Biomimetic Architecture:

a responsive design approach, that respects and learns from nature, defining a design process with which we can develop sustainable and inspiring architecture of the future.

A Thesis Project Presented By

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A responsive design approach that respects and learns from nature, which focus not only on reducing harm to the environment, but also on being a positive contributor to the surrounding ecosystem.

Consequently, this thesis project was conceived to become an integral part of nature and enhance its surroundings. This was the approach taken for the proposed Fletcher Wildlife Garden Interpretative Center (FWG-IC) – a proposed two-level, approximately 1800m² building, designed to act as the nucleus for an area that has seen a significant amount of re-naturalization over the last 25 years in central Ottawa.

The Client: OFNC's FWG

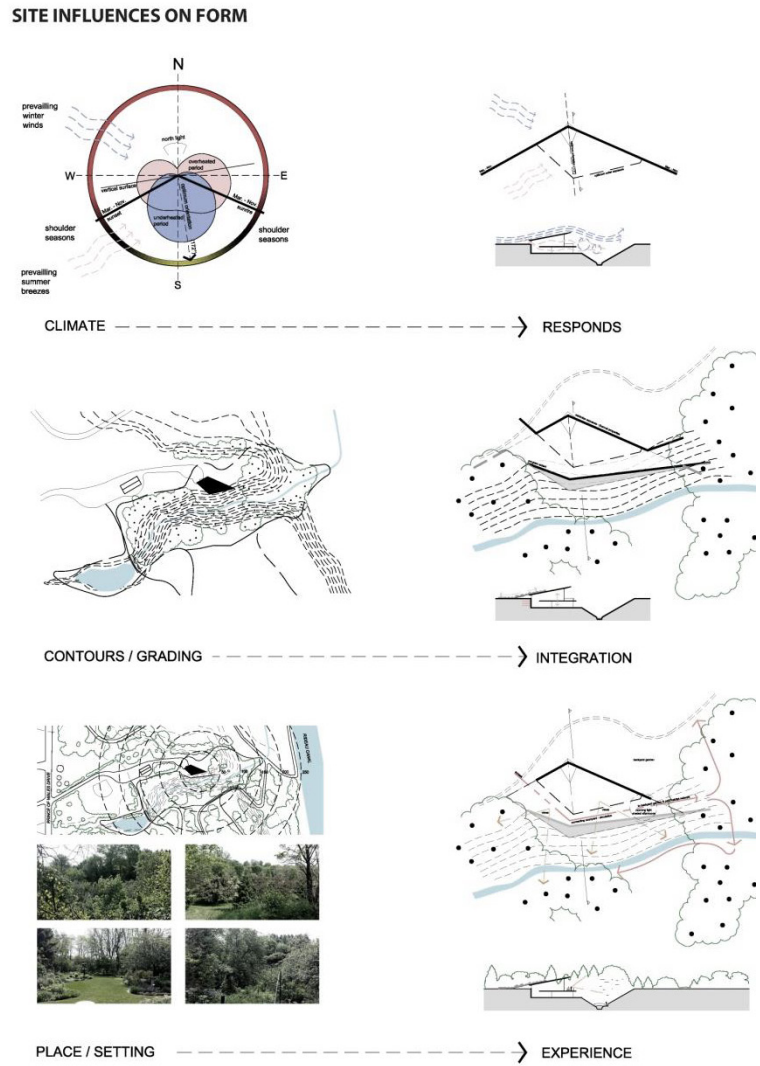
The Fletcher Wildlife Garden (FWG) is a long-term project of the Ottawa Field Naturalists' Club (OFNC). This is a long-term project to demonstrate the value of restoring native habitat in areas where this habitat has been lost or compromised, specifically in urban centers. The current building is small and has outlasted its useful service life and is no longer adequate for the intended use and scope of the potential educational outreach. The new proposed interpretive center will be a landmark for ecological integrity and sustainability, which would make it exceptionally unique to this location.

The interpretive center will address the growing issue of native habitat loss due to the increasing urbanization in Canada. Habitat loss for native flora and fauna is the primary reason for ecological degradation and species extinction. By educating the public via demonstration wildlife gardens, interpretive signage, and from the interpretive center itself, it will be one step in filling a need for further outreach and education as well as potential long-term research to help fulfill the need of FWG mandate.

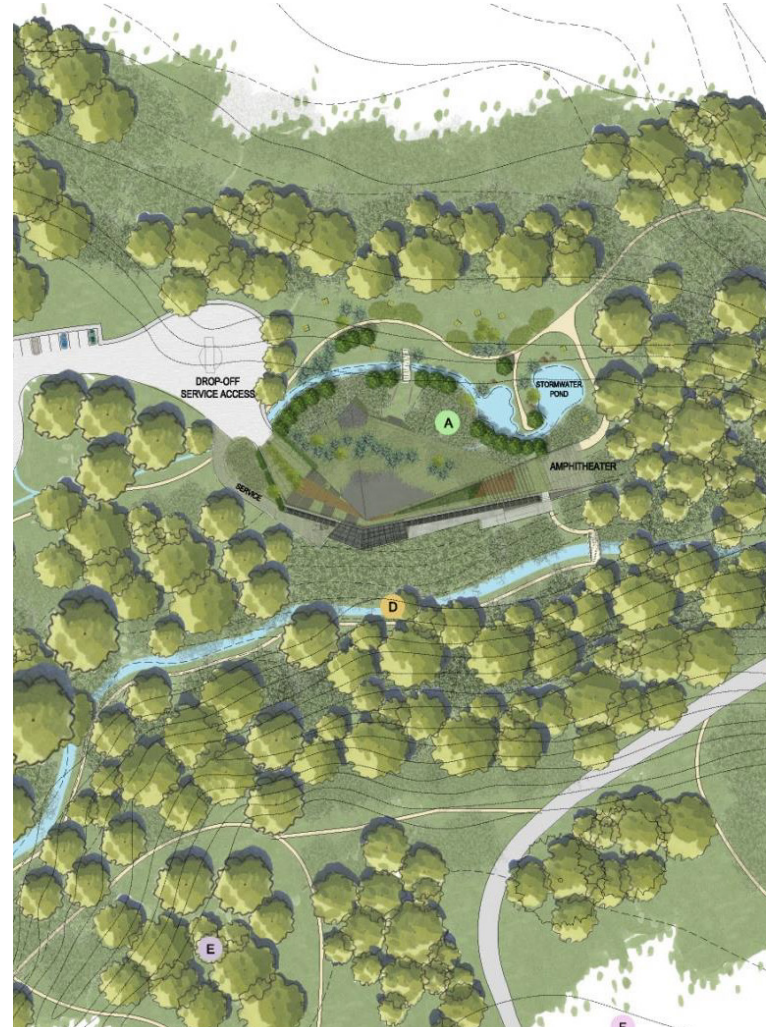
Biomimetic Design Principles

In order to become part of the ecosystem and contribute to area's natural beauty, the design needed to integrate in key areas; each inspired design strategies and defined the form, function, and ultimately the integration of the building into the landscape.

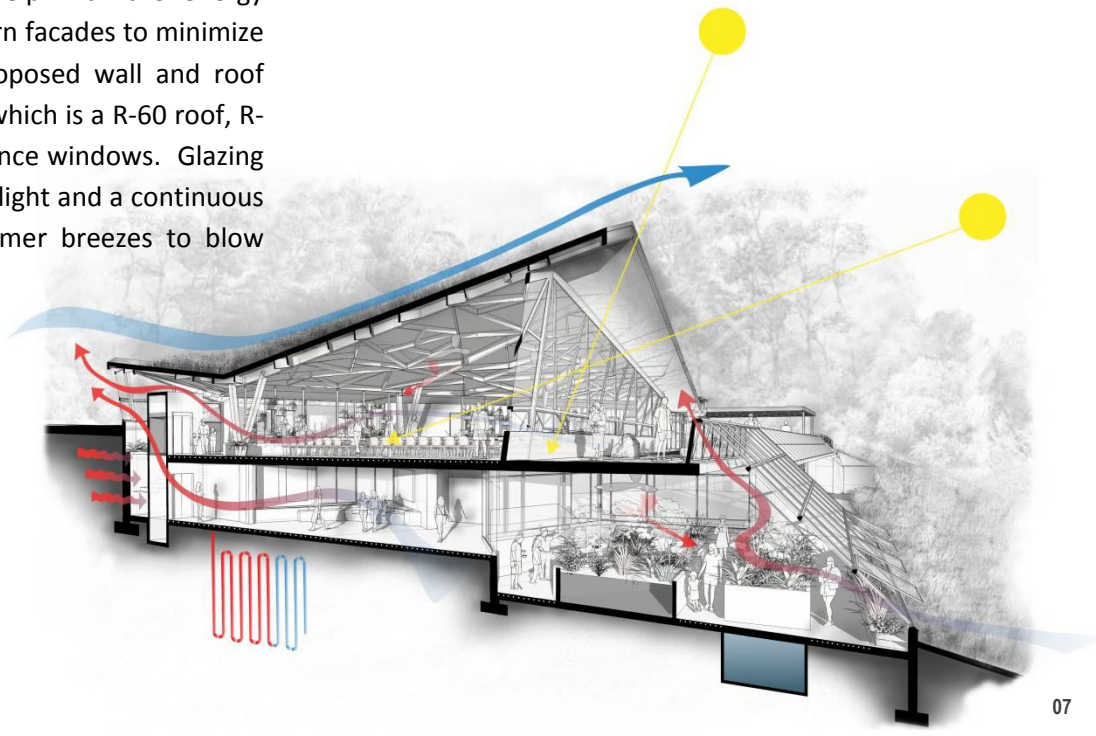
First, the design needed to respond to the specifics of microclimate and adaptable to changing conditions to minimize energy input requirements. – Passive design strategies for heating, cooling and natural lighting. Crucial to this was the interpretation of climatic data, which resulted in the building form responding to optimum exposures throughout the seasons – avoiding sun exposures during the overheating periods and taking advantage of solar exposure during underheating seasons. A cantilevered roof along with a tilted south façade was digitally modeled to react to the path of the sun throughout the year. Different design iterations were tested until an optimum solution was found, meaning the building is shaded during the summer, but allows winter sunlight deep into the building, contributing to passive strategies. Northern exposure was minimized by sheltering most of the façade into the earth, which then becomes less susceptible to the impact of extreme outdoor air temperatures, so the effects of adverse weather is minimized. Temperatures inside the building are more stable requiring less energy inputs.



Second, the building needed to be uniquely embedded in its place, reflecting the natural landscape that surrounds it. Key to this was the removal of the boundaries between the building and the landscape through the integration of building components and systems that stimulate life and biodiversity, extending the design to the landscape. By reflecting the site and ecosystem around it, the building becomes part of the natural environment and shares habitat, water and energy. The proposed exterior materials, such as wood cladding (reclaimed) and natural stone, indigenous to the area, reinforces this idea. The partial planted roof along with exterior gardens provide habitat for other organisms, extending nature to the building. Educational and public areas spill from inside to the immediate exterior gardens and out to the habitat network. A series of bioswales, native plant species and a pond manage stormwater volumes from parking area and the roof, while supporting biodiversity. Captured water is stored in the pond and in an underground cistern, which is to be reused for irrigation, flushing toilets and urinals. Wells top-up water supplies; all wastewater is treated on-site by the incorporation of an eco-machine within the greenhouse, which functions similarly to a wetland, only instead of a body of water, the process occurs within individual tanks, creating independent treatment zones; continuously replenishing and recycling, similar to natural water cycles.



Third, the energy required is achieved by the integration of solar panels along the guard, the greenhouse glazing and parking area. In total approximately 380m² (200 on the building) of surface area is provided, enough for a 95kW PV system, estimated to generate 127MWh per year[1]. It's expected to generate more than enough energy to offset the amount of energy it uses, based on 'Energy Use Intensity' (EUI) of 70kWh/m², which is on par with Canada's most efficient buildings[2]. Geothermal piping brings tempered fluid from deep boreholes. Heat pumps utilize the earth's steady temperature to heat cool and provide hot water. This thermal energy is used for heating the building's water and for heating and to a lesser extent cooling needs. As discussed, the building itself is designed to passively help with the energy requirements, including the design of the northern and southern facades to minimize heating and cooling loads through all the seasons. The proposed wall and roof construction follows the 'Perfect Wall' thermal specifications, which is a R-60 roof, R-40 walls, R-10 slab combined with triple paned, high performance windows. Glazing is provided throughout the southern façade to provide natural light and a continuous connection to the outdoors. Operable windows invite summer breezes to blow through the building, assisted by high efficient ceiling fans.



[1] Modeled using the National Renewable Energy Laboratory (NREL) web platform
[2] Based on NRC's publication "ecoENERGY Efficiency for Buildings"

Last, the focal material is wood; the structure proposed is nearly entirely made up of wood. The project features a geometrically-complex roof, supported by exposed glue-laminated (glulam) beams and struts that were designed as a metaphorical reference to the veins in leaves, but still reflecting the overall architectural expression of the building. The main (expressive) structure is made up of girder beams supported on triangular-shaped columns, secondary and tertiary struts are arranged in a trapezoidal-shaped formation holding thin layers of cross laminated wood panels. A strategic placement of load-bearing members and bracing is anticipated, thus a suggestive lateral support system, focusing on where the heavy vegetated roof is being planned is proposed. Designed and manufactured for easy site assembly and disassembly, without the need of large steel connecting brackets or bolts, each wood member is sized and milled for optimum structural performance by using latest finite element software, where engineers can create an explicitly wood structure executed in an efficient and elegant form. Further, each of the four column-girder-beam assemblies are sized differently, demonstrating a sense of growth as spans increase, which also extends to the south facade structural arrangement. This can be achieved by new prefabrication technologies, which affords a whole new set of possibilities.

Biomimetic Design Product

The proposed interpretive center blends seamlessly with its surroundings in the Fletcher Wildlife Garden and metaphorically similar to a flower, the building reflects its native bioregion; it captures and treats all of its water, it generates its own energy, and it is inspiring. This model of biomimetic design development may seem like a giant leap, but the founding principles are displayed daily as life regenerates. At its core, this design approach aims to enhance the ecosystem around it by producing a surplus of clean energy, water, habitat, and ecosystem amenities. The result is a building that truly reflects the place around it, and the wonder of the natural ecosystem.

Final Boards

BOARDS 1 & 2
Client
Site influences on Form

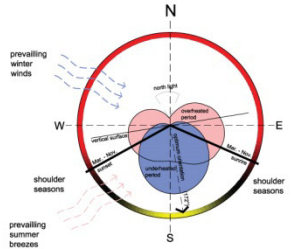
Fletcher Wildlife Garden Interpretive Centre

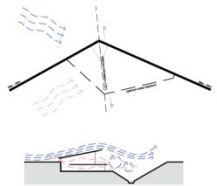
The Fletcher Wildlife Garden (FWG) is a long-term project of the Ottawa Field Naturalists' Club (OFNC). This is a long-term project to demonstrate the value of restoring native habitat in areas where this habitat has been lost or compromised, specifically in backyard gardens. This new proposed interpretive center will be a landmark for ecological integrity and sustainability, which would make it exceptionally unique to this location

Mission Statement:

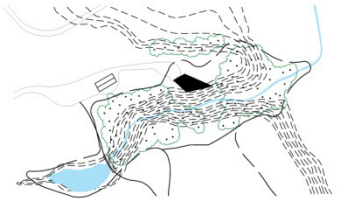
"The FWG seeks to encourage people to create or restore natural landscapes on their property to provide wildlife habitat within the city and to show home owners how they might make their properties, both urban and suburban, more wildlife friendly. The main strategic objectives of the FWG include: outreach and education, habitat improvement and control of invasives. The FWG is accessible to naturalists, gardeners, schoolchildren, and other residents of the city and its suburbs."

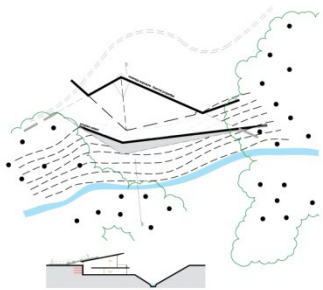
SITE INFLUENCES ON FORM



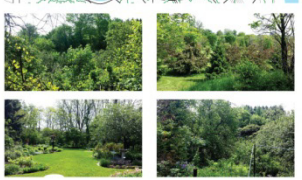


CLIMATE ——— RESPONDS





CONTOURS / GRADING ——— INTEGRATION



PLACE / SETTING ——— EXPERIENCE

BOARD 3
Floor Plans

COMMUNITY ZONE
(Events + Recreation)

The program area where the facility engages the community, providing areas for public functions, including meeting, dining and recreational events

OFFICE ZONE
(Research + Development)

The program area where knowledge is gathered through research and development. The area where most general office of the FWG-IC is located

DEMONSTRATION ZONE
(Teaching + Training)

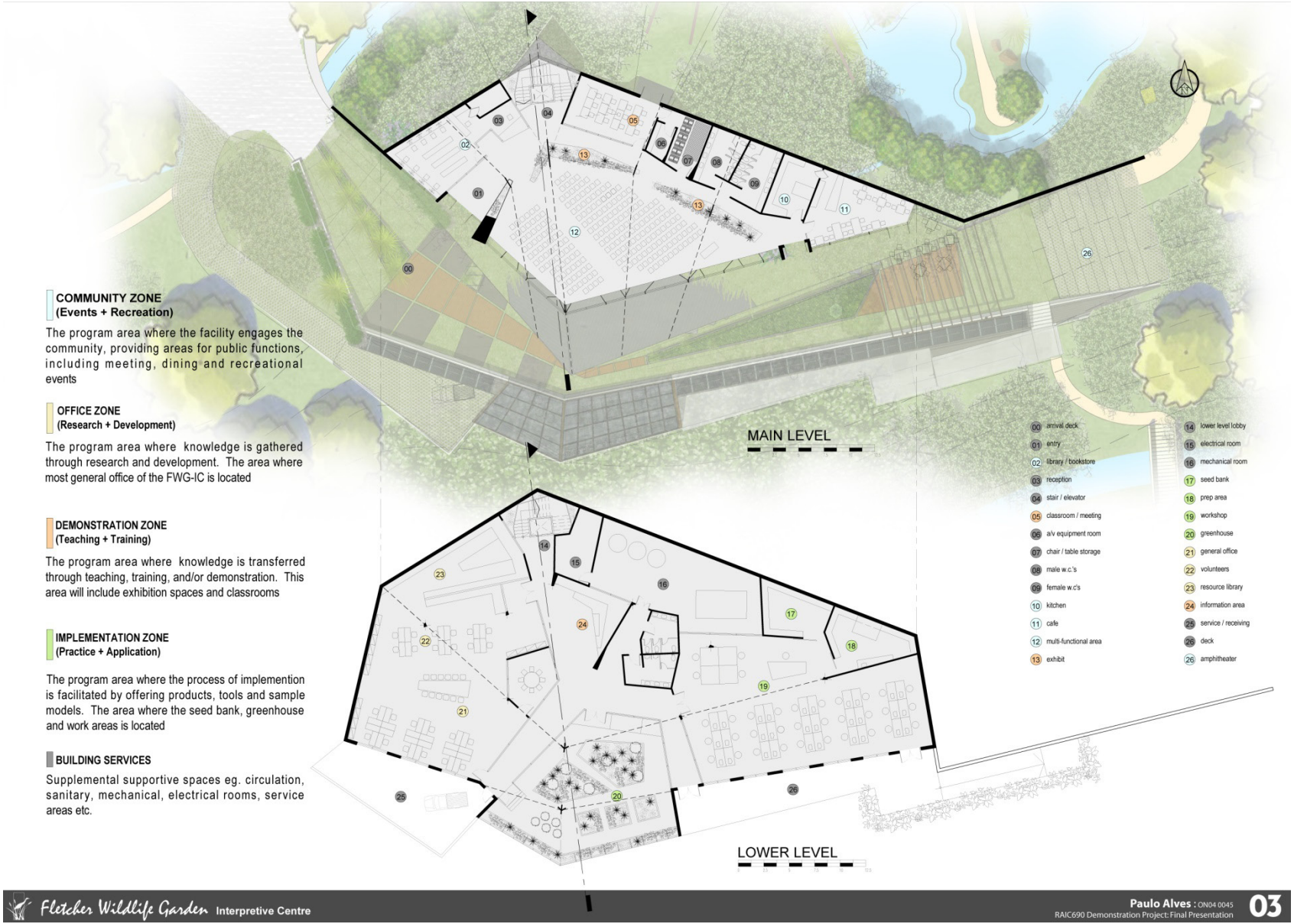
The program area where knowledge is transferred through teaching, training, and/or demonstration. This area will include exhibition spaces and classrooms

IMPLEMENTATION ZONE
(Practice + Application)

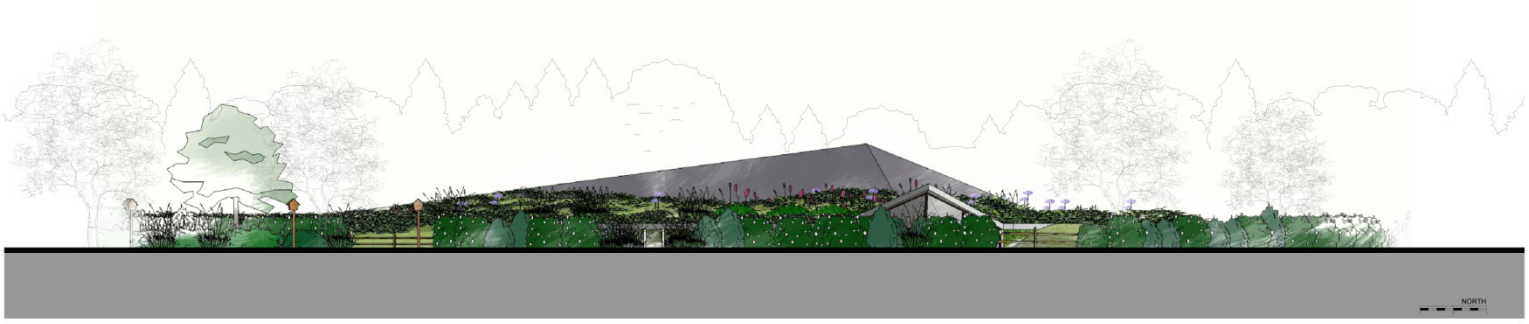
The program area where the process of implemention is facilitated by offering products, tools and sample models. The area where the seed bank, greenhouse and work areas is located

BUILDING SERVICES

Supplemental supportive spaces eg. circulation, sanitary, mechanical, electrical rooms, service areas etc.



BOARD 4
Elevations



BOARD 5
Site Plan

DESIGN FOR INTERFACING LANDSCAPE AND BUILDING

Working in concert with the vegetated roof, the landscaping around the building is designed to slow, channel, filter and absorb excess rainwater from the roof and the site before returning it to the wetland. Additional benefits of this natural approach are that it reduces maintenance and serves as a habitat for wildlife. A combination of strategically located swales, bioswales, and a rain garden receive the runoff from periodic, often intense precipitation, serving as a natural alternative to storm sewers.

BOARD 6
Illustrations

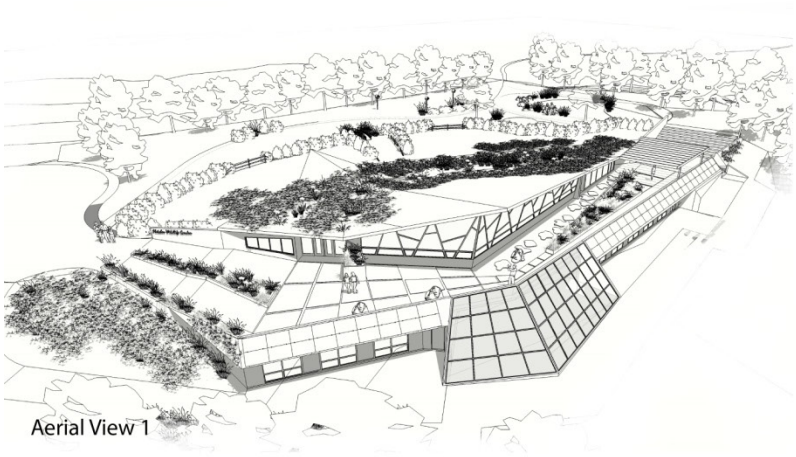
West View

West View - Backyard Garden

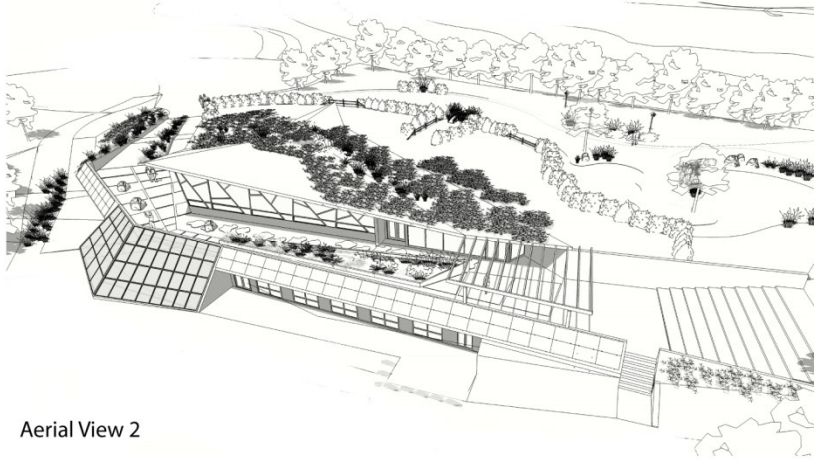
South View

BOARD 7
Illustrations

Entrance



Aerial View 1



Aerial View 2

BOARD 8
Biomimetic Strategies

BIOMIMETIC STRATEGIES

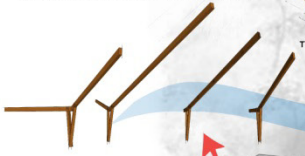
The following is an illustrative summary of some of the strategies being proposed, demonstrating biomimetic principles.

glue-laminated lumber | structure

The main (expressive) structure is made up of girder beams supported on triangular-shaped columns, secondary and tertiary struts are arranged in a trapezoidal-shaped formation holding a thin layer of cross laminated wood panels. A strategic placement of load-bearing members and bracing is anticipated, hence a suggestive lateral support system, focusing on where the heavy vegetated roof is being planned is proposed.

Designed and manufactured for easy site assembly and disassembly, without the need of large steel connecting brackets or bolts, each wood member is sized and milled for optimum structural performance by using latest finite element software, where engineers can create an explicitly wood structure executed in an efficient and elegant form.

TYPICAL COLUMN / GIRDER / BEAM ASSEMBLY



COLUMN / GIRDER / BEAM ARRANGEMENT

vegetated roof | habitat and thermal control

Partially vegetated roof, slows stormwater, helps keep the building cool during the summer, and provides habitat for other organisms. Landscape is allowed to grow freely around the building, bridging the gap between architecture and nature, creating habitat for the many species that exist on site.

glass coatings | ecosystem integration

Integration of glass coatings to prevent birds fly into them. UV reflective coating making it visible to birds while remaining virtually transparent to the human eye. Area is home to over 150 birs species, so the architecture responds to this sensitive ecosystem.

shading of south facade | passive cooling

During the summer, the roof overhang along with the tilted wall protects against direct sunlight providing passive cooling for the interior spaces. Overhang/wall design directly responds to the sun-path during the summer months. This significantly minimizes the need for mechanically cooling interior spaces, hence reducing equipment size.

June 21 | 68 degrees

solar transmission | passive heating

During sunny, cool winter days the south facade is designed to allow deep solar penetration, slightly heating the interior spaces reducing the need for mechanically heating, resulting in energy input reduction.

Dec 21 | 21 degrees

reduced northern exposure | thermal control

In response to the rigours winter, the design addresses prevailing wind patterns accross the site, by reducing northern exposure cold winds are eased over the roof, reducing winter heat loss and protecting the front entrance from direct wind. Large overhangs limit snow accumulation from snow drifts along the front deck.

dehumidification & evaporation | thermal control

Overhangs allow for the integration of a misting system, cooling the immediate exterior temperature. Mechanically Dehumidification of interior spaces, water used for evaporation through the integrated misting system.

photovoltaics panels | energy production

Integrated pv panels produce electricity. Installed as part of the guard, greenhouse glazing and parking - tilted for optimum exposure. Electricity produced sent to grid, building provided with electricity from grid. Designed to be energy neutral or positive.

operable windows | passive cooling

Operable windows at the bottom and top along handrail provides cross ventilation inside greenhouse providing passive cooling during summer months.

building envelope performance targets

Slab: R10
Cosed cell expanded polystyrene insulation under concrete slab

Exterior walls: R40
Insulated concrete forms

Roof: R60
Layer of Expanded Polystyrene Insulation on exterior plus sprayed closed-cell foam insulation u/s roof deck

earth-sheltered facade | thermal control

Earth-sheltered facade, less susceptible to the impact of extreme outdoor air temperatures, so the effects of adverse weather is minimized. Temperatures inside the building are more stable requiring less energy inputs.

interior planting | air purifying

Active Phytoremediation Wall System is a modular-based wall system comprised of pods which house and hydroponically cultivate plants. The exposed root systems enable plants to suck impurities out of the air as it passes by them and are 200-300% more effective at doing so than conventionally potted planted

operable windows | passive cooling

Operable windows on the south and north facades along with high efficiency ceiling fans provide cross-ventilation to cool interior spaces. This strategy improves air quality and reduces energy consumption, hence reducing the size of mechanical equipment.

ground source heat & cool | heating & cooling

Geothermal piping brings tempered fluid from deep boreholes. Heat pumps utilize the earth's steady temperature to heat cool and provide hot water. This thermal energy is used for heating the building's water and for heating or cooling needs, depending on the season.

greenhouse | water treatment

Pre-planting for spring/summer months and part of the black water treatment by the incorporation of the Todd's Eco-Machine. The Eco-Machine functions similarly to a wetland, only instead of a body of water, the process occurs within individual tanks, creating independent treatment zones.