Design with Nature: Learning from Ecological Systems to Educate the Urban Dweller

by

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The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled "Design with Nature: Learning from Ecological Systems to Educate the Urban Dweller" by Clayton Blackman in partial fulfilment of the requirements for the degree of Master of Architecture.

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ABSTRACT

Nature has an effective approach to cycling materials and energy flows to promote life. This thesis aims to expose urbanite users to nature's way of cycling materials. The seawall is the largest public space in Vancouver at the edge of land and sea. A neighbourhood community centre along the edge called the Conservatory for Community Matters is created to nurture environmental stewardship by mimicking natural cycles in its function. By conveying architectural systems and form in a cyclical and organic approach, an architectural intervention can address the daily environmental impact of urbanites while rooting people in place and nature in the city. The community centre's program connects the individually focused daily rituals of eating, making, and exercising to benefit the larger community where urbanites can reintegrate their organic 'wastes' into usable by-products. This promotes a paradigm shift transforming the apathetic consumer into an active member of the urban ecosystem.

ACKNOWLEDGEMENTS

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CHAPTER 1: INTRODUCTION

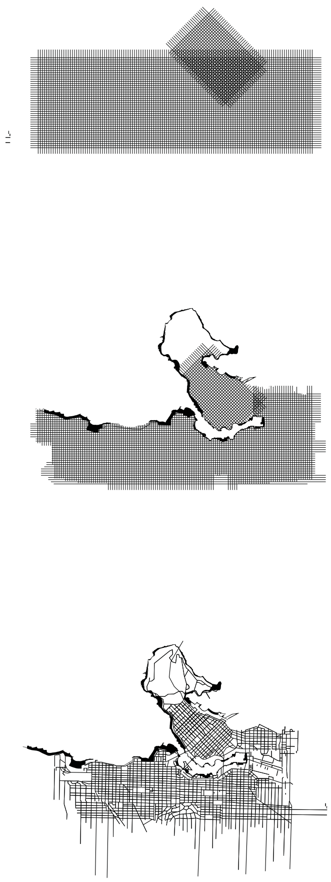


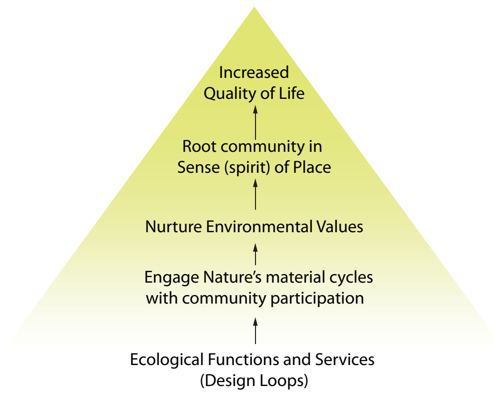
Diagram depicting the linear street grids overlaid on the organic edge condition and geography of Vancouver.

Ecological systems function in a network of nutrient and energy flows where exchanges from one process becomes inputs for another within a series of cycles. On the contrary, traditional man-made linear techniques of material and energy flows accumulate vast amounts of waste and lack proper consideration of their end use. We combine organic with man-made wastes rendering them useless as they reintegrate back into the natural world. The proposed building accentuates natural organic processes through design. By narrating the events of a material's life cycle with the help of the user, the building creates opportunity for not only a first use in a material but their second use as well. A process that is based on user participation efficiently turns usable organic wastes into a valuable resource. The building cycles food, material, water, and waste to achieve reuse by paralleling the flow of people with the flow of materials. The building satisfies individual need, educates the users through participation, and creates a unified sense of community. Ecological Literacy is taught through physical experience and intimacy.

In Vancouver, the seawall edge is the largest cultural space of the city with nodes of activity chained together a transitional path. The community center ties into a section of the edge near Science World that is in need of civic engagement and interest along the waterfront. Within the proposed building, users participate in activities within three essential cycles. Users can be nourished with sandwiches and snacks made from vegetables they grow in the *food cycle*. They can craft and refurbish wood objects in the *material cycle* to generate organic wastes for compost. They can also hydrate, exercise and produce electricity in the *water cycle*. In addition, human waste provides heat through a biodigester and creates nutrient rich water and usable compost. Each material cycle is exposed to the user. Whether it be the food, material, or water, the cycles are revealed to the user from raw material to usable product. The by-product then flows and reintegrates back into neighbouring cycles for community and nature's use.

The building's design is composed of a timber gridshell to emphasize a sense of place within the Pacific Northwest and showcase properties of wood in an innovative way. The thin membered structure is made strong using the bending potential of wood with a double curved network of pieces. This achieves a lightness in materials, while the warmth and patina of wood is accentuated with age through use. On a material scale, the walls of the building between each cycle become locations of material deposits where by-products can be deposited to foster ecological literacy and encourage physical engagement from the user.

A community center called the Conservatory for Community Matters is proposed where a dialogue about nature's material cycles connects nature within the broader community. The building becomes a working ecosystem to promote cooperation with nature's processes. This thesis discusses our current environmental situation, natural and man-made systems, and how natural material cycles can be used beneficially. Within this framework, the chosen site along Vancouver's edge, natural materials, structural form, and material cycles will be further elaborated to connect these ideas to building community in the Conservatory for Community Matters.



A diagram deviated from Stephen Kellert's "Thinking like a Mountain", that describes the process within this thesis (Kellert 2005a).

Thesis Question: How can natural processes shape architecture to nurture ecological literacy within the daily rituals of city dwellers?

CHAPTER 2: OUR CURRENT ENVIRONMENTAL SITUATION

Ecological Footprint

Before an understanding of how nature's processes can influence architectural design - it is important to understand the current pressures from consumers on existing ecosystems in a quantifiable manner within different scales. According to Environment Canada the world is in an ecological deficit (Environment Canada). This means that our demand for natural resources far exceeds the 'supply or regenerative capacity of the earth.' It is best understood under the context of our ecological footprint. Ecological footprint is defined as,

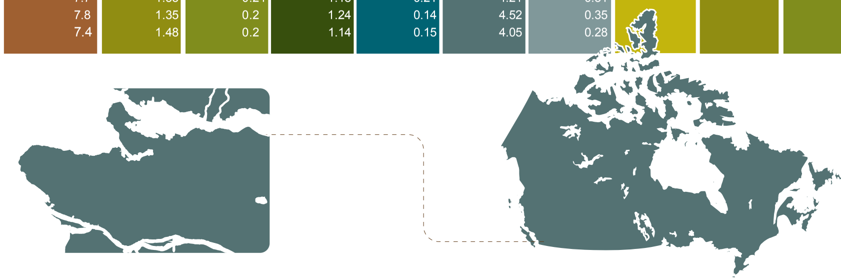
> The area of biologically productive land and water required to produce the resources consumed and to assimilate the wastes generated by humanity, under the predominant management and production practices in any given year. (Global Footprint Network)

The resulting unit for our ecological footprint are global hectares (gha) of land that are biologically productive.

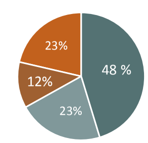
Canada's Ecological Footprint

According to the 2007 Canadian Living Planet Report, the Canadian ecological footprint is 3.5 times the global average (Mitchell 2007). Our footprint is the fourth highest footprint per a capita when compared to other nations. At the current rate, our ecosystems can not support our level of consumption. Due to our expansive landmass, we have not yet exceeded our biocapacity but with the increasing pressure of populations, our natural resources will soon be depleted. A severe decline in resources will continue if change is not made.

	Population	ECOLOGICAL FOOTPRINT (global hectares per capita): Ecological Footprint of Consumption	Cropland Footprint	Grazing Footprint	Forest Footprint	Sea Space Footprint	Carbon Footprint	Built-up Land	BIOCAPACITY (global hectares per capita): Total Biocapacity	Cropland	Land	Forest	Fishing Ground	Built Land	Ecological (Deficit) or Reserve
World	6,671,600,000	2.7	0.59	0.21	0.29	0.11	1.44	0.06	1.8	0.59	0.23	0.74	0.16	0.06	(0.9)
High Income Countries	1,031,400,000	6.1	1.02	0.23	0.70	0.26	3.78	0.11	3.1	0.99	0.29	1.19	0.49	0.11	(3.0)
Middle Income Countries	4,323,300,000	2.0	0.54	0.15	0.20	0.11	0.88	0.07	1.7	0.53	0.22	0.76	0.13	0.07	(0.2)
Low Income Countries	1,303,300,000	1.2	0.46	0.11	0.24	0.06	0.25	0.07	1.1	0.44	0.21	0.29	0.07	0.07	(0.1)
Canada	32,900,000	7.0	0.95	0.26	1.59	0.12	4.03	0.05	14.9	2.61	0.24	8.43	3.59	0.05	7.9
Vancouver	2,500,000	7.7	1.53	0.24	1.18	0.21	4.21	0.31							
Halifax	403,200	7.8	1.35	0.2	1.24	0.14	4.52	0.35							
Toronto	2,615,060	7.4	1.48	0.2	1.14	0.15	4.05	0.28							



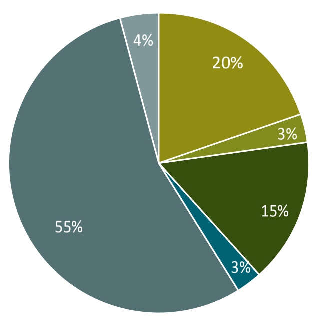
CANADIANS GHG EMISSION SOURCES (indirect + direct)



- MAJOR FUELS AND LUBRICANTS (direct)
- HEATING, LIGHTING, AND APPLIANCES (direct)
- SERVICES (indirect)
- GOODS (indirect)

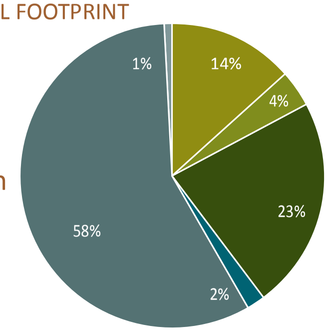
VANCOUVER'S ECOLOGICAL FOOTPRINT

7.71 HA/person



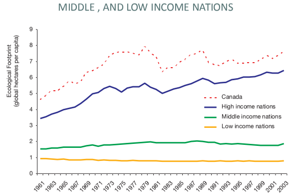
CANADA'S ECOLOGICAL FOOTPRINT

7.0 HA/person

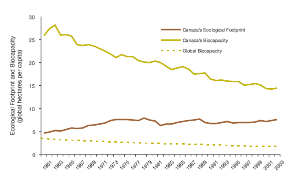


- BUILT-UP LAND
- CARBON FOOTPRINT
- SEAFOOD (SEA SPACE)
- TIMBER AND PAPER (FOREST)
- FOOD (GRAZING LAND)
- FOOD (CROP LAND)

ECOLOGICAL FOOTPRINT OF CANADA, HIGH, MIDDLE , AND LOW INCOME NATIONS



CANADA'S ECOLOGICAL FOOTPRINT AND BIOCAPACITY TRENDS



1.8 global hectares per person (2007 global biocapacity)

AREA x BIOPRODUCTIVITY = **BIOCAPACITY**

OVERSHOOT

POPULATION x CONSUMPTION PER PERSON x RESOURCE AND WASTE INTENSITY = **ECOLOGICAL FOOTPRINT**

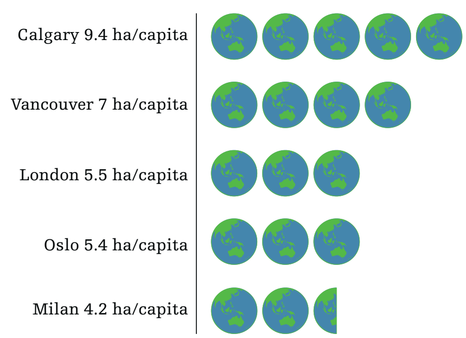
2.7 global hectares per person (2007 global Footprint)

*Ecological Footprint Atlas 2010

Here is a breakdown of inputs (ecological footprint) and wastes in Canada (Data from the Global Footprint 2010).

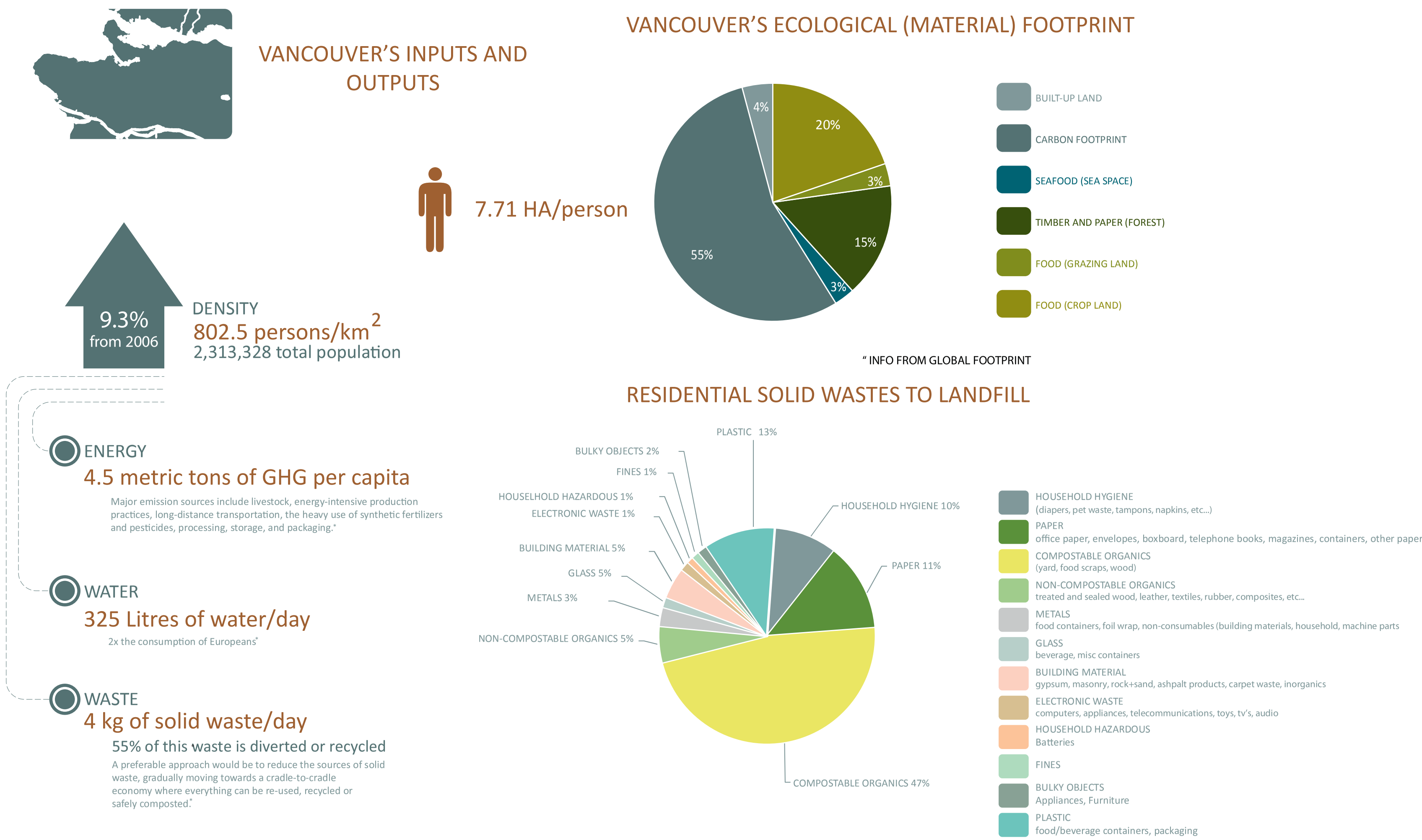
Vancouver's Ecological Imperative

Vancouver, like other cities, has an over barring problem with consumption and resource use that has led to an increasing ecological footprint. We continue to consume vast quantities of resources and produce volumes of GHG, pollutants, and solid waste threatening the regional land's biological capacity for our basic needs (Vancouver 2020, 2011). Although, it is situated in the physically picturesque setting and its' inhabitants have established a myriad of environmental organizations including Global Footprint Network, David Suzuki Foundation, and Greenpeace, it still suffers from over consumption of materials and energy. Vancouver's ecological footprint is 7.71 (gha) compared to that of the world's average of 1.8 (gha); therefore, humans would need 4 earth's of biologically productive land to sustain a whole world of Vancouverites. It's ecological footprint is much worse than denser European cities as seen in the chart below.



The ecological footprint of various cities (gha) (Boyd 2010)

While representing the total ecological footprint and the solid waste stream within Vancouver (on the following page), two prominent aspects became apparent. The city has a heavy reliance on fossil fuels for transportation of goods and for people use. Secondly, that within our waste stream, 40% of its' contents are organic wastes which can be used for compost. Within this understanding, the solution is to think more locally and promote organic wastes for functional reuse.



Here is a breakdown of inputs (ecological footprint) and wastes per person in Vancouver (Data from the Global Footprint Network 2010 and Technology Research inc. 2011).

Vancouver's Commitment to Change

The Municipal Government is highly committed in making change. They believe reducing our ecological footprint does not mean making sacrifices or decreasing our quality of life. It is rooted in education and thinking ecologically. The City of Vancouver has outlined ambitious plans to engage the government, NGO's, businesses, institutions, and residents to actively promote ecological thinking within producers and consumers (Boyd 2010, 49). The government wants to support this goal by creating 'ecologically literate citizens, businesses, and governments.' In addition, city planning is incorporating an integrated systems approach to successfully reduce and optimize their ecological footprint. The City of Vancouver plans to reject the 'business as usual' approach within its long term objectives and goals (Boyd 2010, 6). This new plan focuses on regional networks of distribution and harnessing the local within communities.

By understanding our ecological footprint, communities can understand that the world's resources are limited. Linking an individual's footprint to the overall biocapacity of the world situates a human within the bigger picture of the earth. It forms a new respect for nature's beauty through understanding our dependency. This will lead to ecological literacy and communities can begin to reduce their overall impact on the environment.

Nature and Human Connection

Disconnected Natural Systems in the City

Our detachment from the natural systems that we depend on in cities are an unfortunate result of high population density and urbanization. The sources of our life supporting systems and biocapacity for cities are out of mind and far removed from any sensory engagement of city inhabitants. This includes the agricultural lands that support our daily eating habits, our materials usage, and water consumption.

Unfortunately, the 'prevailing approach' to design of the modern built environment has supported isolating the natural world from the city. This is due to a reductionist approach of material use that doesn't consider design beyond the singular use and prevents interaction with natural processes in a greater system. At the building scale, this may seem like an unavoidable result of human construction and design, but it is 'fundamental design flaw' (Kellert, 2005, 5). With this reduced contact with nature's methodology, we have become conditioned to believe that we are separate from natural processes from which we are biologically created and raised. Fundamentally, we need to change the physical disconnect and encourage the sensory engagement to our materials and fabrication processes within the local community. We can bring people closer to nature on a local scale by harvesting community around the materials we use on a daily basis.

More than half of the world's population are now in cities (Martine 2007, 1) and Canadians spend more than 90% of our time in buildings (Veitch 2011, 1). The author believes that contact with nature is quickly being removed from our lives. Buildings should incorporate as much natural processes and ecological values as possible. This can include an abundance of natural air, on-site water collection, and heat energy within buildings in a more natural way. Any way to incorporate sensory engagements that celebrate natural processes and cycles will inspire healthy lifestyles, creativity and play.

Nature and Human Reconnection

Buildings and communities can physically demonstrate natural processes and cycles to city dwellers locally, where intimate connections to natural materials, their sources and the natural processes can be recreated. An example of this can be seen at UBC's Center for Interactive Research in Sustainability, where black and grey water nutrients are reused within building functions in clear view to the public. The buildings and communities can actively engage in a working relationship to mutually benefit people and natural systems that create spaces conducive to biodiversity. For this, it involves using nature as precedent and considering ecological systems as a means for design. By encouraging the city to not be a linear system but a ecological system that cycles wastes, increases biodiversity and uses feedback loops at multiple scales (Odum 1997, 45), we are in fact designing places that benefit both humans and natural world in the city.

Nurturing our ecological literacy through community outreach and education is crucial to improving our ecological footprint as well as our respect for nature in the city. We gather psychological benefits from the engagement when natural connections are made in the city. Stephen Kellert describes that our increased physical and mental benefits from nature need to be celebrated for these benefits to create environmental awareness (Kellert 2005, 7). Architects have the opportunity to design beautiful spaces that nurture this awareness within inhabitants of the city.

Design with Nature in Mind

For us to reconcile our need for natural systems, we should design with ecological processes. There are fundamental principles as to how we build our urban systems if business is usual. These principles are currently linear, reduced, and mono-cultured in its processes (McDonough 2002, 33). If we consider designing ecologically, we can create integrated processes within buildings that reflect open/ closed loop cycles, multi-purpose systems, and biodiversity. These ecological principles can permeate through all scales of systems design from the industrial, urban, building, household, and user to support design for healthy urban conditions. The comparison chart below describes thinking with ecology in mind versus a linear design approach. If principles like these are understood by the wider community of individuals, change can occur.

INTEGRAL (ecological/cyclical)	LINEAR (business as usual)
Energy flows through loops	Energy flows in straight line
Parts fit overlapping functions	Parts are specialized modular components
Low entropy/high information	High entropy/low information
Open system/closed loops	Closed system/no loops
Memory stored in many different cells	Memory stored in specialized components
High rate of material recovery	High rate of material loss
No waste	High waste
Self-regulating	Imbalance passed along
multipurpose	Single purpose
Steady flow of energy	Surging flow of energy
Diversity, complexity, stability	Uniformity, simplicity, instability
High number of species	Low number of species

A diagram representing integrated cyclical design versus linear design methodologies (Data from the Farallones Institute 1979)

An example of this can be seen in the Integral Urban House, designed by Sim Van der Ryn and Farrallones Institute. It is one of the first buildings to consider designing the household as an integrated urban ecosystem, where all the needed food, energy, and water necessary to sustain a family is contained within their property. According to Macy and Bonnemaison, there are two very important lessons that can be understood from the Integral Urban House that have helped shape ecological design thought. First that in building with ecological systems, the by-product of

Integral Urban House (Mother Earth News 1980) processes, can be looped back into the system to be valuable for other processes. Technology, whether it is highly active or passive, can be used to regulate these flows of energy and materials within the building. Secondly, it brought an awareness to the understanding that an individuals behavior within the household can actually impact the environment at the greater scale of the earth (Macy and Bonnemaison 2003, 332). These fundamental principles have led us to a greater understanding of where our ecological place is within the world.

Since the Integral House is focused on self-sufficiency of energy, food, and waste systems, on a household scale, the proposed building will reflect the essence of the self sufficient house on a community scale by helping to generate its own electricity, and engaging the user in a community environmental culture. By placing the individual within a deeper understanding of natural processes at the scale of the community, a connection that relates people with the greater biosphere can be formed. The community is brought together to understand ecological literacy at multiple scales: at the city scale being along the edge, the building scale with its material choices in addition to its' physical form, and the human scale where materials cycles engage people within its use.

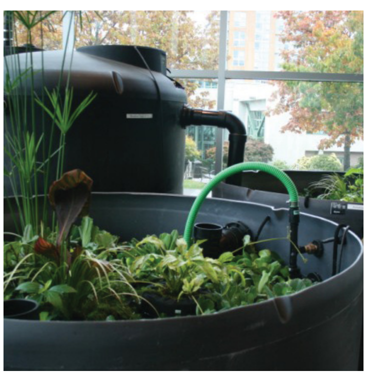
Material Cycles

Material cycles are an important aspect to the functioning of natural systems. When products are manufactured, used, and turn to waste without reintegration or cycling within our economy - it is at the detriment of nature. William Mcdonnough, much like Sim Van der Ryn, understand that human systems can achieve nature's cycling by having two fundamental cycles. The cycles states that products, including architectural components, are either made from biodegradable materials which can be food for the biological system, or they stay in closed loop man-made systems. These two 'metabolisms' remain healthy and valuable when kept separate to avoid cross contamination (Mcdonough 2001, 105).

Exterior of Center for Interactive Research in Sustainability with solar aquatics located in clear view of the public in the glass viewing area on ground level (Erhardt 2011)

Even though both cycles, technical and biological, are essential in understanding how we can reduce our ecological footprint, this thesis focuses on the natural materials cycles from use to reintegration towards an understanding of how to work with nature's biological nutrients and foster a daily partnership between people and nature.

An example of understanding biological cycles, can be seen in the solar aquatic system in the Center for Interactive Research in Sustainability Building at UBC Campus. By creating a system that converts human waste to nutrient rich water (containing nitrates and phosphorous), we are creating mutually beneficial relationship: plants thrive off nutrient rich waters from human waste and human's remove the need to overload sewage lines. It closes the loop locally for the benefit of nature and humans (CIRS).There is not only an ecological incentive in finding opportunities to use materials in every part of the life cycle but an economic one as well.



Blending Tank in the Solar Aquatics (Ekotek 2011)

By connecting community to natural processes, biological material's cycles can be further understood and incorporated within the function of the community. Buildings can tell a story to the user regarding how nature's cycles, building cycles, and user cycles can all work together. By connecting users to the source and localizing the events, users can participate in the cycling of materials to witness the loops themselves. This takes the visual consumption of nature and physically connects material processes to the analytical eye.

By combining the exposure of materials cycles, people can see in sequence how their material use affects the greater system. By understanding the cycles in a holistic manner, users can learn to engage with nature on an intimate level through experience. This thesis will focus on creating experience through nature by reconnecting the city dweller to nature's functions of ecosystems and material cycles to nurture environmental values within their daily lives.

CHAPTER 3: SITE + COMMUNITY

The site chosen for the Conservatory for Community Matters is in the heart of Vancouver along the water's edge at the terminus of False Creek. The water's edge of the city becomes a 'social condenser' for activity and behavior - it is where Vancouverites escape from the city for play. The edge is a perfect place to foster learning and ecological literacy for its popularity for leisure activities amongst the cities inhabitants. Biological activity in all forms gravitate towards the interstitial area between land and sea, or two ecological zones. Vancouver architect Bing Thom understands how being on the edge condition can bring value to learning. Within this between space, opportunities for a more holistic perspective to nature can exist.

> Knowledge is to be found between the cracks rather than in the discipline itself. Outside the classroom, any biologist knows that the richest areas on earth for ecological diversity are found in those margins between biozones. Riparian zones, the bogs, and wetlands that are transition areas between aquatic areas and upland areas, are often referred to as "the ribbon of life." (Thom 2011, 72)

This thesis aims to use the edge condition of Vancouver as an educational tool about the ecology of place between land and sea, city and nature to promote ecological literate residence and engage people on a community level.

Within ecological diction, the edge condition is an important place of activity. The littoral zone is the edge condition of the ocean. It is the shoreline environment surrounding the ocean, which is usually a space rich with biodiversity (Forman 1986, 45). Ecosystems from both land and sea combine here to promote life. Edge conditions such as these, also known as an 'eco-tone', permeates every aspect of natural systems where two or more ecosystems interact (Odum 1997, 54).

Biomass is greatest at the edge – this abundance causes organisms to be drawn to the extremities – whether it be for leisure or nourishment. It always includes a variety of plants, animals, and definitely humans (Forman 1986, 110). Whether these conditions are noticed or not, human development can promote ecological activity in this natural gradient or destroy it with environmental degradation. In the case of the site, industrious activity has caused massive environmental damage to a potentially rich wetland ecosystem in the city. Edge conditions have become an important aspect to the creation and success of the city of Vancouver.

This is a diagram describing the scales of edge within the city. The site is located on the furthest most point within Vancouver. It creates an armature of the gravitation to the edge.

Vancouver's public life and community is largely shaped by its geographic location. Within this section, the physical geography of Vancouver and the proposed site for the Conservancy for Community Matters will be described. The connection between the natural environment, edge, and city dwellers will be further discussed to understand how it influences the people of Vancouver.

Vancouver's Geographic Context

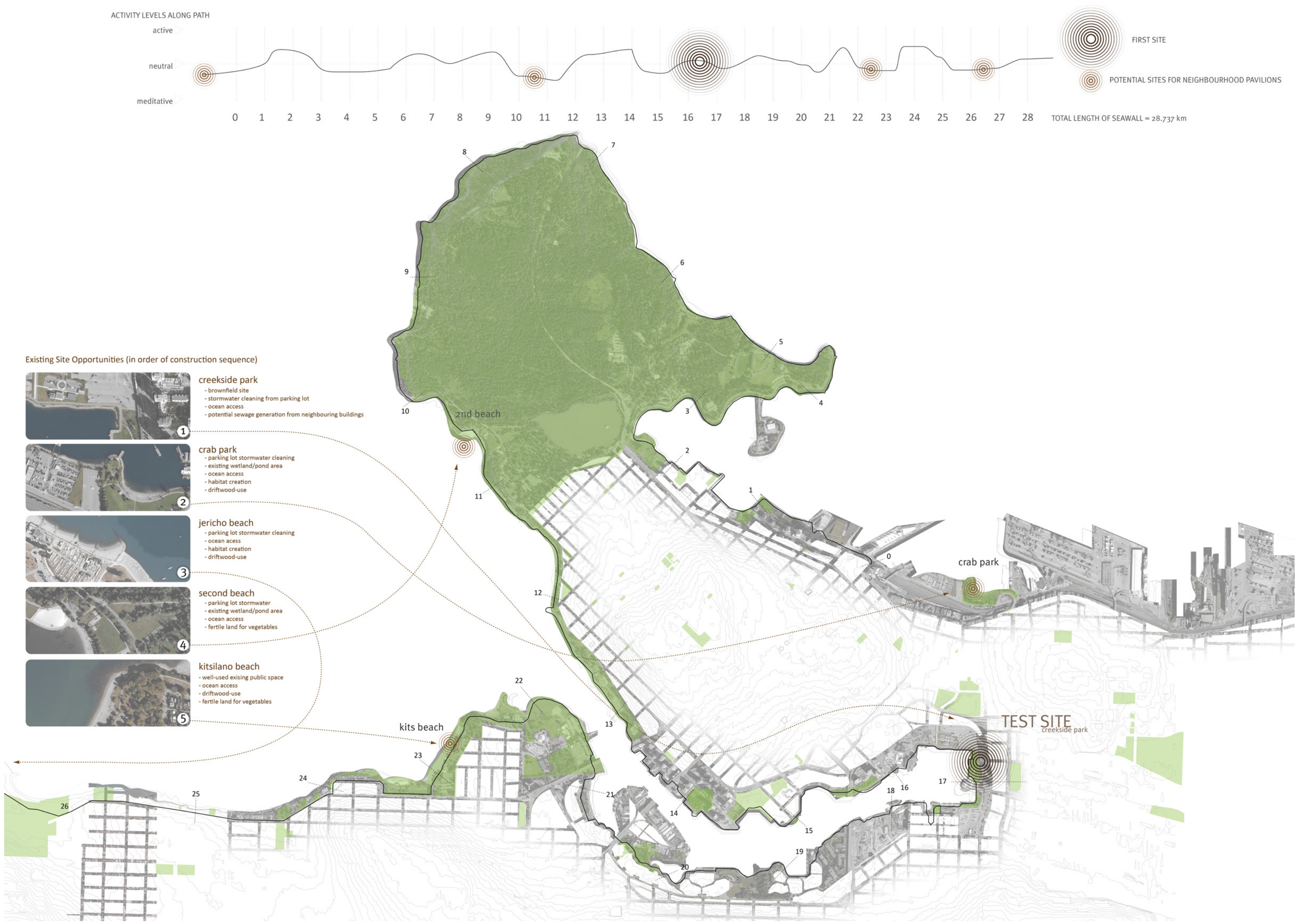
Vancouver, built in 1886, is on the edge of the continent at a point contained by rugged terrain to the north and ocean to the west. It is an edge city which has an urban form that is dramatically shaped by its natural surrounding. It creates a thought provoking dialogue between urban and natural environments. Along a latitude of 49.2505° N, its' proximity to ocean and coastal mountains provides a microclimate within Vancouver that informs its daily natural systems and cityscape. It was first settled on a delta shaped at the natural convergence of land and sea, where glaciation deposited rich, fertile soil. The physical features create an elemental combination of wet and temperate climate for lush greenery, moist clean air, soft refreshing water and a dramatic landscape that springs to life with colour. The downtown core is situated on a small finger of land that is surrounded by the ocean. It is at the termination of the CPR railway and is used as Canada's gateway to the Pacific and Asia.

Natural surroundings are highly influential to the creation of a city's edge. The edge is a place with an abundance of activity – a boundary condition or buffer zone that physically supports an armature for human and natural diversity. In the case of Vancouver, both the biological and cultural flows condense at the edge. It is a place to understand the culture of Vancouver, where the public life is alive with activity and leisure.

Vancouver's Edge

The abundance of edge condition is prevalent at all scales (Leeson 2011)

Vancouver's edge was first formalized to a hard edge with the development of a concrete and stone waterfront path called the seawall. The first phase of construction was completed in the 1930's by James Cunningham. The seawall is a 22 km walking, jogging, cycling, skateboarding, and rollerblading waterfront path that commences in the Burrard Inlet and circumnavigates Vancouver ending in Kitsilano Beach. It is the most popular recreational facility in Vancouver.



A diagram showing the larger context of Vancouver with potential sites of the Community Centers along the edge.


Construction of the Seawall (Vancouver Archives 1963)


One of the many beaches along the seawall: English Bay. (Vancouver Archives 1895)


The Seawall around Stanley Park (Itinerant Element 2012)

It has been built-up around Vancouver to prevent coastal erosion and create a navigable route offering views of the surrounding areas. It defines a boundary between land and sea. The boundary tension is noticeable when observing its ribbon like qualities. The seawall is enjoyed by millions every year for its accessibility to the public within the two contrasting environment. Most seawall users enjoy the precession of the edge and the anticipation of views along the path. This hard path defines the boundary of land and water, work and play, city and nature.

The geographic and urban form make people naturally gravitate towards the edge boundaries for public life. The flows of the city lead to the organic edge, where urbanites can engage with the cycles of nature within the city. The city inhabitants are naturally drawn to edges in the same way nature does. By considering both nature and culturally specific needs as mutually beneficial, Vancouver already has a physical armature for the community to engage about thinking more ecologically and cyclical. However, the visual connection of nature along the seawall becomes the predominant activity of its users and becomes natural spectacle rather than cultivating any physical connections.

> Sooner or later the urban detective in search of clues to understanding Vancouver will reach the edge. Understanding the peculiar culture of Vancouver's Public life and the centrifugal spaces where it takes place, at the edges, and which is so often based on spectacle rather than active collective participation, is central to piecing together the story of the city's emergent urban form. (Berelowitz 2005, 241)

The natural edge is the public space in Vancouver – a place where people get together to be apart of a spectacle of natural setting. As Berlowitz discusses there is a lack of integration and community participation along the edge. This proposed building will provide the needed engagement of its' residences with the materials we use and promote more community-based activities.

Visual Connections to Nature

Diagram describing the visual integration of nature.

While navigating the edge within the city, an individual notices strong visual cues of integration between nature and city; however, the activities do not root the individual in a physical integration or understanding of natural processes. It becomes a superficial connection. The local mountains to the north provide a visual edge against the sky and a backdrop to the city. These visual relationships between natural edge and built edge create a homogenous image of the city within a nature. They create visual boundaries between sky, mountains, buildings, seawall, and water. The unified image provides a feeling of being one with nature, but ultimately leaves the viewer disconnected from nature itself.

For those living in the edge city, the visual aesthetic of nature dominates over the other sensory experiences. The dominance removes any question of ecological literacy that makes the natural world so psychologically intrinsic to our lives. This suppression of the other senses does not give us a true sense of connection to the land that the other senses help to provide. It leads the user into detachment and exteriority, and does not facilitate human rootedness in the world (Pallasmaa 1997, 19).

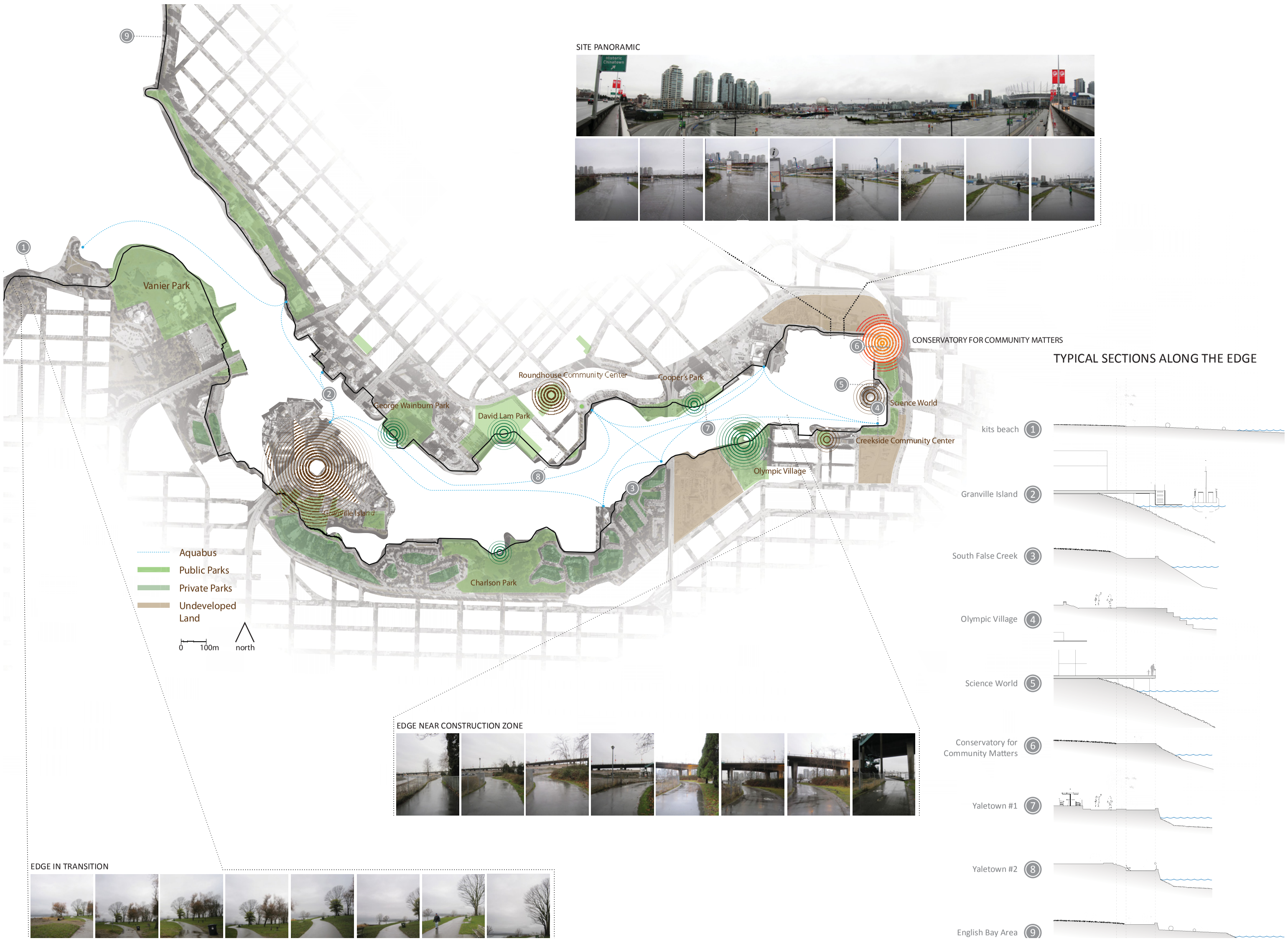
The people of Vancouver are continually loosing grounding with the engagement of the dominant sense. Even though Vancouver is innately tied to its natural environment visually - the other senses need to be activated as well. The intention of the building is to raise awareness with the other senses in a physical and intimate way through an architectural intervention.

Potential Sites Along the Edge

Located on the map (p 18) are potential locations of the proposed community centers along Vancouver's Edge. These sites have been chosen for their various edge conditions with needed community oriented spaces, ecological restoration and stormwater management along the edge of the city. Once the first test site is developed, these selected sites could be used for community centers as well. Each site is unique and would be constructed in hopes to heighten the eccentricities of these places individually. The building's form can respond to the specifics of site by reorganizing different modular elements within the local conditions of each site. By treating nearby stormwater near sites in the biodigester and using materials from the site to be used in the woodshop (including large amounts of driftwood on some of the sites), the buildings can further connect to site within its operational use as well. Since a proposal that considers all of these sites in detail is too large for this body of research, the first test site will be the focus of this thesis.

Test Site

The site of the Conservatory for Community Matters, located in False Creek, was chosen for it's specific urban condition and its close proximity to waters edge. It acts as

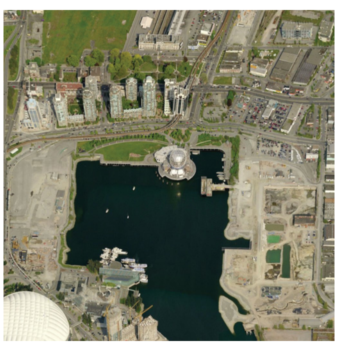


The surrounding site nodes with typical sections along the edge.

Site panorama taken from Georgia Viaduct.

the gateway for commuters travelling back and forth to the downtown core from the areas around Vancouver. The many transportation modes that surround the site include 4 lane streets, two viaducts, the skytrain, the canada line, bike lanes and the seawall. Even though these thoroughfares are important transportation lines into the city, they have a very large presence and create a fragmented human experience within the area. The area is a transitional space that is void of community presence along the water edge. The site was also chosen for its importance in connecting the west and east parts of the city with a large gap in user integration from the high density condos to the large barren concrete urban landscapes. The Conservatory for Community Matters will act as a common space to unite the surrounding west and east residences and engage the users in collective learning and an ecologically literate approach.

Aerial View of False Creek in 1946 showing the connection of land to trainline before infill occured. (Vancouver Archives 1946)



Aerial View of site (Bing Maps 2009)

Originally the site was once a large tidal basin until it was structurally filled in between 1916 and 1917 during Vancouver's early industrial growth. 308 acres as filled east of the site, to create more land for the expanding industry and train yard in WW1 times. Once industry dwindled within the flats in the 1950s, the location became a brownfield site due to its heavily abused industrial past and the hazardous waste saturating the water and land. The site was then capped with concrete for the proposed expo '86 and now lays dormant as a parking lot. It is now owned by Concorde Pacific.

The potential of the site has been recognized by the city and its residents for many years. Many proposals and an international competition called Reconnect raised public awareness around the possibilities of the area to reshape Vancouver. A large focus of the Reconnect competitions were the viaducts to the north of the site.

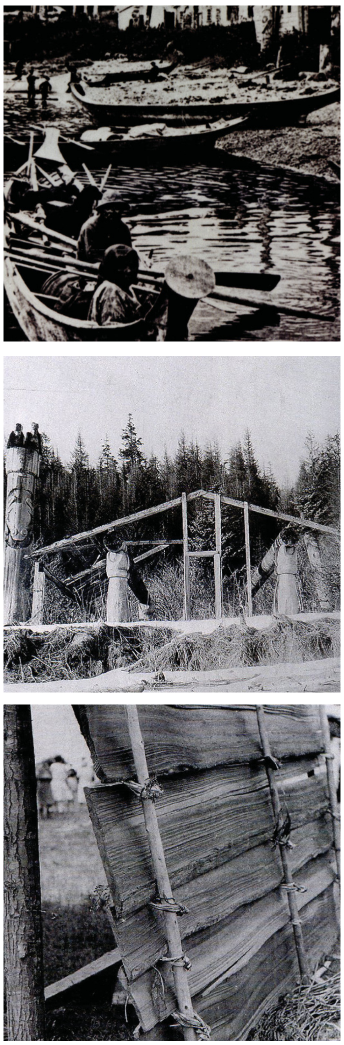
The site for the Conservatory for Community Matters is located beside Science World and a future mix-used residential development by Concorde Pacific. It is also an area under a view corridor of 14 m in height along the site making it an ample location for a low-lying building. The center will provide a cultural hub for the new residences in the area. Located on the south side of the site is Science World. The intention of the community center is to contrast Science World in a complimentary way. Science World was created during Expo 86 as an exhibition center to inspire and promote the future of science and technology (Science World Website). It epitomized renewal and contrasted the industrial wasteland that was once there before it. However, Science World does not engage with the seawall or the surrounding community due to the insular design. The design makes the occupants take a more inward focused approach to science. Science World is set-up off the ground from the ocean ground plane. Its integration and engagement in the waterfront is non-existent. The community center will be installed beside science world to fulfill a connection to the surrounding area that integrate community and the natural environment, much like the nearby Olympic Village.

Site plan of the transportation flows around site.

CHAPTER 4: MATERIAL STRUCTURE

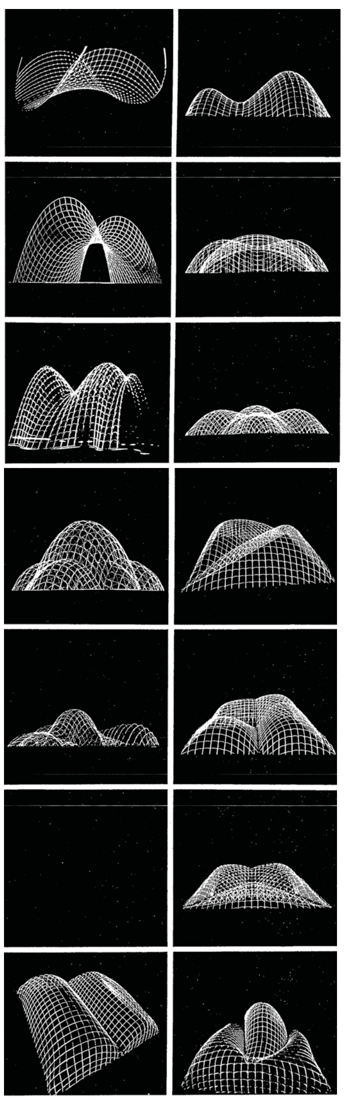
Natural Materials, Wood, and the Northwest Coast

The design of the Community Center establishes a connection to biological systems by celebrating the use of natural local materials in construction. Natural materials, specifically wood, have a long history and relationship to humans. They inherently promote their rich natural qualities and provide information about their life-cycles which includes a narrative of their origin, growth and eventual decay. A feeling of time is rarely seen in artificial products and results only in superficial human connections. Natural materials show the patina of time that is largely missing in Vancouver's new built environment. The missing patina shows a weakened sense of materiality that surrounds the flatness of today's standard construction. The patina of natural materials show how materials are manipulated true to their nature and convinces its user of its place in time through experience (Pallasmaa 2005, 31). Aged natural materials evoke a sense of familiarity and satisfaction among people (Kellert 2007, 7).



Photos of use of wood in Aboriginal Communities of the Pacific Northwest. (Miller 2005)

The natural aging and weathering bring depth to a space. In the case of wood, the natural grey patina of wood gives the building a sense of life and connects the viewer to its natural life cycle. Wood is the all-encompassing material that has been used in the Northwest Coast for centuries. It evokes a rich sense of place that began from the aboriginal coastal tribes of the area. The coastal tribes have used this one material for many aspects of their architecture and crafts leading a truly sustainable life. Cedar, the naturally rot resistant fragrant wood, was used in their post and beam houses, canoes, bentwood boxes, totemic poles, and masks. They were able to create low-impact biological form and shape by knowing the properties of the natural material. The smaller sections where used for bowls and dishes. While the bark was used for baskets, clothing bedding, and even diapers. Respect was not only given to its material properties, but trees were viewed as a supernatural force that permeated throughout all parts of their culture. The history of integration between people and its materials should inform place and today's building culture in BC - much like the 'reciprocal relationship' of the sustainable traditions of Northwest Coast Aboriginals (Miller 2005, 13).



Some of Frei Otto's gridshell ideas (Hennicke 1974)

This view of one material shaping a culture could root Vancouver's architectural form in the same way. With new advances in timber engineering, specifically gridshells and laminated wood, using wood in the building industry is growing significantly in BC. By using wood's inherent bending properties and a natural material historically tied richly to place, wood will be the primary material to used for the community center. Wood also has inherent material advantages of sequestering carbon and offcuts can be utilized as biofuel or simply biodegrade naturally into the biological cycle.

Timber Gridshells

Gridshells are complex in their structural characteristics and form yet have an amazing feel of energy and movement within their structure. They use a network of pieces together to create the shape of the shell. A shell is a three-dimensional structure that gets its strength from its curved form. These structures are extremely efficient in their use of material due to their way of carrying compression, tension, and shear forces within a very thin profile. Since the shell's strength

Giant Clamshell showing curved undulations for strength along the edge condition. (Peter Petrou 2013)

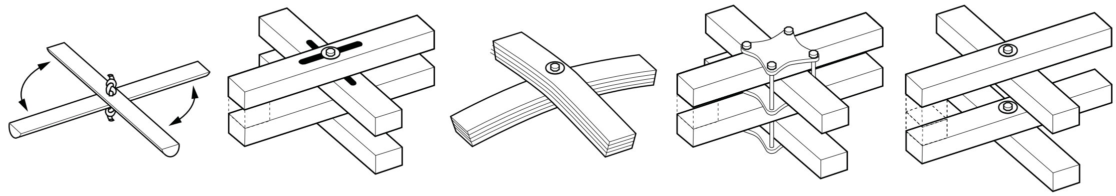
relies exclusively on its form, the geometries and thickness of the material must be considered to resist ‘buckling’ in the structure. (Harris 2003, 1). Shells can be seen in nature’s formation. If you look at the edge of a clamshell, one can see that it gets its strength at the edge with its sinuous convexed and concaved curves.

Gridshells are a deviation of natural shells from nature where the surface is not a continuous material but a man-made grid to form a lattice. The material structure of fabric and mesh are examples of patterns similar to the grid structure. These forms of shells can be made of any material, but are often composed of steel or timber. The natural material can be sawn into long strips and joined end to end within the long grain of the structure. This allows for large grid frameworks to be created and for bending to occur. Frei Otto at the Institute for Lightweight Structures, studied it in great detail in the 60’s.

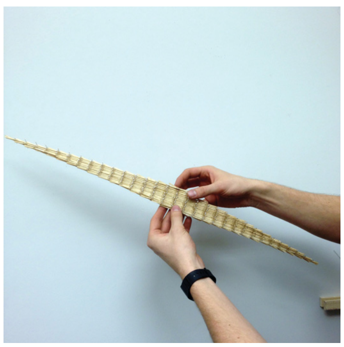
The Lowering of the Downland Gridshell (Harris 2003)

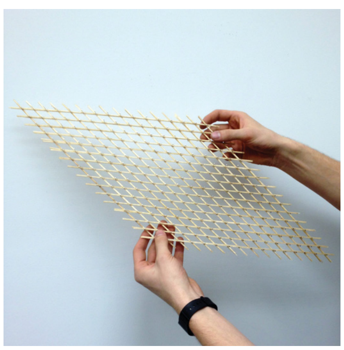
During the construction process, a gridshell is typically laid out as a flat mat and then pushed up or pulled down to create its three-dimensional shape. The forces flow through the strips of material within the sheet. The space between the strips change in cell-size to allow for movement of the strips and ‘scissoring’ to occur to form its shape (Harris 2003, 1). The cell shape changes from a square to a parallelogram depending on deformation of the material. When the flat matt is being formed, the timber lattice must allow for the rotation of the nodes, bending and twisting of the timber material (Harris 2003, 1).

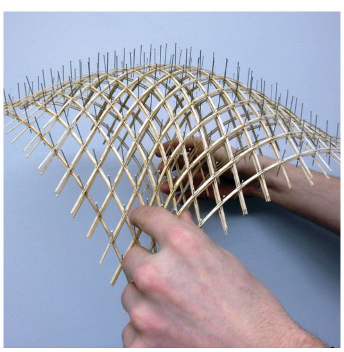
The form’s curvature is dependant on the bending of its materials. It is important to select the right species of wood that is durable and can achieve a sufficient bending radius



Existing precedence of the wood lathe connection detail.





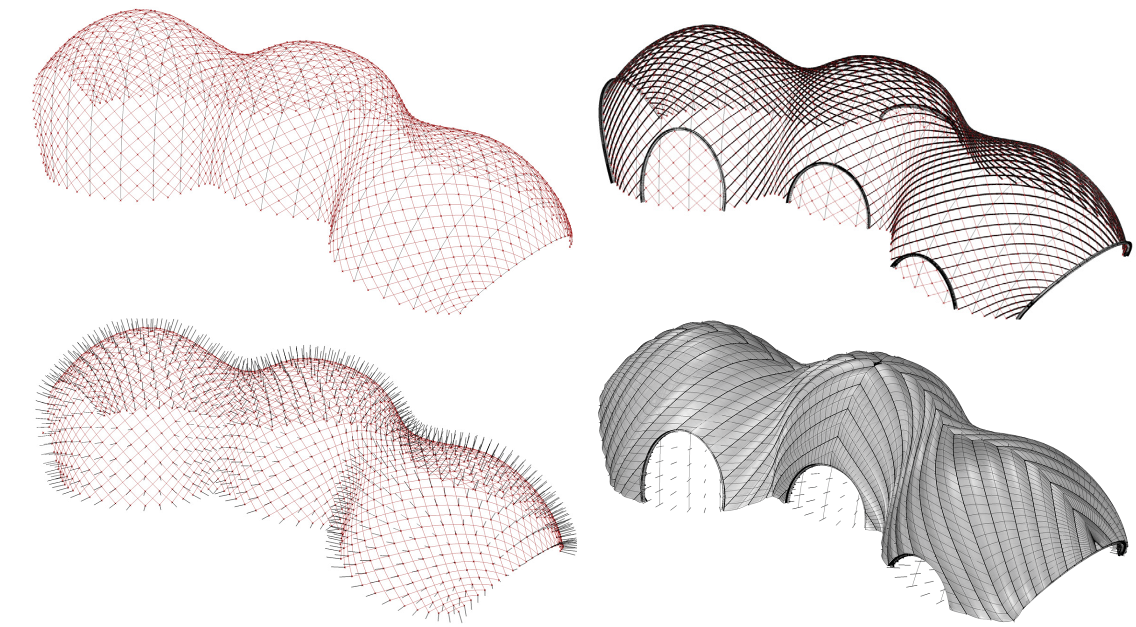


One of the shell process models showing how it can be closed and balloned into a 3D form by pinching at the edge.

without breakage. The Multihalle is built from hemlock chosen for it straightness in grain while the Downland Gridshell built from oak for its strength when bent. Hemlock would be the material of choice due to its local availability around Vancouver, and it's relationship to standard building constructions today.

Gridshells can be multiple layers thick to allow for more bending potential in thinner profiled materials. Like most structures, the material depth becomes important to carry loads along the span of the shell. But what was found in the Downland Gridshell, due to the thinner materials ability to bend more freely, a tighter curvature can be achieved in larger grids. Instead of composing the sheet out of crossed lapped wood - it is double-layered to create more depth in the plane (Harris 2003, 4). Timber gridshell's like the Multihalle and the Downland Gridshell both use double lattice systems to take advantage of the thinner profile while still achieving sufficient material thicknesses for the span to resist 'buckling'. By having the four-layer system, the wood strips when bent need to slide relative to each other but also need to resist rotation within each cell. This makes the connection detail very important to ensure sliding occurs between appropriate lathes. Once the desired shape is achieved, blocking is added between the two layers in both shells to allow for shear strength which transfers the forces within the layers (Harris 2003, 1). The grid, when in the right position, needs triangulation to lock its form into place and prevent any rotation at the nodes. This is done by tension cables in the Multihalle and 'rib lathes' in the Downland Gridshell.

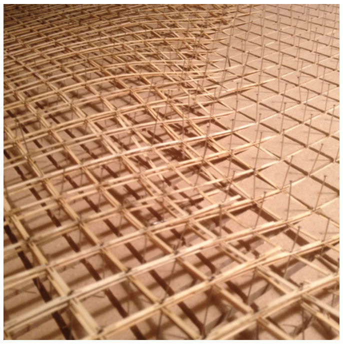
Shell Geometry

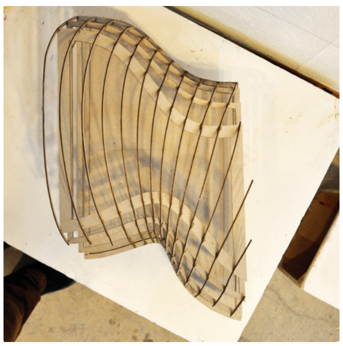


Parametric model of gridshell. Intersections at alternating points were used to reduce processing time on the computer. The model is derived from a surface generated from key sections. The lathes along the surface were produced from diagonal lines connecting the intersection points. Lathe thickness and cell spacing can be adjusted. ETFE cladding is shown three dimensionally modelled with the frame connecting to alternating lathes.

The geometry of the gridshell was modelled both physically and digitally so the techniques can inform one another. The structural characteristics became apparent by understanding the form analytically through digital means and physical means by manipulating a flat matt of grided lathes. The 1:1 detail (p 32) also gave a sense of scale in the roof assembly and cell size.

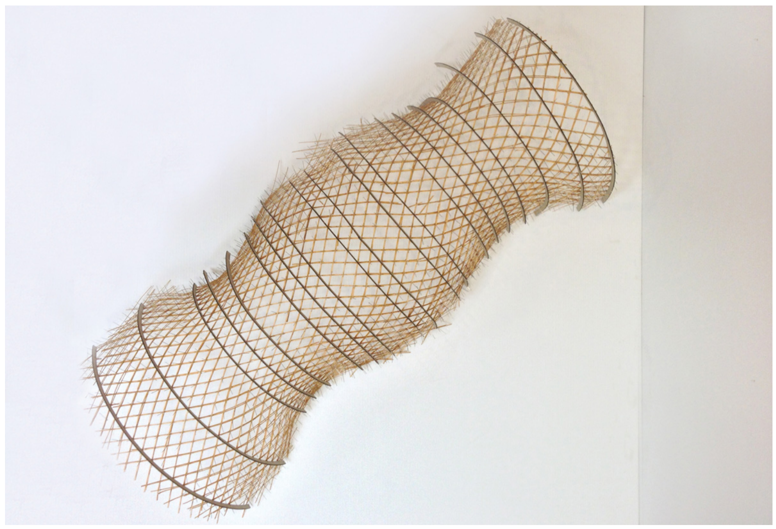
The digital component was created by using three key sections at the center of each peak within the undulating form, one at each saddle and one on each edge. One parabolic curve on the larger *water cycle*, a shorter curve for the *material cycle*, and an arc on a sphere for the *food cycle*. Once the floor plan was created using three circles, the key sections were aligned within Rhinoceros 3D modelling software (www.rhino3d.com), a surface was created. Within parametric modelling,



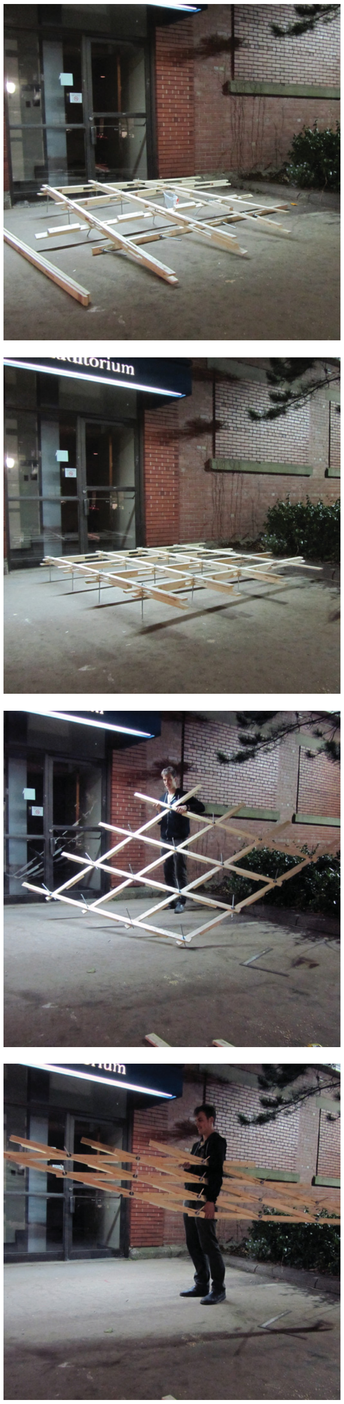



From top left to bottom left: Gridshell jig used to make matt of lathes. Ribs used to create 1:50 model. Some process models with different materials describing form and lightness. Right: Experimenting with different gridshell forms.

a grid of points where mapped on the surface where the frequency of points can be adjusted. A grid of lines was created on the diagonal, which corresponds to lines on the geodesic. The geodesic is the quickest path from one point along an edge to another within a 3D surface. Once the lines were created the 3D lathes where built off of the geometries. The model allows for adjustment in the thickness of each lathe, the cell spacing, and connection component swaps. Once the form was made, section cuts can be extracted to be used for the physical model.



To understand the shells material strengths better physically, models at various scales where made including a large flat matt of shell to test different forms. The physical modelling described something more tactile, where placement of shear blocks and tension cables show how the structure can become rigid from a flexible network of lathes. The model showed amazing resiliency through the process, where if one node was damaged the lathes within its vicinity would compensate. While using string and card, a flat matt can be manipulated into a measured 3D form. The pin connection used is reminiscent of the Multihalle Gridshell by Frei Otto and allows possibilities for cladding systems to be applied to



The 1:1 shell detail with double layer construction. Here is an example of what can be possible with pin connections and scissoring.

the exterior of the shell. By separating the cladding system from the surface of the wood lathes- the wood has the opportunity to dry when wet. During forming, the network of wood gives the active geometry some flexibility with the amount of unplanned breakages before the structural integrity is compromised. In the case of the Downland Gridshell, it had only a few broken lathes within the process. It was also formed while wet, which makes the lathe fibers saturated to help prevent breakages during bending.

ETFE

The Gridshell Structure used for the building will be clad in lightweight ETFE (Ethylene tetrafluoroethylene). It is a translucent plastic that is not derived from petroleum but fluorine. The ETFE is deployed in pneumatic panels that create structural integrity through inflation and its flexibility. There are many advantages to using this material. ETFE can be applied to the flow of the gridshell accommodating complex geometries. The form prevents the use of glass unless it is faceted. The ETFE cushions weigh approximately 1 percent of conventional glass systems, which allows the gridshell to be as light as possible (Le Cuyer 2008, 32). The cushions are very flexible and can handle movement created by wind loads on the gridshell. The opportunities for solar control in the one material can create a highly optimized facade in terms of solar gain and greenhousing. Due to the large pillow size and reduction of mullions, the insulative qualities are better than glazing. The temperature is also moderated through the length of the pillow. UV light transmission is higher than glass, which creates an ample environment for growing vegetables. ETFE has a low flammability and due to being ‘prestressed’ because of inflation, it shrinks to vent fires to

Left: Interior of the Waitomo Caves Visitor's Center (NZ Wood). Right: ETFE and gridshell in combination at the Waitomo Caves Visitor's Center (NZ Wood 2013)

the outside air (Le Cuyer 2008, 114). On an ecological note, the material is recyclable and has a low-embodied energy (Vector Foiltec). ETFE cushions combined with a gridshell would be a highly effective facade system that advantageously uses its form active properties to create a very light and dynamic enclosure system.

An example of an ETFE clad Timber Gridshell structural system can be seen at the Waitomo Cave Center, which uses it not as an enclosed space but simply as a shading canopy over the whole structure. It also uses laminated veneer lumber laminated (LVL) timbers and ETFE spanning 4-5 meters following the structural grid of the wood below (Vector Foiltec).

CHAPTER 5: DESIGN

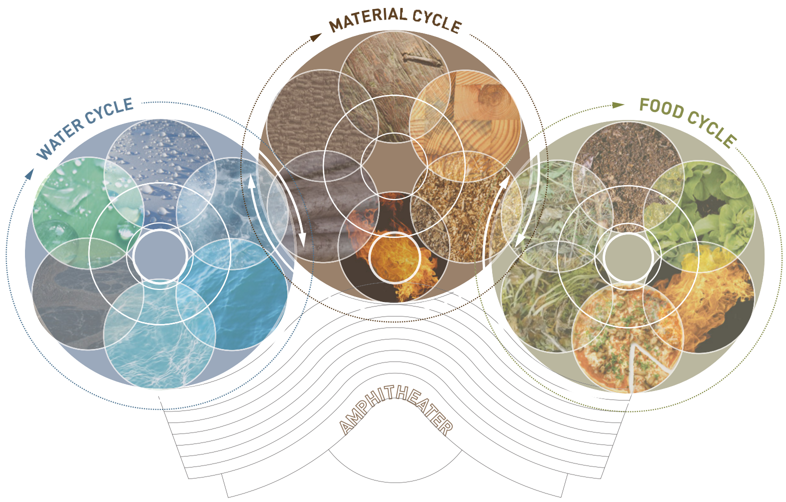


Diagram of Material Program: water cycle, material cycle, and food cycle

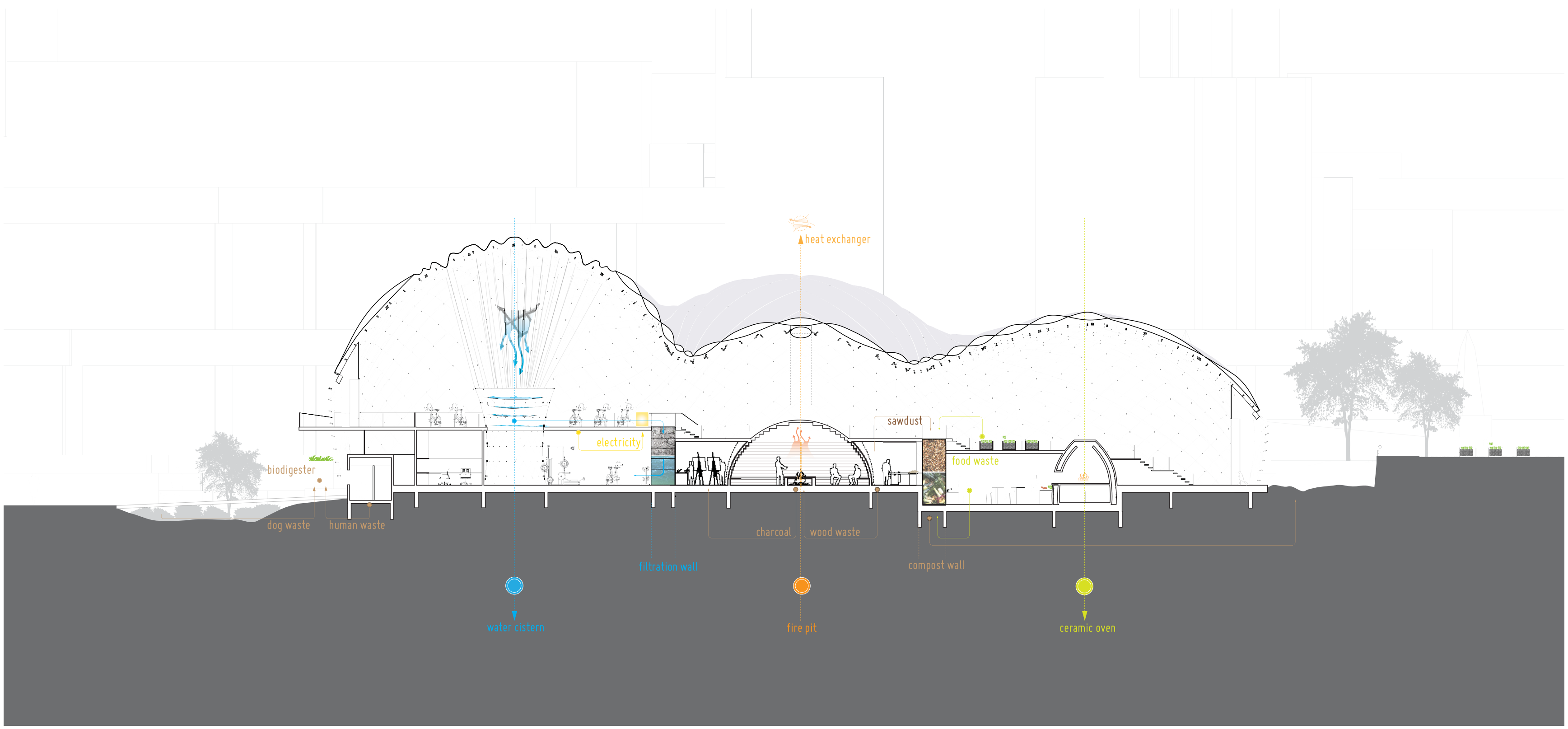
The Conservatory for Community Matters design is influenced by Vancouver's regional surroundings. It contains three programmatic spheres that follow three daily rituals of urbanites: the *water cycle*, *material cycle*, and *eat cycle*. At the building scale, the northern sphere of the building contains the *water cycle*. It is the largest sphere and references the hydrological cycle of Vancouver's local mountains to the north. The *make cycle* is located in the sphere that is setback east into the land to accommodate an amphitheater connecting to the water's edge. The *food cycle* is the southern sphere and embedded into the ground to represent the delta and agricultural lands to the south of the site. The geometries of the three peaks, or synclines, transform from a stretched spherical (ellipsoid shape) to the north to a spherical shape on the southern peak.

Program

A user in each cycle follows material exchanges from material inputs into the building. The material transforms through a series of events and processes, and then visibly cycles back

The False Creek context around the Conservatory for Community Matters.

Site Plan of proposed building on test site located in False Creek.



Long section of the proposed building exemplifying each cycle’s system, the material deposit walls, and the overall programmatic relationship.

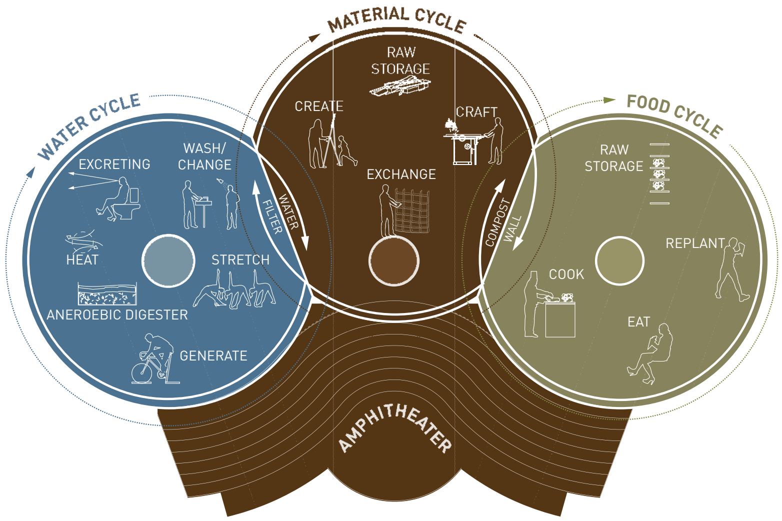
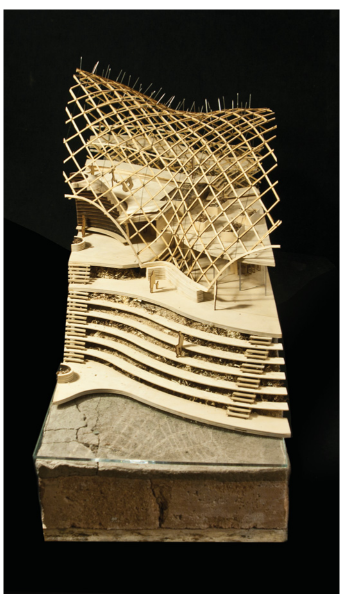
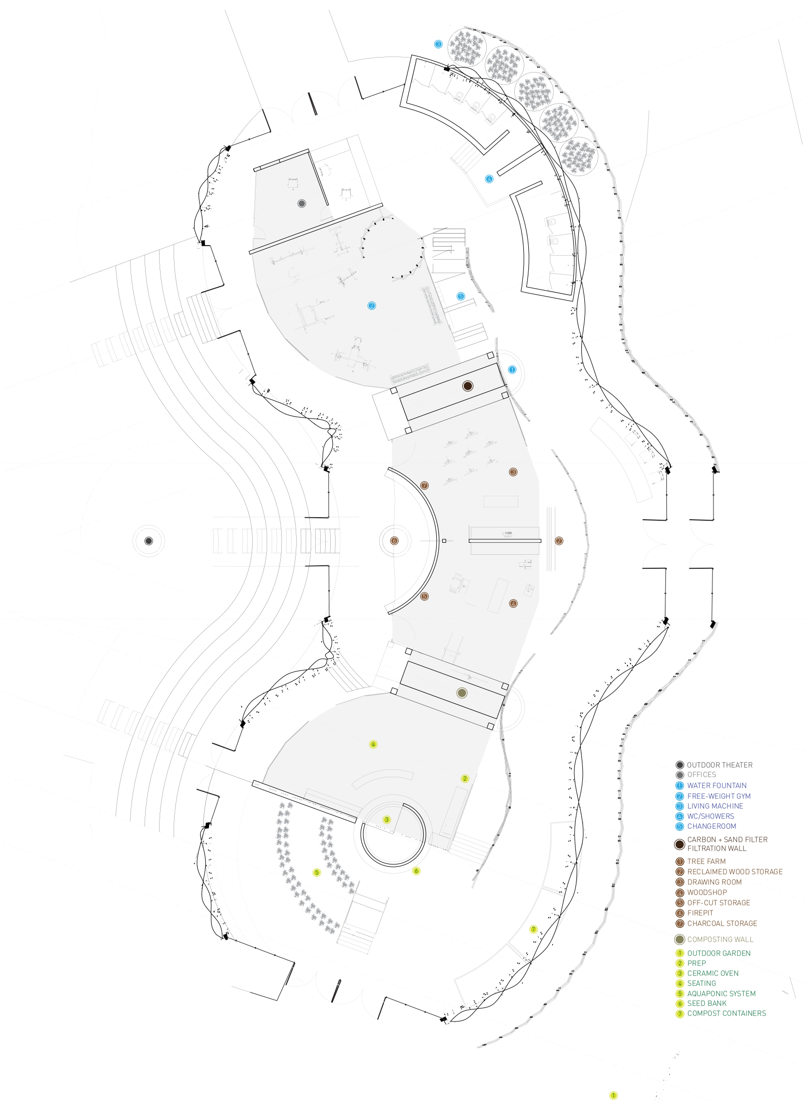


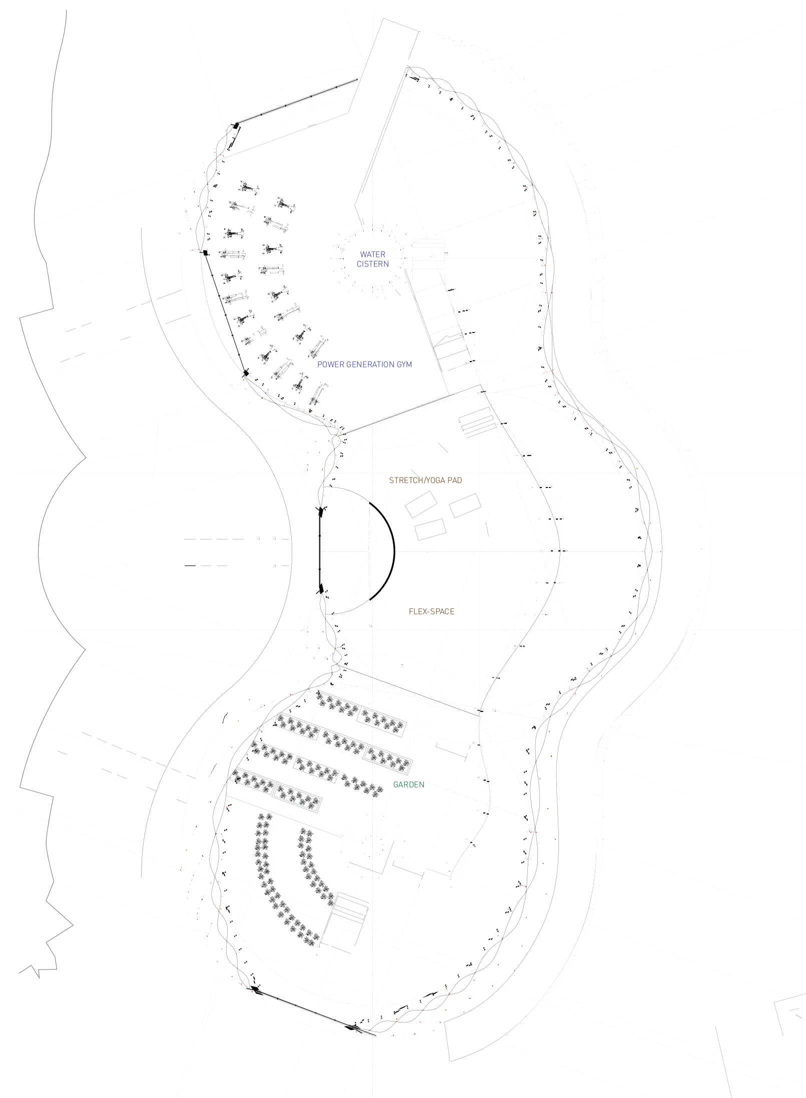
Diagram of User Activities: water cycle, material cycle, and food cycle

into other parts of the building for reuse. This exchange encourages a feedback loop that fosters community interaction and an understanding of material use through user's physical action. Each cycle has experiential nodes or events within the spaces where the user becomes engaged. Within the building overlap occurs in the three cycles. These interconnected spaces fit overlapping functions drawing parallels to how natural processes work. High rates of material recovery happen and the overlapping spaces become material deposits for material exchange. Water and carbon act as a water filtration wall and the carbon (saw dust) and nitrogen (food scraps) overlap within the compost wall. These by-product materials from each cycle are reused to promote nutrient cycling in a regenerative manner. As a person walks the line of the seawall - they are brought into the space to participate in a cyclical process, where sensory and physical connections to the material used is a part of each activity. The activities manifest interaction and sharing amongst the community, where people can begin to discourse about materials we use in an uninhibited open environment.



Sectional model showing some of the wood cycle and food cycle.





First floor plan on the left and second floor plan on the right. The building is composed of three cycles that promote the flow of organic material.

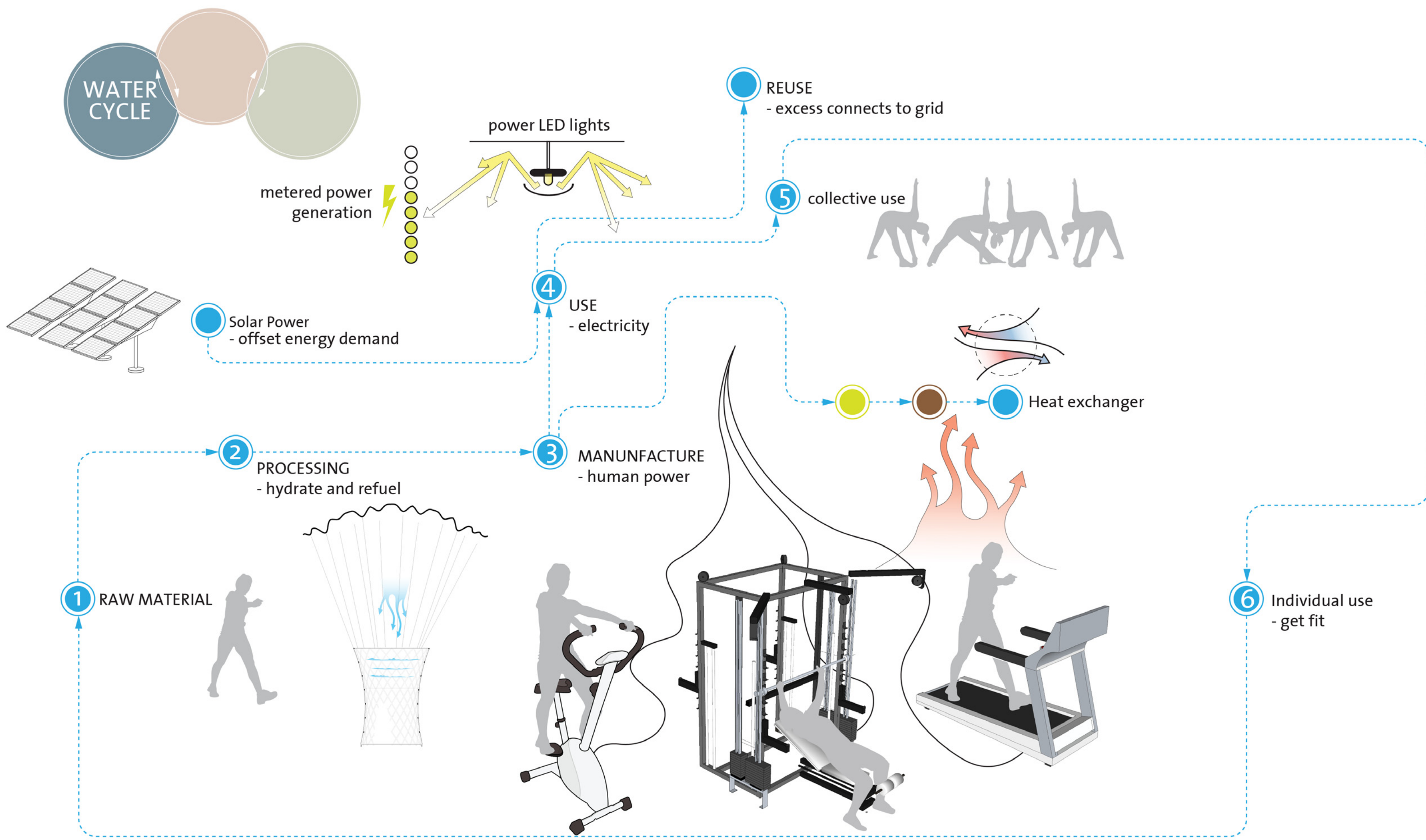
Water Cycle

Water is celebrated on-site from its entrance, through the skin of the building, to use. Water enters from the upper region of the building through the cell openings of the water cycle portion of the gridshell. The water then trickles along tension cables that connect to the water cistern. It percolates through the cistern and travels across the second floor plate into the filtration wall. Water is celebrated with a waterfall to aerate the space before it is transferred for use in the indoor garden, toilet facilities, and water basins. Once used in the toilets and sinks, the blackwater travels to the biodigester, while the greywater is filtered and sanitized for re-use.

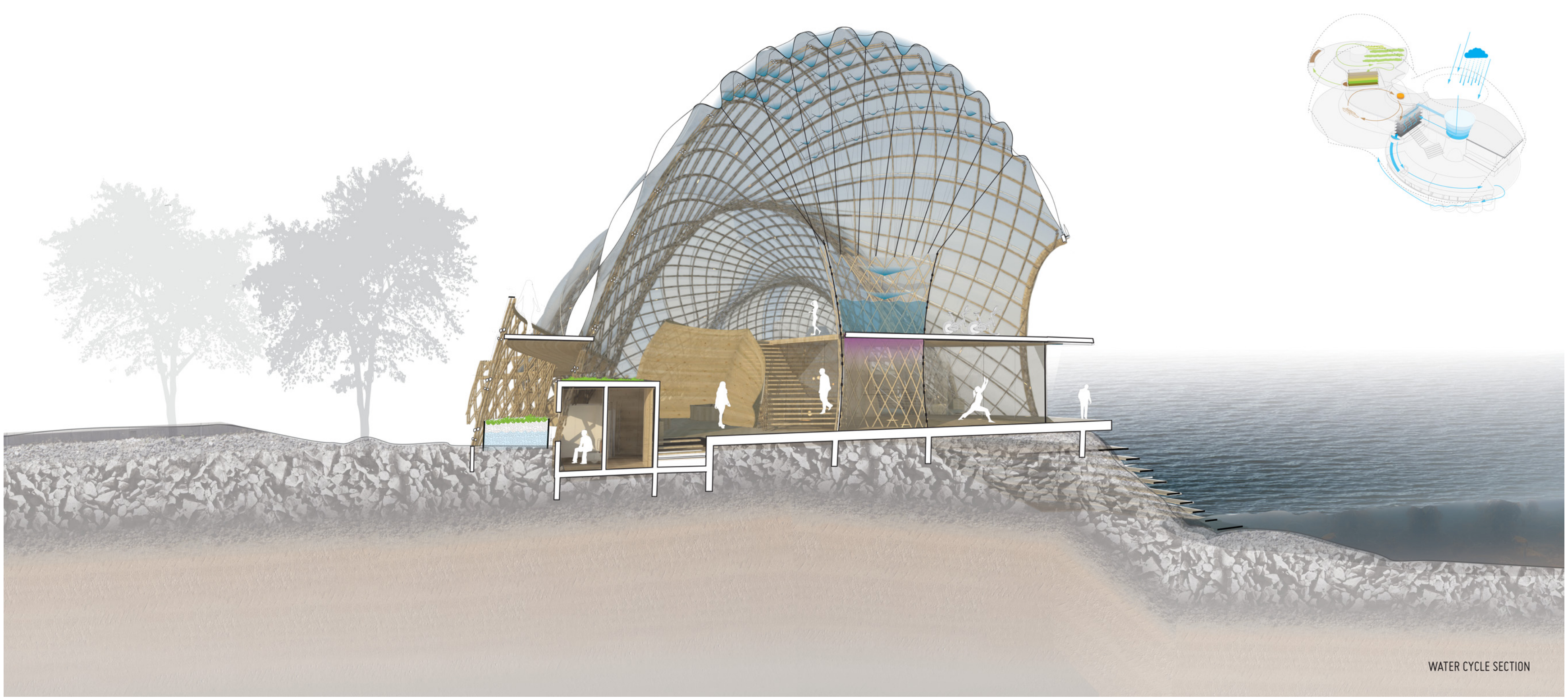
The secondary part of the water cycle program in the building is exercising for individual gain and the generation of electricity for the building. Water is an essential ingredient to exercise, where staying hydrated is an important aspect to fueling your body. With new fitness equipment technology, the ability for a human to generate electricity allows buildings to run partially on human power. The user then becomes aware of the amount of energy that they are producing for the building. A light below the large central cistern signifies power generation. Organized spin bicycling classes will involve 25 participants periodically throughout the day to

	Watts Generated	Power Produced	Carbon Reduction
SINGLE WORKOUT'S IMPACT			
Average Person	25-55 watt hour (Wh)	4+ compact fluorescents for an hour	2 oz. of Co 2 reduced
Elite Athlete	125 watt hour (Wh)	2 laptop computers for an hour	6 oz. of Co2 reduced
GROUP CYCLING CLASS'S IMPACT			
Full Class	2.5-3 kilowatt hour (kWh)	100+ compact fluorescent of central air for an hour	4.5 lbs of Co2 reduced
OVER A MONTH	300 kilowatt hour (kWh)	Light 6 Homes for a month	420 lbs of co2 reduced
OVER A YEAR	3,600 kilowatt hour (kWh)	Light 72 homes for a month	5,000 lbs of co2 reduced

A table describing the possible electricity outputs for human-powered gyms (Data from Go-Green Fitness 2009)



(1) Bring oneself (2) Stretch (3) Generate electricity while exercising (4) Shower/change



Sectional perspective through water cycle representing how water is cycled through the building from the cladding to the biodigester.

have collective power generation workouts. If the gym runs spin classes frequently a sizable amount of energy can be produced. The ritual of going to the water fountain during a fitness routine is an important aspect to regeneration. The individual gets in shape while the collective gets to enjoy human-powered electricity.

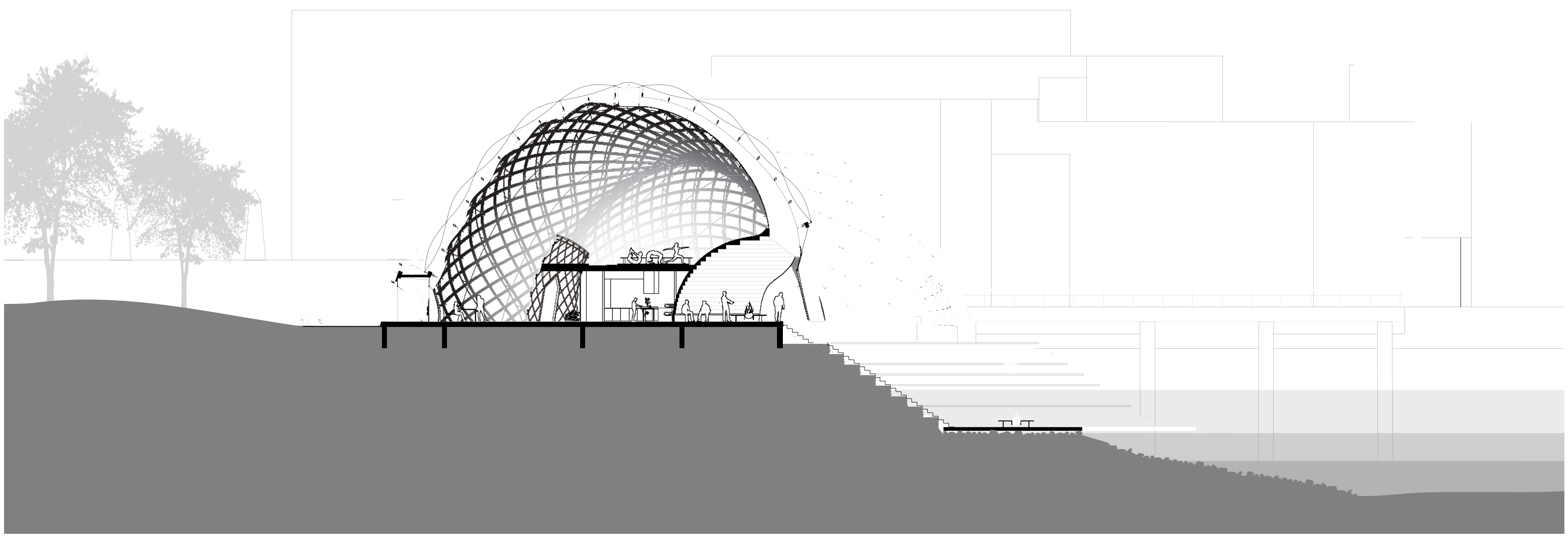
Water Filtration Wall

The wall between the *water cycle* and *carbon cycle* becomes the place of water filtration. Using activated charcoal, a sand filter, and uv light, water is collected on-site, filtered, sanitized and percolated through the building and down into the spaces. The water is filtered for use in the garden and for the toilets on-site.

Material Cycle

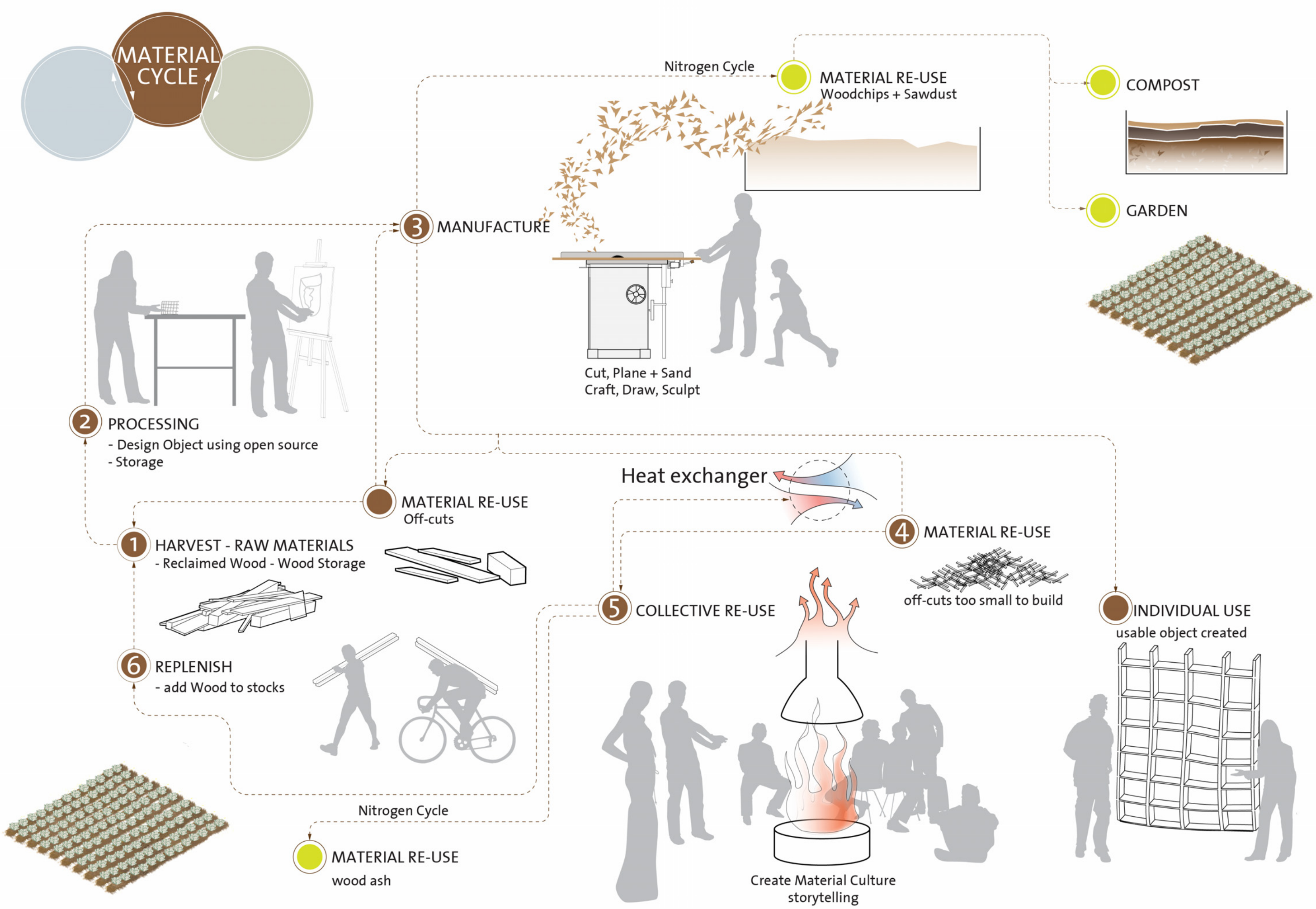
The *material cycle* is composed of a wood shop, drawing room for sketching ideas, and a firepit. The benefits of using wood and building with natural materials will be taught through the physical act of making. The *material cycle* process is dedicated to the storing, designing/refurbishing, planning, and making of objects for the individual to take home while creating offcuts for the firepit. Wood-chips and sawdust are collected for compost. The promotion of salvaged and reclaimed wood for use is encouraged in the wood storage facility. In addition, once something is made, it is exhibited within the space for a week for people to observe. The facility also runs workshops and classes for youth and adult building workshops. The main objective is to learn about local materials through craft and the physical act of making.

The firepit is where the community can congregate to share thoughts and experiences in the community center. The ritual

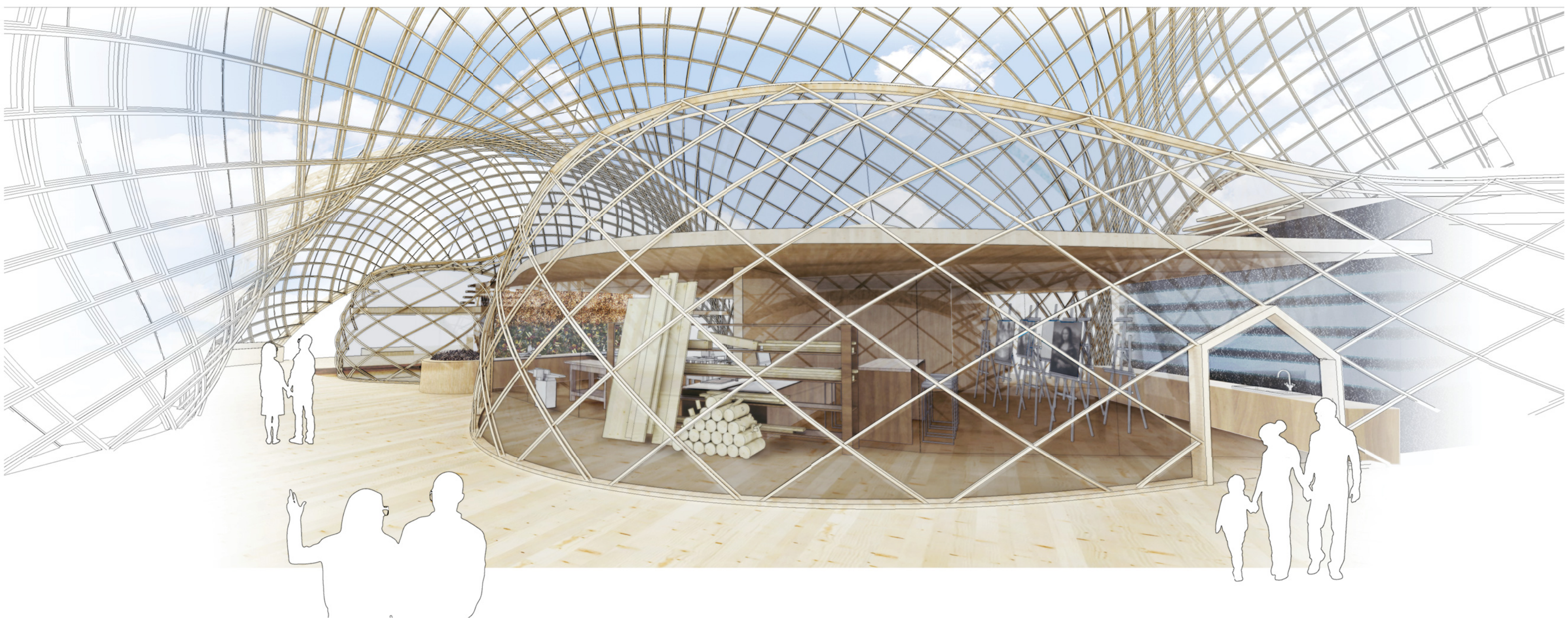


Short section representing the atrium, wood storage, woodshop and firepit relationship. The firepit's smoke is drawn into a heat exchanger for reuse.

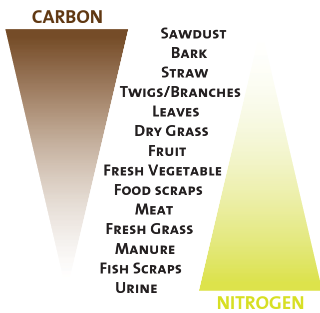
Interior view of the firepit with users roasting marshmallows. The wood shop is to the right.



(1) Bring and Store Reclaimed wood (2) Processing - design using open source (3) Manufacture by hand (4.) finished project is showcased (5) Wood waste is used to campfire (6) Replenish



Perspective of the atrium space with the wood cycle in clear view. The drawing room to the right where charcoal from the firepit is used with the water filtration wall on its right side and the wood shop located on the left beside the compost wall.



Graphic of materials within a carbon to nitrogen ratio. A rich compost is one that layers nitrogen and carbon with a total composition of one part nitrogen to 25-30 parts carbon.

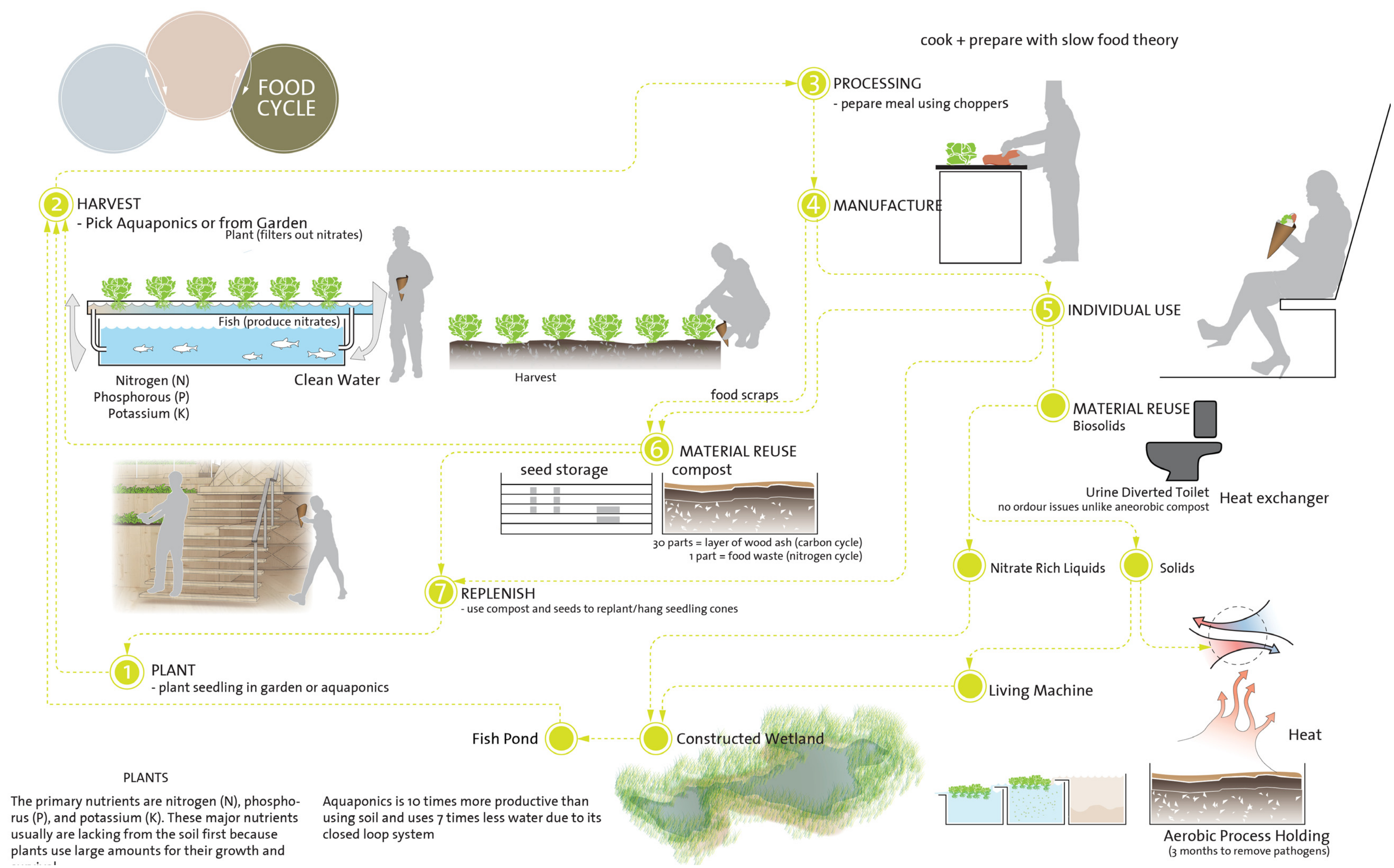
of the campfire is taken into the city where storytelling can create a place of casual community discourse and ecological understanding. The firepit is bordered by necessary fire making tools – sawdust and offcuts accompanied by a bin for the wood ash to be used for compost. The firepit also contains charcoal harvesting for drawing utensils in the drawing room. This promotes use of wood throughout its many cycles. The firepit can be accessed throughout the day and into the night by the user for community campfires along the water's edge.

Compost Wall

The sawdust and wood scraps from the *material cycle* combine with the food scraps of the *food cycle* to form the compost wall. The wall is mostly transparent exposing the combining of organic scraps with sawdust where the two cycles overlap. It is accessible from both sides for continual rotation with the final compost ready for use in the community garden located in the atrium space. The compost wall is monitored by the community. If a compost pile is managed properly with the right ratios and correct amount of turning there should be no odour. Odor is a sign that valuable nutrients are being lost for it is too high in nitrogen. It needs regular maintenance and oxygen to return it back to an aerobic state. The staff of the community center assist in the process.

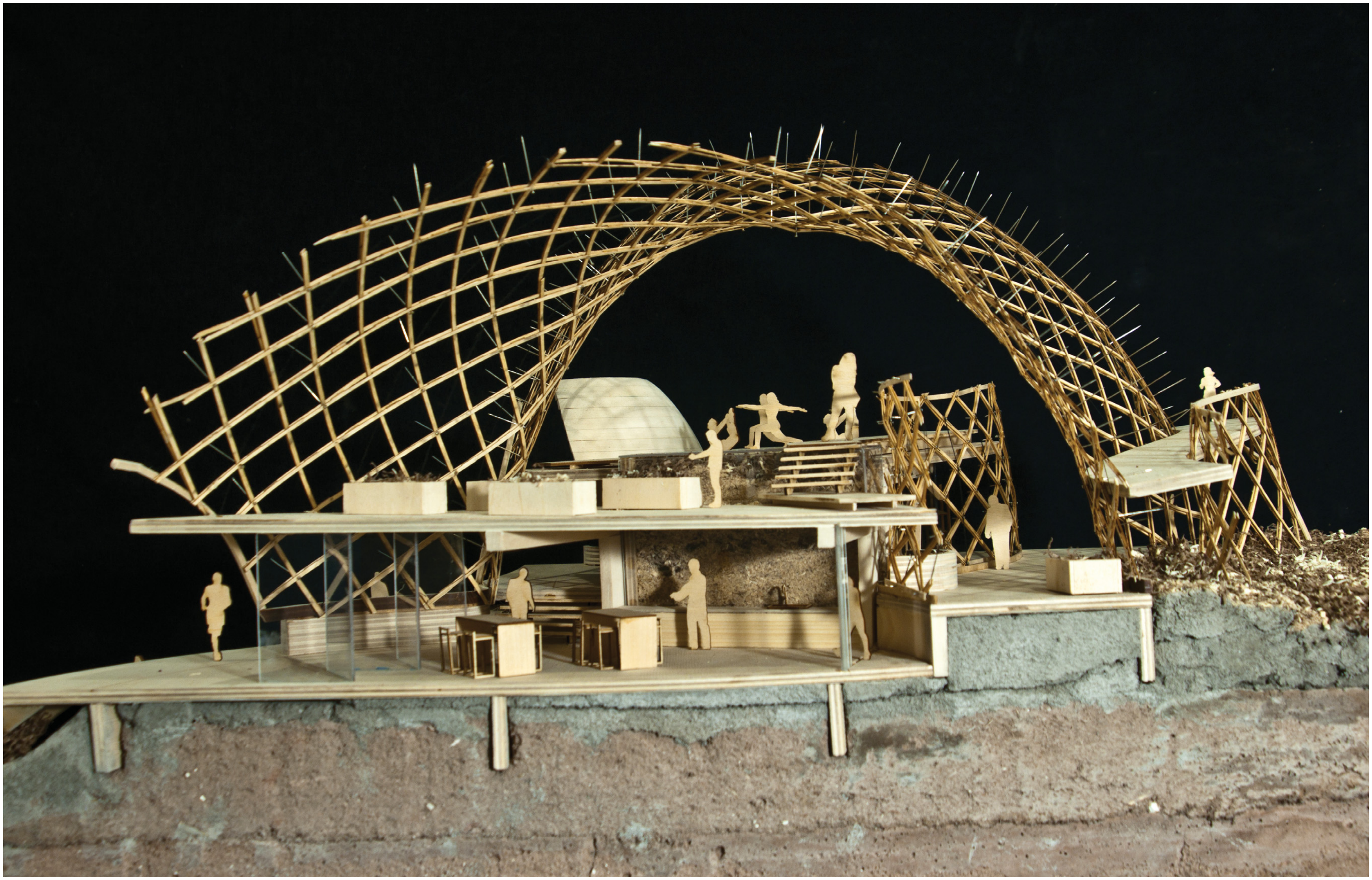
Food Cycle

The *food cycle* is dedicated to the harvesting, preparing, eating, and inputting of food scraps into the collective compost bin. The physical location of the *food cycle* is the lowest in elevation within the building to visually link growing food and the ground plane. This enhances the users connection to the edge and physical ground plane while eating.



(1) Pick up a seedling and transplant in garden (2) Choose your vegetables to eat (3) Prep vegetables (4.) Create meal (5) Eat (6) Turn compost (7) Put new seedling cone in ground

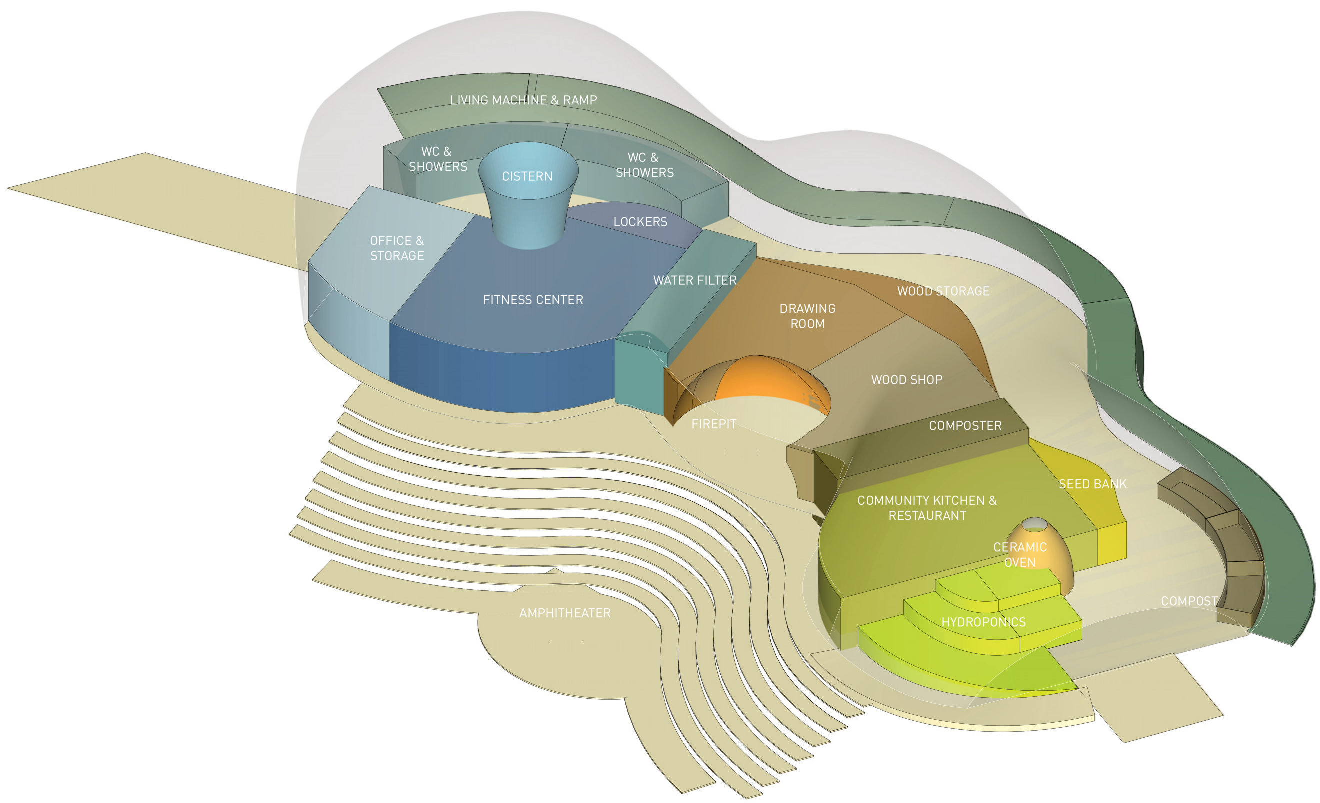
Perspective of the southern entrance looking at the interior garden, aquaponic tanks, and seedling storage within the food cycle.



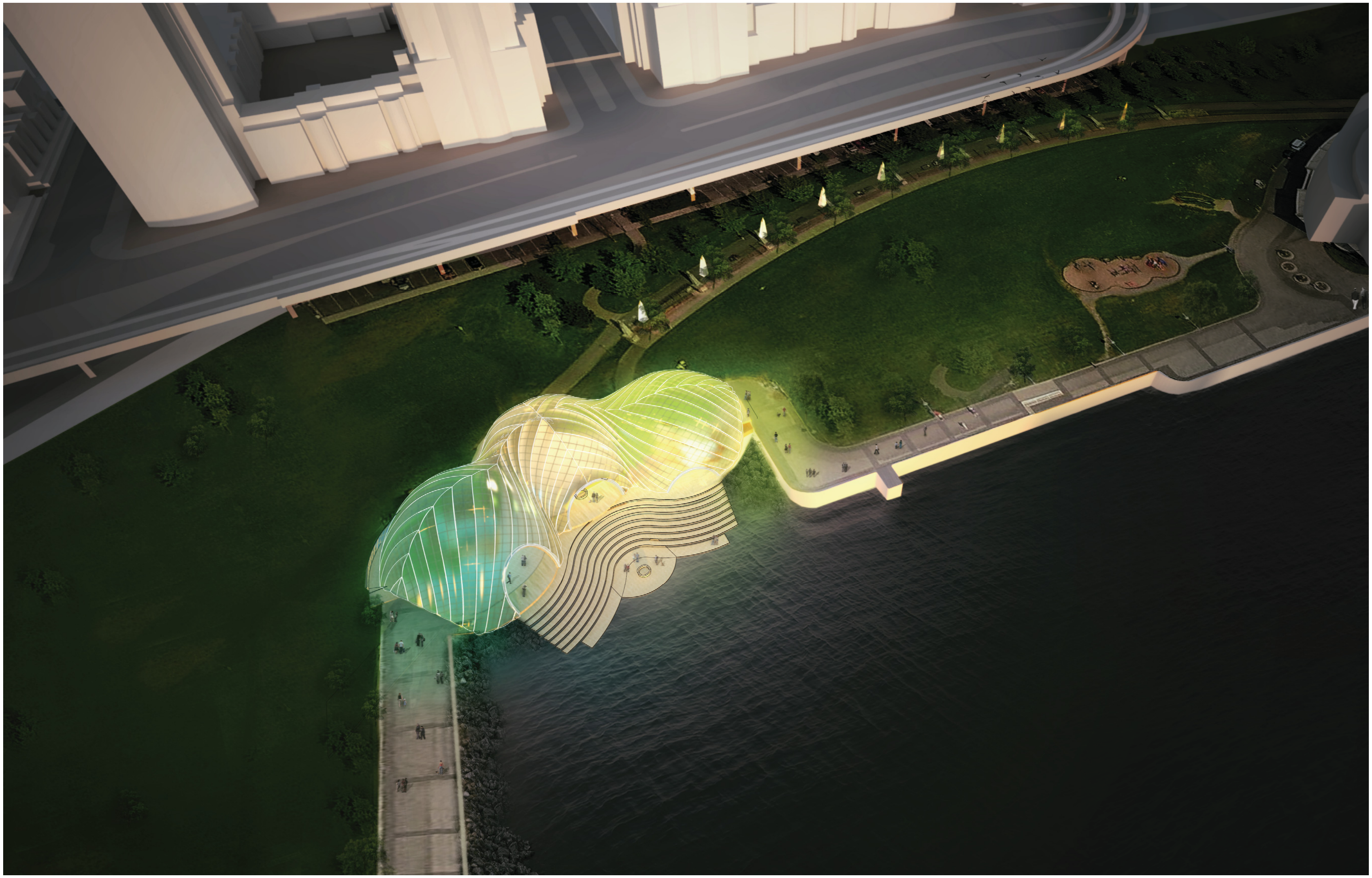
Sectional model showing the community kitchen and the garden planter boxes on the 2nd floor within the food cycle.

The first part of the experience is to engage in gardening with the soil or aquaponic system in a community garden. The vegetables are generally chosen for their resiliency in the greenhouses and aquaponic facilities. Along the way, excess organic materials are brought to the compost wall and then seedlings are replanted in the garden. Vegetables with fast growing rates (lettuce, herbs, and beans) are used for aquaponics. The outside garden is used for seasonal vegetables and engage users with the land.

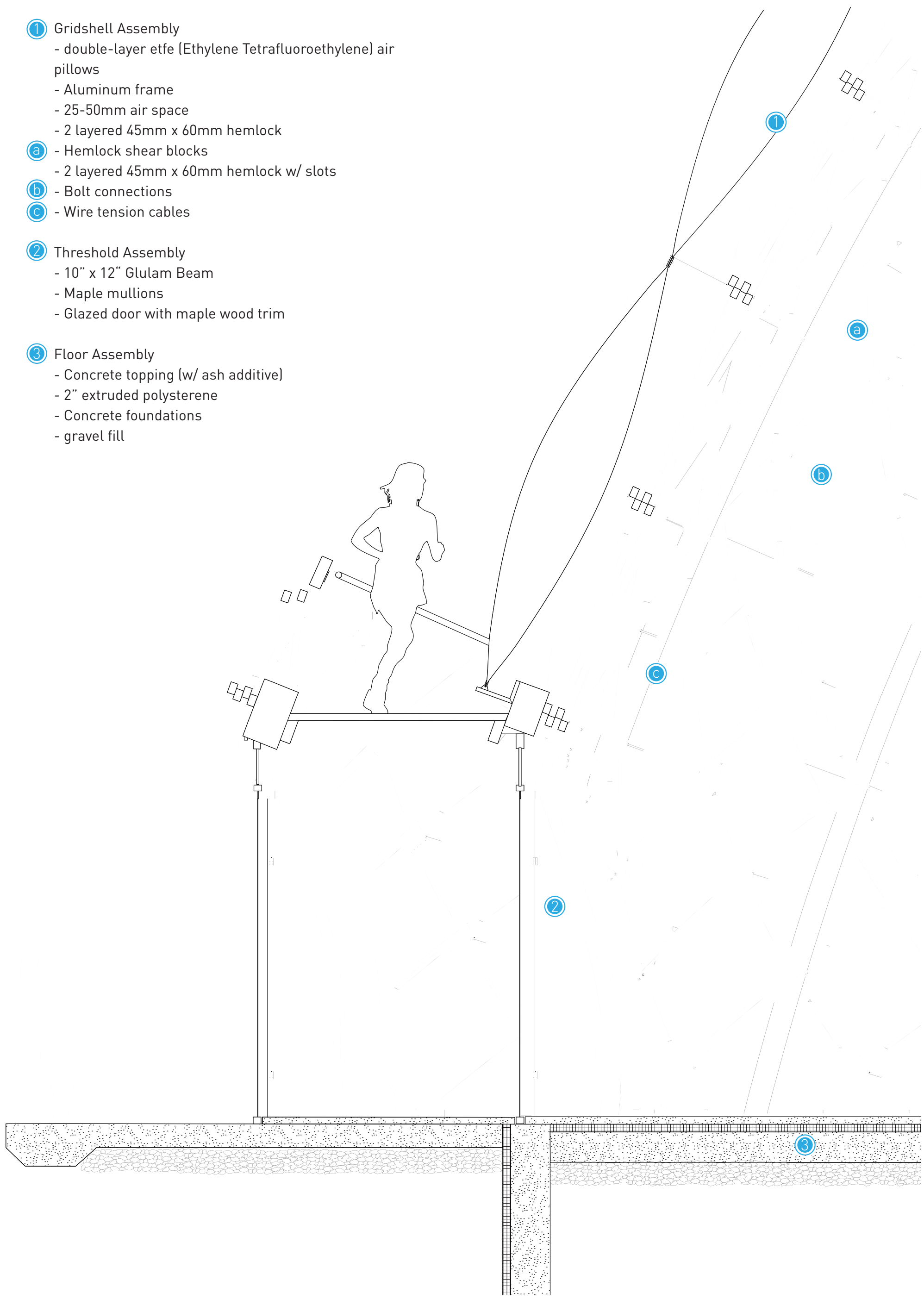
The vegetables are brought into the prep kitchen to be processed. The veggies are looked after and prepared by the user. The process involves appreciating one's food by advocating elements of slow food theory process. The sequence of events brings the user into engagement with the physical act of picking vegetable, preparing the meal and creating the item within the community kitchen. Meals are prepared as a community affair throughout the day. The food is then consumed in the available seating. The compost is turned by the user when needed, applied to the soil with a couple of seeds and the cycle is complete. This process engages users on a community scale as well as the individual scale so skills can be brought home to promote urban agriculture.



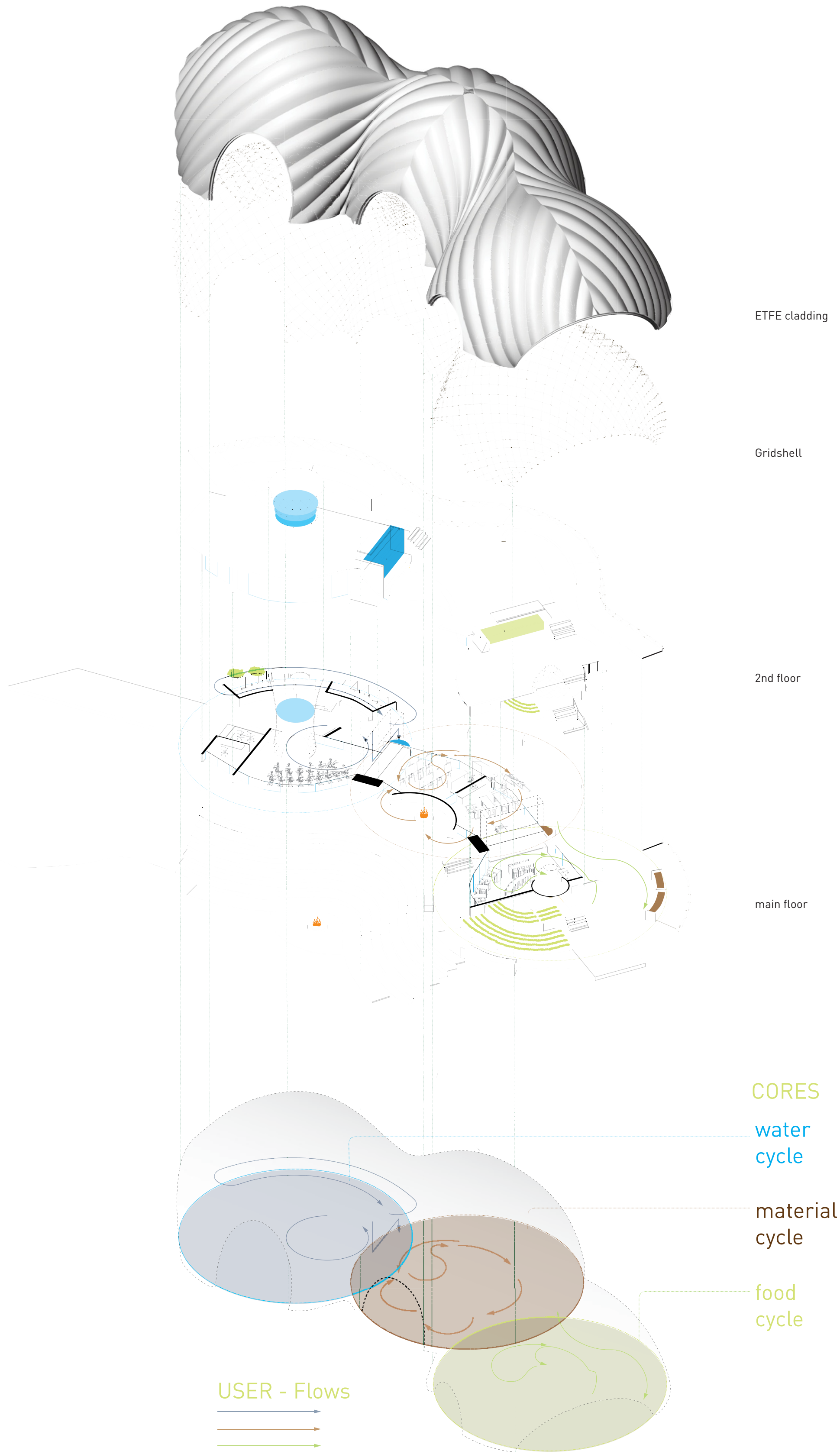
Programmatic massing of building components. From left to right: water cycle, material cycle, and food cycle.



During the evening, the Conservatory for Community Matters becomes a lantern and a place of activity.

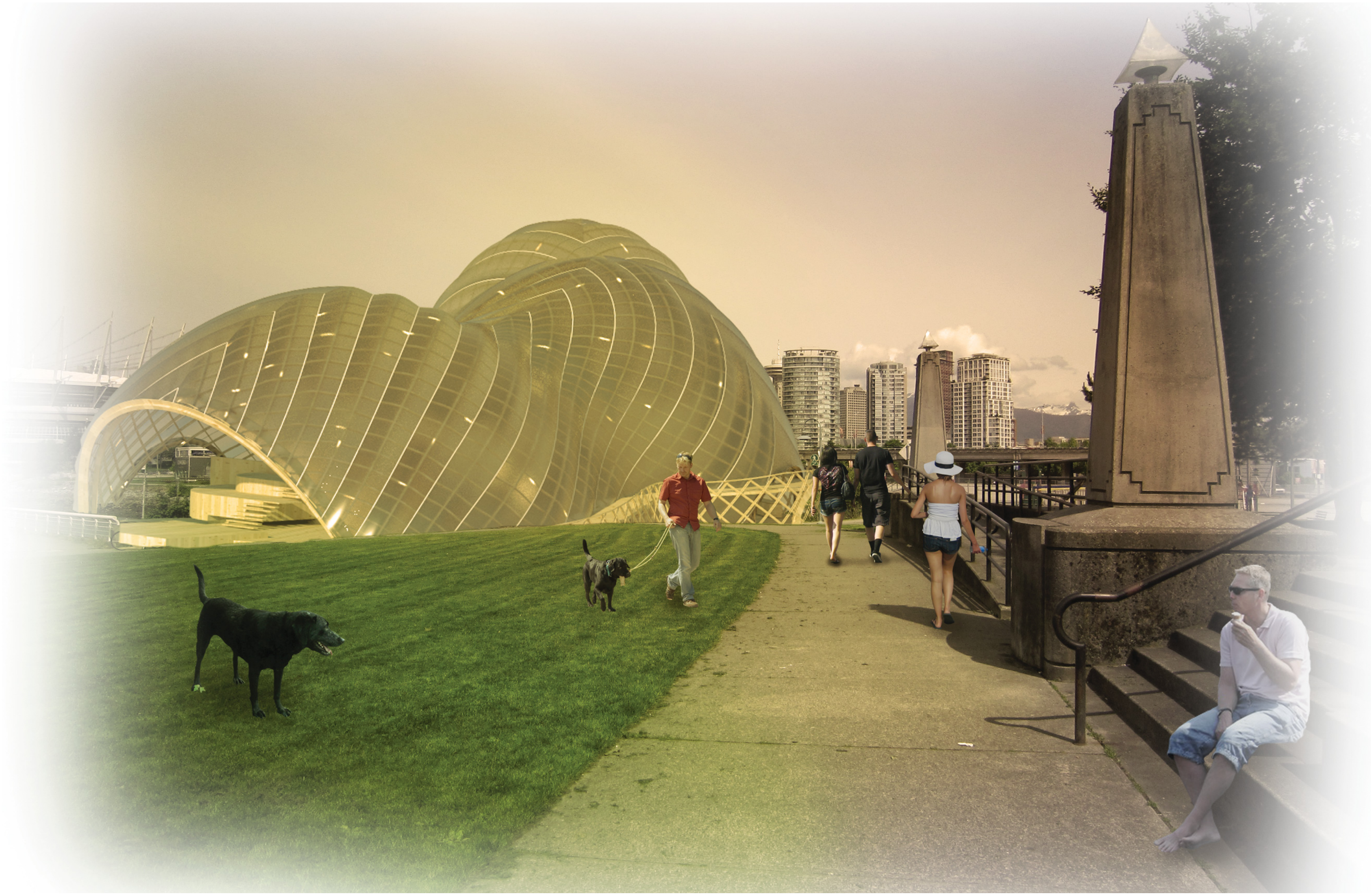


Sectional detail through main entrance showing the gridshell and ETFE building system at 1:50.

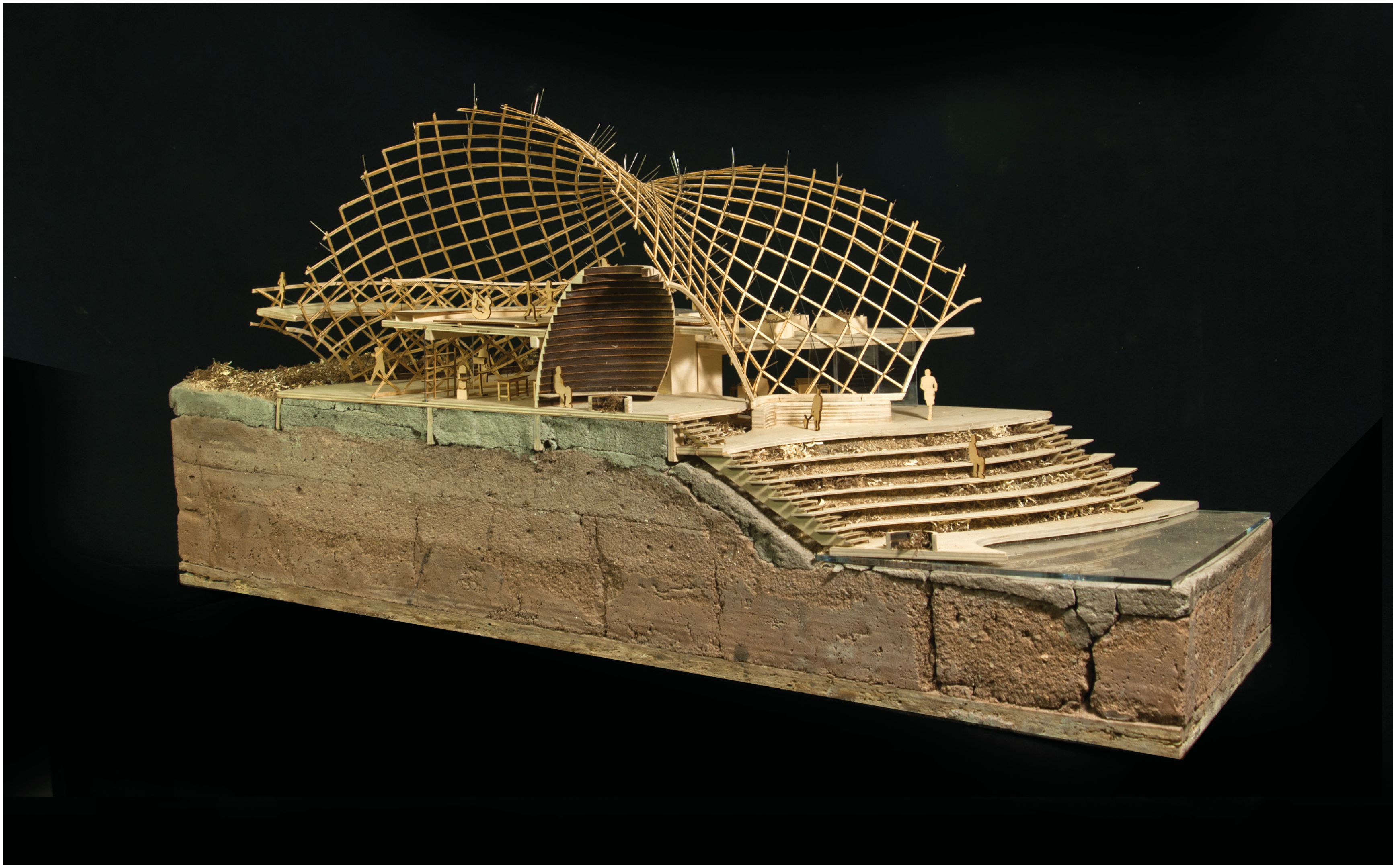


An axonometric showing the programmatic flows through the building and the structural strategy.

Rendering from a view on the northwest of the site.



Rendering looking north towards the entrance and the food cycle.



1:50 sectional model through main entrance. The spaces include the wood shop, firepit, compost wall, and restaurant. in addition to the flexspace and indoor garden on the 2nd floor.

CHAPTER 6: CONCLUSION

Vancouver is a place of natural beauty and spirit. It is a place to stage human and nature's complex relationship, where local community can integrate with their natural surroundings. The inhabitants of Vancouver have the potential to fully understand and appreciate our connection to nature's functions and beauty. By respecting nature's flows, cycles, and processes, people become aware of their action on the larger scale. The user then feels connected to a larger network of relationships within nature and community. The result is the eventual understanding that we, as individuals, have a responsibility to ecologically interact with the environment.

The edge of Vancouver is the perfect public space for learning and nurturing ecological literacy. It is an interstitial space where biodiversity is rich, where land and sea, city and nature meet. The concentration of biological and cultural flows along the city's edge support the project's objectives of a community center that will unite the community and engage the user in natural material processes. The Conservatory for Community Matters connects natural material processes with the user's habits and rituals to change the way we harvest food, make crafts, and generate power to promote a healthier way of life.

During the presentation of the design, many thought provoking questions arose that related to the early stages of the design.

Thoughts of a hands-on approach through prefabricated parts where the user participated in the whole life-cycle of the building from construction, operation maintenance, and decay, where a community 'barn-raising' type of approach could be utilized. The center would be a manifestation of the community's participation much-like the construction of a yurt in a do-it-yourself approach. However, this objective is highly idealized in its approach, and for a larger-scale building, it would be most effective and durable during its life-cycle if it was assembled with a specialized craftsman and maintained continually as the use and popularity of the building creates much more complex needs.

The context of the building was another point of discussion during the presentation. The building is situated on a very important part of *Vancouver 2020: A bright Green Future* action plan, where a building sister to Science World called Sustainability World is proposed. It would connect to a newly created green-tech industrial park to the east of the site and promote green smart growth (Boyd 2010, 50). Would the community Building fit within this plan or would it try and be something different? The buildings location will receive tourists and local community alike, where the users of the building would be a mixed demographic. The massive amphitheater located in the building was designed to specifically cater to large events and discussions on Vancouver's Green Future, but with a much more contextual twist than the outwardly focused Sustainability World. It would serve a different approach where user participation centers around its function. The building doesn't become a demonstration center of what action has been done in the past, but something that continually operates to provide understanding about how people including tourists can shape their world to be less onerous for the excessive materials we use everyday.

By designing with nature in mind, the building promotes nature's cyclical approach to design. This raises awareness to the power of designing architecture for nature and humans symbiotically to positively influence the daily rituals of city dwellers and nurture ecological literacy. The proposed building educates to fundamentally shift the core values of people in hopes of them becoming environmental stewards of the earth.

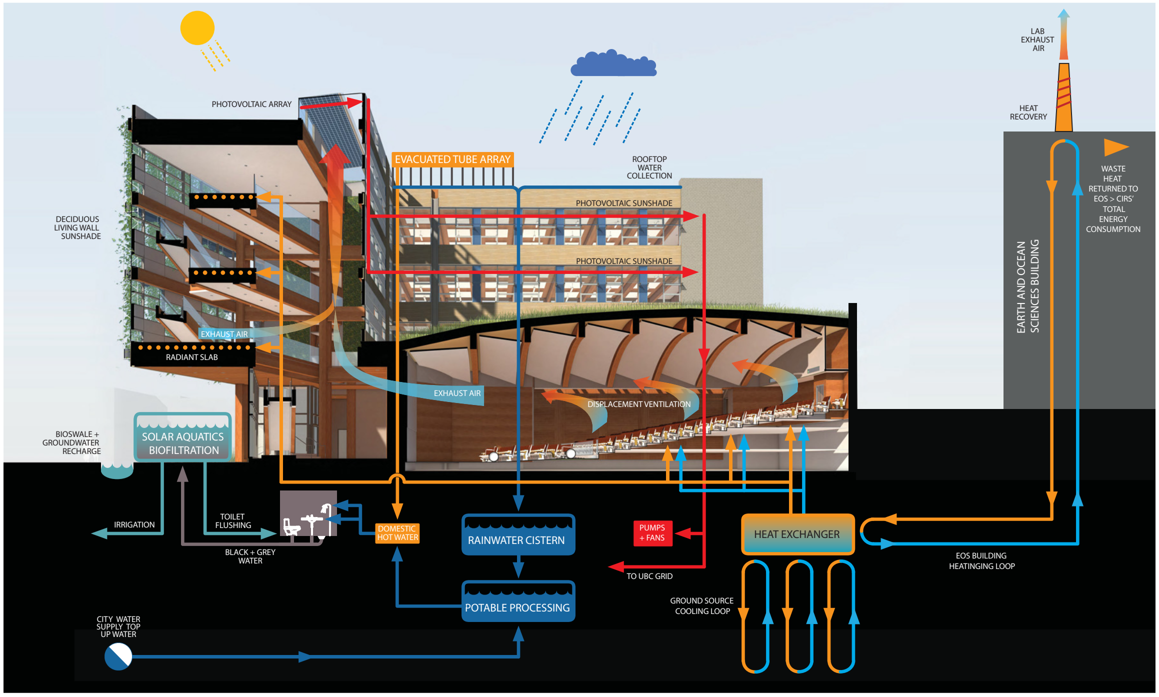
APPENDICES

Appendix A: Thesis Presentation

The Thesis Presentation Tuesday March 19, 2013.

Appendix B: Integrated Building System Precedents

Centre for Interactive Research in Sustainability at UBC, Vancouver BC, 2011. By Busby Perkins and Will.



Sectional Perspective showing Integrated Systems (Busby, Perkins and Will 2012)

Center for Interactive Reasearch in Sustainabililty (CIRS) is a project just recently completed for UBC. It is designed to be a "living laboratory", where systems are fully integrated to create a regenerative building concept. Within the highly interactive CIRS website, the project's vision is:

> To be the most innovative high performance building in North America and an internationally recognized leader in accelerating the adoption of sustainable building and urban development practices. (Center for Interactive Research in Sustainability 2012)

It has contributed immensely to the green building culture within Vancouver, where anyone can access information and be educated on its systems online. Funded by federal and provincial grants, the objective was to create the greenest building in North America. The project will receive LEED platinum and is following the Living Building Challenge objectives. The building has net zero energy, water,

Atrium showing the use of exposed Wood Panels and Glulams

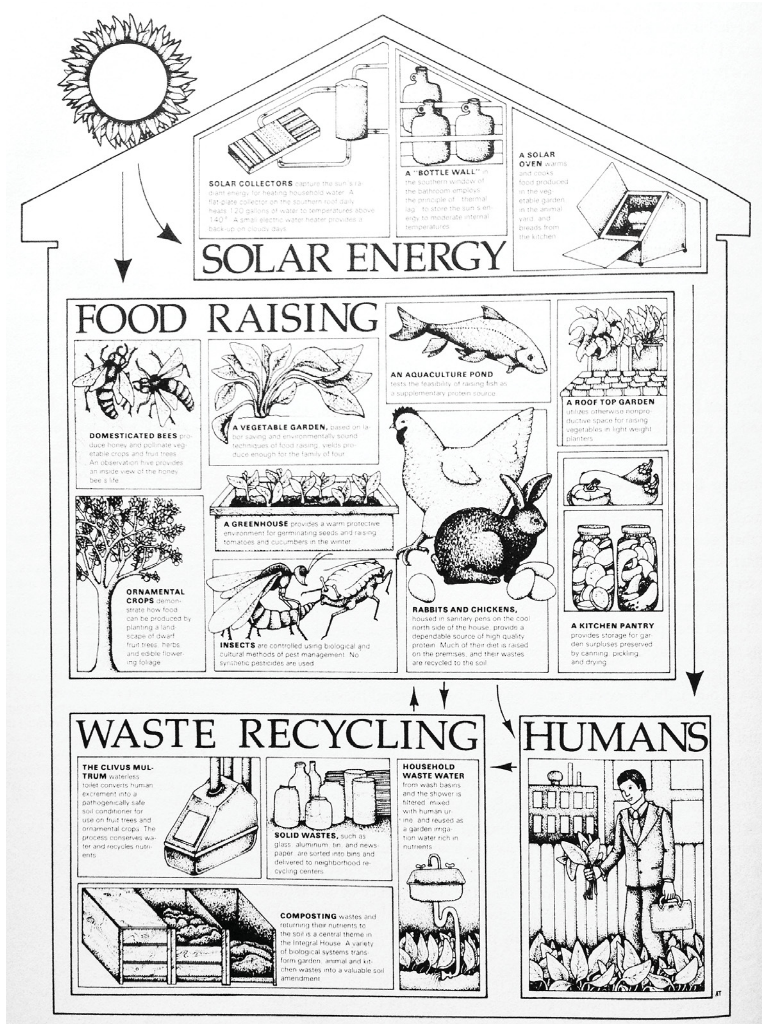
Southwest Facade with the Solar Aquatics located on Ground Level (Erhardt 2011)

carbon construction, and carbon operation. The project's detailing and structure is very minimal to allow for easy maintenance and materials were chosen for their durability and low air pollutants. The structure consists of as much wood as possible: low-formaldehyde glulam-beams and solid wood panels are reminiscent of large timber-frame buildings built in the westcoast modernist style. Beyond the structure, a living system manages both black and grey water to be reintroduced to the site for irrigation and toilet-use. The heating piggybacks off the waste heat generated by the nearby Earth and Sciences Building and hot water is produced by the evacuated solar tubes on the roof. The electricity is generated by solar thin film photovoltaics and in the sunshades. The physical building is not the only 'green' aspect to the building - the client is as well.

The building will only get better with age as the occupants generate a feedback loop. The building learns from its inhabitants on its energy loads and user comfort levels. This very beneficial feedback loop creates a culture of material and energy cycles that mimic an ecosystem. The building's feel explores elements of sustainable design. The living machine becomes the totem or centerpiece for the building.

Predominately due to its efficiency in spatial arrangement, It does not celebrate nature's cycles with visible movement. By exposing and recording the material flows within the building through visuals on site, the building could be more use ecologically to the public than just through diagrams online.

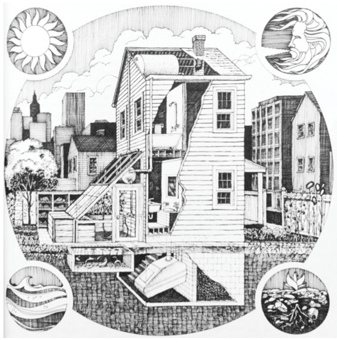
Integral Urban House, San Fransisco CA, 1969. By Farallones Institute



Habitat and Life Support System of an Integral Urban House (Farallones Institute 1979)

The main features of integral system: (1.) Process materials and energy through closed loops and webs of multiple channels (2.) Release Energy within the system in small increments (3.) Maintain a steady state (homeostasis) through negative feedback loops and permeable boundaries (4.) Store information in a decentralized genetic memory.

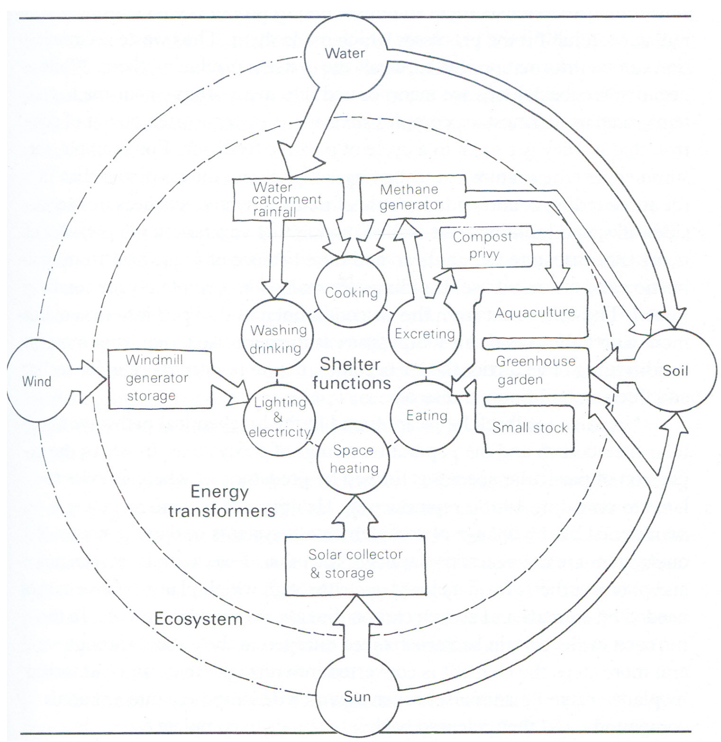
The Integral urban house is used as a model for how we can live less wasteful more symbiotic lives with nature by designing closed loops at the urban household scale - creating a miniature ecosystem. The "life-support systems" create



Sectional Perspective of Exterior showing water system (Farallones Institute 1979)

all the needed food, energy, and water necessary to sustain a family within their property. These closed loops are integrated into one another to form a system where boundaries become permeable and systems mesh together to form intricate flows that create a steady flow of energy to try and achieve balance. It is implicitly mentioned that no man-made system can compare to natural ecosystems ability to function in loops but the more 'pathways, steps, and loops' that can be included in a man-made system the more stable its conditions are to build-upon. If a system is too closed and centralized the system transcends into chaos and failure also called - entropy.

The model is a living experiment and tests the systems functioning for a new form of living that is local, low-tech and represents an attempt to functionally understand ecosystems for human consumption. It doesn't depend on the funneling of supplies into the city as its support system, yet creates local flows where nature's processes are visible



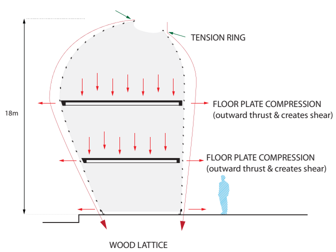
Energy Flow in a Closed System Habitat (Farallones Institute 1979) within an environment for which we hold close – our home.

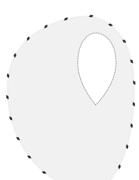
There are innovative passive systems for solar energy, food raising, and waste recycling within this two storey suburban household. The suns' energy is collected from a 'bottle wall', solar oven, and solar collectors. The food systems include rabbit, chicken and fish system for meat along with a large vegetable garden for greens. The compost from the kitchen is mixed in with human wastes to achieve a compost mixture usable in the garden in six months. The grey water is recycled into the garden. Water is captured on-site. All systems are combined with multiple pathways to ensure a constant movement of energy flow throughout the system. The house was selected in a degraded neighborhood, but since its construction, it has created a culture of integral houses within its vicinity.

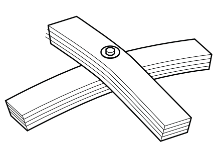
The building is highly influential for its ideas in ecological design and community building. The building does function to create life-support systems but does not represent a system that connects beyond the building scale's flows. The reuse of an existing house is the most sustainable form of material use. However, the purpose of the thesis is to show nature's patterns in form and community engagement. By making it a house, it does not reach a large enough influence to city inhabitants. The integrated systems could possess more elegance, fun and integration in its equipment and architecture. The end result is to treat it not as an additive approach to system thinking but to integrate the form of architecture for education within the context of nature's patterns.

Appendix C: Structural System Precedents

Staircase and exterior view of Tower (Tiainen 2004)







Korkeasaari Zoo Pavilion, Helsinki, 2001. By Helsinki University of Technology Architecture Students

Type of wood: Pine

Detail: 60mm x 60mm Lathes,

Form Finding: Physical Models and Computational Models

Construction Process: 7 prefab profiles, glued and arranged on Floor Plates on Scafolding

Joint: Glued during Prefab Process

Sheer: Floor Plates

SIMILARITIES TO PROPOSED BUILDING:

(1) USE OF FLOOR PLATES FOR SHEAR STRENGTH: Horizontal compression and tension rings from the floor plates achieve its form. The occulus draws the eye up to the sky, very similar to the water cycle's tension cables.

(2) EXPOSED LATHS: The exposed structure gives it a sense of lightness and provides views. The wood has a chance to show its patina with age. It will not rot because it is exposed to constant air flow. It is treated with linen oil so it naturally sealed and will not dry out if its applied regularly

(3) ASSYMETRICAL FORM: It breaks way from structurally static forms of Downland Gridshell. The material depth is thicker though because of it.

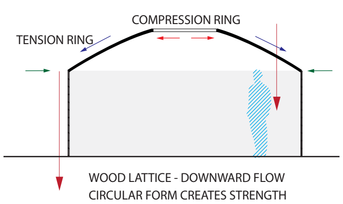
DIFFERENCES:

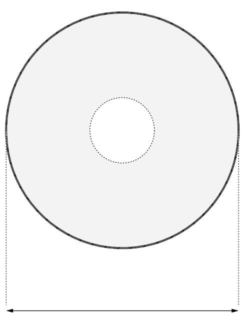
(1) CONSTRUCTION PROCESSES: the beams are laminated together and steam bent before connecting to the network, which makes it a different way of construction - piece by piece. There is also more compressional force on the pieces so they are have to be thicker.

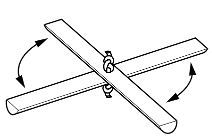
(2) ROUGH OPENINGS THROUGH SHELL: The door opening cut into the gridshell are orthogonal, so a steel frame was used due to its need for extra strength.

(3) CELL SIZE: the cell size is much smaller than the proposed buildings cell size.

Mongolian yurt being constructed (Wikipedia 2013a)







YURTS - All over the world, since 13th Century

Type of wood: Willow Branches

Detail: Varies

Form Finding: easily rotated around within a circle.

Construction Process: Round Lattice Wall into a circle, apply roof members and tension rings, and then clad.

Joint: Lapped and Lashed to create Form

Sheer: Tension Cable at Lattice Top Edge

SIMILARITIES TO PROPOSED BUILDING:

(1) DETAIL :ASSEMBLE TO DISASSEMBLE: The structure is light and can be easily assembled and disassembled for transport. The lattice structure allows the form to scissor to expand when in use and contract. Modern yurts use rivets or bolt connections, but rawhide was once used Anybody can build them

(2) USE OF NATURAL MATERIALS: Willow Branches, Rope and Felt are used. They can withstand Siberian Winters and exemplify highly effecient forms.

DIFFERENCES:

(1) MATERIAL DEPTH: the depth of willow material does not resist buckling when trying to achieve larger spans when forming two way curved shells

(2) FORM: the structure can take on any shape but are usually built in a circular form for maximum efficiency with standard roof rafters placed on-top.

Interior of The Multihalle.
(Eibel 2011)

Mannhiem Multihalle - Mannhiem, Germany, 1975. By Frei Otto and Arup.

Type of wood: Hemlock Pine (chosen for its straight grain)

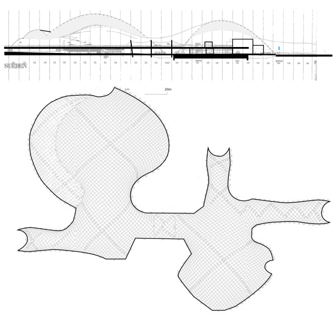
Detail: 50mm x 50mm Lathes

Form Finding: Physical Models, Hanging Chain Models

Construction Process: Raising and Filling

Joint: Finger Jointed (off-site), Lap pieces (on site)

Sheer: Tension Cables

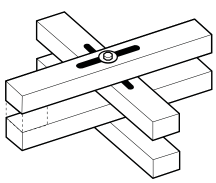


SIMILARITIES TO PROPOSED BUILDING

(1) BIOLOGICAL PRECEDENCE: Frei Otto used biology at a microscopic scale to find structure.

(2) PIONEERING: this structure is the largest and first timber gridshell used in application. Uses the double layer lath technique to add depth to beam-size.

(3) DETAIL: the detail uses a slotted hole for its outside layer to allow for movement between layers. The shell is triangulated with sheer strength using light tension cables.



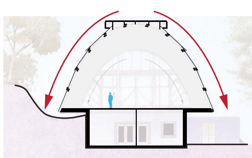
WEAKNESSES

(1) FUNICULAR FORM: funicular structures are composed of catenary curves derived from hanging-chain models. The tension structure switches to compression - limits the form capabilities and strength, according to Bruro Happold Engineers.

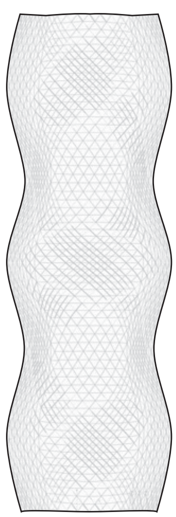
(2) CONSTRUCTION PROCESS: Built by lifting up. Long and unsafe construction time

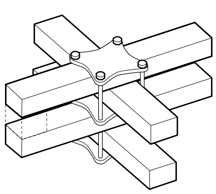
(3) EXTERIOR Cladding: PVC makes the building dark grey in appearance as well it poses some fire-safety issues. ETFE would have been used if it was invented at the time.

Downland Gridshell from the exterior and interior (Davey 2010)



WOOD LATTICE - DOWNWARD FLOW
CURVED BENDING FLOW





Weald & Downland Gridshell, Downlanbd UK, 2002. By Bruro Happold and Edward Cullinan Architects

Type of wood: Oak (chosen for its availability and bent strength)

Detail: 30mm x 50mm Lathes

Form Finding: Physical Models and Computational Modelling

Construction Process: Lowered from Scaffolding

Joint: Finger Jointed (off-site), Scarf Jointed (on site), 145 broken finger-joints

Sheer: Rib Lathes

SIMILARITIES TO PROPOSED BUILDING

(1) SMALLEST AMOUNT OF MATERIAL USED: The material depth is 30 mm x 50mm with a cell size of 1m. This form and double layer allows for reductions in materials. .5 m spacing in valleys for extra support.

(2) CONSTRUCTION PROCESS: The gridshell is lowered compared to built-up and raised in place. Making it safer. It is built in 6 meter patches off-site and brought to site to be scarf jointed. It was raining during construction, which caters to Vancouver's wet weather

(3) WAVE-STRUCTURE: using the synclines and anticlines for strength - using nature as precedent

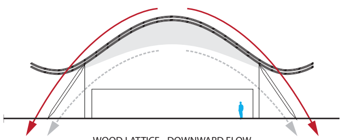
DIFFERENCES

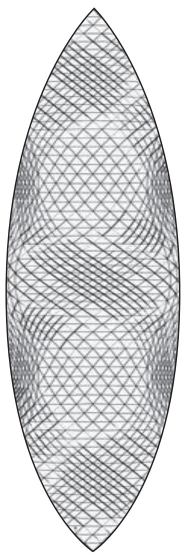
(1) EXTERIOR MASS OF BUILDING: It does not express the beautiful interior structure or construction process

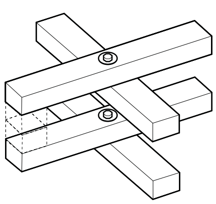
(2) NATURAL LIGHTING: there is not enough lighting in the space and feels heavy.

(3) SEPARATION OF BOX AND SHELL: standardized rectangular rooms are kept separate from free-form: The building's enclosed rectilinear rooms are all placed in the basement.


Undulating Gridshell Roof (Wikipedia 2013b)







Savill Garden Center, Surrey, UK, 2006. By Glen Howells Architects and Bruro Happold

Type of wood: Oak (chosen for its availability and bent strength)

Detail: 60mm x 50mm Lathes

Form Finding: Physical Models and Computational Modelling

Construction Process: Formed. Screwed blocking, add second lattice layer when in place.

Joint: Finger Jointed (off-site), unknown

Sheer: Birch Blywood

SIMILARITIES TO PROPOSED BUILDING:

1.) TECTONICS: The structure feels light with its wrap around glazing much like the ETFE and amount of glazing on the shell.

2.) WAVE-STRUCTURE: using the synclines and anticlines for strength using nature as precedent

3.) PIN CONNECTION: locks the cell size and allows for scissoring

DIFFERENCES:

1.) STRUCTURAL SYSTEM: large steel beams are used to support the edge condition of the project

2.) NATURAL LIGHTING: Glazing on the walls and shell on top. The proposed building will use a transparent ETFE skin that allows extensive natural light to penetrate its core

3.) SEPARATION OF BOX AND SHELL: standardized rectangular rooms separated from free-form shell structure.

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