Cattails & Epinctiéres: Filtering the watershed of the Rat River

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in partial fulfillment of the requirements of the degree of

MASTER OF LANDSCAPE ARCHITECTURE

Department of Landscape Architecture
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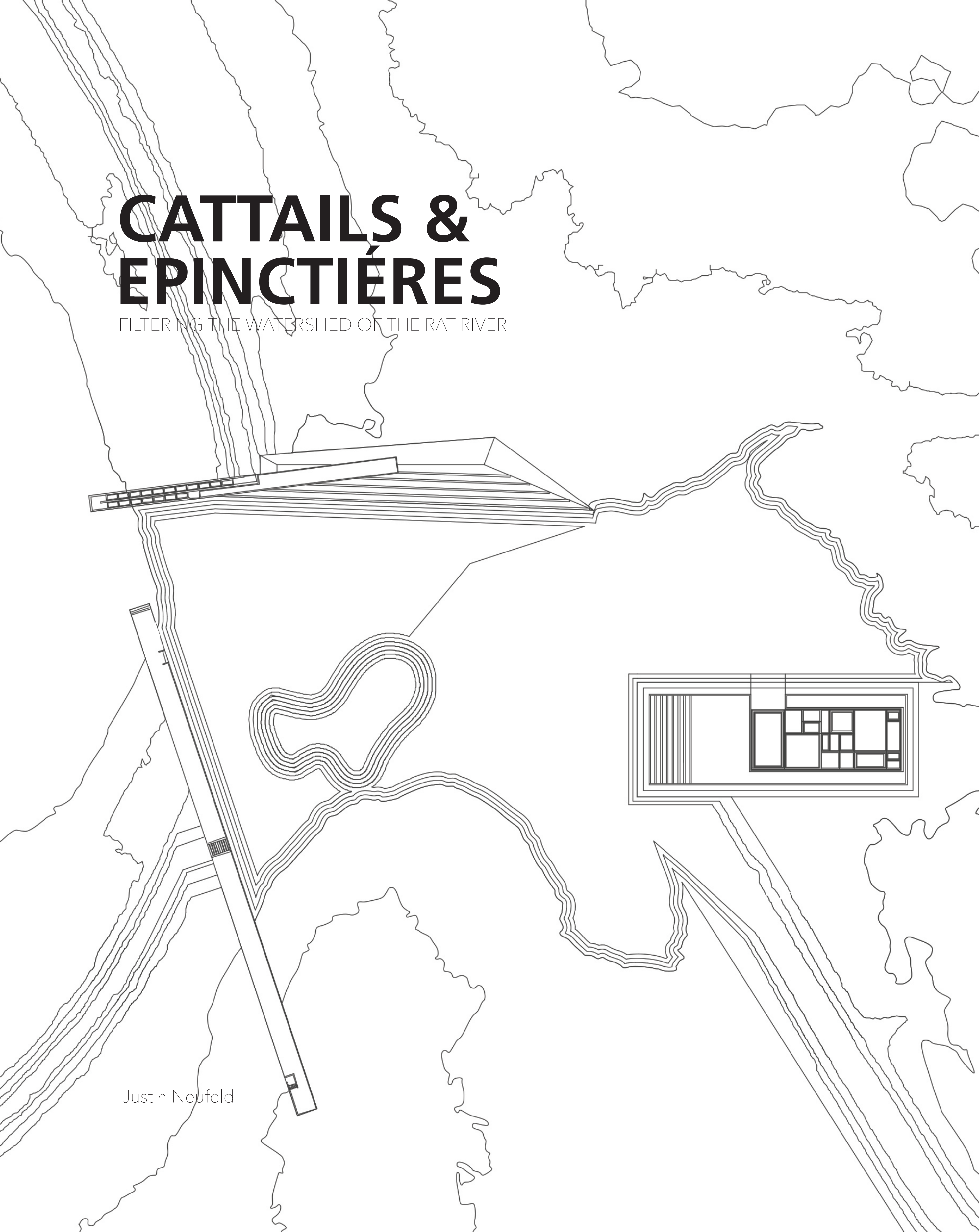
Winnipeg

CATTAILS & EPINCTIÉRES

FILTERING THE WATERSHED OF THE RAT RIVER



Justin Neufeld

ABSTRACT

The current state of Lake Winnipeg is a direct result of ninety years of human abuse. Today, this body of water is the most eutrophic lake in the world (Partners for the Saskatchewan River Basin Board, 2009, p. 142). The pollution of Lake Winnipeg has resulted from excessive nutrient loading in the watercourses. Three major contributors to this eutrophic condition include intensive farming, large sewage treatment facilities within the Lake Winnipeg watershed and the inverted drainage pattern of the lake caused by hydroelectric dams. Intensive farming is increasing the nutrient loading into the lake due to the intensified drainage and the methods in which fertilizer is applied to fields. There is potential to mitigate these effects. This design practicum is about water and water management and how cattails can play a key role within it. The primary goal is to explore the possible capacities of landscape design to combine the functional aspects of filtration and energy generation. The outcome of the practicum will be to distill a site within the Lake Winnipeg's watershed to carry out a physical design. The selected site with all of its facets functions as a test area for the effectiveness and applicability of ecological, economical and aesthetic dimensions through landscape architecture.

In memory of my father.

PREFACE

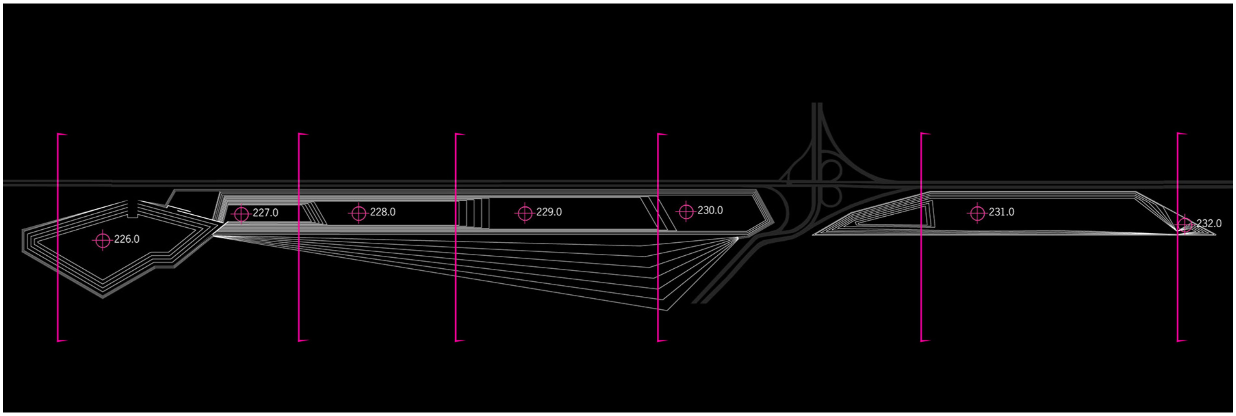
Since beginning my studies in the Department of Landscape Architecture at the University of Manitoba, several of my projects have led to designs that focus on water systems. Each project investigates water systems and their relationship to ecology and biodiversity while allowing me to discover the challenges and complexities of the profession of landscape architecture. These explorations consistently examine the impact that water management has on the shape and operation of landscape projects.

These studies inspired this practicum, exemplifying my continued interest in the subject of water and water management. Over the years I have both acquired and continue to discover knowledge of ways landscape design can play an integral role in the design and management of water systems. Themes of water retention and purification have been pivotal throughout each of these projects. For example, in 2008, in a group project based in Winnipeg, Manitoba, the issue of storm water runoff was addressed in conjunction with a student team of civil engineers. The key to this project was to reverse the slope of the land in order to intercept runoff and filter it before releasing it back along its drainage path toward the river. At the same time this was not just “water functional”, we also created a new public open space for a new urban development in Winnipeg.

In 2009, I built upon this knowledge when researching a project within the Lake Winnipeg watershed, which was based in Winnipeg Beach, Manitoba. The project endeavoured to address and understand Lake Winnipeg’s environmental issues and the impact these issues have on the surrounding region.

The filtration of agricultural runoff through plant material became a large focus for this studio and inspired design concepts in future projects, which combined the functional aspects of filtration with energy generation. For example, in a master’s studio completed in Thunder Bay, Ontario the conversion of a coal fired generation plant into a biomass plant was undertaken. The project utilizes a site located at the mouth of the Kaministiquia River and

Figure 0.1. (below) Interchange Studio, 2007, Winnipeg, Manitoba. Group member Vanessa Jukes [contour map]. Scale Undefined. Using Adobe Illustrator [CAD software]. Vers. CS2. San Jose, California: Adobe Systems, Inc., 2006.



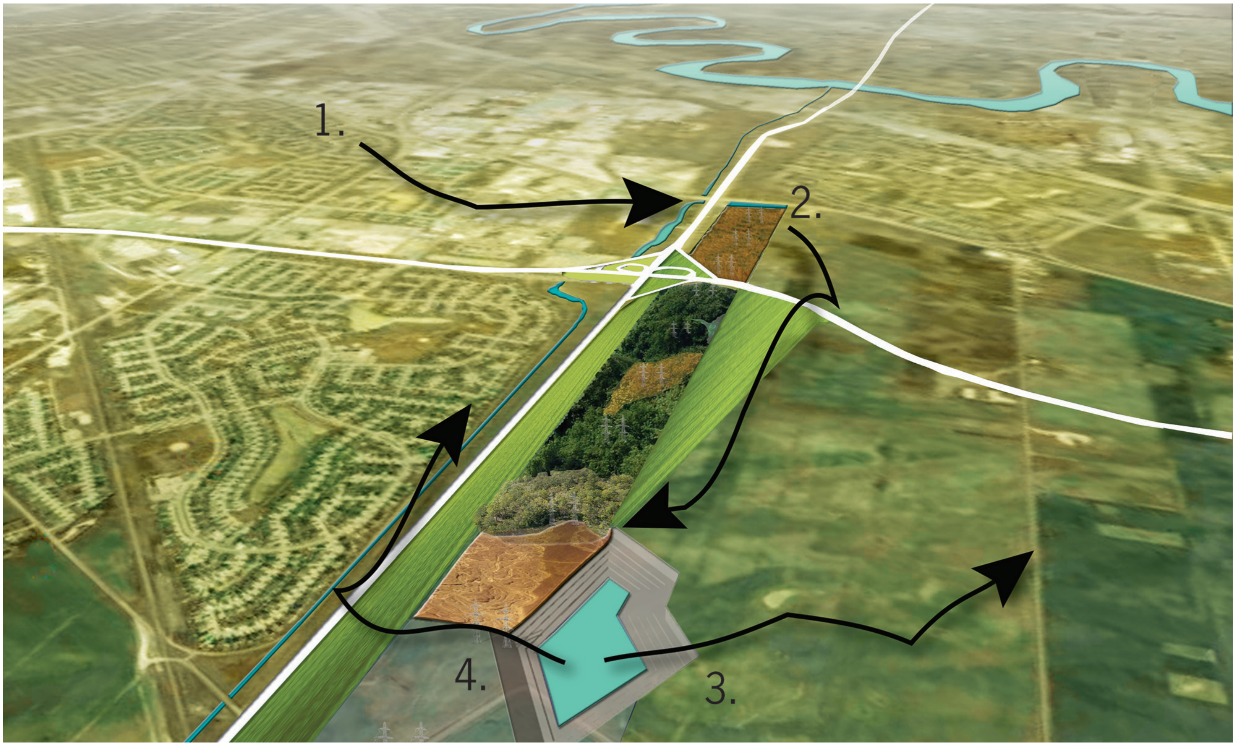


Figure 0.2. (above) Interchange Studio, 2007, Winnipeg, Manitoba. Group member Vanessa Jukes [aerial perspective]. Using Adobe Illustrator [CAD software]. Vers. CS2. San Jose, California: Adobe Systems, Inc., 2006. Based on aerial photo from Google Inc. (2013). Google Earth (Version 7.0.3.8542) © 2013 TerraMetrics [Software]. Available from http://www.google.com/earth/index.html

as a result of the strategic planting of willows, water is filtered before it enters Lake Superior. In addition to the potential for filtering water, the planting of willows creates material to be used in the proposed biomass incinerator.

In 2010, during my final master's studio, I revisited ideas of filtration and retention on a site adjacent to the Saint-Charles River in Quebec City, Quebec. The strategy focuses on creating a model for open spaces along the river that retain water during high tide. After choosing a site I studied how it functioned in order to see if it would be possible to hold water on the site and then slowly release it when the tide lowered. This idea of giving room for the river to move while creating a public space allowed for a connection between people and the river, similar to my very first studio in landscape architecture.

A final example is observed in my final studio project in 2011. In another group project, we worked toward creating a public open space design for the footprint of the ancient Greek city of Priene with a focus on storm water management. Utilizing this footprint, we used the prototype to develop a landscape thus creating a new vision for the periphery of the City of Winnipeg. The subject of discussion and investigation revolved around how landscape architecture can deal with periscapes – sites, neither city nor countryside (Straub, 2011, p. 2).

The design proposal analyzed how the Priene footprint could be inserted on the edge of Winnipeg to house 5,000 people, while addressing functional requirements such as parking and storm water. At the same time, a focus was made toward creating a diversity of open spaces for the new inhabitants. The design works with the existing slope of the agriculture land to capture and hold runoff, which in turn creates a public open space for the residents and works with the existing topography to eliminate the need for underground pipes and other costly infrastructure. Storm water becomes an integral part of the design, which deals with water on site rather than instantly shedding water to the drainage network, simultaneously developing visually appealing water fields as public open space.

Over the years this continual investigation has led to various ideas of how the design of land can be used to handle complex tasks related to water systems. By distilling such a focus I have been able to build on knowledge and maintain a focus on water. I see the role and potential of landscape architecture in discussions that would otherwise default to an engineer's scope. My motivation for this practicum has been the promotion and development of the role of landscape architecture in this field and to be more imaginative with the tasks of retention and purification in various scales and contexts. Water is an important aspect of the future of the profession and of the world.

Figure 0.3. (opposite) Landscape and Urbanism Studio, 2011, Winnipeg, Manitoba. Group members: Neil Eckton and Michael Lucenkiw [rendered plan]. Using Adobe Illustrator [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010. Based on aerial photo from © 2010 Google © 2011 TerraMetrics Retrieved from http://maps.google.ca/


sunset stroll
bbq beach
the pocket
the opening
S-A
S-B
S-C
the path
the pool
0
+1.5
+3
pick and pass
S-D
the pier
the theatre
the agora
the entrance
the gardens
the porch
the pergola
the recreational fields
-5
the sun deck
the boardwalk
the stadium
+1
parking plaza
bus terminal
PLAN 1:1000
N
the perimeter

ACKNOWLEDGEMENTS

I would like to express my most sincere gratitude to my committee chair, Dietmar Straub: he continually conveyed a spirit of adventure in regard to design and the greatest passion to teaching I've ever experienced. Without his guidance and persistent "kicking" this practicum would not have been possible.

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To my family, who have always supported, encouraged and believed in me, in all my endeavors.

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TABLE OF CONTENTS

All photographs, diagrams, drawings and tables are the work of the author unless otherwise stated.

1. INTRODUCTION

1.1 GOAL

This practicum endeavors to exemplify the role of landscape architecture in extrapolating thoughts for Lake Winnipeg's watershed and address the social, economic, and environmental issues related to rural Manitoba. In order to achieve this an exploration of a "typical" condition will be undertaken to create retention/filtration prototypes for this region and identify "variations" for a general scenario. The work focuses on the sub-basin of the Rat River in which a project area will be identified and a site is distilled. Though the Rat River watershed is smaller than other sub-basins of the Red River, it represents a typical water network in southern Manitoba (Simonovic & Juliano, 2001, p. 383). Ultimately this project will attempt to strengthen and support the relationship between Lake Winnipeg and the rural lands of the Red River watershed.

1.2 PROCEDURAL METHOD

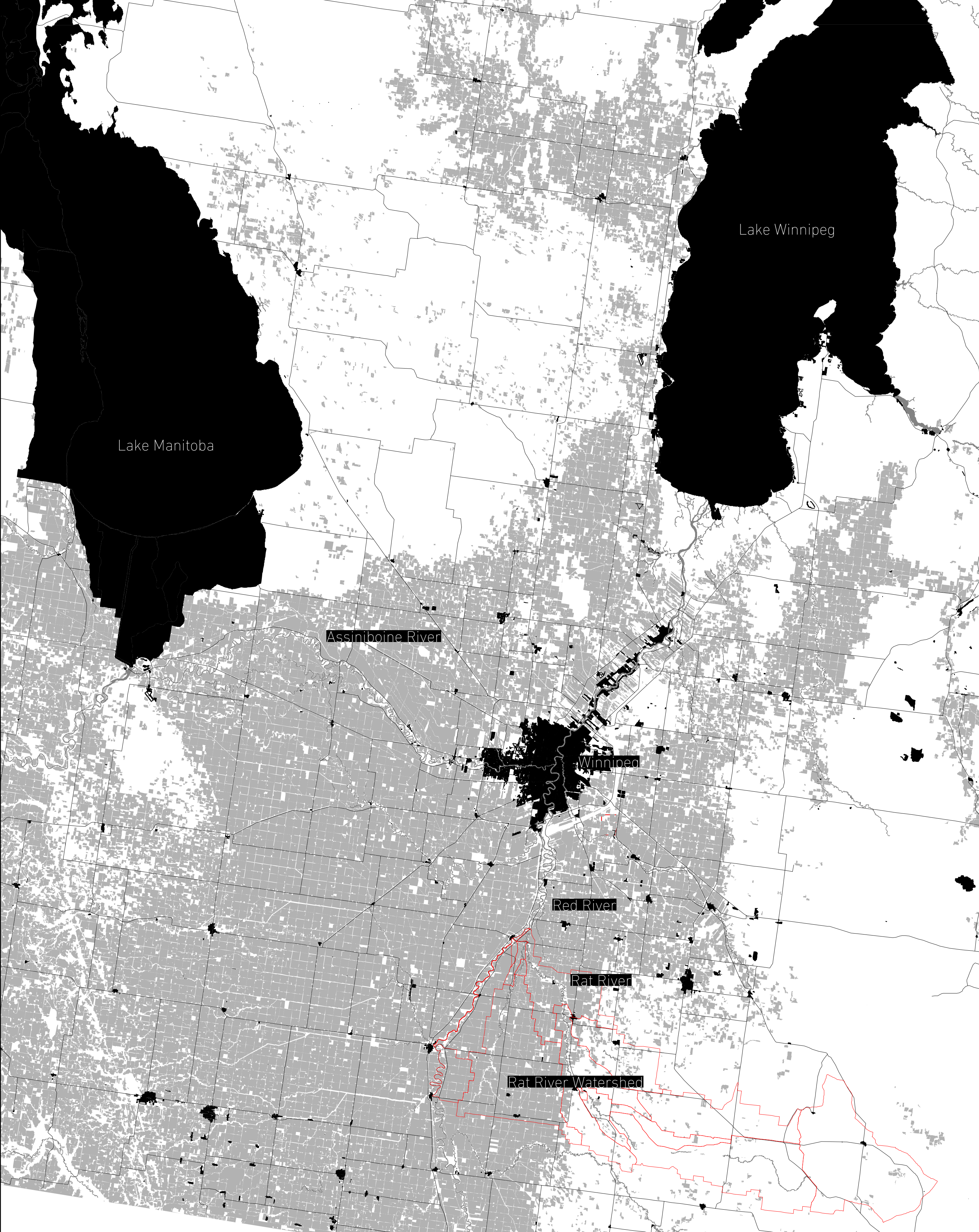
The process is organized into three steps: Assessment of the Historical Context, the Study of the Existing Water Network, and the Proposal of a Physical Design.

The first step is to identify the source of the excess nutrients and discover why the eutrophic condition of Lake Winnipeg is occurring. This will be accomplished with a historical exploration of Lake Winnipeg.

The second step after collecting information on the sources of excess nutrients is a review of cartographic and hydrological data including directions of water flow, the related watersheds and the inputs of nutrients. This review will assist in the selection of an area that will serve as a model site for the entire watershed. The selected area is just south of the small settlement of Otterburne, Manitoba with an approximate population of 300 people. This chosen piece of land is part of the watershed of the Rat River and would be best suited to create retention and filtration prototypes due its low elevation and clay soil type, which allows for water to be easily collected.

The third step organizes information regarding contours, drainage, and soil data. Once the strategic area has been selected, a review of the area's history and its present day use can be conducted. Simultaneously different ideas developed for how to filter water, which led to research conducted at the University

Figure 1.1. (opposite) Southern Manitoba. Cropland, lakes, settlements, major roads and rivers. [computer map]. 1:1,000,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.


Lake Winnipeg
Lake Manitoba
Assiniboine River
Winnipeg
Red River
Rat River
Rat River Watershed

of Manitoba that utilized cattails for filtration, as well as the work being carried out at the International Institute for Sustainable Development (IISD). Coincidentally, the selected project area is home to Providence College, whose vision is to be Canada's most environmentally friendly campus. One of the ways they aim to achieve this is through a biomass incinerator recently built on the campus. This goal, in addition to the aforementioned objective of filtering water, propose a complementary blend of objectives for the selected project area. Calculations are then made to understand how many cattails are needed to filter the excess nutrients from the Rat River watershed, as well as how much energy would be created by harvesting the cattails. When this quantity is estimated, the next course of action is to find the most suitable location. Two separate models indicating possible cattail distribution allowed for a detailed evaluation of the pros and cons of each location. The model with the best plausibility due to economics and existing infrastructure of the drainage network was the most suitable option and was therefore selected. The design of the selected model included sixteen nodes, which were then narrowed down to the selection of one node based on preference to create a detailed design solution.

Figure 1.2. Conceptual structuring of southern Manitoba, based on aerial photo from Google Inc. (2013). Google Earth (Version 7.0.3.8542) © 2013 TerraMetrics [Software]. Available from http://www.google.com/earth/index.html


Lake Winnipeg
Winnipeg
Red River
Rat River
Otterburne
Project Area

1.3 CHAPTER SUMMARIES

Chapter Two: Ice, Water, Land – Genesis of a Landscape

Chapter two identifies the existing geomorphological boundaries and water behavior of southern Manitoba and explores the history of Lake Agassiz. In order to address the issues of Lake Winnipeg, the region is broken down to the watershed scale. This chapter focuses on the Red River watershed with one of its sub basins, the Rat River watershed selected as the 'typical' water network for southern Manitoba.

Chapter Three: Water Issues

Chapter three outlines a number of the major water issues currently faced in Manitoba such as the flooding of the Red River, the conditions for blue-green algae, and the sources of nutrients entering Lake Winnipeg. This chapter shows the importance of having an understanding of the Red River's flooding behaviour, the city of Winnipeg's wastewater treatment upgrade, and the conventions of agricultural drainage, revealing potential areas of intervention.

Chapter Four: History of Drainage

An examination of the historical development of agricultural drainage in southern Manitoba is undertaken in this chapter in order to understand the water issues and conditions. This chapter also describes the conflicts found in private landownership and the subsequent management of the watershed's drainage. The historical account of drainage in Manitoba not only outlines the major infrastructural works of Manitoban farmers, it also describes the challenges of cultivating crops on the Red River flood plain. Lastly, this historical review identifies a socioeconomic component to the noted water issues and the topic requires more than a general understanding of watershed.

Chapter Five: Major Players – Claiming a Lake

Chapter five outlines the major economic forces impacting Lake Winnipeg, shared interests and how the lake is utilized for personal gain. The monetary value of these industries is presented and how they are affecting or are effected by the health of the lake. This information identifies the potential for Landscape Architecture to address these issues.

Chapter Six: Design Ingredients

Chapter six proposes a scenario that examines distilling a test area to provide an option for filtering nutrients and addresses the ecological, economic and social issues discussed in the previous chapters. The proposed scenario looks at the potential use of cattails as a filtering medium to deal with agricultural runoff entering Lake Winnipeg. Also presented in this chapter is the research carried out by the International Institute for Sustainable Development (IISD). The IISD research was consulted in order to calculate the quantity of cattails (800 hectares) that would be needed to filter the Rat River watershed.

Chapter Seven: The Distribution of 800 ha

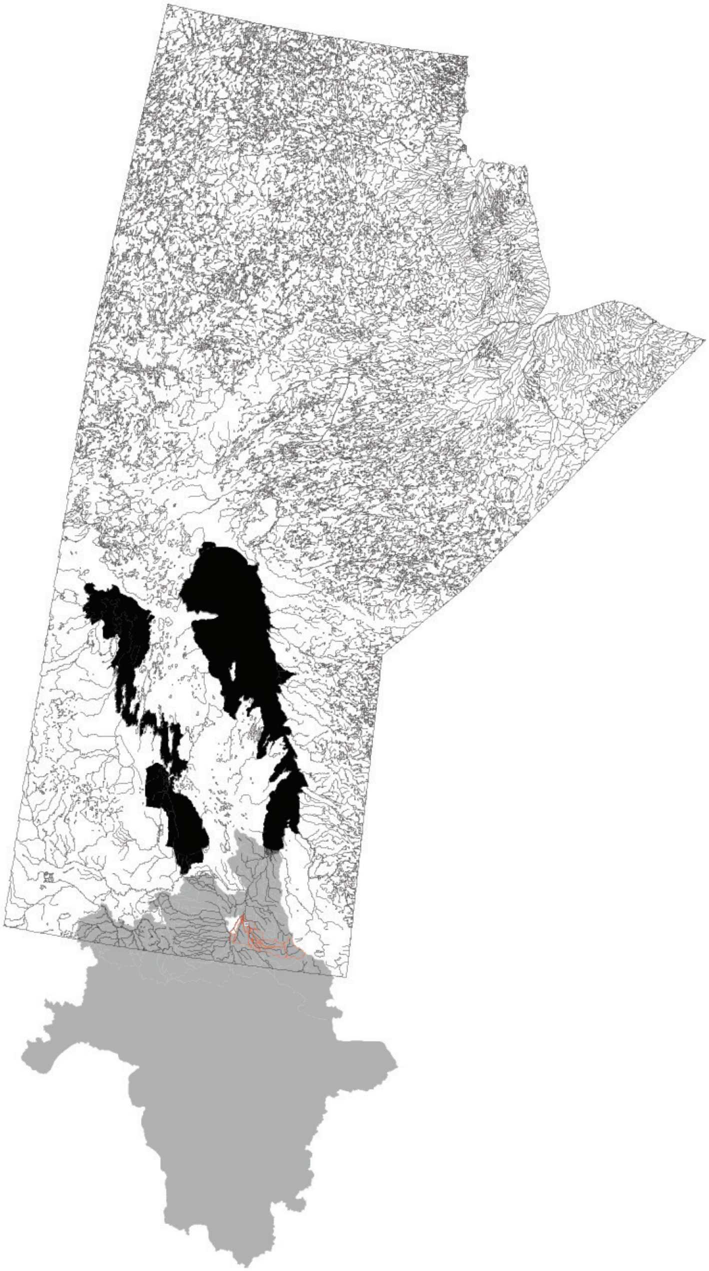
Chapter seven analyzes three separate models for how to position this 800 hectares of cattails within the Rat River watershed. The chapter concludes with a chosen model identifying sixteen nodes that will be strategically placed in the lower portion of the Rat River watershed.

Chapter Eight: Project Area

Chapter eight completes an analysis of the project area utilizing information of its geomorphology, land cover, hydraulic network and existing settlement information.

Chapter Nine: Design

Chapter nine exhibits the physical design of one of the sixteen nodes through the blocking, and ultimately, the holding of water on the land for storage during dry seasons and for creating the conditions for cattails. There is an additional program of three sauna facilities.



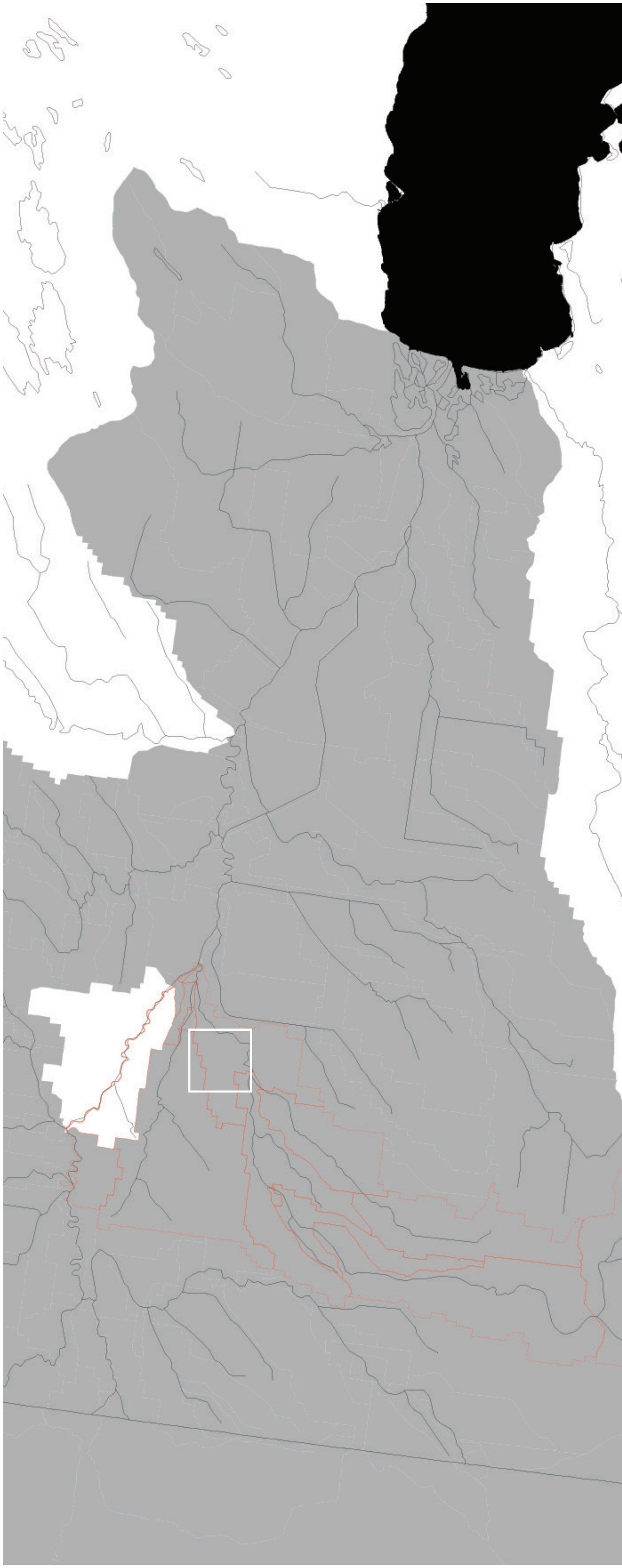
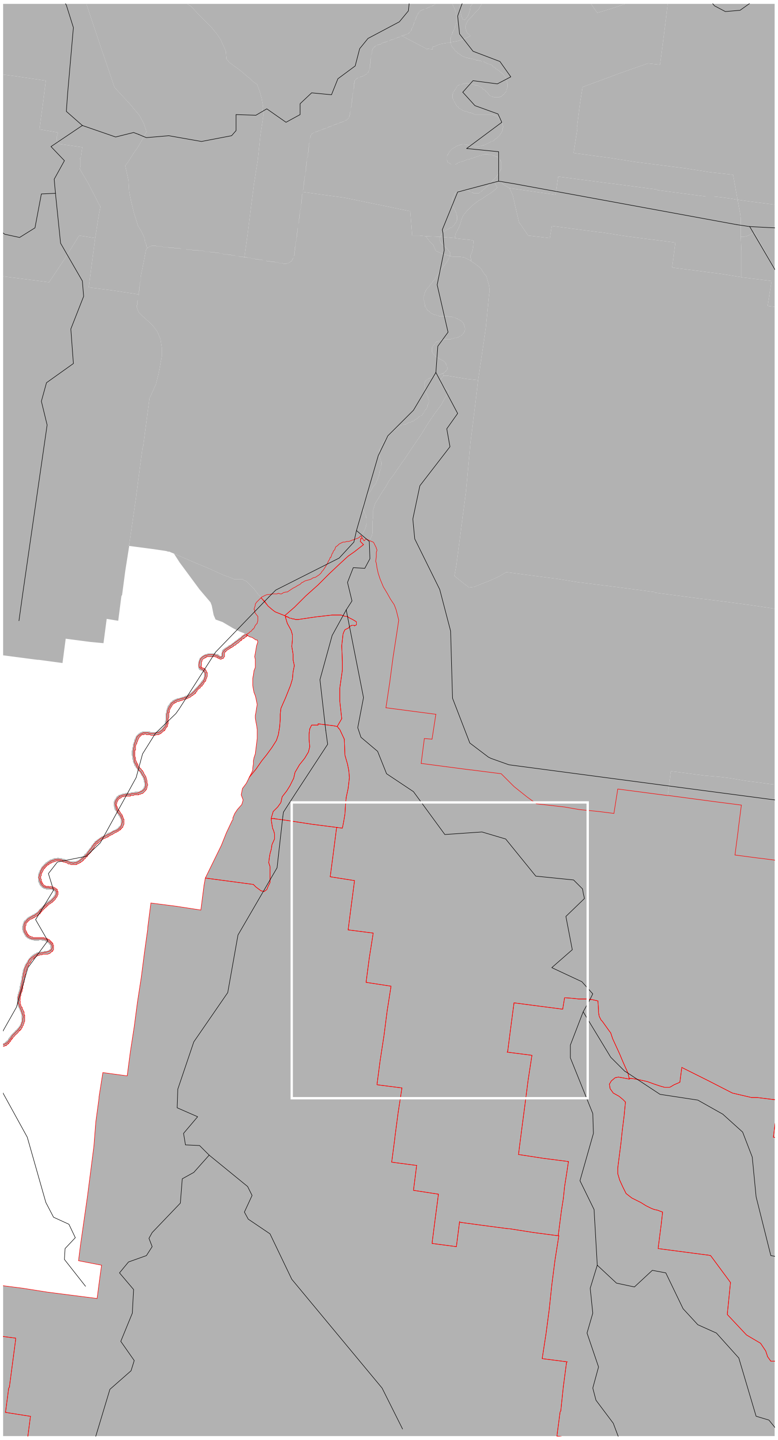


Figure 1.3. (left) Red River Watershed. [computer map]. 1:10,000,000, (center) Rat River Watershed. [computer map]. 1,000,000, (right) Project Area. [computer map]. 1:250,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.



2. ICE, WATER, LAND
GENESIS OF A LANDSCAPE

2.1 LAKE AGASSIZ

Thirteen thousand years ago the Laurentide Ice Sheet retreated north past the continental divide, an area that separates the Mississippi River from the areas draining north. This ice sheet blocked the melted glacial water from draining north. As a result, a lake formed in front of this glacial ice sheet creating the massive 134,000 km^2 body of water known as Lake Agassiz. The depth of Lake Agassiz was increased by the weight of the ice sheet pressing into the earth's crust (Johnson, 1962, p. 158).

Ancient Beaches

Over a period of Lake Agassiz's life the size, shape, and depth of the lake changed considerably and quickly. "Scattered remnants of Lake Agassiz' ancient beaches stretch across the Canadian landscape like partially scrubbed bathtub rings" (Perkins, 2002, p. 283). These ancient beaches were composed of fine clean sand and were created by small wave action (Teller, 1984, p. 39). Gravel beaches and the occasional boulder-filled beach were formed when powerful winds and massive waves washed away the finer particles (Teller, p. 39). The beaches crudely define the Red River watershed and were located about 25-30 kilometers (Michlovic, 1988, p. 55) on either side of the river and rising more than 300 meters.

Figure 2.1. Map of Lake Agassiz. Adapted from "Map Showing the Areas of Lake Agassiz and of the Upper Laurentian Lakes (1895)," from Manitoba Historical Society, 2009, http://www.flickr.com/photos/manitobamaps/4138482030/. © 2009 Manitoba Historical Society. Adopted with permission.

MONOGRAPH XXV. PL. III.

JULIUS BIEN & CO. N.Y.

Silty-Clay

A large portion of Manitoba is covered by deposits of silt and clay, which is "commonly known as Manitoba Gumbo" (Teller, 1984, p. 35). Manitoba Gumbo lined the basin of Lake Agassiz and the deposits vary greatly in thickness across the province (Teller, 1984).

Opening of the North

As the ice retreated a new spillway was created along the eastern edge of Lake Agassiz. This spillway resulted in a 100m-drop in the lake level, which created a downpour of 9,500 cubic kilometers of water towards the Great Lakes and the St. Lawrence River and eventually into the North Atlantic. This abrupt change in the routing of the melt water coincided with the onset of a 1600-year worldwide cold spell. The fresh water to the North Atlantic was interrupted by the expansion of the ice sheet resulting from these cooler temperatures (Perkins, 2002, p. 284). The ice sheet spread southward once more shifting the overflow south into the Mississippi River (Perkins, p. 284). About 8,400 years ago the final shift in water movement was set in motion when the center of the ice sheet collapsed over Hudson Bay. This then allowed water to suddenly spill northward through Hudson Bay and into the North Atlantic once again. As a result of this increase in melt water, global sea levels rose by approximately 0.5 meters over a period of a year. This rise in water levels forced people from around the world who lived near areas affected by sea-level fluctuations to flee their flooded lands (Perkins, p. 284).

11,500 BP

10,900 BP

9,900 BP

9,300 BP

8,200 BP

7,800 BP

Figure 2.2. Melt water and ice sheet of Lake Agassiz. [computer map]. Scale Undefined. Using Adobe Illustrator [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.


Lake Manitoba


Lake Winnipeg
Winnipeg
Project Area

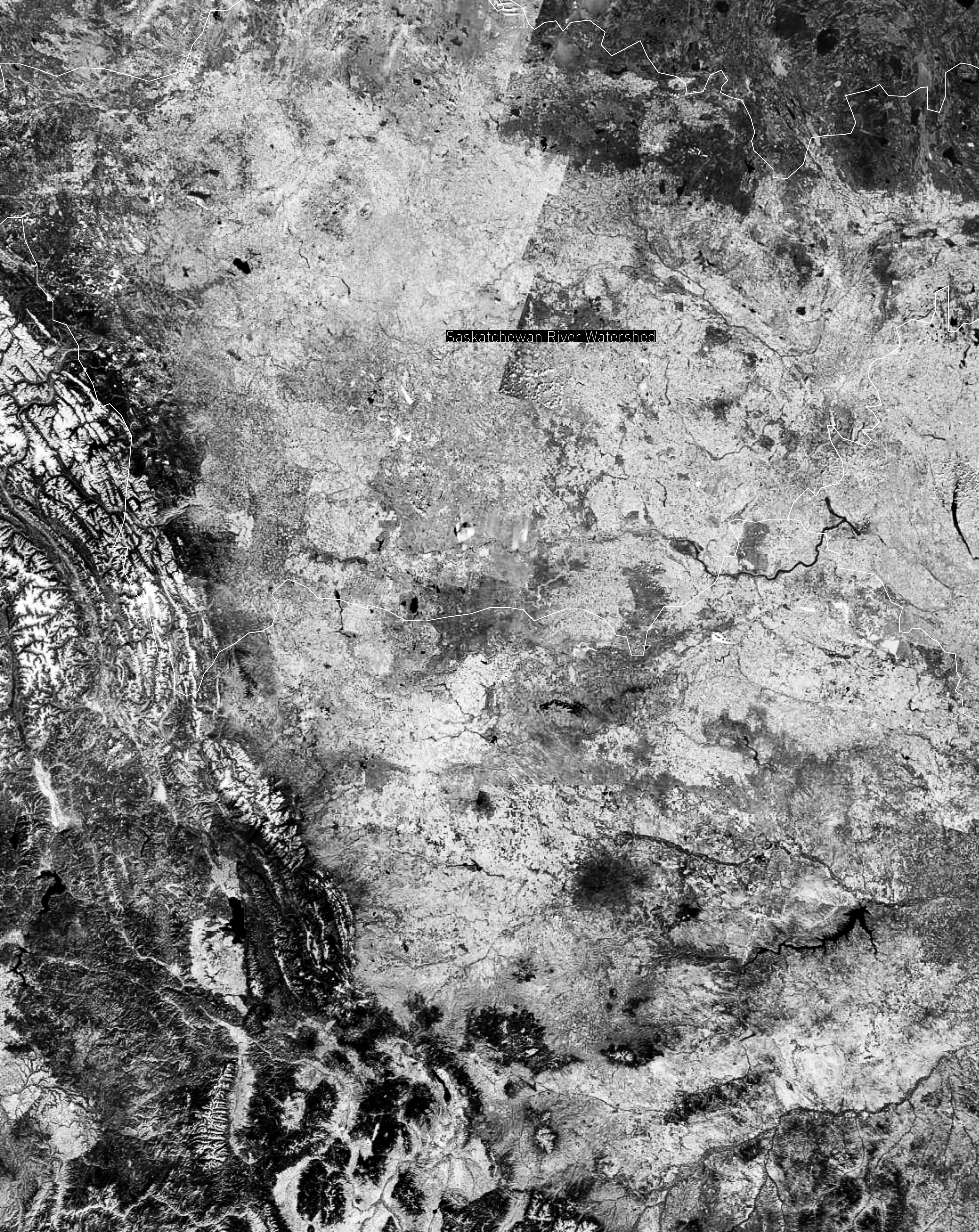
2.2 LAKE WINNIPEG AND ITS WATERSHED

Lake Winnipeg was formed as a result of repeated glaciation and the scraping away of relatively soft sediments along the margin of the Canadian Shield. It is the world's 11th largest freshwater lake, located in the heart of the North American continent at the geographic center of Canada. The lake also has the second largest watershed in Canada. It has the largest basin to surface area ratio in the world and a receiving environment of approximately 1-million square kilometers (Wassenaar and Rao, 2012, p. 1). The water in the lake is exchanged every three to five years on average, which is in drastic comparison to Lake Superior at 191 years (Partners for the Saskatchewan River Basin Board, 2009, p. 139). There are three major rivers running into Lake Winnipeg: the Red River watershed flowing north from the United States and including the Assiniboine River with a majority of agricultural land; the Winnipeg River watershed to the east covered with a majority of boreal forest; and the Saskatchewan River watershed commencing at the Canadian Rockies far to the west. The water eventually leaves Lake Winnipeg through the Nelson River into Hudson Bay (Wassenaar & Rao, p. 1).

There are six million people living within Lake Winnipeg's watershed of which 80% live in major cities. Agriculture lands cover over 50% of the watershed totaling 65 million hectares with more than half of this land being utilized for crop production (Lake Winnipeg Implementation Committee, 2005, p. 12). There are also 17 million livestock within the watershed's boundary (Partners for the Saskatchewan River Basin Board, 2009, p. 140). In addition to agricultural lands, 40% of the watershed is mixed forest and the remaining 10% is comprised of wetlands. Manitoba is home to two of the largest river delta marshes in North America: Delta Marsh, located at the south end of Lake Manitoba, and the Netley-Libau Marsh, at the south end of Lake Winnipeg (Lake Winnipeg Implementation Committee, p. 12).

Figure 2.3. (previous) Southern Manitoba: Clay and Topography. [computer map]. 1:800,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 2.4. (above) Lake Winnipeg watershed in Global Context. Approximately 4 times the size of New Zealand. [computer map]. Scale Undefined. Using Adobe Illustrator [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.


Saskatchewan River Watershed


Lake Winnipeg
Lake Manitoba
Assiniboine River Watershed
Winnipeg River Watershed
Red River Watershed
Imagery ©2011 TerraMetrics

2.3 RED RIVER WATERSHED

Over the past 140 years the wet prairie of the post-glacial Red River watershed has become “one of the largest and most artificially drained agricultural landscapes in the world” (Carlyle, 1984, p. 344). These alterations began with the introduction of the railways with the intention of transporting goods and people across Canada. Soon after, the land was drained and ploughed turning the watershed into a landscape of mile-by-mile roads and ditches. This created a checkerboard of industrial sized agricultural productivity. This ultimately contributed to a large increase of runoff into the Red River and its associated tributaries. Over time, agricultural production has become the main economic driver of Manitoba, building it into what it is today. This is all due to the fact that the Red River watershed is one of the most productive agricultural regions in the world (Red River Basin Board, 2000, p. 1). Farming is a large part of the socioeconomic structure of the province. Over the past 60 years many farmers and related experts have been tackling issues of flooding, drought, drainage, watershed management, and water stewardship while working towards an integrated approach that addresses the many economic, environmental, and social implications that are closely associated with the land and its water.

The flood plain of the 885 km Red River, also known as the Red River watershed, the Red River basin, “the Soup Bowl” (Bower, 2007, p. 799), or the Red River valley, is a highly dynamic landscape composed of industrial farming, flooding, drought, extreme winters, farmsteads, drainage ditches, hydro poles, and shelter belts. The Red River flows north, meandering through the agricultural lands of the watershed until finally reaching Lake Winnipeg. Within Canada, the Red River has seven main tributaries that act as wildlife corridors and transporters of agricultural runoff to Lake Winnipeg. The tributaries of the Red River drain agricultural landscapes of the watershed, contributing to the river as it flows northward. The Red River is joined by the Assiniboine River from the west at Winnipeg that then flows north to enter the south basin of the lake.

The majority of Manitoban residents live in Winnipeg with an approximate population of 680,000 people. In the past 100 years Winnipeg has tried to mitigate the effects of the Assiniboine and the Red Rivers, the two major rivers meeting at its core. In 1962 the city built the Red River floodway to divert floodwaters around the city in response to the destruction caused by the 1950 Red River flood. There are also many issues with bank erosion that have caused considerable damage to publicly and privately owned properties along both rivers.

The watershed of the Red River drains approximately 127,000 km^2 of land, of which 20% is within southern Manitoba. The watershed “is a complex system of 24 sub-basins, each with its own unique drainage characteristics” (Red River Basin Board, 2000, p. 1).

Figure 2.5. (previous) Lake Winnipeg watershed overlaid on aerial map. [aerial map]. Scale undefined. Based on aerial photo from © 2011 Google © 2011 TerraMetrics Retrieved from http://maps.google.ca/

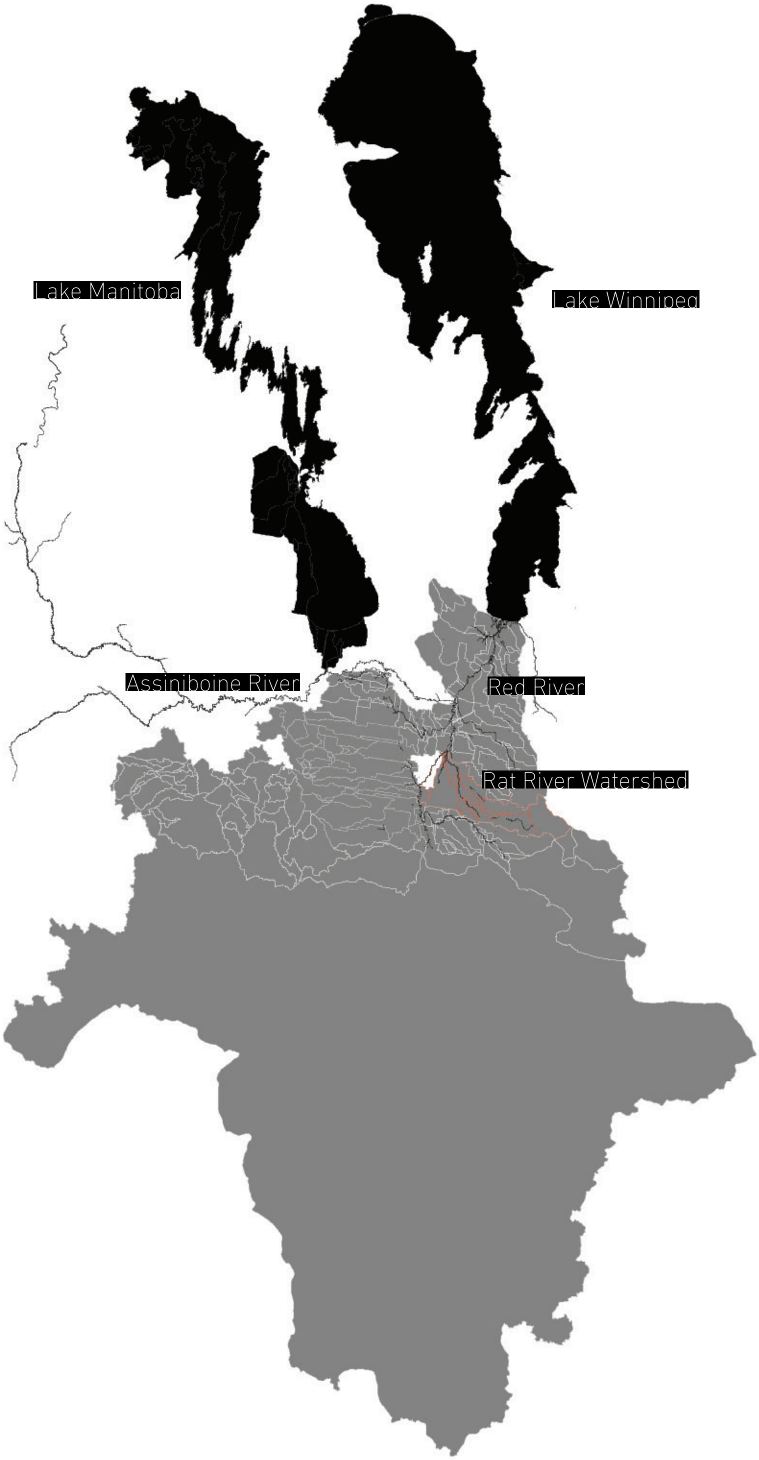


Figure 2.6. Red River watershed. [computer map]. 1:5,000,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

2.4 THE RAT RIVER WATERSHED - EXAMINATION AREA

Southern Manitoba will be the focus of this practicum looking at the six major basins that lie within the province: The Roseau, Seine, LaSalle, Rat, Pembina, and Morris River. The basins are almost entirely contained within the southern half of the province. Of these six basins the project will examine the Rat River as a representative network. “Although one of the smaller watersheds within the Red River basin in terms of drainage area, the Rat River represents a typical river system in the Manitoba portion of the basin” (Simonovic & Juliano, 2001, p. 383). It has an area of approximately 1550km2 and is located 30km southeast of Winnipeg. The 137 kilometer Rat River starts at the Sandilands Provincial Forest and winds its way to the Red River, approximately three kilometers north of the town of Ste. Agathe (Southeast Water Management Association, 2001, p. 2). With a difference in elevation of 152.4 meters the watershed maintains a slope of 0.1185 % or 1118.5 ppm. The lowest area in the west is almost exclusively cropland with poor draining clay soils while the central portion is a mix of trees, grassland, and cropland. Forest and wetland areas characterize the highland with mainly gravel-based soils that efficiently drain the land. The small settlements of Otterburne, St. Pierre-Jolys, and St. Malo are situated adjacent to the Rat River while other smaller settlements and farmsteads are dispersed throughout the watershed. There are a total of 3,000 people living within the area.

Over the past sixty years, farmers have been maximizing lands for agricultural use due to increased food demand and the escalating cost of operating farms. As a result many wetlands have been drained and filled for agricultural use. For example, the Rat River watershed has seen a decrease in wetland areas from approximately 18%, recorded in an 1870 land survey, to presently 3% (Simonovic & Juliano, 2001, p. 381).

Figure 2.7. (previous) Red River meandering through agricultural land. Looking north from St. Jean Baptiste. Adapted from http://www.ncdc.noaa.gov/paleo/pubs/stgeorge2002/stgeorge2002.html. © 1999 G.R. Brooks. Adopted with permission.

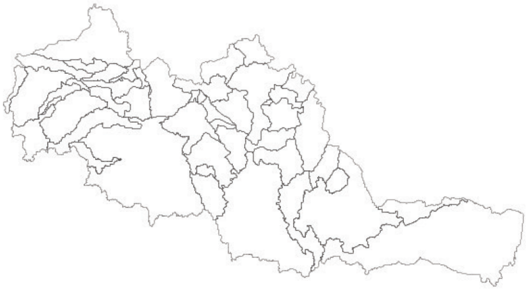
Figure 2.8. Rat River near Otterburne

LaSalle River Watershed

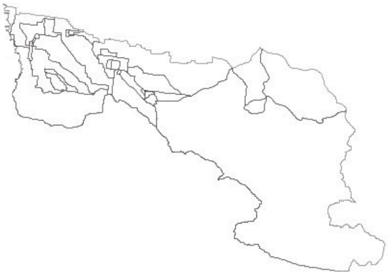
Seine River Watershed

Morris River Watershed

Rat River Watershed



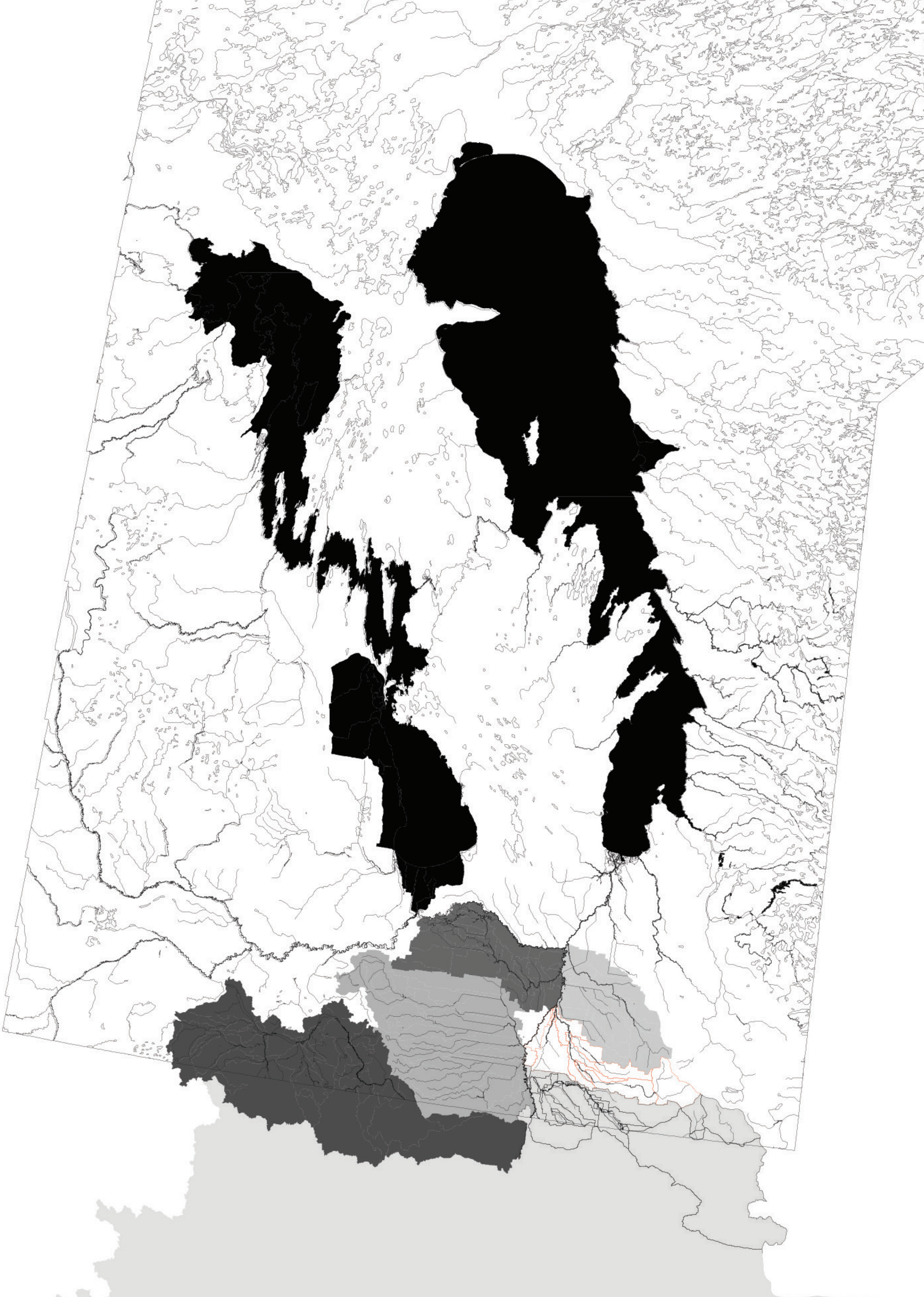
Pembina River Watershed



Roseau River Watershed

Figure 2.9. (above) Sub-watersheds of Manitoba's portion of the Red River watershed. [computer maps]. 1:3,000,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 2.10. (opposite) Lake Manitoba, Lake Winnipeg, and the sub-watersheds of the Red River watershed. [computer map]. 1:3,000,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.



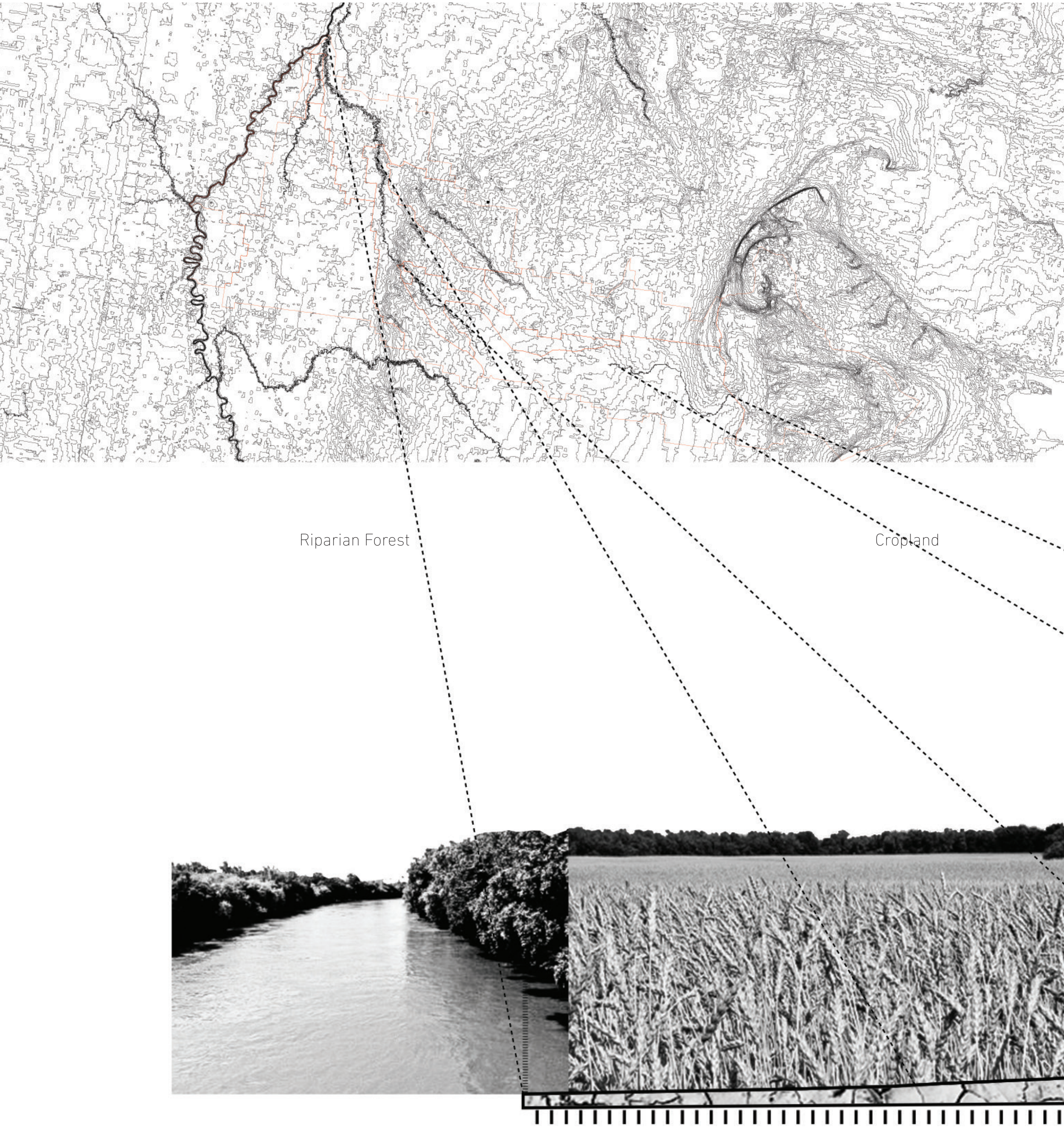
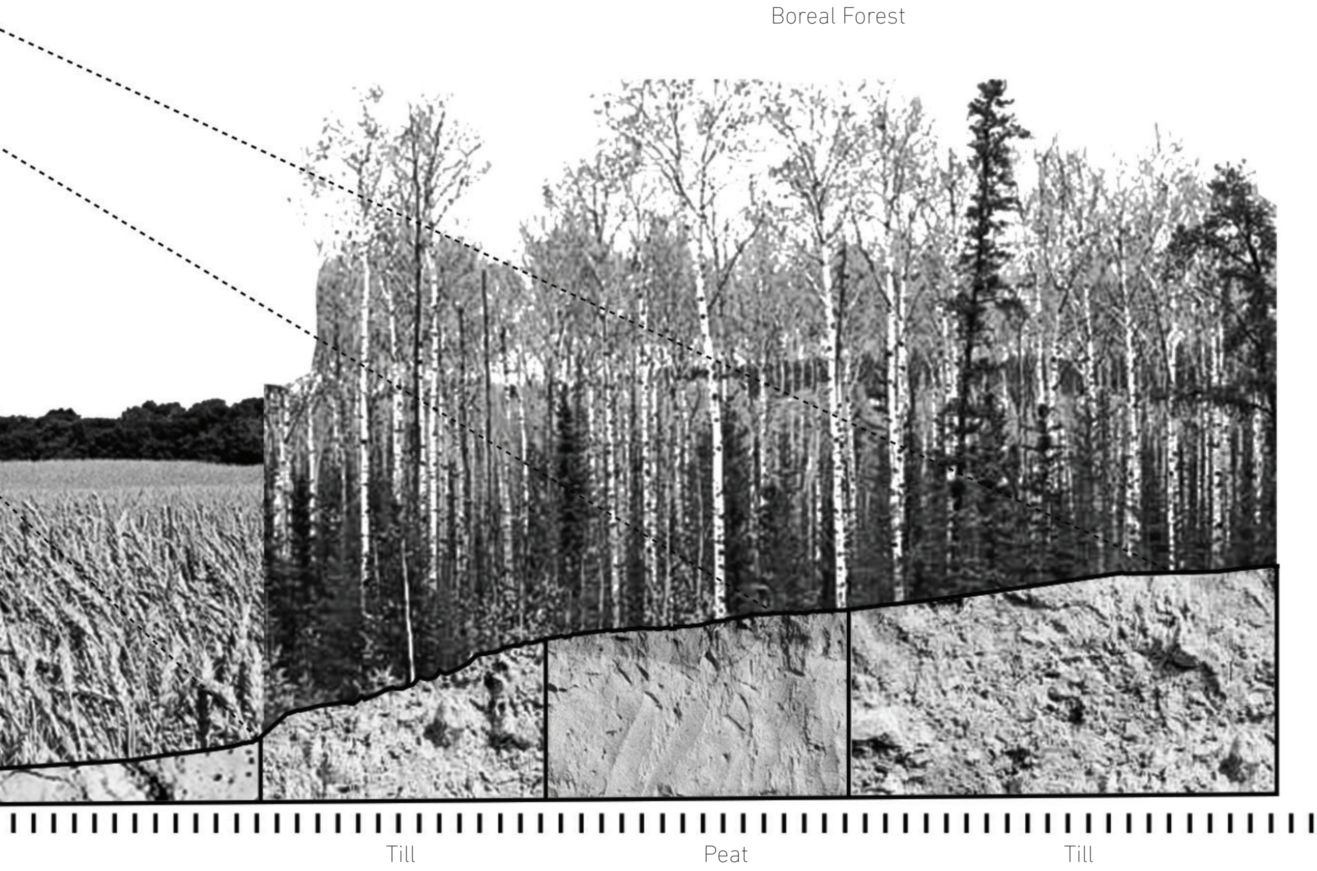

Riparian Forest
Cropland
Rat River meets Red River
Clay

Figure 2.11. (top left) Rat River watershed, topography and Rat River. [computer map]. 1:750,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.
Figure 2.12. (bottom) General Profile of Rat River draining into the Red River. Land cover and soil types, Scale Undefined.



2.5 CONCLUSION

Based on the information discussed above, it is apparent the land has changed from complete submergence under water to an expanse littered with glacial remnants. The movement of these former glaciers created the present day watersheds of Manitoba. For this project, it is important to understand scale specifically in relation to watersheds in order to define a scale that is approachable from a landscape architectural perspective. This scale also affords a manageable understanding of the geomorphology of the land revealing the conditions underlying the water issues of the province.

Figure 2.13. (opposite) Red River Valley. Undraped DEM, 30x VE, Oblique View. Adapted from http://www.manitoba.ca/iem/mrd/geo/demsm/rrvalley1.html. Manitoba Innovation, Energy and Mines, Manitoba Geological Survey © Manitoba Innovation, Energy and Mines. Reproduced from Government of Manitoba with permission from Manitoba Innovation, Energy and Mines.

3. WATER ISSUES

3.1 FLOODING

The very gradual slope and the meandering of the Red River make it prone to flooding. The river has a long history of flooding due to the high levels of moisture in the fall and large quantities of snowmelt runoff, in combination with spring rainfall. Spring melt often proceeds from the south to the north and successive tributaries of the east and west increase the flow of the Red River causing localized flooding. When the river floods it receives more nutrients from the naturally high soil fertility of the watershed.

History of Flooding in the Red River Watershed

The first flood of vast proportions occurred in 1776. Recorded documentation had not been implemented at this time and was therefore part of the oral tradition of the region. The most severe documented flood was of 1826, which was far worse than that of 1997, which has been named the “Flood of the Century” (Juliano, 1999, p. 10). Additionally, significantly large floods have recently occurred in 2005 and 2009. The extent and variation of the floods previously discussed indicate that Manitoba has been experiencing wet and dry cycles for an extended period of time, the beginning of which has not been exactly determined.

Figure 3.1. Flood Protection of homes in Winnipeg. Adapted from “Lyndale Bank, St. Boniface, N23614, 1950” from Manitoba Archives. © Manitoba Archives. Adopted with permission.


PELISSIERS

3.2 ECOLOGICAL CONDITIONS - BLUE TO GREEN

Over the past three decades Lake Winnipeg's water quality has been steadily declining. Currently, Lake Winnipeg has been classified as the most eutrophic fresh water lake in the world and is in a state of crisis in terms of its water quality (Partners for the Saskatchewan River Basin Board, 2009, p. 142).

> It was estimated that in 1968-1970 Lake Winnipeg received 61,920 tonnes of nitrogen/year and 5,215 tonnes of phosphorus/year. In recent years, river and stream monitoring indicates that the loadings are 63,207 tonnes of nitrogen/year and 5,838 tonnes of phosphorus/year. Manitoba Water Stewardship has set goals to reduce the nitrogen and phosphorus loading to Lake Winnipeg by 13 and 10 per cent , respectively to return the lake to a pre-1970 state. (Lake Winnipeg Implementation Committee, 2005, p. 17).

Figure 3.2. (above) Blue-Green Algae in Lake Winnipeg. Adapted from "Victoria Beach on Lake Winnipeg," by G. McCullough, 2012, http://canadawater.wordpress.com/2011/06/08/save-lake-winnipeg-act-on-manitoba-government-agenda/. © 2012 G. McCullough. Adopted with permission.

Possible contributors to the decrease in water quality of Lake Winnipeg are discussed by *the Partners for the Saskatchewan River Basin Board* where they indicate that the amount of phosphorus in commercial fertilizers has caused there to be an imbalance in the natural ratio of nutrients. In order to regain balance, the phosphorus-loaded runoff from the agricultural land and settlements must be decreased (2009, p.144).

Eutrophic vs. Oligotrophic

The quantities of nutrients such as phosphorus and nitrogen are primary determinants for classifying lakes. The trophic state index can be used to roughly estimate the biological condition of a lake (The Environmental Protection Agency, 2013). Extreme nutrient levels in lakes can be classified into two categories; hyperoligotrophic or hypereutrophic. Hyperoligotrophic lakes contain very small amounts of nutrients resulting in very clear water with little to no aquatic vegetation. These lakes have a high quality of drinking water and support many different fish species. Hypereutrophic lakes, such as Lake Winnipeg, contain excessive amounts of nitrogen and phosphorus contributing to an abundance of algal growth and their related toxins (Dodds, Jones & Welch, 1997, p. 1455).

Figure 3.3. (opposite) Blue-green algae in Lake Winnipeg. Adapted from "Blue on Blue (with a touch of green)," by J. Douglas, 2012, http://www.flickr.com/photos/jojo-douglas/7484577006/. © 2012 J. Douglas. Adopted with permission.

Blue-Green Algae

Excessive phosphorus, nitrogen, and carbon concentrations have been increasing in the lake allowing for an increase in the presence of blue-green algal blooms. Global climate changes, such as higher air temperatures, will exacerbate the occurrence and intensity of the algae due to increased evaporation in the lake. Nitrogen and phosphorus are necessary elements of a healthy ecosystem; however human activities such as farming, hydroelectricity, and urban development have negatively impacted the lake and disrupted the balance required for the optimal functioning of this ecosystem. These activities increase the rate in which nutrients are introduced into the hydraulic network and, as a result, enrich the environment for blue-green algal growth (Bourne, Armstrong, & Jones, 2002, p. i).

The dense growth of plant life in the water will lead to a depletion of oxygen in the lake resulting in the reduction of fish populations, as well as other species. The release of toxins from some species of algae is harmful or fatal to various aquatic life, wildlife, and humans (Bourne, Armstrong, & Jones, 2002, p. i). This also has an effect on tourism such as beach life and summer recreation on the lake.

Figure 3.4. Red River and downtown Winnipeg

3.3 SOURCES OF NUTRIENTS

Essentially, all human activities can exacerbate the issue of increased nutrient runoff into waterways. As Bourne, Armstrong, and Jones argue, “the nutrient enrichment or eutrophication of streams and rivers is one of the most important surface water quality issues in Manitoba” (2002, p. 1).

The Regulation of Lake Winnipeg

Since 1976, major dams have been constructed along the Nelson River, the river that drains Lake Winnipeg into the Hudson Bay. This has the effect of stabilizing lake elevations, decreasing outflow during spring and summer, and increasing outflow during fall and winter. Biomass is accumulated due to the stabilization of Lake Winnipeg’s water levels. Though this regulation helps produce vast amounts of hydroelectricity, it negatively affects the water quality by allowing or disallowing nutrients from leaving the lake. The nutrients then settle and support algal growth. (Partners for the Saskatchewan River Basin Board, 2009, p. 144).

The Red River as a Transporter

Of the three main rivers draining into Lake Winnipeg, the Red River is estimated to input the largest amount of nitrogen and phosphorus. (Cicek, Lambert, Venema, Snelgrove, Bibeau, & Grosshans, 2005, p. 530). This level of contribution is due in part to that the soils of the Red River watershed, which are naturally nutrient-rich and when combined with intensive residential and agricultural development drastically increase the amount of nutrients entering Lake Winnipeg (Bourne, Armstrong, & Jones, 2002, p. 2).

Proportions of loading of phosphorus to Lake Winnipeg

Red River = 57.89%

Winnipeg River = 25.56%

Saskatchewan River = 10.65%

Remaining Smaller Rivers (Pigeon, Poplar, Dauphin, Manigotagan, Fisher) = 5.9%

(Lake Winnipeg Implementation Committee, 2005, p. 36)

Wastewater Treatment

The City of Winnipeg's contribution of nutrients to Lake Winnipeg is significant as well. On average the city accounts for 7% of the total phosphorus loading (Partners for the Saskatchewan River Basin Board, 2009, p. 144) and 11% of the total nitrogen loading (Bourne, Armstrong, & Jones, 2002, p. iv). According to the City of Winnipeg's manager of environmental standards the city has one of the worst sewage-treatment plants in the country. The city is currently working on a $365 million upgrade to one of its two existing wastewater treatment facilities (Winnipeg Free Press, 2011). The proposed upgrade is aimed at helping reduce both nitrogen and phosphorus levels entering the Red River and eventually Lake Winnipeg. In addition to Winnipeg's waste treatment facility there are over 400 licensed wastewater facilities and seventy-six industries throughout the province that discharge their wastes to the surface waters (Bourne, Armstrong, & Jones, 2002, p. 4).

Agricultural Runoff

Agricultural runoff in Manitoba is a substantial source of nitrogen and phosphorus from the surface waters of the province. Though only 20% of the Red River watershed lies within Manitoba, it contributes more phosphorus and nitrogen per square kilometer than the 80% of the watershed located in the United States (Lake Winnipeg Implementation Committee, 2005, p. 37). It has also been noted, "the contribution from agricultural land in Manitoba is estimated to be 5% of the nitrogen load and 15% of the phosphorus load to Lake Winnipeg" (Partners for the Saskatchewan River Basin Board, 2009, p. 144). The nutrients from farming come from fertilizer and animal manure applied to cultivated fields. During a rain or flood event these nutrients move into surface water through the drainage network.

Historically, southern Manitoba was characterized by many seasonal wetlands, which acted as filters for runoff and provided habitats for many wildlife. As land drainage occurred many of these wetlands have been drained and filled for agricultural and residential development. The purpose of many drainage activities was not to prevent flooding but to move water off of the fields. This was done to allow farmers to access their lands quicker in the spring to facilitate early seeding to reduce the potential of crop destruction and yield reduction (Red River Basin Board, 2000, p. 3). Inefficient drainage and poor land use practices reduce riparian vegetation and allow wind and water erosion to move nutrients into the water network and eventually Lake Winnipeg.

Figure 3.5. (opposite) 1950 Red River flood extents. Adapted from "A Map Showing the Extent of the Red River Flood of 1950 in Manitoba (1953)," from Manitoba Historical Society, 2008, http://www.flickr.com/photos/manitobamaps/4138482030/. © 2008 Manitoba Historical Society. Adopted with permission.


R2
DAKOTAH
HEADINGLEY
1
ST. JAMES
WINNIPEG
ST. BONIFACE
TRANSCONA
R4
G.W.W.D. RLY.
C.N.R.
Assiniboine River
C.N.R.
C.P.R.
ST. VITAL
FT. GARRY
T10
12
PARISH OF ST. FRANCOIS XAVIER
PARISH OF HEADINGLEY
PARISH OF HEADINGLEY
PARISH OF ST. CHARLES
FORT WHYTE
SPRINGSTEIN
RITCHOT
VERMETTE
PRAIRIE GROVE
PARISH OF ST. VITAL
PARISH OF ST. NORBERT
3
GRANDE POINTE
OAK BLUFF
2
ST. NORBERT
GRANDE POINTE SETTLEMENT
C.P.R.
STARBUCK
T9
HOWDEN
ILE DES CHENES
SANFORD
ST. ADOLPHE
T8
75
PARISH OF STE. AGATHE
DOMAIN
NIVERVILLE
C.P.R.
BRUNKILD
C.P.R.
T7
STE. AGATHE
OSBORNE
C.N.R.
Morris
UNION POINT
ERLING
RAT RIVER
OTTERBURNE
T6
SILVER PLAINS
McTAVISH
AUBIGNY
SETTLEMENT
ST. PIERRE JOLYS
River
C.N.R.
River
T5
Red
LOWE FARM
23
C.N.R.
MORRIS
DUFROST
LA ROCHELLE
ST. MALO SETTLEMENT
STE. ELIZABETH
ST. MALO
T4
SEWELL
ST. JEAN BAPTISTE
75
C.P.R.

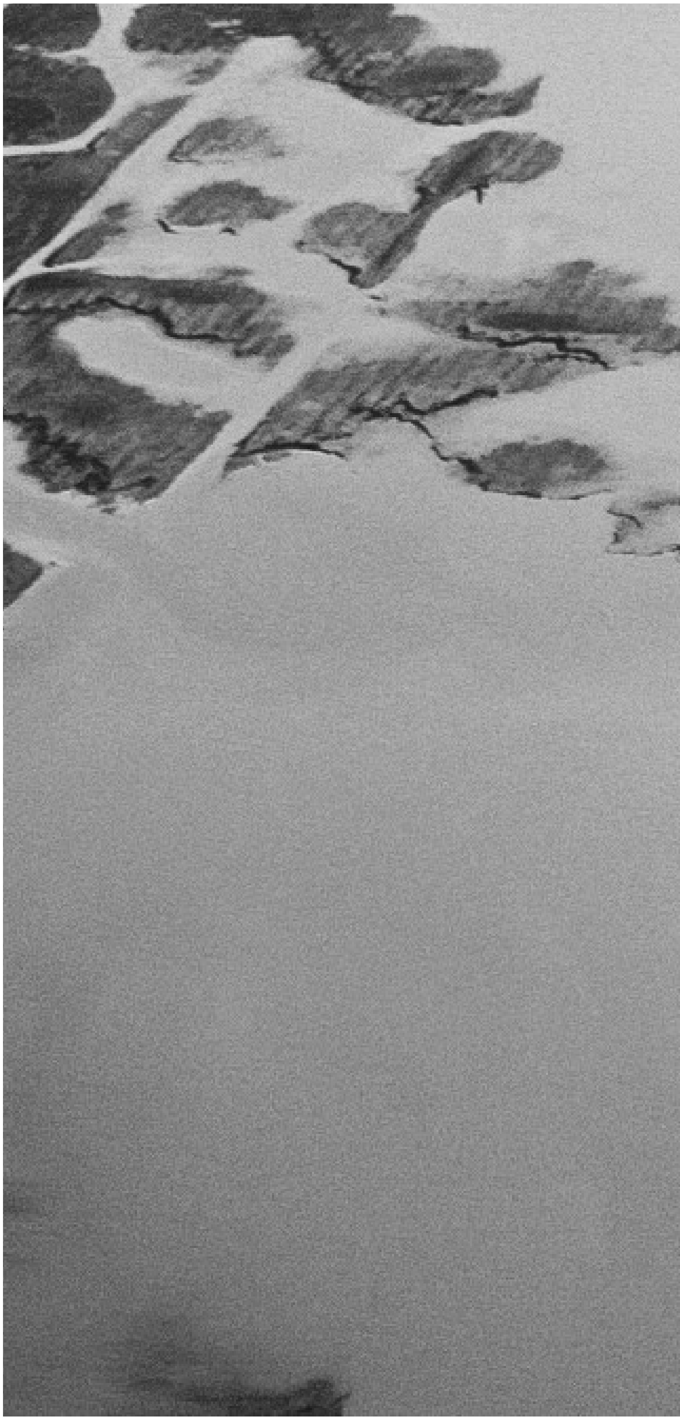
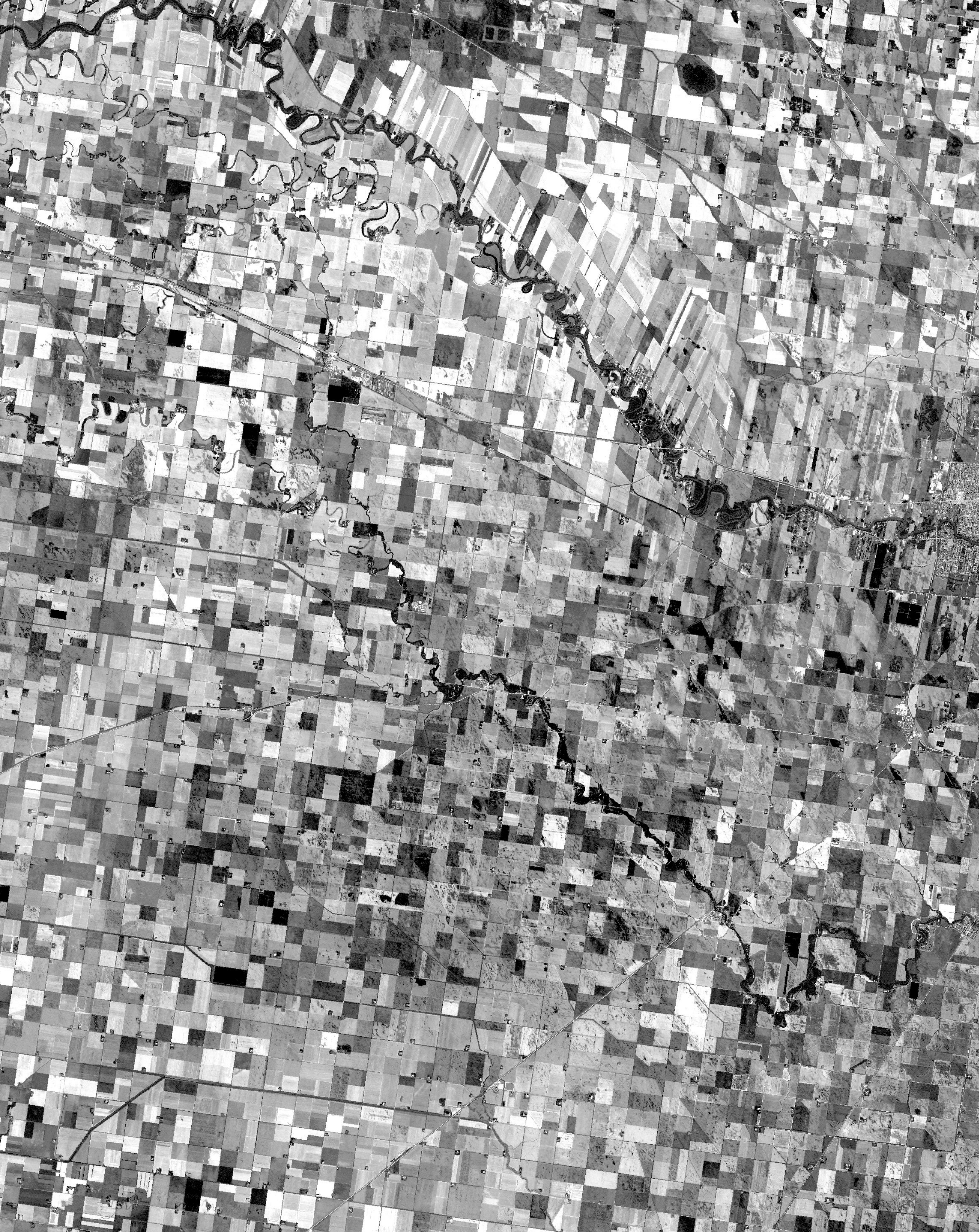


Figure 3.6. Red River flooding. Farm yards protected by ring dikes. Adapted from "RedRiverFlood09_1107" by B. Hildebrand, 2009, http://www.flickr.com/photos/bruce-hildebrand/3488170489/. © 2009 B. Hildebrand. Adopted with permission.

3.4 CONCLUSION

To understand the present day conditions and constraints of the water issues surrounding Lake Winnipeg, the transformations of the past need to be examined. The soil of the Red River watershed is naturally high in nutrients such as nitrogen and phosphorus, but as agriculture practices were developed, the nutrient levels increased. When the Red River floods it carries large amounts of nutrients to Lake Winnipeg contributing to the declining health of the lake. The condition of Lake Winnipeg has been deteriorating for four decades with the increased blooms of blue-green algae. Moving from a wet prairie condition to an agricultural condition is a major transformation, however it is also a major part of today's socioeconomic culture.

Figure 3.7. Aerial photo of the Red River flooding. Adapted from "Red River Flood," by R. Riegel, 2006, http://www.flickr.com/photos/jriegel/2498119537/. © 2006 R. Riegel. Adopted with permission.



4. HISTORY OF DRAINAGE

4.1 THE WET PRAIRIE (1650 - 1930)

From the beginning of the 17th century to the early 20th century, settlers have had an immense impact on Aboriginal people, and the native plants and animals of the wet prairie. They altered populations and inhibited the ways in which the Aboriginal people were able to use the land. Settlers changed the composition of the area by killing off bison, downsizing wildlife habitats and transforming land for agricultural purposes. “Over this relatively short time span, [the settlers] emerged as the dominant ecological component in this landscape” (Hanuta, 2006, p. 49). Since the late 1900s farmers have been perfecting the art of drainage, eliminating the vegetation of the wet prairie, and increasing the runoff of the land.

Non-Anthropogenic Management

Historically prairie fires, poor drainage, herds of bison and flooding have provided the ideal conditions for the growth of grasses that are tolerant to drought and floods. Naturally, bison and fires preserved a boundary between the prairie grasses and the aspen parkland in southern Manitoba (Hanuta, 2006, p. 52). The relatively flat terrain and silty-clay soils created the conditions for the wet prairie allowing water to pool in the subtle depressions of the landscape. The wet prairie of southern Manitoba “is structurally and geomorphologically predisposed to flooding” (Carlyle, 1984, p. 331) and drought allowing the landscape to maintain a palette of flood and drought tolerant vegetation.

Wet Prairie to Farmland

As settlers arrived, many of the trees along the riverbanks of the wet prairie were stripped for heating and building material (Hanuta, 2006, p. 48). With the elimination of the bison herds, taller prairie grasses appeared on the land and were soon referred to as “natural” vegetation by locals and surveyors. Aspen forests began to move inward expanding their boundaries into the wet prairie (Hanuta, 2006, p. 52).

From 1870 to 1880 a vast number of settlers relocated to Manitoba with the assurance that railroads would soon follow. Some of the Mennonite colonies from the southern portions of the province afforded the “somewhat baffled Selkirk Settlers” (Winkler, 1953) a new technique for working with the semi-arid prairies that was brought from Russia-Ukraine. Subsequently, once the Hudson’s Bay Company gave up its administration responsibilities of the territory in the Rupert’s Land Act of 1868 there was an additional influx of settlers. This eventually led to an upset in the racial complexity of Manitoba, as it had been predominantly French and Métis (Winkler, 1953).

The commencement of the Dominion Land Act of 1872 allowed for, “extensive tracts of grassland and Parkland areas [to be] surveyed, settled and cleared for farming” (Hanuta, 2006, p. 8).

Figure 4.1. (previous) Rivers and drainage of southern Manitoba. [aerial map]. 1:250,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 4.2. (opposite) Drainage of southern Manitoba. Adapted from “Drainage, N23584, 1915” from Manitoba Archives. © Manitoba Archives. Adopted with permission.

Figure 4.3. (above) 6' drainage ditch. Adapted from "A 6' drain, N23022, 1911" from Manitoba Archives. © Manitoba Archives. Adopted with permission.

> The Dominion Lands Act of 1872 outlined the provisions for granting homesteads to settlers: free homesteads of 160 acres were offered to farmers who cleared ten acres and built a residence within three years of a registered intent to settle a specific land claim. The Dominion Lands Act imposed a standard measure for surveying, subdividing and settling the prairies: land had to be located through cadastral surveys; individuals had to show that their land was improved upon and had increased in value or use by constructing a dwelling or cultivating the land; letters patent would then be issued to settlers by a Dominion Lands Board which screened and validated all applications (The Encyclopedia of Saskatchewan, 2006).

Soon after, major drainage projects began for the Manitoba and St. Paul Railroads. Ditch-digging machines and horses dug a total of 15 ditches with a total distance of 72 kilometers in the hope that it would encourage farmers to construct their own drainage tying into the railways drainage. More settlers moved into the area with the construction of the Canadian Pacific Railway. (Red River Basin Board, 2000, p.7)

By 1885, most of the adequately drained land in the Red River watershed had been transformed into productive farmland. Although considerable portions of un-drained land in the watershed had been avoided by settlers in favor of drier ground, "With the arrival of the railway and increasing numbers of settlers, demand for land became greater" (Red River Basin Board, 2000, p. 4). It was this increase in demand that pushed the newly arrived settlers to work with land such as bogs and sloughs, that was previously deemed undesirable. In addition to this, large snowfalls or exceptional rainfalls made other areas that were not usually subject to saturation often inaccessible for cultivation. In these areas, "the extent of the drainage problem varied from year to year, but from the beginning, Red River farmers were handicapped by wet land" (Red River Basin Board, p. 4).

Legislation encouraging land drainage for agriculture and economic development was passed in three states in the United States and in Manitoba. The Land Drainage Act of 1895 "provided the creation of drainage districts, administrative entities characteristic of large-scale, government assisted land drainage projects" (Bower, 2007, p. 798).

There was great pressure from farmers and government to remove surplus water from existing and potential agricultural lands during the spring melt and after heavy summer rainfalls. Around this time, the province failed to implement a watershed management plan (Bower, 2007, p. 812). Economic progress prevailed and “24 drainage districts were formed in Manitoba” (Red River Basin Board, 2000, p. 8), draining nearly 800,000 hectares of land. The districts were an answer to the problems of flooded land that interfered with the mile-by-mile private properties of the Dominion Land Survey. Soon after the completion of the drainage network, problems of water between communities situated at various elevations occurred in relation to the dry and wet cycles of the wet prairie. “The water that ran in from higher lands became known as foreign water” (Bower, p. 801) and was central to the conflict over drainage in southern Manitoba (Bower, p. 801). Even though this issue was taking place on a remarkably flat area of land, highlander and lowlander became terms that were prominent in local conversation. This further emphasized the conflicts between the landowners at various elevations within the region (Bower, 2007, p. 802). Federal agencies were presented with contrasting ideas of how to approach drainage activities of the highlands versus the conditions of the lowlands. “Cautious land management” was the answer given by the Department of Agriculture in hopes to mitigate the effects of flooding. On the other hand, the Army Corps of Engineers believed that only built structures such as dams could address this issue (Bower, p. 805). As a result, complications arose in the drainage district. There was a lack of drainage maintenance so farmers were not experiencing the full advantages of the project’s investment and drainage systems in some districts had to handle “foreign water” (Red River Basin Board, p. 8). The drought and depression of the 1930s brought the drainage activities to a halt until after World War II. Additionally, the 1930’s brought economic difficulties that further exacerbated the problems of drainage. The drainage construction costs were left owing and the already much needed maintenance went undone (Red River Basin Board, p. 8).

Figure 4.4. (below) Drainage near farmstead. Adapted from “Drainage East Reserve, N23614, 1955” from Manitoba Archives. © Manitoba Archives. Adopted with permission.

Figure 4.5. Prairies (light grey) and Wetlands (dark grey) of southern Manitoba in 1870 [computer map]. 1:1,000,000. I. Hanuta, Land Cover and Climate for Part of Southern Manitoba: A Reconstruction from Dominion Land Survey Maps and Historical Records of the 1870s Winnipeg, M.B.: University of Manitoba , 2006. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

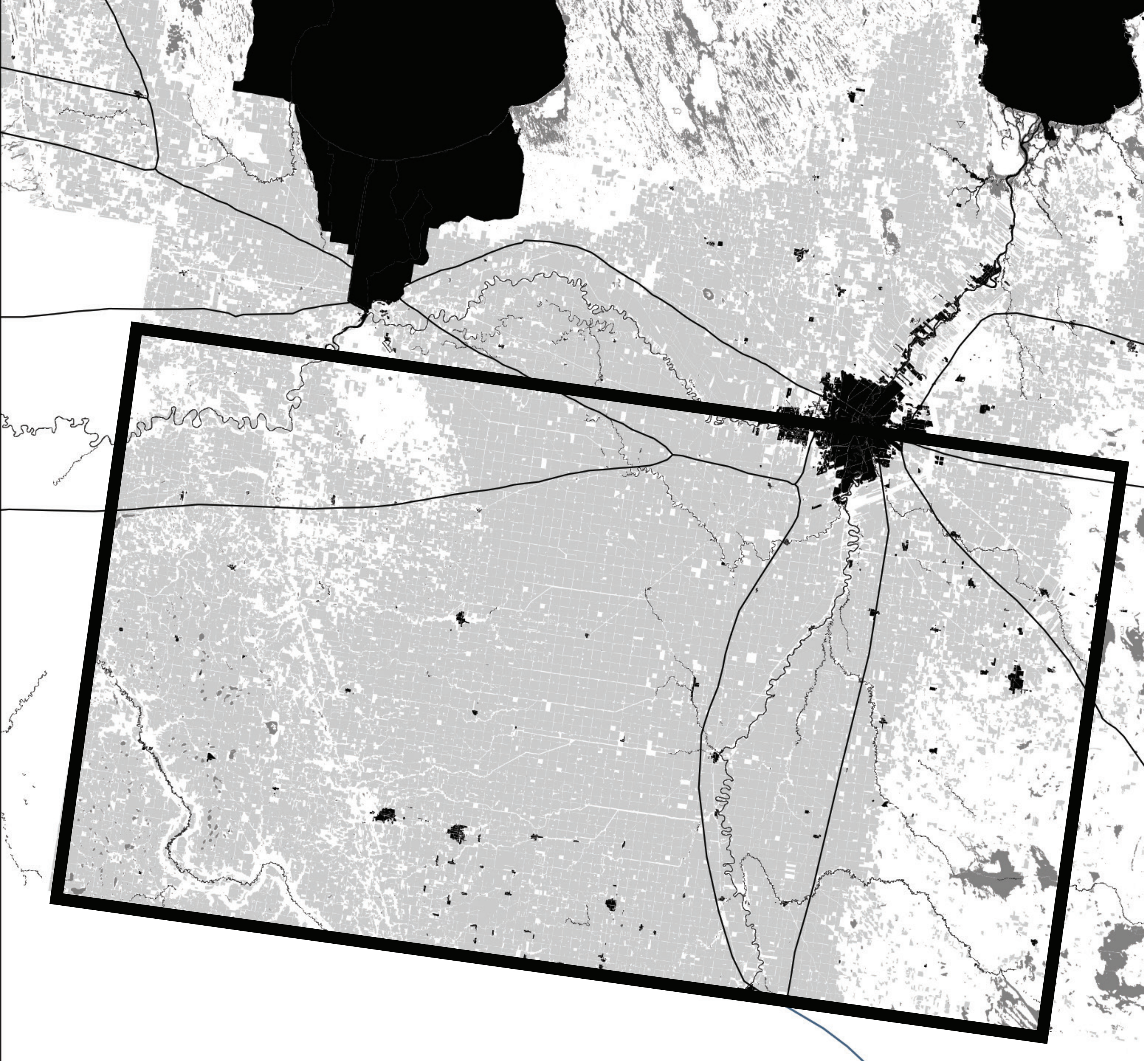


Figure 4.6. Cropland (light grey) and Wetlands (dark grey) of present day southern Manitoba. [computer map]. 1:1,000,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

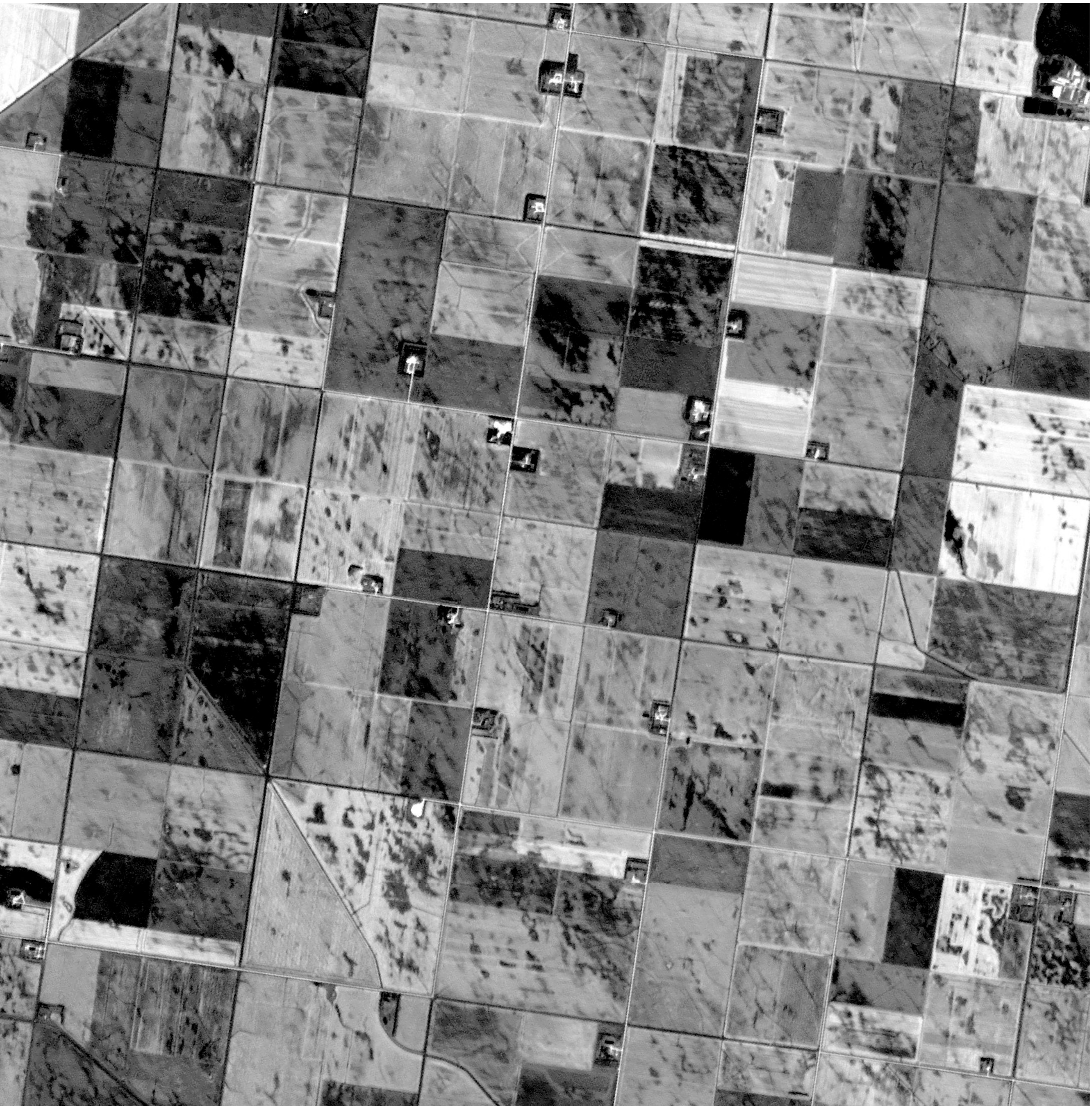
4.2 CONCEPTUAL SPLIT (1950 - PRESENT)

After the war, experts, highlanders, and lowlanders continued to battle with the dilemma of how to deal with drainage issues. In 1947, civil engineer M.A. Lyons, a recent retiree from a long career with Manitoba's Department of Public Works, was asked to conduct an investigation into the drainage problems of the province. It was thought that Lyon's expansive approach would have resulted in a watershed-based concept that would restructure the drainage system along watershed lines, but over the course of his investigation he changed his mind. The report stated that the watershed concept would be of little practical use in contemporary adjustments to the drainage infrastructure. It is not evident whether he no longer believed in watershed management, but he came to the conclusion that a mutual agreement on this approach was not attainable (Bower, 2007, p. 809).

Cost of Drainage

Based on the location of communities it was a point of contention as to who would be responsible for the cost of draining the land. Highlanders believed in their right to dictate agricultural practices on their own sections as defined by the Dominion Land Act. Their claim was that this was the land that they had purchased and they would maintain / develop it as required to suit their needs regardless of the consequences that would occur with their land draining to the lower quarters. The lowlanders, seeing that their lands would be threatened, deemed it suitable to make the

Figure 4.7. Mile to mile grid and field drainage [aerial map]. 1:50,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.



entire watershed pay for the cost of drainage. “Ultimately, it was continued contention over the idea of watershed management, rather than any weakness in the concept itself, that was the key factor in Lyons’s decision not to recommend that the provincial government restructure the drainage system along watershed lines” (Bower, 2007, p. 810). Due to the complexities of identifying and calculating ecological links it was heavily disputed whether a watershed concept would be of benefit. There were also the issues voiced by farmers regarding the use of their land in watershed management as stated by legislation and the ideological principles of land ownership. Even if they were to implement a watershed concept, Lyon doubted that the issues it would bring forth would easily be settled between the communities of the highlanders and the lowlanders. “While water flow between the highlands and the lowlands remained controversial, the matter of drainage provided a link between the seemingly disparate scales of broad ideological principles and local environmental conditions” (Bower, p. 812).

Conservation Programs

By 1965, many questions were being raised regarding the environmental effects of drainage. People became more aware of the potential impacts of drains. Conservation programs such as Ducks Unlimited Canada, a non-profit organization aimed at preserving critical wetlands across North America, supported many projects in the province.

Changes in Farm Economy

In the early 1990s a change in farm economy occurred. Manitoba farmers were being directed to plant more specialized, higher-value crops due to global demand and with these crops provided the means to invest in more precise drainage activities (Red River Basin Board, 2000, p. 10). Crops such as corn, soybeans, canola, and edible beans began to cover southern Manitoba. “Farming practice changes, coupled with the return of a wet cycle, increased size of farms and machinery, narrower profit margins, and the availability of earth-moving equipment resulted in increased on-farm drainage activity” (Red River Basin Board, 2000, p. 10).

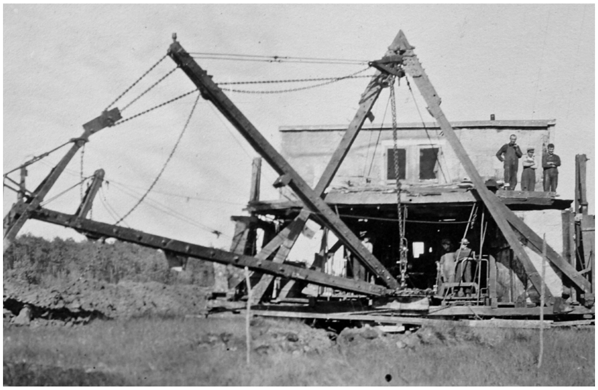


Figure 4.8. (top left) Horse and ox team working on a drain. Adapted from "Horse and ox team working on a drain, 1911" from Manitoba Archives. Figure 4.9. (top right) Drainage, 1911. Adapted from "A.R. Boivins Drainage 60 N20029, 1911" from Manitoba Archives. Figure 4.10. (bottom left) Walking Dredge, 1911. Adapted from "A.R. Boivins Walking Dredge, 1911" from Manitoba Archives. Figure 4.11. (bottom right) Walking Dredge, 1911. Adapted from "A.R. Boivins Walking Dredge, 1911" from Manitoba Archives. © Manitoba Archives. Adopted with permission.

4.3 CONCLUSION

Drainage has tied many of the communities of southern Manitoba together with a shared issue; however it has also caused many conflicts, not only between the farmers and their land, but between the farmers themselves. Drainage practices and the Dominion Land Act have allowed for much of the economic success on the Prairies, but have also been the source of many conflicts and ongoing issues related to water. These drainage practices have been the main conduits of transporting much of the excess nutrients to Lake Winnipeg. As a result, there is a need for more flexible and adaptive approaches for dealing with runoff in southern Manitoba. As such, these proposed approaches must be sensitive to all parties involved as there is widespread invested interest in Lake Winnipeg.

Figure 4.12. (opposite) Drainage lines of southern Manitoba [computer map]. 1:500,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

5. MAJOR PLAYERS
CLAIMING A LAKE

5.1 CONFLICTS OF INTEREST

The interaction between hydraulic, ecological, agricultural and urban development within the Lake Winnipeg watershed is far from productive. Each player - agriculture, hydroelectricity, lake tourism, commercial fishing and the surrounding communities - have specific interests in the lake which affect the economy and the environment.

Agriculture ($4.9 billion in cash receipts for 2011) (Manitoba Government, 2012, p. A14)

The majority of agricultural activity takes place in the Red River watershed which drains into Lake Winnipeg. Activities include cereal, feed, and specialty crop production, as well as range, pastureland, feedlot, and intensive hog operations. Farmers require efficient drainage in order to access their land early in the spring and to keep water from pooling and destroying their crops. The problem is that the excess nutrients from fertilizer and animal manure enter the water network exacerbating the blue green algal problems of Lake Winnipeg.

Hydroelectricity ($1.9 billion in sales) (Manitoba Water Stewardship, 2011, p. 1)

Lake Winnipeg is currently being used as a reservoir to generate energy for the third largest hydroelectric operation in the world and the largest in North America (Manitoba Water Stewardship, 2011, p. 1). The Winnipeg and Nelson Rivers provide the province of Manitoba

Figure 5.1. Grand Beach on Lake Winnipeg. Adapted from "Grand Beach," by Travel Manitoba, 2009, http://www.flickr.com/photos/travelmanitoba/5431567855/. © 2009 Travel Manitoba. Adopted with permission.

with a surplus of renewable energy (Partners for the Saskatchewan River Basin Board, 2009, p. 141). The waters of Lake Winnipeg must be regulated in order to generate the province's much needed hydroelectricity. As a consequence, it is not possible for the nutrients in the water to be released from the lake as part of a naturally occurring cycle.

Lake Tourism ($110 million in expenditures)
(Manitoba Water Stewardship, 2011, p. 1)

Tourism on Lake Winnipeg is a booming industry and is highly centered on the southern basin. This area is home to eight provincial parks and many beaches used annually by the public. Grand Beach and Winnipeg Beach - two of Manitoba's most frequented beaches - account for a combined total of approximately half a million visits per year. Some of the many uses of Lake Winnipeg include all-season recreation, eco-tourism, water sporting events, festivals, resorts and cottage life (Partners for the Saskatchewan River Basin Board, 2009, p. 142). Excessive algal growth in the lake prevents summer recreational uses such as utilizing the beaches and other water activities.

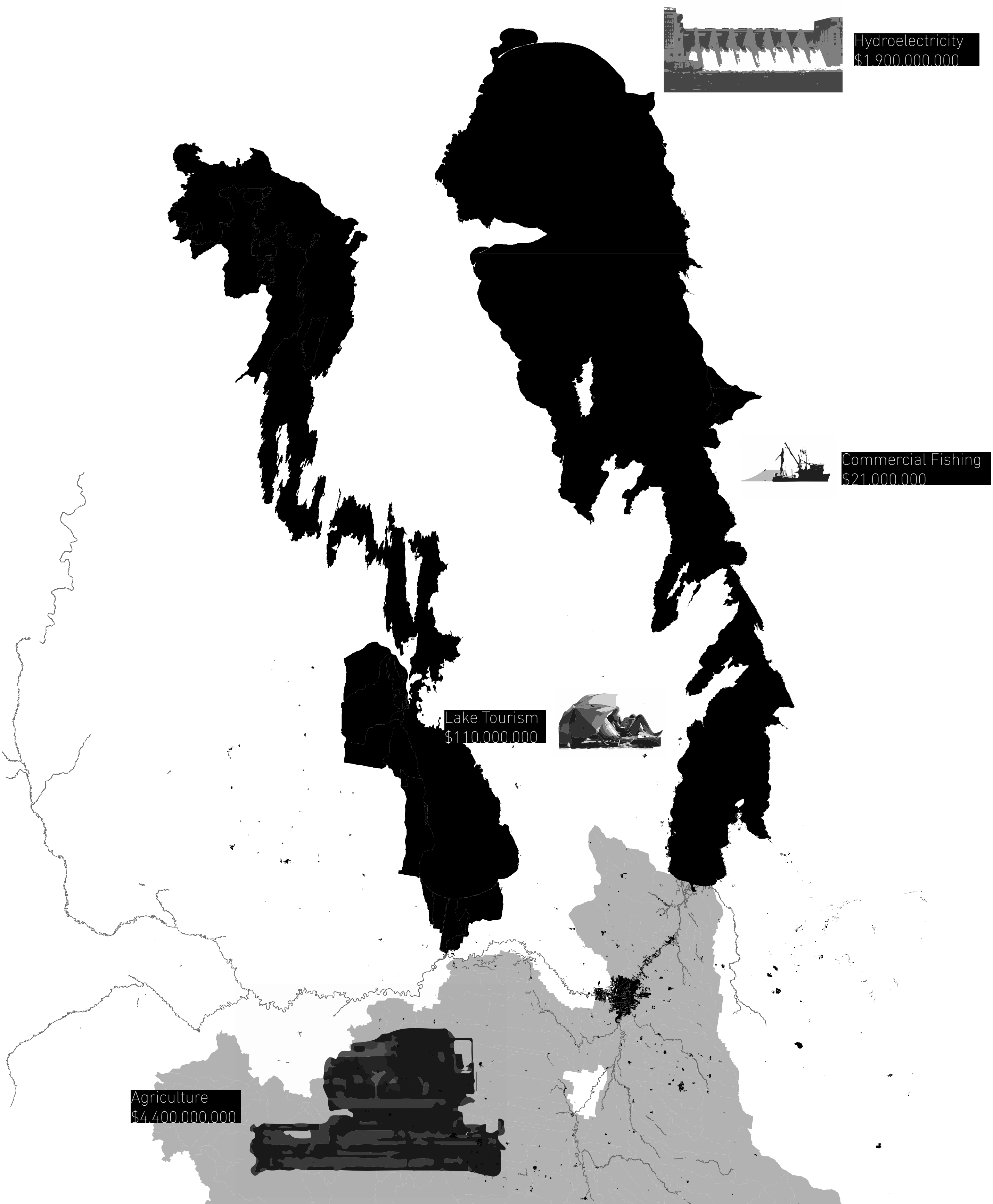
Commercial Fishing ($21 million in returns)
(Manitoba Water Stewardship, 2011, p. 1)

Commercial fishing has been a prominent industry on Lake Winnipeg for the past 125 years. This industry supports the livelihood of about 1,000 commercial fishers, of which approximately 80% are of First Nations or Métis ancestry. (Partners for the Saskatchewan River Basin Board, 2009, p. 142).The excessive algal growth produces toxins that are fatal to many fish species that live in the lake. The algal blooms also have effects on species diversity and quantities available for harvesting.

Communities

The perimeter of Lake Winnipeg is home to almost 23,000 permanent residents living within 30 communities. Of these communities, eleven are First Nations with a combined population of approximately 14,000. Additionally, over 10,000 cottages and seasonal residences populate the shores of the south basin. Some of the smaller communities along the eastern shores take water from the lake and treat it for household use. This untreated water could be significantly affected by a continued decline in the health of the lake (Partners for the Saskatchewan River Basin Board, 2009, p. 140). The toxins from the blue-green blooms have an effect on the taste and odour of drinking water and can adversely affect humans.

Figure 5.2. (opposite) Major players of Lake Winnipeg, based on map of Lake Winnipeg and southern Manitoba. [computer map]. 1:2,500,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba, 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.


Hydroelectricity
$1,900,000,000
Commercial Fishing
$21,000,000
Lake Tourism
$110,000,000
Agriculture
$4,400,000,000

5.2 CONCLUSION

Examining the various relationships between agriculture, hydroelectricity, lake tourism, commercial fishing and the surrounding communities allows for opportunities to rethink the sustainable strategies involved in managing surface waters in Manitoba. This overview of Lake Winnipeg's major players exhibits a long and sensitive competition for the use of the lake. These endeavors have ultimately aided in the perpetual decline in the lake's health. Integrated landscape architectural proposals have the potential to redefine the relationship of the lake with its watershed. This affords the continued use of the lake in all ways previously discussed, while also allowing for a regeneration of the lake's health and longevity that is currently not foreseeable. Increasing communication among the major players when developing long-term strategies for the lake may create new design concepts and landscape structures.

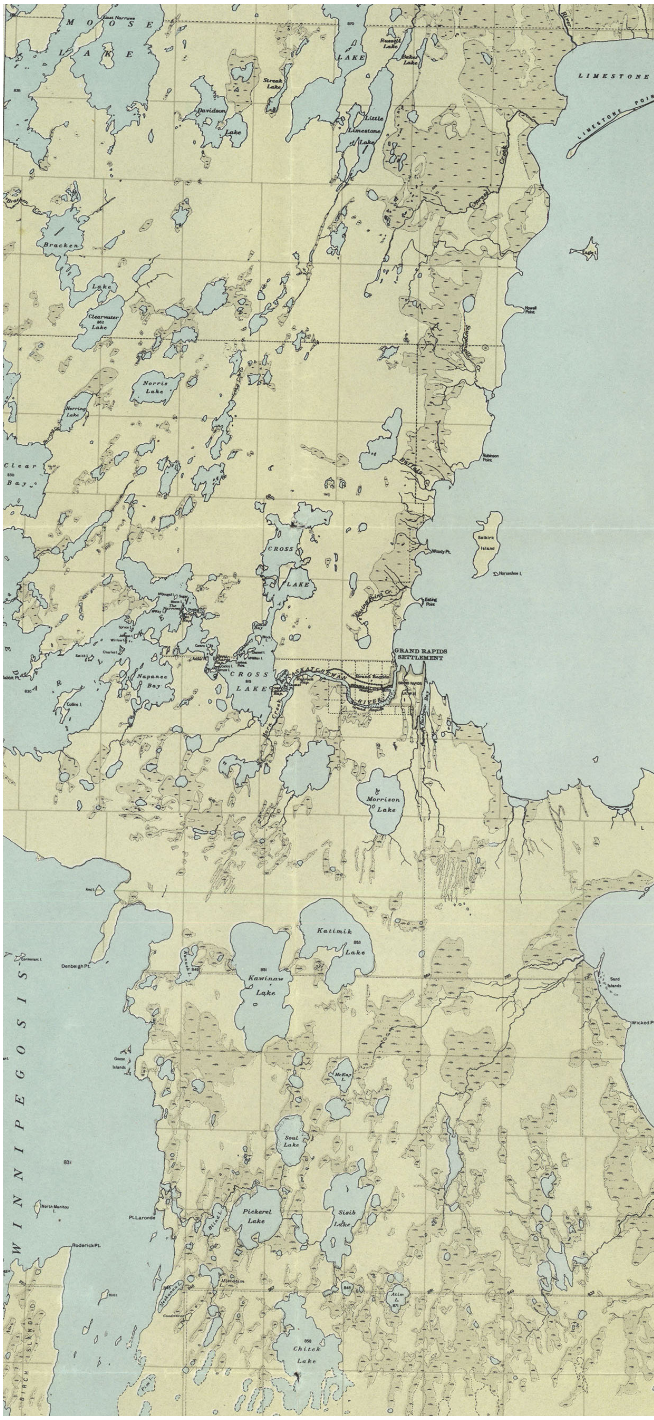


Figure 5.3. Map of Lake Winnipeg. Adapted from "Lake Winnipeg 53L (1931)," from Manitoba Historical Society, 2008, http://www.flickr.com/photos/manitobamaps/2176985812/. © 2008 Manitoba Historical Society. Adopted with permission.


LAKE WINNIPEG
PLAYGREEN LAKE
Ermine Point
Playgreen Pt.
Mossy Point
Warren Landing
Montreal Pt.
GUNISAO RIVER
Diamond Rapid
Costes Lake
McLaughlin River
Lebrix Lake
PRINCIPAL MERIDIAN
Spider Island
Belanger Pt.
Belanger River
Shoal Pt.
Birdnest Pt.
Nanawan River
Mukutawa River
North Branch Poplar River
Poplar Pt.
Poplar River
Marchand Pt.
Marchand Creek
Marchand L.
Manybays Lake
Weaver Lake
McPhail
Big Stone Pt.
Mossy Pt.
Leaf River
Dancing Pt.
Driftwood Bay
713

6. DESIGN INGREDIENTS

6.1 RETHINKING DRAINAGE STRATEGIES

There is a need for adaptive approaches when dealing with runoff in southern Manitoba. This practicum proposes a model area for the entire territory of the Red River watershed. Each sub-basin pollutes the Red River and an approach is required to intercept and filter the water before it leaves each basin. One option is to plant cattails and filter nutrients, creating a filtration system. Utilizing research on the levels of pollutants and the drainage patterns of the sub-basins, filtration designs can be implemented in order to capture the pollutants before they reach the Red River.

Drainage strategies and activities have tediously and steadily worked to improve the efficiency of moving water off the fields. There is a need for projects that work to reverse the thinking surrounding drainage practices and to create landscape projects that serve as blockages that hold water back and allow for passive/natural filtration of nutrients through cattail growth and harvesting. The projects create coordinates in what may appear to be seemingly flat farmland. These small blockages or disturbances are turned into projects that define different structures in the landscape. These projects then become frames for areas in which cattails can be grown to filter the water. Such projects have the potential to generate biodiversity within industrial farmland. By creating these obstructions through various methods such as

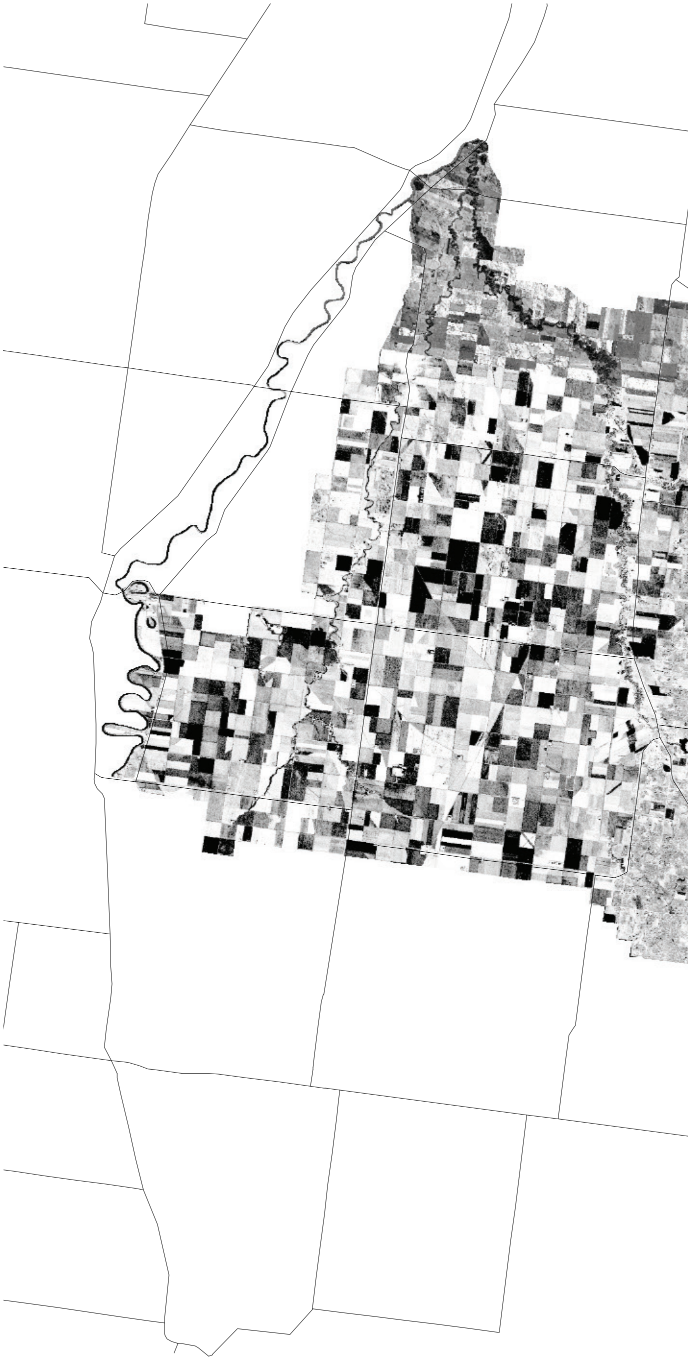
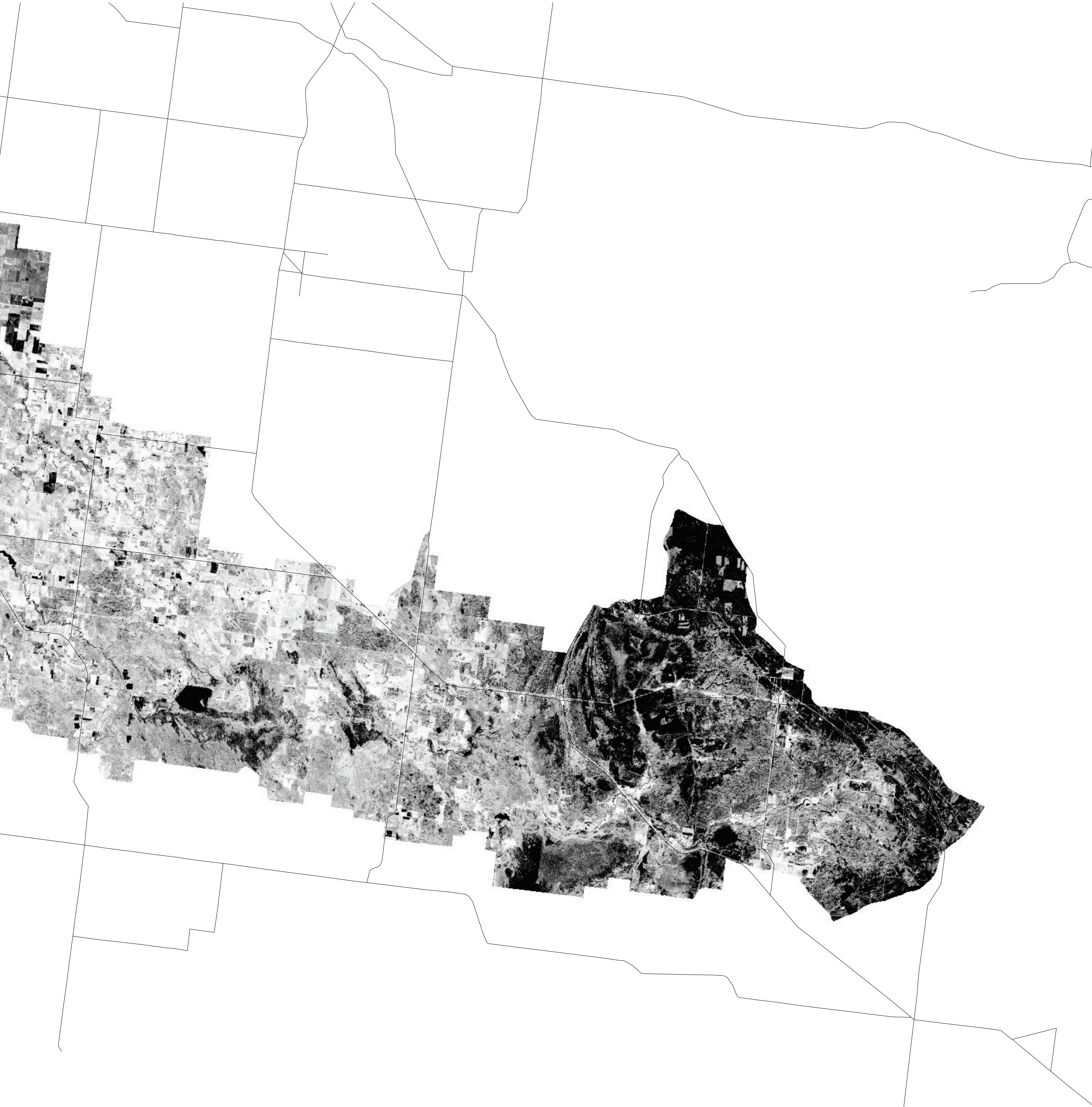


Figure 6.1. Rat River watershed. [aerial map]. 1:400,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.



constructing dikes out of clay, the conditions are created to retain and filter water. A basic rethinking of the conventions in rural Manitoba may bring together many interests.

6.2 CATTAILS

Plant Profile:

Cattails (*Typha* spp.) are plants with tall, skinny leaves and soft, brown, finger-like spears. They grow in swampy areas along ponds, ditches, and other damp locations. Cattails root themselves in low marshy regions which allow their tops to rise up out of the water therefore classifying them as emergent plants. Despite the lack of oxygen in the soil these plants flourish due to a thick system of roots. Cattails can reach up to 0.90 to 2.70 meters high (Lawlor, 2000, p. 48).

Plant Potential:

An additional benefit to planting cattails for filtration is the possibility for them to be harvested for biomass production. Large energy demands and approximate energy consumption amounts for living in Manitoba inevitably led this practicum to the concept of biomass energy production in combination with water filtration through the use of cattails.

Due to increasing demand, particularly in the area of filtration and energy, a market could emerge that utilizes cattails' potential. This new market would be distinguished by the use of plant material and the discussion of sustainability in relation to conceptual coordination and planning. By using cattails for biomass harvesting there is a possibility of earning carbon emission credits (Cicek, Lambert, Venema, Snelgrove, Bibeau & Grosshans, 2006, p. 530). Although sometimes considered a weed, cattails are now attracting attention for their usefulness in areas such as lake restoration, sewage treatment and biomass harvesting (Martin and Fernandez, 1991, p. 7).

The evaluation of combining water filtration and biomass production being carried out by the International Institute for Sustainable Design (IISD) will be used to support the design. Cattails are particularly effective in absorbing nitrogen and phosphorus from sediment and water, assimilating them into biomass. Additionally, they absorb a significant amount of stored phosphorus from sediments during a single growing season. Systems of purification that use emergent helophytes, such as cattails, have been proven to be quite successful in treating water. Helophyte treatment systems can be very suitable for cold or temperate areas and can provide a very complete purification process (Fernandez & Martin, 1991, p. 7). In an ideal scenario, farmers would be able to harvest cattails and sell them to local incinerators throughout the rural communities of the province.

Filtration

Cattails can be used to absorb not only nutrients such as nitrogen and phosphorus but also herbicides, pesticides and other contaminates. As noted by Fernandez & Martin "... cattails have shown very promising perspectives for wastewater treatment for small populations and industries" (1991, p. 7). Additionally, when dealing with the removal of nutrients from polluted lakes and other bodies of water, extensive testing and implementation has shown that human-made wetlands planted with species of an aquatic variety are recognized as a prominent method of treating wastewater that is also low cost (Tian, Zheng, Liu & Zhang, 2008, p. 443).

Harvesting

When harvesting cattail fields there are several methods for ensuring the best yield possible to achieve the most efficient filtration process. Fernandez and Martin concluded that "...the maximum amount of biomass will provide maximum purification efficiency per square unit, not only in nutrient removal but also in organic matter degradation" (1991, p.11). Additionally, a late fall harvest, ideally in late September or early October, would result in a 70% reduction of the nitrogen and phosphorus that had been previously absorbed by the plants (Fernandez & Martin, 1991, p. 11). With regard to the overall costs of this filtration to the farmers, it would be safe to assume that operating costs would be similar to harvesting wheat or silage (Grosshans, 2013, personal communication).

Biomass

More recently, researchers in bioengineering have considered high-efficiency conversion of marsh vegetation, such as reed grass and cattails, for electrical energy and ethanol. "Various studies have been carried out evaluating the technical feasibility and economical viability of cattail production in natural wetlands. Different harvesting systems were evaluated leading to the conclusion that annual harvest of emergent plant material stimulated rapid re-growth the following year and was economic" (Cicek, Lambert, Venema, Snelgrove, Bibeau, & Grosshans, 2006, p. 530).

Figure 6.2. (previous) Sea of cattails. Adapted from "Sea of Cattails," by G. Leigh, 2010, http://www.flickr.com/photos/22780107@N02/4374726664/in/photostream/. © 2010 G. Leigh. Adopted with permission.

Retention

Retention is a benefit from the planting of cattail filtration nodes that have been previously discussed. Related to Grosshans idea of sponges, low lying areas with cattails would be able to retain and hold back water, allowing for greater filtration time. An additional benefit to the sponge concept, also noted by Grosshans, is its potential to reduce the severity of flooding by reducing the amount of water flow at any given time (2001, p.15).

Insulation

Heating is a major expense in northern settlements. Cattails could potentially be used as an inexpensive material to insulate homes (Luamkanchanaphan, Chotikaprakhan, & Jarusombati, 2012, p. 470).

Biodiversity

Wetlands have a broad spectrum of functions associated with them including everything from waterfowl production to increasing plant, wildlife, and aquatic diversity. Over the last few decades, a gradual change has occurred in the public's perception of wetlands and the role that they play in rural and urban environments (Red River Basin Board, 2000, p. 10). Originally, the public viewed the wetlands as stagnant wastelands and resolved they be drained in order to be functional. People are beginning to see these wetlands as a functional and productive part of the ecosystem.

Peat vs. Cattails

Harvesting wetland biomass for energy is not a new concept; peat from fens and bogs has been used as biofuel for centuries (Cicek, Lambert, Venema, Snelgrove, Bibeau & Grosshans, 2006, p. 530). While peat is an excellent source of biomass for energy, the consequences of extracting peat are significant. Peat will take thousands of years to form in some areas, such as sphagnum bogs, and it has an extremely slow annual regrowth rate of approximately one millimeter (Keddy, 2000, p. 497). Displacing peat ultimately extinguishes these habitats, which are nearly irreplaceable, as well as destroys evidence of pollen records in the area. As an alternative, cattails can provide a source of biomass for energy that has a rapid re-growth rate and as such can be harvested multiple times in a single growing season.

Plant Application:

Cattails thrive in an environment of little to no water, approximately zero to two meters. They are considered to be a dominant species throughout their natural environment due to their ability to invade and take over other vegetation. As noted by Grosshans, cattails are an "extremely competitive and invasive species" (2001, p. 62). The ability to control cattails comes through fluctuations in water levels. This is "considered the most natural and effective means..." (Grosshans, 2001, p. 153) for controlling their spread rate.

6.3 EPINCTIÉRES

Plant Profile:

"Les Epinctiéres" are small groves of Tamarack (*Larix laricina*) trees that were dispersed throughout the Otterburne area prior to 1870 and were described as "tamarack islands" (Hanuta, 2006, p. 85). Tamaracks are trees found in bogs, swamps, and fens. "It's the only northern conifer that sheds all its needles in the fall, by its feathery clusters of many short, soft, light blue-green needles; its warty twigs; and its short cones" (Eastman, 1995, p. 188).

In the fall, tamaracks become most noticeable with the changing of the needles to a golden yellow. These trees need full sun and will grow quickly for up to forty or fifty years. After this rapid growth they will then grow slowly and rarely measures higher than 23 meters or older than 150 years. Tamaracks are adaptive to different pH levels but do best in soils that lack nutrients but do receive an inflow of minerals. The roots of tamaracks are shallow and spread far distances making them susceptible to fire and high wind exposure (Eastman, 1995, p. 189).

Plant Potential:

Tamaracks are historically symbolic trees that can be used for creating a unique image for projects. Tamarack trees have been used throughout history for applications such as snowshoes, railway ties, corduroy roads, medicinal uses. The Ojibwe refer to it as "swamp tree" and use it as a source of food, medicine, thread for canoes, and woven bags (NativeTech: Native American Technology and Art, 2000).

Plant Application:

Trees are the most strongly three-dimensional acting, naturally elements. Rows of trees can be highly directional and can help define a spatial situation. They can provide shade, shelter, and when grouped together can act as destinations in the landscape. Functionally they can be used to stabilize soil along waterways and can be used for shelter belts.

6.4 AREA UNDER CONSIDERATION

The lower portion of the Rat River watershed will serve as an area to test approaches of filtration and retention of the runoff from surrounding agricultural lands. This area was chosen due to its having the lowest elevation within the watershed, its clay soil base and its existing land use. Just north of the area is the settlement of Otterburne with the Providence College. The college has recently installed a biomass incinerator that is used to heat the buildings of the campus. There is potential for the harvested cattails to be used for this system. This proposed coupling is underlined by the coordination of local farmers who could sell the harvested cattails to the campus. Due to short travelling distances between the system components, it would be possible to make it more efficient and beneficial for both the campus and the farmer.

There is also the possibility for various recreational opportunities to be integrated into the proposed filtration/retention nodes for the community of Otterburne as well as for the student population of Providence college that is present during the academic year.

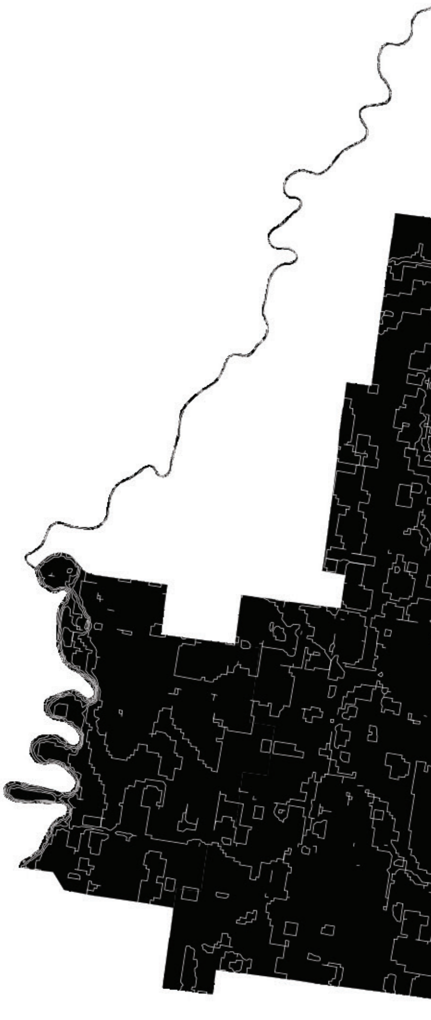
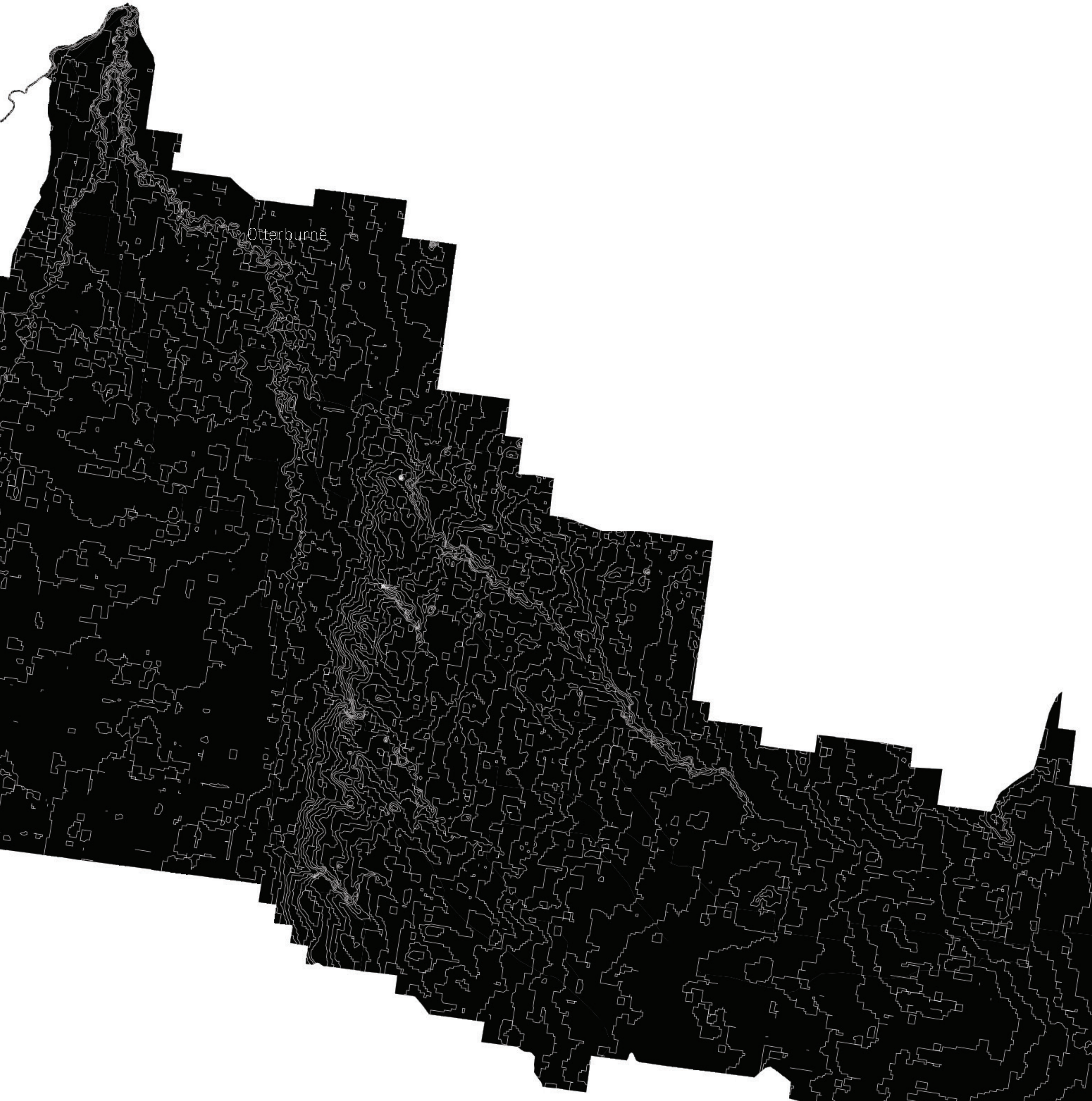


Figure 6.3. (previous) Tamaracks growing around a pond. Adapted from “Tamarack Pond,” by S. Slabik, 2011, http://www.flickr.com/photos/sherrys_corral/6307460774/. © 2011 S. Slabik. Adopted with permission.

Figure 6.4. Lower potion of Rat River watershed. Intervals of 2.00 meters. [contour map]. 1:250,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba, 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.


Otterburne

6.5 AREA CALCULATIONS

An ideal scenario was conceived assuming that all agricultural runoff could be directed through cattails. Based on the conceptual numbers calculated for the Netley-Libau marsh by the International Institute for Sustainable Design (IISD) an estimate was calculated to know how many cattails would be required to absorb the amounts of phosphorus leaving the Rat River watershed.

Average Annual Nutrient Loading of the Rat River Watershed:

24 tonnes of Phosphorus (Bourne, Armstrong, & Jones, 2002, p. 12)

220 tonnes of Nitrogen (Bourne, Armstrong, & Jones, 2002, p. 11)

Nutrient Removal Calculations:

Phosphorus

One hectare of cattails is able to remove 0.2 - 0.6 tonnes of phosphorus per year.

Based on these numbers, in an optimal and ideal situation, to remove 24 tonnes of phosphorus from the Rat River watershed annually would require at least 800 ha of cattails.

Nitrogen

Based on conceptual numbers for Netley-Libau marsh (Cicek, Lambert, Venema, Snelgrove, Bibeau & Grosshans, 2006, p. 533), one hectare of cattails could removes 0.21 tonnes of nitrogen or approximately 5 ha to remove 1 tonne.

The 800 ha of cattails to remove the 24 tonnes of phosphorus would also remove 178 of the 220 total tonnes of nitrogen, eliminating 76% of the total nitrogen load of the Rat River watershed.

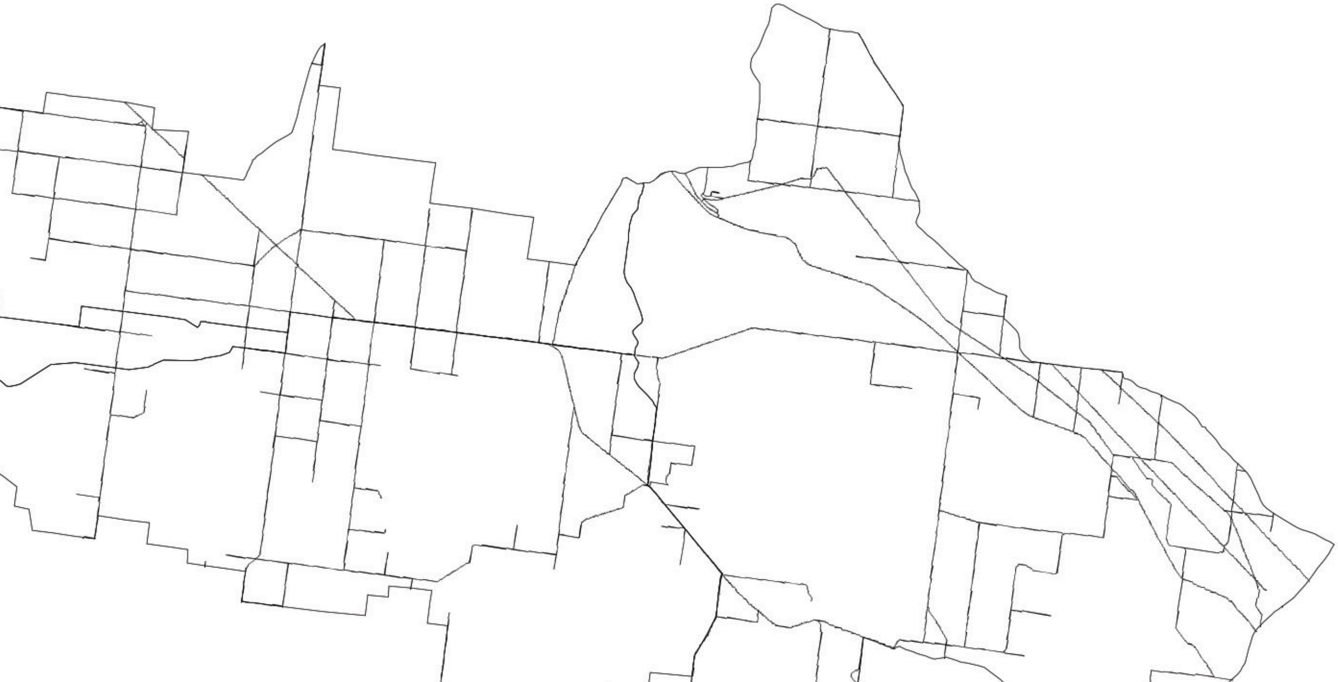
Energy from 800 ha of Cattails:

800 ha could deliver the energy equivalent of 1,788 households that could feed a community like Morden, Manitoba or the whole municipality of De Salaberry with a surplus.

6.6 CONCLUSION

Based on the calculations discussed in the previous section a total land area of 800 hectares of cattail stands are required to filter the nutrients leaving the Rat River watershed. If all 800 hectares of cattails could be harvested, this would generate enough energy for 1,788 households under the status quo of energy demand for Manitoban households.

Figure 6.5. 800 ha of cattails and the Rat River watershed. [computer map]. 1:300,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.



7. THE DISTRIBUTION OF 800 HA

7.1 MODELS

Based on the calculation of the 800 ha cattail stand previously discussed, the project progressed towards a design proposal. Two models were explored to determine the best possible distribution of the requisite cattails. Working with the extremes of possible layout and organization produced two models. Model One - "Concentration" - looked at the idea of occupying one plot of land in which water would be diverted and contained. Model Two - "Decentralization" - studied distributing the cattails into 16 nodes that would work with existing drainage and the lower elevations of the land.

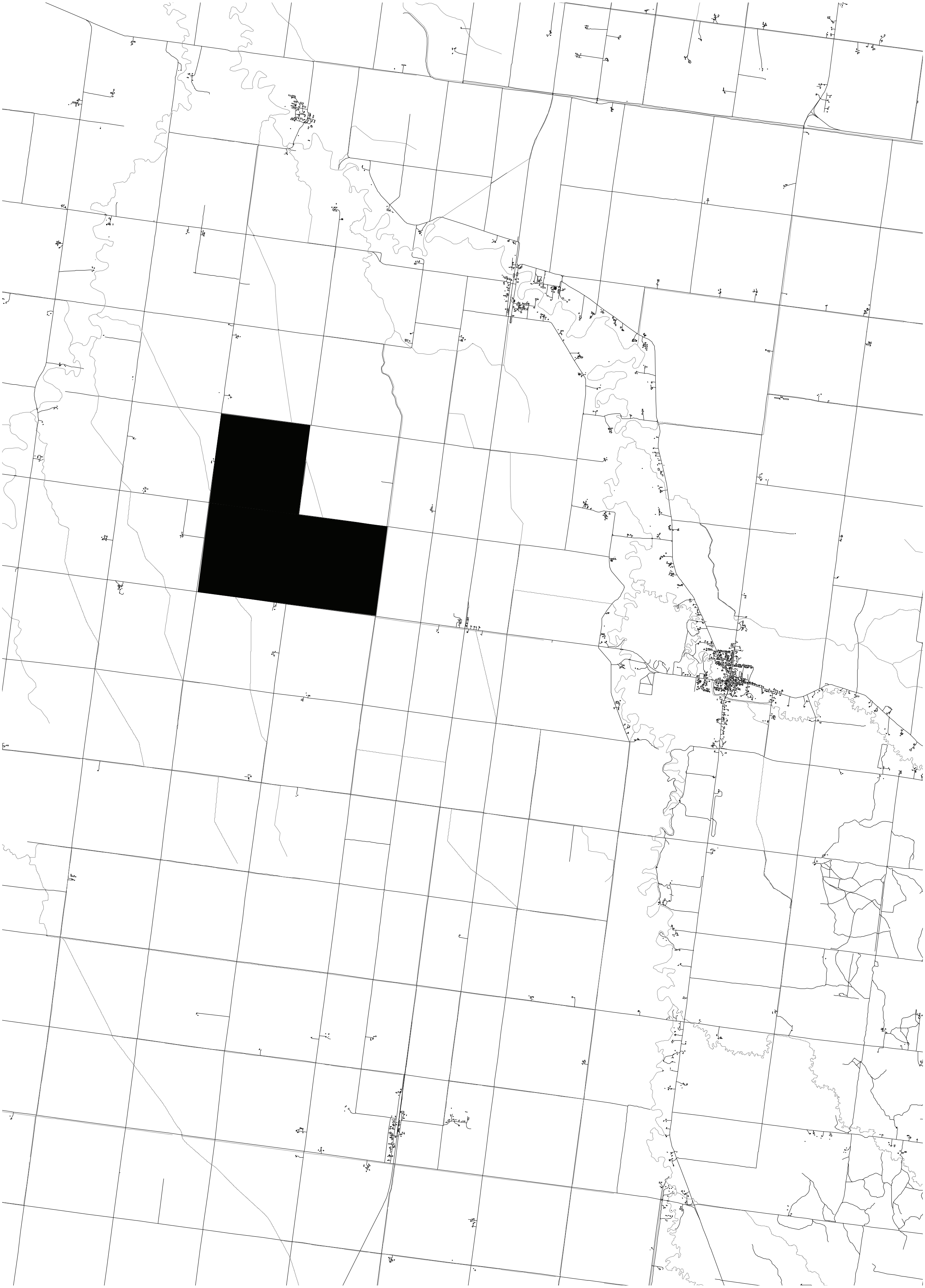
7.2 EVALUATION

The cattail placement in Model One: "Concentration" is centered in one area. This would be very productive economically but would require large amounts of energy to construct. It would be difficult to redirect all the runoff to one location and would require reshaping the entire drainage system.

The advantage of Model Two: "Decentralization" works to minimize the ecological impact by studying the existing topography, drainage and land use. Though it is not efficient in an engineering sense it would be a more careful and sensitive intervention in the landscape.

Comparing the ability of the two models to capture and filter the water, Model Two "Decentralization" is the most promising. This model uses the existing topography with minimal intervention of blocking water. By spreading the project area into sixteen plots, more ground can be covered by the filtration process. Additionally, there would be less agricultural land lost to each owner and costs would be shared by a broader portion of the community rather than having the financial burden shouldered by those few whose land is affected.

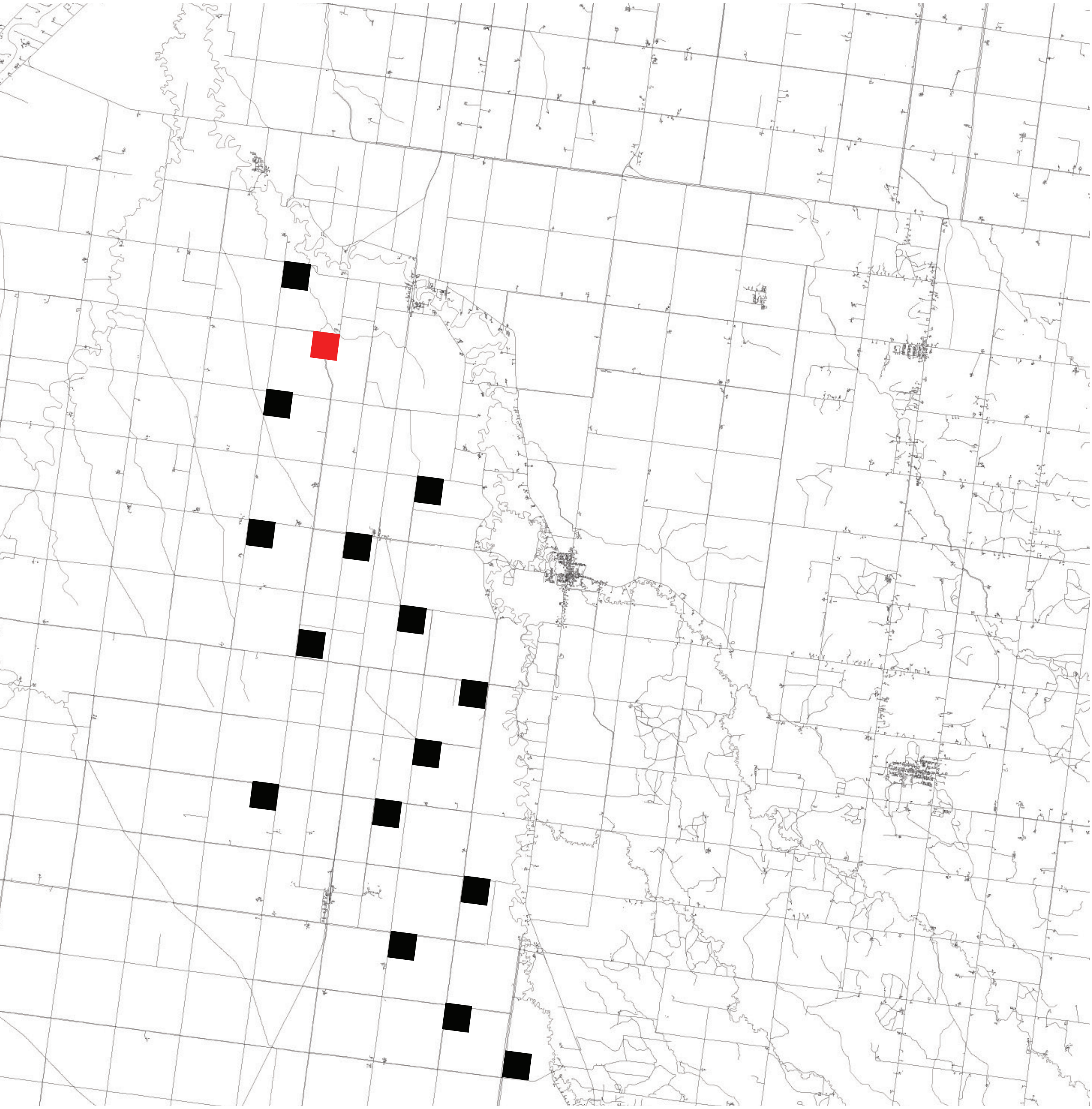
Figure 7.1. (opposite) Model One - "Concentration". [computer map]. 1:100,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.



7.3 CONCLUSION

The selection of the Model Two, involves a mosaic intervention where the 16 filtration fields (nodes) of 50 hectares each are placed within the lower portion of the Rat River watershed. Of these 16 nodes, one was selected for further investigation in this design practicum. Focusing on a smaller, more detailed scale will generate a design to act as an example within the watershed.

Figure 7.2. Model Two - "Decentralization". 16 fields (nodes) for a watershed. [computer map]. 1:150,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.



8. PROJECT AREA

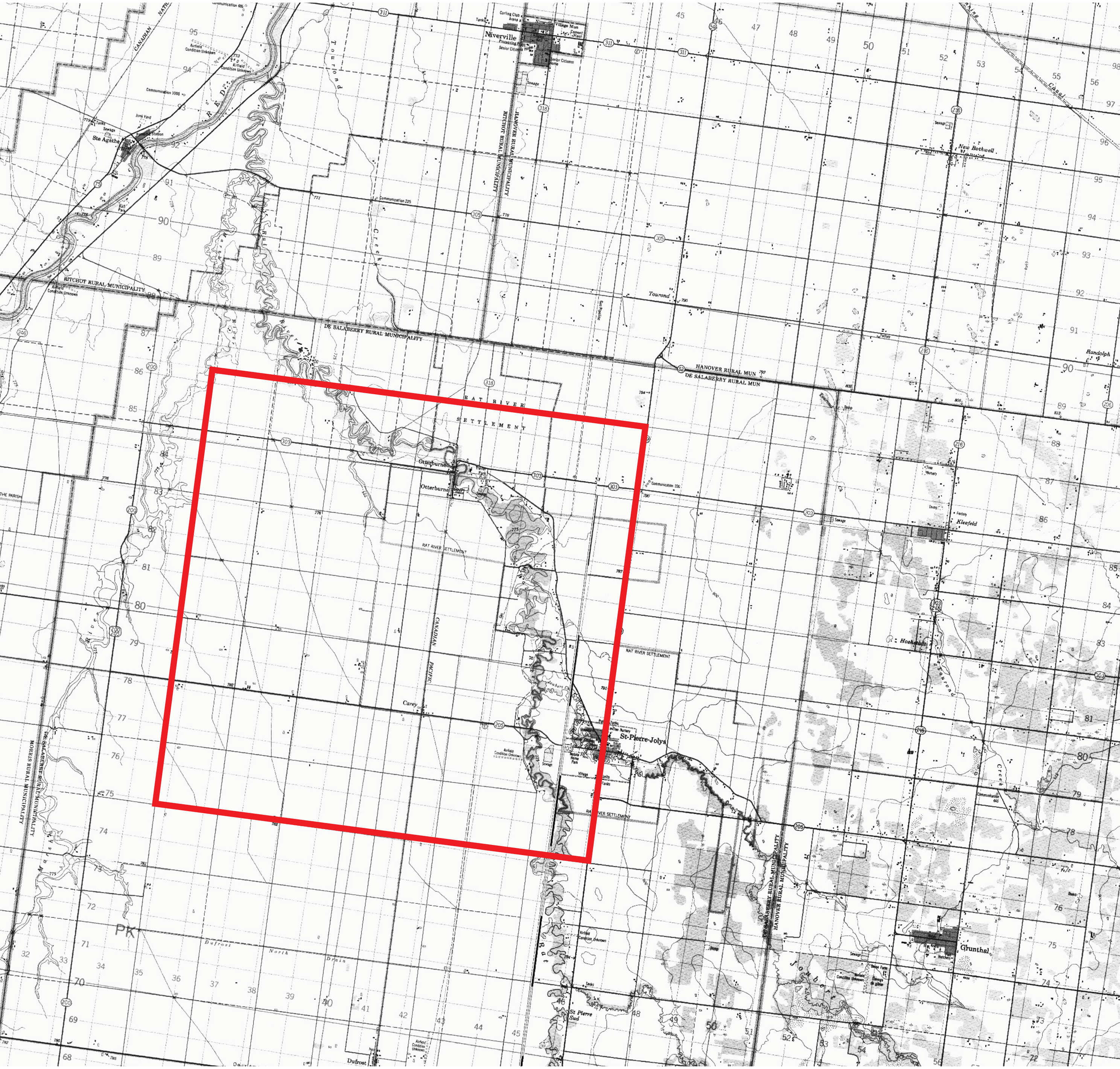
8.1 DISTILLING A SITE

Based on Model Two: "Decentralization", one of the sixteen proposed nodes will be further designed and developed.

Assuming that the runoff can be collected before it leaves the watershed, phosphorus-loaded runoff will be filtered through the proposed 50 hectares of cattails. The selected site is south of the small settlement of Otterburne, Manitoba. Approximately 300 people live in the town and an additional 500 students and staff populate Providence College, located on the north side of the Rat River.

The site was chosen based on its location within the drainage network as well as its proximity to the town of Otterburne. There is potential in the site for allowing students and residents from the town to leave the campus and go into the rural lands.

Figure 8.1. Map of Project Area. [map]. 1:100,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.


Niverville
Ste Agathe
Otterburne
St-Pierre-Jolys
Carey
New Bothwell
Kleefeld
Hochfeld
Grunthal
Randolph
Tourond
St Pierre Sud
Dufrost
RITCHOT RURAL MUNICIPALITY
DE SALABERRY RURAL MUNICIPALITY
HANOVER RURAL MUNICIPALITY
HANOVER RURAL MUN
DE SALABERRY RURAL MUN
MORRIS RURAL MUNICIPALITY
RAT RIVER SETTLEMENT
CANADIAN PACIFIC
Dufrost North Drain
Tourond Creek
Joubert
PK

8.2 SITE

Situated 3.5 kilometers outside of Otterburne, a piece of farmland approximately 35 hectares in area will serve as the site for the intervention. Two north-flowing drainage channels meet at the center of the site where they merge into one and continues north to the Rat River. The drainage channel collects runoff from the surrounding fields and deposits it into the west flowing Rat River. The site is bounded by a small farmstead to the east and a gravel road to the south. The fairly flat landscape allows for clear views out to the horizon in the south and the riparian forest of the Rat River in the north.

Soil

Located within the ancient glacial Lake Agassiz basin, the area consists of high plasticity Lake Agassiz clays that average between 10 and 35 meters in thickness underlain with 25 meters of glacial till and Jurassic shale bedrock (Southeast Water Management Association, 2001, p. 4). The clay soil is capable of retaining water, making it the ideal material for retention basins.

Vegetation

The surrounding fields consist of commercial crops and are rotated annually. The neighbouring farmstead is bordered by belts of spruce, maple, and willow while the drainage channels host a variety of grasses and reeds. The drainage channels are mown, keeping the grasses and reeds short, thus improving the efficiency of the drainage. The riparian conditions along most drains in the area is non-existent thus increasing the speed and rate of sediments and nutrients entering the water network. The absence of riparian vegetation along the drains provides a lack of cover for aquatic species, decreases food sources and increases water temperature (Seine Rat River Conservation District, 2005, p. 26). Any vertical elements such as trees or landforms will be clearly apparent against the long horizon of this open area.

Water

The site and the land adjacent slope to the north with a very little difference in elevation. The drainage channels that run through the site are approximately 1.50 meters deep and collects runoff from the catchment area moving it towards the Rat River. During spring thaw and during rain events, excess fertilizers, pesticides and herbicides move off the land and into the waterways.

Wildlife Habitats

Within the Rat River fish species such as brook stickleback, central mudminnow, johnny darter, blackside darter, fathead minnow and northern pike can be found (Seine Rat River Conservation District, 2005, p. 17). Barriers such as dams and culverts in the drainage system create obstacles for fish moving towards the river leaving them stranded and left to die. Measures to improve fish movement could include structures such as fish ladders allowing them to access habitats upstream.

Animals such as white-tailed deer, foxes, white-tailed jackrabbits, raccoons, skunks, mice and voles frequent the area.

Figure 8.2. (opposite) Site and surroundings. [aerial map]. Scale Undefined. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.


318
RAT RI
SETTLEM
Otterburne
Trailer Park
Otterburne
Sewage
776
RAT RIVER SETTLEMENT
CANADIAN
Gas
0
500
1000 m

Figure 8.4. Site looking East

Land Use

The site and the neighbouring farmstead are privately owned agricultural land within the Municipality of De Salaberry. The commercial crops in the area are grown for food production and synthetic fertilizers are applied to the land. The drainage channels running through the site are maintained and cared for by the municipality as well as the roadside drainage of the mile by mile roads.

Figure 8.3. (opposite) Site and surroundings, based on aerial photo from Google Inc. (2013). Google Earth (Version 7.0.3.8542) © 2013 TerraMetrics [Software]. Available from http://www.google.com/earth/index.html

9. DESIGN

9.1 DESIGN INTENTIONS

The reading of environmental issues, geomorphology, historical contexts, and socioeconomic conditions of the region generated a base of knowledge to explore conceptual approaches. A method was developed with the intention to create a filtration/retention landscape in the agricultural lands just outside the settlement of Otterburne. The design approach considers ecological, economic and aesthetic aspects while the focus of treating water remains central to the project. The concept is principally structured around three main ecological parameters with the addition of a multi-seasonal program. The parameters and program create the framework within which the design process takes place.

Water Retention and Purification

As one of the main objectives, the project must treat and hold runoff from the agricultural lands as well as create possibilities for water storage during dry periods. The site must respond to existing topography, soil conditions and water movement while devising ways of filtering runoff through the use of vegetation.

Mass Balance

Through a mass balance approach, excavated soil will stay on site effectively forcing the design to deal with the consequences of its conception. This not only reduces the expenditure of energy in materials and construction methods but also minimizes the cost of the project.

Biodiversity

A further, crucial objective is to increase plant and animal species contributing to the local biodiversity of the agricultural lands. Filtering sediments and nutrients reduces erosion while improving habitats for aquatic species. Creating destinations for wildlife in the agricultural landscape will provide food, shelter, and a patchwork to travel between river corridors.

Additional Program

As an additional aspect, the design will incorporate an attractive place for multi-seasonal recreation for the neighbouring settlement of Otterburne, the students of Providence College, and adventurous tourists. This destination would provide people in search of recreation and relaxation the opportunity to escape from the confines of the city, as a retreat into the countryside. Increasing accessibility and attractiveness of the drainage system could further highlight this infrastructure as an element of cultural significance and relevance.

Figure 9.1. View looking north towards the design. [physical model, butter-board and bass wood].

9.2 STEPS OF INTERVENTION

The design is envisioned as a precise intervention where water is retained/filtered and a sauna program is incorporated to build further on the environmental value of the project. The design seeks to join the ecological parameters, the sauna program and the existing elements of the site to determine its structure and layout.

Blocking Water

Working with existing landscape features the design carefully reads the existing topography, water movement and soil conditions of the site. By blocking off agricultural runoff from an existing drainage channel, a branch-like reservoir of water is produced. Within the reservoir cattails will be grown in the area outlined by the contour line of +236.50 meters, which is the maximum height of the blockage (See Figure 9.3). The water levels within the outlined area will fluctuate 1.50 meters depending on evaporation rates and rainfall events. During heavy rainfall, water levels will rise, forcing water to spill over the blockage and into the preexisting drainage channel, continuing on its journey northwards to the Rat River. Farmers will continue to cultivate their fields following the contour line containing the cattails.

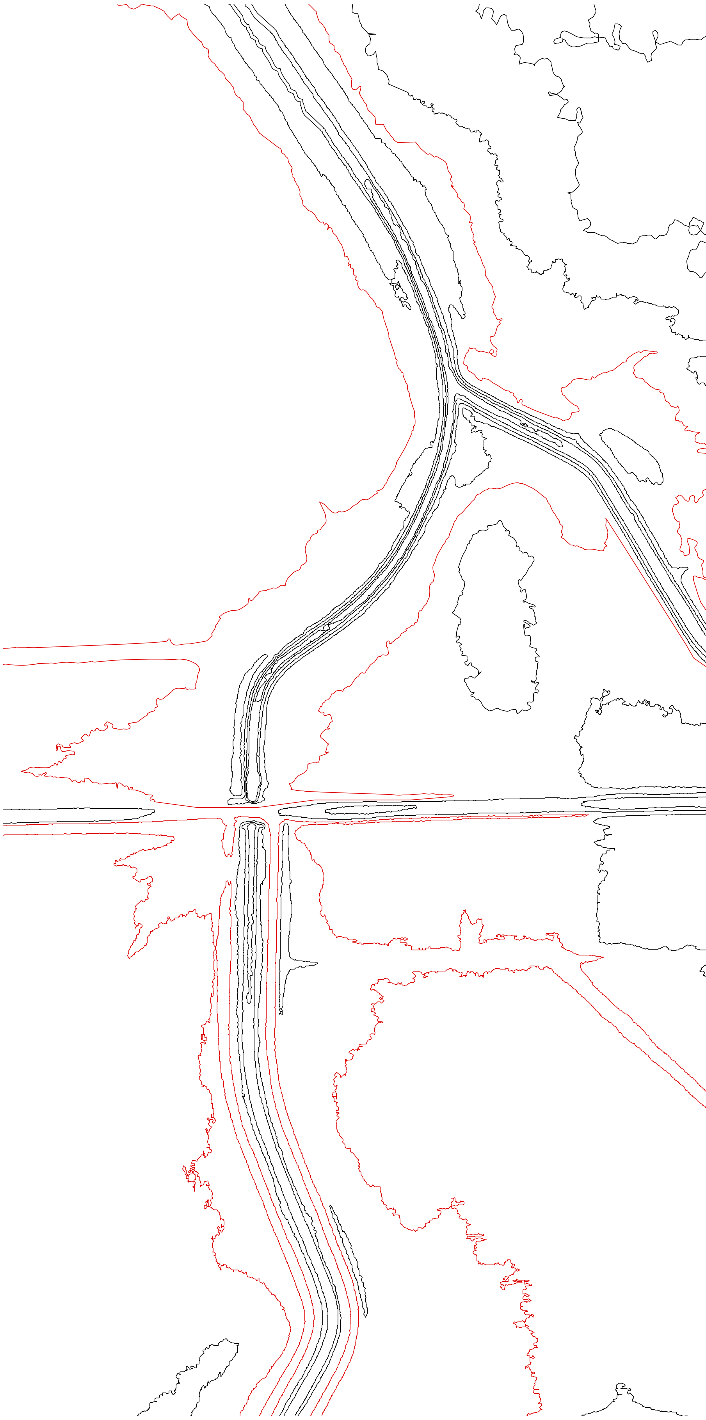
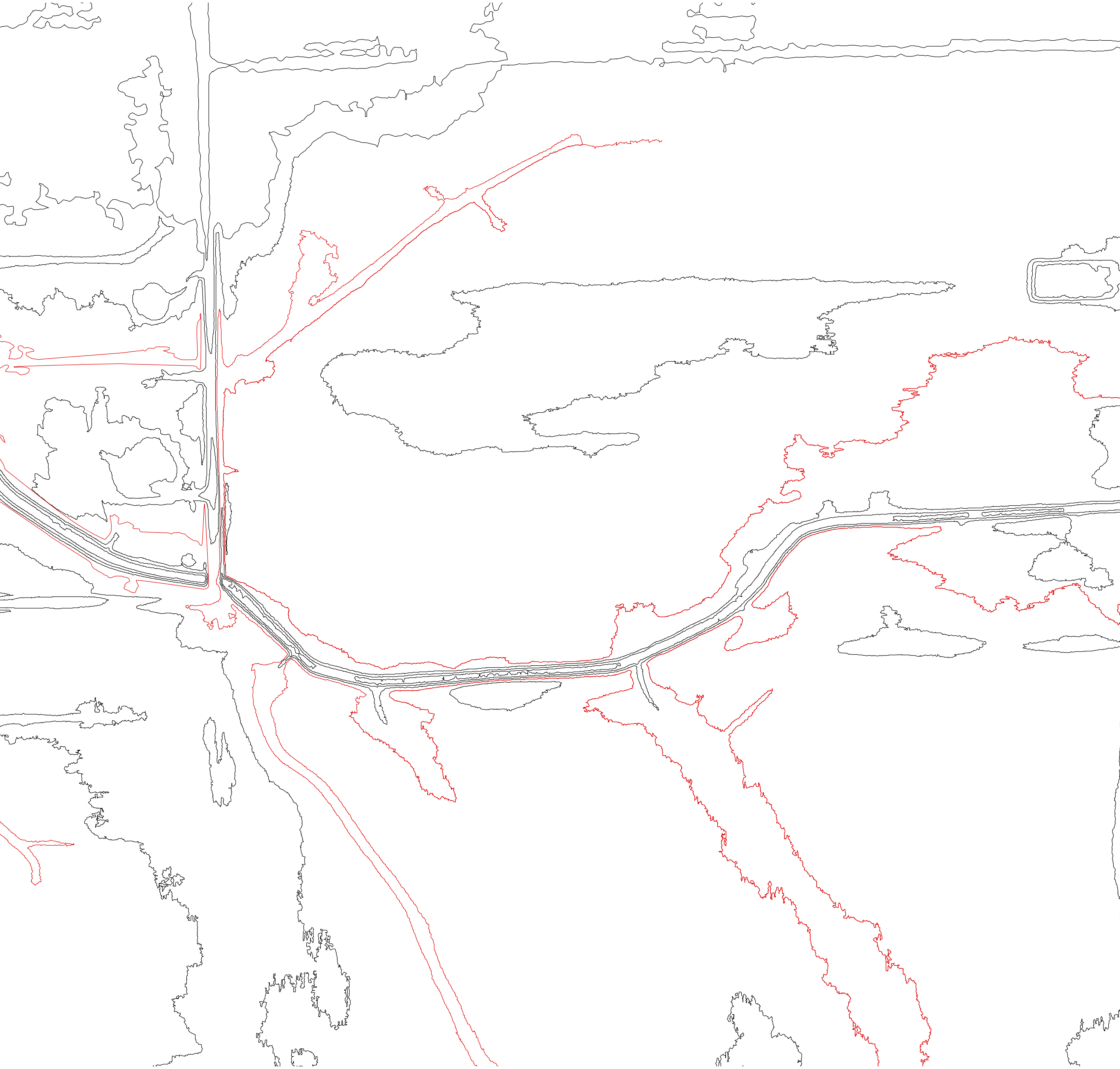
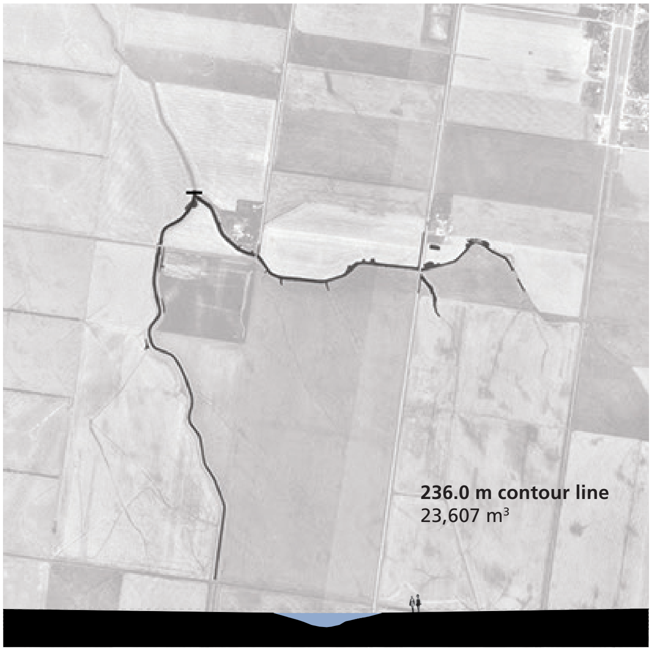


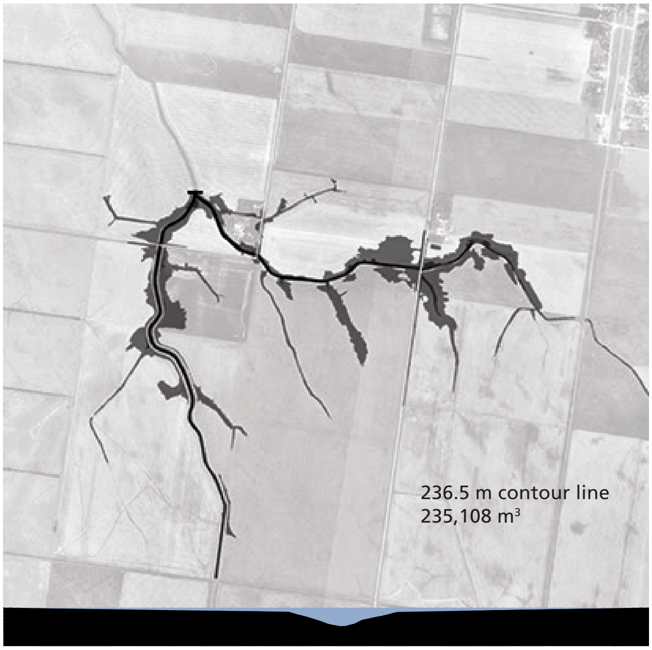
Figure 9.2. 236.50 meter contour line. [contour map]. 1:5,000. Using Adobe Illustrator [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.



The fundamental objective of this project is to retain agricultural runoff in the reservoir for as long as possible so that it can be treated, evaporated, or seep into the ground. Technically, the water is contained by constructing a 1.50 meter high concrete wall that functions as check dam in the existing drainage channel. The existing clay soil and topography provide the conditions to retain the water on site.

Figure 9.3. Four possible levels of flooding. [collaged plans and sections]. Scale Undefined. Using Adobe Photoshop [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.


236.0 m contour line
23,607 m^3


236.5 m contour line
235,108 m^3

Creating a Water Body

The runoff from the catchment area slowly moves into the reservoir and is purified by the cattails. Eventually the water will move north into a body of water, the lowest spot in the reservoir, at the center of the site. The pool of water is formed by excavating an area of approximately 3,400 m^2 to the depth of 2 meters, providing a constant body of filtered water and preventing the growth of cattails. The pool is intended to provide a clear and clean swimming space. The earthworks will be sculpted from the excavated clay soil of the Pool. The landforms will be covered with limestone, forming white masses of distinctive counterpoints in the landscape.

Establishing a Cattail Field

Though the reduction of farmland would result in the lost of crop yields it could be offset with the economic and environmental benefits of growing cattails. If the area is continually too wet it could be returned to a wetland state by establishing a field of cattails in the area. The clay soil and water will provide the adequate conditions for cattails to thrive. Cattails will fill the moistened soil of the blocked drainage channels, increasing the plants' coverage in the rural area that is typically marginalized to the ditches of the mile by mile roads by intensive farming. The field will be seeded through the use of bare rootstalk and seedlings. They will germinate readily and are cost effective means to grow cattails on moist soils. Seeds will be raked and rolled on a moist bed of soil.

Establishing wetland vegetation such as cattails would dissipate energy from the drainage channel and reduce soil erosion in this area. During high water, fish migrating upstream may utilize the cattail field and exit through the fish ladder. The field will provide habitats not only for fish species but as well as for many small invertebrates that then provide food for fish, birds and other wildlife.

Planting a Grove and a Promenade

The choice of tree species for the grove reflects a relationship to the past by alluding to the spatial motif of Epinctiéres - tamarack islands - that were distributed in the area prior to 1870. One body of tamaracks will be planted in a grove formation on the south side of the site creating a unique atmosphere forming a distinguishing element of the design. Approximately 1,200 tamarack seedlings will be planted in a 2.4 m by 2.4 m grid over an area of 7,000 square meters, and will be intentionally culled during the growing phase to create small clearings. More mature tamaracks will be planted around the perimeter of the grid allowing for wind protection while still providing full sun for the younger seedlings in the center. To the west, a 170-meter long allée of tamaracks will form a spatial border to the project.

Younger seedlings are 60 centimeters in height and cost about 2 dollars making the total price for seedlings approximately $2,400 for the project. In optimal growing conditions tamaracks will reach the height of 15 meters in 25 years.

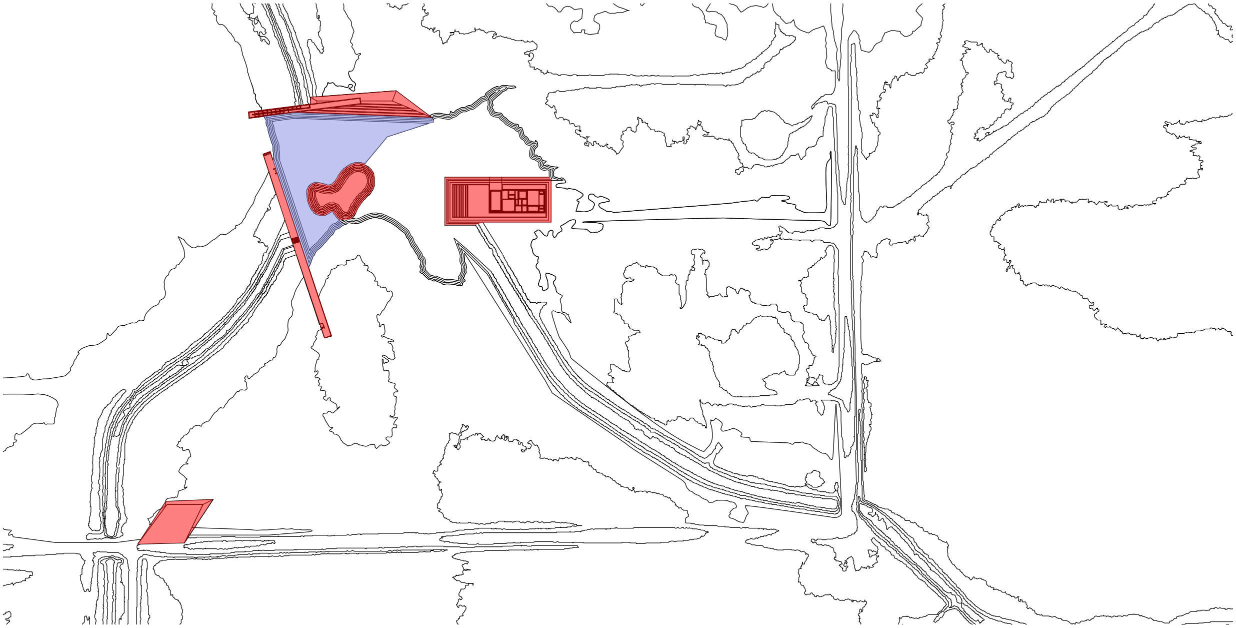


Figure 9.4. Earthworks and water body. [contour map]. 1:5,000. Using Adobe Illustrator [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.

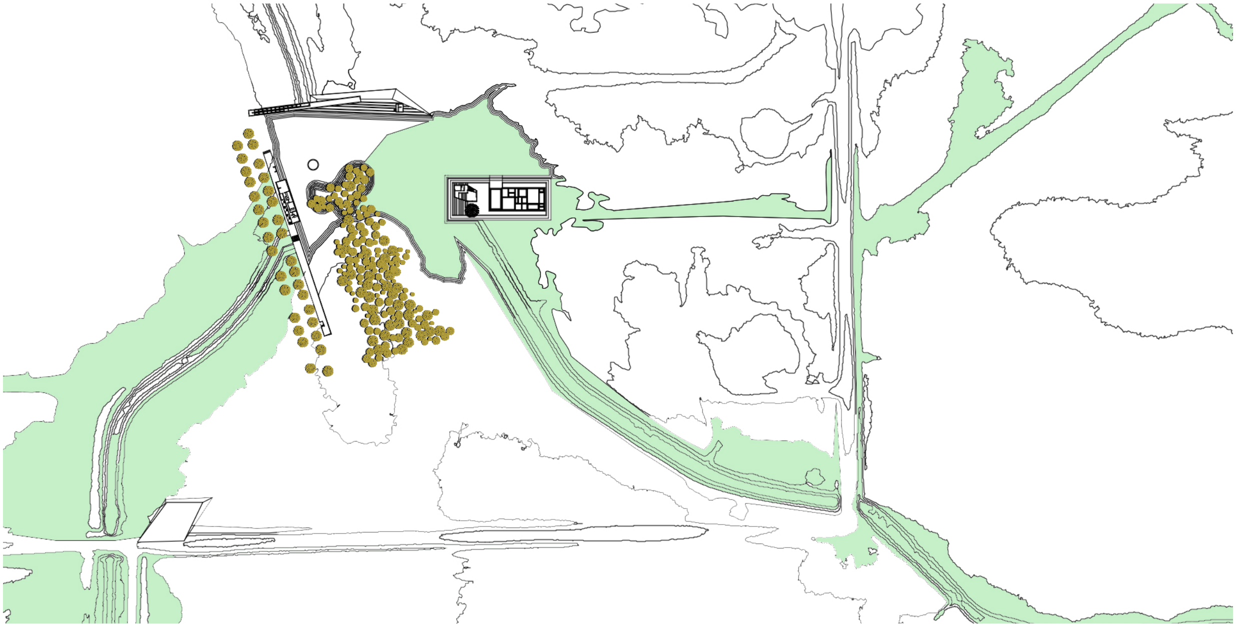
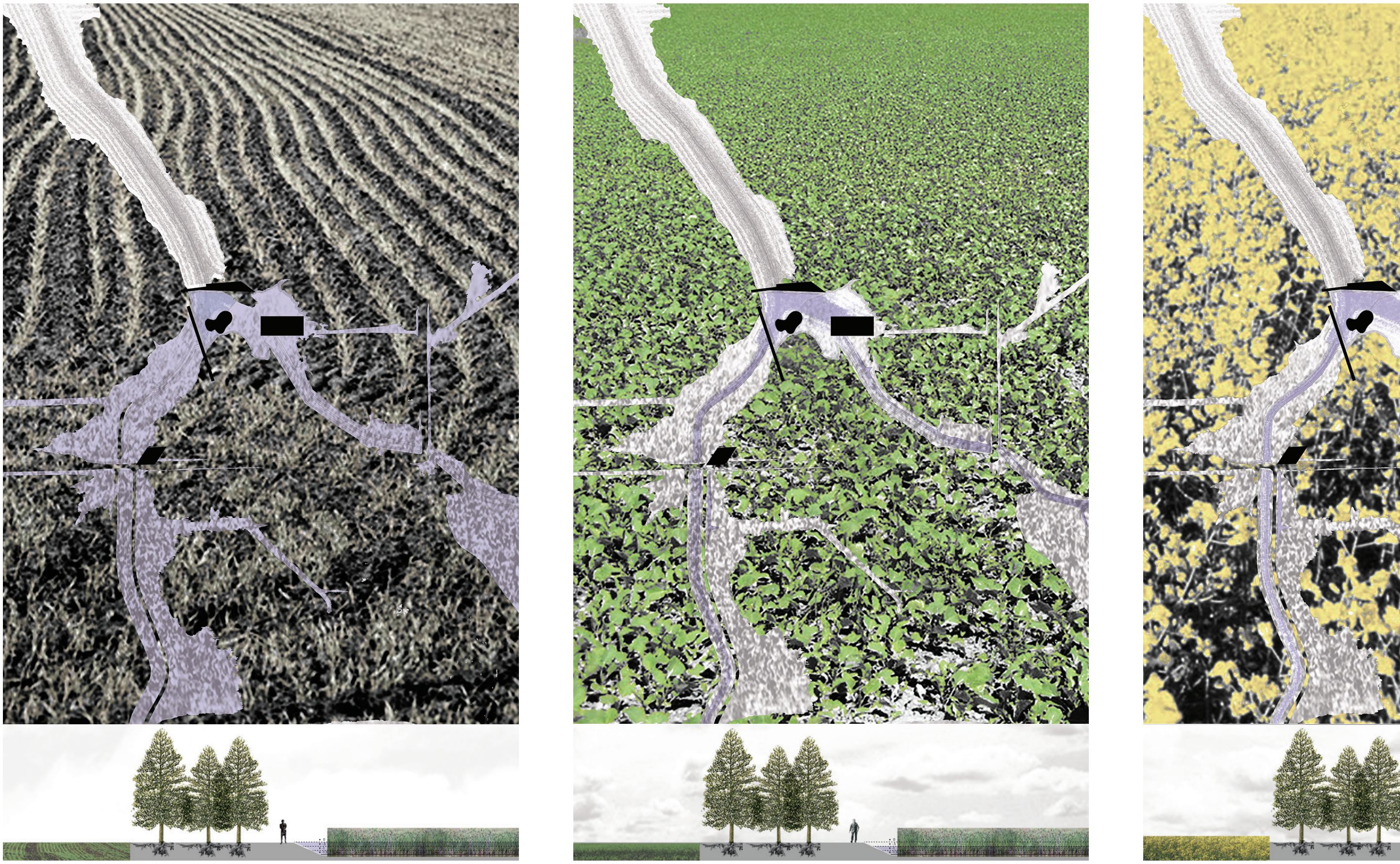
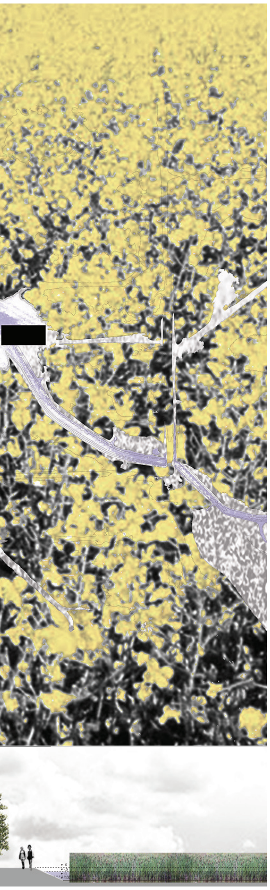


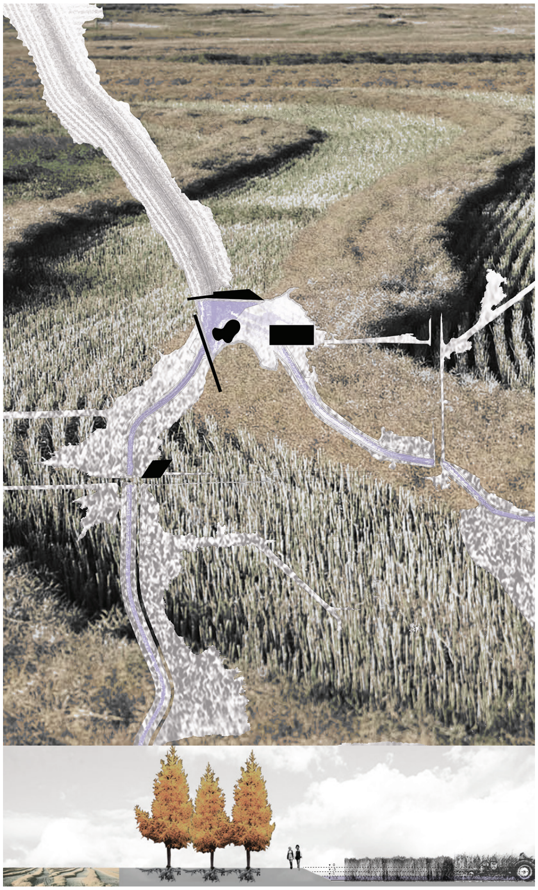
Figure 9.5. Cattails and tamaracks. [computer map]. 1:5,000. Using Adobe Illustrator [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.



Throughout the seasons, the project and its surroundings will undergo various transformations, allowing visitors to experience the temperament of the prairies and the seasonal rhythms of the farmland, tamaracks, cattails and biomass production. The tamaracks will explode into a brilliant gold contrasting nicely with the somber greys of autumn.

Figure 9.6. Plants and seasons. [collaged plans and sections]. Scale Undefined. Using Adobe Photoshop [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.





Adding a Sauna Program

Three different sized sauna facilities are distributed onto the earthworks to accommodate various groups of users. A sauna program was chosen for the site due to it being an appealing program that suits the climate of southern Manitoba. Seen as a multi-seasonal activity a sauna could serve as a destination for small groups, couples or individuals. The history of saunas goes back thousands of years and originated from the innate need for people to bathe and cleanse themselves. In the past, farmers in Finland used to have very few amenities and the sauna was seen as a small paradise after a hard day's work.

> A farmer coming off his field in the early evening would slip into the same hut he used for drying malts and smoking meats. The glowing heat of the savusauna would relax his muscles and soothe his soul. He left rejuvenated, hungry for a large meal and maybe a dance at a neighboring farm (Aaland, 1997).

Located just outside the town of Otterburne, students and residents can travel by bicycle, horseback, snowmobile, cross country skis, car or even walk to the saunas. The facilities will be managed and serviced similar to that of forest cabins in Norway or trekking huts in New Zealand's National Parks. An honour system where donations can be made will offset the costs of maintenance such as trimming around the earthworks that will need to be done 2 or 3 times a year. Visitors will be required to bring their own supplies and clean up after themselves. The neighbouring farmer will maintain and care for the facilities and will supply firewood for sale to be used for the sauna. Guests use the firewood to heat stones in a small fireplace within each sauna room. Once the sauna reaches the desired temperature, the door is opened to release the excess smoke before the guests enter the room.

Harvesting Cattails

Farmers are responsible for cultivating up to the edge of the cattail field maintaining the outline of the reservoir. The cattail field will be staked out along the 236.5 meter contour line as reference points. Farmers will harvest the cattails in late summer when nutrient levels in above ground plants are the highest (Grosshans, Venema, Cicek & Goldsborough, 2011, p. 1125). Cattail swathes will be cut and left to dry to the appropriate moisture level and then bailed. The bales are then transported to a processing plant where they are converted into pellets and used for energy production.

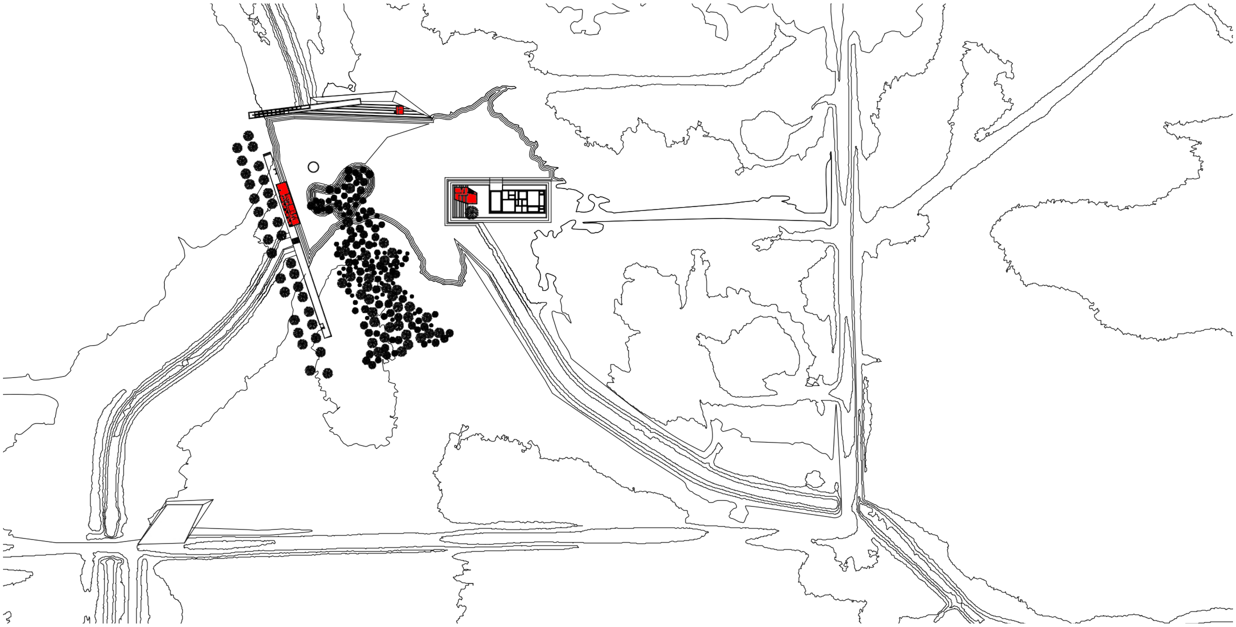


Figure 9.7. Sauna facilities. [computer map]. 1:5,000. Using Adobe Illustrator [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.

As an intermediate presentation for the practicum, the research relating to the project area was displayed in a series of mappings of selected periods in time. From 13,000 thousand years ago to present day land use, the maps attempt to combine spatially referenced information with collaged images of various environmental aspects related to the area. The information was grouped chronologically from left to right: Geomorphology, Pre-1870, Present-day Land Use and Travel Distances. As components for design concepts, the timeline and the existing situations, elements and structures of the project area assisted in developing ideas of a sauna culture within the project area. The final image on the right is a collage of a sauna surrounded by cattails and cropland. Playing with two contrasting images of industrial farming and bathing provokes feelings of oddness and is a point of departure for dialogue and conceptual thoughts.

Figure 9.8. Intermediate presentation board. [collaged maps and photographs]. Using Adobe Photoshop [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.


2050
buildings + islands
transport
tree-scapes
drainage
agriculture
topography
soil
EXISTING STRUCTURE
2050

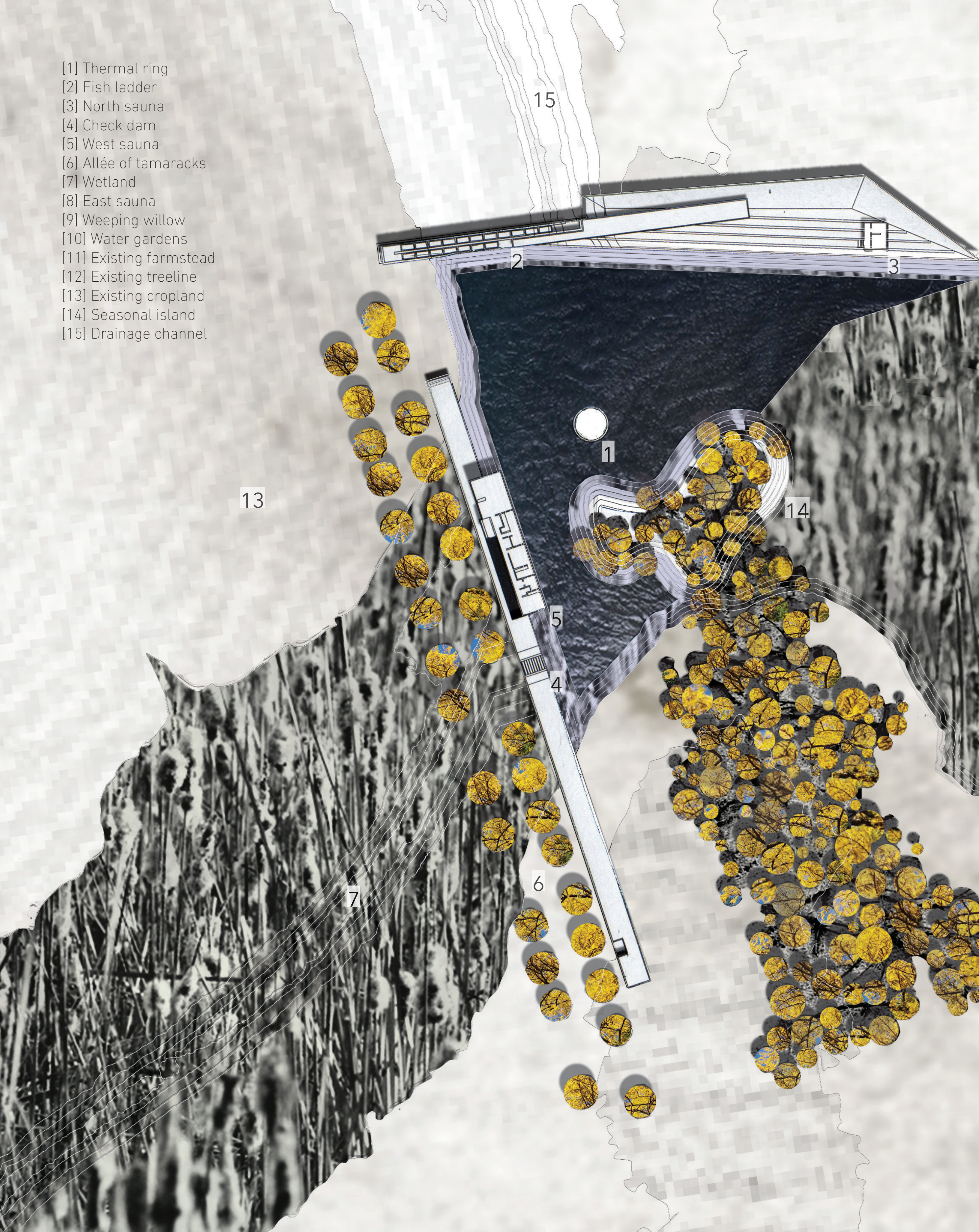
9.3 FIVE BODIES

Five clearly defined bodies with varied forms and purposes exist within a concentrated area of approximately 9 hectares and are arranged along the +236.50 meter contour: the Pool, the Dike, the Promenade, the Peninsula and the Grove. The intention is to create a pleasure ground of freely composed bodies of varying sizes and geometries in contrast to the orthogonal boundaries of the agricultural land. The composition of the bodies works on the confrontation of the various spaces but when combined form a balanced whole. Locally available materials are used, including limestone, concrete and wood, which are familiar and durable materials of the area.

The Dike and the Promenade to the northwest hold back water to form a central body of open water. To the south, a ramped parking lot mediates between the main site and bordering road, while the Peninsula to the east extends the existing tree line and provides access for visitors and residents into the site. The Grove of tamaracks encloses the site to the south, separating the Pool from the road.

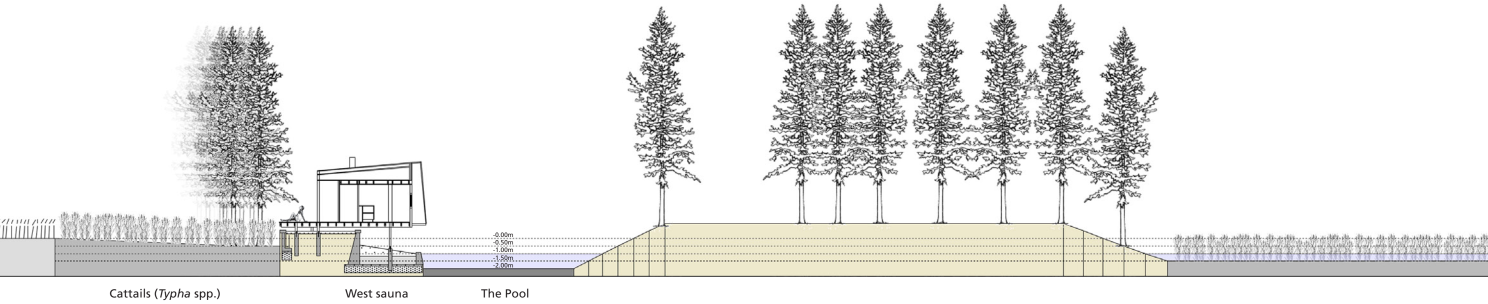
Figure 9.9. Plan of the design. [rendered plan]. 1:2,500. Using Adobe Photoshop [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.


[1] The Pool
[2] The Dike
[3] The Promenade
[4] The Peninsula
[5] The Grove
1
2
3
4
5

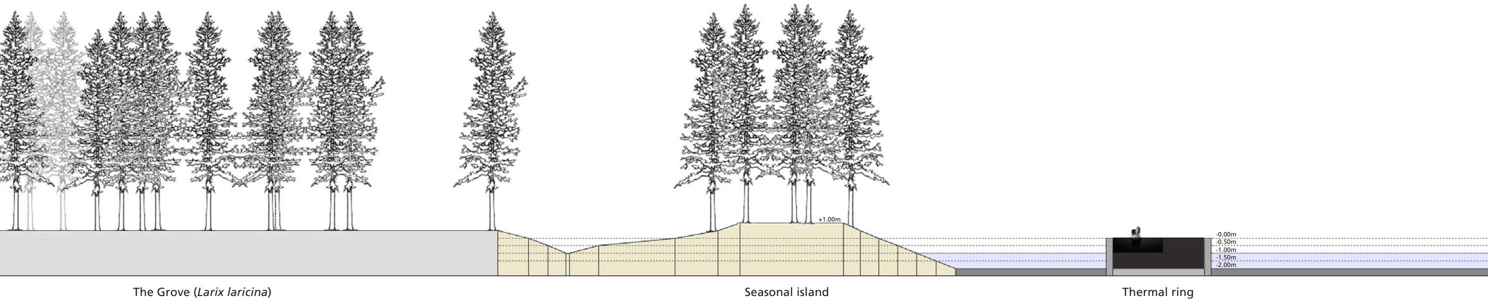


[1] Thermal ring
[2] Fish ladder
[3] North sauna
[4] Check dam
[5] West sauna
[6] Allée of tamaracks
[7] Wetland
[8] East sauna
[9] Weeping willow
[10] Water gardens
[11] Existing farmstead
[12] Existing treeline
[13] Existing cropland
[14] Seasonal island
[15] Drainage channel

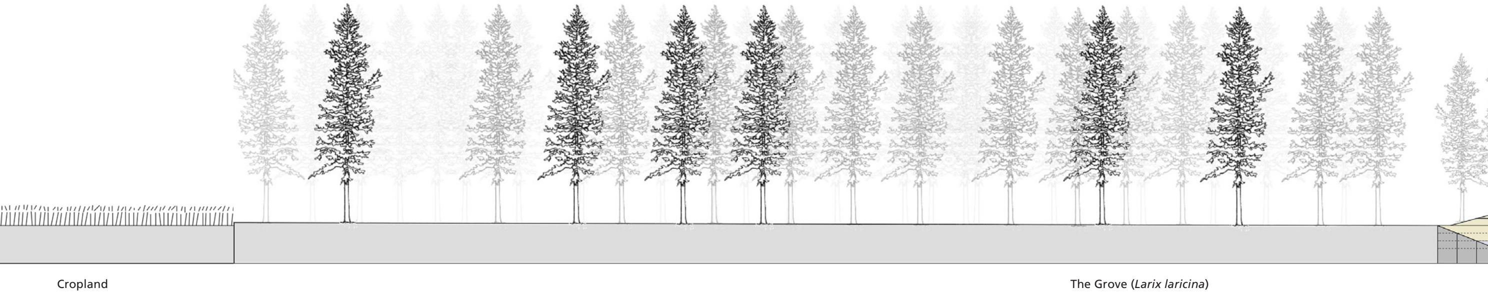
Figure 9.10. Plan of design. 1:1 000.



Section A-A

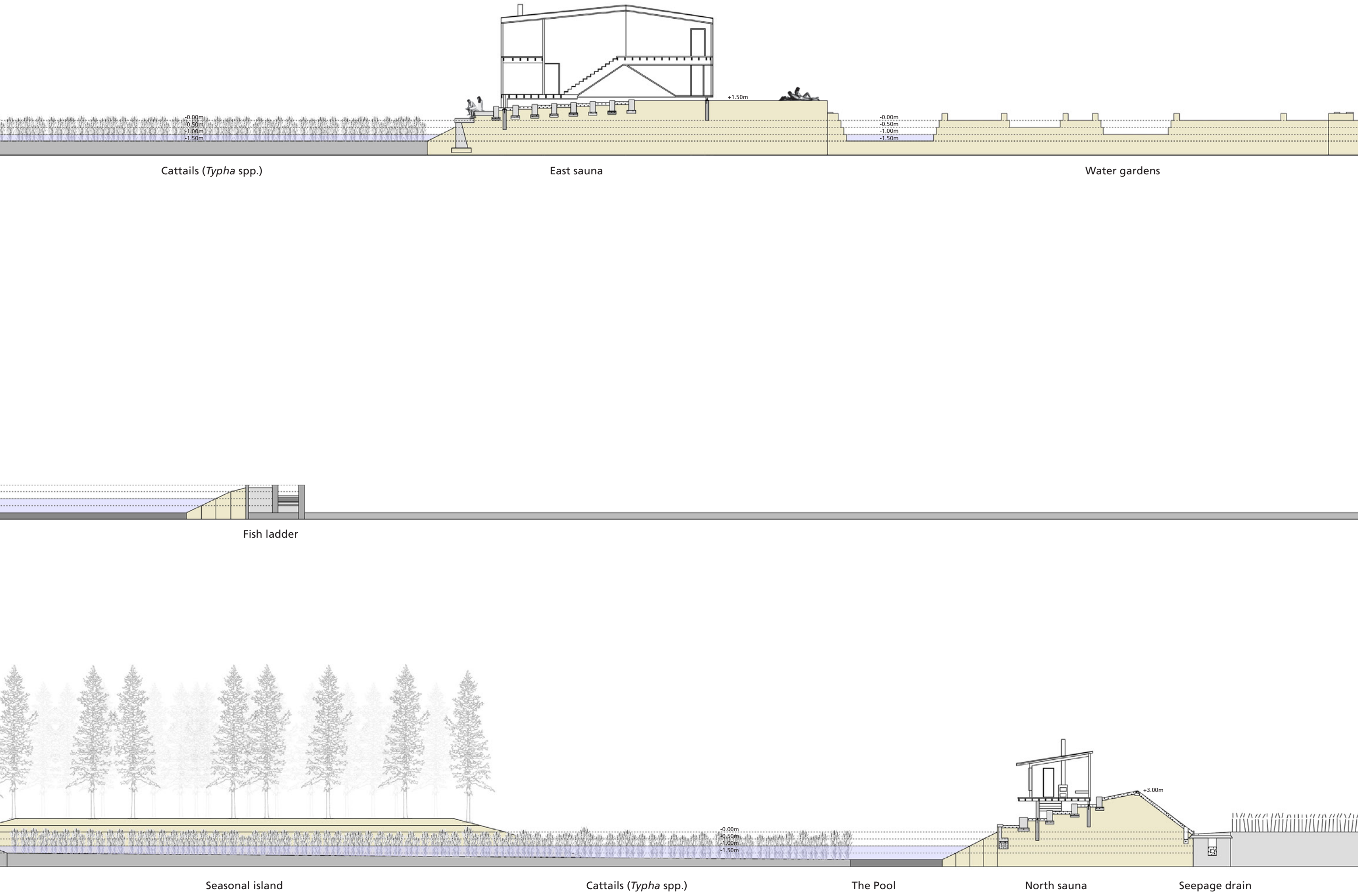


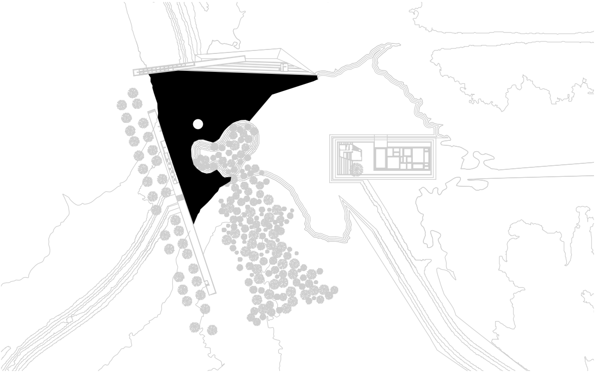
Section B-B



Section C-C

Figure 9.11. Sections of design. [sections]. 1:500. Using Adobe Illustrator [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.





The Pool

Located at the heart of the design, the Pool serves as a retention basin for the north flowing drainage channel. The body of water is carved out from the clay soil and has a uniform depth of 2 meters, preventing the growth of cattails. The area is bound by a limestone shoreline providing a gravelly beach for users of the site. This passive and placid sheet of water, flanked by the Dike, the Promenade and the Grove, provides a centerpiece for the design.

A thermal ring floats slightly off the center of the Pool, allows access to open water during winter months when the water freezes over. The excess heat from the west sauna is pumped through a pipe to the ring. The heat in the ring will maintain a thin layer of ice that can be broken during the winter months.

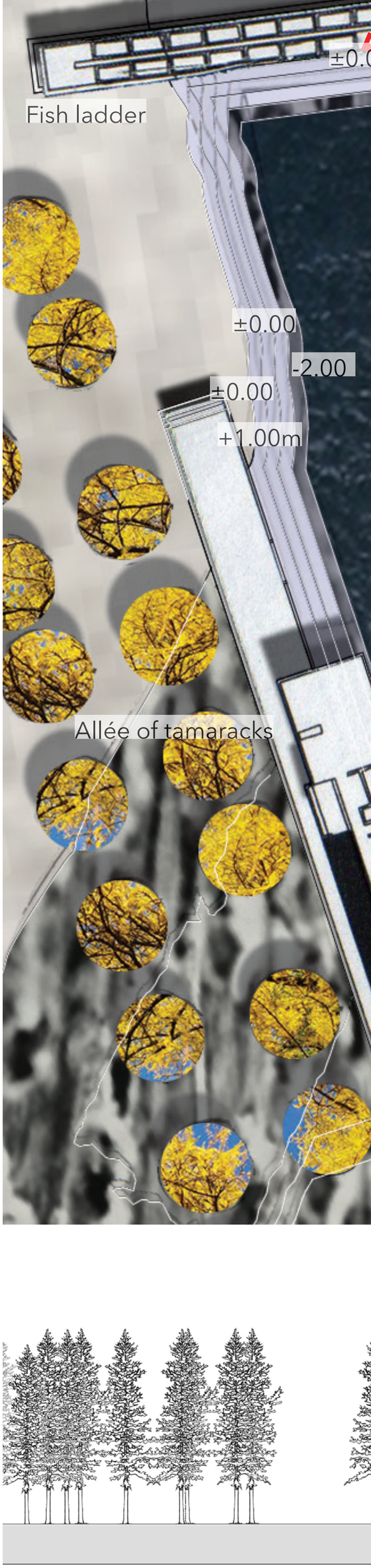


Figure 9.13. Section of the Pool. 1:500.

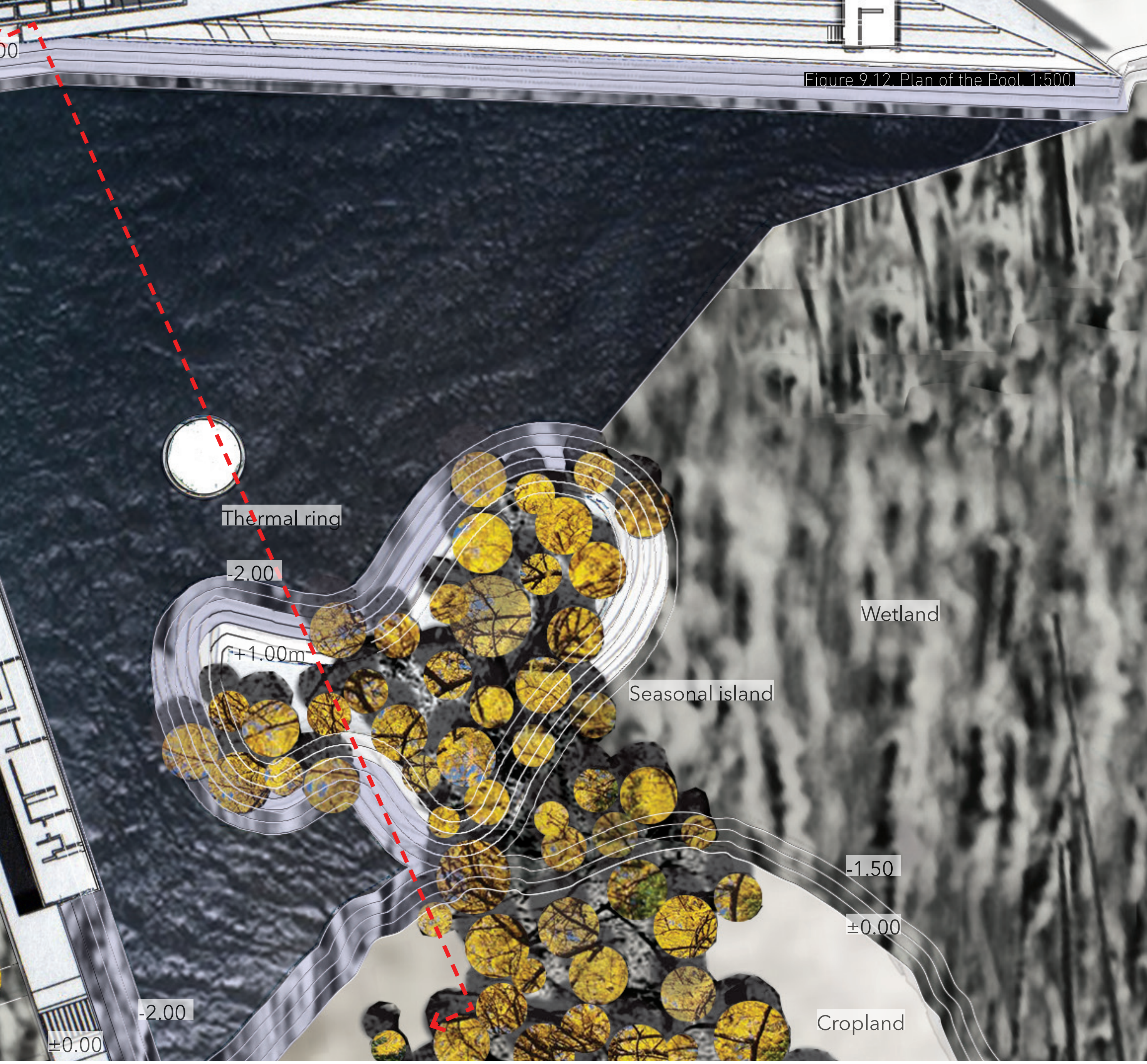
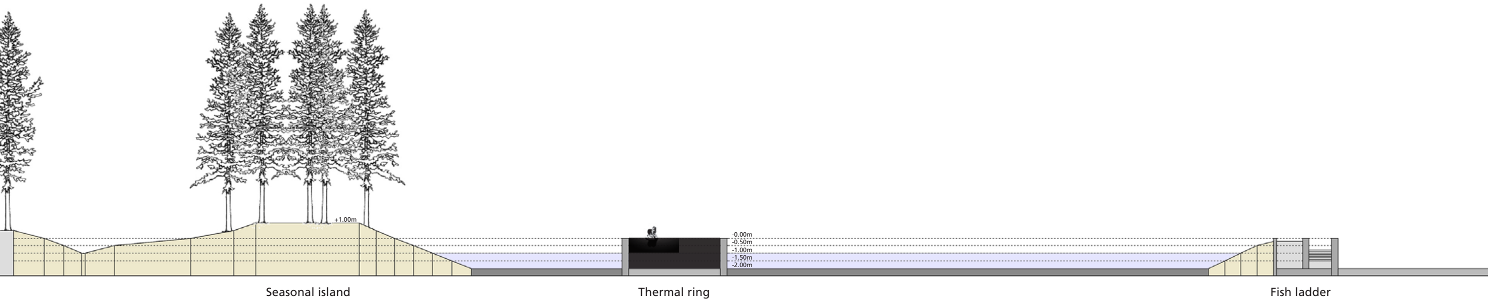
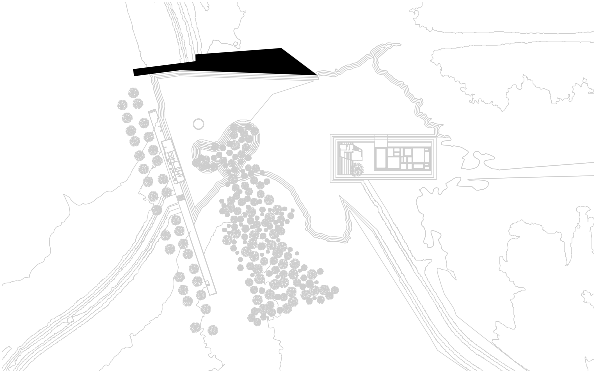


Figure 9.12. Plan of the Pool. 1:500





The Dike

The main blockage is the concrete fish ladder implanted into the side of a large pyramid shaped earthwork. The ladder moves excess water and fish step by step down towards the original drainage channel exiting north of the site.

The highest elevation in the design is marked by the 3-meter peak of the Dike. The north side of the limestone-covered form slopes down to the surrounding farmland, creating a wall of white when seen from afar. A wide flight of large steps are cut out of the south facing slope of the Dike providing a space for sun bathing and viewing the Pool. An isolated sauna sits to the far east side of the steps overlooking the Pool and the field of cattails. The steps allow sauna users to access the Pool to cool off after a hot sauna. The Dike as a whole attempts, to combine the more pragmatic aspect of blocking water with the social space of the steps and sauna.

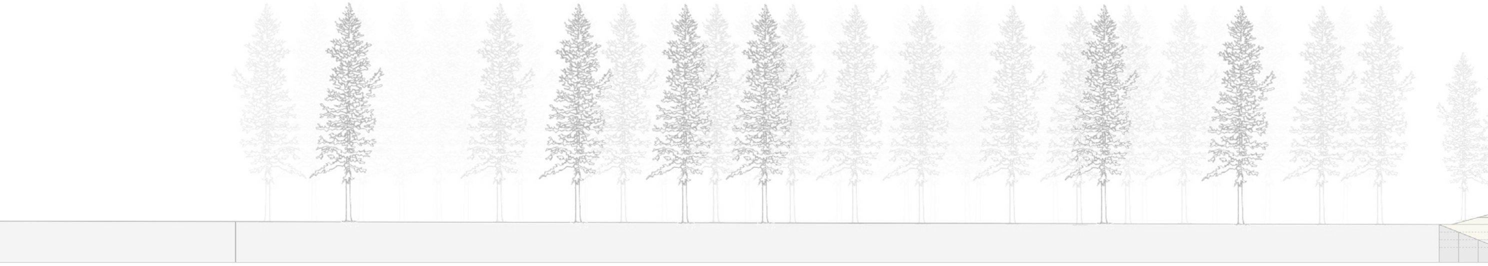


Figure 9.15. Section of the Dike. 1:500.

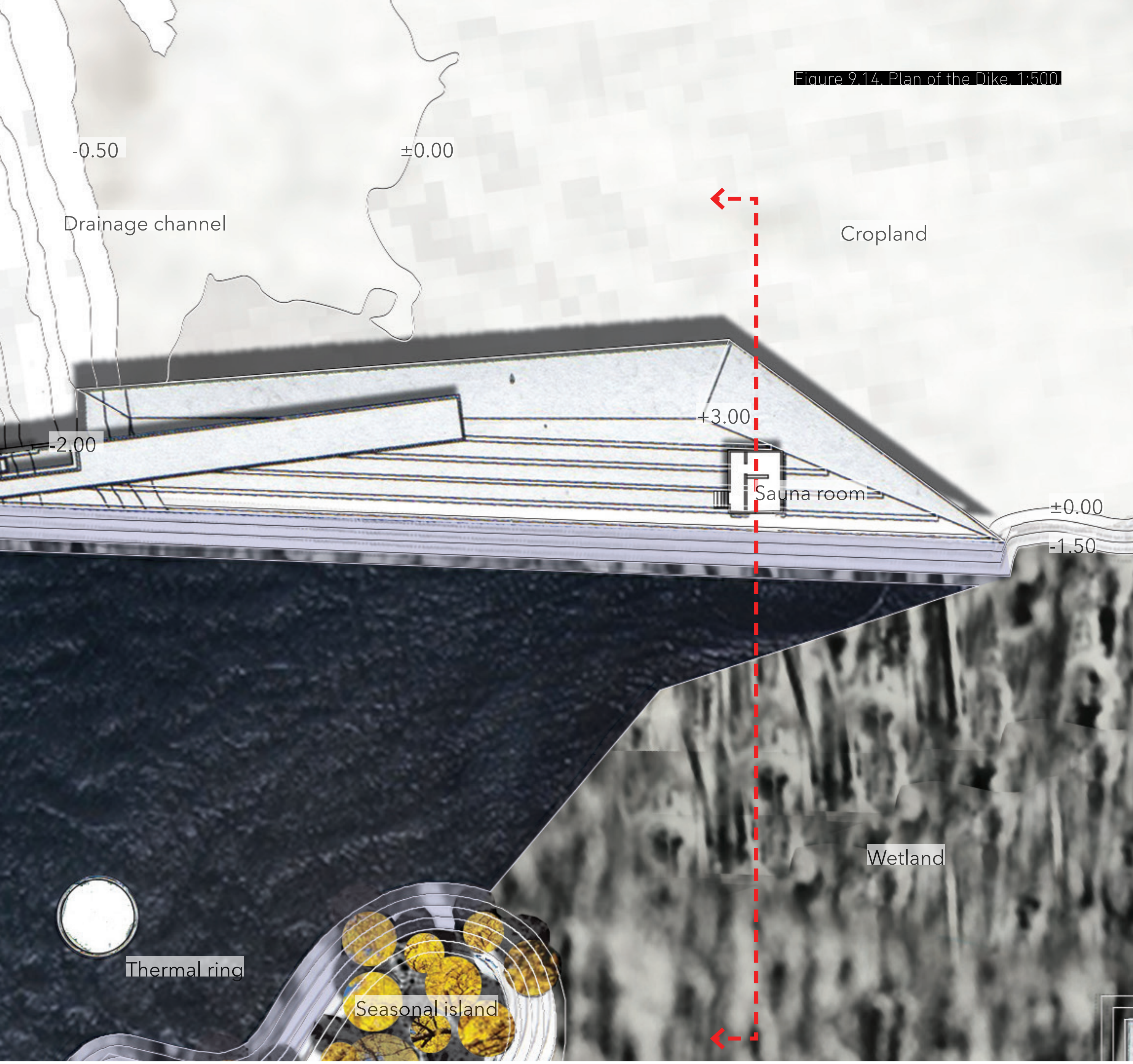
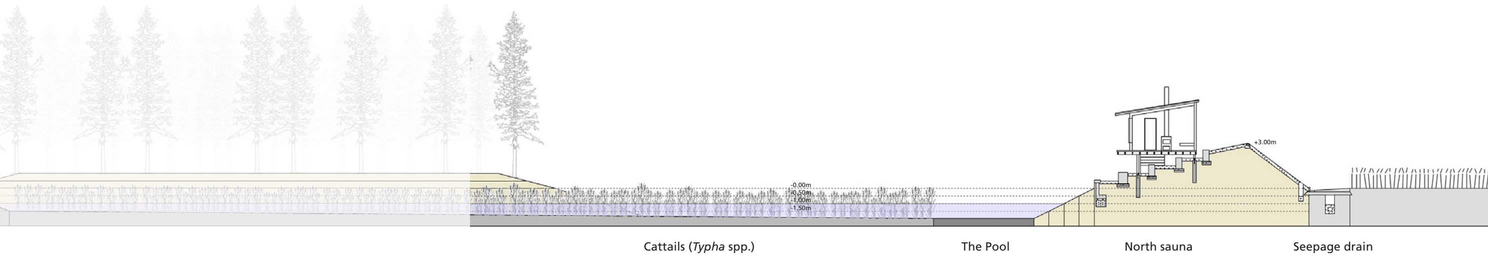
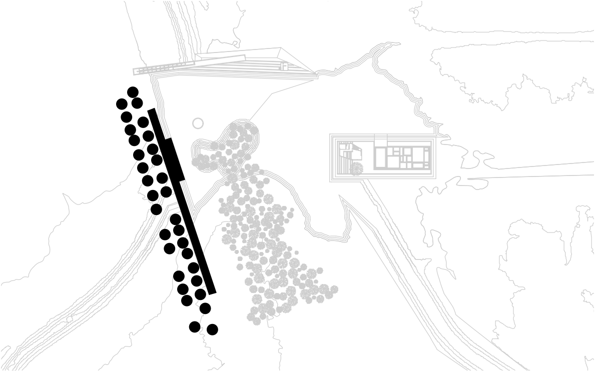


Figure 9.14. Plan of the Dike. 1:500





The Promenade

Access to the project is via a simple sloped parking lot where visitors leave their vehicles to prepare for the expedition. There are no pathways, as one must navigate on the meandering topography line that creates the border between the cattails and cropland. As visitors approach the Promenade they will discover a small set of steps embedded into the side of a low concrete wall that frames the form of the Promenade. As they walk up the steps their gaze is directed out into the open landscape, then down the 130 meter long path of the limestone covered catwalk. The overstated form encourages strolling as visitors traverse the drainage channel to the north side of the site. The 1-meter high concrete frame is backfilled with soil and covered with crushed limestone, separating the Promenade from the fields and cattails. During heavy rain events, the Pool is oxygenated by water from the west drainage channel as it runs over the concrete dam situated in the center of the Promenade and falls into the body of water. The Promenade terminates in the north with a small set of steps leading down into the field on the left and the gravelly beach on the right. The Promenade is bounded on its western side by an allée of tamaracks. The allée emphasizes the orientation of the Promenade and functions as a screen that protects the site from the adjacent field.

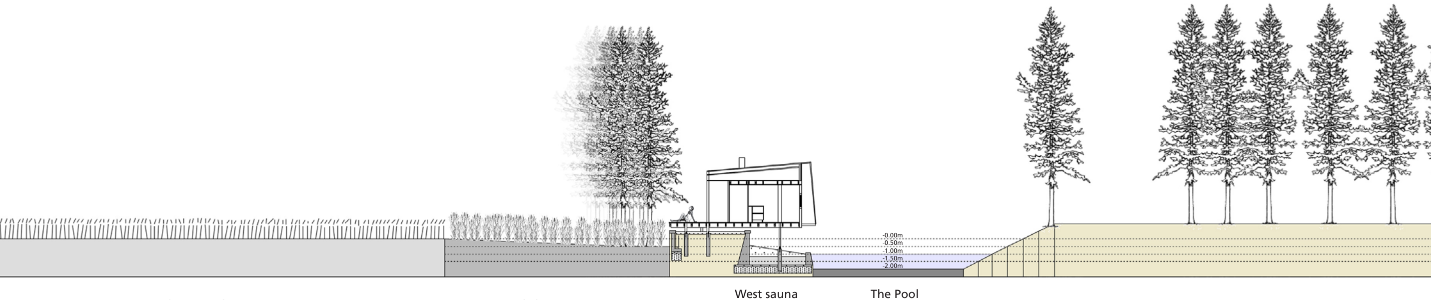


Figure 9.17. Section of the Promenade. 1:500.

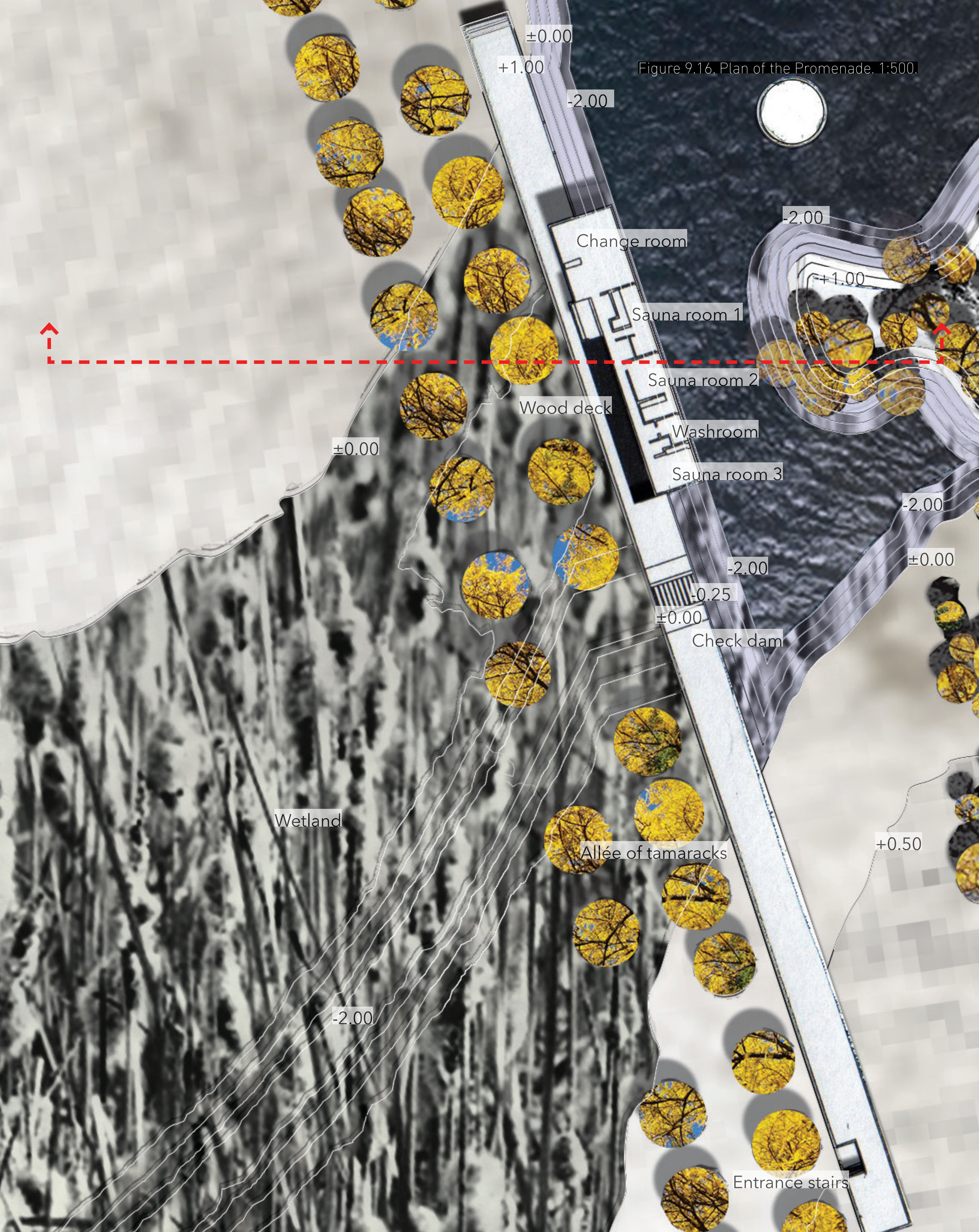


Figure 9.16. Plan of the Promenade. 1:500.

The Peninsula

The landform is laid out like a big rock basking in the sun amongst the cattails. Its form corresponds to that of the existing tree line acting as an extension and allowing access for the neighbouring farmstead. In the east sauna visitors are offered a guest room, bathroom, kitchenette and one sauna room for overnight stays. A dominant weeping willow diffuses the sun on the sauna and marks the end of the Peninsula. Precisely cut steps surrounding the body create a seating area for visitors to scan out across the tops of the cattails. To the east of the sauna are rectangular water gardens situated at different elevations. When water levels rise within the reservoir, water will spill over the side of the Peninsula, filling the series of pools.

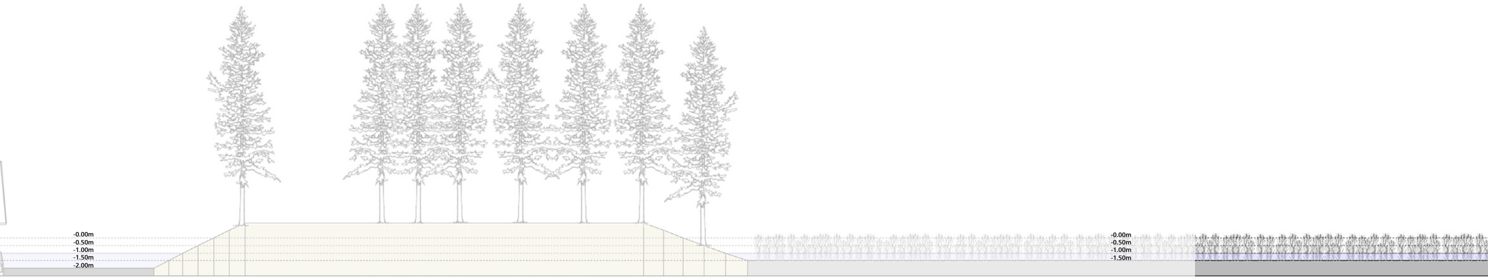


Figure 9.19. Section of the Peninsula. 1:500.

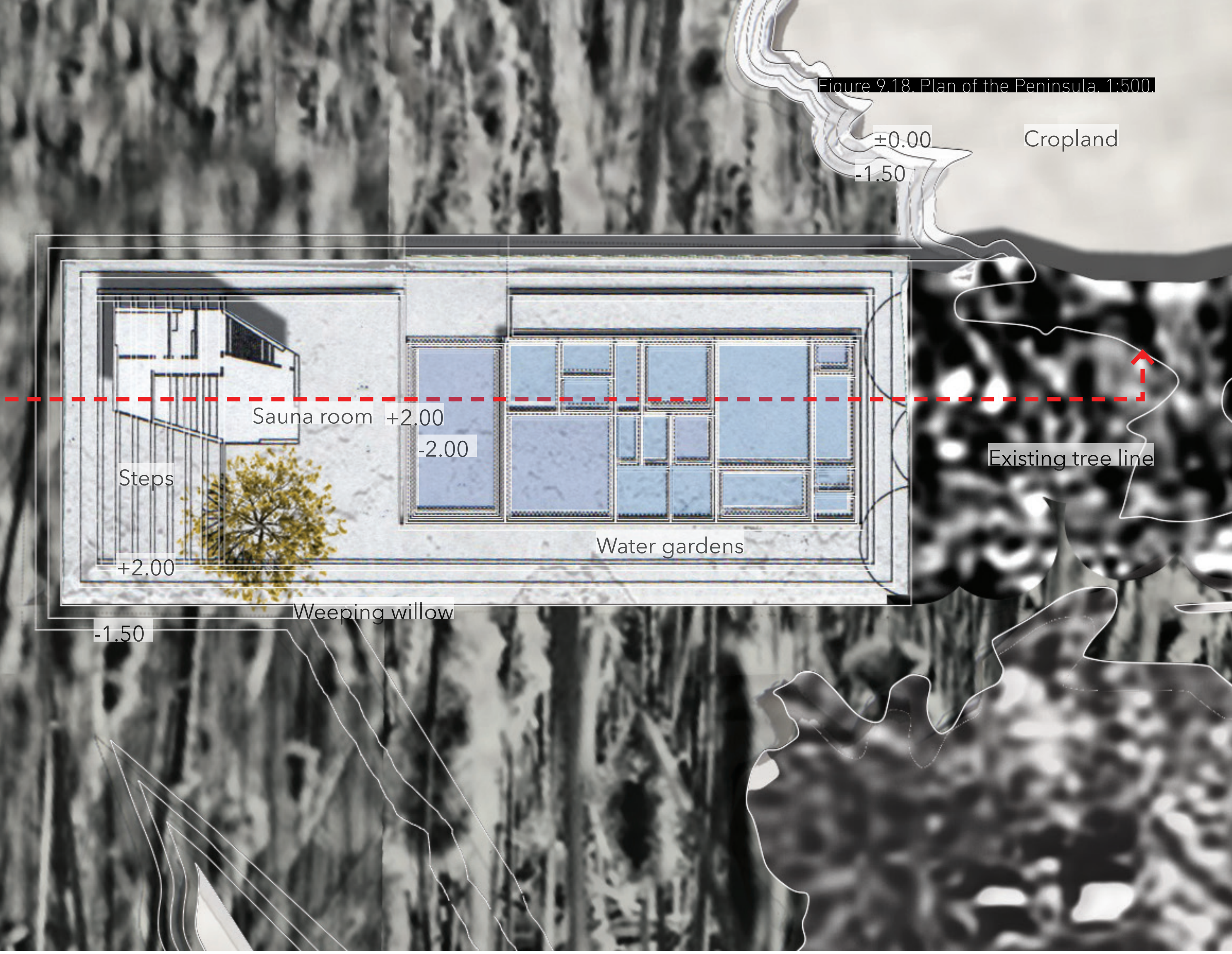
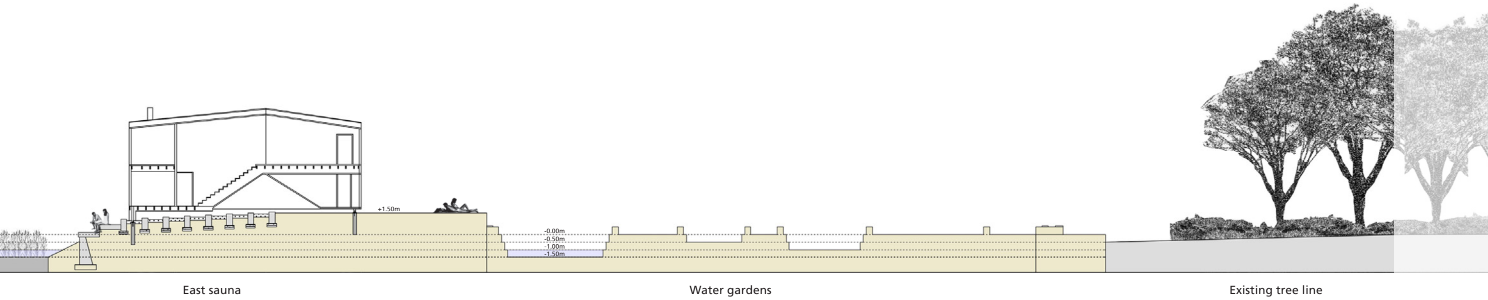
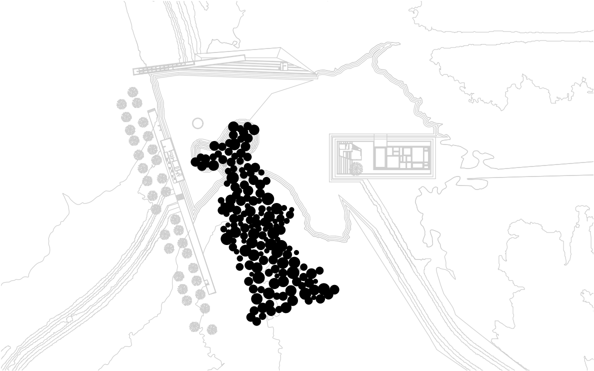


Figure 9.18. Plan of the Peninsula, 1:500.





The Grove

The orientation and form of the Grove places emphasis of the entrance to the Promenade and incorporates the idea of Epinctiéres as a tamarack island. The dense body closes off the project to the south creating separation and protection between the Pool and the road. The trees also obscure the direct view between the east and west saunas increasing the privacy between the buildings. The Grove is extended onto a constructed island that is isolated during heavy rain events. The needles from the tamaracks create a soft reddish brown carpet underneath the canopy.

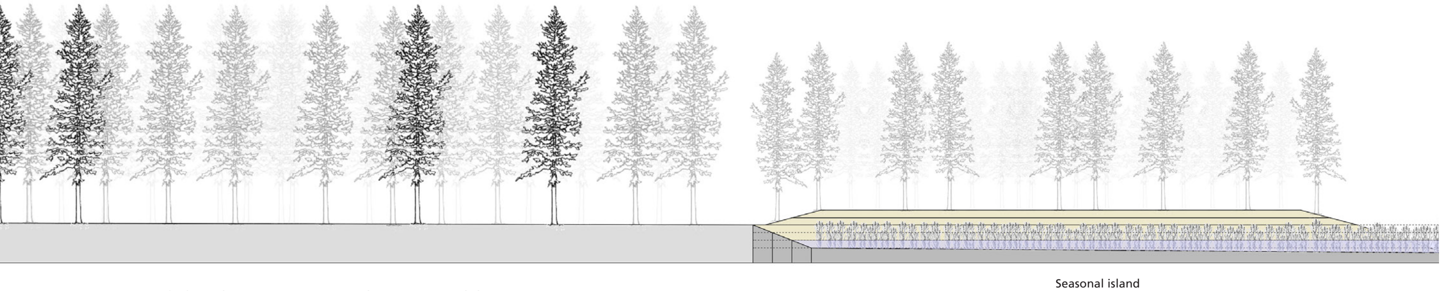
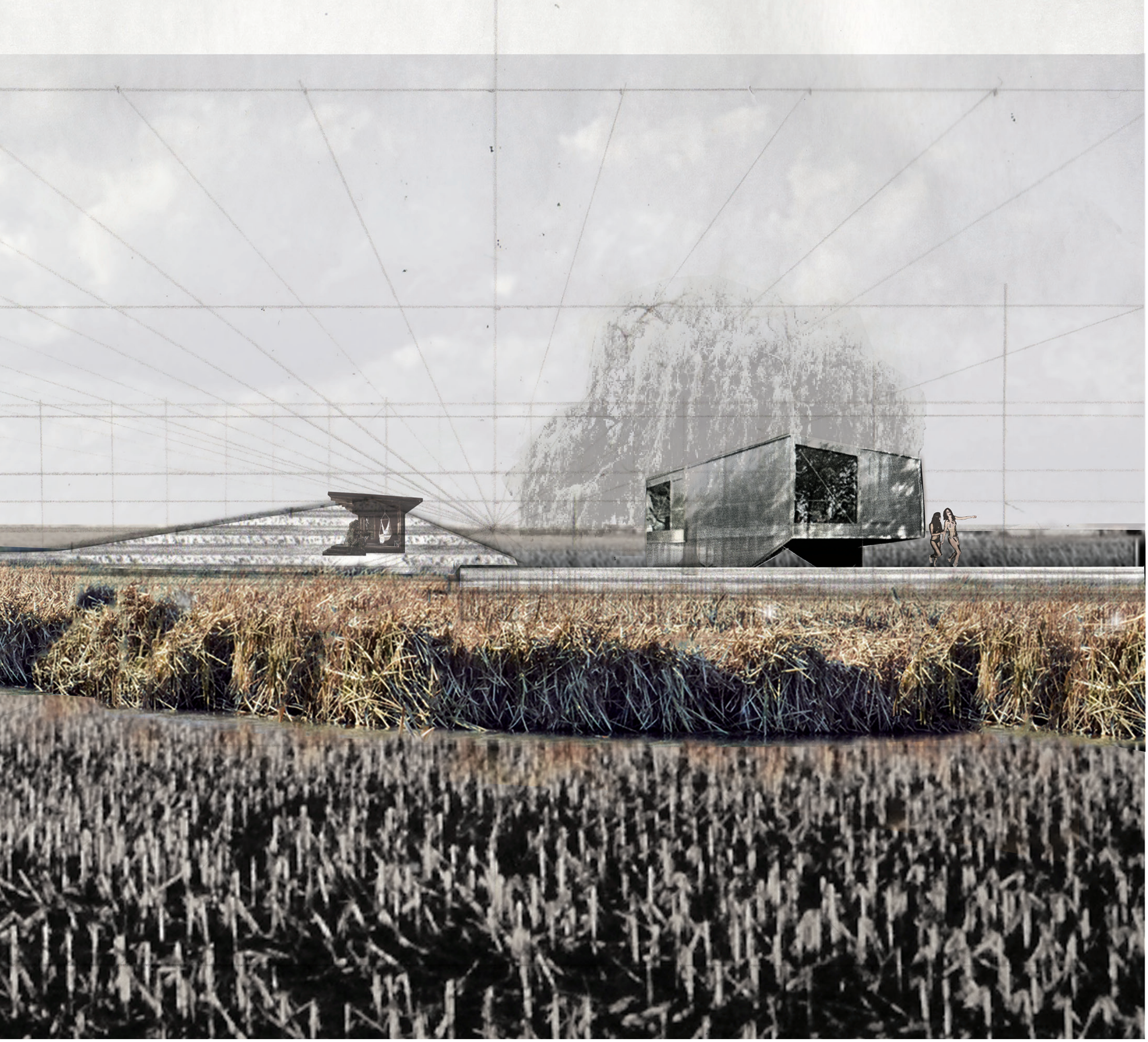


Figure 9.21. Section of the Grove. 1:500.

Figure 9.20. Plan of the Dike. 1:500.

Figure 9.22. Perspective showing view from the south towards the Dike. [collaged perspective]. Using Adobe Photoshop [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.



View looking north towards the Dike. A wall of cattails define the boundary of the filtration area.

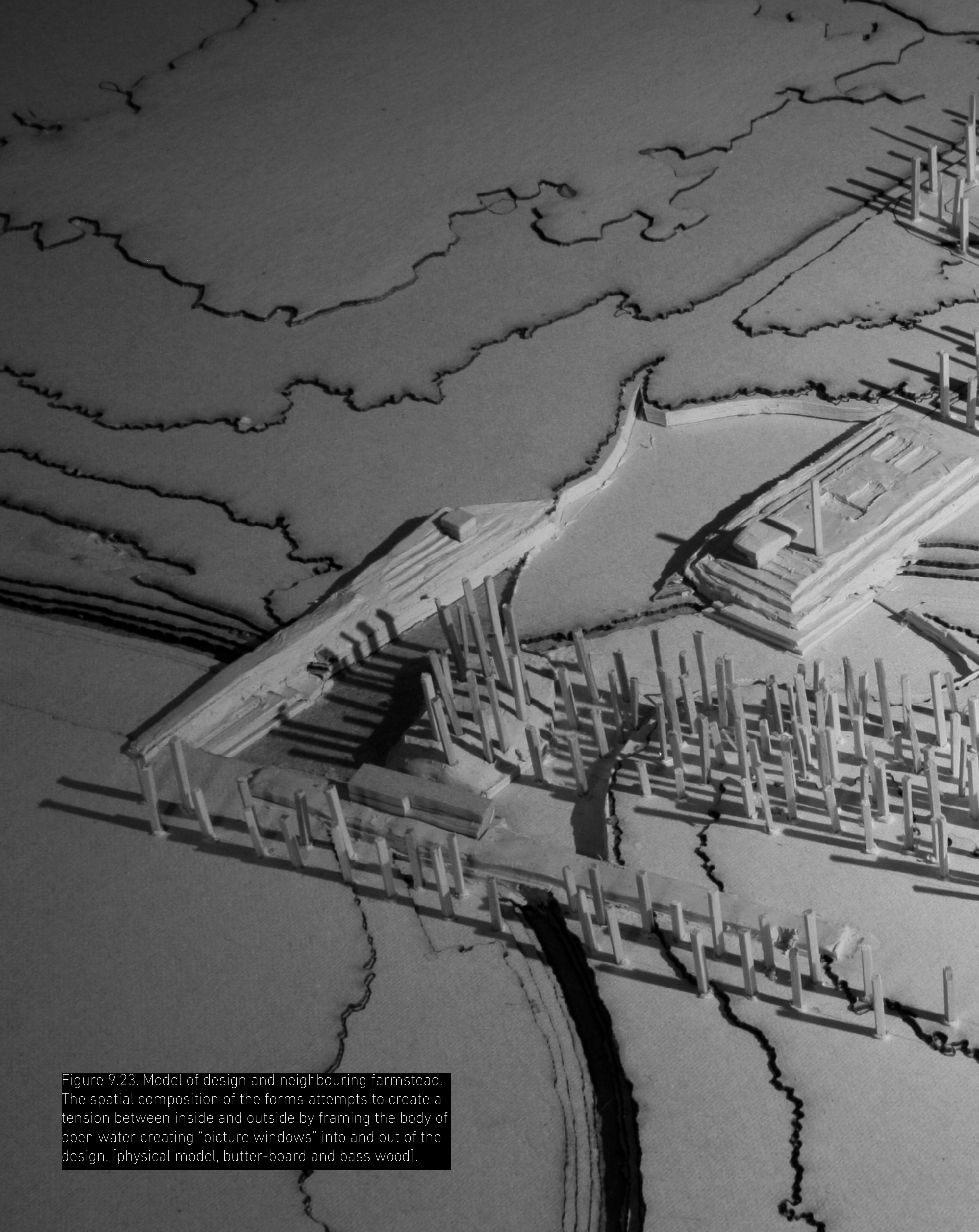


Figure 9.23. Model of design and neighbouring farmstead. The spatial composition of the forms attempts to create a tension between inside and outside by framing the body of open water creating "picture windows" into and out of the design. [physical model, butter-board and bass wood].

9.4 CONCLUSION

The project expresses a relationship to the past, present and future through the convergence of various scales and conditions of the context. Re-evaluating water management options for Lake Winnipeg and the capacity for landscape architecture to engage with the existing situation of the province allows the opportunity to propose long term sustainable strategies. These investigations and research generated knowledge assisted in the creation of a physical design. The design demonstrates how landscape architecture can offer an approach with social and economic dimensions while maintaining ecological objectives.

Water management is an integral part of landscape architecture and design, and an important issue of the future. Landscape design can provide alternatives to the purely engineered responses typical of water management in Manitoba. Presenting landscape architecture projects that deal with the treatment of agricultural runoff to organizations such as Manitoba Water Stewardship, Manitoba Conservation, Manitoba Infrastructure and Transportation, Manitoba Agriculture, Food and Rural Initiatives, municipalities and landowners, could further expand discussions. Landscape architects can play a key role in facilitating these discussions by showcasing projects that address common interests between private and public organizations.

Occupying agricultural land for any purpose other than food production is a sensitive topic that involves open public discussion and careful argumentation. Clarity, transparency and plausibility are required when presenting designs to avoid miscommunication. The potential of these types of projects relies on the cooperation and participation from the farming communities and the expertise from related fields.

Being only one of sixteen possible test plots, the design hopes to inspire a direction for the project area and invite projective design visions for future developments and everyday experiences in the rural landscape.

Figure 9.24. Overview of intervention. [physical model, butter-board and bass wood].

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Figure 0.2. Interchange Studio, 2007, Winnipeg, Manitoba. Group member Vanessa Jukes [aerial perspective]. Using Adobe Illustrator [CAD software]. Vers. CS2. San Jose, California: Adobe Systems, Inc., 2006. Based on aerial photo from Google Inc. (2013). Google Earth (Version 7.0.3.8542) © 2013 TerraMetrics [Software]. Available from http://www.google.com/earth/index.html

Figure 0.3. Landscape and Urbanism Studio, 2011, Winnipeg, Manitoba. Group members: Neil Eckton and Michael Lucenkiw [rendered plan]. Using Adobe Illustrator [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010. Based on aerial photo from © 2010 Google © 2011 TerraMetrics Retrieved from http://maps.google.ca/

Figure 1.1. Southern Manitoba. Cropland, lakes, settlements, major roads and rivers. [computer map]. 1:1,000,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 1.2. Conceptual structuring of southern Manitoba, based on aerial photo from Google Inc. (2013). Google Earth (Version 7.0.3.8542) © 2013 TerraMetrics [Software]. Available from http://www.google.com/earth/index.html

Figure 1.3. Red River Watershed. [computer map]. 1:10,000,000, (center) Rat River Watershed. [computer map]. 1,000,000, (right) Project Area. [computer map]. 1:250,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 2.1. Map of Lake Agassiz. Adapted from "Map Showing the Areas of Lake Agassiz and of the Upper Laurentian Lakes (1895)," from Manitoba Historical Society, 2009, http://www.flickr.com/photos/manitobamaps/4138482030/. © 2009 Manitoba Historical Society. Adopted with permission.

Figure 2.2. Melt water and ice sheet of Lake Agassiz. [computer map]. Scale Undefined. Using Adobe Illustrator [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.

Figure 2.3.Southern Manitoba: Clay and Topography. [computer map]. 1:800,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 2.4. Lake Winnipeg watershed in Global Context. Approximately 4 times the size of New Zealand. [computer map]. Scale Undefined. Using Adobe Illustrator [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.

Figure 2.5. Lake Winnipeg watershed overlaid on aerial map. [map]. Scale undefined. Based on aerial photo from © 2011 Google © 2011 TerraMetrics Retrieved from http://maps.google.ca/

Figure 2.6. Red River watershed. [computer map]. 1:5,000,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 2.7. Red River meandering through agricultural land. Looking north from St. Jean Baptiste. Adapted from http://www.ncdc.noaa.gov/paleo/pubs/stgeorge2002/stgeorge2002.html. © 1999 G.R. Brooks. Adopted with permission.

Figure 2.8. Rat River near Otterburne

Figure 2.9. Sub-watersheds of Manitoba's portion of the Red River watershed. [computer maps]. 1:3,000,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

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Figure 2.11. Rat River watershed, topography and Rat River. [computer map]. 1:750,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 2.12. General Profile of Rat River draining into the Red River. Land cover and soil types, Scale Undefined.

Figure 2.13. Red River Valley. Undraped DEM, 30x VE, Oblique View. Adapted from http://www.manitoba.ca/iem/mrd/geo/demsm/rrvalley1.html. Manitoba Innovation, Energy and Mines, Manitoba Geological Survey © Manitoba Innovation, Energy and Mines. Reproduced from Government of Manitoba with permission from Manitoba Innovation, Energy and Mines.

Figure 3.1. Flood Protection of homes in Winnipeg. Adapted from “Lyndale Bank, St. Boniface, N23614, 1950” from Manitoba Archives. © Manitoba Archives. Adopted with permission.

Figure 3.2. Blue-Green Algae in Lake Winnipeg. Adapted from “Victoria Beach on Lake Winnipeg,” by G. McCullough, 2012, http://canadawater.wordpress.com/2011/06/08/save-lake-winnipeg-act-on-manitoba-government-agenda/. © 2012 G. McCullough. Adopted with permission.

Figure 3.3. Blue-green algae in Lake Winnipeg. Adapted from “Blue on Blue (with a touch of green),” by J. Douglas, 2012, http://www.flickr.com/photos/jojodouglas/7484577006/. © 2012 J. Douglas. Adopted with permission.

Figure 3.4. Red River and downtown Winnipeg

Figure 3.5. 1950 Red River flood extents. Adapted from “A Map Showing the Extent of the Red River Flood of 1950 in Manitoba (1953),” from Manitoba Historical Society, 2008, http://www.flickr.com/photos/manitobamaps/4138482030/. © 2008 Manitoba Historical Society. Adopted with permission.

Figure 3.6. Red River flooding. Farm yards protected by ring dikes. Adapted from “RedRiverFlood09_1107” by B. Hildebrand, 2009, http://www.flickr.com/photos/brucehildebrand/3488170489/. © 2009 B. Hildebrand. Adopted with permission.

Figure 3.7. Aerial photo of the Red River flooding. Adapted from “Red River Flood,” by R. Riegel, 2006, http://www.flickr.com/photos/jriegel/2498119537/. © 2006 R. Riegel. Adopted with permission.

Figure 4.1. Rivers and drainage of southern Manitoba. [aerial map]. 1:250,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 4.2. Drainage of southern Manitoba. Adapted from “Drainage, N23584, 1915” from Manitoba Archives. © Manitoba Archives. Adopted with permission.

Figure 4.3. 6’ drainage ditch. Adapted from “A 6’ drain, N23022, 1911” from Manitoba Archives. © Manitoba Archives. Adopted with permission.

Figure 4.4. Drainage near farmstead. Adapted from “Drainage East Reserve, N23614, 1955” from Manitoba Archives. © Manitoba Archives. Adopted with permission.

Figure 4.5. Prairies (light grey) and Wetlands (dark grey) of southern Manitoba in 1870 [computer map]. 1:1,000,000. I. Hanuta, Land Cover and Climate for Part of Southern Manitoba: A Reconstruction from Dominion Land Survey Maps and Historical Records of the 1870s Winnipeg, M.B.: University of Manitoba , 2006. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 4.6. Cropland (light grey) and Wetlands (dark grey) of present day southern Manitoba. [computer map]. 1:1,000,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 4.7. Mile to mile grid and field drainage [aerial map]. 1:50,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 4.8. Horse and ox team working on a drain. Adapted from “Horse and ox team working on a drain, 1911” from Manitoba Archives. © Manitoba Archives. Adopted with permission.

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Figure 4.10. Walking Dredge, 1911. Adapted from “A.R. Boivins Walking Dredge, 1911” from Manitoba Archives. © Manitoba Archives. Adopted with permission.

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Figure 4.12. Drainage lines of southern Manitoba [computer map]. 1:500,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 5.1. Grand Beach on Lake Winnipeg. Adapted from “Grand Beach,” by Travel Manitoba, 2009, http://www.flickr.com/photos/travelmanitoba/5431567855/. © 2009 Travel Manitoba. Adopted with permission.

Figure 5.2. Major players of Lake Winnipeg, based on map of Lake Winnipeg and southern Manitoba. [computer map]. 1:2,500,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba, 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 5.3. Map of Lake Winnipeg. Adapted from “Lake Winnipeg 53L (1931),” from Manitoba Historical Society, 2008, http://www.flickr.com/photos/manitobamaps/2176985812/. © 2008 Manitoba Historical Society. Adopted with permission.

Figure 6.1. Rat River watershed. [aerial map]. 1:400,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 6.2. Sea of cattails. Adapted from “Sea of Cattails,” by G. Leigh, 2010, http://www.flickr.com/photos/22780107@N02/4374726664/in/photostream/. © 2010 G. Leigh. Adopted with permission.

Figure 6.3. Tamaracks growing around a pond. Adapted from “Tamarack Pond,” by S. Slabik, 2011, http://www.flickr.com/photos/sherrys_corral/6307460774/. © 2011 S. Slabik. Adopted with permission.

Figure 6.4. Lower potion of Rat River watershed. Intervals of 2.00 meters. [contour map]. 1:250,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba, 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 6.5. 800 ha of cattails and the Rat River watershed. [computer map]. 1:300,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 7.1. Model One - “Concentration”. [computer map]. 1:100,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 7.2. Model Two - “Decentralization”. 16 fields (nodes) for a watershed. [computer map]. 1:150,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.

Figure 8.1. Map of Project Area. [map]. 1:100,000. Manitoba Land Initiative databases. Winnipeg, M.B.: Province of Manitoba , 2013. Using ArcGIS [GIS software]. Version 10. Redlands, CA: Environmental Systems Research Institute, 2011.
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Figure 8.3. Site and surroundings, based on aerial photo from Google Inc. (2013). Google Earth (Version 7.0.3.8542) © 2013 TerraMetrics [Software]. Available from http://www.google.com/earth/index.html

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Figure 9.4. Earthworks and water body. [contour map]. 1:5,000. Using Adobe Illustrator [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.

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Figure 9.6. Plants and seasons. [collaged plans and sections]. Scale Undefined. Using Adobe Photoshop [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.

Figure 9.7. Sauna facilities. [computer map]. 1:5,000. Using Adobe Illustrator [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.

Figure 9.8. Intermediate presentation board. [collaged maps and photographs]. Using Adobe Photoshop [CAD software]. Vers. CS6. San Jose, California: Adobe Systems, Inc., 2010.

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Figure 9.23. Model of design and neighbouring farmstead. [physical model, butter-board and bass wood].

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