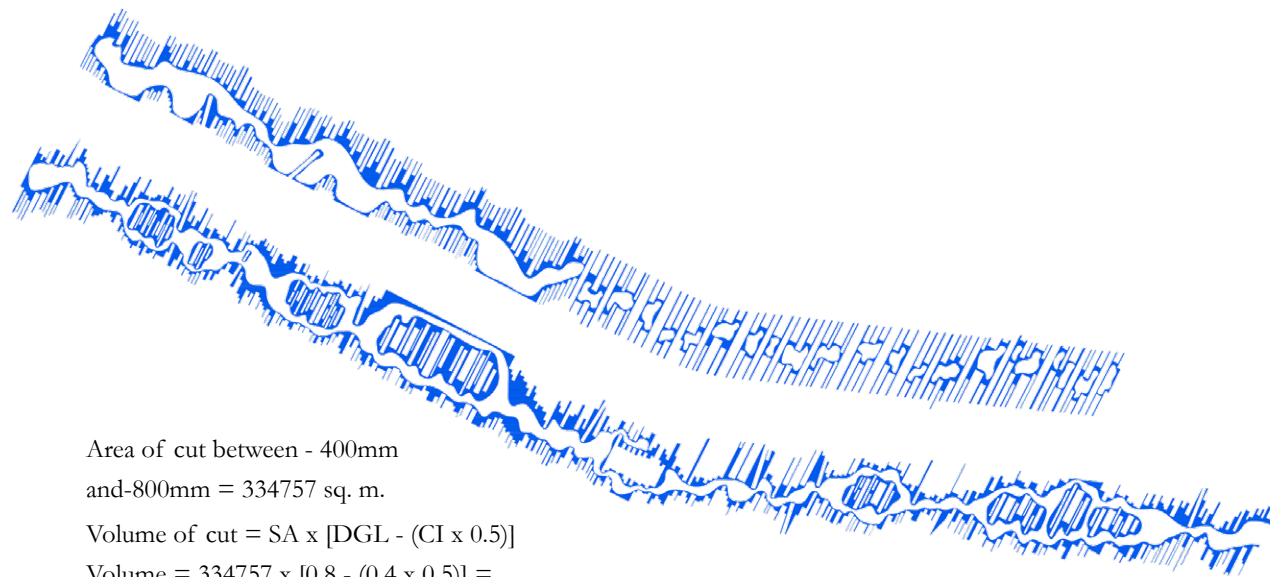
Cut Calculation

For calculating the volume of cut, the ground level is assumed to be 0.00



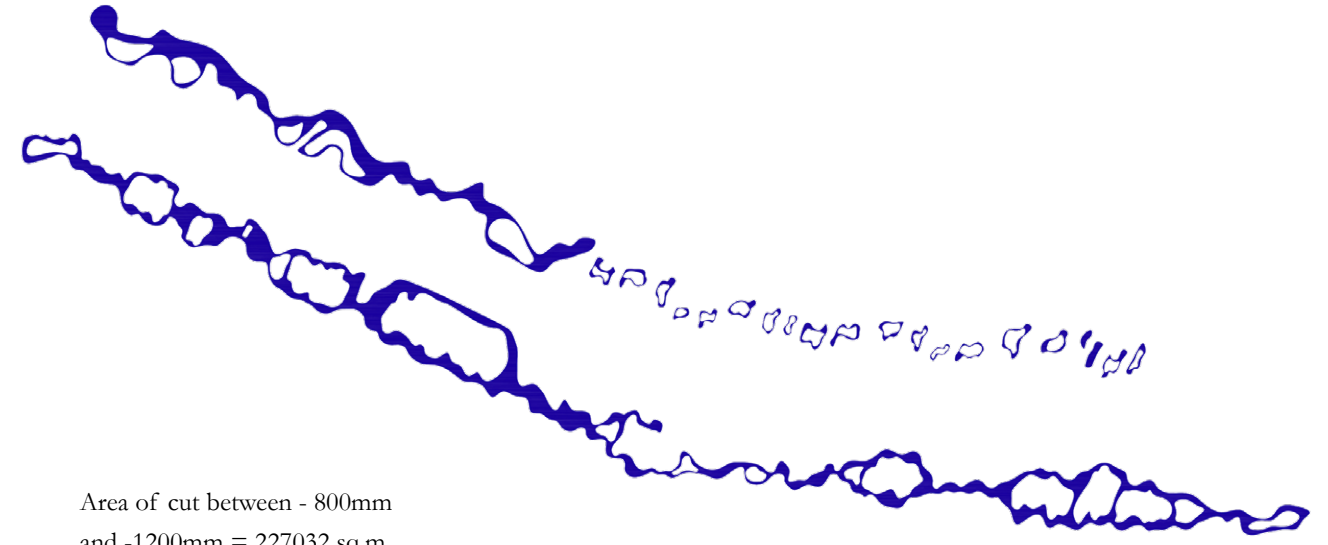
Area of cut between Ground Level (0.00) and -400mm = 381100 sq. m.
 Volume of cut = SA x [DGL - (CI x 0.5)]
 Volume = 381100 x [0.4 - (0.4 x 0.5)] = 76220 cubic meter

Figure 1.23(■) - Area between Ground Level and - 400mm



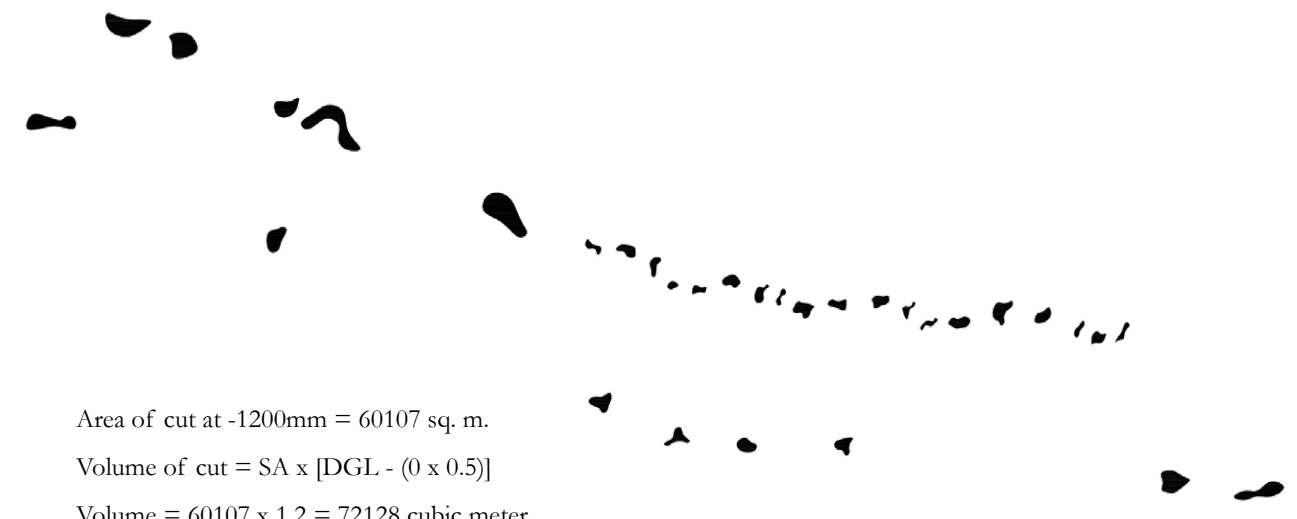
Area of cut between - 400mm and -800mm = 334757 sq. m.
 Volume of cut = SA x [DGL - (CI x 0.5)]
 Volume = 334757 x [0.8 - (0.4 x 0.5)] = 200854 cubic meters

Figure 1.24(■) - Area between -400mm and - 800mm



Area of cut between - 800mm and -1200mm = 227032 sq.m.
 Volume of cut = SA x [DGL - (CI x 0.5)]
 Volume = 227032 x [1.2 - (0.4 x 0.5)] = 227032 cubic meter

Figure 1.25(■) - Area between -800mm and - 1200mm



Area of cut at -1200mm = 60107 sq. m.
 Volume of cut = SA x [DGL - (0 x 0.5)]
 Volume = 60107 x 1.2 = 72128 cubic meter
 Total Volume of cut = 576234 cubic meter

Figure 1.26(■) - Area at -1200mm

Result

Vol. of cut = 1.14 x Vol. of fill

Remaining Soil Volume

The additional volume of cut can either be spread on the agricultural land to increase the productivity of crops or can also be directed to the Ritchot landfill for utilization as a cover material.

Figure 1.27 shows an approximate area that will be covered with the surplus cut volume with a thickness of 100mm.

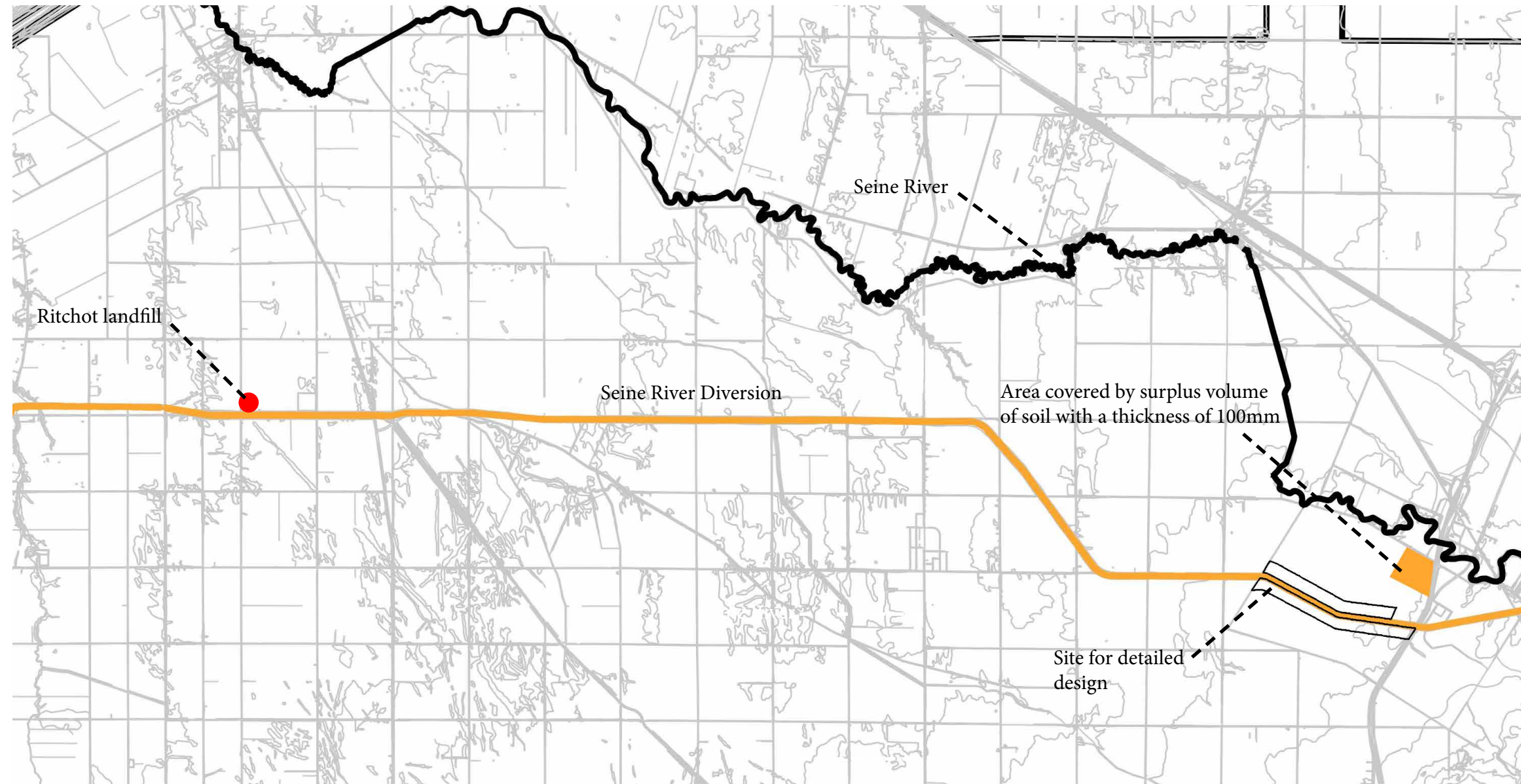


Figure 1.27 - Location of Ritchot Landfill

Cattails Calculation

The proposed wetlands will provide ecological service by treating the impure water using emergent vegetation. The nutrient removal capacity of cattails planted in the proposed wetlands is calculated in this sub-chapter.

The calculation for the two wetlands north and south of the Seine River Diversion are done separately.

An ideal situation is assumed in which the cattails will cover 50 per cent of the area of the sloping portion of the ridges.

One hectare of cattails can remove 0.2 - 0.6 tonnes of phosphorus per year and 0.21 tonnes of nitrogen per year (Cicek et al., 2006, p. 533).

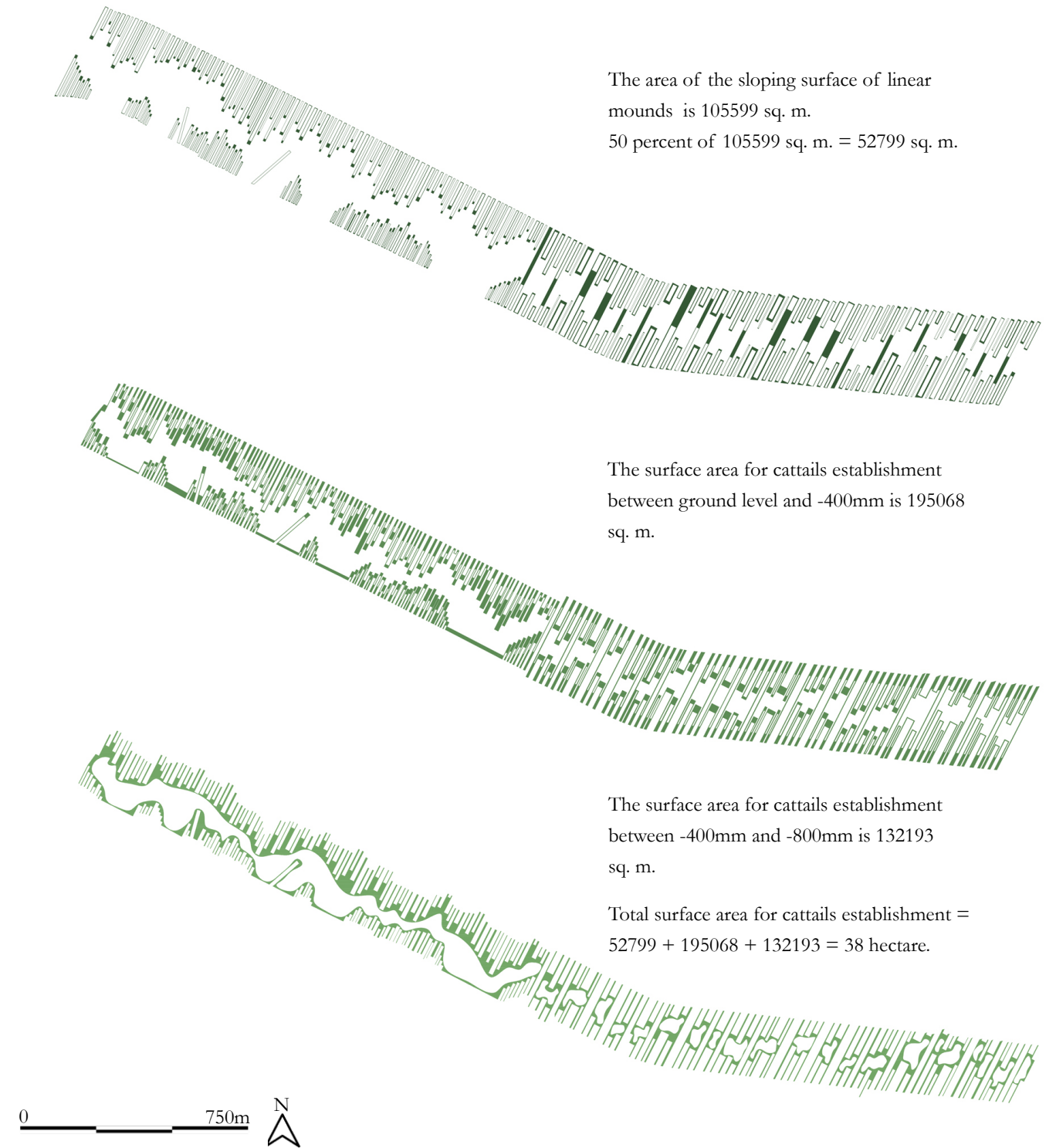
Five hectares of cattails can remove approximately 1 tonne of nitrogen annually (Cicek et al., 2006, p.533).

Figure 1.28 - Northern Wetland's Emergent Vegetation Area on the Slopes of the Ridges

Figure 1.29 - Northern Wetland's Emergent Vegetation Area between Ground Level and -400mm

Figure 1.30 - Northern Wetland's Emergent Vegetation Area between -400mm and -800mm

Wetland, North of the Seine River Diversion



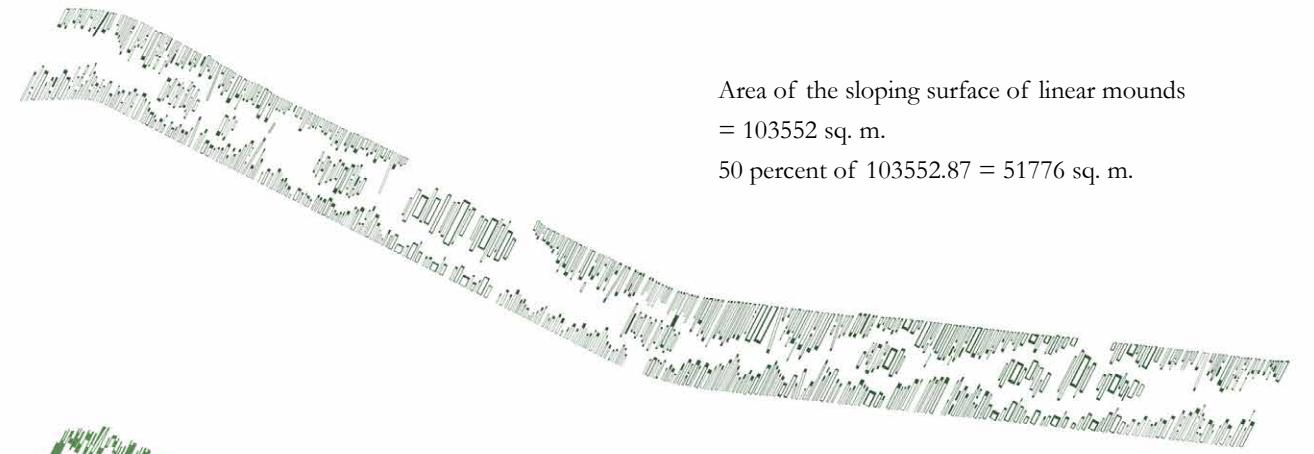
The area covered by cattails in the two wetlands will be dependent on the water fluctuation regime, which is designed to mimic the natural cycle of wetlands to maximize the area of cattails.

The result from the calculations indicated that, in an ideal situation, the two sites would have 82 hectares of cattails.

Result

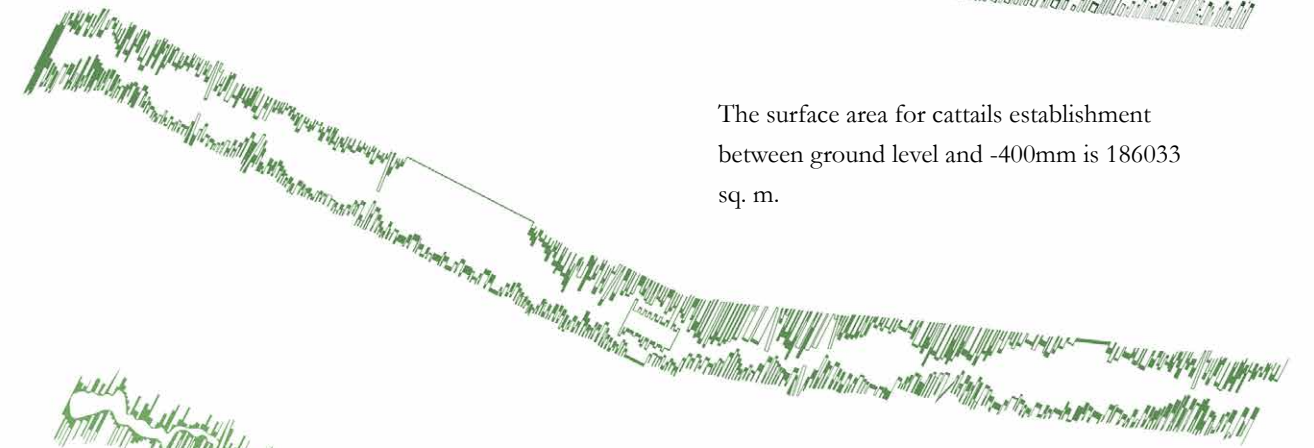
Reduction in phosphorus load by the two sites will vary between a minimum of 16.4 tonnes and a maximum of 49.2 tonnes annually. The sites will also be able to reduce the nitrogen load by 16.4 tonnes annually.

Figure 1.31 - Southern Wetland's Emergent Vegetation on the Slopes of the Ridges



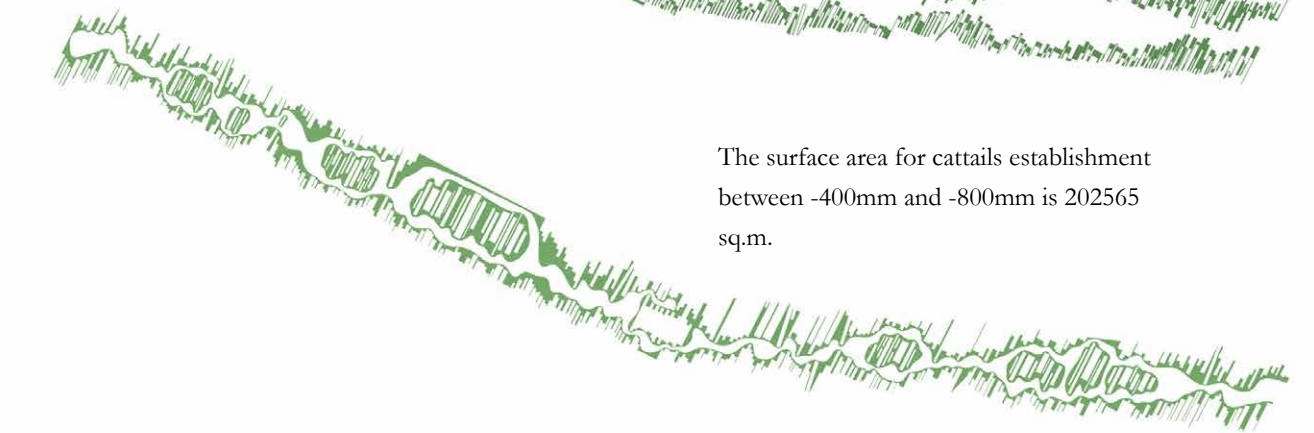
Area of the sloping surface of linear mounds = 103552 sq. m.
50 percent of 103552.87 = 51776 sq. m.

Figure 1.32 - Southern Wetland's Emergent Vegetation between Ground Level and -400mm



The surface area for cattails establishment between ground level and -400mm is 186033 sq. m.

Figure 1.33 - Southern Wetland's Emergent Vegetation Area between -400mm and -800mm



The surface area for cattails establishment between -400mm and -800mm is 202565 sq.m.

Total surface area for cattails establishment = 51776 + 186033 + 202565 = 44 hectare

Sewage Treatment Area - Volume of Water

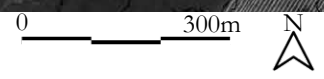
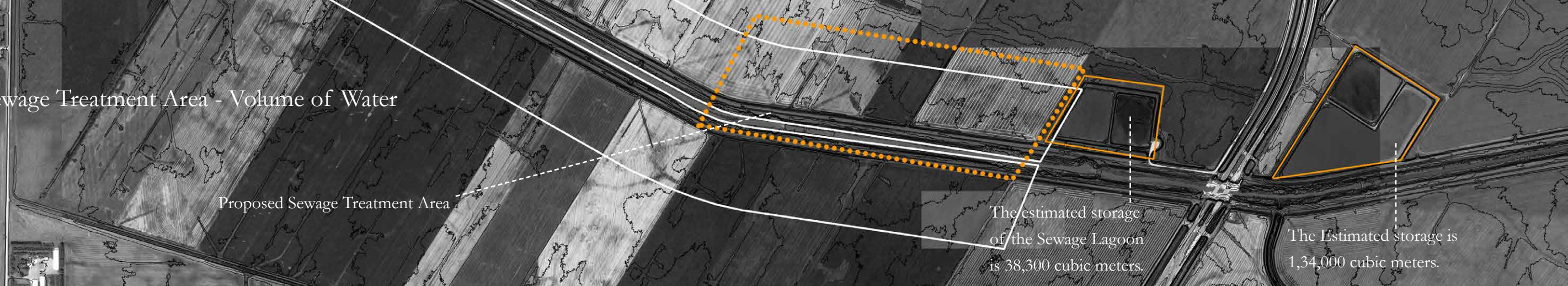


Figure 1.34 - Existing Sewage Lagoons

“The estimated storage volume for the existing sewage lagoons has been calculated as half of the primary cell(s) plus the entire volume of the

secondary/storage cell(s)” (Manitoba Water Services Board, 2001, p. 14). The volume of sewage water discharged into the Diversion varies annually depending upon precipitation and evaporation rates.

The volume of water that the proposed sewage treatment area can store is calculated and compared with the storage capacity of existing sewage lagoons.

Result

At maximum capacity, the Sewage Treatment Area of the design proposal can store and purify the whole estimated storage(38,300 cubic meters) of one sewage lagoon and approximately half of the estimated storage (1,34,000 cubic meters) of the second sewage lagoon (Manitoba Water Services Board, 2001, p. 17).

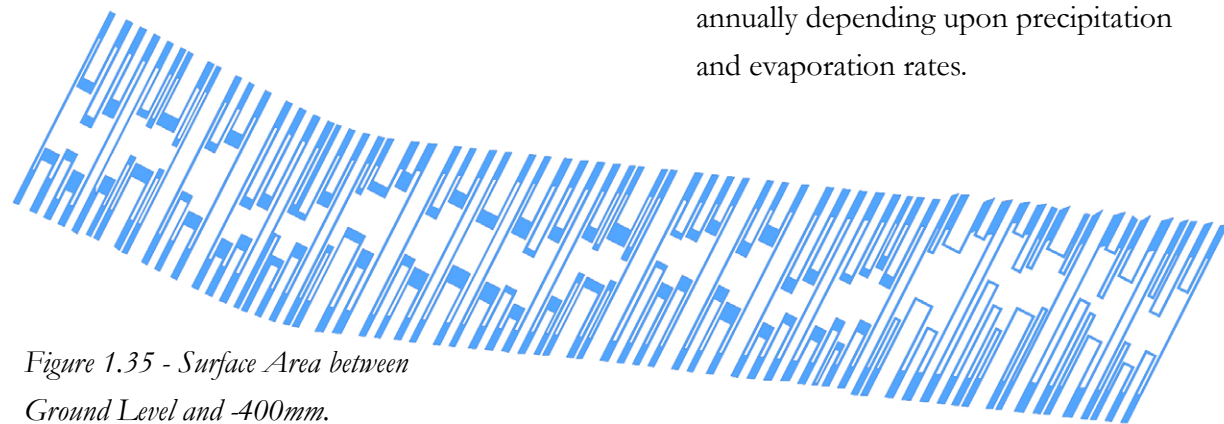
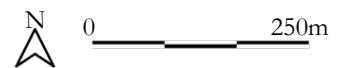


Figure 1.35 - Surface Area between Ground Level and -400mm.

Area of land between Ground Level (0.00) and -400mm is 102477 sq.m.
Volume = 102477 x 0.4 x 0.5 = 20,495 cubic meters



Area of land between -400mm and -800mm = 61517 sq.m.
Volume = (61517 x 0.4 x 0.5) + (61517 x 0.4) = 36909 cubic meters

Figure 1.36 - Surface Area between -400mm and -800mm.

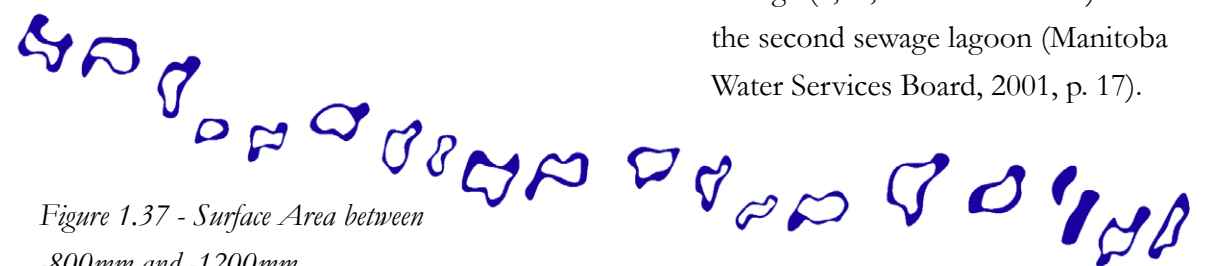
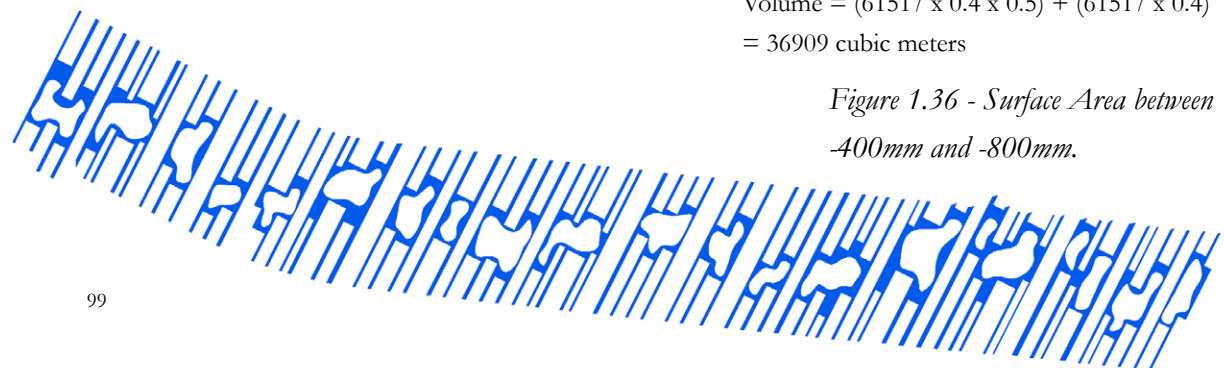


Figure 1.37 - Surface Area between -800mm and -1200mm.

Area of land between Ground Level -800mm and -1200mm = 18693 sq.m.
Volume = (18693 x 0.4 x 0.5) + (18693 x 0.8) = 18692 cubic meters

Area of land at -1200mm = 17557 sq.m.
Volume = 17557 x 1.2 = 21068 cubic meters
Total Volume of Sewage Treatment Area = 20,495 + 36909+ 18692 + 21068 = 97164 cubic meters

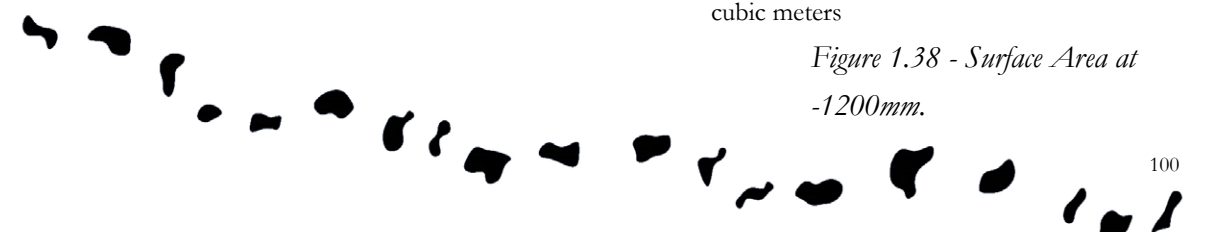


Figure 1.38 - Surface Area at -1200mm.

1.06 Claybars, Potholes and Meanders

The precise topography of the intervention is explained in figure 1.39. The maximum height of the ridges is the same as the top level of the dike, whereas the lowermost level is 1.2 meters below the finished ground level (247.1m).



Figure 1.39 - Precise Design Intervention

Flora and fauna will change the initial preciseness of the design intervention as the site evolves.

The landscape of ridges and furrows will store the runoff from the farmlands and water from the lagoons and Johnson drain. Different habitats of dry meadows, prairie grasses, upland trees and wetlands can be experienced on the site. The linear arrangement of trees attracts people from the Diversion's dike to walk on the ridges and witness the biodiversity inhabiting the proposed wetland infrastructure. The driving experience on the dike is made memorable by the presence of linear rows of trees and their colors in different seasons.



Detailed Plan of Sewage Treatment Area



Figure 1.40 - Site Plan after 20 - 30 Years

1.07 Sewage Treatment Area

The proposed sewage treatment area consists of different cells similar to the Oak Hammock Marsh (refer to chapter 0.91). The existing sewage lagoons provide primary and secondary treatment of the sewage water. The proposed sewage treatment area can provide tertiary treatment of the wastewater before its release into the Seine River Diversion. Emergent vegetation in the sewage treatment area will be predominant, which assists in the purification of water and enhances biodiversity. Sewage water from one cell overflows into the adjacent cell for purification. The number of cells filled will be dependent on the volume of sewage water directed into the design intervention.

A limestone plaza that hosts a wooden deck is constructed to invite people closer to the water for experiencing the wetland and its biodiversity.

The finished level of the deck is higher than the overflow level to allow the water to pass from underneath it.

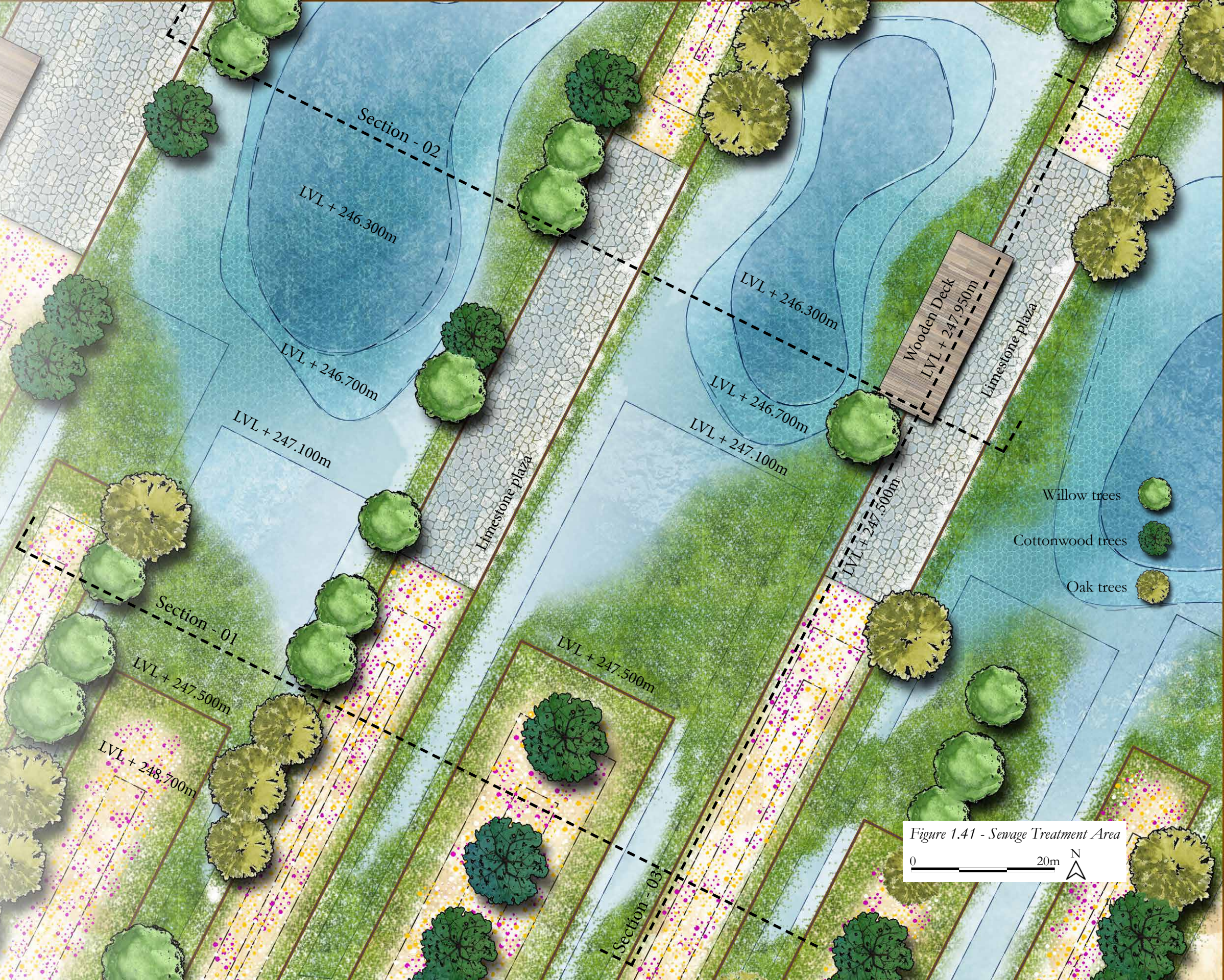


Figure 1.41 - Sewage Treatment Area



Figure 1.42 - Section - 01, Summer Season



Figure 1.43 - Section - 02, Fall Season

0 20m



Figure 1.44 - Section - 03, Winter Season

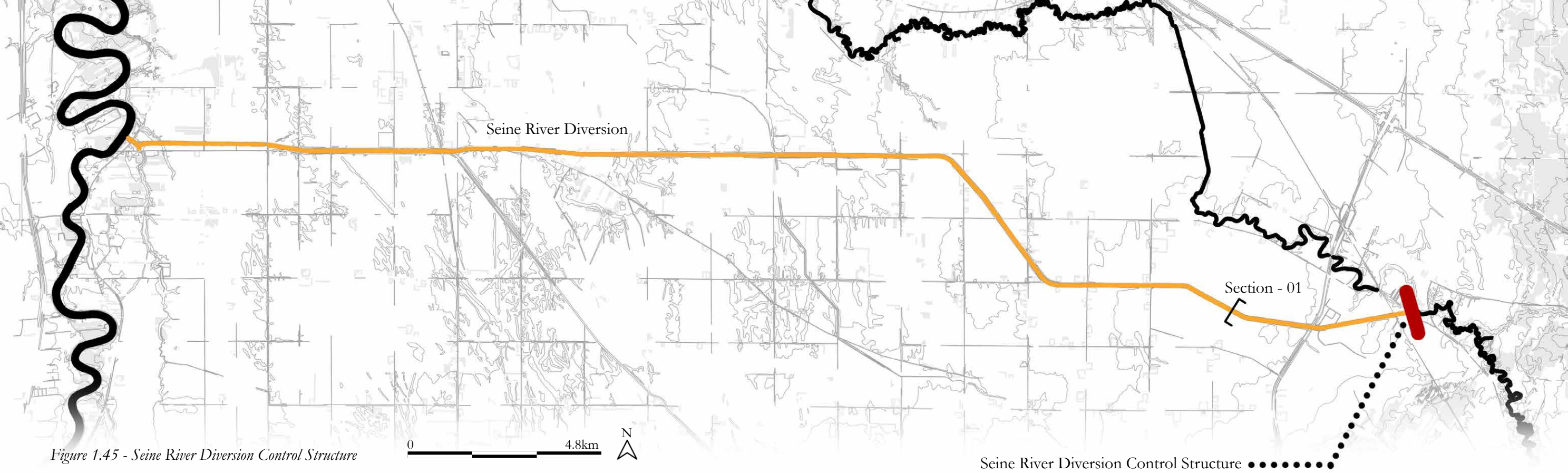


Figure 1.45 - Seine River Diversion Control Structure

1.08 Proposed Water Levels

Water from the Seine River is diverted into the Seine River Diversion using a control structure.

The control structure allows more volume of water to go down the Seine River Diversion to prevent flooding downstream of Ste. Anne and to make room for spring floodwater in the Seine River.

This minimizes the Seine River flooding downstream of Ste. Anne and raises the water level in the Seine River Diversion.

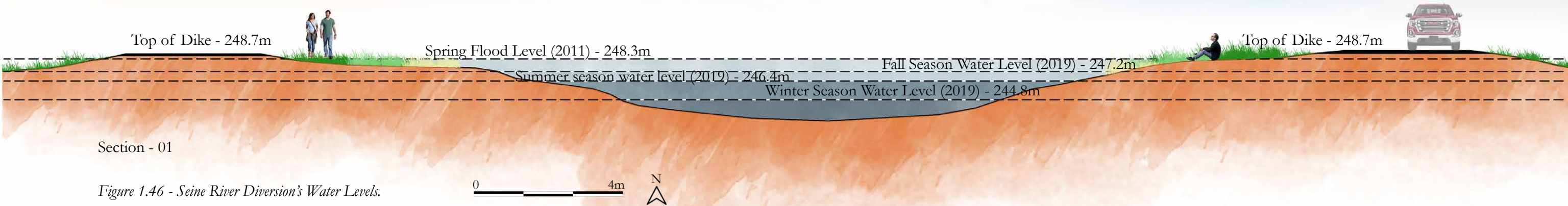


Figure 1.46 - Seine River Diversion's Water Levels.

Figure 1.47 - Sectios collage



Summer Season

The water level in the proposed wetlands will be kept lower to establish the emergent vegetation. The windpump will operate at a low capacity, and water levels in the proposed wetlands will fluctuate between 246.7m and 247.0m.

Fall Season

In the fall season, water levels in the Seine River Diversion are high, as more water from the Seine River is allowed into the Diversion. The windpump will operate at a capacity to ensure that the water level within the proposed wetlands stays between 247.1m and 247.5m. This will increase the volume of water in the wetlands.

Winter Season

In the winter season, the windpump will not operate as water in the Seine River Diversion will be frozen.

The low water level in the summer season and high water level in the fall season will ensure that the proposed wetlands can improve biodiversity and treat poor-quality water.

1.09 The Experience



The windpumps provide a vantage point in the landscape to experience the wetland. Their location is further emphasized in the proposal by placing them on ridges that cross half of the width of the wetlands. Thus, the windpumps act as a focal point in the landscape.

Figure 1.48 - Windpump Perspective



The proposed high points and the windpumps in the landscape provide an experience of being within or over the tree canopies. The linear geometry of the landforms and the different colors of vegetation becomes visible from the windpump.

Figure 1.49 - View from the Windpump



The wooden deck provides a space that invites people closer to the water to witness the biodiversity. The view represents fauna that will inhabit the wetland. The site bustles with life when the migrating birds stop to take a rest in the proposed wetlands. Some birds may even find a new home on the site.

Birds

Mammals

Reptiles

Invertebrates

Amphibians

Fish

Figure 1.50 - View from the Deck

The journey to the limestone plaza and the wooden deck passes through the prairie meadow vegetation planted on the upper portion of the ridges. The path to the limestone plaza is brought to life with the buzzing sounds of different pollinators.



Emergent
Vegetation

Figure 1.51 - Limestone Plaza Perspective

Wet to Wet Mesic Meadow

Low Prairie
Zone

Wet to Wet Mesic Meadow

Emergent
Vegetation

1.1 Conclusion

Like many other engineered drainage infrastructures in Manitoba, the Seine River Diversion deals with several challenges and barriers that should be overcome to improve its ecological conditions. The Diversion is connected to a much larger system, and its poor water quality deteriorates the health of Lake Winnipeg. There are many canals and drains in different parts of the world, with poor ecological conditions contributing to the deterioration of major water bodies. The issues of lost habitats and biodiversity identified in the practicum are not specific to the Diversion. These issues are present in many places on our planet, mainly due to industrialized farming practices. There is a need to rethink and redevelop new methods for food production, land management and water treatment.

The practicum process posed several difficulties, from identifying potential sites parallel to the Diversion to devising a cost-effective multi-faceted prototype design intervention that reinterprets the existing farming practices and creates a new public space. Achieving applicability, simplicity, energy efficiency, and incorporating ecological services in the landscape design are important aspects of thinking required for undertaking such complex projects.

The practicum provides an example of utilizing low-cost, low maintenance and self-sustaining green infrastructure for tackling global issues of lost habitats and biodiversity. It is the hope that this practicum initiates discussions and inspires ecologically oriented projects that can provide innovative and sustainable ways of improving the health of landscapes without decreasing agricultural productivity.

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Figure 0.42 - Kumar, K., 2021. *Major Cities in the Red River Watershed*. 1:2,500,000. Data layer: Manitoba Land Initiative Databases, [shape files, Quick map services]. Winnipeg, M.B.: Kumar, K. Using: Quantum GIS Geographic Information System [QGIS]. Version 3.0.1-Girona. Open Source Geospatial Foundation Project.

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Figure 0.51 - Kumar, K., 2021. *Checkered Landscape*. 1:400,000. Data layer: Manitoba Land Initiative Databases, [shape files, Quick map services]. Winnipeg, M.B.: Kumar, K. Using: Quantum GIS Geographic Information System [QGIS]. Version 3.0.1-Girona. Open Source Geospatial Foundation Project.
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Figure 0.61 - Kumar, K., 2021. *The Waning Seine River*. 1:50,000. Data layer: Manitoba Land Initiative Databases, [shape files, Quick map services]. Winnipeg, M.B.: Kumar, K. Using: Quantum GIS Geographic Information System [QGIS]. Version 3.0.1-Girona. Open Source Geospatial Foundation Project.

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Figure 0.62 - Kumar, K., 2021. *Rural Municipalities of Seine River Watershed*. 1:250,000. Data layer: Manitoba Land Initiative Databases, [shape files, Quick map services]. Winnipeg, M.B.: Kumar, K. Using: Quantum GIS Geographic Information System [QGIS]. Version 3.0.1-Girona. Open Source Geospatial Foundation Project.

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Figure 0.63 - Kumar, K., 2021. *Phosphorus Export to Lake Winnipeg from Seine River Sub-watersheds*. 1:650,000. Data layer: Manitoba Land Initiative Databases, Lake Winnipeg community based monitoring network for calculating phosphorus export, sub-watersheds of Seine River [shape files, Quick map services]. Georeference. Winnipeg, M.B.: Kumar, K. Using: Quantum GIS Geographic Information System [QGIS]. Version 3.0.1-Girona. Open Source Geospatial Foundation Project.
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Figure 0.71 - Kumar, K., 2021. *Seine River Diversion's Sources of Pollution*. 1:100,000. Data layer: Manitoba Land Initiative Databases, Lake Winnipeg community based monitoring network for calculating phosphorus export, sub-watersheds of Seine River [shape files,

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Figure 0.72 - Kumar, K., 2021. *Point and Non-Point Sources of Pollution*. 1:300,000. Data layer: Manitoba Land Initiative Databases, sewage lagoons, manure spreading area, livestock operations, Forest Area [shape files, Quick map services]. Georeference. Winnipeg, M.B.: Kumar, K. Using: Quantum GIS Geographic Information System [QGIS]. Version 3.0.1-Girona. Open Source Geospatial Foundation Project.

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Figure 0.81- Kumar, K., 2021, *Conceptual Sketch of Water Pockets*. [Pencil sketch + digital]. Using: Adobe Photoshop CC 2018 19.1.3.

Figure 0.82 - Kumar, K., 2021. *Selecting Water Pockets*. 1:100,000. Data layer: Manitoba Land Initiative Databases, sewage lagoons [shape files]. Georeference. Winnipeg, M.B.: Kumar, K. Using: Quantum GIS Geographic Information System [QGIS]. Version 3.0.1-Girona. Open Source Geospatial Foundation Project.
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Figure 0.83 - Kumar, K., 2021. *Prairie Topography along the Diversion*. 1:100,000. Data layer: Manitoba Land Initiative Databases, sewage lagoons [shape files]. Georeference. Winnipeg, M.B.: Kumar, K. Using: Quantum GIS Geographic Information System [QGIS]. Version 3.0.1-Girona. Open Source Geospatial Foundation Project.
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Figure 0.91- Kumar, K., 2021, *Precedents*. [Pencil sketch + digital]. Using: Adobe Photoshop CC 2018 19.1.3

Figure 0.92 - Kumar, K., 2021, *Oak Hammock Marsh Location Plan*. 1:400,000. Data layer: Manitoba Land Initiative Databases, [shape files, Quick map services]. Winnipeg, M.B.: Kumar, K. Using: Quantum GIS Geographic Information System [QGIS]. Version 3.0.1-Girona. Open Source Geospatial Foundation Project.
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Figure 0.93 - Google Earth, 2020. 50°13'33"N, 97°08'19"W, elevation 239m. *Oak Hammock Marsh Plan*. Google Maps, CNES / Airbus & Maxar Technologies Map Data [online] Available through: <https://earth.google.com/web/@50.18464915,-97.09003041,233.31558468a,16687.33752714d,35y,-0h,0t,0r> [Accessed 15 December 2020]. Using: Adobe Photoshop CC 2018 19.1.3.

Figure 0.94 - Google Earth, 2020. 50°10'14"N, 97°08'03"W, elevation 232m. *Oak Hammock Marsh Sewage Treatment Area*. Google Maps, CNES / Airbus & Maxar Technologies Map Data [online] Available through: <https://earth.google.com/web/@50.18464915,-97.09003041,233.31558468a,16687.33752714d,35y,-0h,0t,0r> [Accessed 15 December 2020]. Using: Adobe Photoshop CC 2018 19.1.3.

Figure 0.95 - Kumar, K., 17 May 2019, *View from the Roof of Interpretive Center*. [Photograph] (Kartik Kumar's own private collection).

Figure 0.96 - Google Earth, 2020. 38°45'26"S, 177°57'28"E, elevation 100m. *Orongo Station Conservation Masterplan*. Google Maps, CNES / Airbus & Maxar Technologies Map Data [online] Available through: <https://earth.google.com/web/@50.18464915,-97.09003041,233.31558468a,16687.33752714d,35y,-0h,0t,0r> [Accessed 15 December 2020]. Using: Adobe Photoshop CC 2018 19.1.3.

Figure 0.97 - Kumar, K., 2021, *River Aire Conceptual Sketch*. [Pencil sketch + digital] Created based on: ADR, n.d., *Concept drawing*. Reproduced in: Treib, M. 2010. ORO editions: New York

Figure 0.98- Kumar, K., 2021, *Canal Garden and the River Aire*. [Pencil sketch + digital]. Using: Adobe Photoshop CC 2018 19.1.3

Created based on: ADR, n.d., *Canal Garden and the River Aire*. Reproduced in: Treib, M. 2010. ORO editions: New York

Figure 1.01 - Kumar, K., 2021, *Location of Site for Detailed Design Intervention*. 1:100,000. Data layer: Manitoba Land Initiative Databases. [shape files] Winnipeg, M.B.: Kumar, K. Using: Quantum GIS Geographic Information System [QGIS]. Version 3.0.1-Girona. Open Source Geospatial Foundation Project. Adobe Photoshop CC 2018 19.1.3.

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Figure 1.02 - Straub, D., 17 May 2020, *A Straight Line*. [Photograph] (Dietmar Straub's own private collection).

Figure 1.03 - Kumar, K., 2021, *Existing Landscape Surrounding the Site*. 1:10,000. Data layer: Manitoba Land Initiative Databases. [shape files] Winnipeg, M.B.: Kumar, K. Using: Quantum GIS Geographic Information System [QGIS]. Version 3.0.1-Girona. Open Source Geospatial Foundation Project. Adobe Photoshop CC 2018 19.1.3.

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Figure 1.04 - Straub, D., 17 May 2020, *On the Levee*. [Photograph] (Dietmar Straub's own private collection).

Figure 1.05 - Straub, D., 17 May 2020, *Meat Farming*. [Photograph] (Dietmar Straub's own private collection).

Figure 1.06 - Straub, D., 17 May 2020, *Kayaking*. [Photograph] (Dietmar Straub's own private collection).

Figure 1.07 - Straub, D., 17 May 2020, *Fishing on the Diversion*. [Photograph] (Dietmar Straub's own private collection).

Figure 1.08 - Straub, D., 17 May 2020, *Spill into the Red*. [Photograph] (Dietmar Straub's own private collection).

Figure 1.09 - Kumar, K., 2021, *Detailed Topography*. 1:1700. Data layer: Manitoba Land Initiative Databases. [shape files] Winnipeg, M.B.: Kumar, K. Using: Quantum GIS Geographic Information System [QGIS]. Version 3.0.1-Girona. Open Source Geospatial Foundation Project. Adobe Photoshop CC 2018 19.1.3.

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Figure 1.10 - Kumar, K., 2021, *Section across the Seine River Diversion*. Using: Autodesk AutoCAD 2021. Adobe Photoshop CC 2018 19.1.3.

Figure 1.11 - Kumar, K., 2021, *Proposed Prototype Design*. Using: Autodesk AutoCAD 2021. Adobe Photoshop CC 2018 19.1.3.

Figure 1.12 - Straub, D., 17 May 2020, *Kayaking on Seine River Diversion*. [Photograph] (Dietmar Straub's own private collection).

Figure 1.13 - Kumar, K., 2021, *Oxbow Lake of a Meandering River*. [Pencil sketch + digital].

Figure 1.14 - Kumar, K., 2021, *Oxbow Lake of an Engineered Diversion*. [Pencil sketch + digital].

Figure 1.15 - Kumar, K., 2021, *Principal Landforms*. Using: Autodesk AutoCAD 2021. Adobe Photoshop CC 2018 19.1.3.

Figure 1.16 - Kumar, K., 2021, *Deep Marsh*. Using: Autodesk AutoCAD 2021. Trimble

SketchUp version 2017. Chaos Group V-ray version 5. Adobe Photoshop CC 2018 19.1.3.

Figure 1.17 - Kumar, K., 2021, *Shallow Marsh*. Using: Autodesk AutoCAD 2021. Trimble SketchUp version 2017. Chaos Group V-ray version 5. Adobe Photoshop CC 2018 19.1.3.

Figure 1.18 - Kumar, K., 2021, *Wet Meadow*. Using: Autodesk AutoCAD 2021. Trimble SketchUp version 2017. Chaos Group V-ray version 5. Adobe Photoshop CC 2018 19.1.3.

Figure 1.19 - Kumar, K., 2021, *Uplands*. Using: Autodesk AutoCAD 2021. Trimble SketchUp version 2017. Chaos Group V-ray version 5. Adobe Photoshop CC 2018 19.1.3.

Figure 1.20 - Kumar, K., 2021, *Proposed Masterplan*. Using: Autodesk AutoCAD 2021. Adobe Photoshop CC 2018 19.1.3.

Figure 1.21 - Kumar, K., 2021, *Area of Non-sloping Portion of Ridges*. Using: Autodesk AutoCAD 2021.

Figure 1.22 - Kumar, K., 2021, *Area of Sloping Portion of Ridges*. Using: Autodesk AutoCAD 2021.

Figure 1.23 - Kumar, K., 2021, *Area between Ground Level and -400mm*. Using: Autodesk AutoCAD 2021.

Figure 1.24 - Kumar, K., 2021, *Area between -400mm and -800mm*. Using: Autodesk AutoCAD 2021.

Figure 1.25 - Kumar, K., 2021, *Area between -800mm and -1200mm*. Using: Autodesk AutoCAD 2021.

Figure 1.26 - Kumar, K., 2021, *Area at -1200mm*. Using: Autodesk AutoCAD 2021.

Figure 1.27 - Kumar, K., 2021, *Location of Ritchot Landfill*. 1:100,000. Data layer: Manitoba Land Initiative Databases, [shape files]. Winnipeg, M.B.: Kumar, K. Using: Quantum GIS Geographic Information System [QGIS]. Version 3.0.1-Girona. Open Source Geospatial Foundation Project.

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Figure 1.28 - Kumar, K., 2021, *Northern Wetland's Emergent Vegetation Area on the Slopes of the Ridges*. Using: Autodesk AutoCAD 2021.

Figure 1.29 - Kumar, K., 2021, *Northern Wetland's Emergent Vegetation Area between Ground Level and -400mm*. Using: Autodesk AutoCAD 2021.

Figure 1.30 - Kumar, K., 2021, *Northern Wetland's Emergent Vegetation Area between -400mm and -800mm*. Using: Autodesk AutoCAD 2021.

Figure 1.31 - Kumar, K., 2021, *Southern Wetland's Emergent Vegetation on the Slopes of the Ridges*. Using: Autodesk AutoCAD 2021.

Figure 1.32 - Kumar, K., 2021, *Southern Wetland's Emergent Vegetation between Ground Level and -400mm*. Using: Autodesk AutoCAD 2021.

Figure 1.33 - Kumar, K., 2021, *Southern Wetland's Emergent Vegetation between -400mm and -800mm*. Using: Autodesk AutoCAD 2021.

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Figure 1.36 - Kumar, K., 2021, *Surface Area between -400mm and -800mm*. Using: Autodesk AutoCAD 2021.

Figure 1.37 - Kumar, K., 2021, *Surface Area between -800mm and -1200mm*. Using: Autodesk AutoCAD 2021.

Figure 1.38 - Kumar, K., 2021, *Surface Area at -1200mm*. Using: Autodesk AutoCAD 2021.

Figure 1.39 - Kumar, K., 2021, *Precise Design Intervention*. Using: Autodesk AutoCAD 2021. Adobe Photoshop CC 2018 19.1.3.

Figure 1.40 - Kumar, K., 2021, *Site Plan after 20 – 30 Years*. Using: Autodesk AutoCAD 2021. Adobe Photoshop CC 2018 19.1.3.

Figure 1.41 - Kumar, K., 2021, *Sewage Treatment Area*. Using: Autodesk AutoCAD 2021. Adobe Photoshop CC 2018 19.1.3.

Figure 1.42 - Kumar, K., 2021, *Section -01, Summer Season*. Using: Autodesk AutoCAD 2021. Adobe Photoshop CC 2018 19.1.3.

Figure 1.43 - Kumar, K., 2021, *Section -02, Fall Season*. Using: Autodesk AutoCAD 2021. Adobe Photoshop CC 2018 19.1.3.

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Figure 1.47 - Kumar, K., 2021, *Sections Collage*. Using: Autodesk AutoCAD 2021. Adobe Photoshop CC 2018 19.1.3.

Figure 1.48 - Kumar, K., 2021, *Windpump Perspective*. Using: Autodesk AutoCAD 2021. Trimble SketchUp version 2017. Chaos Group V-ray version 5. Adobe Photoshop CC 2018 19.1.3.

Figure 1.49 - Kumar, K., 2021, *View from the Windpump*. Using: Autodesk AutoCAD 2021. Trimble SketchUp version 2017. Chaos Group V-ray version 5. Adobe Photoshop CC 2018 19.1.3.

Figure 1.50 - Kumar, K., 2021, *View from the Deck*. Using: Autodesk AutoCAD 2021. Trimble SketchUp version 2017. Chaos Group V-ray version 5. Adobe Photoshop CC 2018 19.1.3.

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