PURIFYING LANDSCAPE

Wastewater as a Catalyst for Community Gardens in Winnipeg

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I would never have been able to complete my degree and practicum without the support of my committee members, my family, and my friends.

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ABSTRACT

The purpose of this practicum is to design a landscape with the ability to purify wastewater from Winnipeg North End Water Pollution Control Centre and to use the purified water for the irrigation of community gardens. Water pollution has been a big issue around the world. Eutrophication refers to the overabundance of nutrients in waterbodies. Lake Winnipeg, in the province of Manitoba, one of the largest freshwater resources in Canada, has a serious eutrophication problem. One of the major nutrient loading sources is the nutrient-rich inflow from the Red River (Water Stewardship Division, n.d.), which consists of agricultural runoff and municipal and industrial wastewater. In the City of Winnipeg, the North End Water Pollution Control Centre releases a large amount of treated wastewater into the Red River. The treated wastewater is rich of phosphorus, nitrogen, and pathogen. The landscape can play a potential role to purify the nutrient-rich wastewater before it reaches the river while providing outdoor spaces for community gardens and leisurely uses.
INTRODUCTION

Freshwater is one of the most important natural resources for humans and for the environment. Water pollution has been a big world-wide issue. In China, where I grew up, water pollution has been a very serious issue. Half of the ten major river systems, 40% of the major lakes, and 17 out of 31 large freshwater lakes are polluted (Gu, 2014). Over a period of ten years, I have witnessed the deterioration of water quality in the Zi River in my hometown. The river water turned turbid and the fish gradually disappeared. With garbage strewn across its surface and along it banks, this once pristine sight has become unsightly. I moved to Canada when I was 18 years old and I had imagined its beautiful natural environment, especially its large amount of freshwater sources and clean lakes. However, Canada’s freshwater sources are limited and some of them are polluted.

Canada owns 7% of the world’s freshwater sources and has a relatively small population. For this reason, there is a general misconception that Canada has an unlimited supply of high quality freshwater. However, 60% of Canada’s freshwater is located to the north, in the Hudson Bay area and the Arctic. This amount of water is inaccessible to more than three quarters of the Canadians (Ducks Unlimited, n.d.). Due to their scarcity, the few freshwater sources that are accessible must be protected.

One of the largest lakes in Manitoba, Lake Winnipeg, has a serious algae bloom problem. Algae bloom results from an overabundance of nutrients in water, also known as eutrophication. Nutrients in Lake Winnipeg come from many sources, with a large number of these being from the Red River inflow. Along the Red River watershed, there are farmlands and urban areas, where fertilizers are used extensively, the excess of which will leach into rivers and lakes. In urban areas, sewage outlets spew nutrient rich effluent into the vicinal rivers and lakes. The Red River water acts as a vessel in delivering these nutrients into Lake Winnipeg.

In the City of Winnipeg, Manitoba’s capital city through which the Red River flows, efforts have been made to reduce the amount of municipal sewage that ends up in the river. Winnipeg has three water treatment plants which purify sewage water before it is released into the Red River. However, the quality of treated wastewater is questionable. The levels of pathogens (Alberta Agriculture and Rural Development, n.d.; Water and Waste Department of Winnipeg, 2016), as well as nitrogen and phosphorus (Plevan & Blackburn, 2013; Water and Waste Department of Winnipeg, 2016) are still high. There are better methods to reduce the levels of these contaminants. UV light, for instance, has been proven effective in eliminating pathogens (Ma, Zhu, Zhao, & Yang,
2003). Constructed wetlands work really well on nitrogen (Lee, Fletcher & Sun, 2009) and phosphorus (Ayaz, Aktas, Findik & Akca, 2011) removal. The reduction of nutrient levels in treated wastewater can decrease its damage to the Red River water ecosystem.

Landscape architects have applied the knowledge of water purification to solve water pollution problems using constructed wetlands. In China, serious water pollution has resulted in the occurrence of many water purification projects, with a number of these being successfully completed landscape projects. In this study, the two projects I examined are Houtan Park and Qiaoyuan Park. These two parks, designed by Turenscape, are very successful and have gained international acclaim.

When scientific knowledge and design concepts are applied to spatial design, functional and pleasant spaces are created. I aim at creating an outdoor space which can purify treated wastewater and use purified water to irrigate community gardens while providing enjoyable outdoor experiences for visitors.
1

EUTROPHICATION
“The term eutrophication can refer to the natural enrichment of a lake over time, or river along its course, but the word has increasingly assumed a definition that primarily refers to a form of destructive pollution. Eutrophic waters are nowadays commonly thought of as those showing signs of excess nutrients loading with associated changes in flora and fauna” (Jeffries & Mills, 1990).
Various sources of nutrients lead to eutrophication. The main sources are runoff and leaching from agricultural fields, golf courses, lawns, and parklands, which contains artificial fertilizers. Other sources of nutrients includes: municipal and industrial wastewater; atmospheric deposition; release from soils and vegetation and leaching from rocks; enhanced drainage and reduced riparian vegetation (Armstrong, Water Quality Management Section, Water Science and Management Branch, & Manitoba Water Stewardship, n.d.).

The overabundance of nutrients causes significant changes in the water quality. First, the composition of the algae changes. Certain plant species, such as blue-green algae, are toxic and can turn into the dominant species in the water body during the eutrophication processes. Second, the composition of macrophyte communities changes. Tolerant species survive, but vulnerable species perish. This results in a different ecosystem population dynamic. Third, sediment changes occur. Death and decay of plants increase solids in the water, and accelerate sedimentation. The accelerating turbidity, algal blooms, anoxia, and sediment changes will also threaten tolerant species over time. As a result, species diversity decreases as only a few species thrive and increase in productivity. Aside from the biological changes, the appearance or esthetic value of the environment also changes (Jeffries & Mills, 1990). Therefore, eutrophication is a causing aspect of water deterioration.

There are many approaches to preventing and reversing the effects of eutrophication. Jeffries and Mills (1990) established a set of general principles for this purpose. First, reduce the supply of nutrients into the system. For example, this can be achieved by preventing the use of fertilizers and treating polluted water before it was discharged into water systems. Second, remove or reduce nutrients already in the system. For instance, this can be obtained by reducing nutrient-rich sediments and macrophytes. Third, restore biotic conditions that promote a non-eutrophic state. In another word, this method tries to keep the non-eutrophic macrophyte-algal balance in water systems. Therefore, eutrophication can be prevented if using effective methods.
Lake Winnipeg, located in Manitoba, is one of the largest freshwater lakes in Canada and the tenth greatest freshwater lake in the world (Water Stewardship Division, n.d.). Aside from providing freshwater, the lake also creates opportunities for recreation, tourism, fisheries, and hydroelectric generation. In addition, Lake Winnipeg provides habitats for diverse aquatic organisms such as fish, invertebrates, and plants. Along the lakeshore, there are over 23,000 residents who depend on the lake as a resource (Water Stewardship Division, n.d.). Therefore, it is very important for Manitobans to protect Lake Winnipeg from water pollution.

Water eutrophication is a serious problem in Lake Winnipeg. In 2013, the Global Nature Fund identified Lake Winnipeg as “the threatened Lake of the Year” (Living Lakes Canada, n.d.). Recent water quality monitoring data demonstrated that the water in Lake Winnipeg is eutrophic or hypereutrophic, which clearly points out the fact that it is rich in plant nutrients (Environment Canada, 2011). Phosphorus and nitrogen are two of the nutrients that are indispensable for plant growth. An increased amount of phosphorus and nitrogen, two nutrients that are indispensable to plant growth, was found in Lake Winnipeg in the second half of the 20th century and this was attributed to anthropogenic input (Environment Canada, 2011). Thus, finding out the nutrient sources of the anthropogenic input is the first step to solve water eutrophication problems.
Figure 1.6 - Lake Winnipeg
NUTRIENTS IN LAKE WINNIPEG

Generally, nutrient concentrations are higher in the south of Lake Winnipeg and decrease towards the north. From 1999 to 2007, the average total phosphorous concentration in the south side (0.113 mg/L) was three times higher than that in the north (0.044 mg/L); the total nitrogen concentration in the south (0.869 mg/L) was higher than that in the north (0.653 mg/L). This uneven distribution of nutrients may be due to the large quantity of nutrients loading from the Red River (Environment Canada, 2011).

Environment Canada (2011) found that in the high flow years of the Red River, about 68% of the total phosphorous in Lake Winnipeg was from the Red River, 15% from the Winnipeg River, and 5% from the Saskatchewan River. In addition of the total nitrogen load, 34% was from the Red River, 25% from the Winnipeg River, and 10% from the Saskatchewan River. The Red River’s export rate of nitrogen and phosphorus is the highest among Lake Winnipeg’s major tributaries, with the second and third being Winnipeg River and Saskatchewan River, respectively. Finding the nutrient sources in the Red River watershed helps us to understand where these nutrients come from.
NUTRIENTS IN THE RED RIVER

A number of farmlands, rural areas, and urban areas within the Red River watershed load nutrients into the Red River. Red River Basin Commission (2015) found that major phosphorus sources are from agricultural runoff (43%), atmospheric deposition (18%), non-agricultural rural runoff (17%), and domestic/industrial wastewater (11%). This practicum focuses on the nutrients from sewage wastewater of Winnipeg.

Figure 1.9 - Red River watershed. Adapted from Approaches to setting nutrient targets in the Red River of the North, by A. B. Plevan & J. A. Blackburn, 2013. Retrieved from http://ijc.org/files/tinymce/uploaded/IRRB/Approaches%20to%20Setting%20Nutrient%20Targets%20in%20the%20Red%20River%20FINAL.pdf.
SUMMARY

Eutrophication refers to the overabundance of plant nutrients in the water ecosystem, which can lead to a change in algae composition, macrophyte communities, sedimentation, and species diversity. Treatments can be applied to assist in the efforts towards reducing and preventing eutrophication. Lake Winnipeg, the largest freshwater source in Manitoba, has a serious water eutrophication problem. Red River loads a large number of nutrients into Lake Winnipeg. While the nutrients in the Red River come from many sources, with one source being the sewage wastewater from the City of Winnipeg. To minimize the effects of eutrophication in the Lake Winnipeg due to nutrient loading from urban areas, this practicum utilizes landscape architecture principles to filter sewage outflow in order to reduce the urban nutrient runoff into the Red River.
2
WASTEWATER TREATMENT PLANTS IN WINNIPEG
Sewage outflow is recognized as a heavy burden on rivers and lakes. Water quality deterioration, to some extent, is related to the pollutants found in sewage discharges (Environmental Commissioner of Ontario, 2015).
In the City of Winnipeg, efforts have been taken to reduce the potential damage of sewage outflow which ends up in the Red River. Winnipeg has three wastewater treatment plants. The largest wastewater treatment plant is Winnipeg North End Water Pollution Control Centre which treats about 70% of Winnipeg’s sewage wastewater. It serves most of the old City of Winnipeg, including St. Boniface, East, West, North and Old Kildonan, Transcona, and part of St. James. The rest of the city is serviced by West End Water Pollution Control Centre and South End Water Pollution Control Centre (Water and Waste Department of Winnipeg, n.d.).

Controlling the decomposition process in wastewater treatment plants improves the quality of sewage wastewater and benefits the maintenance of healthy water environments in Winnipeg’s rivers. According to Water and Waste Department of Winnipeg (n.d.), Winnipeg wastewater treatment plants collect sewage water through a sewage collection system. The wastewater treatment plants treat wastewater by filtering out inorganic solids such as sand and gravel, and organic materials. Organic materials are broken down by feeding bacteria while using up the oxygen in the water; this decomposition process causes septic conditions which may be followed by unpleasant odors.

The current wastewater treatment plants effectively reduce most of the pollutants that would otherwise end up in the river system. For instance, according to the Water and Waste Department of Winnipeg (n.d.) Winnipeg North End Water Pollution Control Center removes 95% of carbonaceous 5-day biochemical oxygen demand (CBOD5), 93% of total suspended solids (TSS), and 83% of total organic carbon (TOC). However, it reduces only 48% of total phosphorous (TP) and 31% of total kjeldahl nitrogen (TKN) (Water and Waste Department of Winnipeg, n.d.), two of the main contributors to eutrophication.
Figure 2.1 - Winnipeg wastewater treatment plants. Adapted from City of Winnipeg, by Water and Waste Department, n.d., Retrieved from http://members.shaw.ca/gp.lagasse/process.htm.
The levels of nitrogen and phosphorus that remain after treatment can significantly affect the health of the river. The total nitrogen concentration in North End Water Pollution Control Centre from May to October is 29.4, 25.1, 26.0, 25.3, 23.3, and 30.3 mg/L-N respectively (Water and Waste Department of Winnipeg, n.d.). Red River runs through the state of Minnesota and North Dakota in the United States and the province of Manitoba in Canada. There is no total nitrogen target for the Red River established in Manitoba and this practicum uses a target of 2.18 mg/L for Nutrient Ecoregion VI (Corn Belt and Northern Great Plains) that is utilized in the United States, a similar region to Manitoba (Plevan & Blackburn, 2013). These monthly total nitrogen concentration averages in the treated wastewater from 2015 exceed the suggested level by a significant amount from May to October (see figure 2.2).

Furthermore, the total phosphorus concentration in North End Water Pollution Control Centre from May to October is 3.5, 2.8, 3.1, 3.3, 2.9, and 4.0 mg/L-P, respectively (Water and Waste Department of Winnipeg, n.d.). The total phosphorus target for the Red River in the province of Manitoba is <0.05 mg/L (Plevan & Blackburn, 2013). These monthly total phosphorus concentration averages in the treated wastewater from 2015 exceed the suggested level from May to October. The concentration of phosphorus and nitrogen in the treated wastewater has to be reduced before these nutrients reach the Red River and contribute to the eutrophication of the river (see figure 2.3).
PATHOGEN

For the purpose of this practicum, wetlands would effectively reduce the phosphorus and nitrogen levels, and this water will be used for community irrigation. While the treated wastewater meets the standard pathogen levels that are set by Manitoba Water Stewardship, it would not be safe enough for irrigation purposes. Agriculture and Rural Development (n.d.) suggests that irrigation water should not contain more than 100 fecal coliforms per 100ml water. From May to October 2015, the monthly geometric mean of the fecal coliform in the treated wastewater from the North End Water Pollution Control Centre was 86, 60, 174, 289, 131, and 125 per 100ml water respectively (Water and Waste Department of Winnipeg, n.d.). These data demonstrate that the fecal coliform concentration in the treated wastewater exceeds the suggested level for irrigation water for the months of July, August, September and October (see figure 2.4). For the safety of community garden irrigation, pathogen level in the treated wastewater has to be further reduced.

SUMMARY

Sewage wastewater contains harmful pollutants, and three wastewater treatment plants have been built in Winnipeg to reduce the pollutants. Winnipeg North End Water Pollution Control Centre, the largest wastewater treatment plant in Winnipeg, efficiently removes some pollutants, but the water quality of treated wastewater is still questionable. The concentrations of nitrogen and phosphorus are still high, and they can be reduced through natural water treatment processes. The purified water is intended to be reused for community garden irrigation. However, the concentration of fecal coliform pathogen in the treated wastewater is higher than the safe level for irrigation. For the safety of community garden irrigation and the protection of Red River water, the concentration of fecal coliform, nitrogen, and phosphorus in the treated wastewater has to be reduced.

MPN/100ml

![Figure 2.4 - Pathogen concentration comparison bar chart](image-url)
3
WATER PURIFICATION FOR COMMUNITY GARDENS
**PATHOGEN REMOVAL**

According to Ma et al. (2013), Ultraviolet light, in which the electromagnetic waves range from 210 – 328 nm, has a broad-spectrum antibacterial function. Ultraviolet light changes the biological activity of DNA, which limits the reproduction of microorganisms (bacteria, virus, spores, and pathogens), and thus kills microorganisms. In addition, experiment of Ma et al. (2013) showed that when place UV light 22cm above static water surface with water depth of 3cm, almost 90% of the coliform bacteria was killed in 1 minute and 100% was killed in 2.5 minutes. This supports that the use of UV lights is effective on pathogen removal.

**NITROGEN REMOVAL**

Wetlands can reduce nitrogen concentration in water. In wetlands, Lee et al. (2009) found that plants and microorganisms around the plant root zone, and physical precipitation play an important role on nitrogen removal. The major mechanisms for nitrogen removal in wetlands are microbial interactions with nitrogen, plant uptake, chemical adsorption and sedimentation, with the key reactions being nitrification followed by denitrification.

In addition, Lee et al. (2009) also found that wetland plants have significant influence on nitrogen removal. Vegetated wetlands remove a lot more nitrogen than non-vegetated wetlands. The optimal plant types are water-tolerant, rooted in the substrate, with leaves that emerge above the water surface. Commonly used species are reed (Phragmites australis), cattail (Typha spp.), and bulrush (Scirpus spp.). A monoculture of plants is considered to achieve an ideal result for nitrogen removal. They concluded that wetlands can remove 25% to 85% of the nitrogen in water. 60-70% of the nitrogen is removed by denitrification and 20-30% is removed by plant uptake.

Furthermore, Lee et al. also observed that water retention time is very important for nitrogen removal efficiency. They found that the concentration of ammonium and TKN (Total Kjeldahl Nitrogen) decreases rapidly when the water retention time is increased and they recommended an 8-day retention time at above 15°C. Therefore, wetlands with plants and retaining the water for 8 days achieve better result in nitrogen removal.
PHOSPHORUS REMOVAL

Phosphorus concentration can be reduced by wetlands as well. Ayaz et al. (2011) found that phosphorus removal in wetlands involves several mechanisms, such as sorption on filling materials, plants uptake, sedimentation, and complexation.

According to Ayaz et al. (2011), sorption plays the most important role. The efficiency of phosphorus removal in wetlands mainly depends on the sorption capacity of the substrate materials. Also, they found that materials containing aluminum (Al), Iron (Fe), oxide groups or Calcium (Ca) on their surface are very effective in phosphorus removal, because Al, Fe, and oxide groups can undergo reactions very easily, and Ca can precipitate PO4. Fine particle materials are considered to have high phosphorus adsorption capacity due to their large surface areas. The presence of iron within the composition of gravel can increase the phosphorus removal efficiency up to 90%. Ayaz et al. (2011) concluded that iron slag is considered a good substrate for phosphorus adsorption since it has a high amount of Ca, Fe, and Al.

In addition, Ayaz et al. (2011) observed that plant uptake also plays an important role on phosphorus removal. The phosphorus removal efficiency in wetlands with plants is 1.4 -2 times greater than the ones without plants, because phosphorus is more likely stored at the roots rather than leaves.

Furthermore, Ayaz et al. (2011) found that phosphorus removal requires retention time for adsorption and precipitation to react, and the average water retention time for phosphorus removal is 4 days. Zheng, Dunets & Rozema (n.d.) suggested removing and replacing the substrates that are saturated with phosphorus, otherwise the phosphorus removal rate will decrease. In a conclusion, efficient phosphorus removal wetlands are filled with appropriate materials such as iron slag, are vegetated, and can hold the water for 4 days.
CONSTRUCTED WETLAND

Constructed wetlands are also an applicable method to remove nutrients and other pollutants in effluent water, since the removal mechanisms in constructed wetlands are similar to natural wetlands. For instance, in nitrogen removal, Lee et al. (2009) found that mechanisms include microbial interactions being nitrification and denitrification, plant uptake, chemical adsorption, and sedimentation. In phosphorus removal, Ayaz et al. (2011) found that mechanisms include sorption on filling materials, uptake by plants, sedimentation, and complexation. These natural water treatment processes in constructed wetlands remove phosphorus and nitrogen in the water.

Wetland Types

According to Zheng et al. (n.d.), the types of constructed wetlands commonly used in effluent treatment are surface and subsurface flow wetlands with emergent macrophytes. Emergent macrophytes root in substrates and their vegetative parts emerge above the water surface, such as cattails.

Type 1 – Surface Flow Constructed Wetland

A surface flow constructed wetland, based on Zheng et al. (n.d.), is consisted of a sealed basin with a layer of 20-30cm substrate, a water depth of 20-40cm, and macrophytes planting. Polluted water is purified as it flows over the substrate. Surface flow constructed wetlands efficiently remove organic matters through microbial degradation and settling, and inorganic matters through settling. Zheng et al. (n.d.) found that this type of wetland is efficient at nitrogen removal but not in phosphorus removal.

Type 2 – Subsurface flow constructed wetland

A subsurface flow constructed wetland, according to Zheng et al. (n.d.), is consisted of an impermeable basin with a 60 cm substrate of grain size 10-20mm. Wetland plants are rooted in the substrate layer. Water flows through the substrates and plant roots. Based on the flow direction, subsurface flow constructed wetlands can be categorized into two types – horizontal and vertical.

Subsurface Horizontal Flow Constructed Wetland

Based on Zheng et al. (n.d.), in a subsurface horizontal flow constructed wetland, water flows into the wetland through an inlet, runs slowly through the substrate and exits through an outlet on the other side of the wetland. Subsurface horizontal flow constructed wetlands are efficient in organic material and suspended solids removal. They also indicated that this type of wetland is not efficient for either phosphorus or nitrogen removal.

Subsurface Vertical Flow Constructed Wetland

In a subsurface vertical flow constructed wetland, according to Zheng et al. (n.d.), water enters from the surface of the wetland and water level is controlled. The water filtrates downward through the substrate and is collected at the bottom of the wetland and then pumped out. The downward flow enables more oxygen in the wetlands. They concluded that vertical subsurface flow constructed wetlands are efficient at nitrogen removal but not in phosphorus removal.

Figure 3.2 - Subsurface horizontal flow constructed wetland. Adapted from *The Online Compendium of Sanitation Systems and Technologies*, n.d., Retrieved from http://ecompendium.sswm.info/sanitation-technologies/horizontal-subsurface-flow-constructed-wetland?group_code=t.

Figure 3.3 - Subsurface vertical flow constructed wetland. Adapted from *The Online Compendium of Sanitation Systems and Technologies*, n.d., Retrieved from http://ecompendium.sswm.info/sanitation-technologies/vertical-flow-constructed-wetland.
SUMMARY

This practicum uses UV light and constructed wetlands to solve the problems in treated wastewater and reused the purified water for community garden irrigation. The pathogens in the water can be killed by UV light. The concentration of phosphorus and nitrogen in water can be reduced by constructed wetlands (for more details see wetlands section in chapter 6). These water purification systems, when applied to landscape design, have proven to be effective in water purification while creating opportunities for environmental education, experience, and recreation.
4
CASE STUDIES
Landscape architects have applied water purification knowledge in landscape design. In China, a number of water treatment landscape projects, involving the use of constructed wetlands, have been completed in recent years. This practicum uses two selected landscape projects as case studies: Houtan Park and Qiaojuan Park. These two parks have been very successful in water purification and have good international reputations. The projects will be analyzed by decomposition of design layers.
HOUTAN PARK

Landscape Architects: Turenscape
Project location: Shanghai, 2010 Shanghai Expo Park, China
Project size: 14 ha
Date of completion: May, 2010

Context:

The site is a 14 hectare (24.6 acre) narrow and linear band located along Shanghai’s Huangpu riverfront. It was an industrial brownfield that was previously owned by a steel factory and a shipyard. This brownfield had a few remaining industrial structures, and the site was used as a landfill and a storage for industrial materials (Saunders & Yu, 2012).

Design Concept:

Houtan Park was designed to be an innovative illustration of the ecological values and principles demonstrated by the 2010 Shanghai Expo. The design intention was to make the site into a living system with ecological services such as water treatment, flood control, food production, and habitat creation (Saunders & Yu, 2012).

The first challenge was to improve the degraded environment. The surface area as well as the underground area of the site was contaminated with industrial and construction debris. In addition, the polluted Huangpu River was unsafe for swimming and devoid of aquatic life. The design intended to treat the polluted river water and to transform the degraded waterfront into a safe and enjoyable public space (Saunders & Yu, 2012).

The second challenge was to improve flood management. The pre-existing 6.7 meters height flood retention wall on the south side of the park was designed to prevent a one-thousand-year flood. The daily 2.1 meter tidal made the shoreline muddy, and the flood retention wall made the shoreline inaccessible. Therefore, an innovative flood management proposal was necessary (Saunders & Yu, 2012).
Figure 4.2 - Plan of Houtan Park

Figure 4.3 - Design layers of Houtan Park

- Water body
- Terrace and topography
- Trees
- Vegetable gardens
- Special features - red benches, gardens and squares, and docks
Figure 4.4 - Houtan Park
Water Body

A constructed wetland, 1.7 kilometres long and 5 to 30 meters wide, was designed to treat some of the contaminated water from Huangpu River. The wetland treated 2,400 cubic meter of water per day. The treated water was used by the Expo for non-potable uses. The wetland also acts as a flood protection buffer (Saunders & Yu, 2012).

Figure 4.5 - Water body plan
Figure 4.6 - Constructed wetland in Houtan park
Figure 4.7 - Terraces of constructed wetland in Houtan Park
Terraces and Topography

Along the two sides of the wetland waterbody, inspired by Chinese agricultural landscapes, terraces were designed to cater the 3 to 5 meter elevation change from the edge of the wetland water body to the road. The terrace slowed down water runoff and created a treatment sequence for nutrient removal and suspended sediments reduction while creating an enjoyable space for visitors (Saunders & Yu, 2012).

Different wetland plant species are selected to absorb different pollutants in the water. An urban farming environment was created by the selected crops. Crop species included corn, rice, sunflowers, and buckwheat. The terraces along the wetland create opportunities for visitors to experience the agricultural landscape and interact with the wetland (Saunders & Yu, 2012).
Trees

Trees were planted along the edge of the site. On the northwest edge, trees were planted in groves. On the southeast edge, trees were planted in array. The different plant strategy made the landscape more dynamic and created different spatial experiences.

Figure 4.9 - Trees plan
Figure 4.10 - Trees in Houtan Park
Organic vegetable gardens were scattered through the site with most of them located on the north half of the site. These vegetable gardens made the landscape not only beautiful but also productive.

Vegetable Gardens

Figure 4.11 - Vegetation gardens in Houtan Park

Figure 4.12 - Vegetation gardens plan
Red Benches

Red linear benches were installed through the site. In the area where water entered, the benches were shorter and installed along the wetland. In the middle section of the site, where most programs are located and where people might get tired walking through the site, very long red linear benches were installed along the wetland and under the trees. Some fragmented red benches were installed in different directions around the pond located in the other end of the park, so people can enjoy different views while sitting on the benches. These benches provided places for visitors to rest, talk, and enjoy the view.
Gardens and Squares

The hanging garden was transformed from an abandoned steel structure of the old steel factory. Shanghai was the birth place of China’s modern industry. The abandoned symbolic industrial structure was retained and transformed into hanging gardens and viewing platforms. The steel structure creates an opportunities for visitors to experience the spirit of the former industry.
Docks

These docks are reminiscent of ship anchoring docks, but used as a viewing platform for the public. It is a good place for people to gather and enjoy the view of Huangpu River.

Figure 4.16 - A dock in Houtan Park
QIAOYUAN WETLAND PARK

Landscape Architects: Turenscape  
Project location: Tianjin, China  
Project size: 22ha  
Date of Design: October, 2005 – May, 2008  
Date of Completion: 2008

Context:

This is a 22 hectares park located in Tianjin, a northern coastal city in China. The site was used as a garbage dump and a storage place for urban storm water. As a result, the site was heavily polluted. It was surrounded by slums and rickety structures that had been torn down before the design was implemented. The soil was very saline and alkaline. The south and east boundaries of the park were densely populated and the west and north side was bounded by a highway and an overpass. The landscape of this region was flat and was occupied by wetlands and salt marshes, which have been degraded by rapid urbanization and infrastructure construction (Turenscape, n.d.).

Design Concept:

Turenscape (n.d.) states the goal for the design was to “create a park that can provide a diversity of nature’s services for the city and the surrounding urban residents, including: containing and purifying urban storm water; improving the saline-alkali soil through natural processes; recovering the regional landscape with low maintenance native vegetation; providing opportunities for environmental education about native landscapes and natural systems, storm water management, soil improvement, and landscape sustainability; creating a cherished aesthetic experience” (para. 4).

Existing vegetation adapted to the landscape through random succession. This inspired the planting strategy. The planting strategy was called the Adaptation Palettes, which was designed to let nature do the work (Turenscape, n.d.).

Figure 4.18 - Qiaoyuan Park plan

Figure 4.19 - Design layers of Qiaoyuan Park
**Water**

There were 21 digging ponds varying from 10 to 40 meters in width and 1 to 5 meters in depth. They were in different elevation. Some were above the ground level and some were below the ground level, decreasing from north to south. These oval shaped ponds are located in the center of the park. During seasons with high precipitation, some ponds turned into water ponds, some into wetlands, and some remained dry. This strategy created different conditions for the natural process of plant adaptation.
Mounds and Topography

Due to the landscape topography of the park, elevation increases from south to north. There are nine mounds in different diameter located on the north side of the park. The topography created different soil conditions for different plants.
Trees

There was a line of trees along the west of the park, which helped to define the boundary. On the outskirts of the park, tree orchards scattered between pathways. Another line of trees were planted along the pathways that surrounded the ponds. Within the pond area, tree groves were planted where pathways meet. Different tree planting strategies created different spatial experience.
Pathways

Pathways weaved through the landscape like a net, so that visitors can have easy access to each pond.

Figure 4.27 - Pathways plan

Figure 4.28 - A Pathway in Qiaoyuan Park
Special Features - Platforms

Platforms were installed within the pond area, which enabled visitors to get close to the vegetation and the water. The closeness to the ponds allowed visitors to get a different experience at the different ponds.
SUMMARY

Houtan Park and Qiaoyuan Park are two landscape projects in China both designed by Turenscape. The designer successfully targeted the water problems and used scientific and spatial strategies to solve these problems and create pleasant outdoor parks for citizens. Houtan Park was located along Shanghai’s Huangpu riverfront, where there was a polluted industrial brownfield. Turenscape used water treatment, flood control, food production, and habitat creation strategies to bring the site back to life. Qiaoyuan Park was used as garbage dump and a storage place for urban storm water. Turenscape used storm water management, soil improvement, and Adaptation Palettes plant strategies to build a park that had nature services for the city and its residents. These two projects are good case studies that demonstrate how landscape architects can integrate scientific knowledge about water purification processes into spatial urban design, and create a space that has water treatment function as well as social and nature services.
5
SITE INVENTORY AND ANALYSIS
The analysis of Houtan Park and Qiaoyuan Park inspired that such a landscape project should be built to solve water problems in Winnipeg. The target problems of this landscape design are the high level of pathogen, nitrogen, and phosphorus in the treated wastewater from Winnipeg North End Water Pollution Control Centre. The designed landscape also has nature and social services including community gardens where the purified water will be reused as irrigation water. Designing a landscape that is most suitable for its site, the characteristics of the potential users and the existing site conditions need to be analyzed.
SITE LOCATION AND CONTEXT

Winnipeg’s city development originated from the point at which Red River and Assiniboine River meet, and it is the capital city of Manitoba. Winnipeg sits at a latitude of 49°54’ North and a longitude of 97°14’ West, and a low altitude of 787’ above sea level. Winnipeg is Canada’s windiest city since Manitoba has plain topography without natural protection from the winds (Borjeson, 2011). Winnipeg has cold winters and hot summers. The Government of Canada (2016) indicated that Winnipeg’s daily maximum temperature in July is 25.9 °C and daily minimum temperature in January is -21.4 °C. The winter in Winnipeg lasts from November to April.

The Winnipeg North End Water Pollution Control Centre, located in the north of Winnipeg, with the main access being Main Street. A green space to the east of the Winnipeg North End Water Pollution Control Centre separates the water treatment plant from the Red River. This green space is the north part of Kildonan Park Golf Course. To the south and north of the centre are residential areas, most of them being single-family dwellings. A railway bounds the centre on the west, and on the other side of the railway are general industry areas.

The focus of this practicum is the green space to the east of the Winnipeg North End Water Pollution Control Centre. The green space is part of the Kildonan Park Golf Course and is covered by lawn and big trees. The north of the green space is bounded by a berm on which Chief Peguis Trail runs, and the south is also bounded by a berm which divides the golf course into two parts. The Red River bounds the site to the east and Main Street bounds the site to the west.

Kildonan Park Golf Course is Winnipeg’s oldest 18-hole municipal golf course which was built in 1921 (City of Winnipeg, 2016). In Manitoba, the rate of population per 18-hole equivalents is lower than most of other provinces in Canada. For example, the population per 18-hole equivalents in Manitoba is 12,525, but in Quebec is 22,012, in Ontario is 17,169, and in Alberta is 15,160 (Golf Canada and the PGA of Canada, 2015). That means Manitoba has more 18-hole equivalents than other provinces compared to its population. Therefore, transforming part of the golf course into a landscape design will not affect the golf supply, and it provides an opportunity to examine natural processes for water purification and the importance of community gardens. The other part of the golf course will remain and still serves its players.
The nearest community is Margaret Park. Comparing the population census data of Margaret Park and the City of Winnipeg, some of the population characteristics are phenomenal.

**Income**

The percentage of population income ranging from 12,000 to 29,999 is 14.7% higher than that of the city and population income more than 50,000 is 9.9% lower than that of the city.
Education

The education level in this community is roughly lower than Winnipeg’s average. The percentage of people without certificate is 7.7% higher than that of the city’s average, with high school or trade certificate being 9.3% higher than that of the city’s average, and with college and higher degrees being 16.7% lower than that of the city’s average.

Age

The elderly population percentage is much higher than the city’s average. Population percentage of people aged from 35 to 44 is 4.8% higher than that of the city’s average, while people aged from 60 to 84 is 13.3% higher than that of the city’s average.

Mode of Transportation

The percentage of people using public transit is 3.6% higher than that of the city’s average. However, the percentage of people reliant on walking is 3.2% lower than that of the city’s average.
Figure 5.8 - Existing trees

Figure 5.9 - Riparian forest
EXISTING TREES

There are tree corridors on the site and a riparian forest along the river bank. A well maintained lawn covers the tree corridor areas because the areas are used as a golf course. The trees are big and mature, and they provide beautiful linear tree canopies. The dominant tree species is Americal Elm. Other tree species include pines, poplars, ashes, basswoods, and maples. Walking under these tree canopies, it feels open and the shade is delightful (see figure 5.10). The riparian forest feels wilder than the tree corridors. In the riparian forest areas, the trees are big and mature as well, and they provide thick tree canopies. Bushy shrubs and lush grass are under the tree canopies. Tree species include cottonwoods, willows, ashes, and oaks. Shrub species include dogwoods, elderberries, and hawthorns. Walking along the riparian forest, it feels cool and enclosed, and the view of the Red River is very enjoyable (see figure 5.9). The different experience of walking from tree corridors to riparian forest, from maintained areas to wilder areas is wonderful.
EXISTING TOPOGRAPHY

The berm to the north of the site is 10 meters high and is used as the ramp for Kildonan Settlers Bridge. The berm to the south of the site is 6 meters high and was used by a railway. The slopes divide the site from west to east into upper terrace and lower terrace. The slopes on the river bank is steep.
Normal summer water level of Red River is 223.74m and it does not have much influence on the site. In the spring, a moderate flood water level is 227.24m (City of Winnipeg, 2014), and it floods most of the lower terrace. The peak of the 1997 flood is 229.23m (City of Winnipeg, 2015), and it floods the lower terrace but not the upper terrace. In general, the upper terrace does not flood but most of the area of the lower terrace is affected by spring flooding events.
SITE SECTION

Figure 5.13 - Existing site section

Figure 5.14 - Existing slope on the site
The existing water flow process discharges all the treated wastewater into the Red River through underground sewage pipes. The wastewater has high levels of pathogen, nitrogen, and phosphorus.
**PATHWAYS**

The blue arrows indicate the major pedestrian entry points to the site. Pedestrian can access the site easily from north and east entry points. However, pedestrian have difficulties entering the site at the points indicated by the purple circles. Main Street severs the pedestrian connection towards the west with no pedestrian crosswalk.

Figure 5.16 - Pathway connectivity
VEHICLE CIRCULATION

There are two major roads with three lanes in each direction. One is Main Street, north and south bound, and the other one is Chief Peguis Trail, west and east bound. On the north and south side of the site, most lanes serve residential areas. Most of those lanes have one lane in both directions. There are bus stops located along Main Street and Templeton Avenue. It is convenient to get to the site either by bus or by car.
SUMMARY

The problems of high levels of pathogen, nitrogen and phosphorus in the treated wastewater released from Winnipeg North End Water Pollution Control Centre have been targeted. The green space to its east has the potential to build disinfection and wetland systems which treat part of the treated wastewater. The areas that are not covered by trees create opportunities to build community gardens. The beautiful existing trees create different spatial experience. Based on its topography, the site has the possibility to work as a flood retention area. With the improvement of pathway connectivity and the good existing vehicle circulation, the site has potential to bring people from nearby communities as well as other parts of Winnipeg into the site. These opportunities inspire a unique site design that can purify the treated wastewater also provides nature and social services.
6

Design
DESIGN CONCEPT

The intentions of the design are: first, to create a landscape involving UV light disinfection and constructed wetlands which can reduce the phosphorus and nitrogen concentration in the treated wastewater from Winnipeg North End Water Pollution Control Centre; second, to create a pleasant outdoor space for the nearby neighbourhood and other park users. This outdoor space includes community gardens which reuse the purified water for irrigation. Due to space limitation, it is not possible to purify all the treated wastewater. However, the attempt is vital towards creating a space for experience, education and examination. The overall strategies of the site design involve respecting the existing elements on site and using natural processes as a water management strategy.

Intertwining Fingers

The strategy of respecting the existing recommends protecting the beauty of the existing trees and preserving the characteristics of the existing topography. The existing trees are big and mature, and they provide great tree canopies. They are planted in a linear form, which divides the space into ‘fingers’. The intertwining fingers are used as a metaphor to explain the design solutions which preserve the existing tree corridors and riparian forest as a way to define spaces for new design elements. In other words, the design will be proposed within the spaces between the existing tree corridors.
The strategy of using natural processes recommends removing pathogen, nitrogen, and phosphorus in the treated wastewater using methods that already exist in the natural environment. The proposed water process is to redirect about 0.045% of the treated wastewater into the designed area. This water will be disinfected using UV light, and the concentration of nitrogen and phosphorus in the water will be reduced using constructed wetlands. The purified water will be used for community garden irrigation. Any excess irrigation water will be drained into the Red River through underground pipes.
SITE DESIGN
ORIGINAL SCALE 1-500

The site plan displays the design concept, the spatial relationship and placement for all the design elements. The shapes of the four ‘fingers’ are defined by the existing tree corridors. A few trees are taken out (see figure 6.8) due to the placement of the ‘fingers’. The design elements in each ‘finger’ are structured similarly.

At the beginning of each ‘finger’, a pump house is proposed to pump the treated wastewater from underground pipes and to disinfect the wastewater with UV lights. The disinfected wastewater flows into two wetlands sequentially. The first one is for phosphorus removal and the second one is for nitrogen removal. A series of community gardens is located after the wetland areas where the purified wastewater is used for irrigation. Squares in various sizes are proposed in the community gardens area, which provide opportunities for different uses. Fruit trees are planted either singularly or in groups, which create different spatial experiences in the space. At the end of each ‘finger’, the proposed design is connected to the existing lawn, riparian forest, and the Red River.

1. Pumping houses
2. Constructed wetlands
3. Stairs
4. Slopes
5. Green houses
6. Community gardens
7. Manchurian Strain Apricot orchard
8. Early Gold Pear orchard
9. Valentine Cherry orchard
10. Dolgo Crabapple orchard
11. Northland Blueberry orchard
12. Pembina Hybrid Plum orchard
13. Honeywood Saskatoon orchard
14. Berry Blue Honeyberry orchard
15. Pathways
16. Parking lot
17. Compost areas
Figure 6.5 - Site plan (original 1-500)
DESIGN LAYERS
ORIGINAL SCALE 1-3000

Figure 6.6 - Design layers
Trees

Wetlands

Community gardens

Squares

Circulation

Special features - pipe system, pumping houses, hand water pumps, decompose areas, green houses, parking lot

Figure 6.7 - Design layer decomposition
Retaining and Removal of the Existing Trees

Most of the existing trees are retained but some of them will be removed to accommodate the ‘fingers’. The existing trees to be removed are indicated by the black circles. In ‘finger’ 2 and ‘finger’ 4, the tree removal accommodates the extension of the design towards the river in order to attract people to the space. In ‘finger’ 3, the tree removal opens up the center of the space to house the community gardens. Finally, the removal of the trees beside Main Street allows for access to the entrance of the parking lot. The minimal tree removal will retain the existing aesthetics of the mature tree canopy.

Figure 6.8 - Plan of existing trees modification
American Elm
(Ulmus americana)

Paper Birch
(Betula papyrifera)

Green Ash
(Fraxinus pennsylvanica)

Manitoba Maple
(Acer negundo)

Figure 6.9 - Series of existing tree species
New Trees

The proposed trees are fruit trees which contribute towards the productivity, playfulness, and enjoyment of the site. Eight different species of fruit trees of different heights and sizes are selected. As they are planted either singularly or in groups, different spatial experiences are created.

Figure 6.10 - Plan of new trees
The characteristics of the existing topography will be retained. The existing topography has two big terraces. During flood season, the lower terrace acts as a flood retention area while the upper terrace is not affected. The flood retention area is very important towards the vitality of the Red River. The design proposal will involve slight changes to the topography in order to create more vivid experiences. ‘Finger’ 1 and ‘finger’ 4 will integrate the existing slope. The slope in ‘finger’ 2 will be slightly extended and designed into concrete stairs. The slope in ‘finger’ 3 will be designed to have a very gentle slope. The two berms and river bank will not be modified. These little changes give the site new life while its original characteristics are retained.
Figure 6.20 - Model showing proposed topography
WETLANDS

At the west end of each ‘finger’, two wetlands are designed to remove phosphorus and nitrogen. Wetland 1 is designed for phosphorus removal and Wetland 2 is designed for nitrogen removal. Pumping houses are installed at Wetland 1 in each ‘finger’. They pump the wastewater up from the underground pipes and disinfect the water using UV lights. The disinfected water flows into Wetland 1 for phosphorus removal, after which it flows into Wetland 2 for nitrogen removal.

The constructed wetland types, filling substrates, and plantings are different between these two wetlands. The experiment by Ayaz et al. in 2011 found that vertical flow constructed wetlands removed up to 60-90% phosphorus. They also concluded that “iron slag was the most efficient material for phosphorus removal in constructed wetlands compared to gravel, marble stone, and zeolite” (p. 152). However, in Winnipeg, vertical flow constructed wetlands are not a good choice since they require a lot of pipes. Pipes are expensive, and they freeze and get damage very easily during Winnipeg’s cold winter. Furthermore, since sorption of the filling substrates plays the most important role in phosphorus removal wetlands, it is very important for the wastewater to have adequate contact with the filling substrate. Therefore, for phosphorus removal in Winnipeg, a better choice is subsurface horizontal flow constructed wetlands since they require fewer pipes and wastewater still has adequate contact with filling substrate.

In addition, according to Arnason (2010), Richard Grosshans said that cattails’ ability to absorb nutrients is incredible and they can store 8-20 kilograms of phosphorus in one acre of vegetative growth. Therefore, Wetland 1 was designed to be subsurface horizontal flow constructed wetlands containing iron slag in filling substrates and planted with cattails.

Zheng et al. (n.d.) stated that surface flow constructed wetlands were efficient in nitrogen removal. The study by Markantonatos, Bacalis and Lazaras in 1996 (as cited in Wetlands International, 2003) found that the “reed system on gravel reached better nitrification rates, while denitrification was higher in the soil-based reed system” (p. 10). Therefore, Wetlands International (2003) concluded that “a mixture of organic clay soils, sand, gravel and crushed stones could be used to provide support for plant growth. These substrates are ideal reactive surfaces for ion complexation and microbial attachment” (p.10). Thus, Wetland 2 was determined to be surface flow constructed wetlands with a mixture of clay, sand, and gravel as filling substrates and reed planting.
Figure 6.22 - Plan of wetland (original 1:100)
Wetland 1:

- Removes phosphorus
- Wetland type is subsurface horizontal flow constructed wetland
- Water supply pipes drain the water from pumping house into Wetland 1
- Geotextile is used to separate two different substrates while enables water to flow through
- Water level is controlled
- Water supply speed is controlled to ensure the water retention time in Wetland 1 is approximately 4 days
- Filling substrate is iron slag and fine substrate
- Planting is Common cattail - *Typha latifolia* L.
- The slope of the bottom is 0.5%

![Section of wetland 1](image)
Connection between Wetland 1 and Wetland 2:

- Pipes, at 2%, drain the water from Wetland 1 to Wetland 2
Iron slag is a by-product of iron manufacturing. In the process of iron production, iron ore, fluxing agents (such as limestone and dolomite), coke (as fuel), and the reducing agent are added in the blast furnace. Iron ore refers to a mixture of iron oxides, silica, and alumina. In the end, the added fluxing agent slags and iron are produced. The density, porosity and size of iron slag are dependent on the cooling rates and chemical composition (U.S. Geological Survey, 2016).
Common Cattail - *Typha latifolia L.*

According to Lahring (2003), Common Cattail is a common species in the Prairie Provinces that grow in marshes, ditches, ponds, and lakes. The green spongy leaves are flat and sword-like with sheathing at the bottom; they are rich in fibres. The rhizomes are thick, creeping and can grow over 1 meter tall. The underground rhizomes have a lot of side shoots and can grow rapidly under proper conditions. They will be able to adapt to Wetland 1 and grow fast to create thick bushes. The height of these plants is about eye level, creating a sense of enclosure.

**Figure 6.26 - Common Cattail.** Reprinted from *Water and Wetland Plants of the Prairie Provinces* (p. 36), by H. Lahring, 2003, Regina: Canadian Plains Research Center. Copyright 2003 by Canadian Plains Research Center, University of Regina.

**Figure 6.27 - Common Cattail.** Reprinted from *Water and Wetland Plants of the Prairie Provinces* (p. 36), by H. Lahring, 2003, Regina: Canadian Plains Research Center. Copyright 2003 by Canadian Plains Research Center, University of Regina.
Wetland 2:

- Removes Nitrogen
- Wetland type is surface flow constructed wetland
- Water is supplied by pipes
- Water level is controlled
- Water retention time is approximately 4 days
- Filling substrate is a mixture of clay, sand, and limestone gravel
- Planting is Reed - *Phragmites australis (Cav.) Trin ex Steud*
- The slope of the bottom is 0.5%
Connection between Wetland 2 and the Community Gardens:

- Pipes, at 2%, drain the water to the underground water tanks (see figure 6.39)
A mixture of clay, sand, and limestone gravel was determined as a growing medium for reeds, and they are all local materials in Manitoba. Clay has fine particles and it has an enormous capacity to hold water and nutrients, but it has poor air circulation and slow drainage. Sand particles are larger than clay’s. Sandy is exceptional at drainage but ineffective at holding nutrients (Landscape for Life, n.d.). The selected type of gravel is limestone gravel due to its high production in Manitoba.
Reed - *Phragmites australis* (Cav.) Trin ex Steud

Reed grasses are usually found in roadside ditches, marshes, sloughs, and in lakes with margins that are up to 2 m deep. Their rhizomes are very strong and propagate with sharp terminal shoots. Their leaves are 10-40 cm long, 1-3 cm wide, and they are spreading, flat and glabrous (Lahring, 2003). Their stem height is up to 4 meters (Wildscreen Arkive, n.d.). Their height also enhance the feeling of enclosure.
Figure 6.35 - Section elevation AA (original 1-100)
Figure 6.36 - Perspective of wetlands
Wetland areas are the places where the spaces are more defined and the feeling of enclosure is enhanced. It provides opportunity for people to rest and sit.
COMMUNITY GARDENS

The community gardens have 109 plots. The plots are for rent by nearby residents. The size of the plots ranges between 45 m² to 200 m² to serve different family sizes.

The irrigation water is the purified water from the wetlands that is stored in underground water containers. Artificial fertilizer, chemical herbicide and pesticide are prohibited in the community garden. Two green houses are installed for gardeners to grow seedlings.
Figure 6.39 - Section elevation BB (original 1-100)
The community gardens attract residents from nearby neighborhood. The gardens provide people with hands-on experience growing their own vegetables and the happiness of harvesting, while decreasing the daily expense for food purchase. Residents can communicate and learn planting techniques with each other, which improve their planting skill and enhance social connections with other residents. Also, outdoor planting provide opportunities for residents to participate in outdoor activities, which is beneficial to their physical and mental health.
SQUARES

Orchard Square

Nine squares of different sizes are located in the community garden areas. The Orchard Square is the largest and is located at the end of ‘finger’ 2. The Orchard Square has a valentine cherry orchard and big concrete stairs. A ramp cuts the stair in the middle to allow accessibility. The stairs at each side of the ramp are different. At the north side of the ramp, the height of the stair is more suitable for walking. Whereas, at the other side, the design is more suitable for sitting.
Figure 6.42 - Plan of orchard square (original 1-100)
Community Gardens

Valentine Cherry Orchards

Figure 6.43 – Section elevation CC (original 1-100)
The concrete stairs create pleasant seating environment. The stairs open towards the riparian lawn, riparian forest, and the Red River. The seating on the stairs is surrounded by existing big trees and orchards, and it allows visitors to enjoy the sun and the beautiful view of the lawn, riparian forest, and the Red River.
RIPARIAN LAWN, RIPARIAN FOREST, AND THE RED RIVER

Each ‘finger’ leads to riparian lawn, riparian forest, and the Red River. The riparian lawn area is where tree corridors end and is covered by well-maintained grass due to the golf course usage. This area is affected by annual Red River spring flood. It works as a transition area which connects the inner part of the site and the riparian forest, the maintained area and the wild area. The riparian forest has thick tree canopies, bushy shrub, and lush grass. The existing pathway in the riparian forest provides a good opportunity for walking and cycling, and as well as extensive view of the Red River.

The grass on riparian lawn area will require less maintenance. Affected by Red River flooding, wilderness will gradually occur on riparian lawn, but will not be as wild as the riparian forest. The riparian forest will remain as what it is now. Walking from the ‘fingers’, the riparian lawn to the riparian forest, the abrupt change of experiences will be smooth.
Figure 6.46 - Section elevation DD (original 1:1000)
Figure 6.47 - Section of underground water tank (original 1-100)
SPECIAL FEATURES

Four pumping houses are installed at the beginning ends of each ‘finger’. They pump the treated wastewater from underground pipes and disinfect the water. Each of them is 5 meter high and acts as a landmark for each ‘finger’.

Pipes on top of Wetland 1 are installed above the ground, while the others are underground pipes.

11 underground water tanks are installed in community garden areas. These tanks store the purified water released from Wetland 2. Each water tank has a hand water pump for gardeners to pump the water up and to carry it to water their plants (see figure 6.47).

Four compost areas are located in the community garden areas, one on each ‘finger’. Gardeners can use the compost to fertilize their plant. Details of caring the garden without the use of artificial fertilizer, chemical herbicide, and pesticide will be clearly described in the maintenance instructions section.

Two greenhouses are installed, with one on ‘finger’ 1 and the other on ‘finger’ 3. Due to Winnipeg’s cold spring, seedlings can be grown in the green houses prior to transplanting into the plots.

A parking lot is proposed with an entrance on Main Street. It is convenient for people who come to the site by cars.
Concrete
Asphalt
Black granite gravel

Figure 6.48 - Plan of new materials
MATERIAL PLAN

The choice of material depends on the usage and the area’s susceptibility to flooding. Concrete is used in the wetlands and stairs areas because concrete is water resistant and the shape is easily casted. In ‘finger’ 1, 3, and 4 where flooding may occur, asphalt is used. This material would not be washed away by flood and it has some permeability. Black granite gravel is used in the areas that do not get flooded, including the parking lot and some of the garden areas in ‘finger’ 1, 2, and 4.
SECTION ELEVATIONS
Original 1-1000
Figure 6.52 - Site plan (original 1-500)
Figure 6.55 - Section Elevation GG (original 1-1000)
MAINTENANCE INSTRUCTIONS

The purpose of the maintenance instructions is to ensure the landscape functions as envisioned. The maintenance instructions include wetland substrate replacement, soil care, weed control and pest control. Moreover, these will help the site to be cared for by the user with available resources and help the site function properly.

Wetland Maintenance

Regular wetland maintenance – the removal of vegetation from outlet pipes and removal of harmful species such as invasive plant species should be done periodically.

Wetland substrates replacement – the substrates of the wetlands should be replaced every 5 years. This could be done by professionals hired by the manager.

Community Garden Maintenance

Soil care – Artificial fertilizers are not recommended. Planting of some legumes is recommended as they can fix the nitrogen in the soil and fertilize the soil. Dead plants are to be collected and composted. This should be done by the gardeners who rent the planting plot.

Weed control – The use of chemical herbicide is restricted. Weeds can be limited by putting buckwheat straw, cattail straw or reed straw on the newly sown fields. Gardeners should limit the fallow period between the planting of cool season and warm season plants.

Pest control – The garden plots should follow planting strategies that use a mix of plants. It is an ideal way to prevent pest populations from booming since mixed planting makes it harder for pests to find their targeted host plants. The healthy plants or seeds that are not attacked can be saved for next season’s propagation.
Figure 6.56 - Series photos of wetland and garden maintenance
7

CONCLUSION
Water pollution has been a serious issue around the world. One type of water pollution is eutrophication, which refers to the overabundance of plant nutrients in water systems. In Manitoba, Lake Winnipeg has a serious eutrophication problem, with one of the reasons being large amount of nutrient loading from the Red River. Winnipeg’s sewage water is a municipal source of nutrients that contributes to Lake Winnipeg’s eutrophication. Most of Winnipeg’s sewage water is treated by wastewater treatment plants before it ends up in the rivers. The wastewater treatment plants improve the quality of sewage water, but the level of nitrogen and phosphorus, two of the main contributors, are still high. UV light effectively kills pathogens and constructed wetlands effectively remove nitrogen and phosphorus in the water. These two methods can be incorporated in landscape design as ways to treat the sewage water. Successful landscape projects involving wetlands as water treatment methods have been built in China. These projects also work as pleasant outdoor spaces that have nature and social services. Such a landscape project should be built to solve the water problems of the treated wastewater from Winnipeg North End Water Pollution Control Centre, and reuse the water for community garden irrigation. The green space to the east of Winnipeg North End Water Pollution Control Centre potentially provides spaces for disinfection systems, constructed wetlands and other recreation demands. With the analysis of the site, the designed landscape can disinfect the treated wastewater using UV light and remove phosphorus and nitrogen through constructed wetlands, and provide safe water for community garden irrigation, while creating an enjoyable outdoor space that attracts people from the nearby neighbourhood and other parts of the city.

Through the studies of this practicum, space limitation is found to be one of the major problems of treating contaminant water through natural water treatment processes in the urban context. In this design, only 0.045% of the treated wastewater from Winnipeg North End Water Pollution Control Centre is pumped up for further treatment. However, establishing such a landscape project that treats contaminant water through constructed wetlands is essential due to its experiential, educational, and examination values. People who visit the site will have a better understanding of natural water treatment methods and processes. The site will also provide valuable water treatment data for further research.

One landscape water treatment project may not make a big change in the overall water quality of rivers and lakes. However, establishing a large number of such projects in urban areas, big changes could occur. Therefore, further research, analysis, and design that involve natural water treatment systems such as wetlands should be pursued and these projects should be applied to different places that have water pollution problems.

Ultimately, this practicum is an exploration of purifying wastewater using ecological methods and using the resultant water as irrigation. Hopefully, this project will change the way people think about wastewater, give them an understanding towards treating wastewater using natural water treatment systems, and increase awareness in water purification. I believe with more efforts putting into water purification, the image of Canada’s clean lakes will come true.


Ma, J., Zhu, K., Zhao, L., & Yang, J. (2003). Disinfection of E. coli with UV-radiation combined ozone in drinking water treatment. *Journal of Lanzhou Railway University (Natural Sciences)*, 22(3), 34-37. Retrieved from http://wenku.baidu.com/link?url=Tak03TAvAGKBCMszfUCXuSIo0y__GekcerEHfUkq_WAnSr8sWErknuEyEPnD_LFAb8QWNLm9zBnMoVal5UmDUxoPT1xN0yNlaNIF5BmZt_


IMAGES

*ALL PHOTOGRAPHS AND DIAGRAMS ARE CREATED BY THE AUTHOR UNLESS OTHERWISE NOTICED.

Figure 1.1

Figure 1.2

Figure 1.3

Figure 2.4, 2.8, 2.9, 2.11, 2.16

Figure 2.5

Figure 2.13

Figure 2.22, 2.24, 2.26, 2.27, 2.30

Figure 3.1


Figure 6.11


Figure 6.12


Figure 6.13


Figure 6.14


Figure 6.15


Figure 6.16


Figure 6.17


Figure 6.18

Figure 6.25
https://www.flickr.com/photos/vitenskapsmuseet/4146826606/

Figure 6.30
Gilbert, P. (2015). [Untitled online image of clay]. Retrieved July 02, 2016 from https://pixabay.com/zh/%E5%B9%B2%E6%97%B1-%E5%9C%9F%E5%A3%A4-%E5%9C%B0%E7%90%83-%E7%B2%98%E5%9C%9F-%E5%9C%B0%E9%9D%A2%E5%BC%80%E8%A3%82-960110/

Figure 6.32

Figure 6.33

Figure 6.49
https://www.flickr.com/photos/jetheriot/2333089411/in/photostream/

Figure 6.50

Figure 6.51

Figure 6.56
http://www.glgcgroup.com/services/environmental.html
