PARKLAND IN SUPPORT OF BIODIVERSITY

by

Justin Michel Sylvestre

Submitted in partial fulfilment of the requirements for the degree of Master of Architecture at

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SCHOOL OF ARCHITECTURE

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Signature of Author
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ABSTRACT

The Great Lakes of North America hold about one fifth of global surface fresh water excluding glaciers. These watersheds have experienced environmental stress due to dumping of sewage and industrial waste, as well as pesticide runoff from agricultural lands. As an opportunity to learn about water processes and raise awareness about waste, this thesis proposes an ecological solution for passive wastewater treatment. A master plan informs a site strategy in the community of Stoney Point, Ontario for the design of a passive wastewater education centre. The living machine uses design parameters of function, education, and recreation. This thesis is a proposed solution for combining infrastructural public works building and a treatment wetscape for new public parkland. What is the architectural building form in the study of natural wastewater treatment, and how do these studies inform the conversion of open septic cells into a remedi-ated water park?
ACKNOWLEDGMENTS

This work is made possible by those individuals who have radiated their energies, talents and thoughts since 2006. I would like to thank all friends for inspiring me along this path. Thank you.

Special thanks to my supervisor Roger Mullin. I would also like to thank my official and unofficial advisors: Roly Hudson, Christine Macy, Richard Kroeker, Dave Del Porto and Rob Jamieson.

Finally, my family for their continuous encouragement whose love and support made this contribution possible.
INTRODUCTION

Position

This thesis is a contribution to design solutions for new passive wastewater treatment typologies in a region that is characterized as hot and humid and alternately cold and windy. The proposed living machine is located at the edge of a marsh in a rural landscape. The living machine design primarily focusses on parameters of function, education, and recreation, as they shape program, building and landscape. A master plan informs a site strategy at the scale of the community.

These passive systems are formerly known as solar aquatics. These ‘machines’ are commonly very cellular in design (Todd). Aerated aquatic tanks that hold vegetation and wastewater can be eliminated to simplify the system (Del Porto). The proposed solution provides a thin blanket that covers a portion of the treatment wetscape. As an opportunity to learn about water processes and raise awareness about waste, this thesis proposes an ecological solution, making passive wastewater treatment a model educational in the community of Stoney Point, Ontario. Localizing community growth contributes to place making creating new parkland and connecting eastern communities of Lakeshore connecting park lands to park lands and communities.

The Great Lakes watershed has experienced environmental stress that is caused by dumping of sewage, dumping of industrial waste and pesticide runoff.
Mapping Ontario bioregion.
from agricultural lands. The practice of these industries endanger food chains, fish populations, and human health (Wikipedia). The image on previous page 2 indicates the bioregion of Canada, the location of site in relation to the Great Lakes, and the water runoff from agriculture fields after rainfall. Stoney Point is located in the Municipality of Lakeshore, and is geographically positioned at the southeastern edge condition of Lake St. Clair.

Analysis of exercised logistical requirements to shaped understanding of how passive wastewaster treatment systems function. Volume, flow rate and hydraulic resonance time, influent, effluent, gallons per day (g/d) and cubic meters per day are common vocabularies for treatment systems. Key drivers that support ecological treatment systems for treating wastewater passively are as follows: settling tank underground, roofed lagoon aquatics and open lagoon wild life. The open lagoon system is a wetland aquatic treatment system. These systems have design criteria named hydraulic resonance time, (BOD) biological oxygen demand loading rates and water depth (Crites 1998). Passive is defined by moving water with holistically using natural processes of gravity that effectively clean wastewater without the addition.
Southwestern Ontario is situated in a mixed wood plains known as the Carolinian forest. In the mid eighteenth century, the area experienced deforestation. In the mid nineteenth century, the area changed from small farms to larger industrialized agricultural practices. Consequently, traces of old depleted timber frame barns and fragmented patches of native forest are left. Conservation strategies such as ephemeral wetlands, ground water recharge, and landscape restoration are becoming increasingly impor-

of chemicals (Todd). Passive systems rely on hydraulic efficiency (Jamieson). Conventional return activated treatment facilities require mechanical activation and an intricate network of pipes. Ecological is defined by CO2 consuming and CO2 producing. Chemicals are not added into final stages of treatment process. Wild life is the final treatment.

**Landscape**

Southwestern Ontario is situated in a mixed wood plains known as the Carolinian forest. In the mid eighteenth century, the area experienced deforestation. In the mid nineteenth century, the area changed from small farms to larger industrialized agricultural practices. Consequently, traces of old depleted timber frame barns and fragmented patches of native forest are left. Conservation strategies such as ephemeral wetlands, ground water recharge, and landscape restoration are becoming increasingly impor-
tant to promote biodiversity in the area (Dean, Hunter and Morse 2009, 3). The existing forest is mostly condensed around lotic marsh ecosystems, they remain near tributaries, streams and constructed canals.

“Lotic ecosystems sustain some productivity of algae and aquatic plants, but their primary production is not usually large. Most productivity of aquatic invertebrates and fish in lotic ecosystems is sustained by inputs of organic matter from upstream lakes and from the terrestrial watershed in the form of plant debris.” (Freedman 2010, 98)

Point Pelee National Park marshland.
Willow Beach marshland.
Bevel marshland.
Riviere aux Canard marshland.
Holiday Beach marshland.
Collage: existing marshland in Essex County. Orthographic plan drawings of each marsh have been drawn to same scale.
Soil map of Essex County.
Existing carolinian forest.
Lake St. Clair.
Left: memory models found in this building culture tectonic structure.
Right: landscape models of lotic ecosystems.
Point Pelee National Park is a major conservation area geographically situated in Canada’s southern most part.

**Municipality**

The Municipality of Lakeshore in Stoney Point, has acknowledged wastewater treatment issues and is currently proposing a centralized solution connecting several communities with a conventional activated mechanical sewage treatment facility (Town of Lakeshore). The proposal situates the facility adjacent to the existing lagoon treatment cells in Stoney Point. The centralized solution involves kilometers of excavation that disturbs existing regional service lines of hydro, telephone lines, ditches and roadways. This disturbance can be avoided by providing an ecological treatment facility in each community. Images on page 16 study the current master plan provided by the municipality of Lakeshore website.

**Site**

Directly north of Point Pelee and across the mainland of Essex County, the site for the thesis is located (on the fringe of a marsh) in the southeast periphery of Lake St. Clair. In the town of Stoney Point the original natural ecosystem was altered in several ways including urban settlement along the water, farming settlement, passenger railway, altered tributary, and constructed open septic cells for sewage treatment. The site for this thesis has a history of infrastructural work that permanently changed existing marsh land and tributary systems. The railway is obvious evidence of a severing of the Marsh. The map on
Recommended sewage service alternative.

Unserviced wastewater study area.

Existing sewage service area.
right on this page identifies the original location of Little Creek River. We can assume this was due to pragmatic cultivation practice and land parcellation. Late 1970, sewage lagoons emerged as engineered landscapes. They were a solution to wastewater treatment in 1970s (Feedman). How do you reclamate sewage lagoons and convert them into a public works education facility?

In the community of Stoney Point, existing wastewater treatment lagoon cells are currently treated with aluminum sulphate and are drained into the water system every 6 months. In treatment cell number one (refer to page 22) sludge from this lagoon has been accumulating since 1978 (Piescic). Lagoon cell number two was cleaned recently. Here, the biological oxygen demand (BOD) is below Ministry of Environment standard by 60% (Touralias). This is the typical sewage treatment for small urban settlements in area. Each town has a settlement size averaging eight hundred residences and three thousand people per community. Other smaller communities in the surrounding area continue to utilize private on-site septic systems that are becoming an increasing environmental concern (Specifically Lighthouse Cove and Rochester Place) (Town of Lakeshore).

Place Making for Lake St. Clair

Currently, each community around the southeastern border of Lake St. Clair has a conservation area but they are inaccessible. Some area’s show evidence of foot paths. The conservation parkland in Stoney Point has an existing trail however it is uninviting for simple leisure activities such as
walking, running and biking. These proposed conservation areas along the waterfront can create a better sense of place by renovating existing footpaths adding nodes on the waterfront, building lightweight bridges (and boardwalks) over canals, in high water table areas, respectively. Place making for this thesis is about localizing the pedestrian experience by connecting path from parkland to parkland and community

**A Decentralized Solution**

Decentralizing wastewater treatment allows each community to develop a urban metabolism to support community growth and generate an industry flow of nutrients.

“The concept of ‘metabolism’ can be used to form an understanding of this process. As applied to people or other animals, metabolism refers to the processes that are used to produced food and energy for the conduct of daily living. ‘Urban metabolism refers to the material and energy inputs needed to meet living and non-living components of urban systems...’ (Moughtin, Moughtin and Signoretti 2009, 171).
The proposal substitutes a centralized wastewater treatment system (solar aquatic living machine) for smaller natural treatment systems. They are assets for communities as the plant tissue take nutrients and convert them into biomass. Some of the benefits of these natural systems are: livestock feed for farm animals, fuel for biomass, and compost for fertilizer (Freedman). The design and planning for the town of Stoney Point can be a model for the surrounding communities and region. For instance, waste products are integrated into the wider ecosystem enabling new input of material and energy where the output of waste is minimized (Moughtin, Moughtin and Signoretta 2009, 172).

Passive wastewater treatment facilities are also named living machines formerly known as eco-machines and solar aquatics (Todd). Research for the design of living machines and small decentralized wastewater treatment systems was made possible through working directly with David Del Porto at Ecological Engineers and Rob Jamie- son at Dalhousie University Faculty of Environmental Engineering. Together we have designed a passive treatment system that specifically examines open lagoon treatment in a cold climate condition. This part of the design process began by asking the question: how can we optimize the conversion of open lagoon treatment cells into a remedi- ated water park that can treat wastewater naturally?
Metabolism drawing of decentralized locations for eastern communities in the municipality of Lakeshore. Dark blue color represent area of nutrient collection from wastewater flow in each community. The axonometric graphite lines indicate unused parkland and location of proposed pathways in new parks.
This image from google maps identifies land fabric surrounding Stoney Point. The red outline is the location of existing conservation and treatment lagoon. This is the location of the master plan proposal.

Stoney Point context drawing outlining farmland parcellation, automobile transportation roads and Stoney Point urban area. The blue area is the location of existing sewage cells to be remediated and converted into a treatment education centre. The red outline is the indicate the Master Plan and treatment education centre.
The image above identifies adjacent land fabric and views of master plan proposal. Key legend of views are as follows: 1) farmland, 2) proposed location of wastewater education centre, 3) open space between lagoon and trees, 4) view of marsh land from northeastern corner of lagoon; 5) view of Marsh from existing lookout plateform, 6) View of Lake St. Clair from conservation marsh (See panoramas page 23).
View of land water threshold of proposal. View number two is the proposed location of the wastewater education centre.
Existing condition of treatment lagoon cells in background.
DESIGN

Master Planning the Park

The park includes three landscape conditions. The first condition is natural landscape including a farm, a marsh, and a lake; the second is an engineered landscape and includes a composting collection facility, a roofed lagoon (living machine) and an open lagoon; the third is the...
cultural landscape including pool house, cultural facility, and remediated lagoon. The visitor activity centre acts as a node in the landscape and links into the broader urban strategy. This is the primary meeting place when visitors visit the wastewater education centre. The cultural facility is an assembly for gathering that can accommodate small groups of one hundred people.

Diagrams of master plan.
Industry flow diagram suggest is a circular metabolism for Stoney Point.
Water Park Now Accessible

A developed master plan organizes a framework for community growth and logistics for building design. To accommodate public access, the master plan includes pathways, boardwalks and parking. The planning and design of this park is site specific, but it can also become an analogous model for surrounding communities of Lighthouse Cove, Rochester Place, and Comber. Each community can benefit from a treatment wetscape as they have the potential to act as economic engines that support local community growth.

Function

The primary building design for this wastewater treatment facility aligns itself with the secondary treatment phase. Excluding the headworks collection, the wastewater education facility is a three phase treatment. The primary treatment phase is simply one large settling tank located underground adjacent to secondary treatment. The secondary treatment requires building a transparent blanket over treated wastewater for three reasons: 1) to cover a portion of the lagoon to retain heat from incoming influent water, 2) provide shelter from outdoor elements during colder months, and 3) allow sun light to pass through roof envelop. Covering the living machine is critical for this passive wastewater treatment in cold climates. The tertiary treatment phase is an open lagoon treatment wetscape.

The function of this building design was determined by
looking at other solar aquatic systems. They typically vary in size and organization depending on flow rate demand. Most common solar aquatic systems are designed with two rows of double train aeration tanks (eight tanks per row). The organization of these tanks uses the following principle of reactor systems: reactor A is named 'completely mixed reactor' and reactor B is named 'plug flow reactor'. B optimizes hydraulic efficiency as water movement can pass through the flow channel. A is inefficient as it falls outside of the flow channel developing a dead zone during water turbulence. Most solar aquatic systems apply principle B that maintain a length to width ratio between 1:5 and 1:10. (Jamieson).

Secondary treatment is also named covered lagoon and living machine. Four functional requirements for designing this living machine are: 1) maintain 1:5 to 1:10 ratio, utilizing the plug flow reactor system, 2) prevent weather from entering the building during cold winter months, 3) provide a flat covering over roof lagoon secondary treatment, and 4) cross ventilation during warm summer months. The roofed lagoon retains heat from influent water during the cold winter months. Living machine inherently function as a passive system. Some of their positive attributes are as follows:

- they minimize carbon monoxide emissions.
- grow vegetation for compost and animal feed.
- reduce noise in building.
- produce temperate indoor climate.
- gravity systems require less mechanical pumps.

Diagram of two reactor types. System A is named completely mixed reactor and system B is named plug flow reactor. System B optimizes hydraulic efficiency (Jamieson).

Yellow denotes location of sunlight entering roof envelop of the living machine.

Thin shell concrete lightwells support envelop and absorb thermal radiation. This absorption assist regulating indoor air temperature.

Ventilation aperture opens at temperature exceeding **26 Celsius** (80 Fahrenheit).

Vegetation growth in building requires maintenance.

Influent

Effluent

Water flow continues to tertiary treatment process

Input resources are wastewater and waste heat.

Water temperature should not fall below **10 Celsius** (50 Fahrenheit).

To optimize microbial growth, water temperature should stay between **25 - 30 Celsius** (78 - 86 Fahrenheit).
These passive (building design) strategies capture natural elements such as wind and sunlight to assist with building operations.

The primary structure of the building acts as a thermal mass and contributes to passive building strategies. The roofed lagoon has a primary roof structure that is constructed of reinforcement bars and concrete. Thin shell concrete (roof structure) light wells absorb sunlight through the envelop (building stays warmer in winter and cooler and summer). For example, the Stuttgart Train Station in Germany has influenced the design of this structure. Minimizing concrete coverage by maximizing the tensile strengths of rebar, these thin shells create elegant concrete structures. Felix Candela, builder, engineer and artist, has built many thin shell structures.
The interior floor surface is the aeration tank of hydroponic plants that are pathogen removing species and effectively ‘purify’ water. This body of water in the building pertains to the following: nitrification, denitrification, temperature, attached growth, light, carbon requirements, time, micro-nutrients, oxygen and morphological impediments. From a functional point of view, the architectural implications are concerned with temperature and light.

A suspended floor network spanning from service corridor to service corridor crosses the body of water in the building to allow for the maintenance of vegetation. During the summer months, natural ventilation is utilized to keep the indoor temperature below or at 26° C (80° F) (Tregalis).
Drawing of aperture systems that is integrated into the design of the living machine. They can be mechanically or manually operated systems. Manual operation allow facility operators to engage with the architecture of the building and places them in closer relationship with weather.
This architectural design process model investigates movement inside the frame by pulling connected lines. This model is part of Material Investigation course. Professor R. Mullin.
Sequence of aperture opening and closing.
The architectural principle of cross ventilation is utilized during summer months of June, July and August. Operable apertures in roof vents naturally ventilate warm air out as prevailing wind passes through. The prevailing wind in the area comes from three main directions: 1) southwesterly prevailing winds are strong, 2) northeasterly winds are frequently light, 3) northerly winds are cool and light. Birds eye view wind study model specifically examine how southwesterly winds occur on site. Orange area denotes deposit mostly on leeward side of buildings and berms. (See page 32).

**Education**

Living machines have excellent air quality conditions (Todd). They function like a marsh and breath like a rainforest (Tregalis). Providing spaces in the building will give people an opportunity to learn about wastewater and holistic treatment processes of living machines. The proposal considers spaces for two, six, and more and creates a passive wastewater education facility that is an accessible public building. Air and spatial light qualities from plants make these spaces desirable to visit.

The solution for remediating existing sewage lagoons while providing a new wastewater treatment facility for Stoney Point has been simplified by increasing the hydraulic resonance time of wastewater passing through (Jamieson). Typical conventional activated wastewater treatment facilities can process waste in eight hour intervals through activated mechanical equipment. After wastewater passes through head-works cleaning (most wastewater treatment facilities require
Flow rate of water passing through Stoney Point sanitary sewer lines. This flow rate was calculated by dividing current population of 2200 people over current flow rate 920 m³ per day. Data is from Town of Lakeshore 2008 Water and Wastewater Masterplan.
Diagrams of Stoney Point outlining water works and urban area. Projected demand triples in the following 50 years (Town of Lakeshore).
initial cleaning), this system has three steps that require 4, 20, and 90 days in total, to gradually purify wastewater.

The first step is primary treatment. Water passes through settling tank that has a four day (HRT) hydraulic resonance time (Jamieson). During this step of solids collection biogas is harvested for electricity generation (Del Porto 2009, 20). The secondary treatment step is the covered lagoon living machine. During this step the system practically becomes a grey water system having already removed 97 to 99 percent pathogens in the wastewater (Todd). This treatment has a 20 day resonance time (Jamieson). After the effluent passes through treatment step two, removal of pathogens have usually increased up 99 percent (Todd). Final treatment is located in the open lagoons where wild life of the area polish the final phase of water and remediate the open lagoon. This third and final treatment step has a 90 day resonance time period creating place for wild life to migrate.

Papyrus, flowering ginger, hana, primrose and elephant ears are a selection of plants that are pathogen removing (Tregalis). They are common plants in solar aquatic treatment facilities. Other plants that can grow in the covered lagoon living machine are cattails and water lilies (Jamieson). These plants grow in ‘wastewater’ and depend on subsurface flow. Water passes slowly through special surfaces of the plant roots. In time plants grow larger as the process of nutrient cycling continues. The systems have seasonal intelligence creating a biological niche where water is purified by microscopic algae, fungi, bacteria, plants,
Treatment steps for passive wastewater treatment.

**Settling Tank** 4 day hydraulic resonance time

**Covered Lagoon** 20 day hydraulic resonance time

**Remediation Lagoon** 90 day hydraulic resonance time

Treatment steps for passive wastewater treatment.
and snails. Snails feed upon both plant and animal matter. They breathe through a lung-like cavity and exchange gases through their skin (Lyon and Jordon 1989, 125).

The covered lagoon treatment must have a ratio between 1:5 and 1:10. We learned earlier that this ratio optimizes hydraulic efficiency for passive wastewater treatment system strategies. Drawings on the following pages illustrate composite design that negotiate the area required for the lagoon volumetric. Water slabs must have a minimum coverage 1.5 meters and maintain a depth of four meters for both lagoons. The established design criteria for this living machines is as follows:

- the envelop is a blanket light membrane.
- designed to allow future phases 2 and 3.
- water slab of 4 meter thickness.
- ceiling height must be four to six meters above water surface to accommodate vegetation growth.
Drawings of marshland were positioned adjacent to treatment cells applying form finding pattern on the site. These design drawings scale approximate scale of marsh land pattern and lagoon cells.

Building ratio 1:5 and 1:10 analysis.
Logistical sequence drawing one.
Logistical sequence drawing two.
Logistical sequence drawing three.
Logistical sequence drawing four.
Logistical sequence drawing five.
Drawing showing phase one, two and three of secondary treatment. Calculations accommodate population growth and have segmented the project into three building phases. Each phase can function as a separate ecosystem within the living machine system. John Todd biologist of Ocean Arks International claims that you can harvest Japanese koi fish, tomatoes and fungi in the grey water system.
The roof covering does not require very much material to keep weather out of the living machine. The image above is a design process model using materials that reference the forestry and fishing industry. This system is prestressed. Prestressing is often used as a floor condition that achieves long spans.

Net patterns are in tension. These patterns can be used as a structural reinforcement grid for thin shell concrete structures.
- foot print length to width ratio must be between 1:5 and 1:10.

The design began by understanding above criteria and designing sequence patterns and diagrams that inform a building site strategy.

A device was made that allow tensile fabric to be manipulated and studied. This device was constructed to study form of a light well column. These column are arranged in a hexagonal grid supporting the covering of the roofed lagoon. The column spacing has a span of approximately fifteen meters.
Making the light well unit by trowelling plaster over wire mesh. Original scale 1:75.

Laborers placing the concrete on the shell of the Bacardi Rum Factory. (Garlock and Billington 2008, 163).
Light well unit.
Collage: This is a representation of activities, plant life and spatial light qualities in the covered lagoon living machine.
Recreation

Landscape remediation is part of the tertiary treatment process where life can migrate and inhabit the area completing the final phase of the treatment (Jamieson). The final step to this wastewater system is an opportunity in becoming a public parkland. The water has a continuous circulation path that circulates through the new pathway by Lake St. Clair connecting it into the water park. The pathways include walking, running and biking. The open lagoon is an activity centre contributing to public parkland along the lake and in the region.

Topographic study models explore a gradation of landscape patterns that bring new shape and form for the design of berms and swales of the remediated lagoon. The process of moving wire through clay informs the shape of earth berms and drainage swales.
Collage: people utilizing the water park.
Site section drawing. Original scale 1:1000.
Critical section through wastewater education centre. Original scale 1:75.
SUMMARY

Will the light well thin shell concrete units perform?

The light wells have been explored for their shape and spatial qualities. We are beginning to consider the unit as system. The concrete units as primary structure introduce new design criteria and present questions and concerns: would it redirect rainwater or collect it, is concrete exposed to weather, how is the envelop connected to structure, is the roof accessible for leisure and recreation. It was mentioned during the examination that the thin shell concrete units as roof structure would not work as a thermal mass during the winter months. Greater analysis for studying systems performance is necessary for the envelop. Again, the skin membrane that function like a thrombe wall could potentially moderate the indoor air temperature. Conventional greenhouse designs require heavy heat loading as heat loss in these buildings is very high.

Urbanizing Wastewater Treatment in the Town

The current proposal for this thesis sets the wastewater education centre on the fringe of the community in parkland. Perhaps this centre should be combined with water filtering processes that are currently in the centre of Stoney Point. Separating water filtering and wastewater treatment is perhaps an old model for treating water. Combining both ends of treatment within the town is an opportunity to develop civic space and revitalize local communities in the region.
Relocating the wastewater education centre in the town of Stoney Point.

**Botanical Vessels**

Final comments from the examination discussion have expressed that this proposal is a reminder of botanical gardens specific projects include The Eden Project in Cornwall and The National Botanical Garden of Wales in Cardiff. These projects successfully attract an economy of tourism in the United Kingdom. These buildings often stimulate an economy by attracting tourist however, I sense that they don’t necessarily answer local issues. This thesis is a local issue searching for a local solution. As my antithesis, the design of large botanical gardens in this area can be optimized by placing these ‘gardens’ in the Great Lakes. This can be a large scale solution toward re-envisioning our relationship with the watersheds of the Great Lakes and mitigate those ecological challenges of wastewater handling in the Twenty-First Century.
New proposal multiplied at land water threshold around Lake St. Clair and Lake Erie.

Collage: vessels purify water quality as they gently move slowly in the Great Lakes. These vessels have the potential in becoming lake side attractions that encourage water parks.
APPENDIX

Influences

Systemic reclamation of potene marsh in Italy by Allan Berger.

Sculpture of playground by artist Isamu Noguchi.

Soap film bubble model by Frei Otto.
**Illustrating Solar Aquatic Types**

Collage: large roofed lagoon of the palmer lagoon system as a stand-alone solar aquatic facility. Image above is a large lightweight roof covering. The image below is a plan view of the existing lagoons.

Image: small conventional greenhouse of ecological engineers solar aquatic facility at Weston, Massachusetts. The exposed concrete foundation surface has evidence of decay.

Image: long single pitch roof passive solar eco-machine of Omega Centre for Sustainable Living at Rhinebeck, New York. The aeration tank on the right holding plants is a concrete tank.
Solar Aquatic Systems are Worldwide

<table>
<thead>
<tr>
<th>Location of plant</th>
<th>Est. date</th>
<th>Avg. flow (gpd)</th>
<th>Max. capacity (gpd)</th>
<th>Service area (# homes)</th>
<th>Bldg size [m²]</th>
<th>Designer</th>
<th>Notes</th>
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<td>1992</td>
<td>1,000</td>
<td>-</td>
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<td>-</td>
<td>EEA</td>
<td>Pop. 10,000/30,000 in summer</td>
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<td>EEA</td>
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<td>-</td>
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<td>11,000</td>
<td>29</td>
<td>95</td>
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<td>4,000</td>
<td>-</td>
<td>factory</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>LM</td>
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<td>-</td>
<td>-</td>
<td>180</td>
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<td>-</td>
<td>-</td>
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<td>1999</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>EEA</td>
<td>incl. sewage from 30 businesses</td>
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<td>Darrow School, New Lebanon, NY</td>
<td>1998</td>
<td>8,500</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>LM</td>
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<td>Beausoleil, Errington, BC</td>
<td>1996</td>
<td>10,000</td>
<td>13,800</td>
<td>46</td>
<td>210</td>
<td>EEA</td>
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<td>Natl. Audubon Society, Corkscrew, FL</td>
<td>1994</td>
<td>10,000</td>
<td>45,000</td>
<td>50</td>
<td>200</td>
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<tr>
<td>The Body Shop, Littlehampton, UK</td>
<td>1996</td>
<td>13,000</td>
<td>-</td>
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<tr>
<td>Town of Bear River, NS</td>
<td>1995</td>
<td>15,000</td>
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<td>75</td>
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<td>Findhorn Foundation, Scotland</td>
<td>1995</td>
<td>17,000</td>
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<td>-</td>
<td>-</td>
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<td>Meze, France</td>
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<td>140</td>
<td>630</td>
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<td>-</td>
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<tr>
<td>Conserve School, WI</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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<td>Ethel M Chocolates, Henderson, NV</td>
<td>1995</td>
<td>32,000</td>
<td>104,000</td>
<td>150</td>
<td>665</td>
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<td>Mars Inc., Recife, Brazil</td>
<td>1997</td>
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<td>-</td>
<td>factory</td>
<td>-</td>
<td>LM</td>
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<td>City of Frederick, MD</td>
<td>1993</td>
<td>40,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>LM</td>
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</tr>
<tr>
<td>Earth Centre, UK</td>
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<td>40,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>LM</td>
<td></td>
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<td>City of San Francisco, CA</td>
<td>1994</td>
<td>50,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>LM</td>
<td>Pilot project</td>
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<tr>
<td>EFFEM Produtos, Mogi Mirim, Brazil</td>
<td>1998</td>
<td>75,000</td>
<td>-</td>
<td>factory</td>
<td>-</td>
<td>LM</td>
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<td>Beaverbank Villa, NS</td>
<td>1995</td>
<td>80,000</td>
<td>250,000</td>
<td>410</td>
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<td>South Burlington, VT</td>
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<td>240,000</td>
<td>400</td>
<td>1630</td>
<td>LM</td>
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<td>Master Foods, Wyong, NSW, Australia</td>
<td>1995</td>
<td>100,000</td>
<td>214,000</td>
<td>factory</td>
<td>2100</td>
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<td>-</td>
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<td>La Fuente, La Paz, Mexico</td>
<td>1994</td>
<td>155,000</td>
<td>285,000</td>
<td>-</td>
<td>3885</td>
<td>LM</td>
<td>Housing for 3,000 people</td>
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<td>Pet food plant, Sao Paolo, Brazil</td>
<td>1999</td>
<td>200,000</td>
<td>340,000</td>
<td>965</td>
<td>2700</td>
<td>LM</td>
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<tr>
<td>Kal Klin, Vernon, CA</td>
<td>1997</td>
<td>pilot</td>
<td>-</td>
<td>factory</td>
<td>-</td>
<td>LM</td>
<td>Metabolizes heavy metals</td>
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<td>Jewelry plant, Providence, RI</td>
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<td>factory</td>
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<td>Boyne River School, Toronto, ON</td>
<td>n/a</td>
<td>-</td>
<td>school</td>
<td>-</td>
<td>-</td>
<td>LM</td>
<td>300 students</td>
</tr>
<tr>
<td>Town of Fredericksburg, VA</td>
<td>est. 2001</td>
<td>1,000,000</td>
<td>-</td>
<td>4,000</td>
<td>-</td>
<td>EEA</td>
<td>Planned town of Haymount</td>
</tr>
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</table>

Survey of other ecological wastewater treatment systems worldwide (Macy 2001, 13).
Line drawing showing the rhythm of fly casting. I’ve been attached to this drawing since the beginning of thesis design process. Drawing was created for Material Investigation course. Professor R. Mullin.
REFERENCES

Books and Articles


### Buildings and Projects


People and Organizations


Jamieson, Dr. Rob. Environmental Engineering, Dalhousie University, Halifax NS B3J 1Z1.

Piescic, Dan. Engineering and Infrastructure Services, Lakeshore Township, Belle River, ON NOR 1A0.

Sterling, Dr. Shannon. Environmental Science Program, Dalhousie University, Halifax, NS B3H 4J1.


Touralias, Tom. Project Manager, Stantec Consulting Ltd. Windsor, ON N8X 4L4.

Town of Lakeshore, 419 Notre Dame Street, Belle River, ON N0R 1A0.

Tregalis, Dave. Ecological Engineering Group, Weston, MA 02493.

World Wide Web


